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The Need for Time Synchronization

Abstract

Global Navigation Satellite systems (GNSS) play a key role as a timing source for synchronising both wired and wireless telecommunication networks in a variety of sectors like Energy, Telecom, Finance, Enterprise, and even Defence. The need for GNSS in these sectors will continue to grow as new GNSS constellations come up such as Galileo, BeiDou, and IRNSS (NAVIC). This Whitepaper gives a brief overview of the applications of GNSS based time and frequency synchronization in different sectors for those who are new to the idea. The main applications covered are Power Grids, Telecom Infrastructure like Base Stations, Stock Exchanges, large and small enterprise networks, and defence communication networks.

Contents

Power grids

In electrical power grids, the distribution companies use a device known as Phasor Measurement Unit (PMU) to estimate the magnitude and phase angle of an electrical phasor such as Voltage or Current. The measurements are synchronized to a common time source, at different locations on the grid using GPS/GNSS synchronized time source as reference. These devices are also known as Synchrophasors. Ideally, phasors are identical everywhere on the network. By analysing the synchronized measurement of the phasors in real-time at various points in the power grid it is possible to monitor, control and enable automated response to system conditions improving the grid reliability and efficiency. Typically the measurements by PMU at different locations at a particular time are expected to be made within 1us of each other.

Faults in power transmission lines cause transients that travel at near speed of light and propagate along the line as traveling waves. Double ended travelling wave fault location methods use precise measurements of time of arrival (TOA) of the traveling-wave at either ends of the transmission line to locate the faults accurately. To locate the fault within 150 m, the fault locating devices at either ends of the transmission line cannot have a time offset more than 500 ns between them. A fault at a place in the complex interconnected power-grid can affect the operation elsewhere in the grid. So for methodical analysis of the origin and reconstruction of the fault event, the event logs recorded at fault recording devices at various points on the grid must be timestamped with respect to a common time reference. Typically, these timestamp accuracies are expected to be within a quarter of a cycle, which in case of 50 Hz AC case, is 5 ms. Therefore the fault recording devices are required to be synchronized to each other with not more than 5 ms offset between them.

The GPS/GNSS synchronized time servers are typically synchronized to UTC and easily provide 20 ns RMS time accuracy. This time can be distributed to the devices either over dedicated lines using IRIG codes or over the ethernet using NTP and PTP protocols. Only IRIG codes compensated for cable delays and PTP provide microsecond or sub-micro second accuracies, whereas NTP may be used in applications that need 1ms-10 ms time accuracy.

Telecom

Synchronization of base stations is very important to ensure proper signal handoffs and reduced call drops. High speed data service requires stable and accurate frequency synchronization in the network. Typically, in GPRS and UMTS base stations the frequency accuracy requirement on the carrier frequency is +/-50 ppb. This requirement is met by relying on the backhaul transport network such as clock derived from T1/E1 signals for timing recovery. But as the backhaul transport networks switch to packet-based IP/Ethernet networks, this option is eliminated.

The network operators need to have either an independent source of accurate and stable frequency source (for example, Rubidium and GPS disciplined Oscillators) at each of the base stations or make use of synchronization technologies over the packet network such as NTP and PTP (IEEE 1588) to meet their synchronization needs. The quality of synchronization directly impacts the quality of service (QoS) provided by the IP network.

As the mobile communication technologies advance from 2G, 3G, 4G to LTE, there is also requirement for time synchronization of the networks. LTE/TDD networks in particular need time synchronization of less than 1.5 us for small cell radius <3Km and 5-10 us for a cell radius > 3Km.

