Broad Market Potential for Time Synchronization

IEEE 802.3 TSSG Plenary, July. 2009

Chankyun Lee[1], J. Kevin Rhee[1], Kyusang Lee[2],
Seung-Hwan Kim[3], and Seungwoo Lee[3]

[1] KAIST, [2] ACTUS Networks, and [3] ETRI, S. Korea

KAIST ACTUS ACTUS NETWORKS,INC. ETRI

Introduction

- Packet network penetration in the market
  - Low cost, scalability, network reliability, and easy OAM
  - Major Applications
    - Mobile Backhaul and Carrier Ethernet
    - Audio/Video
    - Wireless Networks and PON
    - Military/Manufacturing Industry
    - Power Industry
    - Printing Industry
    - Etc
- Broad market potential for time synchronization
  - Synchronous Ethernet: clock frequency synchronization
  - Precision time packet synchronization: frequency and phase/limited accuracy

Timestamp requirements in systems

- Wireless Networks and PON (Passive Optical Network)
- Circuit Emulation Services
  - SDH/PDH interworking in Packet Network.
- Contents Synchronization
  - Caption synchronization
  - Video encoding/decoding
- Monitoring & Measurement
  - QoS guarantee

Synchronization requirements

Application	Time/Phase Synchronization Requirement
Mobile Backhaul	Depend on the service application
Carrier Ethernet	Accuracy to be determined
Audio	Phase alignment of audio/visual devices within ± 100ns
Network SLA measurement	Time accuracy to be determined
Sensor Networks	Time accuracy to be determined
Power Phase measurement	Time accuracy of < 1*us*
Printing industry	Phase alignment between operations within ± 1*us*

<Synchronization Requirements for some applications>

KAIST

Source: Tim Frost, "The distribution of precise time over packet networks," Symmetricom. ITSF 2008.

Synchronization requirements

Application	Time/Phase Synchronization Requirement
GSM, UMTS-FDD	Fractional frequency accuracy requirement only (50ppb)
UMTS-TDD	Phase alignment between basestations within ± 2.5 *us*
UMTS LTE	Not yet specified. Likely to be around ± 5*us* for MBMS
Mobile WiMAX	Phase alignment between basestations within ± 1*us*, 2 ppm for frequency alignment.
CDMA2000	Time alignment of basestations within ± 10*us*
TD-SCDMA	Phase alignment between basestations within ± 3*us*

