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Coordinated Non-intrusive Capturing of Flow Paths

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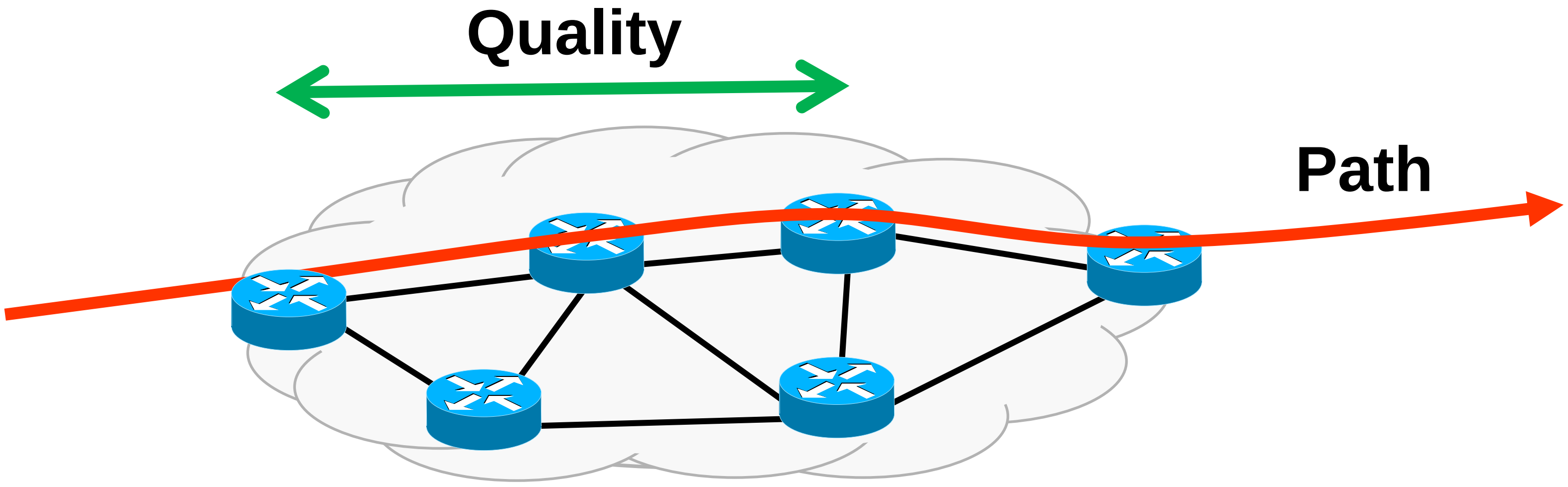
OneLab
FUTURE INTERNET TEST BEDS

Motivation

- Traffic Observation
  - Network operation (management, security,..)
  - Information to users (quality, path)
  - Adaptive network algorithms
- Answering questions
  - routes that are followed by my flows through the network
  - delays and losses that occurred between nodes
  - quality that was experienced by my traffic

