A Case for Packet Sampling

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Motivation: FloCon 2005

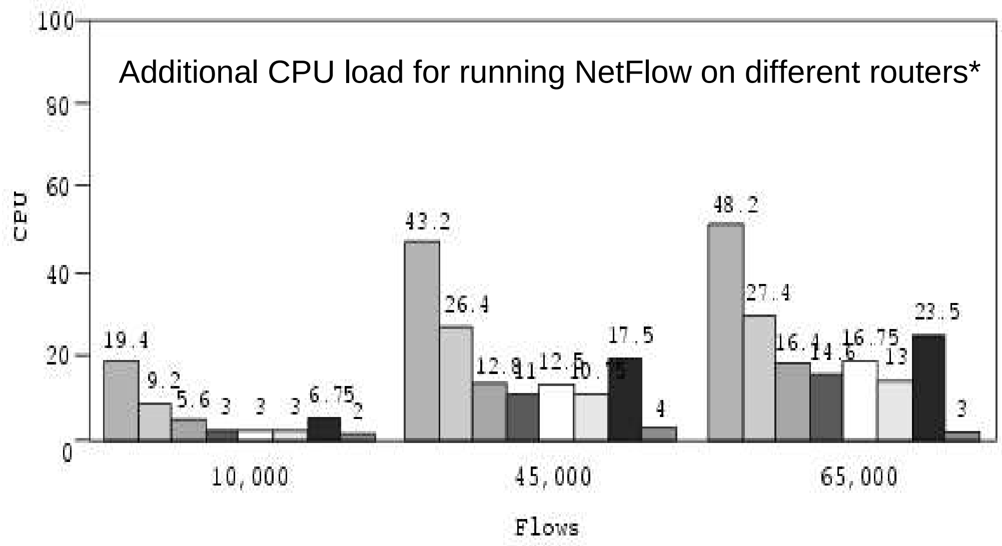
FloCon05 participants:

"We don't believe in Sampling"

- Happy to use flow data
- Very skeptical to packet sampling

The Problem: Limited Resources

- Full packet capture at each node not feasible
  - Increasing data rates
  - Hardware costs
  - Privacy concerns
- Resources are limited
  - Storage
  - Processing
  - Transmission

