Quantifying the Digital Divide: A scientific overview of the connectivity of South Asian and African Countries

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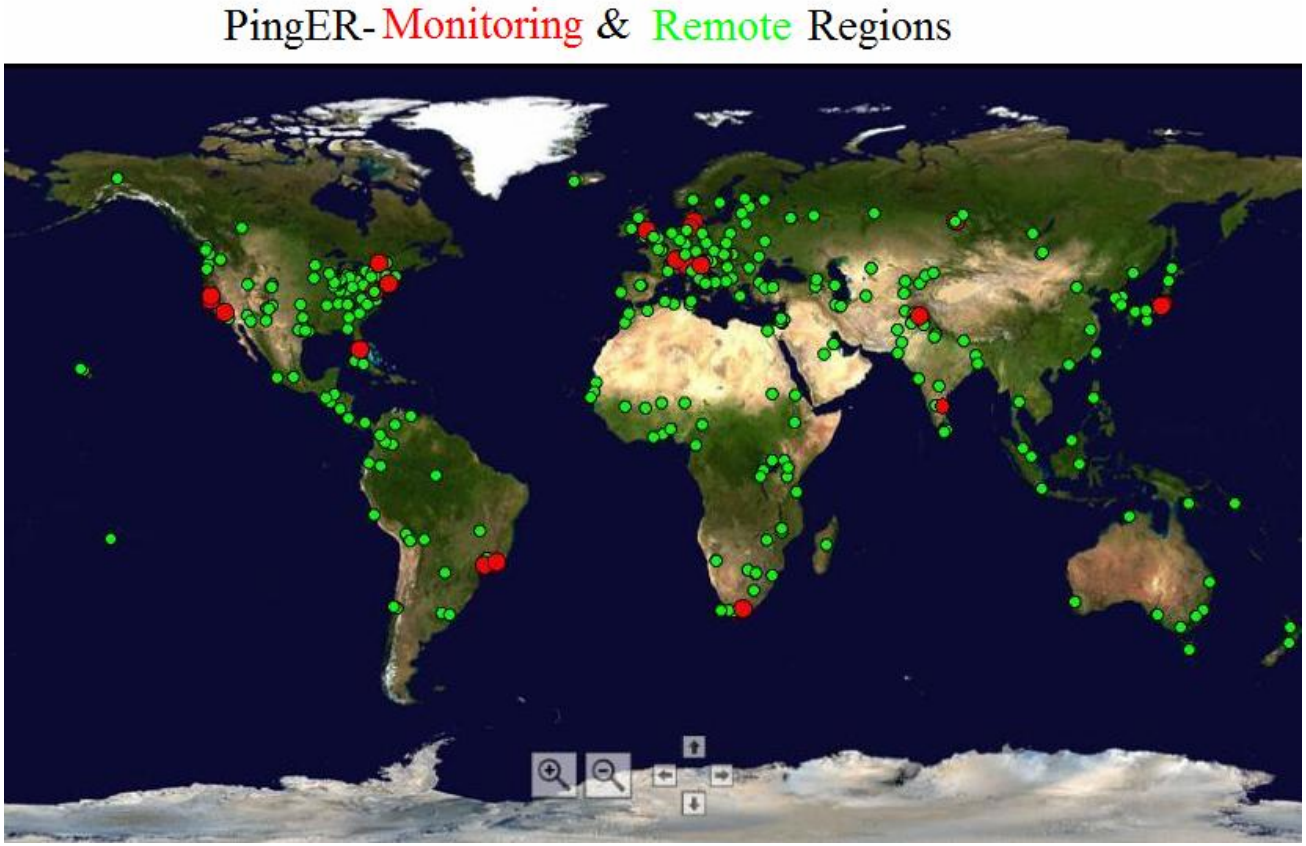
www.slac.stanford.edu/grp/scs/net/talk05/icfa-chep06.ppt

Introduction

- PingER project originally (1995) for measuring network performance for US, Europe and Japanese HEP community
- Extended this century to measure Digital Divide
- Last year added monitoring sites in S. Africa, Pakistan & India
- Will report on network performance to these regions from US and Europe – trends, comparisons
- Plus early results within and between these regions

PingER coverage

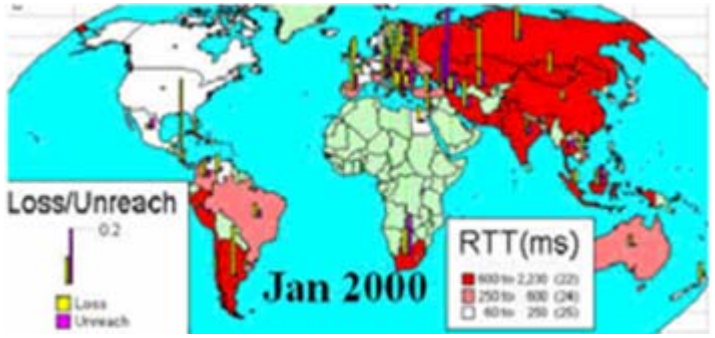
- ~120 countries (99% world's connected population), 35 monitor sites in 14 countries
- New monitoring sites in Cape Town, Rawalpindi, Bangalore
- Monitor 25 African countries, contain 83% African population



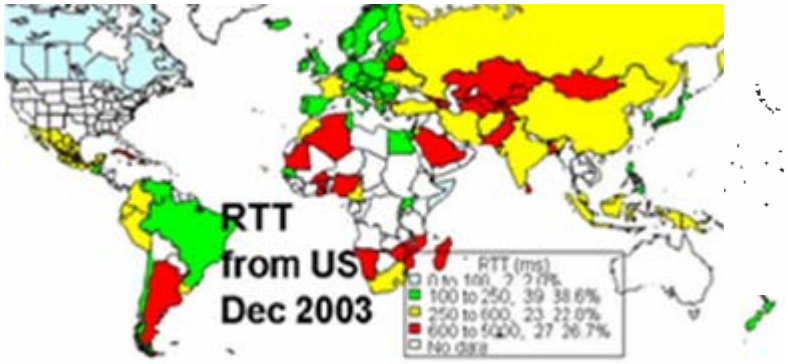
Minimum RTT from US

- Indicates best possible, i.e. no queuing
- >600ms probably geo-stationary satellite
- Only a few places still using satellite, mainly Africa
- Between developed regions min-RTT dominated by distance
  - Little improvement possible

