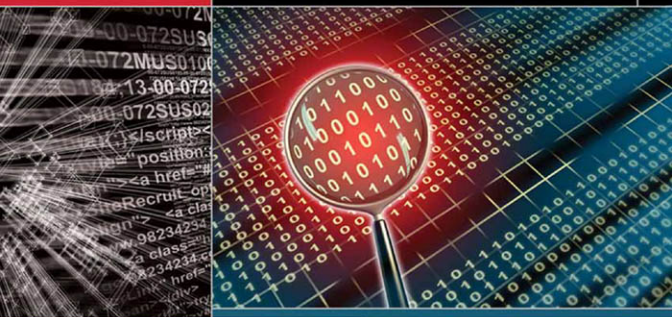




COURSE TECHNOLOGY
CENGAGE Learning

EC-Council | Press

Computer Forensics Investigating Data & Image Files



This title maps to

CHFI

<https://t.me/learningnets>

Computer Forensic
Investigator



The Experts: EC-Council

EC-Council's mission is to address the need for well educated and certified information security and e-business practitioners. EC-Council is a global, member based organization comprised of hundreds of industry and subject matter experts all working together to set the standards and raise the bar in Information Security certification and education.

EC-Council certifications are viewed as the essential certifications needed where standard configuration and security policy courses fall short. Providing a true, hands-on, tactical approach to security, individuals armed with the knowledge disseminated by EC-Council programs are securing networks around the world and beating the hackers at their own game.



The Solution: EC-Council Press

The EC-Council | Press marks an innovation in academic text books and courses of study in information security, computer forensics, disaster recovery, and end-user security. By repurposing the essential content of EC-Council's world class professional certification programs to fit academic programs, the EC-Council | Press was formed.

With 8 Full Series, comprised of 27 different books, the EC-Council | Press is set to revolutionize global information security programs and ultimately create a new breed of practitioners capable of combating this growing epidemic of cybercrime and the rising threat of cyber war.

This Certification: C|HFI – Computer Hacking Forensic Investigator

Computer Hacking Forensic Investigation is the process of detecting hacking attacks and properly extracting evidence to report the crime and conduct audits to prevent future attacks. The C|HFI materials will give participants the necessary skills to identify an intruder's footprints and to properly gather the necessary evidence to prosecute.

Security|5

Security|5 is an entry level certification for anyone interested in learning computer networking and security basics. Security|5 means 5 components of IT security: firewalls, anti-virus, IDS, networking, and web security.

Wireless|5

Wireless|5 introduces learners to the basics of wireless technologies and their practical adaptation. Learners are exposed to various wireless technologies; current and emerging standards; and a variety of devices.

Network|5

Network|5 covers the 'Alphabet Soup of Networking' – the basic core knowledge to know how infrastructure enables a work environment, to help students and employees succeed in an integrated work environment.

Additional Certifications Covered By EC-Council Press:

E|DRP – EC-Council

Disaster Recovery Professional

E|DRP covers disaster recovery topics, including identifying vulnerabilities, establishing policies and roles to prevent and mitigate risks, and developing disaster recovery plans.

C|EH - Certified Ethical Hacker

Information assets have evolved into critical components of survival. The goal of the Ethical Hacker is to help the organization take pre-emptive measures against malicious attacks by attacking the system himself or herself; all the while staying within legal limits.

E|NSA – EC-Council

Network Security Administrator

The E|NSA program is designed to provide fundamental skills needed to analyze the internal and external security threats against a network, and to develop security policies that will protect an organization's information.

E|CSA - EC-Council Certified Security Analyst

The objective of E|CSA is to add value to experienced security professionals by helping them analyze the outcomes of their tests. It is the only in-depth Advanced Hacking and Penetration Testing certification available that covers testing in all modern infrastructures, operating systems, and application environments.

Investigating Data and Image Files

EC-Council | Press

Volume 3 of 5 mapping to

C | HFITM
Computer Hacking Forensic
INVESTIGATOR
Certification



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EC-Council | Press**

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Hacking and electronic crimes sophistication has grown at an exponential rate in recent years. In fact, recent reports have indicated that cyber crime already surpasses the illegal drug trade! Unethical hackers, better known as *black hats*, are preying on information systems of government, corporate, public, and private networks and are constantly testing the security mechanisms of these organizations to the limit with the sole aim of exploiting them and profiting from the exercise. High-profile crimes have proven that the traditional approach to computer security is simply not sufficient, even with the strongest perimeter, properly configured defense mechanisms such as firewalls, intrusion detection, and prevention systems, strong end-to-end encryption standards, and anti-virus software. Hackers have proven their dedication and ability to systematically penetrate networks all over the world. In some cases, black hats may be able to execute attacks so flawlessly that they can compromise a system, steal everything of value, and completely erase their tracks in less than 20 minutes!

The EC-Council Press is dedicated to stopping hackers in their tracks.

About EC-Council

The International Council of Electronic Commerce Consultants, better known as EC-Council, was founded in late 2001 to address the need for well-educated and certified information security and e-business practitioners. EC-Council is a global, member-based organization comprised of industry and subject matter experts all working together to set the standards and raise the bar in information security certification and education.

EC-Council first developed the *Certified Ethical Hacker* (CIEH program). The goal of this program is to teach the methodologies, tools, and techniques used by hackers. Leveraging the collective knowledge from hundreds of subject matter experts, the CIEH program has rapidly gained popularity around the globe and is now delivered in more than 70 countries by more than 450 authorized training centers. More than 60,000 information security practitioners have been trained.

CIEH is the benchmark for many government entities and major corporations around the world. Shortly after CIEH was launched, EC-Council developed the *Certified Security Analyst* (ElCSA). The goal of the ElCSA program is to teach groundbreaking analysis methods that must be applied while conducting advanced penetration testing. The ElCSA program leads to the *Licensed Penetration Tester* (LPT) status. The *Computer Hacking Forensic Investigator* (CHFI) was formed with the same design methodologies and has become a global standard in certification for computer forensics. EC-Council, through its impervious network of professionals and huge industry following, has developed various other programs in information security and e-business. EC-Council certifications are viewed as the essential certifications needed when standard configuration and security policy courses fall short. Providing a true, hands-on, tactical approach to security, individuals armed with the knowledge disseminated by EC-Council programs are securing networks around the world and beating the hackers at their own game.

About the EC-Council | Press

The EC-Council | Press was formed in late 2008 as a result of a cutting-edge partnership between global information security certification leader, EC-Council and leading global academic publisher, Cengage Learning. This partnership marks a revolution in academic textbooks and courses of study in information security, computer forensics, disaster recovery, and end-user security. By identifying the essential topics and content of EC-Council professional certification programs, and repurposing this world-class content to fit academic programs, the EC-Council | Press was formed. The academic community is now able to incorporate this powerful cutting-edge content into new and existing information security programs. By closing the gap between academic study and professional certification, students and instructors are able to leverage the power of rigorous academic focus and high demand industry certification. The EC-Council | Press is set to revolutionize global information security programs and ultimately create a new breed of practitioners capable of combating the growing epidemic of cybercrime and the rising threat of cyber-war.

Computer Forensics Series

The EC-Council | Press *Computer Forensics* series, preparing learners for CIHFI certification, is intended for those studying to become police investigators and other law enforcement personnel, defense and military personnel, e-business security professionals, systems administrators, legal professionals, banking, insurance and other professionals, government agencies, and IT managers. The content of this program is designed to expose the learner to the process of detecting attacks and collecting evidence in a forensically sound manner with the intent to report crime and prevent future attacks. Advanced techniques in computer investigation and analysis with interest in generating potential legal evidence are included. In full, this series prepares the learner to identify evidence in computer related crime and abuse cases as well as track the intrusive hacker's path through client system.

Books in Series

- *Computer Forensics: Investigation Procedures and Response*/1435483499
- *Computer Forensics: Investigating Hard Disks, File and Operating Systems*/1435483502
- *Computer Forensics: Investigating Data and Image Files*/1435483510
- *Computer Forensics: Investigating Network Intrusions and Cybercrime*/1435483529
- *Computer Forensics: Investigating Wireless Networks and Devices*/1435483537

Investigating Data and Image Files

Investigating Data and Image Files provides a basic understanding of steganography, data acquisition and duplication, encase, how to recover deleted files and partitions and image file forensics.

Chapter Contents

Chapter 1, *Steganography*, provides the history and classifications of steganography, explains the difference between steganography and cryptography as well as the essentials of stego-forensics and watermarking. Chapter 2, *Data Acquisition and Duplication*, focuses on how to determine the best data acquisition method, how to make sure crucial data is not lost, and the importance of data duplication. A description of the tools used for data acquisition and duplication is also included. Chapter 3, *Forensic Investigation Using EnCase*, includes coverage of this forensic software suite and how investigators can use EnCase to perform different forensic tasks. Chapter 4, *Recovering Deleted Files and Deleted Partitions*, covers deleting files and the recycling bin as well as file recovery and deleting and recovering partitions. Chapter 5, *Image File Forensics*, covers the various methods that can be used to recover graphics files. It also highlights the various image recovery, steganalysis, and viewing tools that are used and the salient features of these tools.

Chapter Features

Many features are included in each chapter and all are designed to enhance the learner's learning experience. Features include:

- *Objectives* begin each chapter and focus the learner on the most important concepts in the chapter.
- *Key Terms* are designed to familiarize the learner with terms that will be used within the chapter.
- *Case Examples*, found throughout the chapter, present short scenarios followed by questions that challenge the learner to arrive at an answer or solution to the problem presented.
- *Chapter Summary*, at the end of each chapter, serves as a review of the key concepts covered in the chapter.
- *Review Questions* allow learners to test their comprehension of the chapter content.
- *Hands-On Projects* encourage learners to apply the knowledge they have gained after finishing the chapter. Files for the Hands-On Projects can be found on the Student Resource Center. Note: You will need your access code provided in your book to enter the site. Visit www.cengage.com/community/eccouncil for a link to the Student Resource Center.

Student Resource Center

The Student Resource Center contains all the files you need to complete the Hands-On Projects found at the end of the chapters. Access the Student Resource Center with the access code provided in your book. Visit www.cengage.com/community/eccouncil for a link to the Student Resource Center.

Additional Instructor Resources

Free to all instructors who adopt the *Investigating Data and Image Files* book for their courses is a complete package of instructor resources. These resources are available from the Course Technology Web site, www.cengage.com/coursetechnology, by going to the product page for this book in the online catalog, and choosing “Instructor Downloads.”

Resources include:

- *Instructor Manual*: This manual includes course objectives and additional information to help your instruction.
- *Examview Testbank*: This Windows-based testing software helps instructors design and administer tests and pre-tests. In addition to generating tests that can be printed and administered, this full-featured program has an online testing component that allows students to take tests at the computer and have their exams automatically graded.
- *PowerPoint Presentations*: This book comes with a set of Microsoft PowerPoint slides for each chapter. These slides are meant to be used as teaching aids for classroom presentations, to be made available to students for chapter reviews, or to be printed for classroom distribution. Instructors are also at liberty to add their own slides.
- *Labs*: These are additional hands-on activities to provide more practice for your students.
- *Assessment Activities*: These are additional assessment opportunities including discussion questions, writing assignments, Internet research activities, and homework assignments along with a final cumulative project.
- *Final Exam*: This exam provides a comprehensive assessment of *Investigating Data and Image Files* content.

Cengage Learning Information Security Community Site

Cengage Learning Information Security Community Site was created for learners and instructors to find out about the latest in information security news and technology.

Visit community.cengage.com/infosec to:

- Learn what’s new in information security through live news feeds, videos and podcasts;
- Connect with your peers and security experts through blogs and forums;
- Browse our online catalog.

How to Become C|HFI Certified

Today’s battles between corporations, governments, and countries are no longer fought only in the typical arenas of boardrooms or battlefields using physical force. Now the battlefield starts in the technical realm, which ties into most every facet of modern day life. The CIHFI certification focuses on the necessary skills to identify an intruder’s footprints and to properly gather the necessary evidence to prosecute. The CIHFI certification is primarily targeted at police and other law enforcement personnel, defense and military personnel, e-business security professionals, systems administrators, legal professionals, banking, insurance and other professionals, government agencies, and IT managers. This certification will ensure that you have the knowledge and skills to identify, track, and prosecute the cyber-criminal.

CIHFI certification exams are available through authorized Prometric testing centers. To finalize your certification after your training by taking the certification exam through a Prometric testing center, you must:

1. Apply for and purchase an exam voucher by visiting the EC-Council Press community site: www.cengage.com/community/eccouncil, if one was not purchased with your book.

2. Once you have your exam voucher, visit www.prometric.com and schedule your exam, using the information on your voucher.
3. Take and pass the CIHFI certification examination with a score of 70% or better.

CIHFI certification exams are also available through Prometric Prime. To finalize your certification after your training by taking the certification exam through Prometric Prime, you must:

1. Purchase an exam voucher by visiting the EC-Council Press community site: www.cengage.com/community/eccouncil, if one was not purchased with your book.
2. Speak with your instructor about scheduling an exam session, or visit the EC-Council community site referenced above for more information.
3. Take and pass the CIHFI certification examination with a score of 70% or better.

About Our Other EC-Council | Press Products

Ethical Hacking and Countermeasures Series

The EC-Council | Press *Ethical Hacking and Countermeasures* series is intended for those studying to become security officers, auditors, security professionals, site administrators, and anyone who is concerned about or responsible for the integrity of the network infrastructure. The series includes a broad base of topics in offensive network security, ethical hacking, as well as network defense and countermeasures. The content of this series is designed to immerse learners into an interactive environment where they will be shown how to scan, test, hack, and secure information systems. A wide variety of tools, viruses, and malware is presented in these books, providing a complete understanding of the tactics and tools used by hackers. By gaining a thorough understanding of how hackers operate, ethical hackers are able to set up strong countermeasures and defensive systems to protect their organization's critical infrastructure and information. The series, when used in its entirety, helps prepare readers to take and succeed on the CIEH certification exam from EC-Council.

Books in Series

- *Ethical Hacking and Countermeasures: Attack Phases*/143548360X
- *Ethical Hacking and Countermeasures: Threats and Defense Mechanisms*/1435483618
- *Ethical Hacking and Countermeasures: Web Applications and Data Servers*/1435483626
- *Ethical Hacking and Countermeasures: Linux, Macintosh and Mobile Systems*/1435483642
- *Ethical Hacking and Countermeasures: Secure Network Infrastructures*/1435483650

Network Security Administrator Series

The EC-Council | Press *Network Administrator* series, preparing learners for ElnSA certification, is intended for those studying to become system administrators, network administrators, and anyone who is interested in network security technologies. This series is designed to educate learners, from a vendor neutral standpoint, how to defend the networks they manage. This series covers the fundamental skills in evaluating internal and external threats to network security, design, and how to enforce network level security policies, and ultimately protect an organization's information. Covering a broad range of topics from secure network fundamentals, protocols and analysis, standards and policy, hardening infrastructure, to configuring IPS, IDS and firewalls, bastion host and honeypots, among many other topics, learners completing this series will have a full understanding of defensive measures taken to secure their organizations information. The series, when used in its entirety, helps prepare readers to take and succeed on the ElnSA, Network Security Administrator certification exam from EC-Council.

Books in Series

- *Network Defense: Fundamentals and Protocols*/1435483553
- *Network Defense: Security Policy and Threats*/1435483561
- *Network Defense: Perimeter Defense Mechanisms*/143548357X
- *Network Defense: Securing and Troubleshooting Network Operating Systems*/1435483588
- *Network Defense: Security and Vulnerability Assessment*/1435483596

Security Analyst Series

The EC-Council | Press *Security Analyst/Licensed Penetration Tester* series, preparing learners for ElCSA/LPT certification, is intended for those studying to become network server administrators, firewall administrators, security testers, system administrators, and risk assessment professionals. This series covers a broad base of topics in advanced penetration testing and security analysis. The content of this program is designed to expose the learner to groundbreaking methodologies in conducting thorough security analysis, as well as advanced penetration testing techniques. Armed with the knowledge from the *Security Analyst* series, learners will be able to perform the intensive assessments required to effectively identify and mitigate risks to the security of the organizations infrastructure. The series, when used in its entirety, helps prepare readers to take and succeed on the ElCSA, Certified Security Analyst, and LIPT, License Penetration Tester certification exam from EC-Council.

Books in Series

- *Certified Security Analyst: Security Analysis and Advanced Tools*/1435483669
- *Certified Security Analyst: Customer Agreements and Reporting Procedures in Security Analysis*/1435483677
- *Certified Security Analyst: Penetration Testing Methodologies in Security Analysis*/1435483685
- *Certified Security Analyst: Network and Communication Testing Procedures in Security Analysis*/1435483693
- *Certified Security Analyst: Network Threat Testing Procedures in Security Analysis*/1435483707

Cyber Safety/1435483715

Cyber Safety is designed for anyone who is interested in learning computer networking and security basics. This product provides information cyber crime; security procedures; how to recognize security threats and attacks, incident response, and how to secure Internet access. This book gives individuals the basic security literacy skills to begin high-end IT programs. The book also prepares readers to take and succeed on the Securityl5 certification exam from EC-Council.

Wireless Safety/1435483766

Wireless Safety introduces the learner to the basics of wireless technologies and its practical adaptation. *Wirelessl5* is tailored to cater to any individual's desire to learn more about wireless technology. It requires no pre-requisite knowledge and aims to educate the learner in simple applications of these technologies. Topics include wireless signal propagation, IEEE and ETSI wireless standards, WLANs and operation, wireless protocols and communication languages, wireless devices, and wireless security networks. The book also prepares readers to take and succeed on the Wirelessl5 certification exam from EC-Council.

Network Safety/1435483774

Network Safety provides the basic core knowledge on how infrastructure enables a working environment. Intended for those in office environments and for home users who want to optimize resource utilization, share infrastructure, and make the best of technology and the convenience it offers. Topics include foundations of networks, networking components, wireless networks, basic hardware components, the networking environment and connectivity as well as troubleshooting. The book also prepares readers to take and succeed on the Networkl5 certification exam from EC-Council.

Disaster Recovery Professional

The *Disaster Recovery Professional* series, preparing the reader for ElDRP certification, introduces the learner to the methods employed in identifying vulnerabilities and how to take the appropriate countermeasures to prevent and mitigate failure risks for an organization. It also provides a foundation in disaster recovery principles, including preparation of a disaster recovery plan, assessment of risks in the enterprise, development of policies, and procedures, and understanding of the roles and relationships of various members of an organization, implementation of the plan, and recovering from a disaster. Students will learn how to create a secure network by putting policies and procedures in place, and how to restore a network in the event of a disaster. The series, when used in its entirety, helps prepare readers to take and succeed on the ElDRP, Disaster Recovery Professional certification exam from EC-Council.

Books in Series

- *Disaster Recovery*/1435488709
- *Business Continuity*/1435488695

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Acknowledgements

Michael H. Goldner is the Chair of the School of Information Technology for ITT Technical Institute in Norfolk Virginia, and also teaches bachelor level courses in computer network and information security systems. Michael has served on and chaired ITT Educational Services Inc. National Curriculum Committee on Information Security. He received his Juris Doctorate from Stetson University College of Law, his undergraduate degree from Miami University and has been working for more than 15 years in the area of Information Technology. He is an active member of the American Bar Association, and has served on that organization's cyber law committee. He is a member of IEEE, ACM, and ISSA, and is the holder of a number of industrially recognized certifications including, CISSP, CEH, CHFI, CEI, MCT, MCSE/Security, Security +, Network +, and A+. Michael recently completed the design and creation of a computer forensic program for ITT Technical Institute and has worked closely with both EC-Council and Delmar/Cengage Learning in the creation of this EC-Council Press series.

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Steganography

Objective

After completing this chapter, you should be able to:

- Understand steganography
- Recount the history of steganography
- Explain the classifications of steganography
- Identify image steganography
- Detect steganography
- Explain the differences between steganography and cryptography
- Explain stego-forensics
- Explain watermarking
- Select appropriate steganography tools

Key Terms

Cover medium the medium used to hide a message with steganography

Digital watermark a digital stamp embedded into a digital signal

Least significant bit (LSB) a steganography technique in which the rightmost bit in the binary notation is substituted with a bit from the embedded message

Steganography the practice of embedding hidden messages within a carrier medium

Stego-key the secret key used to encrypt and decrypt messages hidden by steganography

Stego-medium the combined cover medium and embedded message used in steganography

Stegosystem the mechanism used in performing steganography

Introduction to Steganography

Steganography is the practice of embedding hidden messages within a carrier medium. Mathematicians, military personnel, and scientists have used it for centuries. The use of steganography dates back to ancient Egypt. Today steganography, in its digital form, is widely used on the Internet and in a variety of multimedia forms.

Modern steganography works by replacing bits of useless or unused data in regular computer files with bits of different, invisible information. When a file cannot be encrypted, the next best option for safe transfer is steganography. Steganography can also be used to supplement encryption. When used in this manner, steganography provides a double measure of protection, as the encrypted file, once deciphered, will not allow a message hidden by steganography to be seen. The receiver of the file has to use special software to decipher a message hidden by steganography.

Stegosystem Model

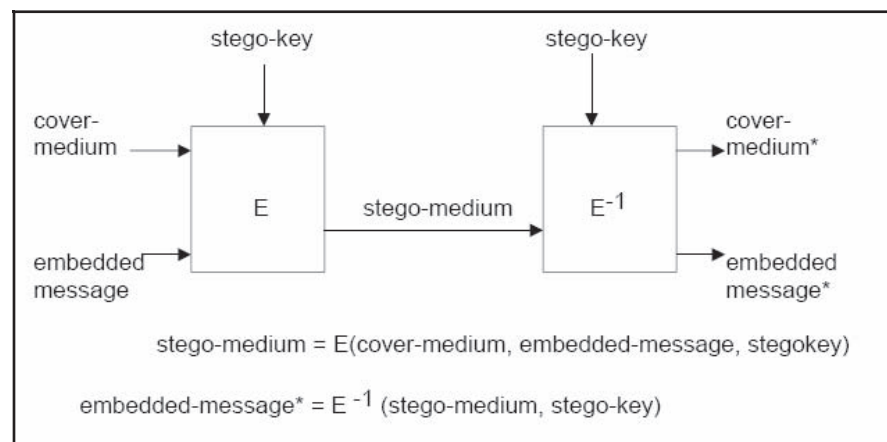
A *stegosystem* is the mechanism that is used in performing steganography (Figure 1-1). The following components make up a stegosystem:

- *Embedded message*: The original secret message to be hidden behind the cover medium
- *Cover medium*: The medium used to hide the message
- *Stego-key*: The secret key used to encrypt and decrypt the message
- *Stego-medium*: The combined cover medium and embedded message

Application of Steganography

Steganography can be used for a variety of legal and illegal uses. It can be used for the following purposes:

- *Medical records*: Steganography is used in medical records to avoid any mix-up of patients' records. Every patient has an EPR (electronic patient record), which has examinations and other medical records stored in it.
- *Workplace communication*: Steganography can be used as an effective method for employees who desire privacy in the workplace to bypass the normal communication channels. In this area, steganography can be an obstacle to network security.



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Figure 1-1 A stegosystem is the mechanism used to embed a hidden message within a cover medium.

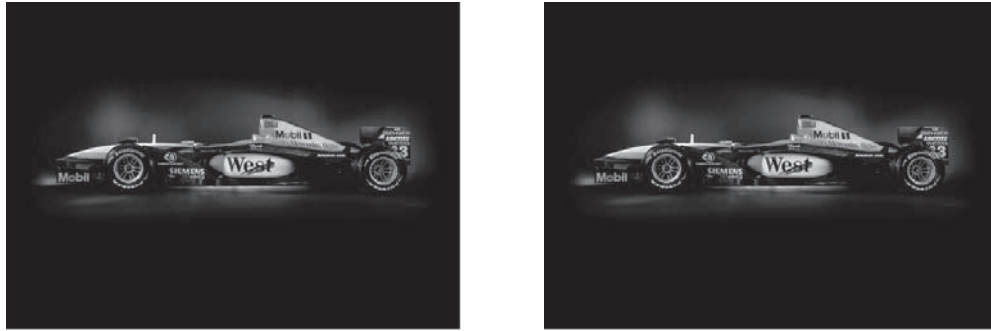


Figure 1-2 An embedded message is not typically visible to the naked eye.

- *Digital music:* Steganography is also used to protect music from being copied by introducing subtle changes into a music file that act as a digital signature. BlueSpike Technology removes a few select tones in a narrow band. Verance adds signals that are out of the frequency range detectable by the human ear. Others adjust the sound by changing the frequency slightly. Digital audio files can also be modified to carry a large amount of information. Some files simply indicate that the content is under copyright. More sophisticated steganography versions can include information about the artist.
- *Terrorism:* Certain extremist Web sites have been known to use pictures and text to secretly communicate messages to terrorist cells operating around the world. Servers and computers around the world provide a new twist on this covert activity. Figure 1-2 shows two photos: one has a message embedded, and the other does not.
- *The movie industry:* Steganography can also be used as copyright protection for DVDs and VCDs. The DVD copy-protection program is designed to support a copy generation management system. Second-generation DVD players with digital video recording capabilities continue to be introduced in the black market. To protect itself against piracy, the movie industry needs to copyright DVDs.

Classification of Steganography

Steganography is classified into the following three major categories (Figure 1-3):

- Technical steganography
- Linguistic steganography
- Digital steganography

Technical Steganography

In technical steganography, physical or chemical methods are used to hide the existence of a message. Technical steganography can include the following methods:

- *Invisible inks:* These are colorless liquids that need heating and lighting in order to be read. For example, if onion juice and milk are used to write a message, the writing cannot be seen unless heat is applied, which makes the ink turn brown.
- *Microdots:* This method shrinks a page-sized photograph to 1 mm in diameter. The photograph is reduced with the help of a reverse microscope.

Linguistic Steganography

Linguistic steganography hides messages in the carrier in several ways. The two main techniques of linguistic steganography involve the use of semagrams and open codes.

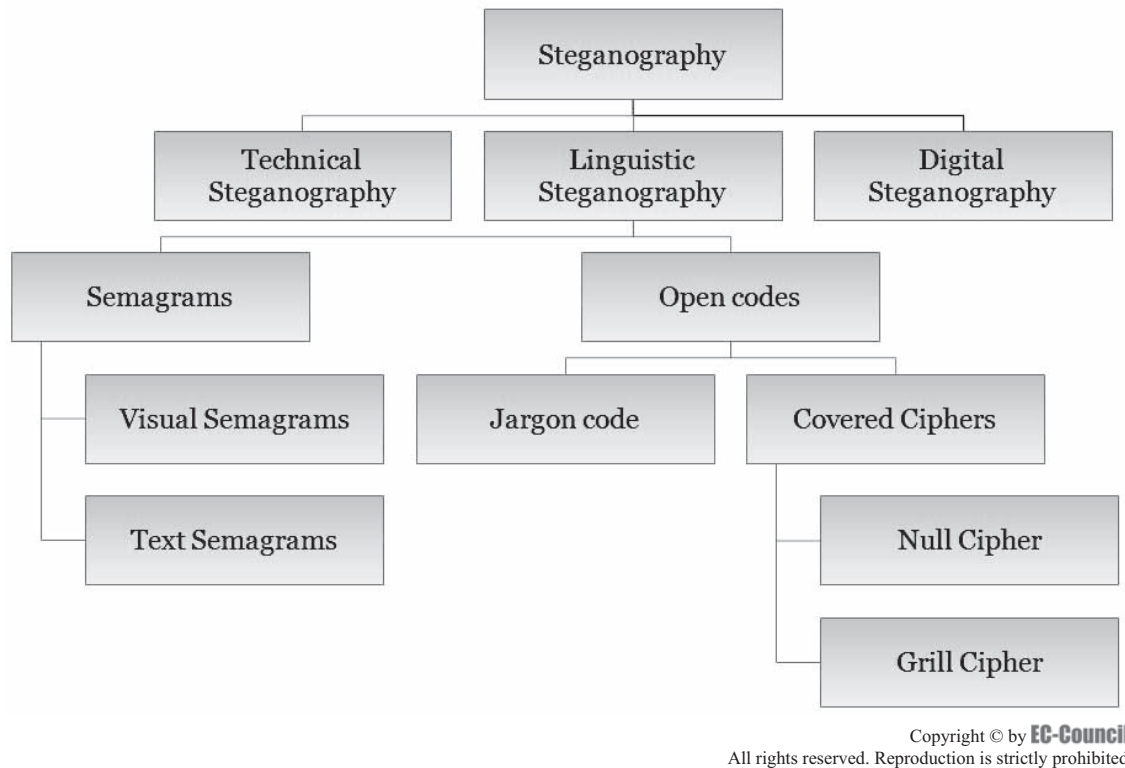


Figure 1-3 Steganography is classified into three main categories.

Semagrams

Semagrams hide information through the use of signs or symbols. Objects or symbols can be embedded in data to send messages. Semagrams can be classified into the following types:

- *Visual semagrams*: In this technique a drawing, painting, letter, music, or any other symbol is used to hide the information. For example, the position of items on a desk or Web site may be used to hide some kind of message.
- *Text semagrams*: In this technique, a message is hidden by changing the appearance of the carrier text. Text can be changed by modifying the font size, using extra spaces between words, or by using different flourishes in letters or handwritten text.

Open Codes

Open codes make use of openly readable text. This text contains words or sentences that can be hidden in a reversed or vertical order. The letters should be in selected locations of the text. Open codes can be either jargon codes or covered ciphers.

- *Jargon codes*: In this type of open code, a certain language is used that can only be understood by a particular group of people while remaining meaningless to others. A jargon message is similar to a substitution cipher in many respects, but rather than replacing individual letters the words themselves are changed.
- *Covered ciphers*: This technique hides the message in a carrier medium that is visible to everyone. Any person who knows how the message is hidden can extract this type of message. Covered ciphers can be both null and grill ciphers.
 - *Null ciphers*: Null ciphers hide the message within a large amount of useless data. The original data may be mixed with the unused data in any order—e.g., diagonally, vertically, or in reverse order—allowing only the person who knows the order to understand it.
 - *Grill ciphers*: It is possible to encrypt plaintext by writing it onto a sheet of paper through a separate pierced sheet of paper or cardboard. When an identical pierced sheet is placed on the message, the original text can be read. The grill system is difficult to crack and decipher, as only the person with the grill (sheet of paper) can decipher the hidden message.

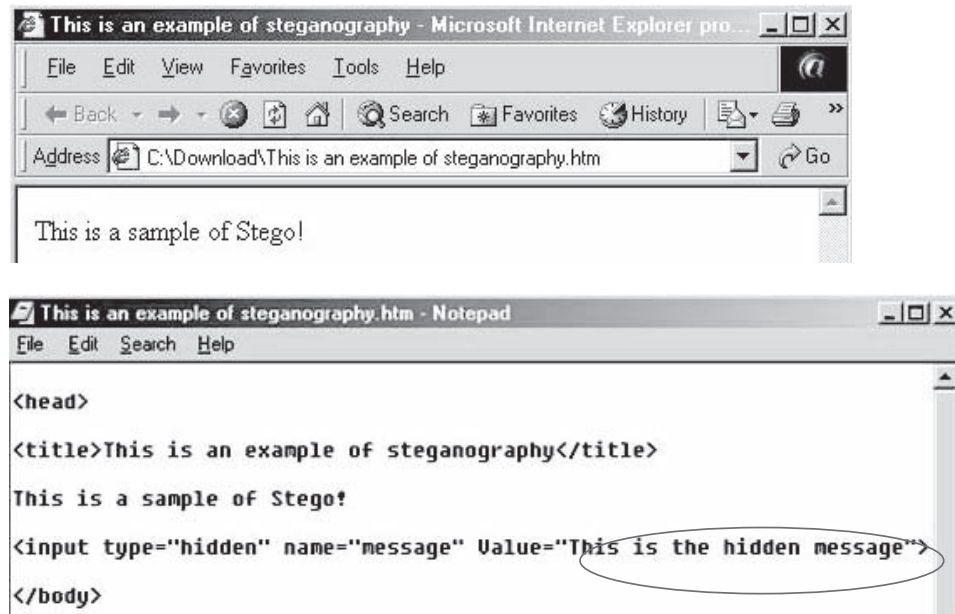


Figure 1-4 The source file can reveal an injected message when compared to the altered file.

Digital Steganography

In digital steganography, the secret messages are hidden in a digital medium. The following techniques are used in digital steganography:

- Injection
- Least significant bit (LSB)
- Transform-domain techniques
- Spread-spectrum encoding
- Perceptual masking
- File generation
- Statistical method
- Distortion technique

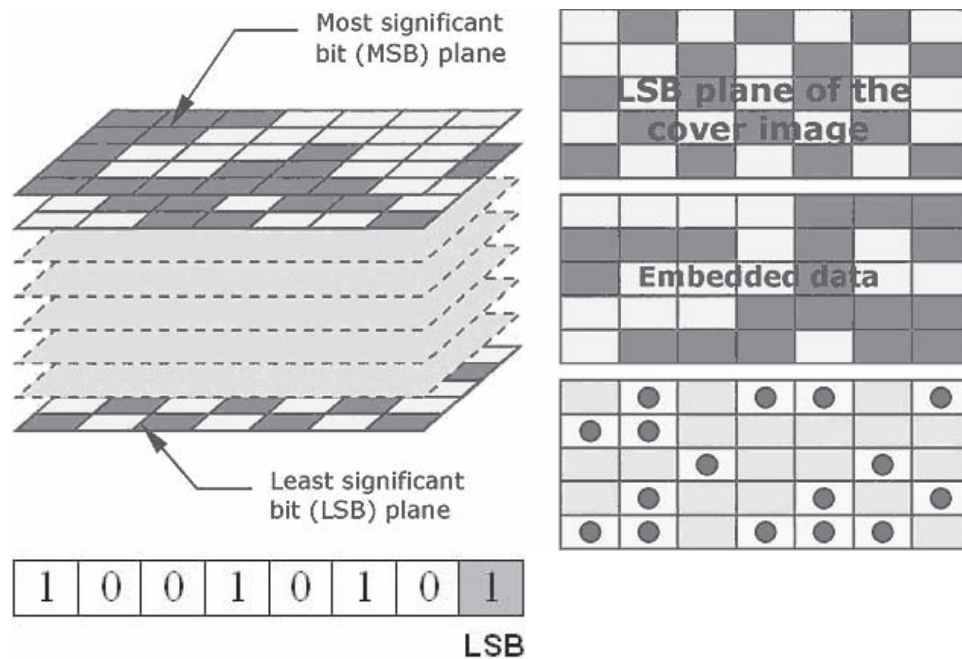
Injection

With the injection technique, the secret information is placed inside a carrier or host file. The secret message is directly inserted into a host medium, which could be a picture, sound file, or video clip. The drawback to this technique is that the size of the host file increases, making it easy to detect. This can be overcome by deleting the original file once the file with the secret message is created. It is difficult to detect the presence of any secret message once the original file is deleted.

In the Web page shown in Figure 1-4, the message “This is a sample of Stego” is displayed. In the source code of the Web page, the secret message “This is the hidden message” can be viewed.

Least Significant Bit (LSB)

With the *least-significant-bit (LSB)* technique, the rightmost bit in the binary notation is substituted with a bit from the embedded message. The rightmost bit has the least impact on the binary data. If an attacker knows that this technique is used, then the data are vulnerable.



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Figure 1-5 LSB substitutes the rightmost bit in the binary notation with a bit from the embedded message.

Figure 1-5 shows a basic LSB approach. Bit planes of a grayscale image are imprinted with the most significant bit (MSB) on top. The dark boxes represent binary value 0, and the light boxes represent binary value 1. The LSB plane of the cover image is replaced with the hidden data.

Transform-Domain Techniques

A transformed space is generated when a file is compressed at the time of transmission. This transformed space is used to hide data. The three transform techniques used when embedding a message are: discrete cosine transform (DCT), discrete Fourier transform (DFT), and discrete wavelet transform (DWT). These techniques embed the secret data in the cover at the time of the transmission process. The transformation can either be applied to an entire carrier file or to its subparts. The embedding process is performed by modifying the coefficients, which are selected based on the protection required. The hidden data in the transform domain is present in more robust areas, and it is highly resistant to signal processing.

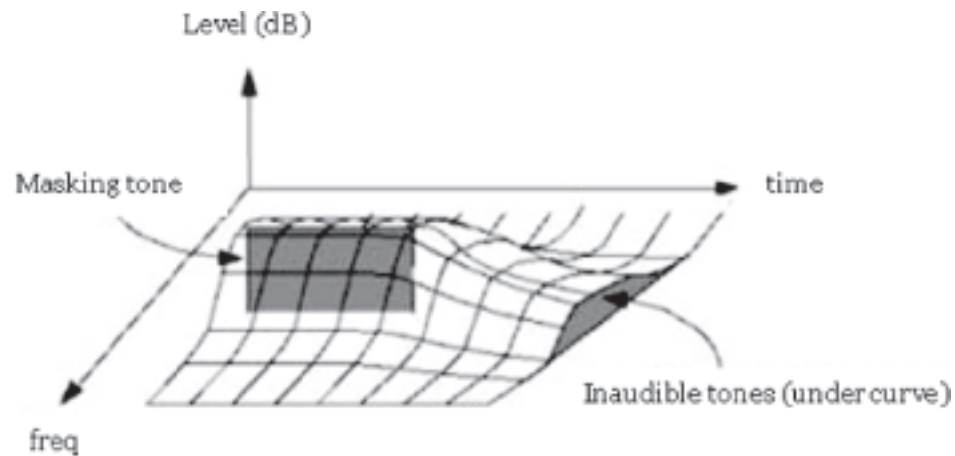
Example: Images sent through Internet channels typically use JPEG format because it compresses itself when the file is closed. A JPEG file makes an approximation of itself to reduce the file's size and removes the excess bits from the image. This change and approximation results in transform space that can be used to hide information.

Spread-Spectrum Encoding

Spread-spectrum encoding encodes a small-band signal into a wide-band cover. The encoder modulates a small-band signal over a carrier.

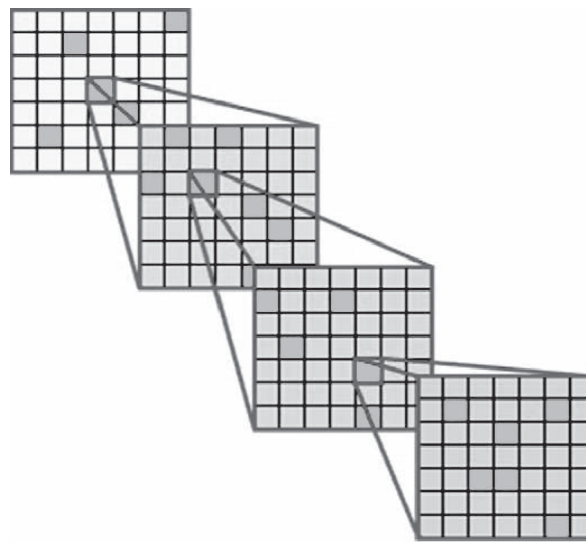
Spread-spectrum encoding can be used in the following ways:

- *Direct sequence:* In direct-sequence encoding, the information is divided into small parts that are allocated to the frequency channel of the spectrum. The data signal is combined during transmission with a higher data-rate bit sequence that divides the data based on the predetermined spread ratio. The redundant nature of the data-rate bit sequence code is useful to the signal-resist interference, allowing the original data to be recovered.
- *Frequency hopping:* This technique is used to divide the bandwidth's spectrum into many possible broadcast frequencies. Frequency hopping devices require less power and are cheaper, but are less reliable when compared to direct sequence spectrum systems.



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Figure 1-6 Perceptual masking uses masking tones to hide messages within audio signals.



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Figure 1-7 The statistical method embeds one bit of information in a digital carrier.

Perceptual Masking

Perceptual masking is the interference of one perceptual stimulus with another, resulting in a decrease in perceptual effectiveness (Figure 1-6). This type of steganography makes one signal hard to identify due to the presence of another signal.

File Generation

Rather than selecting a cover to hide a message, this technique generates a new cover file solely for the purpose of hiding data. A picture is created that has a hidden message in it. In the modern form of file generation, a spam-mimic program is used. Spam mimic embeds the secret message into a spam message that can be e-mailed to any destination.

Statistical Method

This method uses a one-bit steganographic scheme. It embeds one bit of information in a digital carrier, creating a statistical change. A statistical change in the cover is indicated as a 1. A 0 indicates that a bit was left unchanged (Figure 1-7). The work is based on the receiver's ability to differentiate between modified and unmodified covers.

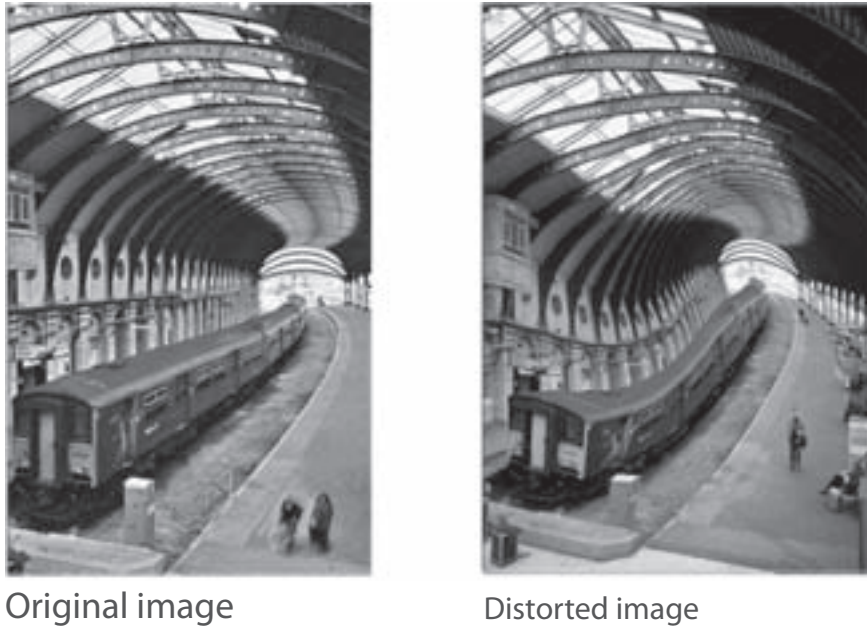


Figure 1-8 In the distortion technique, an encoder performs a sequence of modifications to the cover that correspond to a secret message.

Distortion Technique

This technique creates a change in the cover object in order to hide the information. An encoder performs a sequence of modifications to the cover that corresponds to a secret message. The secret message is recovered by comparing the distorted cover with the original (Figure 1-8). The decoder in this technique needs access to the original cover file.

Digital File Types

The various techniques used in steganography are applied differently depending on the type of file that is being used to encode the message. The three digital file types are text files, audio files, and video files.

Text Files

The following steganography methods are used in text files:

- Open-space
- Syntactic
- Semantic

Open-Space Steganography

This method uses white space on the printed page. Open-space methods can be categorized in the following three ways:

- *Intersentence spacing*: This method encodes a binary message by inserting one or two spaces after every terminating character. This method is inefficient since it requires more space for a small message, and the white spaces can be easily spotted.

- *End-of-line spacing*: Secret data is placed at the end of a line in the form of spaces. This allows more room to insert a message but can create problems when the program automatically removes extra spaces or the document is printed as hard copy.
- *Interword spacing*: This method uses right justification, by which the justification spaces can be adjusted to allow binary encoding. A single space between words is 0, and two spaces is 1.

Syntactic Steganography

This method manipulates punctuation to hide messages.

Look at the following example:

- Laptop, iPod, USB
- Laptop iPod USB

The punctuation marks are missing in the second phrase. These punctuation marks can be used to hide the message.

Semantic Steganography

This method of data hiding involves changing the words themselves. Semantic steganography assigns two synonyms primary and secondary values. When decoded, the primary value is read as 1 and the secondary as 0.

Image Files

Image files commonly use the following formats:

- *Graphics Interchange Format (GIF)*: GIF files are compressed image files that make use of a compression algorithm developed by CompuServe. GIF files are based on a palette of 256 colors. They are mainly used for small icons and animated images since they do not have the color ranges needed for high-quality photos.
- *Joint Photographic Experts Group (JPEG)*: JPEG files are the proper format for photo images that need to be small in size. JPEG files are compressed by 90%, or to one-tenth, of the size of the data.
- *Tagged Image File Format (TIFF)*: The TIFF file format was designed to minimize the problems with mixed file formats. This file format did not evolve from a de facto standard. It was made as the standard image file format for image file exchange.

The following steganography techniques are used to hide a message in an image file:

- Least-significant-bit (LSB) insertion
- Masking and filtering
- Algorithms and transformation

Least-Significant-Bit (LSB) Insertion

Using the LSB insertion method, the binary representation of the hidden data can be used to overwrite the LSB of each byte inside the image. If the image properties indicate that the image is 24-bit color, the net change is minimal and can be indiscernible to the human eye.

The following steps are involved in hiding the data:

- The steganography tool makes a copy of an image palette with the help of the red, green, and blue (RGB) model.
- Each pixel of the eight-bit binary number LSB is substituted with one bit of the hidden message.
- A new RGB color in the copied palette is produced.
- With the new RGB color, the pixel is changed to an eight-bit binary number.

Look at the following example:

```
01001101 00101110 10101110 10001010
10101111 10100010 00101011 10101011
```

Seen above are the adjacent pixels made up of eight bits. If the letter *H* is represented by binary digits, 01001000 needs to be hidden in this file, and the data would need to be compressed before being hidden.

After *H* is combined, the changed binary values would be as seen below:

```
01001100 00101111 10101110 10001010
10101111 10100010 00101010 10101010
```

Eight bits, which is four of the LSBs, have been successfully hidden. The above example is meant to be a high-level overview. This method can be applied to eight-bit color images. Grayscale images are also used for steganographic purposes. The drawback to these methods is that they can be detected by anyone who knows where to search for them.

Masking and Filtering

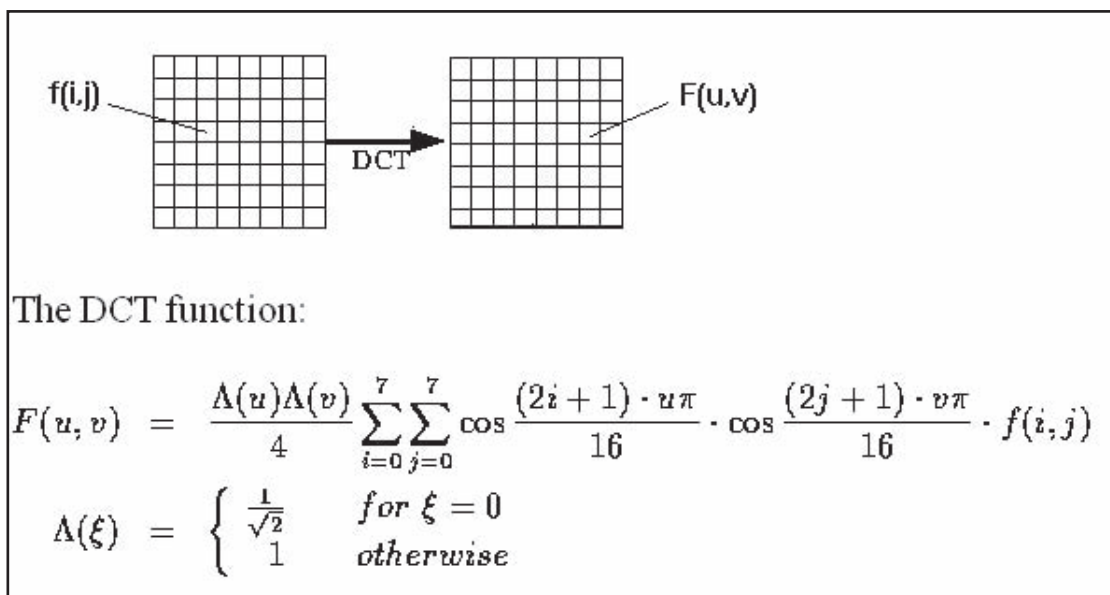
Masking and filtering techniques are commonly used on 24-bit and grayscale images. Grayscale images that hide information are similar to watermarks on paper and are sometimes used as digital versions. Masking images entails changing the luminescence of the masked area. The smaller the luminescent change, the less chance there is that it can be detected. Steganography images that are masked keep a higher fidelity rate than LSB through compression, cropping, and image processing. The reason that images encoded with masking have less degradation under JPEG compression is because the message is hidden in significant areas of the picture. The tool named Jpeg-Jsteg takes advantage of the compression of JPEG and keeps high message fidelity. This program uses a message and lossless cover image as input and produces an output image in JPEG format.

Algorithms and Transformation

Mathematical functions can be used to hide data that are in compression algorithms. In this technique, the data are embedded in the cover image by changing the coefficients of an image, (e.g., discrete cosine transform coefficients).

If information is embedded in the spatial domain, it may be subjected to loss if the image undergoes any processing techniques like compression. To overcome this problem, the image would need to be embedded with information that can be hidden in the frequency domain, as the digital data is not continuous enough to analyze the data of the image that transformations are applied on.

Figure 1-9 depicts one of the algorithms used in this method.



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Figure 1-9 Mathematical functions can be used to hide data that are in compression algorithms.

Audio Files

Hiding information in an audio file can be done either by using LSB or frequencies that are inaudible to the human ear. Frequencies over 20,000 Hz cannot be detected by the human ear.

Information can also be hidden using musical tones with a substitution scheme. For example, tone F could represent 0, and tone C could represent 1. By using the substitution technique a simple musical piece can be composed with a secret message, or an existing piece can be used with an encoded scheme that represents a message.

Low-Bit Encoding in Audio Files

Digital steganography is based on the fact that artifacts, such as bitmaps and audio files, contain redundant information. Compression techniques such as JPEG and MP3 remove parts of the redundancy, allowing the files to be compressed. By using the DigSteg tool, the computer forensic investigator can replace some of the redundant information with other data.

Low-bit encoding replaces the LSB of information in each sampling point with a coded binary string. The low-bit method encodes large amounts of hidden data into an audio signal at the expense of producing significant noise in the upper frequency range.

Phase Coding

Phase coding involves substituting an initial audio segment with a reference phase that represents the data. This method is carried out using the following steps:

1. The original sound sequence is shortened into segments.
2. Each segment creates a matrix of the phase and magnitude by using the discrete Fourier transform (DFT) algorithm.
3. The phase difference is calculated between each adjacent segment.
4. New phase frames are created for all other segments.
5. A new segment is created by combining the new phase and the original magnitude.
6. These new segments are combined together to create the encoded output.

Spread Spectrum

In most communication channels, audio data is limited to a narrow range of frequencies to protect the bandwidth of the channel. Unlike phase coding, direct-sequence spread spectrum (DSSS) introduces some random noise to the signal. The encoded data is spread across as much of the frequency spectrum as possible.

Spread spectrum is used in audio files both to embed data in the audio file and to send the audio file.

Echo Data Hiding

In this technique, an echo is introduced into the original signal. Three properties of this echo can then be varied to hide data:

- Initial amplitude
- Decay rate
- Offset

Video Files

Discrete cosine transform (DCT) manipulation is used to add secret data at the time of the transformation process of the video. The techniques used in audio and image files can also be used in video files, as video consists of audio and images. A large number of secret messages can be hidden in video files because a video is a moving stream of images and sound. Due to this, an individual watching the video will not observe any distortion in the video caused by the hiding of data.

Steganographic File System

A steganographic file system is a method used to store files that encrypts and hides the data within those files. It hides the user's data in other, seemingly random files, allowing users to give names and passwords for some files while keeping others secret.

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A steganographic file system is used to overcome the drawback of using individual files for data hiding. The following methods are used to construct a steganographic file system:

- Method 1:
 - Program operates using a set of cover files with initially random content.
 - The cover files are modified to store data files.
 - Cover files should be large enough to ensure that all attempts to access cover files remain computationally infeasible.
- Method 2:
 - File system begins with random data.
 - The encrypted blocks are written to the pseudorandom locations using the key acquired from the file-name and directory password to hide the file blocks in random data. When the file system continues to be written to, collisions occur and the blocks are overwritten, allowing only a small portion of the disk space to be safely utilized.
 - Multiple copies of each block should be written.
 - A method to identify the blocks when they are overwritten is also required.

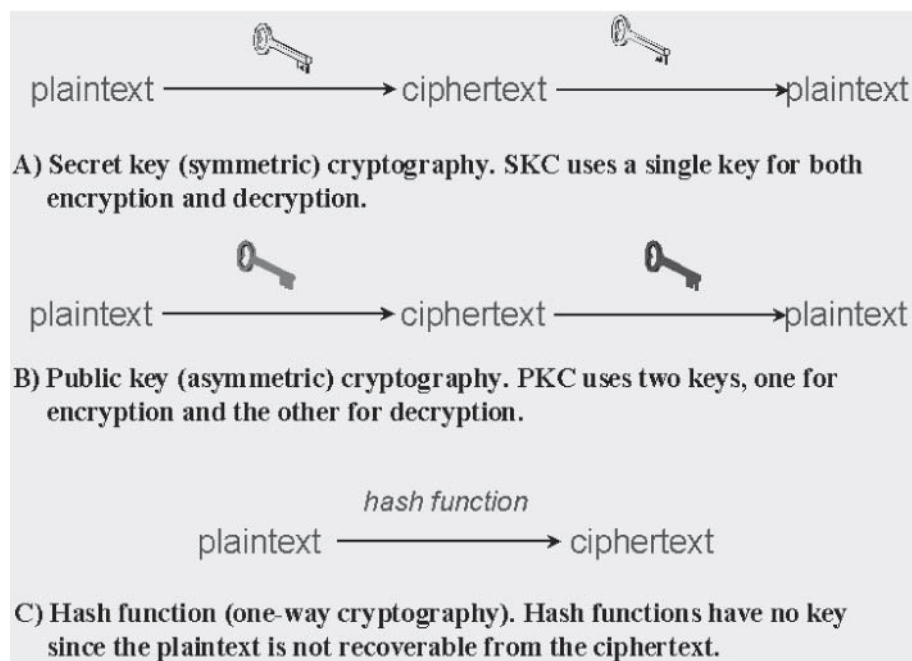
Cryptography

Cryptography is the art of writing text or data in a secret code. It involves encrypting plaintext data into an unreadable format called a ciphertext. This encryption process is based on mathematical algorithms. These algorithms use a secret key for secure encryption (Figure 1-10).

The following are three types of cryptographic schemes used:

- Secret-key (or symmetric) cryptography
- Public-key (or asymmetric) cryptography
- Hash function

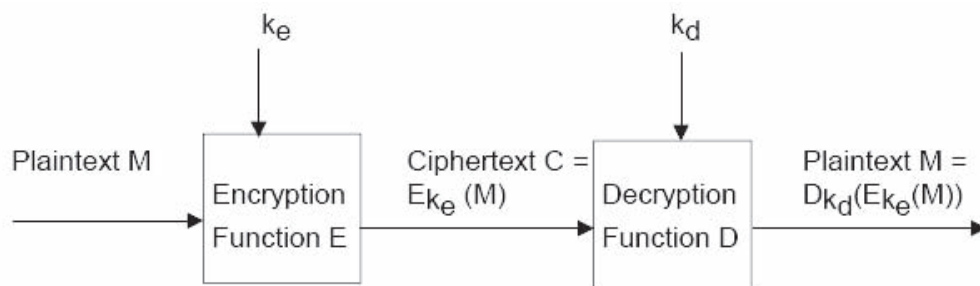
In each of these schemes the primary unencrypted data is plaintext which is encrypted into ciphertext.



Source: <http://www.garykessler.net/library/crypto.html>. Accessed 2/2007.

Figure 1-10 Cryptography can be performed in three different ways.

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Figure 1-11 A cryptosystem uses a key to convert plaintext to ciphertext.

Model of a Cryptosystem

A cryptosystem is a pair of algorithms that use a key to convert plaintext to ciphertext and back again. Figure 1-11 illustrates the cryptography process. The following key explains the symbols:

- Plaintext M: The original text to be encrypted to form the ciphertext
- k_e : The key used for encrypting the message
- Ciphertext C: The text obtained after encrypting the original message: Ciphertext $C = E_{k_e}(M)$
- k_d : The key used for decrypting the ciphertext: Plaintext $M = D_{k_d}(C)$, where $C = E_{k_e}(M)$

Steganography Versus Cryptography

Steganography is defined as the art of hiding data within other data. It replaces bits of unused data from various media files with other bits that, when assembled, reveal a hidden message. The hidden data can be plaintext, ciphertext, an audio clip, or an image.

In cryptography an encrypted message that is communicated can be detected but cannot be read. In steganography, the existence of the message is hidden. Steganography is used to hide information when encryption is not a safe option. From a security point of view, steganography should be used to hide a file in an encrypted format. This is done to ensure that even if the encrypted file is decrypted, the message will still remain hidden.

Another contrast between steganography and cryptography is that the former requires caution when reusing pictures or sound files, while the latter requires caution when reusing keys.

In steganography, only one key is used to hide and extract data. In cryptography, the same key or two different keys for encryption and decryption can be used.

Public Key Infrastructure (PKI)

Public Key Infrastructure (PKI) is used for secure and private data exchange over the Internet. It uses a public and private cryptographic key pair that is obtained and given to the public key owner. PKI provides a digital certificate that can identify an individual or organization and directory services that can store and, when necessary, revoke the certificates. It uses public-key cryptography, which is the most commonly used method on the Internet for authenticating a message sender or encrypting a message.

PKI consists of the following components:

- A certificate authority (CA) that issues and verifies the digital certificate
- A registration authority (RA) that acts as the verifier for the certificate authority before a digital certificate is issued to a request
- One or more directories where the certificates (with their public keys) are held
- Key management protocols

The primary goal of a key management scheme is to provide two communicating devices with a common or shared cryptographic key. The term *session key* is used to identify a short-lived key. This key does not require a session-based communication model. *Master key* is used to denote a key having a longer life period than a session key.

Watermarking

Traditionally, paper was manufactured from wet fiber which was then subjected to high pressure to extract any moisture present in it. If the press mold had a pattern in it, that pattern, or watermark, would be left on the paper. This term has been incorporated into the term *digital watermark* in the technology field, but the meaning is essentially the same. **Digital watermarks** are, in essence, digital stamps embedded into digital signals. A digital stamp can contain many kinds of data, and can be both visible and invisible. Often, the digital data found hidden in a watermark are a digital multimedia object. While digital images are most often mentioned in reference to digital watermarking, it is important to remember that watermarks can be applied to other forms of digital data such as audio and video segments.

Application of Watermarking

Watermarking is used to facilitate the following processes:

- Embedding copyright statements into images that provide authentication to the owner of the data
- Monitoring and tracking copyright material automatically on the Web
- Providing automatic audits of radio transmissions. These audits show any music or advertisement that is broadcasted
- Supporting data augmentation. This enables users to add more information to the existing data present on the Web
- Supporting fingerprint applications

Steganography Versus Watermarking

The main purpose of steganography is to hide a message m in data d to form new data D , which is different from d , so that a third person cannot detect the m in D . Conversely, the main purpose of watermarking is to hide the data m in data d to form new data D so that a third person cannot remove or replace the m in D . Steganography hides the message in one-to-one communication, while watermarking hides the message in one-to-many communication. The main goal of steganography is to protect the data from detection, while that of watermarking is to protect data from distortion by others.

In steganography a message of any length can be hidden, whereas in watermarking only small messages can be hidden. Steganography is used for the purpose of secret communication, while watermarking is used for authentication and copyright protection.

Categories of Watermarks

Watermarks are split into two categories: visible and invisible.

- **Visible:** A visible watermark is the most robust as it is not part of the foundation of the image. The watermark's presence is clearly noticeable and often difficult to remove. A good example of a visible watermark is a television identification logo that appears on a television screen. The watermark can either be solid or semitransparent. Removing it would require a great deal of work.
- **Invisible:** The main purpose of an invisible watermark is to identify and verify a particular piece of information in data. An invisible watermark is imperceptible but can be extracted through computational methods. An invisible watermark contains information about the watermark itself or the information present in the image that is hiding the data. The data hidden in the image can be accessed with a password, termed a watermark key. There is a big difference between a watermark key and an encryption key. A watermark key is used only for watermarks, whereas an encryption key is used for information that is to be encrypted.

Watermarks and Compression

The application of watermarks in the modern world mainly concerns images, audio, and video. Watermarks are used in the case of MP3s and DVDs as a tool to ensure copyrights are enforced.

Types of Watermarks

- *Semifragile*: Semifragile watermarks are used at the time of soft-image authentication and integrity verifications. They are robust to any common image processing of loose compression, but are fragile in case of any malicious tampering that changes the image content.
- *Fragile*: Fragile watermarks are less robust when modified. A small change in the content will destroy the embedded information and show that an attack has occurred. Any tampering with the image will modify its integrity.
- *Robust*: A robust watermark can be either visible or invisible. Robust watermarks are resistant to any kind of attack and will not affect the quality of the data. They are difficult to remove or damage. Robust watermarks are used in the case of copyright protection and access control. Most of these are found on television broadcasts during which the channels impose their logos in the corner of the screen to let people know what they are viewing and to signify copyright.

Digimarc's Digital Watermarking

Digimarc's digital watermarking technique enables users to embed a digital code into an image, audio, video, or text file. This digital code is unnoticeable in normal use and can only be detected by computers and software.

Digimarc's digital watermarking is used to embed copyright messages into the image, video, and audio files that provide authentication to the owner of the data.

The image gets split into a number of subimages. A Web browser puts all the pieces of the images together at display time, making a new image that is an exact replica of the original image. Both images are watermarked with Digimarc's, but the watermark is not readable in a small, partitioned image. Because all marking techniques need a marked image of minimal size, it is difficult to detect the mark from the image. It works because it is hard for copyright marking techniques to embed the watermark in an image having a size of less than 100×100 pixels. In addition, the bandwidth required for the embedding process is less.

Attacks on Watermarking

Robustness Attack

This attack attempts to remove watermarks from an image. It can be divided into the following categories:

- *Signal-processing attacks*: These attacks apply techniques such as compression, filtering, resizing, printing, and scanning to remove the watermark.
- *Analytical and algorithmic attacks*: These attacks use algorithmic techniques of watermark insertion and detection to remove the watermark from the image.
- *Presentation attacks*: Presentation attacks are carried out to change the watermarked data in such a way that a detector cannot detect it. The watermark will appear as it did before the attack. It is not necessary to eliminate the watermark to carry out the attack. The following instances are examples of presentation attacks:
 - An automated detector cannot detect the misalignment of a watermarked image.
 - A detector cannot detect the rotation and enlargement of a watermark.
- *Interpretation attacks*: Interpretation attacks catch the weakness of watermarks, such as wrong and multiple interpretations. A watermark can be created from the existing watermark image with the same strength as the original watermark.
- *Legal attacks*: Legal attacks mainly target digital information and copyright laws. Attackers can change the watermarked copyrights in order to create doubts about copyright in a court of law. These attacks depend upon the following conditions:
 - Existing and future legislation on copyright laws and digital information ownership
 - The credibility of the owner and the attacker
 - The financial strength of the owner and the attacker
 - The expert witnesses
 - The competence of the lawyers

The following techniques are commonly used to remove watermarks:

- *Collusion attack*: A collusion attack is carried out by searching for a number of different objects having the same watermark, allowing the forensic investigator to isolate and remove the watermark by comparing the copies.
- *Jitter attack*: A jitter attack upsets the placement of the bits that identify a watermark by applying a jitter effect to the image. By applying a jitter effect, the forensic investigator is able to gauge the integrity of the watermark.
- *StirMark*: A StirMark attack can be applied to small distortions that are designed to simulate the printing or scanning process. If a hard-copy photograph has been scanned, it would appear obvious that subtle distortions are introduced, no matter how careful the user is. The StirMark attack can be used for JPEG scaling and rotation. This attack is effective, as some watermarks are resistant to only one type of modification.
- *Anti-soft bot*: A benefit of watermarking in the realm of the Internet is the ability to use software robots, sometimes called soft bots or spiders, to search through Web pages for watermarked images. If the soft bot finds a watermarked image, it can use the information to determine if there is a copyright violation.
- *Attacks on echo hiding*: Echo hiding is a signal processing technique that places information into an audio data stream in the form of closely spaced echoes. These echoes place digital tags into the sound file with minimal sound degradation. Echo hiding is also resistant to jitter attacks, making a removal attack the usual method for getting rid of the watermark. In echo hiding, most echo delays are between 0.5 and 3 milliseconds; in anything above 3 milliseconds the echo becomes noticeable.

Mosaic Attack

A mosaic attack works by splitting an image into multiple pieces and stitching them back together using JavaScript code. In this attack the marked image can be unmarked, and later all the pixels are rendered in a similar fashion to the original marked image.

This attack was prompted by automatic copyright detection systems which contain watermarking techniques and crawlers that download images from the Internet to determine whether or not they are watermarked.

Mosaic Attack – JavaScript Code

```
<nobr>
<img SRC="kings _ chapel _ wmk1.jpg" BORDER="0" ALT="1/6" width="116"
height="140">
<img SRC="kings _ chapel _ wmk2.jpg" BORDER="0" ALT="2/6" width="116"
height="140">
<img SRC="kings _ chapel _ wmk3.jpg" BORDER="0" ALT="3/6" width="118"
height="140">
</nobr>
<br>
<nobr>
<img SRC="kings _ chapel _ wmk4.jpg" BORDER="0" ALT="4/6" width="116"
height="140">
<img SRC="kings _ chapel _ wmk5.jpg" BORDER="0" ALT="5/6" width="116"
height="140">
<img SRC="kings _ chapel _ wmk6.jpg" BORDER="0" ALT="6/6" width="118"
height="140">
</nobr>
```

Issues in Information Hiding

The following three sections discuss issues that must be considered when hiding information.

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Level of Visibility

The way a message is embedded will determine whether the data is perceptible or not. To reduce the theft of data, the presence of a watermark is often publicized. However, publicizing the presence of a watermark also allows various methods to be implemented to attempt to alter or disable the watermark. When the visibility of the data is increased, the potential for manipulation of the data also increases.

Robustness Versus Payload

In order to have a robust method of embedding a message, redundancy should be maintained to resist changes made to the cover. However, increasing the robustness of the message means that less space is usable for the payload. Robustness must be weighed against the size of the payload.

File Format Dependence

Conversion of files that have lossless information to compressed files with lossy information can destroy the secret information present in the cover. Some processes embed the data depending on the file format of the carrier, while others do not depend on the file format. The JPEG compression algorithm uses floating-point calculations to translate the picture into an array of integers. This conversion process can result in rounding errors that may eliminate portions of the image. This process does not result in any noticeable difference in the image. Nevertheless, embedded data could become damaged.

Some other popular algorithms, namely Windows Bitmap (BMP) and Graphic Interchange Format (GIF), are considered lossless compressions. The compressed image is an exact representation of the original.

Detecting Steganography

The following indicators are likely signs of steganography:

- *Software clues on the computer:* The investigator should determine the filenames and Web sites the suspect used by viewing the browser's cookies or history. An investigator should also look in registry key entries, the mailbox of the suspect, chat or instant messaging logs, and communication or comments made by the suspect. Because these data are important for investigation, they give clues to the investigator for further procedures.
- *Other program files:* It is also important to check other program files because it is possible that a nonprogram file may be a cover file that hides other files inside it. The investigator should also check software that is not normally used for steganography such as binary (hex) editors, disk-wiping software, or other software used for changing data from one code to another.
- *Multimedia files:* The investigator should look for large files in the system, as they can be used as carrier files for steganography. If the investigator finds a number of large duplicate files, then it is possible that they are used as carrier files.

Detection Techniques

Detecting steganographic content is difficult, especially when low payloads are used. The following techniques are used for detecting steganography:

- *Statistical tests:* These tests reveal that an image has been modified by examining the statistical properties of the original. Some of the tests are not dependent on the data format and will measure the entropy of the redundant data, so the images with hidden data will have more entropy than the original image.
- *Stegdetect:* Stegdetect is an automated tool that detects the hidden content in images. It detects different steganographic methods for embedding steganographic messages in images.
- *Stegbreak:* Stegbreak breaks the encoding password with the help of dictionary guessing. It can be used in launching dictionary attacks against JSteg-Shell, JPHS, and OutGuess.
- *Visible noise:* Attacks on hidden information can employ detection, extraction, and disabling or damaging hidden information. The images that have large payloads display distortions from the hidden data.
- *Appended spaces and invisible characters:* Using invisible characters or appended spaces is a form of hiding data in the spaces of the text. The presence of many white spaces is an indication of steganography.

- *Color palettes*: Some application characteristics are exclusive to steganography tools. The color palettes used in steganographic programs have unique characteristics. Modifications in the color palettes create a detectable steganographic signature.

Detecting Text, Image, Audio, and Video Steganography

Hidden information is detected in different ways depending on the type of file that is used. The following file types require specific methods to detect hidden messages.

Text Files

When a message is hidden in a text file so that the message can be detected only with the knowledge of the secret file, it was probably hidden by altering the cover source. For text files, the alterations are made to the character positions. These alterations can be detected by looking for text patterns or disturbances, the language used, and an unusual number of blank spaces.

Image Files

The hidden data in an image can be detected by determining changes in size, file format, last modified time stamp, and color palette of the file.

Statistical analysis methods can be used when scanning an image. Assuming that the least significant bit is more or less random is an incorrect assumption since applying a filter that shows the LSBs can produce a recognizable image. Therefore, it can be concluded that LSBs are not random. Rather, they consist of information about the entire image.

When a secret message is inserted into an image, LSBs are no longer random. With encrypted data that has high entropy, the LSB of the cover will not contain the information about the original and is more or less random. By using statistical analysis on the LSB, the difference between random values and real values can be identified.

Audio Files

Statistical analysis methods can be used for audio files since LSB modifications are also used on audio.

The following techniques are also useful for detecting hidden data:

- Scanning information for inaudible frequencies
- Determining odd distortions and patterns that show the existence of secret data

Video Files

Detection of secret data in video files includes a combination of the methods used in image and audio files.

Steganalysis

Steganalysis is the reverse process of steganography. Steganography hides data, while steganalysis is used to detect hidden data. Steganalysis detects the encoded hidden message and, if possible, recovers that message. The messages are detected by verifying the differences between bit patterns and unusually large file sizes.

Steganalysis Methods/Attacks on Steganography

Steganography attacks are categorized by the following seven types:

1. *Stego-only attack*: The stego-only attack takes place when only the stego-medium is used to carry out the attack. The only way to avoid this attack is by detecting and extracting the embedded message.
2. *Known-cover attack*: The known-cover attack is used with the presence of both a stego-medium and a cover medium. The attacker can compare both media and detect the format change.
3. *Known-message attack*: The known-message attack presumes that the message and the stego-medium are present and the technique by which the message was embedded can be determined.
4. *Known-stego attack*: In this attack the steganography algorithm is known, and the original object and the stego-objects are available.
5. *Chosen-stego attack*: The chosen-stego attack takes place when the forensic investigator generates a stego-medium from the message using a special tool.

6. *Chosen-message attack*: The steganalyst obtains a stego-object from a steganography tool or algorithm of a chosen message. This attack is intended to find the patterns in the stego-object that point to the use of specific steganography tools or algorithms.
7. *Disabling or active attacks*: These attacks are categorized into the following six types;
 - 1) *Blurring*: Blurring attacks can smooth transitions and reduce contrast by averaging the pixels next to the hard edges of defined lines and the areas where there are significant color transitions.
 - 2) *Noise reduction*: Random noise in the stego-medium inserts random-colored pixels into the image. The uniform noise inserts pixels and colors that look similar to the original pixels. Noise reduction decreases the noise in the image by adjusting the colors and averaging the pixel values.
 - 3) *Sharpening*: Sharpening is the opposite of the blurring effect. It increases the contrast between the adjacent pixels where there are significant color contrasts that are usually at the edge of objects.
 - 4) *Rotation*: Rotation moves the stego-medium to give its center a point.
 - 5) *Resampling*: Resampling involves a process known as interpolation. This process is used to reduce the raggedness associated with the stego-medium. It is normally used to resize the image.
 - 6) *Softening*: Softening of the stego-medium applies a uniform blur to an image in order to smooth edges and reduce contrasts. It causes less distortion than blurring.

Stego-Forensics

Stego-forensics is an area of forensic science dealing with steganography techniques to investigate a source or cause of a crime. Different methods of steganalysis can be used to unearth secret communications between antisocial elements and criminals.

Tools

2Mosaic

2Mosaic (Figure 1-12) is a small, command-line utility for Windows that will break apart any JPEG file and generate the HTML code needed to reconstruct the picture.

2Mosaic is a presentation attack against digital watermarking systems. It is of general applicability and possesses the property that allows a marked image to be unmarked and still rendered by a standard browser in exactly the same way as the marked image.

The attack was motivated by an automatic system which was fielded for copyright piracy detection. It consists of a watermarking scheme plus a Web crawler that downloads pictures from the Internet and checks whether they contain a watermark.

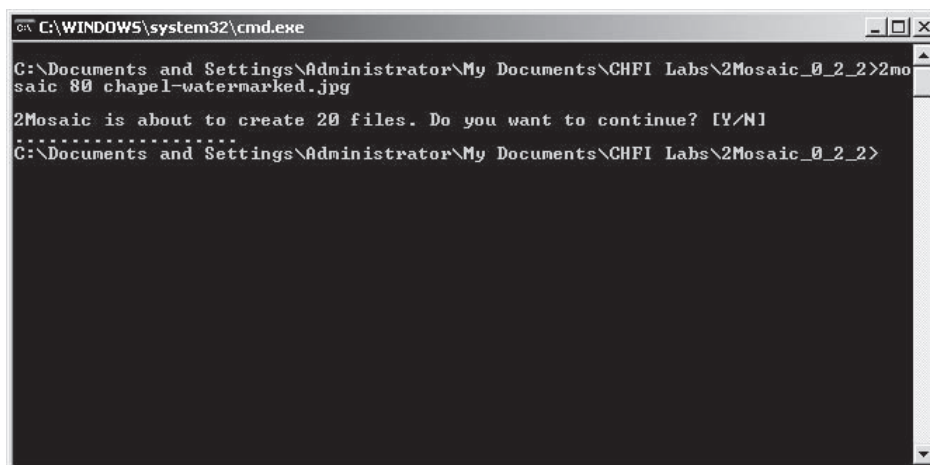


Figure 1-12 2Mosaic can break a JPEG file apart and reconstruct it without a watermark.

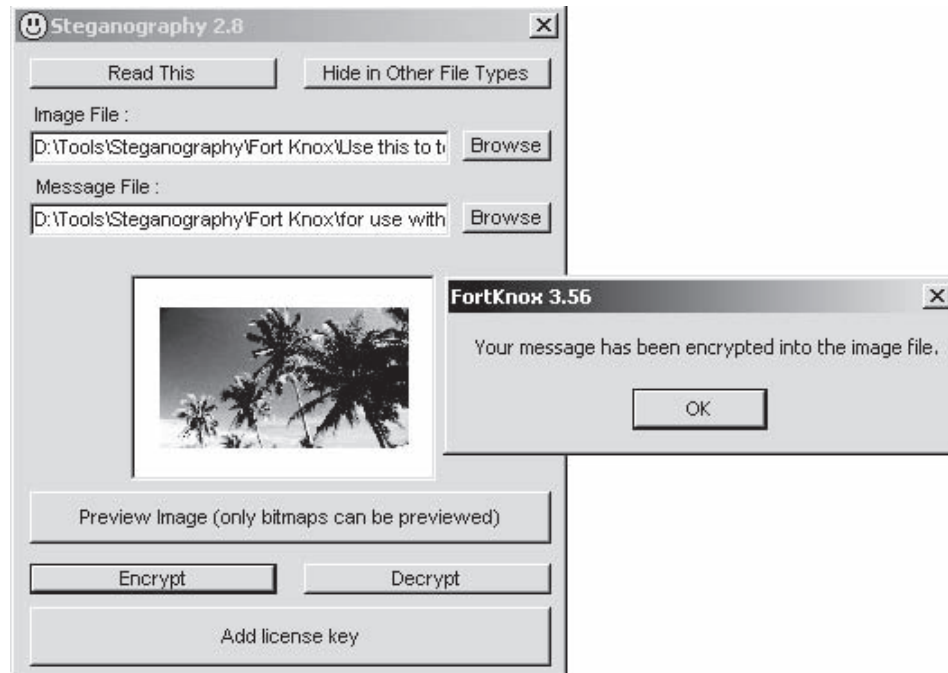


Figure 1-13 FortKnox can be used to encrypt messages into image files.

It consists of chopping an image up into a number of smaller subimages that are embedded in a suitable sequence in a Web page. Common Web browsers render juxtaposed subimages stuck together, so they appear identical to the original image. This attack appears to be quite general; all marking schemes require the marked image to have some minimal size (one cannot hide a meaningful mark in just one pixel). Thus, by splitting an image into sufficiently small pieces, the mark detector will be confused. The best that one can hope for is that the minimal size could be quite small, rendering the method impractical.

FortKnox

FortKnox is security software used to secure folders, encrypt files, and encrypt, split, and transmit data. It contains other useful security tools for the user (Figure 1-13). This tool is helpful in steganography as it uses algorithms such as MD5, Blowfish, CryptAPI, and other steganography techniques in fulfilling user security and profile-building needs. Additional features of the program include a password protection lock, the ability to hide and secure files and folders, logon password masking, and the ability to instantly lock multiple gigabyte-sized folders in multiple drives.

The FortKnox application can also hide messages in image files by using powerful, unbreakable, military-grade encryption software. Both the CryptAPI and Blowfish algorithms are military grade. After hiding a message in an image, the application is able to send it as a stealth e-mail. The built-in steganography software is called Steganography 2.8.

BlindSide

The BlindSide tool can hide files of any file type within a Windows bitmap image (Figure 1-14). The original and the encoded image look identical to the human eye. However, when the image is executed through BlindSide, the concealed data can be extracted and retrieved. For added security, the data can be scrambled with a password so that no one will be able to access the data. The BlindSide tool analyzes color differentials in an image so that it will only alter pixels it knows will not be noticeable to the human eye. The main limitation to BlindSide is that each image has its own capability that is dependent on color patterns within it.

