SyncE and PTP Update
The Past, the Present and the Future

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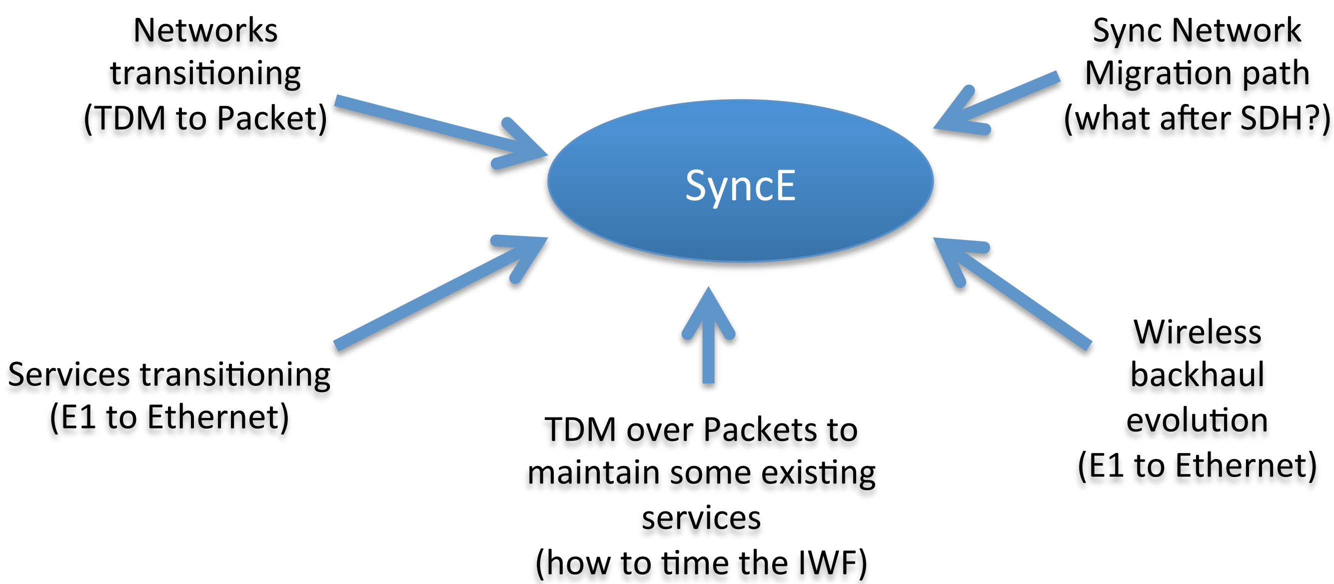
Objective and outline

- Objective:
  - To provide an update on the state of Synchronous Ethernet (SyncE) and IEEE1588 (PTP) technologies, key components in next generation synchronization
  - Focus is on telecom (due to time limitations)
- Outline:
  - Technologies review: What they are and the original drivers
  - Recent developments
  - Example of future application areas (e.g. 5G)