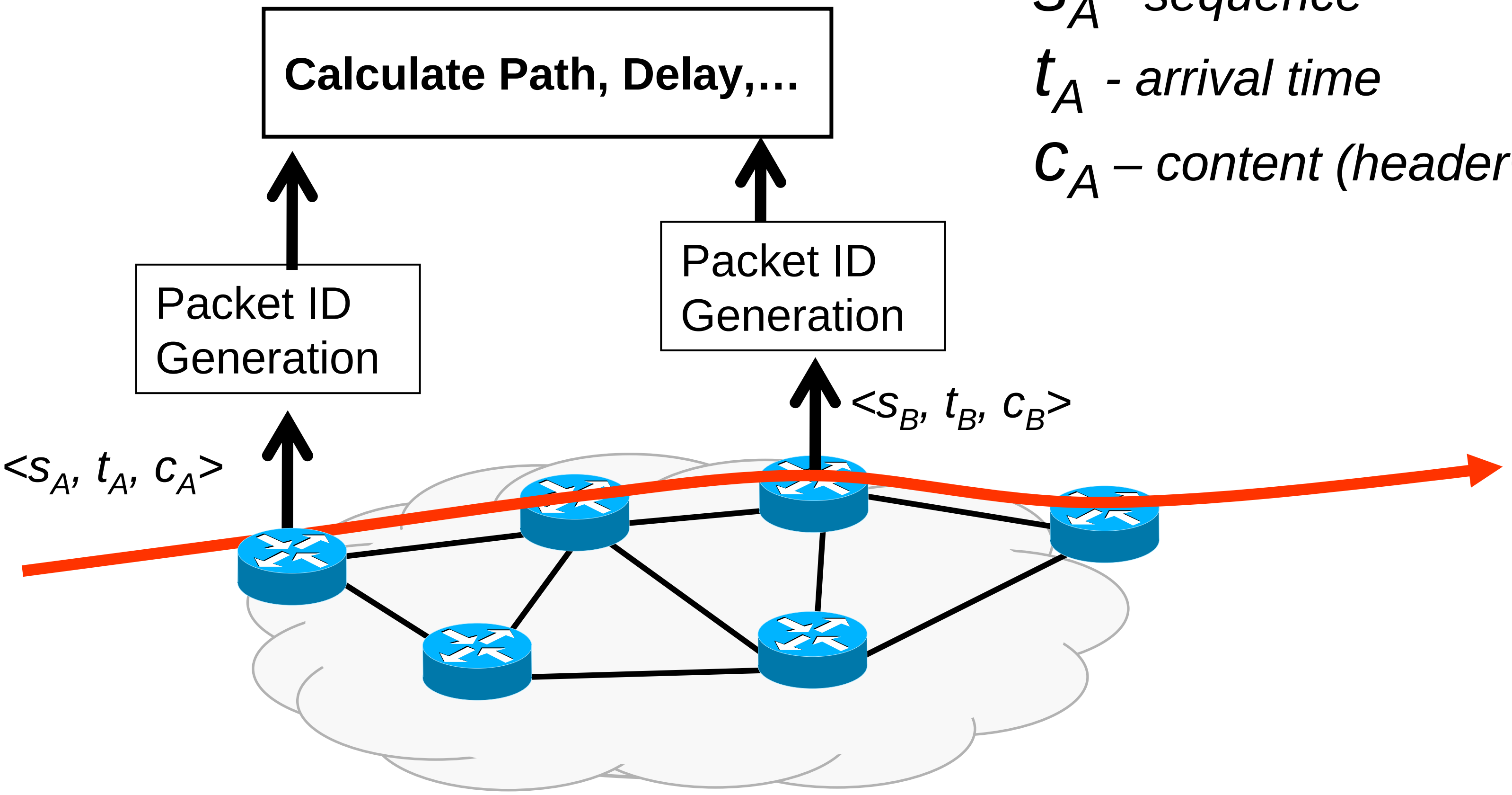
Coordinated Traffic Observation

- Hop-by-hop ***path*** and ***quality*** of packet delivery



- ***Coordinated*** network observation
- ***Non-Intrusive*** measurement method

Capturing the Path



Calculate Path, Delay,…

Packet ID Generation

Packet ID Generation

$<s_A, t_A, c_A>$

$<s_B, t_B, c_B>$

s_A - *sequence*

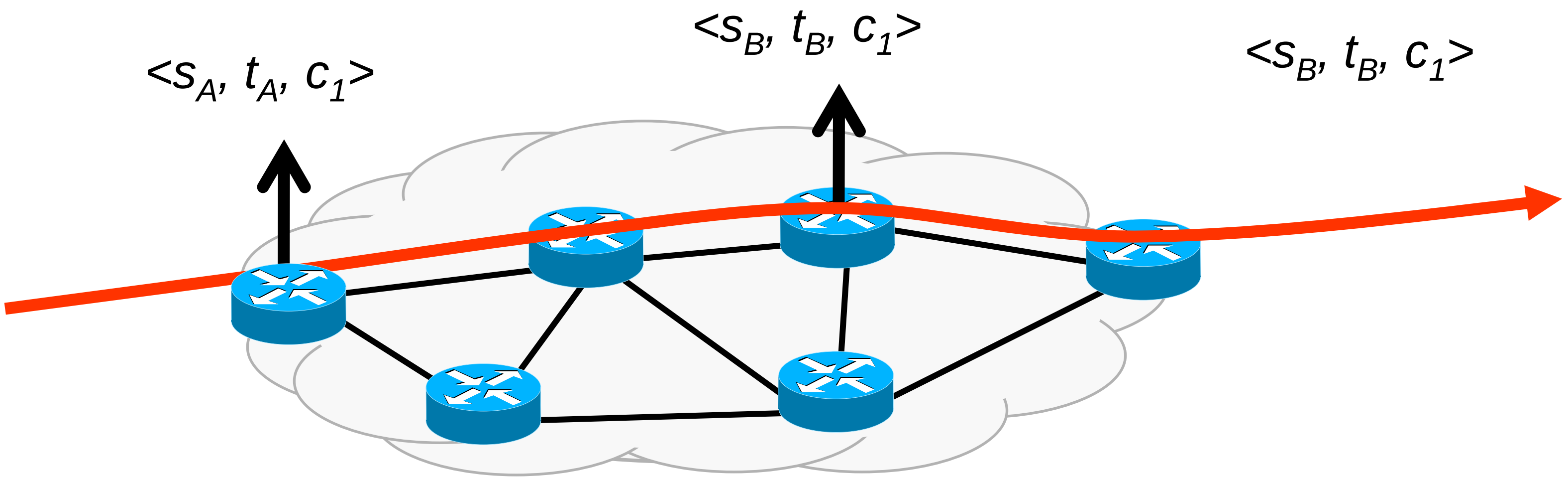
t_A - *arrival time*

c_A – *content (header+payload*

Correlation of events at different observation points based on **packet ID** (from parts of packet content)

Challenge: Coordinated Data Selection

Select same packet at different observation points


