Performance Analysis of Communication Networks

Homework assignment III

Planet-lab measurements report

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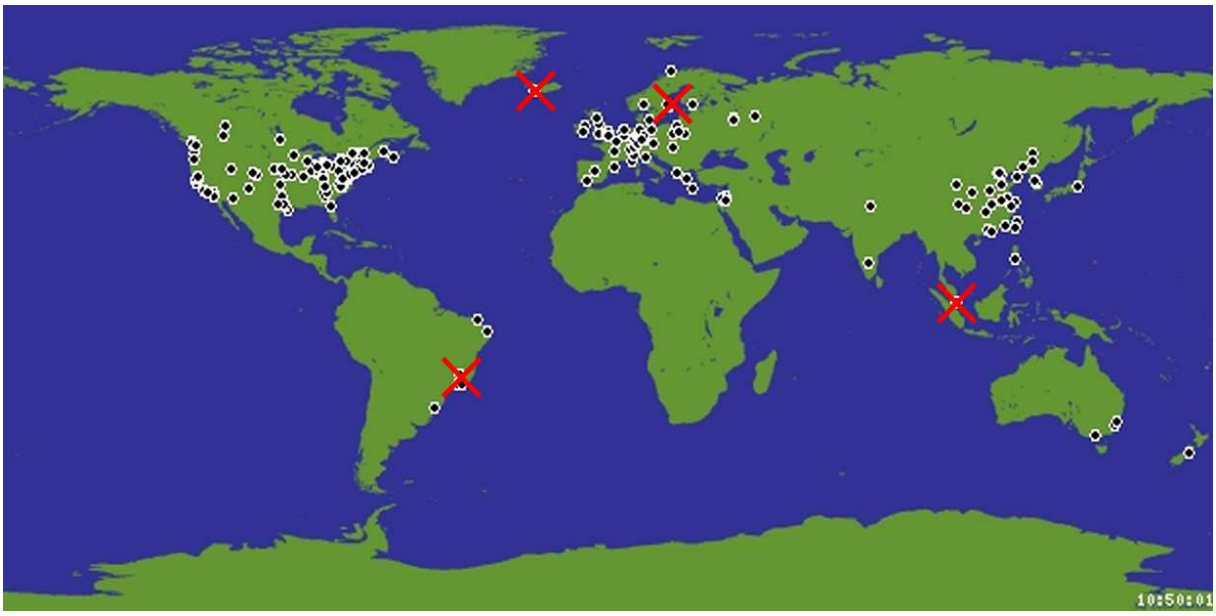
Nr: **????????**

Selected servers

List of selected servers with country where servers belong:

- planetlab2.ru.is (Iceland)
- planetlab2.pop-mg.rnp.br (Brazil)
- planetlab2.singapore.equinix.planet-lab.org (Singapore)
- planetlab-1.it.uu.se (Sweden)

I have selected two geographically far-away servers (Brazil, Singapore), which are not too close to important trans-oceanic backbones and two servers relatively closer to each other (Iceland, Sweden).



Map of the World: Red crosses represent servers' locations *Source: Planet-lab.org*

Measurements schedule

Because selected servers are spread in different time zones described below, I have decided to process all measurements three times during same working day around 10:30am of all used time zones. I have considered the time 10:30am in particular time zones as a rush hour with a lot of blocking network traffic, so the later comparing of results could be more interesting. Because Iceland and Sweden are just +/- 1:00, their rush hours can be considered for the same time, say 11:00am (which is 10:00am in Iceland).

List of particular time zones:

- Iceland – GMT = (Amsterdam time-1:00)
- Brazil (eastern part) – GMT-3:00 = (Amsterdam time-4:00)
- Sweden – GMT+1:00 = (Amsterdam time)
- Singrapore – GMT+8:00 = (Amsterdam time+7:00)

Due to information above, my measurements took place on Friday, November 25, 2005 at 3:30am, 11:00am and 14:30am.