SYNCE AND PTP UPDATE: THE PAST

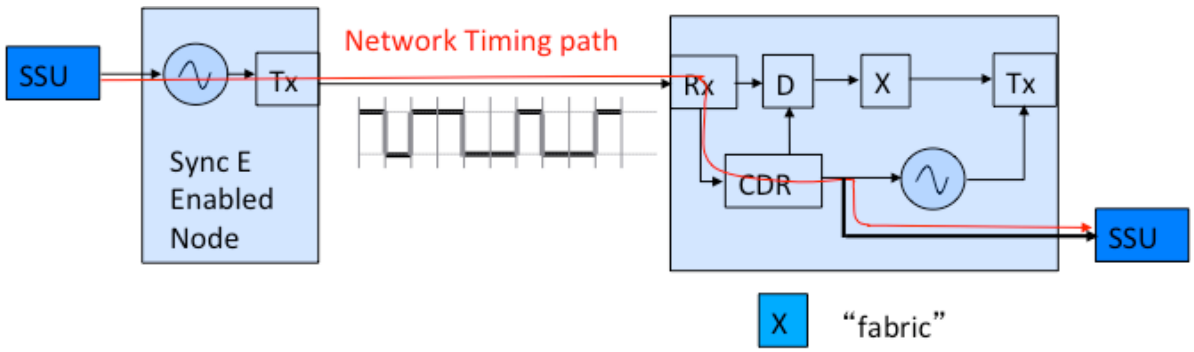
BACKGROUND

SyncE: Why was it developed



Ethernet PHY became obvious choice for Sync network evolution

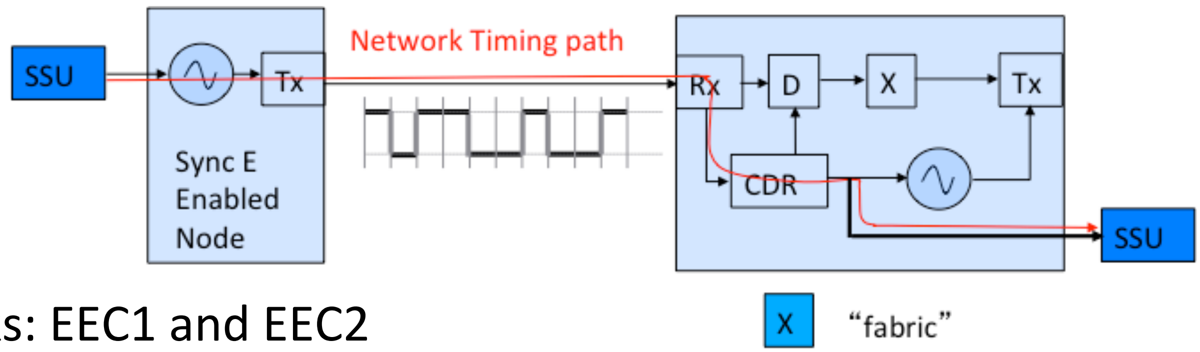
SyncE concept and components



Initial applications:

- Providing timing to Circuit Emulation
- General network timing distribution
- Timing to wireless backhaul

SyncE concept and components



- Clocks: EEC1 and EEC2
  - EEC1: based on G.813 Option 1 (SEC)
  - EEC2: based on G.812 Type IV/G.812 Option 2 (Stratum 3)
- Network Element functions:
  - Ethernet Synchronization Messaging Channel (ESMC)
  - G.781 protection

