INFORMATION MODEL OF A UNIVERSAL AGENT FOR DISTRIBUTED POWER GENERATION MANAGEMENT

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ABSTRACT. Smart Grid is an electrical grid which includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy sources, and energy efficient resources. Electronic power conditioning and control of the production and distribution of electricity are important aspects of Smart Grid. The roll-out of Smart Grid technology also implies fundamental re-engineering of the electricity services industry, although the typical usage of the term is focused on the technical infrastructure. The paper aims to propose information model of a universal agent for power supply management. The model is designed for user interface developers and operating officers. The hypothesis is as follows: the description of the nodes through which the agent runs should contain software definitions. The software of each node is sufficient to be detailed with elements up to level Manager and Program. The model should possess the following features: The nodes through which the agent runs should be represented as physical points. For each point software is represented as a set of functions. Functions are grouped according to open systems interconnection (OSI) areas: security, maintenance, configuration, accounting, and performance. We focus on the configuration area because it contains the agent's routing data. The software components in the configuration area are detailed to the functional element access manager, which directs the agent to the next element on his way.

Design methodology for this information model includes defining of managed object classes for the nodes through which the agent runs. Definitions are represented verbally and by UML (Unified Modeling Language) diagrams. UML diagrams are classified in two types: behavior diagrams and structure diagrams. Class diagrams, a type of structure diagrams, are suitable for describing nodes in Smart Grid. Class diagrams describe objects types in the system and different types of static relationships among them. These diagrams also show "Part-of" relationships, associations, attributes, class operations, and limits in the way the objects are connected. The models are influenced by similar management models in telecommunications. The result is a management model design for Smart Grid: a model for the management of a network and its elements through which a universal agent runs. The object oriented method is used. The objects classes that are managed are defined in compliance with the managed units. Guidelines for the definition of managed objects (GDMO) from the network management standards are observed. UML is used for the model description. At this stage, objects are represented only with names, "Part-of" relationships, and associations. At the next stage, attributes and operations will be added to the managed objects. With this defining level, the model is a good basis for user interface development.

Keywords: Information model, universal agent, distributed energy resources (DER), distributed power generation

ИНФОРМАЦИОНЕН МОДЕЛ НА УНИВЕРСАЛЕН АГЕНТ ЗА УПРАВЛЕНИЕ НА РАЗПРЕДЕЛЕНО ГЕНЕРИРАНЕ НА МОЩНОСТ

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РЕЗЮМЕ. Smart Grid е електромрежа с разнообразие от оперативни и енергийни измервания, включващи умни електромери, умни приложения, възобновяеми енергийни източници и енергоефективни ресурси. Обуславяне на електронна мощност и контрол на производството и разпределението на електричество са важни аспекти на Smart Grid. Разгръщането на технологията за Smart Grid изисква препроектиране на индустрията за електроуслуги, въпреки че типичното използване на термина се фокусира върху техническата инфраструктура. Статията цели да предложи информационен модел на универсален агент за управление на електроснабдяването. Моделът е предвиден за разработчици на потребителски интерфейс и служители по експлоатация. Хипотезата е следната: Описанието на възлите, през които преминава агентът, трябва да съдържа дефиниции на софтуер. Софтуерът на всеки възел е достатъчно да се детайлизира с елементи до ниво мениджър и програма. Моделът трябва да притежава следните качества: Местата, през които минава агентът, се представят като физически възли. За всеки възел софтуерът е като множество от функции. Функциите се групират в съответствие с областите за взаимодействие на отворени системи (OSI): защита, поддържане, конфигурация, таксуване и технически характеристики. Фокусираме върху област конфигурация, защото тя съдържа данни за маршрутизиране на агента. Софтуерните компоненти в област конфигурация се детайлизират до мениджър Достъп до елемент, който насочва агента към следващия елемент по неговия път. Методологията за проектиране на този информационен модел включва дефиниране на класове управлявани обекти за възлите, през които преминава агентът. Дефинициите са представени словесно и чрез диаграми на UML (Унифициран език за моделиране). UML диаграмите се класифицират в два вида: диаграми на поведение и диаграми на структура. Диаграмите на класове, вид диаграми на структура, са подходящи за описване на възлите в Smart Grid. Диаграмите на класове описват типовете обекти в системата и различните видове статични взаимоотношения между тях. Тези диаграми показват също отношение „Част от", асоциации, свойства, операции на класовете и ограничения в начина, по който са свързани обектите. Моделите имат влияние от аналогични модели за управление на телекомуникациите. Резултатът е проект на модел за управление в Smart Grid: модел за управление на мрежа и нейните елементи, през които преминава универсален агент. Използван е обектно ориентиран метод. Класовете управлявани обекти са дефинирани в съответствие с управляваните единици. Следвани са Препоръки за дефиниране на управлявани обекти (GDMO) от стандартите за управление на мрежи. За описание на модела е използван UML. На този етап обектите са представени само чрез имена, отношения „Част от" и асоциации. На следващия етап ще се добавят атрибути и операции към управляваните обекти. С това ниво на дефиниране моделът представлява добра основа за разработване на потребителски интерфейс.

