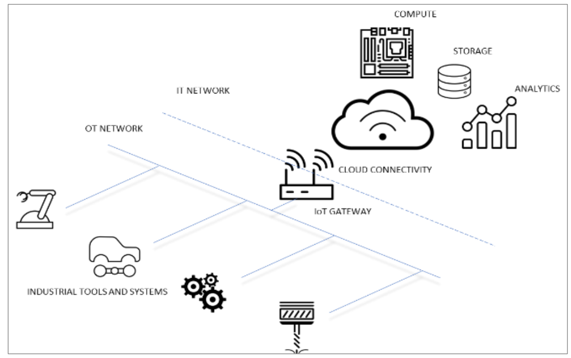
Precise Time Synchronization for Industrial IoT Applications

White Paper

This white paper provides an overview of the use of precise time synchronization in various Industrial IoT applications. Time synchronization technology has largely been driven by applications in telecom. However, recent advances in manufacturing automation, mining, oil and gas exploration and power generation rely on precise time stamping of data. This paper makes the case for precise time synchronization in these applications and the benefits thereof.

The IoT network is viewed as a combination of two separate networks – the 'IT' or, Information Technology network and the 'OT' or, Operational Technology network. The IT network provides connectivity and cloud-based infrastructure for data storage, processing and analytics. The OT network comprises a plethora of connectivity technologies and protocols that interconnect IoT device endpoints such as sensors and actuators within a local network. An IoT gateway acts as a bridge between the OT network and IT network and is therefore a critical part of the IoT infrastructure. So, what does this have to do with time synchronization?



Many Industrial IoT applications rely on precise coordination between sensors and actuators. In some applications, input from various sensors must be combined (or, fused) to derive the logic that drives actuators and other control systems. Since sensor fusion for low-latency time-sensitive applications must happen in real-time, the ideal place to implement it is at the edge of the OT network – in the IoT gateway. Such coordination requires precise timestamping of data that is being collected by various sensors. In addition, the biggest promise of IoT is the rich analytics from collected data and the operational efficiency that can be driven, based on these analytics. In a real-time context, such analytics only make sense when the time context of events are properly understood and factored in. Therefore, it is no surprise that precise time synchronization is emerging as a key enabler of real-time Industrial IoT applications.

Manufacturing Automation

Synchronized clocks, for example, can precisely timestamp the moment when a sensor measurement is going to be shared with the network. Beyond just being able to tell the right time when a sensor reading was taken – and therefore enabling critical analytics upstream (or at the edge computing node), poor sync could have other damaging consequences. If device clocks are out sync, messages being sent across the OT network by various devices and sensors will collide and require retransmission, thus causing increased power consumption. Clocks drift out of synchronization, especially those using low cost, commodity parts (low power IoT applications usually use off-the-shelf computing parts that are low cost as well, and therefore this becomes a de-facto choice for such implementations). Even in applications that do not directly involve real-time control, a robust and precise synchronized infrastructure is required for efficient post-processing and analytics. This need for precise time synchronization in an Industrial network has led to the development of several standards grouped under the umbrella term "Time Sensitive Networks" (or, TSN) under the auspices of IEEE. One of the key components of TSN is a network-based protocol for synchronizing the local clocks on networking equipment in the OT network. This protocol is defined by the IEEE1588 standard and is commonly known as "Precision Timing Protocol", or PTP.

Mining, Oil and Gas Exploration

The mining industry uses a technique called "Measurement While Drilling" or, MWD to characterize rock masses during the drilling process by continuously monitoring various drill performance parameters such as Penetration Rate, Specific Energy, Torque, Vibration and Air Pressure, among others. The data thus collected can be processed to provide vertical views for analysis of fluctuations in a drill hole, and horizontal views, which are critical (for both safety and optimal positioning) for planning mine blasts. Processing and analysis of MWD data involves correlating the various parameters and this is where precision time synchronization becomes important.

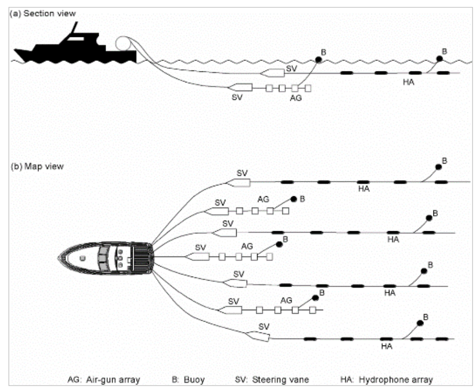
Mining systems are typically equipped with GPS receivers that provide the time base for timestamping data. GPS-based timestamping works well in areas that are fully exposed to the open sky, where GPS signals are not obstructed. However, in underground mining operations, where GPS signals do not reach, alternate mechanisms are required to deliver precise time to locations where it is needed. PTP, a specialized precise time distribution protocol can be used to deliver GPS-sourced time to various endpoint locations over wired links.

In addition to improving the quality of data collected during drilling operations, precise time synchronization can also help to improve the safety conditions inside a mine. As mining vehicles are starting to become autonomous, having precise timing in a vehicle and across the entire mine is critical to implementing collision avoidance systems and enabling a full 'scenario' analysis for post-event reviews.

