Broadband Quality of Service

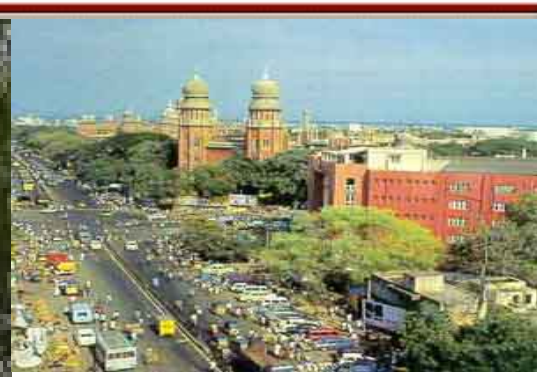
Prof. Timothy Gonsalves
Dept of Computer Science & Engg
TeNeT Group, IIT-Madras

R.Thirumurthy
Midas Communication Technologies Pvt Ltd

Overview

- The users
- The QoS metrics
- The evaluation methodology
- ITU-T 1540/1541
- Summary

The Next Billion

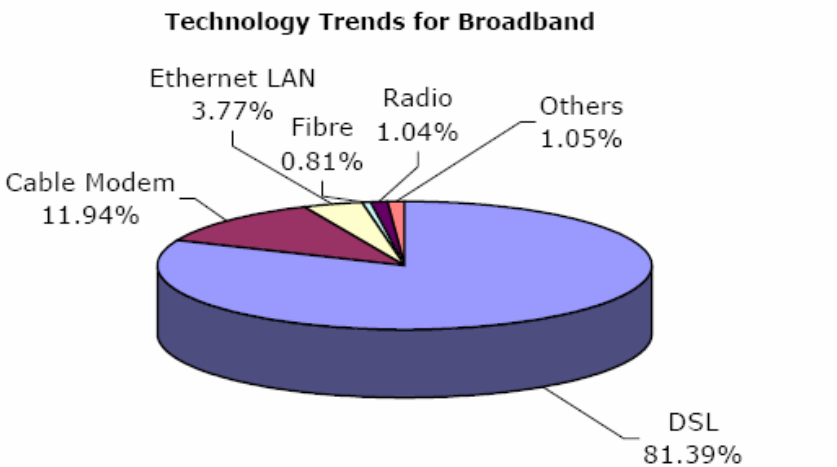


Existing Coverage
~30% of population
1700 Towns ~200M people
Negligible rural coverage

Emerging Market Explosion

- India adds 10M telephone lines monthly: crossed 250M in 2007
  - Was struggling 12 years ago to add 1M lines yearly
  - Right price point exploded the market

- Government policy to add 50M Broadband connections in 4 years
  - Today only 2.5M Broadband connections