Measurement timings

Each of scheduled measurements consisted of:

- PING to each of the other servers Duration: 2 min Interval: 1 sec
- TRACEROUTE to each of the other servers Count: 1
- PATHCHIRP to each of the other servers Duration: 1 min

Presentation of measurements

As a result of the PING measurements I have prepared summary table, where basic statistics can be found and also graph table for all "from-to" combinations of servers. All scheduled measurements are represented in graphs as three series as obvious from legend. Graphs show progress of RTT during each of 2 minutes tests.

As a result of bandwidth measurements there is also summary table with weighted average, minimum and maximum and graph table for all servers' combinations as well as for the PING measurements. Weighted average is used because the bandwidth estimations obtained from "pathchirp" tool are not evaluated within fixed time interval, so the values have not the same weight. Graphs show progress of estimated bandwidth during each 1-minute test.

All graphs in both graph tables have the same scales for both axes, so the results are easier for visual comparison.

Traceroute results recorded during all three measurements were the same within each combination, so there is only one traceroute list per each combination. As the form of presentation of traceroute results I have chosen cross table for comparing the numbers of hopes and the overall map with all routes.

Observations

- PING
    - PING graphs clearly prove my estimation about time zones. Server in Brazil had during Friday's morning almost twice RTT as during previous night
    - The fact that the servers from Iceland and Sweden are pretty close is also perceptible in particular graph; RTT is really low. Looking at the graph we can also see that the direction from Sweden to Iceland is more varying than the opposite direction
- BANDWIDTH
    - Bandwidth graphs show similar information as PING graphs, which is notably lower unused capacity during working day than during night, especially for the Brazil's server
    - Bandwidth values between European servers are very fast as expected, but there is one interesting fact. The unused bandwidth from Iceland to Sweden is almost half of the unused bandwidth from Sweden to Iceland. This fact is probably given from the setting of the Iceland-Europe backbone, which is dimensioned more for the traffic incoming to Iceland. Moreover, on the Iceland we won't expect a lot of heavy traffic Internet servers, so the outgoing traffic is not so crucial
- Maps
    - On a map for the route from server in Brazil to server in Singapore we can see interesting fact that route is crossing twice whole continent of North America
    - On another map for the routes from the server in Singapore it is interesting that the route to Brazil is going via Asia and Europe, but connections to both European servers are going via North America
    - Another fact partially visible on maps is that most of traffic to South America is going via the North American backbones. I have tried to find some combination of server in Brazil with another available planet-lab server, where connection would be routed via Atlanstis2 submarine cable, which connects South America with Africa and Europe, but all connections went via North America