Jan 2000

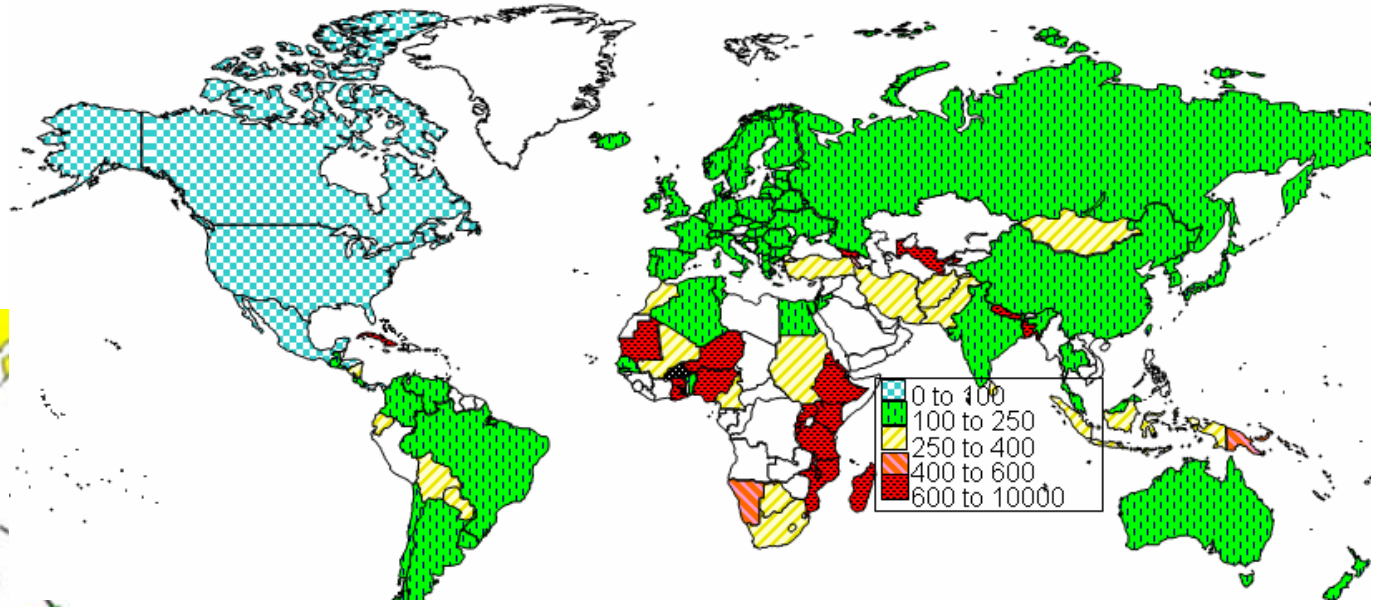


Dec 2003

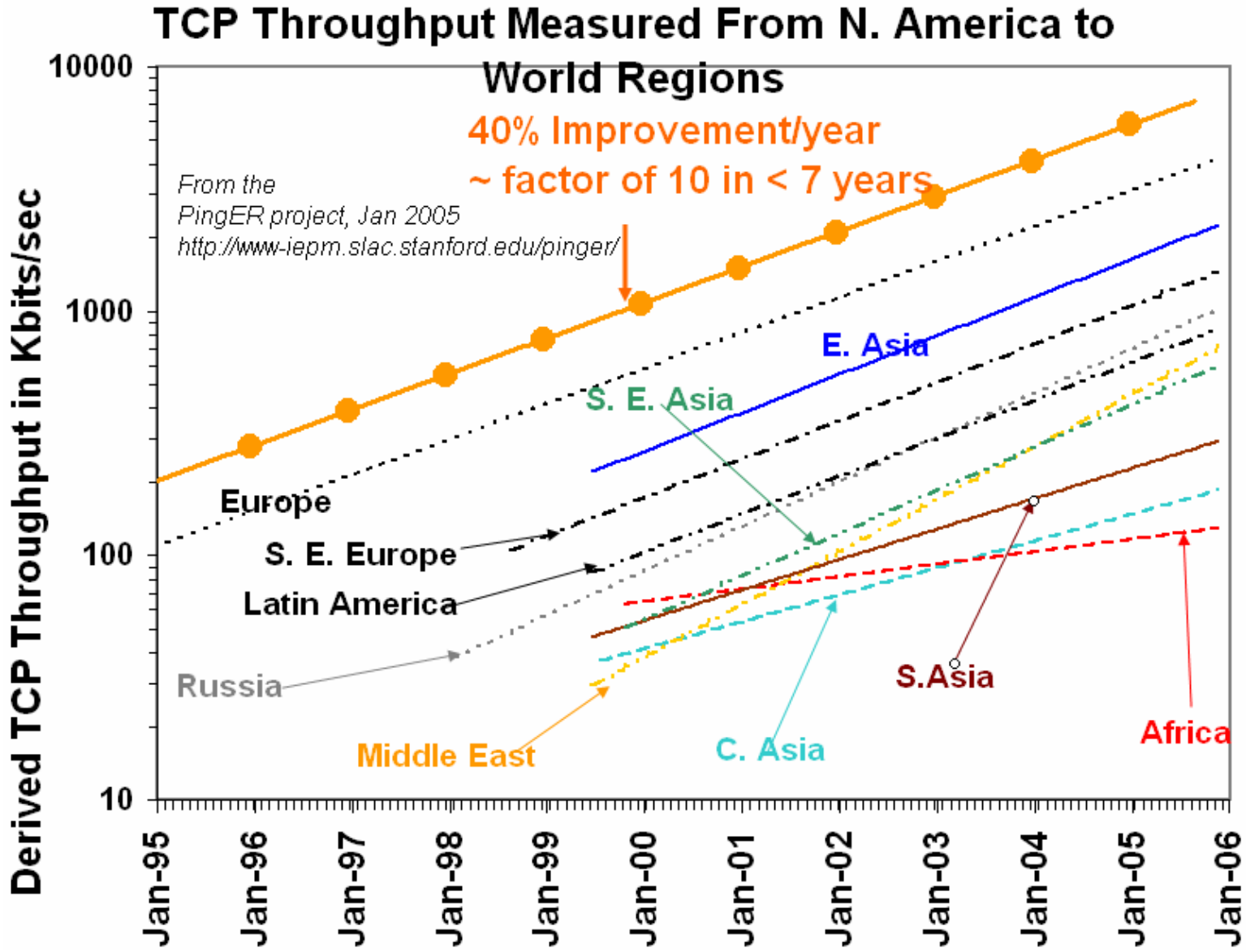


Min RTT From US to the World Dec 2005

The PingER Project: http://www-iepm.slac.stanford.edu/pinger/



World thruput seen from US



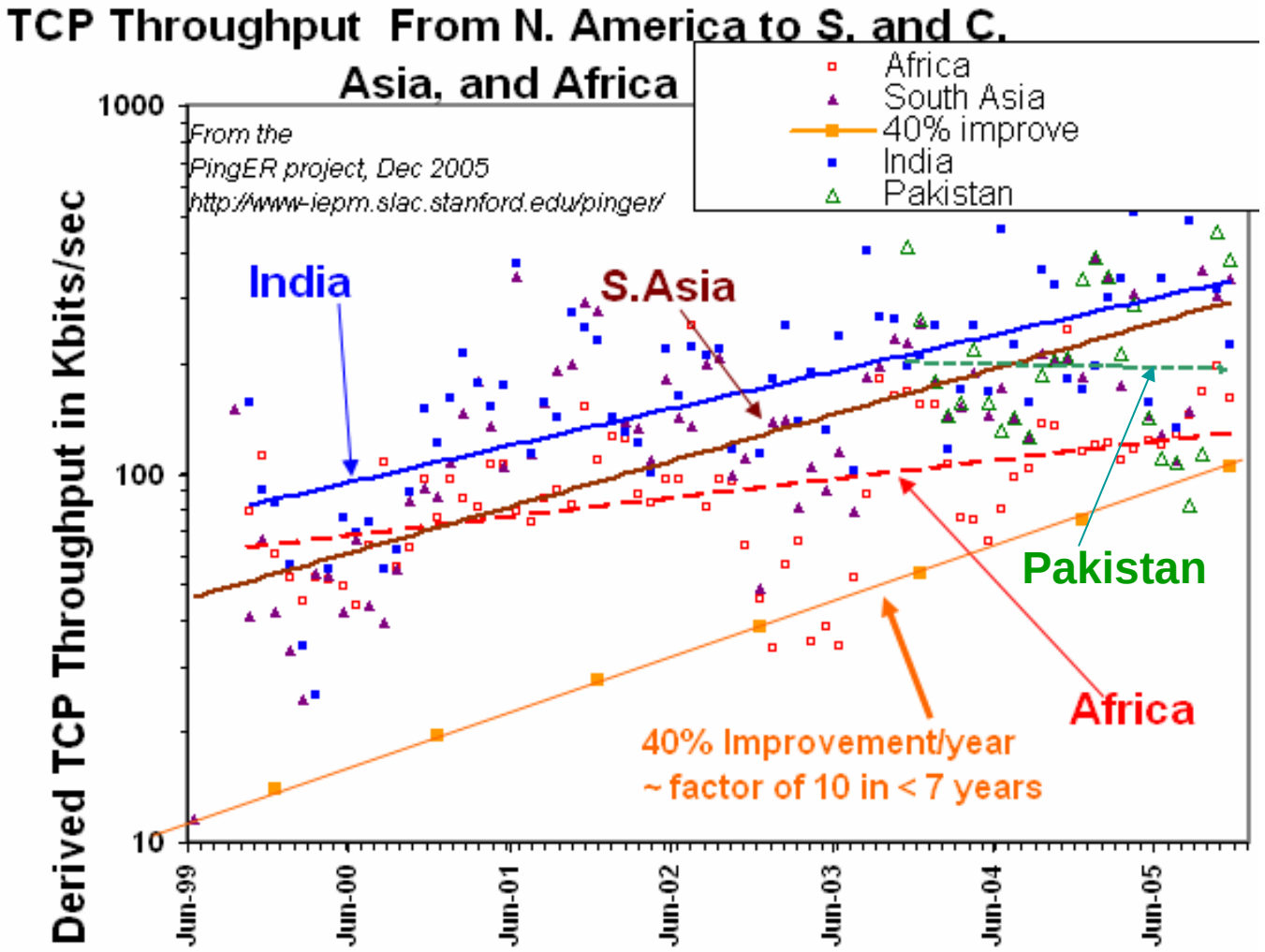
Behind Europe

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

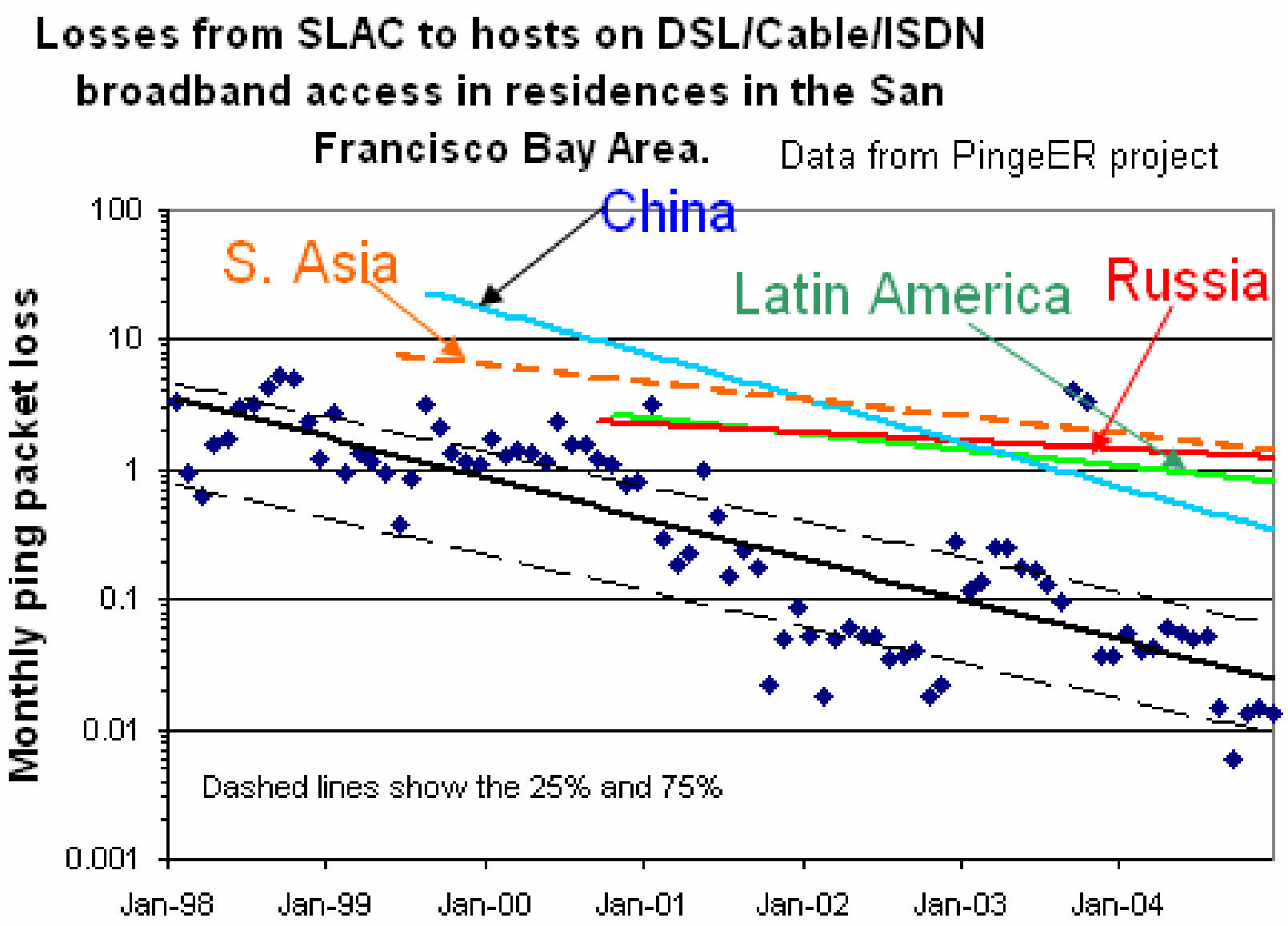
S. Asia & Africa from US

- Data v. noisy but there are noticeable trends
- India may be holding its own
