NSRL Project

NSRL
National
Software
Reference
Library

Introduction

The National Software Reference Library is:

- A physical collection of over 4,000 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

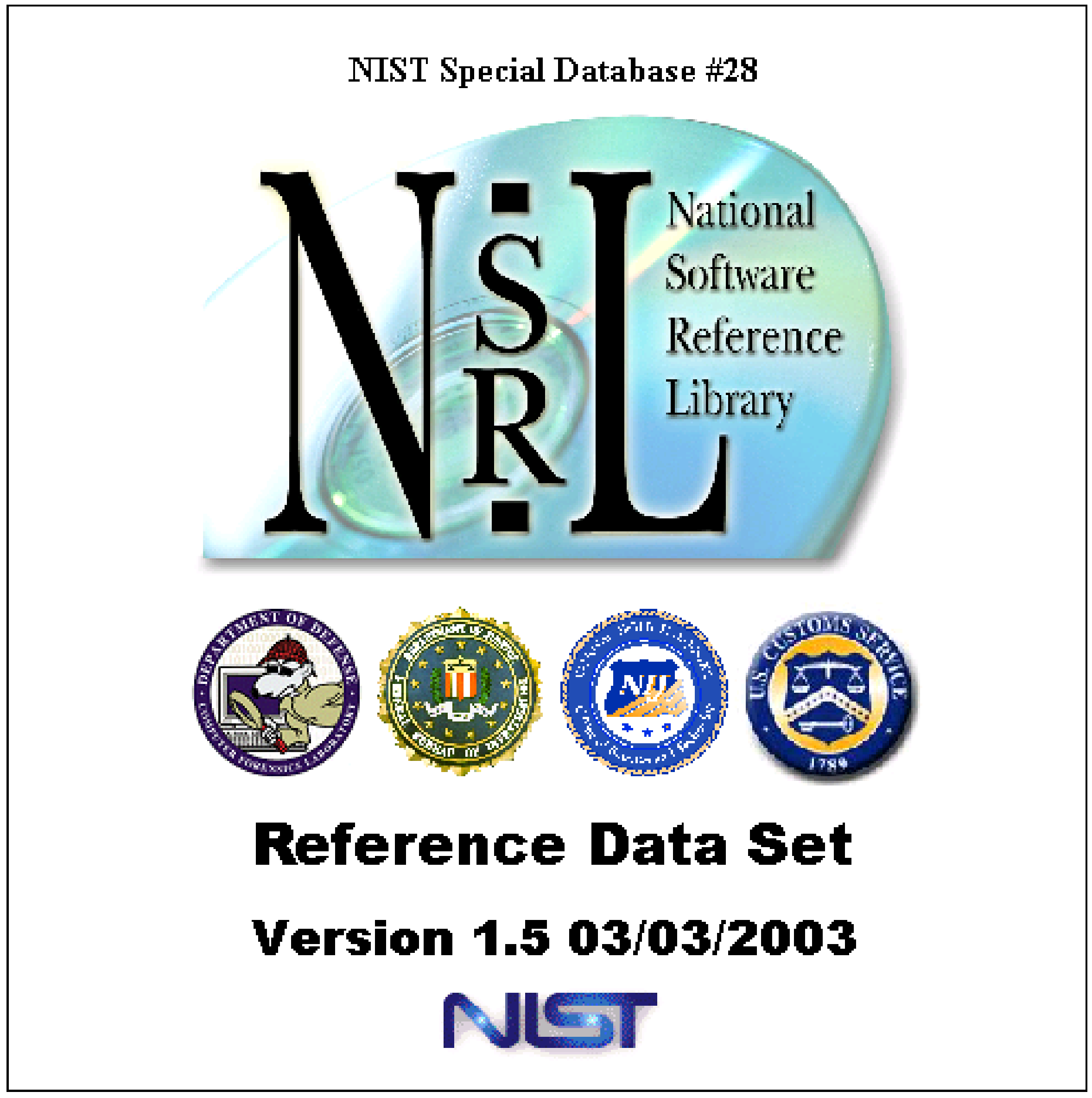
NSRL Software Collection

- 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 is 11 GB for 4,000 applications with 15,000,000 files



