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The Role of MPLS Technology in the Evolution of Mobile Backhaul Networks

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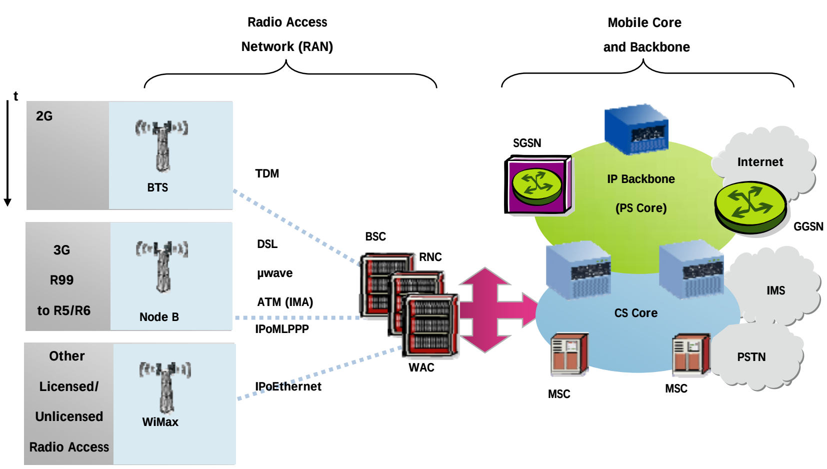
Agenda

1. Drivers and Business Challenges
2. Evolution to the NGN Backhaul
3. Challenges in Deploying the NGN Backhaul
4. Summary

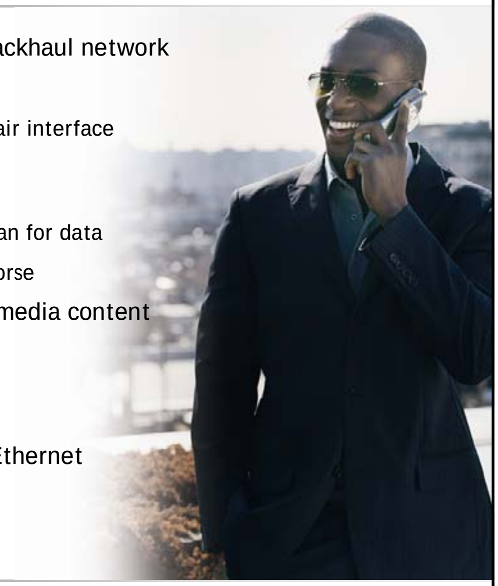
1 Drivers and Business Challenges

Mobile Network Architecture



Drivers for Re-architecting the Mobile Backhaul Network

- Steady growth of bandwidth in the backhaul network
  - New base stations, higher bandwidth
  - Backhaul needs to align with expanded air interface capacities (e.g., HSDPA)
- Revenue per bit decreasing
  - Revenue/bit for voice is much higher than for data
  - High speed data (HSDPA) will make it worse
- QoS support for delay sensitive multimedia content and applications
  - Video distribution
  - Music, gaming
- 3GPP standards will transition to IP/Ethernet
  - IP RAN, BTS with Ethernet



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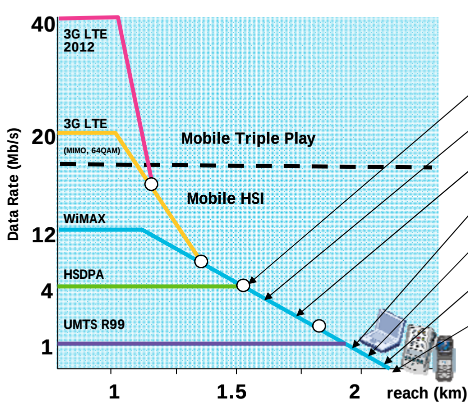
Mobile Service Speed Evolution

Radio sector capacity



Service	Delay budget
HDTV	Low
Broadcast TV	Low
High speed	High
Low-speed Internet	High
Person-to-person video	Low
VoIP	Low
SMS	High

(Basis: Frequency Band in the 2 GHz range, using 10 Mz)