Ping statistics – RTT, packet loss

From\To	Iceland	Brazil	Singapore	Sweden
Iceland	X	RTT MIN: 300.020 ms RTT AVG: 315.033 ms RTT MAX: 437.404 ms RTT MDEV: 24.853 ms LOSS: 5%	RTT MIN: 408.908 ms RTT AVG: 432.824 ms RTT MAX: 542.082 ms RTT MDEV: 29.932 ms LOSS: 4%	RTT MIN: 19 ms RTT AVG: 35 ms RTT MAX: 63 ms RTT MDEV: 13 ms LOSS: 0%
		RTT MIN: 300.190 ms RTT AVG: 310.978 ms RTT MAX: 1138.158 ms RTT MDEV: 76.867 ms LOSS: 0%	RTT MIN: 408.977 ms RTT AVG: 413.118 ms RTT MAX: 458.428 ms RTT MDEV: 6.212 ms LOSS: 0%	RTT MIN: 41.145 ms RTT AVG: 42.043 ms RTT MAX: 43.162 ms RTT MDEV: 0.409 ms LOSS: 0%
		RTT MIN: 410.370 ms RTT AVG: 566.835 ms RTT MAX: 1386.193 ms RTT MDEV: 93.900 ms LOSS: 3%	RTT MIN: 409.315 ms RTT AVG: 415.337 ms RTT MAX: 486.329 ms RTT MDEV: 8.403 ms LOSS: 0%	RTT MIN: 41.337 ms RTT AVG: 42.078 ms RTT MAX: 45.171 ms RTT MDEV: 0.502 ms LOSS: 0%
Brazil	RTT MIN: 300.167 ms RTT AVG: 314.075 ms RTT MAX: 683.477 ms RTT MDEV: 39.465 ms LOSS: 0%	X	RTT MIN: 523.789 ms RTT AVG: 666.805 ms RTT MAX: 814.205 ms RTT MDEV: 51.773 ms LOSS: 5%	RTT MIN: 270.291 ms RTT AVG: 275.411 ms RTT MAX: 334.879 ms RTT MDEV: 10.592 ms LOSS: 0%
	RTT MIN: 299.844 ms RTT AVG: 371.412 ms RTT MAX: 944.639 ms RTT MDEV: 90.306 ms LOSS: 0%		RTT MIN: 398.108 ms RTT AVG: 558.594 ms RTT MAX: 969.972 ms RTT MDEV: 89.868 ms LOSS: 0%	RTT MIN: 270.710 ms RTT AVG: 344.521 ms RTT MAX: 809.668 ms RTT MDEV: 102.672 ms LOSS: 0%
	RTT MIN: 476.773 ms RTT AVG: 544.033 ms RTT MAX: 1372.762 ms RTT MDEV: 85.085 ms LOSS: 3%		RTT MIN: 584.223 ms RTT AVG: 803.062 ms RTT MAX: 1637.386ms RTT MDEV: 124.188 ms LOSS: 3%	RTT MIN: 393.832 ms RTT AVG: 539.459 ms RTT MAX: 736.040 ms RTT MDEV: 61.220 ms LOSS: 5%
