FUTEBOL
Federated Union of Telecommunications Research Facilities for an EU-Brazil Open Laboratory

rMBOS: Reconfigurable Multiwavelength Bus with Optical Sharing

Moises R. N. Ribeiro and Flavio Rabello De Souza*

Federal University of Espirito Santo (Ufes)

**Telecomminications National Agency (ANATEL)*

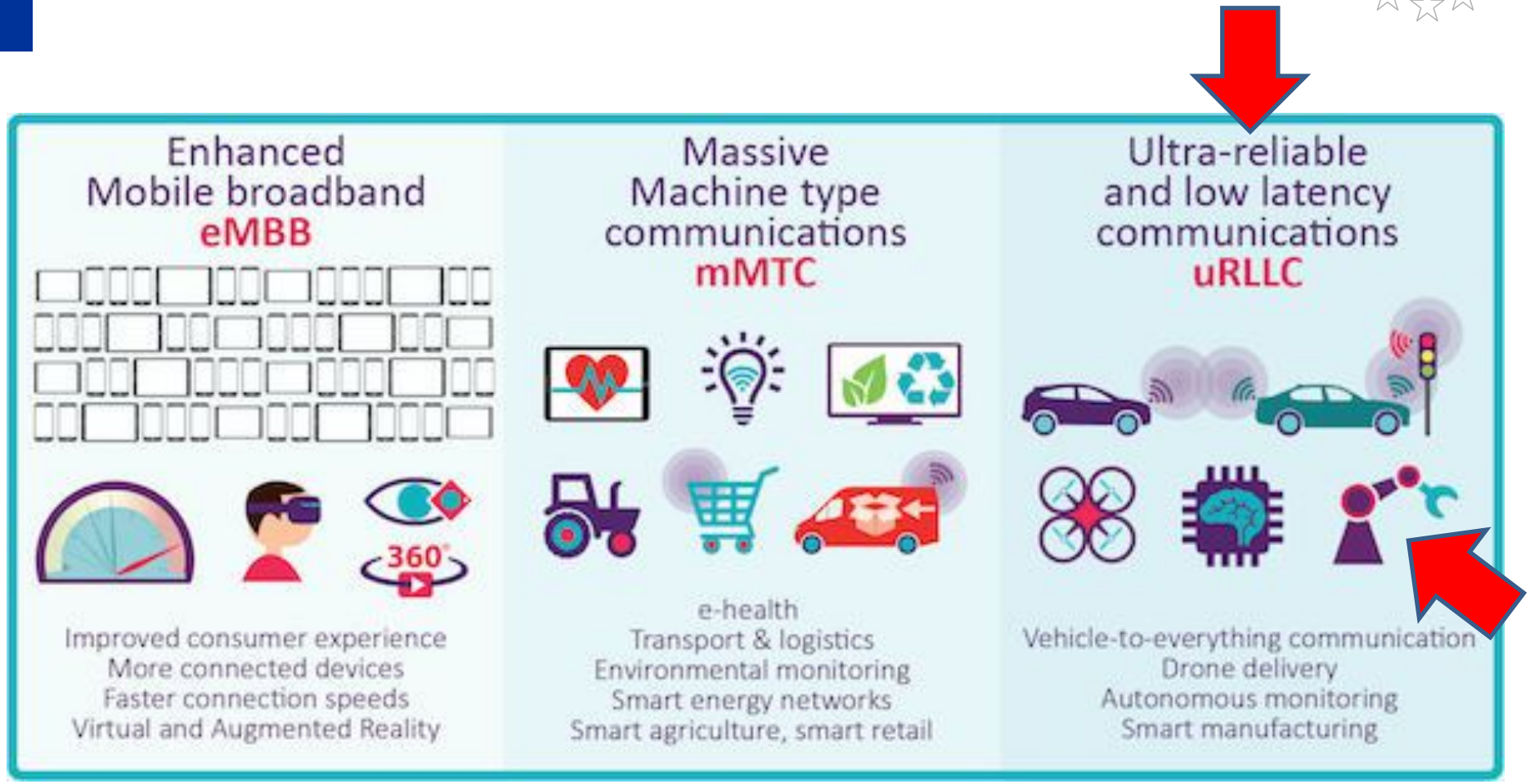
Brazil

21th International Conference on Optical Network Design and Modeling
May 15-18, 2017 Budapest, Hungary
Invited Presentation - RS7: Multicasting
Wednesday, May 17, 13:20 - 15:00

Roadmap

- Context & Motivation
- FUTEBOL Demos
- Looking Beyond 5G
- rMBOS Design Principles
- Preliminary Results
- Conclusion and Discussion

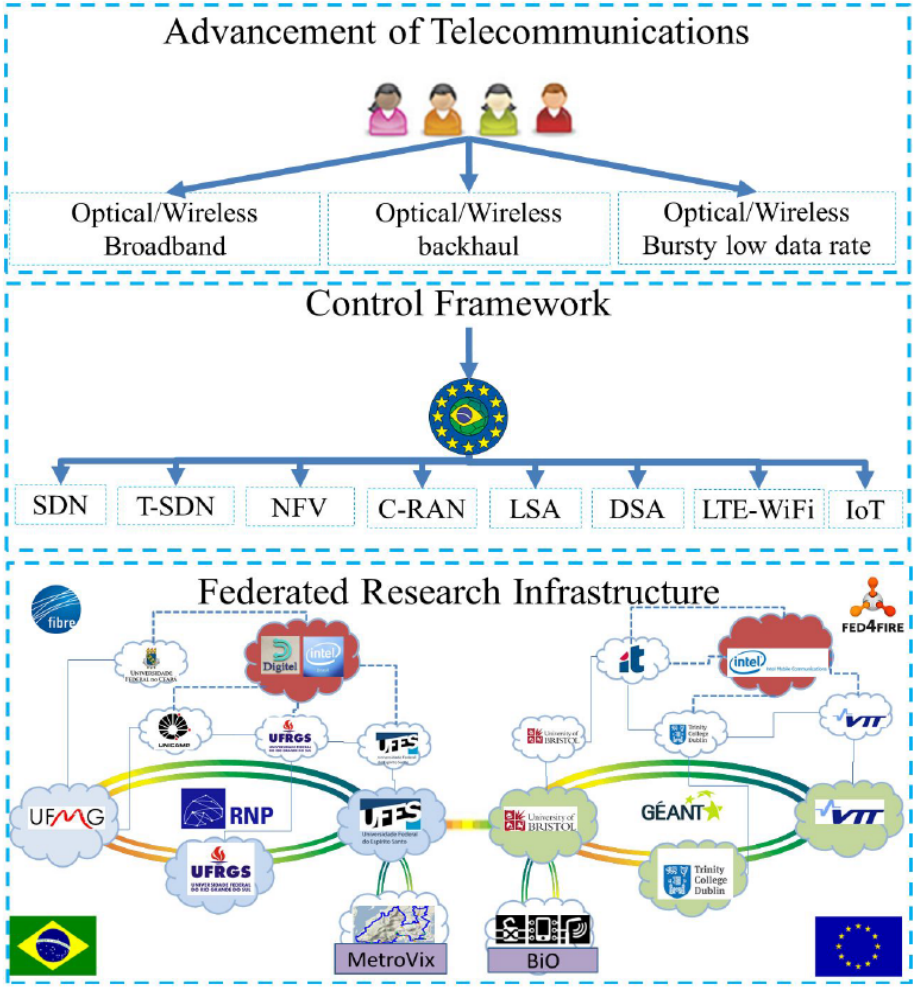
Context & Motivation: 5G Services



Source: https://fredcavazza.net/2017/02/28/enjeux-et-usages-de-la-5g/

Context & Motivation: Horizon 2020 EU-BRAZIL(FUTEBOL 2016/2019)

- A Research Question:
  - How to support cost effectively requirements for optical front/back haul supporting 5G?
    - uRLLC
    - mMTC
    - eMBB
    - IoT
    - ?



http://www.ict-futebol.org.br/

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Futebol Use Cases and Experiments

Use case 1: The impact of broadband wireless and Dynamic Spectrum Access on optical infrastructure

- Experiment 1: Licensed Shared Access for extended LTE capacity with E2E QoE

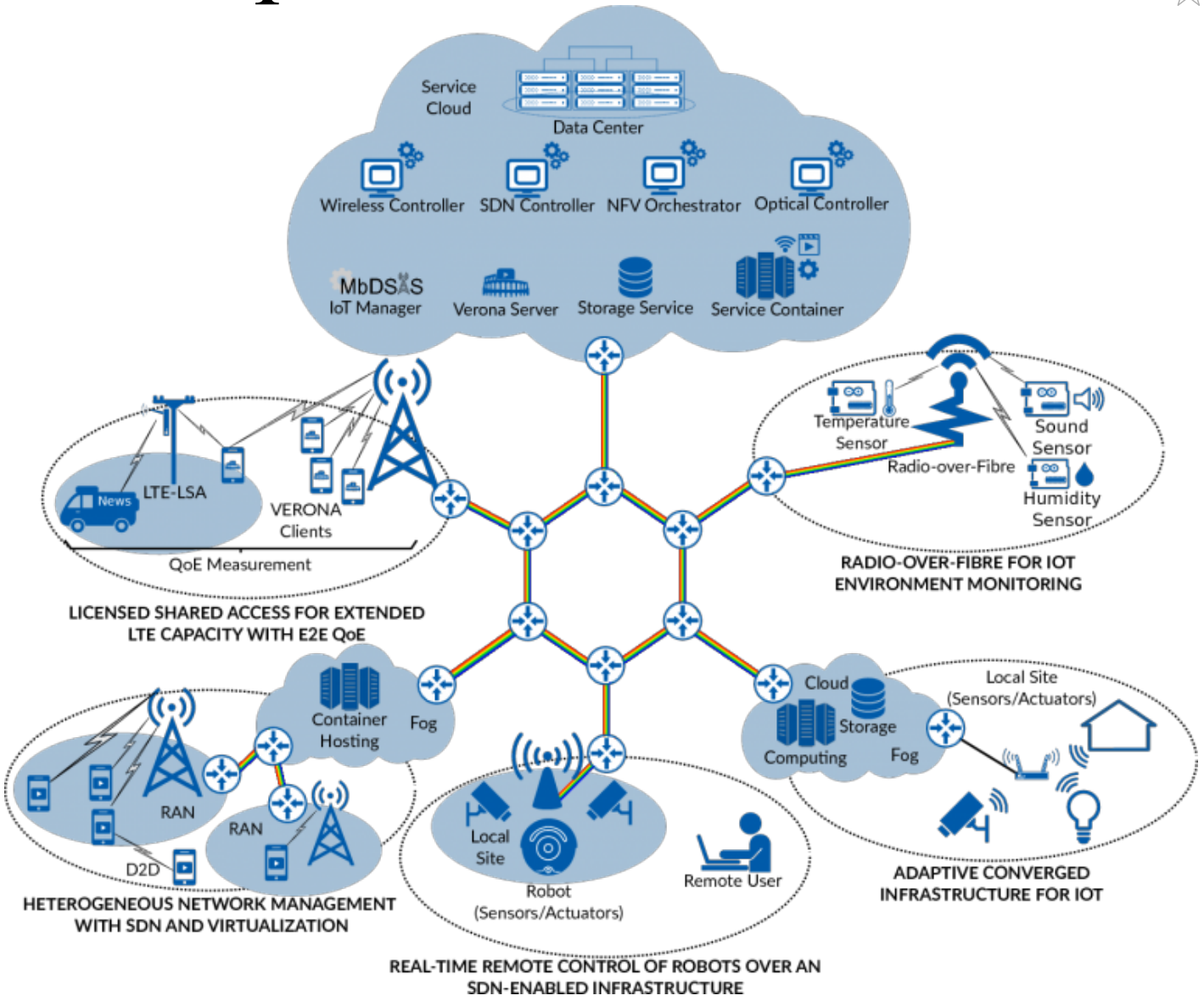
Use case 2: The design of optical backhaul for next-generation wireless

