Applicability of OTN for NGFI / CPRI Fronthaul

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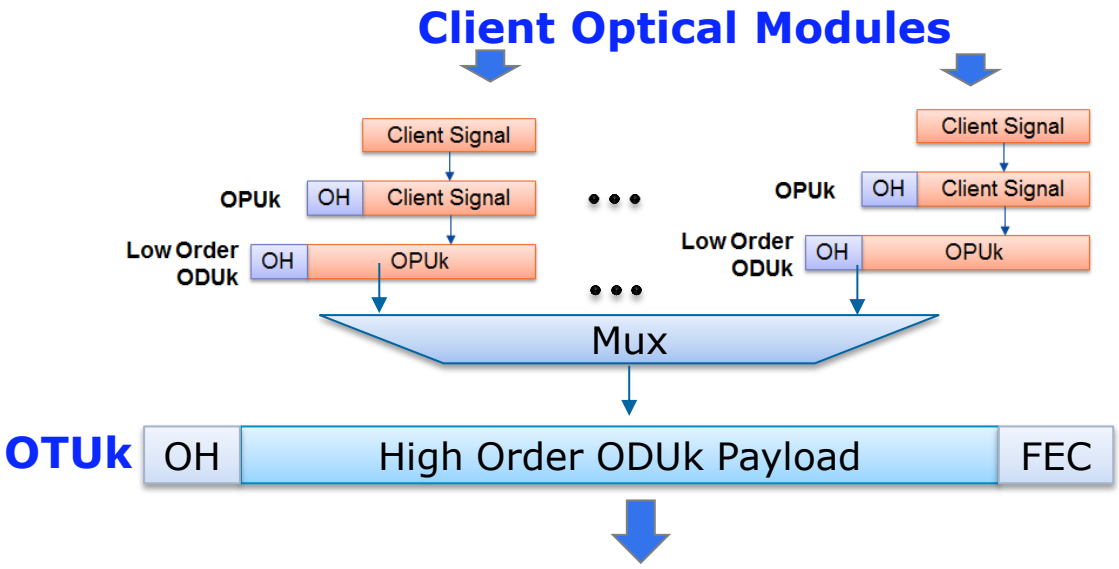
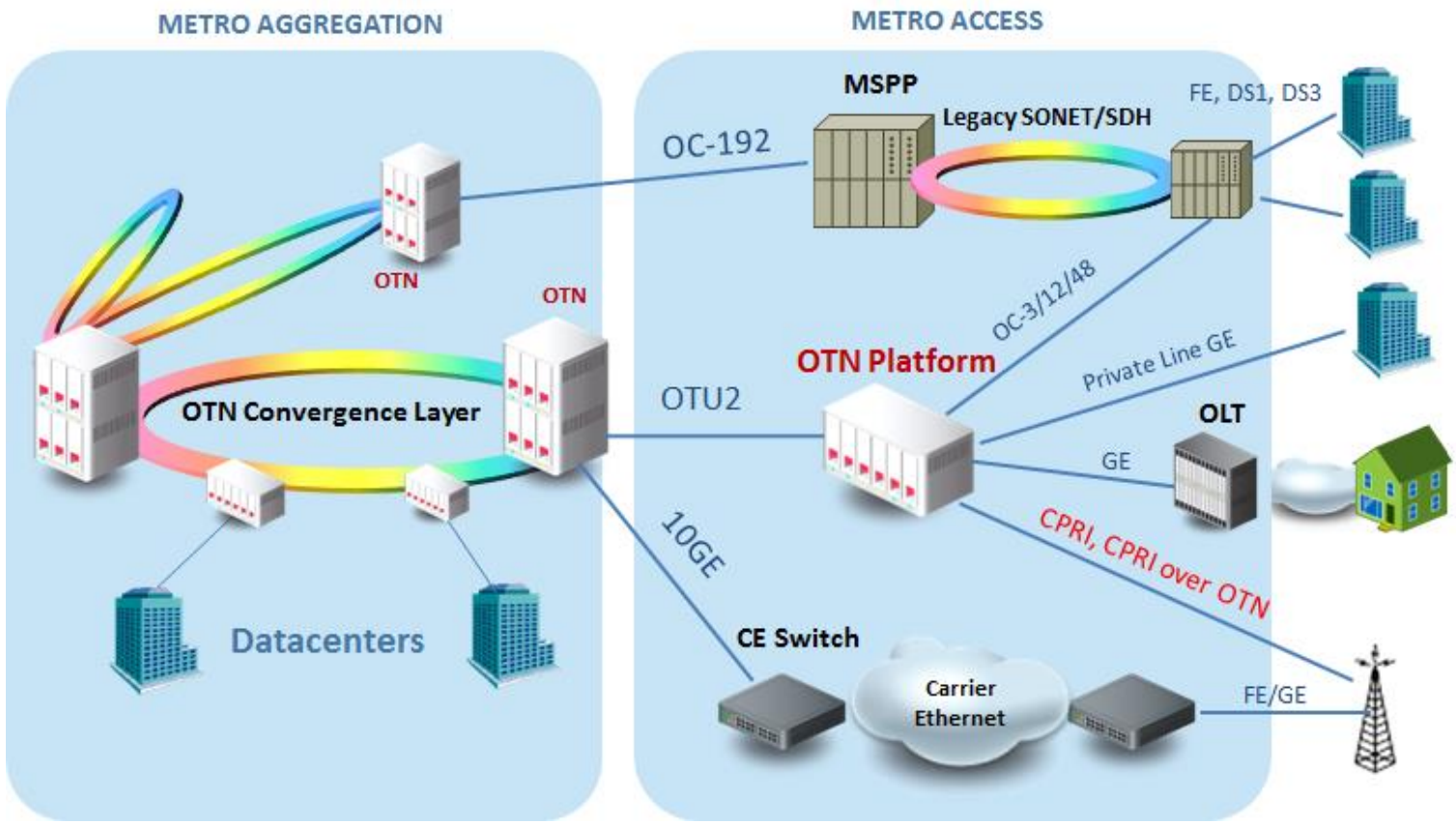
Introduction to OTN

