A STUDY ON THE APPLICATION METHOD OF IEC 61850 FOR DATA ACQUISITION AND EXCHANGE IN SMART DISTRITUTION ENVIRONMENT

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ABSTRACT

The current distribution automation system supervises and controls distribution system though centralized communication with FRTU(Feeder Remote Terminal Unit)s using DNP 3.0. In the smart grid environment, it is difficult to understand a state of distribution power system at the current communication structure, because power flow fluctuates due to new elements such as DG(Distributed Generator) and EV(Electric Vehicle). In this situation, system operators have difficulties to judge the state of distribution power system intuitively. It is necessary to judge the state of distribution power system by network analysis applications. The synchronized snap shot data of entire distribution power system is required for input data of network analysis applications in order to judge the state of distribution power system. So the new data acquisition schema is proposed which can acquire synchronized snap shot data.

Since it is also difficult to protect the distribution power system in smart grid environment, many studies about the protection method using communication between terminal units have been proposed. For protecting distribution power system using communication, Peer to Peer communication of high performance is required.

The distribution system of smart gird environment needs to adopt IEC 61850 because that support standardized information model and communication of high performance between IEDs. But it is difficult to adopt IEC 61850 considering characteristics of smart distribution system. Therefore, It is required to apply IEC 61850 considering characteristics of smart distribution system.

In this paper, in order to improve the operating efficiency of distribution automation system in the smart grid environment, new data acquisition scheme and communication method for protection applying IEC 61850 are proposed.

INTRODUCTION

Distribution Automation System has to protect facilities and restore outage as soon as possible in order to reduce blackout time and provide high quality service to customer. It should also include the optimal operation in order to increase efficiency in view of the economy. The current Distribution Automation System supervises and controls distribution system through centralized communication with hundreds of FRTU(Feeder Remote Terminal Unit)s.

The existing radial distribution power system which is not linked DG(Distributed Generator) and EV(Electric Vehicle) is relatively easy to correct set value and operate protection equipments because the power flow is one direction and the load is predictable to some extent. In contrast, the distribution power system in smart grid environment includes many DGs and EVs which have heavy fluctuations of input and output. And the configuration of distribution system will be change form radial to loop and mesh configuration. In this case, it is difficult to understand the state of current distribution power system due to fluctuating power flow caused by DG and EV. In this situation, system operators have difficulties to judge the state of distribution power system intuitively. It is necessary to judge the state of distribution power system by network analysis applications.

The synchronized snap shot data of entire distribution system is required for exact input data of network analysis applications in order to judge the state of distribution power system. But it is difficult to acquire snap shot data in current distribution system because current distribution system acquires data through polling method using DNP 3.0 protocol.

In the smart grid environment, the protection and service restoration by communication between FRTUs is required but FRTUs cannot directly exchange information with each other in current distribution automation system. The DNP 3.0 protocol is unsuitable for smart distribution system in the view of performance although it can support peer to peer communication.

The distribution system of smart grid environment needs to adopt IEC 61850 because that support standardized information model and communication of high performance between IEDs. But it is difficult to adopt IEC 61850 to distribution system because IEC 61850 focus to substation automation. Therefore, it is required to apply IEC 61850 considering characteristics of smart distribution system.

In this paper, in order to improve the operating efficiency of distribution automation system in the smart grid environment, new data acquisition scheme and

communication method for protection applying IEC 61850 are proposed.

IEC 61850 DATA MODELING

A data model of FIED(Feeder IED) was defined using logical node in order to apply IEC 61850 to distribution system. The data model is shown below Fig 1.

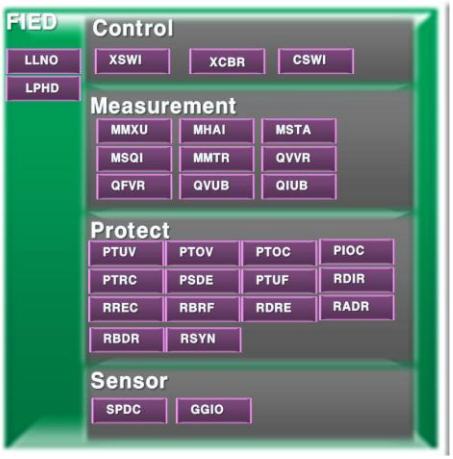

Fig. 1. IEC 61850 Data Modeling

The current distribution automation system acquires data using DNP 3.0 protocol and acquisition data defined DNP index. The data mapping is needed between IEC 61850 and DNP index data. The data mappings are shown below in Table 1.

