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# A Practical Guide of Troubleshooting IEC 61850 GOOSE Communication

Wei Huang, ABB Inc.

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# A Practical Guide of Troubleshooting IEC 61850 GOOSE Communication

## Speakers

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# Agenda

- Introduction
- IEC 61850 GOOSE Application
- GOOSE Configuration and Communication Message
- Troubleshooting of GOOSE Communication
- Summary

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# Troubleshooting of GOOSE Communication

## Introduction

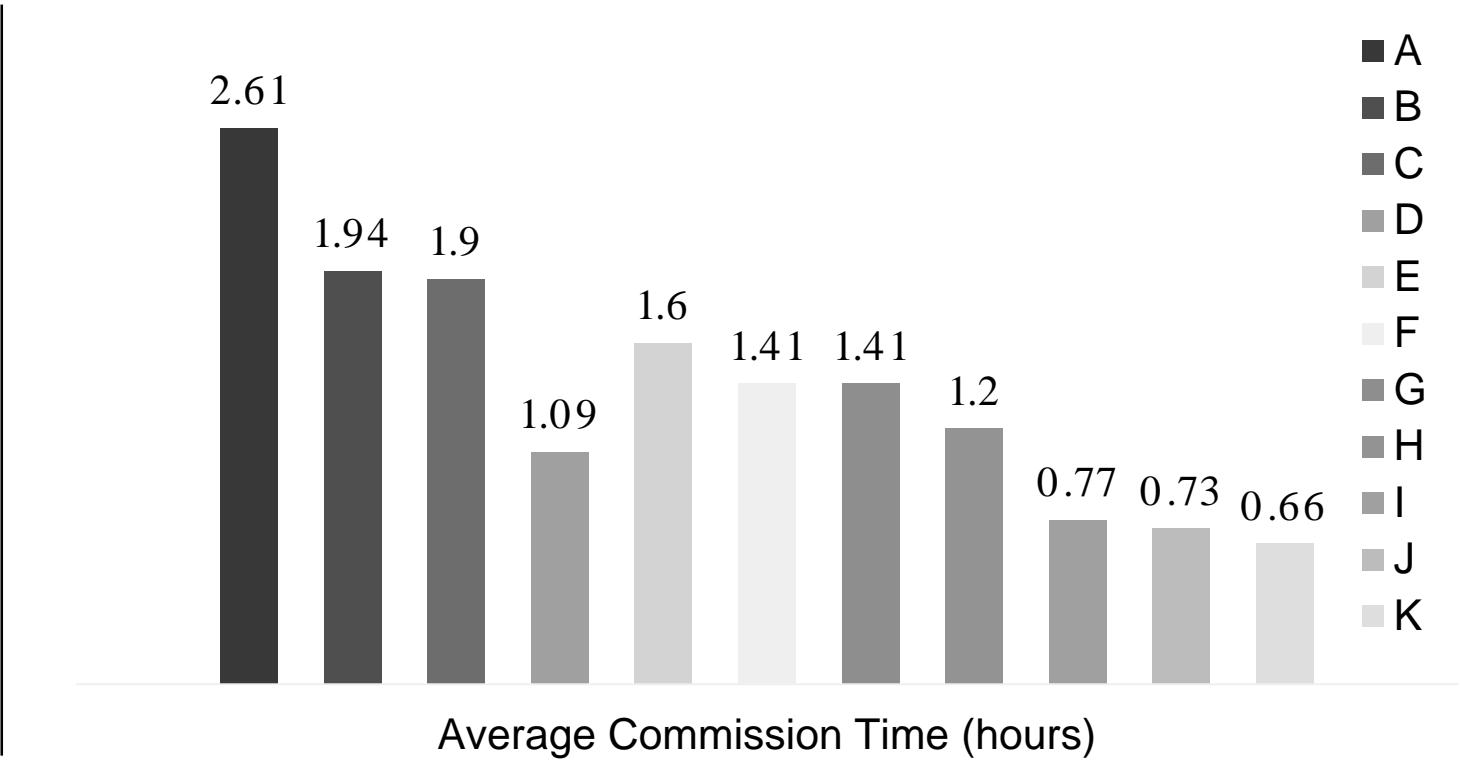
- Review IEC 61850 GOOSE Applications
- Analyze IEC 61850 Data Mode and GOOSE Configuration
- Introduce a Systematic Troubleshooting Approach

# Troubleshooting of GOOSE Communication

## Introduction

Average commission time per IED is reduced from 2.61 hours to 0.66 hour.

Reduce System Commissioning Time by 75%.



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# Troubleshooting of GOOSE Communication

## IEC 61850 GOOSE Applications

- Automatic BUS Transfer Scheme

- ❑ [4] V. G. Duong, and J. Cueco, "Bus Protection? A New and Reliable Approach" *pacworld*, June 2015.