- Africa & Pakistan are falling behind



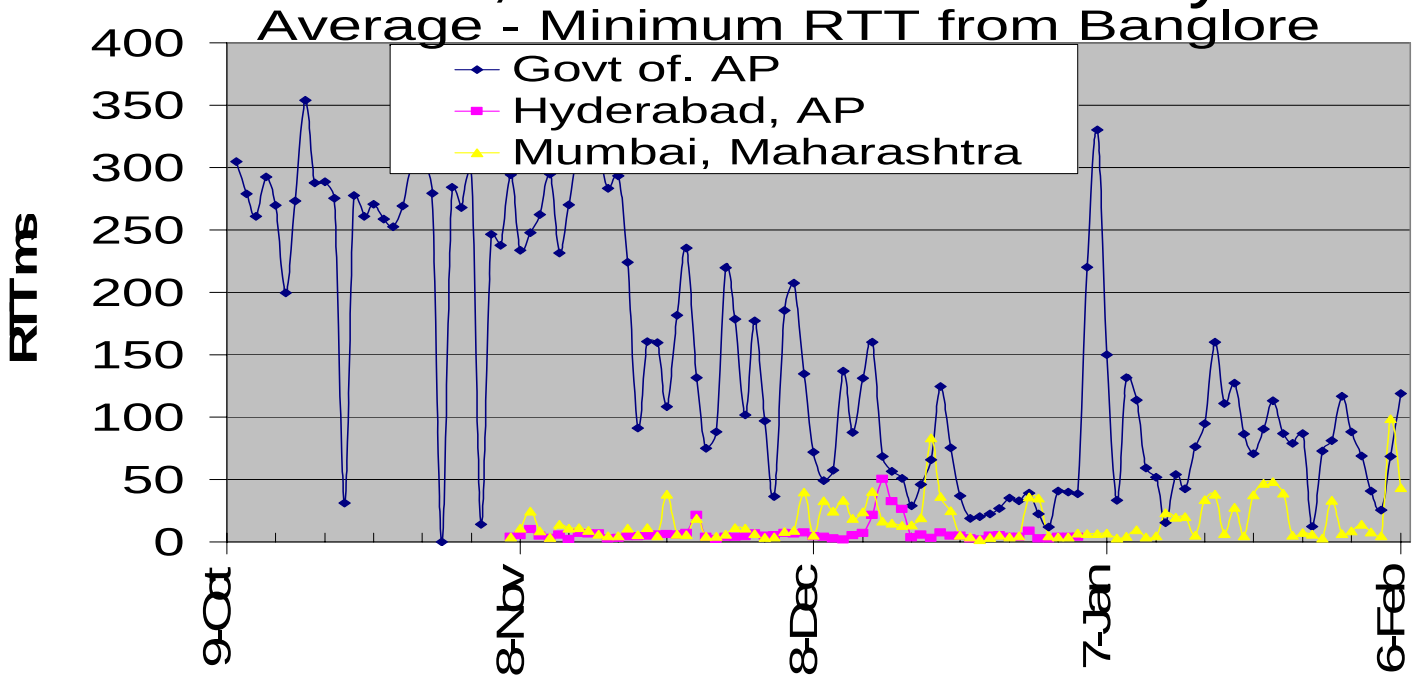
Compare to US residence

- Sites in many countries have bandwidth< US residence



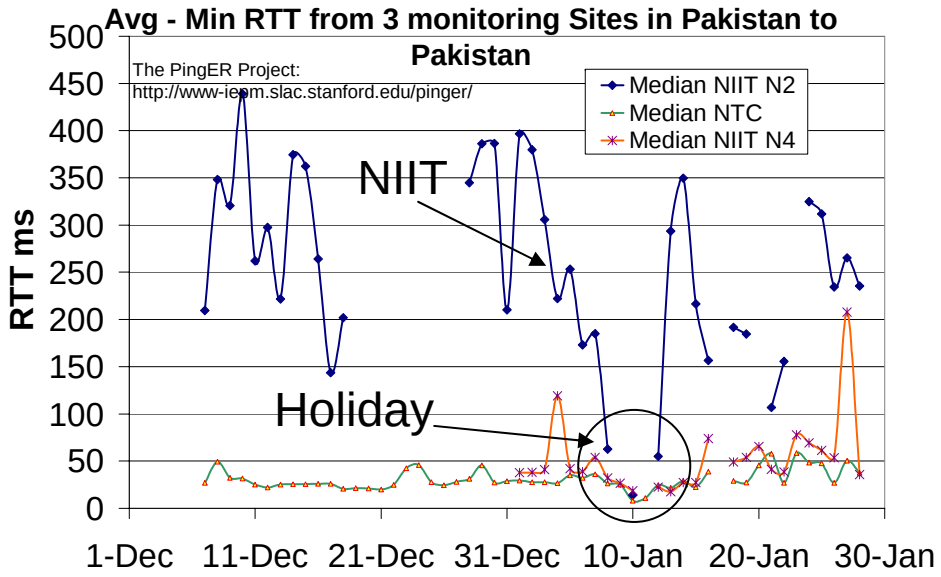
India to India

- Monitoring host in Bangalore from Oct ’05
  - Too early to tell much, also need more sites, have some good contacts
- 3 remote hosts (need to increase):
  - R&E sites in Mumbai & Hyderabad
  - Government site in AP
- Lot of difference between sites, Gov. site sees heavy congestion

