

Computer Forensics: Tool Testing & National Software Reference Library

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24 April 2003**

NIST United States Department of Commerce
National Institute of Standards and Technology

Outline

- Overview of computer forensics at NIST
- Description of CFTT and NSRL projects
- Questions and answers

A Shocking Revelation . . .

Computers can be involved in crime . . .

- As a victim
- As a weapon
- As a witness
- As a record
- As contraband

Outline of an Investigation

- Get proper authorization
- Seize evidence (Hard drives, floppies ...)
- Create duplicates for analysis
- Analyze the duplicates
 - Exclude known benign files
 - Examine obvious files
 - Search for hidden evidence
- Report results

Investigators Need ...

Computer forensic investigators need tools that ...

- Work as they should and
- Produce results admissible in court
- Reference data to reduce analysis workload

Goals of CF at NIST

- Establish methodology for testing computer forensic tools (CFTT)
- Provide international standard reference data that tool makers and investigators can use in an investigations (NSRL)

Computer Forensics Partners



Why NIST/ITL is involved

- **Mission: Assist federal, state & local agencies**
- **NIST is a neutral organization – not law enforcement or vendor**
- **NIST provides an open, rigorous process**

Computer Forensics in ITL

Located in Software Diagnostics and Conformance Testing (SDCT) Division

- Includes development of specifications and conformance tests for use by agencies and industry
- Work is funded by Federal agencies and NIST internal funds
- Homeland Security support of agencies investigating terrorist activities

Computer Forensics Tool Testing (CFTT)



A Problem for Investigators

Do forensic tools work as they should?

- Software tools must be ...
 - Tested: accurate, reliable & repeatable
 - Peer reviewed
 - Generally accepted
- ... by whom?
- Results of a forensic analysis must be admissible in court

CFTT Presentation Overview

- Project Tasks
- Current activities
- Challenges
- Testing Hard Drive Imaging Tools
- Benefits of CFTT

Project Tasks

- Identify forensics functions e.g.,
 - disk imaging,
 - hard drive write protect,
 - deleted file recovery
- Develop specification for each category
- Peer review of specification
- Test methodology for each function
- Report results

Current Activities

- Hard drive imaging tools
- Software hard drive write protect
- Hardware hard drive write protect
- Deleted file recovery

Challenges

- No standards or specifications for tools
- Forensic vocabulary incomplete
- Arcane knowledge domain (e.g. DOS)
- Reliably faulty hardware

Hard Drive Imaging

- SCSI vs IDE
- Drive access
- Clone vs image
- Excess sectors on dst
- I/O errors
- Corrupt image file

Testing Hard Disk Drive Imaging Tools

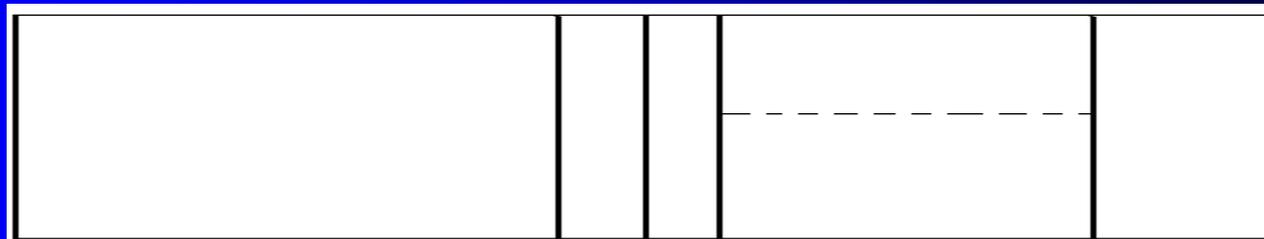
Need to verify...

