The Interoperability Dilemma

Way Too Expensive & Complex
I need the Phase A voltage for the 345KV primary feeder #1. It is in Register 4023 and 4024. Traditional Register-based Protocols Carry Significant Configuration Costs & Complexity.
Standards Are Good!

“Standards are great. Everyone should have one.”

– Bob Metcalfe, Co-inventor of Ethernet

Fewer of the Right Standards are Better!!
Where We have Come From...

Communication Networks and Systems in Substations

**IEC 61850**

Global Driver

- Necessity to simplify & standardize Substation design, Construction, commissioning, operation and maintenance

Driven By

- Utilities through UCA & IEC standard committees

EPRI-Project UCA.2

The international Goal

Experience with IEC 60870-5 and -6
IEC 61850 Scope

61850 Addresses All Aspects of Substation Communication and Configuration
IEC61850 Modeling Approach

• Define the Semantics (meaning) of information

• Define the Syntax (structure) of information
IEC 61850 & The Digital Substation

LEVEL 3
Enterprise

LEVEL 2
Substation

LEVEL 1
IEDs

LEVEL 0
Sensors, I/O

EMS/DMS/OMS

61850 Station Bus:
Client/Server; GOOSE

NWIP
IEC to EMS

Multilink Switch

61850 Process Bus

Multilink Switch

61850 Configuration
Some Terms

• Master Slave – a master controls slave access to the network (e.g. Modbus).

• Peer-to-peer – any entity may access the network equally
  – Client-Server – defines roles between 2 peers on a network.
  – Publisher-Subscriber – a one to many, connectionless communication architecture
IEC 61850 Standard

Basic principles
Glossary
General Requirements
System and project management
Communication requirements
Substation Automation System Configuration
Basic Communication Structure (4 sections)
Mapping to MMS and Ethernet
Sampled Measured Values
Mapping to Ethernet
Conformance testing

Structured Using Extensive Past Experience
Anatomy of an IEC61850 Object Names

“MMXU2$MX$A” = Feeder #2 Current Measurements

...Intuitive, Standardized Object Naming
Logical Node

Definition: A Logical Node is an abstract model of a real device or function

- **XCBR**: Circuit Breaker
- **RSYN**: Protection Related
- **YPTR**: Transformer
Logical Node Groups

L System LN (2)
P Protection (28)
R Protection related (10)
C Control (5)
G Generic (3)
I Interfacing and archiving (4)
A Automatic control (4)
M Metering and measurement (8)
S Sensor and monitoring (4)
X Switchgear (2)
T Instrument transformers (2)
Y Power transformers (4)
Z Further power system equipment (15)

Examples:

PDIF: Differential protection
RBPF: Breaker failure
XCBR: Circuit breaker
CSWI: Switch controller
MMXU: Measurement unit
YPTR: Power transformer
Logical Node Names

Example for Breaker:

dddXCBR01

Logical Node Instance #

Logical Node Name per IEC 61850-7-4 (breaker)

Optional Application Specific Prefix

Simple, Structured Naming
Logical Node Tree...

“Tree” View of Measurement Unit

```
  MMXU
   ├── MX
   │   └── TotW
   │       └── TotVAr
   ├── CF
   │   └── TotVA
   │       └── TotPF
   ├── DC
   │   └── Hz
   │       └── PPV
   │           └── PhV
   │               └── A
   │                   └── W
   │                       └── W
   │                           └── VAr
   │                               └── VA
   │                                   └── TotPF
   │                                       └── Z

  Data Items
```
## Functional Constraints...