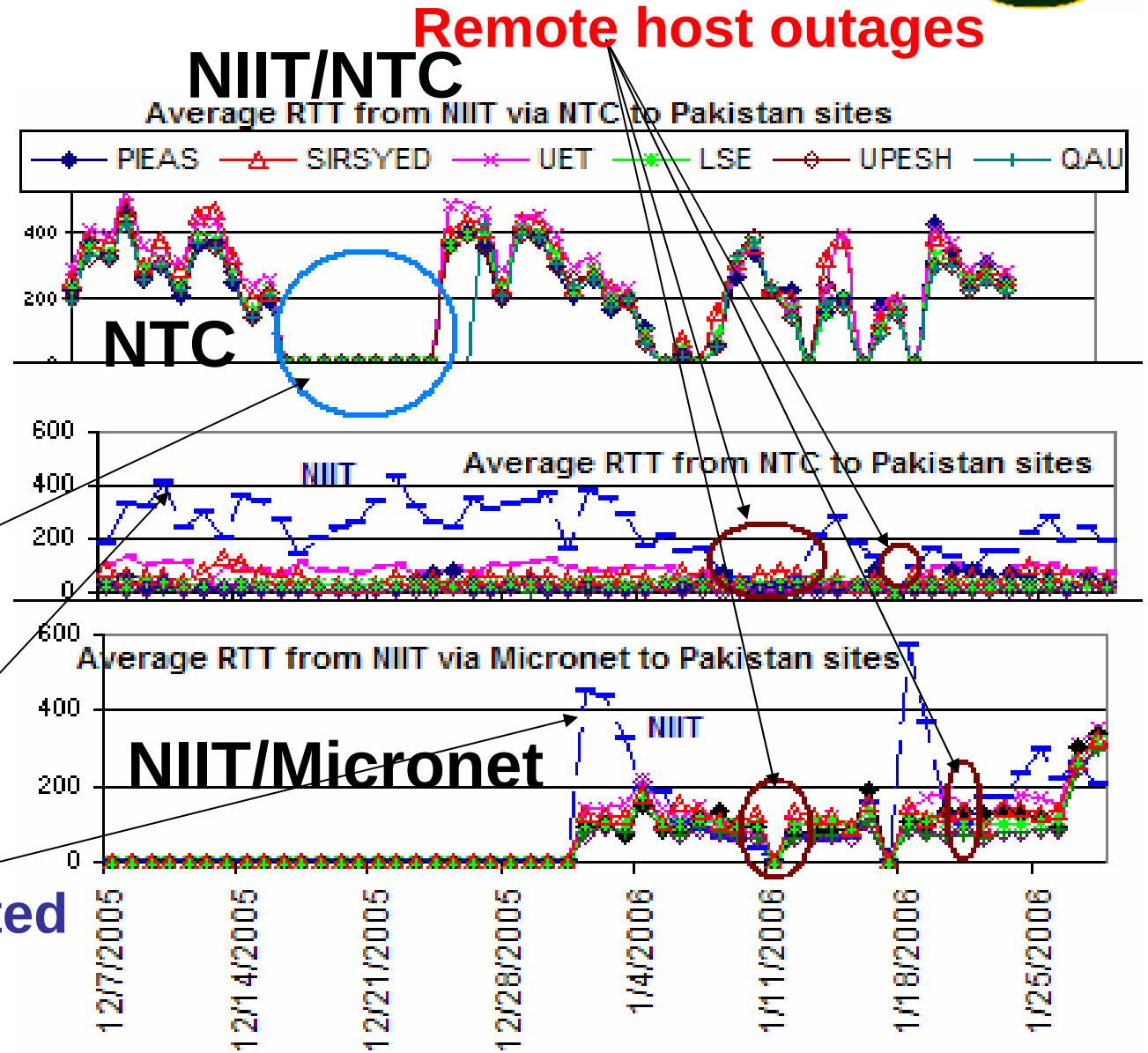


Pakistan to Pakistan

- 3 monitoring sites in Islamabad/Rawalpindi
  - NIIT via NTC, NIIT via Micronet, NTC (PERN supplier)
  - All monitor 7 Universities in ISB, Lahore, KHI, Peshawar
    - Careful: many University sites have proxies in US & Europe
- Minimum RTTs: best NTC 6ms, NIIT/NTC 10ms - *extra 4ms for last mile*, NIIT/Micronet 60ms – slower links different routes
- Queuing = Avg(RTT)-Min(RTT)
  - **NIIT/NTC heavily congested**
    - 200-400ms queuing
  - Better when students holiday
  - NIIT/Micronet & NTC OK
  - Outages show fragility



Pakistan Network Fragility



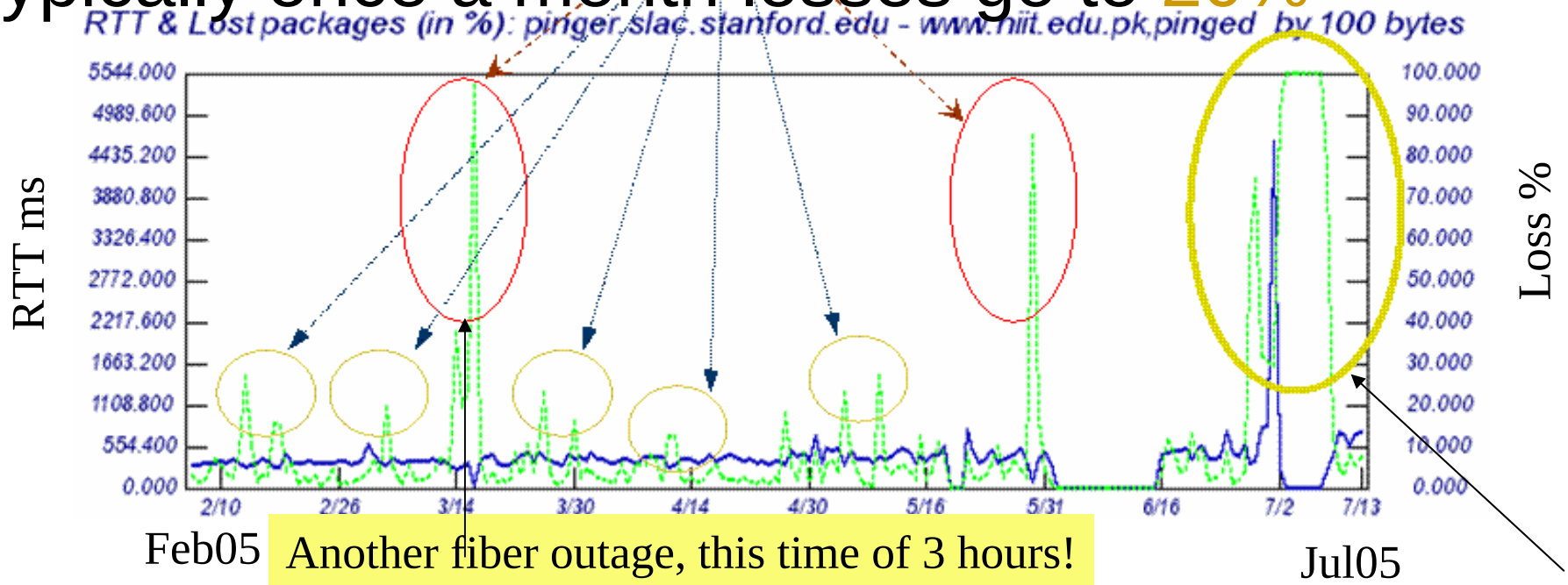
NIIT outage

NIIT/NTC heavily congested

Other sites OK

Pakistan International fragility

- Typically once a month losses go to 20%



Feb05

Another fiber outage, this time of 3 hours! Power cable dug up by excavators of Karachi Water & Sewage Board