- Experiment 2.1: Heterogeneous network management with SDN and virtualization
- **Experiment 2.2: Real-time remote control of robots over an SDN infrastructure**

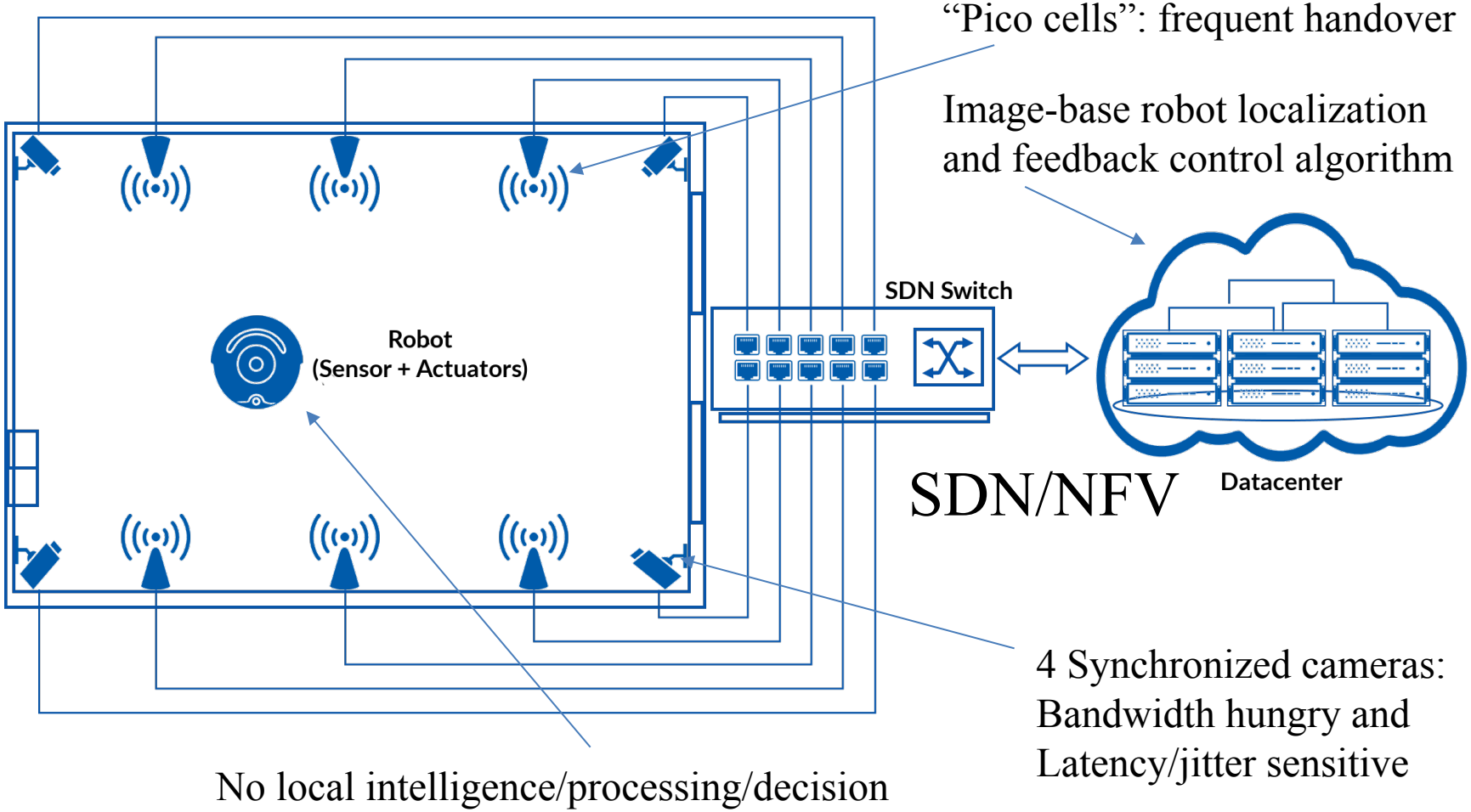
Use case 3: The interplay between bursty, low data rate wireless and optical network architectures

- Experiment 3.1: Adaptive converged infrastructure for IoT
- Experiment 3.2: Radio-over-Fibre for IoT environment monitoring

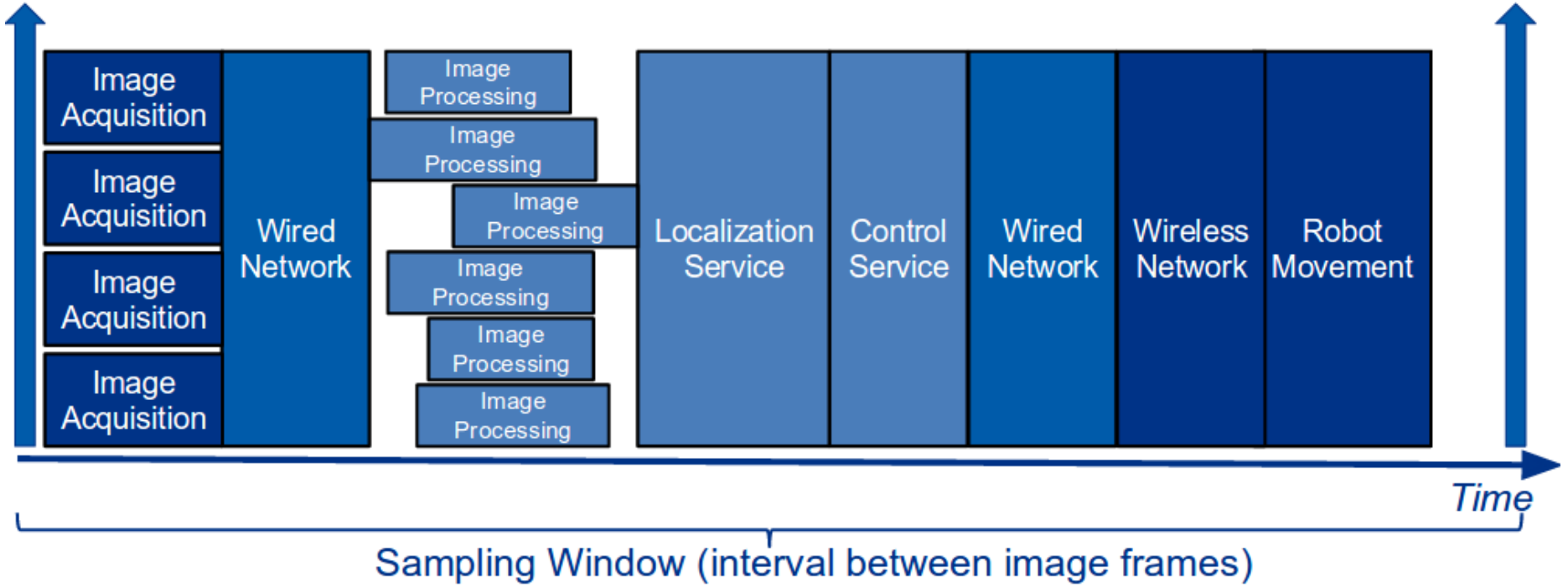
Futebol Experiments



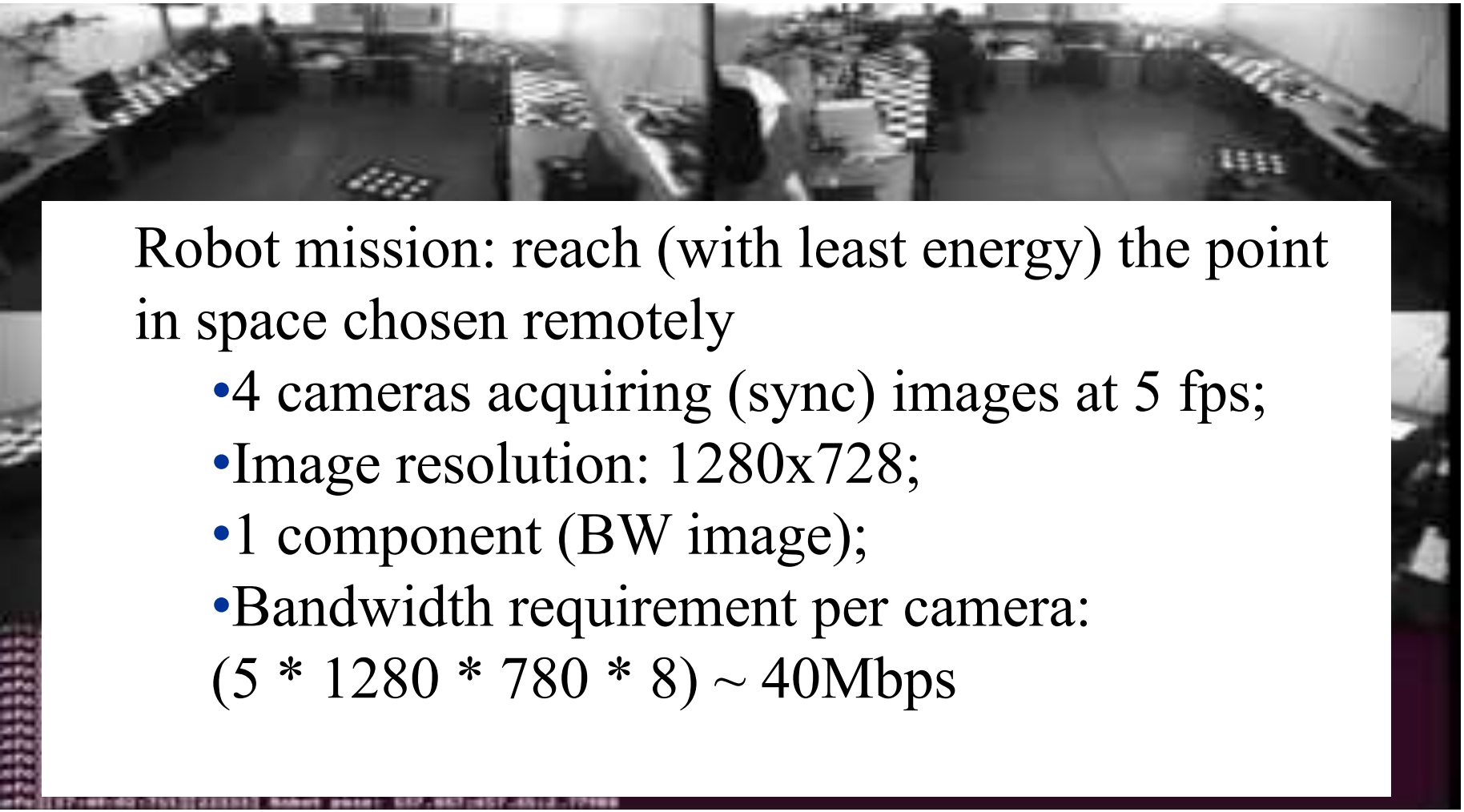
Futebol Challenge @ uRLLC: Intelligent Space & Cloud Robotics



The Deadline Challenge



Preliminary Result: Intelligent Space (no NFV, no SDN, no Handover)

