Cranfield UNIVERSITY

Centre for Forensic Computing

An automated timeline reconstruction approach for digital forensic investigations

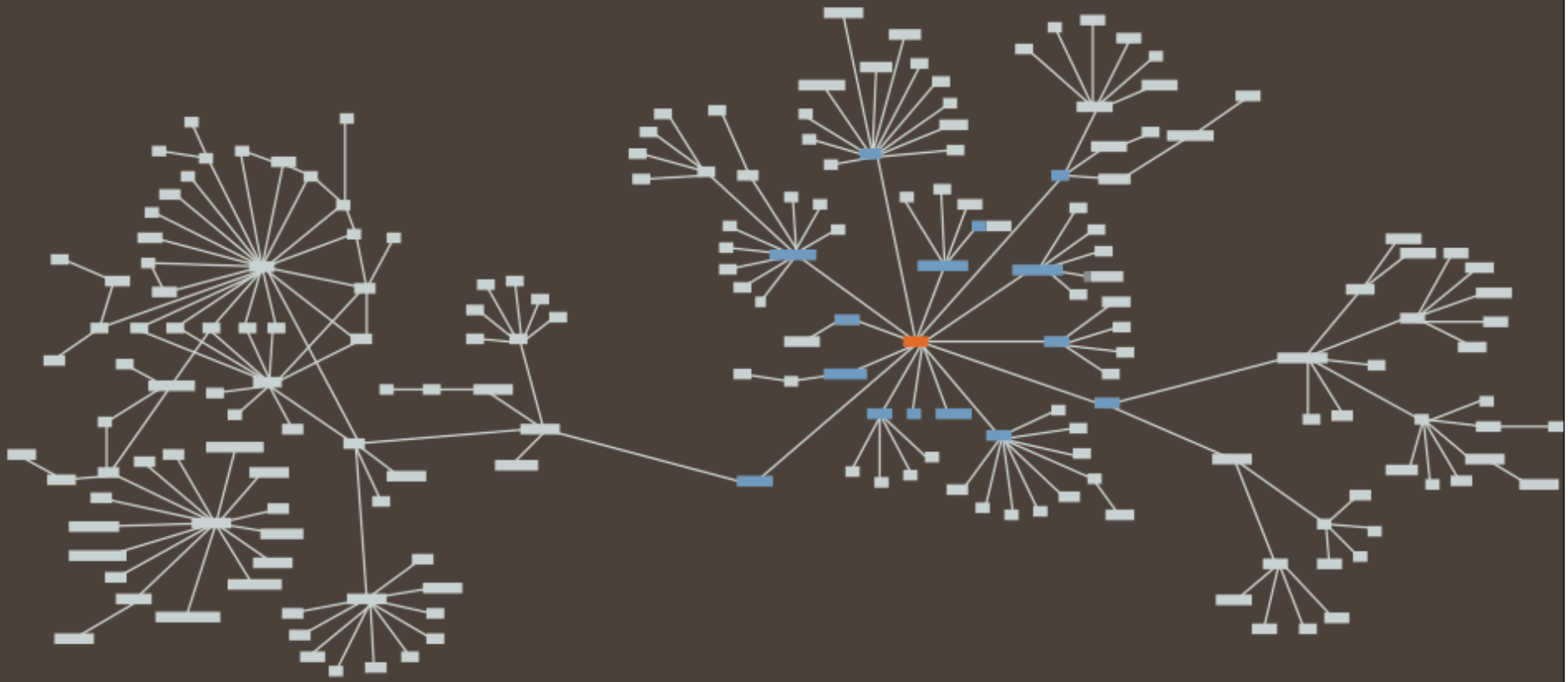
Dr Chris Hargreaves & Jony Patterson

EPSRC

Engineering and Physical Sciences Research Council

Making Sense

Enhancing Investigative Capability Through Science & Technology



Research Aim

- Part of the project is concerned with providing a ‘gist’ of various data sources
  - documents
  - images
  - videos

Research Aim

- What is the ‘gist’ of a hard drive?
  - gallery view of pictures
  - proportion of the disk that are system files, images, videos etc.
  - list of email addresses
  - ...

Summary of a hard drive?

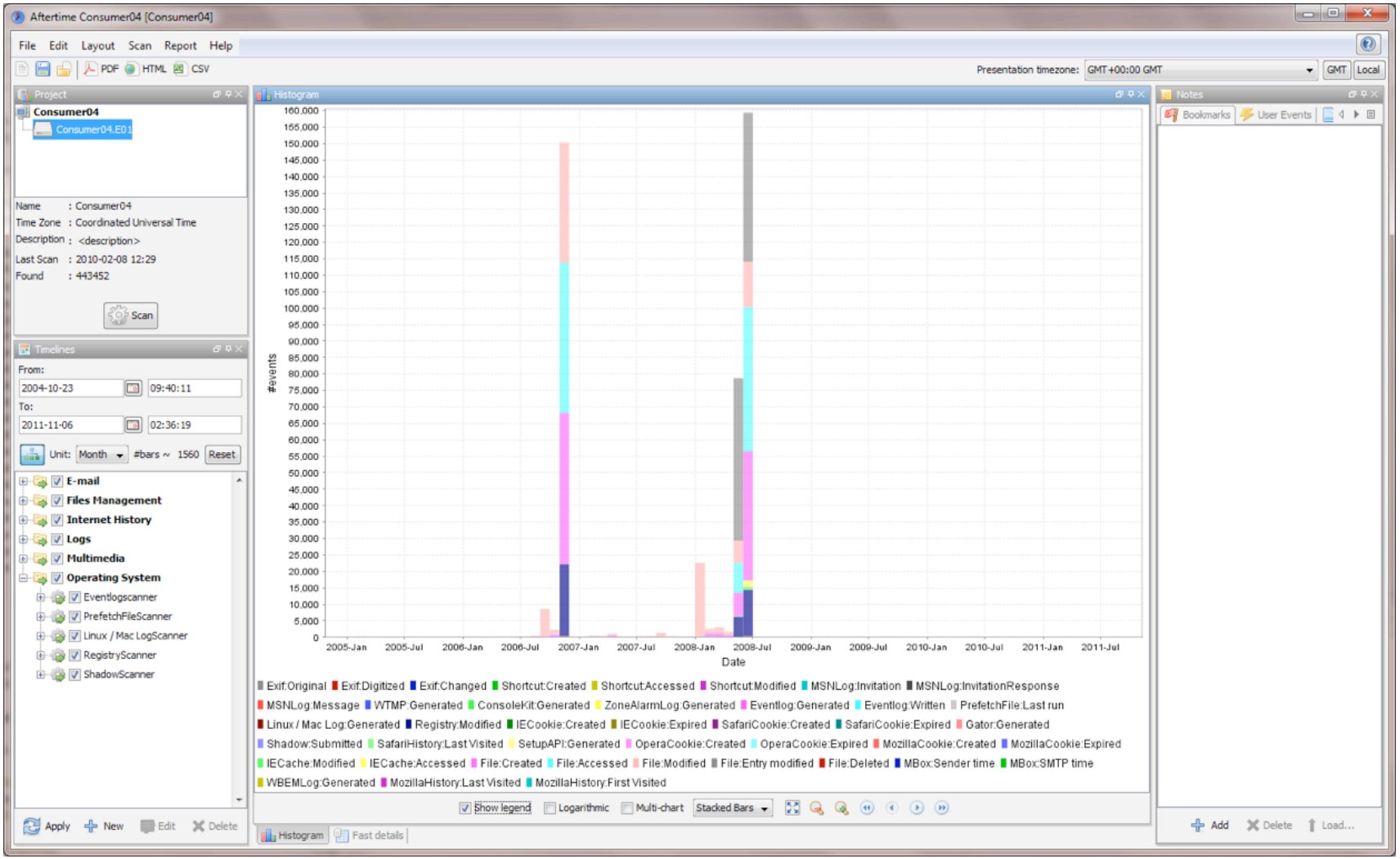
"what is the event history of this computer?"

