Targeting Situation Awareness:

The Challenges of Traffic Observation

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Network Measurements

- Basis for network research
  - But: Scientists from other disciplines are shocked:

"[network research] had not managed to execute the usual elements of successful research… measure, model, make prototypes"

Source: Looking over the Fence at Networks, National Research Council, Washington DC, 2001

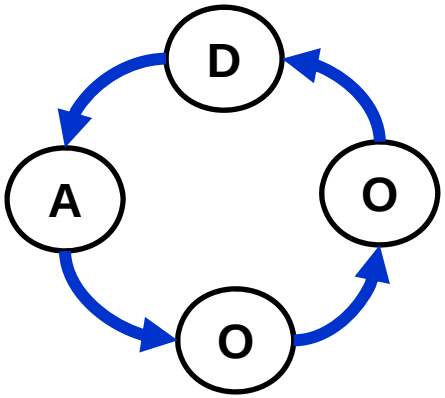
- Essential for network operation
  - Network management
  - Network security
  - Support for service provisioning
- Required for Future Internet

Future Internet Promises

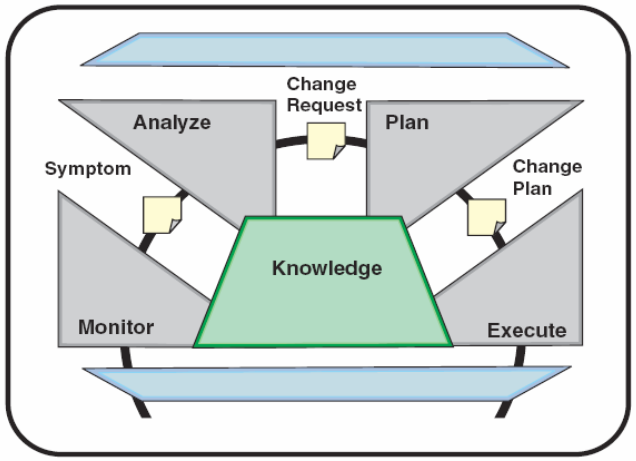
- Self-* (self-management, self-protection)
  - Reducing human intervention
  - Providing mobility, security, QoS, GreenIT,…
- Evolutionary and revolutionary approaches
  - Overlays ➔ Virtualization
  - In-network management
  - Functional composition
  - Business/Application-oriented networking
  - And many more

