Orion: RAN Slicing for a Flexible and Cost-Effective Multi-Service Mobile Network Architecture

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[*]The University of Edinburgh

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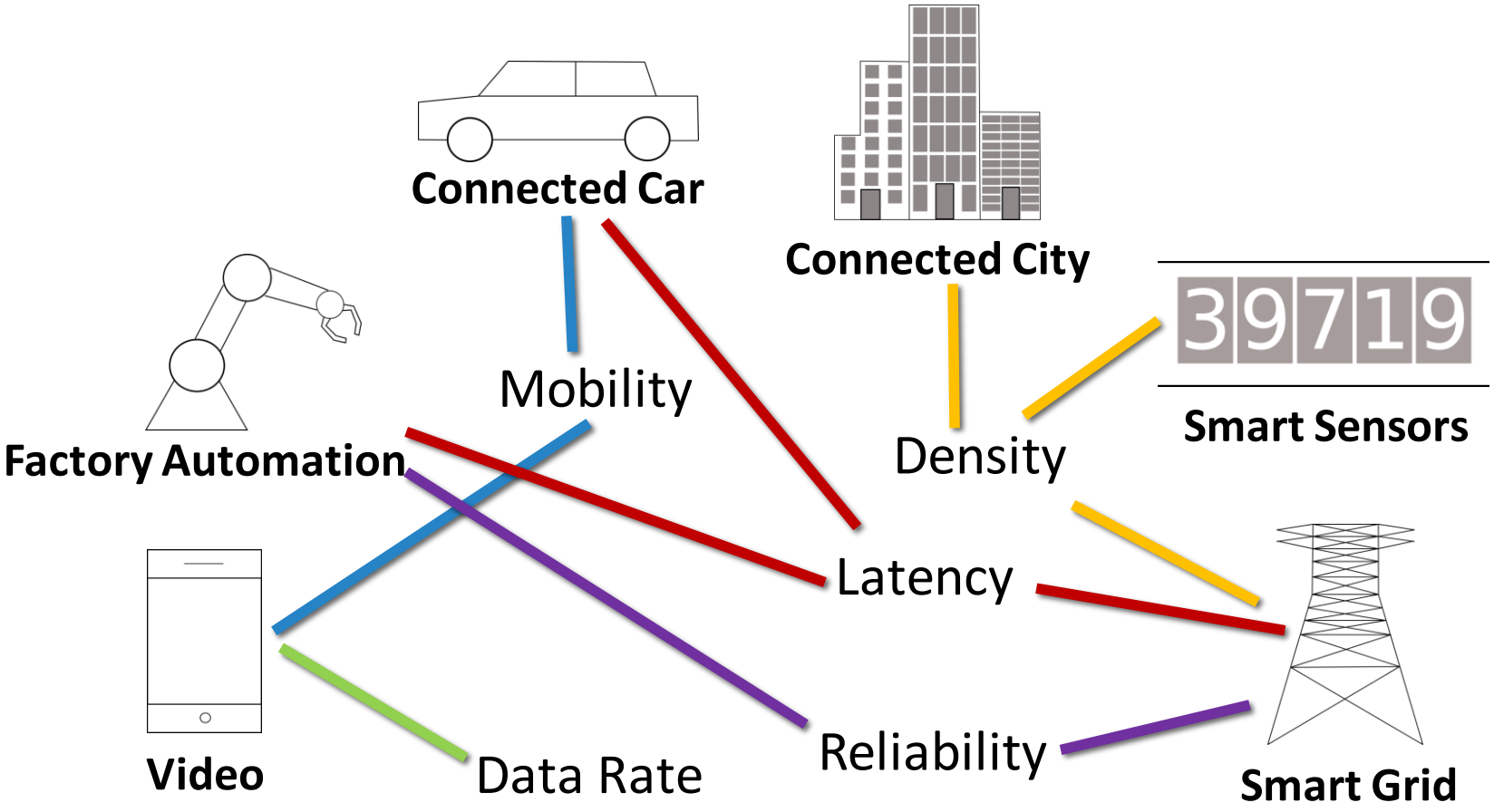
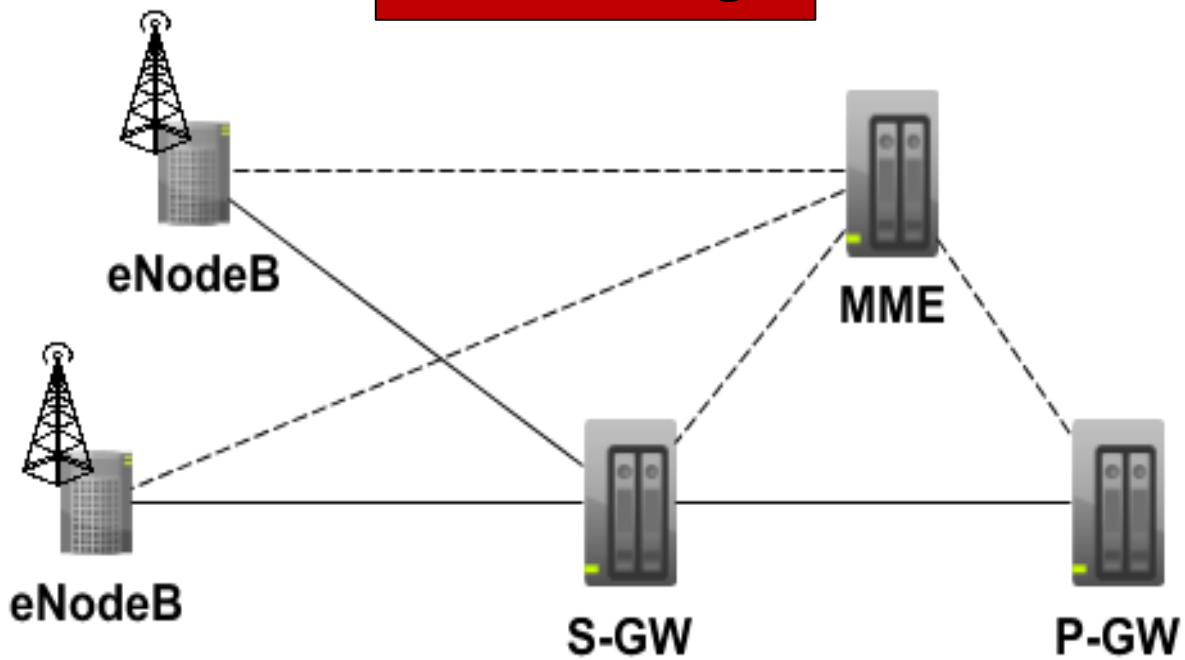
Service-oriented 5G view



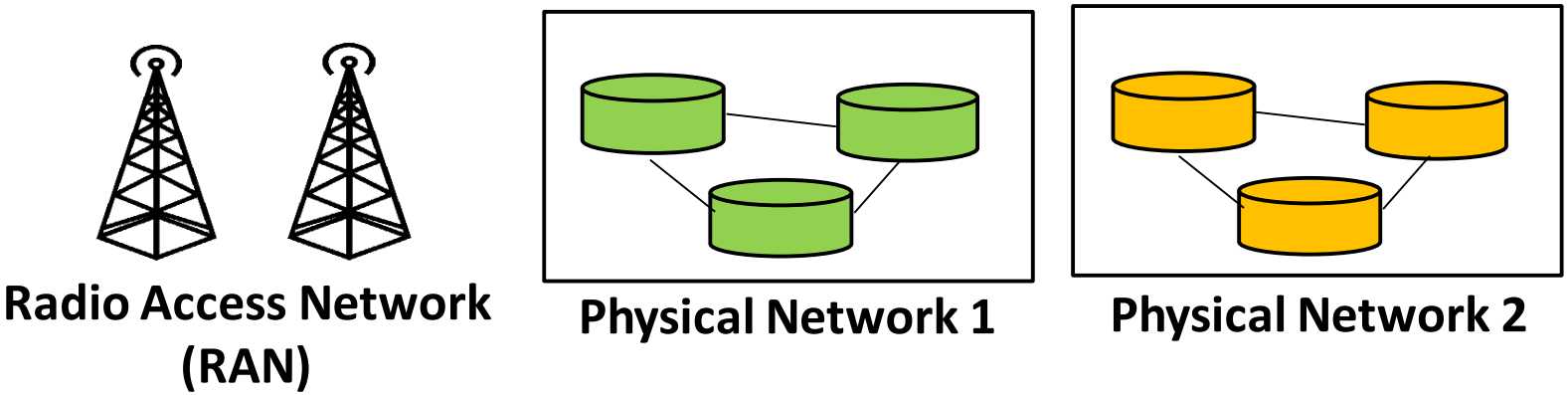
Limitations of conventional mobile network architectures

Fixed and Rigid



Conventional One-size Fits All Mobile Network Architecture - Optimized for Mobile Broadband

Towards a service-oriented architecture



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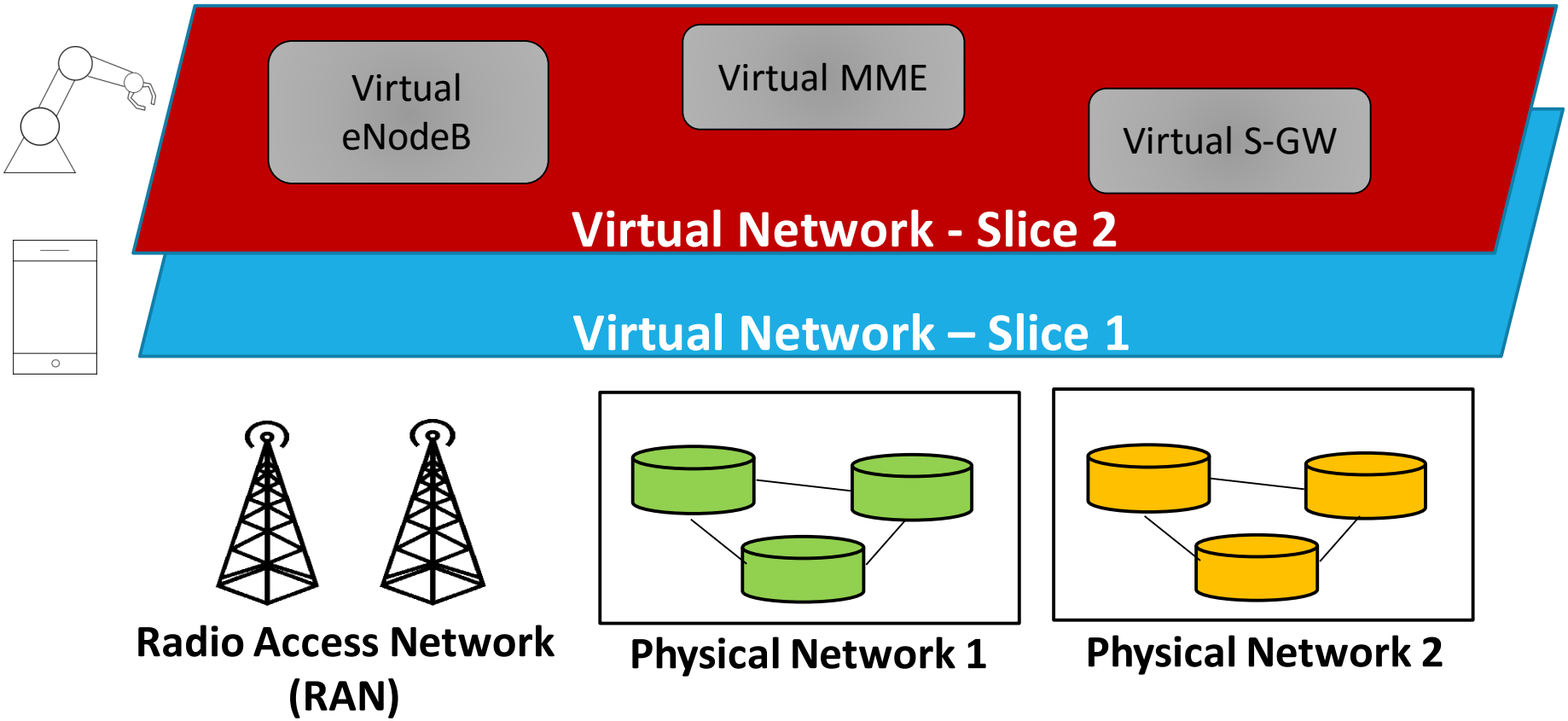

