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GPS Everywhere versus Synchronization System - IEEE 1588v2 Telecom Profile

Challenges and Benefits

White Paper

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Introduction

This provides a deep analysis between the following two synchronization implementation methods for mobile networks:

- "Scenario 1: GPS Everywhere": GPS everywhere to all access equipment (Macrocell, Smallcell, Picocell, and so on.)
- "Scenario 2: System Synchronization": Synchronization network distributing timing through the IP networks.

All analysis considers a technical and financial point of view.

Scenario 1: GPS Everywhere

Many Vendor/NEMS offer synchronization based on GPS antennas to each Cell Site deployed. This method is common for turnkey projects, normally used during technology migration as it evolves from 2G to 3G or 3G to 4G networks.

This implementation method can guarantee an autonomous model to turnkey projects, as there is no need for any integration with existent resources and possible issues with carrier network as congestion, QoS configuration to sync packets, PDV, and so on, enable initial working and faster acceptance.

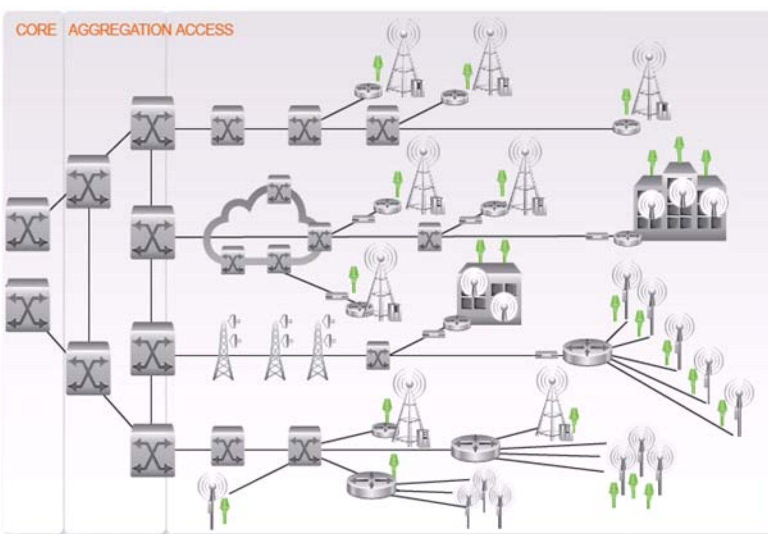

Figure 1 **• GNSS for Every Base Station, Cell Site Router or NID**

Although the scenario 1, using GPS in each Cell Site, aims at reducing the cost and ensuring the timing of all the antennas, there are significant technical points of vulnerability that must be considered for a mobile network expansion design.

GNSS System

GNSS system (GPS, Glonass, Beidou or Galileu) naturally operates intermittently with various vulnerability times throughout the day. This results in loss of GNSS visibility constellation due to:

- Meteorological factors such as rain, fog, heavy clouds, and so on, which attenuate a naturally weak signal (GPS signal reaches the Earth with signal strength around -150 dBm to -160 dBm).
- Factors related to infrastructure where GPS is located, as limited satellite view or excessive signal attenuation, nearby engines, and so on as shown in Figure 2.
- Atmospheric effects and interferences regarding RF signal, such as Doppler, nonlinear attenuation, shadows, signal reflection or multi-path, and so on as shown in Figure 4.
- External interferences from noise sources such as: radio transmission in general, jammers (privacy devices that blocks GPS signal), harmonics, and so on as shown in Figure 3.

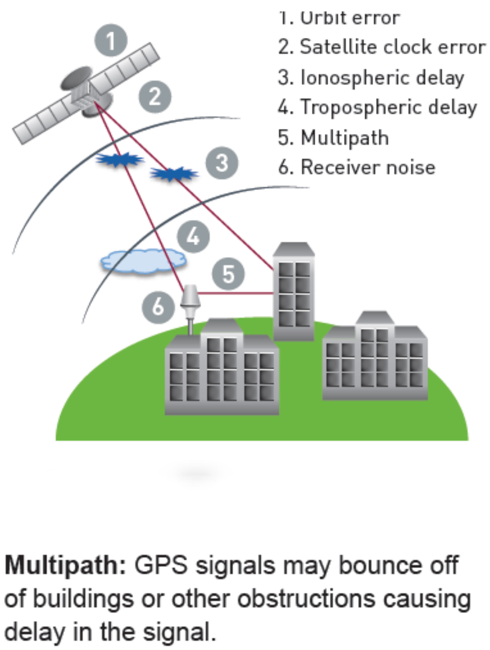

Figure 2 • **Sources of GPS timing errors**

Figure 3 • **Jammer Device and Spoofing Equipment**

Figure 4 **• GPS Receivers are Exposed to Interface and GPS Antennas are Exposed to Breakage**

Indoor Installations

Installation of a GPS antenna indoors mainly in the small cell scope is often difficult. Usually due to large distances, local infrastructure requires significant modifications or new paths for cables, costs of roof top rental, and so on. Among other details, this demands re-amplification of GPS signals, which may endanger the installation process or impair the installation.