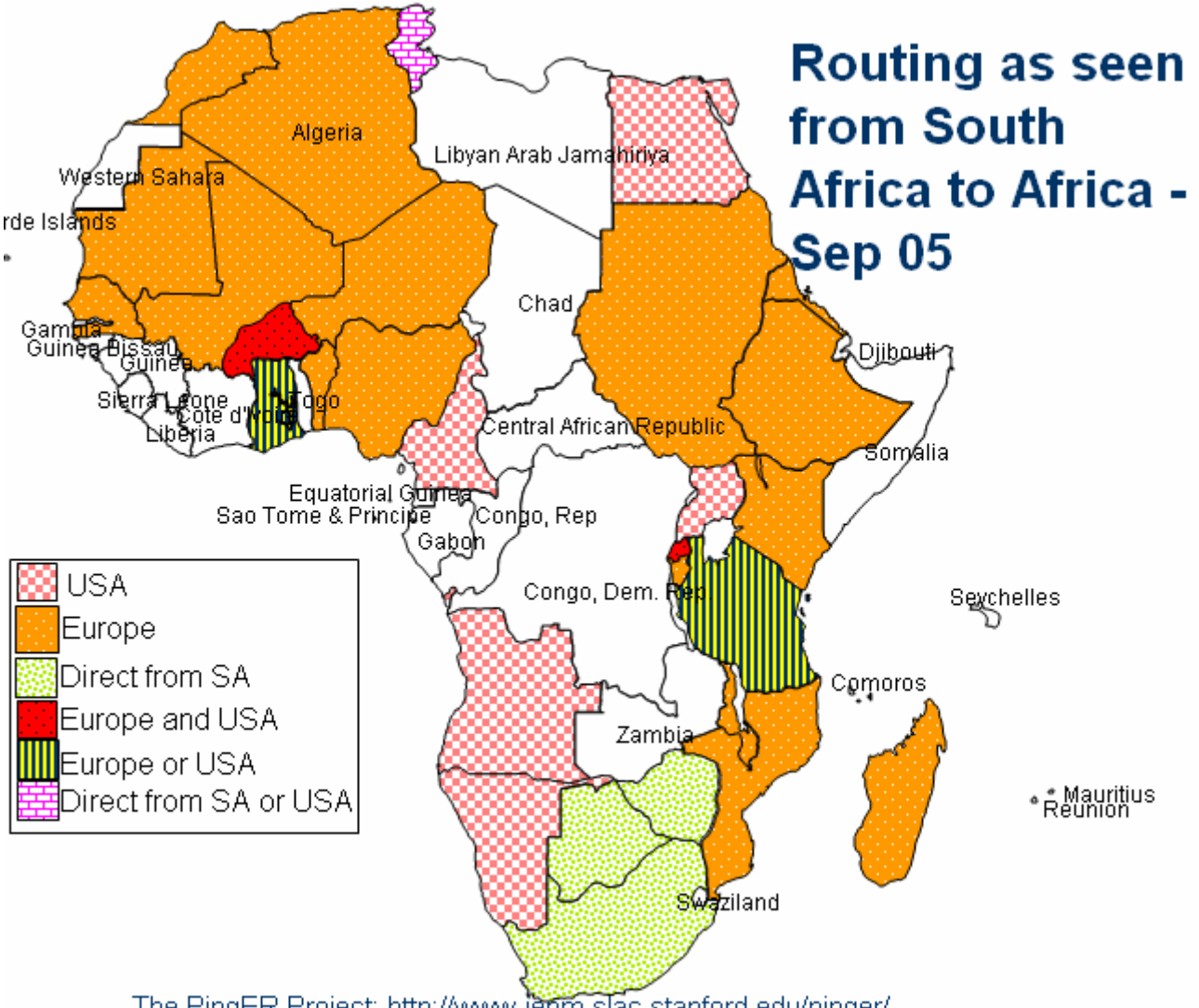
Jul05

Fiber cut off Karachi causes 12 day outage Jun-Jul '05, Huge losses of confidence and business

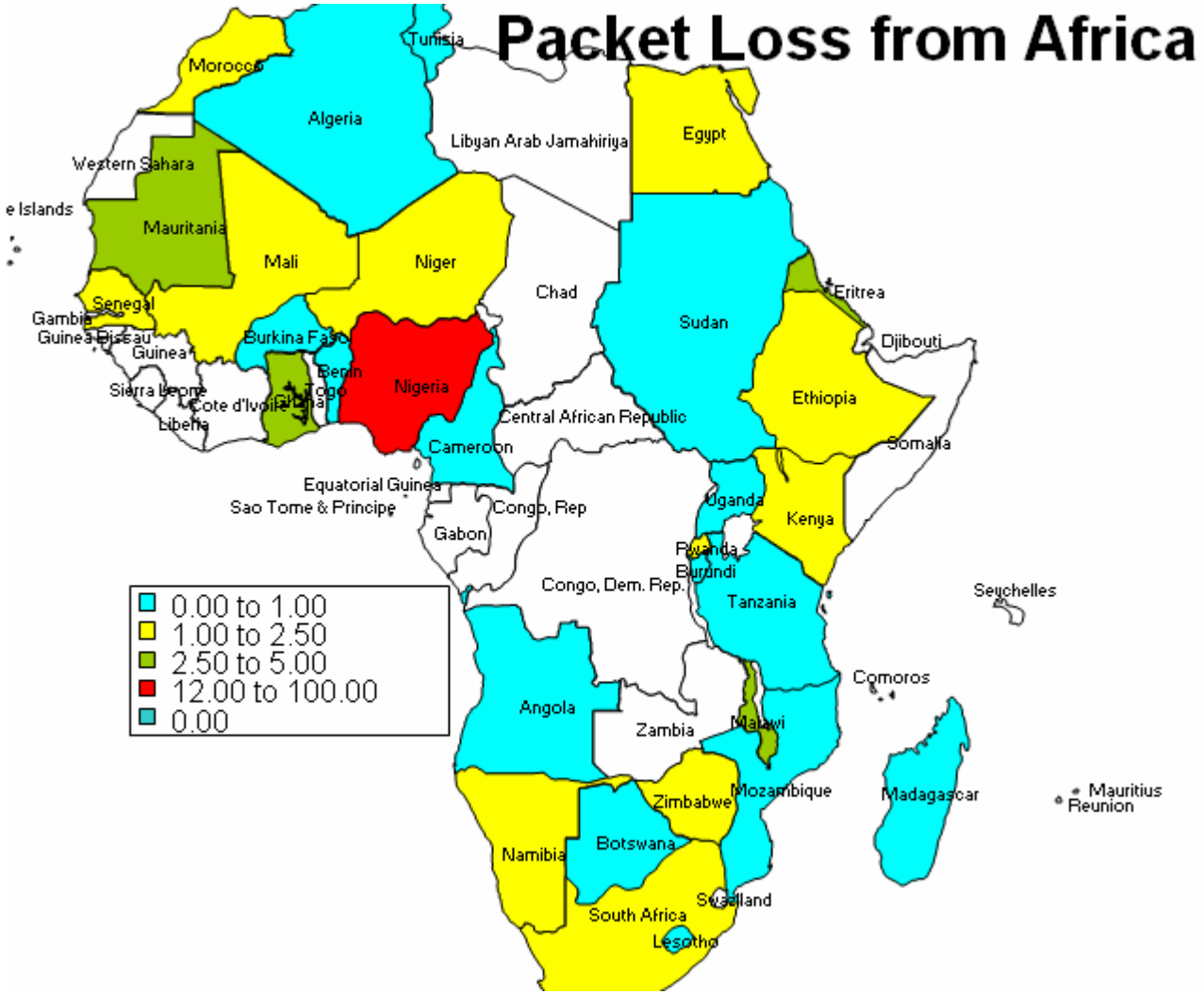
- Infrastructure appears fragile
- Losses to QEA & NIIT are 3-8% averaged over month

Routing in Africa

- Seen from ZA
- Only Botswana & Zimbabwe are direct
- Most go via Europe or USA
- Wastes costly international bandwidth

