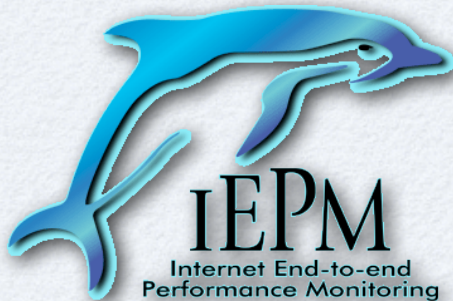




Ping End-to-End Reporting (PingER)

presentation for

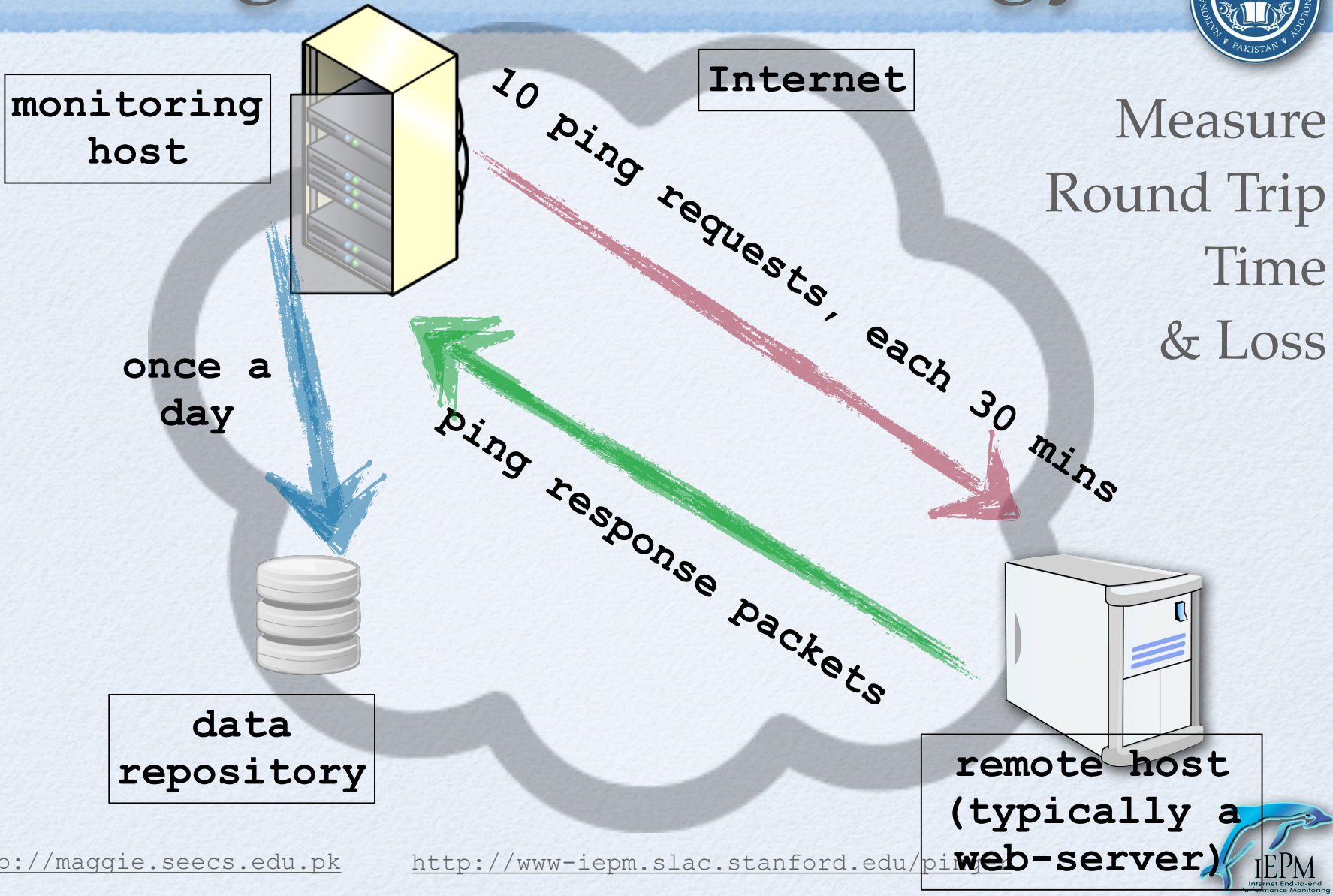
PERN / PERN2 Special Interest Group for Network Monitoring



PingER Project

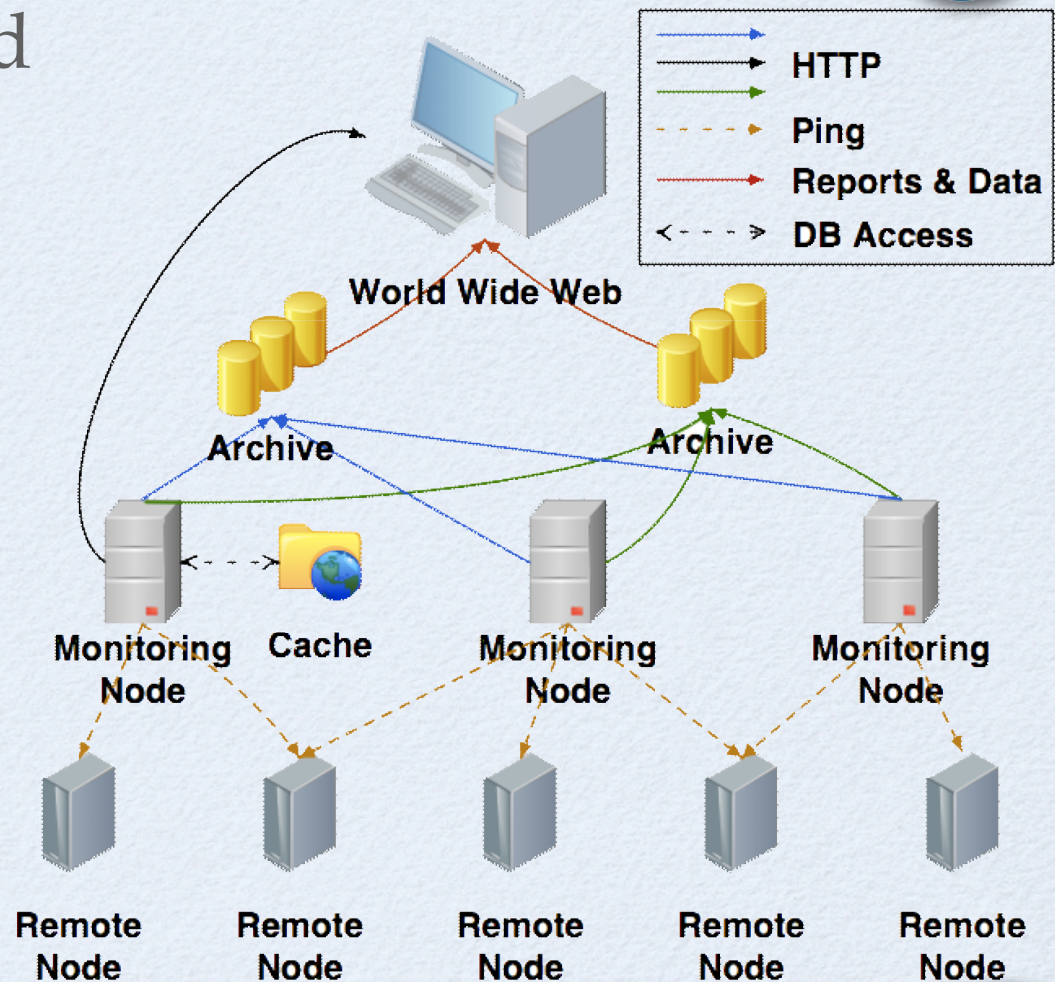
- Arguably the world's most extensive active end-to-end Internet Performance Project (emphasis Digital Divide)
 - Partially funded by MoST Pakistan, US State Department
 - Last six years - a joint development effort of **Stanford University (SLAC) & NUST (SEECs)**
 - Many **SEECs students cut their teeth on it**, several research papers & studies
- Results:
 - Highly successful in quantifying E2E performance (e.g ICFA - SCIC International Committee for Future Accelerators Standing Committee on Inter-Regional Connectivity)
 - **Identified & quantified rates of improvement for regions/countries**
 - How far behind, catching up, falling behind
 - Many presentations to funding agencies, politicians, NRENs, recommendations
 - Case studies identified: **fragility of e2e connections, last mile congestion problems, inefficient routing**