- Source disk not changed
- Copied information is accurate
- Behavior if source is smaller than destination
- Behavior if source is larger than destination

Testing Hard Disk Drive Imaging Tools

Testing support Tools

- Detect change SHA-1
- Compare Source to Destination
- Track relocated information



ASCII String 25 bytes

Fill Bytes 487 Bytes

Testing Hard Disk Drive Imaging Tools

Setup Source

Wipe

Load OS

Hash



Impact

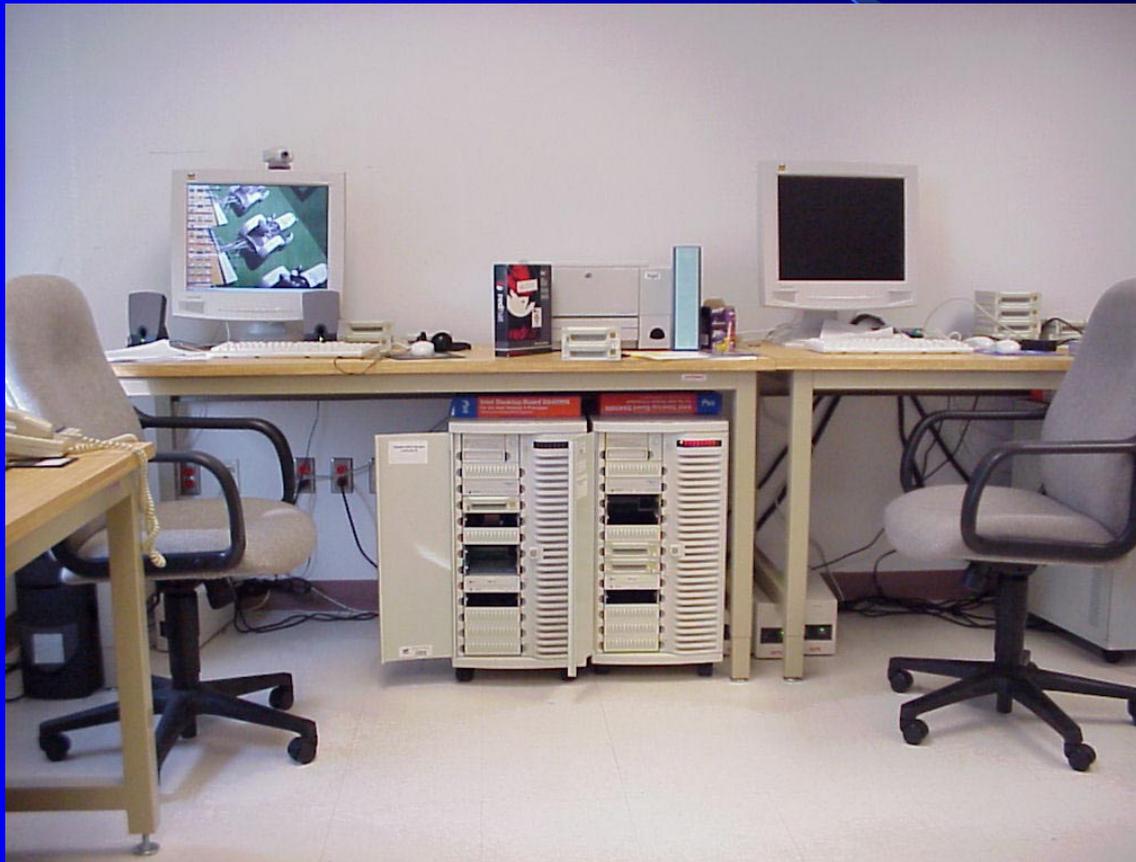
- Release 18 (Feb 2001) - A US government organization was doing some testing and uncovered an issue under a specific set of circumstances.
- Linux doesn't use the last sector if odd
- Several vendors have made product or documentation changes

Benefits of CFTT

Benefits of a forensic tool testing program

- Users can make informed choices
- Neutral test program (not law enforcement)
- Reduce challenges to admissibility of digital evidence
- Tool creators make better tools

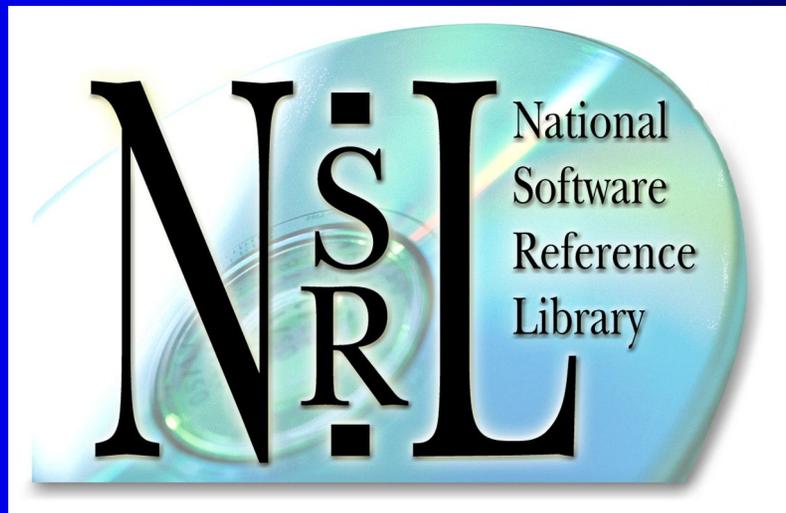
Lab Facilities



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NSRL Project



Introduction

The National Software Reference Library is:

