Wireless Backhaul

Synchronization

Abstract

This paper focuses on Next Generation Backhaul Networks' Synchronization and the way it is implemented by Ceragon's high-capacity, LTE-Ready point-to-point microwave solution, the FibeAir® IP-10. The following discussion is focused on 3GPP migration (GSM, UMTS, and LTE). 3GPP2 (CDMA, CDAM 2000) and WiMAX are out of the scope of this paper.

Why is synchronization an issue?

Mobile base-stations need a highly accurate timing signal that has to be shared across the entire network. If an individual base-station drifts outside of the specified +/-50 PPB (Parts per Billion) limit, mobile handoff performance degrades resulting in high disconnected calls rate and poor data services quality.

As long as mobile base-stations rely purely on TDM based T1/E1 or SONET/SDH backhaul connections, synchronization is not an issue. Yet as the aggregate cost of TDM backhaul connections rises, driven by the need to deliver more and more capacity in support of data and video applications, operators are beginning to transfer their networks to more cost-efficient packet-based solutions. This move breaks the end-to-end clock synchronization chain that enabled 2G and early 3G networks to keep synchronized.

Unlike legacy TDM networks, packet-based networks are not deterministic. Packets may follow more than one rout from source to destination and their order of arrival is not necessarily similar to the order in which they are transmitted. Packets may also be lost on the way and require retransmission. It's plain to see then, that packet based networks will require a specialized device in order to support the sub-microsecond levels of synchronous timing and frequency needed by mobile base-stations,.

FDD and TDD – Synchronization Characteristics

Two technologies serve the air interface of a mobile cell site. GSM (2G and 2.5G) and UMTS (3G) networks primarily use FDD (frequency division duplex). CDMA networks, WiMAX data networks use TDD[1].

FDD uses different frequency subsets for each call or session, thus requiring very accurate frequencies to allow subscribers to roam from cell to cell, and use the same frequency throughout the entire conversation. Typically, FDD is handled by supplying a traceable clock through the transmission, or backhaul network. TDD on the other hand, uses timeslots as well as frequencies. It not only needs the same frequency but also the same phase alignment. TDD may be more complex (and costly) but it can lead to better spectrum utilization. This is due to the fact that two TDD end-points share the same frequency, transmitting in different timeslots, while FDD uses two different frequency bands, one for upstream transmission and another for downstream.

Synchronizing Next Generation Networks

As long a cell site hosts both a 2G and 3G base-station, the issue of synchronization is not a pressing one. Operators can extract the clock signal from the T1/E1 or SONET/SDH transport network used for the 2G base-station, and use it to drive synchronization to the 3G equipment. Yet operators need to prepare their networks for that time in the future when a circuit-based connection from which to extract a timing signal is no longer available (either Greenfield deployments or once the migration to IP has been completed).

In the following paragraphs we will discuss in short various ways of facilitating synchronization over packet-based networks:

- Timing over Packet (ToP) refers to the distribution of frequency, phase, and absolute time information across an asynchronous packet switched network. The timing packet methods may employ a variety of protocols to achieve distribution, such as IEEE1588, NTP, or RTP.