NIST Special Database #28

NSRL

National Software Reference Library

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

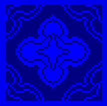
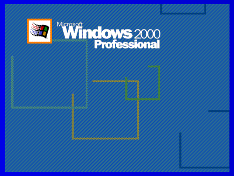
Use of the RDS

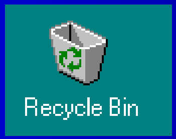
- Eliminate as many known files as possible from the examination process using automated means
- Discover expected file name with unknown contents
- Identify origins of files
- Look for malicious files, e.g., hacker tools
- Provide rigorously verified data for forensic investigations

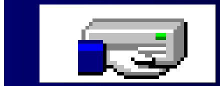
RDS Field Use Example

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

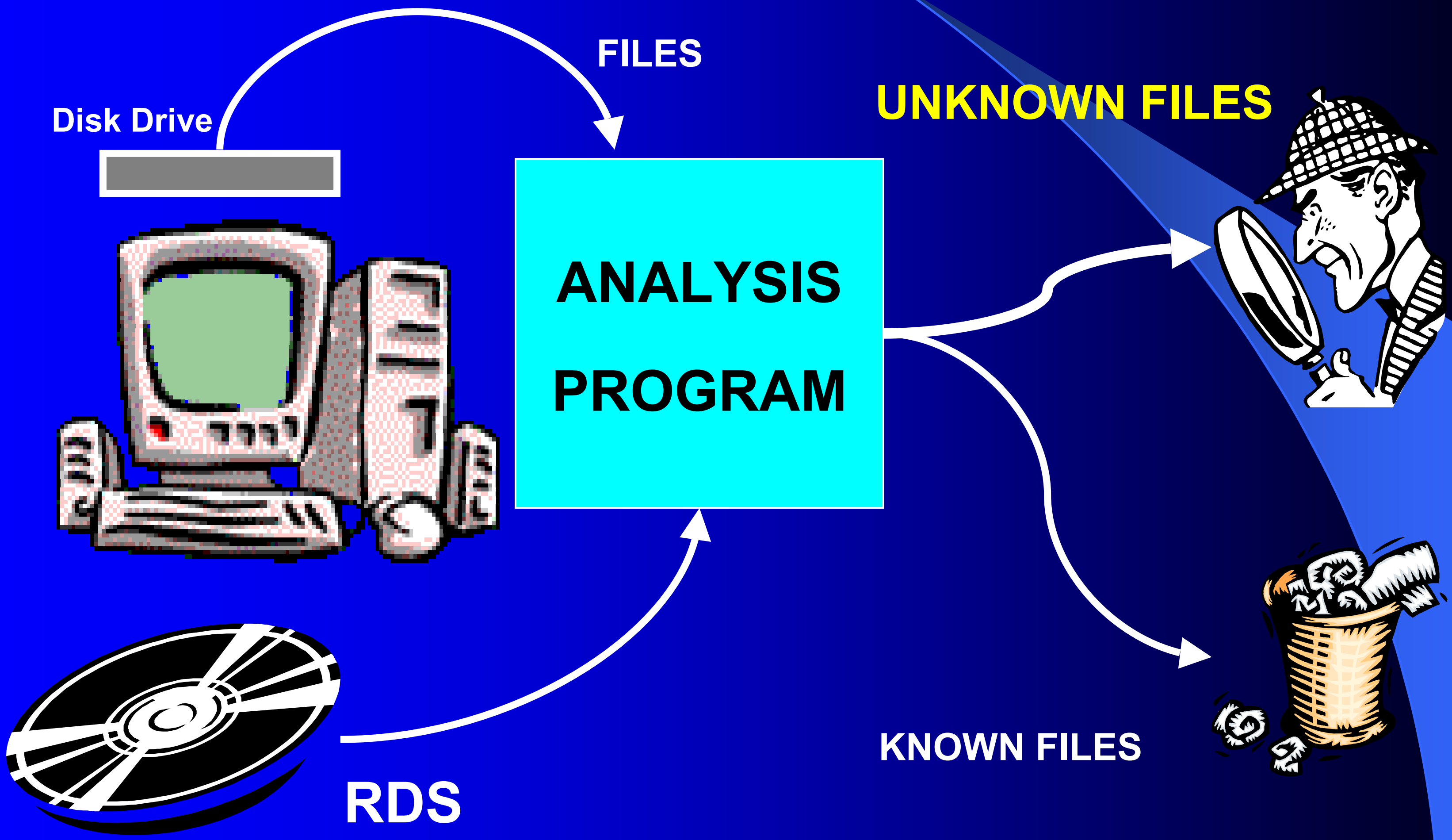
e.g.,  

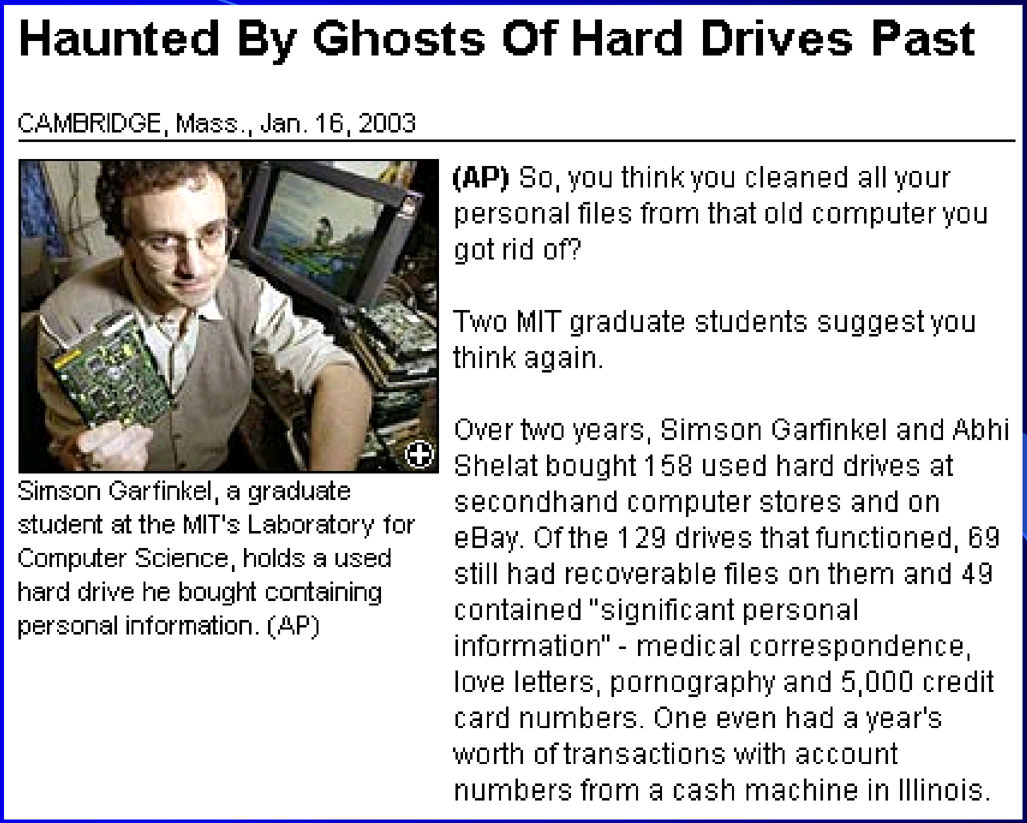




By using the RDS and an analysis program the investigator would not have to look at these files to complete her investigation.

