IP RAN

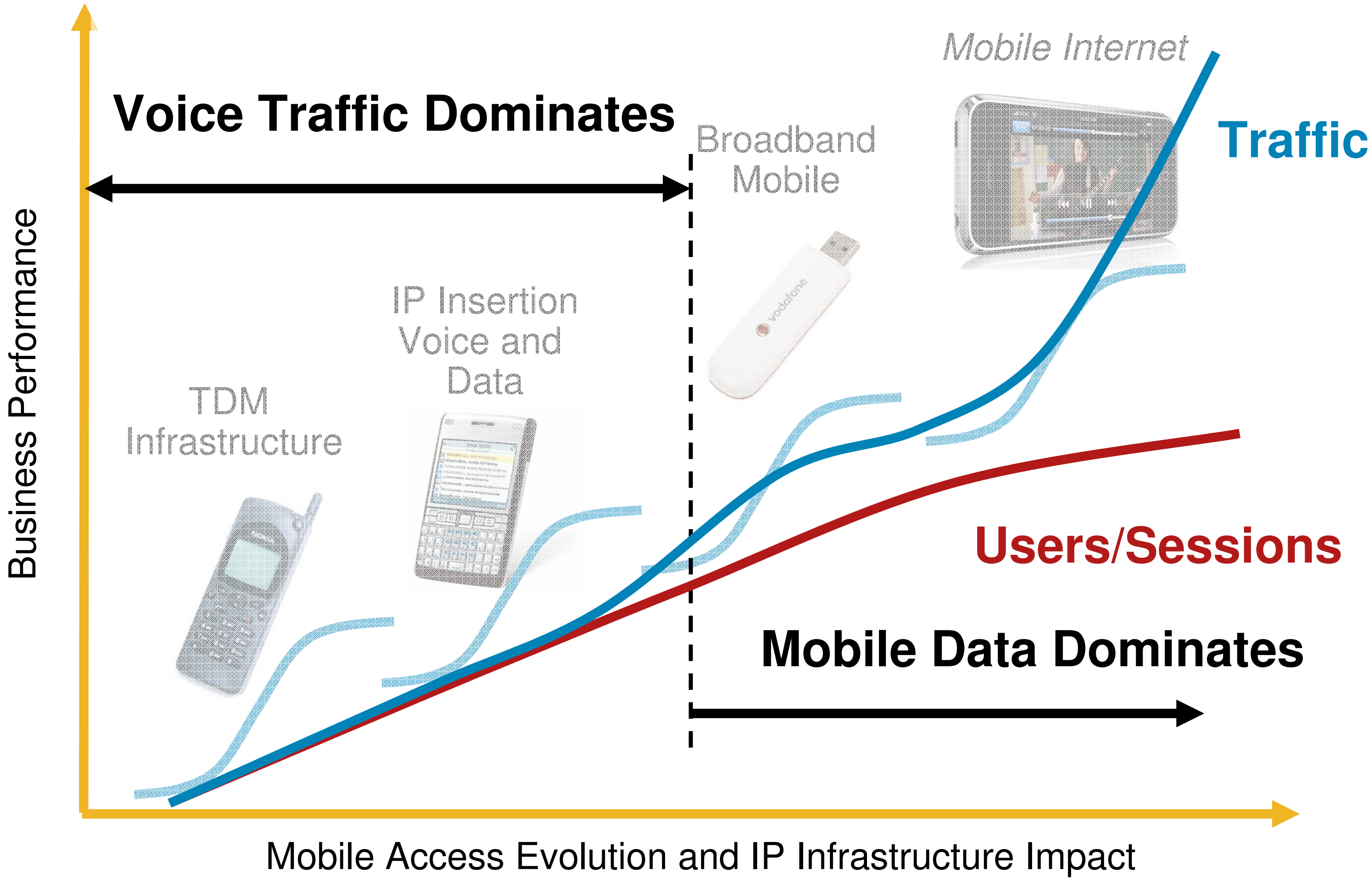
Kasu Venkat Reddy, Solution Architect
Santanu Dasgupta , Consulting Systems Engineer

Agenda

- Market Drivers for Next-Gen RAN
- Technical Requirements
- RAN Architecture Evolution
- Packet Based RAN Concepts
- Design for Packet-Based RAN
- Summary

Evolution and Disruption

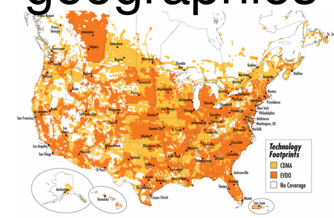
Transitioning to the Mobile Internet



Mobile Internet Is Changing the Industry

Handsets: Powerful new devices with compelling UIs (iPhone, Instinct, BB Bold, SE Xperia, etc.)

Broadband: High speed networks based on HSPA and EV-DO are now available in many geographies



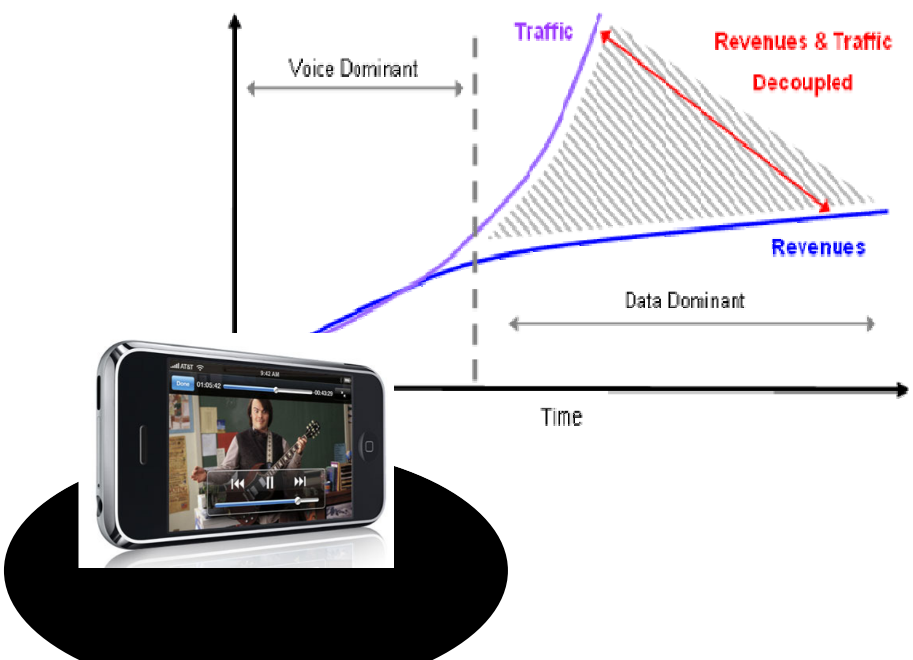
Billing Plans: None of this would be possible without aggressive flat rate all-you-can-eat billing plans

Apps: Lots of compelling apps are moving over from the wired world to join emerging LBS services

Opportunities with Packet Based RAN

Reduce Operational Cost

- Backhaul of cell tower traffic and leasing T1s account for 20% of mobile operator OpEx
- Drive down "per bit" cost in exponentially



IP Based Converged Transport

- 2G networks use TDM circuits for RAN transport
- 3G (UMTS) networks use ATM for RAN transport
- 4G is all IP
- Service delivery over any access network

RAN Backhaul Scalability

- Easier addition of new RAN bandwidth
- Rollout new services faster
- Meet capacity demand, expected to grow 4x to 10x as migration to 3G and 4G proceeds
- LTE will drive 100Mbps – 1Gbps per cell-site

Technical Requirements

Next-Gen Backhaul Requirements

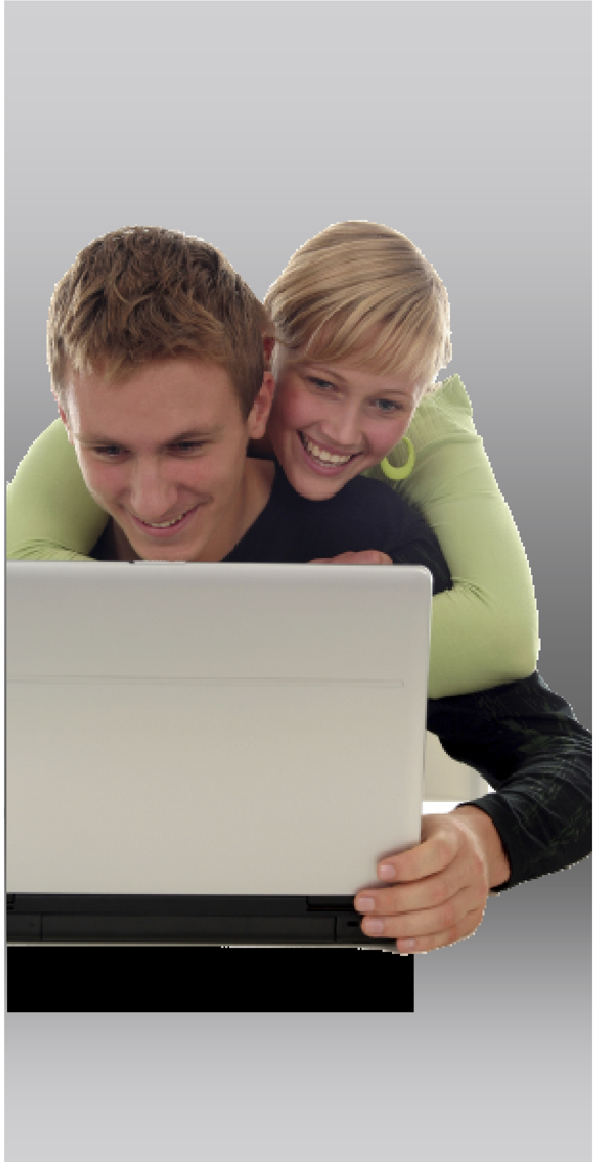
- Common and cheap transport
- Generation and service independent
- Traffic type awareness and prioritization (QoS)
- Scalability
- Service Resiliency
- Clock distribution mechanism
- Large scale provisioning and network visibility
- Work with existing backhaul interfaces (T1/ATM/Sonet)

[redacted]

