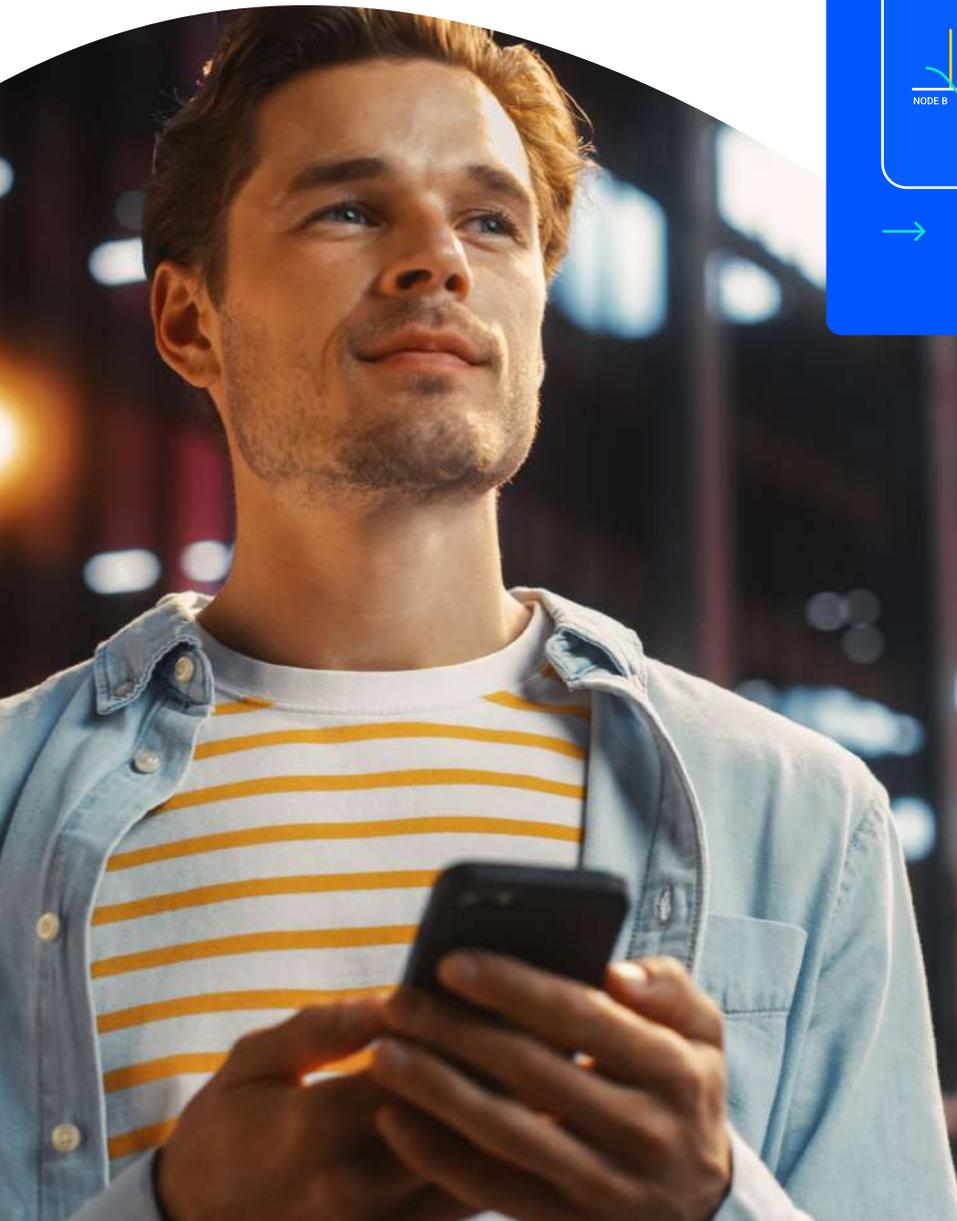
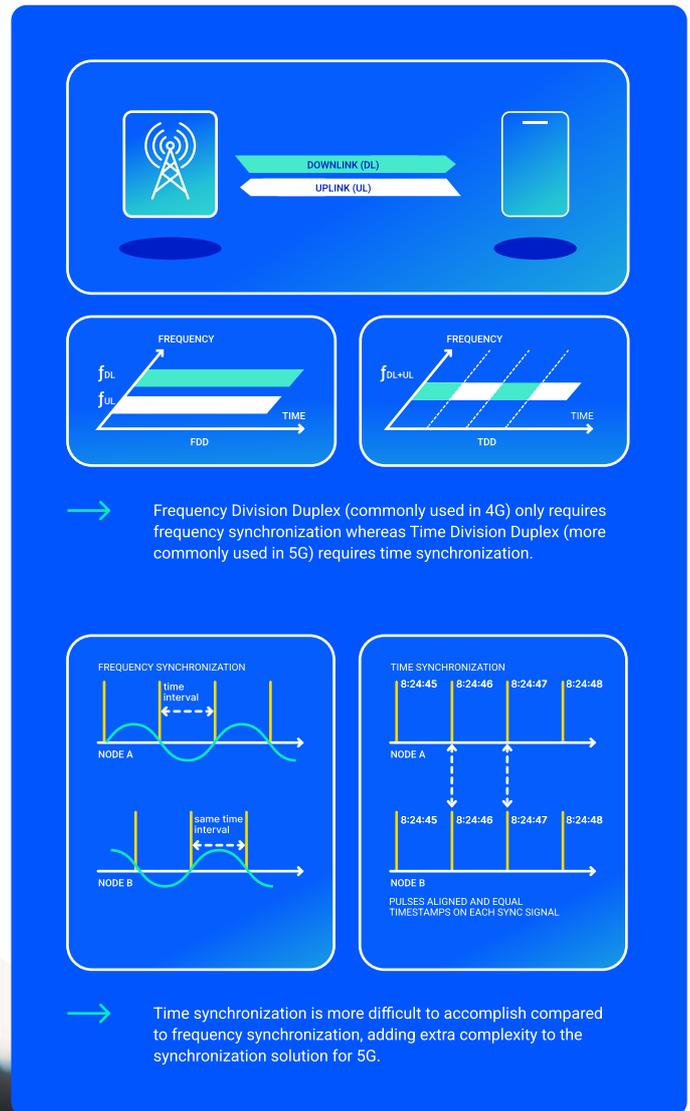