[1] TDD may be used in some particular cases of UMTS

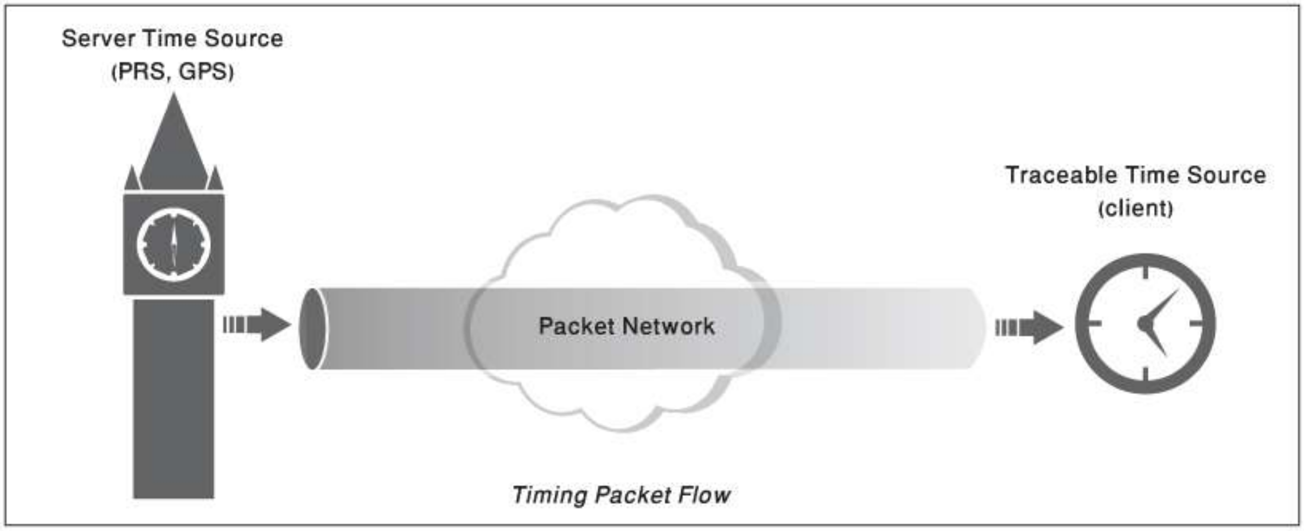

Figure 1: Timing over packet concept

- Synchronous Ethernet (SyncE) is a synchronization method promoted by the ITU and IEEE. SyncE (defined in the ITU standards G.8261, G.8262 and G.8264) defines the precision time protocol, PTP for transporting timing-over-packet. This synchronization method uses the physical layer to deliver clock signals. Based on SDH/TDM timing, and with similar performance, SyncE does not change the basic Ethernet standards.

- Another alternative method of applying synchronization over next generation networks is using GPS at the cell site. This technology provides both frequency synchronization and accurate timing and is the de facto method for WiMAX and CDMA. But GPS has a number of drawbacks including cost of device and antenna installation or the fact that the GPS network is operated and controlled by the US military add some political perspective as well. GPS-based synchronization is outside the scope of this document

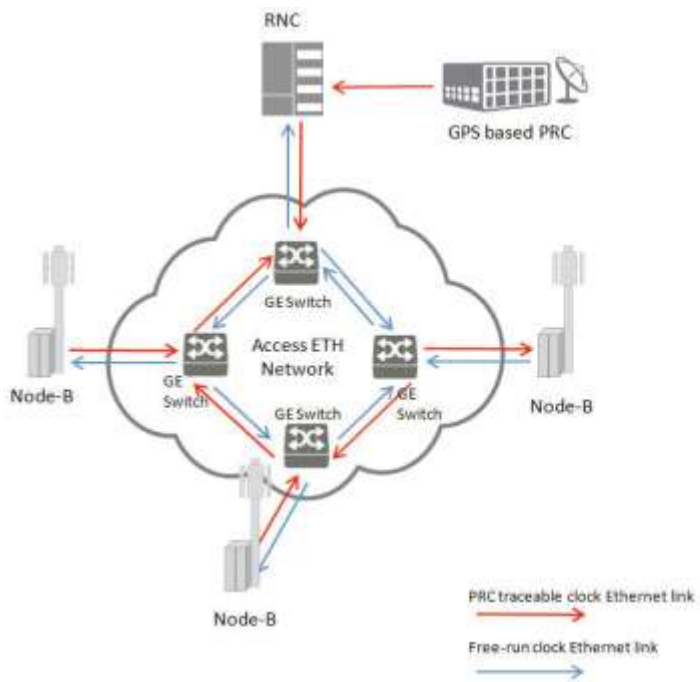

Figure 2: SyncE network concept

Ceragon's Native[2] Synchronization Solution

Ceragon supports a variety of synchronization methods over its high-capacity wireless solutions. Using Ceragon's solution, operators benefit from unmatched flexibility and can select any of combination of following techniques: Synchronization using native E1/T1 trails, "ToP-aware" transport, SyncE.

Synchronization using Native E1/T1 Trails

Using this technique, each T1/E1 trail carries a native TDM clock, which is compliant with GSM and UMTS synchronization requirements.

Ceragon's FibeAir IP-10 implements a PDH-like mechanism for providing the high precision synchronization of the native TDM trails. This implementation ensures high-quality synchronization while keeping cost and complexity low as it eliminates the need for sophisticated centralized SDH-grade "clock unit" at each node.