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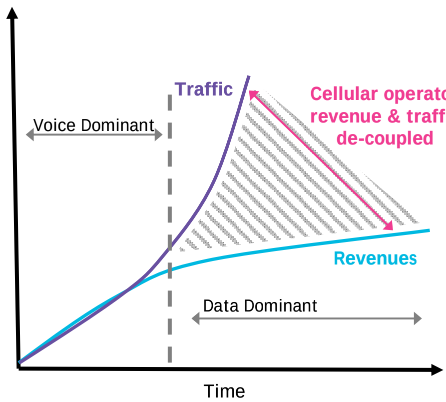
The Challenge of Mobile Broadband



- Revenue per bit decreasing
- Value (to end users) of applications not related to data volumes
- Mobile network operators need to substantially reduce their cost per bit of traffic transferred

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Transforming the Mobile Backhaul Network

RAN transport network must transform to support an order of magnitude **more bandwidth** at a *fraction of the cost per Mb/s* while supporting an *increasingly demanding Payload*

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Mobile Backhaul Evolution -- Objectives and Approach

- Objectives
  - Scalable, efficient solution leveraging cost points of carrier grade Ethernet
  - Retain determinism, control, and availability of current solutions
  - QoS capabilities to support the range of services for 3G and beyond
  - Future-proof network elements – coexistence of new and legacy interfaces
- Approach -- Network convergence
  - 2G/3G networks
  - Mobile/fixed networks
  - Convergence lowers cost per bit of traffic transferred, taking advantage of:
    - Single network infrastructure
    - Single management approach
    - Maximum statistical multiplexing

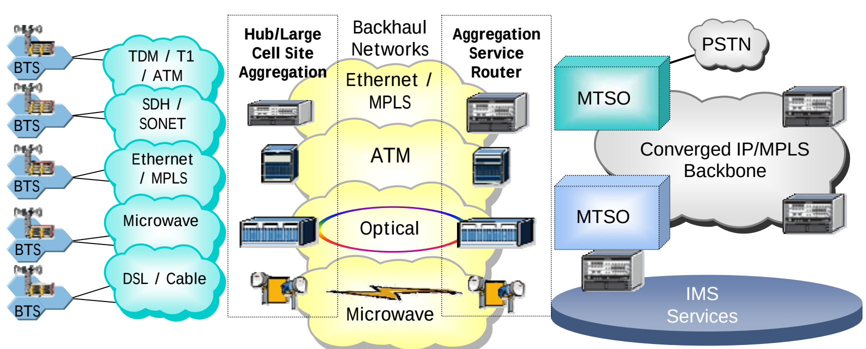
Why Ethernet and MPLS for Mobile Backhaul Networks

- Carrier Ethernet = Ethernet + MPLS
- MPLS adds carrier-grade capabilities
  - *Scalability* - millions of users/end points
  - *Resiliency* - high availability including rapid restoration
  - *Manageability* – ease of troubleshooting & provisioning
  - *Traffic Engineering plus QoS* – support for current and future services
  - *Multiservice* – support for 2G, 3G ATM and IP RAN
- MPLS pseudowires support transport of traffic from a range of interface types including TDM, ATM, MLPPP/HDLC, and Ethernet
- Use of MPLS pseudowires for backhauling traffic such as TDM and ATM allows legacy equipment to be used while leveraging the advantages of packet transport
- Carrier Ethernet has been proven in multiple service provider deployments

