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# Improving NTP Installed Based Time Accuracy

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# NTP - it's been awhile…

- Network Time Protocol (NTP) is a networking protocol for clock synchronization between computer systems over packet-switched, variable-latency data networks
- Invented by Professor David L. Mills at 1981 – Started at 1977 ( my birthday present … ?)
- NTP is used to deliver time to various applications , including enterprise ,financial , telecom , power…

In operation since 1985, NTP is one of the oldest Internet protocols in current use


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# How many NTP clients are out there?

- MIT research from Dec 1999 estimates the NTP network contains at least **175,000 hosts.**
- Aug , 2005, querying an initial set of 263 public NTP servers - stratum 1 and 2 - listed on NTP Public Services Project - discovering **1,278,834** unique IP addresses.
- As of October 2015, there were over 2 billion personal computers used worldwide …
- **Few 10's to 100's millions ?**


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# Typical Time Accuracy Achieved by NTP

- Highly dependent on NTP server accuracy , network asymmetry ,PDV and NTP client implementation
- In most cases 100 microseconds to 100 milliseconds is achievable

Reaching microseconds level with existing NTP solutions is challenging!


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# Time is Money…

- SEC Rule 613 issued August 2012
  - Requires all actions placed on any US exchange to be recorded to accuracy of at least **1mS**.
  - Enables auditing in case of fraud investigation
- European Securities and Markets Authority (ESMA) 1464, Sep 2015 and 1464 Annex:
  - Transactions executed on a trading venue
    - Activity using high frequency algorithmic trading technique - **Clocks Synchronized to within 100 uS**
    - Any other trading activity - **Clocks Synchronized to within 1mS**

- Many Algo traders want to record transaction times in order to:
  - Audit the performance of their algorithms and Analyse historic data to improve their trading strategies.


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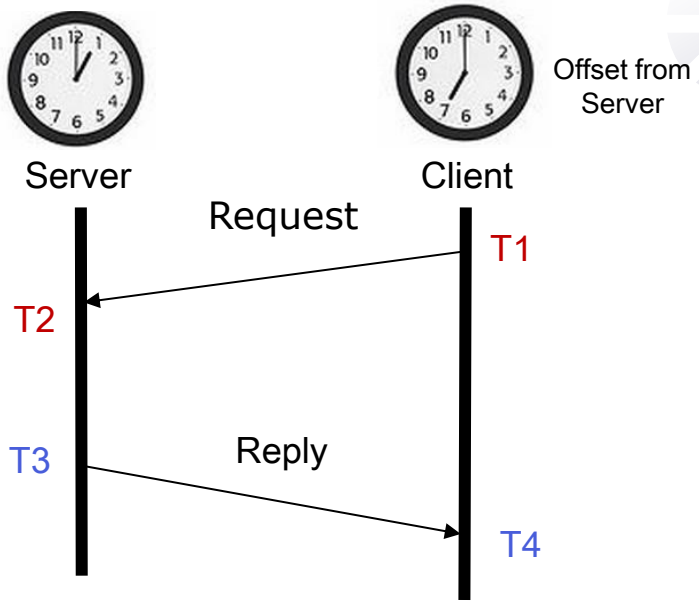
# NTP Packet Exchange

**T1** – Time request sent by the client (using Client clock)

**T2** – Time request received by the server (using Server clock)

**T3** – Time reply sent by the Server (using Server clock)

**T4** – Time reply received by the Client (using Client clock)




T2 = T1 + Delay_CS - Offset

T4 = T3 + Delay_SC + Offset

Symmetry: Delay_CS = Delay_SC = Delay

Offset = ((T4-T3)-(T2-T1))/2

Asymmetry: Delay_CS != Delay_SC :

Offset+(Delay_CS-Delay_SC)/2=(T4-T3)-(T2-T1))/2

Delays must be symmetrical and constant – Asymmetry and PDV will impact Client performance



