Efficiency Considerations for EPoC PHY Design

Hesham ElBakoury

www.huawei.com

HUAWEI TECHNOLOGIES CO., LTD.

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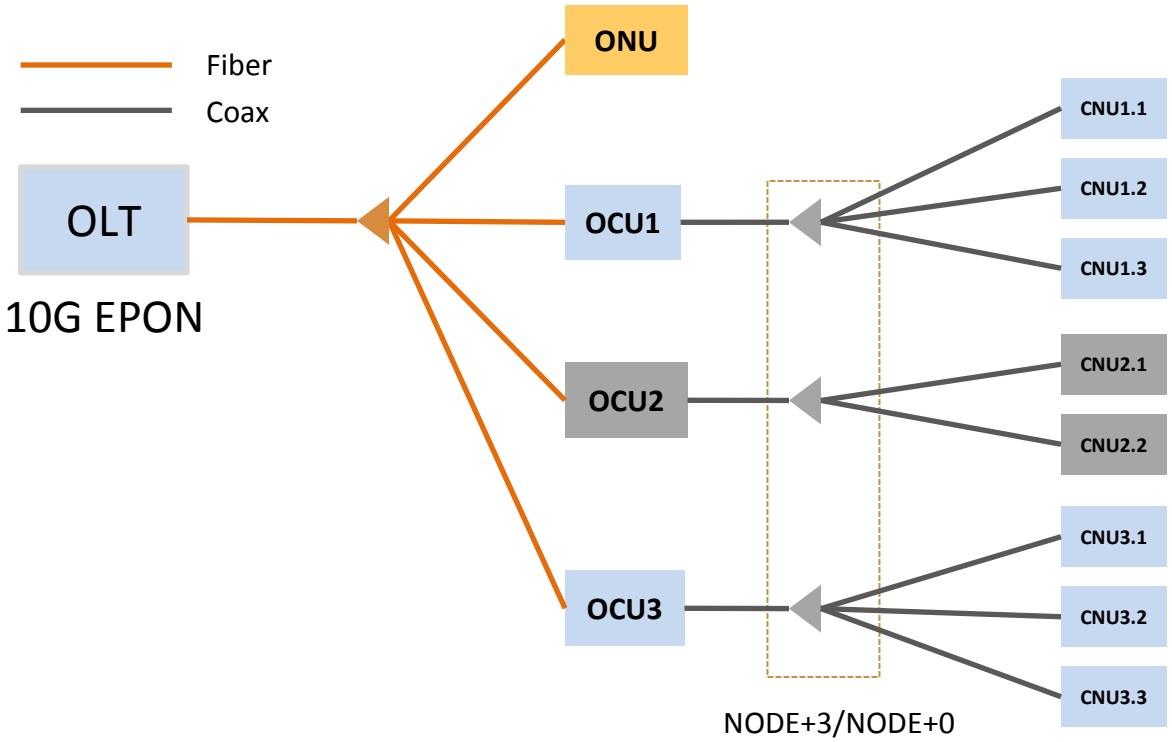
Scope

- The contents of this document is for information only.
- This is NOT a proposal.
- We understand that some of the features in this contribution are out of scope of the EPoC specification, but EPoC PHY design should consider and provide the possibility to realize these features.

