# ETHERNET TIME & SYNC

In Telecoms, Power, Finance, Cars, ...

ITSF Budapest, Nov 2014

# PTP Profiles

IEEE 1588 states in clause 19.3.1.1:

*"The purpose of a PTP profile is to allow organizations to specify specific selections of attribute values and optional features of PTP that, when using the same transport protocol, inter-work and achieve a performance that meets the requirements of a particular application."*

Calnex
Insight and Innovation

## PTP Profile Comparison for ITU-T Telecom Applications

| | ITU-T PTP Telecom Profile for Frequency (G.8265.1 Annex A) | ITU-T PTP Telecom Profile for Phase/Time (G.8275.1 Annex A) |
|---|---|---|
| **Objective** | Frequency distribution to better than 16ppb (long term fractional frequency offset specified in G.8261.1) | Time distribution to better than ±1.5µs |
| **Profile Identification** | | |
| profileName | ITU-T PTP Profile for Frequency Distribution without timing support from the network (Unicast mode). | ITU-T PTP profile for phase/time distribution with full timing support from the network. |
| profileVersion | 1.2 | 1.0 |
| profileIdentifier | 00-19-A7-00-01-00 | 00-19-A7-01-01-00 |
| Specified by | ITU-T | ITU-T |
| Location | www.itu.int | www.itu.int |
| **PTP Options** | | |
| Permitted Nodes | Ordinary clocks (i.e. Grandmasters, slave-only clocks). | Ordinary clocks (i.e. Grandmasters, slave-only clocks), boundary clocks. |
| Prohibited Nodes | Boundary clocks, transparent clocks. | Transparent clocks. |
| Transport Mechanisms | Both masters and slaves must support IEEE1588-2008 Annex D IPv4/UDP stack.<br>Both masters and slaves may support IEEE1588-2008 Annex E IPv6/UDP stack. | Required: IEEE802.3 Ethernet, as per IEEE1588-2008 Annex F.<br>The use of VLAN tags is not allowed.<br>Other transport mechanisms (e.g. IP/UDP as in Annexes D & E) are for further study. |
| Multicast or Unicast | Both masters and slaves must support full unicast operation (see details below). | Full multicast operation, using both of the addresses noted in IEEE1588-2008 Annex F.<br>Unicast is not permitted. |
| BMCA | Static BMCA specified (see below). | Alternate BMCA specified (see below). |
| Path Delay Measurement | Uses delay_request/response mechanism, if required (i.e. two-way operation).<br>Peer delay mechanism must not be used. | Uses delay_request/response mechanism.<br>Peer delay mechanism must not be used. |
| PTP Management | Not specified in this version of the profile. | Not specified in this version of the profile. |
| Message Types | Used: Announce, Sync, Follow-up, Delay_Req, Delay_Resp, Signaling<br>Not used: Pdelay_Req, Pdelay_Resp, Pdelay_Resp_Follow_Up<br>The use of Management messages is for further study. | Used: Announce, Sync, Follow-up, Delay_Req, Delay_Resp<br>Not used: Pdelay_Req, Pdelay_Resp, Pdelay_Resp_Follow_Up<br>The use of Signaling and Management messages is for further study. |
| One-step and Two-step clock | Master may support either one-step or two-step clocks, or both.<br>Slaves must support both one-step and two-step clocks, without configuration. | Clocks may transmit messages using either one-step or two-step modes.<br>Clocks must be capable of receiving and handling messages from both one-step and two-step clocks, without configuration. |
| One-way and Two-way Operation | Masters must support both one-way and two-way operation.<br>Slaves may support either one-way or two-way, or both. | Only two-way operation is permitted. |
| Clock Identity | EUI-64 (as specified in clause 7.5.2.2.2 of IEEE1588-2008). | EUI-64 (as specified in clause 7.5.2.2.2 of IEEE1588-2008). |
| Security | For further study.<br>IEEE1588-2008 Annex K experimental security protocol is not mentioned. | For further study.<br>IEEE1588-2008 Annex K experimental security protocol is not used. |

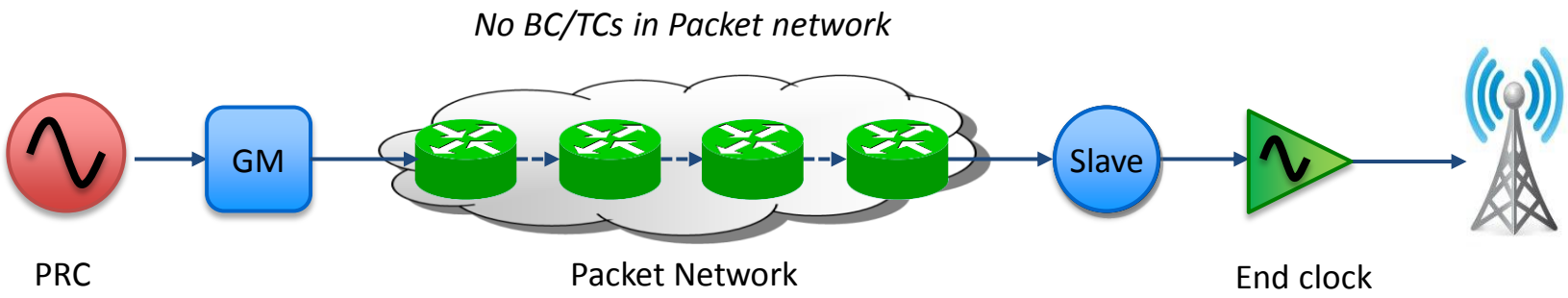
## PTP Profile Comparison for ITU-T Telecom and IEEE Power Applications