Ключови думи: информационен модел, универсален агент, разпределени енергийни ресурси, разпределено генериране на мощност

Introduction

Modern power supply includes the intensive introduction of renewable energy sources. This leads to the accumulation of large energy quantities in the network and causes disbalance. One of the solutions to the problem is energy distribution automation. The concept is called Smart Grid (IEC, 2012). Smart Grid is an electro grid which includes a variety of operating end energy measurements and uses smart meters, smart applications, renewable energy sources, and energy efficient resources. Electronic power conditioning and energy manufacturing and distribution control are important network aspects. Smart Grid deployment also includes fundamental redesign of electro services industry, although the typical term usage focuses on the technical infrastructure.

In contrast to the traditional network, Smart Gird enables each node to produce and store energy all over the network. This means that the energy is not bound to the source where it was originally produced. The energy could run through the network and could be stored where it is most needed. This potentially guarantees faster supply. Recently, big producers have been paying a lot of money for energy supply networks. With Smart Grid, the whole network could act as a supply network. Each node with a capacity, not just the producers, could demonstrate the presence of energy. There are special security mechanisms embedded in Smart Grid basic levels, which guarantee the secure uploading and storage of energy.

The information model of agent and nodes should use the block chain technology (https://www.hyperledger.org/projects/fabric 2017). It creates an architecture based on the storage and usage of energy and not on the location in the network. There are two types of flows in a block chain: energy and agent (request). The user sends an agent to the network to find energy and to provide it back. The agent has a label – a string of bits. The label is named Uniform Resource Identificator (URI). URI uses the hierarchical naming system and has three basic parts:

- Prefix, which nodes use to find the general direction for energy;
- Date and time when the agent was created;
- Source number which should be checked together with the whole number of sources in this direction.

For instance, an agent could be named so: Direction/020617/1633/source=1:5/.

In this case, Direction is the routable prefix for energy, 020617 is the date 2nd of June 2017, 1633 is the time 16:33, it begins to check source 1 in this direction, the possible sources are 5.

New way of routing

For the energy of "Direction" to be distributed in Smart Grid, a node (Smart Meter) issues an energy request labeled with routable Direction. The nearest node sends the request while it finds energy. Then the node sends the energy back to the user by following the same way and using the same interface or gateway through which the request has entered the system. However, if the node does not contain energy in its storage, the forwarding-machine writes the request in Pending Interest Table, or PIT (a log which consists of the running copy of all requests that have recently passed through the node and have not found energy). Also, the gateway, through which every request enters, is remarked, as well as the gateway, through which it runs forward. When a new request comes and it is written in the PIT, the forwarding-machine sees all unsatisfied requests and sends the new one along exactly the same route. The idea is that the entries in the PIT create a trail for every request to trace its route through the network, while it finds the searched energy. Then this trail consults the PIT in every node to follow the reverse way to the original user and notes that the request has been satisfied. However, if a request enters the node and the forwarding-machine finds neither uploaded energy, nor any entry for a previous request in the PIT, the node calls the Forwarding Information Base (FIB). FIB is a table with all URI-prefixes (the routable prefixes for the whole network). When a new source is installed, it is entered in FIB and a new entry is added in PIT for future calling. When the next request comes and the last source could not satisfy it, the forwarding-machine checks FIB. Then it sends the request through a gateway which moves it nearer to this location. Figure 1 shows the new way of routing. Figure 2 shows Elements of Node.