2 Evolution to the NGN Backhaul

Wireless Infrastructure / Backhaul Architectures

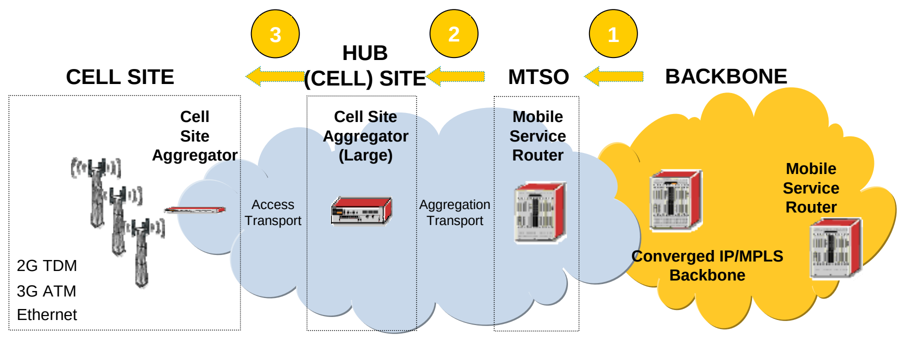
- Many RAN access / aggregation transport options
- Mobile Infrastructure moving to end-to-end IP (backbone and RAN)
- Backhaul aggregation offered over many transports
  - ✓ Native Ethernet/MPLS, ATM, Optical, and Microwave



Every network has a different starting point and each site may have different requirements

Extending MPLS from Backbone to RAN

Three Phased Deployment



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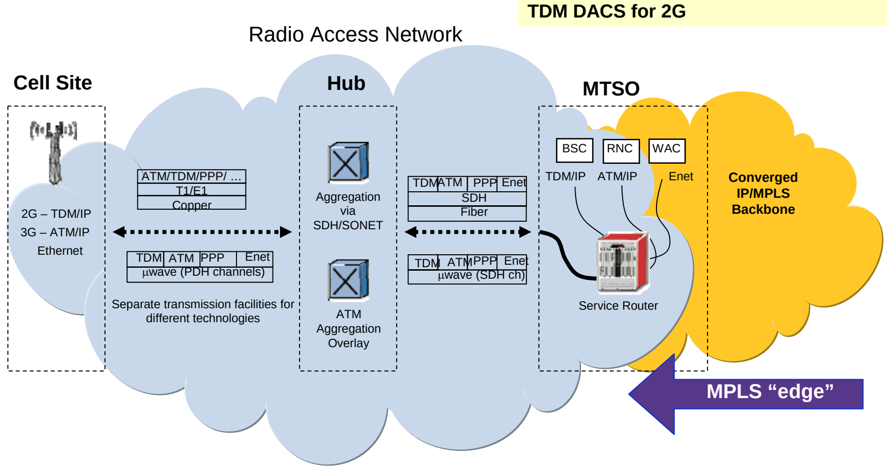
Phase 1 - RAN Transformation in MTSO

MTSO service router performs:
ATM aggregation for 3G
IP routing for PPP(3G)
Ethernet aggregation for 3G/WiMAX
TDM DACS for 2G