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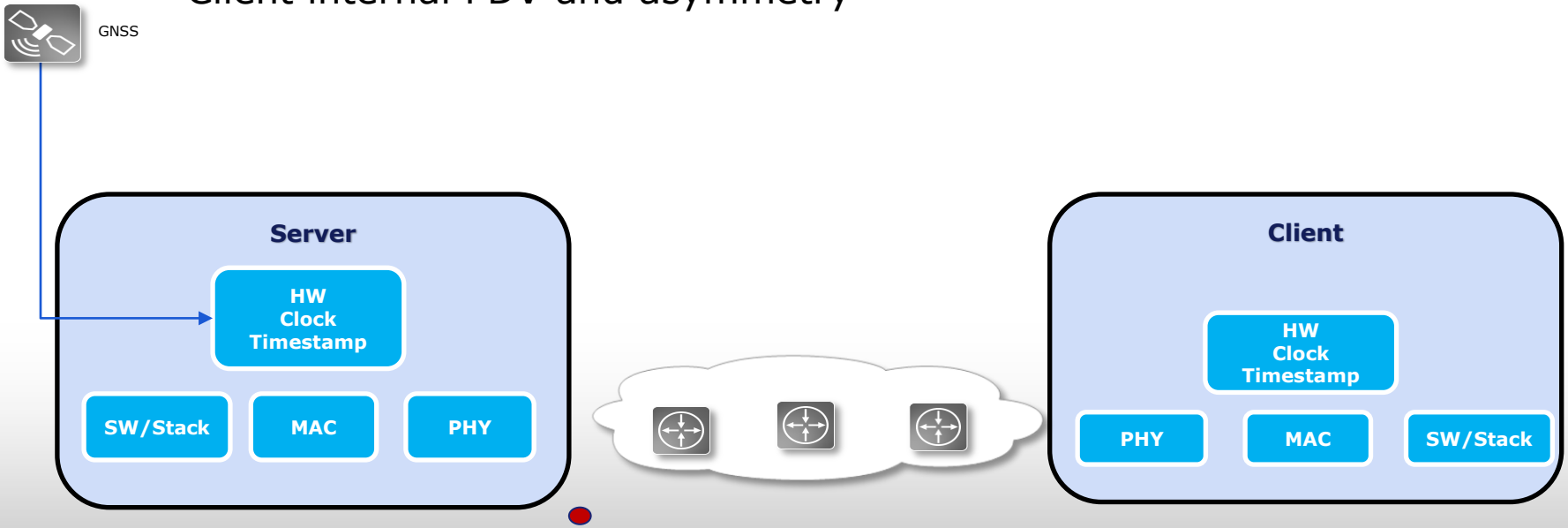
# Sources of Inaccuracy

- Server time reference inaccuracy
- Server internal PDV and asymmetry
- Network PDV and asymmetry
- Client internal PDV and asymmetry





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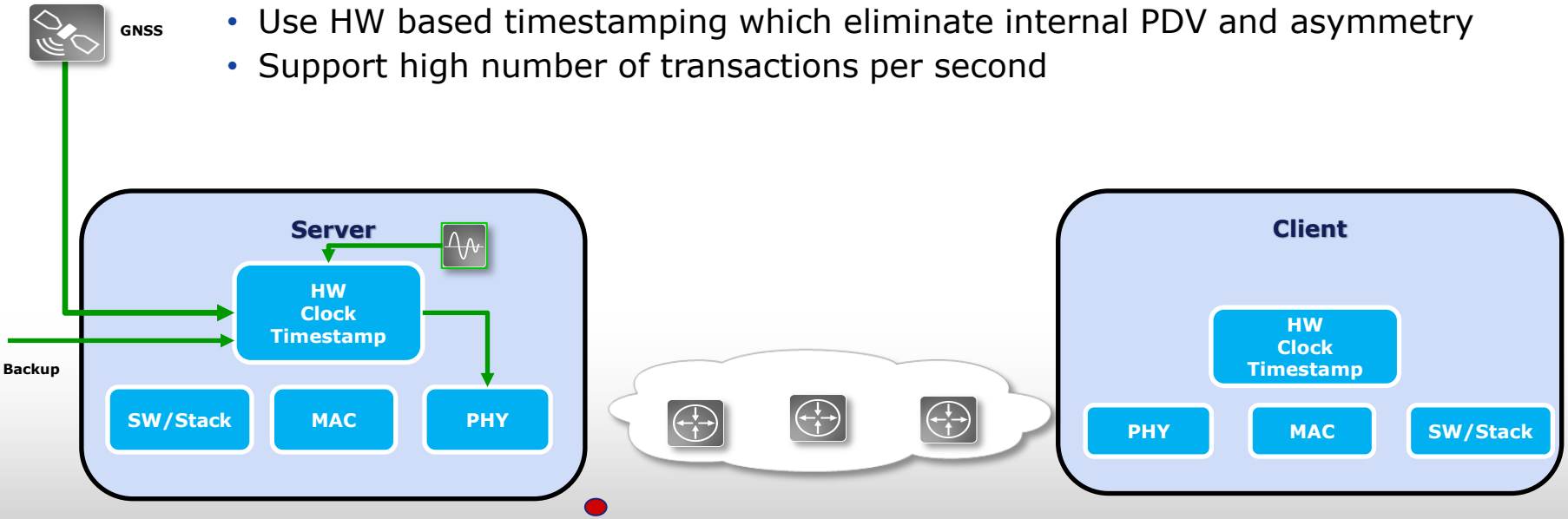
# Improving Accuracy - Server Side