The BlindSide tool can be used in many ways. The main advantage of BlindSide is that it uses a steganographic technique, supplemented with a cryptographic algorithm. This means that one can pass messages without arousing suspicion. BlindSide allows the user to encrypt messages with a password-based encryption so

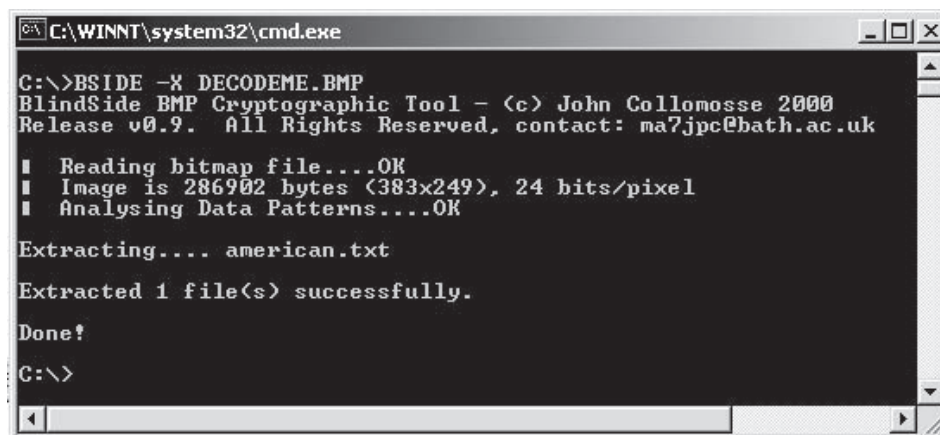


Figure 1-14 BlindSide can extract embedded messages from a variety of files.

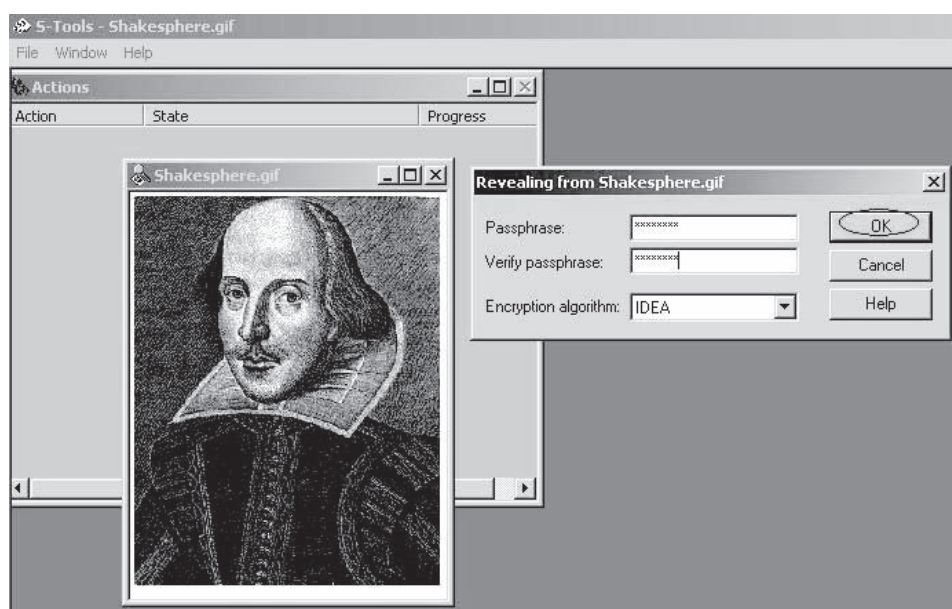


Figure 1-15 S-Tools can hide multiple files within a single object.

that even if someone did examine these images, they would need a password to obtain the secret data. Digital publishers typically use BlindSide to embed a license file and copyright notice within the images that are to be published. A similar procedure could be applied to images on a company's Web pages.

S-Tools

The S-Tools steganographic tool has the ability to hide multiple files within a single object (Figure 1-15). S-Tools first compresses the individual files, which are stored with their names, and then it inserts filler on the front of the data to prevent two identical sets of files from encrypting in the same way. All files are then encrypted using the passphrase that the user generates. The encryption algorithms operate in cipher-feedback mode. The S-Tools application seeds a cryptographically strong, pseudorandom number from the passphrase and uses its output to choose the position of the next bit from the cover data to be used.

For example, if a sound file had 100 bits available for hiding and the user wanted to use 10 of those bits to hold a message, S-Tools would not choose bits zero through nine as they are easily detected by a potential enemy. Instead, it might choose bits 63, 32, 89, 2, 53, 21, 35, 44, 99, and 80.

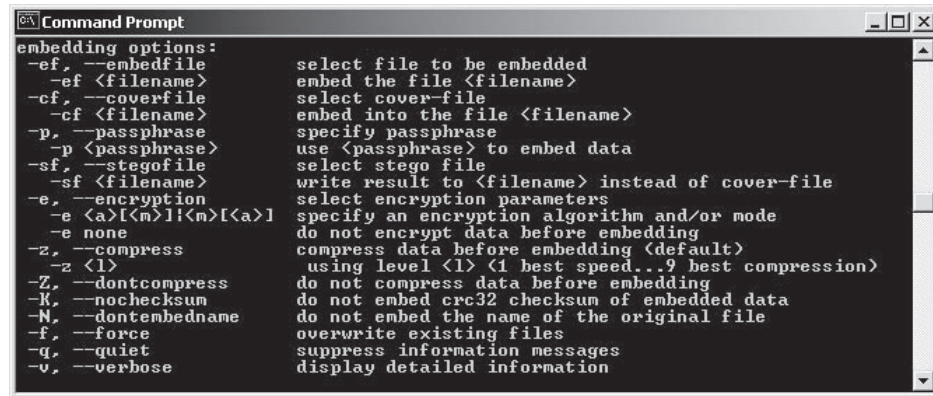


Figure 1-16 StegHide enables users to embed messages into various types of files.

StegHide

StegHide (Figure 1-16) is a steganography tool that is able to hide information in images and audio files. The color and frequencies are not changed during the embedding process. Features of this tool include compression of the embedded data, encryption of the embedded information, and automatic integrity checking using a checksum. JPEG, BMP, and WAV file formats are supported for use as a cover file. No such restrictions are imposed on the format of the secret data.

StegHide also uses the graph-theoretic approach to steganography. The investigator does not need to know anything about graph theory to use the StegHide application. The following steps illustrate the working of an embedding algorithm:

1. The secret information is compressed and encrypted.
2. Based on a pseudorandom number, a sequence of pixel positions, which is initialized with a passphrase, is created.
3. By using a graph-theoretic matching algorithm, the application finds pairs of positions so that exchanging their values has the effect of embedding the information.
4. The pixels at the remaining positions are also modified to contain the embedded information. The default encryption algorithm is Rijndael, with a key size of 128 bits in the cipher block-chaining mode.

Snow

Snow is a steganography tool that exploits the nature of white space. It achieves this by appending white space to the end of lines in ASCII text to conceal messages. White-space steganography can be detected by applications such as Word.

Snow is susceptible to this factor. The basic assumption of Snow is that spaces and tabs are generally not visible in text viewers and therefore, a message can be effectively hidden without affecting the text's visual representation from the casual observer. Encryption is provided using the ICE encryption algorithm in one-bit cipher-feedback (CFB) mode. Because of ICE's arbitrary key size, passwords of any length up to 1,170 characters are supported. Snow takes advantage of the fact that, since trailing spaces and tabs occasionally occur naturally, their existence will not be sufficient to immediately alert an observer who may stumble across them.

The Snow program runs in two modes: message concealment and message extraction (Figure 1-17). The data are concealed in the text file by appending sequences of up to seven spaces, interspersed with tabs. This usually allows three bits to be stored every eight columns. The start of the data is indicated by an appended tab character, which allows the insertion of e-mail and news headers without corrupting the data. Snow provides rudimentary compression, using Huffman tables optimized for English text. However, if the data are not text, or if there is a lot of data, the use of an external compression program such as compress or gzip is recommended. If a message string or message file is specified on the command line, Snow attempts to conceal the message in the file <infile>, or standard input otherwise. The resulting file is written to <outfile> if specified, or standard output if not specified. If no message string is provided, Snow attempts to extract a message from the input file. The result is written to the output file or standard output.

To Encode the Message to a file — myfile.doc

```
snow -m "Swiss bank a/c: 3453434" -p "password-123" myfile.doc
myfile2.doc.
```

To extract the message, the command would be

```
snow -p "password-123" myfile2.doc
```

Figure 1-17 Snow uses white space to hide messages.

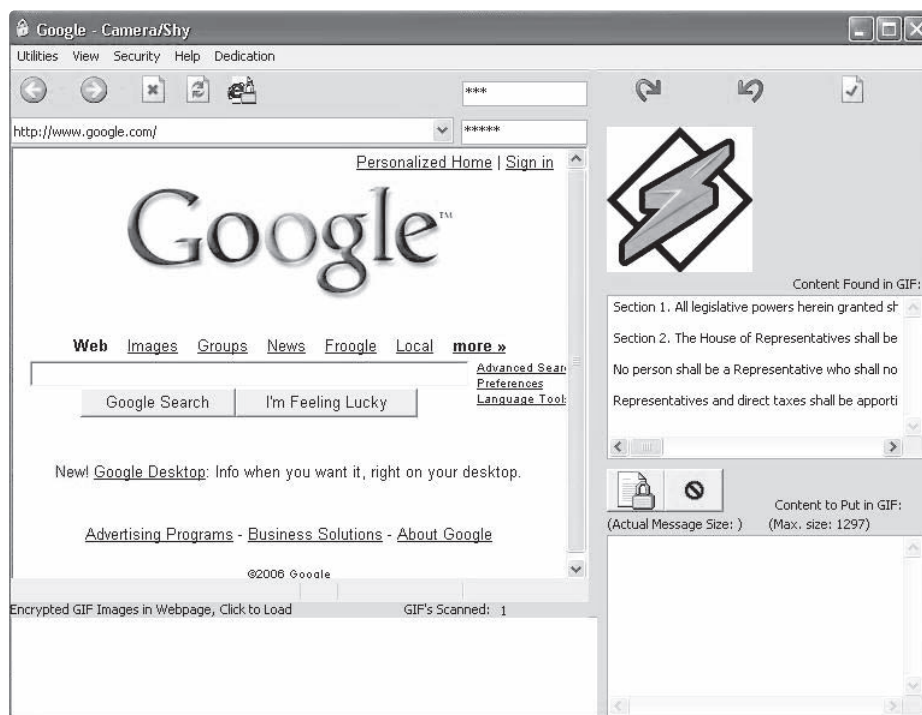


Figure 1-18 Camera/Shy allows users to embed messages in GIF files.

Camera/Shy

Camera/Shy is a simple steganography tool that allows users to encrypt information and hide it in standard GIF images. What makes this program different from most steganography tools is its ease of use, making it a desirable component of a cracker's arsenal.

While other steganography programs are command-line based, Camera/Shy is embedded in a Web browser (Figure 1-18). Other programs require users to know beforehand that an image contains embedded content. Camera/Shy however, allows users to check images for embedded messages, read them, and embed their own return messages with the click of a mouse.

The Camera/Shy program allows Internet users to conceal information, viruses, or exploitative software inside graphics files on Web pages. Camera/Shy bypasses most known monitoring methods. Utilizing LSB steganographic techniques and AES 256-bit encryption, this application enables users to share censored information with their friends by hiding it in plain view as an ordinary GIF image. Moreover, it leaves no trace on the user's system. It allows a user to make a Web site C/S-enabled (Camera/Shy-enabled) and allows a reader to decrypt images from an HTML page on the fly.

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Steganos

Steganos is a steganography tool that combines cryptography and steganography to hide information. It first encrypts the information and then hides it with steganographic techniques. With the help of Steganos the user can store a file with a copyright and prove ownership of a picture if someone tries to use it.

Steganos can hide a file inside a BMP, VOC, WAV, or ASCII file.

Pretty Good Envelope

Pretty Good Envelope is a steganography tool that can hide messages in a larger binary file and also retrieve those messages. This tool uses an algorithm that hides one message behind the other. It can be used with any graphics, binary, or WAV files.

Gifshuffle

Gifshuffle hides messages inside GIF images by mixing up the colors within the images so that it is difficult to find the original message. It supports GIF images that have features such as transparency and animation. Gifshuffle compresses the message using Huffman tables. If there is a lot of data or the data does not contain text, then a gzip compression program is used. The message also gets encrypted using the ICE encryption algorithm in the one-bit cipher-feedback (CFB) mode. ICE supports arbitrary keys and passwords of any length.

For example, to hide the message “eccouncil is best” in the file ecc.gif with compression and encryption using the password “eccouncil,” the following command should be used:

```
gifshuffle -C -m “eccouncil is best” -p “eccouncil” ecc.gif outfile.gif
```

To extract the message, the following command should be used:

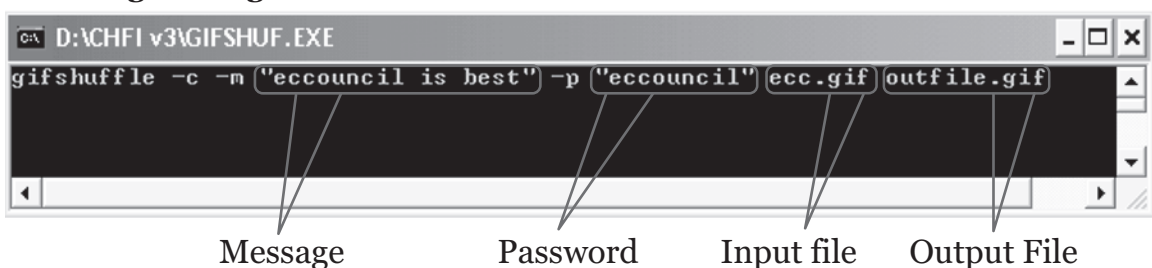
```
gifshuffle -C -p “eccouncil” outfile.gif
```

See Figure 1-19 for an illustration of this process.

The following syntax is used in the commands:

- -C: Compress the data if concealing, or uncompress it if extracting
- -m: message string; the contents of this string will be concealed in the input GIF image.
- -p: password; with this password, data will be encrypted during concealment and decrypted during extraction.

Hiding Message



Extracting Message

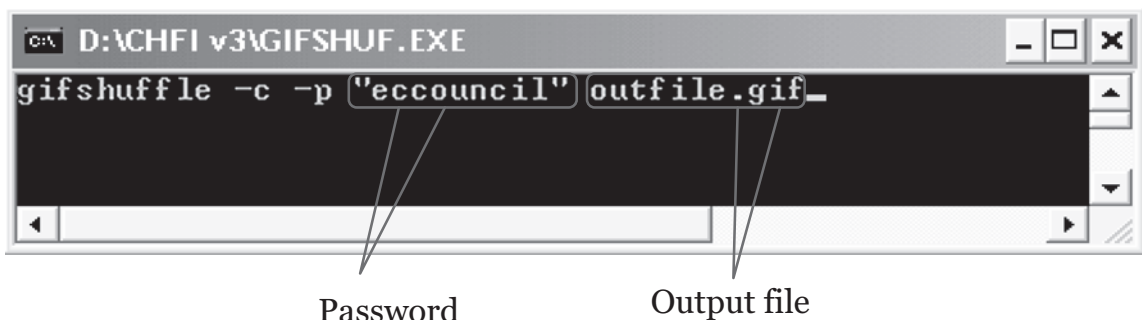


Figure 1-19 Gifshuffle can embed and extract messages in GIF files.

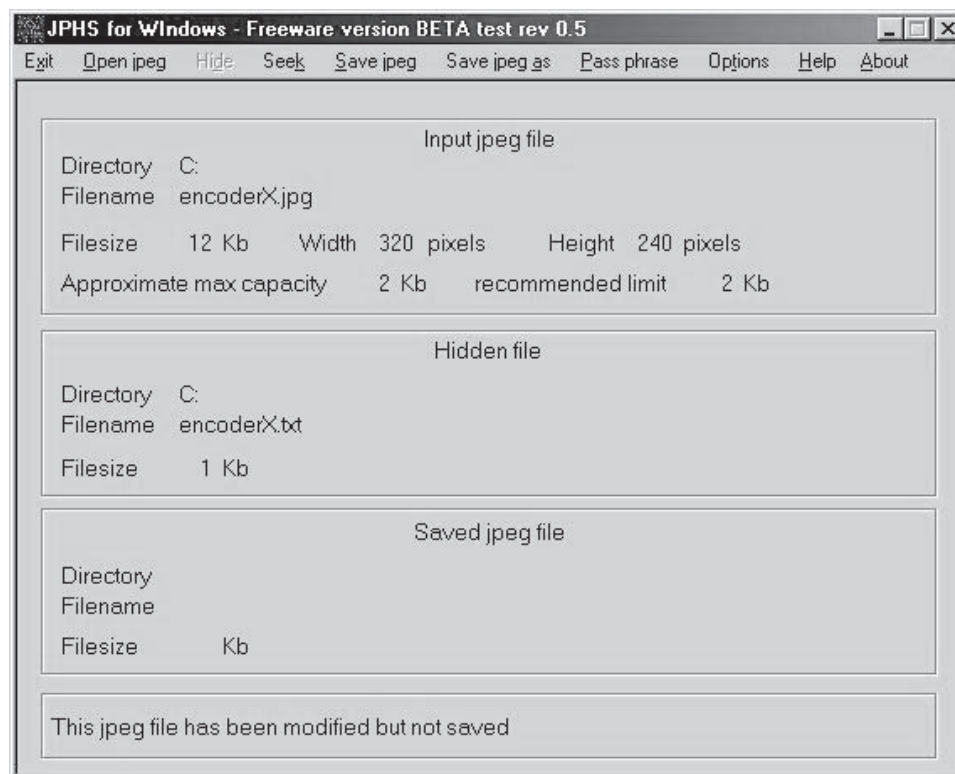


Figure 1-20 JPHS use JPEG files to hide and extract messages.

JPHS

JPHS (Figure 1-20) hides files in JPEG format. For a typical visual image and a low insertion rate of up to 5%, it is nearly impossible for someone to detect that a JPEG file processed with this tool contains hidden data.

wbStego

wbStego is a tool that hides any type of data behind the following types of files:

- Windows bitmaps with 16, 256, or 16.7 million colors
- ASCII or ANSI text files
- HTML files
- Adobe PDF files

wbStego allows the user to insert copyright information into a file to prove ownership. wbStego also provides cryptographic functions that encrypt the data before hiding it. It uses algorithms such as Blowfish, Twofish, CAST, and Rijndael (AES).

wbStego supports the following two user interfaces:

- *Wizard mode*: This mode gives detailed information about step-by-step encoding and decoding. In each step, input data get checked and verified. Files can simply be dragged into the wbStego wizard window (Figure 1-21).
- *Flowchart mode*: This mode uses a single flowchart to display the encoding and decoding process. Files can simply be dropped onto the relevant icon (Figure 1-22).

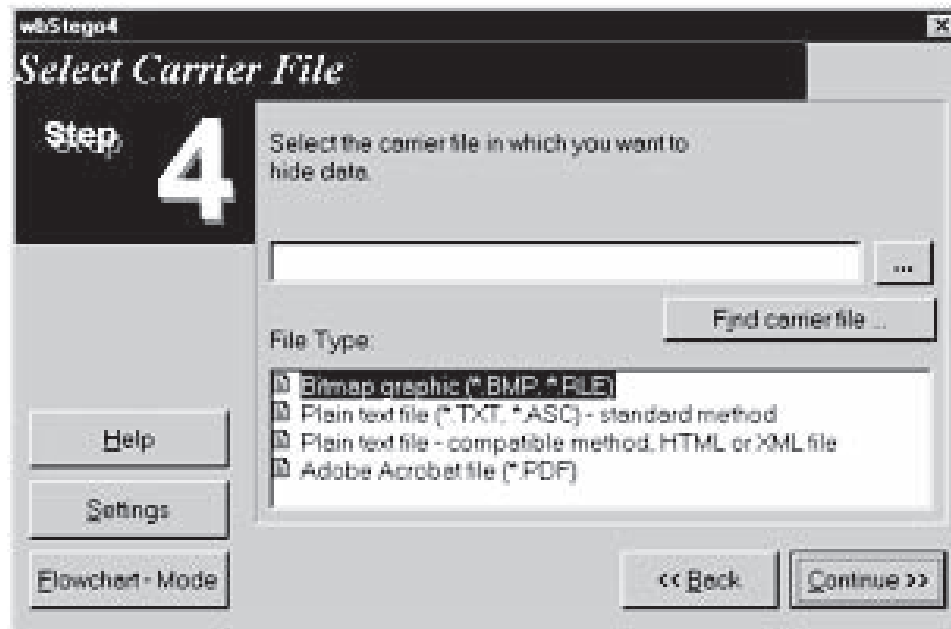


Figure 1-21 wbStego's wizard mode allows the user to verify input data.

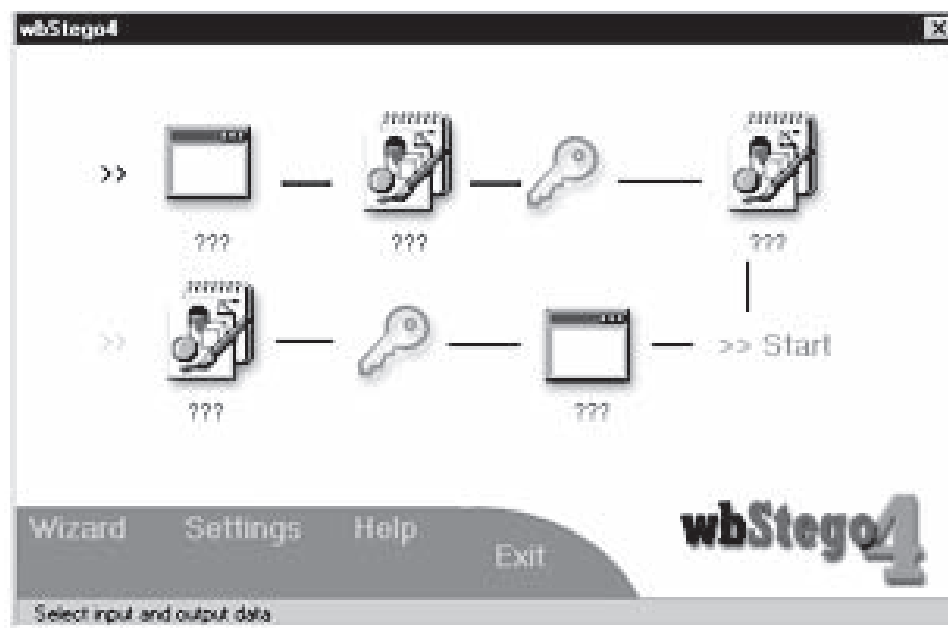


Figure 1-22 wbStego's flowchart mode uses symbols to streamline the encoding and decoding process.

OutGuess

OutGuess is a steganography tool that inserts hidden information into redundant bits of data sources. During extraction, the redundant bits are extracted and written back after modification. OutGuess supports PNM and JPEG images. In the JPEG format, OutGuess maintains statistics based on frequency counts (Figure 1-23). Before hiding the data, OutGuess determines the size of the hidden data and maintains the statistics. Due to this, statistical tests based on frequency counts are unable to detect the presence of steganographic content.

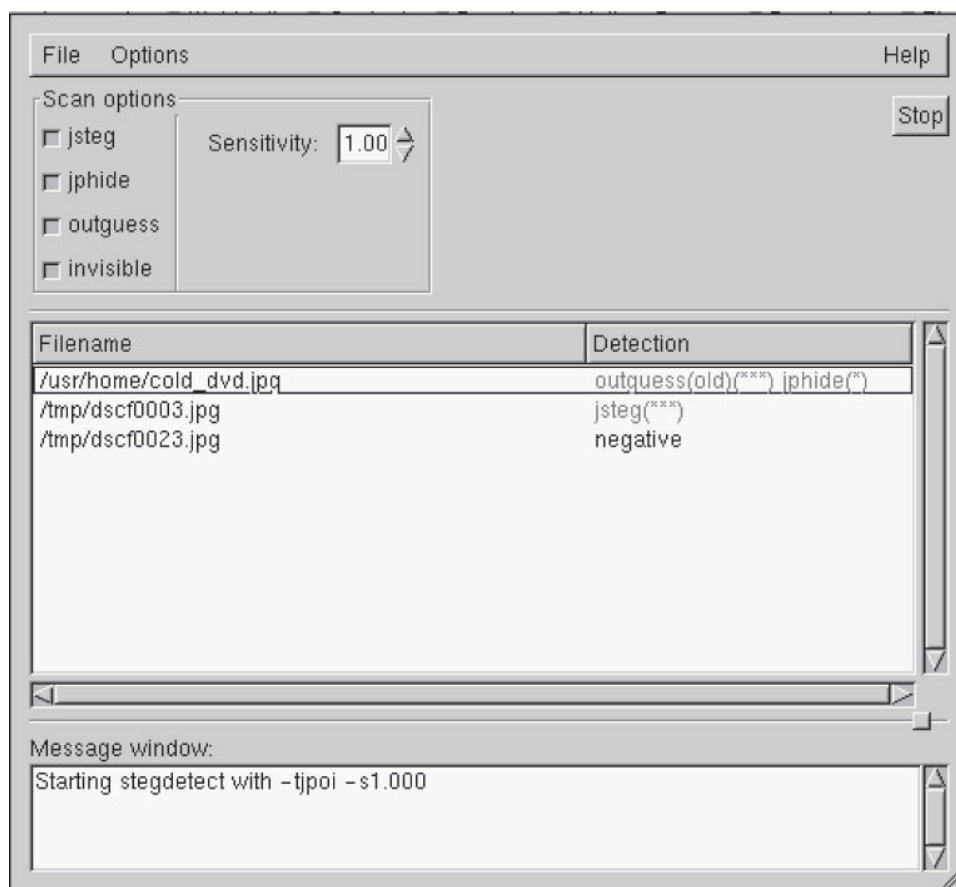


Figure 1-23 OutGuess allows users to embed messages into JPEG files.

The following example is of the data embedding procedure:

```
outguess -k "my secret key" -d hidden.txt demo.jpg out.jpg
```

Reading demo.jpg....

JPEG compression quality set to 75

Extracting usable bits: 40,059 bits

Correctable message size: 21,194 bits, 52.91%

Encoded 'snark.bz2': 14,712 bits, 1839 bytes

Finding best embedding...

0: 7467(50.6%)[50.8%], bias 8137(1.09), saved: -13, total: 18.64%

1: 7311(49.6%)[49.7%], bias 8079(1.11), saved: 5, total: 18.25%

4: 7250(49.2%)[49.3%], bias 7906(1.09), saved: 13, total: 18.10%

59: 7225(49.0%)[49.1%], bias 7889(1.09), saved: 16, total: 18.04%

59, 7225: Embedding data: 14,712 in 40,059

Bits embedded: 14,744, changed: 7225(49.0%)[49.1%], bias: 7889, tot: 40,032, skip: 25,288

Foiling statistics: corrections: 2590, failed: 1, offset: 122.585494 +- 239.664983

Total bits changed: 15,114 (change 7225 + bias 7889)

Storing bitmap into data...

Writing foil/out.jpg....

The following example is of the data extraction procedure:

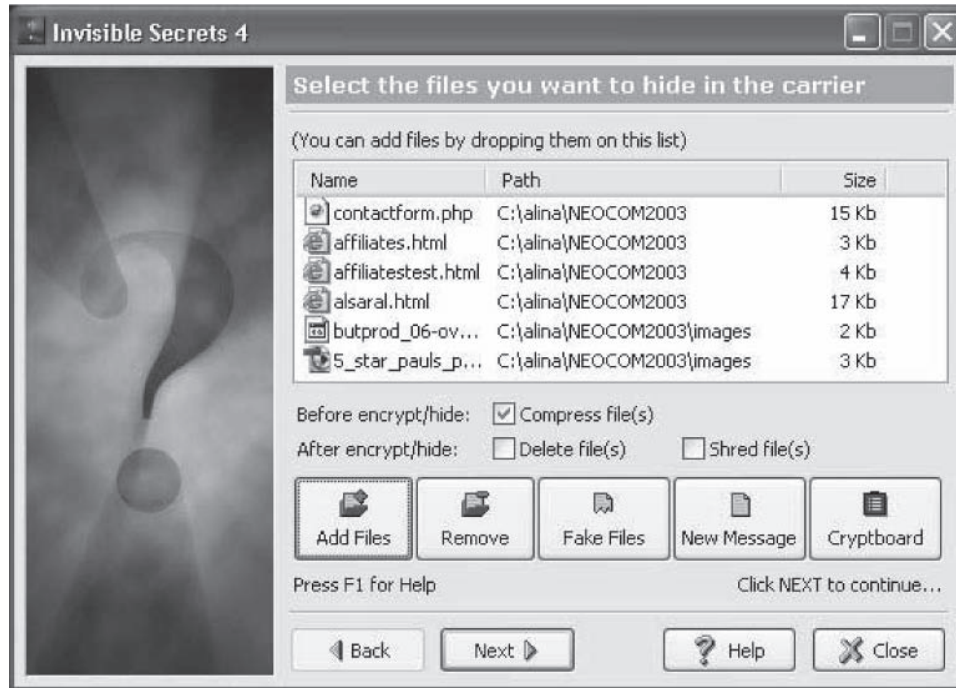
```
outguess -k "my secret key" -r out.jpg hidden.txt
```

Reading out.jpg....

Extracting usable bits: 40,059 bits

Steg retrieve: seed: 7225, len: 1839

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Source: <http://www.neobytesolutions.com/invisiblesecrets/screen.php>. Accessed 2/2007.

Figure 1-24 Invisible Secrets 4 allows the user to select a variety of files.

Invisible Secrets 4

Invisible Secrets 4 supports both cryptography and steganography. It first encrypts the message and then hides it behind a variety of files. The user can directly encrypt and hide files from Windows Explorer and transfer them over the Internet via e-mail. Invisible Secrets 4 can hide information behind JPEG, PNG, BMP, HTML, and WAV files.

Invisible Secrets 4 includes the following features:

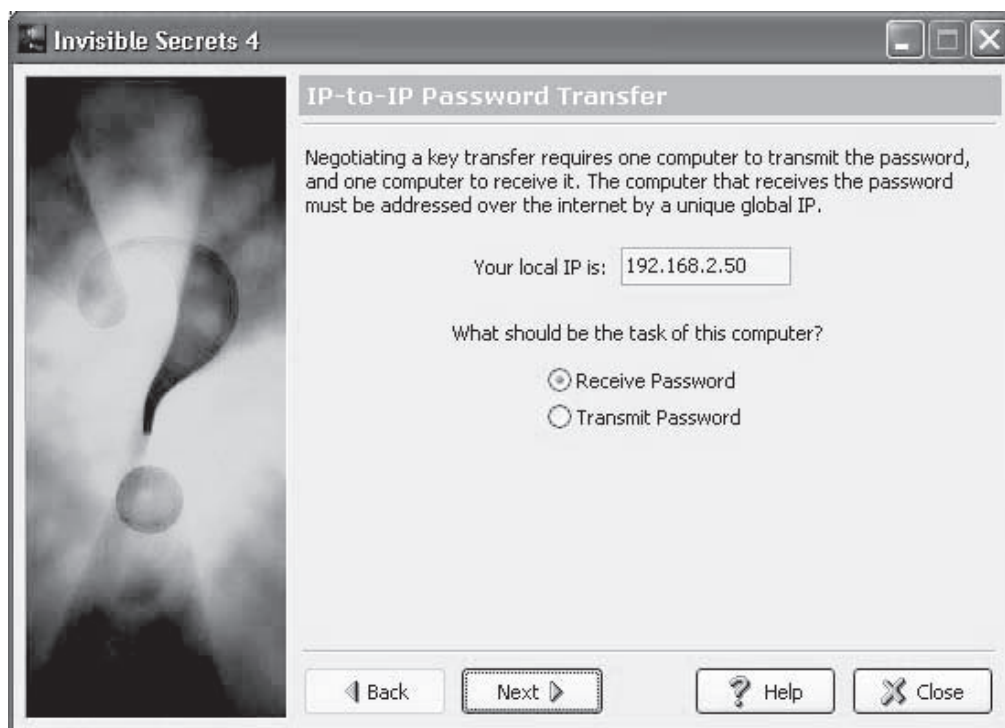
- Helps to hide files (Figure 1-24), encrypt files, destroy Internet traces, shred files, make secure IP-to-IP password transfers (Figure 1-25), and even lock any application on a computer
- Allows data compression before the encrypt/hide process
- Uses strong file-encryption algorithms, including Rijndael (AES)
- Supports password management solutions that store all passwords
- Supports a shredder that destroys files, folders, and Internet traces beyond recovery
- Has a locker that allows password protection for certain applications
- Creates self-decrypting packages that can be mailed over the Internet
- Helps transfer passwords securely over the Internet

Masker

Masker provides strong security for data. It encrypts files and hides those files behind image, video, program, or sound files. It provides up to 448-bit encryption and password protection. The cover file remains functional. This means that if it is a sound or video file, it can be played without trouble.

Masker includes the following features:

- Hides files, folders, and subfolders within a carrier file (Figure 1-26)
- Reveals and extracts hidden files and folders from a carrier file
- Encryption (up to 448 bits) and compression
- Seven strong encryption algorithms (Blowfish, Rijndael, etc.) are available



Source: <http://www.neobytesolutions.com/invisiblesecrets/screen.php>. Accessed 2/2007.

Figure 1-25 Invisible Secrets 4 allows the user to conduct an IP-to-IP password transfer.

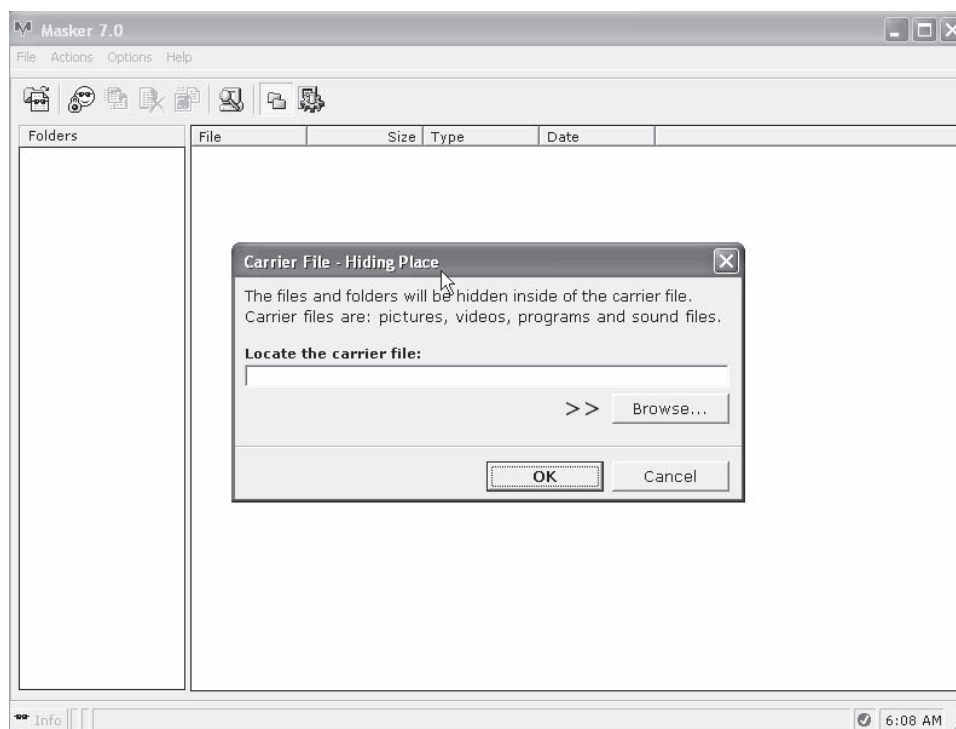
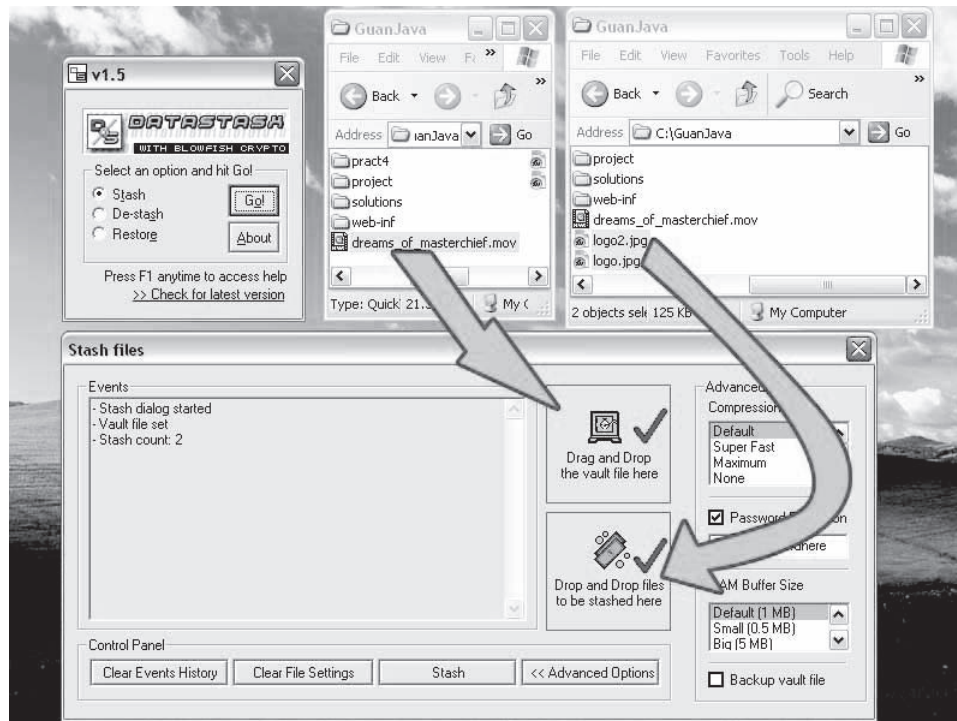


Figure 1-26 Masker allows files and folders to be hidden within another file.

- Supports multiple hideouts
- Preview function (hidden files can be previewed and modified in hidden mode)
- Search function
- Lock/unlock function blocks unauthorized use



Source: http://www.skyjuicesoftware.com/software/ds_info.html. Accessed 2/2007.

Figure 1-27 Data Stash features a simple drag-and-drop user interface.

Data Stash

Data Stash (Figure 1-27) is a steganography tool that hides sensitive data files behind other files. With this tool the user can use any large bitmap or database file as the cover file and select the files to be hidden by using the drag-and-drop function. In this method the carrier file remains active. This tool supports password protection, with the help of Blowfish encryption.

Data Stash includes the following features:

- Hides files within files
- Receptacle file remains fully functional
- Supports a wide variety of file formats (MPEG, JPEG, MP3, EXE, COM, etc.)
- Password protection using Blowfish encryption
- Fast operation

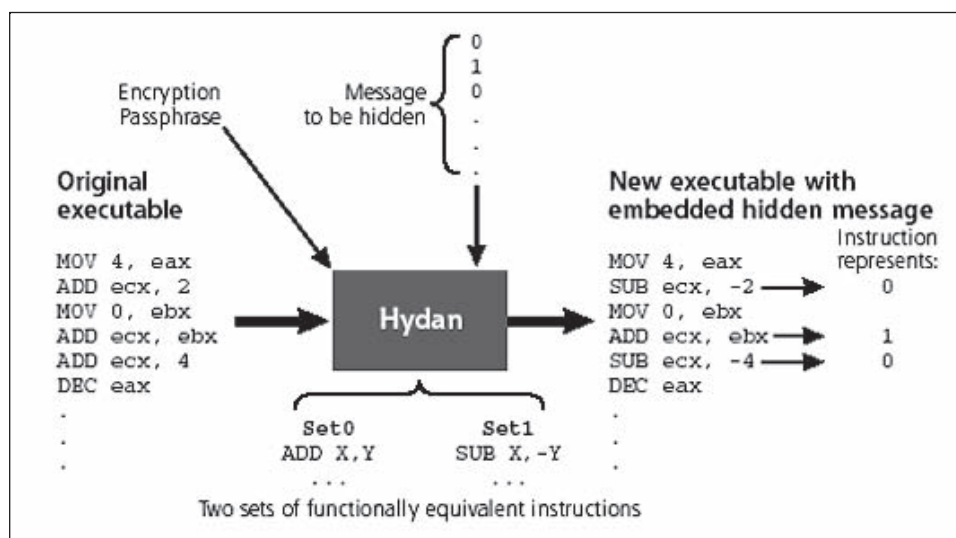
Hydan

Hydan is a steganography tool used to hide data files. It defines sets of functionally equivalent instructions and uses the redundancy in i386 machine code instructions. Hydan embeds data into binaries, forming a covert channel that can be used to transport secret messages. It supports watermarking to prevent copyright issues. Hydan includes the following features:

- Application file size remains unchanged
- Message is Blowfish-encrypted with a user-supplied passphrase, before being embedded
- Encoding rate: 1/110

Figure 1-28 shows how Hydan embeds data using polymorphic coding techniques. Figure 1-29 shows Hydan encrypting and hiding a message inside a calculator program.

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Figure 1-28 Hydan uses polymorphic coding techniques.

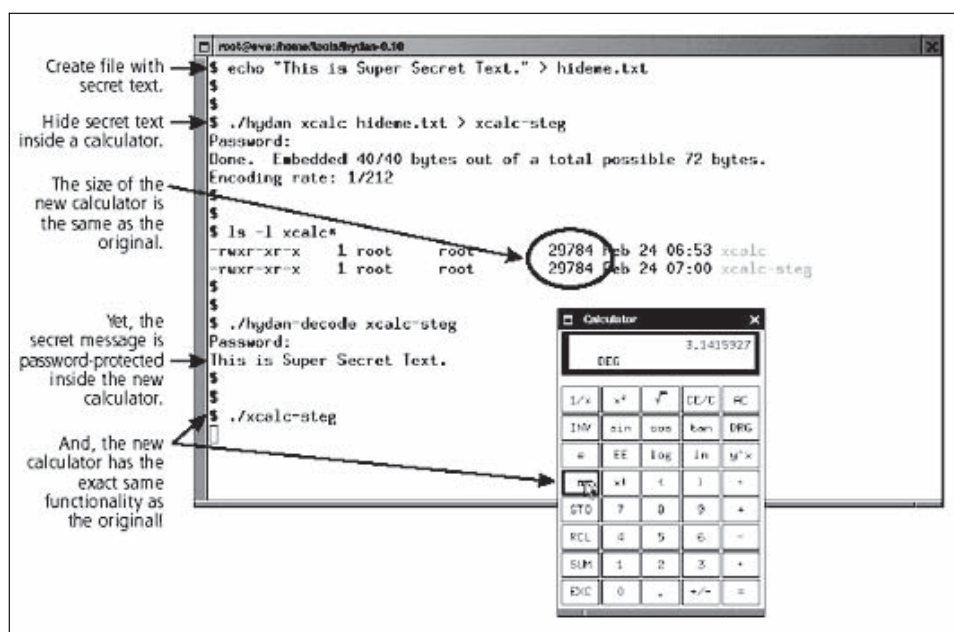


Figure 1-29 Hydan can embed messages in a variety of programs.

Cloak

Cloak is a steganography tool that provides security for personal data. This tool compresses, encrypts, and hides data behind images, and sends e-mail messages securely. It comes with Microsoft Outlook, which helps users send secure files and e-mails in combination with Cloak. It uses 256-bit encryption algorithms, supports seven image formats, and creates custom security certificates.

Cloak includes the following features:

- Compresses and encrypts all important documents into a secure Cloak file
- Encrypts and hides files within images; files hidden with Cloak are undetectable and cannot be decrypted without the correct password
- Sends and receives e-mails that are encrypted and cannot be noticed

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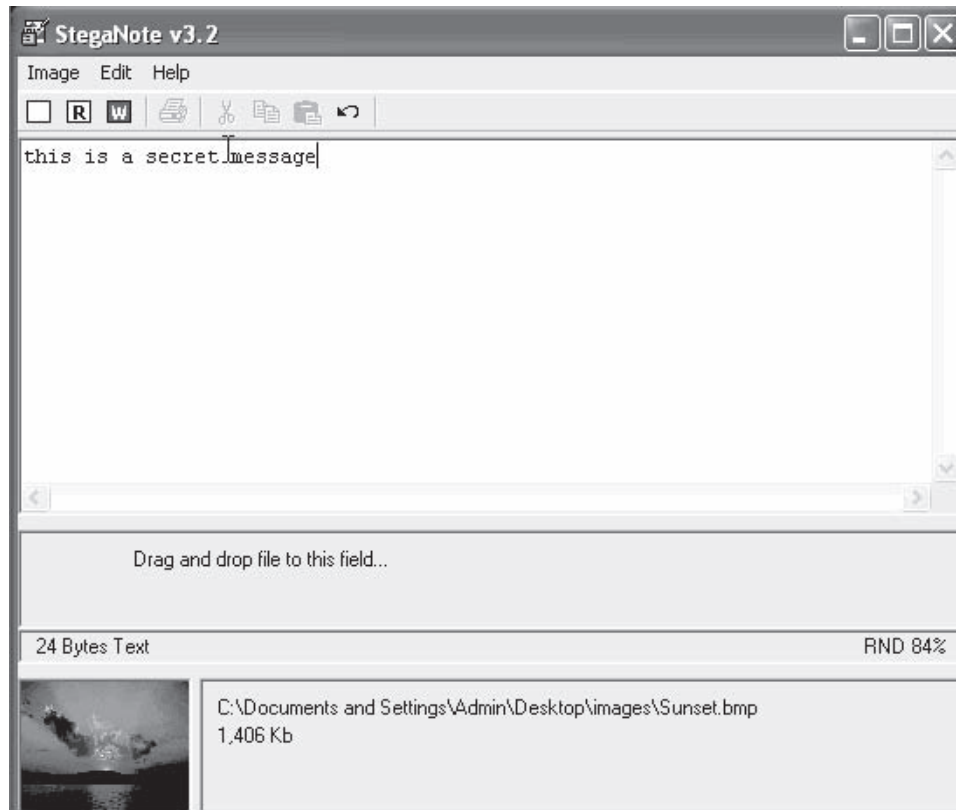


Figure 1-30 StegaNote uses cryptosecure steganography.

- Securely shreds and permanently deletes documents permanently from a system; documents cannot be reconstructed or recovered once they have been shredded with Cloak
- Permanently erases Internet and system traces, including cookies, temporary Internet documents, Internet history files, recently typed URLs, and recently accessed documents

StegaNote

The StegaNote tool (Figure 1-30) uses cryptosecure steganography that mixes up the compressed file and text from a text editor with the cover file, rendering it invisible to the human eye. This tool hides data in image files. It uses the RPP (random pixel positioning) technique, making it impossible to extract the original data. RPP uses a pseudorandom number generator (PRNG) in feedback mode, and starts with the key or password, which contains a series of coordinates to detect the pixels used to hold the data. This spreads data over the cover image. The data bits are stored into the LSB of the colors red, green, and blue. The main use of the RPP is to protect data against cryptanalysis. It has an easy and clear user interface.

Stegomagic

Stegomagic (Figure 1-31) is a steganography tool that uses text, WAV, 24-bit BMP, and 256-color BMP files to hide data. The size of the cover file remains the same except in the case of text files. Data is encrypted and protected with a password using the DES algorithm and it is subsequently hidden behind the cover file. It supports all Microsoft Windows environments.

Hermetic Stego

The Hermetic Stego tool (Figure 1-32) hides data files in either a single image or a set of BMP images. The data file may be of any type and size. It hides the data with or without a key. Hermetic Stego has the following features:

- It can hide data of any type and any size.
- The bits of data are inserted into the bytes of image files, making it impossible to crack.
- Data can be transported with or without the stego-key, which encrypts the data.

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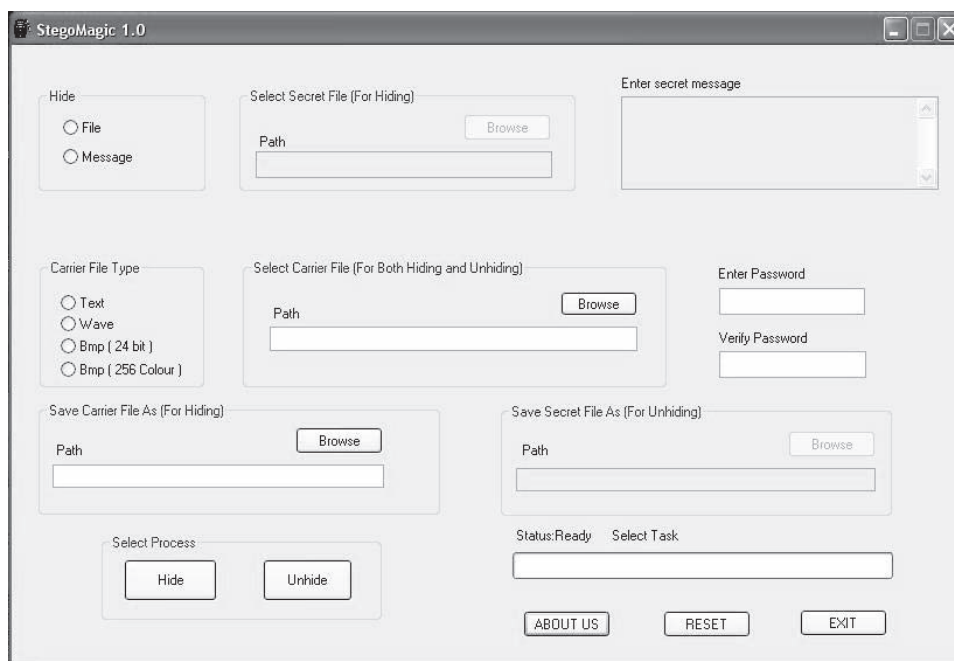
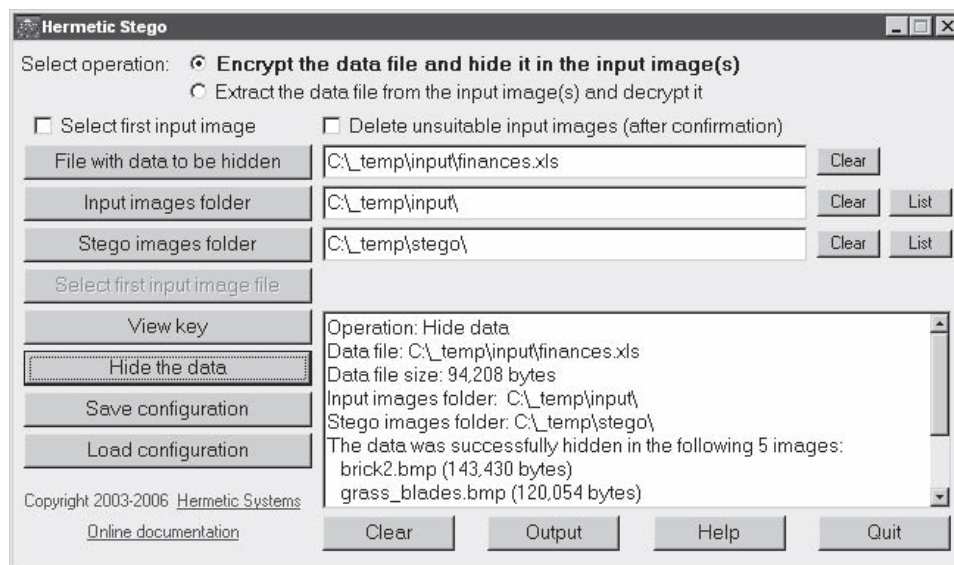


Figure 1-31 StegoMagic supports 24-bit and 256-color BMP files.



Source: <http://www.hermetic.ch/hst/hst.htm>. Accessed 2/2007.

Figure 1-32 Hermetic Stego allows the user to encrypt data and hide them in another file.

A user takes the following steps to hide data files:

- Select the data file to be hidden.
- Enter the stego-key.
- Select the image files in which to hide the data and the input image file folder that contains the BMP images for hiding the data.
- Specify the folder to receive the stego images; this is known as the Stego images folder.

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StegParty

StegParty is a system for hiding information inside plaintext files. Unlike similar tools currently available, it does not use random gibberish to encode data. Instead, it relies on small alterations, like changes in spelling and punctuation, to the message. StegParty also does not, by default, use white space to encode data. This is because whites-space-encoded messages are too easy to detect, and too easy to alter in a way that would destroy the encoded message. But since StegParty is customizable, features can be added.

Stego Suite

Stego Suite is a tool that identifies the presence of steganography without prior knowledge of the steganography algorithm that might have been used against the target file. This is known as blind steganography detection.

Stego Suite's tools provide the ability to quickly examine and evaluate digital images and/or audio data for the presence of hidden information or communications. It comprises the following three tools:

- StegoWatch
- StegoAnalyst
- StegoBreak

StegoWatch

StegoWatch allows users to detect digital steganography and can use a dictionary attack to extract information that has been embedded with some of the most popular steganography tools.

StegoAnalyst

StegoAnalyst is a full-featured imaging and analysis tool. It allows investigators to search for visual clues that steganography has, in fact, been utilized in both image and audio files. A file viewing panel is provided that displays the individual file image or audio wave and the file attributes, including image details, DCT coefficients, and color pairs (Figure 1-33). In order to allow investigators to look for further clues that steganography is in use, filter options are included that transform the images into one of three different presentations: intensity, saturation, or hue. Other filter options display only selected least significant bits (LSBs) of specific colors. Since many steganographic techniques use LSBs for data hiding, viewing the LSBs of an image can sometimes reveal indicators of steganography.

StegoBreak

StegoBreak is a built-in utility designed to obtain the passphrase that has been used on a file found to contain steganography. Included with the purchase of the tool are popular password dictionaries used to execute a dictionary attack (Figure 1-34). Investigators also have the ability to bring in other dictionaries. Alternately, if they have obtained the password through suspect questioning, they can run the password against the detected image or audio files.

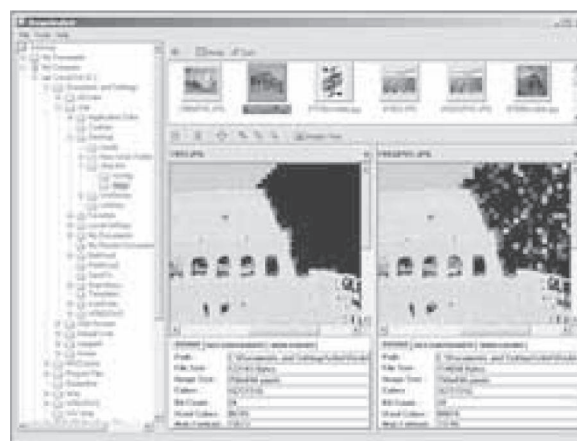


Figure 1-33 StegoAnalyst provides a file viewing panel to compare altered files.



Source: http://www.infoassure.in/stego_suite.html. Accessed 2/2007.

Figure 1-34 StegoBreak allows the user to obtain a password used for steganography.

StegSpy

StegSpy detects steganography and the program used to hide the message. It also identifies the location of the hidden content. StegSpy currently identifies the following programs:

- Hiderman
- JPHS
- Masker
- JPegX
- Invisible Secrets

Stego Hunter

Stego Hunter is designed to quickly, accurately, and easily detect steganography programs as a first step in the investigation process. With Stego Hunter, results are easily reported to the investigator of any installed or even previously installed applications. The suspected carrier types are flagged to further the investigation process. Forensic images of other popular forensic tools such as EnCase, FTK, dd, and Safeback can be scanned.

WNSTORM

WNSTORM is used to encrypt files to keep prying eyes from invading a user's privacy. It can hide files within PCX images. WNSTORM's method of hiding files in PCX images is very secure. A user can take the PCX image containing the hidden data and send it to any source. Only the sender and the one whom the password is shared with can get at the hidden data file.

Xidie

Xidie (Figure 1-35) enables the user to hide and encrypt files within other files. It can encrypt sensitive information while simultaneously hiding it in a file that will not look suspicious. The carrier files are fully functional and almost identical to the original files.

Options like encrypt and burn, hide and burn, encrypt and mail, hide and mail, etc., make the work easier. The program directly transfers archives through the use of an FTP module.

CryptArkan

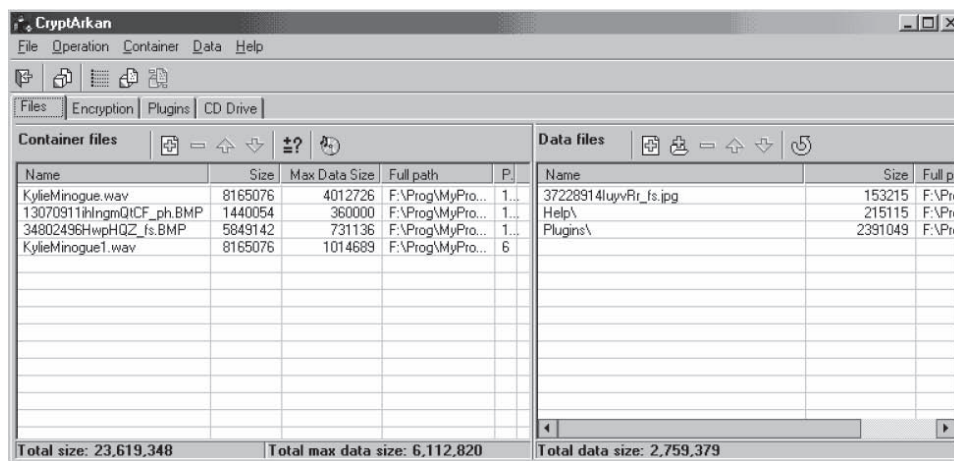
CryptArkan (Figure 1-36) encrypts and hides data files and directories inside one or more container files. Hidden data can be directly read off an audio CD.

CryptArkan performs the following functions:

- Encrypts data files to be hidden
- Hides data files in multiple container files
- Can hide whole directories, preserving subdirectory structure
- Can use different hiding methods for separate container files
- Uses different amounts of the original container file for data



Figure 1-35 Xidie performs steganographic functions with a user-friendly interface.



Source: <http://www.kuskov.com/cryptarkan/manual/overview.html>. Accessed 2/2007.

Figure 1-36 CryptArkan allows the user to hide entire directories.

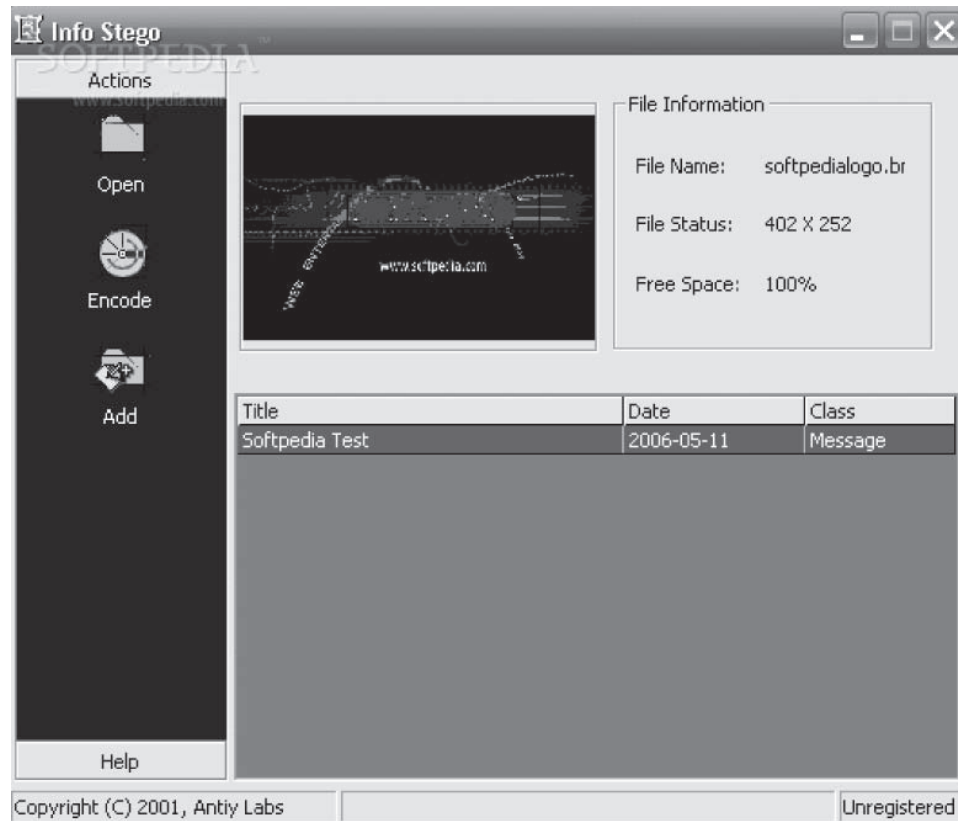
Info Stego

Info Stego (Figure 1-37) is a tool that allows the user to protect private information, communication secrets, and legal copyright using information-watermark and data encryption technology. It can hide important information within a file without noticeably changing the file cover.

Stealth Files

Stealth Files (Figure 1-38) is a tool that takes a PGP 2.x encrypted message and strips any standard headers off to ensure that the result looks like random noise. If the PGP random number generators are secure, and if IDEA and RSA (RSA when normalized) produce good-quality random numbers, the result should look like white noise

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Source: <http://www.antiy.net/infostego/>. Accessed 2/2007.

Figure 1-37 Info Stego can hide data within image files without visibly changing the images.

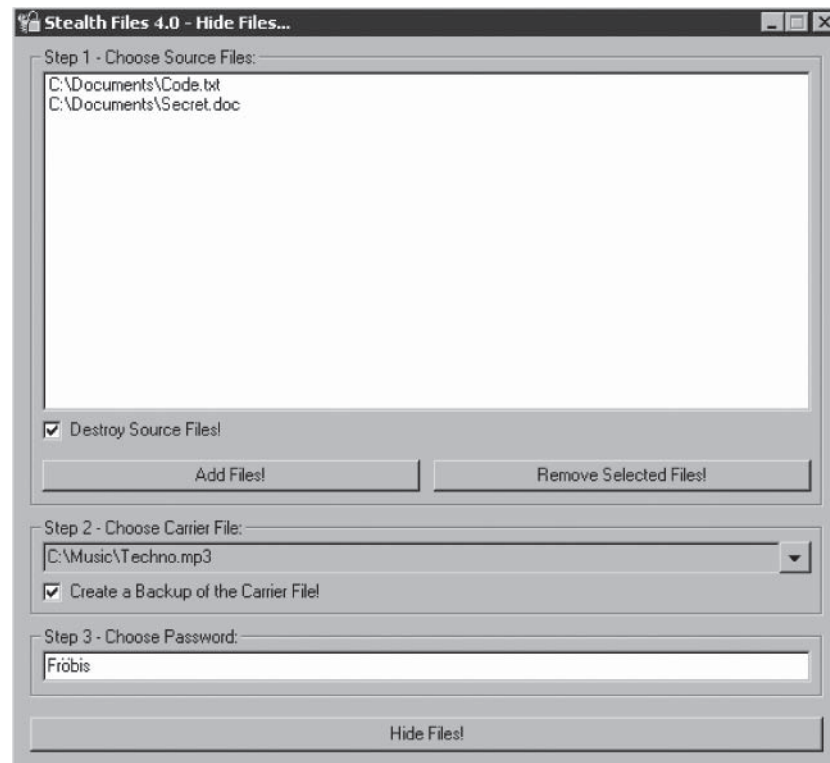


Figure 1-38 Stealth Files can make encrypted messages look like white noise.

and stand up to analysis as being indistinguishable from white noise. Stealth Files can also be used to produce random numbers.

InPlainView

InPlainView allows the user to hide any type of information within a BMP file, as well as recover it. The program lets the user store any type of file within a 24-bit BMP image without altering its size or appearance. It supports filename drag-and-drop capability and includes password protection.

EzStego

EzStego is an easy-to-use tool for private communication. It hides an encrypted message in a GIF image file. It works like invisible ink for Internet communication. EzStego is a standalone Java application.

Jpegx

Jpegx (Figure 1-39) encrypts and hides messages in JPEG files to provide an ample medium for sending secure information. The images remain visually unchanged but the code inside is altered to hide the message. It can clean JPEG files of hidden messages.

Camouflage

Camouflage (Figure 1-40) allows the user to hide files by scrambling them and then attaching them to a carrier file. A camouflaged file behaves like a normal file and can be stored, used, or e-mailed without attracting attention. It can be password protected for additional security.

Scramdisk

Scramdisk (Figure 1-41) is a program that allows for the creation and use of virtual encrypted drives. A container file is created with a specific password on an existing hard drive. The container can then be mounted by Scramdisk software, which creates a new drive letter to represent the drive.

Scramdisk allows virtual disks to be stored in the following ways:

- In a container file on a FAT-formatted hard disk
- On an empty partition
- Stored in the low bits of a WAV audio file

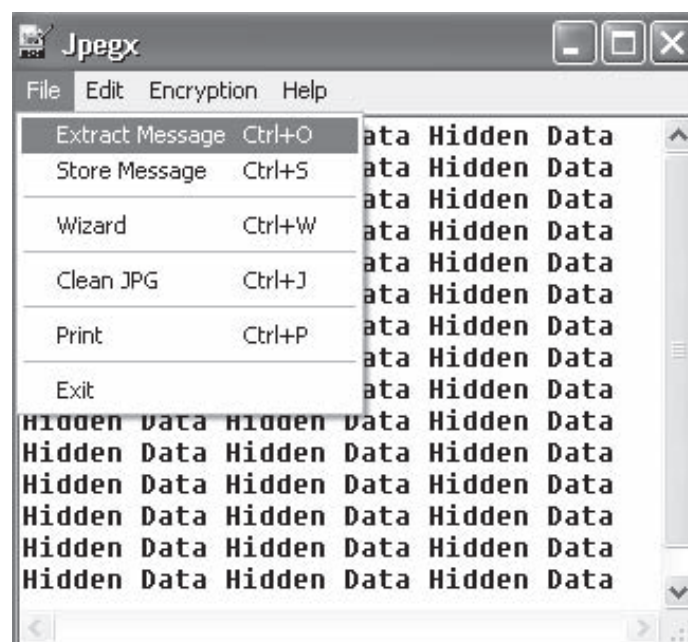


Figure 1-39 Jpegx encrypts and hides messages in JPEG files.

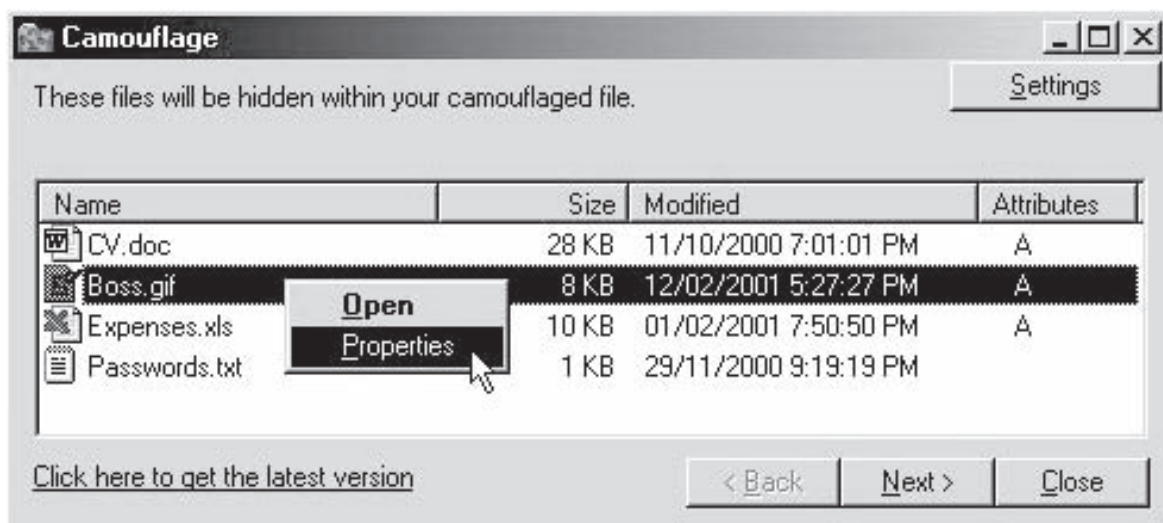


Figure 1-40 Camouflage scrambles messages and attaches them to carrier files.

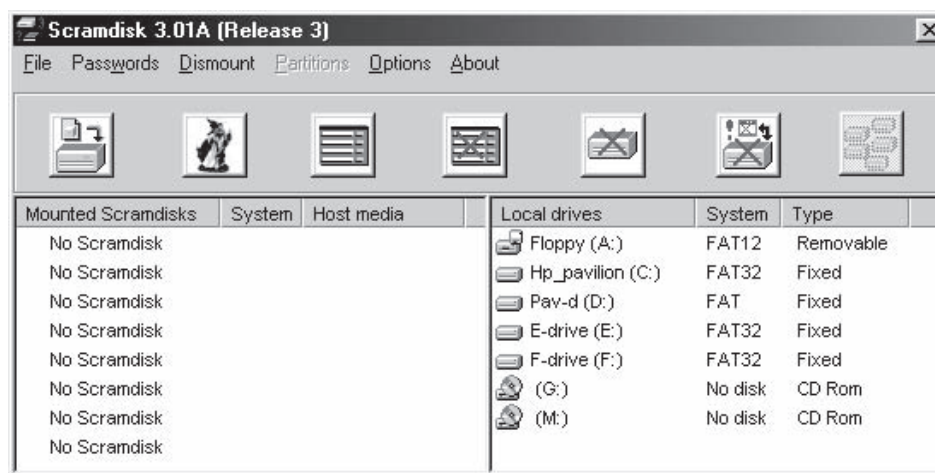


Figure 1-41 Scramdisk creates virtual encrypted drives.

CryptoBola JPEG

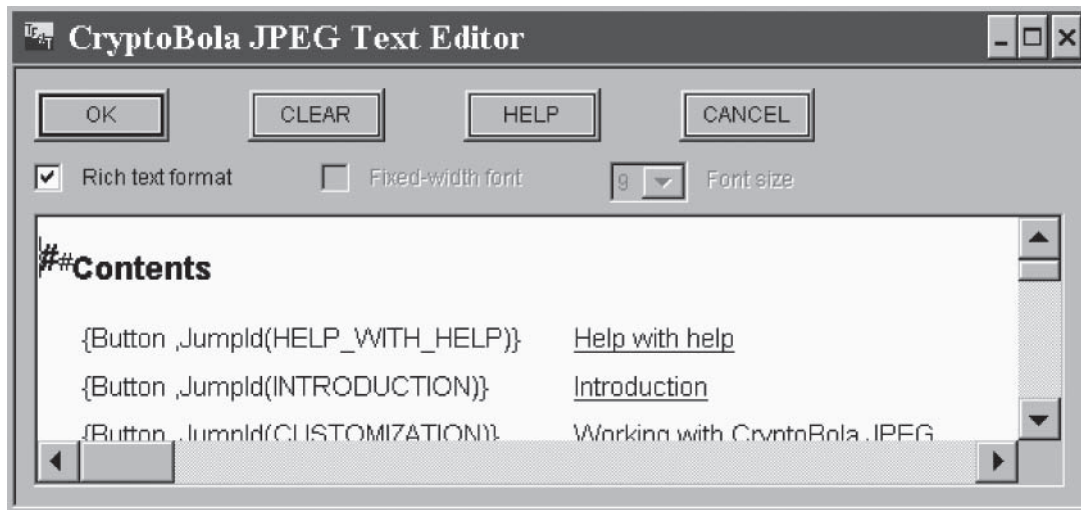
CryptoBola JPEG (Figure 1-42) stores only the ciphertext without any additional information like filename, type, or length. It determines which parts (bits) of the JPEG-encoded data play the least significant role in the reproduction of the image and replaces those bits with the bits of the ciphertext. The plaintext can be any data file or it can be entered in edit mode directly before the actual embedding takes place.

Steganosaurus

Steganosaurus is a plaintext steganography utility that encodes a (usually encrypted) binary file as gibberish text. The encoding is based on either a spelling dictionary or words taken from a text document.

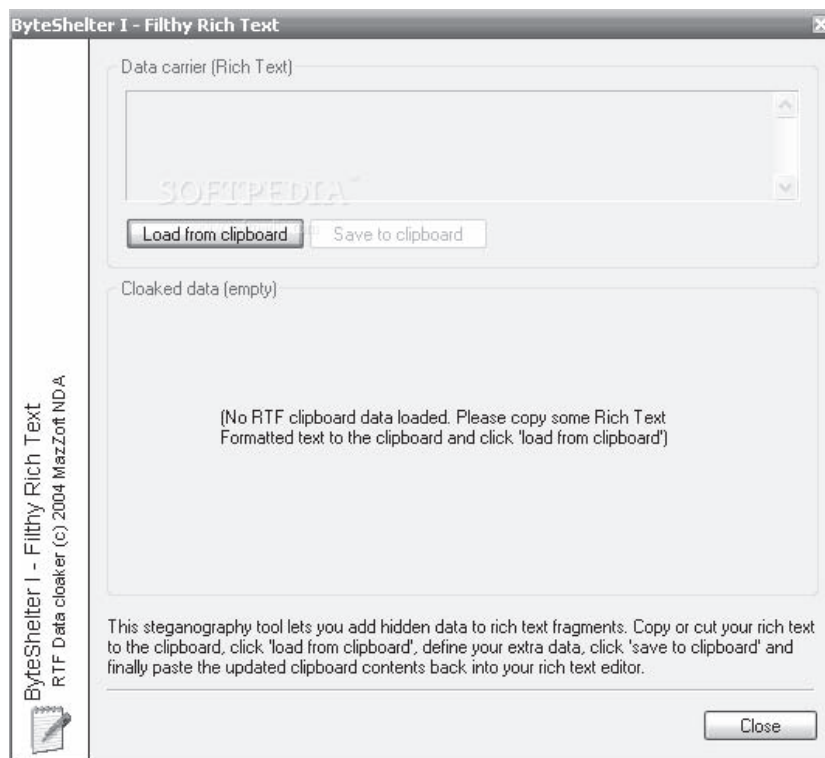
ByteShelter I

ByteShelter I (Figure 1-43) encrypts data and hides it in DOC files or e-mail messages. ByteShelter can be used to hide files and/or text in rich-text fragments.



Source: <http://www.cryptobola.com/>. Accessed 2/2007.

Figure 1-42 CryptoBola stores ciphertext in JPEG files.



Source: <http://www.softpedia.com/get/Security/Encrypting/ByteShelter.shtml>. Accessed 2/2007.

Figure 1-43 ByteShelter I encrypts data and hides it in DOC files or e-mail messages.

appendX

appendX is a steganography tool that simply appends data to other files (like JPEGs or PNGs) to hide it. It supports PGP header stripping. It allows the user to remove any appendX data from a specified file.

Z-File

Z-File's camouflage and encryption system integrates compression, encryption, and camouflage technology to protect personal privacy and business core data. The files will be effectively compressed, strongly encrypted, and implanted into an ordinary image. This procedure leaves no indication that the file contains any meaningful information other than a simple image.

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MandelSteg and GIFExtract

These two programs allow the user to hide confidential data in fractal GIF images, giving an increased level of security compared to sending PGP-encrypted e-mail over the Internet. MandelSteg will create a Mandelbrot image (though it could easily be modified to produce other fractals), storing the data in the specified bit of the image pixels, after which the recipient can use GIFExtract to extract that bit plane of the image.

Chapter Summary

- Steganography is the method of hiding information by embedding the message into a seemingly harmless message.
- Cryptography is the technique of encoding the contents of a message in such a way that its contents are hidden from outsiders. Here, existence of the message is clear but the meaning is obscured.
- Watermarking is used for authentication and copyright protection.
- Data Stash is a security tool that allows the user to hide sensitive data files within other files.
- Stegomagic hides any kind of file or message in text, WAV, 24-bit BMP, and 256-color BMP files.
- Steganalysis is a technique used to detect and extract hidden data.
- Steganography is used for secure and secret communication.

Review Questions

1. Define steganography.

2. What is a watermark?

3. How is steganography different from cryptography?

4. Name the three main types of steganography.

5. How is steganography used with audio files?

6. What is a cover medium?

7. Name two legal uses for steganography.

8. Explain the least-significant-bit method of steganography.

9. Name two methods used to embed messages in a text file.

10. Explain the process of echo data hiding.

Hands-On Projects



1. Use the S-Tools program to hide a file inside a WAV file.
 - Navigate to Chapter 1 of the Student Resource Center.
 - Install and launch the S-Tools program (Figure 1-44).

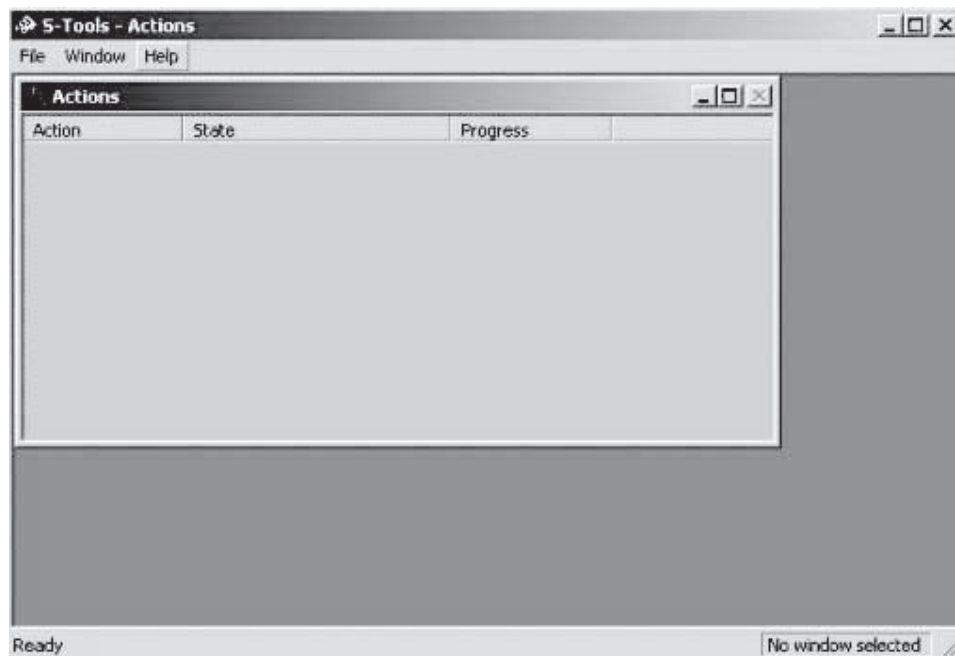


Figure 1-44 Install and launch the S-Tools program.

- Drag a WAV file from Windows Explorer to the **Actions** window (Figure 1-45).

