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Where do security bugs come from?

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- **Security Consultant, iSEC Partners**
- **(Research) Badass**

Agenda

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- What is a security bug?
- Who is looking for security bugs?
- Trust relationships
- Sample of bugs found in the wild
- Operation Aurora
- Stuxnet
- I'm in love with security; whatever shall I do?

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What is a Security Bug?

- What is security?
- Class participation: Tacos, Salsa, and Avocados (TSA)

What is security?

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"A system is secure if it behaves precisely in the manner intended – and does nothing more" – Ivan Arce

- Who knows exactly what a system is intended to do? Systems are getting more and more complex.
- What types of attacks are possible?

First steps in security: define your security model and your threat model

Threat modeling: T.S.A.

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- Logan International Airport security goal #3: prevent banned substances from entering Logan
- Class Participation: What is the threat model?
  - What are possible avenues for getting a banned substance into Logan?
  - Where are the points of entry?
- Threat modeling is also critical, you have to know what you're up against (many engineers don't)

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Who looks for security bugs?

- Engineers
- Criminals
- Security Researchers
- Pen Testers
- Governments
- Hacktivists
- Academics

Engineers (create and find bugs)

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- Goals:
  - Find as many flaws as possible
  - Reduce incidence of exploitation
- Thoroughness:
  - Need coverage metrics
  - At least find low-hanging fruit
- Access:
  - Source code, debug environments, engineers
  - Money for tools and staff

Engineering challenges

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- People care about features, not security (until something goes wrong)
- Engineers typically only see a small piece of the puzzle
- "OMG PDF WTF" (Julia Wolf, 2010)
  - How many lines of code in Linux 2.6.32?
  - How many lines in Windows NT 4?
  - How many in Adobe Acrobat?

Engineering challenges

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- People care about features, not security (until something goes wrong)
- Engineers typically only see a small piece of the puzzle
- "OMG PDF WTF" (Julia Wolf, 2010)
  - How many lines of code in Linux 2.6.32?
    - 8 – 12.6 million
  - How many lines in Windows NT 4?
    - 11-12 million
  - How many in Adobe Acrobat?
    - 15 million

Criminals

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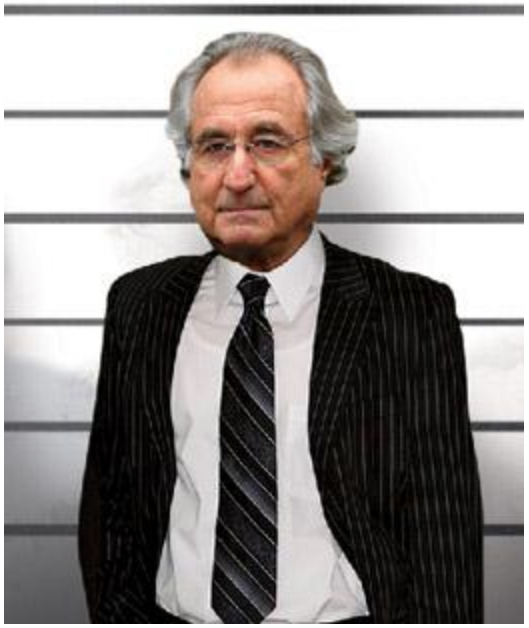
- Goals:
  - Money (botnets, CC#s, blackmail)
  - Stay out of jail
- Thoroughness:
  - Reliable exploits
  - Don't need 0-days (but they sure are nice)
- Access:
  - Money
  - Blackbox testing



Security Researchers

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- Goals:
  - Column inches from press, props from friends
  - Preferably in a trendy platform
- Thoroughness:
  - Don't need to be perfect, don't want to be embarrassed
- Access:
  - Casual access to engineers
  - Source == Lawyers

Pen Testers

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- Goals:
  - Making clients and users safer
  - Finding vulns criminals would use
- Thoroughness:
  - Need coverage
  - Find low-hanging fruit
  - Find high impact vulnerabilities
  - Don't fix or fully exploit
- Access:
  - Access to Engineers
  - Access to Source
  - Permission

Governments

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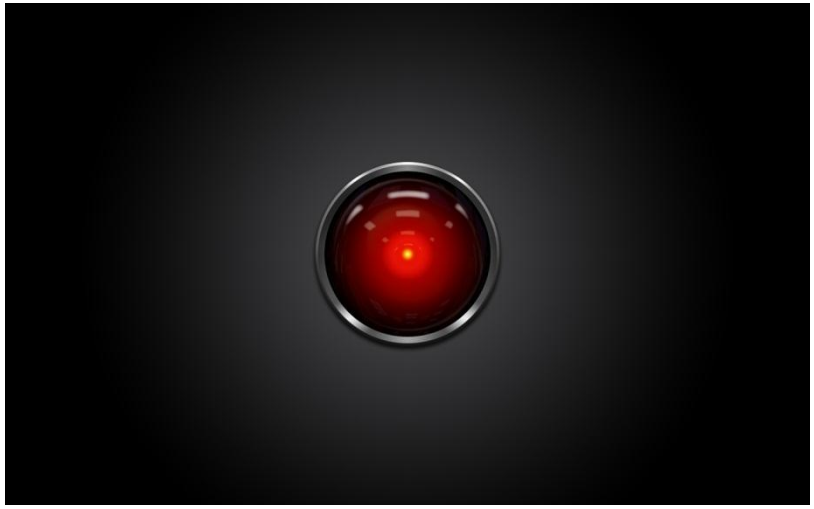
- Goals:
  - Attack/espionage
  - Defend
- Thoroughness:
  - Reliable exploits
- Access:
  - Money
  - Talent
  - Time



Hacktivists

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- Goals:
  - Doing something "good"
  - Stay out of jail
- Thoroughness:
  - Reliable exploits
  - Don't need o-days
- Access:
  - Talent
  - Plentiful targets

Academics

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- Goals:
  - Finding common flaws and other general problems
  - Developing new crypto
  - Make something cool and useful
  - Make everyone safer
- Thoroughness:
  - Depth in area of research
- Access:
  - Creating new things
  - Blackbox

Techniques

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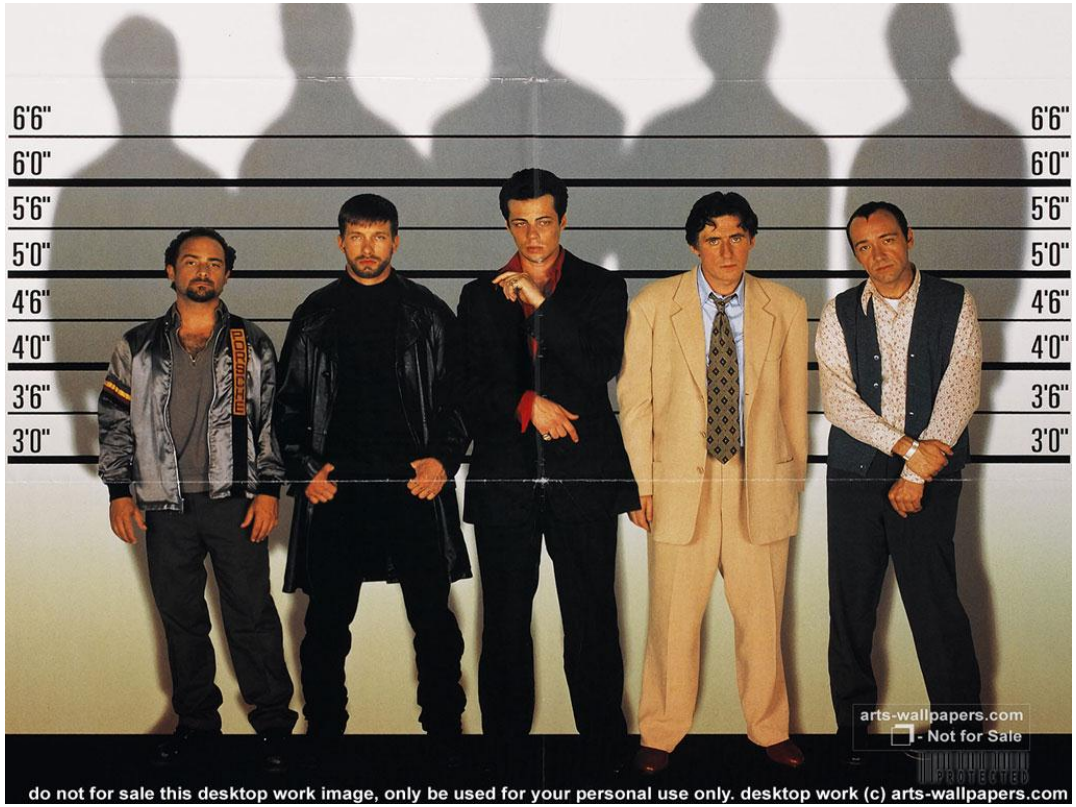
- With access:
  - Source code review
  - Engineer interviews
  - Testing in a controlled environment
- Without access:
  - Blackbox testing
  - Fuzzing (give weird inputs, see what happens)
  - Reverse Engineering
  - Social Engineering

Overall Goals

- All are looking for the similar things: vulnerable systems
- Let's dive in and look at vulns that we all look for



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Bad Engineering Assumptions

Therac-25 (the engineer)

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- Two modes of operation: image and radiation treatment
- Intended invariant: in radiation treatment mode, a protective focusing shield must be in place

Therac-25

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Shield code was something like:

```
//global persistent variable, single byte value
ub1  protectiveShield; //zero if shield isn't needed
…
//do we need a shield?
if(treatmentMode) then
{
        protectiveShield++;
} else {
        protectiveShield = 0;
}
…
if(protectiveShield) {
        putShieldInPlace();
} else {
        removeShield();
}
```

Therac-25

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- Flawed assumption: protectiveShield would always be non-zero in treatment mode
- Impact: people actually died

Therac-25

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- Flawed assumption: protectiveShield would always be non-zero in treatment mode
- Impact: people actually died
- My classmate's conclusion: "I learned to never write medical software"

Designing Systems

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Think like a security researcher:

- What assumptions are being made?
- Which assumptions are wrong?
- What can you break if the assumption is wrong?

