Lecture 23: Reviewing Logs

CS 5430

4/23/2018

Classes of Countermeasures

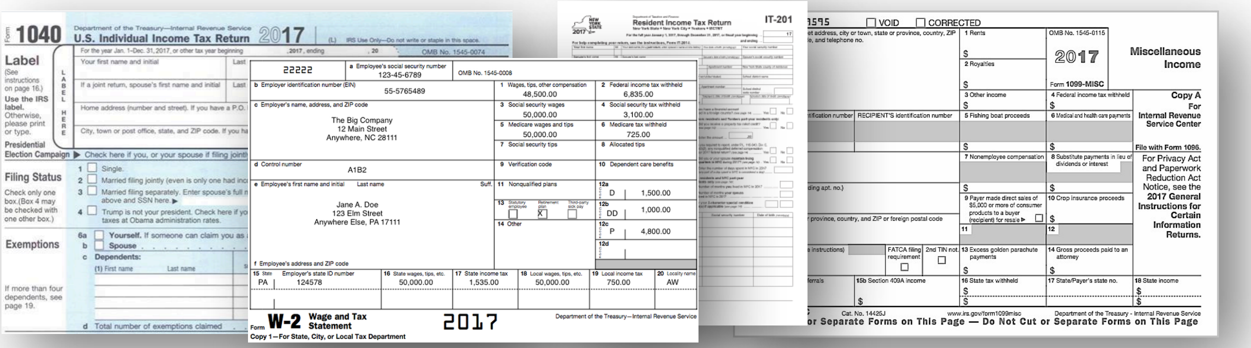
- **Authentication:** mechanisms that bind principals to actions

- **Authorization:** mechanisms that govern whether actions are permitted

- **Audit:** mechanisms that record and review actions

Uses of audit

- **Individual accountability:** deter misbehavior



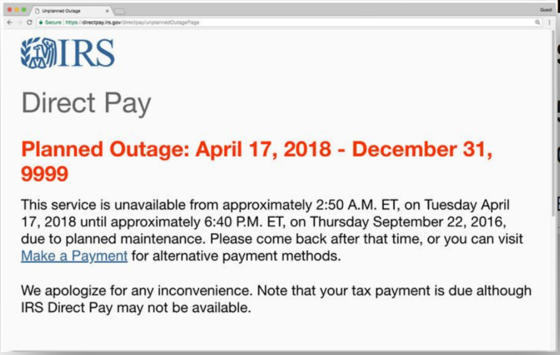
1040 U.S. Individual Income Tax Return 2017

