SDN-based Mobile Networking for Cellular Operators

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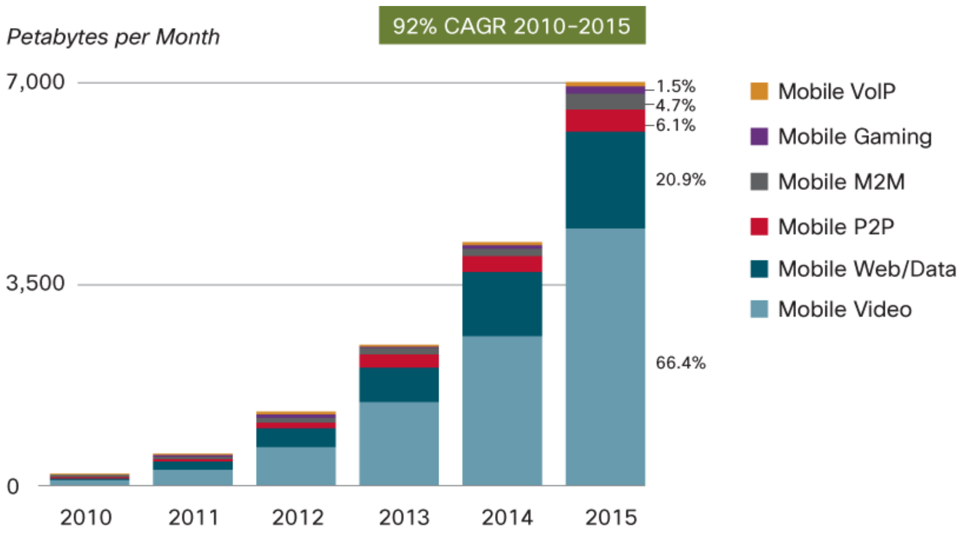
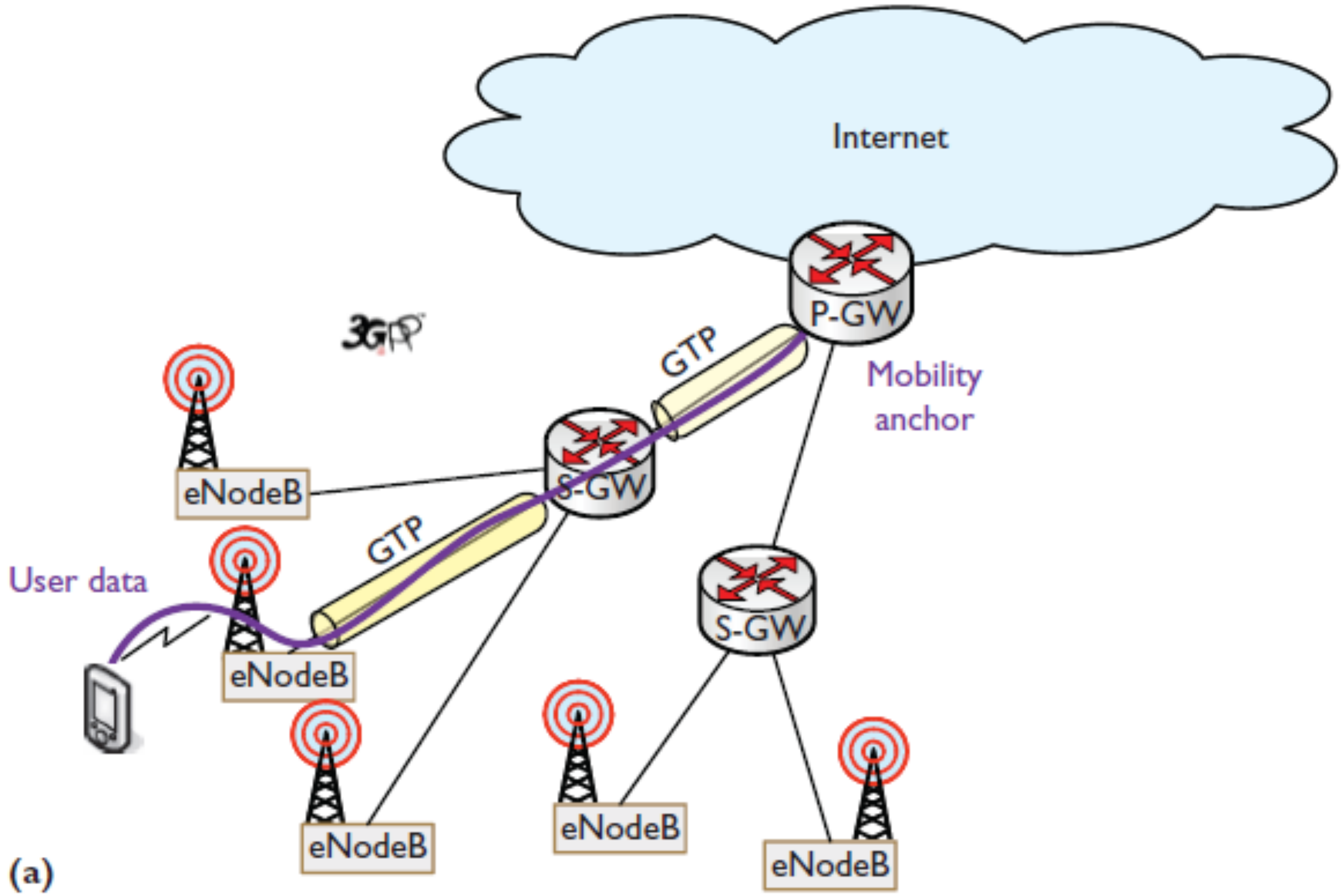
Background

- The data explosion currently we're facing with has a serious impact on current cellular networks that are highly centralized