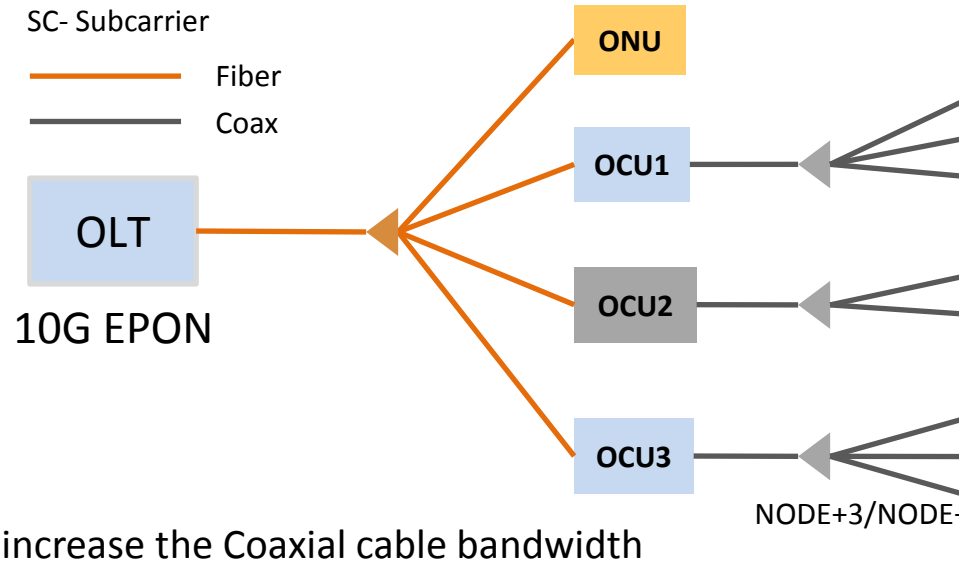
Agenda

- **Concurrent upstream transmission of CNUs and ONUs.**
  - Fully utilize the capacity of 10G EPON.Link.
  - Fully utilize the potential capacity of Coaxial cable.
- **CNU Power savings**
- **Cost-performance considerations for CNU.**
- **Considerations for future evolution.**

Typical EPOC Deployment Scenario



Downstream Efficiency of Coaxial Cable



UNICAST SCHEME

SC 1	SC 2	SC 3	SC 4
8	10	10	10
10	8	10	12
12	8	12	12
8	12	8	10
8	12	8	8
12	12	12	10
12	10	12	12
10	8	12	12

Bit-loading table

BROADCAST SCHEME

8	8	8	8

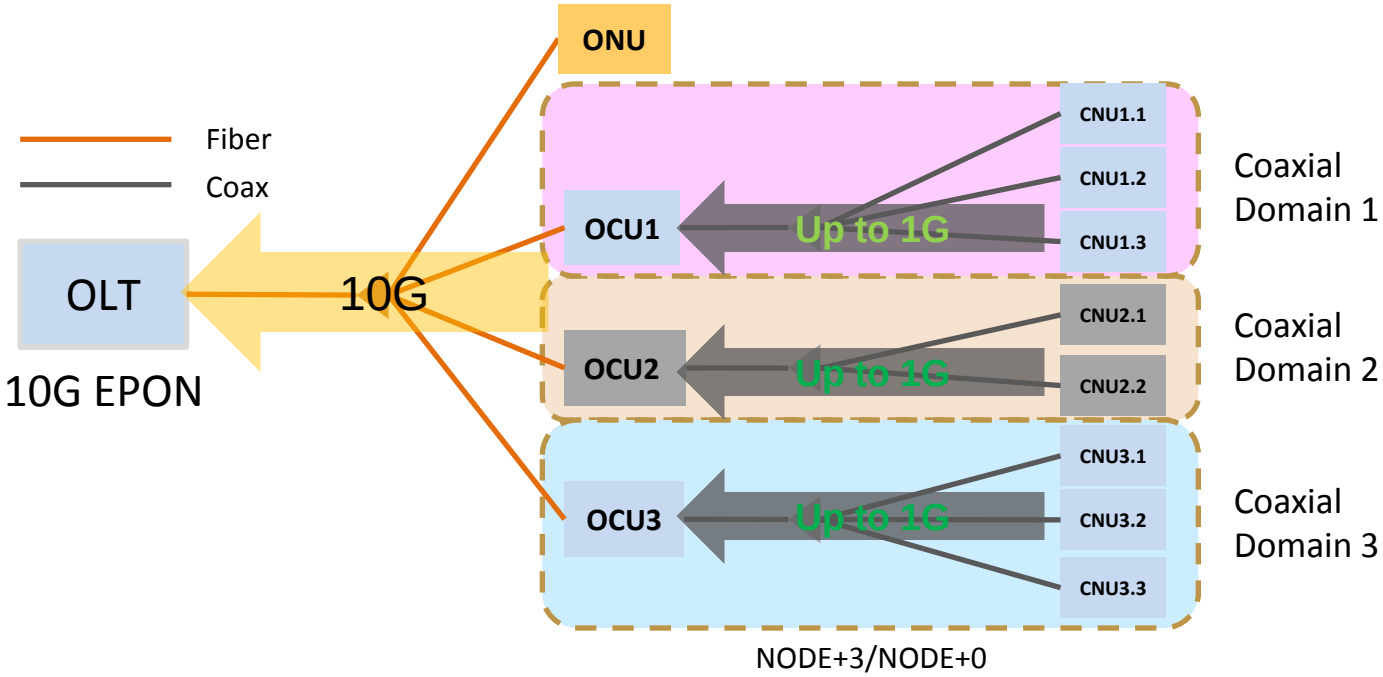
❑ To increase the Coaxial cable bandwidth utilization in the downstream, the following features should be considered for further analysis :

