Synchronization Requirements in Cellular Networks over Ethernet

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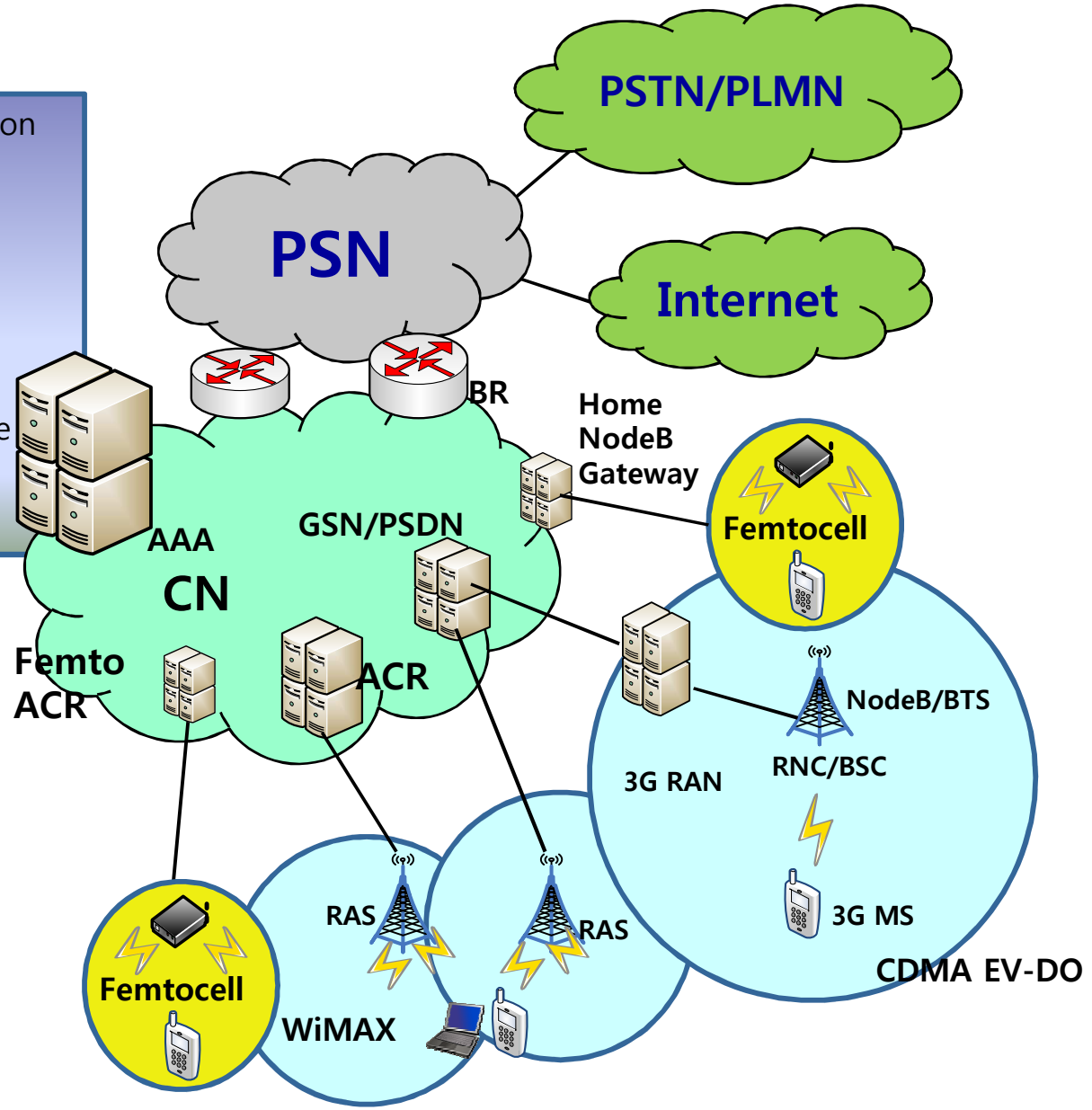
Mobile Cellular Network: WiMAX/EV-DO