<Synchronization Requirements for cellular basestations>

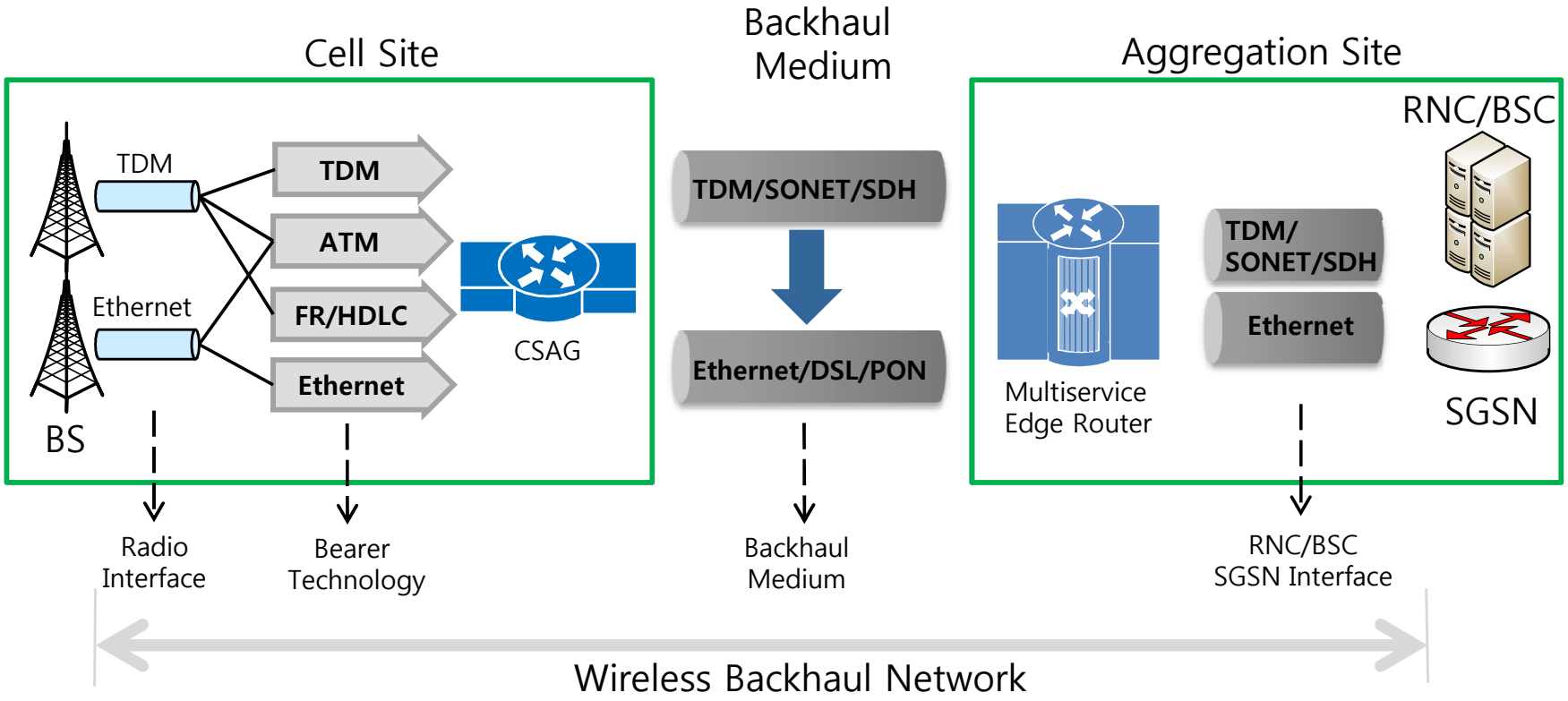
Wireless Backhaul have to guarantee synchronization requirements!

KAIST

Source: Tim Frost, "The distribution of precise time over packet networks," Symmetricom. ITSF 2008.