<table>
<thead>
<tr>
<th>FC Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST</td>
<td>Status Information</td>
</tr>
<tr>
<td>MX</td>
<td>Measurands (analog values)</td>
</tr>
<tr>
<td>CO</td>
<td>Control</td>
</tr>
<tr>
<td>SP</td>
<td>Set point</td>
</tr>
<tr>
<td>SV</td>
<td>Substitution</td>
</tr>
<tr>
<td>CF</td>
<td>Configuration</td>
</tr>
<tr>
<td>DC</td>
<td>Description</td>
</tr>
<tr>
<td>SG</td>
<td>Setting Group</td>
</tr>
<tr>
<td>SE</td>
<td>Setting Group Editable</td>
</tr>
<tr>
<td>EX</td>
<td>Extended Definition (naming – read only)</td>
</tr>
<tr>
<td>BR</td>
<td>Buffered Report</td>
</tr>
<tr>
<td>RP</td>
<td>Unbuffered Report</td>
</tr>
<tr>
<td>LG</td>
<td>Logging</td>
</tr>
<tr>
<td>GO</td>
<td>GOOSE Control</td>
</tr>
<tr>
<td>GS</td>
<td>GSSE Control</td>
</tr>
<tr>
<td>MS</td>
<td>Multicast Sampled Value (9-2)</td>
</tr>
<tr>
<td>US</td>
<td>Unicast Sampled Value (9-1)</td>
</tr>
<tr>
<td>XX</td>
<td>Used as wild card in ACSI</td>
</tr>
</tbody>
</table>
Logical Node Tree...
“Tree” View of Measurement Unit

MMXU
  ───MX
  │  ──TotW
  │  ──TotVAr
  │  ──CF
  │  ──TotVA
  │  ──TotPF
  │  ──DC
  │  ──Hz
  │  ──PPV
  │  ──PhV
  │  ──PhA
  │  ──instCVal
  │  ──PhB
  │  ──cVal
  │  ──PhC
  │  ──neut
  │  ──net
  │  ──res
  │  ──net
  │  ──res
  │  ──Z
  │  ──ang
  └──common Data Class – "WYE"

July 8, 2005
Common Data Classes (CDC)

Defines structure for common types that are used to describe data objects.

CDC are complex objects built on predefined simple base types organized into functional constraints (FC)

Examples:
- Single point status (SPS) – on/off
- Double point status (DPS) – on/off/transient
- 3 phase measurement (WYE)

Logical Node $\rightarrow$ FC $\rightarrow$ Data Items $\rightarrow$ Common Data Class
# Common Data Classes Table

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPS</td>
<td>Single Point Status</td>
</tr>
<tr>
<td>DPS</td>
<td>Double Point Status</td>
</tr>
<tr>
<td>INS</td>
<td>Integer Status</td>
</tr>
<tr>
<td>ACT</td>
<td>Protection Activation</td>
</tr>
<tr>
<td>ACD</td>
<td>Directional Protection Activation Info.</td>
</tr>
<tr>
<td>SEC</td>
<td>Security Violation Counting</td>
</tr>
<tr>
<td>BCR</td>
<td>Binary Counter Reading</td>
</tr>
<tr>
<td>MV</td>
<td>Measured Value</td>
</tr>
<tr>
<td>CMV</td>
<td>Complex Measured Value</td>
</tr>
<tr>
<td>SAV</td>
<td>Sampled Value</td>
</tr>
<tr>
<td>WYE</td>
<td>Phase to ground measured values for 3-phase system</td>
</tr>
<tr>
<td>DEL</td>
<td>Phase to phase measured values for 3-phase system</td>
</tr>
<tr>
<td>SEQ</td>
<td>Sequence</td>
</tr>
<tr>
<td>HMV</td>
<td>Harmonic value</td>
</tr>
<tr>
<td>HWYE</td>
<td>Harmonic value for WYE</td>
</tr>
<tr>
<td>HDEL</td>
<td>Harmonic value for DEL</td>
</tr>
</tbody>
</table>
## Common Data Classes Table...

