
# PingER: getting a lot from a simple utility

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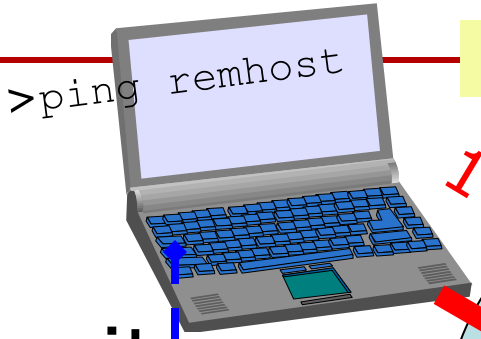
# Measurement Mechanism: PingER




Uses ubiquitous ping

Monitor Host

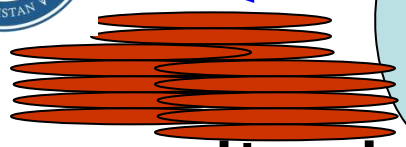
Once a Day

10 ping request packets each 30 mins

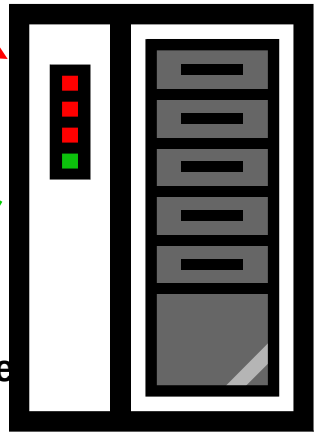
Ping response packets

Internet

Remote Host (typically web server)



Repositories



NUST

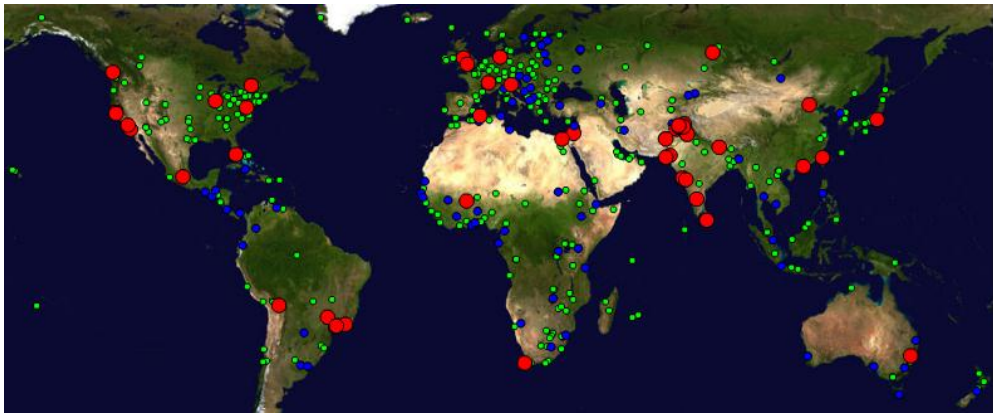
Fermilab

SLAC NATIONAL ACCELERATOR LABORATORY

**Measure Round Trip Time & Loss**

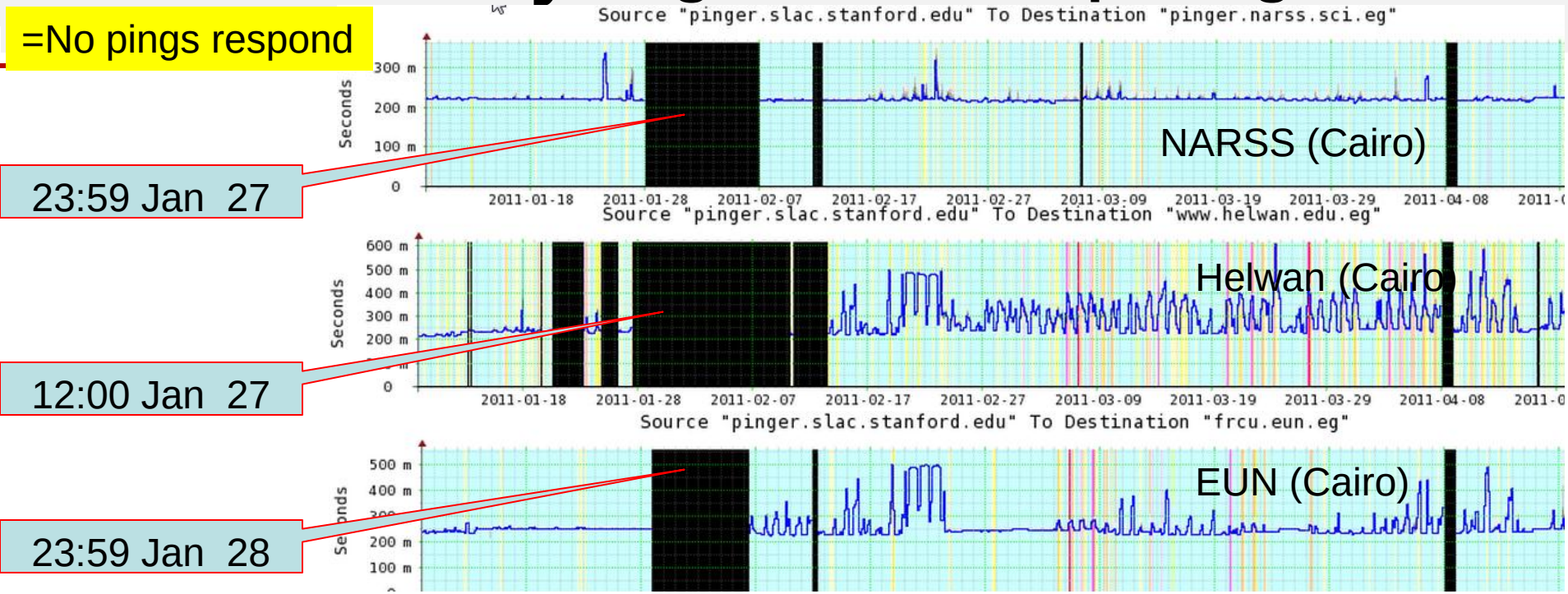
# Deployment

- Measurements from 1995 on reporting reliability & quality
- ~ 99% of world's population in monitored countries
- Collaborations with NUST, Pakistan, FNAL & ICTP Italy
  - Monitors >90 in 23 countries – 4 in Africa:
    - Algeria, Burkina Faso, Egypt, S. Africa
  - Beacons ~ 100
  - Remote sites (~740) – 50 African Countries



