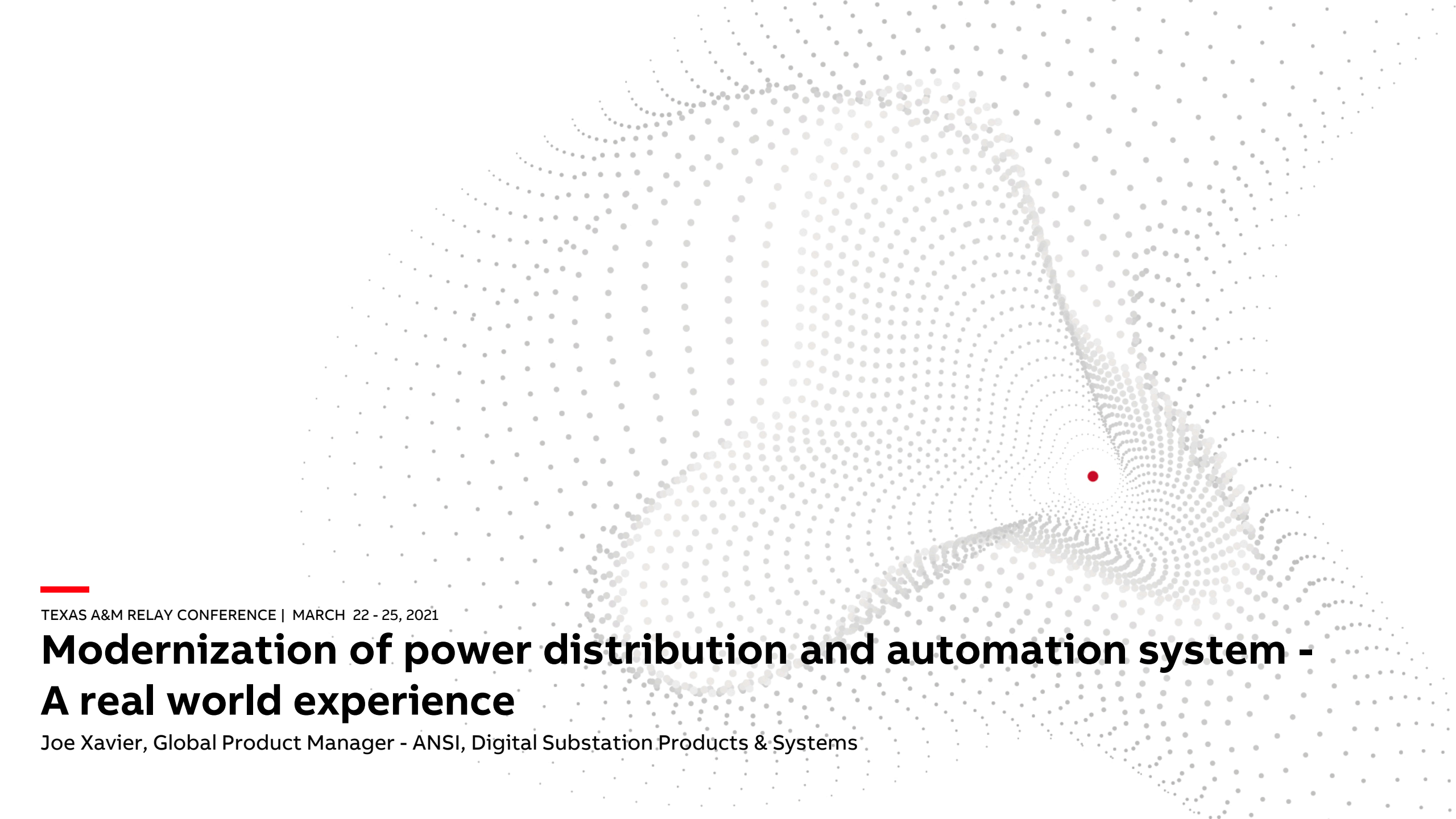


TEXAS A&M RELAY CONFERENCE | MARCH 22 - 25, 2021

Modernization of power distribution and automation system - A real world experience

Joe Xavier, Global Product Manager - ANSI, Digital Substation Products & Systems

Content

- Project overview
- Solution drivers
- Protection and Control architecture
- IEC 61850 Implementation primer
- Lessons learned
- Summary
- Q&A