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPC</td>
<td>Controllable Single Point</td>
</tr>
<tr>
<td>DPC</td>
<td>Controllable Double Point</td>
</tr>
<tr>
<td>INC</td>
<td>Controllable Integer Status</td>
</tr>
<tr>
<td>BSC</td>
<td>Binary Controlled Step Position Info.</td>
</tr>
<tr>
<td>ISC</td>
<td>Integer Controlled Step Position Info.</td>
</tr>
<tr>
<td>APC</td>
<td>Controllable Analogue Set Point Info.</td>
</tr>
<tr>
<td>SPG</td>
<td>Single Point Setting</td>
</tr>
<tr>
<td>ING</td>
<td>Integer Status Setting</td>
</tr>
<tr>
<td>ASG</td>
<td>Analogue Setting</td>
</tr>
<tr>
<td>CURVE</td>
<td>Setting Curve</td>
</tr>
<tr>
<td>DPL</td>
<td>Device Name Plate</td>
</tr>
<tr>
<td>LPL</td>
<td>Logical Node Name Plate</td>
</tr>
<tr>
<td>CSD</td>
<td>Curve Shape Description</td>
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</tbody>
</table>
# Common Data Class Example

**Single Point Status (SPS)**

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Attribute Type</th>
<th>FC</th>
<th>TrgOp</th>
<th>Value/Value Range</th>
<th>M/O/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataName</td>
<td>Inherited from Data Class (see IEC 61850-7-2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## DataAttribute

### status

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Attribute Type</th>
<th>FC</th>
<th>TrgOp</th>
<th>Value/Value Range</th>
<th>M/O/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>stVal</td>
<td>BOOLEAN</td>
<td>ST</td>
<td>dchg</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
<tr>
<td>q</td>
<td>Quality</td>
<td>ST</td>
<td>qchg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t</td>
<td>TimeStamp</td>
<td>ST</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### substitution

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Attribute Type</th>
<th>FC</th>
<th>TrgOp</th>
<th>Value/Value Range</th>
<th>M/O/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>subEna</td>
<td>BOOLEAN</td>
<td>SV</td>
<td></td>
<td></td>
<td>PICS_SUBST</td>
</tr>
<tr>
<td>subVal</td>
<td>BOOLEAN</td>
<td>SV</td>
<td></td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
<tr>
<td>subQ</td>
<td>Quality</td>
<td>SV</td>
<td></td>
<td></td>
<td>PICS_SUBST</td>
</tr>
<tr>
<td>subID</td>
<td>VISIBLE STRING64</td>
<td>SV</td>
<td></td>
<td></td>
<td>PICS_SUBST</td>
</tr>
</tbody>
</table>

### configuration, description and extension

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Attribute Type</th>
<th>FC</th>
<th>Text</th>
<th>M/O/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>VISIBLE STRING255</td>
<td>DC</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>dU</td>
<td>UNICODE STRING255</td>
<td>DC</td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>cdcNs</td>
<td>VISIBLE STRING255</td>
<td>EX</td>
<td></td>
<td>AC_DLNDM</td>
</tr>
<tr>
<td>cdcName</td>
<td>VISIBLE STRING255</td>
<td>EX</td>
<td></td>
<td>AC_DLNDM</td>
</tr>
<tr>
<td>dataNs</td>
<td>VISIBLE STRING255</td>
<td>EX</td>
<td></td>
<td>AC_DLNDM</td>
</tr>
</tbody>
</table>

---

*Makes Maximum Re-Use of Data Attributes*
## Logical Node Example

### Measurement Unit (MMXU) illustration as per Standard From IEC61850-7-4

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Attr. Type</th>
<th>Explanation</th>
<th>T</th>
<th>M/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNName</td>
<td></td>
<td>Shall be inherited from Logical-Node Class (see IEC 61850-7-2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Common Logical Node Information
- LN shall inherit all Mandatory Data from Common Logical Node Class
- EEHealth: INS - External equipment health (external sensor)

#### Measured values
- TotW: MV - Total Active Power (Total P)
- TotVAR: MV - Total Reactive Power (Total Q)
- TotVA: MV - Total Apparent Power (Total S)
- TotPF: MV - Average Power factor (Total PF)
- Hz: MV - Frequency
- PPV: DEL - Phase to phase voltages (VL1VL2, ...)
- PhV: WYE - Phase to ground voltages (VL1ER, ...)
- A: WYE - Phase currents (IL1, IL2, IL3)
- W: WYE - Phase active power (P)
- VAr: WYE - Phase reactive power (Q)
- VA: WYE - Phase apparent power (S)
- PF: WYE - Phase power factor
- Z: WYE - Phase Impedance
IEC 61850 Profiles