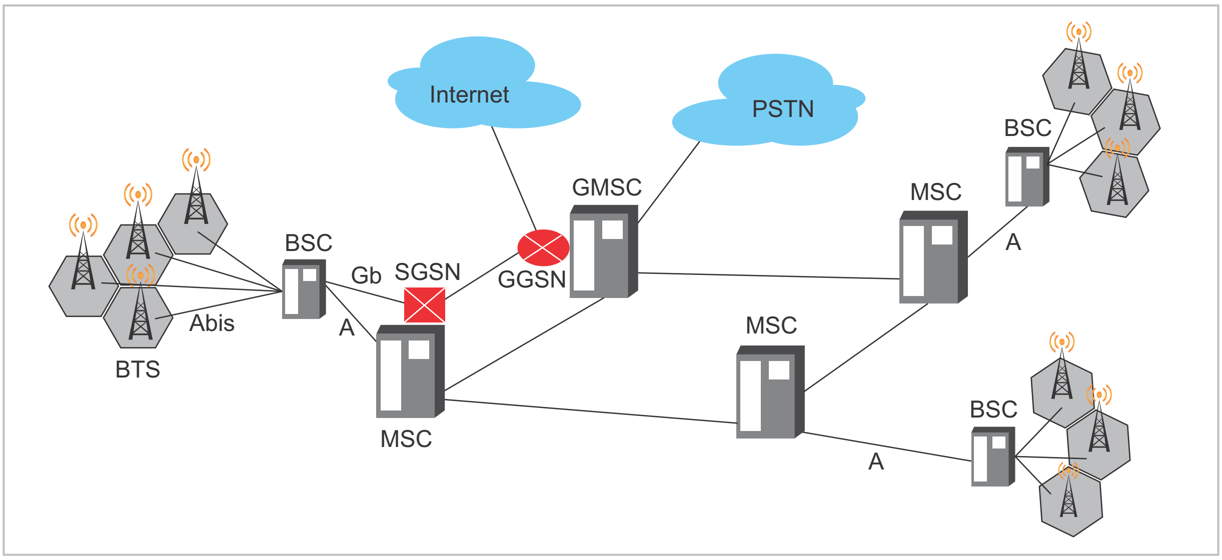

Figure 1 : Backhaul transport network interfaces used for synchronization in a GSM/GPRS network

Stock exchanges

In Stock trading, accurate timestamping of each transaction is important for a fair and secure operation. This also helps trace any irregularities and transaction failures. Most of the financial markets are synchronised using NTP protocol which provide up to tens of milliseconds of time synchronization to UTC. Recently the European Security Market Authority (ESMA) has defined in the Markets in Financial Instrument Directive (MIFID 2) within RTS 25 a timestamping requirement for transaction or an event to be accurate to 100 us of UTC time. Similar requirements would be brought into financial markets elsewhere in the world.

NTP in as is format would no longer be able to support such accuracy requirements, forcing the Financial market data networks to look at more accurate PTP protocols for its synchronization needs.

Defence

Defence networks use multiple communication channels such as wired Ethernet communication link, satellite radio link and fiber optic radio link for communication between different terminals that are far apart. These terminals could be stationary or mobile, on land, at sea or airborne. Although the network synchronization techniques and accuracies defined for telecom sector applications suffice for most of the defence network requirements, albeit there are certain applications where the synchronization and reliability requirements are very stringent. What makes the synchronization even more challenging in the defence sector is the associated harsh environment that the equipment is required to operate in. Almost all of the equipments in this sector need to qualify MIL standards for Environment and EMI/EMC. The methods and interfaces used for synchronization are very diverse in defence sector and mainly depend on the end application.

Although the synchronization requirements of different applications are mostly unavailable in the public domain. Some of the synchronization applications in defence include:

- Synchronization of defence communication network
- Distributed Radar synchronization and synchronization of ground missile system equipment
- Time and frequency synchronization of Mobile communication terminals in the field
- Accurate synchronization of equipment onboard ships and submarines with reliable and good hold-over performance
- Time Synchronization of equipment onboard fighter aircrafts and helicopters

The time synchronization requirements vary from a few milliseconds in communication networks to a few nanoseconds in distributed radar applications.

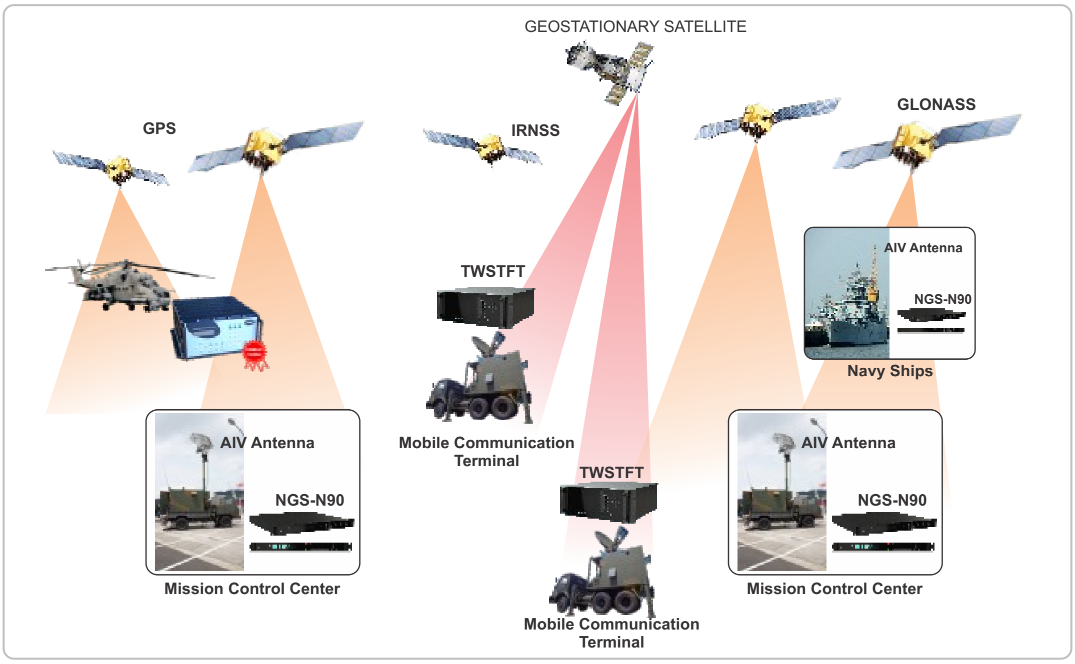

Figure 2 : Accord's Time synchronization products for defence

Enterprise networks

The need for synchronization of network elements in an enterprise network stems from the need for ability to analyse the fault or event logs in the network and take prompt corrective action to reinstate the network communication in case of network failure. This analysis is not possible unless the event logs in various network elements such as routers, switches, servers, desktops, laptops etc are all accurately time stamped with reference to a standard time source such as UTC. The network administrators are tasked to minimize the downtime of a network which can potentially cost money to the company. The accurately timestamped logs are the only way an admin can diagnose and address the fault in the network. These time stamps are required to be accurate to a few milliseconds.