Singapore	RTT MIN: 408.901 ms RTT AVG: 427.883 ms RTT MAX: 618.649 ms RTT MDEV: 34.585 ms LOSS: 3%	RTT MIN: 513.572 ms RTT AVG: 585.434 ms RTT MAX: 718.438 ms RTT MDEV: 46.004 ms LOSS: 5%	X	RTT MIN: 373.481 ms RTT AVG: 395.807 ms RTT MAX: 463.862 ms RTT MDEV: 27.779 ms LOSS: 3%
	RTT MIN: 408.881 ms RTT AVG: 411.732 ms RTT MAX: 430.264 ms RTT MDEV: 3.479 ms LOSS: 0%	RTT MIN: 398.774 ms RTT AVG: 525.514 ms RTT MAX: 995.937 ms RTT MDEV: 93.434 ms LOSS: 0%		RTT MIN: 373.802 ms RTT AVG: 376.490 ms RTT MAX: 395.704 ms RTT MDEV: 3.981 ms LOSS: 0%
	RTT MIN: 409.597 ms RTT AVG: 415.475 ms RTT MAX: 464.736 ms RTT MDEV: 7.290 ms LOSS: 0%	RTT MIN: 538.982 ms RTT AVG: 762.770 ms RTT MAX: 1589.650 ms RTT MDEV: 110.252 ms LOSS: 1%		RTT MIN: 373.887 ms RTT AVG: 377.797 ms RTT MAX: 401.762 ms RTT MDEV: 3.835 ms LOSS: 0%
Sweden	RTT MIN: 40.791 ms RTT AVG: 41.791 ms RTT MAX: 42.700 ms RTT MDEV: 0.404 ms LOSS: 0%	RTT MIN: 270.312 ms RTT AVG: 293.026 ms RTT MAX: 391.431 ms RTT MDEV: 27.989 ms LOSS: 7%	RTT MIN: 373.709 ms RTT AVG: 398.808 ms RTT MAX: 479.958 ms RTT MDEV: 29.334 ms LOSS: 3%	
	RTT MIN: 41.153 ms RTT AVG: 41.896 ms RTT MAX: 42.582 ms RTT MDEV: 0.425 ms LOSS: 0%	RTT MIN: 270.329 ms RTT AVG: 316.387 ms RTT MAX: 980.345 ms RTT MDEV: 86.345 ms LOSS: 0%	RTT MIN: 373.520 ms RTT AVG: 376.568 ms RTT MAX: 410.225 ms RTT MDEV: 5.145 ms LOSS: 0%	
	RTT MIN: 41.205 ms RTT AVG: 42.042 ms RTT MAX: 44.068 ms RTT MDEV: 0.427 ms LOSS: 0%	RTT MIN: 410.160 ms RTT AVG: 526.924 ms RTT MAX: 1453.032 ms RTT MDEV: 104.369 ms LOSS: 5%	RTT MIN: 373.981 ms RTT AVG: 377.374 ms RTT MAX: 389.878 ms RTT MDEV: 3.713 ms LOSS: 0%	

