An Overview of Synchronization over Packet Networks

Silvana Rodrigues

System Architect

silvana.rodrigues@zarlink.com

http://timing.zarlink.com/

http://cesop.zarlink.com/

Agenda

- **Synchronization over Packet Networks**
- **Current Solutions**
  - Network Time Protocol (NTP)
  - IEEE-1588™
  - Common Synchronization Solutions
    - *Global Positioning System (GPS)*
    - *High Precision Oscillators*
  - Synchronous Residual Time Stamp (SRTS)
  - Adaptive Clock Recovery
- **Applications**
  - Circuit Emulation Services (CES)
  - Wireless Backhaul
  - Broadband Access
- **Standards Activities for Synchronization over Packet Networks**

Synchronization over Packet Networks

- **Network infrastructure is converging to asynchronous packet-based architecture**
  - Traditional T1/E1 are being replaced by Ethernet
  - Synchronous applications require accurate timing to be distributed over the packet network
    e.g. Wireless backhaul
  - Timing sensitive services are difficult to transition to packet-based architecture without packet-based precision timing reference
  - Cost-sensitive applications will benefit from transmitting synchronization across packet networks instead of using GPS, expensive oscillators, or access to a PRS clock

Current Solutions

NTP

- **NTP version 3 is described in RFC 1305**
- **Simple Network Time Protocol (SNTP) is described in RFC 2030**
- **Designed to synchronize the computer clocks over the network**
  - Poor precision

    Accuracy in the order of milliseconds

IEEE-1588™

- **Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control System**
- **A packet-based protocol that uses a precision timestamp method at source and end points**
  - Distributes a frequency and optionally a phase or epoch aligned clock reference.
  - Sync messages are sent at the source (master) to the end points (slaves)
  - A follow-up message containing precise sending time is sent to the slaves
  - All slaves compute the offset and correct their clocks
- **Applications include industrial controls, test and measurement, military test, telecom, automotive, power grid substation automation and metering automation**

Common Synchronization Solutions

- **GPS**
  - GPS is a satellite navigation system developed and operated by the U.S. Department of Defense
    GPS is widely used on CDMA applications
  - Requires antenna to satellite line-of-sight
    Does not work in concrete canyons
- **High Precision Oscillators**
  - Requires routine calibration
  - High cost precludes high volume

SRTS

- **SRTS is described in ITU-T I.363.1 "B-ISDN ATM Adaptation Layer"**
- **SRTS is covered by US Patent No. 5,260,978, assigned to Telcordia**
- **Uses Time Stamp to recover the clock**
  - The difference between the local service clock and the network provided reference clock is encoded as a residual time stamp at the transmitter
  - The receiver uses the received residual time stamp and the network provided reference clock to reconstruct the local service clock at the receiver node
- **Must have a common reference clock available at both ends of the network**
  - Physical clock
  - GPS

Adaptive Clock Recovery

- **The Adaptive Clock Recovery method is based on:**
  - Averaging the arrival rate of the packets over a period of time
  - Inter-arrival time of the packets
  - The fill level of the jitter buffer
- **Packet Delay Variation is a concern**
  - It feeds through as a frequency variation

    High frequency jitter can be filtered out, but wander is more difficult to filter

Application Examples

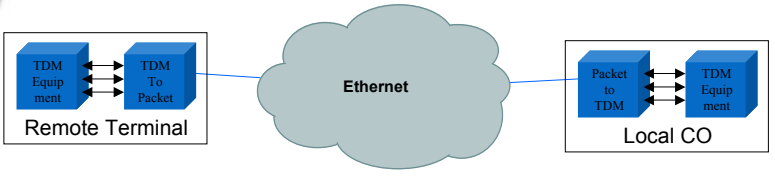
CES

- **As traditional T1/E1 are being replaced by Ethernet, provision for TDM traffic must be made**
  - Circuit Emulation Service carries TDM traffic, timing and signaling through a Packet Network