Decision cycles within networks

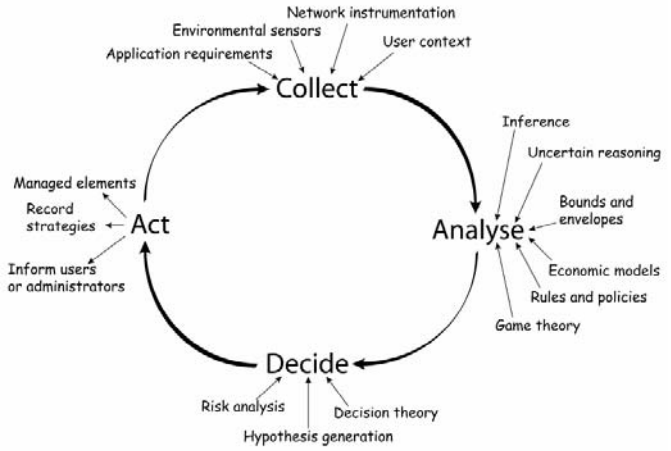
Decision Cycles



Human [Boyd]: OODA
Observe-Orient-Decide-Act



Autonomic Computing [IBM]: MAPE
Monitor-Analyze-Plan-Execute



Autonomic Communication [Dobson]:
Collect-Analyze-Decide-Act

Establish Situation Awareness

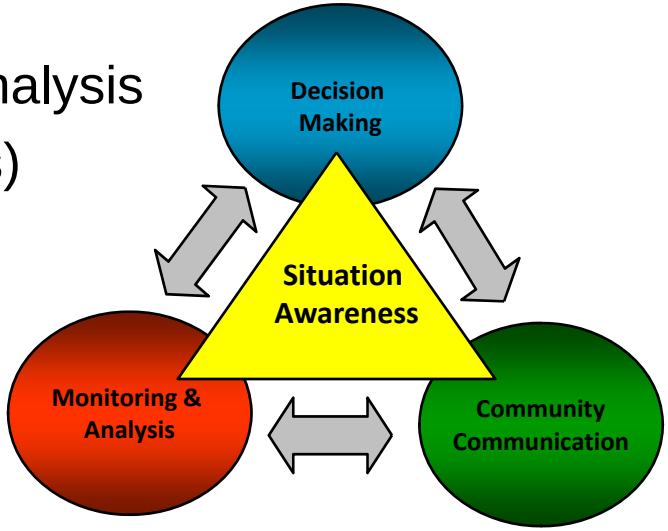
Situation Awareness

- A state of knowledge of the situation
  - Constantly evolving picture of the state of the environment
  - 3 levels: Perception, Inference, Prediction

Basis for sound decisions

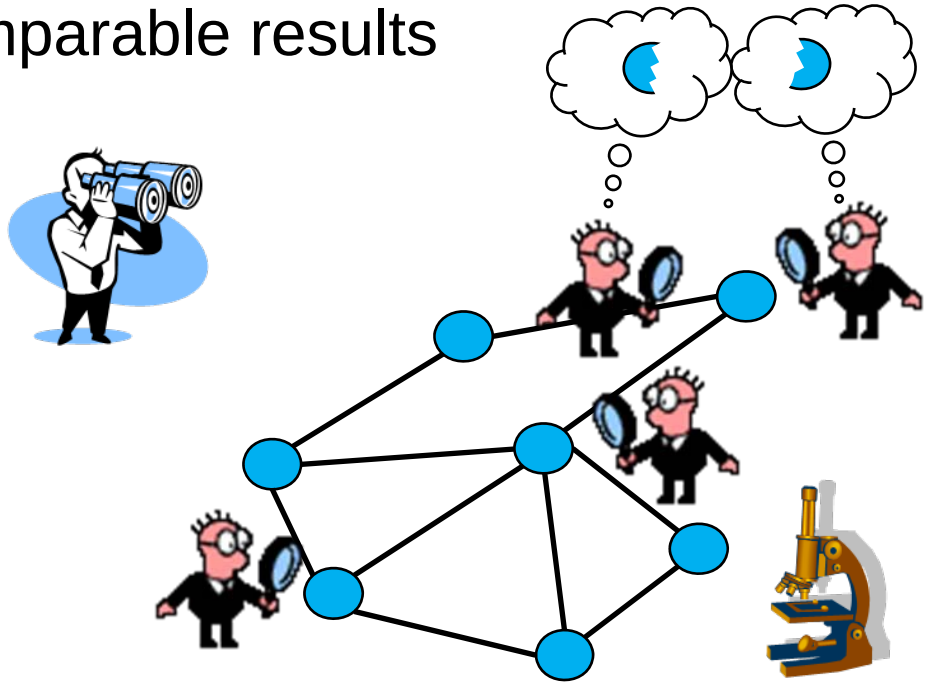
How to Achieve Situation Awareness?

- **Monitoring & Analysis**
  - Network measurements at multiple observation points
  - Changing viewpoints (zoom in and out)
  - Analysis (inference, prediction)
- **Community Communication**
  - Share viewpoints
  - Share resources for monitoring and analysis
  - Share local decisions (analysis results)



Desired Features for Traffic Observation

- **Network-wide**: multiple observation points
- **Flexible**: change viewpoints
- **Shareable**: comparable results