Legend:

	Time	Time	Time
Iceland	2:30	10:00	13:30
Brazil	23:30	7:00	10:30
Singapore	10:30	18:00	21:30
Sweden	3:30	11:00	14:30

Unused bandwidth statistics - weighted average, min, max

From\To	Iceland	Brazil	Singapore	Sweden
Iceland	X	WA: 12.12 Mbps MIN: 6.09 Mbps MAX: 19.34 Mbps	WA: 32.11 Mbps MIN: 18.66 Mbps MAX: 51.71 Mbps	WA: 23.85 Mbps MIN: 18.53 Mbps MAX: 34.50 Mbps
		WA: 11.29 Mbps MIN: 4.22 Mbps MAX: 18.60 Mbps	WA: 29.82 Mbps MIN: 23.06 Mbps MAX: 37.42 Mbps	WA: 23.66 Mbps MIN: 16.48 Mbps MAX: 36.69 Mbps
		WA: 6.48 Mbps MIN: 2.72 Mbps MAX: 9.96 Mbps	WA: 29.19 Mbps MIN: 24.36 Mbps MAX: 46.77 Mbps	WA: 28.62 Mbps MIN: 18.12 Mbps MAX: 50.42 Mbps
Brazil	WA: 9.00 Mbps MIN: 4.31 Mbps MAX: 13.93 Mbps	X	WA: 7.97 Mbps MIN: 3.95 Mbps MAX: 13.42 Mbps	WA: 8.88 Mbps MIN: 6.14 Mbps MAX: 13.96 Mbps
	WA: 11.04 Mbps MIN: 7.59 Mbps MAX: 15.66 Mbps		WA: 6.39 Mbps MIN: 2.95 Mbps MAX: 15.08 Mbps	WA: 8.99 Mbps MIN: 5.13 Mbps MAX: 12.47 Mbps
	WA: 10.27 Mbps MIN: 6.02 Mbps MAX: 15.07 Mbps		WA: 6.70 Mbps MIN: 3.66 Mbps MAX: 11.84 Mbps	WA: 10.09 Mbps MIN: 5.72 Mbps MAX: 13.66 Mbps
Singapore	WA: 14.77 Mbps MIN: 8.35 Mbps MAX: 19.18 Mbps	WA: 18.45 Mbps MIN: 10.32 Mbps MAX: 24.41 Mbps	X	WA: 11.57 Mbps MIN: 6.60 Mbps MAX: 17.08 Mbps
	WA: 14.52 Mbps MIN: 7.49 Mbps MAX: 23.98 Mbps	WA: 12.39 Mbps MIN: 5.72 Mbps MAX: 20.90 Mbps		WA: 12.77 Mbps MIN: 7.77 Mbps MAX: 17.17 Mbps
	WA: 16.86 Mbps MIN: 6.81 Mbps MAX: 31.67 Mbps	WA: 4.58 Mbps MIN: 1.35 Mbps MAX: 9.96 Mbps		WA: 13.78 Mbps MIN: 7.95 Mbps MAX: 18.30 Mbps
Sweden	WA: 70.88 Mbps MIN: 54.29 Mbps MAX: 90.13 Mbps	WA: 12.51 Mbps MIN: 6.77 Mbps MAX: 20.67 Mbps	WA: 31.42 Mbps MIN: 23.04 Mbps MAX: 38.43 Mbps	
	WA: 67.48 Mbps MIN: 44.08 Mbps MAX: 87.11 Mbps	WA: 9.60 Mbps MIN: 5.43 Mbps MAX: 14.82 Mbps	WA: 14.55 Mbps MIN: 9.74 Mbps MAX: 18.15 Mbps	
	WA: 61.65 Mbps MIN: 37.07 Mbps MAX: 87.80 Mbps	WA: 6.84 Mbps MIN: 1.23 Mbps MAX: 14.78 Mbps	WA: 25.86 Mbps MIN: 21.35 Mbps MAX: 26.70 Mbps	