Ideal to migrate from SDH, but new services need phase/time

IEEE 1588/PTP

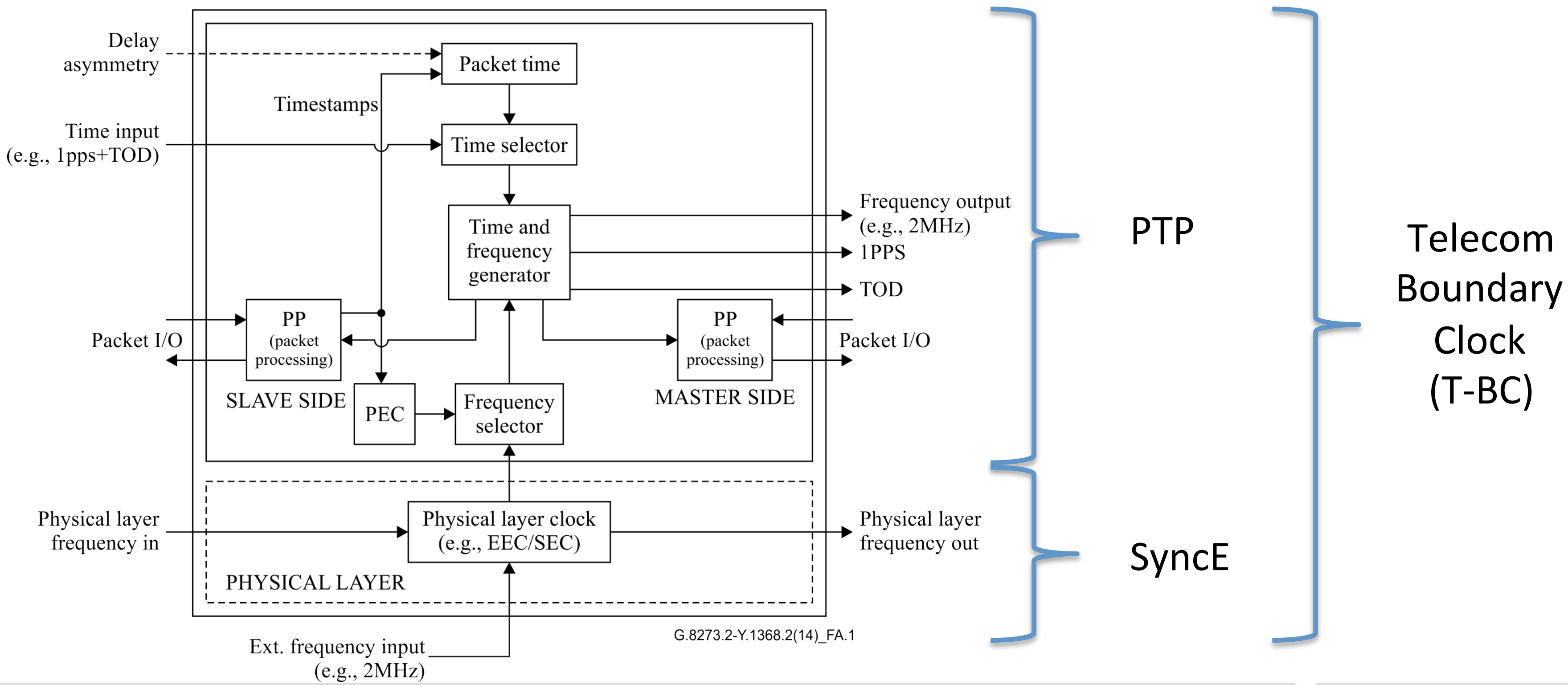
- IEEE1588: Standard for A Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
  - Developed by the IEEE for use in the industrial automation sector to define a system for distributing accurate time/phase in a packet based network environment. (NTP insufficient)
- Viewed as an ideal way to support frequency/phase/time
- IEEE1588(2008), "Version 2", defined capabilities to allow telecom application
  - Profile mechanism
  - Specialty clocks (Boundary and Transparent)
  - But still more needed…

ITU-T defined telecom profiles

- Multiple profiles developed
  - Frequency only
  - Frequency, phase and time
    - With full network support (all network elements operate as boundary clocks)
    - With Partial support (not all network need to be boundary clocks)
- Defined in ITU-T Recommendations
  - G.8265.1 (Frequency)
  - G.8275.1 (Frequency/phase/time with full support)
  - G.8275.2 (Frequency/phase/time with partial timing support) < recent

Multiple profiles address different network architectures

SyncE *and* PTP work together (T-BC)



SYNCE AND PTP UPDATE: THE PRESENT

RECENT DEVELOPMENTS

Recent developments: SyncE

- Clocks: New clocks being developed
  - Enhanced Ethernet Equipment Clock (e-EEC)
  - Improved performance (holdover, noise, transient)
- ESMC enhancements
  - New content to be carried in ESMC to provide capabilities such as hop count to enable better control of network performance

Extended ESMC QL

Table 11-4 – Extended QL TLV format

Octet number	Size/bits	Field
1	8 bits	Type: 0x02
2-3	16 bits	Length: 00-19
4	8 bits	Enhanced SSM code (see Table 2)
5-12	64 bits	SyncE Master Id, Note1
13	8 bits	Flag; Note2
14	8 bits	Number of cascaded eEECs from the nearest SSU/PRC
15	8 bits	Number of cascaded EECs from the nearest SSU/PRC
16-20	32 bits	Reserved for future use

Note1: default value = all ones

Note2: bit 0 = mixed EEC/eEEC (=1 if at least one of the clocks is not an eEEC; =1 if all clocks are eEEC) ; bit 1 = partial chain (=1 , if the TLV has been generated in the middle of the chain and the count of the EEC/eEEC is incomplete) ; bits 7-2 reserved for future use

Table 11-5 : Enhance SSM messages for synchronous Ethernet.

