# “Wireless over Pseudowires”
# Ready for Prime Time

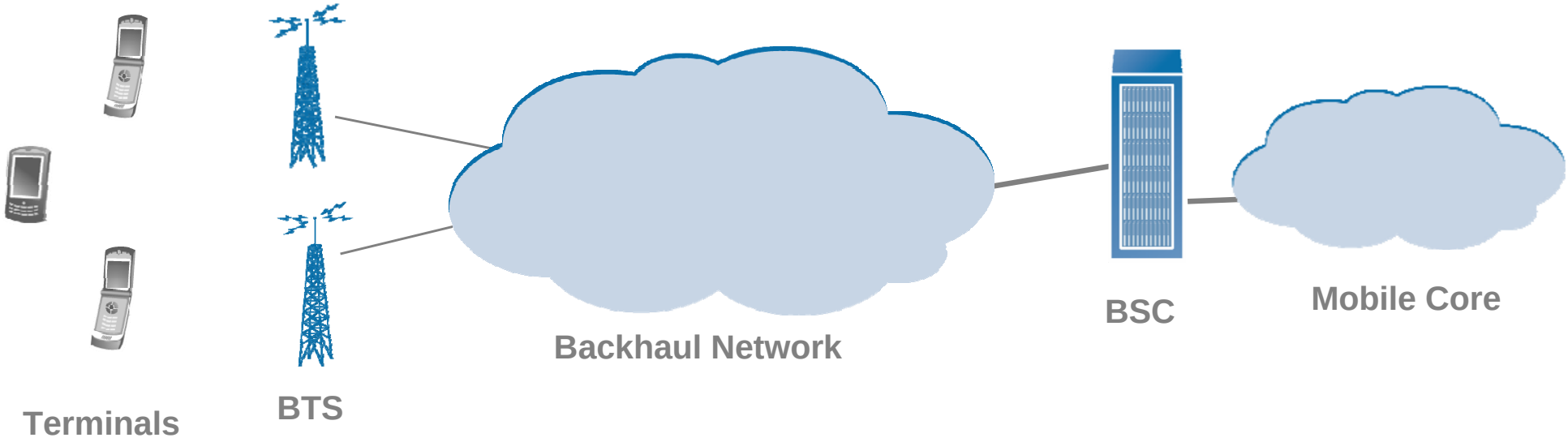
Presented by:
Giles Heron
Director of Data Network Consulting, Tellabs
May 2, 2007

# Agenda

- The challenge of mobile backhaul
- “Wireless over Pseudowires”
- Case studies
- Network synchronization
- Future migration to all-IP

# The Challenge of Mobile Backhaul

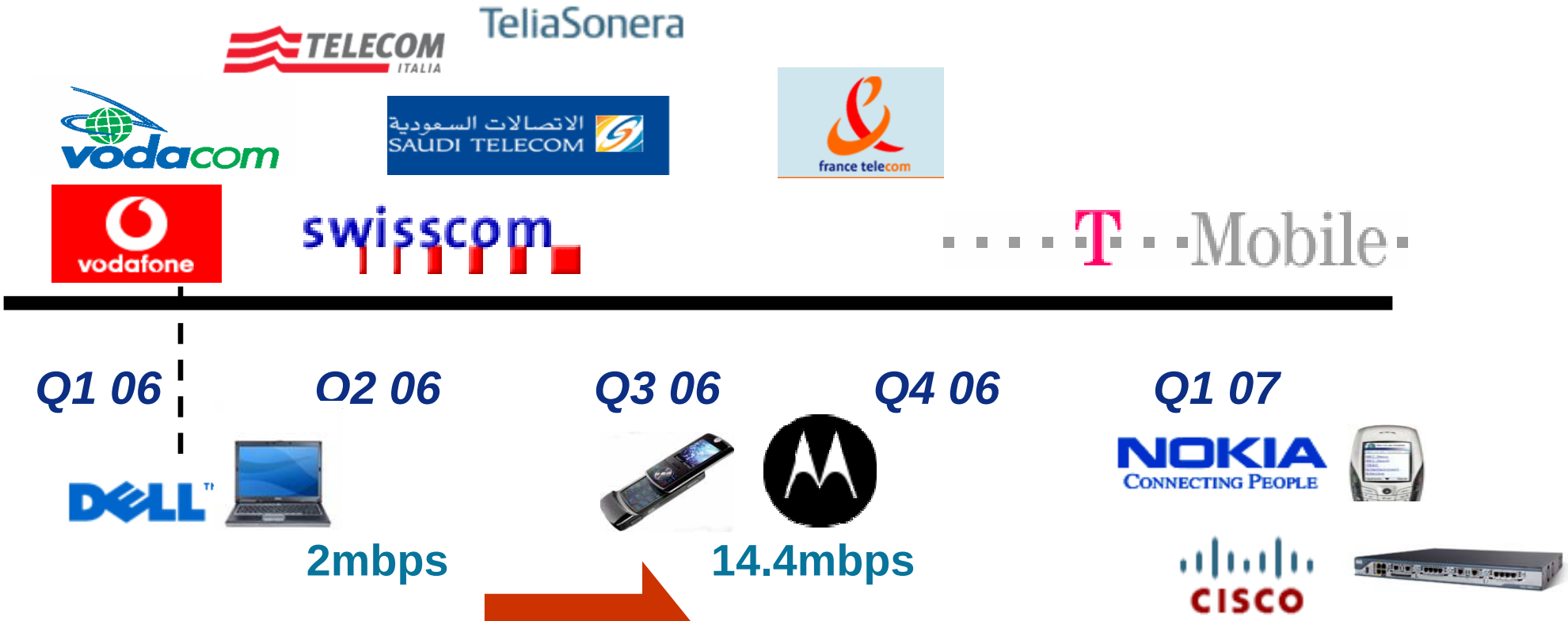
*What is the Backhaul Network?*




- Connects the mobile base stations (BTS/NodeB) to the radio controllers (BSC/RNC) which sit at the edge of the mobile core
- Also known as the RAN (Radio Access Network)

# The Challenge of Mobile Backhaul

*The Bandwidth Explosion - impact of HSPA*



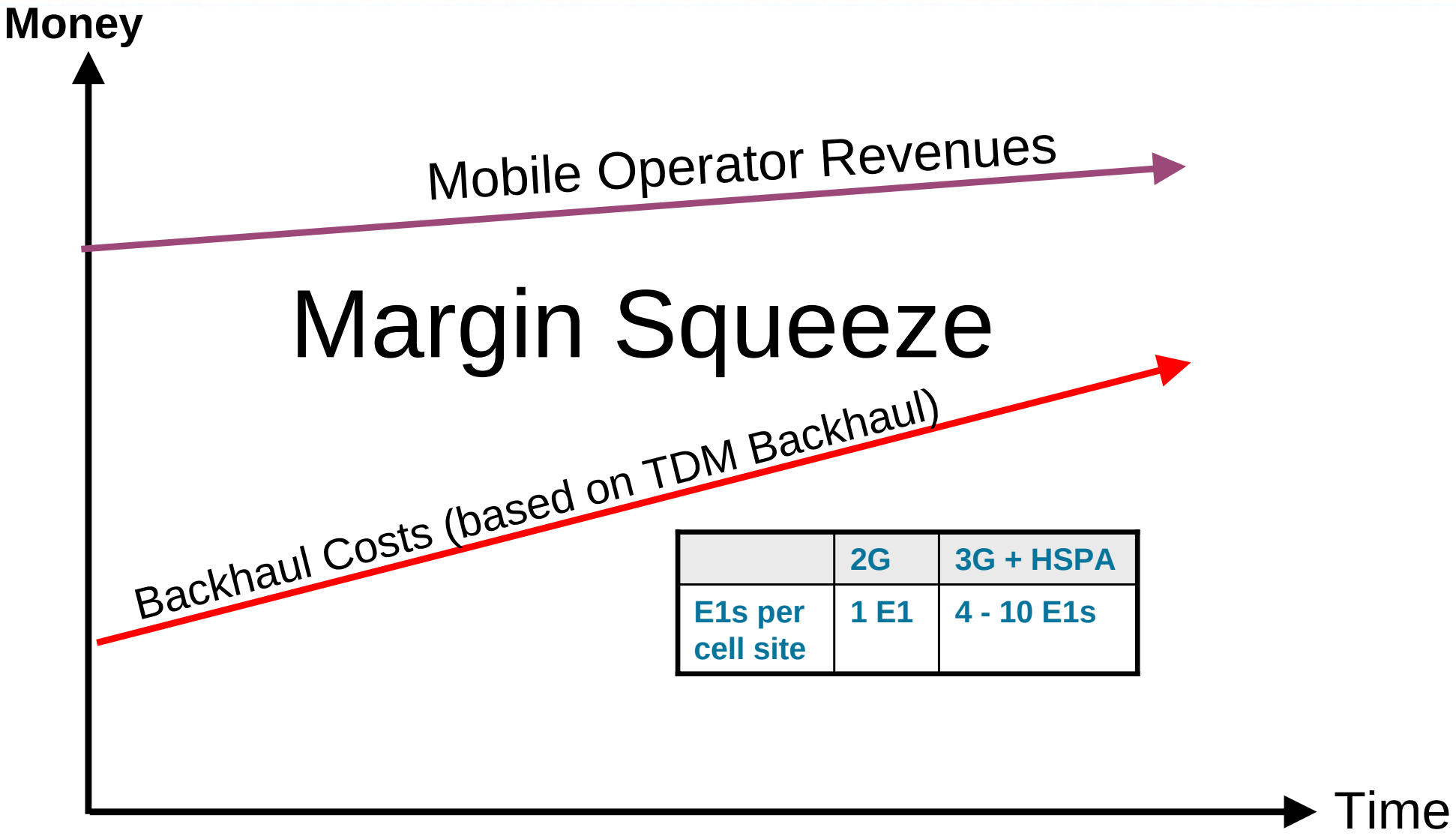

- Over 50 Operators i… …ave adopted HSPA
- 400+ HSPA enabled terminals (Phones/Laptops) on the market

