



The BLU Project

Past, Present, and Future

The “BLU people”



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1. Challenges

2. Tools

3. Solutions

- At the beginning (2006):
 - Broadband for rural areas (in northern Italy)
- Today:
 - Coverage: >90% northern Italy, > 50% central Italy
 - 230K customers (4% market share)
 - From 30Mbps to 1Gbps and white-label wholesale
- Each month:
 - 13K new customers

FWA – Anatomy of a Base Transceiver Station

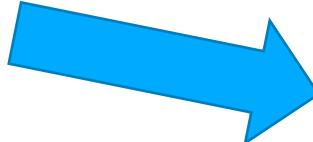
To the top

- Backhaul (PTP links)
- Client access (PMP links)

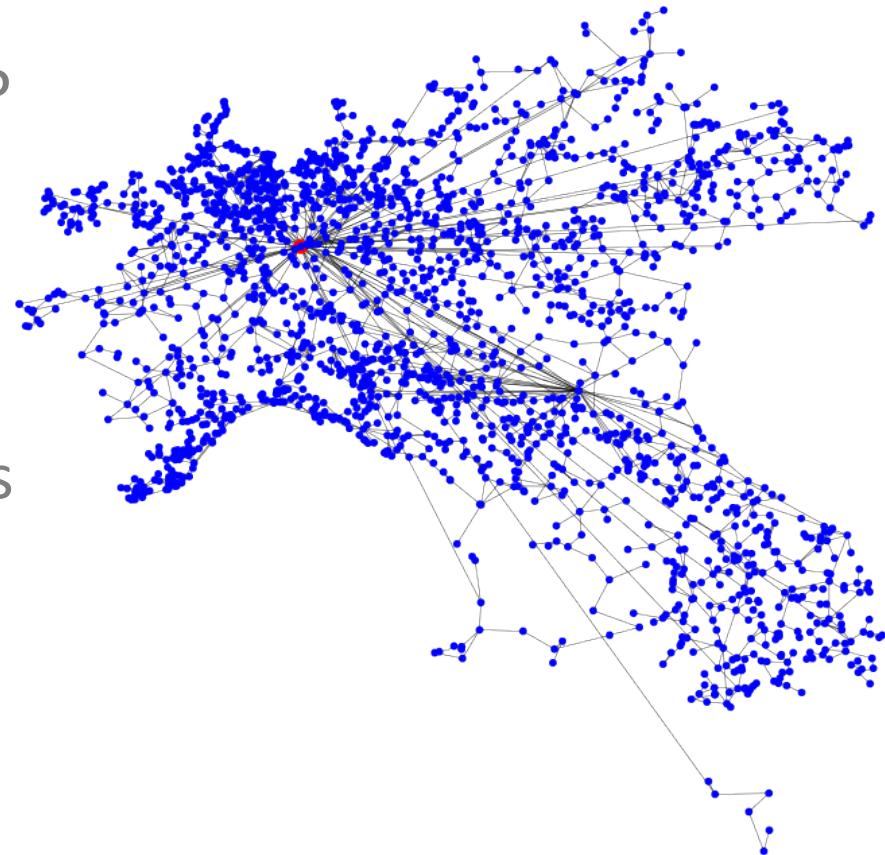


To the ground

- Routers, switches
- Energy stations



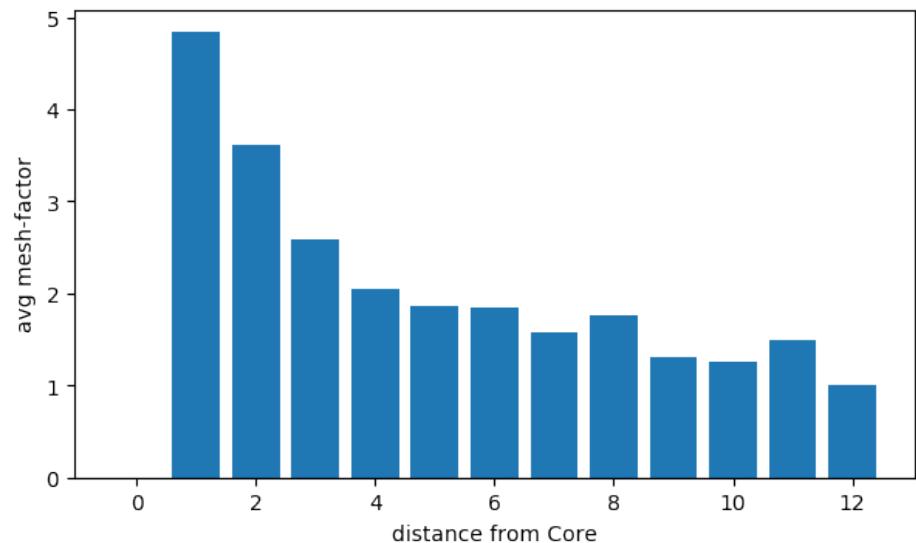
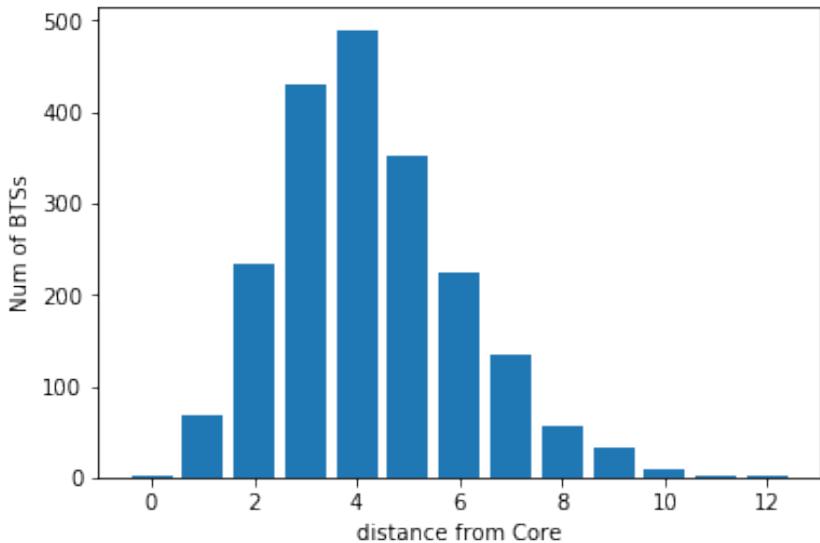
- Fixed Wireless Access (FWA) ISP
- Core in Milan
- Backhaul connections by means of **wireless** links established between *Base Transceiver Station*



(A very) Distinguishing feature

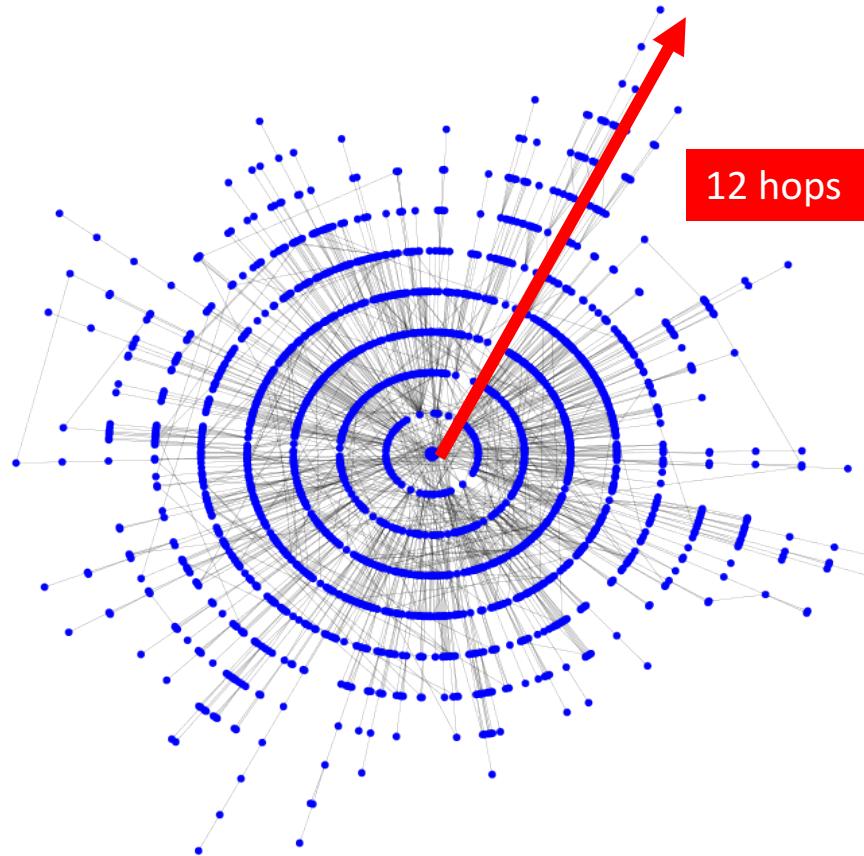
Opportunistic approach

- New link established whenever two BTSSs “see eachothers”



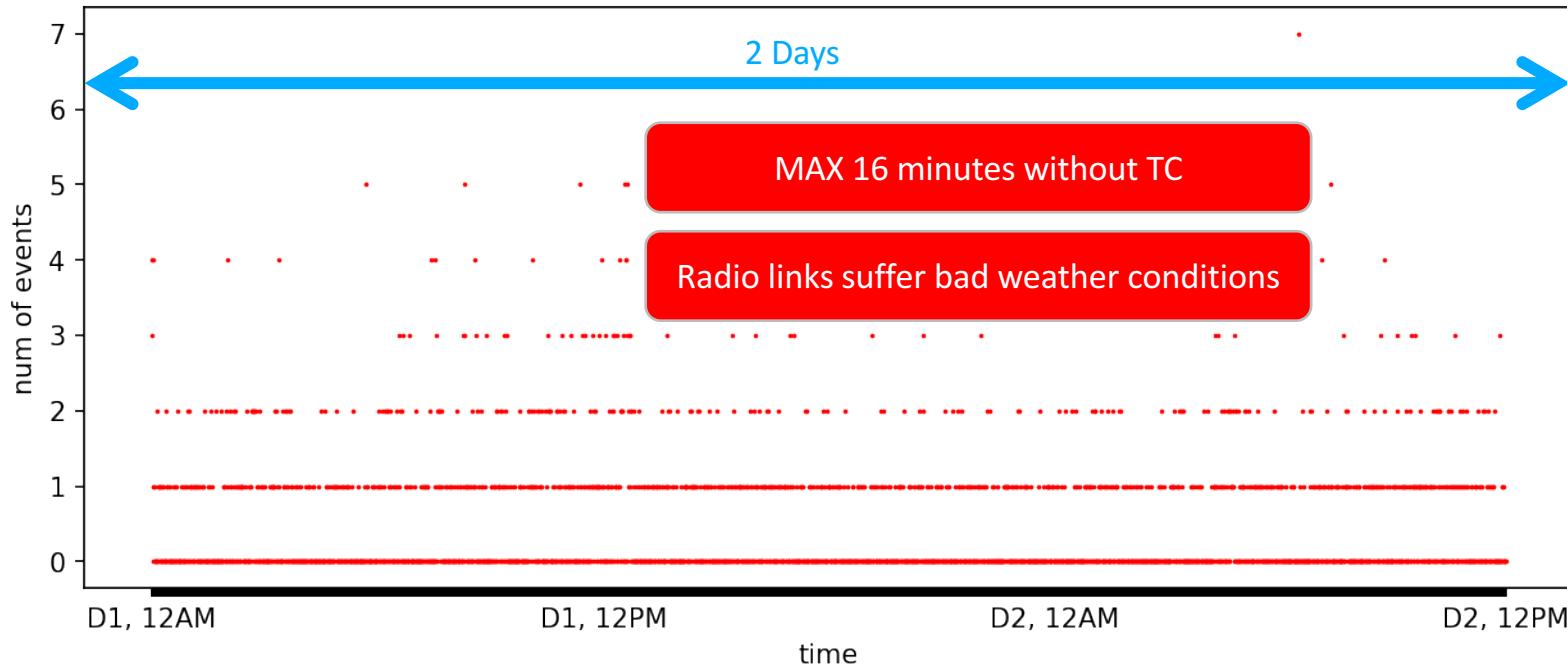
Challenges

Diameter of the network



Challenges

Topology changes



Our solution: the BLU project



BLU routers



BLUos

The screenshot shows a web-based interface for managing network flows. The top navigation bar includes 'Tools', 'Add', 'Delete', 'Apply changes', and 'Reset changes'. On the left, there's a sidebar with 'Navigation' and sections for 'Hosts Management', 'BLU Hosts', 'BLU Versions', 'BLUUserstate matrix', 'Templates', 'Hosts Templates', and 'DVS Flows'. The main content area displays a table of flows, with columns for 'bridge', 'locked', and 'status'. The table lists numerous flow entries, each with a unique identifier and specific parameters like 'actiondrop', 'actionforward', and 'actions-normal'. At the bottom, there are buttons for 'Commands Manager' and a footer note 'Displaying 1 - 30 of 130'.

