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Time Synchronization in Power Utilities

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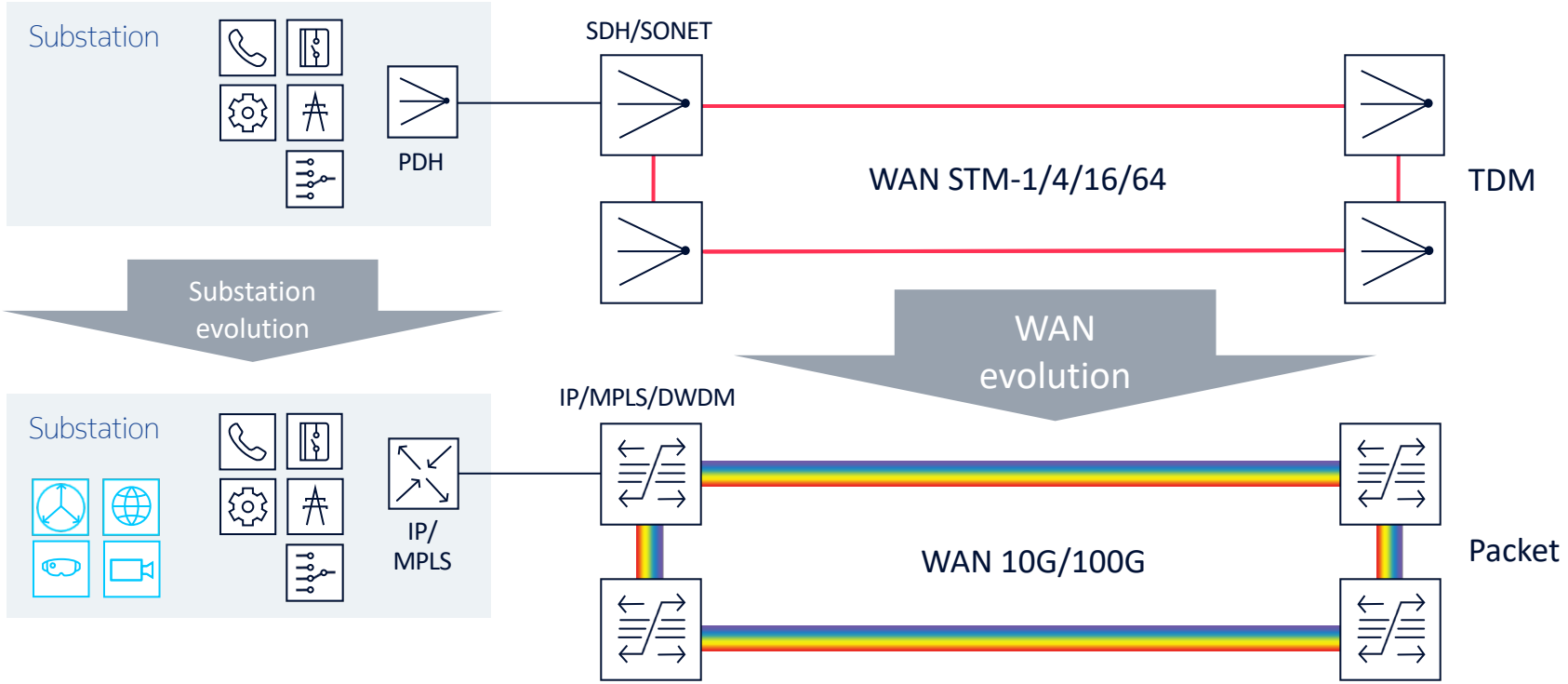
9 November 2022