$\langle s_A, t_A, c_1 \rangle$
$\langle s_B, t_B, c_1 \rangle$
$\langle s_B, t_B, c_1 \rangle$

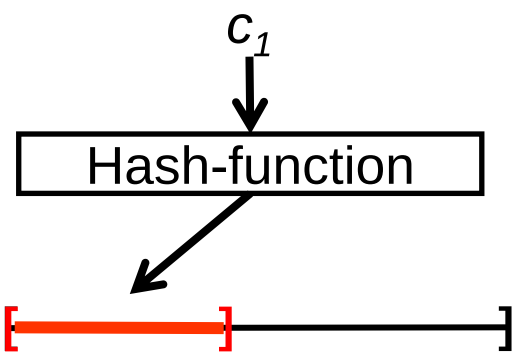
<u>Selection Processes:</u>

Filtering: f(c_i) ➔ parts on c remain ➔ can select same packets ☺

Sampling: f(s_i) *or f(t_i,)* ➔ *s, t* change ➔ cannot select same ☹

Hash-based Selection [RFC5475]

Goal: Select same packet at different observation points



Packet Content: c_1

Hash-function

Hash-value:

Selection Decision: $f(c_1)=1$ $f(c_1)=0$

Duffield, Grossglauser: Trajectory Sampling, 2001

[RFC 5475] Zseby, Molina, Duffield, Niccolini, Raspall. Sampling and Filtering Techniques for IP Packet Selection, RFC 5475, Standards Track, March 2009.