Legend:

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Iceland	2:30	10:00	13:30
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Singapore	10:30	18:00	21:30
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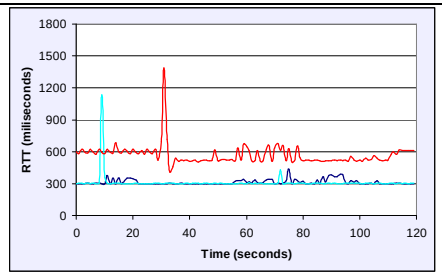
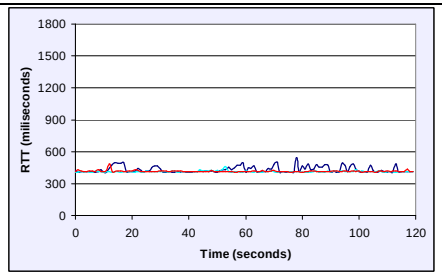
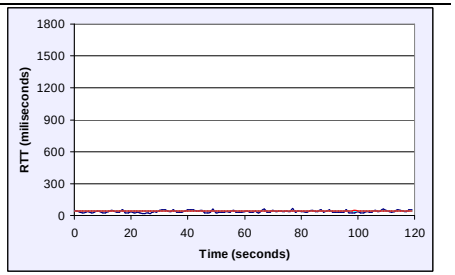
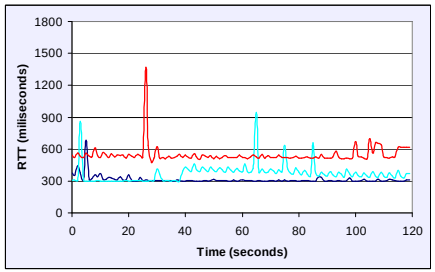
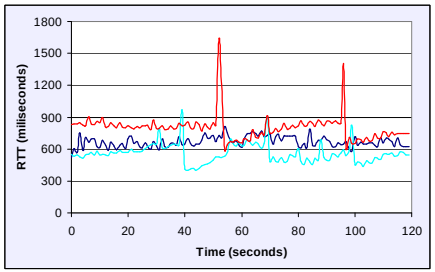
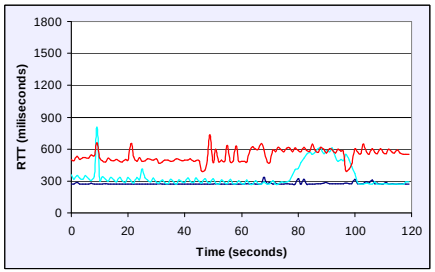
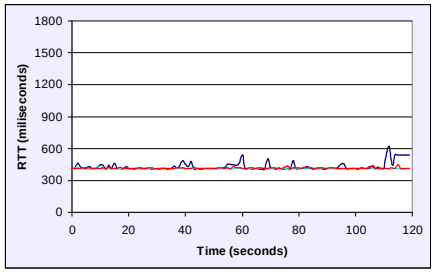
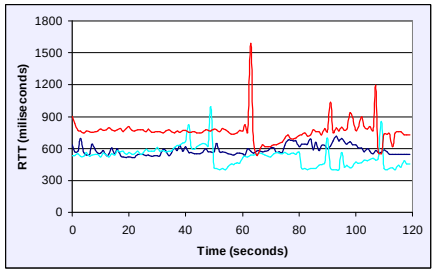
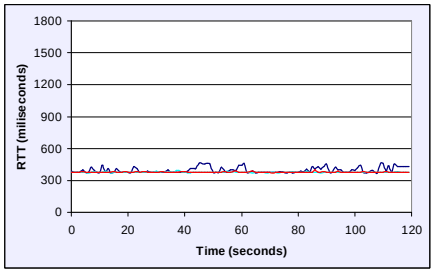
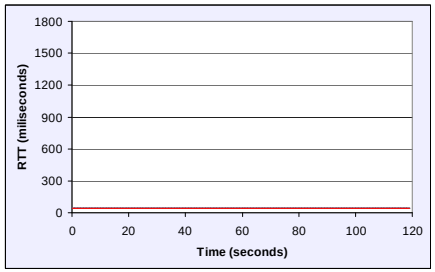
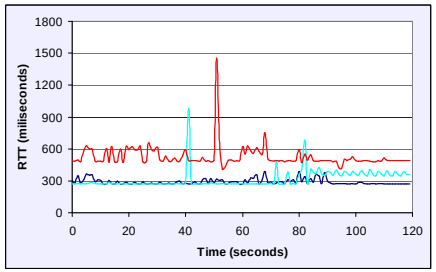
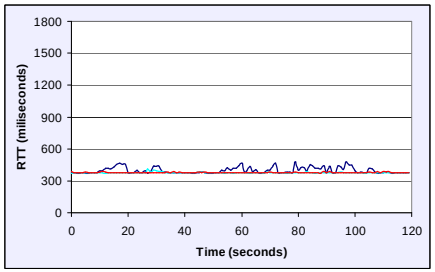
Hop list counts