- Use telecom grade NTP server
  - GNSS as reference with backup options (PTP/Sync-E/BITS)
  - High end local Oscillator for enhanced phase holdover
  - Meet ITU-T G.8272 PRTC: +/- 100 nsec from UTC on PPS & packet interfaces
  - Use HW based timestamping which eliminate internal PDV and asymmetry
  - Support high number of transactions per second





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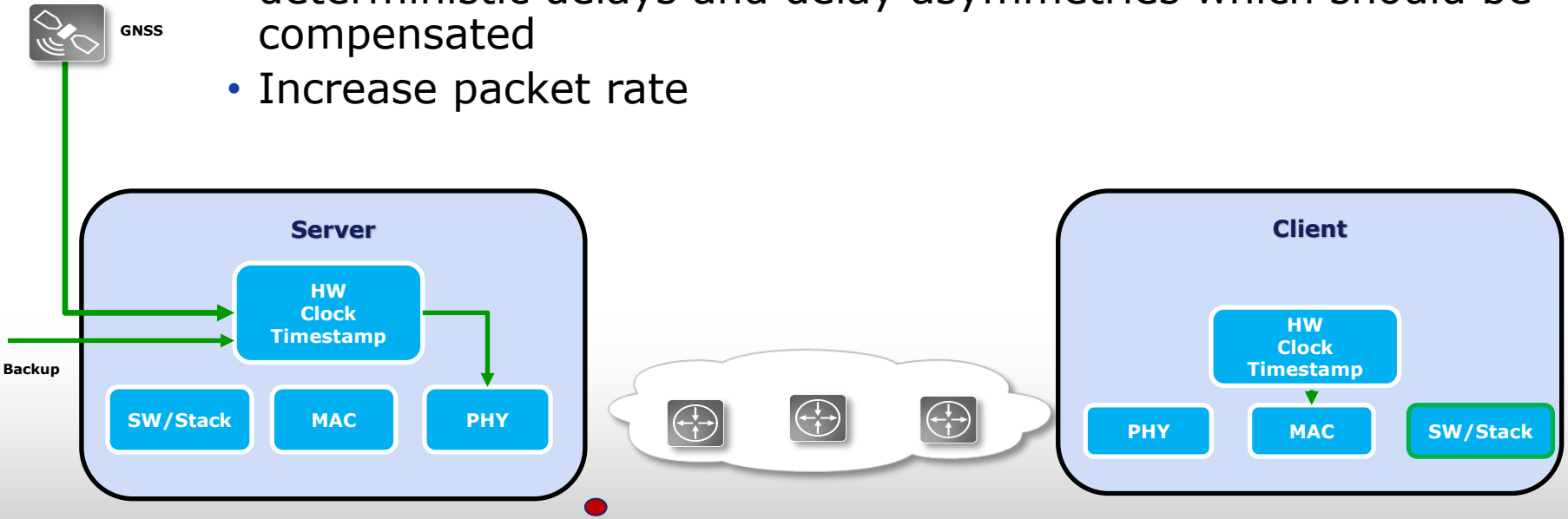
# Improving Accuracy - Client Side

