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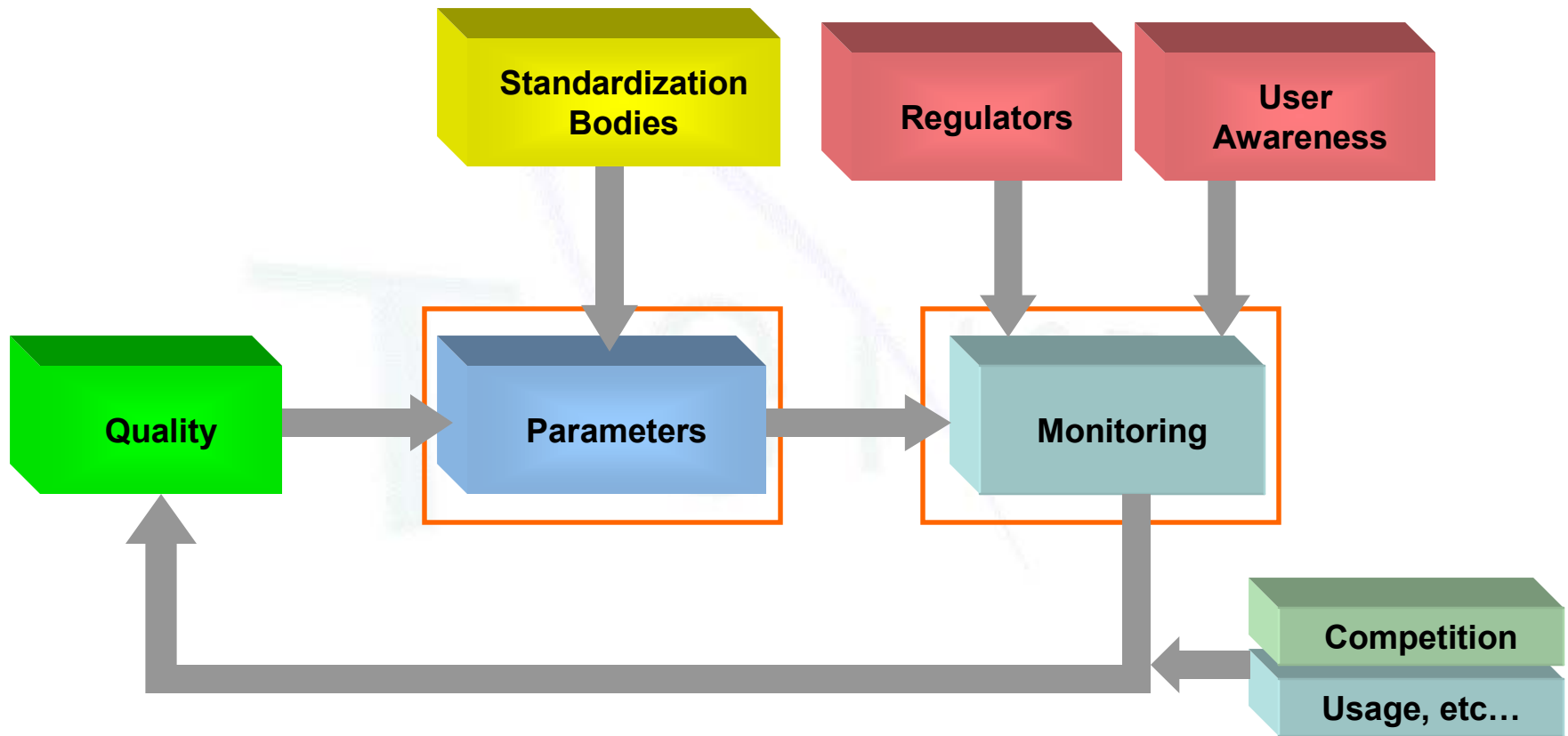
# Broadband Quality of Service

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- The QoS metrics
- The evaluation methodology
- AT-Tester
- Summary