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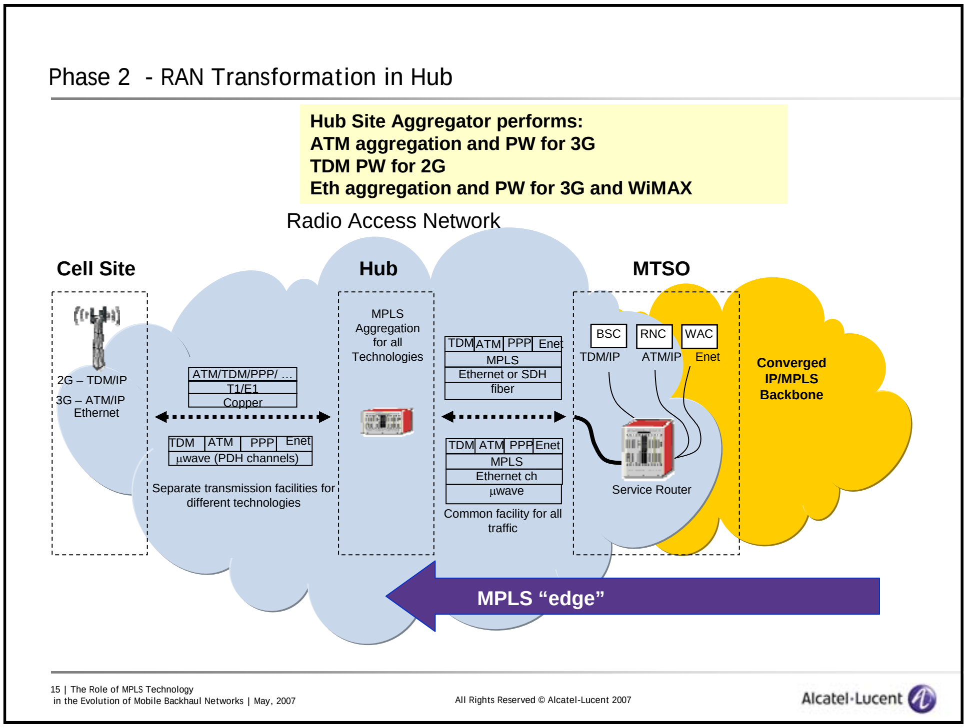
Phase 2 - RAN Transformation in Hub
Hub Site Aggregator performs:
ATM aggregation and PW for 3G
TDM PW for 2G
Eth aggregation and PW for 3G and WiMAX
Radio Access Network
Cell Site
Hub
MTSO
2G – TDM/IP
3G – ATM/IP
Ethernet
ATM/TDM/PPP/ ...
T1/E1
Copper
TDM ATM PPP Enet
µwave (PDH channels)
Separate transmission facilities for different technologies
MPLS Aggregation for all Technologies
TDM ATM PPP Enet
MPLS
Ethernet or SDH
fiber
TDM ATM PPP Enet
MPLS
Ethernet ch
µwave
Common facility for all traffic
BSC
RNC
WAC
TDM/IP
ATM/IP
Enet
Service Router
Converged IP/MPLS Backbone
MPLS "edge"
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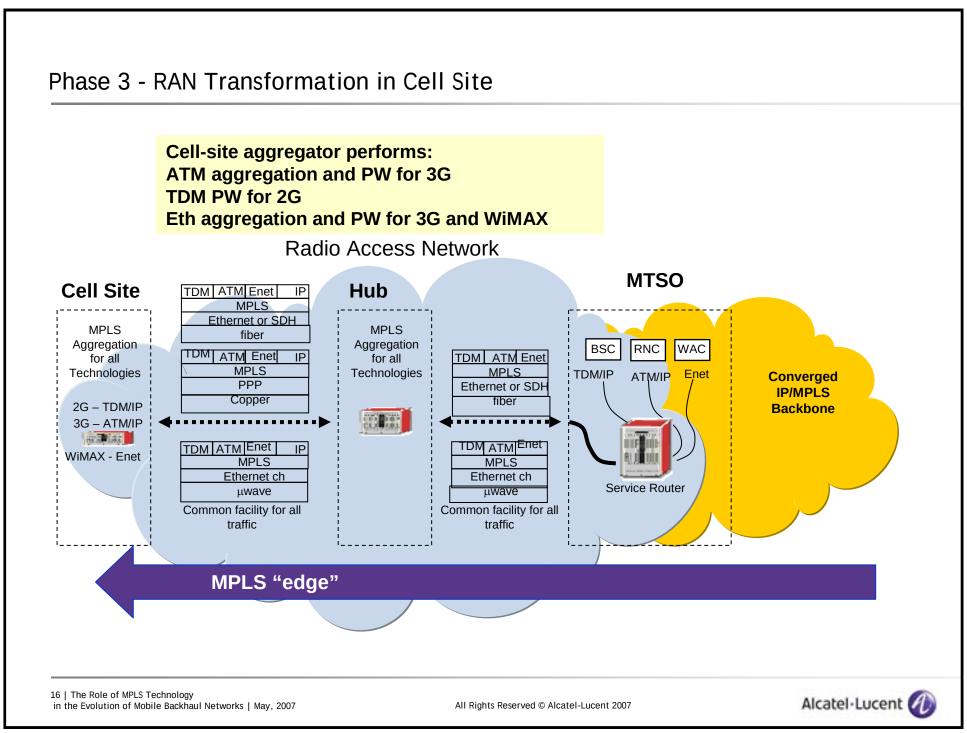
Phase 3 - RAN Transformation in Cell Site
Cell-site aggregator performs:
ATM aggregation and PW for 3G
TDM PW for 2G
Eth aggregation and PW for 3G and WiMAX
Radio Access Network
Cell Site
Hub
MTSO
MPLS Aggregation for all Technologies
2G – TDM/IP
3G – ATM/IP
WiMAX - Enet
TDM ATM Enet IP
MPLS
Ethernet or SDH
fiber
TDM ATM Enet IP
MPLS
PPP
Copper
TDM ATM Enet IP
MPLS
Ethernet ch
µwave
Common facility for all traffic
MPLS Aggregation for all Technologies
TDM ATM Enet
MPLS
Ethernet or SDH
fiber
TDM ATM Enet
MPLS
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Common facility for all traffic
BSC
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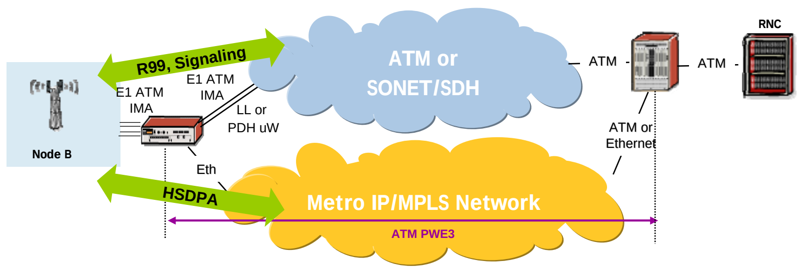
HSDPA Offload

