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Throughput metrics and packet delay in TCP/IP networks

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Introduction

One year ago, at RIPE 56 meeting in Berlin, we presented a method of measurement of available bandwidth between two points in a global network.

C – minimum transmission rate among all links in path

B_{av} – minimum spare link capacity [1]

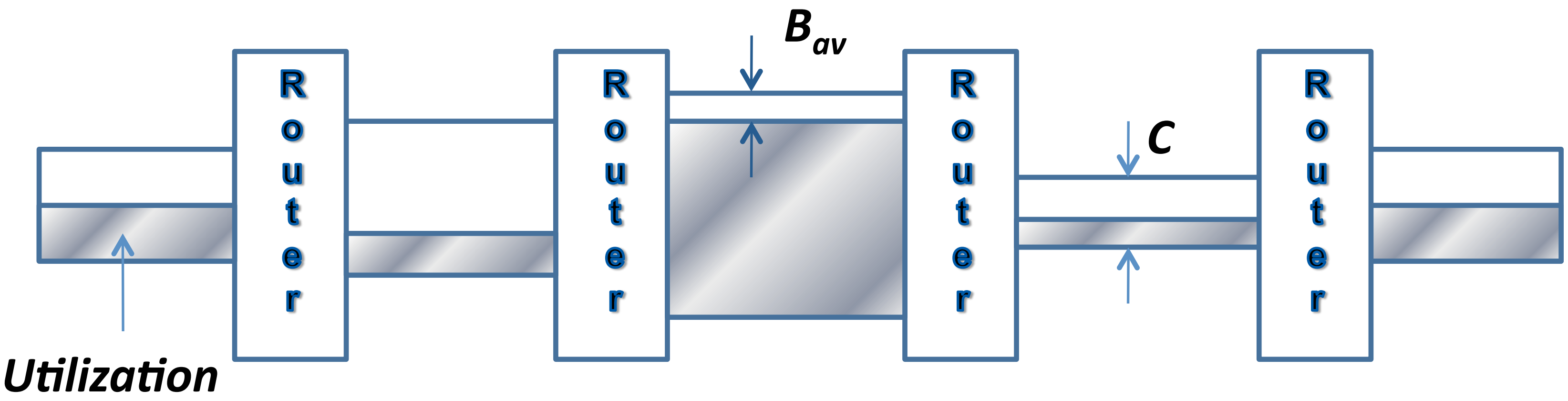

Figure 1: Two bandwidth metrics

[1] Dovrolis C., Ramanathan P., and Moore D., Packet Dispersion Techniques and a Capacity-Estimation Methodology, IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 12, NO. 6, DECEMBER 2004, p. 963-977