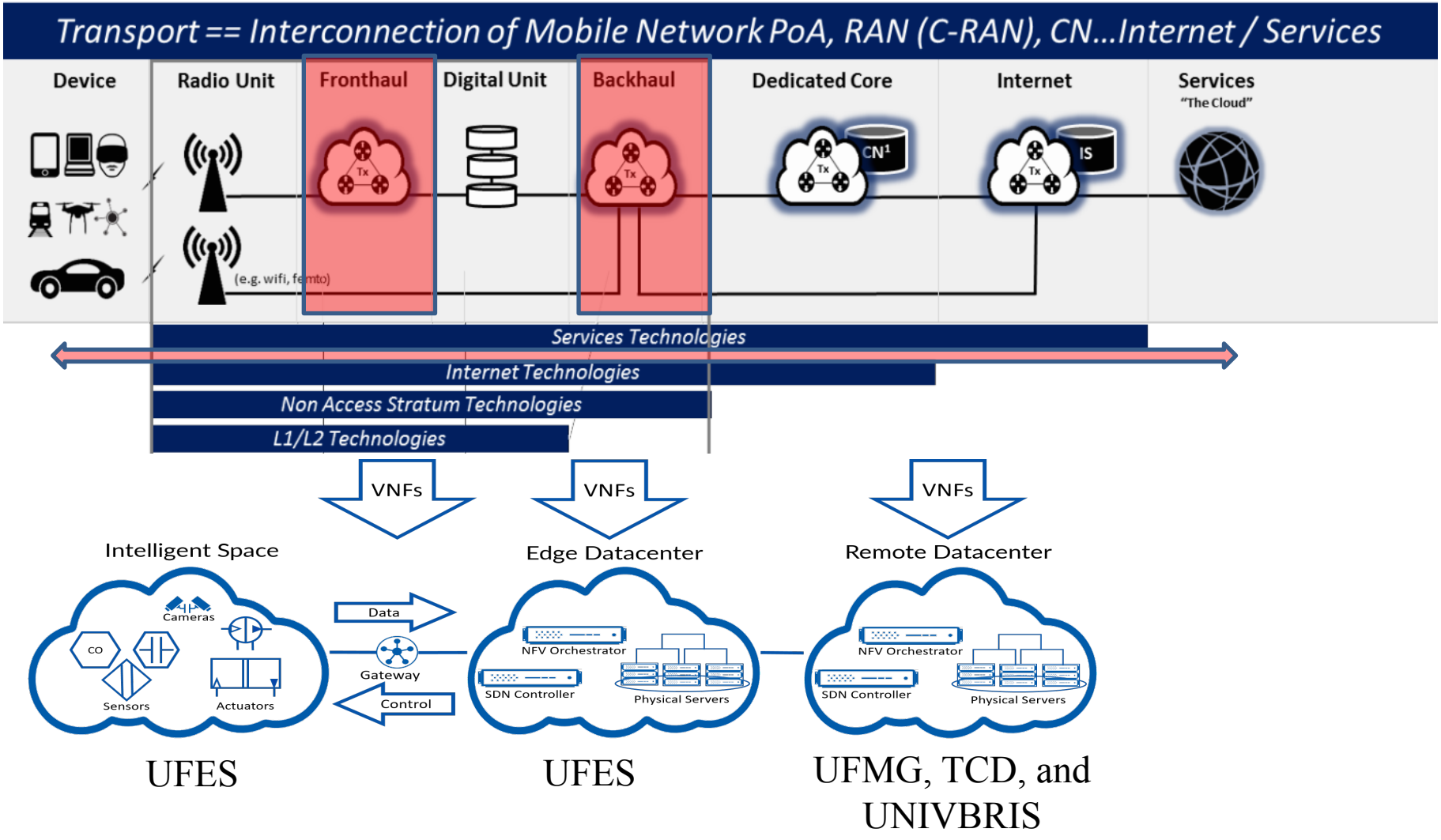


Robot mission: reach (with least energy) the point in space chosen remotely

- 4 cameras acquiring (sync) images at 5 fps;
- Image resolution: 1280x728;
- 1 component (BW image);
- Bandwidth requirement per camera:

(5 * 1280 * 780 * 8) ~ 40Mbps

Modern Wireless vs. Our Demo Infra



Source: adapted from Mourad, A., "Fronthaul and Backhaul for 5G and Beyond" COST IRACON, Durham, October 2016

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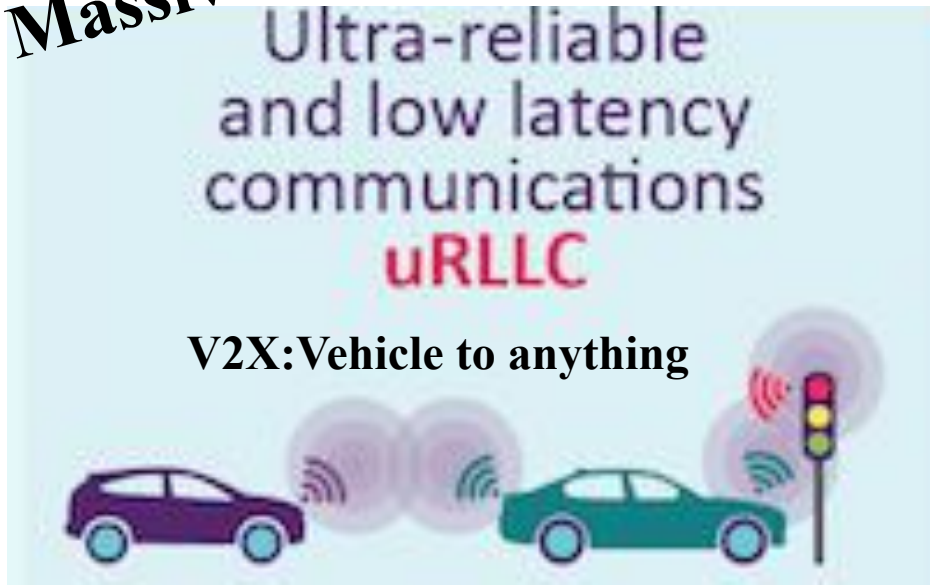
Looking Beyond: 5G(+)

Broadband Mobile
Massive-type machine



Cyber-physical systems

Source: adapted from https://fredcavazza.net/2017/02/28/enjeux-et-usages-de-la-5g/

Challenges for the Fronthaul

Mapping the 5G(+) KPIs on the Fronthaul

Capacity Data rate	Ways to reduce required fronthaul capacity, apply compression or consider new functional splits
Latency	Need fast and resilient (time sensitive) fronthaul networking, an intelligent use of the edge
Cost	Lower dependency on fiber and proprietary CPRI, use Ethernet-based where suitable, use standardized OAM
Flexibility	Make it softwarized, bring SDN, support centralized and distributed DUs (Digital Units/Clouds)
Efficiency	Move from dedicated CBR CPRI links to more shareable fronthaul networking (statistical mux)

Source: Mourad, A., "Fronthaul and Backhaul for 5G and Beyond" COST IRACON, Durham, October 2016

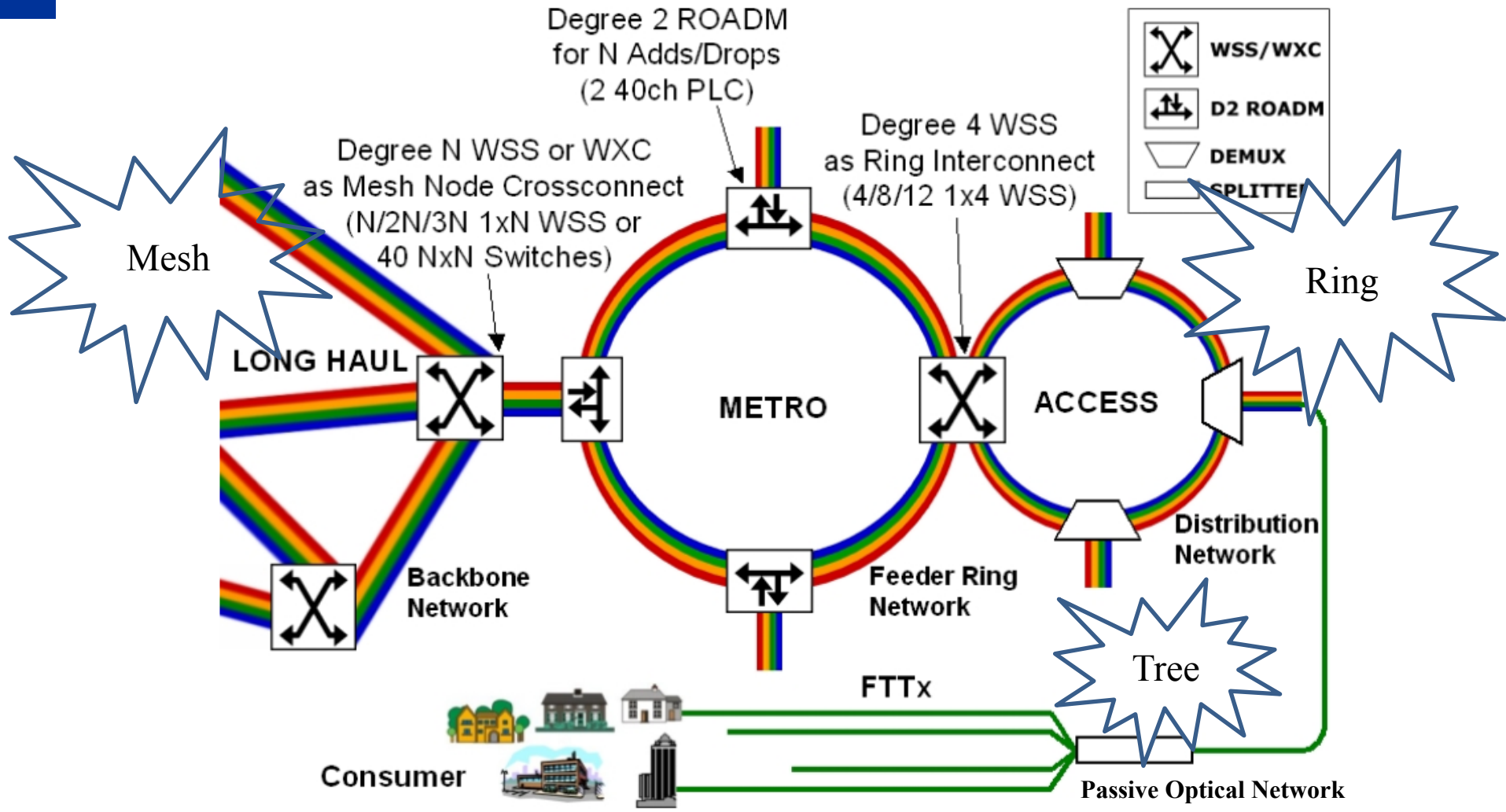
Challenges for the Backhaul

Mapping the 5G(+) KPIs on the Backhaul

Capacity Data rate	Need bigger pipes (Gbps optical and wireless) and ways to offload traffic to the edge where possible
Latency	Need fast and resilient forwarding, intelligent leveraging of edge infrastructure
Cost	Use less fibers, away from specialized switching HW (embrace NFV), unify the management, use standardized OAM
Flexibility	Make it softwarized, bring SDN, make it virtualized, bring NFV, embrace the cloud
Efficiency	Enable access-aware resource optimization, switch on/off cells, support cooperative schemes

Source: Mourad, A., "Fronthaul and Backhaul for 5G and Beyond" COST IRACON, Durham, October 2016

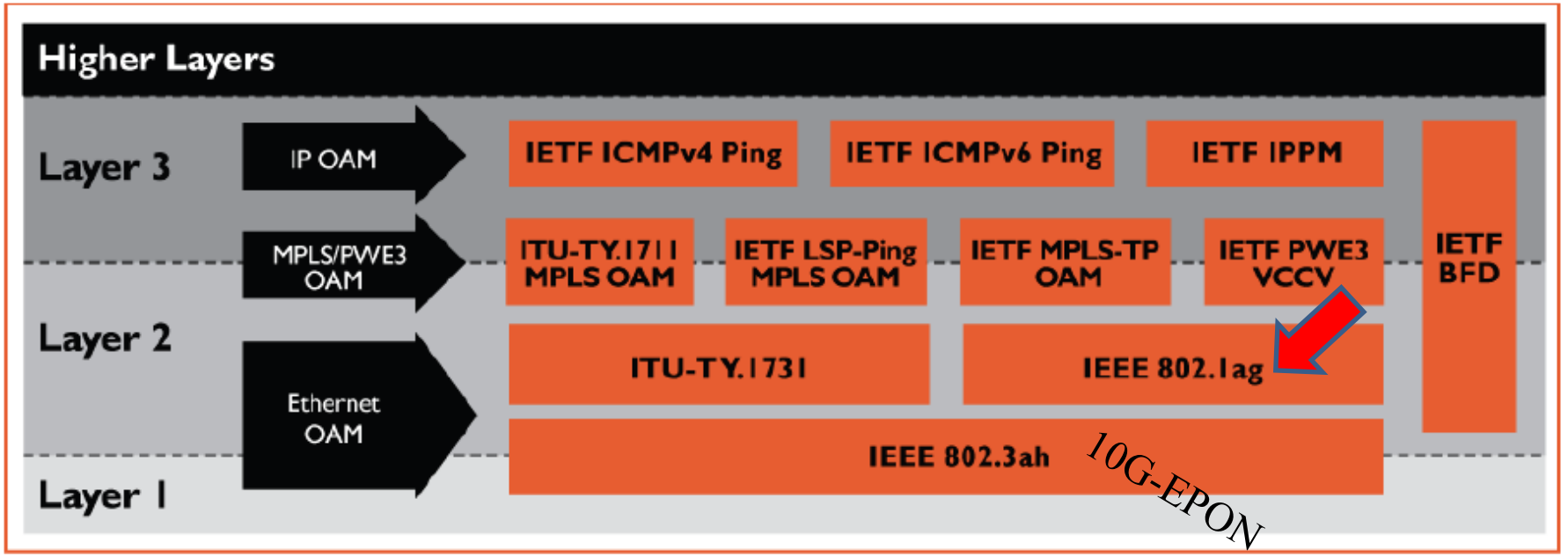
Optical Network Topologies in back/fronthaul



Source: adapted from Eldada L., "ROADM architectures and technologies for agile optical networks", Proc. SPIE 6476, Optoelectronic Integrated Circuits IX, 647605 (February 14, 2007)

What is OAM about?