| | Profile for Phase/Time (G.8275.1 Annex A) | IEEE PTP Profile for Power Systems Applications (C37.238-2011) |
|---|---|---|
| | ...etter than ±1.5µs | Time distribution to better than ±1µs |
| | | |
| | ...hase/time distribution with full timing ...work. | IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications. |
| | | 1.0 |
| | | 1C-12-9D-00-00-00 |
| | | IEEE 1588 Profile for Power System Applications Working Group of the IEEE Power System Relaying Committee and IEEE Power System Substation Committee. |
| | | http://standards.ieee.org |
| | | |
| | ...ndmasters, slave-only clocks), boundary clocks. | Ordinary clocks, peer-to-peer transparent clocks, boundary clocks. |
| | | |
| | ...thernet, as per IEEE1588-2008 Annex F.<br>...is not allowed.<br>...anisms (e.g. IP/UDP as in Annexes D & E) are for | IEEE 802.3 Ethernet, as per IEEE1588-2008 Annex F (PTP directly over Ethernet).<br>VLAN tags (IEEE802.1Q) are mandatory, with a default priority of 4, and default VLAN ID of 0.<br>Other transport mechanisms are prohibited. |
| | ...n, using both of the addresses noted in ...F.<br>...ted. | Full multicast operation, using MAC addresses specified in IEEE1588-2008 Annex F:<br>- Uses MAC address 01-80-C2-00-00-0E for Pdelay messages.<br>- Uses MAC address 01-1B-19-00-00-00 for other messages. |
| | ...fied (see below). | Uses default BMCA specified in clauses 9.3.2, 9.3.3 and 9.3.4 of IEEE1588-2008. |
| | ...esponse mechanism.<br>...n must not be used. | Peer delay mechanism. |
| | ...ersion of the profile. | Management specified by way of a SNMP MIB:<br>- Grandmaster support for SNMP MIB is mandatory.<br>- SNMP support for other devices is optional.<br>- Ordinary clocks not supporting SNMP must provide the following information: Timeinaccuracy, traceability, offset from GM, alarm if offset from GM reaches a configurable limit. |
| Message Types | Used: Announce, Sync, Follow-up, Delay_Req, Delay_Resp<br>Not used: Pdelay_Req, Pdelay_Resp, Pdelay_Resp_Follow_Up<br>The use of Signaling and Management messages is for further study. | Used: Announce, Sync, Follow-up, Pdelay_Req, Pdelay_Resp, Pdelay_Resp_Follow_Up<br>Not used: Delay_Req, Delay_Resp, Signaling, Management |
| One-step and Two-step clock | Clocks may transmit messages using either one-step or two-step | One-step operation is recommended, although two-step operation |

# Telecoms

*Specifically Mobile Backhaul*

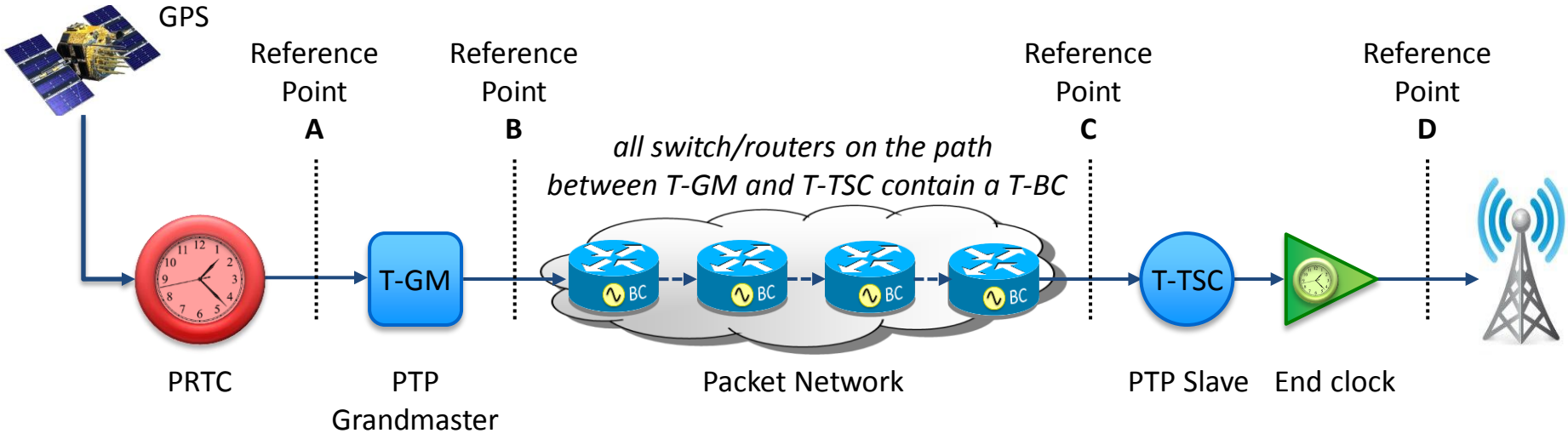
# PTP with No Timing Support (G.8265.1)




## Features

- Packet timing protocols such as PTP or NTP used to deliver frequency
- Aims to deliver at least same quality of timing as TDM

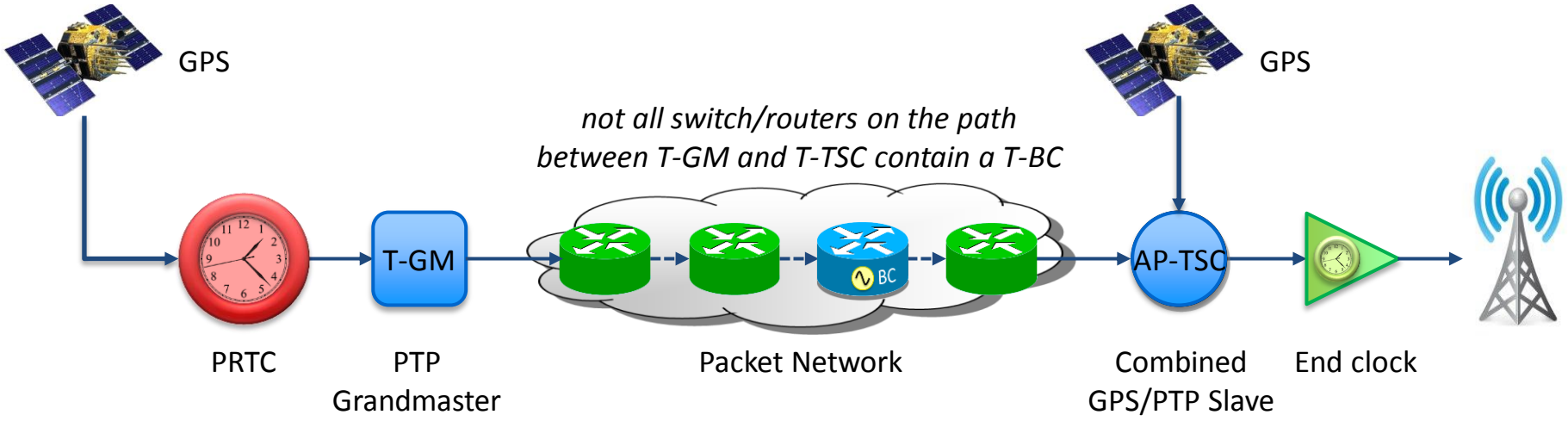
# PTP with Full Timing Support (G.8275.1)




## Features

- Every network element in the path must be “PTP aware”
- Each node contains a Telecom Boundary Clock (T-BC), avoiding accumulation of PDV along the path
- Can use a combination of SyncE & PTP, where SyncE provides the frequency and the PTP the phase/time

# PTP with Assisted Partial Timing Support




**Features**

- Objective is backup to GPS: i.e. “assisted holdover”
- Can use GPS when in service to monitor PTP service quality and measure network asymmetry
- PTP can maintain timebase when GPS is out of service
  (e.g. due to jamming or antenna failure)

