MOBILE BACKHAULING IN FIBER

A WHITE PAPER BY THE TECHNOLOGY & TRAINING COMMITTEE

June 2016

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INTRODUCTION

Mobile networks are evolving into newer technologies and generations that are giving possibilities for new speeds and throughputs as well as applications and services opening up new realms for mobility.
This generates new requirements for access networks to evolve and be able to support ever increasing bandwidth demand as well delay and delay variation requirements for traffic flow.

This paper shows how fiber based backhaul is seen as the ultimate goal for mobile backhauling in its different type of architectures including PON, P2P and ring topologies - providing superior throughputs and speeds and better maintenance.

MOBILE NETWORKS EVOLUTION

Mobile networks and technology are changing rapidly driven by new technology evolution in 4G and 5G as well as hungry demand for bandwidth and changes in consumer behavior.
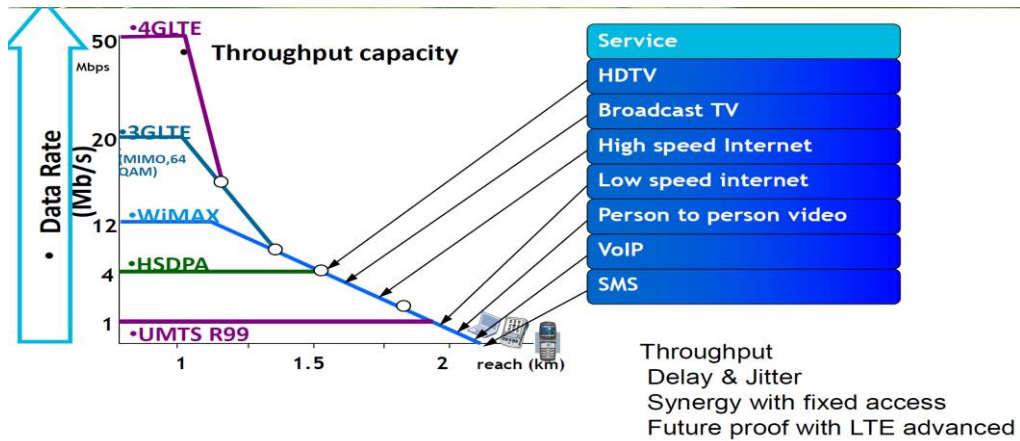
Source: Nokia

Consumer demand for wireless bandwidth is increasing due to new applications, increasing use of internet services and the rise of user generated content. Mobile networks are evolving in two dimensions:

➢ Technology evolution toward 4G (LTE and LTE-A) and future evolution to 5G networks.
➢ Mobile networks are becoming Heterogenous Networks (HETNETs) with heterogeneous access via different micro, metro and small cells.
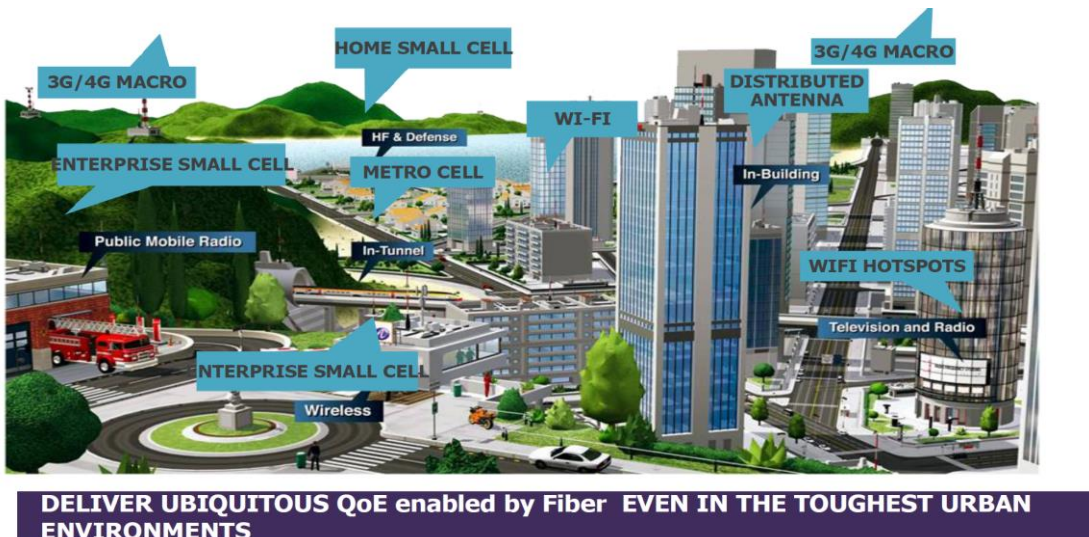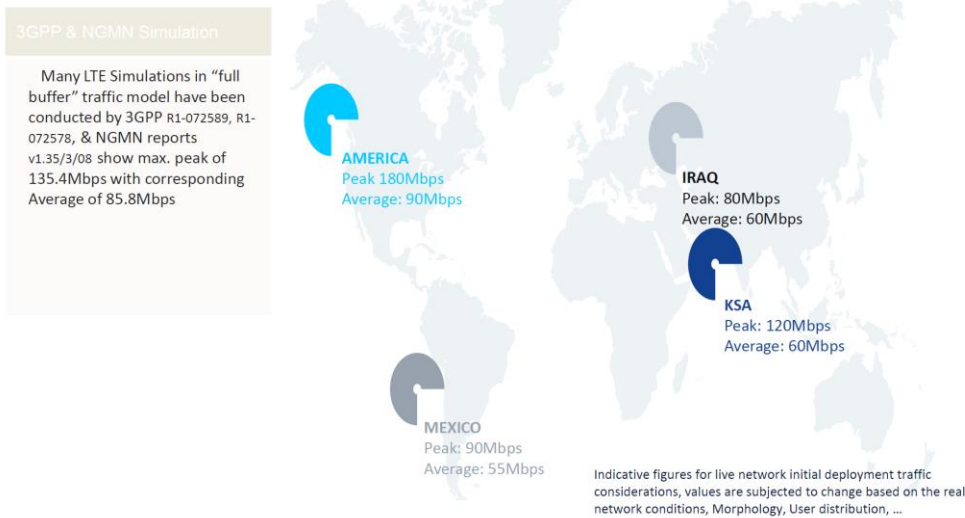

Source: Nokia

FIBRE BACKHAUL OPTIONS

A number of backhaul options have evolved backhaul mobile traffic whether macro, metro or small cells in HETNET configurations. These options leverage fiber technologies and architectures to be able to cater for the huge throughputs as well as the stringent delay / delay variation requirements for traffic flows.

4G throughputs are now looking at sustainable averages of 60 mbps and peaks reaching more than 100 Mbps and with implementation of LTE-Advanced. The peak figures are expected to reach 300Mbps and beyond.

3GPP & NGMN Simulation

Many LTE Simulations in "full buffer" traffic model have been conducted by 3GPP R1-072589, R1-072578, & NGMN reports v1.35/3/08 show max. peak of 135.4Mbps with corresponding Average of 85.8Mbps

AMERICA
Peak 180Mbps
Average: 90Mbps

IRAQ
Peak: 80Mbps
Average: 60Mbps

KSA
Peak: 120Mbps
Average: 60Mbps

MEXICO
Peak: 90Mbps
Average: 55Mbps

Indicative figures for live network initial deployment traffic considerations, values are subjected to change based on the real network conditions, Morphology, User distribution, …

Source: Nokia

We can see a number of options considered for Backhauling Mobile Wireless sites using fiber. There are compared in the following table.

Solution	Optical Carrier Ethernet	FTTH	MPLS
Topology	Advantage	advantage	Advantage
Cost per bit	Strong advantage	Advantage	Advantage
Scalability	Strong advantage	Advantage	Strong advantage
Fault tolerance and resilience	Strong	Strong	Strong
Manageability Upgradability	Advantage	Advantage	Advantage

The table compares FTTH and MPLS backhauling and Carrier Ethernet based on a number of factors that include topology and cost per bit and scalability and resilience and manageability.

Every solution has its advantages and strong points and these depend greatly on the availability of Fiber and the topology of transmission facilities.

In reality these solutions can be used to backhaul macro cells and metro cells and as well small cells providing fibre to cell site connectivity to connect to the backhaul network and stream traffic towards the evolved packet core for signalling and switching with great efficiency, higher throughput and lower maintenance costs.

FTTH AS A FIBRE BACKHAUL OPTION

GPON and P2P access is already widely deployed for residential and business service delivery in many markets. FTTH network offers a viable alternative to address the mobile backhaul challenge that is created by expanding its footprint to backhaul wireless networks in HETNET configurations.