- Bus protection scheme

- ❑ [5] J. S. Cramond, A. Carreras and V. G. Duong, "Protections to consider with Automatic bus Transfer Scheme," *IEEE 2013 66<sup>th</sup> Annual Conference for Protective Relay Engineers*, p.11, April 2013.

- Sympathetic Tripping Logic

- ❑ [9] P. Naik, N. Nair, and V. Vyatkin, "Sympathetic Trip Protection Scenario in IEC 61850," Australian Power Electronics Conference (AUPEC2011), Brisbane, 2011

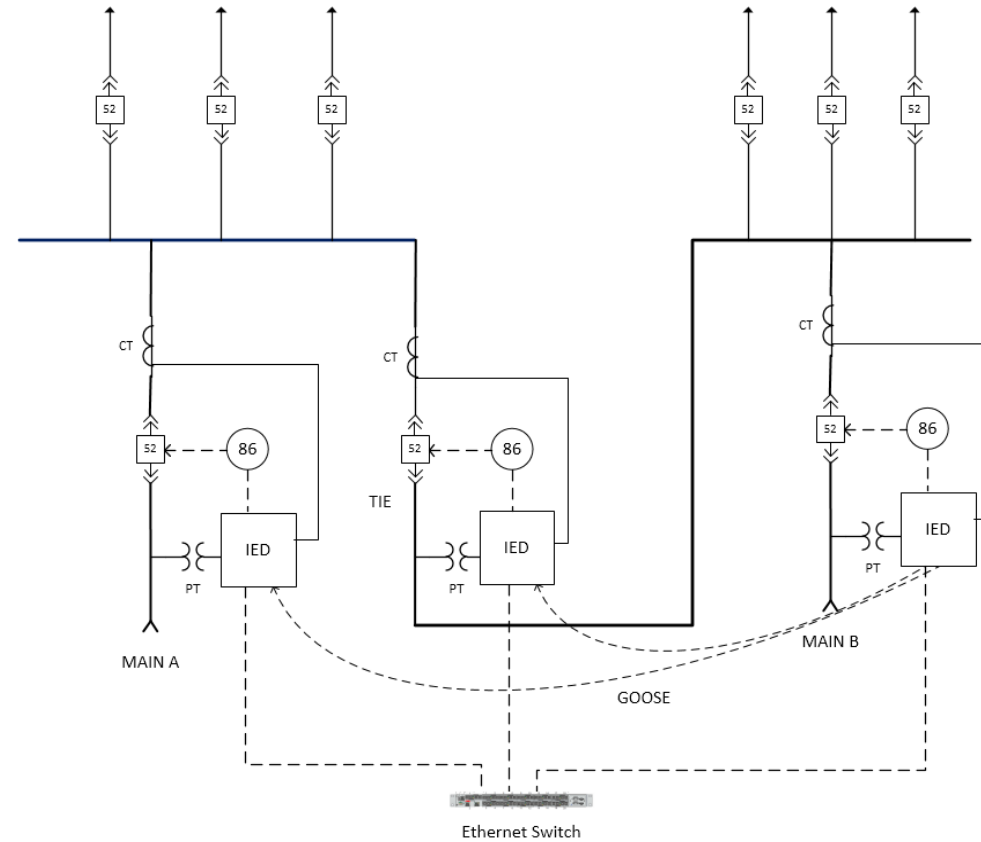
- Load Tap Changer Control

- ❑ [10] N. Sichert, "Transformer load tap changer control using IEC 61850 GOOSE messaging," M.S. dissertation, Dept. Electrical Engineering, Univ. Tennessee at Chattanooga, Chattanooga, Tennessee, 2012.

# Troubleshooting of GOOSE Communication

## IEC 61850 GOOSE Applications

Typical network scheme of a GOOSE application.





# Troubleshooting of GOOSE Communication

## IEC 61850 GOOSE Configuration

### IEC 61850 GOOSE

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Data Model

- Semantic Hierarchical Object Data Model

GOOSE Configuration

- GOOSE Data Set
- GOOSE Control Block
- GOOSE Subscription

### FirstName.LastName@Country.Company.Organization

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wei.huang@us.abb.com

### LogicDevice.LogicNode.DataObject.DataAttribute

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Ctrl.CBCSW1.Pos.stVal

LD0.PEMMXU1.TotW.mag.f

# Troubleshooting of GOOSE Communication

## IEC 61850 GOOSE Configuration

### IEC 61850 GOOSE

#### Data Model

- Semantic Hierarchical Object Data Model

#### GOOSE Configuration

- GOOSE Data Set
  - List of data points
- GOOSE Control Block
- GOOSE Subscription

### GOOSE Data Set

Data set entries 10 / 256

- CTRL.CBCSWI1.Pos.stSeld (ST)
- CTRL.CBCSWI1.Pos.q (ST)
- LD0.PEMMXU1.TotW.mag.f (MX)
- LD0.PEMMXU1.TotW.q (MX)
- LD0.PEMMTR1.DmdWh.actVal (ST)
- LD0.PEMMTR1.DmdWh.q (ST)
- LD0.PHHPTOC1.Op.general (ST)
- LD0.PHHPTOC1.Op.q (ST)
- LD0.PHPTUV1.Op.general (ST)
- LD0.PHPTUV1.Op.q (ST)**