The system is designed to deliver T1/E1 traffic and recover T1/E1 clock, complying with G.823 "synchronization interface" jitter and wander. This means that operators can use any (or all) of the system's T1/E1 interfaces in order to deliver synchronization reference via the radio to remote site (e.g. Node-B). Each trail is independent of the other, meaning that the FibeAir IP-10 does not imply any restrictions on the source of the TDM trails. (i.e. each trail carries its own clock, and no synchronization between trails is assumed). Each is also mapped independently over the radio frame and the integrated cross-connect elements. Timing can be distributed over user traffic carrying T1/E1 trails or dedicated "timing" trails. This method eliminates the need to employ emerging ToP techniques.

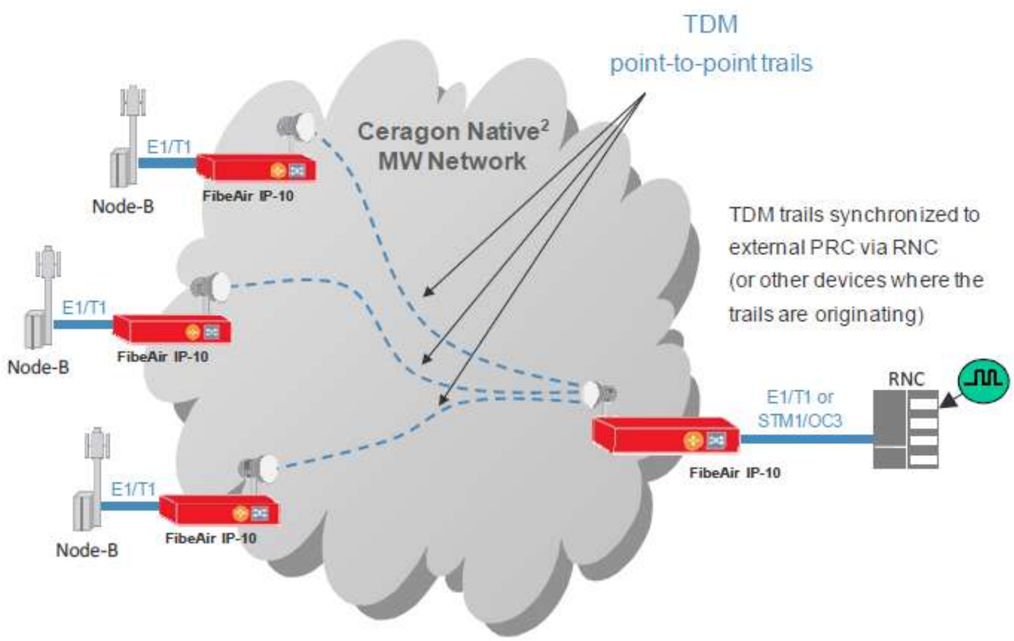

Figure 3: Synchronization using native E1/T1 trails

ToP-Aware Transport

Ceragon's FibeAIr IP-10 features an integrated advanced QoS classifier. The QoS classifier supp orts the identification of standard ToP control packets (i.e. IEEE1588v2 packets), and assigns to them the highest priority/traffic class. This ensures that ToP control packets will be transporte d with maximum reliability and minimum delay, to provide the best possible timing accuracy.