AAA Authentication, Authorization and Accounting
ACR Access Control Router
AR Access Router
BR Broader Router
GSN GPRS Support Node
HA Home Agent
IMS IP Multimedia Sub-system
PSDN Packet Data Serving Node
RAS Radio Access Station



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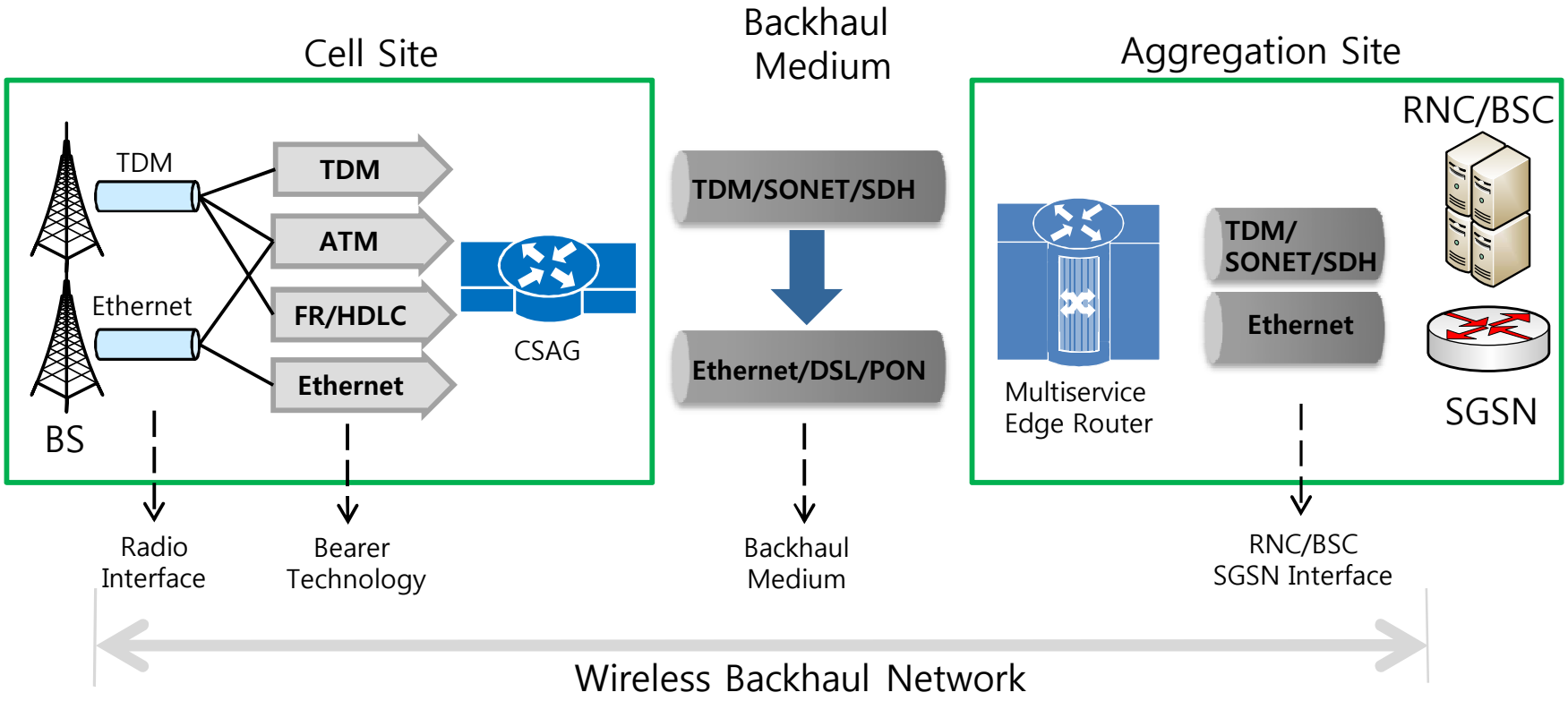
Wireless backhaul