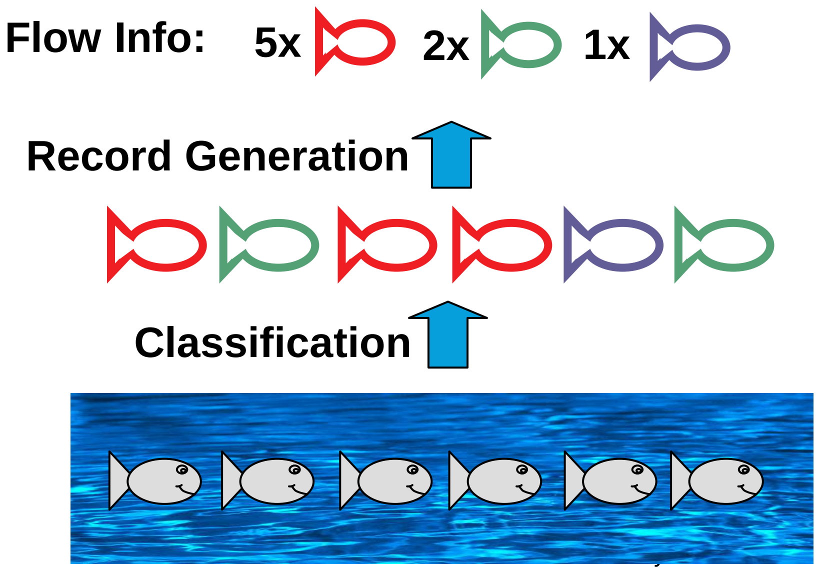


We cannot measure everything

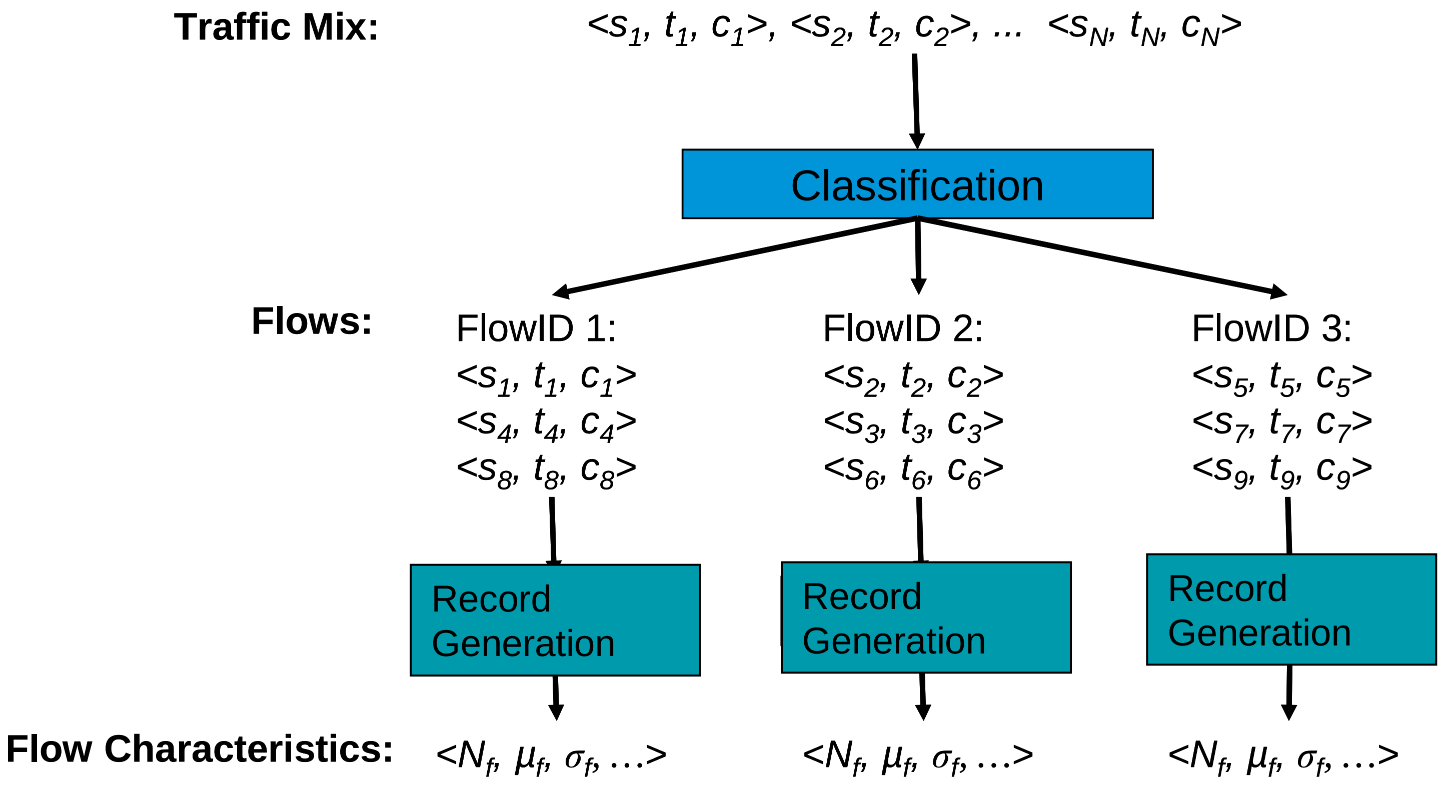
*source: NetFlow Performance Analysis, Cisco white paper
http://www.cisco.com/warp/public/cc/pd/iosw/prodlit/ntfo_wpa.jpg

Solution1: Flow Data

- Grouping of packets into flows (classification)
- Reporting of flow information only
- Disadvantages:
  - Per-packet information is lost
  - Information and effort depends on flow definition