Resident Income Tax Return IT-201

W-2 Wage and Tax Statement 2017

2017 Form 1099-MISC Miscellaneous Income

- **Event reconstruction:** determine what happened and how to recover



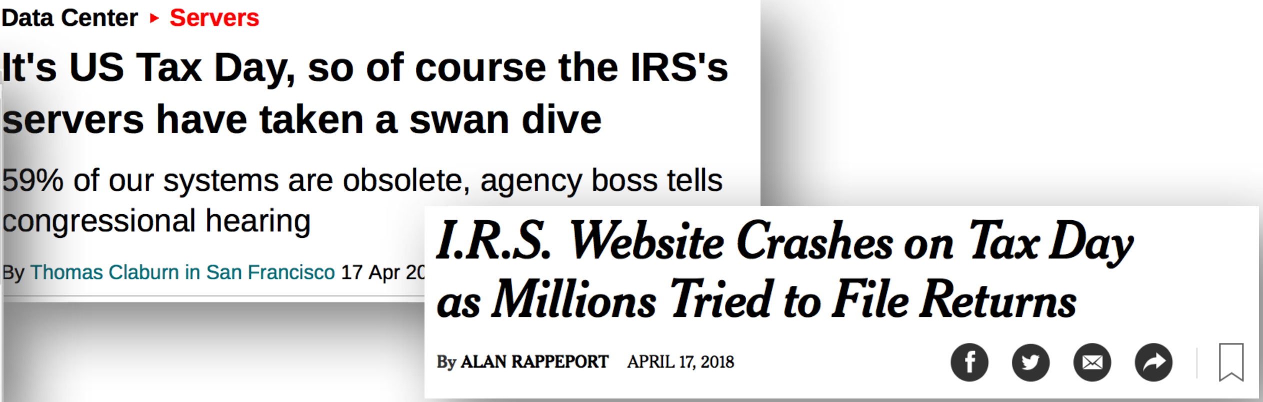
IRS

Direct Pay

Planned Outage: April 17, 2018 - December 31, 9999

This service is unavailable from approximately 2:50 A.M. ET, on Tuesday April 17, 2018 until approximately 6:40 P.M. ET, on Thursday September 22, 2016, due to planned maintenance. Please come back after that time, or you can visit Make a Payment for alternative payment methods.

We apologize for any inconvenience. Note that your tax payment is due although IRS Direct Pay may not be available.



Data Center ▸ Servers

It's US Tax Day, so of course the IRS's servers have taken a swan dive

59% of our systems are obsolete, agency boss tells congressional hearing

By Thomas Claburn in San Francisco 17 Apr 20

I.R.S. Website Crashes on Tax Day as Millions Tried to File Returns

By ALAN RAPPEPORT APRIL 17, 2018

- **Problem monitoring:** real-time intelligence

Audit tasks

- **Recording:**
  - what to log
  - what not to log
  - how to protect the log
- **Reviewing:**
  - manual exploration
  - automated analysis

MANUAL

Manual review

- Enable administrators to explore logs and look for {states, events}
- **Issues:**
  - Designers might not have anticipated the right {states, events} to record
  - Visualization, query, expressivity (HCI/DB issues)
  - Correlation amongst multiple logs

Interfaces

- **Flat text** [example: last time's syslog]
- **Hypertext** [example]
- **DBMS** [example: queries in CMS]
- **Graph** (nodes might be entities like processes and files, edges might be associations like forking or times) [example]

Techniques

- Temporal replay: animate what happened when [example]
- Slice: display minimal set of log events that affect a given object

AUTOMATIC

Automated review and response

- **Review:** detect suspicious behavior that looks like an attack, or detect violations of explicit policy
  - Custom-built systems
  - Classic AI techniques like training neural nets, expert systems, etc.
  - Modern applications of machine learning
- **Response:** report, take action

INTRUSION DETECTION

Intrusion detection

Intrusion detection system (IDS):

- automated review and response
- responds in (nearly) real time
- components:
    - sensors
    - analysis engine
    - countermeasure deployment
    - audit log

Example: Network monitoring

- **Suspicious behavior:** opening connections to many hosts
- **Automated response:** router reconfigures to isolate suspicious host on its own subnet with access only to (e.g.) virus scanner download, notifies administrators
- **Issue:** errors...

Errors

- False positive: raise an alarm for a non-attack
  - makes administrators less confident in warnings
  - perhaps leading to actual attacks being dismissed
- False negative: not raise an alarm for an attack
  - the attackers get in undetected!
- Tradeoff between the two needs to be tunable; difficult to achieve the right classification statistics

Identification methodologies

[Denning 1987]

1. Signature based: recognize known attacks
2. Specification based: recognize bad behavior
3. Anomaly based: recognize abnormal behavior

1. Signature-based detection

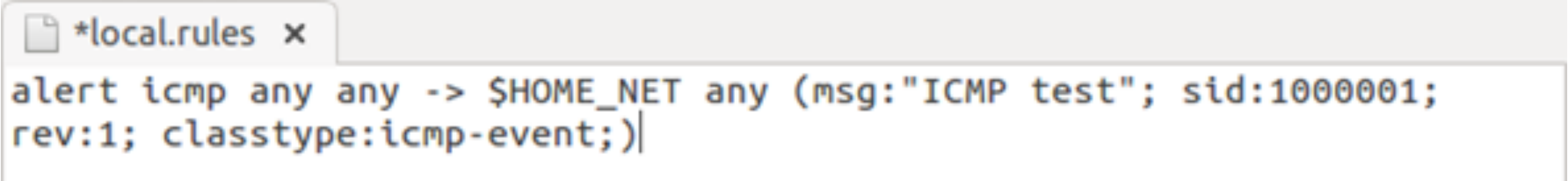
- A.k.a. *misuse detection* and *rule-based detection*
- Characterize known attacks with signatures
- If behavior ever matches signature, declare an intrusion
- **Issues:**
    - Works only for known attacks
    - Signature needs to be robust w.r.t. small changes in attack

