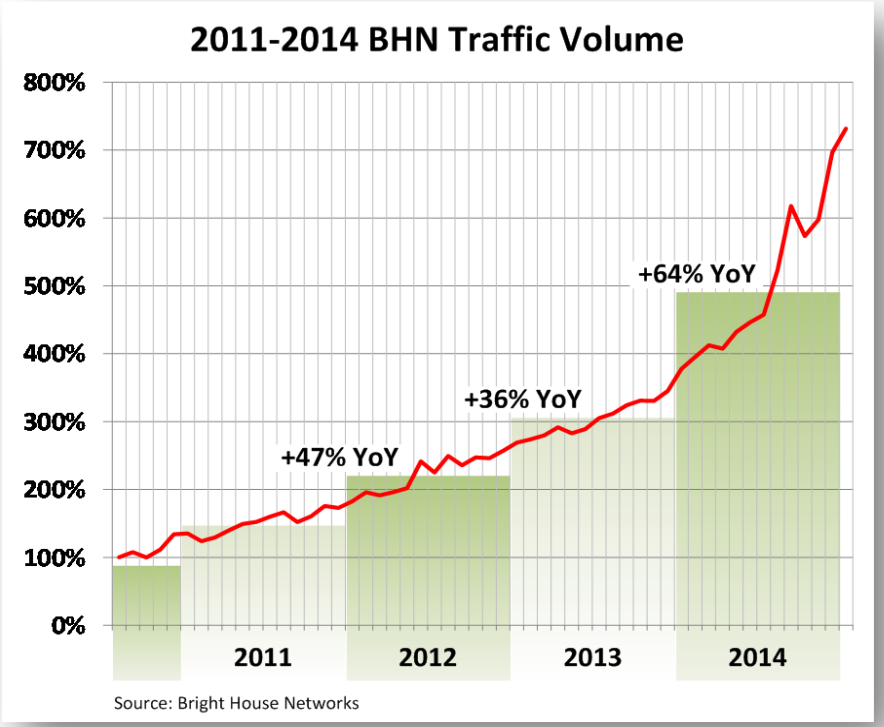
THE NEED FOR HIGHER SPEED

CONTACT:
MAREK HAJDUCZENIA
NETWORK ARCHITECT, PRINCIPAL ENGINEER
EMAIL: MAREK.HAJDUCZENIA@MYBRIGHTHOUSE.COM

Network Traffic Growth

- Volume of traffic flowing between access and edge POPs increases very rapidly YoY
- **High-capacity business customers on PON double their bandwidth demand every 24-36 months**.
  - Business services deployed on PON without oversubscription (CIR only)
  - For example, local FL schools moved from 10 Mbps (2011) to 600 Mbps (2015)
  - Operators run out of bandwidth on OLT ports before running out of power budget (bandwidth limitation)
- Residential access bandwidth demand closely follows maximum speeds of wired and wireless home networks
  - In 3-5 years, home network speeds will increase to 2.5/5G thanks to 802.3bz
  - High speed MOCA / G.hn also target multi-gigabit in-home connections



