Translating from Telecom PTP Profile to Power PTP Profile for GNSS-Backup

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MEINBERG

The Synchronization Experts.

WORKSHOP ON SYNCHRONIZATION AND TIMING SYSTEMS

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Dr. Arnold has over 15 years experience developing precise time and frequency equipment. He is currently a Principal Technologist with Meinberg USA. He is a Chair of the IEEE 1588 Working Group, Chair of the ISPCS IEEE 1588 Plugfest Committee, and technical editor for IEEE 1952. He holds a Ph.D. in Electrical Engineering from the University of Illinois.

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Tahmina Hoque has over 25 years of experience in Telecom network technology. She is currently an Applications Engineer at Meinberg USA, where she works closely with the power grid Industry professionals to meet timing requirements. Her background in test &measurement, Ethernet/IP/Optical networks, and Synchronization guide her in developing power grid timing solutions. She is also a member of the IEEE PES (Power Energy Society) where she contributes to standards pertaining to timing of the grid. Tahmina earned her BEng Electrical with a concentration in Telecom at Concordia University in Montreal, Canada.

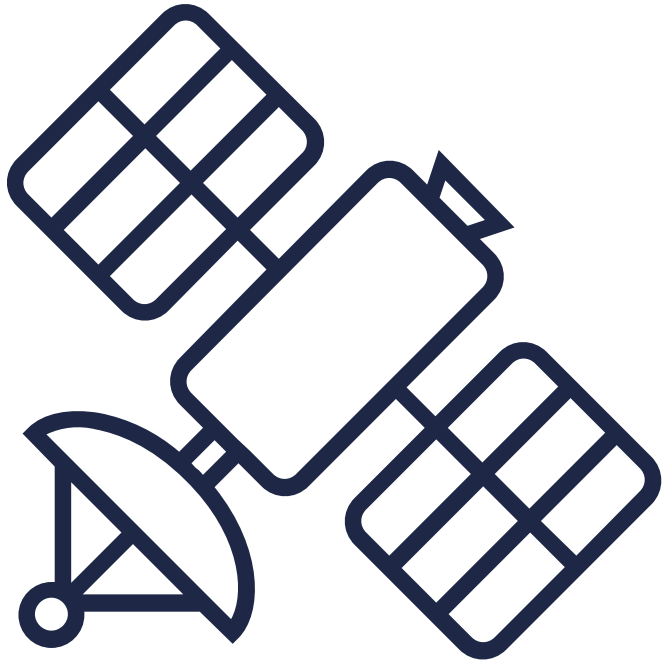
Agenda

- Introduction
- GNSS outage in power grid substation
- Failover options
- PTP telecom profile to power profile translation
- Timing accuracy issue
- Takeaways & Conclusions

Introduction

- As a starting point, let us consider the increased use of alternate energy sources with intermittent production:
  - Balancing energy flows in power grids become more complex
  - Leads to an increased dependency on synchrophasor measurements of current and voltage throughout the transmission network to detect energy flow instabilities before they lead to a cascade blackout
- Grid operators need to compare the measurements throughout the grid on the same timescale
  - The IEEE Standard for Synchrophasor Measurements for Power Systems (IEEE C37.118) establishes a time synchronization requirement of 1us to UTC for all phase measurement units.
  - This specification ensures that the contribution to measurement error remains significantly below 1% of the total vector error.

GNSS Outage in a Power Station



How does GNSS failure affect the Power Grid?

- GNSS outage
  - Antenna failure
  - Receiver failure
  - Jamming
  - Detected Spoofing*
- What happens when the PTP Grandmaster Clock (GC) is in holdover mode?
  - OCXO (20 us or more in 24 hours)
  - Rb (1 us in 24 hours)
  - Cs unlikely to be available

- All substation time distribution mechanisms affected
  - PTP
  - IRIG-B
  - NTP
  - Etc.