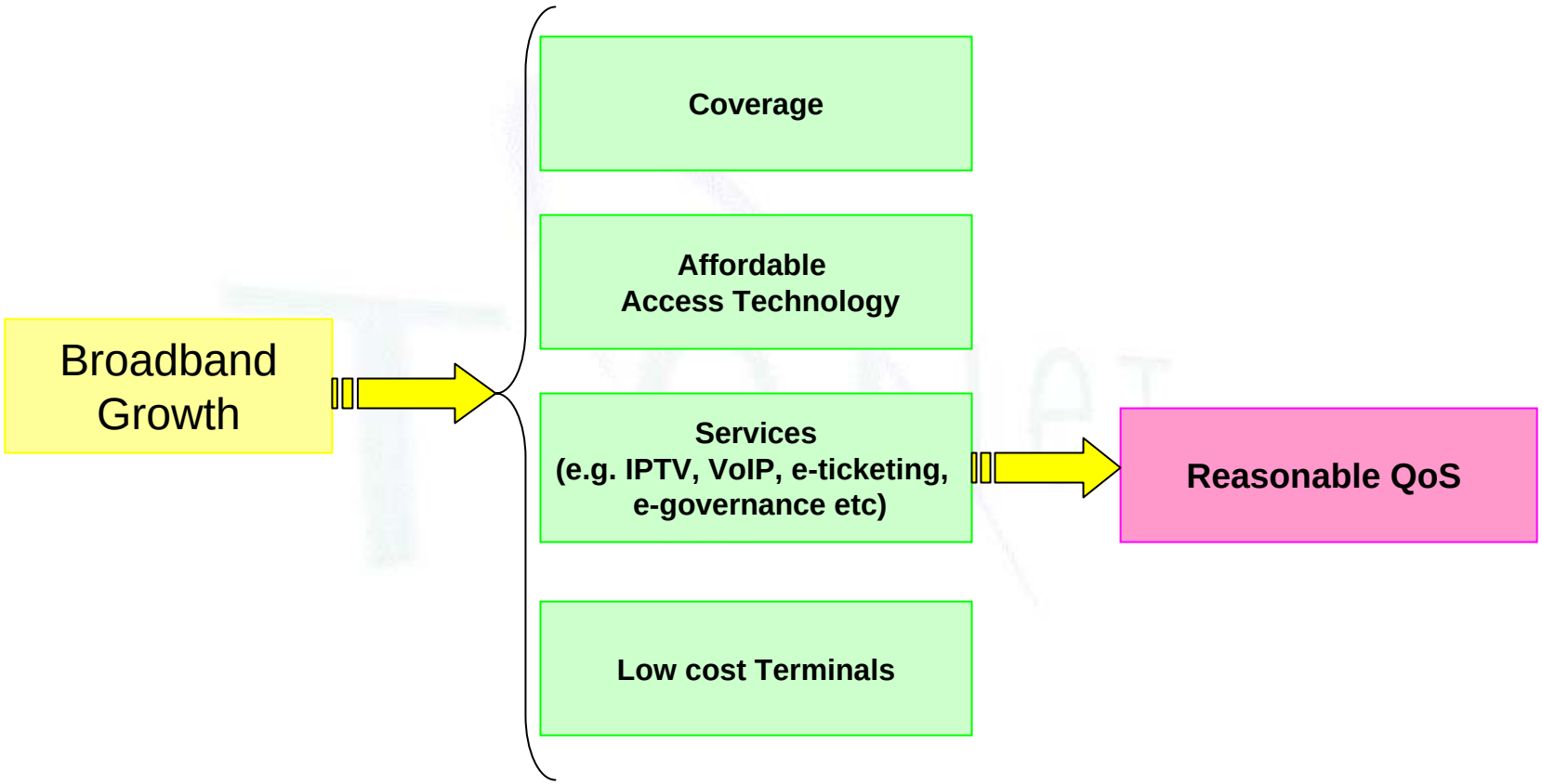


Similar trend in other Emerging Markets

Broadband Users

- Dense urban areas – 10,000 people/sq. km
- Sparse rural areas
  - Village every 3-10 km
  - Population 1,000 - 25,000
  - Within 25 km of fibre
- ARPU today for 2.5M subscribers : Rs. 280 ($7)
- ARPU tomorrow for rapid expansion: Rs. 100 ($2.5)

Enablers for Broadband Growth



Broadband QoS Defined

- ITU-T: 1.5 Mb/s
- TRAI : 256 kb/s
- Subscriber:
  Good experience with common services -- multi-media browsing, downloads, streaming media, VOIP, multi-player games
  Requires 256 kb/s - 1 Mb/s
- QoS Metrics Standardization
  - ITU-T 1540/1541
  - IETF IPPM

Relation with ITU-T Y.1540

ITU-T 1540	Remarks
Throughput	Defined in ITU-T Y.1221
IPTD	IP packet Transfer Delay
IPDV	IP packet Delay Variation
IPLR	IP packet Loss Ratio
IPER	IP Packet Error Ratio
SIPR	Spurious IP packet Ratio
Availability	• Y.1540 defines availability if IPLR < 0.75. • Minimum observation period of 5 min. • Defined as Percent availability

IETF–IPPM
IP Performance Metrics

IPPM	Remarks
Link/Path Bandwidth Capacity **RFC5136**	Capacity of the Link/Path
Bulk Transport Capacity **RFC3138**	Bandwidth available at transport layer
One-way & Two-way Delay **RFC2679, RFC2681**	Delay experienced by the packet from source to destination (and back)
Delay Variation **RFC3393**	Variation in Delay
Packet Re-ordering **RFC4737**	Number of packets received out of sequence in the Destination
One-way & Two-way Loss **RFC2680**	Number of packets lost from source to destination (and back)
Loss-pattern **RFC2680**	Number of packets lost from source to destination (and back)
Connectivity **RFC2680**	Number of packets lost from source to destination (and back)