Figure 5 **• Aspects of Indoor Installations**

Total Cost of Ownership

Even at a reduced cost of GPS antenna, when all the variable are considered besides the number of antennas, the Total Cost of Ownership (TCO) tends to be pretty complex to determine (or in particular case overcomes expectations versus planning). Some causes of this complexity are:

- Logistics to maintain a large number of antennas, in additional a relative stock for possible replacements. Plus all paperwork involved as invoices, drive field teams, outage period, call center tickets, and so on must be added to total logistics costs. Remembering that many places in the world have a huge incidence of lightning and vandalism.
- As Nodeb or eNodeB clocks are not designed to support holdovers for a long time (normally they are designed to holdover signal from a couple of minutes to a few hours in some cases), Cell Sites due to distance can go days without sync signal, This can affect the network quality and loss in revenue after the Cell Site is out of service; not to mention the additional logistics and the costs therein to replace "a" GPS antenna.

New LTE-A Features

For the new services coming with LTE-A, the lack of synchronization in the eNodeBs crucially affects the network quality as a whole. **The users at the impacted eNodeB notice them, and the users around the site notice the service degradation where LTE-A features are activated (LTE-A features will be used to mitigate interference conditions in a shared resource, heterogeneous network among the different Cell Sites)**.Table 1 shows the importance of synchronization in LTE-A applications.

Table 1 • **Importance of Synchronization**

Application	Need for Compliance	Impact of Non-compliance
LTE-FDD	Call Initiation	Call interference and dropped calls
LTE-FDD	Time slot alignment	Packet loss/collisions and spectral inefficiency
LTE-A MBSFN	Proper time alignment of video signal decoding from multiple BTSs	Video broadcast interruption
LTE-A MIMO/COMP	Coordination of signals to/from multiple base stations	Poor signal quality at edge of Cells, LBS accuracy
LTE-A eICIC	Interference coordination	Spectral inefficiency and service degradation
Needs and impact are cumulative		

Holdover for Phase

Holdover is another important consideration. Oscillators made for end equipment such as routers, switchers, eNodeBs and so on are made to receive an external synchronization signal, from a robust source that can maintain holdover when cases mentioned in "GNSS System" occurs. In addition for phase, end equipment oscillator cannot maintain holdover, due to its type. Normally, Stratum 3, robust sync sources as GMCs are built with good oscillators such as Stratum 2 (Rubidium) or Stratum 2E (Improved Quartz). Rubidium can maintain up to 72 hours for phase and Improved Quartz up to 12 hours.

Scenario 2: System Synchronization

After network startup phase, carriers tend to migrate synchronization to protected, managed and scalable timing systems. Normally adopting Precision Time Protocol (PTP) to distribute timing through network is also known as IEEE 1588..