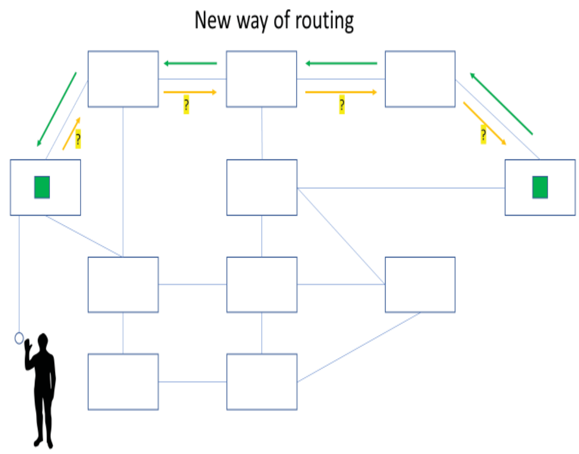

Fig. 1. New way of routing

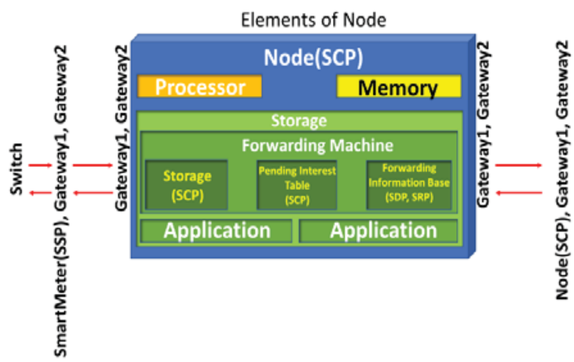

Fig. 2. Elements of Node

Scope

This paper aims to offer an information model of a universal agent for power supply management. The model is designed for user interface developers and operating officers.

Thesis

The model should include description of nodes through which the agent runs.

Hypothesis

The description of nodes should include software definitions. It is sufficient for the software of each node to be detailed with elements up to level Manager and Program. The model should possess the following features: the places through which the agent runs are represented as physical points; software as a set of functions is represented for each node; functions are grouped according to OSI areas: security, maintenance, configuration, accounting, and performance; the focus is on the configuration area because in contains agent routing data; software components in the Configuration area are detailed up to Element access manager which directs the agent to the next element on his way.

Methodology

The mmethodology for the information model design of an agent for distributed power generation includes a definition of the managed object classes for the nodes through which the agent runs. Definitions are represented verbally and by UML (Unified Modeling Language) diagrams (Gentleware, 2017; Fowler, 2004). UML diagrams are classified in two types: behavior diagrams and structure diagrams. Class diagrams, a type of structure diagrams, are appropriate for the Smart Grid node description. A class diagram describes the types of objects in the system and the different kind of static relationships between them. Diagrams also show "Part of"-relationships, features, and operations of classes, and the limits of the way in which the objects are connected. The "Part of"-relationship is shown with a rhombus and a line. The features are one term but they are represented with two quite different notations: attributes and associations. The notation for an attribute describes a distinct feature like text (second row) in a rectangle envisaged for a class. The association is a directed line between two classes and its direction is from class-source to class-aim. The name of a feature is set on the aimed end of the association with its majority. The end-aim of the association is connected to the class which is the feature type. The majority of a feature is a note for how many objects could complete the feature. Operations are actions which a class could realize. Obviously, they correspond to the methods of a class. Although there is a distinction between Operation and Method, Operation is the term for a method – declaration of procedure. The method is a code from which the procedure consists. Operation and Method are differentiated by polymorphism. The models have the impact of similar models for telecommunications management (Magedanz, 1994).

Results

In this section are represented designed models for management in Smart Grid: the model for the management of a network and its elements through which a universal agent runs. Object oriented method is used. The classes of managed objects are defined according to the managed units. The Guidelines for definitions of managed objects (GDMO) (ISO/IEC/IS, 1989) from the network management standards are followed. UML is used for Model description. At this stage, objects are represented with names, "Part of"-relationships, and associations.