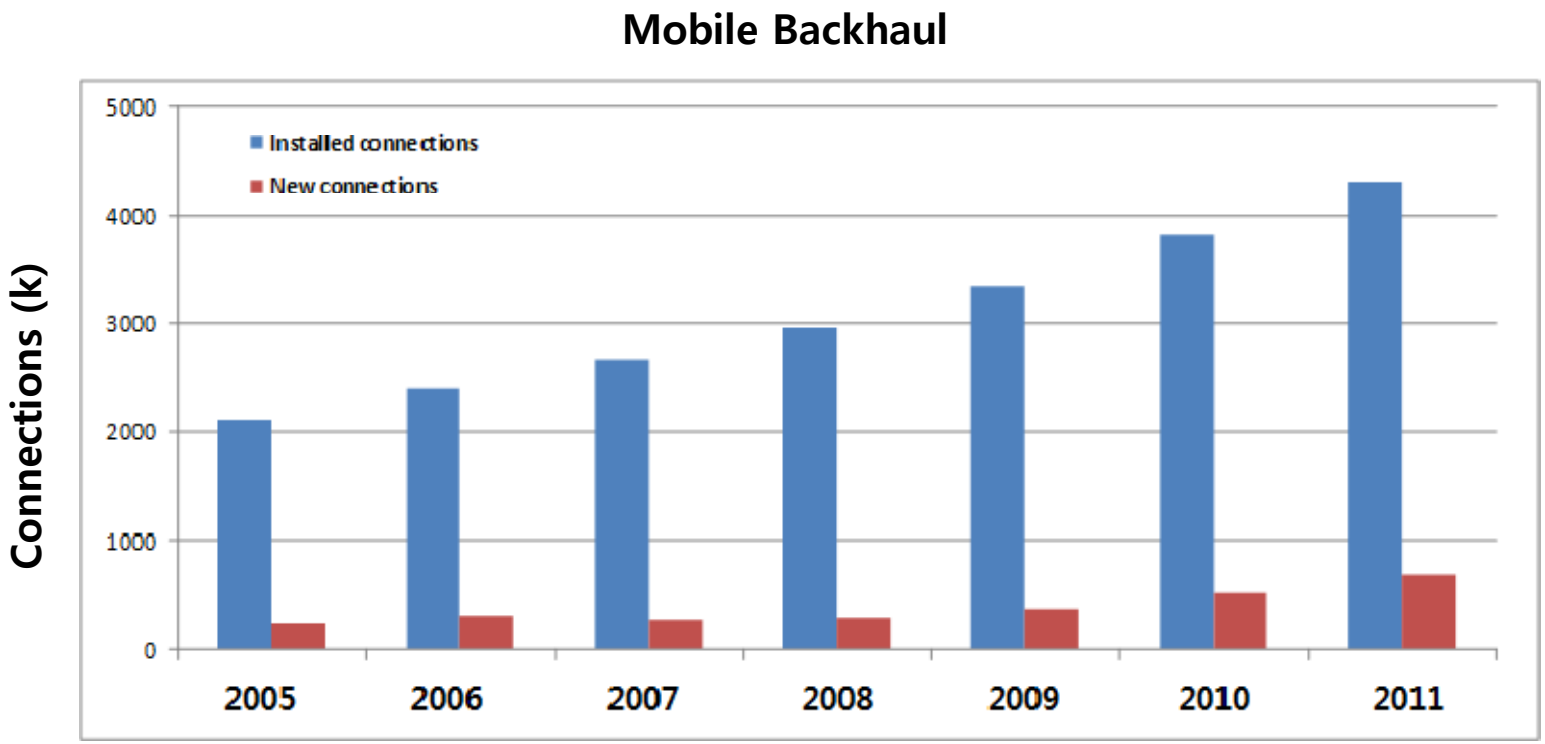
Wireless backhaul

- 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

Mobile backhaul dynamic growth



Source: *Mobile Backhaul Equipment, Installed Base, and Services,* October 2008

- Connections increase more than 10% of last year.
- 3G and 4G is driving 25-40% a year growth in mobile backhaul traffic.
- Data oriented mobile traffic is increasing.

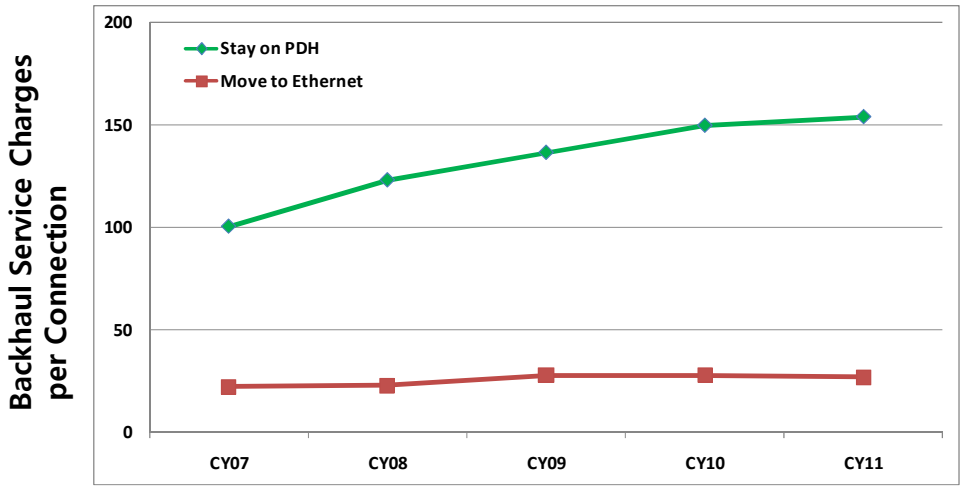
Mobile backhaul opportunity (US)