"Operations, Administration, and Maintenance, referring to detection and diagnosis of link failures in a communication network"



Source: adapted from Mizrahi, T., and Yerushalmi, I., "The OAM Jigsaw Puzzle" (MARVEL White Paper)

OAM Functionalities

- **Keepalive** for detecting connection failures.

  Once detected, the defect can be reported to a network management system. When protection switching mechanisms are deployed, once a fault is detected, the system can automatically switch to an alternate path.

  Keepalive mechanisms can be divided into two categories:

  - **Periodic messages** that are sent proactively at a constant transmission rate; sometimes referred to as continuity checks.
  - **On-demand messages** that are sent to verify a specific connection; sometimes referred to as connectivity verification mechanisms.

- **Performance measurement mechanisms**:

  Packet loss measurement: Provides a mechanism that computes the packet loss rate between two nodes.

  Delay measurement: Measures the packet delay and the delay variation between two nodes.

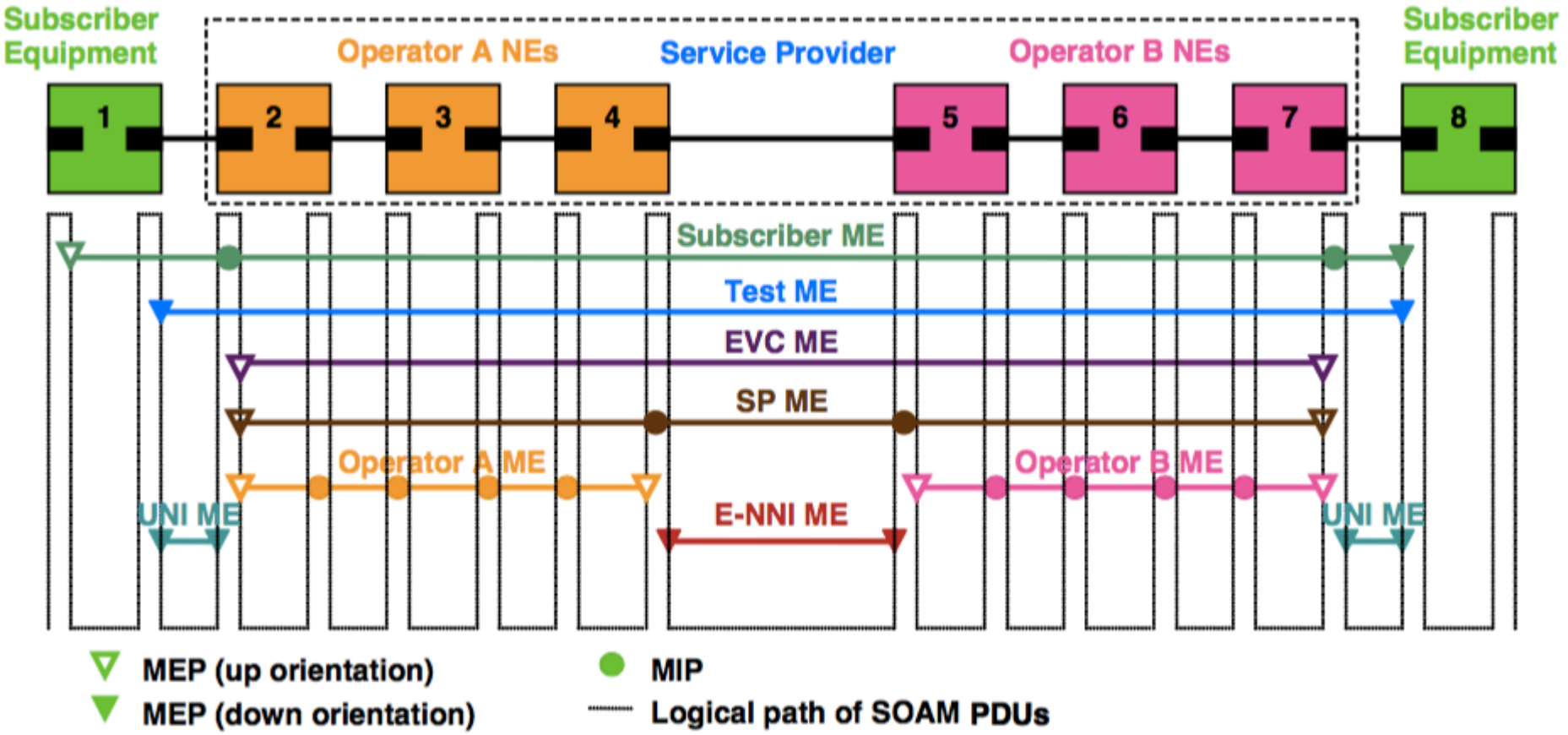
  Throughput measurement: Measures the traffic throughput between two nodes.

- **Path discovery and fault localization**.

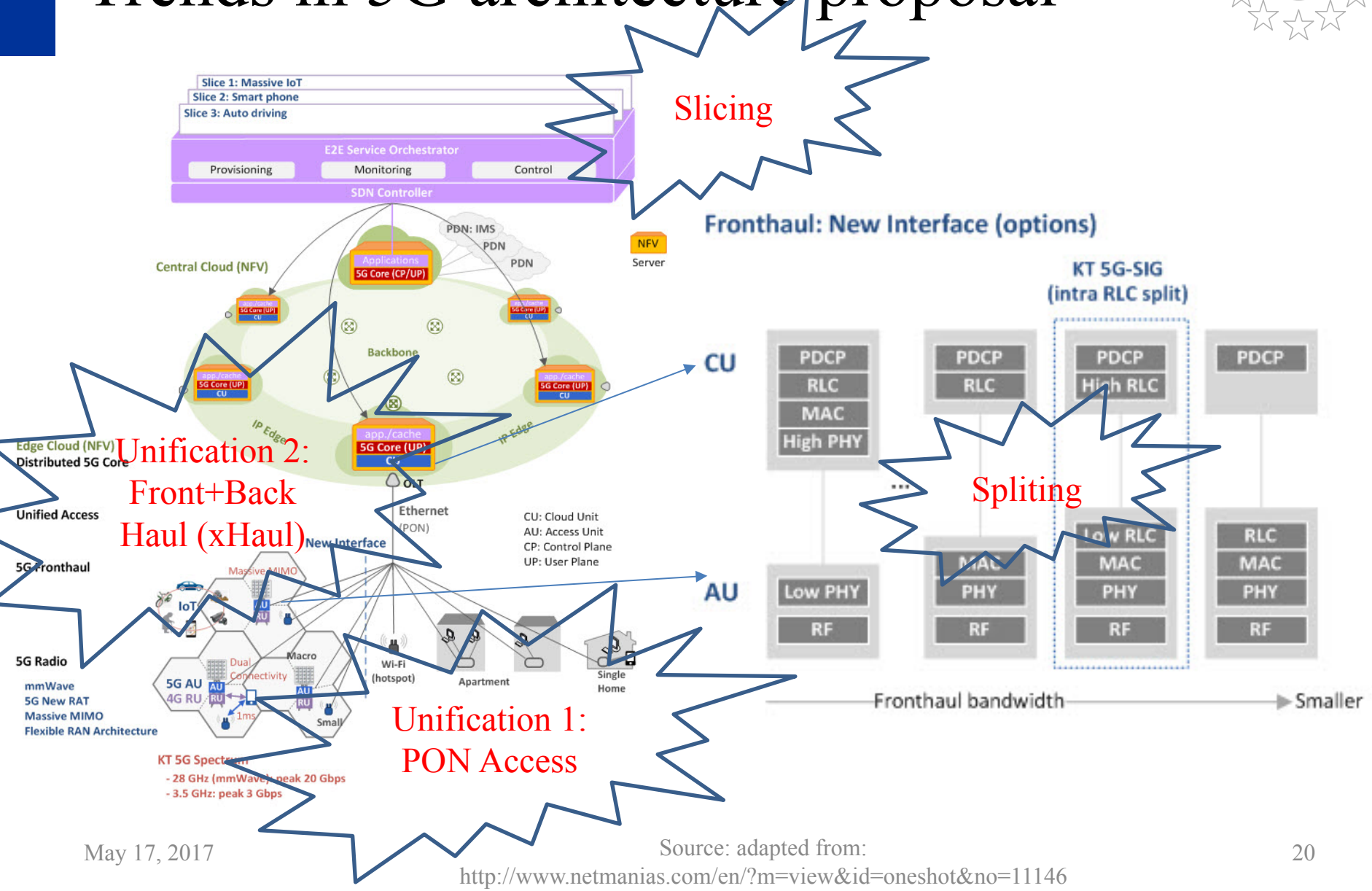
  These mechanisms allow a node to learn the topology of the network, and to localize link failures.