The Confused Deputy

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- Tricking an authority into letting you do something you shouldn't be able to do
- Most security problems could fall under this broad definition

The Confused Deputy

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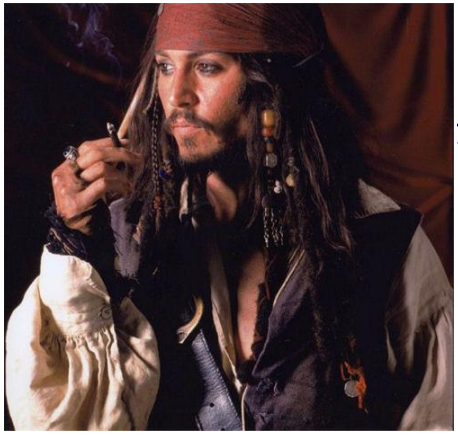
"How to Shop for Free Online"* (security researcher and academic)

- Three-party payment systems (Cashier as a Service):
  - Merchant (seller)
  - Payment provider
  - ~~Cheater~~ User
- Communication between parties go through the user

* http://research.microsoft.com/pubs/145858/caas-oakland-final.pdf

The Confused Deputy



0: I'd like to buy Book

1: Pay my CaaS $10, TxID: 123

6: I'm done!

7: I'll send Book!

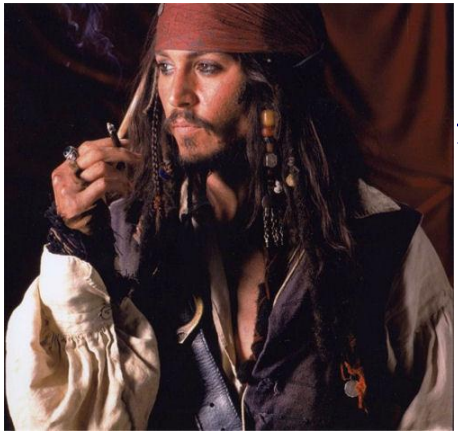
2: Here is $10 for TxID: 123

3: TxID: 123 has been paid for

4: OK

5: Transaction complete

The Confused Deputy



0: I'd like to buy Book

1: Pay my CaaS $10, TxID: 123

6: I'm done!

7: I'll send Book!

2: Here is $1 for TxID: 123

3: TxID: 123 has been paid for

4: OK

5: Transaction complete

The Confused Deputy

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- The merchant thinks something ties the payment amount to the transaction
- Impact: shopping for free
- Solutions?
- Read the paper, lots of things can and do go wrong

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Sample of bugs found in the wild

CRIME

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```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

username=tom&password=hunter2
```

Stack

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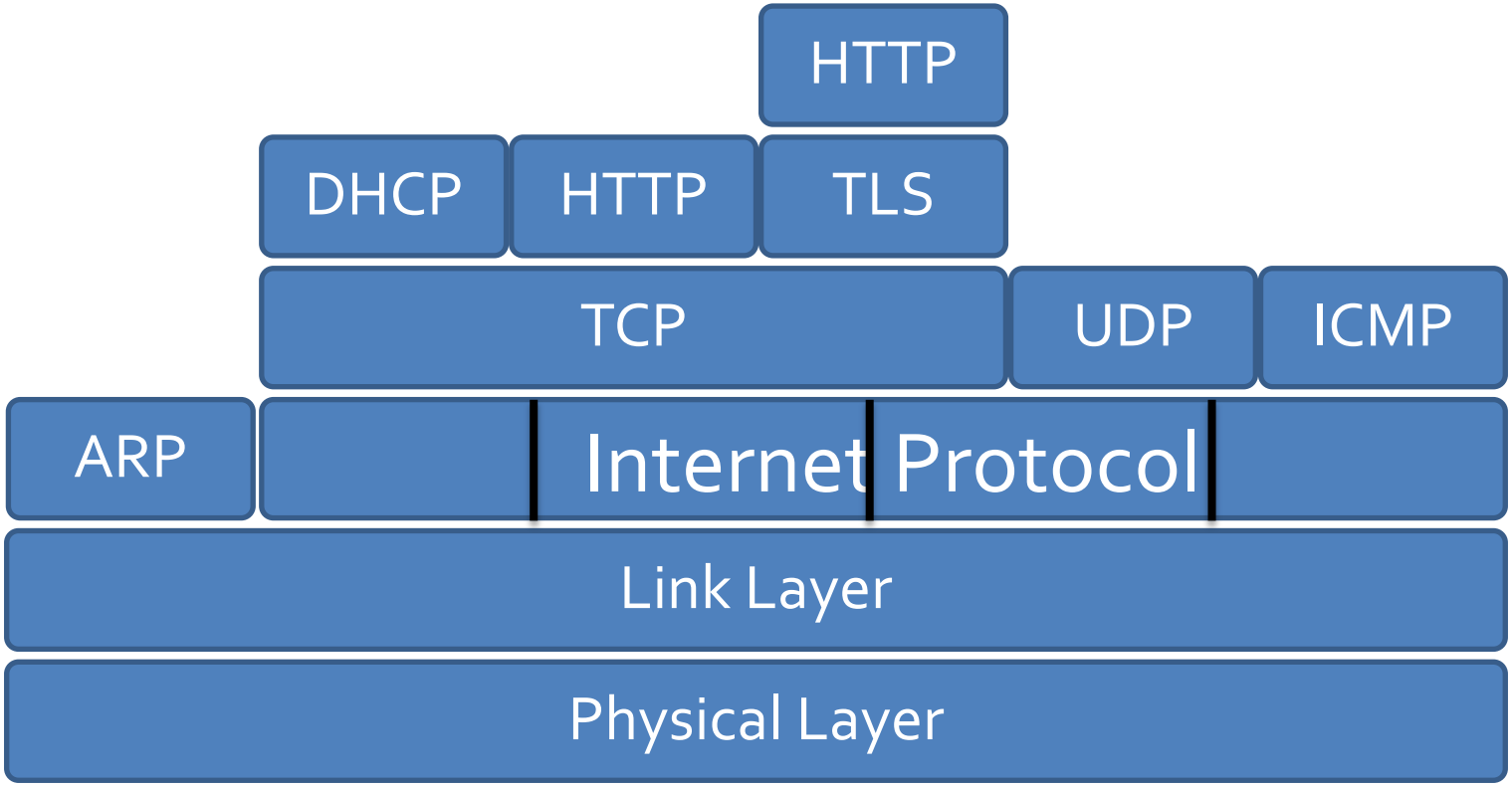

Stack

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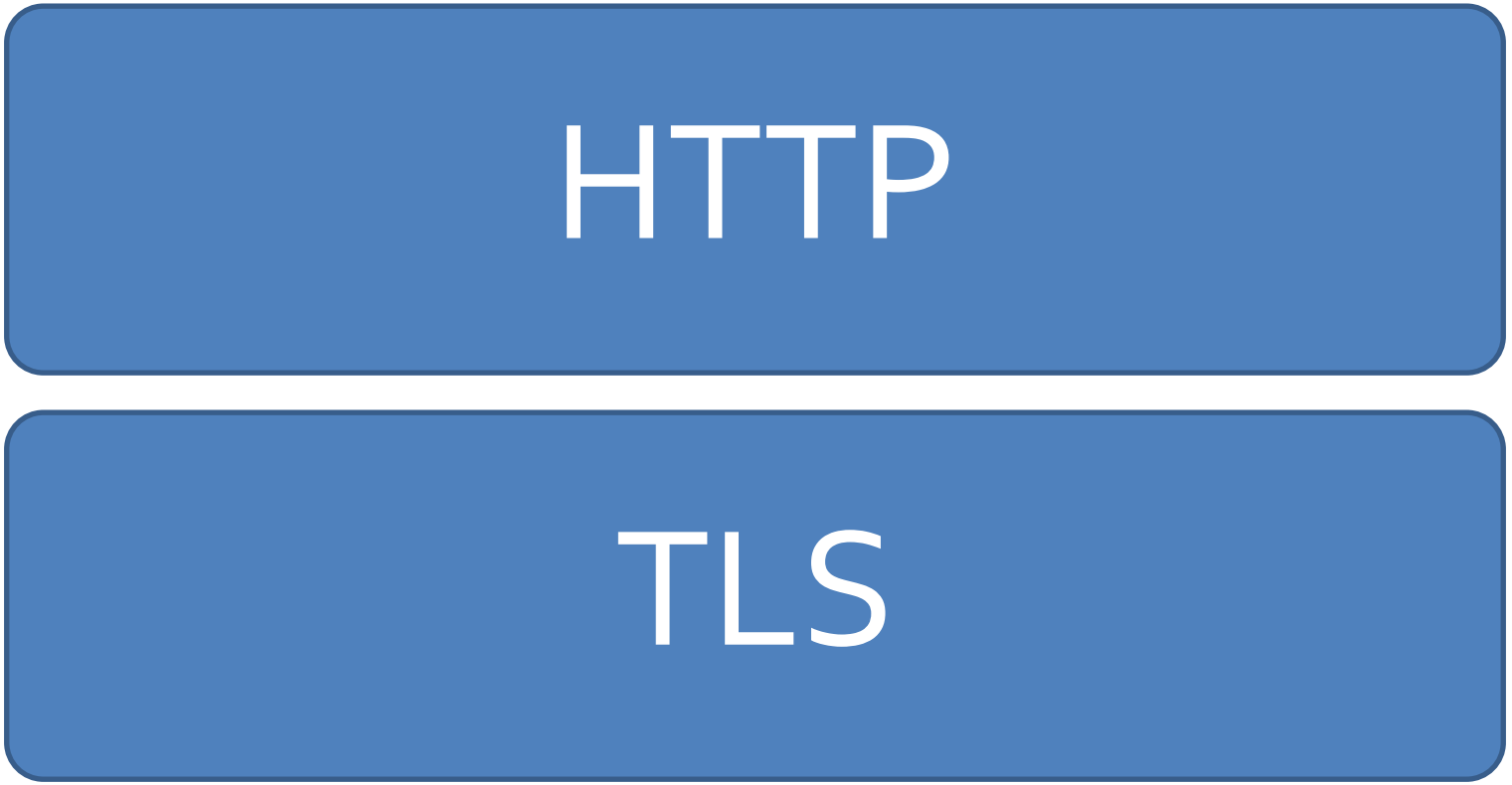
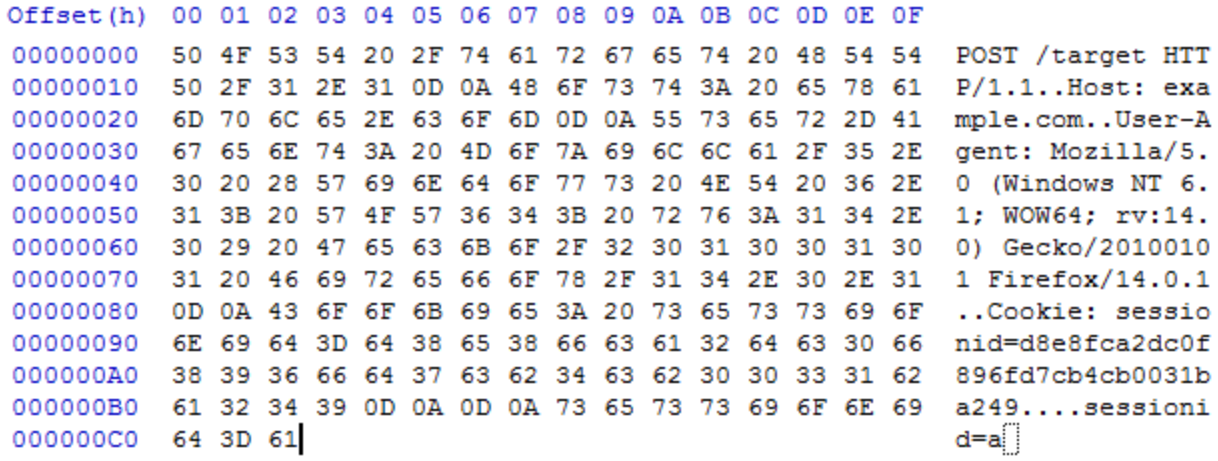


HTTP