Mobile Operators Looking for Options

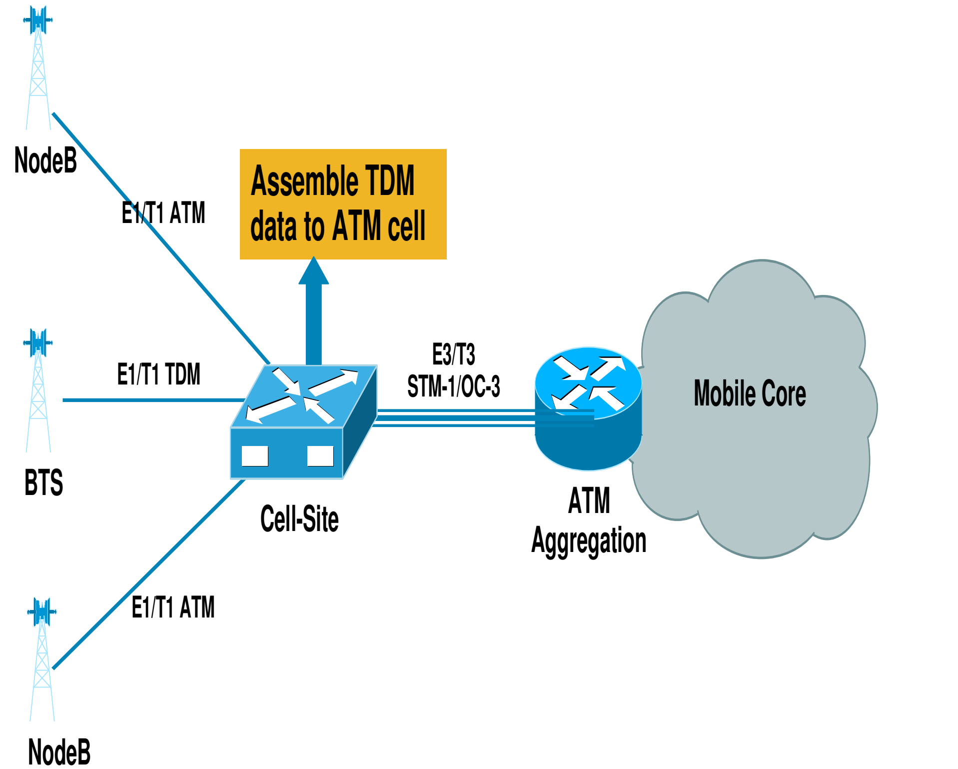
- Convergence over ATM
- RAN Optimization, with HSPA Offload
- Microwave
- Ethernet based BTS / Node-B
- IP/MPLS based transport

Winner: IP/MPLS based transport



Convergence Over ATM

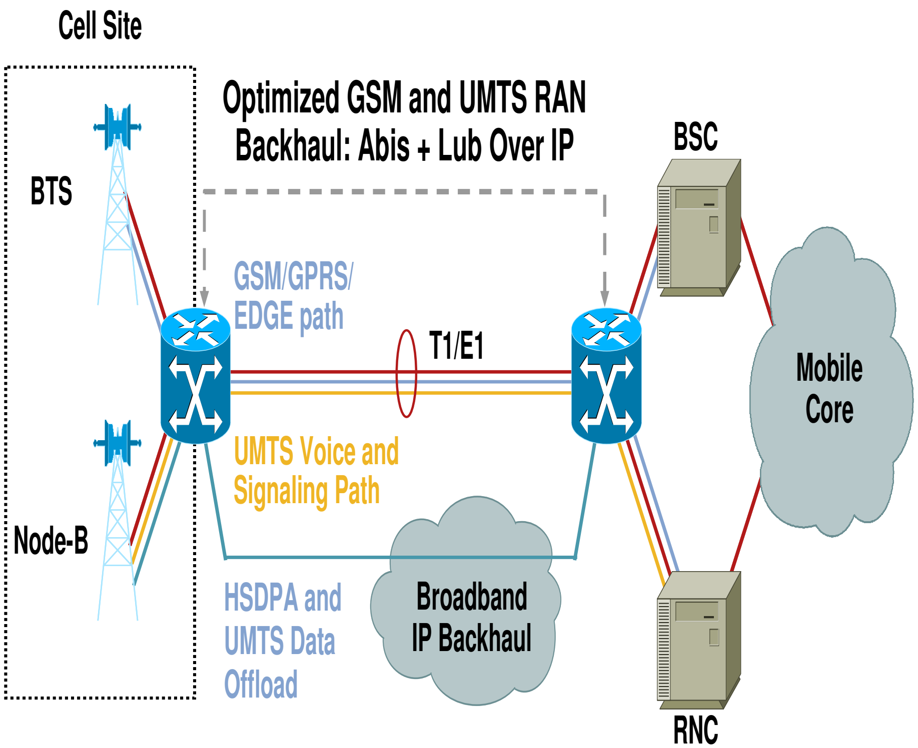
- Aggregate 2G/3G traffic using single ATM access link
- Incremental deployment of 3G with existing 2G
- Not flexible enough to deliver statistical / bursty traffic
- Cost per mobile phone increases significantly faster than ARPU
- Multicast not easy
- Not future proof



Aggregate traffic from 2G/2.5G BTS or 3G Node-B on a single ATM trunk

RAN-Optimization with HSPA Offload

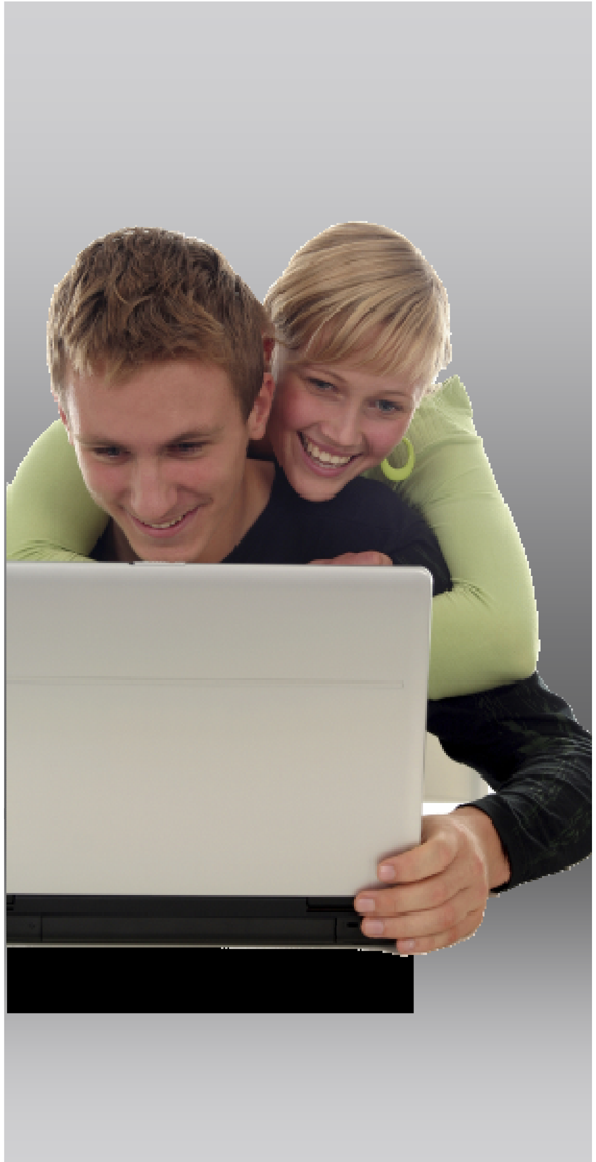
- Optimization by suppressing silence/repetitive frames, compressing headers
- Data offloading to DSL while 2G and 3G voice still over T1/E1
- Temporary solution, Not future proof
- Reduction in voice quality
- Not necessarily standards based



- 50% efficiency gain on GSM, 15-90% on UMTS
- HSPA offloaded to DSL, Eth etc

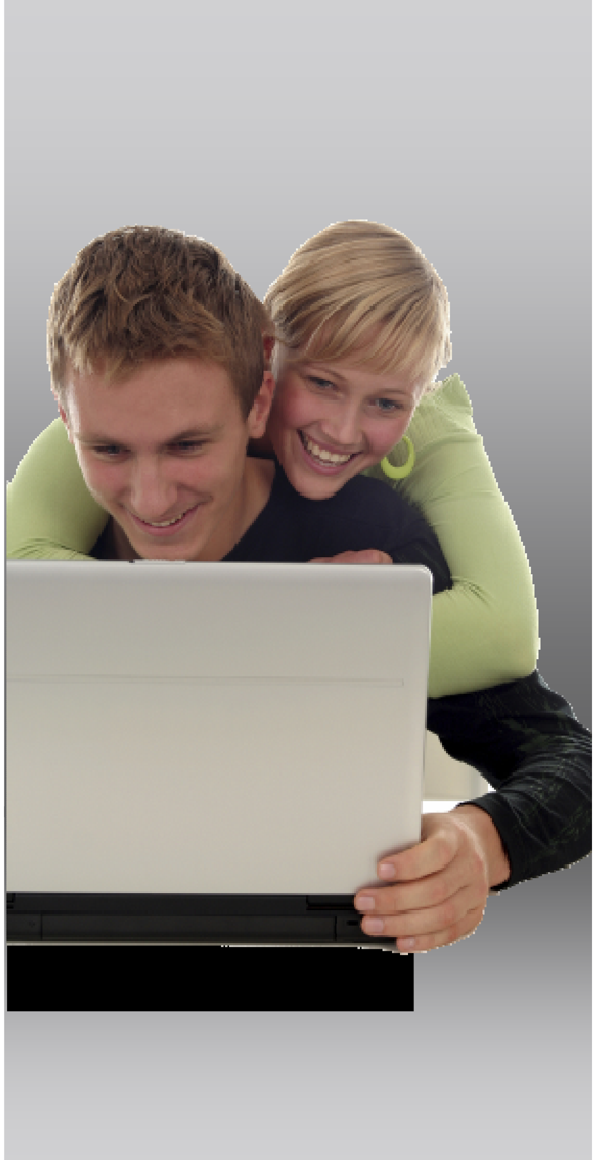
Microwave

- Point to multipoint microwave radio links
- On demand bandwidth allocation for Node-B's
- Nodal concept simplifies the end to end provisioning
- Geography based limitations (Line of sight)
- Spectrum / license availability
- Requires contract renegotiations / new permits in buildings
- Cheap until 16 E1 then cost goes up significantly