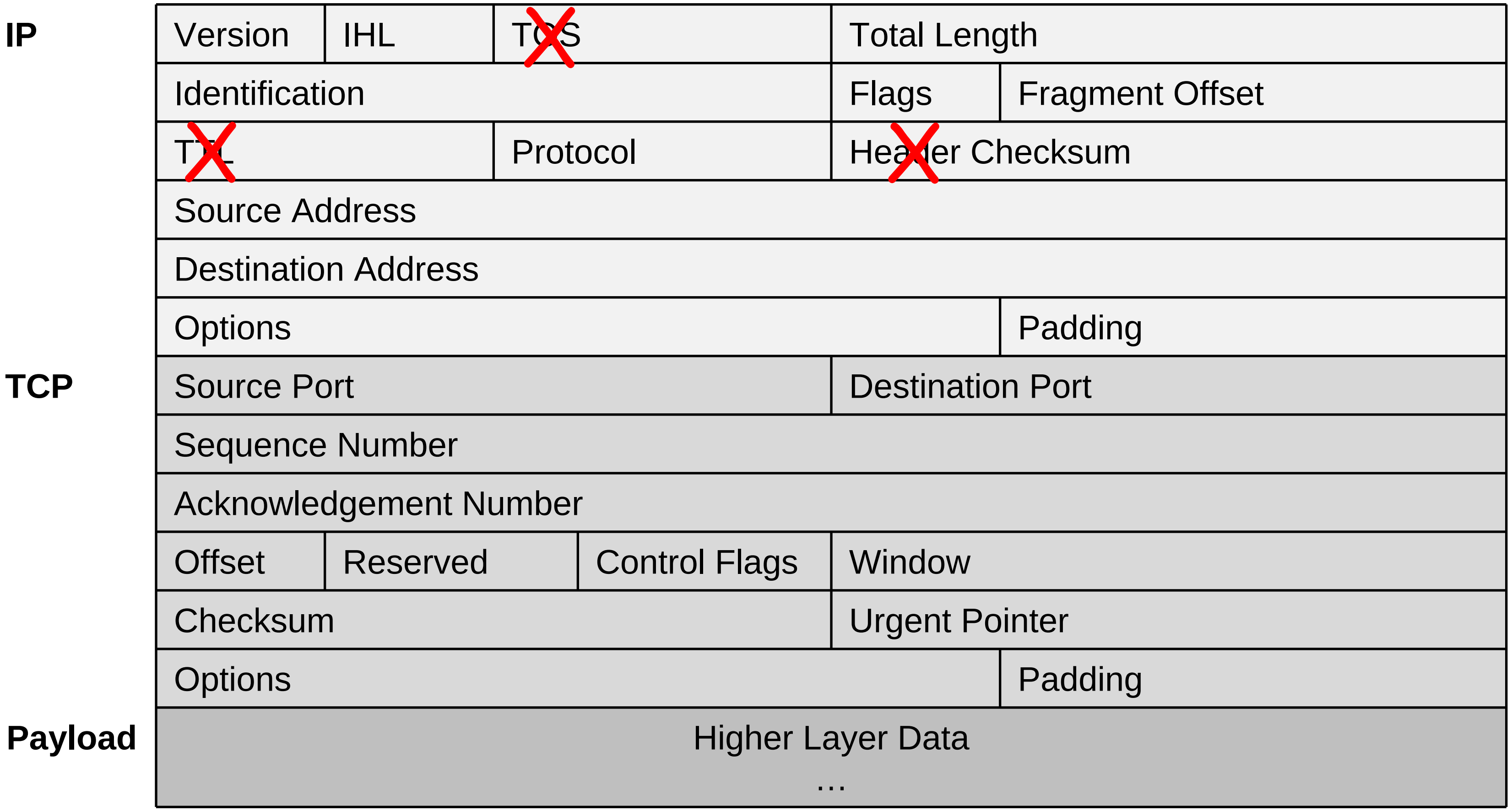
Challenges

Goal: Emulate random selection

- **Problem1:** Some content not suitable ➔ Content Selection
- **Problem2:** Predictability of selection decision ➔ Detection Avoidance
- **Problem3:** Deterministic operation ➔ Biased Selection
- **Problem4:** Variability of traffic ➔ Sample size variation