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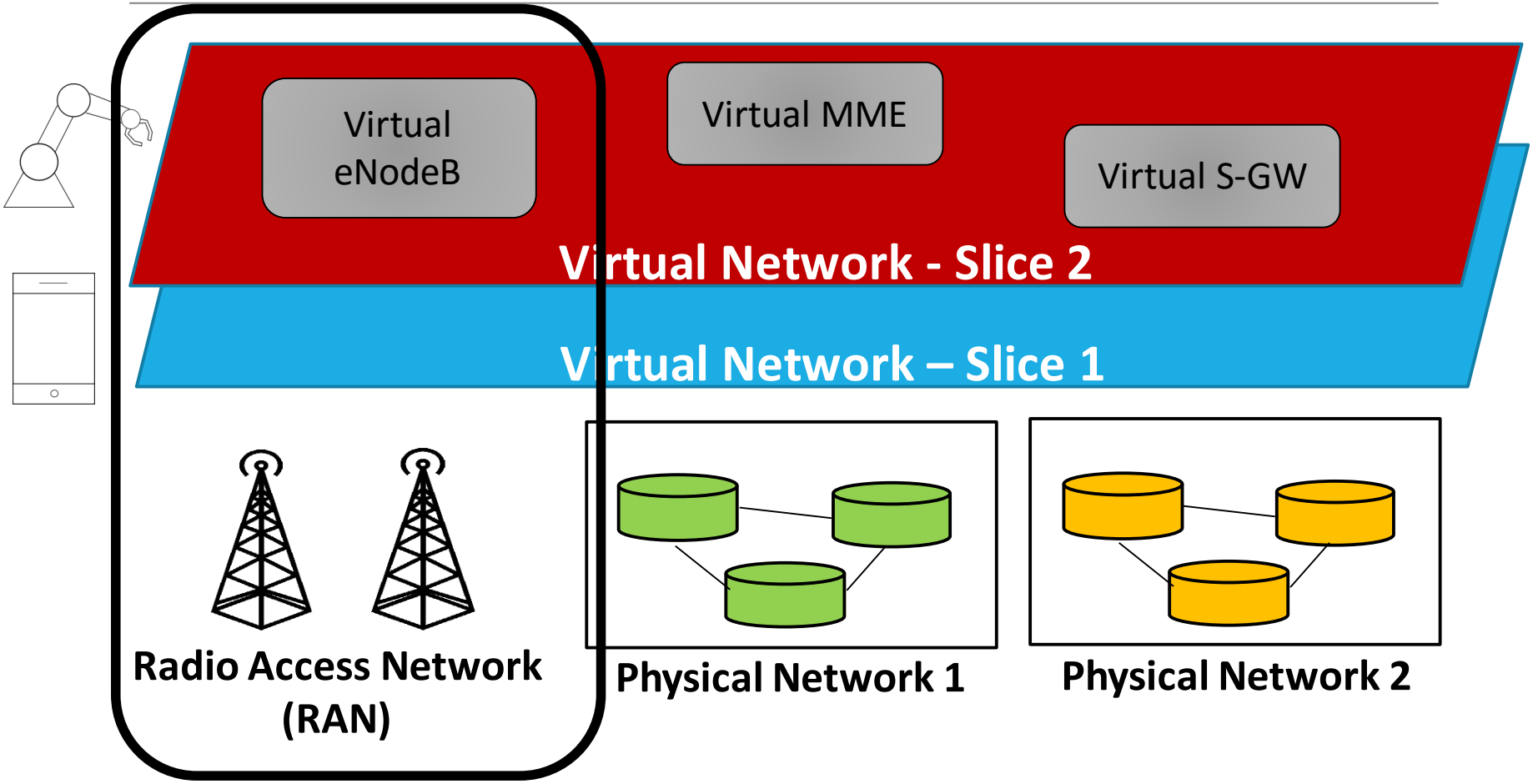
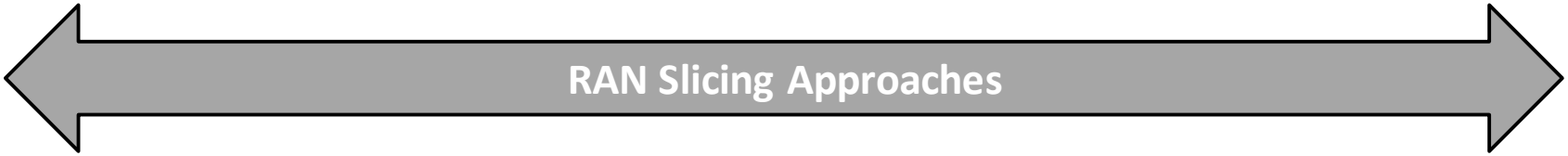


RAN Slicing



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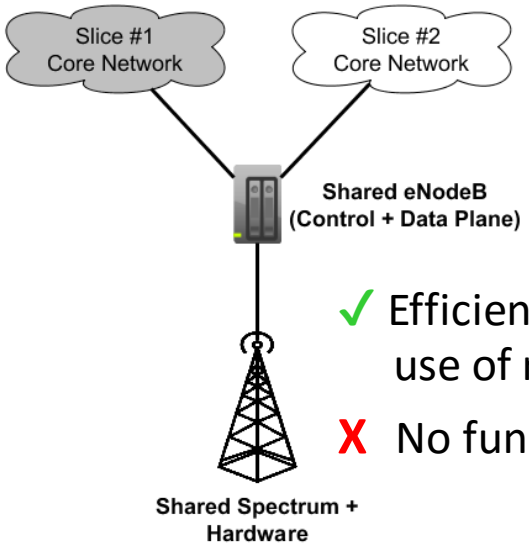


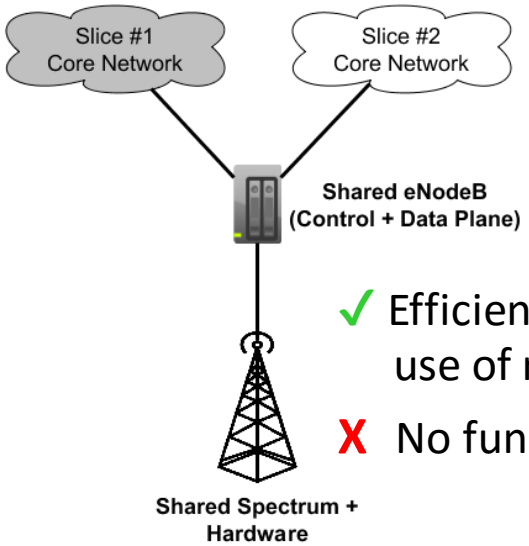
✓ Efficient and adaptive use of radio resources

X No functional isolation

RAN Sharing
(e.g. [NVS - IEEE/ACM TON 2012], [FlexRAN use case – CoNEXT 2016])

RAN Slicing Approaches

RAN Slicing



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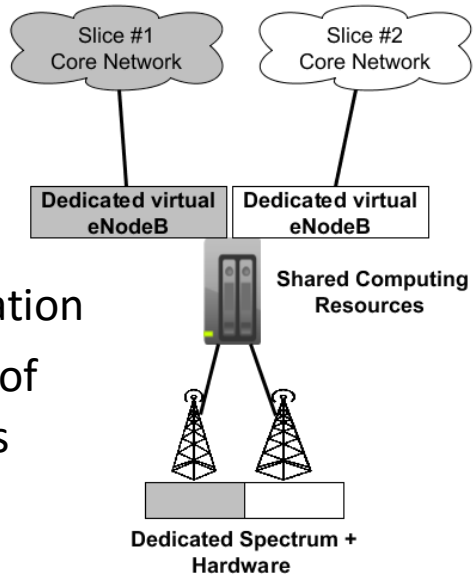

Full isolation
(e.g. [FLARE – JIP 2017])

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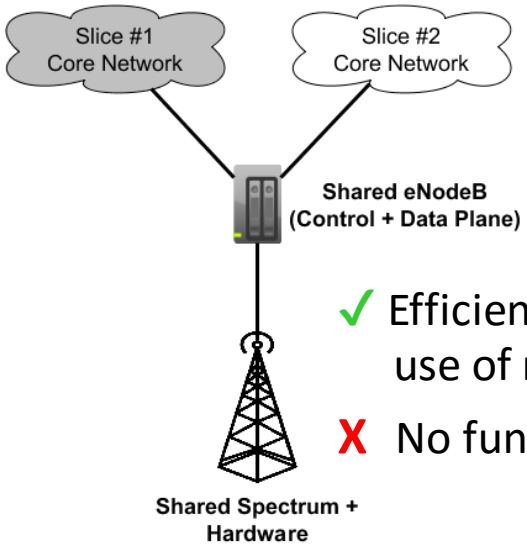

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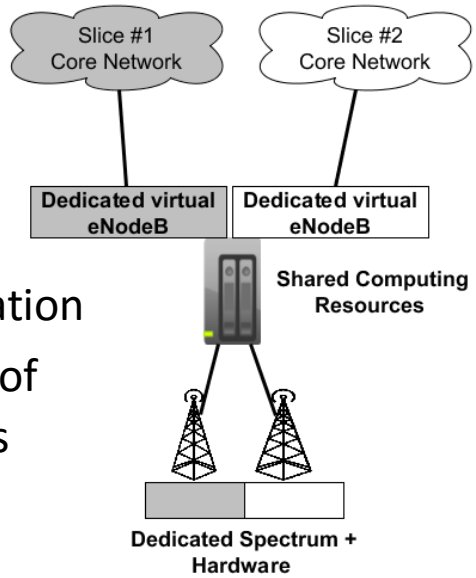

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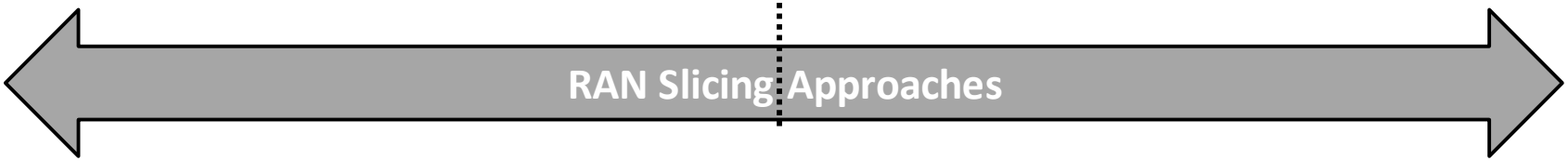
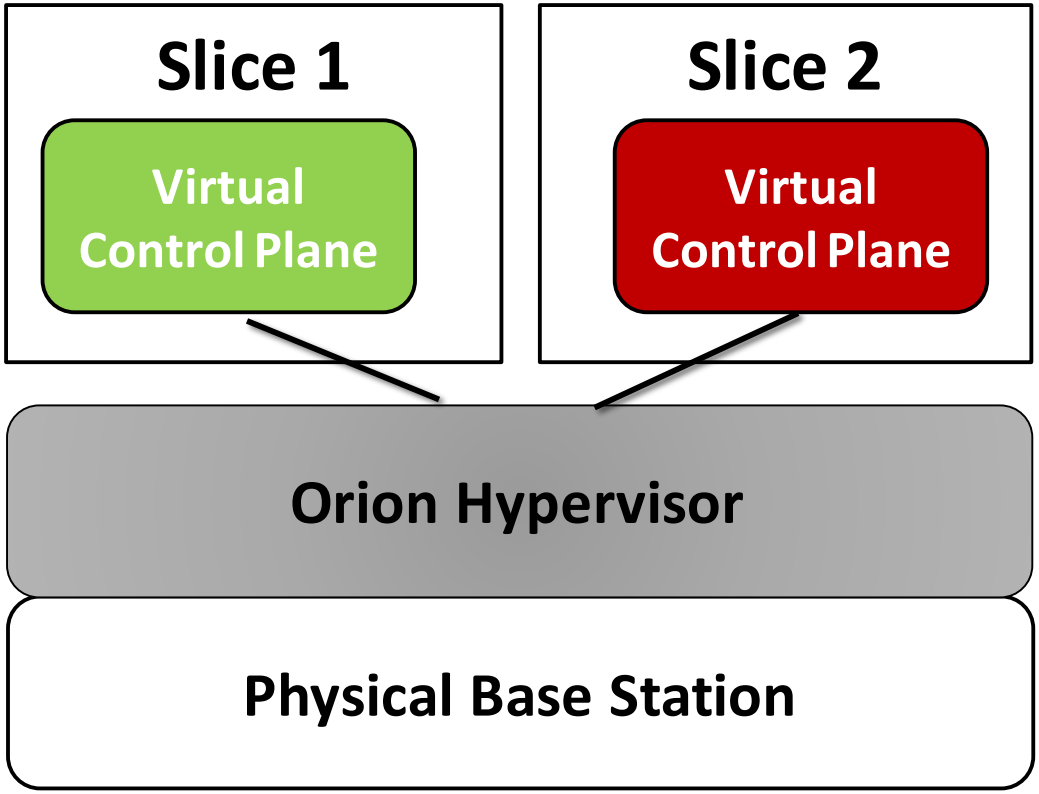


Our contribution: **Orion**

Orion RAN slicing system

- Enable functional isolation among slices and the efficient utilization of the underlying RAN resources
- Introduce a novel set of abstractions for the virtualization of the radio resources
- Deployment in an end-to-end setting
- Concrete prototype implementation & Detailed experimental evaluation
- Multi-Service slice extensions for support of OTT service providers

