

# Coordinated Non-intrusive Capturing of Flow Paths

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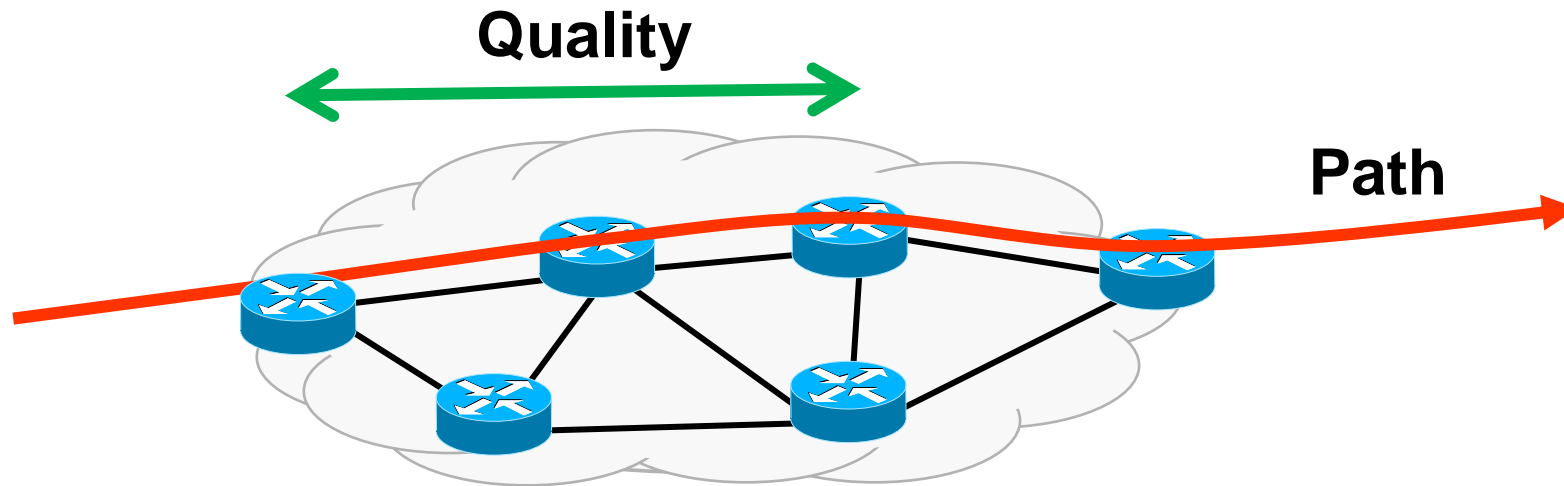
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# Motivation