BLU-GW

The BLU project

Routers

- TileGX architecture
- 72 core CPU
- 16 GB DDR3 RAM
- 128GB SSD
- Low power: 90W avg, 150W max
- 24x1G ports, 2x10G ports
- IEEE 1613 compliant
 - Electromagnetic compatibility
 - Error-free operation in -15C/+75C environment
 - EMI fields of up to 180V/m



Based on 6windgate by 6WIND S.A.

- Linux 3.10.61
- OpenVSwitch
- 6WIND userspace network stack
 - Based on DPDK
 - Associate cores to ports (different configuration based on the routers tasks/position)
 - Userspace dataplane – HIGHLY EFFICIENT
- PPP daemon
- DHCP relay
- Quagga (BGP)

EOLO customizations

- OpenVSwitch mac-learning improved
- RFC 3107 inside Quagga BGP
- Automatic set-up/rescue procedure
 - Self-management strategies
 - Corrupted configurations
 - Host temporarily disconnected
- Monitoring daemons
 - LLDP neighboring details
 - Bandwidth (radio links suffer bad weather, interferences, etc.)
 - Tx/Rx traffic on each interface (both BH and Access)

- Avoid (or, at least, limit) human error
- Full management of our BLU routers
 - Parallel execution of commands
 - Scheduler for night updater
 - Success/failure/rollback
- Collection and analysis of data from the BLU routers
 - Topology updates
 - Statistics, logs and error messages
- Statistics visualization

The BLU project

BLU-GW - Management

Navigation

- Tools
- Users Management
- Hosts Management
- Commands Manage...
- Engineering

 - Commands queue
 - Hosts Commands
 - Spanrega Executions
 - OVS Flows
 - Hosts Locks
 - OVS Stats

Commands queue

insert_time	execute_time	worker_reserve	command	source	pro	username	exit	resid	not_before	not_after	abc	tr	exhumable	delay_mode	callback_url	callback_url_id	
2017-1...			on host	on bridge...	API	0	userBugw	0	1	2017-1...		0	0	1	30_SEC	https://eoli...	https://eoli...
2017-1...			on host	on bridge...	API	0	userBugw	0	1	2017-1...		0	0	1	30_SEC	https://eoli...	https://eoli...
2017-1...			on host	on bridge...	API	0	userBugw	0	1	2017-1...		0	0	1	30_SEC	https://eoli...	https://eoli...
2017-1...			on host	on interfa...	API	0	userBugw	0	1	2017-1...		0	0	1	30_SEC	https://eoli...	https://eoli...
2017-1...			on host	on interfa...	API	0	userBugw	0	1	2017-1...		0	0	1	30_SEC	https://eoli...	https://eoli...
2017-1...			on host	on interfa...	API	0	userEolia	0	1	2017-1...		0	0	1	30_SEC	https://eoli...	https://eoli...
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		0	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...	2017-1...	2017-10-2...	on host	on interfa...	UNSE...	100	userBugw	0	4	2017-1...		0	1	0	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	del bondi...	UNSE...	100	userBugw	0	4	2017-1...		0	1	0	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	on interfa...	UNSE...	100	userBugw	0	4	2017-1...		0	1	0	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	on interfa...	UNSE...	100	userBugw	0	4	2017-1...		0	1	0	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	on interfa...	UNSE...	100	userBugw	0	4	2017-1...		0	1	0	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	on interfa...	UNSE...	100	userBugw	0	4	2017-1...		0	1	0	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	on interfa...	UNSE...	100	userBugw	0	4	2017-1...		0	1	0	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	on bridge...	UNSE...	100	userBugw	0	4	2017-1...		0	1	1	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	on bridge...	UNSE...	100	userBugw	0	4	2017-1...		0	1	0	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	on interfa...	API	100	della	0	0	2017-1...		0	1	1	30_SEC	https://eoli...	https://eoli...
2017-1...	2017-1...	2017-10-2...	on host	on system...	CLI	100	albe	0	0			0	1	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...	2017-1...	2017-10-2...	on host	n interfac...	CLI	100	dox	0	0			0	1	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		
2017-1...			on host	on eng s...	CONFIF...	0	userBugw	0	5	2017-1...		1	0	0	30_SEC		

Page 1 of 668
Displaying 1 - 30 of 20031

The BLU project

BLU-GW - Management

Navigation

- Tools
- Users Management
- Hosts Management
 - Hosts
 - BLUos Versions
 - BLUos/template matrix
- Templates**
- Interfaces Templates

Hosts Templates

Edit template Spare Rev. 58

type: Spare

```
<? /*  
=====  
== Template: BLU Spare  
=====  
*/ ?>  
  
<? /*===== Set the local hostname =====*/ ?>  
on host <?= $hostname; ?> on system set hostname <?= $hostname.\n"; ?>  
  
<? /*===== Create a single bridge with all the physical ports =====*/ ?>  
on host <?= $hostname; ?> add bridge ovsbr0  
  
on host <?= $hostname; ?> on bridge ovsbr0 add flow "table=0,priority=1,dl_vlan=150,actions=resubmit(,1)" at-reboot  
on host <?= $hostname; ?> on bridge ovsbr0 add flow "table=0,priority=0,actions=drop" at-reboot  
  
on host <?= $hostname; ?> on bridge ovsbr0 add flow "table=1,priority=1,dl_type=0x863,actions=resubmit(,2)" at-reboot  
on host <?= $hostname; ?> on bridge ovsbr0 add flow "table=1,priority=1,dl_type=0x864,actions=resubmit(,2)" at-reboot  
on host <?= $hostname; ?> on bridge ovsbr0 add flow "table=1,priority=0,actions=drop" at-reboot  
  
on host <?= $hostname; ?> on bridge ovsbr0 add flow  
"table=2,priority=2,in_port=LOCAL,dl_dst=ffff:ffff:ffff:ff:ff:ff,actions=NORMAL" at-reboot  
on host <?= $hostname; ?> on bridge ovsbr0 add flow "table=2,priority=1,in_port=LOCAL,actions=resubmit(,3)" at-reboot  
on host <?= $hostname; ?> on bridge ovsbr0 add flow "table=2,priority=0,actions=drop" at-reboot  
  
on host <?= $hostname; ?> on bridge ovsbr0 add flow "table=3,priority=0,actions=drop" at-reboot
```

delta_version:

before:

version: 806

extra:

priority: 0

delay_after_update: 0

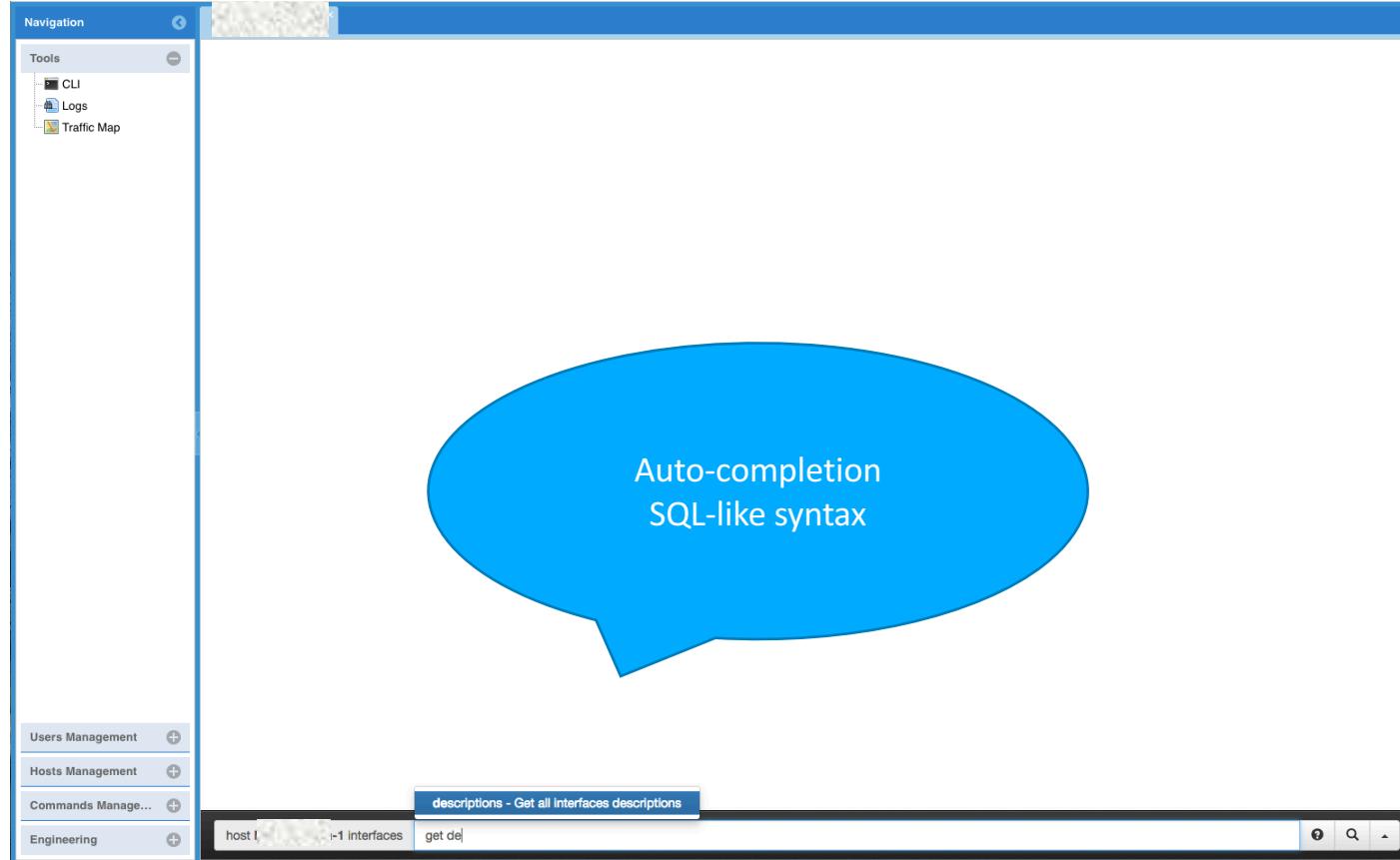
Commands Manage... Engineering

Save Cancel

Openflow template editor

The BLU project

BLU-GW - Monitoring



The BLU project

BLU-GW - Monitoring

Navigation

- Tools
- CLI
- Logs
- Traffic Map

on t

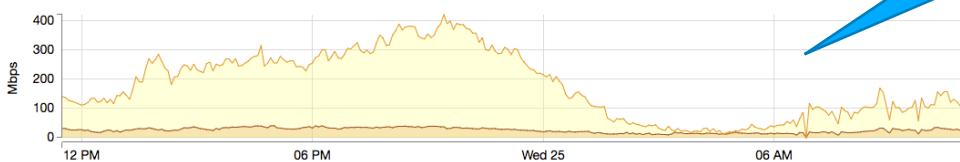
interfaces get descriptions

Oct, 25 11:27 Hide

Name	Description	Template	Status	PHY	Link	Safe-mode	Port Type
eth4		Accesso EW - rev. 56	enabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Up, 100 Mbps, Full-duplex	disabled	
eth6		Accesso EW - rev. 56	enabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Up, 100 Mbps, Full-duplex	disabled	
eth9		Power - rev. 56	enabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Up, 100 Mbps, Full-duplex	disabled	
eth11		Backhaul - rev. 56	disabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Down	disabled	
eth12	teRena	Backhaul Terminale - rev. 56	enabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Up, 1 Gbps, Full-duplex	disabled	
eth13	tezza	Backhaul - rev. 56	enabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Up, 1 Gbps, Full-duplex	disabled	
eth14	calunga	Backhaul Terminale - rev. 56	enabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Up, 1 Gbps, Full-duplex	disabled	
eth15		Backhaul - rev. 56	enabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Up, 1 Gbps, Full-duplex	disabled	
eth17	o	Backhaul - rev. 56	enabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Up, 1 Gbps, Full-duplex	disabled	Fiber
eth18	do	Backhaul - rev. 56	enabled	Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	Up, 1 Gbps, Full-duplex	disabled	Fiber
eth26		Backhaul - rev. 56	enabled	Up, 10 Gbps, Full-duplex	Up, 10 Gbps, Full-duplex	disabled	Fiber
ethgrp0		Aggregatore - rev. 56	enabled	eth20: Up, 10 Mbps, 100 Mbps, 1 Gbps, Full-duplex, Half-duplex	eth20: Up, 1 Gbps, Full-duplex	disabled	Copper

Interface conf.

Tx/Rx



400
300
200
100
0 Mpbs

12 PM 06 PM Wed 25 06 AM

RX TX

host N... 1 interfaces Type the command here...

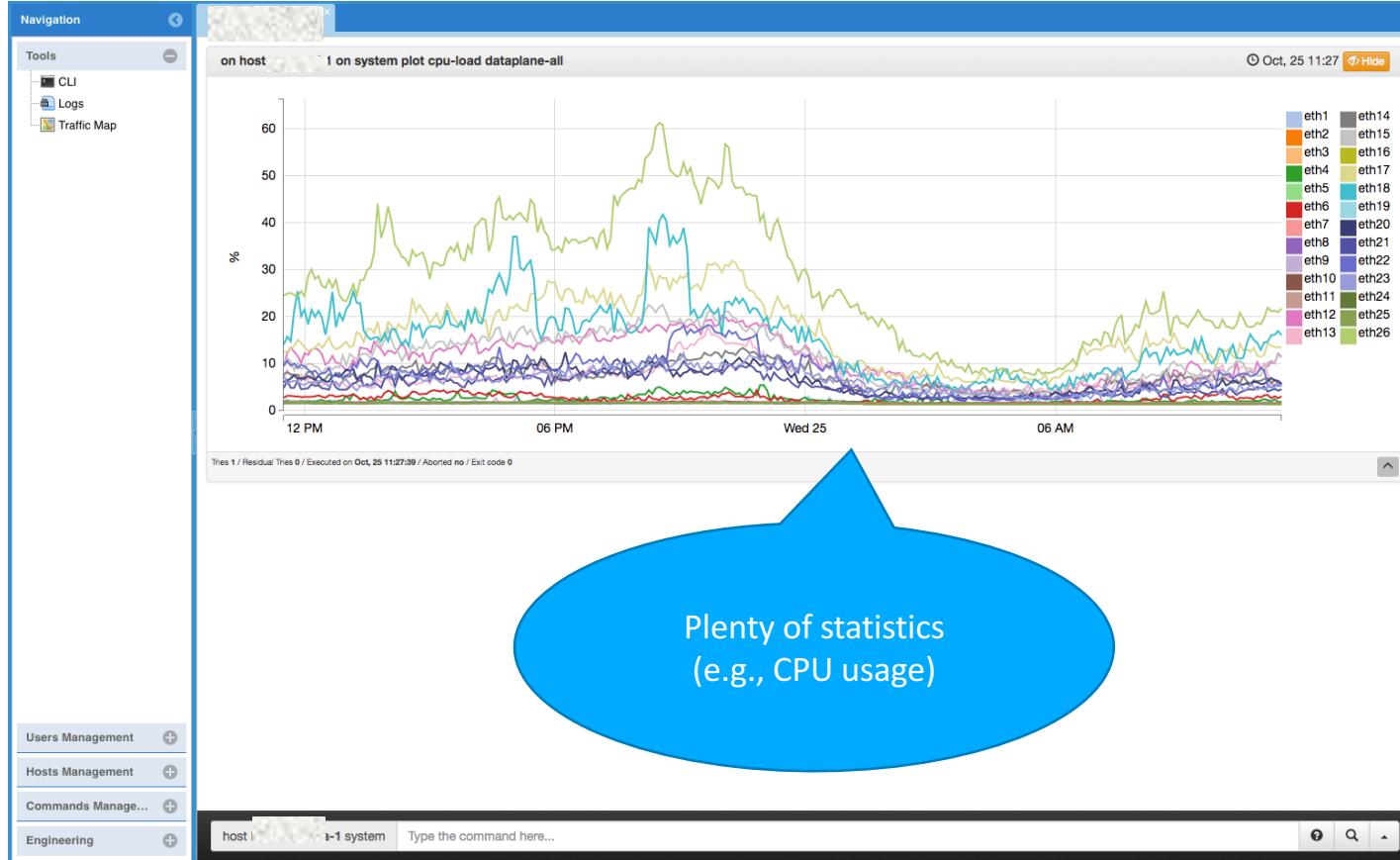
?

Search

17

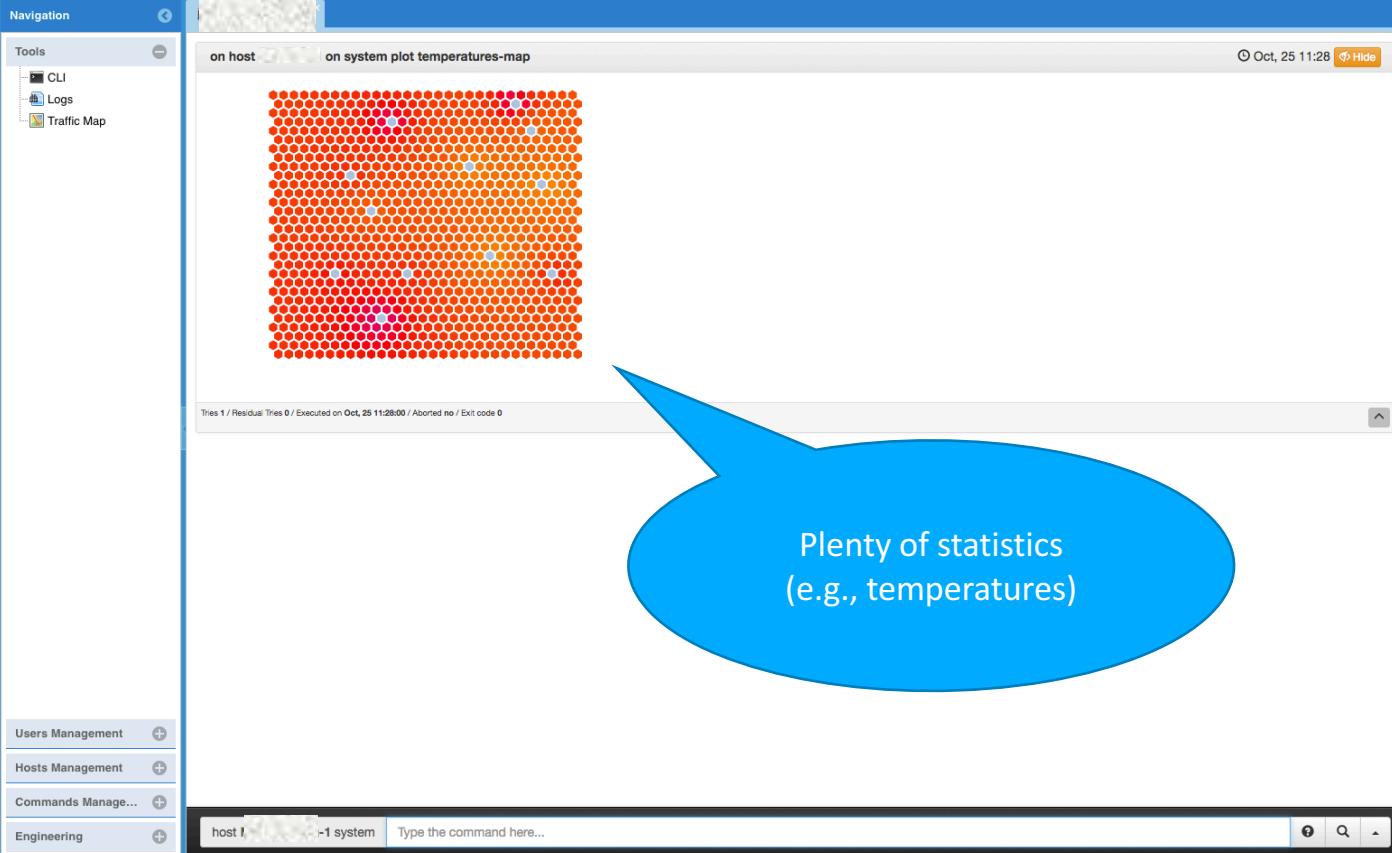
The BLU project

BLU-GW - Monitoring



The BLU project

BLU-GW - Monitoring

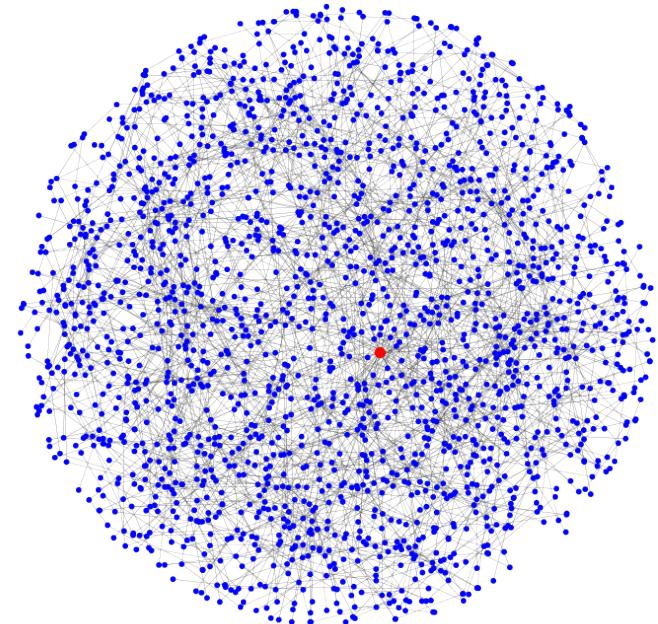


The screenshot shows a monitoring interface for the BLU-GW system. On the left, a navigation sidebar includes 'Tools' (CLI, Logs, Traffic Map), 'Users Management', 'Hosts Management', 'Commands Manage...', and 'Engineering'. The main area displays a 'plot temperatures-map' titled 'on host' and 'on system'. The plot consists of a grid of red hexagons, with a few blue and purple ones scattered across them, indicating temperature variations. A blue speech bubble points to this plot with the text: 'Plenty of statistics (e.g., temperatures)'. At the bottom, there's a command-line interface (CLI) with a search bar containing 'host ! -1 system' and a placeholder 'Type the command here...'. The date and time 'Oct, 25 11:28' are also visible at the top right.