# Troubleshooting of GOOSE Communication

## IEC 61850 GOOSE Configuration

### IEC 61850 GOOSE

#### Data Model

- Semantic Hierarchical Object Data Model

#### GOOSE Configuration

- GOOSE Data Set
  - List of data points
- GOOSE Control Block
  - Define how to send these data points
- GOOSE Subscription

### GOOSE Control Block

Object Properties	
<b>Communication</b>	
App ID	0002
MAC Address	01-0C-CD-01-00-01
Max Time	1000
Min Time	4
VLAN ID	003
VLAN Priority	4
<b>Data</b>	
Clients	(Collection)
<b>General</b>	
Application Id	A6LD0/LLN0.gcbGOOSE
Config Revision	1
Data Set	dsGOOSE
Description	
Name	gcbGOOSE
Type	GOOSE
<b>Substation</b>	
Access Point	LD0
IED	A6
Logical Device	LD0
Logical Node	LLN0
Subnetwork	WA1

# Troubleshooting of GOOSE Communication

## IEC 61850 GOOSE Configuration

### IEC 61850 GOOSE

#### Data Model

- Semantic Hierarchical Object Data Model

#### GOOSE Configuration

- GOOSE Data Set
  - List of data points
- GOOSE Control Block
  - Define how to send these data points
- GOOSE Subscription
  - Map GOOSE receiving IED to the data set

### GOOSE Subscription

	F615_11_138_F28A1 (LD0)	F615_11_138_F29A1 (LD0)	F615_11_138_M1A1 (LD0)	F615_11_138_M2A1 (LD0)	F615_11_138_M3A1 (LD0)	F615_11_138_M4A1 (LD0)	F615_11_138_TABA1 (LD0)	F615_11_138_TBCA1 (LD0)	F615_11_416_F01A1 (LD0)	F615_11_416_F02A1 (LD0)	F615_11_416_F03A1 (LD0)	F615_11_416_F04A1 (LD0)	F615_11_416_F05A1 (LD0)
F61511_138_M2A1.LD0.LLN0.ATS_MB1_TO_TBC	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F61511_138_M2A1.LD0.LLN0.ATS_MB1_TO_TIES	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F61511_138_M2A1.LD0.LLN0.gcbM2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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# Troubleshooting of GOOSE Communication

## A Systematic Approach

### New Technologies and Challenges

- OSI 7 layer Model
- Object Oriented Design
- Unified Modeling Language
- Publish – Subscribe Model
- XML
- ...

# Troubleshooting of GOOSE Communication

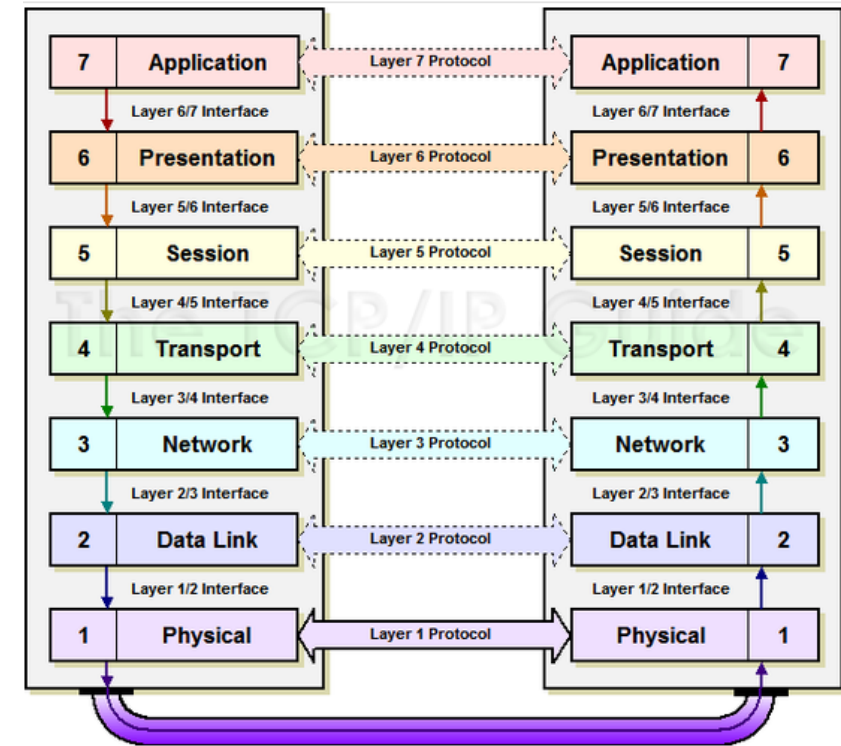
## A Systematic Approach

### A Systematic Approach

New Technologies and Challenges

- OSI 7 layer Model
- Object Oriented Design
- Unified Modeling Language
- Publish – Subscribe Model
- XML