SOLUTION BRIEF:

# Technology for GNSS independent sync in 5G networks

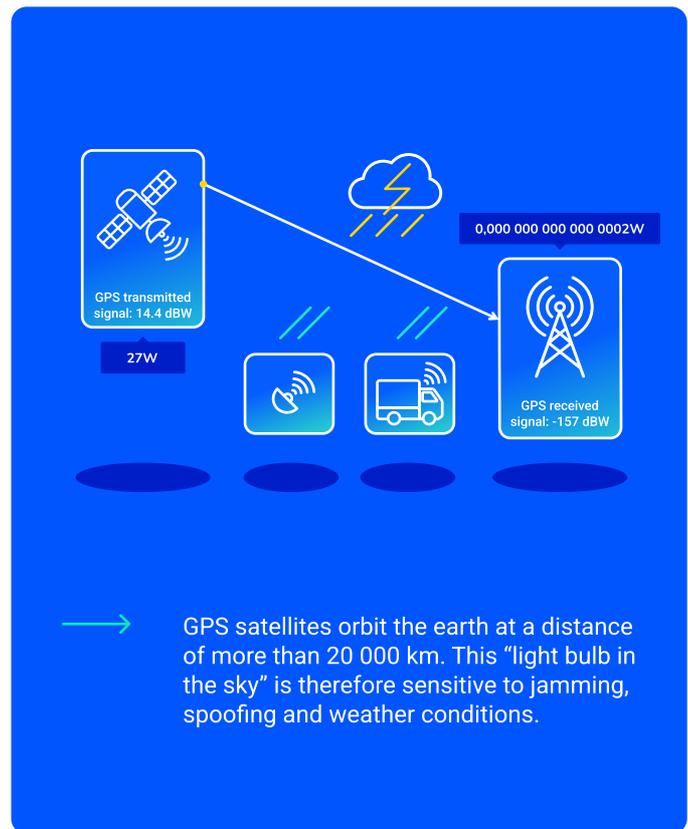
The evolution of 5G with Standalone, 5G advanced and later on 6G gives the promise of services beyond traditional mobile broadband with a variety of use cases within everything from blue light to industry 4.0 and media production. Many of these use cases are seen as critical, and being able to deliver them means the underlying infrastructure needs to be resilient and secure. A key component for running a resilient mobile network is the network synchronization. Without it, the network will fail to operate.

In 5G, synchronization is different from what has been the norm in legacy technologies. In 4G, mostly running on FDD bands, it was sufficient with frequency synchronization, whereas 5G with mostly TDD frequency bands as well as advanced functionalities like Massive MIMO, Carrier Aggregation and Coordinated Multi-Point (CoMP), time synchronization is required.