2mbps UMTS → 14.4mbps HSPA

***Dramatic increase in capacity in the backhaul network***

# The Challenge of Mobile Backhaul

*The Bandwidth Explosion – Margin Squeeze*

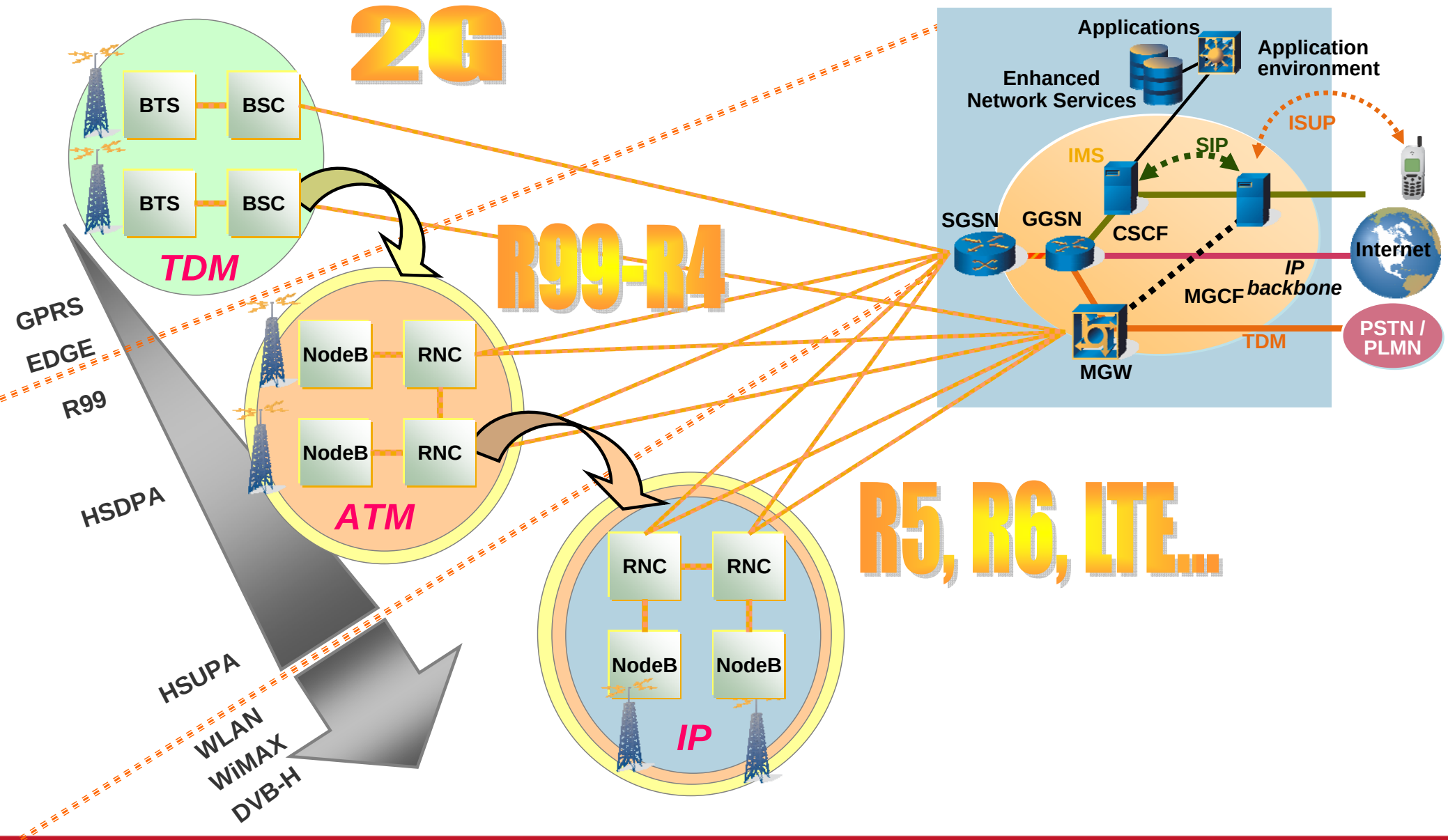



| | 2G | 3G + HSPA |
|---|---|---|
| E1s per cell site | 1 E1 | 4 - 10 E1s |

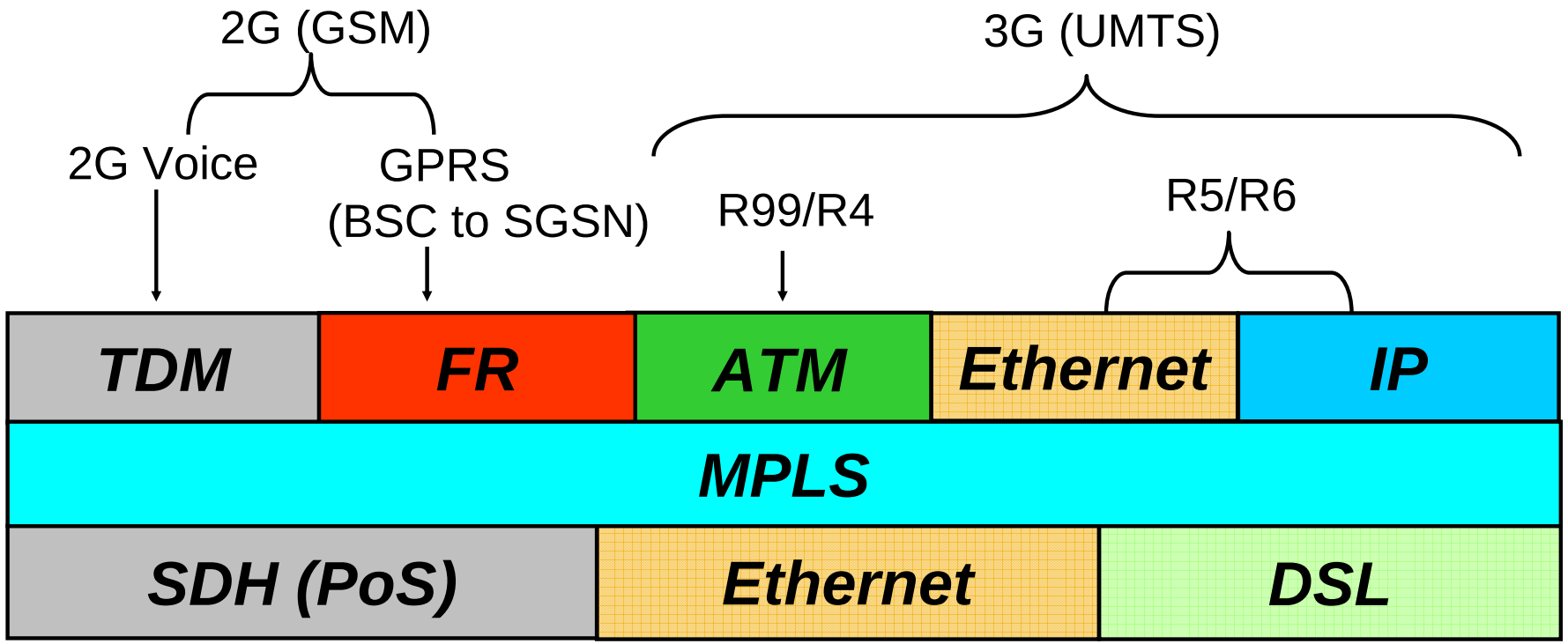
***The operator's goal - decouple cost from capacity***

# The Challenge of Mobile Backhaul

*Technology Evolution – TDM to ATM to IP*



# Wireless over Pseudowires
## *MPLS Pseudowires*

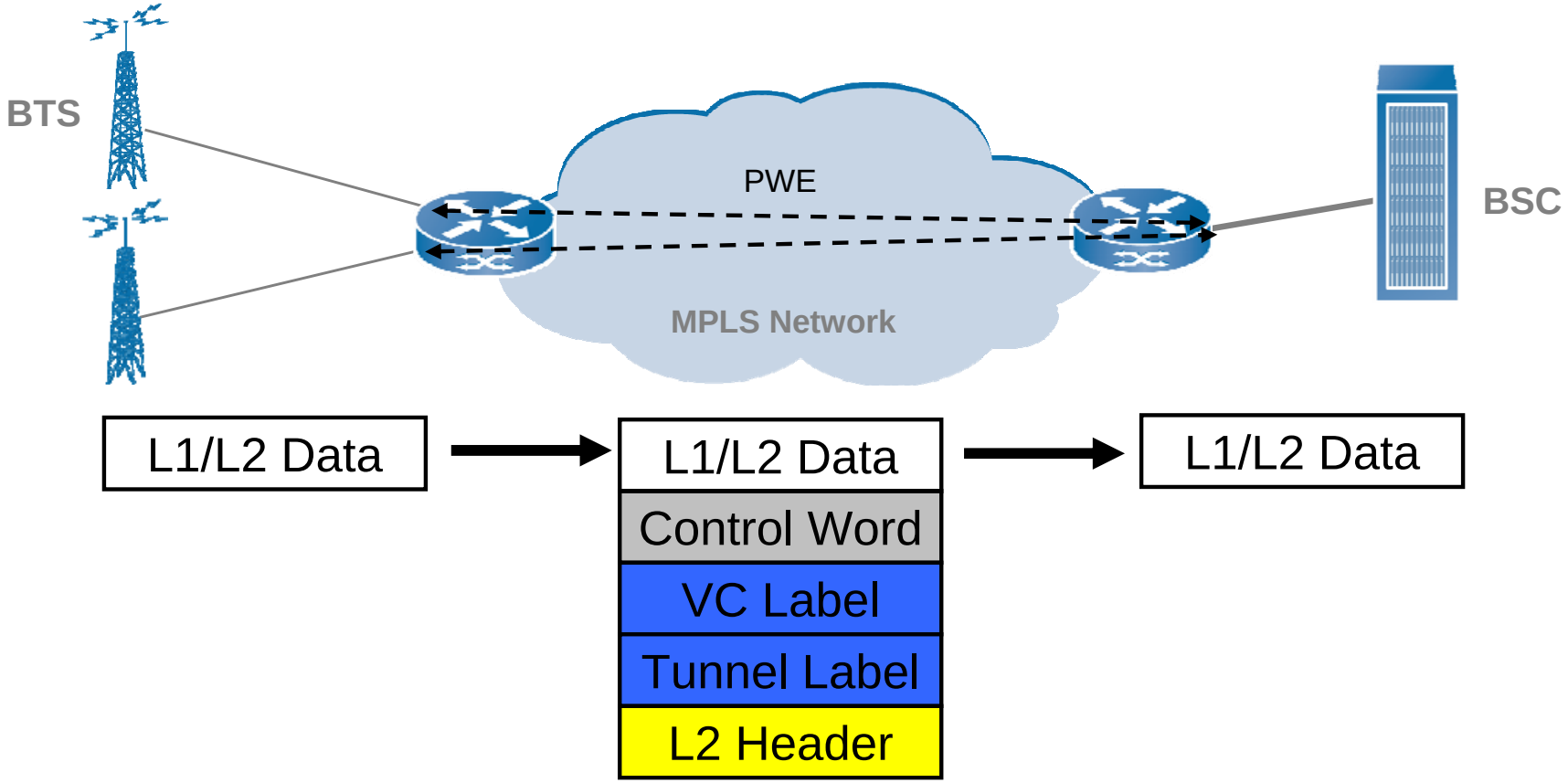



- **Pseudowires decouple service from transport**
  - > Enables convergence of all services over one network
  - > Which enables use of the cheapest available transport

***Enables operator to decouple cost from capacity***

# Wireless over Pseudowires

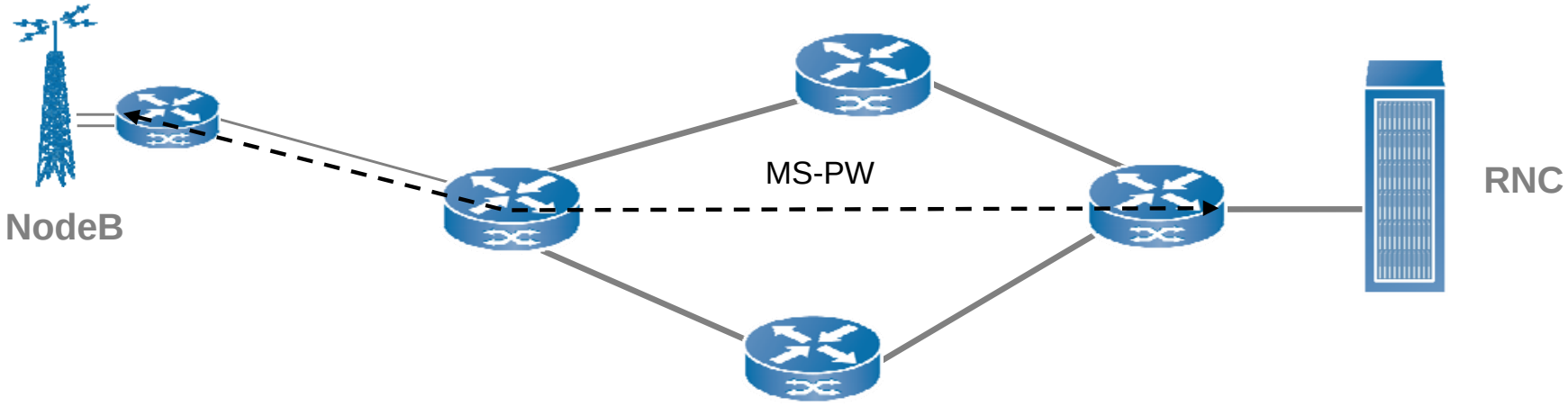
*Generic view of Pseudowire Backhaul*




**PW Encapsulation**

- Pseudowires create circuit layer on top of IP/MPLS
  - Use MPLS LSPs for protection
  - Reparent Base Stations by redirecting circuit endpoints