- 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

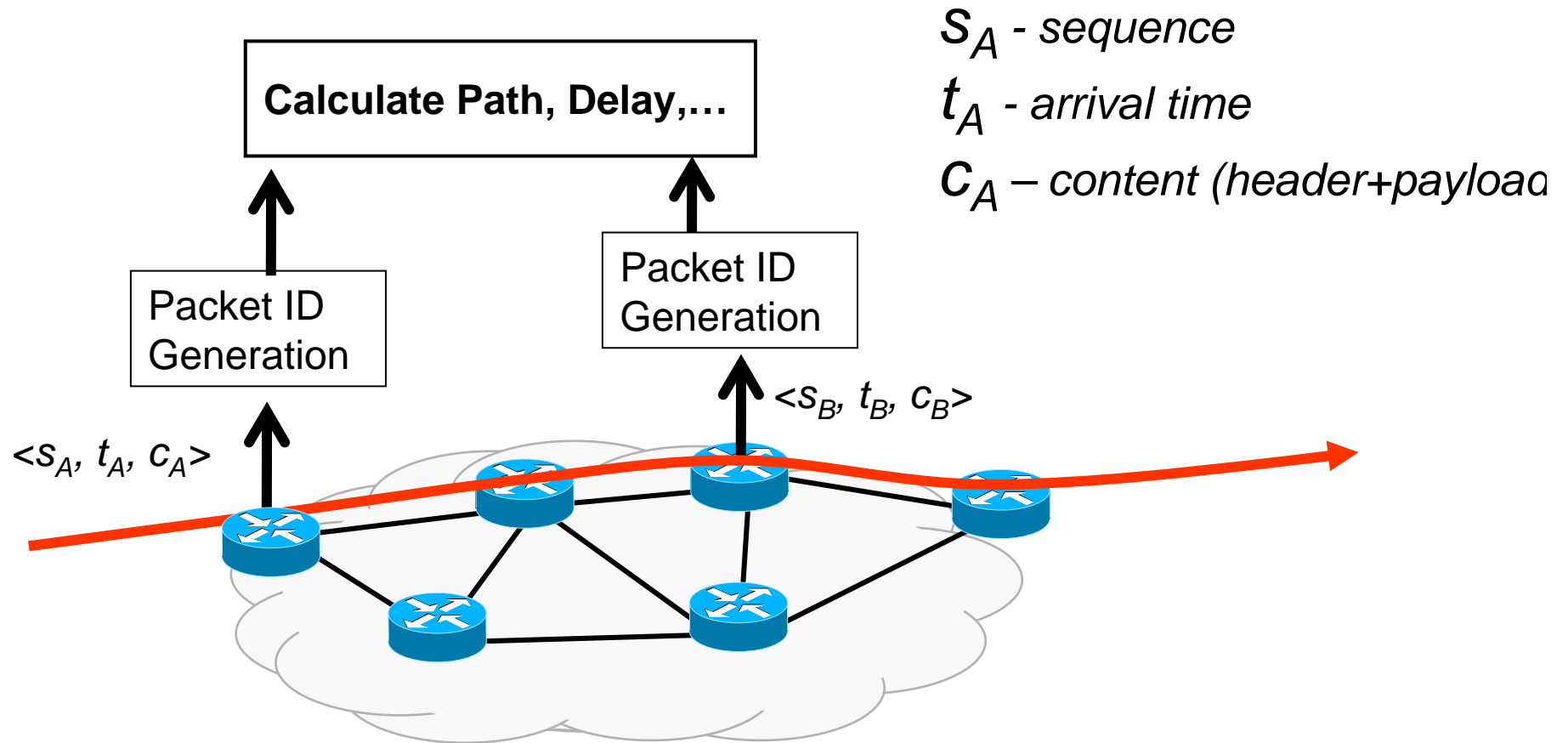
# Coordinated Traffic Observation

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



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

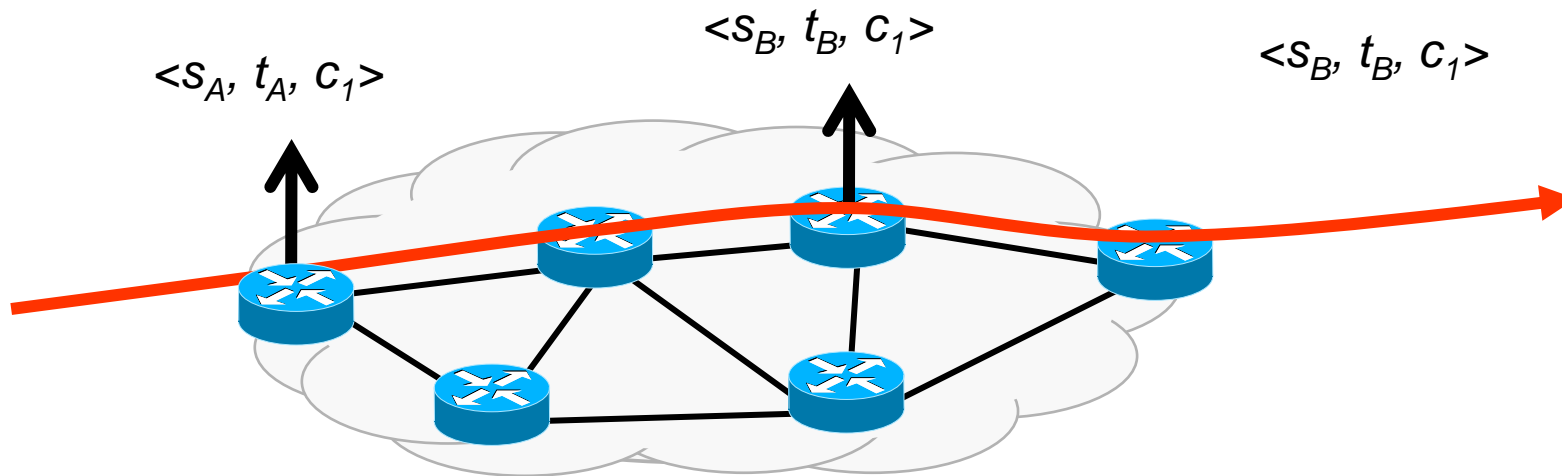
# Capturing the Path



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



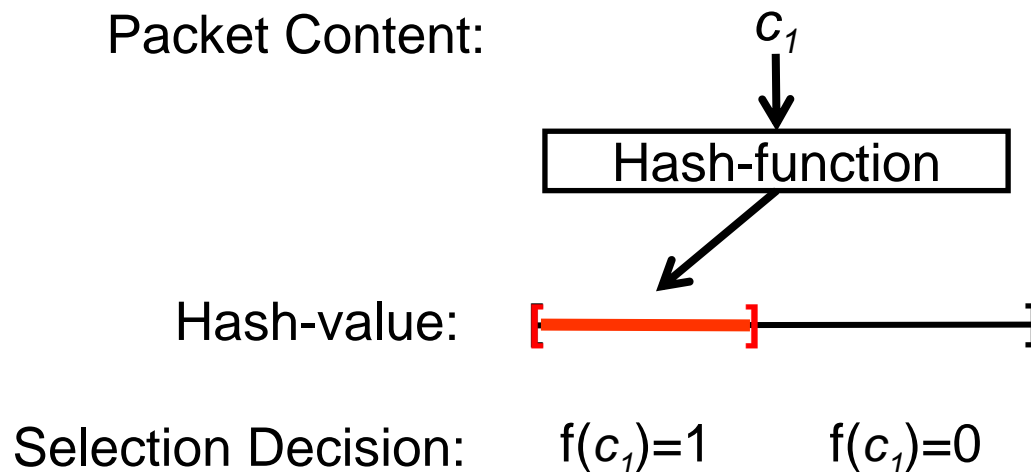
## Selection Processes:

Filtering:  $f(c_i)$   $\rightarrow$  parts on  $c$  remain  $\rightarrow$  can select same packets 😊

Sampling:  $f(s_i)$  or  $f(t_i)$   $\rightarrow$   $s, t$  change  $\rightarrow$  cannot select same 😞

# Hash-based Selection [RFC5475]

**Goal: Select same packet at different observation points**



Duffield, Grossglauer: 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

<b>IP</b>	Version	IHL	<del>TOS</del>	Total Length	
	Identification			Flags	Fragment Offset
	<del>TTL</del>	Protocol		<del>Header</del> Checksum	
	Source Address				
	Destination Address				
	Options				Padding
	<b>TCP</b>	Source Port			Destination Port
Sequence Number					
Acknowledgement Number					
Offset		Reserved	Control Flags	Window	
Checksum			Urgent Pointer		
Options				Padding	
<b>Payload</b>		Higher Layer Data ...			