Suitable Content

Criterion1: Invariant on the path



IP

Version | IHL | ~~TOS~~ | Total Length

Identification | Flags | Fragment Offset

~~TTL~~ | Protocol | ~~Header Checksum~~

Source Address

Destination Address

Options | Padding

TCP

Source Port | Destination Port

Sequence Number

Acknowledgement Number

Offset | Reserved | Control Flags | Window

Checksum | Urgent Pointer

Options | Padding

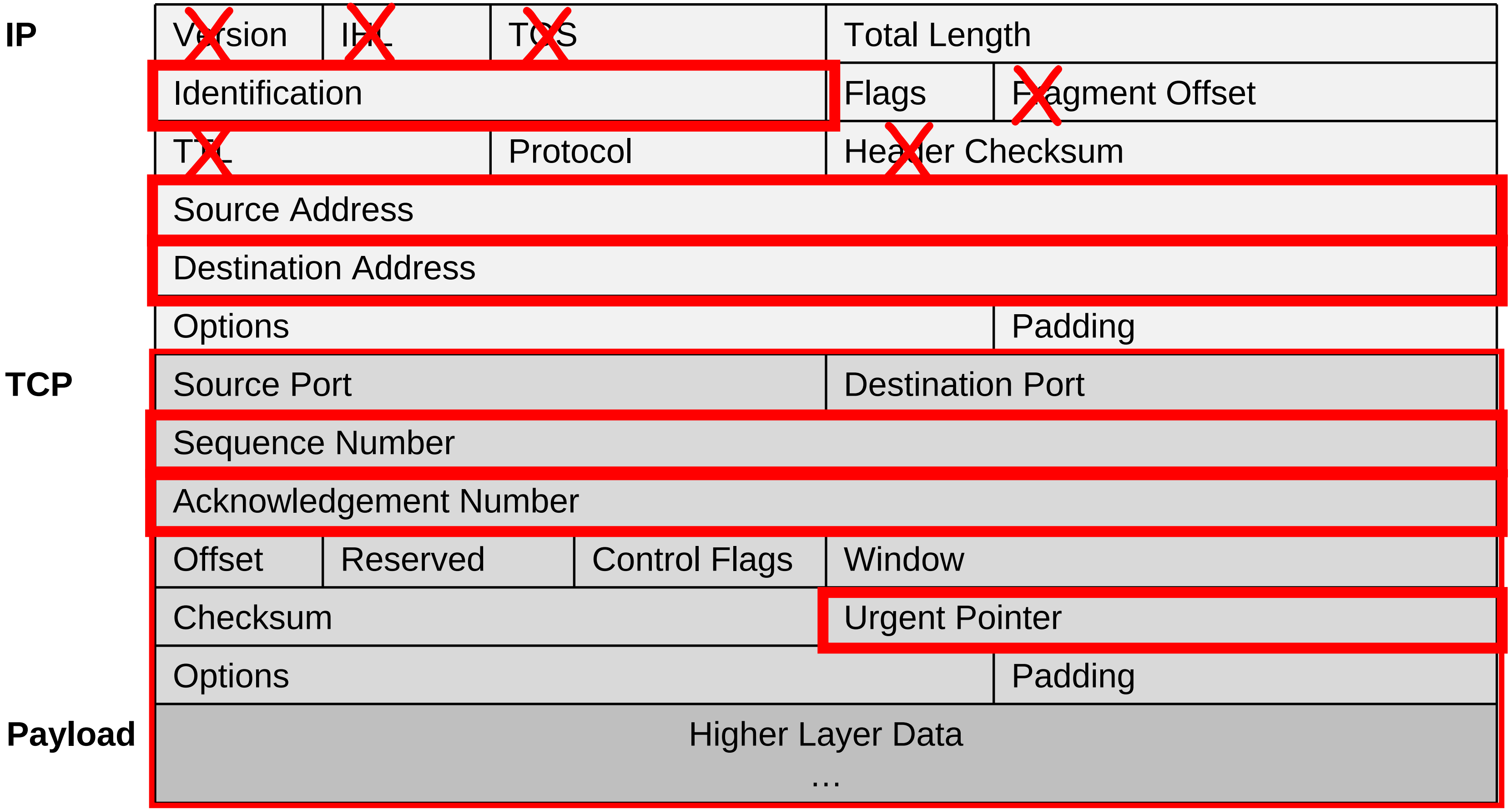
Payload

Higher Layer Data

…

Suitable Content

Criterion2: Variable among packets ➔ Theoretical and Empirical



IP

~~Version~~ | ~~IHL~~ | ~~TOS~~ | Total Length

Identification | Flags | ~~Fragment Offset~~

~~TTL~~ | Protocol | ~~Header Checksum~~

Source Address

Destination Address

Options | Padding

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Sequence Number

Acknowledgement Number

Offset | Reserved | Control Flags | Window

Checksum | Urgent Pointer

Options | Padding

Payload

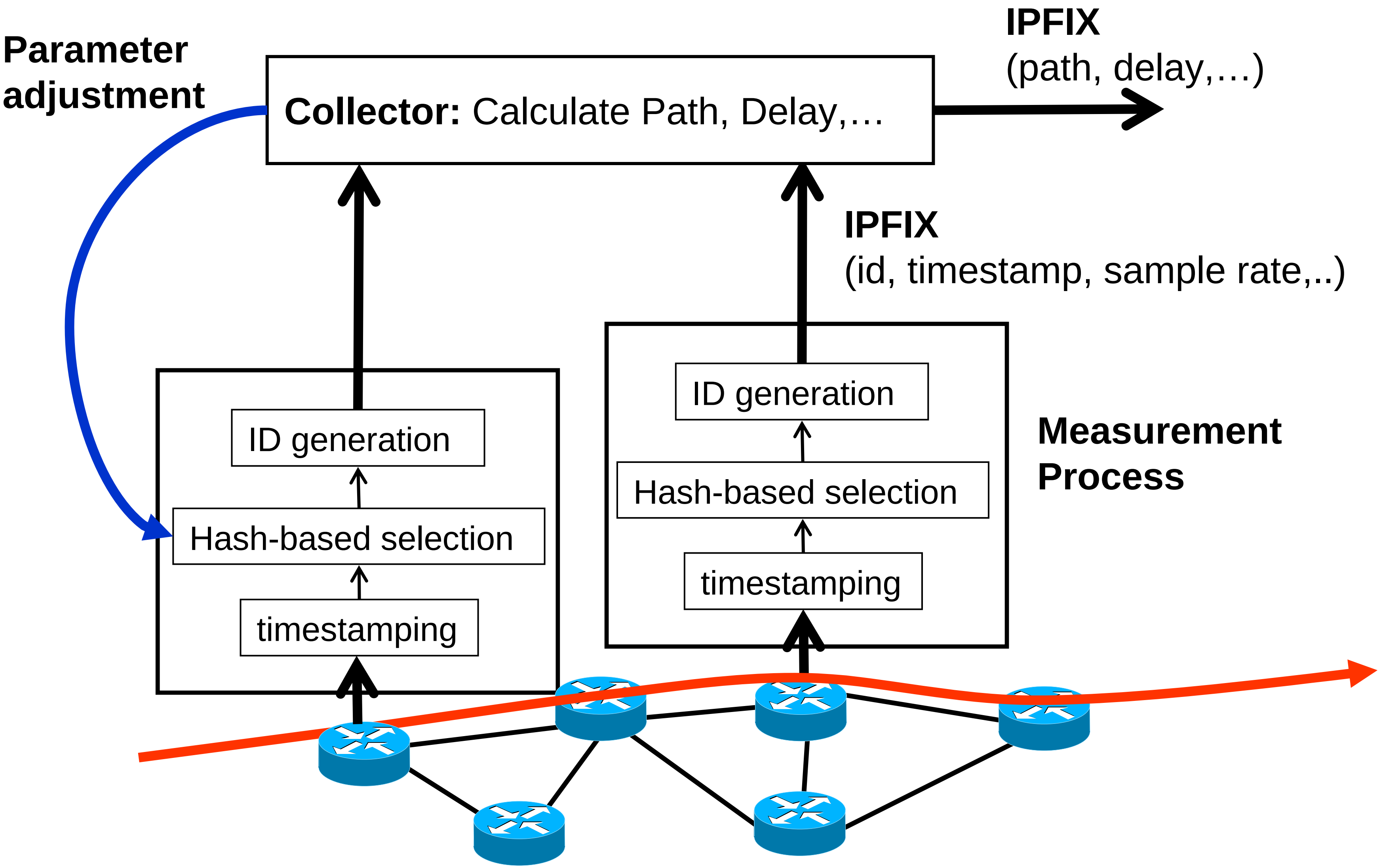
Higher Layer Data

…

Coordinated Packet Selection

- Problem1: Content selection (further challenges)
  - IPv6 ➔ different fields, few data available
  - Middlebox operations (e.g., NAT)
- Problem2: Predictability of selection decision
  - [Goldberg&Rexford, 2007]: Crypto-strong PRF with secret key