Evolution of power utility networks



Network sync requirements in power utilities

Wide area precision time requirements in current power systems

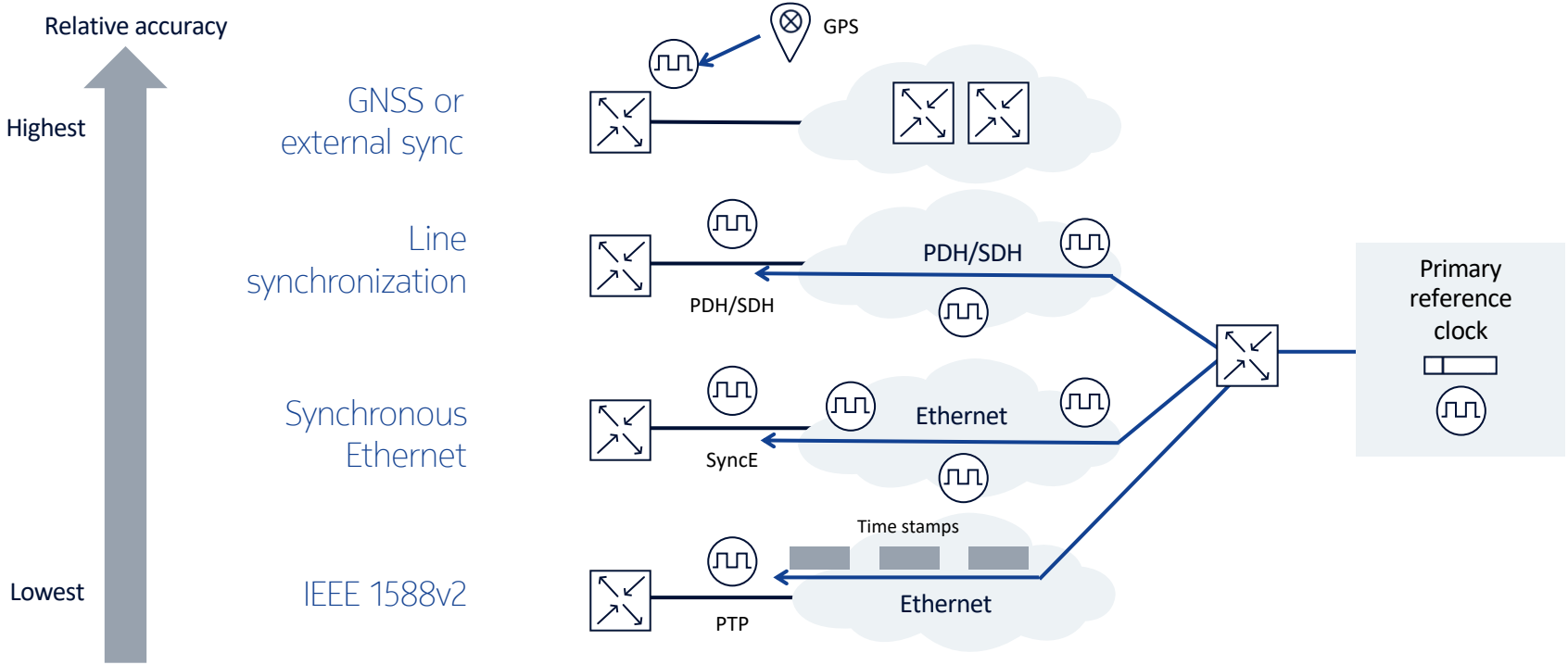
Applications	Time accuracy requirement
Traveling wave fault detection and location	100 to 500 ns
Synchrometrology (synchrophasors) Wide area protection Frequency event detection Anti-islanding Droop control Wide Area Power Oscillation Damping (WAPOD)	Better than 1 µs
Line differential relays	10 to 20 µs
Sequence of events recording	50 µs to ms
Digital fault recorder	1 ms
Communication events	
Substation local area networks (IEC 61850 GOOSE)	100 µs to 1 ms
Substation local area networks (IEC 61850 sample values)	1 µs

Source: NIST report:

