GPS Synchronization

SOLVING THE RADIO CO-LOCATION PROBLEM IN A DENSE NETWORK

The "Dense Deployment" Problem

In a densely deployed network, interference among your own radios becomes an issue. Many radios need to be deployed in close proximity. Other radios may be operating in another frequency channel and antennas may be pointed in other directions, but due to the very short distance, the received signal from another radio's transmitter may be very strong and could severely degrade the performance for all of the radios at the same location.

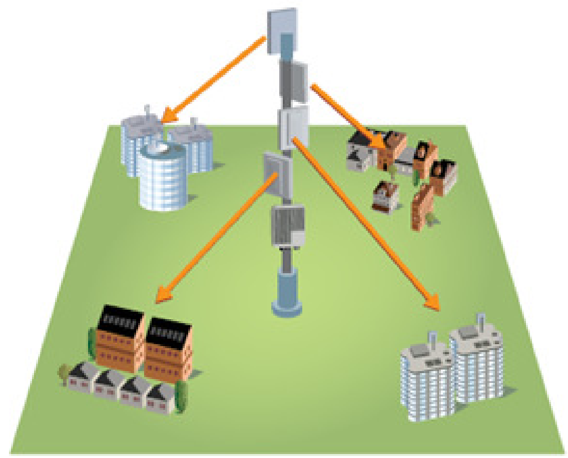
Yet, in a densely deployment network, the "co-location" of radios is desirable. ISPs need to add base stations to increase the network capacity. Backhaul radios may be added to handle the increase traffic. Video surveillance networks may need to co-locate many PTP radios at the hub site.

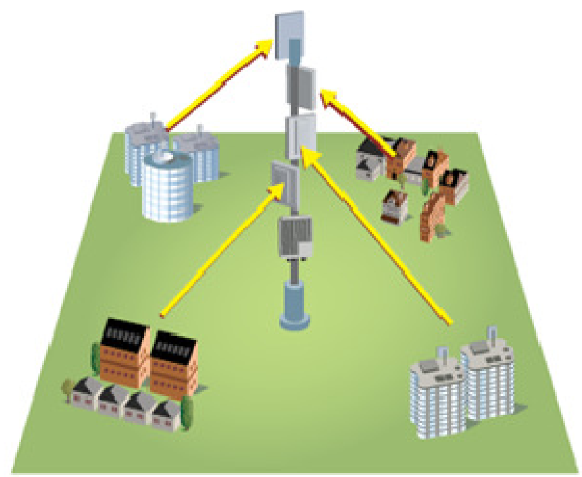
In most cases, the "real-estate" at the tower or rooftop comes at a premium—the space at a tower may be limited and you may be given only a small section to mount many radios (sometimes, many radios on a single mast). Heavy tower lease costs may lead you to consider radios and antennas to be mounted practically next to one another.

The Solution: Synchronization via GPS

One solution to avoid this type of "self-interference" is to time the transmit and receive windows for all radios. That way, no radio would be in the "receive" mode when other radios are in the "transmit" mode. Time slots are designed in a way to repeat these transmit and receive windows in a periodic manner.

In order to synchronize these time slots for many radios, a reference signal is needed and that reference is provided by the GPS system, which provides pulses at 1-second intervals. All radios participating in the synchronization network must be connected to a GPS controller that feeds reference signals based on GPS pulses. GPS signals can provide common references to multiple GPS controllers deployed regionally over many sites. The benefit of GPS is that it is available anywhere, the system is very reliable, and the access to the signal is easy with a small GPS antenna.





HOW GPS SYNCHRONIZATION WORKS:

The top diagram indicates a downlink time slot where all base stations on the same tower are transmitting packets to clients (base station receivers not open).