Clock	Message	SSM code
As per G.781/G.8264	QL as per G.781/G.8264 (refer to the QL TLV)	0xFF
PRTC	QL-PRTC	0x20
ePRTC	QL-ePRTC	0x21
eEEC	QL-eEEC	0x22

Recent developments: IEEE 1588

- Ongoing work by IEEE to develop next version
- Partial timing support profile (G.8275.2) published
- Boundary clock specification published
- Ongoing work on Enhanced PRTC
- Development of PTP over OTN

SYNCE AND PTP UPDATE: THE FUTURE

APPLICATIONS TO 5G

Synchronization: 5G networks

- SyncE and PTP were developed to support evolving wireless backhaul needs
  - Synchronization network expected to support continued evolution to 5G
- 5G networks will:
  - Support new services:
    - IoT, Sensor Networks, tactile internet
  - Provide higher performance:
    - Higher bit rates, higher speed mobility handoff, lower latency
  - New deployment cases:
    - Higher connection densities, new spectrum allocation, use of unlicensed spectrum
  - New Radio Access Network (RAN) architectures

Are changes needed to synchronization network capabilities?

Capability delta against current

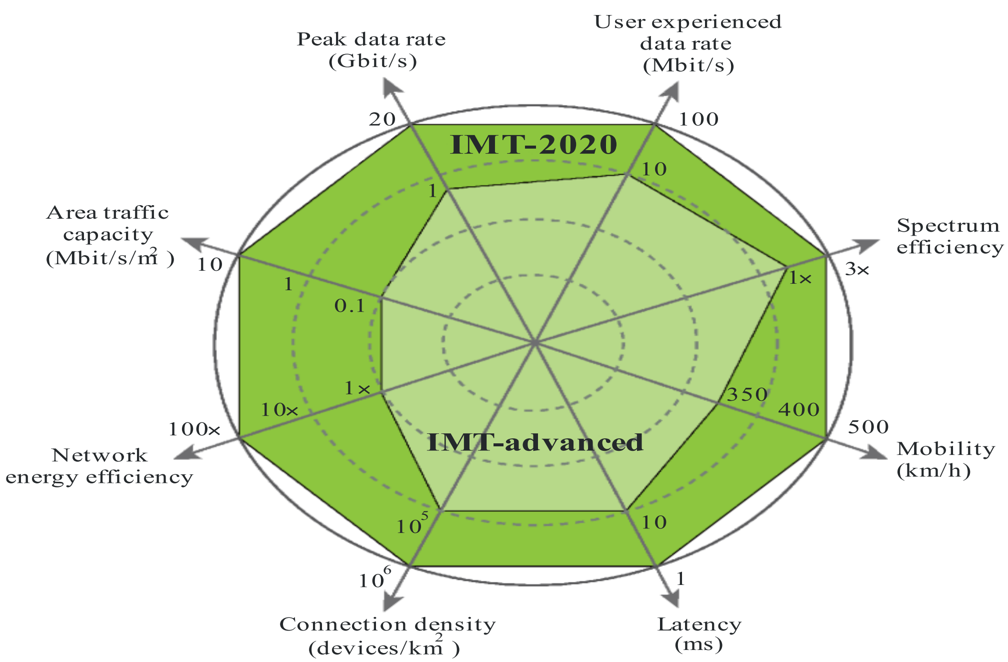


Figure: ITU-R M.2083

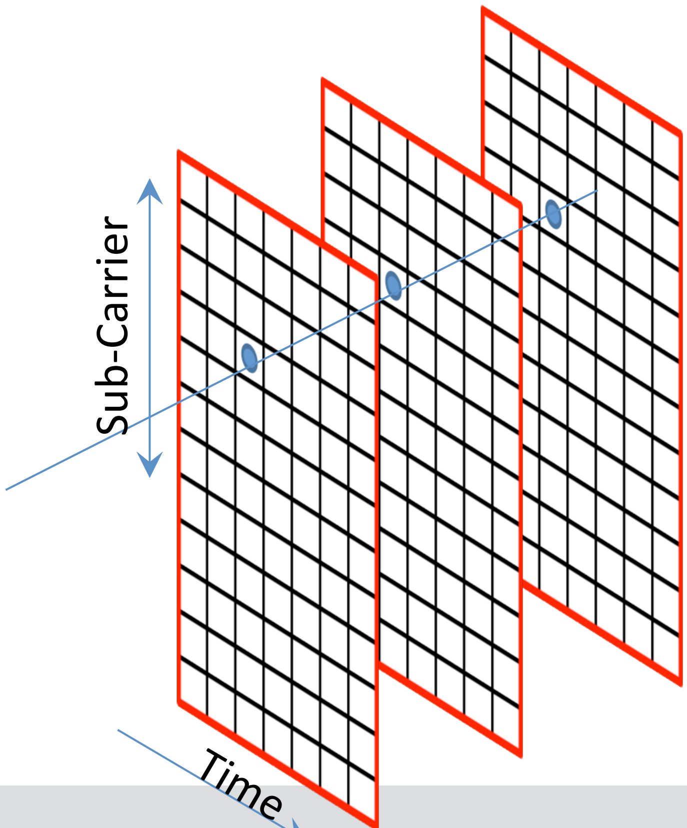
5G realized by:

- **Peak data rate : New spectrum allocation**
- **User data rate: CoMP, MIMO**