- If possible – use HW based timestamping which eliminate internal PDV and asymmetry
- If not possible – optimize the SW design by targeting deterministic delays and delay asymmetries which should be compensated
- Increase packet rate





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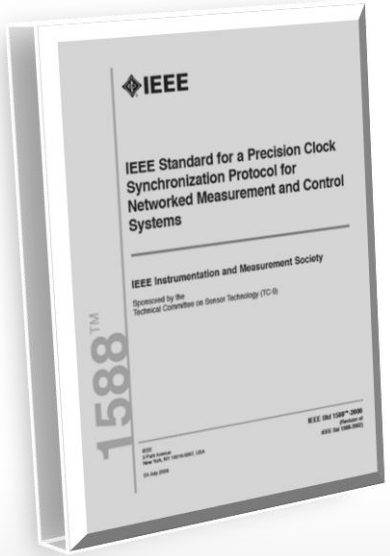
# Can PTP Help ?

- PTP is the selected solution for delivering time , accurate within sub-microsecond in telecom/power/ Audio & Video application
- Fully standardizes and adopted by operators
  - Telecom ITU-T G.8275.x
  - Power IEEE C37.238-2011
  - Audio and Video Profile - IEEE 802.1AS




PTP can deliver time within sub-microsecond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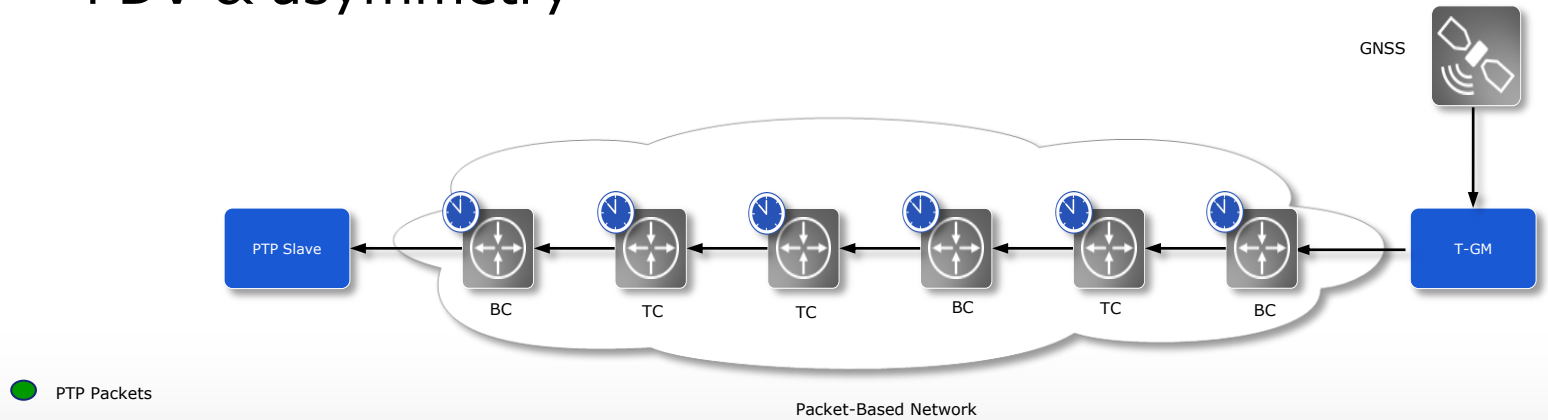
# Can PTP Help ?

