Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X
IMPACT FACTOR: 6.017

IJCSMC, Vol. 8, Issue. 2, February 2019, pg.80 – 85

Smart Grid's Big Data Wireless Computing

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Abstract— The main reason for seeking a better improvements in the smart grid development which increases data volume and complexity is economics, reliability and efficiency of the grid. This type of data requires a powerful technology to analyze and process big data. In this report, we propose an intelligent grid analysis architecture for the analysis of data transmission, storage and resources based on four fields of communication. We are proposing a data-enabled large-scale storage plan for big data wireless computing, that makes wireless communication big data awareness for smart grids. Genetic Algorithm (GA) for storage planning and internal optimization to plan daily energy was adopted as an optimization approach. This will reduce the long - term costs of consumers.

I. INTRODUCTION

Intelligent grid is a modern power grid technology supported by advanced technologies of monitoring, sensing, communication and control, to provide customers with sustainable, cost effective and safe energy. A huge coverage of large quantities of intelligent measuring and sensing was deployed with the development of intelligent grid progress. This has resulted in many heterogeneous multi - source smart grid data. The quality of the intelligent grid can be increased by an enormous extraction of value, which can also serve various types of customers better than the conventional grid. IBM used four environment and climatic data petabytes, for example. A model was developed in the wind turbine localization, allowing the optimum installation site for ventilators, which improves wind turbine production efficiency and extends service life [1]. However, the high volume, variety, and speed of intelligent grids in the intelligent grid in wireless communication technology is a demanding requirement for large data computing. Compared to conventional wired communication technologies, wireless communications technology has a special advantage for deployment, expansion and cost-effectiveness. Furthermore, the high data rates and reliability characterize wireless communications with advanced technology. A lot of research has been carried out on smart grid applied wireless communication technologies. In order to optimize the management of spectrum resources, Yu et al. [2], for example, worked on the technology of cognitivism of radio in smart grid which generally, offers promising support for smart grid Big Data calculation. In wireless big data computing, the smart grid is widely used with four aspects: costing, planning for network demand response, and client profiling. The Smart Grid is a broad application. In this paper, a housing energy storing mechanism was represented on the proposed architecture of smart grid – data. The planning problem of public utilities owned energy storage devices has already been dealt with [3]. However, as far as we know, little research is still being done on energy storage device planning in the consumer side. This article focuses on energy storage devices in every consumer's Home with historical energy consumption data. An approach is developed in order to ensure optimal use of storage devices at long-term overall cost for every consumer using genetic algorithm (GA). Moreover, an energy planning

scheme for the optimization of energy storage plans is proposed on the basis of a game theory. The Nash balance from the proposed power planning game is a significant advantage for all consumers to achieve a satisfactory reduction in the billing.
This article is about wireless data calculation - wide - scale smart grid. The consistency between Big Data and Smart Grid Data is first examined. For this purpose it proposes a large data computing architecture. In the architecture there are four levels: data resource, transmission of data, data storage as well as data analysis. In connecting the other two levels with the network, the data transmission level is a key element. A broad, hierarchical wireless architecture is then outlined to deal with data transfer in Big Data Computing's intelligent grid. For different areas of the architecture, possible wireless technologies are listed. Some key technologies will be highlighted in order to allow big data - wireless knowledge. We are introducing an energy storage plan with wireless architecture of large data computing. As energy planning is a problem which can further break down, a hybrid approach is suggested, which includes external genetic algorithm optimisation and internal game - based optimisation.

The rest of our paper is arranged accordingly. This section describes the large - format smart grid computing architecture. Then we introduce the hierarchical architecture of Smart Grid - Big Data Wireless Communication. Then we analyze Planning of energy storage issue on the consumer side. A hybrid approach was proposed consisting of an algorithm for internal energy plans to optimize and to optimize externally.

II. SMART GRID’S COMPUTING ARCHITECTURE

The creation of a wide range of intelligent grid IT management systems promotes the development of energy – from electricity generation to power production, distribution of energies and loads. Jiang et al. [4] outlined analytical framework frameworks and key technology for a comprehensive underdevelopment of smart grid - big data applications. Hu et al. [5] discussed improvement in Big Data Security and challenges on the smart network and provided a number of Big Data analysis taxonomies. In general, large numbers are very wide in the intelligent grid and early research in this area is still under way. Firstly, when conventional technologies cannot deal with data computing, the characteristics of large data in the intelligent grid are new challenges. On the other hand, large - scale smart grid computing infrastructure has still to be unified and there may be practical difficulties with data acquisition and analysis.

