Towards a Future Multi-Service Mobile Network Architecture

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5G Outlook

Evolutionary View

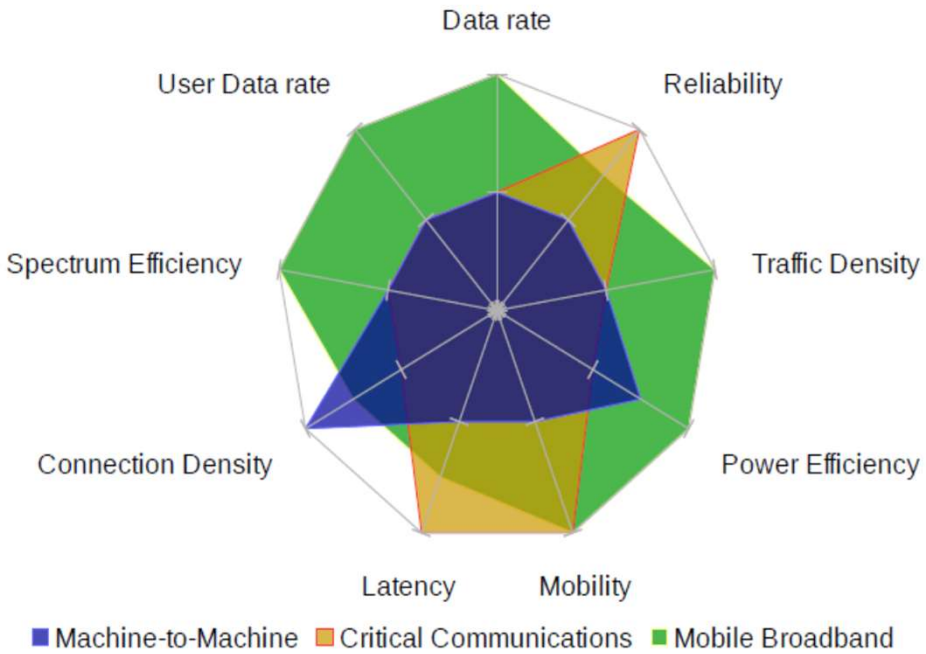
+

Service Oriented View

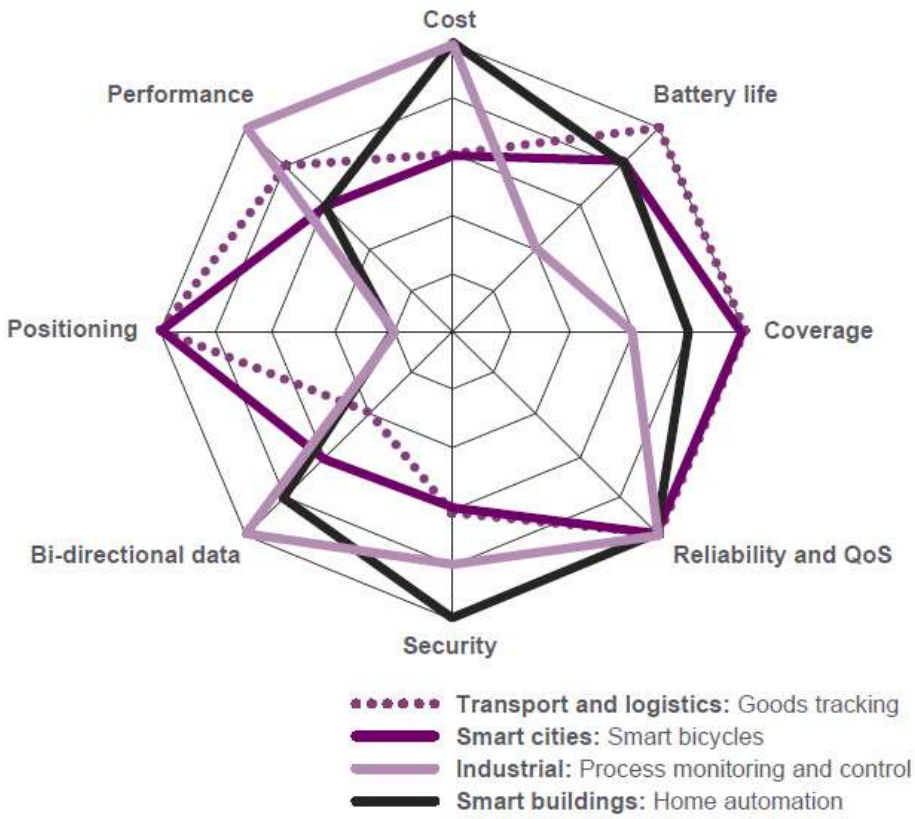
→

5G

Envisioned 5G Services with Diverse Requirements



Source: ITU 2015

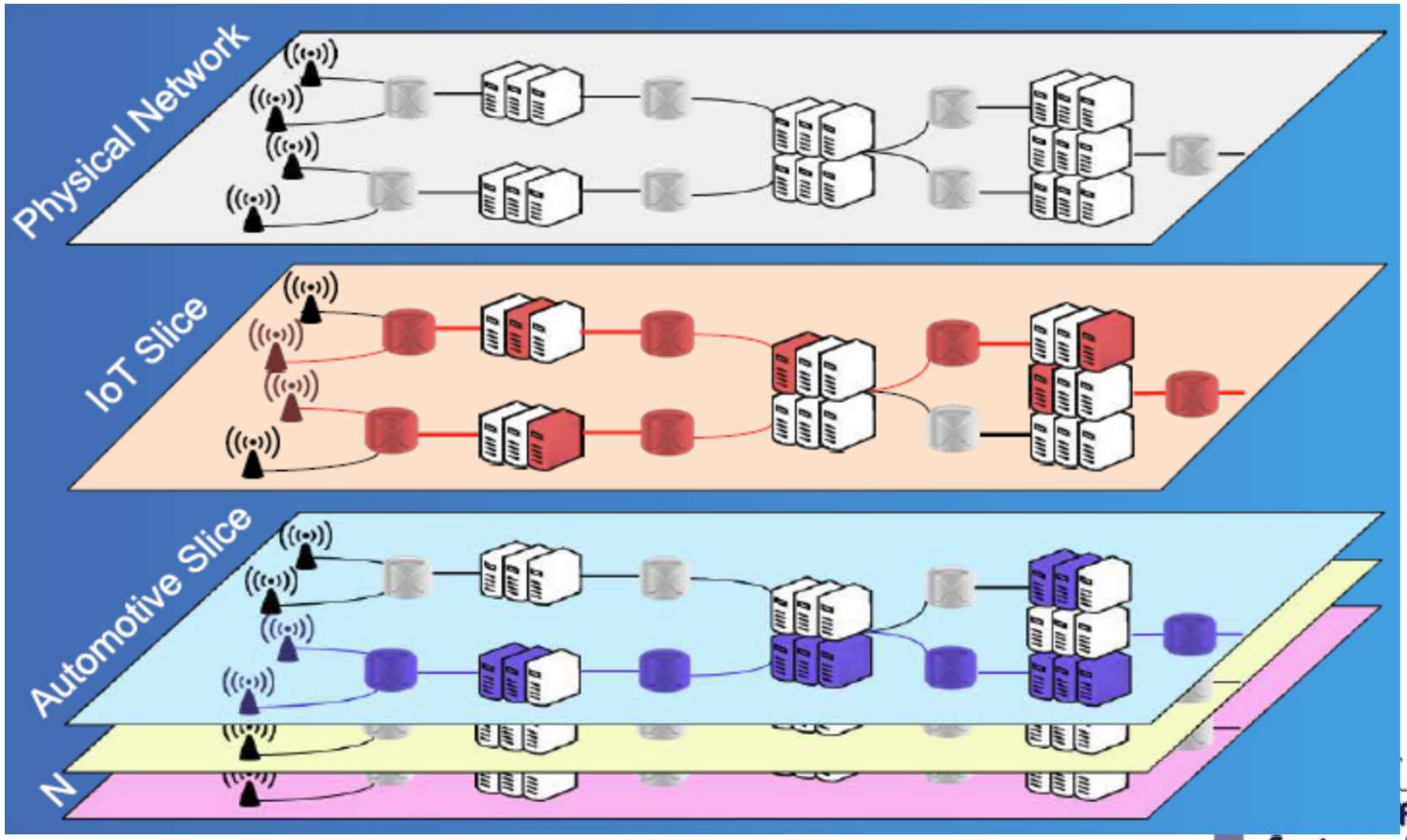


Source: Ericsson Jan'16

- ***A one-size fits all architecture unlikely to be suitable for such diverse use cases***
- ***On the other hand, building a different network per service not a viable option***

"Network slicing" for supporting multiple services in 5G

- Need a highly flexible mobile network architecture that can turn the underlying physical infrastructure into multiple logical networks or *slices*, one per service instance
- Key enablers: **virtualization** and **network softwarization**



Source: Gronsund, RedHat Forum 2016

Our Work

… focuses on RAN

Flexible & Programmable Control Plane

Control-Data Plane Separation API

FlexRAN [CoNEXT'16 & IEEE 5G Summit Nov'16]

Slice 1's Control Plane

Slice 2's Control Plane

…

Slice N's Control Plane

RAN Infrastructure & Resource Virtualization

Control-Data Plane Separation API

Orion [MobiCom'17]