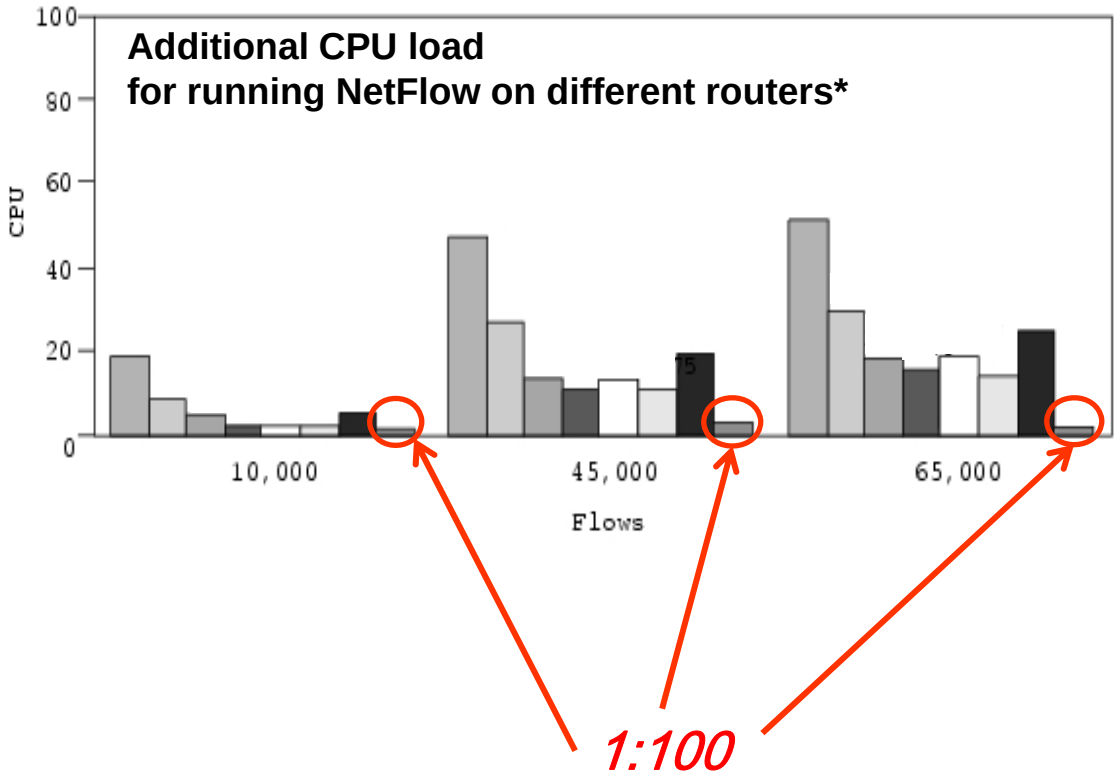
But: We can not measure everything everywhere!

Challenges of Traffic Observation

- Resource Limitations
  - Resource Consumption
  - Resource Control
  - Measurement adaptation
- Sharing Data
  - Multipoint Measurements
  - Comparability of measurement results
  - Standardized interfaces
  - Privacy
- Protection of measurement system
  - Against overload from traffic fluctuation
  - Against attacks

Resource Consumption

- Resource Limitations
  - Processing power
  - Transmission
  - Storage
- Demand depends on
  - Data rates
  - Required granularity
- Solutions
  - Dedicated Hardware
  - Improved Algorithms
  - Data Selection