Example: Tripwire

[open source tool and commercial product]

- **Policy:** certain files shouldn't change
- **State snapshot:** analyzes filesystem, stores database of file hashes
- **Automated response:** runs (e.g. daily) and reports change of hash
- **Issues:** where to store database, how to protect its integrity, how to protect tripwire itself?

Example: Snort



```
alert icmp any any -> $HOME_NET any (msg:"ICMP test"; sid:1000001;
rev:1; classtype:icmp-event;)
```

```
# alert tcp $EXTERNAL_NET any -> $HOME_NET 53 ( msg:"OS-LINUX
OS-LINUX x86 Linux overflow attempt ADMv2";
flow:to_server,established; content:"|89 F7 29 C7 89 F3 89 F9 89
F2 AC|<|FE|",fast_pattern,nocase; metadata:ruleset community;
service:dns; classtype:attempted-admin; sid:265; rev:15; )
```

Network-based IDS

- Typically a separate machine
- Stealth mode:
  - one NIC faces the network being monitored, no packets ever sent out on it, no packets can be routed specifically to it
  - another NIC faces a separate network through which alarms are sent
- Honeypot:
  - dedicated machines(s) or networks
  - purpose is to look attractive to attacker
  - but actually just a trap: monitored to detect and surveil attacker

2. Specification-based detection

- Characterize good behavior of program with a specification
- If behavior ever departs from specification, declare an intrusion
- **Issues:**
  - Effort to create specifications
  - Any program is a potential vulnerability if executed by a privileged user

Example: Distributed Program Execution Monitor (DPEM)

[Ko et al. 1997]

- Monitors Unix audit logs
- Analyst writes grammar in DSL to describe good behavior
- Parser checks conformance of logs with grammar
- *Distributed* because it combines information from multiple hosts

3. Anomaly-based detection

- Characterize normal behavior of system
- If behavior ever departs far enough from normal, declare an intrusion
- **Issues:**
  - Feature identification
  - Obtaining data on what is normal

Example: Haystack

[Smaha 1988]

- Monitors value of some statistic of interest over a sliding time window: a_i, a_{i+1}, ..., a_j
- Determine lower and upper bounds t_L and t_U such that 90% of values lie between t_L and t_U
- If next value is outside t_L and t_U, raise an alarm
- Adaptive: as window moves, detector itself adjusts

Statistical models

- Threshold models: min and max
- Moment models: mean and standard deviation
- Markov models: probability of next event based on current state
- Seems like a job for machine learning…

Machine learning

- Despite extensive academic research, “Machine learning [for IDS] is rarely employed in…real world settings” [Sommer & Paxson 2010]
- ML is great for classification: finding similarities
- ML is not as great at outlier detection: here, “normal vs. abnormal”
- ML in adversarial setting not well understood

Identification methodologies

1. Signature based: recognize known attacks
2. Specification based: recognize bad behavior
3. Anomaly based: recognize abnormal behavior

INTRUSION RESPONSE

Intrusion handling

[Northcutt 1998]

1. Preparation
2. Identification
3. Containment
4. Eradication
5. Recovery
6. Follow up

Automated response

- **Monitor:** collect (additional) data
- **Protect:** reduce exposure of system
- **Alert:** call a human

Counterattack

- **Legal:** file criminal complaint
- **Technical:** damage attacker to stop attack or prevent future attacks
  - Might harm an innocent party
  - Might expose you to legal liability