Research Aim
Summary

- Needs to provide a ‘gist’ - a ‘summary of activity on the disk’
- Need an event reconstruction tool that produces ‘human understandable events’
- Needs to satisfy forensic requirements, particularly traceability, repeatability
- Needs to be extensible, i.e. allow the community to add
  - EnScript, RegRipper, Volatility

Existing timeline tools

Aftertime



Netherlands Forensic Institute (NFI Labs). 2005. Aftertime, http:www.holmes.nl/NFIlabs/Aftertime/index.html;

Zeitline

Zeitline

File Edit Event Timeline View Help

test

test

Import from FLS filter: scan15.fls

Import from FLS filter: scan15.fls

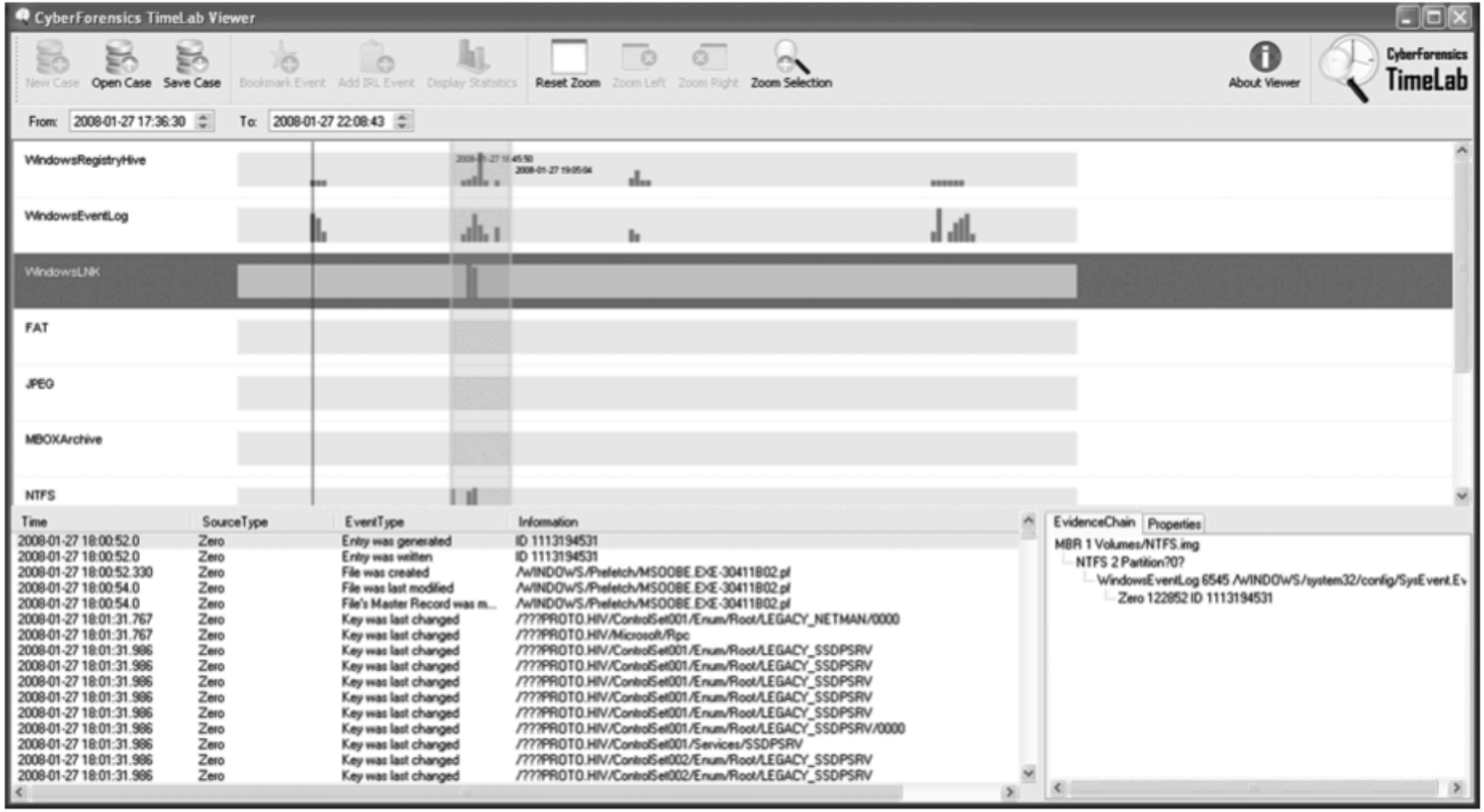
1994-07-13 21:57:49.0 M.. /root/.bash_logout
1994-07-13 22:05:25.0 M.. /etc/skel/.bash_logout
1995-08-23 11:56:14.0 M.. /etc/skel/.bashrc
1995-08-23 15:02:38.0 MA. /root/.Xdefaults
1995-08-23 15:03:58.0 M.. /root/.bash_profile
1995-08-23 15:04:30.0 M.. /root/.bashrc
1996-02-06 16:04:01.0 M.. /mnt/floppy
1996-03-04 10:07:42.0 M.. /root/.tcshrc
1997-09-16 10:12:06.0 MA. /etc/ppp/ip-down
1998-05-05 16:32:26.0 MA. /dev/atibm
1998-05-05 16:32:26.0 MA. /dev/aztcd
1998-05-05 16:32:26.0 MA. /dev/cdu535
1998-05-05 16:32:26.0 MA. /dev/cm206cd
1998-05-05 16:32:26.0 MA. /dev/cua0
1998-05-05 16:32:26.0 MA. /dev/cua1
1998-05-05 16:32:26.0 MA. /dev/cua2
1998-05-05 16:32:26.0 MA. /dev/cua3
1998-05-05 16:32:26.0 MA. /dev/fd0
1998-05-05 16:32:26.0 MA. /dev/fd0D360
1998-05-05 16:32:26.0 MA. /dev/fd0D720
1998-05-05 16:32:26.0 MA. /dev/fd0H1440
1998-05-05 16:32:26.0 MA. /dev/fd0H360
1998-05-05 16:32:26.0 MA. /dev/fd0H720
1998-05-05 16:32:26.0 MA. /dev/fd0d360
1998-05-05 16:32:26.0 MA. /dev/fd0h1200
1998-05-05 16:32:26.0 MA. /dev/fd0h360
1998-05-05 16:32:26.0 MA. /dev/fd0h720
1998-05-05 16:32:26.0 MA. /dev/fd1
1998-05-05 16:32:26.0 MA. /dev/fd1D360

Time: 1994-07-13 21:57:49.0
Adjusted time: 1994-07-13 21:57:49.0
Reported time: 1994-07-13 21:57:49.0
Name: M.. /root/.bash_logout
Filename: .bash_logout
Path: /root
Size: 24
MTime: 1994-07-13 21:57:49.0
ATime: 2001-03-16 09:52:59.0
CTime: 2001-03-15 06:18:14.0
User ID: 0
Group ID: 0
Permissions: -rw-r--r--

Source: FLS filter: scan15.fls
Created: 2012-08-04 17:47:41.842

Buchholz, F. & Falk, C., 2005. Design and Implementation of Zeitline: a Forensic Timeline Editor. *Digital Forensics Research Workshop*.

Existing Work on Timelines: Cyber Forensic Time Lab (CFTL)



From: 2008-01-27 17:36:30

To: 2008-01-27 22:08:43

Time	SourceType	EventType	Information
2008-01-27 18:00:52.0	Zero	Entry was generated	ID 1113194531
2008-01-27 18:00:52.0	Zero	Entry was written	ID 1113194531
2008-01-27 18:00:52.330	Zero	File was created	/WINDOWS/Prefetch/MSOOBE.EXE-30411B02.pf
2008-01-27 18:00:54.0	Zero	File was last modified	/WINDOWS/Prefetch/MSOOBE.EXE-30411B02.pf
2008-01-27 18:00:54.0	Zero	File's Master Record was m...	/WINDOWS/Prefetch/MSOOBE.EXE-30411B02.pf
2008-01-27 18:01:31.767	Zero	Key was last changed	/???PROTO.HIV/ControlSet001/Enum/Root/LEGACY_NETMAN/0000
2008-01-27 18:01:31.767	Zero	Key was last changed	/???PROTO.HIV/Microsoft/Rpc
2008-01-27 18:01:31.986	Zero	Key was last changed	/???PROTO.HIV/ControlSet001/Enum/Root/LEGACY_SSDPSRV
2008-01-27 18:01:31.986	Zero	Key was last changed	/???PROTO.HIV/ControlSet001/Enum/Root/LEGACY_SSDPSRV
2008-01-27 18:01:31.986	Zero	Key was last changed	/???PROTO.HIV/ControlSet001/Enum/Root/LEGACY_SSDPSRV
2008-01-27 18:01:31.986	Zero	Key was last changed	/???PROTO.HIV/ControlSet001/Enum/Root/LEGACY_SSDPSRV
2008-01-27 18:01:31.986	Zero	Key was last changed	/???PROTO.HIV/ControlSet001/Enum/Root/LEGACY_SSDPSRV
2008-01-27 18:01:31.986	Zero	Key was last changed	/???PROTO.HIV/ControlSet001/Enum/Root/LEGACY_SSDPSRV/0000
2008-01-27 18:01:31.986	Zero	Key was last changed	/???PROTO.HIV/ControlSet001/Services/SSDPSRV
2008-01-27 18:01:31.986	Zero	Key was last changed	/???PROTO.HIV/ControlSet002/Enum/Root/LEGACY_SSDPSRV
2008-01-27 18:01:31.986	Zero	Key was last changed	/???PROTO.HIV/ControlSet002/Enum/Root/LEGACY_SSDPSRV

EvidenceChain | Properties

MBR 1 Volumes/NTFS.img
  NTFS 2 Partition?0?
    WindowsEventLog 6545 /WINDOWS/system32/config/SysEvent.Ev
      Zero 122852 ID 1113194531

Olsson, J. & Boldt, M., 2009. Computer forensic timeline visualization tool. Digital Investigation, 6(Supplement 1), pp.S78–S87.

log2timeline

```
sansforensics@SIFT-Workstation: ~/Desktop/VMware-Shared-Drive/Red Team Disk Images
s$ log2timeline-sift -win7 -i Hilton.dmg
[LOG2TIMELINE-SIFT] MFT directly callable, no need for special parsing.
[PreProcessing] The default browser of user peter according to registry is: (FIR
EFOX.EXE)
[PreProcessing] Unable to determine the default browser for user default
[PreProcessing] Hostname is set to PETER-PC
[PreProcessing] The timezone according to registry is: (@.,-262) @tzres.dll,-262
[PreProcessing] The timezone settings are NOT overwritten so the settings might
have to be adjusted.
[PreProcessing] The default system browser is: : IEXPLORE.EXE ("C:\Program Files
\Internet Explorer\iexplore.exe" -nohome)
Local timezone is: UTC (UTC)
Local timezone is: UTC (UTC)
Loading output file: csv
```

Guðjónsson, K., 2010. Mastering the Super Timeline with log2timeline. pp.1–84.