The BLU project

Phase1 - Challenges

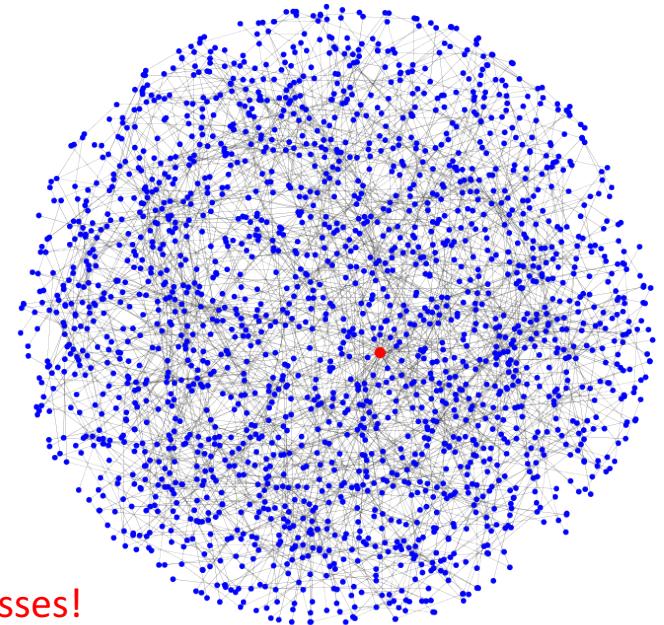
- Backhaul:
 - Wireless links
 - PVST+ L2
- Very high number of mac-address!
- PPP? DHCP?
- Traffic balancing? Overloaded links?



The BLU project

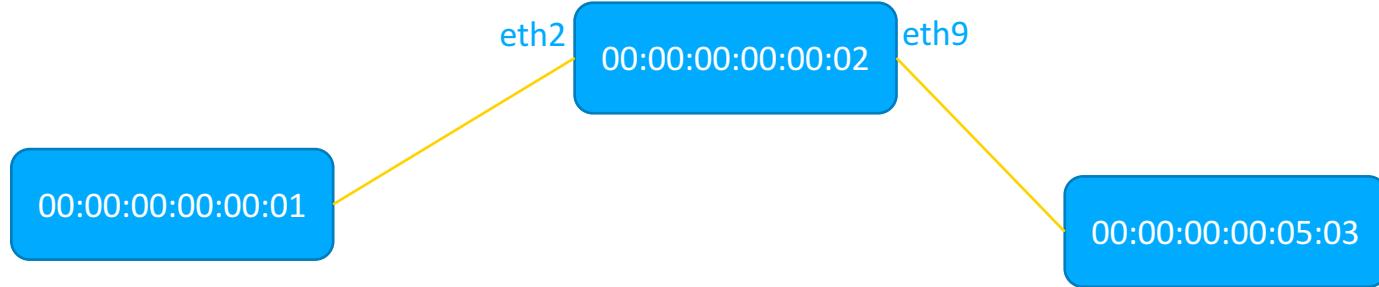
Phase1 - Solution

- Backhaul:
 - Wireless links
 - PVST+ L2
- Very high number of mac-address!
 - PPP server/DHCP relay on the BLU
 - Each BLU advertises to the core its PPP/DHCP IP pools
- Traffic balancing? Overloaded links?
 - Multiple BH vlans (cost changes determine different paths)
- Cost changes performed manually!
- OVS still suffers the high number (> 1K per BLU) of mac-addresses!
 - Flows-handling performance decreases – traffic gets lost



The BLU project

BLUos – Hacking OVS



```
in_port(2),eth(src=00:00:00:00:01,dst=00:00:00:00:05:03),...,actions:9  
in_port(9),eth(src=00:00:00:05:03,dst=00:00:00:00:01),...,actions:2
```

The BLU project

BLUos – Hacking OVS



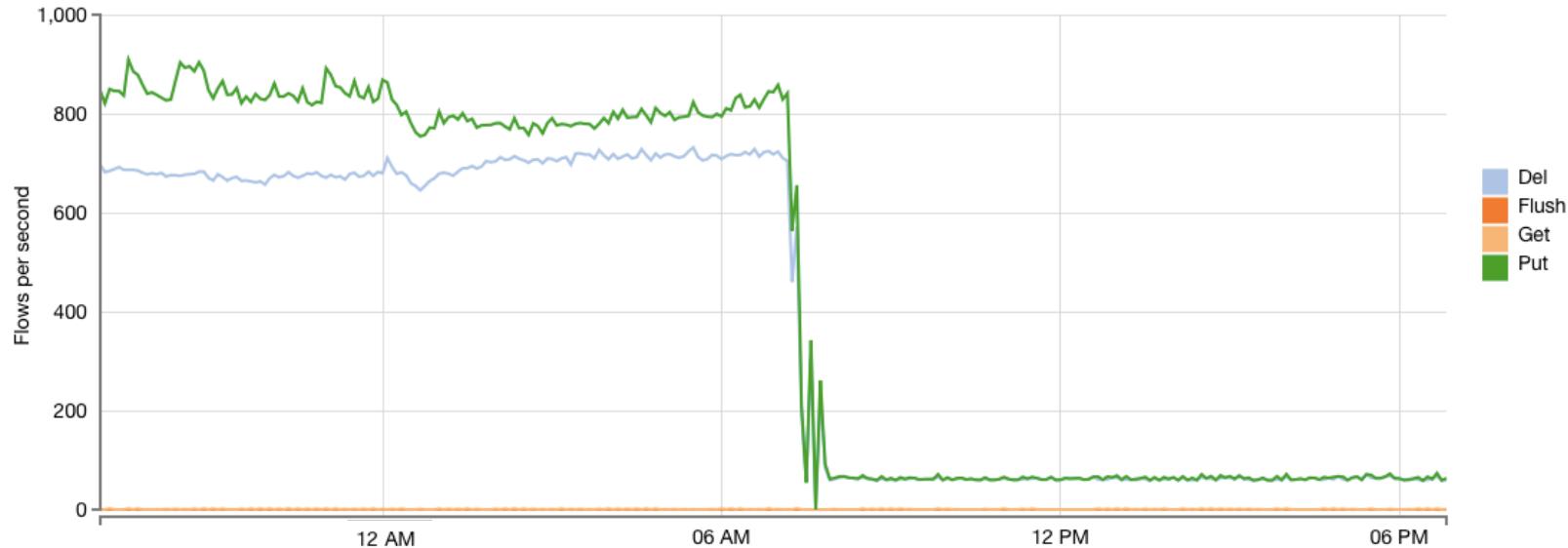
The BLU project

BLUos – Hacking OVS



The BLU project

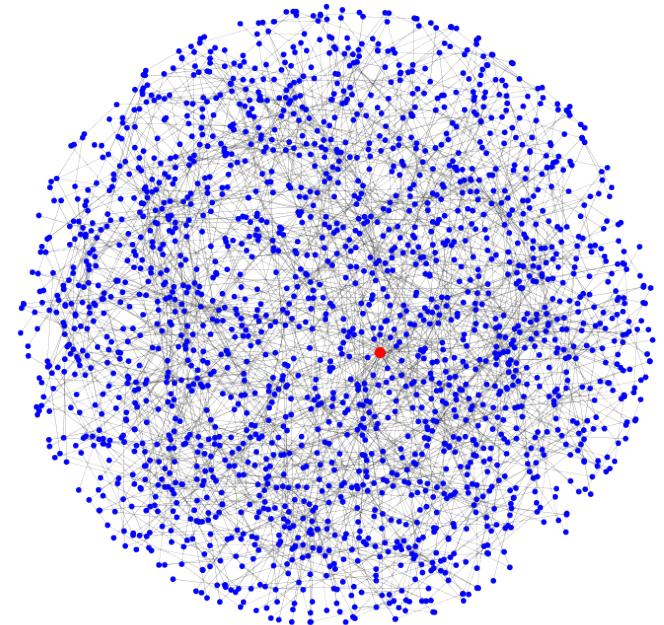
BLUos – Hacking OVS



The BLU project

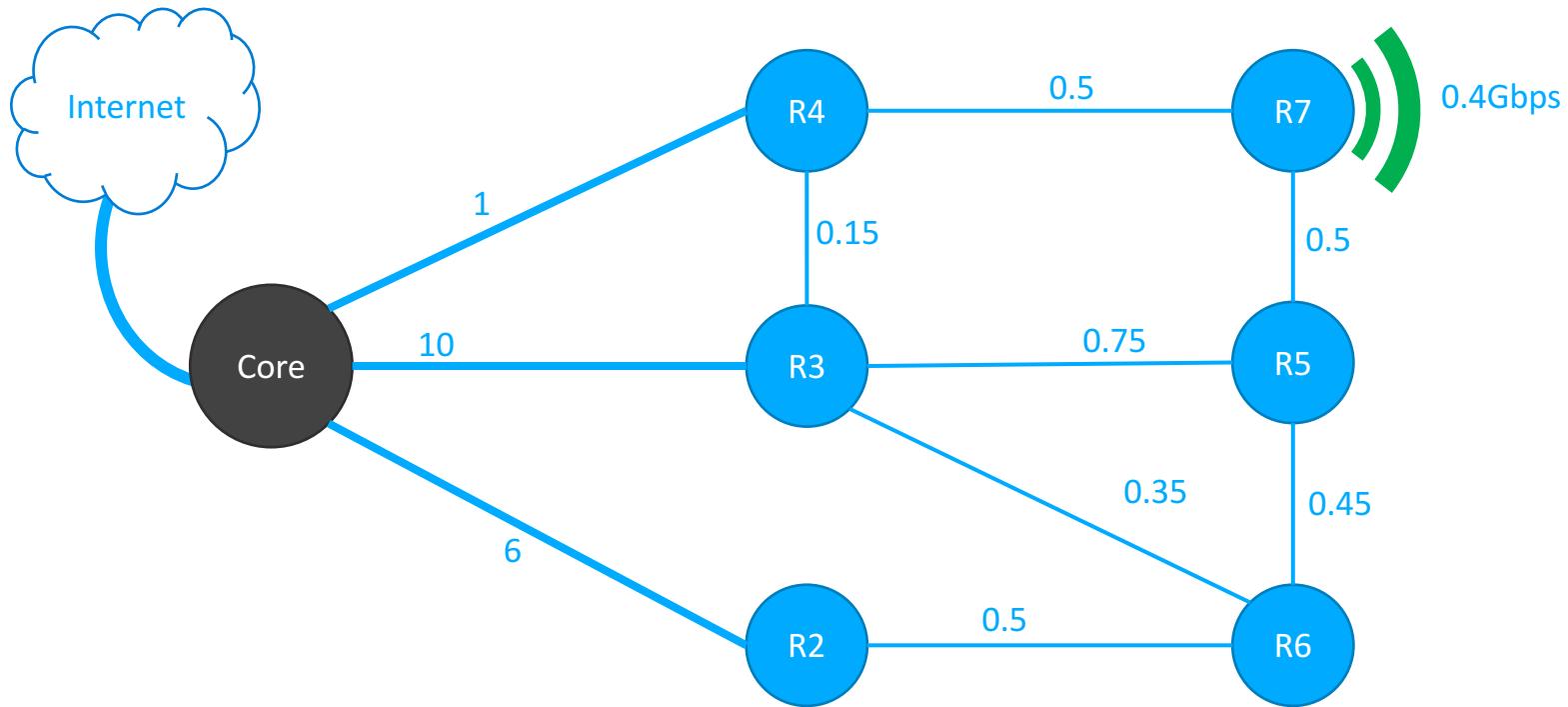
Phase2

- BLUGW knows
 - Link capacity
 - Residual BH link capacity
 - BLUs' "desired bandwidth" (access ifaces bandwidth)
- A centralized SDN controller decides the routing
 - Residual capacity gets optimized
 - Informs the BLU on how to handle traffic
- Openflow rules for MPLS label switching
- RFC3107 for (downlink) traffic labeling