# Unreachability: e.g. N. African uprisings Jan '11

=No pings respond




23:59 Jan 27

12:00 Jan 27

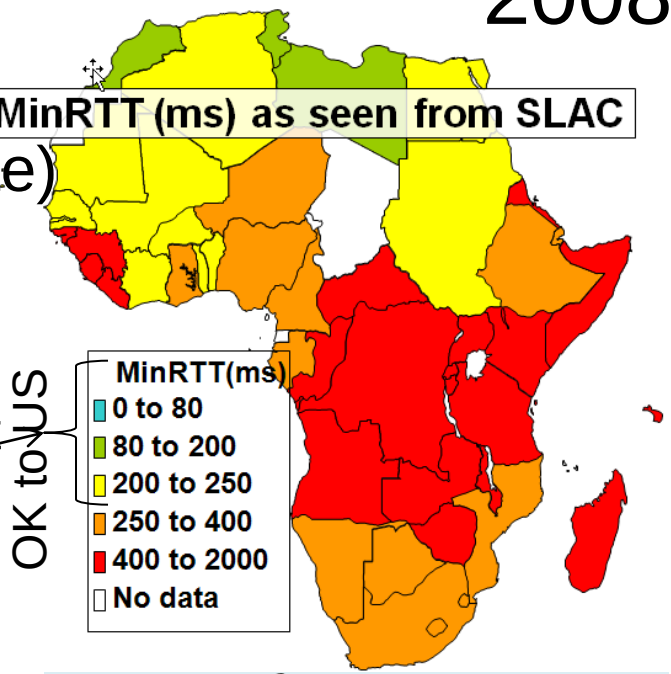
23:59 Jan 28

- Impact varied: start time, recovery time, after effects
- Egypt University Network (EUN) down least time
  - NARSS via Alternet->Italy->Egypt, Helwan &EUN via PCCW Global
- Libya first went dark 06:00 Feb 19 for 3 days, then again on Mar 4th more permanently
- Algeria, Morocco, Tripoli not noticeable

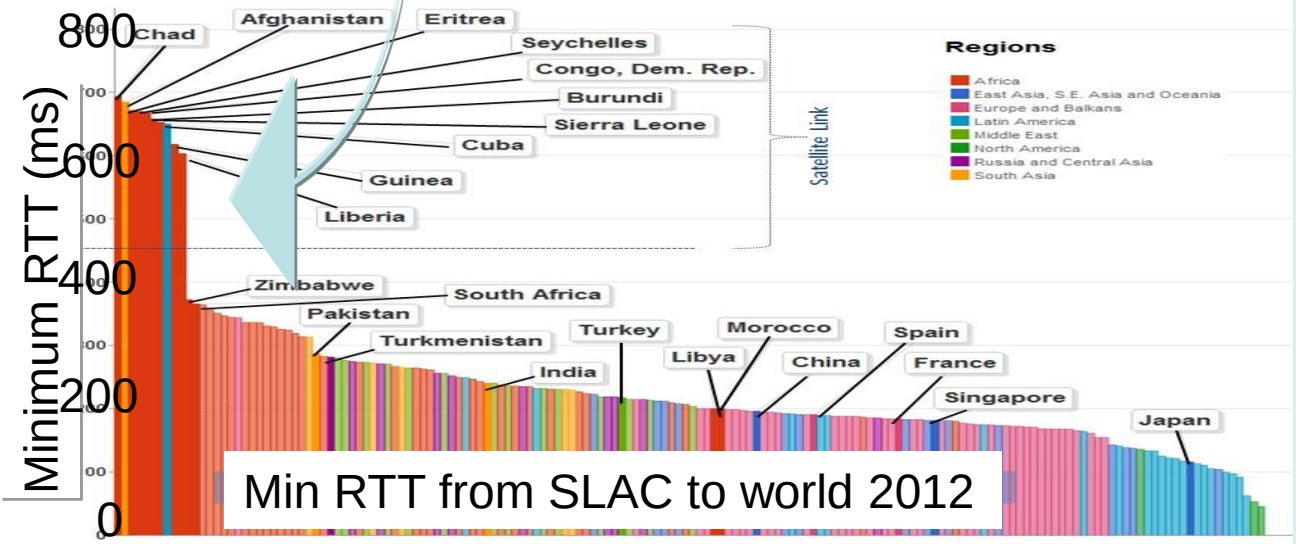
# Min-RTT satellite vs fibre

2008

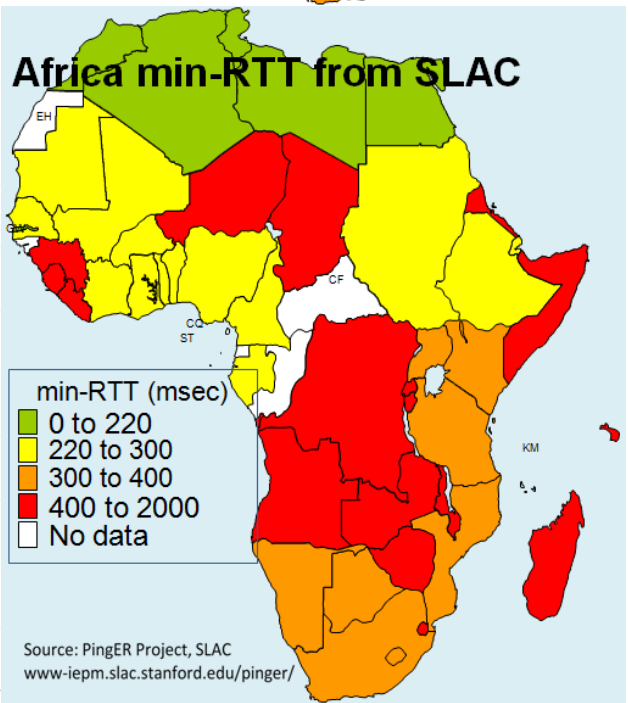
- GEOS (Geostationary Earth Orbit Satellite)
  - good coverage, but expensive in $/Mbps
    - broadband costs 50 times that in US, >800% of monthly salary c.f. 20% in US
  - & long delays min RTT > 450ms easy to spot
  - N.b. RTTs > 250ms v. bad for VoIP