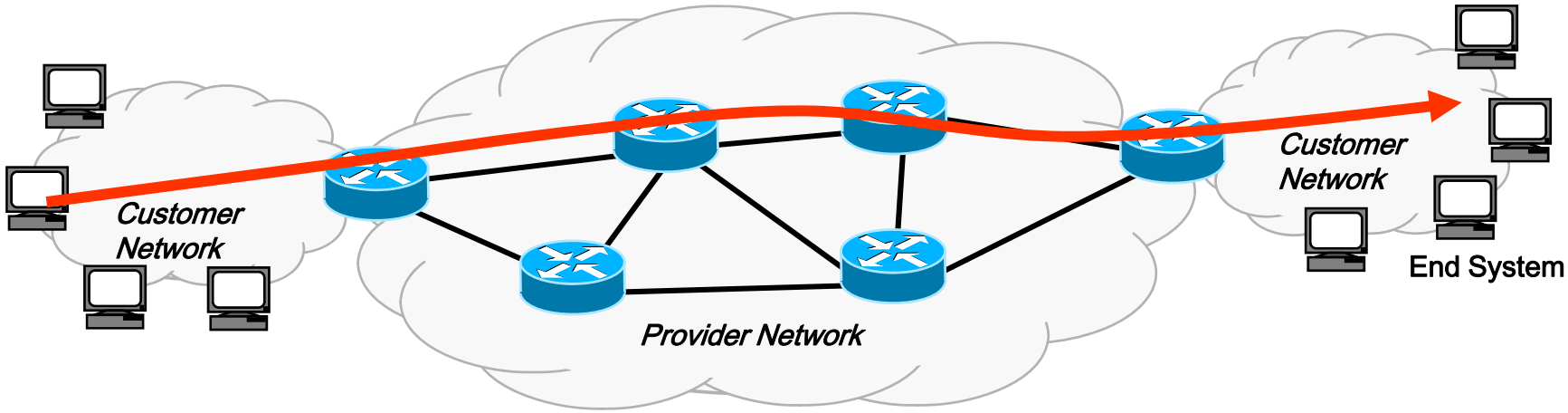
*source: NetFlow Performance Analysis, Cisco white paper

Example: Flow Measurements

Flow:= *packets with common properties*

Examples

- all packets from host A to host B
- all small packets
- all TCP-SYN packets
- all HTTP packets with URL www.whitehouse.gov



Example: Flow Measurements

Packet Attributes at Observation Point
s_i, –sequence number
t_i – arrival time
c_i – content (header, payload)

Packets: $<s_1, t_1, c_1>, <s_2, t_2, c_2>, \ldots <s_N, t_N, c_N>$

Classification $f(c_i)$

Flows:

FlowID 1:
$<s_1, t_1, c_1>$
$<s_4, t_4, c_4>$
$<s_8, t_8, c_8>$

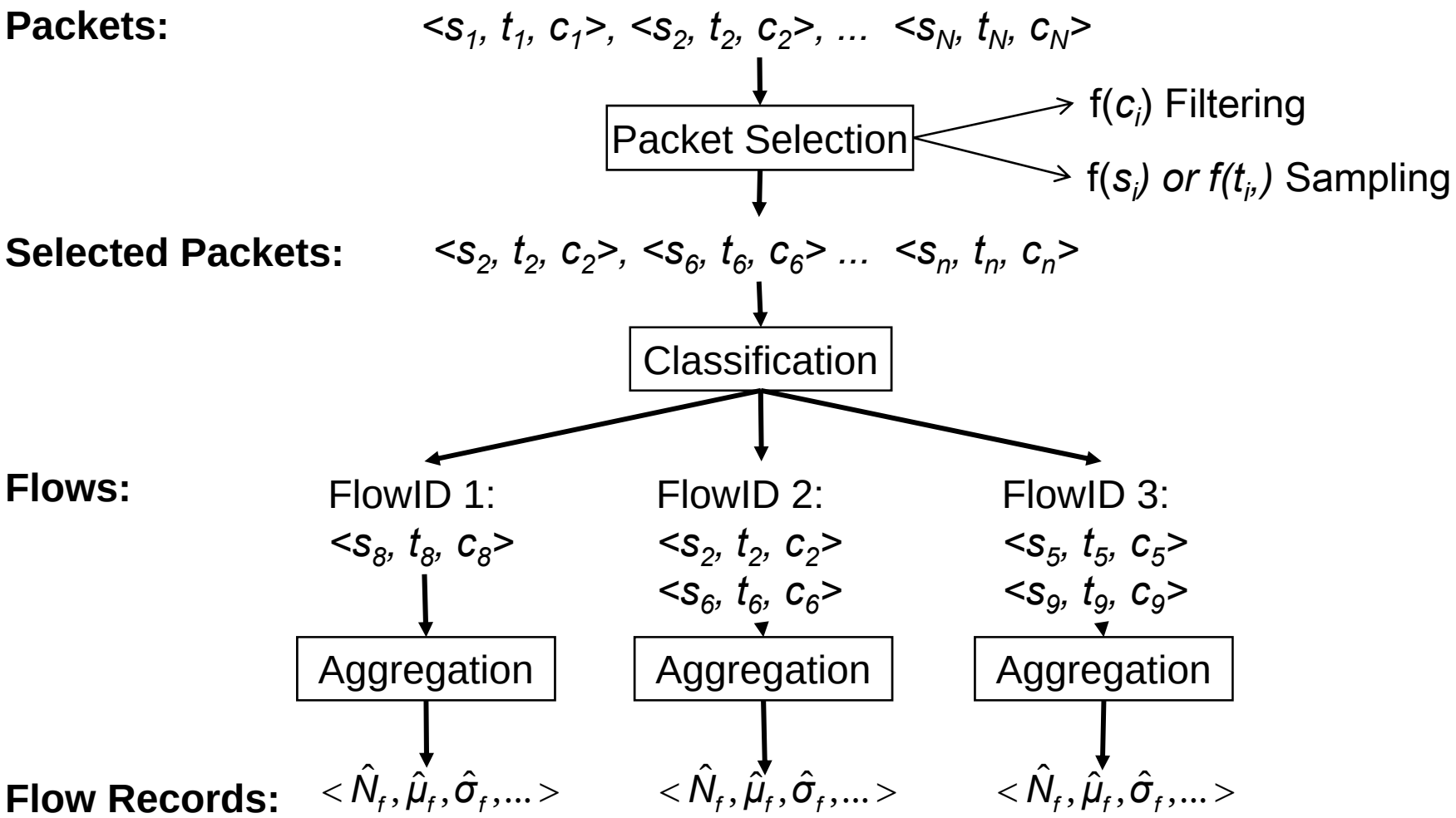
FlowID 2:
$<s_2, t_2, c_2>$
$<s_3, t_3, c_3>$
$<s_6, t_6, c_6>$

FlowID 3:
$<s_5, t_5, c_5>$
$<s_7, t_7, c_7>$
$<s_9, t_9, c_9>$

Aggregation | Aggregation | Aggregation

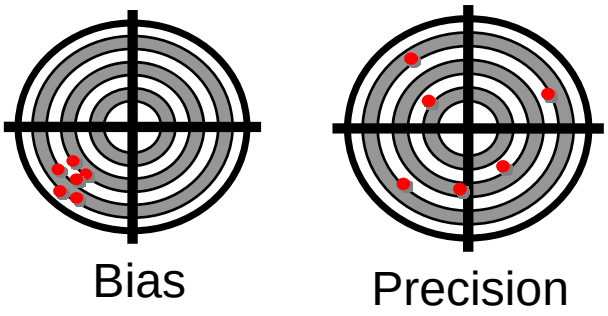
Flow Records: $< N_f, \mu_f, \sigma_f, \ldots >$ | $< N_f, \mu_f, \sigma_f, \ldots >$ | $< N_f, \mu_f, \sigma_f, \ldots >$