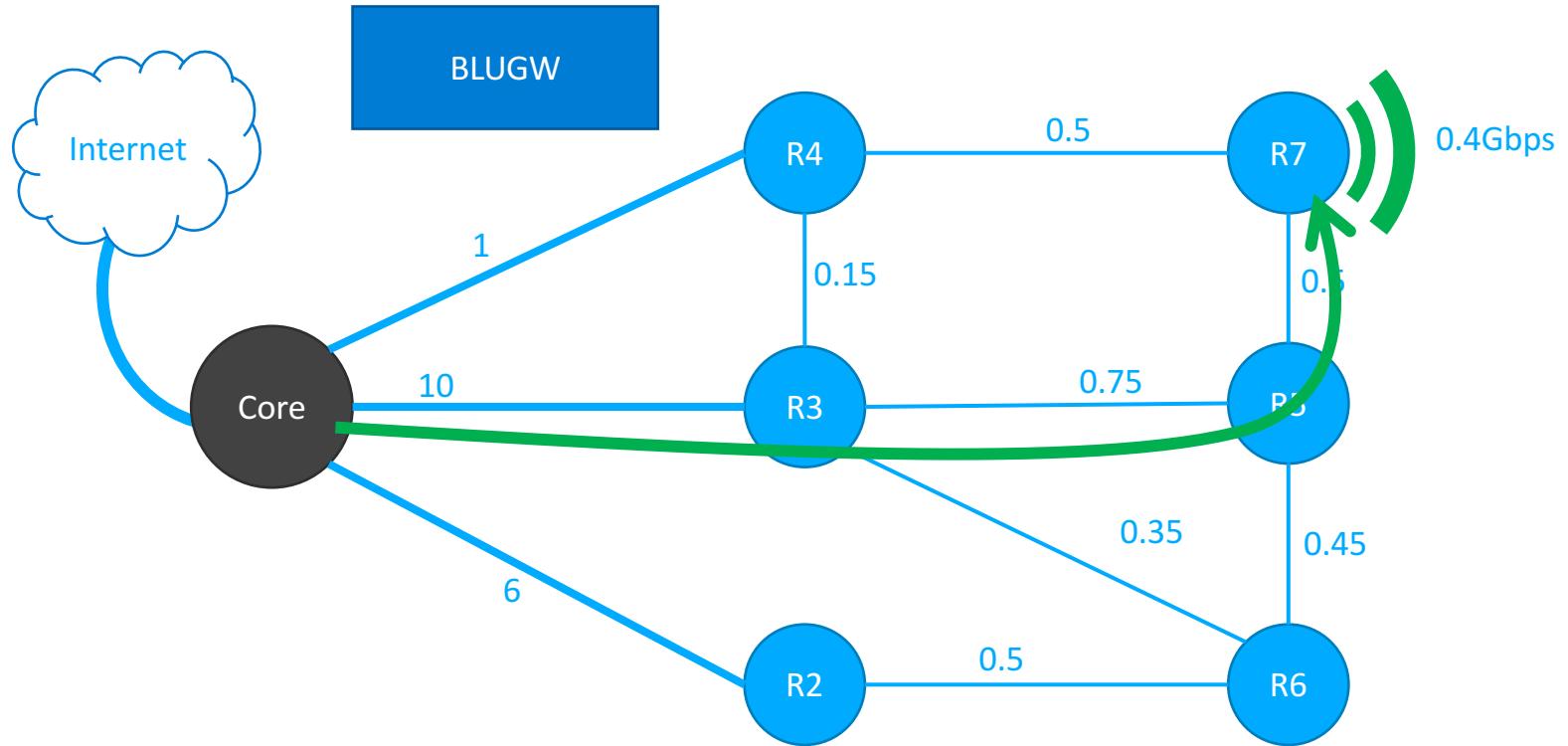
The BLU project

Phase2



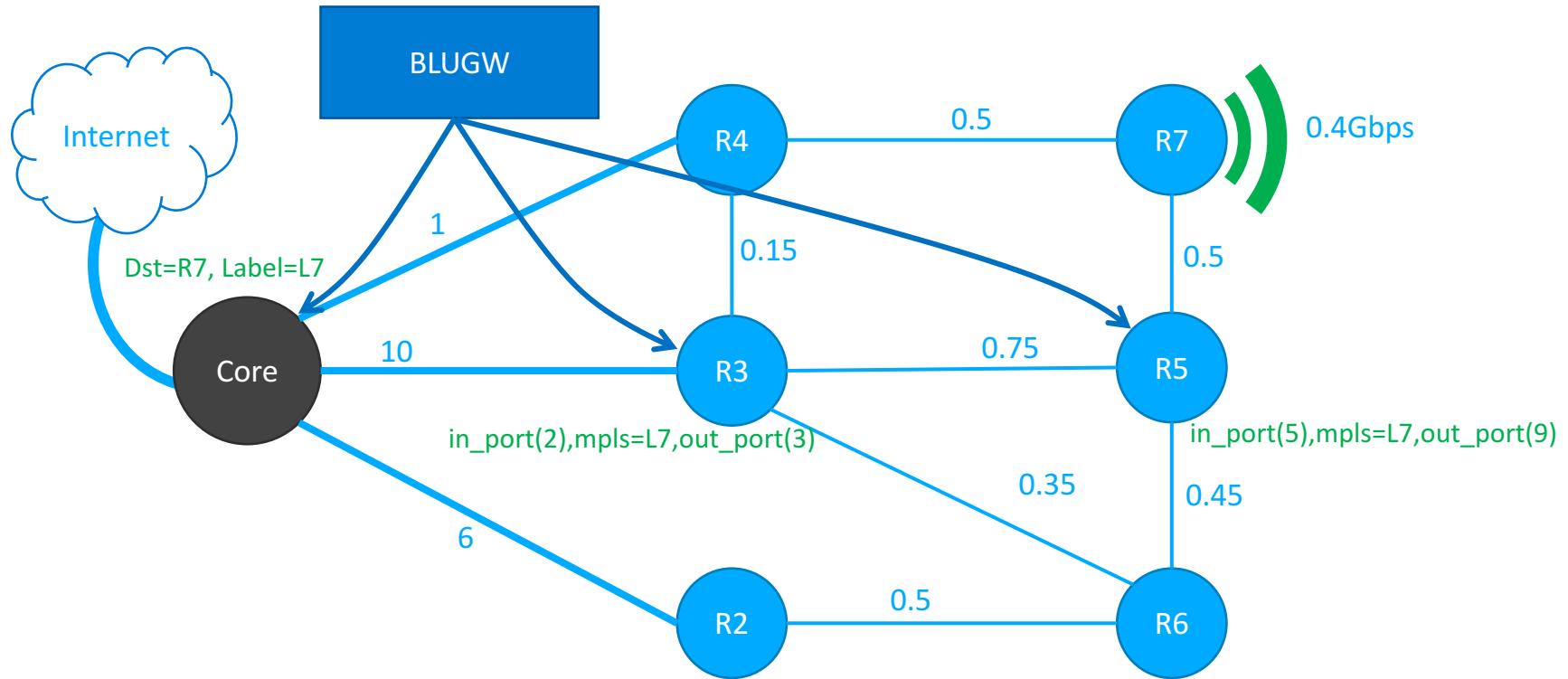
The BLU project

Phase2



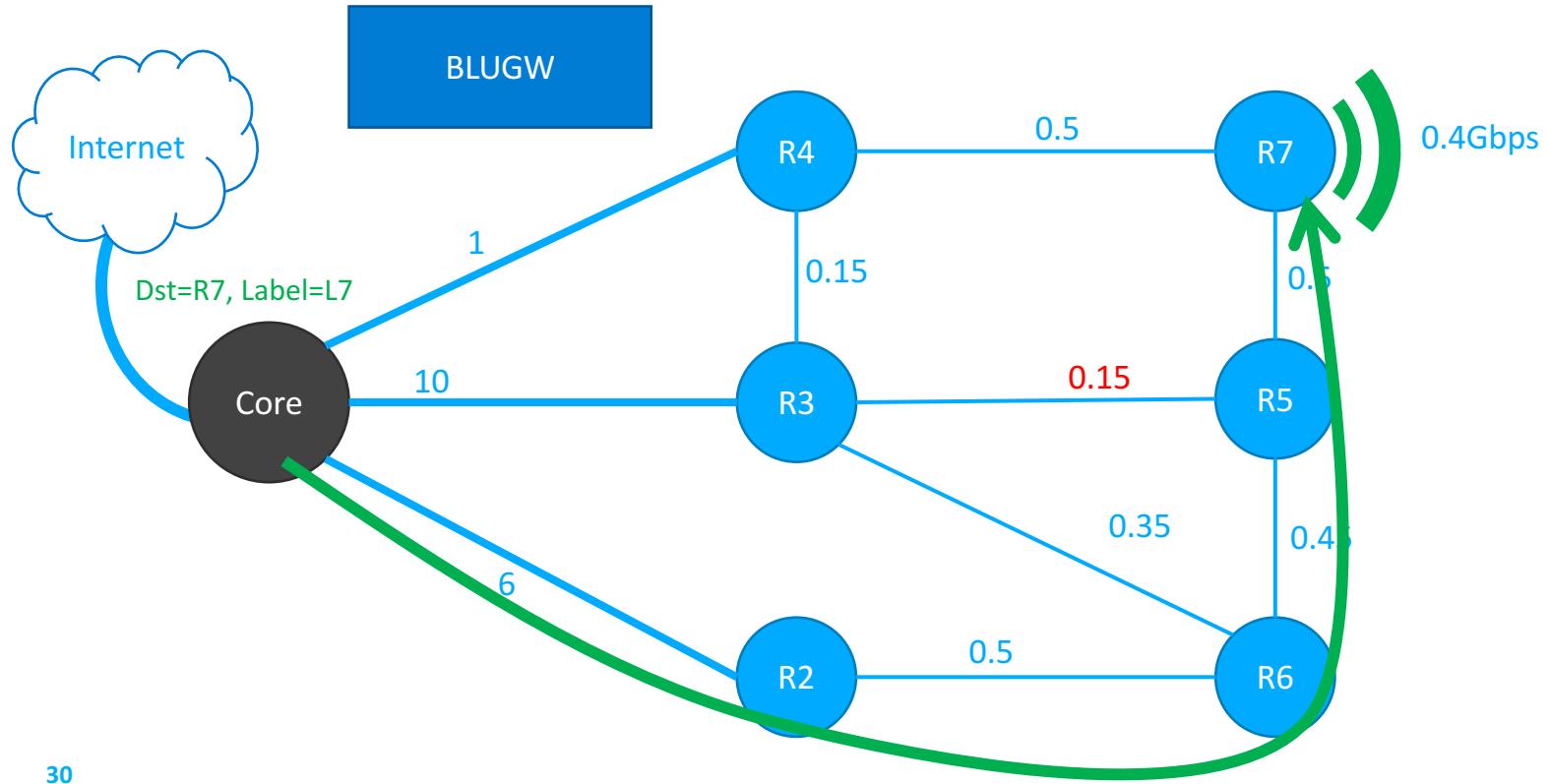
The BLU project

Phase2



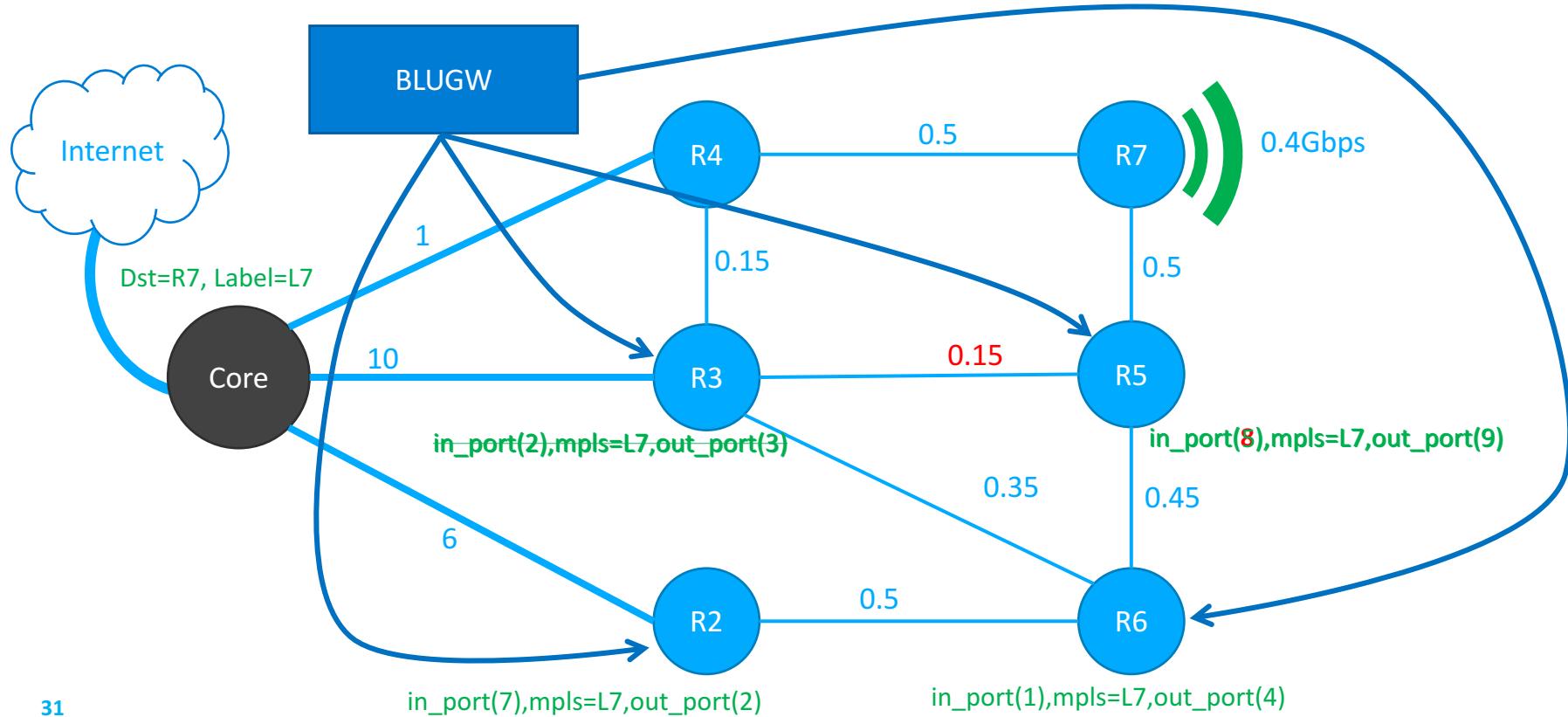
The BLU project

Phase2



The BLU project

Phase2

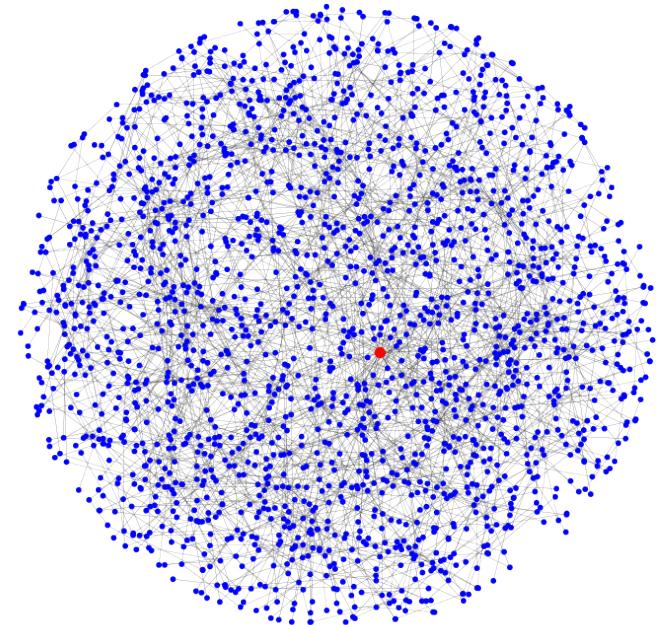


- OpenFlow granularity is rather small
 - A single flow through the network requires all the BLUs along the path to be (re)programmed
- Every time the network changes (!!!) the controller needs to re-compute the routes and upgrade the BLU
