

Network Protocols in Power Systems GOOSE

Physical Devices in Power Systems

- Primary
 - Circuit breakers, Disconnect and grounding switches, Power transformers, Instrument transformers, generators etc.
- Secondary
 - Reclosers, Annunciators, Meters, Sensors, Fault recorders, control switches

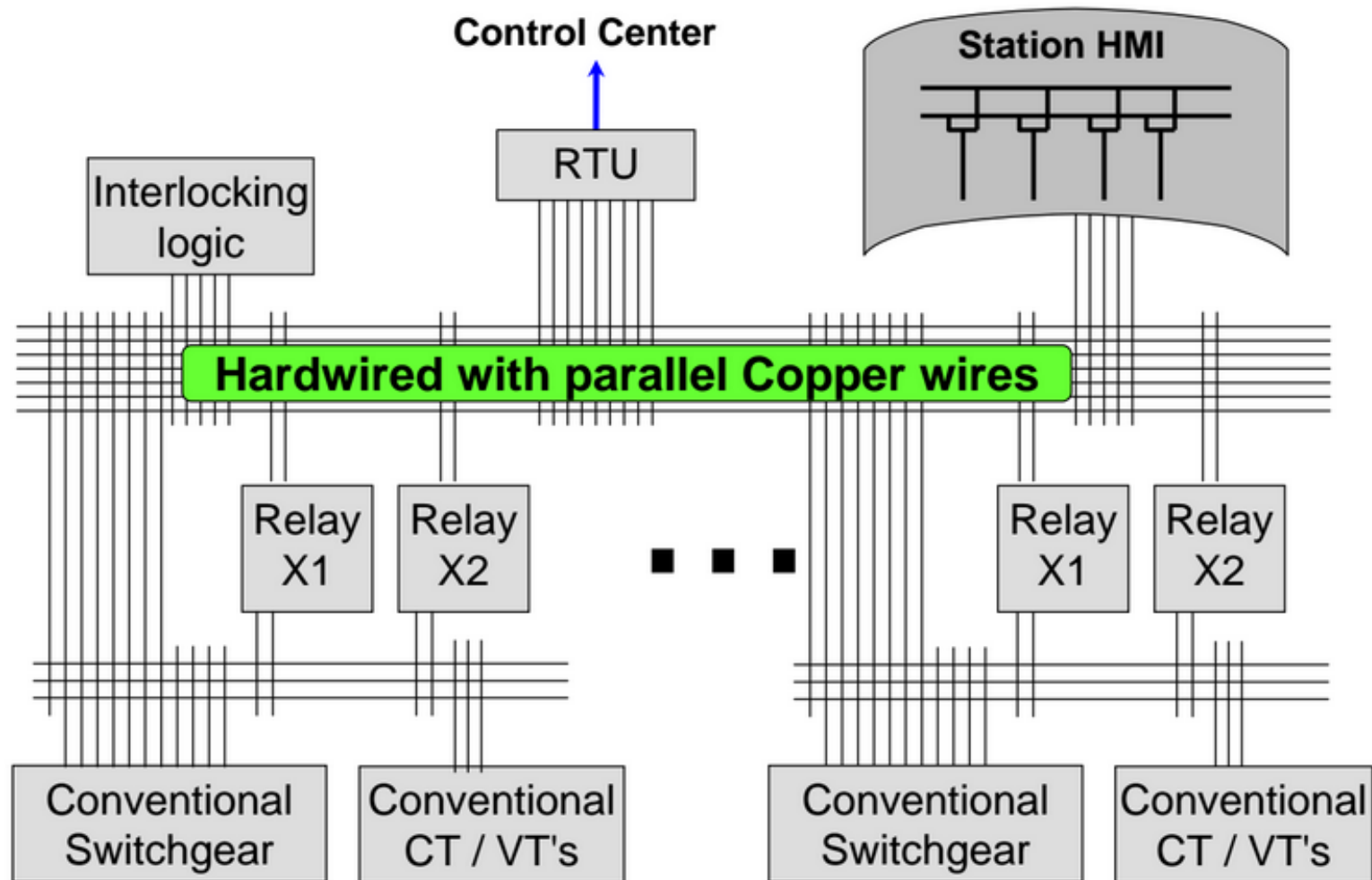
Network Protocols in Power

- DNP
- Goose
- Please add if any