- PTP accuracy is also affected by PDV & asymmetry but …
- The use of PTP aware network elements - Boundary Clocks (BC) and Transparent Clocks (TC) can be used to eliminate PDV & asymmetry




TC's and BC's are the main advantage of PTP over NTP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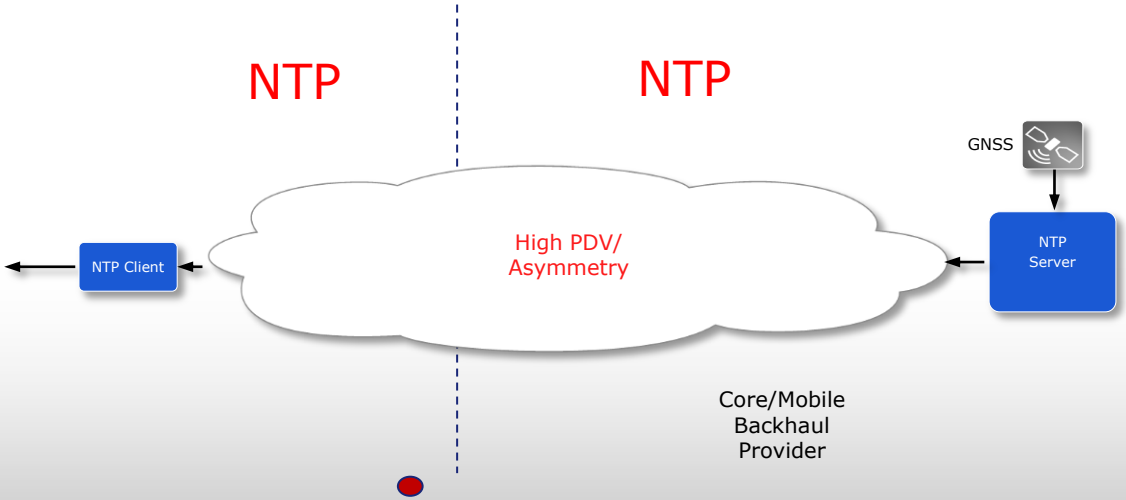
# The Solution

Combine PTP with NTP by using PTP BC/TC to overcome PDV and asymmetry



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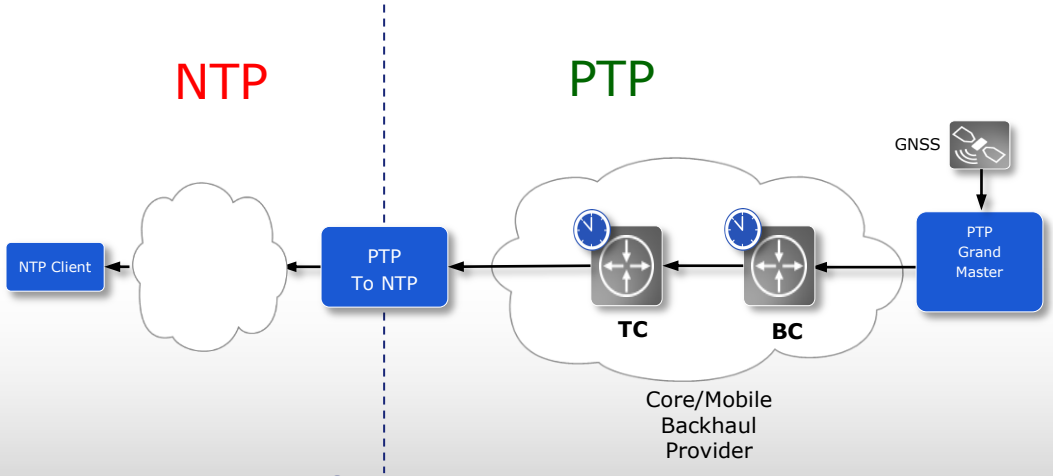




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# Equipment Requirements:

- "All in one" Cost effective device which can be a PTP Slave , BC, GM , Probe , NTP server , including PTP  to NTP translation
- Can support PTP and NTP simultaneously
- Can translate from PTP input to NTP output
- Include High quality local oscillator and back up options via Sync-E/BITS
- Optimal - Sync-E/BITS/CLK/PPS+ToD fan-out
- Sync probing and assurance