Orion overview



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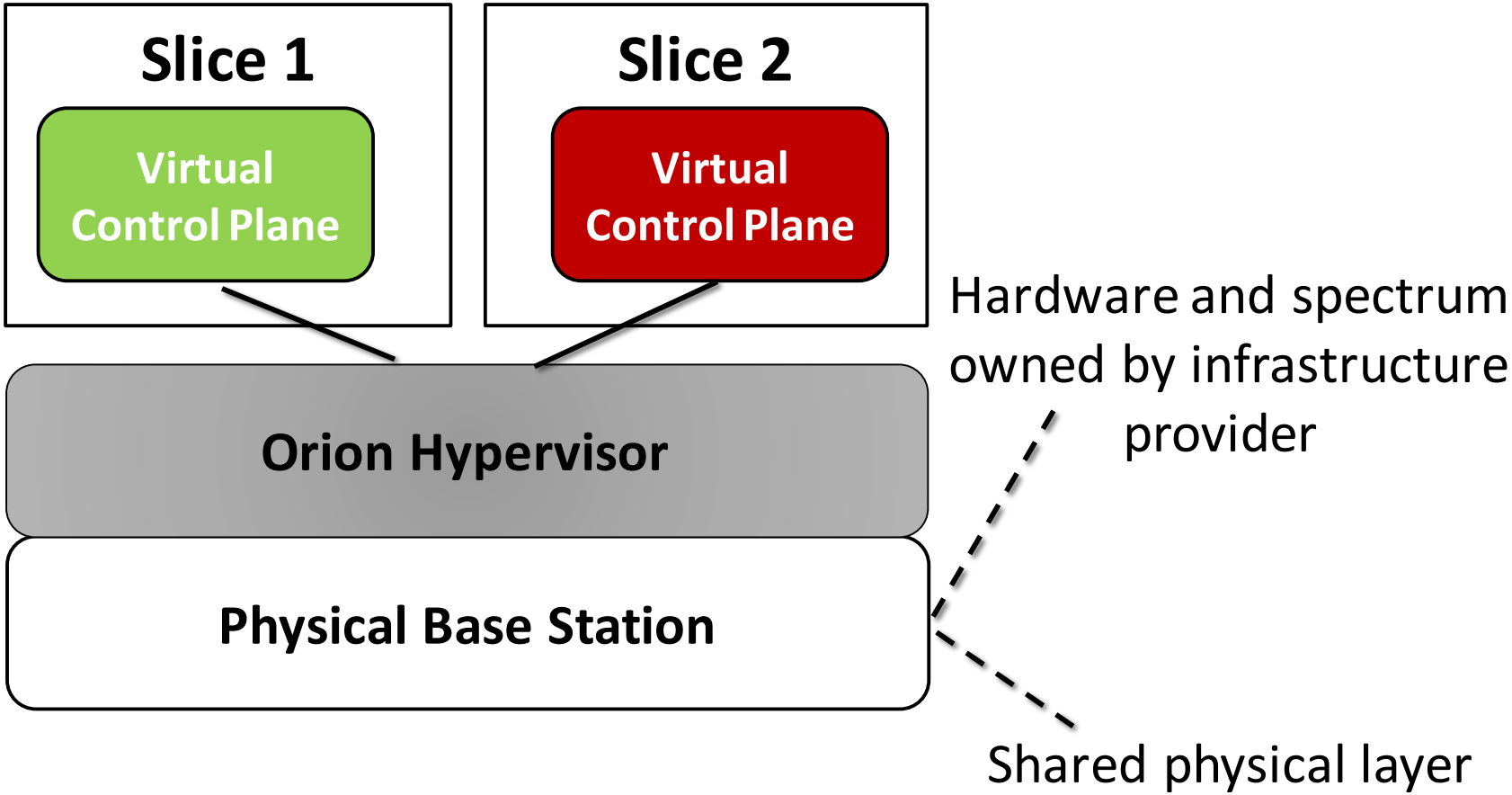

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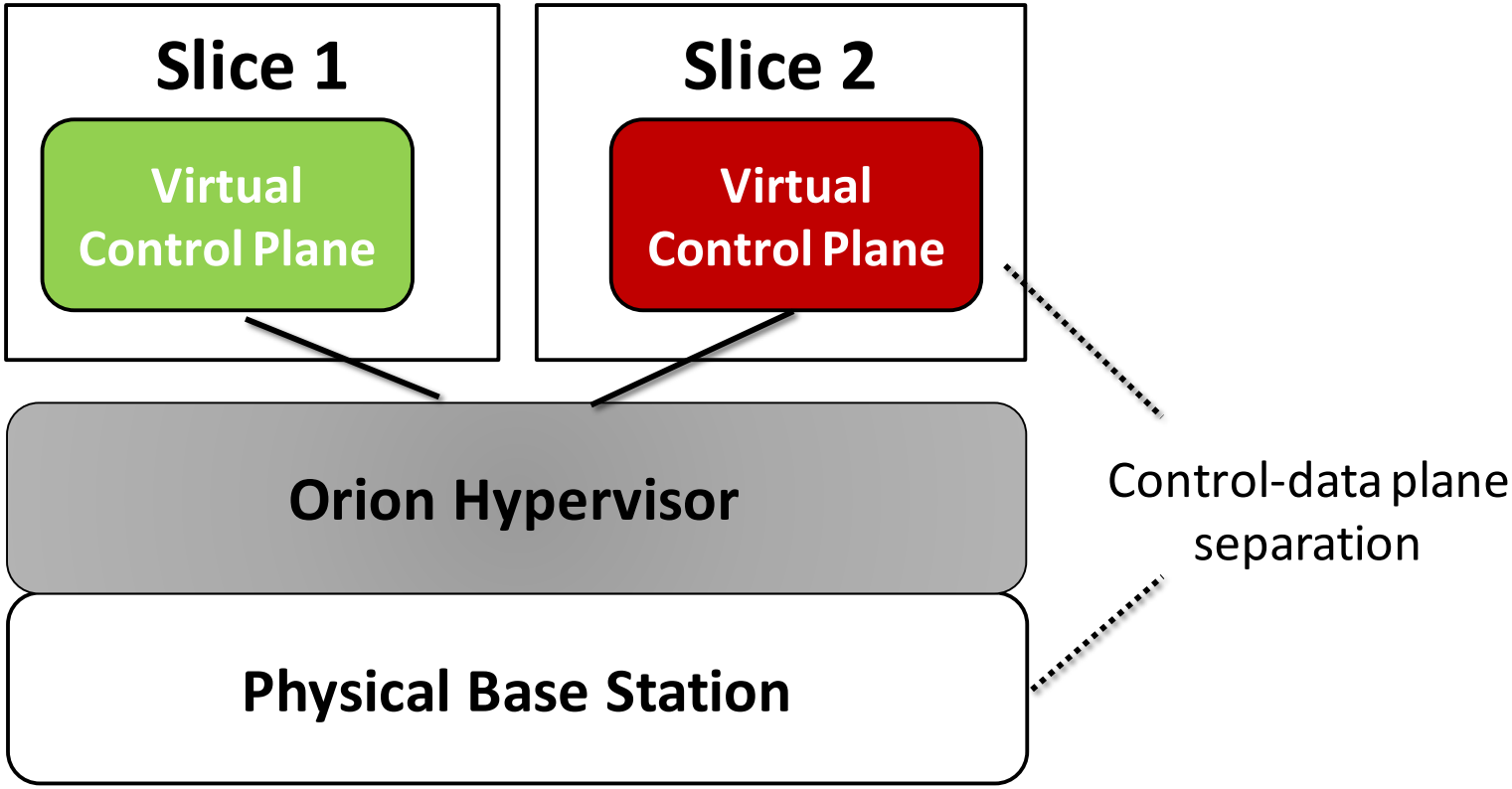

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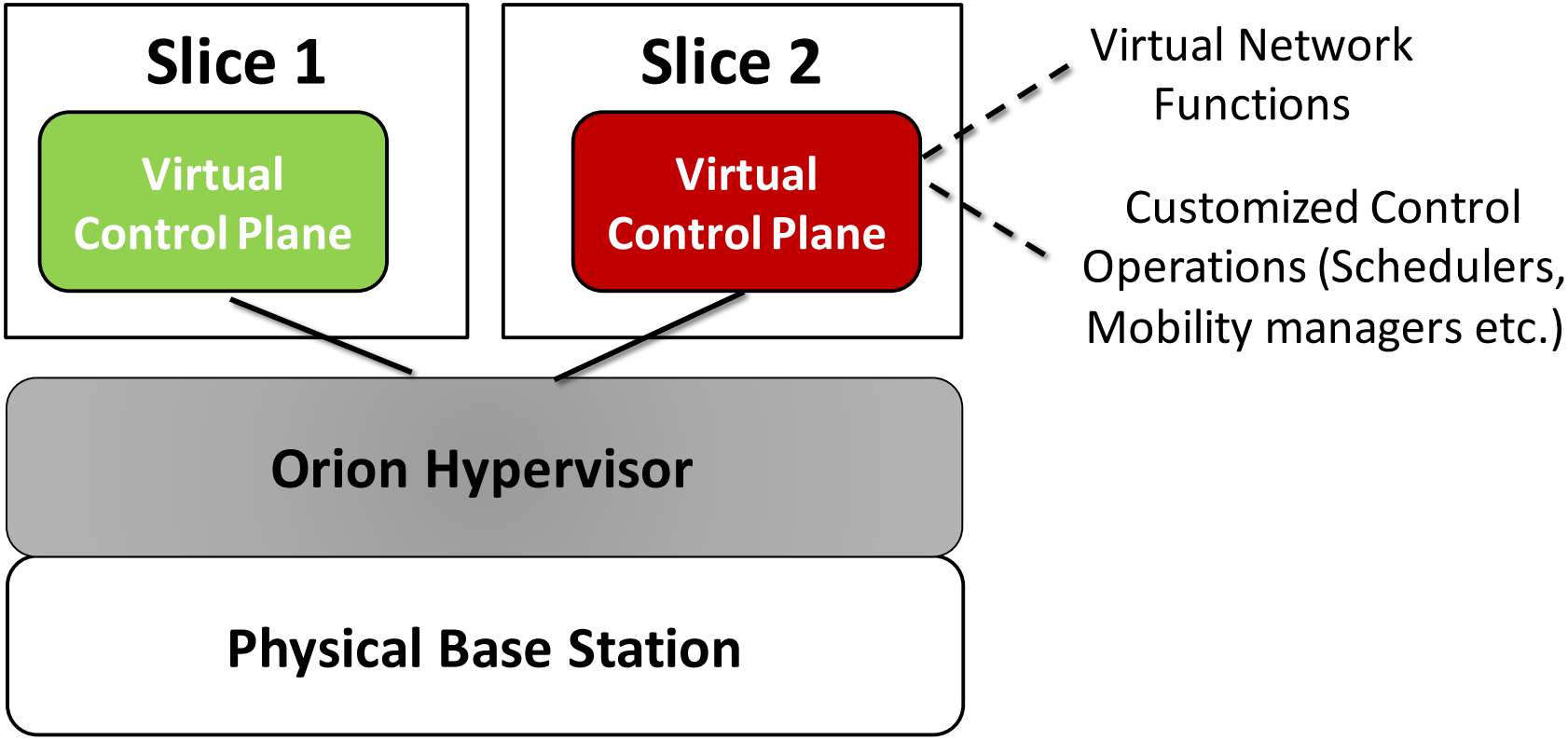

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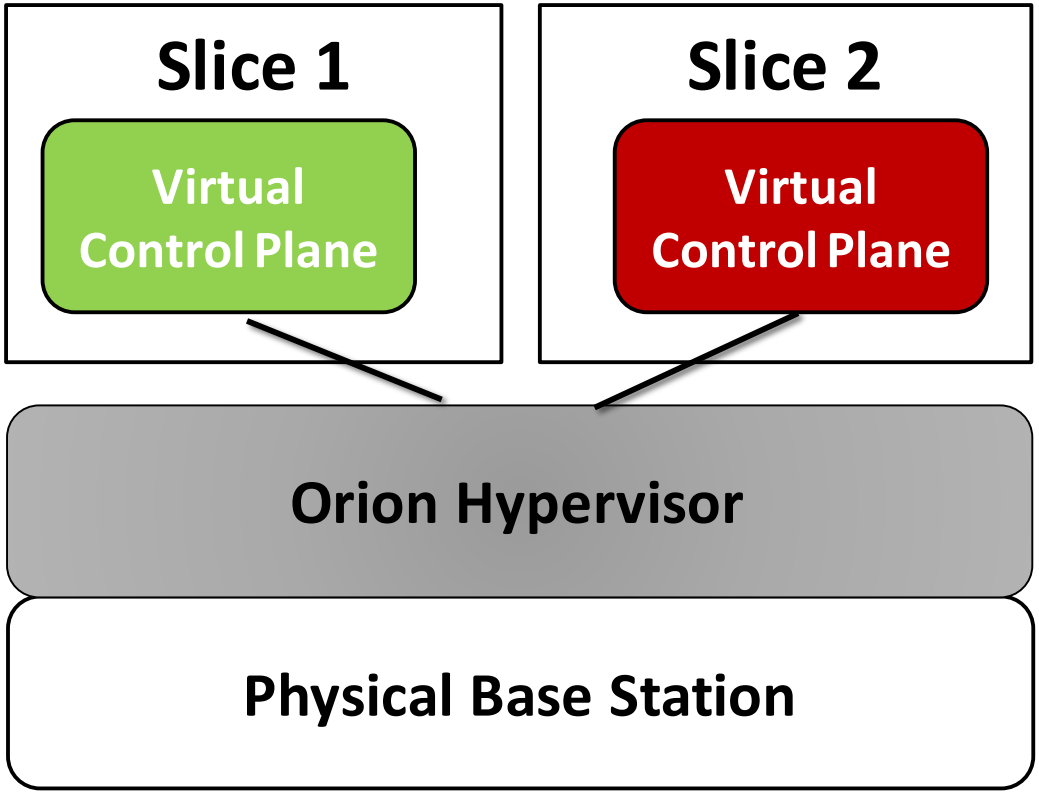
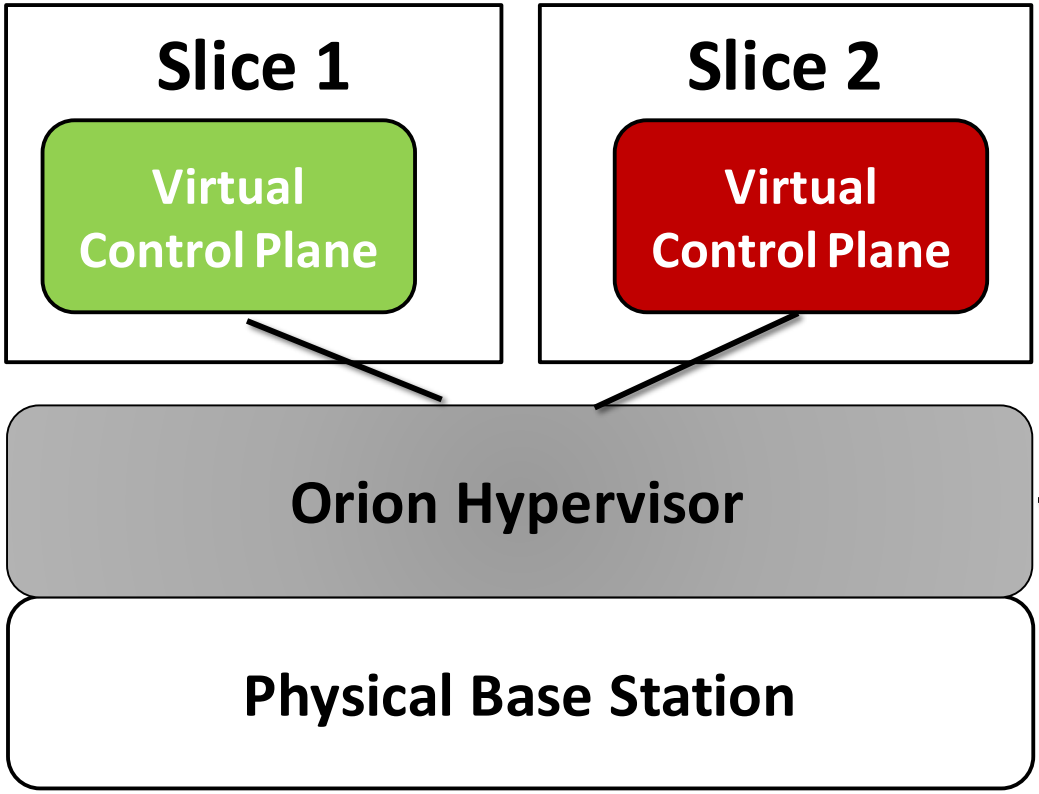