    It allows existing TDM legacy equipment to be maintained

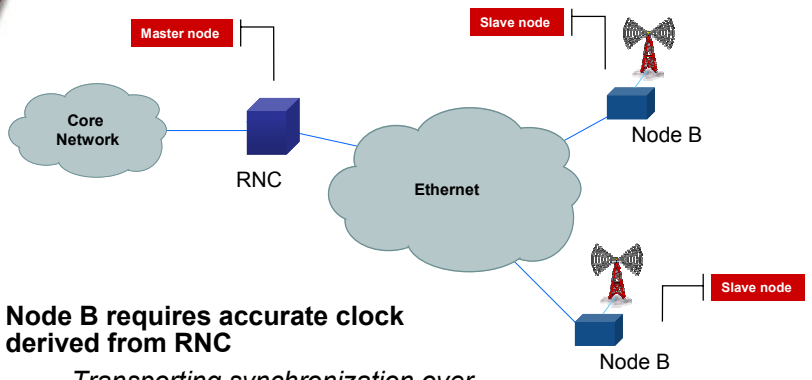
    Need to meet synchronization specifications, e.g. G.823 and G.824

CES Application



- **The clock of the TDM signal must be identical on both sides of the network**
  - Slips would occur if they were different
  - Relevant synchronization standards to be met in this example are G.822, G.823 and G.824

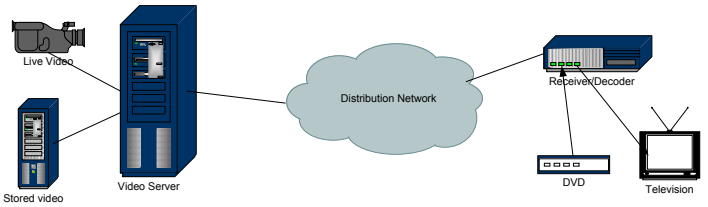
Wireless Backhaul Application



- **Node B requires accurate clock derived from RNC**

  Transporting synchronization over the Ethernet avoids the need of a GPS on every Node B

Broadband Access Application



- **Precise synchronization at the end point is very important**

  Reduces the complexity of the video recovery and the de-jittering technology

Standards Activities for Synchronization over Packet Networks

ITU, Study Group 15, Question 13

- **October 2003 meeting**
  - Start to work on synchronization issues related to TDM over Ethernet
  - The conclusions of the meeting were that transport of TDM over packet needs to be compliant with existing TDM timing standards (G.823 and G.824 for PDH)
- **April 2004 meeting**
  - Start to work on a single recommendation with a scope limited to the transport through Ethernet
  - The title of this recommendation is “G.pactiming: Timing and Synchronization aspects of Packet Networks”
- **September 2004 meeting**
  - First draft of G.pactiming created
  - Several areas in the recommendation require further work

ATIS – OPTXS (Optical Transport and Synchronization Committee)

- **OPTXS-SYNCH (formerly T1X1.3)**
  - Working on a technical report "Synchronization of Packet Networks"

    The report addresses synchronization issues in packet networks

    The report addresses the transport of TDM-type services over a packet – it includes xDSL, Ethernet and MPLS, which may use either IP or ATM

IEEE-1588™

- **Three subgroups were active over the last year**
  - Technical Extensions Task Group
  - User Requirements Task Group
  - Conformance and Interpretation Increased
- **Workshop was held in September 2004**
  - The group decided to create a PAR (Project Authorization Request) to be presented to IEEE
  - The PAR addresses:

    Resolution of known errors

    Conformance enhancements

    Enhancements to address new applications

Summary

- An overview of Synchronization over Packet Networks was presented
- Work on synchronization over Packet Networks is happening within several standards bodies
- The ongoing evolution of the Packet Network will most likely increase the need for transporting synchronization over asynchronous networks

References

- Jean-Loup Ferrant, ITU contribution WD16: "Report of the SG15/13 Interregnum Meeting", Alcatel, France
- Jean-Loup Ferrant, ITU contribution WD4: "Q13 report April 2004" ", Alcatel, France
- John Eidson, IEEE-1588™ Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
- IEEE1588™ web site, http://ieee1588.nist.gov/
- RFC 1305, David L. Mills, University of Delaware
- RFC 2030, David L. Mills, University of Delaware
- ITU-T Recommendation I.363, B-ISDN ATM Adaptation Layer (AAL) Specification
- OPTXS, Synchronization Subcommittee http://www.atis.org/0240/synch.asp
- Tim Frost, Circuit Emulation over Packet Switched Networks , Zarlink Semiconductor, http://cesop.zarlink.com/articles.htm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