ITU-T Y.1541 IP QoS Classes

Params	Class-0	Class-1	Class-2	Class-3	Class-4	Class-5
IPTD	100 ms	400 ms	100 ms	400 ms	1 s	U
IPDV	50 ms	50 ms	U	U	U	U
IPLR	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	U
IPER	1×10^{-4}	1×10^{-4}	1×10^{-4}	1×10^{-4}	1×10^{-4}	U

Broadband QoS Metrics

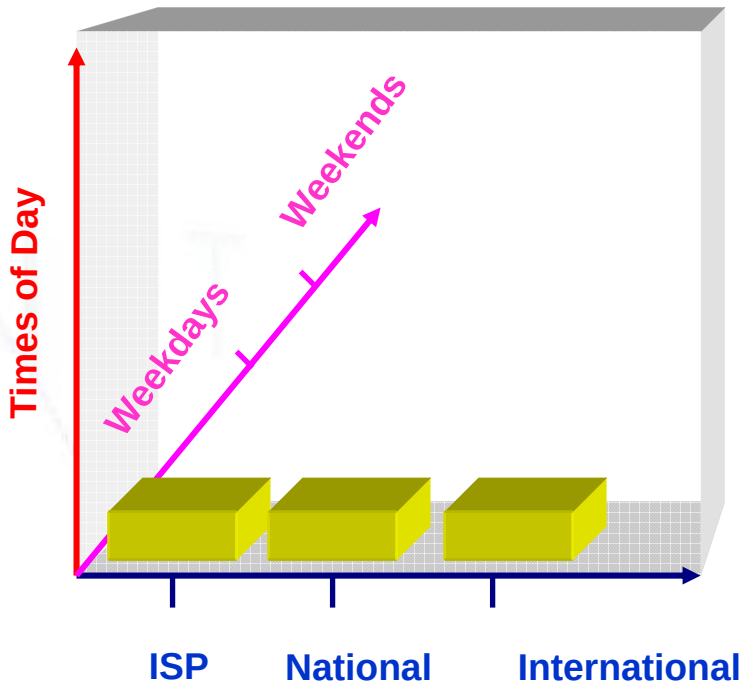
- More Subscriber Oriented Metrics, objective way of measuring subscriber QoE
  - Download throughput
    - Download Bandwidth available to the user
  - Upload throughput
    - Upload Bandwidth available to the user
  - Round-trip delay (RTT)
    - Time taken for a packet to reach a destination and return
  - Delay jitter
    - Average variation in RTT
  - Packet loss
    - No of packets lost, expressed in %
  - Availability of service

Comparison with ITU-T & IETF

Our Model	IETF IPPM	ITU-T
Throughput (upload & Download)	• Link/Path Bandwidth Capacity • Bulk Transport Capacity	ITU-T Y.1221
Delay (RTT)	One-way & Two-way Delay	IP packet Transfer Delay (IPTD)
Jitter	Delay Variation	IP packet Delay Variation (IPDV)
Packet Loss	• Loss-pattern • One-way & Two-way Loss	IP packet Loss Ratio (IPLR)
		IP Packet Error Ratio (IPER)
	Packet Re-ordering	
		Spurious IP packet ratio (SIPR)
Availability	Connectivity	Defined with IPLR (IPLR < 0.75)

Test Methodology (1)