- 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

TRAI 15Jan09 Paper discuss the QoS requirement to be met by the Operators

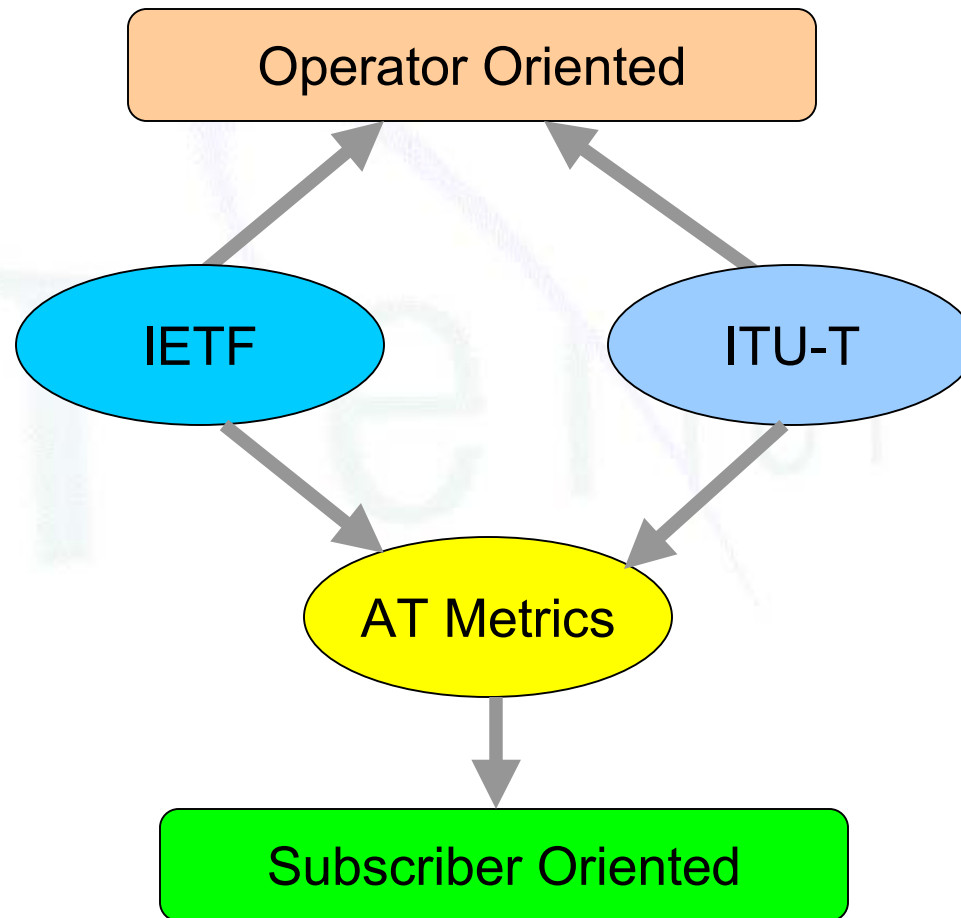


# Parameters in ITU-T Y.1540

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	<ul style="list-style-type: none"> <li>• Y.1540 defines availability if <math>IPLR &lt; 0.75</math>.</li> <li>• Minimum observation period of 5 min.</li> <li>• Defined as Percent availability</li> </ul>

Params	Class-0	Class-1	Class-2	Class-3	Class-4	Class-5
<b>IPTD</b>	100 ms	400 ms	100 ms	400 ms	1 s	U
<b>IPDV</b>	50 ms	50 ms	U	U	U	U
<b>IPLR</b>	$1 \times 10^{-3}$	$1 \times 10^{-3}$	$1 \times 10^{-3}$	$1 \times 10^{-3}$	$1 \times 10^{-3}$	U
<b>IPER</b>	$1 \times 10^{-4}$	$1 \times 10^{-4}$	$1 \times 10^{-4}$	$1 \times 10^{-4}$	$1 \times 10^{-4}$	U

