An Architectural Vision for IMT 2030

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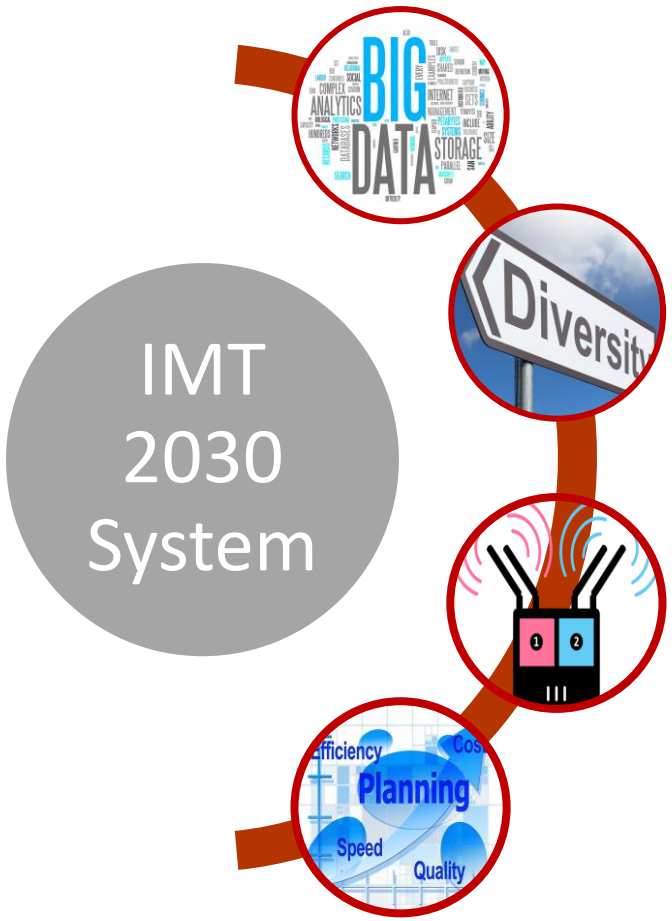
Agenda

- IMT 2030 System
  - Requirements
- Limitations of 5G System Architecture
- IMT 2030 System Architecture
  - Some Initial Thoughts

Requirements for IMT-2030 System



- Huge Data Volume
  - Mobile Networks – Primary vehicle for Connectivity
- Immense Service (Use Case) Diversity
  - “Very High Throughput” to “Very Low Throughput” Applications
  - “Latency Tolerant” to “Stringent Low Latency” Applications
- Diverse Set of Users
  - Stationary Users, Mobile Users, Users moving at very high speeds
  - Humans, Machines
  - Connectivity for everything/everywhere
- A Variety of Access Technologies
  - Cellular Access, WLANs, Satellite Access…
  - Small Cells, Large Cells
  - Unicast, Broadcast
- Efficient & Cost-effective Service Delivery
  - Sustainability

Existing 5GS Architecture – Some Limitations

Existing 3GPP 5G Architecture

1 **Converged Core - Multi-RAT Unification in Core**

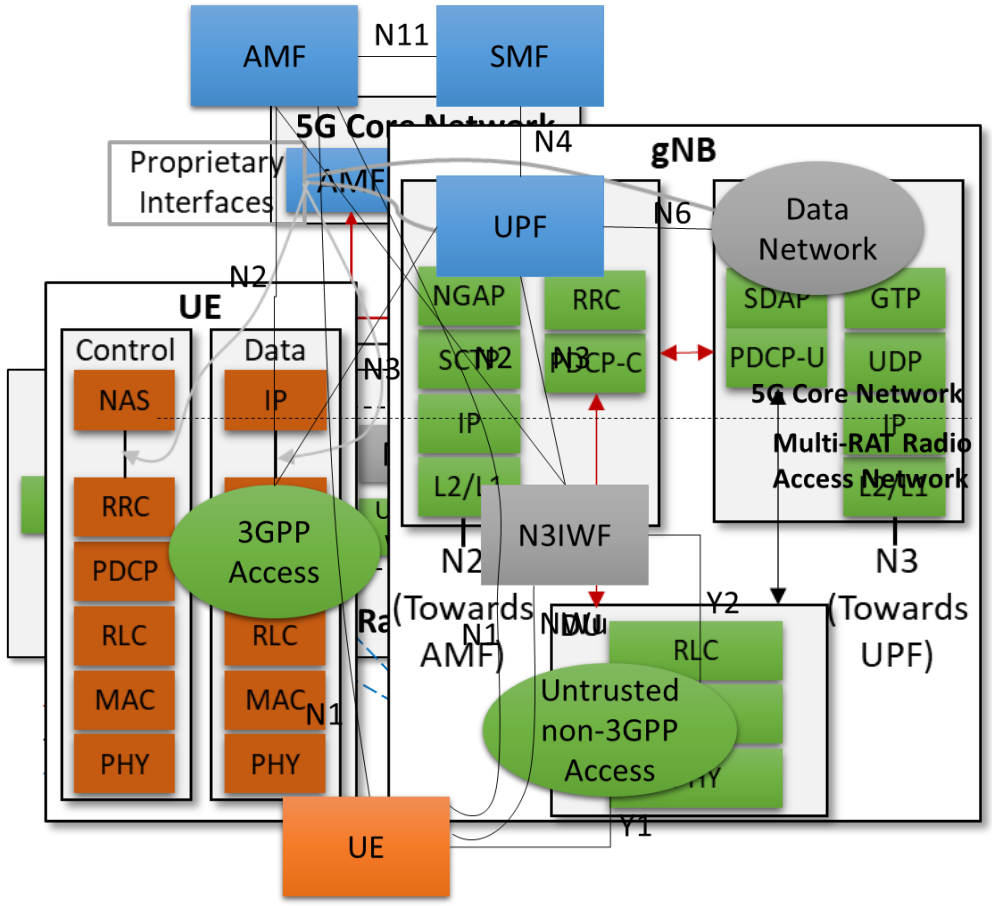
- **But No Unification at RAN Level**
- **Fragmented Decision Making in RAN**