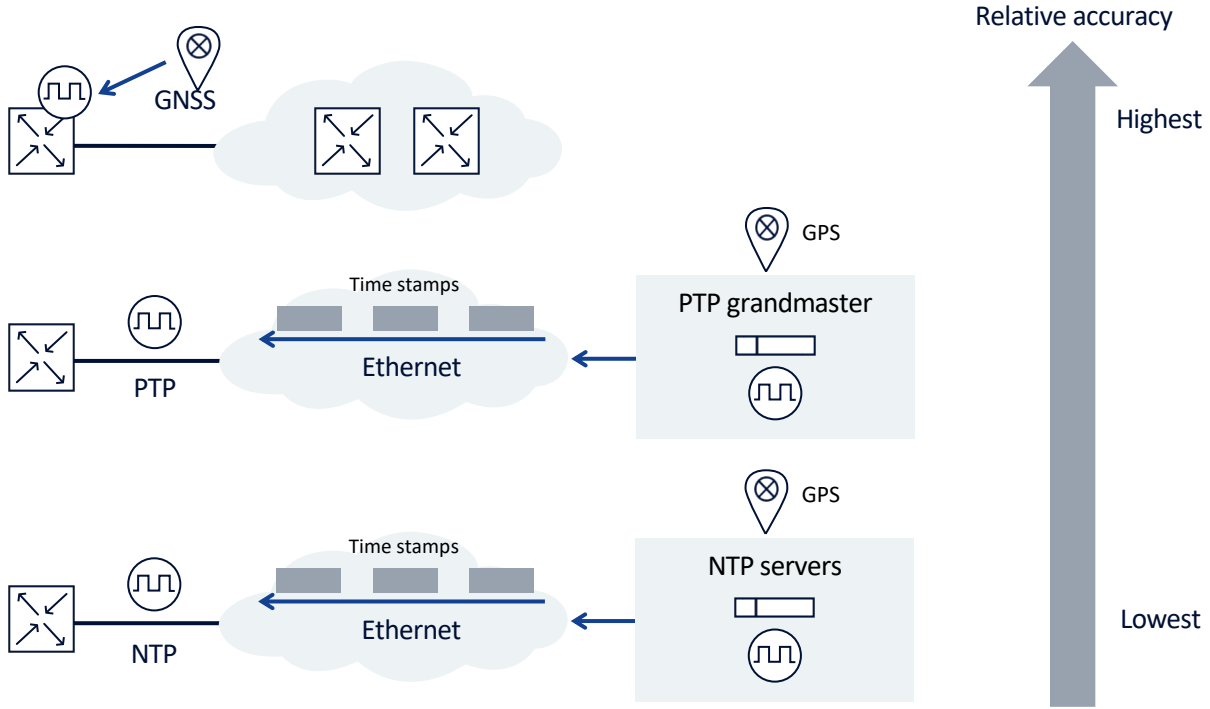
Timing challenges in the Smart Grid

Power utility profile specifies better than 1 µsec network target

Frequency sync options



Time sync options



IEC 61850's choice - IEEE 1588v2

Profiles tailored for the need of different industries and applications

Default profile

IEEE1588-2008 Annex J

Power profiles

IEC 61850-9-3 (2016)

IEEE C37.238 (2017)

ITU-T Telecom profile

G.8265.1 (2010)

G.8275.1 (2014)

G.8275.2 (2016)

