Transport Network Requirements and Architecture for 5G

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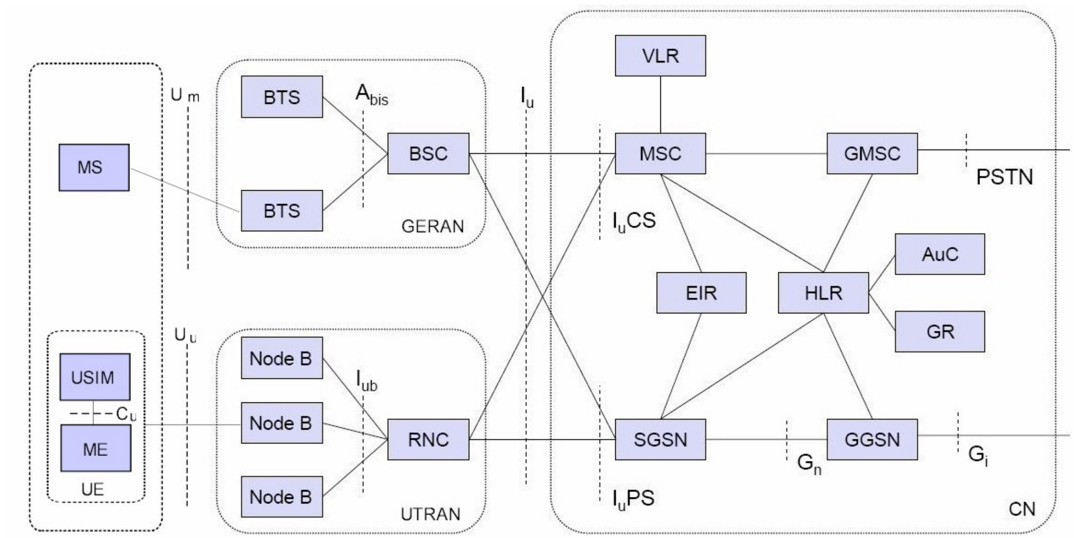
Distinguished Systems Engineer

