Timing for Power Distribution

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Traditional Timing & Synchronisation Applications

- Sequence of Events
- SCADA
- Multi-Channel Disturbance Recorders
- Power Line Protection (Particularly Differential Protection)
- Frequency Synchronisation of Telecoms Infrastructure (SDH & PDH)

Smart(er) Grid Applications 1

- Wide Area Measurement, Protection and Control (WAMPACS)
  - Synchronised Phasor Measurement (Synchrophasors) enable
    - Grid State Estimation
    - Grid Modelling
    - Closed Loop Protection
    - Regional and Centralised Decision Engines

Smart(er) Grid Applications 2

- Fault location by detecting and analysing the time taken for traveling wave disturbances to reach detectors.
- Higher timing accuracy and synchronisation of detectors on transmission lines enable enhanced fault location accuracy.
- Each 3 ns of timing error equates to 1 meter of location error.

Smart(er) Grid Applications 3

- WAMPACS holds the promise of better protecting Transmission Grids against cascading loss of power such as that in the Northeast of the USA & Canada on the 14th of August 2003 which disconnected 55 million people.
- Smart Metering (AMI), spot pricing
- Scheduling - e.g. charging/discharging algorithms for EVs

Accuracy Requirements

- Sequence of events accurracy of 1 ms
- SCADA accuracy of 1 ms
- Unit Protection (differential protection) 200 µs - 400 µs relative
- Phasor Measurement Unit 1 µs- 1.5 µs
- Fault Detection 300 ns

Sources of Time & Frequency

- For time of day – at present typically GNSS with antennae close to point of use
- In future IEEE1588 (PTPV2) over packet networks tied to an ePRTC
- 5G particularly for dispersed assets ?
- Frequency distributed over Telecoms network via SDH or SyncE
- Frequency, typically tied to GNSS based PRC

Risks

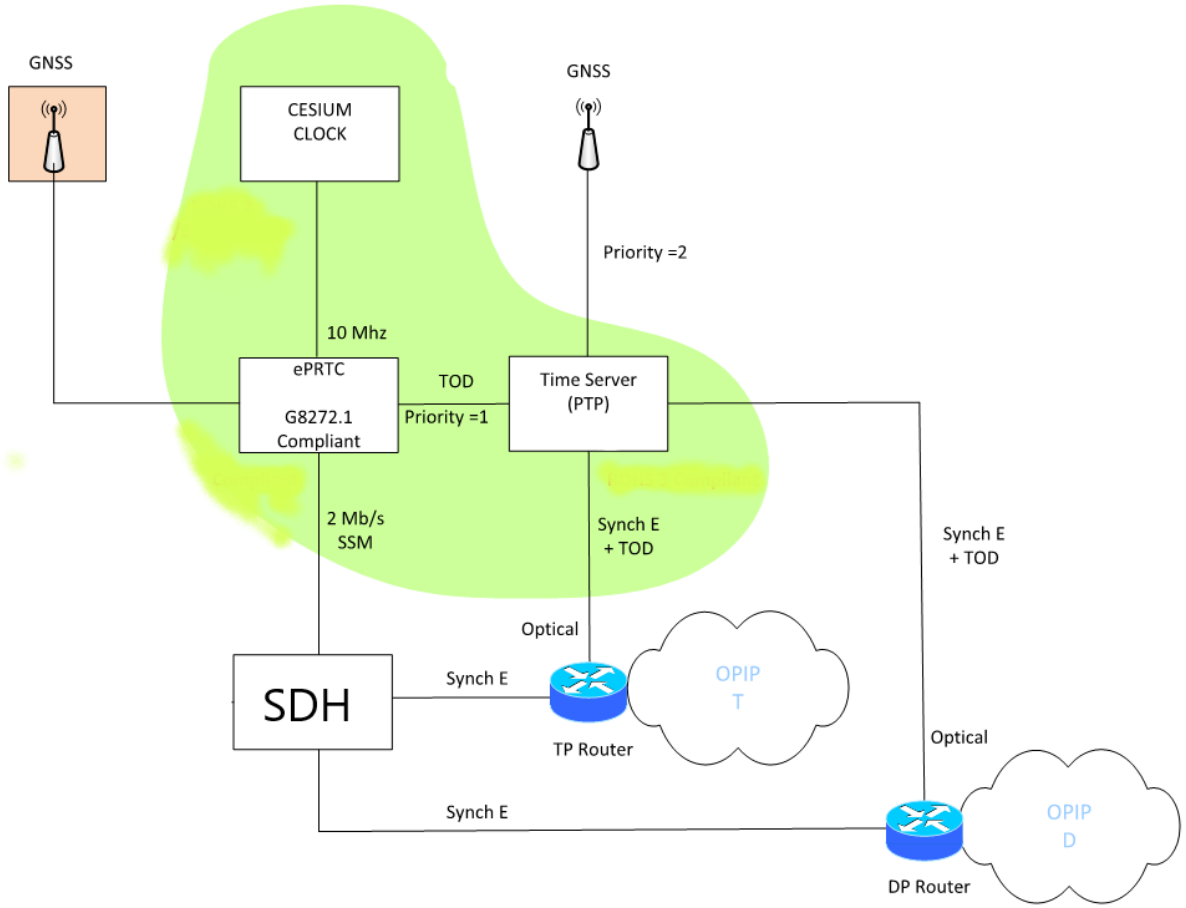
- Availability of GNSS
  - Local jamming
  - Possibility of degraded accuracy at times of military conflict

Mitigation of GNSS vulnerabilities

- Enhanced holdover enabled by Cesium clocks is becoming an increasing attractive option for Utilities.

- Distribution of time using a combination of IEEE 1588, SyncE and hardware enabled routers and switches.

Clock Distribution Architecture



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Renewables and Smart Grid

- Renewables (Wind and Solar) are vital in the fight against climate change as they do not contribute to greenhouse gases.
- Renewables enable electrification of heating and transportation.
- Integration of renewables into the power grid is challenging as available generation can vary rapidly requiring enhanced management capability supported by better and more accurate data
- **Phasor Measure Units provide this data but require 1 - 1.5 µs timing accurracy**

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Conclusions

- Electricity Grids are becoming ever more complex largely due to the increased quantities of distributed generation, most of it renewable and contributing little or nothing to system inertia.

- In order to manage the new intrinsically less stable scenario more data is required, much of which is of little value unless sampled at a timing accuracy of 1 µs.

- Management systems based on enhanced communications, enhanced timing accuracy, real time decision engines and data analytics will be the cornerstone of highly responsive Power Grid managemnt in the future.

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