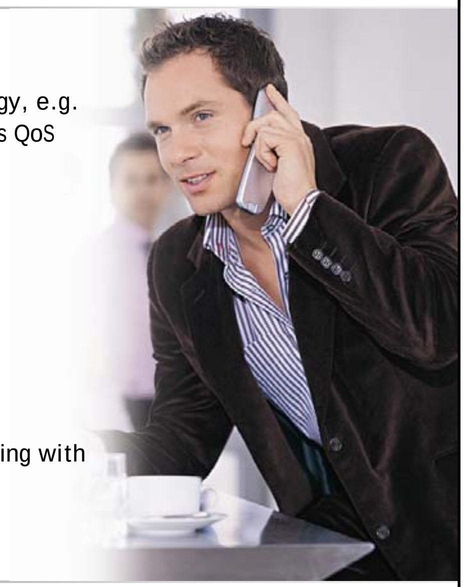
- Hybrid backhauling scenario
  - Allows for cost-effective support of HSDPA traffic over a metro IP/MPLS network
  - Synchronization and delay-sensitive traffic as today
- Can use DSL when copper access is available at the Node B
  - DSL offload of HSDPA while maintaining R99 ATM or TDM circuits to hub site



3 Challenges in Deploying the NGN Backhaul

Challenges to be Addressed in Mobile Backhaul Networks

- Carrier-grade IP/MPLS services
  - Addressed with proven MPLS technology, e.g. traffic engineering and resiliency, plus QoS
- Scalability to large numbers of cell sites
- Multi-domain environments
- Multi-technology environments
- BTS synchronization
  - Carrier frequency accuracy of 50 PPB for GSM/W-CDMA
  - Need to preserve synchronization/timing with Carrier Ethernet transport



Addressing Scalability, Multi-domain, and Multi-technology Challenges with Multi-Segment Pseudo Wires

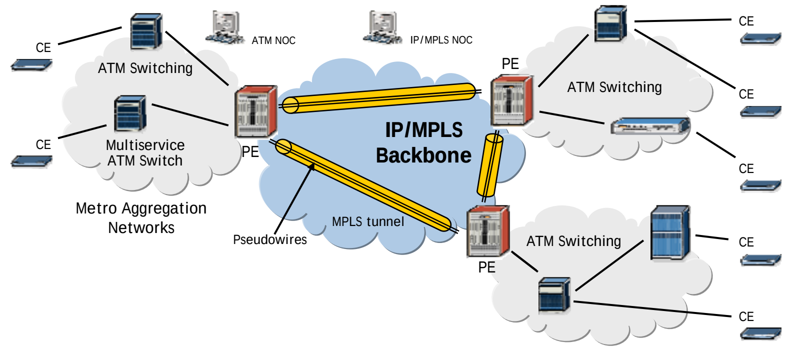
- Multi-segment pseudowire (MS-PW):
  - A static or dynamically configured set of two or more contiguous PW segments that behave and function as a single point-to-point PW
- MS-PWs extend the capabilities of single-segment pseudowires (SS-PWs) with respect to
  - Scalability to a large number of customer edge devices
  - Multi-domain operation
  - Multi-technology operation
- Many of the use cases envisioned for MS-PWs apply to the evolution of mobile backhaul networks