Existing network

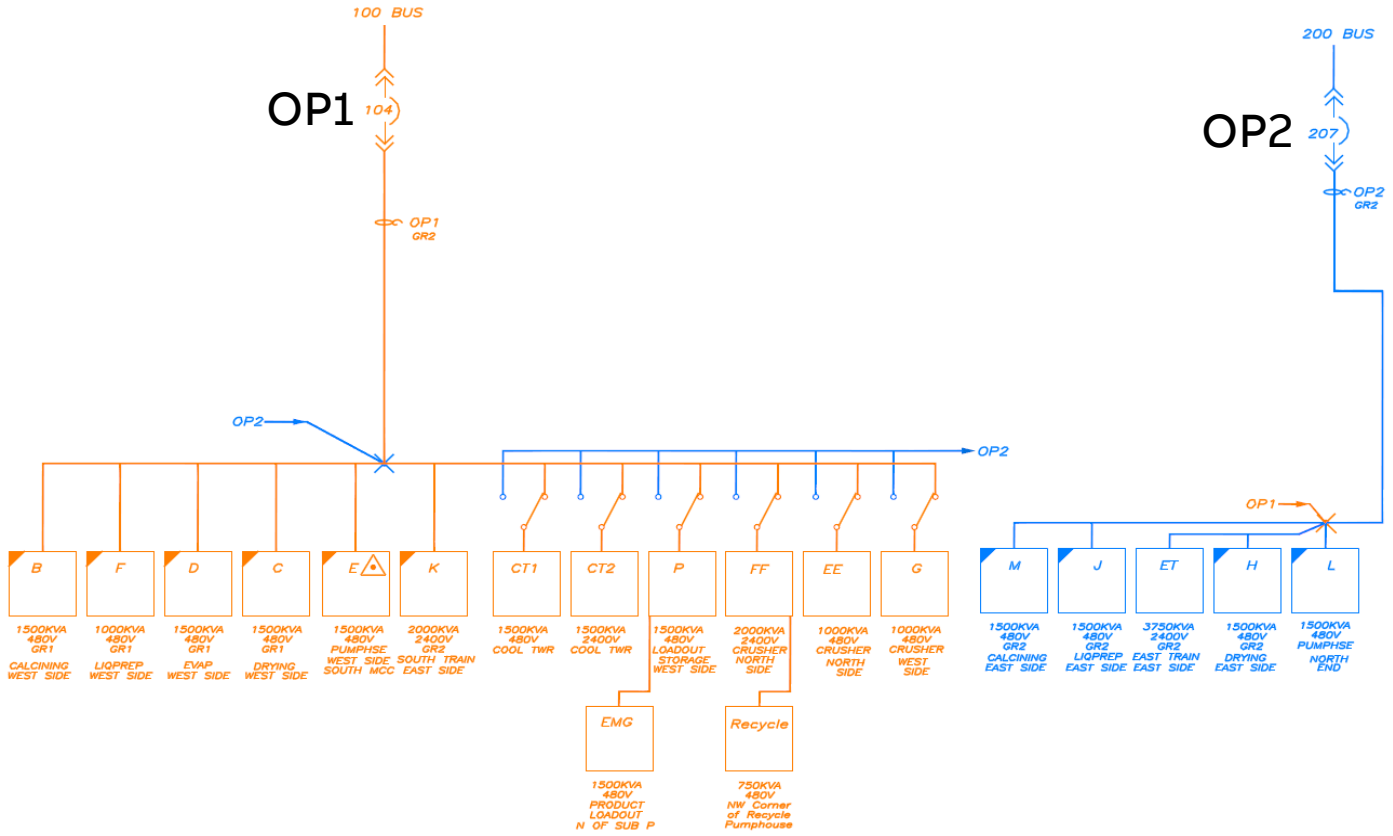
Large process industry

Large Soda Ash (Trona) mine in Wyoming

Originally built in 1968

Aging power distribution infrastructure causing frequent power interruptions

No integration of power distribution system with the plant operations



Project Drivers

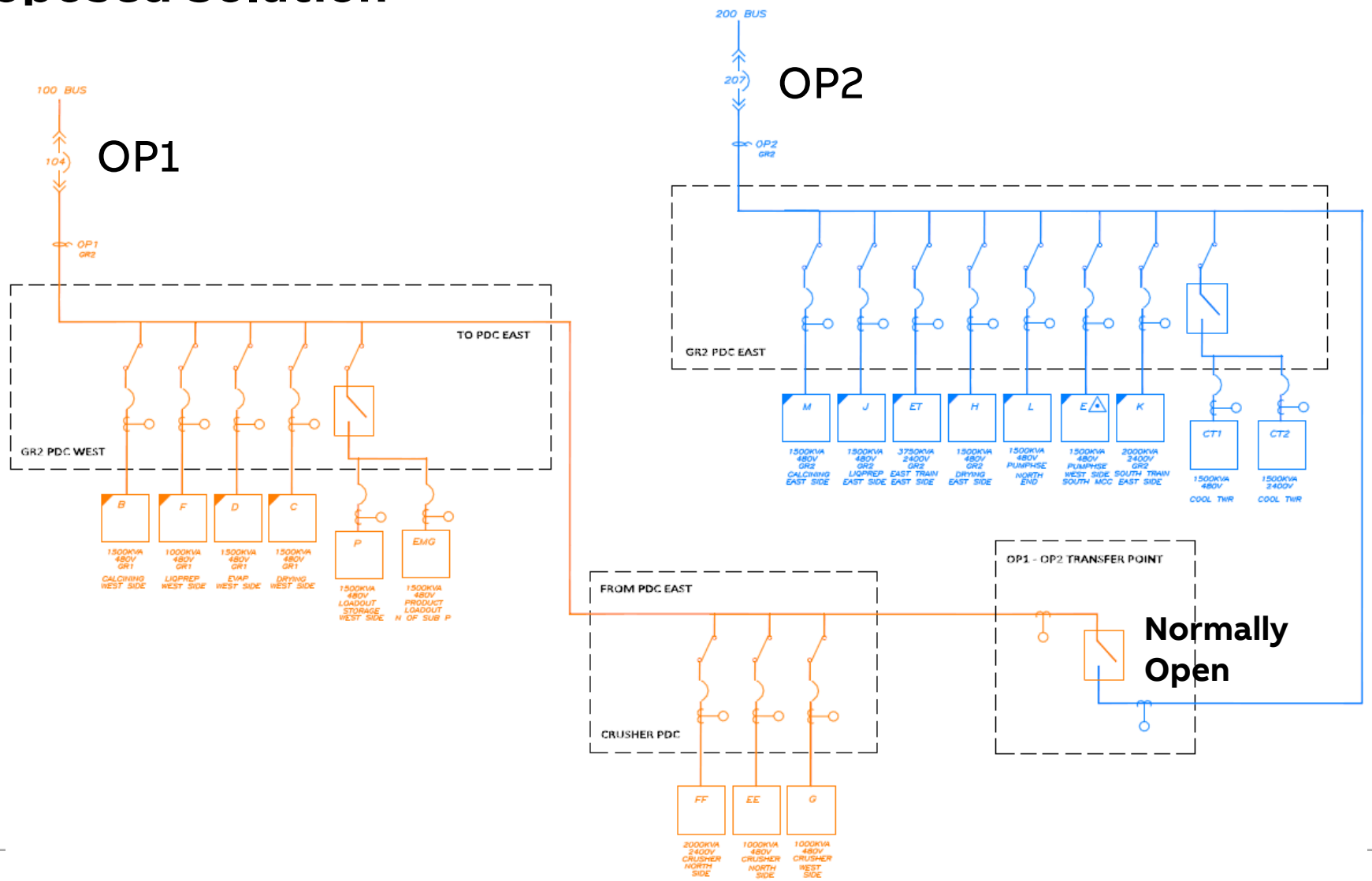
Problems with the current system

- Over the last 30 years these connections were subjected extreme weather, Trona dust, Soda Ash,
- The 11 distribution locations were installed to be load-break isolation points, but most connections cannot be used as load-break points anymore because of the difficulty in disconnecting and the hazard of reconnecting online
- OP1 and OP2 faults, although short in duration, cause significant prolonged production downtime
- Coordination of the existing protection system allows some feeder faults to travel all the way upstream and trip OP1 or OP2 feeder breakers
- From January 2013 to June 2016, OP1 and OP2 related failures caused more than 28,000 tons for lost SA production
- Equipment damages because of power loss: motors, transformers, PLCs, etc.