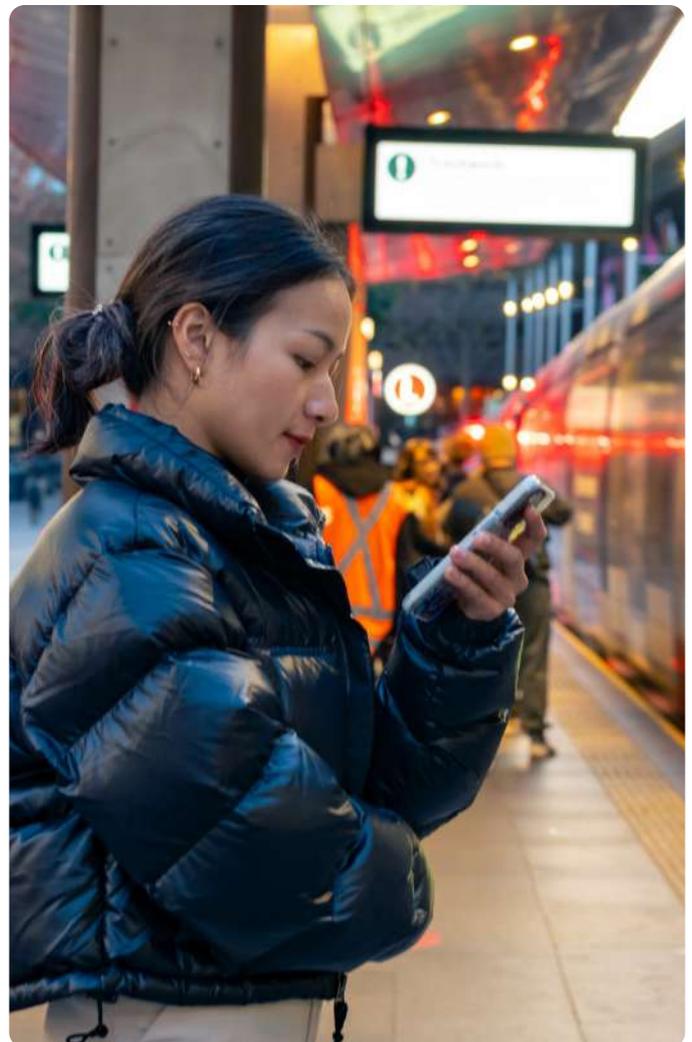
## Using GNSS for time synchronization

Global Navigation Satellite Systems GNSS, which includes Global Positioning System GPS, is a technology now taken for granted in a variety of different industries from transport to finance. In telecommunications, it is a common source for network synchronization. Its accuracy, and the fact that the signal can be received at every radio site with line of site to the sky, makes it a relatively cheap option that is fast to deploy. From a resilient point-of-view, it does however come with challenges. Given that the signal is transmitted from satellites makes it weak and the signal can easily be disrupted by jamming or spoofing. The current geopolitical landscape is affecting the view of how reliable GNSS really is, and disruptions and outages are becoming a recurrent phenomenon, something now very notable in e.g. the aviation industry. Disruptions can be triggered by malicious groups or by foreign powers which has created awareness among both mobile operators and regulators, that it is important to secure resilient synchronization that doesn't depend on only GNSS.