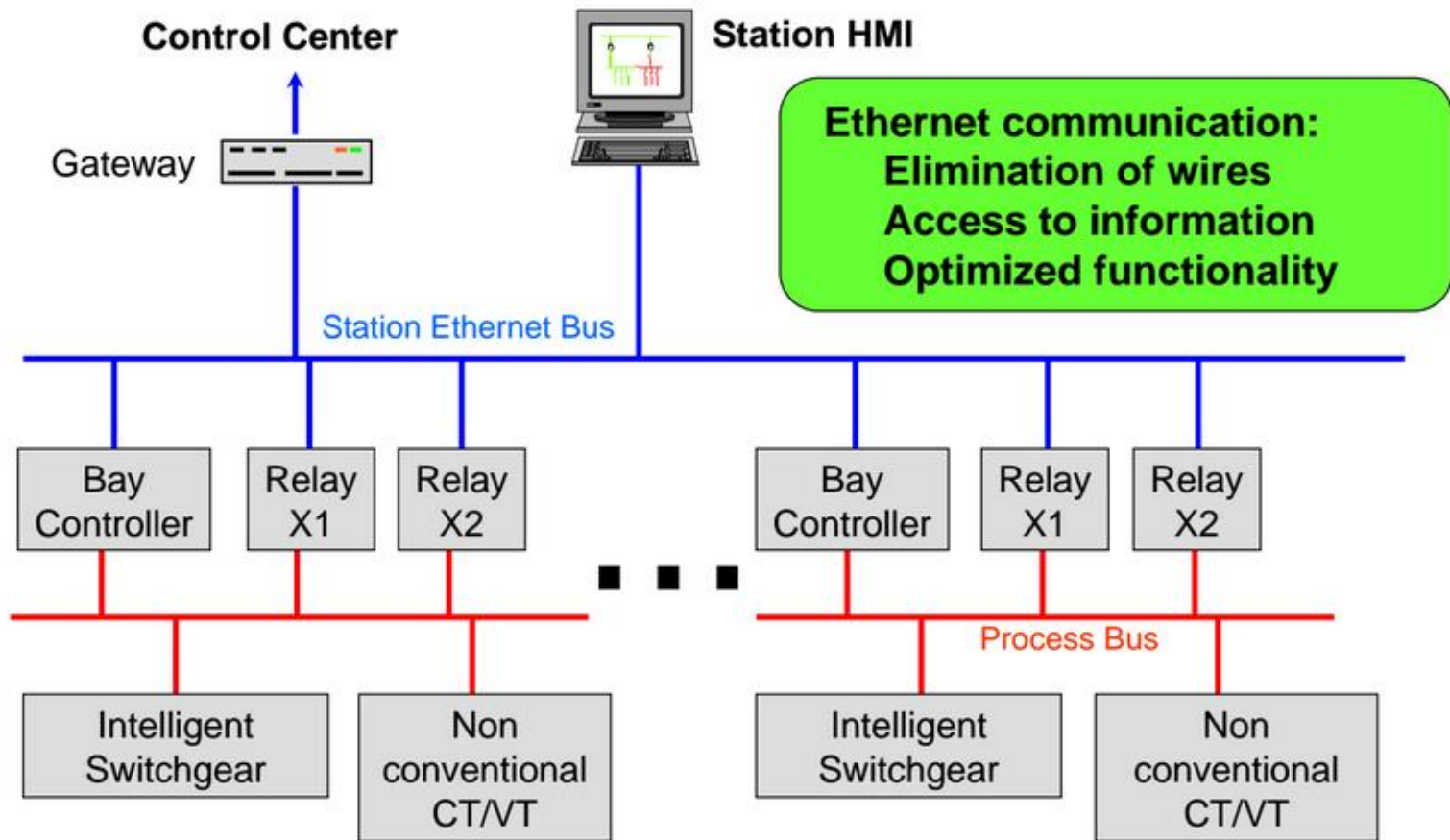
GOOSE

- GOOSE (Generic Object Oriented Substation Event)
- It is a mechanism for the fast transmission of substation events, such as commands, alarms, indications, as messages
- A single GOOSE message sent by an IED can be received and used by several receivers
- GOOSE takes advantage of the powerful Ethernet and support realtime behavior
- It is used for e.g.
 - Tripping of switchgear