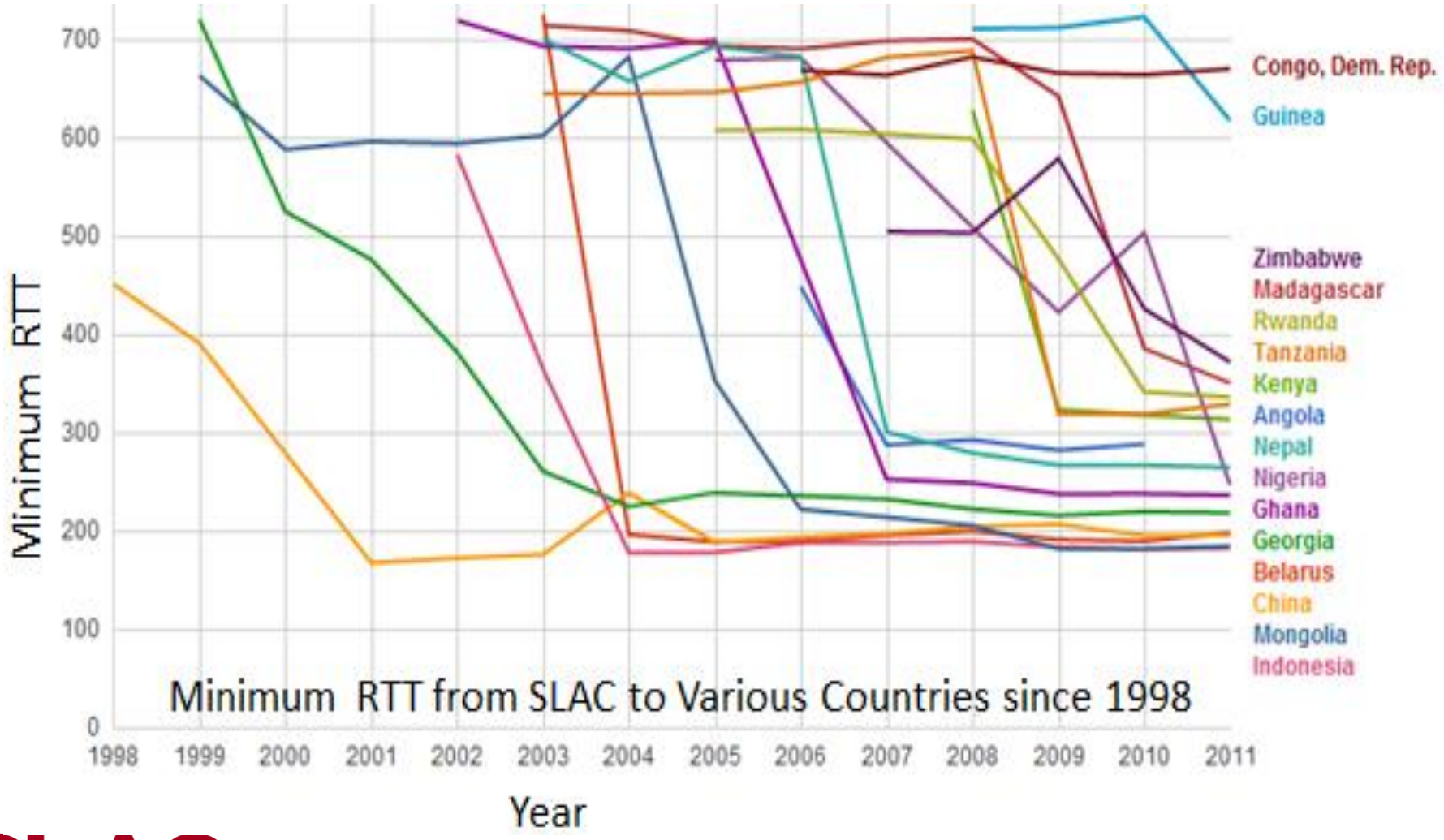

GEOS




Min RTT from SLAC to world 2012

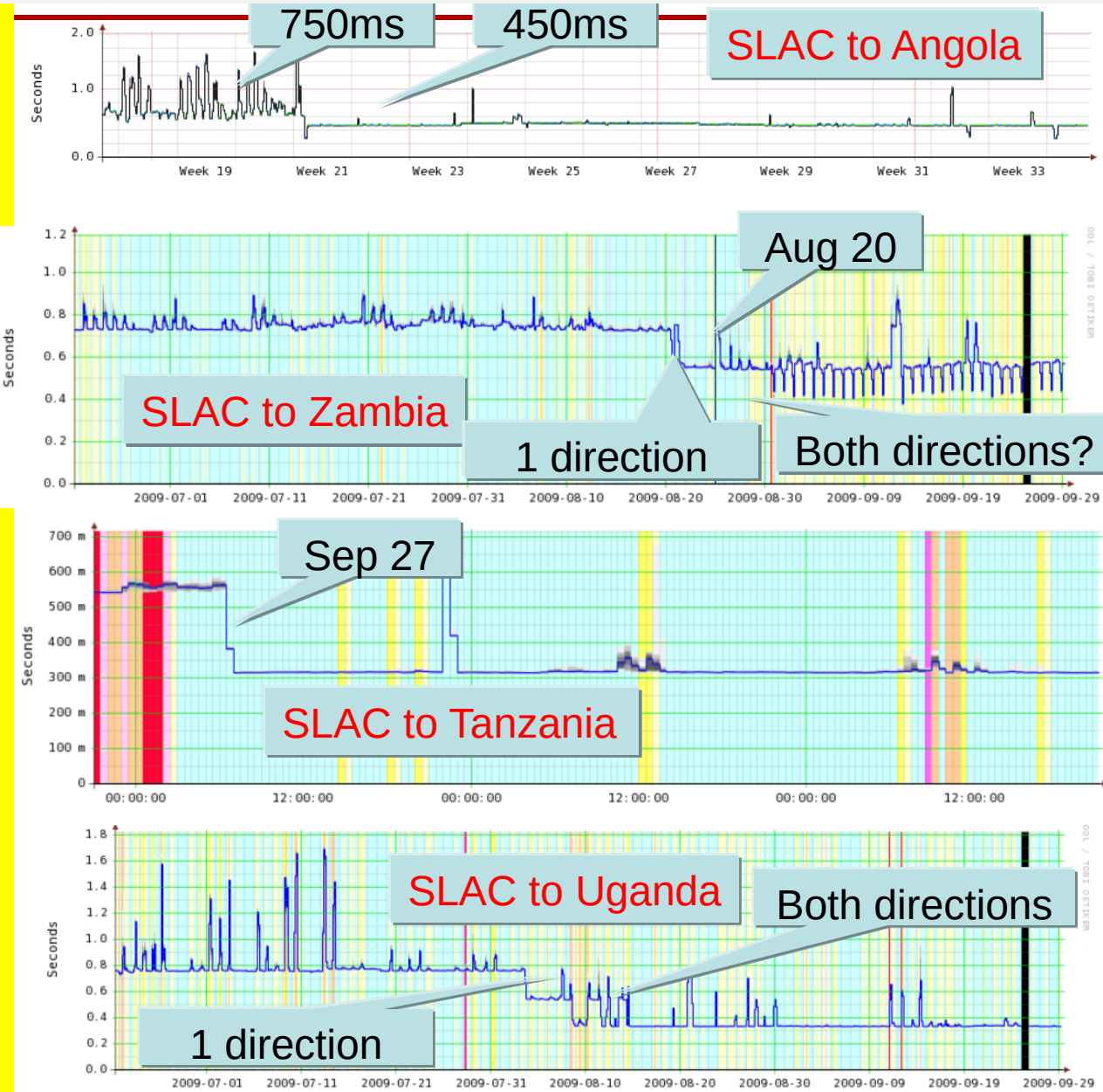


# Conversion history seen by min-RTT



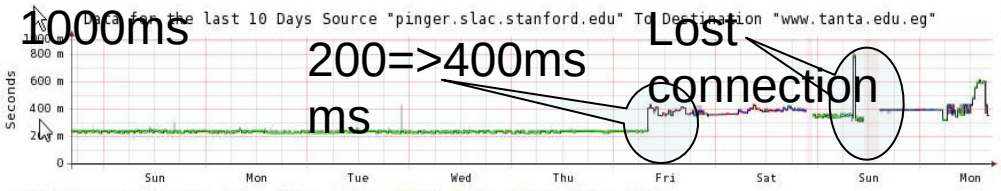
# RTT, e.g. spot big changes

- **Angola** step mid-May, more stable
- **Zambia** one direction reduce 720>550ms
  - Unstable, still trying?
- **Tanzania**, also dramatic reduction in losses
- **Uganda inland** via Kenya, 2 step process
- Rwanda Sep 25
- Many sites still to connect



# RTT's illustrate multiple routes important

- Not only for competition
  - Need redundancy
- Mediterranean Fibre cuts
  - Jan 2008 and Dec 2008
  - Reduced bandwidth by over 50% to over 20 countries
- New cable France-Egypt Sep 1