III. SMART GRID DATA BIG DATA CHARACTERISTICS

The data generated by the intelligent grid indicated the properties, quantity, speed, variety, value and truthfulness of large data and its unique features.
Volume: The collection points and specimen frequency has increased to provide smart grid devices with accurate, real - time operating status information. Terabytes to petabytes range in volume of intelligent grid data.
Velocity: Two dimensions are required for intelligent grid data processing. Effectual data must be displayed quickly in order to record the operations of each detail fully and correctly and fully reflect the manufacturing process. The total data, however, must be analysed throughout the sampling to facilitate the decision-making process. The data of Smart grid offer more efficiency required than offline data processing. Intelligent grid data.
Variety: A great deal of structured, unstructured and semi - structured data, including selected logs, sites, social data sets, table and diagrams, can be found on the smart grid. Unstructured data account to a significant data of smart grid proportion and makes it have 60% increasing. [6]. Furthermore, for this data there are not the same frequency of requests and treatments and performance requirements.
Value: The intelligent grid data value is directly connected with data applications. But the density of the value is low. For video, in the continuous monitoring procedure, it possible to be just 1 to 2 s is the useful data. The same problem exists with state monitoring of power transmission equipment. The abnormal data is only very small, but most of the data collected is normal.
Veracity: Authenticity may be regarded for certain data quality requirements as a new attribute of intelligent grid data. The genuineness of the intelligent grid data makes the data type reliable. The impact of data analysis results can be influenced by high quality data. The inherent unpredictability of certain data cannot, however, even the best method of data purging.
A large range of applications for the intelligent big data technology grid show the correspondence between the features of the intelligent grid and large data. In this respect, a large data calculation architecture for intelligent grid analysis is offered in the following section.

IV. GRAND DATA FOR SMART GRID TRADA ANALYTICS ARCHITECTURE

In view of the generation, transfer and processing of large data, which is usually summarized in a hierarchical architecture. In this section, we are proposing a large data computer architecture especially in connection with intelligent grid analytics. The Level of Data Source: The smart grid data is generated from a variety of longitudinal and/or distributory data sources, such as data from the distribution and transfer of systems, PMU and AMI data, and generation data and intelligence-related information. These data are distributed across sites and managed across enterprises / departments that belong to a wide variety of Systems such as CIS collection systems, WAMS systems, distribution management systems, energy management system (EMS), finance management system (FMS). These systems are compiled in various locations and managed by various organizations. This information is not entirely separate. In intelligent grid data there is a complex relationship that is interrelated and influenced. For example, Weather and socio - economic conditions may affect users' consumption of electricity. Power market data can be used as a basis for decision making the generation of appropriate public sector and GIS data by an energy company must be used as reference to municipal planning information. Big data –Smart grid generated through sensors, structure and processes are transmitted directly to a central resource network management database, i.e. a Cloud data center or centralized database.

Data Storage Level: A lot of meaningless data contained in intelligent does not have to occupy a lot of storage space. For the upcoming data calculation, the challenge is new. Therefore, in two methods, batch processing and stream processing, the intelligent Grid data can be stored and processed at the data centers [7]. Streaming means that when new data comes in and the desired results will be returned immediately. This model is suitable for companies with high real - time smart grid requirements which includes joint programming of load and power supply, monitoring of equipment online, etc. before processing the data is stored which is the Batch processing. This model is designed to design an intelligent network that is very large and complicated [8].

Data Analysis: In different applications fields, different analytical methods and tools were used in two extract value directions. One is customer - oriented service (DSM, for example). In DSM, customers are classified according to different features such as conditions of climatic and patterns of energy consumption. A total demand response can be obtained in a certain region or class of users through a clustering on the basis of category analyses. The results of the analysis can provide the basis for developing the request management response. The other direction is to provide utilities - based services, for example a load forecast [9]. In charge prediction, the complexity of charge forecasting with large applications and high precision prediction increases distributed energy sources and microgrids. Therefore many factors must be considered in the load prediction.

Data Transection: This one creates an inner bridge between three levels on each level. Advanced communications technologies are enormously needed to meet the challenges of large - scale data collection, processing and analysis. Wireless communications, like cost efficiency and flexibility in comparison to wireless technologies, have unique advantages. The following section presents in detail wireless technology for Big Data calculation in the Smart Grid.

V. STRUCTURE OF SMART GRID DETA HERARCHIKAL COMMUNICATION

The Smart Grid is available for wireless communication in various ways [10]. The Smart Grid is normally divided into three main areas, namely a home zone (HAN, NAN) and a wide network (WAN) because of the different communication coverage and its various utilities. An additional domain for highly calculated smart grids is to include a central unit in hierarchical architecture proposed for wireless communication.