```
Offset(h)  00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

00000000   50 4F 53 54 20 2F 74 61 72 67 65 74 20 48 54 54  POST /target HTT
00000010   50 2F 31 2E 31 0D 0A 48 6F 73 74 3A 20 65 78 61  P/1.1..Host: exa
00000020   6D 70 6C 65 2E 63 6F 6D 0D 0A 55 73 65 72 2D 41  mple.com..User-A
00000030   67 65 6E 74 3A 20 4D 6F 7A 69 6C 6C 61 2F 35 2E  gent: Mozilla/5.
00000040   30 20 28 57 69 6E 64 6F 77 73 20 4E 54 20 36 2E  0 (Windows NT 6.
00000050   31 3B 20 57 4F 57 36 34 3B 20 72 76 3A 31 34 2E  1; WOW64; rv:14.
00000060   30 29 20 47 65 63 6B 6F 2F 32 30 31 30 30 31 30  0) Gecko/2010010
00000070   31 20 46 69 72 65 66 6F 78 2F 31 34 2E 30 2E 31  1 Firefox/14.0.1
00000080   0D 0A 43 6F 6F 6B 69 65 3A 20 73 65 73 73 69 6F  ..Cookie: sessio
00000090   6E 69 64 3D 64 38 65 38 66 63 61 32 64 63 30 66  nid=d8e8fca2dc0f
000000A0   38 39 36 66 64 37 63 62 34 63 62 30 30 33 31 62  896fd7cb4cb0031b
000000B0   61 32 34 39 0D 0A 0D 0A 73 65 73 73 69 6F 6E 69  a249....sessioni
000000C0   64 3D 61                                        d=a
```

SSL

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349	74.125.227.62	192.168.24.100	TLSv1	296	Encrypted Handshake Message, Change
350	192.168.24.100	97.107.139.108	TLSv1	720	Application Data, Application Data
351	74.125.227.62	192.168.24.100	TLSv1	107	Application Data
354	97.107.139.108	192.168.24.100	TLSv1	1506	Application Data, Application Data
355	74.125.227.62	192.168.24.100	TLSv1	283	Application Data
356	97.107.139.108	192.168.24.100	TLSv1	110	Application Data, Application Data
358	192.168.24.100	97.107.139.108	TLSv1	720	Application Data, Application Data
359	74.125.227.62	192.168.24.100	TLSv1	122	Application Data
361	97.107.139.108	192.168.24.100	TLSv1	1506	Application Data, Application Data
362	97.107.139.108	192.168.24.100	TLSv1	110	Application Data, Application Data

Time

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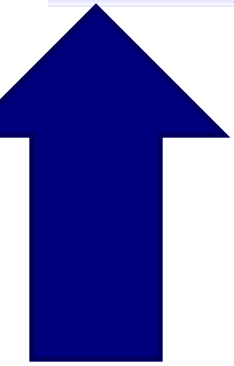
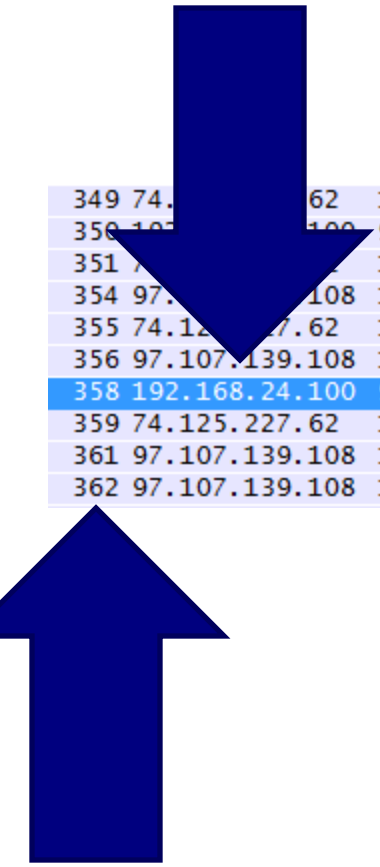
349	74.125.227.62	192.168.24.100	TLSv1	296	Encrypted Handshake Message, Change
350	192.168.24.100	97.107.139.108	TLSv1	720	Application Data, Application Data
351	74.125.227.62	192.168.24.100	TLSv1	107	Application Data
354	97.107.139.108	192.168.24.100	TLSv1	1506	Application Data, Application Data
355	74.125.227.62	192.168.24.100	TLSv1	283	Application Data
356	97.107.139.108	192.168.24.100	TLSv1	110	Application Data, Application Data
358	192.168.24.100	97.107.139.108	TLSv1	720	Application Data, Application Data
359	74.125.227.62	192.168.24.100	TLSv1	122	Application Data
361	97.107.139.108	192.168.24.100	TLSv1	1506	Application Data, Application Data
362	97.107.139.108	192.168.24.100	TLSv1	110	Application Data, Application Data



From



349	74.	62	192.168.24.100	TLSv1	296 Encrypted Handshake Message, Change
350	192.	100	97.107.139.108	TLSv1	720 Application Data, Application Data
351	7		192.168.24.100	TLSv1	107 Application Data
354	97.	108	192.168.24.100	TLSv1	1506 Application Data, Application Data
355	74.12	7.62	192.168.24.100	TLSv1	283 Application Data
356	97.107.139.108		192.168.24.100	TLSv1	110 Application Data, Application Data
358	192.168.24.100		97.107.139.108	TLSv1	720 Application Data, Application Data
359	74.125.227.62		192.168.24.100	TLSv1	122 Application Data
361	97.107.139.108		192.168.24.100	TLSv1	1506 Application Data, Application Data
362	97.107.139.108		192.168.24.100	TLSv1	110 Application Data, Application Data

To

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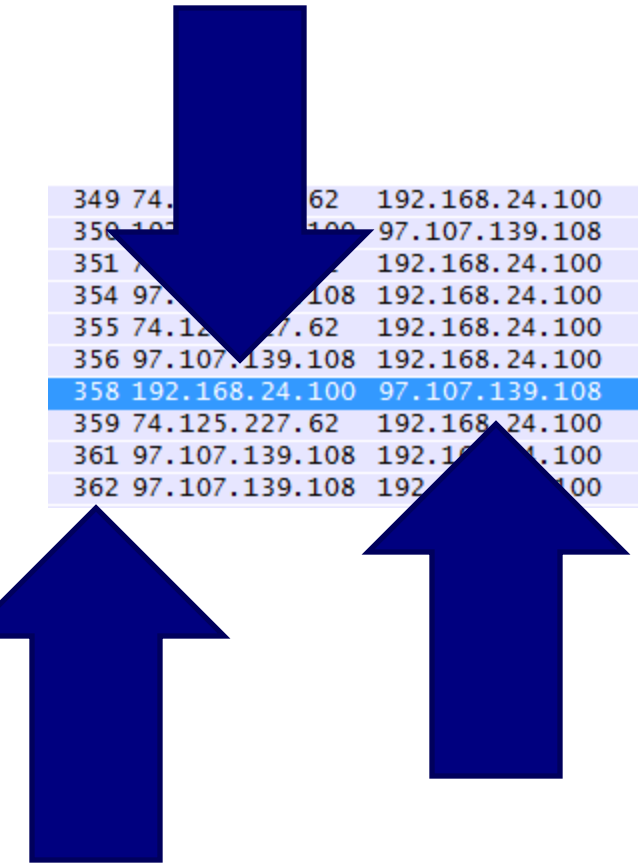
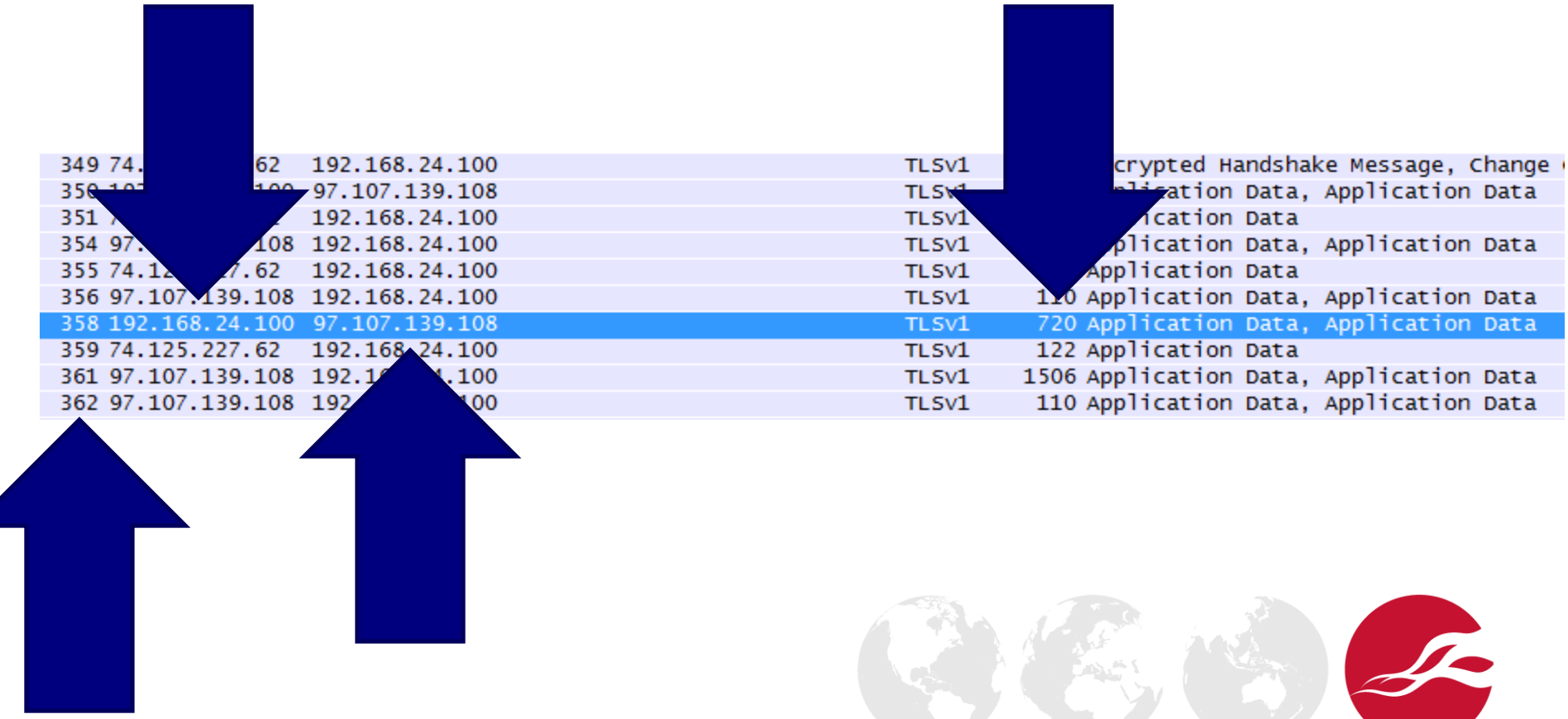
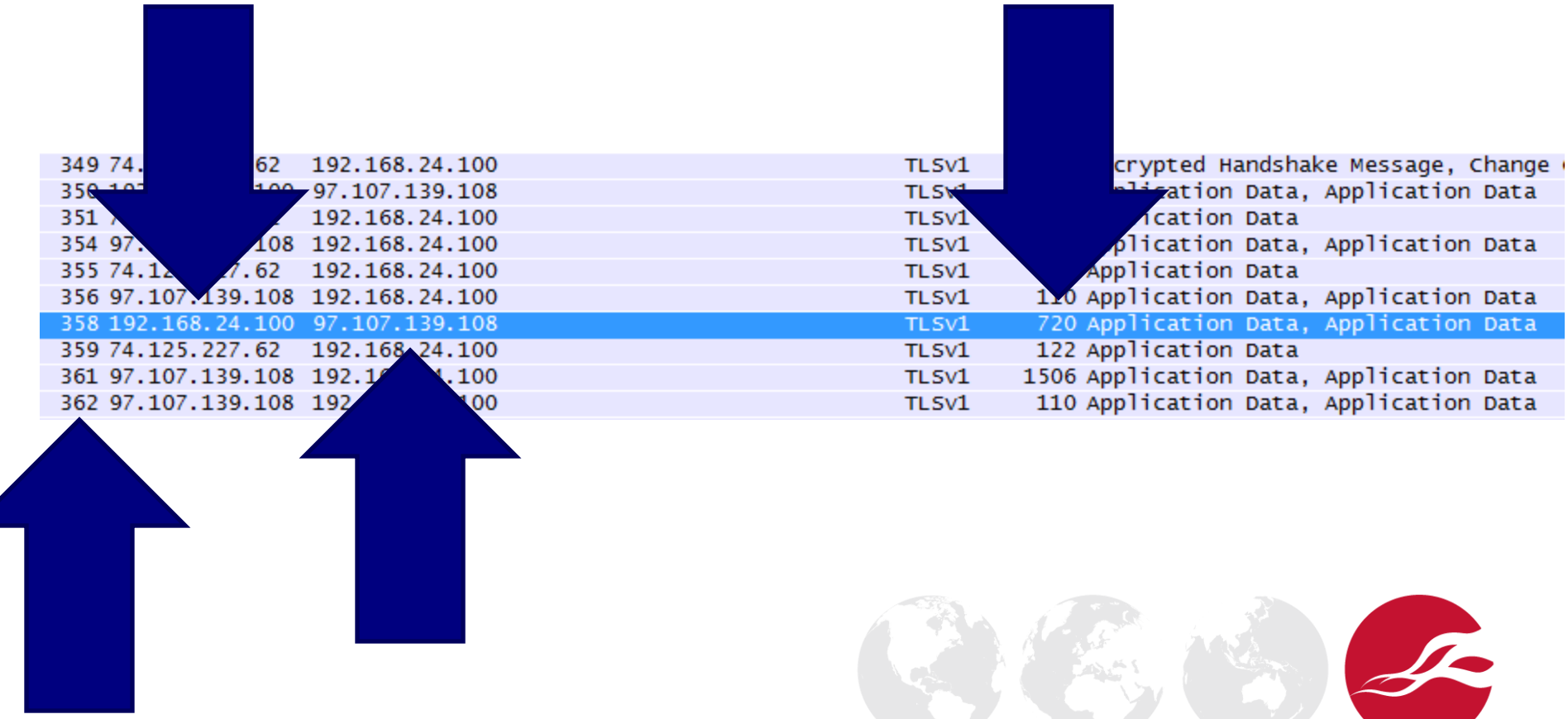


349	74.	62	192.168.24.100	TLSv1	296 Encrypted Handshake Message, Change
350	10	100	97.107.139.108	TLSv1	720 Application Data, Application Data
351	7		192.168.24.100	TLSv1	107 Application Data
354	97.	108	192.168.24.100	TLSv1	1506 Application Data, Application Data
355	74.12	7.62	192.168.24.100	TLSv1	283 Application Data
356	97.107.139.108		192.168.24.100	TLSv1	110 Application Data, Application Data
358	192.168.24.100		97.107.139.108	TLSv1	720 Application Data, Application Data
359	74.125.227.62		192.168.24.100	TLSv1	122 Application Data
361	97.107.139.108		192.1	4.100	TLSv1 1506 Application Data, Application Data
362	97.107.139.108		192	100	TLSv1 110 Application Data, Application Data

Length


349 74. 62 192.168.24.100 TLSv1 crypted Handshake Message, Change
350 97.107.139.108 TLSv1 lication Data, Application Data
351 192.168.24.100 TLSv1 ication Data
354 97. 108 192.168.24.100 TLSv1 plication Data, Application Data
355 74.12 7.62 192.168.24.100 TLSv1 Application Data
356 97.107.139.108 192.168.24.100 TLSv1 110 Application Data, Application Data
358 192.168.24.100 97.107.139.108 TLSv1 720 Application Data, Application Data
359 74.125.227.62 192.168.24.100 TLSv1 122 Application Data
361 97.107.139.108 192.1 .100 TLSv1 1506 Application Data, Application Data
362 97.107.139.108 192 100 TLSv1 110 Application Data, Application Data

Traffic Analysis. Huge Field



HTTP

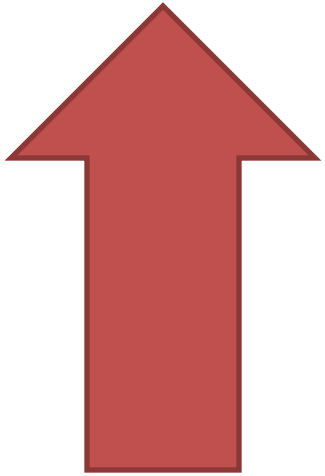
```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