- **Spectrum efficiency: Modulation**
- **Mobility: Faster hand-off capability (CRAN)**
- **Latency: Movement of service data bases**
- **Connection density: CRAN architecture**
- **Network energy: CRAN architecture**
- **Area traffic capacity: CRAN/CoMP/MIMO**

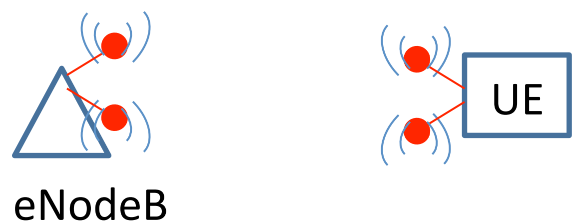
Synchronization requirements?

- Synchronization requirements will be based both service needs and the needs of the infrastructure
  - Service needs:
    - M2M, IoT may require accurate synchronization, which may or may not be provided by the network
  - Infrastructure needs:
    - New air interfaces may be defined
    - New capabilities related to time-sensitive networks may be needed and may require synchronization support from the network

Air interface is more complex



- Existing sync network based on TDM slip rate objectives, requiring control of pointer adjustments in SDH
- Air interface is more complex: OFDM symbols (subcarriers) are represented by resource blocks in a frame structure. (FDD shown)
- In the case of MIMO, each antenna will have a frame structure.
- Where multiple antennas share the same system clock, usually not an issue.
- CoMP or Carrier Aggregation may need some assistance where antennas are driven by different oscillators.