2 **Tight and proprietary coupling between Radio and CN protocol stacks**

- **Loss of Flexibility – Can you connect 5G RAN to 4G Core or directly to Internet w/o Core?**

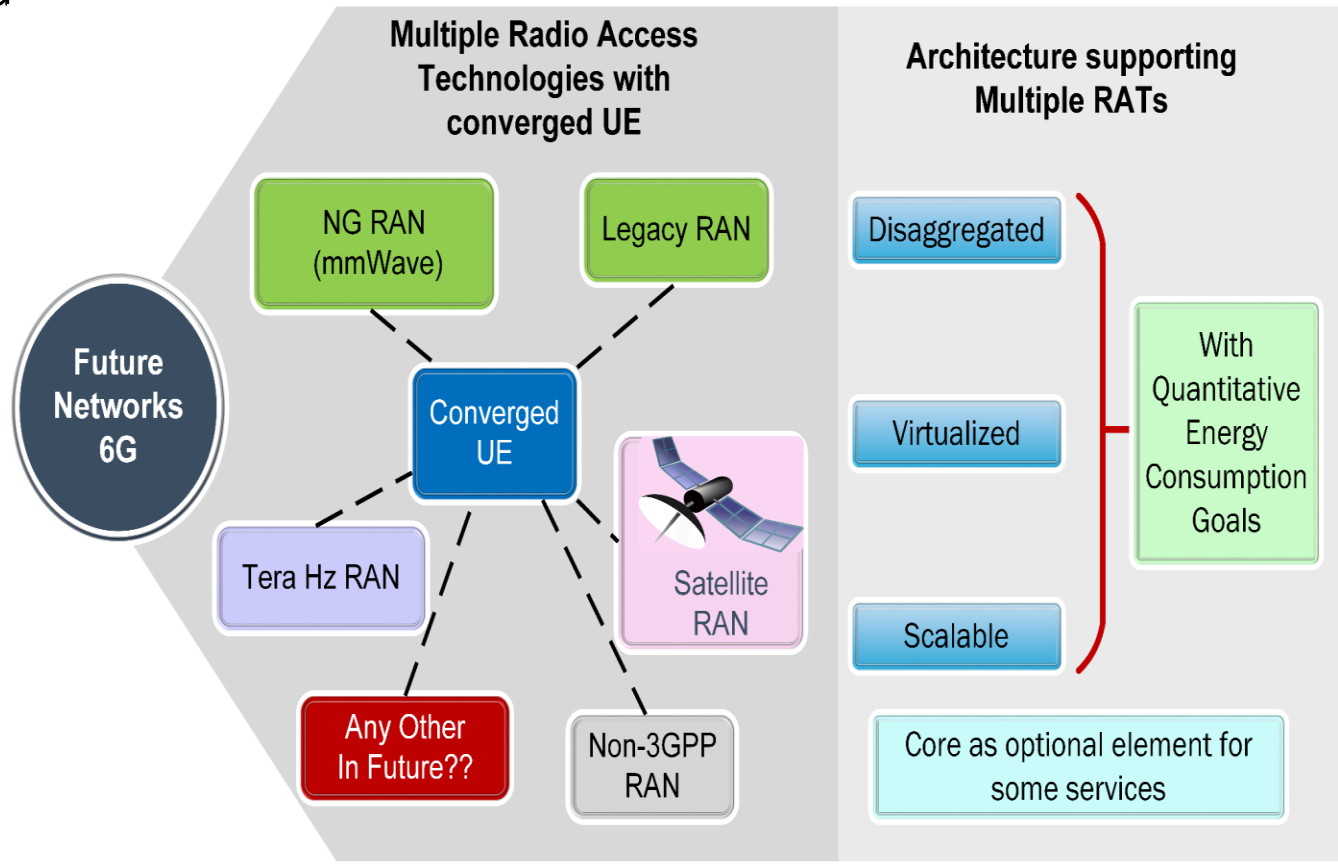
3 **Service/User Agnostic Handling**

- **Fixed Route/Path for Control & Data flows**
- **Usage of Core Network in every Scenario**
  - **Usage of Tunnels for all data flows**
- **No use case specific variation in Protocol Behaviour**



Architecture for IMT 2030 - Points to Ponder (1/3)