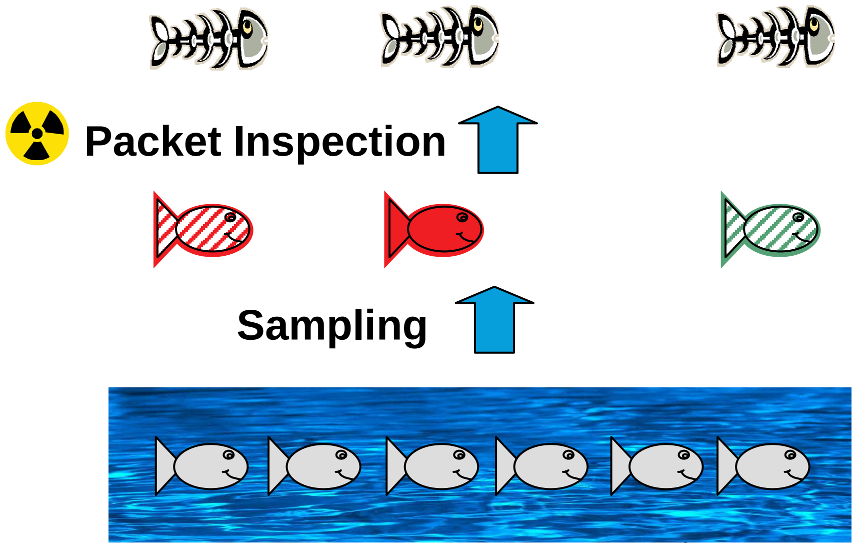
Flow Data Generation



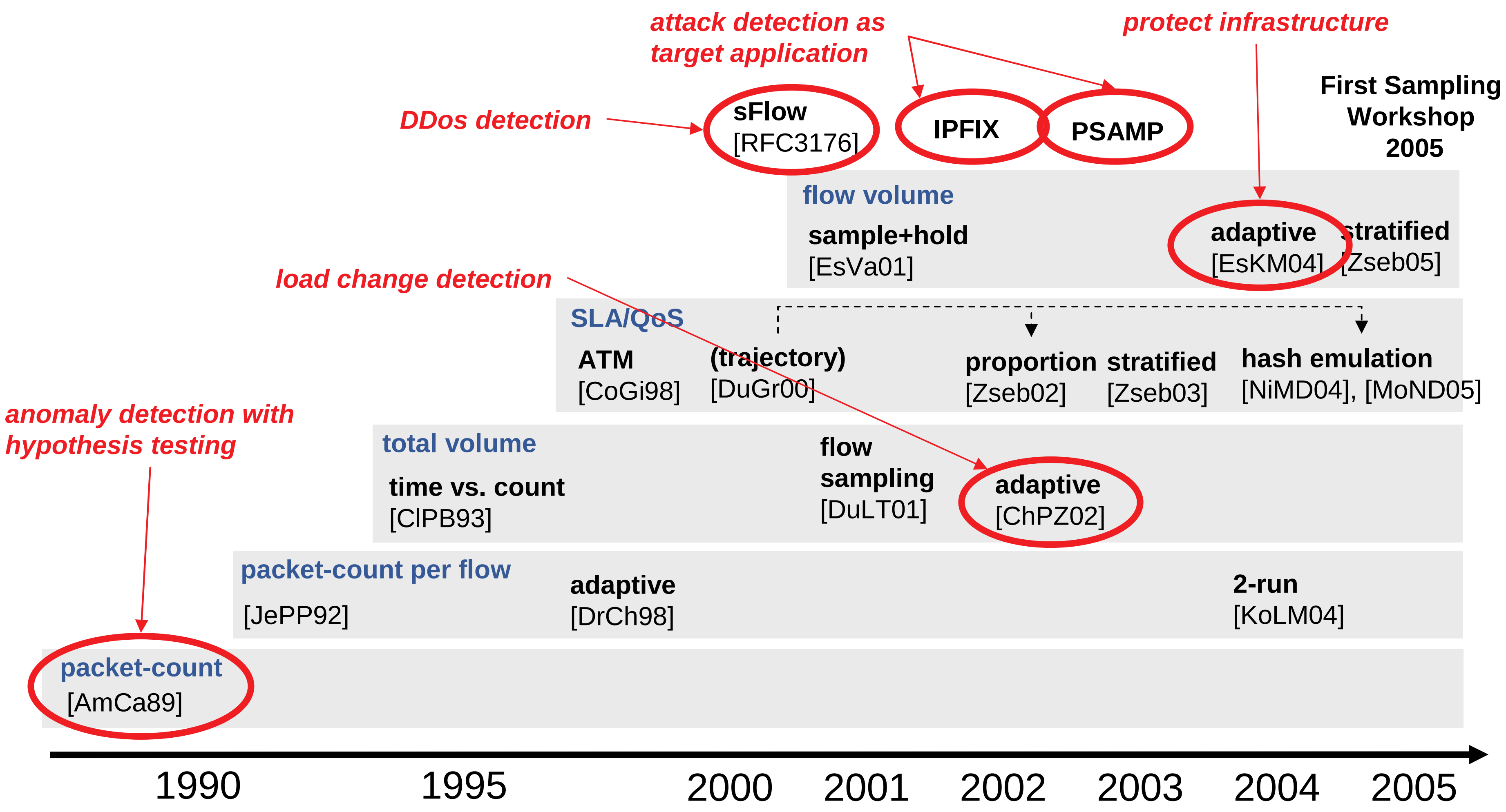
- Information about packets is discarded
- Available information depends on
  - Flow definition
  - Flow characteristics that are reported

