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Mobile Switch Center (MSC) and Base Station Controller (BSC) Synchronization

January 1999

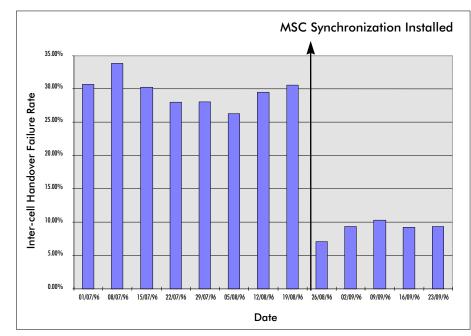


All around the globe, wireless carriers are turning digital. Existing cellular analog providers are upgrading to digital and expanding networks. New PCS/DCS carriers race to compete. The new digital technologies-TDMA, CDMA, and GSM-promise new capabilities and levels of quality, efficiency, and penetration difficult to imagine only a few years ago. The impact is revolutionary.

Potentially.

Without precision synchronization, these major investments in digital networks may fall short. To deliver the advanced digital services and superior utilization that digital networks promise, with the dependability and quality customers expect, carriers need the support of precision network synchronization systems.

Results from a trial conducted in a GSM network, illustrated below, make the point. The deployment of GPS timing systems and associated Stratum 2E clocks have a dramatic impact on handover success rates due to proper synchronization of T1/E1 span lines interconnecting the Mobile Switching Center (MSC), Base Station Controllers (BSC), and other key network elements, including each wireless base station (Base Transceiver Station, or BTS).



The GSM carrier concluded from these results that synchronization is like power and ground. It too is fundamental to a digital wireless network. Timing errors lead to poor performance and low reliability!

Synchronizing the Mobile Switching Center

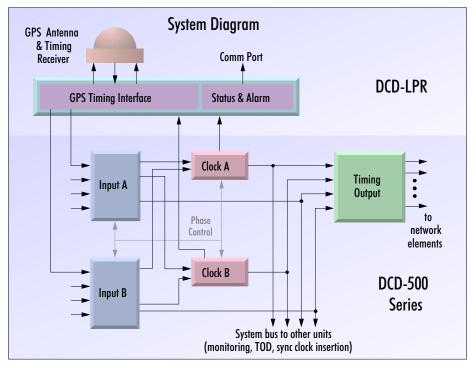
In the digital wireless network, faulty synchronization can cause continued data retransmission or lost data at the MSC, the heart of wireless infrastructure networks. Timing errors at the MSC directly lead to data errors, poor capacity utilization, and cascading failures that in extreme cases can bring the MSC and all connected cells down. By deploying very accurate clock systems throughout the network, all traceable to universal coordinated time (UTC), these phenomena are largely eliminated.

Cellular and PCS/DCS wireless service providers can control their own destiny by deploying Symmetricom's Stratum 1 traceable timing references and clocks at MSC locations, ending synchronization-caused performance problems. The most cost-effective approach references the Global Positioning System (GPS).

Symmetricom's DCD-LPR (Digital Clock Distributor-Local Primary Reference) is an extremely reliable and accurate clocking system that receives timing input directly from GPS. Used in conjunction with Symmetricom's DCD-500 series distribution shelves, the DCD-LPR is the ultra-reliable solution of choice for the MSC.



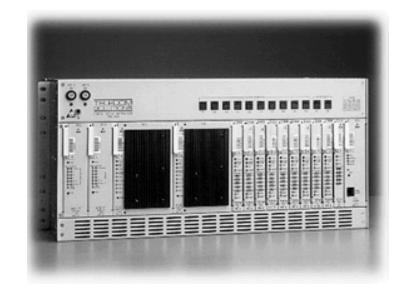
Symmetricom recommends deploying DCD-LPR as illustrated below in all MSC locations.



The fault-tolerant DCD-LPR system provides the high levels of reliability the network requires, ensuring continued operation of the MSC at maximum efficiency. The GPS-derived timing signal is used to steer dual rubidium-based Stratum 2E atomic clocks or quartz-based Stratum 3E clocks, in an ensemble arrangement, providing holdover accuracy that is better and far more reliable than from any single source. The DCD-500 series shelf uses a quadruplicated system bus, meaning that three out of four system buses can fail before timing performance is reduced.

The rooftop antenna equipment is built to withstand temperatures from -40 to +70 °C, and winds to 100 knots. A fiber-optic antenna cable and lightning protection provide electrical isolation to safeguard office-mounted equipment, while freeing antenna installation from distance restrictions common to metallic cable.