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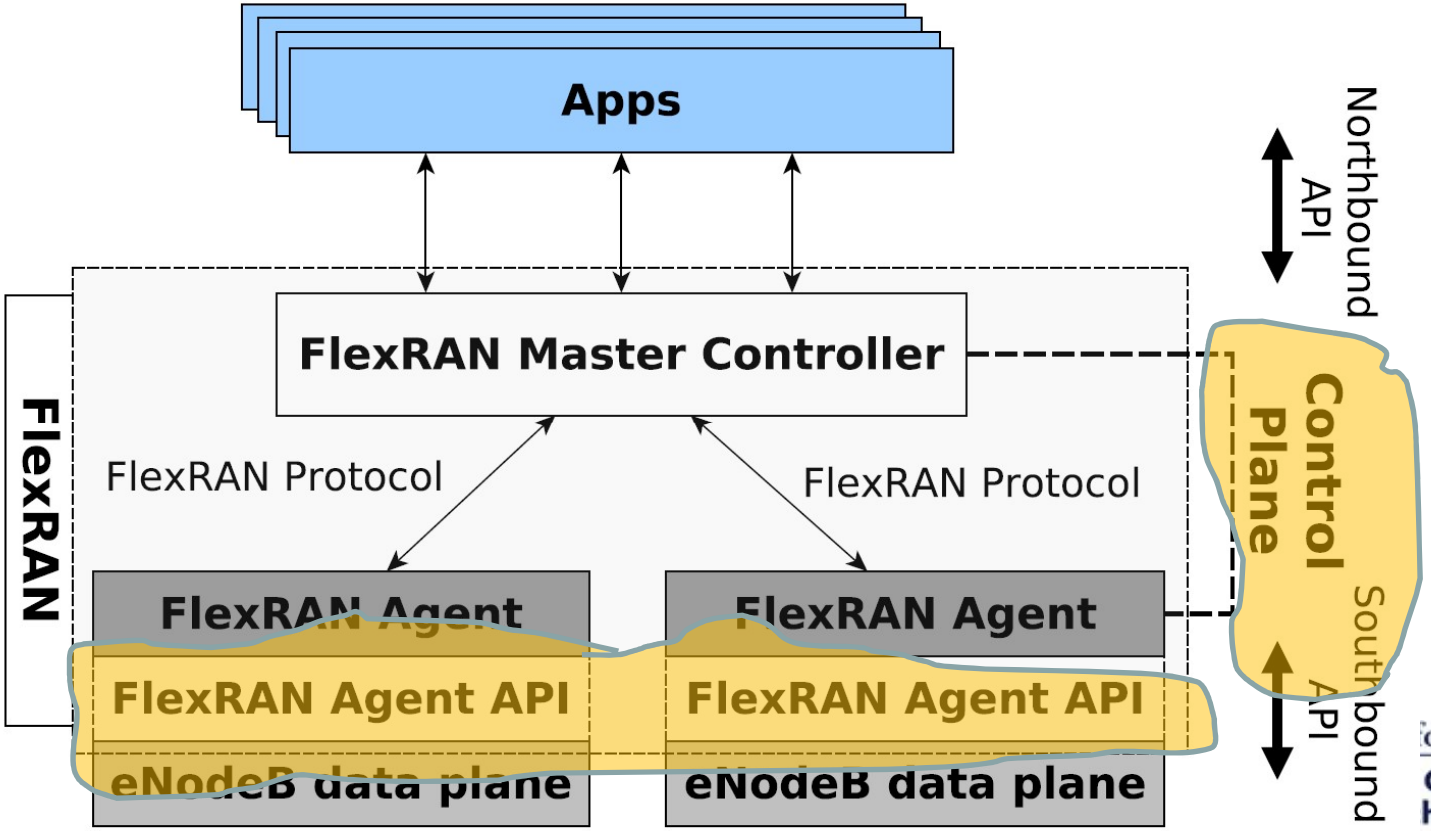
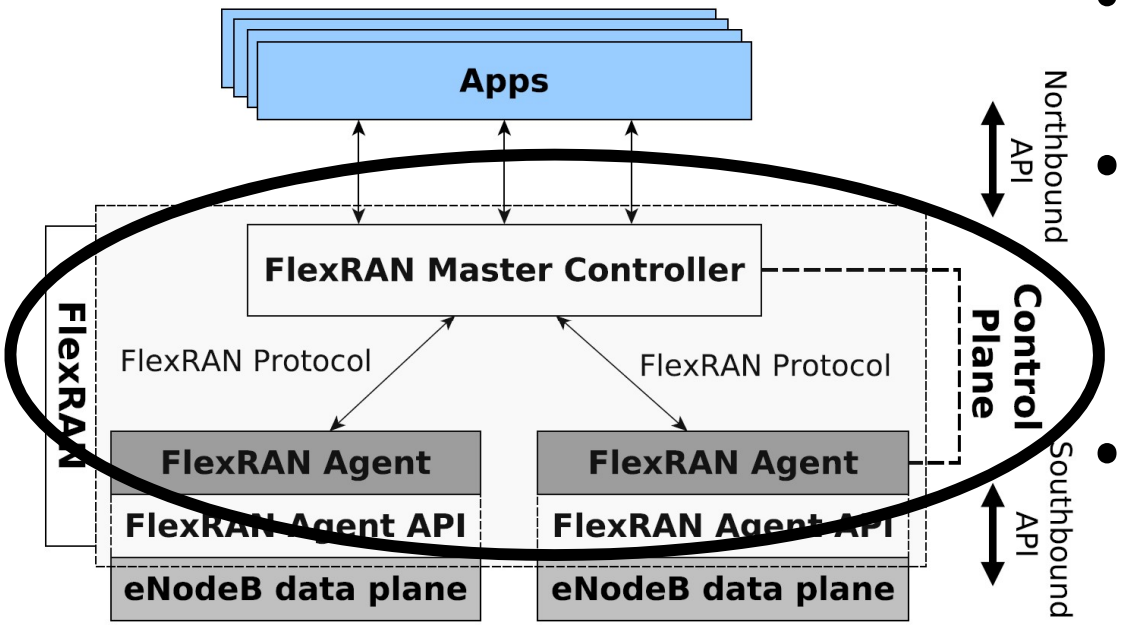
FlexRAN [CoNEXT'16 & IEEE 5G Summit Nov'16]