"All in one" product for all next gen and legacy sync requirements


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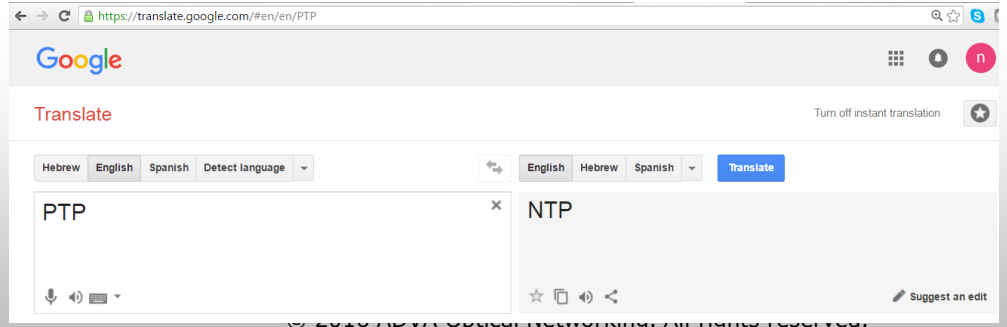
# PTP to NTP Translation

- No standards available but…
- PTP deliver information which enable to construct UTC
  - TAI + UTC offset + Leap second information
- Information related to clock quality
  - clockClass
  - clockAccuracy
  - …
- NTP Stratum level
  - Can be Stratum 2 when locked to partial on path support PTP
  - Can be Stratum 1 when locked to full on path support PTP



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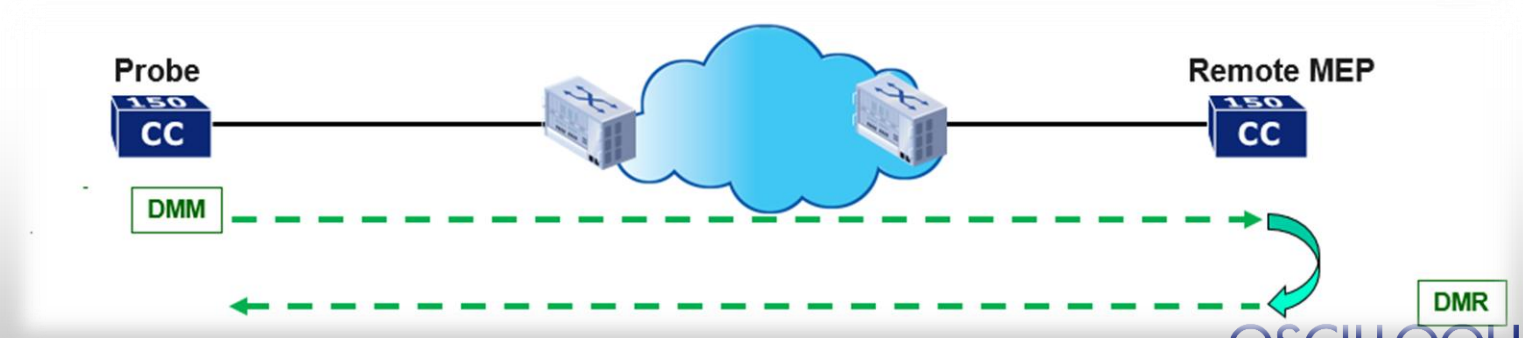
# Y.1731 Ethernet OAM

- Time synchronization is required between the source and destination devices in order to provide accurate one-way delay (latency) or delay-variation measurements
- Legacy network element are using NTP to create the required common time
- Limited accuracy of measurement due to NTP server location