PingER Methodology



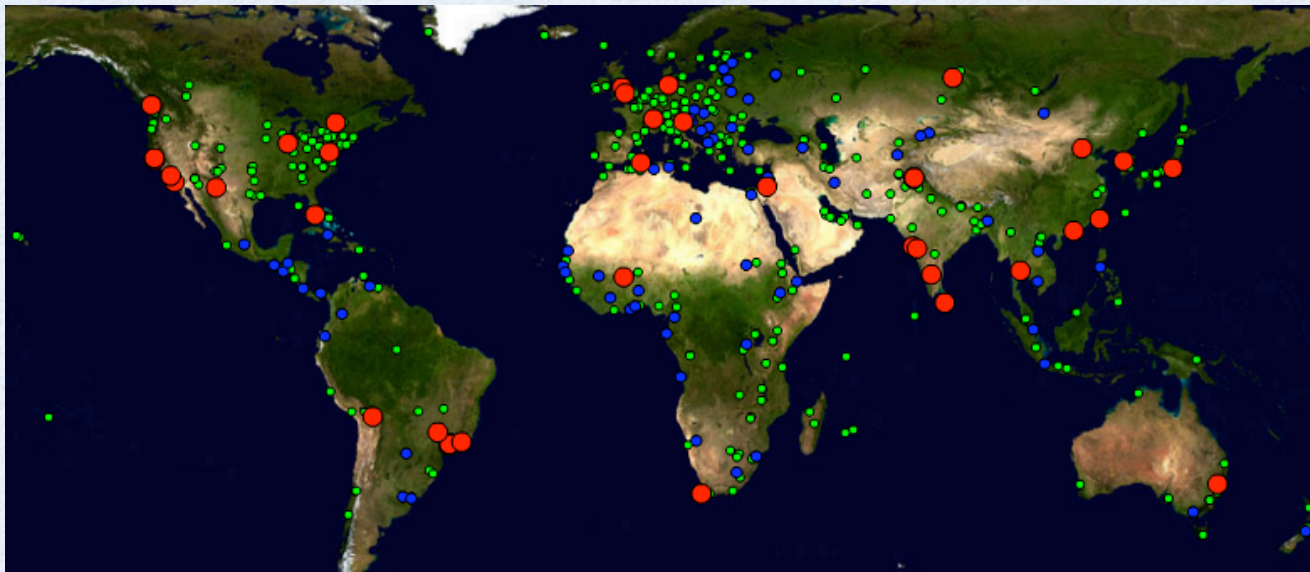
Pinger Architecture

- Monitor hosts send 21 pings each 30 mins to **Remote Hosts** and cache results
- Archive hosts gather data daily, **save, analyze & make results available publicly via web**



Pinger Deployment

- 166 countries (98.3% world's population, >99% world's connected population)
- 45 monitoring nodes in 23 countries
- 890 remote nodes at over 650 sites in over 165 countries (beacons ~ 90)



What is measured?

- E2E Network Performance Metrics
 - Round Trip Time (delay / latency) - **ms**
 - Packet Loss - **%**
 - Throughput (derived) **Kbps**
 - Jitter - **ms**
 - Unreachability - **%**

Why are we here?



- **Deployment of PingER monitoring nodes at the 80+ universities connected via PERN**
 - Facilitate measurement of user-experience
 - End-to-end performance measurement
- Urge universities to utilize PERN connectivity
 - Host university servers on PERN links
- Provide universities with real-world measurements for analysis and research
 - Build network monitoring tools
 - Analyse network measurements

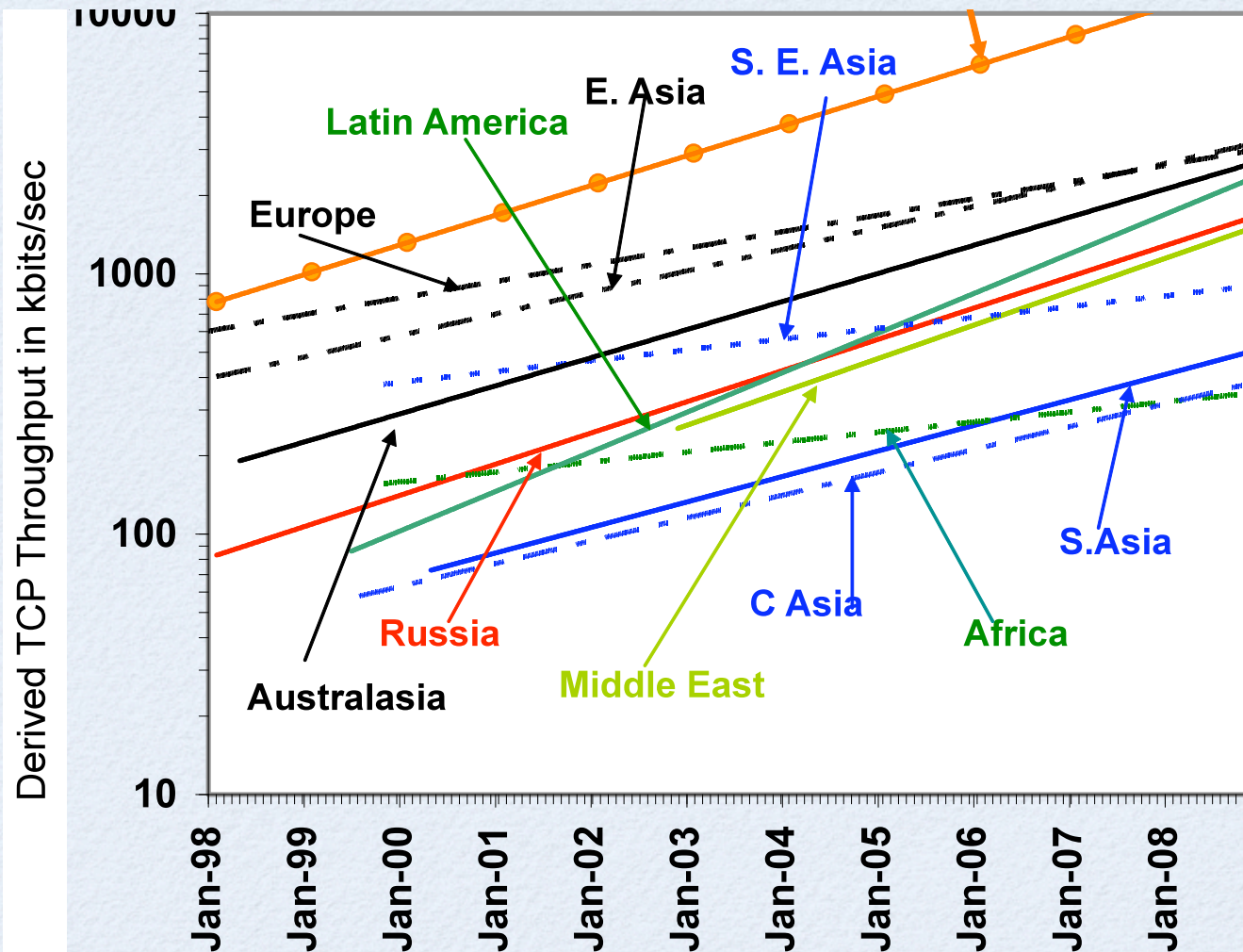
Why is this important?