Conventional Substation Automation System

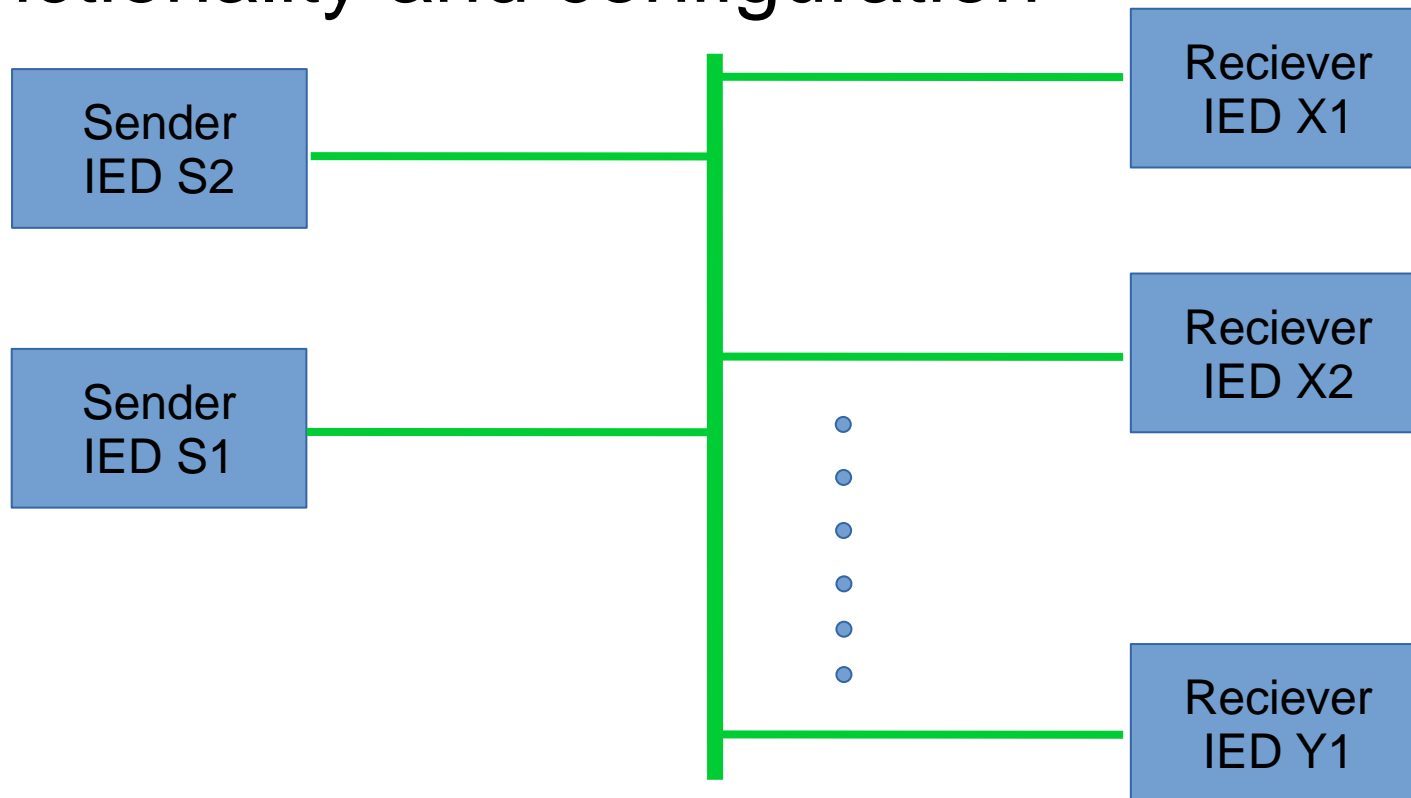


IEC 61850 Station and Process Communications



Typical GOOSE Communication

- One device (sender) publishes information, only the subscriber devices are receiving it.
- The reaction of each receiver depends on its functionality and configuration



Basic Network Terminologies

- Network: A group of computers and IED's connected together in a way that allows information to be exchanged
- Node: Any device that is connected to or is part of network
- IP Address: numerical address label assigned to devices participating in computer network
- LAN: A local Area Network is a computer network covering a small physical area like a substation, building or substation.
- MAC Address: A media access control address

IP Address

- Two Options
 - IPv4 – 32 bit number (four octets) – 2^{32} addresses
 - IPv6 – 128 bit number – 2^{128} addresses
- IPv4 example: 0.0.0.0 – 255.255.255.255

Class	Size of network number bit field	Size of rest bit field	Number of networks	Addresses per network	Start address	End address
Class A	8	24	128	16,777,216	0.0.0.0	127.255.255.255
Class B	16	16	16,384	65,536	128.0.0.0	191.255.255.255
Class C	24	8	2,097,152	256	192.0.0.0	223.255.255.255
Class D (multicast)	not defined	not defined	not defined	not defined	224.0.0.0	239.255.255.255
Class E (reserved)	not defined	not defined	not defined	not defined		