Other profiles

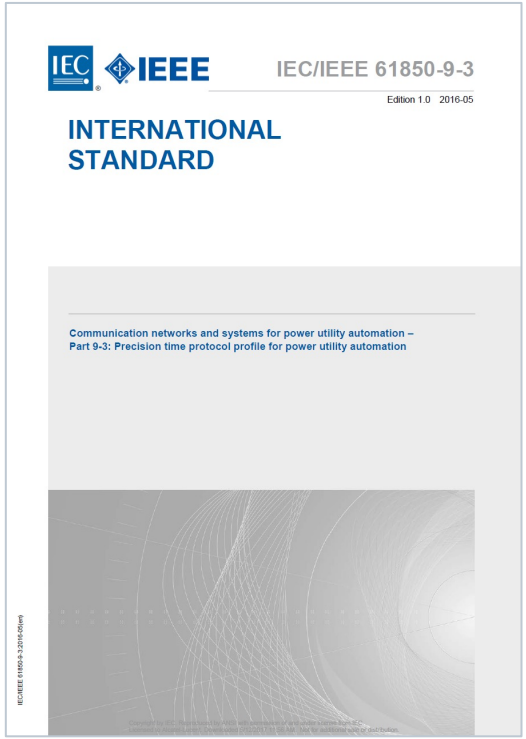
Finance

SMPTE (motion picture AV)

AES67 (audio)

IEC/IEEE 61850-9-3 power utility profile

- Support time and frequency recovery
- Transport of PTP over Ethernet with peer delay mechanism
- Network performance target: 1 µsec
- Clock types:
  - Grandmaster Clock (GM)
  - Slave Clock (SC)
  - Boundary Clocks (BC)
  - Transparent Clocks (TC)
- Best Master Clock Algorithm (BMCA) provides automatic parent clock recovery, in case of failure, for Boundary Clocks and Slave Clocks
- C37.238-2017 Profile
  - Extension of IEC/IEEE 61850-9-3, to provide additional functionality
  - Includes a mandatory TLV (total time inaccuracy) and an optional TLV (alternate time offset)



IEEE1588v2 - Telecom and power profiles

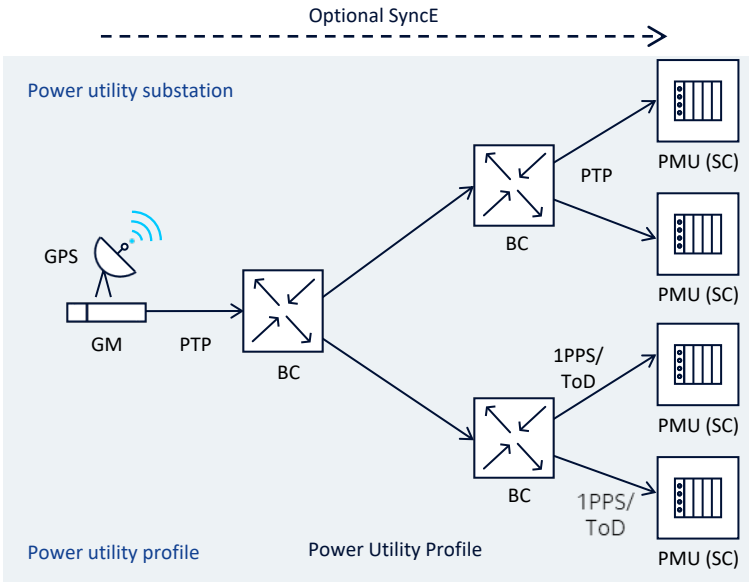
1. ITU-T Telecom profile for frequency (G.8265.1)
   - Frequency distribution only
2. ITU-T Telecom profile for time with full timing support (G.8275.1)
   - Time/phase distribution only, NOT frequency
3. ITU-T Telecom profile for time with partial timing support (G.8275.2)
   - Time/phase and frequency distribution

1. IEEE 1588v2 default profile
   - Time/phase and frequency distribution
2. IEC/IEEE 61850-9-3 power profile
   - Time/phase and frequency distribution
3. IEEE C37.238-2017 power profile for frequency
   - Time/phase and frequency distribution

Profile	Standards encap type	Freq recovery	Time recovery	Per BC clock time accuracy: max |time error|
1588 default	IP or Ethernet	Yes	Yes	
G.8265.1	IP	Yes	No	
G.8275.1	Ethernet	No	Yes	Class A/B/C = 100/70/30 nsec
G.8275.2	IP	Yes	Yes	Max |TE| For further study, dTE_L = 200 nsec
61850-9-3	Ethernet	Yes	Yes	200 ns
C37.238-2017	Ethernet	Yes	Yes	200 ns