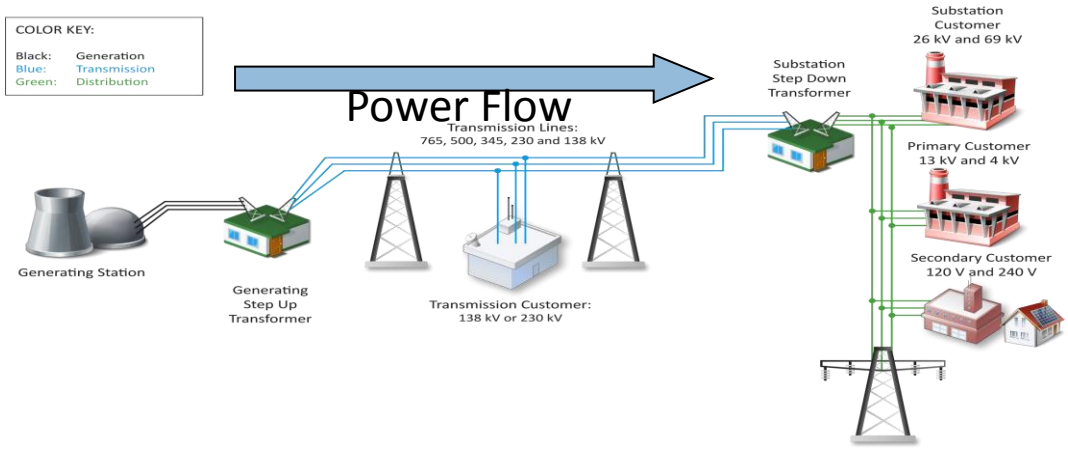
# Power

# Power – the need for Sync

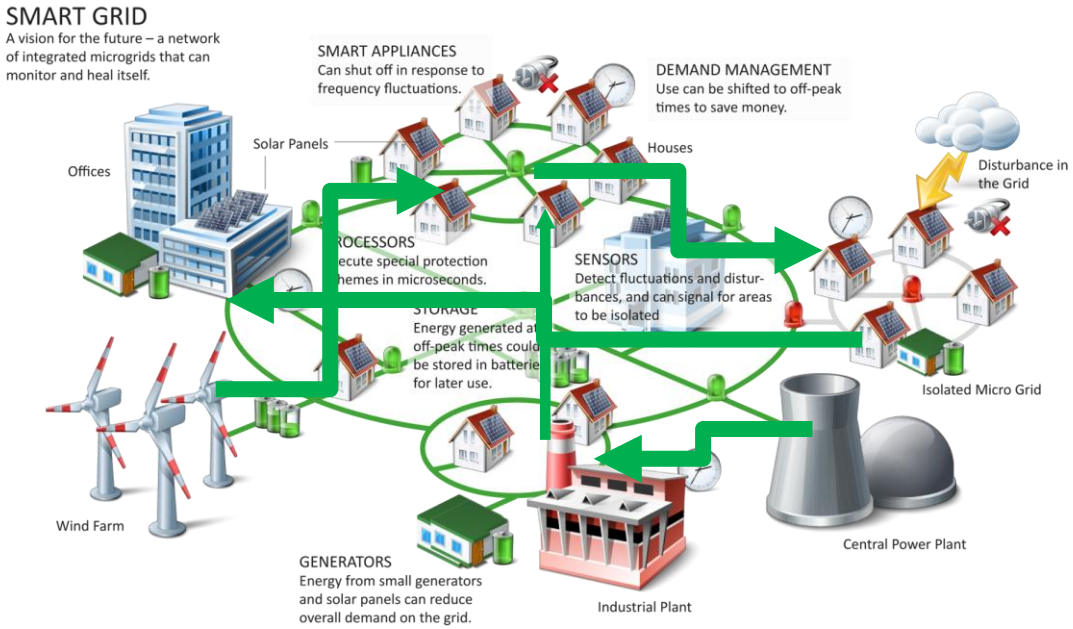
- "The Power Grid" is one of the world's largest infrastructures

- High synchronization requirements due to distributed nature of the grid and the critical balance between power generation and consumption
  - Power can't be stored easily so Grids Generate according to Demand
  - Need good Comms and Sync to correlate Demand and Generation
  - Has evolved from seconds to milliseconds and will evolve to microseconds → **Greater Efficiencies**
  - Also enables the **Greater Diversity** of the Smart Grid

