Base Station Synchronization in Wireless Networks: Cellular, Fixed Broadband, Wireless LAN

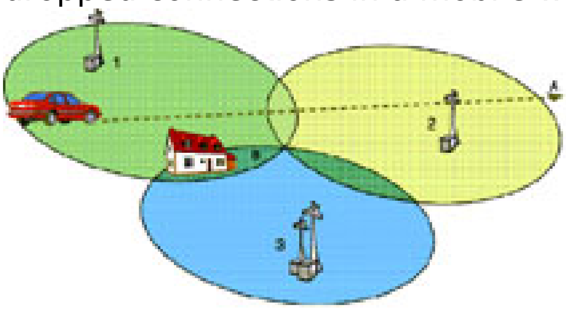
Datum-Irvine

Wireless networks come in many different flavors, from the familiar cellular phone network to fixed broadband to wireless LANs. Although each is a very different application they are all dependent on a common base station architecture. The base station, (also called cell site, picocell, or access point depending on the technology) is the connection point between the wired and wireless world. And it is the last point where a synchronization reference can be introduced into the network before signals hit the airwaves.

And while all communications, wireless or wireline, require synchronization the unique nature of the wireless network places a premium on base station synchronization. In fact, in providing quality wireless communications, synchronization is as important as cell coverage, signal strength, or bandwidth. Your wireless network can have the best cell plan, state-of -the-art transmitters, and employ the latest modulation technique, but your network won't get off the ground without world-class synchronization. Two chief design considerations drive this requirement for base station synchronization.

1. Soft hand off as mobile users move from one cell to another

In any mobile network, customers must be able to maintain a connection as they move from cell to cell. Take the familiar situation of talking on a mobile phone while driving. Your trip takes you through a cellular network as shown by arrow A below. For your call to continue without being dropped as you pass from cell 1 to cell 2 requires a soft handoff of your signal between the cells. If the signals transmitted from these two cells are not closely synchronized, the signal reception cannot be smoothly transitioned between cells. The soft handoff fails and your call is dropped. Lack of proper synchronization between cells is one of the primary reasons for dropped connections in a mobile wireless network.



2. Coherency in overlapping coverage areas

But what about wireless networks where customers don't move, such as a wireless LAN, or fixed wireless technologies like, MMDS, Wireless Local Loop, or Digital Broadcast. Why do these networks require tight base station synchronization? The answer is coherency in overlapping coverage areas. Refer again to the simple wireless network above. The wireless customer is at point B, they are receiving at least 2 signals: one from Cell 1 and one from Cell 3. If the Cells are not synchronized their signals will interfere with each other and the result is lost or degraded reception for the wireless customer. This synchronization requirement is common across both mobile and fixed wireless networks.

How Do I Synchronize My Wireless Network?

So, how are base stations synchronized to meet these critical requirements of wireless networks? Today, the solution that combines both high performance and low cost requirements of the wireless world is the GPS (Global Positioning System) Disciplined Oscillator.

Although GPS is most closely associated with navigation applications, GPS satellites transmit a highly accurate one pulse per second signal (1PPS) which can be used to synchronize GPS receivers to within a few nanoseconds (1E-9) of GPS Time1. This accuracy rivals cesium atomic clocks at a fraction of the cost and size. The GPS signal also has the benefit of being available in the same format anywhere in the world that has a sky view. And with the advent of low-cost GPS receivers, each base station in a wireless network can be inexpensively outfitted with a GPS synchronization reference.

However, a GPS receiver alone is not enough. Although the 1PPS from a GPS receiver is extremely accurate over the long term, its short term stability (one pulse measured against the next pulse) can vary significantly. Moreover, the GPS signal reception is subject to regular temporary outages. These outages can be caused by RF interference from co-located transmitters, severe weather, or obstructed sky-view (from buildings, foliage, etc.). To solve these issues, a stabile reference oscillator is added to the GPS timing system to provide a frequency with excellent phase noise and short-term stability. When this oscillator is disciplined, or locked, to the GPS receiver 1PPS output, the result is a system with the cesium-like long-term stability of GPS along with spectral purity and shot term stability that is only limited by the oscillator employed in the system.

The second function of the reference oscillator is to maintain the accuracy of the system during losses of the GPS signal like those described above. The time that the oscillator can remain accurate while not locked to GPS is referred to as the holdover period. The duration of this holdover period is dependent on the stability of the oscillator. Below are some typical values for the holdover for Quartz and Rubidium oscillators, two commonly implemented applications, E911 and CDMA.

Accuracy &lt 1 sec
(E911/ Wireless Location/Digital Broadcast
Requirements)
Quartz = Up to 2 hours
Rubidium = Up to 24 hours

Accuracy &lt 7 sec
(CDMA Requirements)
Quartz = Up to 4 hours
Rubidium = Up to 48 hours

Today, the 2 hour holdover provided by the typical ovenized crystal oscillator is sufficient to cover most temporary losses of GPS signal in non-critical applications. But next generation network standards with goals of better reliability and higher performance are pushing requirements beyond the capabilities of crystal. CDMA, for example, calls for a minimum of 8 hours of holdover, with most manufacturers using a de facto standard of 24 hours. These new standards can only be met with the stability of a rubidium oscillator.

And there are real world factors, beyond standards, driving the need for more stabile oscillators in GPS timing systems. As feasible antenna locations become more crowded and antenna systems are relegated to less optimal sites, GPS signal loss due to RF interference and obstructed sky-view has become more prevalent. To combat this trend, many network designers opt for the additional holdover of rubidium to ensure continuous service. And in the event of a permanent failure of the GPS receiver or antenna the extended holdover of rubidium provides enough time for maintenance crews to service the system before synchronization falls out of tolerance. In this way a wireless network provider can be sure that their network will never suffer a loss of operation (and revenue) due to GPS failure. This is especially important for mission critical and high reliability applications.

So, it is this combination of the GPS Receiver and high stability oscillator that can synchronize a wireless network with high performance and reliability. Today, GPS Disciplined Oscillators are found in every form of wireless network: Cellular, Fixed Broadband, Digital Broadcast, Private Radio, Wireless LAN and more. And with GPS receivers being manufactured in large volume and small size the GPS Disciplined Oscillator system can meet the cost targets of all these highly competitive telecom markets.

Datum-Irvine has been a provider of GPS based timing and synchronization solutions since the launch of the Global Positioning System in the 1970s. In fact, Datum provides the time and frequency standards on board 22 of the 27 GPS satellites currently in operation. Today there are many companies manufacturing GPS disciplined time references. But Datum, with its StarLoc family of products, is the only manufacturer that provides the full spectrum of GPS solutions, including both quartz and rubidium oscillators, in a compact, low-cost design that can be tailored to the needs of any network synchronization requirement.

1. GPS Time is a precise time standard that is related to UTC (Coordinated Universal Time). The major difference is that GPS time is a continuous time usually measured in weeks and seconds from the GPS time zero point of midnight, January 5, 1980. Controlled by UTC, GPS time is not corrected with leap seconds, and so is currently ahead of UTC by 13 seconds.