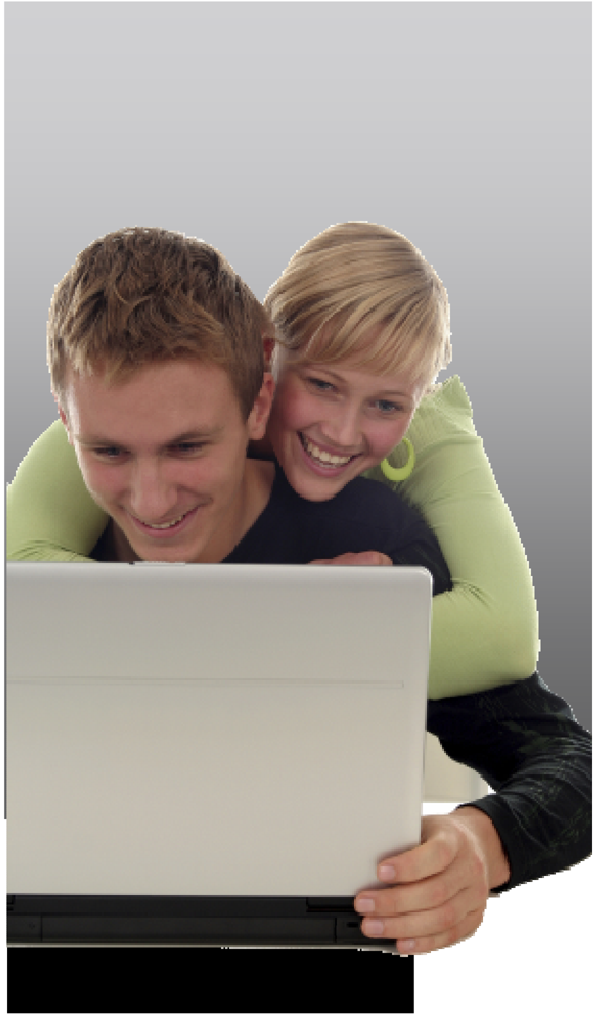
Ethernet Enabled NodeB

- Makes data offloading easier
- For voice traffic, NodeB must originate PWE
- In most cases, basic ethernet connectivity – not sufficient for end-to-end reliable transport
- Not necessarily standards based
- RAN vendors have no MPLS legacy
- Provisioning / troubleshooting MPLS advanced features on NodeB is a challenge
- Subject to inherent security risks of IP / MPLS



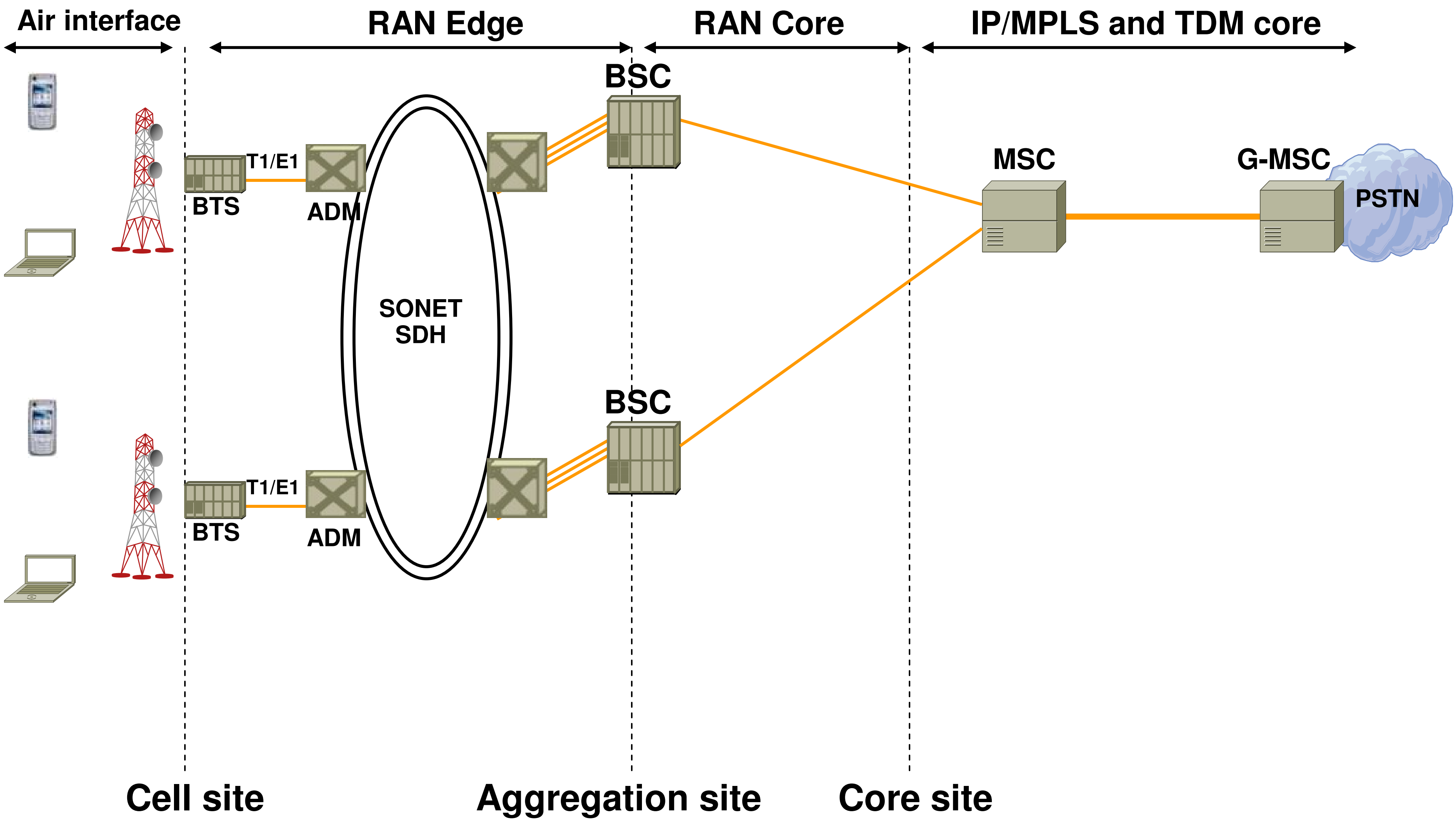
IP/MPLS Based Transport

- High capacity packet network
- Access Agnostic
- Unified transport
- Widely deployed
- Ethernet to cell site results in even more cost savings
- Operational experience with their existing IP/MPLS core
- Proven QoS, high availability and security
- Clock synchronization over packet network is relatively new