- Scalable Architecture
  - Further Disaggregation of Control and User Plane
  - Modular and Reusable Network Functions
- Unified Multi-access RAN
  - Unified Treatment of Dual Connectivity …
- Usage of SDN Paradigm
  - Separation of Control & Data Plane
  - Logically Centralized Control Plane
- Virtualization of Network Resources
  - Better support for Network Slicing,…

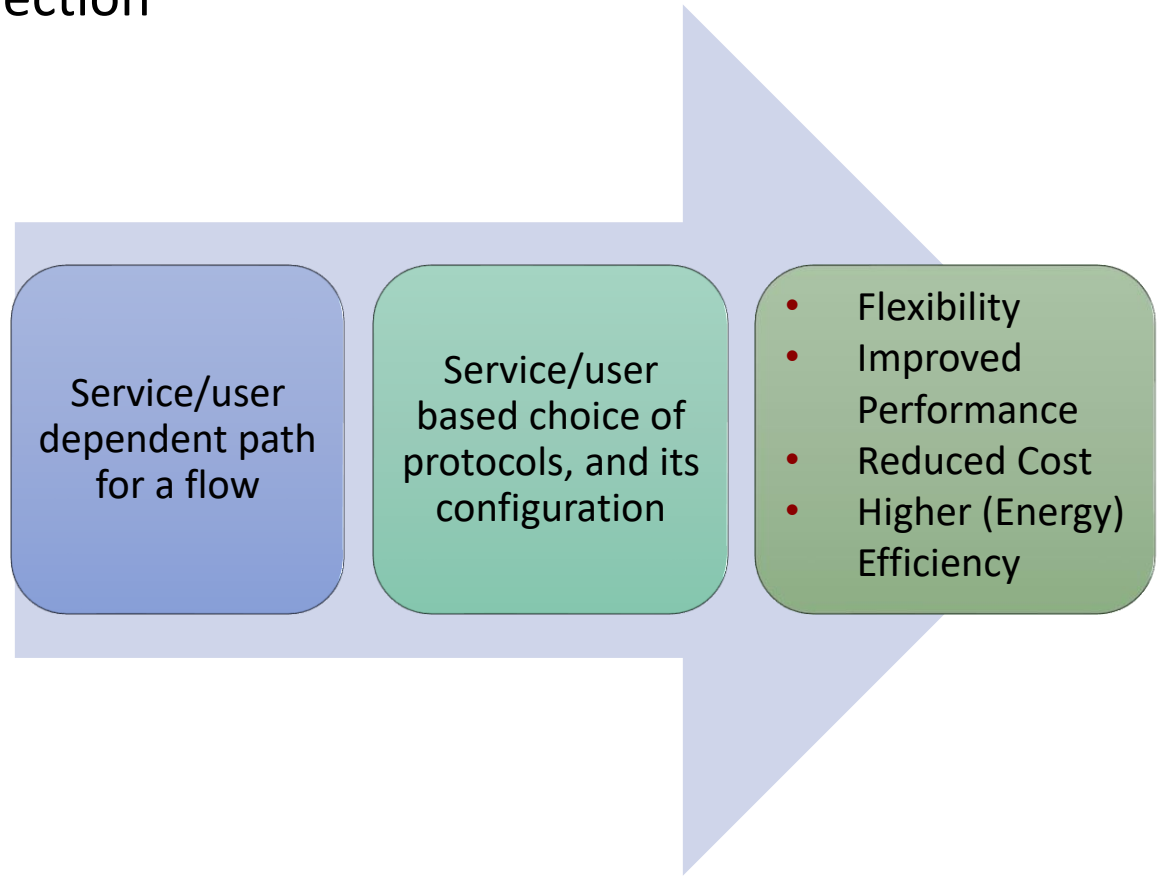


Architecture for IMT 2030 - Points to Ponder (2/3)

- Need for core in cellular network
  - Mobility - Anchored in Core
  - Also Authentication, Access Control…
- A large % of mobile network users not “mobile”
  - Rural Broadband Connectivity, IoT …
  - **Can we bypass core for such users?**
  - Direct Connectivity to Internet from RAN
- Should we decouple RAN from Core?
  - Interworking of any RAN with any Core
    - Non Standalone Architecture requires 5G RAN to interwork with 4G Core
    - Achieved with the help of 4G-RAN
    - Not possible w/o 4G RAN
  - Connect future 6G RAN to 5G Core

Architecture for IMT 2030 - Points to Ponder (3/3)

- Flexible Architecture
  - Service/User Specific Protocols/Functions Selection
    - Different protocols for different services
    - Service/User Dependent Route/Path?
  - Flexible Protocol Structure
    - Not rigidly layered
    - Tunnelling protocols not required for all users
- Intelligence-driven Network
  - Optimization of Services/Applications
    - AI/ML Model/Data Distribution
    - Federated Learning
  - AI-powered Network Design & Optimization
    - AI-powered Optimization
    - AI-powered Protocol Stacks
    - Learning-oriented Network Design