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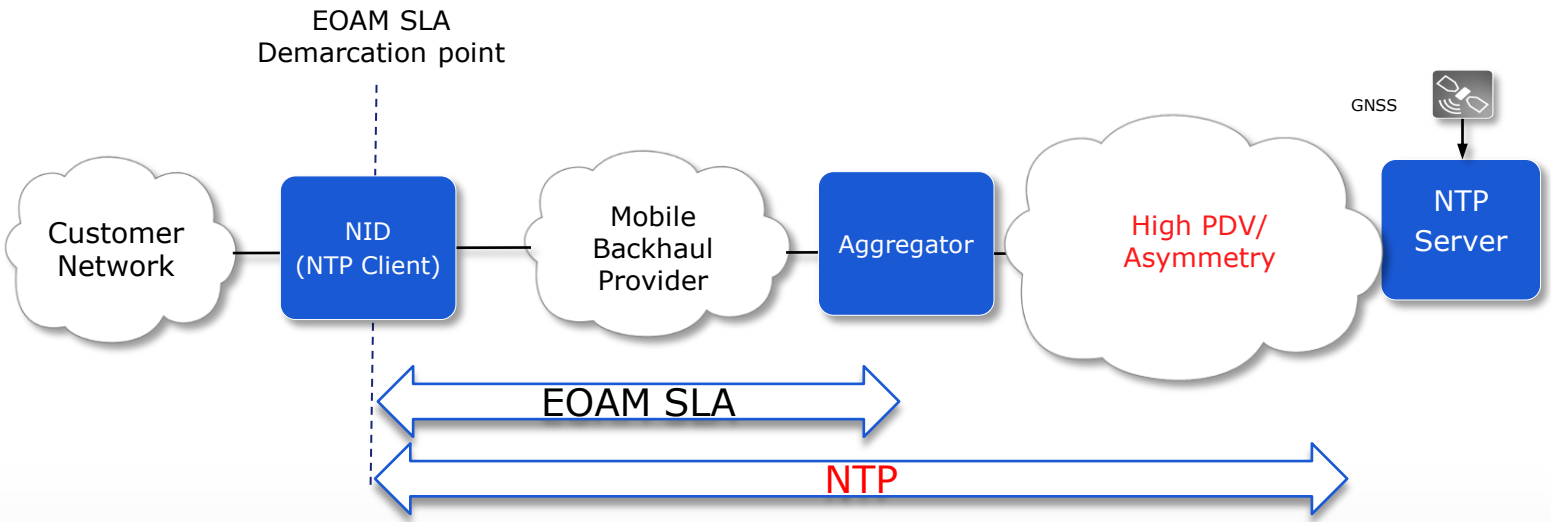
# Example - EOAM





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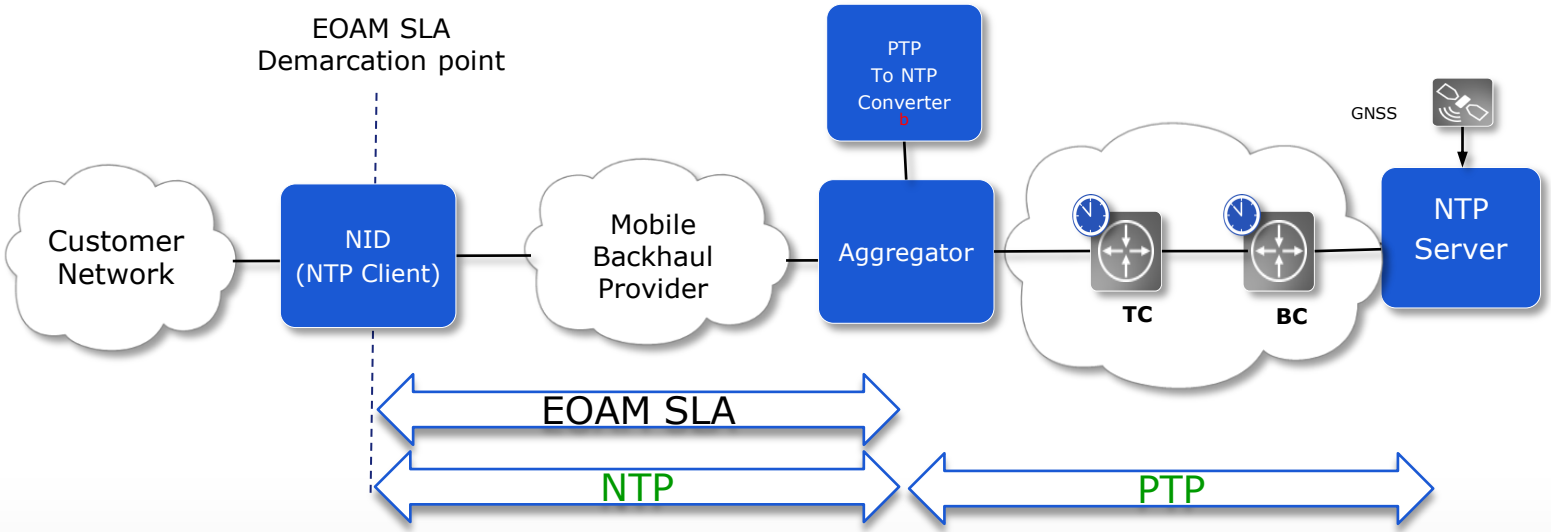
# Example - EOAM