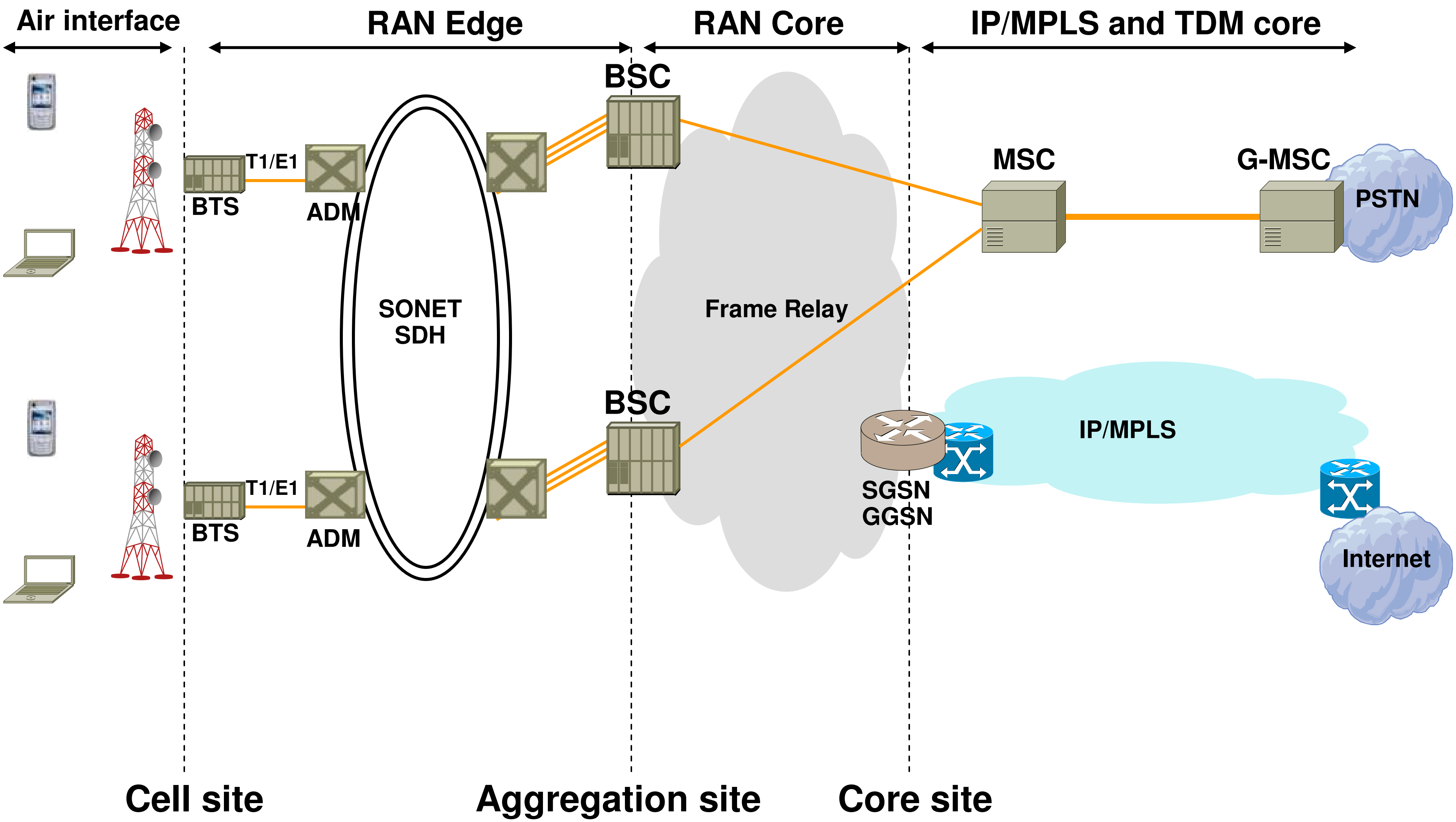


RAN Architecture Evolution

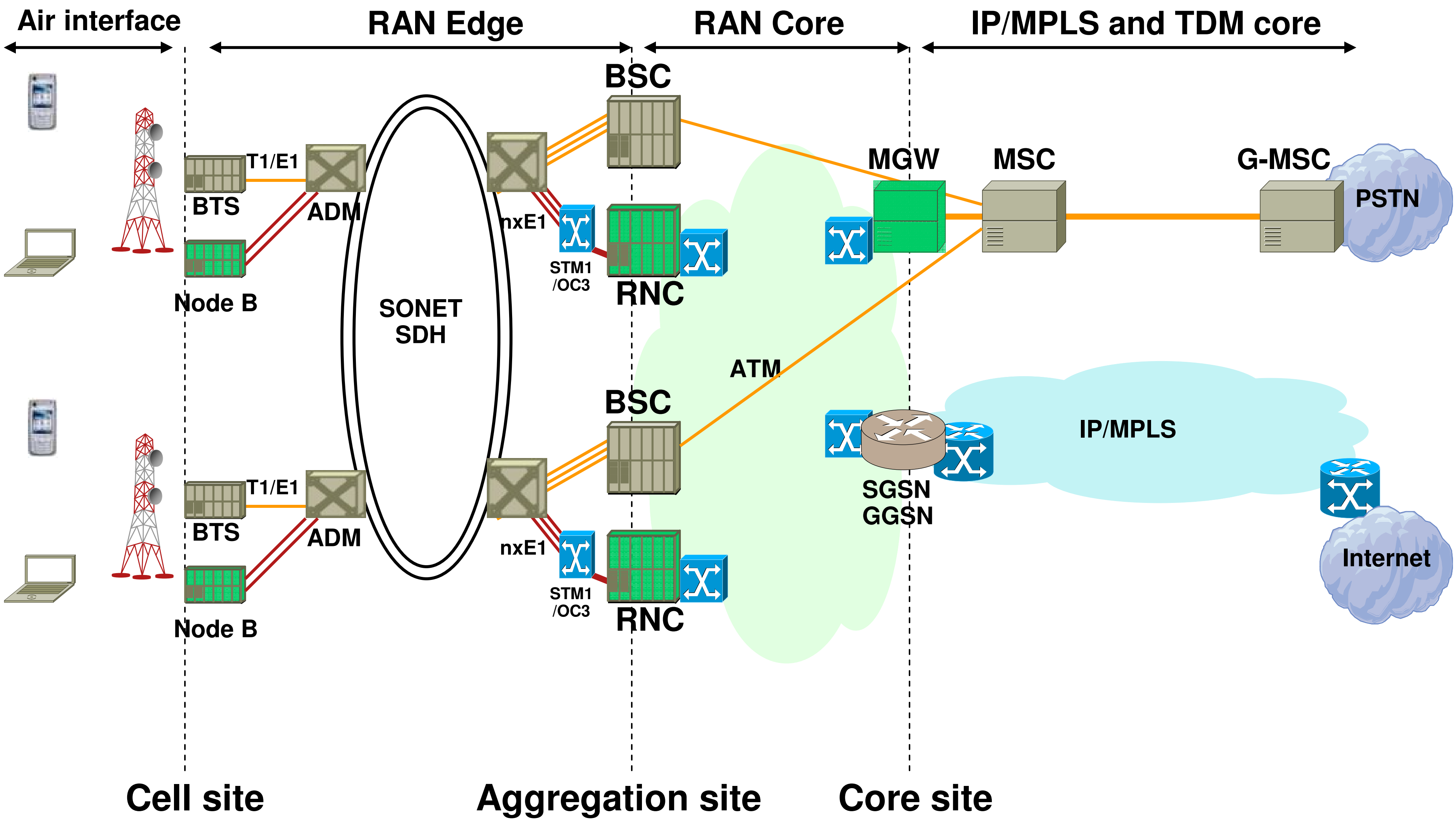
RAN Architecture with 2G TDM Voice



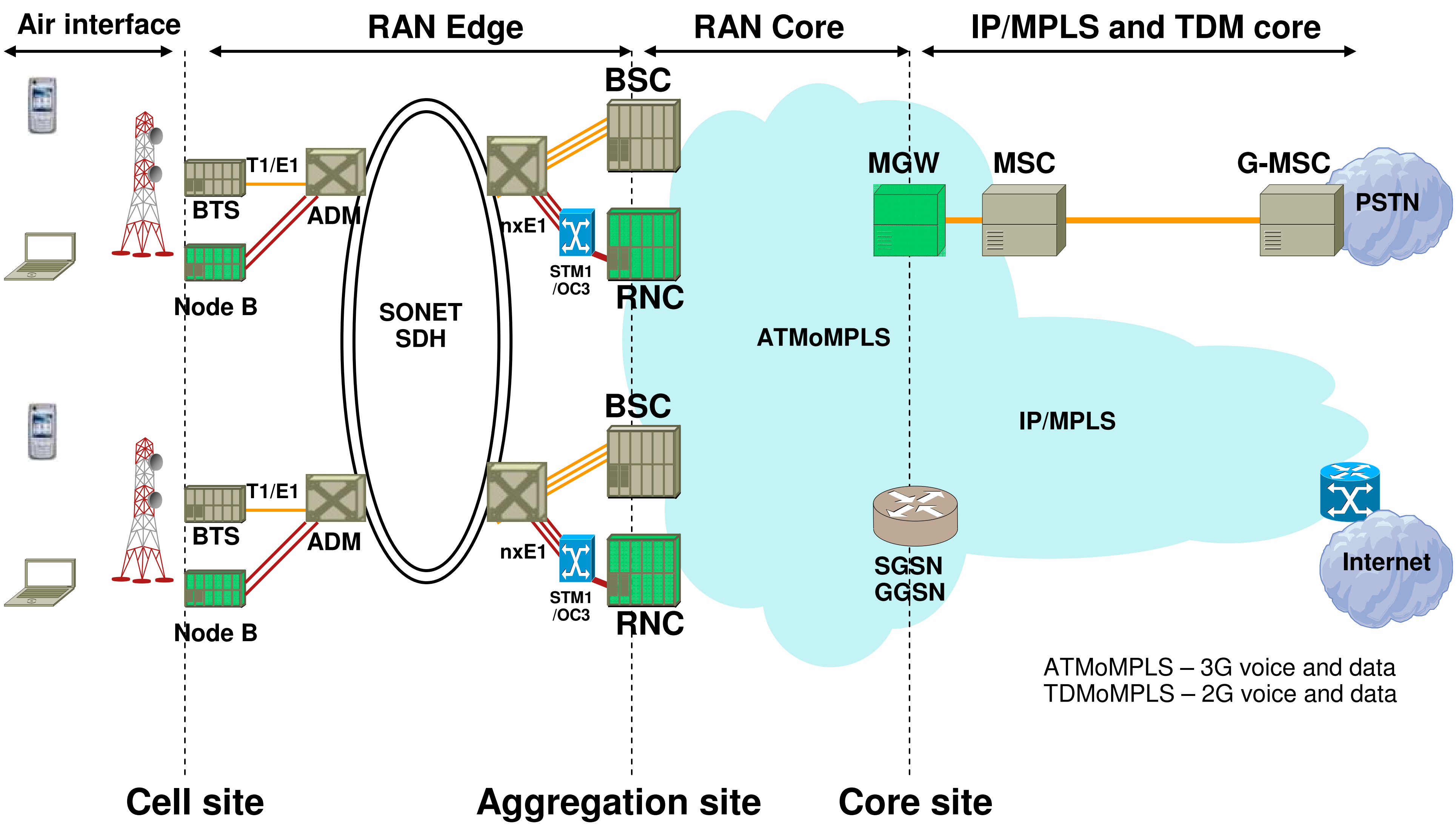
2.5G Adds GPRS Data



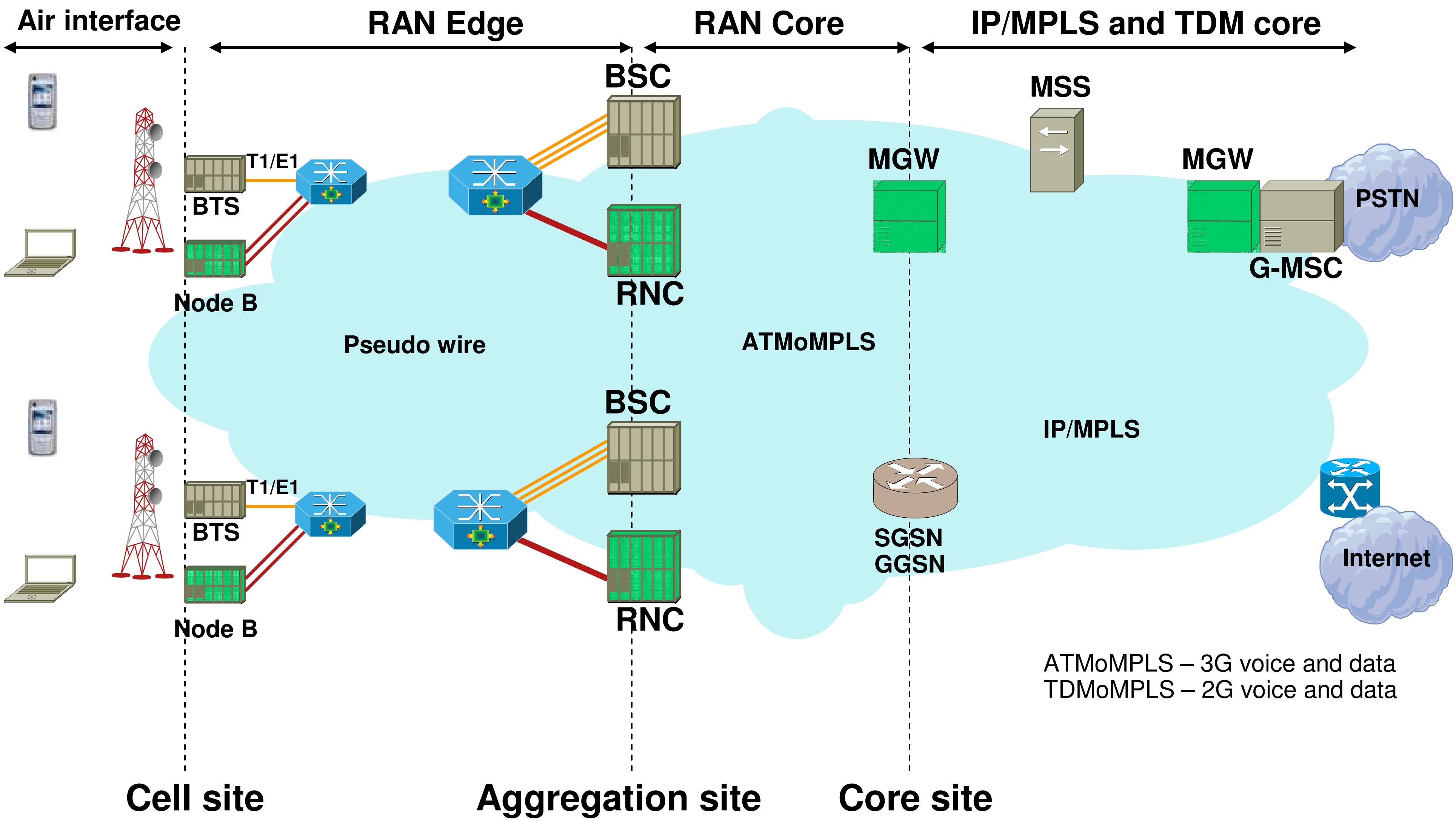
UMTS Adds ATM RAN



ATM Pseudowires in RAN Core

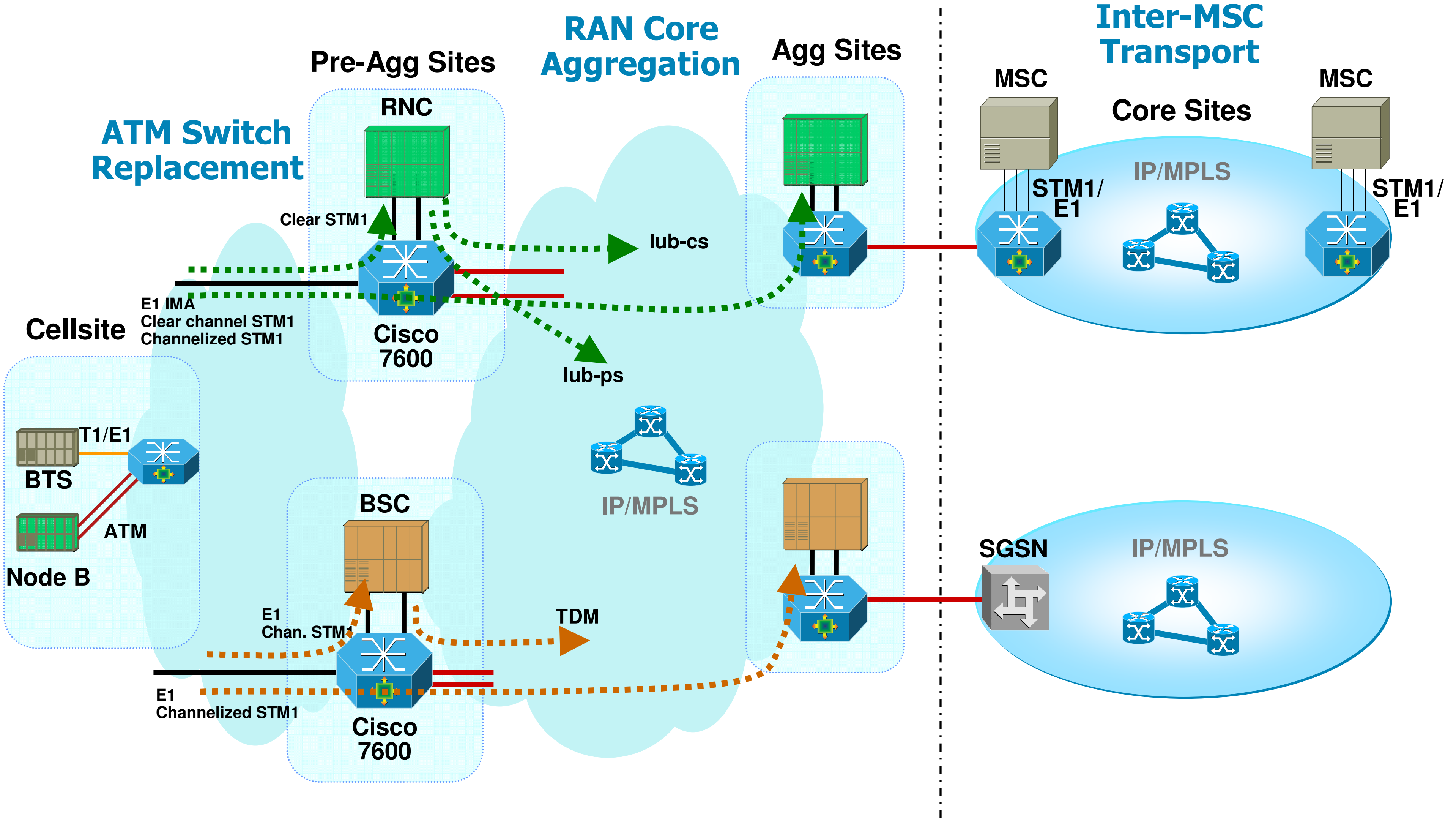


Converged IP Backbone



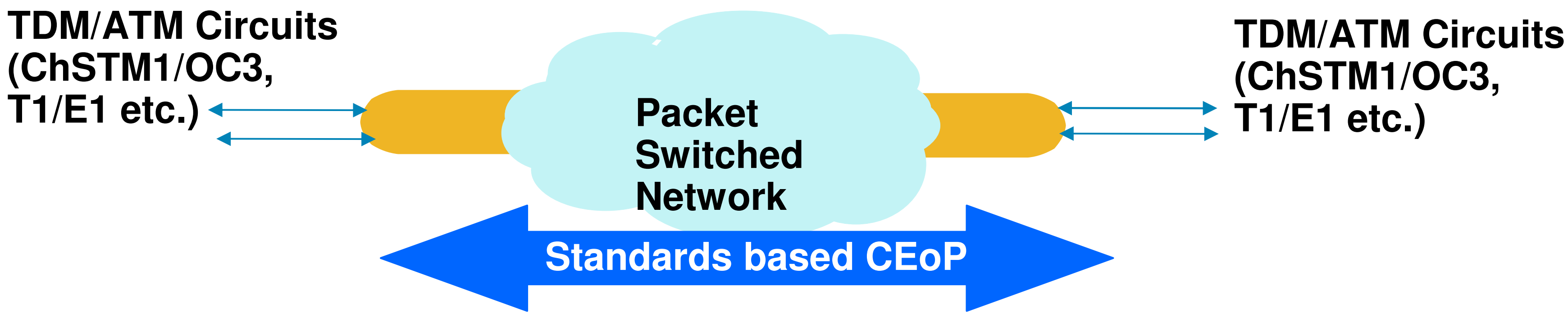
ATMoMPLS – 3G voice and data
TDMoMPLS – 2G voice and data

Deployment Scenarios



Packet Based RAN Concepts

Circuit Emulation Over Packet (CEoP)

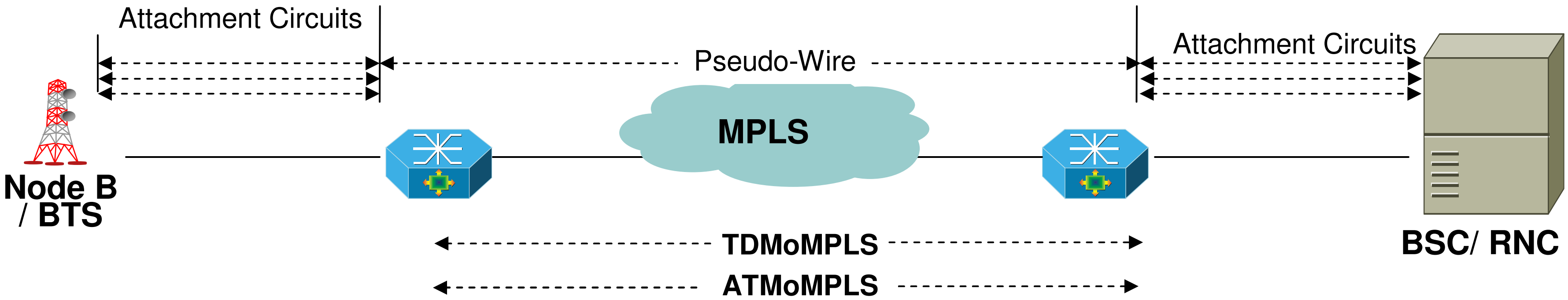


- Circuit Emulation = imitation of a physical communication link
- CEoP imitates a physical communication link across Packet network
- Allows the transport of any type of communication over Packet
- Ideal for TDM or Leased Line replacement and legacy network consolidation

Pseudowire Types Used in RAN Transport

- ATM pseudowire
  - Used for 3G only
  - Inefficient for a single cell but only sends traffic when required
  - Use of cell packing can reduce overhead with minimal impact on latency
- TDM pseudowire
  - Used for 2G; can be used for 3G
  - Just as a real TDM circuit, bandwidth is wasted when the circuit is not being fully utilized.
- For 3G networks an ATM pseudowire offers an advantage over a TDM pseudowire

Pseudowire Basics



- Pseudowire (PW): A mechanism that carries the essential elements of an emulated service from one Device to one or more other Devices over a Packet Switched Network (PSN).
- Within the context of PWE3, this uses IP or MPLS network as the mechanism for packet forwarding.
- Having a common PW layer provides the simplification of deployment, management and provisioning.
- Industry has GOOD experience deploying some of these PW types already, and the concept now can be extended to TDM & ATM for RAN purpose.

TDMoMPLS – either SAToP or CESoPSN
SAToP : Structured Agnostic TDM over Packet : draft-ietf-pwe3-satop-05.txt , RFC-4553
CESoPSN : Circuit Emulation Services over Packet Switched Network : draft-ietf-pwe3-cesopsn-07.txt

SAToP Standards

RFC 4553: Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP)

This specification describes edge-to-edge emulation of the following TDM services described in [G.702]:

- E1 (2048 kbit/s)
- T1 (1544 kbit/s)
- E3 (34368 kbit/s)
- T3 (44736 kbit/s)

The protocol used for emulation of these services does not depend on the method in which attachment circuits are delivered to the PEs.