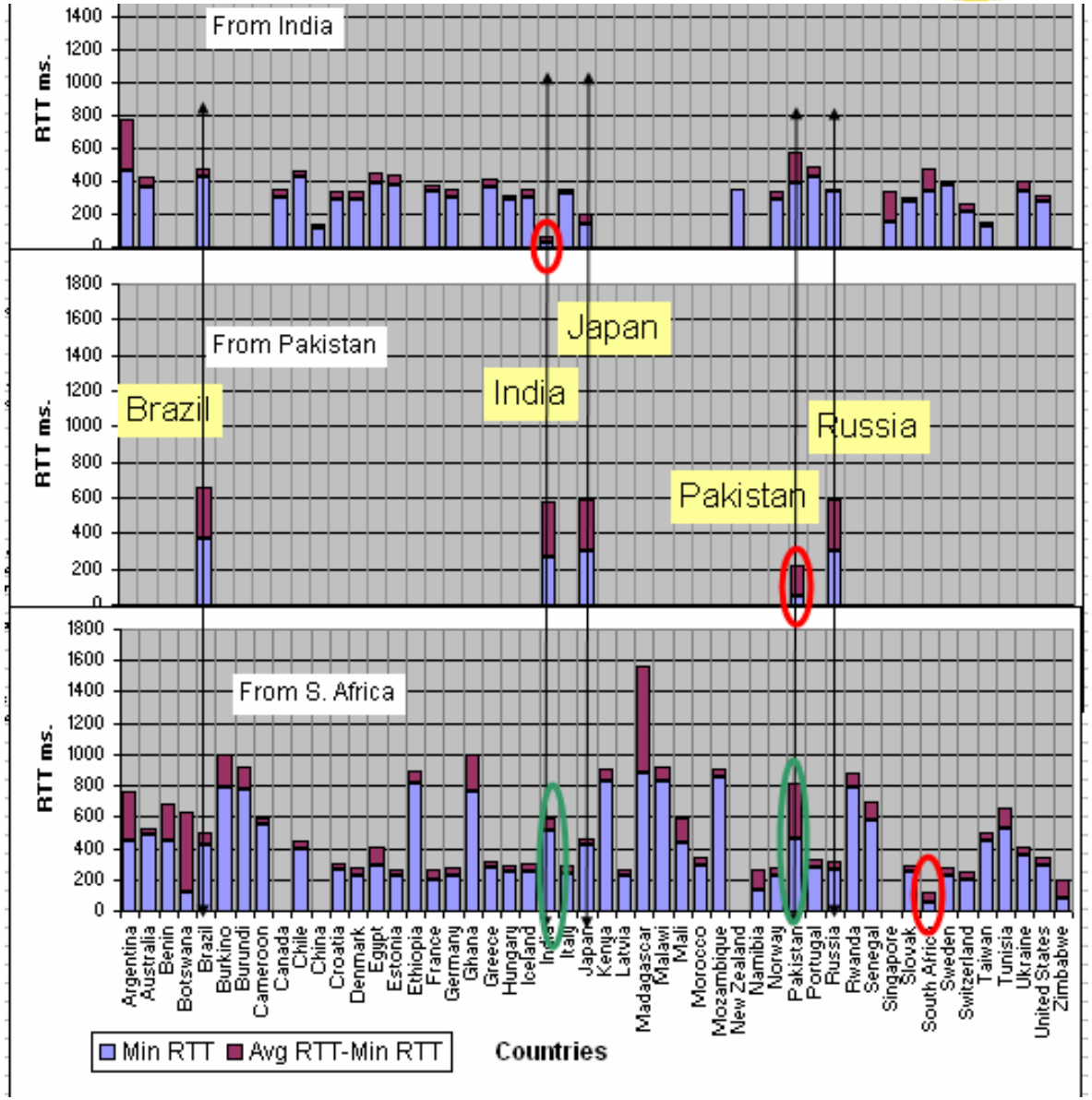


The PingER Project: http://www-iepm.slac.stanford.edu/pinger/


Packet Loss from Africa
Tunisia
Morocco
Algeria
Libyan Arab Jamahiriya
Egypt
Western Sahara
e Islands
Mauritania
Mali
Niger
Chad
Sudan
Eritrea
Djibouti
Senegal
Gambia
Guinea-Bissau
Guinea
Burkina Faso
Benin
Nigeria
Togo
Ghana
Sierra Leone
Cote d'Ivoire
Liberia
Central African Republic
Ethiopia
Somalia
Cameroon
Equatorial Guinea
Sao Tome & Principe
Congo, Rep
Gabon
Uganda
Kenya
Rwanda
Burundi
Congo, Dem. Rep.
Tanzania
Seychelles
Comoros
Angola
Zambia
Malawi
Mozambique
Zimbabwe
Madagascar
Mauritius
Reunion
Namibia
Botswana
Swaziland
South Africa
Lesotho
0.00 to 1.00
1.00 to 2.50
2.50 to 5.00
12.00 to 100.00
0.00

Between Regions

- Red ellipses show within region
- Blue = min(RTT)
- Red = min-avg RTT
- India/Pak green ellipses
- ZA heavy congestion
  - Botswana, Argentina, Madascar, Ghana, BF
- India better off than Pak



Overall

- Sorted by Median throughput
- Within region performance better (blue ellipses)
- Europe, N. America, E. Asia Russia generally good
- M. East, Oceania, S.E. Asia, L. America acceptable
- Africa, C. Asia, S. Asia poor

Remote regions ======v	Monitoring Country Top Level Domain ==========>													
	CH	DE	DK	HU	UK	CA	US	RU	JP	BR	IN	PK	ZA	Median
Europe	33985	9529	6504	14288	27683	2385	2214	1143	1151	1371	704		1113	2299
N. America	2200	2298	2081	2134	3089	607932	66557	546	2128	1529	902		963	2131
Russia	4543	3394	3445	2857	3049	1137	1362	2865	910		528	110	861	2109
S.E. Europe	5446	5464	5330	18427	3824	2048	1492	1041	1129		641		1096	2048
E. Asia	767	1165	1060	1159	1330	1675	2277	631	103904	590	1869	115	523	1159
M. East	917	1489	1303	1303	1250	758	964	420	472		260		498	917
Oceania	744			1079		1447	1469	349			802		656	802
S.E. Asia	540						1055							798
L. America	842	617	482	567	594	706	1289	261	496	15980	265	98	375	567
Africa	450	428	596	548	977		423	266	239	784			652	499
C. Asia	275						323							299
S. Asia	371						1957			97	798	203	81	287
Median	804	1894	1692	1303	2190	1561	1415	546	1020	1078	704	113	654	859
	CH	DE	DK	HU	UK	CA	US	RU	JP	BR	IN	PK	ZA	

Conclusions

- S. Asia and Africa ~ 10 years behind and falling further behind creating a Digital Divide within a Digital Divide
- India appears better than Africa or Pakistan
- Last mile problems, and network fragility
- Decreasing use of satellites, still needed for many remote countries in Africa and C. Asia
  - EASSy project will bring fibre to E. Africa
- Growth in # users 2000-2005 400% Africa, 4000% Pakistan networks not keeping up
- Need more sites in developing regions and longer time period of measurements

More information

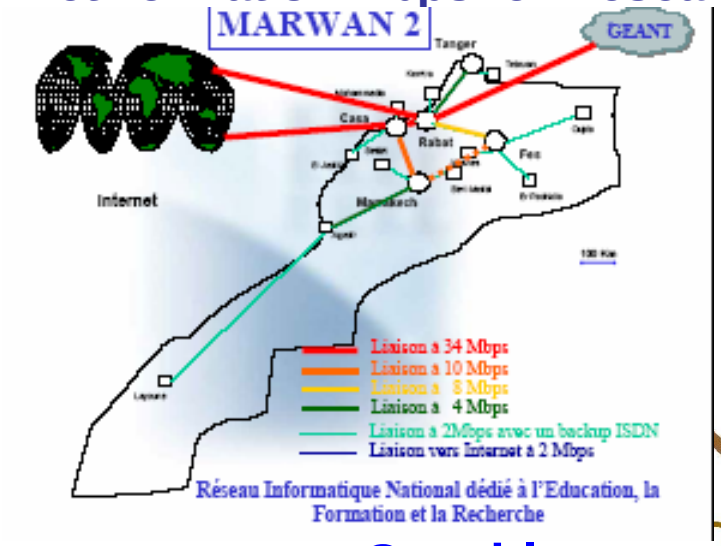
- Thanks to: Harvey Newman & ICFA for encouragement & support, Anil Srivastava (World Bank) & N.Subramanian (Bangalore) for India, NTC and PERN for Pakistan monitoring site, FNAL for PingER management support, Duncan Martin & TENET (ZA).
- Future: work with VSNL for India, Julio Ibarra for L. America
- Also see:
- ICFA/SCIC Monitoring report:
  - www.slac.stanford.edu/xorg/icfa/icfa-net-paper-jan06/
- PingER project:
  - www-iepm.slac.stanford.edu/pinger/

Extra slides

Abdeslam Hoummada

Maroc Wide Area Network
MARWAN 2

Network at 34 Mbps for Research and high education



Réseau GEANT

Connexion vers les réseaux de la Recherche, Europe, Amérique...