- A physical collection of over 3,800 software packages on secured shelves
- A database of file “fingerprints” and additional information to uniquely identify each file on the shelves
- A Reference Data Set (RDS) extracted from the database onto CD, used by law enforcement, investigators and researchers

Addressing Industry Needs

- No unbiased organizations were involved in implementing investigative tools
- Law enforcement had no control over quality of data provided by available tools – data was market-driven
- Traceability - No repositories of original software available for reproducing data
- Each tool provided a limited set of capabilities

NSRL Software Collection

- Media in format as available to the public
- Consumer products available in stores
- Developer products available as vendor services
- Malicious software
- “Cracked” software



NSRL Software Collection

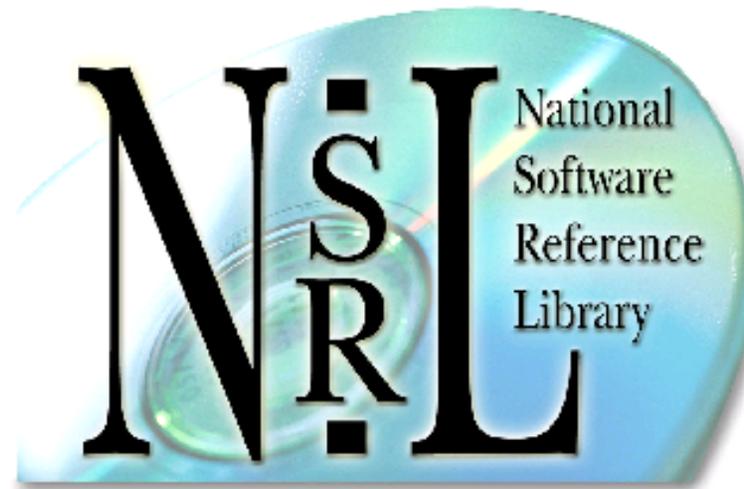
- Balance of most popular (encountered often) and most desired (pirated often)
 - Currently 32 languages
- Software is purchased commercially
- Software is donated under non-use policy
- List of contents available on website

www.nsrl.nist.gov

NSRL Software Database

- Information to uniquely identify every file on every piece of media in every application
- Database schema is available on website
- 4,200 Bytes per application
- 750 Bytes per file
- Total database size now 9 GB for 3,800 applications with 13,400,000 files

NIST Special Database #28



Reference Data Set

Version 1.5 03/03/2003

NIST

NSRL Reference Data Set

- The Reference Data Set (RDS) is a selection of information from the NSRL database
- Allows positive identification of manufacturer, product, operating system, version, file name from file “signature”
- Data format available for forensic tool developers
- Published quarterly

Use of the RDS

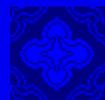
- Eliminate as many known files as possible from the examination process using automated means
- Discover expected file name with unknown contents
- Identify origins of files
- Look for malicious files, e.g., hacker tools
- Provide rigorously verified data for forensic investigations

RDS Field Use Example

You are looking for facility maps on a computer which is running Windows 2000.