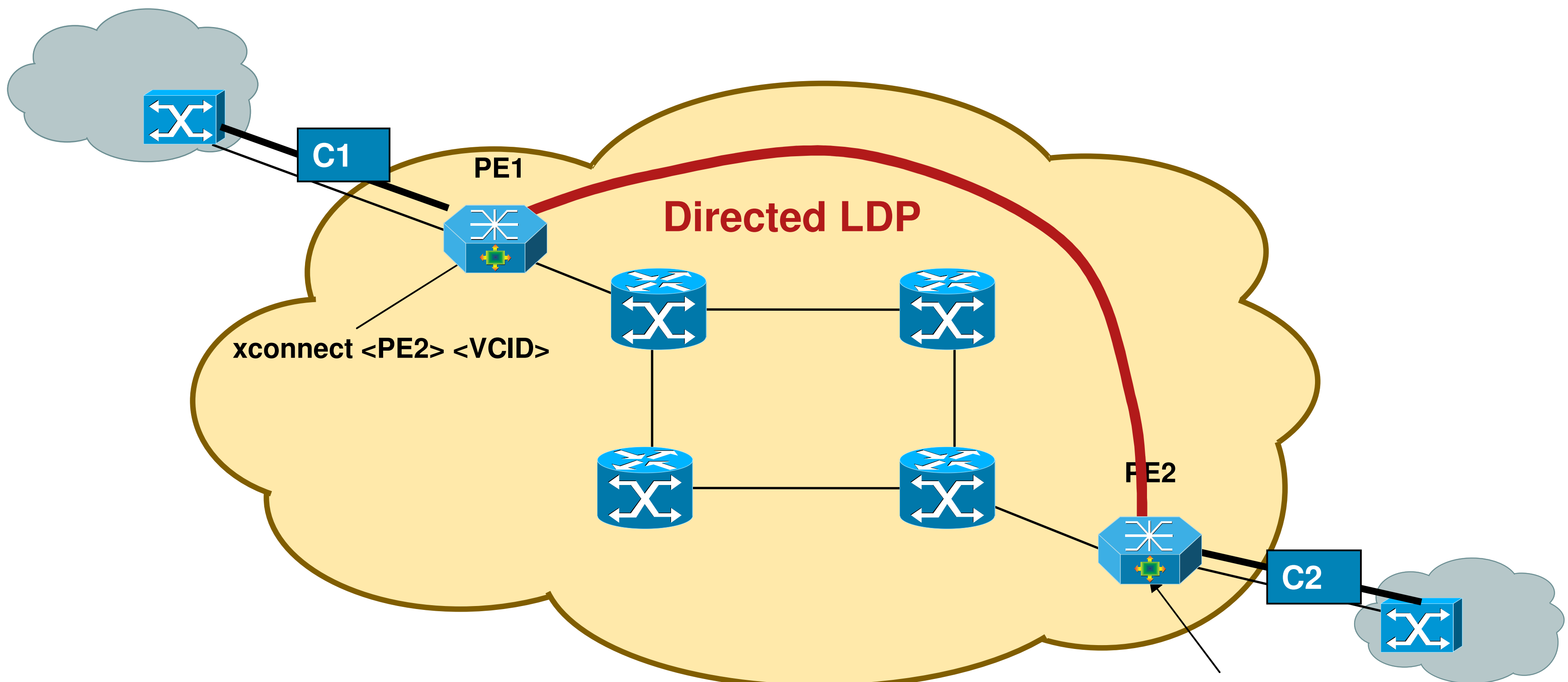
CESoPSN Standard

Structure-aware TDM Circuit Emulation Service over Packet Switched Network (CESoPSN), draft-ietf-pwe3-cesopsn-06.txt

CESoPSN protocol designed to meet the following constrains:

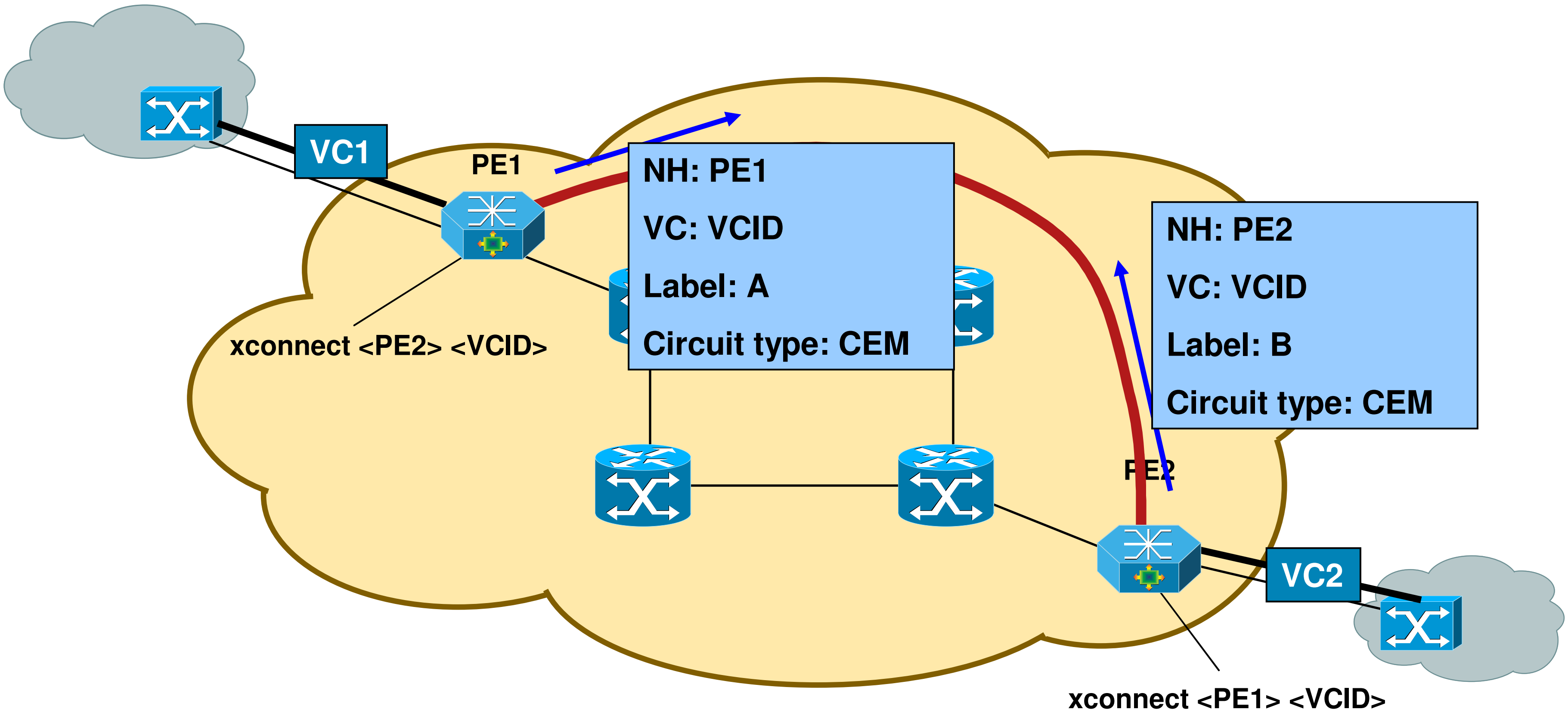
- Fixed amount of TDM data per packet: All the packets belonging to a given CESoPSN PW MUST carry the same amount of TDM data.
- Fixed end-to-end delay: CESoPSN implementations SHOULD provide the same end-to-end delay between a given pair of CEs regardless of the bit-rate of the emulated service.
- Packetization latency range:
  - SHOULD support packetization latencies in the range 1 to 5 milliseconds
  - Configurable packetization latency MUST allow granularity of 125 microseconds
- Common data path for services with and without CE application signaling.

MPLS Core: Pseudo-Wire Signalling



Based on xconnect command, both PE's will create directed LDP session if doesn't exist already

MPLS Core: VC Label Distribution



CEM = SAToP E1, T1, E3, T3,
CESoPSN basic, CESoPSN TDM with CAS

VC Label distributed through directed LDP session

FEC TLV tells the circuit type

LDP: Pseudo-Wire id FEC TLV

VC TLV	C	VC Type	VC info length
Group ID			
VC ID			
Interface Parameter			

VC TLV = 128 or 0x80

VC Type:	0x0011	E1 (SaToP)
	0x0012	T1 (SaToP)
	0x0013	E3 (SaToP)
	0x0014	T3 (SaToP)
	0x0015	CESoPSN basic mode
	0x0017	CESoPSN TDM with CAS