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# Time As a Service – TAAS (Time is money again…)

- Operators are upgrading their networks in order to deliver accurate phase required for RAN applications (LTE-A/LTE-TDD)
- The accurate time delivered via PTP can be translated to NTP and be offered as a service
- Such a service can be used to improve installed base NTP clients time accuracy

Time as a Service – new potential source of revenue


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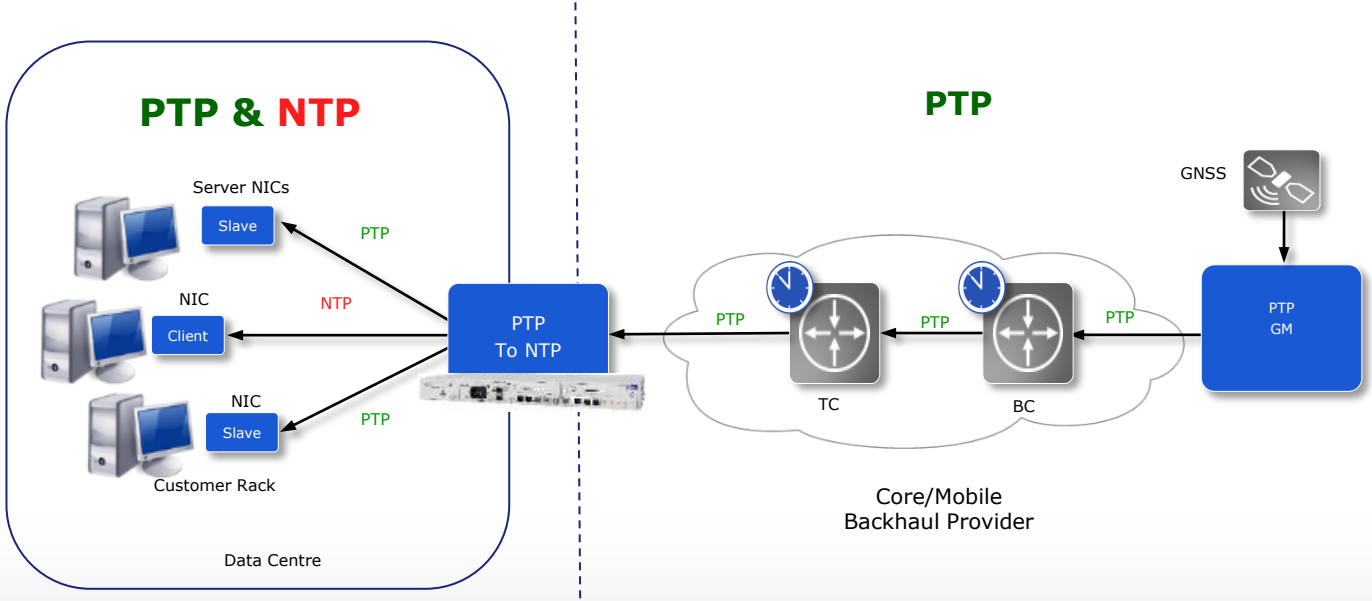
# Time as a Service into Data Centre
# Financial Markets, Health, Media




Bring accurate time and frequency into data centers



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# Summary

- Time accuracy of NTP installed based clients can improved significantly by combining the following:
- Upgrade of NTP servers to telecom grade servers (with +/- 100 nsec on NTP packet interface)
- Combine PTP with NTP to overcome asymmetry and PDV
- Translation from PTP to NTP should be done as close as possible to NTP clients
- Leverage investment made for PTP to improve NTP accuracy – both can be offer as service (TAAS)



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