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HOW I MET YOUR BROWSER: GOING INCOGNITO DOESN'T HIDE YOUR BROWSING FROM RAGAMUFFIN

#OSDFCon

OSDFCON 2017 – HERNDON (VIRGINIA)

AGENDA

- Introduction
  - What is Chrome Ragamuffin
  - What Chrome Ragamuffin is not
  - Why Chrome Ragamuffin should be useful
  - Goal
  - Tools of the trade
- Forensic Overview
  - Chrom(e|ium) overview
  - Objects we have focused on
  - Case Study
  - Chrome Ragamuffin architecture
  - State of art
  - Work in progress and future works

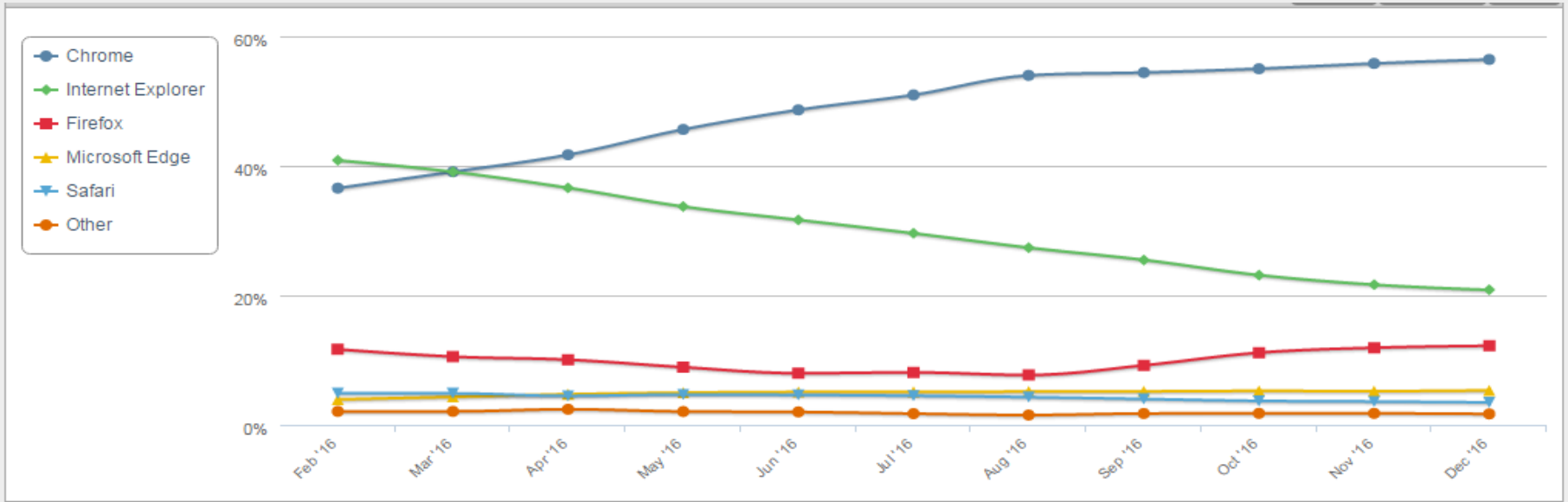
WHAT IS CHROME RAGAMUFFIN?

- Internal research project
- It is a memory forensics tool
- Three main functionalities:
  - Detailed overview about user navigation
  - Web page contents
  - Client-site attacks traces