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

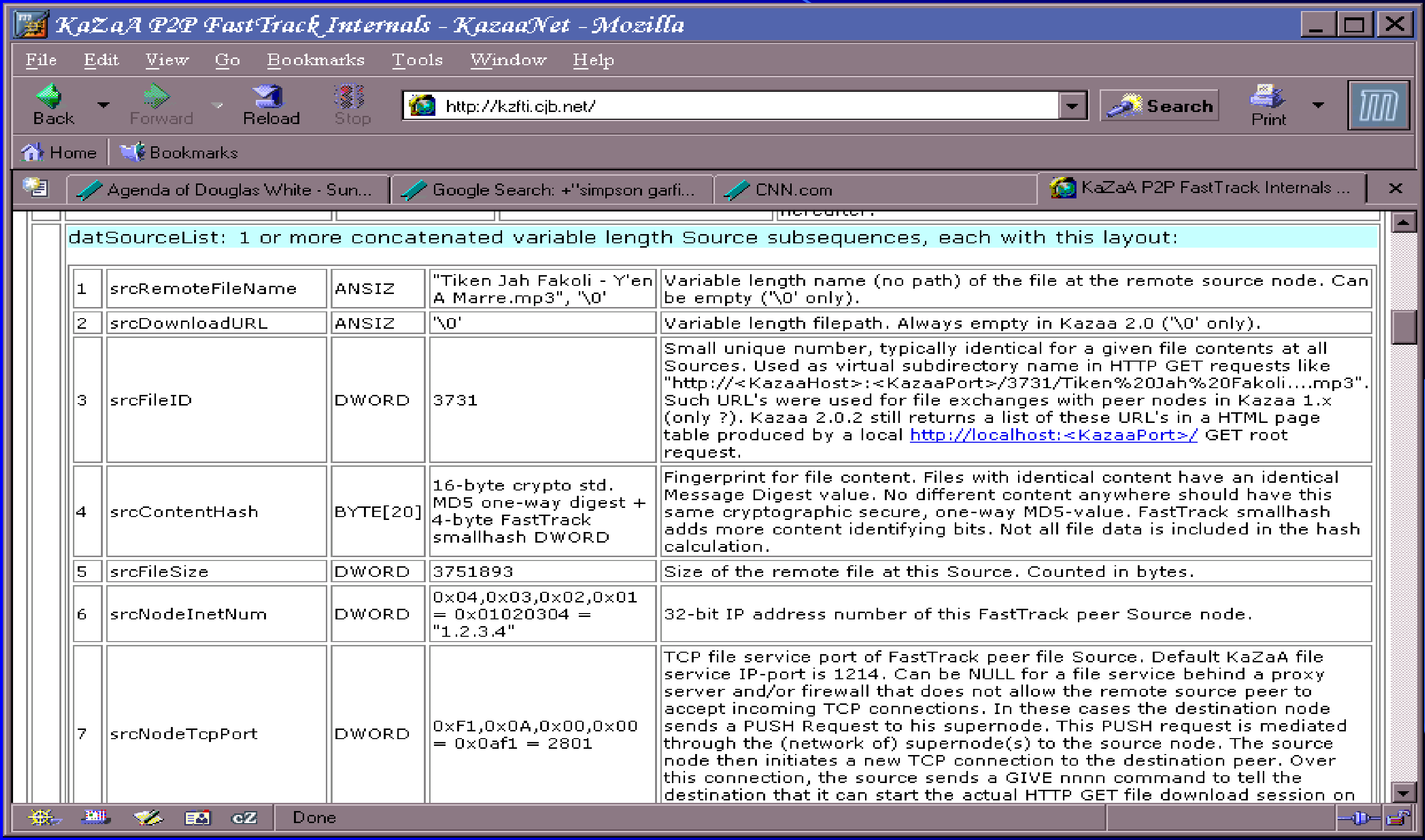
Filename	Bytes	SHA-1
NT4\ALPHA\notepad.exe	68368	F1F284D5D757039DEC1C44A05AC148B9D204E467
NT4\I386\notepad.exe	45328	3C4E15A29014358C61548A981A4AC8573167BE37
NT4\MIPS\notepad.exe	66832	33309956E4DBBA665E86962308FE5E1378998E69
NT4\PPC\notepad.exe	68880	47BB7AF0E4DD565ED75DEB492D8C17B1BFD3FB23
WINNT31.WKS\I386\notepad.exe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