### OSI 7 Layer Model



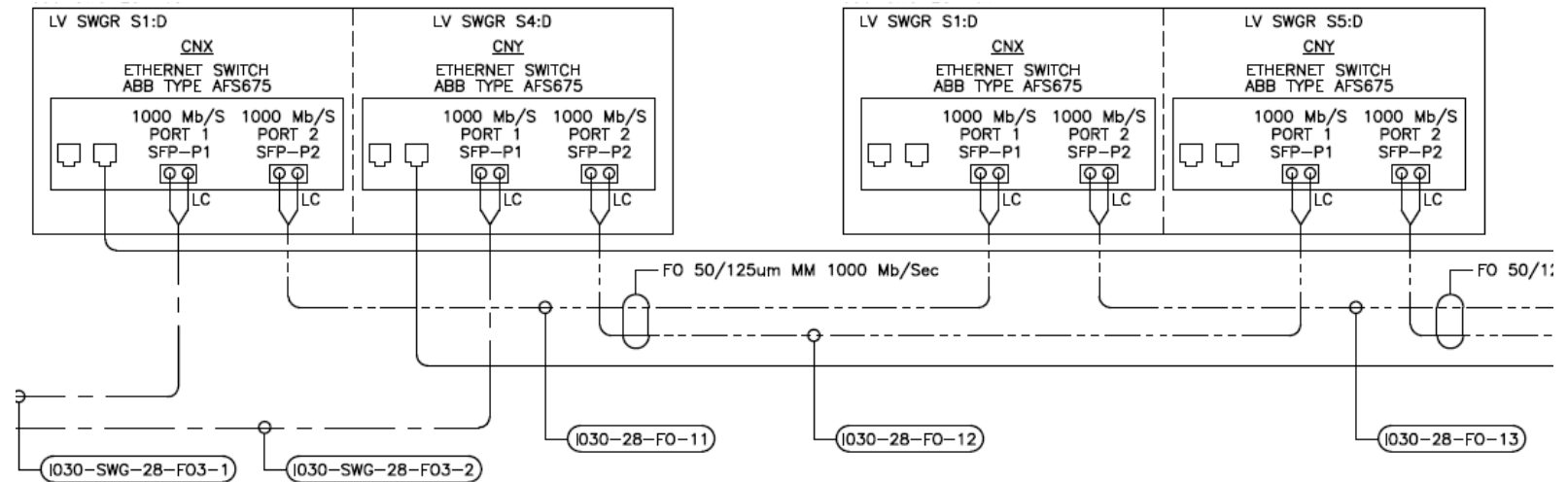
# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
  - Check actual wiring against design
- Hardware Connection
- GOOSE Publishing
- GOOSE Receiving
- Redundancy

### Network Scheme



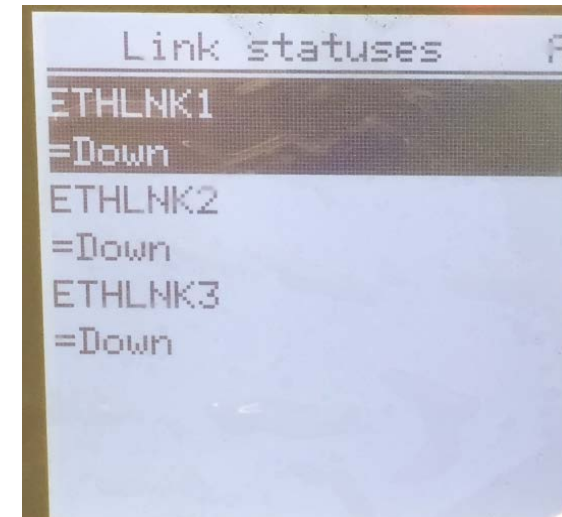
# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
- Hardware Connection
  - LED Status
  - Network Port Status
  - Ping
- GOOSE Publishing
- GOOSE Receiving
- Redundancy

### Network Status





# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
- Hardware Connection
- GOOSE Publishing
  - GOOSE Capture
  - Parameters
  - Data Points
  - VLAN
- GOOSE Receiving
- Redundancy