The HAN as a fundamental unit of an intelligent network communication system mainly consists of intelligent devices and SMs that collect information from intelligent devices via wireless communication to manage electricity consumption in real time [11]. In order to generate and transmit information on total energy consumption between HANs and NANs, all data collected for meter reading are collected. The building area (BAN) and industrial area (IAN) networks, applicable for trade and industrial scenarios, are similar concepts in HANs. HANs are extensively investigating wireless technologies including ZigBee, WiFi and mobile networks. The NAN is generally preferred to connecting a final - mile user network SMs and other distribution automation collectors to a wide area network. In addition, the surveillance and management of information collectors establishes a separate network, the FAN (Field Area network) which is similar to NAN's geographical dimension. The NAN / FAN gateway with a range of kg/s and bandwidth of 10 and100 kb/s / nodal may be considered for each SM/distribution collector. Cell technology is normally considered to be a powerful NAN candidate.

A wide area network collects and transfers data from several NAN / FANs to a central management unit. In the meantime, all transmitters and distribution systems are covered by the WAN. A wide area network can therefore include a vast area extending up to thousands of kilometers. In addition, the technology for high - speed communications like fiber optic communication and cell communication requires a bandwidth of 10 - 100 Mb / s / node to ensure the high amount of data transmission. Users typically use a hybrid solution to combine wired and wireless communication technology for a WAN in order to ensure reliability and latency. Another Wi-Fi technology is Cognitive radio (CR), alongside cellular technology like NAN. Server - linked internal network control and data center consisted within the main unit.

VI. COMMUNICATION TECHNOLOGY OF BIG - DATA - AWARENESS

Once the large-scale wireless architecture of communication has been developed, certain key technologies to improve the quality of wireless communication and to develop new applications should be highlighted. As follows, we describe them. SDN is a revolutionary network architecture designed to disconnect control aircraft and aircraft. Software-defined networking is an advanced network architecture. Because of simplified features, underlying equipment such as smart electronic devices (IEDs) may take full package forwarding decisions, taking into account service quality (QoS), experience quality (QoE) and applications. The centralized controller manages and controls the underlying hardware to assign network resources on demand in a flexible way. A SDN-active communication network will be investigated in order to handle the enormous amount of time critical information on a Smart Grid. To improve default tolerance, advanced allegory for the SDN controller is still needed to resource efficiency and achieve real - time capacity.

Cloudlets and Clouds: Power should be managed in real time, from power production to energy distribution, in the intelligent grid. The sizeable solution for smart grid applications such as condition monitoring is provided by a cloud-based network of radios (C-RAN). In order to centrally optimize massive state data management across the network, resources computing including computing, storage and networking are packed and transferred to the cloud [12]. The cloud-light concept suggests a light cloud that takes into account both central and local data processes, with low storage and computer capacity for base stations (CBSs) [13]. Cloudlets can help to transmit delay-sensitive applications in data.

Crowdsourcing: the main resources might be shared among SMs for common interests. For example, SMs can work with others in a high volume of traffic, in addition to direct transmission from a BS to a SM, in a given region. In [14] Mobile networks, data transmission mechanisms, which share transmission channels with neighboring mobile devices to prevent network traffic congestion in the big data environment, are similar to crowded. In the meantime, incentives to encourage broadcast channel sharing behaviors can be adopted. Free transmission can therefore be used in full and reliable data transmission guaranteed. Under this circumstance.

Cache Control: Different applications in smart grid have different communication requirements. While some applications require less demand, such as load forecasting, many more applications need near-earth data transmission, such as a wider range of PMU situation sensitivity. Distributed cache is an efficient way to reduce high traffic volumes in real time. Because the cache size is limited, cache contents have to be classified, organized carefully and updated promptly to maximize the bandwidth use of your system. Labels are incorporated and marked into content objects. Cached content can easily be classified according to the labels. Contents with types requiring more numbers of access are cached continuously while other contents are regularly removed.

VII. NETWORK PLANNING ENERGY FOR ENERGY

Data analysis in the area of network planning is an important way to use smart grid Big Data Computing. We present a residential energy storage program for large-scale data computing in this section. As an example. A system model in which clever SM devices are equipped is considered. Each user then decides to use energy store equipment and energy storage equipment to improve planning of energy and reduce costs. There are two sub-problems: the energy planning problem for each intelligent device in determining the particular pattern of energy consumption and the energy supply planning problem for each consumer.

VIII. SYSTEM MODEL

For one source of energy and N consumers, the power system is considered. Each consumer receives an SM which can monitor and monitor the operation of devices and storage devices in accordance with a specific timetable. In order to achieve an optimized energy plan. We split the H time slots for one day. Assume h = 24, for example, and every slot lasts 1 hour. We denote that consumer load n is I n^h at slot h. The total charge is therefore h at slot h

$$L_h = \sum_{n=1}^{N} I_n^h$$

A well-developed DLC charge system, available as a quadratic function $C = K_h L_h^2$, has been introduced in which Kh varies from time to time.