Source: adapted from Mizrahi, T., and Yerushalmi, I., "The OAM Jigsaw Puzzle" (MARVEL White Paper)

OAM Hierarchy



Trends in 5G architecture proposal

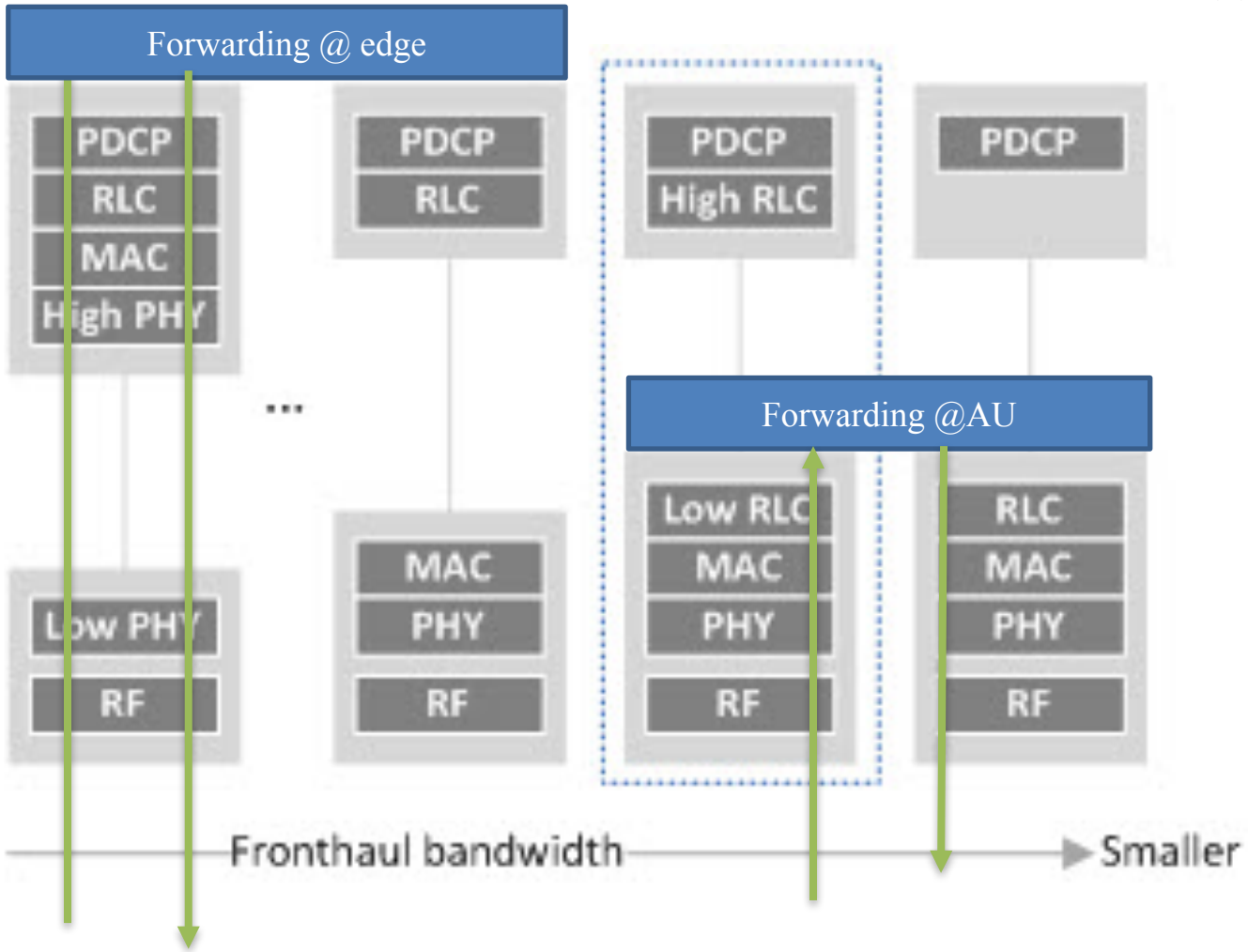


Source: adapted from:
http://www.netmanias.com/en/?m=view&id=oneshot&no=11146

Game Changer: Inter AU traffic

KPI: "Offload traffic to the edge"

Fronthaull: Tree-based PON (not survivable!)

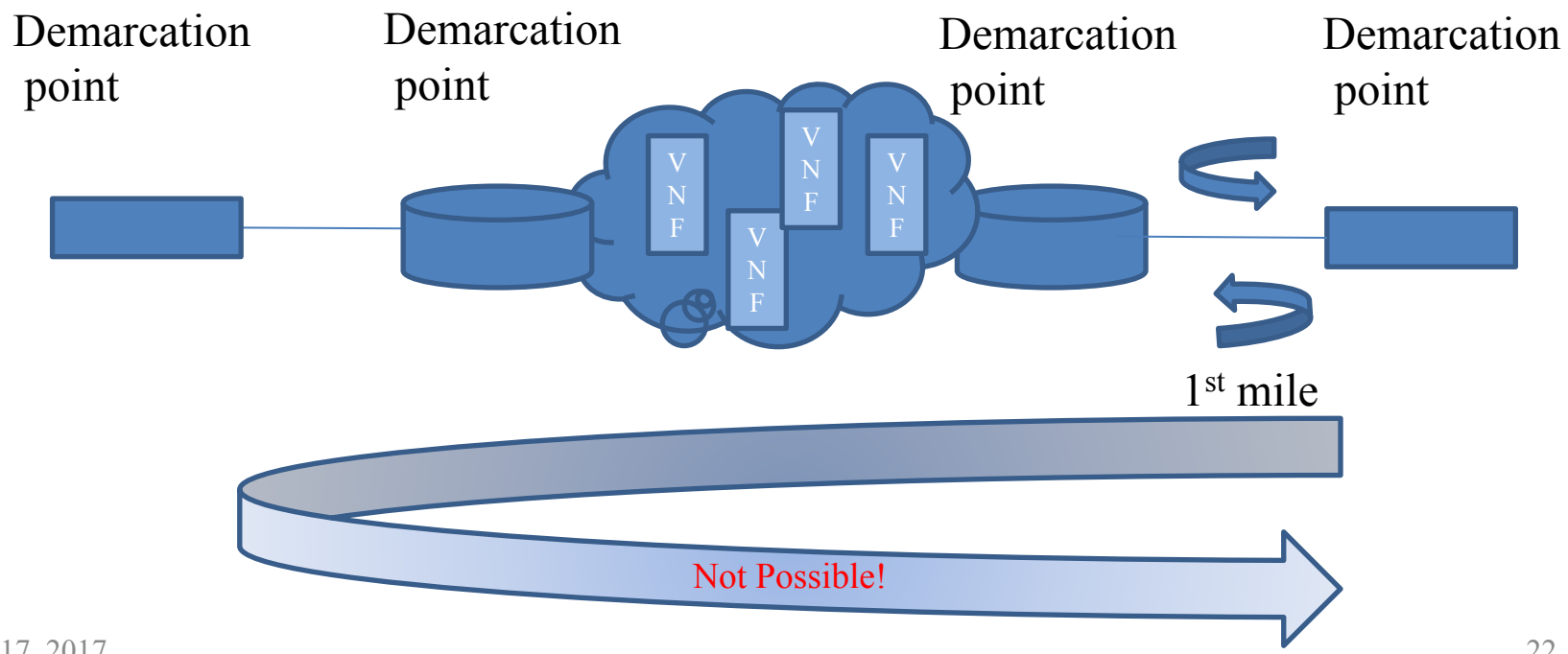


KPI: "Fast and Resilient (?) fronthaul networking"

Source: adapted from: http://www.netmanias.com/en/?m=view&id=oneshot&no=11146

Game Changer: E2E QoE/QoS over Slices

In virtualized networks, it is impossible to associate cause and effect using link-oriented view from 802.11ah solution



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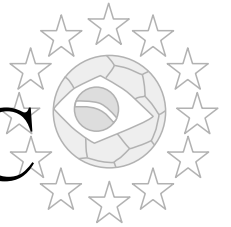
rMBOS design principles for uRLLC

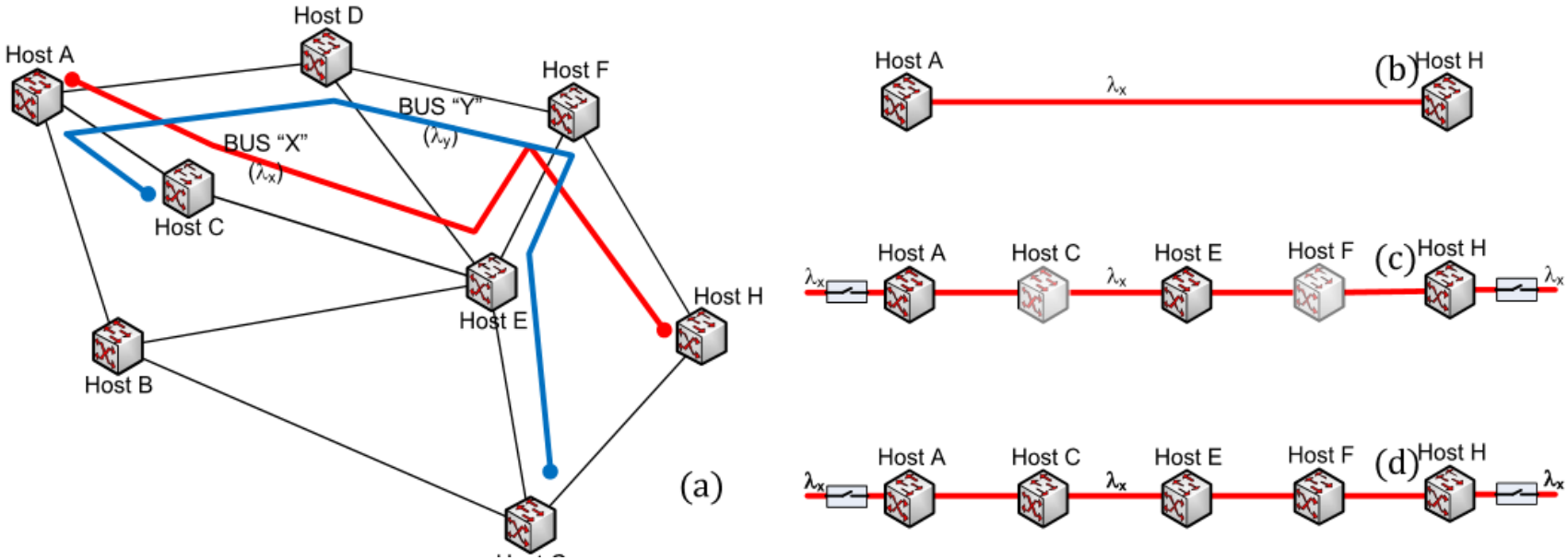


- Slicing QoS/QoE and OAM
  - 802.1ag @connectivity and ITU-T Y1731 @service monitoring
- Splitting
  - Bring forwarding to AU for V2X and related
  - Minimize Latency and up/down (front haul) traffic
- Unification and Reliability
  - Fully Ethernet-based
  - complexity reduction: OAM+MAC @ AU
  - Xhaul over Ring (survivability) or Mesh (resiliency)

rMBOS Implementation Principles

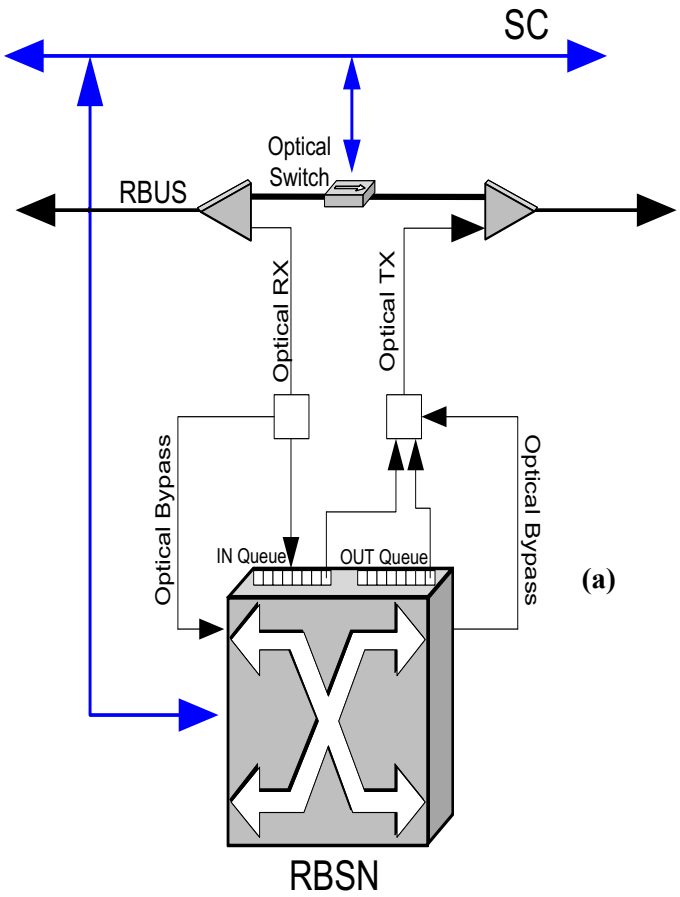
- Lowest possible cost
  - Share fibers and lighpaths (broadcast&select)
  - Provide some limited reconfiguration capability
- Hybrid Control Plane
  - Centralized SDN should not be agile enough
  - Reconfiguration, latency reduction without compromissing reliability
- MAC (shared lightpath) pigbacking CCM
  - Continuity check Messages can be used as “gate frames”
  - Use as much as possible 802.1ag/ITU-T Y1731 extension options