Metric	2005	2010 Projected	Source
US mobile backhaul market (Relative value)	100	300 - 600	CTIA (2005), CED Magazine (2010), First Avenue Networks (2006)
Number of cell sites	182,000	272,000	PunkZiegel (2006)
T1 equivalents per site	1 to 6	12 to 16	Visant (2005), Nokia (2005)
Average voice minutes per user/month	731	1,000 to 1,200	Telephia (2005), Visant (2005), First Avenue Networks (2006)
Cellular voice penetration	61%	75%	Diffusion Group (2005)
3G data subscriber penetration/subs	0.3% / 540,000	14% / 24 million (2008)	Yankee Group (2005)
Number of mobile TV users	1.2 million	15 million (2009)	eMarketer (2005)
Bandwidth required for 30 minutes of IPTV is equivalent to one month's Internet usage			Nokia (2005)

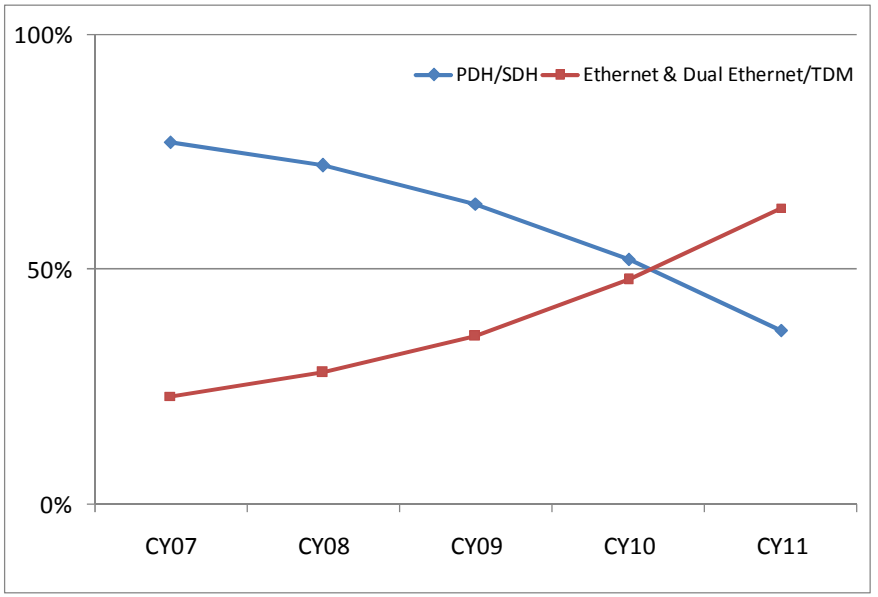
Source: Michael Gallagher, "Backhaul forecasting," First Avenue Networks. Feb. 2006.

Ethernet solves backhaul cost problem

PDH and ATM over PDH vs New Wireline:



Ethernet vs PDH/SDH Microwave Equipment Worldwide Revenue Share



- Ethernet relatively requires smaller service charges per connection than PDHs.
- New IP/Ethernet wireline will be the best choice for cost saving.
- Legacy TDM-based system is being replaced packet-based Ethernet solutions. (More bandwidth per connection)
- The Carrier Ethernet markets are expected to increase 76% by 2011

KAIST

Source: *Mobile Backhaul Equipment, Installed Base, and Services October 2008*
Source: *Infonetics Research, Microwave Equipment Market Outlook. March 2009*