*Note: Undetected spoofing is a different and serious problem, but not addressed in this presentation

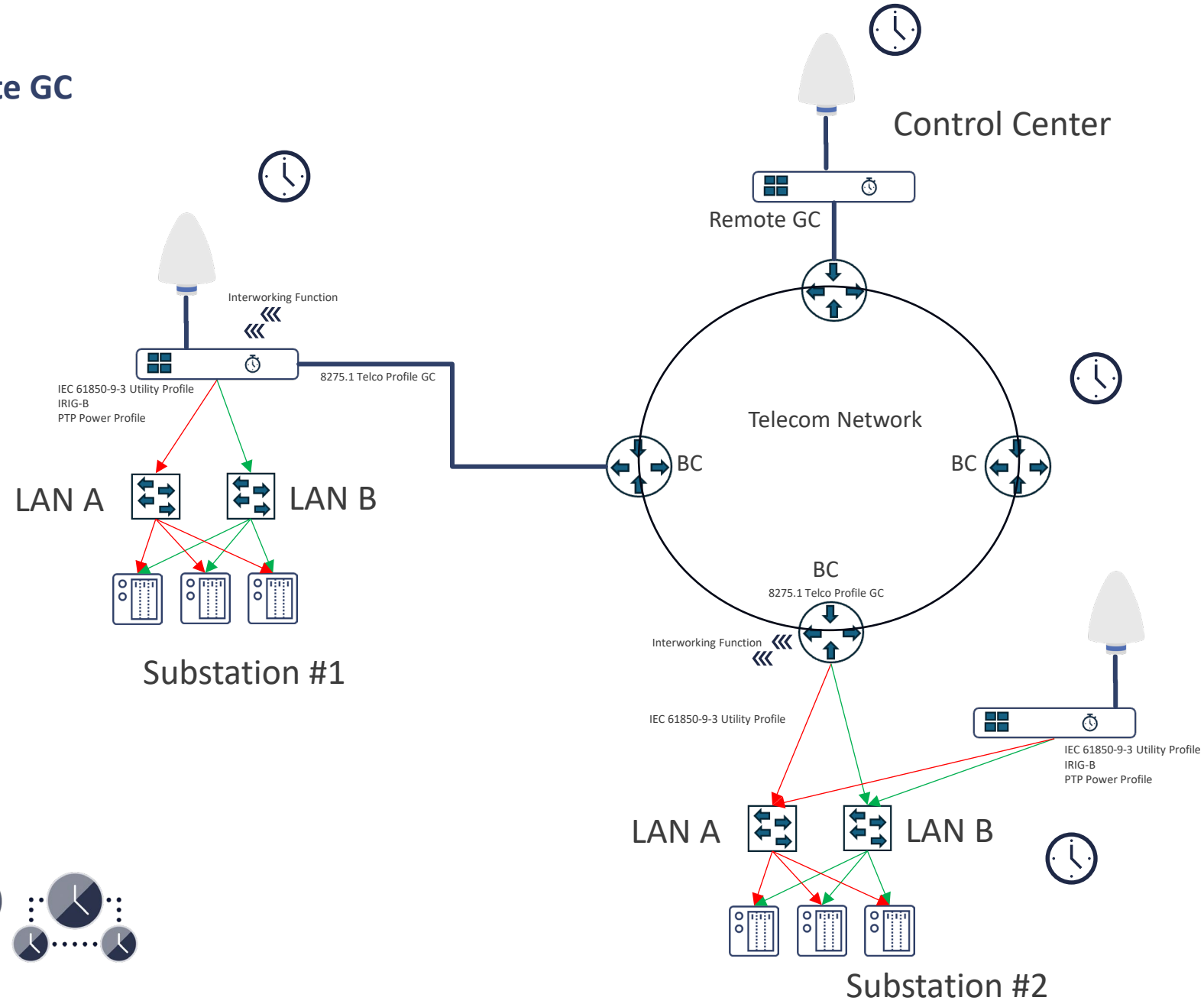
Failover Options

GNSS outage solutions

- BPS (Broadcast Positioning System)
  - Promising potential
  - But not ready yet
- LEO satellites
  - Much harder to jam and spoof than GNSS
  - Subscription required
- ePTS (Enhanced Partial Timing Support) to remote GC
  - Promising potential
  - No ratified standard yet (under development for G.8275.2)
- PTP to remote GC
  - Easy to implement today