- The first concrete software-defined RAN (SD-RAN) platform
  - Focuses on radio resource management
  - Open source: being used by ~15 research groups from industry and academia worldwide



FlexRAN Control Plane



- Hierarchical controller architecture
- Key features:
  - Virtualized control functions (*a la* NFV)
  - Control delegation
- Enable
  - Programmability
  - Flexible and dynamic RAN control function placement: different degrees of coordination among BSs
  - Real-time control

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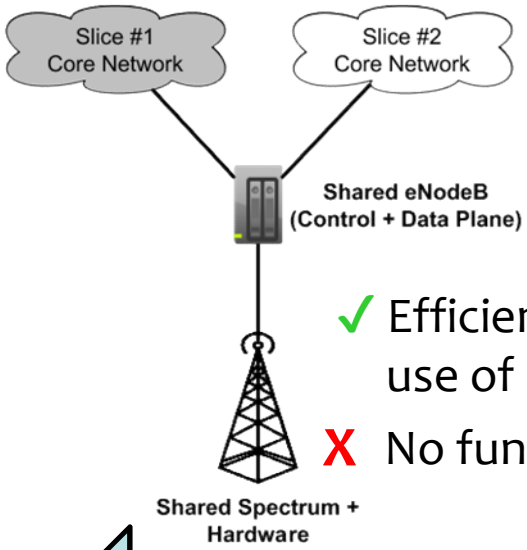
RAN Slicing

RAN Slicing
State of the Art

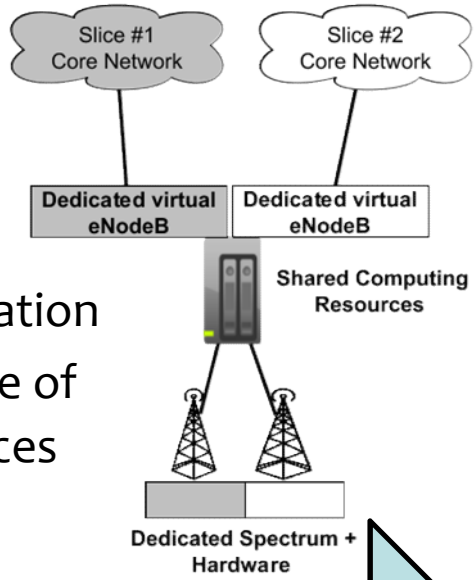


✓ Efficient and adaptive use of radio resources

X No functional isolation

✓ Functional isolation

X Inefficient use of radio resources



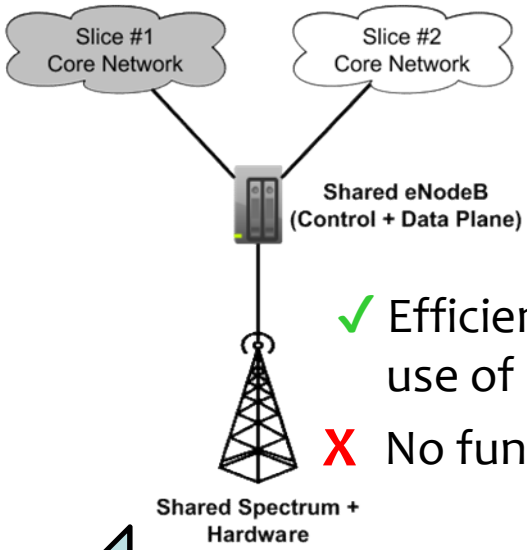
RAN Sharing
(e.g. [NVS – IEEE/ACM TON 2012])

Full Isolation
(e.g. [FLARE – JIP 2017])