### GOOSE Communication Capture

No.	Time	Source	Destination	Protocol	Length	Info
110	0.678732	AbbPower_e5:17:43	Iec-Tc57_01:00:23	GOOSE	218	
111	0.678732	AbbPower_e5:17:43	Iec-Tc57_01:00:23	GOOSE	221	
112	0.685409	AbbPower_e5:15:37	Iec-Tc57_01:00:23	GOOSE	204	
114	0.689671	AbbPower_e5:15:35	Iec-Tc57_01:00:23	GOOSE	154	
118	0.712663	AbbPower_e5:15:3d	Iec-Tc57_01:00:23	GOOSE	204	

```
Frame 111: 221 bytes on wire (1768 bits), 221 bytes captured (1768 bits) on interface 0
  Ethernet II, Src: AbbPower_e5:17:43 (00:90:4f:e5:17:43), Dst: Iec-Tc57_01:00:23 (01:0c:cd:01:00:23)
    Destination: Iec-Tc57_01:00:23 (01:0c:cd:01:00:23)
    Source: AbbPower_e5:17:43 (00:90:4f:e5:17:43)
    Type: IEC 61850/GOOSE (0x88b8)
  GOOSE
    APPID: 0x0503 (1283)
    Length: 201
    Reserved 1: 0x0000 (0)
    Reserved 2: 0x0000 (0)
  gosePdu
    gobRef: F615_23_416_FIA1LD0/LLN0$gcbFDR
    timeAllowedtoLive: 2000
    datSet: F615_23_416_FIA1LD0/LLN0$gdsFDR
    goID: F615_23_416_FIA1LD0/LLN0.gcbFDR
    t: Oct 19, 2016 13:02:00.390521585 UTC
    stNum: 1
    sqNum: 18621
    test: False
    confRev: 100
    ndsCom: False
    numDatSetEntries: 12
  allData: 12 items
    Data: bit-string (4)
      padding: 6
0000 01 0c cd 01 00 23 00 90 4f e5 17 43 88 b8 05 03  ....#. .O.C...
0010 00 c9 00 00 00 00 61 81 be 80 22 46 36 31 35 5f  ....a. ..F615
0020 32 33 5f 34 31 36 5f 46 31 41 31 4c 44 30 2f 4c  23_416_F 1A1LD0/L
0030 4c 4e 30 24 47 4f 24 67 63 62 46 44 52 81 02 07  LN0$GO5g cbFDR...
0040 d0 82 1f 46 36 31 35 5f 32 33 5f 34 31 36 5f 46  ...F615_23_416_F
0050 31 41 31 4c 44 30 2f 4c 4c 4e 30 24 67 64 73 46  1A1LD0/L LN0$gdsF
0060 44 52 83 1f 46 36 31 35 5f 32 33 5f 34 31 36 5f  DR..F615_23_416
0070 46 31 41 31 4c 44 30 2f 4c 4c 4e 30 2e 67 63 62  FIA1LD0/ LLN0.gcb
0080 46 44 52 84 08 58 07 6e c8 63 f9 39 24 85 01 01  FDR..X.n .c.95...
0090 86 02 48 bd 87 01 00 88 01 64 89 01 00 8a 01 0c  ..H.... .d.....
00a0 ab 35 84 02 06 40 84 03 03 00 00 83 01 01 84 03  .5...@. ....
00b0 03 00 00 87 05 08 00 00 00 00 84 03 03 00 00 83  .....
00c0 01 00 84 03 03 00 00 83 01 00 84 03 03 00 00 83  ....
```

# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
- Hardware Connection
- GOOSE Publishing
  - GOOSE Capture
  - Parameters
  - Data Points
  - VLAN
- GOOSE Receiving
- Redundancy

### GOOSE Communication Capture

```
▶ Frame 111: 221 bytes on wire (1768 bits), 221 bytes captured (1768 bits) on interface 0
  ▲ Ethernet II, Src: AbbPower_e5:17:43 (00:90:4f:e5:17:43), Dst: Iec-Tc57_01:00:23 (01:0c:cd:01:00:23)
    ▶ Destination: Iec-Tc57_01:00:23 (01:0c:cd:01:00:23)
    ▶ Source: AbbPower_e5:17:43 (00:90:4f:e5:17:43)
      Type: IEC 61850/GOOSE (0x88b8)
    ▲ GOOSE
      APPID: 0x0503 (1283)
      Length: 201
      Reserved 1: 0x0000 (0)
      Reserved 2: 0x0000 (0)
      ▲ gosePdu
        gocbRef: F615_23_416_F1A1LD0/LLN0$GO$gcbFDR
        timeAllowedtoLive: 2000
        datSet: F615_23_416_F1A1LD0/LLN0$gdsFDR
        goID: F615_23_416_F1A1LD0/LLN0.gcbFDR
        t: Oct 19, 2016 13:02:00.390521585 UTC
        stNum: 1
        sqNum: 18621
        test: False
        confRev: 100
        ndsCom: False
        numDatSetEntries: 12
      ▲ allData: 12 items
        ▲ Data: bit-string (4)
          ...
```

# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
- Hardware Connection
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  - GOOSE Capture
  - Parameters
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- Redundancy

### GOOSE Value and Quality

```
ndsCom: False
numDatSetEntries: 12
  allData: 12 items
    Data: bit-string (4)
      Padding: 6
      bit-string: 40
    Data: bit-string (4)
      Padding: 3
      bit-string: 0000
    Data: boolean (3)
    Data: bit-string (4)
    Data: floating-point (7)
    Data: bit-string (4)
```

