Joint ITU-T/IEEE Workshop on The Future of Ethernet Transport

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Examples of Time Transport

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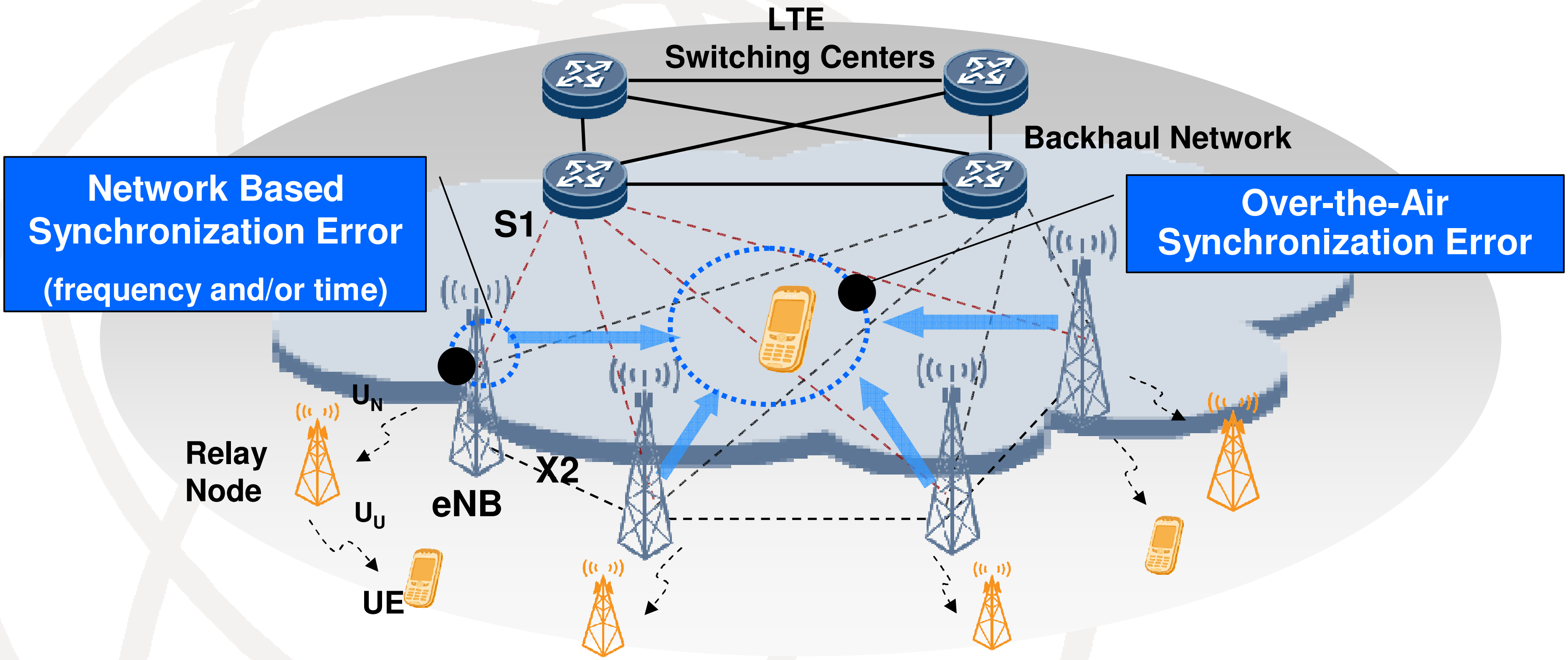
Outline

- LTE-Advanced Time Synchronization Examples
- Time Distribution over Packet Transport Network
- Latest Field Trials
- Performance Results & Voice/Data Service Results
- Summary

LTE-Advanced
Network Synchronization Overview



- 3GPP TR36.814 defines further advancements for LTE

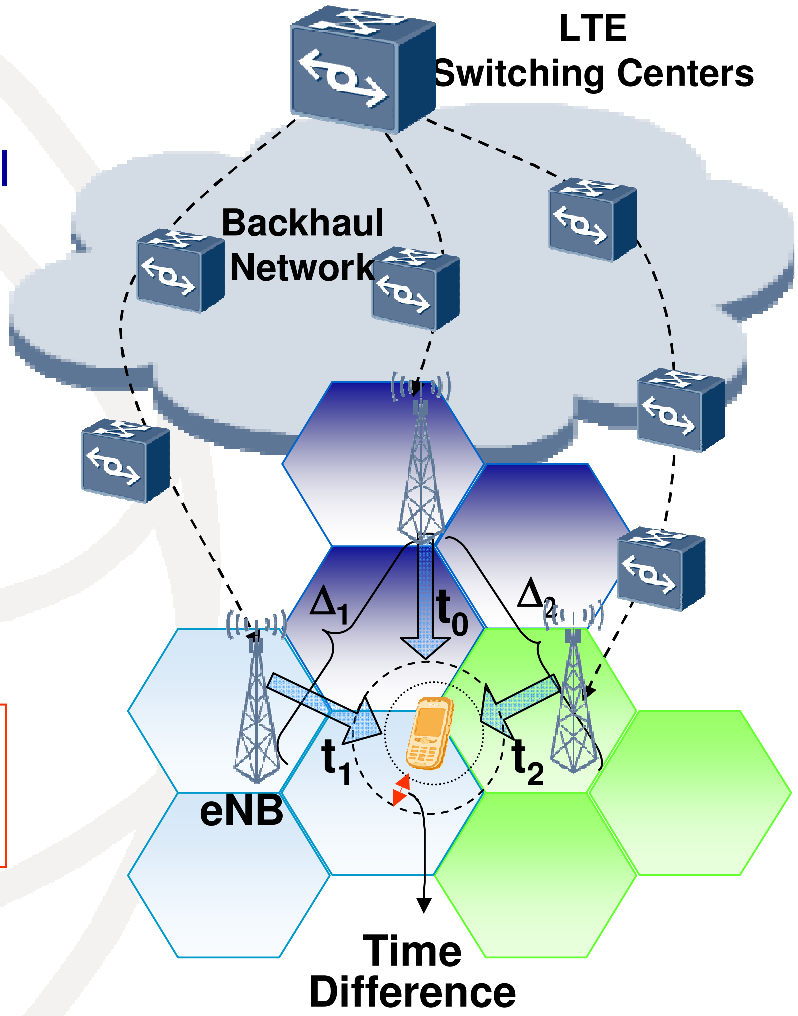
LTE / LTE-A phase/time specs are beyond current GSM/UMTS frequency specs (50ppb) imposing further requirements on the transport network