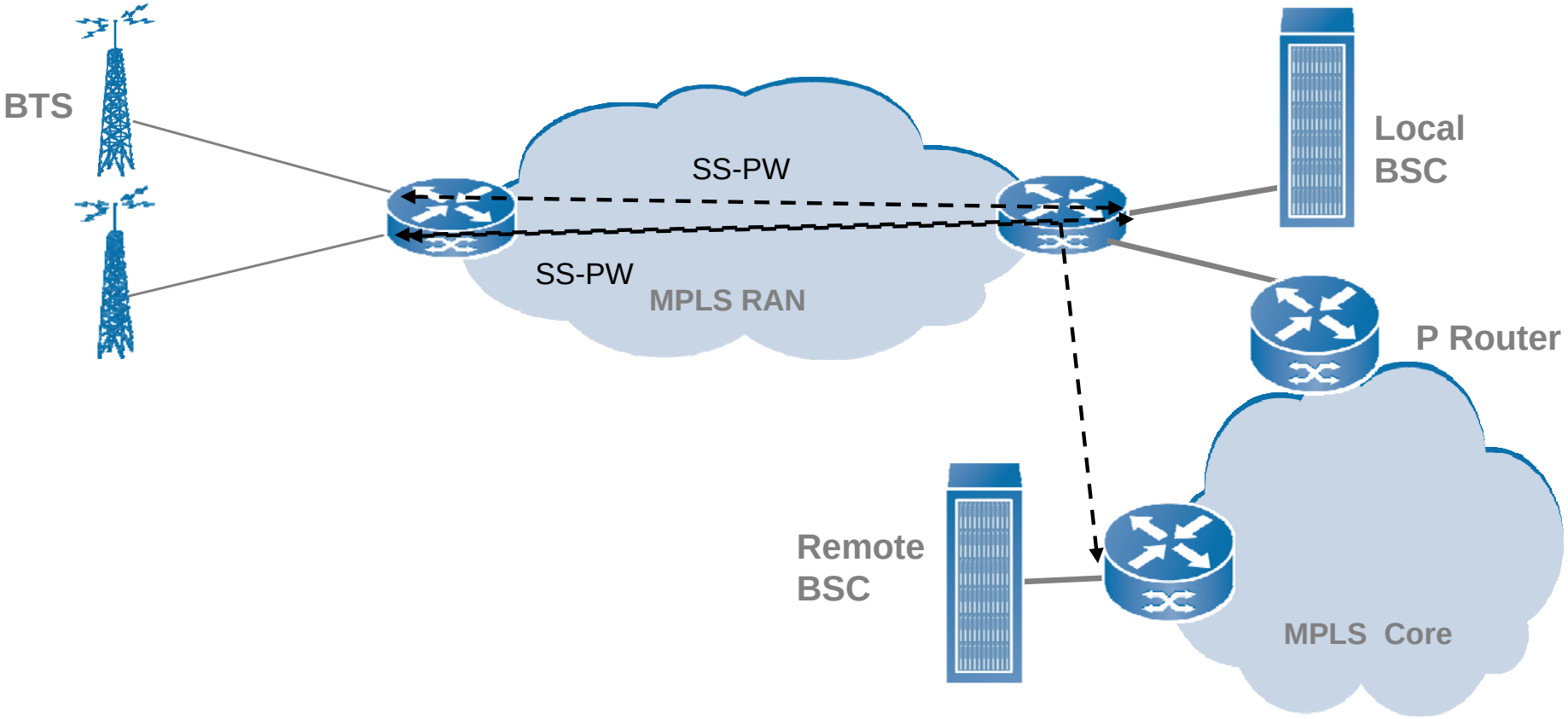
# Wireless over Pseudowires
## *Using Pseudowire Switching in the RAN*




- Cell-Site boxes may be small “pizza box” MSA devices
  - No routing or signalling
  - Pseudowire forwarding, no L3
- No protection available from cell-site to hub (copper T1/E1, or microwave)
  - But carriers wish to make use of protection from the hub site towards the core

# Wireless over Pseudowires

## *Using Pseudowire Switching to Cross the Core*

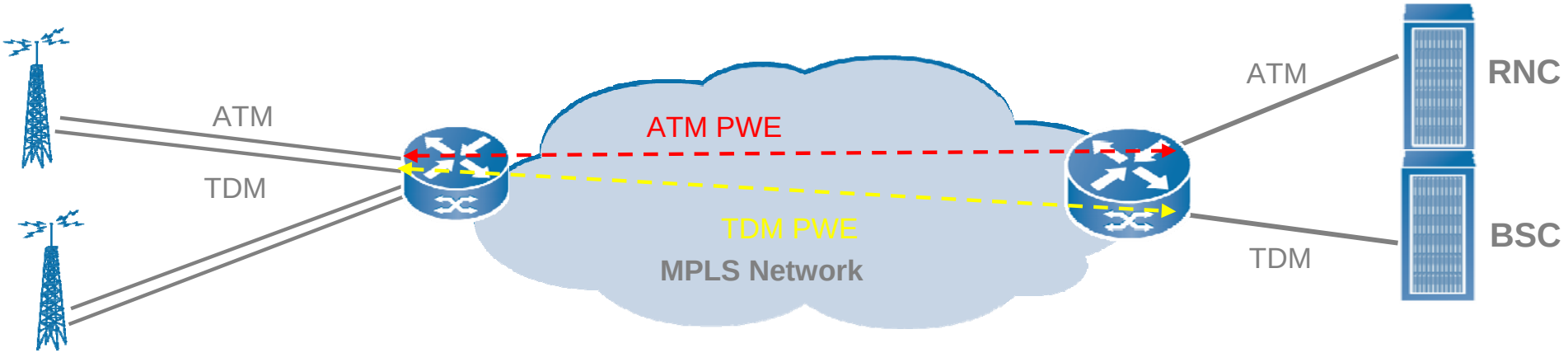



- Carriers want to keep RAN and core separate
- Carriers sometimes need to reparent to BSCs or RNCs outside the RAN
- Pseudowires can be switched at the RAN/core boundary

# Case Studies
## *Rural Deployment – Optimising Capacity*

- **Capacity Today**
  - > Leased T1/E1 or PDH microwave from cell site to hub site
  - > Leased SONET/SDH (or SONET/SDH microwave) from hub to RNC site

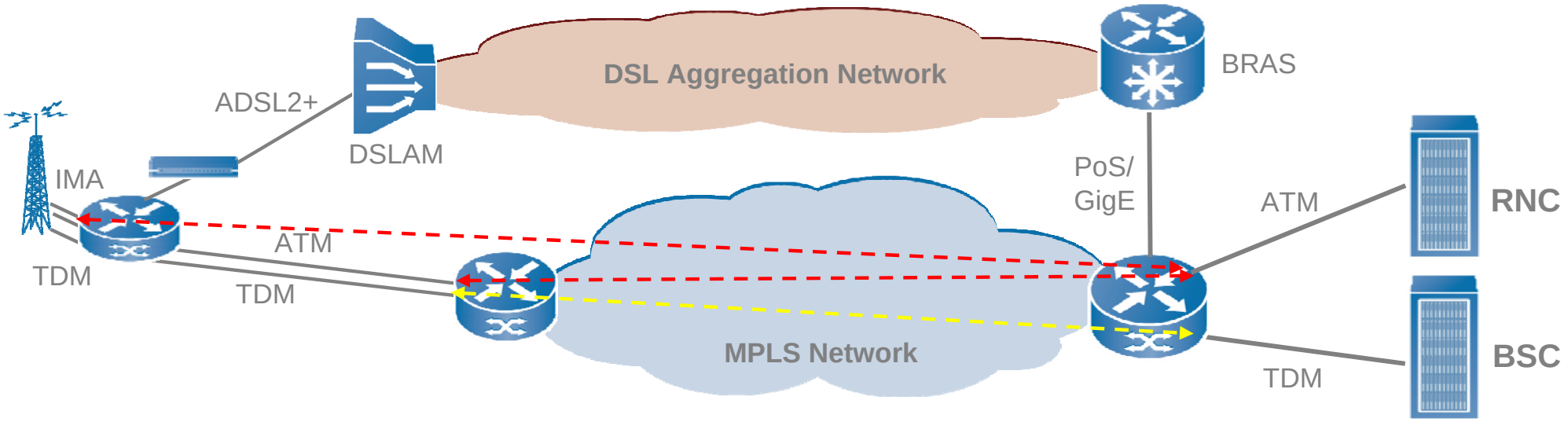
- **Solution: MPLS at Hub Site**
  - > Maintain ATM or TDM T1/E1 circuits to hub site
  - > Use MPLS PWE from hub site to RNC site
    - – Enables clear-channel transport (plus option to use Ethernet if available)
    - – Enables statistical gain between cell-sites



# Case Studies
## *Suburban Deployment – Adding HSDPA*

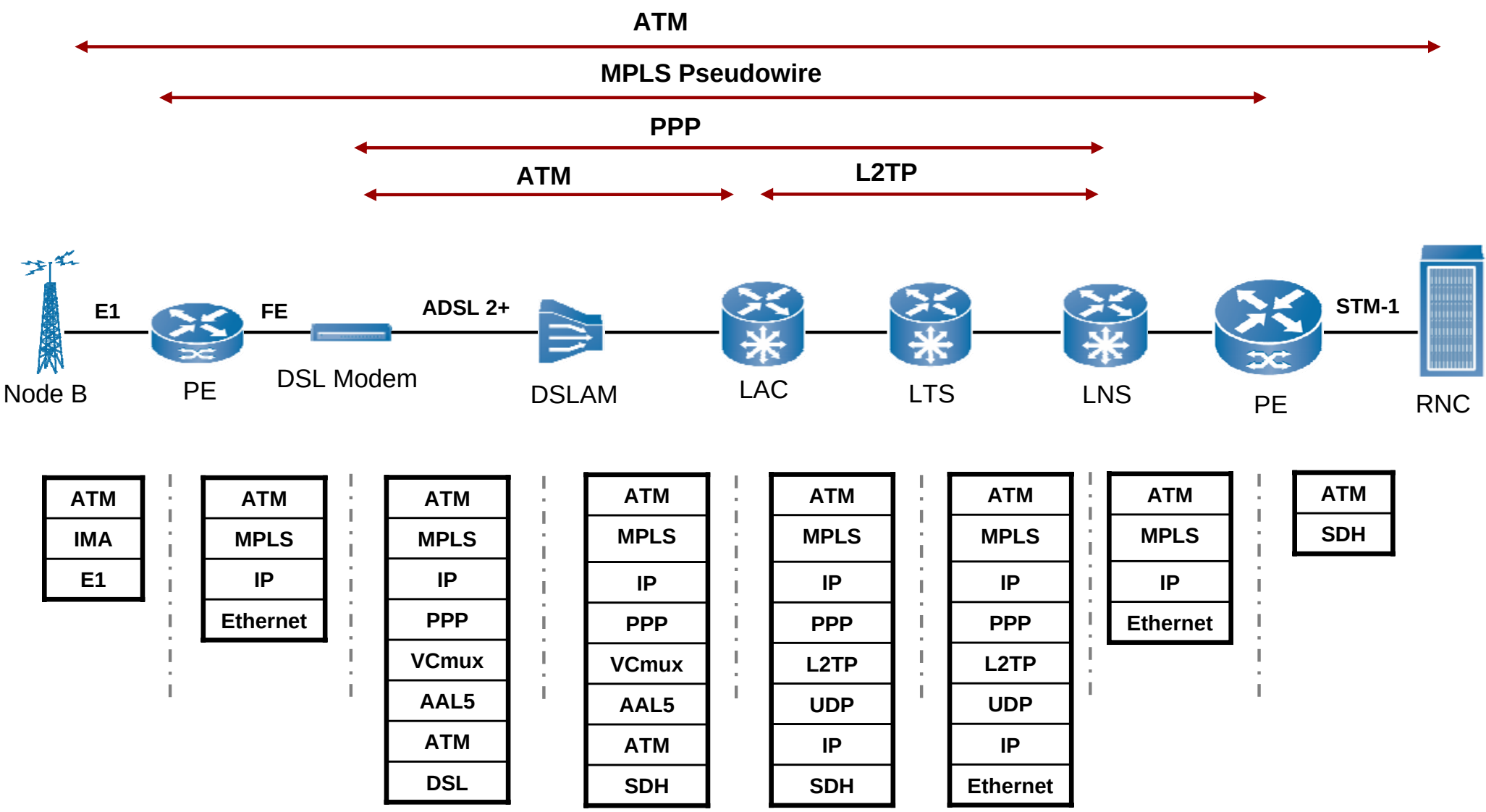
- **Capacity Today**
  - > Leased T1/E1 or PDH microwave from cell site to hub site
  - > SDH/SONET from hub site to RNC site

