Measurement and Security

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“If you can not measure it, you can not improve it.”

“When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of *Science*, whatever the matter may be.”

—Lord Kelvin

Questions

- What can measurement tell us?
- What would we like it to tell us?
- What seems beyond reach?

Obvious Results

- If there's too much traffic all over, there's probably a worm outbreak
- If there's too much traffic towards a single point, it's probably a DDoS attack
- Or is it?

What is the Traffic Mix?

- Random protocols from random addresses?
  ☞Probably an attack
- All TCP port 80 from plausible addresses?
  ☞Maybe it’s DDoS, maybe it’s a flash crowd

Taking a Closer Look

- What is the historical behavior of this destination?
- If it’s never received port 80 traffic before, it’s probably an attack
- What is the distribution of source traffic, compared with historical patterns?
- If the pattern is very different, it’s likely an attack

Controlling DDoS

- Not possible to block DDoS attacks
- Often, we can mitigate it if we can measure sources in real-time
- For sources with excess traffic over historical data, clamp to historical rate
- Note requirements: real-time data *and* historical archive

Early Warnings

- Monitor protocol distribution
- Unusual protocol types may indicate something suspicious
- AT&T detected Slammer and other attacks *before* they hit

Packet Telescopes

- Listen for “backscatter” from DDoS attacks on unused address space
- Detect attacks, learn incidence rate, discover targets
- Note: doesn’t detect attacks from non-forged addresses. Measure that at destination; compare rates.

Dark Address Space

- No one should be trying to talk to “dark” address space
- Probes to such addresses indicate compromised or evil machines
- Learn about new attack techniques

Botnet Command and Control

- Suppose you’ve identified several bots attacking some target
- To whom else do those bots speak?
- A common peer who is not a victim may be the control node

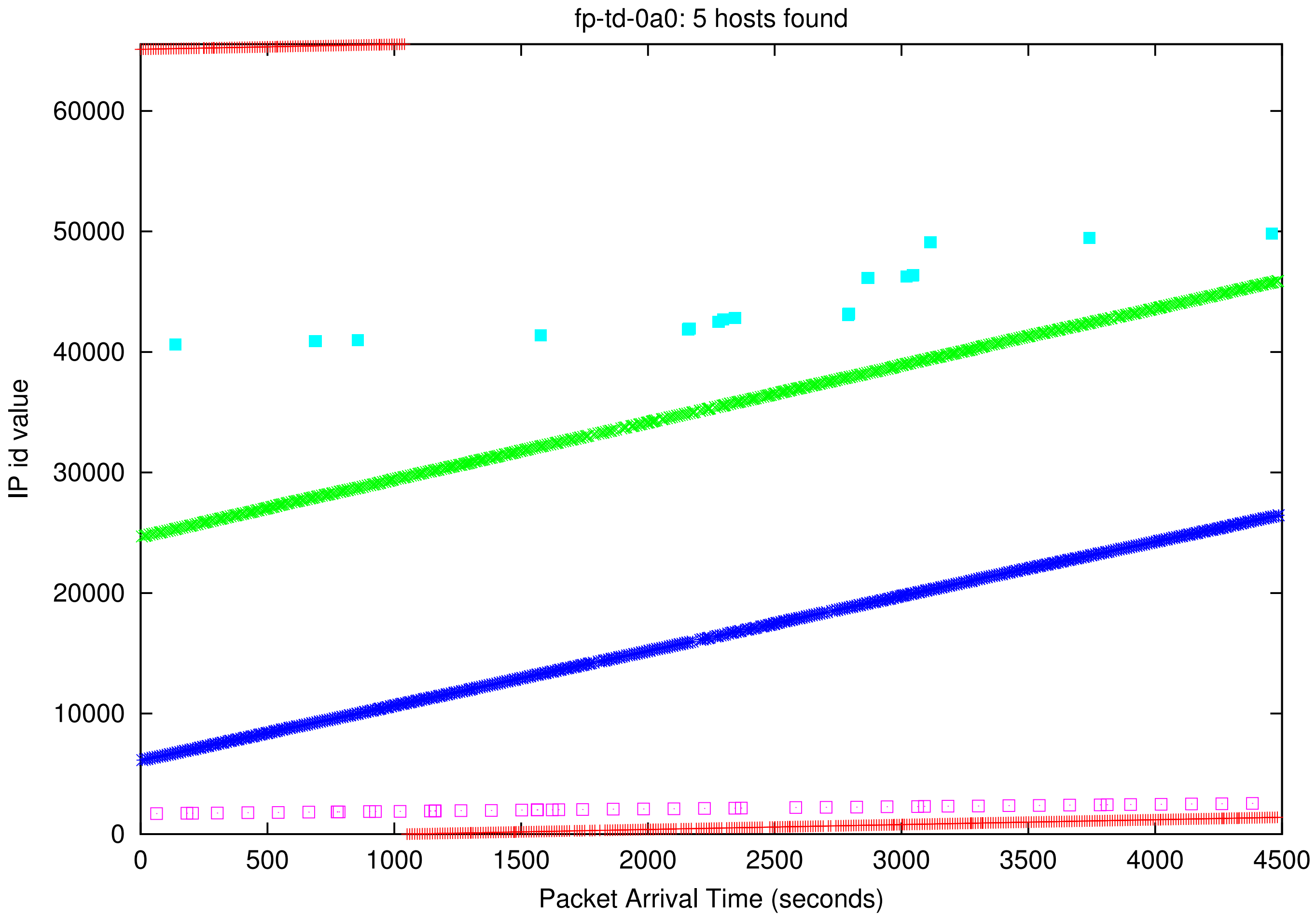
Detecting Routing Attacks

- It is not currently feasible to prevent BGP attacks
- Routes to major destinations tend to remain constant
- Changes indicate either an attack or a major outage

Counting Hosts Behind a NAT Box

- Observation: the `IPid` is usually implemented as a counter.
- By detecting *approximate sequences* of `IPid`, we can detect distinct hosts.
- Packets with the same IP address but belonging to different `IPid` sequences come from different hosts.

Experimental Graph



Traffic Analysis

- Many traffic patterns show through encryption
- Look at packet sizes, timing, and direction
- Very hard to hide

How Secure is a Network? A Host?

- That’s the question of most interest!
- Unfortunately, we can’t answer it yet
- But measurements can help

Monitor Outbound Traffic

- *Know* what a host should be sending
- Watch for differences
- Deviations may indicate misbehavior
- Outbound traffic often more significant than inbound

Do Host and Network Scans Help?

- Risk is proportional to number of exposed ports (see Microsoft's RASQ)
- Actually, proportional to weighted sum of exposed ports — some services are riskier than others
- Get weights from historical data

Measuring Client Risk

- Measure outbound traffic type
- Look for signature of particular implementations
- Again, weight sum appropriately

Is this Doable?

- Some of this is being done today
- Most is clearly feasible
- The trick is integrating all of the results

Conclusions

- Measurements can help us run a secure network
- Historical data archive almost as important as real-time measurement
- Need to develop proper statistical models