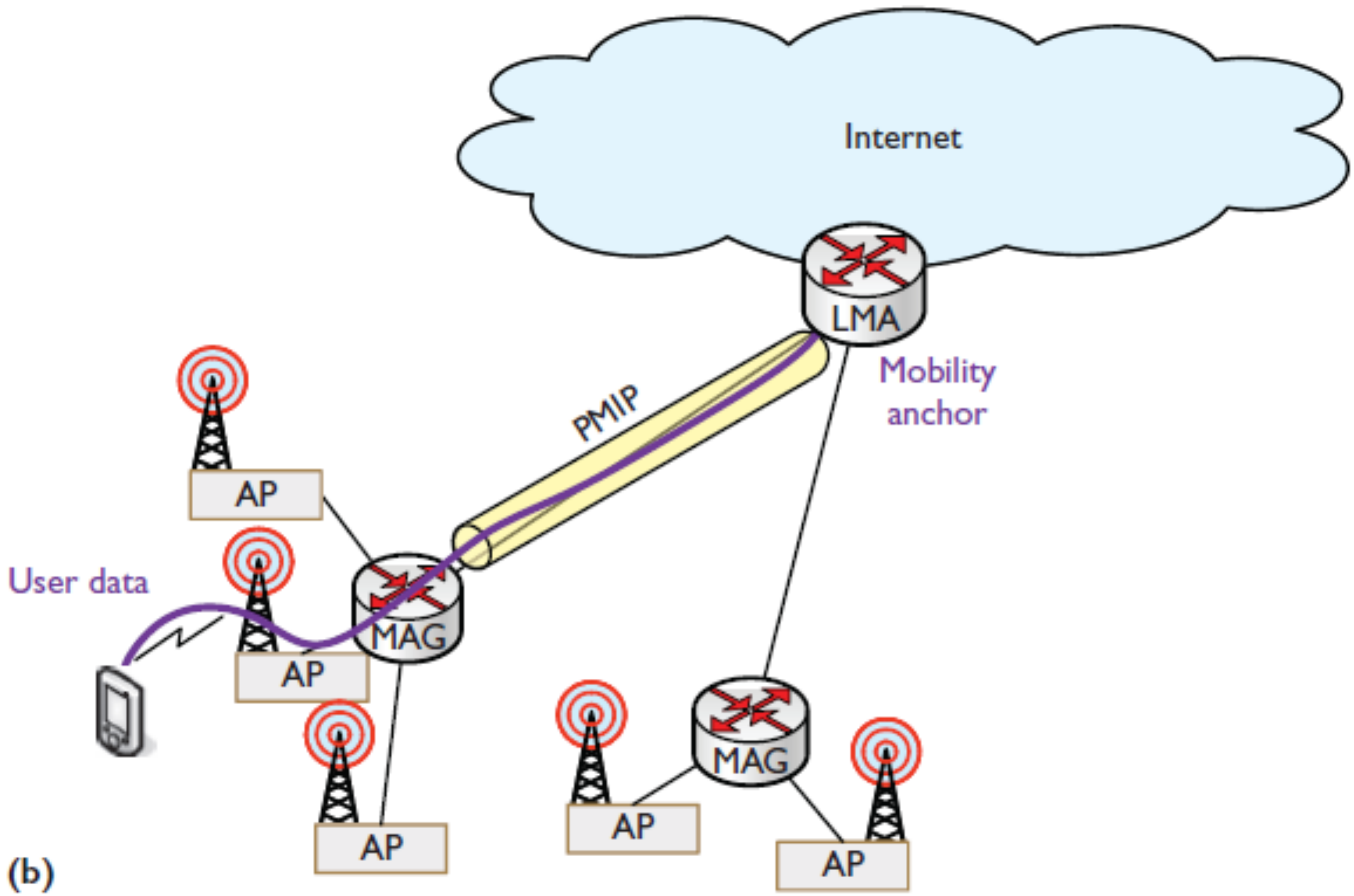
VoIP traffic forecasted to be 0.4% of all mobile data traffic in 2015.
Source: Cisco VNI Mobile, 2011

Current mobile architecture deployed (3GPP-based)



- K. Pentikousis and P. Bertin, “Mobility management in infrastructure networks,” IEEE Internet Computing, vol. , no. , pp. ,

Current mobile architecture deployed (IP-based)



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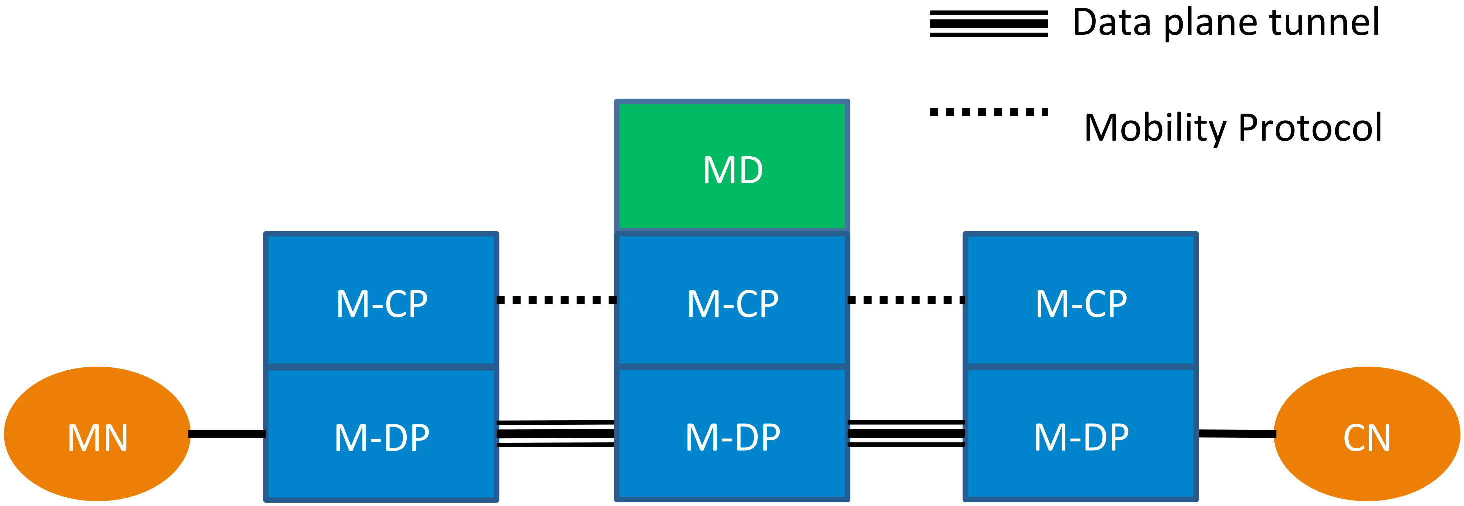
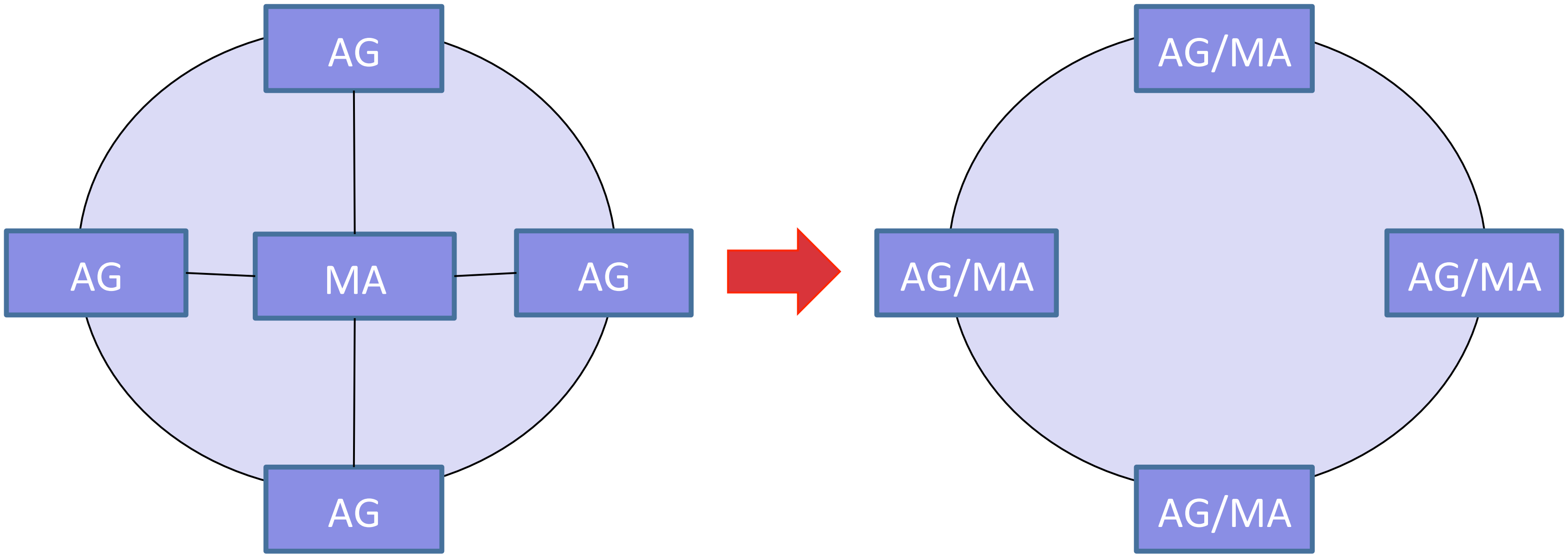
Centralized mobility management architecture