- Standardized in ITU-T G.709
- Multiservice support
  - FE/GE/10GE/40GE/100GE/etc
  - SONET/SDH
  - FC/SAN
  - Video
  - CPRI
- Client mapping into OPUk
  - BMP
  - AMP
  - GFP (-F or –T)
  - GMP
- OTN provides
  - Bit transparency
  - Timing transparency
  - Extensive carrier grade OAM
  - Carrier grade protection support



OTUk	Approximate Line Rate
OTU1	2.5G
OTU2	10G
OTU3	40G
OTU4	100G
OTUCn	Nx100G

OTN: Ubiquitous Transport Layer

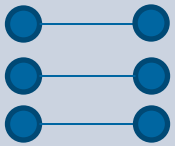
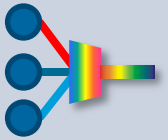
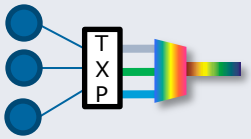
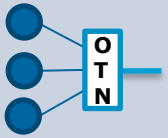
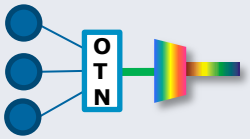


- Deployed in transport networks globally … and pushing deeper into the "metro access"
- Supports all client types with service assuredness, carrier grade OAM
- Meets requirements for CPRI Transport

ITU-T SG15 Work on Radio over OTN

- Q11 has active projects on mapping CPRI clients into OTN for transport
  - G.Sup56 – OTN transport of CPRI signals
    - Including both a straight CBR signal mapping (with the required receiver timing recovery filter requirements) and methods to multiplex multiple CPRI signals prior to mapping into OTN
  - Preparing to launch a new project on radio transport over OTN, going beyond G.Sup56
    - E.g., higher signal rates, different network topologies, 5G considerations, etc.
    - Liaison sent to IEEE 1914, CPRI TWG, 3GPP RAN3, IEEE 802.1 TSN, and ITU-T FG IMT2020 expressing the Q11 desire to work cooperatively with each group in this area.
- Q13 has ongoing simulation and analysis work on the frequency accuracy / performance requirements for carrying CPRI over OTN