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The Model

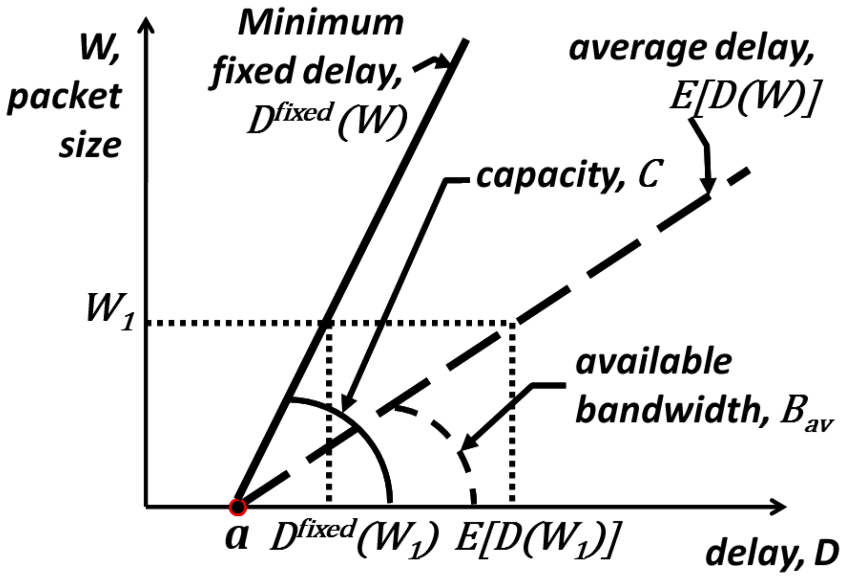

Figure 2: Packet Size vs Delay

$$D(W) = D^{fixed}(W) + d^{var} \qquad (1)$$

$$D^{fixed}(W) = \mathbf{D}_{\min} + W / C \qquad (2)$$

The Model

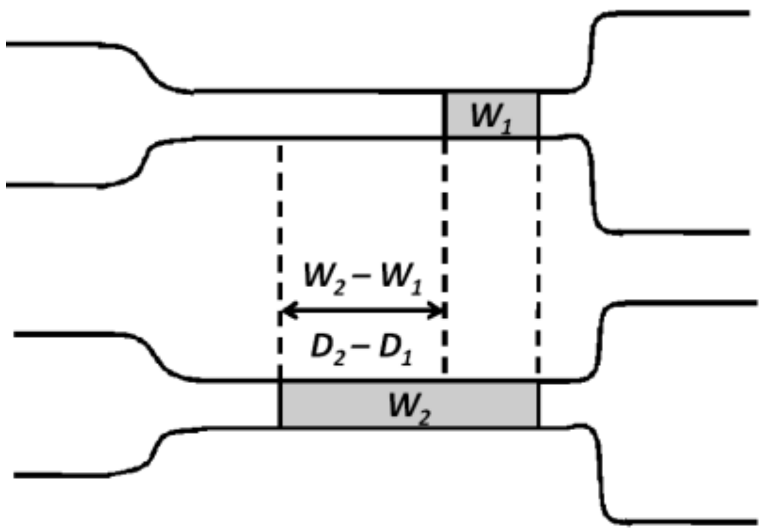

Figure 3: Available Bandwidth Illustration

$$B = \frac{W_2 - W_1}{D_2 - D_1} \qquad (3)$$

$$B_{av} = \frac{W_2 - W_1}{D^{av}(W_2) - D^{av}(W_1)} \qquad (4)$$

$$C = \frac{W_2 - W_1}{D^{\min}(W_2) - D^{\min}(W_1)} \qquad (5)$$

Changing packet size

The design of the RIPE TTM system meets all requirements shown by our method, namely it allows to change the size of a testing package and to find network delay with a split-hair accuracy.

We should choose two different sizes of packages. The first size of package will be **100 byte** as default. In the other case it is reasonable to add testing **1024 byte** packages with frequency of 60 times in a minute.