Extreme™
Customer-Driven Networking

3G & 4G Sites Infrastructure

Current: 4G

Only a few large centralized data centers



Source: Ericsson

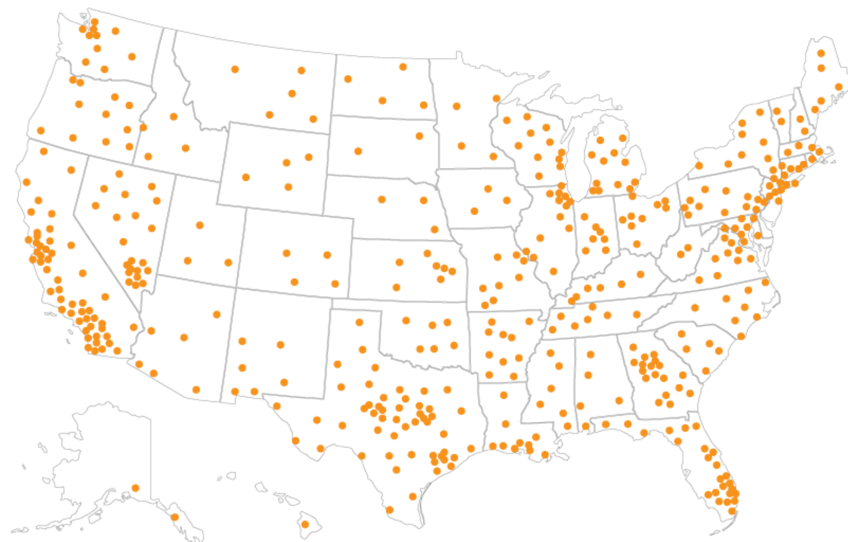
5G Sites Infrastructure

Current: 4G

Only a few large centralized
data centers

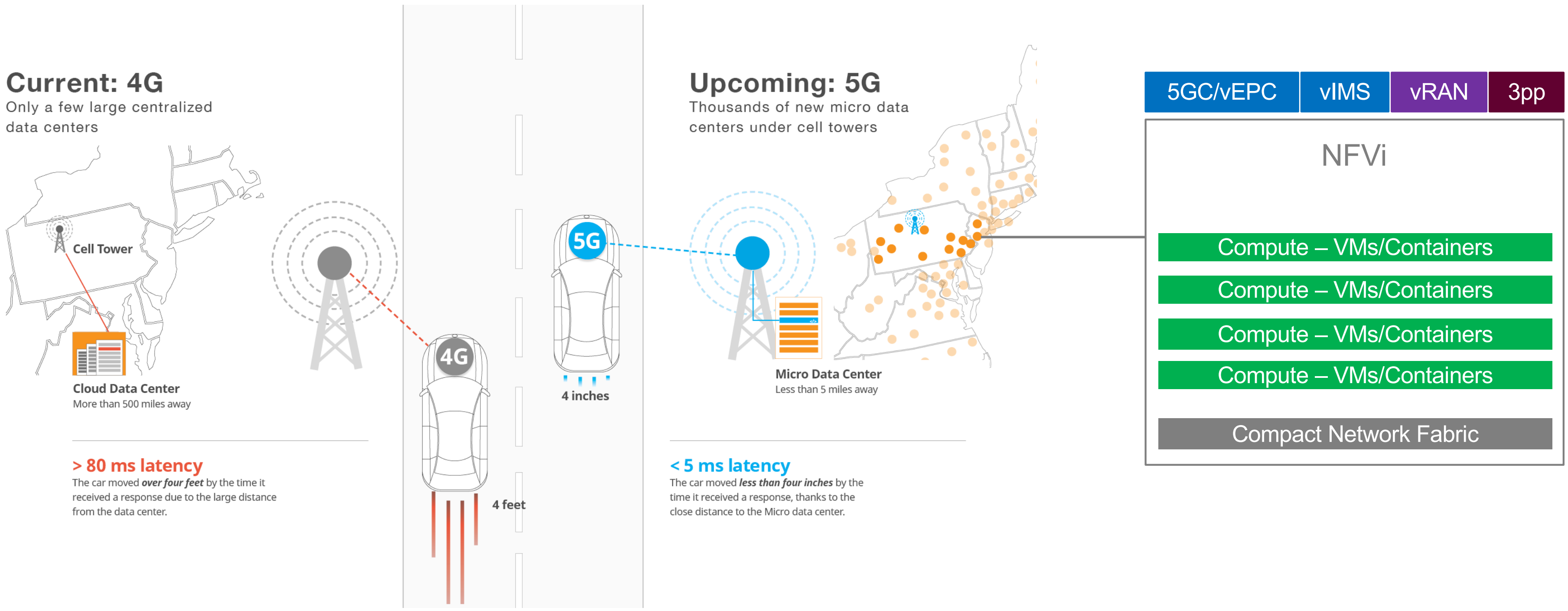
Upcoming: 5G

Thousands of new micro data
centers under cell towers

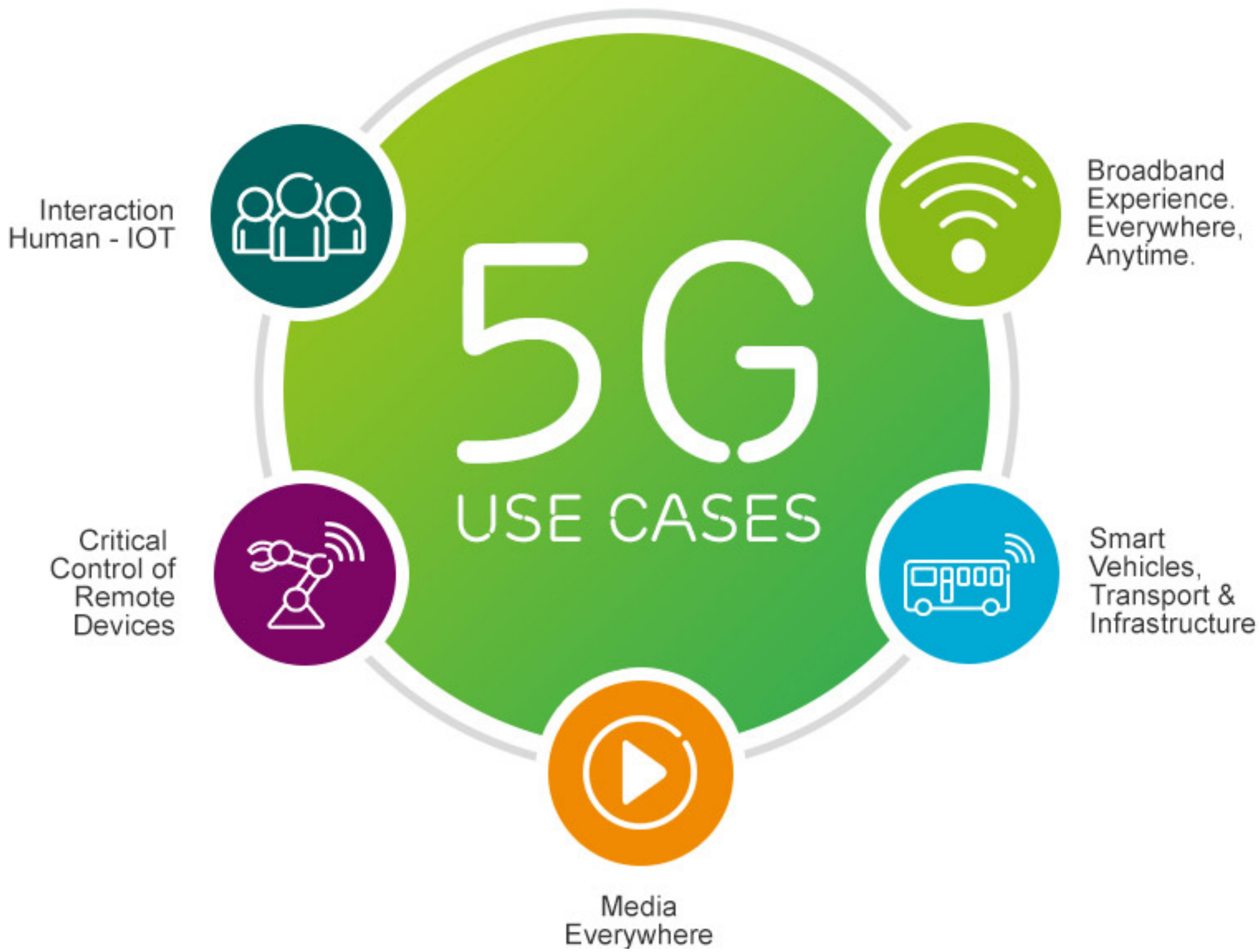


Source: Ericsson

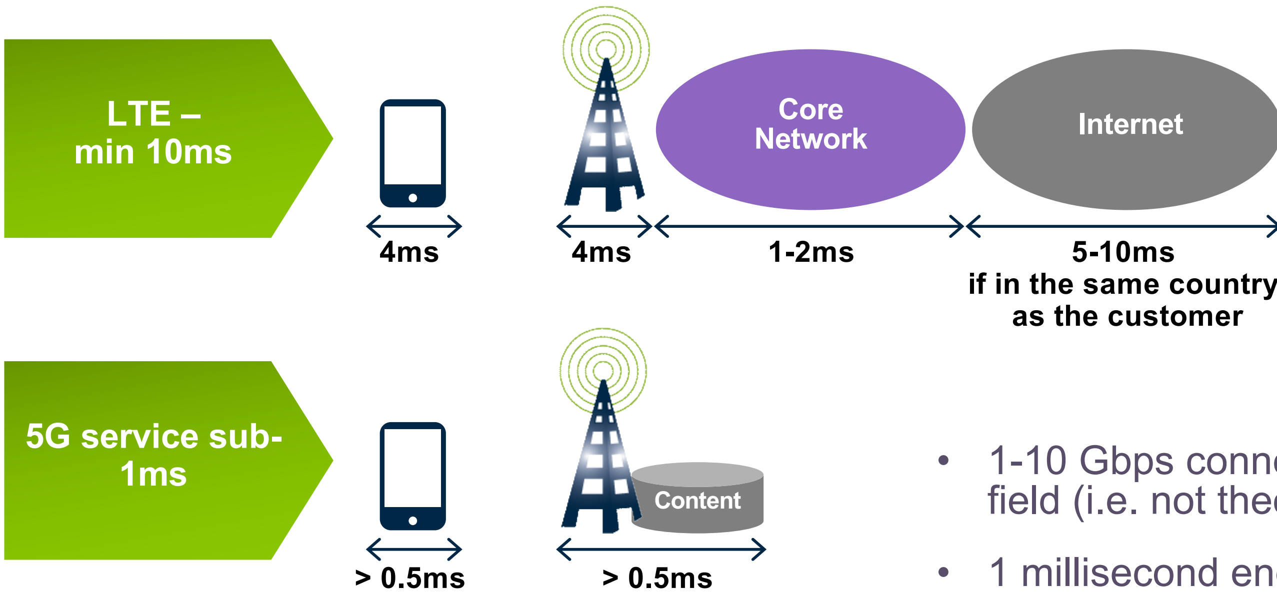
5G NFV Infrastructure



Source: Ericsson


5G
USE CASES
Interaction
Human - IOT
Broadband
Experience.
Everywhere,
Anytime.
Critical
Control of
Remote
Devices
Smart
Vehicles,
Transport &
Infrastructure
Media
Everywhere

Mobile - 5G Requirements

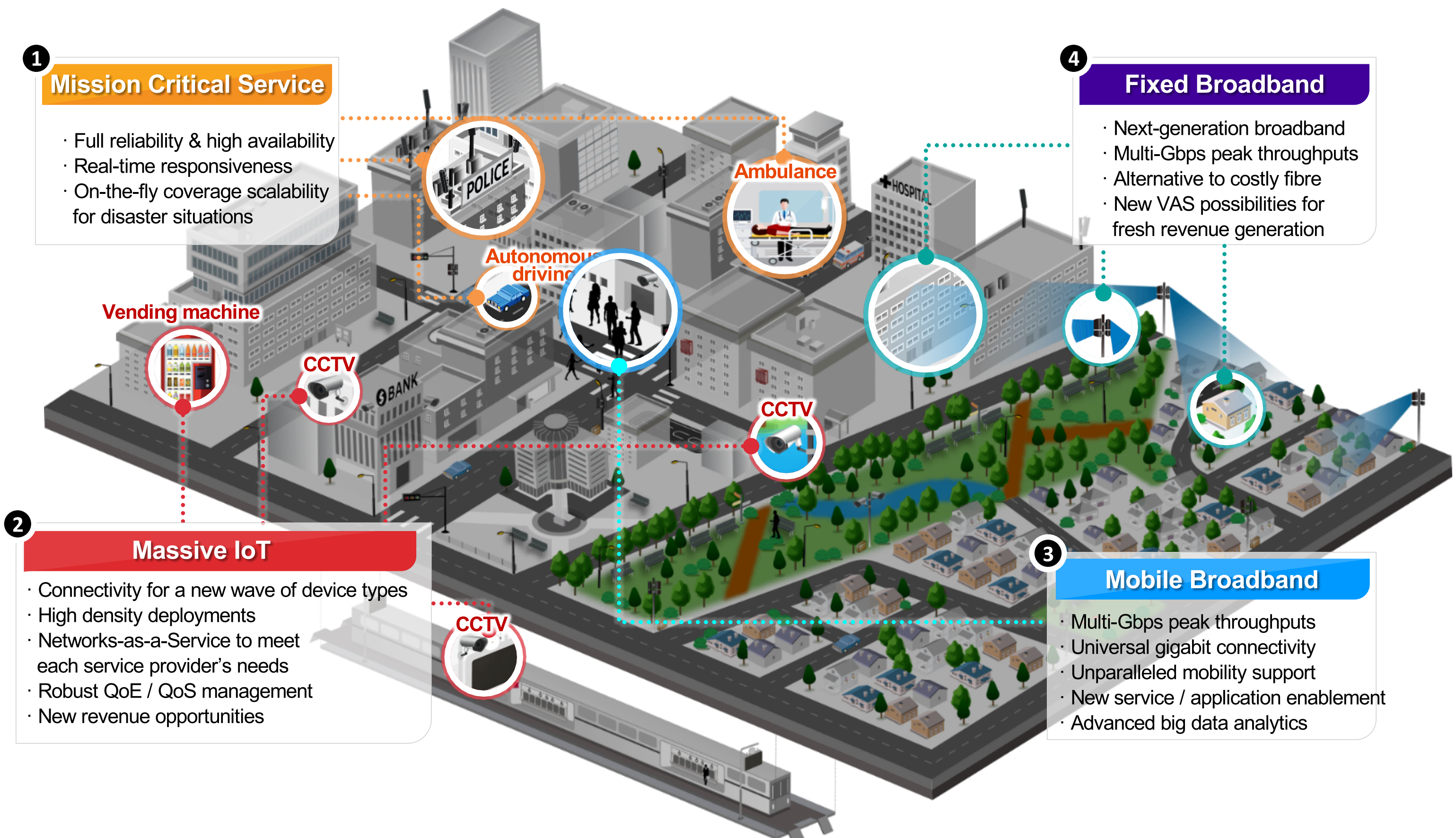


Source: GSMA

- 1-10 Gbps connections to end points in the field (i.e. not theoretical maximum)
- 1 millisecond end-to-end round trip delay (latency)
- 1000x bandwidth per unit area
- 90% reduction in network energy usage

5G Scenarios…

- Key Scenarios to be Addressed by 5G



Requirements

- 10x bandwidth per connection
- Low-ms latency
- Five 9's reliability
- 100% coverage
- >10x connections
- 50Mbps per connection everywhere
- 1000x bandwidth/area
- 10 year battery life
- Reduction in TCO

Different Context of the same environment

Requirements

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Applications

- Enhanced Mobile BB
- Connected vehicles
- AR/VR
- S-UHD/3D Video
- Haptics/Sensing
- Massive IoT
- Remote machine control
- Mission critical services
- Fixed-wireless access
- …