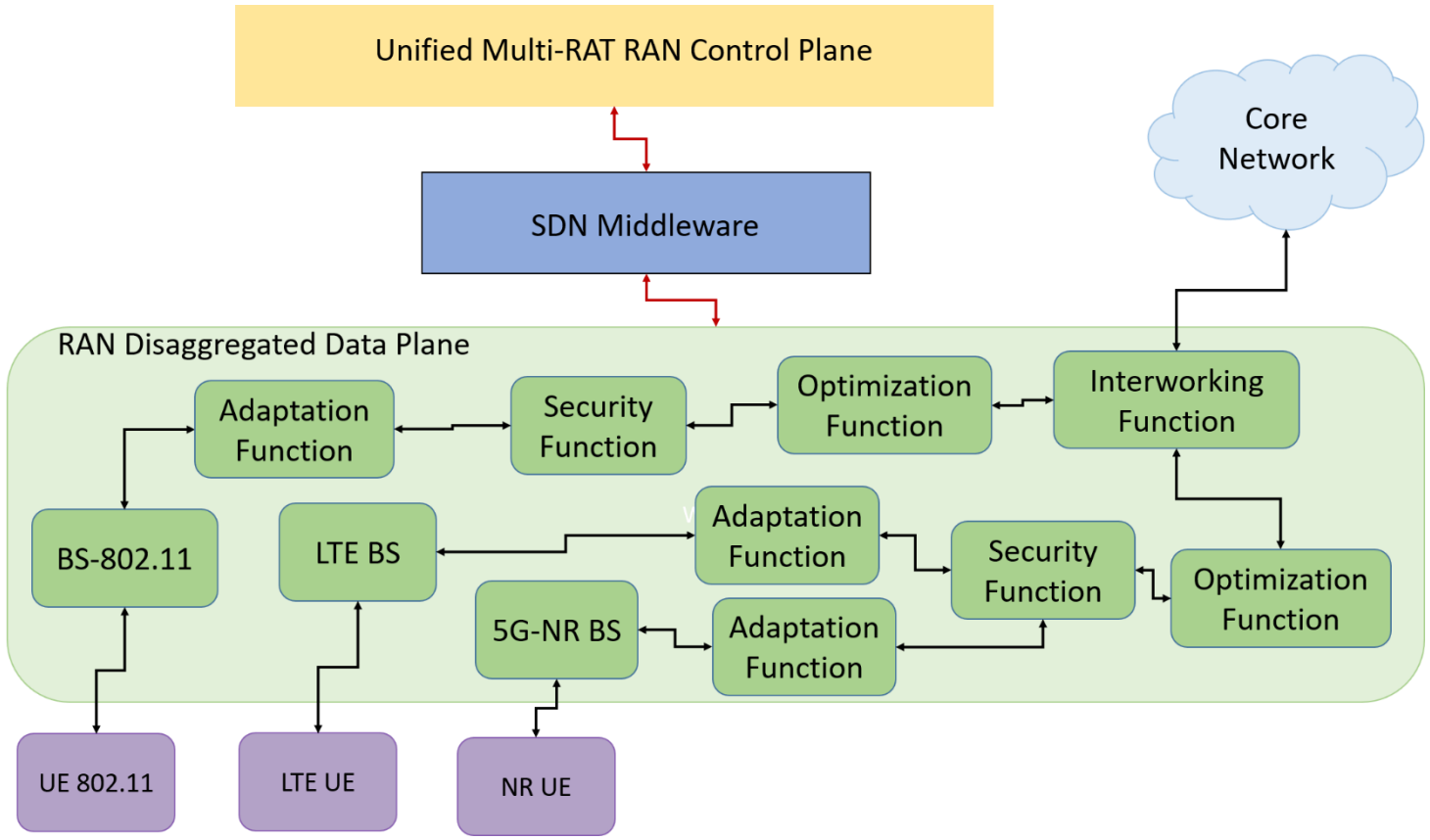
IMT 2030 System Architecture – A few proposals

Scalable Architecture - RAN User(Data) Plane Disaggregation

- RAN User (Data) Plane of most RATS perform similar functions in 5G
  - Radio Tx/Rx
  - PHY & MAC
  - Link Adaptation
  - Security (Encryption)
  - Optimization - Header Compression …
  - Interworking with Core
- Can we Disaggregate RAN along these simpler functions?
- Does it help in unified treatment of RATs?
- Does it help in Load Management, Dual Connectivity?