LTE-Advanced

Coordinated Multi-Point Transmission*

- Radio transmissions from multiple base stations radiate at the same time (spatial multiplexing), giving better cell edge performance and higher data rates
- Broadcast service on the air interface
- Accurate time synchronization required at base station (GPS, IEEE1588-time, etc.) for aligning radio transmissions

Time difference = *max*{ $t_0-(\Delta_1+t_1)$, $t_0-(\Delta_2+t_2)$ } $\leqslant$ *x* µsec

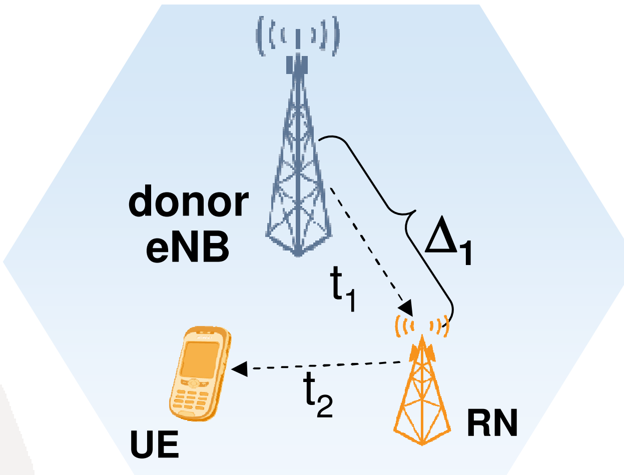


*Illustrative example

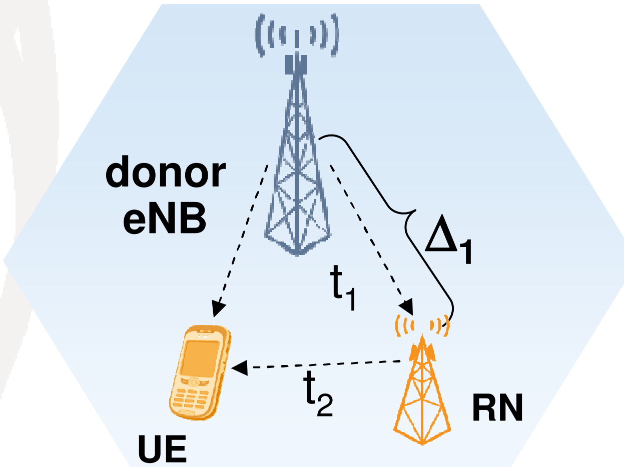
LTE-Advanced

Relay Function*

- Relay used to improve the coverage of high data rates sites, temporary network deployment, coverage in new areas, etc.
- The relay node (RN) is wirelessly connected to radio-access network via a donor cell (eNB).
- The UE may need to get timing info from RN over the air, and where the RN also obtains timing over the air from the donor eNB.
- Some relay nodes have strigent time alignment such as Example 2
  - RN nodes might be equipped with GPS or is synchronized via the radio interface
  - Donor eNB might be equipped with GPS or is synchronized via IEEE1588-time