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





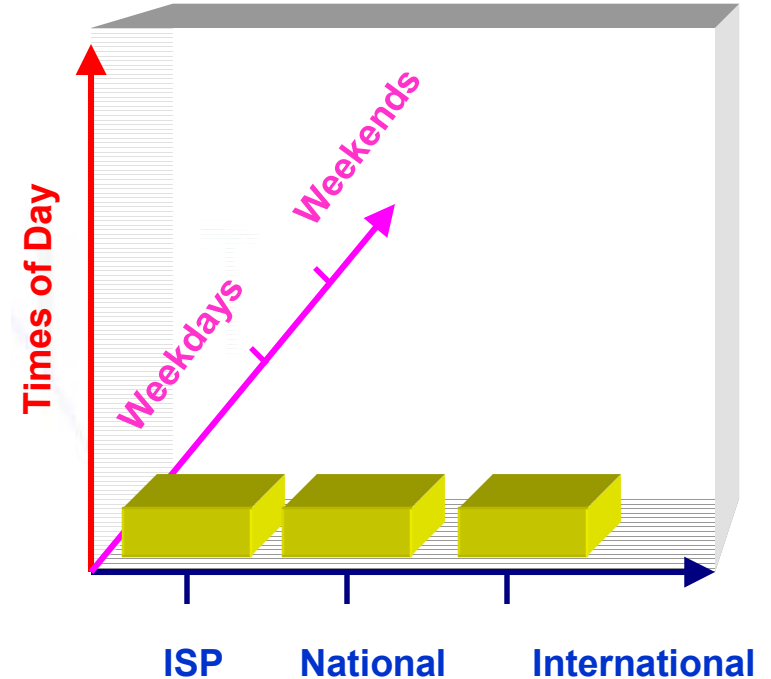
- More Subscriber Oriented Metrics, objective way of measuring subscriber QoE
  - Download throughput
    - Download Bandwidth available to the user
  - Upload throughput
    - Upload Bandwidth available to the user
  - Round-trip delay (RTT)
    - Time taken for a packet to reach a destination and return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

# Comparison with ITU-T & IETF

AT Model	IETF IPPM	ITU-T
Throughput (upload & Download)	<ul style="list-style-type: none"> <li>• Link/Path Bandwidth Capacity</li> <li>• Bulk Transport Capacity</li> </ul>	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	<ul style="list-style-type: none"> <li>• Loss-pattern</li> <li>• One-way &amp; Two-way Loss</li> </ul>	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