Source: Amazon

Source: Argos

RAN Slicing
State of the Art



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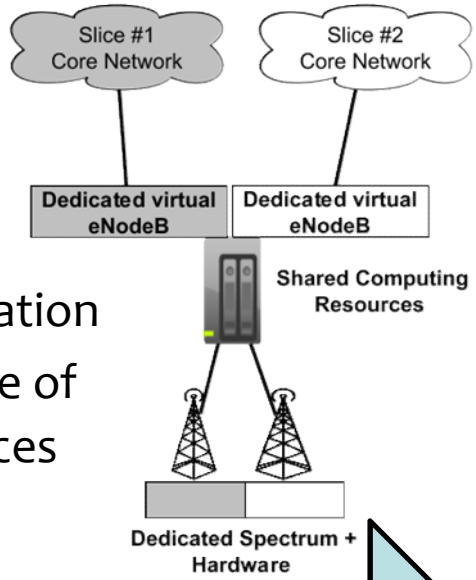

RAN Sharing
(e.g. [NVS – IEEE/ACM TON 2012

Full Isolation
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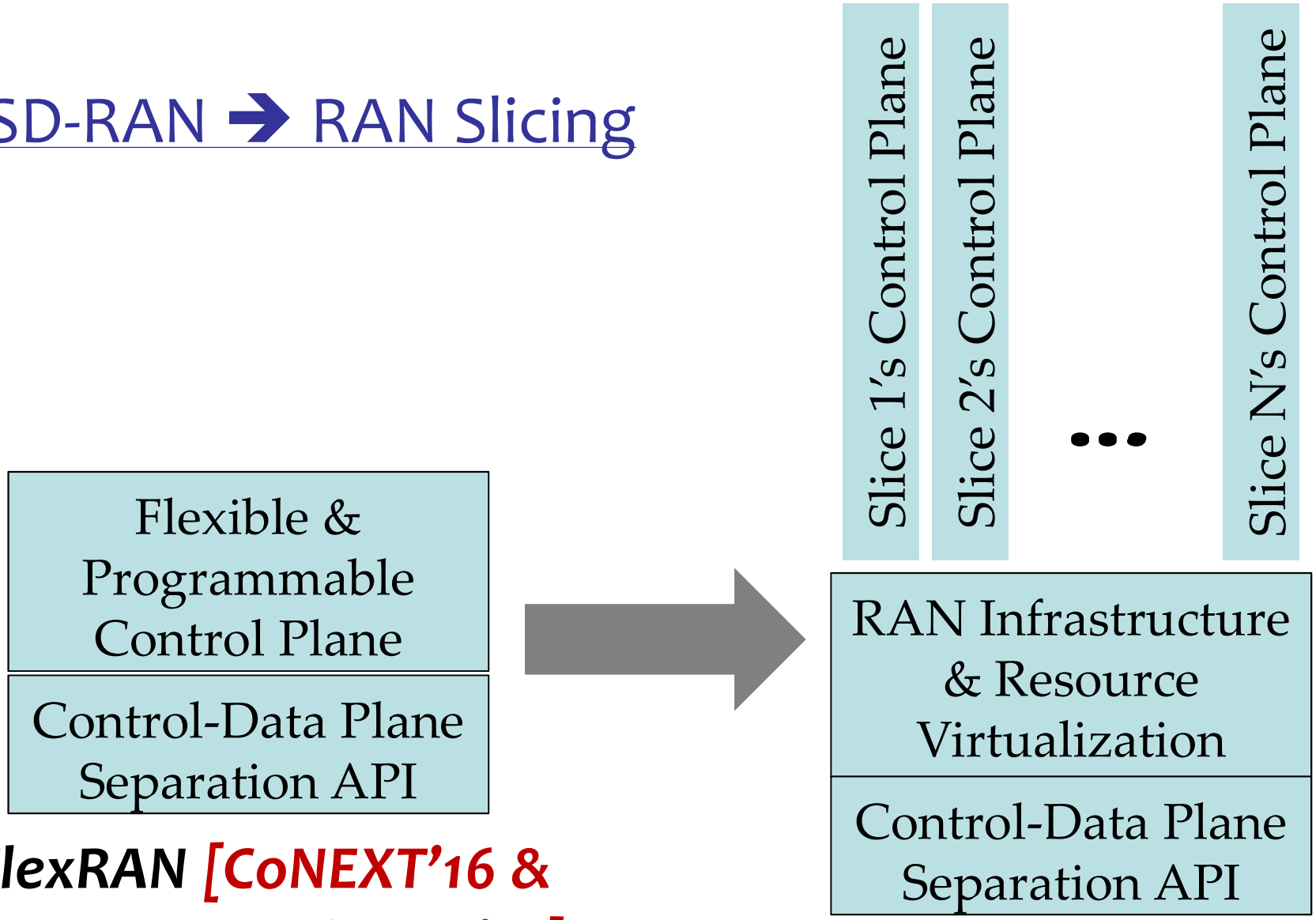
Source: Amazon

Source: Toasteroid

Source: Argos

SD-RAN ➔ RAN Slicing



FlexRAN [CoNEXT'16 & IEEE 5G Summit Nov'16]

Orion [MobiCom'17]