# Suitable Content

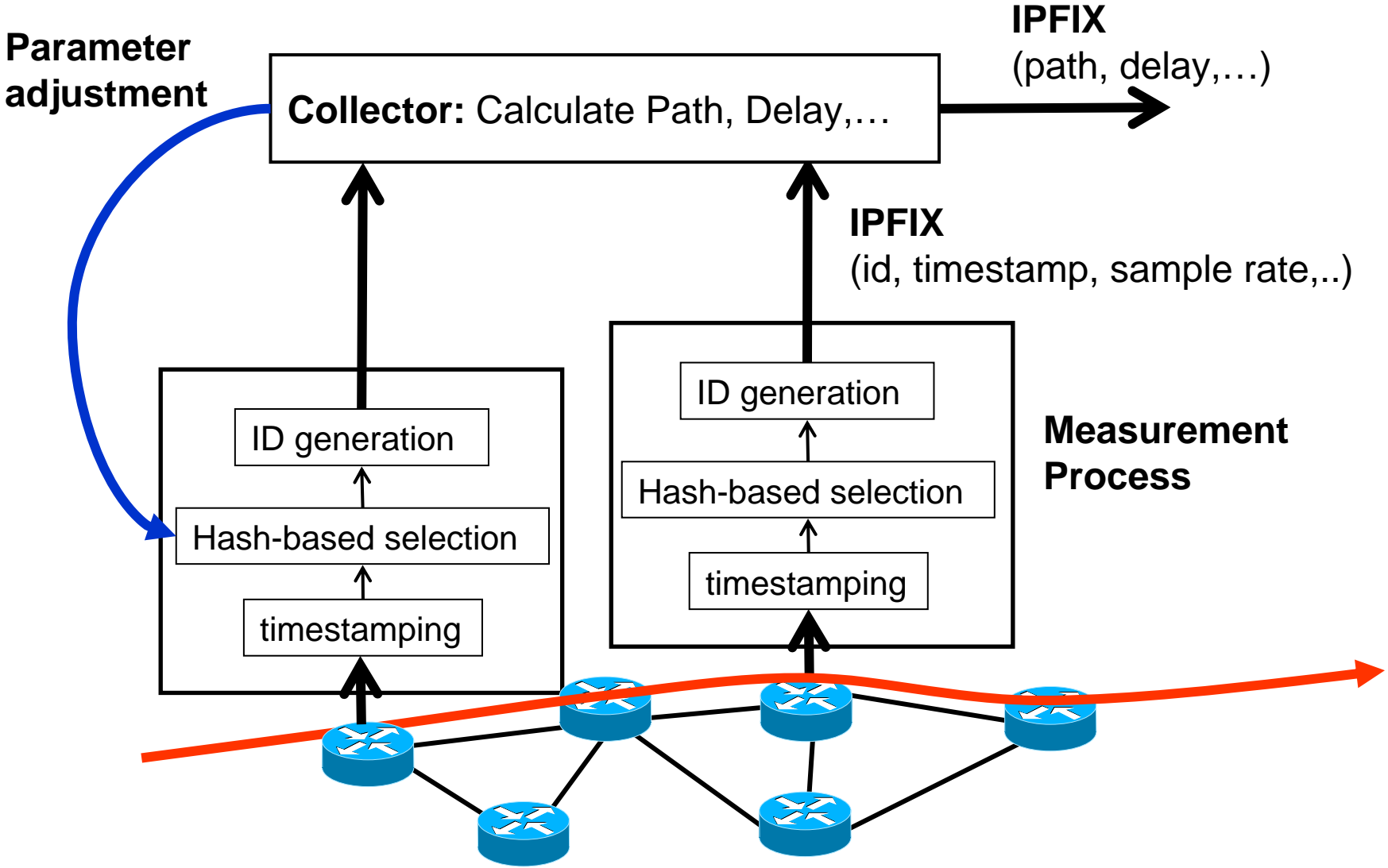
**Criterion2: Variable among packets → Theoretical and Empirical**

<b>IP</b>	<del>Version</del>	<del>IP L</del>	<del>TOS</del>	Total Length		
	Identification			Flags	<del>Fragment Offset</del>	
	<del>TTL</del>	Protocol		<del>Header Checksum</del>		
	Source Address					
	Destination Address					
	Options			Padding		
<b>TCP</b>	Source Port			Destination Port		
	Sequence Number					
	Acknowledgement Number					
	Offset	Reserved	Control Flags	Window		
	Checksum			Urgent Pointer		
	Options			Padding		
<b>Payload</b>	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