- M-CP: Mobility Control Plane
- M-DP: Mobility Data Plane



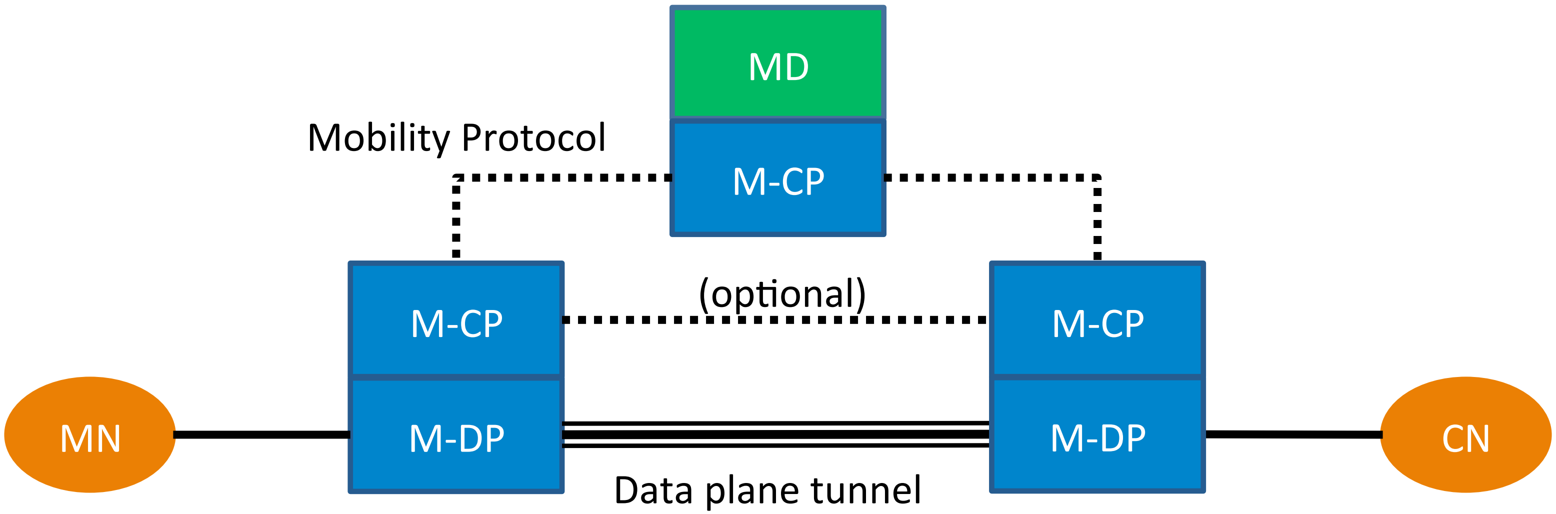
Distributed mobility management architecture

- A key idea is to distribute mobility anchor functions into the edges

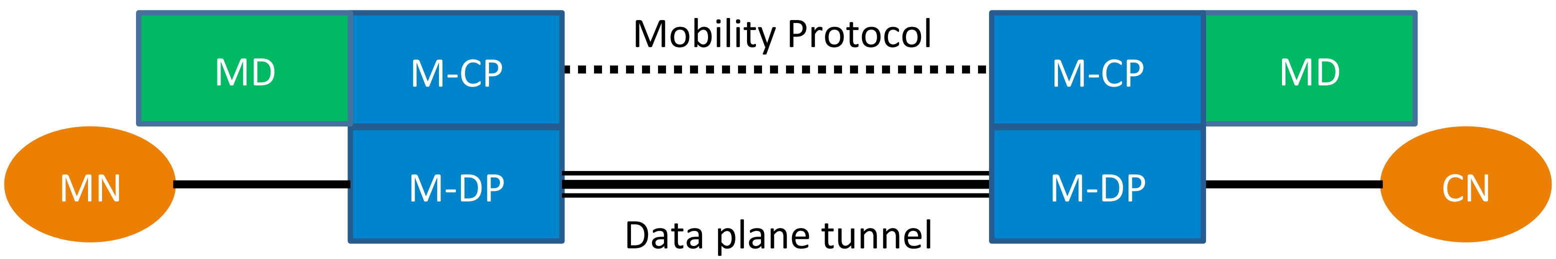


  - Access Gateway (AG), Mobility Anchor (MA)

Distributed mobility management architecture



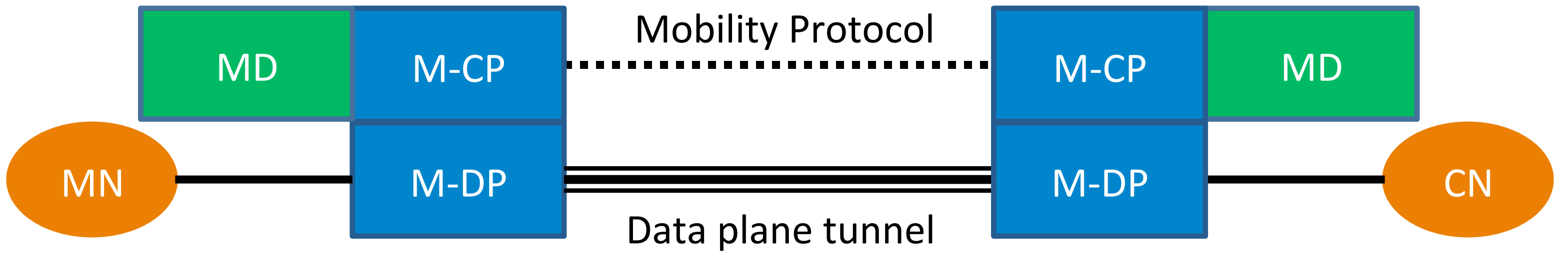
(a) Partially-distributed



(b) Fully-distributed

Distributed mobility management architecture

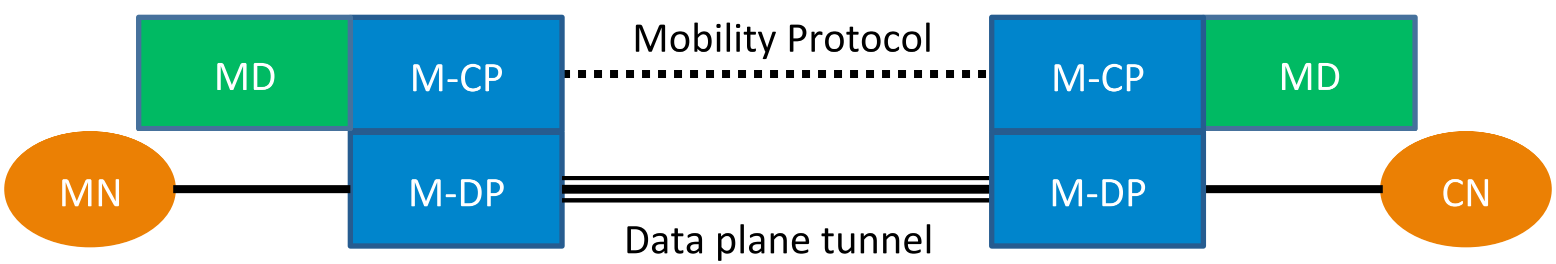
- The partially-distributed model could be seen quite reasonable
- But the control plane distribution in fully-distributed model, e.g. using peer-to-peer (P2P) approach is still yet convinced in terms of reliable operation support