Existing termination points

Plant environmental conditions

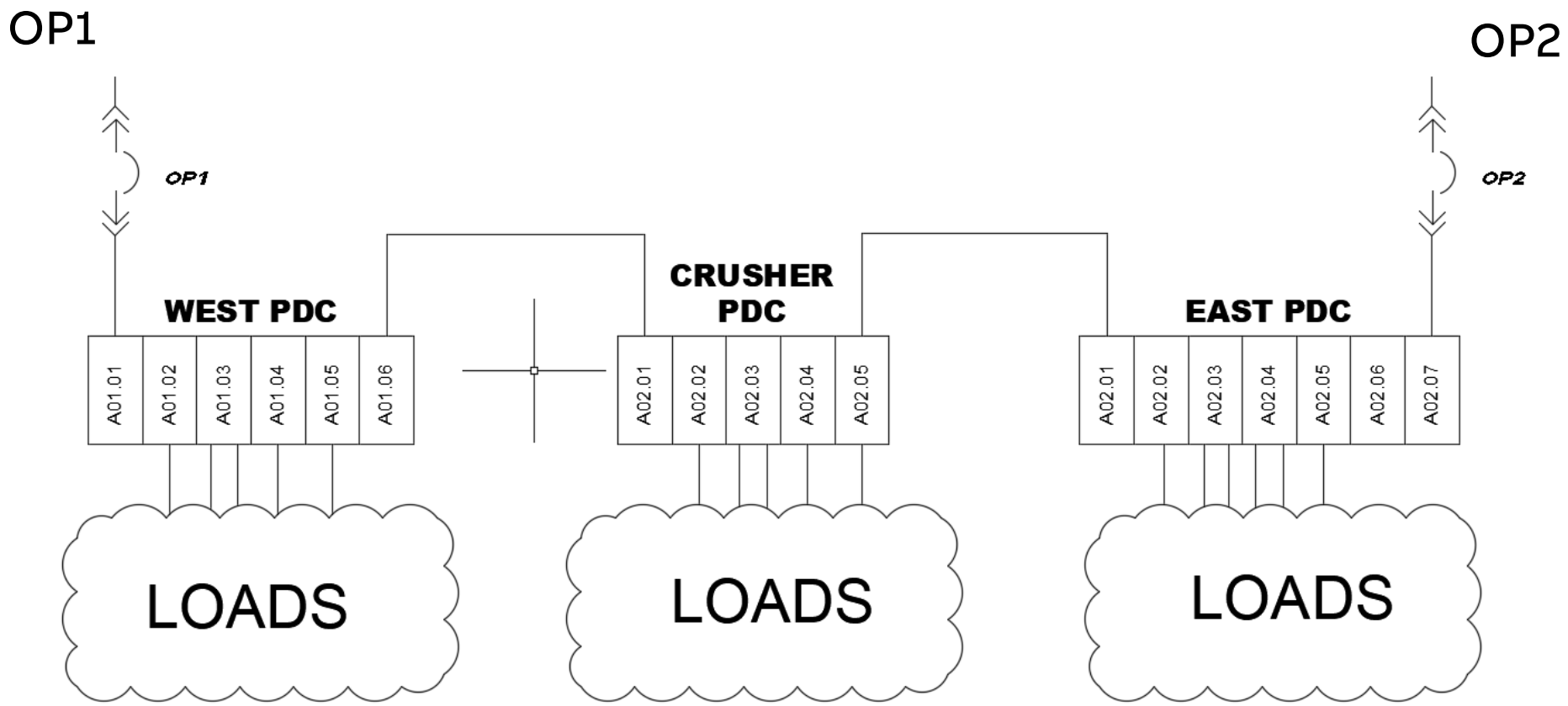
Original Proposed Solution



Design Review

- Initial discussion with consultants
- Performed a system study to identify possible solutions
- Discussed probable solutions with TATA Consulting Engineers, India, to confirm the solution is the best practice in industry
- Three new power distribution centers (PDC) will feed East GR2, West GR2 and Crusher
- The switchgear will have relays with transformer protection elements, so existing unsafe oil-switches can be eliminated
- The relays communicate to provide faster tripping and better fault segregation

Final Solution



Advantages of New Design

Safe

- Arc-flash hazard mitigation
- Faster tripping time for high-current faults using Bus Blocking protection scheme
- Feeder relays include distribution transformer protection

Robust

- Fault Detection, Isolation, Restoration (FDIR) minimizes downtime
- Distribution equipment is in a controlled indoor environment
- Easier trouble-shooting – all information displayed on Substation HMI

Future Ready

- Relay and SCADA communications via IEC 61850 protocol

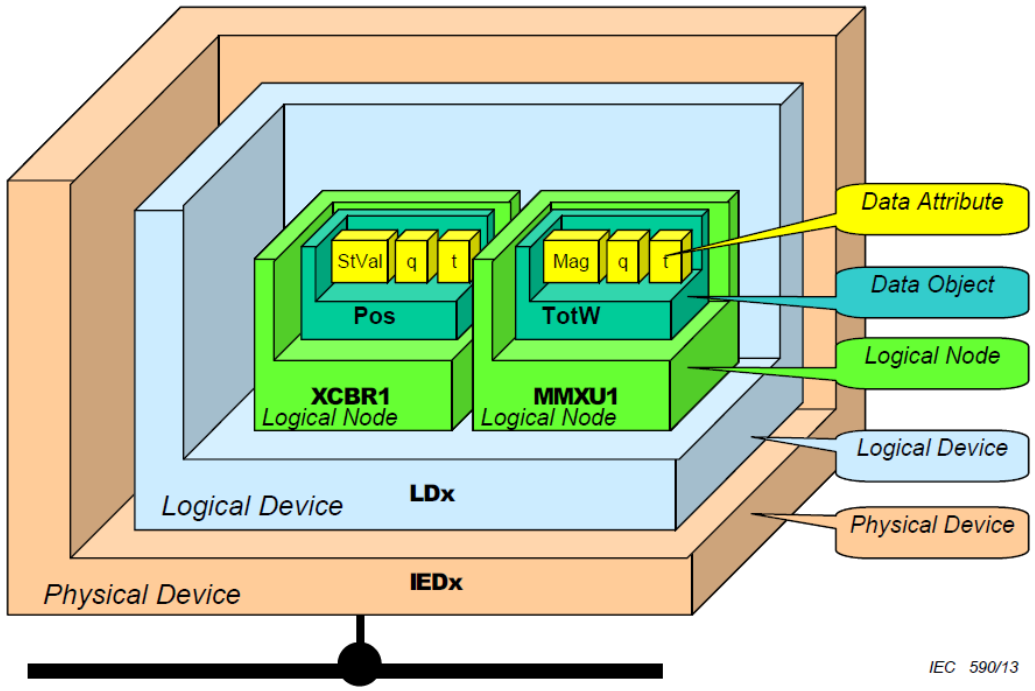
Cost Conscience

- No time-based maintenance using breakers with magnetic actuators
- Maintenance on OP1 & OP2 without an outage
- Reduced cable run distances by almost half
- Reduced spare parts inventory

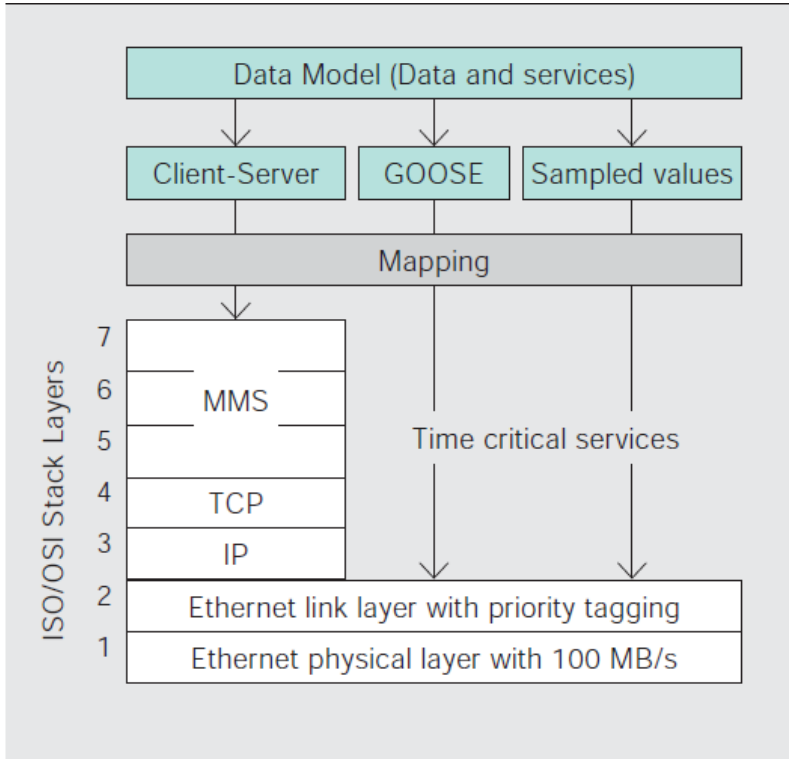
What is IEC 61850?