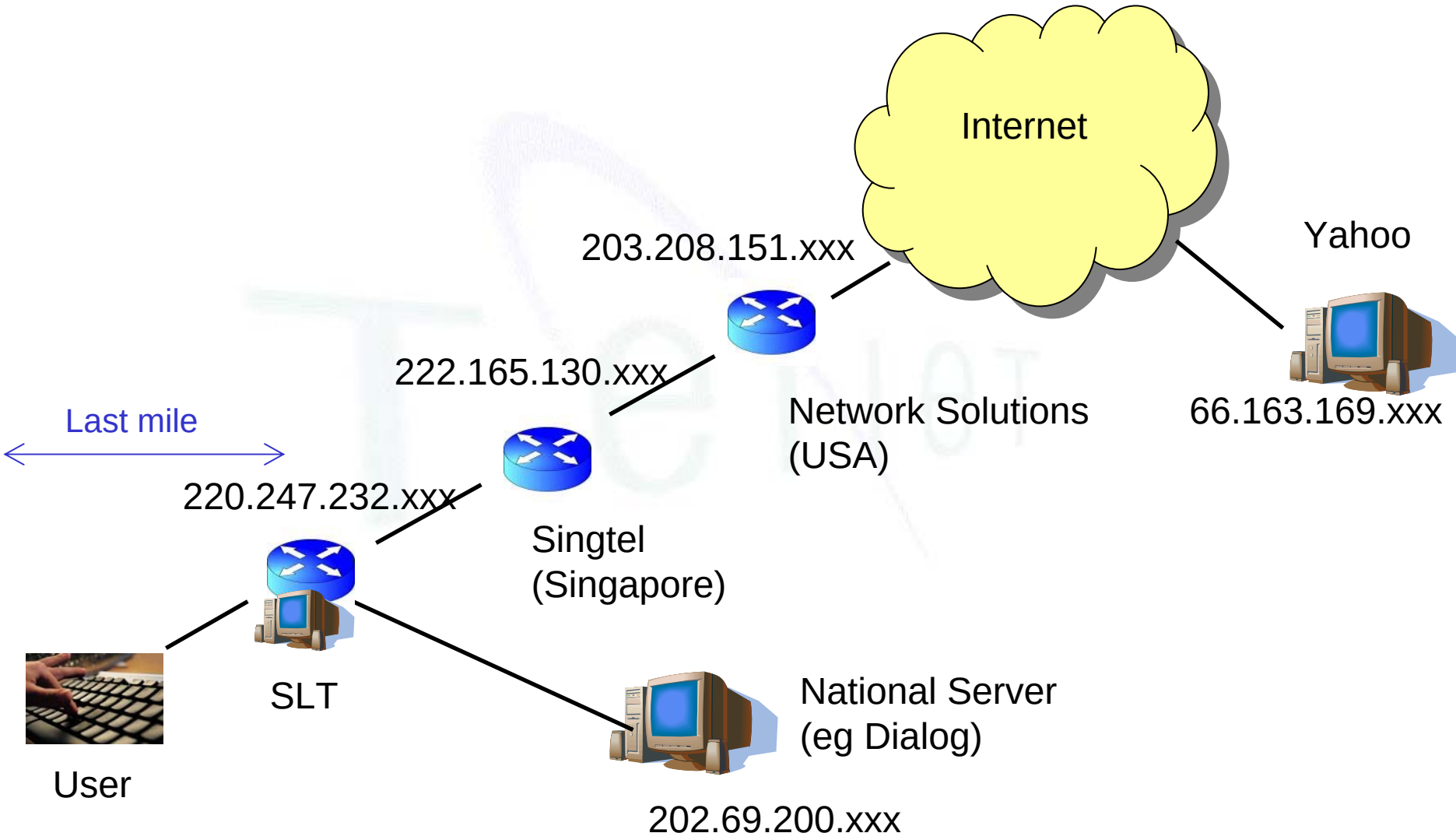
- Tests 6 parameters
  - Covers most aspects of subscriber QoE
- Tests three servers (ISP, National, International)
  - ISP local N/w, National Peering and International Bw
- Repeated at different times of the day
  - Provisioning & Dimensioning of N/w
- Repeated at weekdays and weekends
  - Provisioning & Dimensioning of N/w



Test Methodology (2)

