Master thesis proposal:

**Time Synchronization for Ethernet communication based Line differential Protection**

**Background:**
Today most of the Line differential protection relays communicate over SONET (Synchronous optical Networking) or SDH (synchronous Digital Hierarchy), which provides a symmetric communication delay in both directions. The symmetric delay is utilized to achieve time synchronization for measurement data between the IEDs. One drawback is that dedicated communication equipment is needed both inside and outside the IEDs.

Furthermore, SONET/SDH network equipment is being replaced by new technologies (i.e. Ethernet/IP based network). Thus it is hard for the utilities to get access to SONET/SDH networks. In addition, these networks can be shared for other communication in power systems.

**Description:**
The idea is to exchange the data over Ethernet/IP based networks instead. However, the communication delay in such networks is not constant and can therefore affect the performance of the protection algorithm. Thus some other type of time synch is needed. GPS can be an alternative solution. However, it is too sensitive to disturbance and spoofing. So a backup time synch solution is needed.

If accurate time synchronization can be achieved, then the data exchange can be done with a certain amount of jitter without too much impact on the line differential application. Sample data exchange between the IEDs is based on UDP and to use IEEE1588-2008 time synchronization over the communication channel to get a solution that is independent of GPS receivers.

IEEE 1588-2008 can provide a high precision time synch in a local Ethernet network. But validation of IEEE1588 in long distance and WAN based communication is required. In addition, a solution from other domain (e.g. telecom) can be an interesting alternative.

The idea is to utilize ABB IEDs and make a few different setups. This will include a point-to-point connection (dedicated fiber), switched Ethernet network and WAN setup with additional “simulated” network load. Also Quality-of-Service (QoS) features should be investigated to see if they could give a better performance.

The IED setup might need some hardware and firmware modification in comparison to standard IEDs in order to perform the practical tests. The student supported by ABB developers will do those modifications. The sample data can be sent using an already existing UDP format, but this might also need some modifications/additions.
The thesis work will involve the following tasks:

- Investigation of availability of IEEE 1588-2008 compliant network equipment (e.g. switches and routers) for substation-to-substation communication. This investigation should also include time synchronization solutions from other domains, which require high precision time sync, e.g. tele-communication
- Literature review
- IP-Issues (IP=Intellectual Property)
- Setup a long-range Ethernet transceiver to run on dedicated fiber
- Examine the impact of adding switches and WAN networks in-between.
- Consideration of two time synchronization options
  - Synchronize over the communication channel (e.g. adjust clock of IEDs)
  - Detect time difference between the IEDs
- Analysis the effect of transmission delays and jitter on protection functions.
- Investigate QoS possibilities to increase performance.
- Project documentation.

Requirements for the student:

- Communication networks
- OSI reference model
- Programming skills: C/C++ (preferable)
- Power System Protection (recommended)

Involved company: ABB

Starting date: January 2017

Place: ABB (Västerås) mainly and KTH (Stockholm)

Estimated duration: 20 weeks (30 ECTS)

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