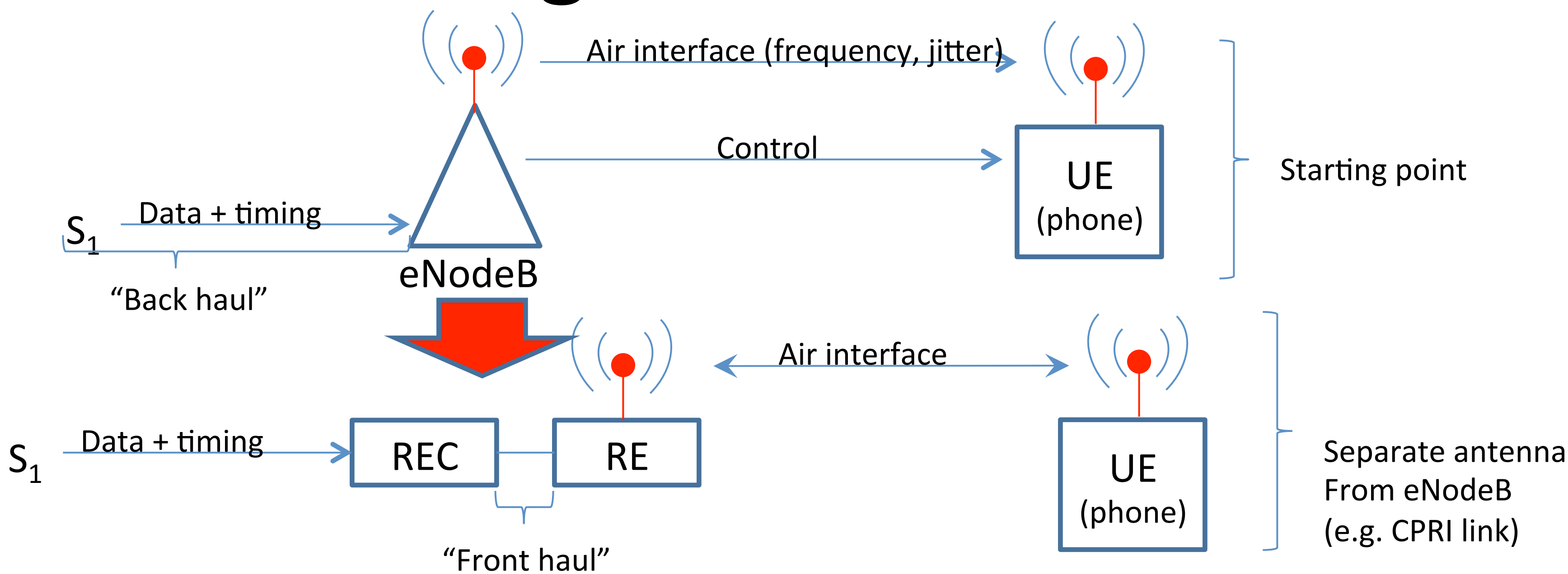


NEW ARCHITECTURE CONSTRUCTS: CRAN AND NETWORK SLICING

5G: New architectural components

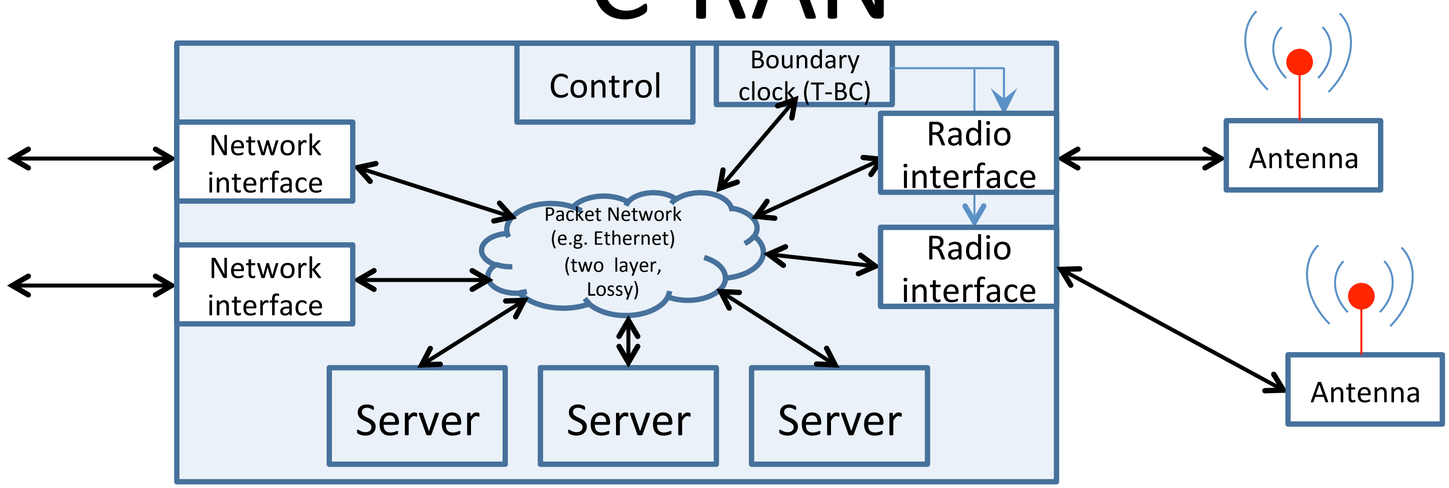
- Centralization of functions and the use of data centre techniques are seen as key to supporting 5G requirements
- Architecture:
  - C-RAN (Cloud-RAN, Centralized-RAN)
    - Localizes the functions to allow sharing of resources
  - Network slicing
    - Controlling how the end-to-end network is shared between different user (groups) to achieve different network objectives
    - Involves aspects of virtualization and orchestration