Overview of our approach

high-timeline

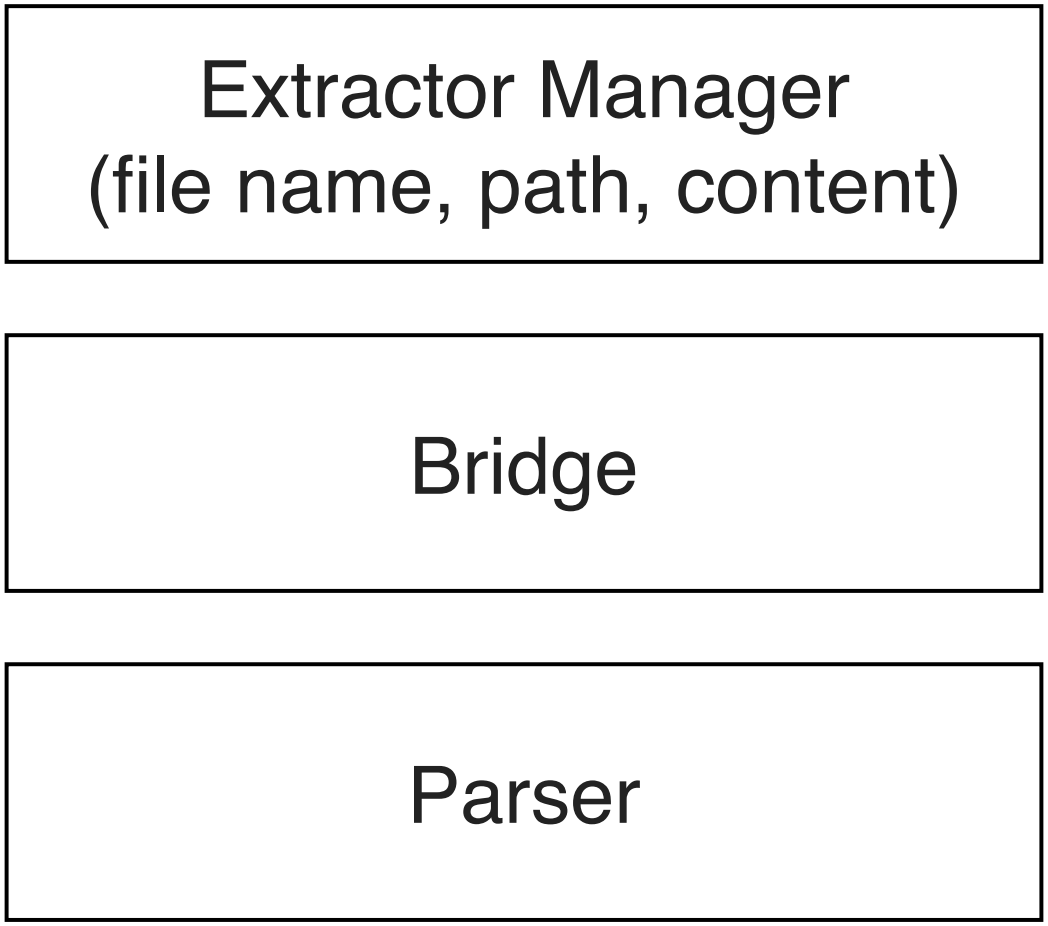
low-level event database

disk image

Software Components

- **Low level events**
- **Low level timelines**
- **High level events**
- **High level timelines**
- Case management
- Time converters
- File system/disk image access
- Utilities e.g logging

Low-level time extraction



Extractor Manager can match on file name/path

```
elif file_name_and_path[-11:] == "_CACHE_MAP_":
    logging.debug("%s is a Firefox Cache Map. Running parser..."
                                                % file_name_and_path)
    firefox_extractor = FirefoxCacheBridge.FirefoxCacheTimeExtractor(file_name_and_path,
                                                                     mount_path, evidence)
    firefox_event_timeline = firefox_extractor.GetTimes()
    logging.debug("Extracted %d events from %s" % (len(firefox_event_timeline),
                                                   file_name_and_path))
    return firefox_event_timeline
```

Extractor Manager can match on file signature

```
elif file_header[0:4] == b"\xFF\xD8\xFF\xE1" or file_header[0:4] == b"\xFF\xD8\xFF\xE0":
    logging.debug("TimeExtractor found an jpg file (%s)" % file_name_and_path)
    jpg_file_extractor = EXIFBridge.EXIFTimeExtractor(file_name_and_path,
                                                      mount_path, evidence)
    jpg_file_event_timeline = jpg_file_extractor.GetTimes()
    logging.debug("Extracted %d events from %s" % (len(jpg_file_event_timeline),
                                                      file_name_and_path))
    return jpg_file_event_timeline
```

Low-level event format

id	258920
min_date_time	1301136207.4043
max_date_time	1301136207.4043
evidence	CH-TestImage2
plugin	Registry Parser
type	Last Updated
path	/Software/Microsoft/Internet Explorer/TypedURLs
device	CH-TestImage2
keys	(“url1”:“http://www.google.co.uk”)

Low-level event format: provenance

dataprov_source	/Users/Chris/NTUSER.DAT
dataprov_type	offset
dataprov_value	274784

Currently identified data provenance

- **offset**, e.g. in a Registry hive, index.dat, $mft
- **sql statement**, e.g. places.sqlite
- **line number**, e.g. setupapi.log

We have a SQLite database containing millions of low-level events

id	min_date_time	max_date_time	evidence	plugin	type	path	dataprov_source	dataprov_type	dataprov_va
0	1300991498.468	1300991498.468	HC-TechCom	MFT	Created	/$MFT	/$MFT	offset	0
1	1300991498.468	1300991498.468	HC-TechCom	MFT	Modified	/$MFT	/$MFT	offset	0
2	1300991498.468	1300991498.468	HC-TechCom	MFT	Entry Modified	/$MFT	/$MFT	offset	0
3	1300991498.468	1300991498.468	HC-TechCom	MFT	Accessed	/$MFT	/$MFT	offset	0
4	1300991498.468	1300991498.468	HC-TechCom	MFT	Created	/$MFTMirr	/$MFT	offset	1024
5	1300991498.468	1300991498.468	HC-TechCom	MFT	Modified	/$MFTMirr	/$MFT	offset	1024
6	1300991498.468	1300991498.468	HC-TechCom	MFT	Entry Modified	/$MFTMirr	/$MFT	offset	1024
7	1300991498.468	1300991498.468	HC-TechCom	MFT	Accessed	/$MFTMirr	/$MFT	offset	1024
8	1300991498.468	1300991498.468	HC-TechCom	MFT	Created	/$LogFile	/$MFT	offset	2048
9	1300991498.468	1300991498.468	HC-TechCom	MFT	Modified	/$LogFile	/$MFT	offset	2048
10	1300991498.468	1300991498.468	HC-TechCom	MFT	Entry Modified	/$LogFile	/$MFT	offset	2048
11	1300991498.468	1300991498.468	HC-TechCom	MFT	Accessed	/$LogFile	/$MFT	offset	2048
12	1300991498.468	1300991498.468	HC-TechCom	MFT	Created	/$Volume	/$MFT	offset	3072
13	1300991498.468	1300991498.468	HC-TechCom	MFT	Modified	/$Volume	/$MFT	offset	3072
14	1300991498.468	1300991498.468	HC-TechCom	MFT	Entry Modified	/$Volume	/$MFT	offset	3072
15	1300991498.468	1300991498.468	HC-TechCom	MFT	Accessed	/$Volume	/$MFT	offset	3072
16	1300991498.468	1300991498.468	HC-TechCom	MFT	Created	/$AttrDef	/$MFT	offset	4096
17	1300991498.468	1300991498.468	HC-TechCom	MFT	Modified	/$AttrDef	/$MFT	offset	4096
18	1300991498.468	1300991498.468	HC-TechCom	MFT	Entry Modified	/$AttrDef	/$MFT	offset	4096
19	1300991498.468	1300991498.468	HC-TechCom	MFT	Accessed	/$AttrDef	/$MFT	offset	4096
20	1300991498.468	1300991498.468	HC-TechCom	MFT	Created	/$Bitmap	/$MFT	offset	6144
21	1300991498.468	1300991498.468	HC-TechCom	MFT	Modified	/$Bitmap	/$MFT	offset	6144
22	1300991498.468	1300991498.468	HC-TechCom	MFT	Entry Modified	/$Bitmap	/$MFT	offset	6144
23	1300991498.468	1300991498.468	HC-TechCom	MFT	Accessed	/$Bitmap	/$MFT	offset	6144
24	1300991498.468	1300991498.468	HC-TechCom	MFT	Created	/$Boot	/$MFT	offset	7168
25	1300991498.468	1300991498.468	HC-TechCom	MFT	Modified	/$Boot	/$MFT	offset	7168