Utility/Substation Address Recommendation/Example

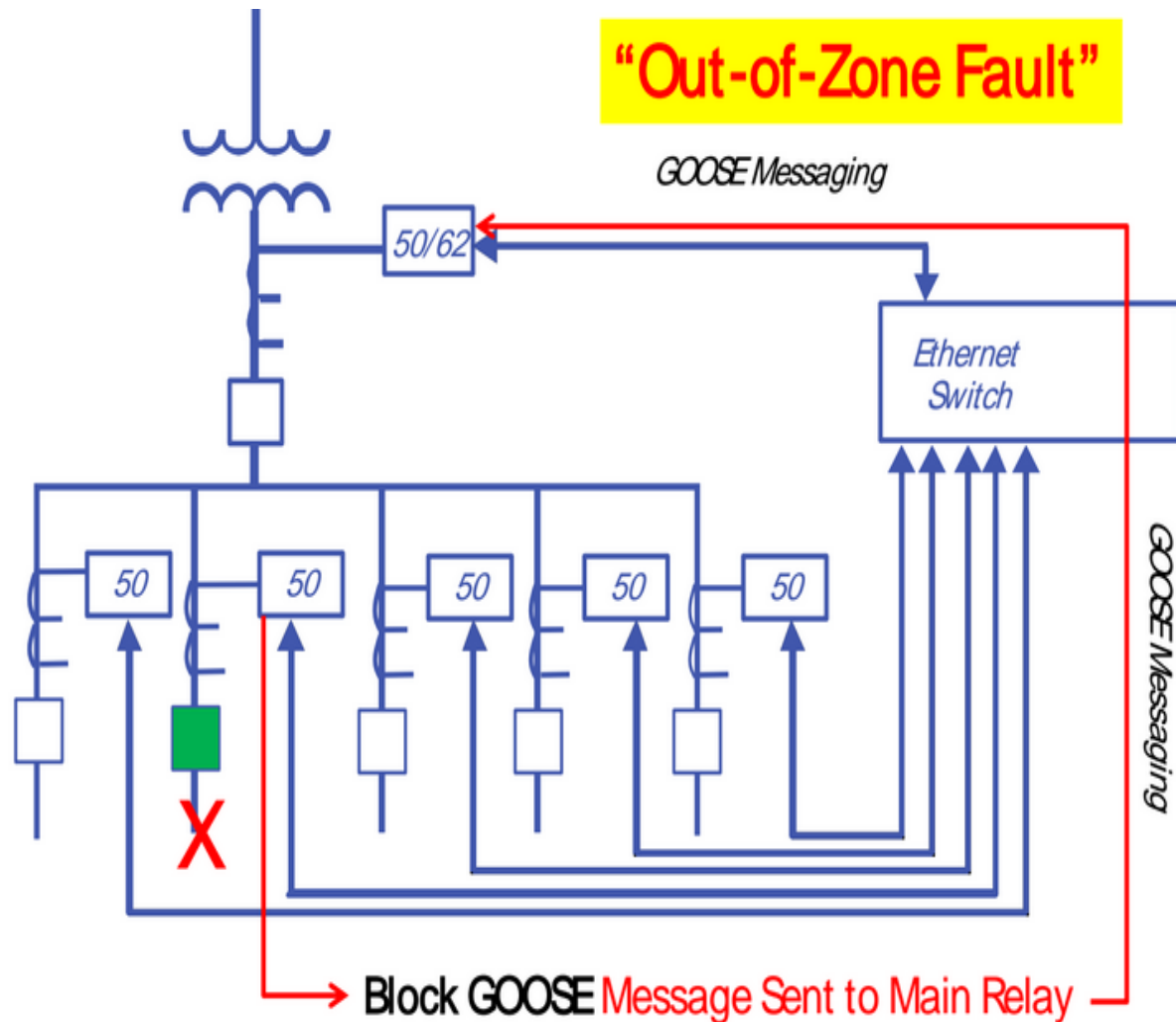
- Use Class A private address range that starts with 10.0.0.0 and use octet 2 as district or territory identifier.
 - Allowing upto 256 districts
- Configure octet 3 for substation identifier
 - Allowing upto 256 substation per district
- Finally use octet 4 to assign the IEDs in substation or site
 - Allowing upto 256 IEDs per substation
- NOTE: GOOSE messages do not use the IP, subnet mask, nor gateway addresses instead

Ethernet for GOOSE

- Tripping via LAN must meet or exceed point to point wiring.
- Protocol used must be equivalent to applying voltage on a wire
- To meet this requirement (back in 2001) a 4ms application layer to application layer time was defined.
- Luckily, ethernet was just the thing which could meet these specifications.
 - Fast : 1 – 2 ms
 - Reliability by message repeat