The solution needs to provide rich features to allow operators to capitalize on the running residential FTTH deployment to make the transformation to an all-packet, high-capacity and cost efficient mobile backhaul network. The solution should include very high speed non-blocking bandwidths, large set of quality of service capabilities and a set of support tools to monitor and troubleshoot the network.

A very challenging dimension in full packet based mobile backhaul network is that of synchronization. GPON and P2P solutions provide a wide array of options for frequency synchronization. On the OLT side, frequency synchronization options include BITS, SyncE and IEEE1588v2. These functions can work in conjunction with a variety of ONTs.

FTTH fulfils numerous benefits and capability in backhauling Mobile networks including service offerings as well as reliability, availability and efficient bandwidth scaling and converged transport - not to mention the Quality of Service, synchronization capabilities and OAM features for management.
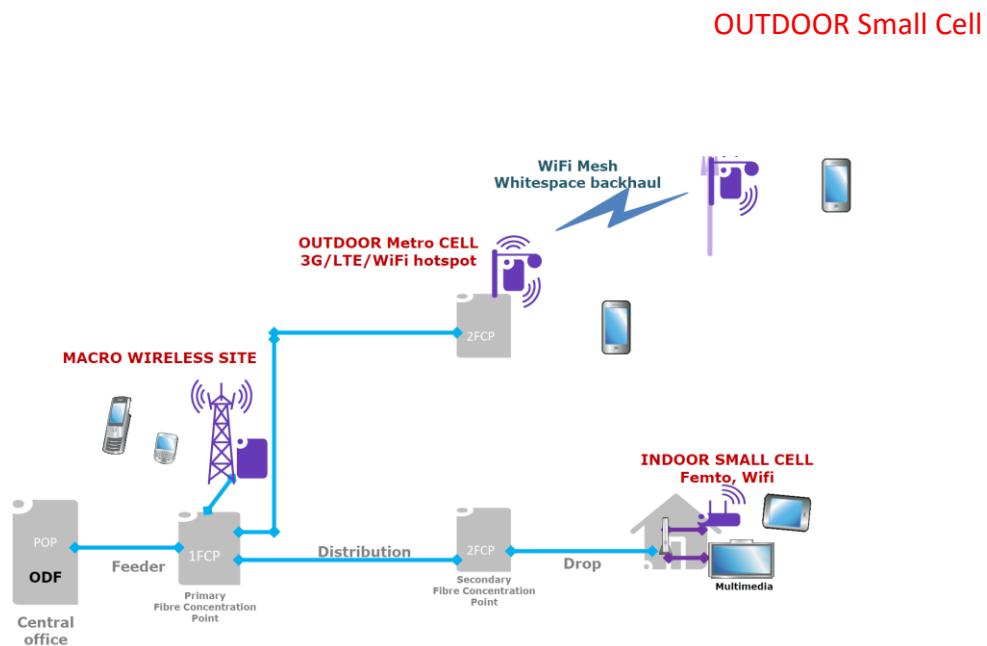

Source: Nokia

The diagram demonstrates the network connectivity for FTTH PON and P2P to connect the OLT in the central office to Macro sites and as well to Metro and WiFi sites. The outside plant can be planned to have a primary concentration point with optical pass through or optical split leading to a subsequent secondary concentration point for second stage split or pass through to connect to home/building or Macro or Metro or WiFi hotspot.

The following diagram shows the end to end architecture for FTTH from Core to Access indicating the topology and connectivity of the Edge and aggregation layer to OLT in the access layer.

Ring or dual homed connectivity may be used from the Edge across aggregation to the Access network depending on available transmission and its topology.
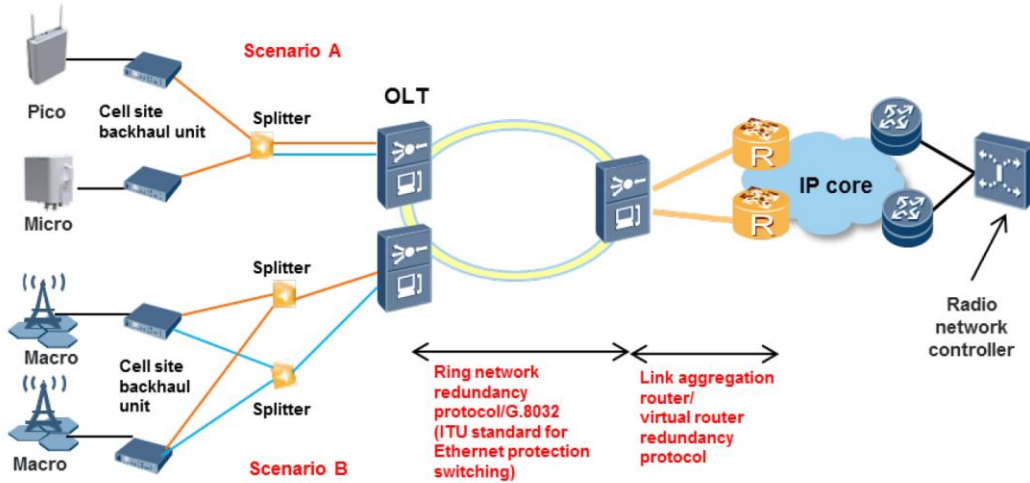
Source: Ovum, interviews with PON equipment vendors