## Using network-based synchronization with PTP IEEE1588

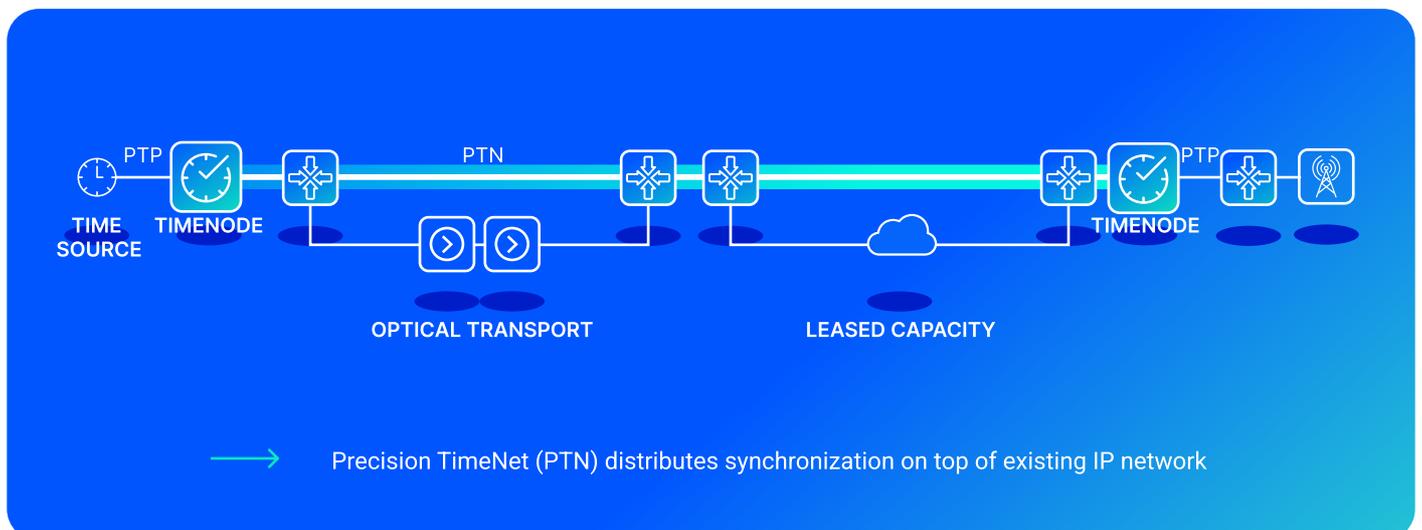
Precision Time Protocol PTP, or IEEE1588, is the traditional network-based synchronization used for mobile networks. It comes in profiles Partial Timing Support ((or ITU-T G-8275.2) and Full Timing Support (or ITU-T G-8275.1). Since Partial Timing Support is not as stringent as Full Timing Support, it will suffer from time delay variations over long distances and through multiple hops. It is not adequate to use for 5G networks. Full Timing Support delivers sufficient performance but comes with other challenges. Implementing Full Timing Support requires hardware support, including high-precision oscillators and clock recovery equipment, in every network node. These necessitate substantial investments in hardware upgrades and can lead to increased complexity in network deployment and management. This hardware dependency also means that any failure in a single node could potentially impact the synchronization status of several other nodes downstream, thereby posing a risk to network stability. The protocol is also not compatible for networks with leased capacity. Service providers that lease bandwidth or network infrastructure from third-party vendors, can therefore not use Full Timing Support over these paths.



# Introducing Precision TimeNet for a disaggregated time synchronization



Precision TimeNet PTN is a technology, developed by Net Insight, that disaggregates the synchronization function from the hardware. It thus creates a synchronization overlay across the existing IP infrastructure without requiring PTP IEEE1588 hardware support in intermediate nodes. Instead, PTN uses end-nodes, called TimeNodes, to convert and distribute synchronization over the network. The solution also includes orchestration to monitor and manage the synchronization end-to-end.



When synchronization is run as an overlay service in the network the synchronization traffic will meet challenges that could degrade synchronization accuracy if not properly handled. Main challenges are Packet Delay Variation and Asymmetries.

**Packet Delay Variation**, sometimes called jitter, is the variation in time it takes for different time packets to travel through the network due to traffic interference, statistical effects, buffer handling in routers and QoS mechanisms.

To handle Packet Delay Variation, advanced network level algorithms need to be run. PTN uses an adaptable and flexible way to send timestamps so that traffic impairments may be overcome. PTN can adapt the rate of timestamps depending on the bandwidth available and the current jitter levels on the links. Around 4000 to 8000 timestamps per second are normally used in PTN, allowing it to run intelligent filtering algorithms with adjustable filter bands. This can be compared to traditional PTP, often using 16 or 64 timestamps per second which limits statistical information.

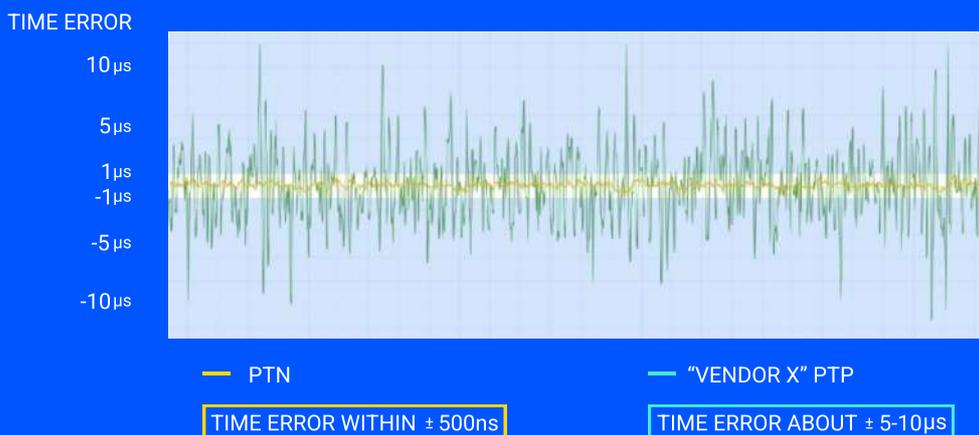
### History of Precision TimeNet



Precision TimeNet (PTN) is based on technology that has been in use for over 20 years in the broadcasting industry. Accurate synchronization is crucial for digital TV (DVB-T) and since many countries recognize national TV as mission critical and have identified the vulnerabilities of GNSS/GPS, there were requirements early on for GNSS/GPS independent synchronization implementations that worked over leased capacity.