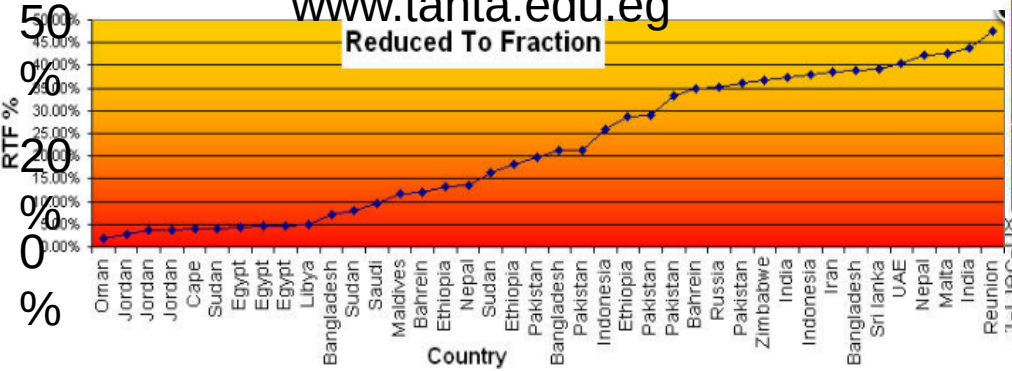



1000ms

200=>400ms ms

Lost connection

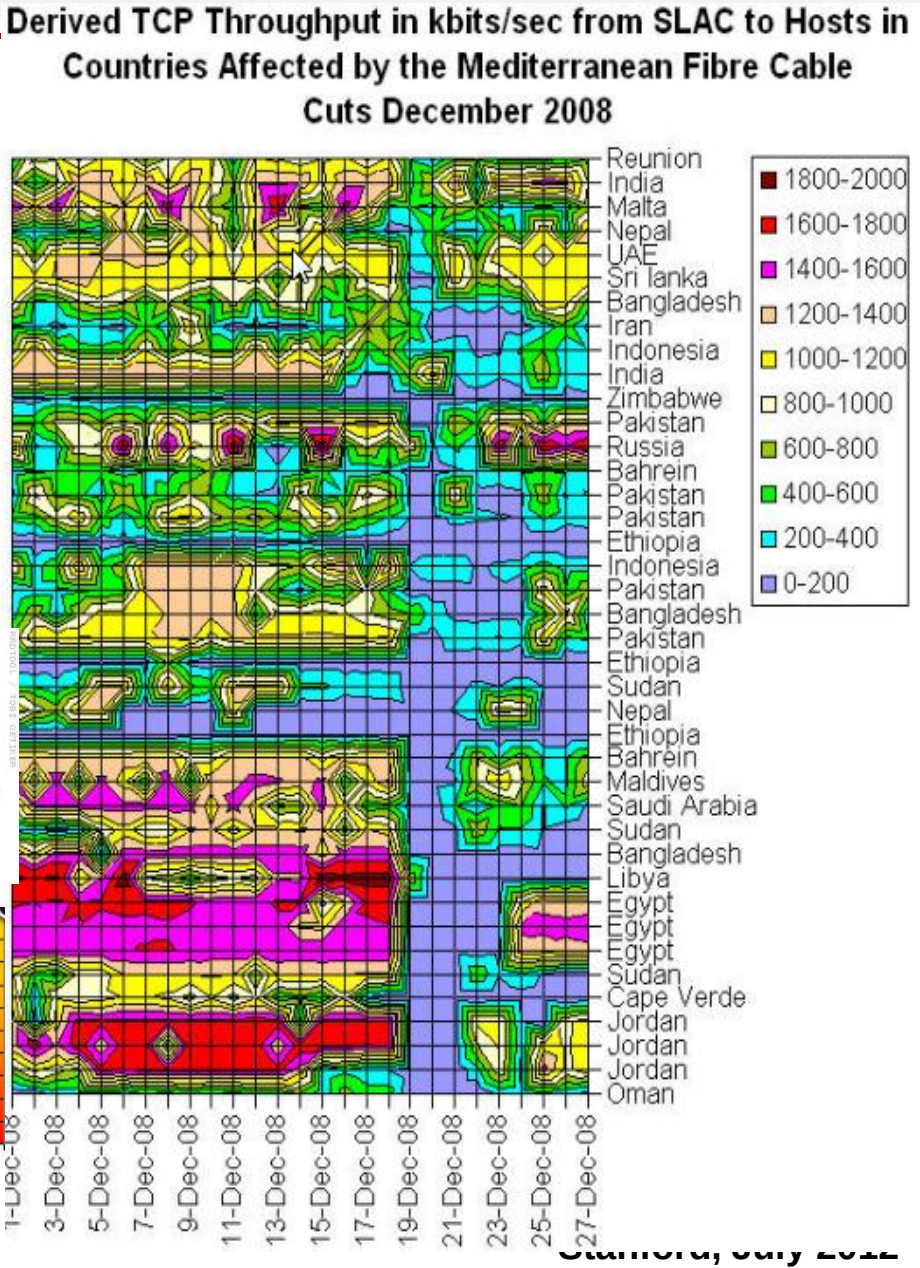
SLAC – www.tanta.edu.eg



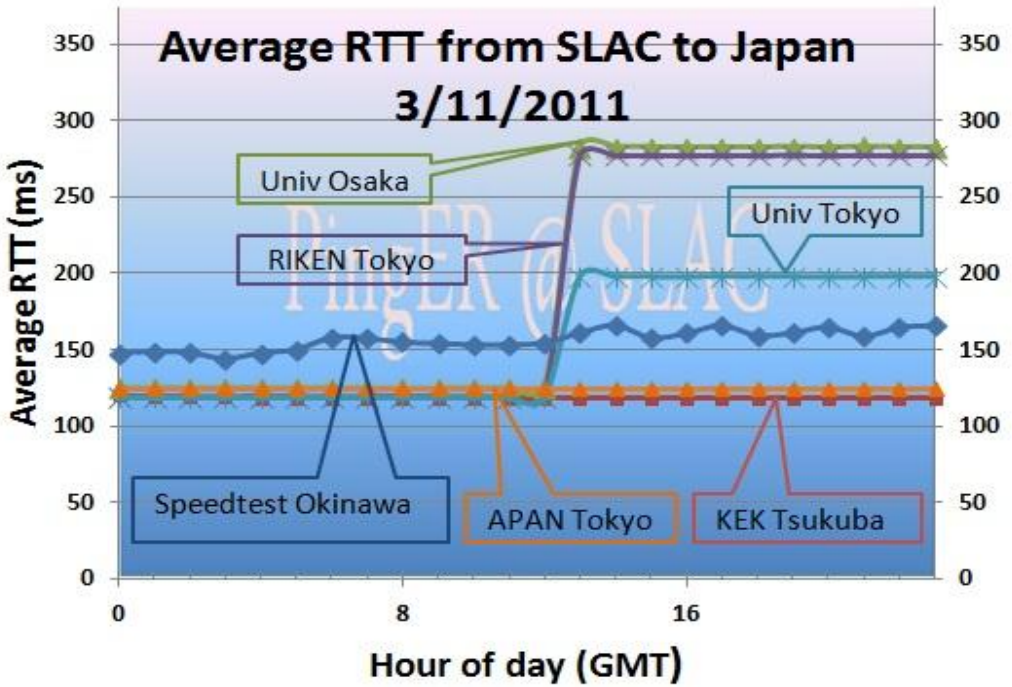

50%

20%

0%



