Middleware-based Implementation of Smart Micro-grid Monitoring Using Data Distribution Service over IP Networks

Kai Shi
University of Liverpool
K.Shi@liverpool.ac.uk

Yanbing Bi
University of Liverpool
byb@liverpool.ac.uk

Lin Jiang
University of Liverpool
L.Jiang@liverpool.ac.uk

***Abstract*- Information and communication infrastructure inevitably impact the control and monitoring of smart grid. Smart grid communication need to be reliable, high-efficiency, secure and real-time. This is demanded by the flexible integration of units such as distributed generators, smart meters, dynamic demand-side response, and smart appliances etc. Conventional power grid communication requires upgrading but special and dedicated communication networks are feasible for distribution system due to high costs and long construction time. Data distribution service is a new data delivery service that can addressed the communication challenges causes by distributed energy management. The middleware technology can provide fast prototyping way to provide an efficient and reliable data communication for smart micro-grid monitoring. The purpose of this paper is presenting an implementation of DDS middleware based data monitoring in smart micro-grid.**

***Index Terms*—smart grid communication, data distribution service, middleware, micro-grid monitoring**

I. INTRODUCTION

Smart grid is the next generation power grid which combines energy systems and information and communication technologies (ICTs). It basically consists of conventional power grids, communication systems, and control systems [1]. For economics and environmental protection purposes, renewable energy resources such as wind power, solar energy, and hydropower etc. will be extensively involved into the power grid. As these kinds of energy resources are distributed, small and local, the distributed generation (DG) becomes more popular recently [2].

As distributed energy resources are intermittent and sporadic, the present energy management system and power grid are challenged by the problems such as energy storage, integration of renewable energy and voluminous data management [3]. Thus, information and communication infrastructures have inevitable impacts on the power grid innovations. The communication on smart grid is required to be reliable, high-efficiency, secure and real-time. The conventional power-line communications (PLCs) and current infrastructure cannot satisfy these requirements [4]-[5]. In [6], the researchers proposed and implemented a solution for monitoring and controlling of EMS/SCADA by means of web services based on IEC 61970 and IEC 61850, which demonstrates the feasibility of applying IP network communication and CORBA technology into implementation was made. A new generation communication model called data distribution server (DDS) has been provided by OMG, which is expected to replace CORBA and provide more reliable and efficient data communication [7]. The data distribution service can be applied into power system communication and its data centric publish/subscribe communication feature is able to solve the problems caused by integrating large amount distributed power generations [8]-[9]. The reuse of the existing network infrastructure can reduce the cost of facility construction and application of middleware can shorts the developing period and reduces the development difficulties.

In this paper, a DDS based data communication platform for smart micro-grid is proposed. It is implemented as a wind turbine real-time monitoring system to show the feasibilities and advantages of using data distribution service and middleware into smart micro-grid monitoring on over the IP Network.

II. DATA DISTRIBUTION SERVICE

The data distribution service (DDS) is a data centric publish/subscribe (DCPS) standard that is come up by Object Management Group (OMG). It aims achieve the real-time, reliable, high-performance and dependable communication over publishers and subscribers. The DCPS communication architecture was proposed to be applied into the development of smart grid information and communication infrastructure. The publish/subscribe communication model used in is

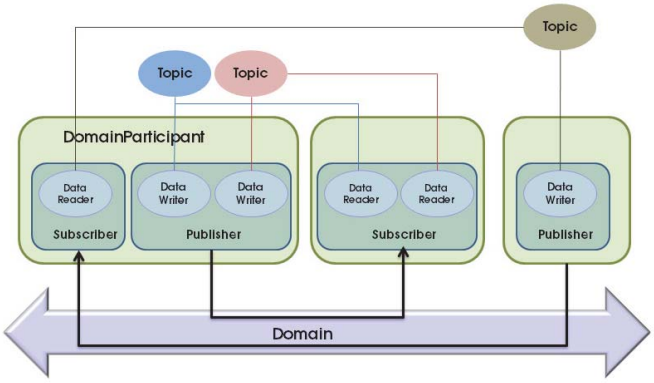

Fig. 1. RTI Data Distribution Service Model [10]

978-1-4799-6557-1/14/$31.00 ©2014 IEEE

shown in Fig. 1 [10]. In this model, data publishers determine the types of data that are available to be published and the interest in some types of data depends on the data subscribers [11]. All data are published or subscribed to/from the DDS domain. A certain interest of data types in subscribers and the availability of data types in publishers can be matched by DDS middleware and then the required data communication is achieved [12]-[13]. RTI Data Distributed Service is a world-leading DDS middleware service provider. By using its DDS middleware, the efficiency and reliability of the data communication can be guaranteed.