Filename	CRC32	MD5	Bytes	SHA-1
null.dat	00000000	D41D8CD98F00B204E9800998ECF8427E	0	DA39A3EE5E6B4B0D3255BFEF95601890AFD80709

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


KaZaA P2P FastTrack Internals - KazaaNet - Mozilla
File Edit View Go Bookmarks Tools Window Help
Back
Forward
Reload
Stop
http://kzfti.cjb.net/
Search
Print
Home
Bookmarks
Agenda of Douglas White - Sun...
Google Search: +"simpson garfi...
CNN.com
KaZaA P2P FastTrack Internals ...
Done

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 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

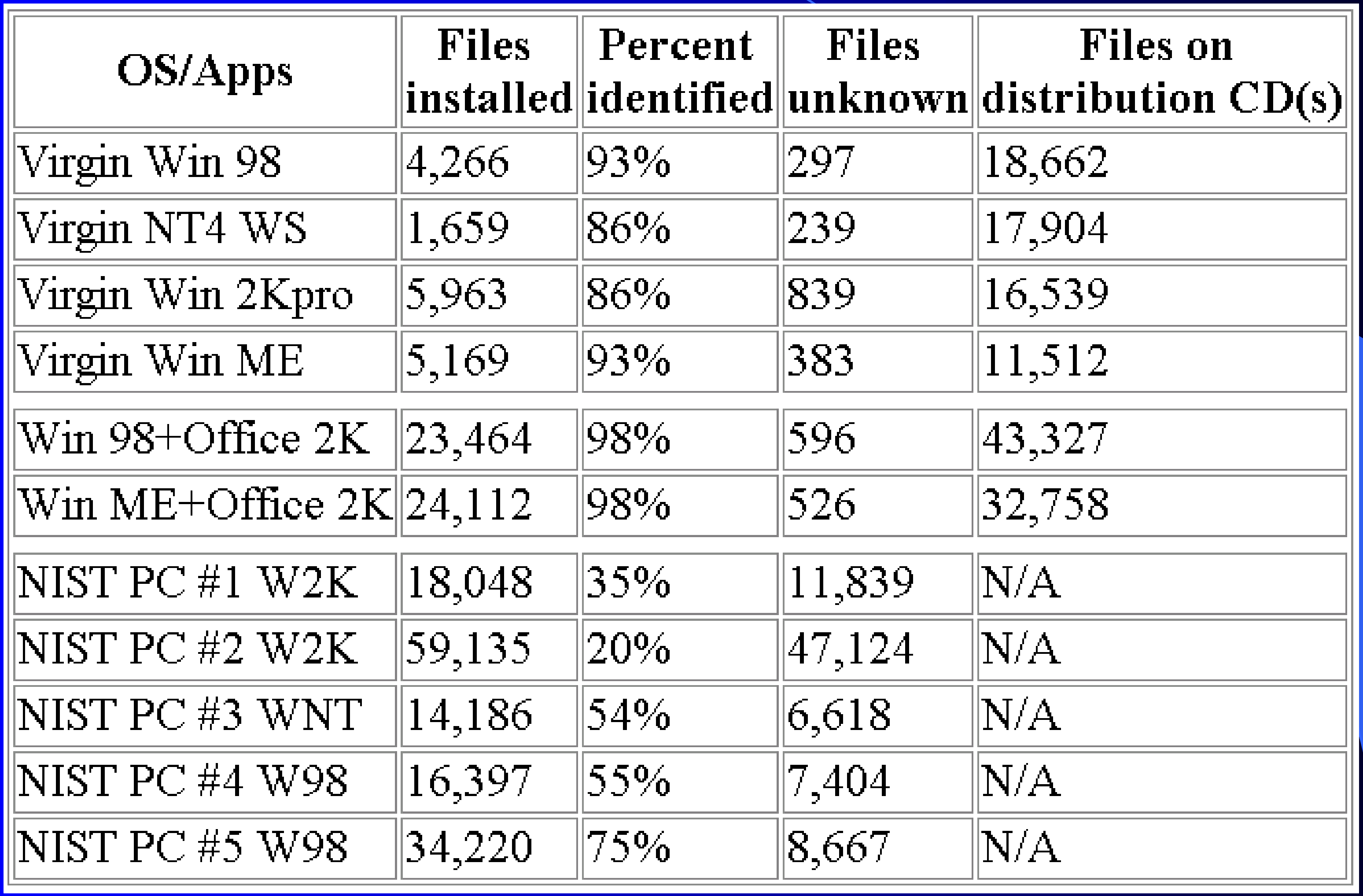
KaZaA Peer-to-Peer (P2P) FastTrack File Formats