The evolving base-station model



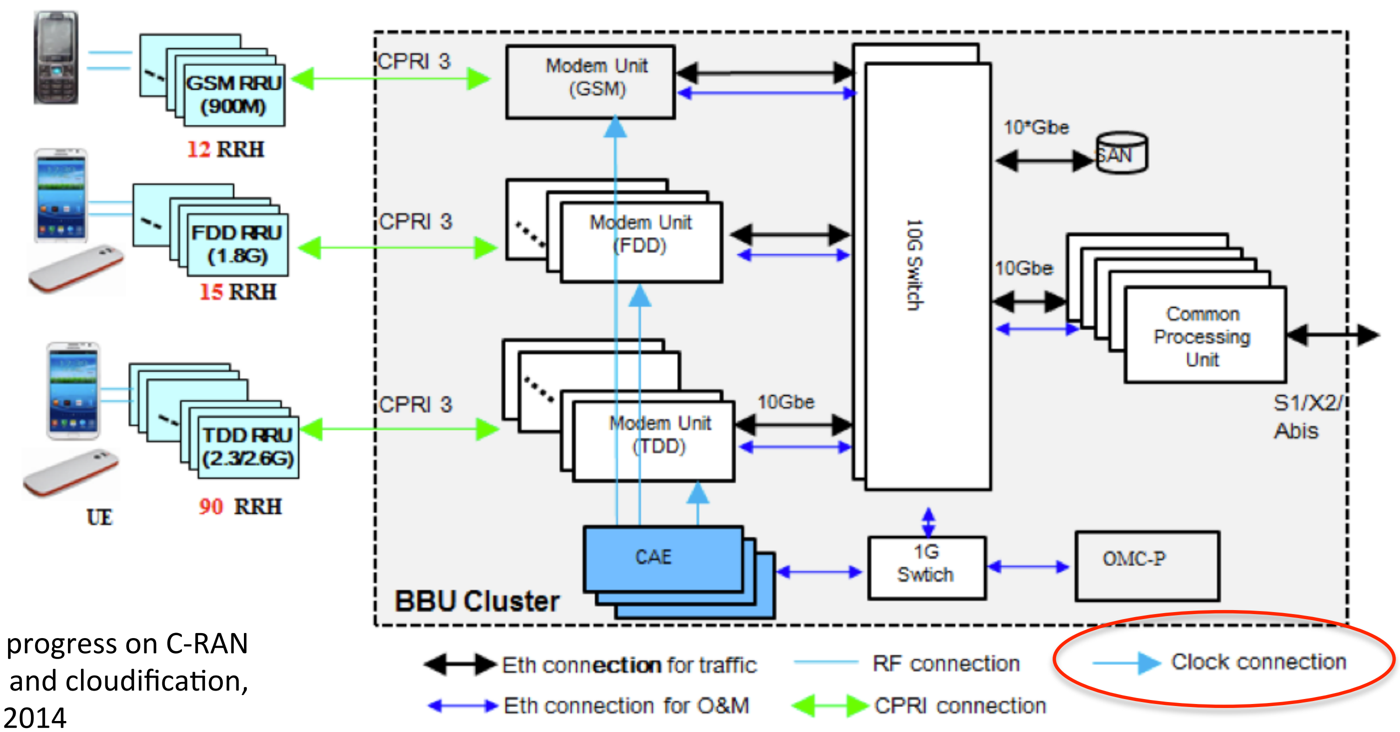
In practice, a network may have hundreds or thousands of base stations.
Are there any efficiencies that can be gained by centralizing some functions?