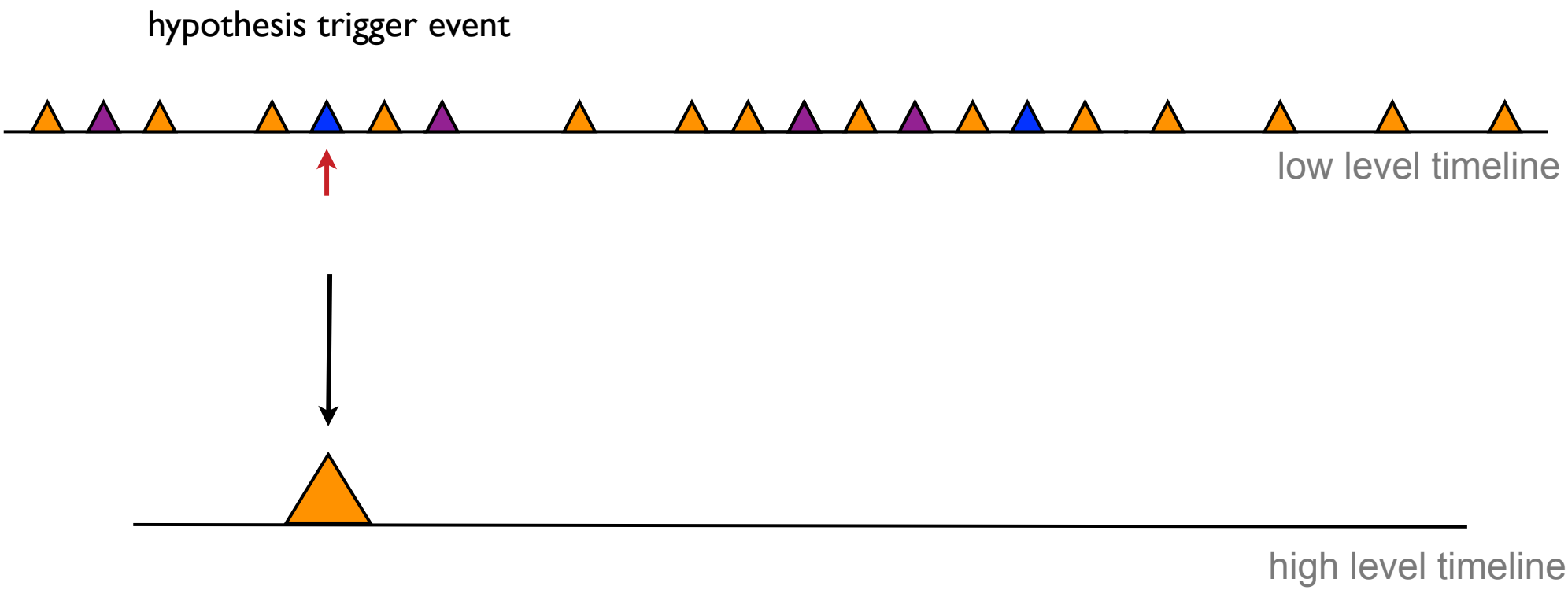
select *, rowid "NAVICAT_ROWID" from "main"."events" limit 0,1000

1

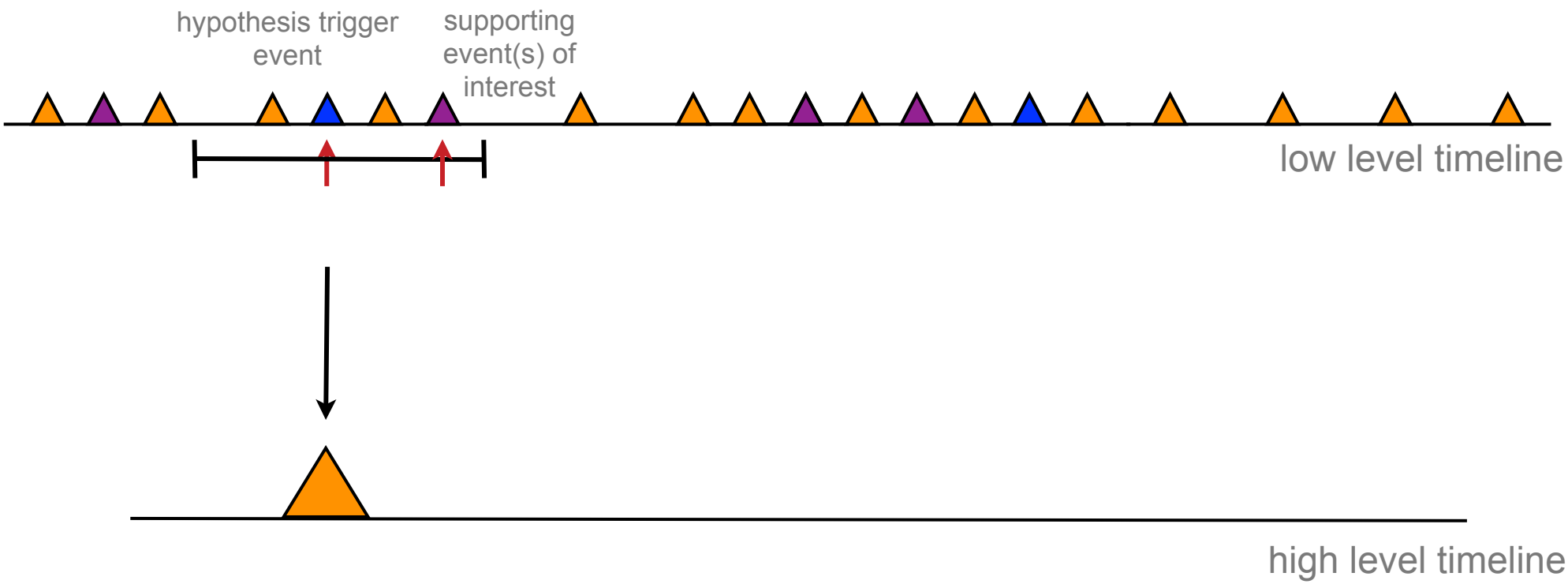
1000 records in page 1

Automated Analysis

Analysis Concept (simple)



Analysis Concept (slightly more complex)



Simple test events

```
flickr_search_test = PyDFT.Core.LowLevelEvent.LowLevelEvent()
flickr_search_test.type = "URL Visit"
flickr_search_test.path = "http://www\.flickr.com/search/\?q=([^&]+)"
```

Events can be directly compared

```
def __eq__(self, other):
    """A low level event is the same as another if all the attributes match"""
    if type(other) != PyDFT.Core.LowLevelEvent.LowLevelEvent:
        return False
    if self.evidence != other.evidence:
        return False
    if self.plugin != other.plugin:
        return False
    if self.event_provenance.source != other.event_provenance.source:
        return False
    if self.event_provenance.type != other.event_provenance.type:
        return False
    if self.event_provenance.value != other.event_provenance.value:
        return False
    if self.date_time_min != other.date_time_min:
        return False
    if self.date_time_max != other.date_time_max:
        return False
    if self.path != other.path:
        return False
    if self.type != other.type:
        return False
    if self.keys != other.keys:
        return False
    return True
```

...but searches are more powerful if you can use regex

```
def Match(self, test_event):
    """Tries to match a test event with the current event and returns true if they match"""
    if not re.search(test_event.evidence, self.evidence):
        return None
    if not re.search(test_event.type, self.type):
        return None
    if not re.search(test_event.plugin, self.plugin):
        return None
    if re.search(test_event.path, self.path) == None:
        return None
    if test_event.event_provenance.source != None:
        if not re.search(test_event.event_provenance.source, self.event_provenance.source):
            return None
    if test_event.event_provenance.type != None:
        if not re.search(test_event.event_provenance.type, self.event_provenance.type):
            return None
    if test_event.event_provenance.value != None:
        if not re.search(test_event.event_provenance.value, self.event_provenance.value):
            return None
    for each_test_key in test_event.keys:
        # if key does not exist...
        if each_test_key not in self.keys:
            return None
        # if key data does not match...
        if not re.search(test_event.keys[each_test_key], self.keys[each_test_key]):
            return None
    else:
        return True
```

Basic Event Matching

```python
def AmazonSearches(low_timeline, queue, start_id, end_id):

    test_events_dict = GetAmazonTestEvents()
    trigger_matches_from_low_timeline = low_timeline.FindMatchingEventsinIdRange(start_id,end_id, test_events_dict)

    high_level_timeline = PyDFT.Core.HighLevelTimeline.HighLevelTimeline()

    for each_low_event in trigger_matches_from_low_timeline:
        matched_trigger = each_low_event.MatchAnyTestEvent(test_events_dict)
        if matched_trigger:
            # make high level event
            high_event = PyDFT.Core.HighLevelEvent.HighLevelEvent()
            high_event.AddTime(each_low_event.date_time_min)
            high_event.AddTime(each_low_event.date_time_max)
            high_event.type = "Amazon search"
            high_event.category = "Web"
            high_event.evidence_source = each_low_event.evidence
            high_event.device = each_low_event.evidence

            # get search terms and other detail
            search_term = GetSearchTermFromURL(test_events_dict[matched_trigger].path, each_low_event.path)
            high_event.description = "Amazon search for '%s'" % search_term
            high_event.keys["Search term"] = search_term
            if "Page Title" in each_low_event.keys:
                high_event.keys["Page Title"] = each_low_event.keys["Page Title"]

            # Add reasoning for this high level event
            reasoning = PyDFT.Core.HighLevelEvent.ReasoningArtefact()
            reasoning.id = each_low_event.id
            reasoning.test_event = test_events_dict[matched_trigger]
            reasoning.description = "Amazon search URL found (%s)" % each_low_event.path
            high_event.trigger = reasoning

            # Add the event to the high-level timeline
            high_level_timeline.AddEvent(high_event)

    queue.put(high_level_timeline)
```