GOOSE Application 1

Bus Zone Interlocking Protection Scheme

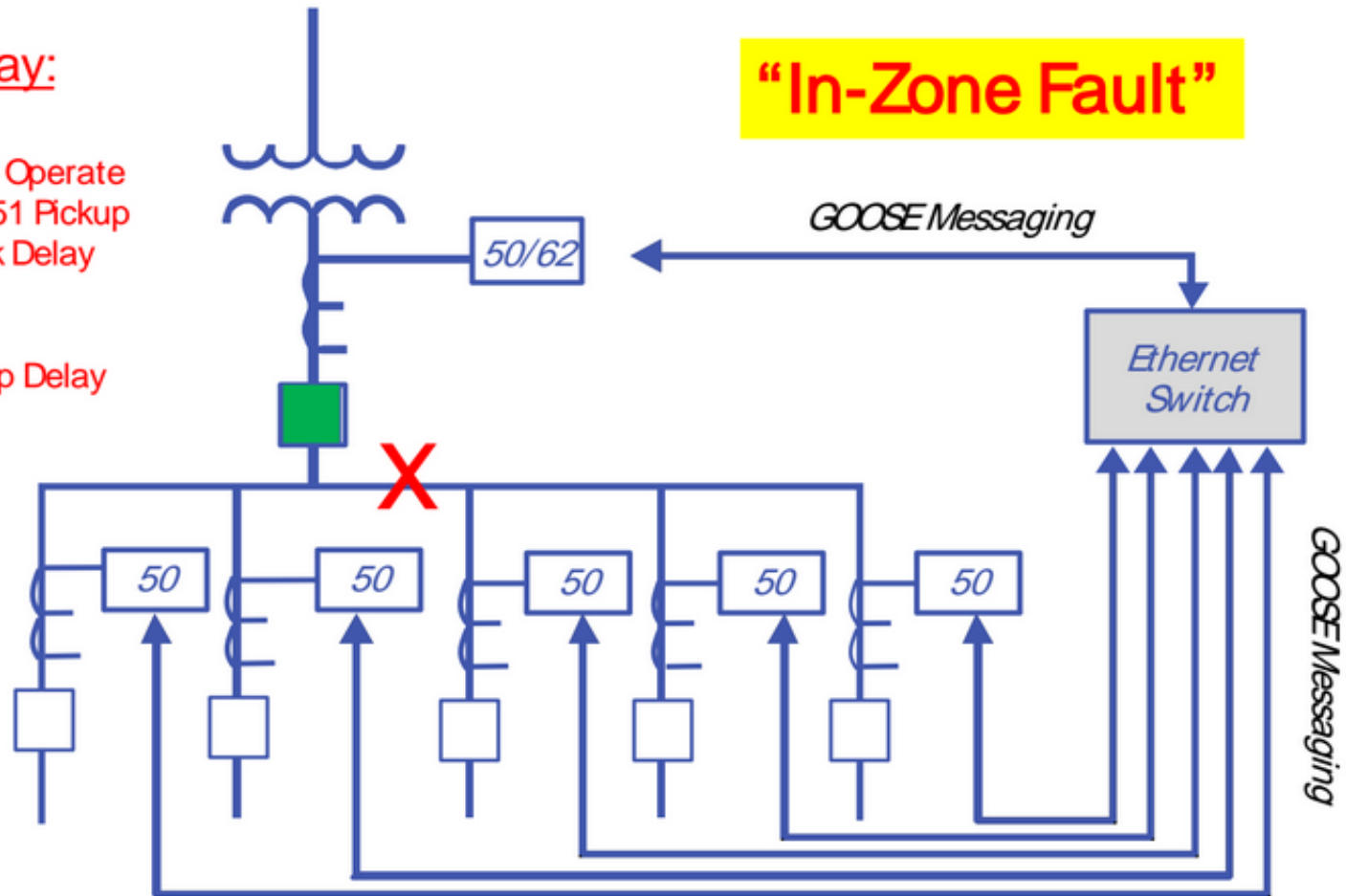


GOOSE Application 1

Bus Zone Interlocking Protection Scheme (2)

Main Trip Delay:

20ms	Main 50 Operate
20ms	Feeder 51 Pickup
2-4ms	Network Delay
8-16ms	Margin
50-60ms	Main Trip Delay



No Block GOOSE Message Sent to Main Relay
Main Breaker Trips after 3-4 Cycles

GOOSE Application 2

Fast Load Shedding

- Rapidly Sheds Load in Large Industrial Facility for Loss of Incoming Sources to Avoid Complete System Collapse while Maintaining Power to as Much of the Process as Possible
- Fast Initiation of Load Shedding before System Frequency/Voltage Declines, which Maintains System Stability – Unlike Undervoltage, Underfrequency, or Rate of Frequency Decay Load Shedding Schemes
- Scheme uses IEC61850 Based Relays on Ethernet Network to Calculate/Transmit Power at Locations Throughout Facility (Generation.