Disaggregated Data Plane for Multi-RAT RAN

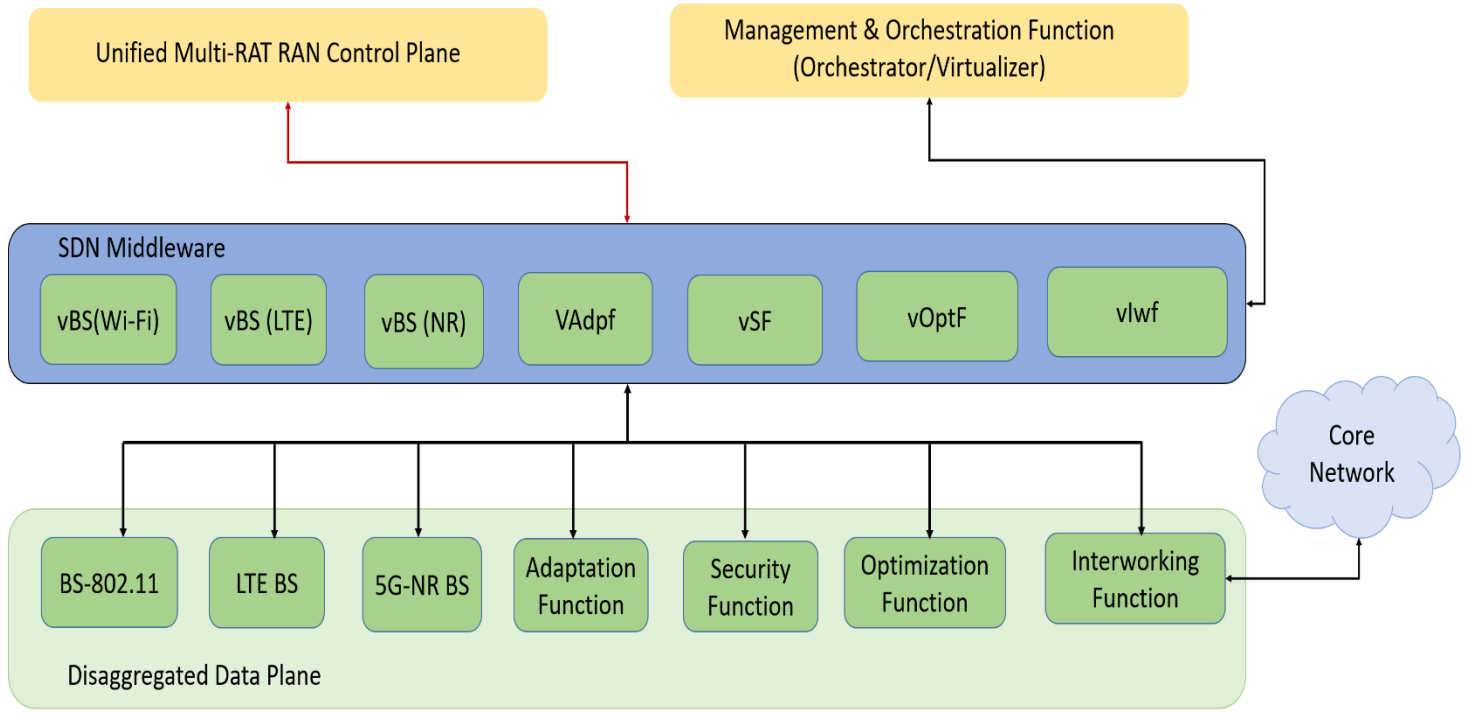
- Modular Data Plane Functions
- Base Station(BS) Function
  - MAC and Physical Layer
  - Rx/Tx may be a Separate Function
- Security Function (SF)
  - Encryption and Integrity
- Optimization Function (OptF)
  - IP Header Compression etc.
- RAN Adaptation Function (AdpF)
  - Link Control, ARQ etc.
- Interworking Function (IWF)
  - Interworking with Core
- *An individual Controller may be responsible for controlling a subset of modular functions*



Courtesy : IEEE 1930.1

Unification & Virtualization of Disaggregated Multi-RAT RAN

- Virtualization Layer (SDN Middleware)
  - A Layer between Control & Data Plane
  - Abstract Information Model of Multi-RAT RAN Data plane
    - Virtualize Underlying Data Plane
    - Modularized Information Model
  - Unify Control & Management of Multi-RAT RAN
- Unified Control Plane
  - Usage of SDN Technology
  - Controls RAN Data Plane Functions of all RATS
  - SDN Middleware Abstraction helps in Unified Control
- Improved handling of
  - Load balancing, Dual Connectivity, Network Slicing



Courtesy : IEEE 1930.1

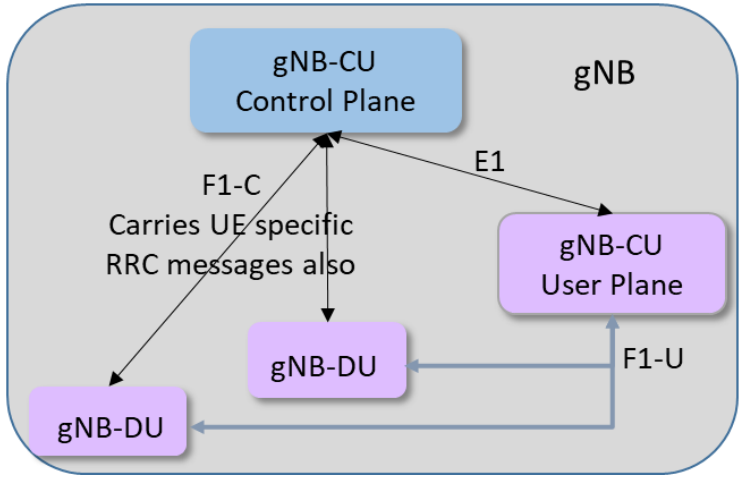
Further Disaggregation of Control Plane

- 5GS Architecture supports Disaggregation
- Further Possibilities of Disaggregation
  - Additional Data Plane Disaggregation
    - IEEE 1930.1 - Previous Slides
  - Further Disaggregation in Control Plane - Next
- Existing 5GS Control Plane
  - Two Types of Tasks
  - Task #1
    - Controls User Plane - “Network/Resource Control”
  - Task #2
    - Exchanges Signalling Messages with UE - UE Control & State Management
    - Provide Services such as Mobility, Authentication…
- Disaggregate (Decouple) Task #2 from #1