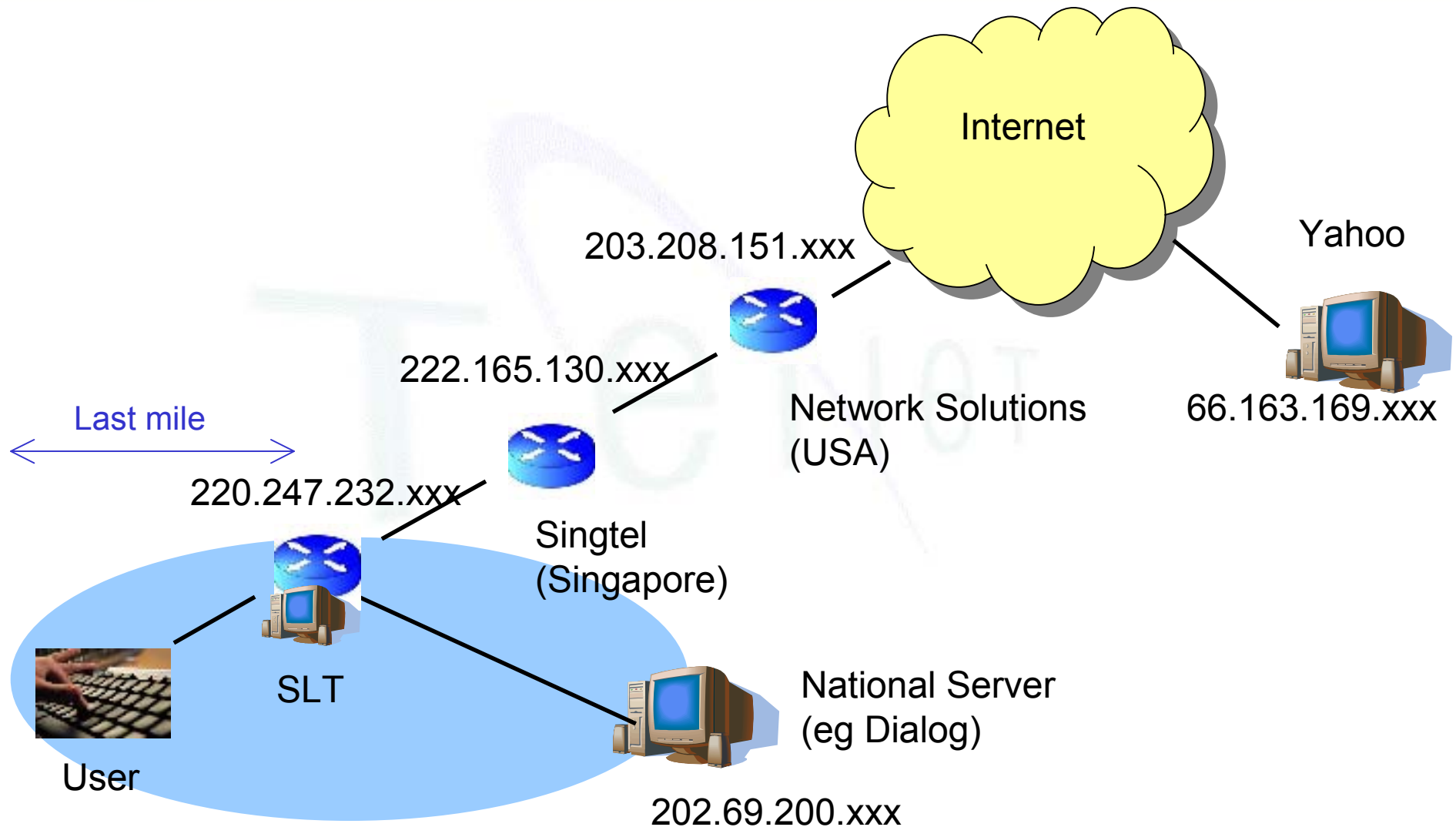


# Test Methodology (2)

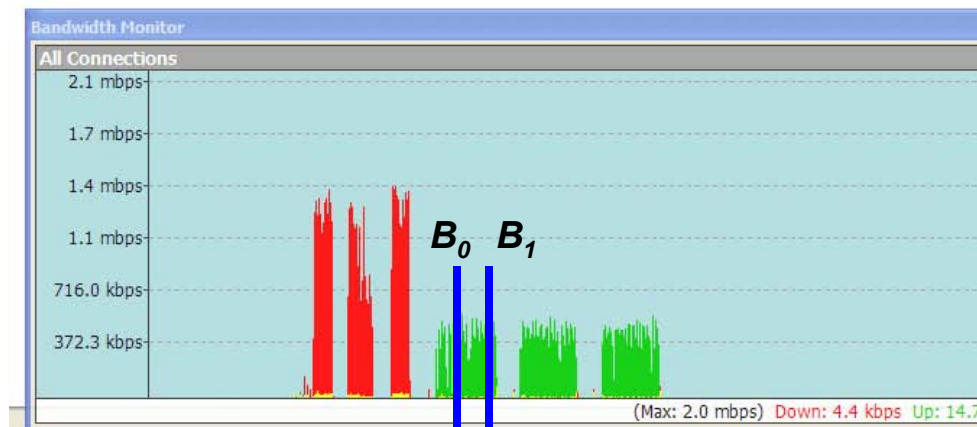
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- Uses commonly available tools
  - BW monitor
  - Ping
  - Tracert
- Tests for long intervals to minimize effects of short term variations (e.g. 100 pings, 100 sec download)
- Variations studied and outliers removed

# Network Diagram of a Test

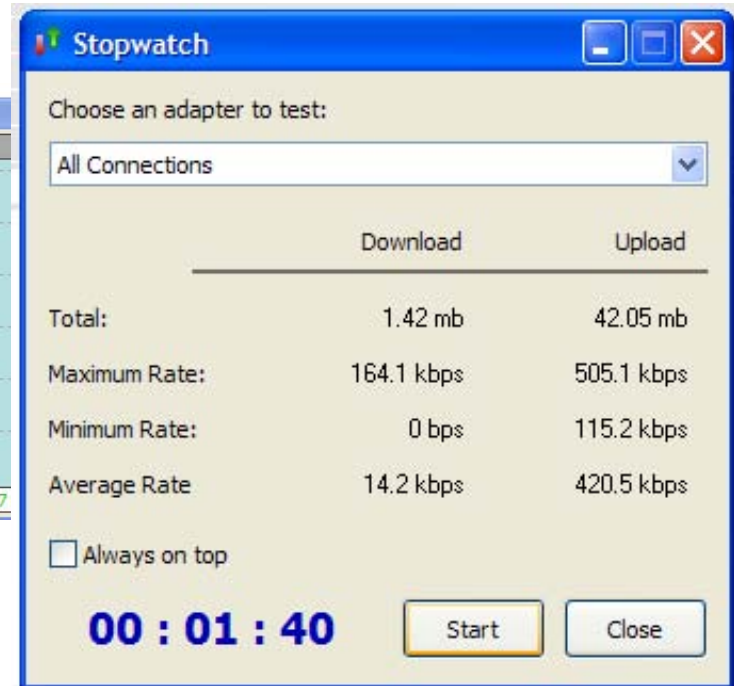


- Download/Upload a large file (~ 5 MB)
- Throughput Measurement
  - A. File size / Elapsed time (Displayed by file transfer utilities)
  - B. More Accurate Result