Multisegment PW Background 1/2

Single domain convergence on MPLS

PWs have been used in single MPLS domains to enable L2 & L3 services to share same infrastructure

- Consolidation on a single MPLS core, with Layer 2 backhaul
- Deployment of MPLS in the metro for carrier Ethernet services, VPLS, triple play, etc.
- Convergence in the core only requires a limited number of tunnels
- Architecture scales well for most scenarios: only a limited number of tunnels/PEs, already substantial aggregation at the core edge



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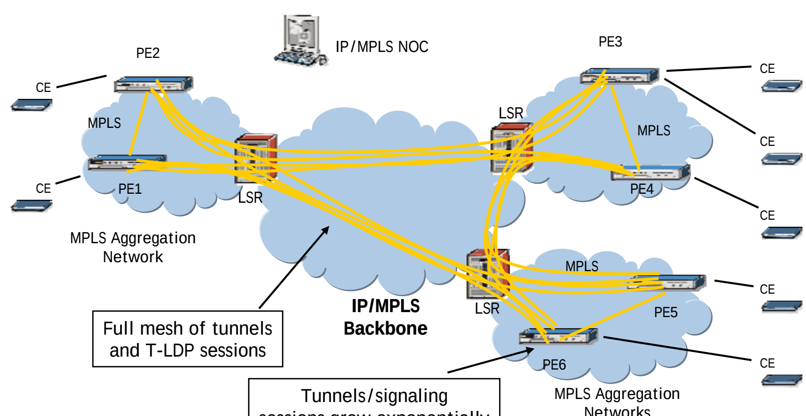
Multisegment PW Background 2/2

Extending the MPLS enabled area



Full mesh of tunnels and T-LDP sessions

Tunnels/signaling sessions grow exponentially

Need to minimize number of tunnels terminating on access/aggregation to:
- Lower complexity and minimize cost
- Simplify provisioning

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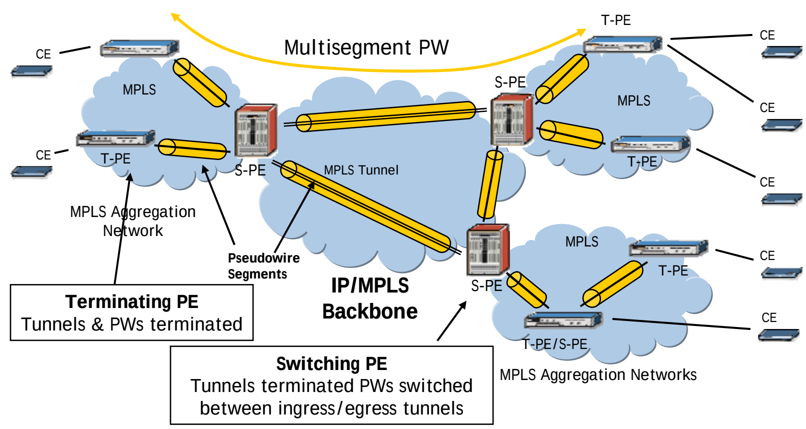
Multisegment PW Architecture

draft-ietf-pwe3-ms-pw-arch-02.txt



Natively switch PWs without native service processing in S-PEs
No implication on underlying IGP domains
Transparency to end to end layer 2 VPN service

Multisegment Pseudowire Use Cases

Applicability to mobile backhaul networks (draft-ietf-pwe3-ms-pwrequirements-05.txt)