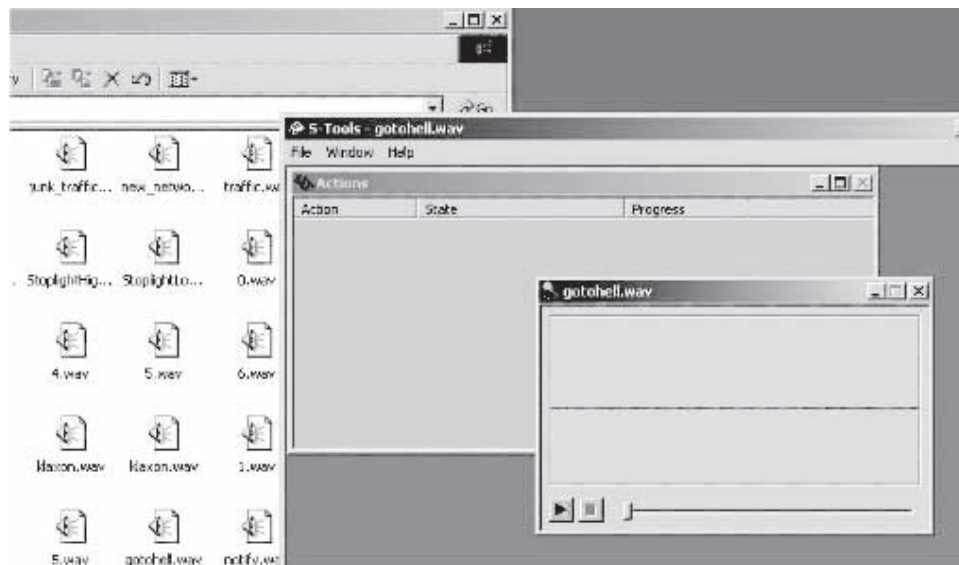


Figure 1-45 Drag a WAV file to the **Actions** window.

- Select a file to be hidden and drag that file inside the window of the WAV file (Figure 1-46).

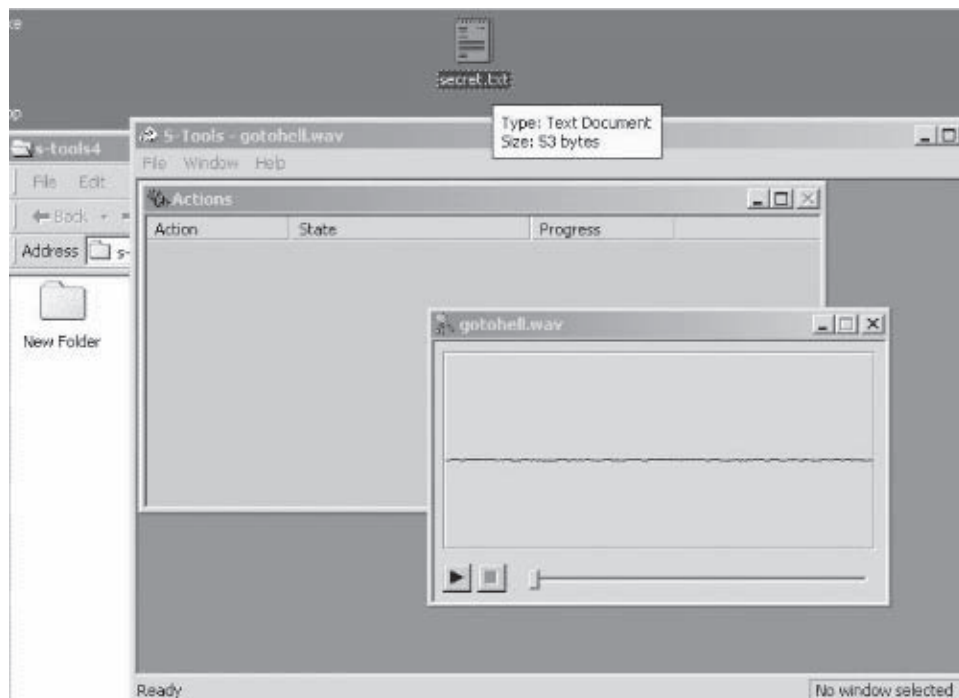


Figure 1-46 Select a file to be hidden.

- Enter the passphrase (Figure 1-47).

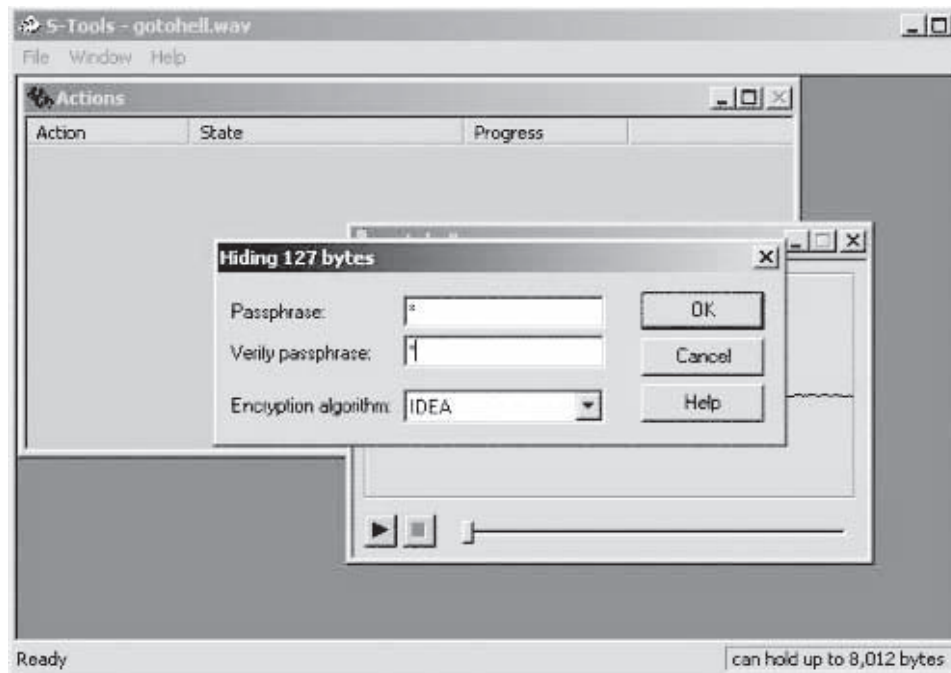


Figure 1-47 Enter the passphrase.

- Right-click the **hidden data** window and select **Save** (Figure 1-48).
- To view the data file, select **Reveal**.

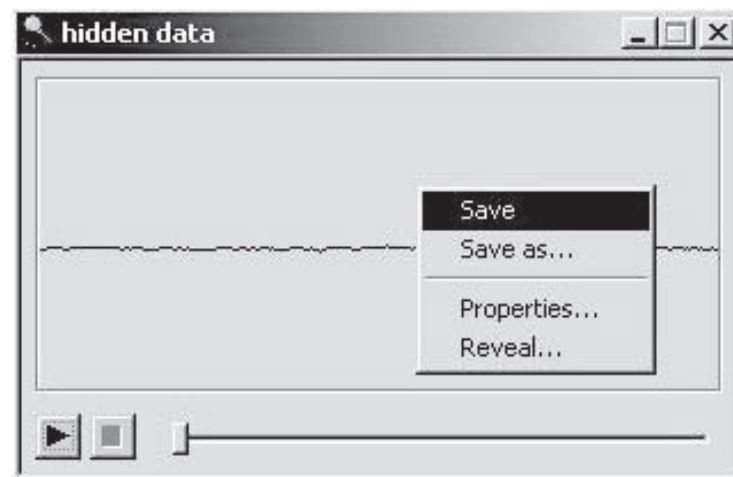


Figure 1-48 Right-click the **hidden data** window and save the file.

2. Use the StegHide program to hide text in images.
 - Navigate to Chapter 1 of the Student Resource Center.
 - Open the StegHide program in the command shell (Figure 1-49).

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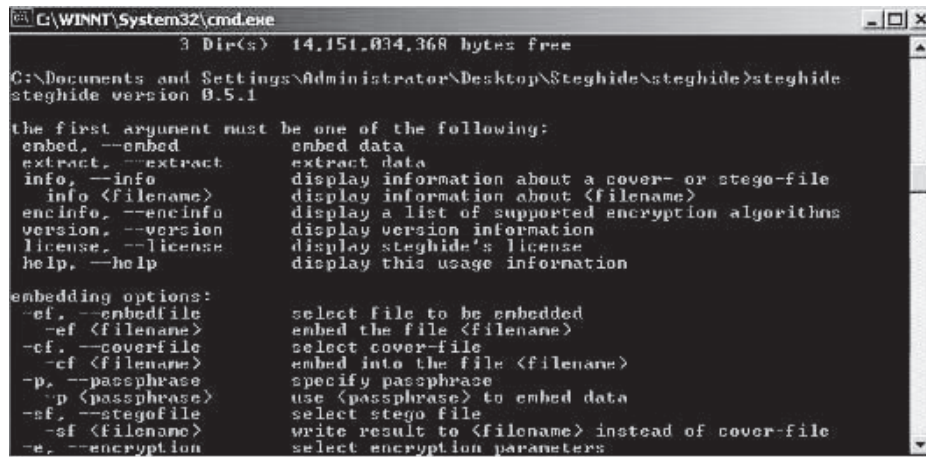


Figure 1-49 Open the StegHide program in the command shell.

- To embed emb.txt in cvr.jpg, use the following command: **steghide embed -cf cvr.jpg -ef emb.txt**.
 - To extract embedded data from stg.jpg, use the following command: **steghide extract -sf stg.jpg**.
3. Use the FortKnox program to hide data within another file.
 - Navigate to Chapter 1 of the Student Resource Center.
 - Install and launch the FortKnox program.
 - Explore various options (Figure 1-50).

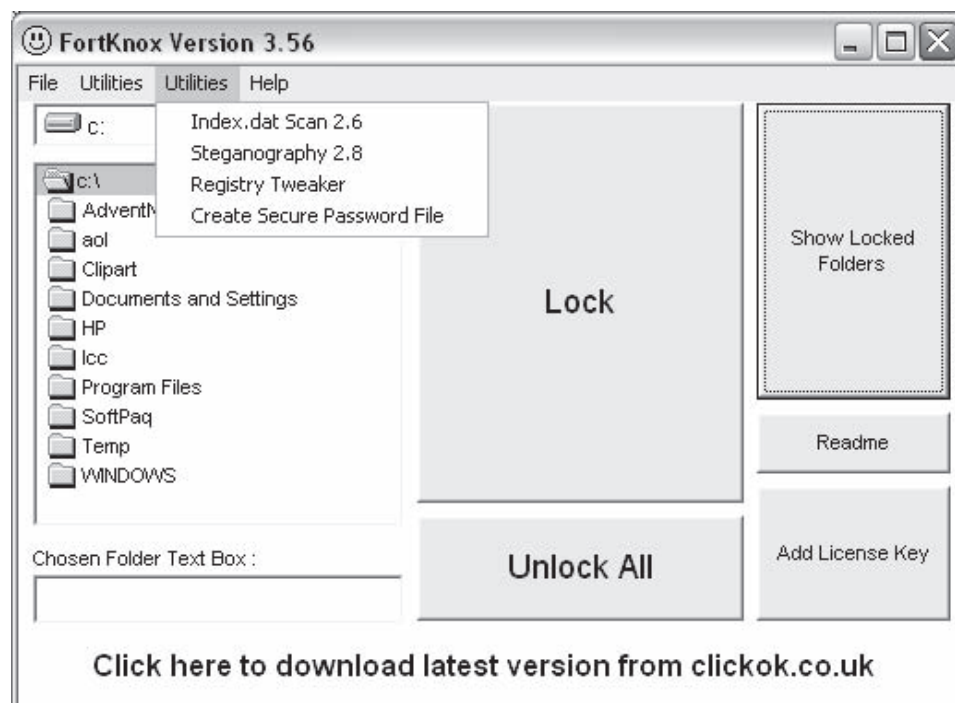


Figure 1-50 Explore the various options in FortKnox.

- Select **Steganography 2.8** from the Utilities menu. Browse the image file and message file, and click the **Encrypt** button (Figure 1-51).

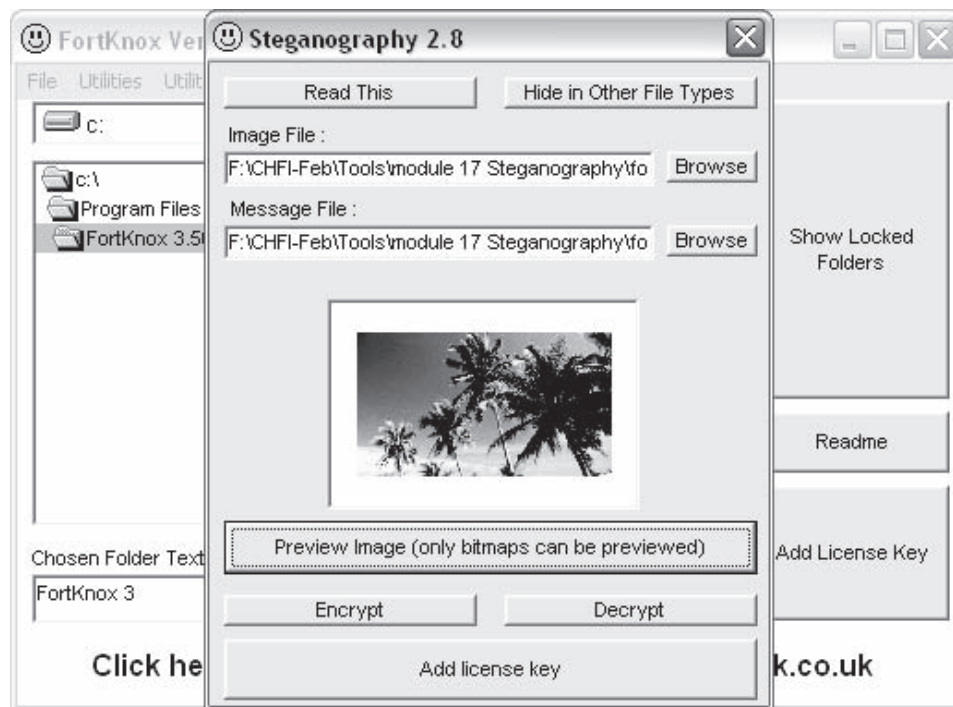


Figure 1-51 Browse the image and message files, and click the **Encrypt** button.

- Select **Windows Security** from the Utilities (Figure 1-52).

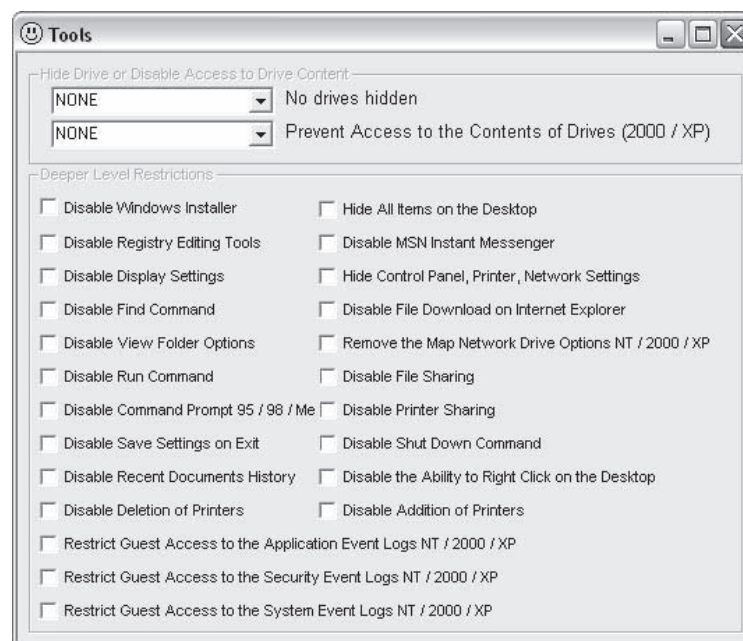


Figure 1-52 Select **Windows Security** from the Utilities.

Data Acquisition and Duplication

Objectives

After completing this chapter, you should be able to:

- Determine the best data acquisition methods
- Understand data recovery contingencies
- Understand the need for data duplication
- Use common data acquisition tools
- Use common data duplication tools

Key Terms

Data acquisition the act of taking possession of or obtaining control of data and adding it to a collection of evidence

Data duplication the act of making a copy of data already acquired to preserve the original evidence in pristine condition

Sparse data copy a copy that an investigator makes of only part of a large set of data in which only the data pertinent to the investigation is included, in order to reduce the overall size of the evidence file; this technique is often used when copying data from RAID arrays, when dealing with terabytes or petabytes of information, or when only specific evidence is needed

Transmission Control Protocol (TCP) a protocol that implements a core set of rules that allow reliable connection-oriented connections between host computers over a network

User Datagram Protocol (UDP) a nonreliable protocol that implements a best-effort set of rules that allow for network communication where exact delivery of each packet is not critical, such as for streaming video

Case Example

Jeremy Johnson, 26, was hired by Adams Central School District as a teacher. During his tenure as a teacher, there were rumors around the school campus about an inappropriate relationship between him and a female student. Both denied the rumors. Since school officials had no evidence of the relationship, they could only issue a warning. Several months later, the student told her cousins about the relationship. This triggered an investigation by the Adams County Sheriff's Department.

The police searched Johnson's home. Johnson's bedroom matched the description given by the student in an interview with a female police officer. Johnson continued to deny the girl's claims concerning their sexual relationship. During the search, they seized his laptop and desktop computer. The investigators were able to verify that Johnson and the student exchanged e-mails. Johnson had reportedly set up an e-mail account for the girl in his wife's name. Though the e-mails were not explicit, the investigators could prove that Johnson and the student had been having a sexual relationship.

Later, the forensic examiner found that Johnson had been trading child pornography over the Internet. He had hundreds of nude pictures of children obviously under the age of 18. He had tried to hide the images by putting them in a folder labeled "music."

Jeremy Johnson was arrested and jailed on 19 charges of child seduction, a Class D felony.

Introduction to Data Acquisition and Duplication

This chapter focuses on data acquisition and data duplication. *Data acquisition* is the act of taking possession of or obtaining control of data and adding it to a collection of evidence. *Data duplication* is the act of making a copy of data already acquired to preserve the original evidence in pristine condition. The chapter starts by discussing how to determine the best data acquisition methods for a certain situation. It then discusses how to make sure crucial data is not lost during the acquisition process. The chapter then covers the importance of data duplication before moving on to descriptions of the tools investigators use for data acquisition and duplication.

Determining the Best Acquisition Methods

Forensic investigators can acquire digital evidence using the following methods:

1. Creating a bit-stream disk-to-image file
2. Making a bit-stream disk-to-disk copy
3. Creating a sparse data copy of a folder or file

Disk-To-Image File

Creating a bit-stream disk-to-image file is the most common method forensic investigators use. When using this method, forensic investigators are able to make as many copies of the digital evidence as they need. Investigators are able to image the original disk to another disk. An investigator can then make use of other tools such as EnCase, FTK, Smart, Task, and Ilook to read and analyze the image file.

Disk-To-Disk Copy

If an investigator is unable to create a bit-stream disk-to-image file, the alternative is to create a bit-stream disk-to-disk copy of the suspect's disk drive in order to acquire the information from it. There are several bit-streaming programs that can copy the information from one disk to another. Disk-to-disk imaging tools include SafeBack, SnapCopy, and Norton Ghost. Many of these applications run under MS-DOS.

Sparse Data Copy

There are times during a forensic investigation when an investigator finds incriminating evidence in a particular file or folder. Therefore, it would not be necessary to create a bit-stream disk-to-image file or a disk-to-disk copy. The investigator would just need to create a sparse data copy of the folder or file. A *sparse data copy* is a copy that an investigator makes of only part of a large set of data in which only the data pertinent to the investigation is included. An investigator may choose to make a sparse data copy to reduce the overall size of an evidence file.

Data Recovery Contingencies

Investigators must make contingency plans when data acquisition failure occurs. To preserve digital evidence, investigators must create a duplicate copy of the evidence files. In case the original data recovered is corrupted, investigators can make use of the second copy. Investigators can use forensic tools such as EnCase and SafeBack to obtain multiple copies.

Typically, computer forensic investigators make at least bit-stream image copies of the digital evidence that is collected. Investigators have at their disposal more than one bit-streaming tool. They should use at least two of these tools to make copies of the digital evidence in case one tool doesn't properly acquire the data.

During the data recovery process, an investigator must remember not to make any changes to the digital evidence. Forensic activities must be performed only on the bit-stream copies of digital evidence to ensure that the original evidence is not altered or corrupted.

The Need for Data Duplication

Investigators need to be concerned about destructive devices that can be planted in computer systems by their owners. Evidence can be destroyed if an investigator is not careful. These destructive devices can overwrite data fragments, and they can alter or destroy data stored in the Windows swap file. A suspect could use a self-destructing program that could wipe out any evidence when it detects a certain trigger. This can hamper an investigation and make the collection of evidence much more difficult. Thus, data duplication is essential for the proper preservation of digital evidence.

Data Acquisition Software Tools

There are many different data acquisition tools available to forensic investigators. All of these tools have different features that make them useful in different situations.

Windows Standard Tools

Windows data acquisition tools—such as xcopy, diskcopy, Volume Shadow Copy, and Windows Explorer—allow an investigator to easily examine or acquire evidence from a disk with the help of removable media, such as a USB storage device. These tools can also use Firewire to connect hard disks to forensic lab systems. However, Windows data acquisition tools cannot acquire data from a protected area of a disk.

Windows is equipped with many tools that are intended for administrators but are also useful for computer forensic investigators. These tools permit the investigator to acquire and replicate digital evidence. The forensic investigator is able to find out where logical volume information is found and is able to collect evidence from a system even when it is running. Windows data acquisition tools enable forensic investigators to acquire a full logical image of a drive. But, Windows tools can only acquire data that the operating system can recognize and do not include slack space or deleted files.

Home and workplace computer systems are designed with hard drives with large storage capacities. Imaging a 500 GB hard drive using traditional methods, for instance, may take a total of 24 hours to complete. From a forensic investigative point of view, 24 hours is a long time. This can lead to a loss of productivity for the company that owns the computer containing the evidence.

On the other hand, data acquisition programs like dd and netcat usually spend a lot of time copying data from one buffer to another. In order to image a logical volume, data on the volume must be paged from internal buffers to the file systems in memory. This process takes a lot of time, and this is one of the main limitations of standard forensic tools when compared to Windows forensic tools.

Linux Standard Tools

Forensic investigators use the built-in Linux command dd to copy data from a disk drive. This command can make a bit-stream disk-to-disk copy or a disk-to-image file. The dd command can copy data from any disk that Linux can mount and access. Other forensic tools, such as AccessData FTK and Ilook, can read dd image files.

One of the advantages of using the dd command in Linux is that it is free software that does not rely on any additional resources from the computer. The dd command in Linux can create images of ext2, ext3, UNIX, FAT12, FAT16, FAT32, NTFS, HFS, and HPFS file-system disks. The dd command also enables examiners to extract digital evidence and copy it to any type of media that the Linux operating system is able to access.

The `dd` command in Linux does have certain limitations. An investigator needs to understand and be able to implement advanced UNIX shell scripting commands. The investigator must also define the exact number of blocks in the save set volume in order to create a volume save set. Also, the `dd` command is not available in all versions of Linux.

Using the `dd` Command

The syntax for the `dd` command is as follows:

`dd if=<source> of=<target> bs=<byte size> (usually some power of 2, not less than 512 bytes [i.e., 512, 1024, 2048, 4096, 8192]) skip= seek= conv=<conversion>`

- *source*: where the data is to be read from
- *target*: where the data is to be written to
- *skip*: number of blocks to skip at start of input
- *seek*: number of blocks to skip at start of output
- *conv*: conversion options

For example, an investigator would use the following commands for these tasks:

- To make a complete physical backup of a hard disk:
`dd if=/dev/hda of=/dev/case5img1`
- To copy one hard disk partition to another hard disk:
`dd if=/dev/sda2 of=/dev/sdb2 bs=4096 conv=notrunc,noerror`
- To make an image of a CD:
`dd if=/dev/hdc of=/home/sam/mycd.iso bs=2048 conv=notrunc`
- To copy a floppy disk:
`dd if=/dev/fd0 of=/home/sam/floppy.image conv=notrunc`
- To restore a disk partition from an image file:
`dd if=/home/sam/partition.image of=/dev/sdb2 bs=4096 conv=notrunc,noerror`
- To copy RAM memory to a file:
`dd if=/dev/mem of=/home/sam/mem.bin bs=1024`

Using `dd` to Extract the MBR

The master boot record (MBR) is the consistent starting point for hard disks. It stores information about the disk. The MBR is always located at cylinder zero, head zero, and sector one, the first sector on the disk.

The MBR consists of the following:

- *Master partition table*: This table contains a complete description of the partitions on the disk.
- *Master boot code*: This is the small bit of code that the BIOS loads to start the bootstrapping process.

To see the contents of the MBR, an investigator uses the following commands:

```
dd if=/dev/hda of=mbr.bin bs=512 count=1
od -xa mbr.bin
```

This `dd` command must be run as root. It reads the first 512 bytes from `/dev/hda` (the first IDE drive) and writes them to the `mbr.bin` file.

The `od` command prints the binary file in hex and ASCII formats.

Using `netcat` with `dd`

The `netcat` command supports the `dd` command with networking features. An investigator can use it to read and write data across the network using TCP or UDP. **TCP** is a protocol that implements a core set of rules that allow reliable connection-oriented connections between host computers over a network. **UDP** is a nonreliable protocol that implements a best-effort set of rules that allow for network communication where exact delivery of each packet is not critical, such as for streaming video.

To make a partition image on another machine:

- On a source machine:
`dd if=/dev/hda bs=16065b | netcat targethost-IP 1234`
- On a target machine:
`netcat -l -p 1234 | dd of=/dev/hdc bs=16065b`

DriveSpy

DriveSpy enables an investigator to direct information from one particular sector range to another sector. The DriveSpy application gives forensic investigators two methods to access disk sectors:

1. Defining the absolute starting sector after a command and the total number of sectors to be read on the drive
2. Listing the absolute starting and ending sectors

Many of the DriveSpy commands are able to work with multiple ranges of sectors. These commands include CopySect, SaveSect, WriteSect, and Wipe. When a sector range is required as a parameter for a DriveSpy command, the ranges may be specified using the following syntax:

[Drive ID]: [Absolute Start Sector],[Number of Sectors]
[Drive ID]: [Absolute Start Sector]-[Absolute End Sector]

An investigator specifies the exact sector range by identifying a starting sector and then the total number of sectors using the first syntax. The second syntax defines a range by identifying both the starting and ending sectors. A comma and a hyphen differentiate the two syntaxes.

DriveSpy Data Manipulation Commands

There are two commands in DriveSpy that are used for data manipulation:

1. **SaveSect:** The SaveSect command is used to copy particular sectors on a disk to a file. The SaveSect command copies the sectors as a bit-stream image so that the file is a duplicate of the original sectors. The syntax for the SaveSect command is as follows:
SAVESECT [Source Sector Range] [Destination File]
If a path is not identified in the file specification, the file is created in the current working directory.
2. **WriteSect:** The WriteSect command is used to regenerate information acquired through the SaveSect command. The WriteSect command copies the contents of an image file created by SaveSect to a series of sectors. The syntax for the WriteSect command is as follows:
WRITESECT [Source File] [Destination Sector Range]
As with the SaveSect command, if a path is not identified in the file specification, the file is created in the current working directory.

DriveSpy Data Preservation Commands

The DriveSpy application gives forensic examiners the ability to create and restore compressed images of drive partitions. If an investigator makes an image of a DOS partition, the free space is not included, as DOS cannot see the free space in a cluster. However, if an investigator makes an image of a non-DOS partition, every byte is preserved, including the free space.

There are three data preservation commands available in DriveSpy:

1. **SavePart:** The main function of the SavePart command is to generate an image of a partition. The syntax of the SavePart command is as follows:
SAVEPART [Destination File]
Investigators mainly make use of the SavePart command in DriveSpy to create a compressed forensic image of the present partition. SavePart allows an investigator to span media to store the complete image when necessary. After creating an image of the partition, DriveSpy provides a summary of the MD5 hash that is maintained for the image to ensure data integrity when the image is restored.
2. **WritePart:** The main function of the WritePart command is to restore an image of a partition. The image can be one that is stored in the partition that is being examined. The syntax of the WritePart command is as follows:
WRITEPART [Source File]

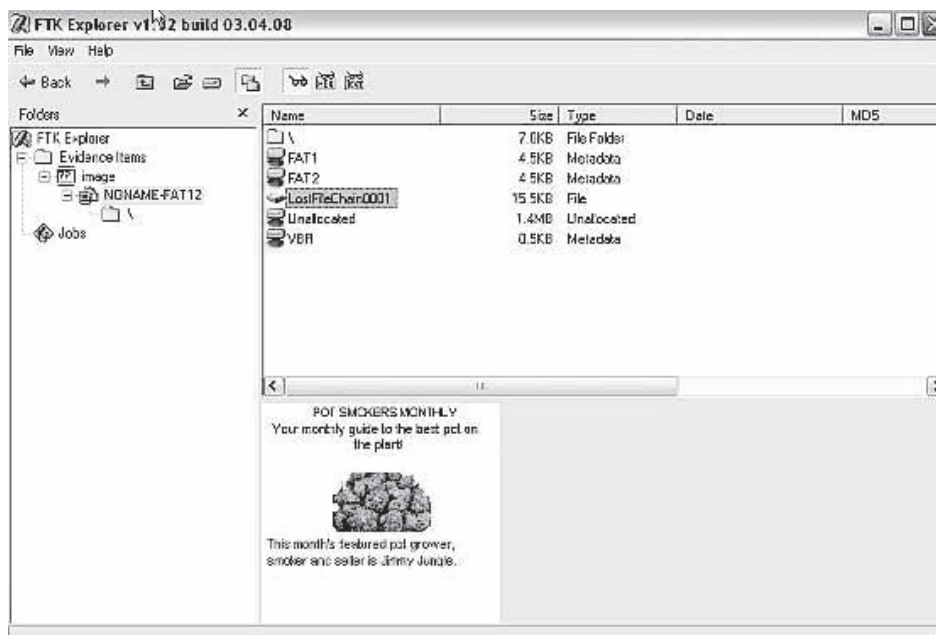


Figure 2-1 FTK Imager is a powerful data acquisition tool.

If the image is stored across many parts of media, the WritePart command would automatically look for the media that is necessary.

3. **CopySect:** The main function of the CopySect command is to copy sectors from one disk to a location on the same disk or on a different disk. The syntax of the CopySect command is as follows:
COPYSECT [Source Sector Range] [Destination Sector Range]

Forensic investigators most often use the CopySect command as it helps in creating direct disk-to-disk images of suspect media.

FTK Imager

The Forensic Toolkit Imager (FTK Imager) is a commercial forensic imaging software package distributed by AccessData.

FTK Imager allows a forensic investigator to acquire physical device images and logically view data from FAT, NTFS, ext2, ext3, HFS, and HFS+ file systems. Figure 2-1 shows the main FTK Imager screen.

Mount Image Pro

Mount Image Pro is a computer forensics tool that allows an investigator to mount the following types of images:

- EnCase
- UNIX/Linux dd
- SMART
- ISO

Key Features of Mount Image Pro

The following are the key features of Mount Image Pro:

- It maps an image as a single drive letter so that an investigator can explore unused or unpartitioned disk space or map specific drive letters to any or all partitions within the image files. Figure 2-2 shows an image selection screen in Mount Image Pro.
- It fully maintains MD5 hash integrity.

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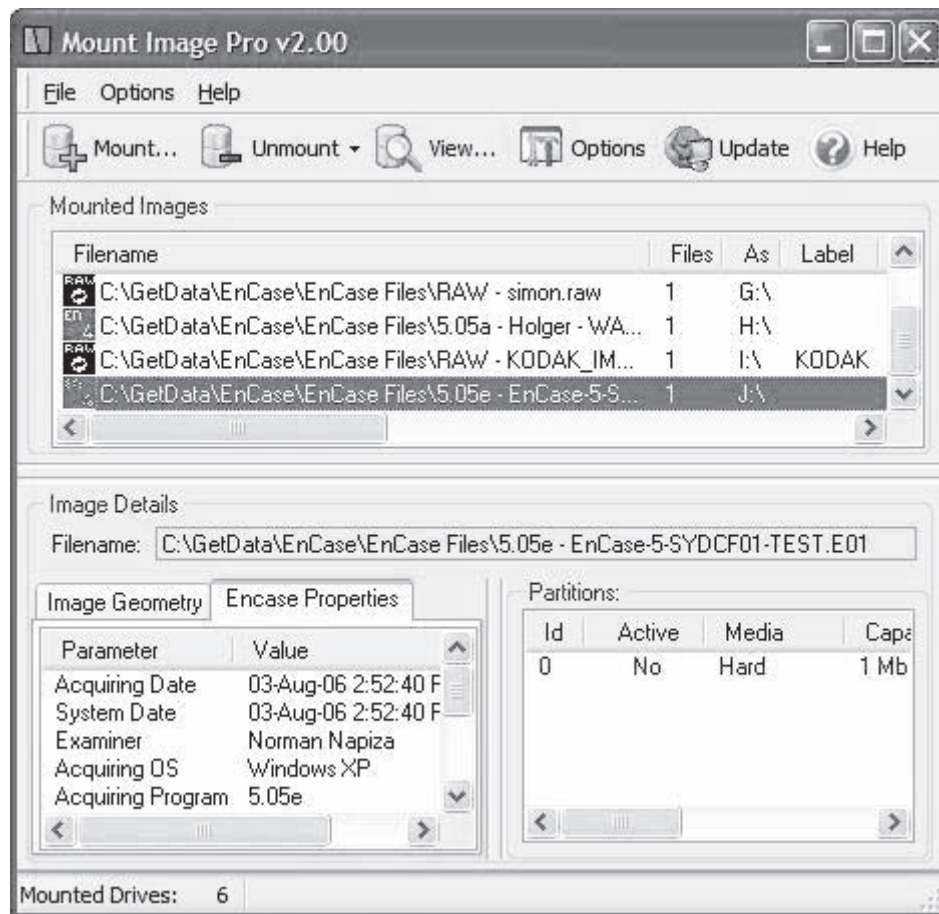


Figure 2-2 An investigator can examine the properties of an image in Mount Image Pro.

- It will open EnCase password-protected image files without the password.
- It is compatible with third-party file-system drivers for Linux.

System Requirements for Mount Image Pro

The following are the system requirements for Mount Image Pro:

- *Operating system:* Windows 2000/XP/2003/Vista
- *RAM:* 128 MB recommended
- *Hard disk:* At least 6 MB of free disk space

Drive SnapShot

Drive SnapShot is a data acquisition tool that creates an exact disk image. It can create this image while an investigator continues doing his or her work in Windows. Booting into DOS is not necessary. It is compatible with all Windows file systems and most Linux file systems. Only a user with administrative privileges can use Drive SnapShot. Figure 2-3 shows the startup screen for Drive SnapShot.

System Requirements for Drive SnapShot

- *Operating system:* Windows NT 4.0 SP3/2000/XP/2003/PE/Vista
- *RAM:* 8 MB
- *Hard disk:* At least 2 MB of free disk space

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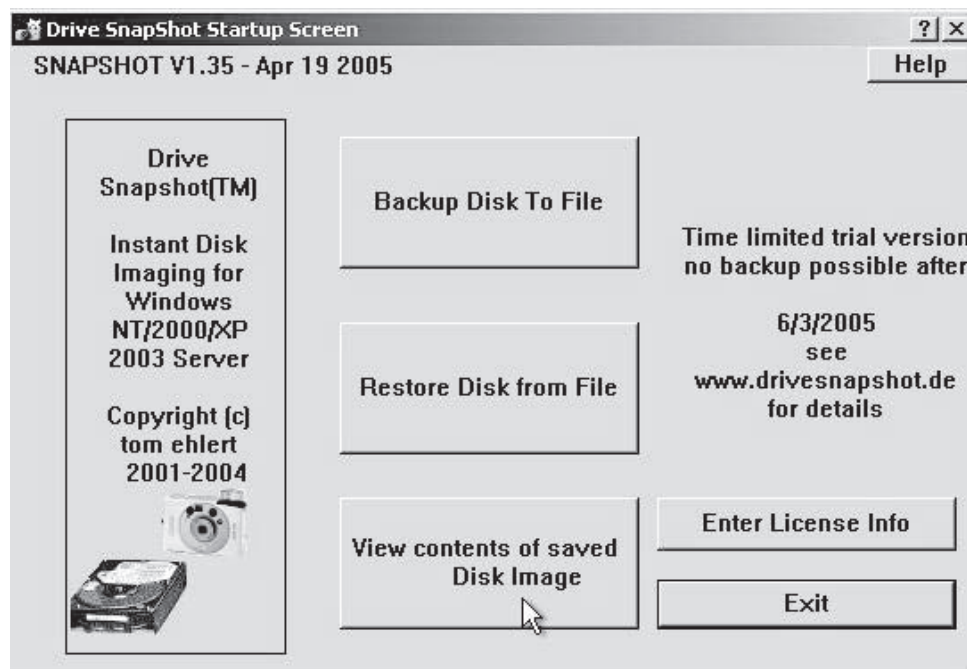


Figure 2-3 Drive SnapShot can create disk images of Windows and Linux file system disks.

SnapBack DatArrest

DatArrest is a tool used for disk imaging and file recovery. A user can make an image of a server while it is running and being used. When using DatArrest, a user can copy the following:

- Server or PC hard drive to removable media
- Hard drive to hard drive
- Tape to tape

Images captured by DatArrest contain all the system software, networking software, associated drivers, software applications, configurations, data files, and CMOS settings for the system.

SafeBack

SafeBack is a data acquisition tool that investigators can use to create bit-stream backups of entire hard drives or partitions on hard drives. It ensures data integrity using CRC-32. SafeBack creates a log file of all transactions it performs.

Data Acquisition Hardware Tools

Forensic investigators use a variety of hardware tools to acquire data from a suspect's computer systems both in the lab and in the field. Some of these tools acquire data by connecting directly to the storage devices, while others can acquire data through Firewire or USB ports.

Image MASter Solo-3

The Image MASter Solo-3 is a lightweight handheld tool that investigators use to acquire data. It can pull data off of PATA, SATA, and SCSI notebook and desktop hard drives. It can also pull data off of flash memory cards. An investigator can also connect the device to a computer's USB or Firewire port and acquire data from any storage device in the system. The Image MASter Solo-3 can copy up to two evidence disks at a time at speeds exceeding 3 GB/min. Figure 2-4 shows the Image MASter Solo-3 with two evidence disks attached.

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Figure 2-4 The Image MASter Solo-3 performs high-speed data acquisition.

The following are the specifications of the Image MASter Solo-3:

- *Supply voltage:* 90–230 V/50–60 Hz
- *Power consumption:* 10 W without drives
- *Operating temperature:* 5°C–55°C
- *Relative humidity:* 20%–60% noncondensing
- *Net weight:* 2.2 lbs
- *Overall dimensions:* 8.3" × 5.8" × 2.2"
- *Power supply:* UL and PSU certified, with universal autoswitching input voltage

The following are some of the features of the Image MASter Solo-3:

- *MD5 and CRC-32 hashing:* MD5 and CRC-32 hashing ensure data integrity.
- *Touch-screen user interface:* The unit's advanced touch-screen user interface and programmable keyboard provide for ease of use.
- *Built-in write protection:* The suspect drive's data is protected with built-in write protection.
- *Audit trail and logs:* An investigator can print detailed operational event log information or save it to a CompactFlash card.
- *Upgradeability:* An investigator can perform software and firmware upgrades using a CompactFlash card.

The following are some of the software features of the Image MASter Solo-3:

- *Device configuration overlay (DCO) option:* DCO can be used to hide and protect part of a drive from the operating system and file system. If the Image MASter Solo-3 detects a DCO on a suspect's drive, it can capture this hidden data.
- *Host protected area (HPA) option:* An HPA may exist on a drive, hiding a certain portion of the drive's contents from the operating system and file system. If an HPA exists on a suspect's drive, the Image-MASter Solo-3 can acquire data stored in the HPA.

- *WipeOut DoD option:* WipeOut was designed to meet the U.S. Department of Defense specification DOD 5220-22M, regarding the sanitization of hard disk drive data. WipeOut performs three iterations to completely erase the contents of a hard drive.
- *WipeOut fast option:* The WipeOut fast option provides a quick non-DoD method of sanitizing a drive of all previously stored data.
- *Linux dd capture option:* The Linux dd capture option captures data as individual Linux dd segmented files. This option allows an investigator to perform multiple data acquisition operations using the same evidence drive.

LinkMASter-2

The LinkMASter-2 acquires data from a laptop or desktop by imaging a suspect's hard drive through the computer's USB or Firewire ports. It captures data at speeds exceeding 3 GB/min. It uses write protection and supports MD5, CRC-32, and SHA-1 hashing to ensure data integrity. Figure 2-5 shows the LinkMASter-2 attached to a laptop.

The following are the specifications of the LinkMASter-2:

- *Supply voltage:* 100–240 V/50–60 Hz
- *Power consumption:* 3.5 W without drives
- *Operating temperature:* 5°C–55°C
- *Relative humidity:* 20%–60% noncondensing
- *Net weight:* 0.55 lb
- *Overall dimensions:* 5.5" × 3" × 1"
- *Power supply:* universal autoswitching input voltage

The following are some of the features of the LinkMASter-2:

- *Forensic toolkit graphical user interface:* The LinkMASter-2 forensic toolkit application provides all the tools necessary to perform high-speed data acquisition operations. The interface runs on the Windows XP Professional platform.
- *Multiple media support:* The device supports data transfers between PATA, SATA, and SCSI hard drives. With its built-in 2.5" interface, it supports capturing data to notebook drives.
- *Audit trail and logs:* An investigator can print detailed operational event log information or save it.



Figure 2-5 The LinkMASter-2 reads data through USB and Firewire ports.

The following are some of the software features of the LinkMASter-2:

- *LinkMASter application:* The LinkMASter application is run from the supplied LinkMASter bootable CD, which provides write protection for the suspect's drive during initialization and during data acquisition.
- *Single capture option:* The single capture option allows an investigator to acquire data using a forensic sector-by-sector format method.
- *Linux dd capture option:* The Linux dd capture option supports seizing the entire contents of a suspect's drive by capturing data as individual Linux dd segmented files, which are then stored in individual sub-directories on the evidence drive. This option allows any number of seizures to be performed using the same evidence drive, provided there is adequate space to save the seized data.
- *Intelligent capture option:* The intelligent capture option (IQCopy) provides a fast method of acquiring data from FAT16, FAT32, and NTFS file systems. This method analyzes the file system and captures only the allocated drive space.
- *WipeOut DoD option:* This option is designed to erase all data on disk drives. WipeOut was designed to meet the U.S. Department of Defense specification DOD 5220-22M, regarding the sanitization of hard disk drives.
- *WipeOut fast option:* The WipeOut fast option provides a quick non-DoD method of sanitizing a drive of all previously stored data.

RoadMASter-2

The RoadMASter-2 is a forensic data acquisition and analysis tool designed for use in the field. It provides an investigator with all the tools necessary to acquire and analyze data from Firewire and USB ports, flash memory cards, and PATA, SATA, and SCSI disks. Figure 2-6 shows the RoadMASter-2.

The following are the specifications of the RoadMASter-2:

- *Supply voltage:* 100–240 V/50–60 Hz
- *Power consumption:* 150 W without drives
- *Operating temperature:* 5°C–55°C
- *Relative humidity:* 20%–60% noncondensing
- *Net weight:* 32 lbs
- *Overall dimensions:* 13" × 21" × 7.5"
- *Power supply:* universal autoswitching input voltage
- *Processor:* AMD64 3500+



Figure 2-6 The RoadMASter-2 is used for data acquisition in the field.

- *Memory:* 2 GB RAM
- *Hard drive:* 60 GB 7200 rpm internal IDE drive
- *Other storage:* CD-RW, DVD+RW, DVD-RW, floppy disk
- *Display:* 15" TFT color LCD display
- *Card reader/writer:* 1–7 multiscard read/write slots and 1–7 multiscard read-only slots
- *Sound system:* Stereo speakers and line in/line out connector
- *Operating system:* Windows XP Professional

The following are some of the features of the RoadMASter-2:

- *MD5, CRC-32, and SHA-1 hashing:* These hashing techniques ensure data integrity.
- *Forensic toolkit graphical user interface:* The RoadMASter-2 forensic toolkit application provides an investigator with all the tools necessary to perform high-speed forensic data acquisition operations.
- *High-speed operation:* Data transfer rates can exceed 3.3 GB/min.
- *Multiple capture methods:* Investigators can acquire data using a forensic sector-by-sector format method or using a Linux dd segmented file format method. The Linux dd capture method allows an investigator to put multiple images on one evidence drive.
- *Built-in write protection:* The data on the suspect's drive is protected with built-in write protection.
- *Multiple media support:* The RoadMASter-2 supports data transfers between PATA, SATA, and SCSI hard disk drives. Interface ports and readers are available to support flash memory cards, external Firewire and USB drives, and DVD and CD media. The built-in 2.5" interface supports notebook drives.
- *Preview and analysis:* The toolkit provides an investigator with the capability to preview and analyze a suspect's write-protected data.
- *Audit trail and logs:* An investigator can print detailed operational event log information or save it.

The following are some of the software features of the RoadMASter-2:

- *WipeOut DoD option:* This option is designed to completely erase data on disk drives. WipeOut was designed to meet the U.S. Department of Defense specification DOD 5220-22M, regarding the sanitization of hard disk drives.
- *WipeOut fast option:* The WipeOut fast option provides an investigator with a quick non-DoD method of sanitizing a drive.
- *LinkMASter application:* The LinkMASter application is run from the supplied LinkMASter bootable CD, which provides write protection for the suspect's drive during initialization and during data acquisition.
- *Intelligent capture mode:* The intelligent capture option (IQCopy) provides a fast method of acquiring data from FAT16, FAT32, and NTFS file systems. This method analyzes the file system and captures only the allocated drive space.

Data Duplication Software Tools

Computer forensic investigators have many software tools at their disposal for the purpose of data duplication. These tools provide high-speed backup and imaging capabilities.

R-Drive Image

R-Drive Image is a software tool used to create disk images with various compression levels for backup or duplication purposes. A disk image file contains an exact byte-by-byte copy of a hard drive, partition, or logical disk. These image files can then be stored on a variety of media, including removable media such as CD-RWs and DVD-RWs. Figure 2-7 shows the action selection screen for R-Drive Image.

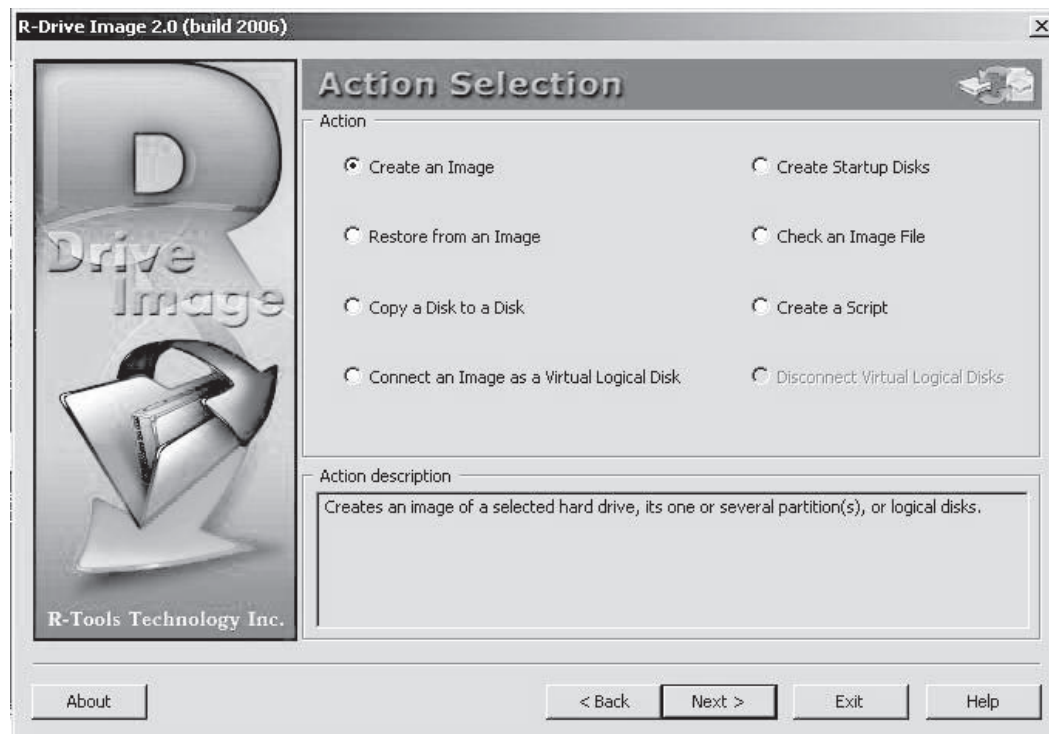


Figure 2-7 R-Drive Image is used for data duplication.

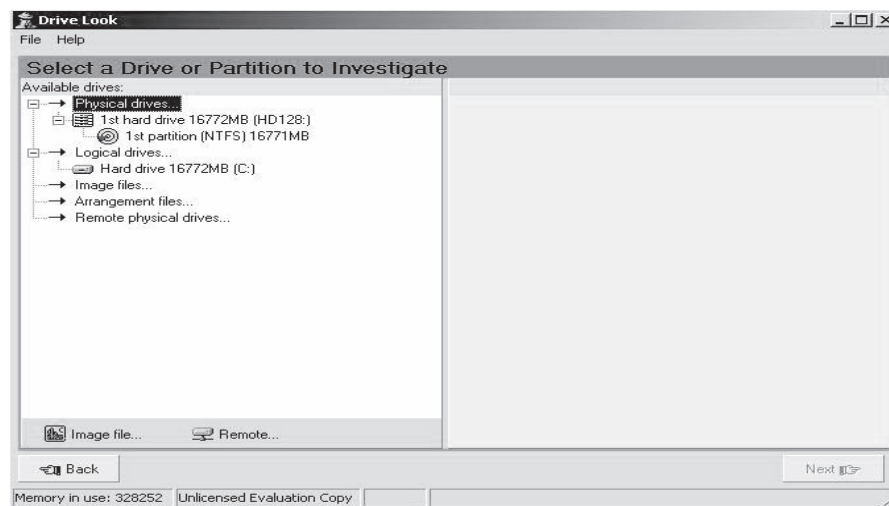


Figure 2-8 DriveLook allows an investigator to remotely access drives.

DriveLook

DriveLook provides access to remote drives through serial cables or TCP/IP. Figure 2-8 shows a screenshot of DriveLook.

Forensic investigators use this tool to:

- Index a drive for all text that has ever been written to it
- Search the drive for particular words

- View the location of words in a disk editor
- Switch between hex and text views
- Use image files as input

DiskExplorer

The DiskExplorer tool is a sophisticated disk editor that allows a forensic investigator to investigate a FAT or NTFS drive and recover data from it. Figure 2-9 shows a screen displaying the partition table of a drive.

An investigator can perform the following tasks using DiskExplorer:

- Navigate through the drive by jumping to the partition table, boot record, master file table, and root directory
- Choose between views such as hex, text, index allocation, MFT, boot record, and partition table, and inspect file entry details
- Save files and directories from anywhere on the drive
- Identify the file a certain cluster belongs to
- Create a virtual volume when the boot record is lost or corrupt
- Edit the disk drive by using the direct read/write mode or the virtual write mode

Save-N-Sync

Save-N-Sync allows an investigator to synchronize and backup files from a source folder on one computer to a target folder on a second networked computer or local storage device. An investigator can manually or automatically schedule regular synchronization and backup operations. It works on Windows NT, 2000, and XP. Figure 2-10 is a screenshot from Save-N-Sync.

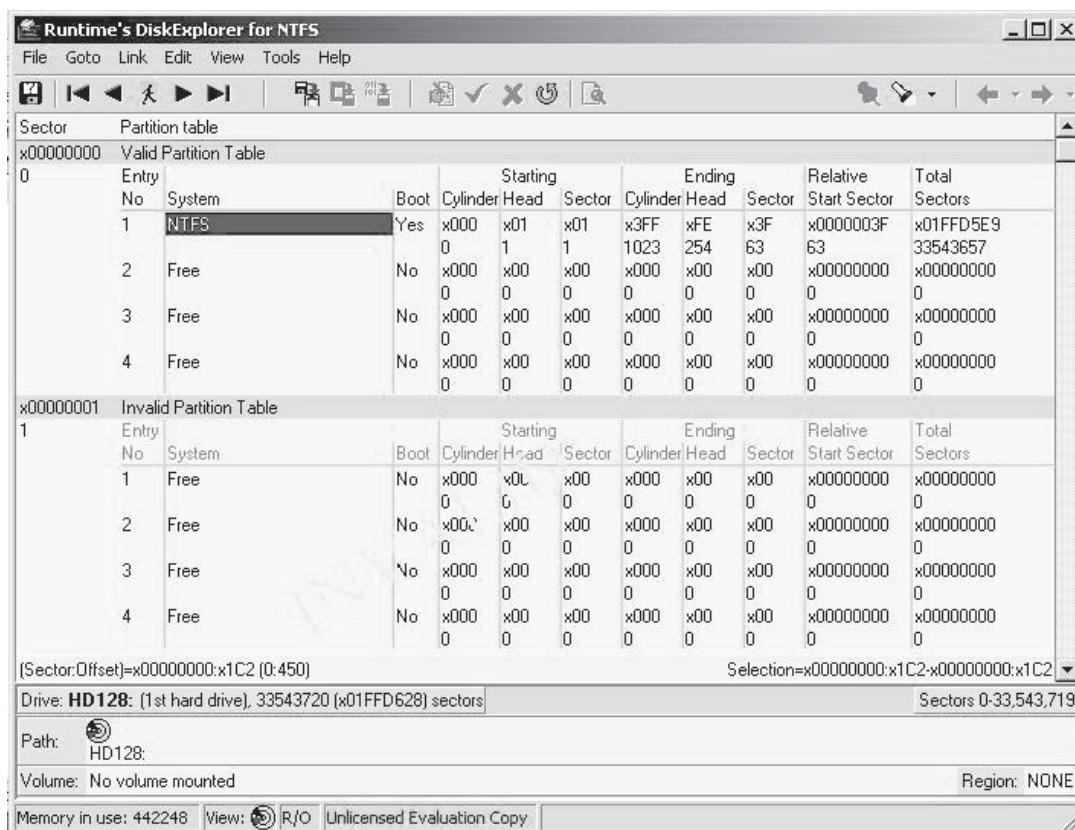


Figure 2-9 DiskExplorer allows an investigator to recover data.

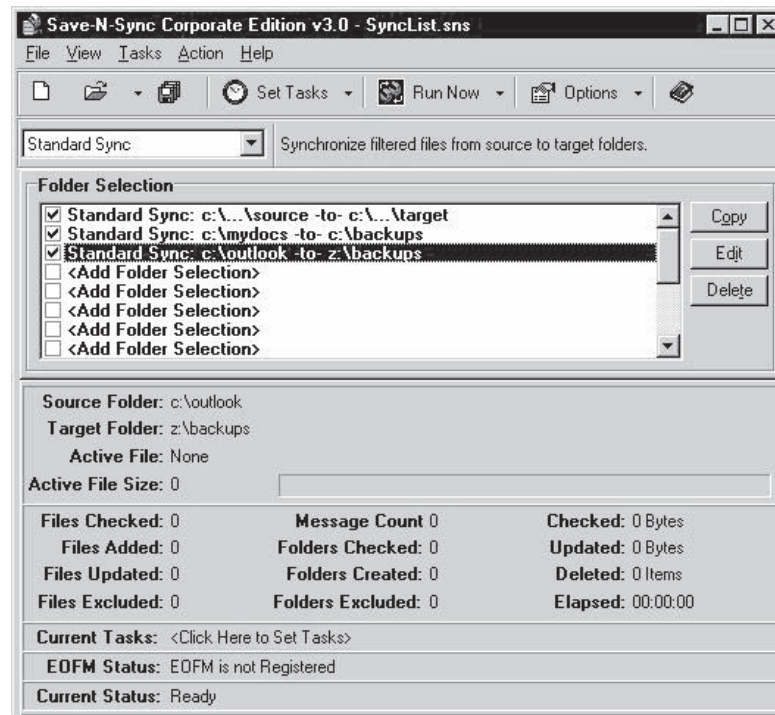


Figure 2-10 Save-N-Sync is used for data backups and data synchronization.

The following are some of the features of Save-N-Sync:

- *Standard and bidirectional synchronization:* Standard synchronization compares source and target files, and new or updated files on the source PC are copied to the target PC or storage device. Bidirectional synchronization adds the extra step of copying the files back to the source.
- *Daily timer:* This feature allows an investigator to schedule file synchronizations for any time on any day of the week.
- *Unobtrusive background processing:* An investigator can continue working, even during the synchronization process.
- *Embedded open file manager option:* This option allows an investigator to backup locked files, such as Outlook and QuickBooks files.
- *File attribute transfers:* File attributes are maintained when a file is copied from the source to the target.
- *Extensive filtering capabilities:* An investigator can include or exclude specific files or folders.
- *Command-line capabilities:* Save-N-Sync can be launched from the command line, a batch file, or a script.

DFSMSdss

Data Set Services (DFSMSdss) is a component of IBM's DFSMS (Data Facility Storage Management Subsystem). An investigator can use this tool to quickly and efficiently duplicate data. DFSMSdss can copy data from one disk to another or from a disk to a tape.

The following are some of the features of DFSMSdss:

- *Movement and replication of data:* The tool offers powerful, user-friendly functions that allow an investigator to move or copy data between volumes of like and unlike device types. It can also copy data that has been backed up.
- *Backup and recovery of data:* With this tool, an investigator can backup and recover data at both the data set and volume levels. An investigator can also use DFSMSdss to restore vital system packs during disaster recovery without a host operating system.

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- *Conversion of data sets and volumes:* DFSMSdss converts data sets and volumes to system-managed storage, or returns data to a non-system-managed state, as part of a recovery procedure that doesn't include moving data.

SCSIPIAK

SCSIPIAK is a software-based data conversion and duplication system. SCSIPIAK is a set of system tools that extend the support of tape drives under Microsoft Windows NT and Windows 2000.

These tools allow an investigator to identify drives on a SCSI bus, transfer data between disks and tapes or optical discs, and copy data between tapes or optical discs.

SCSIPIAK reads data from a tape or optical disc and simultaneously writes it to up to seven drives at once. The image file from the tape or optical medium is stored along with an index file, which contains details of the tape file and set marks, directory partitions, or unused optical sectors. This allows an investigator to duplicate even complex-format tapes and optical discs.

Data Duplication Hardware Tools

The data duplication hardware tools that forensic investigators use are high-speed, high-volume devices. Most of these tools also provide investigators with the capability to completely erase data from a disk.

ImageMAStter 6007SAS

The ImageMAStter 6007SAS is a high-speed data duplication device. It has a graphical Windows XP-based interface and a gigabit Ethernet connection. It can copy an SATA, SAS, SCSI, or IDE hard drive to any seven SAS, SATA, or IDE local or network hard drives. Figure 2-11 shows the ImageMAStter 6007SAS.

The following are the specifications of the ImageMAStter 6007SAS:

- *Supply voltage:* 100–240 V/50–60 Hz
- *Power consumption:* 125 W without drives
- *Operating temperature:* 5°C–55°C
- *Relative humidity:* 20%–60% noncondensing
- *Net weight:* 40 lbs



Figure 2-11 The ImageMAStter 6007SAS performs high-speed data duplication over local or network connections.

- *Overall dimensions:* 21" × 16.75" × 6.75"
- *Power supply:* UL and PSU certified universal autoswitching input voltage

The following are some of the features of the ImageMASSter 6007SAS:

- *High-speed copy operation:* Data transfer rates exceed 3.7 GB/min.
- *Multiple copy modes:* The device supports sector-by-sector and data-only copying. Multiple images can be stored on a single target drive.
- *Hot swapping of drives:* Hard drives can be removed or connected while the system is on (hot swap).

The following are some of the software features of the ImageMASSter 6007SAS:

- *IQCopy:* IQCopy provides a fast method of duplicating Windows 95, 98, 2000, and XP drives. The device analyzes the file system and copies only the allocated drive space. IQCopy automatically scales hard drive partitions to the size of the target drive. It allows an investigator to mix different-sized drives in the same duplication process. IQCopy can create a fully operational data copy in under a minute.
- *Image copy:* The ImageMASSter 6007SAS transfers data using a sector-by-sector copy method to produce an exact image of a source drive. All allocated and unallocated drive space is copied. The device supports all operating systems and file systems.
- *WipeOut DoD option:* This function is designed to erase all data on hard disk drives, to U.S. Department of Defense specification DOD 5220-22M. An investigator can sanitize up to nine drives simultaneously at speeds exceeding 3 GB/min.
- *WipeOut fast option:* The WipeOut fast option provides a quick non-DoD method of wiping hard drives of all previously stored data.
- *Log information display and storage:* The device provides functions to display and store real-time event information in a log.
- *Error detection and verification:* The ImageMASSter 6007SAS provides automatic real-time CRC-16 error detection and correction.
- *Management of user-defined settings:* This built-in feature allows authorized users to store multiple user-defined unit settings.

Disk Jockey IT

Disk Jockey IT is a high-speed data duplication tool. It can copy data from PATA and SATA desktop and laptop drives. It is a lightweight handheld device that can copy data to one or two target drives at speeds exceeding 2 GB/min. Figure 2-12 shows the Disk Jockey IT.

The following are some of the features of the Disk Jockey IT:

- *Stand-alone HD mode:* An investigator can mount one or two PATA or SATA hard drives on a Windows or Macintosh computer, through Firewire or USB 2.0, without installing any extra drivers. The Disk Jockey IT includes 2.5" laptop adapter cables and 3.5" desktop cables.

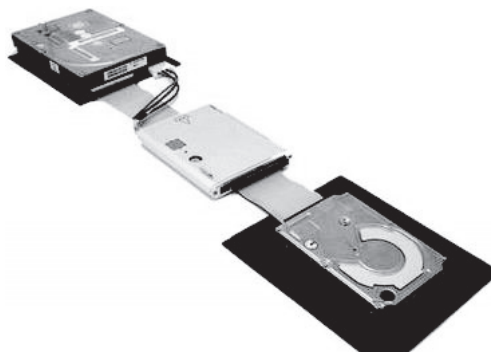


Figure 2-12 The Disk Jockey IT can copy data from one drive to one or two target drives.

<https://t.me/learningnets>

- *Mirroring*: The Disk Jockey IT allows an investigator to mirror two hard drives for real-time backup (RAID 1). If one drive fails, there will be no downtime, as the data is stored simultaneously on the second drive.
- *Spanning*: An investigator can easily make one large logical volume from two disks attached to the Disk Jockey IT. The investigator can then connect the Disk Jockey IT to a Firewire or USB port on a Windows or Macintosh computer to access the two drives as standard external storage.
- *Disk copy compare/verification*: This feature allows an investigator to verify that a copy is an exact duplicate, ensuring that there is no data loss.
- *Hard disk read test*: The Disk Jockey IT can perform a sector-by-sector hard disk read test to test the overall health of a hard drive.
- *Two levels of erasure*: The Disk Jockey IT offers two levels of disk erasure. The first is a fast, one-pass erase. The second is a more thorough three-pass erase that an investigator can use when he or she needs to feel more confident that the data is irretrievably erased.

QuickCopy

QuickCopy is a tape duplication system. The following are some of the features of QuickCopy:

- Duplicates a master tape to one or more target tapes
- Duplicates from master images stored on local or network hard drives
- Capable of multitasking for mixed jobs. For instance, it can duplicate a 4-mm tape and a DLT simultaneously.
- Provides 100% verification of all copies made
- Uses the Microsoft NT operating system and graphical user interface (GUI)
- Can also copy CD media with the QuickCopy-CD option

Chapter Summary

- This chapter has discussed the different procedures that forensic investigators follow in the duplication, acquisition, and preservation of data.
- Investigators can acquire data in three ways: by creating a bit-stream disk-to-image file, by making a bit-stream disk-to-disk copy, or by creating a sparse data copy of a specific folder or file.
- Data duplication is essential for the proper preservation of digital evidence.
- Windows data acquisition tools allow an investigator to easily acquire evidence from a disk with the help of removable media, such as USB storage devices.
- Forensic investigators use the built-in Linux command `dd` to copy data from a disk drive.
- The `SavePart` command generates an image of a partition on a hard disk.

Review Questions

1. What are the methods investigators use to acquire digital evidence?

2. How does an investigator acquire data on Linux?

3. What do the SavePart and WritePart commands in DriveSpy do?

4. Why is there a need for data duplication?

5. How is netcat used with dd to acquire data?

6. Write down the hardware tools used for data acquisition.

7. Write down the hardware tools used for data duplication.

8. What file systems does dd work with?

9. Describe the features of QuickCopy.

10. What are the system requirements for Drive SnapShot?

Hands-On Projects



1. Follow these steps:

- Navigate to Chapter 2 of the Student Resource Center.
- Change to the dd\bin\UnicodeRelease directory.
- Type the following command:
`dd if =\\.\D:\pagefile.sys of=d:\myimage.img`
 (You can replace the file with PhysicalDrive0 to image the complete disk.)

Figure 2-13 shows a screenshot of this process.

2. Follow these steps:

- Navigate to Chapter 2 of the Student Resource Center.
- Install and launch Mount Image Pro.
- Click **Mount** (Figure 2-14).

```

C:\WINDOWS\System32\cmd.exe - dd if=\\.\D:\pagefile.sys of=d:\myimage2.img

C:\Documents and Settings\Haja\My Documents\CHFI v2.2 Stuff\CHFI v2 Labs\Module
10 - Data Acquisition and Duplication\dd\bin\UnicodeRelease>dd if=\\.\D:\pagefil
e.sys of=d:\myimage2.img
Forensic Acquisition Utilities, 1, 0, 0, 1035
dd, 3, 16, 2, 1035
Copyright (C) 2002-2004 George M. Garner Jr.

Command Line: dd if=\\.\D:\pagefile.sys of=d:\myimage2.img
Based on original version developed by Paul Rubin, David MacKenzie, and Stuart K
emp
Microsoft Windows: Version 5.1 (Build 2600.Personal Service Pack 2)
29/08/2005 07:51:49 (UTC)
Current User: HAJAXP\Haja

CopyFileEx \\.\D:\pagefile.sys to d:\myimage2.img...Failed!
There is not enough space on the disk.
Copying \\.\D:\pagefile.sys to d:\myimage2.img...
-

```

Figure 2-13 An investigator can use dd to image a disk.

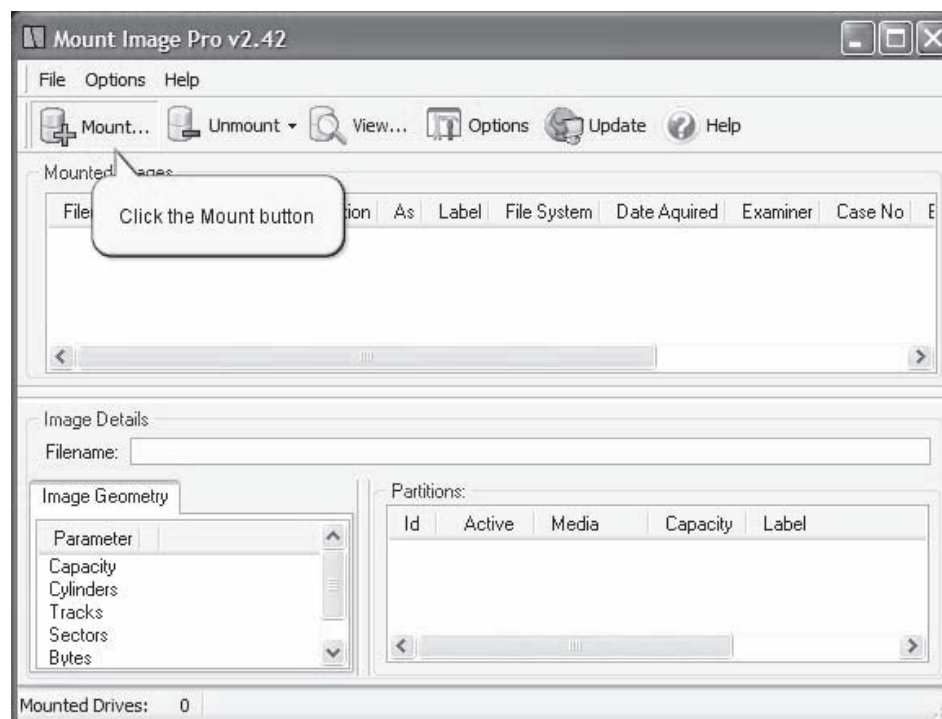


Figure 2-14 Click the Mount button to choose the image file to mount.

- Select the EnCase image file (Figure 2-15).

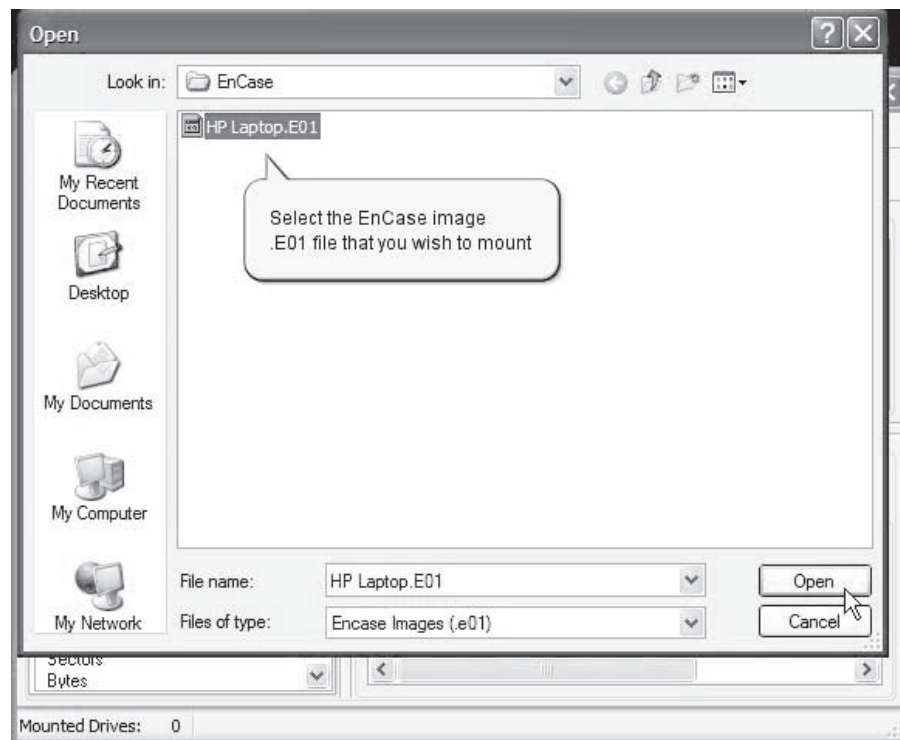


Figure 2-15 Select the image file that you want to mount.

- Select the proper start drive letter.
- Check the **Mount as single drive** box and click OK (Figure 2-16).

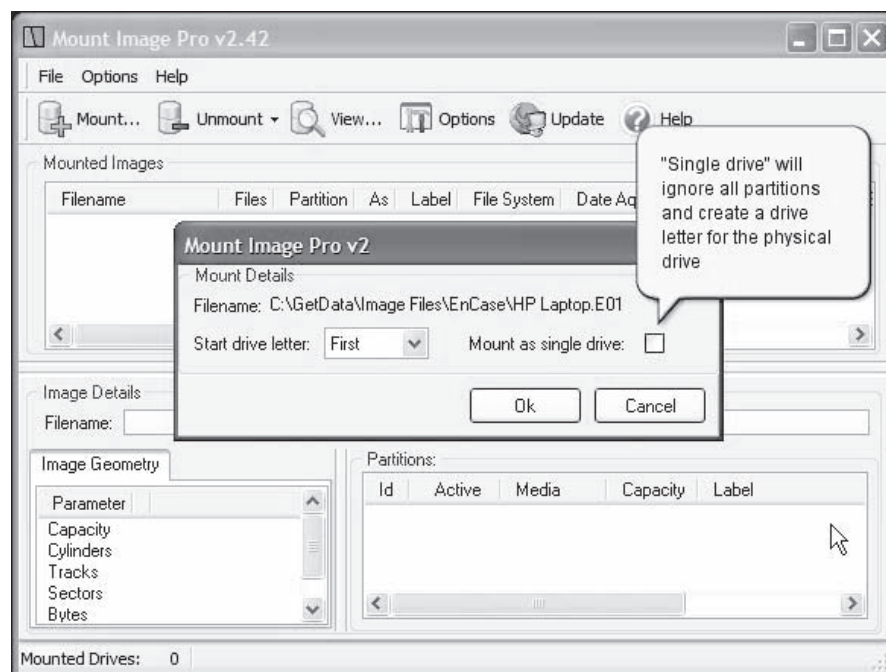


Figure 2-16 Choose this option to mount the entire image as a single drive.

- Click on the **Encase Properties** tab (Figure 2-17).

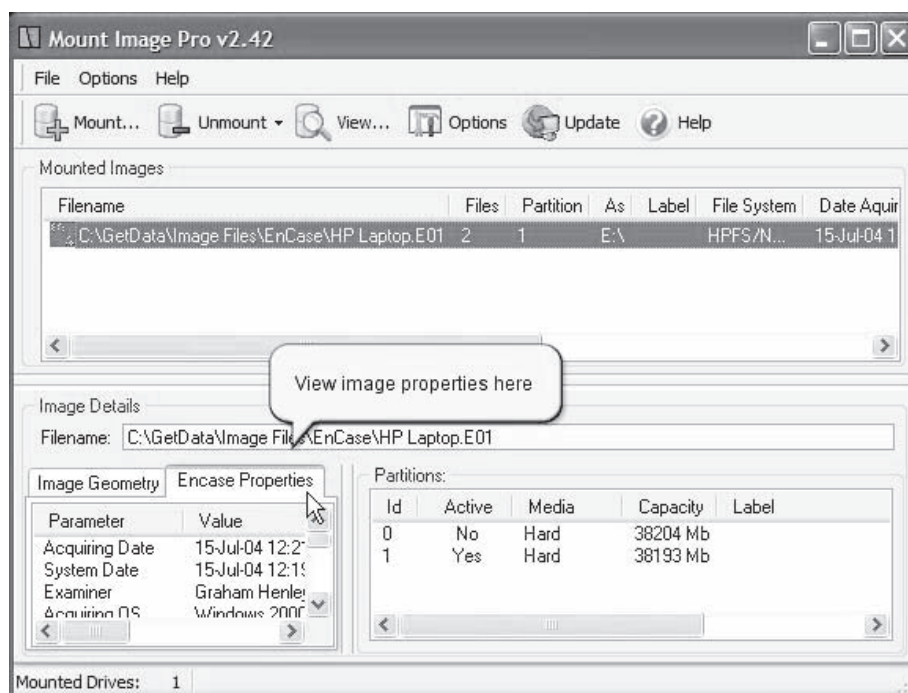


Figure 2-17 You can view the properties of the image once you've mounted it.

- Double-click the mounted image to open Windows Explorer (Figure 2-18).

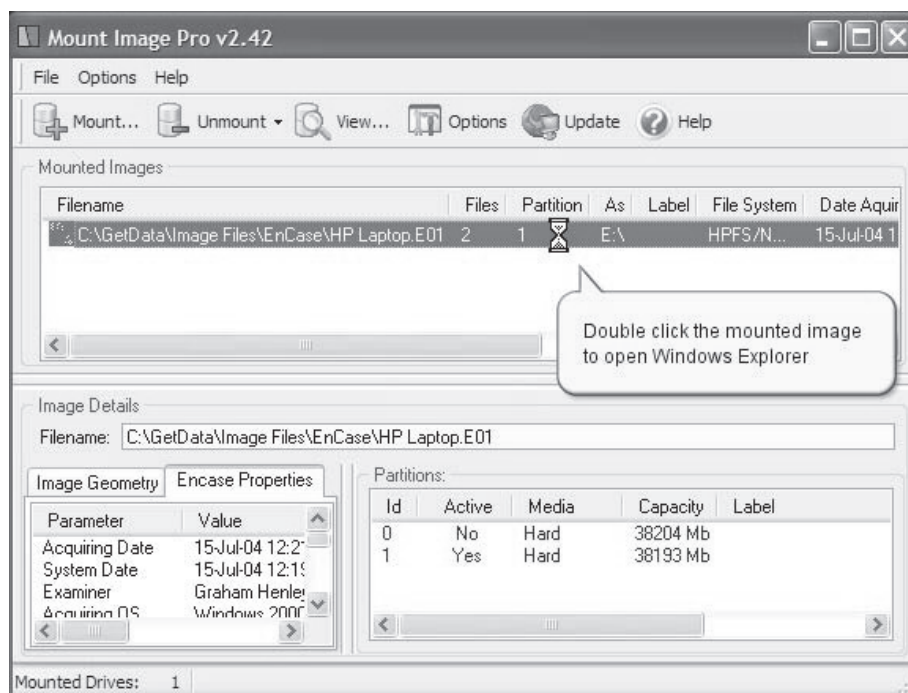


Figure 2-18 You can double-click the mounted image to open it in Windows Explorer.

- Browse the read-only contents of the EnCase image in Windows Explorer (Figure 2-19).

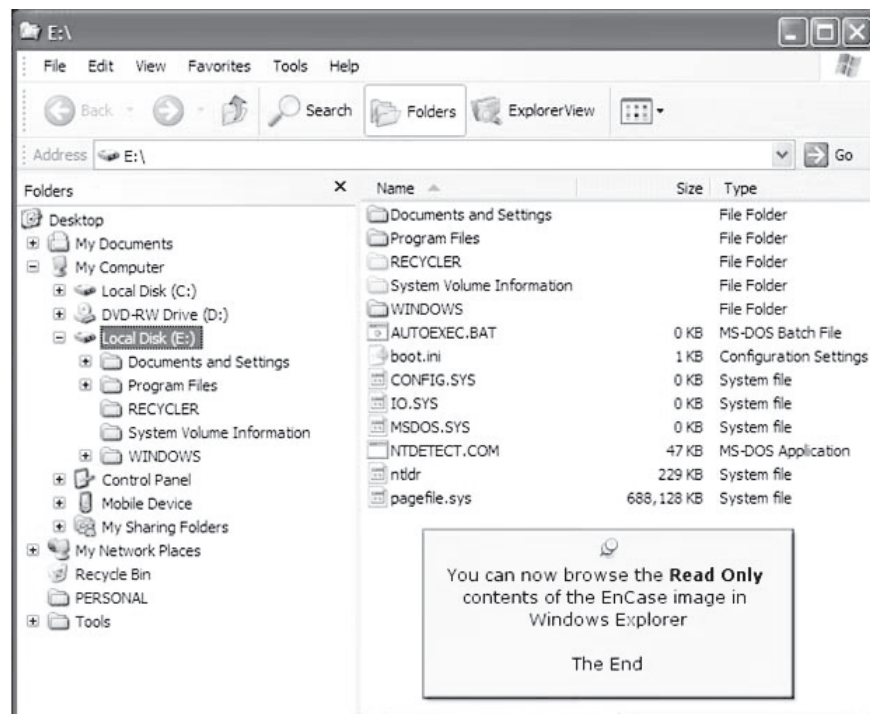


Figure 2-19 This is the contents of the mounted image. Note that the image can't be written to.