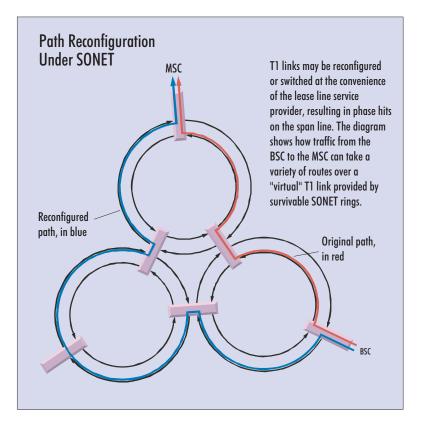
The MSC contains many different types of network equipment, in addition to the switching element. DCD-LPR serves as the Building Integrated Timing Supply (BITS) as first defined by Bellcore and AT&T, and now prescribed by ANSI Standards for all national and regional carriers for their central office nodes. Besides ensuring, no matter what other network conditions exist, that switching equipment is properly synchronized, deploying BITS clocks at the MSCs also provides any other collocated network element such as a digital cross connect system, BSC, BTS, ATM node and channelization equipment with continuous, Stratum 1 traceable time and frequency references with Stratum 2E or 3E holdover.



Base Station Controller Synchronization

The Mobile Switching Center is definitely the heart of the wireless infrastructure network. Every circuit from a mobile handset is served by a BTS which then homes into the MSC via the BSC. The MSC routes the calls to the PSTN, another MSC, an Internet Service Provider (ISP), or a private network for connection to the appropriate destination. If every base station talked directly to the MSC, traffic would become too congested. To ensure quality communications via traffic management, the wireless infrastructure network uses Base Station Controllers as a way to segment the network and control congestion. The result is that MSCs route their circuits to BSCs which in turn are responsible for connectivity and routing of calls for 50 to 100 wireless base stations.

If the MSC is the heart, then the MSC-BSC-BTS connections are the major arteries of the wireless infrastructure. The general synchronization plan for wireless networks is to deploy Stratum 1 reference sources at the MSC locations with Stratum 2E or 3E holdover clocks and associated distribution equipment. All network clocks located in other network elements such as a BSC and or BTS must be traceable to the Stratum 1 source in the MSC.

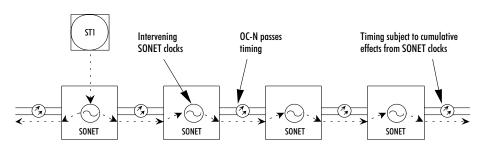




The simplest approach is to "slave" the BSC and BTS to the "master" clock in the MSC. Implementation of this master-slave plan requires disciplining resident clocks in the BSC/BTS to a recovered network reference. However, a simplistic master-slave plan typically falls short of its goal because of network performance impairments created by SONET and the increasing likelihood that wireless infrastructure circuits will be transported over multiple networks for ubiquitous connections between the MSC and BSC/BTS.

SONET Ring Synchronization Considerations

Traditional telephony networks, composed primarily of OC-3 and OC-12 circuits for interoffice trunking, are the mainstay of MSC-BSC-BTS connectivity. As illustrated above, MSC-BSC-BTS connectivity is typically accomplished today by interlocking SONET rings. Where multiple SONET rings are used, multiple SONET network elements (NEs) are cascaded with an associated deterioration in traceable Stratum 1 reference. As shown in the diagram below, the SONET NE uses the derived T1 as a traceable synchronization reference to discipline embedded SONET clocks within each network element. Each node in a SONET network represents a location where timing is received, derived and then retransmitted. SONET network elements use a 20 ppm accuracy clock, compared to the more stringent frequency stability requirements of the cellular/ PCS "on air" channels of 0.05 ppm for CDMA and GSM and 0.5 ppm for TDMA. When these SONET 20 ppm clocks are cascaded, timing characteristics can be expected to accumulate. So, when many clocks are linked together, timing problems can and do occur. Due to the much higher bit rates and the smaller equipment buffers of SONET, even a small perturbation in timing can have a dramatic impact on network operation.



Reconfiguration of SONET Rings-Synchronization Considerations

Additionally, as shown in the SONET ring diagram, network service providers can and do reconfigure circuit routing. These circuits, which the wireless service providers lease from wired service providers, allow MSC-BSC-BTS connectivity.

In the past, there was only one wired service provider for each geographic territory, the local telephone company. Deregulation of the telecommunications industry has created a new class of service providers sometimes referred to as Competitive Access Providers (CAPs) or Competitive Local Exchange Carriers (CLECs). CLECs typically offer SONET transport at a much lower cost than the local telephone company, but, because of their recent emergence and financial constraints, usually have much smaller service areas. Wireless service providers are now likely to have a mix of leased-line service providers within the same geographic region.