Bit(s)	IEC 61850-7-3		Bit-String	
	Attribute name	Attribute value	Value	Default
0-1	Validity	Good	0 0	0 0
		Invalid	0 1	
	Reserved	1 0		
	Questionable	1 1		
2	Overflow		TRUE	FALSE
3	OutOfRange		TRUE	FALSE
4	BadReference		TRUE	FALSE
5	Oscillatory		TRUE	FALSE
6	Failure		TRUE	FALSE
7	OldData		TRUE	FALSE
8	Inconsistent		TRUE	FALSE
9	Inaccurate		TRUE	FALSE
10	Source	Process	0	0
		Substituted	1	
11	Test		TRUE	FALSE
12	OperatorBlocked		TRUE	FALSE

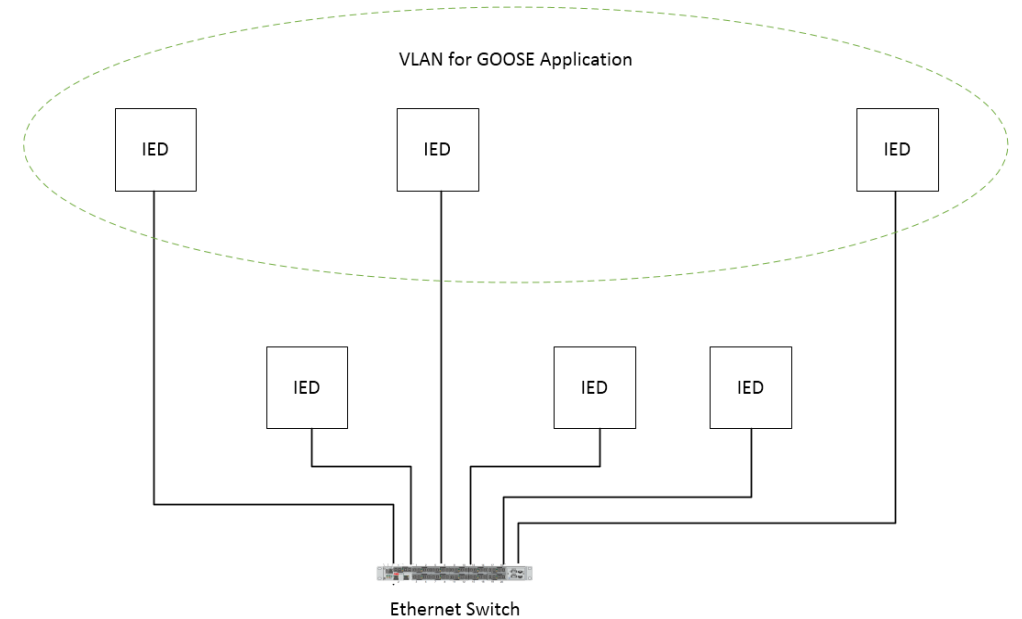
# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
- Hardware Connection
- GOOSE Publishing
  - GOOSE Capture
  - Parameters
  - Data Points
  - VLAN
- GOOSE Receiving
- Redundancy

### VLAN



# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
- Hardware Connection
- GOOSE Publishing
- GOOSE Receiving
  - GOOSE Communication Status
  - On-line Mode
- Redundancy
- GOOSE Receiving

### GOOSE Communication Status



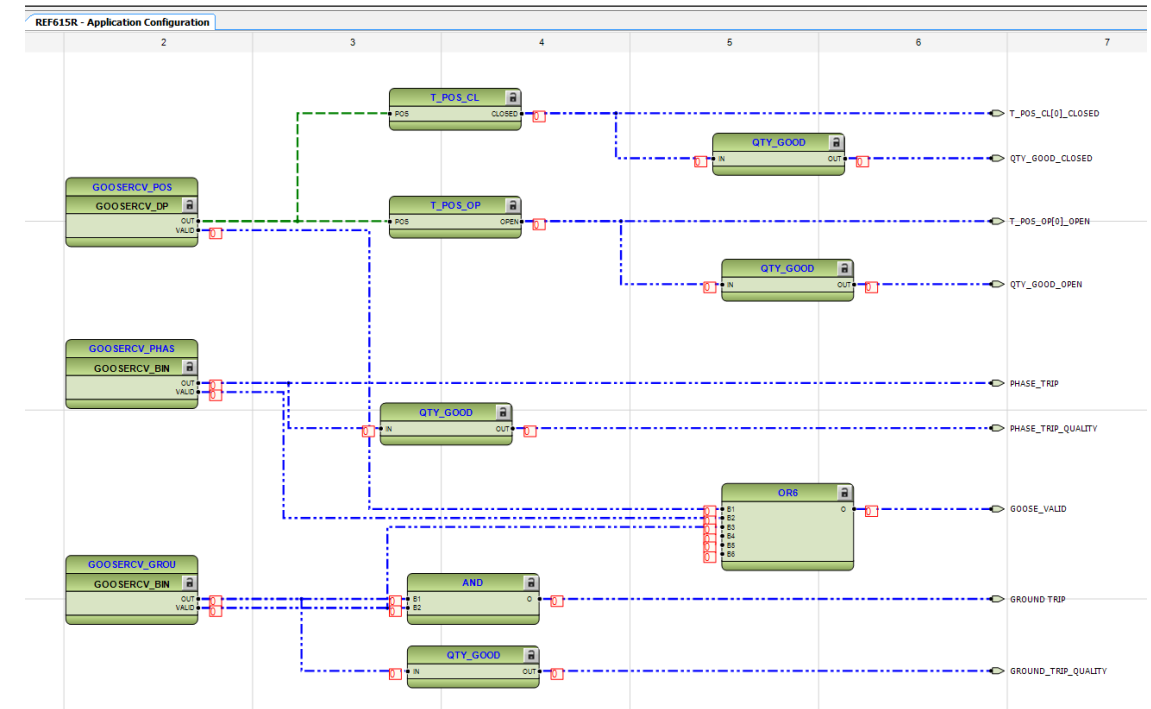
# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
- Hardware Connection
- GOOSE Publishing
- GOOSE Receiving
  - GOOSE Communication Status
  - On-line Mode
- Redundancy
- GOOSE Receiving