- ✓ **Downstream Unicast**: each subscriber uses different bit loading determined by the channel conditions.
- ✓ **Downstream scheduling**: Develop a downstream scheduling mechanism to determine the symbols and subcarriers a CNU can use to receive unicast and multicast traffic.

Suppose each subscriber is receiving the same data frame sizes

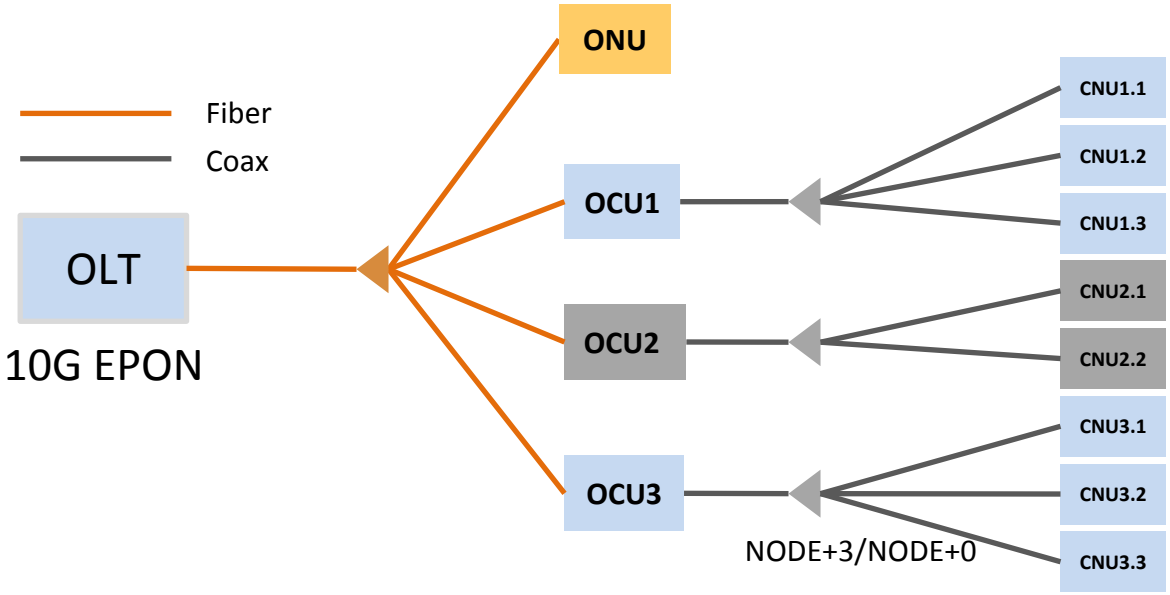
- the average bit loading of unicast scheme is 10.3 bits;
- the average bit loading of broadcast scheme is 8 bits;
- the total improvement is 28.8%;
- for the same data load, the unicast scheme will shorten the communication duration around 22.4%.

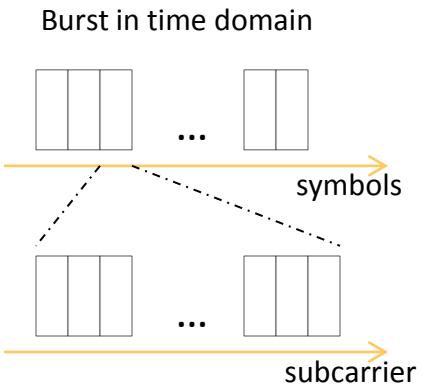
Upstream Efficiency on EPON



❑ To maximize the upstream bandwidth utilization of the10G EPON link we should connect multiple ONUs and OCUs to a single 10G EPON port and support concurrent upstream transmissions of CNUs in different coaxial domains.