Fronthaul Options

Point to Point		• One fiber for each CPRI signal → not economical
Microwave		• Capable of supporting up to CPRI option 3 • Limited rate/reach limit application space
Passive WDM		• WDM optical modules directly installed in the RRH combined with a WDM mux
Active WDM		• External transponder + WDM mux
OTN (Grey)		• Supports CPRI and Ethernet • Scales to 100G+ • Saves optical module cost vs. WDM
OTN + WDM		• Adds WDM for ring applications adding protection and increased fiber capacity • Lower cost and increased scalability vs. WDM

OTN Enables Enhanced Reach

	100GBASE-ER without OTN	100GBASE-ER with OTN	100GBASE LR (QSFP28) without OTN	100GBASE LR (QSFP28) with OTN
Transmit Power	-2.9	-2.9	-7	-7
Receiver Sensitivity (dB)	-20.9	-20.9	-11.5	-11.5
Remaining System Budget (dB)	-18	-18	-4.5	-4.5
OTN FEC	0	-6.2	0	-6.2
Total Remaining Budget	-18	-24.2	-4.5	-10.7
1310nm Fiber loss (dB/km)	-0.45	-0.45	-0.45	-0.45
Reach (km)	40	53.8	10	23.8

Max reach LR4 optics → **10km**

OTU4 FEC adds ~0.65us of latency

Extends reach of low cost LR4 client optics to 24km

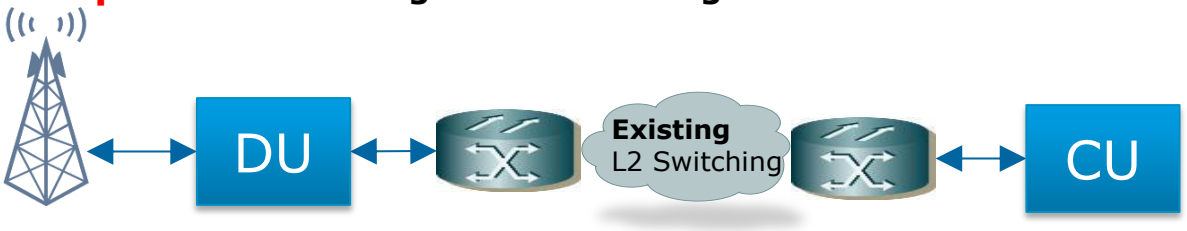
Enables enhanced reach without the use of coherent DSPs

- Advantages of OTN (OAM, encryption, reach) without the added power and cost of a coherent modem

DU: Digital Unit
CU: Central Unit

NGFI Transport Options

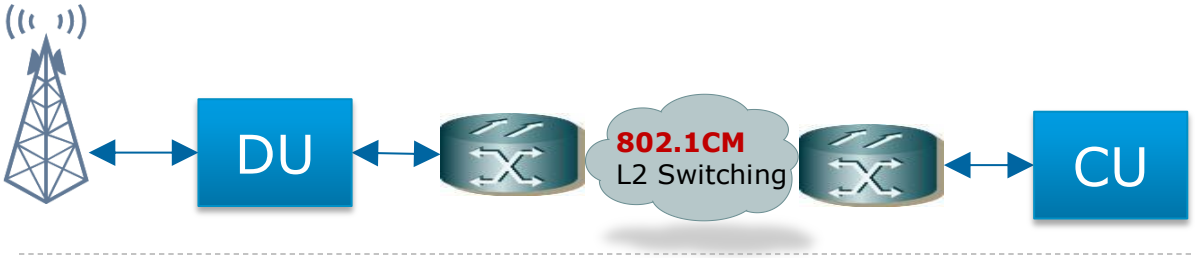
Option #1 Existing ENET Switching Network



Pros:
- Can leverage existing transport
- Availability of transport

Cons:
- Cannot support PHY layer splits
- Cannot support CPRI
- Bandwidth scalability in 5G era?