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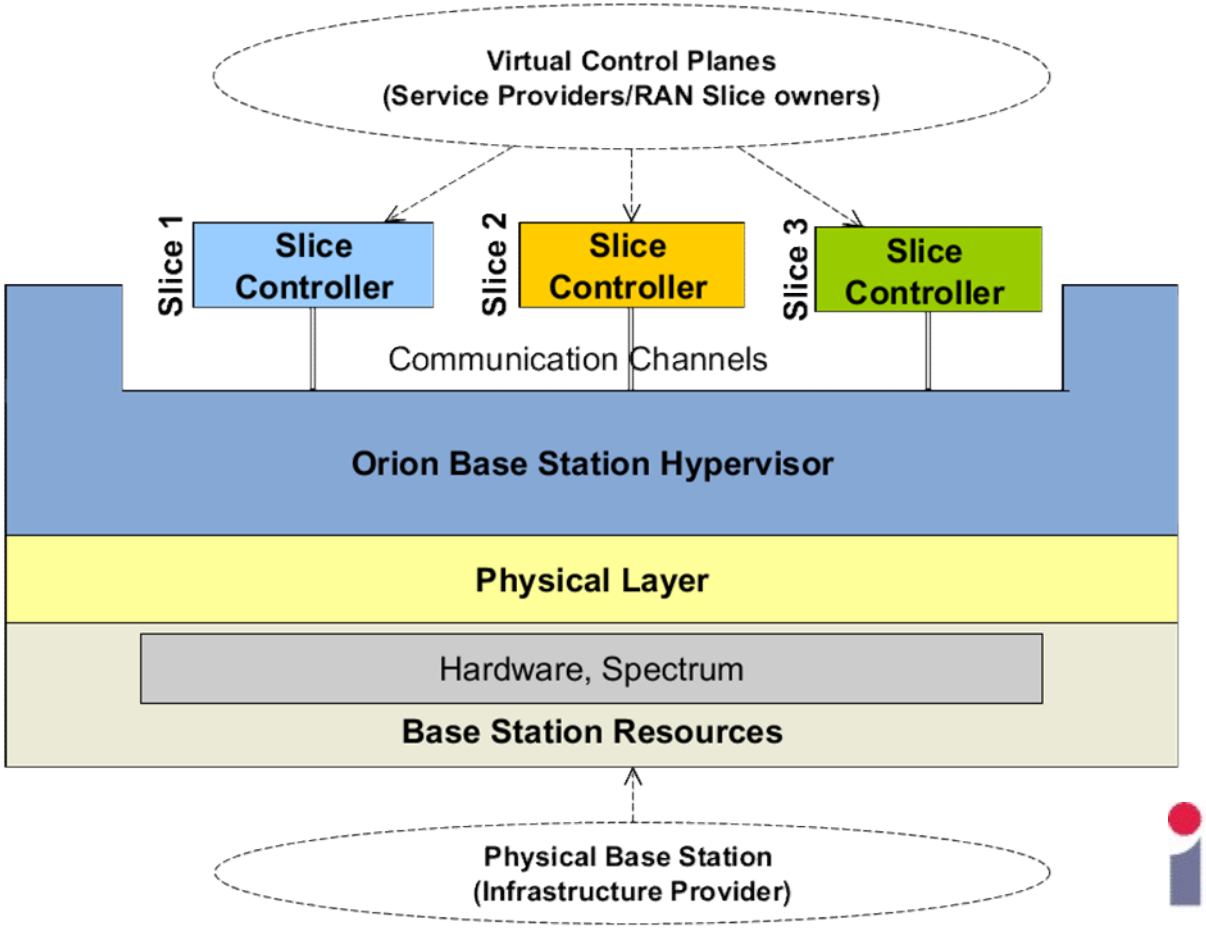
Orion [MobiCom'17]

- The first RAN slicing system to provide both:
  - full functional and performance isolation between slices, and
  - efficient sharing of radio and spectrum resources



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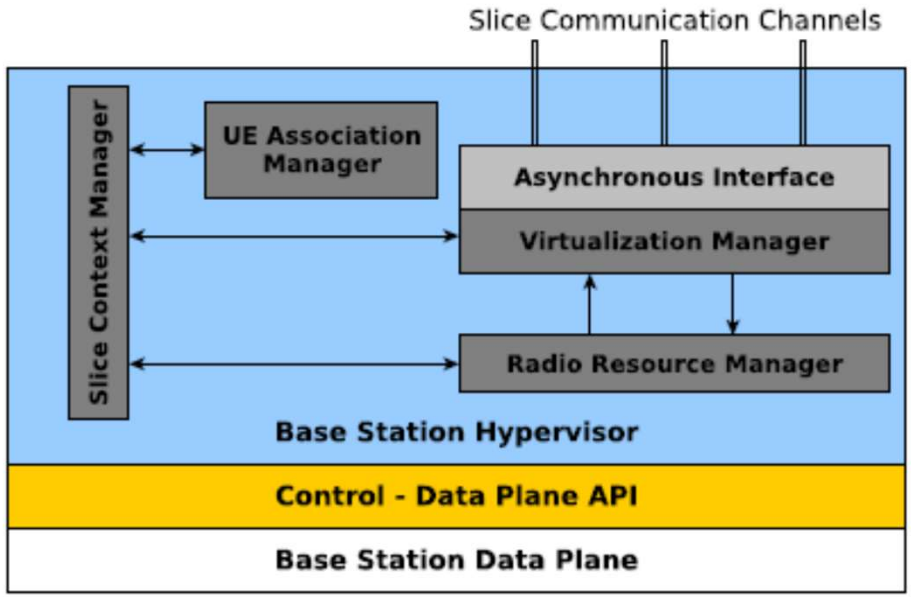
Orion Base Station Hypervisor