45 Mbps

Algeria & tunisia connected to Geant - 45 Mbs

Rabat

Casablanca

Université

Université

Université

Université

Université

Institut

Institut

Université

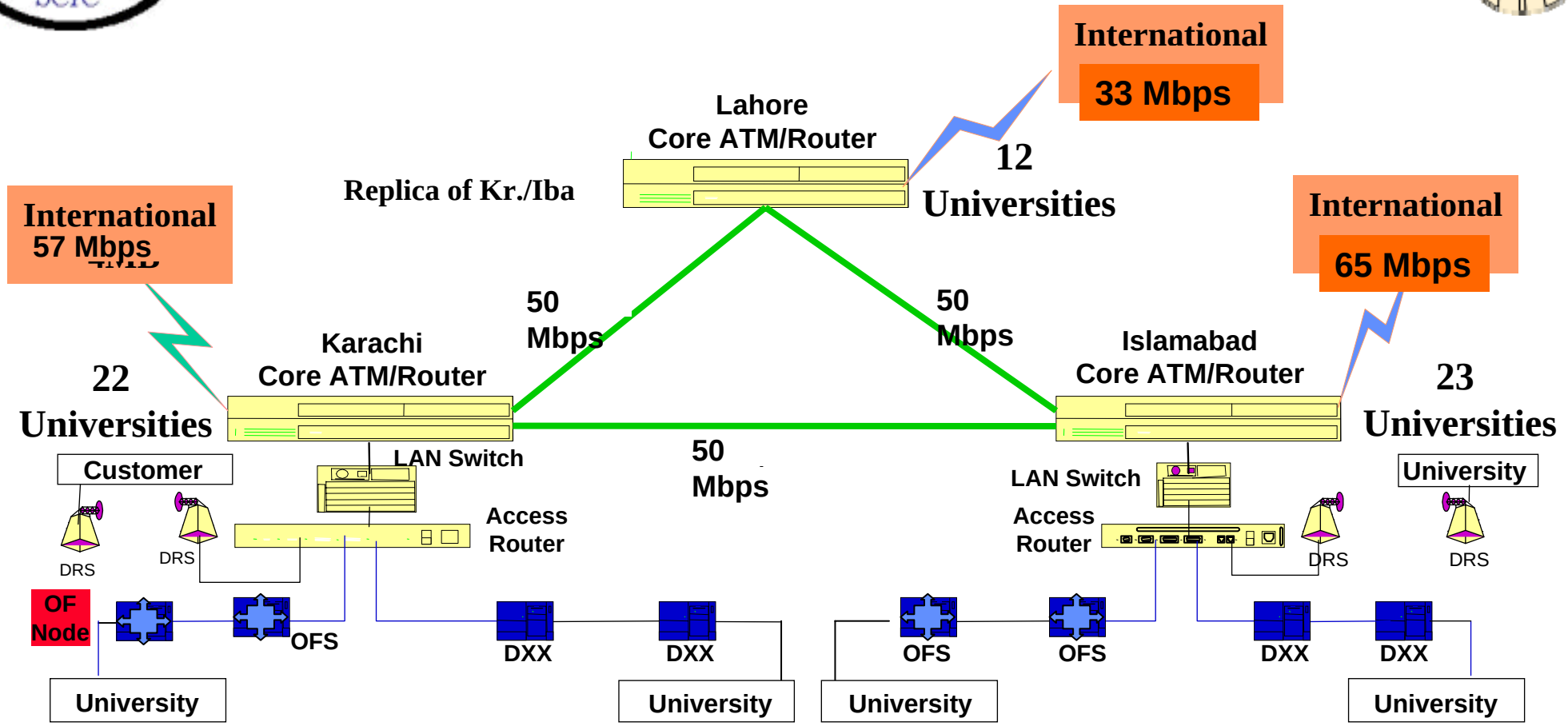
34 Mbps

2 Mbps

80% universities connect
Typically 2Mbps connection
Monopoly carrier

45 Mbit/s
34 Mbit/s
2 Mbit/s

PERN: Network Architecture

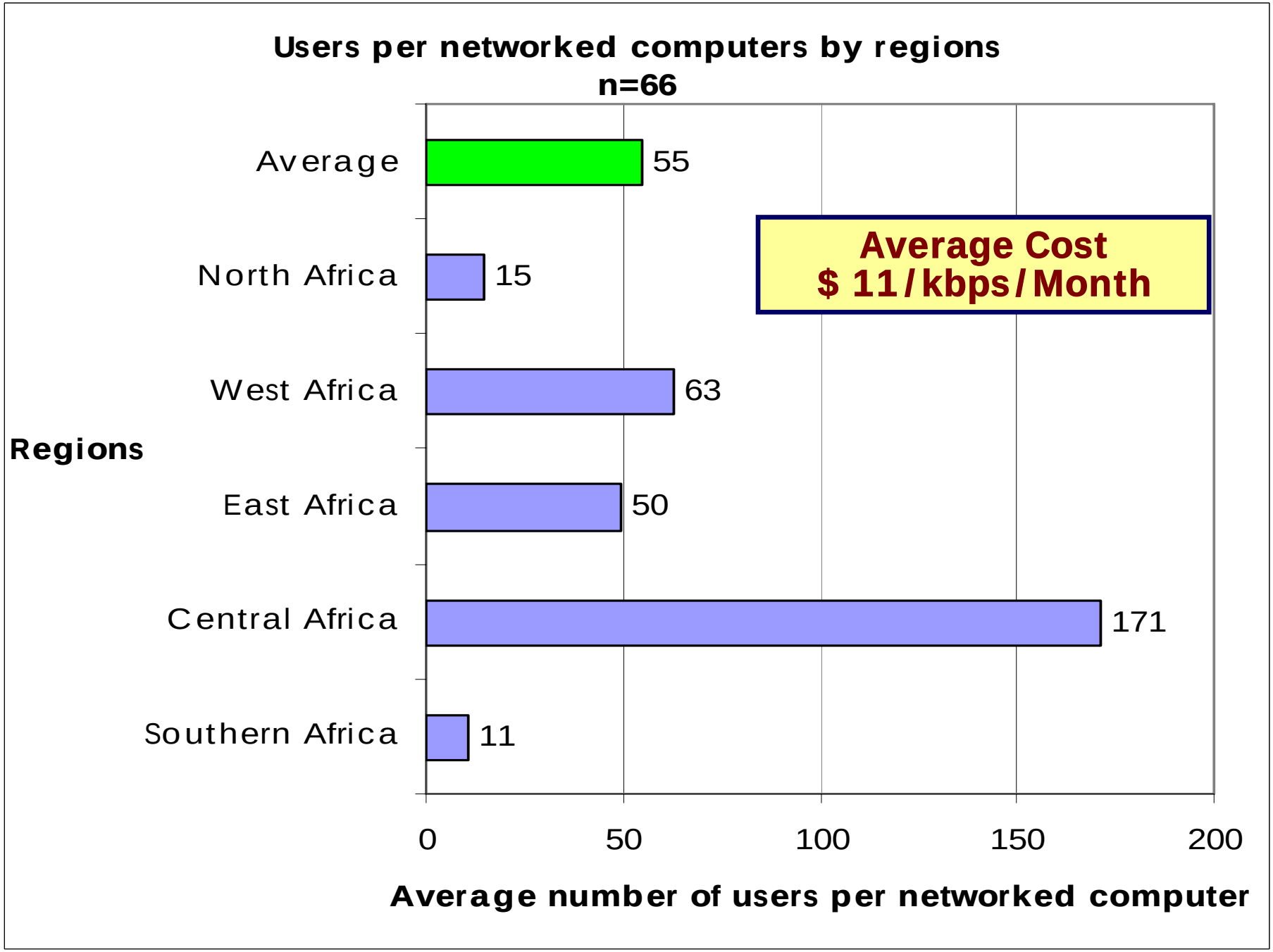


- HEC will invest $ 4M in Backbone
- 3 To 9 Points-of-Presence (Core Nodes)
- $ 2.4M from HEC to Public Universities for Last Mile Costs
- Possible Dark Fiber Initiative

Many systemic factors:

