Implementation of Time Synchronization System

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Abstract- **Accurate timing is often required for the intelligent electronic devices (IEDs) , mission critical applications & all real time network systems etc. A common method of achieving this is direct connection of a device to a local GNSS receiver and the use of its 1PPS synchronizing signal and the IRIG-B coded message.**
However, concerns about GNSS reliability are encouraging the use of timing systems (TSS) less dependent on the direct use of local GPS/GLONASS/IRNSS receivers.
The "Time Synchronization System" is a real time embedded system used in association with GNSS receiver to provide stable accurate 1PPS signal to be used as major source to synchronize the multiple nodes over network thus helping the network nodes work in tandem on same time source.

Index Terms- **TSS, GNSS, 1PPS, IRIG-B.**

I. INTRODUCTION

Time synchronization (now onwards referred as TSS) is a multi-constellation (GPS, GLONASS, and SBAS) receiver with Rubidium oscillator based precise timing system.
TSS provides an extremely disciplined 1PPS timing signal aligned to GPS/GLONASS PPS signal. Internal rubidium oscillator provides the best possible holdover accuracy. System outputs timecode (IRIG-B and NMEA) signals for external device synchronization. To support network time synchronization, TSS supports the latest features of network time protocol (NTP) on Gigabit Ethernet port (10/100/1000Base-T).
The chassis supports GNSS input (GPS + GLONASS + SBAS (GAGAN)), IRIG-B input and NMEA input to synchronize the TSS time in the order of few nanoseconds. TSS is powered by AC 230V or 28VDC Power.

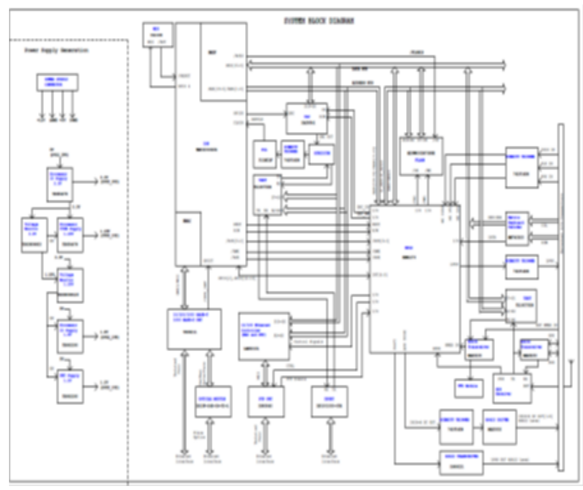

Fig1: System Block Diagram

II. TIME SYNCHRONIZATION PROTOCOLS

The different time synchronization protocol accepted internationally ie:
a) NTP protocol
It is one of the oldest and widely used protocols for time synchronization. It uses UDP/IP (USER DATAGRAM PROTOCOL) for sending the information through internet. PORT123 is dedicated universally for NTP communication between client and the server. Since the interconnected network is generally available and many NTP client software also available freely, there is no need for any additional infrastructure for synchronizing time over the Ethernet. The time offset between the client and the server is computed based on the four time stamps. These four time stamps are as follows Client transmit time stamp (CT) , Server receive (SR), Server Transmit(ST) and Client Receive(CR) . Based on these time stamps the offset is computed at the client end using the following formula

$$Ocs = ((SR- CT)-(CR- ST))/2 \qquad (1)$$

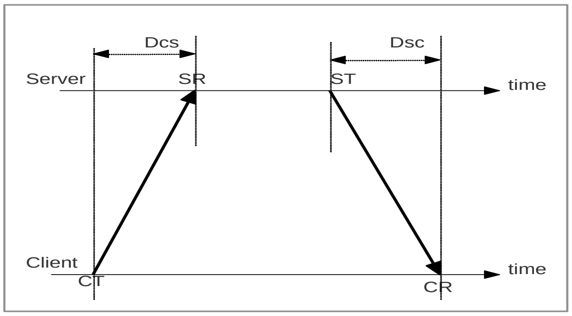

Fig 2 : Time synchronizing using NTP

b) IRIG B codes

Inter-range instrumentation group time codes are one of the standard time synchronizing methods employed in Defense or Aerospace application. This standard consists of a family of rate-scaled serial time codes with formats containing up to four coded expressions or words. All time codes contain control functions (CFs) that are reserved for encoding various controls, identification, and other special-purpose functions. IRIG- A has a time frame of 0.1 seconds with an index count of 1 millisecond and contains TOY in days, hours, minutes, seconds, tenths of seconds, and year information in a binary coded decimal (BCD) format and seconds-of-day in straight binary seconds (SBS).

The TSS proposed can make use of both these protocols to synchronize the systems over connected networks by utilizing 1PPS of GNSS signal or locally generated LPPS using stable rubidium oscillator.

III. SYSTEM ARCHITECTURE

The system architecture of a TSS using multi GNSS receiver is shown in below fig

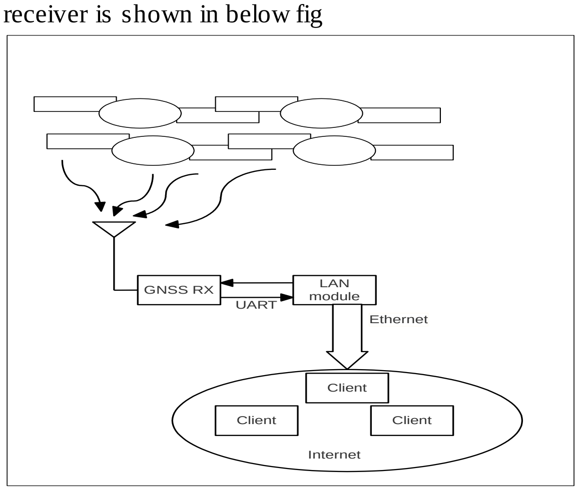

Fig: 1: System architecture of GNSS based NTP

The multi GNSS receiver that was used for this work is from ACCORD Software and System Pvt ltd. The LAN module is a system on module that houses a SoC that converts serial data to Ethernet.