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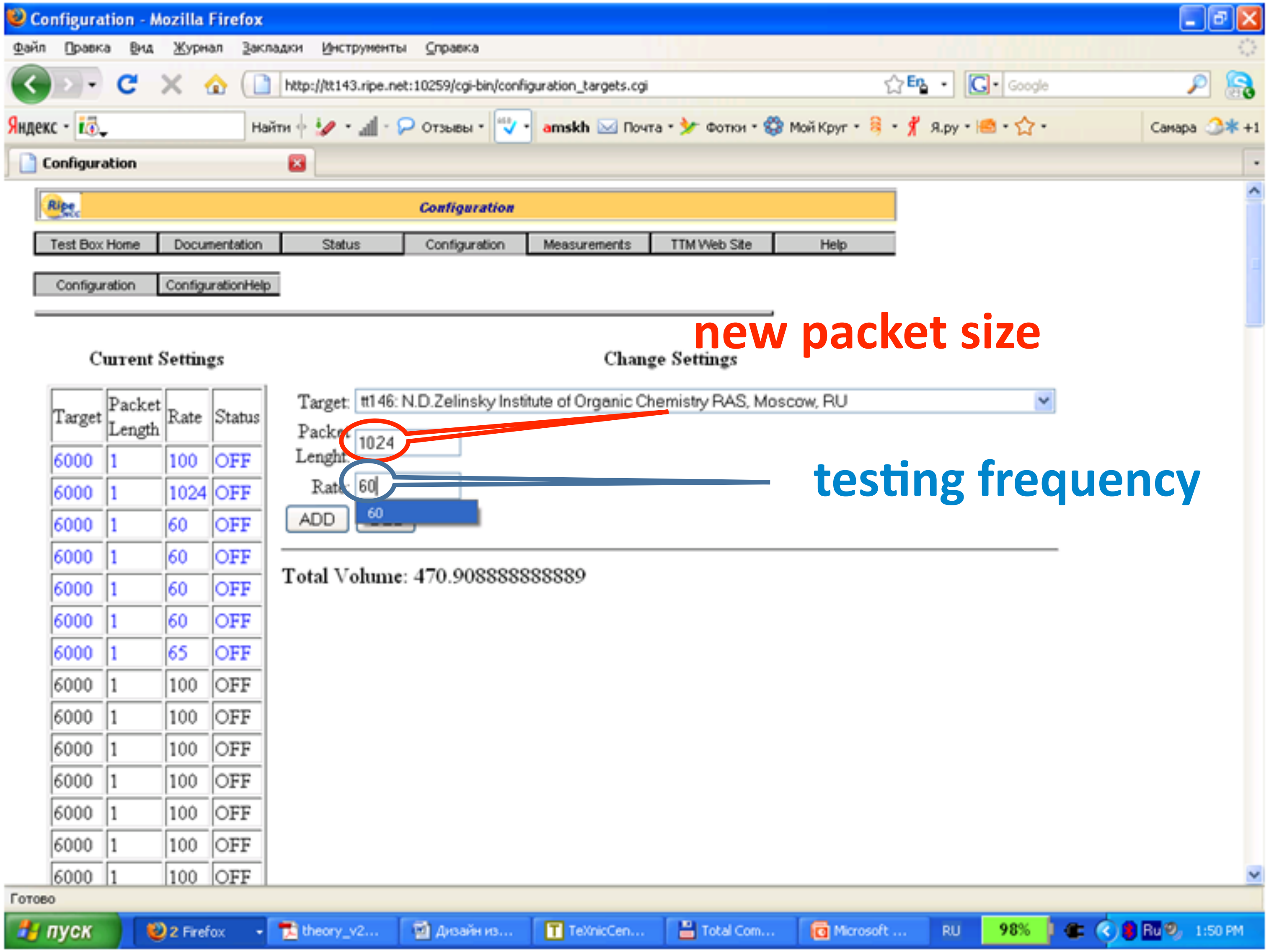

Testing results

Testing results are available in telnet to RIPE Test Box on port 9142. It is important to get the data from both ends of the investigated channel simultaneously, in the case presented here it is tt01.ripe.net and tt143.ripe.net.

$ telnet tt143.ripe.net 9142

$ telnet tt01.ripe.net 9142

Obtained data will contain required delay of packages of the different sizes. Also, we need to distinguish packages.

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The data from sending Box

Therefore at first we should reverse to sending Box and will find the lines:

packet size

```
SNDP 9 1240234684 -h tt12.ripe.net -p 6000 -n 100 -s 1039148429
SNDP 9 1240234684 -h tt120.ripe.net -p 6000 -n 100 -s 1039148446
SNDP 9 1240234684 -h tt01.ripe.net -p 6000 -n 1024 -s 1039148464
SNDP 9 1240234685 -h tt164.ripe.net -p 6000 -n 100 -s 1039148548
SNDP 9 1240234685 -h tt01.ripe.net -p 6000 -n 100 -s 1039148557
SNDP 9 1240234685 -h tt161.ripe.net -p 6000 -n 100 -s 1039148599
SNDP 9 1240234686 -h tt118.ripe.net -p 6000 -n 100 -s 1039148654
SNDP 9 1240234686 -h tt01.ripe.net -p 6000 -n 1024 -s 1039148655
SNDP 9 1240234686 -h tt17.ripe.net -p 6000 -n 100 -s 1039148662
```

Last value in the string is sequence number of the packet. It is necessary to us to find this number on the receiving side at the channel.