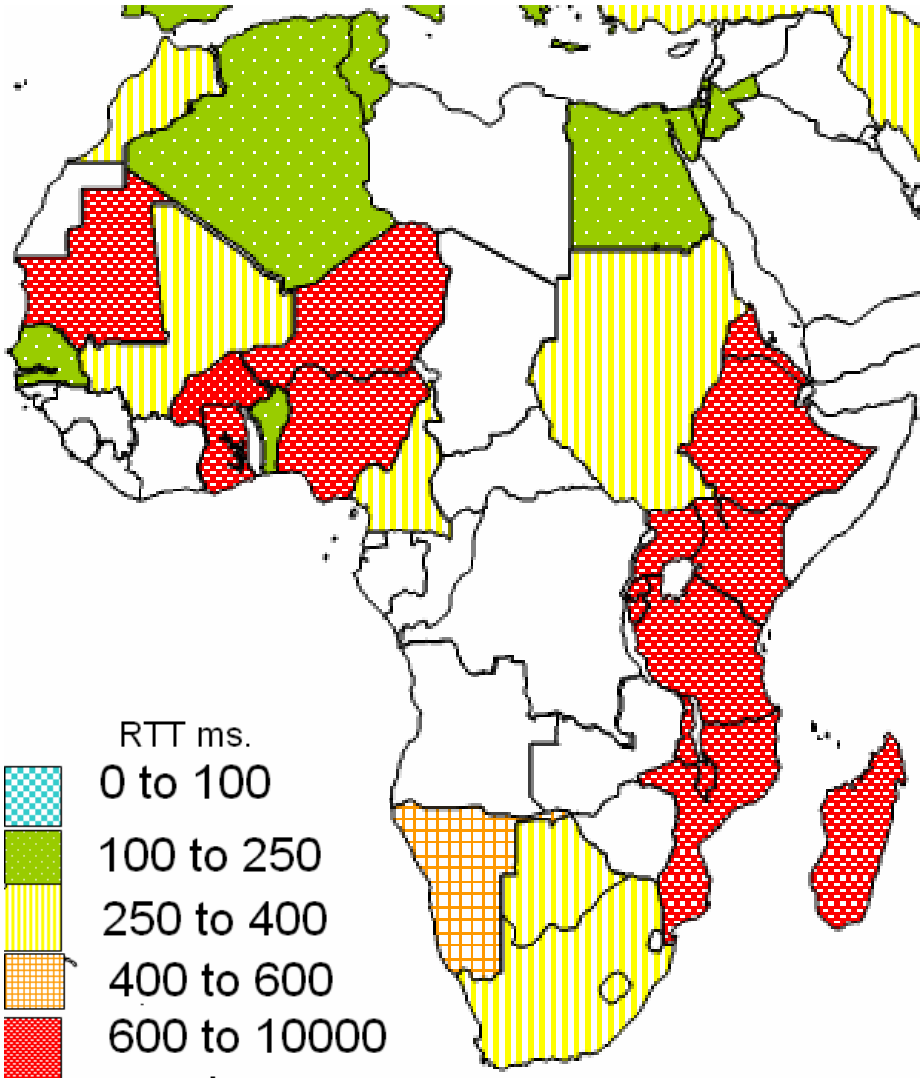
Electricity,
Import duties,
Skills

M. Jensen

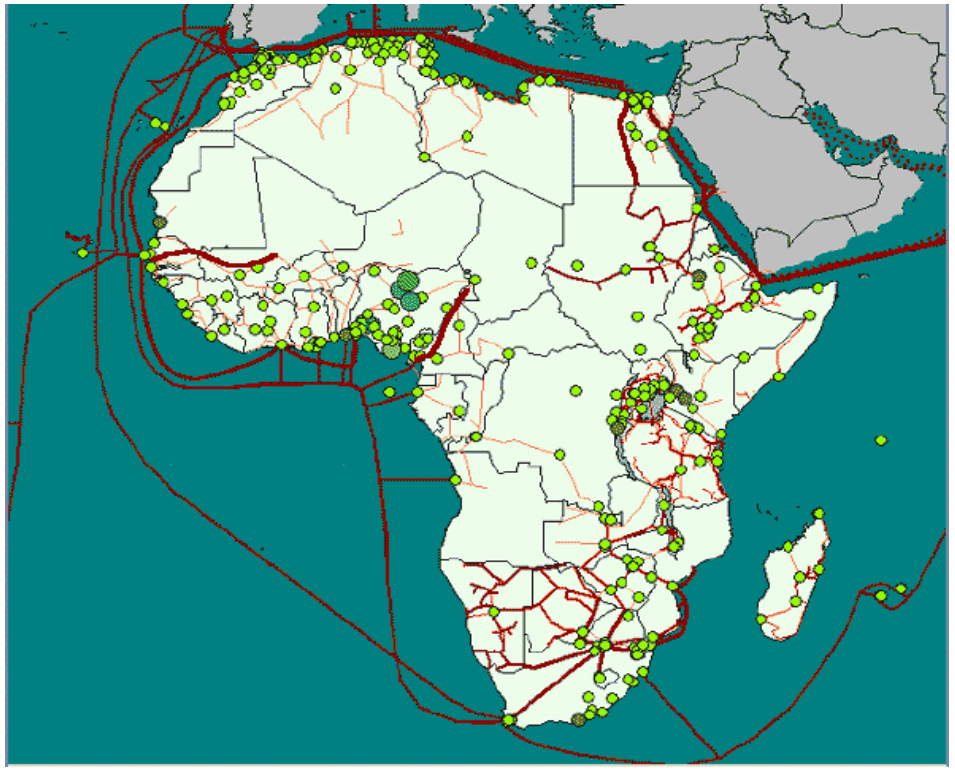

Users per networked computers by regions
n=66
Average
North Africa
West Africa
East Africa
Central Africa
Southern Africa
55
15
63
50
171
11
Average Cost
$ 11/kbps/Month
Regions
0
50
100
150
200
Average number of users per networked computer

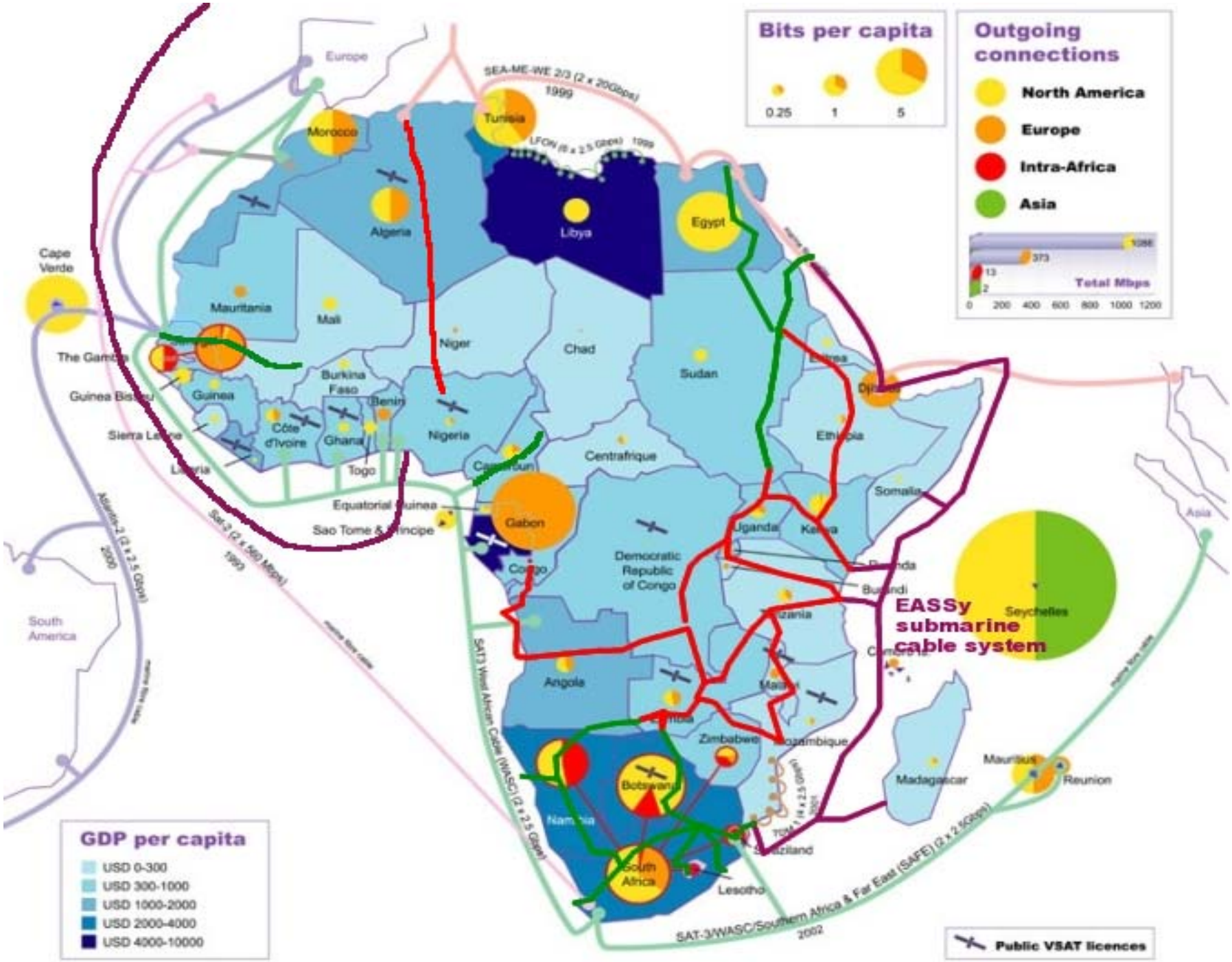
Satellites vs Terrestrial

- Terrestrial links via SAT3 & SEAMEW (Mediterranean)
- Terrestrial not available to all within countries



PingER min-RTT measurements from S. African TENET monitoring station




Bits per capita
0.25
1
5
Outgoing connections
North America
Europe
Intra-Africa
Asia
1086
373
13
2
Total Mbps
0
200
400
600
800
1000
1200
Europe
SEA-ME-WE 2/3 (2 x 20Gbps)
1999
Tunisia
Morocco
LFON (6 x 2.5 Gbps) 1999
Algeria
Libya
Egypt
Cape Verde
Mauritania
Mali
Niger
Chad
Sudan
The Gambia
Guinea Bissau
Guinea
Burkina Faso
Benin
Côte d'Ivoire
Ghana
Togo
Nigeria
Sierra Leone
Liberia
Cameroun
Centrafrique
Equatorial Guinea
Sao Tome & Principe
Gabon
Congo
Democratic Republic of Congo
Ethiopia
Somalia
Uganda
Kenya
Rwanda
Burundi
Tanzania
Seychelles
EASSy submarine cable system
Comoros
Asia
South America
Atlantis-2 (2 x 2.5 Gbps) 2000
Sat-3 (2 x 560 Mbps) 1999
SAT3 West African Cable (WASC) (2 x 2.5 Gbps)
Angola
Malawi
Zimbabwe
Mozambique
Madagascar
Mauritius
Reunion
Botswana
Namibia
Swaziland
South Africa
Lesotho
SAT-3/WASC/Southern Africa & Far East (SAFE) (2 x 2.5Gbps) 2002
GDP per capita
USD 0-300
USD 300-1000
USD 1000-2000
USD 2000-4000
USD 4000-10000
Public VSAT licences