- Problem3: Bias
  - Traffic Dependent (!)
- Problem4: Sample size variation
  - Adaptation to CPU load ➔ but further investigations needed

Adaptation of Parameters



Parameter adjustment

Collector: Calculate Path, Delay,…

IPFIX
(path, delay,…)

IPFIX
(id, timestamp, sample rate,..)

ID generation

Hash-based selection

timestamping

ID generation

Hash-based selection

timestamping

Measurement Process

Advantages

- Non-intrusive
  - No test traffic, no side effects
  - Quality statement about real traffic ➔ SLA validation
- Controllable costs
  - Sampling parameter adjustment
  - Heterogeneous/federated environments
- Privacy-preserving
  - Sampling and aggregation, no DPI
- Standardized data export (IPFIX)
  - Comparability of results, re-usability of tools, traces
  - Reduction of errors from conversion steps

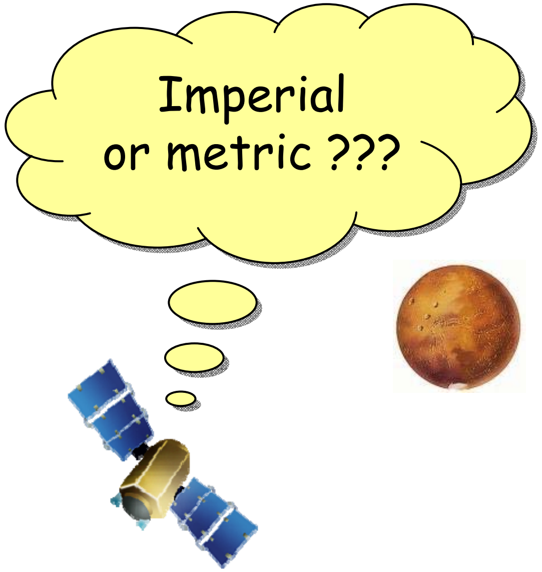
Main Contributions

- Investigations on suitable hash-functions
  - Statistical properties, performance [HeSZ08]
- Sampling parameter adjustment
  - Adjust accuracy and resource consumption
  - Coordinate parameter settings in heterogeneous/federated environments
- Contributions to Standardization
- Deployment in experimental facilities
- Open Source Packet Tracking Software