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The data from receiving Box

sequence number of the packet

```
RCDP 12 2 192.36.143.194 3685 193.0.0.228 6000 1240234684.397023 0.011001 0X2107 0X2107 1039148474    0.000015   0.000008
RCDP 12 2 194.25.0.198 2248 193.0.0.228 6000 1240234684.437001 0.008700 0X2107 0X2107 1039148400    0.000005   0.000008
RCDP 12 2 89.186.245.200 60322 193.0.0.228 6000 1240234684.785799 0.044084 0X2107 0X2107 1039148464    0.000002   0.000008
RCDP 12 2 89.186.245.200 53571 193.0.0.228 6000 1240234685.788367 0.043591 0X2107 0X2107 1039148557    0.000002   0.000008
RCDP 12 2 89.186.245.200 55418 193.0.0.228 6000 1240234686.794059 0.044168 0X2107 0X2107 1039148655    0.000002   0.000008
```

For set number of a packet it is easy to find network delay, in our case - 0.044084 seconds. The following number of packet 1039148557 has the size of 100 bytes and the delay is 0.043591 seconds. Thus, the difference is - 0.000493 seconds

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Average and minimum values

tt143 -> tt01

N	Sequence number	Packet size, *W (bytes)*	Network Delay, *D, sec*	*$D_2 - D_1$ sec*	Min *ΔD, sec*	Average *ΔD, sec*
1	1039148464	1024	0.044084	0.000493	**0.000531**	**0.000562**
	1039148557	100	0.043591			
2	1039148857	1024	0.044126	0.000613		
	1039148947	100	0.043507			
3	1039149056	1024	0.044106	0.000592		
	1039149142	100	0.043514			
4	1039149846	1024	0.044038	0.000418		
	1039149538	100	0.043620			
5	1039149645	1024	0.044205	0.000696		
	1039149730	100	0.043509			

tt01 -> tt143

N	Sequence number	Packet size, *W (bytes)*	Network Delay, *D, sec*	$D_2 - D_1$ *sec*	Min *ΔD, sec*	Average *ΔD, sec*
1	1039149017	1024	0.033720	0.000480	**0.000431**	**0.000443**
	1039149673	100	0.033240			
2	1039149414	1024	0.033638	0.000234		
	1039149872	100	0.033404			
3	1039149603	1024	0.033709	0.000248		
	1039150067	100	0.033461			
4	1039149807	1024	0.033895	0.000688		
	1039151248	100	0.033207			
5	1039150010	1024	0.033777	0.000563		
	1039151853	100	0.033214			

Calculation of bandwidth and capacity

Then the required bandwidth and capacity of the link (tt143 -> tt01) can be calculated as

$$B_{av} = \frac{W_2 - W_1}{D_2^{av} - D_1^{av}} = \frac{924 * 8}{0.000562} = 13.15[Mbps]$$

$$\tilde{N} = \frac{W_2 - W_1}{D_2^{\min} - D_1^{\min}} = \frac{924 * 8}{0.000531} = 13.92[Mbps]$$

Calculation of bandwidth and capacity

The bandwidth and capacity of the return link (tt01 -> tt143) can be calculated as

$$B_{av} = \frac{W_2 - W_1}{D_2^{av} - D_1^{av}} = \frac{924*8}{0.000443} = 16.9[Mbps]$$

$$\tilde{N} = \frac{W_2 - W_1}{D_2^{\min} - D_1^{\min}} = \frac{924*8}{0.000431} = 17.15[Mbps]$$