- Scalability – to hundreds of base stations connecting to RNC/BSC site
  - MS-PWs allow for a partial mesh, versus a full mesh, of tunnels
  - PWs from many PEs in the access domain may be aggregated into a small number of PSN tunnels in the aggregation domain
- Multi-domain operation – including multi-provider backhaul networks
  - MS-PWs allow for per-domain operation and maintenance procedures such as control plane security (e.g., MD5 key administration for LDP sessions)
  - Policies (e.g., admission control, QoS mappings) may be applied to PWs at domain boundaries
- Multi-technology operation
  - Interconnect domains of static PWs with LDP signalled PWs
  - Interworking of PSNs: leverage mechanisms from non-MPLS access infrastructures

Addressing Base Station Synchronization Requirements

- Some access technologies (e.g., GSM, UMTS) require only frequency (or “timing”) synchronization, while others (e.g., CDMA, WiMAX) require both frequency and phase (or “time”) synchronization.
- For base stations using carrier Ethernet transport, there are several approaches for timing and time synchronization:
  - GPS synchronization
  - PDH/SDH clocking
  - Synchronous Ethernet
  - Adaptive and differential clock recovery
  - Packet-based timing protocols (e.g. IEEE 1588 v2)
- A packet-based timing protocol is likely to be one of the approaches used.
- Packet-based timing protocols will require a network infrastructure that can support stringent packet QoS and resiliency requirements.

The Critical Role of QoS and Resiliency in Support of Packet-based Timing Protocols

- How well the RAN supports synchronization using packet-based timing protocols depends on the QoS and resiliency capabilities in the network
- Inadequate QoS or resiliency can lead to impairments as represented by these metrics – and affect the synchronization of RAN equipment
- **Packet Transfer Delay**
  - May cause a lag in response to changes in the master clock
  - Static delay is not usually a problem for recovery of clock frequency or phase
- **Packet Delay Variation (PDV)**
  - Appears as change in frequency or phase of the recovered clock
  - Multiple causes, including queuing delays, routing changes, congestion, etc.
- **Extended Packet Loss (Network Outages)**
  - May cause clock recovery process to go into “holdover” from lack of information

Achieving Stringent Quality of Service in the Mobile Backhaul – Leveraging MPLS Technology as Deployed in Support of Triple Play Services

- QoS and resiliency capabilities are in wide use today to support differentiated content delivered to triple play customers
- Current-generation MPLS infrastructure for triple play can include
  - Traffic-engineered MPLS tunnels and backup tunnels
  - Per-subscriber, per-service queuing
  - Priority scheduling
- These capabilities allow different service types to coexist and each service type to meet its own SLA
- The mobile backhaul infrastructure for delivering differentiated next-generation mobile services, including packet-based timing distribution, can leverage these triple play capabilities
  - At a base station there may be a PW per service, including 2G, 3G voice, 3G data, and timing distribution
  - At the access/aggregation network boundary, switching PE nodes could aggregate the PWs carrying like services into common TE tunnels for transport to BSC/RNC sites

4 Summary

Summary

Benefits of MPLS Technology in Mobile Backhaul Networks

- Carrier-grade capabilities
  - Scalability
  - Resiliency
  - Manageability
  - Traffic engineering plus QoS
  - Multiservice operation
- Phased migration
- Additional capabilities through use of multi-segment pseudowires
  - Further scalability benefits leading to lower complexity and cost
  - Allows for per-domain operational and maintenance procedures
  - Supports interworking of different PSN types across domains

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Selected Relevant Industry Standards Specifications and Work in Progress

IETF PWE3

Requirements for Inter-Domain Pseudo-Wires

- draft-ietf-pwe3-ms-pw-requirements-05.txt

An Architecture for Multi-Segment Pseudo Wire Emulation Edge-to-Edge

- draft-ietf-pwe3-ms-pw-arch-02.txt

ITU-T

- Recommendation G.8261 "Timing and Synchronization in Packet Networks"

IEEE

- IEEE draft standard 1588 v2 (Precision Clock Synchronization Protocol) – work in progress

MFA Forum

- Work item on using MPLS technology in mobile networks

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