Radio resources and data plane state must be isolated among control planes

Orion overview



Ensures isolation among slices

- Virtualization of the radio resources
- Virtualization of the data plane state

Virtualizing the radio resources

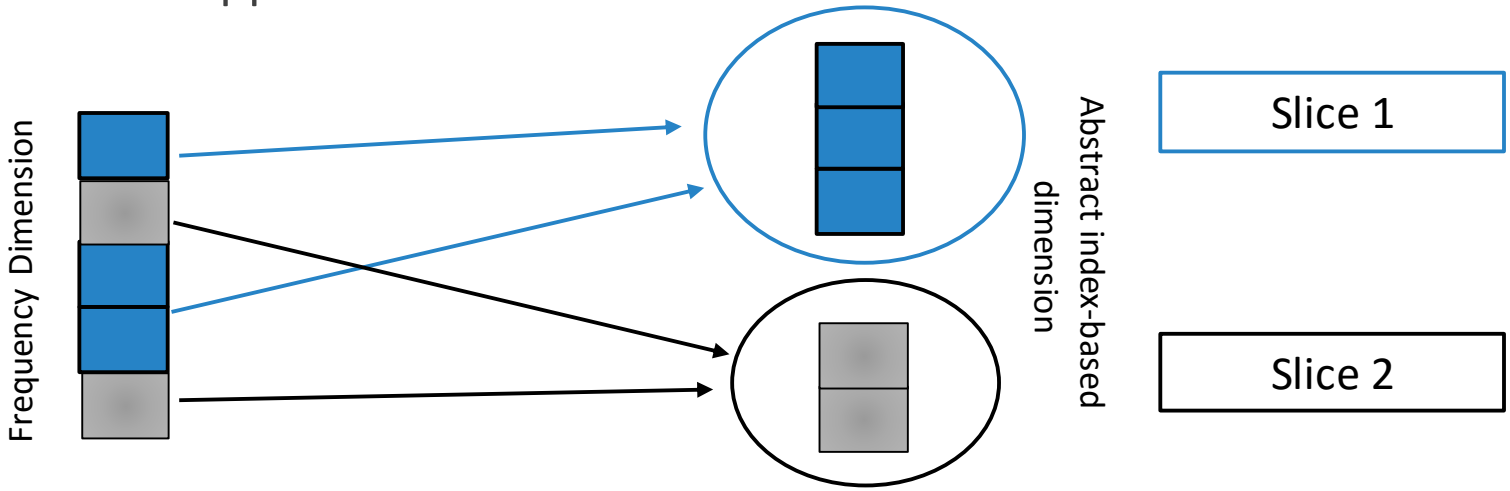
Dynamically partition resources to slices based on SLAs

- Omit resources not dedicated to a slice
  - Random Access and Broadcast handled by the physical base station

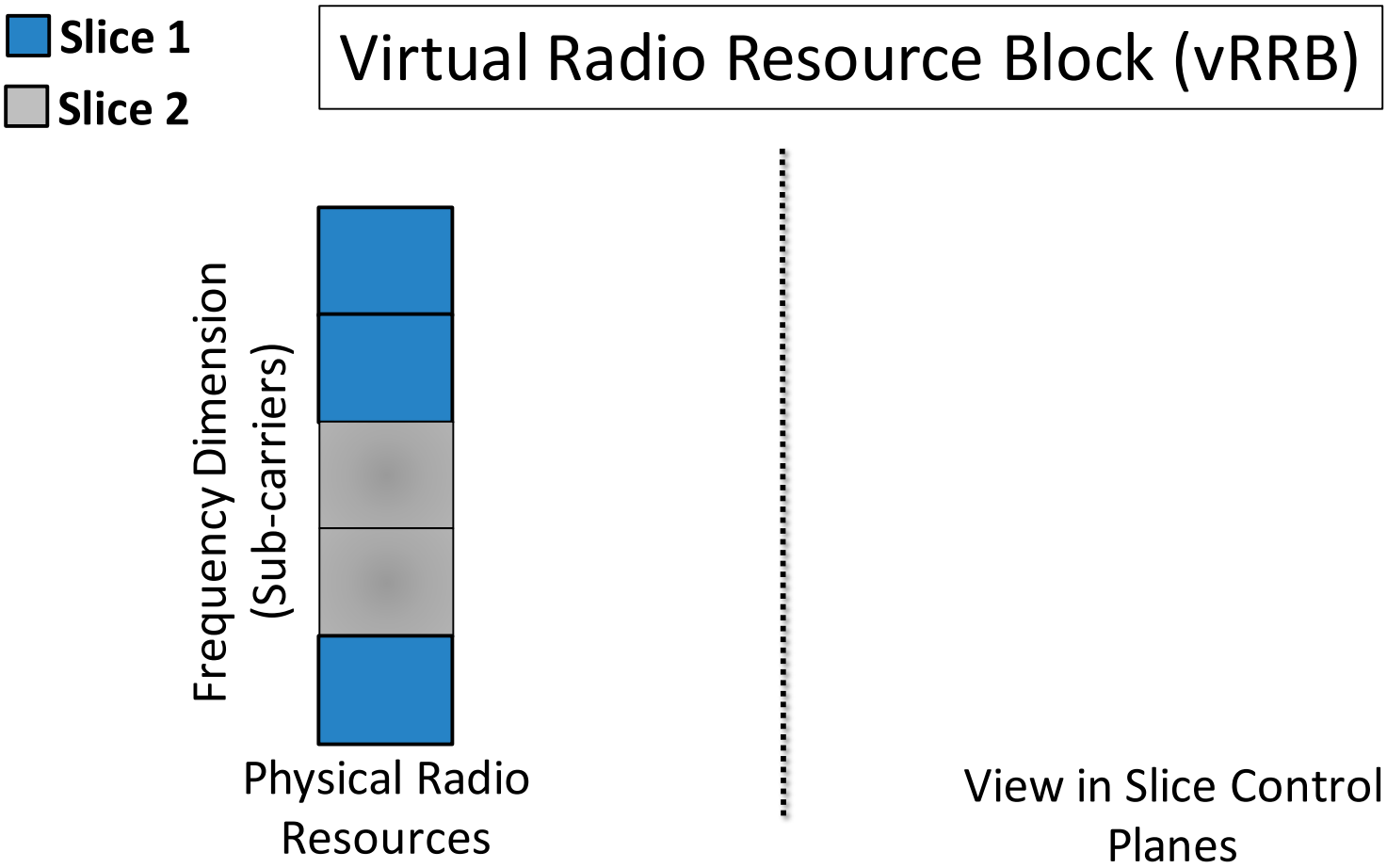
Abstract the frequency dimension

- Inference and manipulation of resources from competing slices is prevented

Generic and applicable to different OFDM-based RATs



Virtualizing the radio resources



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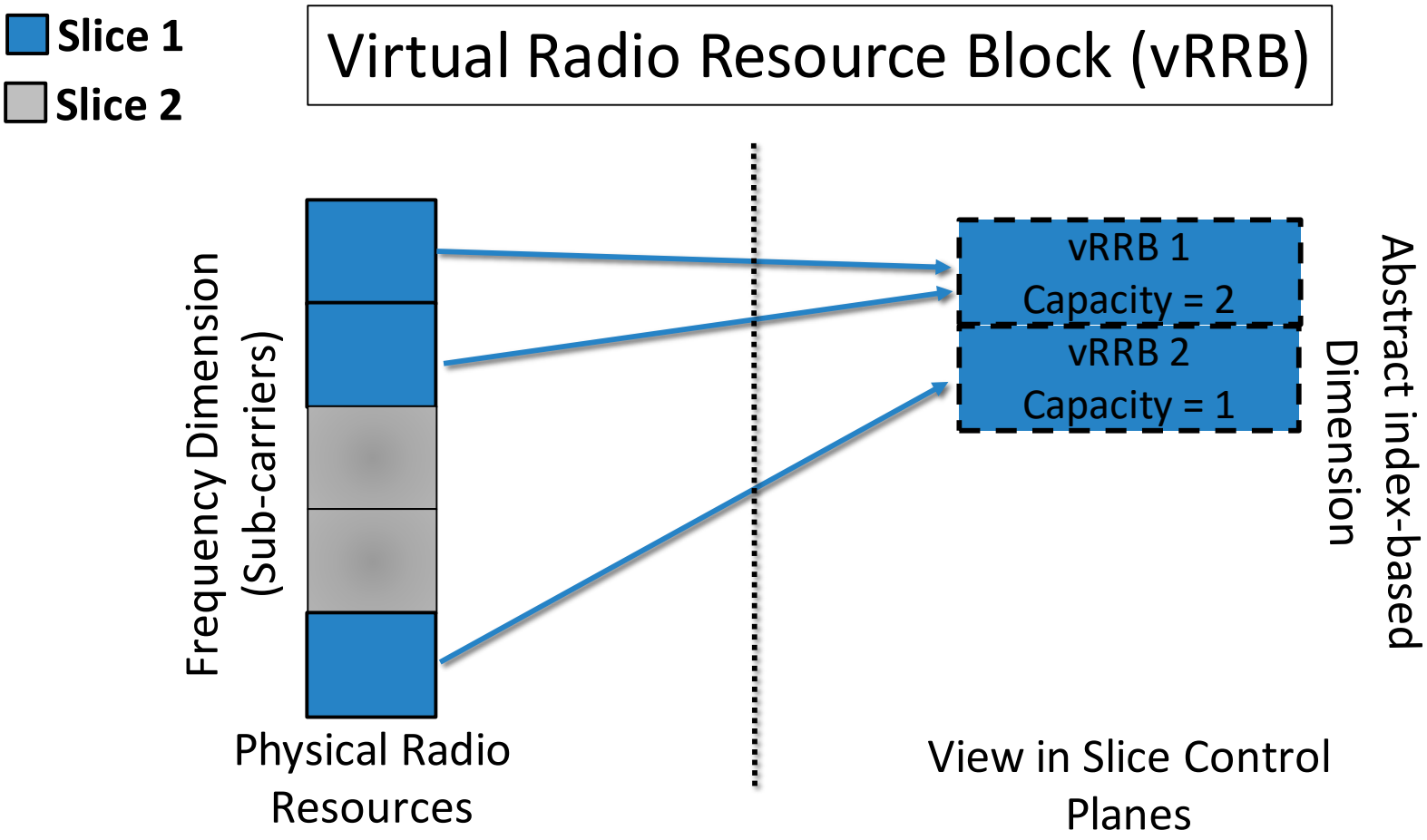