Data model & communication structure

Data model

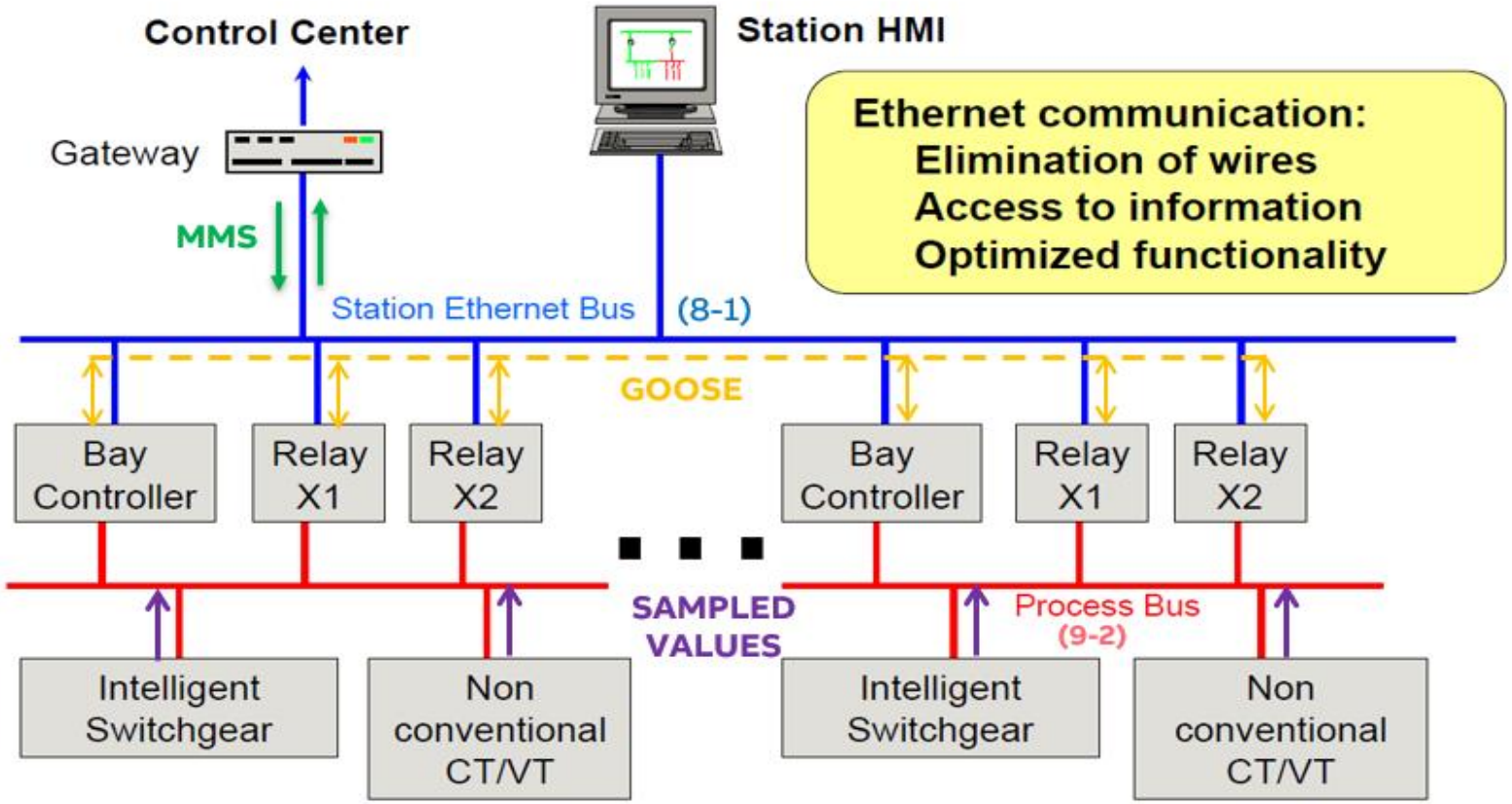


Communication structure



What is IEC 61850?

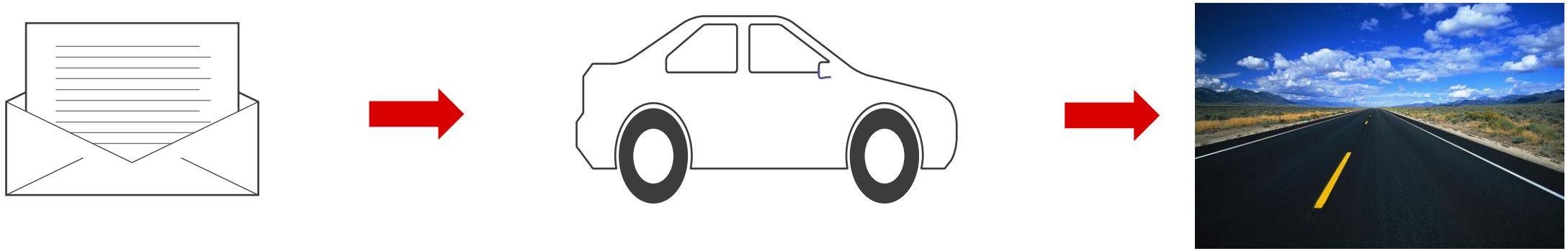
Substation automation system – Station bus & Process bus



What is IEC 61850?