Table 1. Data Mapping

Logical Node	Function
CSWI	Switch Open Control / Switch Close Control
GGIO	Battery Charge Fail / Battery Discharge Battery Test / Door Open / Handle Lock Fault Indicator Permanent Fault Indicator Temporary Fault Indicator Reset / PQM Reset
LLN0	Self Diagnosis
LPHD	Self Diagnosis Status External Power Loss / Cold Restart
MHAI	Current PHD / Voltage PHD Harmonic
MMTR	Watt Hour
MMXU	Current / Voltage Apparent, Active, Reactive Power Power Factor / Fault Current RMS Current / RMS Voltage Sag / Swell / Interruption
MSQI	Positive Sequence Current / Voltage Negative Sequence Current / Voltage
	Zero Sequence Current / Voltage
MSTA	Average Load Current Peak Load Current (Day)
PIOC	Instantaneous Trip
PSCH	Protection Coordination
PSDE	SEF Detection
PTOC	Over Current / Fault Detection Fault Indicator / Fault Indicator Count
PTOV	Over Voltage / Swell Source Side Hot Line / Load Side Hot Line
PTUV	Under Voltage / Sag / Interruption
PTUF	Under Frequency Detection
RDRE	Waveform
RADR	Waveform(Analog Input)
RBDR	Waveform(Binary Input)
RBRF	Trip Fail
RDIR	Power Flow Direction
RREC	Reclosing Status / Reclosing Time Reclosing inhibition
RSYN	Phase Sync. Fail
SPDC	PD Detection
TCTR	Current Sampling Data
TVTR	Voltage Sampling Data
XCBR	Breaker Status / Control / Control Lock Breaker Local Remote / Operation Count
XSWI	Switch Status / Control / Control Lock Switch Local Remote / Operation Count

The data that not defined in IEC61850 was mapped using GGIO. The data mappings are shown below in Table 2.

Table 2. Data Mapping using GGIO

Data	Data Attribute	Function	Type
Alm	stVal,q,t	Temporary, Permanent Fault Indicator	Status
OpCntRs	ctlVal	Temporary, Permanent FI Total Count	Count
OpCntRs	ctlModel	Temporary, Permanent FI Total Count Reset	Control
OpCntRs	sbotimeout	Temporary, Permanent FI Total Count Reset	Control Setting
OpCntRs	stVal,q,t	Temporary, Permanent FI Total Count Reset	Control Setting
Ind	stVal,q,t	Door Open Handle Lock Battery Charge Fail Battery Discharge	Status
AnIn	mag,q,t	TD	Meas.

		Internal Temperature	
SPCSO	ctlVal	Fault Indicator Reset PQM Reset Battery Test	Control

The results of data mapping confirmed that most data currently using in distribution system is defined in IEC 61850 but the purpose and characteristic of data were not entirely compatible in some cases. Therefore the appropriate logical nodes for distribution system should be added to IEC 61850 in future.

DATA ACQUISITION SCHEME FOR NETWORK ANALYSIS

The current distribution automation system acquires data through periodic polling method using DNP 3.0 protocol. In this case, measured time of acquired value is when FRTU sends response message. So the time gap is more and more increasing when data of entire distribution system are acquired. As a result, measured times have great gaps between first acquired value and last acquired value. In the distribution power system of smart grid environment, it is difficult to understand state of distribution system existing data acquisition scheme. And it is also difficult to supply input data when using network analysis application in order to judge state of distribution power system exactly. We can consider data acquisition method through reporting service of entire nodes at same time. But this method can cause overburden to server in case of large scale system. So the new data acquisition scheme is proposed. The new data acquisition scheme is that the IEDs store measured data at certain time and the distribution automation system server request the stored data. In this way the distribution system server can acquire synchronized data of all IEDs.

It is necessary to distinguish between measure data for network analysis and measure data for network operation in order to efficiently acquire and manage data. The data can be divided into two groups, one is current measured values for network operation and the other one is synchronized values for network analysis. The divided data can be overlapped but it is difference in using purpose and measured time. The divided data are configured each logical node. Logical node for network operation is continuously updated in real time and logical node for network analysis is updated every synchronized setting time. Synchronized data group only included data for network analysis can be acquired through configuring separate logical node and grouping data set. This method has the advantage of data acquisition in case of requiring synchronized data in distribution power system including many IEDs because it must be acquired in execution period of network application program. And it is also has the advantage of efficient to manage acquisition schedule separately by characteristics of data.