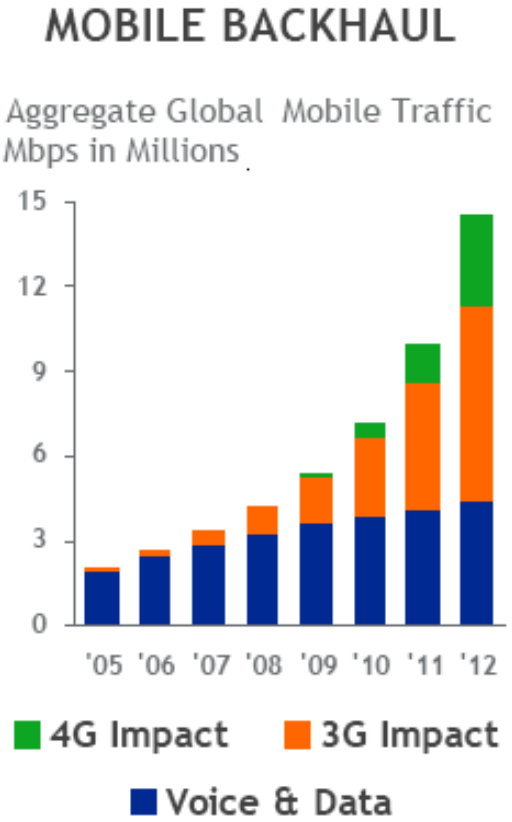
- Wireless backhaul network connects wireless base stations to the corresponding BSC
- It delivers the expected bandwidth requirements of new technologies such as WiMAX, 3G, and 4G.
- PSN and TDM can be used for wireless backhaul network



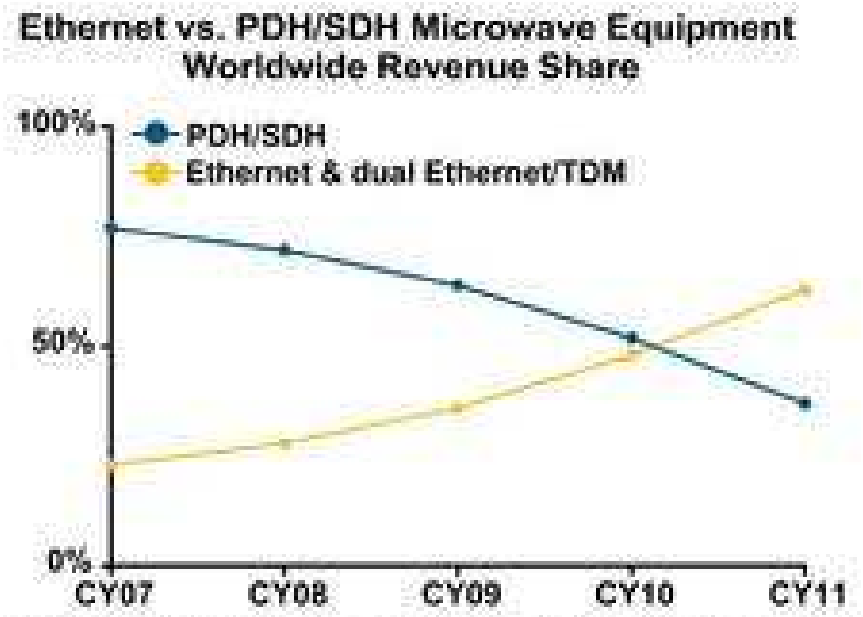
BSC: Base Station Controller
PSN: Packet Switched Network

Backhaul Market Growth

- 3G and 4G is driving 25-40% a year growth in mobile backhaul traffic
- The Carrier Ethernet markets are expected to increase 76% by 2011
- Data oriented mobile traffic is increasing
- Legacy TDM-based system is being replaced packet-based Ethernet solutions (More bandwidth per connection)



Source : Nortel ,June 11 2008



Source: Infonetics Research, Microwave Equipment Market Outlook March 2009

Carrier Class Ethernet Backhaul

- PSN(ETH, IP/MPLS) has been replacing TDM networks (SDH/PDH)
  - Cheaper CAPEX and OPEX
  - High Utilization

- However, it needs guaranteed
  - Network Resilience
  - Fault/Performance monitoring via OAM
  - QoS, Delay, Jitter
  - Timing/Synchronization transport

- Ethernet should support the aforementioned functions and meet time/sync requirements!!