Packet Selection



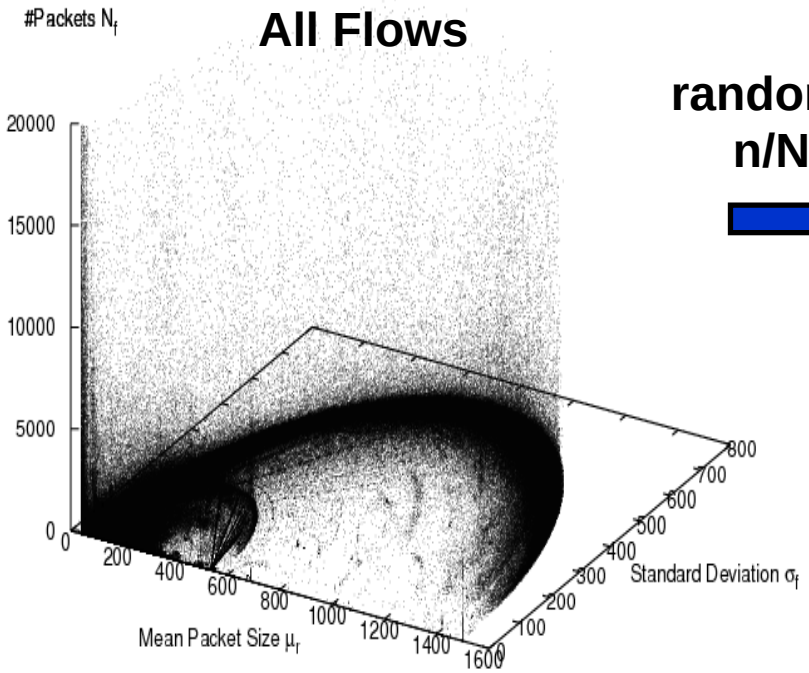
Problem1: Accuracy Assessment

Accuracy Assessment required



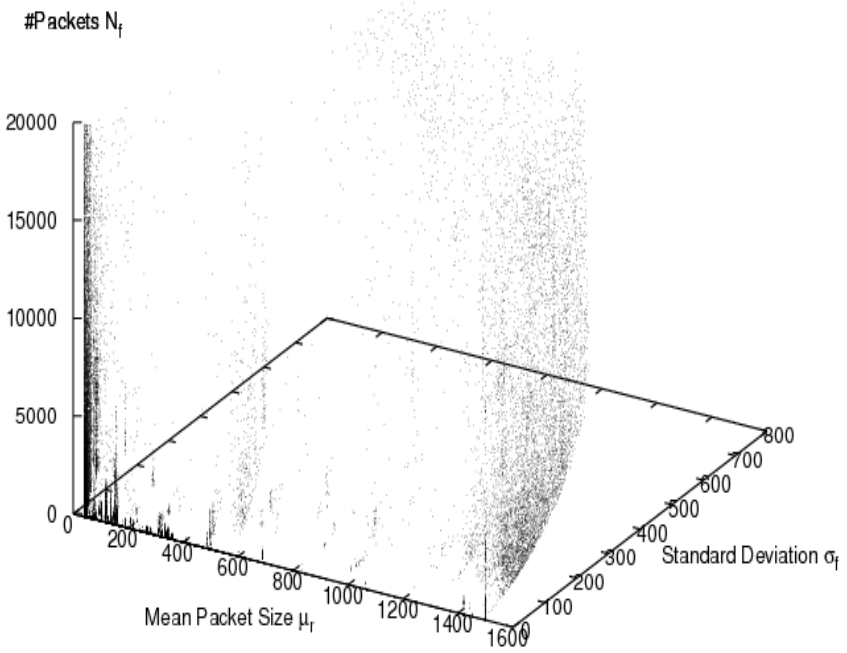
- Achievable accuracy depends on
  - Sampling and estimation method
  - Sampling parameters
  - Population characteristics ← **unknown and highly dynamic**
- Accuracy assessment **during** measurement
  - For each measurement interval
  - For each flow
  - Based on sampled data

Estimation Accuracy



CIRIL S24D00

random nofN
n/N=5%



CIRIL S24D00, compliant, rel. stderr<0.05

$$StdErr_{rel} = \frac{1}{N_f \cdot \mu_f} \cdot \sqrt{\frac{N \cdot N_f \cdot \left(\sigma_f^2 + \mu_f^2\right)}{n} - \frac{N_f^2 \cdot \mu_f^2}{N}}$$