Like the wrist watches, the clock sources in the PCs and other network elements lose or gain time with time depending on the characteristics of the oscillators used inside. Typically, these oscillator frequencies are not accurate and stable and tend to vary with ambient temperature and with age. The accuracy provided by these PC clocks is good enough when the resolution of time accuracy required is of the order of seconds. But for network management applications and in applications where transactions happen much faster, millisecond resolution of time stamping accuracy is essential. This accuracy is easily achievable using NTP servers on the network and having all the terminals synchronized to the Server.

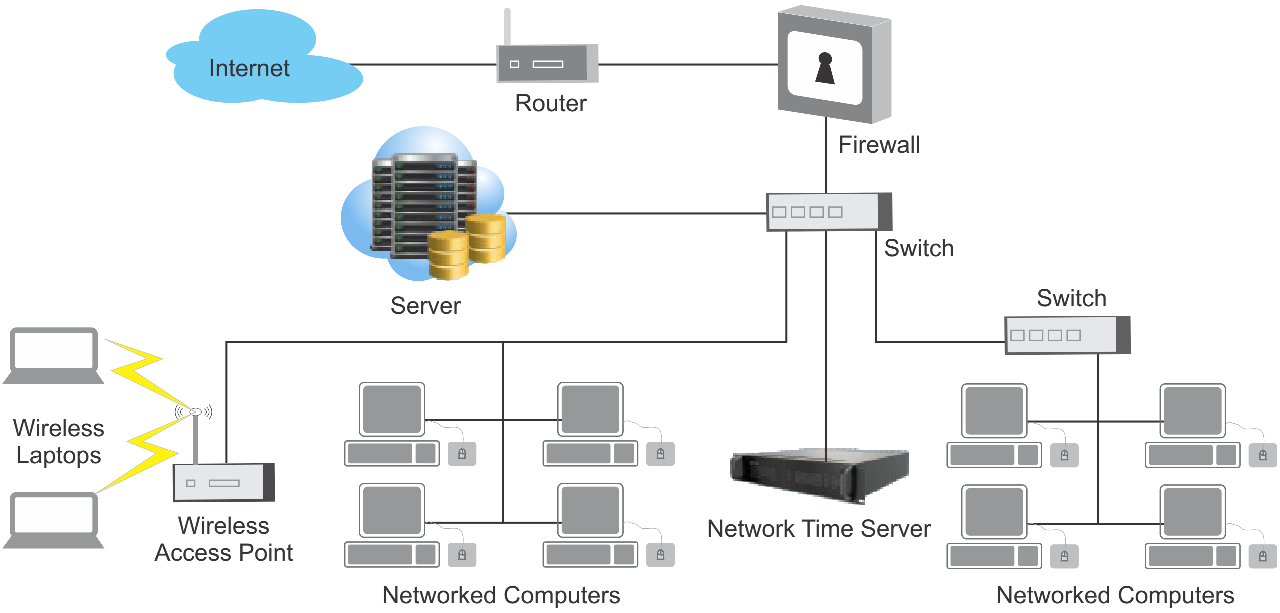

Figure 3 : An example of an enterprise network with Network time server deployment

Accord's Network Time Server NGS-N90 is designed to cater to different applications and comes with multitude of standard and non-standard customizable options to meet the specific customer requirements. To know about how we may help you in customizing our time and frequency solutions to meet your requirement, please contact ibd@accord-soft.com *with your queries.*

Check out NGS-N90: http://accord-soft.com/GNSS_network_time_server.html

References

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About the Author

Pranav Ginde is a Principal Technical Lead at Accord Software & Systems Pvt. Ltd. He holds a Master's degree in Communication and Signal Processing from IIT-Bombay and has over 11 years of experience in the design and development of GNSS receivers, CDMA transceivers and Time and frequency synchronization products at Accord.

About Accord Software & Systems

Accord Software & Systems designs and manufactures innovative solutions to help Customers maintain a Competitive advantage in their markets and achieve their business goals. We provide cutting-edge Positioning, Navigation and Timing products and solutions to Industry leaders in the Defence, Commercial and Semiconductors Business areas.

Accord has developed a vertically integrated GPS/GNSS portfolio consisting of Semiconductor ICs, Modules and solutions that cater to a variety of applications like Avionics, Automotive, Industrial, IoT, Marine, Telecommunications.

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