Optical Sharing using Wavelength Blocker-like OADM

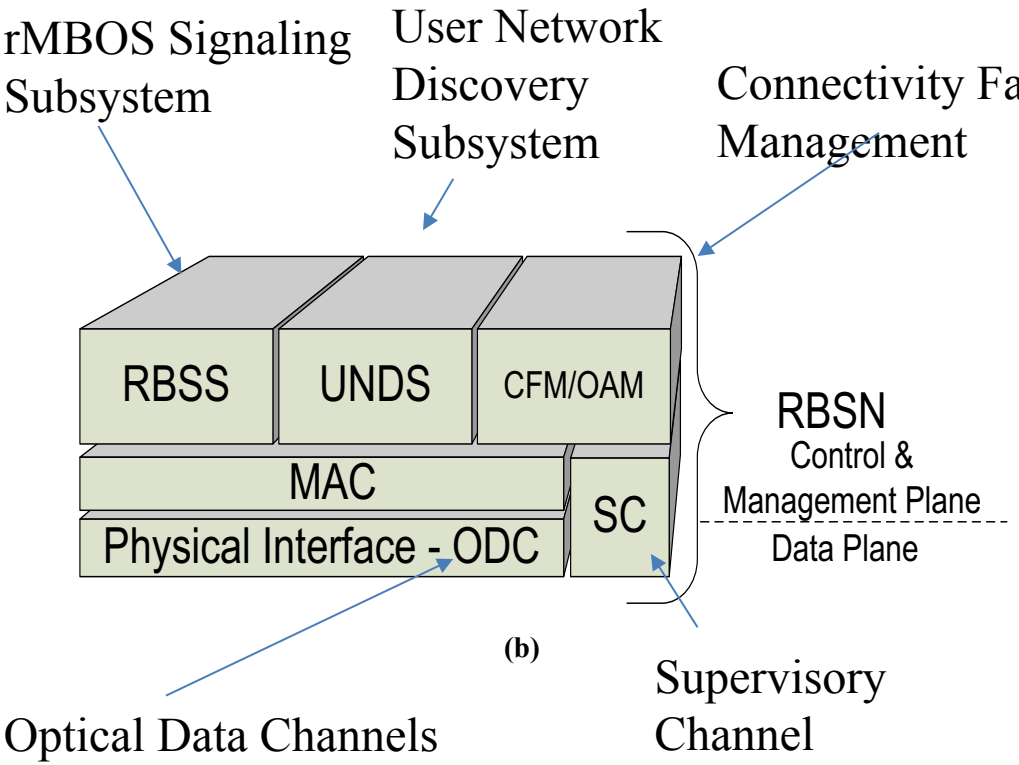


Challenge: Power budget due to power splitters

Elements of a rMBOS Switching Node



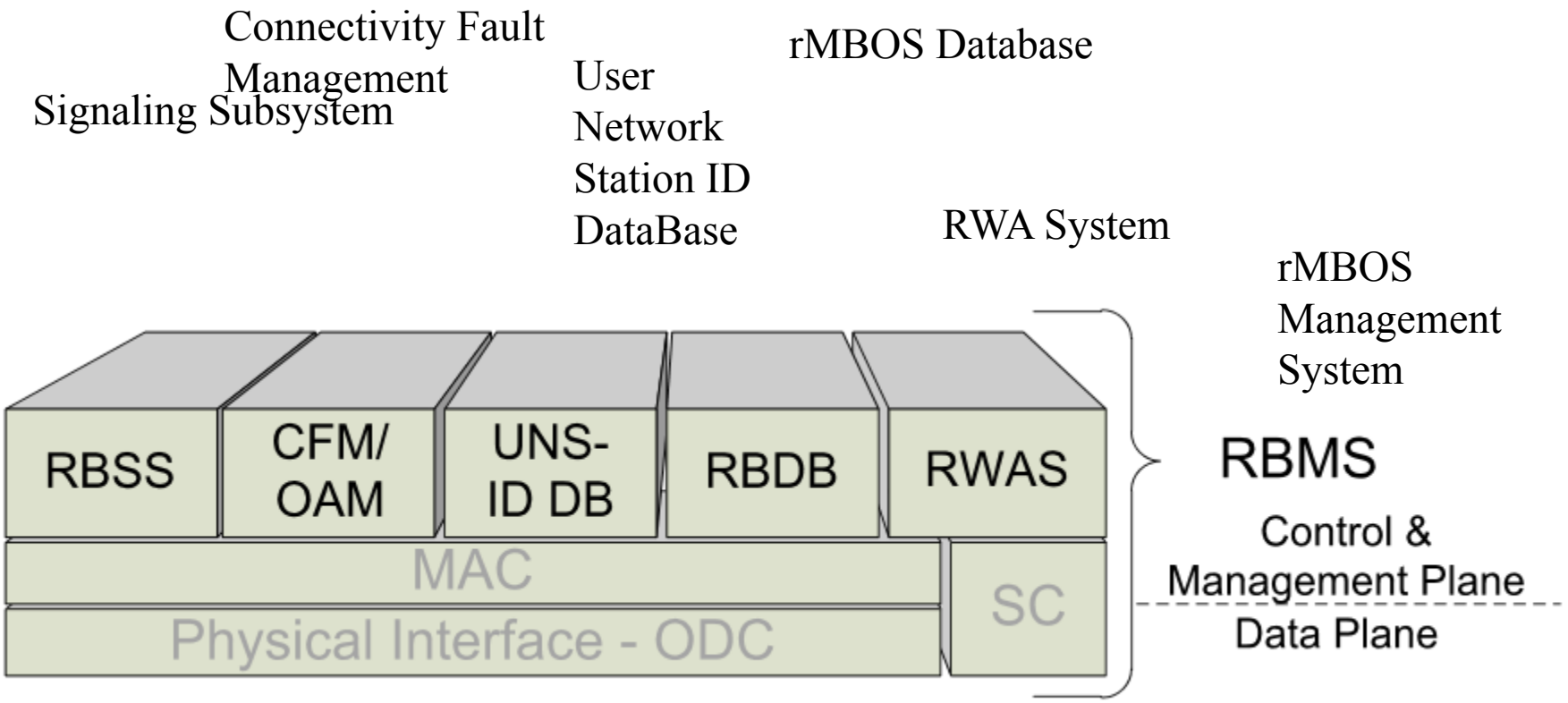
(a)



(b)

RBSN: rMBOS Switch Node

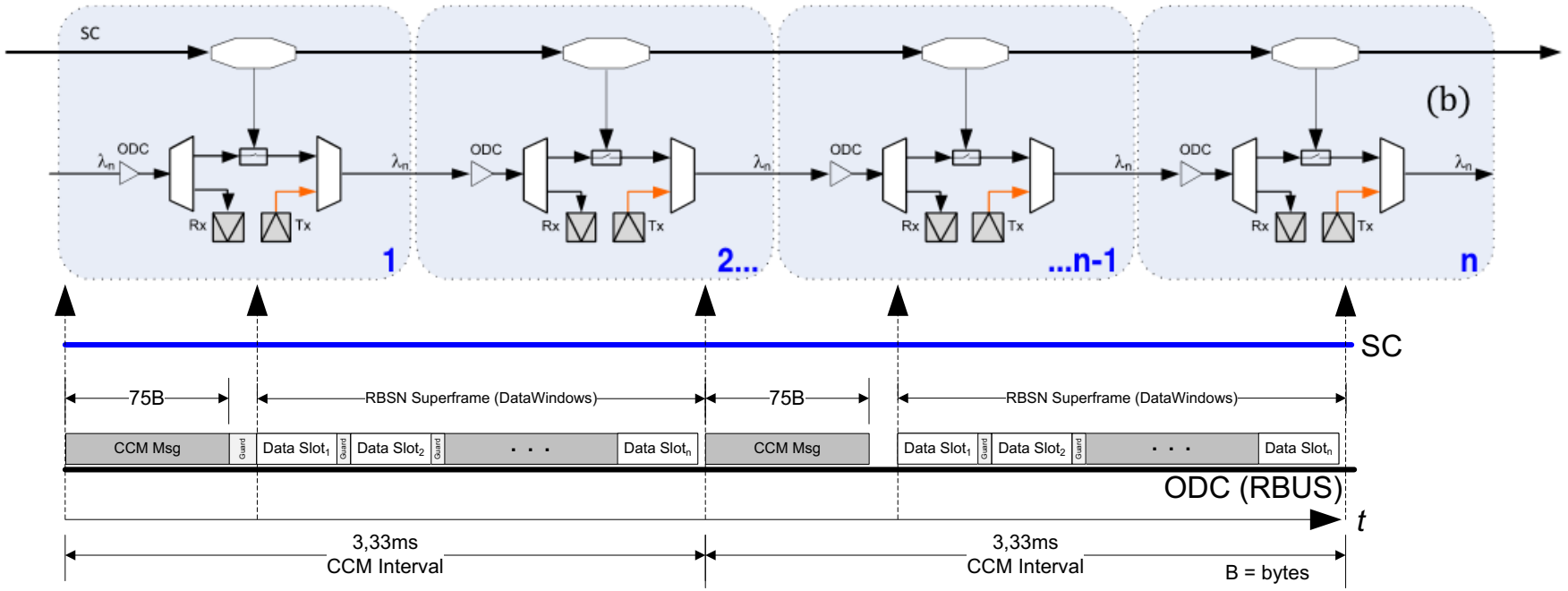
rMBOS Management System



rMBOS architecture OpCodes

OpCode	Code	Description
RBREQ	01	Connectivity request
RBSET	02	RBSN's configuration message.
RBFIN	03	Connectivity finalization request.
RBACK	04	Positive confirmation message.
RBDNY	05	Negative confirmation message.
RBDBM	06	Message used for RBDB related operations.
Reserved	07-254	Reserved for future implementations.

Continuity Check Messages (CCM) and MAC operation



	1								2								3								4							
	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
1	MEL								Version (0)								OpCode (CCM=1)								Flags								TLV Offset (70)							
5	Sequence Number (0)																															
9	MEP ID																															
13	MEG ID (48 bytes)																															
17																																
...																																
49																																
53																																
57																	TxFCf															
61	TxFCf																RxFCb															
65	RxFCb																TxFCb															
69	TxFCb																RBSN-Index$_i$								Superframe Timeslot$_i$							
73	RBSN-Index$_j$								Superframe Timeslot$_j$								End TLV (0)															