# Power Grid vs Smart Grid




Simple topology means sync is needed but milliseconds is ok

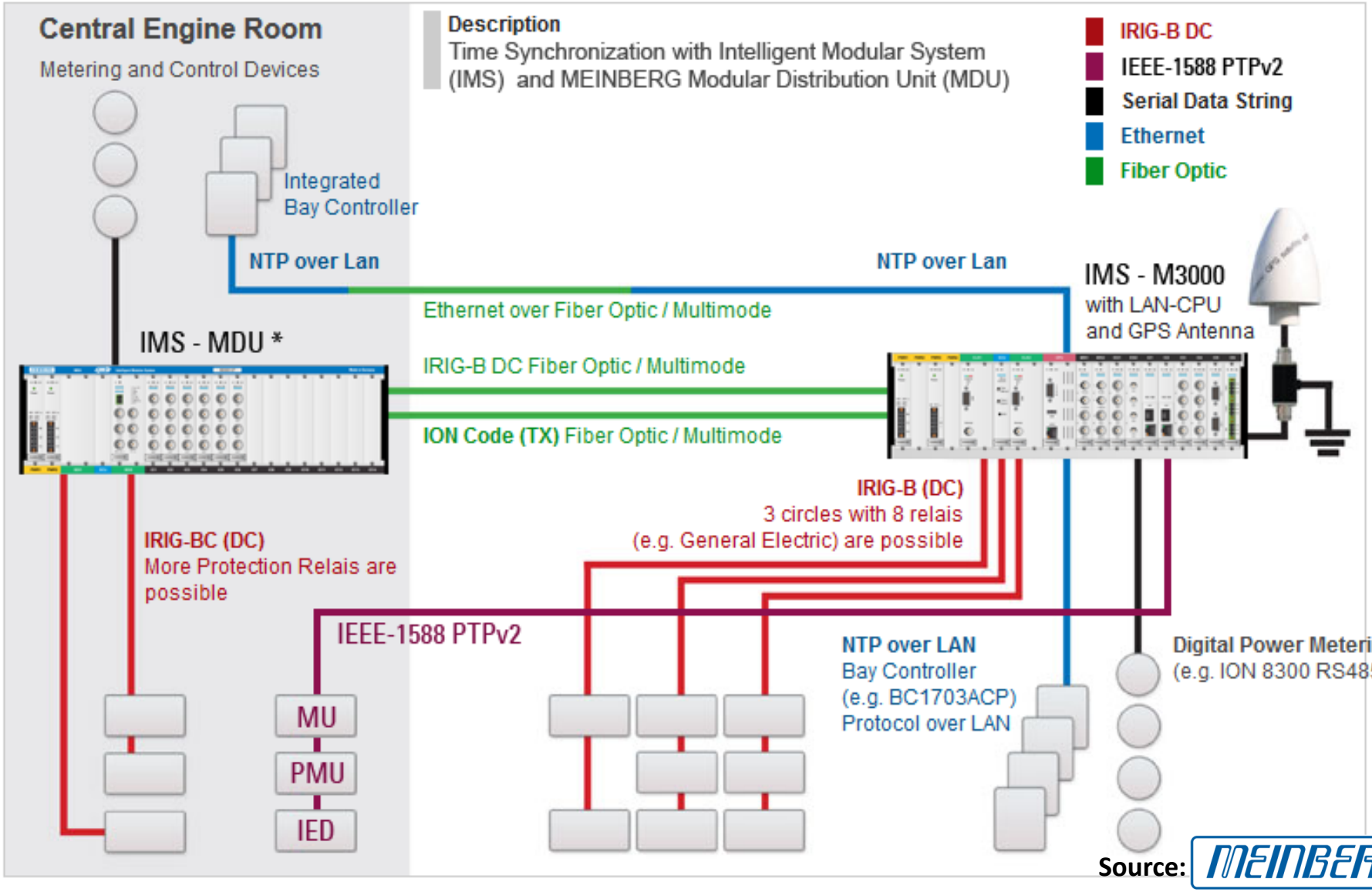



Greater complexity and diversity plus less predictability drives the need for better sync

Source: MEINBERG

# 1588v2 for Substation Communications

Calnex

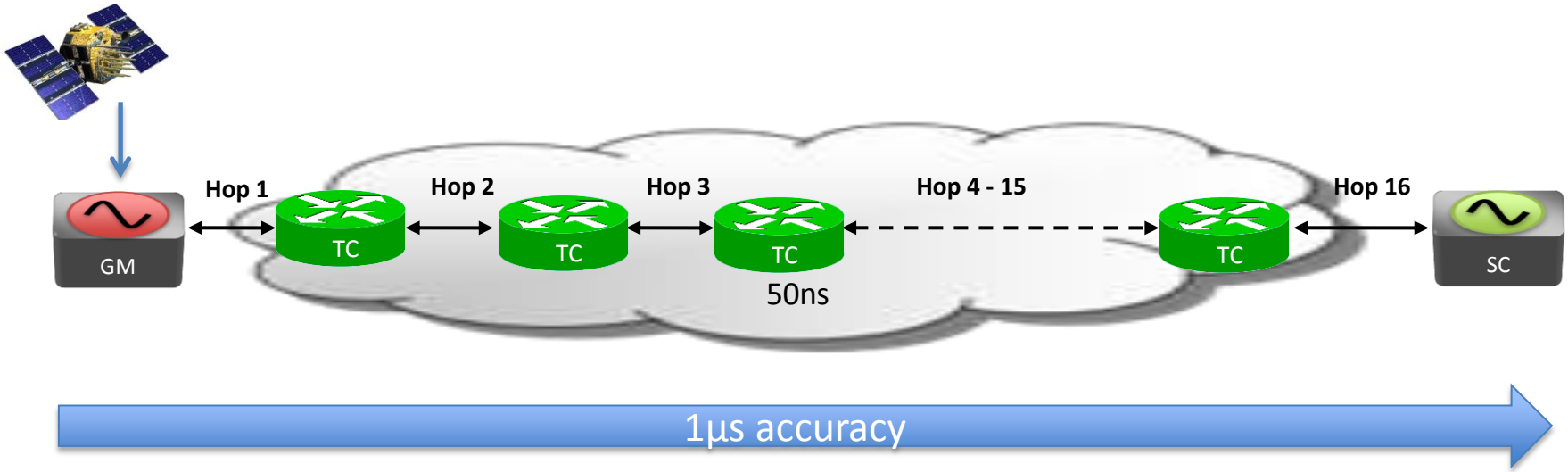



Source: MEINBERG

# Power Profile – IEEE C37.238-2011

- LAN (Layer 2 Ethernet Mapping)
- IEEE 802.1Q VLAN tags
- Multicast addressing
- Switches are Transparent Clocks
- Peer-to-peer delay measurement
- Time transfer accuracy and holdover time defined
- Message Rates
  - Sync ( & optional Follow_up) - 1 per second
  - Announce – 1 per second
  - Peer Del_Req, Peer Del_Resp, - 1 per second
- Minor revision under development to align with new IEEE 1588