Ethernet – The Foundation of All Future Substation Communications
Abstract Communications Service Interface (ACSI)

- Defines a set of Abstract Services to manipulate and access data objects
- Defines a base set of data types for describing objects
- Defines the behavior of an Object

Abstraction Makes 61850 “Future Proof“!
Examples

Abstract Communications Service Interface

- GetDataValues – Read
- SetDataValues – Write
- GetDataDirectory – Read list of object names

Self-Description Differentiates 61850 From All Other Existing Protocols
Grant County PUD Experience

Substation Modernization Pilot did 2 substations
  - DNP3.0 over TCP and UDP
  - UCA2.0 (subset of IEC61850)
Time to get DNP3 relay configured and communicating:  ~ 2-3 days
Time to get UCA/IEC61850 relay configured and communicating:  2-3 hours

Minimization of Configuration is a Major Customer Requirement
UR Implemented 61850 Services

Abstract Communications Service Interface

Buffered report control
Unbuffered report control
GOOSE
GSSE (UCA GOOSE)
ServerDirectory
Time (SNTP)
GetFile / GetFileAttributes
Associate
GetDataSetValue
SetDataSetValues

GetDataSetDirectory
GOOSE
GSSE (Generic Substation Status Event)
SBO

Abort
Release

LogicalDeviceDirectory
LogicalNodeDirectory

GetAllDataValues
GetDataValues
SetDataValues

GetDataDirectory
GetDataDefinition

Report (buffered & unbuffered)
- data-change (dchg)
GetBRCBValues
SetBRCBValues

Highlighted Services Enable Self-Description
IEC 61850 Station Bus Transactions

Simplified! Making It All Work Together
Relay to Relay Communications - Functional Requirements

Requirements:

• Reliable Message delivery from one to multiple other devices - simultaneously

• Fast Delivery (< 4ms)
**Generic Object Oriented Substation Event (GOOSE)**

- User Dataset sent in Multicast message
- Primarily Local but Wide Area possible (and operating!)
- Bridgeable but not routable
- Sent on change of state
- Sent periodically for self-test
- Reliability by message repeat

**GOOSE Header:**
- Multicast Address
- Name
- Time Until Next GOOSE
- Etc.

**User-Defined Dataset**
- Status Information
- **Analog Values**
- Data Quality
- Time

Fast, Reliable, Interoperable Device to Device Communication
VLAN Packet Structure

- 4 bytes added to the Ethernet frame
- Tag Protocol Identifier (TPID) set to 8100 hex ...identifies an 802.1Q message type
- 12 bits used for VLAN Identifier
- 3 bits used for Priority – 8 levels
Ethernet VLAN

- R1
- R2
- R3
- R4
- R5
- R6
- R7

- Ethernet Switch w/ VLAN
- VLAN 5 Message
- Ethernet VLAN 5
- Mux

Future technologies and network infrastructure considerations.
Ethernet Priority

- IEC GOOSE implements the 802.1Q priority setting
- Priority messages moved to the priority queues
- Implemented in many Ethernet switched

New “high priority” message for Port 6

15 µsec

Ethernet Switch
Additional Services

**GOOSE**

- **GetGoReference** – Retrieve the Data Name for a specific dataset member reference
- **GetGOOSEElementNumber** – Retrieve the position of a member in a Dataset

What is element 5 called?

Element 5 is “BFI”

Services Enable Virtual Wire Check
Goose Impact: LAN Interlocking and Tripping

Ideal for interlocking
- Multicasting eliminates multiple connections between devices
- Simplified logic program replaces complex one

Inter-zone Protective Relaying
- Improved Performance
- Complete Solution Using UR

61850 GOOSE | Traditional Wiring
Remote Breaker Control

Line Protection
Transformer Protection
Bus Protection

Trip/Block
Trip/Block
Trip/Block

Control House
Switch Yard

Ethernet Switch

XCBR1
Local Position
BlkOpn
BlkCls

XCBR2
Local Position
BlkOpn
BlkCls

SIMG1
Pressure
InsTr
Density
InsBlk
Temp

C30

Via FlexLogic
Via GOOSE
Palo Verde Nuclear Power Plant
The Need For Mitigation?