http://kzfti.cjb.net/

SHA-1 Mathematics

- Bit sequence is padded to a multiple of 512
- Messages of 16 32-bit words, n*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

Effectiveness 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

Hashkeeper Comparison

- May 2002 article by Dan Mares comparing Hashkeeper to NSRL
- http://www.scmagazine.com/scmagazine/sc-online/2002/article/24/article.html
- http://www.nsrl.nist.gov/documents/dm_july02/

- Using Hashkeeper 001-243 and NSRL 1.2 (June 2002):

Source	Unique MD5s	MD5s in Hashkeeper	MD5s in NSRL	Common
	in data file	NOT in NSRL	NOT in Hashkeeper	to Both
NSRL	4,022,258		3,777,082	245,176
Hashkeeper	766,854	411,962		245,176

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

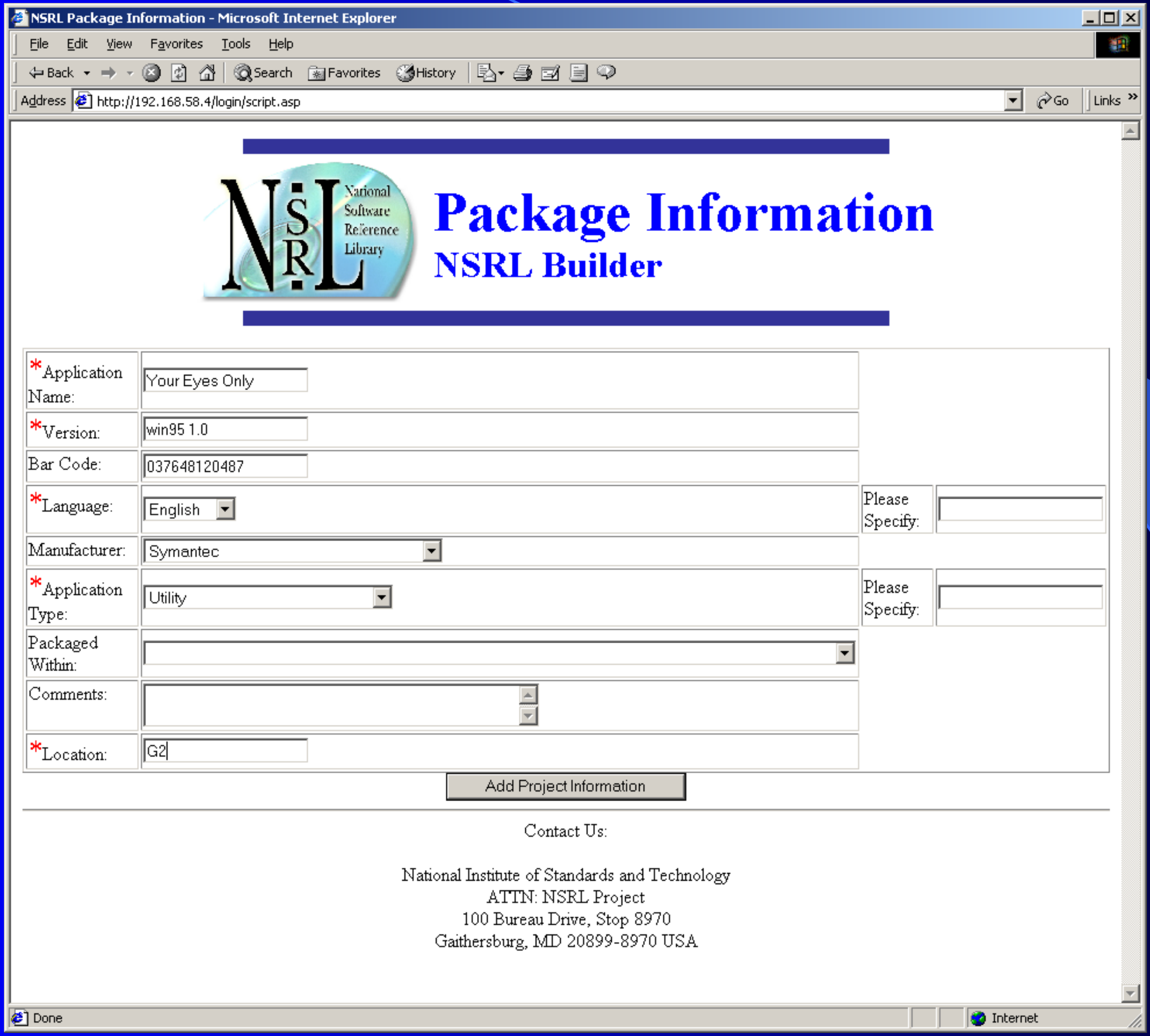
- Building profile of a “master” image
- Statistical weights for application identification
- Cross-system relationships
- Installation locations
- Old compression technologies