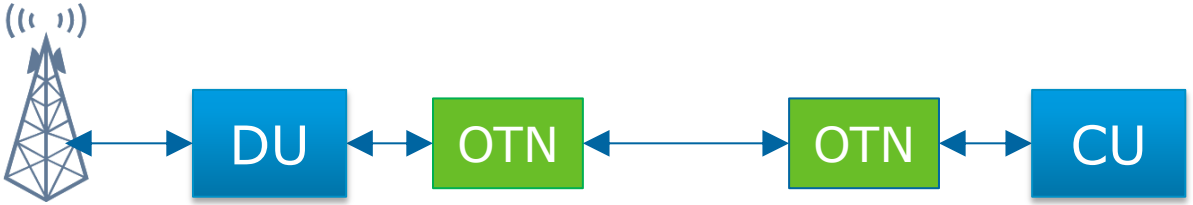
Option #2 New ENET Switch with 802.1CM



Pros:
- Supports any functional split

Cons:
- Requires new network w/802.1CM
- Cannot support CPRI
- Bandwidth scalability in 5G era?

Option #3 OTN



Pros:
- Supports any functional split
- Supports CPRI and Ethernet
- Scales to 100G+
- Lower latency relative to ENET SW
- Enables use of short reach optics
- Can be switched
- Includes Forward Error Correction

Cons:
- Requires access to fiber

Synchronization with OTN

ToD and Frequency Synchronization:

- Support for PTP and SyncO have been standardized
- The OSMC (OTN Synchronization Messaging Channel) is used to carry PTP and SSM (Synchronization Status) messages
- ToD distribution mechanism is similar to that of an ITU-T G.8275.1 (fully PTP-aware) Ethernet network

Client Timing Transparency:

- OTN could behave like a PTP Transparent Clock and pass the Ethernet's PTP timing through transparently
- OTN can pass the SyncE frequency through transparently