- Palo Verde Unit 2 Was Up-Rated by 121MW.
- This Impacted the safe Operation of the California Oregon Intertie
- Loss of any 2 Palo Verde Units under full load requires mitigation
Design Parameters

• Shed 120 MW of load upon loss of any 2 units
  – If the sum of any 2 generators exceeds 2574 MW
  – If the 2 units trip within 5 minutes of one another
• Load must be shed within 1 second
• No automatic restoration (Supervisory only)
• Redundant with no common mode failures

And the Solution Is...
Arming Logic

Gen1

Gen2

Gen3

MW

Σ

ARM Load

Yes

GEN (1+2) or
GEN (2+3) or >2550MW
GEN (1+3)

No

UN-ARM Load
Substation Dynamic Load Aggregation

Armed Load’

ARM Load

PU - Pick Up

DO – Drop Out

<150MW ?

Yes

Enable Sum

New Armed Load

Station Load

Σ

Substation XYZ
SRP SONET System

Data In

Network elements:
17 OC-48 Nodes
218 MUX Nodes

Data Out
Palo Verde **Round Trip** Communication Timing

<table>
<thead>
<tr>
<th>Site</th>
<th>Ethernet</th>
<th>G.703 Direct I/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaucho</td>
<td>14ms</td>
<td>11ms</td>
</tr>
<tr>
<td>Alameda</td>
<td>14ms</td>
<td>20ms</td>
</tr>
<tr>
<td>Indian Bend</td>
<td>14ms</td>
<td>33ms</td>
</tr>
<tr>
<td>Buckhorn</td>
<td>14ms</td>
<td>46ms</td>
</tr>
</tbody>
</table>

Multicast through fiber

61850 Provides New Solutions to Complex Power System Issues
SCL – Substation Configuration Language

- Description language for communication in electrical substations related to the IEDs

- XML based language that allows a formal description of
  - Substation automation system and the switchyard and the relation between them
  - IED configuration
SCL File Types

**SSD**: System Specification Description.
- description of the entire system.

**SCD**: Substation Configuration Description.
- description of a single substation.

**ICD**: IED Capability Description.
- description of items supported by an IED.

**CID**: Configured IED Description.
- configuration for a specific IED.

Intended to Address *ALL* Aspects of Power System Configuration
Example of SCL

```xml
<?xml version="1.0" encoding="UTF-8" ?>
    xsi:schemaLocation="http://www.iec.ch/61850/2003/SCL SCL.xsd">
    <Header id="SISCO_IED1_Complete" version="1" revision="2" toolID="xml spy" nameStructure="IEDName" />
    <Communication>
        <SubNetwork name="Subnetz1" type="8-MMS/TCP">
            <Text />
            <BitRate unit="b/s" multiplier="M">100</BitRate>
            <ConnectedAP iedName="SISCO_IED1" apName="AXS4MMS_CIGRE">
                <Address>
                    <P type="IP" xsi:type="tP_IP">192.168.2.11</P>
                    <P type="IP-SUBNET" xsi:type="tP_IP-SUBNET">255.255.255.0</P>
                </Address>
                <GSE IdInst="CTRL" cbName="Control_DataSet1">
                    <Address>
                        <P type="VLAN-ID" xsi:type="tP_VLAN-ID">001</P>
                        <P type="VLAN-PRIORITY" xsi:type="tP_VLAN-PRIORITY">4</P>
                        <P type="MAC-Address" xsi:type="tP_MAC-Address">01-0C-CD-01-F1-04</P>
                        <P type="APPID" xsi:type="tP_APPID">0000</P>
                    </Address>
                    <MinTime unit="s" multiplier="m">10</MinTime>
                    <MaxTime unit="s" multiplier="m">2000</MaxTime>
                </GSE>
            </ConnectedAP>
        </SubNetwork>
    </Communication>
</SCL>
```

Easily Readable & Logical Format
61850 Process Bus

61850 Process Bus

- Synchronous sampling
- Reduction of Point-Point wiring
- Minimization of configuration time
- Elimination of copper wire
Why a Process Bus?

