XIRAF
Ultimate Forensic Querying

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Introduction

XIRAF

“An XML Information Retrieval Approach to Digital Forensics”

Collect, manage, and query information extracted from digital evidence
Outline

• Problem statement
• XIRAF approach
• XIRAF architecture
• Forensic application areas
• Initial experiments
• Conclusion
Typical investigation steps

1. Media capture
2. Feature extraction
3. Analysis
4. Reporting
Problem identification

- Large amounts of data
  - Investigation restricted by deadlines
  - Too much information to track manually
- Diversity of data and tools
  - Many different formats
  - Many stand-alone forensic tools
Approach

- Clean separation between feature extraction and analysis
- A single, XML-based output format for tools
- XML database technology to analyze extracted features
- Use of existing forensic analysis tools
XIRAF architecture

Feature Extraction Framework

Tool Repository
- tool A
- tool B
- tool C

Tool Invocation Process

Storage Subsystem
- Annotations
- XML document
- Case Data
- Binary Large Object (BLOB)

Query Interface
- MonetDB/XQuery DBMS
- StandOff extensions

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Tool wrapper

```
//file[mime="image/jpeg"]
```

- Metadata (features/traces)
- New view of the original data

- Data from evidence files `Photo03.jpg`
- Optional: additional metadata

<photo>
  <camera>Canon</camera>
  <taken-on>
    <date>15-12-2005</date>
  </taken-on>
</photo>
Tool repository

• Feature extraction tools
• Gain knowledge about an ‘object’:
  • volume
  • file-system
  • image
  • email
• Some of the wrapped tools:
  • file-system dissector
  • windows registry analyzer
  • EXIF-data parser
  • carving tool
  • IE-history parser
  • Hashing tool
XIRAF architecture

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Feature extraction framework

- Tool Repository
  - tool A
  - tool B
  - tool C

- case initialization

- is there input for the tool?

- run tool

- storage subsystem
Feature extraction framework

Storage subsystem
- Case Data (BLOB)
- Annotations (XML)

Tool Invocation
- fetch data for tool
- for each item of data: call wrapper
- collect and check output
- merge with current data

tool-execution wrapper
- pre-process input
- post-process output

Forensic Analysis Tool

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Feature extraction

```xml
<case name="testcase">
  <image path="/casedata/HD-A.img">
    <image path="/casedata/HD-B.e01">
      <image path="/casedata/HD-C.e01">
        <volume label="MP3"/>
      </image>
    </image>
  </image>
</case>
```

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XIRAF architecture
Virtual BLOB and XML

```xml
<case name="testcase">
  <file name="\Photos\HD-B.e01">
    <image path="\Photos\HD-B.e01" start="76800" end="74999"/>
    <image path="\Photos\HD-B.e01" start="20000" end="29999"/>
    <image path="\Photos\HD-B.e01" start="30000" end="59999"/>
  </file>
  <modified date="2006-08-15T09:10:00"></modified>
</case>

... 

<volume type="FAT" start="1000" end="19999"/>
<volume type="NTFS" start="35000" end="39999"/>
```
Storage subsystem

- Virtual BLOB mapping
  - evidence files
  - alternative representations
- Single XML document
  - extracted features
  - references to layout
XIRAF architecture
XQuery language

- Database language:
  - large XML documents
  - sorting/grouping/selecting/(updating)
- Example: timeline
  - different tools produce date-elements

```xml
for $i in doc("case.xml")//date
order by $i
where $i > $lowerbound
   and $i < $upperbound
return $i
```
Forensic application areas

- search for keywords, MD5s, URLs

```xml
for $i in doc("case.xml")//file
for $j in doc("CP-hashes.xml")//md5
where $i/md5 = $j
return <file> { $i/@name } </file>
```

```xml
let $word_list :=
  doc("terrorism-words.xml")//word
for $i in doc("case.xml")//*[@
where some $i in $word_list
  satisfies blob-contains($i,$j)
return element { name($i) } { $i/@* }
```
Benefits

- Exploit exhaustive runs of tools
- Use knowledge from previous investigations
- Integrated data schema

- Added functionality:
  - XQuery extensions to relate XML to Virtual BLOB content
let $d := doc("case.xml")$
for $i$ in $d//\text{object of interest}$
where $i/descendant::\text{contains}[	ext{so-contains}(%\text{keyword 1}%)]$
and $i/ancestor::\text{contains}[	ext{so-contains}(%\text{keyword 2}%)]$
and (some $j$ in $i//\text{date}//date$
satisfies $j \geq %\text{lowerbound}%$ and $j < %\text{upperbound}%$)
return element { name($i$) } { $i/@* $ }
Initial Experiments

- Evidence: 2 hard disks
  - (2 x 120GB)
- ~200MB XML
  - ~2.5M elements
- Recognized ~90000 files
  - file-systems / unallocated space
- ~500000 timestamps
  - file-system, registry, EXIF, .LNK, log-entry, cookie, etc
Conclusion

- Separation of feature extraction and analysis seems a viable approach
- Integrated querying of multiple tools becomes possible
Status & Future Work

- Prototype implementation (Java/Python)
- Make system production-ready
- More tools, query patterns
- Connect XIRAF to existing knowledge-bases
More information

- xiraf-info@holmes.nl
- http://www.forensischinstituut.nl/
- http://monetdb.cwi.nl/