3. Follow these steps:

- Navigate to Chapter 2 of the Student Resource Center.
- Install and launch the R-Drive Image program.
- Click **Next** (Figure 2-20).

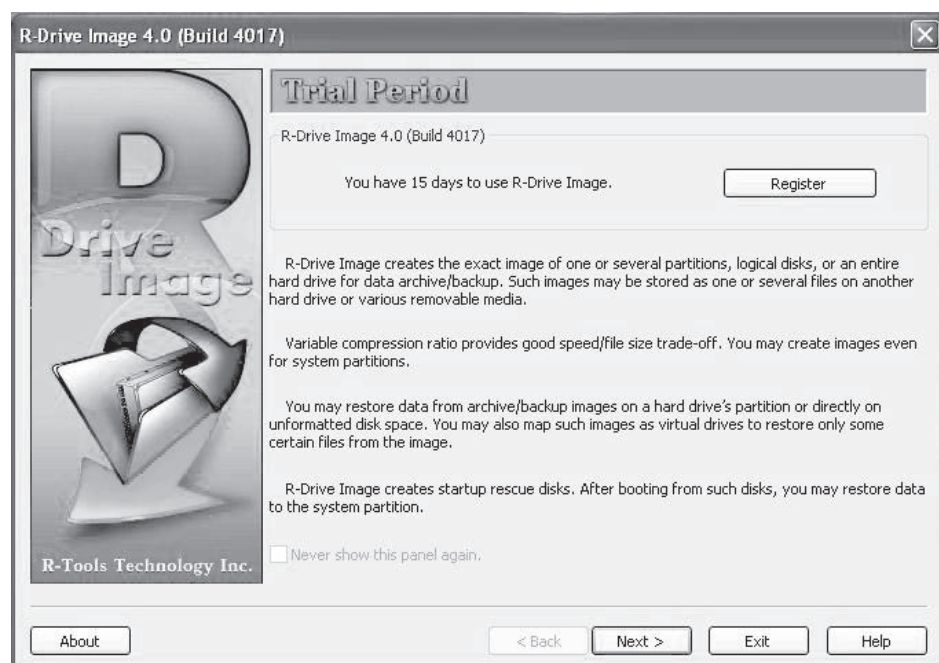


Figure 2-20 This is the opening screen for R-Drive Image.

- Click **Create an Image** (Figure 2-21).

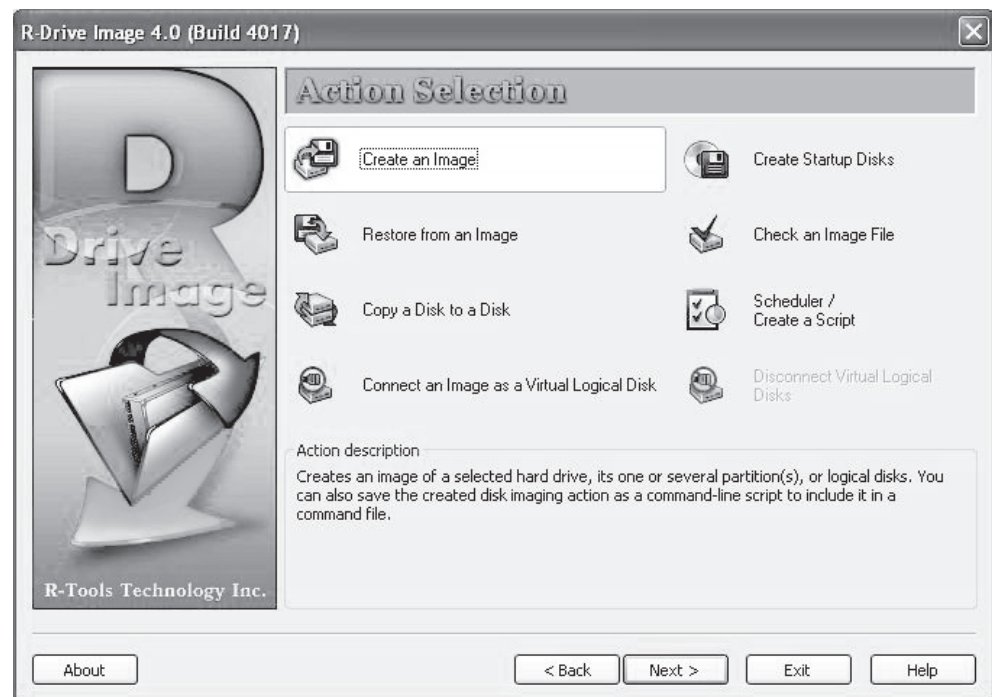


Figure 2-21 R-Drive Image can create images of entire hard drives or individual partitions.

- Click **Next**.
- Select a partition and click **Next** (Figure 2-22).

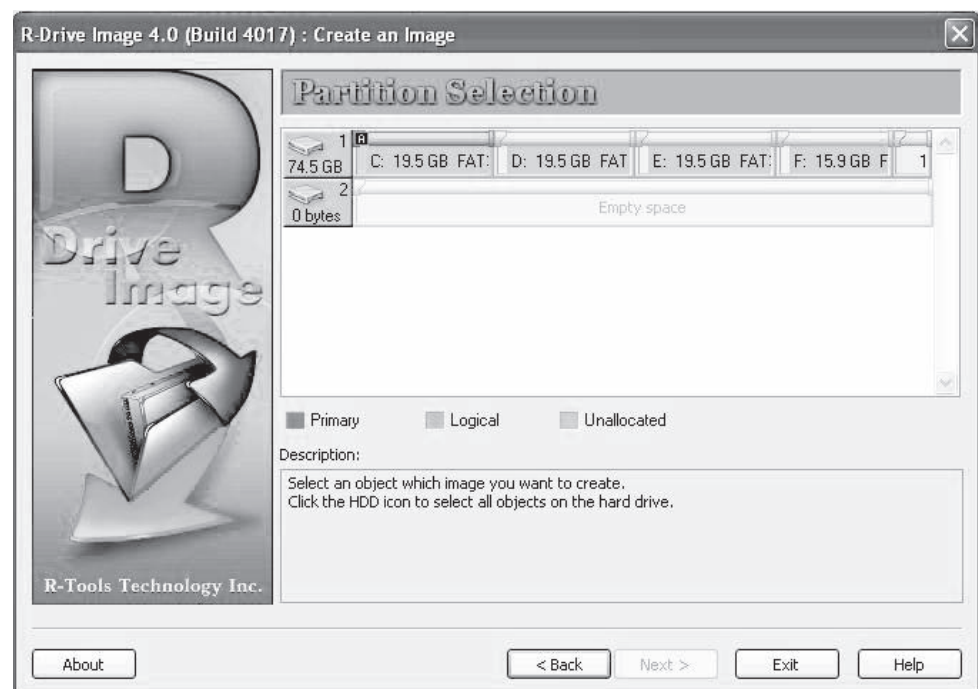


Figure 2-22 R-Drive Image shows information about all partitions on a drive during the selection process.

- Select a destination and click Next (Figure 2-23).

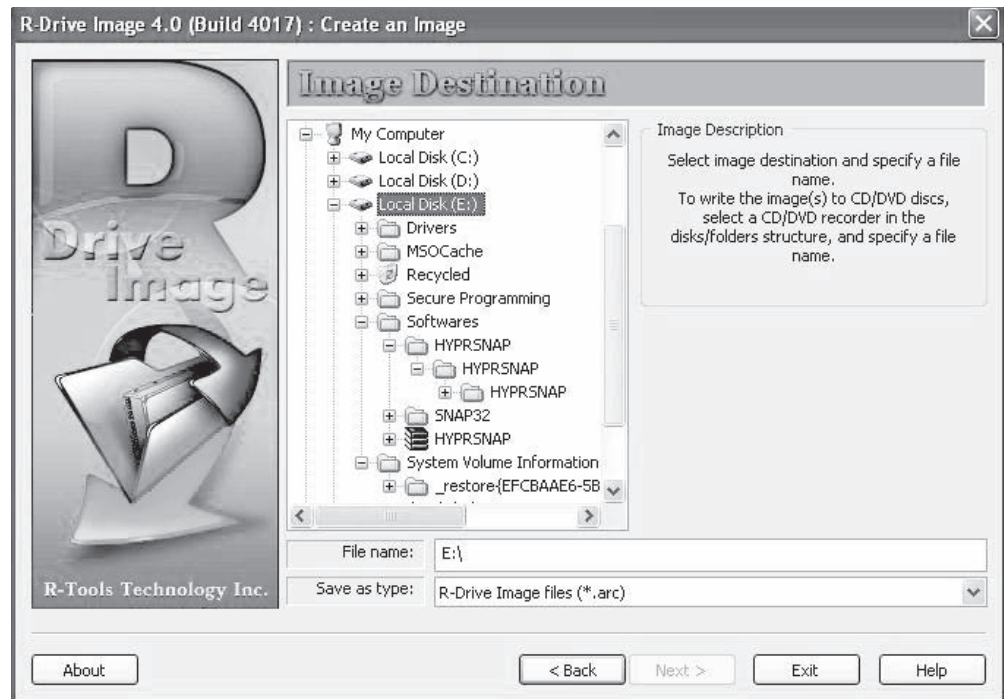


Figure 2-23 R-Drive Image can write images to various types of media, including hard disks and optical media.

4. Follow these steps:
 - Navigate to Chapter 2 of the Student Resource Center.
 - Install and launch the Save-N-Sync Corporate Edition program.

- Click **Add** and specify the source and target folders (Figure 2-24).

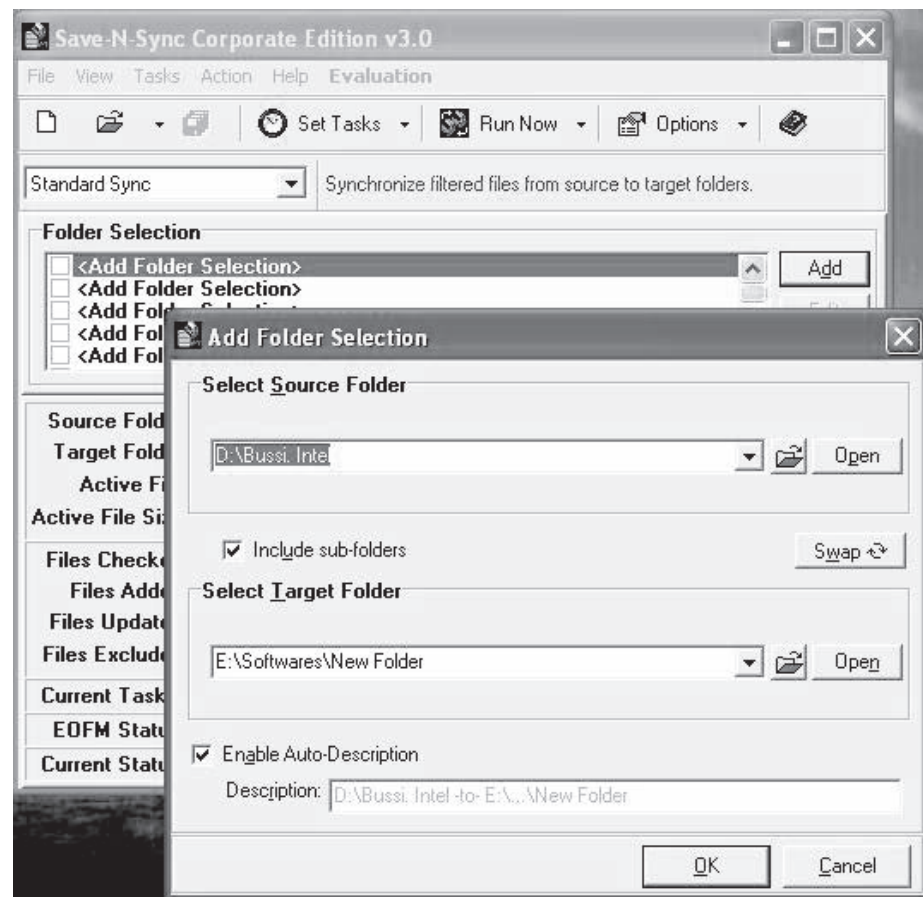


Figure 2-24 Specify the source and target folders.

- Click **OK**.

- Click **Run Now** (Figure 2-25).

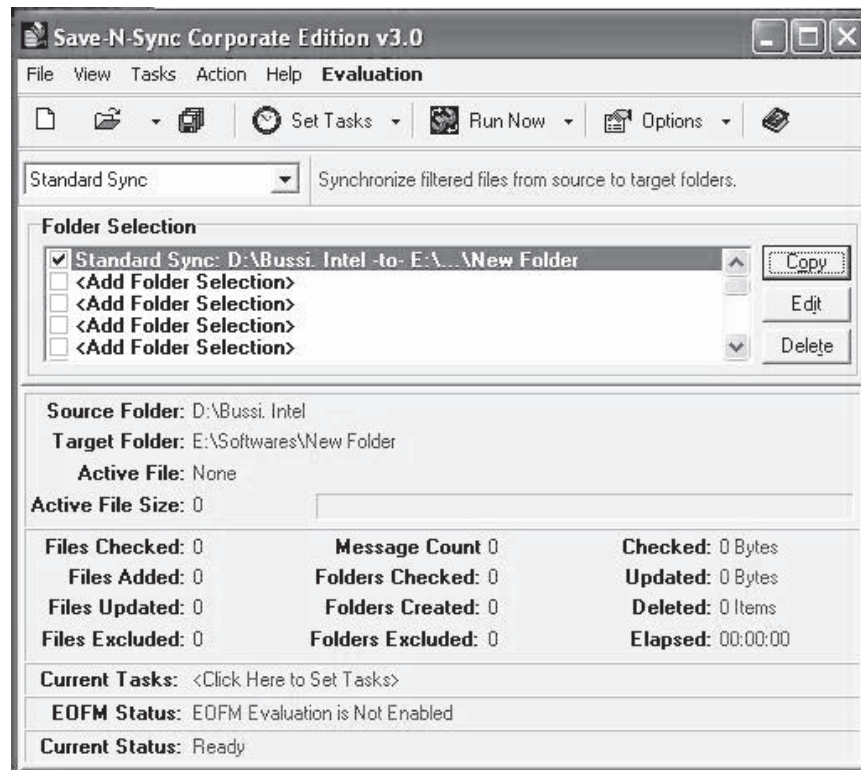


Figure 2-25 Click **Run Now** to finalize your selections.

- Click **Yes** to save the changes (Figure 2-26).

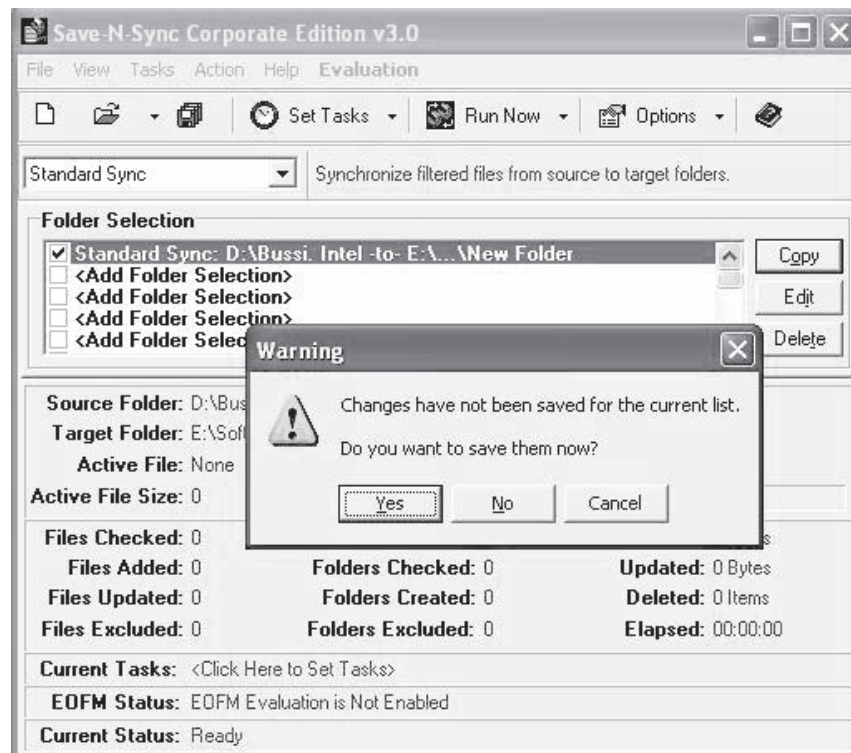


Figure 2-26 Click **Yes** to save the changes you have made.

- Click **OK** (Figure 2-27).

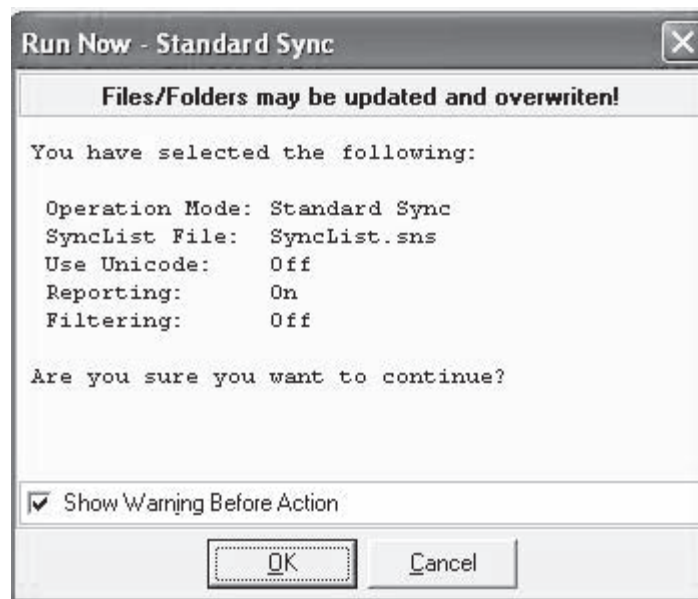


Figure 2-27 Click **OK** to start the sync process.

5. Follow these steps:
 - Navigate to Chapter 2 of the Student Resource Center.
 - Install and launch the FTK Imager program.
 - Click **File** and then click on **Add Evidence**.
 - Choose **Logical Drive** as the source evidence type (Figure 2-28).

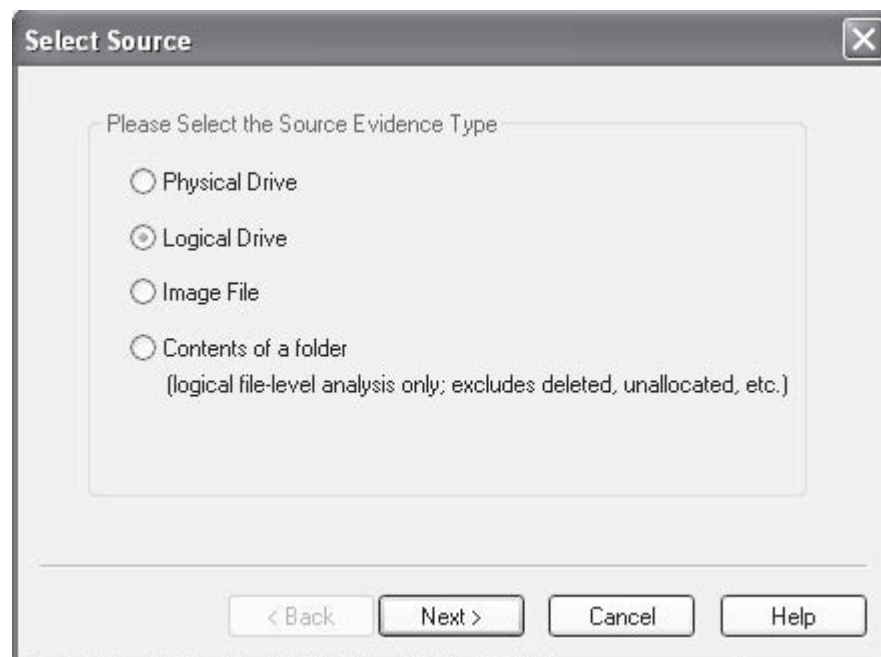


Figure 2-28 The source evidence for this project is a logical drive, so choose **Logical Drive**.

Forensic Investigations Using EnCase

Objectives

After completing this chapter, you should be able to:

- Understand evidence files
- Verify evidence file integrity
- Perform hashing
- Configure EnCase
- Search using EnCase
- Use bookmarks in EnCase
- View recovered files
- Understand the master boot record
- Understand the NTFS starting point
- Understand hash values
- Perform signature analysis
- Perform e-mail recovery

Key Terms

Cyclic redundancy check (CRC) a type of function that takes a quantity of data of any size and produces an output of a fixed length, usually a 32-bit integer that is generally used to verify the integrity of the original data

Checksum (also called a hash sum) a fixed-size integer resulting from the application of an algorithm to a block of digital data for the purpose of verifying the integrity of the original data; often used when comparing copied data with the original data

Hashing a well-defined mathematical function that converts a large variable-sized amount of data into a small fixed-length integer that may serve as an index into an array, as a method of obscuring and protecting passwords being transferred over a network, or to verify the integrity of stored data; Message Digest v5 (MD5) and Secure Hashing Algorithm (SHA) are two of the most common hashing functions.

Introduction to Forensic Investigation Using EnCase

This chapter focuses on forensic investigation using EnCase. EnCase is a forensic software suite that provides investigators with a full set of tools for forensic investigations. The chapter gives some information about EnCase and discusses how investigators can use EnCase to perform different forensic tasks.

Evidence Files

An evidence file is the core component of EnCase. It is a proprietary file created by EnCase to compress and preserve bit-stream images of acquired media. The EnCase evidence file is widely known throughout the law enforcement and computer security industries. Courts in the United States, including at the federal appellate level, and in the international community have accepted EnCase evidence files in both civil and criminal cases.

EnCase evidence files are used to preserve evidence and continue the examination without having to restore the image to separate media. The bit-stream image in an EnCase evidence file can be mounted as a read-only file or virtual drive, from which EnCase reconstructs the file structure using the logical data in the bit-stream image. This allows the investigator to search and examine the contents of the acquired drive within the EnCase Enterprise Examiner environment. The EnCase evidence file contains an exact copy of the data from the original media, including time stamps, deleted files, unallocated space, and file-system attributes. An investigator can easily transfer an EnCase evidence file to different types of media and archive it for future reference. If necessary, an investigator can also use the evidence file to restore the exact image to another hard drive. An evidence file consists of the following:

- *Header*: The header contains the date and time of evidence acquisition, the examiner's name, notes on the acquisition, an optional password, and its own cyclic redundancy check (CRC) checksum. **CRC** is a type of function that takes a quantity of data of any size and produces an output of a fixed length, usually a 32-bit integer that is generally used to verify the integrity of the original data. A **checksum** is a fixed-size integer resulting from the application of this algorithm. The header is always prefixed with *Case Info*.
- *Checksum*: One of the main parts of an EnCase evidence file is CRC checksums. An evidence file saves checksums for every block of 64 sectors (~32 KB) of evidence.
- *Data blocks*: Data blocks contain an exact replica of the original evidence. EnCase saves a bit-stream image of evidence.
- *Footer*: The footer contains an MD5 hash for the entire bit-stream image.

Verifying Evidence Files

After burning the discs, an investigator can run **Verify Evidence Files** from the **Tools** menu on each disc to verify that the burn was thorough and that the evidence file segment is intact.

Evidence File Format

Each evidence file is an exact sector-by-sector copy of a floppy or hard disk. Every byte of the file is verified using a 32-bit CRC, and it is virtually impossible to tamper with the evidence once it has been acquired.

EnCase uses ASR Data's Expert Witness Compression Format for storing images of evidence; this format can reduce file sizes by up to 50%.

EnCase can store media data in multiple evidence files called segment files. Each segment file consists of multiple sections. Each section consists of a section start definition. This definition contains a section type.

From version 4 onward, EnCase has had two header sections, header and header2. The header section is defined once, and the header2 section is defined twice within the file; both copies of header2 contain the same information.

Verifying File Integrity

Whenever an investigator adds an evidence file to a case, he or she can use EnCase to verify the integrity of the file (Figure 3-1).

Hashing

Hashing is a well-defined mathematical function that converts a large variable-sized amount of data into a small fixed-length integer that may serve as an index into an array, as a method obscuring and protecting passwords being transferred over a network, or to verify the integrity of stored data. EnCase calculates an MD5 hash when it acquires a physical drive or logical drive, as shown in Figure 3-2.

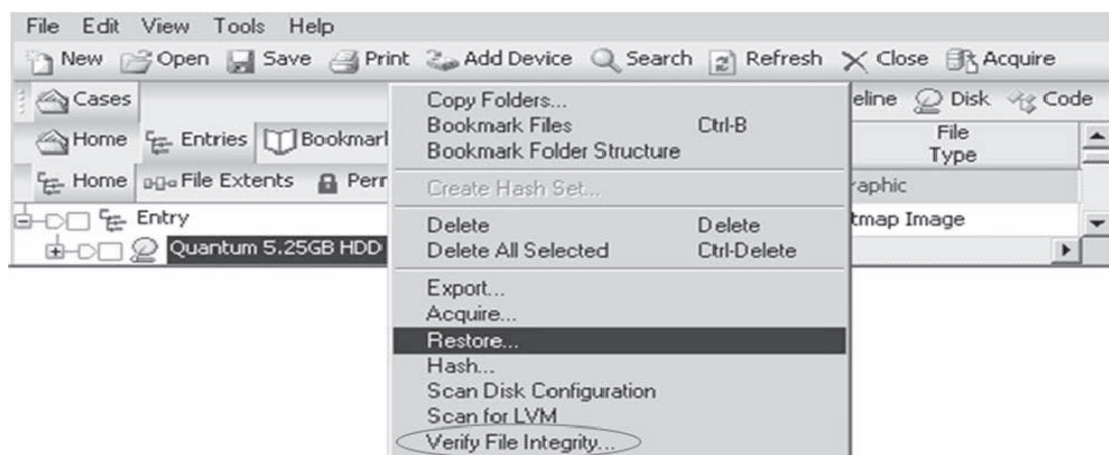


Figure 3-1 Verifying file integrity is a crucial step during an investigation.

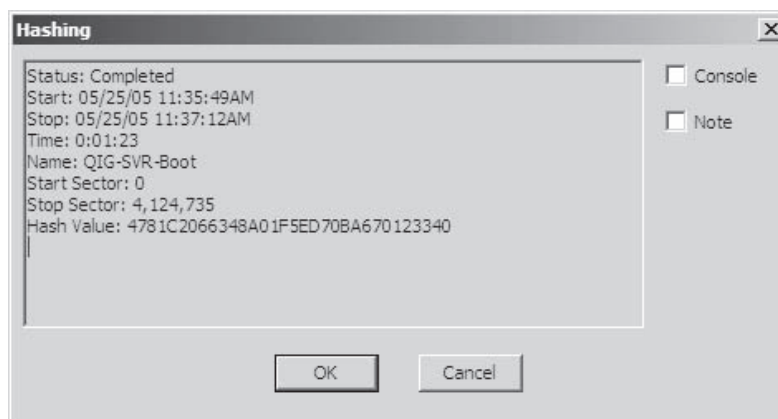


Figure 3-2 MD5 hashing helps to verify file integrity.

Acquiring an Image

An investigator can acquire an image by performing the following steps:

1. Click **File** and then **Add Device** to acquire the image. The investigator can alternately click the **Add Device** button on the toolbar. Figure 3-3 shows a screenshot of this process.
2. Select the device type. If the device is a USB drive, it should not be connected to the forensic computer prior to the boot process.

Configuring EnCase

An investigator can click **Tools** and then **Options** to configure EnCase. Figures 3-4 and 3-5 depict some of the **Options** screens.

View Menu

An investigator can launch various utilities using the **View** menu (Figure 3-6). The **View** menu includes the following options:

- Cases
- File types
- File signatures
- File viewers
- Keywords
- Search IDs
- Text styles
- Scripts
- Hash sets
- Encryption keys
- EnScript types

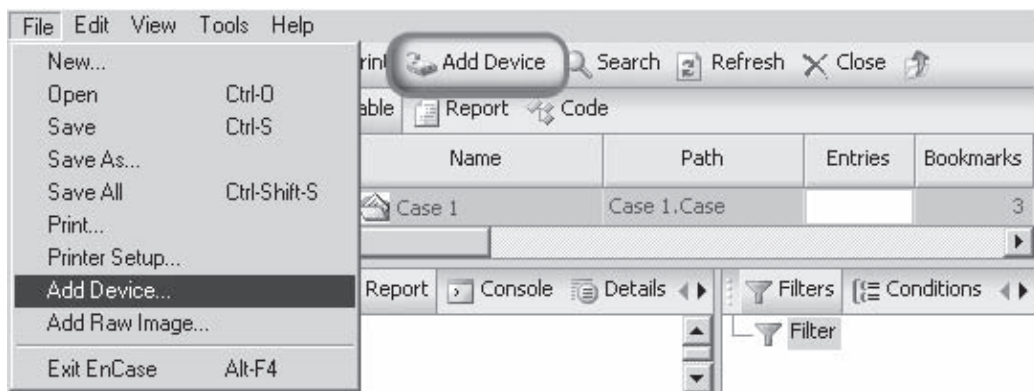


Figure 3-3 An investigator can acquire an image of a device by adding the device to the evidence file.

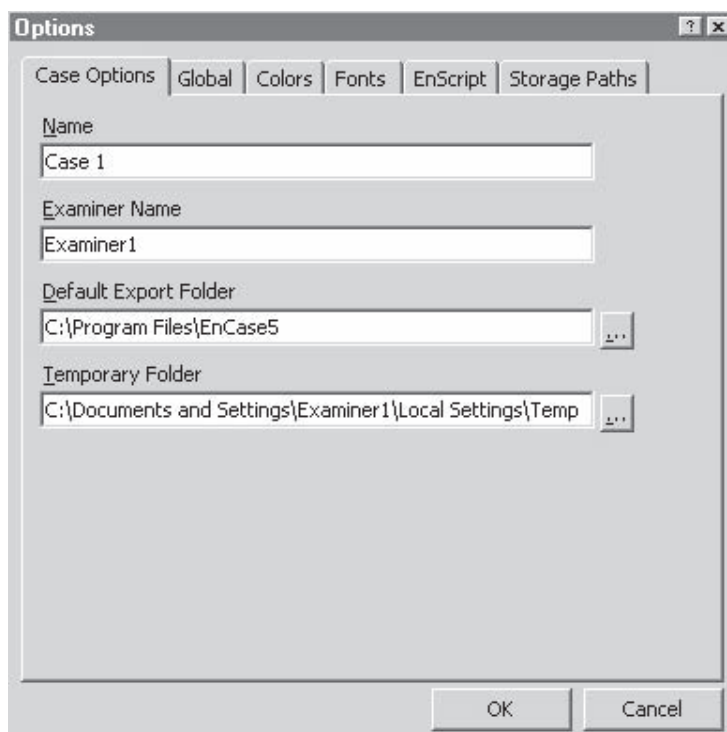


Figure 3-4 The **Case Options** tab allows an investigator to configure basic options about a case.

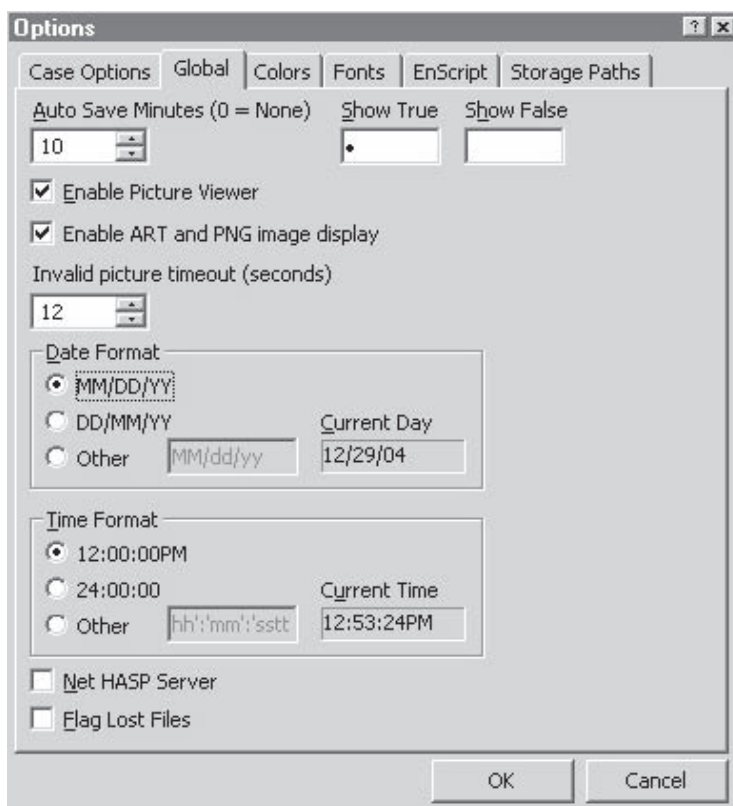


Figure 3-5 The **Global** tab allows an investigator to configure program options.

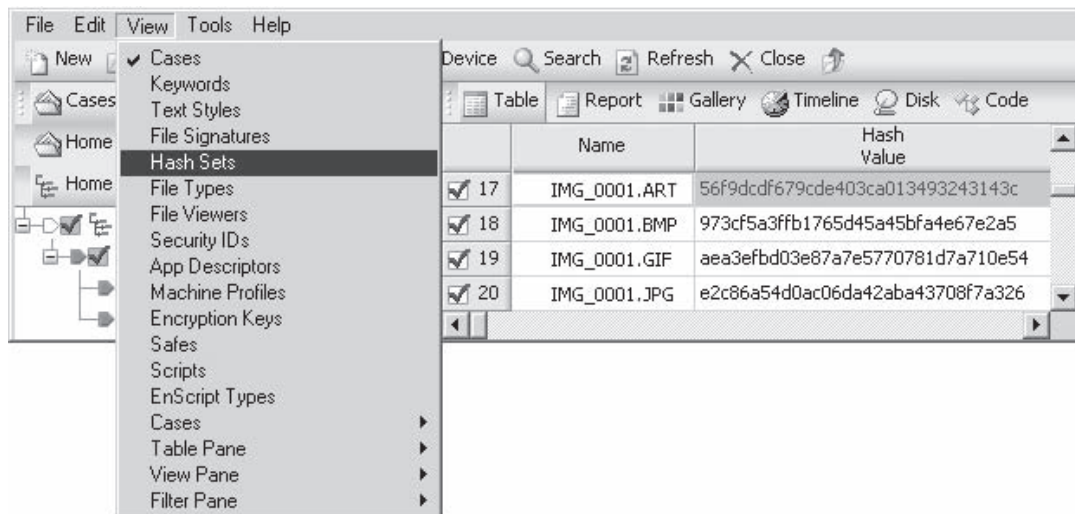


Figure 3-6 The **View** menu provides an investigator with many different utilities.

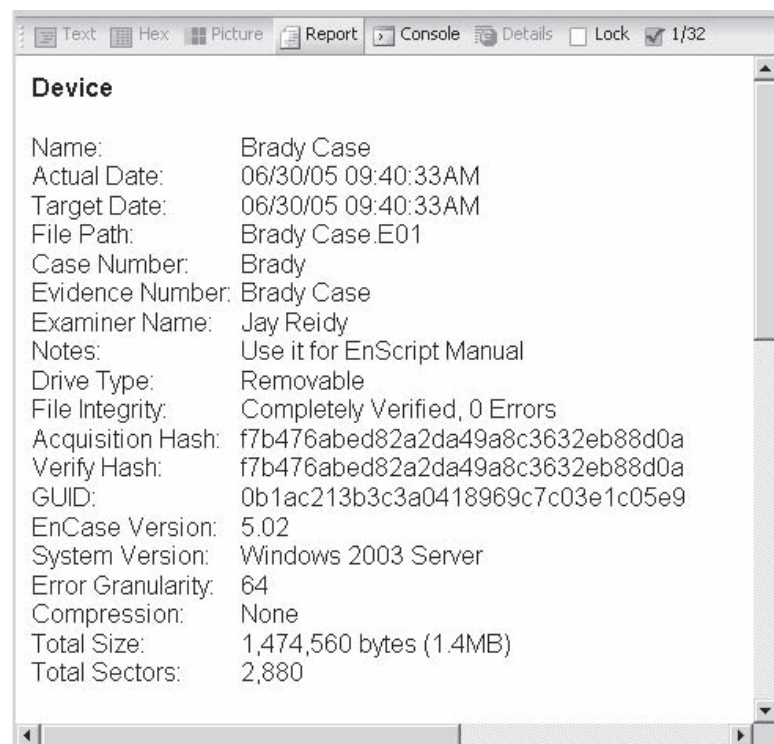


Figure 3-7 The **Device** report displays important information about an acquired device.

Device Tab

The **Device** report shows information about the currently selected device, as shown in Figure 3-7. The information displayed includes the following:

- Evidence number
- File path
- Examiner name

- Actual date
- Target date
- Total size
- Total sectors
- File integrity
- EnCase version
- System version
- Acquisition hash
- Verify hash
- Notes

Status Bar

The status bar (Figures 3-8 and 3-9) provides the following sector details for a selected file:

- Physical sector number
- Logical sector number

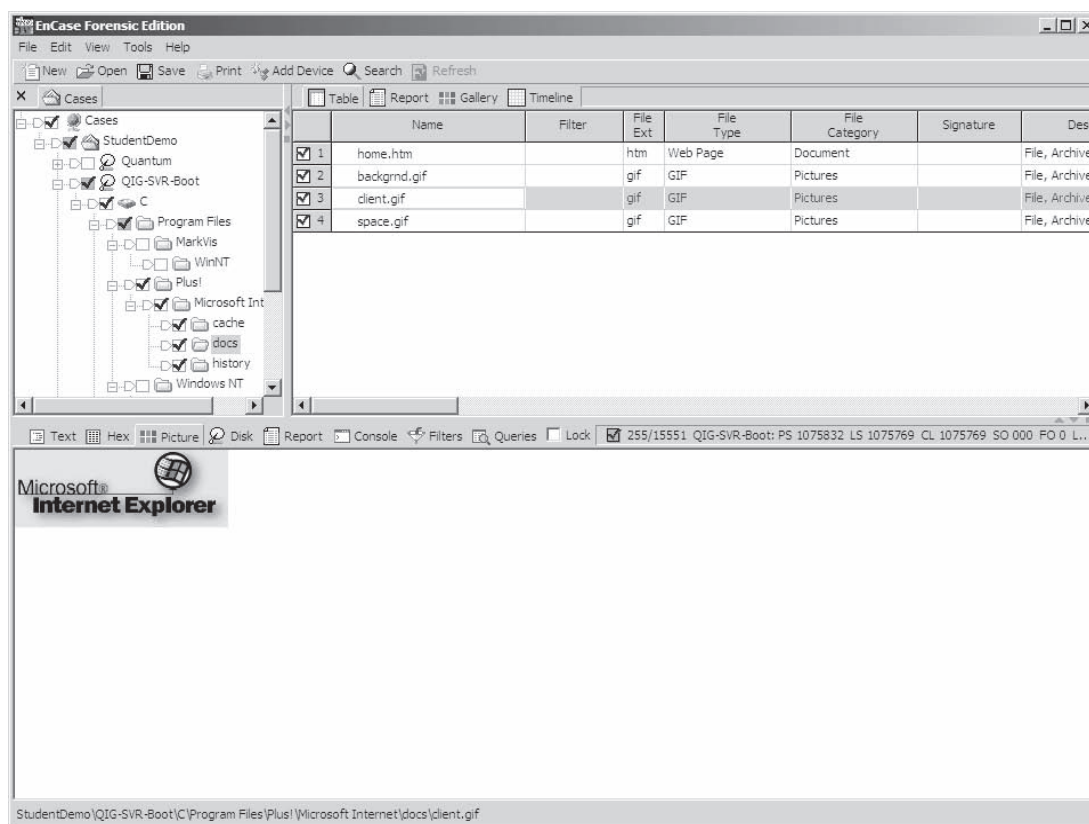


Figure 3-8 An investigator can view information about EnCase's current task in the status bar.

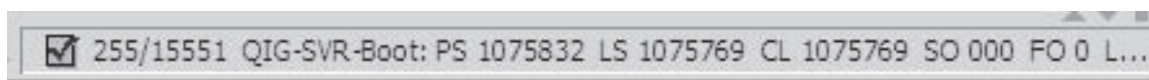


Figure 3-9 This shows a closer view of the status bar.

- Cluster number
- Sector offset
- File offset
- Length

Searching

EnCase provides powerful searching capabilities. An investigator can perform keyword searches at the logical level (file level) or physical level (byte-by-byte). EnCase can locate information anywhere on physical or logical media by using its deep analysis features. EnCase has the following advanced search capabilities:

- *Concurrent search*
- *Proximity search*
- *Internet and e-mail search*
- *E-mail address search*
- *Global Regular Expressions Post (GREP) search*: The GREP search utility enables the investigator to search for information with a known general format, such as any telephone numbers, credit card numbers, network IDs, logon records, or IP addresses, even when the specific number is not known
- *File finder*: This searches within the page file, unallocated clusters, selected files or entire cases, looking for specific file types and structured data

EnCase provides the following search options:

- *Case sensitive*: EnCase searches for keywords only in the exact case specified in the text box.
- *GREP*: The keyword is a regular expression.
- *RTL reading*: This is a keyword search in a right-to-left sequence for international language support.
- *Active code page*: This option allows an investigator to enter keywords in many different languages.
- *Unicode*: This enables investigators to search for keywords with international language characters.
- *Big-endian Unicode*: This enables investigators to search for keywords with international language characters.

Figure 3-10 shows a screenshot of the **Search** window.

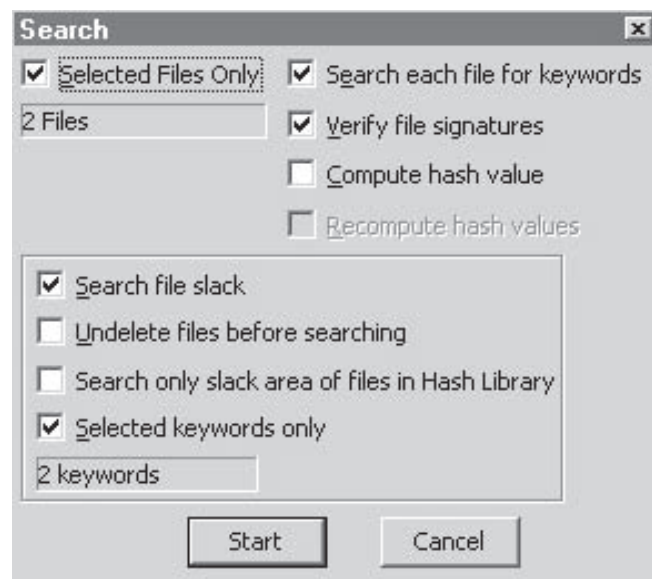


Figure 3-10 The **Search** window allows an investigator to choose different search options.

Keywords

A key component of any search is the keywords and their rules. Keywords are saved in the keywords.ini file. An investigator chooses keywords based on what he or she is investigating. For example, the investigator might want to add keywords such as the following:

- *kill*
- *suicide*
- *cheat*
- *Swiss bank*
- *San Francisco*

Adding Keywords

To add keywords, an investigator needs to right-click **Keyword** and select **New**, as shown in Figures 3-11 and 3-12.

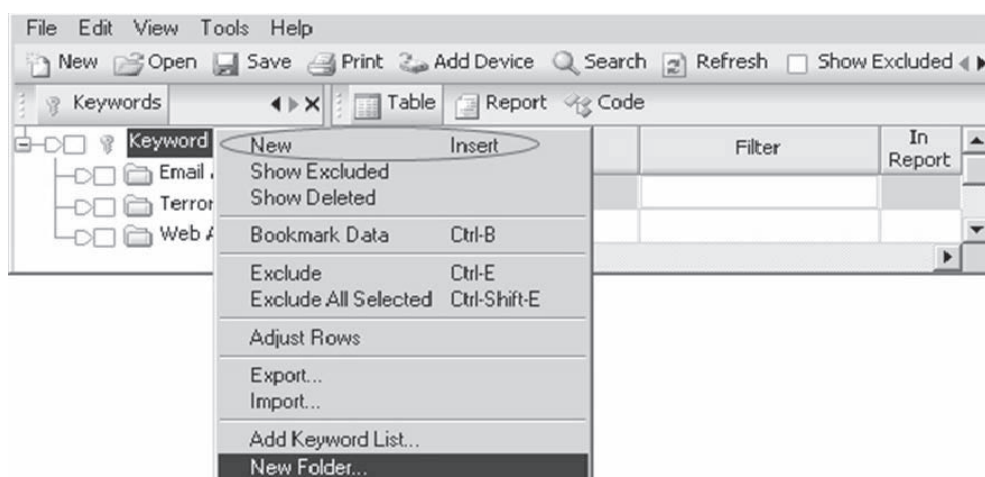


Figure 3-11 The **Keyword** menu allows an investigator to add new keywords to a search.

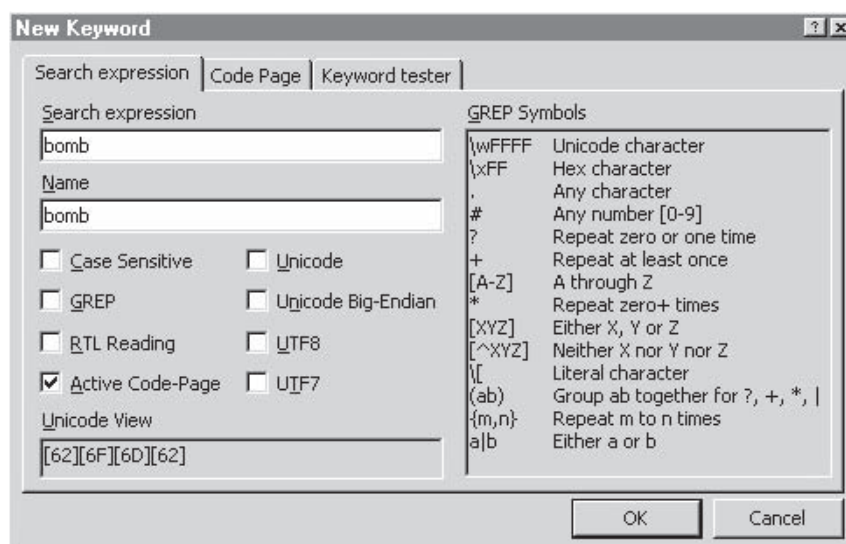


Figure 3-12 An investigator can set options for keywords in the **New Keyword** window.

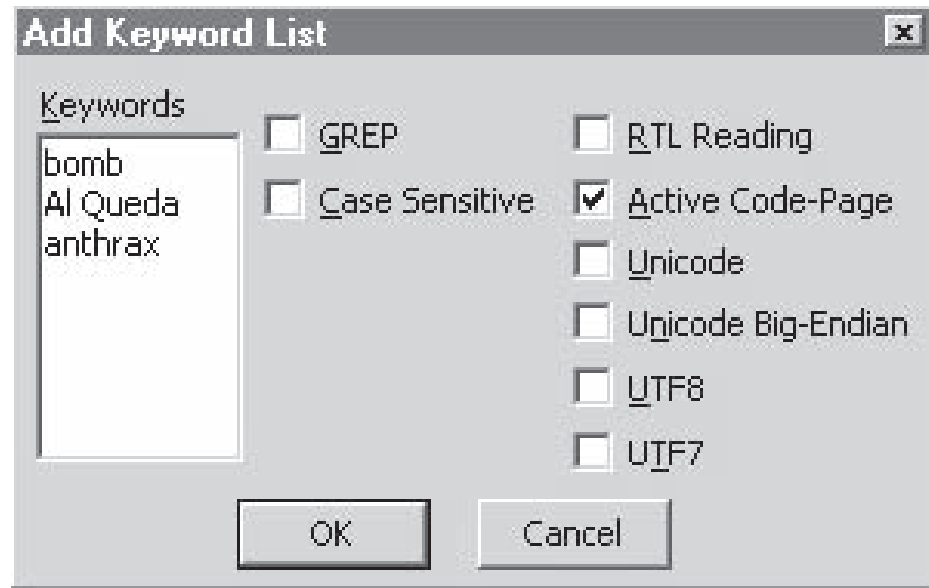


Figure 3-13 The **Add Keyword List** menu allows an investigator to add a list of keywords to a search and set the same options on all of them.

Grouping Keywords

An investigator can group keywords to organize search terms. To do so, he or she right-clicks **Keyword**, selects **New Folder**, and types in a folder name.

Adding Multiple Keywords

To add multiple keywords, an investigator can right-click the keyword folder and choose **Add Keyword List**. Figure 3-13 shows a screenshot of the **Add Keyword List** window.

Starting the Search

An investigator can search a set of files, a set of folders, or an entire drive by performing the following steps:

1. Check the keywords that need to be searched.
2. Click the **Search** button.

Search Hits Tab

The **Search Hits** tab reveals the search results, as shown in Figure 3-14.

Bookmarks

EnCase allows an investigator to bookmark files, folders, or sections of a file for easy reference. The investigator can view bookmarks by clicking **View** and then **Bookmark**. Figure 3-15 shows the **Bookmarks** tab.

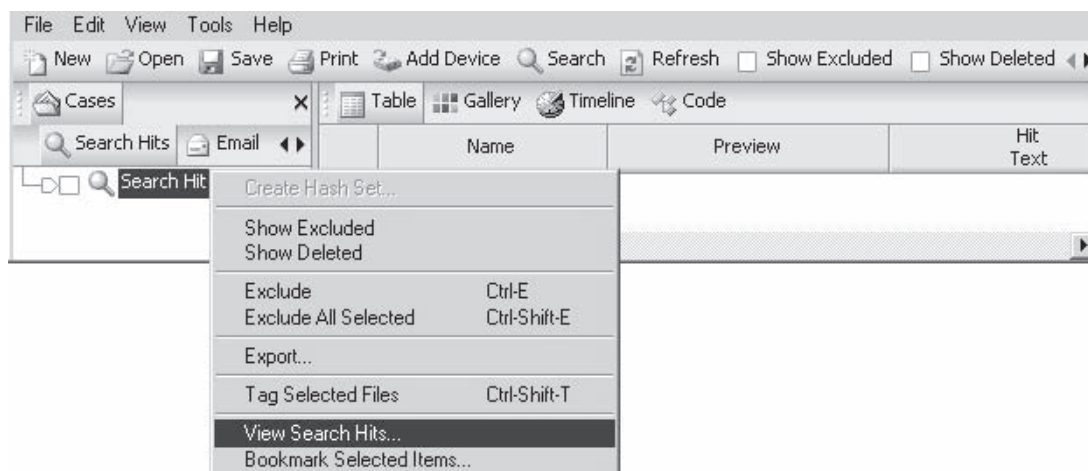


Figure 3-14 The Search Hits tab shows the results of a search.

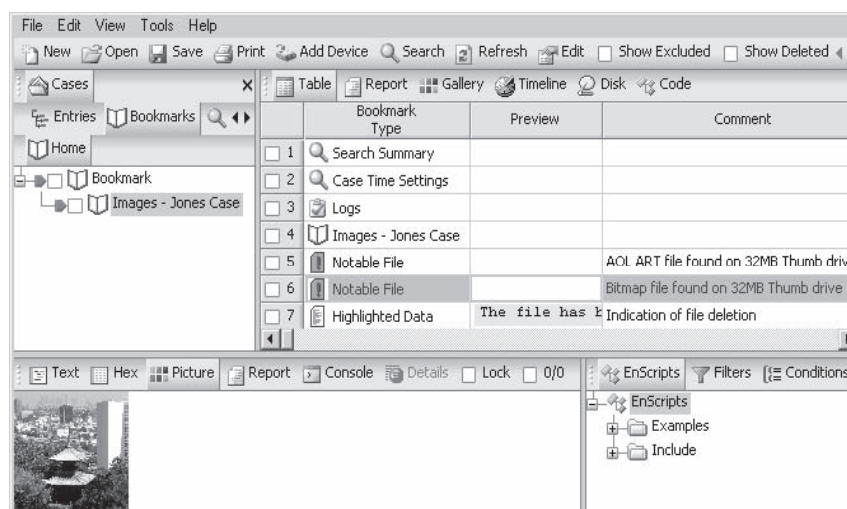


Figure 3-15 The Bookmarks tab shows the bookmarks that an investigator has created.

Creating Bookmark Folders

An investigator can create a bookmark folder by checking **Create new bookmark folder** in the **Bookmark Files** window, as shown in Figure 3-16.

Adding Bookmarks

An investigator can add a bookmark by right-clicking on any file and selecting **Bookmark Files**, as shown in Figure 3-17.

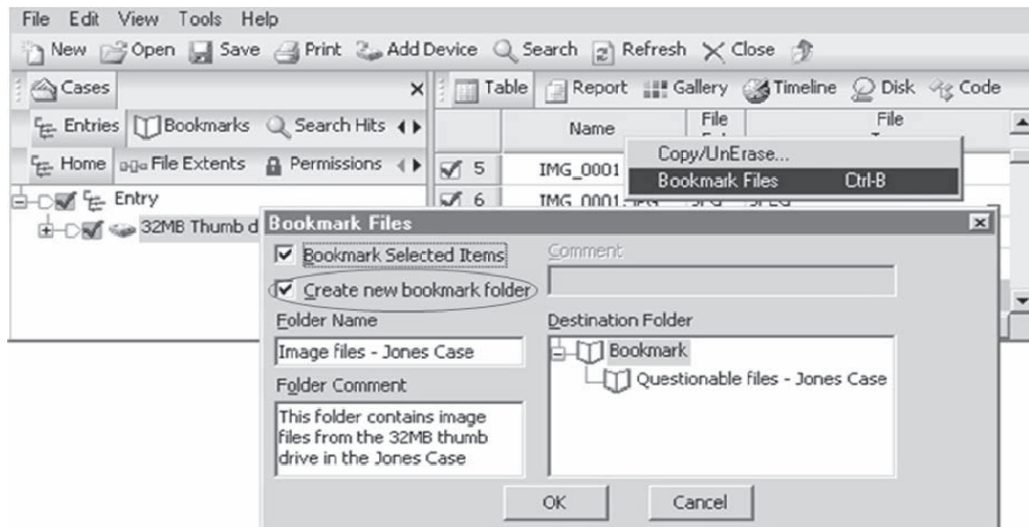


Figure 3-16 Bookmark folders allow an investigator to organize bookmarks.

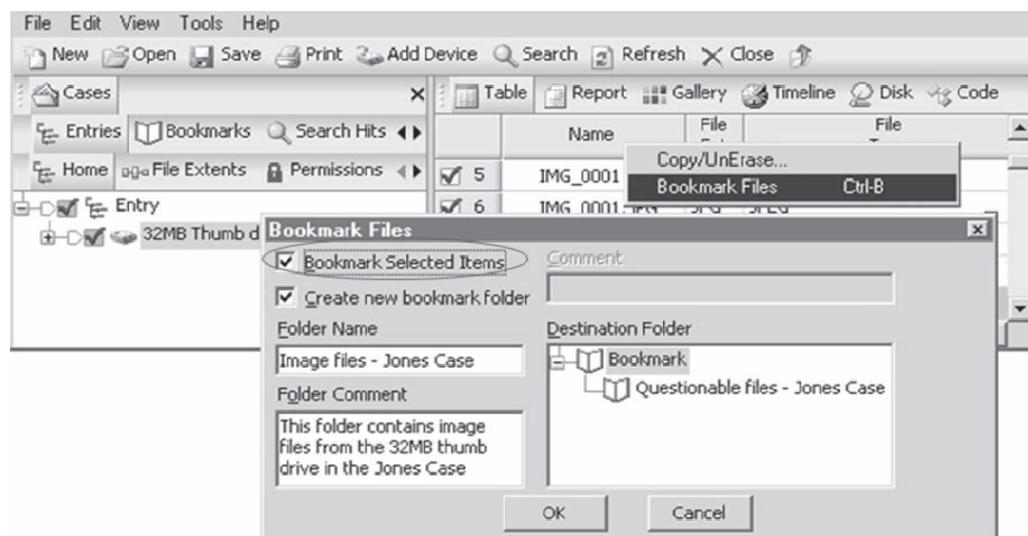


Figure 3-17 An investigator can bookmark files easily.

Bookmarking a Selected Area

An investigator can bookmark a selected area by highlighting the text area and selecting **Bookmark Data**, as shown in Figure 3-18.

Recovering Deleted Files/Folders in a FAT Partition

An investigator can recover deleted files and folders by right-clicking a FAT drive and selecting **Recover Folders**, as shown in Figures 3-19 and 3-20.

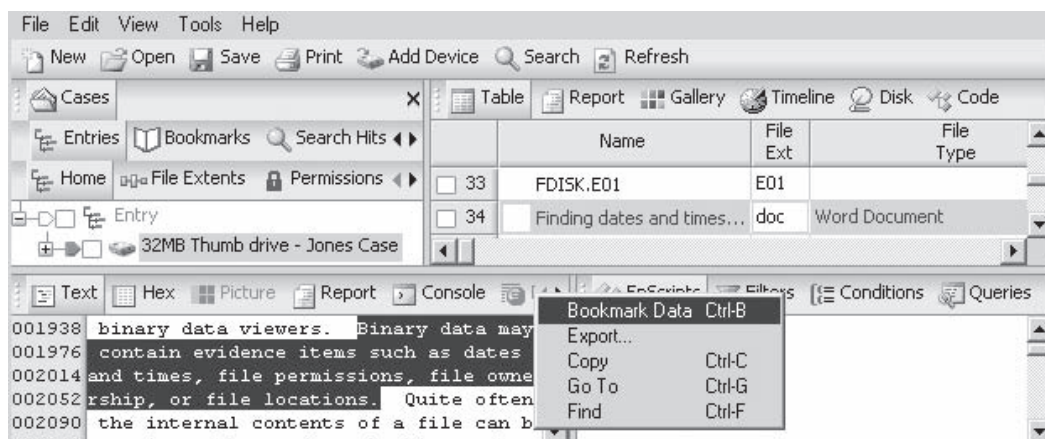


Figure 3-18 An investigator can bookmark an area of text.

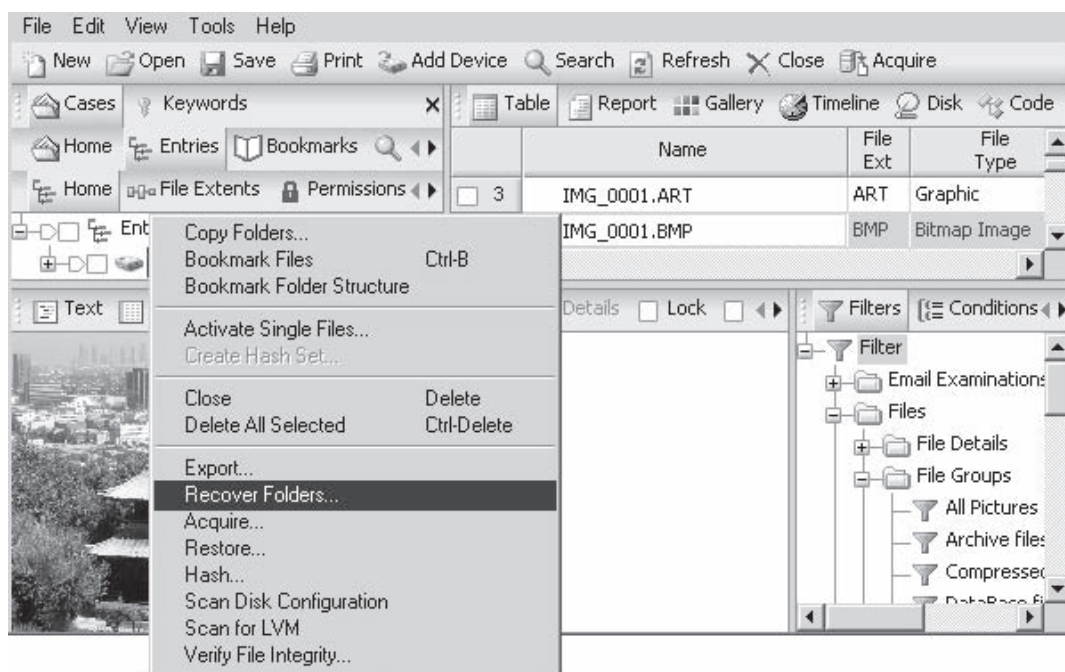


Figure 3-19 EnCase allows an investigator to recover deleted files and folders.

Viewing Recovered Files

An investigator can select the **Recovered Folder** to view the deleted files and folders that have been recovered, as shown in Figure 3-21.

Recovering Files/Folders in an NTFS Partition

EnCase searches unallocated clusters in the master file table (MFT) to recover files and folders. It uses a similar recovery method with an NTFS partition as it does with a FAT partition.

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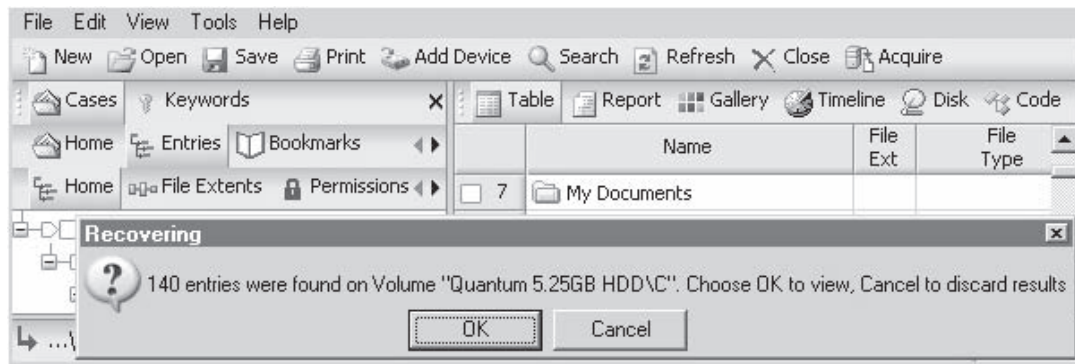


Figure 3-20 An investigator can view the file and folder recovery results or discard them.

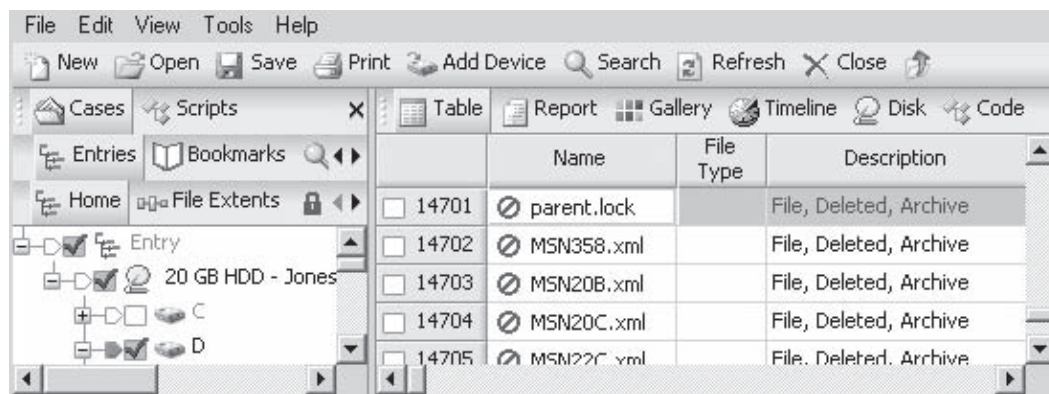


Figure 3-21 The **Recovered Folder** shows the files and folders that EnCase has recovered.

EnCase automatically rebuilds the structure of the formatted NTFS. It automatically searches the drive and finds artifacts from the previous partition. The partition information, directory structure, and folder structure are then automatically rebuilt. This capability is of critical importance in cases where a machine has been repurposed to another employee in the organization. If an individual who is the subject of an investigation used a repurposed machine, an investigator would need to recover the files from the previous NTFS volume.

The folder recovery process can be slow and may take 60 minutes (1 hour) for 100-GB hard drives.

The following are the steps to recover folders on an NTFS partition:

1. Right-click on the volume and select **Recover Folders**.
2. Choose **OK** to begin the search for NTFS folders.

Master Boot Record (MBR)

The master boot record (MBR) resides at the first sector (sector 0). The sector offset (SO) 446 contains the partition table.

The MBR allows four entries:

- Each entry is 16 bytes long.
- Partition entries range from LE 64 to 55 AA.

The following are the steps for checking MBR entries:

1. Select sectors SO 446 to LE 64 (Figure 3-22).
2. Right-click and select **Bookmark**.
3. Select **Windows** and then **Partition Entry**.
4. Enter a name for the bookmark.

NTFS Starting Point

Track 0 is normally considered the first 63 sectors of a disk and is reserved for the MBR. The MBR holds the partition table and the default Microsoft bootstrap code.

NTFS partitioning rules start the first primary partition in the 64th sector, as shown in Figure 3-23.

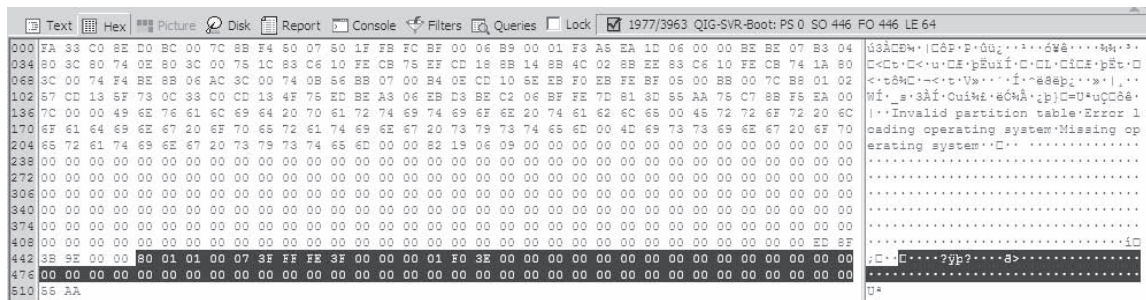


Figure 3-22 An investigator can bookmark the master boot record.

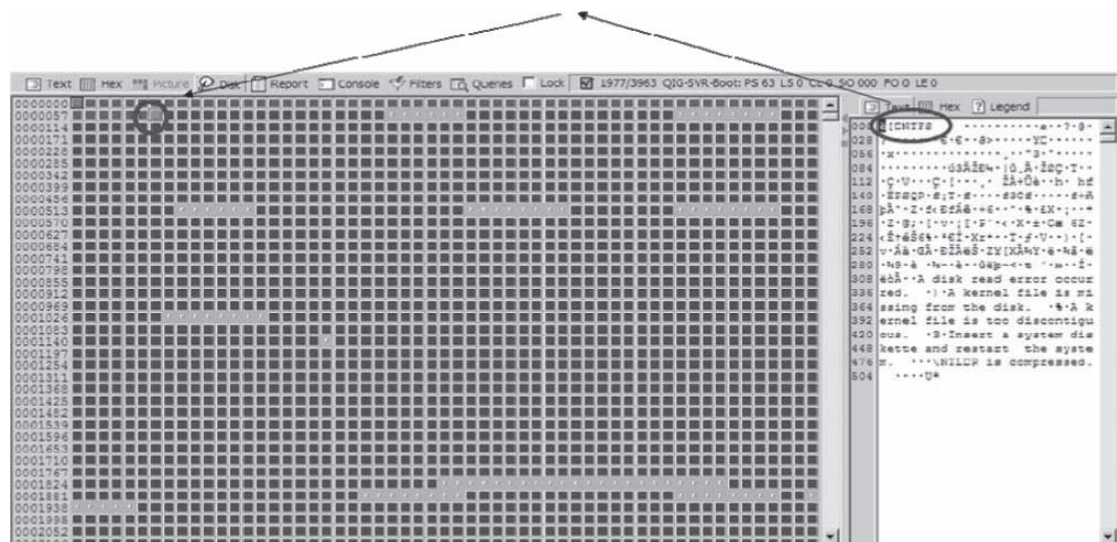


Figure 3-23 The first primary partition on an NTFS disk starts in the 64th sector, immediately following the MBR.

Viewing Disk Geometry

An investigator can view disk geometry by highlighting the case and clicking **Report** on the top menu, as shown in Figure 3-24.

Recovering Deleted Partitions

There are two ways to check for deleted partitions:

1. Search for the following in the unused disk area:
 - a. MSWIN4.1 (FAT partition)
 - b. NTFS (NTFS partition)
2. Look manually on the disk at the end of the first volume.

An investigator can recover the partition by right-clicking the area to recover and selecting **Add Partition**, as shown in Figure 3-25. An investigator can delete a partition by right-clicking and selecting **Remove user defined partitions**.

Hash Values

Figure 3-26 shows a list of hash values for the files in a case.

Creating Hash Sets

An investigator can create a hash set by performing the following steps:

1. Select the files to be included in the hash set.
2. Right-click and choose **Create Hash Set** (Figure 3-27).

MD5 Hash

The MD5 hash is a 128-bit (16-byte) value that uniquely describes the contents of a file. It is a one-way hash function that converts a message into a fixed string of digits called message digests.

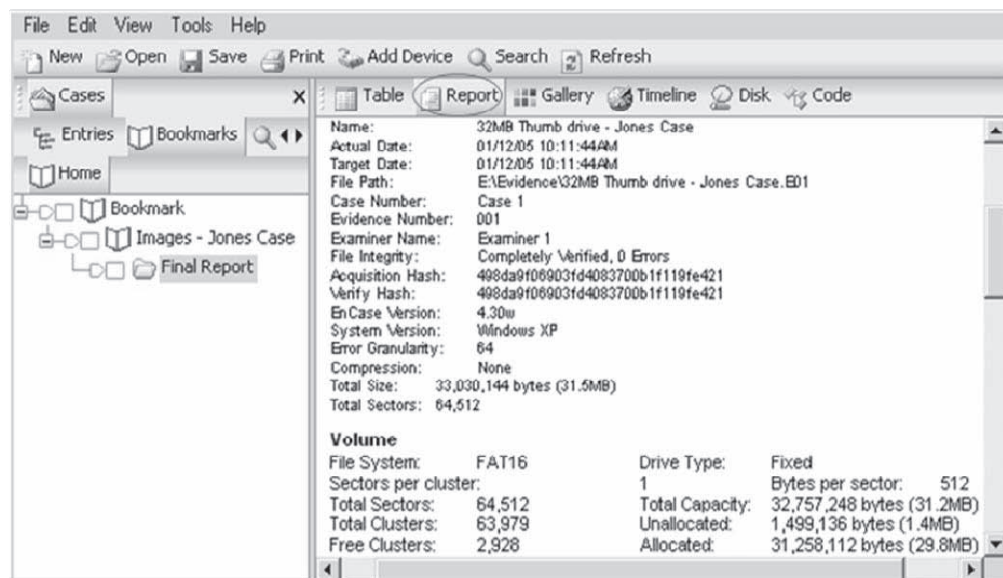


Figure 3-24 The Report tab shows the disk geometry of all devices in a case.

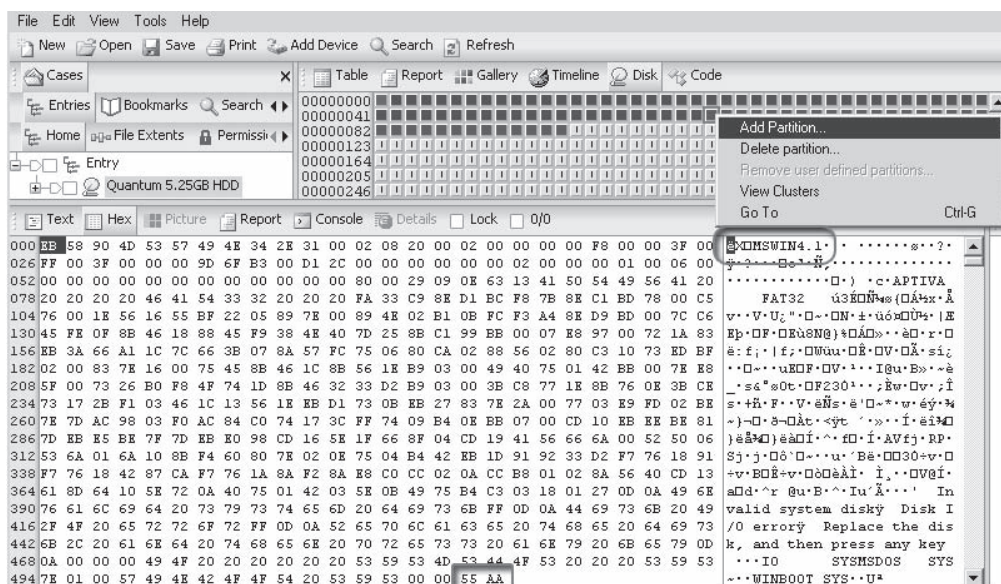


Figure 3-25 An investigator can recover deleted FAT and NTFS partitions.

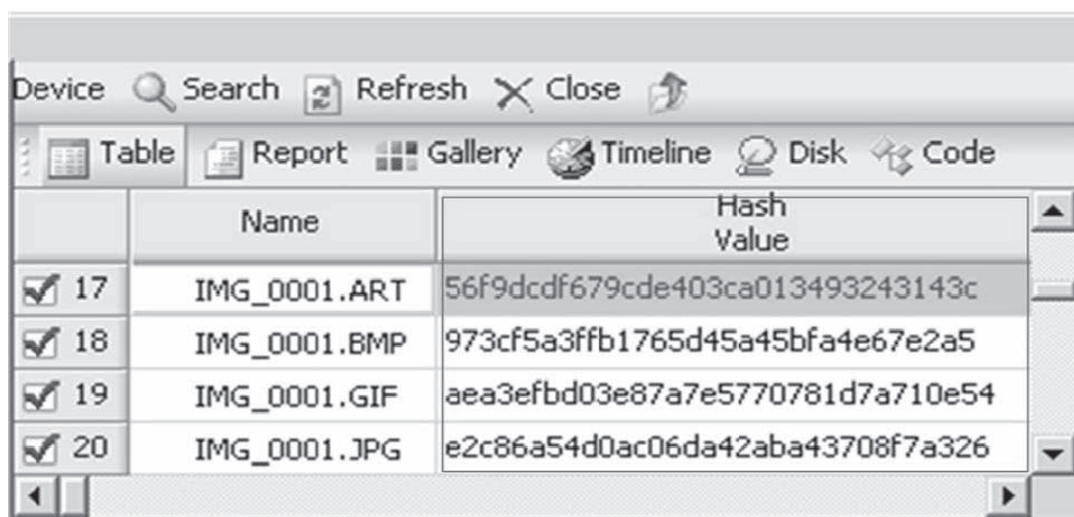


Figure 3-26 EnCase hashes files to help in verifying file integrity.

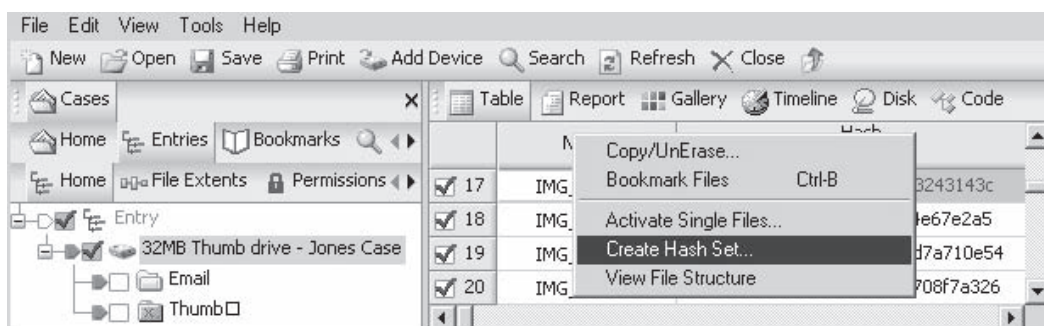


Figure 3-27 Hash sets allow an investigator to organize hash values.

The purpose of the value within EnCase is to verify that the evidence file EnCase created is the same in byte structure as the original media. EnCase also uses MD5 hashing to create hash sets that are then added to the hash library. Hash sets are collections of hash files.

EnCase can create a hash value (digital fingerprint) for any file in the case.

The chance of two files having the same hash value is 2^{-128} . The likelihood of duplication in MD5 is 340,282,366,920,938,463,463,374,607,431,768,211,456 to 1.

Creating Hashes

An investigator can click **Search** and select **Compute Hash Value** to create a hash for every allocated file. Figure 3-28 shows computed hash values for a set of files in the right column.

Viewers

EnCase allows an investigator to use external viewers to view files. EnCase will copy a file to a temporary folder before launching the viewer to display the file. EnCase can use the following types of viewers:

- *External viewer:* EnCase can be enhanced quickly to use external file viewers, easing the analysis of foreign file types, and allowing for the use of native applications from the source machine.
- *Registry viewer:* The integrated registry viewer organizes the registry data file into folders, giving examiners an expedient and efficient way to view the Windows registry and determine values.
- *EnCase viewer:* The fully integrated picture viewer automatically locates and displays many known graphical image types, including Microsoft thumbs.db files.
- *Timeline:* This integrated viewer allows an examiner to see all relevant time attributes of all the files in the case (or selected group of files) in a powerful graphical environment.

An investigator can see the viewers by clicking **Viewers** in the **View** menu. The investigator can create a new viewer just by entering the application path, as shown in Figure 3-29.

Signature Analysis

The ISO (International Organization for Standardization) and ITU (International Telecommunication Union) work to standardize types of electronic data. When a file type becomes standardized, a signature or header is stored along with the data. Applications use the header to correctly parse the data. An investigator can view the file signature to identify the file type, even if its extension has been changed.

To perform signature analysis, an investigator can select **View** and then **File Signatures**.

Viewing the Results

Figure 3-30 shows the results of signature analysis.