# PTP Power Profiles – IEEE C37.238-2011

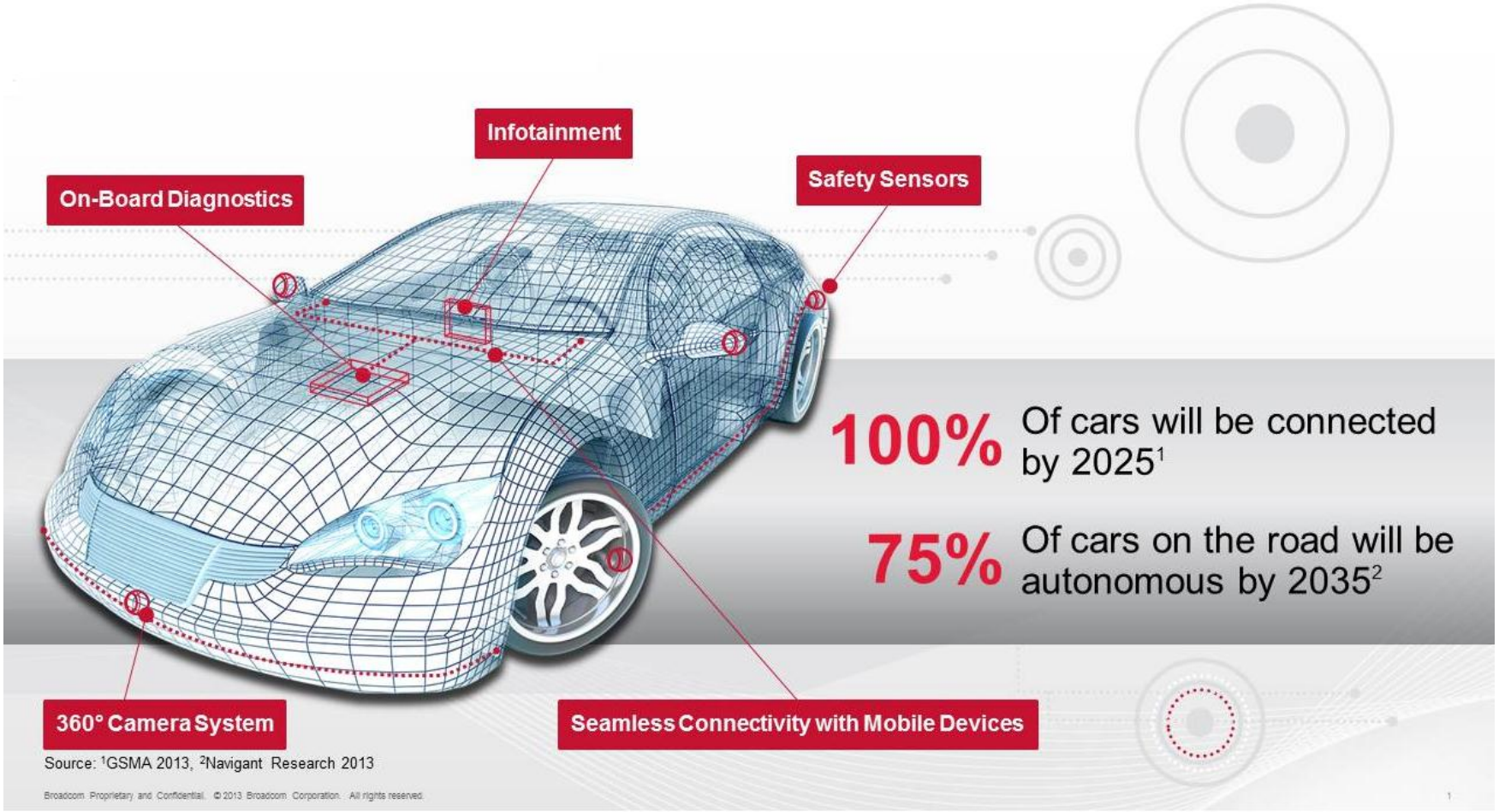



- Maximum 16 hops
- Network loads up to 80% wire-speed (line rate) on each link.
  - Random-length Ethernet frames shall be used: 80% with priority 4 and 20% with lower priority

Calnex

# Automotive

# The Connected Car



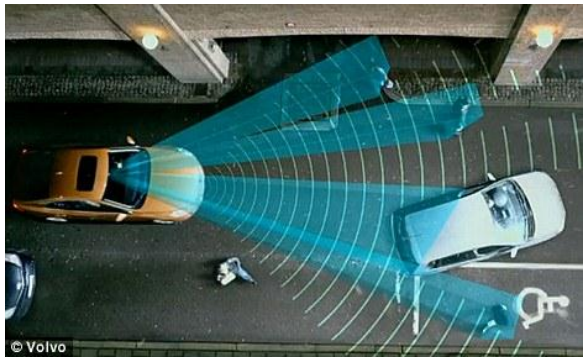
# Moving to new Applications

Calnex

### Assisted Parking

© forcegt.com / Ford

### Object Detection



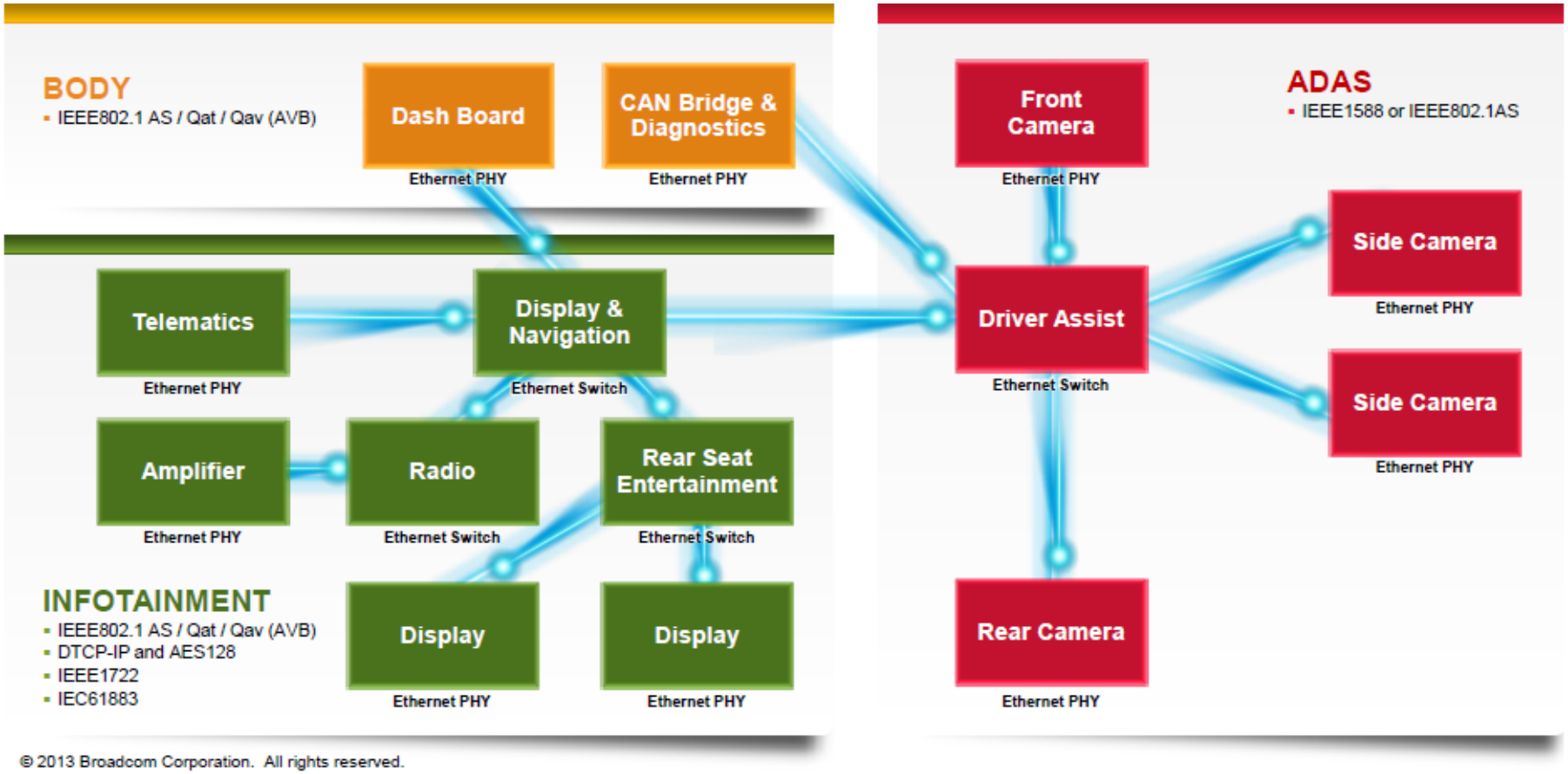

© Volvo

### Self Driving Vehicles

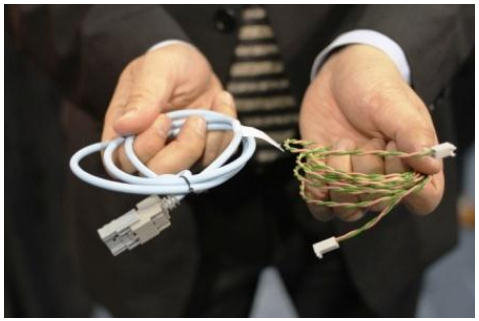
© Google

All these new Applications need Cameras and Sensors with control systems that need accurate timing