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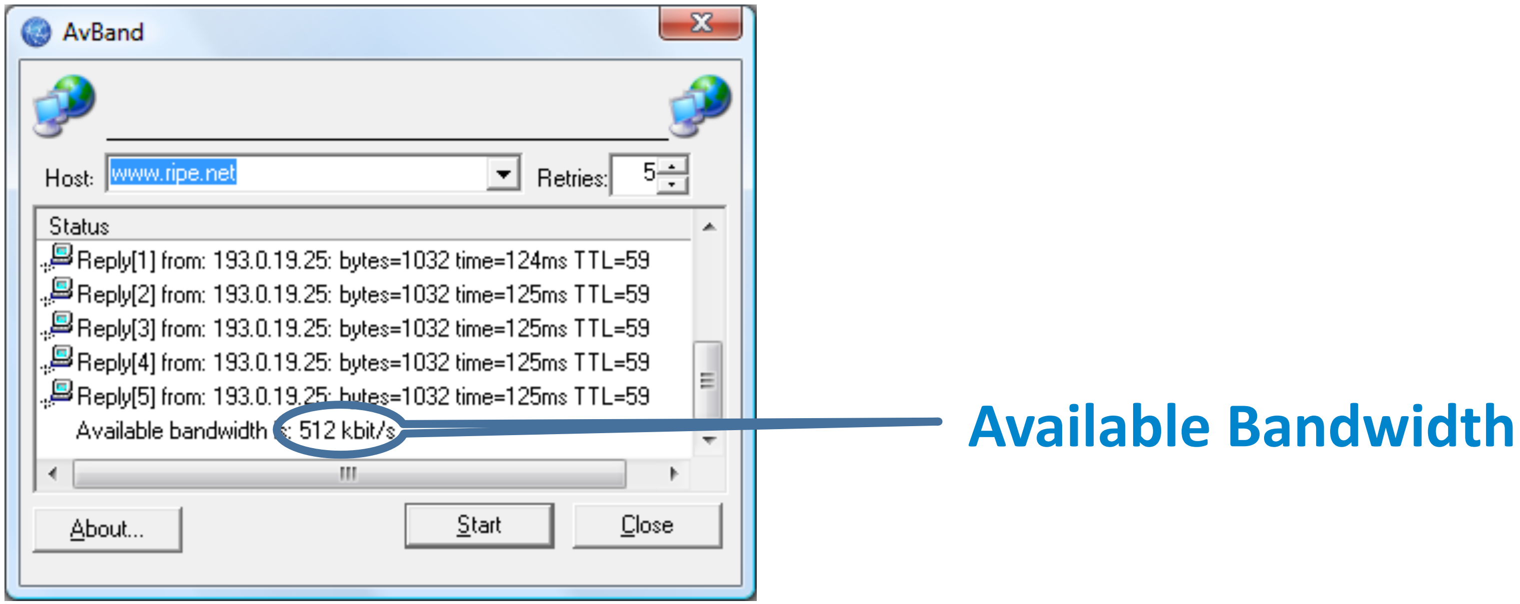
Utility AvBand

We have developed utility AvBand (Available Bandwidth) that realize new method, using algorithm *ping*. Its advantage consist in possibility of working with any router, which responds to packages of inquiries ICMP Echo.



Additional measurements

The main problem of our work is the little number of measurements. At this moment we made one experiment with RIPE TTM system that gives high precision of measurement and some local experiments.

Also it will be great to include in the RIPE TTM system that makes statistics on packets, possibility of calculation ***available bandwidth*** and ***capacity***.

It is ideal to compare the results received by our method with values measured by alternative methods, first of all by means of the utility *pathrate* and *pathload*. Unfortunately, such tests are not made yet.

We are **looking for partners** that can help us to make additional measurements with RIPE TTM system and utility *pathrate* and *pathload*.

Thank you for your attention!