Example 1

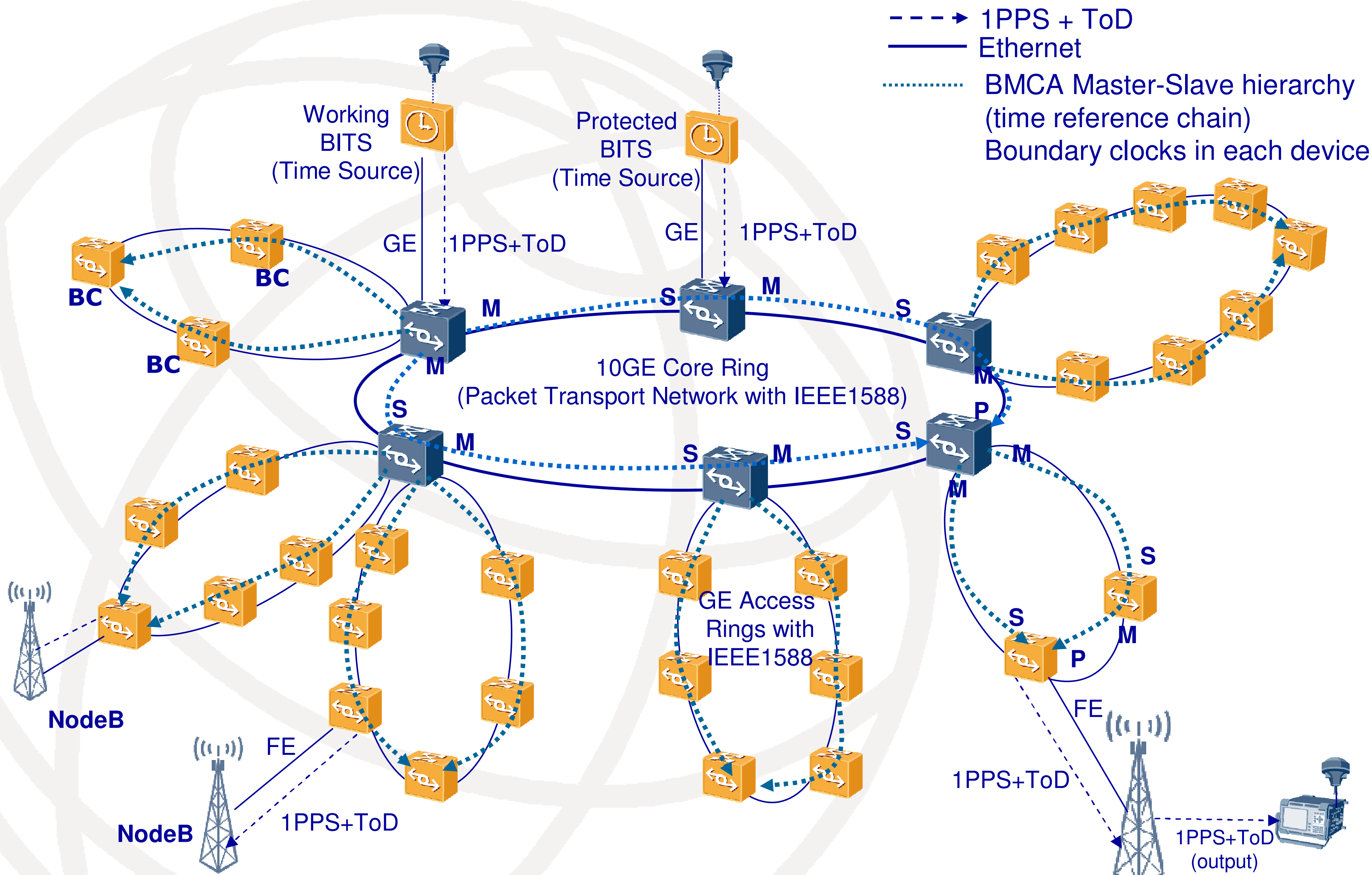


Example 2

*Illustrative example

Field Trial Topology

City-Wide Time Distribution, Joint with China Mobile



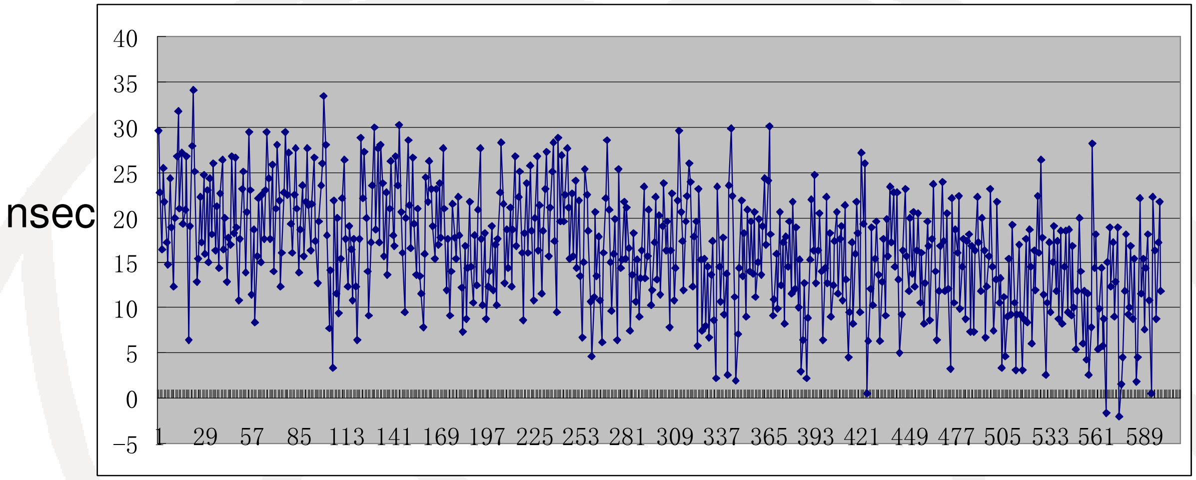
Requirement at NodeB: < ± 1.5usec of cumulative time error