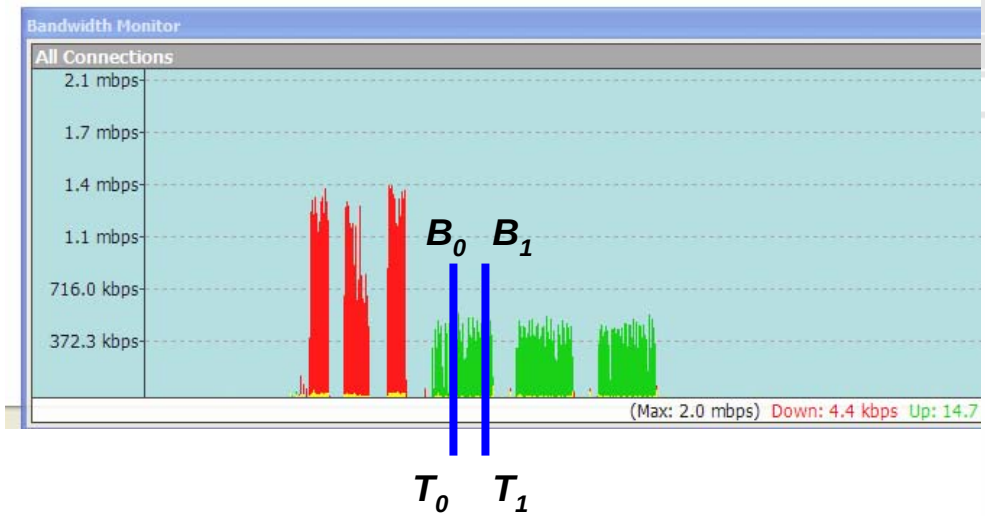
- Uses commonly available tools
  - BW monitor
  - Ping
  - Tracert
- Tests for long intervals to minimize effects of short term variations (e.g. 100 pings, 100 sec download)
- Variations studied and outliers removed

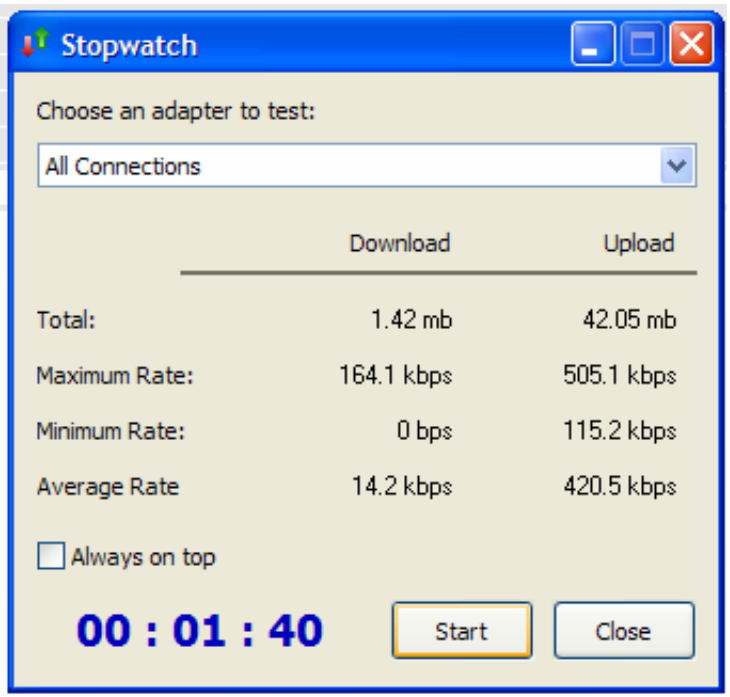
Network Diagram of a Test



Throughputs

- Download/Upload a large file (~ 5 MB)
- Throughput Measurement
  A. File size / Elapsed time (Displayed by file transfer utilities)
  B. More Accurate Result