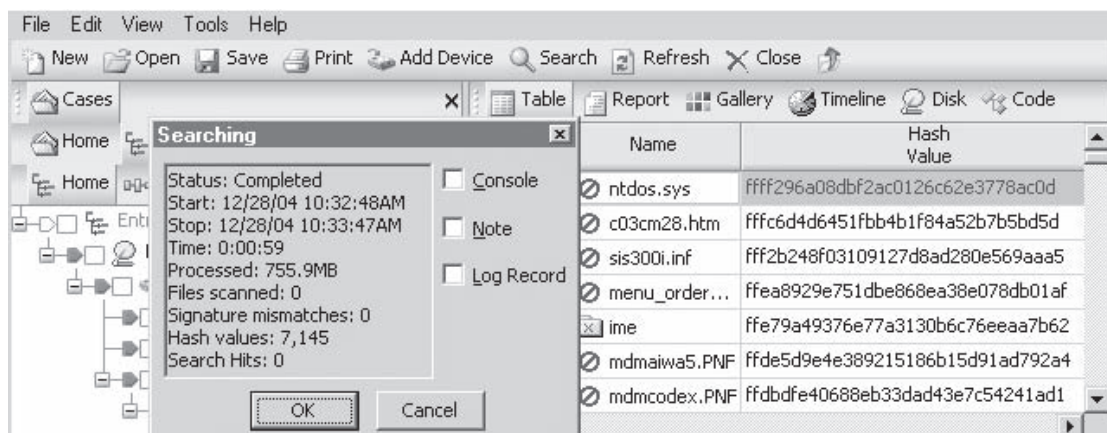


Figure 3-28 An investigator can easily create hash values for every file in a case.

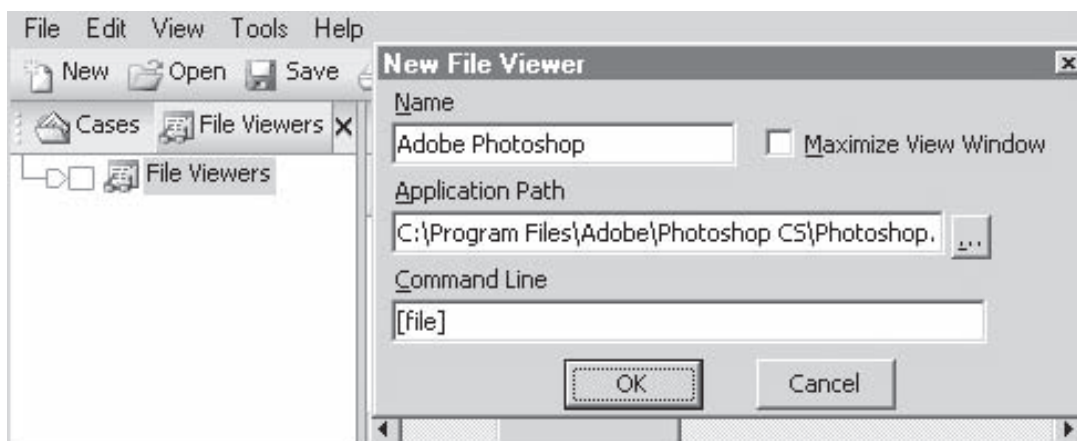


Figure 3-29 An investigator can easily create a new type of external viewer.

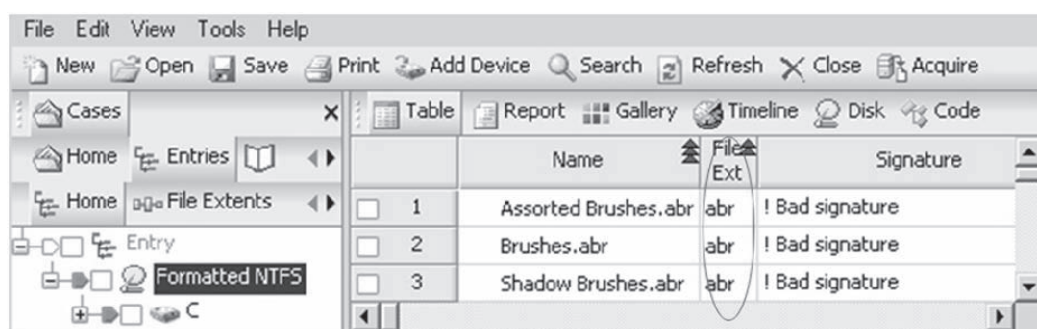


Figure 3-30 EnCase displays the results of signature analysis once it has completed the task.

Copying Files and Folders

An investigator can select a group of files and folders to copy, as shown in Figure 3-31. The investigator can unerase the file if EnCase indicates that it has been deleted.

E-Mail Recovery

The default path for Outlook Express 5/6 in Windows XP is \Documents and Settings\<username>\Local Settings\Application Data\Identities\<userid>\Microsoft\Outlook Express.

The following are the Outlook mailbox file names:

- Inbox.mbx
- Outbox.mbx
- Sent Items.mbx
- Deleted Items.mbx
- Drafts.mbx

An investigator can view these files in EnCase.

Reporting

The final stage of forensic analysis is reporting. A report must be easy to understand and cover in-depth information about the evidence. To create a report, an investigator can click **Report** in the **Bookmarks** menu. Figure 3-32 shows a final report.

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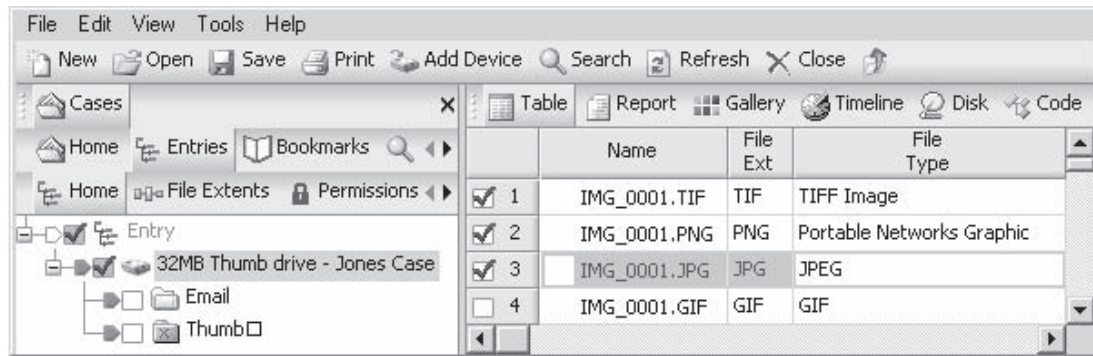


Figure 3-31 An investigator can copy and unerase files and folders.

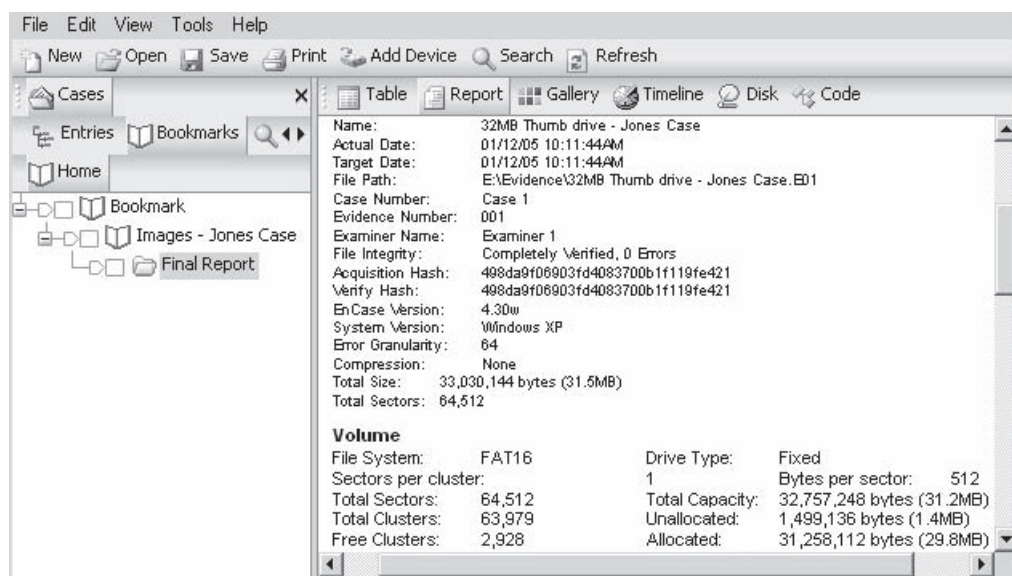


Figure 3-32 The final report shows the analysis results for a case.

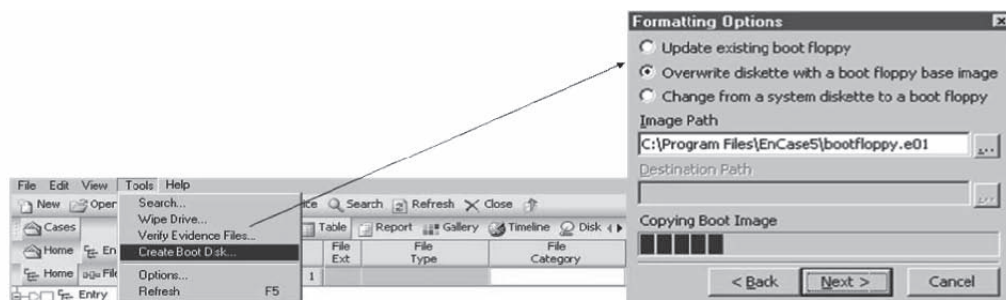


Figure 3-33 An investigator can use an EnCase boot disk to create a bit-stream image of a device.

EnCase Boot Disks

An investigator can create a boot disk directly in EnCase. The investigator can use this boot disk to boot up in MS-DOS mode. By using this disk, he or she can create bit-stream images. Figure 3-33 shows EnCase creating a boot disk.

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Chapter Summary

- The evidence file is the core component in EnCase.
- Each evidence file is an exact sector-by-sector copy of a floppy or hard disk.
- EnCase calculates an MD5 hash when it acquires a physical drive or logical drive.
- EnCase provides powerful searching capabilities.
- EnCase allows an investigator to bookmark files, folders, or sections of a file for easy reference.
- EnCase searches unallocated clusters in the master file table (MFT) to recover files and folders.
- EnCase can create a hash value (digital fingerprint) for any file in a case.

Review Questions

1. What is an evidence file, and what is it used for?

2. Describe the main parts of an evidence file.

3. Describe the steps involved in acquiring an image of a storage device.

4. What does the Device tab show?

5. What is the purpose of an EnCase boot disk?

6. What is the purpose of file-signature analysis?

7. How does EnCase use MD5 hashing?

8. Describe the kinds of searches an investigator can perform using EnCase.

Hands-On Projects



1. Perform the following steps:
 - Install EnCase.
 - Create a case file structure on the desktop:
 - Create a “MY CASES” folder to represent a pristine forensic hard drive.
 - Create a subfolder of MY CASES called “Case 1” to represent the case.
 - Create three subfolders of Case 1 called “evidence,” “temp,” and “export.”
 - Start Encase, and select **File** and then **New** from the menu.
 - The **Case Options** window for the new case opens. Set the options as follows:
 - Name: Case 1 (already identified)
 - Examiner Name: <enter your name>
 - Default Export Folder: <click “...” and browse to newly created export folder>
 - Temporary Folder: <click “...” and browse to newly created temp folder>
 - Select **File** and then **Save** from the menu. Name the case “Case 1” and save it in the MY CASES\Case 1 folder. You now have the structure necessary to support an entire forensic research project.
2. Perform the following steps:
 - Create a second case and name it “StudentDemo” (refer to the first hands-on project for how to create a case if necessary).
 - Copy all five evidence files from the Labs CD to StudentDemo/Evidence.
 - Start EnCase, select **File** and **Open** from the menu, and navigate to the StudentDemo case file.
 - When prompted, navigate to the correct path of your copied Quantum.E01 evidence file, and click **Open**.
 - Correct the location of support directories by selecting **Tools** and then **Options** from the menu.
 - Identify your name, export directory, and temp directory, as in the first hands-on project.
 - Save your case.
 - You now have a snapshot of a complete forensic investigation underway.
3. Perform the following steps:
 - Open the StudentDemo case. Note the three panes:
 - *Left*: Contains evidence file listings
 - *Right*: Contains folders and subfolders within the selected evidence file
 - *Bottom*: Contains the contents of the selected file structure
 - In the left pane, expand (click “+”) the C: drive within the Quantum evidence file.
 - In the left pane, highlight the My Documents folder by clicking on the folder name. Notice the itemized list of 22 files and subfolders in the right pane.
 - Click on the pentagon to the left of the My Documents folder name. Notice the itemized list has changed to 1,437 files and folders.
 - Hold the Ctrl key, and click on the pentagon to the left of the PhotoDlx folder. Notice how additional files and folders have been added to the itemized list. Deselect PhotoDlx’s contents by clicking the pentagon again.

- Highlight an image file in the right pane. Notice that images are interpreted and displayed in the bottom pane. Notice that icons at the top of the bottom pane change how file contents are displayed. Notice the text at the top right of the bottom pane identifies the exact position in the evidence file. The following are what the abbreviations here stand for:
 - *PS*: physical sector
 - *LS*: logical sector
 - *CL*: cluster number
 - *SO*: sector offset
 - *FO*: file offset
 - *LE*: file length in bytes
- Prepare a list of words to search for by selecting **View** and then **Keywords** from the menu. Notice the new view in the left and right panes. Use the following words: *investigator*, *search warrant*, and *reports*.
- Right-click on **Keywords** in the left pane, and select **New Folder**.
- Right-click on **Folder** and select **Rename**. Backspace and rename the folder “SearchWords” and press **Enter**.
- Highlight SearchWords in the left pane, and right-click in the right pane to add a search word. Notice the **New Keyword** window opens. Here are some things worth noting:
 - The **GREP** check box indicates a phrase could be part of a word.
 - **Active Code-Page** assists in identifying the language.
 - **Unicode** turns on/off the Unicode interpreter.
 - Modifies the Unicode interpreter.
 - **UTF8** modifies the Unicode interpreter.
- Add the words *victim*, *bomb*, *explosion*, *fire*, *gun*, and *pain* with only **Active Code-Page** checked. Click **OK** to close the **New Keyword** window.
- Click on the **Search** icon in the top toolbar.
 - Check the box next to **Selected File Only**, and click **Start**.
 - Notice the flashing status at the bottom right of the screen showing the estimated time to completion.
 - Notice the search cannot be interrupted once started.
 - Notice that multiple searches can be started at one time.
 - Notice the summary screen display upon completion of the search.
- View search results when the search is complete by selecting **View** and then **Search Hits** from the menu. Click on individual search terms in the left pane, and view contextual hits in the right pane.
- Highlight the word *bomb* in the left pane.
- Locate search result #702 in the right pane.
 - Choose to review the contents as text in the bottom pane.
 - Select **View** and then **Text Styles** from the menu.
 - Highlight **Low Bit - ASCII** in the left pane.
 - Highlight **ASCII@80** in the right pane.

- Bookmark this evidence for later reference.
 - Choose **View** and then **Bookmarks** from the menu.
 - Right-click on **StudentDemo** in the left pane, and select **New Folder**.
 - Right click on **Folder 1** to rename it to **Quantum.E01**.
 - Click and drag in the bottom pane to select text of interest (a few paragraphs).
 - Right-click the selected text and select **Bookmark Data**.
 - Create a comment by which to recognize this text.
 - Identify the destination folder as **Quantum.E01** and click **OK**.
4. Perform the following steps:
- Open the **StudentDemo** case. Expand the **Quantum bit image** file.
 - Highlight the **C:** drive in the left pane.
 - Place a check mark next to **Unallocated Clusters** in the right pane. Note how the check marks echo back to the left pane's identifiers.
 - Select **View** and then **Keywords** from the menu.
 - As before, right-click on **Keywords** in the left pane and create a new folder. Backspace, and rename the folder "File Headers."
 - Copy a current definition for JPEG headers from the Signatures database to your folder:
 - Select **View** and then **File Signatures** from the menu.
 - Scroll down on the right pane just past halfway to locate the **JPEG Image** entry.
 - Right-click on this entry, and select **Edit**.
 - The **Search Expression** data field (containing `\xFF\xD8\xff[\xFE\xE0]\x00`) is highlighted.
 - Press **Ctrl+C** to copy the highlighted text.
 - Click the **Cancel** button to close the JPEG definition window.
 - Click on the **Keywords** tab at the top of the left pane to return to the **Keywords** window.
 - Right-click on your new folder, **File Headers**, and select **New**.
 - With the cursor in the **Search Expression** field of the **New Keyword** window, press **Ctrl+V** to paste the text you copied from the signatures database.
 - Add a descriptive title like "JPEG" to the **Name** field, and check the **Grep** check box.
 - Click **OK** to save and close the **New Keyword** window.
 - Check the check box to the left of your new keyword.
 - Perform the search:
 - Click the **Search** icon in the toolbar.
 - Check the check box to the left of **Selected Files Only** to limit the search to unallocated space.
 - Ensure **Search each file for keywords**, **Search file slack**, and **Selected keywords only** are checked.
 - Clear checks from **Verify file signatures**, **Compute hash value**, and **Search only slack area of files in Hash Library**.
 - Click the **Start** button to begin the search.
 - At completion of the search, a status screen opens.

- View the search results:
 - Select **View** and then **Search Hits** from the menu.
 - Highlight the JPEG search string in the left pane. View the results in the right and bottom panes.
 - Check the check box to the left of the JPEG keyword in the left pane.
 - Scroll to the last column in the right pane, titled **Pictures**.
 - Right-click inside this column and select **Picture-Invert Selected Items**. Note that images are now viewable in the bottom frame.
 - Save and close the EnCase application.
5. Perform the following steps:
- Open the StudentDemo case.
 - Right-click on the **QIG-SVR-Boot** file entry and select **Scan RAID configuration**.
 - Note: Upon completion, a new entry is created in the left pane, indicating a composite virtual drive.
 - Note: The composite virtual drive is identified by the last volume drive letter assigned to it.
 - Note: The drive is ready for forensic analysis.

Recovering Deleted Files and Deleted Partitions

Objectives

After completing this chapter, you should be able to:

- Delete files
- Understand what happens when a file is deleted
- Understand the Recycle Bin
- Perform data recovery in Linux
- Know and understand data recovery tools
- Delete partitions
- Recover deleted partitions
- Know and understand partition recovery tools

Key Terms

Recycle Bin a space on a disk for files and folders that are marked for deletion

Recycled folder a folder on each drive to which files deleted by compliant programs are moved

SID (security identifier) a unique name assigned by a Windows domain controller to identify a specific computer on a network

Undelete to restore the content in files that have been deleted deliberately or accidentally from a disk

Case Example

William Hickey, a 44-year-old Mingus Union High School teacher, was suspected of downloading child pornography onto the school's computer, but no charges were filed against him.

Though Hickey had tendered his resignation, he was allowed to work from home until his resignation went into effect on December 22, 2006. Police seized the computer and sent it to the Department of Public Safety. There, police investigated whether it contained images of child pornography. They did locate some pornographic images but have not identified any potential victims. It was reported, however, that the forensic investigation could take weeks, or even months, to conduct tests.

Upon the receipt of the lab reports, the district attorney will decide whether charges should be filed.

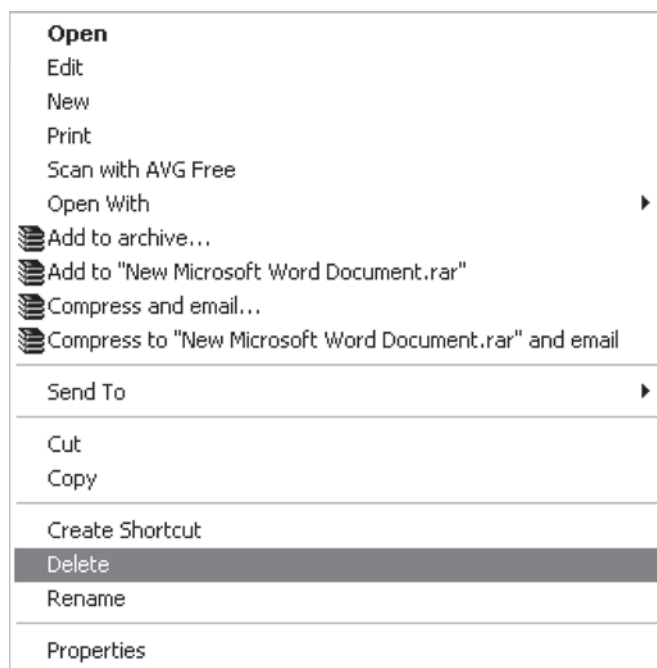
Introduction to Recovering Deleted Files and Deleted Partitions

This chapter focuses on recovering deleted files and deleted partitions. It begins by covering deleting files and the Recycle Bin. It then moves on to the subject of file recovery, including file recovery in Linux and the file recovery tools that forensic investigators use. The chapter then discusses deleting and recovering partitions. It finishes with an overview of partition recovery tools.

Deleting Files

There are different ways to delete files, depending on the file system and operating system a computer is using. On a Windows system, most deleted files are sent to the Recycle Bin. The **Recycle Bin** is a space on a disk for files and folders that are marked for deletion. The following steps show one way to delete files by moving them to the Recycle Bin:

- Right-click on the file or folder you want to remove, and choose the **Delete** option in the context menu (Figure 4-1).
- Windows will confirm that you wish to send the file to the Recycle Bin. Click on **Yes** to delete the file (Figure 4-2).



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Figure 4-1 This is a context menu that shows how to delete files from a Windows machine.

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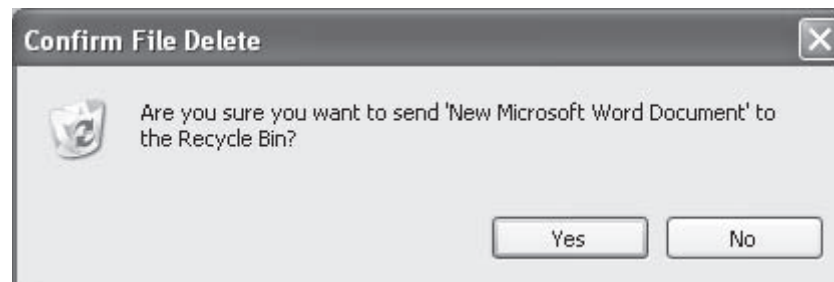


Figure 4-2 This is the dialog box that will pop up when you are about to delete a file. Choose **Yes** if you are sure you want to delete the file.

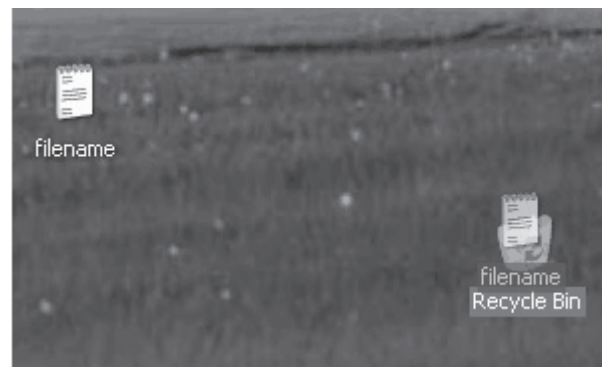


Figure 4-3 This image shows dragging and dropping files into the Recycle Bin.

There are other options for deleting files on a Windows computer:

- Select the file or folder you want to delete, and press the Delete key on the keyboard.
- Select the file or folder you want to delete. Go to the taskbar option **File** and click **Delete**.
- Drag and drop files into the Recycle Bin (Figure 4-3).

What Happens When a File Is Deleted in Windows?

When a user deletes a file, the operating system does not actually erase the file. It marks the file name in the master file table (MFT) with a special character that tells the processor that the file has been deleted.

The operating system replaces the first letter of a deleted file name with a hex byte code: E5h. E5h is a special tag that indicates that the file has been deleted. The corresponding cluster of that file in FAT is marked as unused, though it will continue to contain the information until it is overwritten.

The Recycle Bin in Windows

The Recycle Bin is located on the Windows desktop. When a user deletes an item from the hard disk, the Recycle Bin icon changes from empty to full. However, this item has not actually been erased. It is tagged as information to be deleted. When the user empties the Recycle Bin, he or she is telling the computer that the space those files used is now free to store new information.

Items deleted from removable media, such as a flash memory card or network drive, are not actually stored in the Recycle Bin. When a user ejects the removable media, he or she will no longer be able to access the files he or she deleted or moved to the Recycle Bin. The items present in the Recycle Bin still take up dedicated, adjustable space on the hard disk. These items can be restored to their original positions with the help of the **Restore all items** option of the Recycle Bin. After being deleted from the Recycle Bin, these items still take up space in the hard disk until the operating system overwrites the location where the information is stored.

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When the Recycle Bin becomes full, Windows automatically deletes the older items. Because the Recycle Bin takes up a specific space on each partition of the hard disk, very large items are not stored in the Recycle Bin. They are deleted permanently.

A user can manipulate the Recycle Bin in a number of ways. The following steps show how to change the storage capacity of the Recycle Bin:

- Right-click on **Recycle Bin** and choose **Properties**.
- Increase or decrease the storage capacity by moving the bar.

The following steps show how to restore files in the Recycle Bin:

- Open Recycle Bin.
- Right-click the item to restore. Then choose **Restore**.

It is possible to select more than one item to restore. Select the items to restore, and choose **Restore All** (Figure 4-4).

The following steps show how to delete files in the Recycle Bin:

- Open Recycle Bin.
- Right-click the file to delete, and choose **Delete**.

Storage Location of Recycle Bin in FAT and NTFS

On a FAT drive, deleted files are stored in the location **C:\RECYCLED**; on an NTFS drive, files are stored in the **C:\RECYCLER** folder.

The Recycle Bin folders in FAT and NTFS have two different names to avoid confusion, in case a computer system has both file systems, or a file system is converted to another file system, as when FAT is converted to NTFS.

FAT and NTFS Recycle Bins have different internal structures. All recycled files in the FAT system are dumped into a single **C:\RECYCLED** directory, while recycled files on the NTFS system are categorized into directories named as **C:\RECYCLER\S- ...**, based on the user's Windows *security identifier (SID)*. Figure 4-5 shows a command shell viewing one of these directories.

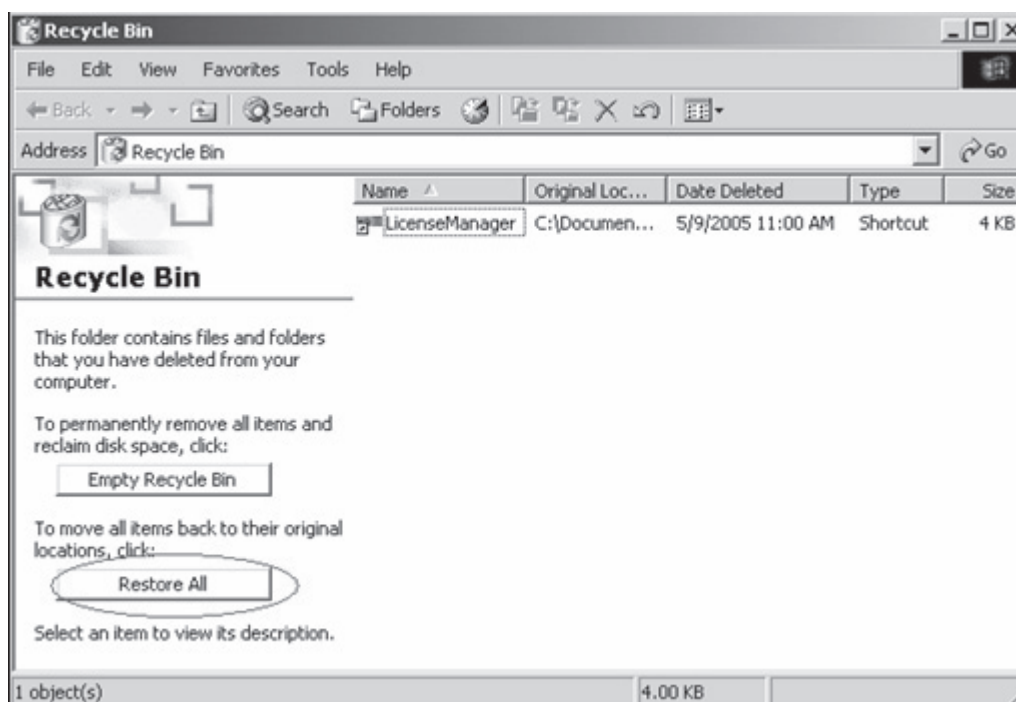


Figure 4-4 This image shows the Restore All feature of the Recycle Bin.

```

C:\WINDOWS\System32\cmd.exe

Directory of D:\RECYCLER
01/07/2005  03:54 PM    <DIR>          .
01/07/2005  03:54 PM    <DIR>          ..
05/18/2005  02:28 PM    <DIR>          S-1-5-21-2275786481-1800536561-533452318-
500
05/21/2005  06:00 AM    <DIR>          S-1-5-21-3020190987-1822439336-4113303836
-1005
               0 File(s)              0 bytes
               4 Dir(s)      1,362,382,848 bytes free

D:\RECYCLER>dir /h
Invalid switch - "h".

D:\RECYCLER>cd S-1-5-21-2275786481-1800536561-533452318-500
D:\RECYCLER\S-1-5-21-2275786481-1800536561-533452318-500>dir
Volume in drive D has no label.
Volume Serial Number is 3761-1CB9

Directory of D:\RECYCLER\S-1-5-21-2275786481-1800536561-533452318-500
01/07/2005  03:13 PM             176,594 Dd1
01/07/2005  03:26 PM    <DIR>          Dd2
03/27/2005  07:24 AM    <DIR>          Dd3
03/30/2005  01:02 AM      31,195,136 Dd4
03/30/2005  01:19 AM      262,144 Dd5
03/27/2005  12:31 PM      524,288 Dd6
               4 File(s)      32,158,162 bytes
               2 Dir(s)      1,362,382,848 bytes free

D:\RECYCLER\S-1-5-21-2275786481-1800536561-533452318-500>notepad Dd5
D:\RECYCLER\S-1-5-21-2275786481-1800536561-533452318-500>

```

Figure 4-5 This shows the locations of the Recycler directory in NTFS. The security identifier is S-1-5-21-2275786481-1800536561-533452318-500.

By default, Windows reserves 10% of the hard drive space for the Recycle Bin. The maximum possible capacity for any drive over 40 GB is 3.99 GB per drive. Items that exceed the capacity of the Recycle Bin are deleted immediately.

How the Recycle Bin Works

Each hard disk has a hidden folder named **Recycled**. This folder contains the files deleted from Windows Explorer or My Computer.

Deleted files are stored in the *Recycled folder*. Each deleted file in the folder is renamed. A hidden file called INFO2 holds the original names and paths. This information is used to restore the deleted files to their original locations.

The syntax for renaming is the following: **Dxy.ext**.

- All recycled files begin with the letter *D*; *D* denotes that a file has been deleted.
- The second letter (*x*) is the letter of the drive where the file is located. If the file resides on the main hard drive, it will be the letter *C*. If it is on the floppy drive, it will be the letter *A*.
- The final piece (*y*) denotes a sequential number starting from 0.
- The file will keep the same extension as the original file, such as .doc or .pdf.

Consider the following example:

- *New file name*: Dc1.txt = (C drive, second file deleted, a .txt file)
- *INFO2 file path*: C:\Windows\Desktop\Forensics.txt
- *New file name*: De7.doc = (E drive, eighth file deleted, a .doc file)
- *INFO2 file path*: E:\Homework\James Joyce Essay.doc

Damaged or Deleted INFO2 File

Once the INFO2 file is damaged or deleted, it will not appear in the Recycle Bin, but the deleted renamed files will still be present in the Recycled folder. Because the files were renamed in the Recycled folder, but not changed, they can be searched and restored by locating the file based on the new naming convention and renaming the file.

```

C:\RECYCLED>attrib -h info*
C:\RECYCLED>dir

Volume in drive C is C_QUANTEX
Volume Serial Number is 0F46-160A
Directory of C:\RECYCLED

.                <DIR>                01-29-02  4:00p  .
..               <DIR>                01-29-02  4:00p  ..
DC0              CHM                414,293  10-25-00  2:08p  DC0.CHM
INFO2            <DIR>                1,140   07-22-02  12:57p  INFO2
DC1              EXE                806,003  06-17-02  7:51a  DC1.EXE
DC2              DOC                19,456   05-25-99  4:18p  DC2.DOC
DC3              WBK                25,088   05-04-02  10:05p  DC3.WBK
5 file(s)        1,265,980 bytes
2 dir(s)         8,603.48 MB free

C:\RECYCLED>

```

Source: http://www.geekgirls.com/windows_recycle_bin.htm. Accessed 2/2007.

Figure 4-6 This shows the location of the INFO2 file in the Recycled directory in a FAT file system. The other four files in that directory are files that have been deleted.

When the INFO2 file is deleted, it will be re-created when a user restarts Windows. If the Recycle Bin is damaged and not working, the user must delete the hidden INFO2 file from the Recycled folder and restart Windows to re-create the INFO2 file; this will enable the user to access the deleted files in the Recycle Bin. A user can also delete the INFO2 file from a command prompt window:

- `cd recycled`
- `attrib -h inf*`
- `del info`

Figure 4-6 shows the location of the INFO2 file in a FAT file system.

Damaged Files in the Recycled Folder

Damaged or deleted files will not appear in the Recycle Bin. In such cases, follow the steps below to recover the deleted files:

- Make a copy of the **Recycled\Desktop.ini** file in a separate folder, and delete all the contents from the Recycled folder.
- Delete all files in the Recycle Bin.
- Restore the Desktop.ini file to the Recycled folder.
- If there is no Desktop.ini file or if it is damaged, re-create it by adding the following information to a new Desktop.ini file:

```
[.ShellClassInfo]
CLSID={645FF040-5081-101B-9F08-00AA002F954E}
```

Damaged Recycled Folder

At times, the Recycled folder itself can be damaged. In this case, a user will still be able to send files to the Recycled folder, even though the Recycle Bin on the desktop appears full. The user will not be able to view the contents of the Recycle Bin, and the **Empty Recycle Bin** command will also be unavailable. Figure 4-7 shows a damaged Recycle Bin.

To fix this, a user needs to delete the Recycled folder and restart Windows; Windows will regenerate the folder and restore its functionality.

Creating a New Desktop.ini File in Windows

1. Right-click any empty space on the Windows desktop.
2. Choose **New** and select **Text Document**.
3. Name the document **Desktop.ini**. Windows will warn you about changing the file extension.
4. Copy and paste the following into the new file:

```
[.ShellClassInfo]
CLSID={645FF040-5081-101B-9F08-00AA002F954E}
```

5. Save the file and move it to the Recycled folder.

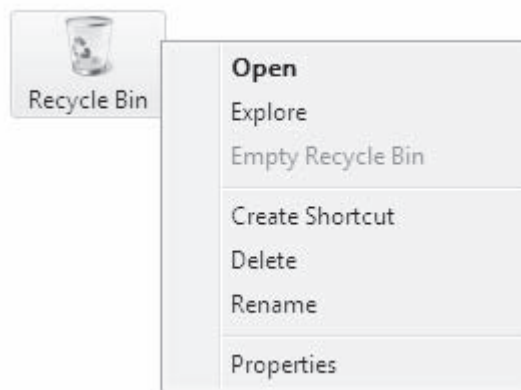


Figure 4-7 This shows a corrupted or damaged Recycle Bin. The bin appears full, but in the context menu, the option **Empty Recycle Bin** is grayed out.

The Recycled folder can also be generated from the command prompt:

- `attrib -s -h recycled`
- `del recycled`

Close the command window and restart the computer.

How to Undelete a File

If a file has been deleted from the Recycle Bin, in order to fully or partially restore it, a user will have to *undelete* the file. The process of file undeletion involves locating the data on the disk partitions and allowing the operating system to access the file. There are two main ways of carrying this out:

- Modify the existing file system to remove the “deleted” flag from the file to restore it.
- Locate the data in the partition, and copy it to a new file.

Data Recovery in Linux

The main advantage that Linux has over Windows is its ability to access and recover data from otherwise problematic machines. All file systems are supported in a standard stock kernel, which should have the ability to support older file systems. Therefore, the Linux kernel supports a large number of file systems, including VxFS, UFS, HFS, and the aforementioned NTFS and FAT systems. Note that Mac OS X is based on OpenBSD and thus uses the same UNIX/Linux kernel.

Individuals can, in some cases, dual-boot Linux and Windows; this can be done by using FAT and NTFS. Data of machines that fail to boot in a Windows environment can easily be recovered using bootable Linux, such as Knoppix.

In Linux, files that are deleted using the command `/bin/rm` remain on the disk. If a running process keeps a file open and then removes the file, the file contents are still on the disk, and other programs will not reclaim the space. The second extended file system (ext2) is commonly used in most Linux systems. The design of the ext2 file system is such that it shows several places where data can be hidden.

It is worthwhile to note that if an executable erases itself, its contents can be retrieved from a `/proc` memory image. The command `cp /proc/$PID/exe/tmp/file` creates a copy of a file in `/tmp`.

Tools to Recover Deleted Files

Tables 4-1, 4-2, 4-3, and 4-4 show a sample of some tools investigators use to recover deleted files:

Active@ UNDELETE	Fundelete	Restorer2000
Active@ UNERASER	Handy Recovery	Search and Recover
BadCopy Pro	Mycroft V3	SUPERFileRecover
DiskInternals Uneraser	O&O Unerase	Undelete
eData Unerase	PC Inspector File Recovery	VirtualLab
Easy-Undelete	PC Inspector Smart Recovery	WinUndelete
File Recover	R-Undelete	Zero Assumption Recovery
File Scavenger	Recover My Files	
File-Saver	Recover4all Professional	

Table 4-1 This table lists file recovery tools for Windows

e2undel	R-Linux	Stellar Phoenix
---------	---------	-----------------

Table 4-2 This table lists file recovery tools for UNIX-based operating systems

eIMAGE Recovery (image and media files)	Repair My Excel (Microsoft Excel files)
ImageRecall (image files)	RecoverPlus Pro (image files)
OfficeFIX (Microsoft Office files)	Zip Repair Pro (compressed files)
Word Repair (Microsoft Word Files)	

Table 4-3 This table lists file recovery tools based on file type

CD Data Rescue (CDs and DVDs)	eIMAGE Recovery
CDRoller (CDs and DVDs)	inDisc Recovery (CDs and DVDs)
DiskInternals Flash Recovery (flash drives)	IsoBuster (CDs and DVDs)
DiskInternals CD and DVD Recovery (CDs and DVDs)	

Table 4-4 This table lists file recovery tools based on media type

<https://t.me/learningnets>

File Recovery Tools for Windows

Tool: Active@ UNDELETE

Operating Systems: Windows XP/98/ME/NT 4.0/2000/2003 server

File Types: All

Media: Hard drives, including RAID arrays, and removable media

Web Site: <http://www.active-undelete.com/>

Cost: \$39.99

Active@ UNDELETE is a powerful data recovery software that helps a user recover lost, deleted, and formatted data from hard drives, floppy disks, basic and dynamic volumes, hardware or software RAID (RAID0 and RAID5). It supports compressed, encrypted, and fragmented files. Besides hard disk drives and floppies, the program supports recovery from removable devices such as Secure Digital, CompactFlash, SmartMedia, Sony Memory Stick, Zip drives, and USB hard drives.

Active@ UNDELETE will help users restore data residing on hard drives formatted in FAT12, FAT16, FAT32, NTFS, NTFS5, NTFS, and EFS file systems, and it works under all Windows family operating systems: Windows 95/98/ME/NT/2000/2003 server and Windows XP. Active@ UNDELETE incorporates many wizards that provide expert users full control over the process of data restoration.

The following are some of the features of Active@ UNDELETE:

- Recovers files on IDE/ATA/SATA/SCSI hard disk drives
- Recovers files on removable devices (SmartMedia, Secure Digital, Memory Stick, etc.)
- Supports external Zip drives and USB hard drives
- Recovers files from deleted, damaged, formatted, or reformatted partitions
- Supports FAT12, FAT16, FAT32, NTFS, NTFS5, NTFS, and EFS file systems
- Supports recovery of compressed, fragmented, and encrypted files on NTFS
- Advanced search by file name, file date, mask, size range, and attributes
- Two types of drive and device scan: Basic (fast) and Thorough (slow)
- Ability to create and work with raw and compressed disk images representing the whole drive in one file
- Ability to connect to remote machines and scan, create disk images, and recover data remotely
- Supports hardware and software RAID

Figure 4-8 shows a screenshot from Active@ UNDELETE.

Tool: Active@ UNERASER

Operating Systems: DOS and Windows

File Types: All

Media: Hard drives and floppy disks

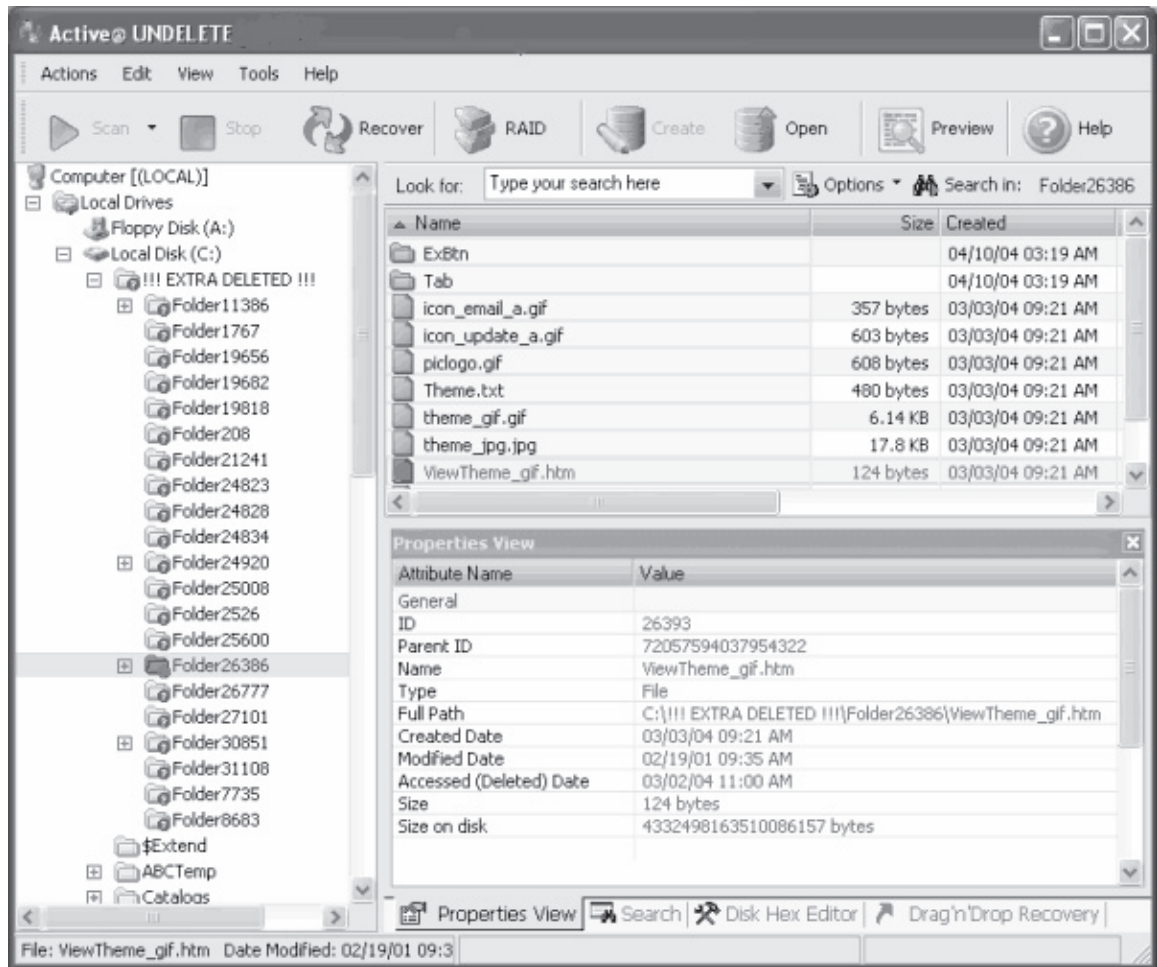
Web Site: <http://www.uneraser.com/>

Cost: \$49.99

Active@ UNERASER is powerful hard drive recovery software for DOS and Windows (Console) that can recover deleted files and folders on FAT12, FAT16, FAT32, and NTFS file systems. It can even restore files from deleted and reformatted partitions.

With this data recovery software, NTFS drives can be recognized and deleted items can be recovered while working from the DOS and Windows (Console) environment. It is not necessary to install the utility on a hard drive, as it fits on a bootable floppy disk, removing the possibility of overwriting the data a user wants to recover.

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Source: <http://www.active-undelete.com/>. Accessed 2/2007.

Figure 4-8 This figure shows the Active@ UNDELETE application screen.

The following are some of the features of Active@ UNERASER:

- Recovers lost data on all DOS/Windows systems, whether FAT or NTFS partitions
- Undeletes compressed, fragmented, sparse, and encrypted files on NTFS
- Recovers deleted files with long or non-English file names
- Unformats (i.e., recovers) files from formatted hard drives
- Creates and works with raw and compressed drive images for backup purposes
- Unerases files from deleted and damaged partitions and logical drives
- Scans hard drives and displays deleted FAT and NTFS partitions and/or logical drives
- Views files and any sector contents in hex/text viewer
- Supports LBA mode for access to large hard drives
- Two types of drive and device scan: Basic (fast) and Thorough (slow)
- Full support for long and localized file names for display and recovery
- Extended file and drive attributes support for information display
- Encrypting File System (EFS) support in Windows (Console) application

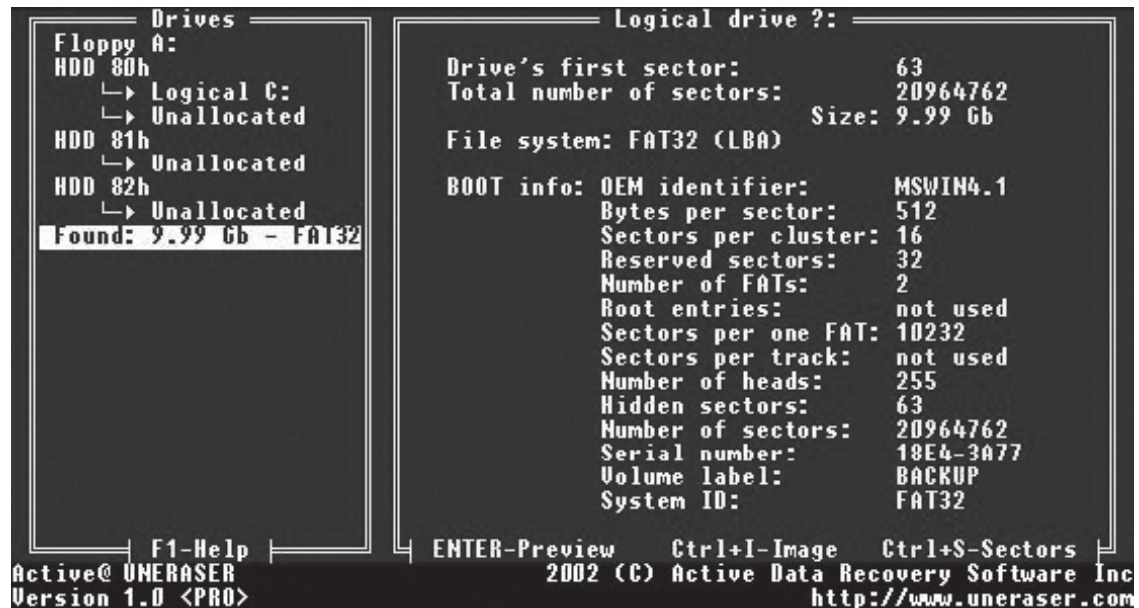


Figure 4-9 This figure shows the Active@ UNERASER application recovering files from a hard drive. Notice that the application found 9.99 GB of data to recover.

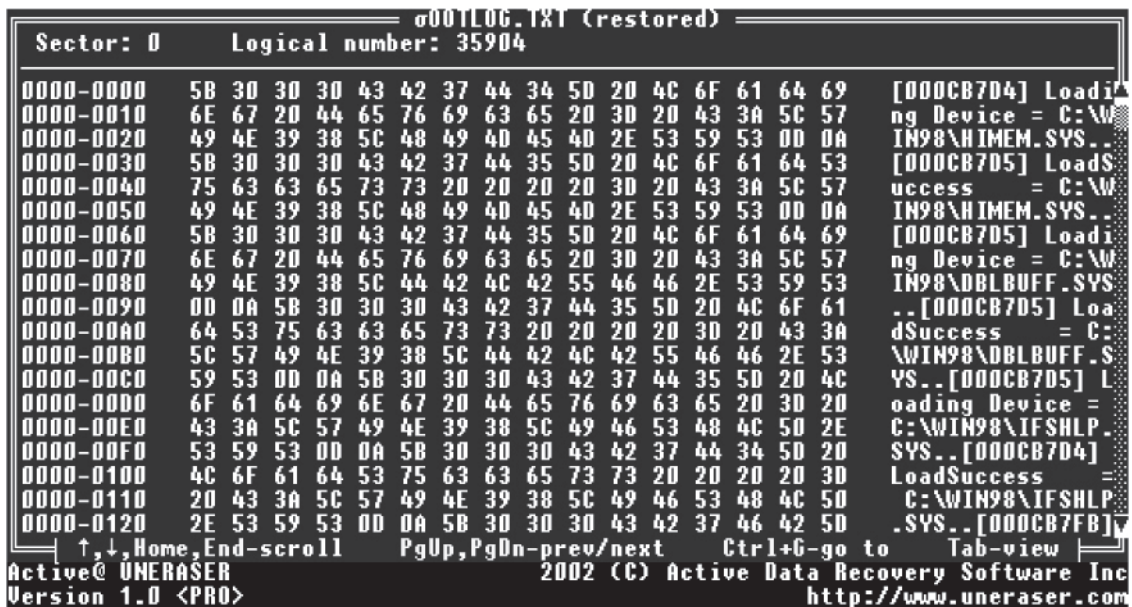
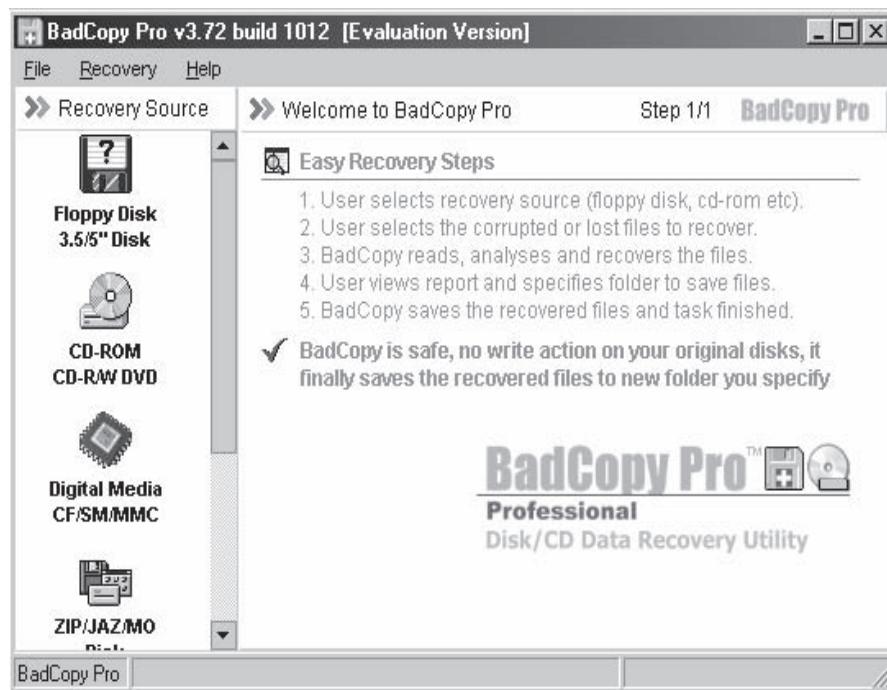


Figure 4-10 This image shows the recovery success for each of the sectors on the disk.

- Advanced searching: by mask, size, attribute, deleted/existing only
- Advanced disk imaging: raw and compressed disk images, composing disk images from raw chunks (created by other tools), and checking disk image consistency
- Read and copy existing files from NTFS to FAT partition

Figures 4-9 and 4-10 show screenshots from Active@ UNERASER.



Source: <http://www.jufsoft.com/badcopy/>. Accessed 2/2007.

Figure 4-11 This screenshot shows BadCopy Pro.

Tool: BadCopy Pro

Operating Systems: Windows

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.jufsoft.com/badcopy/>

Cost: \$39.50

BadCopy Pro is an application that helps in recovering corrupted or lost data fully from floppy disk, CD, CD-R, CD-RW, digital media, and Zip drives or disks. This tool also supports all kinds of damage situations for any file types. The software does not write data to the original disk; however, it saves the recovered information to a new folder that the user specifies. BadCopy Pro also helps in the retrieval of data from all sessions on multi-session CDs. This application is powerful in recovering deleted files from other removable storage hardware. Figure 4-11 shows a screenshot from BadCopy Pro.

Tool: DiskInternals Uneraser

Operating Systems: Windows

File Types: All

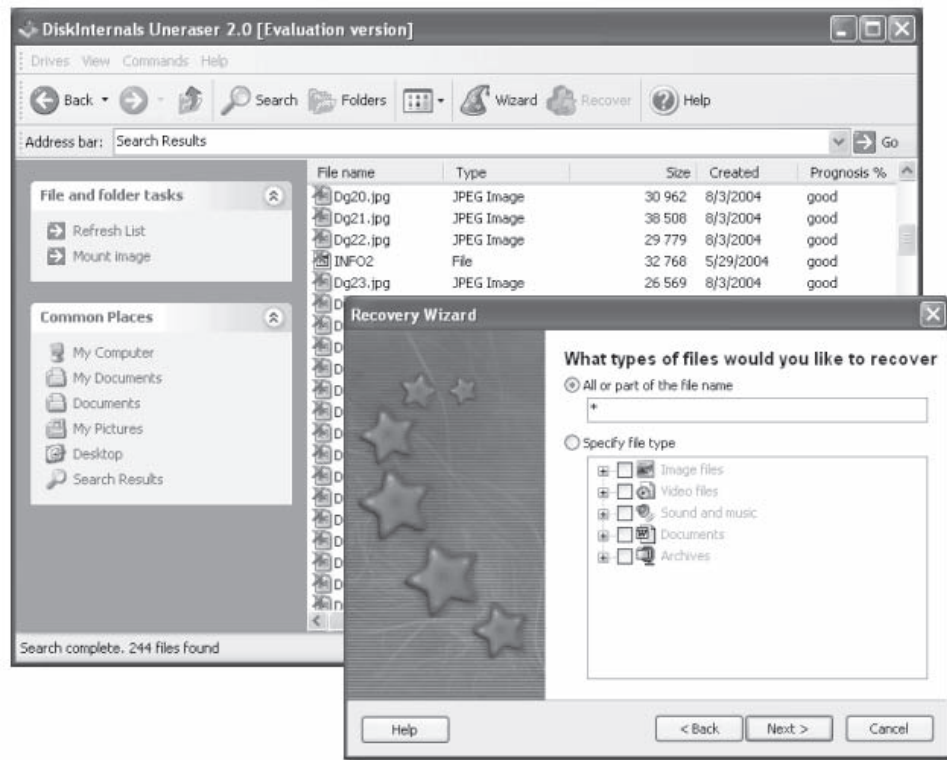
Media: Hard drives and removable media

Web Site: <http://www.diskinternals.com/>

Cost: \$39.95

DiskInternals Uneraser can recover any deleted file, including documents, photos, mp3s, and Zip files, or even folders and damaged disks. In addition to HDD, the program supports any type of storage media (music sticks, cameras, flash drives, USB drives, etc). It works with encrypted files and helps undelete files lost because of a virus attack, or an employee's malicious behavior.

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Source: <http://www.diskinternals.com/>. Accessed 2/2007.

Figure 4-11a This screenshot shows DiskInternals Uneraser.

The following are some of the features of DiskInternals Uneraser:

- Standard Windows Explorer interface, drag-and-drop support.
- Works under Microsoft Windows 95, 98, ME, NT, 2000, XP, 2003 Server.
- Supported file systems: FAT12, FAT16, FAT32, NTFS (NT 4), NTFS5 (2000, XP).
- Supports hidden file systems: Hidden FAT12, Hidden FAT16, Hidden FAT32, and Hidden NTFS.
- Recovers compressed files (NTFS, NTFS5) and encrypted files (NTFS5).
- Ignores file access rights (NTFS).
- Recognizes localized names.
- Long file names support (FAT12, FAT16, and FAT32).

Figure 4-11a shows a screenshot from DiskInternals Uneraser.

Tool: eData Unerase

Operating Systems: Windows ME/NT/2000/XP/2003

File Types: All

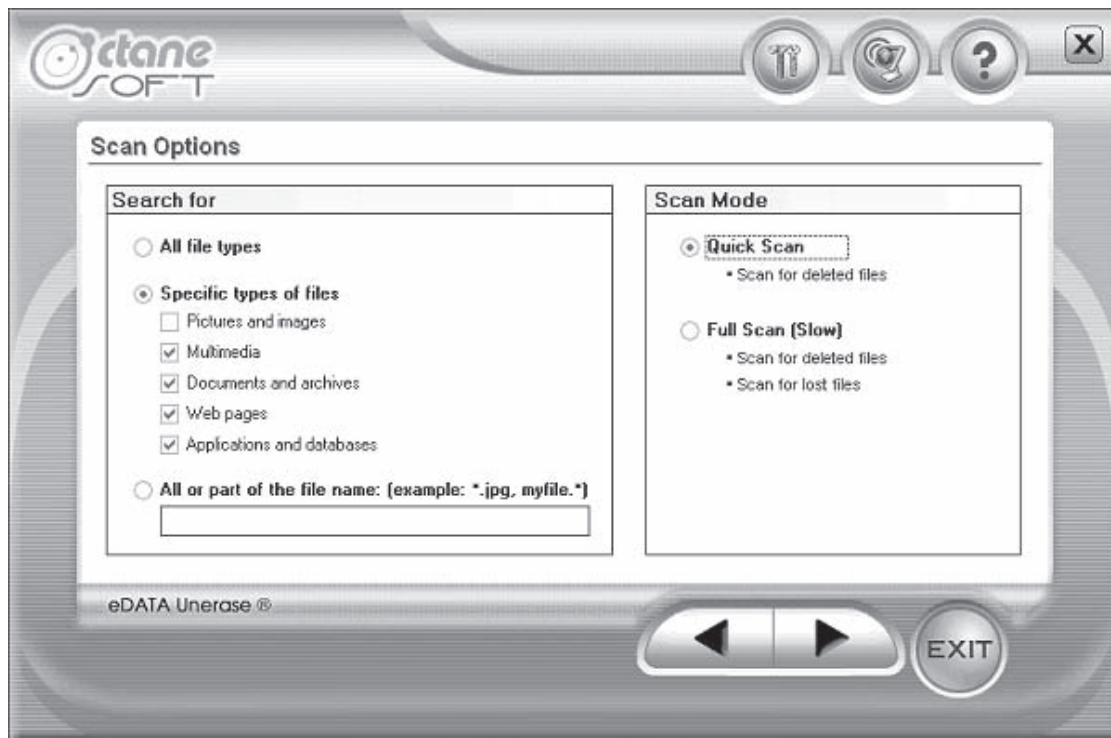
Media: Hard drives and removable media

Web Site: http://www.octanesoft.com/data_recovery.html

Cost: \$32.00 (for professional version)

eData Unerase recovers deleted files, files emptied from the Recycle Bin, and files lost due to the format of a hard drive, virus infection, unexpected system shutdown, or software failure. Simply use eData Unerase to perform hard drive data recovery, or recover deleted files from floppy disks, Zip drives, CompactFlash cards, SmartMedia cards, or other removable media types.

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Source: http://www.octanesoft.com/data_recovery.html. Accessed 2/2007.

Figure 4-12 This image shows eData Unerase. Notice that you can choose specific file types, and you have a choice of a quick scan or full scan.

It combines two methods to recover a user's files: Quick Scan (scan for deleted files) and Full Scan (scan for deleted and lost files). It also incorporates a search-specific facility, making file recovery easier and more effective.

The following are some of the features of eData Unerase:

- Recovers files from FAT12/16/32 and NTFS hard drives, Memory Sticks, USB flash drives, memory cards, removable media, and more
- Recovers files that have been removed or emptied from the Recycle Bin or lost due to a power failure or virus attack
- Full Scan (cluster scan) works on healthy and corrupted hard drives
- Easily scans for group of file types, and the deleted file list includes filters for sorting

Figure 4-12 shows a screenshot from eData Unerase.

Tool: Easy-Undelete

Operating Systems: Windows XP, 2000, 2003, and NT (can also recover from drives with Linux partitions)

File Types: All

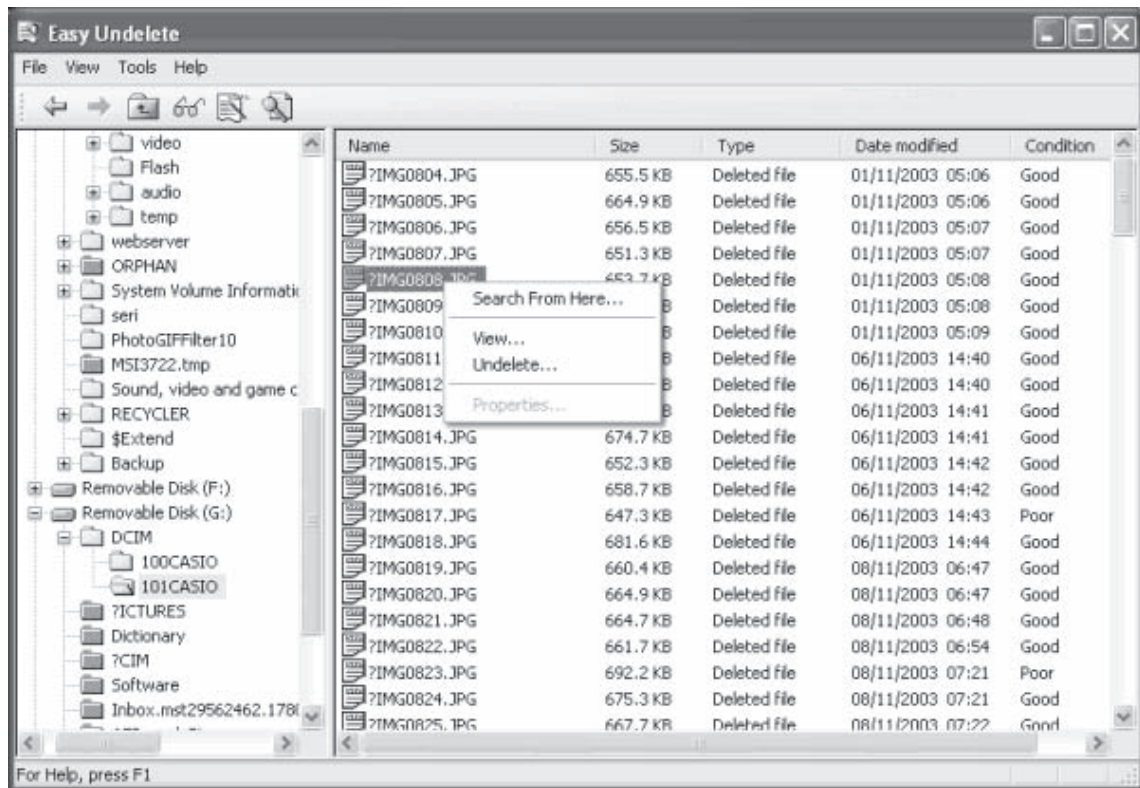
Media: Hard drives and removable media

Web Site: <http://www.easy-undelete.com/index.html>

Cost: \$23.00

Easy-Undelete is a powerful and user-friendly data recovery and undelete solution for Windows. It can recover lost files and folders on NTFS and FAT volumes, or on any physical storage device, and can preview images and binary files before recovery.

<https://t.me/learningnets>



Source: <http://www.easy-undelete.com/index.html>. Accessed 2/2007.

Figure 4-13 This image shows files that have been recovered using Easy-Undelete.

The following are some of the features of Easy-Undelete:

- Recovers lost or accidentally deleted files on any physical storage device, including memory cards, Disk-On-Key drives (thumb drives), Zip disks, reformatted volumes, repartitioned volumes, and drives with non-Windows partitions, such as Linux or OS X partitions
- Deleted file and folder recovery from NTFS, FAT32, FAT16, and FAT12 volumes
- Runs on any version of Windows, and under Windows XP, 2000, 2003, and NT, Easy-Undelete 3.0 is based on a Unicode (a set of more than 100,000 coded characters that represent text-based systems in various languages) core and can scan and recover files with file names in any language
- Uses multiple scanning algorithms to make sure users have the best chances of finding the files or folders they lost
- Can preview JPEG, PNG, TIFF, GIF, BMP, ICO, TGA, PCX, WBMP, and PNM graphics files, without having to recover them first
- Can preview any other kind of file, in a hexadecimal view
- Can be used by advanced users to recover specific clusters; when certain clusters have been lost, Easy-Undelete can preview the contents of the remaining clusters
- Runs without installation

Figure 4-13 shows a screenshot from Easy-Undelete.

Tool: File Recover

Operating Systems: Windows 2000/XP/Vista

File Types: All

Media: Hard drives

Web Site: <http://www.pctools.com/file-recover/>

Cost: \$39.90

File Recover allows a user to recover documents and files that have been lost by accidental deletion. These files may be lost by the emptying of the Recycle Bin, or by using other deletion actions that bypass the Recycle Bin altogether. Such actions include Windows SHIFT+DELETE, command line deletion, deleting excessively large files, or using applications that delete files without the Recycle Bin.

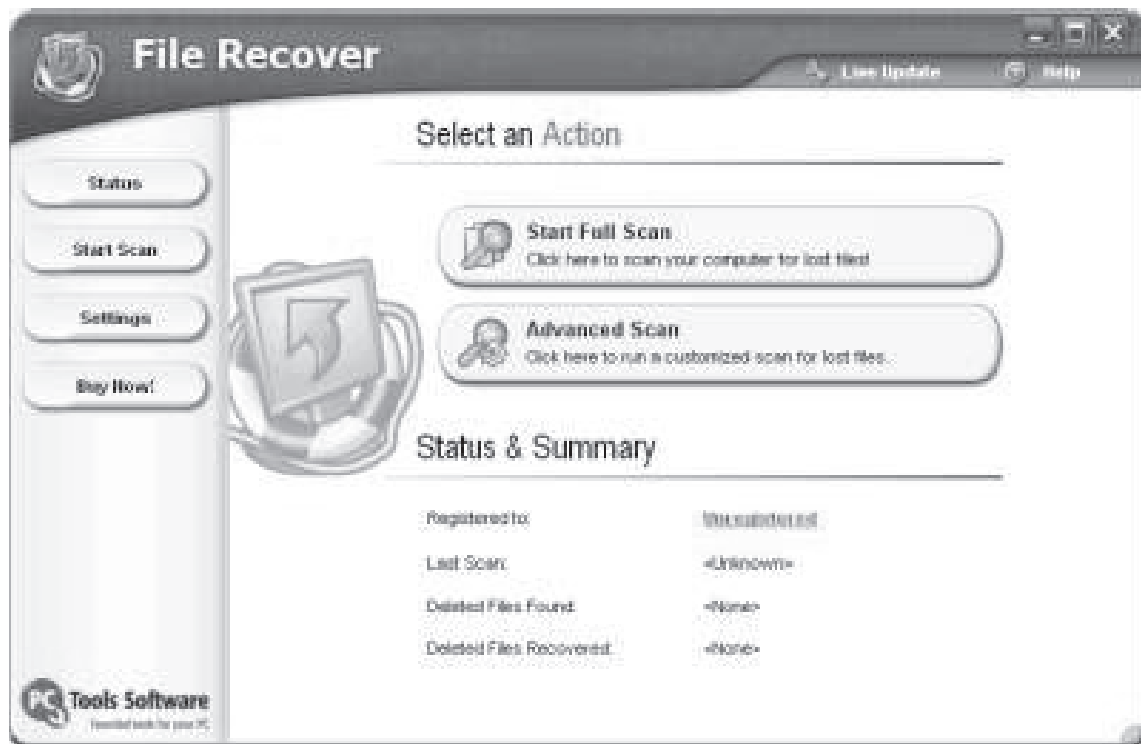
File Recover identifies the contents of such lost files on the hard drive, and allows the user to recover them. If a file has been partially overwritten, File Recover attempts to reconstruct as much of the file as possible, with the remaining contents. This allows the user to salvage at least part, if not all, of that recovered file to continue using it as required.

It supports hard disks for FAT12/16/32 and NTFS file systems and will recover files on logical and physical hard disks. The programs also support batch file recovery.

The following are some of the features of File Recover:

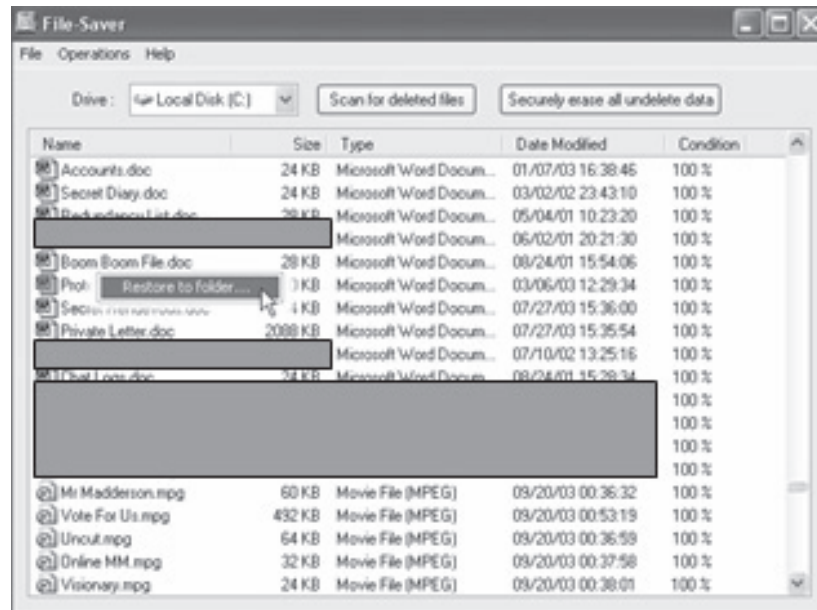
- Recovers files instantly from hard drives, floppy drives, and other types of fixed media; if the user is a home user or a network administrator, File Recover fills a critical gap in his or her data protection strategy.
- Rapid scan engine; a typical hard drive can be scanned for recoverable files within minutes.
- Scans all files and directories on selected hard drives
- Searches for a recoverable file by using part, or all, of its file name
- Utilizes a nondestructive, read-only file recovery approach; File Recover will not write or make changes to the section of the drive from which it is recovering data.
- Batch file recovery (recovers multiple files in one action)
- Works around bad-sector disk areas and recovers data where other programs fail
- Supports standard IDE/ATA/SCSI hard drives, including drives larger than 8 GB
- Supports hard drives formatted with Windows FAT16, FAT32, and NTFS file systems

Figure 4-14 shows a screenshot from File Recover.



Source: <http://www.pctools.com/file-recover/>. Accessed 2/2007.

Figure 4-14 This image shows the opening screen of the File Recover application.



Source: <http://www.file-saver.com>. Accessed 2/2007.

Figure 4-15 This image shows files that can be recovered using the File-Saver application.

Tool: File-Saver

Operating Systems: Windows 95/98/NT/2000/ME/XP/.NET Server

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.file-saver.com>

Cost: Approximately \$34.95

The File-Saver application restores hundreds of files that have been deleted from Windows machines whether they were deleted by another program, or emptied from the Recycle Bin. If it has been deleted, File-Saver can undelete it.

The tool can check whether or not the data lost can be recovered successfully. This function is helpful for users as they can be ensured of the data that is lost permanently.

This tool supports unlimited file recovery. Additionally, all undelete information related to the system can be erased with the help of this tool. Repeatedly overwriting the reusable areas of the deleted files by random data achieves this.

Figure 4-15 shows a screenshot from File-Saver.

Tool: File Scavenger

Operating Systems: Windows NT/2000/XP

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.quetek.com/prod02.html>

Cost: \$49.00

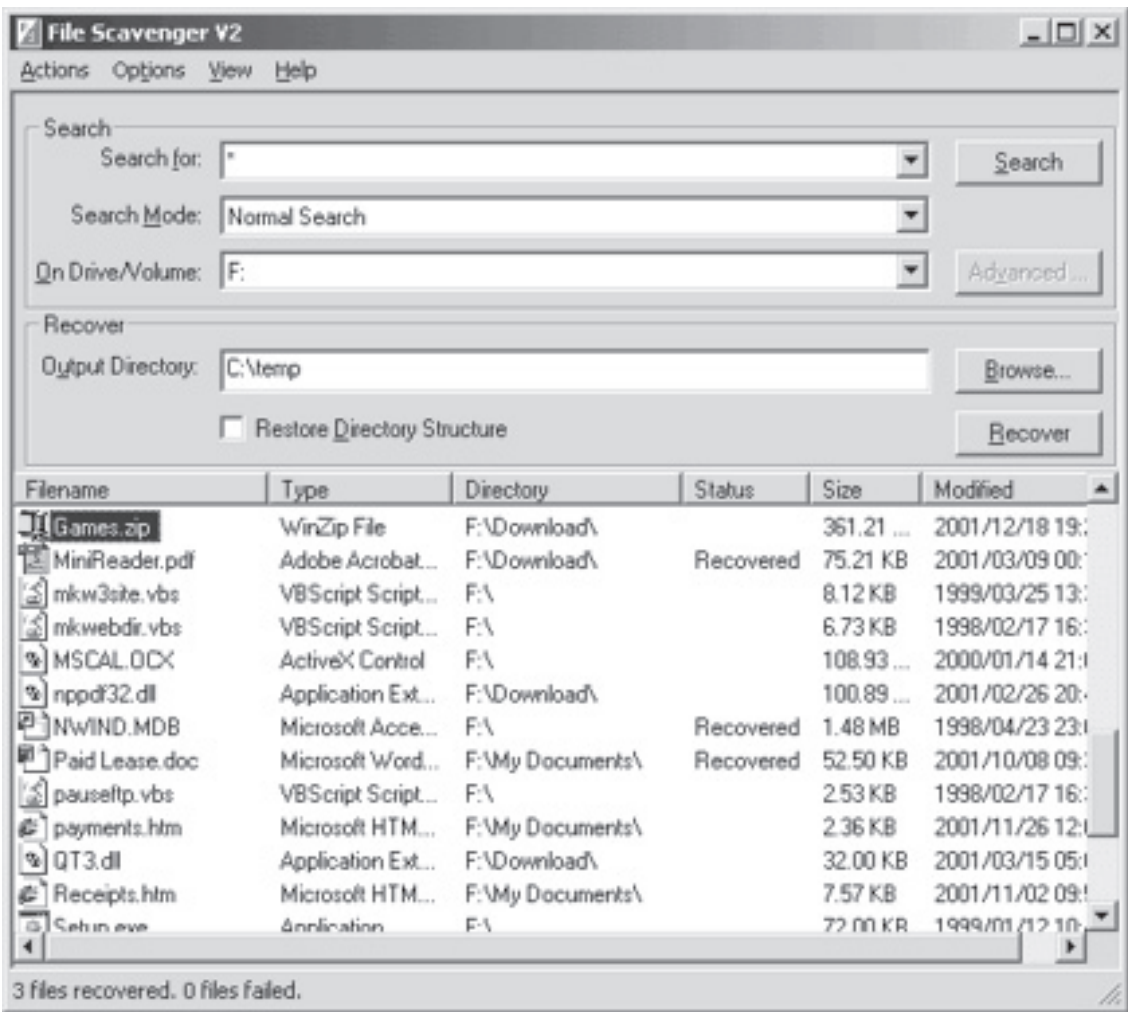
File Scavenger is a Windows NT/2000/XP file undelete utility that can recover accidentally deleted files. This includes files that have been removed from the Recycle Bin, DOS shell, network drives, or Windows Explorer. This tool supports file compression, dynamic disks, alternate data streams, sparse files, and so on.

The File Scavenger application supports both basic and dynamic disks. The File Scavenger application can recover files that have been reformatted or are in corrupted volumes by using the Defunct Volume Search, which can scan the entire drive to find traces of defunct or stripped volumes. File Scavenger is equipped with advanced algorithms to transparently handle disks that have many bad sectors or badly corrupted partitions. The software can be installed on a hard drive or run from a floppy disk.

File Scavenger version 3 can recover files that have been accidentally deleted (including files removed from the Recycle Bin, in a DOS window, from a network drive, or from Windows Explorer with the Shift key held down), provided that recovery is attempted before the files are permanently overwritten by new data. File Scavenger supports: basic and dynamic disks, NTFS compression, alternate data streams, and sparse files.

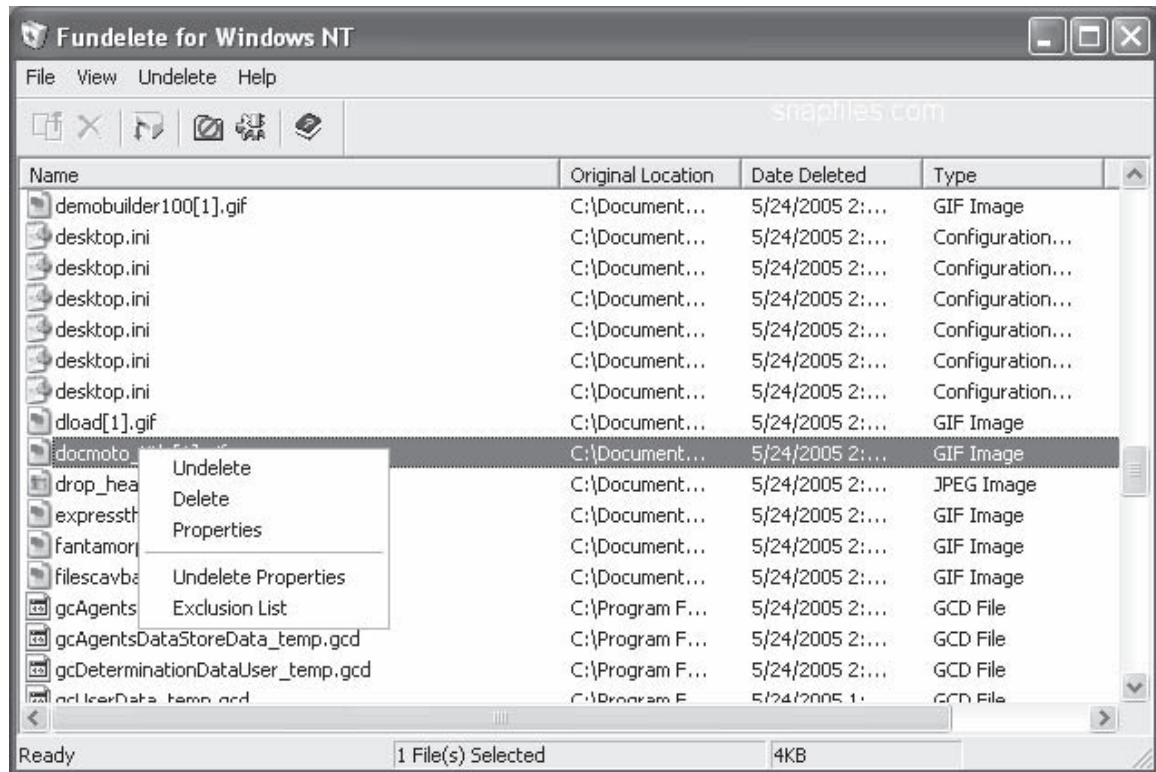
File Scavenger can also recover files from a reformatted or corrupted volume. This is even possible when the volume has been deleted, and its original position and size are unknown. This tool can scan an entire physical hard drive to look for traces of defunct volumes. File Scavenger uses advanced algorithms to transparently handle disks with many bad sectors and badly corrupted partitions. The software can be installed on a hard drive, or run from a portable storage device such as a Memory Stick, removable drive, CD, or floppy disk. To run File Scavenger, a user must log on as a system administrator to the computer where data recovery is intended.