Field Trial Setup
Time Distribution

- One Core 10GE ring with 6 Access GE ring
  - Approximately 75 nodes, covering one city, multi-vendor equipment
- Two Time Reference Sources
  - Dual mode GPS/Beidou receivers, connected to packet transport nodes via Gigabit Ethernet interface (running IEEE1588) or direct 1PPS+ToD interface
- Packet Transport Nodes
  - IEEE1588 Boundary Clock & Best-Master Clock Algorithm. IEEE1588 terminated in each port, 10GE & GE timestamping (similar in spirit to 802.3bf architecture)
  - Synchronous Ethernet & ESMC channel for frequency distribution
  - IEEE1588 time and SyncE frequency reference chain are congruent
  - Fiber asymmetry compensated section-by-section
- NodeB base stations
  - Receive time synchronization from Fast Ethernet interface (running IEEE1588) or direct 1PPS+ToD coaxial input.
  - NodeB can output 1PPS interface for measurement purposes
- Traffic
  - PTN carries real voice/data services
- Measurement equipment
  - TimeAcc 1PPS+ToD analyzer, call quality drive test tool and voice call generator
- Test Scenarios
  - Long term cumulative time error performance
  - Time Reference protection switch, PTN protection switch
  - BMCA master-slave hierarchy, SyncE reference switch
  - Quality of voice/data service, handoff and call completion

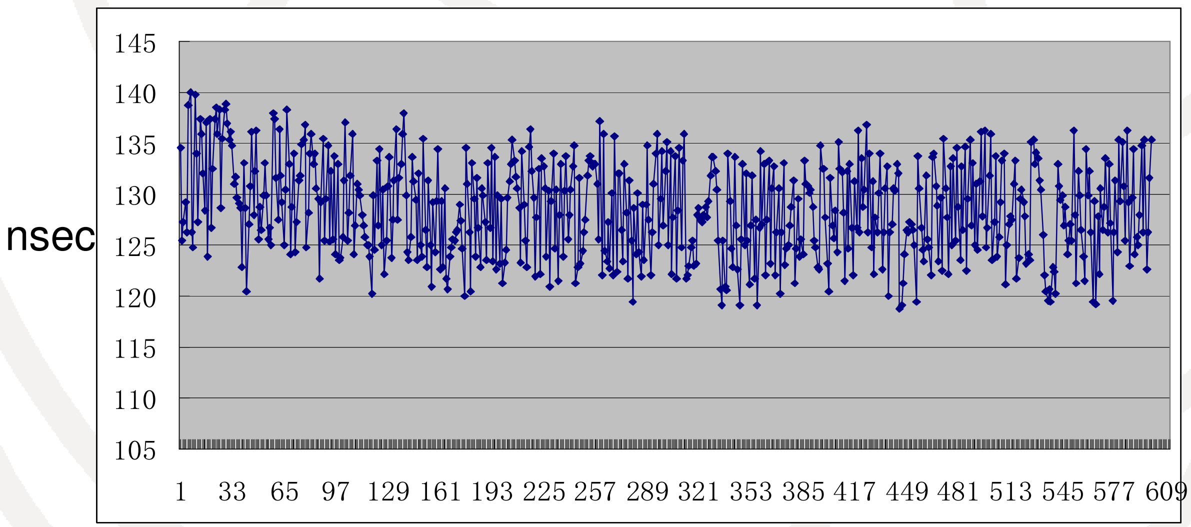
Performance Results

Cumulative Time Error (nsec) versus Time at NodeB



Scenario1: BITS uses 1PPS+ToD to provide time to packet transport, and BTS uses IEEE1588 FE to recover time

Result: Acceptable performance



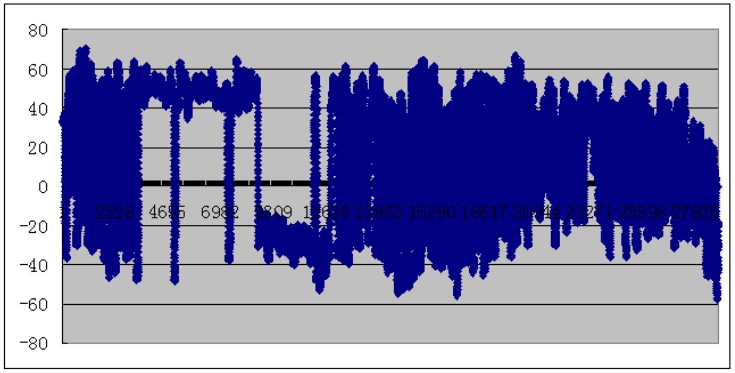
Scenario2: BITS uses 1PPS+ToD to provide time to packet transport, and BTS uses 1PPS+ToD interface to recover time

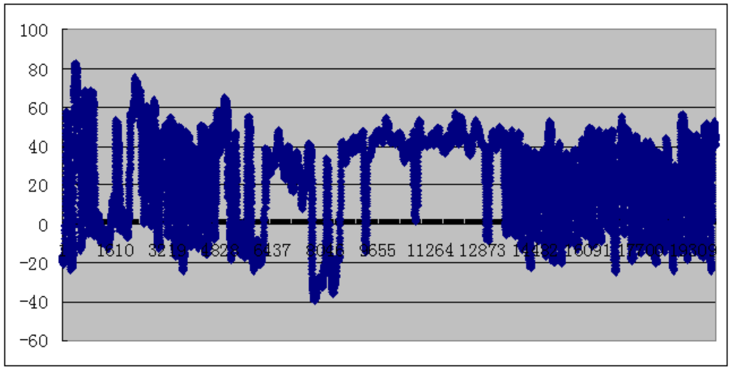
Results: NodeB not capable of compensating (at the time of the trial) for 1PPS+ToD coaxial cable delay and internal delay