- Problem Diagnosis is challenging
 - Convince service providers that there is a problem
 - Need multiple pieces of information from multiple sources
- Performance measurements facilitates
 - Network operations
 - Allows for trend analysis, planning and provisioning

The image features a minimalist, abstract landscape. A wide, flat, light-colored ground extends to the horizon. A prominent, solid blue horizontal band, resembling a body of water or a low-lying forest, stretches across the middle of the frame. The sky above is a pale, clear blue. The overall composition is clean and serene.

World View

Throughput as seen from US



Behind Europe
 6 Yrs: Russia, Latin America
 7 Yrs: Mid-East, SE Asia
 10 Yrs: South Asia
 11 Yrs: Cent. Asia
 12 Yrs: Africa

South Asia, Central Asia, and Africa are in Danger of Falling Even Farther Behind

Case Study: Pakistan

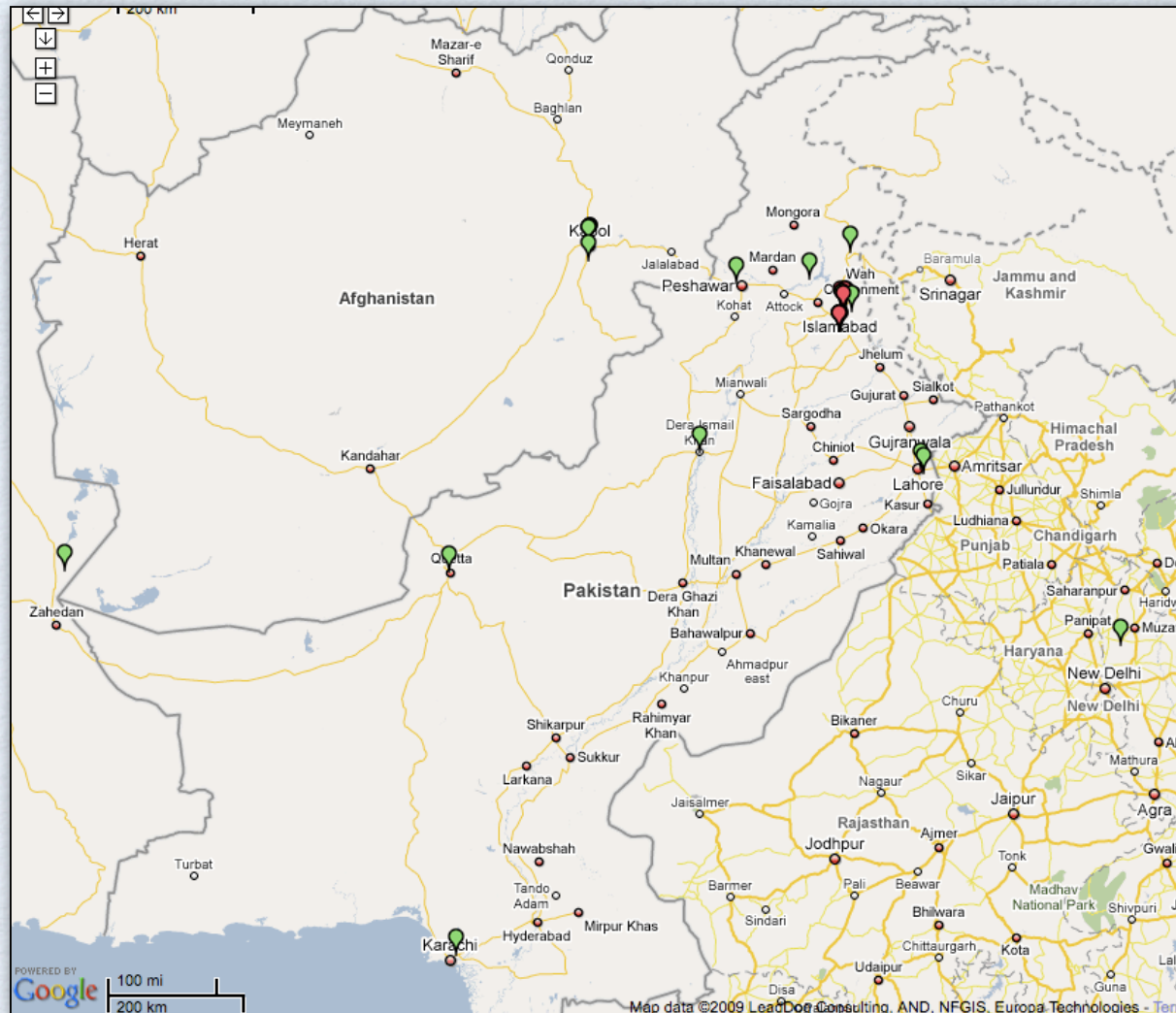
Monitoring nodes in Pakistan

Location	No. of monitoring nodes
SEECs, NUST, Islamabad	4
NCP, Quaid-e-Azam University, Islamabad	1
COMSATS University, Islamabad	1
Pakistan Education Research Network (PERN), Islamabad	1
Micronet/Nayatel Pakistan, Islamabad	1

Remote nodes in Pakistan

Remote Node	University/ Organization Location	Service Provider	Available Bandwidth	End Host Location
LSE (lahoreschoolofeconomics.edu.pk)	Lahore			Lahore
COMSATS (comsats.edu.pk)	Islamabad	PERN		Islamabad
BUITMS (buitms.edu.pk)	Quetta	PERN		Quetta
SSUET (ssuet.edu.pk)	Karachi	PERN		Karachi
UPESH (www.upesh.edu.pk)	Peshawar	PERN*		Islamabad
PIEAS (www.pieas.edu.pk)	Nilore	PERN*		Islamabad
NUST/SEecs (www.seecs.edu.pk) formerly NIIT	Islamabad	Micronet/ Nayatel (dsl.net.pk) and PERN	1 - 1.5 Mbps and 32 Mps	Islamabad
GIKI (www.giki.edu.pk)	Topi	PERN*		Topi
UET (uet.edu.pk)	Lahore	PERN*		Lahore
HU (hu.edu.pk)	Hazara	PERN*		Hazara
PERN (www.pern.edu.pk)	Islamabad	PERN		Islamabad
DSL.NET (dsl.net.pk)	Islamabad	Micronet/ Nayatel (dsl.net.pk)		Islamabad
NAYATEL (nayatel.com)	Islamabad	Micronet/ Nayatel (dsl.net.pk)		Islamabad
SDNPK (wb.sdnpk.org)	Islamabad	Cyber NET (cyber.net.pk)		Islamabad