# In-Car Communications - Tomorrow



# New Automotive Ethernet Interfaces



- OABR – OPEN Alliance BroadR-Reach
  www.opensig.org
  http://en.wikipedia.org/wiki/BroadR-Reach_Ethernet_standard

- 2-wire unshielded twisted pair copper instead of 8-wire shielded twisted pair
- Today 10/100 Mbit/s  (1 Gbit/s in planning )
- Easy and less expensive to install (reduce connectivity cost 80%)
- Weight reduction up to 30%

- Now being standardised through IEEE:
  - 802.3bw – 100Base-T1, expected completion Feb. 2016
  - 802.3bp – 1000Base-T1, expected completion May 2016

# IEEE 802.1AS

Calnex

- The standard for transport of precise timing and sync in Time Sensitive Networks, (formerly known as AVB – Audio/Video Bridging)

- Includes a PTP profile:
  - Ethernet
  - Multicast
  - Boundary Clock switches
  - Single Master Clock
  - Pdelay_Req mechanism (Not mandatory to use)
  - VLANs can be used

- Standard being used in Automotive, Professional Audio and Video and some Industrial networks

# Finance

# The need for Sync in Financial Networks

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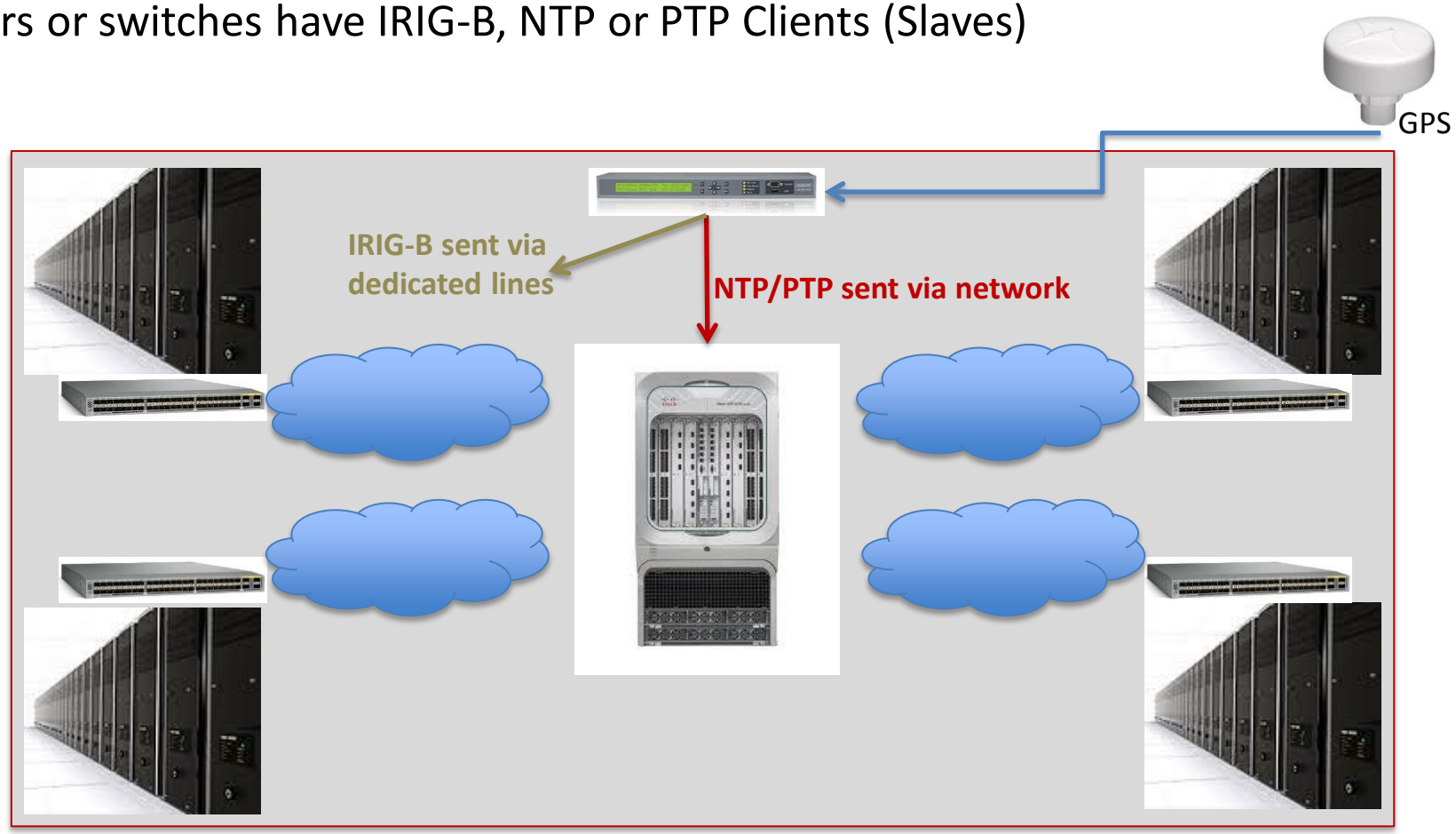
- High-Frequency Trading (HFT) requires accurate timestamping of trades for:
  - Accurate records of transactions during playback regression to improve trading algorithms
  - Reporting and regulatory purposes, disputes, etc.
- GPS has primarily been used for this but faces issues:
  - Coverage and signal loss is a significant and expensive issue
  - Security - a US$20 device can jam GPS signals
- 1588v2 PTP is getting a lot of interest
  - Time can be delivered via the Ethernet network
  - However accuracy needs to be verified during trials and monitored in-service