### Managing Packet Delay Variation

CUSTOMER MEASUREMENTS OF PTN VS PTP



This field test was made over a period of 14 days on a network segment with significant packet delay variations. In the PTP case, the time was sent from a single TimeTransmitter to a TimeReceiver. In the PTN case there were two parallel time transfer links set up between two TimeNodes, using the same path, but with different characteristics such as packets sizes, rates and skew. The time error in the receiving end was measured against a known reference.

The requirement for 5G transport is that the maximum time error cannot exceed 1.1 μs.

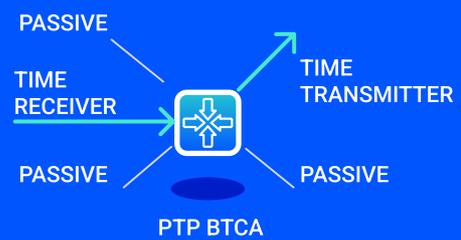
During the full period, the time error in the PTP equipment varied between 5-10 μs per day, with maximum time errors reaching about 100 μs. During the same period, the time error for PTN never exceeded +/- 500 ns.



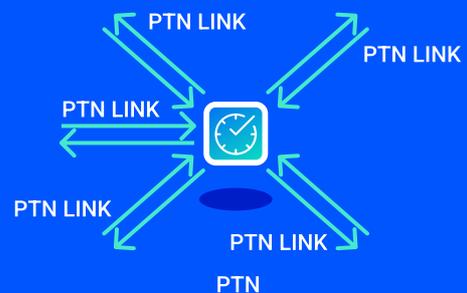
**Asymmetries** are differences in delay in the forward- and backward direction in the network. The asymmetry can change in any moment and is often due to changes in delay profiles in the underlying transport, most likely the optical layer, or due to protection switching or traffic reroutes. Asymmetry changes can be as small as 100 nanoseconds and up to microseconds or as large as several milliseconds.

Identifying changes in delay profiles requires additional algorithms in place on top of what is needed to handle packet Delay Variation. Asymmetry changes of a few microseconds are often buried within several microseconds of Packet Delay Variation. Any persistent change in delay profile should immediately be compensated for. If a change in the underlying transport is not identified and handled, a constant time error is created in the network.

### Bi-directional timing



**PTP** only transfers time from a single TimeTransmitter to a TimeReceiver with no ability to send time in both directions. PTP uses the standard Best TimeTransmitter Clock Algorithm (BTCA) to determine this single Time Transmitter while keeping all other peers passive without transporting time.



**PTN** uses full bi-directional synchronization and mesh connectivity to be able to analyze network asymmetries. Time is always transported in both forward and backward directions. PTN also receives time from all peers, regardless of whether the time information is actively used by the nodes for timekeeping.

