Trends in Time & Phase Synchronization

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Introduction

- Drivers for synchronization in the network
- Migration from Traditional networks for voice to Packet networks for multimedia applications
- The evolving Core & Edge networks
- The evolving synchronization requirements
Drivers for Synchronization in the Network
The Circuit Switched Network

Edge

- PDH Networks
- 2G BTS
- 3G Node B
- Wireless Networks
- BSC/RNC
- ONT/DSL Modem
- Legacy FAX
- IAD
- Access Networks
- SOHO/Residential

Core

- DS1
- ADM
- MSPP
- ADMS
- SONET
- SONET
- SONET
- SONET
- DS1
- ADM
- ADM
- SONET
- OLT
- DLC DSLAM
- Edge Core
- Access Networks
- PDH Networks
- SONET
- MSPP
- DS1
- ADM

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Power Matters.
From Voice to Applications

- Video is the major contributor to internet traffic

  YouTube™

  Over 800M unique visitors per month
  Over 4Bn videos viewed per day

  2Bn hours viewed in Q4CY11
  Over 20M subscribers world wide

  Netflix

  Over 4Bn videos viewed per day

  245 terabytes per second by 2015

- Emergence of Cloud Computing will accelerate traffic further

  Google

  845M monthly active users by end CY11

  Search engine accounts for 7% of Internet traffic

  Internet Traffic is growing 40% annually

1 - YouTube web statistics   2 – Netflix web statistics
3 – Facebook web statistics   4 - Fifth annual Cisco VNI Forecast (2010-15)
Applications go Mobile

- 5.5Bn mobile subscribers, 78% of the world population
  - Tablets to reach 63M units by 2011, expected to reach 129M by the end of 2012

- YouTube
  - Over 600M mobile videos viewed per day
  - Mobile traffic tripled in 2011

- Facebook 425M monthly active mobile users by end CY11

Global mobile data traffic to increase 18x from 2011 to 2016

Exabytes per Month

1 - IHS iSuppli, March 2012
2 – YouTube web statistics
3 – Facebook web statistics
4 – Cisco VNI Global Mobile data report
Core Network Transition

Solving the Traffic load Problem
SONET - Falling Short

- Specifically designed for the high speed transmission of a single application, Voice
- Specifically designed for frequency traceability
  - GPS or Cesium Sources
- Network applications have brought new demands on the network core
  - Massive amounts of asynchronous data traffic
  - Time Alignment
- SONET is struggling to keep up with the increasing bandwidth demands
  - 40G may be a bridge too far for SONET
The Emergence of OTN

- OTN provides flexibility and scalability for both data traffic and synchronization
- Even though OTN itself does not require synchronization, SONET, synchronous Ethernet and other transport signals can have their own timing carried transparently end-to-end
- Asynchronous packet networks do not require synchronization, these also can be carried by OTN
Optical Transport Network

- OTN can meet the traffic mix demands
- OTN makes WDM manageable and provides a common foundation
- OTN enables efficient bandwidth utilization at 40G and above
OTN Timing Transparency

- OTN physical layer is asynchronous and therefore does not require the sophisticated timing distribution associated with TDM hierarchy
- OTN includes per-service timing adjustments to carry Client timing preserved through network
- OTN’s transparency enables carrying any service
- Timing transparency is important for offering wholesale services for third-party providers
Market Rapidly Transitioning to OTN

- OTN spending will be about 65% of total optical spend by 2015
  - Overall optical market growth +6% CAGR (2010 to 2015)
  - OTN market growth +16% CAGR (2010 to 2015)

Source: Infonetics 2012 OTN Hardware Report
Edge Network Transition
Solving the Bandwidth and Synchronization Problem
Servicing the Application Demands

- To meet the data demands of existing and new applications, we have a number of years of infrastructure build-out still to come
  - Less than 80% of the population is covered with 2G
  - Less than 30% of the population is covered with 3G
- 4G investment to kick in during CY12 to CY16
Ensuring the User Experience

Ethernet installed cell site backhaul connections continue to increase as a portion of total connections from 26% in 2010, to 79% by 2015.
Synchronization for Mobile Networks

- **FDD applications for 2G & 3G**
  - Frequency accuracy from 15ppb to 50ppb
- **TDD applications for 3G & 4G**
  - Frequency & Phase alignment to better than +/-1us

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**Dedicated Clocks**
- GPS
- BITS/SSU (SASE)

**Packet Network**
- Synchronous Ethernet (SyncE)
- IEEE 1588 v2
- NTP v4
- OTN Transport

**Circuit Network**
- T1/E1
- Leased Lines - T1/E1

**Packet Network**
- CESoP (adaptive or differential)

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End Node (BTS)
Use Of Protocol & Physical Layer Synchronization

Is it time to get synchronization from the “Cloud” not the “Sky”?

- SyncE for frequency and IEEE1588 for phase
- SyncE for frequency and IEEE1588 for phase
- SyncE Retrofit for frequency
- IEEE-1588 for frequency
Timing Distribution Protocol & Physical

Protocol Layer (IEEE 1588)

Physical Layer (SyncE)

Node 1
- Master
- Ethernet PHY
- Switch
- Ethernet PHY
- 1588 DPLL
- BITS

Node 2
- Slave
- Ethernet PHY
- Switch
- Ethernet PHY
- Master
- Extracted Clock
- SincE DPLL
- BITS

Node 3
- Slave
- Ethernet PHY
- Switch
- Ethernet PHY
- Master
- Extracted Clock
- SincE DPLL
- BITS

Eth 1588 DPLL

Eth 1588 DPLL

Eth 1588 DPLL

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SyncE for FDD

- The clocks are designed to control jitter and wander in the network
- Uses SONET synchronization concepts for packet networks
- Use the Ethernet bit timings to transport physical layer frequency synchronization between Ethernet switches
- Already widely used by equipment vendors
IEEE1588 for FDD

- **Telecom Profile for Frequency**
  - A PSN may be inserted between the server and client, that is not aware of protocol layer synchronization packets (e.g. IEEE 1588-2008)
  - Suitable for frequency (MTIE, TDEV, FFO) transfer
SyncE-IEEE1588 for TDD

- **Aware Networks**
  - Targeted for TDD basestation applications
  - Uses Boundary Clock + SyncE

- **Telecom Profile for Phase**
  - The PSN has ‘on-path support’ where each switch / router is aware of protocol layer synchronization packets (e.g. Boundary Clock)
  - Support frequency (MTIE, TDEV, FFO) & phase/time (PPS, ToD) transfer
Summary

- “Applications” drive the shape & structure of the network
  - Data is king, Voice is just another Application
- “Wireless Networks” drive the need for Synchronization
  - Frequency & Phase
- Protocol & Physical layer Synchronization
Questions for the Conference

- Can synchronization be sold as a service with pricing based on features and accuracy?

- Can Cloud and Sky synchronization live in harmony?
  - Can we ever live without GPS?