(b) Fully-distributed

Distributed mobility management architecture

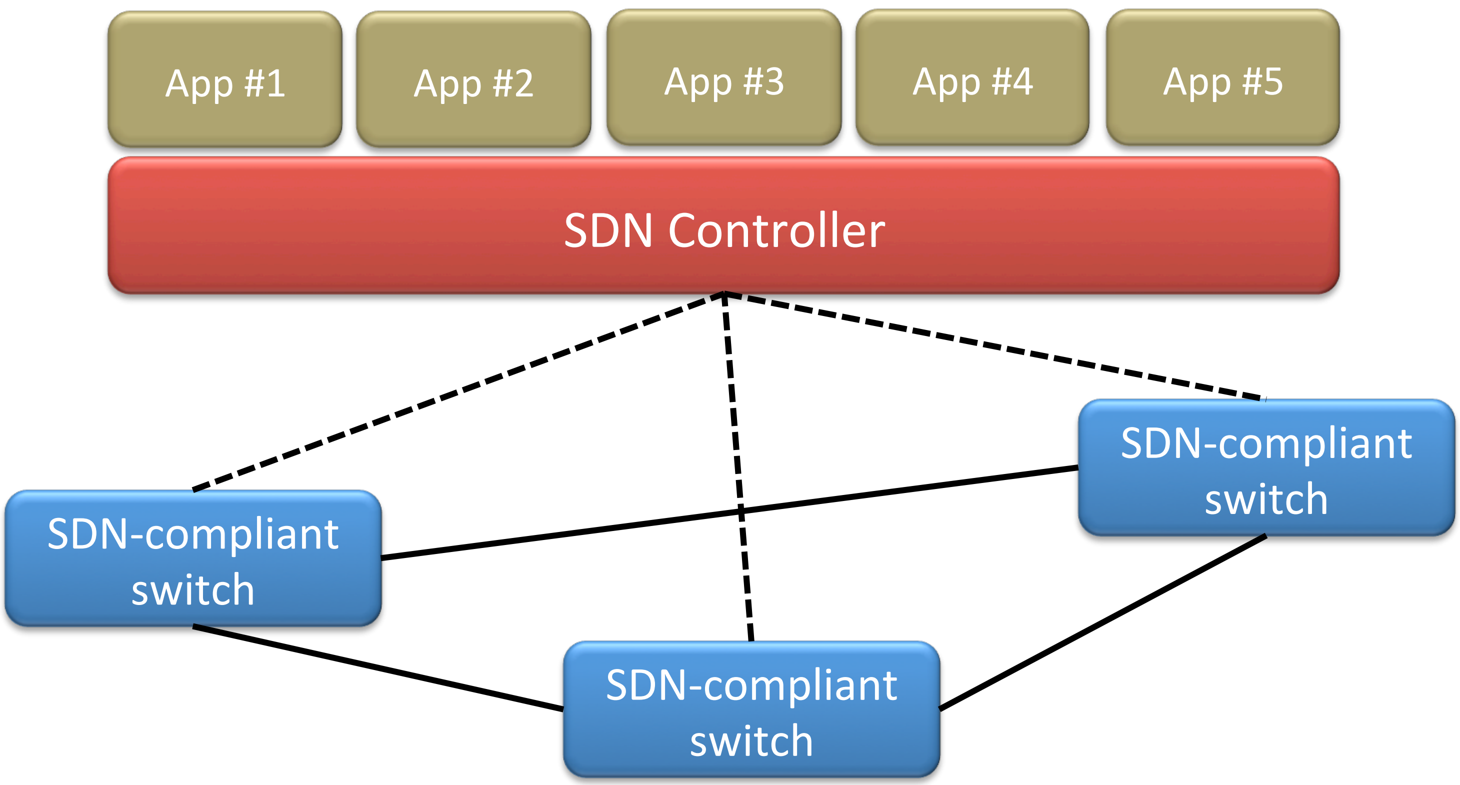
- A large volume of control signaling for managing distributed mobility database
- Could be hard to enforce network policies
- Still remains low flexibility and vulnerability for effective network operations



(b) Fully-distributed

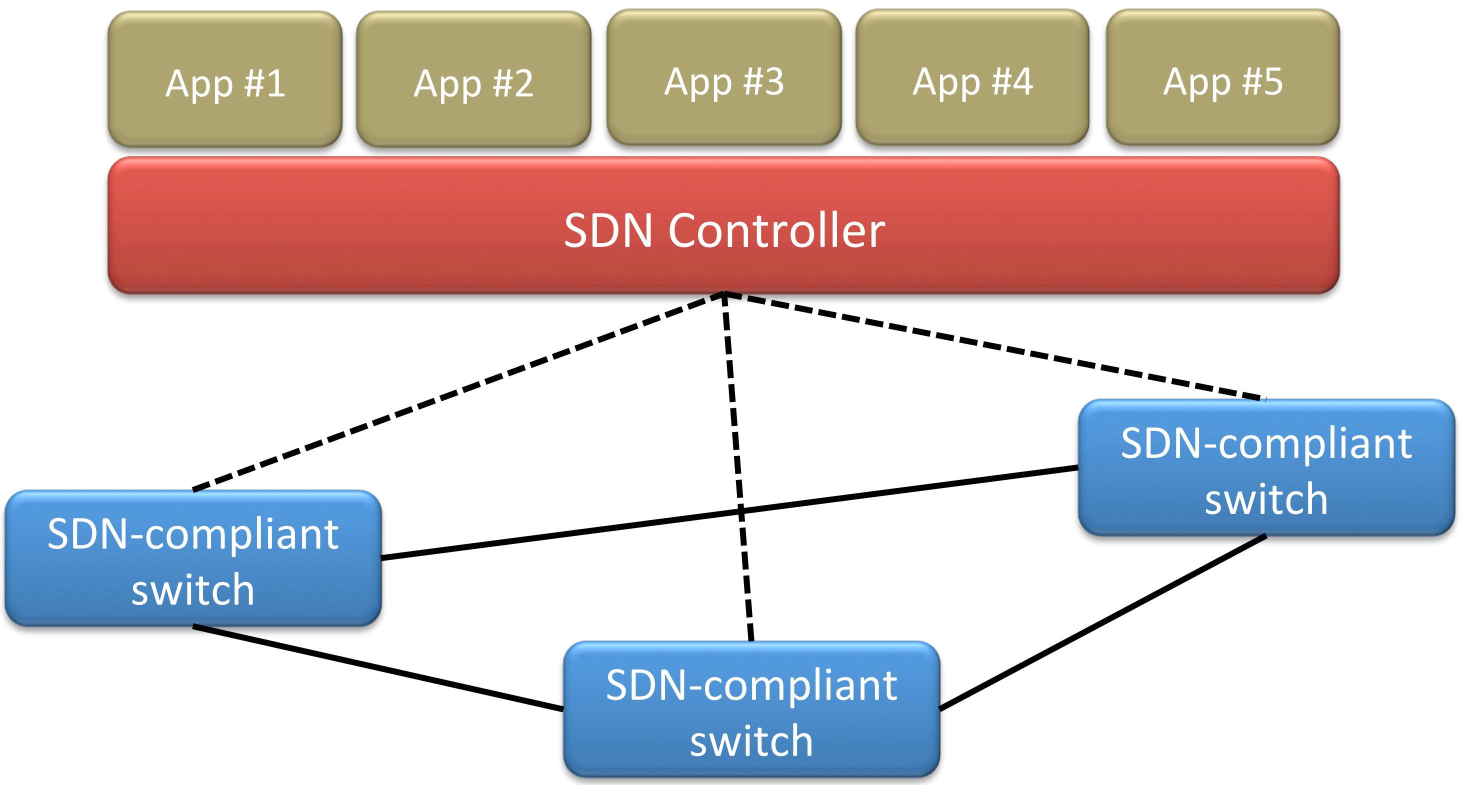
Software-Defined Networking (SDN)