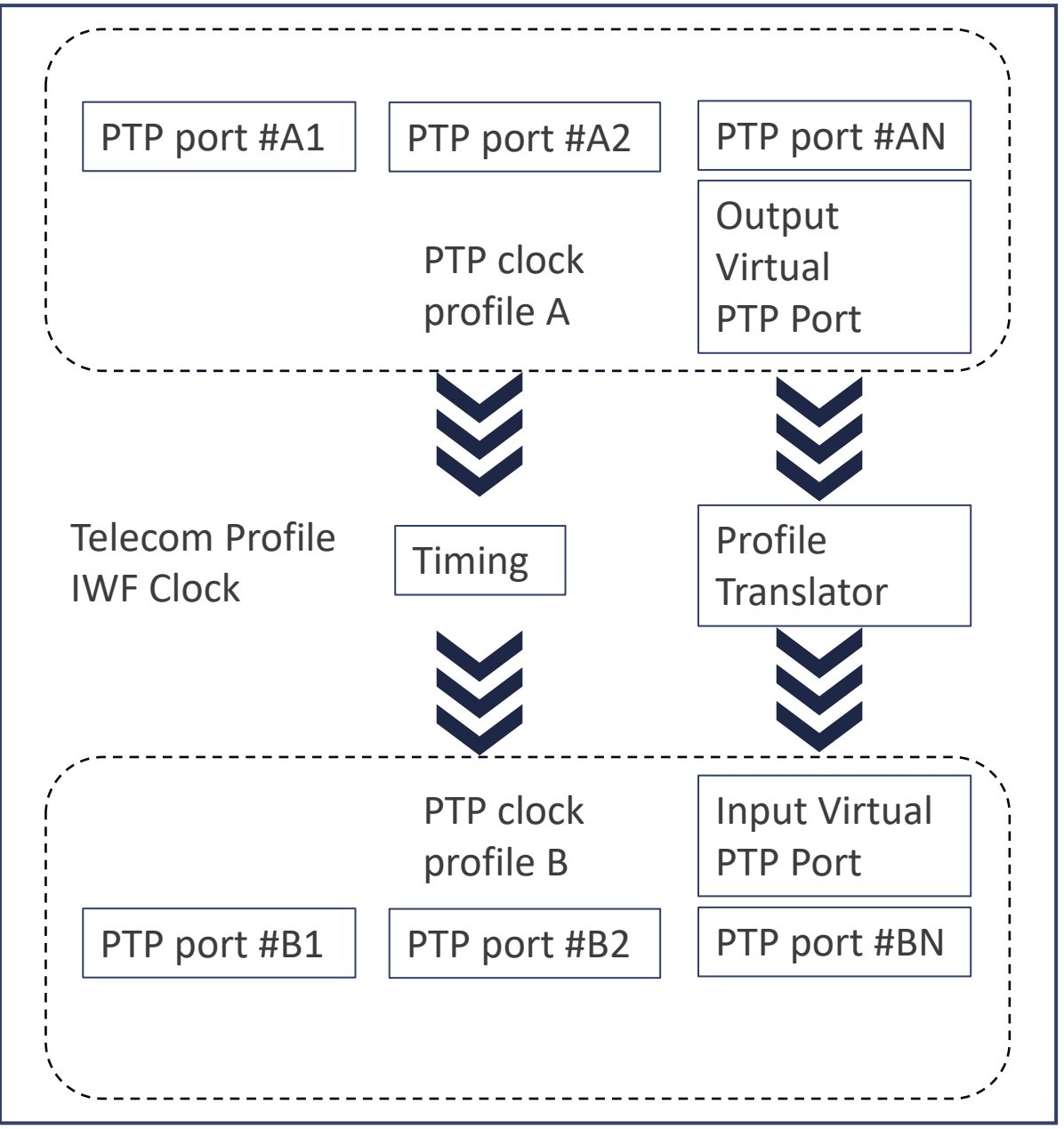
PTP Profile Translation

PTP to remote GC



PTP

Interworking Function (IWF)