FIBRE BACKHAUL SYNCHRONIZATION

Synchronization is an important topic for mobile backhaul as providing an accurate and stable clock is mandatory for mobile networks for cell site synchronization.

Highlighted in the table are the main synchronization techniques available and considered.

Approach	Characteristics	Assessment	Freq Sync	Phase Sync
External techniques				
External Synchronization	Clock received from an external source – e.g. GPS satellite	• Provides reliable and accurate clocking solution (50ns accuracy) • not always viable: need space and roof access, indoor cells, … • Expensive dedicated hardware required	√	√
Packet based techniques				
out-of-band IEEE1588v2	ToP uses a stream of time-stamped messages	• Delivers Phase and Frequency lock (TDD and FDD systems) • "Always-on" • Dependant upon network load • Dependant on hop count – may impose HW dependency on network nodes	√	√
In-band CESoP	Clock is received from the CES clock	• Inexpensive solution • Need highly accurate CES clock recovery • Frequency lock only, no phase/timing info	√	
PHY techniques				
Line synchronization GPON PHY	Clock is extracted from the received synchronous data stream	• Independent of network load, good performance • Simple and available – inherent to GPON • Frequency lock only, no phase/timing info	√	
Synchronous Ethernet	Uses the Ethernet physical layer to distribute clocking	• Independent of network load • Requires all Ethernet elements in data stream to be SyncE capable • Frequency lock only, no phase/timing info	√	

Clock Delivery Options
Multiple Clock Delivery Techniques Exist
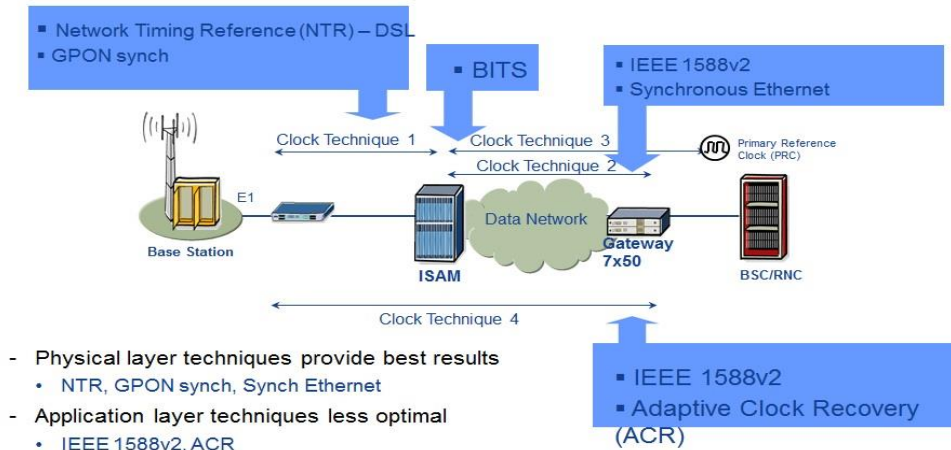
Source: Nokia

The above diagram indicates the different clock synchro techniques that can be used in conjunction with FTTH whether PON or P2P to deliver the required clock accuracy.

GPON supports PHY layer synchronisation that can deliver clock to base stations or cell site gateway in mobile sites. The clock can be delivered to OLT via BITS or packet synchronization like SynchE or 1588v2. Most modern OLT and ONT implementations support 1588v2 clock support to relay and deliver reliable 1588v2 clock to Radio base stations.1588v2 is becoming a more prominent synchronization techniques as it supports LTE Carrier aggregation and LTE-A advanced with its relay of TOD and phase information.