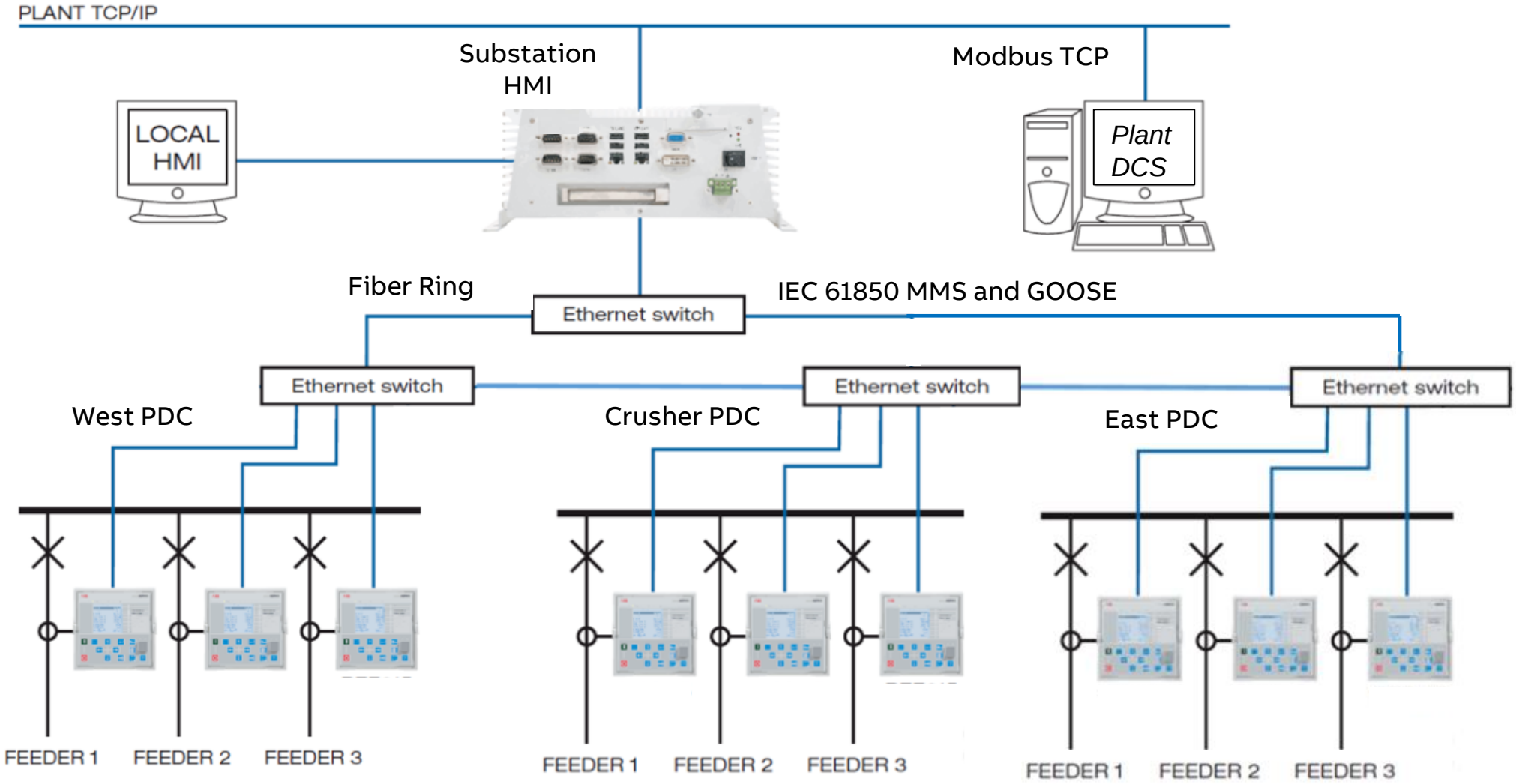
GOOSE structure

Data set (information) | **GCB** | **Network**



- GOOSE messages are based on change event
- GOOSE messages include diagnostic functions (a “heartbeat” to all devices subscribed is sent periodically)
- GOOSE messages are managed by GCBs (GOOSE control block) inside IEDs
- GOOSE messages send “data sets” upon changes of state

Communications Architecture



Protective Relays

Feeder protection relay

Advanced digital relays with native IEC 61850

- Full complement of feeder protection functions
- Cable Fault Detection (CFD) on the mains
- Fast Bus protection
  - IEC 61850 GOOSE - < 10ms
- Metering and breaker control
- Digital fault recording
- Only 2 relay style variants

Lesson Learned – Plan your Network architecture and nomenclature prior to beginning any relay programming

Reliable and cost-effective fast bus protection

Features and benefits

Overview

- Utilizing directional overcurrent elements of feeder protection relays
- Reliable: operates only against faults on the protected bus
  - All contributing breakers are tripped and block-closed
  - Acceptable operating speed
- Secured: able to distinguish external (through) faults
  - Allows the individual breaker to trip first

Features

- Flexible to multiple incoming / contributing sources
- Dedicated bus protection relay is not required
- A “master” relay is assigned to perform the bus protection scheme with a “backup” relay automatically assuming the “master” relays operation during relay failure
- High speed communication via IEC61850 GOOSE messaging

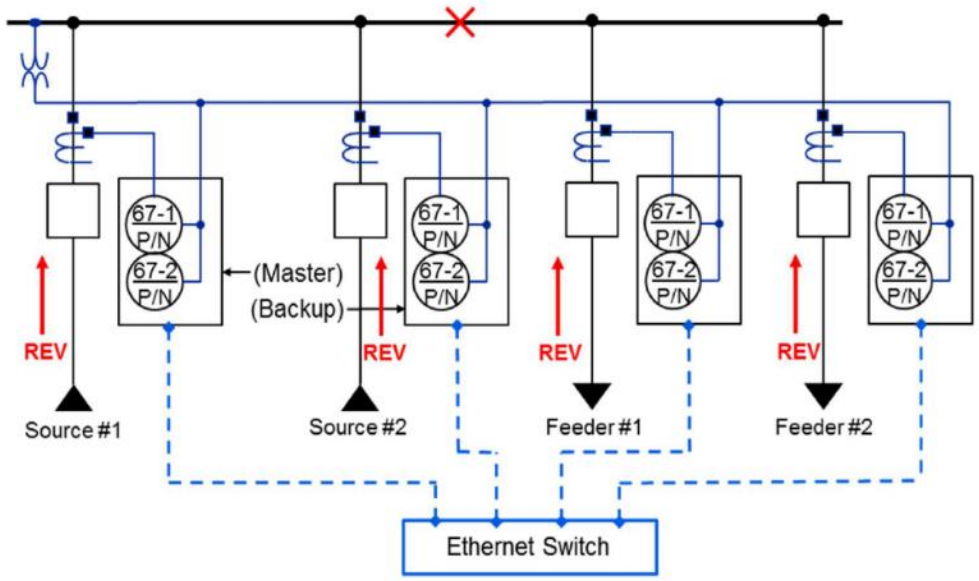
Benefits

- Adaptable towards increases in system fault levels
- Flexible to new bus additions of loads and sources
- Reduction of wiring versus conventional schemes and potentially removes the requirements for dedicated bus CTs
- Improved scheme security by being immune to the effects of CT saturation
- Communication redundancy