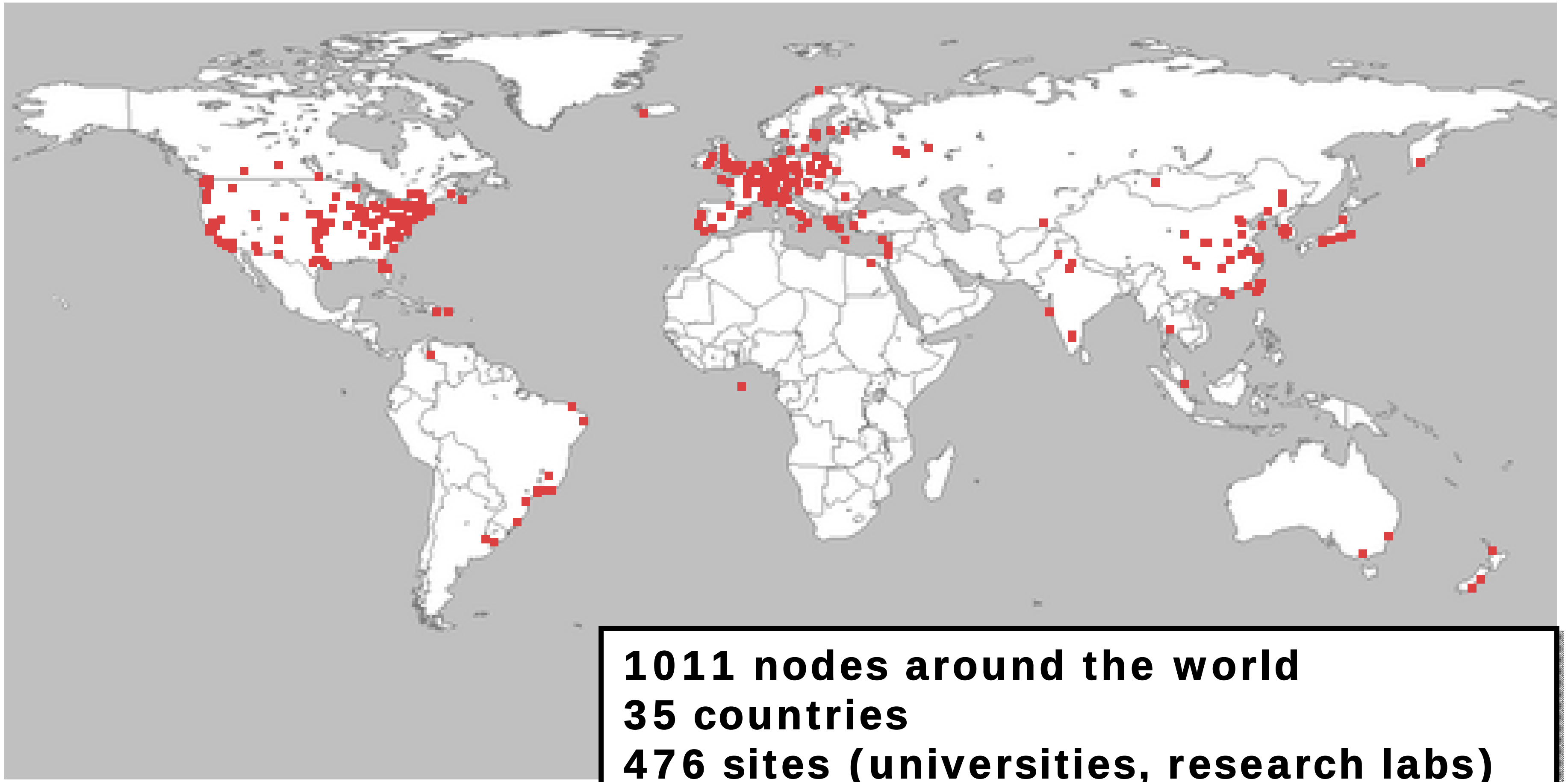
HeSZ08] Henke, Schmoll, Zseby: Empirical Evaluation of Hash Functions for Multipoint Measurements, ACM Comput. Commun. Rev. CCR 38, 3, July 2008.