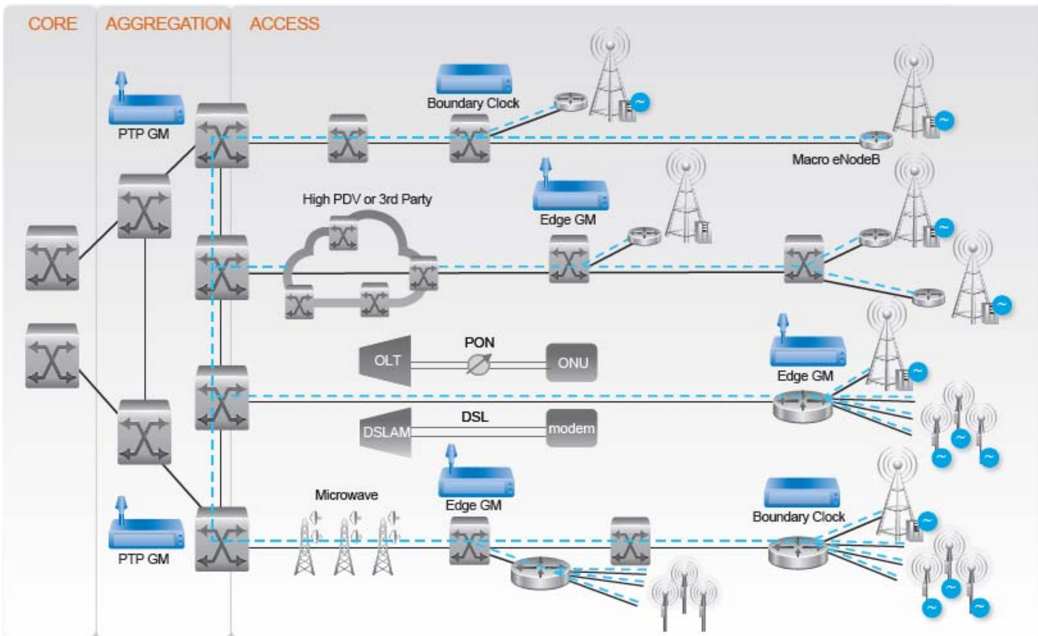

Figure 6 **• Partial On-Path Support and Edge Grandmaster Deployment Scenarios**

The scenario demonstrated above in Figure 6 with IEEE 1588 distribution, is the preferred method for carriers, because it protects investment and adds capacity to expand the network using the currently deployed synchronization infrastructure (complies with ITU-T G.8265.1 telecom profile), considering maximum number of hops allowed per transport network type in the project. For instance, even if GPS to Cell Site is already implemented, IEEE1588 is the only feasible protection mechanism if the local GPS in the Cell Site fails or gets damaged.

This type of approach also allows service providers to be ready for a new synchronization requirement that LTE-A demands for time and phase, based on profile ITU-T G.8275.2, which will be launched soon to the market. The main change adopted in the network topology by ITU-T G8275.2 is to attend with phase PTP clients, which guarantees time error budget in the target of ±1.5 μs. Figure 7 shows the ITU-T G.8275.2 - Network Topology.

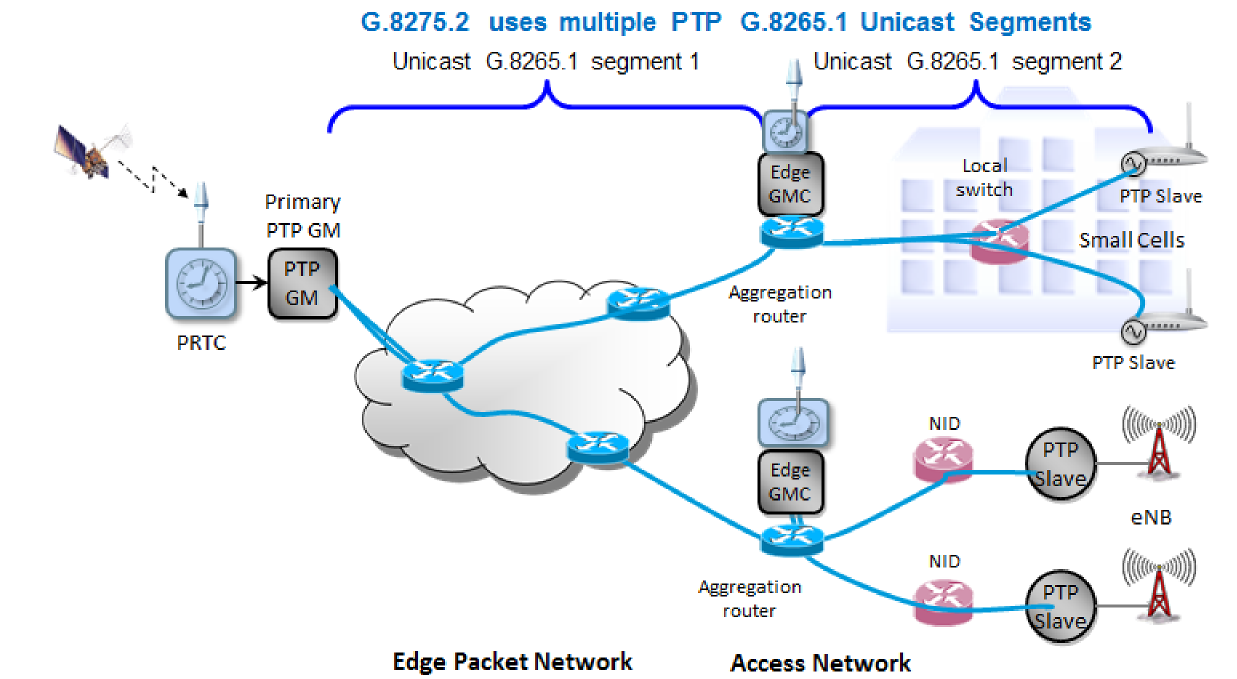

Figure 7 **• ITU-T G.8275.2 - Network Topology**

Advantages of PTP System over GPS Everywhere

Advantages of PTP System over GPS Everywhere:

- **Low Cost**: Lower final cost of the project, as a Grand Master Clock (GMC) can serve hundreds of LTE Cell Sites, in addition to supplying timing to 2G, 3G and the transmission network (Ethernet or Carrier Ethernet). Ensures the evolution and expansion of the network, without extra costs, while considering the GMC capacity limits and maximum number of hops.
- **Robustness**: The GMCs are much more robust and work with physical protection 1+1 (Modules and Oscillators are duplicated), in addition to systemic operation with geographic protection.
- **Long Term Holdovers:** Timing equipment is designed to have long term holdovers, using Rubidium as high performance oscillators thereby mitigating GPS vulnerabilities or loss of signal due to GPS antenna damage. Holdover in the end network elements as Cell Sites is virtually nonexistent.
- **Ease of Distribution**: Synchronization system can distribute a sync signal for the entire network from core to access, creating a single system shared by the entire network, This reduces investment costs as this resource can be implemented in conjunction with other areas at the service provider network.
- **Ease of Monitoring:** In a synchronization system based on 1588v2 or PTP, it is possible to monitor the flow from GMC to PTP client, so the operator can have a complete view about all synchronized PTP clients, increasing the visibility and control of network.
- **Telecom Profile Standard**: IEEE1588 was chosen by Deutsche Telecom, British Telecom, At&t and many others as an economic solution over "GPS Everywhere".

GPS at the macro eNodeB is not future proof (too expensive to add GPS to each small Cell later on).

Marketing News and Disruptions

Microsemi recently launched an innovative GMC to mitigate indoor installations and needs of GPS antenna outdoor.

IGM 1100i (Integrated GNSS Master) does not need an external antenna to work and can fit easily in an indoor environment as an AP WiFi or Femtocell for instance.

An alternative to this approach is now available by deploying a solution that fully integrates a 1588v2 PTP grandmaster with GNSS receiver and antenna in a small, fully contained package, designed to mount indoors. This approach eliminates the need for an outdoor antenna and related cabling which dramatically decreases the effective cost of the solution while providing all the performance requirements of a 1588 Grandmaster Clock.

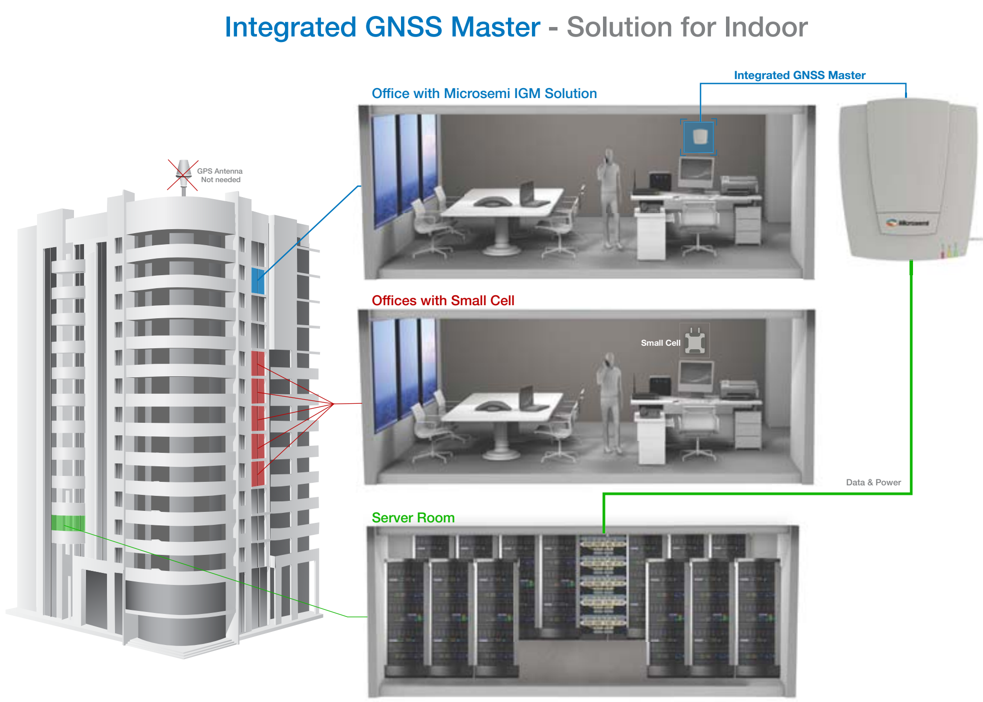

Figure 8 **• IGM Solutions for Indoor Environment**

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