Disaggregation in RAN Control Plane
(Decouple UE Signaling Exchange from Resource Control)

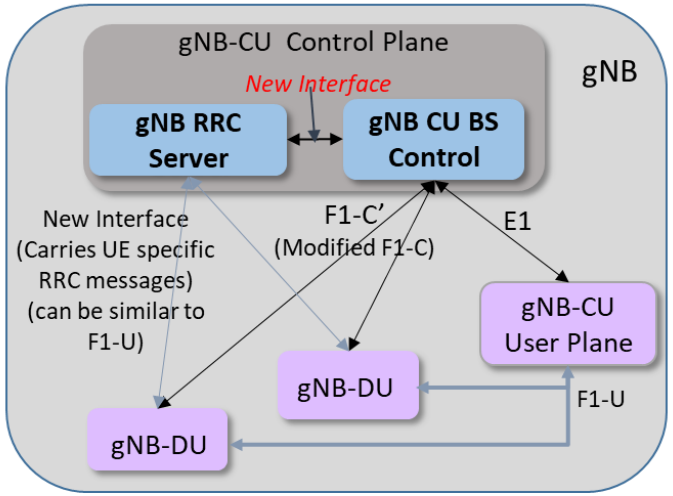
Existing gNB Architecture

(Tightly coupled RRC signalling handling + gNB Resource Control within gNB-CU-CP)



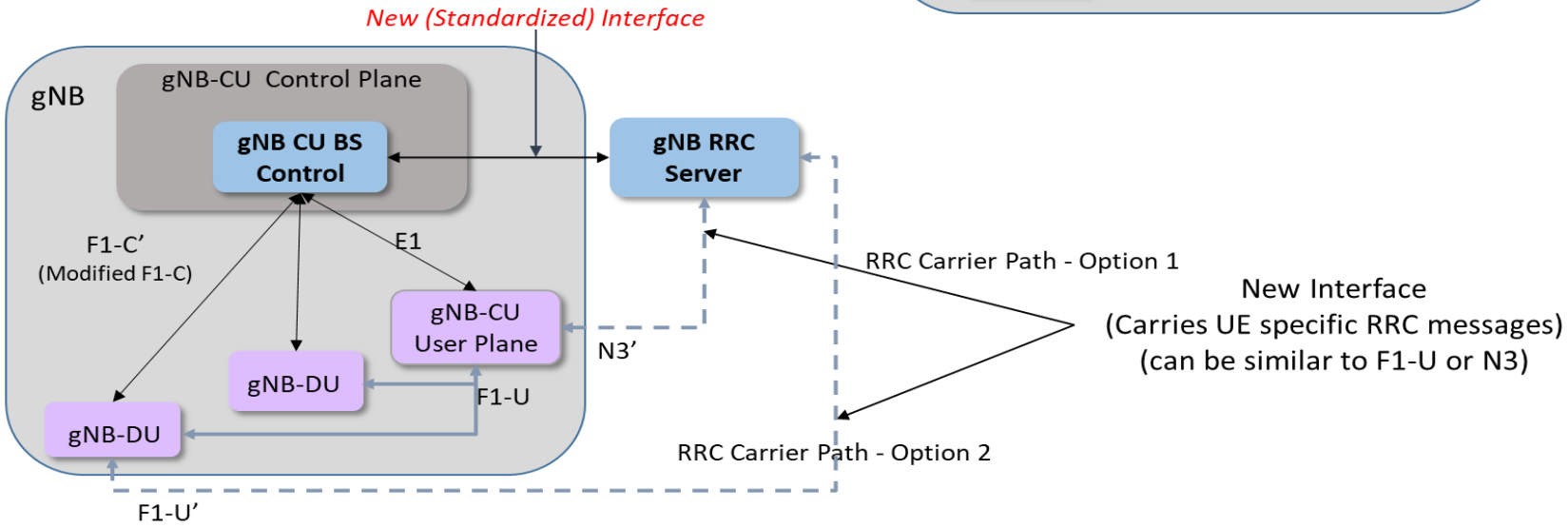
Proposed Disaggregated gNB Control – Option I

(Decoupled gNB RRC signalling handling from gNB Resource Control within gNB-CU-CP)