Standardization is Crucial

- Provide comparability of results
  - Allow comparison of results
  - Provide reference data
- Reduce Costs
  - Common interfaces for analysis tools
  - Re-usage of archived data
- Reduce errors
  - Avoid error-prone conversion steps
  - Gain experiences with only one format



PlanetLab



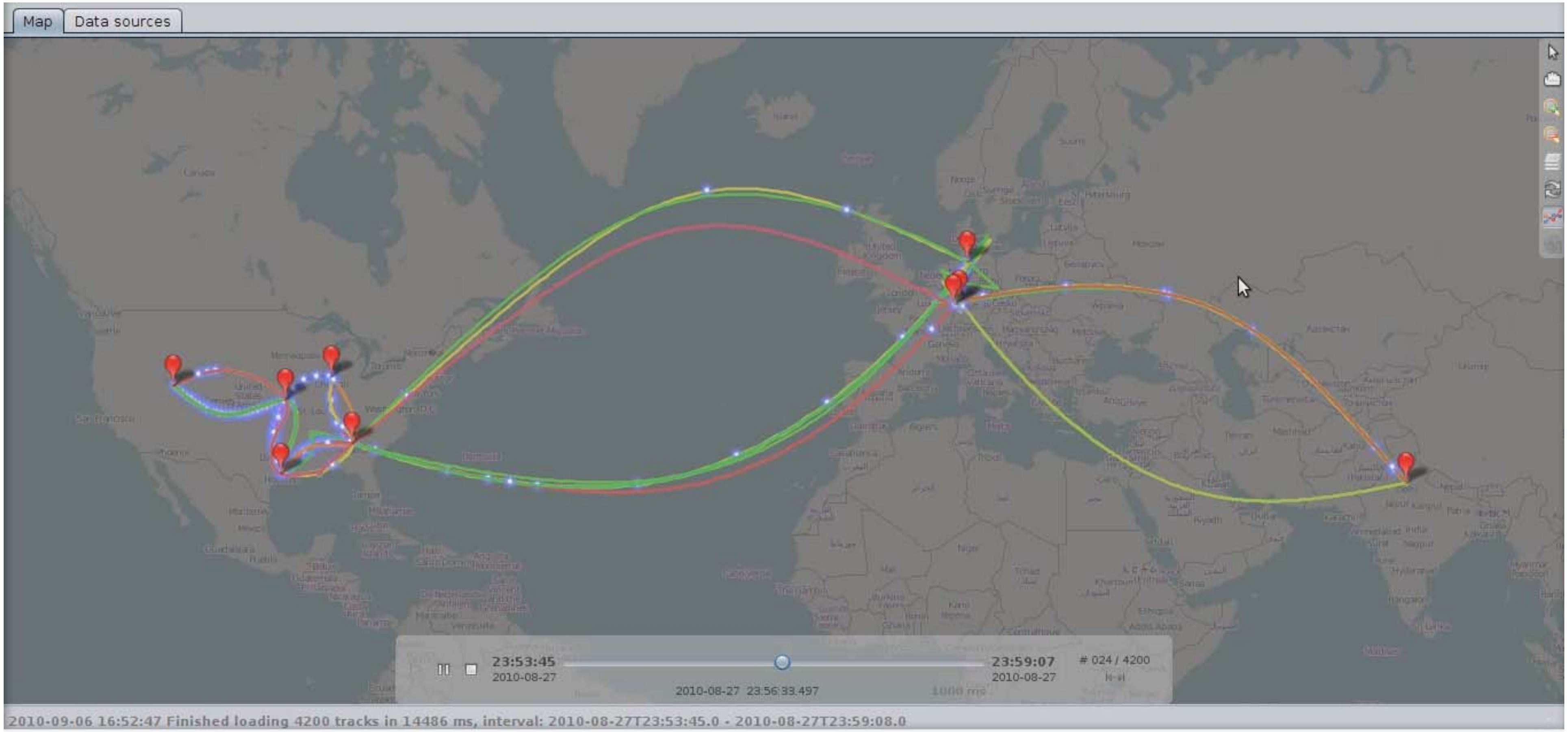
Picture from www.planet-lab.org

1011 nodes around the world
35 countries
476 sites (universities, research labs)
more than 1000 researchers

PlanetLab Europe

- PlanetLab Nodes in Europe
  - PLE Control in Paris (UPMC)
  - In cooperation with PlanetLab Central, Princeton
  - PLE users have access to whole PlanetLab
  - Profit from additional testbeds and new tools
- Supported by the EU FIRE Project OneLab
  - Development of new tools for PLE users
  - Integration of new testbed types: wireless, autonomic, DTNs, etc.
  - Federation with other testbeds
- http://www.planet-lab.eu/

Demonstration



2010-09-06 16:52:47 Finished loading 4200 tracks in 14486 ms, interval: 2010-08-27T23:53:45.0 - 2010-08-27T23:59:08.0

Future Work

- Deployment in Future Internet testbeds
  - Support for experimentere
  - OneLab, G-Lab, Federica, KOREN, ..)
- Solutions for IPv6
  - Different Header fields
  - Different traffic patterns

  ➔new recommendations for hash functions
- New Applications
  - Support for Routing Security

Thank you!

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