- **Solution: MPLS at Cell Site with DSL offload**
  - > Maintain ATM or TDM T1/E1 circuits to hub site
  - > Add wholesale ADSL capacity for 3G data using PWE over IP



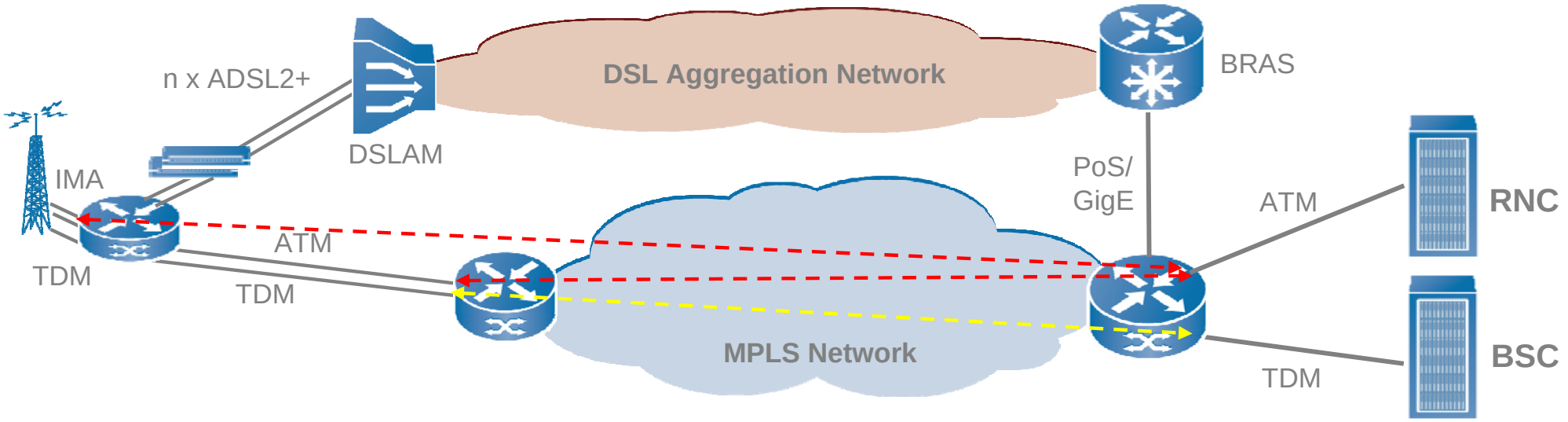
# Pseudowires over DSL

*Using MPLS over IP (RFC4023)*



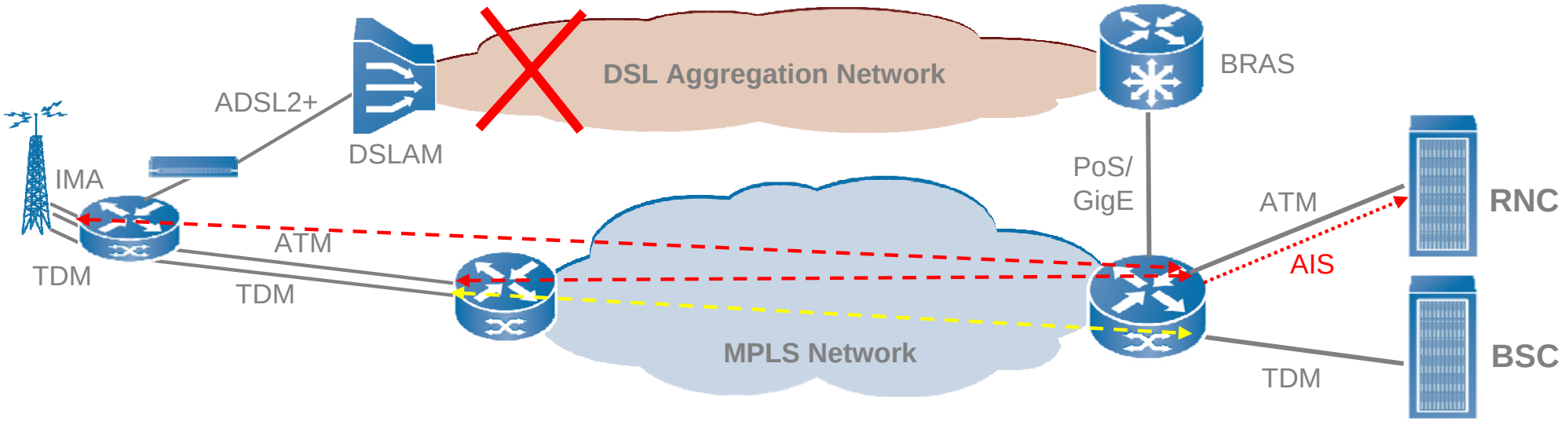
# Pseudowires over DSL
*Using multiple DSL loops*

- **Multiple DSL loops may be required to enable full-speed HSDPA**
  - > Per VC load-sharing gives no benefit as typically one VC for HSDPA
  - > Per AAL2 session load-sharing restricts per-user performance
  - > Per packet load balancing works, but:
    - – Requires MPLS/IP tunnel per DSL loop – with BFD to detect failures
    - – Overall performance limited to N x speed of slowest DSL loop
    - – Requires sequence number in the pseudowire Control Word



# Pseudowires over DSL
*Using MPLS over IP (RFC4023)*

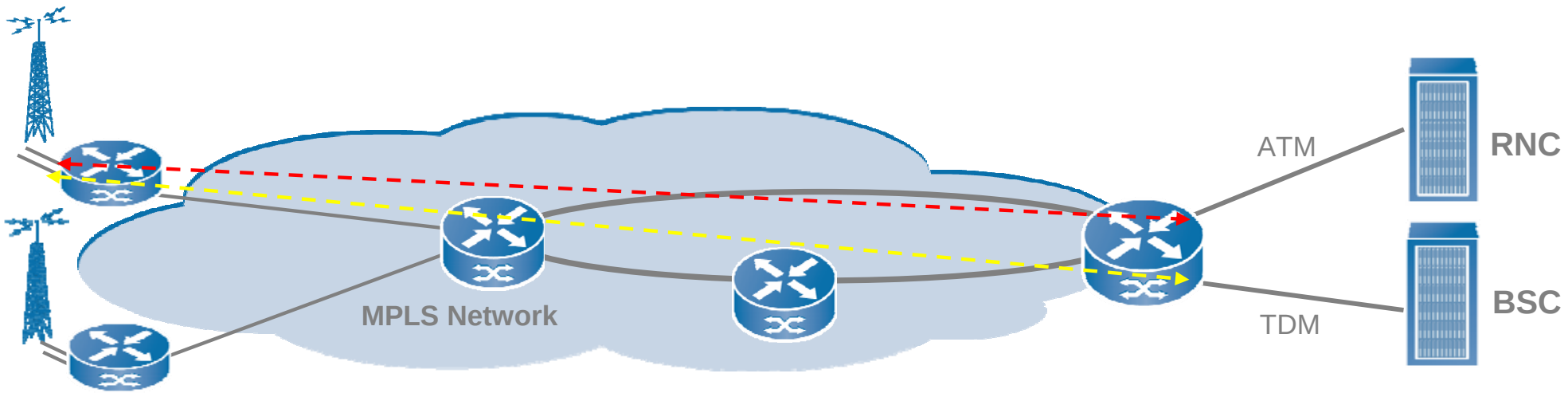
- **"Overlay Network" causes control plane challenges**
  - > tLDP session as per RFC4447 can be used to provision PWs, but failure detection will be slow
  - > VCCV-BFD from PE to PE provides faster detection
    - – As no QoS in DSL network VCCV packets may be lost due to overload
  - > Need mechanism to notify DSL network failures to the RNC



# Case Studies
## *Urban Deployment – Fibre to the Cell Site*

- **Capacity Today**
  - > Leased T1/E1 or PDH microwave from cell site to hub location
  - > SDH/SONET from hub location to RNC site

- **Solution: MPLS at Cell Site**
  - > Use FE or GigE over fibre from cell site to hub location
  - > Use GigE or 10GigE over fibre from hub site to RNC site

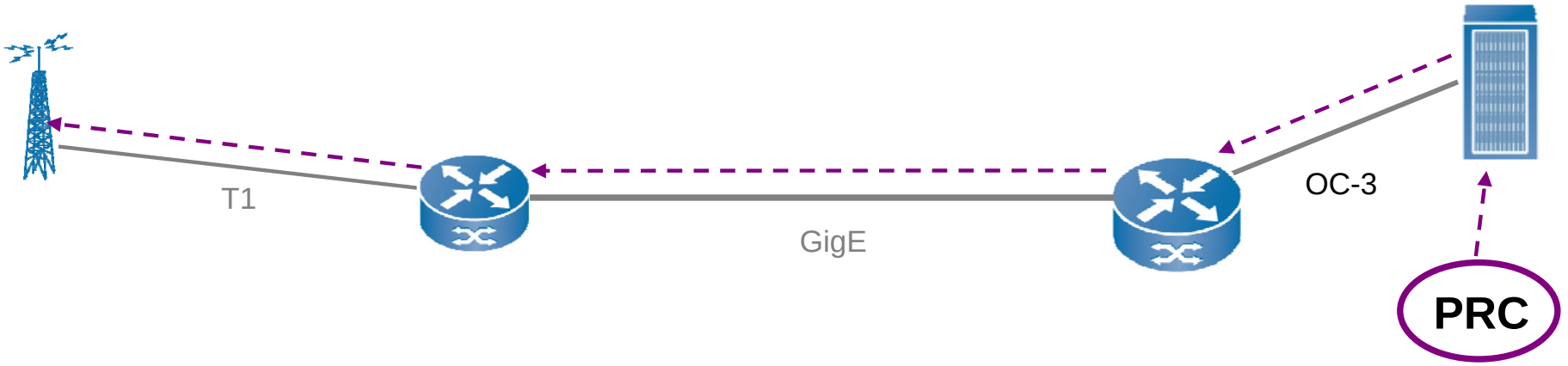


# Synchronization
## *Distributed*

- **Use external clock at each site**
  - > Expensive proposition to provide a clock at every cell-site!