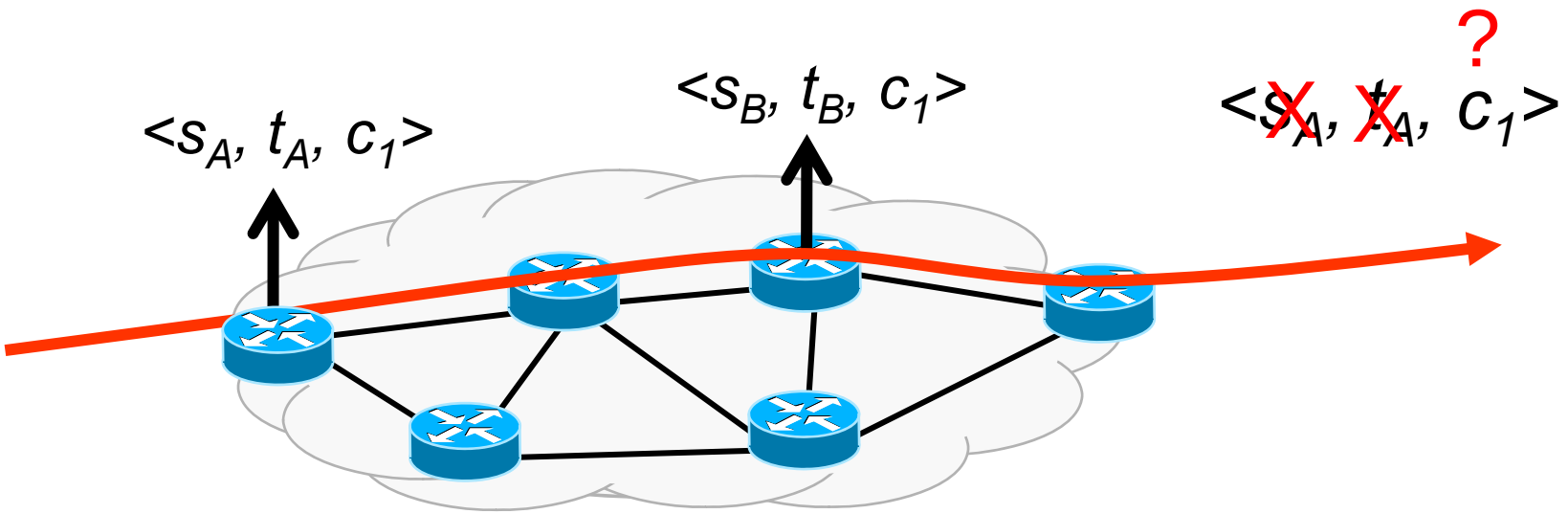
NetFlow Records $N_f, \sum x_f \quad \sum x_f^2$

Store sum of squares !