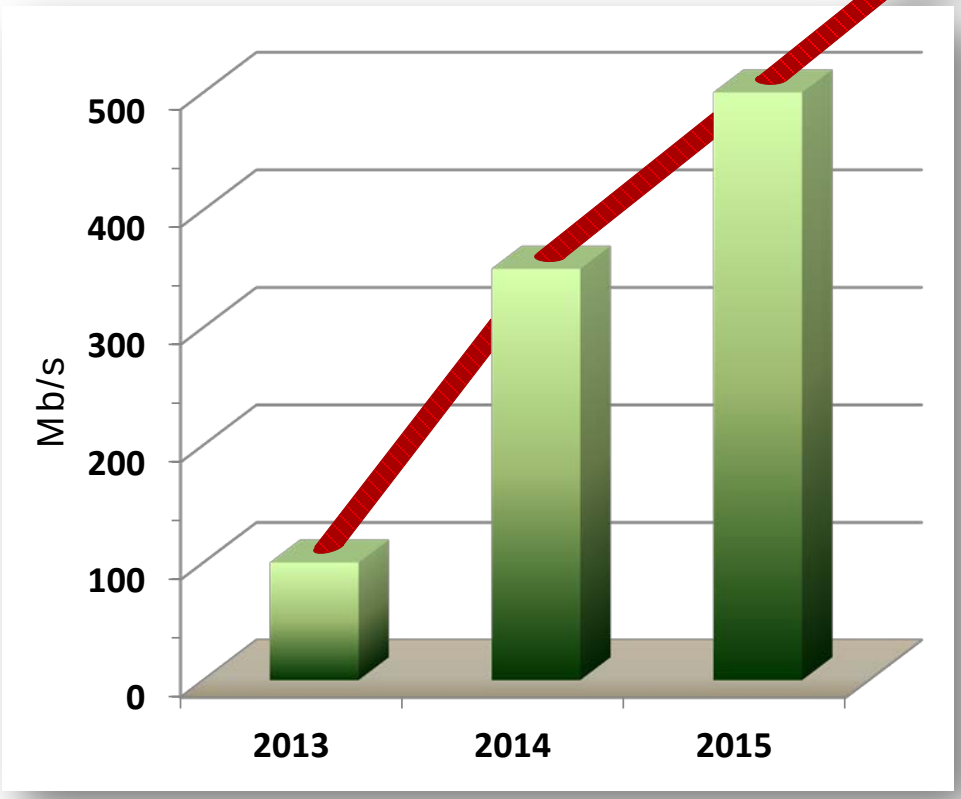
Last update: March 2015

30+% CAGR is industry wide

For BHN, 2014 CAGR is 64% and 2015 CAGR so far is ~52%.

Example of CBH Traffic Growth

Data volume depends on: number of active devices, user activity, type of devices, device capabilities, and types of consumed digital content



Source: Bright House Networks

provisioned CIR data rates **per cell tower per carrier!**

2013: ~100 Mb/s
mostly 3G, little 4G traffic

2014: ~350 Mb/s
broader adoption of 4G devices (single channel LTE)

2015: 800 Mb/s by Q3 2015
increased LTE traffic volume and LTE channel bonding (especially in metro areas)

2016: ~1.2 Gb/s (projected)

LTE channel bonding and increase in the number of connected devices, including vehicular devices (networked cars)

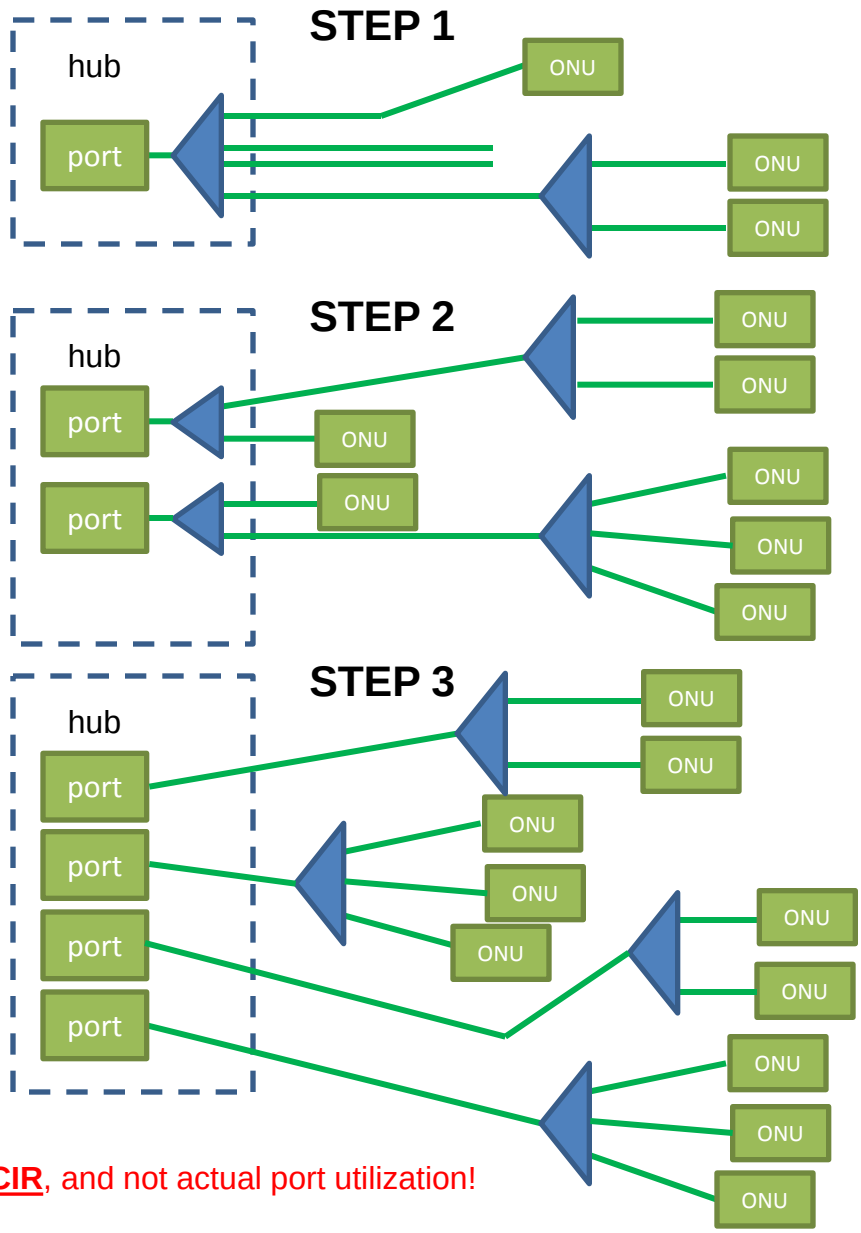
A single ONU per tower, NOT!