username=tom&password=hunter2
```

HTTP

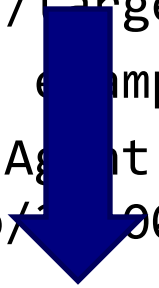
```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

username=tom&password=hunter2
```



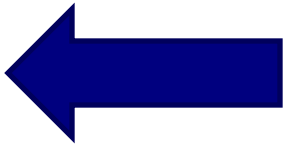
Attacker wants to know this

Attacker Can Control



```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

username=tom&password=hunter2
```



HTTP

```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

username=tom&password=hunter2
```

HTTP

```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

sessionid=a
```

HTTP

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```
Offset(h)  00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

00000000   50 4F 53 54 20 2F 74 61 72 67 65 74 20 48 54 54  POST /target HTT
00000010   50 2F 31 2E 31 0D 0A 48 6F 73 74 3A 20 65 78 61  P/1.1..Host: exa
00000020   6D 70 6C 65 2E 63 6F 6D 0D 0A 55 73 65 72 2D 41  mple.com..User-A
00000030   67 65 6E 74 3A 20 4D 6F 7A 69 6C 6C 61 2F 35 2E  gent: Mozilla/5.
00000040   30 20 28 57 69 6E 64 6F 77 73 20 4E 54 20 36 2E  0 (Windows NT 6.
00000050   31 3B 20 57 4F 57 36 34 3B 20 72 76 3A 31 34 2E  1; WOW64; rv:14.
00000060   30 29 20 47 65 63 6B 6F 2F 32 30 31 30 30 31 30  0) Gecko/2010010
00000070   31 20 46 69 72 65 66 6F 78 2F 31 34 2E 30 2E 31  1 Firefox/14.0.1
00000080   0D 0A 43 6F 6F 6B 69 65 3A 20 73 65 73 73 69 6F  ..Cookie: sessio
00000090   6E 69 64 3D 64 38 65 38 66 63 61 32 64 63 30 66  nid=d8e8fca2dc0f
000000A0   38 39 36 66 64 37 63 62 34 63 62 30 30 33 31 62  896fd7cb4cb0031b
000000B0   61 32 34 39 0D 0A 0D 0A 73 65 73 73 69 6F 6E 69  a249....sessioni
000000C0   64 3D 61                                         d=a
```