Middleware is a type of computer software with which software developers can easily perform some communication and I/O programming. The DDS middleware enables the feature of fast prototyping in data communication programmes. The middleware provides appropriate application programming interfaces (APIs) for developers to develop IP network data communication applications. Its architecture is illustrated in Fig. 2 [11].

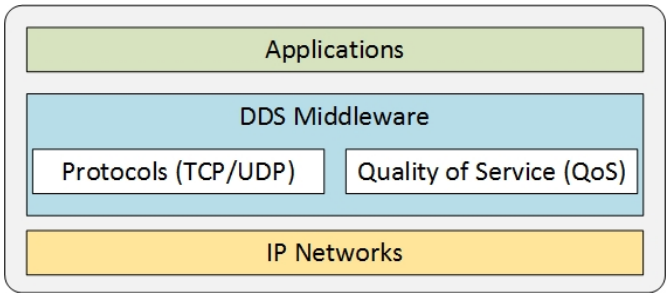

Fig. 2. DDS middleware architecture [11]

With DDS middleware, developers can focus more on the specific purposes of the software development. For development of a networking data communication programme, developers focus on the data types used in communication, communication protocols, and the Quality of Service (QoS). The networking and communication developing and coding are never minded because the middleware can do it for developers. The basic steps of the rapid prototyping using DDS middleware is shown in Fig 3. Developer needs to define the data of interest within an IDL

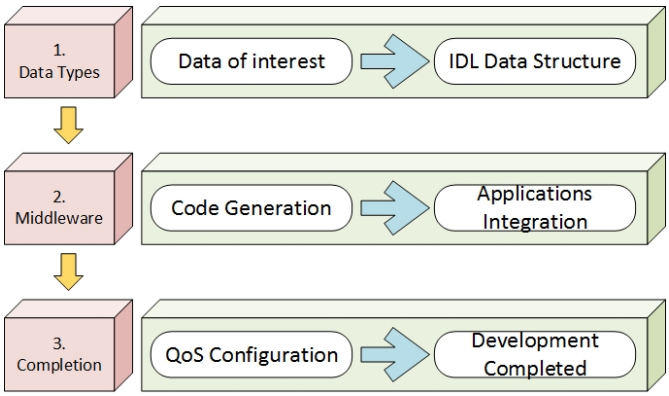

Fig. 3. Fast prototyping steps for enabling data communication

file that can be converted into a networking programme by middleware. Then, the generated networking programme can be simply integrated into the main application project and it performs data communication function as developed expected. After configuring the required QoS settings, the whole application is ready to use. With these simple steps, developer can develop a networking and communication application without any specific knowledge of network programming.

III. Proposed Data Communication Platform

Fig. 4 shows a proposed design of micro-grid data communication platform. The data of interests can be measured and collected from the distributed generation side such as wind turbines, solar panels, and CHP etc. The data communication is based on the IP network using TCP/IP and UDP protocols for the purpose of reusing existing network infrastructure to save both time and money. The data collected can be published using DDS based applications into the DDS domain through IP network. There are also some DDS subscribers located in the communication network which are able to receive data of interest from this DDS domain. As it is a data-centric publish/subscribe communication, the identifications or network locations of each publishing/subscribing end is not necessary. The only thing cared is what types data is of interest. This distributed data communication and management mode fits the features of the micro-grid that includes several distributed generations. Moreover, as the data publishers and subscribers can exist in one end at the same time, the two-way communication can be achieved to have both monitoring data receiving and some control message sending from generation side.

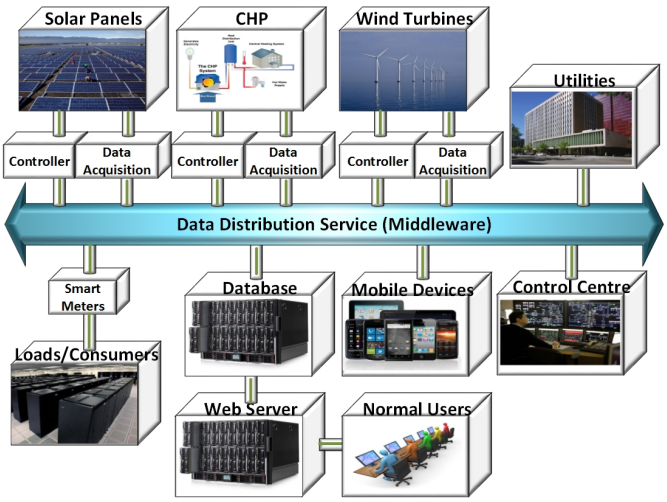

Fig. 4. DDS based micro-grid data communication architecture

A. IP network and web server

As the DDS data communication is based on IP network, so it can reuse the existing network facilities. Protocols used for the data communication is TCP/IP and UDP. A web server is built to provide the interface for user to monitor and analysis data. The web