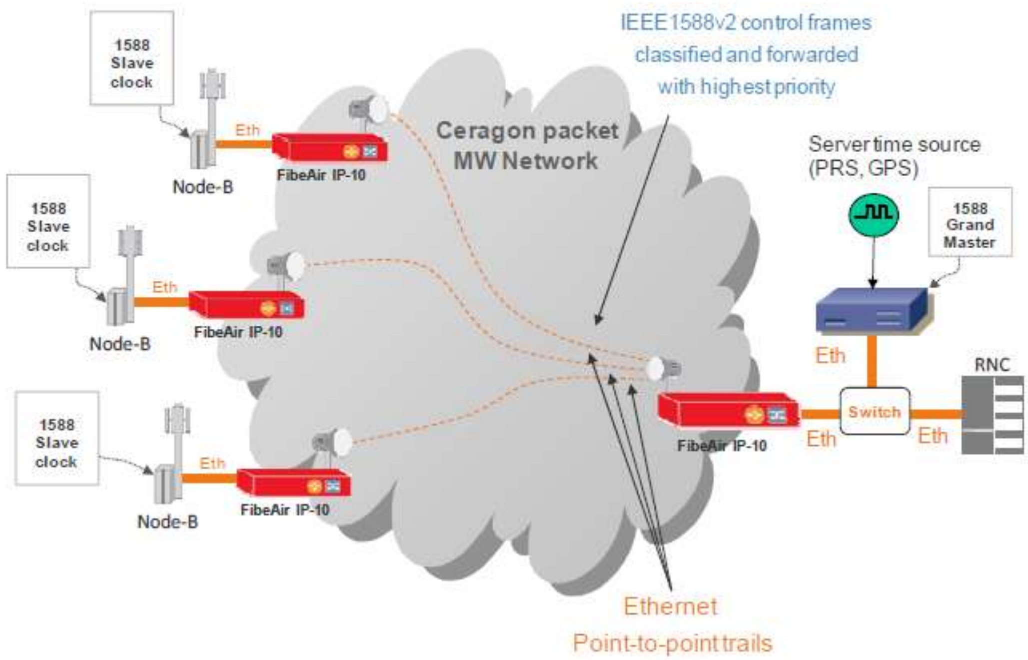

Figure 4: Synchronization support using "ToP aware" transport

SyncE

The SyncE technique supports synchronized Ethernet outputs as the timing source to an all-IP RBS. This method offers the same synchronization quality provided over E1 interfaces to legacy RBS.

Ceragon's SyncE supports two modes:

- **Sync from Co-Located T1/E1 Mode**

  The clock for SyncE interfaces can be derived from any co-located traffic-carrying T1/E1 interface at the BTS site. This solution is depicted in Figure 5 below.

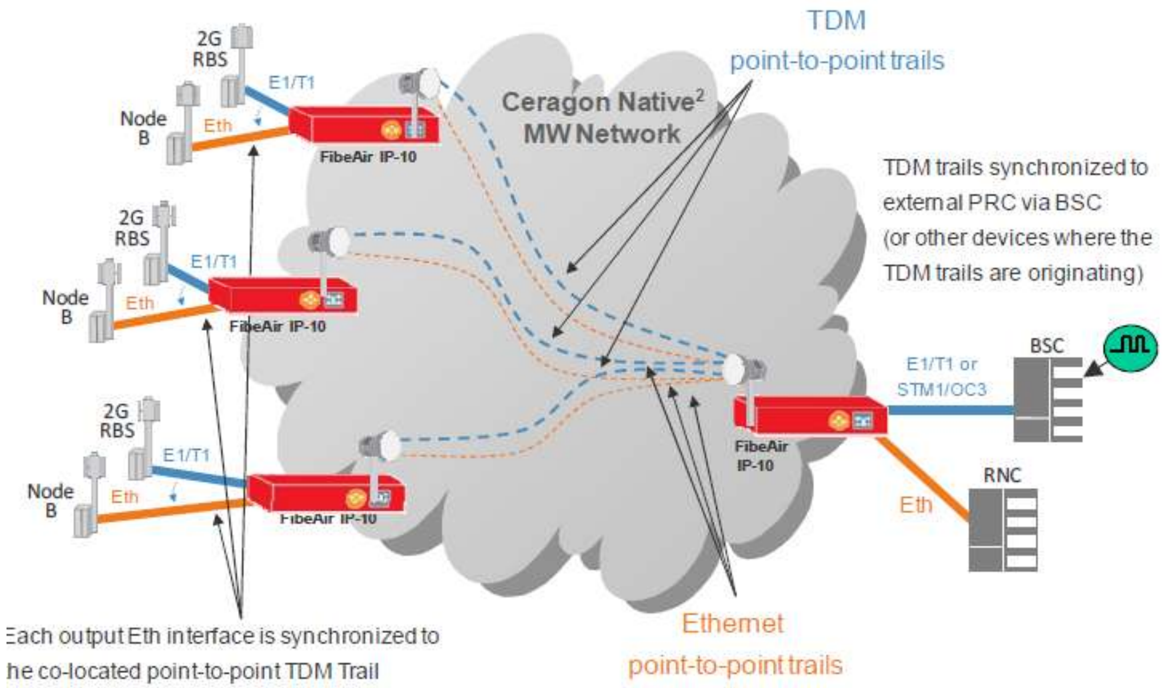

Figure 5: SyncE from co-located T1/E1 source

- **Native Sync Distribution Mode**

  Synchronization is distributed natively over the radio links. In this mode, no TDM trails or T1/E1interfaces at the tail sites are required. Synchronization is provided by the E1/STM-1 clock source input at the fiber hub site (SSU/GPS). This solution is depicted in Figure 6 below.