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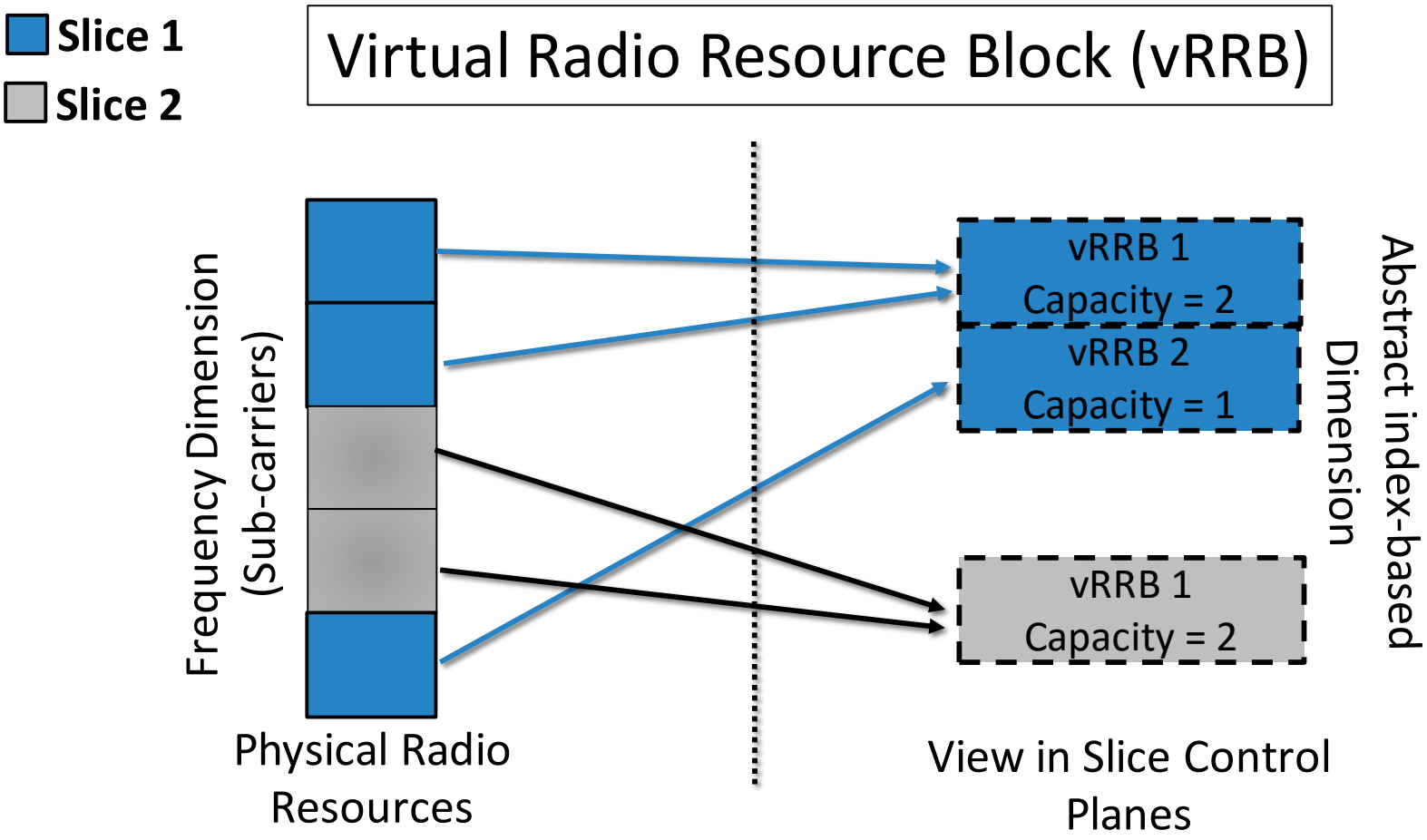

Virtualizing the radio resources

Physical radio resources (and vRRBs) **cannot** always be used in all combinations for the scheduling of a UE

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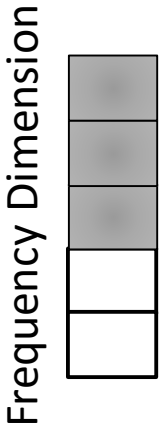
e.g. UL scheduling in LTE



Valid resource allocation (contiguous allocation)

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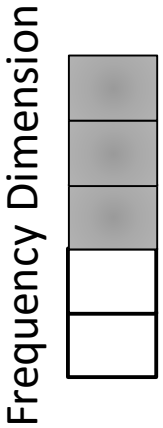

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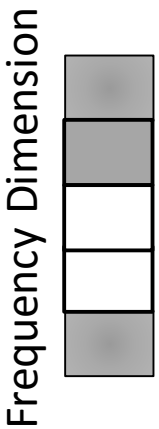

Invalid resource allocation (non-contiguous)

Virtualizing the radio resources

Physical radio resources (and vRRBs) **cannot** always be used in all combinations for the scheduling of a UE

Problem for slice control plane when abstracting the frequency dimension

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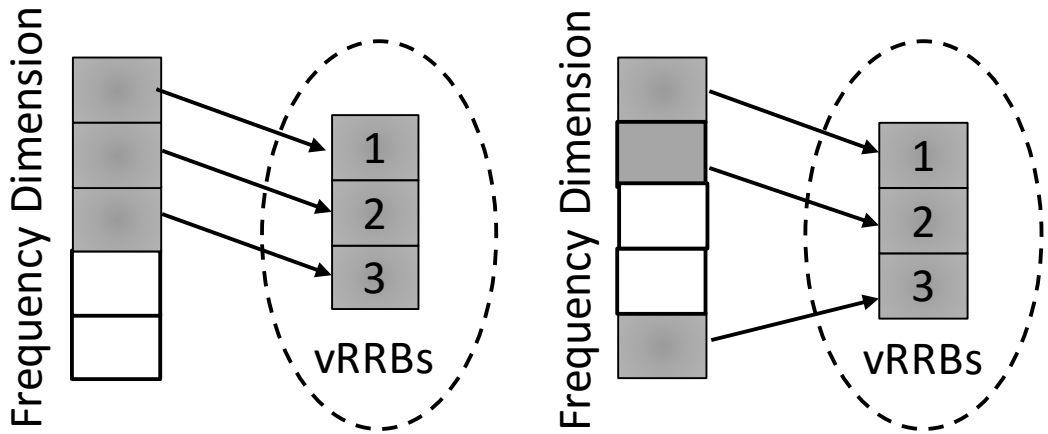

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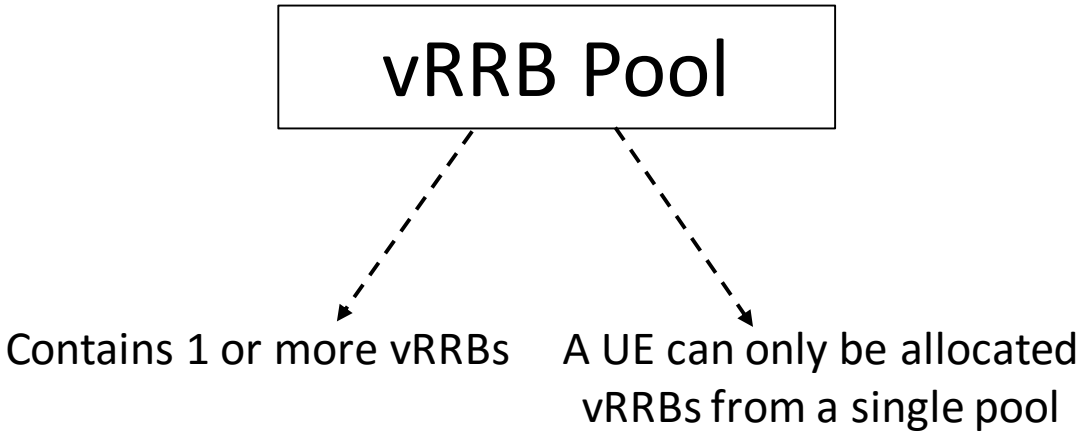

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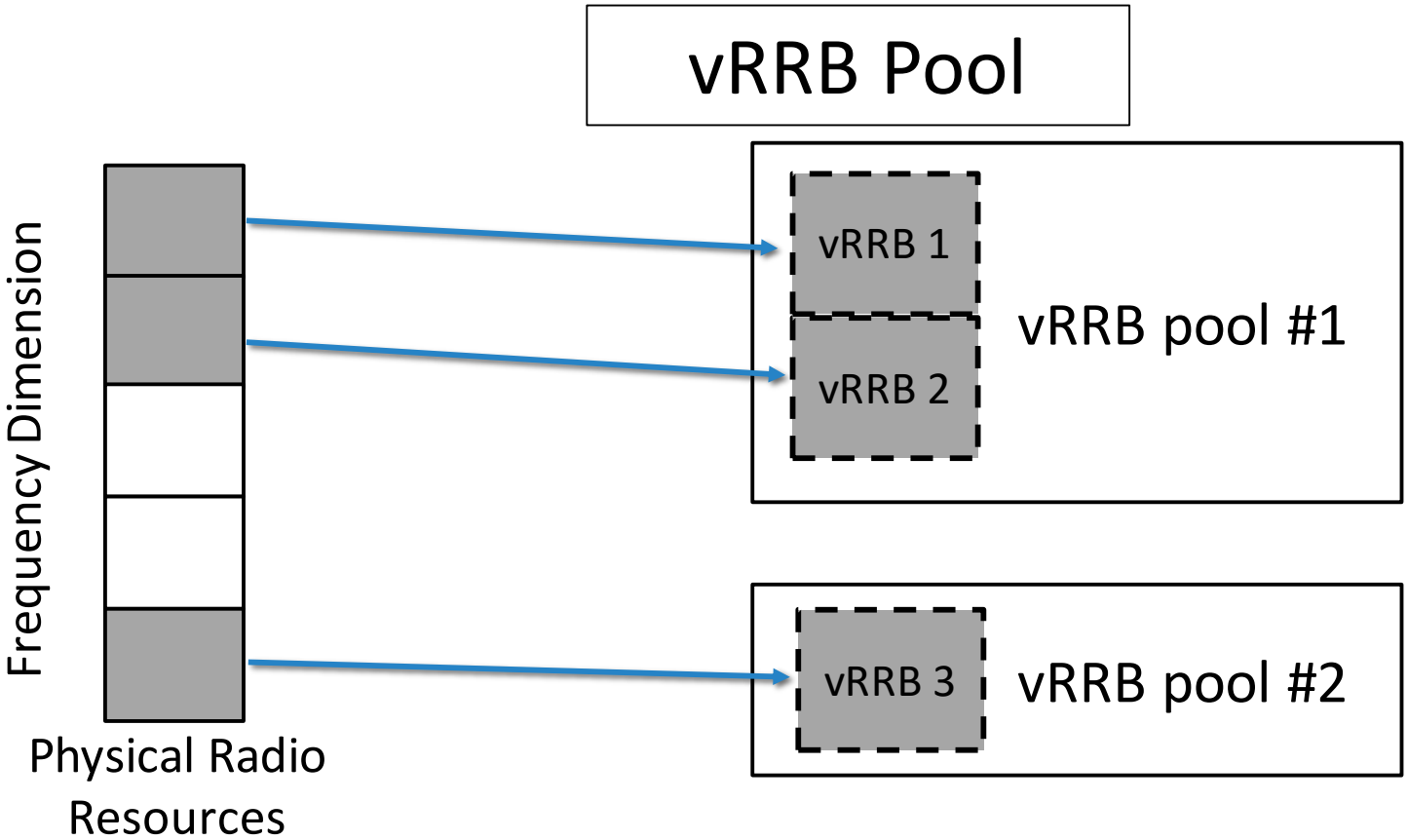
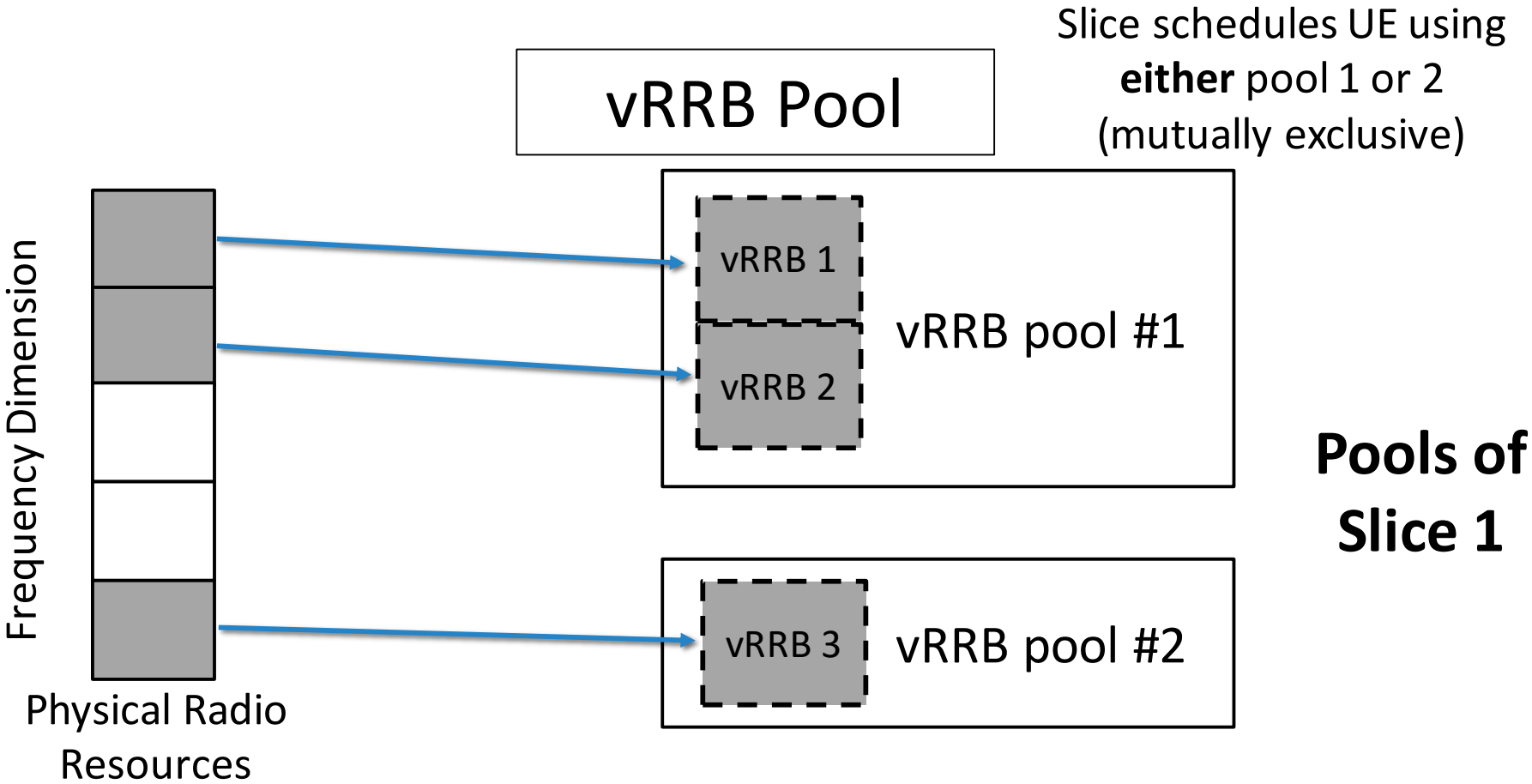
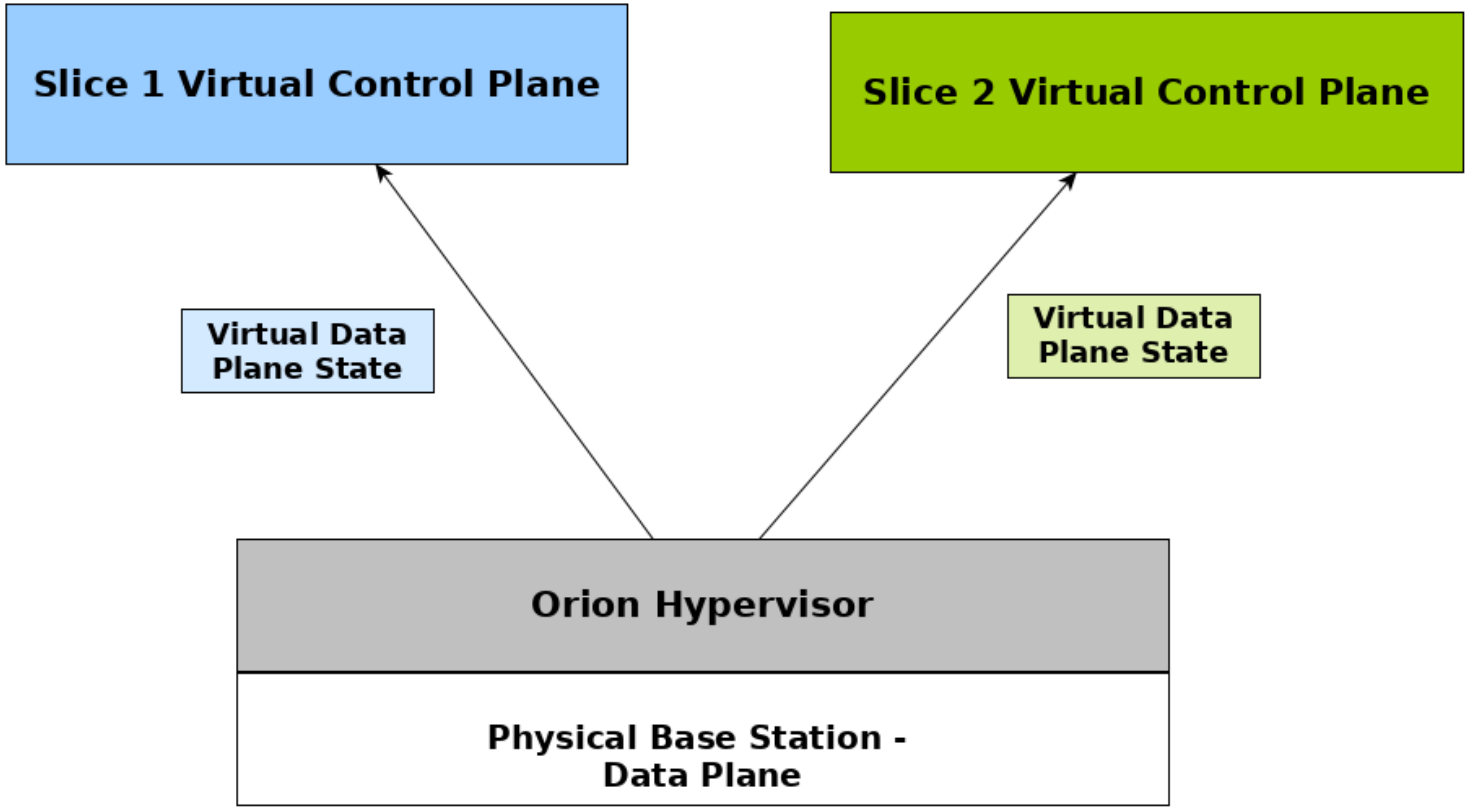