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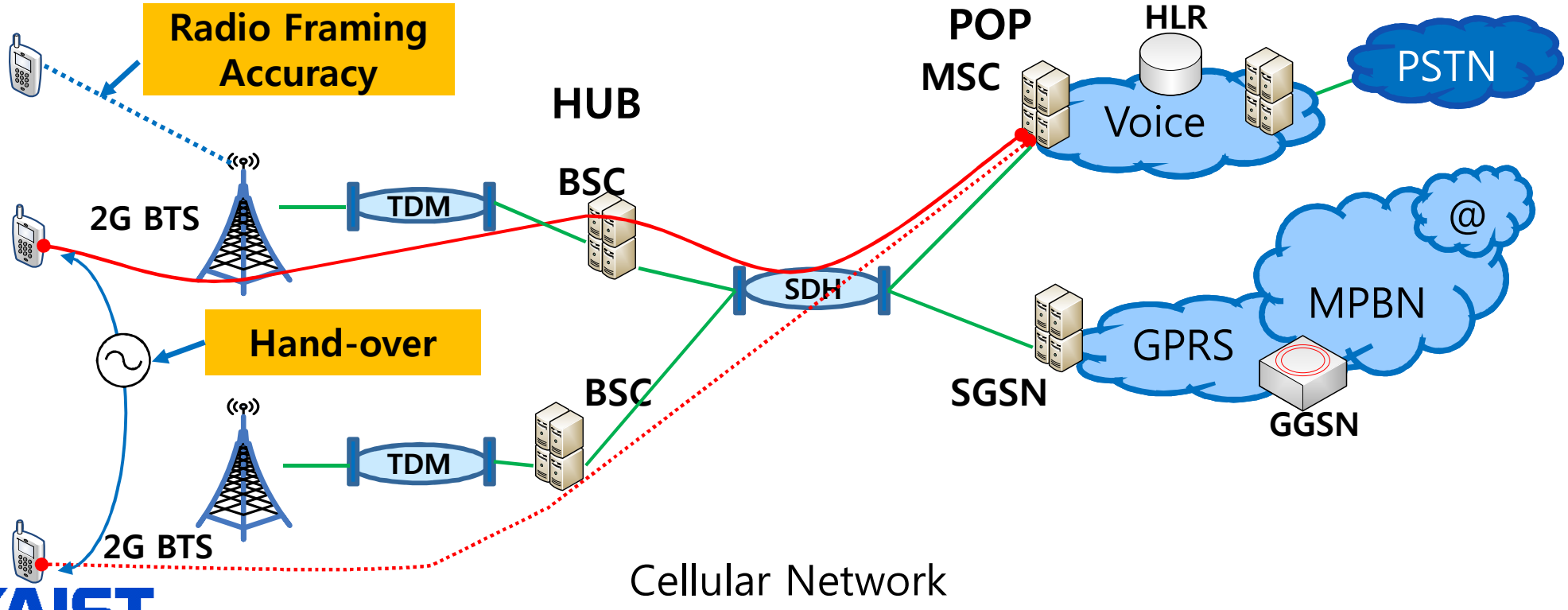
Synchronization in Backhaul

- Why Synchronization?
  - BTS/NodeB are synchronized to BSC, RNC, MSC, and MGW for end-to-end sync
  - For Radio Framing Accuracy and Hand-over, 0.05ppm sync at BTS/NodeB is needed
  - Significant to interference control on cell boundaries