- Defined by ITU-T to translate among ITU-T defined profiles. For example:
  - G.8275.1, Full on path support
  - G.8275.2, Partial timing support
- An IWF can be defined to translate from G.8275.1 or G.8275.2 to IEC 61850-9-3 or IEEE C37.238
- PTP domains are isolated from each other, but time can be transferred external to PTP
  - Using a common local hardware clock
  - Or by locking one clock to another

Timing Accuracy Issue

Power grid timing requirements

Common equipment and systems	Time synchronization accuracy
MU	Better than 1µs
PMU	Better than 1µs
Protection (Logic)	Better than 55µs (f_0=50Hz)
Fault Recorder	Better than 1ms
BCU	Better than 1ms
Protection (Event recording)	Better than 1ms
BIED	Better than 1ms
SIPS	Better than 10ms
Metering IED	Better than 1s
Computer Monitoring System	Better than 1s

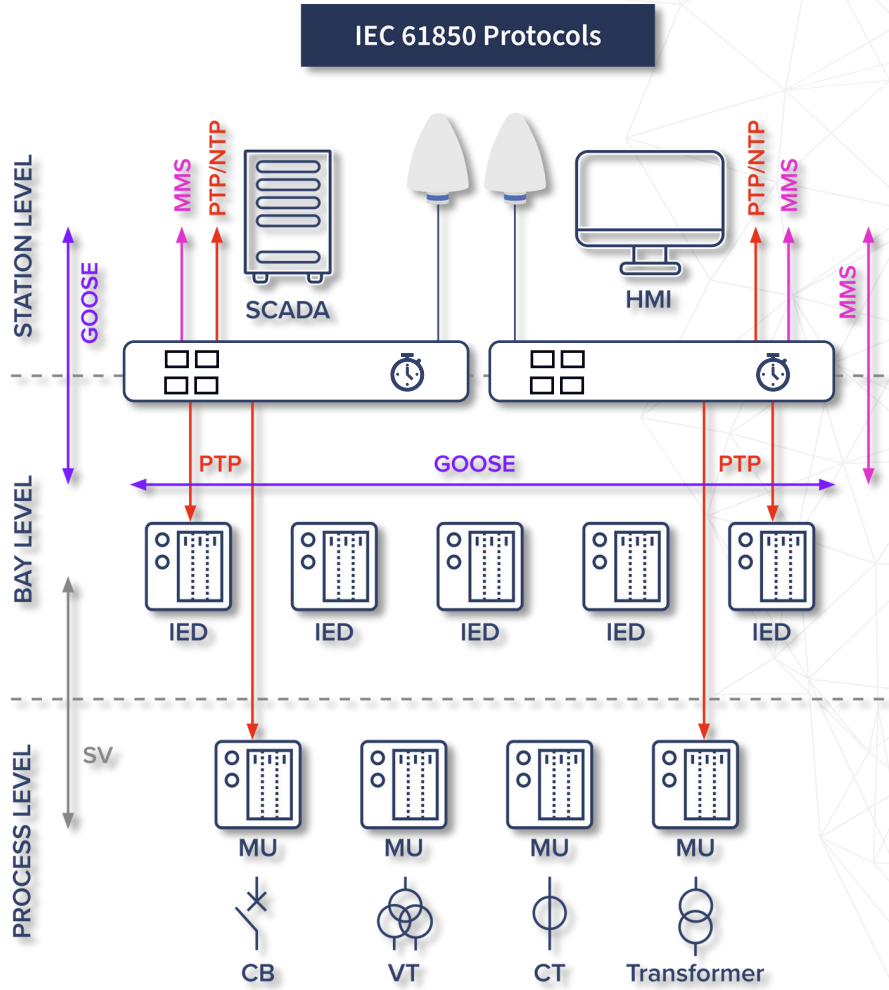
Requires FTS G.8275.1

PTS would work G.8275.2

Table Source: Cigre B5/D2, Doc 885, Table 4.1

FTS: Full Time Support

PTS: Partial Time Support



Functioning of communication protocols in IEC 61850

MU: Merging Unit
PMU: Phasor Measurement Unit
CB: Circuit Breaker
VT: Voltage Transformer
CT: Current Transformer
GOOSE: Generic Object-Oriented Substation Event
SCADA: Supervisory Control and Data Acquisition
HMI: Human to Machin Interface
IED: Intelligent Electronic Device