Upstream Efficiency of Coaxial Cable





❑ To maximize the bandwidth utilization of the Coaxial cable in the upstream, multiple CNUs under the same OCU should share the same symbol for upstream transmission.

❑ Large FEC code word for uplink transmission is not a good choice (FEC code can't be share by different CNUs)

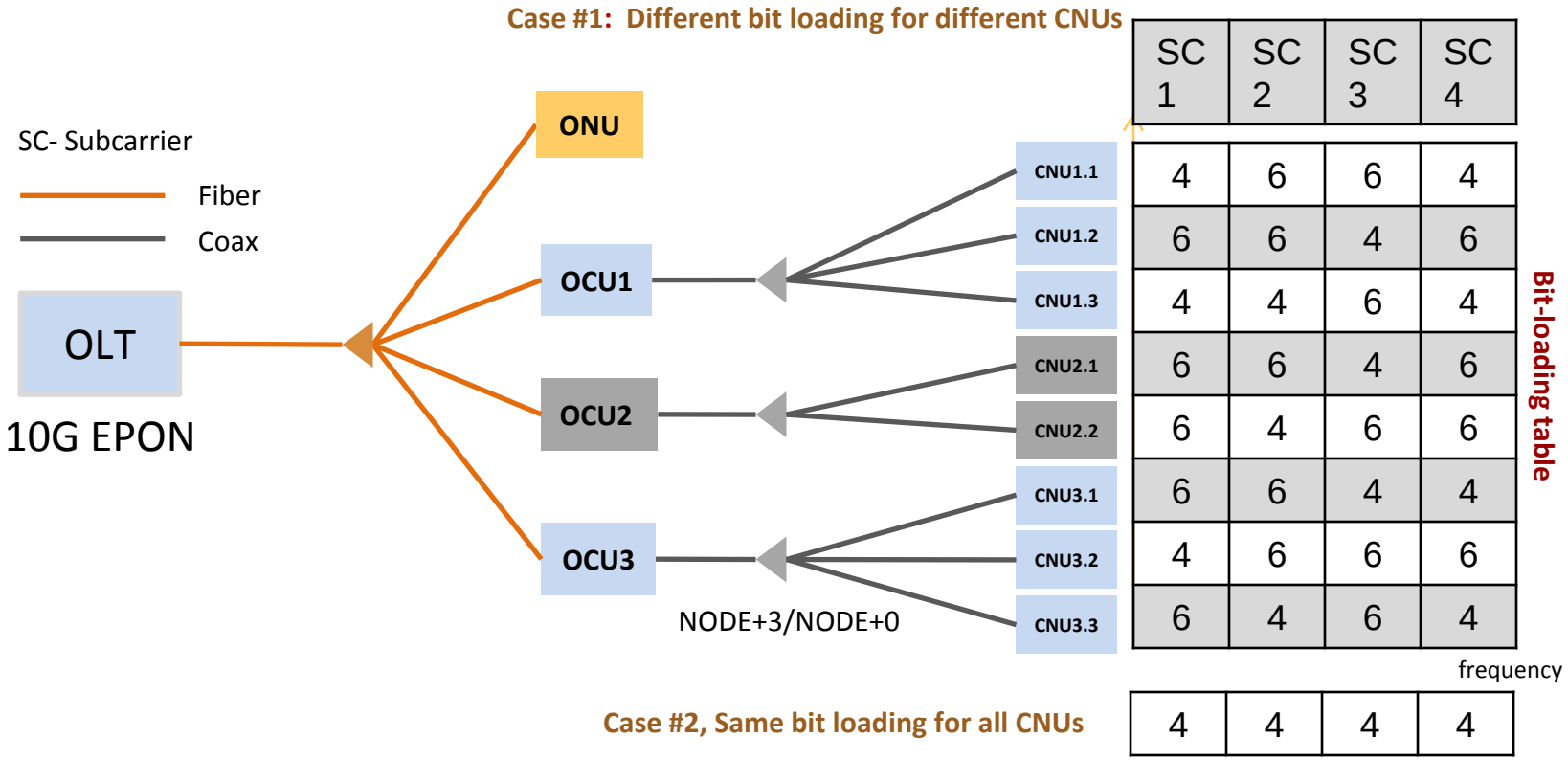
Suppose each burst uses only one symbol, each symbol duration is 40us, and the bit loading supports a 500Mbps channel data rate