- Upgrades **need to be atomic**, high risk of inconsistent state of the network
- There is no a “**BIG RED BUTTON**” to be pressed in case of critical issues!
 - How to go back to a safe configuration in case of troubles?

The BLU project

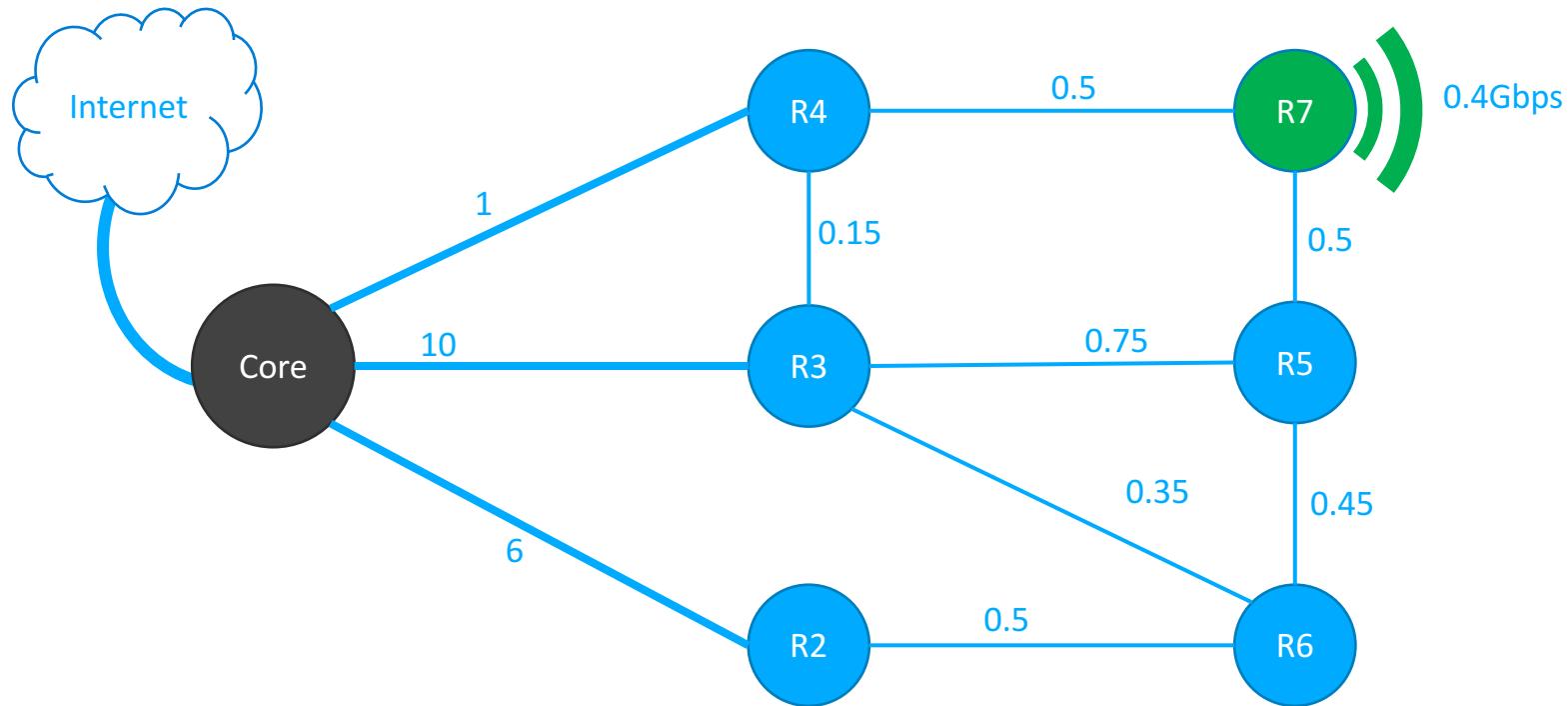
Phase3

- Segment Routing philosophy
- IGP running on the BLU routers
 - eBGP, RFC3107
- RFC 3107 + SR policy for downlink traffic labeling
- Label switching (OVS)
 - eBGP governs Open vSwitch: active routes determine label switching flows