GOOSE Application 2

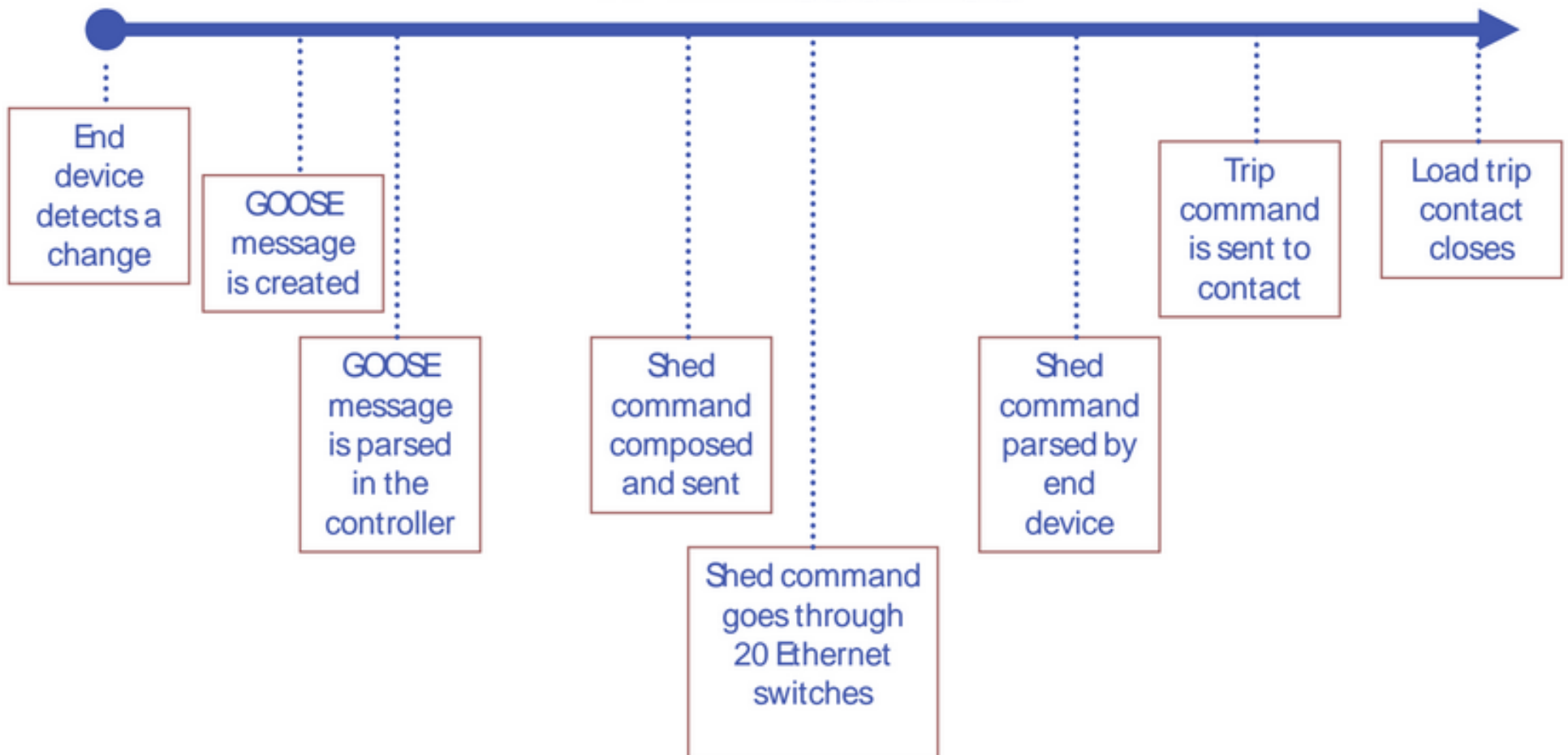
Fast Load Shedding (2)

- Aggregators Combines Load Information from Multiple IEDs into Single IEC61850 Message – Extends Number of Loads Fast Load Shedding Scheme can Control
- Aggregators Retransmit up to Next Level (Master Controller)
- Generation or Power Sources are Connected to Master Controller
- Master Controller Determines Loads to Shed Based on User Configuration, Shed Groups and Priorities