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 Search Favorites History
Address http://192.168.58.4/login/script.asp
Go Links
National Software Reference Library
Done
Internet

Package Information

NSRL Builder

*Application Name:	Your Eyes Only		
*Version:	win95 1.0		
Bar Code:	037648120487		
*Language:	English	Please Specify:	
Manufacturer:	Symantec		
*Application Type:	Utility	Please Specify:	
Packaged Within:			
Comments:			
*Location:	G2		

Add Project Information

Contact Us:

National Institute of Standards and Technology
ATTN: NSRL Project
100 Bureau Drive, Stop 8970
Gaithersburg, MD 20899-8970 USA

Hashing Operations

- Spring 2003 – accepting software
- Hashing constellation runs 24/7
- Processed over 15M files, 10M SHAs
- Byte signature file type verification
- CAB, ZIP, TAR, SFX, UU, compress

Hash Calculation Times

```
Statistics on three runs totalling 10GB of data

 User+System Time = 740.5350 Seconds
%Time ExclSec CumulS #Calls sec/call Name
 41.2   305.2 304.69   1000   0.0031 Digest::SHA1::addfile
 28.5   211.1 210.58   1000   0.0021 String::CRC32::crc32
 23.8   176.3 175.75   1000   0.0018 Digest::MD5::addfile

  User+System Time = 791.8629 Seconds
%Time ExclSec CumulS #Calls sec/call Name
 42.8   339.6 339.64    100   3.3965 Digest::SHA1::addfile
 30.3   240.6 240.64    100   2.4065 String::CRC32::crc32
 26.6   211.2 211.25    100   2.1126 Digest::MD5::addfile

  User+System Time = 836.9632 Seconds
%Time ExclSec CumulS #Calls sec/call Name
 42.4   355.1 355.12     10   35.512 Digest::SHA1::addfile
 30.5   255.3 255.31     10   25.531 String::CRC32::crc32
 27.0   226.4 226.41     10   22.641 Digest::MD5::addfile
```

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

Contacts

Jim Lyle
www.cftt.nist.gov
cftt@nist.gov

Doug White
www.nsrl.nist.gov
nsrl@nist.gov

Barbara Guttman
barbara.guttman@nist.gov

Sue Ballou, Office of Law Enforcement Standards
Steering Committee Rep. For State/Local Law Enforcement
susan.ballou@nist.gov