❑ then each uplink burst can carry 2500 Bytes

❑ but in the typical traffic loading case, 50% of the packets are 64 Bytes

❑ allocating a single burst to one CNU is a big waste when there is only one 64 bytes to be transmitted (2500/64 = 39).

Upstream Efficiency of Coaxial Cable

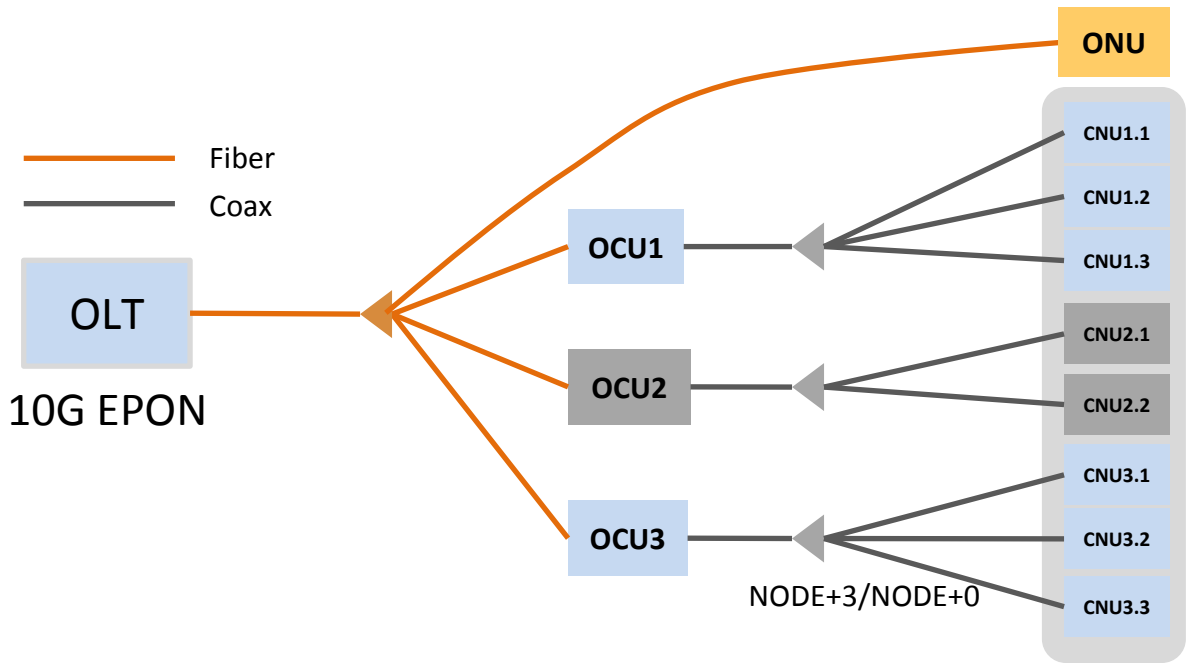


❑ To maximize the Coaxial cable bandwidth utilization in the upstream, different CNUs should use different bit loading in the coax uplink according to the channel condition.

Suppose each CNU has the same data packet sizes to be transmitted

- the average bit loading of case 1 is 5.18 bits;
- the average bit loading of case 2 is 4 bits;
- the total improvement is 29.5%;
- for the same data load, case 1 will shorten the communication duration around 22.8%.

