Smart Unpacking

Understanding Files Through Patterns

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Disclaimer

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Outline

- NSRL Project Description
- Smart Unpacking Description
- Smart Unpacking use
- Smart Unpacking overview

Introduction to the NSRL

- Is a computer forensics project at NIST
- Is composed of 3 things:
  1. **library:** physical collection of software media and packages
  2. **database:** logical collection of collected file information
     - file name, size, type, package, MD5, SHA1, etc.
  3. **RDS:** (Reference Data Set) and other products
     - Produced quarterly
     - Metadata db – close to 75M files; publicly available data + db schema

NSRL Use (Data Reduction)

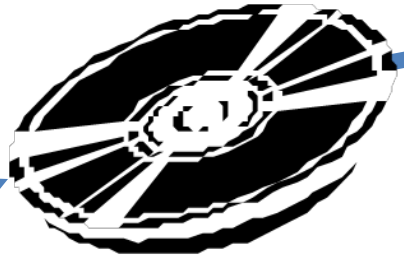
Disk Drive

FILES

Analysis Program

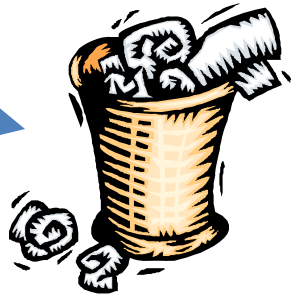
UNKNOWN FILES

RDS



File info

KNOWN FILES



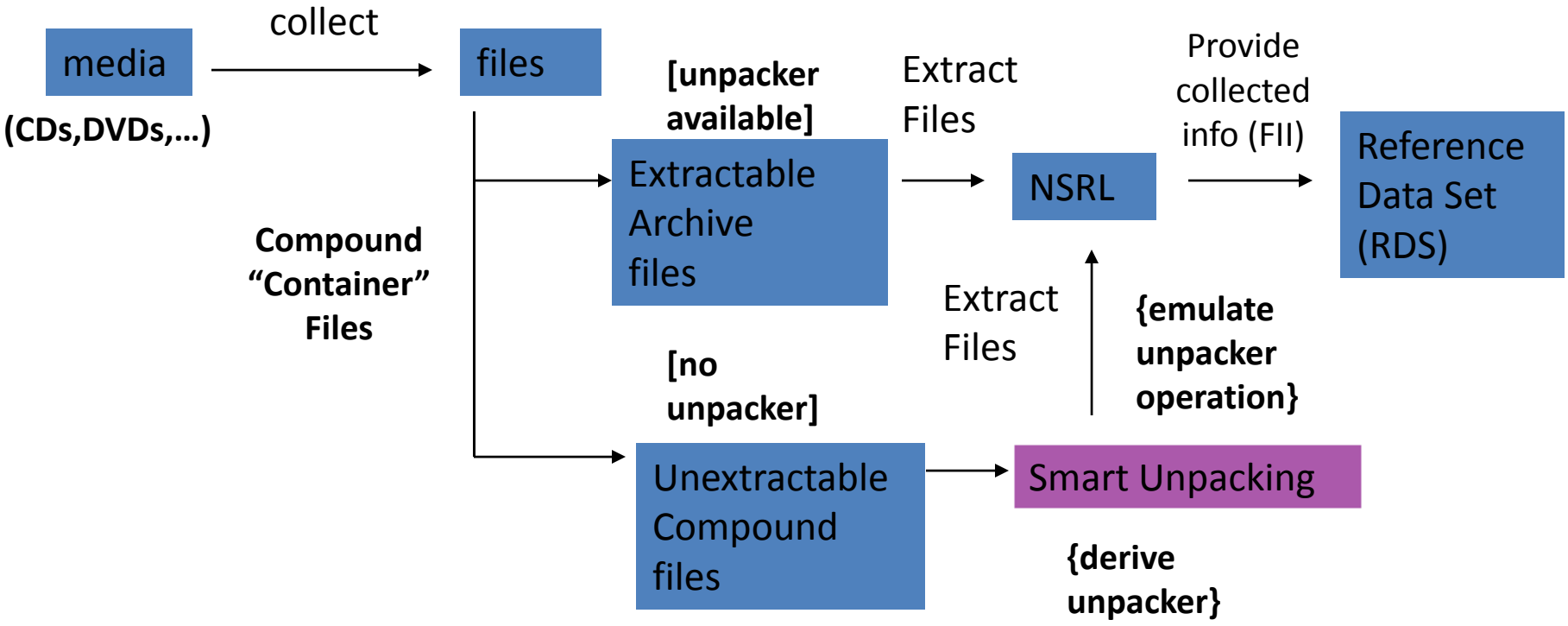
NSRL

- Unpack archives
- Provide File info

NSRL Use

- Application of NSRL unique identification
  - Law Enforcement
    - Automated elimination of “known” app files from an investigation
    - Positive ID of “interesting” files
    - Forensic tools use various metadata
    - NIST/NSRL – provides – unbiased, court-admissible data to NIJ, FBI, DoD
  - NARA Presidential search
  - Voting – baseline maintenance; auditing
  - Ongoing research – online archive of data, file-type identification
  - Used by all major tools

NSRL File Extraction



The Need

NSRL wants more files …

- Two primary ways to get more
  1. Get more media (containing files)
  2. Unpack more compound files (i.e., archives)
- Fundamental challenge
  - get files out of archives
- Why is it hard?
  - different versions, different formats
  - corruption
  - unpacker not always available or current

This need will always exist

Smart Unpacking Approach

Addresses NSRL Need by creating a *process, tools, and techniques* for …

1. Getting files out
2. Doing this in a general, reliable, testable manner
3. Producing unpacker programs and measures of unpacking results