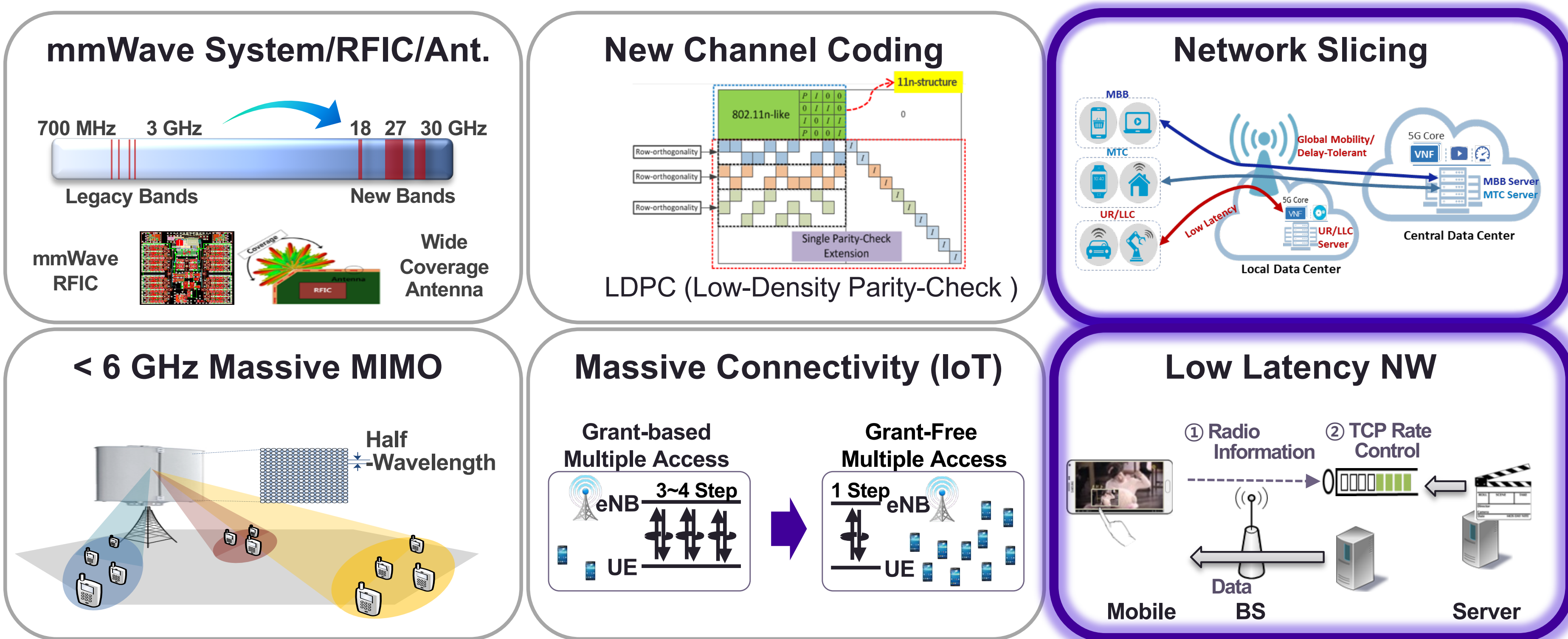
Customer segments

- Consumer
- Auto industry
- Health
- Industry 4.0
- Agriculture
- Smart City/Public sector
- Smart building
- Utilities
- Education
- Transport
- …

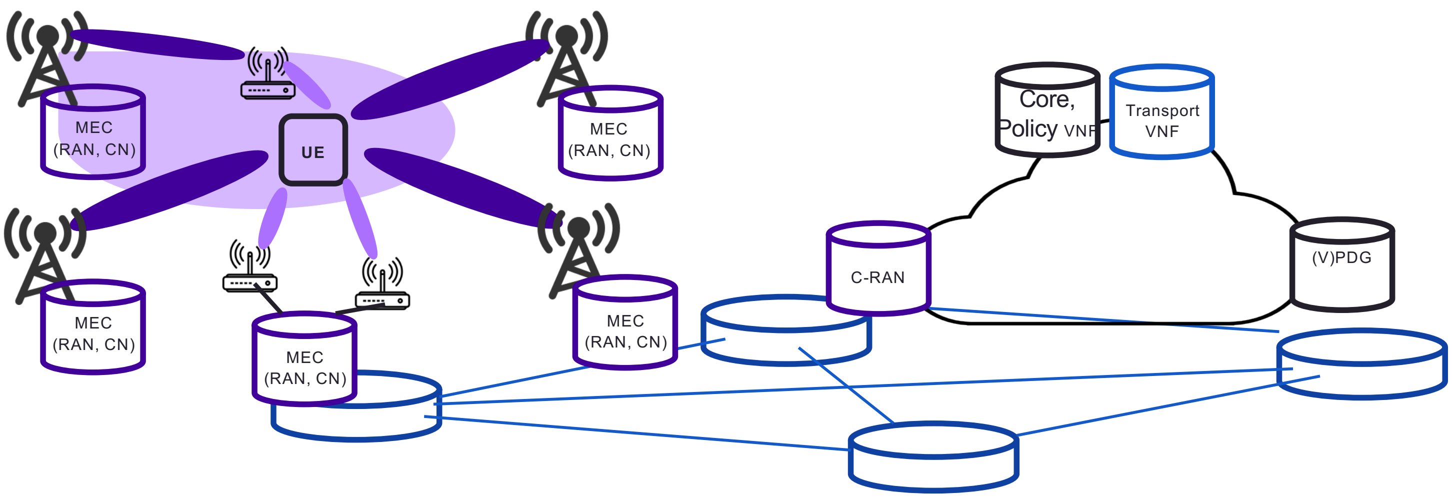
MNO biz model

- B2C
- B2B
- B2B2C

5G Service Enablers



5G Topology Flexibility…?



