# Automated Target Definition Using Existing Evidence and Outlier Analysis

Brian D. Carrier

Eugene H. Spafford

CERIAS - Purdue University

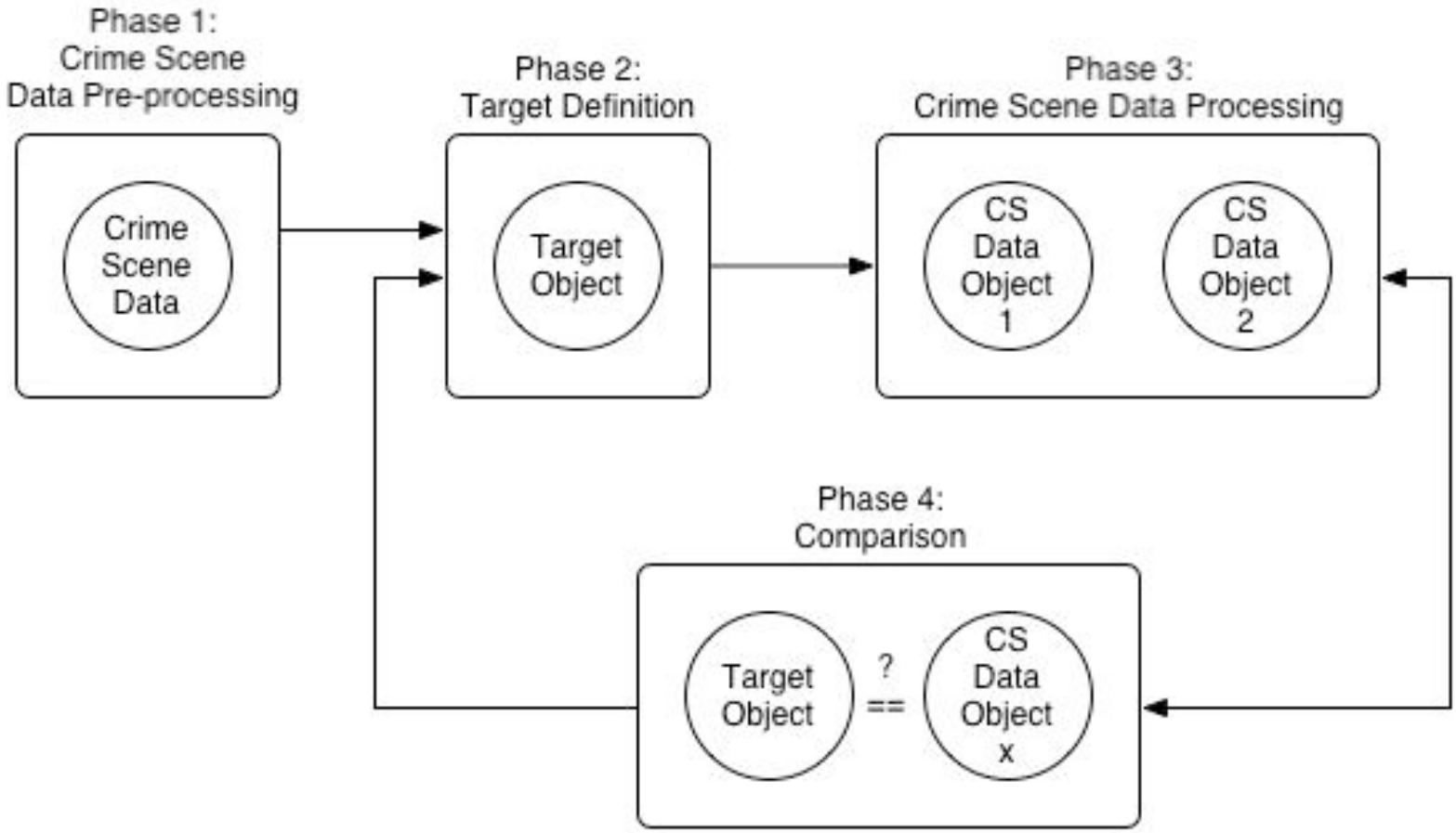
DFRWS 2005

# Searching Phases

1. Crime Scene Data Preprocessing

2. Target Definition
   - For what are we looking?
3. Crime Scene Data Processing
   - Process abstraction layers
4. Comparison
   - Are the crime scene data and the target similar?

# Searching Phases



# How Do We Define Target Objects?

- Develop a hypothesis
  - Experience and training
  - Existing evidence
- Determine what evidence would support or refute hypothesis
- Define the attributes in a target object

# Existing Evidence Automation in Autopsy

1. Investigator identifies “evidence”
2. Tool makes suggestions for future searches
3. Tool saves approved searches
4. Investigator selects suggested searches

# Suggested Targets

- Files in same parent directory
- Files with same temporal data
- Files with similar names
- Files with same application type
- Files with file name in content
- Files with similar content

# Case Study Results

- Honeynet Forensic Challenge
- We find `/dev/ptyp` using experience
- Autopsy suggests similar times, name in content etc.
- Finds `/bin/ps` file and `/usr/man/.Ci` directory

# New Topic: File Hiding Techniques

- Change MAC times
- Use similar names
- Pad data to maintain size or CRC
- Make “innocent looking” directory
- Special characters

Make file characteristics “fit in”

# Spatial Outlier

- Outliers objects are “grossly different” from all other objects
- Spatial outliers are “grossly different” from local objects
- Hypothesis: Hidden files could be spatial outliers in their parent directory