195 Bytes

HTTP

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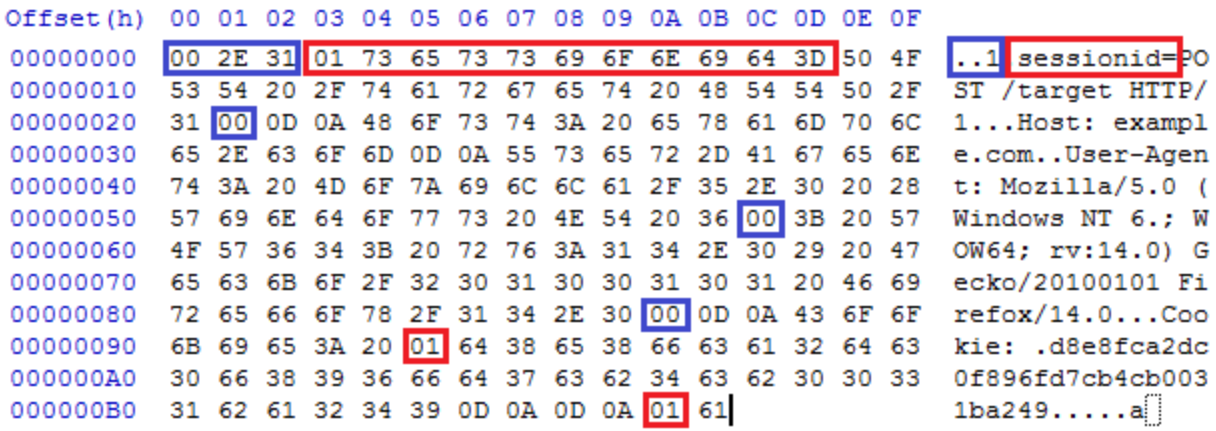
```
Offset(h)  00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

00000000   00 2E 31 01 73 65 73 73 69 6F 6E 69 64 3D 50 4F  ..1 sessionid=PO
00000010   53 54 20 2F 74 61 72 67 65 74 20 48 54 54 50 2F  ST /target HTTP/
00000020   31 00 0D 0A 48 6F 73 74 3A 20 65 78 61 6D 70 6C  1...Host: exampl
00000030   65 2E 63 6F 6D 0D 0A 55 73 65 72 2D 41 67 65 6E  e.com..User-Agen
00000040   74 3A 20 4D 6F 7A 69 6C 6C 61 2F 35 2E 30 20 28  t: Mozilla/5.0 (
00000050   57 69 6E 64 6F 77 73 20 4E 54 20 36 00 3B 20 57  Windows NT 6.; W
00000060   4F 57 36 34 3B 20 72 76 3A 31 34 2E 30 29 20 47  OW64; rv:14.0) G
00000070   65 63 6B 6F 2F 32 30 31 30 30 31 30 31 20 46 69  ecko/20100101 Fi
00000080   72 65 66 6F 78 2F 31 34 2E 30 00 0D 0A 43 6F 6F  refox/14.0...Coo
00000090   6B 69 65 3A 20 01 64 38 65 38 66 63 61 32 64 63  kie: .d8e8fca2dc
000000A0   30 66 38 39 36 66 64 37 63 62 34 63 62 30 30 33  0f896fd7cb4cb003
000000B0   31 62 61 32 34 39 0D 0A 0D 0A 01 61             1ba249.....a
```

HTTP



Offset(h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
00000000	00	2E	31	01	73	65	73	73	69	6F	6E	69	64	3D	50	4F	..1 sessionid=PO
00000010	53	54	20	2F	74	61	72	67	65	74	20	48	54	54	50	2F	ST /target HTTP/
00000020	31	00	0D	0A	48	6F	73	74	3A	20	65	78	61	6D	70	6C	1...Host: exampl
00000030	65	2E	63	6F	6D	0D	0A	55	73	65	72	2D	41	67	65	6E	e.com..User-Agen
00000040	74	3A	20	4D	6F	7A	69	6C	6C	61	2F	35	2E	30	20	28	t: Mozilla/5.0 (
00000050	57	69	6E	64	6F	77	73	20	4E	54	20	36	00	3B	20	57	Windows NT 6.; W
00000060	4F	57	36	34	3B	20	72	76	3A	31	34	2E	30	29	20	47	OW64; rv:14.0) G
00000070	65	63	6B	6F	2F	32	30	31	30	30	31	30	31	20	46	69	ecko/20100101 Fi
00000080	72	65	66	6F	78	2F	31	34	2E	30	00	0D	0A	43	6F	6F	refox/14.0...Coo
00000090	6B	69	65	3A	20	01	64	38	65	38	66	63	61	32	64	63	kie: .d8e8fca2dc
000000A0	30	66	38	39	36	66	64	37	63	62	34	63	62	30	30	33	0f896fd7cb4cb003
000000B0	31	62	61	32	34	39	0D	0A	0D	0A	01	61					1ba249.....a

187 Bytes

HTTP

```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

sessionid=d
```

HTTP

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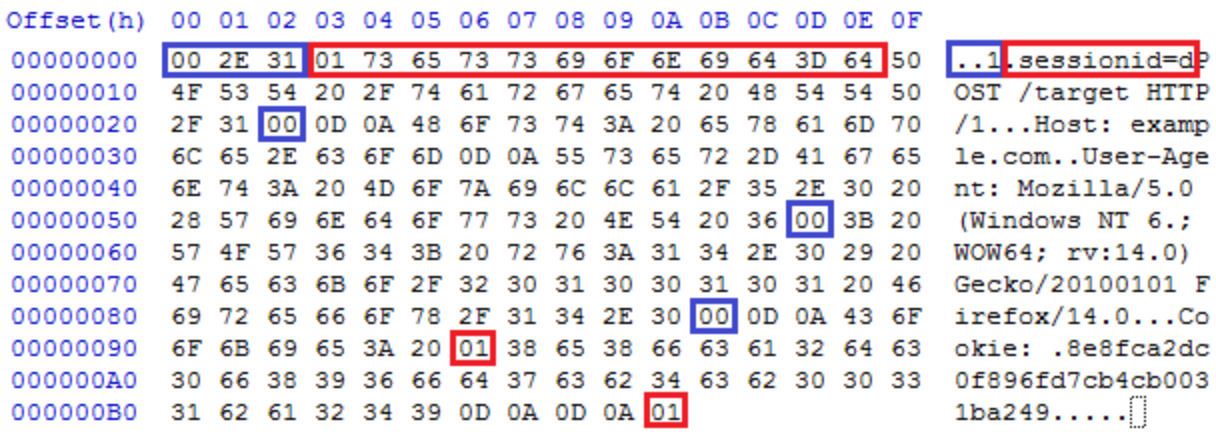

```
Offset(h)  00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

00000000   00 2E 31 01 73 65 73 73 69 6F 6E 69 64 3D 64 50  ..1.sessionid=dP
00000010   4F 53 54 20 2F 74 61 72 67 65 74 20 48 54 54 50  OST /target HTTP
00000020   2F 31 00 0D 0A 48 6F 73 74 3A 20 65 78 61 6D 70  /1...Host: examp
00000030   6C 65 2E 63 6F 6D 0D 0A 55 73 65 72 2D 41 67 65  le.com..User-Age
00000040   6E 74 3A 20 4D 6F 7A 69 6C 6C 61 2F 35 2E 30 20  nt: Mozilla/5.0
00000050   28 57 69 6E 64 6F 77 73 20 4E 54 20 36 00 3B 20  (Windows NT 6.;
00000060   57 4F 57 36 34 3B 20 72 76 3A 31 34 2E 30 29 20  WOW64; rv:14.0)
00000070   47 65 63 6B 6F 2F 32 30 31 30 30 31 30 31 20 46  Gecko/20100101 F
00000080   69 72 65 66 6F 78 2F 31 34 2E 30 00 0D 0A 43 6F  irefox/14.0...Co
00000090   6F 6B 69 65 3A 20 01 38 65 38 66 63 61 32 64 63  okie: .8e8fca2dc
000000A0   30 66 38 39 36 66 64 37 63 62 34 63 62 30 30 33  0f896fd7cb4cb003
000000B0   31 62 61 32 34 39 0D 0A 0D 0A 01               1ba249.....
```

186 Bytes

HTTP

```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

sessionid=da
```

HTTP

iSECpartners part of nccgroup

```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

sessionid=da
```

188 Bytes

HTTP

iSECpartners part of nccgroup

```
POST /target HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:14.0)
Gecko/20100101 Firefox/14.0.1
Cookie: sessionid=d8e8fca2dc0f896fd7cb4cb0031ba249

sessionid=d8
```

187 Bytes

Fundamental Internet Protocols Still Have Bugs!

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- SSL!
- DNS!

- DNSSEC (Ho Boy, DNSSEC)
- IPv6 (Ho Boy, IPv6)

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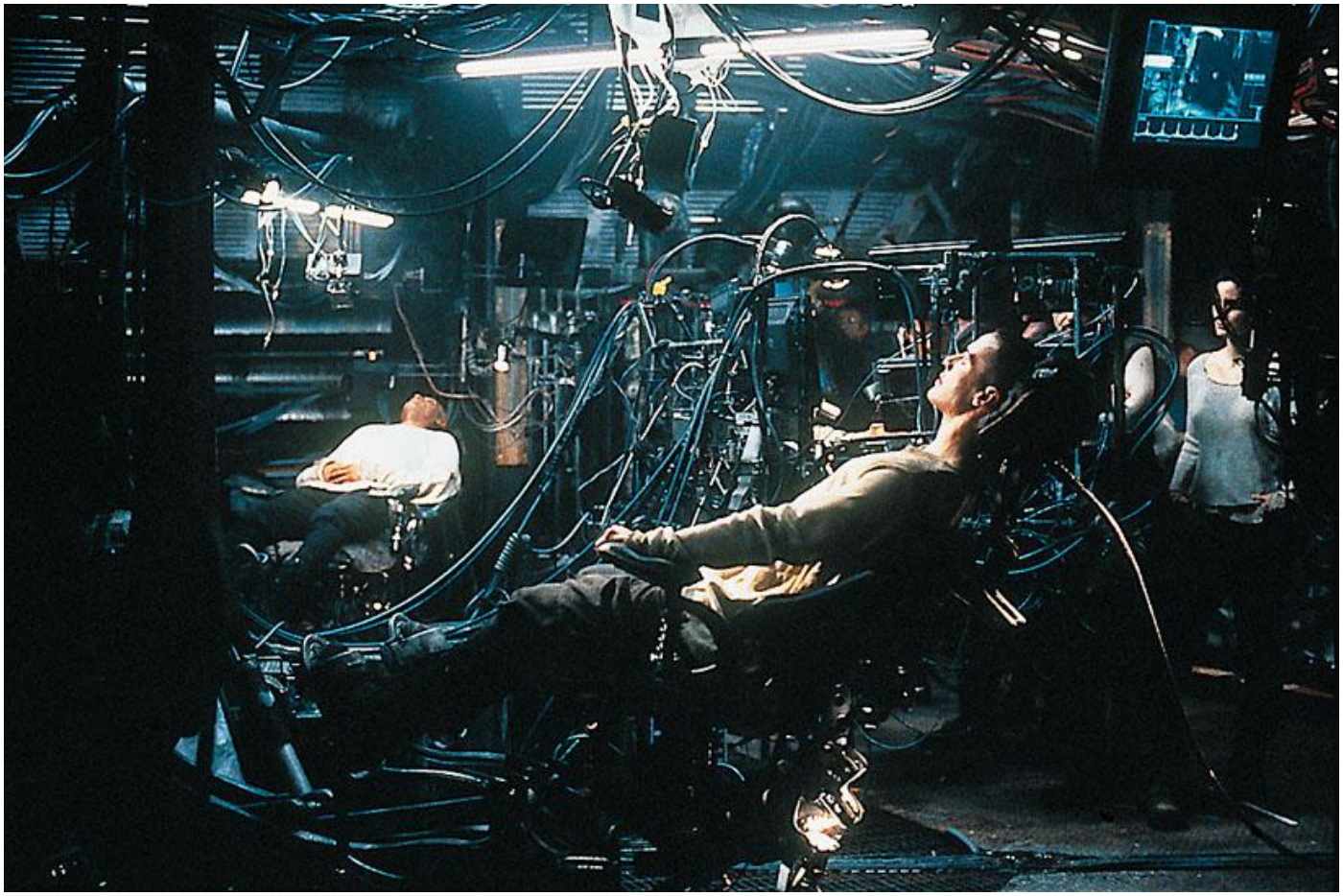
Memory Corruption: Operation Aurora