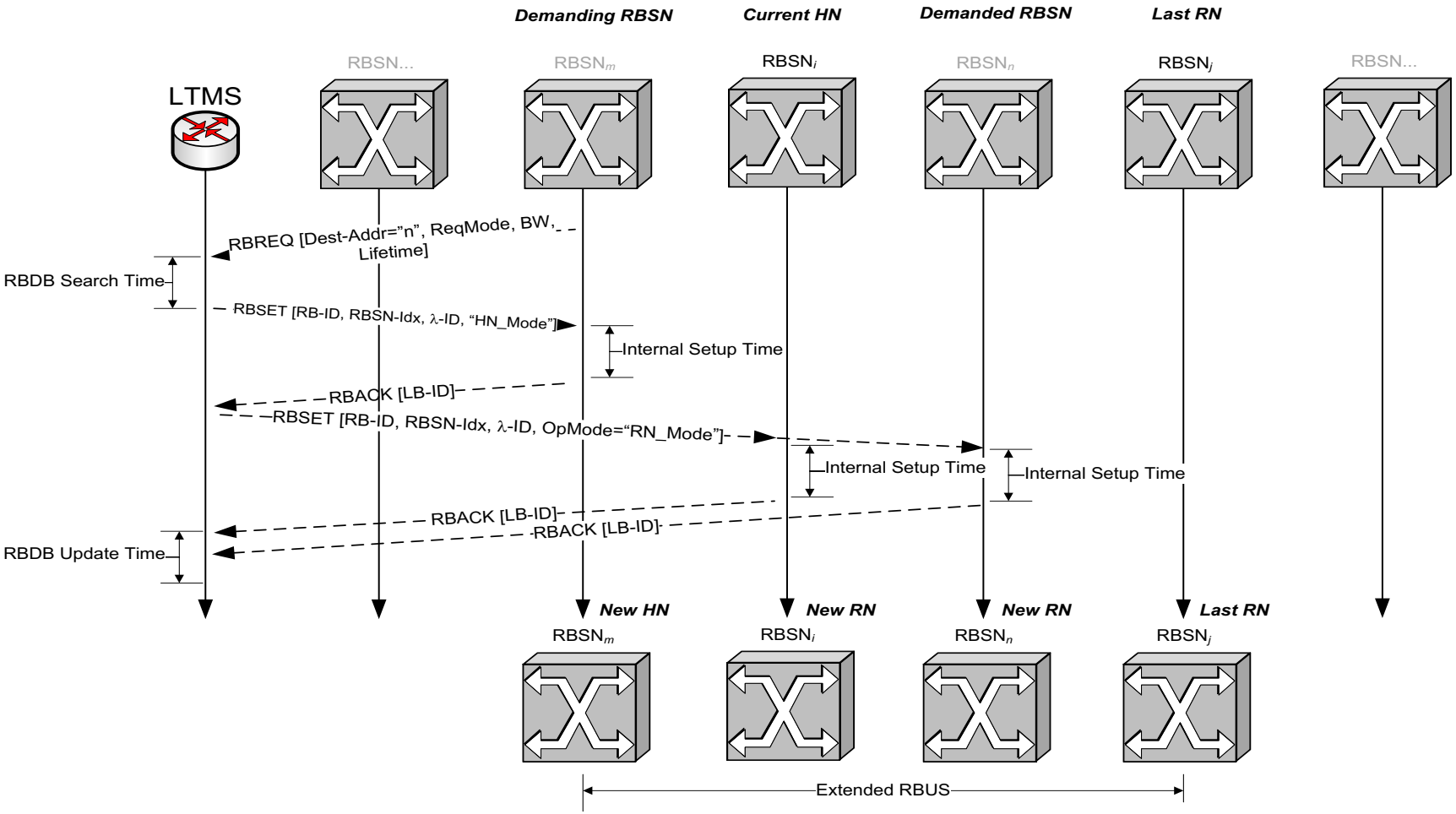
Flags

8	7	6	5	4	3	2	1
RDI	Reserved (0)				CCM Interval		

OpMode Field

OpMode	Value	Description
CN_Mode	01	Informs the RBSN that it will operate as Head Node
RN_Mode	02	Informs the RBSN that it will operate as Regular Node
Disconnect	03	Informs the RBSN that it should disconnect from the RBUS.
Reserved	04 to 07	Reserved values for future extensions.

Connection request between RBSNm and RBSNn serviced by preexistent rBUS

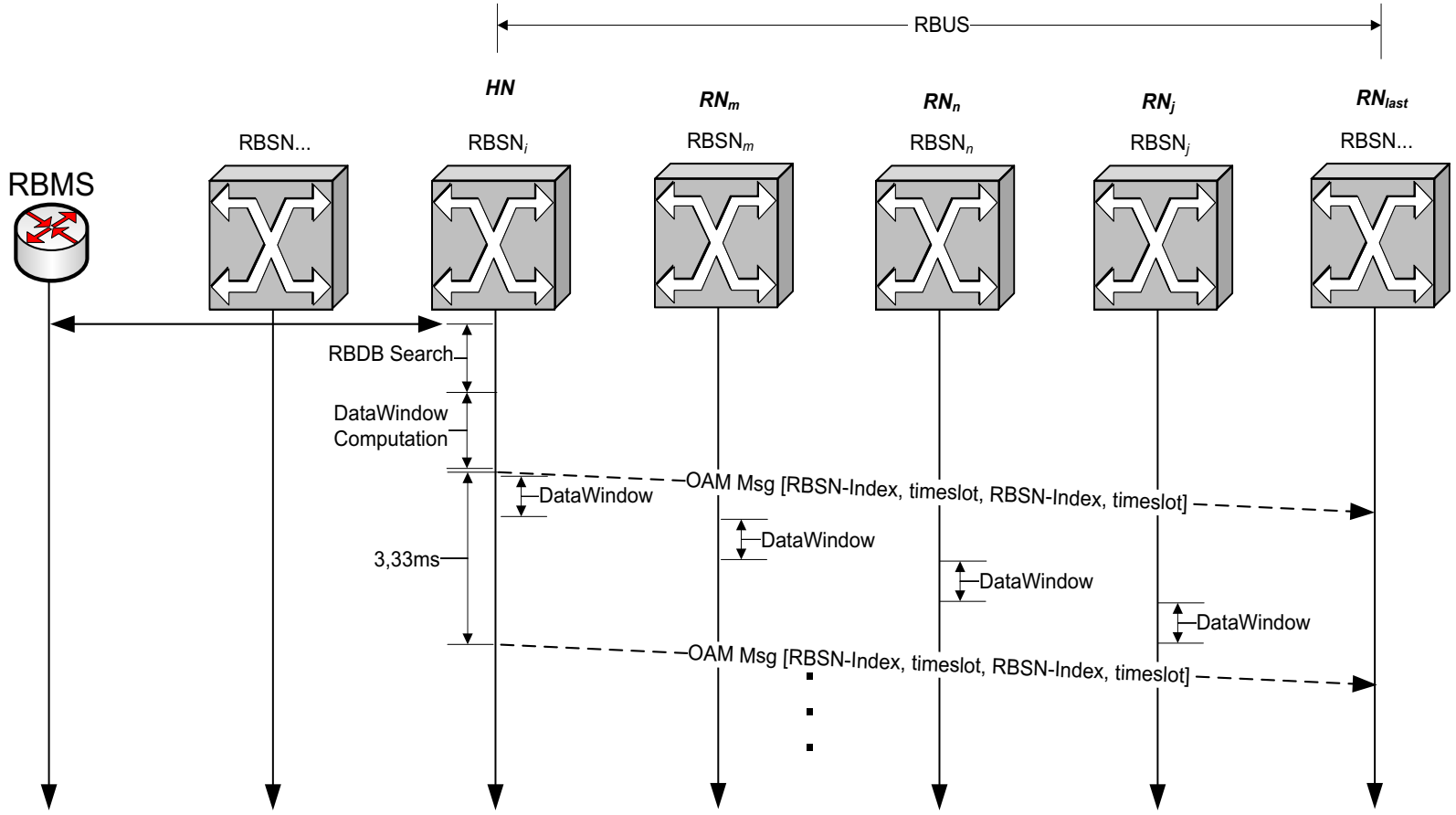


ReqMode Field

ReqMode	Value
Auto	000
CN_Mode	001
P2P_Mode	010
Protection_Mode	011
Reserved	100 à 111

Name	Value	Description
BW	De 00000 à 11111	Representing increments of 3%, ranging from 0 to 96%.