Figure 4-16 shows a screenshot from File Scavenger.



Source: <http://www.quetek.com/prod02.html/>. Accessed 2/2007.

Figure 4-16 This image shows files that have been recovered by File Scavenger.



Source: <http://www.sysinternals.com/Utilities/Fundelete.html>. Accessed 2/2007.

Figure 4-17 This image shows files that can be undeleted from the C: drive by the Fundelete application.

Tool: Fundelete

Operating Systems: Windows ME/2000/XP

File Types: All

Media: Hard drives

Web Site: <http://www.sysinternals.com/Utilities/Fundelete.html>

Cost: Free

The Fundelete tool works just like the Recycle Bin in standard Windows. In NT 4.0, the Recycle Bin stores only those files that are deleted from the Explorer GUI, and files deleted from command window, or from other programs deleted permanently. Fundelete works as the Recycle Bin in Windows, and stores all the files deleted from any program so that it is easy to restore them. It has the same configuration as the Recycle Bin. Fundelete also has filtering ability so that it does not send certain designated files, based on the file extension, to the Recycle Bin. Files such as editor backup files, and temporary files can be filtered out and directly deleted.

Fundelete notes and can recover those files that are deleted after the application's installation.

Figure 4-17 shows a screenshot from Fundelete.

Tool: Handy Recovery

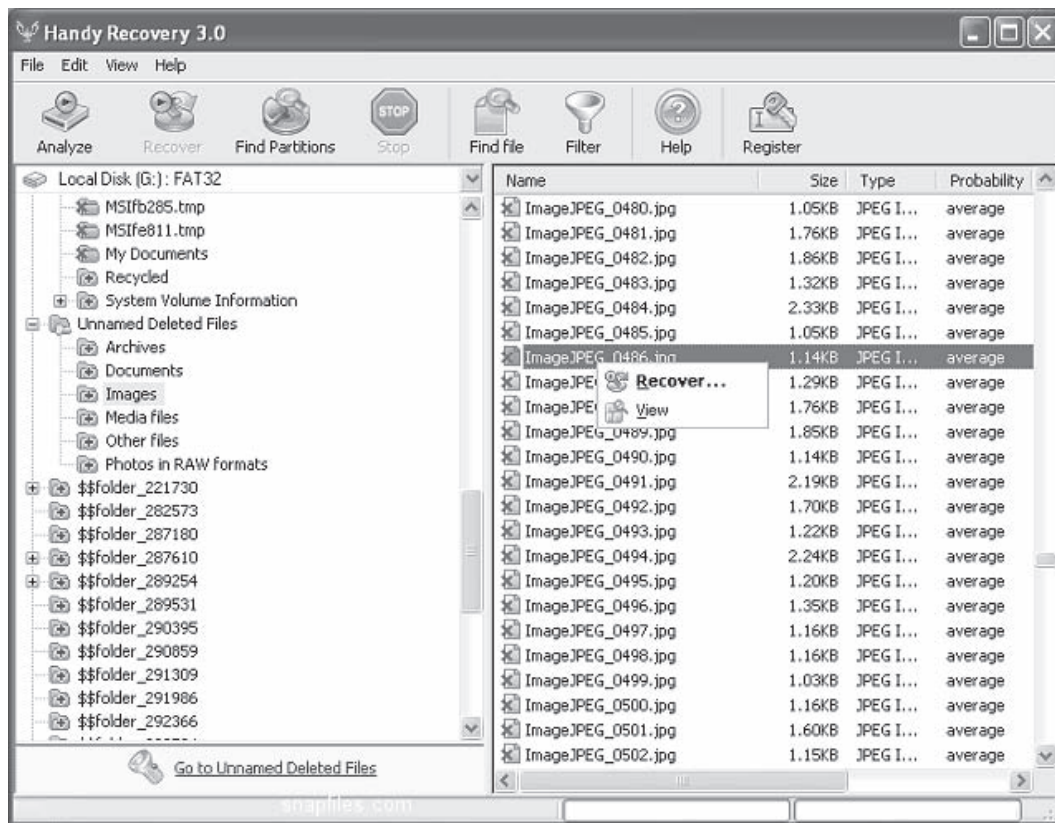
Operating Systems: Windows 9x/ME/NT/2000/XP/2003/Vista

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.handyrecovery.com/>

Cost: \$165.00



Source: <http://www.handyrecovery.com/>. Accessed 2/2007.

Figure 4-18 This image shows the Handy Recovery tool. Notice how you can set the tool to search for partitions as well as single files.

Handy Recovery is designed to restore files accidentally deleted from hard disks and floppy drives. The program can recover files damaged by virus attacks, power failures, and software faults, or files from deleted and formatted partitions. If some programs do not use the Recycle Bin when deleting files, Handy Recovery can restore such files. It can also recover files moved to Recycle Bin after the Recycle Bin has been emptied.

With Handy Recovery, users can browse the contents of their disks like they do in Windows Explorer. The only difference is that they see deleted files and folders along with the regular ones. The program can search for files by name or mask and show the probability of successful recovery for each file. Recovered files can be saved to any disks accessible on your system.

Users can also restore the full branch of the folders tree containing selected files and folders. Along with the main file data, the program can recover alternate data streams that are used on the NTFS file system to store additional information about files.

Handy Recovery supports all Windows file systems for hard and floppy drives including FAT12/16/32, NTFS/NTFS5 and image recovery from CompactFlash, SmartMedia, MultiMedia, and Secure Digital cards. It can recover compressed and encrypted files on NTFS drives.

Figure 4-18 shows a screenshot from Handy Recovery.

Tool: Mycroft

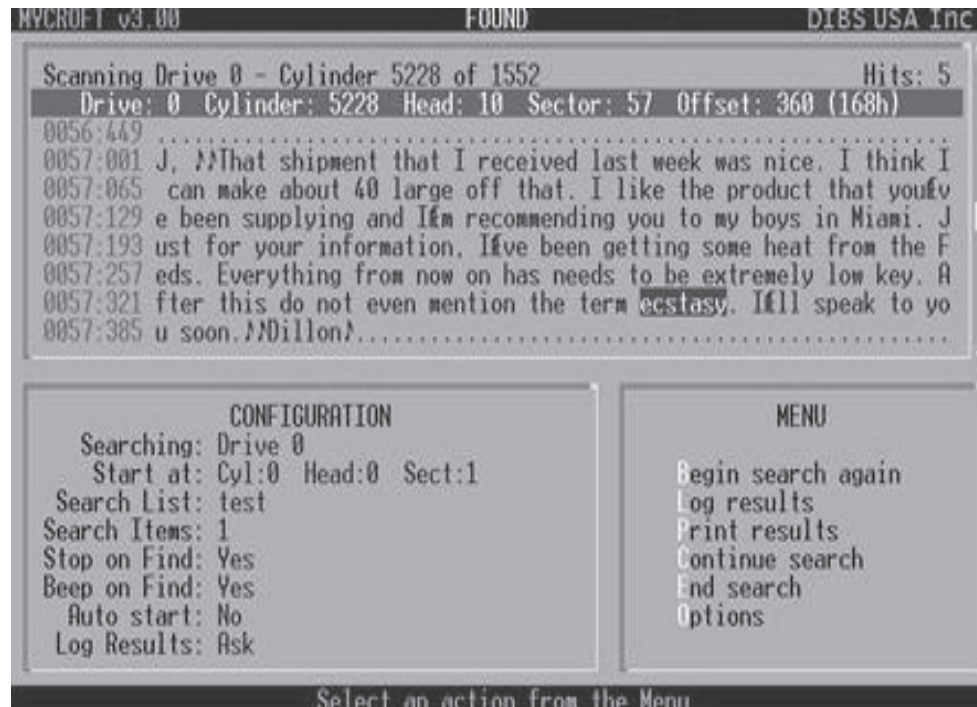
Operating Systems: Windows XP

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.dibsusa.com>

Cost: \$165



Source: <http://www.dibsusa.com>. Accessed 2/2007.

Figure 4-19 This image shows the Mycroft tool. It can search for incriminating data using keywords. The text in the deleted message in this image highlights the key term: *ecstasy*.

Mycroft is an efficient, high-speed search engine that is useful for forensic investigators. This tool helps search a suspect's computer hard disks for evidence at the rate of 5 MB per second. The searches can be started on any PC-based operating system. This tool can help forensic investigators eliminate systems from an investigation without copying, and "sniff out" relevant terms on a suspect computer on-site, when searching for or seizing specific evidence.

When an investigator carries out a search, Mycroft locks the suspect drive to prevent any change in the information in the drive. The investigator then has the freedom to search for the target data, without corrupting the evidence on the drive. The Mycroft application has an added advantage of allowing the investigator to specify up to 460 search items, which can include text files or images. All the search items are saved onto a boot disk and can be entered prior to the search, to save time for the investigation. This application also marks each physical location of a search hit so that it will be able to log it onto the boot disk.

The Mycroft tool is used for the following purposes:

- Sorting out suspect computers from a given pool before copying the data
- Searching unallocated sectors in the disk to map the given information in order to identify stolen computers
- Searching for references to specific types of crimes on the suspect systems
- Conducting the first high-speed search to test the search attributes

Figure 4-19 shows a screenshot from Mycroft.

Tool: O&O UnErase

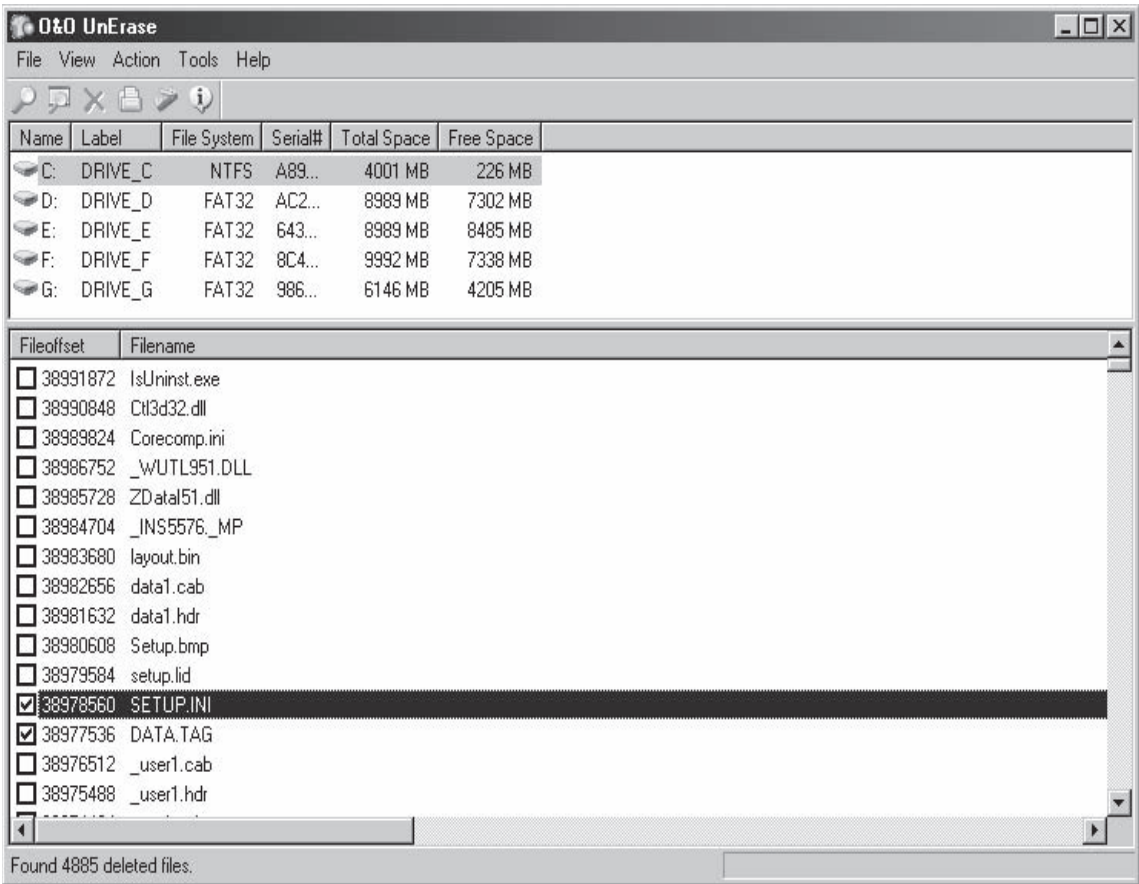
Operating Systems: Windows NT/2000/XP

File Types: All

Media: Hard drives and removable media, including some digital cameras

Web Site: <http://www.oo-software.com/home/en/products/oonerases/>

Cost: \$29.95



Source: <http://www.oo-software.com/home/en/products/oonerases/>. Accessed 2/2007.

Figure 4-20 This image shows the O&O UnErase tool. Notice that it can search both NTFS and FAT file systems on different drives or partitions at the same time.

With O&O UnErase, investigators can recover data that was deleted from the hard disk due to virus attacks or software problems, or accidentally, by using an innovative algorithm, allowing many files to be restored at one time.

This tool is also equipped with a helpful user interface that enables users to recover deleted files. The GUI is similar to that of Windows Explorer.

Figure 4-20 shows a screenshot from O&O UnErase.

Tool: PC Inspector File Recovery

- Operating Systems:** Windows
- File Types:** All
- Media:** Hard drives
- Web Site:** http://www.pcinspector.de/Sites/file_recovery/info.htm?language=1
- Cost:** Free

When a boot sector is damaged or a file is erased from the system, PC Inspector File Recovery recovers lost files and finds partitions automatically. This utility supports the FAT and NTFS file systems, and enables file recovery with the original time and date stamp. It can recover files without the header entry and can restore them to the network drive, if required. PC Inspector File Recovery scans drives and automatically adds recovered files to an Explorer-style navigation tree retrieved from the deleted folder.

Figure 4-21 shows a screenshot from PC Inspector File Recovery.



Source: http://www.pcinspector.de/Sites/file_recovery/info.htm?language=1. Accessed 2/2007.

Figure 4-21 This image shows the PC Inspector File Recovery tool.

Tool: R-Undelete

Operating Systems: Windows 9x, ME, NT, 2000, XP, 2003, and Vista

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.r-undelete.com/>

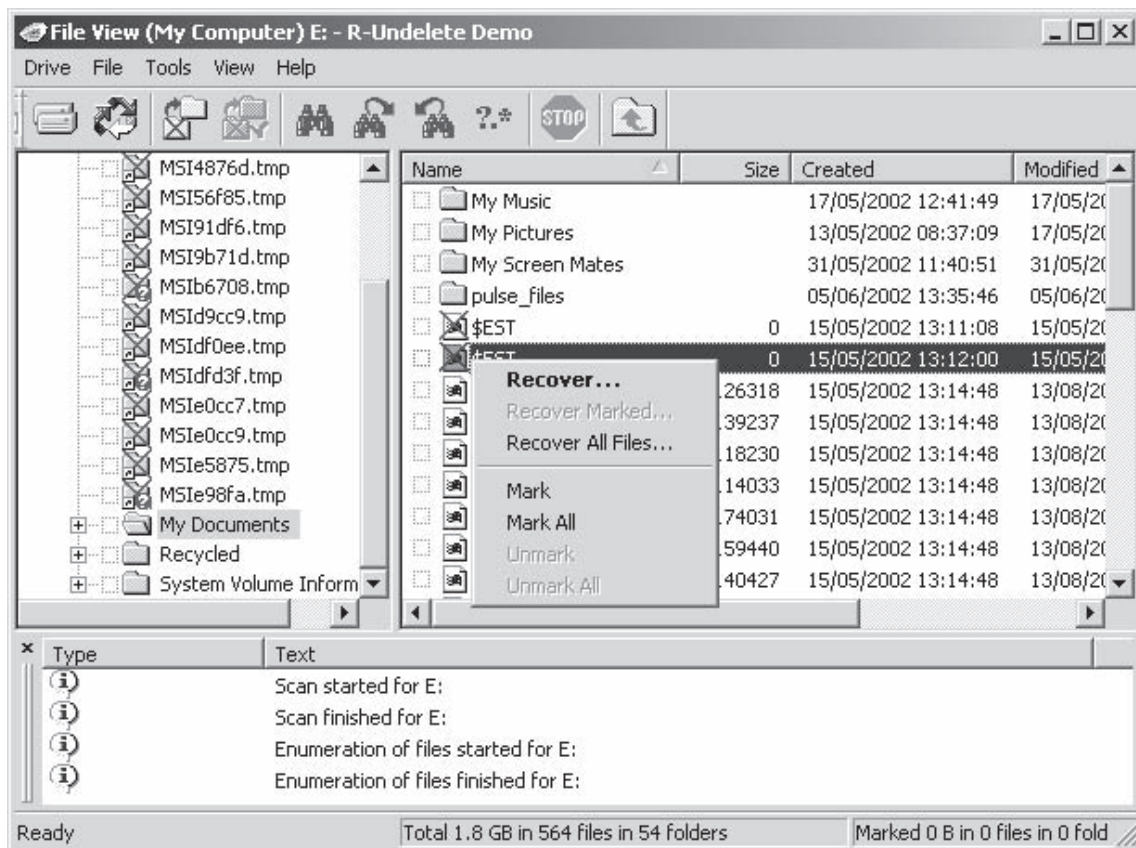
Cost: \$54.99

R-Undelete is an inexpensive solution for FAT and NTFS file systems. R-Undelete can undelete files on any valid logical disks visible by the host OS. It cannot, however, undelete files on damaged or deleted volumes, or in the case of hard drive repartitioning. R-Undelete 3.0 has a wizard-style interface and additional file recovery algorithm that increases file recovery quality.

The following are some of the features of R-Undelete:

- Recovers files that were:
 - Removed without the Recycle Bin, or when the Recycle Bin has been emptied
 - Removed by virus attack or power failure
- Undeletes lost files from FAT (FAT12, FAT16, FAT32), NTFS, and NTFS5
- Recovers NTFS compressed, encrypted files, and alternative data streams
- Recovers files on damaged or deleted partitions
- Reconstructs damaged RAID

Figure 4-22 shows a screenshot from R-Undelete.



Source: <http://www.r-undelete.com/>. Accessed 2/2007.

Figure 4-22 This image shows the R-Undelete tool.

Tool: Recover My Files

Operating Systems: Windows

File Types: All

Media: Hard drives

Web Site: <http://www.recovermyfiles.com/>

Cost: \$99.95

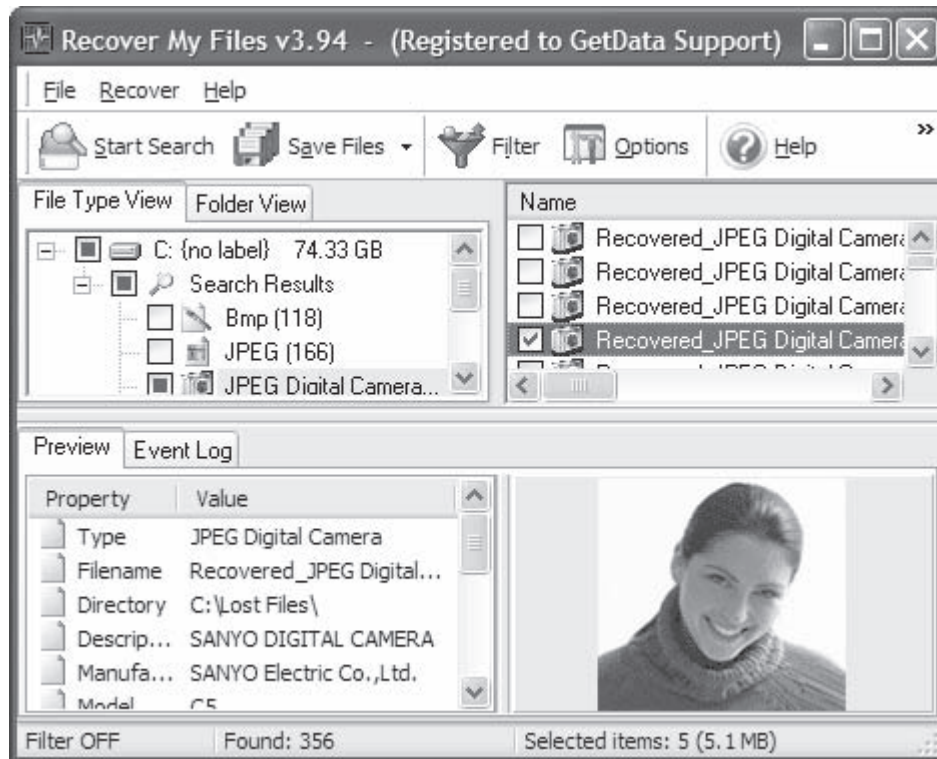
Recover My Files data recovery software will recover deleted files emptied from the Windows Recycle Bin, or files lost due to the format or corruption of a hard drive, virus or Trojan infection, unexpected system shut-down, or software failure.

The following are some of the features of Recover My Files:

- Recovers deleted files, even if emptied from the Recycle Bin
- Recovers formatted hard drives, even if the user has reinstalled Windows
- Recovers a user's files after a hard disk crash
- Retrieves files after a partitioning error
- Recovers documents, photos, video, music, and e-mail
- Recovers files from hard drive, camera card, USB, Zip, floppy disk, or other media
- Recover My Files is compatible with Windows XP and works with FAT12, FAT16, FAT32, NTFS, and NTFS5 file systems

Figure 4-23 shows a screenshot from Recover My Files.

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Source: <http://www.recovermyfiles.com/>. Accessed 2/2007.

Figure 4-23 This image shows the Recover My Files tool. Notice that it can preview image files before recovering them.

Tool: Recover4all Professional

Operating Systems: Windows Vista/XP/2000/NT/ME/98/95

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.recover4all.com/>

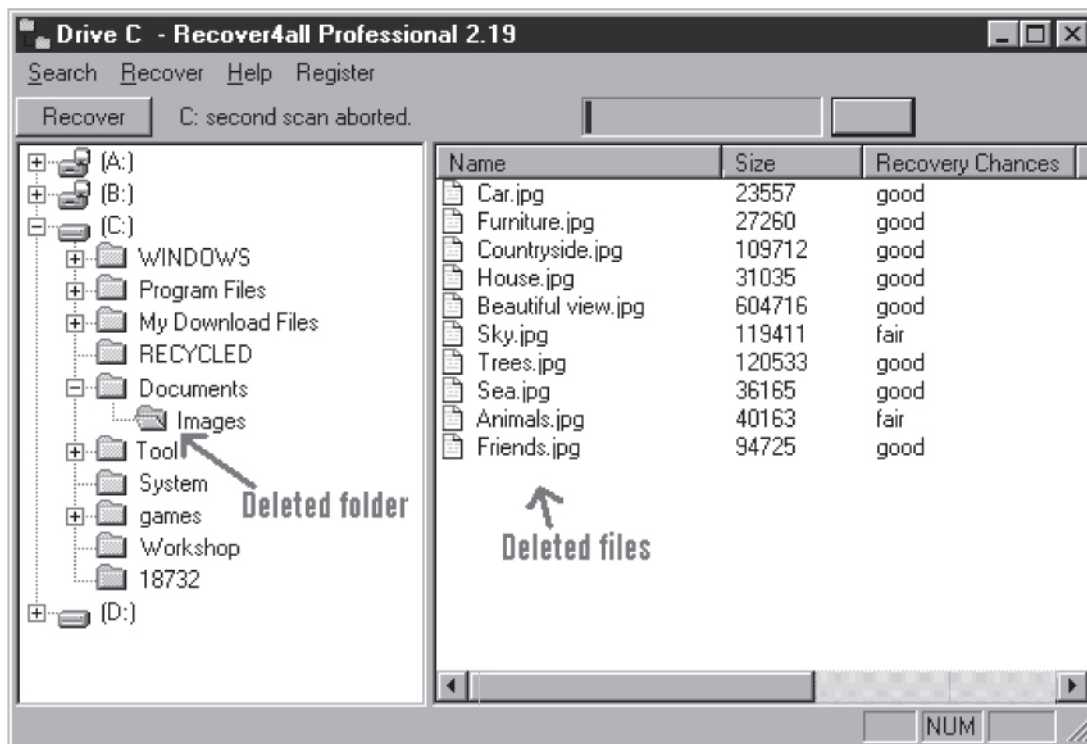
Cost: \$49.00

With Recover4all Professional software, a user can recover files that were accidentally deleted in Windows. It does not matter if the files went through the Recycle Bin, and have been lost since the bin was emptied, or were directly deleted. To prevent files that were already deleted from becoming overwritten, Recover4all does not require installation, and can run directly from a floppy disk.

The following are some of the features of Recover4all Professional:

- Supports all file types including documents, images, movies, and music
- Can recover from formatted drives and within deleted folders
- Supports all NTFS and FAT file systems, all kinds of compressed drives and files, Windows ME/XP protected files, all RAID levels, and all third-party encrypted drives not encrypted by Windows
- Supports long file names in all languages
- Supports drives recognized by Windows with IDE, SCSI, USB, PCMCIA, and other interfaces
- Supports local internal and external drives, such as hard disks; removable drives, like Zip drives, floppy disks, and magneto-optical discs, and all memory cards like CompactFlash, SmartMedia, Secure Digital, and Memory Stick

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Source: <http://www.recover4all.com/>. Accessed 2/2007.

Figure 4-24 This image shows the Recover4all tool.

- Multithreaded on FAT drives: a user can browse and recover while the program still searches deleted files
- Does not require installation to protect already deleted files from becoming overwritten
- Does not recover files to the drive where they were deleted from, in order to protect them from becoming overwritten

Figure 4-24 shows a screenshot from Recover4all Professional.

Tool: Restorer2000

Operating Systems: Windows

File Types: All, including compressed files

Media: Hard drives, including RAID systems, and removable media

Web Site: <http://www.restorer2000.com/>

Cost: \$29.95

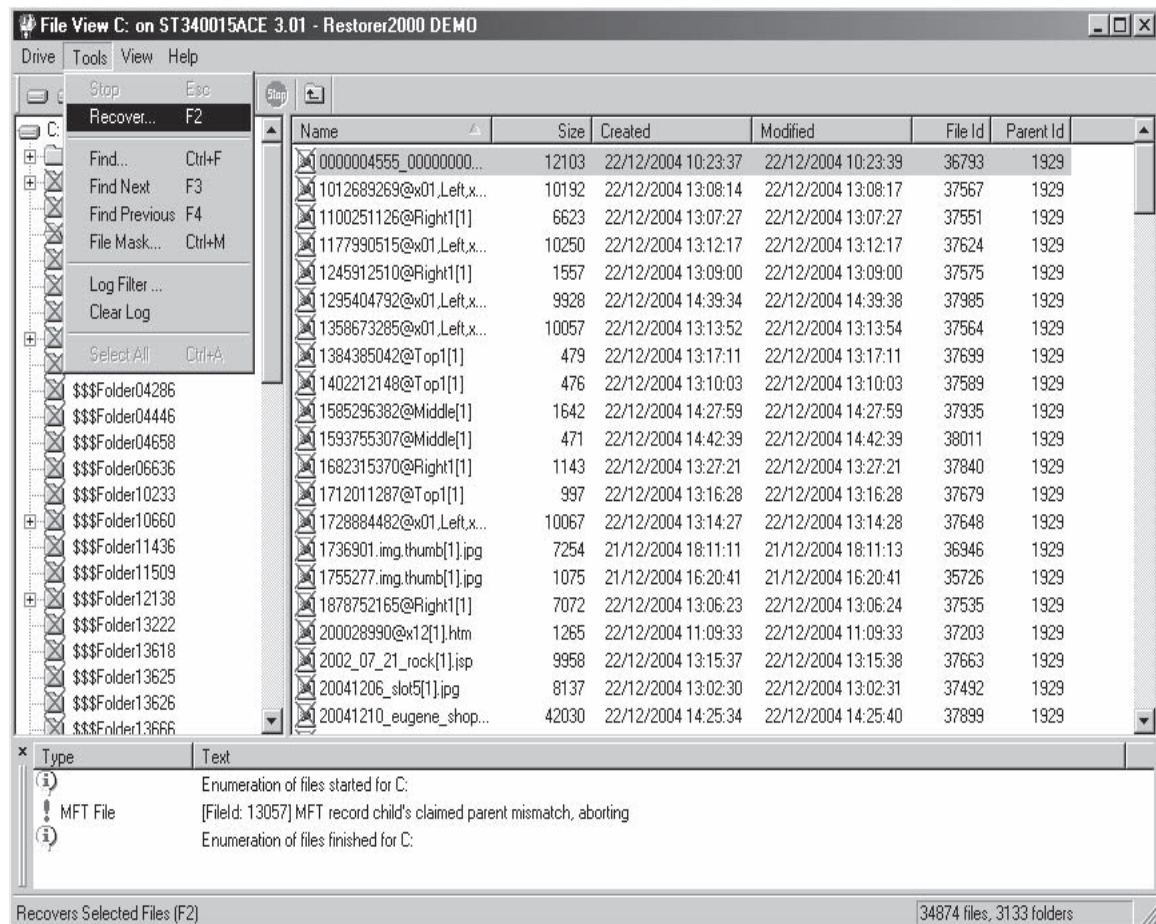
Restorer2000 can recover data in NTFS or FAT partitions that has been deleted, erased, or reformatted due to the following reasons:

- The Recycle Bin is emptied or files are deleted using the Shift+Delete key combination.
- The file was deleted due to hardware/software misconfiguration, power failure, or virus attack.
- The hard drive has been accidentally formatted.
- There were problems during boot up.

The Restorer2000 application can recover files with foreign language file names, long file names, NTFS-compressed file names, and alternative data streams, such as Windows 2000 file information. The software has adjustable parameters that give the forensic investigator full control over the recovery procedure. Drive image creation is also a feature of this tool, as long as the system's hardware is fully functional.

Figure 4-25 shows a screenshot from Restorer2000.

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Source: <http://www.restorer2000.com/>. Accessed 2/2007.

Figure 4-25 This image shows the Restorer2000 tool.

Tool: Search and Recover

Operating Systems: Windows

File Types: All, including e-mail messages

Media: All hard drives and removable media

Web Site: <http://www.iolo.com/>

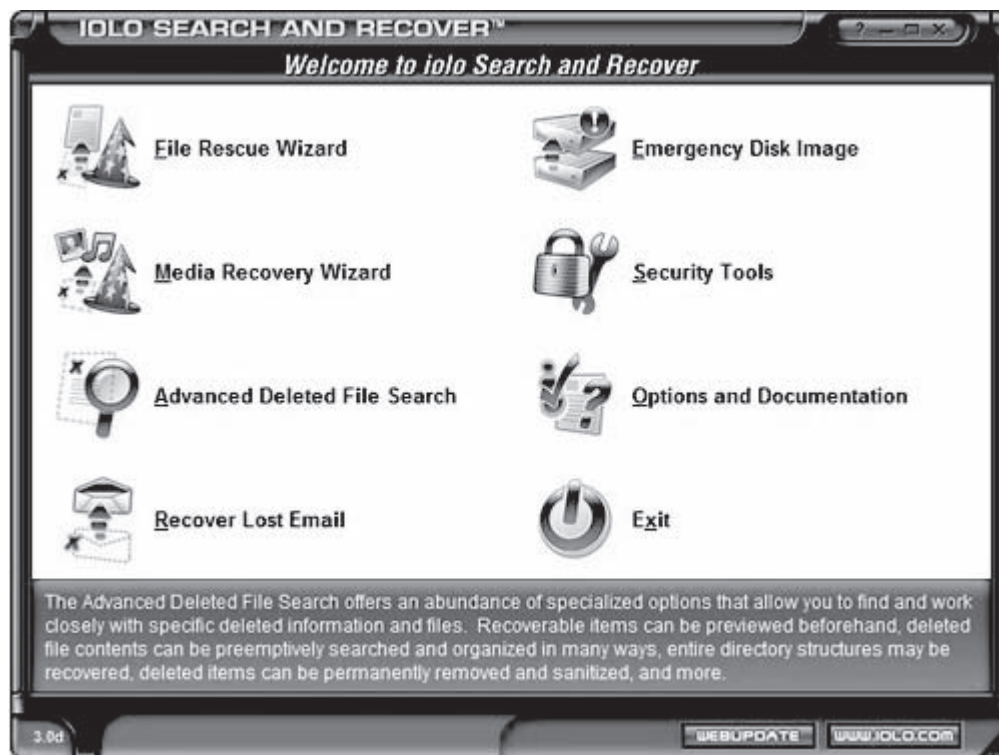
Cost: \$29.95 (shareware)

Search and Recover combines powerful technology with intuitive features to rescue data from a user's drives or devices. Search and Recover allows the investigator to quickly recover deleted or destroyed files, folders, songs, pictures, videos, programs, critical system components, Web pages, and e-mail messages in Microsoft Outlook and Outlook Express, Netscape, and Eudora.

The following are some of the features and advantages of Search and Recover:

- *Recovers data to optical media:* Saves recovered data directly to CD or DVD to keep it safe from further harm
- *Immediate recovery:* Runs rescue tools directly from a CD to prevent further data loss and ensure recovery results

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Source: <http://www.iolo.com/>. Accessed 2/2007.

Figure 4-26 This image shows the Search and Recover tool. This application allows users to recover files as well as e-mail messages.

- *Disk imaging*: Makes data recovery easy by creating mirror copies of entire drives prior to or after a disaster
- *Virtual drives*: Keeps data safe by creating virtual, or logical, drives that work just like a normal hard drive, CD, or DVD
- *Secure file deletion*: Permanently erases sensitive information from a user's PC or digital device
- *Extended Outlook recovery*: Recovers deleted tasks, notes, journals, contacts, and more from Microsoft Outlook

Figure 4-26 shows a screenshot from Search and Recover.

Tool: SUPERFileRecover

Operating Systems: Windows 98, 98SE, ME, 2000, and XP

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.superfilerecover.com/>

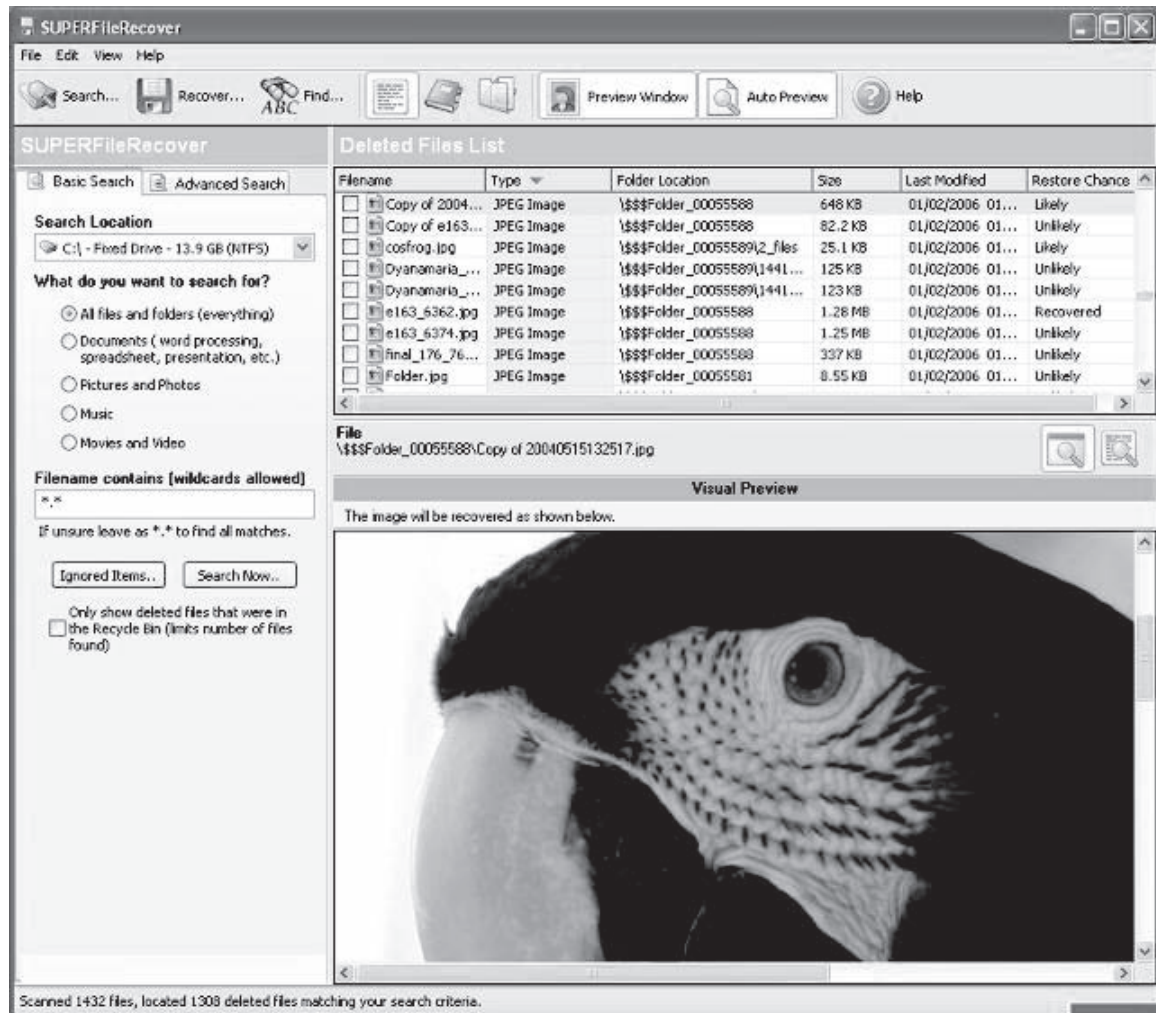
Cost: \$29.95

SUPERFileRecover can recover deleted files, such as documents, spreadsheets, pictures, and movies. The following are some of the features of SUPERFileRecover:

- Utilizes read-only scanning, so that the data on a user's drive remains intact no matter how many times he or she scans and attempts recovery
- Searches most drives in less than one minute; search time varies depending on search criteria and the number of deleted files on the drive
- Previews text documents and pictures to find the specific file a user may have deleted

Figure 4-27 shows a screenshot of SUPERFileRecover.

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Source: <http://www.superfilerecover.com/>. Accessed 2/2007.

Figure 4-27 This image shows the SUPERFileRecover tool. This application previews images before they are recovered.

Tool: Undelete

Operating Systems: Windows NT 4.0 Workstation, 2000 Professional, XP Home Edition, XP Professional Edition

File Types: All

Media: Hard drives, including RAID arrays, and removable media

Web Site: <http://www.undelete.com/file-recovery.asp>

Cost: \$59.95

Undelete replaces the Windows Recycle Bin with a “Recovery Bin” that intercepts all deleted files, no matter how they were deleted. Undelete supports NTFS and 16/32-bit FAT file systems, but not the 12-bit FAT file system. (The 12-bit FAT file system is used on FAT volumes smaller than 16 MB in size, such as 1.44-MB floppy diskettes.) Right-click the file, select **Recover**, and the file is back. Undelete 5 includes Emergency Undelete, which can recover files deleted before Undelete was installed, provided they haven’t been overwritten on the user’s hard drive, and SecureDelete, an electronic shredder to completely erase confidential files.

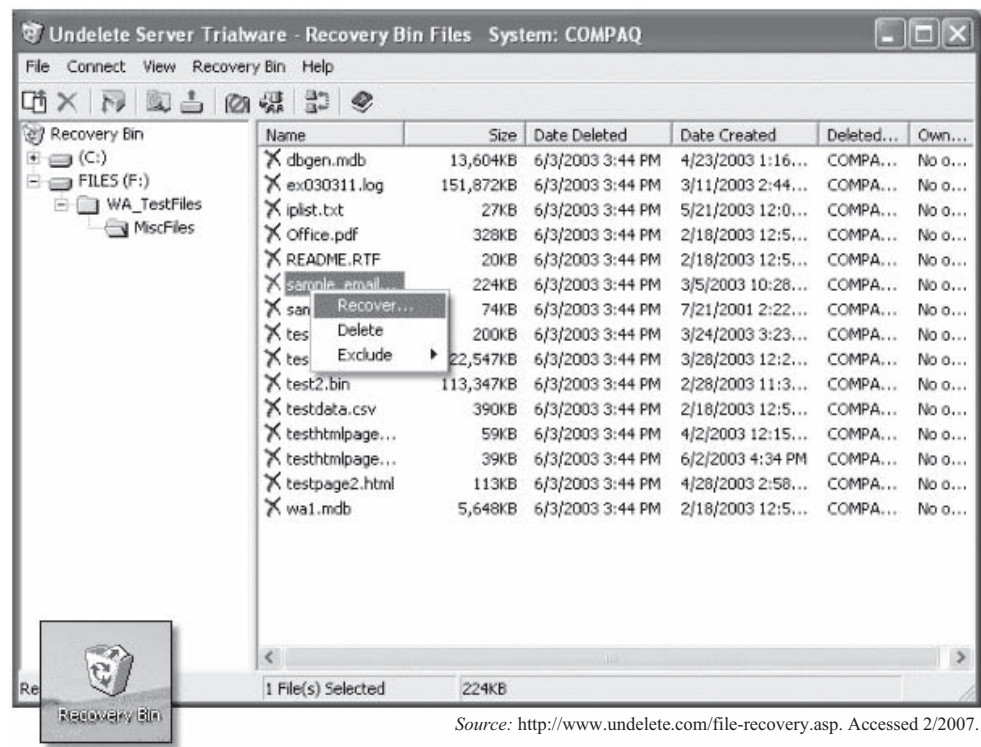


Figure 4-28 This image shows the Undelete tool. Notice the Recovery Bin feature in this image.

The following are some of the features of Undelete:

- Undelete automatically captures old versions of Microsoft Office files (Word, Excel, and PowerPoint), allowing for the recovery of earlier versions that have been saved over.
- The Recovery Bin mimics the directory structure of the user's disk, and includes a powerful search function, making it easy to find and recover files.
- The Undelete Professional Edition can connect to the Undelete Server Edition Recovery Bins installed on the network file servers. If a user deletes a file on a network share, he or she can recover it remotely from the system he or she is using.

Figure 4-28 shows a screenshot from Undelete.

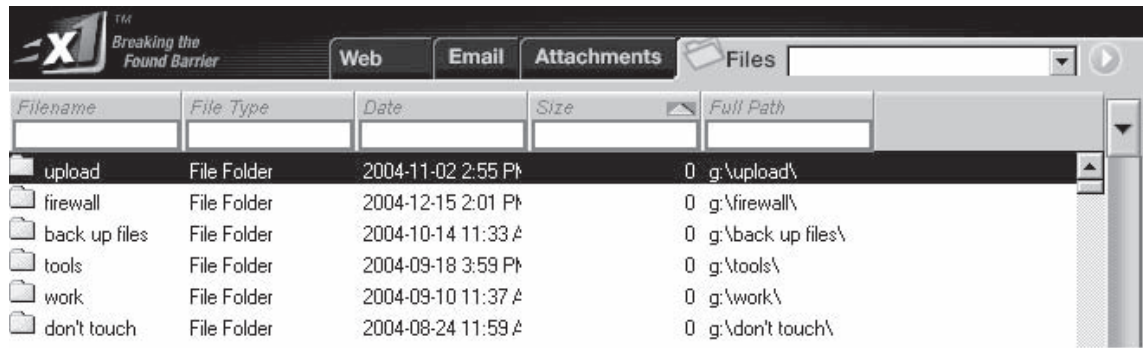
Tool: VirtualLab

Operating Systems: Windows/Mac OS 9.x and X
File Types: All
Media: Hard drives and removable media
Web Site: <http://www.binarybiz.com/vlab/>
Cost: \$39.95 (Windows); \$129.95 (Mac)

VirtualLab recovers deleted files from removable drive formats and digital camera media. It recovers files from disks no longer recognized by the operating system. The VirtualLab application also undeletes files thrown in the trash or deleted by a virus. It recovers deleted files and ghosted or damaged partitions. The program also recovers files after a format or restore from original system disks. It recovers damaged RAID servers and failed rebuilds. The X1 application quickly locates e-mails, files on the hard disk, and Web pages.

Figure 4-29 shows a screenshot of the columns generated by X1.

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Source: <http://www.binarybiz.com/vlab/>. Accessed 2/2007.

Figure 4-29 This image shows the VirtualLab X1 tool.

Tool: WinUndelete

Operating Systems: Windows 98/NT/2000/ME/XP/2003

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.winundelete.com/>

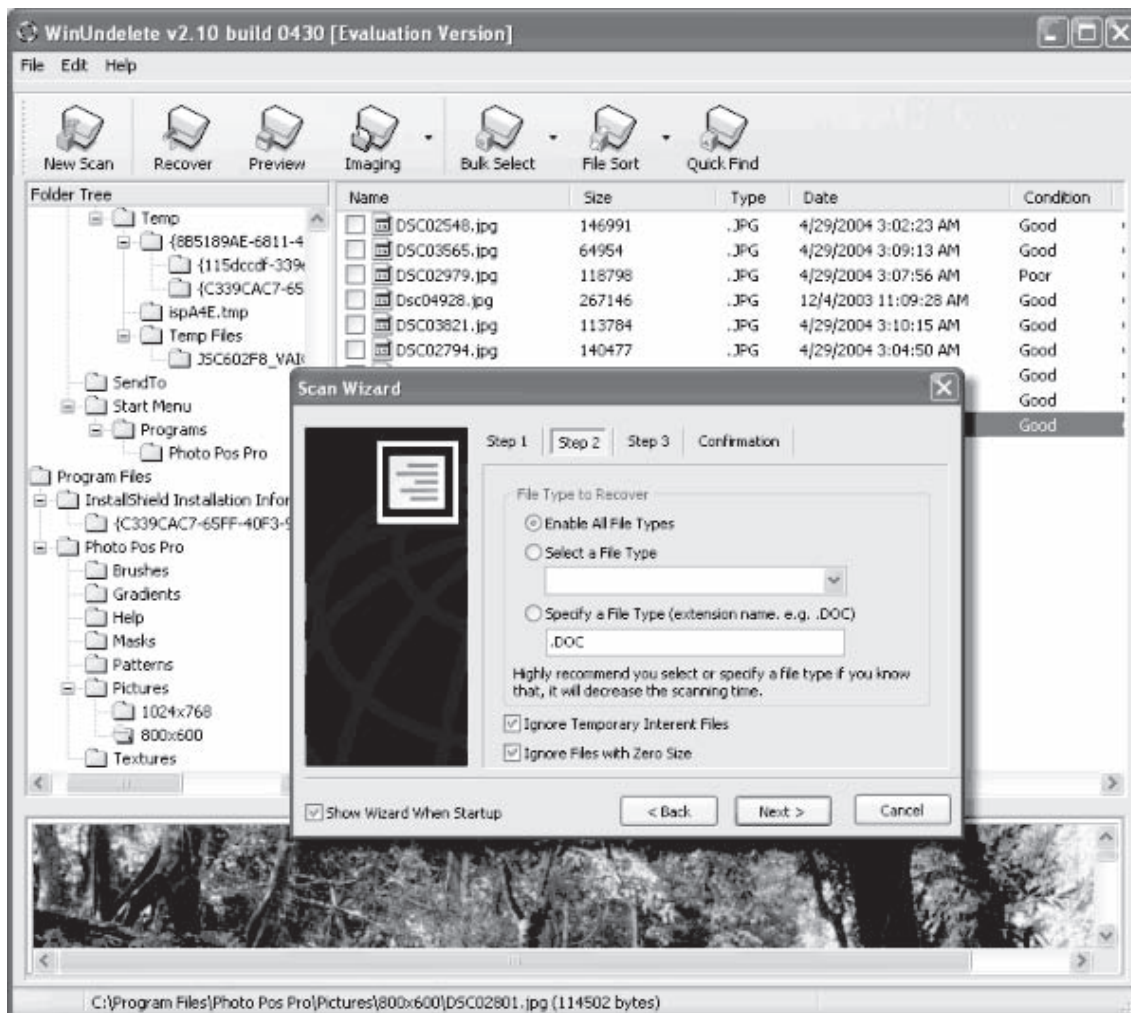
Cost: \$49.95

WinUndelete is part of the WinRecovery suite of applications. It can recover deleted files from hard drives, floppy disks, Zip drives, USB external drives, digital camera cards, and more. WinUndelete recovers deleted files after emptying the Recycle Bin, or using other deletion actions that bypass the Recycle Bin. WinUndelete can recover data from both FAT and NTFS, file systems.

The following are some of the features of WinUndelete:

- Supports FAT12/16/32, NTFS, and NTFS5 file systems
- Performs nondestructive and read-only scan and file recovery
- Sorts files by name, type, size, date, and more
- Displays a list of files or shows the entire folder structure
- Restores original create and modified file dates
- Supports non-English languages
- Filters files by extension and file type
- Bypasses temporary Internet files and zero-length files
- Enables partial file name and path name search
- Enables saving deleted files to WinUndelete image file before recovery
- Recovers NTFS compressed data streams
- Previews images, plain text, and Microsoft Office documents before recovery
- Recovers files deleted even after the user has emptied the Recycle Bin, files deleted accidentally from a network share, files deleted from the DOS command prompt, and files deleted in other applications, or by viruses

Figure 4-30 shows a screenshot from WinUndelete.



Source: <http://www.winundelete.com/>. Accessed 2/2007.

Figure 4-30 This image shows the WinUndelete tool.

Tool: Zero Assumption Recovery

Operating Systems: Windows NT/2000/XP/2003/Vista

File Types: All

Media: Hard drives, including RAID arrays, and removable media

Website: <http://www.z-a-recovery.com/>

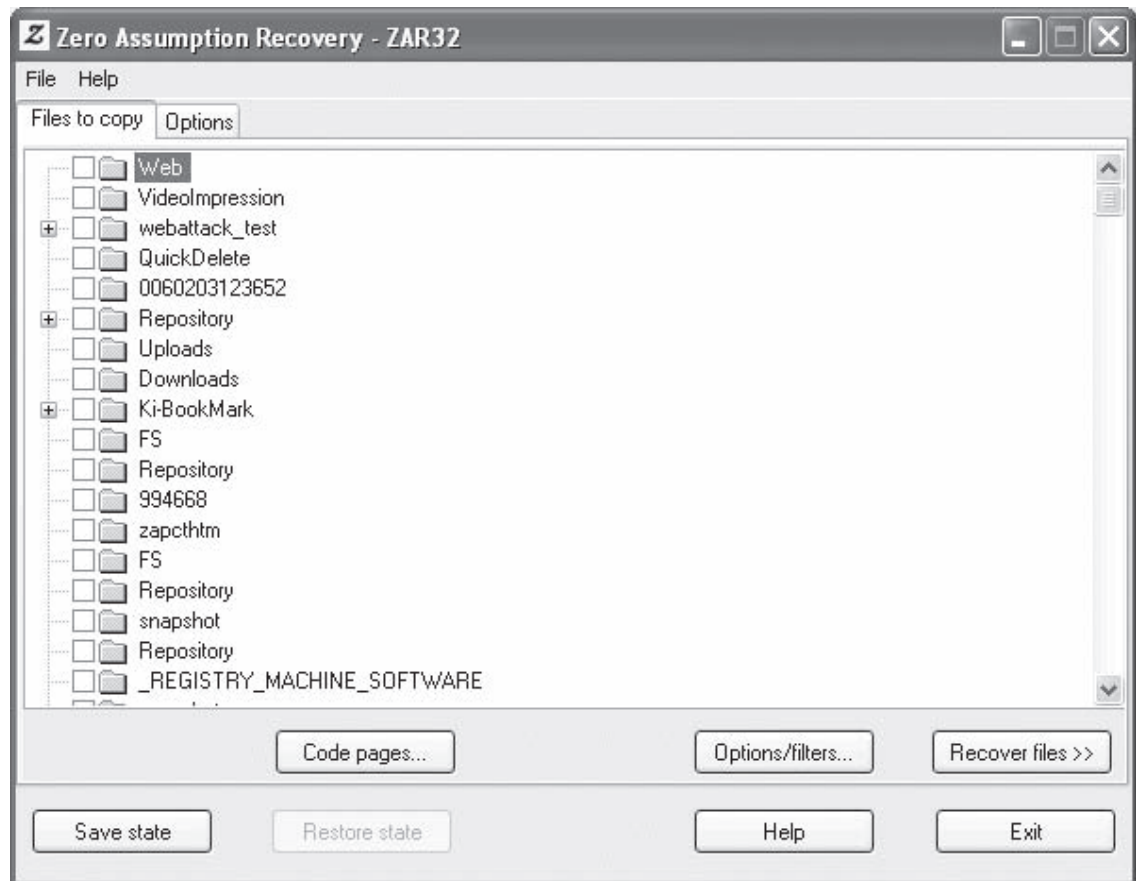
Cost: \$49.95

Zero Assumption Recovery provides a suite of highly effective and thorough data recovery software for Microsoft Windows operating systems. It recovers data lost due to accidental reformatting, power spikes, virus attacks, and hardware malfunctions. ZAR is a data recovery solution for FAT16/FAT32/NTFS file systems.

The following are some of the features of Zero Assumption Recovery:

- Runs on Windows NT/2000/XP/2003/Vista
- Supports FAT16, FAT32, and NTFS (all versions) file systems
- Provides limited ext2 (Linux file system) support
- Supports partition recovery

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Source: <http://www.z-a-recovery.com/>. Accessed 2/2007.

Figure 4-31 This image shows the Zero Assumption Recovery tool. This screen shows files that can be recovered.

- Supports hardware RAID 0 and RAID 5 recovery
- Supports long and international file names
- Supports native NTFS compression

Figure 4-31 shows a screenshot from Zero Assumption Recovery.

Tools for Use with UNIX-Based Systems

Tool: *e2undel*

Operating Systems: Linux ext2 only

Web Site: <http://e2undel.sourceforge.net/>

Cost: Free

The e2undel tool supports Linux systems with the ext2 file system. It includes a library that can recover deleted files by the file name.

Ext2 is an old UNIX file system. When a file is recovered in a medium, three parts of the file should be checked: file content; metadata that contains creation time, date, owner and user rights of the file; and the file name. This tool does not manipulate the internal ext2 structure. It requires only read access to the file system.

This tool is not compatible with other Linux file systems, such as ext3, ReiserFS, XFS, and JFS.

Figure 4-32 shows a screenshot from e2undel.

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```
odi@tikal: ~/devel
# e2undel -d /dev/hdb6 -s /tmp -a -t
e2undel 0.74
Trying to recover files on /dev/hdb6, saving them on /tmp

/dev/hdb6 opened for read-only access
244320 inodes (137236 free)
488242 blocks of 4096 bytes (31284 free)
last mounted on Sun Dec 9 10:18:20 2001

reading log file: opening log file: No such file or directory
no entries for /dev/hdb6 found
searching for deleted inodes on /dev/hdb6:
=====|
244320 inodes scanned, 807 deleted files found

  user name | 1 <12 h | 2 <48 h | 3 <7 d | 4 <30 d | 5 <1 y | 6 older
-----+-----+-----+-----+-----+-----+-----
        foo |      6 |      72 |      33 |      28 |      384 |      0
        root |      0 |      83 |      48 |      35 |      114 |      0
Select user name from table or press enter to exit: foo
Select time interval (1 to 6) or press enter to exit: 1