More Complex Event Matching

Methods for matching

```
MatchAnyTestEvent(self, dict_of_test_events)

FindMatchingEventsinIdRange(self, start, end, test_events)

FindEventsInSubTimeline(self, event_list, start, end)

FindEventsRelatedToAPath(self, path)
```

YouTube example test events

```
# Construct the test event -- matching url
trigger_test_event = LowLevelEvent.LowLevelEvent()
trigger_test_event.type = "URL Visit"
trigger_test_event.path = "http://[a-zA-Z0-9]*?\.youtube\.com/watch\?v=([^&]+)&?(.*)"


videoplayback_access_test = PyDFT.Core.LowLevelEvent.LowLevelEvent()
videoplayback_access_test.type = "Accessed"
videoplayback_access_test.path = "/Temporary Internet Files/Low/Content.IE5/(.+)/(videoplayback\[[0-9]{1}\])"


videoplayback_modify_test = PyDFT.Core.LowLevelEvent.LowLevelEvent()
videoplayback_modify_test.type = "Modified"
videoplayback_modify_test.path = "/Temporary Internet Files/Low/Content.IE5/(.+)/(videoplayback\[[0-9]{1}\])"

videoplayback_firefox_test = PyDFT.Core.LowLevelEvent.LowLevelEvent()
videoplayback_firefox_test.plugin = "Firefox Cache"
videoplayback_firefox_test.type = "Cached"
videoplayback_firefox_test.keys["url"] = ".*?youtube.com/videoplayback"
```

Patterson, J. & Hargreaves, C. (2011) Automated Identification and Reconstruction of YouTube Video Access, Proceedings from 5th Cybercrime Forensics Education and Training

High-level event format


```
<event>
    <min_date_time>1291573279.718</min_date_time>
    <max_date_time>1291573279.718</max_date_time>
    <evidence_source>CH-Smythe-01</evidence_source>
    <description>Google Search for 'pdf creator'</description>
    <category>Web</category>
    <device>CH-Smythe-01</device>
    <type>Google Search</type>
    <files></files>
    <summary></summary>
    <trigger_evidence_artefact>
        <reasoning_artefact>
            <description>Google search URL found in /Documents and Settings/Alan/Local Set
            <id>42117</id>
            <test_event>
                <low_event>
                    <type>URL Visit</type>
                    <path>http://(.+\.)(google)\.[A-z]{2}.*/(.+)</path>
                </low_event>
            </test_event>
        </reasoning_artefact>
    </trigger_evidence_artefact>
    <key name="URL">http://www.google.co.uk/search?hl=en&source=hp&q=pdf+creator&meta=&aq=
    <key name="Search_Term">pdf creator</key>
    <key name="Browser">IExplorer</key>
</event>
```

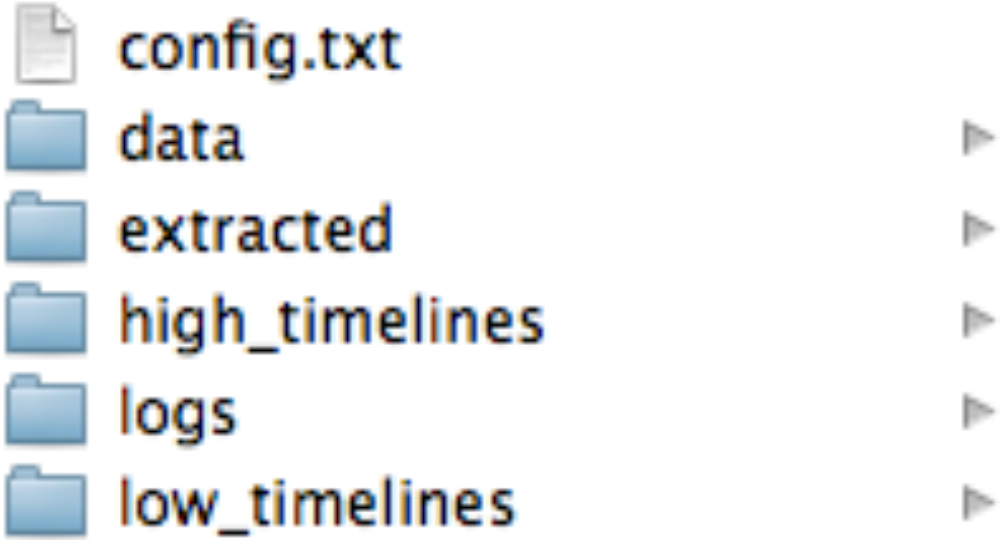
Supporting and contradictory artefacts


```
<supporting_artefacts>
    <reasoning_artefact>
        <description>InstallDate artefact found in Registry</description>
        <id>553204</id>
        <test_event>
            <low_event>
                <plugin>Registry Parser</plugin>
                <path>}/Microsoft/Windows NT/CurrentVersion$</path>
                <key name="InstallDate">.*</key>
            </low_event>
        </test_event>
    </reasoning_artefact>
</supporting_artefacts>
<contradictory_artefacts>
    <reasoning_artefact>
        <description>Windows Folder created not found at similar time</description>
        <id>-1</id>
        <test_event>
            <low_event>
                <plugin>Mounted File System</plugin>
                <type>Created</type>
                <path>^Windows$</path>
            </low_event>
        </test_event>
    </reasoning_artefact>
</contradictory_artefacts>
```

High-level event format


```
<event>
    <min_date_time>1291579906</min_date_time>
    <max_date_time>1291579906</max_date_time>
    <evidence_source>CH-Smythe-01</evidence_source>
    <description>panther.pdf created</description>
    <category>User Activity</category>
    <device>CH-Smythe-01</device>
    <type>PDF created</type>
    <files>
        <file>
            <original_file>/Documents and Settings/Alan/Desktop/panther.pdf</original_file>
            <copied_file>CH-Smythe-01_0000000A.pdf</copied_file>
        </file>
    </files>
    <summary></summary>
    <trigger_evidence_artefact>
        <reasoning_artefact>
            <description>Created time for .pdf file panther.pdf in /Documents and Settings/Alan/Desktop/</des
            <id>329</id>
            <test_event>
                <low_event>
                    <type>Created</type>
                    <path>.+\.pdf$</path>
                </low_event>
            </test_event>
        </reasoning_artefact>
    </trigger_evidence_artefact>
    <key name="File Size">39880</key>
    <key name="File Name">panther.pdf</key>
    <key name="File Path">/Documents and Settings/Alan/Desktop/panther.pdf</key>
</event>
```