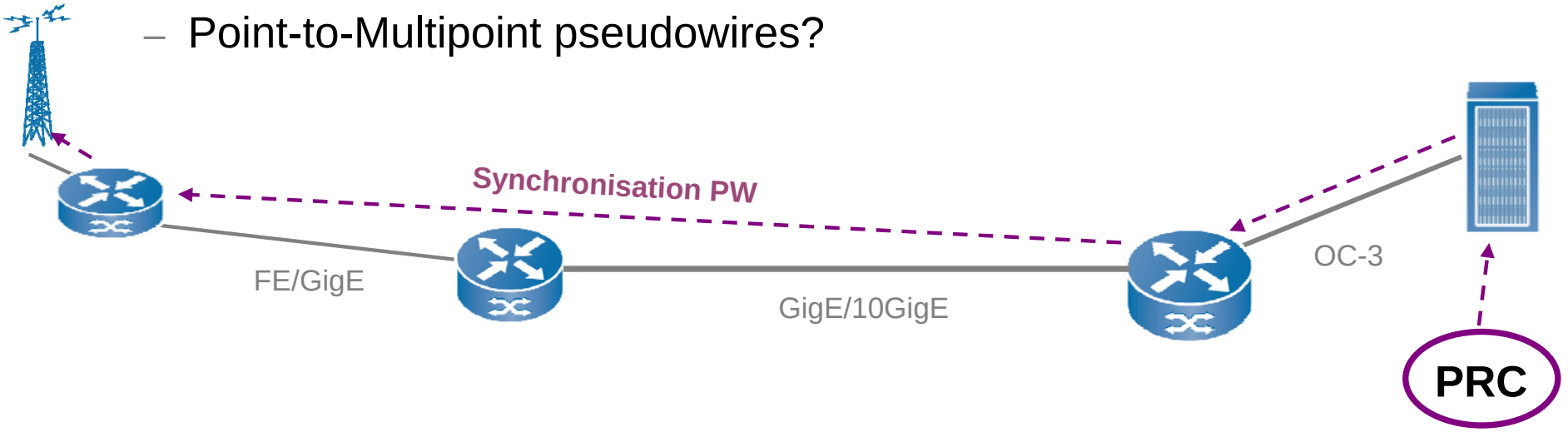
# Synchronization
## *Synchronous Physical Layer*

- **Synchronise all elements from the physical layer**
- **Distribute timing from one element to the next**
- **Well known and understood using SDH/SONET or E1/T1 circuits**
- **Ethernet Based**
  - > G.8261
- **Good fit for rural and suburban scenarios above**
- **Good fit for urban scenario if deploying a dedicated network**



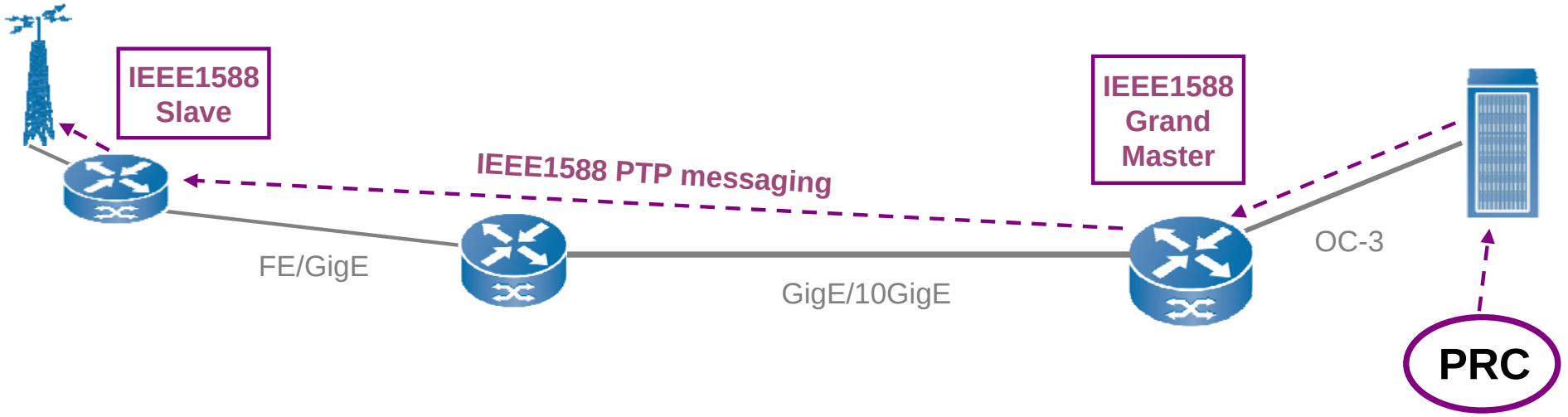
# Synchronization
## *Adaptive Timing*

- **Monitor jitter buffer levels**
- **Perform averaging and low pass filter to detect jitter**
  - > Tolerant to packet loss and reordering
  - > Vulnerable to low frequency jitter components
- **Two methods:**
  - > Synchronise each pseudowire
  - > Synchronise node using “synchronisation pseudowire”
    - – P2MP 64k CESoPSN Pseudowire?
    - – Point-to-Multipoint pseudowires?



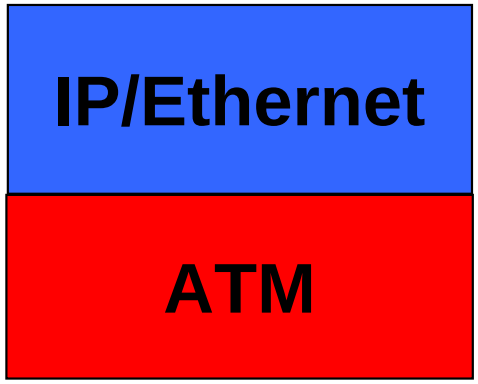
# Synchronization
## *IEEE1588 Precision Time Protocol*

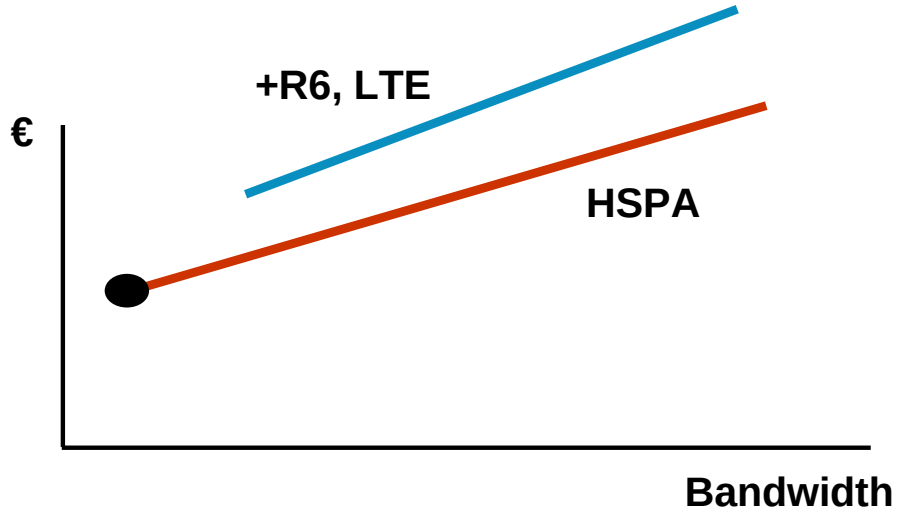
- **Hierarchical tree with master/slave clocks**
- **Designed for testing/automation applications**
  - > Being enhanced for telecom applications
- **Future – TICTOC?**