A. Managed Objects Classes for node SSP (Service Switching Point – Smart Meter)

A Managed object (MO) Switch represents the information for a switch in the user's premises. MO SSP represents the management information for a node SSP. MO SSF (Service Switching Function) represents the management information for SSP functionality. MO SSFConfiguration represents the configuration of SSF functionality. MO SSFMaintenance represents the duties for maintenance of SSF functionality. MO SSFSecurity represents the rules for security of SSF functionality. MO SSFPerformance represents parameters for the performance of SSF functionality and their management. MO SSFAccounting represents the management information for the accounting of the used energy. MO TriggerTable represents service trigger information in Smart Grid. MO TriggerInfo represents the trigger description needed for request (agent) direction to service execution. MO FeatureSupplyManager represents the mechanism for competitive realizations support of service in Smart Grid and of service out of Smart Grid in a request. MO SGSwitchingManager represents the mechanism which interacts with SCF (Service Control Function) for service provision. SCF detects events which should be reported to active service realization and it manages SSF resources which should support service realizations. MO FEAccess Manager represents the mechanism for information exchange with functional elements by notifications. MO SCF will be represented in the next paragraph. MO BasicSupplyManager represents the mechanism for basic service return, after search execution. MO NonSGFeatureManager represents the mechanism for feature calling out of Smart Grid (for instance, the usage of own solar source). MO SSFUsageLog represents collected entries for energy usage. MO SSFAccountingLog represents the collected entries for energy accounting during service execution. Figure 3 shows UML diagram of Managed Objects Classes for SSP (Smart Meter).

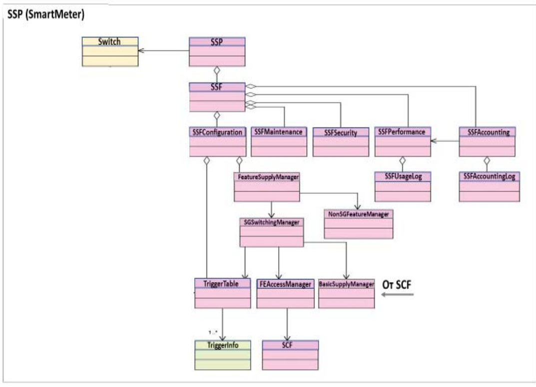

Fig. 3. UML diagram of Managed Objects Classes for SSP-SmartMeter

B. Managed Objects Classes for node SCP (Service Control Point – Storage, PIT)

MO SCP represents the information for node SCP. MO SCF (Service Control Function) represents the management information for a SCP. MO SCFMaintenance represents the rules for the maintenance of SCF. MO SCFSecurity represents the rules for the security of SCF. MO SCFConfiguration represents the configuration of SCF. MO SCFPerformance represents the parameters of performance for SCF and their management. MO SCFAccounting represents the information for accounting management in SCF.MO SCFPreventiveFunction represents testing programs in SCF by normal work conditions. MO LogicExecutionEnvironment represents the environment for logic execution with all the participating managers, programs and data. MO LogicExecutionManager represents the information for the functionality which processes and controls the whole service execution. MO ProgramLibrary represents the resource for different programs storage in SCF. MO Program represents the description of a service logic program. MO DataAccessManager represents the information for the storage, management, and access to SCF shared information and for the access to remote information in other functional elements by MO FEAccessManager. MO FEAccessManager and MO SSF are represented in paragraph A. Managed Objects Classes for node SSP. MO SCF is represented above. MO SDF will be represented in the next paragraph. MO SCFUsageLog represents the collected entries for the usage of SCF. MO SCFAccountingLog represents the collected entries for the accounting of SCF during service execution. Figure 4 shows the UML diagram of the managed objects classes for node SCP.