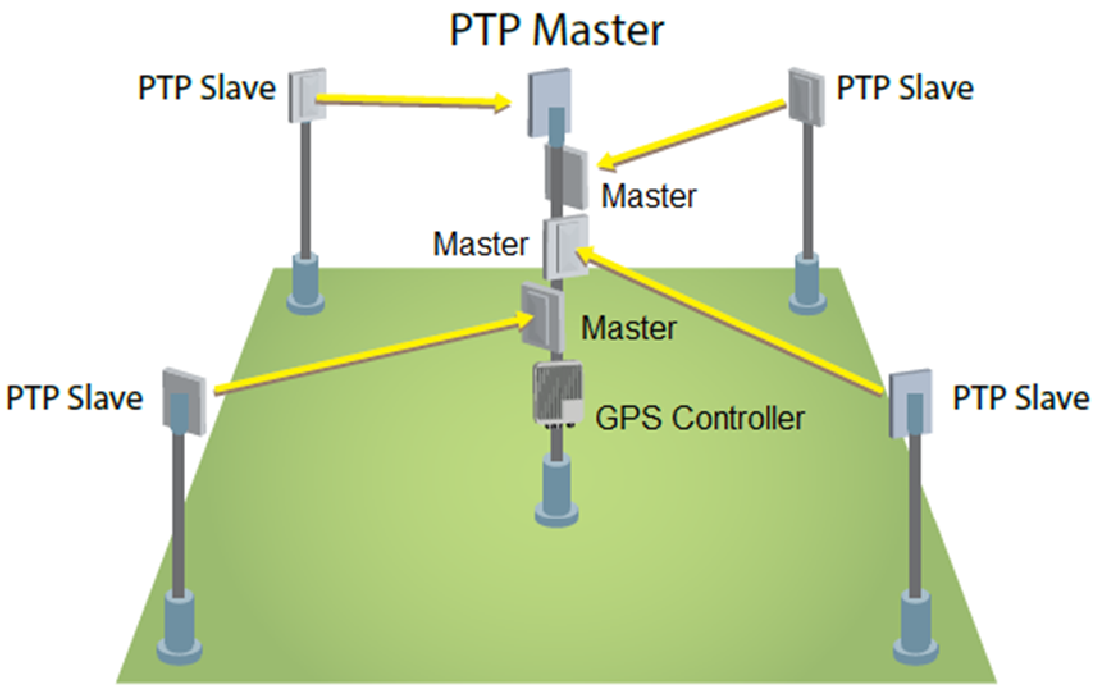
The bottom diagram indicate an uplink time slot where all base stations are receiving packets from client units. During this slot, all base station transmitters are shut down, thereby eliminating receipt of unwanted transmit signals from neighboring base stations.

Main Applications

As mentioned previously, the main purpose of GPS synchronization is to eliminate problems associated with radio co-location. The following are the primary applications where GPS synchronization is particularly useful.

- ISP Networks — A base station site is typically deployed with multiple base station sectors, which increase the network capacity and also allows directivity of sector antenna for optimum coverage from the base station site. At times, the ISP may need to add additional base stations to handle increased amount of traffic. GPS synchronization thus provides easy scalability for network expansion by allowing additions in a tight space without reconfiguring the tower-top hardware already installed.
- Aggregation of data to a central hub site — Many network architectures require data to be brought to a central site. ISP traffic may be brought to a point of presence to be transported to its backbone network. Video surveillance images need to be backhauled to a central monitoring station for instant analysis, response decision, and storage for future use. Due to high bandwidth cameras these days, the hub site may need a co-location of multiple radios, including multipoint base stations and/or PTP links. This case is shown in the diagram below.

In fact, the use of GPS antennas has been a popular approach in the cellular industry where space optimization is a key issue in deployment.