# Japanese Earthquake & Tsunami

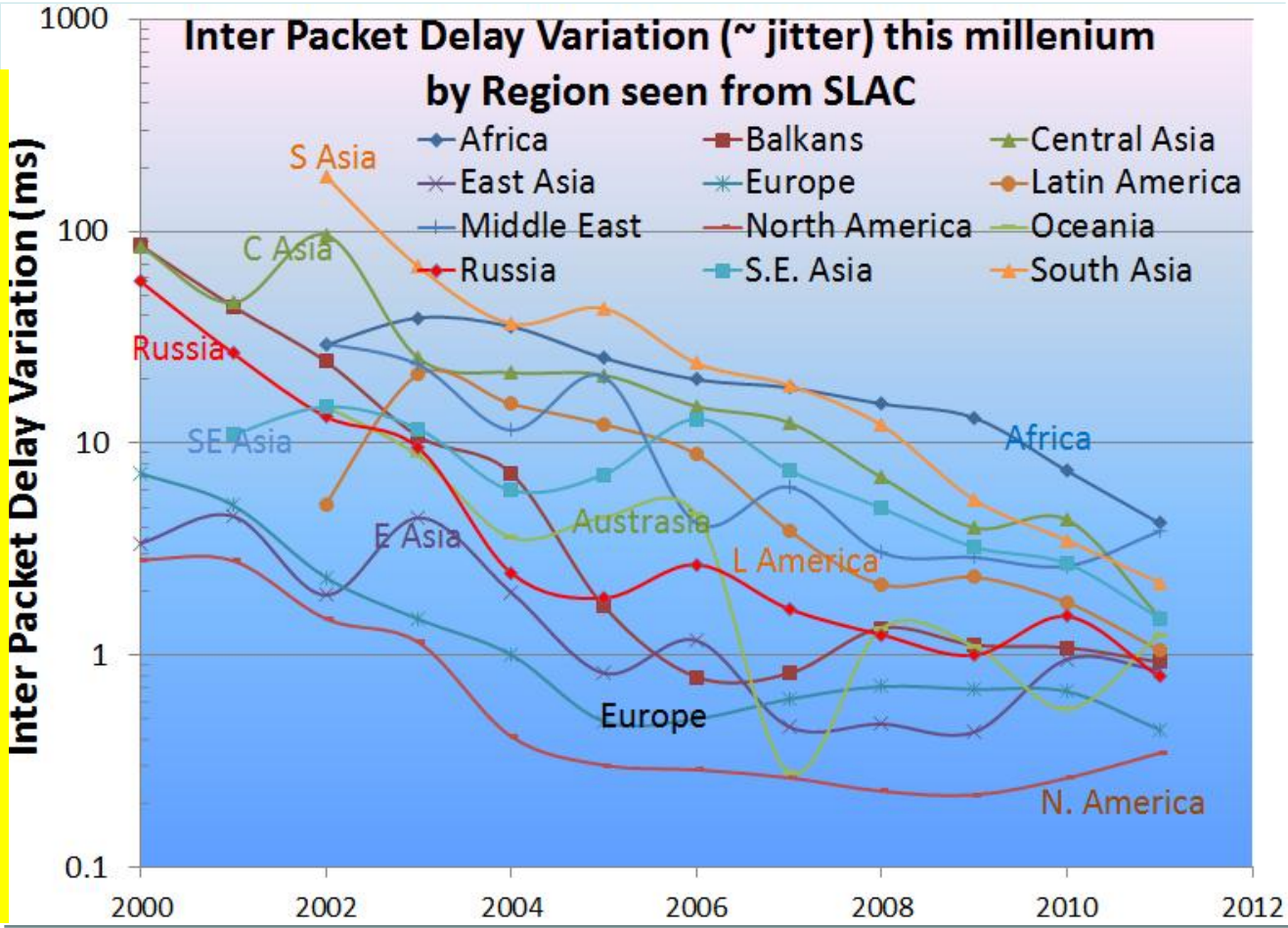
# RTT Variability = Jitter

- Standard deviation or IQR = a measure of jitter
- Inter Packet Delay = another measure of jitter
- Exponential improvement (factor 10 on 6 yrs)