Leased-line service providers can have differing approaches to network synchronization. They also periodically reconfigure facilities. These are factors wireless service providers cannot control. Certainly, wireless service provider should hold their leased-line service provider to very high standards in the area of synchronization. The problem is, however, that leased-line services typically do not come with a "quality of synchronization" specification. Or if they do, these services will carry higher service rates. So, wireless carriers are left at the mercy of their leased-line provider when it comes to synchronization quality received at BSC and BTS locations.

Even if high quality synchronization is available, network reconfiguration is inevitable. When these circuits are re-arranged, phase hits occur. Phase hits result in frequency shifts well in excess of proper synchronization guidelines (such as ANSI T1.101) for network end-points and of CDMA, GSM and TDMA specifications. Phase hits and frequency shifts of these magnitudes will result in problems with voice and data transmissions at the BSC and frequency movements in the "on air" channels at the BTS.



BSC Synchronization Issues

MSC-BSC-BTS connectivity requires proper synchronization. The simplest solution, as discussed previously, is a master-slave configuration where BSC and BTS clocks are disciplined to the recovered network clocks from the MSC. Major problems in implementing this simple master-slave solution include:

- cascaded SONET clocks degrade performance from 20 parts per million to unacceptable performance after passing as few as a couple of SONET network elements
- recovering clock from SONET transport is not always possible
- recovered clock from SONET facilities echo any transmission impairments experienced along the lines such as facility reconfigurations and SONET pointer adjustments
- traceability to a Stratum 1 reference source must be maintained
- multiple leased-line carriers magnify the problem by differing synchronization plans and crossing and re-crossing network boundaries

Synchronization is guaranteed

Removing problems presented by cascading SONET clocks, a multitude of leased-line service providers and network reconfigurations is easy. Just assume direct responsibility for the synchronization network. By installing standalone Primary Reference Sources and Building Integrated Timing Supply within all major transport nodes and BSCs, wireless providers should eliminate all synchronization-related problems.

Symmetricom has designed the TimeSource 3000 specifically for the transport node and MSC/BSC application. The TimeSource 3000 allows continuous Stratum 1 reference via GPS receiver as well as Stratum 3E holdover, with as many as 10 outputs for timing of collocated network elements. The TimeSource 3000 puts the GPS receiver in the antenna housing, allowing antenna installation up to 1,000 feet from the office equipment without requiring in-line amplifiers.

Symmetricom also offers the TimeSource 2500, which shares standalone PRS performance with the TimeSource 3000. However, it comes with a special antenna and software that allows placement of the small antenna unit in a window or through the wall to allow low cost installations where economical rooftop antenna placement is not available. Equipped with a rubidium oscillator, it provides stable time and frequency references, meeting CDMA requirements, despite viewing a single GPS satellite no more than 40% of the time. With the TimeSource 2500, GPS in the window shows Cesium the door.

Together, the TimeSource 2500 and TimeSource 3000 offer economical solutions to meet the widest range of MSC and BSC environments.

Symmetricom has both standalone solutions for the MSC, BSC and BTS and modules that can be integrated directly into network elements. Call one of our representatives today to learn more about recommendations for network synchronization and associated equipment designed for mobile switching, base station control and cell site equipment. Please visit our web site at www.symmetricom.com, or give us a call at one of the locations on the back cover.



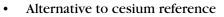
TimeSource 3000



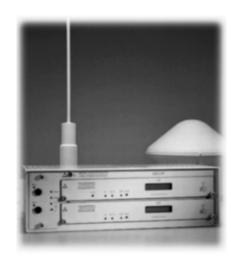
- Stand alone Primary Reference Source (PRS)
- BESTIME clock algorithm allows ensembling of up to four time/ frequency references in addition to GPS
- GR2830, ANSI T1.101 and NEBS compliant
- T1, 10 MHz, 1 PPS and time of day outputs
- TL1 and TimeScan management
- Up to 10 outputs (2 standard)
- 3.5 inch high shelf
- IF antenna provides 1,000 foot cable runs without amplifiers
- Sync Status Messaging (SSM)

TimeSource 2500





- Network Primary Reference Source (PRS)
- BESTIME clock algorithm allows ensembling of up to four time/ frequency references in addition to GPS
- No outside antenna required antenna in the window operation
- Network PRS GR2830 MTIE and TDEV compliant
- 2 T1's, 10 MHz, 1PPS/time of day outputs
- BTMON PC management
- 3 inch high shelf
- Optional wall mount antenna
- Sync Status Messaging





Symmetricom

2300 Orchard Parkway San Jose, CA 95131, USA tel: 408-433-0910 fax: 408-428-7897 e-mail: sync@telecom.com http://www.symmetricom.com

Symmetricom Europe

2 The Billings Walnut Tree Close Guildford, Surrey GU1 4UL, England tel: 44-1483-510300 fax: 44-1483-510319

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