intra-RBUS communication process



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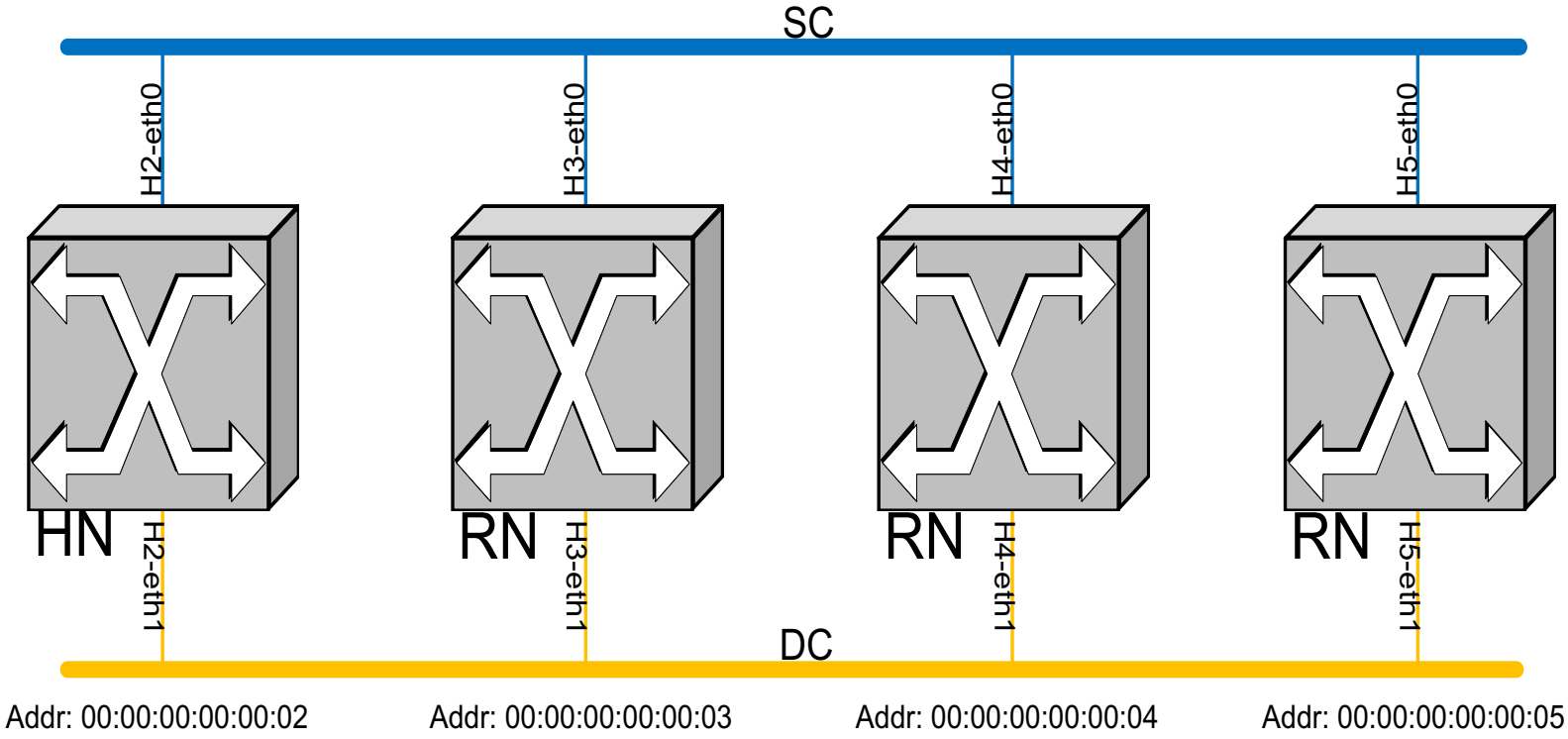
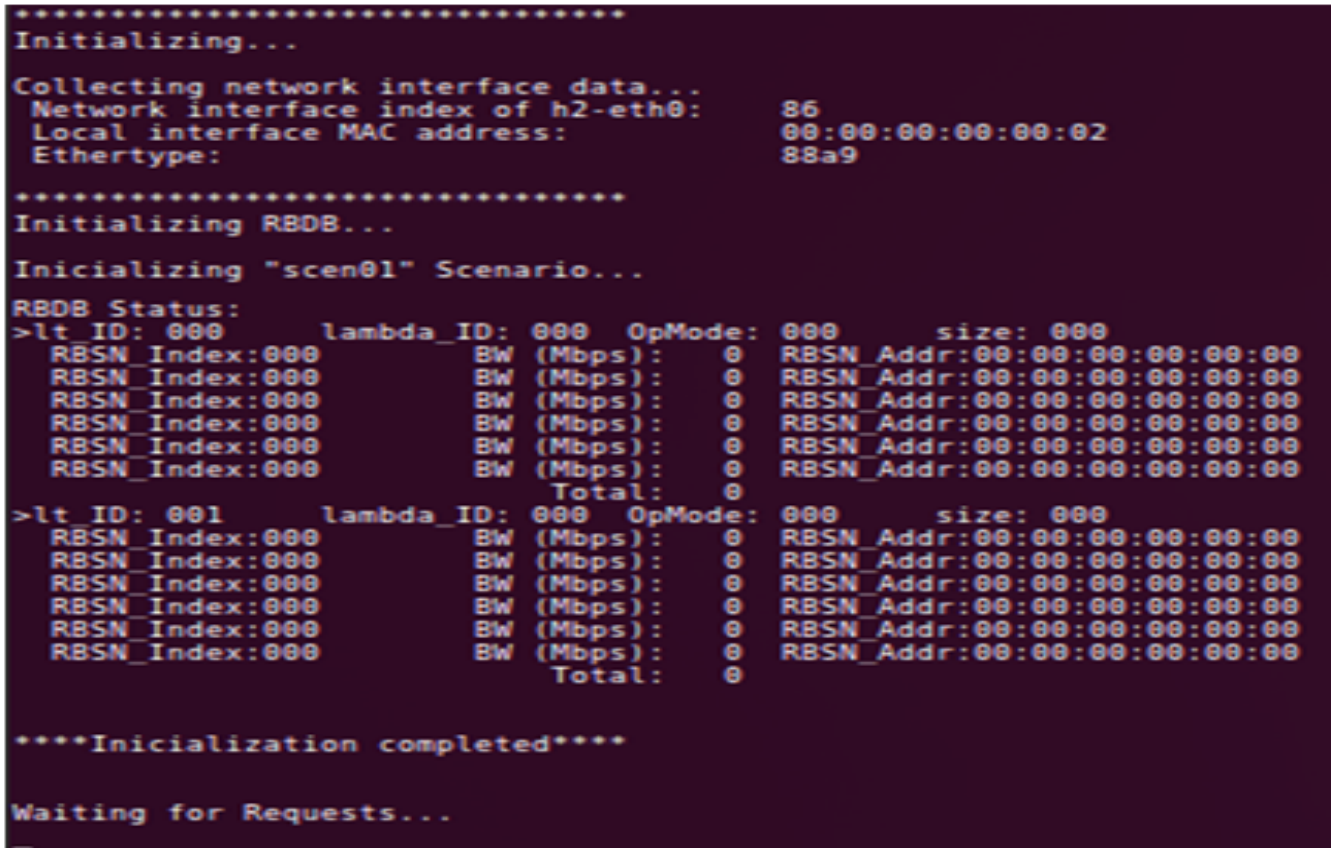
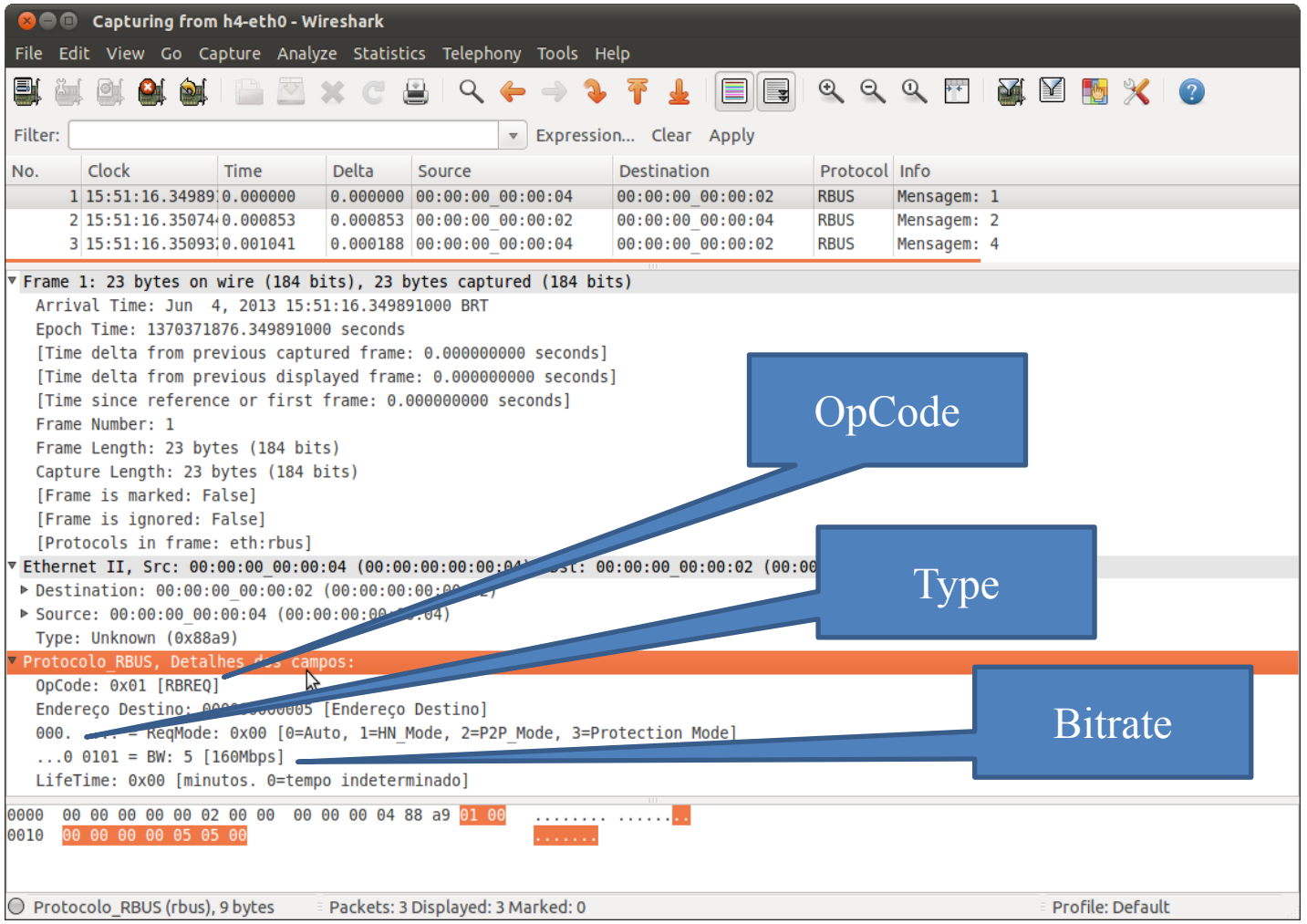
rMBOS Emulation Logical Setup



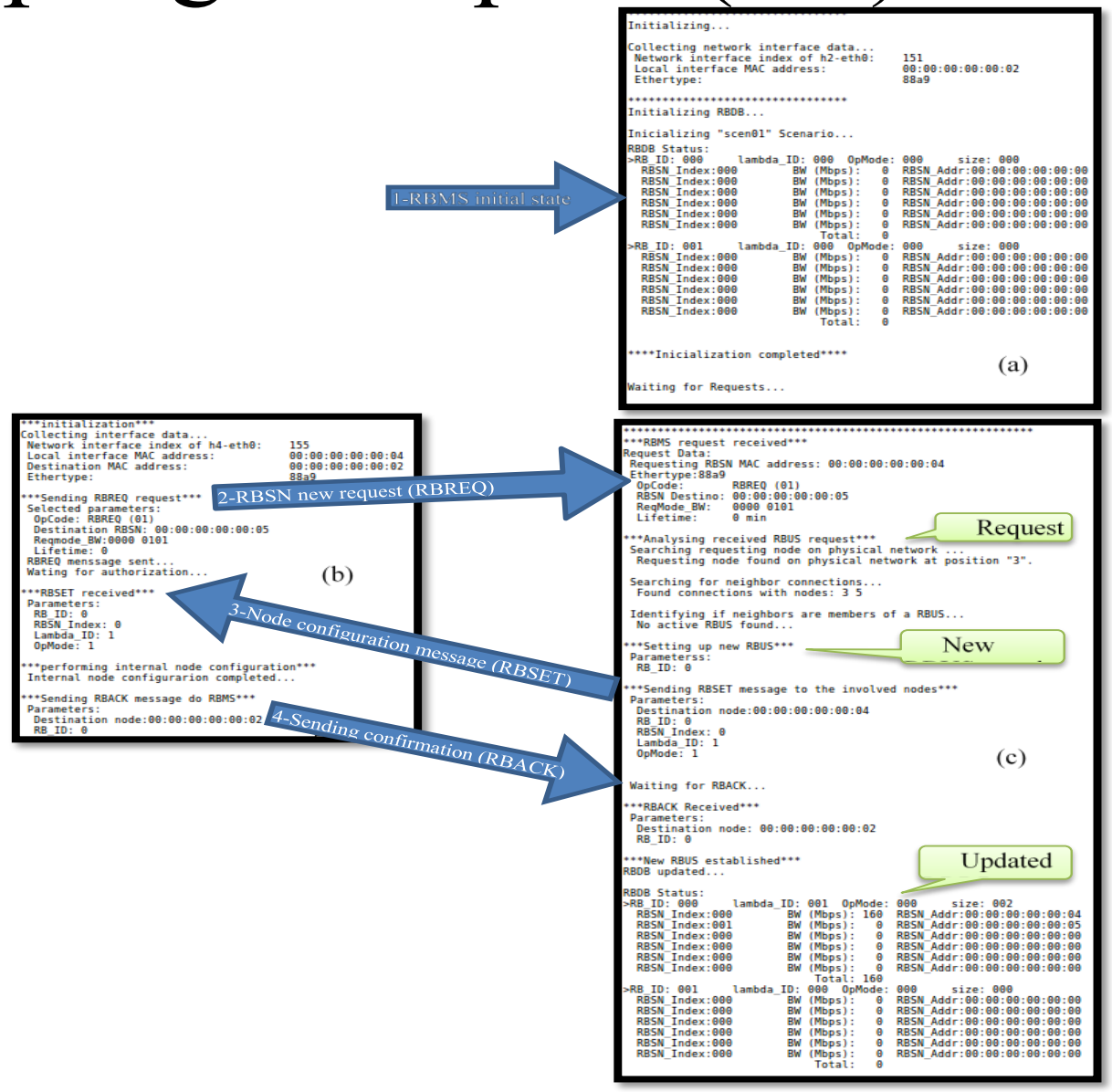
RBMS Initialization & Discovery



Accepting a Request (1/2)



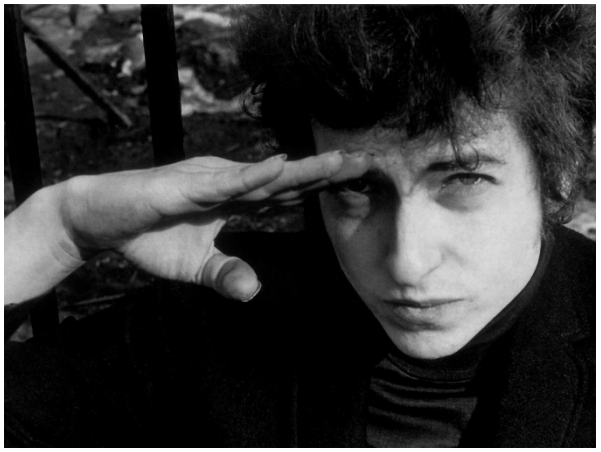
Accepting a Request (2/2)



Conclusion and Discussion

- Front/Backhaul not prepared for uRLLC
- The important role of OAM is overlooked
- E2E performance in NFV yet to be tacked
- Low cost front/backhaul is urgently needed
  - New Architectures
  - New Prototocols
- Ethernet Phy/Framing/OAM and SDN/NFV for the rest

Dylan's message to the telecom and datacom guys about SDN/NFV



"Come gather around people
Wherever you roam
And admit that the waters
Around you have grown
And accept it that soon
You'll be drenched to the bone
And if your breath to you is worth saving
Then you better start swimming or you'll sink like a stone
For the times they are a-changing"

The Times They Are A Changin' (Bob Dylan 1964)

Thank You!

Questions? Comments?

Moises R. N. Ribeiro
moises@ele.ufes.br
http://www.ict-futebol.org.br/

Acknowledgments

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