C-RAN



- **C-RAN:**
  - **Localize functions associated with radio base Station control with the goal of achieving statistical gains.**
  - **Data centre model**
  - **Allows tighter control of latency and synchronization in the case of distributed MIMO, or CA, where normally separate base-stations would have been deployed**
  - **Above example shows timing distribution via boundary clocks, but other possibilities exist.**
  - **Synchronization impact: consistent with existing HRM for time/phase/frequency**

CRAN example (CMCC)



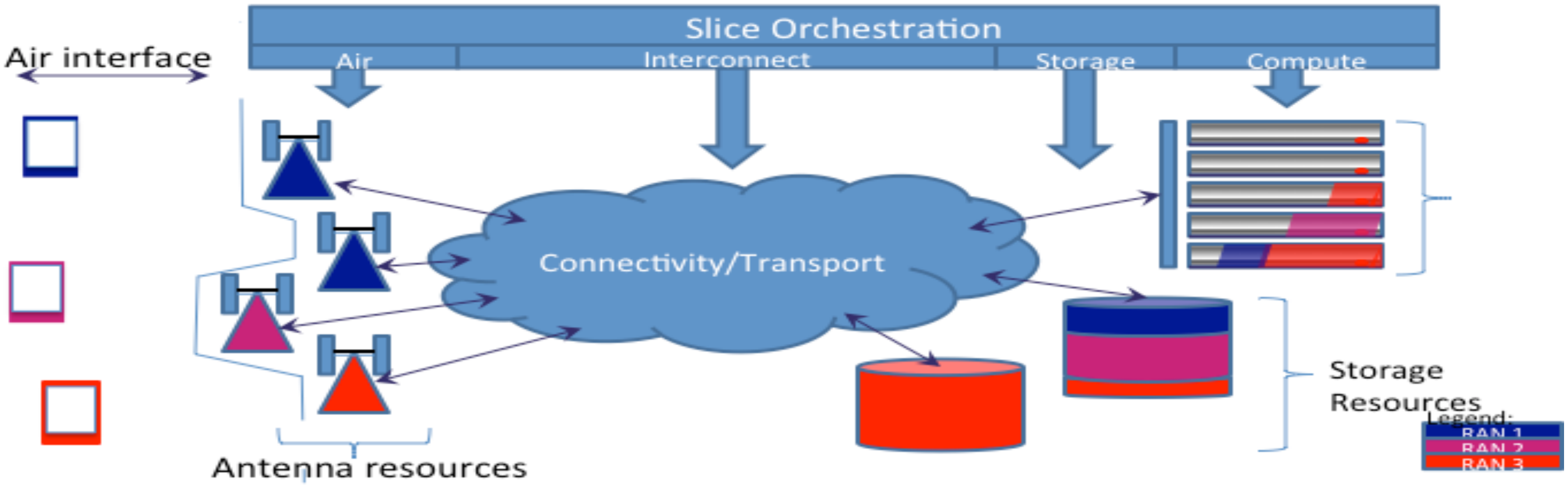
From: Recent progress on C-RAN centralization and cloudification, Chih-lin et al, 2014

Network slicing

- 5G networks will aggregate multiple services on possibly separate radio access technologies
  - Spectrum may be shared and needs control and coordination
  - Network slice represents the portion of all network resources that may be allocated to a service or user.

Synchronization impact: Slicing orchestration needs to consider synchronization of air Interface.

Slicing: allocate and connect resources



- **Slicing separates resource and will enable the CRAN**
- **For 5G, multiple air interfaces need to be considered**
- **Functions for control based on NFG and SDN to run packet core functions on general purpose CPUs**
- **Synchronization of base-stations/antenna resources are needed as in any RAN**
- **What aspects related to sync are required?**

Summary

- SyncE and PTP are well established and offer high levels of performance
- New functionality will offer enhanced network functionality
- Evolving 5G wireless architecture and services may require higher performance from sync network
  - Enhanced EEC starts to address performance
- 5G will offer new services and support new technology.
  - Some services may require accurate time (e.g. location accuracy) even though the fundamental transport doesn't need it.
  - PTP natural technology
- New CRAN architectures for 5G appear to be well supported by current synchronization techniques.
  - Some further work may be required to define certain components, slicing support aspects and potentially new air interface definitions.

Thank you

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