Coexistence of EPON ONUs and EPoC CNUs



❑ Assume the OLT supports maximum number of 32 ONUs/OCUs

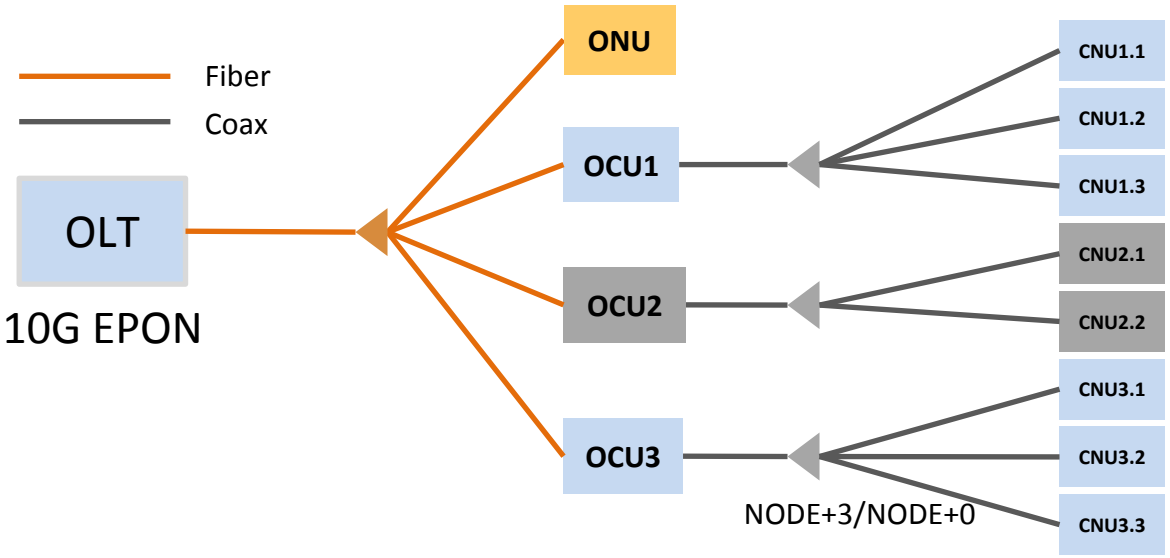
Maximum number of CNUs is 32*N

❑ where N the maximum number of CNUs that an OCU can support.

❑ To maximize the bandwidth utilization of EPON link, and reduce the delay of ONU traffic as more CNUs are added, we should allow concurrent upstream transmissions of CNUs and ONUs.

✓ The new extended MPCP GATE messages should be backward compatible with current messages.

Considerations for Power Savings

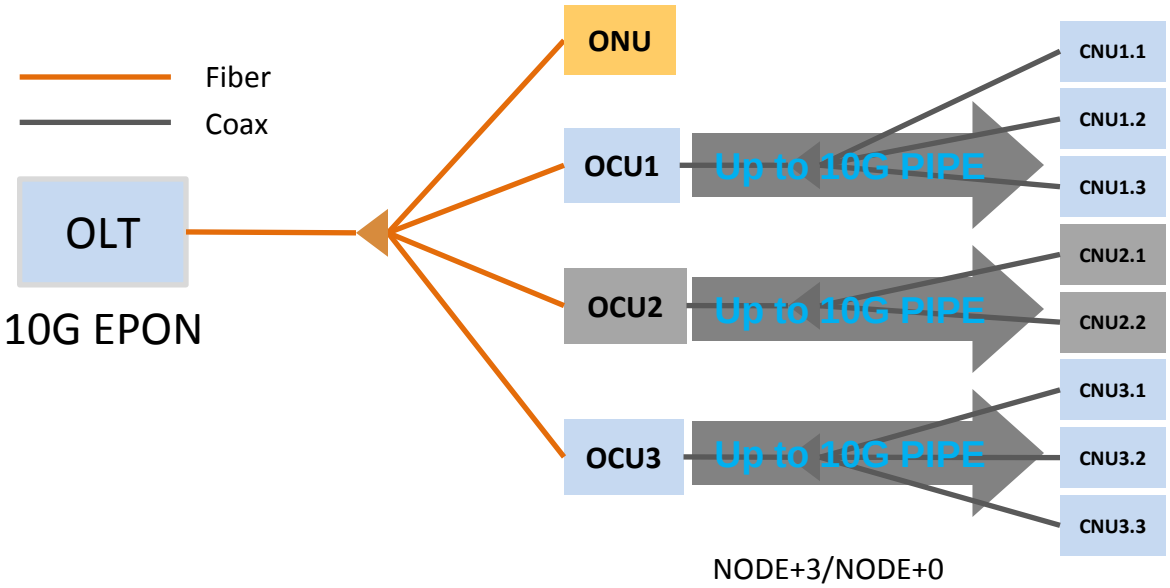


	PHY	MAC
Broadcast scheme	100%	
Uni-cast scheme		

CNU power consumption

• To reduce CNU power utilization a downstream scheduling mechanism is required to support unicast on coaxial downstream. This mechanism allows CNU to only receive data destined for it..