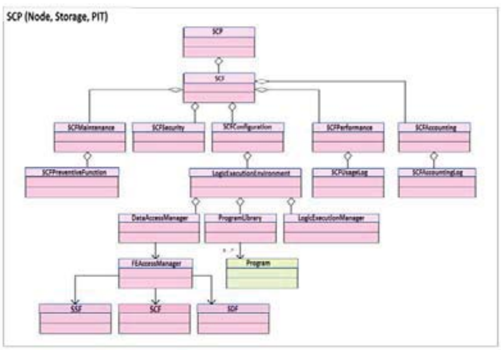

Fig. 4. UML diagram of Managed Objects Classes for node SCP

C. Managed Objects Classes for node SDP (Service Data Point – FIB)

MO SDP (Service Data Point) represents the information for a node SDP. MO SDF (Service Data Function) represents the management information for a SDP. MO SDFConfiguration represents the configuration of SDF. MO SDFPerformnce represents the quantity parameters of SDF and their management. MO SDFAccounting represents management information for the accounting of SDF. MO SDFMaintenance represents the rules for maintenance of SDF. MO SDFDataManager represents the information for the storage, management, and access to data in SDF. MO SDFDataBase represents the information for the Data Base in SDF. MO FEAccessManager is represented in paragraph A. Managed Objects Classes for node SSP. MO SDFData represents an entry in functional element SDF for a service request. MO Template represents the description of an entry format for each request in Smart Grid. MO SCF was explained in the previous paragraph. MO SRF will be represented in the next paragraph. Figure 5 shows the UML diagram of Managed Objects Classes for node SDP.

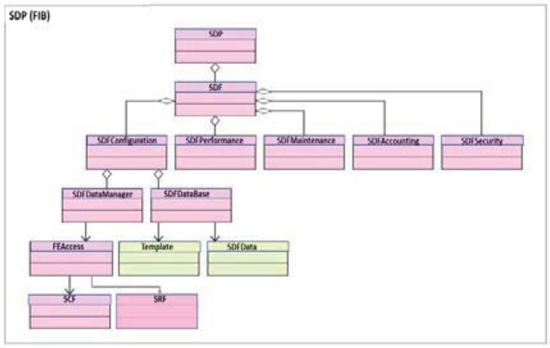

Fig. 5. UML diagram of Managed Objects Classes for node SDP

D. Managed Objects Classes for node SRP (Service Resource Point – FIB)

MO SRP (Service Resource Point) represents the information for the distributed power sources. MO SRF (Service Resource Function) represents management information for a SRP. MO SRFPerformance represents the parameters for the performance of SRF and their management. MO SRFAccounting represents the management information for accounting in SRF. MO SRFMaintenance represents the rules for the maintenance of SRF. MO SRFSecurity represents the rules for the security of SRF. MO FEAccessManager is represented in the previous paragraph. MO ResourceManager represents the information for the resources managed from SRF. MO SRFDataBase represents the information for Data Base in SRF. MO SRFUsageLog represents the collected entries for the usage of SRF. MO Resource represents the description of the resources used as energy sources. MO AtomicPowerSt describes the data for the atomic power stations used. MO CoalPowerSt describes the data for the coal power stations used. MO WaterPowerSt describes data for used water power stations. MO SolarPowerSt describes the data for the used solar power stations. MO WindPowerSt describes the data for the used wind power stations. MO SDF was represented in paragraph C. Managed Objects Classes for node SDP. Figure 6 shows the UML diagram of the Managed Objects Classes for node SRP.

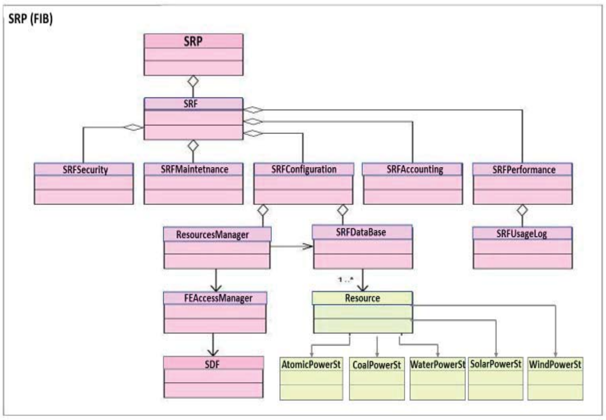

Fig. 6. UML diagram of Managed Objects Classes for node SRP

The chosen granularity degree by node description gives an idea about the work volume which should be completed in the development phase. The comparison of the proposed model and those of other researchers is difficult because they are business secrets. The differences could be found in the managed objects names and in the organization of the structures. The disadvantages could be found in the limited number of details.

Conclusion

This paper represents the design of an information model for a universal agent for power generation and supply management in Smart Grid. The model corresponds to the responsibilities of actor Network operator. Managed objects classes are defined that represent managed resources for network elements following the object oriented method. Managed Objects Classes are organized in a hierarchy which shows the correlation between them and relates to their easier realization. At this stage, the software for the management of each node is detailed with elements up to level Manager and Program. The managed objects are defined only with name, "Part of" relationships, and associations. Attributes and operations will be added at the next stage. Nevertheless, the model is a good basis for user interface development.

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