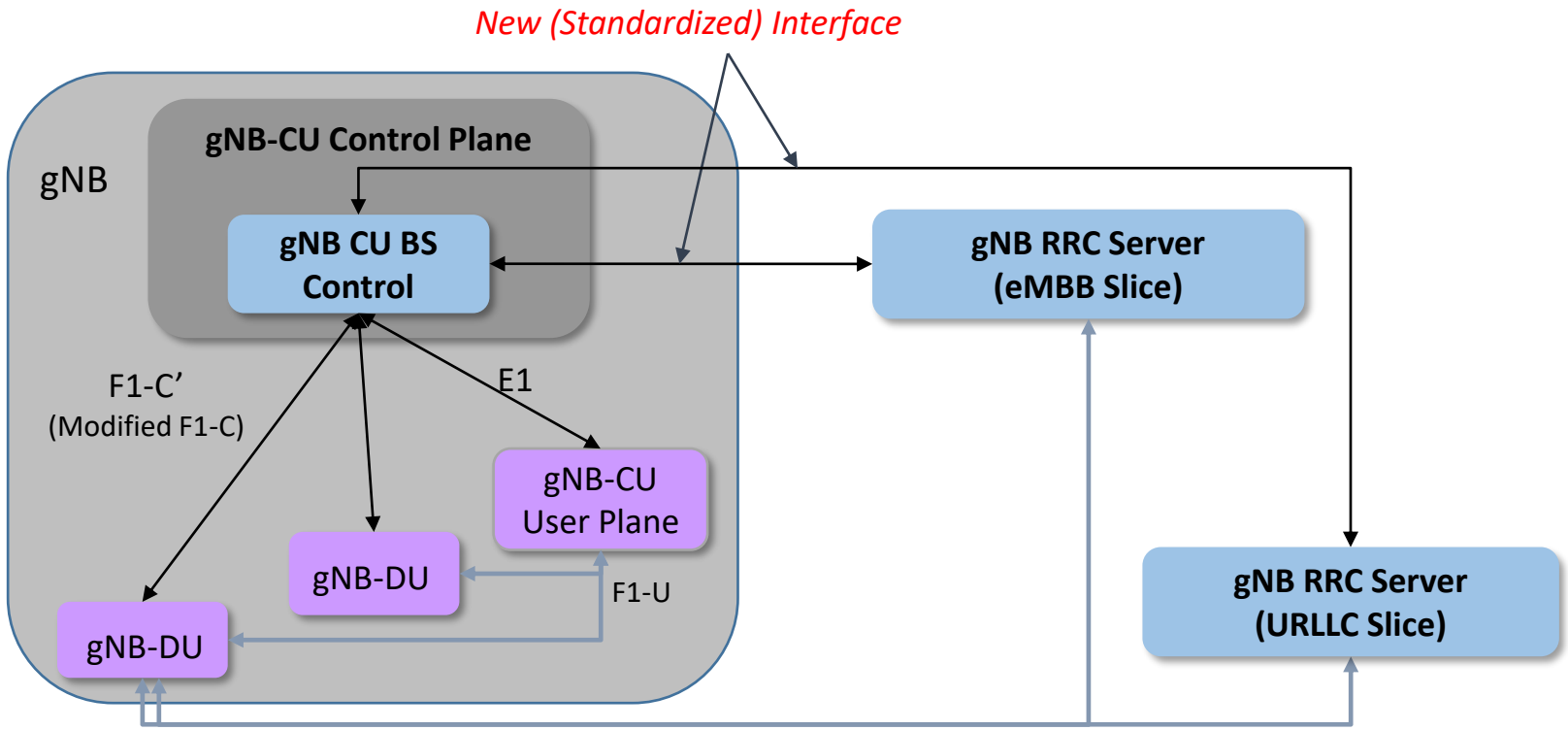


Proposed Disaggregated gNB Control – Option II

(gNB RRC Server taken out of gNB-CU-CP and placed in the user (data) plane as a service function)



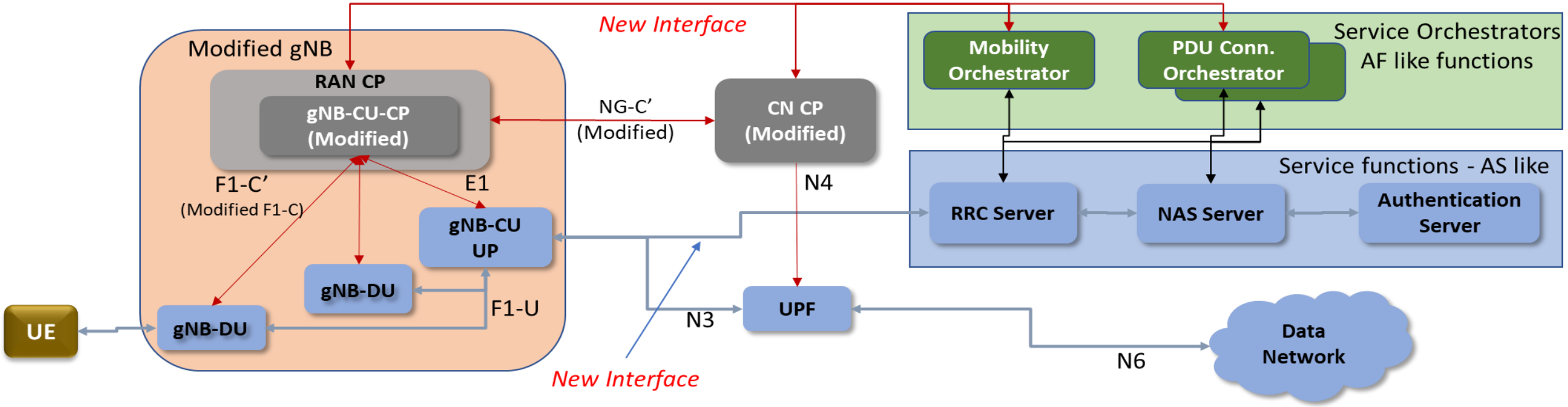
Disaggregation of RAN Control Plane
(Slice specific Deployment of UE Signaling handling)