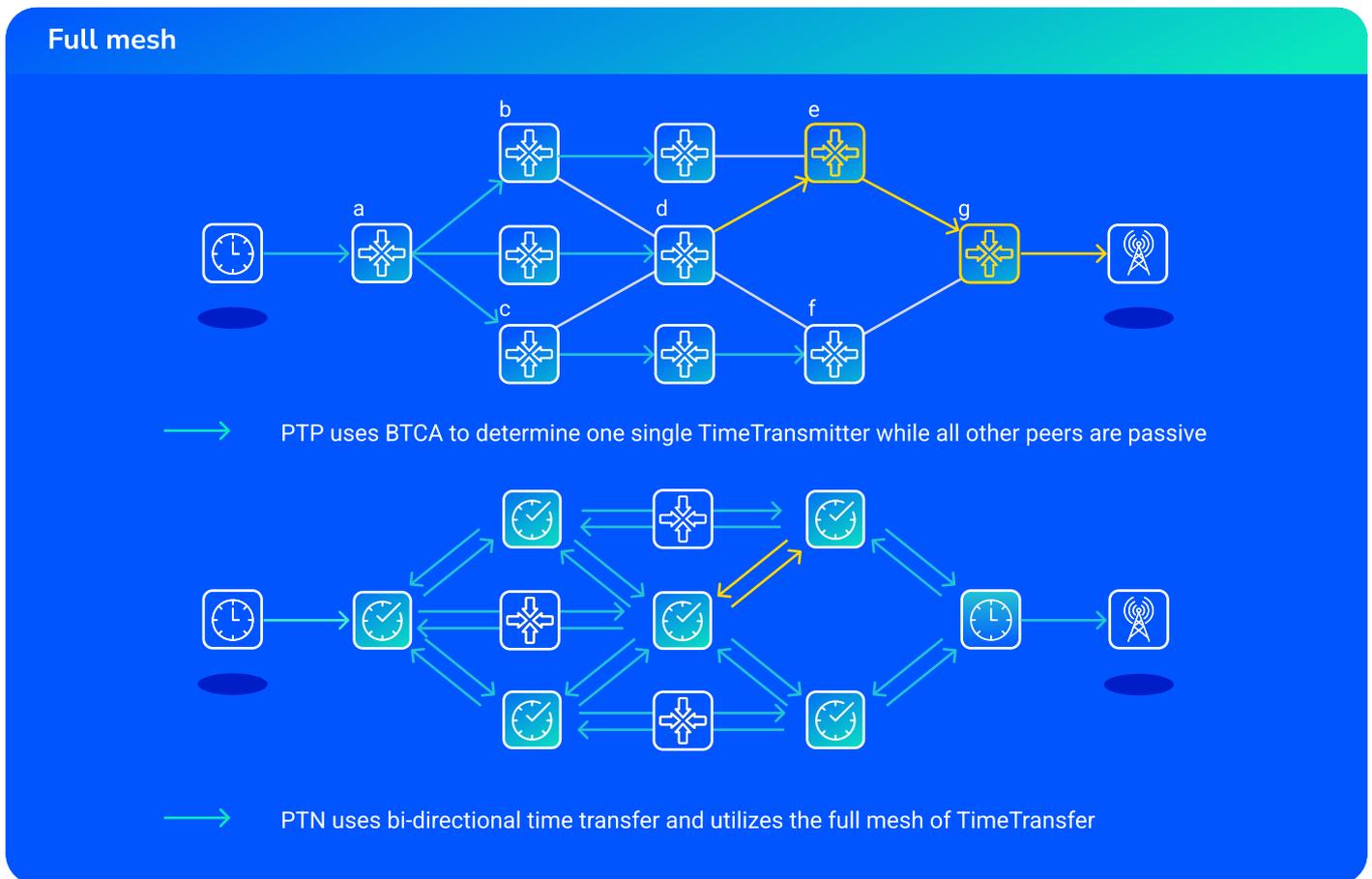
Bi-directional timing and mesh, lets PTN have complete sync information about the network. This is used by the TimeNodes to evaluate synchronization options, weight different routes, make real-time decisions to use one or more links to synchronize its time or to detect and correlate for network events.

In below example, there is a sample network where there is a change of delay profile, a new asymmetry, in the link between Nodes d and e.

In the case of PTP, the TimeReceiver cannot draw correct conclusions from the limited data received. It will follow the delay change over the troublesome link and the time received at the end-point from Node g

will therefore be wrong. This is a common situation in PTP networks where unhandled asymmetry changes in the network results in a constant time error (cTE).

In PTN, node d has active time transfers from nodes a, b, c, f and e. It can easily determine that the time over the troublesome link (from node e) differs from all other nodes. Since node e gets the time also from nodes b,d and g, there will be a significant spread in the time received from these nodes. This results in PTN discovering and handling new asymmetries. The two nodes d and e affected by troublesome link can easily time on other stable links while determining a new delay profile for the troublesome link.



**Orchestration**

PTN uses more than 100 metrics per second from each node in the network to characterize the underlying transport from a time transfer perspective. These metrics are not only on the current node time, but also time and transport related information on all peer links such as unidirectional delays, variation of delay both before and after the timestamp selection algorithms, link change detection metrics and various essential filtered metrics per node and per link.

Fully bi-directional metrics on all links, both those actively used for synchronization and those currently unused, are gathered by the synchronization orchestration. This allows for a complete view of all links in both directions and lets the orchestration analyze the synchronization network. This end-to-end view lets the orchestration optimize the network or correlate for networks events not handled by the real time control mechanisms in the individual TimeNodes.