Solution2: Packet Sampling

- Random Selection of some packets
  - Report parts or full packet information
  - Estimation of metrics based on sample
- Provides different viewpoint
  - Packet data can reveal further information
  - Sampled data sufficient for some metrics
- Helps to protect measurement infrastructure during attack



Sampling: State of Art



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Packet Sampling

Real metric substituted by estimate

➔ Accuracy statement is essential

Accuracy depends on

- Sampling scheme
- Estimation method
- Position of sampling process in measurement sequence
- Population characteristics (e.g. variance of metric of interest)

A Simple Example

Goal: Estimation of packet proportions (e.g. TCP-SYN packets in a flow)

Real proportion: $P = \frac{M}{N}$ Estimate: $\hat{P} = \frac{m}{n}$

Estimation Accuracy (random n-of-N): $\sigma_{\hat{P}} = \sqrt{\frac{P \cdot (1-P)}{n}} \cdot \sqrt{\frac{N-n}{N-1}}$

Confidence Limits: $Prob\left(\hat{P} - z_c \cdot \sigma_{\hat{P}} \leq P \leq \hat{P} + z_c \cdot \sigma_{\hat{P}}\right) = 1 - \alpha$

Example: - Measurement interval with N=10,000 packets
- Random packet selection 1% (n=100)

$\hat{P} = 0.9$ ➔ $\sigma_{\hat{P}} = 0.03$ ➔ 0.8226 ≤ P ≤ 0.977, with 99% confidence

$\hat{P} = 0.1$ ➔ same accuracy

$\hat{P} = 0.5$ (worst case) ➔ $\sigma_{\hat{P}} = 0.05$ ➔ 0.371 ≤ P ≤ 0.629, with 99% confidence

Works with other packet properties, too!

Advise

- Don't restrict your analysis to flow data
  - Include further viewpoints
  - Use sampling in addition or as alternative to flow data
- Trust the power of statistics
  - It's a mature and well established field
  - ➔ full range of proven techniques
- Use sampling where applicable
  - Applicability depends on traffic profile, metric of interest, accuracy demand
    - Sampled data sufficient to detect large events (high volumes, high packet counts)
    - May be sufficient to estimate #pkts with specific properties (e.g. SYN, VoIP packets, small packets, packets with same content, etc.)
    - Others ➔ depends on scenario
  - Difficulties with rare events (stealth attacks, slow port scans)
  - Not suitable to re-assemble connections (but filtering may be)

Thank you for your attention!

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