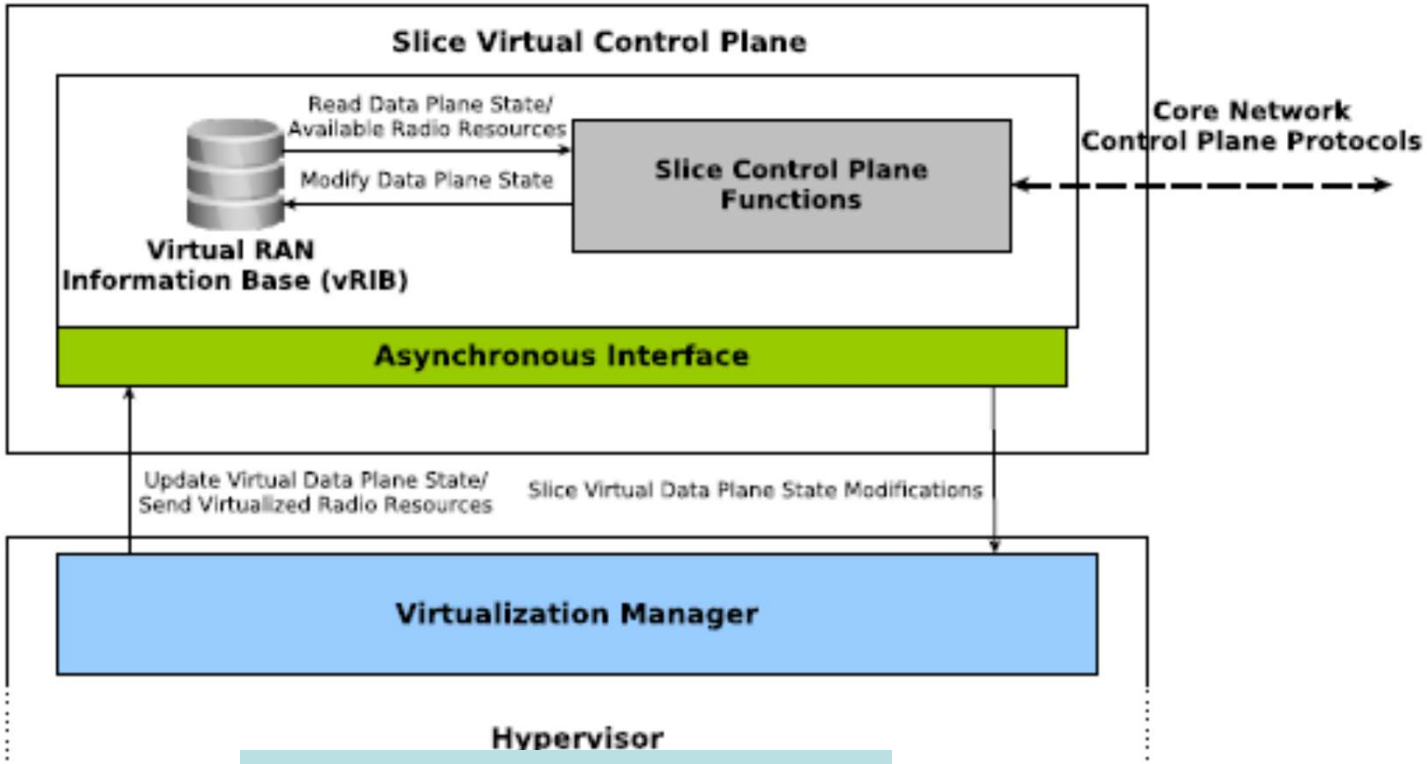


Base Station Hypervisor

- Slice context manager does life-cycle management of each slice (SLA, active UEs, admission control)
- Virtualization manager
  - *Provides a generic form of abstraction for virtualizing radio resources and data plane state*
  - Presents a virtual/isolated view to each slice virtual control plane
- Radio resource manager allocates physical resources among slices
- UE association manager handles:
  - Slice discovery by UEs
  - Mapping UEs to slices