Deployment in Pakistan

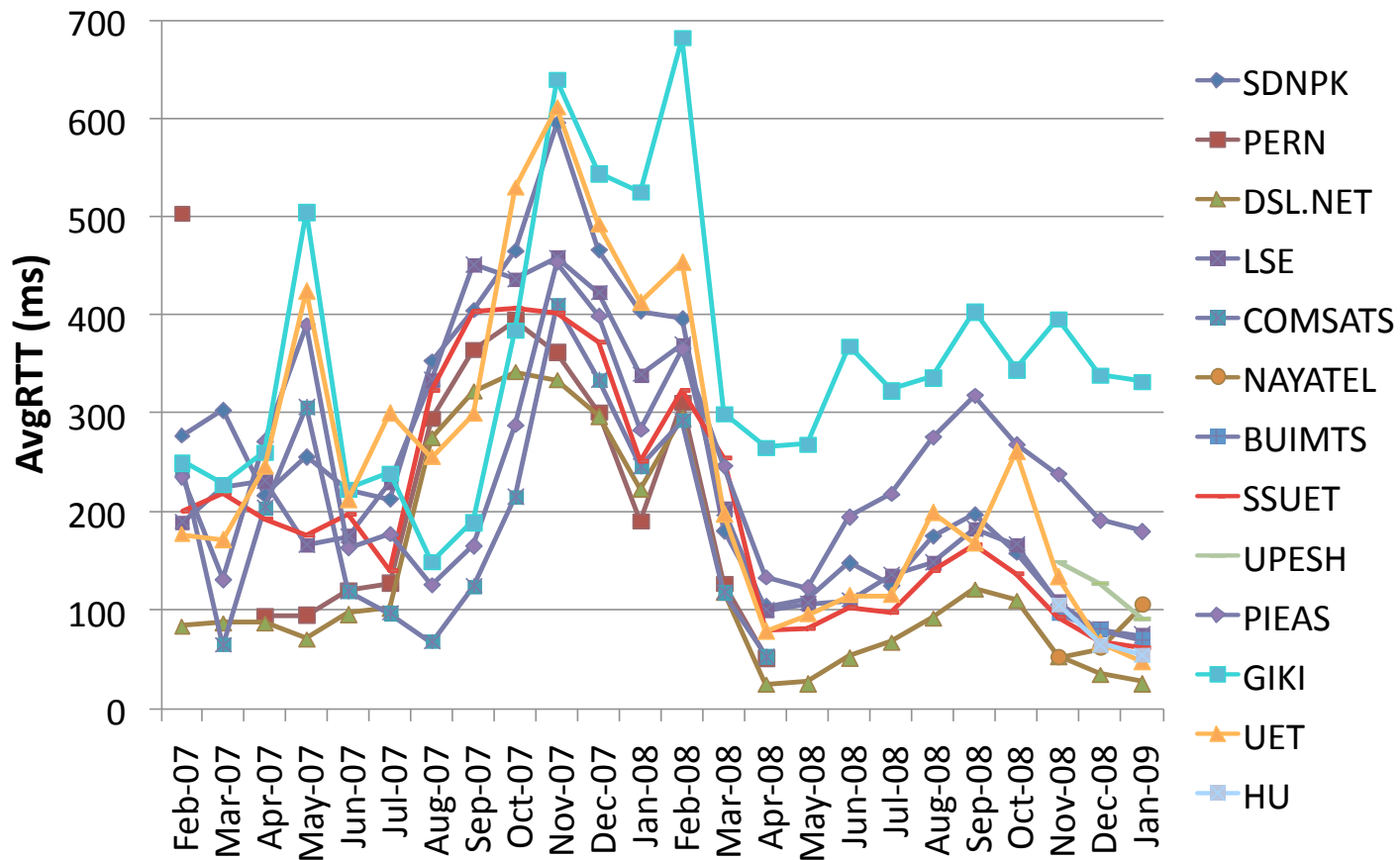


<http://maggie.seecs.edu.pk>

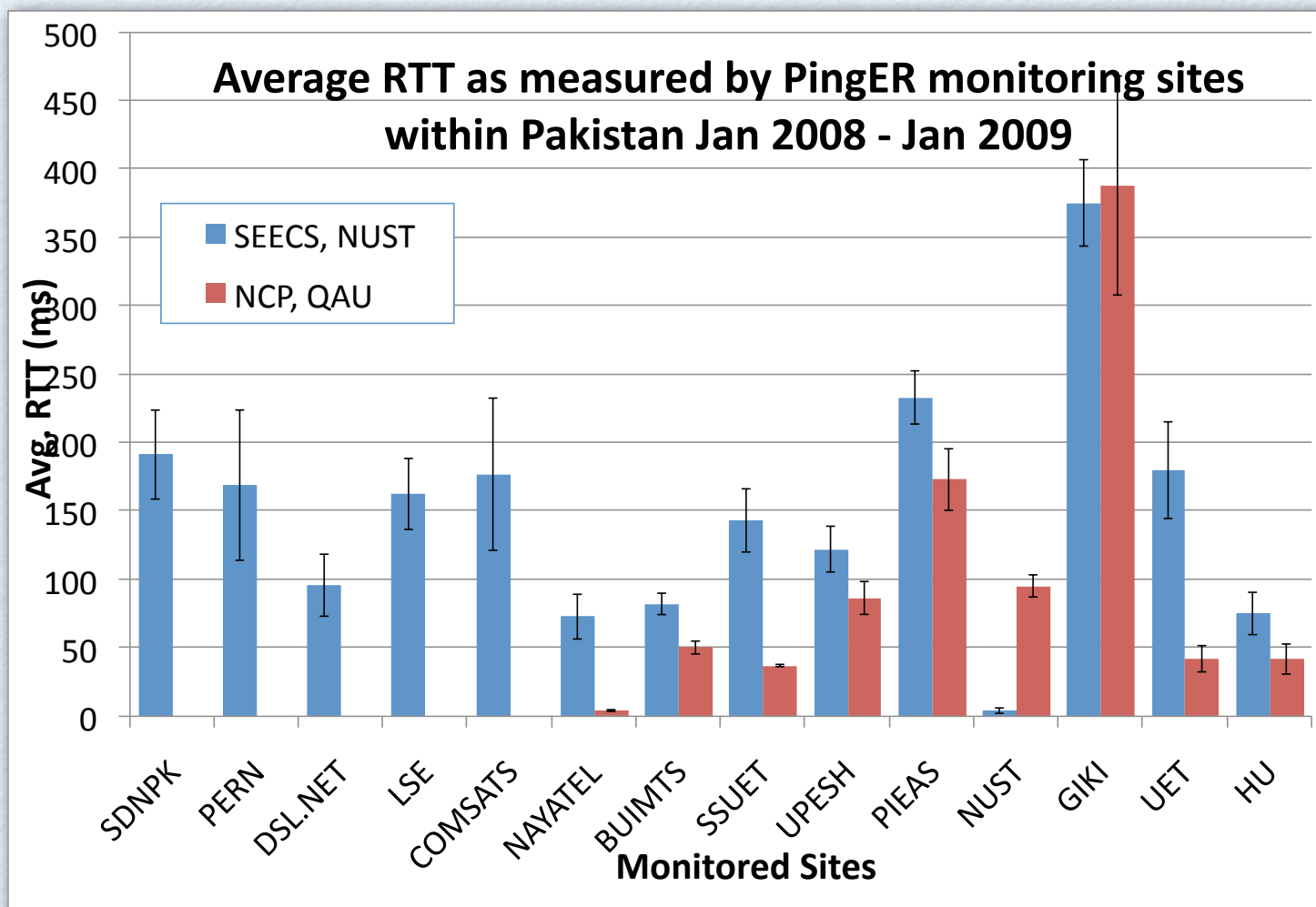
<http://www-iepm.slac.stanford.edu/pinger>

Average RTT (ms)

