Substation Communication Topologies

Vendors serving the electric power market do a great job of developing new tools and techniques that can change our approach to solving problems and implementing systems. We do our best to keep up with available technology and sometimes that means challenging our longstanding work practices against new ideas.

Clients have been queried regarding optimization of the substation communication topology used in their substations. Additionally, information was also collected on specification, price, and performance information from several vendors in this technical area. We have experience applying a wide range of protection and integration technology. SEL equipment figures prominently in this analysis.

This article describes two possible communication topologies and compares their relative advantages and disadvantages on the basis of:

- Implementation cost & flexibility
- Reliability/stability
- Performance

Finally, we make a ranking of the topologies and a recommendation. Depending on your values, your final selection may run either way. This article illustrates some of the trade-offs that are involved in the decision.

Definition of Common Terms

Several aspects of the compared topologies are shared by the options. These are defined once here for brevity.

Protective Relays
Approximately 30 SEL substation protective relays are assumed for the typical application. Also covered under this heading are substation logic processors and programmable controllers communicating using SEL serial protocol.

Revenue Meter
A dedicated substation revenue/power quality meter is assumed to be a non-SEL device that communicates using a serial protocol. We assume that to collect data from the Revenue Meter, the communication processors compare require some degree of additional programming beyond the configuration necessary to support an SEL device.

Substation HMI
An optional, stand-alone substation touch panel HMI is assumed to perform data collection, data presentation, and substation control via a serial Modbus data map implemented in the master communication processor.

Substation SCADA Server
Collects data via a Modbus connection and prepares the data for periodic collection by the Enterprise SCADA Master PC located remotely. We assume the substation server software runs in a Windows Server environment and requires SQL Server support.

Topology Option 1

Option 1 consists of the substation communication topology based on the SEL-2032 Communication Processor. Prices used for this comparison are based on prices at the time of printing in 2006. Prices may vary so please contact SEL for current rates.

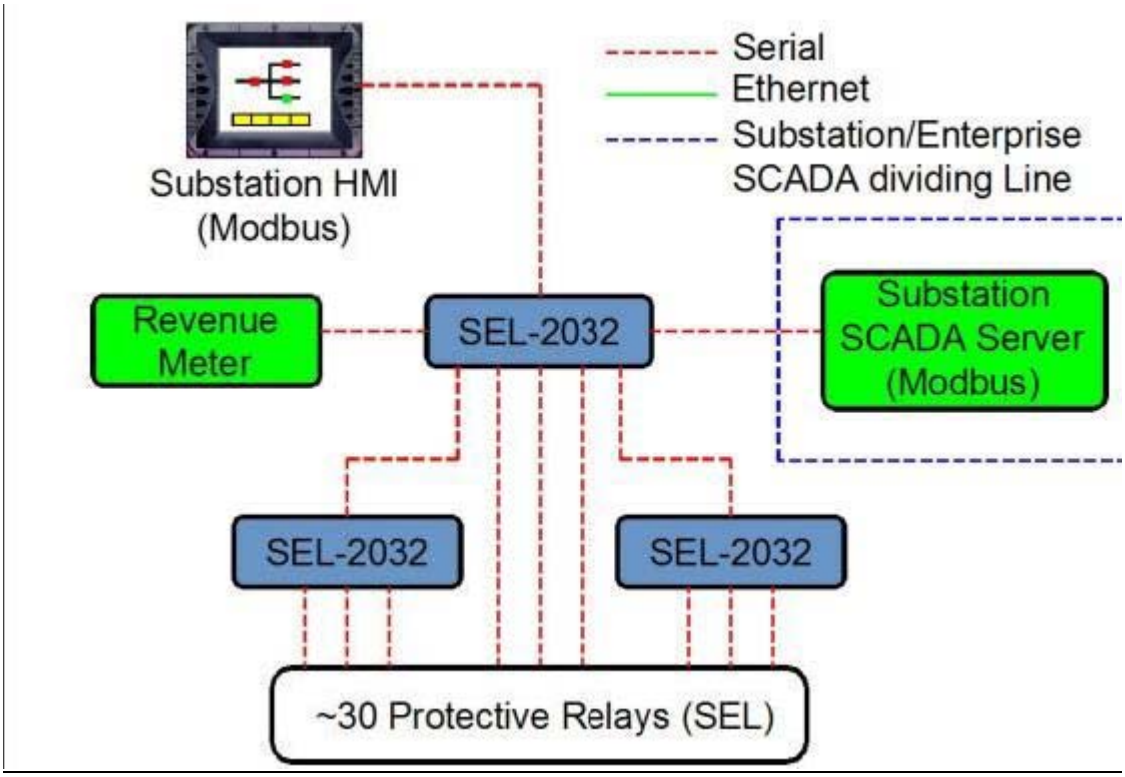

Figure 1: SEL-2032-based Communication Topology

This topology has the following attributes:

- The SEL-2032 offers a very stable and deterministic (repeatable) real-time operating system, purpose built for the application.
- The communication processors individually demonstrate a 335 year Mean-Time Between Failures (MTBF) for a data collection system MTBF estimate of 111 years (the MTBF of the 3 devices is one third the MTBF of an individual). Including the Server PC reduces the full system MTBF estimate to 32.75 years, assuming a 20 year MTBF estimate for the Server PC.
- System expansion or modification requires an additional communication processor and complex programming.
- The substation server and master communication processor are each single-point failure locations for the enterprise SCADA system.
- SCADA server unavailability does not impact the optional local HMI.
- There is a clear line of demarcation between the substation data collection system and the enterprise SCADA data transfer system.
- Price of the communication processors alone is $12,950. Allowing $6,000 for the server PC raises the system price to $18,950.