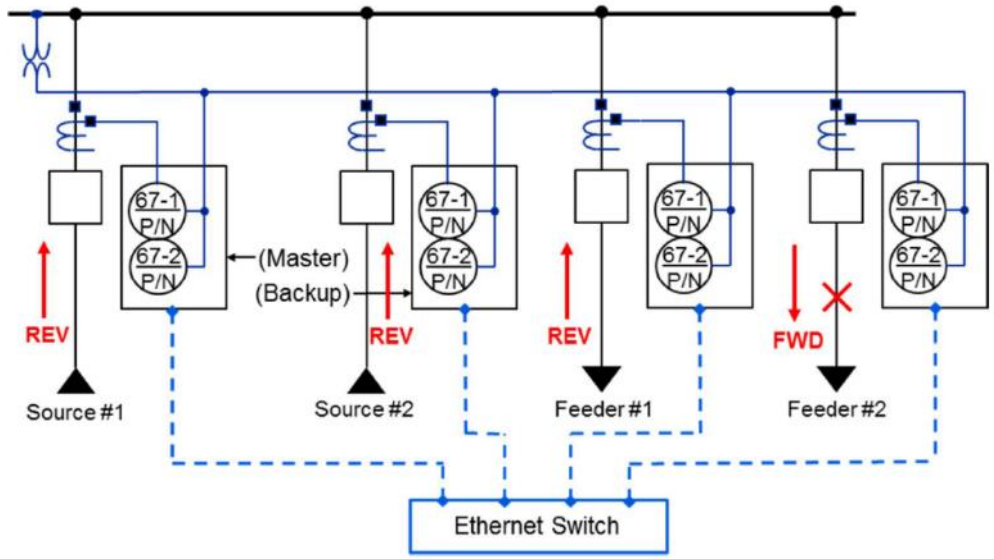
Fast Bus Protection

Scheme operation

Operation during internal (bus) fault



Operation during external (feeder) fault



Lesson Learned – Test sample before you program scheme

GOOSE & MMS Configuration

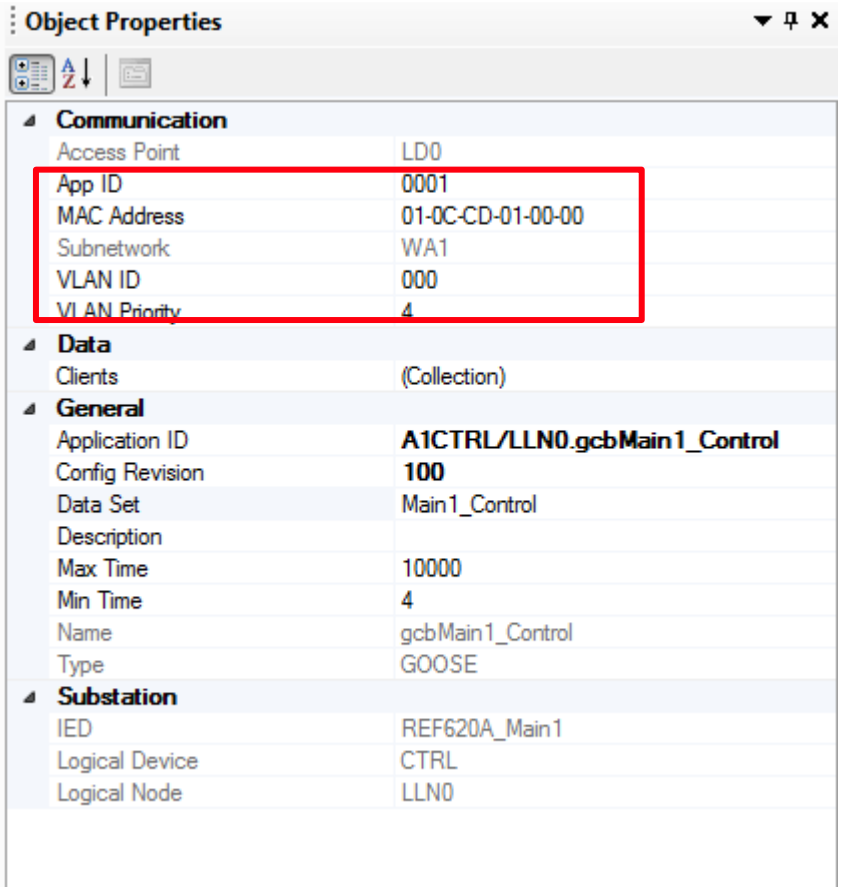
Network information

Device addressing

- IP Address & Subnet
- APP ID, MAC Address
- VLAN ID

Things to Remember

- Set-up structure in advance of programming
- Test the structure before replication
- Determine what devices are in each Project File
  - One for each Substation/Switchgear
- App ID
  - Must be unique to entire project
  - Limited to 3FFF
- MAC Address
  - Limited to 01-0CCD-01-01-FF



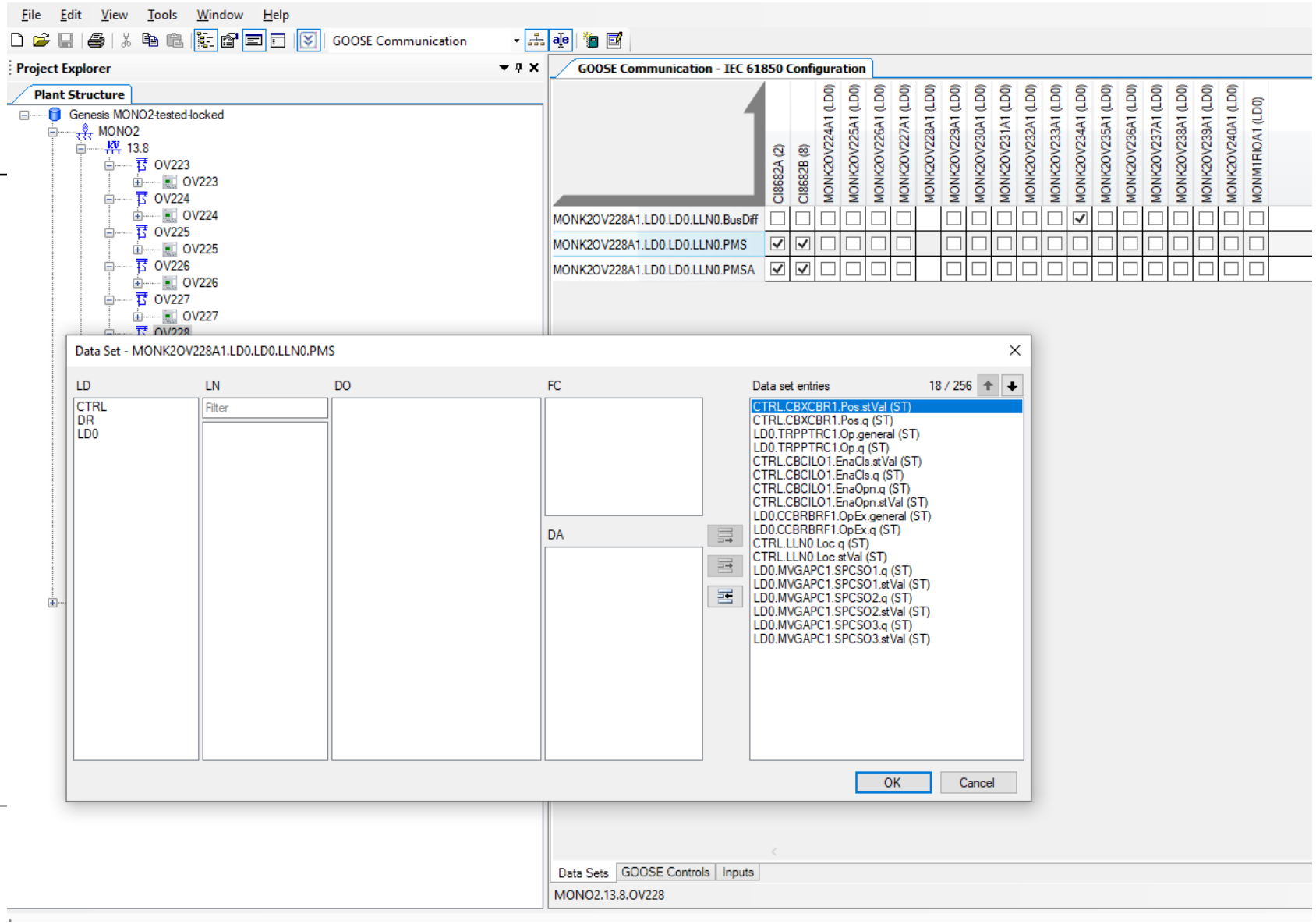
GOOSE messaging

Data Sets, GOOSE Control Blocks

GOOSE Engineering

GOOSE DATA SETS

- 20 Elements per Set
- 8 Sets Max
- Digitals in one Data Set
- Analogs in another
  - Minimize Analogs
- Add Value (Val) and Quality (q) to the data