Case folder structure



Results

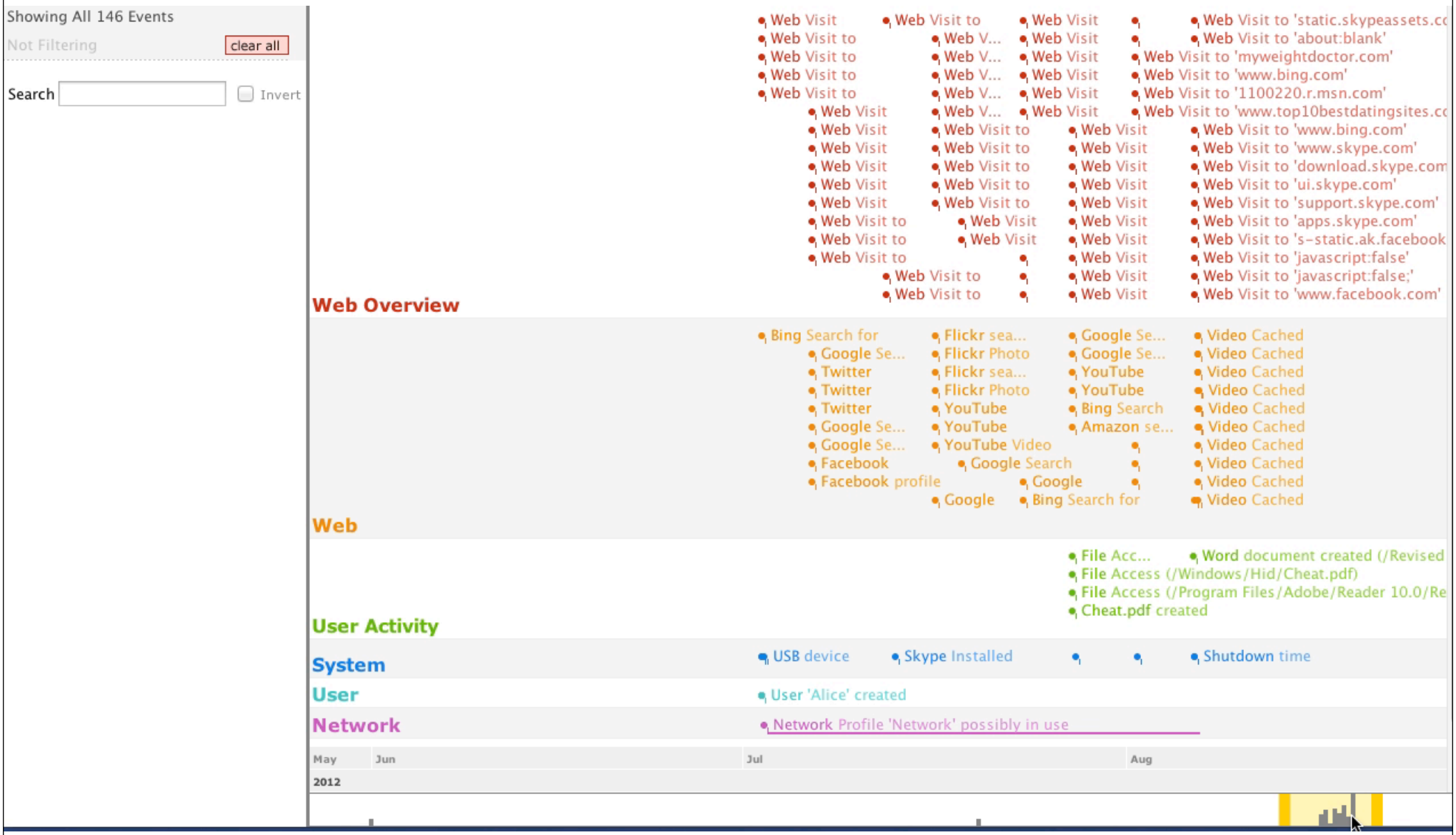
Performance

Table 1
Example times for timeline generation and analysis. The first is from a small, test VM, others are from 'real world' systems.

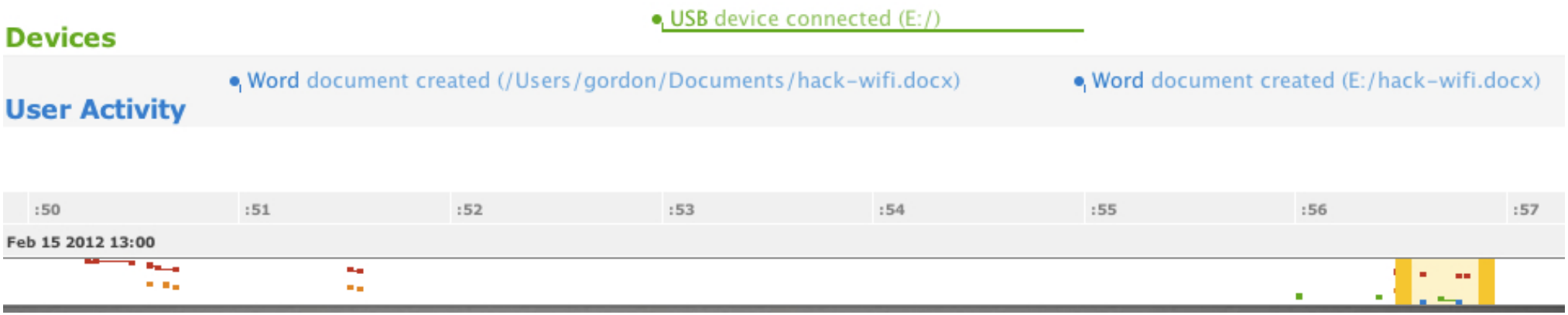
Volume size	Approx. time system in use	Low-events produced	Time for low generation (hh:mm)
20 GB	2 months	0.6 million	0:15
100 GB	2 years	1.2 million	0:42
250 GB	5 years	1.6 million	1:05

Volume size	Number of analysers	High-events produced	Time for analysis
20 GB	19	666	0:28
100 GB	19	2704	1:10
250 GB	17	3902	1:14

Visualising high-level timelines using Timeflow



https://github.com/FlowingMedia/**TimeFlow**/wiki/


USB device connected (E:/)
Devices
Word document created (/Users/gordon/Documents/hack-wifi.docx)
Word document created (E:/hack-wifi.docx)
User Activity
:50
:51
:52
:53
:54
:55
:56
:57
Feb 15 2012 13:00

Timeline Controls

Zoom

zoom out 2X

zoom out 100%

Layout

loose

diagonal

graph

Global Controls

Showing All 87 Events

Not Filtering

clear all

Label Description

Groups EvidenceSource

Color Type

Color Legend: 'Type'

Picture Taken - 25

User created - 17

Skype Call (outgoing) - 12

Skype Contact Request - 10

Skype Call (incoming) - 8

Skype Contact Request to/from johnmiller7935

CH-TomDavies-01

Skype Contact Request to/from johnmiller7935

Skype Call to John Miller

CH-JodySmith-01

Skype Contact Request to/from johnmiller7935

CH-MichelleSmith-01

Skype Call to Jody Smith

Skype Installed

Skype Call to Jody Smith

Skype Call from Jody Smith

Skype Contact Request to/from michellesmith993

created

Skype Contact Request to/from jodysmith7654

CH-JohnMiller-01

14:00

15:00

Oct 31 2011

Display | Filter

Timeline | Calendar | List | Table | Bar Graph | Summary | Notes

Timeline Controls

Zoom: zoom out 2x; zoom out 100%

Layout: loose; diagonal; graph

Global Controls

Showing All 266 Events

Not Filtering — clear all

Label: Description

Groups: EvidenceSource

Color: EvidenceSource

Color Legend: 'EvidenceSource'

Computer 1 - 76
Computer 2 - 72
Computer 4 - 64
Computer 3 - 58

Computer 1

Web Visit to
Web Visit to
Generic STORAGE_DEVICE USB
Word document created
Web Visit to 'trailers.apple.com'
Web Visit to 'www.apple.com'
File
Local Visit to '/E:/Client%20de...
Google Search for 'itunes trailers'
Word document created
Word document created
Local Visit to '/C:/Users/georgina/Des...
Web Visit to 'Computer'
Google Search for
Google Search for
Google Search for
Google Search for
Word document created (/Users/georgina/Desktop/Notes
File Access (Users/georgina/Desktop/Notes on meeting
Local Visit to '/C:/Users/georgina/Desktop/Notes%20on
Word document created (E:/Notes on meeting with client
Word document created
Web Visit to 'www.tutor2u.net'
Web Visit to
Local Visit to '/E:/Notes%20on%20meeting%20with%20cl
Web Visit to 'www.bbc.co.uk'
Shutdown time
Network
Google Se...
File Access (Users/georgina/Desktop...
Local Visit to '/C:/Users/georgina/...
Web Visit to 'www.myvue.com'
Google Search for 'apple movie trailers'

Computer 2

Local Visit to '/C:/Users/georgina/Desktop...
Word document created
Shutdown time
File Access (Users/georgina/Desktop/Future security
File Access (Users/georgina/Desktop/Past and Current Security thre
Local Visit to '/C:/Users/georgina/Desktop/Future%20s...
Local Visit to '/C:/Users/georgina/Desktop/Past%20and%20Current
File Access (/Users/georgina/De...
File Access (Users/georgina/Desktop...
Freecom_Databar USB device connected
Word document created
Word document created
Word document created (E:/Past and Current Security
Word document created
Word document created
Local Visit to '/E:/Past%20and%20Current%20Security
Word document created
Local Visit to '/C:/Users/georgina/Desktop/...
Google Search for 'lifehacker'
Word document created (C:/Users/georgina/Desktop...
Generic STORAGE_DEVICE USB
Web Visit to 'www.google.co.uk'
Local Visit to '/C:/Users/georgina/Desktop/Finan...
Word document created
Web Visit to 'lifehacker.com'
Web Visit to 'Computer'
Word document created
Web Visit to 'jalopnik.com'

Computer 4

Amazon search for watch
Web Visit to 'amazon.co.uk'
Web Visit to 'www.amazon.co.uk'
Amazon search for external hard drives
Word document created (/Users/georgina/Desktop/Office Documents.docx)
File Access (Users/georgina/Desktop/Office Documents.docx)
Word document created (E:/Office Documents.docx)
Local Visit to '/C:/Users/georgina/Desktop/Office%20Documents.docx'
Word document created (E:/Client
Local Visit to '/E:/Office%20Documents.docx'
Generic STORAGE_DEVICE USB device
Word document created (E:/Document H.docx)
Local Visit to '/E:/Client%20details.docx'
Word document created (/Users/georgina/Desktop/Docu
Web Visit to 'Computer'
Local Visit to '/E:/Document%20H.docx'
Network Profile 'Network 3' possibly in
Local Visit to '/E:/Client%20details.docx'
Shutdown time

Computer 3

Web Visit to 'Computer'
Shutdown time
File Access (Users/georgina/Desktop/Document H.docx)
Word document created (/Users/georgina/Desktop/Document H.docx)
Word document created (C:/Users/georgina/Desktop/Document H.docx)
Network Profile 'Network
Local Visit to '/C:/Users/georgina/Desktop/Document%20H.docx'
Generic STORAGE_DEVICE USB device connected
Google Search for 'bbc news'
Word document created (E:/Payroll details.docx)
Web Visit to 'www.google.co.uk'
Local Visit to '/E:/Payroll%20details.docx'
Web Visit to 'www.bbc.co.uk'