Cellular Network

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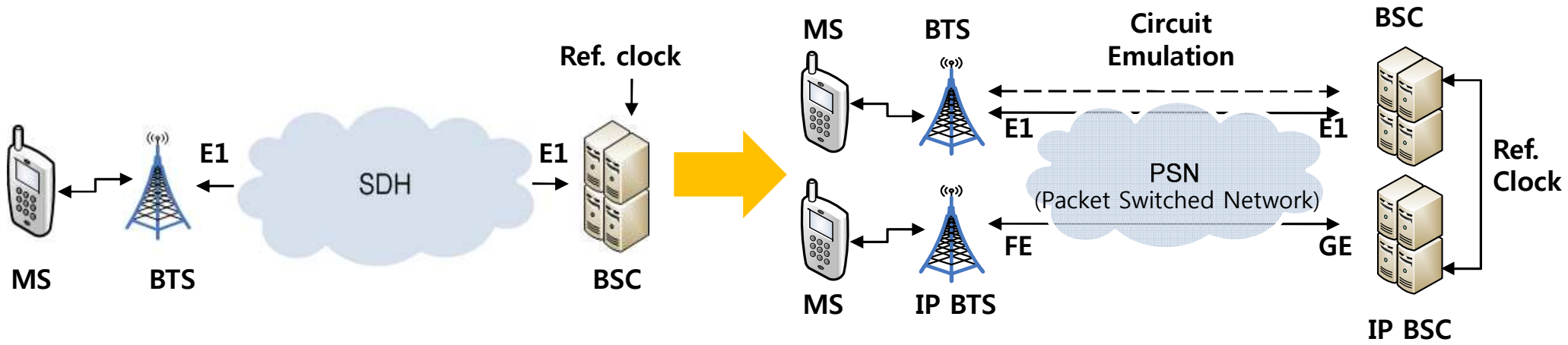
Requirements of backhaul synchronization - Synchronization in 2G/GSM

- Sync requirement in legacy 2G/GSM
  - SDH freq. sync: ±50ppm
  - BTS freq. sync: ±0.05ppm
  - Ref. clock is distributed via SDH/PDH

- Sync requirement in future 2G/GSM
  - PSN freq. sync: Not strict
  - BTS freq. sync: ±0.05ppm
  - Ref. clock is distributed via PSN
    - IEEE 1588 is being used.

Source: A. Zhou, X. Duan, "Requirements and viewpoints for backhaul synchronization," IETF TICTOC WG, Mar, 2008



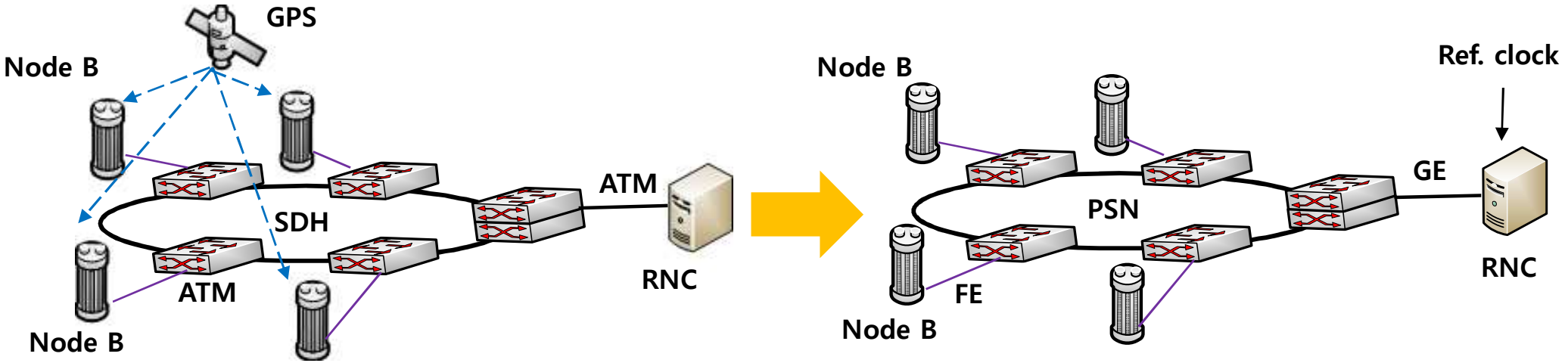
Legacy 2G/GSM Networks

2G/GSM Networks

Requirements of backhaul synchronization - Synchronization in 3G/TD-CDMA

- Sync requirement in legacy 3G/TD-CDMA
  - SDH freq. sync: ±50ppm
  - BTS freq. and phase sync: ±0.05ppm and ±3μs
  - Ref. clock is distributed via SDH/PDH for transport network.
  - BTSs are synced via GPS.