- A single physical cell tower (infrastructure) typically shared by multiple mobile operators (MNOs)
- For QoS / monitoring / billing purposes, each MNO is provided with an ONU
  ⇒ **1+ ONU / cell tower**

- Even today, a single cell tower in urban area can burst close to 1 Gb/s at peak hours.
- This traffic volume will approx. double in the next 12 months:
  - Driven by adding more LTE bands
  - Emergence of 5G will push up to 10Gb/s per MNO
- In urban areas, the aggregate bandwidth per PON will quickly reach 70% capacity of 10G-EPON.
- Similar aggregation trends can be also seen in backhaul for xDSL/C-DOCSIS deployments
  - Migration away from P2P / analog backhaul solutions used today

Example of Deployment Strategy (1)

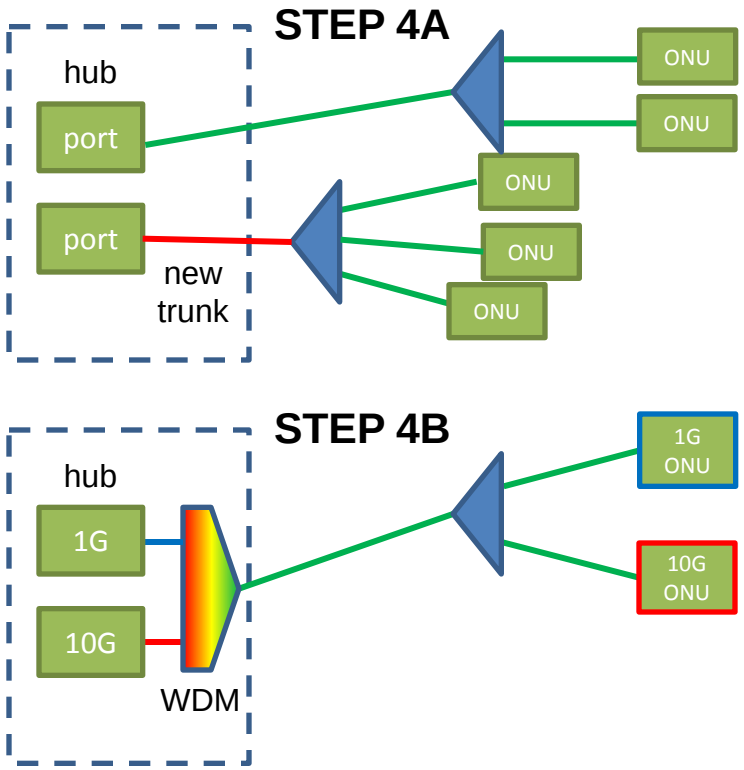
- Some operators use a specific deployment model for deployment of business services over 1G-EPON
  - **STEP 1**: 4 trunk fibers are combined at hub end into an EPON OLT port
  - **STEP 2**: at ~70% port capacity, PON is decombined into 2 x 1:2 splitters (2 EPON ports are used)
  - **STEP 3**: at ~80% port capacity, each PON is further decombined into 2 direct trunks, each into a dedicated EPON port
  - At each step, each PON is also split in the field at locations driven by customer demand and guidelines from fiber team. The process is dynamic and bound by power budget, construction cost, etc.
  - When capacity demand in the given area is very strong, STEP 2 is skipped



NOTE: **port capacity** is measured as **aggregate of provisioned CIR**, and not actual port utilization!

Example of Deployment Strategy (2)

- 10G-EPON is added to PON branches driven by bandwidth demand
  - At ~90% port capacity, when customer connection requests are received, STEP 4A or 4B can be taken
  - **STEP 4A**: if there is spare trunk fiber, or construction cost is low, additional trunk fiber is added to 1G-EPON.
  - **STEP 4B**: if trunk fiber is exhausted and construction cost is high, 10G-EPON is added to selected PON branch.
  - In urban areas, 10G-EPON overlay is most common due to lack of fiber and high construction cost. In rural areas, STEP 4 is rarely reached.
  - In STEP 4B, high bandwidth services (CBH, former CWDM) are moved to 10G-EPON (typically, 300 Mbps and more).