"Softwarisation" of the Network

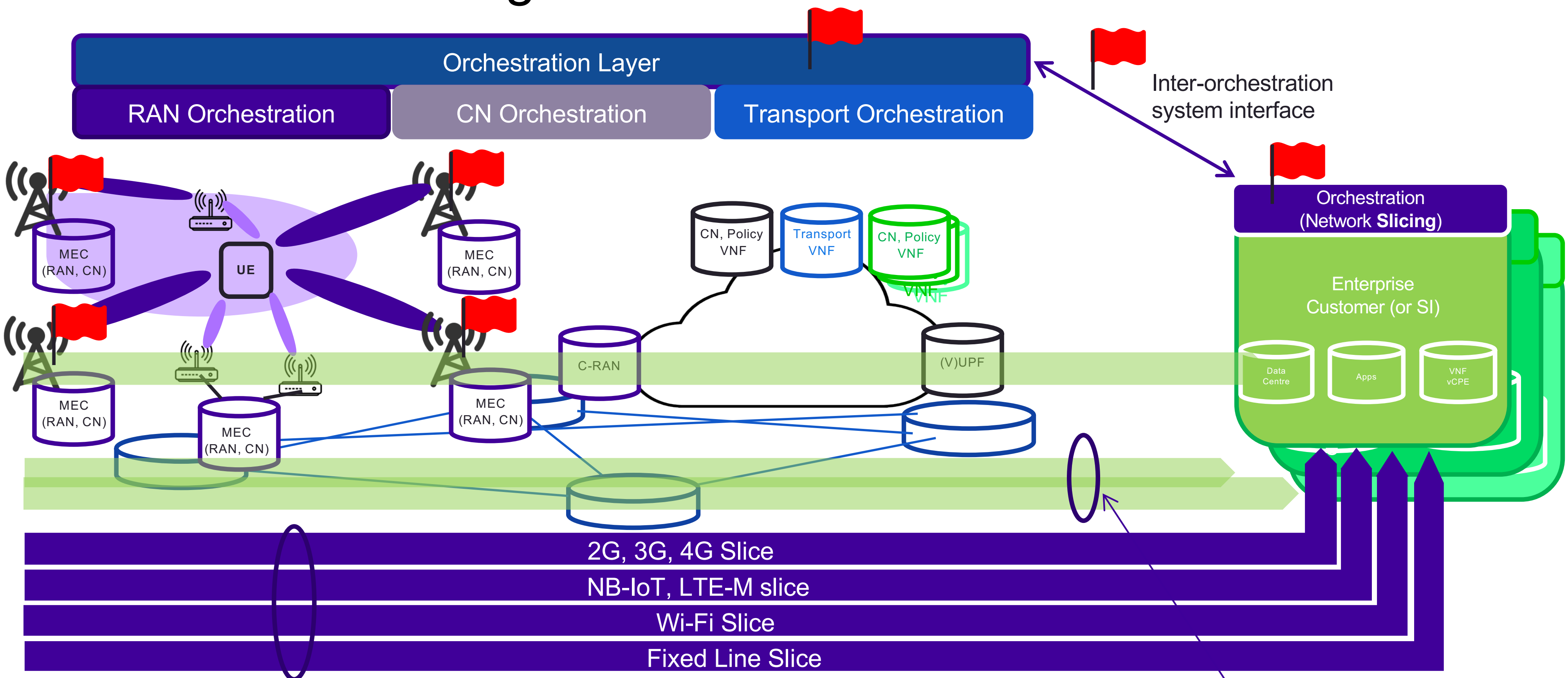
C-RAN – removal of functionality from cell sites to consolidation point in the network

NFV and SDN – enabling flexibility in where functions are deployed and scaled

MEC – pushing Core Network functions and content ingress to cell sites

CP/UP split – decoupling of user plane traffic from control plane functions

5G Network Slicing



Potentially multiple other network slices per network customer

One (or more) 5G slice per enterprise customer

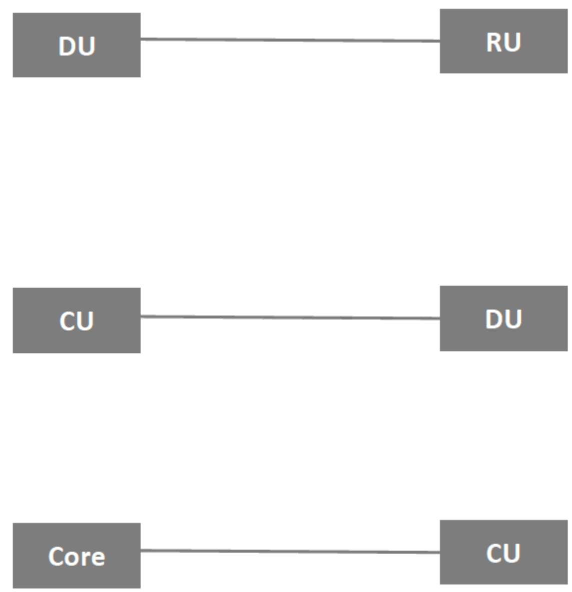
5G Transport is More Than a Necessary Cost…

- It is an investment in critical assets that enables customers to interact with services
- It is an architecture that will underpin the long-term development of the 5G commercial offer
- Part of a "universal edge" based on packet/optical integration, SDN, and etc, etc.