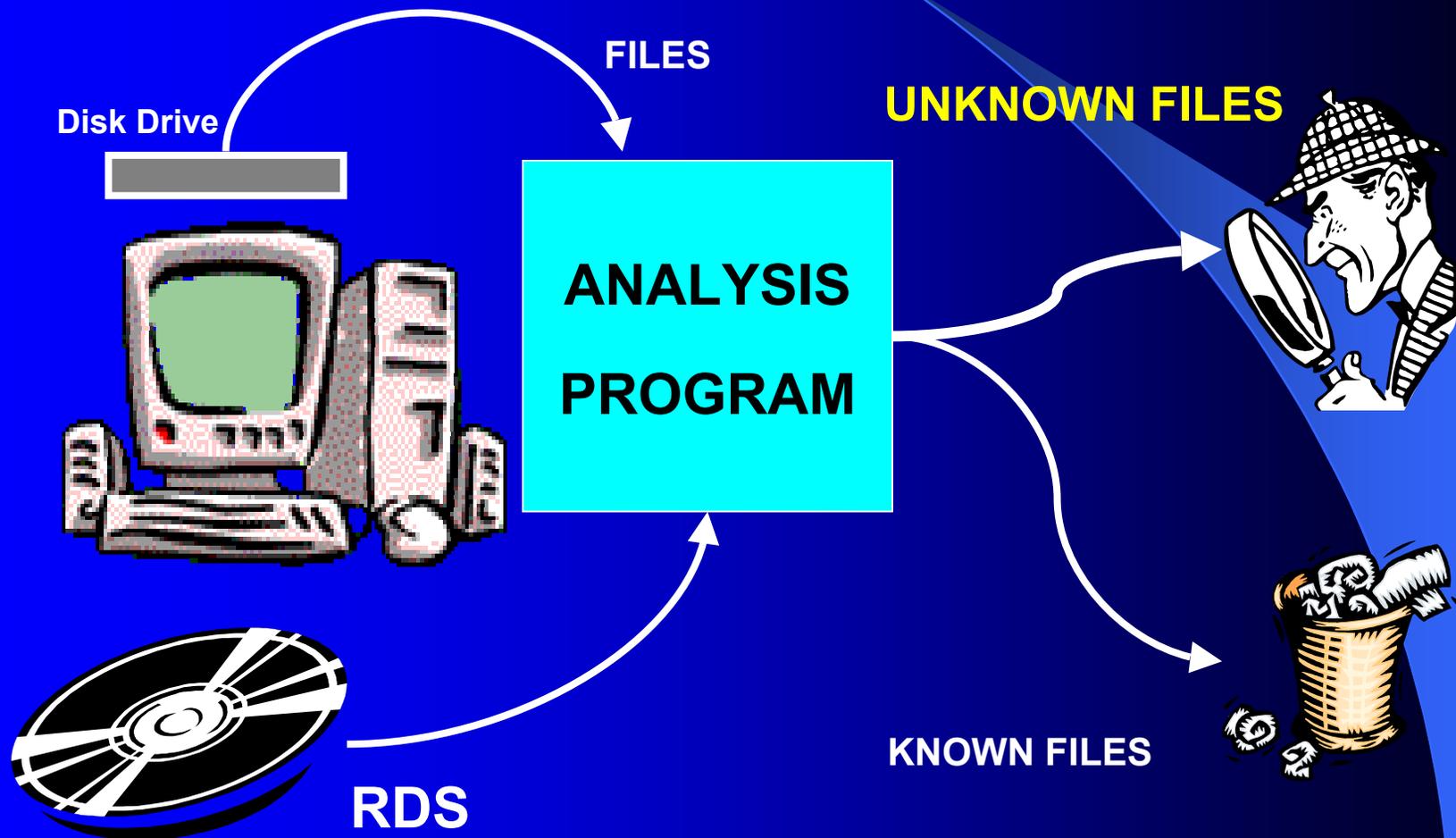
Windows 2000 operating system software contains 5933 images which are known gifs, icons, jpeg files

e.g.,



By using the RDS and an analysis program the investigator would not have to look at these files to complete her investigation.

RDS Field Use Concept



Haunted By Ghosts Of Hard Drives Past

CAMBRIDGE, Mass., Jan. 16, 2003



Simson Garfinkel, a graduate student at the MIT's Laboratory for Computer Science, holds a used hard drive he bought containing personal information. (AP)

(AP) So, you think you cleaned all your personal files from that old computer you got rid of?

Two MIT graduate students suggest you think again.

Over two years, Simson Garfinkel and Abhi Shelat bought 158 used hard drives at secondhand computer stores and on eBay. Of the 129 drives that functioned, 69 still had recoverable files on them and 49 contained "significant personal information" - medical correspondence, love letters, pornography and 5,000 credit card numbers. One even had a year's worth of transactions with account numbers from a cash machine in Illinois.