Topology: IEC 61850-9-3 end-to-end, single Location

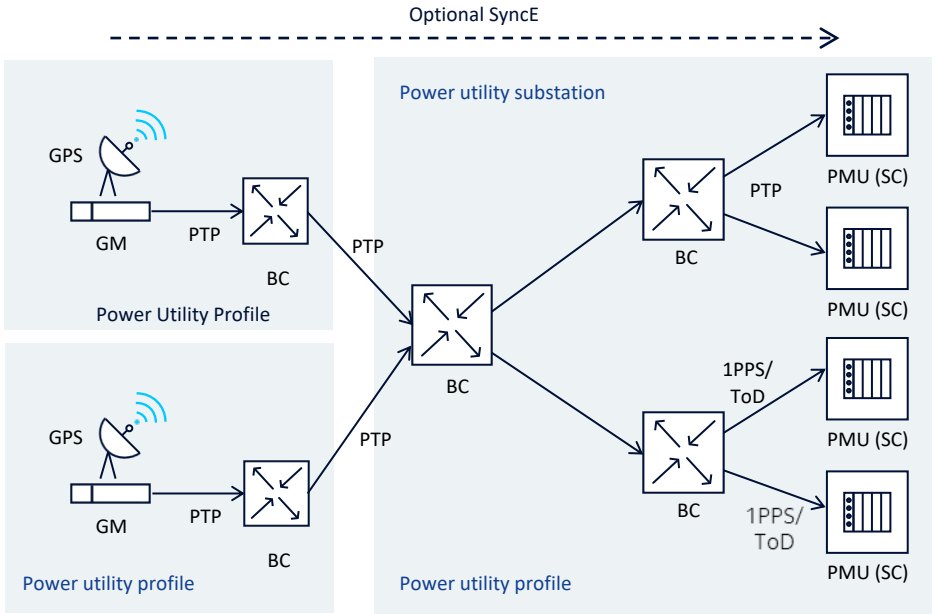
PMU Slave Clock with Power Utility Profile Support