5G Transport Platforms and Technology

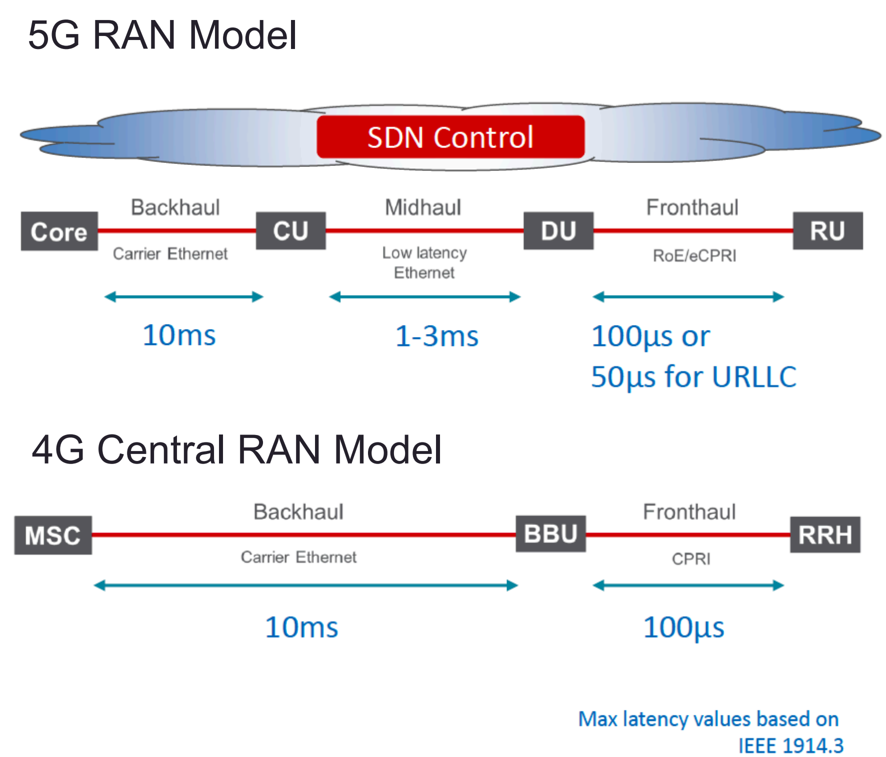
Optical Transport

- Fronthaul @ 5 µsec to 100 µsec
  - TSN
  - WDM active and passive
  - Dedicated dark fiber
- Midhaul @ 1ms
  - OTN
  - WDM
  - Low latency Ethernet
- Backhaul @ 10ms
  - Carrier Ethernet



4G to 5G Network Evolution Challenges

- Latency budget
  - FH: 4G is 75µs to 100µs while ultra low latency requires under 50µs
  - MH: New for 5G @ 1ms to 3ms max
  - BH: Unchanged
- Connectivity
  - 4G using CPRI is P2P and P2MP
  - 5G is Cloud based and will also need MP2MP
- Synchronization
  - 4G using GPS
  - 5G using PTP and SyncE
- Massive MIMO transport rate impact



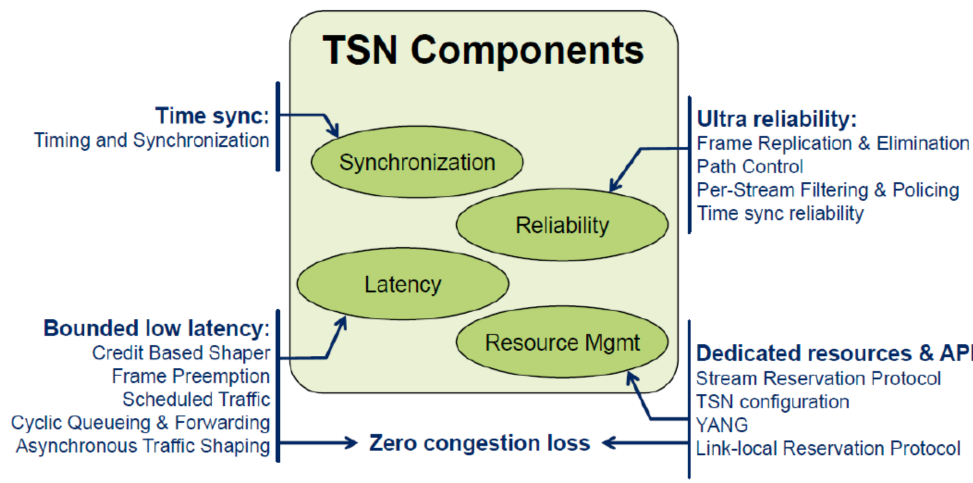
TSN (Time Sensitive Networking)

- TSN is part of the 802.1Q family of standards and is designed to provide **deterministic messaging on standard Ethernet networks**
- Important to many industries – e.g. aerospace, automotive, transportation and utilities, and of course, manufacturing – where TSN is emerging as the baseline for real-time networking
- A wide variety of applications and users, contributing scale to the technology relative to a mobile-only standard
- A common X-Haul transport network for 5G RAN, serving fronthaul, mid-haul and backhaul, can therefore be developed using TSN

What is TSN…

- IEEE 802.1CM standard
- TSN enables reliable, deterministic real-time communication over Ethernet (RTCoE)
- Reliable, deterministic RTCoE is achieved using
  - Time synchronization
  - Scheduler shared between network components
  - Frame replication
- Offers
  - Bounded low latency
  - Low delay variation
  - Extremely low loss

Time-Sensitive Networking



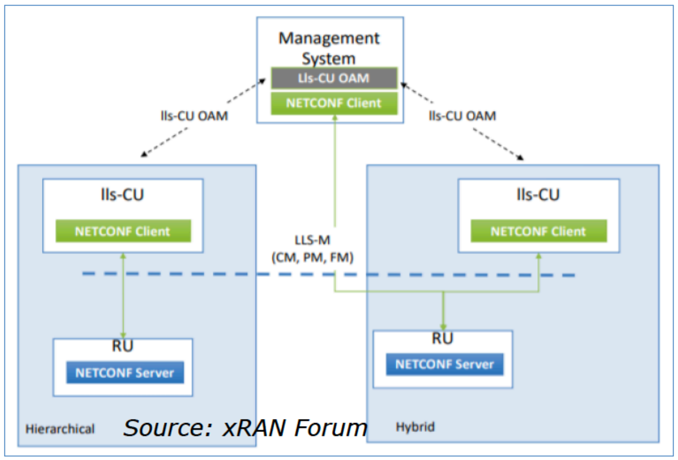
Source: IETF

5G Model Driven Automation

- The new metro-edge network will be SDN-based, programmable, and open to multi-domain orchestration
- Automation is especially important at the edge because
  - there will be significantly greater number of functions to manage; and
  - equipment may be deployed in locations that are not staffed
- Model-driven, intent-based configuration is of primary importance to lowering opex
- NETCONF/YANG gaining broad-based support as operators migrate away from CLI-based device management to API-driven devices