WHAT CHROME RAGAMUFFIN IS NOT

- IDS/NIDS
- Browser extension
- Anti-virus
- SQLite databases analyzer

WHY CHROME RAGAMUFFIN SHOULD BE USEFUL



MONTH	CHROME	INTERNET EXPLORER	FIREFOX	MICROSOFT EDGE	SAFARI	OTHER
February, 2016	36.56%	40.85%	11.68%	3.94%	4.88%	2.08%
March, 2016	39.09%	39.10%	10.54%	4.32%	4.87%	2.09%
April, 2016	41.71%	36.61%	10.06%	4.73%	4.47%	2.42%
May, 2016	45.63%	33.71%	8.91%	4.99%	4.69%	2.07%
June, 2016	48.65%	31.65%	7.98%	5.09%	4.64%	1.99%
July, 2016	50.95%	29.60%	8.12%	5.09%	4.51%	1.73%
August, 2016	53.97%	27.38%	7.69%	5.16%	4.28%	1.51%
September, 2016	54.41%	25.48%	9.19%	5.16%	4.00%	1.75%
October, 2016	54.99%	23.13%	11.14%	5.26%	3.69%	1.79%
November, 2016	55.83%	21.66%	11.91%	5.21%	3.61%	1.78%
December, 2016	56.43%	20.84%	12.22%	5.33%	3.47%	1.70%

- Most used browser
- We hadn't tools to analyze web browser internals
- It can **find** a lot of **new artifacts**