The GNSS receiver sends a time message in standard NMEA 0183 format. This time message is in binary format consisting of hour, seconds and nano seconds field. On receipt of this message the LAN module updates its system time every second. Upon every NTP request the system time is used for time stamping (SR and ST).

There are two threads that run constantly i.e ACTIME thread, NTP thread. The flow chart of the same is shown below in Fig 4

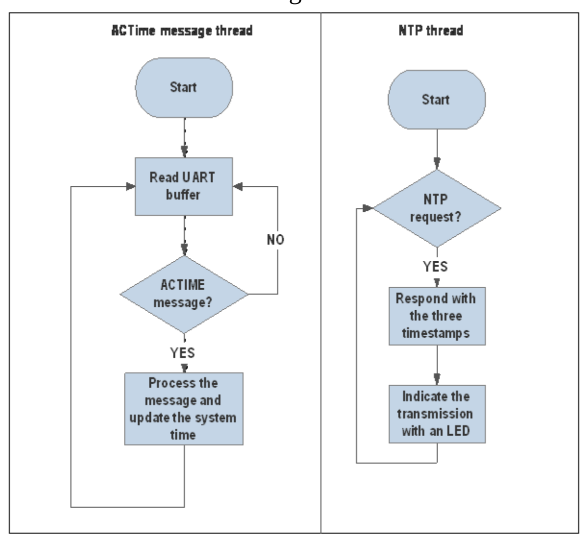

Fig 2: ACTime message and NTP thread

IV. RESULTS

For testing the system for performance of time synchronization, TSS was connected to a network with the server IP address set as 192.168.3.217. A computer system with Windows 7 operating system present in the same network is installed with custom NTP client software. In the same network the another computer system with Red Hat Enterprise Linux operating system is also used to log the time offset observed periodically from the our NTP server.

To measure the relative offset, Google’s NTP server is set as the primary reference source at the client. The time measurement then observed of our server is with respect to the time.google.com. The hardware setup is as shown in the below Fig. 5

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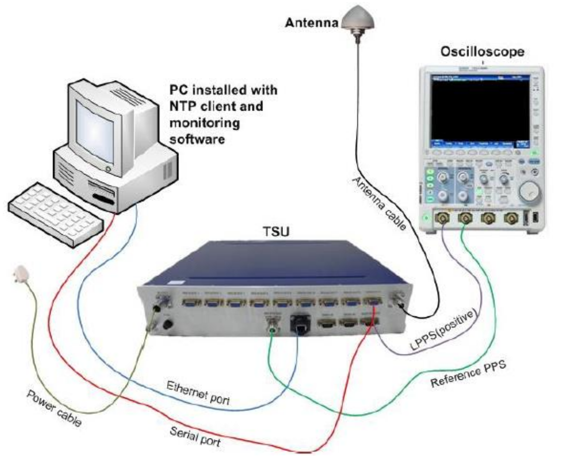

Fig 5: System Set up diagram

The client was setup to send request to the time server once every eight seconds. The logged data is analysed for offset and network delay. The data was logged for two trials and the results are averaged. The average offset and delay during the two trials of the test is as mentioned in below table

Table **1**: Average Offset and network delay

	Trial1	Trial2
Average Offset	-8.8ms	-12.2ms
Average Delay	0.905ms	0.915ms

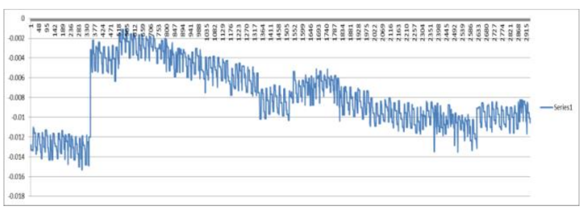

Fig 6: Offset trend, Trial 1

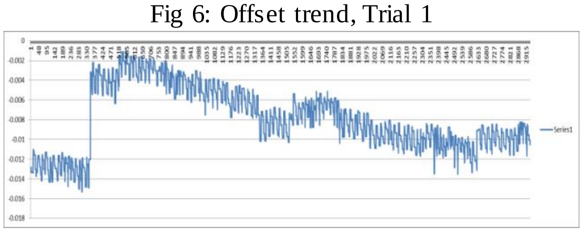

Fig 7: Offset trend, Trial 2

V. CONCLUSION

TSS was implemented using GNSS receiver. The receiver was set to provide position with all constellations i.e. GPS, GLONASS and GAGAN. The average number of satellites used for time and position computation during the entire trial was more than 7 to 8 . The antenna was placed on top of floor for better visibility of clear sky & free from obstacles.

The processing time variation was not captured during the implementation. Only the time data propagation delay from the receiver to the LAN module was compensated for time updating. The average offset in time that was observed at the client was less than -10ms.

VI. AKNOWLEDGEMENTS

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