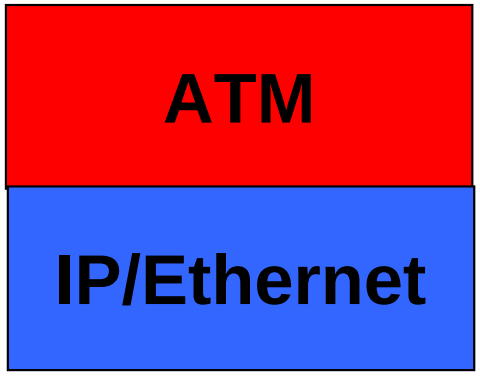


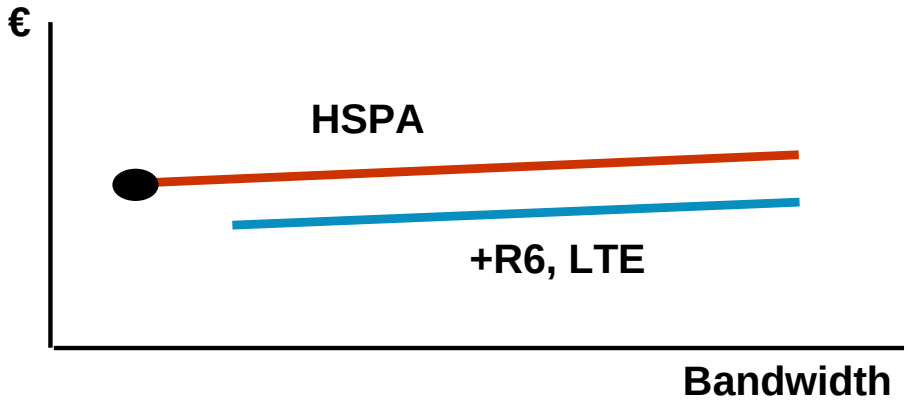
# Mobile Technology Migration

*Enable IP – reducing cost per bit - HSPA, R6, LTE*

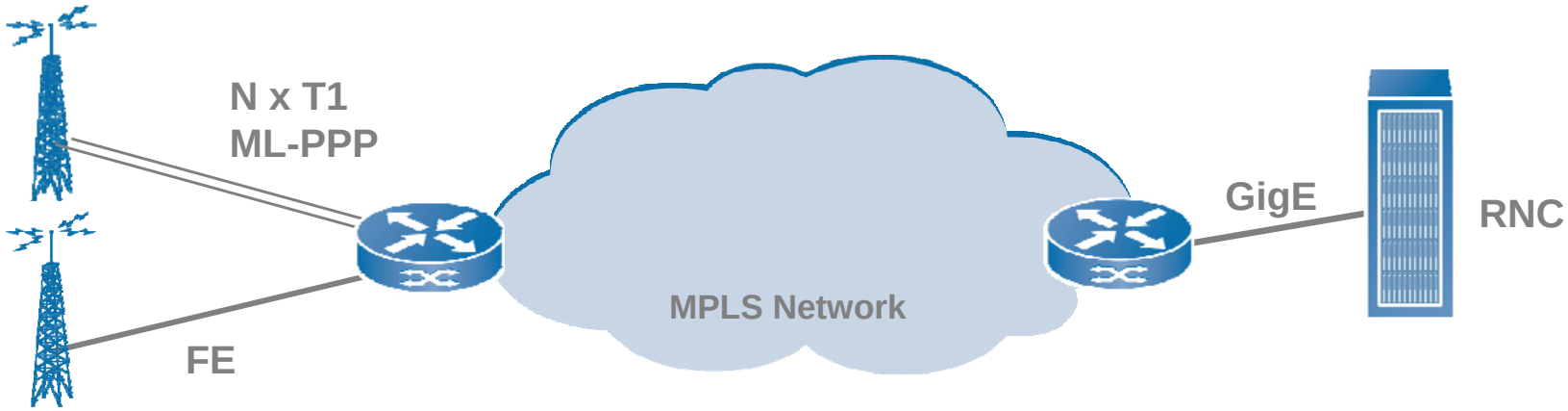


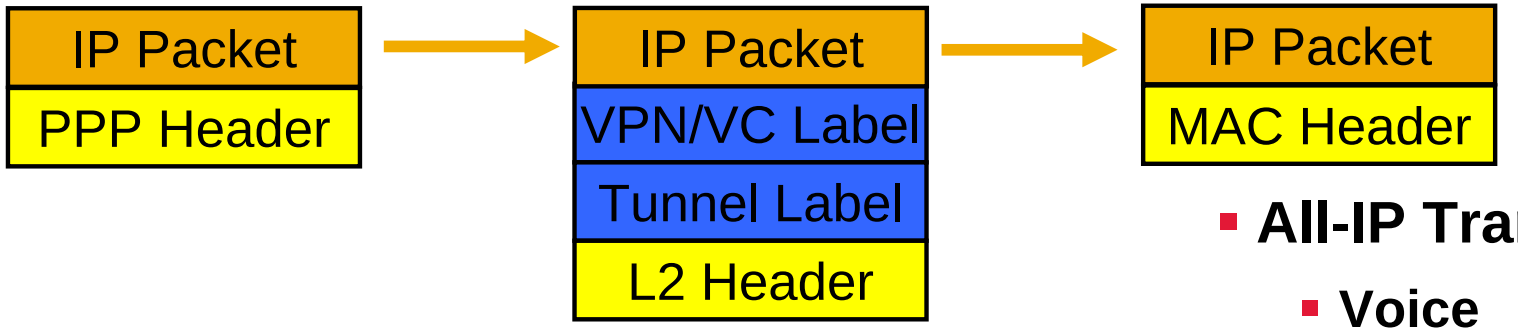



# 3G Backhaul Using MPLS
## *Migration to R5/R6*

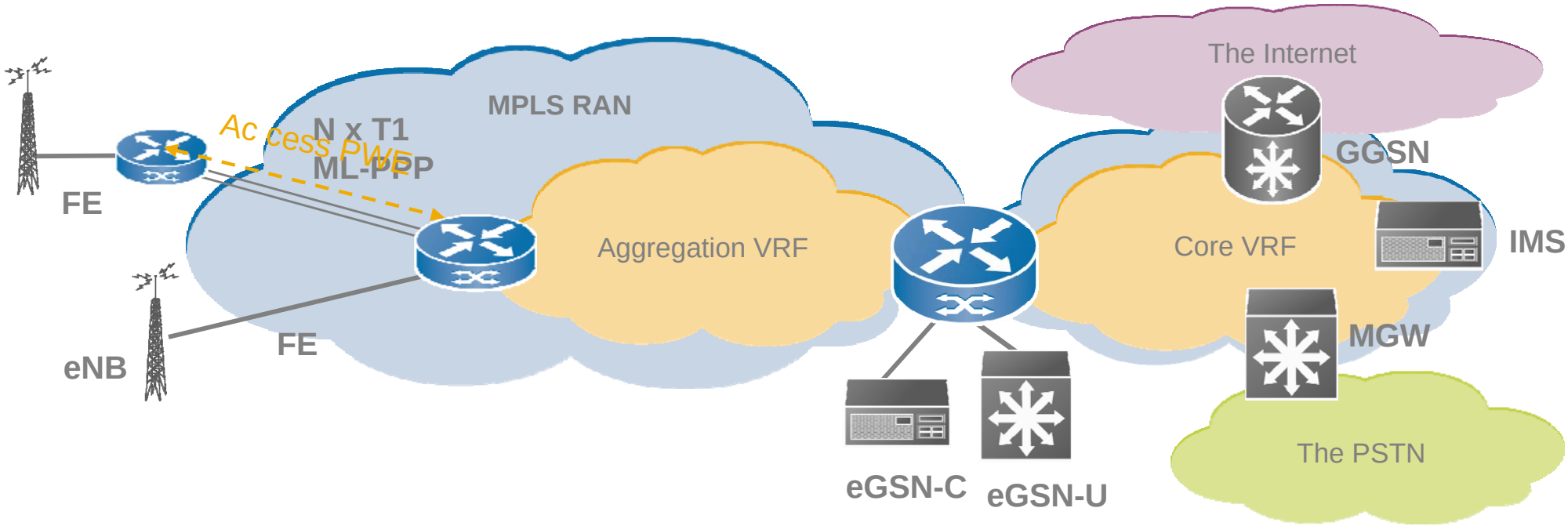



**VPN or IP-PW Encapsulation**

- **All-IP Transport**
  - **Voice**
  - **Data**
  - **Signalling**
  - **Management**

# 3G Backhaul Using MPLS
## *LTE*




- **NodeBs (now eNB) are meshed from a data plane perspective**
  - Enables call handover between adjacent cell-sites
- **Hierarchical IP-VPN model**
  - Optional PWE in access (cell site to hub)
  - VRFs in aggregation (hub to RNC site)
  - VRFs in mobile core

# “Wireless over Pseudowires”
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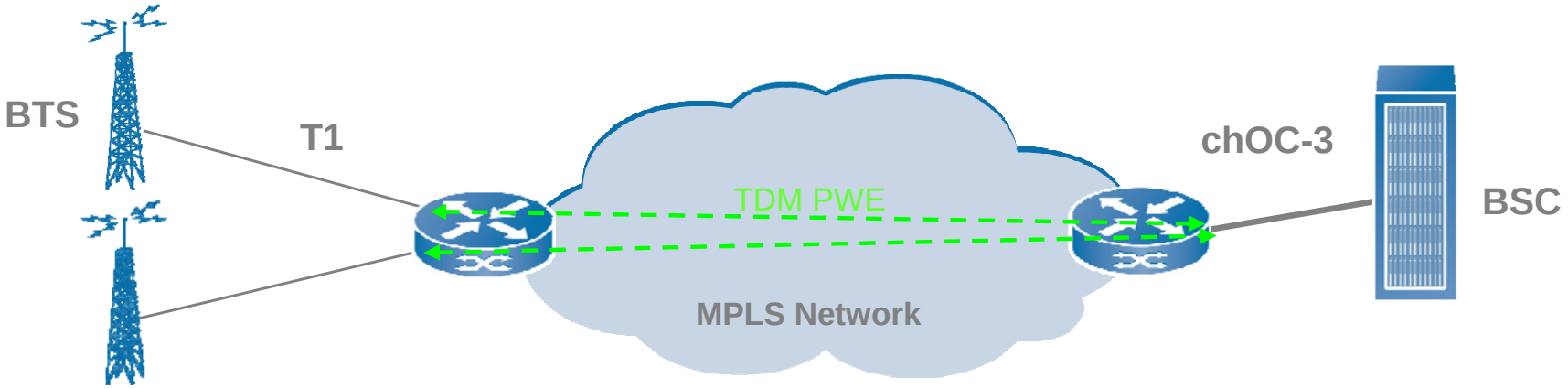
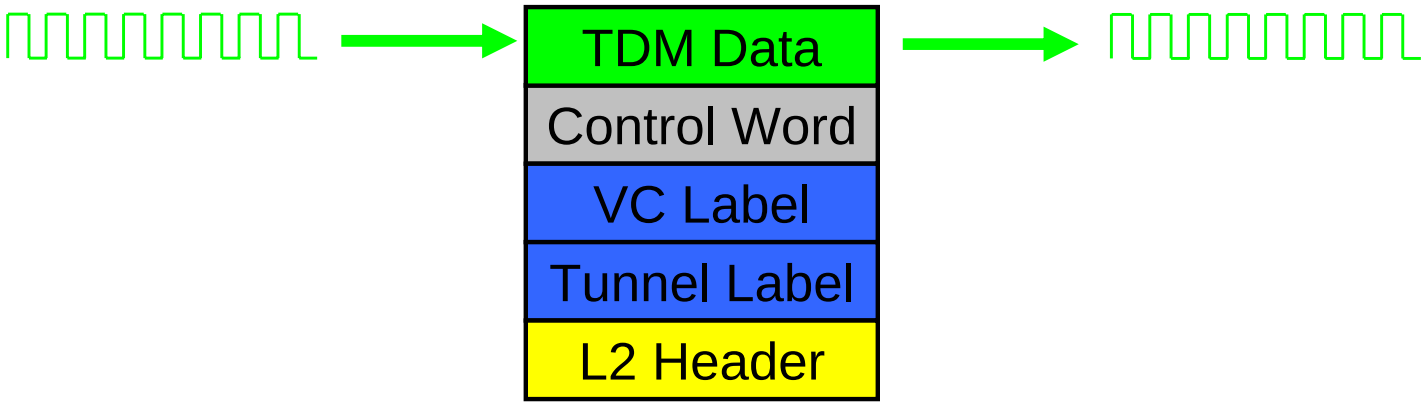
# Backup Slides

- **GSM Backhaul using TDM Pseudowires (SAToP or CESoPSN)**
- **GPRS Transport using FR Pseudowires**
- **UMTS Backhaul ATM VP Pseudowires**
- **UMTS Backhaul using ATM VC Pseudowires**
  - VC Cell Pseudowires
  - AAL5 SDU Pseudowires
  - IP/ATM Termination into VRF
- **CDMA 1xRTT Backhaul using HDLC Pseudowires**

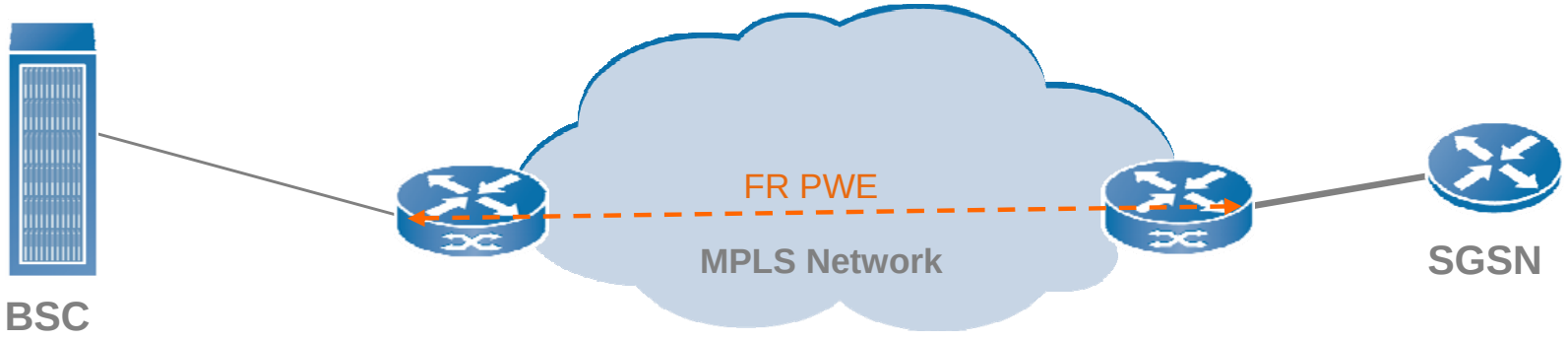
# GSM Backhaul Using MPLS
## *TDM Pseudowires using SAToP or CESoPSN*