VEGAS project, funded by Cisco Systems

Problem2: Multipoint Data Selection

Goal: Select same packet at different observation points



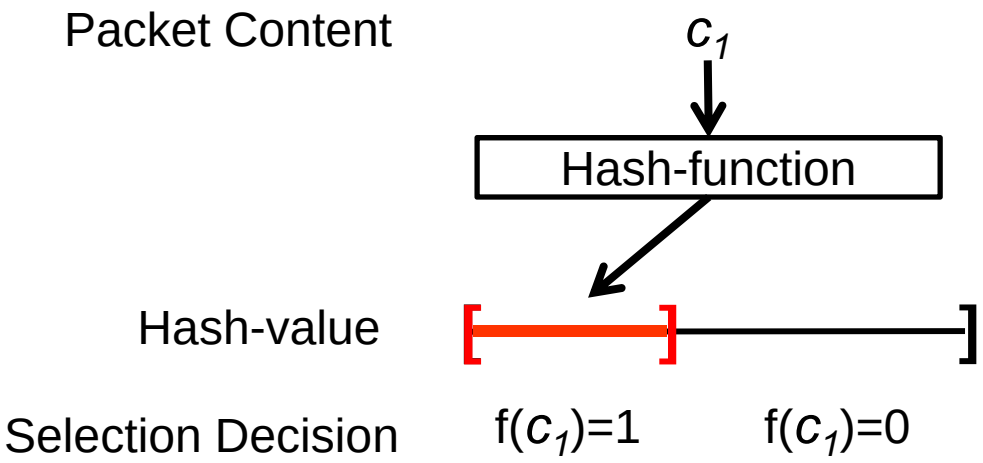
Sampling: f(s_i) *or* *f*(t_i,) ➔ ☹

Filtering: f(c_i) ➔ ☺

Packet Attributes at Observation Point
s_i, –sequence number
t_i – arrival time
c_i – content (header, payload)

Coordinated Packet Selection

Trajectory Sampling [Duffield&Grossglauser, 2001]



Goal: Emulate random selection

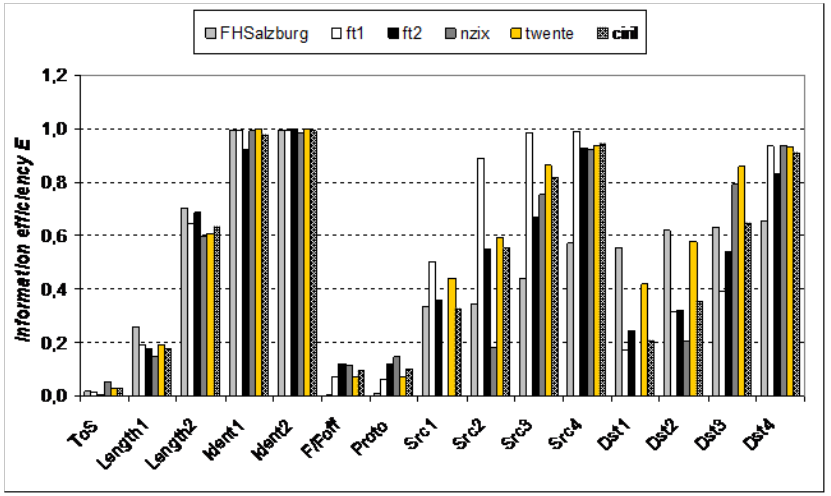
Coordinated Packet Selection

Problem1: Content Selection

Problem2: Detection Avoidance

Problem3: Random Emulation

Problem4: Sample size variation



FOKUS Contribution

- Empirical investigations on suitable content
  - invariant on the path, variable among packets
  - Initial investigations on IPv6
- Empirical investigations on bias
  - different traces and functions
- Standardization of suitable hash functions

IETF Standardization

- IP Flow Information Export (IPFIX) ➔ RFC5101
  - Export of flow information from routers and probes
  - Flexible flow definition
- Packet Sampling (PSAMP)
  - Export of packet information over IPFIX
  - Specification of packet selection techniques
  - Configuration of packet selection techniques
- FOKUS contribution
  - IPFIX requirements (RFC3917), implementation guidelines, applicability statement, file format, testing, extensions
  - PSAMP selection techniques
  - FOKUS Open Source IPFIX library

Conclusion

- Traffic observation is essential
  - For network research and operation
  - For future Internet concepts
- Some solutions, but still many challenges
  - Example: Resource consumption
  - Example: Multipont data selection

- Ongoing activities towards future Internet
  - ANA: Functional Composition
  - 4WARD: In-Network management based on situation awareness
  - PRISM: privacy-preserving methods to achieve situation awareness
  - Onelab2: support for experimental research

Thank you!

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FOKUS Open Source IPFIX Library:
http://net.fokus.fraunhofer.de/libipfix/

Measurement data always welcome at:
http://www.ist-mome.org/

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