# Sync in the trading floor

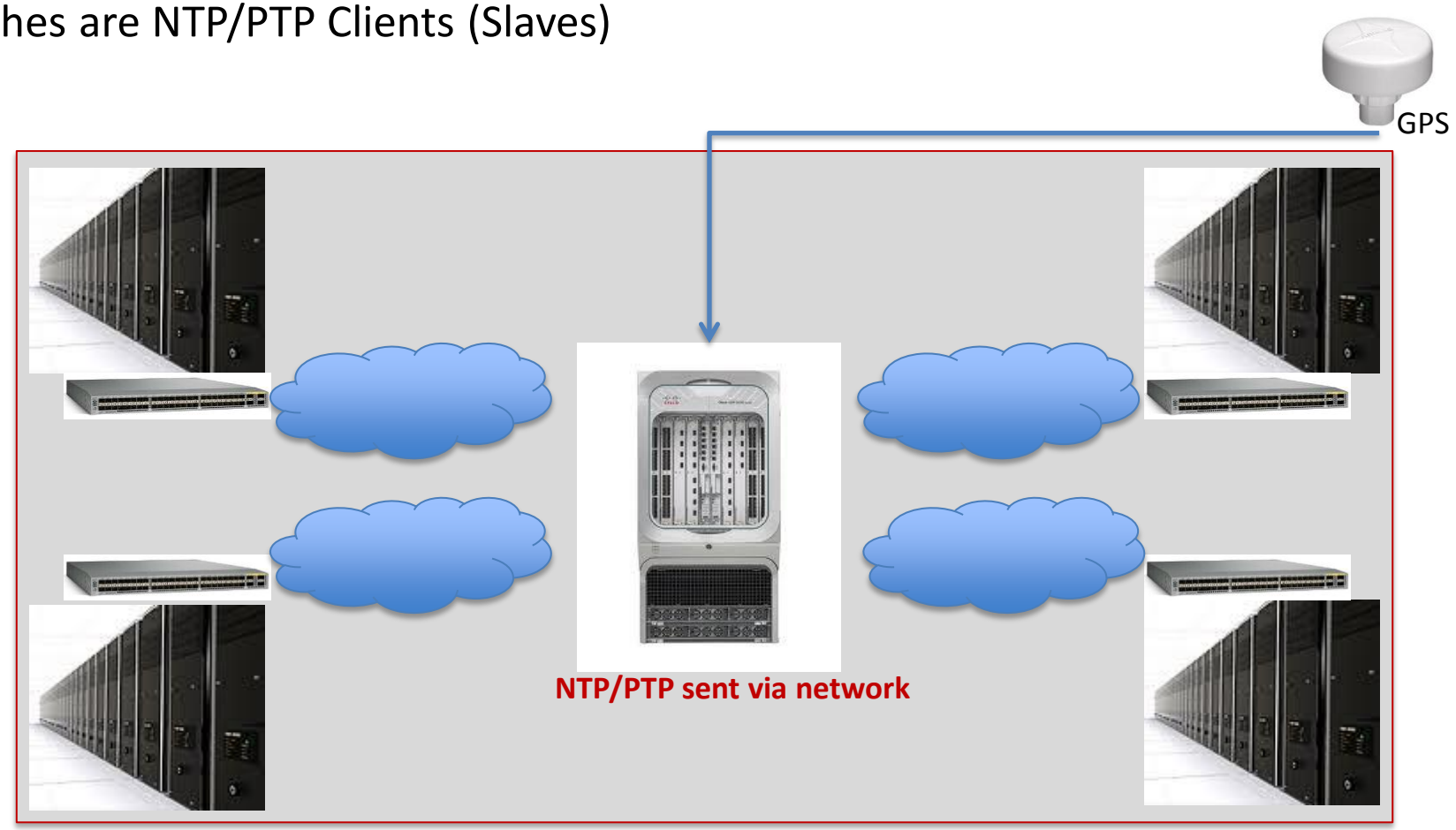
Calnex

Scenario 1 – all servers co-located in the Trading Exchange or Data Warehouse
GPS-locked Time-master, feed to servers via IRIG-B, NTP or 1588v2 PTP
Servers or switches have IRIG-B, NTP or PTP Clients (Slaves)



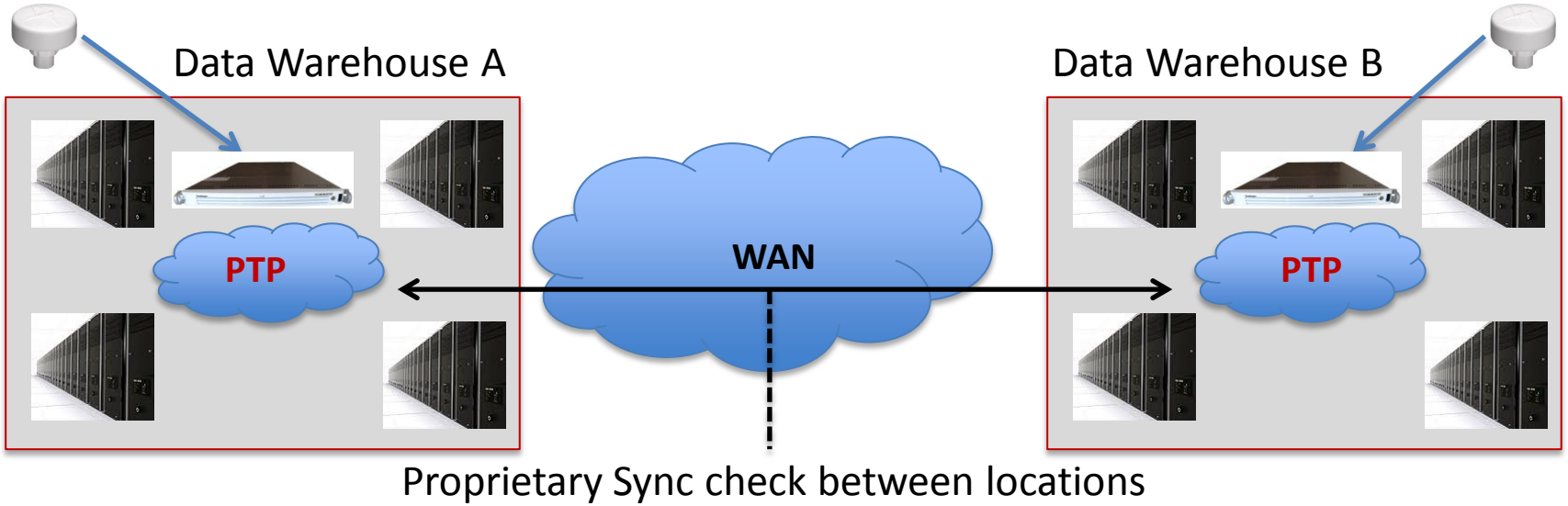
# Sync in the trading floor

Scenario 2 – all servers co-located in the Trading Exchange or Data Warehouse
GPS-locked  Router is 1588v2 PTP Master
Switches are NTP/PTP Clients (Slaves)