- The control and data planes are decoupled
- Network intelligence and state are logically centralized



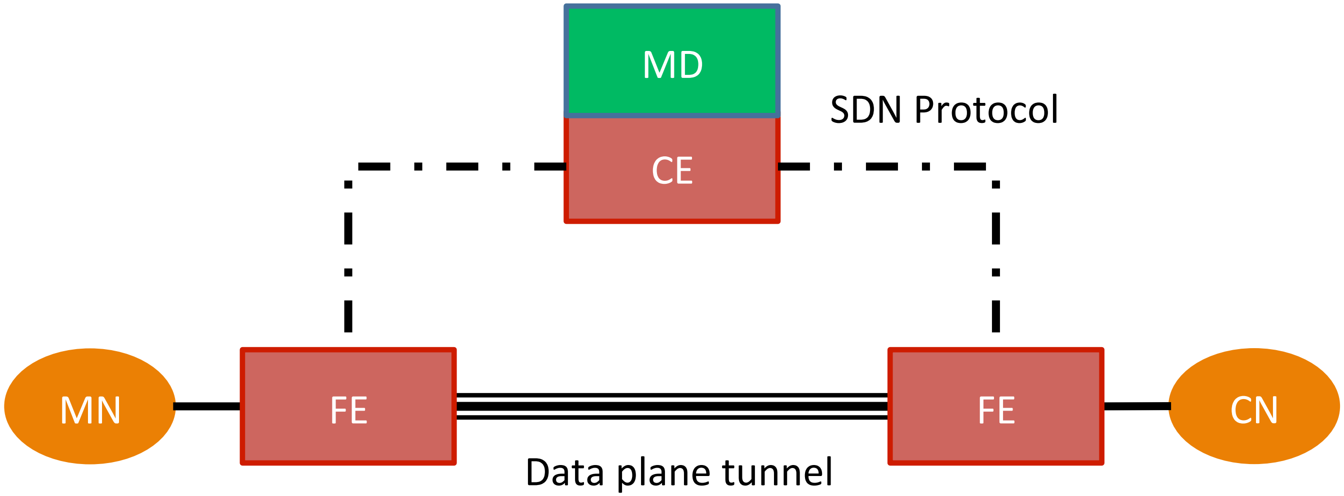
Software-Defined Networking (SDN)

- The underlying network infrastructure is abstracted from the applications, thus greatly simplifying network design and operations