### On-line Mode



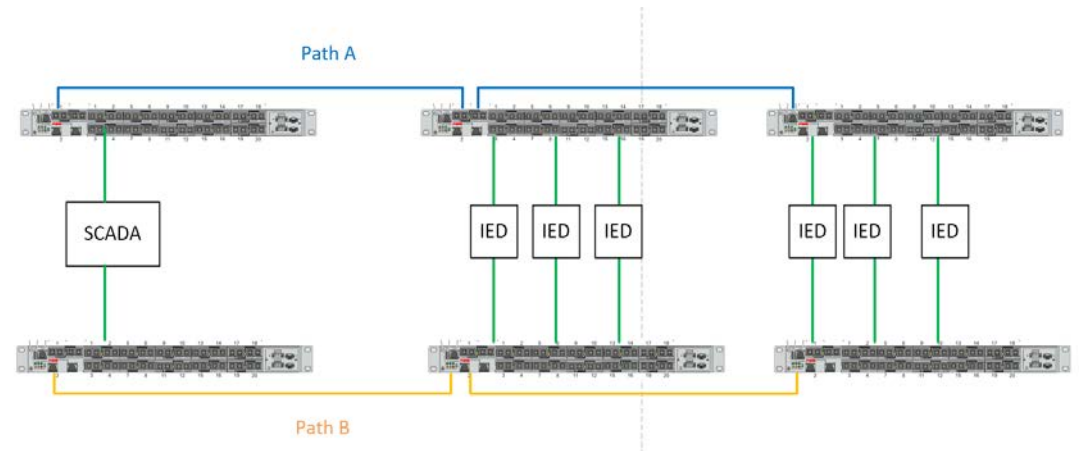
# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
- Hardware Connection
- GOOSE Publishing
- GOOSE Receiving
- Redundancy
  - Disable Redundancy
  - Enable Redundancy

### PRP (Parallel Redundancy Protocol) Network

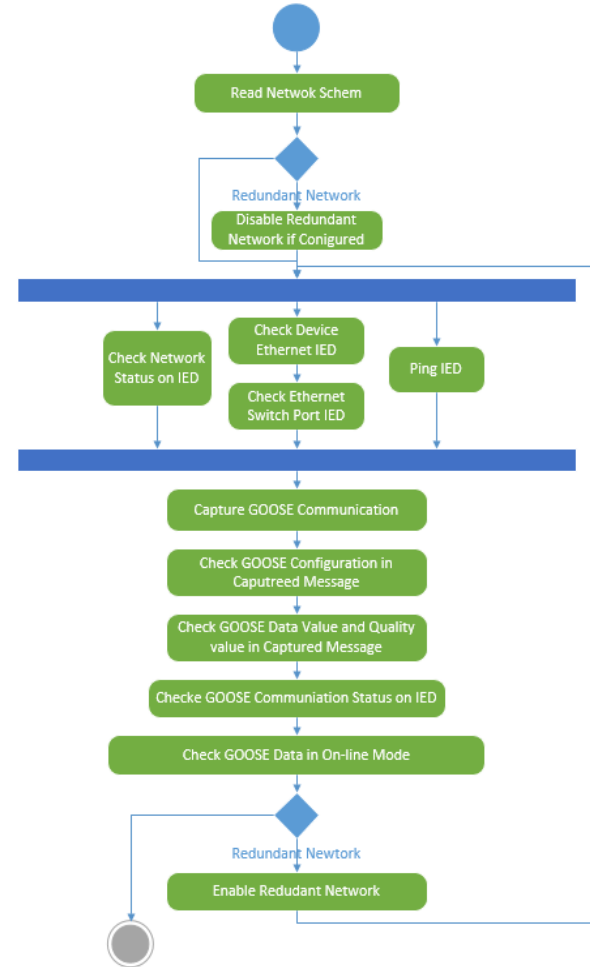


# Troubleshooting of GOOSE Communication

## A Systematic Approach

### A Systematic Approach

- Network Scheme
- Hardware Connection
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- GOOSE Receiving
- Redundancy