Sensitive to queuing and congestion

Mainly due to edge, so distance insensitive

Important for real time: VoIP, gaming, haptic surgery

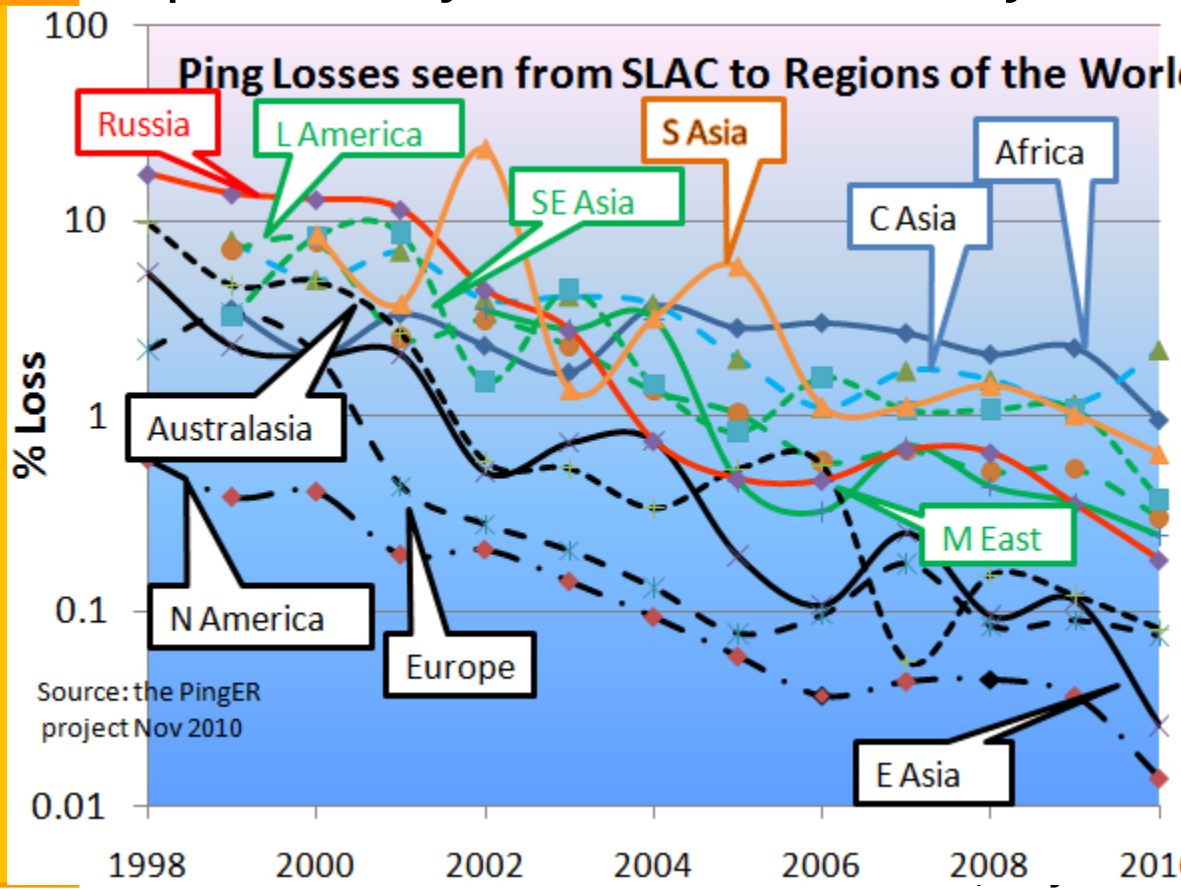


# Losses

- Low losses are good.
- Real time impact due to recovery timeouts, e.g. echoing typing
- Losses are mainly at the edge, so distance independent
- Losses improving roughly exponentially, ~factor 100 in 12 years

Loss has Similar behavior to thruput

- Best <0.1%: N. America, E. Asia, Europe, Australasia
- Worst> 1%:
  - Africa & C. Asia