# 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

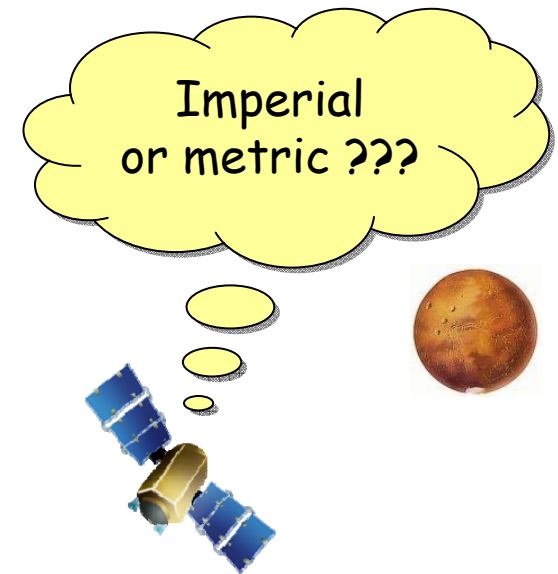
# Main Contributions

- 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

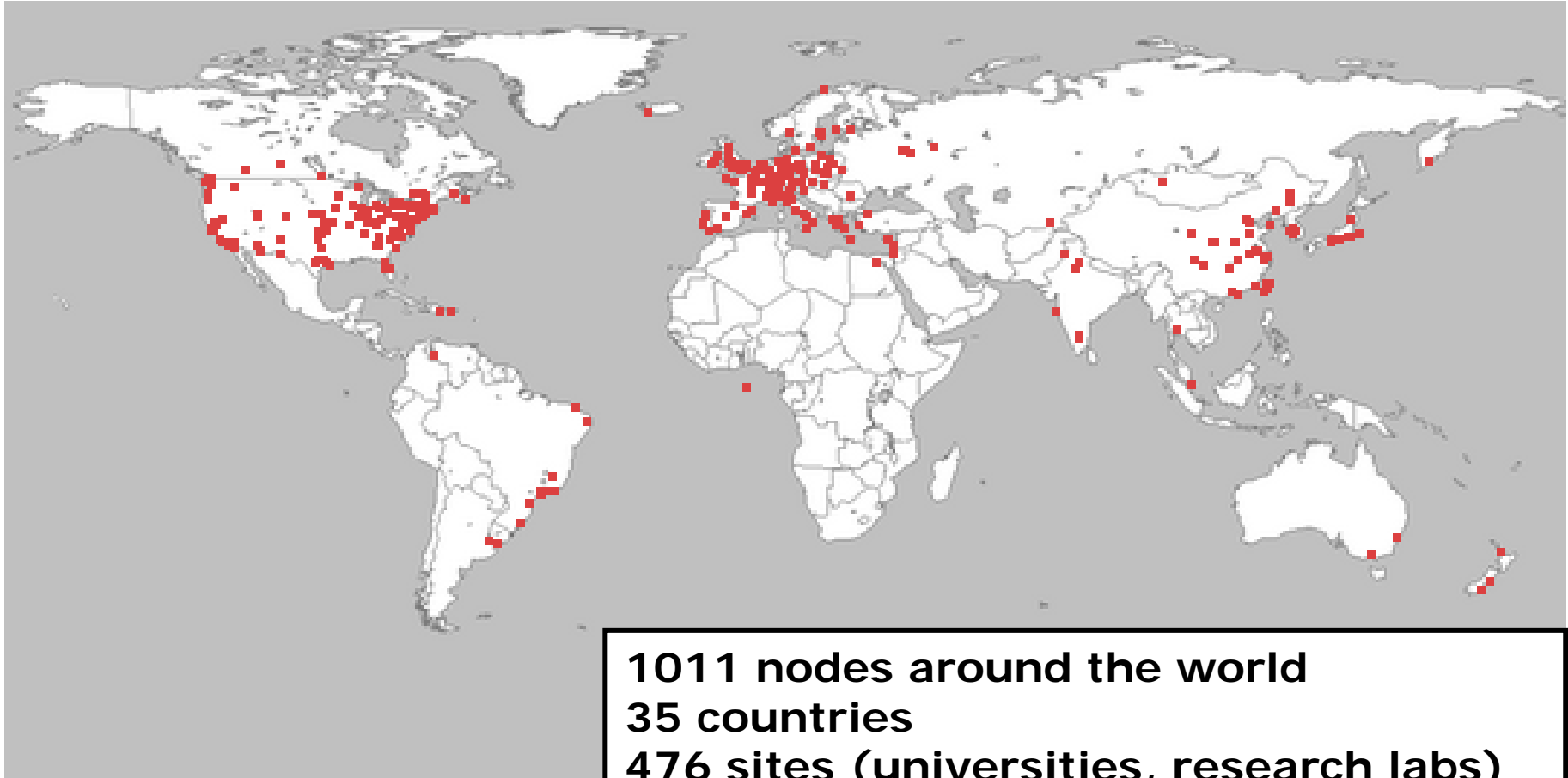
HeSZ08] Henke, Schmoll, Zseby: Empirical Evaluation of Hash Functions for Multipoint Measurements, ACM Comput. Commun. Rev. CCR 38, 3, July 2008.