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TOOLS OF THE TRADE

- Source code analysis

- Debugging and data structures analysis

- Data structures extraction

- to implement the Proof of Concept

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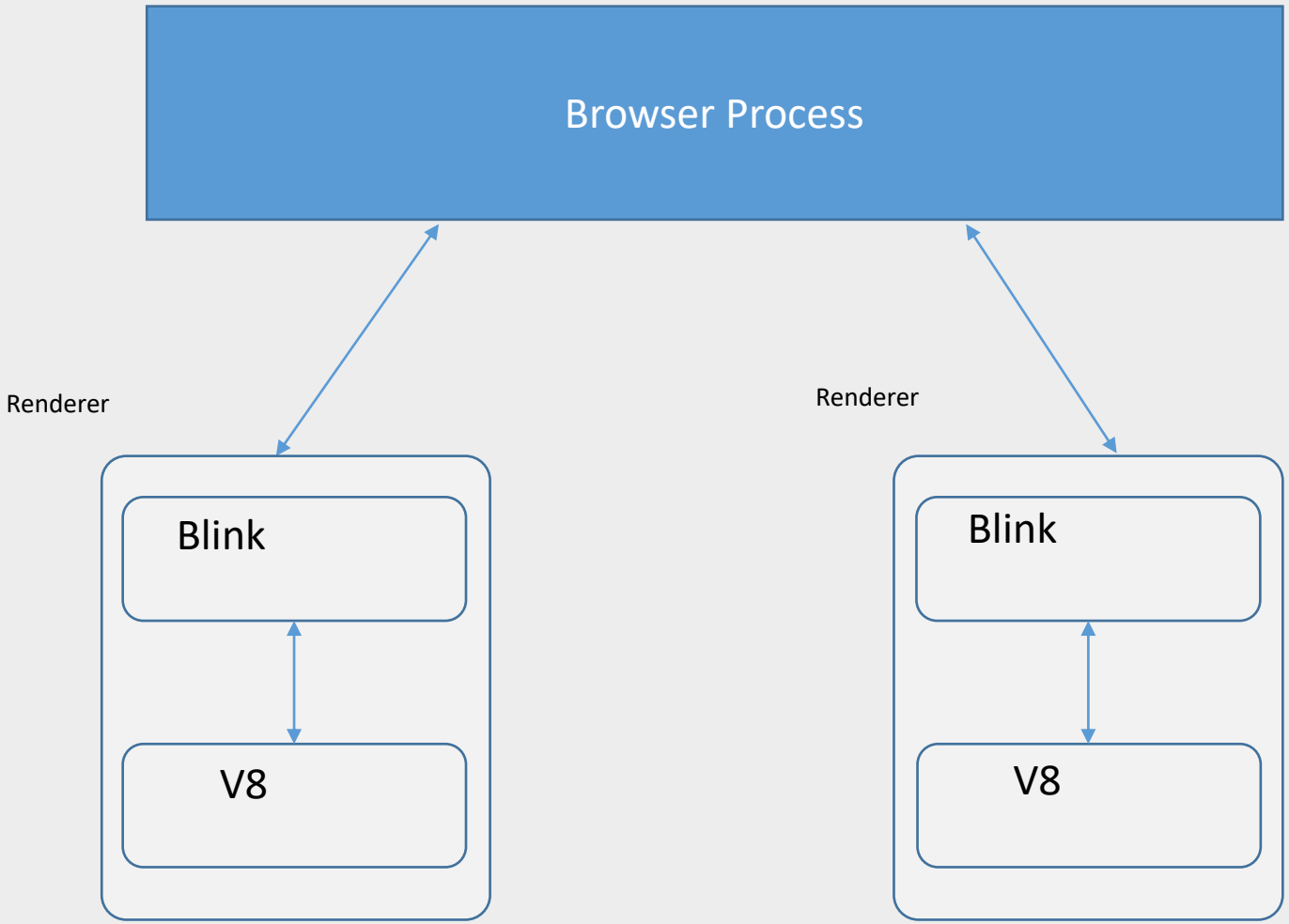
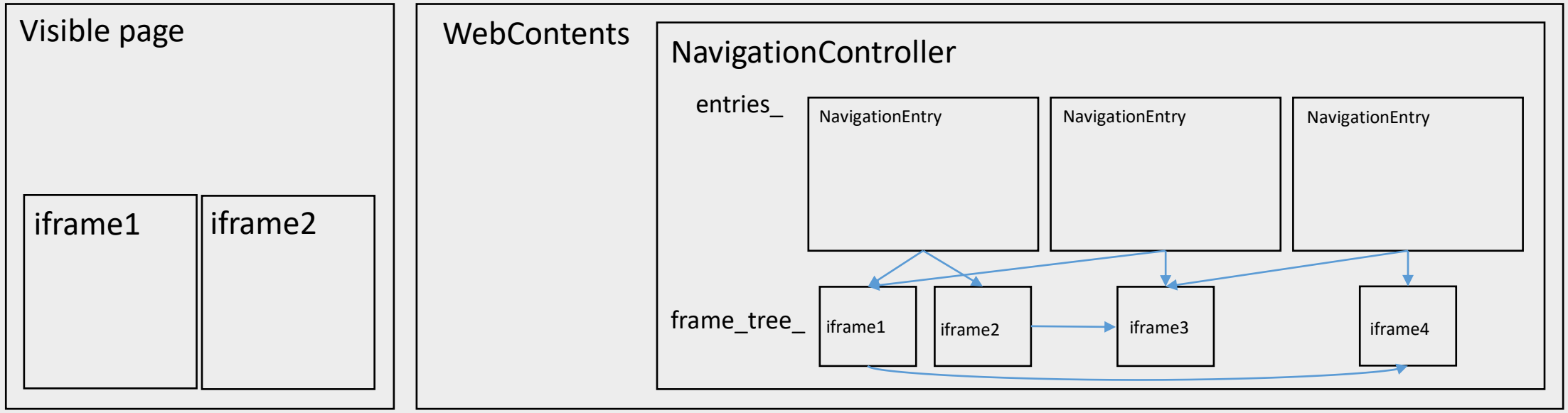
FORENSIC OVERVIEW