# Derived Throughput

Derived throughput ~ 8*1460/(RTT*sqrt(loss))
Mathis et. al

**Europe, E. Asia & Australasia merging**

**Behind Europe:**

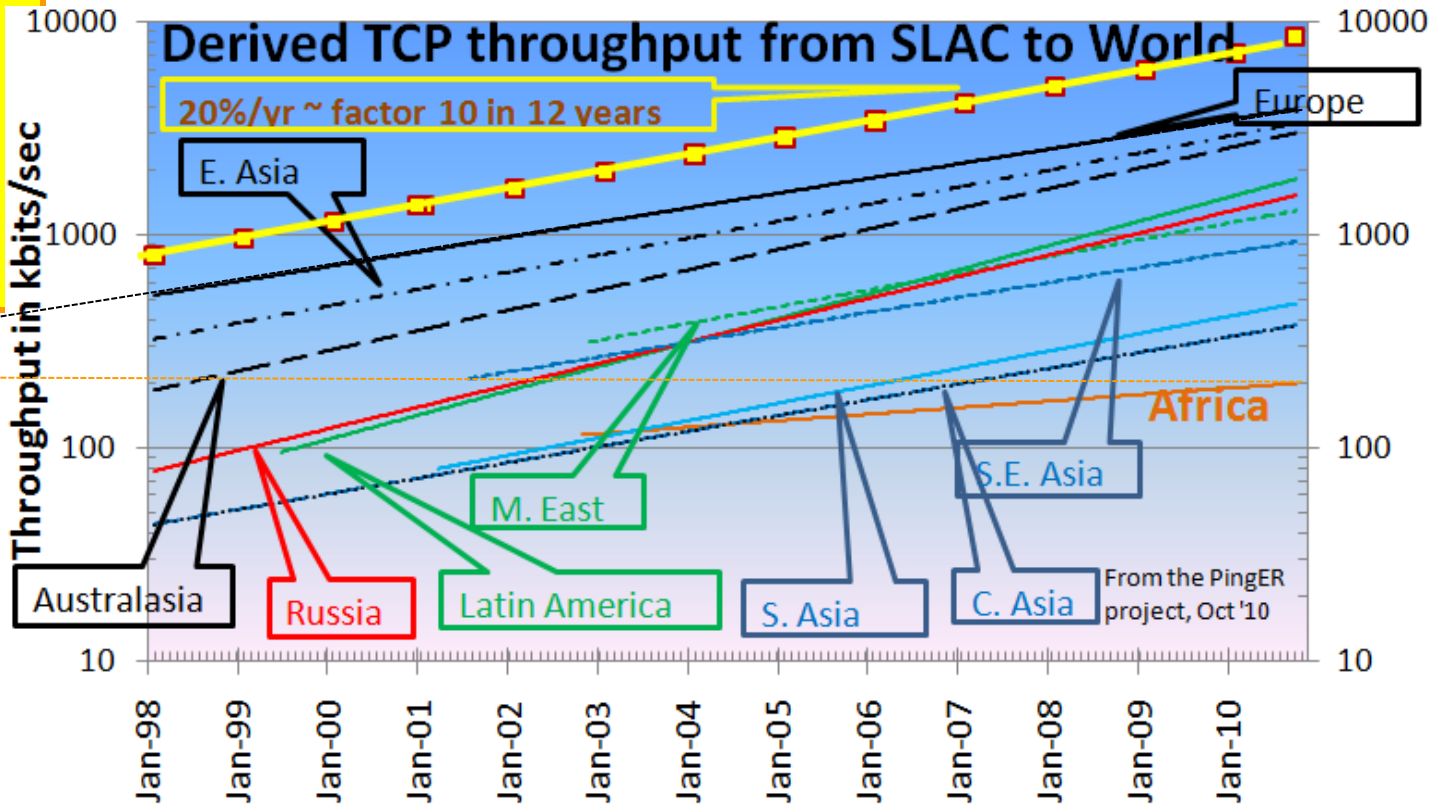
5-6 yrs: Russia, L America, M East

9 yrs: SE Asia

12-14 yrs: India, C. Asia

18 yrs: Africa

Feb 1992

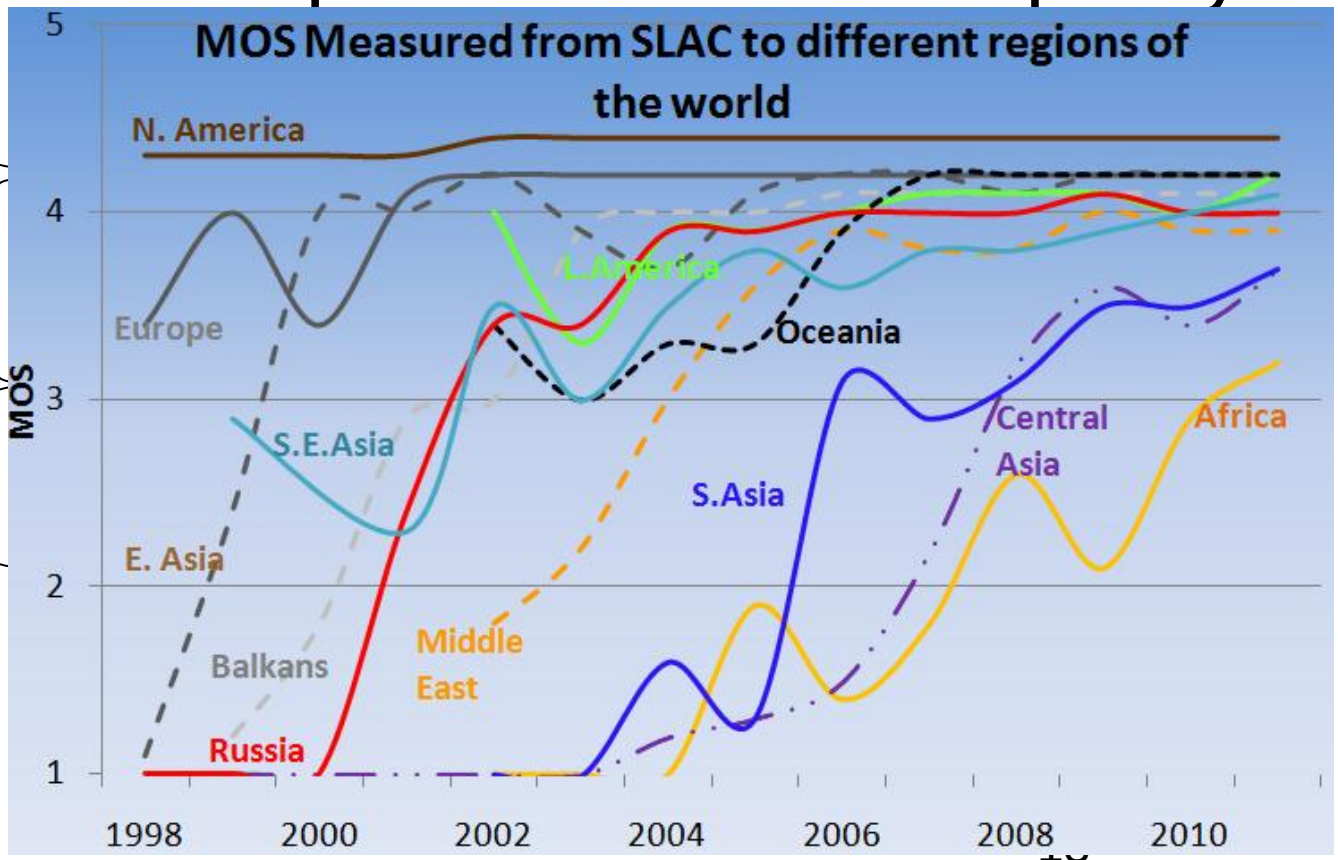



***Africa in danger of falling even further behind.***
***In 10 years at current rate Africa will be 70 times worse than Europe***

# Mean Opinion Score MOS)

- Used in phone industry to decide quality of call
- MOS = function(loss, RTT, jitter)
- 5=perfect, 1= lowest perceived audible quality
- >=4 is good
- 3-4 is fair,
- 2-3 is poor.