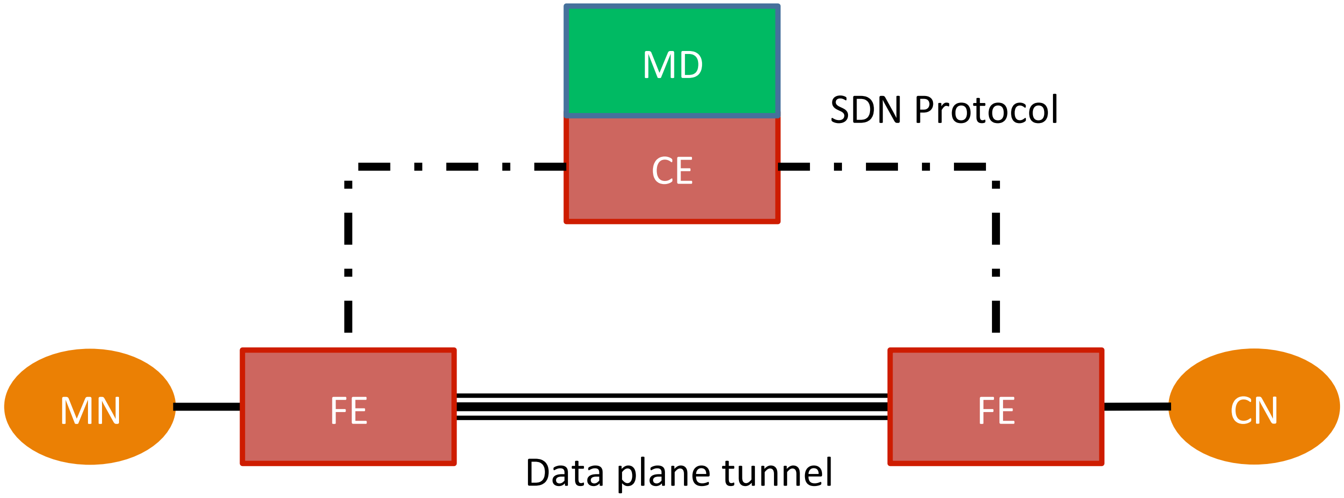
SDN-based mobile network architecture

- Fully-separated control plane: a new paradigm on progressing



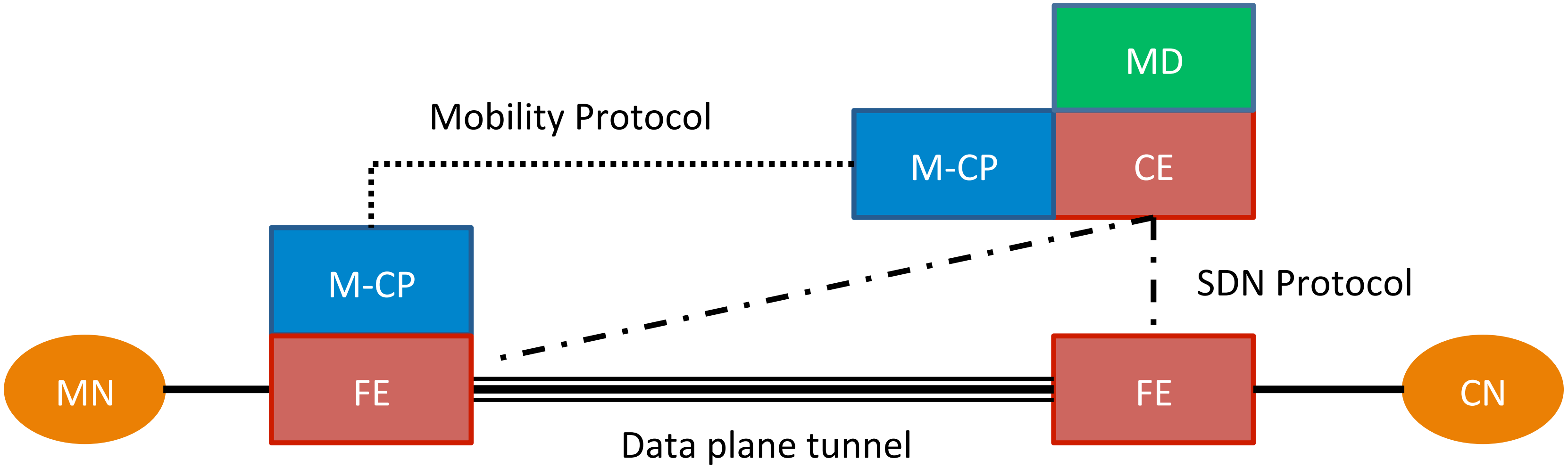
SDN-based mobile network architecture

- Lack of features for enhanced mobility support and network scalability



Proposed architecture model #1

- Partially-separated model with a single controller structure



(a) Partially-separated with single control model

Proposed architecture model #1

- Mobility detection and binding management are enabled by the legacy mobility protocol

- A SDN protocol is used to monitor current mobility support resources from the deployed FEs and to deliver command to the FEs involved in packet forwarding of the flow.

Proposed architecture model #1

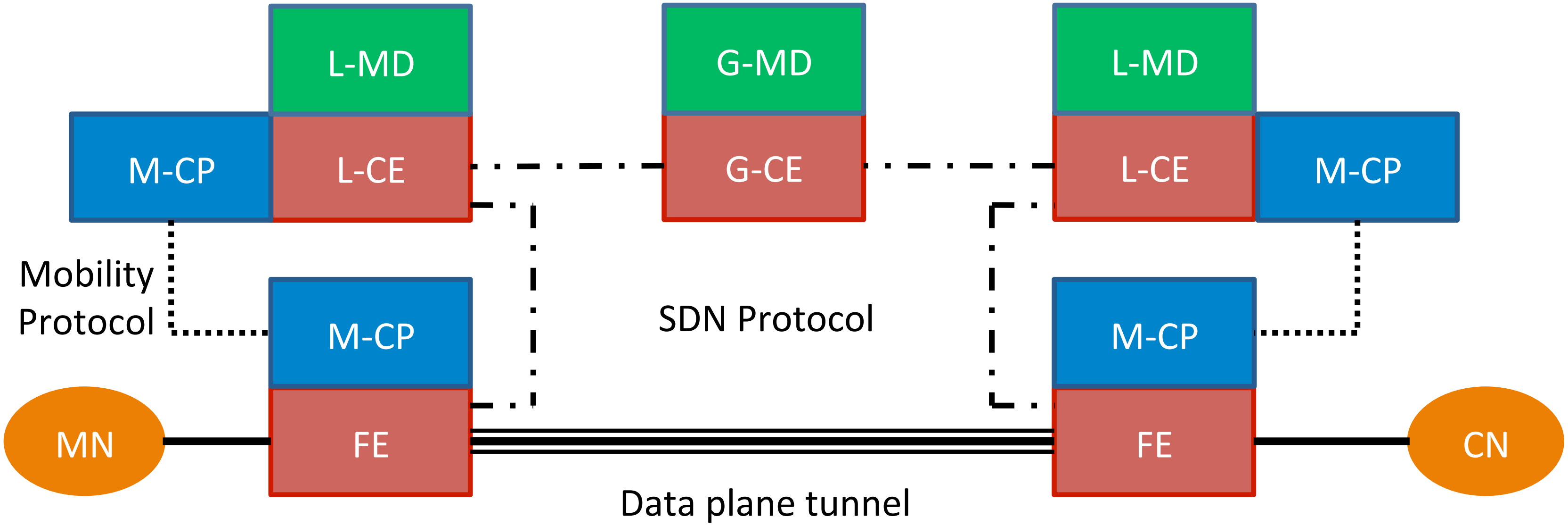
- Pros.
  - Reusability of the legacy features made and matured for a long time
  - Improved and fast link recovery
  - Highly complementary to fill gaps from legacy control plane and SDN-based control plane

Proposed architecture model #1

- Cons.
  - Implementation of the controller may be complex than the other options
    - Interface between M-CP and CE required
  - Heterogeneous signaling should be quickly interpreted, being able to act on proper FEs

Proposed architecture model #2

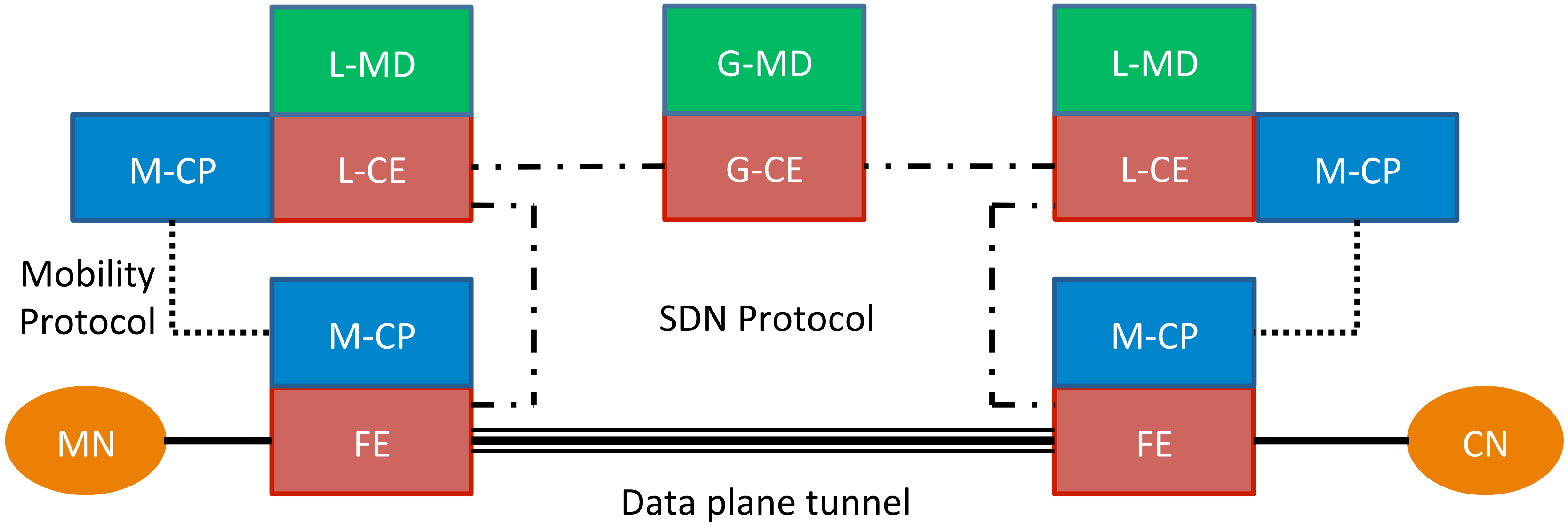
- Partially-separated model with hierarchical controller structure