xRAN Adopts NETCONF/YANG

YANG based Management-plane for 5G RAN



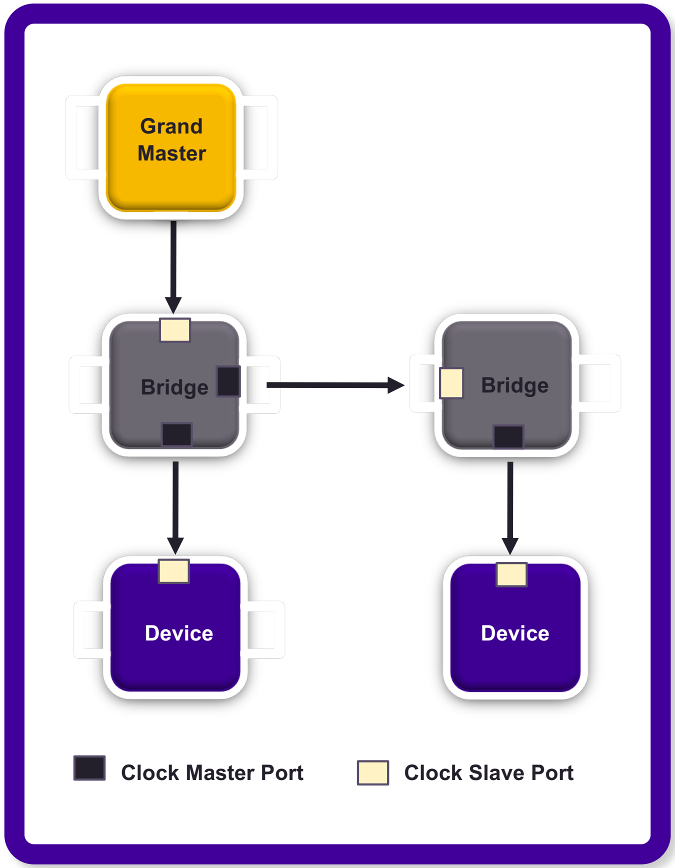
Source: xRAN Forum

- Programmatically configure and manage RUs (in LLS architecture)
- Simplify integration between CU and RU, even (especially!) in multi-vendor scenarios
- Model the state of 5G RUs, enabling programmatic control of radio resources across a coverage area
- Lays the foundation for cross-domain orchestration of the RAN with other domains that have already adopted NETCONF/YANG

With a full mesh packet network architecture, cross domain control will allow operators to support end-to-end services, with the appropriate resources allocated in the radio, core, and transport.

PTP (1588v2) on Ethernet

- The IEEE 1588v2 Precision Time Protocol (PTP) defines a packet-based time synchronization method that provides frequency, phase and time-of-day information with sub-microsecond accuracy. PTP relies on the use of carefully time stamped packets to synchronize one or more slave clocks to a master clock. Synchronous time information is distributed hierarchically, with a grand master clock at the root of the hierarchy. The grand master provides the time reference for one or more slave devices. These slave devices can, in turn, act as master devices for further hierarchical layers of slave devices.

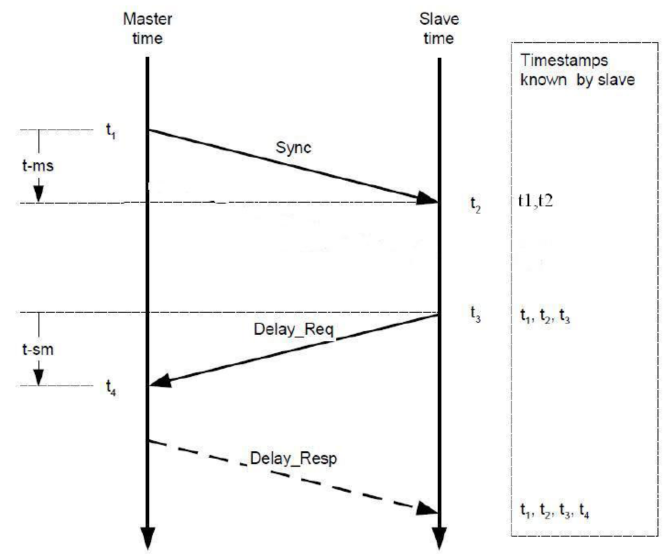


Precision Time Protocol (1588v2)