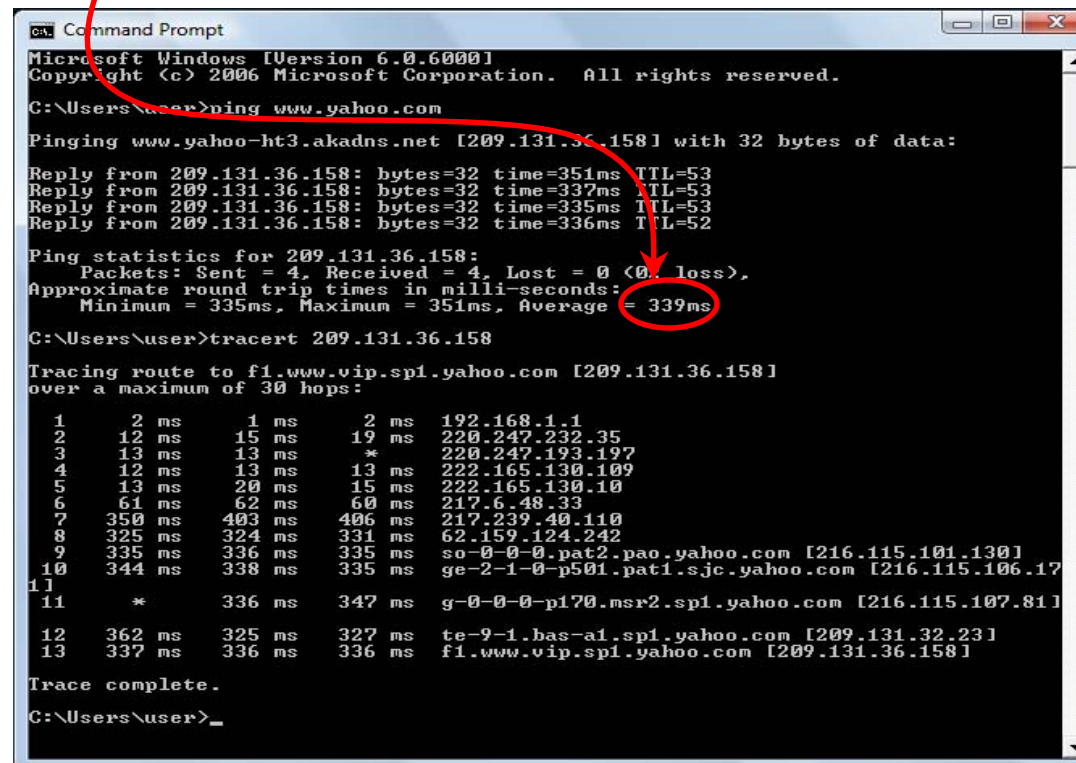
$T_0$   $T_1$

$$\text{Throughput} = (B_1 - B_0) / (T_1 - T_0)$$



# 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



```
Microsoft Windows [Version 6.0.6000]
Copyright (c) 2006 Microsoft Corporation. All rights reserved.

C:\Users\user>ping www.yahoo.com

Pinging www.yahoo-ht3.akadns.net [209.131.36.158] with 32 bytes of data:

Reply from 209.131.36.158: bytes=32 time=351ms TTL=53
Reply from 209.131.36.158: bytes=32 time=337ms TTL=53
Reply from 209.131.36.158: bytes=32 time=335ms TTL=53
Reply from 209.131.36.158: bytes=32 time=336ms TTL=52

Ping statistics for 209.131.36.158:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 335ms, Maximum = 351ms, Average = 339ms

C:\Users\user>tracert 209.131.36.158

Tracing route to f1.www.vip.sp1.yahoo.com [209.131.36.158]
over a maximum of 30 hops:
  0  1 ms    1 ms    1 ms    192.168.1.1
  1  12 ms   15 ms   19 ms   220.247.232.35
  2  13 ms   13 ms   *      220.247.193.197
  3  12 ms   13 ms   13 ms   222.165.130.109
  4  13 ms   20 ms   15 ms   222.165.130.10
  5  61 ms   62 ms   60 ms   217.6.48.33
  6  350 ms  403 ms  406 ms  217.239.40.110
  7  325 ms  324 ms  331 ms  62.159.124.242
  8  335 ms  336 ms  335 ms  so-0-0-0.pat2.pao.yahoo.com [216.115.101.130]
  9  344 ms  338 ms  335 ms  ge-2-1-0-p501.pat1.sjc.yahoo.com [216.115.106.17]
 10  *      336 ms  347 ms  g-0-0-0-p170.msr2.sp1.yahoo.com [216.115.107.81]
 11  362 ms  325 ms  327 ms  te-9-1.bas-a1.sp1.yahoo.com [209.131.32.23]
 12  337 ms  336 ms  336 ms  f1.www.vip.sp1.yahoo.com [209.131.36.158]

Trace complete.

C:\Users\user>
```