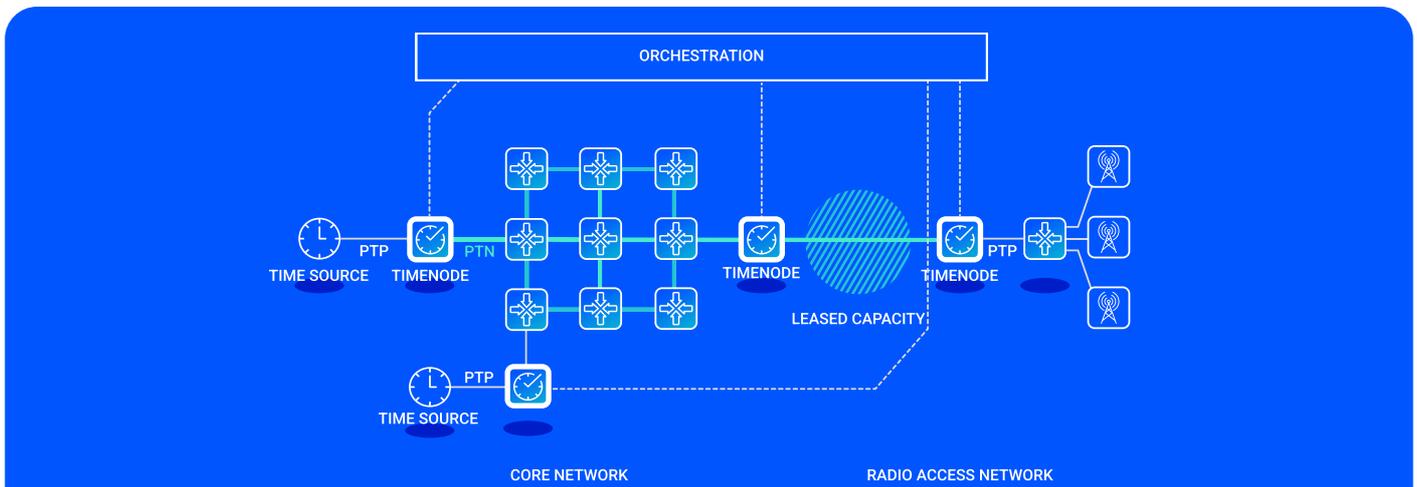
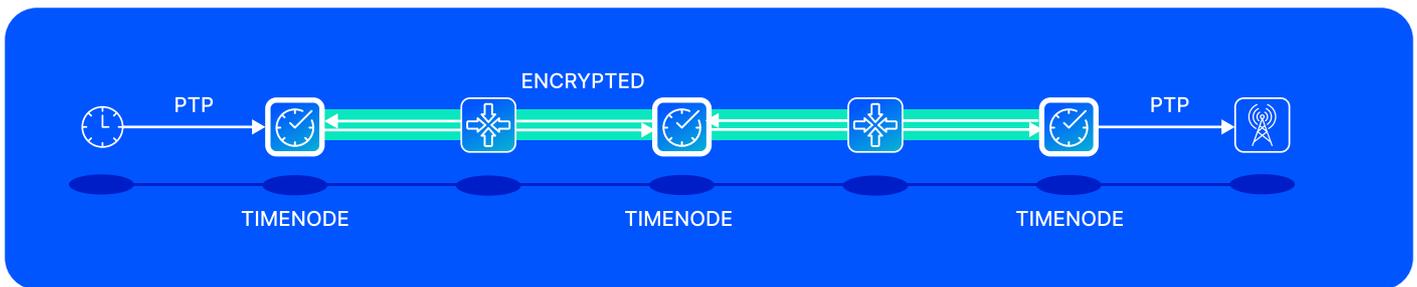
By gathering all metrics, PTN provides a data lake of information for the network orchestration to assess. Artificial Intelligence and Machine Learning is used to further increase synchronization management and decrease the need for manual operation. With advanced algorithms that can learn from data, identify patterns, and make decisions with minimal human intervention, the telemetry from the network is key to efficiently monitor, assess and analyze the network.

**Security**

The threat landscape has evolved significantly in recent years and the security and integrity of the network is becoming a key requirement to trust the network with critical services. Timing is one of these foundations that must be secure and reliable. The transfer of time across the network must be able support functionality such as authentication of

origin, data integrity, confidentiality, replay protection, and nonrepudiation of source.

PTN has been designed from the beginning to run precise timing in critical networks and therefore includes security in the base protocol design. The timing flows are encrypted with strong AES encryption that prevents distortion or tampering with the timing. The overlay service is handled with well understood methods. PTN always uses 2-step timestamping, so encryption does not affect the accuracy of the timestamping. By contrast, PTP is traditionally sent unencrypted and unauthenticated. PTP standards IEEE 1588-2019 do propose a handful of different approaches to introducing security also in PTP, though they are not always implemented, or may not be applicable for Wide Area Networks.



In a mobile network, PTN and PTP are often used together to transport the timing from the time source to all the users of precision time.