GOOSE Application 2

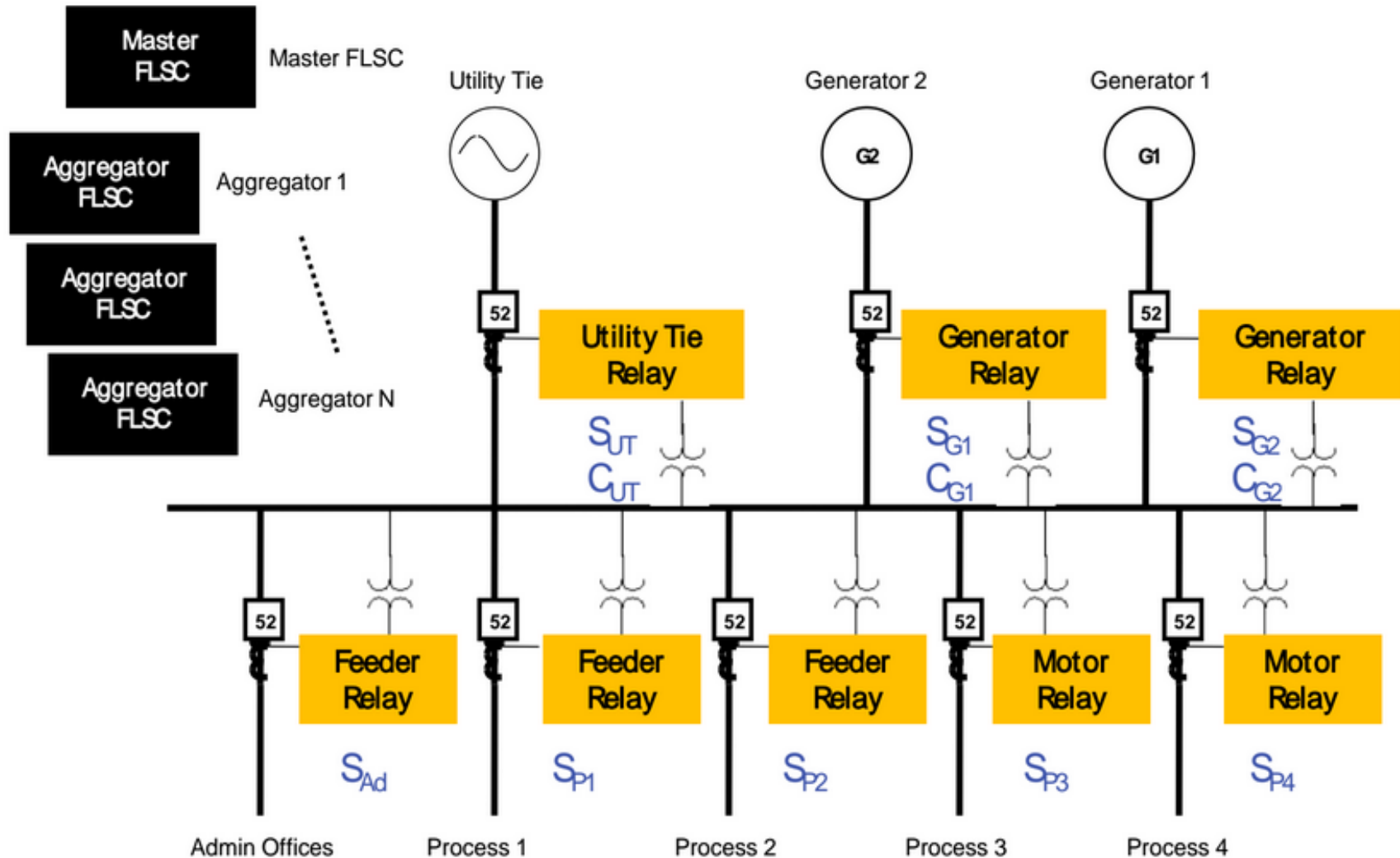
Fast Load Shedding (3)

17 milliseconds



GOOSE Application 2

Fast Load Shedding (4)



Demo – Analyzing GOOSE Messages using Wireshark