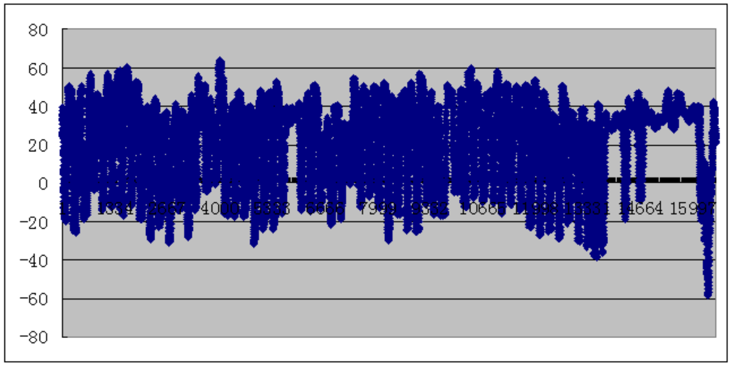
Delay compensation of every single element is necessary

Performance Results

Long term Cumulative Time Error (36 hours)

nsec

0 – 12 hours

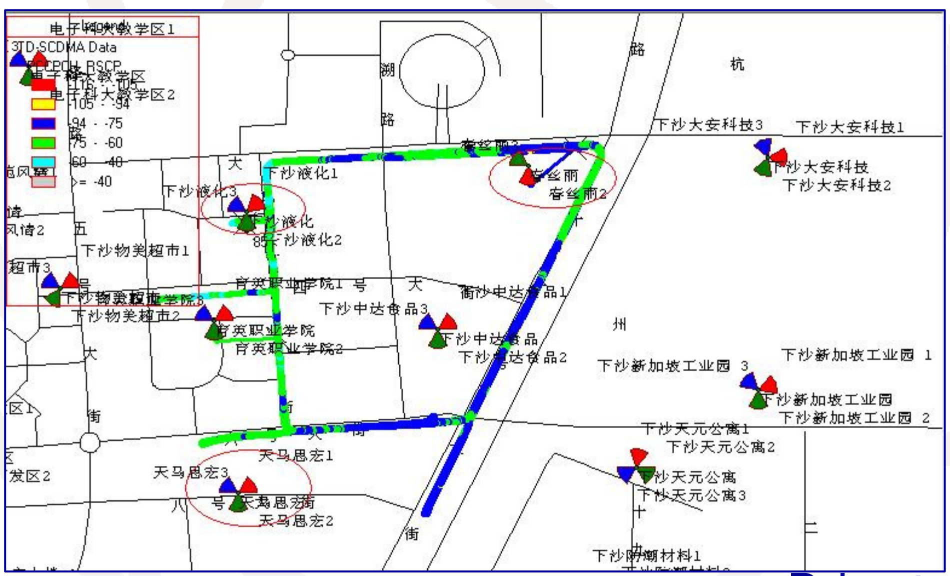
nsec

12 - 24 hours

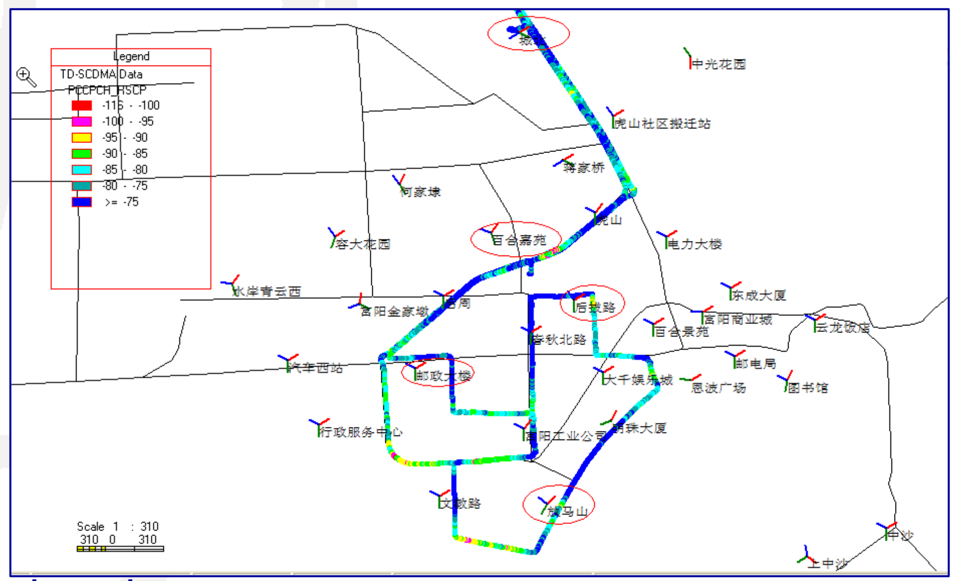
nsec

24 - 36 hours

- Long-term cumulative time error < ± 1.5usec

Voice/Data Quality Results

- Drive tests
  - Between NodeBs supporting IEEE1588 time sync
  - Between NodeBs supporting IEEE1588 and NodeBs supporting GPS
- Voice/Data Services under test & Handoff performance
  - AMR voice, VP and PS384 (various wireless codecs)
  - Eg., AMR traffic: 100-seconds call with 10-seconds interval
  - Drive speed: 40 – 60km/hour
- Tests (reference C1065 – Geneva June 2010)
  - Successful handoff ratio between adjacent base stations: 100%
  - Call completion ratio: 100%
  - Average voice MOS (mean opinion score): 3.46