- **Jitter**: Variation in RTT

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

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

$r_k$  =  $k^{th}$  RTT reading

- Measured by pinging 100 packets to destination



- **Packet Loss** = Number of packets (in %) which do not reach the destination
  - Measured by Ping
- **Availability** =  $1 - \text{Prob}[\text{Service unavailable for } >30 \text{ sec}]$ 
  - Service Unavailable > 30 sec, measured by continuous failure of ping packet for greater than 30 sec.

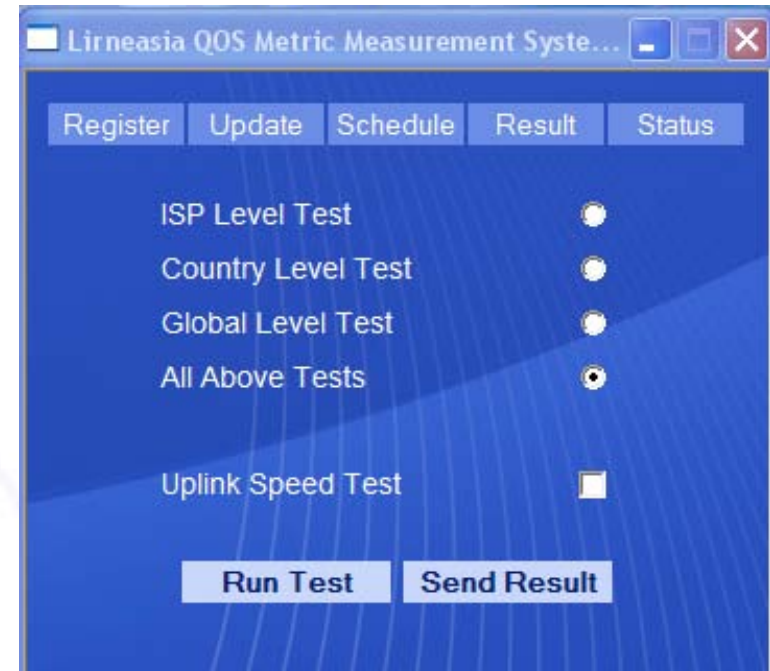
Service	Throughput		Delay		Loss
	Download	Upload	RTT	Jitter	
Browse (text)	↑	-	↑	-	-
Browse (media)	↑	-	↑	↑	↑
Download file	↑	-	-	-	-
Transactions	-	-	↑	↑	-
Streaming media	↑	-	↑	↑	↑
VOIP	↑	↑	↑	↑	↑
Games	↑	↑	↑	↑	↑

++    ↑ highly relevant    ↑ very relevant    ↑ relevant    - not relevant


- 08:00 hrs: Lean period
- 11:00 hrs: Peak Business hours
- 15:00 hrs: Peak business hours
- 18:00 hrs: Shift from business to residential usage
- 20:00 hrs: Early residential users
- 23:00 hrs: Late residential users

# AT Tester

- Windows based test software to measure the Broadband QoSE
- Measure the performance at different levels
  - ISP
  - National
  - Global
- Server Aggregates the result ([www.broadbandasia.info](http://www.broadbandasia.info))
- Success depends on more volunteers