- Sync requirement in future 3G/TD-CDMA
  - BTS freq. and phase sync: ±0.05ppm and ±3us
    - IEEE 1588 is being used for frequency and phase sync.



Legacy 3G/TD-CDMA Networks

3G/TD-CDMA Networks

Next major market opportunities - Sync requirements of Femtocell and WiMAX

- Femtocell
  - The small cell deployed indoors, which communicates with cellular network over a broadband connection.
- Synchronization of Femtocell
  - Related handover and interference.
  - Time sync accuracy (Timing difference bet. Macro BS and the Femto BS)
    - 0.2 μs (The distance bet. Femto BSs = 30m)
- WiMAX
  - Freq. and phase accuracy by WiMAX Forum: 2ppm, 1μs (for TDD)
  - IEEE 1588 over IP/Ethernet backhaul
    - Low-cost-standalone solution
    - Provides sub microsecond accuracy
    - IEEE 1588 to WiMAX/Femtocell is under study at IEEE 802.16m.

Source: WiMAX Forum Tech. WG,"WiMAX Forum Mobile System Profile Specification: Release 1.5 Common Part," rev. 0.2.1, Feb 2009.

Source: Guang Han, et al., "Time synchronization for Femtocells," IEEE 802.16m, Oct2008

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Summary of synchronization requirements

- Two mobile wireless network sync schemes
  - FDD radio-based mobile wireless sync
    - WCDMA FDD in GSM and FDD LTE
    - Freq. accuracy: 0.05ppm
  - TDD radio-based mobile wireless sync
    - It requires freq. accuracy, phase alignment, and time alignment.
    - CDMA, cdma2000, Mobile WiMAX 802.16e, TDD LTE
    - Freq. accuracy: 0.05ppm
    - Inter-BTS time alignment: 2.5μs to 10μs

<Summary of synchronization Requirements>

	GSM/WCDMA/ CDMA2000	TD-CDMA	WiMAX	Femtocell
Freq. accuracy	0.05 ppm	0.05 ppm	2 ppm	
Timing accuracy		3μs	1μs (for TDD)	0.2μs

Source: Patrick Diamond, "Packet Synchronization in Cellular Backhaul Networks," Semtech White Paper Oct. 2008)
Source: S.-P. Yeh, et al, "WiMAX Femtocells: A Perspective on Network Architecture, Capacity, and Coverage," IEEE Comm. Mag., Vol. 46, Issue 10, Oct. 2008
Source: V. Chandrasekhar, et al., "Femtocell Networks: A Survey," IEEE Comm. Mag., Vol. 46, Issue 9, SEP. 2008

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Supports of 1588 & 802.1AS

- Using IEEE 1588 for WiMAX may be adequate.
  - However, it is not suitable to support legacy 2G/3G, and 4G.
  - IEEE 1588 or 802.1AS should support sync requirements for legacy systems and new systems.
  - More accurate timestamp function is needed!!
  - Options
    - Use of very accurate clock
    - Timestamp in physical Layer

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Architectural consideration of timestamp for 802.3