07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00

Jun 22 2012

Visualising high-level timelines using d3.js
(work in progress)

d3.js used to show high and supporting low-level events

1385	Sat Mar 26 2011 08:14:19 GMT-0400 (EDT)	Sat Mar 26 2011 08:14:19 GMT-0400 (EDT)	HC-TechCom	Web Visit to 'uk.msn.com'	Web Overview	HC-TechCom	Web Visit
1464	Sat Mar 26 2011 08:14:45 GMT-0400 (EDT)	Sat Mar 26 2011 08:15:27 GMT-0400 (EDT)	HC-TechCom	Web Visit to 'res:'	Web Overview	HC-TechCom	Web Visit
1462	Sat Mar 26 2011 08:15:00 GMT-0400 (EDT)	Sat Mar 26 2011 08:15:00 GMT-0400 (EDT)	HC-TechCom	Web Visit to 'track.searchignite.com'	Web Overview	HC-TechCom	Web Visit
1446	Sat Mar 26 2011 08:15:04 GMT-0400 (EDT)	Sat Mar 26 2011 08:15:22 GMT-0400 (EDT)	HC-TechCom	Web Visit to 'www.apple.com'	Web Overview	HC-TechCom	Web Visit
1367	Sat Mar 26 2011 08:15:24 GMT-0400 (EDT)	Sat Mar 26 2011 08:15:24 GMT-0400 (EDT)	HC-TechCom	Google Search for 'laptops'	Web	HC-TechCom	Google Search
1445	Sat Mar 26 2011 08:15:24 GMT-0400 (EDT)	Sat Mar 26 2011 08:15:27 GMT-0400 (EDT)	HC-TechCom	Web Visit to 'www.google.co.uk'	Web Overview	HC-TechCom	Web Visit
1361	Sat Mar 26 2011 08:15:27 GMT-0400 (EDT)	Sat Mar 26 2011 08:15:27 GMT-0400 (EDT)	HC-TechCom	Google Search for 'laptops'	Web	HC-TechCom	Google Search
1447	Sat Mar 26 2011 08:15:30 GMT-0400 (EDT)	Sat Mar 26 2011 08:15:38 GMT-0400 (EDT)	HC-TechCom	Web Visit to 'news.idg.no'	Web Overview	HC-TechCom	Web Visit
1467	Sat Mar 26 2011 08:19:51 GMT-0400 (EDT)	Sat Mar 26 2011 08:19:51 GMT-0400 (EDT)	HC-TechCom	Shutdown time	System	HC-TechCom	Shutdown time

High Level Event Details

id: 1467
min_date_time: Sat Mar 26 2011 08:19:51 GMT-0400 (EDT)
max_date_time: Sat Mar 26 2011 08:19:51 GMT-0400 (EDT)
evidence_source: HC-TechCom
description: Shutdown time
category: System
device: HC-TechCom
type: Shutdown time
summary:
keys(0):
files(0):
supporting(1):
· Shutdown time found in /CMI-CreateHive{3D971F19-49AB-4000-8D39-A6D9C673D809}/Microsoft/Windows/CurrentVersion/Reliability/shutdown: 397081
Last Updated/Reliability/shutdown$

contradictory(0):

Low Level Event Details

id: 397081
min_date_time: Sat Mar 26 2011 08:19:51 GMT-0400 (EDT)
max_date_time: Sat Mar 26 2011 08:19:51 GMT-0400 (EDT)
evidence: HC-TechCom
plugin: Registry Parser
type: Last Updated
path: /CMI-CreateHive{3D971F19-49AB-4000-8D39-A6D9C673D809}/Microsoft/Windows/CurrentVersion/Reliability/shutdown

dataprov_source: /Windows/System32/config/SOFTWARE
dataprov_type: offset
dataprov_value: 4034800

Keys:
ReasonCode ff000500
type REG_DWORD

Low-event provides link to raw data

Inspector

Type	Value
Signed Byte	-88
Unsigned Byte	168
Signed Short	-88
Unsigned Short	65448
Signed Int	-88
Unsigned Int	4294967208
Signed Int64	9125323740282...
Unsigned Int64	9125323740282...
Float	
Double	4.566870217492...
String	¨ÿÿÿnk
Unicode	𐀀𐀁𐀂𐀃𐀄Nj
DOSDATE	
DOSTIME	
FILETIME	12/01/1629 17:...
OLETIME	
time_t	02/07/2106 06:...

Auto | Variables | F

SOFTWARE

Edit As: Hex | Run Script | Run Template

```
         0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F   0123456789ABCDE
3D:9010h: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
3D:9020h: D8 FF FF FF 76 6B 0F 00 48 00 00 00 48 80 3D 00  Øÿÿÿvk..H...H€=
3D:9030h: 02 00 00 00 01 00 73 00 4D 65 73 73 61 67 65 46  ......s.MessageF
3D:9040h: 69 6C 65 4E 61 6D 65 00 B0 FF FF FF 25 00 57 00  ileName.°ÿÿÿ%.W
3D:9050h: 69 00 6E 00 44 00 69 00 72 00 25 00 5C 00 73 00  i.n.D.i.r.%.\.s
3D:9060h: 79 00 73 00 74 00 65 00 6D 00 33 00 32 00 5C 00  y.s.t.e.m.3.2.\
3D:9070h: 64 00 72 00 69 00 76 00 65 00 72 00 73 00 5C 00  d.r.i.v.e.r.s.\
3D:9080h: 74 00 63 00 70 00 69 00 70 00 2E 00 73 00 79 00  t.c.p.i.p...s.y
3D:9090h: 73 00 00 00 65 00 6D 00 A8 FF FF FF 30 94 28 00  s...e.m.¨ÿÿÿ0"(.
3D:90A0h: 68 94 28 00 B0 94 28 00 20 28 29 00 48 29 29 00  h"(.°"(. ().H))
3D:90B0h: 98 2A 29 00 E8 2A 29 00 40 2B 29 00 B8 6B CB 00  ˜*).è*).@+).¸kË.
3D:90C0h: F8 6B CB 00 88 2B 29 00 68 F6 6A 00 50 D8 74 00  økË.ˆ+).höj.PØt.
3D:90D0h: 38 6C CB 00 40 0E 33 01 C0 BD C5 00 90 0B 33 01  8lË.@.3.À½Å...3.
3D:90E0h: 48 0F 33 01 C0 0F 33 01 18 15 26 00 43 00 75 00  H.3.À.3...&.C.u.
3D:90F0h: A8 FF FF FF 6E 6B 20 00 7D 4C 58 1B B0 EB CB 01  ¨ÿÿÿnk .}LX.°ëË.
3D:9100h: 00 00 00 00 70 11 46 00 00 00 00 00 00 00 00 00  ....p.F.......
3D:9110h: FF FF FF FF FF FF FF FF 01 00 00 00 70 19 01 00  ÿÿÿÿÿÿÿÿ....p...
3D:9120h: C0 57 4A 00 FF FF FF FF 00 00 A0 00 00 00 00 00  ÀWJ.ÿÿÿÿ.. ....
3D:9130h: 14 00 00 00 04 00 00 00 65 00 72 00 08 00 00 00  ........e.r....
3D:9140h: 73 68 75 74 64 6F 77 6E C0 FF FF FF 6C 68 05 00  shutdownÀÿÿÿlh..
3D:9150h: 78 A9 47 00 9A 56 B5 38 F0 80 3D 00 98 1D 6E F9  x©G.šVµ8ð€=.˜.nù
3D:9160h: D0 11 46 00 09 C8 01 00 40 C5 85 00 EE E3 DA 1A  Ð.F..È..@Å….îãÚ.
3D:9170h: 68 49 93 00 29 13 F2 09 44 00 20 00 2F 00 64 00  hI“.).ò.D. ./.d.
3D:9180h: 20 00 30 00 20 00 2F 00 E0 FF FF FF 76 6B 03 00   .0. ./.àÿÿÿvk..
3D:9190h: 76 00 00 00 A0 1A AE 00 01 00 00 00 01 00 00 00  v... .®.......
3D:91A0h: 55 52 4C 68 70 65 66 30 F0 FF FF FF D0 E5 AA 00  URLhpef0ðÿÿÿÐåª.
3D:91B0h: D8 7A AE 00 D0 E5 AA 00 08 00 00 00 08 DA B7 00  Øz®.Ðåª......Ú·.
3D:91C0h: F0 FF FF FF D8 CD AF 00 00 CE AF 00 C0 A6 86 25  ðÿÿÿØÍ¯..Î¯.À¦†%
3D:91D0h: E0 FF FF FF 76 6B 06 00 04 00 00 80 2A 00 00 00  àÿÿÿvk.....€*...
3D:91E0h: 01 00 00 00 01 00 32 00 44 65 6C 65 74 65 65 00  ......2.Deleteeˆ
```