<http://www.cbsnews.com/stories/2003/01/16/tech/main536774.shtml>

Hashes

- Like a person's fingerprint
- Uniquely identifies the file based on contents
- You can't create the file from the hash
- Primary hash value used is Secure Hash Algorithm (SHA-1) specified in FIPS 180-1, a 160-bit hashing algorithm
 - 10^{45} combinations of 160-bit values
- “Computationally infeasible” to find two different files less than 2^{64} bits in size producing the same SHA-1
 - 2^{64} bits is one million terabytes

Hashes

- SHA-1 values can be cross-referenced by other products that depend on different hash values
- Other standard hash values computed for each file include Message Digest 5 (MD5), and a 32-bit Cyclical Redundancy Checksum (CRC32), which are useful in CF tools and to users outside LE

Hash Examples

Filename	Bytes	SHA-1
NT4\ALPHA\notepad.exe	68368	F1F284D5D757039DEC1C44A05AC148B9D204E467
NT4\I386\notepad.exe	45328	3C4E15A29014358C61548A981A4AC8573167BE37
NT4\MIPS\notepad.exe	66832	33309956E4DBBA665E86962308FE5E1378998E69
NT4\PPC\notepad.exe	68880	47BB7AF0E4DD565ED75DEB492D8C17B1BFD3FB23
WINNT31.WKS\I386\notepad.exe	57252	2E0849CF327709FC46B705EEAB5E57380F5B1F67
WINNT31.SRV\I386\notepad.exe	57252	2E0849CF327709FC46B705EEAB5E57380F5B1F67

Related History

- CRC concept dates from 1960's
- MD5 algorithm published in 1991
- Tripwire open source tool 1992
- Unix command "md5sum" available
- FIPS 180-1 (SHA-1) published in 1995
- Unix command "sha1sum" available
- Known File Filter project 1998
- FIPS 180-2 (SHA-512) published in 2002

Hashes in P2P

datSourceList: 1 or more concatenated variable length Source subsequences, each with this layout:

1	srcRemoteFileName	ANSIZ	"Tiken Jah Fakoli - Y'en A Marre.mp3", "\0"	Variable length name (no path) of the file at the remote source node. Can be empty ("\0" only).
2	srcDownloadURL	ANSIZ	"\0"	Variable length filepath. Always empty in Kazaa 2.0 ("\0" only).
3	srcFileID	DWORD	3731	Small unique number, typically identical for a given file contents at all Sources. Used as virtual subdirectory name in HTTP GET requests like "http://<KazaaHost>:<KazaaPort>/3731/Tiken%20Jah%20Fakoli....mp3". Such URL's were used for file exchanges with peer nodes in Kazaa 1.x (only ?). Kazaa 2.0.2 still returns a list of these URL's in a HTML page table produced by a local <a href="http://localhost:<KazaaPort>/">http://localhost:<KazaaPort>/ GET root request.
4	srcContentHash	BYTE[20]	16-byte crypto std. MD5 one-way digest + 4-byte FastTrack smallhash DWORD	Fingerprint for file content. Files with identical content have an identical Message Digest value. No different content anywhere should have this same cryptographic secure, one-way MD5-value. FastTrack smallhash adds more content identifying bits. Not all file data is included in the hash calculation.
5	srcFileSize	DWORD	3751893	Size of the remote file at this Source. Counted in bytes.
6	srcNodeInetNum	DWORD	0x04,0x03,0x02,0x01 = 0x01020304 = "1.2.3.4"	32-bit IP address number of this FastTrack peer Source node.
7	srcNodeTcpPort	DWORD	0xF1,0x0A,0x00,0x00 = 0x0af1 = 2801	TCP file service port of FastTrack peer file Source. Default KaZaa file service IP-port is 1214. Can be NULL for a file service behind a proxy server and/or firewall that does not allow the remote source peer to accept incoming TCP connections. In these cases the destination node sends a PUSH Request to his supernode. This PUSH request is mediated through the (network of) supernode(s) to the source node. The source node then initiates a new TCP connection to the destination peer. Over this connection, the source sends a GIVE nnnn command to tell the destination that it can start the actual HTTP GET file download session on