Topology Option 2

Option 2 consists of an SEL-3332 substation server for data collection and control concentration and a dedicated Substation SCADA Server. The topology is illustrated in Figure 2. Prices used for this comparison are based on prices at the time of printing in 2006. Prices may vary so please contact SEL for current rates.

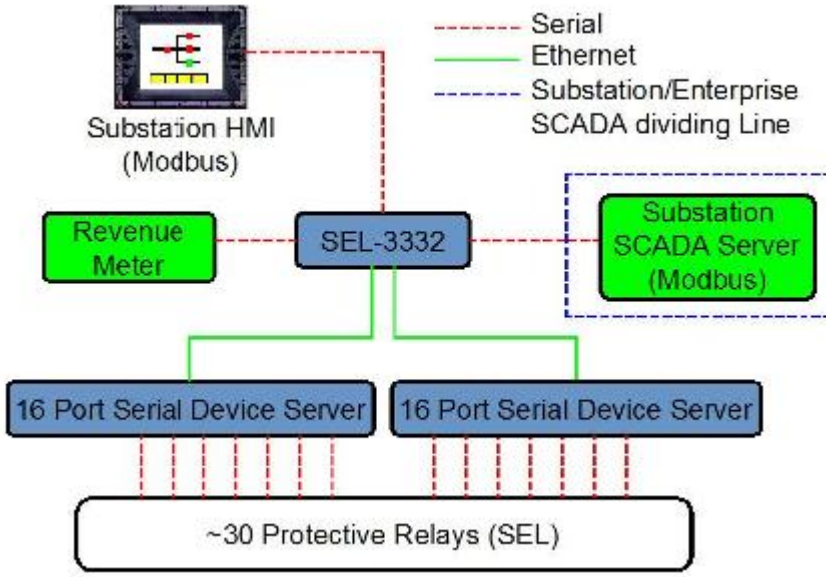

Figure 2: SEL-3332-based Communication Topology

This topology has the following attributes:

- The SEL-3332 is an embedded PC device running a Windows operating system and substation data collection software suite.
- The SEL-3332 supports multiple protocols and an OPC Client, simplifying integration with non-SEL devices.
- The SEL-3332 software suite simplifies system configuration as compared to the SEL-2032. Initial configuration and modifications to the installed system are less time- and experience-intensive.
- Two serial device servers are required to provide the necessary number of serial ports to communicate with the 30 protection and control devices. These devices cost $2725 each and have an estimated MTBF of 78 years.
- The SEL-3332 demonstrates a 50 year Mean-Time Between Failures (MTBF) for a data collection system MTBF estimate of 22.3 years. Including the Server PC reduces the full system MTBF estimate to 10.6 years, assuming a 20 year MTBF estimate for the Server PC.
- System expansion or modification requires additional communication devices that are generally less expensive than an SEL-2032 communication processor and that have a less laborious configuration.
- The substation server and SEL-3332 are each single-point failure locations for the enterprise SCADA system.
- SCADA server unavailability does not impact the optional local HMI.
- There is a clear line of demarcation between the substation data collection system and the enterprise SCADA data transfer system.
- Price of the SEL-3332 and Serial Device Servers is $13,500. Allowing $6,000 for the server PC raises the system price to $19,500.

Topology Comparison & Recommendation

Table 1: Topology Comparison Summary		
Criteria	**Option 1**	**Option 2**
Component Price Estimate	$12,950	$13,500
Operating System	Dedicated, Real-Time	Windows XP Embedded
Deterministic Performance	Excellent	Good
SEL Communication Support	Excellent	Excellent
Non-SEL Communication Support	Good, but requires experience and special tools	Excellent
Ease of Modification by Non-Expert	Poor	Good
Estimated System MTBF	32 yrs	11 yrs

Given the proximity of prices, the selection falls to preference using other criteria. Our strictly technical preference (and usual recommendation) is for Option 1 systems for the following reasons:

- We have the tools and experience in working with the SEL-2032 to simplify development and testing that we perform.
- We highly value the device's deterministic performance.
- We (and our clients) highly value the option's high reliability as expressed by MTBF. Clients who have never used SCADA or substation HMIs quickly find them indispensable once installed. The importance of system reliability and availability are usually much higher after the system is installed than it was while the system was merely being contemplated. However, we recognize the following benefits to the owner that are afforded by the Option 2 system:
- Ease of system modifications provided by the Option 2 system software.
- Potentially greater ability to transport data to other entities (tie utility, PPA, etc.). In the end, both system topologies can be fielded in cost efficient, high performance, and highly reliable manners. From our perspective, the final decision is heavily dependent on your relative values of high reliability and ease of modification.