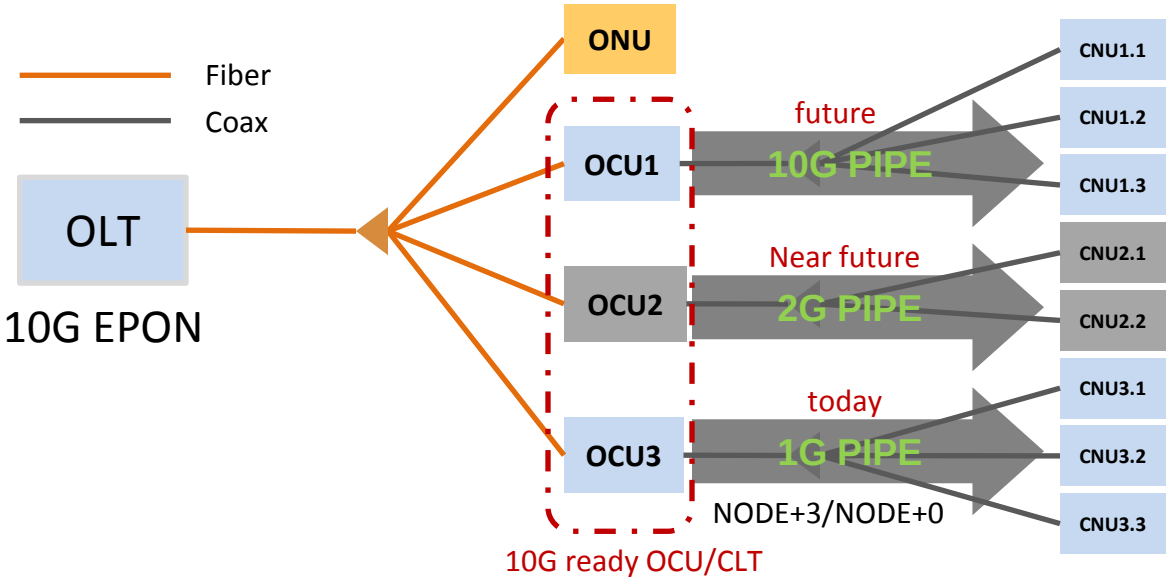
The Cost-Performance Considerations for the CNU



- ❑ suppose the coaxial cable provides 1Gbps every 120MHz under the average conditions;
- ❑ to support the EPoC objective of "up to 10Gbps" the link would need 1.2GHz total spectrum.
- ❑ broadcast scheme requires each CNU to handle the entire spectrum of 1.2GHz. This will significantly increase the CNU cost.
- ❑ uni-cast scheme only requires the CNU to handle the allocated spectrum which is relatively narrow (for example 120MHz). This is more cost effective
  - ❑Around 9/10 savings in the cost of the physical circuit and processor

• To maximize the CNU device cost-performance, a downstream scheduling mechanism is required to support unicast on coaxial downstream. This mechanism allows CNU to only receive data destined for it.

Considerations for Future Evolution



Smooth migration for future upgrade

- ✓ 10G ready OCU/CLT
- ✓ 1Gbps data rate at beginning.
- ✓ OCU/OLT are 10G ready, just plug and play.
- ✓ add higher speed CNU in future.

❑ Broadcast scheme can't provide this feature

- ✓Broadcast scheme requires all the CNUs to have the same capability (receive the entire spectrum and process the entire signal in the physical layer).

• To provide a smooth CNU upgrade using a 10G ready OCU/CLT, a downstream scheduling mechanism is required to support unicast on coaxial downstream. This mechanism allows CNU to only receive data destined for it.

THANK YOU