From\To	Iceland	Brazil	Singapore	Sweden
Iceland	X	23	30	15
Brazil	21	X	23	18
Singapore	23	17	X	20
Sweden	15	20	27	X

Ping graph table

From\To	Iceland	Brazil	Singapore	Sweden
Iceland	X			
Brazil		X		
Singapore			X	
Sweden				

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Unused bandwidth graph table

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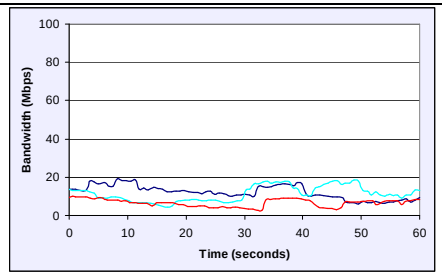
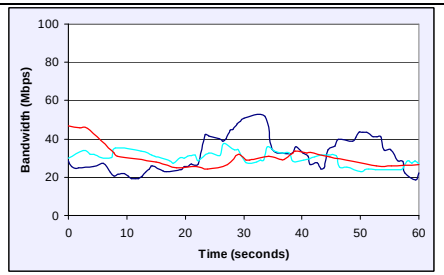
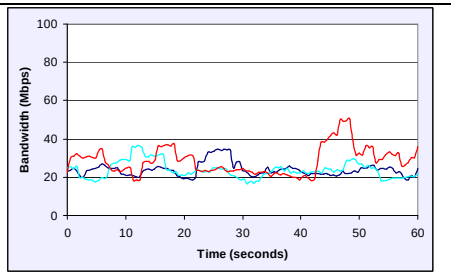
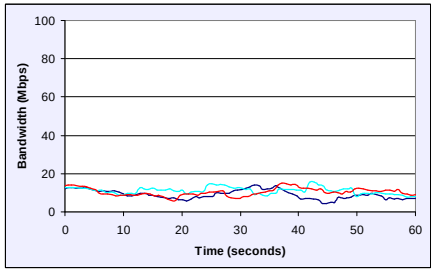
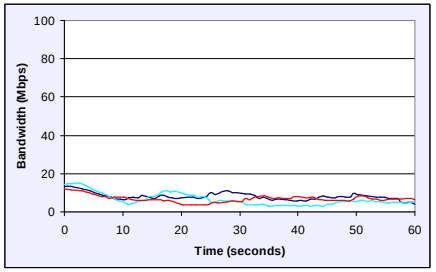
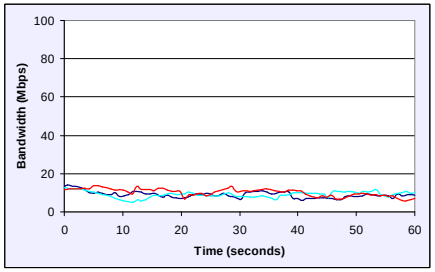
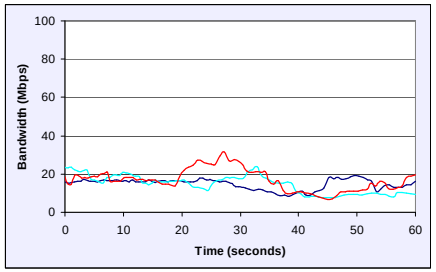
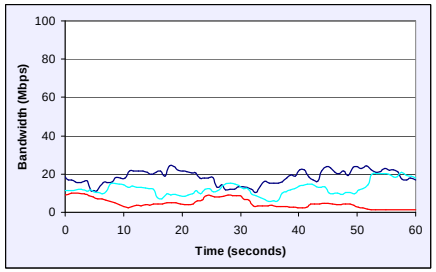
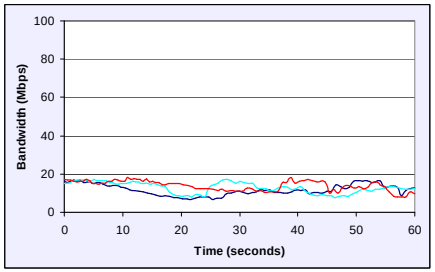
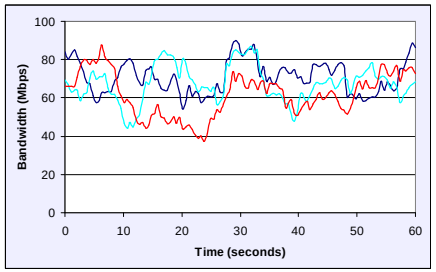
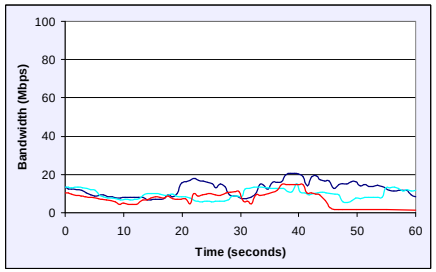
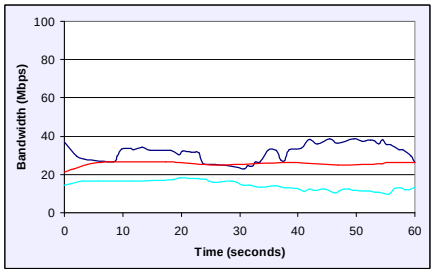
Iceland	X			
Brazil		X		
Singapore			X	
Sweden				