Drive test routes

Summary

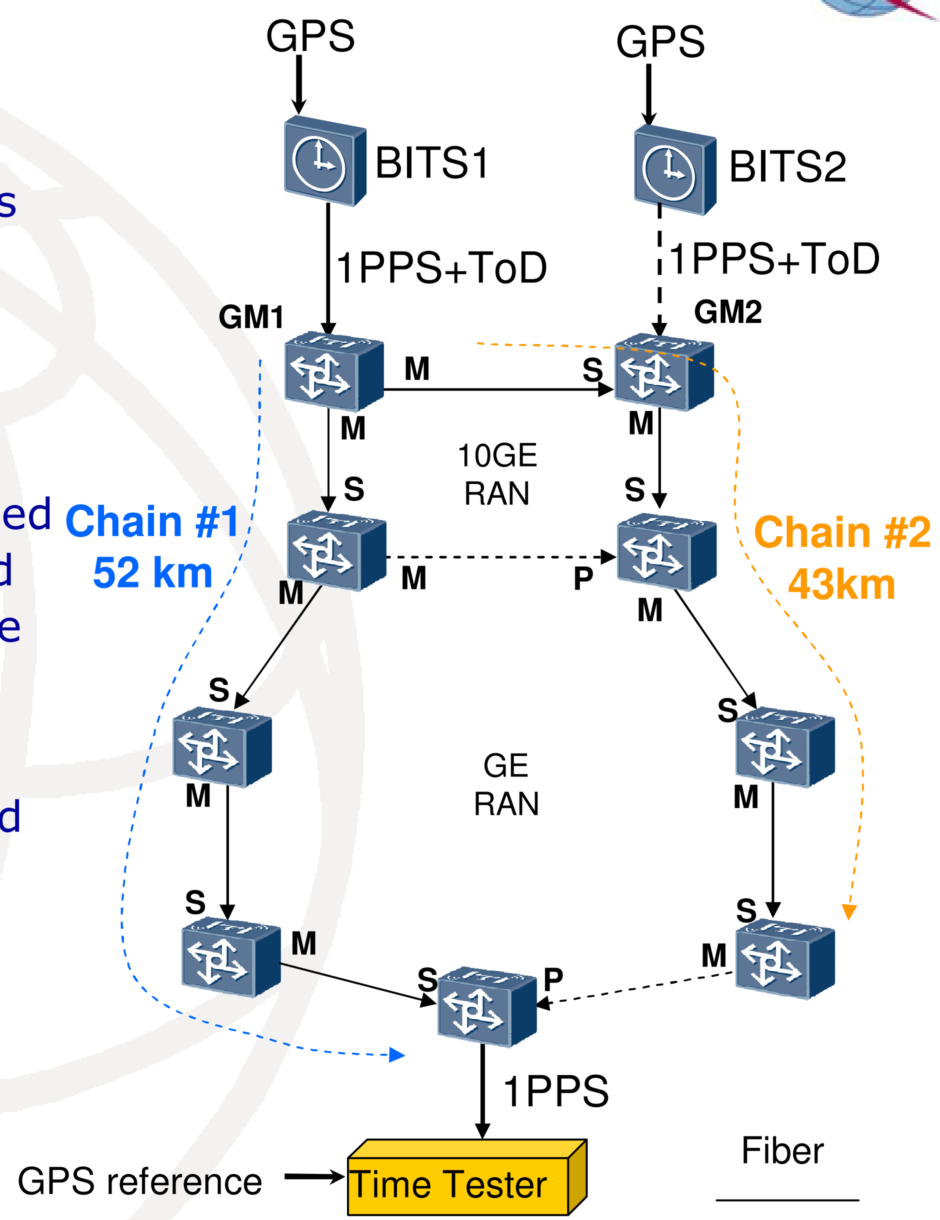
- Accurate Phase/Time distribution over large-scale Packet Transport Network is progressing within Q13, primarily serving wireless radio interfaces requirements
- Various Field Trials
  - IEEE1588 distribution over Packet Transport Network
  - IEEE1588 distribution over Optical Transport Network
- Field trials using Boundary Clocks & Best Master Clock show good results
  - Cumulative time error < ±1.5 usec for TD-SCDMA NodeB
  - Packet impairments: reference switch, protection switch
  - Good voice & data quality of service
  - Successful handoff and call completion
- Additional references:
  - C599, ZTE/CMCC, Geneva, October 2009
  - WD29, Huawei/CMCC, Lannion, December 2009
  - C1065, ZTE/Huawei/CMCC/CATR, Geneva, June 2010
  - C1064/65, ZTE/CMCC/CATR, Geneva, June 2010

Additional Slides

- Additional performance results
  - Time distribution via IEEE1588
  - Frequency distribution Synchronous Ethernet
- Boundary Clock

Trial Results

- 2 time synchronization reference chains
- A chain consists of 15 nodes
- Each node implements IEEE1588 (for time) and Synchronous Ethernet (for frequency)
- Default Best Master_Clock Algorithm used to establish Master-Slave hierarchy and electing new GrandMaster during failure
- GM1 is the initial GrandMaster of the network
- 1PPS signal (cumulative time error) and 2.048MHz signal (time interval error) used for time and frequency measurements