# Variant of Iterative Z Algorithm

## Lu, Chen, & Kou - 2003 IEEE CDM

1. Compute average attribute value (g) for each directory
2. Compute distance ($h_i$) from each file to g
3. Compute mean ($\mu$) and std dev ($\sigma$) of $h_i$
4. Standardize each $h_i$ :

$$y_i = \left| \frac{h_i - \mu}{\sigma} \right|$$

- If largest $y_i$ is > $\theta$ (2 or 3), it is an outlier

# Single Attribute Results

| | / partition | | | /usr/ partition | | |
|---|---|---|---|---|---|---|
| **Attribute** | **Hits** | **Accuracy** | **Comp** | **Hits** | **Accuracy** | **Comp** |
| **App Type** | 1.01% | 10.00% | 14.00% | 9.15% | 3.08% | 18.58% |
| **Block** | 6.93% | 6.22% | 60.00% | 3.96% | 2.97% | 7.74% |
| **C-time** | 2.24% | 26.92% | 84.00% | 1.27% | 54.44% | 45.51% |
| **M-time** | 0.75% | 5.77% | 6.00% | 8.26% | 7.63% | 41.49% |
| **Size** | 4.78% | 2.41% | 16.00% | 5.84% | 3.22% | 12.38% |

| | Combined | | |
|---|---|---|---|
| **Attribute** | **Hits** | **Accuracy** | **Comp** |
| **App Type** | 7.14% | 3.33% | 17.96% |
| **Block** | 4.69% | 4.15% | 14.75% |
| **C-time** | 1.51% | 44.37% | 50.67% |
| **M-time** | 6.41% | 7.58% | 36.73% |
| **Size** | 5.58% | 3.05% | 12.87% |

/: 6,951 files and 50 (0.72%) involved

/usr/: 21,267 files and 323 (1.49%) involved

# Results Summary

- Trojan exec on `/` not found, but was found on `/usr/` because of starting block
- Many false positives were obvious: README files
- Generic Windows System:
  - 2.58% files identified (5.07% on honeypot)
  - 100% false positive rate

# Multiple Attributes

1. Standardize all attributes
2. Compute average attribute for each directory (g) and distance for each file (hi)
3. Compute directory mean and variance-covariance

$$\mu_S = \frac{1}{|NN(x_i)|} \sum_{x \in NN(x_i)} h(x)$$

$$\Sigma_s = \frac{1}{|NN(x_i)|} \sum_{x \in NN(x_i)} [h(x) - \mu_s][h(x) - \mu_s]^T$$

# Multiple Attributes (2)

4. Compute Mahalonobis distance for each file:

$$a_i = (h(x_i) - \mu_s)^T \Sigma (h(x_i) - \mu_s)$$

5. Standardize distances and determine if largest is > 3

- Lu, Chen, Kou - 15th IEEE Conference on Tools with AI

# Multiple Attribute Results

| | / partition | | | /usr/ partition | | |
|---|---|---|---|---|---|---|
| **Attribute** | **Hits** | **Accuracy** | **Comp** | **Hits** | **Accuracy** | **Comp** |
| **C- and M-time** | 0.30% | 85.71% | 36.00% | 0.56% | 23.33% | 8.67% |
| **C-, M-time, and Size** | 0.22% | 53.33% | 16.00% | 0.32% | 43.28% | 8.98% |
| **C-, M-time, Size, and Block** | 0.22% | 53.33% | 16.00% | 0.22% | 31.91% | 4.64% |
| **C-, M-time, Size, Block and App Type** | 0.10% | 57.14% | 8.00% | 0.15% | 38.71% | 3.72% |

| | Combined | | |
|---|---|---|---|
| **Attribute** | **Hits** | **Accuracy** | **Comp** |
| **C- and M-time** | 0.50% | 32.62% | 12.33% |
| **C-, M-time, and Size** | 0.29% | 45.12% | 9.92% |
| **C-, M-time, Size, and Block** | 0.22% | 37.10% | 6.17% |
| **C-, M-time, Size, Block and App Type** | 0.13% | 42.11% | 4.29% |

Clean Windows:

C&M: 0.63%

C,M,&S: 0.54%

# Hidden Directories

- Calculate average attribute value for files in a directory
- Compare with other directories at same “level”
- Detect outliers using “iterative Z”

# Directory Outlier Results

| | / partition | | | /usr/ partition | | |
|---|---|---|---|---|---|---|
| **Attribute** | **Hits** | **Accuracy** | **Comp** | **Hits** | **Accuracy** | **Comp** |
| **App Type** | 0.00% | 0.00% | n/a% | 7.44% | 0.00% | 0.00% |
| **C-time** | 2.25% | 0.00% | n/a% | 1.65% | 0.00% | 0.00% |
| **M-time** | 1.12% | 0.00% | n/a% | 1.38% | 0.00% | 0.00% |
| **Size** | 1.12% | 0.00% | n/a% | 3.77% | 0.00% | 0.00% |

| | Combined | | |
|---|---|---|---|
| **Attribute** | **Hits** | **Accuracy** | **Comp** |
| **App Type** | 6.88% | 0.00% | 0.00% |
| **C-time** | 1.70% | 0.00% | 0.00% |
| **M-time** | 1.36% | 0.00% | 0.00% |
| **Size** | 3.57% | 0.00% | 0.00% |

- `/` had 89 and 0 hidden directories
- `/usr/` had 1,088 and 1 hidden directory
- Was found when $\theta = 2$
- 0.78% on Windows System

# Conclusions

- Implemented a tool to suggest and save searches
- Implemented outlier analysis algorithms to find hidden & new files

- What is human error rate?
- Honeypot is not an ideal case study (little user activity before and after incident)

# Future Work

- Investigate human error rate
- Identify which techniques work better with different types of incidents
- Incorporate data mining with other analysis techniques - keyword searching, hashes etc.

Brian Carrier

carrier@cerias.purdue.edu

www.cerias.purdue.edu