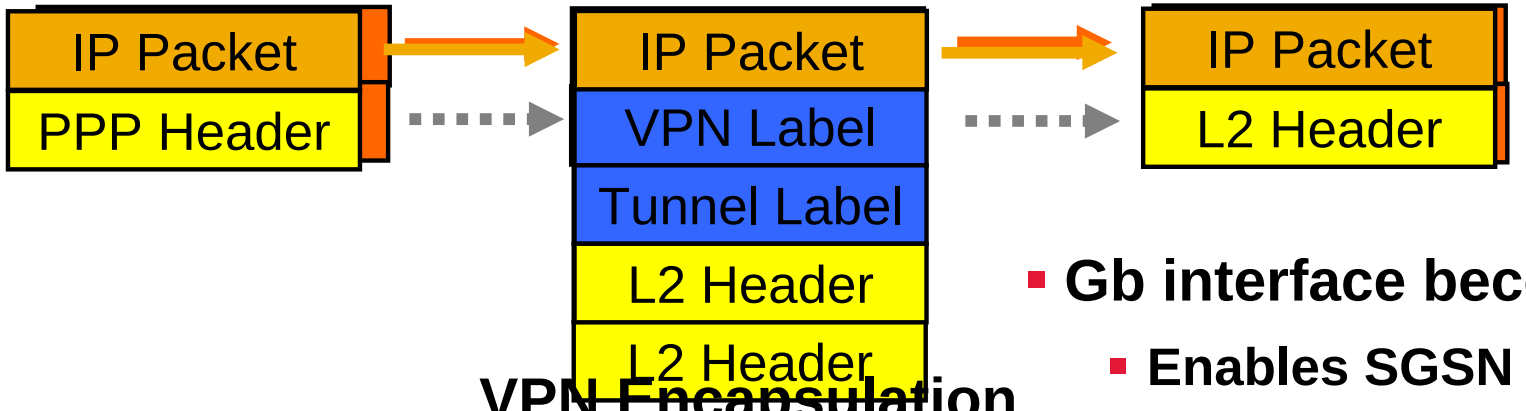



**PW Encapsulation**

# GSM - GPRS Transport Using MPLS
## *FR Pseudowires - Migrating to IP VPN*



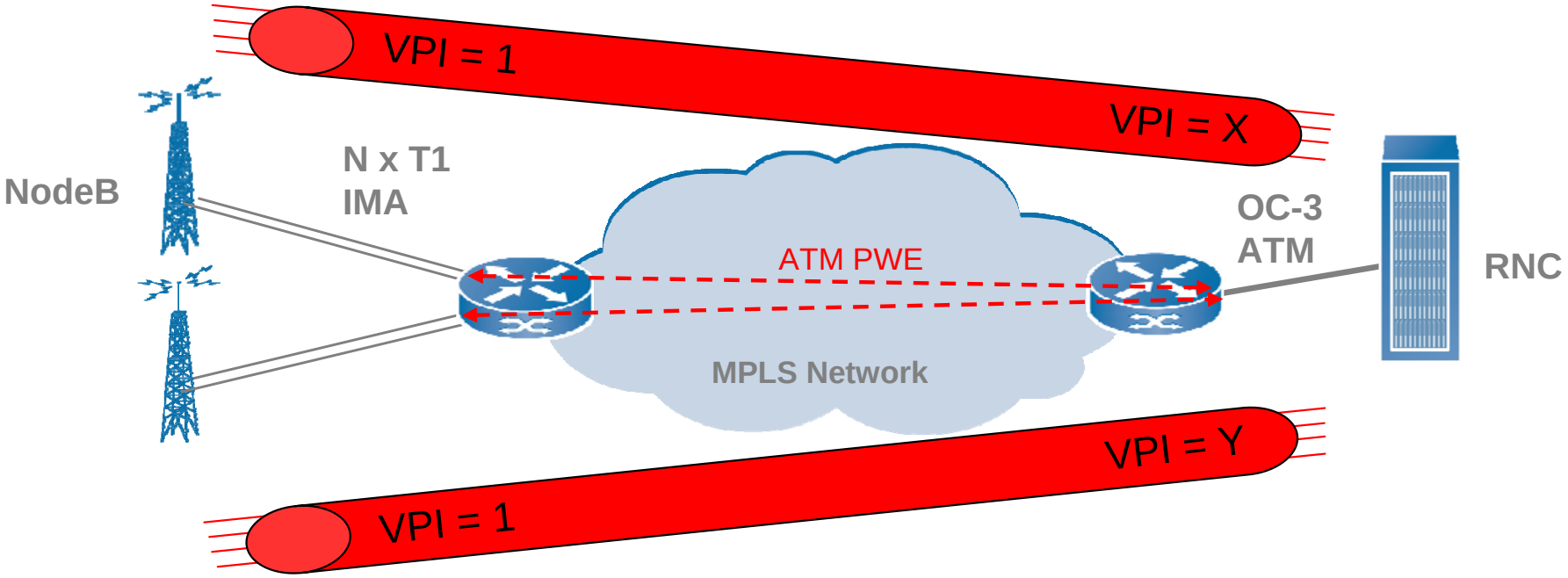



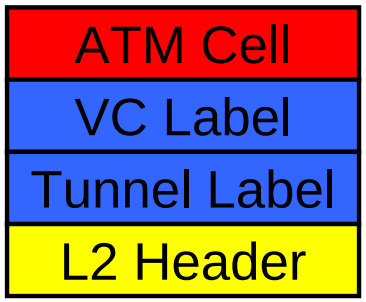

**VPN Encapsulation**

**PW Encapsulation**

- **Gb interface becoming IP**
  - **Enables SGSN pooling**
  - **Requires IP-VPN for GPRS backhaul**

# UMTS Backhaul Using MPLS
## *ATM VP Pseudowires*

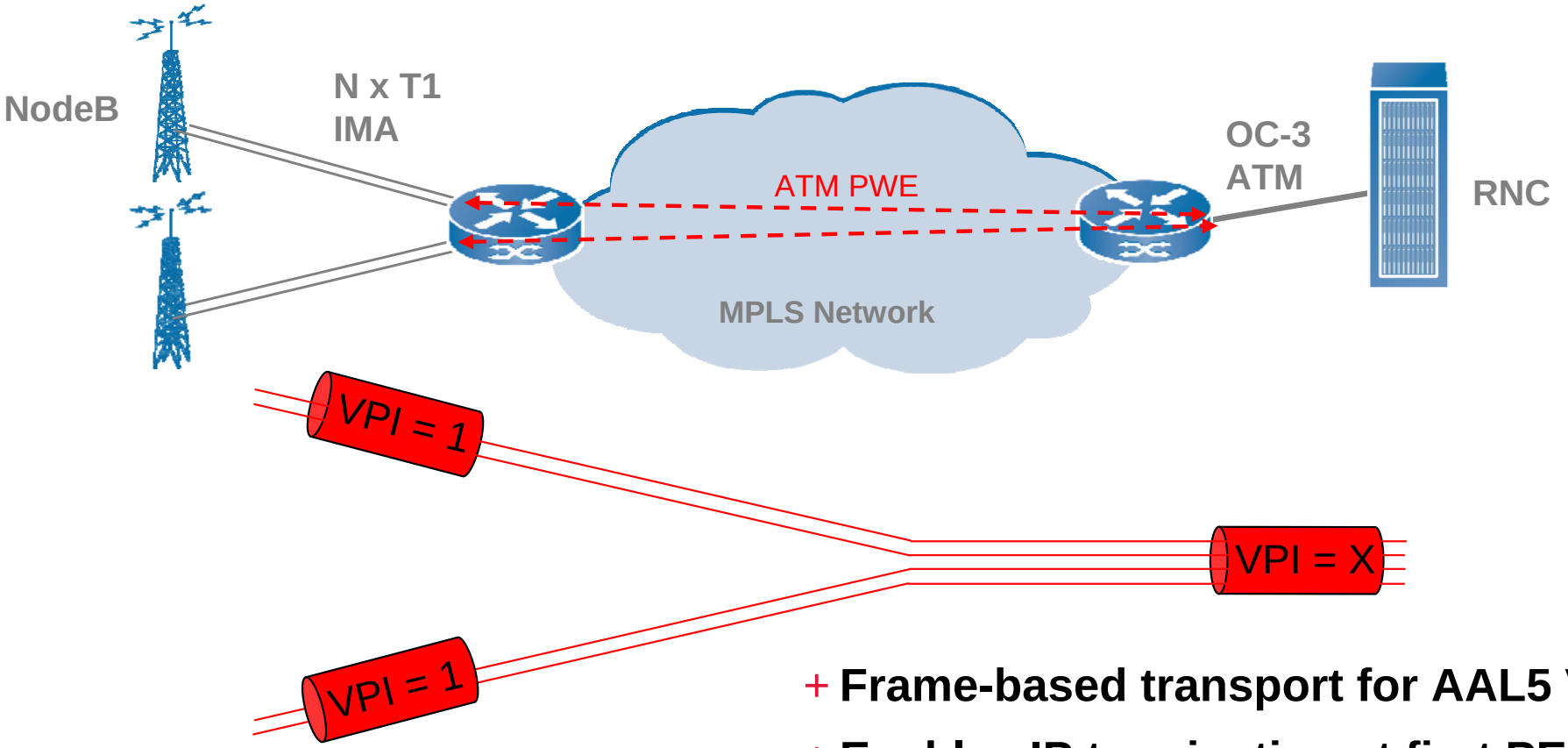



**PW Encapsulation**

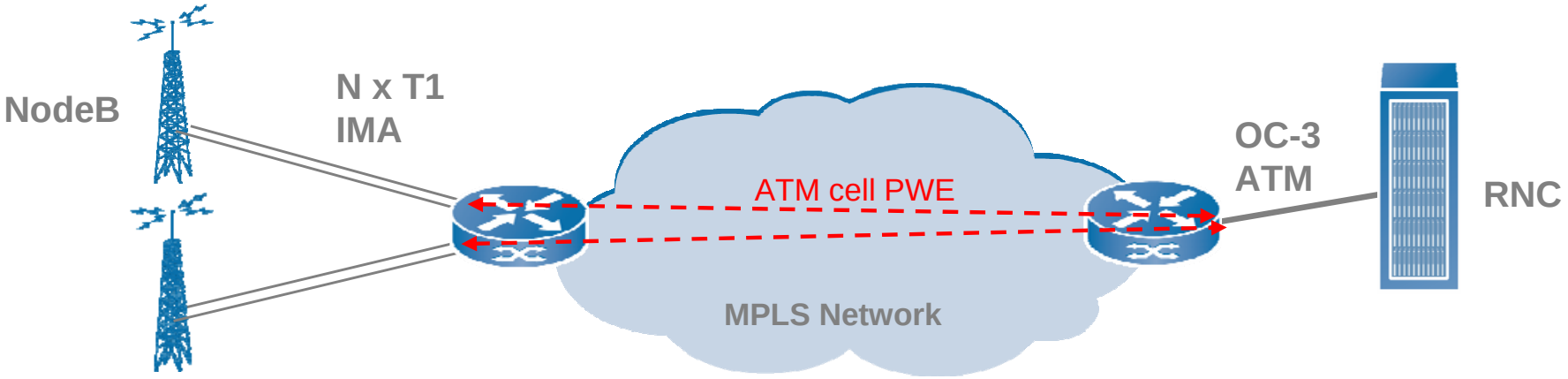
+ **Simple to provision**
- **Inefficient transport**
- **Requires CBR QoS for VP**

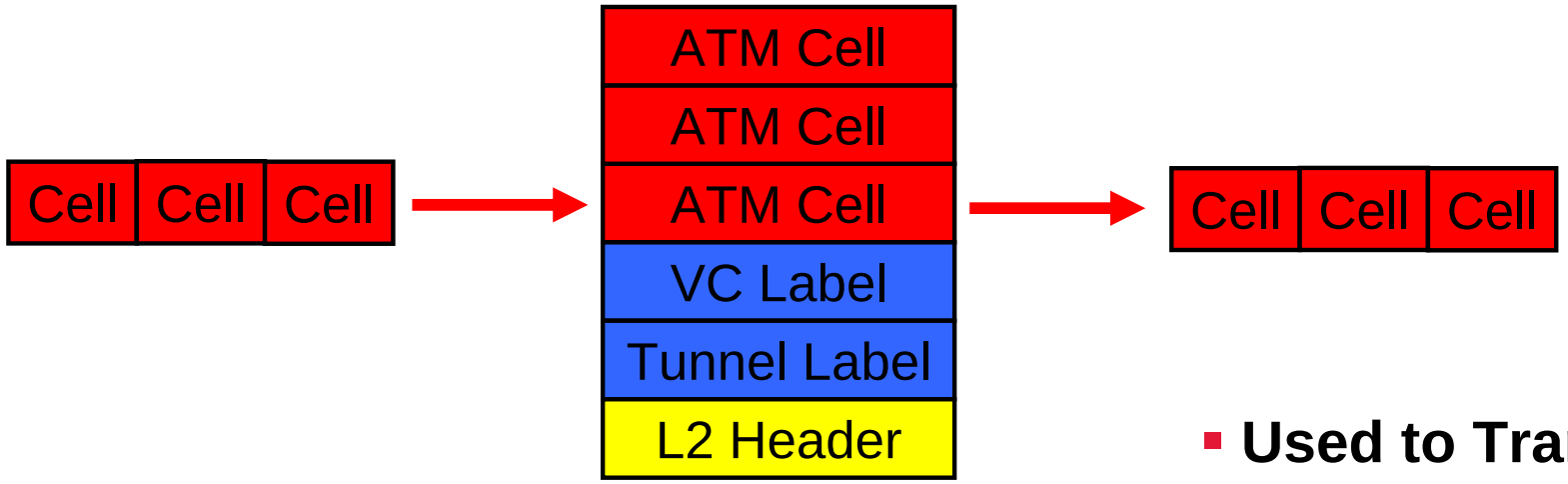
# UMTS Backhaul Using MPLS
## *ATM VC Pseudowires*




+ **Frame-based transport for AAL5 VCs**
+ **Enables IP termination at first PE for management and signalling traffic**
+ **Enables per-VC QoS (CBR, VBR, UBR)**
- **Complex to provision**