Single location, GPS-sourced

Topology: IEC 61850-9-3 end-to-end, multiple Locations

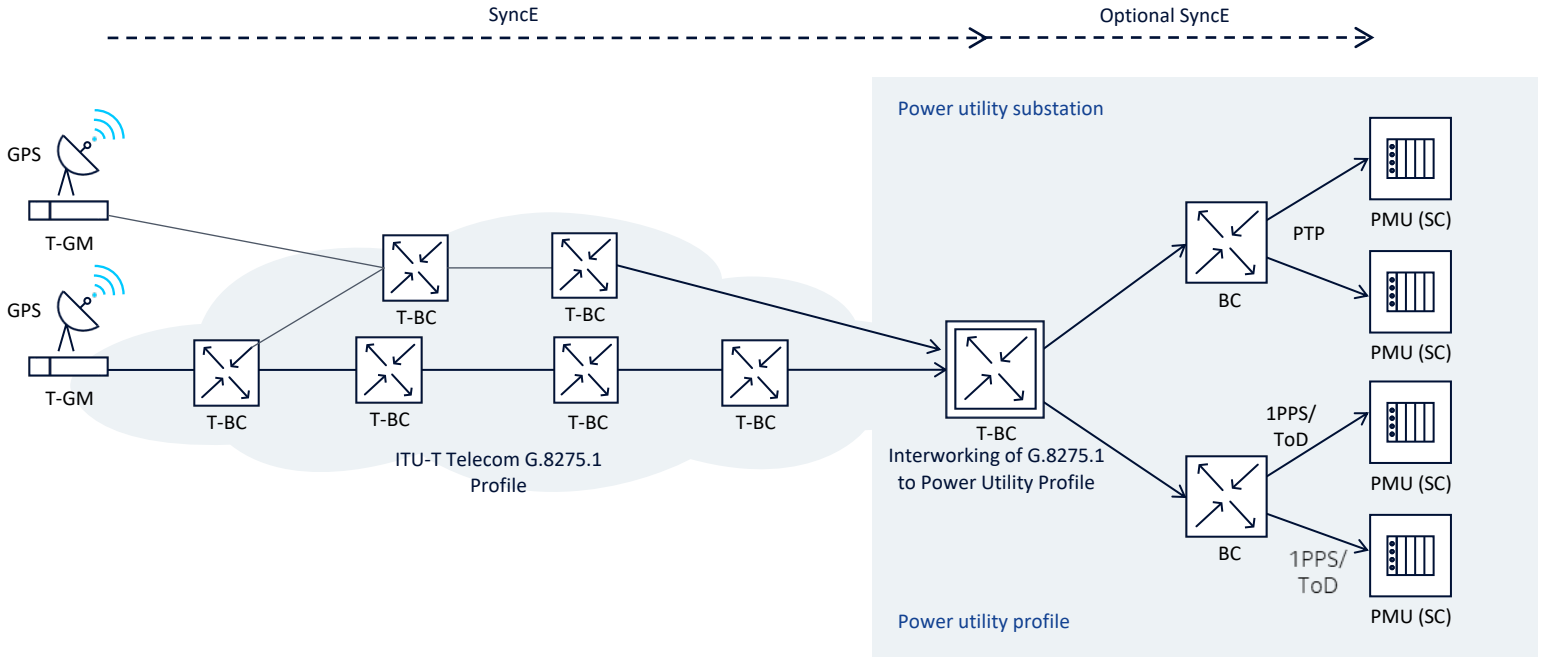
PMU slave clock with power utility profile support



Multi-location, redundant GPS-sourced

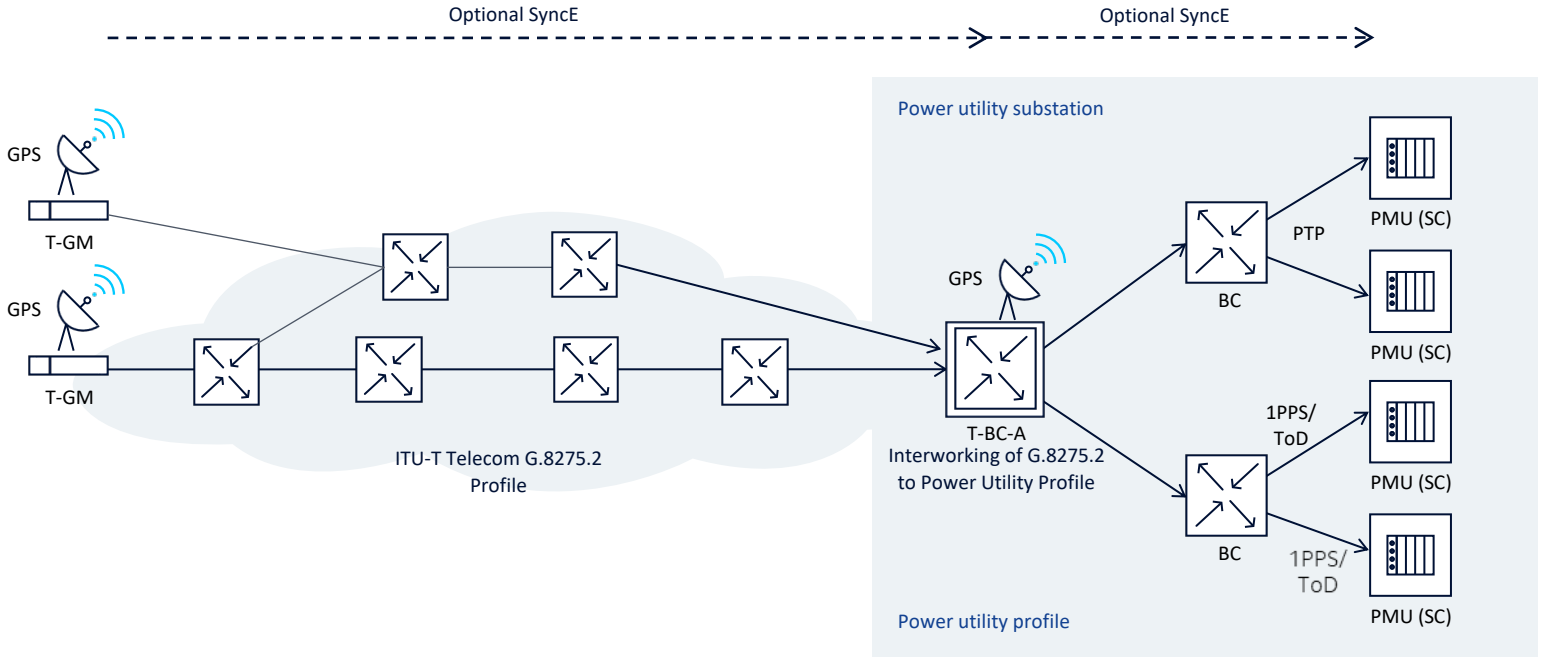
Inter-site sync blueprint with profile interworking