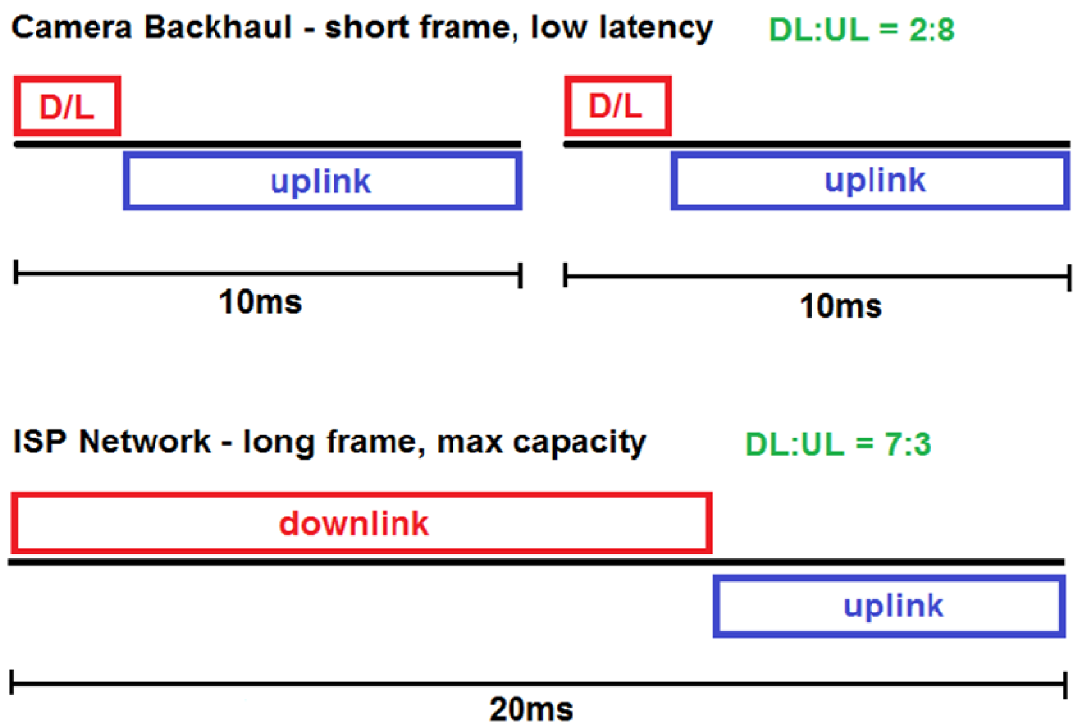


PTP Backhaul Link Synchronization:

In addition to multipoint base stations, PTP backhaul links can be synchronized in a similar way when many PTP links need to be aggregated at a central hub site. In order to do this, all Master PTP units, much like multipoint base stations, should be mounted at the central site.

Solectek GPS MAC: How it Works

In order to implement synchronization, Solectek has incorporated a new protocol called GPS MAC (GMAC). The GMAC is an enhanced version of Solectek's earlier polling MAC protocol, a deterministic multiple access scheme for multipoint base stations. With GMAC, time slots of downlink and uplinks are implemented on top of polling MAC. The following diagram illustrates how the time slots work for two different applications:



Network operators must choose the following parameters:

- Frame size — This defines the each cycle of one downlink time and one uplink time slot. The choices are 10ms and or 20ms. The shorter frame size has the advantage of lower latency. The longer frame size maximizes throughput but has a longer latency.
- Downlink/Uplink Radio (D/U ratio) - This defines the ratio between downlink and uplink within each cycle (frame size). The Downlink heavy applications link ISP services may use something like 7:3 ratio, whereas uplink heavy video surveillance network may use 2:8.
- During the downlink time slot, base station sends packets to subscriber units in a round-robin, deterministic manner controlled by the underlying polling MAC protocol. Subscribers send packets to base station during the uplink time slot in a similar manner.

Better Utilization of Frequency Channels

Without GPS synchronization, co-location of radios was based on three factors:

- Frequency channel separation — use of channels far apart from each other will allow better isolation.
- Physical separation — larger distances between radios will allow better isolation.
- Polarization separation — alternate use of vertical and horizontal polarizations can further isolate radios.

Of these polarization separation is no long in play due to modern radios' use of MIMO, dual polarization antennas. Without synchronization, there is no usable set of guidelines for just how far apart channels and physical distance have to be and this is particularly true when there are a number of radios being co-located.

With the use of GPS synchronization, the following simple rules apply:

- Physical separation — There is no real requirement for physical separation, other than the practical distances needed for mounting hardware and routing cables.
- Channel separation — With the close proximity deployment, channels must be separated by one more than adjacent channel. For example, two 20 MHz channels centered at 5735 and 3775 MHz can be co-located, but not 5735 and 5755 MHz.

Note — In cases where you are forced to use adjacent channels, at least 6 ft of physical distance between the antennas and a good directivity separation is recommended.

Field Test Case:

The above picture indicates the antennas used in actual field tests. All three are identical 90 deg sector antennas operating at 5.8GHz. Note that they are as closely mounted as possible, given the mounting hardware and cable routing.