AvgRTT as seen from SEECS, NUST Feb 07 - Jan 09

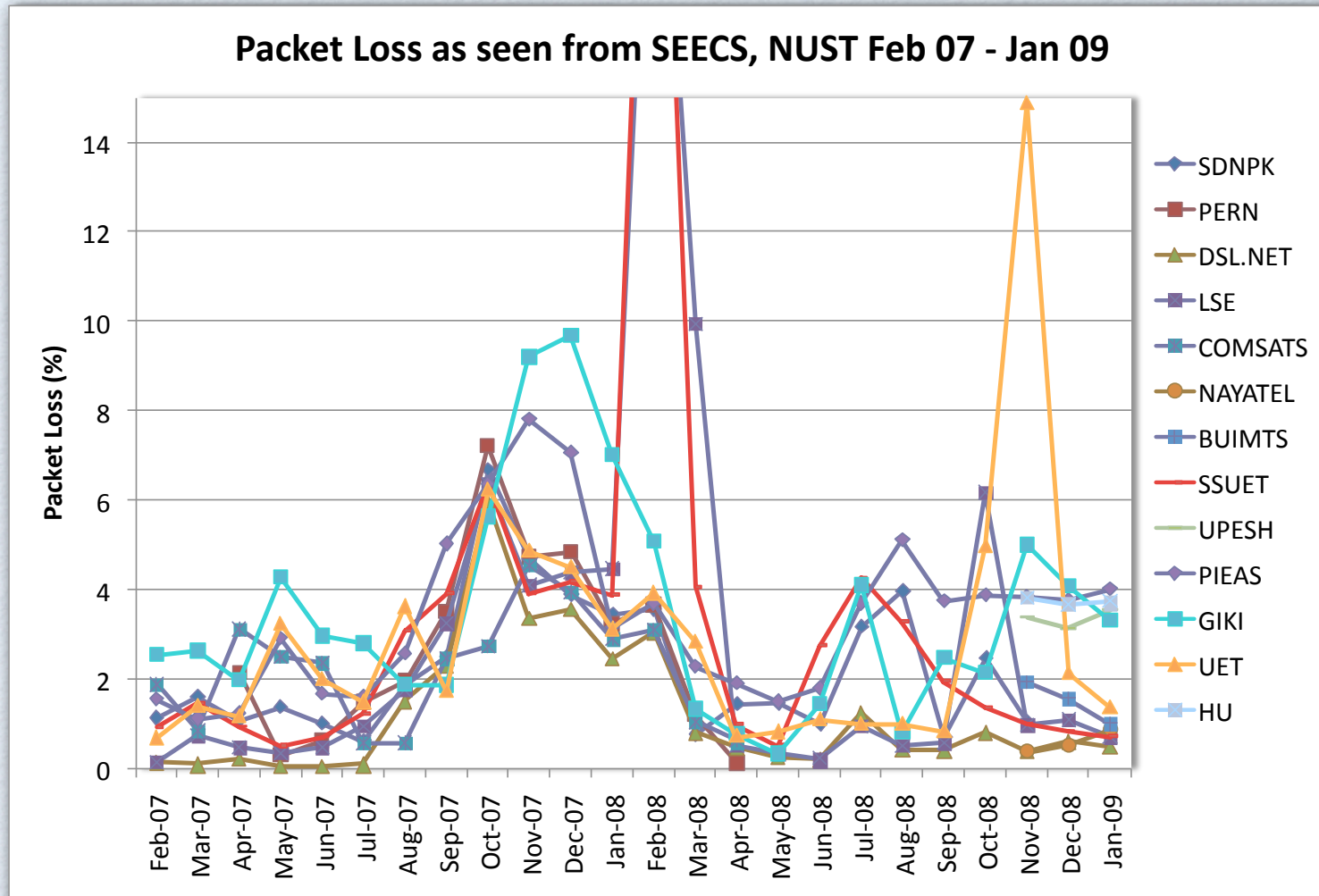


Average RTT (ms)

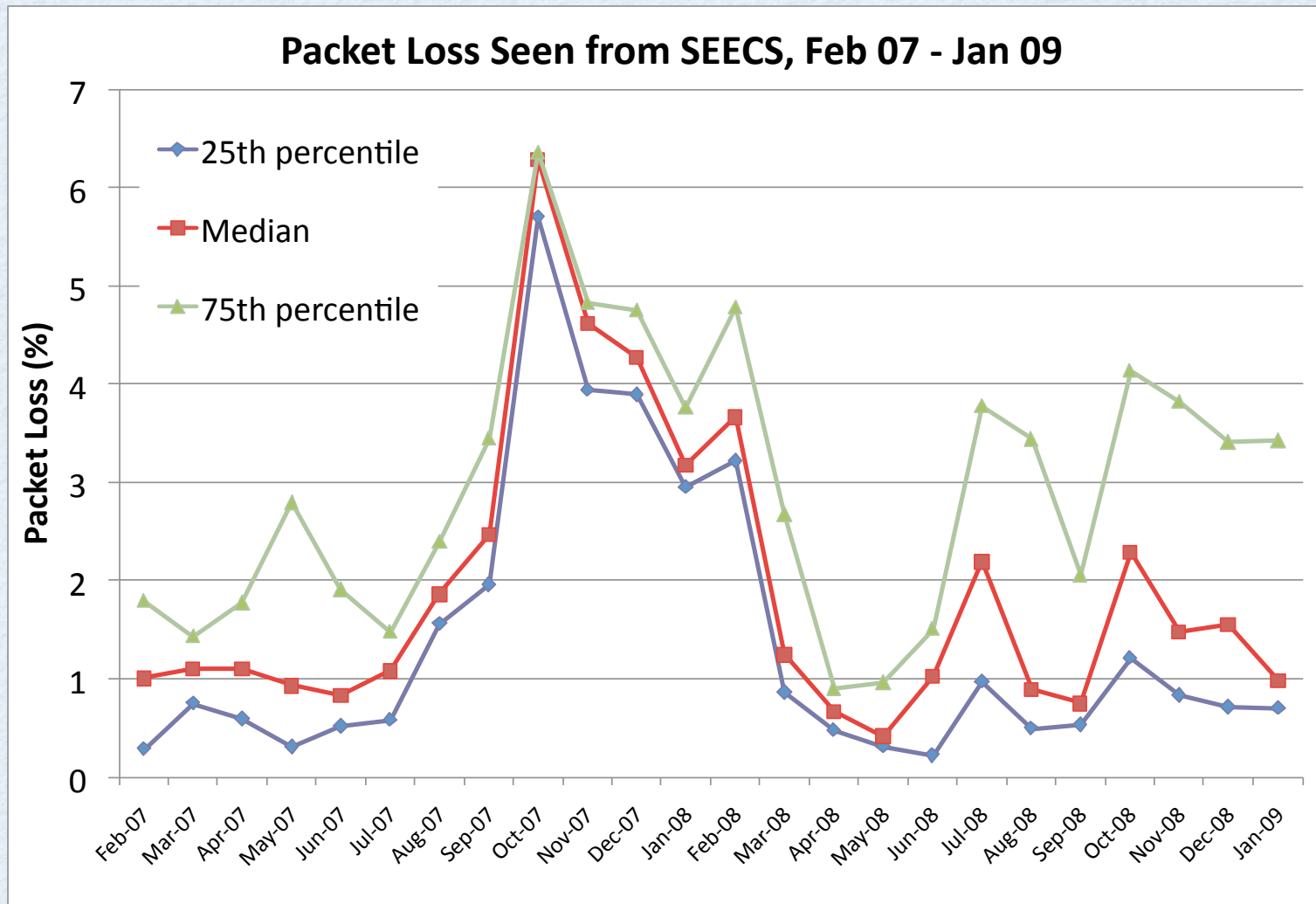


Packet Loss (%)