C: 1 control word present

Group ID: If for a group of VC, useful to withdraw many labels at once

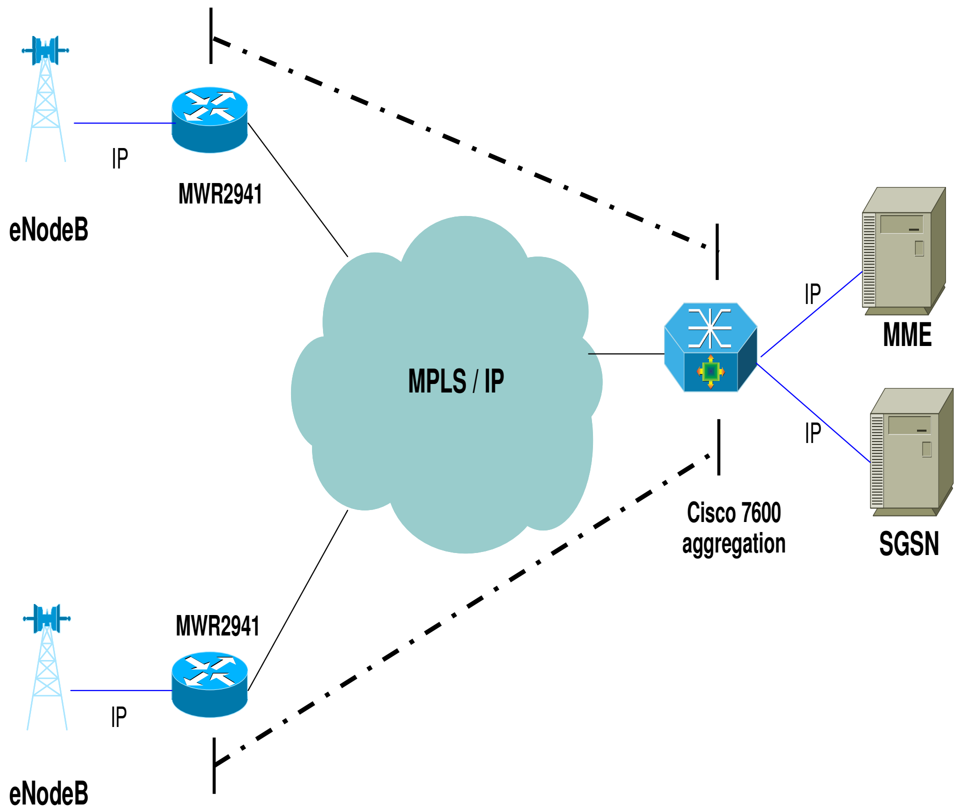
VC ID : ID for the transported L2 vc

Int. Param: classical + IETF-PWE3-TDM-CP-Extension

Native IP Over MPLS

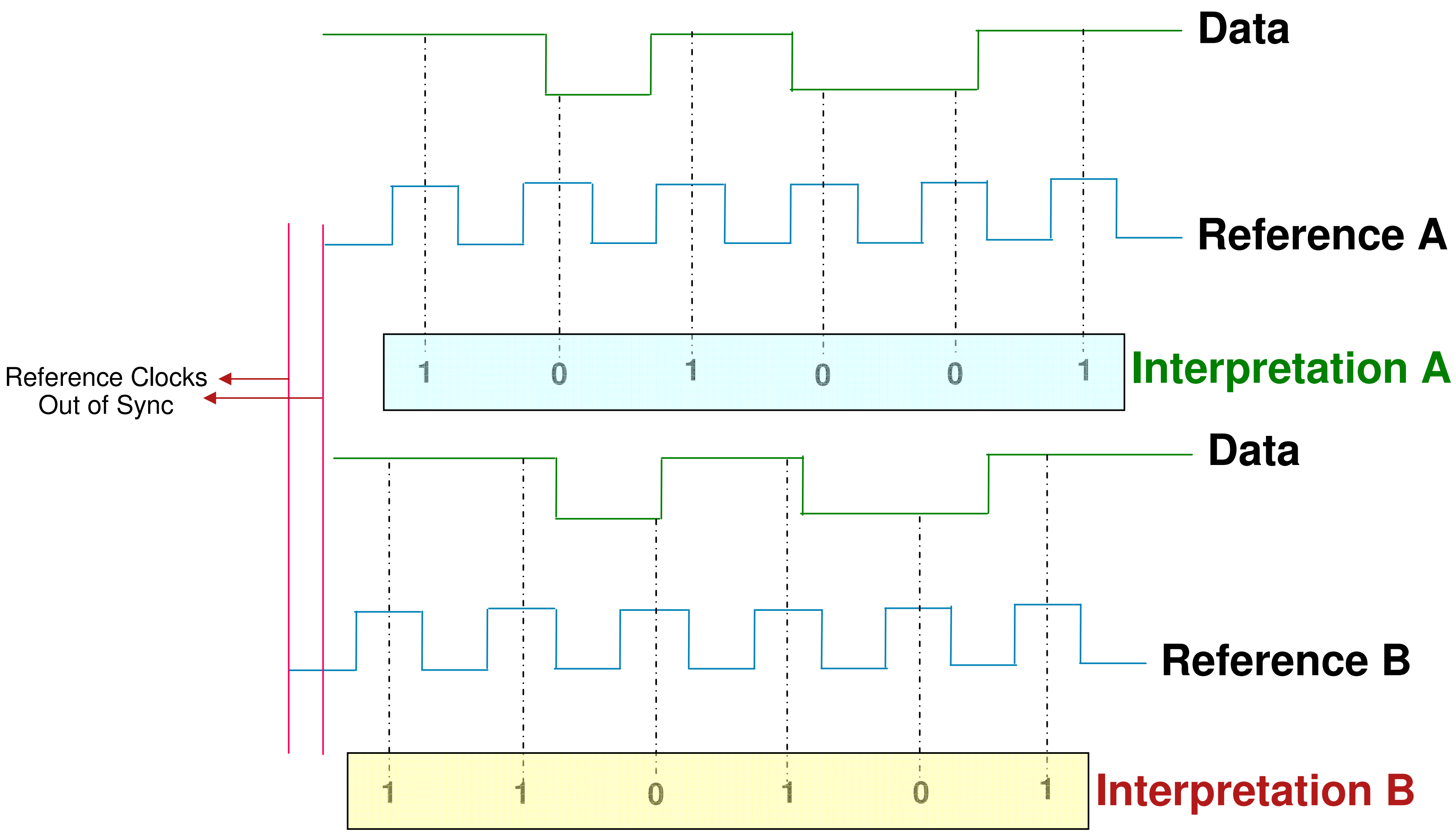
- Pure IP routing from eNode-B to MME/SGSN in the mobile core.
- Utilize MPLS/IP core

  Leased Eth or Own-built
- Efficient to operate, avoids routing in the entire core



IP RAN Clocking

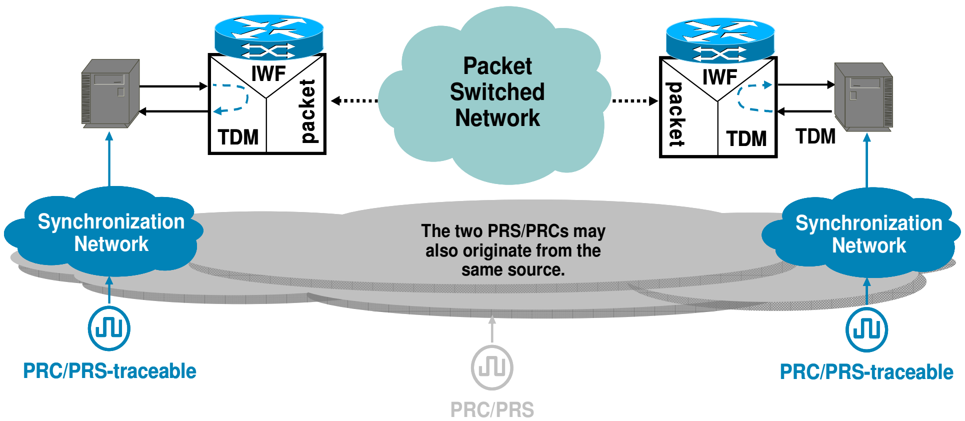
Why Is Clocking Important?



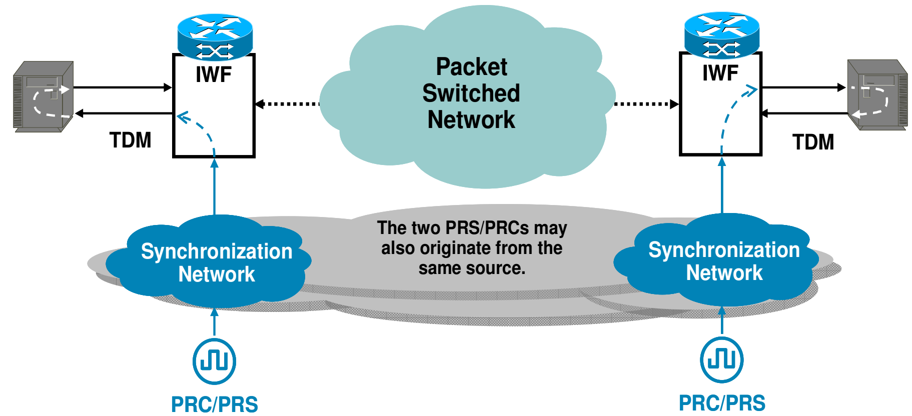
Clock Recovery

- Clock recovery is required for TDM emulation as receiver is supposed to run with same clock as source.
- Three principal methods to recover the TDM service clock:
  - Synchronous – Reference clock at TDM systems or IWF
    - Cell-site and aggregation devices receive clock from external sources e.g. BITS, Sonet/T1, GPS
  - Adaptive methods
    - Clock is derived based on packet arrival rates
  - Differential methods
    - Cell site and Aggregation routers have the same clock source. In addition, the TDM clocks are derived from differential information in RTP header of the packet with respect to the common clock