Net: OTN fronthaul can play a role in cell-site synchronization

Ethernet Mappings into OTN

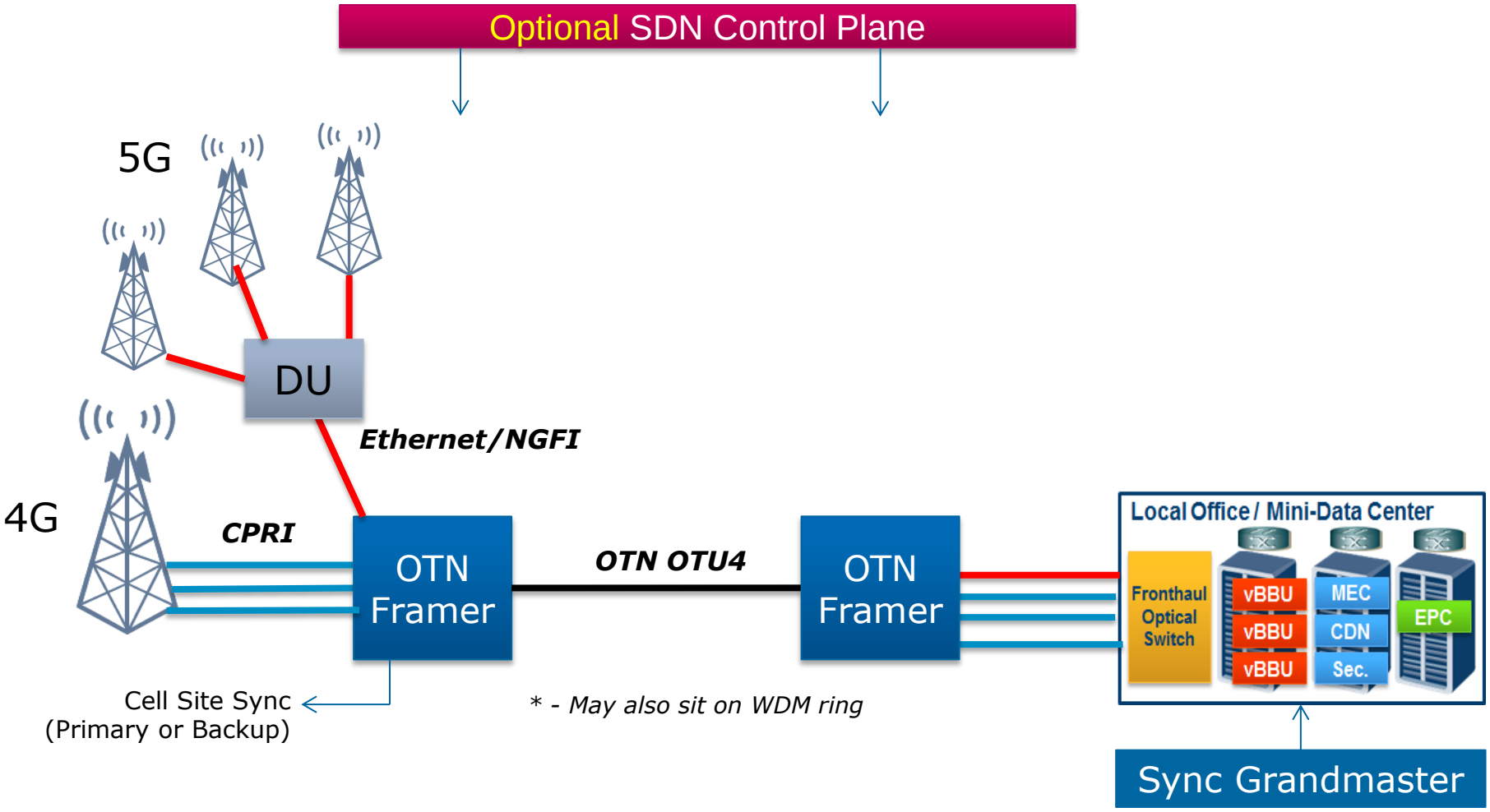
Timing Transparent Constant Bit Rate Mappings:

- The Bit-Synchronous Mapping Procedure (BMP) and the Generic Mapping Procedure (GMP) carry constant bit-rate Ethernet streams transparently across OTN

Reduced Bandwidth Packet-Based Mappings:

- GFP-F based mapping terminates the Ethernet stream, encapsulates the original messages into GFP frames, and multiplexes these frames into OTN tributaries. Original timing is lost (unless PTP TC functionality is used).
- TTT and GFP-T based mappings improve the efficiency of the original stream while carrying it across OTN in GFP frames and maintaining frequency and pseudo bit transparency

OTN Fronthaul Application Example



Conclusion and Proposal

Technical Benefits of OTN Fronthaul:

- Can multiplex multiple CPRI signals into 10G, 40G, or 100G+ containers
- Can support both Ethernet and CPRI into the same outgoing OTUk signal
- Enables use of any Functional Split between CU and DU
- Provides carrier grade OAM
- Is Lower latency and jitter in comparison to Ethernet
- Can be SDN managed
- With FEC, extends reach of 10km optics to > 24km

Economic Benefits of OTN Fronthaul:

- OTN can leverage lower cost grey optics
- Improved fiber efficiency and scalabilty → more CPRI's per 10G or 100G wavelength

Proposal #1: IEEE1914 should ensure that NGFI is defined to be compatible with existing Ethernet standards to ensure OTN may be used for fronthaul transport

Proposal #2: IEEE1914 should consider NGFI mappings that take advantage of OTN's standardized GFP-F mapping procedures