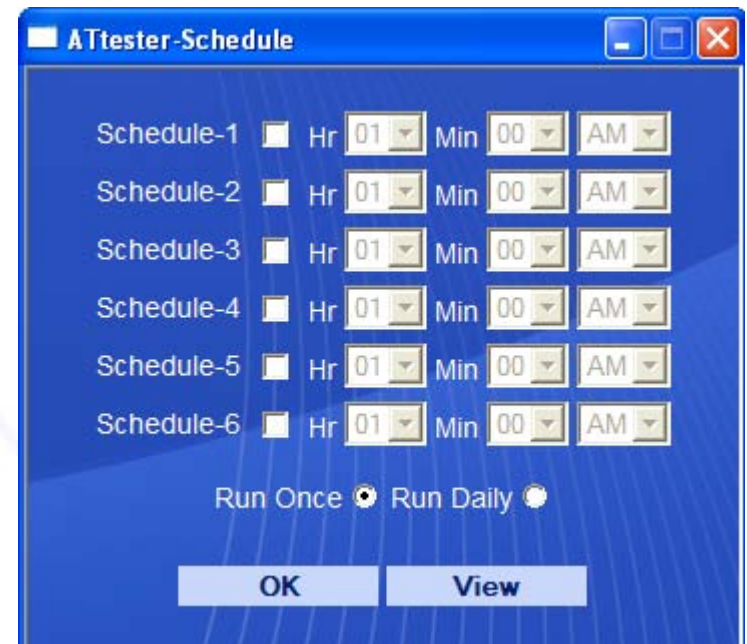
- Registration of end user
  - Service Provider including region
  - Advertised Download Speed
  - Package Type (Business /Residential)
  - E-mail id of the end user



The screenshot shows a dialog box titled "ATtester-Register" with a "Registration" section. It contains the following fields and controls:

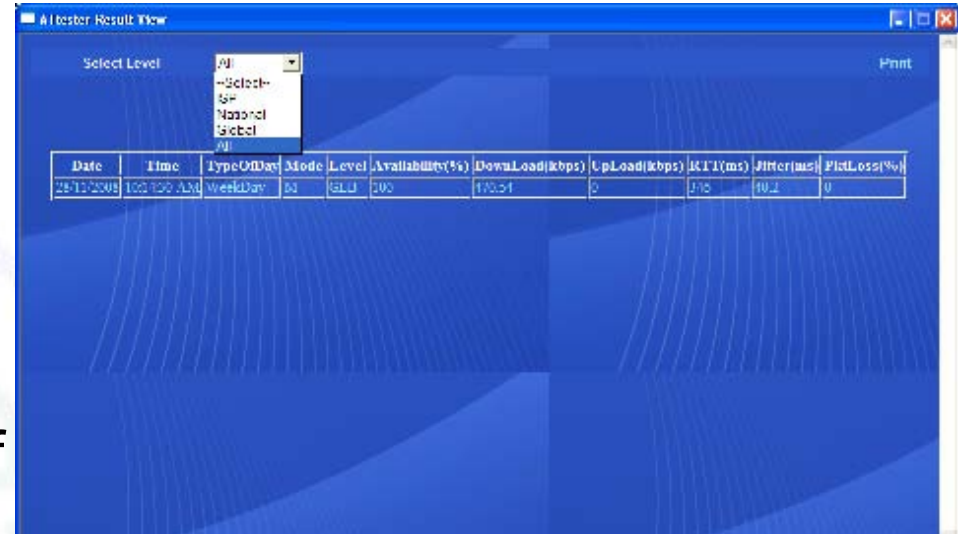
- Service Provider: A text input field.
- Other ISPs: A text input field.
- Download Bandwidth: A text input field.
- User Type: A dropdown menu currently set to "Business".
- Email-Id: A text input field.
- Buttons: "Register" and "Close".

- Testing invoked as per configured schedule
- Scheduled to run once or daily
- Prompt the user before executing the test



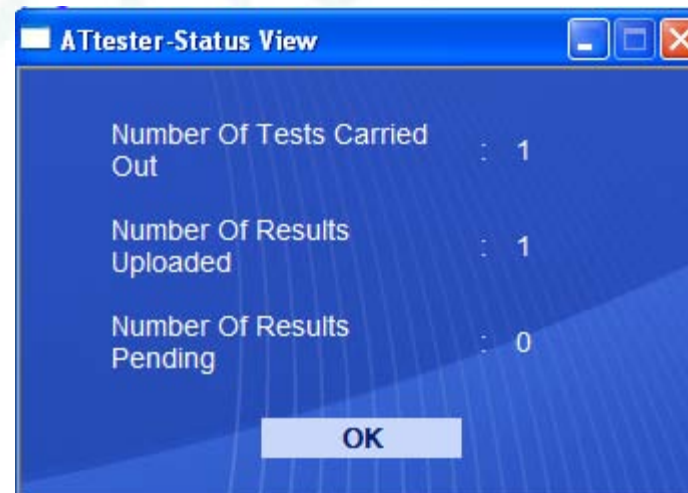
# AT-Tester : Results & Status

- Display the results of the tests executed
  - Filtered for ISP, National, Global
  