• Need for an interface with optical voltage and current transformers
• Desire to eliminate copper wiring in the field
• Desire to minimize configuration time
• Desire to optimize re-configuration
Process Bus Interface with Conventional CTs and PTs

Implementation Needs:
- Time Sync through the network
- Voltage, Current, Input, Output processing
- Redundant 100BaseFx fiber communication ports
- Redundant Power Supply

Merging Unit (MU)
- Voltage/Current/other analogs
- Contact/Status Inputs
- Control Outputs
IMPLEMENTATION GUIDELINE FOR DIGITAL INTERFACE TO INSTRUMENT TRANSFORMERS USING IEC 61850-9-2

Purpose: to define a subset of IEC 61850-9-2 that shall support a fast market introduction of this standard.
## Process Bus Dataset & Common Data Class

### LN LLN0

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PhsMeas1</td>
</tr>
<tr>
<td></td>
<td>IATCTR.Amp</td>
</tr>
<tr>
<td></td>
<td>IBTCTR.Amp</td>
</tr>
<tr>
<td></td>
<td>ICTCTR.Amp</td>
</tr>
<tr>
<td></td>
<td>Inm/cICTCTR.Amp</td>
</tr>
<tr>
<td></td>
<td>UATVTR.Vol</td>
</tr>
<tr>
<td></td>
<td>UBTVTR.Vol</td>
</tr>
<tr>
<td></td>
<td>UCTVTR.Vol</td>
</tr>
<tr>
<td></td>
<td>Unm/cTVTR.Vol</td>
</tr>
</tbody>
</table>

### MSVCB01

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Attribute Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>instMag.iq</td>
<td>INT32 Quality</td>
</tr>
<tr>
<td>sVC</td>
<td>ScaledValueConfig</td>
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</tbody>
</table>

#### Defined per the Implementation Agreement

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>sVC.offset</td>
<td>0</td>
</tr>
<tr>
<td>sVC.scaleFactor</td>
<td>0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>sVC.offset</td>
<td>0</td>
</tr>
<tr>
<td>sVC.scaleFactor</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Analog Filter Compensation

Provides Compensated Sample Time Stamping
Sample Sets: Single or Aggregated

80 samples/nominal cycle
1 sample set/packet

256 samples/nominal cycle
8 samples/packet

Sampling Capability for Now and the Future
IEC61850 Substation Architecture

Simplified Architecture... Positioned for the Future
Redundancy Implementations

Redundant Port: 2 independent Ethernet ports with 2 different addresses

- **Ethernet1**
  - MAC – 1
  - IP Addr - 1

- **Ethernet2**
  - MAC – 2
  - IP Addr - 2

Redundant Media: 1 Ethernet port with switched media

- **Ethernet**
  - MAC – 1
  - IP Addr - 1

Switch

- **Primary**
- **Back-Up**

Switches on loss of Ethernet link pulses

Easy to Configure for Redundancy
Process Bus System Implementation

Swift & Economical Test Capabilities
IEC61850 Benefits - 1

• High-level services enable self-describing devices & automatic object discovery saving $$$$$ in configuration, setup and maintenance.

• Standardized naming conventions with power system context eliminates device dependencies and tag mapping saving $$$$ in configuration, setup, and maintenance.

• Standardized configuration file formats enables exchange of device configuration saving $$$$ in design, specification, configuration, setup, and maintenance.
IEC61850 Benefits - 2

• Higher performance multi-cast messaging for inter-relay communications enables functions not possible with hard wires and save $$$$ in wiring and maintenance.

• Multi-cast messaging enables sharing of transducer (CT/PT) signals saving $$$$ by reducing transducers and calibration costs.