Pools of Slice 1

Virtualizing the radio resources



Virtualizing the data plane state



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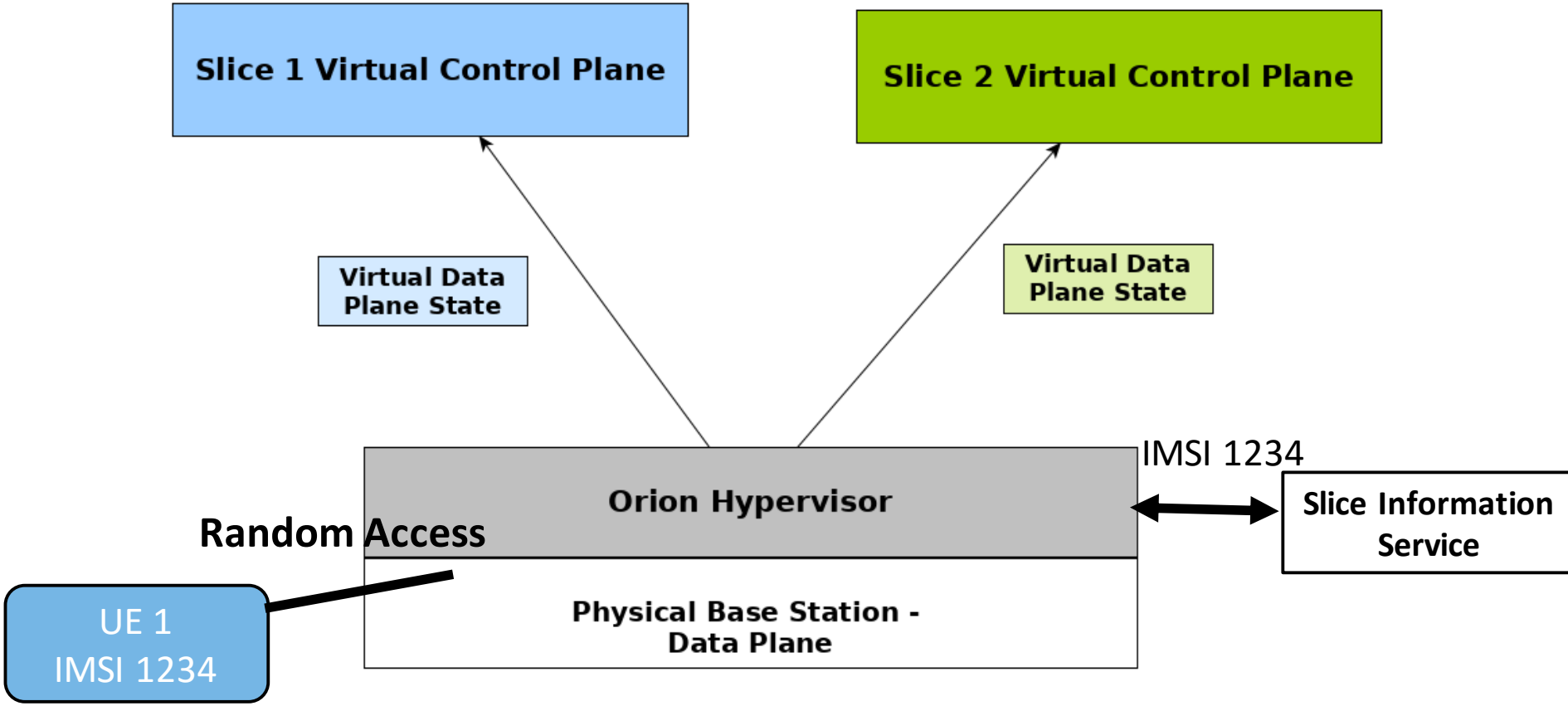

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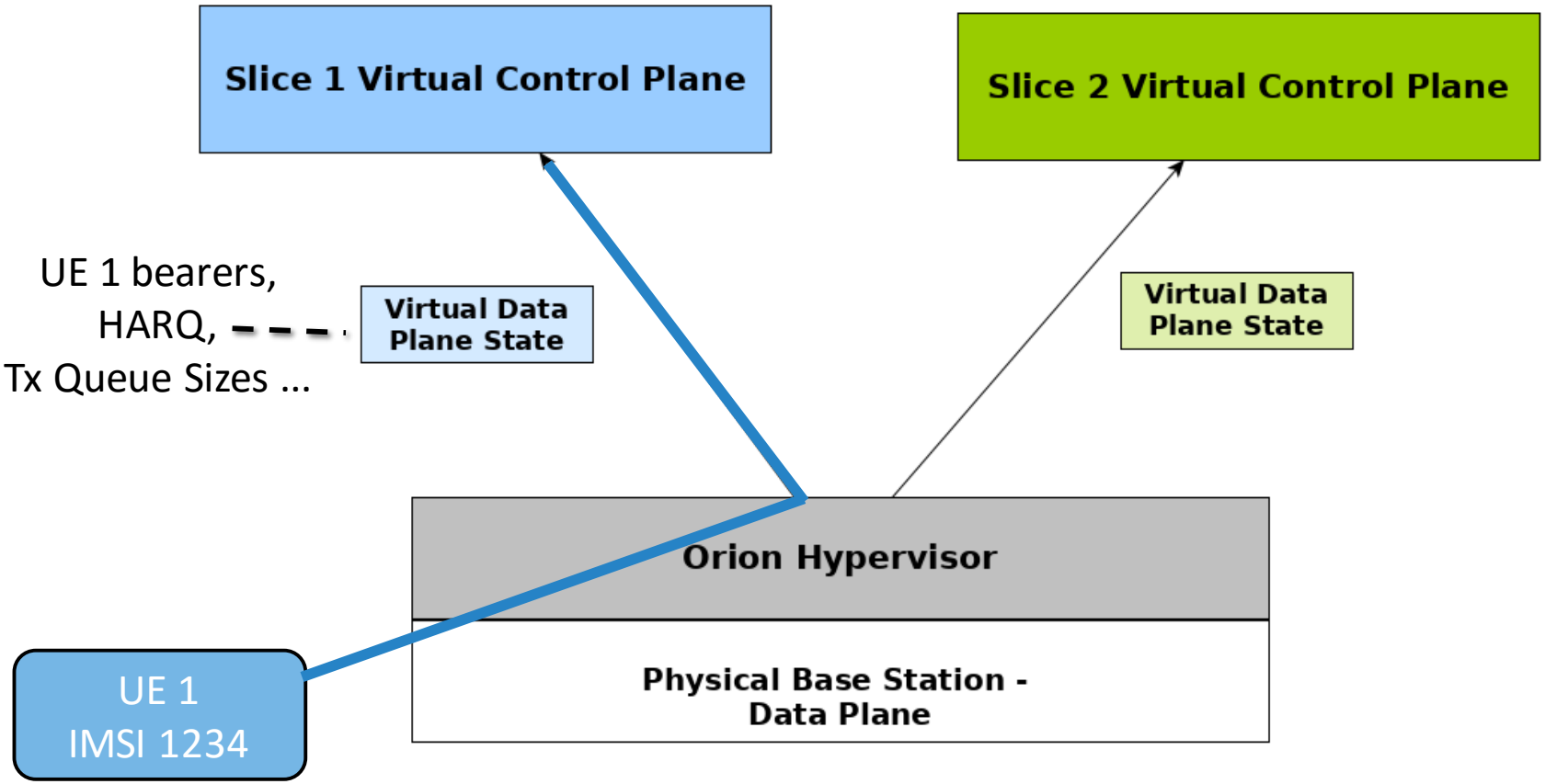