- Display the current status of AT-Tester
  - Tests Done
  - Result Uploaded
  - Pending Results



The screenshot shows the 'ATtester Result View' window. It features a 'Select Level' dropdown menu with options: All, --Select-- (selected), National, Global, and All. Below the menu is a table with the following data:

Date	Time	TypeOfDay	Mode	Level	Availability(%)	Download(kbps)	UpLoad(kbps)	RTT(ms)	Jitter(ms)	PktLoss(%)
28-11-2008	10:11:00 AM	WeekDay	01	GLU	100	170.51	0	170	10.1	0




The screenshot shows the 'ATtester-Status View' window with the following status information:

Number Of Tests Carried Out	: 1
Number Of Results Uploaded	: 1
Number Of Results Pending	: 0


An 'OK' button is located at the bottom of the window.






**LIRNEasia**  
www.lirneasia.net

*Do you get quality Broadband?*

Funded by  
IDRC  CRDI



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**ISP Summary Report**

**Country**

**Region**

ISP Name	Download Bandwidth	Download Speed (kbps)			RTT (ms)			Detailed Report
		ISP	National	Global	ISP	National	Global	
ADNSL	256kbps	243.17	198.30	218.86	29.61	753.00	803.83	
SKYbd	256kbps	232.58	223.76	210.32	33.89	34.06	344.47	

\* We have given here all possible speeds. Please note some of them might not be offered by your ISP.



## Detailed Report

<b>Country</b>	Bangladesh	<b>Region</b>	Dhaka
<b>ISP Name</b>	SKYbd	<b>Download Bandwidth</b>	256kbps

Type of Test : ISP

Total number of test(s) executed : 36

### Week Day (Sun-Thu)

Time of Day	Download Speed (kbps)	Upload Speed (kbps)	RTT (ms)	Jitter (ms)	Availability (%)	Packet Loss (%)
8:00 AM	252.19	118.88	36.33	0.5	100	0
11:00 AM	230.99	96.19	36.33	0.53	100	0
3:00 PM	219.2	94.67	46.33	0.5	96.67	3.33
6:00 PM	211.39	95.04	24.33	0.43	100	0
8:00 PM	222.35	93.63	27	0.27	100	0
11:00 PM	242.77	89.65	29.67	0.6	100	0



# ISP Detailed Report ....

[www.broadbandasia.info](http://www.broadbandasia.info)

Type of Test : **National**

Total number of test(s) executed : **36**

## Week Day (Sun-Thu)

Time of Day	Download Speed (kbps)	Upload Speed (kbps)	RTT (ms)	Jitter (ms)	Availability (%)	Packet Loss (%)
8:00 AM	238.29	131.63	38.67	0.3	100	0
11:00 AM	202.43	122.16	41.67	0.13	100	0
3:00 PM	202.19	103.09	26	0.43	100	0
6:00 PM	208.72	136.13	38.67	0.5	100	0
8:00 PM	193.89	81.17	31.33	0.57	100	0
11:00 PM	232.93	104.91	38	0.53	96.67	3.33

## Week End (Fri-Sat)

Time of Day	Download Speed (kbps)	Upload Speed (kbps)	RTT (ms)	Jitter (ms)	Availability (%)	Packet Loss (%)
8:00 AM	321.17	112.21	30.67	0.43	100	0
11:00 AM	194.75	111.76	40	0.63	100	0
3:00 PM	212.96	125.79	35	0.17	100	0
6:00 PM	223.46	149.09	30	0.43	100	0
8:00 PM	224.37	117.89	31	0.23	100	0
11:00 PM	230	118.77	27.67	0.2	96.67	3.33

- As Internet access becomes more essential, tremendous potential for broadband growth
  - Cost of service and QoS are key
- Six objective measures for QoS
- Test methodology to minimize bias and error
- AT-Tester & Test results
- **Open, democratic approach:**
  - Millions of individuals measure their quality of service
  - Publicize it to induce operators to improve quality

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## Reference Links

- AT Test Result - <http://www.broadbandasia.info>
- TeNeT Group – <http://www.tenet.res.in>
- Articles on the various broadband technologies --  
<http://en.wikipedia.org>

**Thank You**