KaZaa Peer-to-Peer (P2P) FastTrack File Formats

<http://kzfti.cjb.net/>

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SHA-1 Mathematics

- Bit sequence is padded to a multiple of 512
- Messages of 16 32-bit words, $n \cdot 512$, $n > 0$
- 80 logic functions are defined that accept 3 32-bit words and produce 1 32-bit word
- 80 constants defined, 5 32-bit buffers initialized
- 80 step loop:
 - Manipulate message into 80 32-bit words
 - Use shifts, functions, addition on buffers
- 160-bit SHA is string in the 5 32-bit buffers

Application of RDS

OS/Apps	Files installed	Percent identified	Files unknown	Files on distribution CD(s)
Virgin Win 98	4,266	93%	297	18,662
Virgin NT4 WS	1,659	86%	239	17,904
Virgin Win 2Kpro	5,963	86%	839	16,539
Virgin Win ME	5,169	93%	383	11,512
Win 98+Office 2K	23,464	98%	596	43,327
Win ME+Office 2K	24,112	98%	526	32,758
NIST PC #1 W2K	18,048	35%	11,839	N/A
NIST PC #2 W2K	59,135	20%	47,124	N/A
NIST PC #3 WNT	14,186	54%	6,618	N/A
NIST PC #4 W98	16,397	55%	7,404	N/A
NIST PC #5 W98	34,220	75%	8,667	N/A

NIST Research

- Hash collisions
- Software distribution metrics
- Operating/File system effects
- Physical/Virtual machine effects
- “Mining” dynamic files
- Offsite hashing

Software Installation Issues

- Dynamic files are “missed” by RDS
- Installed on virtual machines which can be saved in the NSRL on media
- Delineation of static sections of files for probability of identification
- Independent of installation location

NARA Research

- Use hashing process on non-classified Presidential materials
- Identify application files
- Identify duplicate files
- Access to older installed software

NARA Statistics

- 93 computer systems
 - Pre-filtered to contain only software
- 51,146 individual files
- 7,610 file names
- 11,118 distinct files (SHA-1)
- 8,077 files originating in specific application(s)
- 4,326 of 8,077 exactly match application file names

Further NARA Research

- Building profile of a “master” image
- Statistical weights for application identification
- Cross-system relationships
- Installation locations
- Old compression technologies

NSRL Environment

- Isolated network with domain controller, DHCP
- Database server, File server, Web server
- Batching stations use web browser interface
- Hashing constellation
- Virtual machines for installations
- CVS source code repository

Input Process

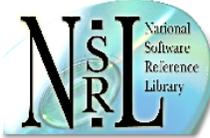
- Package is acquired
- Web interface used to enter information about manufacturer, product, OS and assign an ID
- Media are batched
- Approximately 15 minutes per package

NSRL Package Information - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites History Print Mail News RSS

Address http://192.168.58.4/login/script.asp Go Links



Package Information

NSRL Builder

*Application Name:	<input type="text" value="Your Eyes Only"/>	
*Version:	<input type="text" value="win95 1.0"/>	
Bar Code:	<input type="text" value="037646120487"/>	
*Language:	English <input type="button" value="v"/>	Please Specify: <input type="text"/>
Manufacturer:	Symantec <input type="button" value="v"/>	
*Application Type:	Utility <input type="button" value="v"/>	Please Specify: <input type="text"/>
Packaged Within:	<input type="text"/>	
Comments:	<input type="text"/>	
*Location:	G2 <input type="text"/>	

Contact Us:

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Done Internet

Hashing Operations

- Spring 2003 – accepting software
- Hashing constellation runs 24/7
- Processed over 13.4M files, 9M SHAs
- Byte signature file type verification
- CAB, ZIP, TAR, SFX, UU, compress

Data Verification

- Multiple and independent techniques from different perspectives
 - We use test files with known signatures
 - Parallel database system: Match results with other system
 - Human verification
 - Database rules and constraints
 - Periodic database queries: Predefined procedures to search for and report anomalies in the database
 - User feedback: Error reports and RDS updates

Future Operation Tasks

- More hardware platforms
- More archive tools
- Redundant hashing in constellation
- Scheduled rebatching
- Additional algorithms – AES
- Open source LAMP distribution

NSRL Accomplishments

- RDS CD Version 1.5 distributed 3/3/2003
 - 102 subscriptions (Vendors, corporations, universities, and law enforcement agencies)
 - Free redistribution, NIST traceable
- Incorporated into vendor products
- Used by FBI, DCCC, Secret Service, Customs Service (Homeland Security)

NSRL/CFTT Team



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