Legend:

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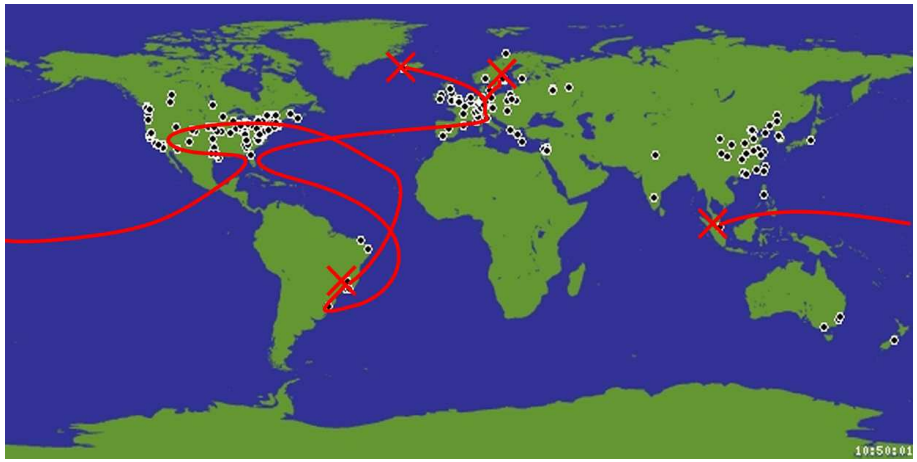
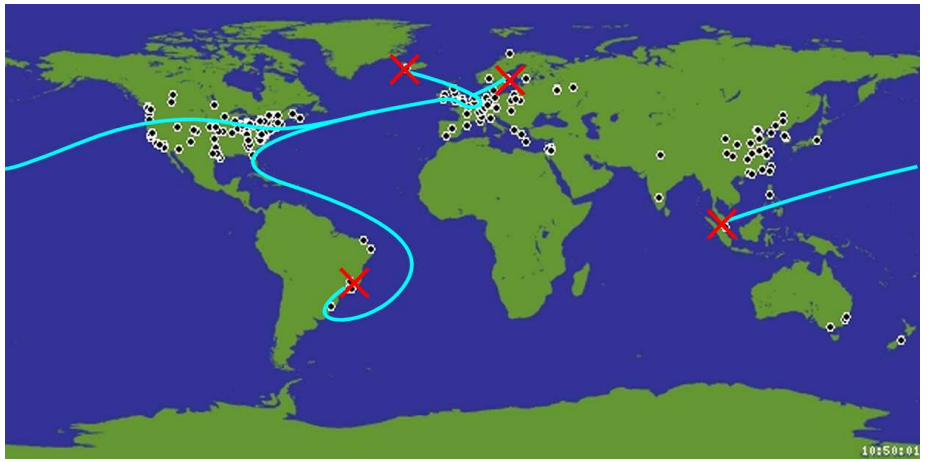
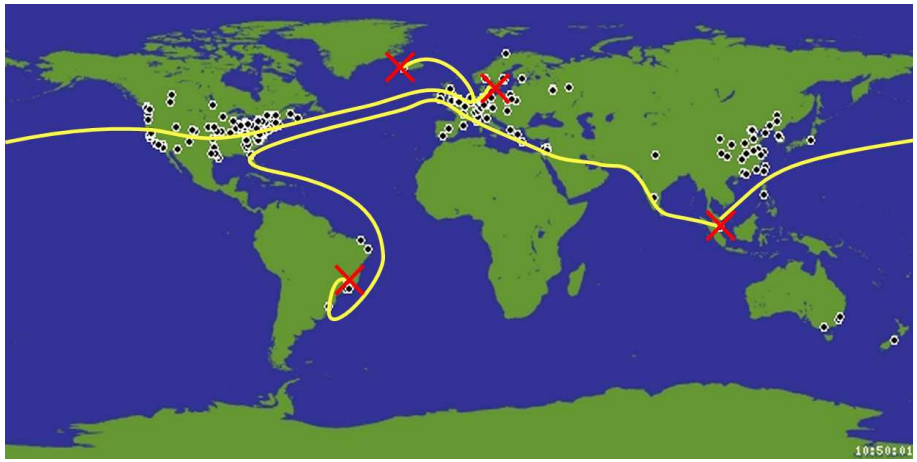
Hops map



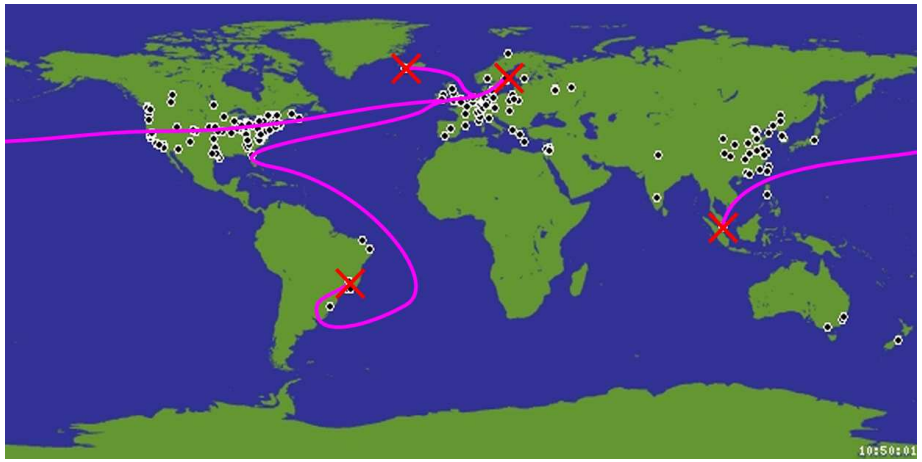
Map of the World: Routes from the server in Brazil to other servers



Map of the World: Routes from the server in Sweden to other servers



Map of the World: Routes from the server in Singapore to other servers



Map of the World: Routes from the server in Iceland to other servers

Source: Planel-lab.org / VisualRoute.com / FranceTelecom.com / Paint Shop Pro software