A_n devices are deployed for each consumer. Equipments are composed of two categories: non - shifting equipment must work over a predetermined period of time. Shiftable devices can however be shifted to avoid maximum time within a certain range. Start and end times are described by beginning at n and ending at n and total daily use is desired at En, a. In addition, EMI, N and EMAX, N represent for one operating time the minimum and maximum energy consumption of devices. All of these parameters limit the programming of mobile devices. Consumers can choose storage devices in addition to residential appliances. Power can be stored and consumed in advance at peak times. The energy from the consumer's storage is described as $S_{in,n}^h$ *and* $S_n^h = S_{in,n}^h - S_{out,n}^h$.

The ability of the consumer storage device is known as Smax and limits maximum energy consumption. The maximum load and discharge rate (smax, in, n, out and n) limits the maximum flow of energy to and from the consumer storage device over a certain time period.

IX. ENERGY STORAGE PLANNING

In the next paragraph, we propose a hybrid approach to storage planning consisting of external GA-based optimization and an internal energy optimization algorithm. The GA shows the storage capacity of all storage devices for consumers. There are several base units to each power storage device. We call the base device BU, and KnBU has a non-negative integer capability as a consumer power device 1 / n/ N. A particular case is kn = 0, meaning that the consumer n does not use a Storage Device.
There are as many basic units for each consumer as possible, which we call Kmax. Some economic and technological conditions influence this maximum value. The GA is therefore restricted by the value Kmax, i.e. it ought to meet kn Kmax for each 1 n N. The fitness function shows the total cost of installation and daily energy consumption of the initial storage equipment. The energy schedule proposed will provide the consumers with optimal energy planning. After that, the fitness function will be computed to assess people and decide if the AG is to be stopped. The GA ends when the fitness function is minimum constant or reached throughout the assigned number of generations. Each user's energy storage device has the optimal output of GA.

X. DISCOUNTER ENERGY

In this sub-section, we use a theoretical approach to shape the energy management problem. Consumers are regarded as players that are concerned with reducing their own costs in the energy planning game proposed. For each consumer strategy, the limitations already described in the calendar and storage device are limited. The user shall therefore charge each user's costs

$$C_n = \sum_{h=1}^{H} K_h \,(\sum_{a=1}^{A_n} e_{n,a}^h + s_n^h)^2$$

In the proposed energy planning game, there are several Nash balance sheets and the same cost. With the proximal discomposure algorithm and the best reaction algorithm [15] we can achieve an optimal schedule.

XI. THE PROPERTIES MECHANISM IMPLEMENTATION

The mechanism for storage planning consists of external optimization and internal optimization. When an optimized solution is solved based on the current situation, the load and other information can be simultaneously processed for each customer.

Populations are constantly updated in external optimization. In order to assess the population with their optimized time schedules and costs, internal optimization must be defined by the consumer when new populations are generated. Fitness function is calculated. The energy programming mechanism has a nesting loop for internal optimization and can be further divided into two phases: initialization and runtime. The central unit broadcasts on {K} to (h h=1)^H in the first initialization phase of the external loop.

In the meantime, all consumers are chosen at random for their initial strategies. The first strategies are launched at random to regularize the play of all consumers and their corresponding loads are announced when the process is initialised. Then the inner loop runtime phase starts. Each user is solved separately for their optimization problem, and their new timetable is communicated to others. Users will constantly have updated optimization problems fixed once new loads are received before no new updates are reported. The regularized game was resolved at this point and the answer is the next strategy. The process begins until a solution for energy planning converges with the strategy. Following the planning process, the total grid costs are compared to non-storage costs. In the case of storage planning, storage equipment will at the beginning cost relatively highly. Then the daily cost is lower and in both cases the difference between the total costs is gradually diminished. The total cost for storage planning after 169 days is reduced compared to the other case. If we consider a 10 year lifespan, a total of $ 24.497 would be saved with storage planning compared to the case without the use of storage.

The energy schedule contributes significantly to flattening the maximum grid load for each single day. The load is displayed in the figure at every slot during the day. According to the wishes of the consumer, the case with the proposed mechanism of energy programming and energy use pattern of origin can be compared. The energy planning scheme reduces the peak load while the peak load increases off-peaks and the peak-to-average (PAR) ratio (pop-to-average) drop from 4.66 to 4.34. This leads directly to the previously shown daily savings.

CONCLUSION

In this paper, the features of Smart Grid Big Data was discussed and a Smart Grid Analytics Big Data architecture was proposed. Then the wireless communication hierarchy for the smart grid was proposed, which includes large data knowledge and technology. We took into consideration residential storage planing on smart grids as a Fall study of the proposed architecture, and we recommended the hybrid approach of external GA optimisation and an internal energy planning optimisation algorithm. We considered wireless communication technologies. Finally, the results of the simulation are shown in the proposed storage scheme. The overall cost of consumers is significantly reduced in the long term by the storage planning scheme.

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