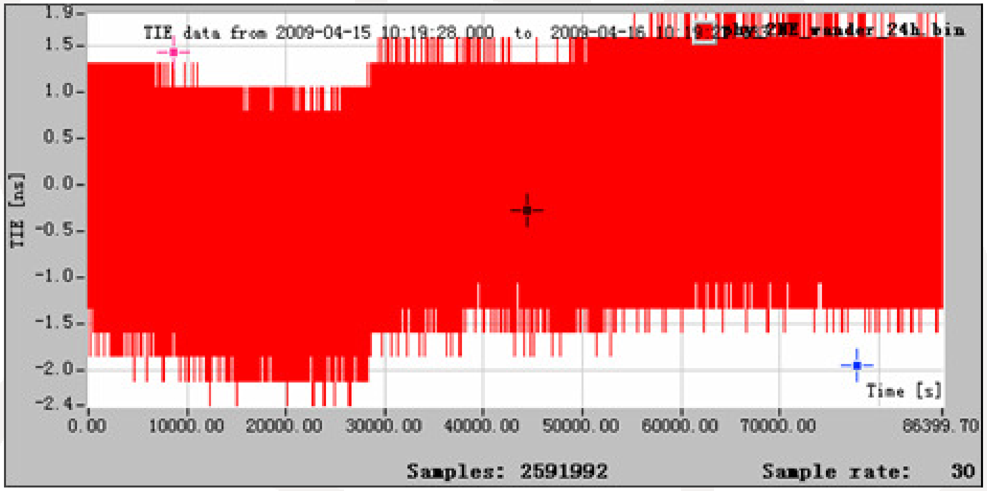
M: Master port
S: Slave port (only 1 per switch)
P: Passive port

GM: GrandMaster

Frequency and Time Results

Performance of two Boundary Clocks connected via single GE link

Frequency (SyncE)

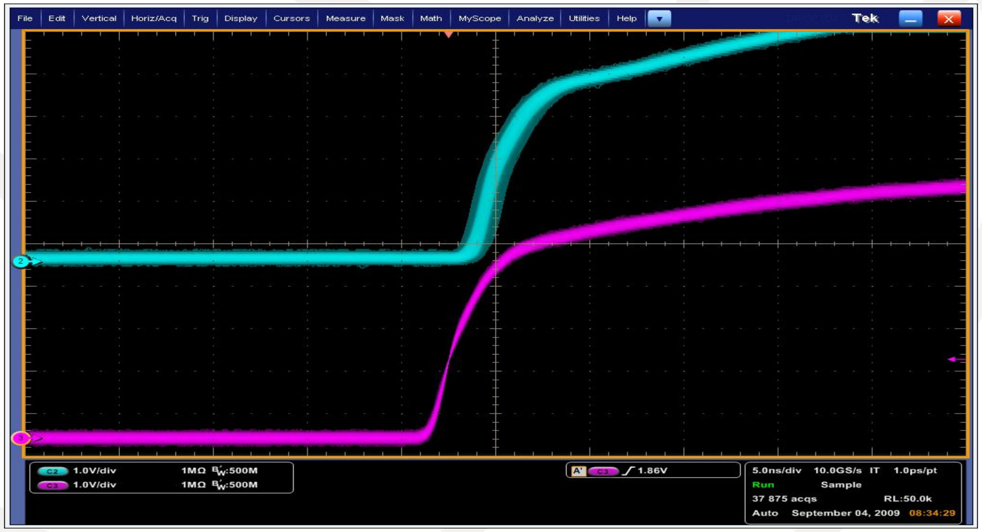


± 3 nsec on 2.048MHz output

~= 10^{-11} frequency offset

→ PRC traceable results

Time (IEEE1588)