(b) Partially-separated with hierarchical control model

Proposed architecture model #2

- Mobility domain could be localized and isolated for enabling fast event collection and enforcing commands into FEs



(b) Partially-separated with hierarchical control model

Proposed architecture model #2

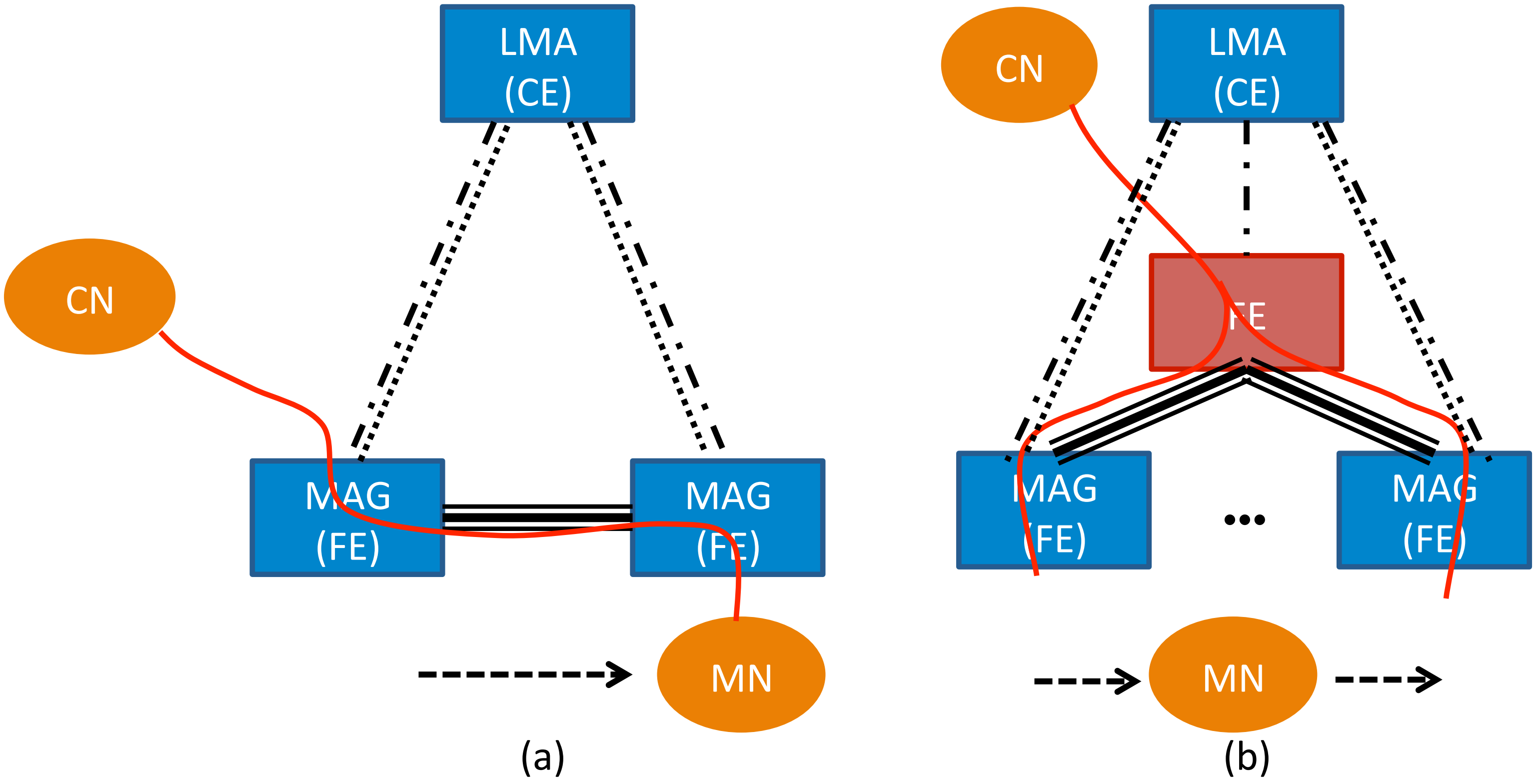
- Pros.
  - Scalability is enhanced with inherited features of partially-separated model
  - High-processing-required sub-controllers can leverage cloud resources deployed at data centers,

Proposed architecture model #2

- Cons.
  - Implementation may be complex since sub-controllers are connected with three different entities (FE, L-CE, G-CE)

Applicability based on #1

- PMIPv6



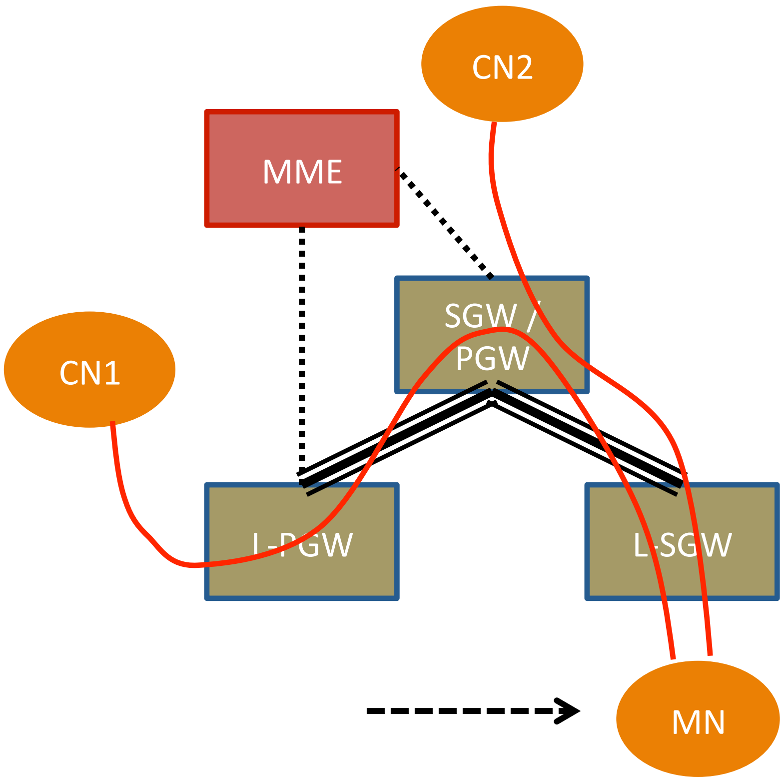
Applicability based on #1

- Flexible mobility anchor selection could be made, based on flow type and mobility speed

