Breaking the Performance Wall: The Case for Distributed Digital Forensics

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Breaking the Performance Wall: The Case for Distributed Digital Forensics

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Single CPU Forensics Investigations
Single CPU State of the Art

✓ “Start right away” approach (e.g., Encase)
  – Little preprocessing of evidence
  – Can start working right away…
  – Ridiculously slow searches for large disk images
  – Unacceptable performance for larger images

✓ Preprocessing-first approach (e.g., FTK)
  – Substantial preprocessing of evidence
  – Can’t work on case until after preprocessing completes
  – …can take days
  – Have keyword indices, thumbnails, etc. available
  – Ridiculously slow searches for un-indexed things
  – Example: regular expression searches

✓ Common trait: Too slow.
Symptoms

✓ Machines tied up for days doing preprocessing
✓ Painful to “think outside the box” (i.e., outside the index) during investigation
✓ If a regular expression search takes an entire day to complete, what do you do in the meantime?
✓ Hint: It requires a $300 video card
✓ For large collections of digital evidence, no extra resources to devote to “cooler” tools
The Culprit: The Entire Machine

CPU driving investigation... For simple analysis, OK. But it’s holding us back.

Hard drives storing digital evidence for investigation... Capacity OK. WAY too slow.

Memory. WAY too small.

Case is OK.
What **could** we be doing?

- Summaries for digital video files
  - Extraction of key frames
- Better image classification
  - Beyond hashing—feature identification
- Searching audio files for voiceprints
- Generation of searchable text from audio files using speech recognition
- Automatic detection of steganography
- Backgrounding digital evidence preprocessing…
  - Analysis of evidence during preprocessing phase
  - means…investigatory phase can start right away
- Live searches…regular expression searching…even on huge drive images…uninterrupted brainstorming!
- What else do you want to do?
The Solution: Distributed Forensics

- Forensics analysis on a cluster
- More CPUs == more horsepower for sophisticated processing
- If you have high performance file storage, e.g., a RAID…
- …can load the file server much more effectively
- More memory == can cache digital evidence for analysis
- Cache entire disk image in memory of cluster machines
Why don’t we already do this?

- Cluster computing is fairly mature…
- Why so few distributed forensics tools?
- Field is young?
- Requires more sophistication on the part of tool builders?
- Cost?
  - ~$125K for a dedicated machine that can process 200GB images entirely in memory
  - Can be clever and do it for less
- We’re not being elitist. We just can’t take it anymore!
Distributed Digital Forensics (DDF) Framework
Requirements For Framework

- **Scalable**
  - Want to support at least IMAGE SIZE / RAM_PER_NODE nodes
- **Platform independent**
  - Want to be able to incorporate any (reasonable) machine that’s available
- **Lightweight**
  - Horsepower is for forensics, not the framework—less fat
- **Highly interactive**
- **Extensible**
  - Allow incorporation of existing sequential tools
  - e.g., stegdetect, image thumbnailing, file classification, hashing, …
- **Robust**
  - Clusters can be ‘notorious’
  - Must handle failed nodes smoothly
Goals for Framework

- Allow investigation to begin “immediately” after drive image is loaded
- SIGNIFICANTLY speed up traditional evidence processing
- Beat the hell out of high performance file servers
- Cache all evidence in RAM
- Enable new investigatory techniques
- $N$ machines $\rightarrow$ greater than $N$-fold speedup
- Brainstorming == ON during investigation. No extensive idle time for human allowed
Protocol

$id$ JOIN $name$ $cache_size$ $IP$ $port$
$id$ LEAVE $name$
$id$ EXIT
$id$ SHUTDOWN $name$
$id$ STARTUP $name$
$id$ CACHE $file_name$ $file_size$ $hash$ $reply_port$ $file_data$
$id$ FETCH $file_name$ $reply_port$
$id$ LOAD $files$ $reply_port$
$id$ STORE $files$ $reply_port$
$id$ FREE $files$ $reply_port$
$id$ DONE
$id$ ERROR $code$ $message$
$id$ REPORT $report$
$id$ PROGRESS $processed$ $all$
$id$ CANCEL $req_id$
Protocol (2)

<id> CLASSIFY <files> <progress> <reply_port>
<id> HASH <method> <files> <progress> <reply_port>
<id> GREP <expr> <files> <progress> <reply_port>
<id> THUMB {<files>|<type>} <tdir> <progress> <reply_port>
<id> STEGO {<file>|<type>} <progress> <reply_port>
<id> CRACK <file> <key_range> <progress> <reply_port>
<id> EXEC <command> <arguments> <reply_port>
Experimental Setup

...all your data are belong to us...

72 x 2.4GHz P4s
Experimental Setup (2)

File Server
- CPU: 2x1.4GHz Xeon
- RAM: 2GB

RAID: 504GB

Switch
- 96-port, 10/100/1000 Mb
- 24 Gb Backplane

Node
- CPU: 2.4 GHz Pentium 4
- RAM: 1 GB

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A Few Preliminary Results

✓ Target:
  - Dell Optiplex GX1 w/ 6.4GB IDE drive
  - NTFS, ~110,000 files in ~7,800 directories
  - Imaged using dd w/ a Linux boot disk

✓ Machine used for “traditional” investigation:
  - 3GHz P4, 2GB RAM, 2 x 73GB 15Krpm Ultra320 SCSI
  - FTK v1.43a

<table>
<thead>
<tr>
<th>Initial Operation</th>
<th>Time (hh:mm:ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTK Add Evidence</td>
<td>1:38:00</td>
</tr>
<tr>
<td>CACHE</td>
<td>0:09:36</td>
</tr>
<tr>
<td>8-node LOAD</td>
<td>0:03:58</td>
</tr>
<tr>
<td>1-node LOAD</td>
<td>0:05:19</td>
</tr>
</tbody>
</table>

more nodes better at loading the fileserver
Results (2)

- Live string search: "Vassil Roussev"
- Regular expression search: \(v[a-z]*i[a-z]*a[a-z]*g[a-z]*r[a-z]*a\)

<table>
<thead>
<tr>
<th></th>
<th>Search time: String Expression (mm:ss)</th>
<th>Search time: Regular Expression (mm:ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTK</td>
<td>08:27</td>
<td>41:50</td>
</tr>
<tr>
<td>8-node System</td>
<td>00:27</td>
<td>00:28</td>
</tr>
</tbody>
</table>

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A Different Experiment

- Stego detection using Stegdetect 0.5 under RH9 Linux on the cluster

- Traditional:
  - 6GB image mounted using loopback device
  - `find /mnt/loop -exec ./.stegdetect '{}' \;`
  - 790 seconds == 13:10 minutes

- Using the distributed framework
  - Stegdetect 0.5 code incorporated into framework
  - Detection against cached files
  - “STEGO” command (after IMAGE/CACHE)
  - 82 seconds == 1:22 minutes

- 9.6X faster with 8 machines

- CPU bound operation
To Do…

✓ User interface!  (unless you love Putty)
To Do (2)

- Code cleanup
- Case persistence
- Better fault tolerance
- Intelligent caching schemes to support larger images
- Will swap save us?
- Collaboration with colleagues (you?) working in:
  - Image analysis/classification
  - Speech recognition
  - Stego
  - Other CPU horsepower-intensive, forensics-applicable stuff
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