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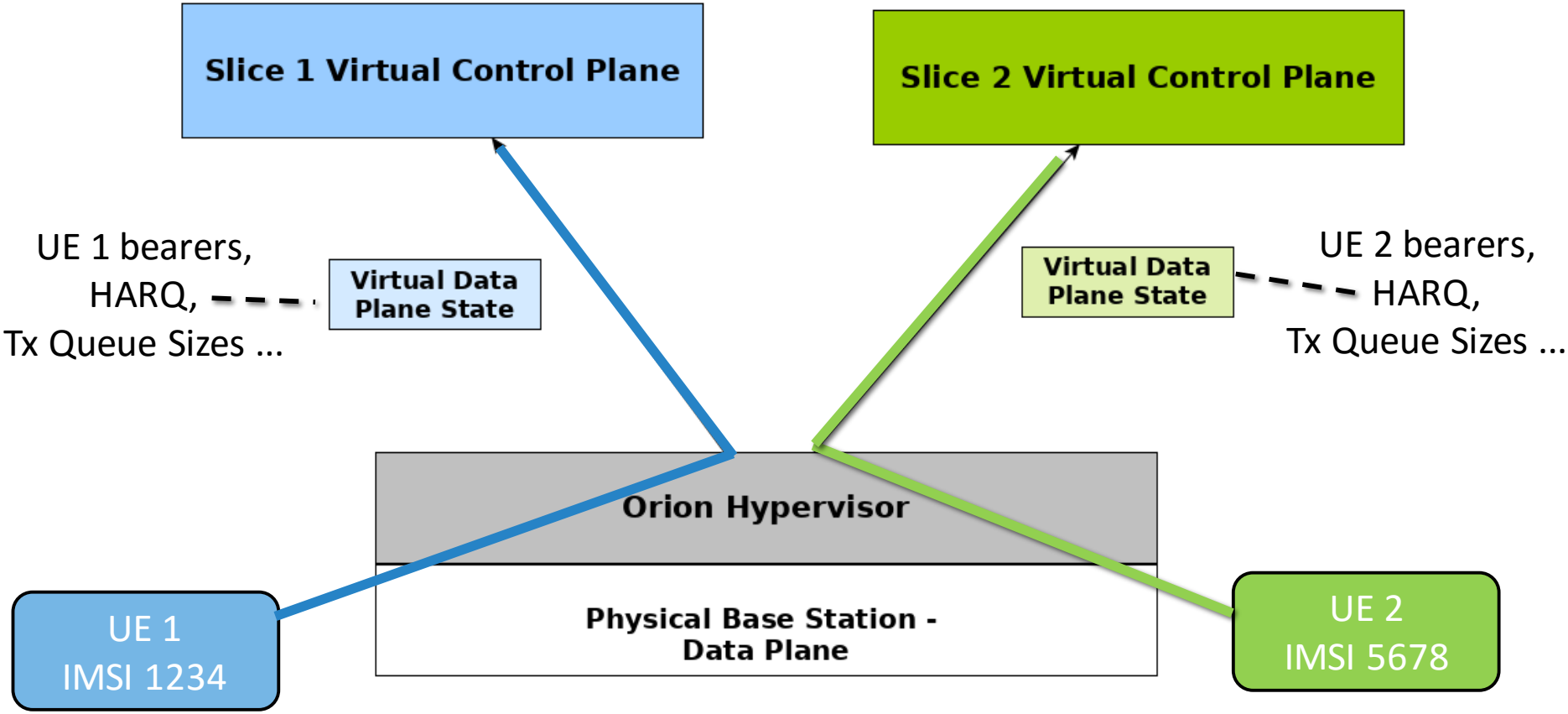
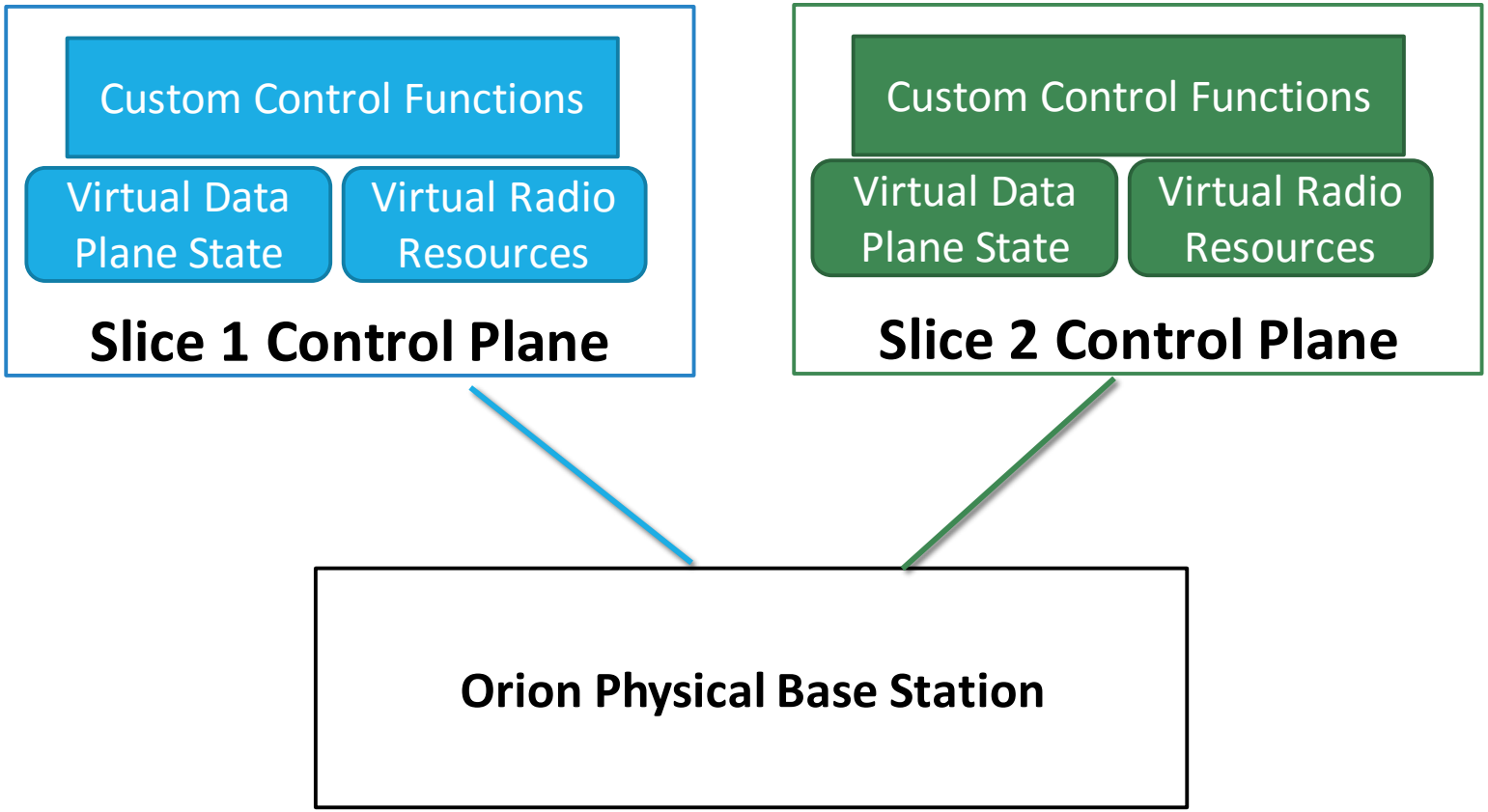


Slice Isolation



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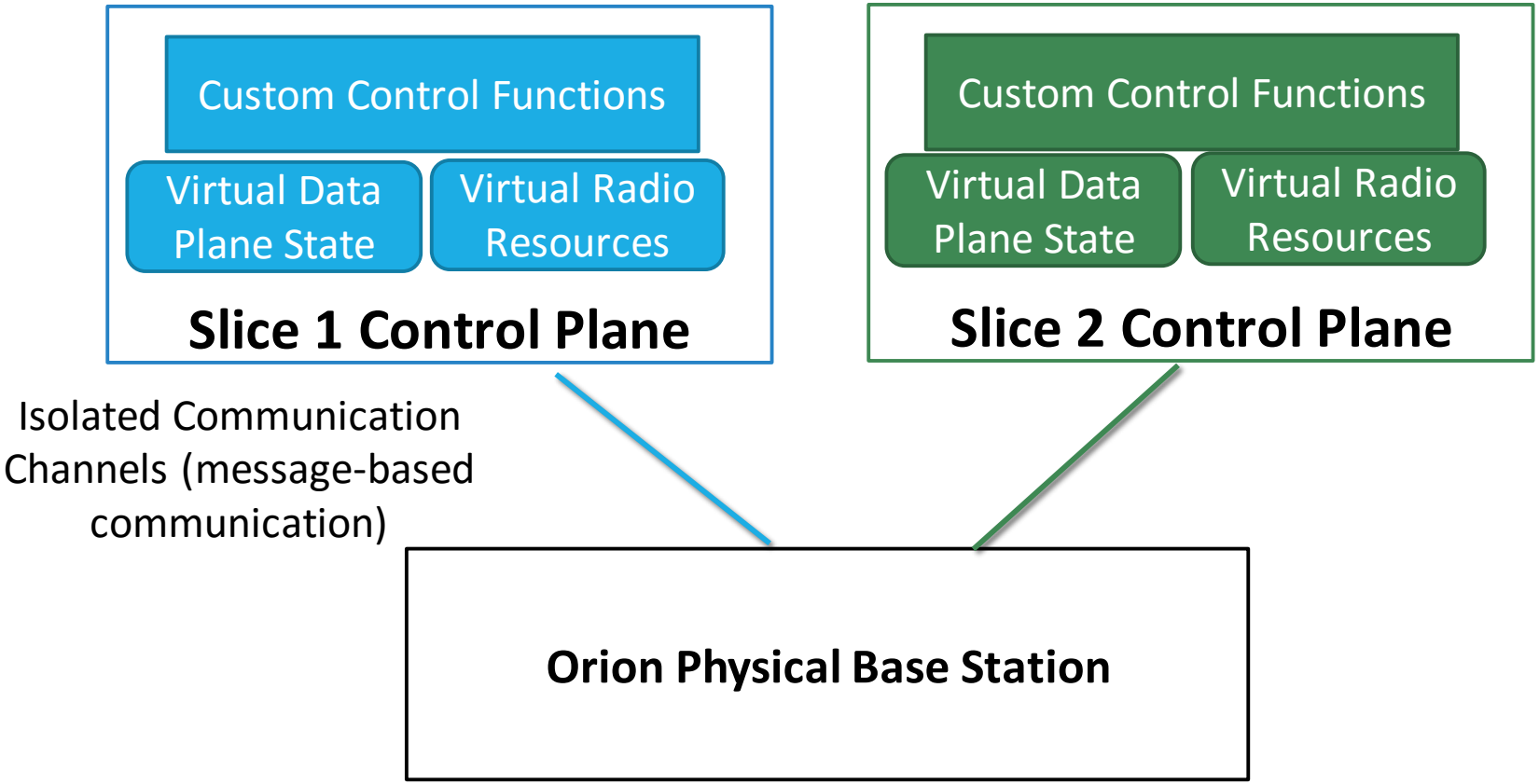

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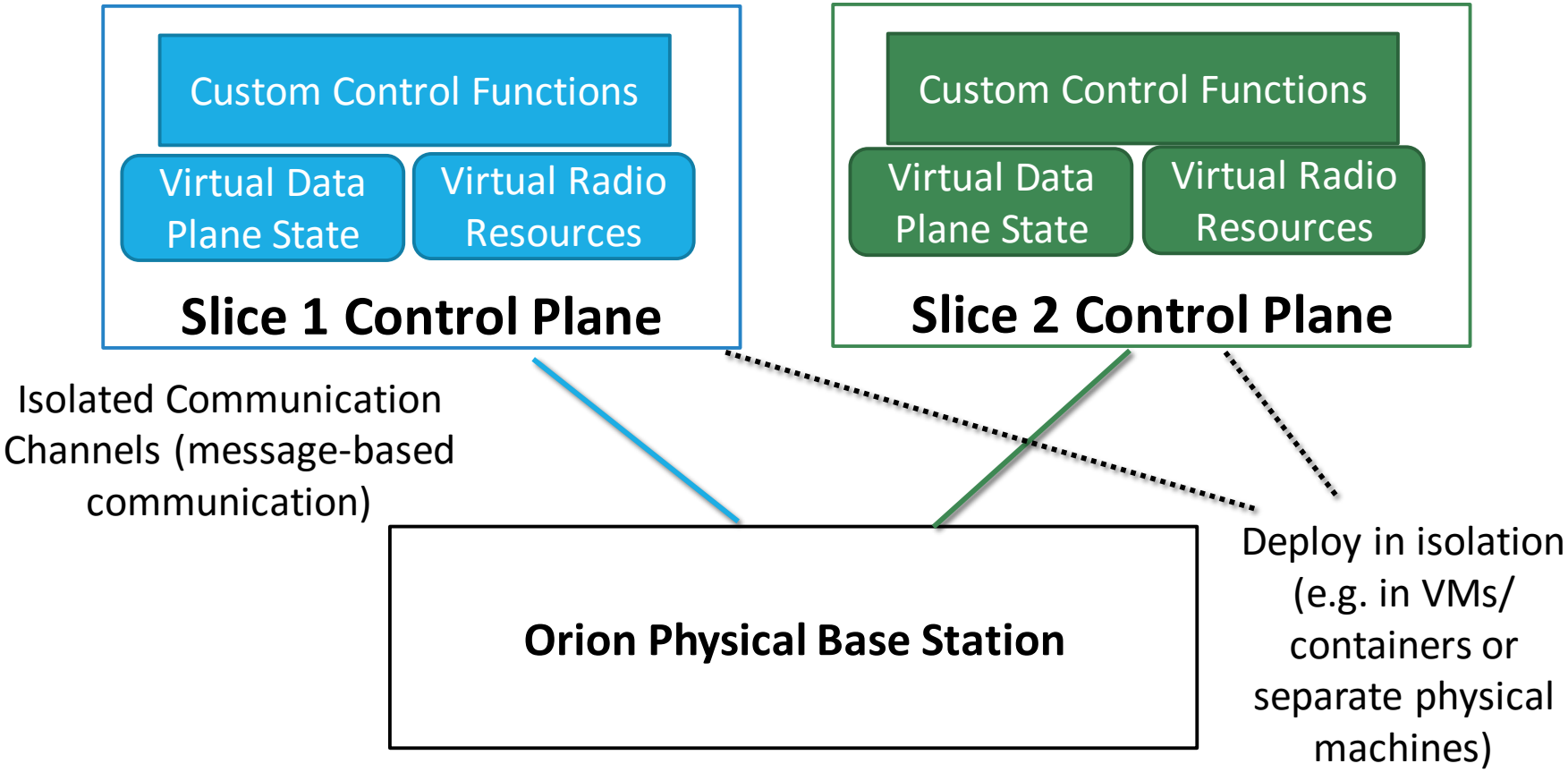
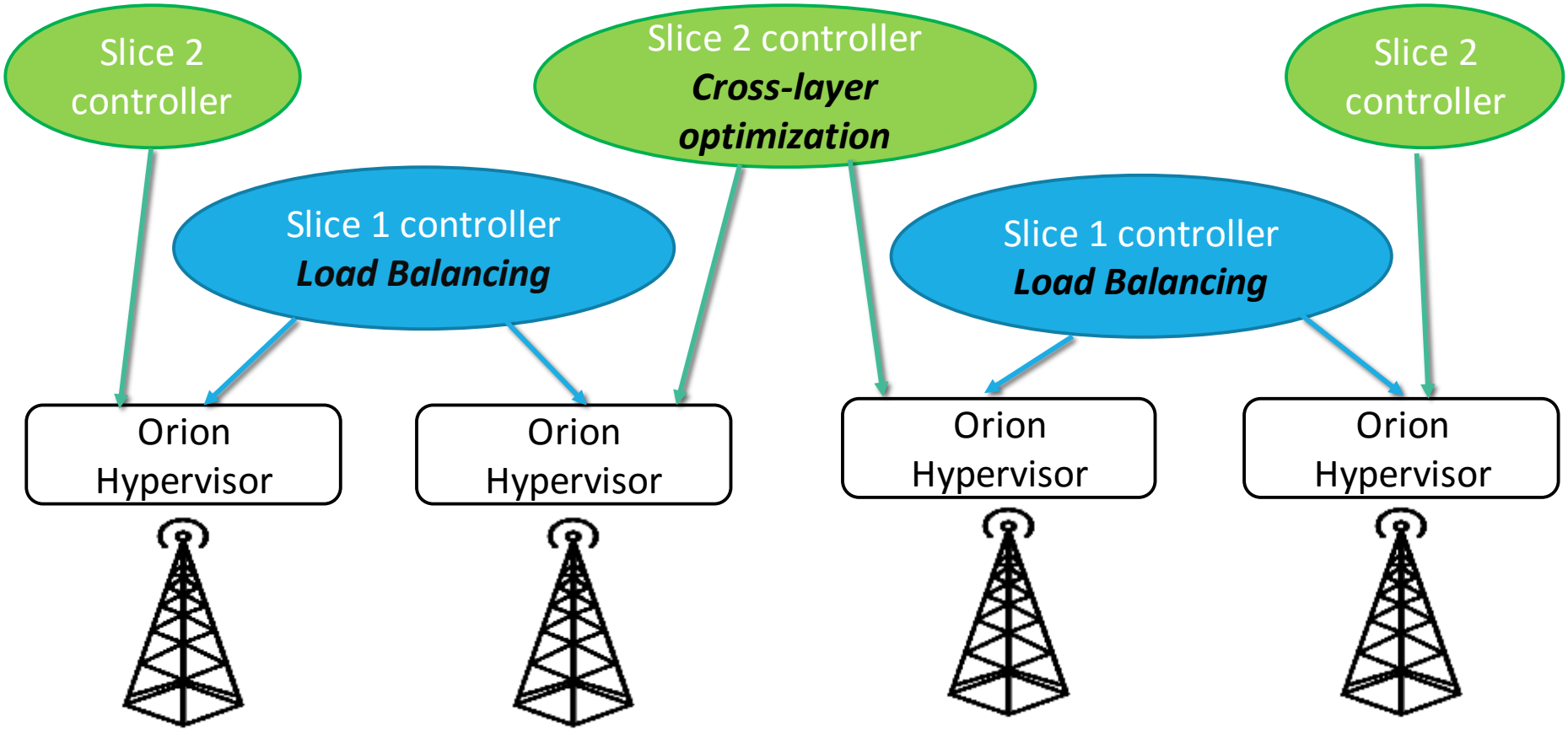