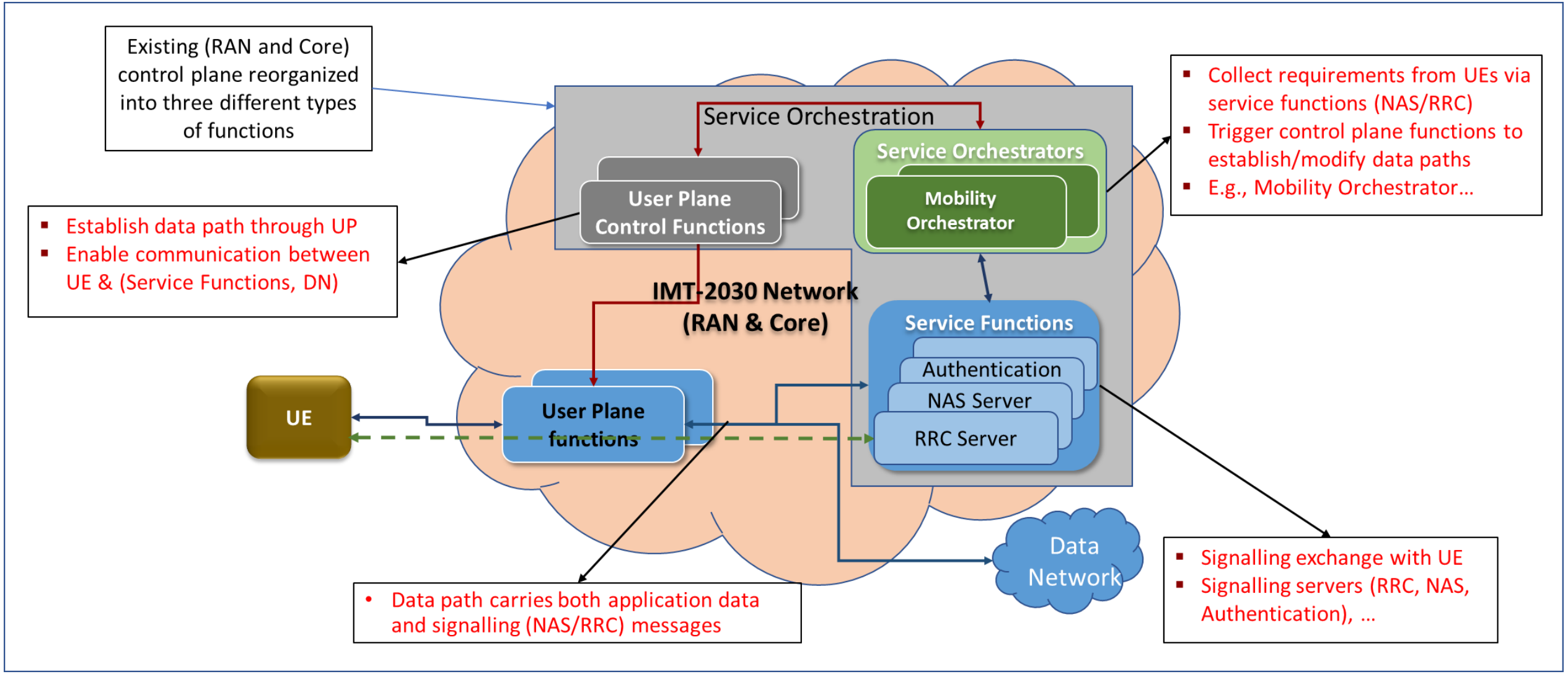
Disaggregation applied to RAN+CN Control Plane

- UE Signalling Exchange functionality separated from Control Plane Functions
  - Signalling Service Functions – NAS Server, RRC Server, Authentication Server, …
  - Service Orchestrator - Mobility Orchestrator …
- Control Plane : User Plane Control (Resource Control)
- UE Signalling (RRC/NAS) Messages
  - A form of Data (Payload) flowing through 5G network - A different paradigm

Leads to a Generic Service-driven Architecture



A Service Driven Architecture for IMT-2030



Source: Meghna Khaturia, Akshatha Nayak Manjeshwar, Pranav Jha and Abhay Karandikar, ICIN (2021)

Service Driven Architecture - Highlights

Enhanced Modularity & Flexibility

- Disaggregated and Modular Control Plane
- Possibility of Use case specific variants of UE Signalling Protocols
- But Impact on UE Signalling Message not necessary
- Flexible Signaling Handling function Placement and Chaining

Simpler Control Plane

- Primarily controls User Plane as in SDN paradigm
- Does not exchange signalling messages with UEs
- Simpler message flow & protocols
- Improved control plane performance

Change in Paradigm

- UE Signalling as Payload (Data)
- All Services treated Uniformly - external AF/AS based and internal services
- Improved Network Access Security
- Aligned with End-to-End Design Principle of Internet

THANK YOU