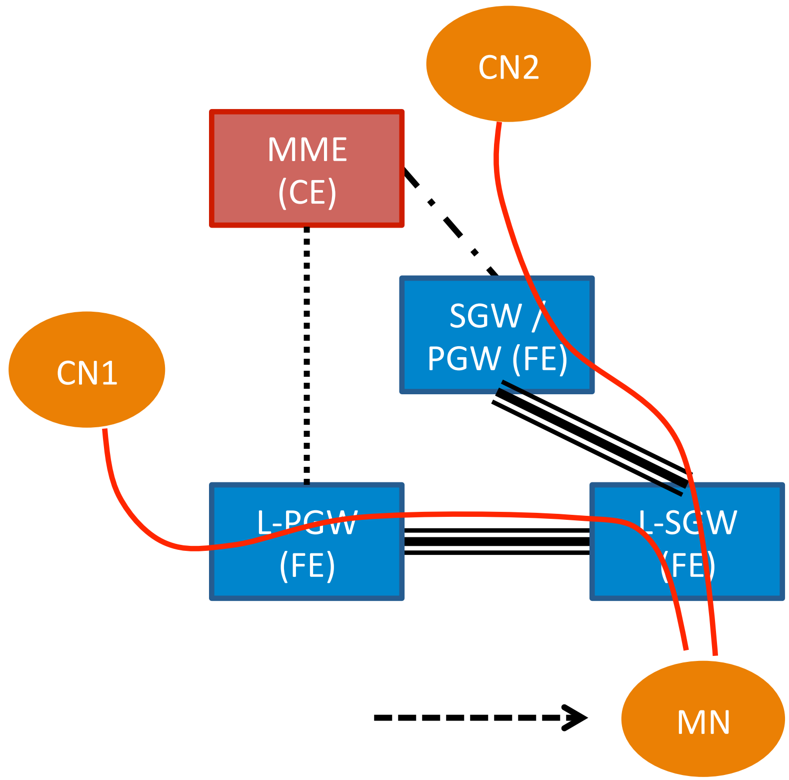
- Improved forwarding technique could be added for Seamless handover, e.g. bi-casting in a predictive handover case

Applicability based on #1

- 3GPP Evolved Packet Core (EPC)



(a) Gateway selection in
3GPP EPC standards



(b) Enhanced gateway selection over the proposed
SDN-based 3GPP EPC architecture

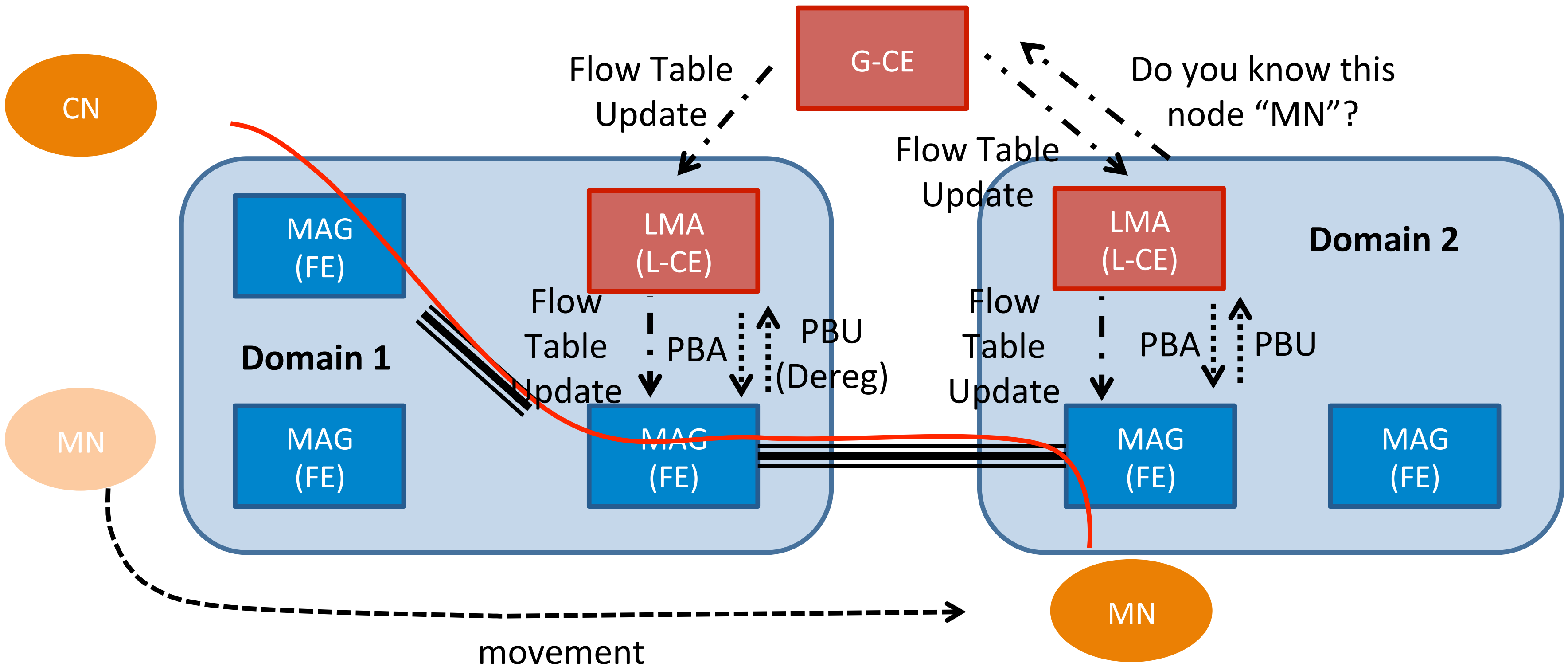
Applicability based on #1

- Where multiple PDN connection are required: one is anchor at a centrally located PGW while the other is a local PGW for SIPTO traffic

- Intelligent mobility anchor selection could be made, since the controller has a holistic view of the network

Applicability based on #2

- Mobility support between localized mobility domains (PMIPv6 case)



Performance – Handover Latency

- Proportional to the time spent to detect the changed location of an MN and update the flow table entries of the FEs pertaining to the MN's handover
- Resulted from chosen mobility management protocol and instantiated SDN controllers for each

Performance – Reliability

- Easy to take immediate actions against unexpected network events such as a link failure or a binding failure

- Reliability and flexibility added

Performance – Compatibility

- It can basically accommodate location management and tracking/paging functions currently implemented in the operator domain

- More specific compatibility aspects depend on an integration design goal

Implementation Challenges – Handover Support

- Detection of attachment and detachment of the MNs during the handover
- Added API and rule actions required
- Import the external management mechanism such as Media-Independent Handover (MIH) with SDN could be an option

Implementation Challenges – Data Path Management

- How tunneling capability could be provided?
  - VLAN tags and MPLS labels in the OpenFlow
  - But additional rules and actions definition required for the matching of IP or GTP tunneling
  - Currently, using Iptables rules, iproute, …

Implementation Challenges – Hierarchy of Controllers

- It can be conjectured that the L-CE can be an OpenFlow controller while the G-CE should be a network application
- The notion of query and answer models should be embedded between the controllers for retrieving mobility-related information

Conclusion

- Partially-separated SDN mobile architectures presented
  - Being able to reuse legacy mobility control plane for location management and enhanced mobility management capabilities

- The architectures were distinctively given with the considerations of different controller models: single and hierarchical controller

Conclusion

- Expected applicability scenarios and examples given, focused on flexibility and reliability in providing the mobility management operation
- Performance ad implementation challenges discussed

End of Presentation

- Thanks for your attention