Slice Flexibility/Configurability

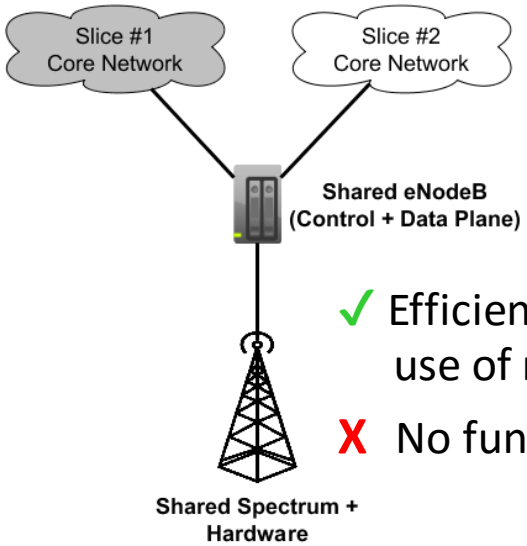


Orion Implementation

Implemented over OpenAirInterface open source LTE platform

- Implemented Hypervisor component from scratch
- Modified code to capture information relevant to mapping of UEs to slices and to support multiple core networks over the same eNodeB
- Employed FlexRAN SD-RAN platform for separation of control & data plane
- Modified FlexRAN protocol and controller for support of virtualized radio resource abstraction

Evaluation



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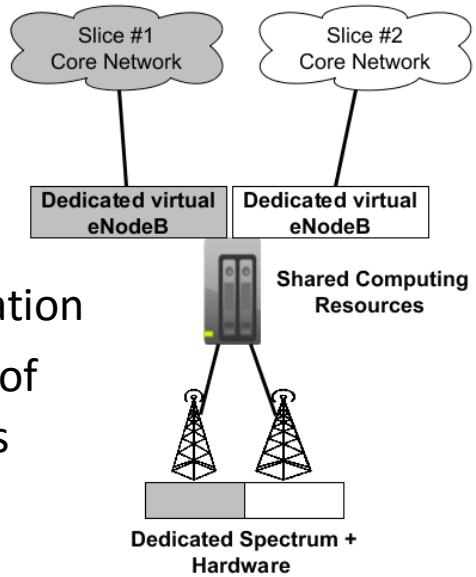


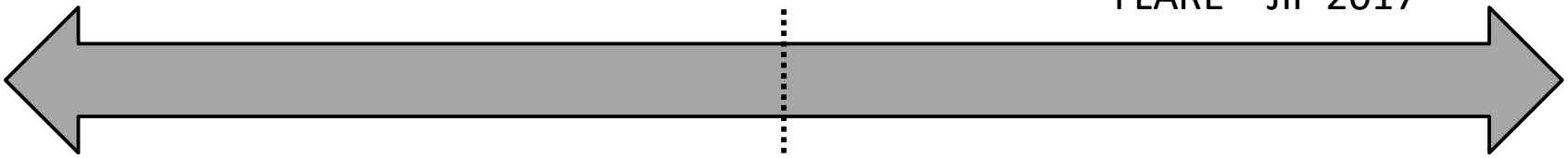
RAN Sharing

FlexRAN use case – CoNEXT 2016

Orion

Full isolation

FLARE – JIP 2017



Evaluation

Scalability

Comparison with state-of-the-art

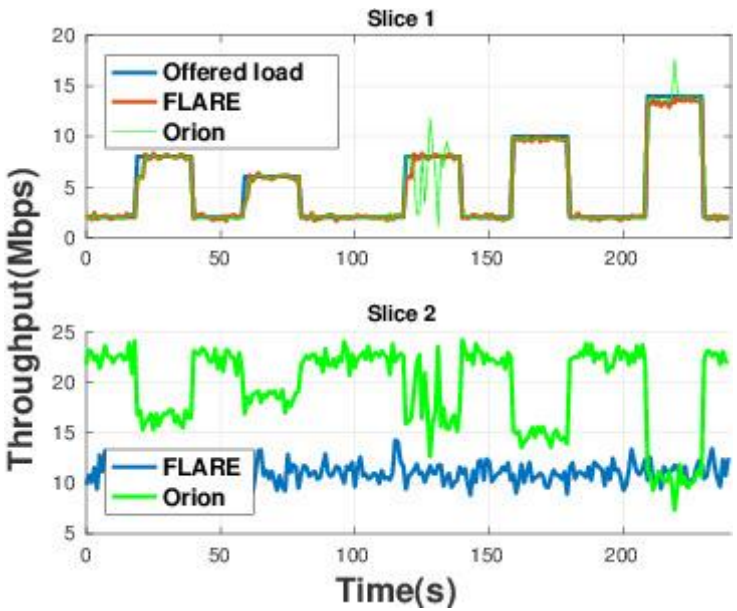
Impact of communication channel

Isolation capabilities

Flexible radio resource allocation

Deployment in an end-to-end setting

Flexible Radio Resource Allocation



FLARE with 2 slices, each with 5MHz of spectrum as baseline

Orion with 2 slices and a pool of 10MHz of spectrum

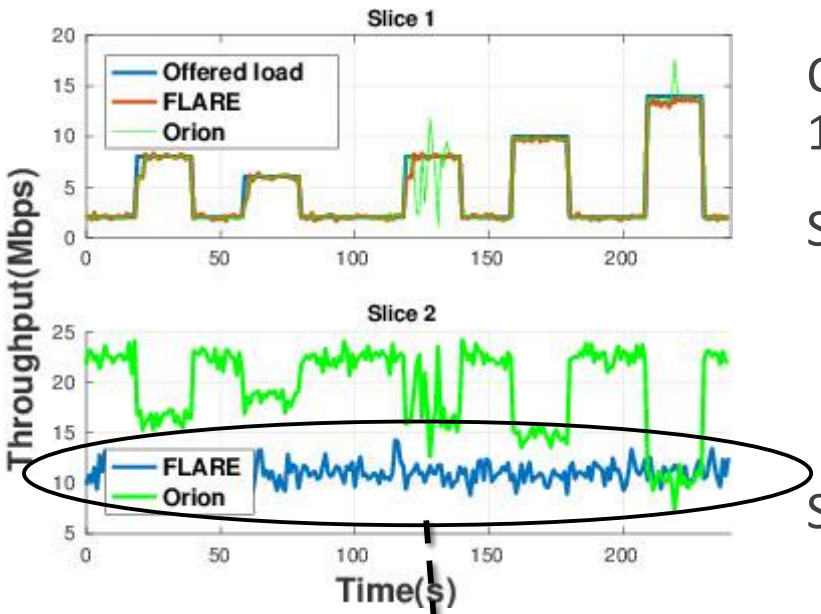
Slice 1:

- Constant TCP flow of 2Mbps
- Sporadic short-lived TCP flows with various rates (4-12Mbps)

Slice 2:

- UEs streaming DASH videos supporting multiple bitrates

Flexible Radio Resource Allocation



UEs in FLARE retain the same video bitrate

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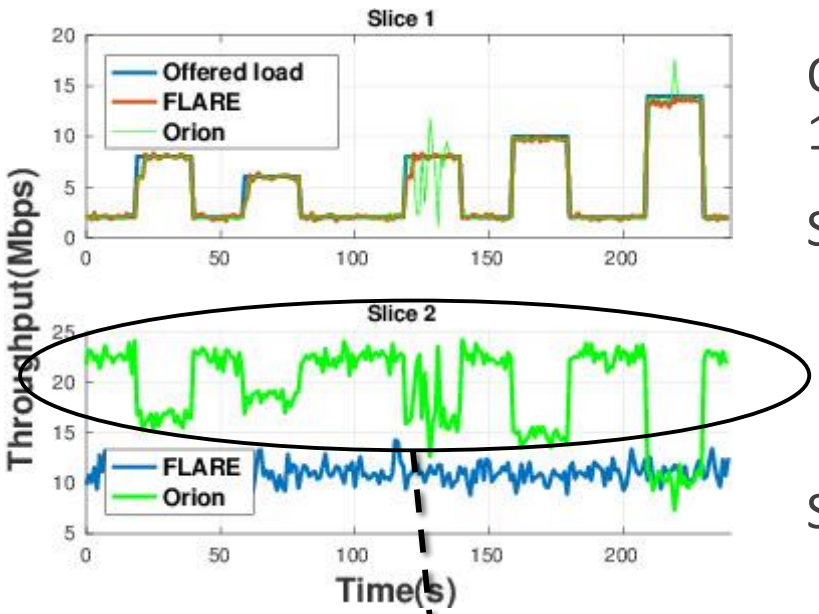

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Slice 2:

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Orion slice 2 borrows unused resources from slice 1

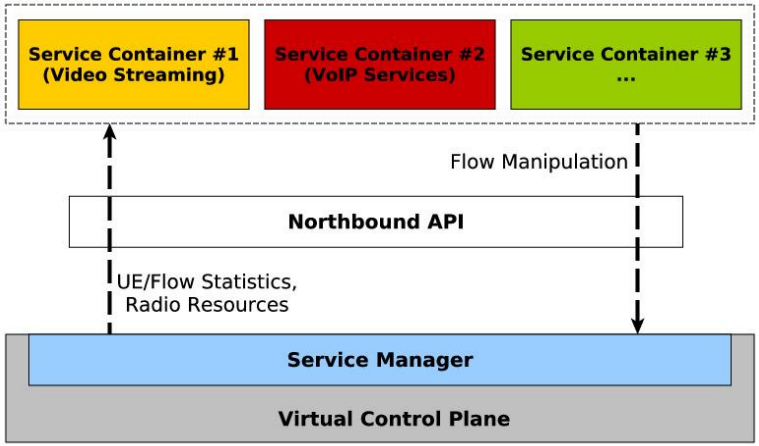
Multi-Service Slice Extension

Orion assumes 1:1 relationship between UE and slice

- Good for MVNOs and verticals
- Limited for multi-service environment (e.g. MVNO with OTTs)

Orion service container extension

- Real-time control capabilities for OTT applications



Conclusions

Orion RAN Slicing System

- A lightweight and flexible RAN virtualization solution
- Deployment in an end-to-end setting
- Multi-Service slice extensions for support of OTT service providers

Future Work

- Support for functional splits to enable RAN-as-a-Service(RaaS) paradigm
- Multi-RAT support