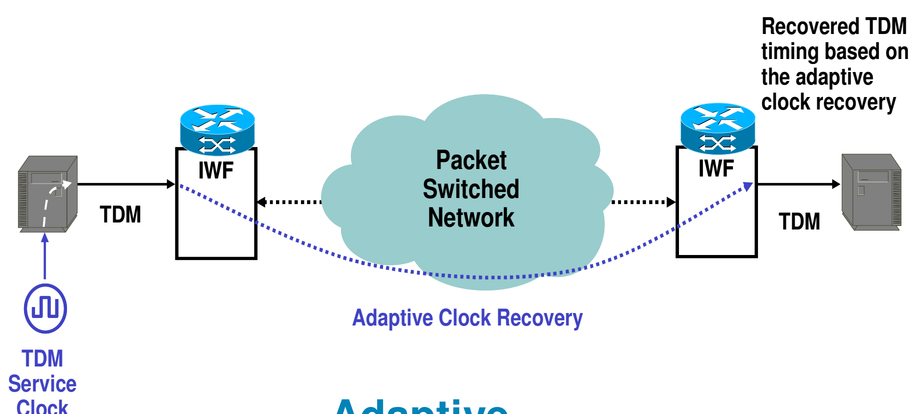
Clock Sync on Packet Network



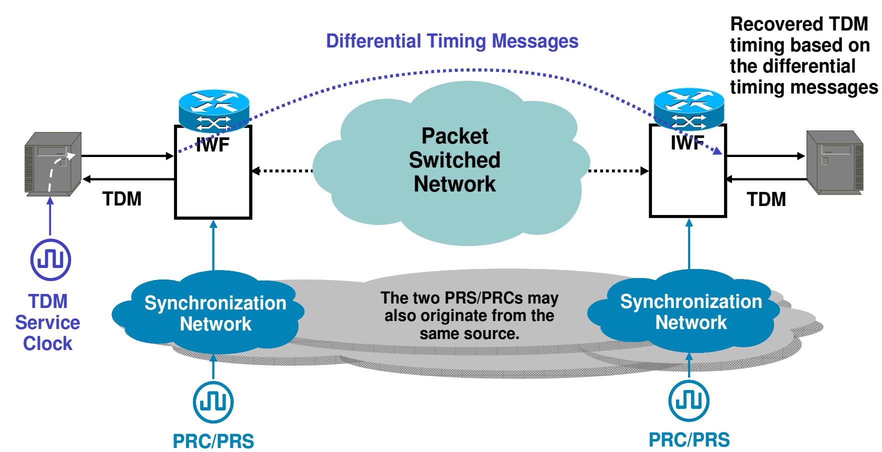
Synchronous, Ref at End Systems



Synchronous, Ref at IWF

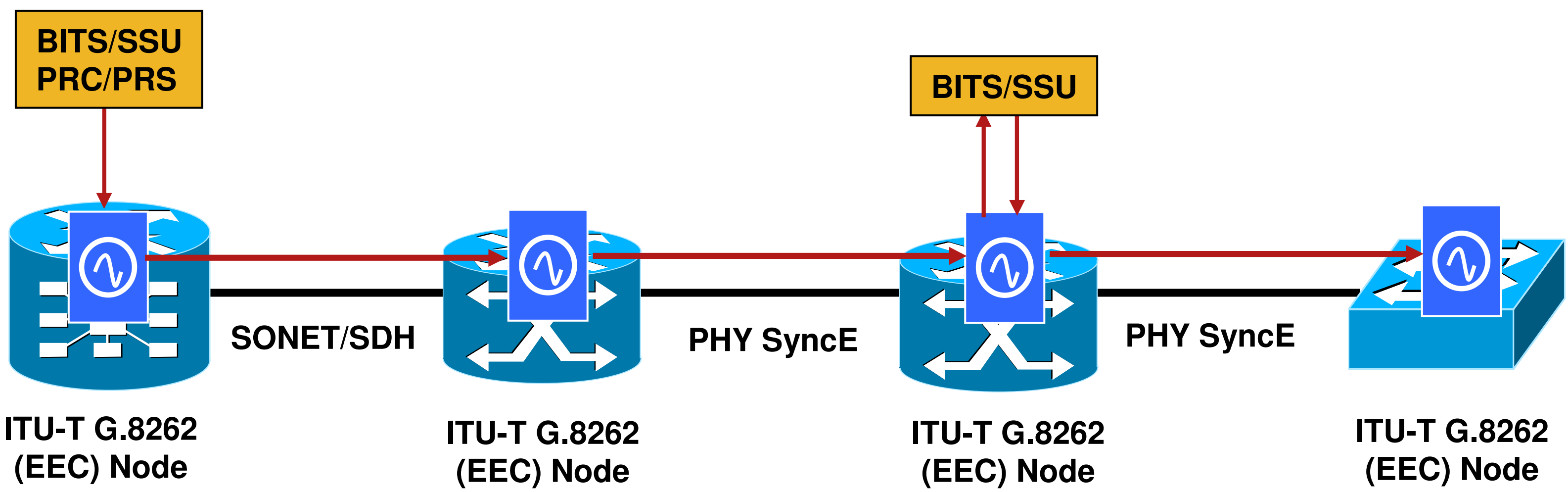


Adaptive



Differential

Synchronous Ethernet (PHY Layer)



- Equivalent to SDH/SONET Synchronization Architecture
  - Enable to maintain ITU-T G.803 synchronization chain (clause 8.2.4)
- As SDH/SONET SyncE is a Physical Layer Synchronization method.
  - G.8261 defines Synchronous Ethernet clock performance limits.
- Extend previous ITU-T (and Telcordia) node clock recommendations
  - G.8262 defines synchronous Ethernet Equipment Clock (EEC)
- Ethernet Slow Protocol to extend the SSM traceability function
  - G.8264 defines ESMC (Ethernet Synchronization Messaging Channel) to support SSM

IEEE 1588-2008 (PTPv2) In A Nutshell

- IEEE Std 1588-2008 is actually a "toolbox".
- The protocol can use various encapsulations, transmission modes, messages, parameters and parameter values…
- Multiple "Clocks" are defined: OC (slave/master), BC, TC P2P, TC E2E, with specific functions and possible implementations.
- IEEE 1588-2008 added the concept of PTP profile.

  Every standard organization can define its own profile(s) using a subset of the IEEE 1588-2008 protocol.

- For telecom operators, saying "IEEE1588 support" is not sufficient information.

  Node characterization, interoperability, performance and metrics…

IP RAN
QoS And Security

Why QoS?

- Latency – time taken for a packet to reach its destination
- Jitter – change in inter-packet latency within a stream over time i.e. variation of latency
- Packet loss – measure of packet loss between a source and destination

- QoS provides:
  - Congestion Avoidance
  - Congestion Management
- Prioritize critical traffic over best-effort
  - Signaling and Clocking <-> Voice <-> Real-time <-> Data

Factors Affecting End-to-End Latency

- Packetization delay – segment, sample, process data and convert to packets
- Serialization delay – time taken to place bits of the packet on to the physical media
- Processing delay – time taken to accept packet, place it on the input queue, decide output interface, place it in the output queue
- Propagation delay – time taken to transmit the bits across the physical media
- Queuing delay – how long the packet stays in the output queue before being sent out

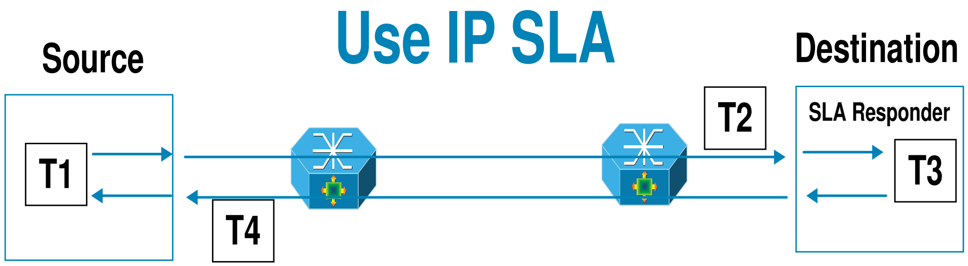
Fixed Delays (Packetization, Serialization, Processing delay)

Variable Delays (Propagation, Queuing delay)

QoS addresses Queuing delay
TE addresses propagation delay

Proactive Approach – Measure Performance

- Run IP SLA between the cell-site and Aggregation routers
- Collect Latency, Jitter and Packet Loss



- Source and Destination synced using NTP
- T1 = origination timestamp
- T2 = Arrival at destination timestamp
- T3 = Departure (from destination) timestamp
- P = (T3 – T2), processing delay at destination
- T4 = Arrival at source timestamp
- RTT = (T4 – T1 – P), round trip time

Security

- Service Provider Best practices for box-level security:
  - Lock-down VTYs, telnet
  - Disable unused services
  - Multiple bad password attempts
- Protection from cell-site router hijack
  - ACLs on aggregation router
  - Control Plane Policing on aggregation router
- Eavesdropping
  - 3GPP has recommended using IPSEC security for signaling

Design for IP RAN

Packet RAN Scenario

Cell-site router

Short-haul	Backhaul
Node-B connected via T1/IMA	ATM Psuedowires for voice and data VCs (Eth)
	ATM Psuedowire for data VCs (Eth) Voice VCs on IMA (T1)
Node-B connected via Eth	Routed (Eth or MLPPP on T1)
BTS connected via T1	TDM Psuedowires for voice and data VCs (Eth)
	TDM cross-connect (T1)
	RAN Optimization (T1)

Overall Design Procedure

- Calculate bandwidth requirements for the cell-site and aggregation location
- Choose the right “packet based RAN option / design”
- MPLS Core – Leased or Built, customer dependant
- Choose appropriate redundancy and connectivity between:
  - Cell-site router and Node-B / BTS
  - Aggregation router and RNC / BSC
- Routing protocol between aggregation and cell-site routers
- Ensure clocking / clock recovery at every node
- Ensure resiliency for every failure type – link and node
- Apply QoS and Security

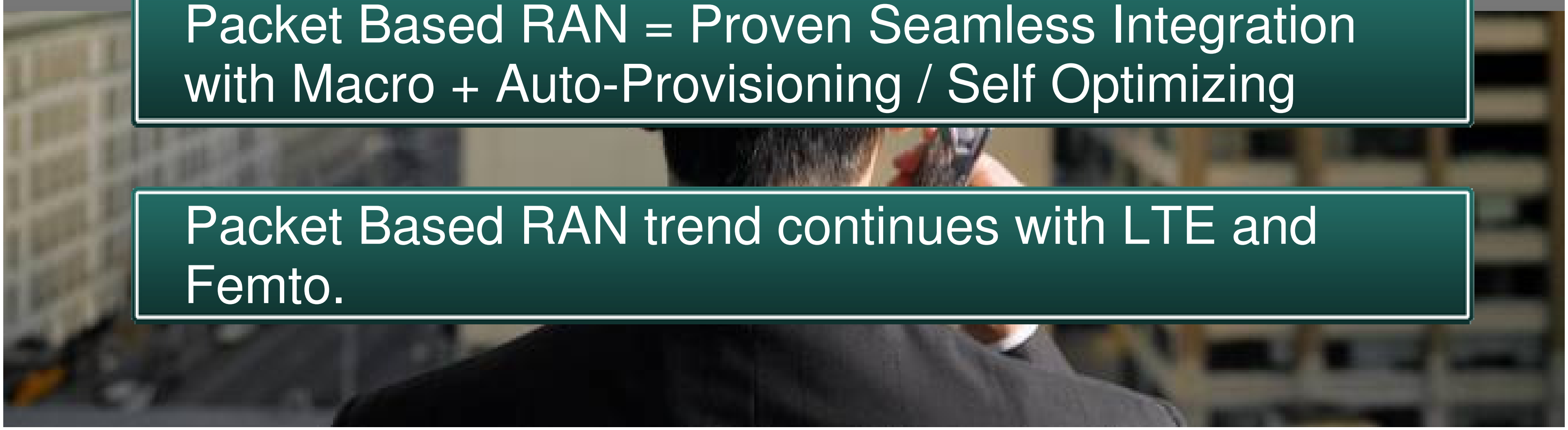
Summary

Operators looking for cost-effective and scalable next-gen RAN solution.

IP/MPLS based RAN provides a converged solution for the operator's 2G, 3G and 4G networks.

Packet Based RAN = Proven Seamless Integration with Macro + Auto-Provisioning / Self Optimizing

Packet Based RAN trend continues with LTE and Femto.



Q and A