Eg. 802.3ba model

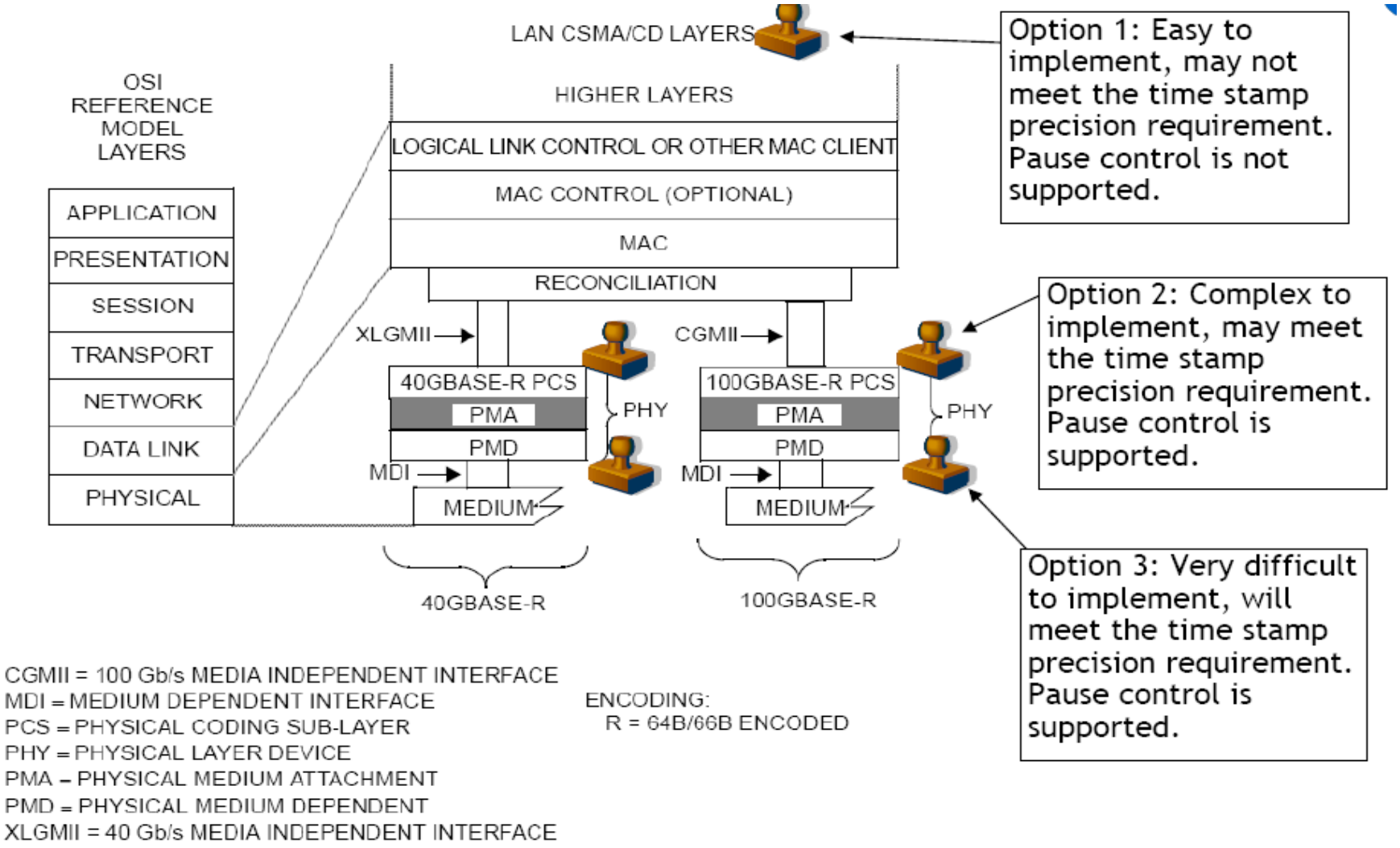

Figure 153–1—40GBASE-R and 100GBASE-R PMA relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model and IEEE 802.3 CSMA/CD LAN model

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Conclusions

- Time synchronization in fast growing mobile backhaul market
  - Time sync application in the backhaul market is anticipated to be even larger than AV applications in the near future.
- IEEE 1588 and IEEE 802.1AS will be the major solutions.
  - Multi-hop Precision Time Protocol will be used.
  - PTP messages will be transported over wired/wireless multi-hops.
- Current timestamp at MAC or client layer may not be qualified for ppb level synchronization accuracy requirements.
- IEEE 802.3 needs to provide more accurate timestamp information.
  - IEEE 802.3 may require a timestamp function in the PCS, PMA, or PMD sublayer.

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