GOOSE messaging

Bring signals to the logic blocks

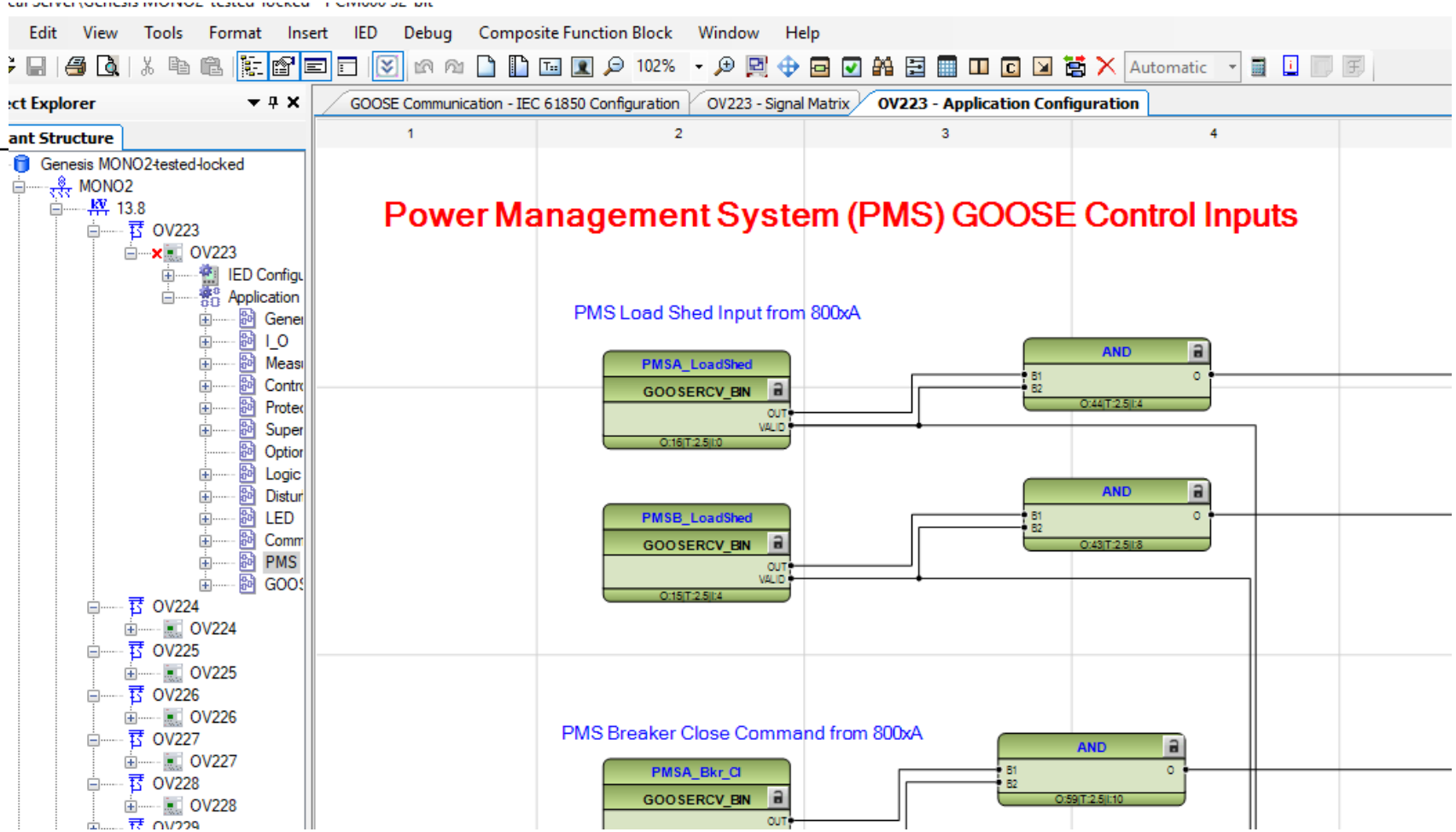
Application Configuration

- Insert GOOSE Receive function blocks
- Tie Signals to Relay logic

Things to Remember

- Be thoughtful with structure
  - Logic Design
  - Tabs

- ***Naming is Everything!***
- ***Test before you replicate***



GOOSE messaging

Create connections

Tie up the signals

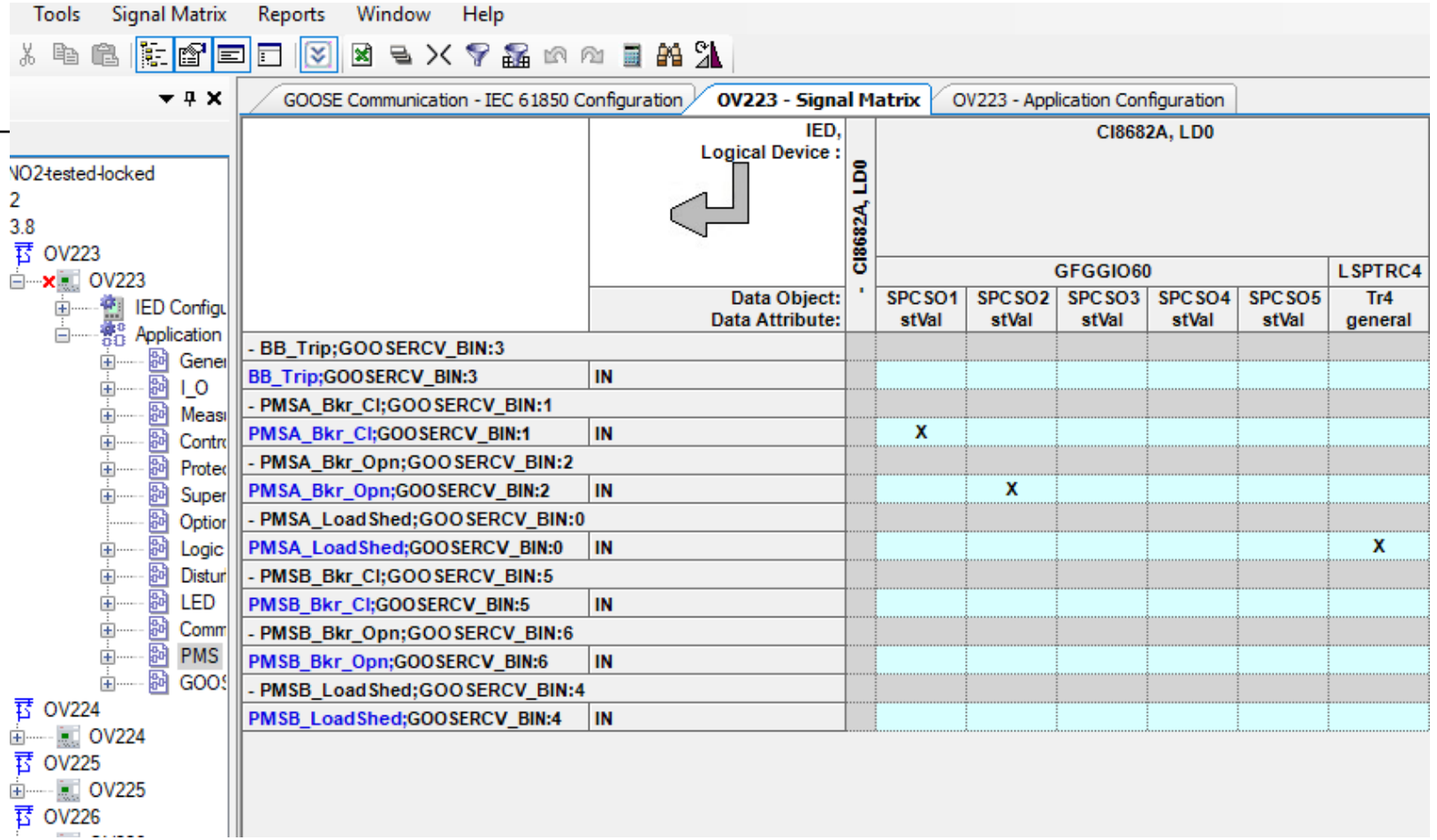
Signal Matrix

- Connect GOOSE Signals to
- GOOSE Receive function blocks

Things to Remember

- Naming is Everything
  - Relays
  - Other devices
- Test before you replicate

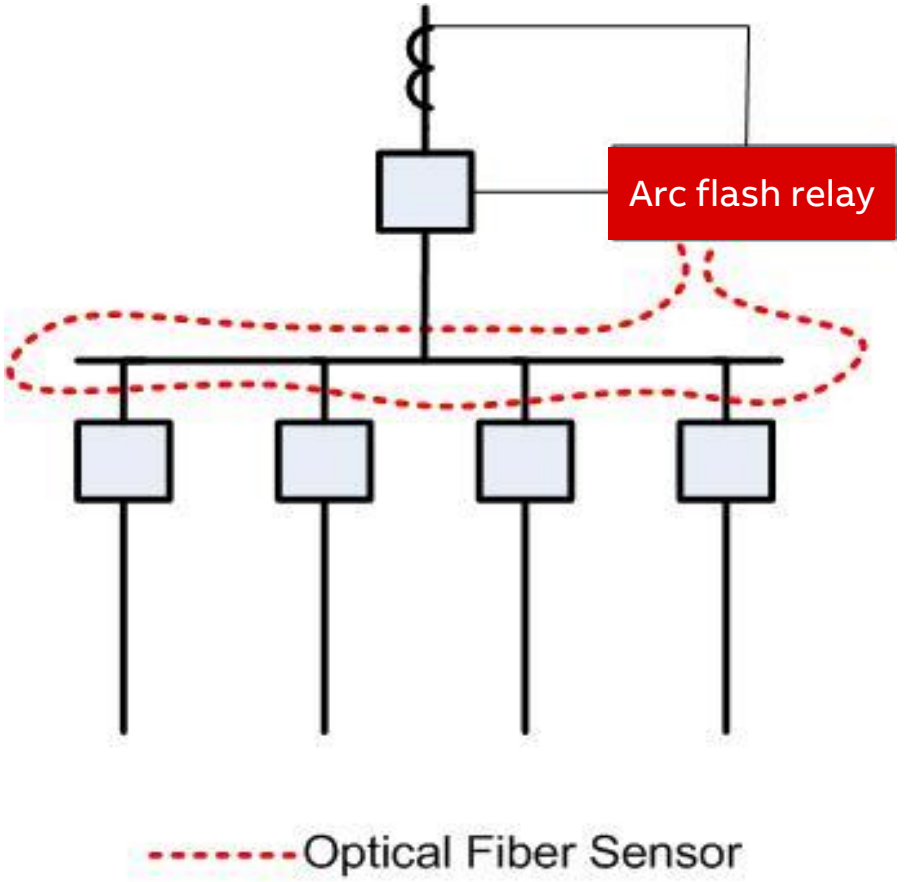
- ***No Room for Error here!***



Arc Flash Detection

Enhancing safety

- Fully independent of feeder protection protection
- ~ 2.5ms arc flash detection
- ~ 50ms total (incl breaker opening) clearing time
- Current arming to prevent nuisance trips



Lesson Learned – Plan for more fiber loops than you think

Substation HMI

Grid Automation Controller

IEC 61850 Communications Protocol

- GOOSE Control
- MMS Metering