Operation Aurora (government)

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Use after free vulnerability (MS10-002 – Remote Code Execution in IE 5-8)

- Memory typically has a reference counter (how many people have a handle to me?)
- Improper reference counter allowed Javascript to still reference a function in a freed block of memory
  - Free memory
  - Heap spray attack code (likely it gets written to the freed block because of how IE memory management works)
  - Call function
  - Fairly reliable code execution

Operation Aurora

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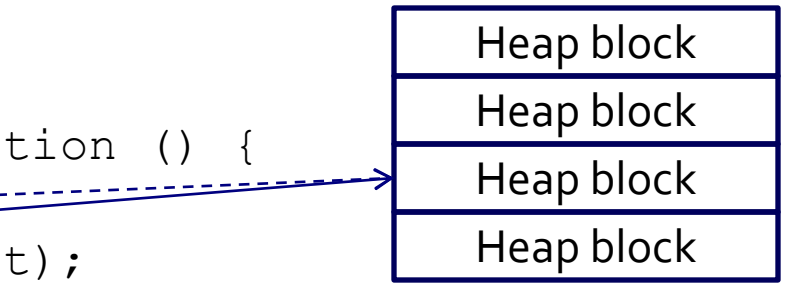
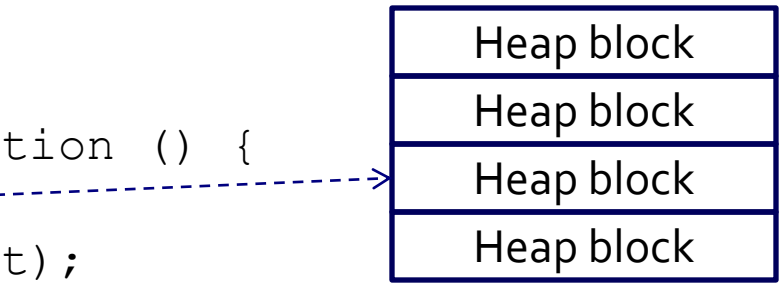
```
function window :: onload ()
{
    var SourceElement =
document.createElement ("div");
    document.body.appendChild
(SourceElement);
    var SavedEvent = null;
    SourceElement.onclick = function () {
        SavedEvent =
document.createEventObject (event);
        document.body.removeChild
(event.srcElement);
    }
    SourceElement.fireEvent ("onclick");
    SourceElement = SavedEvent.srcElement;
}
```



Operation Aurora

iSECpartners part of nccgroup

```
function window :: onload ()
{
    var SourceElement =
document.createElement ("div");
    document.body.appendChild
(SourceElement);
    var SavedEvent = null;
    SourceElement.onclick = function () {
        SavedEvent =
document.createEventObject (event);
        document.body.removeChild
(event.srcElement);
    }
    SourceElement.fireEvent ("onclick");
    SourceElement = SavedEvent.srcElement;
}
```



Operation Aurora

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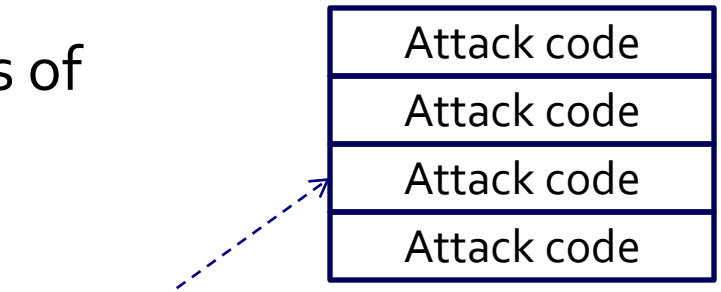
- Heap Spray!
  - Create a bunch of elements with attack code and then free them (attack code gets written to lots of heap blocks)
  - IE Small Block Manager Reuses memory pages
- Call the event pointing to freed memory
- Code execution!



Operation Aurora

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- Valuable exploit! How was it used?
- Social Engineering (get someone to click a link), almost always the weakest link
- Escalate privileges (cached credentials)
- Spread (Active Directory, brute force attack)
- Gather (source code, financial data)
- Exfiltration (to China, out of intranet on Christmas)

Operation Aurora

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- Advanced Persistent Threat
  - Advanced attackers with talent (zero days) and time (months or years)
  - Targeted attacks (not just going after the vulnerable)
  - Non-traditional attacks, likely hard to monetize
- Whodunit?

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Stuxnet (gov't / security researcher)

Stuxnet (so Amazing)

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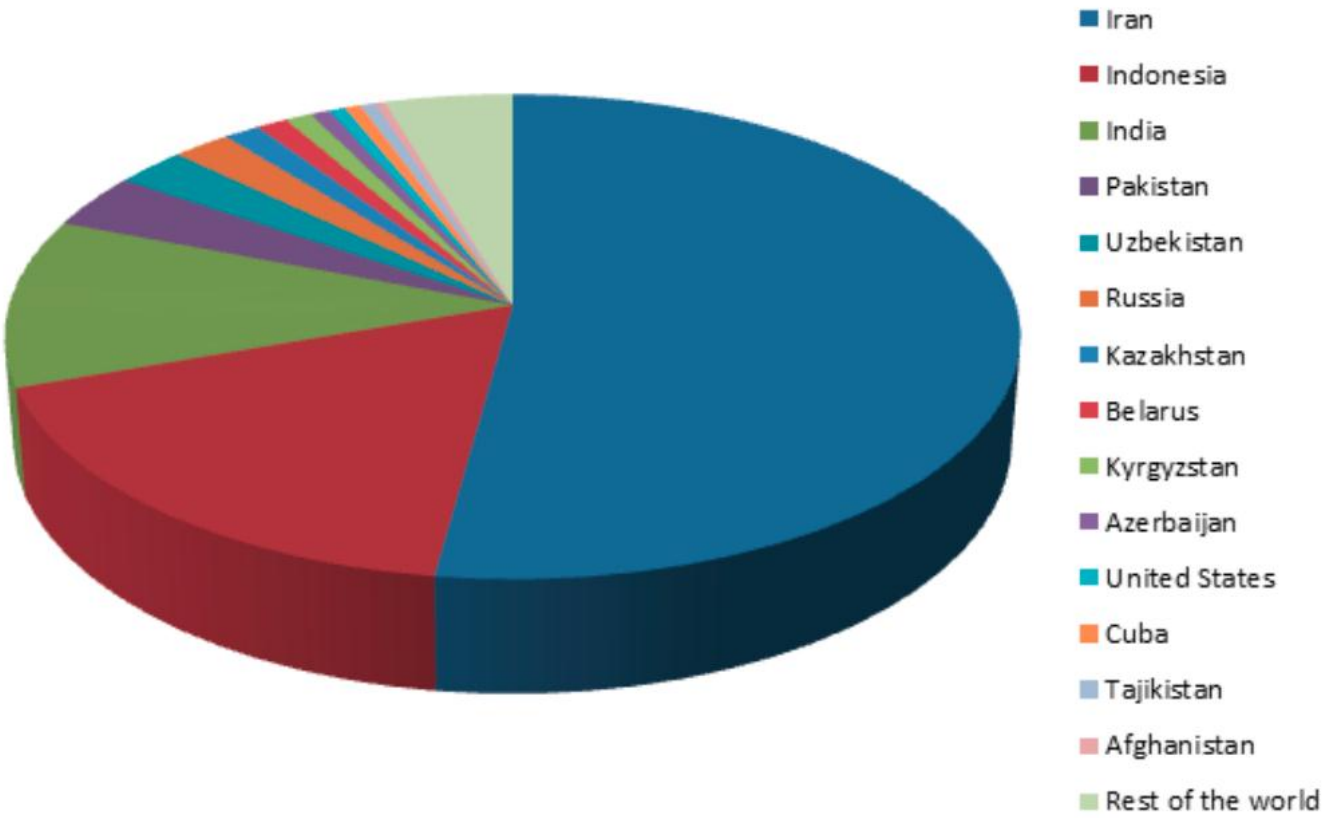
- [worm [rootkit [rootkit [sabotage]]]]
- Five zero-day vulnerabilities
- Two stolen certificates
- Almost surgically targeted
- Eight propagation methods
- Partridge in a malware pear tree

Stuxnet



http://www.eset.com/resources/white-papers/Stuxnet_Under_the_Microscope.pdf

The Target

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- Mixed MS Windows environment = *Redundant*
- Not exploiting memory corruption = *Reliable*
- Target: Iranian air-gapped networks operating centrifuges to enrich nuclear material (Natanz)
- How can you get a foot in the door? USB keys

USB Vulnerability

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Zero-Day* Vulnerabilities:

- **MS10-046 (Shell LNK / Shortcut)**
- MS10-061 (Print Spooler Service)
- MS10-073 (Win32K Keyboard Layout)
- MS08-067 (NetPathCanonicalize()), (Patched)
  http://www.phreedom.org/blog/2008/decompiling-ms08-067/
- MS10-092 (Task Scheduler)
- CVE-2010-2772 (Siemens SIMATIC Static Password)

MS10-046 (Shell LNK/Shortcut)

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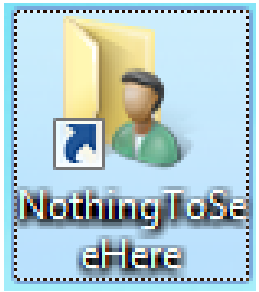
- You know, shortcuts and such
- Where does the icon come from?
- Loaded from a CPL (Control Panel File) specified by the user
- A CPL is just a DLL
- USB keys have attack DLL and a shortcut referencing the DLL
- Plugging in the USB stick leads to arbitrary code execution



MS10-046 (Shell LNK/Shortcut)

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Flaw: we should run a user-specified DLL to display an icon for a shortcut?!

But I'm not Admin!

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Zero-Day* Vulnerabilities:

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MS10-073 (Win32K Keyboard Layout)

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- Keyboard layouts can be loaded into Windows
- In XP, anyone can load a keyboard layout (later version only allow admins)
- Integer in the layout file indexes a global array of function pointers without proper bound checking
- Call any function, but I want to call *my* function…

MS10-073 (Win32K Keyboard Layout)

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- How do we call attack code?
- Find the pointer to the global function array
- Find a pointer into user-land (modifiable by your program)
- Inject your attack code there
- Call the modified function (runs as SYSTEM)

MS10-073 (Win32K Keyboard Layout)

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Flaws: improper bound checking on the keyboard layout function index and allowing standard users to specify layouts

But I'm not an Admin!