inode   size  deleted at      name
-----+-----+-----+-----
184219   7240  Dec  9 18:14 2001 * data
184231   2192  Dec  9 18:14 2001 * ASCII C program text
184233  42024  Dec  9 18:28 2001 * application/x-gzip
184235   1520  Dec  9 18:28 2001 * text/html
202733   1344  Dec  9 12:51 2001 * ASCII English text
217164   7404  Dec  9 17:58 2001 * image/jpeg
Select an inode listed above or press enter to go back: 184231
2191 bytes written to /tmp/inode-184231-ASCII_C_program_text
Select an inode listed above or press enter to go back:
```

Source: <http://e2undel.sourceforge.net/>. Accessed 2/2007.

Figure 4-32 This image shows the e2undel tool.

Tool: R-Linux

Operating Systems: Recovers Linux ext2 file system; Host OS: Windows 9x/ME/NT/2000/XP
File Types: All
Media: Logical and physical disks, including network drives and removable media
Web Site: <http://www.r-tt.com/>
Cost: Free

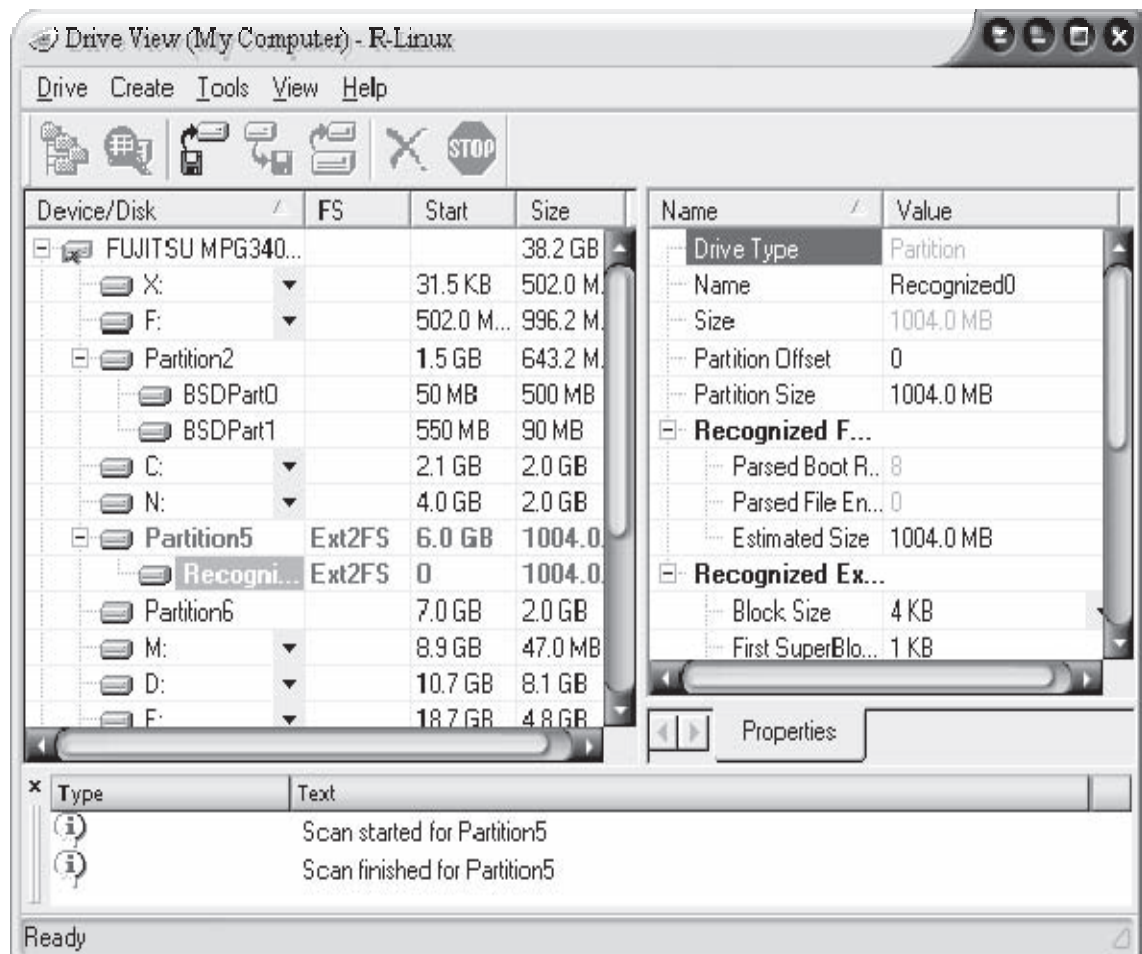
R-Linux is a free data recovery tool that supports the ext2 file system in Linux and other UNIX versions. Files from logical disks are recovered, even if the records are lost. It creates image files for the entire disk/partition, or for a part of it. Such image files can be processed like regular disks. The application recognizes localized names. R-Linux can also recover files that can be saved on any disks accessible by the host operating system.

R-Linux uses a unique IntelligentScan technology and a flexible parameter setting that gives the investigator control over the data recovery. It recovers files from existing logical disks even when file records are lost. R-Linux is a “lite” version of a more powerful file recover utility, R-Studio. R-Studio utilizes the IntelligentScan technology to its full extent, and can recover data from partitions with broken file systems. Also, R-Studio can recover data over a network.

The following are some of the features of R-Linux:

- Standard Windows Explorer–style interface
- Can save recovered files on any disks visible to the host operating system
- Recovers files from disks with bad sectors

Figure 4-33 shows a screenshot from R-Linux.



Source: <http://www.r-tt.com/>. Accessed 2/2007.

Figure 4-33 This image shows the R-Linux tool. Notice that different partitions can be scanned and recovered.

Tool: Stellar Phoenix

Operating Systems: Linux ext2 and ext3; Macintosh OS version available

File Types: All

Media: Hard drives and removable media

Web Site: <http://www.stellarinfo.com/>

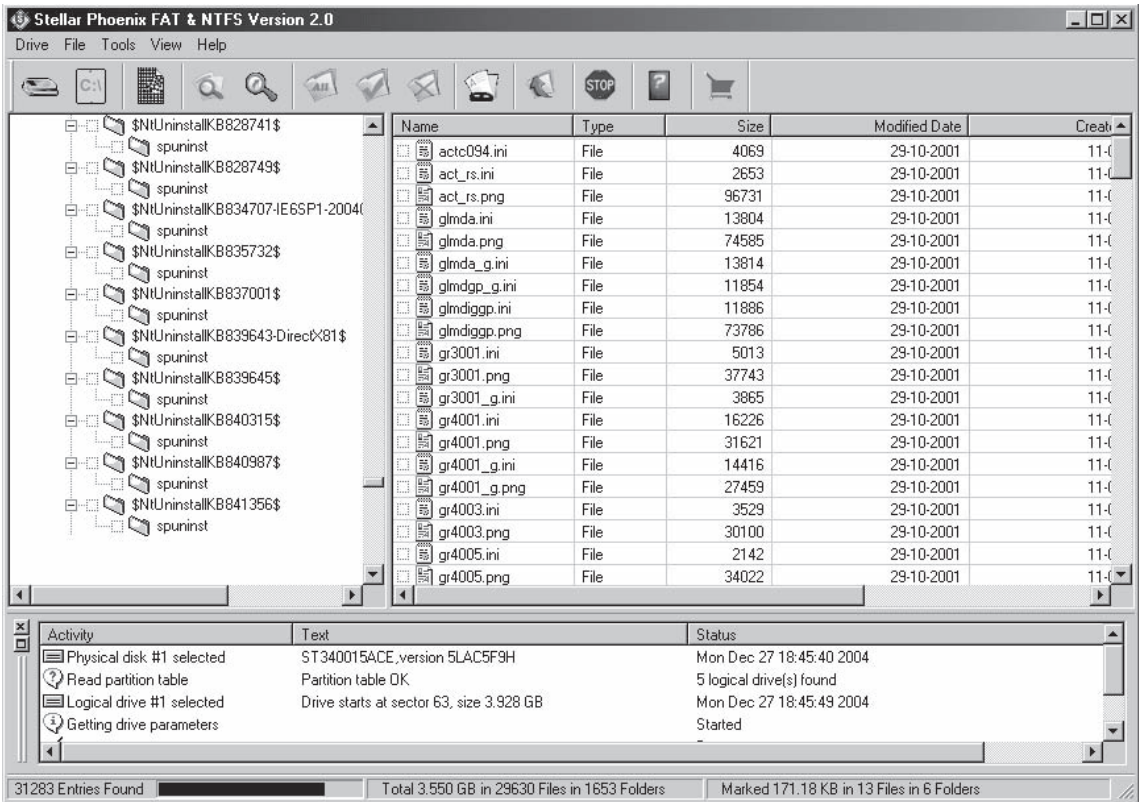
Cost: \$129.00

Stellar Phoenix is fully automated data recovery software for Linux and supports the ext2 and ext3 file systems. An automated wizard walks the investigator through three steps: Evaluate, Analysis, and Recover. During the scan, the tool automatically recognizes lost partitions, files, and folders for recovering data.

The tool has read-only functions. The recovered data is copied to another removable drive, other functional partition, or other hard drive/floppy disk/network volume.

Stellar Phoenix has different versions for different file systems. It allows for the recovering of data from hard drives that are damaged for any reason, such as accidental format, partition loss, or corruption due to a virus attack or directory deletion.

Figure 4-34 shows a screenshot from Stellar Phoenix.



Source: <http://www.stellarinfo.com/>. Accessed 2/2007.

Figure 4-34 This image shows the Stellar Phoenix tool.

Tool: OfficeFIX

Operating Systems: Windows and Mac OS
File Types: Microsoft Office files only
Media: N/A
Web Site: <http://www.cimaware.com/>
Cost: \$39.50

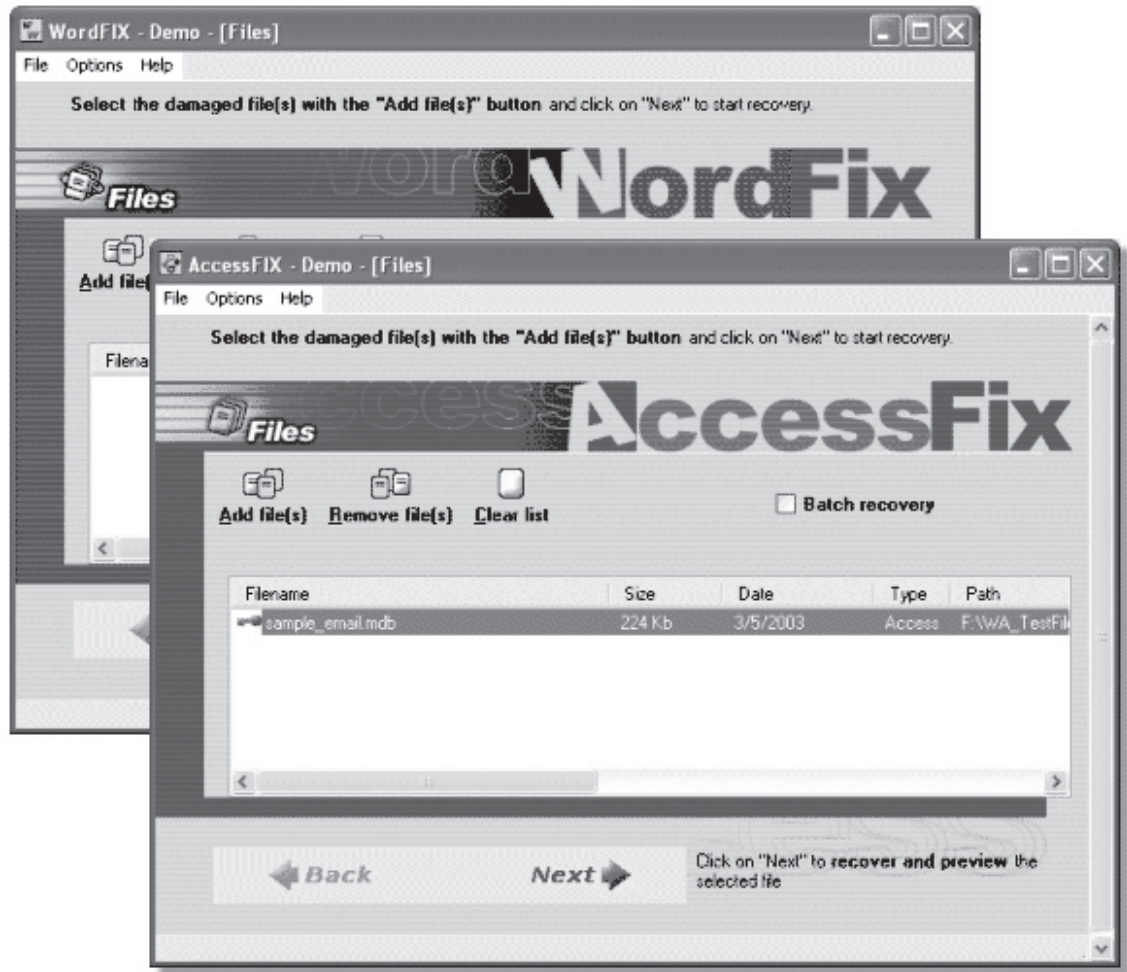
OfficeFIX is a Microsoft Office recovery suite. OfficeFIX recovers the information from a damaged or corrupted file, and stores it into a new file. It includes data recovery from ExcelFIX, AccesssFIX, and WordFIX. The following are some of the features of OfficeFIX:

- It recovers data from MS Access 95/97/2000/XP.
- It supports all versions of MS Excel.
- It also recovers data from all versions of MS Word documents, including Word for Macintosh.

The following are some of the limitations of OfficeFIX:

- It does not recover Excel sheets with:
 - Password-protected files
 - Visual Basic and macros
 - Array formulas
 - Pivot tables (only cell values are recovered)

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Source: <http://www.cimaware.com/>. Accessed 2/2007.

Figure 4-35 AccessFIX and WordFIX are two tools that are included in the OfficeFIX suite.

- It does not recover password-protected access files if the **security file** option is set.
- It does not recover password-protected Word files.
- It recovers text data, table data, and basic formatting in a document.
- It does not recover Japanese or Chinese characters.
- WordFIX cannot currently repair embedded OLE objects in Word documents, such as Excel spreadsheets and Microsoft Visio diagrams, or audio or video files, ActiveX controls, or macros.

Figure 4-35 shows a screenshot from OfficeFIX.

Tool: Repair My Excel

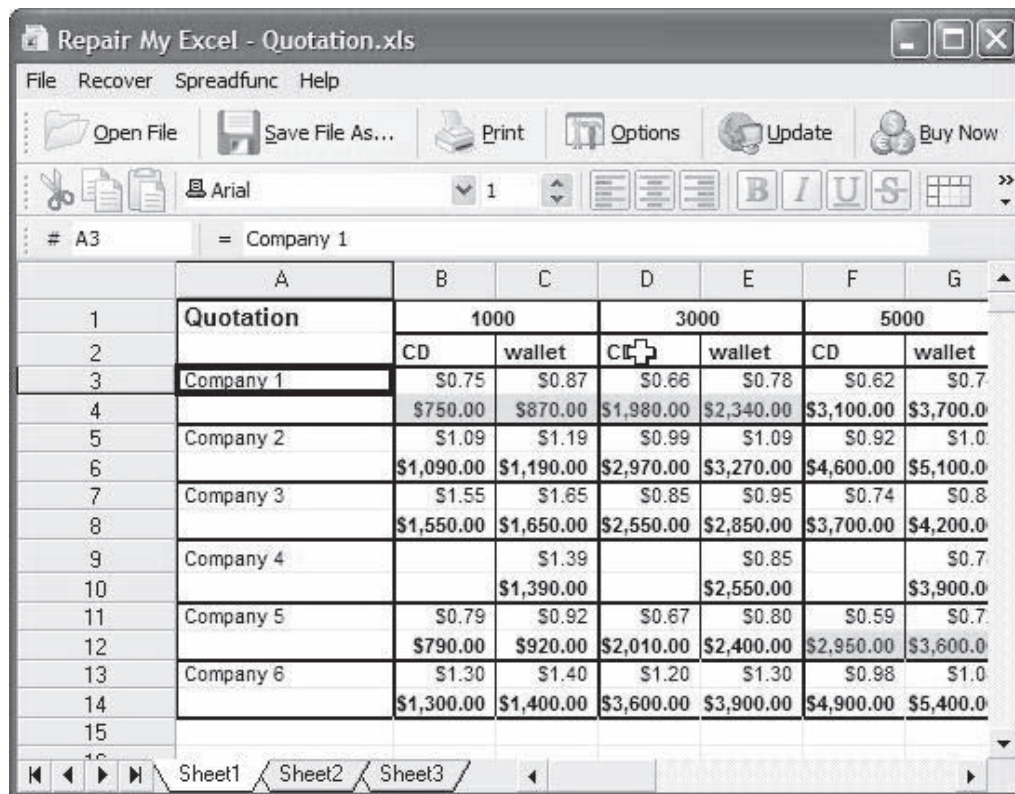
Operating Systems: Windows 9x/ME/2000/XP/2003

File Types: Microsoft Excel files versions 95, 97, 2000, XP, and 2003

Media: Hard drives

Web Site: <http://www.repairmyexcel.com/>

Cost: Free



Source: <http://www.repairmyexcel.com/>. Accessed 2/2007.

Figure 4-36 Repair My Excel is a very simple and limited freeware tool.

Repair My Excel is a Microsoft Excel file recovery software capable of restoring damaged or corrupt files that cannot be opened. Repair My Excel works with all versions of Microsoft Excel including 95, 97, 2000, XP, and 2003. It repairs Excel files, extracts the content of the damaged Excel file, and creates a new error-free file.

It fixes errors like:

- “Unable to read file”
- “The document is corrupt and cannot be opened...”

The following are some of the key features of Repair My Excel:

- Recovers all Excel versions, including Excel 97, 2000, 2002, XP, and 2003
- Recovers the names of worksheets and Excel formulas
- Repairs Excel formatting, including font, color, hyperlinks, and URLs
- Offers a full preview of the recovered file when running the evaluation version

Figure 4-36 shows a screenshot from Repair My Excel.

Tool: RecoverPlus Pro

Operating Systems: Windows

File Types: Image files

Media: Hard drives and removable media

Web Site: <http://www.arksoft.com/>

Cost: \$34.95

RecoverPlus Pro is a data recovery tool that recovers deleted images from hard drives. It supports media recovery, photo recovery, card recovery, and file recovery. It scans the user's card, stick, drive, CD, DVD, digital camera connection, reader, or anything with a drive letter, and uses **Save All** for saving to the directory the user wants. It supports more than 40 file types by default, and new formats can be added.

The following are some of the features of RecoverPlus Pro:

- Supports picture recovery for JPG, JPE, JPEG, TIF, TIFF, GIF, BMP, PNG, PSD, EPS, PCX, raw CRW, CR2, NEF, ARW, MRW, DCR, FOVB, PEF, ORF, RAF, X3F, RDC, DNG, and RAW
- Recovers RAW files from Canon, Nikon, Sony, Konica, Minolta, Rollei, Leica, Hasselblad, Kodak, Fuji, Olympus, Panasonic, Pentax, Sigma, Samsung, Adobe, and Foveon
- Displays full-screen versions of recovered photos
- Supports any connection with a drive letter, such as a hard or removable disk, reader, camera, card, stick, iPod, Image Tank, or CD/DVD via connections such as USB, PCMCIA, Firewire, and others

Figure 4-37 shows a screenshot from RecoverPlus Pro.



Source: <http://www.arksoft.com/>. Accessed 2/2007.

Figure 4-37 RecoverPlus Pro is a robust tool to recover image files.

Tool: ImageRecall

Operating Systems: Windows 9x/ME/NT4/2000/XP or any Mac OS 9.1+, including Mac OS X (except 10.3.9)

File Types: Image and media files

Media: Hard drives and removable media

Web Site: <http://www.flashfixers.com/software/>

Cost: \$39.95

ImageRecall is digital photo recovery software. It recovers lost data and digital images from memory cards, hard drives, and all other media. It supports all popular images, including RAW, audio, video, and data files. The recovered files can be previewed (JPEG) and saved to a folder on the user's hard drive, or burned directly to CD.

The following are some of the features of ImageRecall:

- Recovers faster (60% faster than previous versions)
- Rebuilds corrupt image files
- Scans cards for damage
- Views photos during the recovery process
- Backs up corrupted cards on a hard drive
- Selects specific file types for recovery
- Retrieves images from corrupt CDs
- Saves recovered images directly to PC or CD

Figure 4-38 shows a screenshot from ImageRecall.



Source: <http://www.flashfixers.com/software/>. Accessed 2/2007.

Figure 4-38 ImageRecall is a tool for recovering image files.

Tool: eIMAGE Recovery**Operating System:** Windows ME/NT/2000/XP/2003**File Types:** Digital images and media files**Media:** Hard drives and removable media, including some cell phones and PDAs**Web Site:** http://www.octanesoft.com/photo_recovery.html**Cost:** \$27.00

eIMAGE Recovery can help a user recover digital images and media files lost on corrupted, erased, or damaged memory cards. It can also recover files lost due to a virus attack or electronic failure. Memory cards supported include, CompactFlash, SmartMedia, Memory Sticks, mmd, XD, multimedia, or Secure Digital memory cards. It supports file formats: BMP, JPG, JPEG, GIF, PNG, TIF, TIFF, Fuji Raw File (RAF), Kodak Raw File (DCR), Zigma Raw File (X3F), RIFF, AVI, MID, MIDI, MOV, MPG, MPEG, and WAV.

Figure 4-39 shows a screenshot of eIMAGE Recovery.



Source: http://www.octanesoft.com/photo_recovery.html. Accessed 2/2007.

Figure 4-39 eIMAGE Recovery includes a wizard that walks you through file recovery.

Tool: Word Repair**Operating Systems:** Windows**File Types:** Microsoft Word 6.0, Word 95, 97, 2000, XP, and 2003 for Windows files**Media:** Hard drives**Web Site:** <http://www.repairmyword.com/>**Cost:** Free

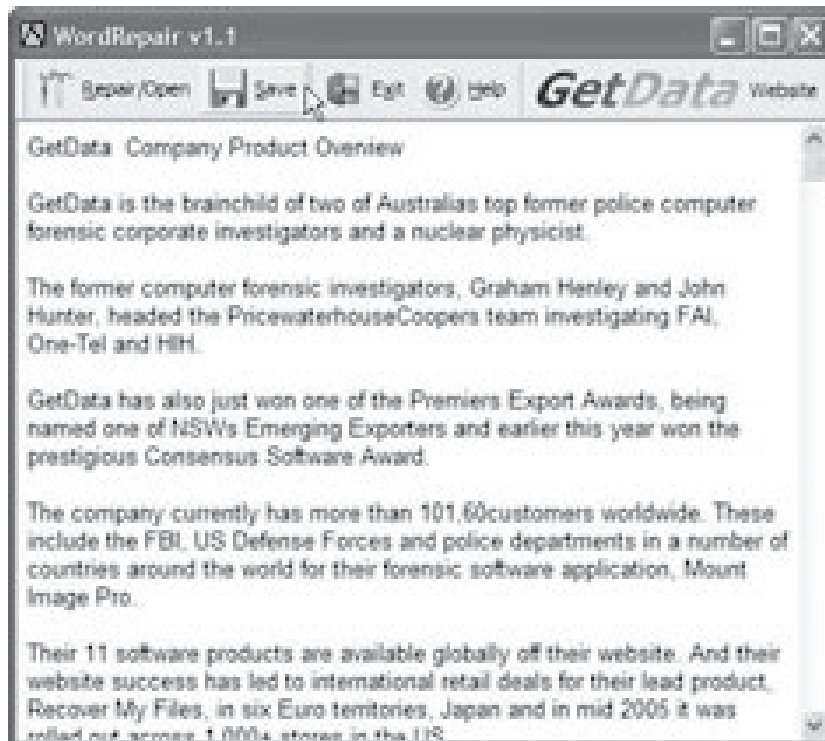
Word Repair is a data recovery program for Microsoft Word documents. It is designed to recover text from damaged or corrupt Word files (.doc files) that will not open normally. The recovered text can then be saved as an error-free Microsoft Word document.

Some common error messages that can prevent a user opening a Microsoft Word document include:

- “The document name or path is not valid. Try these suggestions. Check the file permissions for the document or drive. Use the File Open dialog box to locate the document.”
- “Word cannot open the document.”
- “Word cannot open the document: user does not have access privileges.”
- When a user attempts to open a Microsoft Word 97 document in Microsoft Word version 6.x or 7.x, the document contains garbage characters.

Word Repair will allow the user to obtain access to the contents of corrupt word documents. It will repair Microsoft Word 6.0, 95, 97, 2000, XP, and 2003 for Windows and is simple to use. Open the corrupt Word file, preview the recoverable text in the preview window, and save this text to a new error-free Word file.

Figure 4-40 shows a screenshot from Word Repair.



Source: <http://www.repairmyword.com/>. Accessed 2/2007.

Figure 4-40 Word Repair can recover many different versions of Microsoft Word files.

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Tool: Zip Repair Pro

Operating Systems: Windows
File Types: Compressed files (.zip)
Media: N/A
Web Site: <http://www.ziprepair.com/>
Cost: \$29.95

Zip Repair Pro is a utility that will repair corrupt Zip files. Usually a corrupt Zip file gives the error message:

“Cannot open file: it does not appear to be a valid archive.”

The following are some of the features of Zip Repair Pro:

- Creates an error-free backup of a user’s original file for instant access
- Fixes CRC errors in .zip files so that data can still be uncompressed
- Supports spanned Zip volumes, including the Zip64 format; a user can now repair and extract from a spanned Zip set, even if part of the set is missing.
- Supports huge file sizes 2 GB+ (as long as there is enough disk space)

Type**Tool: CD Data Rescue**

Operating Systems: Windows
File Types: All
Media: CDs and DVDs
Web Site: <http://www.naltech.com/cddr.htm>
Cost: \$19.95

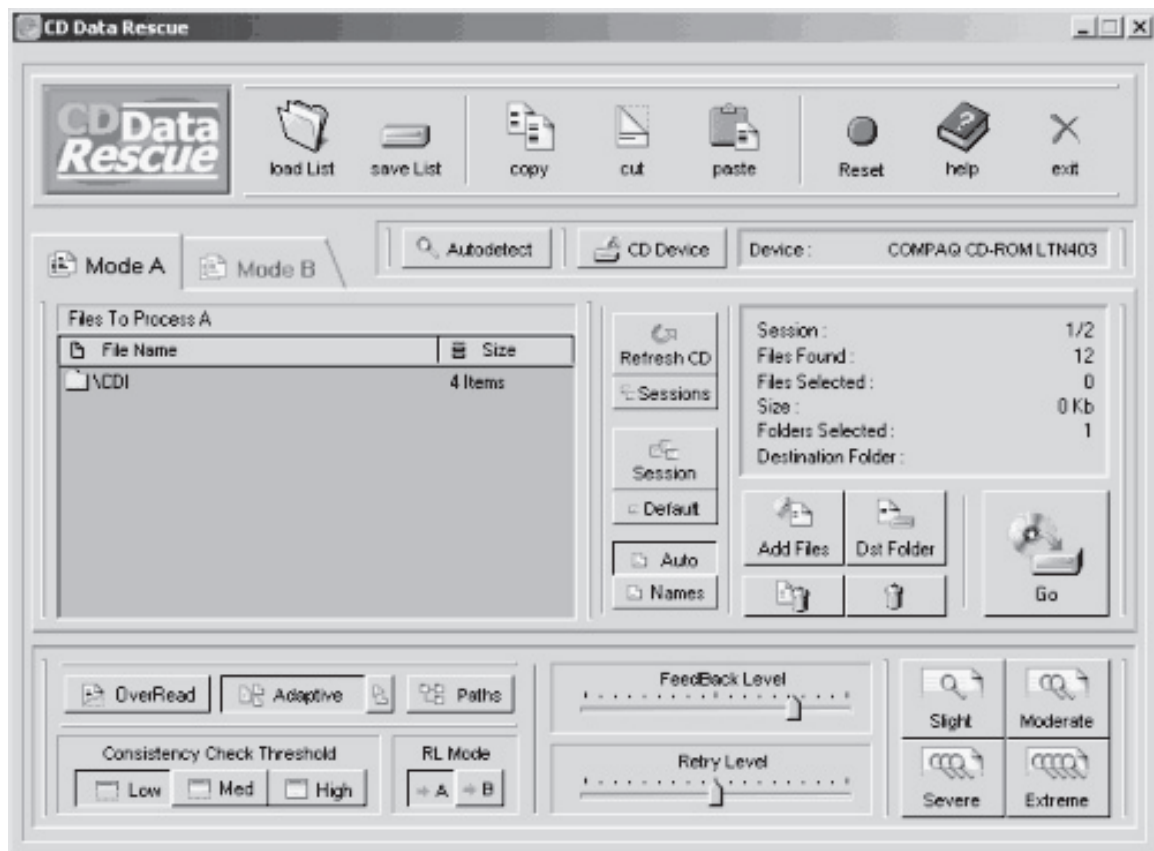
CD Data Rescue recovers files from damaged, scratched, or defective CD-ROM, CD-R, and CD-RW discs. It also supports Mount Rainier/Easy Write MRW discs. With this product, a user can easily recover files, folders, or deleted files from CDs. It also can recover files from quick-formatted CD-RW discs.

CD Data Rescue recovers unreadable and deleted files from CDs recorded by common CD writing software in ISO and UDF formats. It features full real UDF recovery supported for UDF packet-writing software (mode B): DirectCD (including old versions and compressed CDs), InCD, packetCD, etc. The tool also supports discs recorded by Sony digital cameras.

The following are some of the features of CD Data Rescue:

- Updated Recovery Wizard
- Automatically detects and renames unnamed files with the correct file type
- Complete UDF file system recovery
- Uses exclusive recovery technology that allows a user to achieve the best performance recovering data
- Can recover data from CDs and DVDs recorded in the ISO 9660 format and UDF format

Figure 4-41 shows a screenshot from CD Data Rescue.



Source: <http://www.naltech.com/cddr.htm>. Accessed 2/2007.

Figure 4-41 This image shows the CD Data Rescue screen.

Tool: CDRoller

Operating Systems: Windows 95/98/ME/2000/XP

File Types: All

Media: CDs and DVDs

Web Site: <http://www.cdroller.com/>

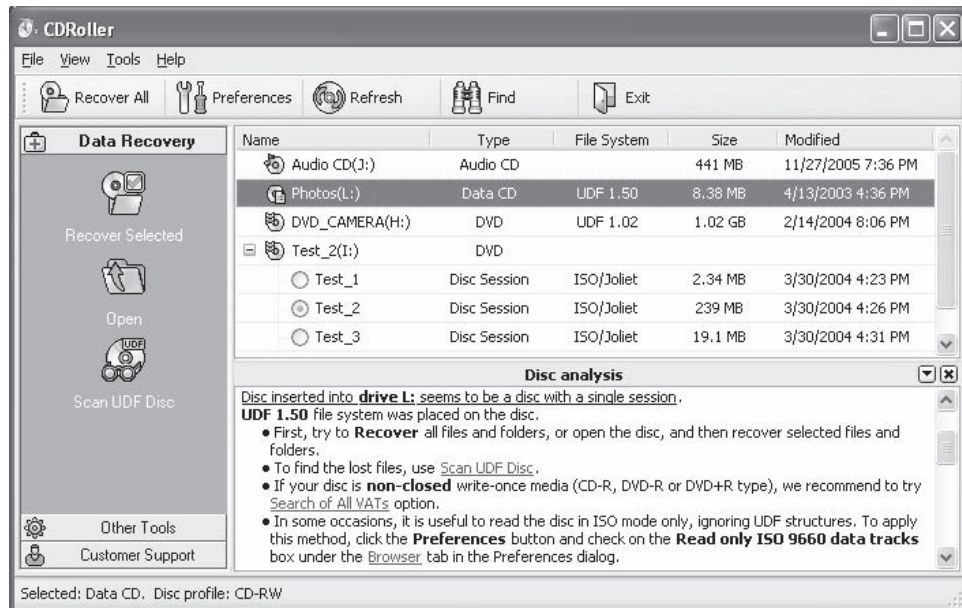
Cost: \$39.00

CDRoller supports the industry-standard ISO 9660 file system, including Microsoft's extensions for long file names support, and so-called Joliet extensions. CDRoller also supports discs formatted in the UDF file system, including versions 1.02, 1.50, 2.0, 2.01, and also the UDF bridge format.

The following are some of the features of CDRoller:

- Includes support for a wide set of CD and DVD formats such as CD-DA, CD-ROM, CD-WO, CD-ROM XA and Mixed-Mode CD, stamped multisession CD, CD-MRW (Mt. Rainier CD-RW), DVD-ROM, DVD-R, DVD-RW, DVD+R, DVD+RW, and DVD-RAM
- Effectively retrieves the data off discs created by drag-and-drop CD/DVD writing software
- Recovers CD and DVD data created by standalone devices that record directly onto discs
- Includes a built-in video splitter that splits the recovered VOB or VRO files into a several clips (scenes), automatically converting a "raw" DVD-video into MPEG files without the loss of quality; specially tested on the discs created by Hitachi DVD camcorders
- Retrieves backup files from discs recorded in several stages (multisession discs)

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Source: <http://www.cdroller.com/>. Accessed 2/2007.

Figure 4-42 CDRoller can recover data from many DVD and CD formats.

- Includes a built-in UDF reader; there is no need to install third-party software, for example, the Roxio (Adaptec) UDF reader driver
- Finds and retrieves the lost files on UDF discs, including accidentally deleted files, files on quick-formatted discs, files on incorrectly closed discs
- Identifies the lost files on ISO/Joliet discs with a damaged file system (volume descriptors, path tables, and directories), using raw data only
- Rescues the data from scratched, damaged, or defective discs
- Provides direct access to the hardware, bypassing the Windows file system, and looks for lost tracks (sessions) every time a user inserts a new disc into the drive

Figure 4-42 shows a screenshot from CDRoller.

Tool: DiskInternals Flash Recovery

Operating Systems: Windows 95, 98, ME, NT, 2000, XP, and 2003 Server

File Types: All

Media: Flash memory devices

Web Site: <http://www.diskinternals.com/flash-recovery/features.shtml>

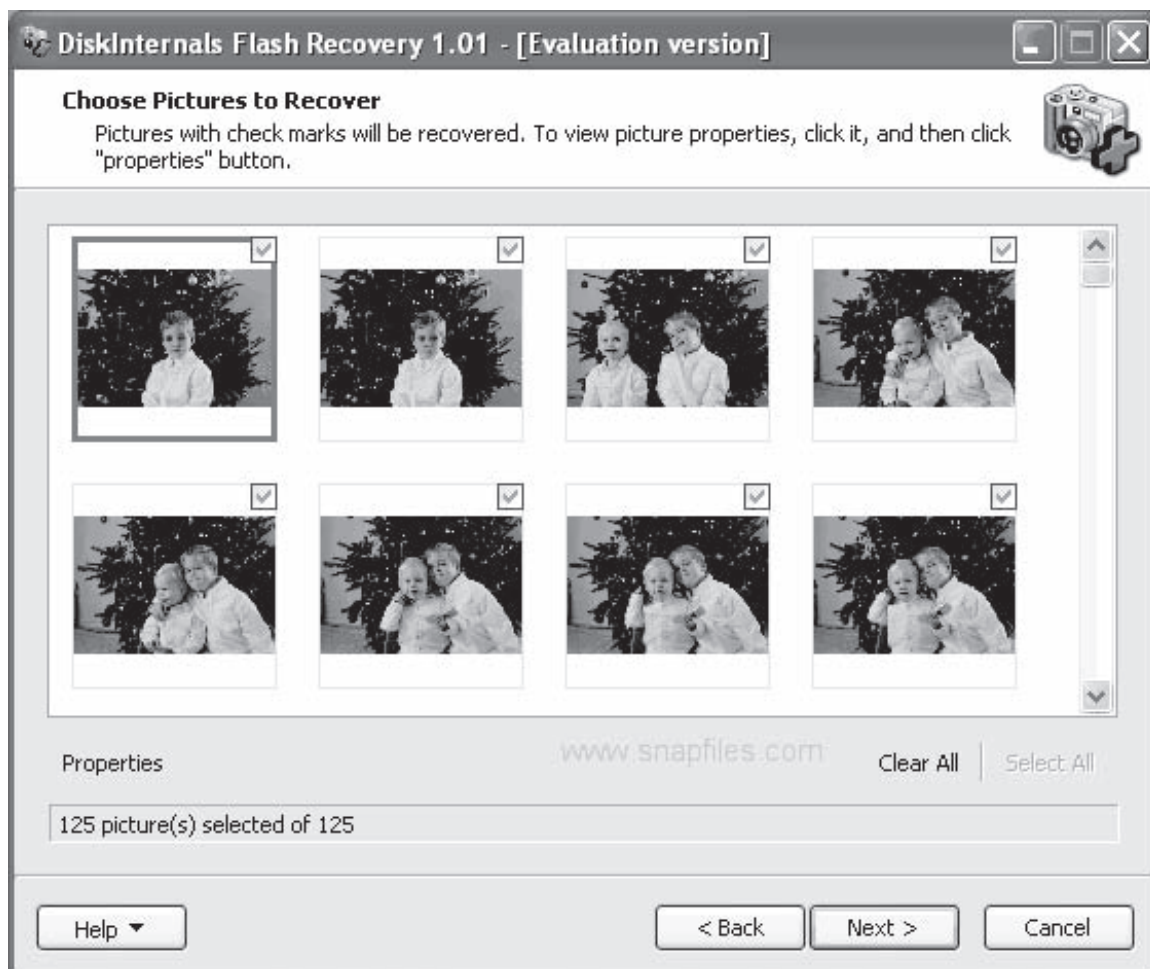
Cost: \$39.95

DiskInternals Flash Recovery is a flash memory file recovery tool that restores corrupted and deleted photographs, or ones lost due to hardware malfunctions. This utility works even if a memory card was reformatted. The program recovers images from hard drives, external drives, cameras, and flash memory devices such as SmartMedia, CompactFlash, Memory Stick, MicroDrive, xD Picture Card, Flash Card, PC Card, Multimedia Card, Secure Digital Card, and many others.

The following are some of the features of DiskInternals Flash Recovery:

- Easy Recovery Wizard
- Can preview and recover JPEG, JPG, TIFF, BMP, PNG, GIF, TGA, and other images
- Supports FAT12, FAT16, FAT32, NTFS (NT 4), and NTFS5 (2000, XP) file systems

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Source: <http://www.diskinternals.com/flash-recovery/features.shtml>. Accessed 2/2007.

Figure 4-43 Flash Recovery can restore most deleted or damaged photograph files.

- Can save recovered files on any (including network) disks visible to the host operating system
- Creates recovery snapshot files for logical drives; these files can be processed like regular disks.
- Recovers pictures deleted by accident
- Recovers photos from erased or formatted media or deleted from digital cameras or the Recycle Bin
- Allows a user to preview recoverable images before purchasing the program

Figure 4-43 shows a screenshot from DiskInternals Flash Recovery.

Tool: DiskInternals CD and DVD Recovery

Operating Systems: Windows

File Types: All

Media: CDs and DVDs

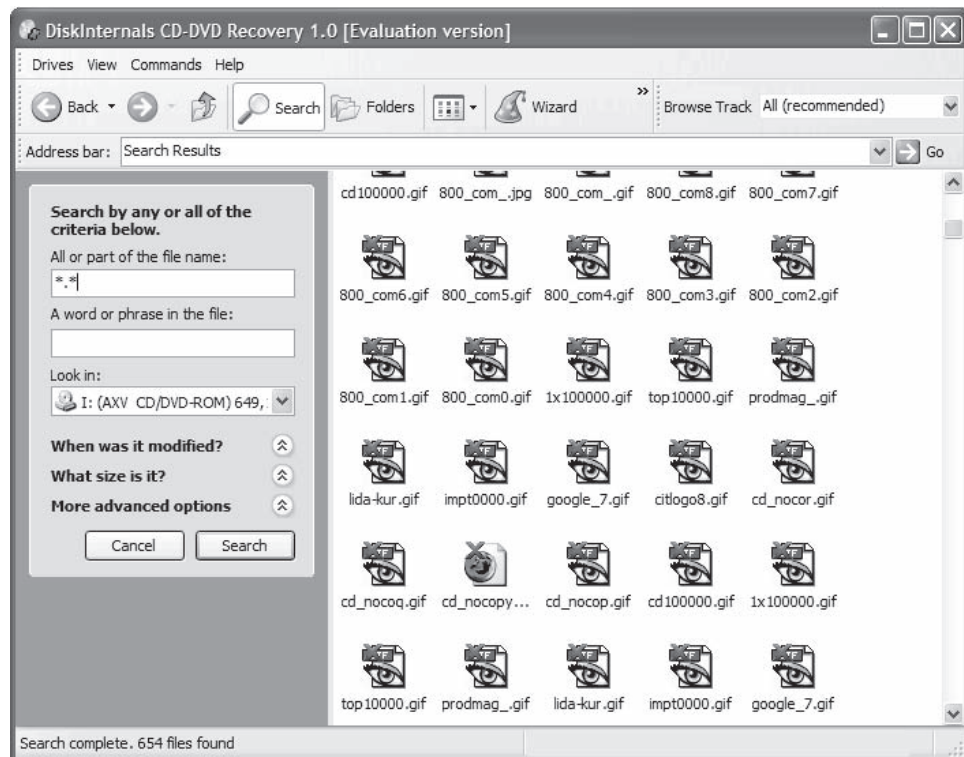
Web Site: <http://www.diskinternals.com/cd-dvd-recovery/>

Cost: \$39.95

DiskInternals CD and DVD Recovery is a software solution capable of recovering data from CDs and DVDs, including multisession discs. It supports the following discs: CD-R, CD-RW, DVD-R, DVD+R, DVD-RW, DVD+RW, DVD+R DL, DVD-R DL, and DVD-RAM.

The program recovers any type of files (data, pictures, video, and music) and processes ISO 9660, Joliet, and UDF file systems. The program uses a smart file recovery algorithm that skips bad sectors.

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Source: <http://www.diskinternals.com/cd-dvd-recovery/>. Accessed 2/2007.

Figure 4-44 CD and DVD Recovery includes a wizard to walk you through the restoration process. The program shows every file that can be recovered. You can choose files to restore.

The process of recovery is straightforward. The program starts working automatically, and doesn't require the additional setup changes. Advanced users can use a manual recover process that allows them to isolate each session or track, and choose the appropriate file system per session.

Figure 4-44 shows a screenshot from DiskInternals CD and DVD Recovery.

Tool: inDisc Recovery

Operating Systems: Windows 98/ME/NT/2000/XP/2003

File Types: All

Media: CDs and DVDs

Web Site: <http://www.octanesoft.com/>

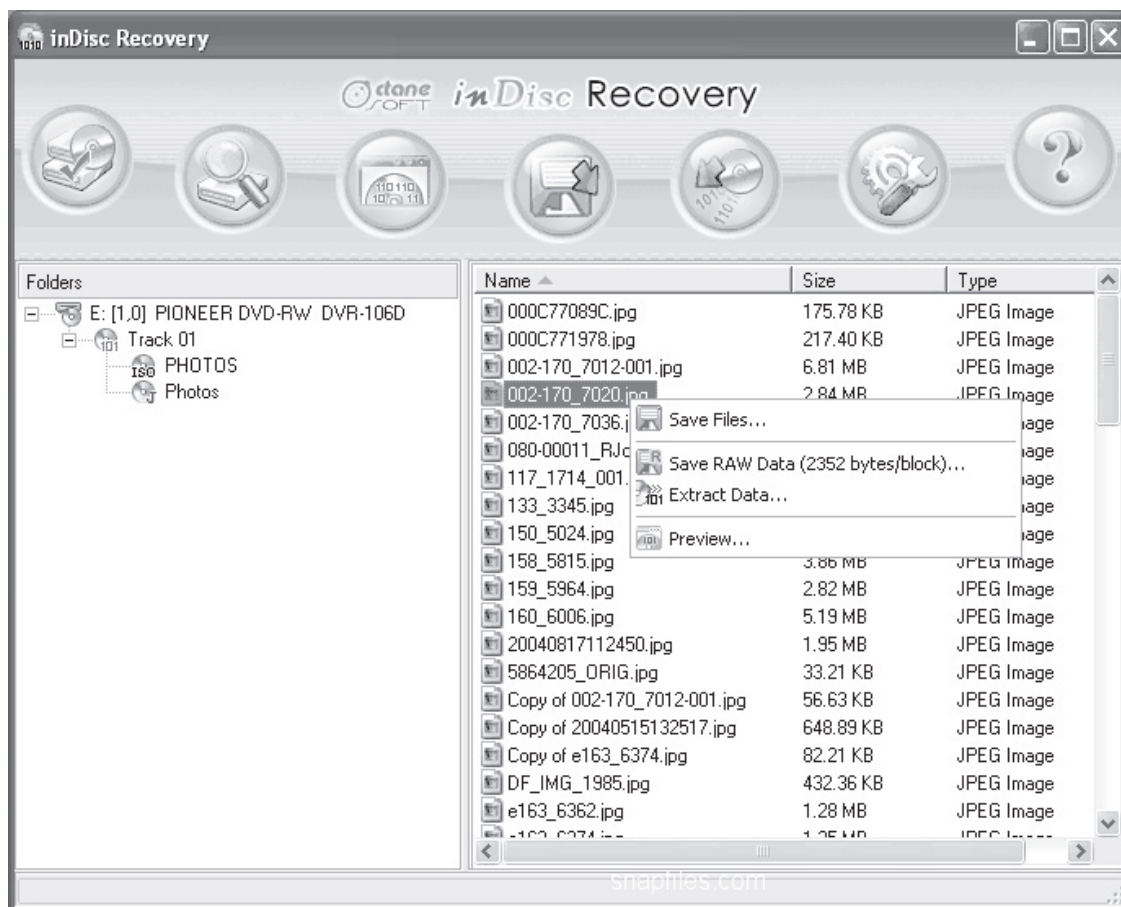
Cost: \$39.50

inDisc Recovery is CD/DVD data recovery software. It is specifically designed to recover any type of deleted, lost, or unreadable files and folders from damaged, scratched, or defective CDs and DVDs created by CD/DVD writing software in ISO 9660 and UDF formats, as well as Microsoft's extensions for long file names support and Joliet extensions. CD-R, CD-RW, DVD-R, DVD+R, DVD-RW, DVD+RW, DVD1R DL, DVD-R DL, and DVD-RAM discs are supported.

The user can access all tracks and sessions located on the damaged disc.

The following are some of the features of inDisc Recovery:

- Effectively recovers lost data from CD and DVD discs created by common CD/DVD writing software in ISO, UDF, and Joliet formats
- Finds and recovers deleted files from RW discs that have been deleted through Quick Format mode



Source: <http://www.octanesoft.com/>. Accessed 2/2007.

Figure 4-45 inDisc Recovery can recover files from CDs and DVDs.

- Supports CD-ROM, CD-R, CD-RW, DVD-ROM, DVD-R, DVD-RW, DVD+R, DVD+RW, and DVD-RAM
- Supports multisession media
- Ability to preview image, ASCII, and hex data

Figure 4-45 shows a screenshot from inDisc Recovery.

Tool: IsoBuster

Operating Systems: Windows (but works on Mac-formatted discs)

File Types: All

Media: CDs and DVDs

Web Site: <http://www.isobuster.com/isobuster.php>

Cost: \$29.95

IsoBuster is a highly specialized, yet easy-to-use, CD and DVD data recovery tool. It supports all CD and DVD formats, and common CD and DVD file systems. Start up IsoBuster, insert a CD or DVD, select the drive (if not selected already), and let IsoBuster compile the media. IsoBuster immediately shows the user all the tracks and sessions located on the media, combined with all file systems that are present. This way, the user gets access to all the files and folders per file system instead of being limited to one file system. The user can access data from older sessions and data that Windows does not see or hides from view.

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The following are some of the features of IsoBuster:

- Recovers data from all possible CD and DVD formats: CD-i, VCD, SVCD, SACD, CD-ROM, CD-ROM XA, CD-R, CD-RW, CD-MRW, DVD-ROM, DVCD, DVD-RAM, DVD-R, DVD-RW, DVD+R, DVD+RW, DVD+MRW, DVD+R Dual Layer, DVD-R Dual Layer, DVD+RW Dual Layer, DVD+VR, DVD+VRW, DVD-VR, and DVD-VM
- Exclusively provides all device access, media access, data gathering, and interpretation; it does not rely on Windows to provide or interpret the data, and so can work completely independently from Windows' limitations.
- Uses primary and secondary file systems to get to the data and/or make use of file system data that might be ignored or forgotten by the operating system
- Supports mounting several virtual sessions inside a single DVD+RW or DVD-RW track
- Reads and extracts files, CD/DVD images, tracks, and sessions from all optical media
- Scans for lost UDF files and folders, and for lost ISO 9660/Joliet sessions
- Finds lost data on CDs or DVDs created with integrated drag-and-drop applications, otherwise known as packet-writing software; optimized, but not exclusively, for Roxio Direct CD, Roxio Drag-to-Disc, Ahead/Nero InCD, Prassi/Veritas/Sonic DLA, VOB/Pinnacle Instant-Write, and CeQuadrat Packet CD
- Supports direct CD compressed files
- Built-in UDF reader, UDF 1.02 (e.g., DVDs), UDF 1.5 (e.g., packet writing on CD-R, DVD+R, DVD-R, CD-RW, DVD+RW, and DVD-RW), and UDF 2.01, 2.50
- Finds lost pictures created and saved to CD or DVD with Sony Mavica, other digital cameras, or other devices with embedded UDF write functionality
- Finds lost movies created and saved to CD or DVD with Hitachi, other digital cameras, or other devices with embedded UDF write functionality
- Automatically finds extensions based on file content to try to give an appropriate name to an orphaned file; this built-in file identifier assigns the proper extension to the file so that Windows applications can open the file. Only needed for orphaned files without a name.
- Has transparent built-in support for Mac Resource Fork extensions in the UDF file system

Figure 4-46 shows a screenshot from IsoBuster.

Tool: PC Inspector Smart Recovery

Operating Systems: Windows 9x/ME/NT 4.0/XP/2000

File Types: Media and image files

Media: Flash drives, digital cameras

Web Site: http://www.pcinspector.de/smart_media_recovery/uk/welcome.htm

Cost: Free (sometimes bundled with digital cameras)

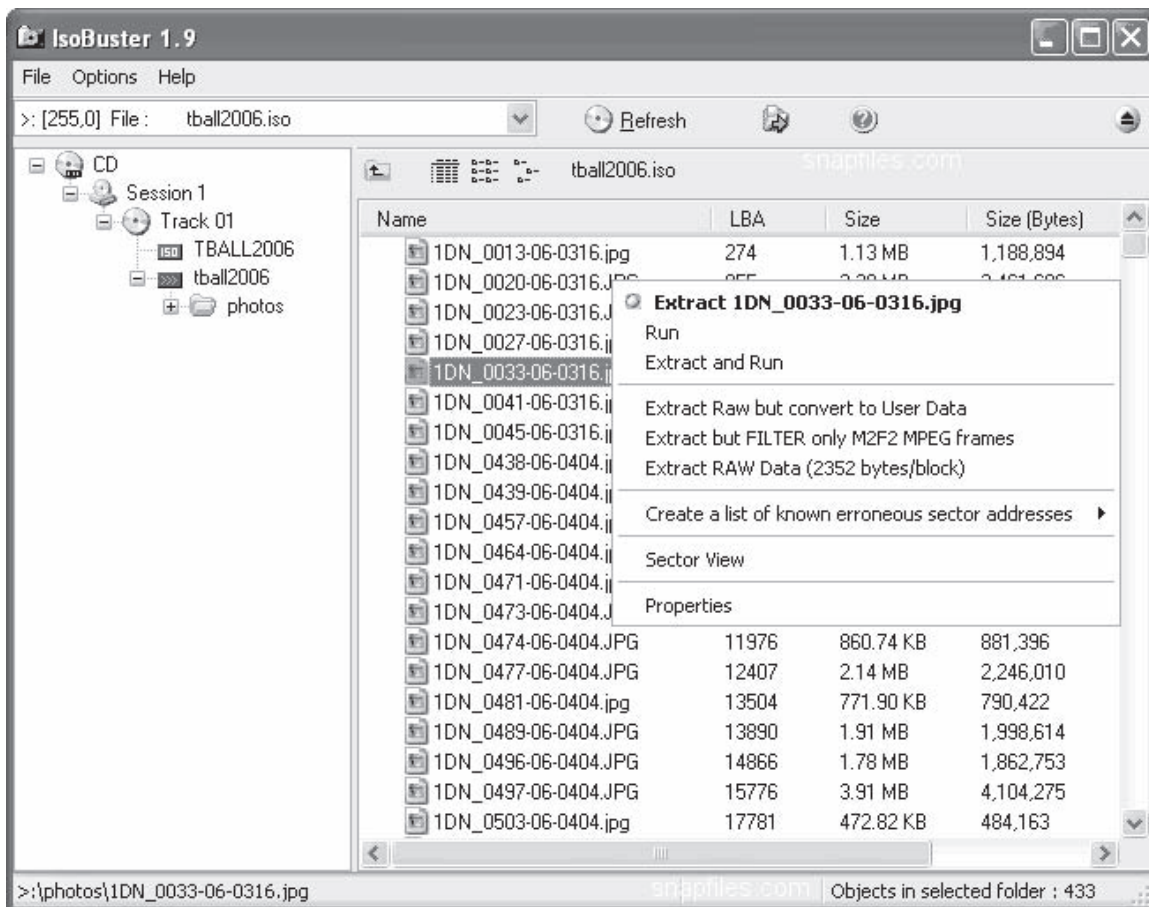
PC Inspector Smart Recovery recovers data from data devices, such as CompactFlash cards, SmartMedia, and digital cameras. It recovers accidentally deleted files, videos, and pictures from media devices.

The following are some of the features of PC Inspector Smart Recovery:

- Recovers data from CONVAR for CompactFlash cards, SmartMedia, Sony Memory Sticks, IBM Micro Drives, Multimedia Cards, Secure Digital cards, or any other data carrier for digital cameras
- Supports the following picture formats: .jpg, .amr, .tif, .bmp, .gif, Canon .crw, Fuji .raf, RICOH .raw, Olympus .orf (E-XX), Olympus .orf (C5050), Nokia 3gp, Kodak .dcr, Minolta .mrw, Nikon .nef (D1H/D1X), Nikon .nef (D2H/D2X), Nikon .nef (E5000/E5700), Sigma/Foveon .x3f, mp4, QuickTime .mov (Konica Minolta), Video files in .avi, and audio files in .wav, and .dss format

Figure 4-47 shows a screenshot from PC Inspector Smart Recovery.

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Source: <http://www.isobuster.com/isobuster.php>. Accessed 2/2007.

Figure 4-46 IsoBuster includes a variety of formats for extraction.



Source: http://www.pcinspector.de/smart_media_recovery/uk/welcome.htm. Accessed 2/2007.

Figure 4-47 A user can recover many different types of media files using PC Inspector Smart Recovery.

Recovering Deleted Partitions

Deletion of a Partition

In Windows systems, a user can delete a partition by:

- Using the Windows interface
- Using a command line

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What Happens When a Partition Is Deleted?

- When a user deletes a partition on any logical drive, all the data on that drive is lost.
- If a user deletes a partition on a dynamic disk, all dynamic volumes on the disk are deleted, thus corrupting the disk.

Deletion of a Partition Using the Windows Interface

Use the following procedure to delete a partition using the Windows interface:

- Open Computer Management:
 - Click **Start → Control Panel**.
 - Double-click **Administrative Tools → Computer Management**.
- In the console tree:
 - Click **Computer Management (Local) → Storage → Disk Management**.
- Right-click the partition, logical drive, or basic volume you want to delete, and then click **Delete Partition**.

Figure 4-48 shows deletion of a partition using Computer Management.

Deletion of a Partition Using the Command Line

Use the following steps to delete a partition using the command line:

- At the command prompt, type **diskpart**.
- At the DiskPart prompt:
 - Type **list disk**:
 - Note the disk number of the disk from which the partition is to be deleted.

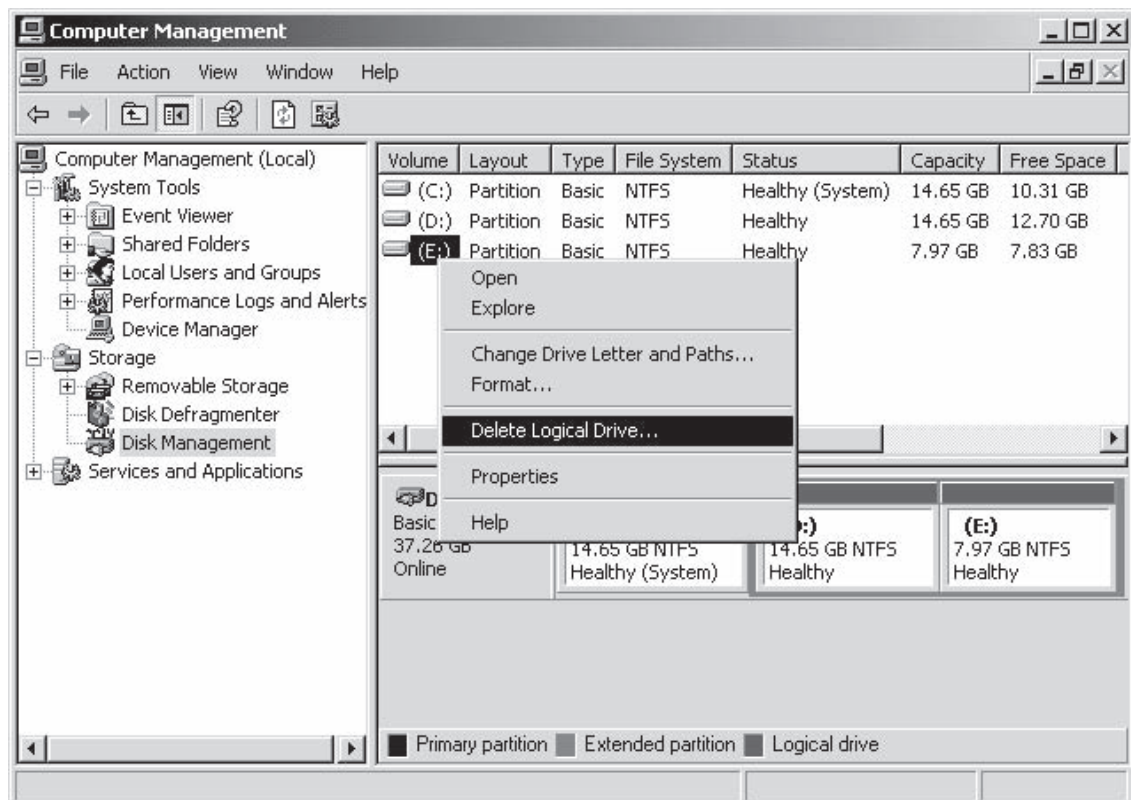


Figure 4-48 This image shows deletion of a partition using the Computer Management utility.

- Type **select disk n**:
 - Selects disk number *n*.
- Type **list partition**:
 - Note the number of partitions.
- Type **select partition n**:
 - Selects partition *n*.

Common Terms

List disk: It gives the list of disks and information about the each disk, such as its size, free space available, whether the disk is basic or dynamic, and if the disk uses either a master boot record (MBR) or GUID partition table (GPT) partition.

Select disk: It selects the specified disk; *n* denotes the disk number.

List partition: It shows the list of partitions in the partition table of the current disk.

Select partition: It selects the specified partition *n* that denotes the partition number. If the partition is not provided, the select command lists the current partition.

Delete partition: It deletes the partition. Partitions such as a system partition or boot partition, which contains an active paging file or crash dump, cannot be deleted.

```

C:\WINDOWS\system32\cmd.exe - diskpart
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\Administrator>diskpart

Microsoft DiskPart version 5.1.3565

Copyright (C) 1999-2003 Microsoft Corporation.
On computer: ECC-D2A79601C0F

DISKPART> disklist

Microsoft DiskPart version 5.1.3565

ADD                - Add a mirror to a simple volume.
ACTIVE             - Marks the current basic partition as an active boot partition.
ASSIGN             - Assign a drive letter or mount point to the selected volume.
BREAK             - Break a mirror set.
CLEAN              - Clear the configuration information, or all information, off the
                    disk.
CONVERT            - Converts between different disk formats.
CREATE             - Create a volume or partition.
DELETE            - Delete an object.
DETAIL            - Provide details about an object.
EXIT              - Exit DiskPart
EXTEND            - Extend a volume.
HELP              - Prints a list of commands.
IMPORT            - Imports a disk group.
LIST              - Prints out a list of objects.
INACTIVE          - Marks the current basic partition as an inactive partition.
ONLINE            - Online a disk that is currently marked as offline.
REM              - Does nothing. Used to comment scripts.
REMOVE            - Remove a drive letter or mount point assignment.
REPAIR            - Repair a RAID-5 volume.
RESCAN            - Rescan the computer looking for disks and volumes.
RETAIN            - Place a retainer partition under a simple volume.
SELECT            - Move the focus to an object.

DISKPART>
  
```

Figure 4-49 Image shows the available switches that can be used with the DiskPart command

```

C:\WINDOWS\system32\cmd.exe - DISKPART

DISKPART> SELECT DISK 0

Disk 0 is now the selected disk.

DISKPART> LIST PARTITION

   Partition ###   Type              Size      Offset
   -----
   Partition 1     Primary             15 GB      32 KB
   Partition 2     Extended           23 GB      15 GB
   Partition 3     Logical            15 GB      15 GB
   Partition 4     Logical           8158 MB      29 GB

DISKPART>

```

Figure 4-50 Notice the four different partitions. Different partitions can have different types, such as Primary or Extended with logical drives being part of the extended partition.

```

C:\WINDOWS\system32\cmd.exe - DISKPART

DISKPART> SELECT DISK 0

Disk 0 is now the selected disk.

DISKPART> LIST PARTITION

   Partition ###   Type              Size      Offset
   -----
   Partition 1     Primary             15 GB      32 KB
   Partition 2     Extended           23 GB      15 GB
   Partition 3     Logical            15 GB      15 GB
   Partition 4     Logical           8158 MB      29 GB

DISKPART> SELECT PARTITION 4

Partition 4 is now the selected partition.

DISKPART> DELETE PARTITION

```

Figure 4-51 The command Delete Partition will remove the information from partition 4. The data will still be stored, but it will be unavailable to the user, as the space will be listed in the OS as free space and may be overwritten as new information is stored.

- Type delete partition:
 - Deletes the partition.

Figures 4-49, 4-50, and 4-51 show screenshots from DiskPart.

Recovery of Deleted Partitions

The recovery of deleted partitions is the process by which a user can evaluate and extract deleted partitions. The partition recovery process is important in case of data recovery. This recovery helps in recovering the partitions that are lost accidentally, or due to virus, software malfunction, or even sabotage. There are some tools available for the recovery of deleted partitions.

Tools to Recover Deleted and Damaged Partitions

Table 4-5 lists tools used to recover partitions:

Acronis Recovery Expert	GetDataBack	Recover It All!
Active@ Disk Image	Deleted NTFS Partition Recovery	Scaven
Active@ Partition Recovery	Partition Table Doctor	TestDisk
DiskInternals Partition Recovery		

Table 4-5 These tools are used to recover deleted or damaged partitions

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Tool: Acronis Recovery Expert

Acronis Recovery Expert, included in the Acronis Disk Director Suite 10.0, completely protects a user's data, allowing him or her to recover deleted or lost partitions. It also protects the user's system from hardware or software failure, virus attack, or hacker intrusion.

If a user's PC becomes unbootable after a power outage or a system error, he or she can recover it with Acronis Recovery Expert.

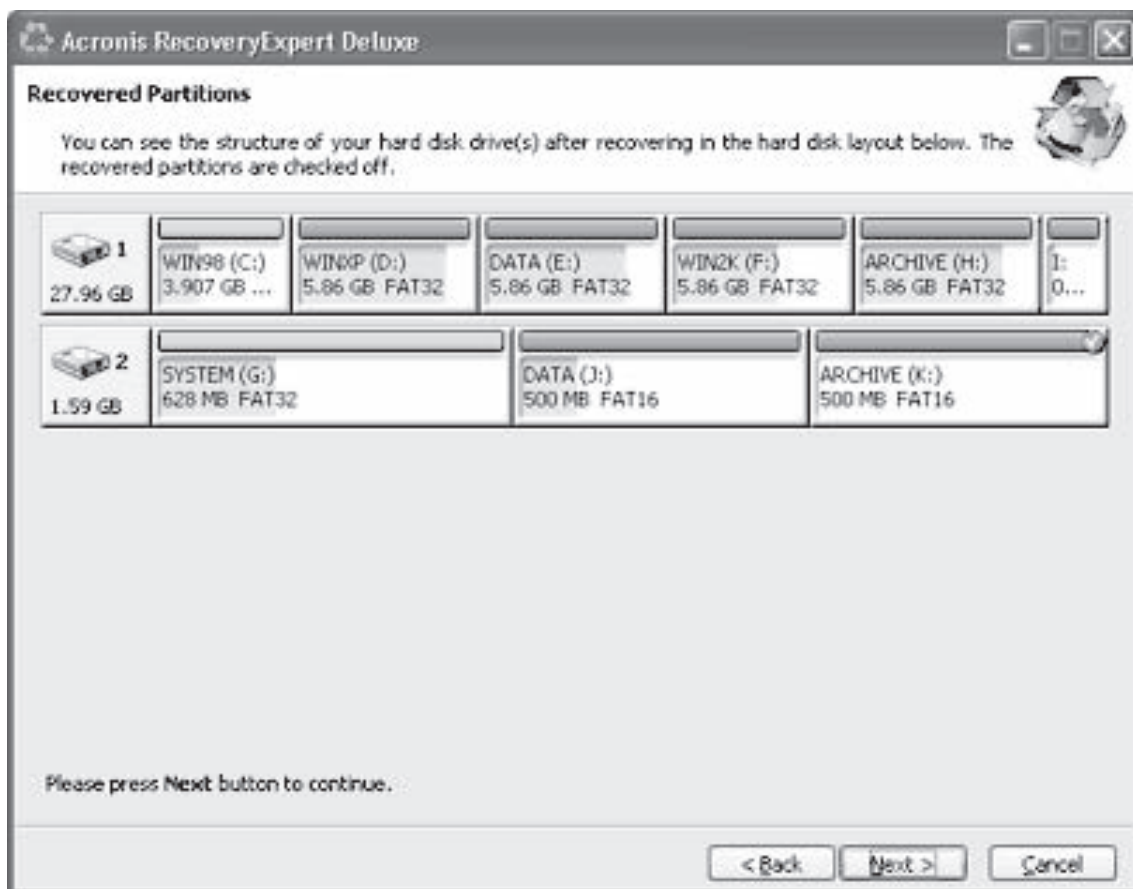
The following are some of the key features of Acronis Recovery Expert:

- Supports the following file systems: FAT16, FAT32, NTFS, HPFS (OS/2); ext2, ext3, ReiserFS, Swap (Linux)
- Provides automatic and manual recovery modes
- Independently works from bootable CDs or diskettes, enabling a user to recover partitions even if his or her operating system fails to boot
- Supports large disks over 180 GB
- Provides a Windows XP-like wizard-style interface for superior usability and ease of use

Figure 4-52 shows a screenshot from Acronis Recovery Expert.

Tool: Active@ Disk Image

Active@ Disk Image is a DOS-based solution designed for complete backup and restoration of the whole HDD, as well as the particular FAT/NTFS partitions and logical drives.



Source: <http://www.acronis.com/>. Accessed 2/2007.

Figure 4-52 You can see from this image that each of these physical hard drives has several partitions. Note the partitions that were recovered are checked off.

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Users can create compressed and noncompressed raw images (containing all of a drive's data—a mirror of a drive's surface stored in one or a set of files), as well as compressed data images (containing only the drive's used clusters, saving users space and increasing speed).

A unique feature of Active@ Disk Image is the ability to open disk images and preview files and folders inside, before image restoration. Users can even copy specific files or folders from the image to another location.

To restore accidentally deleted files, use Active@ Disk Image to make an image of the disk (snapshot), from which users can later try to restore deleted files without the risk of overwriting important data on original disk. If the disk shows bad clusters, users can effectively stop this process to preserve whatever is still readable as an image, and try to restore data later.

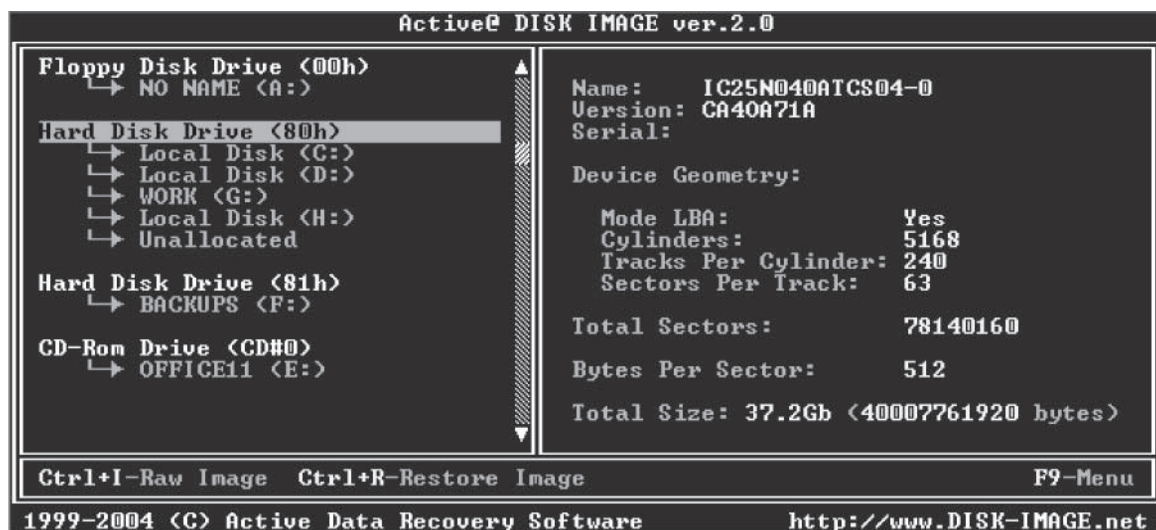
The following are some of the features of Active@ Disk Image:

- Can be run from a DOS bootable floppy or CD-ROM
- Displays complete HDD, partition, and disk image information
- Creates compressed and noncompressed raw images for the physical drive (HDD)
- Restores compressed and noncompressed raw images back to the physical drive or partition
- Creates compressed data images for any partition on the HDD
- Displays contents of any physical sector on the drive or within the disk image
- Allows viewing of all files and folders inside disk image before restoration using the preview mode
- Allows the copying of specific files and folders from the image to another location
- Supports IDE/ATA/SCSI/USB drives
- Supports large (more than 128 GB) hard disk drives and partitions
- Supports FAT12, FAT16, FAT32, NTFS, and NTFS5 file systems
- Supports partitions created in MS-DOS, Windows 95/98/ME/NT/2000/XP/2003/XP Professional x64/XP Home x64/2003/2003 Server x64

Figures 4-53 and 4-54 are screenshots from Active@ Disk Image, showing an example of the recovery process after scanning unallocated space on the hard drive.

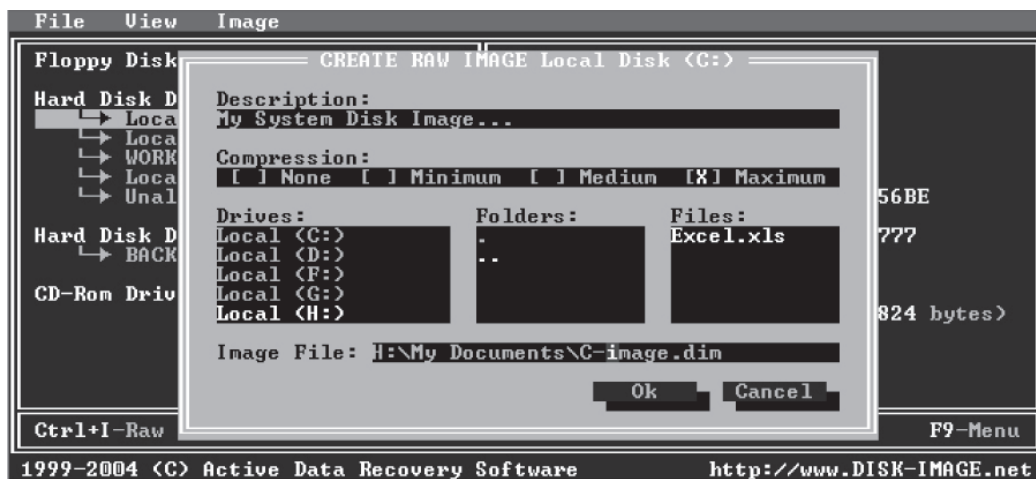
Tool: Active@ Partition Recovery

Active@ Partition Recovery for DOS can recover deleted partitions only if its location on a hard disk drive has not already been overwritten. If an MBR backup was created by using Active@ Partition Recovery, users can always restore MBR and partition information.



Source: www.disk-image.net. Accessed 2/2007.

Figure 4-53 Using Active@ Disk Image, a user can look at the properties of all the storage devices in a system.



Source: <http://www.disk-image.net>. Accessed 2/2007.

Figure 4-54 Users can create images of particular partitions using Active@ Disk Image.

Active@ Partition Recovery for Windows will help if a nonsystem partition is lost (i.e., users can boot Windows, install, and run the software from under the Windows operating system to recover deleted or damaged partitions located on data volumes). BOOT.INI is corrected automatically (if needed) to keep the system bootable, and damaged volume boot sectors are corrected to maintain integrity of the partition. The software can repair the MBR and delete invalid partitions.

Active@ Partition Recovery can:

- Recover deleted partitions (FAT, FAT32, and NTFS)
- Restore deleted FAT and NTFS logical drives
- Create drive images for backup purposes
- Scan hard drives and detect deleted FAT and NTFS partitions and/or logical drives
- Preview files and folders on deleted partition or drive, to recover proper data
- Backup MBR (master boot record), partition table, and boot sectors
- Restore MBRs, partition tables, and boot sectors from backup if damaged
- Undelete partitions (primary and extended)
- Be stored on a bootable floppy disk due to its small size
- Display complete physical and logical drive information
- Be used with ease: controlled by only arrow, Enter, and Esc keys

Figures 4-55 and 4-56 show screenshots from Active@ Partition Recovery.

Tool: DiskInternals Partition Recovery

DiskInternals Partition Recovery is intended for users who need to recover data or lost partitions. DiskInternals Partition Recovery includes a step-by-step wizard and requires no special skills to operate. This product includes DiskInternals NTFS and DiskInternals FAT recovery products.

DiskInternals Partition Recovery recovers data from damaged, deleted, lost, or reformatted partitions, image files, or important documents. The software includes a Partition Recovery Wizard, NTFS Recovery Wizard, and a FAT Recovery Wizard.

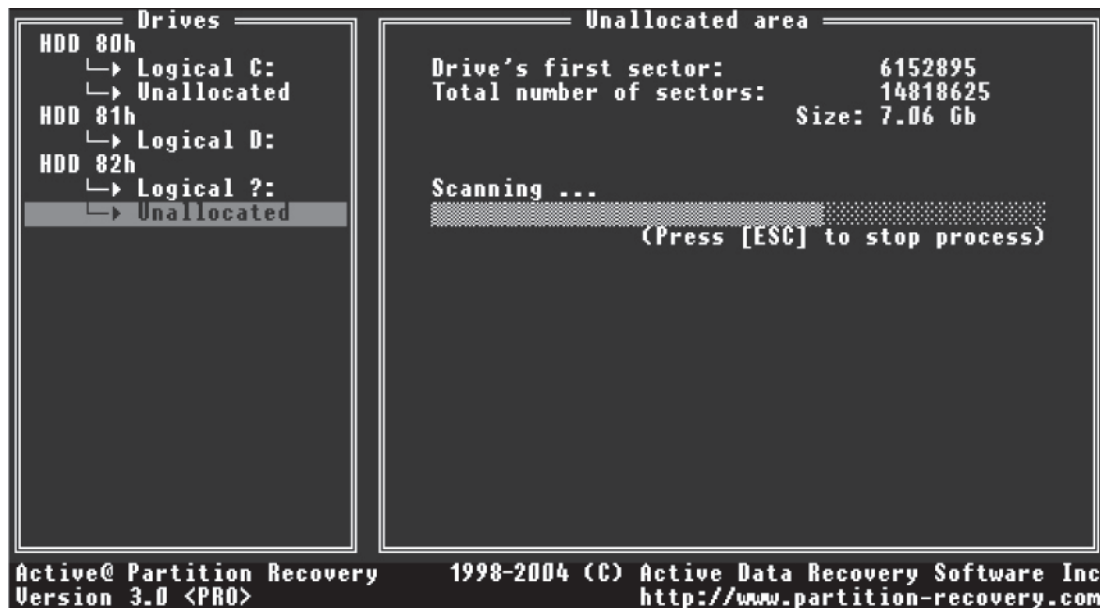
DiskInternals Partition Recovery supports a multitude of file systems, including:

- FAT12, FAT16, FAT32, and VFAT
- NTFS, NTFS4, and NTFS5

The tool scans every disk sector for recoverable data. DiskInternals Partition Recovery repairs data from virtual disks, and it does not matter if these files or folders were deleted before recovery or not.

Figure 4-57 shows a screenshot from DiskInternals Partition Recovery.

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Source: www.partition-recovery.com. Accessed 2/2007.

Figure 4-55 Active@ Partition Recovery can scan a drive to find deleted partitions.



Source: www.partition-recovery.com. Accessed 2/2007.

Figure 4-56 This screenshot shows that the software will create an image of the deleted partition on the selected drive.

Tool: GetDataBack

GetDataBack will recover data from a lost, deleted, damaged, formatted or reformatted, or crashed hard drive's partition table, boot record, FAT/MFT, or root directory. GetDataBack also recovers files over a user's local network or over a serial cable; this feature enables the user to run GetDataBack on one computer while accessing the drives of another computer. It also recovers data from removable drives and logical drives.

GetDataBack supports Unicode, which allows the recovery of files with names encoded in nonstandard character sets. This includes all Unicode character sets, such as Japanese, Chinese, Korean, Russian, and Greek. It is recommended to perform the data recovery on an NT/XP computer because Windows 9x/ME does not fully support Unicode.

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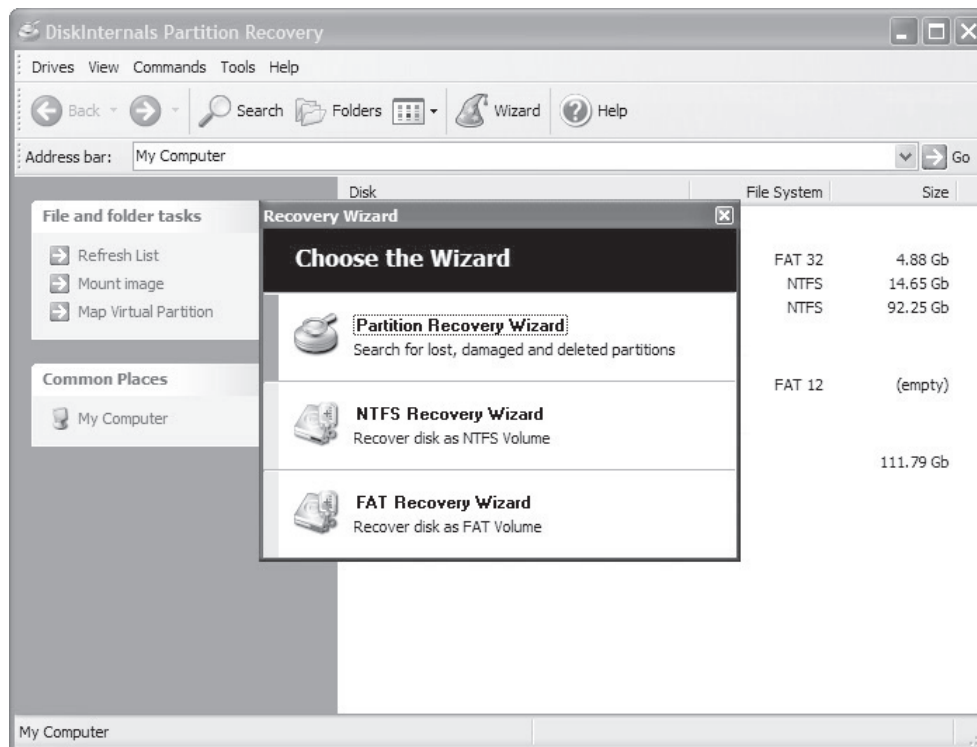


Figure 4-57 This image shows that the software will create an image of the deleted partition on the selected drive.

GetDataBack can be used for FAT and NTFS to recover files from drives with their respective file system. GetDataBack for FAT and NTFS can run under Windows 95/98/ME/NT/2000/XP.

Figures 4-58 and 4-59 show screenshots from GetDataBack for NTFS and FAT.

Tool: Deleted NTFS Partition Data Recovery

Deleted NTFS Data Recovery software has been designed and developed to recover data from Windows NT/2000/2003/XP operating systems. It retrieves data files and folders lost due to formatted/damaged/overwritten/deleted/corrupted partitions from NTFS-based operating systems, such as Windows NT/2000/XP/2003, from the hard disk. It also recovers data from storage media such as Zip drives, digital cameras, Pen drives, key chain drives, Memory Cards, and Flash memory.

The software provides an effective graphical user interface with built-in user-friendly support, providing the fastest and safest data retrieval facilities. The software is also helpful in computer forensics.

The following are some of the key features of Deleted NTFS Partition Data Recovery:

- Is easy, safe, read-only, and nondestructive
- Recovers data lost due to overwritten, damaged, or corrupted partitions in all logical drives or if the user's drive is accidentally formatted
- Recovers data from previously existing partitions in the user's drive and from bad sectors affected by storage media or drives
- Recognizes and keeps long file names when restoring files and folders.
- Provides recovery of deleted files and folders, even after the Recycle Bin has been emptied, or use of the Shift+Delete key combination has happened
- Recovers data even if the "Drive Not Formatted" message is displayed on the user's computer screen

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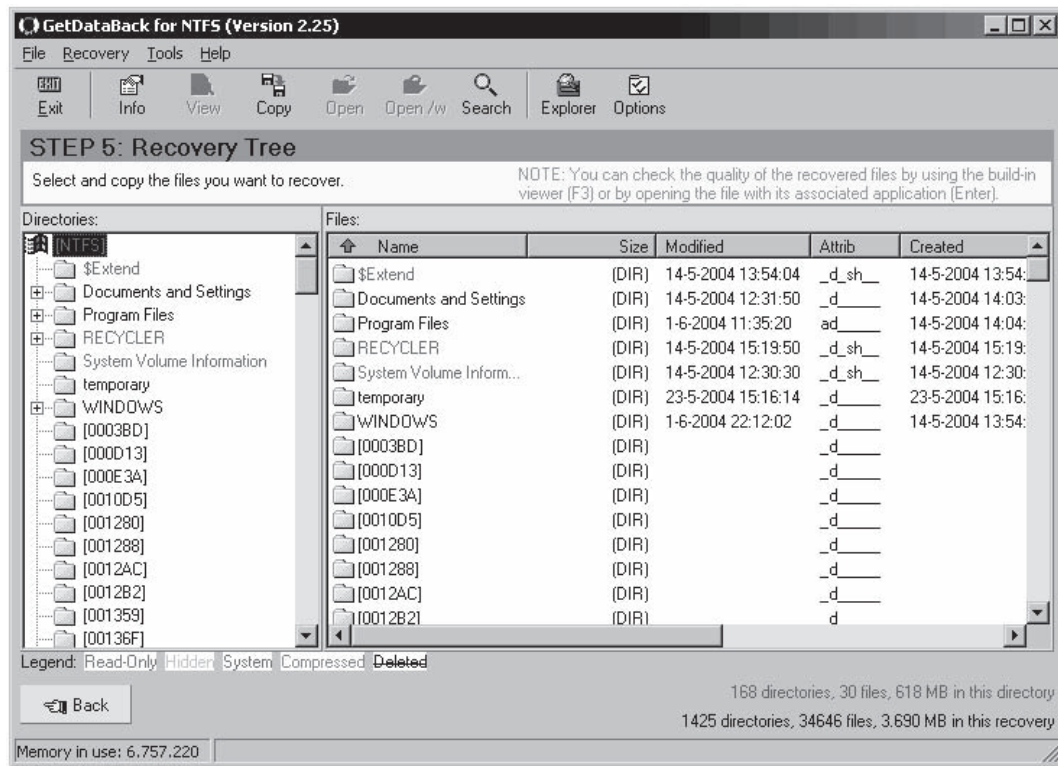


Figure 4-58 This image shows GetDataBack for an NTFS drive. System files are shown in red.

Tool: Partition Table Doctor

The Partition Table Doctor will recover a user's data if the partition table, or boot sector, on a hard disk is lost or damaged due to a virus attack, software failure, Fdisk or PartitionMagic misapplication, and so on. The Partition Table Doctor can recover partitions.

The Partition Table Doctor only modifies a partition table or boot sector, which means that the software will never attempt to write to the data area of the drive that a user wants to recover.

Partition Recovery tools provide a graphical user interface (GUI), and it is easy to create an emergency floppy disk or bootable CD. Though the software is easy to follow, advanced users can improve the results by analyzing the reports, examining the file system details, and selecting specific sectors to modify.

Figure 4-60 shows a screenshot from Partition Table Doctor.

Tool: Recover It All!

Recover It All! recovers and restores deleted or damaged partitions or boot sectors. It is designed for FAT16, FAT32, and Windows 2000. The software performs all functions, including partition recovery in memory first, eliminating the need for recovery at the file level.

The following are some of the features of Recover It All!:

- Recovers data and partition tables lost due to formatting, Fdisk, virus attack, deletion, and many other scenarios
- Provides true 32-bit recovery without truncating files, and keeps long file names intact
- Works with most RAIDs
- Recovers entire directories
- Repairs partitions and boot sectors even from virus attacks or accidental use of Fdisk, and restores lost partitions and corrupt partitions
- Is safe because all recovery functions are performed in memory first

<https://t.me/learningnets>

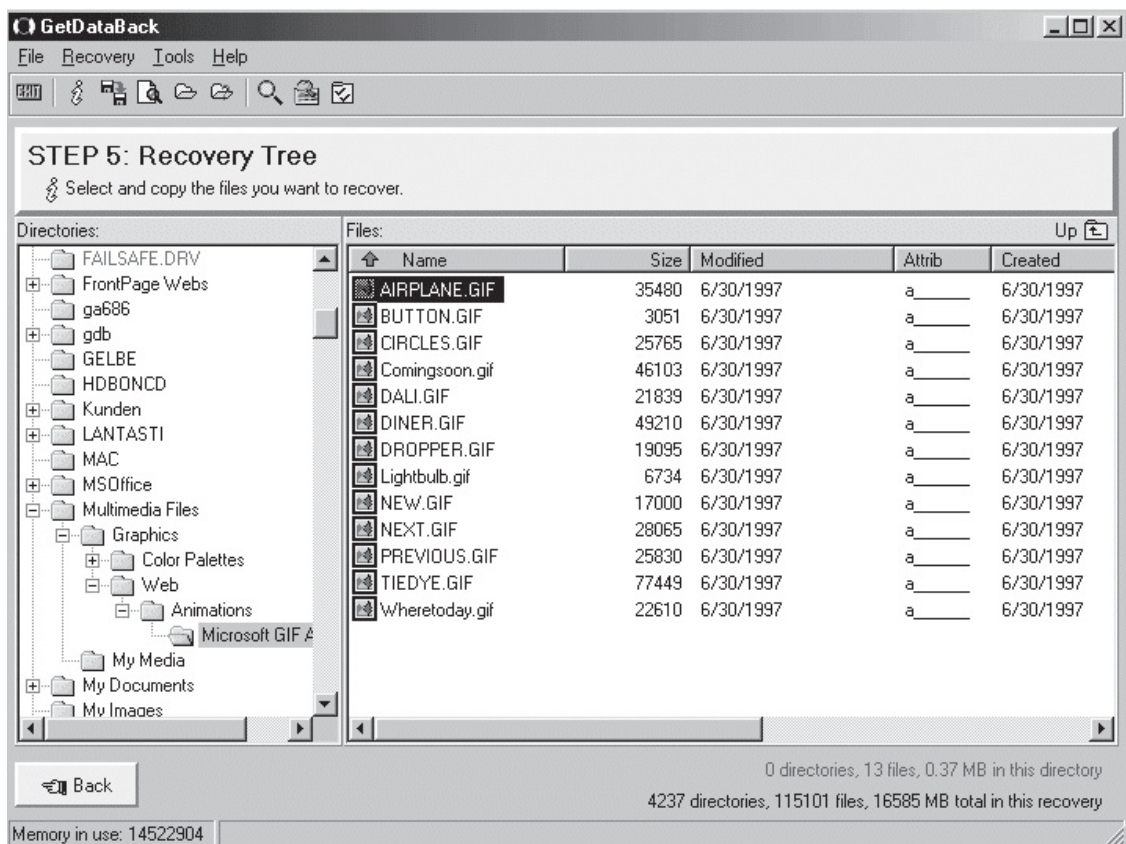


Figure 4-59 This image shows GetDataBack for FAT. Files to the right can be recovered individually.

- Is easy to use, powerful, and quick
- Recovers deleted files

Tool: Scaven

Scaven is a microtool for data recovery. It was designed to perform unattended multisession searches through large hard drives. It records the position of matches found to the output text file in a sector: offset: match format (fixed size column).

Scaven is an effective tool and time saver in recovering data from:

- Files permanently deleted
- Files lost through overwrite
- Accidentally formatted drives
- Drives with damaged MBR/lost partitions
- Drives with corrupted FATs
- Drives that have developed bad sectors

The following are some of the features of Scaven:

- Performs a multiple-string search in a single pass
- Works with any size LBA hard drive (up to 138 GB)
- Automatically detects drive geometry (CHS and LBA)
- Can access drives invisible on DOS

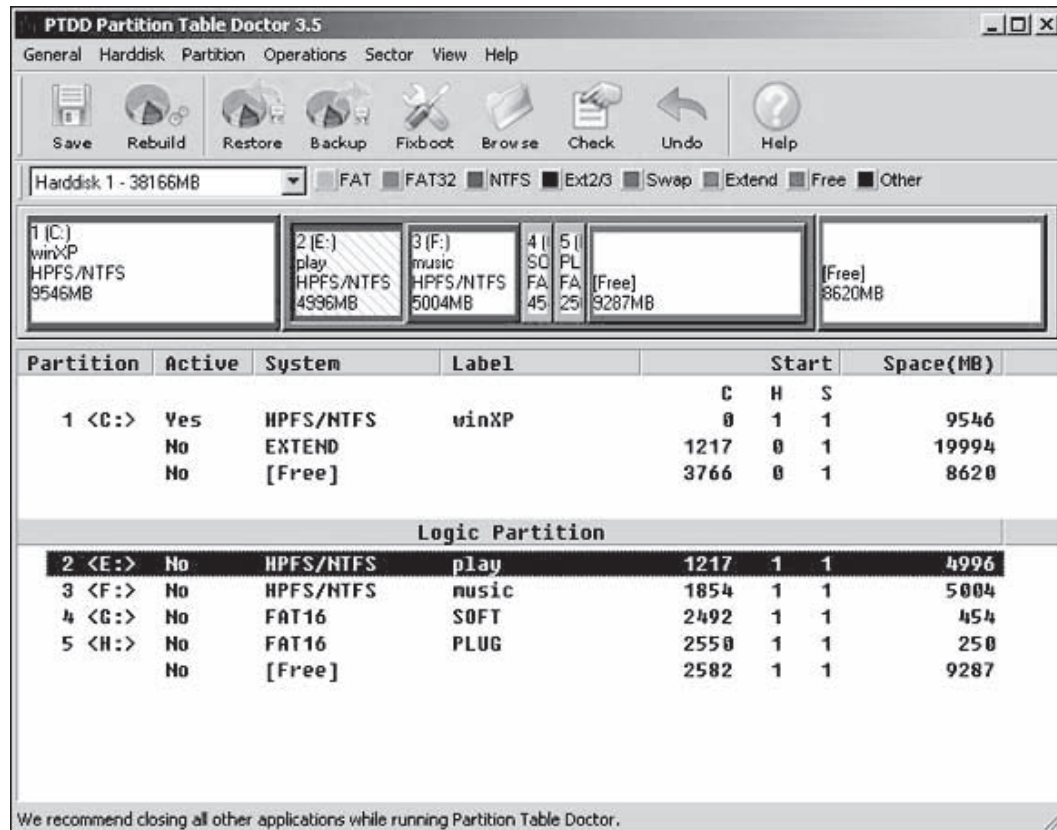


Figure 4-60 This image shows Partition Table Doctor. Notice that different partitions can be recovered at the same time.

- Fits on a single floppy and leaves plenty of room (size <10k) on the hard drive
- Records the position of matches found as sector number: offset
- Records the location of bad sectors as a sector number
- Uses standard text files for input/output
- Was written in a plain assembler for the sake of size/speed

Tool: TestDisk

TestDisk is free data-recovery software. It was primarily designed to help recover lost partitions and/or make nonbooting disks bootable when these symptoms are caused by faulty software, certain types of viruses, or human error (such as accidentally deleting the partition table).

TestDisk supports the following operating systems:

- DOS (either real or in a Windows 9x DOS box)
- Windows (NT4, 2000, XP, 2003)
- Linux
- FreeBSD, NetBSD, and OpenBSD
- SunOS
- Mac OS

TestDisk can find lost partitions for the following file systems:

- BeFS (BeOS)
- BSD disklabel (FreeBSD/OpenBSD/Net BSD)
- CramFS, Compressed File System
- DOS/Windows FAT12, FAT16, and FAT32
- HFS and HFS+
- JFS, IBM's Journaled File System
- Linux ext2 and ext3
- Linux Raid

TestDisk queries the BIOS or the OS in order to find the hard disks and their characteristics (LBA size and CHS geometry). TestDisk does a quick check of the user's disk's structure, and compares it with the user's partition table for entry errors. If the partition table has entry errors, TestDisk can repair them. If the user has missing partitions, or a completely empty partition table, TestDisk can search for partitions and create a new table, or even a new MBR, if necessary.

However, it is up to the user to look over the list of possible partitions found by TestDisk and to select the one(s) that were being used just before the drive failed to boot or the partition(s) were lost. In some cases, especially after initiating a detailed search for lost partitions, TestDisk may show partition data that is simply the remnants of a partition that had been deleted and overwritten long ago.

TestDisk has features for both novices and experts. For those who know little or nothing about data recovery techniques, TestDisk can be used to collect detailed information about a nonbooting drive, which can then be sent to a tech for further analysis. Those more familiar with such procedures should find TestDisk a handy tool in performing on-site recovery.

Figures 4-61, 4-62, and 4-63 show screenshots from TestDisk.

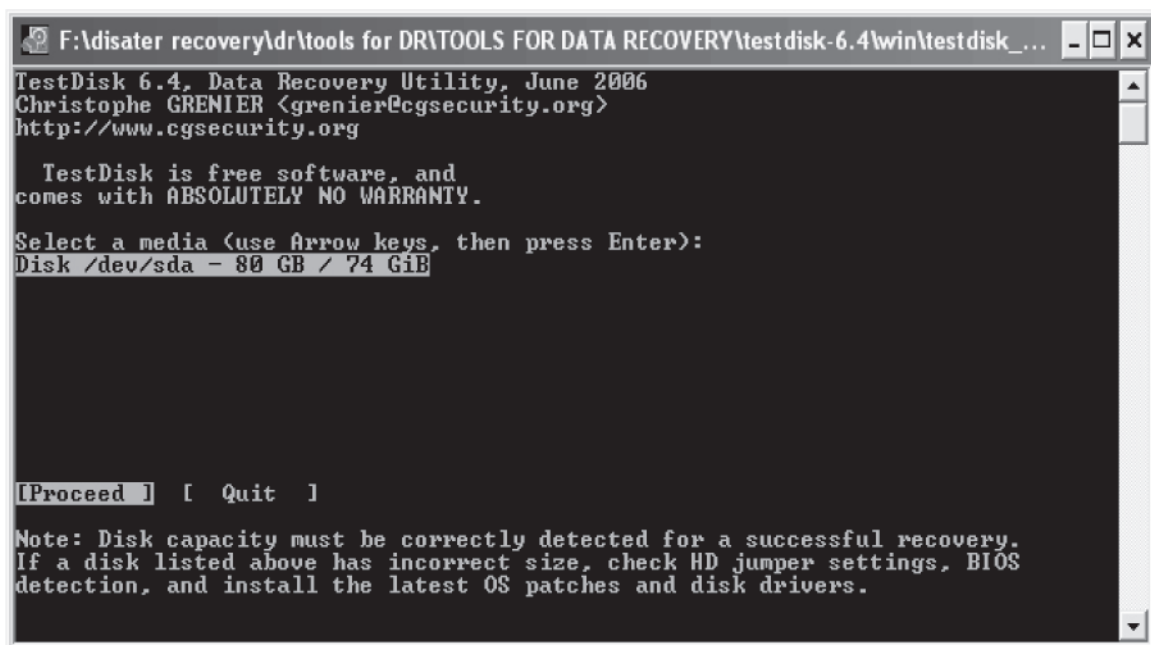
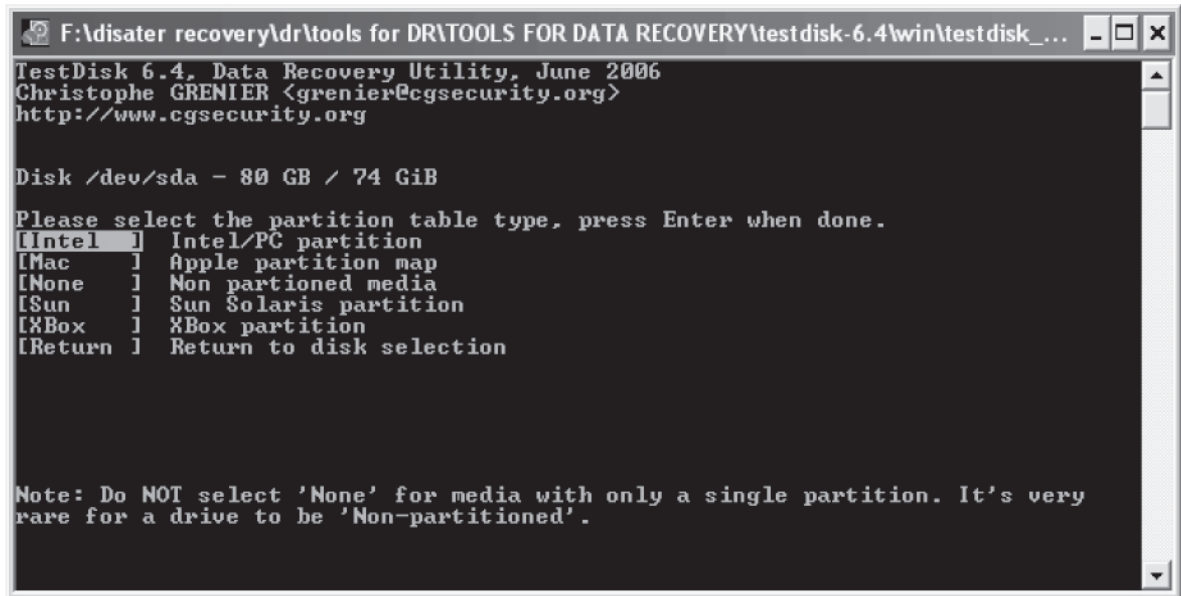
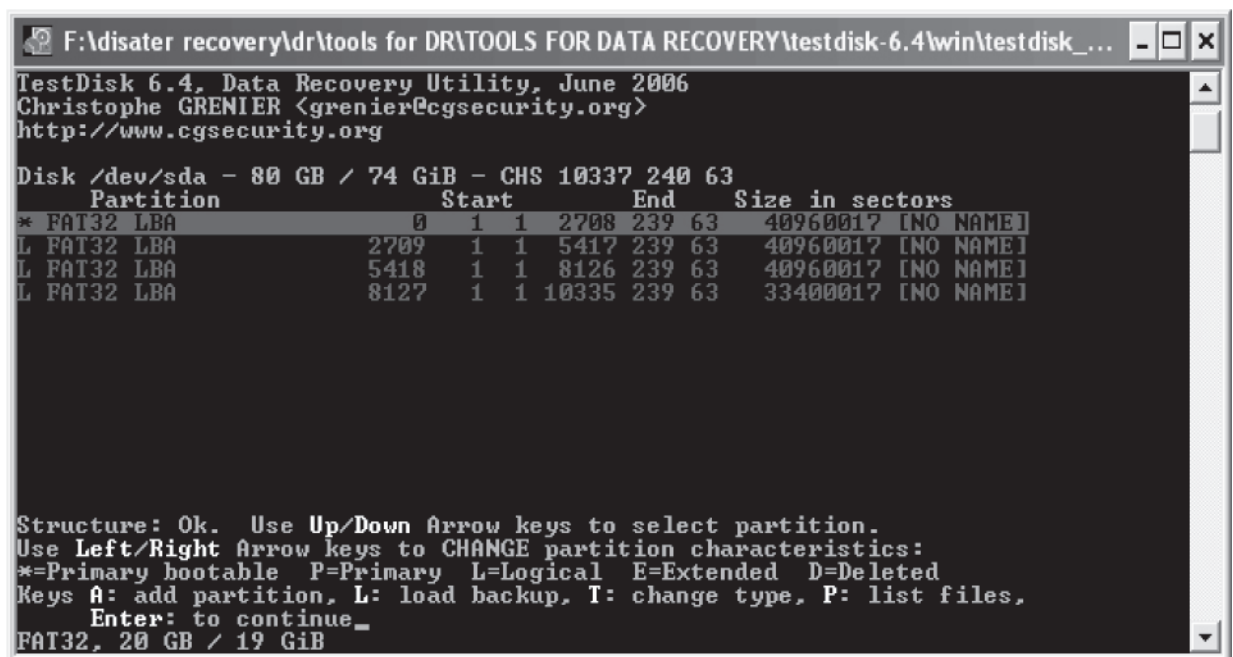


Figure 4-61 These images show the TestDisk application being used to recover lost partitions.



Figures 4-62 These images show the TestDisk application being used to recover lost partitions.



Figures 4-63 These images show the TestDisk application being used to recover lost partitions.

Chapter Summary

- In Windows, files in the Recycle Bin are stored in the C:\RECYCLED folder on FAT file systems, and in the C:\RECYCLER folder on NTFS file systems.
- Damaged files in the Recycled folder do not appear in the Recycle Bin.

- In Linux, files that are deleted using **/bin/rm** remain on the disk.
- Files or folders deleted from removable media are not stored in the Recycle Bin.
- Deleting a partition on a dynamic disk can delete all dynamic volumes on the disk, thus leaving the disk in a corrupt state.
- Recovery of deleted partitions is the process by which the investigator evaluates and extracts deleted partitions.

Review Questions

1. What happens when a file is deleted in Windows?

2. How does the Recycle Bin work in Windows?

3. Why are the Recycle Bin folders differently named on NTFS and FAT file systems?

4. Explain the following:

- a. Damaged or deleted INFO2 file
- b. Damaged Recycled folder

5. Describe the data recovery process in Linux.

6. How can you delete a partition using the command line?

7. Write down the steps to delete a partition using the Windows interface.

8. Name three events that can cause data loss in files, folders, or file structures.

9. Which tools recover deleted files in Linux?

10. Which tool would you use to recover a BeOS formatted partition? Why?

Hands-On Projects



1. Run the R-Linux tool and recover deleted files from Linux.
2. Download Recover My Files from <http://www.recovermyfiles.com/>, run, and see the result.
3. Run the CDRoller tool and try to recover deleted data from a CD and DVD.
4. Run the Partition Table Doctor tool and recover deleted partitions.
5. Run the PC Inspector Smart Recovery tool and try to recover the deleted images from a digital camera.

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Image File Forensics

Objectives

After completing this chapter, you should be able to:

- Recognize graphic image files
- Explain data compression
- Locate and recover graphic image files
- Analyze graphic image file headers
- Reconstruct file fragments
- Identify and use tools for viewing graphic images
- Understand steganography in graphic image files
- Perform steganalysis in graphic image files
- Identify and use graphic image file forensic tools

Key Terms

Bitmap (BMP) a raster-based image format closely associated with Microsoft and many Microsoft image programs save files as BMPs by default. BMP files typically do not compress well, and so are larger than other compressed formats.

CMYK a color model that stands for Cyan, Magenta, Yellow, and Key (black); also known as the four-color model, CMYK works by subtracting some colors from white (all colors), leaving the resulting hue. CMYK is a model used by commercial printers and is capable of rendering millions of colors.

Carving *see* salvaging

Dithering a method used to create the illusion of greater color depth by blending a smaller number of colored dots together

Graphic Interchange Format (GIF) an 8-bit RGB bitmap format for images with up to 256 distinct colors per frame

Grayscale images in grayscale only include intensity information. Only shades of black and white (or gray) are rendered.

Huffman Coding Algorithm a variable-to-fixed lossless compression algorithm

Indexed color a color system in which every color is coded to a specific number (or index)

Interlacing a mechanism that makes images appear faster on-screen by first displaying a low-resolution version of the image and gradually showing the full version

Joint Photographic Experts Group (JPEG) file format a raster image compression format

Lempel-Ziv-Welch (LZW) algorithm a variable-to-fixed compression algorithm used in GIF files

Limited color palette each color in the GIF color table is described in RGB values, with each value having a range between zero and 255

Linear discriminant analysis a method of classification by comparing two or more samples; in Stegdetect software, it identifies the steganography by comparing the two images.

Lossless compression describes a compression algorithm that maintains data integrity

Lossy compression describes a compression algorithm that does not maintain data integrity, leading to possible loss of data

Pixel short for *picture element*, a pixel is a single point in a graphic image. On monitors, pixels are arranged in rows and columns to display pictures and text. To display a picture, pixels on the screen are closely connected.

Portable Network Graphics (PNG) a lossless, well-compressed format for displaying raster graphics; PNGs were created to replace GIFs. They support alpha channels and generally have smaller file sizes than the older GIF format.

RGB (Red-Green-Blue) color model the representation of colors based on combinations of red, green, and blue; this model is generally used in monitors, cameras, and televisions and is less likely in print production.

Raster image a file in which the information is converted into pixels; raster images are nonscalable.

Salvaging reconstructing an image file that was accidentally or deliberately destroyed using file fragments; synonymous with *carving*

Steganalysis retrieving information hidden in image files

Tagged Image File Format (TIFF) a flexible raster image file format, commonly used in desktop publishing and photography, that allows for multiple modes of compression and color depths

Vector image images in which information is stored as mathematical expressions rather than pixels; because the calculations can be done for any given space, vector images are scalable.

Vector quantization a lossy data compression technique in which vectors are used to compress the file

Zone Information Protocol (ZIP) a method of compressing computer data or files to save space

Case Example 1

Assistant Attorney General Alice S. Fisher, of the Criminal Division, and U.S. Attorney Chuck Rosenberg, of the Eastern District of Virginia, announced in Federal Court on September 8, 2006, the sentencing of Nathan L. Peterson, of Antelope Acres, California, to 87 months imprisonment.

Peterson was accused of stealing intellectual property of various software companies, such as Adobe Systems Inc., Macromedia Inc., Microsoft Corporation, Sonic Solutions, and Symantec Corporation. Peterson ran a Web site, <http://www.ibackups.net> and sold illegal copies of copyrighted software products at a price lower than the suggested retail price. The software was reproduced and distributed through an instantaneous computer download of an electronic copy, and/or by shipment through the mail on CDs.

As of February 2005, Peterson had made illegal sales of over \$5.4 million of copyrighted software, which resulted in a loss of approximately \$20 million to the owners. With this money, Peterson led a lavish lifestyle that included multiple homes and a boat. He also maintained numerous assets, such as bank accounts and a garage full of stylish cars.

After receiving complaints from copyright holders, an FBI undercover agent, posing as a customer, made purchases from the Web site. As a result of this investigation, the Web site was discontinued in February 2005. On December 13 of the same year, Peterson pleaded guilty to two counts of criminal copyright infringement for selling pirated software. The court also forfeited the proceeds of his illegal conduct and ordered him to pay restitution of more than \$5.4 million.

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Case Example 2

Most e-mail applications include a spam-detection component to identify keywords and strings of language contained in known spam. This reduces unwanted advertisements in the end users' mailboxes. To combat this, some spammers embed spammed ads in graphics files, so the messages go through undetected by the software and land in users' mailboxes. This has triggered the use of images in spam by spammers around the globe. Spammers target zombie machines to send images spam to various recipients around the globe.

The antispam e-mail vendor Vircom, released an upgrade to its antispam engine. Modus 4.35, released in May 2006, has the capability to detect image-based spam with a 95% success rate. Most of the antispam engines available in the world do not have protection for image spam. Modus 4.35 can detect patterns and keywords within the image and return the information to the e-mail software to classify or not classify the e-mail as junk.

Introduction to Image File Forensics

This chapter covers the various methods in which a forensic investigator can go about recovering graphics files. This chapter mainly deals with understanding the basic concept of recovering graphics files. The chapter also highlights the various image recovery, steganalysis, and viewing tools that are used and the salient features of these tools.

Introduction to Image Files

An image is an artifact that reproduces the likeness of some object. Photographs, faxes, photocopies, reflections, and views from microscopes and telescopes are all images. Computer forensics, with regard to recovering graphic image files, is of prime importance to many corporate organizations. A large number of computer forensics investigations include graphic images, typically downloaded from the Internet and sent through e-mails by employees of the company. In order to examine and recover these deleted files, a computer investigator needs to know the basics of image file graphics, including:

- Features of graphic image files
- Common image file formats
- Compression methods used by image files

Computer forensic investigators need to identify image file fragments and repair damaged image file headers. There are many tools in a computer forensic investigator's arsenal to recover image files. Examiners also give importance to the process of steganography, in which data is hidden inside files and images. They also analyze image file headers from unknown image file formats, a painstaking process. It is important to properly recover image files in order to use the hidden data as evidence.

There are four different kinds that can be used in an image. The **CMYK** scale is best for print production. The colors used in a CMYK image are percentages of cyan (blue), magenta (reddish-pink), yellow, and black. These result in millions of possible color combinations. Another scale is **RGB** (red, green, blue), which results in 256 possible colors. **Indexed color** contains the colors in RGB, but only the colors used by the image. Images can also be **grayscale**, which only shows shades of the colors black and white.

There are several different kinds of image file formats. Image formats can differ in color, ease of use, and size during the reproduction process. They also have specific internal structures that are important to an investigator analyzing or repairing files.

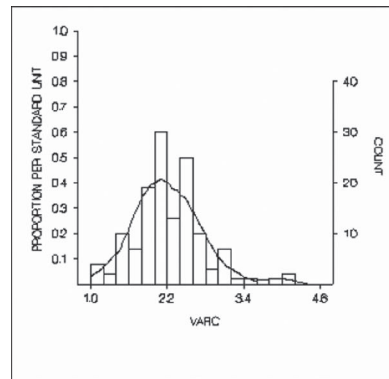
Images can be broadly categorized into vector images and raster images.

Understanding Vector Images

Vector images use geometrical shapes and primitives, such as points, lines, curves, and polygons, based upon mathematical equations, in order to represent images in a computer. Because each image is basically an equation, it is easy to move, scale, rotate, and fill a completed image. The file size of a vector image is relatively small, because it stores only the mathematical calculations, not the images, of the pictures included. Vector images can be easily embedded into another program without bloating the host file size.

It is possible to enlarge a vector image without affecting the quality of the image; the graphic program simply multiplies the existing pixels on the image file by the magnification you select. When investigators examine images in forensic investigations, they can enlarge elements greatly to examine them better.

Vector files can be converted into raster files, as long as there are no other images, such as digital photography or scanned photographs, in the vector file format.



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Figure 5-1 A metafile contains both vector and raster elements.

Understanding Raster Images

Unlike vector images, **raster images** are composed of a collection of pixels. A **pixel** is a single point in a graphic image. The quality of raster images is specified by the number of pixels present and information present in each pixel. Because the number of pixels is fixed when the image is set, if you enlarge the image, it loses its quality. (Imagine a photograph. When you enlarge the photograph, the picture becomes blurry, and it is harder to see specific elements.)

In every raster image, pixels are associated with three 8-bit color values (0–255 values) that define the amount of each of the three colors (red, green, and blue) in each pixel. Images that have less color require less information per pixel. Images that have only black and white pixels contain only a single bit for each piece of information.

File formats such as BMP, JPEG, and GIF are examples of the raster image. In a raster image, the pixels are arranged in rows that make the image file easier to print. When any type of image is printed, it has to be converted to a raster image first to print the pixels line by line, in order to finish the complete set of pixels.

Metafile Graphics

Metafile graphics include both raster and vector images. When a metafile is enlarged, some parts of the image show a lower resolution, thereby giving the image a shady appearance. An example of a metafile is a photograph of an image file with arrows superimposed on the photograph. If a metafile is enlarged, the area created with a raster format loses some resolution, and the quality of the file will be low. However, the formatted area of the vector will remain sharp and clear without any loss to compression. Figure 5-1 shows a standard metafile graphic.

Understanding Image File Formats

A file format is a way to encode information to be stored in a computer file. Graphical editors that can save image file formats include Microsoft Paint, Macromedia Freehand, Adobe Photoshop, and GIMP for Linux. Many of these graphic editors are especially optimized for one particular file format. For example, Microsoft Paint

File Format	File Extension
Graphics Interchange Format (GIF)	.gif
Joint Photographic Experts Group (JPEG)	.jpg
Tagged Image File Format (TIFF)	.tif
Windows Bitmap (BMP)	.bmp
JPEG 2000	.jp2
Portable Network Graphics (PNG)	.png

Table 5-1 This table shows popular standard image formats and file extensions

can be used to work on only bitmap images. Macromedia Freehand generates and reads vector shapes. Forensic investigators usually use Adobe Photoshop, as it works on both bitmap images as well as vector graphics.

Many graphic-editing applications allow the examiner to create and save files in one or more of the standard image file formats. Table 5-1 shows commonly used image file formats.

GIF (Graphics Interchange Format)

GIF is a file format that contains 8 bits per pixel and displays 256 colors per frame. CompuServe generated the GIF format in 1987. GIF uses lossless data compression techniques, which maintain the visual quality of the image.

Features of GIF are as follows:

- **Limited color palette:** GIF image file consists of a color table, which stores the image consisting of 2, 4, 8, 16, 32, 64, 128, or 256 colors. Each color in this table contains an RGB (Red, Green, Blue) value within a range of zero to 255. GIF does not support the CMYK (Cyan, Magenta, Yellow, Key (Black)) color combination.
- **Dithering:** The size of the GIF file depends on the number of colors used. For example, if 256 colors are used, then it becomes 9.5 Kb. For 32 colors, it becomes 4.4 Kb, and for 16 colors, it is 1.9 Kb. **Dithering** is used to limit the size file. It combines smaller color dots together to form the greater color depth. Dithering adds noise to the image and it decreases the sharpness of the image.
- **LZW compression:** GIF uses the LZW (Lempel-Ziv-Welch) compression technique. This lossless data compression algorithm combines the string of same byte values into the single code word. It reduces the size of the 8-bit pixel data by about 40% or greater.
- **Interlacing:** GIF has a Web-specific feature known as **interlacing**. It helps to display the image quickly on the screen. This feature first shows the low-resolution version of the image and gradually displays the full version of the image. Table 5-2 shows the pattern of the lines of pixels displayed in an interlaced GIF.

Pass	Interval	Line numbers
1	8	1, 9, 17, 25, 33. . .
2	8	5, 13, 21, 29, 37. . .
3	4	3, 7, 11, 15, 19. . .
4	2	(all even rows) 2, 4, 6, 8, 10. . .

Table 5-2 This table shows the pattern of pixels displayed in an interlaced GIF

GIF File Structure A GIF file, consists of the following elements:

- **Header:** The GIF file starts with a 6-byte header, which identifies the type of GIF image. The first three bytes identify the file as the GIF format. The second three bytes tell the version of GIF format: 87a or 89a.