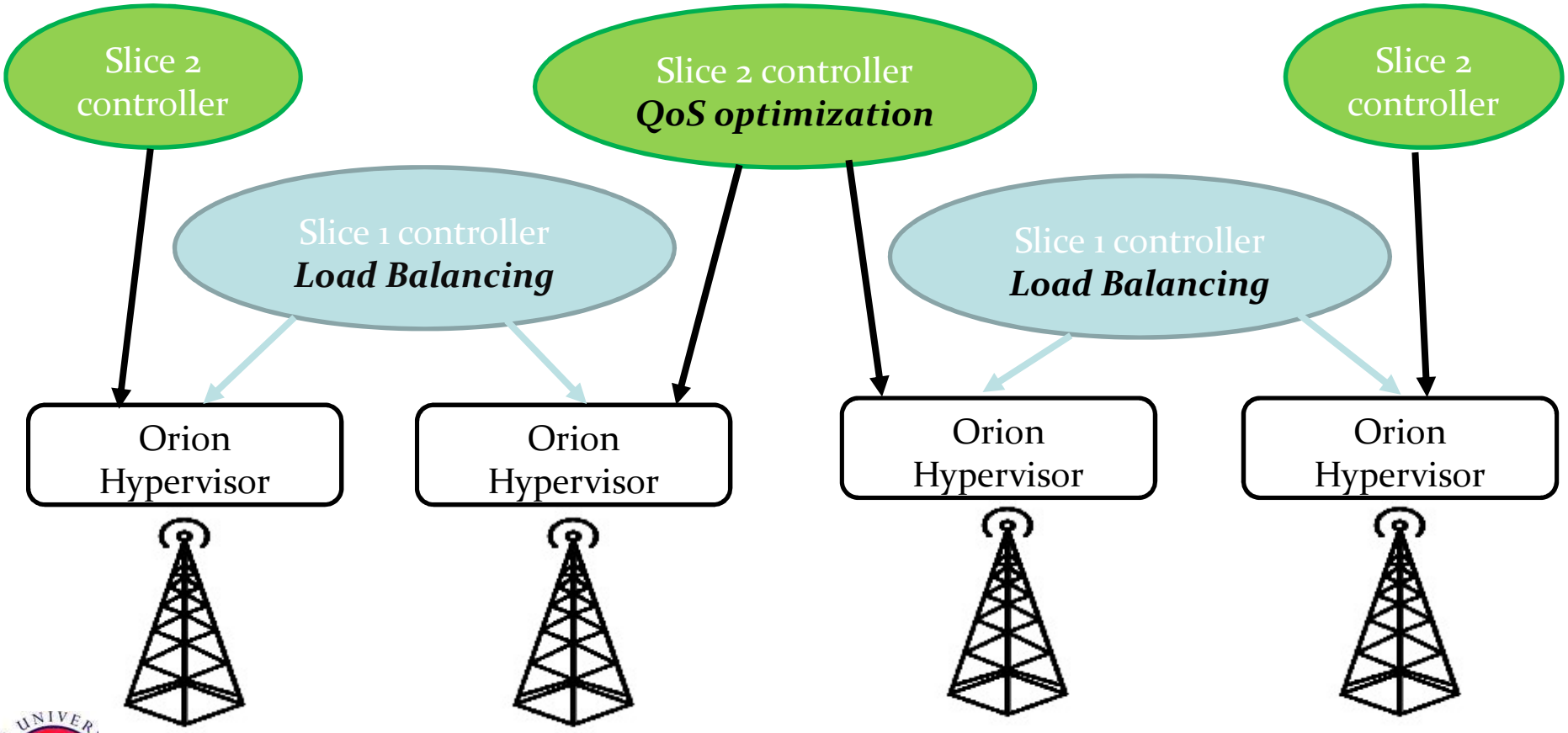
Slice Virtual Control Plane

- Interacts with the underlying infrastructure via the Virtualization Manager of the Hypervisor
- Operates over vRIB, the locally maintained state of virtual radio resources and data plane



Virtual Control Plane of a Slice

Slice Flexibility/Configurability



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Orion Demonstration (1/2)

- Creation and operation of RAN slices
  - Dynamic slice creation via configuration files
  - VNF placement & chaining
    - Different EPC configurations (shared EPC/MOCN)
    - Co-located / Distributed virtual slice control planes
  - Slice monitoring
    - Demonstration of data plane state isolation among slices
- Slice functional isolation
  - Create slices with different scheduling functions
  - Change scheduler (scheduling policy) over one slice and observe how other slices remain unaffected

Orion Demonstration (2/2)

- Slice radio resource isolation
  - Creation of slices with different radio resource requirements
    - Best effort
    - Average throughput
    - Static resource block allocation
  - Demonstration of flexible and dynamic re-allocation of radio resources among slices

Summary

- Service-oriented view of 5G offers a unique opportunity for significant innovation on the architectural front and democratisation of mobile network ecosystem
- Developed systems, focused around the RAN, that form the key building blocks to enable 5G network slicing
  - FlexRAN SD-RAN platform (http://networks.inf.ed.ac.uk/flexran)
  - Orion RAN slicing system
- Further challenges [IEEE Communications, May 2017]:
  - Accommodating multiple radio access technologies (RATs) when virtualizing the RAN
  - Holistic and agile slice orchestration and service assurance
  - Robustness of softwarized mobile network infrastructure