Smart Unpacking - How it works

3 major steps

Representation → Inference → Unpacking

1. **Representation**
   - choose primitives
   - encode data to differentiate key patterns
2. **Inference**
   - perform pattern-theoretic and other analyses on representations
   - locate files and meta-data
   - derive measures
   - derive + test unpacker
3. **Unpacking**
   - extract files
   - measure results

Example Smart Unpacking Experiment

Unextractable Archive

acpid*.deb

Archive NSRL cannot unpack:
total files extracted = 0

Chaos

```
213c617263683e0a6465626961 6e2d62
696e617279202020313039393333 03833
383720203020202020203020202020 20
313030363434202034202020202020 20
2020600a322e300a636f6e74726f6c2e
7461722e677a2020313039393333 03833
383720203020202020203020202020 20
313030363434202034313832202020 20
2020600a1f8b0800000000000003ed5b
ff731cc595f7af9abfe2c54e619b9256
df25220e5f8ced234ea0f0c59854ee2e
45f5eef4eeb677667a6ea667e555f1c7
d830fbcb9914a94b38305c4c52a46c13
```

```
dmaaaamlaaaaaadaaaaaasssn
nnnnsssssssdlbbbzzzzzzbbkf
```

```
dmamladasnsnsnsnsnsnsdl
adbabdbabkbdbdbabadba
```

Representation & transformation

```
dma+mla+da+s+n+s+ns+ns+n
pb+kbabab+alb+kbadnb+dab
```

```
a = alpha = upper or lower
b = binary
d = delimiters = punctuati
e = email = at symbol = @
f = 0xff = all one bits
k = brackets, parentheses
l = newline
m = markup = html or xml =
n = numeric = 0..9
p = path = slash (fwd or b
s = space
t = dot = period
w = white space = tab
z = 0x00 = the zero byte =
```

Order

```
0x00000000      dm
0x00000002      aml
0x00000008      ad
0x0000000f      asnsnsnsnsnsdlntnl
0x00000048      at
0x00000050      at
0x00000054      asnsnsnsnsnsdlbzbkf
0x00000091      ab
0x0000009b      ab
0x0000009f      abdbdbd
0x000000a8      ab
0x000000ad      abt
0x000000b0      ab
0x000000b6      ab
0x000000bb      ab
```

```
Files Unpacked

File: ../../../data/acpid_1.0.4-1_i386.deb
- file header (bytes read = 60) relative t
-- saving file to filename=[debian-binary]
```

SU process derives unpacker + extracts files:
total files extracted = 89

An Example Usage of Smart Unpacking

1. File ACPID*.deb was **1** archive in NSRL
   - Applied SU process, tools, techniques
2. Now it is **89** files
   - Derived unpacker program, executed it, extracted files
3. Verification
   - Found alternate unpacker program and verified SU result
   - Original archive had corrupted data, causing format variances from standard format

Technical /Scientific Basis and Methods

Methods used to Discern Structure and Metadata
-Modeling
-Uniqueness features in – syntax, content, abstract pattern representations

Pattern Theory

$$G = \{g_0, g_1, ..., g_i, g_i^0\} = generator\_space$$
$$S : G \longleftrightarrow G, s \in S = similarity\_group$$
$$G = \bigcup_{\alpha \in A} G^{\alpha} = partition\_of\_generators$$
$$b_1, b_2, ..., b_{\omega} = bond\_values$$
$$B_s(g) = \{b_j; j = 1,2,3,..., w(g)\} = bond\_structures$$
$$B_v(g) = \{\beta j = 1,2,..., w(g)\}$$
...

Formal Language Theory

Context-free grammars

$$G = (V, \Sigma, R, S) = grammar$$
$$V = nonter \min als$$
$$\Sigma = ter \min als$$
$$S = start\_rule$$
$$R = rules$$
...

Mathematical Modeling based on:

- Information Theory
- Statistics
- Probability
- Universal Algebra
- Topology
- Graph Theory, and more …

Parser Theory

- Variable lookahead mechanisms
- Multi-channel token processors
- Augmentation with syntactic and semantic predicates for context-sensitivity

Measurements and Measurability

- Derived from mathematical models

Next Steps

- Production-quality
- Validation + Testing
- Integration into NSRL ops

NSRL + SU Use (Data Reduction)

Disk Drive

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Analysis Program

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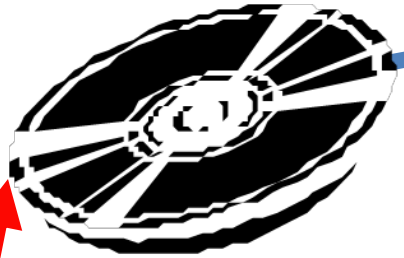
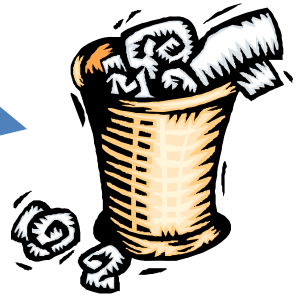


RDS

MORE File info

KNOWN FILES



NSRL

- Unpack archives
- Provide FII

Smart Unpacking → {unextractable archives}

***NSRL Unpackers* → {extractable archives}**

SU Useful for Other Things

- SU can add to current NSRL/CF efforts
  - Block hashing
    - locate, optimize blocks to hash
    - Associate parse-rule for fixed-sections with variable content to BH algorithm
      - NOW:
        - » hash according to parse rule rather than fixed content
  - File Carving/Content Analysis
    - Through pattern experiments, build up corpus of useful alphabets, primitives, and rules
    - Make higher-level reductions of content
      - NOW:
        - » Use existing techniques (suffix arrays, bioinformatics) on these abstract, compressed representations rather than just raw data

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