NG-EPON becomes needed when 1G/10G overlay reaches ~70% aggregate capacity.

The only way forward is to deploy more fiber (cost prohibitive)!!

How much bandwidth is needed?

- When 1G/10G overlay system becomes bandwidth constrained:
  - 25/25G system would remedy the capacity problem for following 2-3 years.
  - 25/25G system becomes insufficient when high bandwidth circuits reach ~10 Gbps.
  - The *next-NG-EPON* would need to double capacity (50G). 50/50G system would last again 2-3 years before capacity would become again exhausted.
  - The *next-next-NG-EPON* would then needed to double capacity again, reaching 100G or more.
- Bandwidth demand from top business customers doubles every 2-3 years.
- EPON must be ready to deliver scalable capacity beyond 10G and minimize need for future standards.
  - Equipment generations are *generally* OK (as long as we keep ODN passive).
  - Standard generations every 2-3 years are NOT OK. One standard cycle (~2-3 years) = 6-10 year in product cycles = late to market.
- A path forward to 100G for EPON will be needed
  - acceptable intermediate steps through 25G / 50G, if needed by product implementations.

When do we need NG-EPON?

- The combination of ODN planning and capacity management for business services will give operators around 4-6 years before 1G/10G overlay systems begin to run out of capacity.
  - ~2019: start testing and deploying next generation EPON with 10G+ capacity
  - If no alternative is available, selected customers will be moved to CWDM
    - additional construction costs for fiber deployment, P2P ports on edge equipment etc.
  - Cost-effectiveness of future EPON should be measured against TCO, including cost of deploying fiber capacity in urban areas, and not just cost of replacing electronics on both ends of already existing fiber plant.
- Timelines to get NG-EPON for individual operators will vary
  - Depending on customer population, service types, deployment model, etc.
  - In urban areas, with large number of customers, PON is **the only cost-effective way** to deliver business services without access to unlimited trunk fiber resources

Do we need more than 10G / ONU?

- 1 Gbps business services are becoming increasingly popular.
  - Delivery today is possible only on CWDM or 10G-EPON.
- Data rates will be increasing over time
  - Today 2-3 Gbps delivered over 10G hand off
- To guarantee longer life span for any NG-EPON technology, 10G+ handoff (UNI) on ONU needs to be supported
  - This means that the ONU must be able to received more than 10G (e.g., up to 25G) and hand it off to customer.
  - Long term this number will need to increase (e.g., multiple 25G streams)
- Migration towards higher data rates on EPON is unavoidable
  - As long as business service market remains attractive to operators, PON remains an attractive means of delivering business services
  - Obviously, PON only makes sense if its TCO (and deployment) is cost-competitive to deploying and maintaining P2P WDM solutions

1G/10G/NG on the same ODN?

- Data rates in business services are pushed by medium and top tier customers with multi-gigabit circuits.
  - Served with 10G-EPON today, and NG-EPON in the future.
- By volume, the most of business customers require ~100 Mbps services
  - These customers typically migrate from legacy T1/T3 lines to Ethernet transport.
  - 1G-EPON is and will remain a very cost-effective solution for such customers
  - Many of the lower tier customers never upgrade their bandwidth and could be left on existing 1G-EPON for many years to come.
- The value of 1G/10G overlay solution today is in its flexibility to address specific customer tier in the most cost-effective manner
  - When NG-EPON becomes available, support for coexistence with 1G-EPON on the same ODN should be guaranteed by proper wavelength allocation plan.
  - This will allow extended ROI for operators, **even if this increases the cost and complexity of optics for NG-EPON**.

Summary

- Business services are successfully delivered over 1G/10G-EPON overlay today.
- Deployment for business access is different from residential access
  - Driven primarily by customer demand
  - Less susceptible to high cost of electronic devices
- Top tier business customers double their bandwidth demand every 24-36 months, driving PON capacity.
  - To continue to address business access market, EPON capacity needs to accompany bandwidth growth trends
    - 25G+ required by 2018, 50G will be welcome
    - 50G required by ~2022, 100G will be welcome
- UNI speed will need to evolve together with EPON speed
  - at least 25G UNI will be needed in NG-EPON
  - for future products, LAG on UNI side might be useful as well (Nx10G)
- WDM coexistence of 1G/10G/NG-EPON on the same ODN
  - Required for the cost-optimized delivery of services to different customer tiers over a single ODN.

THANK YOU!