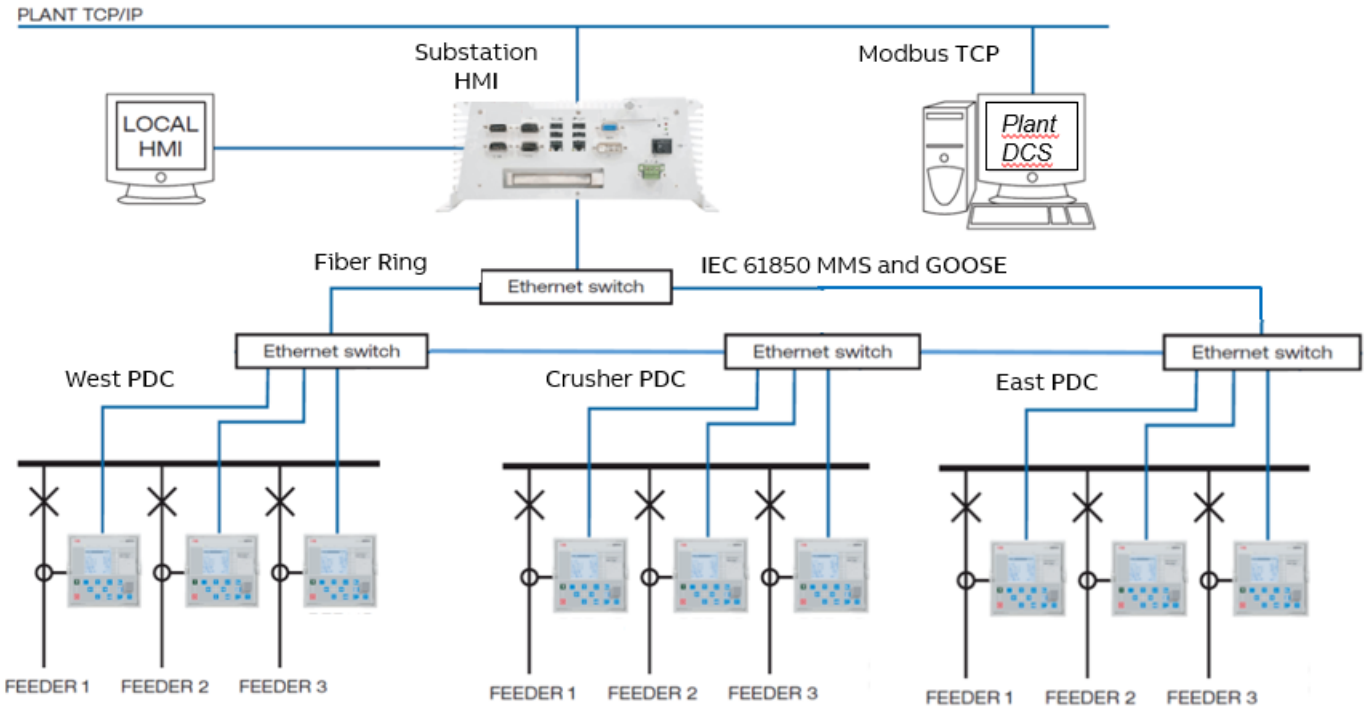
Fault Detection, Isolation, and Restoration (FDIR)

- < 2 second transfer using 61850 GOOSE

Full relay information available via IEC 61850 MMS

Integration with Plant DCS via MODBUS

Web Interface – monitor and control from anywhere with access to network



Lesson Learned - Use a GOOSE Network Analyzer

Distribution protection and automation solution: A real world experience

Lessons learned from an actual project – Concept, Design, Implementation

Summary

Network design benefits

Redesigning the radial system to ring network to enable automatic fault detection, fault isolation and service restoration brought in substantial benefit to operations by reducing down time

IEC 61850 control efficiencies

IEC61850-based protection schemes helped to reduce overall cost, increase safety, and improve efficiency of operations

Plan in advance

The lessons learned from this modernization project around engineering, testing and commissioning is a valuable asset in future implementations

Thanks for your attention!

QUESTIONS?