Broad Market potential -Carrier Ethernet

- Synchronization is required
  - Circuit emulation, DRM

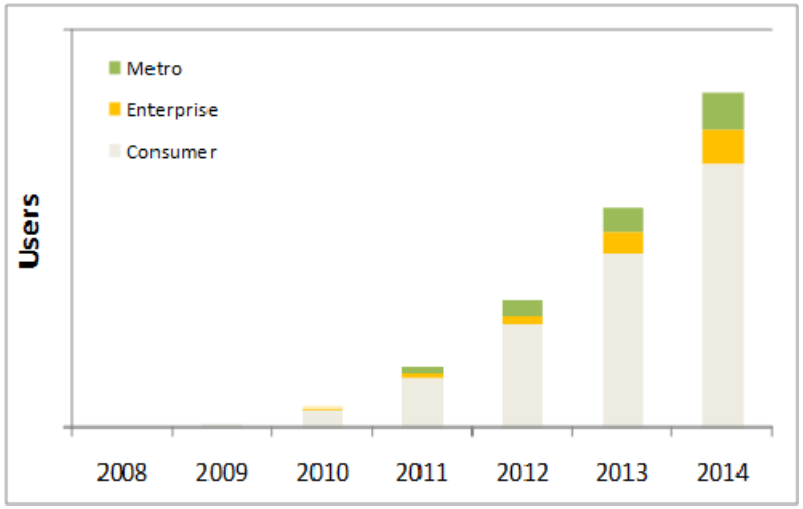
- CAGR for Carrier Ethernet – 1.38

Metric	2005	2010 Projected	Source
Carrier Ethernet market (Service revenue)	100	500	Infonetics Research (2005)
Number of metro Ethernet subscribers	250,000	4 million	Visant Strategies (2005)
Increased capacity demands from enterprises, from 10 Mbps to 100 Mbps			Verizon (2005)

Source: Michael Gallagher, "Backhaul forecasting," First Avenue Networks. Feb. 2006.

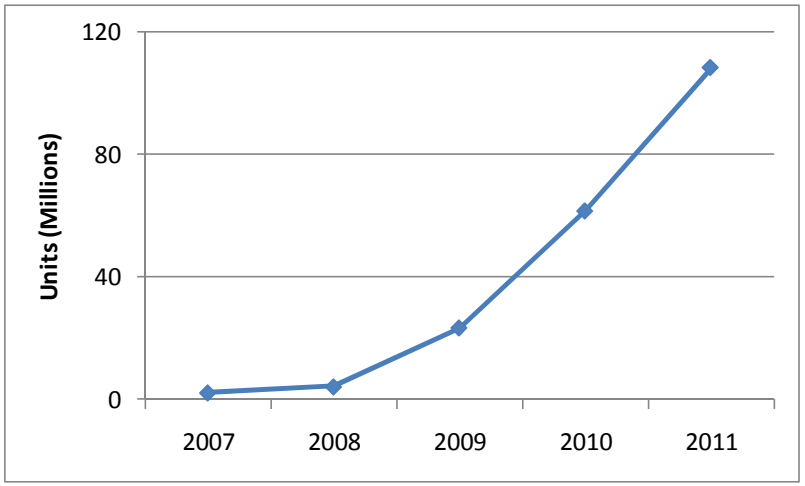
Broad Market potential
- Femtocell and WiMAX

Femtocell users



- Femtocell
  - The small cell deployed indoors, which communicates with cellular network over a broadband connection.
  - Sync is related to handover and interference.
  - Time sync accuracy requirement (Timing difference bet. Macro BS and the Femto BS)
    - 0.2 μs (The distance BSs = 30m)

Fixed and Mobile WiMAX Equipment and Mobile WiMAX Devices



- 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

KAIST

Source: ABI Research
Source: Infonetics Research, WiMAX and WiFi Mesh Network Equipment and Devices Quality Worldwide Market Share and Forecasts 2008.

Conclusions

- Time synchronization in fast growing broad market
  - Mobile backhaul market
    - Circuit emulation is critical to market for graceful migration to 4G
    - Backhaul is anticipated to be even larger than AV applications in the near future.
  - Carrier class Ethernet market
  - Other markets

- IEEE 802.3 needs to provide more accurate timestamp information.
  - State-of-the-art:

    > sub-microsecond accuracy in lab qualifications

    > millisecond accuracy in field trials under high traffic volume

KAIST