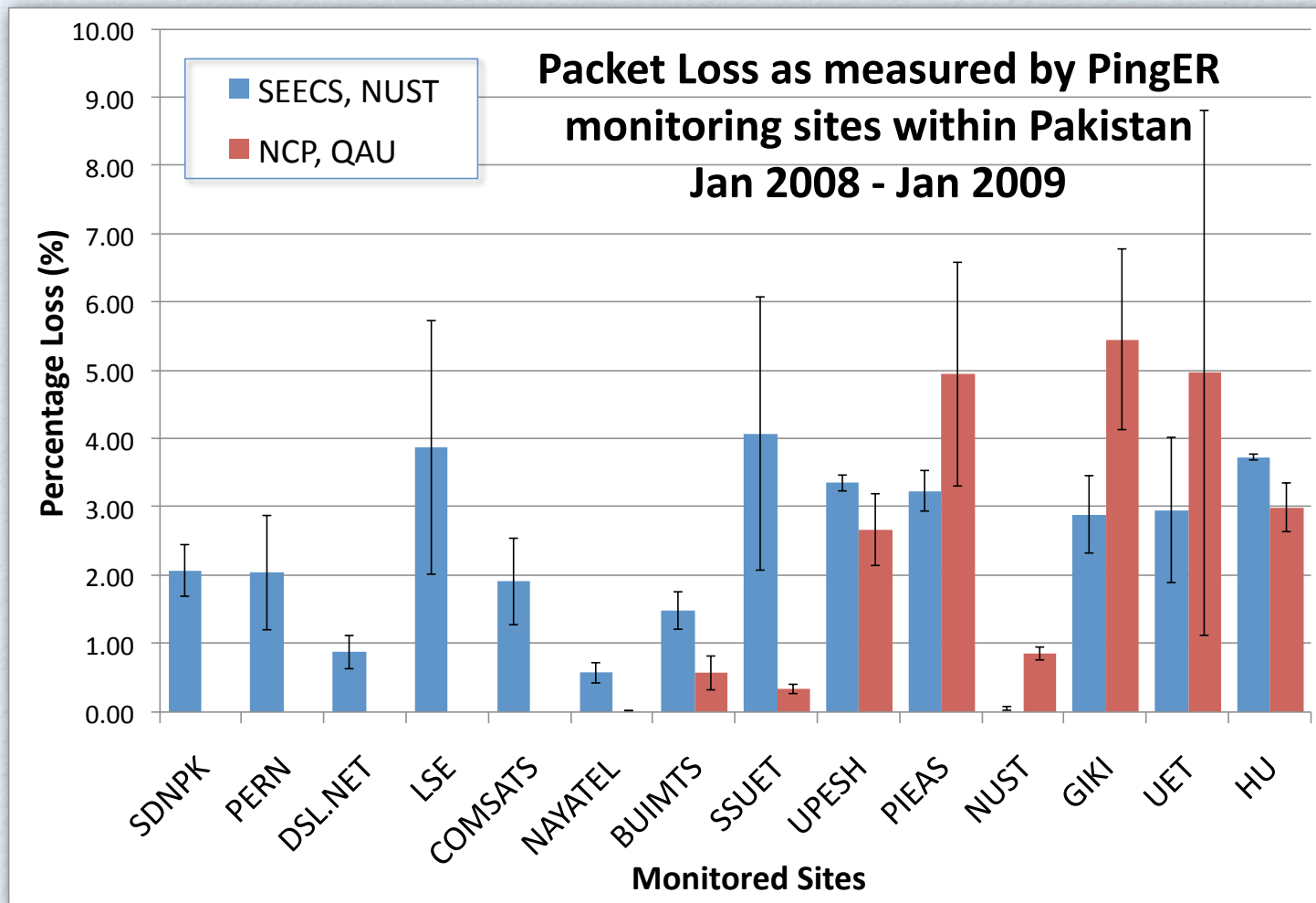
Packet Loss as seen from SEECs, NUST Feb 07 - Jan 09



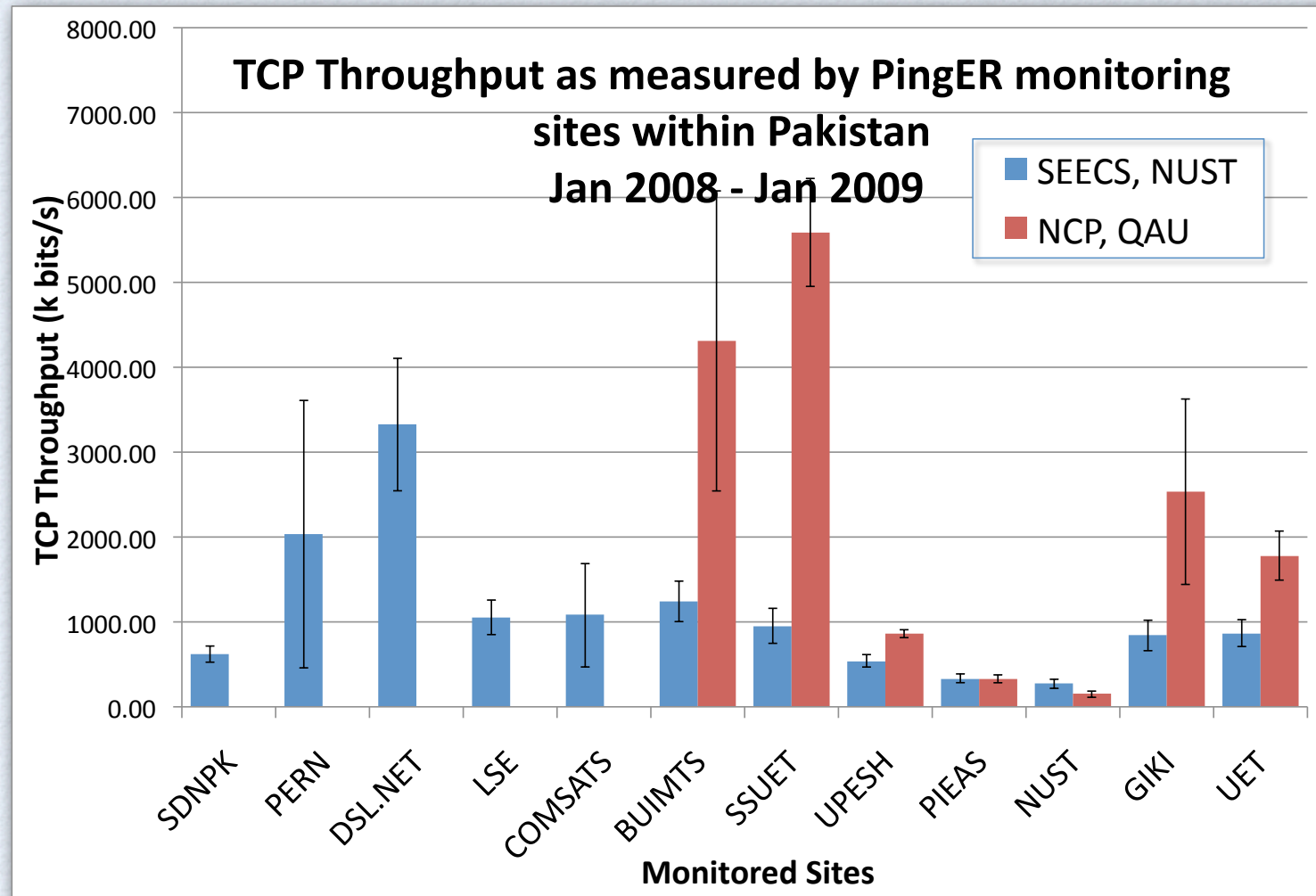
Packet Loss (%)



Packet Loss (%)



Throughput (Kbps)