IWF issue: Accumulated Inaccuracy

Total inaccuracy delivered to IED is 250 ns + 15x50 ns = 1000 ns
Up to 15 hops in substation network still delivers 1 µs

G.8275.1, Full timing support

Total inaccuracy delivered to IED is 100 ns + 6x70 ns + 200 ns + 6x50 ns = 1020 ns

- Error budget includes path to backup substation.
- More T-BCs means fewer allowed substation TCs

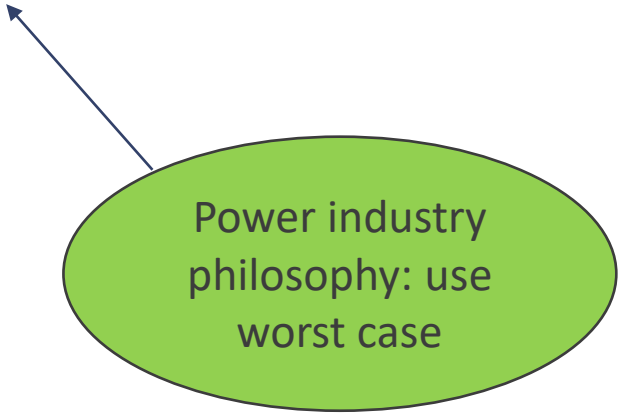
Telecom backup error budget can be reduced using:

- T-GM with ePRTC (50 ns)
- Higher class T-BCs
- Max constant time error (cTE) budgeting rather than max error for T-BCs
  - Due to jitter filtering T-BC PLLs

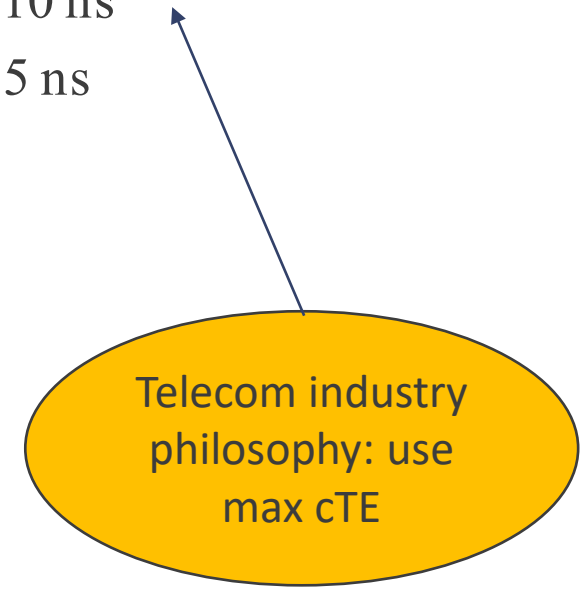
TC: Transparent Clock
BC/T-BC: Boundary Clock
GC/T-GM: Grandmaster Clock
IWF: Interworking Function

ITU-T clock inaccuracy specifications

- T-GM
  - Based on PRTC: 100 ns to UTC
  - Based in ePRTC: 50 ns to UTC
- T-BC maximum inaccuracy
  - Class A: 100 ns
  - Class B: 70 ns
  - Class C: 30 ns
  - Class D: TBD



- T-BC maximum constant time error
  - Class A: 50 ns
  - Class B: 20 ns
  - Class C: 10 ns
  - Class D: 5 ns



Takeaways

- Alternate energy production from sources that frequently turn on and off lead to requirements for more synchrophasor measurements.
- Substation timing systems vulnerable to disruptions in GNSS availability
- Substation timing can be more resilient with backup to another substation using Telecom Profile PTP
  - Since most GNSS disruptions are local, other substations are generally unaffected
- Telecom and power PTP profiles are incompatible requiring an interworking function to translate from one to another
- Getting time synchronization from another substation means that the error budget must include time inaccuracy between substations
- Tightest substation timing requirements can only reliably be met with FTS telecom PTP

Thank You For Your Time

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