Extend existing G.8275.1 PTP network to interwork with power profile



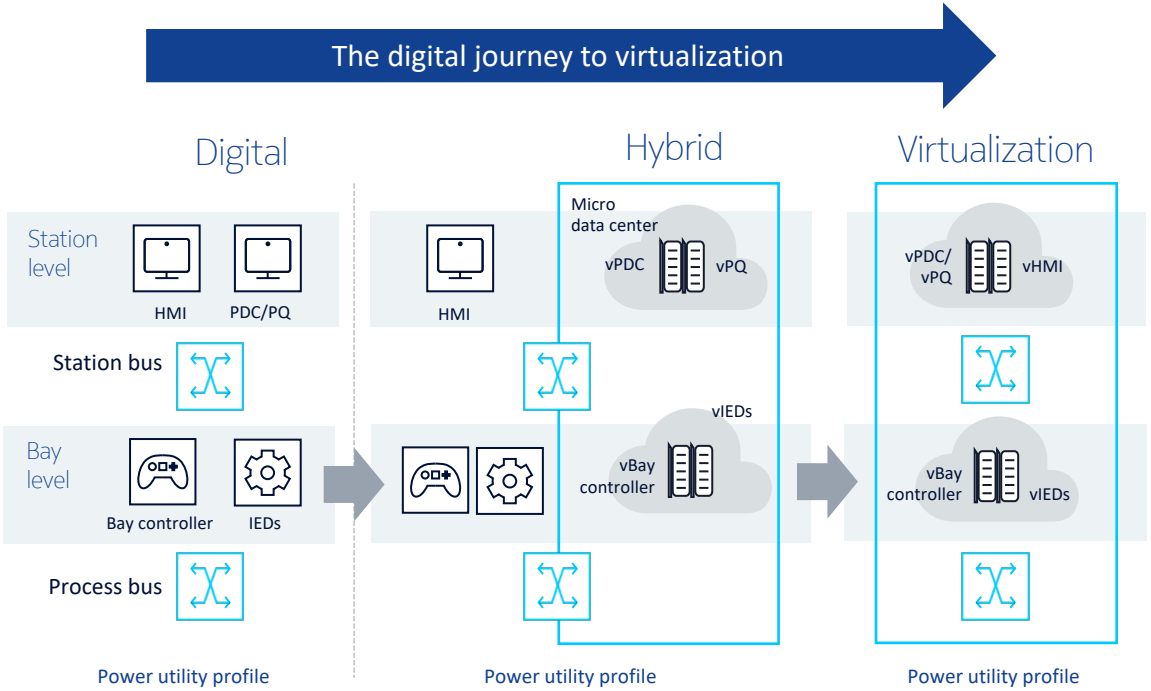
Inter-site sync blueprint with profile interworking