Mathis et. al

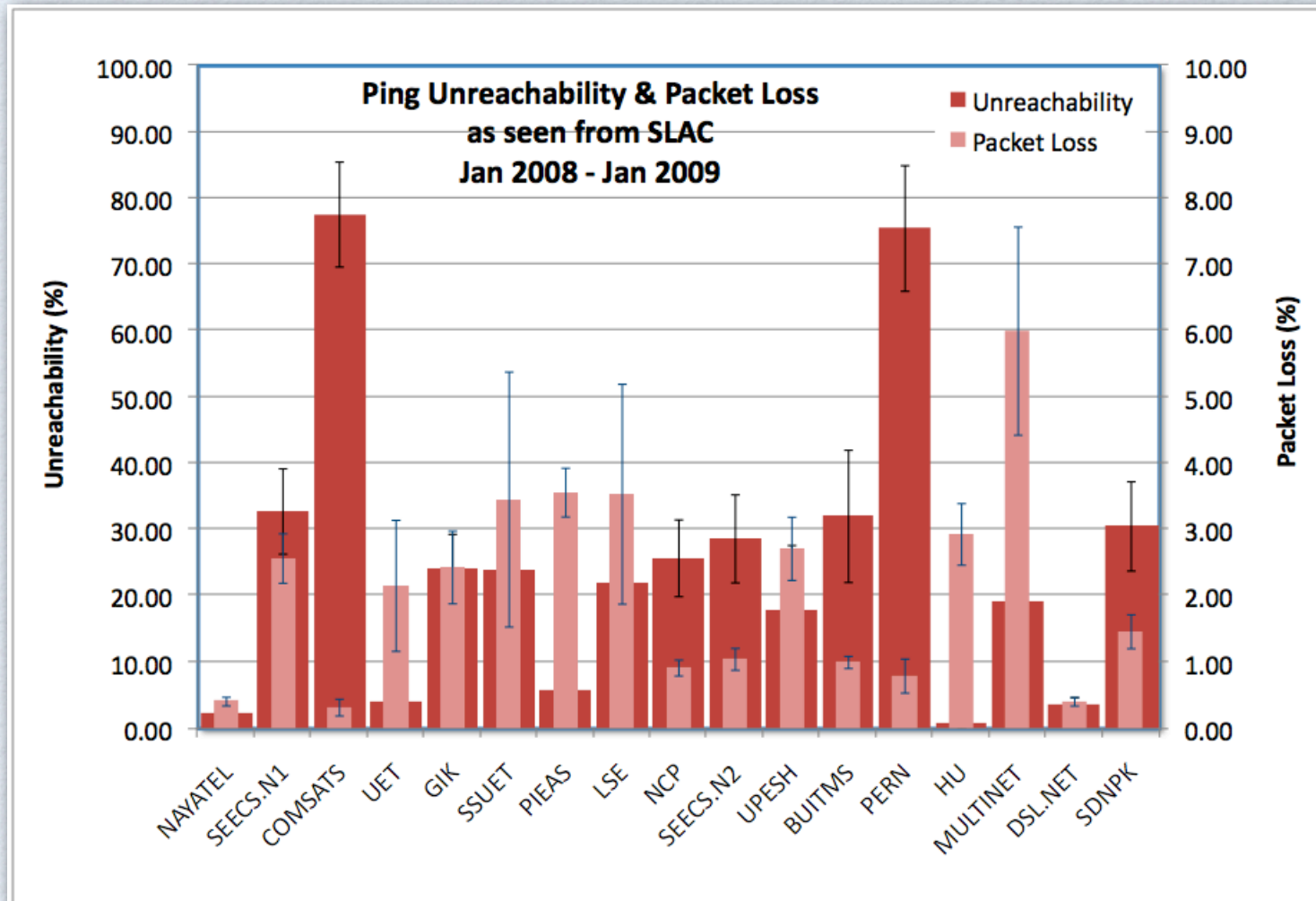
Throughput or Rate $< (MSS \sim 1460 \text{ Bytes} / RTT) * (1 / \sqrt{\text{loss}})$

The macroscopic behavior of the TCP congestion avoidance algorithm by Mathis, Semke, Mahdavi & Ott in *Computer Communication Review*, 27(3), July 1997