GOOGLE CHROME OVERVIEW



OBJECTS WE HAVE FOCUSED ON

Browser process



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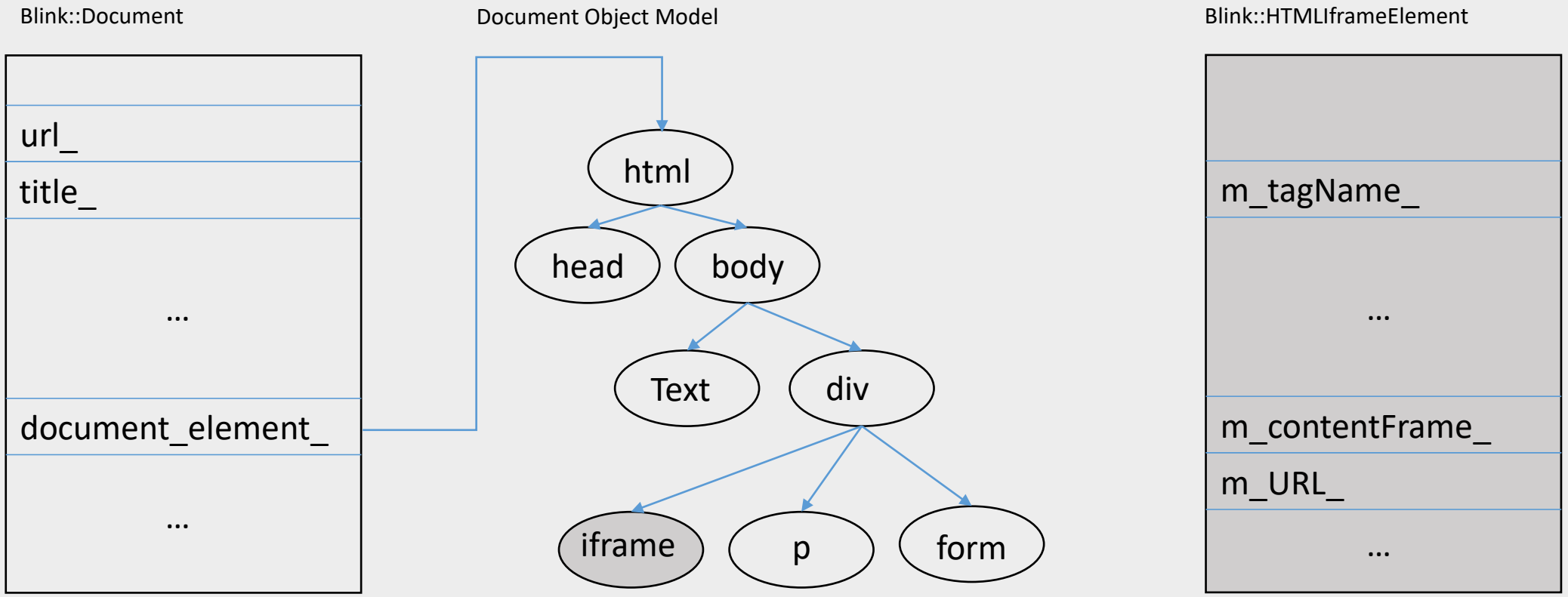
OBJECTS WE HAVE FOCUSED ON