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Zero-Day* Vulnerabilities:

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- CVE-2010-2772 (Siemens SIMATIC Static Password)

MS10-092 (Task Scheduler)

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- Standard users can create and edit scheduled tasks (XML)
- After a task is created, a CRC32 checksum is generated to prevent tampering
- … CRC32 …

MS10-092 (Task Scheduler)

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- Standard users can create and edit scheduled tasks (XML)
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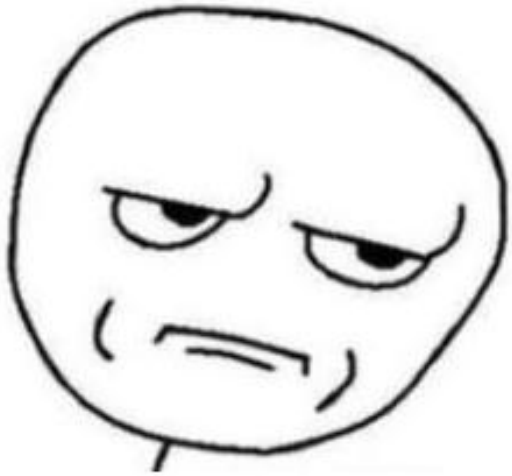

CRC32

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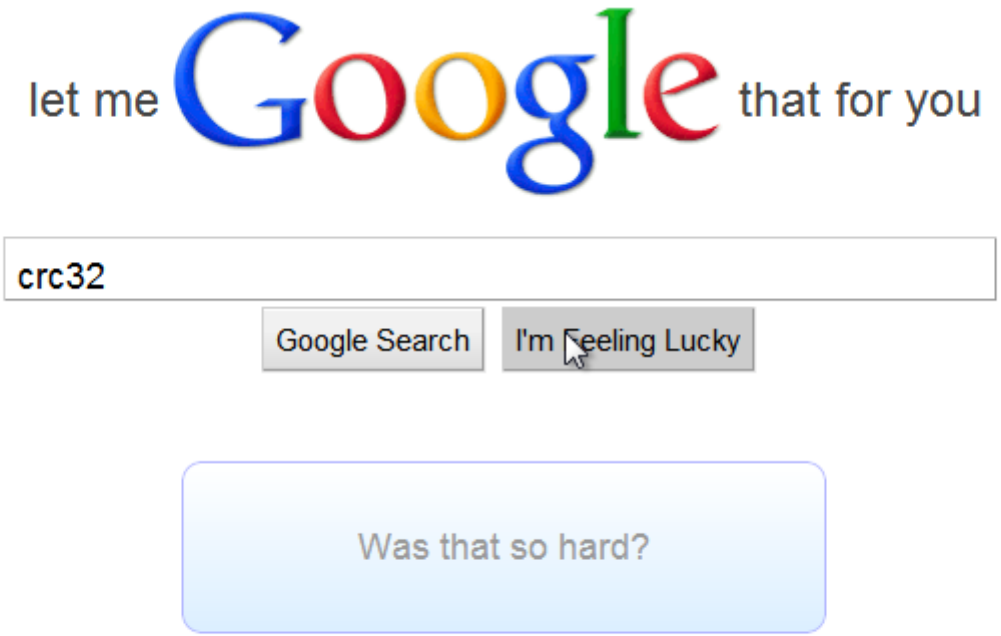
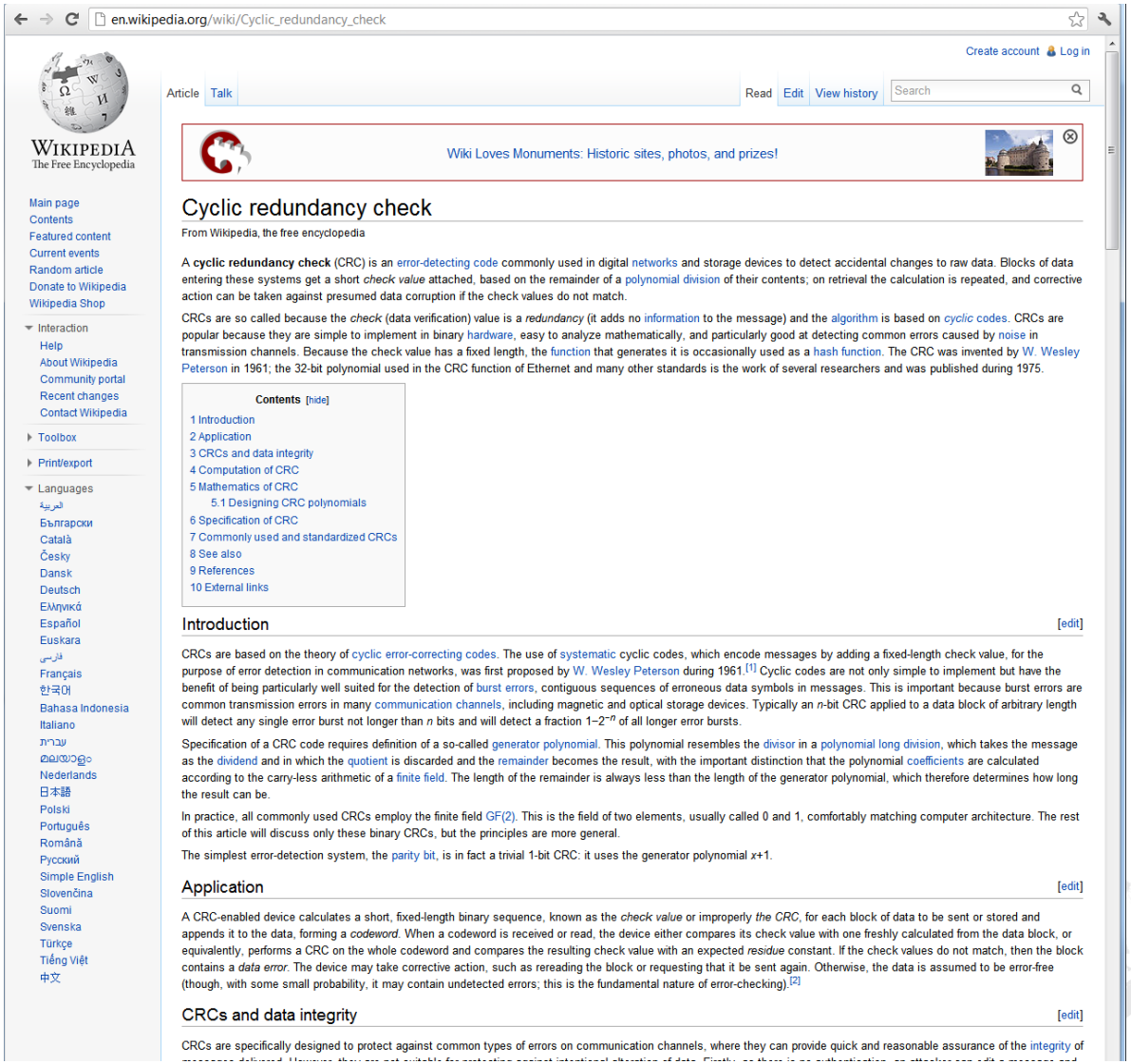


CRC32



en.wikipedia.org/wiki/Cyclic_redundancy_check

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The Free Encyclopedia

Wiki Loves Monuments: Historic sites, photos, and prizes!

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Cyclic redundancy check

From Wikipedia, the free encyclopedia

A **cyclic redundancy check** (CRC) is an error-detecting code commonly used in digital networks and storage devices to detect accidental changes to raw data. Blocks of data entering these systems get a short *check value* attached, based on the remainder of a polynomial division of their contents; on retrieval the calculation is repeated, and corrective action can be taken against presumed data corruption if the check values do not match.

CRCs are so called because the *check* (data verification) value is a *redundancy* (it adds no information to the message) and the algorithm is based on *cyclic* codes. CRCs are popular because they are simple to implement in binary hardware, easy to analyze mathematically, and particularly good at detecting common errors caused by noise in transmission channels. Because the check value has a fixed length, the function that generates it is occasionally used as a hash function. The CRC was invented by W. Wesley Peterson in 1961; the 32-bit polynomial used in the CRC function of Ethernet and many other standards is the work of several researchers and was published during 1975.

Contents [hide]

1 Introduction
2 Application
3 CRCs and data integrity
4 Computation of CRC
5 Mathematics of CRC
5.1 Designing CRC polynomials
6 Specification of CRC
7 Commonly used and standardized CRCs
8 See also
9 References
10 External links

Introduction [edit]

CRCs are based on the theory of cyclic error-correcting codes. The use of systematic cyclic codes, which encode messages by adding a fixed-length check value, for the purpose of error detection in communication networks, was first proposed by W. Wesley Peterson during 1961.[1] Cyclic codes are not only simple to implement but have the benefit of being particularly well suited for the detection of burst errors, contiguous sequences of erroneous data symbols in messages. This is important because burst errors are common transmission errors in many communication channels, including magnetic and optical storage devices. Typically an *n*-bit CRC applied to a data block of arbitrary length will detect any single error burst not longer than *n* bits and will detect a fraction $1-2^{-n}$ of all longer error bursts.

Specification of a CRC code requires definition of a so-called generator polynomial. This polynomial resembles the divisor in a polynomial long division, which takes the message as the dividend and in which the quotient is discarded and the remainder becomes the result, with the important distinction that the polynomial coefficients are calculated according to the carry-less arithmetic of a finite field. The length of the remainder is always less than the length of the generator polynomial, which therefore determines how long the result can be.

In practice, all commonly used CRCs employ the finite field GF(2). This is the field of two elements, usually called 0 and 1, comfortably matching computer architecture. The rest of this article will discuss only these binary CRCs, but the principles are more general.

The simplest error-detection system, the parity bit, is in fact a trivial 1-bit CRC: it uses the generator polynomial $x+1$.

Application [edit]

A CRC-enabled device calculates a short, fixed-length binary sequence, known as the *check value* or improperly *the CRC*, for each block of data to be sent or stored and appends it to the data, forming a *codeword*. When a codeword is received or read, the device either compares its check value with one freshly calculated from the data block, or equivalently, performs a CRC on the whole codeword and compares the resulting check value with an expected *residue* constant. If the check values do not match, then the block contains a *data error*. The device may take corrective action, such as rereading the block or requesting that it be sent again. Otherwise, the data is assumed to be error-free (though, with some small probability, it may contain undetected errors; this is the fundamental nature of error-checking).[2]

CRCs and data integrity [edit]

CRCs are specifically designed to protect against common types of errors on communication channels, where they can provide quick and reasonable assurance of the integrity of

Enhance!