Can link to files associated with the event

75	Fri Jul 27 2012 16:45:11 GMT-0400 (EDT)	Fri Jul 27 2012 16:45:12 GMT-0400 (EDT)	JP-Alice_Dylan	Web Visit to '127.0.0.1:49180'	Web Overview	JP-Alice_Dylan	Web Visit
79	Fri Jul 27 2012 16:45:12 GMT-0400 (EDT)	Fri Jul 27 2012 16:45:12 GMT-0400 (EDT)	JP-Alice_Dylan	Web Visit to '127.0.0.1'	Web Overview	JP-Alice_Dylan	Web Visit
20	Fri Jul 27 2012 16:50:36 GMT-0400 (EDT)	Fri Jul 27 2012 16:51:11 GMT-0400 (EDT)	JP-Alice_Dylan	File Access (/Users/Alice/Desktop/Cheat.pdf)	User Activity	JP-Alice_Dylan	File Access
22	Fri Jul 27 2012 16:50:36 GMT-0400 (EDT)	Fri Jul 27 2012 16:53:12 GMT-0400 (EDT)	JP-Alice_Dylan	File Access (/Windows/Hid/Cheat.pdf)	User Activity	JP-Alice_Dylan	File Access
80	Fri Jul 27 2012 16:50:36 GMT-0400 (EDT)	Fri Jul 27 2012 16:50:36 GMT-0400 (EDT)	JP-Alice_Dylan	Web Visit to 'Computer'	Web Overview	JP-Alice_Dylan	Web Visit
21	Fri Jul 27 2012 16:50:46 GMT-0400 (EDT)	Fri Jul 27 2012 16:51:11 GMT-0400 (EDT)	JP-Alice_Dylan	File Access (/Program Files/Adobe/Reader 10.0/Reader/Legal/ENU/license.html)	User Activity	JP-Alice_Dylan	File Access
11	Fri Jul 27 2012 16:52:56 GMT-0400 (EDT)	Fri Jul 27 2012 16:52:56 GMT-0400 (EDT)	JP-Alice_Dylan	Cheat.pdf created	User Activity	JP-Alice_Dylan	PDF created
62	Fri Jul 27 2012 16:55:01 GMT-0400 (EDT)	Fri Jul 27 2012 16:55:01 GMT-0400 (EDT)	JP-Alice_Dylan	Google Search for 'how to kill your husband'	Web	JP-Alice_Dylan	Google Search

High Level Event Details

id: 22
min_date_time: Fri Jul 27 2012 16:50:36 GMT-0400 (EDT)
max_date_time: Fri Jul 27 2012 16:53:12 GMT-0400 (EDT)
evidence_source: JP-Alice_Dylan
description: File Access (/Windows/Hid/Cheat.pdf)
category: User Activity
device: JP-Alice_Dylan
type: File Access
summary:
keys(3):
- Drive_Letter:C:/
- Extension:.pdf
- Filename:Cheat.pdf

files(1):
- Windows/Hid/Cheat.pdf:
JP-Alice_Dylan_00000012.pdf

supporting(5):
- Link file created in Recent Folder

localhost:8000/data/JP-Alice_Dylan_00000012.pdf

Low Level Event Details

id: 225114
min_date_time: Fri Jul 27 2012 16:53:12 GMT-0400 (EDT)
max_date_time: Fri Jul 27 2012 16:53:12 GMT-0400 (EDT)
evidence: JP-Alice_Dylan
plugin: IExplorer Parser
type: URL Visit
path: file:///C:/Windows/Hid/Cheat.pdf

dataprov_source: /Users/Alice/AppData/Local/Microsoft/Windows/History/History.IE5/MSHist012012072720120728/index.dat
dataprov_type: offset
dataprov_value: 22016

Keys:
URL file:///C:/Windows/Hid/Cheat.pdf
Index_Type Daily
User Alice

Can show low-level events that occurred at a similar time

116	Fri Jul 27 2012 16:44:39 GMT-0400 (EDT)	Fri Jul 27 2012 16:44:45 GMT-0400 (EDT)	JP-Alice_Dylan	Web Visit to 'www.google.com'	Web Overview	JP-Alice_Dylan	Web Visit
117	Fri Jul 27 2012 16:44:46 GMT-0400 (EDT)	Fri Jul 27 2012 16:50:24 GMT-0400 (EDT)	JP-Alice_Dylan	Web Visit to 'get.adobe.com'	Web Overview	JP-Alice_Dylan	Web Visit
118	Fri Jul 27 2012 16:44:53 GMT-0400 (EDT)	Fri Jul 27 2012 16:44:53 GMT-0400 (EDT)	JP-Alice_Dylan	Web Visit to 'aihdownload.adobe.com'	Web Overview	JP-Alice_Dylan	Web Visit
75	Fri Jul 27 2012 16:45:11 GMT-0400 (EDT)	Fri Jul 27 2012 16:45:12 GMT-0400 (EDT)	JP-Alice_Dylan	Web Visit to '127.0.0.1:49180'	Web Overview	JP-Alice_Dylan	Web Visit
79	Fri Jul 27 2012 16:45:12 GMT-0400 (EDT)	Fri Jul 27 2012 16:45:12 GMT-0400 (EDT)	JP-Alice_Dylan	Web Visit to '127.0.0.1'	Web Overview	JP-Alice_Dylan	Web Visit
20	Fri Jul 27 2012 16:50:36 GMT-0400 (EDT)	Fri Jul 27 2012 16:51:11 GMT-0400 (EDT)	JP-Alice_Dylan	File Access (/Users/Alice/Desktop/Cheat.pdf)	User Activity	JP-Alice_Dylan	File Access
22	Fri Jul 27 2012 16:50:36 GMT-0400 (EDT)	Fri Jul 27 2012 16:53:12 GMT-0400 (EDT)	JP-Alice_Dylan	File Access (/Windows/Hid/Cheat.pdf)	User Activity	JP-Alice_Dylan	File Access
80	Fri Jul 27 2012 16:50:36 GMT-0400 (EDT)	Fri Jul 27 2012 16:50:36 GMT-0400 (EDT)	JP-Alice_Dylan	Web Visit to 'Computer'	Web Overview	JP-Alice_Dylan	Web Visit

files(1):
- Windows/Hid/Cheat.pdf:
JP-Alice_Dylan_00000012.pdf

supporting(5):
- Link file created in Recent Folder
(/Users/Alice/AppData/Roaming/Microsoft/Windows/Recent/Hid.lnk):
44932
Mounted File System|MFT Created
/Users/(.*?)/AppData/Roaming/Microsoft/Windows/Recent/((.*?)\.lnk)

- Recent from Index.dat (file:///C:/Windows/Hid/Cheat.pdf):
225114
IExplorer Parser URL Visit Windows/Hid/Cheat.pdf$

- Recent from Index.dat (file:///C:/Windows/Hid/Cheat.pdf):
225094
IExplorer Parser URL Visit file:///([A-z]{1}:/)(.+/(.+(\.[A-z]{3,4})))$

- Recent from Index.dat (file:///C:/Windows/Hid/Cheat.pdf):
225114
IExplorer Parser URL Visit file:///([A-z]{1}:/)(.+/(.+(\.[A-z]{3,4})))$

NT/CurrentVersion/Schedule/TaskCache/Tree/Microsoft/Windows Defender/MP Scheduled Scan","/Windows/System32/config/SOFTWARE","offset","11608096","Index=03000000","type=REG_DWORD","Id={E411FF2B-B998-4740-817F-643AC040E78C}",

"4436","1343422229.717599","1343422229.717599","JP-Alice_Dylan","MFT","Created","/Windows/System32/LogFiles/Scm/e411ff2b-b998-4740-817f-643ac040e78c","/$MFT","offset","1149952","IsDirectory=False","FileSize=0","MFT_record_number=1123","InUse=True",

"4437","1343422229.717599","1343422229.717599","JP-Alice_Dylan","MFT","Modified","/Windows/System32/LogFiles/Scm/e411ff2b-b998-4740-817f-643ac040e78c","/$MFT","offset","1149952","IsDirectory=False","FileSize=0","MFT_record_number=1123","InUse=True",

"4438","1343422229.717599","1343422229.717599","JP-Alice_Dylan","MFT","Entry Modified","/Windows/System32/LogFiles/Scm/e411ff2b-b998-4740-817f-643ac040e78c","/$MFT","offset","1149952","IsDirectory=False","FileSize=0","MFT_record_number=1123","InUse=True",

"4439","1343422229.717599","1343422229.717599","JP-Alice_Dylan","MFT","Accessed","/Windows/System32/LogFiles/Scm/e411ff2b-b998-4740-817f-643ac040e78c","/$MFT","offset","1149952","IsDirectory=False","FileSize=0","MFT_record_number=1123","InUse=True",

"65312","1343422231.948403","1343422231.948403","JP-Alice_Dylan","MFT","Modified","/Windows/Prefetch/AUDIODG.EXE-BDFD3029.pf","/$MFT","offset","16741376","IsDirectory=False","FileSize=0","MFT_record_number=16349","InUse=True",

Evaluation (1)

- Demonstrated as a feasible approach
- Provenance can be preserved
- Performance-wise ok, and can be improved
- Implementation:
  - Gaps in extractor scope (notably evtx)
  - Supporting and contradictory should be automatically added
  - Analyser scripts need some simplification

Evaluation (2)

- High-level event format is only loosely evaluated with useful examples
- Taxonomy of event types and categories

Future Work

- More extractors including importing from other tools
- More complex analysers
- Testing
- Parallel processing
- Cross-drive analysis
- Evaluation of high-level and low-level timelines
- Visualisations

Questions?

Dr Chris Hargreaves
Lecturer
Centre for Forensic Computing
Cranfield University
Defence Academy of the UK
Shrivenham, UK

c.j.hargreaves@cranfield.ac.uk

Jony Patterson
Research Fellow
Centre for Forensic Computing
Cranfield University
Defence Academy of the UK
Shrivenham, UK

j.patterson@cranfield.ac.uk