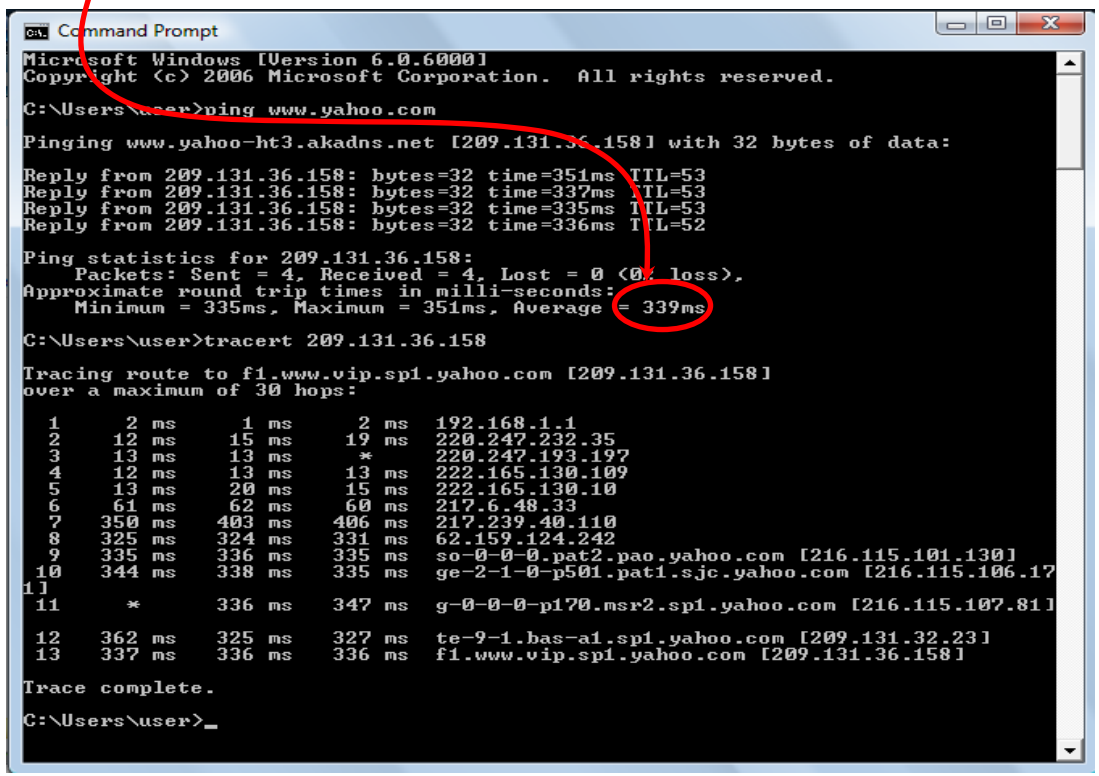




Throughput = $(B_1 - B_0) / (T_1 - T_0)$

Round Trip Time (RTT)

- RTT: Time taken for a packet to reach the destination and return.
  - Average RTT (***M***) measured using Ping with 100 packets



Jitter and Round Trip Time

- Jitter: Variation in RTT

$$\sum_{k=1}^{k=n} | M - r_k | \; / \; 100$$

M = Average RTT; n=sample size = 100;

$r_k = k^{th}$ RTT reading

- Measured by pinging 100 packets to destination

Packet Loss and Availability

- Packet Loss = Number of packets (in %) which do not reach the destination
  - Measured by Ping

- Availability = 1 – Prob[Service unavailable for >30 sec]
  - Service Unavailable > 30 sec, measured by continuous failure of ping packet for greater than 30 sec.

Relevance of Metrics

	Throughput		Delay		
Service	Down	Up	RTT	Jitter	Loss
Browse (text)	++	-	++	-	-
Browse (media)	+++	-	++	+	+
Download file	+++	-	-	-	-
Transactions	-	-	++	+	-
Streaming media	+++	-	++	++	++
VOIP	+	+	+++	+++	+++
Games	+	+	+++	++	++

+++ highly relevant, ++ very relevant, + relevant, - not relevant

Test Timings

- 08:00 hrs: Lean period
- 11:30 hrs: Peak Business hours
- 15:00 hrs: Peak business hours
- 18:00 hrs: Shift from business to residential usage
- 20:30 hrs: Early residential users
- 22:30 hrs: Late residential users

Conclusions

- Tremendous potential for broadband growth
  - Cost of service and QoS are key
- Six objective measures for QoS
- Test methodology to minimize bias and error
- Tests carried out by LirneAsia in Sri Lanka and India

Future Work

- Design a non-intrusive technique for continuous monitoring of QoS parameters and mechanism for automatic publication
  - Subscriber centric
  - Operator centric
- Class of Service aware QoS Measurement
  - Measure QoS performance for different classes of traffic
  - Bit error tolerant audio codecs for VoIP services

Links

- TeNeT Group – http://www.tenet.res.in
- Articles on the various broadband technologies -- http://en.wikipedia.org
- Broadband QoS study -- http://www.lirneasia.net/projects/current-projects/2241/

- Email: tag@tenet.res.in,rtm@midascomm.com

Thank You