# Sync in the trading floor

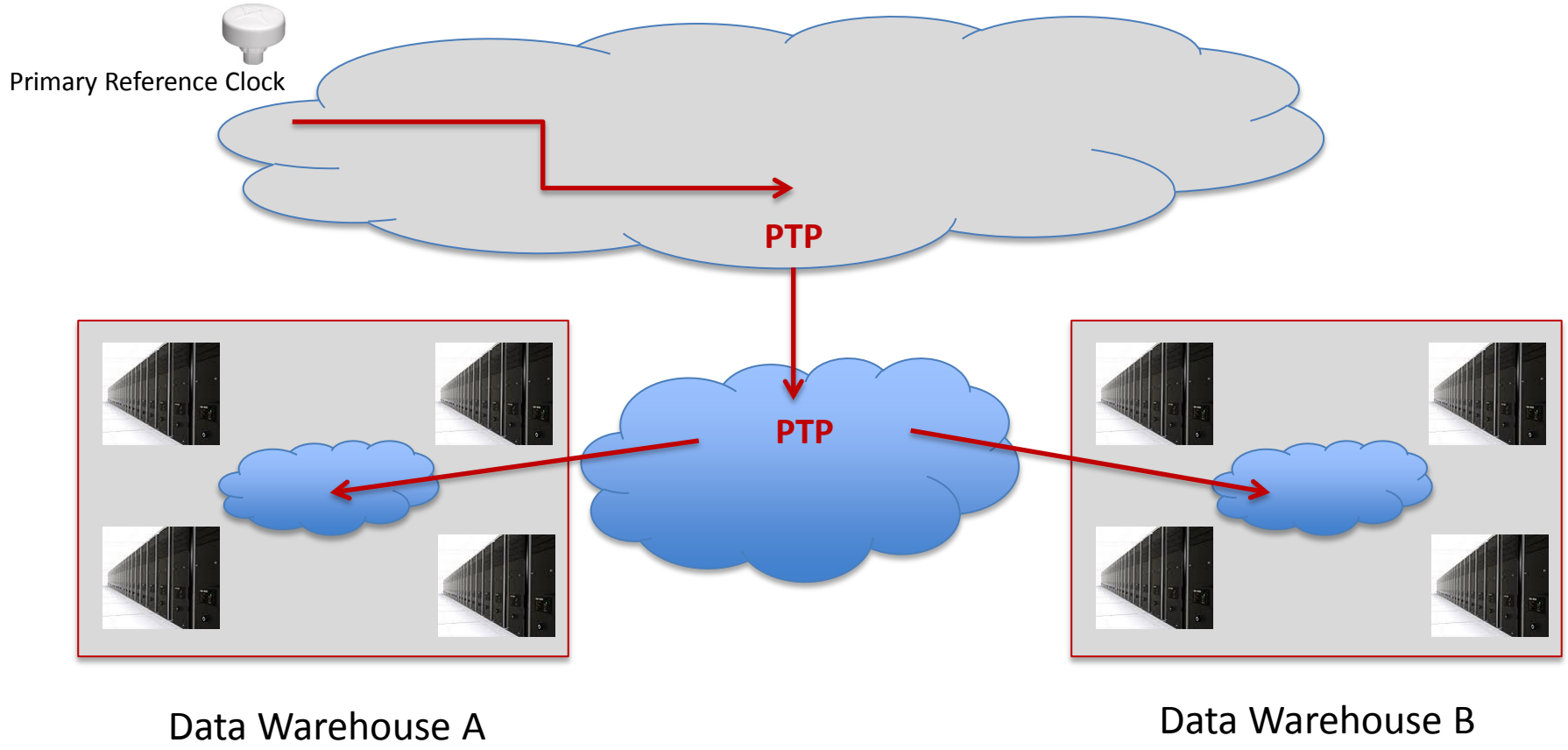
Scenario 3 –servers located in multiple locations
GPS at every location, either Scenario 1 or Scenario 2 at each location
Switches are NTP/PTP Clients (Slaves)



# Sync in the trading floor

Calnex

Scenario 4 –servers located in multiple locations
1588v2 PTP (Timing Service) from Telco Carrier



# The Requirement and The Options

Calnex

## Requirement

- Conventional wisdom is:
  - The applications need 1ms, so the hardware needs **1µs**

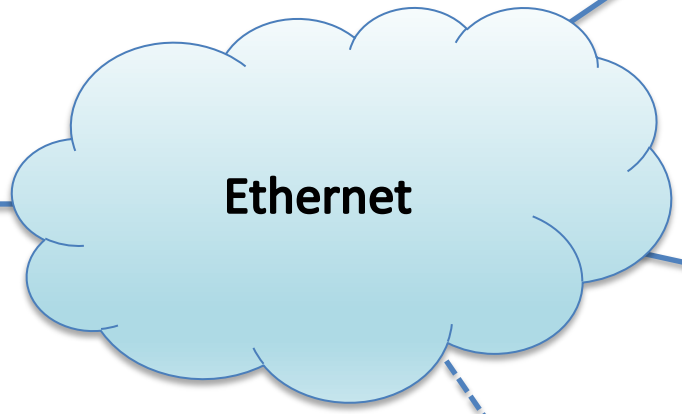
## Options

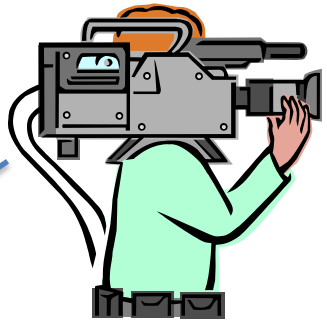
- GPS and IRIG-B
  - IRIG-B is old technology (limited support) and needs a costly dedicated link
  - Used in older installs
- GPS and NTP
  - Not accurate enough - deliver 1ms rather than 1µs
  - Used when 1ms is sufficient
- GPS and 1588v2 PTP (or PTP-only)
  - Loading changes cause PDV and Asymmetry, which cause inaccuracy
  - Ongoing trials and investigations
- PTP Profile
  - IETF: Draft Enterprise Profile for PTP (latest version -04, October 2014)
  - Ongoing Working Group calls

Calnex

# Broadcast

# Broadcast Studios



- Increasingly, studio equipment connected via Ethernet
- Digital TV studio needs synchronization to within 1µs

# Broadcast PTP Profile

Calnex

SMPTE standardising on use of PTP for synchronisation

- Replacing analog Genlock
- Most equipment has two Ethernet connections:
  - “essence” (i.e. the media stream)
  - Control/management interface
- Proposal to run PTP over the control/management connection
- For large studios, transparent clocks needed to reduce PDV

SMPTE PTP Profile has gone to ballot:

- Draft ST 2059-2: “Precision Time Protocol SMPTE profile for time and frequency synchronization in a professional broadcast environment”
- In Comment Resolution Phase