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Data Distribution Service (DDS) based implementation of Smart grid devices using ANSI C12.19 standard

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Abstract

Today's power grid has so many challenges in terms of centralized power generation, limited flow of information, limited support for distribution, poor management of peak loads and power disruptions. Due to these limitations several organizations are working on Smart grid. Smart grid consists of numerous kind of heterogeneous devices that increase the complexity and inefficiency. To cope with heterogeneity and provide interoperability among the communication of these devices, middleware is considered to be the best approach. There are so many middlewares that have been proposed so far but Data Distribution Service (DDS) middleware provides high level of reliability and efficiency by addressing more performance metrics and several QoS policies especially in real time and mission critical applications. We have considered Smart grid standard ANSI C12.19 based DDS deployment in transmission and consumption sides. Data structures are obtained for topics formation over RTI Connext to establish communication and to conduct experimental study for the analysis of interoperability and other performance metrics to prove that DDS is better solution for Smart grid data interoperability and high reliability.

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Keywords: DDS; Smart grid; RTI Connext; RTPS; QoS; performance metrics; ANSI C12.19.

1. Introduction

The traditional power grid only deals with the data that it has supplied but obtains no data in response for the delivery of energy and power. Smart grid is modern power grid that uses digital and analogue communication

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system to collect the information and then it responses according to the collected information. In this way it collects the information from consumer and suppliers in an automated way, thus ensures the reliability, economics, sustainability and efficiency of the production and distribution of electricity[1].

Smart grid contains large amount of various kind of devices, hardware and software of distributed systems that require real time responses. Middleware is like a software that addresses heterogeneity and complexity in these kind of distributed systems. Middleware is used to integrate, control and manage large amount of heterogeneous electrical elements together. Because of their heterogeneous nature, one can find great difficulty in establishing communication among these. So as to provide interoperability, establish reliable communication and to provide QoSs, the middleware architecture is the best solution so far[2,3]. There are several middlewares that have been developed for Smart grid such as GridStat[4], RabbitMQ[5], XMPP[6], USN[7], Service Oriented[8] and DDS[9].

Data Distribution Service (DDS) is considered as a best middleware for Smart grid due to its data management capabilities related to real time publish subscribe and mission critical applications. It also consists of rich Quality of Service (QoS) policies that can be used for various puposes[2,10]. As DDS provides almost every kind of performance metrics so we considered DDS middleware to conduct our experimental study over Smart grid. DDS communication model is based on publish subscribe architecture so we considered Smart grid devices as publisher and subscriber applications to communicate with each other. ANSI C12.19 Smart grid standard[11] is used to get data structures to build topics to establish communication among these devices by setting certain QoS contracts provided by DDS. RTI Connext is used to perform publish subscribe communication and to conduct several experimental analysis that include latency, jitter and throughput.

This paper explores to provide middleware based solution by implementing ANSI C12.19 using DDS. The solution is independent of physical communication network that is flexible, scalable and with rich QoS functionalities. DDS RTI Connext has been used as an implementation tool and several tests have been performed to validate ANSI C12.19 implementation on DDS.

Rest of the paper is organized in the following way. Section 2 briefly explains DDS basics and architecture, section 3 highlights some of the related research work that explains the popularity of middleware specially DDS in various domains. In section 4 some description related to ANSI C12.19 is given while section 5 discusses its implementation over DDS. Section 6 deals with experimental setup and QoS policies used to assess proposed approach. Results and analysis are given in section 7 that concludes with a hint to adopt DDS in Smart grid communication infrastructure.

2. DDS basics and architecture

DDS is a middleware technology based on publish subscribe model[12]. It is particularly for distributed real time and mission critical systems in which heterogeneous data related to development, deployment and maintenance is obtained. DDS is data centric model that provides rich set of QoS policies through which real time systems requirement can be fulfilled. There are several other platform dependent middlewares either with standalone components or with built in modules in various shapes such as Web Services[13], Java RMI[14], OPC[15], CORBA[16] based on either message passing communication model or client server model but they are not that appropriate for real-time mission critical systems[3,17]. DDS is released by OMG[12] for heterogeneous real-time applications which is a platform independent publish/subscribe middleware standard. DDS is able to implement wide variety of mechanisms by defining certain QoS according to required behavior. With the help of these rich specifications, several applications are developed that support certain programming languages in combination with traditional general purpose operating systems. There are some open sources of DDS such as OpenSplice[18] and Open DDS[19] while DDS Connext is Real Time Innovation's proprietary implementation[20]. DDS architecture is shown in Fig. 1 in which components that require QoS can also be seen.

3. Related work

Abdel Rahman et al.[2] surveyed about Message Oriented Middleware (MOM) for real time and distributed environment in smart grid. So far this is the only paper that analyzes the smart grid middlewares based on their functionality and performance.