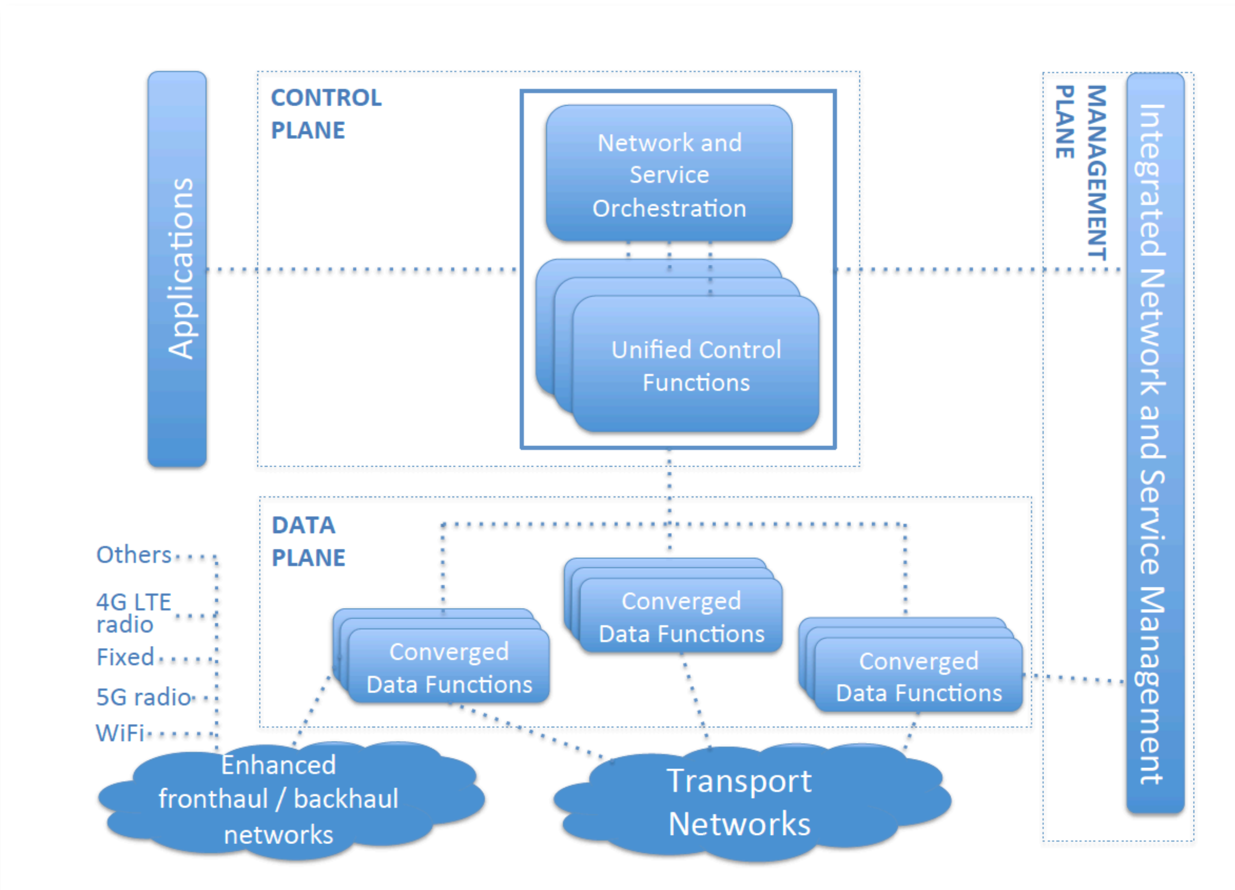
PTP Overview

- IEEE 1588-2008
  - Also known as Precision Timing Protocol (PTP)
  - 1588-2008 is also referred to as version 2 (v2)
  - Intended to synchronize independent clocks to a high degree of precision on separate nodes over a distributed network
  - Defines how to transfer precise time over networks. It does not define how to recover frequency or high precision time of day
- Message Exchange Pattern
  - A) The master sends a Sync message to the Slave and notes the time t1 at which it was sent.
  - B) The Slave receives the Sync message and noets the time of reception t2.
  - C) The Master conveys to the Slave the timestamp t1 by either
    - Embedding the timestamp t1 in the Sync message. This requires some sort of hardware processing for highest accuracy and precision. This is called as one step clocking.
    - Embedding the timestamp t1 in a Follow_Up message. This is called as two step clocking.
  - D) The Slave sends a Delay_Req message to the Master and notes the time t3 at which it was sent.
  - E) The Master receives the Delay_Req message and notes the time of reception t4.
  - F) The Master conveys to the Slave the timestamp t4 by embedding it in a Delay_Resp message.

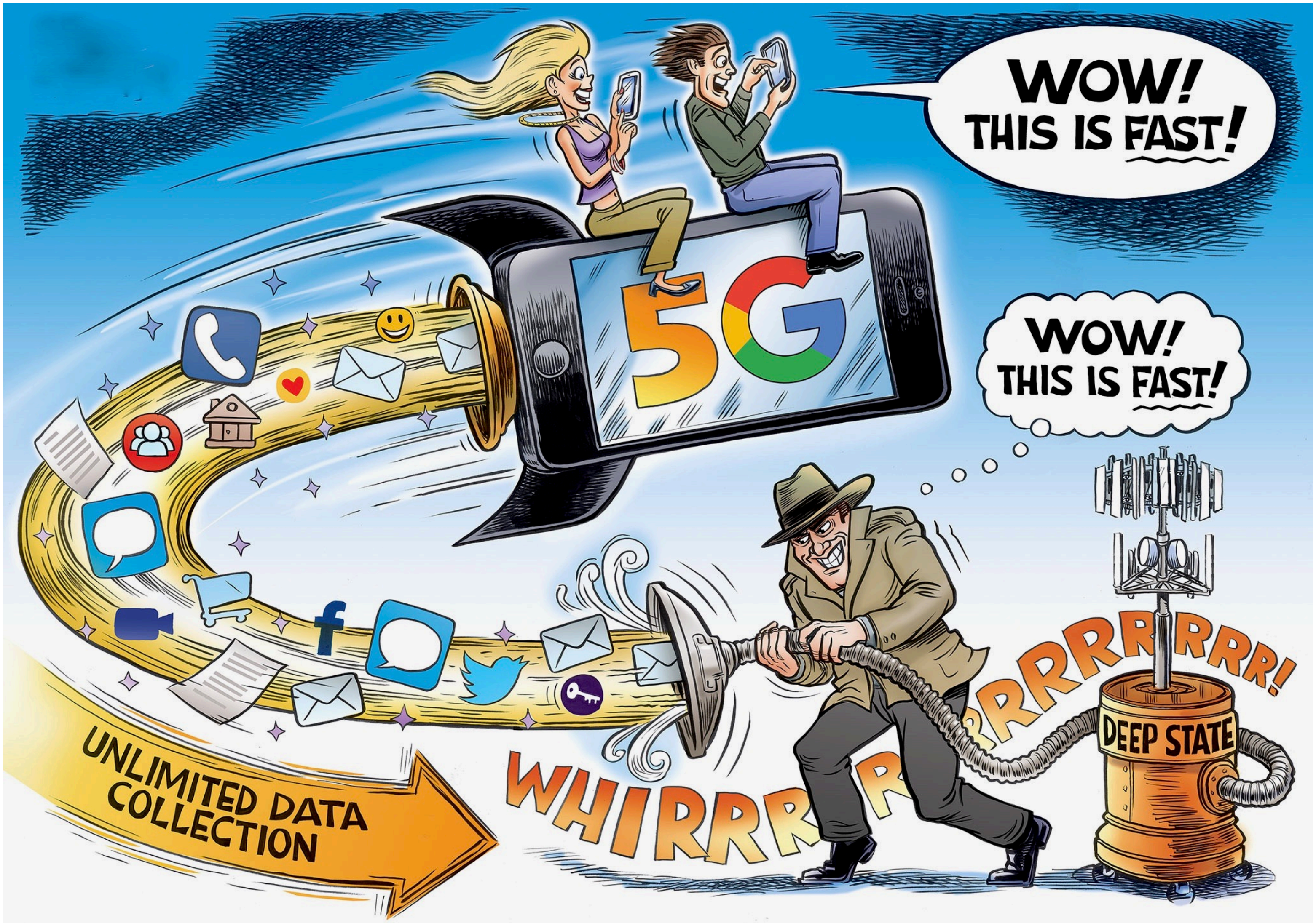
Basic Synchronization message exchange



5G High Level Network Architecture



Source: ITU, 3GPP


WOW!
THIS IS FAST!
WOW!
THIS IS FAST!
5G
DEEP STATE
WHIRRRRRRRRRRRRRRR!
UNLIMITED DATA COLLECTION