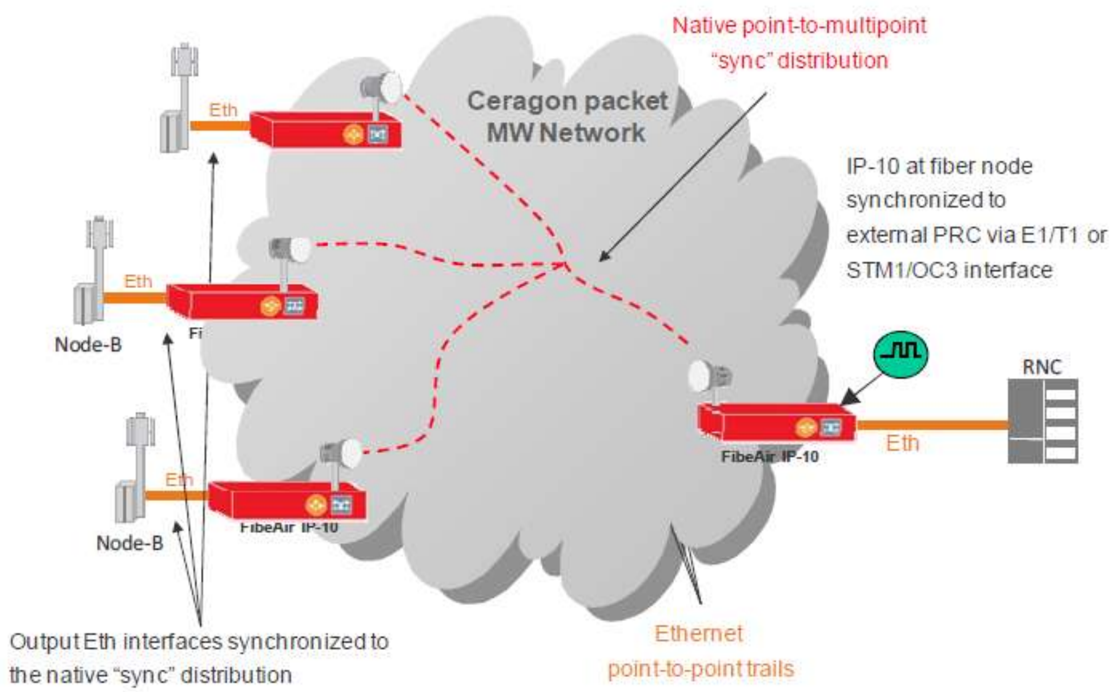

Figure 6 Native SyncE distribution

Conclusion

In order to ensure continues, high quality of service, mobile base-stations need a highly accurate timing signal that has to be shared across the entire network. In the legacy TDM world, synchronization was not an issue. But as networks evolve towards an IP-based architecture, the end-to-end clock synchronization chain needs to be re-examined.

This paper presented a number of methods in which operators can address next generation networks synchronization. It also described the various methods in which synchronization is addressed over Ceragon's advanced FibeAir IP-10 wireless backhaul solution.

About Ceragon Networks

Ceragon Networks Ltd. (NASDAQ: CRNT) is the premier wireless backhaul specialist. Ceragon's high capacity wireless backhaul solutions enable cellular operators and other wireless service providers to deliver 2G/3G and LTE/4G voice and data services that enable smart-phone applications such as Internet browsing, music and video. With unmatched technology and cost innovation, Ceragon's advanced point-to-point microwave systems allow wireless service providers to evolve their networks from circuit-switched and hybrid concepts to all IP networks. Ceragon solutions are designed to support all wireless access technologies, delivering more capacity over longer distances under any given deployment scenario. Ceragon's solutions are deployed by more than 230 service providers of all sizes, and hundreds of private networks in more than 130 countries. Visit Ceragon at www.ceragon.com.