IoT has the potential to bring about transformative changes to the Oil and Gas industry. In particular, IoT will enable improvements in operational efficiencies, provide enhanced safety and improve the quality of data collection for analytics, while lowering the cost of oil and gas production. Oil and Gas companies will have granular and unprecedented visibility over their infrastructure and operations, with the ability to monitor and control asset performance in real-time. As with Mining operations, Oil and Gas operations also involve drilling through layers of earth, using MWD techniques. One of the key business requirements here is to be able to predict drilling equipment failure in order to achieve zero unplanned down time. Equipment failure can put a rig out of production and cause cascading logistical and planning problems that prove costly. Such Non-Productive Time (or, NPT) are expensive, costing around $150,000 per incident. Precise timestamping of drill data can help to improve the quality of data, provide for enhanced real-time control of drilling operations and alert operators with early warning signals about impending problems with the drilling equipment.

Seismic Data Acquisition

Seismic Data Acquisition involves collecting signals reflected from various layers of subterranean earth in order to study the structure of the subsurface layers. A seismic survey uses an energy source, such as a small explosive that is set off in a shallow hole (also known as 'shot hole'), or a large vibrator truck that can generate a vibration on the ground. This shock wave, or seismic wave that is generated on the surface of the ground travels through the subterranean layers of the earth, is reflected by subsurface formations, and returns to the surface where it is recorded by receivers called geophones – similar to microphones, which are placed in a matrix configuration on the surface. By analyzing the time it takes for the seismic waves to reflect off of subsurface formations and return to the recorders on the surface, geophysicists can generate a 3D map of subsurface formations and anomalies and predict where oil or gas may be trapped in sufficient quantities for exploration activities.



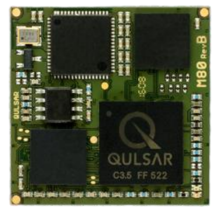
Marine seismic data acquisition uses the same principle of recording reflected signals. In this case, a water gun or an air gun is used to create a high-pressure wave. This wave travels down through the depths of the ocean, until it hits the various subterranean layers of earth at the bottom of the ocean and is reflected back. The reflected signal is then recorded by hydrophones that are located on the surface of the ocean. A marine seismic source is powerful, efficient, and effective due to improvements in towing technology, air gun performance and air gun array design. Towing two parallel streamer cables in three-dimensional surveys is now the rule rather than the exception and recording between 240 and 480 channels of seismic data is common.

With both, land and marine seismic data acquisition, the time difference between generating a seismic shock wave and receiving it at a recording station could range from a few milliseconds to perhaps 1000s of milliseconds. In order to accurately analyze the recorded data and generate 3D maps of the subsurface formations, it is important to ensure that the clocks of the shock sources and the recording receivers are all synchronized to a common time base. GPS could be used for this purpose. However, since the hydrophones are submerged underwater, GPS signals may not reach them. An alternate mechanism such as PTP is suitable for delivering precise timing to the hydrophones.

Wind Turbines

Recent advances in wind turbine research have focused on improving the operational efficiency and noise characteristics of wind turbines. In large wind farms, turbines "shadow" one another, and reduce the amount of wind that reaches downstream turbines. This creates "wakes" that reduce turbine output and increase fatigue issues that impact a turbine's longevity and reliability. Using accelerometers and vibration sensors, parameters such as wind direction and velocity are continuously monitored in order to steer the turbine for increased operational efficiency. In turbines that are located near populated areas, noise emissions that usually originate from rotating or vibrating parts must be reduced to a minimum. By using accelerometers, microphones, and rotation sensors, it is possible to measure and correlate relevant parameters, determine transfer functions and locate possible sound sources. To achieve meaningful results, data must be collected from various points on the turbine such as the turbine's nacelle, on the blades, the rotor, the tower itself and at various positions at ground level. Data collected from these sensors must be timestamped at a gateway before being processed (in the cloud or edge) for analytics. In some cases, the gateway itself must have some edge computing capabilities to be able to process and fuse the sensor data in order to control the turbine operation in real-time and with low latency.

Precise Timing Solutions



Qulsar solves these problems through an elegant suite of end-to-end precise synchronization products for multiple Industrial IoT applications. The Qg 2 Multi-Sync Gateway system is designed to serve as a source of GNSS-synchronized time stamps. The Qg 2 system delivers these time stamps using PTP to timing slave devices that are typically located in endpoint devices where sensor measurements are being made. Qulsar has a range of hardware modules and software-only implementations for timing slaves that can be tightly coupled and designed into these endpoint devices. Together, Qg 2 and the embedded slaves can be used to overcome network packet jitter and variability issues to deliver high precision sync in a scalable and robust way. In addition, for wireless environments, Qulsar's wireless sync (Quki) technology can be leveraged for distributing precise synchronization, thereby dramatically reducing deployment complexity and cost.

Qulsar's mix of Platform/Software-as-a-Service and embedded solutions can be deployed in multiple ways at the edge of a network and can be used as an edge computing platform, adaptable for collating and marking time-series data accurately for such applications.

Contact us at sales@qulsar.com if your application needs robust and precise timing solutions.

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