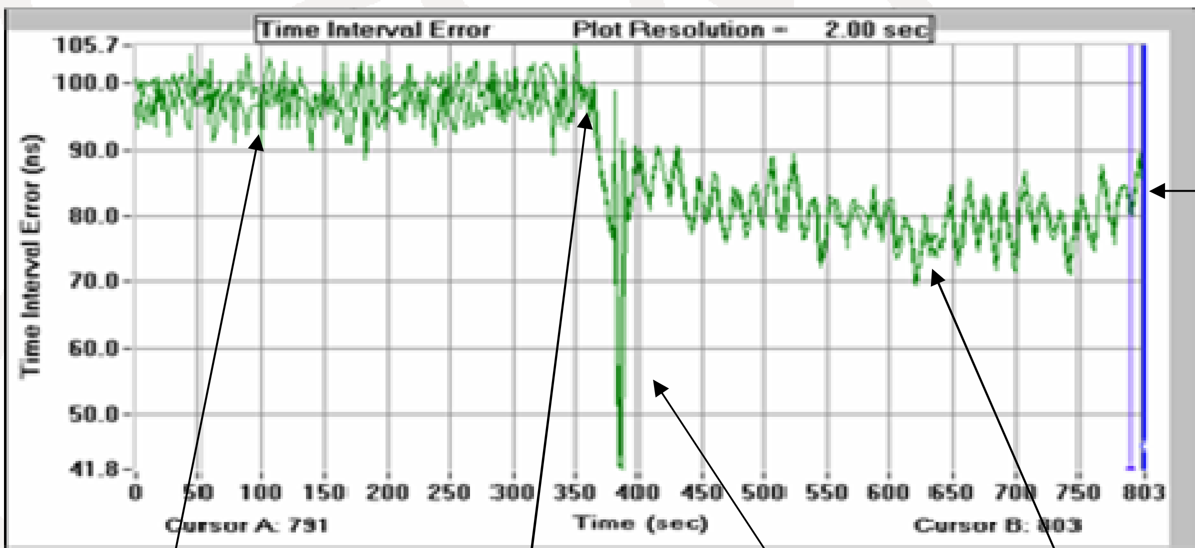
± 2 nsec 1PPS pk-to-pk jitter

\+ 3 nsec static time error due in part to fiber asymmetry

Frequency and Time Results

Protection scenario from Chain#1 to Chain#2

- Master failure done by disconnecting 1PPS interface/cable from GM1
- Master2 is the new GrandMaster, produceed by BMCA & the exchange of Announce messages. Time is distributed through Chain #2



+ 80nsec Static Time Error (eg., fiber asymmetry, timestamping error, temperature)

Chain #1 Time error performance ($\pm$ 15 nsec)

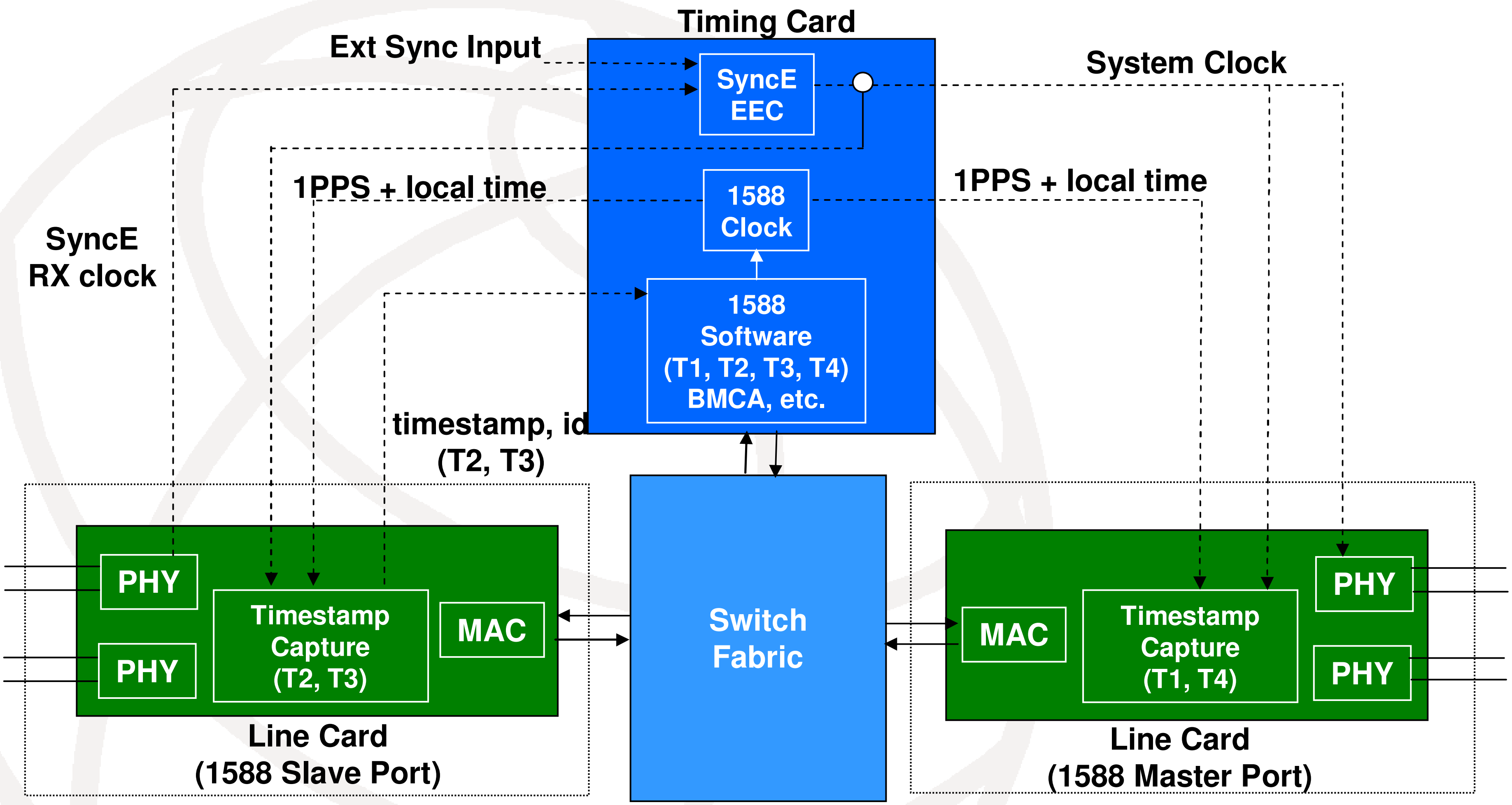
Protection Switch from Chain 1 → 2

Phase Transient (~ 60 nsec)

Chain #2 Time error performance ($\pm$ 20 nsec)

Results demonstrate the robustness and performance when using IEEE1588 node-by-node time synchronization

Boundary Clock System



Boundary Clock is similar in concept to current SDH/SONET/SyncE synchronization system (deal with time and not just frequency)