```
typedef struct _GifHeader
{
    // Header
    BYTE Signature[3];          /* Header Signature (always "GIF") */
    BYTE Version[3];           /* GIF format version ("87a" or "89a") */
}
```

- **Logical screen descriptor:** The logical screen descriptor contains data about the screen and color, which helps to display the GIF image. It describes the ScreenHeight and ScreenWidth fields, as well as screen resolution.

- *Global color table:* The logical screen descriptor is followed by the global color table. The size of the table depends upon the number of colors chosen for the image. All GIF images include three colors: red, green, and blue. There are 256 possible combinations of these three colors that can create a spectrum of colors accessible to the user. When saving an image, the user selects a maximum amount of colors in the final image, always in the power of two (i.e., 2, 4, 8, 16, 32 . . . 256). The more colors selected, the larger the file.

```
typedef struct _GifColorTable
{
    BYTE Red;      /* Red Color Element */
    BYTE Green;    /* Green Color Element */
    BYTE Blue;     /* Blue Color Element */
} GIF_COLORTABLE;
```

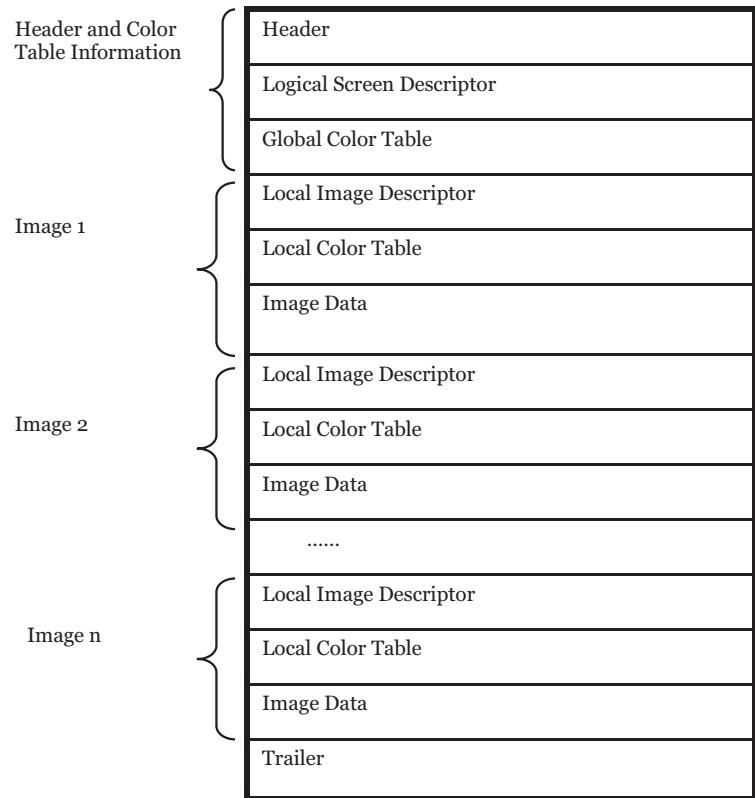
- *Local image descriptor:* Each image has a local image descriptor before the image data. The structure of the local image descriptor is as follows:

```
typedef struct _GifImageDescriptor
{
    BYTE Separator; /* Image Descriptor identifier */
    WORD Left;      /* X position of image on the display */
    WORD Top;       /* Y position of image on the display */
    WORD Width;     /* Width of the image in pixels */
    WORD Height;    /* Height of the image in pixels */
    BYTE Packed;    /* Image and Color Table Data Information */
} GIFIMGDDESC;
```

The separator indicates the start of the image descriptor data block. The left and top are the coordinates of upper-left corner pixel of the image. These coordinates are considered (0, 0). The width and height indicates the image size in the pixels. The BYTE Packed Image and Color Table Data Information includes the following five subfields:

- Bit 0: local color table flag
 - Bit 1: interlace flag
 - Bit 2: sort flag
 - Bit 3–4: reserved
 - Bit 5–7: size of local color table entry
- *Local color table:* The local image descriptor is followed by the local color table. It has the same format as the global color table. Every element consists of the three colors: red, green, and blue.

```
typedef struct _GifColorTable
{
    BYTE Red;      /* Red Color Element */
    BYTE Green;    /* Green Color Element */
    BYTE Blue;     /* Blue Color Element */
} GIF_COLORTABLE;
```



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Figure 5-2 Notice that there are several images in this GIF, but information about each image is contained in the single header.

- *Image data:* The image data in the GIF file is compressed by using the LZW compression algorithm. Data is encoded in a continuous stream, read from start to finish. It stores the data in a series of data subblocks. Each data block starts with the count byte. The count byte is between one and 255 and shows the number of data bytes in the subblock.

Figure 5-2 shows a GIF file structure.

There are currently two versions of GIF:

- *GIF 87a:* The first version of GIF was generated in 1987. It uses the LZW file compression technique, and supports features such as interlacing, 256-color palettes, and multiple image storage.
- *GIF 89a:* This version was generated in 1989. It supports features like background transparency, delay times, and image replacement parameters. These features are useful for storing multiple images as animations.

JPEG (Joint Photographic Experts Group)

JPEG is a commonly used method to compress photographic images. It uses a compression algorithm to minimize the size of the file without affecting the quality of the image.

The JPEG file format is useful for the following applications: digital cinema, digital photography, printing and scanning, document imaging, medical imaging, wireless imaging, remote sensing and GIS, image archives and databases, facsimiles, surveillance, and prepress.

JPEG compression happens in four phases:

1. First, the JPEG algorithm divides the image in separate blocks of 8×8 pixels.
2. The compression algorithm then applies a discrete cosine transform (DCT) for the whole image. DCT exchanges the values of images for every pixel in each block to an 8×8 matrix of DCT coefficients.

- Next, the compression algorithm checks the JPEG image quality asked for by the user, and then calculates two separate tables of quantization constants, one for luminance and one for chrominance. These constants quantize the DCT coefficients.
- The last step is to compress these coefficients using a Huffman or arithmetic coding scheme.

JPEG File Structure The first bits of a file identify the type of file. Every JPEG file starts with binary value 0xffd8 (SOI—start of image) and ends with binary value 0xffd9 (EOI—end of image), so ffd8 (the 0x is implied) shows that it is a JPEG file when viewed with a hex editor. A JPEG bit-stream contains a sequence of data chunks, or segments, and every chunk starts with a marker value. The basic format of a segment is as follows is followed by the 16-bit integer value that determines the file size value. The most significant byte of the marker (the left-most bit) is 0xff. The lower byte of the marker determines the type of marker.

The basic format of a segment is as follows:

0xff + marker number (1 byte) + data size (2 bytes) + data (n bytes)

For example, for the marker FF E1 00 0E, the marker (0xFFE1) has 0x000E (which equals 14) bytes of data. But the data size 14 includes the data size descriptor (2 bytes); thus, only 12 bytes of data follow after 0x000E.

Figure 5-3 shows a JPEG file structure. Figure 5-4 shows possible kinds of segment markers in JPEGs.

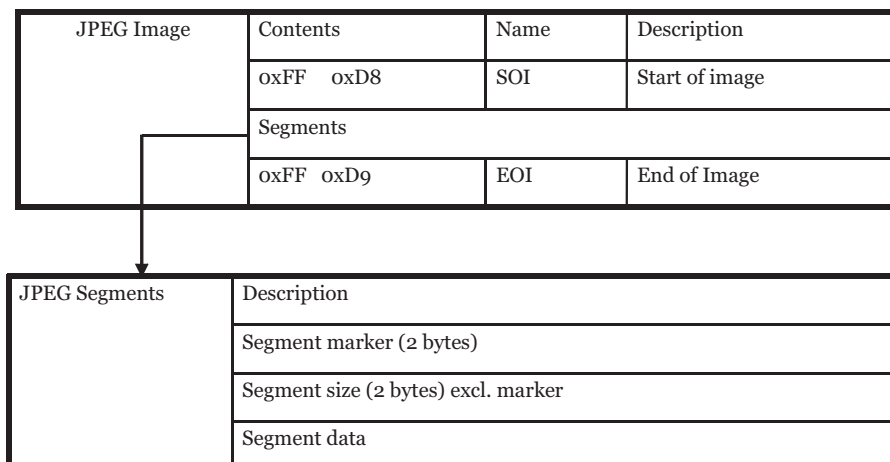
JPEG 2000

JPEG 2000 is the new version of JPEG compression from the JPEG committee. JPEG 2000 employs wavelet technology so images can be better compressed without affecting quality of an image.

JPEG 2000 Features

- JPEG 2000 offers a 20% improvement in compression efficiency over the current JPEG format.
- It employs wavelet technology with the existing compression algorithm. Wavelet technology gives improved image quality and better compression.
- It offers lossless compression mode as an option. The size of the lossless JPEG 2000 image will be half the original image.
- This compression was developed mainly for use on the Internet.
- It can handle RGB, LAB, and CMYK formats with up to 256 channels of information.

JPEG File Structure



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Figure 5-3 A JPEG image is divided into segments.

Some JPEG segment markers		
Contents	Name	Description
0xFF 0xE0	APP0	Application marker (in every JPEG file)
0xFF 0xDB	DQT	Quantization Table
0xFF 0xC0	SOF0	Start of frame
0xFF 0xC4	DHT	Define Huffman Table
0xFF 0xDA	SOS	Start of scan
0xFF 0xED	APP14	This is the marker where Photoshop stores its information

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Figure 5-4 A JPEG segment must contain an application marker, but may also contain any or all of the other information. The SOI marker and the EOI marker have no data following, but the other markers have data with them.

BMP (Bitmap) File

The **BMP (Bitmap)** file format is a standard file format for a Windows DIB (Device Independent Bitmap) file. Microsoft developed this format to store bitmap files in DIB format so that on any kind of display, Windows can display it. Bitmap images can be animated. The size and color of these images can vary from 1 bit per pixel (black and white) to 24-bit color (16.7 million colors).

BMP File Structure Every bitmap file contains the following data structure:

- *File header:* The first part of the header that includes the data about the type, size, and layout of a file
- *Information header:* A header component that contains the dimensions, compression type, and color format for the bitmap
- *The RGBQUAD array:* A color table that comprises the array of elements equal to the colors present in the bitmap; this color table does not support bitmaps with 24 color bits, as each pixel is represented by 24-bit RGB values in the actual bitmap.
- *Image data:* The array of bytes that contains bitmap image data; image data comprises color and shading information for each pixel.

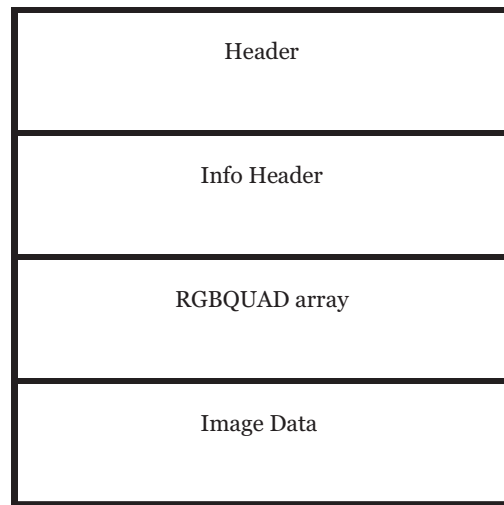
Figure 5-5 shows the file structure of a bitmap file.

PNG (Portable Network Graphics)

PNG is a lossless image format intended to replace the GIF and TIFF formats. PNG improves the GIF file format and replaces it with the image file format. It is copyright- and license-free.

PNG file format supports:

- 24-bit true color
- Transparency—both normal and alpha channel

BMP

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Figure 5-5 Bitmaps have a very basic structure for image information.

PNG File Structure

- PNG File Signature:
 - PNG file signature shows that the remainder of a file has a single PNG image.
 - The images are comprised of a series of chunks, starting with an IHDR chunk and ending with an IEND chunk.

Chunk Layout

- Chunk layout follows the header.
- Each chunk in a set suggests some information about the image.
- Every chunk has a header specifying the size and type of chunk.
- Every chunk consists of four parts:
 - *Length*: a 4-byte unsigned integer that gives the number of bytes present in the chunk's data field
 - *Chunk type*: a 4-byte chunk type code
 - *Chunk data*: the data bytes appropriate to the chunk type, if any; this field can be of zero length.
 - *CRC (Cyclic Redundancy Check)*: a 4-byte CRC calculated on the preceding bytes in the chunk; it includes the chunk type code and chunk data fields, but not the length field.

Tagged Image File Format (TIFF)

TIFF is a raster file format for digital images, created by Aldus, now controlled by Adobe. It was originally intended for use with PostScript printing. The main advantage of the TIFF file is that it can contain several image formats in a file. Tags are used to describe how the data should be represented in the final image.

The TIFF file can be used as a container for JPEG files. The file extension is .tif. TIFF supports both lossy and lossless compression algorithms; the lossless algorithms include PackBits and the LZW algorithm.

It has the following features:

- *Extendability*: This format can add new images and new information about the images without invalidating older image types.

- *Portability*: TIFF is flexible and platform-independent.
- *Revisability*: It was designed to efficiently exchange image information. It is also used as a native internal format for image editing applications.

TIFF File Structure

TIFF files are composed of three data structures:

- *Image file header (IFH)*: The image file header is the first data structure in the TIFF.
 - This 8-byte image file header is fixed at the location offset zero. The first two bytes contain the information about byte ordering, which is very important when the file is created. It either contains two bytes of “II” (hex 4949) for an Intel-created image file, or “MM” (hex 4D4D), for a Motorola-created image file.
 - Versions in the IFH consist of the decimal value of 42₁₀. It verifies that the present file is TIFF or not. This number remains constant, but if someone changes it, it means the TIFF file format has been changed and TIFF reader becomes unable to read that file.
 - The last four bytes in the IFH give the number of bits from the start of the file to the image file directory structure.
 - Notice that nothing about the image itself is included in the IFH. All image information is stored in the image file directory.
- *Image file directory (IFD)*: The IFD holds all the information about an image. If the file contains more than one IFD, there is more than one image in the file.
 - Each IFD entry consists of: a 16-bit header that tells the number of included tags, and all the directory entries (DEs) for a given image. Each DE is 12 bytes long.
 - After all DEs have been listed, the remaining bytes include the offset to the next IFD. If it is the last IFD in the file, then the storage location of the offset is four bytes of zeros.
- *Directory entry (DE)*: The DE is contained in the IFD. The DE is 12 bytes divided into four parts.
 - The first part is the tag field; it defines the raster data present in the TIFF files.
 - The next field is the type field, which specifies the data type of the image parameter, each having the integer number.
 - Length is the third field; it specifies the number of items of particular data types used. This value represents the number of data units in this particular entry; it does not represent the number of bytes needed to store the entry.
 - The last part of a DE contains the offset of the file to actual data related to the tag.

Figure 5-6 shows the file structure of a TIFF.

ZIP (Zone Information Protocol)

ZIP (Zone Information Protocol) is a method of compressing files designed by Phil Katz. Tools such as WinZip and WinRAR use this protocol to compress files. In ZIP, several files may be gathered together and compressed into a single “archive” file. A zipped file must be uncompressed in order to be used. Zip files can contain any file, such as text files, pictures, executables, music, and so on, and can be password protected for security purposes.

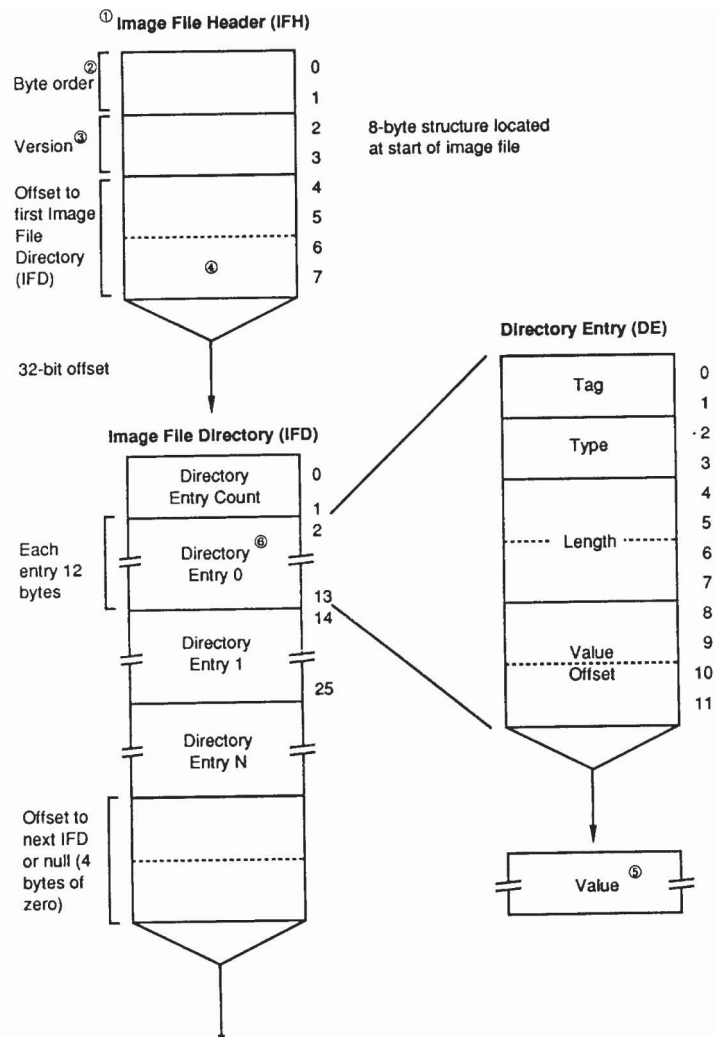
Zip files contain all the information about a zipped file, such as the name of the file, its path, on which data it is created, related time, and last modification.

There are several advantages to Zip files:

- It compresses a number of files into a single file, which reduces the space on the hard disk.
- Zip files can be transmitted faster over a network.
- Several files can be transferred at once.

Data Compression in Image Files

Image file formats, like bitmaps, cannot compress data without the help of some compression tools. Some of the most popular image file formats use the Graphics Interchange Format (GIF) and Joint Photographic Experts Group (JPEG) to compress data. This saves disk space and reduces the time it would take to transfer the image



Source: http://www.ee.cooper.edu/courses/course_pages/past_courses/EE458/TIFF/. Accessed 2/2007.

Figure 5-6 TIFFs include an image file header and image file directory. Notice that the DE is part of the image file directory.

from one system to another. Compression tools make the data compact and reduce the file size so drive space can be saved.

Data compression is a procedure that makes use of multifaceted algorithms used to reduce the file size. Typically, coding the data from a larger image to another smaller one is known as data compression. Vector quantization is similar to data compression. A vector image makes use of a mathematical equation that is similar to rounding up decimal values to eliminate unnecessary data.

Data compression is of interest in computer forensics because of its advantages in data processing, such as the cost savings and large volume of data manipulated in many business applications. The genre of local redundancy present in business data files comprise runs of zeros in numeric fields, series of blanks in alphanumeric fields, and fields present in some records and null in others.

Understanding File Compression

Most files use the same information, meaning they repeat the same sentences or words many times. File compression programs simply get rid of the redundancy. The file compression techniques list the information that is repeated, assign a code or number to each unique bit of information, and use the code to compress the information.

In this technique, repeated words are selected and stored into the dictionary. This dictionary consists of the words and numbers assigned to them. So when any word is repeated, the number is written, rather than the

word. It is necessary to maintain the dictionary because the dictionary is used to decompress the file. Most compression methods use the LZ adaptive dictionary-based algorithm.

For example: The cat is in the tree.

1 2 3 4 1 5

In the above example “the” word is repeated twice, so rather than write “the” two times, it is easier to give the number.

There are two main techniques of data compression:

- *Lossless compression*: **Lossless compression** maintains data integrity.
- *Lossy compression*: Lossy compression does not maintain data integrity.

Lossless Compression Algorithms

Huffman Coding Algorithm

The **Huffman Coding Algorithm** is a fixed-to-variable length code algorithm. It takes input characters that have a fixed length and gives the output, which has a variable length. The main concept behind the algorithm is that short code words are assigned to those input blocks that have high probabilities, and long code words to those with low probabilities. The characters can be arranged in any way.

This algorithm combines two possible characters into a single possibility by adding the code word. This procedure is continued until only one character remains. The tree is formed, and from that code tree, the Huffman code is obtained. Huffman codes are not unique. You can assign any label, such as a label to the upper branches of zero, and to the lower branches a label of one.

This algorithm uses two possible characters. In the example below, these characters are zero and one. The values with the highest probability, *a* and *e*, have the shortest codes (00 and 10). The values with the lowest probability, *j* and *b*, have the longest codes (111111 and 111110). Once these values are compressed, the file will be shorter because there will be fewer long-code values in the resulting file than short-code values.

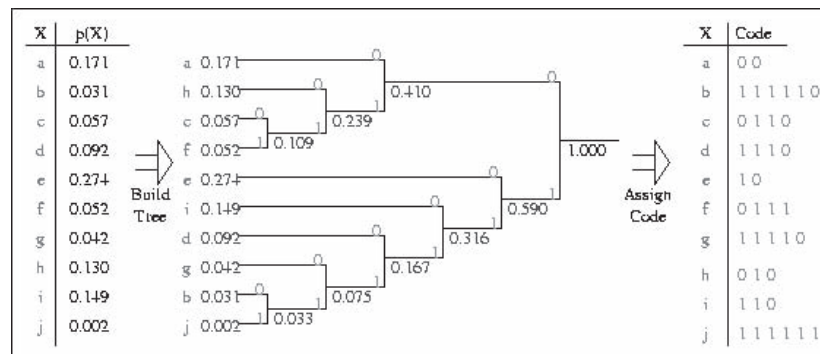
Figure 5-7 shows a possible Huffman Coding system.

Lempel-Ziv-Welch Coding Algorithm

The **Lempel-Ziv-Welch (LZW) algorithm** is used in most of the lossless compression techniques. LZW is a fixed-to-variable length code algorithm. Input is given in the variable length, while the output is given in the fixed length. It was generated not for a particular source, but for a large class of sources. In this algorithm, the input is given to the nonoverlapping blocks that have different lengths.

The following explains how to apply the encoding algorithm:

1. First, create a dictionary which contains all the blocks of one length, but all are nonoverlapping blocks ($D=\{a,b\}$).
2. Find the longest block *W* present in the dictionary.



Source: <http://computer.howstuffworks.com/framed.htm?parent=file-compression.htm&url=http://www.data-compression.com/lossless.html>. Accessed 2/2007.

Figure 5-7 In this image, read the binary numbers backwards to reach the letters, discounting the 1.000. For example, F is 0111.

<https://t.me/learningnets>

3. Encode that W, by its value present in the dictionary.
 4. Add W, followed by the first symbol of the next block to the dictionary.
 5. Return to step 2 and repeat the same procedure.
- In this way, the final amount of bits needed to contain the same information is reduced.

Consider the following example.

A	000	E	100
B	001	F	101
C	011	G	110
D	111	STOP char	010

In this example, the word BEAD would be encoded 001/100/000/111/010. Remember that when you apply LZW, you bundle single length entries and add new codes. For some of these codes, you may need to expand the returned code length (for example, adding another digit: 000 to 0000). Applying the LZW, the dictionary may be expanded to include the following entries:

AB	0000	AD	0101
BC	0001	AE	1010
CD	0011	AF	1001
DE	0111	AG	1011
EF	1111	BD	0110
FG	1110	BE	1101
AC	0100	STOP char	0010

Now the word BEAD would be encoded 1101/0101/0010, which is three bits shorter. If the dictionary is further expanded, the returned strings would get longer, but they include more values per string, and the overall length of the file is compressed.

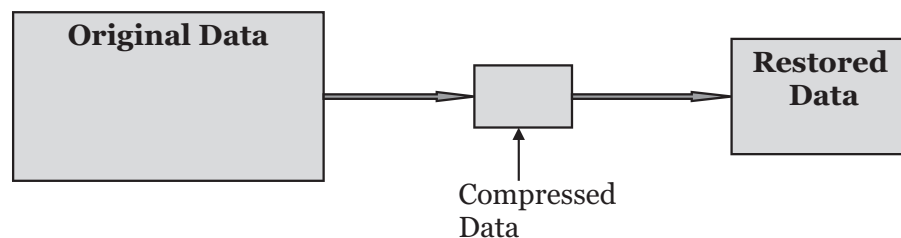
Lossy Compression

Lossy compression is different from lossless compression, as it can compress data permanently by overlooking some parts of the data. However, data integrity is not maintained in the lossy data compression technique.

The lossy data compression technique is never used for text compression. When a JPEG file is saved under a different image format, lossy compression is used to compress the data. However, once the image file is decompressed, the user will lose a lot of information. Another form of lossy compression is when vectors are used to compress the file, known as *vector quantization*.

Figure 5-8 shows lossy compression.

Lossy compression



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Figure 5-8 In lossy compression, the restored data is less than the original data. For this reason, lossy compression is never used for text because the text is directly encoded, so any loss of information would be a critical loss.

Vector Quantization

Vector quantization is a lossy data compression technique. Vector quantization uses an algorithm to find out if the data can be disregarded based on vectors that are present in the image file. The algorithms used are based on the principle of block coding. In each block, the information is replaced by the approximate average value.

Figure 5-9 shows a sample of vector quantization. In this example, any value within a block that falls between -4 and -2 will return the value -3 (code 00). Therefore, any slight nuances to the image will be lost.

Locating and Recovering Image Files

The first and most valid step that the forensic examiner must take is to search and recover any image files that are appropriate to the case at hand. Images are not necessarily present in standard image formats; therefore, investigators must also examine files that are of nonstandard formats.

The Windows and DOS operating systems have a wide variety of tools that can recover image files. These tools search for and retrieve specific information that is embedded in the image itself. Every image file has a header, which gives programs instructions about how the image file should be displayed on the screen. When an image file is dispersed into many areas on the disk, the forensic investigator should recover all the fragments in order to regenerate the image file. Looking for pieces of a file is known as *salvaging*, and in some parts of North America it is called *carving*.

In order to carve image file data from free space in the disk, it is essential to know about data patterns. These enable a forensic investigator to identify image file fragments. In any forensic investigation, this would be the first step in locating image files. After recovering the parts of a fragmented image file, the next step is to restore the data fragments. The most common tool used for this purpose is DriveSpy. This tool is used to carve known data sets from the leftover recovered data. This information must be restored to view the image file.

Using DriveSpy to Locate and Recover Image File Fragments

Figure 5-10 shows the output of a DriveSpy search. It shows the location of the cluster, sector, and offset.

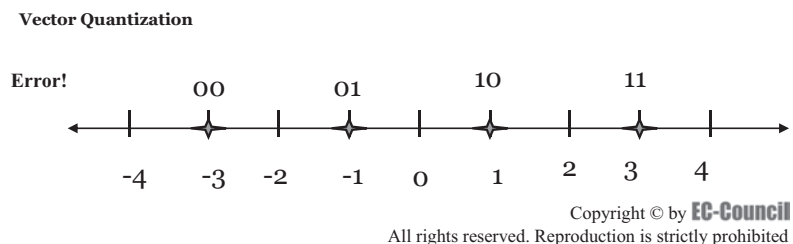
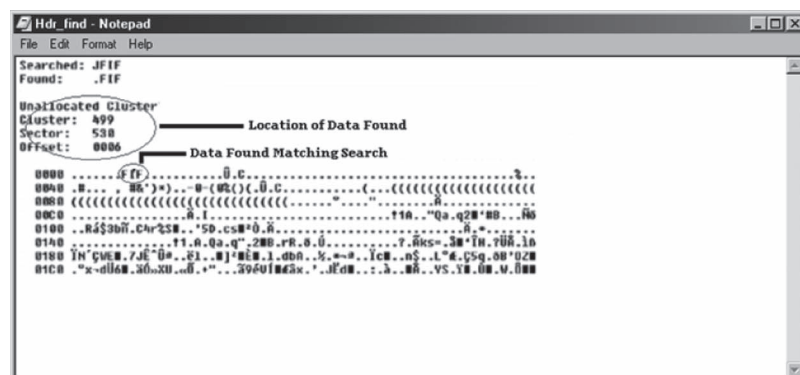


Figure 5-9 Vector quantization is a kind of averaging, causing a lossy compression of data.



Source: DriveSpy software. Accessed 2/2007.

Figure 5-10 Fragmented image information from DriveSpy.

<https://t.me/learningnets>

Computer forensic investigators use DriveSpy to locate and recover image file fragments. Investigators use the following simple steps to locate JPEG files on a disk:

1. Open a DOS command prompt window. Type in **DriveSpy** and press Enter to run the DriveSpy application.
2. At the DriveSpy SYS prompt, enter **Output Hdr_find.log** to enable the application to record the output of the commands that can be used in a text file named Hdr_find.log.
3. Insert the target investigation floppy disk into the A:\ drive. At the SYS prompt, type **Drive A**, and then press the Enter key to navigate to drive A:\.
4. From the DA command prompt, type **Part 1** and then press Enter to display the partition information for the floppy disk.
5. From the DAP1 command prompt, type **Search [filename]** (enter the file or folder name to look for) and press Enter. This will start a keyword search. At the prompt, press Y to turn off page mode.

From this process, the DriveSpy application searches the floppy disk for data that will match the search criteria, and can record this data in Hdr_find.log file. The log file can be viewed from Notepad as seen above.

Analyzing Image File Headers

Investigators must analyze image file headers when normal forensic tools cannot recognize new file extensions. Hexadecimal values present in the header can be used to define a file type in DriveSpy. A hexadecimal editor, such as Hex Workshop, can help access the file header.

For instance, when an investigator encounters a .h9 Freehand file, the file headers section of DriveSpy.ini is not able to define the .h9 format. In order to determine the file type, the investigator will need to know the file's good header value. This can be found by comparing the existing file headers with file headers of another image file format. The investigator can then identify a tool that can rescue and display the image.

Repairing Damaged File Headers

Investigators recover damaged remnants from free space on the drive. This information would be similar to headers from common image files. Header data that is partly overwritten can be used to repair damaged headers. The HEX Workshop application can be used to repair damaged headers.

Each image file has a special file header value that depends upon the format of the file type. An investigator can identify residual data from partially overwritten headers in file free space by examining common image header values. For example, the JPEG image file format has a hexadecimal value of FF D8 FF E0 00 10. Most JPEG files have the letters JFIF after the hexadecimal values of the file, as in FF D8 FF E0 00 10 JFIF. If a file fragment is found with JFIF, or the hexadecimal value associated with JPEG files, it is possible to identify the JPEG image.

Carving Data from Unallocated Space

Once a forensic investigator has identified data, a computer forensic program can carve, or retrieve, the fragmented image file. DriveSpy is the most popular tool used by forensic investigators for this purpose.

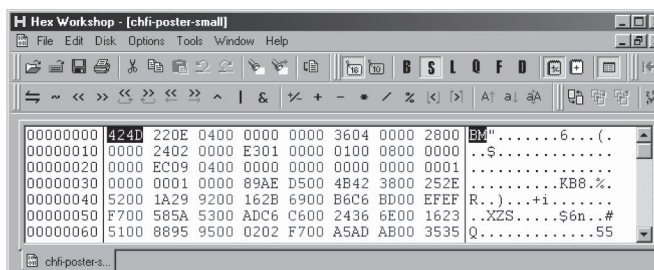
First, the investigator creates a duplicate bit-stream copy of the original evidence files using Digital Intelligence Image. Once the target disk contains the complete image of the file, DriveSpy can locate the file on the original disk and carve the data from the unallocated space. The SaveSect command is then used to save the file as an external file.

Reconstructing File Fragments

Corruption of data prevents investigators from reconstructing file fragments from an image file. Data can be corrupted accidentally without the knowledge of the user of the computer, or the data can be corrupted intentionally. It is up to the forensic investigator to find out how the data was corrupted. File fragments can be reconstructed by using DriveSpy to examine a suspect disk. Investigators can then build the case based on the reconstructed data.

Many forensic investigations lead to the conclusion that the suspect has intentionally corrupted data in order to hide incriminating evidence. The suspect may have done this by corrupting cluster links in a FAT table of a disk. A disk-editing tool can help a forensic investigator access the FAT table and identify the corrupted cluster. Corrupted clusters display 0000 in the disk editor. Take the example of the screenshot shown in Figure 5-11 where the image file header is a bitmap (shown in the highlighted portion of the hexadecimal values).

Figure 5-11 shows the output of Hex Workshop when repairing a fragmented image file.



Source: Hex workshop software. Accessed 2/2007.

Figure 5-11 Fragmented data is encoded in hexadecimal. It can be repaired using a disk-editing tool.

Identifying Unknown File Formats

Computer forensic investigators often come across unknown image file formats. The following is a list of non-standard image file formats:

- Targa (.tga)
- Raster Transfer Language (.rtl)
- Photoshop (.psd)
- Illustrator (.ai)
- Freehand (.h9)
- Scalable vector graphics (.svg)
- Paintbrush (.pcx)

In order to find and view nonstandard image file formats, forensic investigators can use any search engine, using the image file extension, to identify and download a tool that can view the image.

The following tools can identify nonstandard file formats:

- FILExt
- IrfanView
- ACDSee
- ThumbsPlus
- AD Picture Viewer
- Max
- FastStone Image Viewer
- XnView

Tool: FILExt FILExt is a quick way to identify the file type or parent application of a file based on the extension. On the FILExt Web site, enter the extension (for example, .Imp), and the application will return the most likely file type as well as some notes about the parent application and/or history of the file type. Some even return header strings in hexadecimal. Some extensions, such as .crc, will return several possible parent applications or file types. A forensic investigator can use the header strings to confirm which of the returned file types it is.

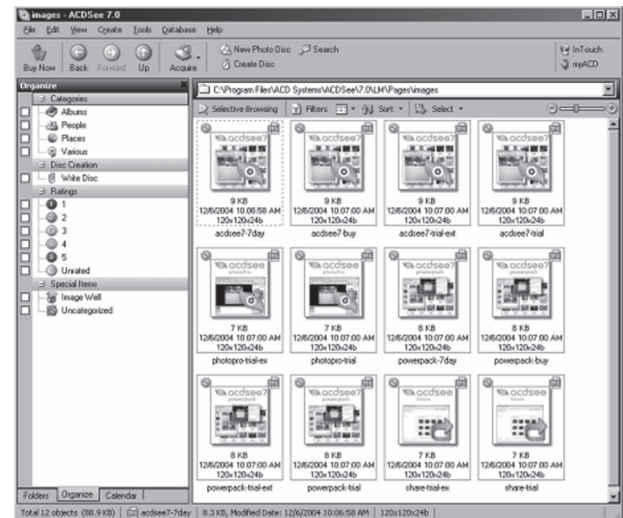
Tool: Picture Viewer: IrfanView IrfanView is an image viewing program that supports many nonstandard file formats including:

- Targa (.tga)
- Illustrator (.ai)
- Scalable vector graphics (.svg)
- FlashPix (.fpx)



Source: IrfanView software. Accessed 2/2007.

Figure 5-12 IrfanView can recover several image file formats.



Source: ACDSee software. Accessed 2/2007.

Figure 5-13 ACDSee can recover several image file formats.

Some notable features of IrfanView include:

- Ability to edit and add to images
- Various view options, including slideshow and thumbnail view
- Batch conversion
- Command line options
- Multipage TIFF editing and lossless JPEG rotation

Figure 5-12 shows the IrfanView application screen.

Tool: ACDSee ACDSee is an image-viewing program that allows an investigator to find, view, manage, and edit images. With ACDSee version 7, investigators can also acquire image files, create PDFs, and view unknown file formats, including media files. ACDSee viewer displays images in full resolution.

Figure 5-13 shows the ACDSee application screen.

Tool: ThumbsPlus ThumbsPlus is an image-cataloguing program that enables an investigator to locate, view, edit, print, and organize images, metafiles, fonts, and movies.

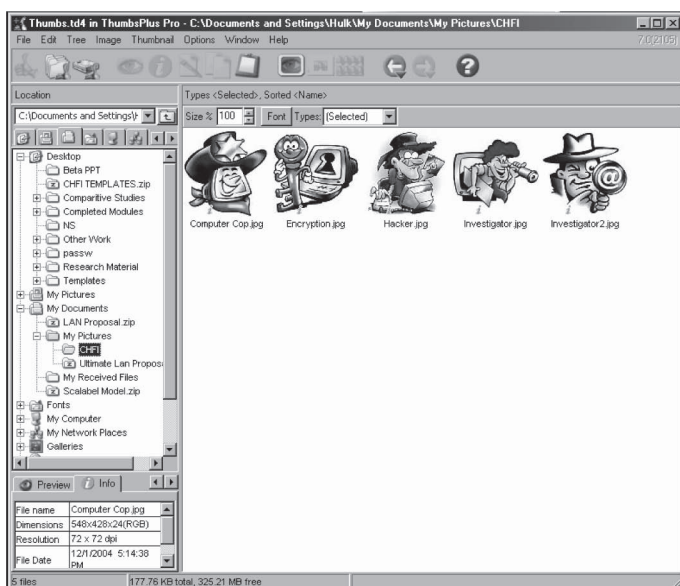
Version 6.0 supports a variety of file formats, including:

- Common formats: TIFF, JPEG, PNG, RAW
- Photoshop (.psd), including documents loaded with plug-ins
- Various camera file formats
- Images loaded using new Cerious plug-ins
- Scanned images (TWAIN)

Figure 5-14 shows thumbnails to be recovered via the ThumbsPlus application.

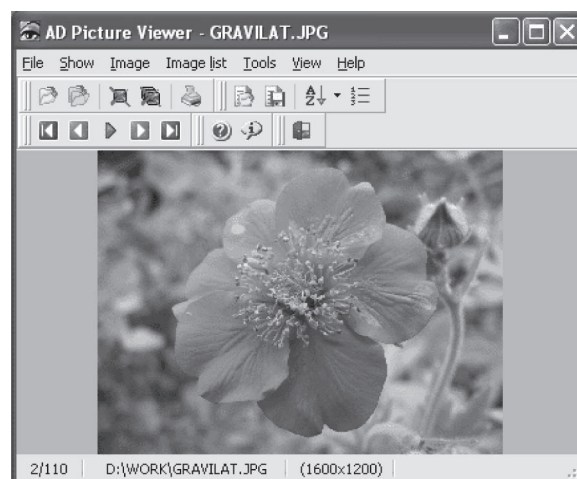
Tool: AD Picture Viewer AD Picture Viewer is a fast and compact image viewer for the Windows environment. It allows an investigator to view, print, organize, and manage images. It supports all popular graphic formats.

Figure 5-15 shows an image displayed by AD Picture Viewer.



Source: ThumbsPlus software. Accessed 2/2007.

Figure 5-14 The images in this screenshot can be recovered by ThumbsPlus.



Source: ADViewer software. Accessed 2/2007.

Figure 5-15 AD Picture Viewer can display a wide variety of image formats.

Tool: Picture Viewer Max Picture Viewer Max is an image and multimedia viewer for Windows 98/ME/2000/XP. It locates, views, edits, prints, organizes, sends and receives picture and image files, including videos, sounds, music, text files, documents, HTML, and system files. A forensic investigator can edit picture/image files using techniques such as flip, reverse, rotate, resize, brightness, contrast, color saturation, gray scale, hue, and other special effects and filters.

Some notable features of Picture Viewer Max are:

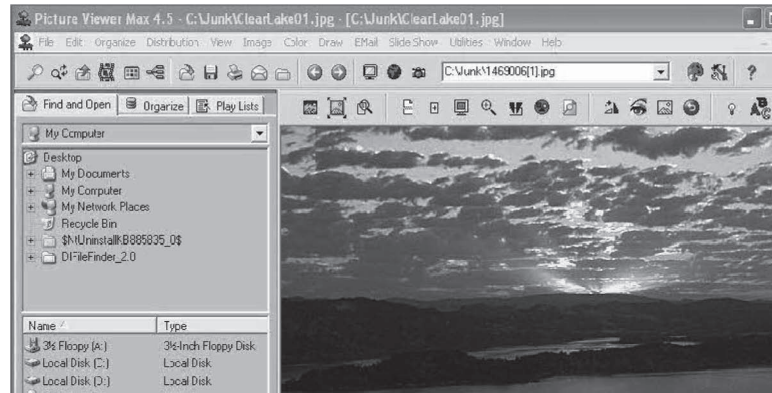
- It can add 3-D text and geometric shapes to pictures and images displayed in a multiple document interface.
- It can create blank picture frames with color gradients for logos or picture backgrounds.
- It supports: JPG, CMP, GIF, uncompressed TIF, TIFF, BMP, ICO, CUR, PCX, DCX, PCD, FPX, WMF, EMF, FAX, RAW, AWD, XPB, XPM, IFF, PBM, CUT, PSD, PNG, TGA, EPS, RAS, WPG, PCT, PCX, CLP, XWD, FLC, ANI, SGI, XBM, MAC, IMG, MSP, CAL, ICA, SCT, SFF, SMP, TXT, BAT, LST, WRI, SYS, RTF, HTM, HTML, PSP, ASP, DOC, PDF, AVI, AVI(DivX), MPG, MPEG, MOV, MP3, M3U, ASX, ASF, MID, RMI, MP2, AIFF, M1V, WMA, and WMV.
- It can convert picture file formats between picture file types.
- It can print up to eight pictures on a page, with titles for each page and picture. Select your font and color for all printed text.
- It can receive pictures and Zip files by e-mail, and view, edit, save, and print with Picture Viewer Max.

Figure 5-16 shows Picture Viewer Max.

Tool: FastStone Image Viewer The FastStone Image Viewer is an image browser, converter, and editor. It has a nice array of features that include: image viewing, management, comparison, red-eye removal, e-mailing, resizing, cropping, and color adjustments.

Some notable features of FastStone Image Viewer are:

- Image modification tools: Resize/resample, rotate/flip, crop, sharpen/blur, brightness/contrast
- Support for all major graphic formats (BMP, JPEG, JPEG 2000, animated GIF, PNG, PCX, TIFF, WMF, ICO, and TGA), and popular digital camera RAW formats (CRW, CR2, NEF, PEF, RAF, MRW, ORF, SRF, and DNG)
- High quality magnification and a musical slideshow with 150+ transitional effects



Source: <http://www.accessoryware.com/PictView.htm>. Accessed 2/2007.

Figure 5-16 Picture Viewer Max supports a huge variety of file types, including image, music, and movie files.

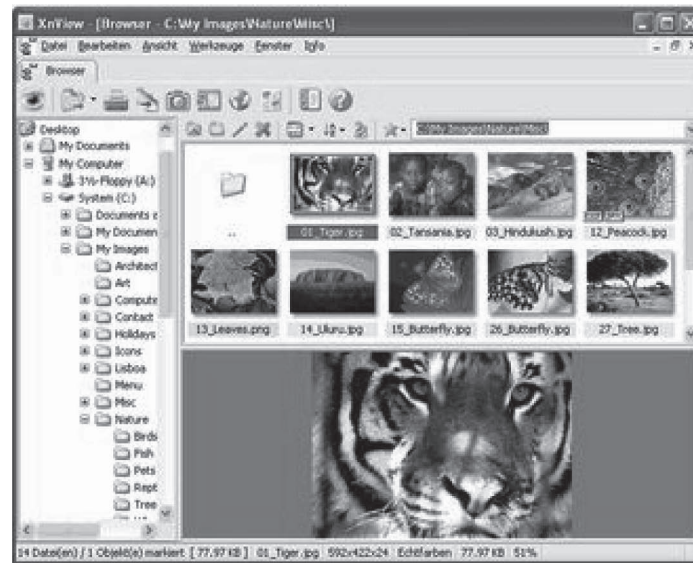


Source: <http://www.faststone.org/FSViewerDetail.htm>. Accessed 2/2007.

Figure 5-17 FastStone Image Viewer is an image editing and management tool.

- Image annotation and scanner support
- Image color effects: gray scale, sepia, negative, red/green/blue adjustment
- Image special effects: watermark, annotation, drop shadows, framing, bump map, lens, morph, waves
- Image management, including tagging capability, with drag-and-drop and copy to/move to folder support
- Versatile screen capture capability

Figure 5-17 shows the application screen for FastStone Image Viewer.



Source: XNView software. Accessed 2/2007.

Figure 5-18 This is the XnView application screen.

Tool: XnView The XnView tool can display and convert graphics files. It supports more than 400 graphics formats. It supports Windows, MacOS X, Linux x86, Linux ppc, FreeBSD x86, OpenBSD x86, NetBSD x86, Solaris sparc, Solaris x86, Irix mips, HP-UX, and AIX.

XnView includes the following features:

- It can import about 400 graphics file formats and export about 50 graphics file formats.
- It can support multipage TIFF, animated GIF, and animated ICO, as well as Image IPTC and EXIF metadata.
- It can support resize, rotate, and crop.
- It includes support for auto levels and contrast.
- The user can apply filters and effects (for example, blur, average, emboss, lens, wave) and modify the number of colors.
- It supports full-screen mode.
- It has support to create or edit multipage files (TIFF, DCX, LDF).
- It prints, drags and drops, and has 44 languages in Windows.

Figure 5-18 shows the XnView application.

Tool: FACES—Sketch Software FACES contains a database of more than 3850 facial features, including tools and accessories. This utility allows you to compose many images with their permutations and combinations. Law enforcement agencies use the software to identify suspects.

The features included in the software are coded in morphological order, and allow you to design images or faces of your choice with ease. One of the main features of this software is the utility InterCode, which encrypts the composite image and converts it into a character ID code. There exists a unique InterCode with every original image. When you click in the InterCode, a corresponding composite image appears on the screen. Thus, the software performs the process in seconds. This software is primarily used by law enforcement agencies and crime branch investigation organizations in identifying suspects.

Figure 5-19 shows the FACES sketch software application screen.



Source: <http://www.facesinterquest.com>. Accessed 2/2007.

Figure 5-19 Users can add or change facial features to develop a composite image of a suspect.

Steganography in Image Files

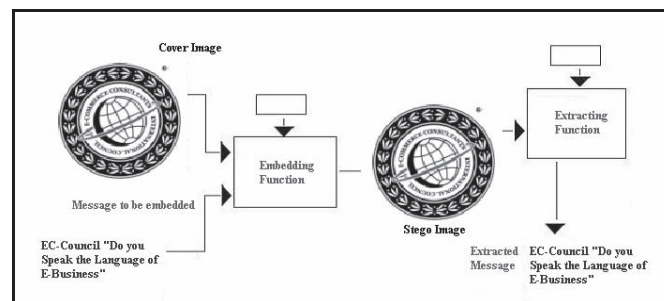
Since the introduction of the Internet, hidden messages inside digital images have become the most common and highly effective form of steganography. Images are stored as a group of pixels, 8–24 bits per pixel. This group of pixels can be stored in a second image file in one of three ways.

There are also three methods that are used to hide the messages inside these images, they include:

1. Least-significant-bit method
2. Filtering and masking
3. Algorithms and transformation

Figure 5-20 shows the process of steganography, embedding a message into an image and extracting it for analysis.

Steganography in Image Files



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Figure 5-20 Notice how a secret message is embedded into an unrelated image.

Steganalysis

Steganalysis is the reverse process of steganography. Steganography hides the data, while steganalysis is used to detect the data hidden via steganography. Steganalysis determines the encoded hidden message, and if possible, recovers that message. The message can be detected by looking at variances between bit patterns and unusually large file sizes.

There are two main challenges of steganalysis:

- The data may have been encrypted before it was hidden.
- If some of the signal or file contains noise or irrelevant data encoded into it, steganalysis can be complicated and take longer.

Tool: Hex Workshop

The Hex Workshop is a set of hexadecimal development tools for Microsoft Windows, combining advanced binary editing with the ease and flexibility of a word processor. With Hex Workshop, forensic investigators can edit, cut, copy, paste, insert, and delete hex; print customizable hex dumps; and export to RTF or HTML for publishing. Additionally, investigators can go to, find, replace, compare, and calculate checksums and character distributions within a sector or file.

Hex Workshop is integrated with Windows Explorer so investigators can hex-edit from the most frequently used workspaces. Hex Workshop includes a Base Converter for converting between hex, decimal, and binary, and a Hex Calculator supporting arithmetic and logical operations. The Hex Workshop also contains a Data Inspector and Structure Viewer so examiners can view and edit interpreted decimal values and embedded arithmetic and logical operations, allowing direct manipulation of the data.

Some features of the Hex Workshop application include:

1. A highly customizable editing environment
2. Data in its natural and native structured form as viewed through the Structure Viewer
3. Dynamic bookmarks in a simple macro language
4. The ability to edit sectors of floppies and hard disks
5. Prints high-quality hex dumps with customized headers, footers, and fonts
6. Views and edits raw binary data as decimal values with the Data Inspector
7. Interprets values in either little-endian (e.g., Intel) or big-endian (e.g., Motorola) byte ordering
8. Manipulates data using one of 22 embedded operations: byteflip, inverse bits, left shift, right shift, rotate left, rotate right, block shift left, block shift right, XOR, OR, AND, change sign, plus, minus, multiply, divide, mod, setfloorvalue, setceilingvalue, uppercase, lowercase, and swapcased
9. Inserts external file contents or save a block of data as a new file
10. Changes are tracked and coded in color
11. Exports and copies hex as RTF, text, and HTML for publishing or as C source or Java source
12. Imports and exports Intel hex code and Motorola S-Records.
13. Finds and replaces hex, bitmasks, decimal, or ASCII (including Unicode) values
14. Easily navigates documents and sectors using the goto command
15. Views text interpretations under ASCII, DOS, EBCDIC, Macintosh, Windows, and Unicode character set filters
16. A binary compare tool to find differences in files
17. Calculates checksums and digests (MD2, MD4, MD5, SHA1) for all or part of a file
18. Views character distributions and exports results as tabbed text or comma-separated values
19. File/disk properties with the click of the mouse
20. File/disk attributes in the status bar
21. Online help including multiple character tables and list of data types and ranges

Figure 5-20a shows the Hex Workshop application.

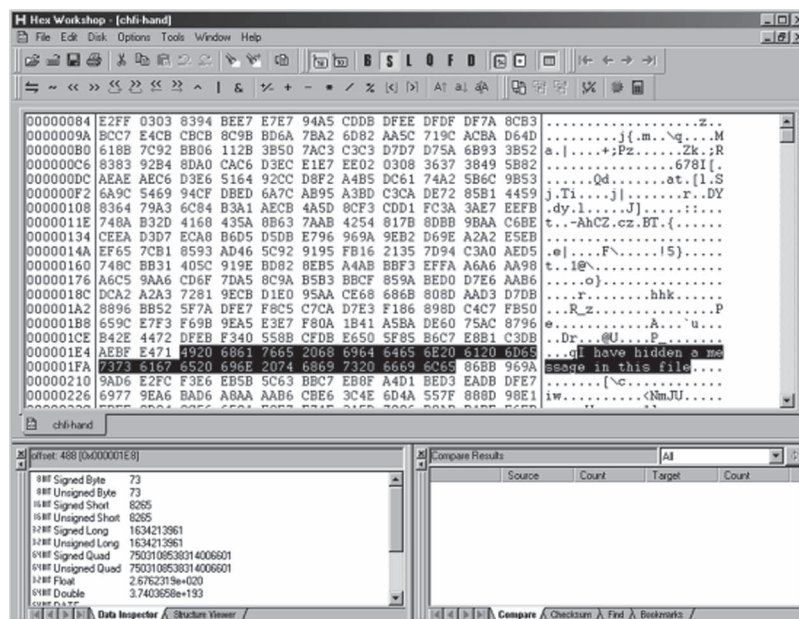


Figure 5-20a Hex Workshop is one of the most popular applications for steganalysis and image recovery.

Tool: S-Tools

The S-Tools steganographic tool has one advantage over other steganographic tools: hiding multiple files in one object. S-Tools first compresses individual files. This application inserts some random data strings on the front of the data in order to prevent two identical sets of files encrypting the same. All the files are then encrypted using a user-generated pass phrase. The encryption algorithms all operate in cipher feedback mode. The S-Tools application seeds a cryptographically strong pseudorandom number from the pass phrase, and uses its output in order to choose the position of the next bit from the cover data.

Take the following example: If a sound file had 100 bits available for hiding, and the user wanted to hide 10 bits in it, then S-Tools would not choose bits 0 through 9, as they are detectable by a potential enemy. Instead it might choose bits 63, 32, 89, 2, 53, 21, 35, 44, 99, and 80. It might even choose any ten others; it all depends on the pass phrase used. Thereby, an investigator would have a difficult time in deciphering the code.

Tool: Stegdetect

Stegdetect is used for the detection of steganographic content in an image. Stegdetect supports linear discriminant analysis. *Linear discriminant analysis* is the technique that determines the stego image that contains the hidden data. It detects different steganographic methods to embed hidden information in JPEG images.

Stegdetect supports several different feature vectors, and automatically computes receiver operating characteristics, which can be used to evaluate the quality of the automatically learned detection function.

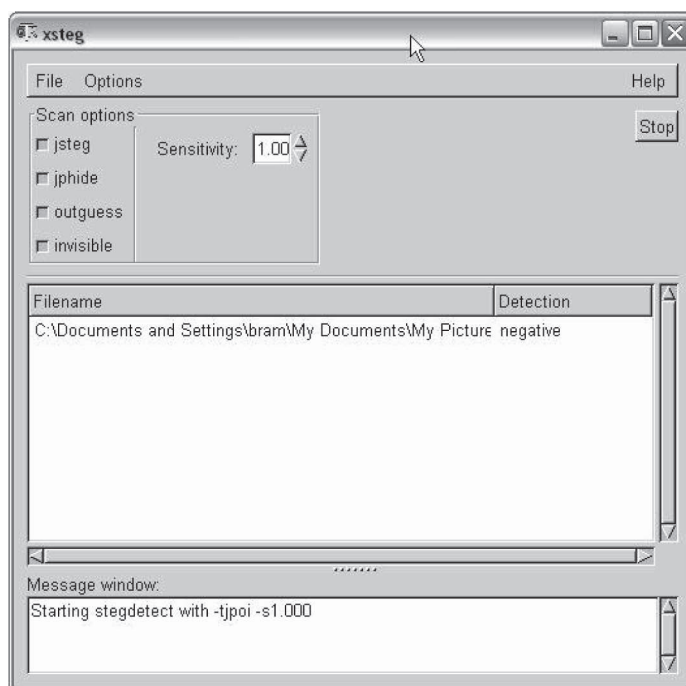
Can penetrate information hidden using applications such as jsteg, jphide (UNIX and Windows), Invisible Secrets, Outguess v.01.3b, F5, appendX, and Camouflage.

Figure 5-21 shows the application screen for xsteg.

Tool: GFE Stealth (Graphics File Extractor)

GFE stealth is an image file forensics tool, which reveals the exact copies of the graphics file images from ambient data sources and SafeBack bit-stream image backup files. It quickly detects all graphics file images on the hard disk drive, and extracts the required images with the help of the graphics file viewer. It recovers GIF, BMP, and JPEG files from the computer. It recovers the image files quickly, which saves the investigator time.

GFE Stealth operates under DOS, Windows 98/NT/2000/XP. It identifies partial image file patterns (caused due to fragmentation and/or file corruption) and views and reconstructs the files. The search engine ensures that every byte is checked for integrity. When the software is combined with other NTI software processes,



Source: xsteg software. Accessed 2/2007.

Figure 5-21 In this image, the software shows that it has not detected steganography in the selected file.

it operates in batch file mode for automatic processing. The software is very fast and evaluates graphic image files quickly.

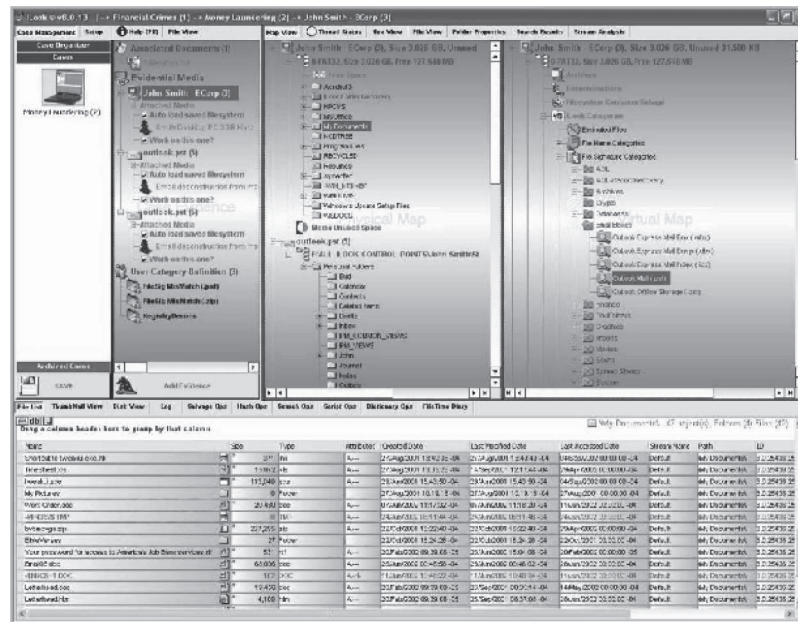
Tool: ILook v8

ILook is a multithreaded, Unicode-compliant image file forensic investigation tool. It recovers images from seized computer systems or other digital media quickly. It is also used to detect images obtained from forensic imaging tools that produce a raw bit-stream image. It supports Windows 2000 or Windows XP 32-bit platforms and the Windows Server 2003 64-bit platform.

Some features of ILook include:

- Identification and support of the following file systems: FAT12, FAT16, FAT32, FAT32x, VFAT, NTFS, HFS, HFS+, Ext2FS, Ext3FS, SysV AFS, SysV EAFS, SysV HTFS, CDFS, Netware NWFS, ReiserFS, and ISO9660
- An Internet Explorer-like interface allowing an investigator to view and navigate the file system as it originally appeared on the suspect's computer
- Granular extraction facilities that allow all or part of a file system to be extracted from an image
- Fast, sophisticated, regular expression search engine
- Built-in multiformat file viewing
- Password and pass-phrase dictionary generators
- File salvage (carve) capabilities
- Orphaned FAT directory recovery
- Hash analysis functions
- Data tagging and categorization features
- Case and evidence management features and multievidential item handling
- Internet cache and mailbox deconstruction functions
- Additional imager built into ILook for imaging directly attached devices

<https://t.me/learningnets>



Source: <http://www.ilook-forensics.org/iLook8.html>. Accessed 2/2007.

Figure 5-22 This is the ILook application screen.

- File filtering and elimination functions
- Search-results database stores the results of all searches run against any item in a case

Figure 5-22 shows the ILook application screen.

Tool: P2 eXplorer

Paraben's P2 eXplorer allows an investigator to mount a forensic image and explore it as though it were a drive. The image is not just mounted to view logical files, but is mounted as the actual bit-stream image, preserving unallocated, slack, and deleted data.

P2 eXplorer is able to:

- Mount compressed and encrypted PFR images and several images at a time
- Mount Paraben's Forensic Replicator images (PFR), EnCase images (up to v4.02), SafeBack 1 and 2 images, WinImage noncompressed images and RAW images from Linux dd and other tools
- Support dynamic drive images and both logical and physical image types
- Autodetect image format
- Shell support easy mounting/unmounting as well as mounting over a network
- Write-protect for preserving evidence
- MD5 checksum verify and hash verify

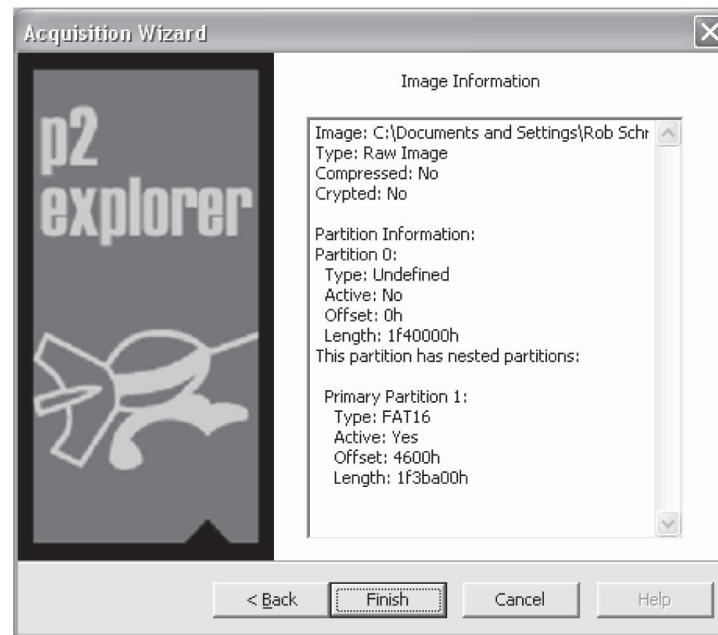
Figure 5-23 shows the P2 eXplorer screen.

Identifying Copyright Issues with Graphics

Section 106 of the 1976 Copyright Act gives the owner of a graphic or image copyright the exclusive right to do and to authorize any of the following:

- Reproduce the copyrighted work in copies or phonorecords;
- Prepare derivative works based upon the copyrighted work;
- Distribute copies or phonorecords of the copyrighted work to the public by sale or other transfer of ownership, or by rental, lease, or lending;
- In the case of literary, musical, dramatic, and choreographic works, pantomimes, and motion pictures and other audiovisual works, perform the copyrighted work publicly;

<https://t.me/learningnets>



Source: https://www.paraben-forensics.com/catalog/product_info.php?cPath=25&products_id=268. Accessed 2/2007.

Figure 5-23 This figure shows an image mounted as a drive. It has a secondary “partition,” which may be a hidden image.

- In the case of literary, musical, dramatic, and choreographic works, pantomimes, and pictorial, graphic, or sculptural works, including the individual images of a motion picture or other audiovisual work, display the copyrighted work publicly; and
- In the case of sound recordings, perform the work publicly by means of a digital audio transmission.

Chapter Summary

- An image is an artifact that reproduces the likeness of some subject.
- A file format is a particular way to encode information for storage in a computer file.
- Standard image file formats include JPEG, GIF, BMP, TIFF, and PNG.
- Data compression means encoding the data to take up less storage space and less bandwidth for transmission.
- Data compression is performed by using a complex algorithm to reduce the size of a file.
- Lossy compression compresses data permanently by removing information contained in the file.
- Image files have a unique file header value. Common image header values have residual data from partially overwritten headers in file slack.

Review Questions

1. Describe three differences between vector images and raster images.

2. Name three image file formats and name whether each is vector, raster, or both.

3. How does file compression work?

4. What is the difference between lossless and lossy data compression? Which would you use with text files?

5. Describe two main differences between the LZW and Huffman coding systems.

6. When you analyze image file headers, what are you looking for?

7. What does carving mean?

8. Name a steganalysis tool and describe how it works.

9. How do you reconstruct file fragments?

10. List three different image file forensic tools. Describe why you would use each.

Hands-On Projects



1. Install ACDSee and search for images on your hard disk.
2. Install XnView and convert a BMP file to a GIF format. Find the difference in the size of the image file.
3. Install S-Tools and try to hide/unhide an image file. Find out whether the amount of free space on the disk changes when you hide/unhide an image file.
4. Use Photoshop to edit an image of your choice.

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