Extend existing G.8275.2 PTP network to interwork with power profile



Evolving substation to the future of virtualization

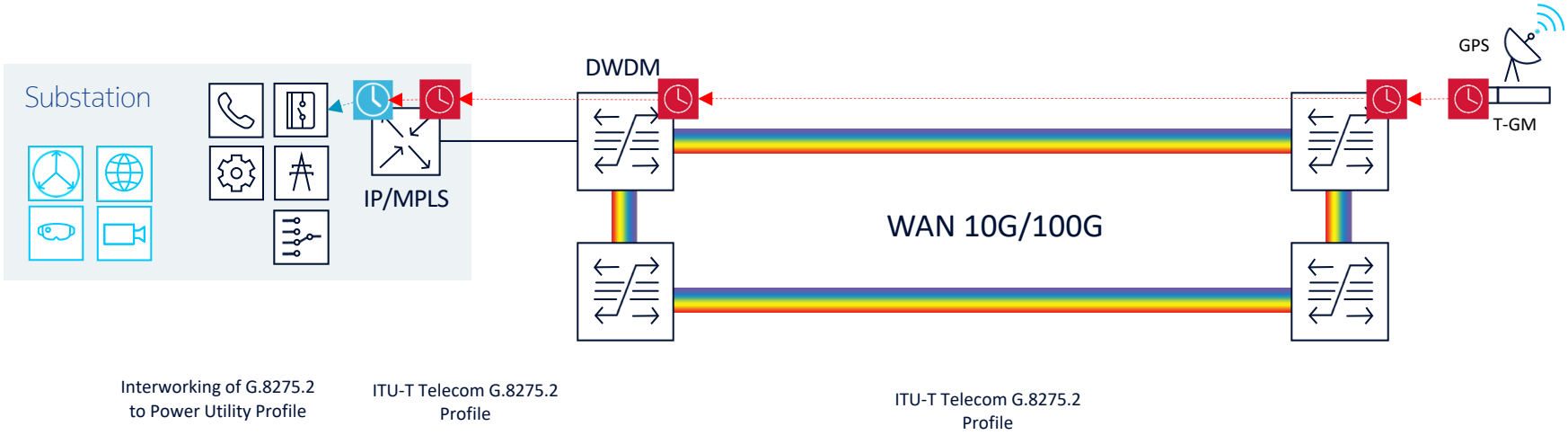
IEC 61850 networking continues to play a foundational role



Harnessing the power of cloud

- NERC report on virtualization
- Virtualization of station and bay level equipment
- Standardization of hardware
- How should the network evolve to become cloud adaptive?

Evolution of time synchronization in power utility networks



Ensure that all elements in the chain are time sync aware

Conclusions

- IEC 61850 time synchronization network designs must provide accuracy and resilience
  - Substation applications absolutely rely on it
- Leverage existing assets and technologies already in use
  - For example, other PTP profiles, SyncE, GM clocks, fiber, legacy PDH/SDH
- Design a resilient and highly accurate timing network with the “Keep It Simple, Substation” principle. Recommend:
  - Redundant GMs and timing paths (BC with BMCA)
  - SyncE for frequency if available
  - Profile interworking where it helps
  - Also include the DWDM network (if present) in the time sync design
- Reduce the overall cost to build and maintain by choosing and implementing the right technologies and timing network topologies

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Scan for more information on Nokia's IEC 61850 solution

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Providing accurate time synchronization for substation automation with IEEE1588v2

Application note

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A digital journey from conventional to virtualized substations

Powered by IEC 61850

White paper

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