# Troubleshooting of GOOSE Communication

## Result

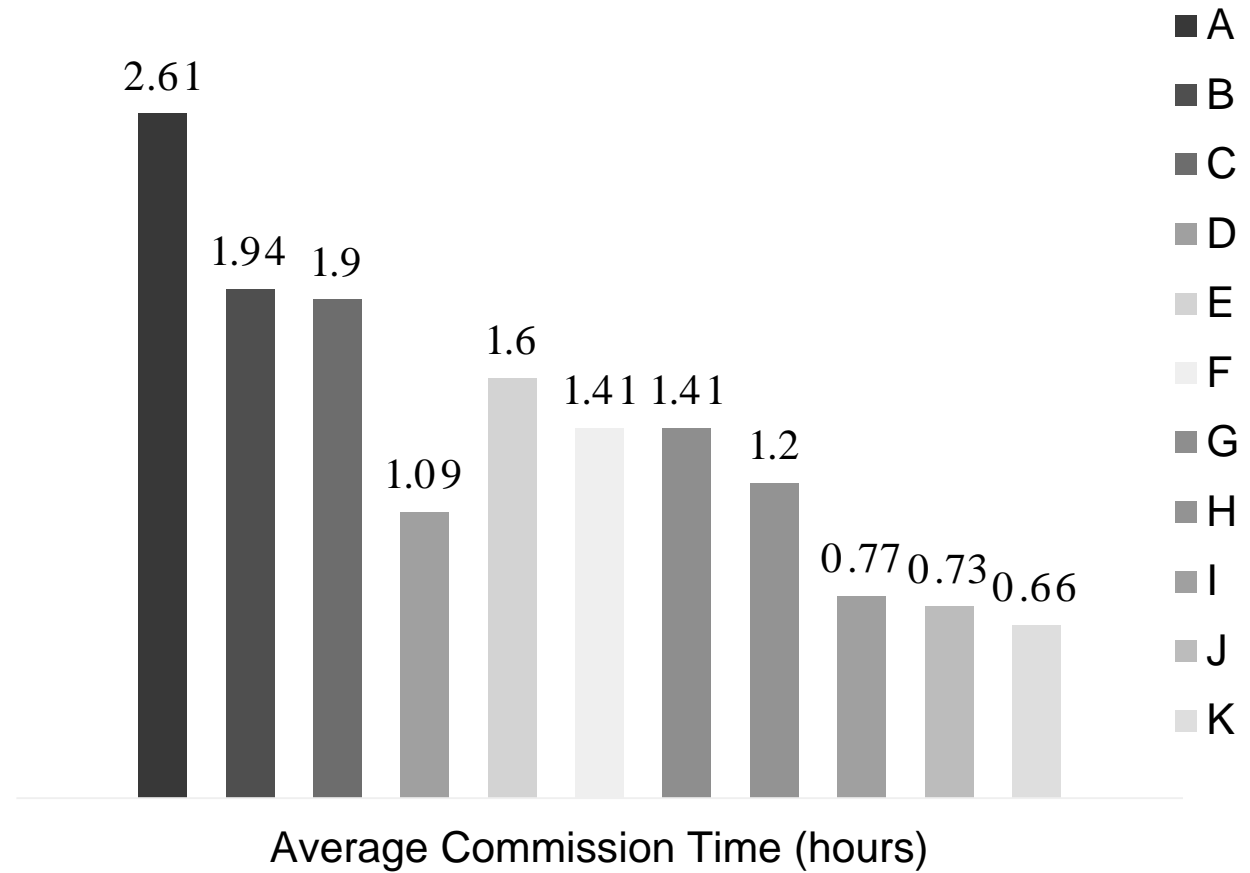
Substation	SS-A	SS-B	SS-C	SS-D	SS-E	SS-F	SS-G	SS-H	SS-I	SS-J	SS-K
Number of IED	46	95	21	22	25	17	17	61	60	48	62
Commission Hours	120	184	40	24	40	24	24	73	46	35	41
Average Commission Hours	2.61	1.94	1.90	1.09	1.60	1.41	1.41	1.20	0.77	0.73	0.66

# Troubleshooting of GOOSE Communication

## Result

Average Commission Time Per IED reduced from 2.61 hour to 0.66 hour.

Reduce System Commissioning Time by 75%.



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# Troubleshooting of GOOSE Communication

## Summary

- Introduction
- IEC 61850 GOOSE Application
- GOOSE Configuration and Communication Message
- Troubleshooting of GOOSE Communication
  - Network Scheme
  - Hardware Connection
  - GOOSE Publishing
  - GOOSE Receiving
  - Redundancy

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# Q&A and Contact information

If you have questions, please contact me further

## Speakers

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**ABB**