Renderer process



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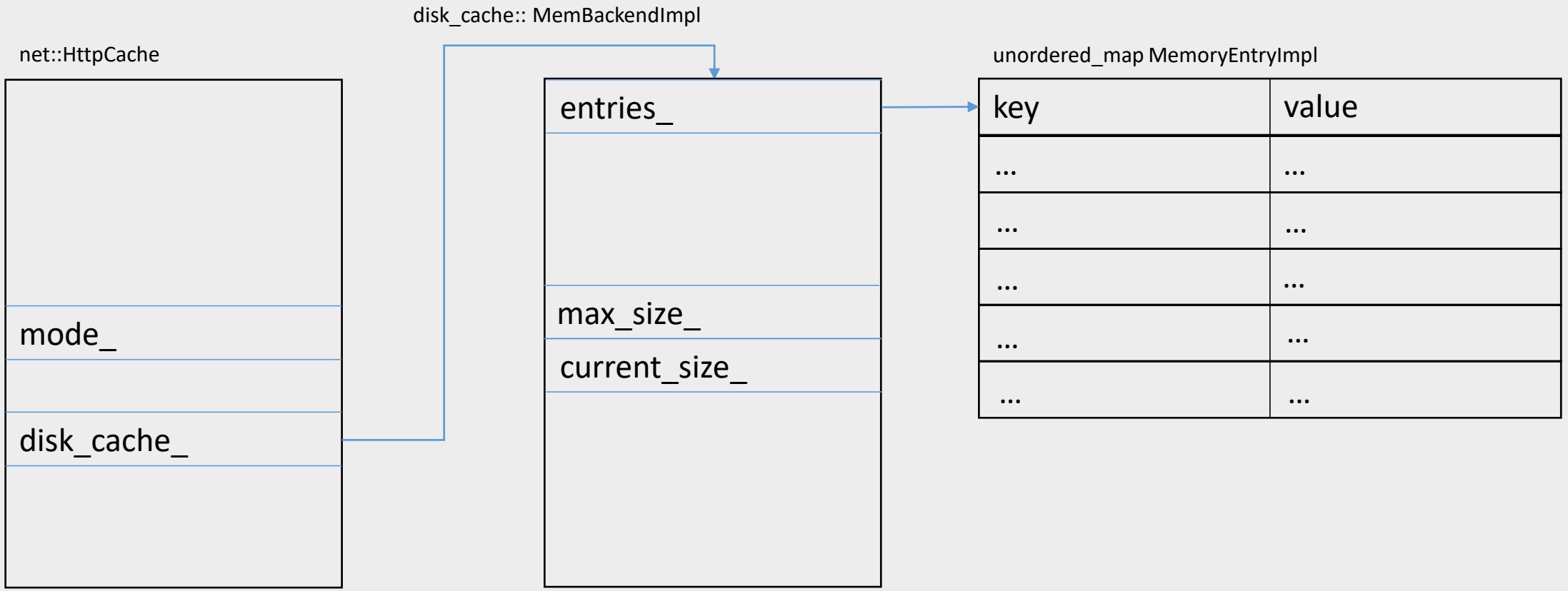
OBJECTS WE HAVE FOCUSED ON

Browser process



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OBJECTS WE HAVE FOCUSED ON
Example 1

Browser objects:

- Evidence: offset object, url, status code, method, transition, timestamp, restore type, page type, **form params**

ID	Offset	Title	User typed url	Original request url	Status code	Method	PageState address	Transition	Referer	UTC Timestamp	Restore Type	Page type
5	2.5719 1E+12	None	**http://192.168.0.11 /example1.html**	http://192.168.0.11 /example1.html	200	GET	None	**User used the address bar to trigger this navigation**	None	10/1/2017 16:12	Entry was not restored	NORMAL
5	2.5719 1E+12	frame_entry_ object	http://192.168.0.11/ **iframe1**.html	http://192.168.0.11 /iframe1.html	None	GET	None	None	**http://192.168.0.11/example1.html**	10/1/2017 16:12	None	**<!--framePath //<!--frame0-->-->**
5	2.5719 1E+12	frame_entry_ object	http://192.168.0.11/ **iframe2**.html	http://192.168.0.11 /iframe2.html	None	GET	None	None	**http://192.168.0.11/example1.html**	10/1/2017 16:12	None	**<!--framePath //<!--frame1-->-->**
7	2.5718 8E+12	frame_entry_ object	http://192.168.0.11/ iframe3.html	http://192.168.0.11 /iframe2.html	None	GET	None	None	http://192.168.0.11/iframe1.html	10/1/2017 16:12	None	<!--framePath //<!--frame0-->-->
8	2.5719 E+12	frame_entry_ object	http://192.168.0.11/ iframe3.html	http://192.168.0.11 /iframe3.html	None	GET	None	None	http://192.168.0.11/iframe2.html	10/1/2017 16:12	None	<!--framePath //<!--frame1-->-->

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OBJECTS WE HAVE FOCUSED ON
Example 1

Renderer objects:

- Evidence: PID of the **tab** which **contains** the **specific document**, document **offset**, **URL** of the document, **title**, **<html>** node address of the DOM tree

```
✘ cubo@cubo /run/media/cubo/7E8B39162F6BE7AA/dump vol.py --plugins $SECURITY/tools/volatility/plugins/chrome_ragamuffin -f example1.vmem --profile Win10
x64_14393 chrome_ragamuffin --analysis renderer -p 4088
Volatility Foundation Volatility Framework 2.6
Pid      Document offset      URL                                                Title                                              DOM start address
-------- -------------------- -------------------------------------------------- -------------------------------------------------- ------------------
    4088 0x3e7ca5a25c0        http://192.168.0.11/example1.html                  PROVA                                              0x3e7ca5a3210
    4088 0x3e7ca5a9220        http://192.168.0.11/iframe3.html                   404 Not Found                                      0x3e7ca5a9ed0
    4088 0x3e7ca5aa588        http://192.168.0.11/iframe3.html                   404 Not Found                                      0x3e7ca5ab238
cubo@cubo /run/media/cubo/7E8B39162F6BE7AA/dump
```

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OBJECTS WE HAVE FOCUSED ON
Example 1

Renderer objects:

Evidence: By the "**DOM start address**" field we can **get** the entire **Document Object Model tree** in its **dot** (**high-level** structure of the page) and **text** notation (**detailed** contents)

Node tag: iframe
Node attributes: {'src': 'iframe1.html'}
Memory offset: 0x3e7ca5a3650
Contained document offset: 0x3e7ca5aa588

Node tag: iframe
Node attributes: {'src': 'iframe2.html'}
Memory offset: 0x3e7ca5a4570
Contained document offset: 0x3e7ca5a9220

OBJECTS WE HAVE FOCUSED ON
Cross-Site Request Forgery

Browser objects:

- Evidence: offset object, url, status code, method, transition, timestamp, restore type, page type, **form params**

Entry ID	Offset	Title	User typed url	Original request url	Status code	Method	PageState address	Transition	Referer	UTC Timestamp	Restore type	Page type
2	0x192d2a03c60	None	http://192.168.1.124/notexists.html	http://192.168.1.124/notexists.html	0	GET	None	Typed URL in the address bar	None	18/09/17 14.50	**Entry was not restored**	**ERROR**
3	0x192d2a02900	Test	http://192.168.1.124/index.html	http://192.168.1.124/index.html	200	GET	None	Typed URL in the address bar	None	18/09/17 14.50	Entry was not restored	**NORMAL**
3	0x192D2508540	None	http://192.168.1.124/changepassword.php	http://192.168.1.124/changepassword.php	None	**POST**	**0x192D64A2EE0**	None	http://192.168.1.124/hghrueguoeir.html	19/09/17 14.50	None	**<!--framePath //<!--frame0--->**

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OBJECTS WE HAVE FOCUSED ON
Cross-Site Request Forgery

POST Params:

- With the memory address, we can dump the **PageState** object which contains **serialized information** about the **submitted form**

```
In [18]: i.dump_page_state()
Out[18]: '\xac\x01..\x19.......N...h.t.t.p.:./.1.9.2...1.6.8...1...1.2.4./.c.h.a.n.g.e.p.a.s.s.w.o.r.d...p.h.p...@.
..<.!.-.-.f.r.a.m.e.P.a.t.h. ./.<.!.-.-.f.r.a.m.e.0.-.-.>.-.-.>.....L...h.t.t.p.:./.1.9.2...1.6.8...1...1.2.4./.h
.g.h.r.u.e.g.u.o.e.i.r...h.t.m.l.....\xab\x02\x07\x85\xafY\x05.\xac\x02\x07\x85\xafY\x05.\x02..........\x01...\x01..
.....-...new_username=username&new_password=qwerty1345...\x0e\xb8\x07\x85\xafY\x05.....B...a.p.p.l.i.c.a.t.i.o.n./.x.
-.w.w.w.-.f.o.r.m.-.u.r.l.e.n.c.o.d.e.d.......'

In [19]:
```

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OBJECTS WE HAVE FOCUSED ON
Cross-Site Request Forgery

Renderer objects:

- Evidence: PID of the **tab** which **contains** the **specific document**, document **offset**, **URL** of the document, **title**, **<html>** node address of the DOM tree

```
cube@trallallino ~/security/tools/ragamuffin/dump develop ● vol.py --plugins ~/security/tools/volatility/plugins/chrome_ragamuffin -f windows_csrf.
vmem --profile Win10x64_14393 chrome_ragamuffin --analysis renderer
Volatility Foundation Volatility Framework 2.6
Pid      Document offset      URL                                                Title                                              DOM start address
-------- -------------------- -------------------------------------------------- -------------------------------------------------- ------------------
    4916 0x11dad2f8380        https://www.google.it/_/.../newtab?espv=2&ie=UTF-8 None                                               0x11dad2f9030
    4916 0x11dad4025c0        chrome-search://most-vis...%20su%20questa%20pagina None                                               0x11dad403270
    2212 0x3416fde25c0        chrome://apps/                                     Nuova scheda                                       0x3416fde3270
    3268 0x31da1fe25c0        https://it-it.facebook.com/                        Facebook: accedi o iscriviti                       0x31da1fe3270
    3268 0x31da21101e8        https://staticxx.faceboo...ommon/referer_frame.php None                                               0x31da2110e98
    5416 0x1e1842825c0        chrome://settings/                                 Impostazioni                                       0x1e184283270
    5416 0x1e184327ab8        about:blank                                        None                                               0x1e1843286d8
    5416 0x1e184329680        about:blank                                        None                                               0x1e18432a2a0
    5416 0x1e18432b248        about:blank                                        None                                               0x1e18432be68
    3212 0x216b1d41838        None                                               None                                               0x216b1d42488
    3212 0x216b1d425c0        http://192.168.1.124/index.html                    PROVA                                              0x216b1d43210
```

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OBJECTS WE HAVE FOCUSED ON
what do we get from those?

Renderer objects:

Evidence: By the "**DOM start address**" field we can **get** the entire **Document Object Model tree** in its **dot** (**high-level** structure of the page) and **text** notation (**detailed** contents)

Node tag: iframe
Node attributes: {'src': **'hghrueguoeir.html**', 'style': **'display: none**;'}
Memory offset: 0x216b1d43650
Contained document offset: 0x216b1d41838

- Node tag: html
Node attributes: {lang=it}
Memory offset: 0x2669a62b8b8
- Node **tag**: head
Node attributes: {}
Memory offset: 0x2669a62b920
- Node tag: body
Node **attributes**: {class=test, id=123}
Memory offset: 0x2669a62b988
- Node tag: h1
Node attributes: {id=title}
Memory offset: 0x2669a62b9f0
- Node tag: **Text**
Content: **You've successfully changed your password**

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CHROME RAGAMUFFIN ARCHITECTURE

Implemented in two parts:

1. *libchrome_$release.py* library
   - **VTypes**
   - **WTF::StringImpl, Vector** objects and other **platform-specific data types**
2. *chrome_ragamuffin.py* plugin
   - This is the **main plugin**.
   - **signatures**, **validation,** render the **output**

STATE OF ART

Other tools

- WebCapsule/ChromePic
  - **Instrumentation** of the web browser source code
  - Records and Replay **key logger**

- Chrome History (@superponible)
  - **SQLite databases** in memory (visited pages, cookies, search terms ecc.)
  - SQLite databases are **saved on disk**

STATE OF ART

Chrome Ragamuffin

- Pro
  - Agnostic approach
  - Whole address space (a lot of new artifacts)
  - Overcoming incognito mode

STATE OF ART

Chrome Ragamuffin

- Limitations
  - Garbage Collector (Olipan, Scavenger ecc.) **collects** unused **objects**

WORK IN PROGRESS

- ⏳ HTTP cached Response Body (Work in progress)
- ⏳ V8 (for now, Isolate, Heap, Spaces, Page Memories) (Almost-Work-in-progress)
- ⏳ Automatic VTypes extraction
- ⏳ Linux/macOSx support

THANKS

- Join the project on github! Search for *cube0x8 (“cube” “zero” “x” “eight”) (https://github.com/cube0x8/chrome_ragamuffin)*
- Email: **alessandro.devito@truel.it**

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