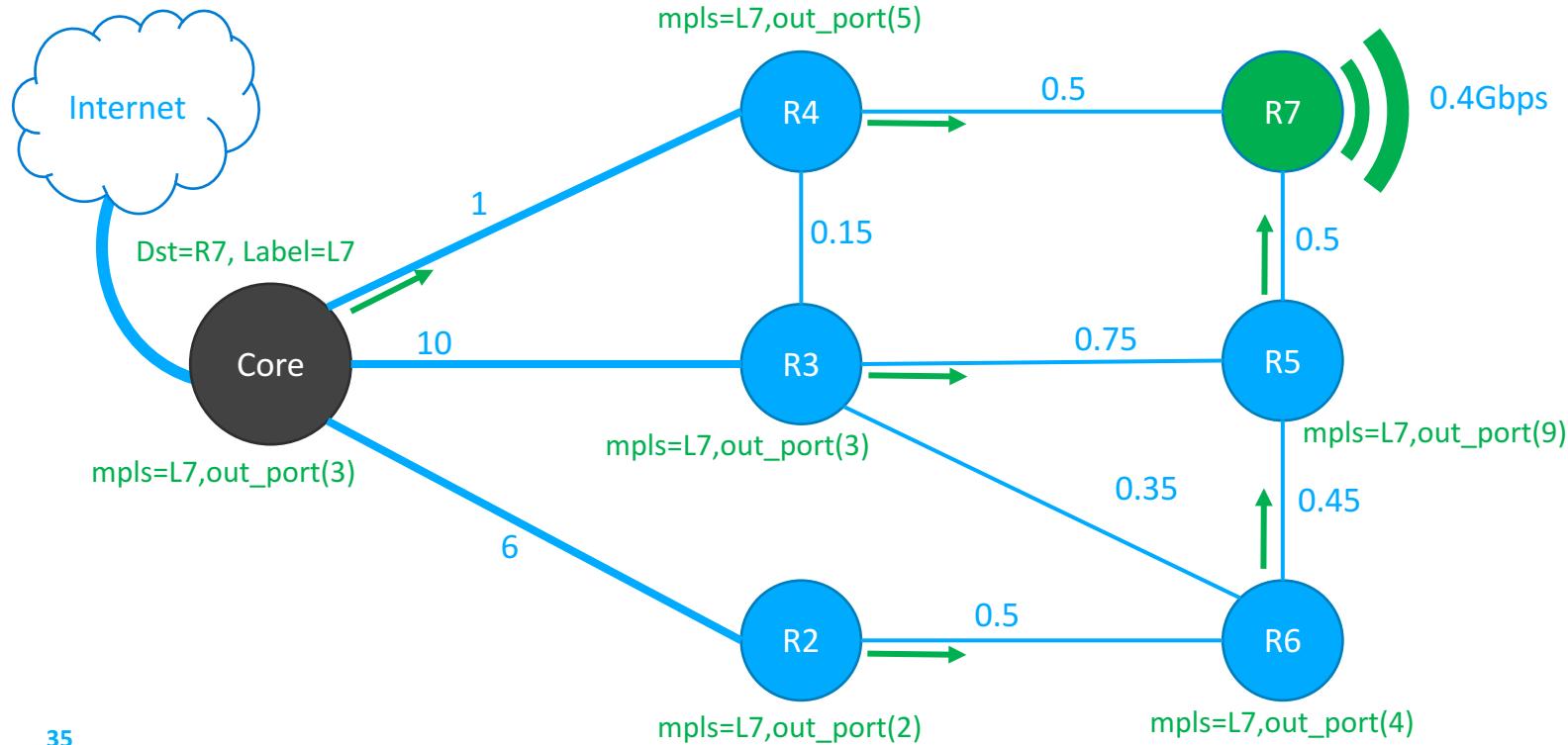
The BLU project

Phase3



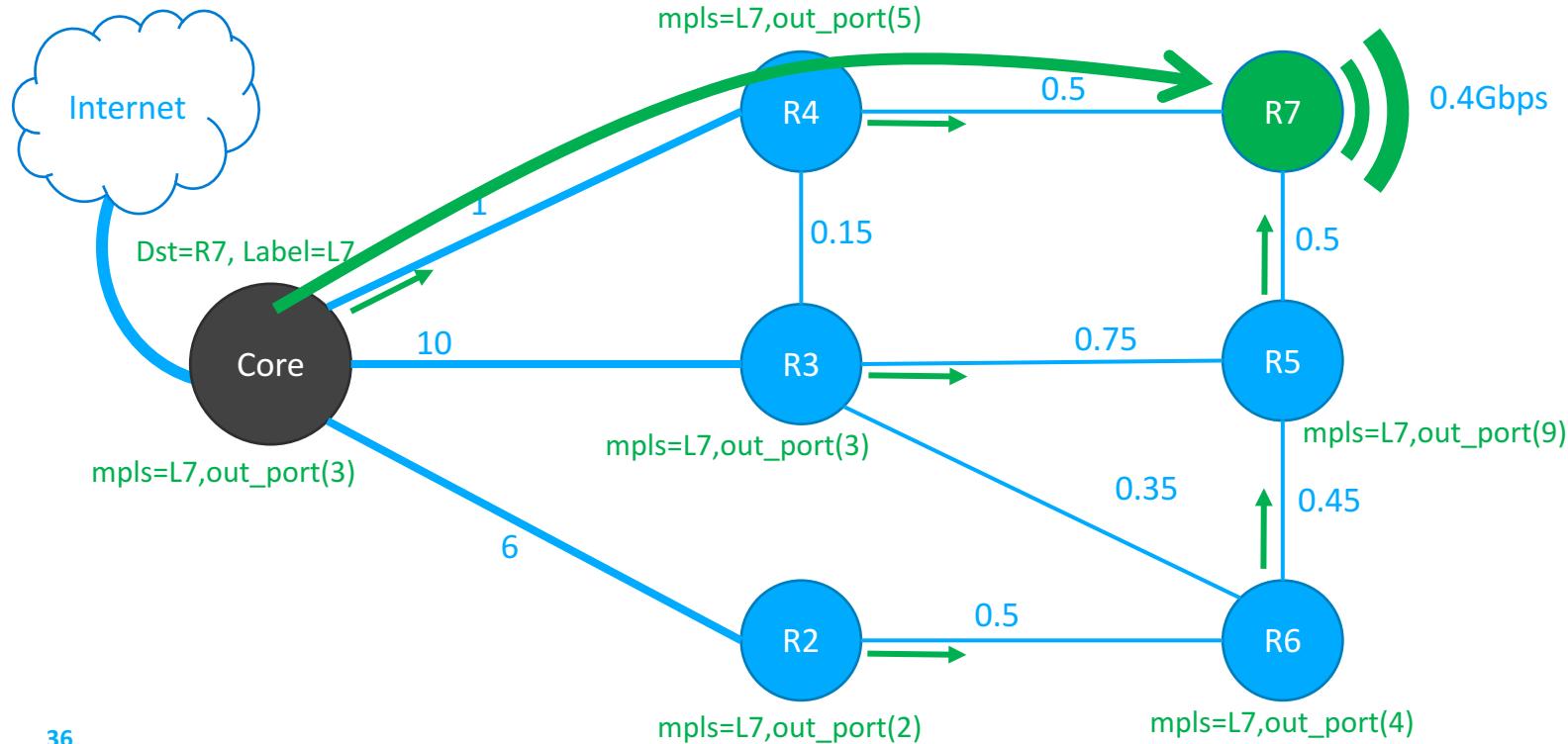
The BLU project

Phase3



The BLU project

Phase3



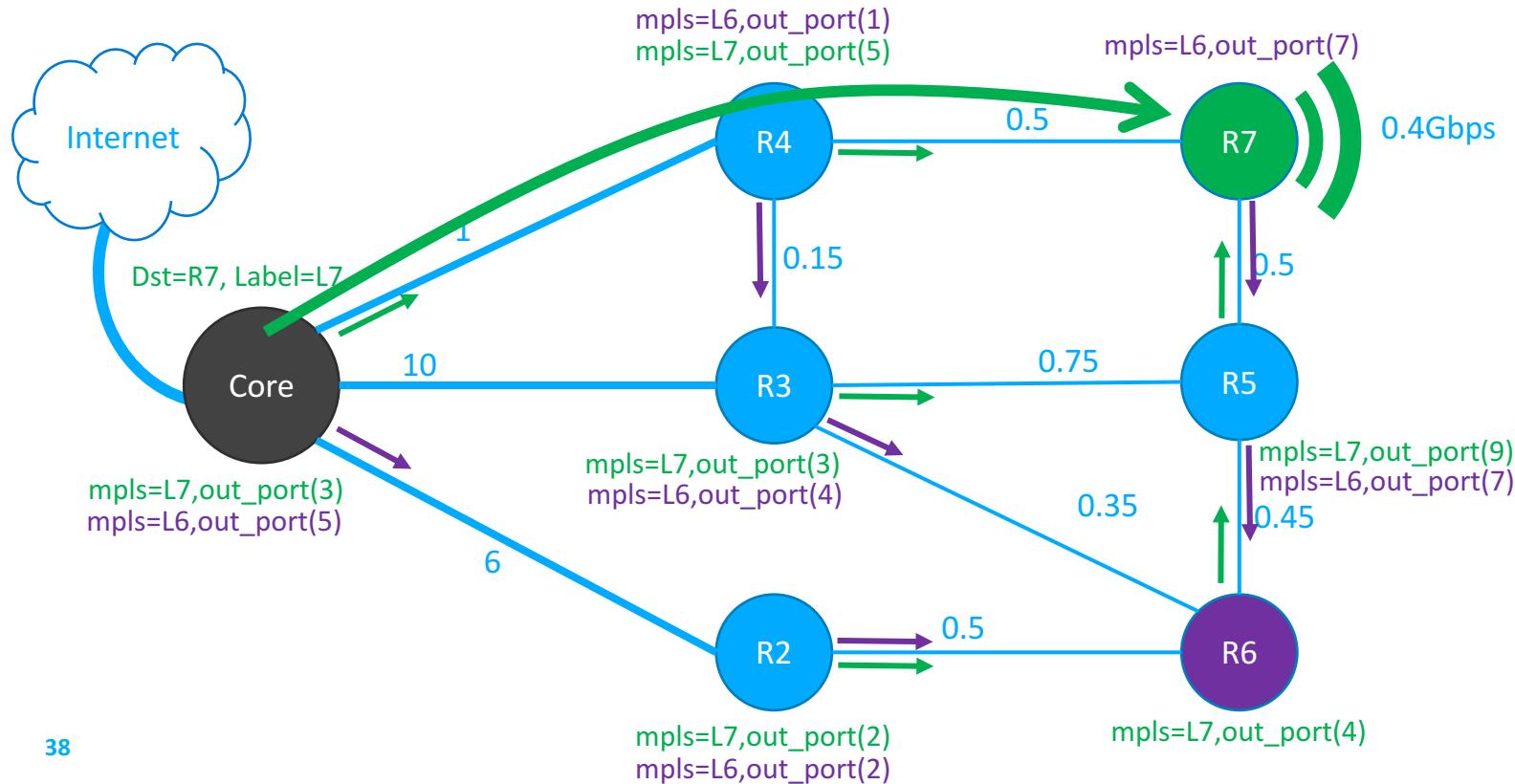
The BLU project

Phase3 – Traffic Engineering

- How to optimize the traffic flows?
- BLUGW still knows
 - (quasi-)Real time topology
 - Residual bandwidth
 - Desired access ifaces bandwidth
 - NEW: BLUs' IGP routing tables
- Optimization goes through these points:
 - Find a waypoint where to route the traffic to be optimized
 - Instruct the CORE on the required label stack