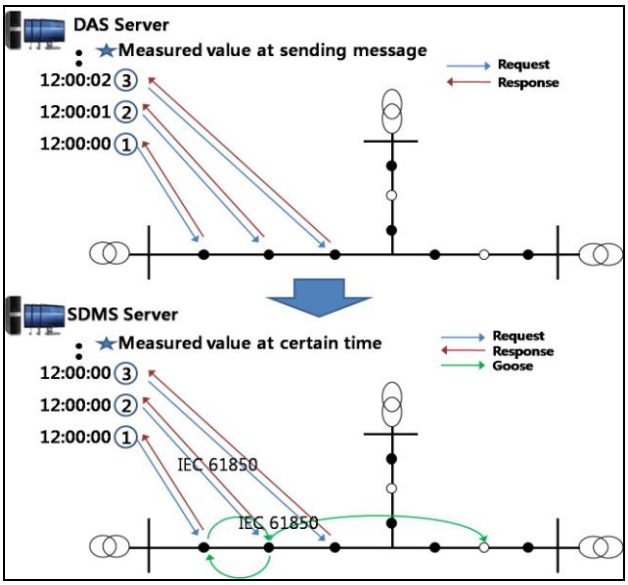

Fig. 2. Data Acquisition Scheme for Network Analysis

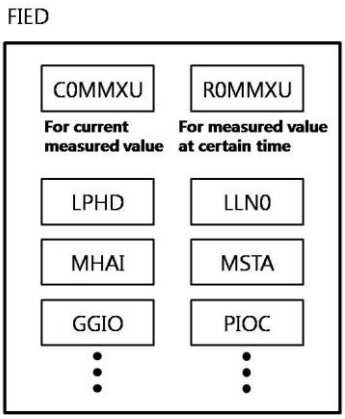

Fig. 3. Logical Node for Data Acquisition

```
<DataSet name="Input">
  <FCDA ldInst="C1" lnClass="R0MMXU" lnInst="1"
   doName="A.phsA" daName="cVal.mag.f" fc="MX" />
  <FCDA ldInst="C1" lnClass="R0MMXU" lnInst="1"
   doName="A.phsB" daName="cVal.mag.f" fc="MX" />
  <FCDA ldInst="C1" lnClass="R0MMXU" lnInst="1"
   doName="A.phsC" daName="cVal.mag.f" fc="MX" />
                    :
</DataSet>
```

Fig. 4. Dataset for Synchronized Data Acquisition

DATA EXCHANGE METHOD AMONG IEDS

The current distribution automation system supervises and controls distribution system communication with field devices but the communication between field devices is not currently supported.

The distribution power system in smart grid environment includes many DGs and EVs which have heavy fluctuations of input and output. And the configuration of

distribution system will be change from radial to loop and mesh configuration. In this case, it is not easy to protect distribution power system using current protection method. Therefore protection and service restoration by communication is required. So communication method between IEDs that appropriate for protection using communication. This paper describes the application method and consideration when Goose service applied to distribution system.

For the Goose service, communication setting of publisher and subscriber is required. There two methods are used, that set communication using CID file or IED configuration tool. In the distribution system, there are many cases to reset subscriber address because network configuration is frequently changed, for example adding IED, network reconfiguration and etc. So the current setting methods are not appropriate for protection in distribution system. The remote setting method is needed to set subscriber address in order to apply Goose message in distribution system. In this paper, logical node was defined for remote subscriber address setting using GGIO because there is not appropriate logical node for remote address setting in IEC 61850. And GrRef(Data Object) was added to GGIO for remote address setting so it is possible to set subscriber address using intAddr(attribute of GrRef). The distribution system can set remotely subscriber address of IEDs using defined logical node. It is possible to reset subscriber address promptly through this method when it is needed by network configuration change. And The Goose service is utilized for protection and restoration of distribution power system using this method.

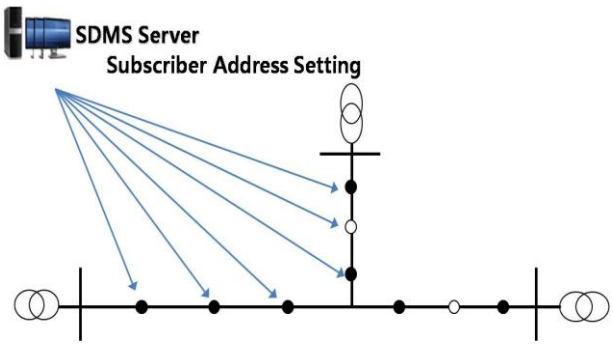

Fig. 5. Subscriber Address Setting

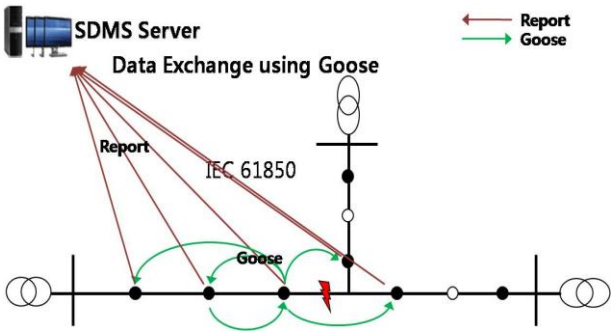

Fig. 6. Data Exchange using Goose

CONCLUSTION

In the smart grid environment, improvement of data acquisition and protection method is inevitable in order to judge exactly and operate efficiently the distribution power system. It is also necessary to improve interoperability through design of standardized system because various equipment and system will be interconnected.

The distribution power system in smart grid environment includes many DGs and EVs which have heavy fluctuations of input and output. And the configuration of distribution system will be change form radial to loop and mesh configuration. In this case, it is difficult to understand the state of current distribution system due to fluctuating power flow caused by DG and EV. Therefore, the synchronized snap shot data of entire distribution system is required in order to judge the state of distribution power system. In this paper, new data acquisition scheme applying IEC 61850 was proposed.

The distribution power system in smart grid environment, protection and service restoration by communication is required. In this paper, the application method of Goose service in distribution system was proposed.

It is possible to provide exact input data to network analysis application through proposed data acquisition schema. So it is possible to analyze state of distribution exactly. And the Goose service can be used to protect and restore distribution power system through proposed application method.

Acknowledgments

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government Ministry of Knowledge Economy. (No. 2009T100200067)

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