Anomaly Sampling
(bringing diversity to network security)

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Flocon – October, 2006
Ok, let’s get it out of our system

- “Sampling” by itself is a general term, like “aggregation”.
  - Sampling: \(\approx\) \{things of type X\} → smaller \{things of type X\}.
  - Aggregation: \(\approx\) \{things of type X\} → smaller \{things of type Y\}.
  - Both:
    - Turn “too much stuff” into “hopefully enough stuff” to solve problems that you care about.
    - Useful at multiple stages of data collection, data management and analysis. Hierarchical approaches are very nice.

- Note: “rotating pcap files, keeping the last 3 days” is **sampling**, with algorithm: sample all packets less than 3 days old.
Ok, let’s get it out of our system

• Sampling is not always keep/discard.
  – Sampled items could be given higher priority.
  – Sampled items might be separately kept to allow more efficient initial analyst queries against the dataset. (Same with aggregation)
  – Sampled items may be sufficient for a variety of basic reports which would save processing, etc..

• So…, in this presentation, “sampling” has no direct relationship to the ongoing packet / flow sampling argument discussion.
  – You could imagine using this on a stream of packets, or a stream of flows, or syslog entries. Please, imagine that.
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Prioritization

Flagging

Potential Initial Query Optimizer

Detection

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Basic Idea

• Existing systems focus on accurate counting of packets (or bytes) for large traffic aggregates
  – e.g., Smart Sampling, Traffic Summaries, Adaptive NetFlow, …

• Instead, focus on interesting, new information
Why? – Operational Network Security

• Forensics – “Bad guy did something”
  – When did they do it?
  – How did they do it?
  – What other machines did they get?

• Detection
  – Host ABC unexpectedly responded to a probe
  – Host XYZ used a service it never did previously
Living on the Network Edge

• The problem is **ours**, not our customer’s.
• We care about **all** of the hosts.
• But each as an **individual**.
  – Some hosts are naturally more important.
  – Each host has its own services, risks, users, threats to other resources, ...
• We care about **small** events, not affecting performance.
• The problem remains **after** the “event” is over.
• Monitored network bandwidths are still high.
Basic Idea

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- Instead, focus on interesting, new information
What is “interesting” and “new”? 

• Imagine you are the poor recipient of collected network data. What do you see? 
  – Here’s a record about our web server. Oh, and here’s another record about our web server. And our mail gateway. Oh, here’s another packet about our web server, ….

• Please, tell me something I don’t know 
  – Tell me what is “abnormal”, “unusual” or “new”.
  – Tell me “just enough” about everything.
  – Do not prioritize telling me redundant information.

• These change over time.
System Components

• Diversity Score Assigner
  – Module assigns vague, relative rankings to items (packets, flows, …) based on how similar/different this item is to previously seen items.
  – Many different approaches for this, but there appear to be a decent set of them which cover a wide range of uses when given some parameters.
  – Some approaches are very efficient in memory or CPU requirements.

• Sampling Rate Adjustor
  – The scores produced above are based on the data stream without any knowledge of the desired sampling rate.
  – Variety of algorithms to dynamically keep effective sampling rate near the target sampling rate, while maintaining diversity score information.
Feature Spaces

• Operator chooses sets of fields/etc. over which they want coverage: (e.g.)
  – Source IP address
  – Destination IP address
  – Source & destination IP address pair
  – Protocol, source port, destination port
  – Src. IP addr., protocol, src. port
  – Src. IP addr., protocol, dst. Port
  – ...

• Might chose weights to specify relative importance
Controlled Experiment

• Packet trace of live traffic in and out of central computing and network operations building (at university).

• Trace happens to contain some centralized nessus and nmap scanning from network operations. Plus main campus web servers, mail servers, desktops, ....

• Inserted an IRC exchange between 1 server and 3 clients
  – B → X, X → B (message, TCP ACK)
  – X → A, X → B, X → C, X → D (message broadcast)
  – A → X, B → X, C → X, D → X (TCP ACKs)
  – 10 packets for entire exchange, 8 unidirectional flows, 4 bidirectional flows.
## Experiment Results

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Target Rate</strong></td>
<td>1 / 10</td>
</tr>
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<td><strong>Filter</strong></td>
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<tr>
<td><strong>Scheme</strong></td>
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<td>None</td>
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<td>100%</td>
<td>1.26</td>
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Conclusions

• Anomaly detection is radically different for security at the edge compared with performance inside an ISP.

• *Appropriate* sampling techniques can:
  – greatly reduce the amount of data to look at (either by human or software)
  – focus attention on new, interesting events
  – provide good coverage for first-pass forensics analysis

• This approach can be applied to many streams of data: packets, flows, syslog, web logs, …
• To facilitate searching for and sharing of data
  – Index as much as possible, including datasets not publicly available
  – DatCat doesn’t store any network data itself

• To enhance documentation of datasets via public annotations
  – Easy place for anyone (not just the dataset creator) to provide additional information

• To advance network science by promoting reproducibility
  – Paper X ran their detection algorithm on dataset X and had a false positive rate of 0.2. Using our algorithm on dataset Y, we get a false positive rate of 0.1. Therefore our algorithm is better. …

  – Persistent handles to allow for consistent citing and comparison: http://imdc.datcat.org/collection/1-003M-5=AOL+500k+User+Session+Collection