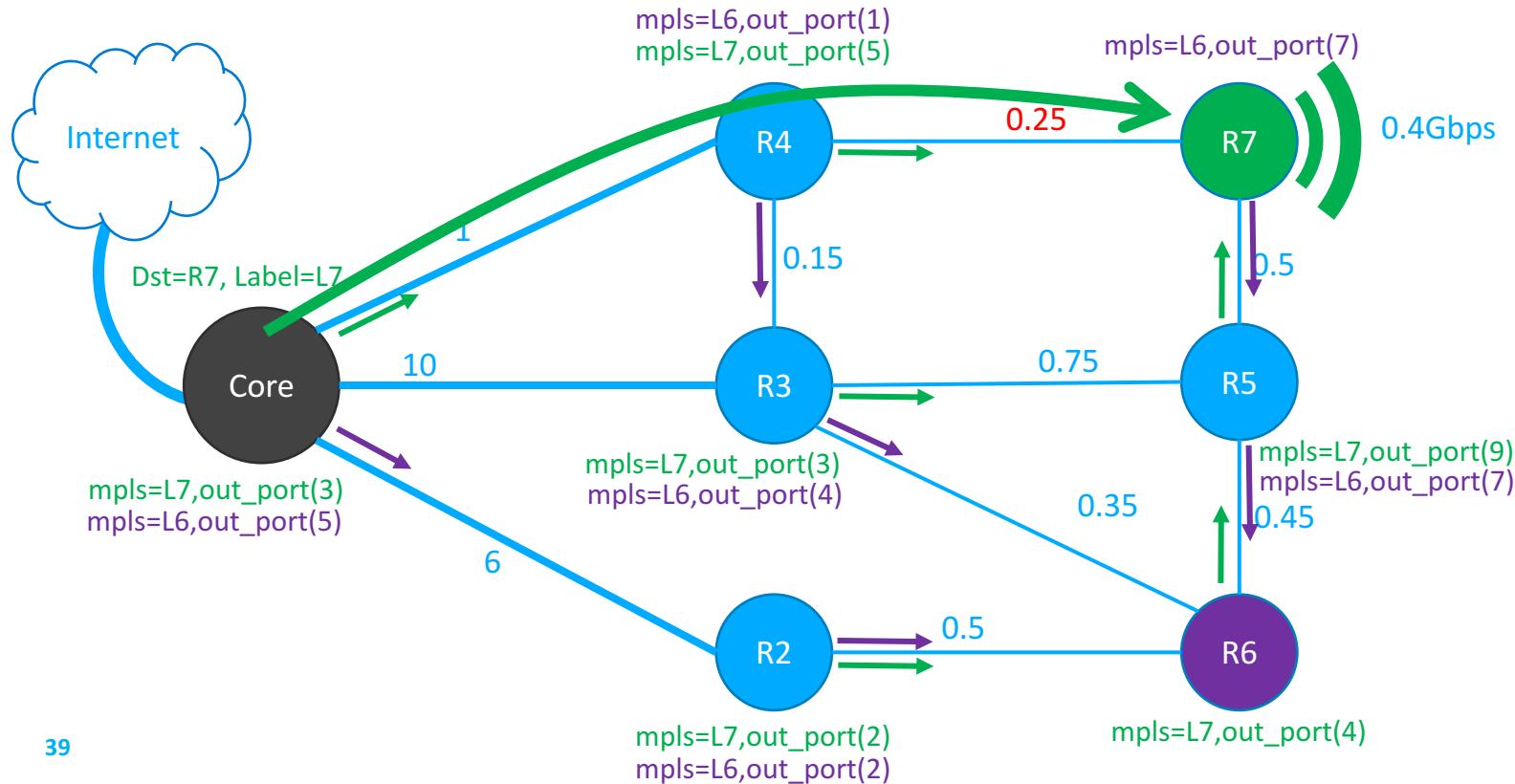
The BLU project

Phase3



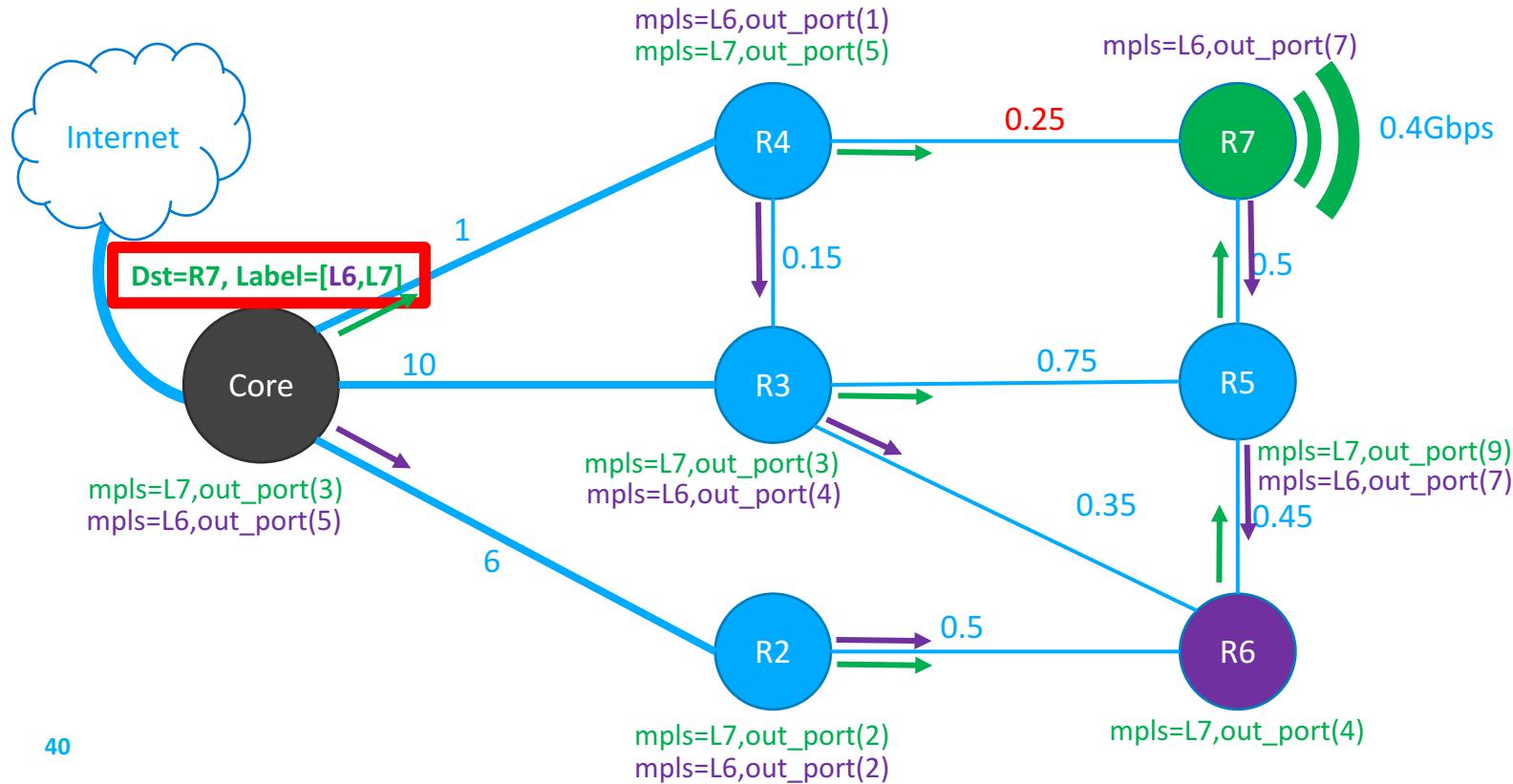
The BLU project

Phase3



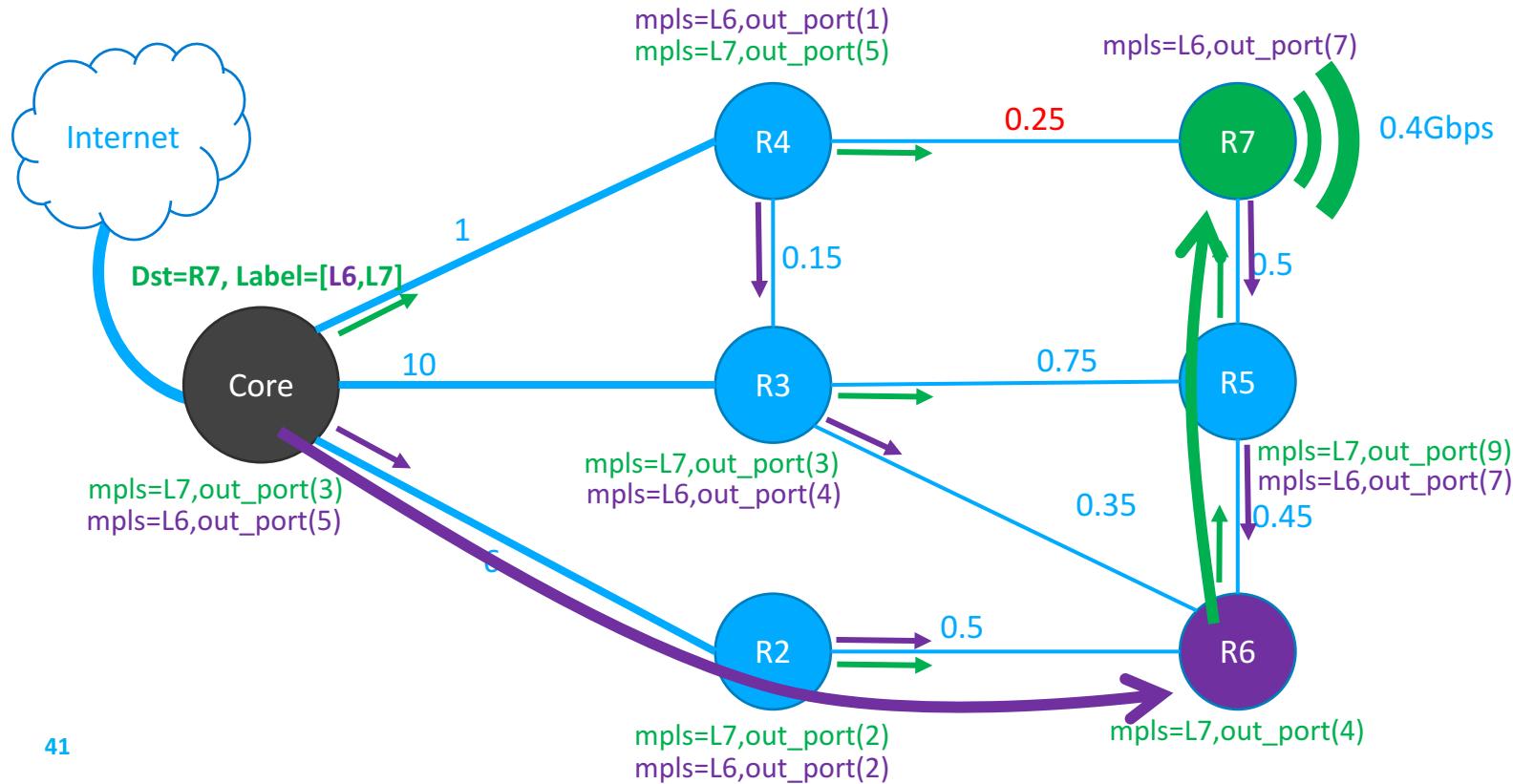
The BLU project

Phase3



The BLU project

Phase3



The BLU project

Phase3 - Pros



- No need to re-program the BLUs from BLUGW
 - They automatically learn how to forward MPLS labels based on IGP routes
- Optimizer:
 - Comes into play only in case of congestion
 - Many tools to tackle the optimization problem
 - Operations research, LP, SMT, etc. + a lot of heuristics
- We do have a “Big Red Button” now!
 - In case of troubles, turning off the optimizer reverts to shortest path forwarding

- New hardware ()
 - Motivation: need of more than 2x10G interfaces on important sites
 - Single  instead of many BLUs (power efficiency)
 - Intel based
 - BLUos compliant
- Latency-based optimizations for “delay-aware” traffic (e.g, voice, video streaming, etc.)
 - BLUs can measure latency for their BH links
 - Optimizer can take these values into consideration
- BLU2BLU (almost) for free!
 - src BLU tags traffic with the dst BLU's label
 - ...or stack of labels (depending on what the optimizer says)

Thank you!

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If you are interested in the BLU project,
do not hesitate to contact us!