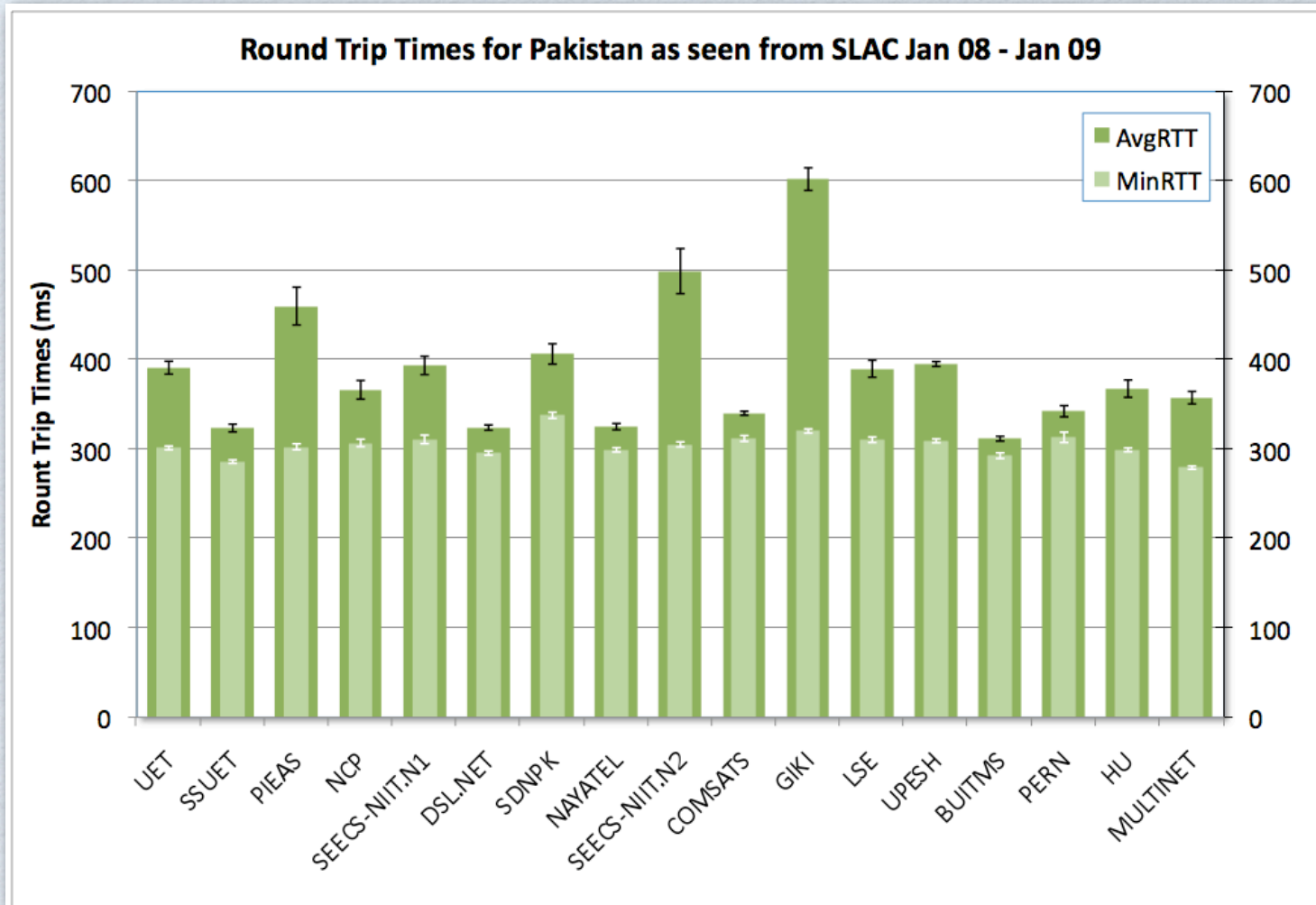
Traceroute results

Last mile effects

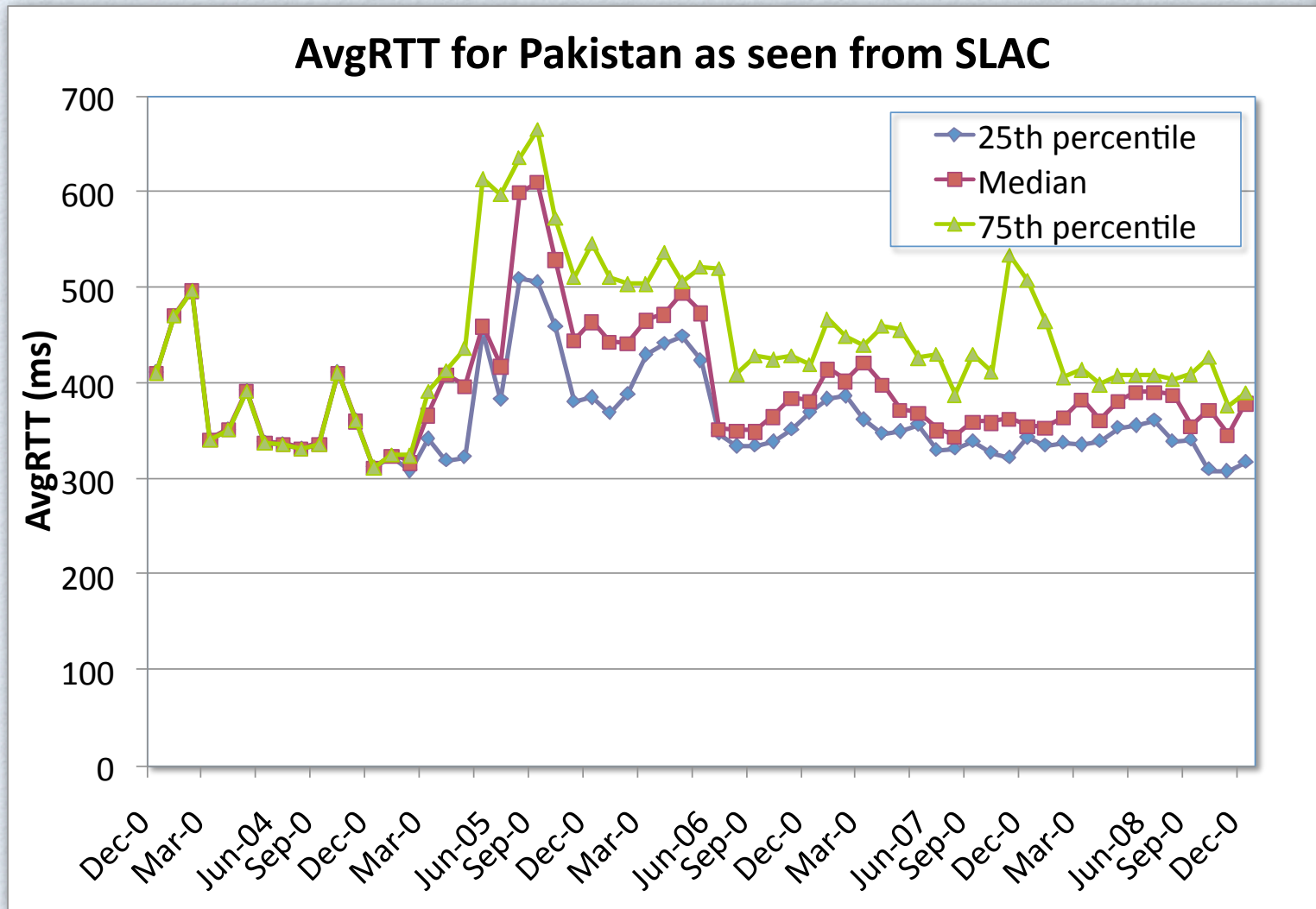
Unreachability & Loss



Average RTT (ms)



Average RTT (ms)



Inferences

- National backbone is well provisioned
- Last mile effects
 - congestion & losses
 - power outages

What to do?

- Deploy PingER
 - Monitoring & reverse traceroute scripts to be installed
 - Node owned by the respective university
- PingER requirements
 - Node should run Linux
 - Node name must be registered with a DNS
 - Web (http) and ICMP (ping traceroute) traffic should be allowed
 - Node preferably close to the border (DMZ), can be within the local LAN
 - Minimal disk storage and network access

Conclusion

- Performance monitoring is vital for
 - network operations,
 - trend analysis,
 - planning and provisioning
- Provides opportunities for computer network research
- We encourage all universities to participate
 - and utilize the PERN connectivity



Thank you

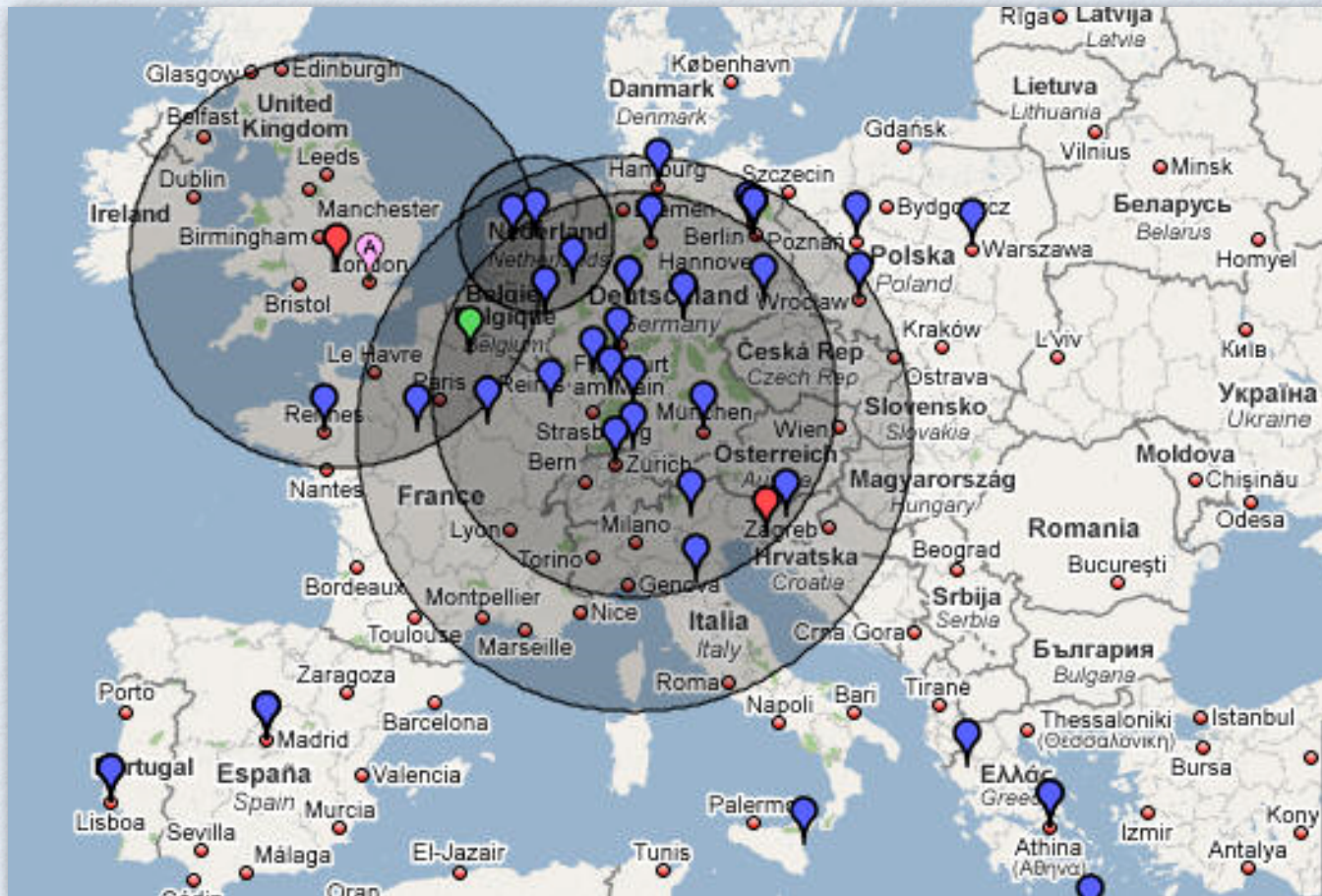
Questions?

Selected Projects

- Anomalous Event Detector
- TULIP - Trilateration Utility for Locating IP Addresses
- PingER validation toolkit
- PingER regional case studies
 - Africa, Pakistan, South Asia, East Asia, Latin America etc
 - ICFA reports 2007, 2008 and 2009
- ViPER - PingER Visualization
- PingER motion charts
- PingER executive plots
- Google maps for PingER
- and many others ...

TULIP

Trilateration Utility for locating IP addresses



<http://maggie.seecs.edu.pk>

<http://www-iepm.slac.stanford.edu/pinger>

PingER Motion Charts