# 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



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

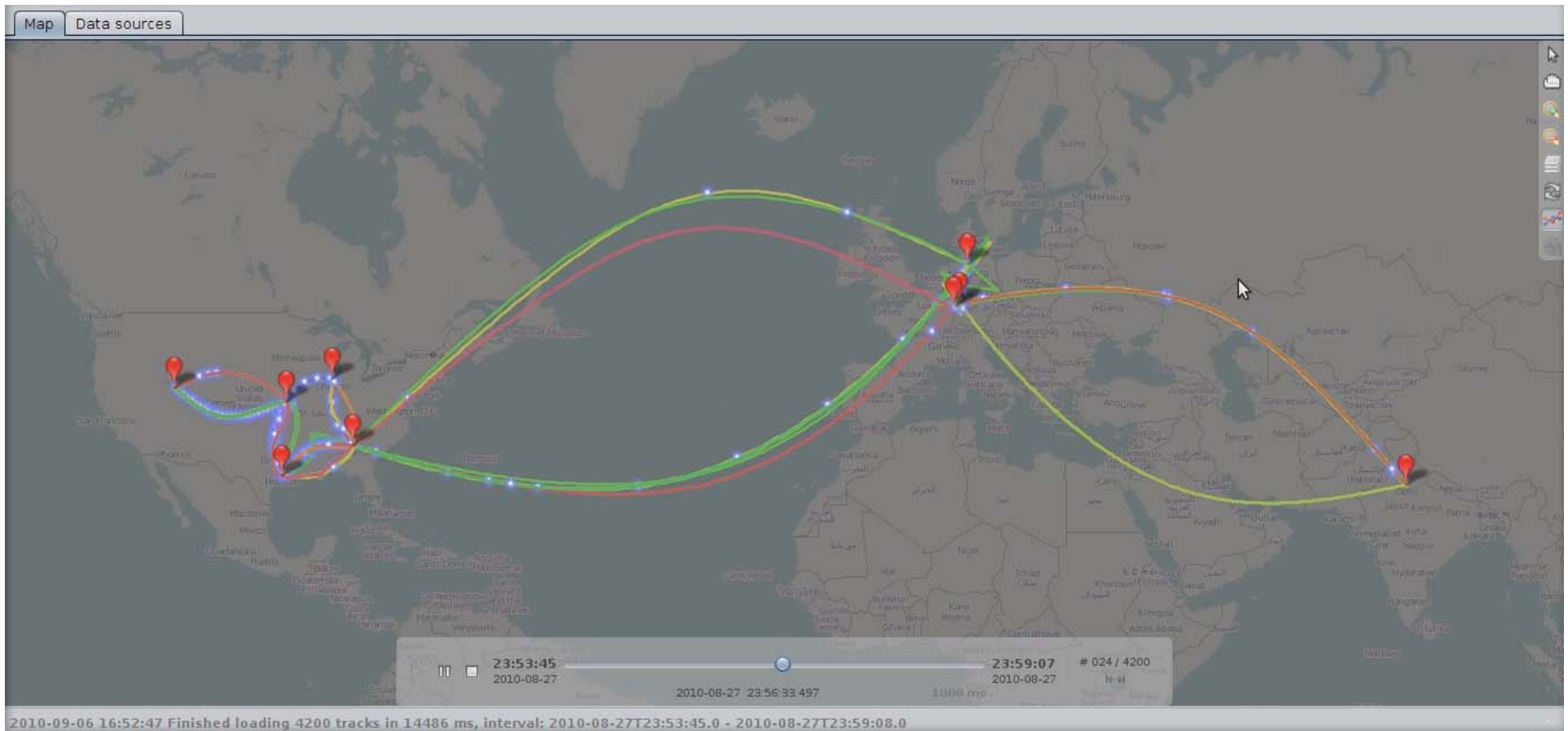
Picture from [www.planet-lab.org](http://www.planet-lab.org)

# 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



# 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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