Usable



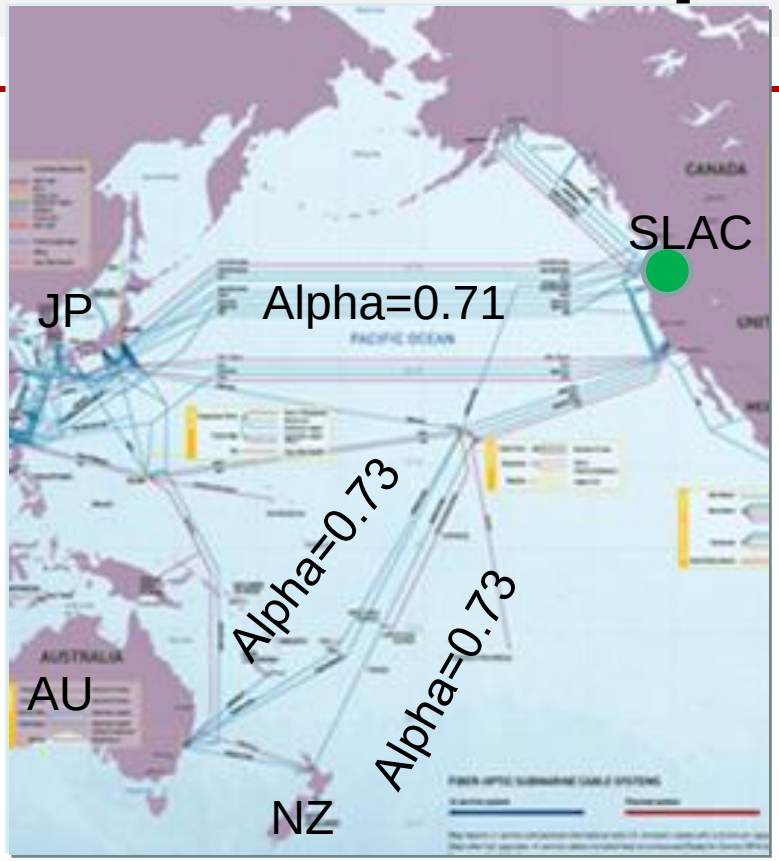

From the PingER project http://www-iepm.slac.stanford.edu/pinger

Important for VoIP

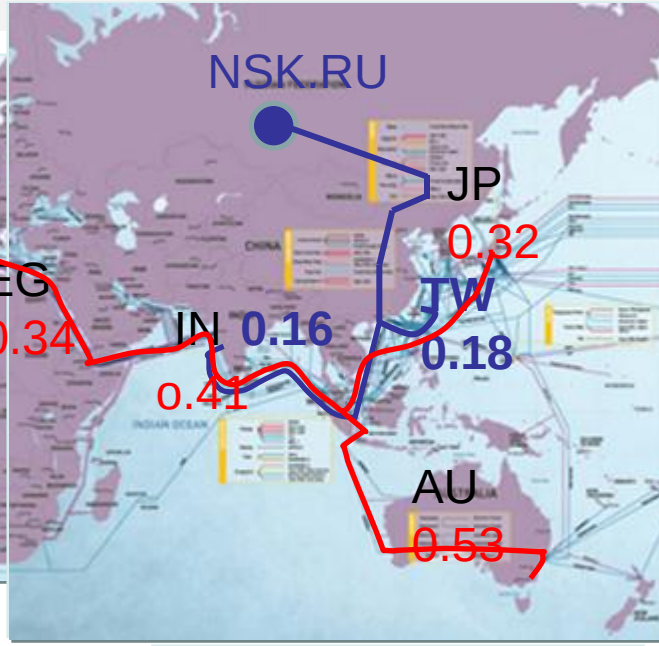
# Directness of connection (Alpha)

- Alpha to allow for delays in network equipment & indirectness of actual route. D = 1 way distance
  - *Alpha = D(km) / (min_RTT[msec] * 100 [km/msec])*
    - Max(Alpha) =1 = direct (great circle) route and no network delays
    - Alpha typically ~ 0.45
    - Low values typically mean very indirect route, or satellite or slow connection (e.g. wireless)
    - Alpha > 1 probably identifies bad coordinates for hosts.
- If know lat/long of monitor and remote host then know D, so with min-RTT can estimate Alpha
- Alpha > 1 impossible so good diagnostic for invalid lat/longs or min_RTT

# Alpha worldwide









- Interest in Polar route with Global warming

# Other metrics

- Duplicate packets (try ping www.cern.ch, load balancing?)
- Out of order packets (parallel paths)
- Conditional Loss Probability (non-random loss)
  - one packet is lost the following packet is also lost
  - route change, loss of sync, spanning tree reconfig
- Maximum packet loss (useful for buffer bloat?)

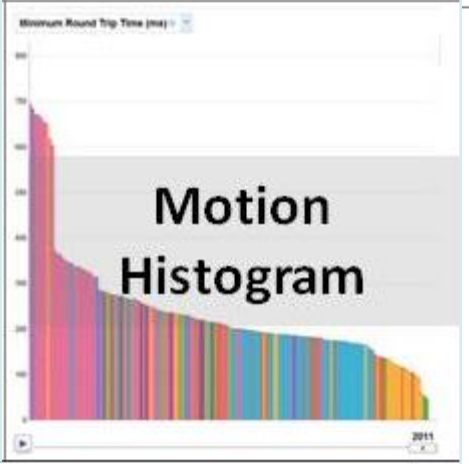
# Demo

- Interactive demonstrations of the data mining capabilities of public data sources provided by organizations such as the UN and ITU coupled with monitoring data from PingER
- http://www-iepm.slac.stanford.edu/pinger/explorer.html

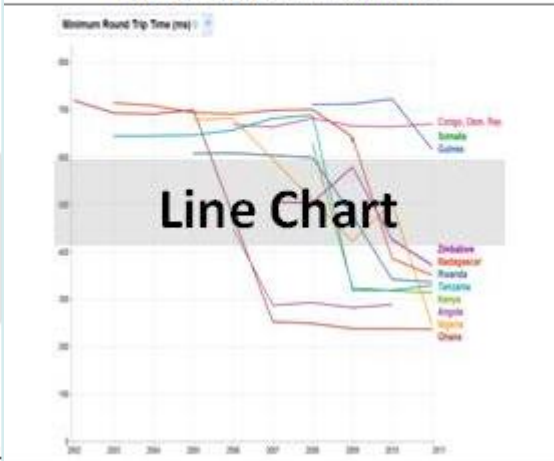
Motion (time) bubble (size=population) chart for world countries colored by region showing throughput vs average RTT.


Motion (time) world map of minimum RTT by color with bubble size indicating population.


Bar chart of the minimum RTT for all the countries of the world colored by region with time as motion.




Minimum RTT time series for selected countries. Note sudden drop offs from >450ms to < 450ms ms as countries moved from Geo-stationary satellite to terrestrial connections.



# More Information

- PingER web home page
  - http://www-iepm.slac.stanford.edu/pinger/
- Tutorial on network monitoring
  - http://www.slac.stanford.edu/comp/net/wan-mon/tutorial.html
- PingER data Explorer
  - www-iepm.slac.stanford.edu/pinger/explorer.html
- Telegeography submarine cable map
  - http://www.submarinecablemap.com/

# Directivity (Alpha) from SLAC to world