# UMTS Backhaul Using MPLS
## *ATM VC Cell Pseudowires*

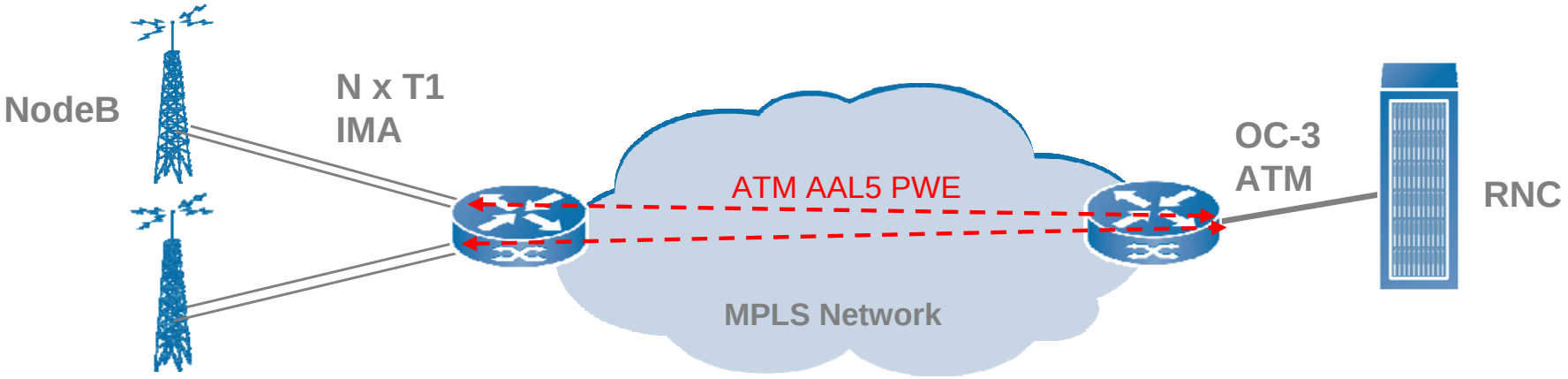


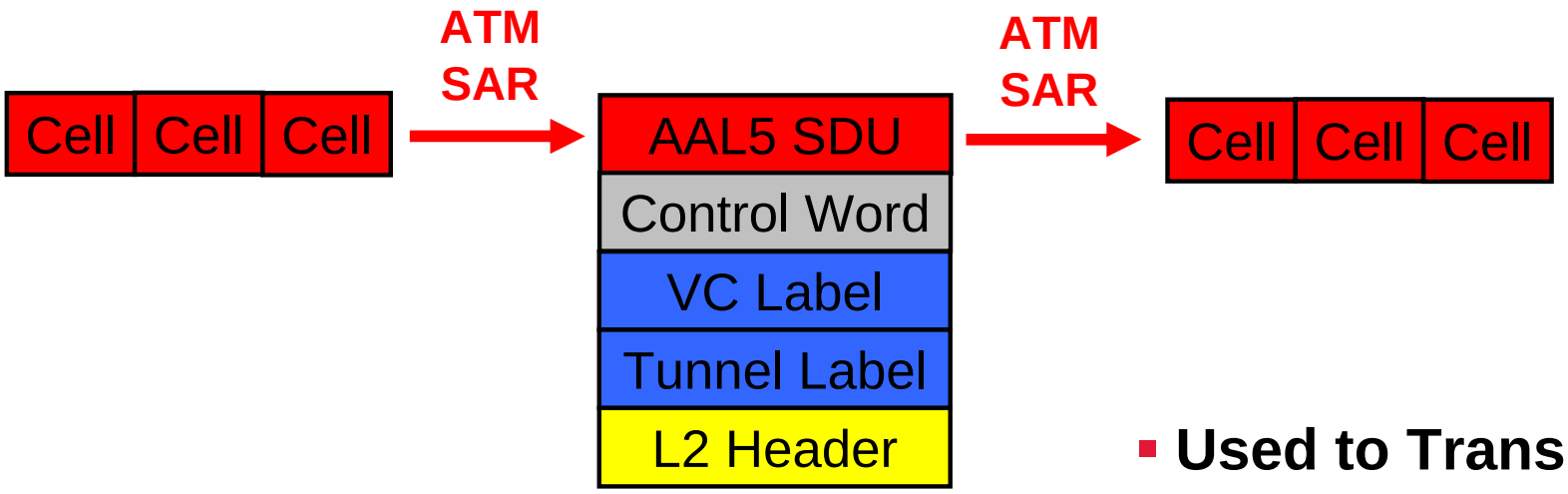




**PW Encapsulation**

- **Used to Transport**
  - **Sync (AAL0)**
  - **Bearer (AAL2)**

# UMTS Backhaul Using MPLS
## *ATM AAL5 SDU Pseudowires*

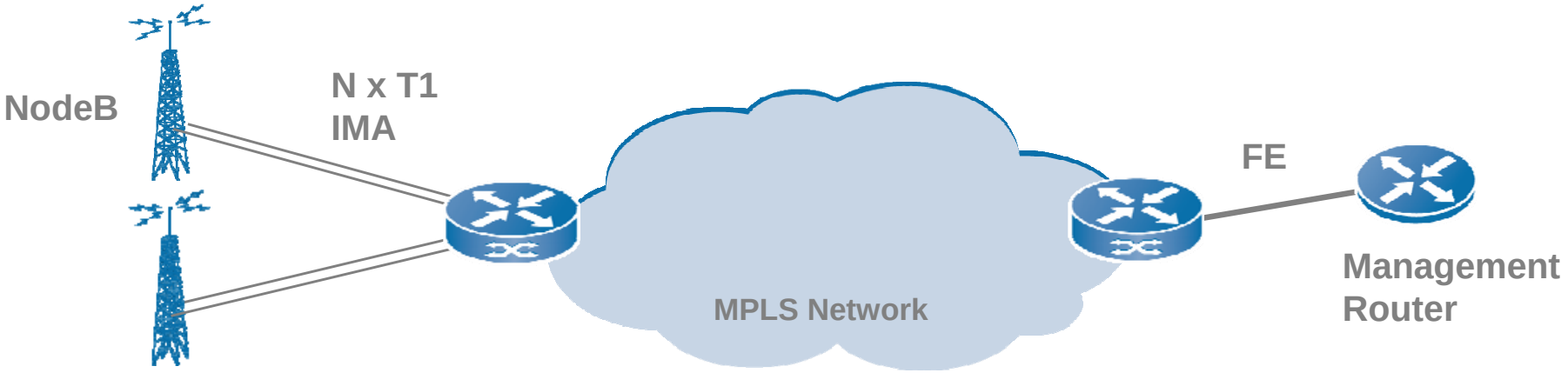


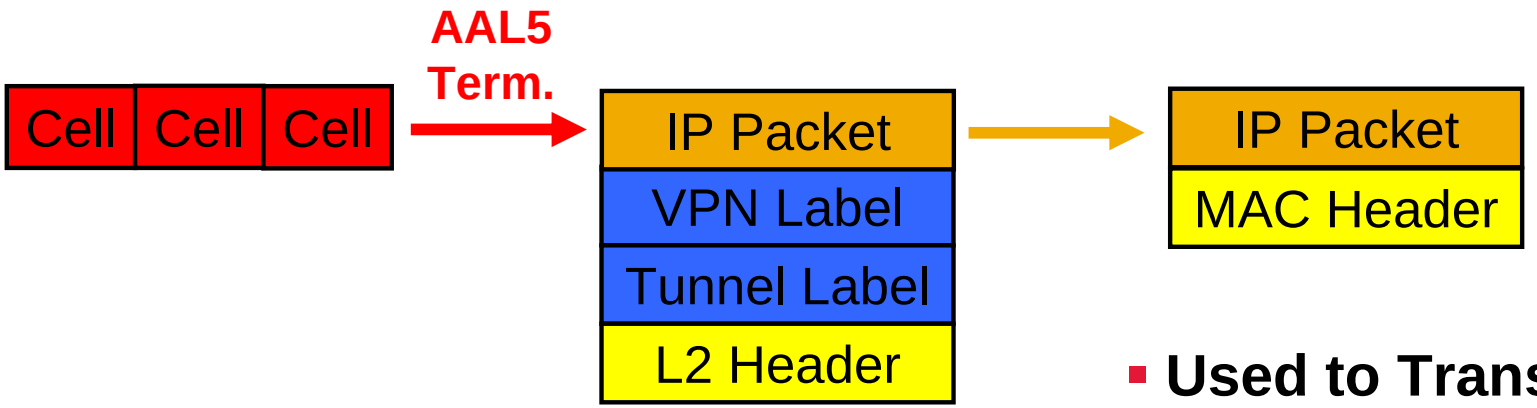




**PW Encapsulation**

- **Used to Transport**
  - **Signalling (QSAAL)**
  - **Other data**

# UMTS Backhaul Using MPLS
## *IP/ATM Termination into VRF*

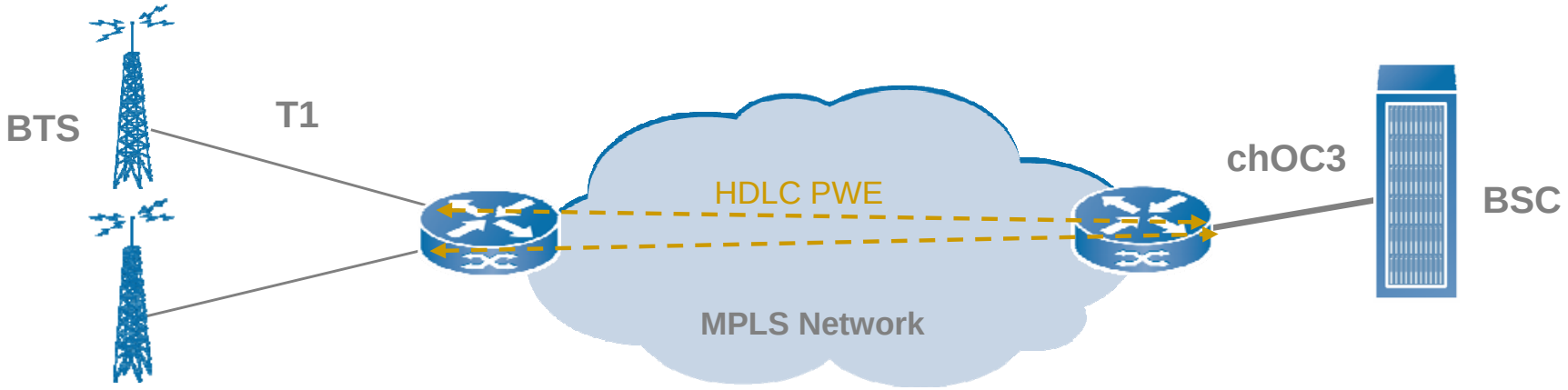


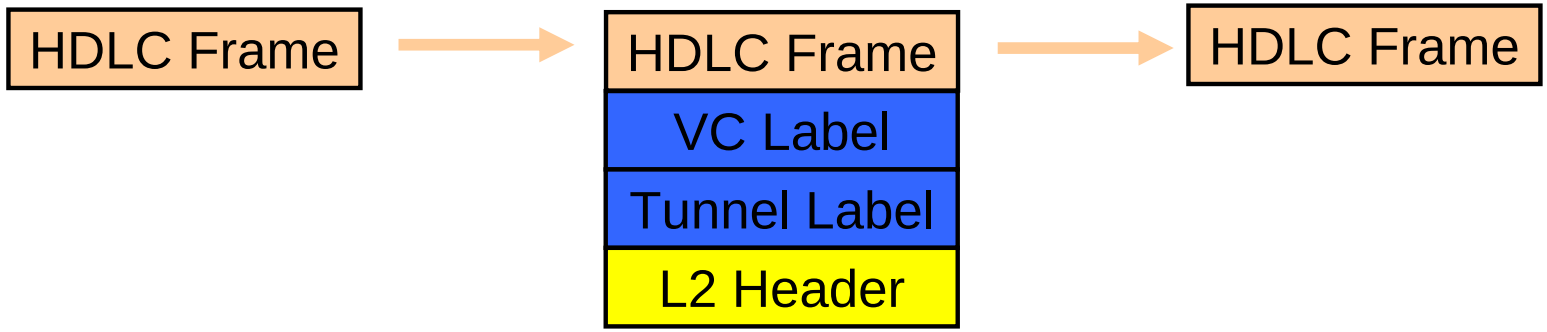




**VPN Encapsulation**

- **Used to Transport**
  - **Management (Mub)**
  - **Signalling (SIGTRAN)**
  - **Sync? (IEEE1588)**

# CDMA 1xRTT Backhaul Using MPLS
## *HDLC Pseudowires*




**PW Encapsulation**