In the simplified network example above there are TimeNodes with PTN technology placed at the edges of the IP network to facilitate distribution of precise time through the IP / DWDM network. TimeNodes are usually placed close to the Provider Edge routers (PE-Routers) to facilitate scaling of time services. One TimeNode can transport time to and from maximum 32 peer TimeNodes. TimeNodes close to PE-routers also

provide a monitoring point for the synchronization orchestration of the network.

If precise time is distributed over leased capacity, TimeNodes are usually placed on the edges of the leased capacity services such as Metro Ethernet E-Line or E-LAN services.

If there is a PTP enabled access network, the TimeNodes hand over a fully compliant PTP Full Timing Support to access routers or cell site routers to deliver precise time to the base stations.

# Bringing business value with Precision TimeNet synchronization

## Resilience

### Secure network sync without relying on GNSS

Select whichever sync trails are reliable and distribute timing throughout the network on top of existing network infrastructure.

### Guarantee reliability and security by distributing sync with mesh technology

Using multipath mesh lets the synchronization traverse to alternative network paths if certain routes go down and encryption and authentication makes the sync transmission more secure from attacks.

### Capture issues proactively with end-to-end sync orchestration

Providing automated network diagnostics to help perform overall network health-checks to troubleshoot and detect where potential problems will occur.

## Cost efficiency

### Low investment since sync is deployed over existing network infrastructure

Synchronization gets distributed over existing IP/MPLS infrastructure regardless of hardware and works over leased capacity.

### Vendor independence in existing infrastructure

Since synchronization works on top of the IP network, there is no need to select specific vendors for existing network infrastructure.

### Fast deployment since no need to upgrade existing network hardware nodes

Since synchronization is distributed disaggregated from network hardware, it is not necessary to upgrade existing network nodes.



## 5G monetization

### Offer time to enterprise customers

Accurate time and positioning are required by many enterprises, from industry 4.0 to media production and the financial sector. Being able to deliver this gives possibilities for new use-cases on top of existing 5G network infrastructure where investments have already been made.

### Secure robustness for critical 5G services

Guarantee a robust synchronization for advanced 5G services where time and positioning are required, to further differentiate 5G from 4G. This is crucial for

critical use cases, like blue light services, where strict SLA:s need to be fulfilled.

### Provide synchronization for sites where GNSS is difficult to install

For both macro networks and private networks there can be either bigger areas that are GNSS denied environments, or specific sites where GNSS is challenging to install. For these areas or sites, a network-based synchronization is required to deliver an adequate service.

# Vision of Precision TimeNet

Our vision is for network-based synchronization to become fully virtualized. This already today means the synchronization function is decoupled from the underlying hardware in existing network infrastructure, and more long-term it means all synchronization nodes will themselves become virtual. Fully disaggregating sync from the hardware lets the sync be distributed throughout all parts of a network, reaching all nodes no matter

how remote or complex the sites, or if a network includes leased capacity. This will be a key corner stone as networks evolve, also beyond only telecoms, to provide societal critical services. AI will continue to play a key role in orchestrating synchronization, as data and metrics gathered from distributed nodes are centrally processed to fully automate operations while proactively capture any issues and events.



## Key takeaways

- Resilient time synchronization can be complex to achieve in 5G networks. Overrelying on GNSS makes the network sensitive to jamming and spoofing, something today's global geopolitical situation has highlighted. Using a traditional PTP IEEE1588 solution requires hardware support throughout the network and is not supported over leased capacity.
- Precision TimeNet (PTN) is a synchronization technology that disaggregates the synchronization function from the hardware, allowing sync to run on top of existing network infrastructure, including over leased capacity. Using bi-directional and mesh functionalities assure synchronization resilience, and end-to-end orchestration secures sync performance across the whole network.
- Running synchronization with PTN lets mobile operators have a resilient sync that fulfils the requirements of 5G in a cost-efficient way while enabling new 5G monetization possibilities.



## About Net Insight

Net Insight empowers 5G networks with high accuracy time synchronization. Our GNSS independent sync secures network resilience, reduces cost and complexity while enabling successful 5G monetization. With over two decades of trusted experience serving the media and entertainment industries, we are now tailoring our leading sync solution for telecommunications. Net Insight is a publicly traded company on the Nasdaq, based in Sweden and serves **500+ clients across 75+ countries**.

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### Net Insight HQ

Smidesvägen 7  
171 41 Solna, Sweden

### Net Instight Asia

81 Ubi Avenue 4, #10-15  
UB.ONE 408830, Singapore

### Net Insight North America

770 Paseo Camarillo, suite 320  
Camarillo, California 93010, US