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CRCs and data integrity [edit]

CRCs are specifically designed to protect against common types of errors on communication channels, where they can provide quick and reasonable assurance of the integrity of messages delivered. However, they are not suitable for protecting against intentional alteration of data. Firstly, as there is no authentication, an attacker can edit a message and recompute the CRC without the substitution being detected. This is even the case when the CRC is encrypted, one of the design flaws of the Wired Equivalent

"However, [CRCs] are not suitable for protecting against intentional alteration of data." – Wikipedia (Cyclic redundancy check)

MS10-092 (Task Scheduler)

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- Created task as normal user, record CRC32 value
- Modified user definition in the task to LocalSystem
- Take CRC32 of the task XML, pad until the CRC32 matches original

MS10-092 (Task Scheduler)

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- Created task as normal user, record CRC32 value
- Modified user definition in the task to LocalSystem
- Take CRC32 of the task XML, pad until the CRC32 matches original
- ?????
- Profit!

MS10-092 (Task Scheduler)

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Flaw:

Security Research

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"Our job is to read one more sentence in the man page than the developer did." –Chris Palmer (former iSECer)

- Be really curious
- Think about how components interact with each other

Let's Spread!

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Zero-Day* Vulnerabilities:

- MS10-046 (Shell LNK / Shortcut)
- **MS10-061 (Print Spooler Service)**
- MS10-073 (Win32K Keyboard Layout)
- MS08-067 (NetPathCanonicalize()), (Patched)
  http://www.phreedom.org/blog/2008/decompiling-ms08-067/
- MS10-092 (Task Scheduler)
- CVE-2010-2772 (Siemens SIMATIC Static Password)

MS10-061 (Print Spooler Service)

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- Enumerates printer shares
- Connects to printer and asks to print two files to SYSTEM32
- Should fail?! Printer should connect as Guest, which shouldn't have privilege to create files in SYSTEM32

MS10-061 (Print Spooler Service)

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- "//We run as system because in XP the guest account doesn't have enough privilege to do X/Y/Z"
- Stuxnet payload is dropped

MS10-061 (Print Spooler Service)

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- How do we execute? Enter the MOF
- MOF files are basically script files
- A process monitors the following directory for new files and executes them: Windows\System32\wbem\mof\
- MOF file executes the Stuxnet payload

MS10-061 (Print Spooler Service)

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Flaws:

- Printer spooler runs as SYSTEM (highest privilege) and allows arbitrary files to be written to arbitrary places
- File creation leads to arbitrary code execution

Let's Spread!

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MS08-067 (NetPathCanonicalize())

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- Known, patched (recent) vulnerability that allowed you to drop a payload and schedule it for execution

Flaws:

- Unpatched systems
- RPC flaw that allows unauthorized remote users to schedule tasks

Rootkits

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- Goal: maintain control in secret
- Anti-Virus: Behavior Blocking
  - Hook (modify behavior) of ntdll.dll (used to load DLLs)
  - Load a fake DLL name
  - AV says "that doesn't exist, that's fine"
  - Hook reroutes to a Stuxnet DLL
  - Hook "trusted" binaries (based on installed AV)
- Two stolen certificates:
  - Signs MrxCls.sys: launches Stuxnet on boot
  - Signs MRxNet.sys: hides Stuxnet filesystem objects and hooks new filesystem objects

Hammer Time

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Zero-Day* Vulnerabilities:

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- MS10-092 (Task Scheduler)
- **CVE-2010-2772 (Siemens SIMATIC Static Password)**

When and Where?

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- Stuxnet is targeted for the Natanz Nuclear Facility
  - Targets a configuration with six centrifuge cascades in a very specific configuration
  - Attacks specific controllers/hardware used at Natanz
  - Certainly had a test environment
- Where did the intelligence come from?

When and Where?

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President Ahmadinejad's homepage! Here he is at Natanz. Wait, what's that on the screen?

When and Where?

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Full resolution photos?? ENHANCE!

IR-1 cascade model

RCG	1								2							3							4							5							6						
Line 1			⊕		⊕	⊕	⊕		⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Line 2	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Line 2	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Line 4			⊕		⊕	⊕	⊕		⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Row	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Stage	1	2	3	4		5		6		7		8			9			10				11				12				13				14			15						

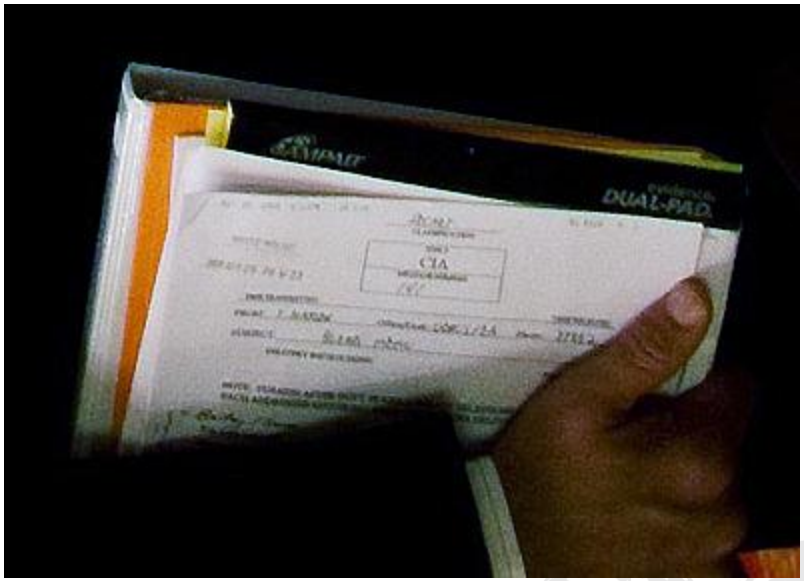
RCG: Rotor Control Group, a group of up to 28 centrifuges

Stage: Enrichment stage, with the general flow direction from right to left

Row: Row number of a centrifuge quadruple, corresponding to the floor markings

When and Where?

Don’t get too ‘Merica on me, we do it too…



CVE-2010-2772 (Static Password)

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- Siemens' controllers for centrifuges run WinCC
- WinCC SQL database servers
  - Connect using a hardcoded password
  - Loads Stuxnet as binary into a table
  - Executes binary as a stored procedure

CVE-2010-2772 (Static Password)

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- Step7 DLL is renamed and replaced with an attack DLL
- If the PLC matches the desired profile, it's infected
- Breaks centrifuges by spinning them in weird ways while reporting everything is fine

Stuxnet: Fun Facts

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- Black Market value of these vulns… probably millions
- Probably set back Iran's nuclear program by years
- Stolen code signing certificates actually signed the virus to make it look legitimate
- Virus phoned command and control centers to gather data, update, and presumably limit the scope of infection
- Whodunit?
- Learn more:
  - http://www.youtube.com/watch?v=rOwMW6agpTI
  - http://go.eset.com/us/resources/white-papers/Stuxnet_Under_the_Microscope.pdf
  - http://www.symantec.com/content/en/us/enterprise/media/security_response/whitepapers/w32_stuxnet_dossier.pdf
  - http://www.digitalbond.com/2012/01/31/langners-stuxnet-deep-dive-s4-video/
  - https://www.youtube.com/watch?v=rsXe2Gr2e3Q

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But Wait… There's More!

Flame (Stuxnet's Cousin)

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- Spyware
- Does crazy things like:
  - Get all the GPS tags from all your photos
  - Get your contact list from any Bluetooth attached phone
  - Screenshots, keystroke logging, audio recording

MD5 is Broken (an Interlude)

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- MD5 is broken because you can find collisions
- Specifically, chosen-prefix collision
- Demonstrated to be feasible in 2008 to generate a rogue CA (http://marc-stevens.nl/research/papers/CR09-SSALMOdW.pdf)
- Attack required 3 days running on 215 PS3s to find a collision
- Everyone panics, CAs stop using MD5 entirely

Flame (Stuxnet's Cousin)

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- Microsoft forgot about one Microsoft Terminal Server still issuing MD5 certificates
- Attackers devised a new way to find MD5 collisions
- Harder challenges, 1 ms time window to get the right timestamp
- Created an arbitrary MS root certificate for signing anything

Flame (Stuxnet's Cousin)

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- Microsoft forgot about one Microsoft Terminal Server still issuing MD5 certificates
- Attackers devised a new way to find MD5 collisions
- Harder challenges, 1 ms time window to get the right timestamp
- Created an arbitrary MS root certificate for signing anything
- …. Like Windows Updates

Flame (Stuxnet's Cousin)

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- "Oh Hai! I'm a Windows Update server!"
- "Oh Hello, I need an update."
- "Here, have delicious delicious Flame!"
- "You silly goose, this is signed by MS! I'll install it!"

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I Love Security, What's Next?

- Ethics in security
- Possible Careers

Ethics in Security

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- Big ethical debates used to be:

  Responsible vs Full Disclosure

Ethics in Security

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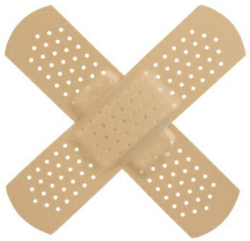
- Big ethical debates used to be:

  Responsible vs Full Disclosure

- Debate has shifted to:

  Disclosure vs Selling Weapons



Careers in Security

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- Shape your job around your ethical standpoint, not vice versa

Careers in Security

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- Shape your job around your ethical standpoint, not vice versa
- Write security relevant software

Careers in Security

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- Shape your job around your ethical standpoint, not vice versa
- Write security relevant software
- Write (more) secure software

Careers in Security

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- Shape your job around your ethical standpoint, not vice versa
- Write security relevant software
- Write (more) secure software
- Be a criminal

Careers in Security

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- Shape your job around your ethical standpoint, not vice versa
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- Academia

Careers in Security

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- Shape your job around your ethical standpoint, not vice versa
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- Write (more) secure software
- Be a criminal
- Academia
- Pen testing!

Pen Testing (at iSEC Partners)

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- See new companies every 2-3 weeks and touch a wide variety of technologies
- Do awesome research (be a pen tester and a security researcher)
- Have a big impact by making the world safer
- Spend most of your time being clever and thinking
- See us at the job fair on Friday!

Thanks for listening!

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Come to Hotel Kendall on Thursday evening for free food and a talk about IPv6 by Tom (the American Room @6pm 9/20)

Help with material from:

- Aaron Grattafiori (Senior Security Consultant, iSEC Partners)
- Alex Stamos (Co-Founder iSEC Partners)

Images:

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