Research on Key Technologies of Intelligent Energy Gateway Based on Fog Computing Technology

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Abstract. The global low-carbon emission reduction pressure increases, the development of new energy technology and the new generation of information and communication technology starts to change the energy consumption pattern. Integrated energy services are getting more and more attention. For this reason, an intelligent energy gateway design method based on fog computing technology is proposed in this paper. Firstly, the construction concept of comprehensive energy internet platform is put forward, and the construction goal, architecture and function of the platform are expounded. Secondly, the key technologies of intelligent energy gateway under the framework of fog computing are summarized, which provides a feasible scheme for the design of integrated energy internet platform. Finally, the design results of integrated energy gateway software and hardware parts are given. The rationality and effectiveness of the scheme under the framework of fog computing are proved.

1. Introduction

At present, the world energy pattern is undergoing profound adjustment. The global low-carbon emission reduction pressure increases, the development of new energy technology and the new generation of information and communication technology starts to change the energy consumption pattern. At the same time, power system reform and policy changes have also changed the competitive pattern of the energy market. It is the general trend to promote smart development in the energy sector, accelerate the development of comprehensive energy services, and promote the development of the energy internet. To support the development of integrated energy services, we propose an intelligent energy gateway design method based on fog computing technology. Firstly, the construction concept of comprehensive energy Internet cloud platform is put forward, and the construction goal, architecture and function of the platform are expounded. Secondly, the key technologies of intelligent energy gateway under the framework of fog computing are summarized, which provides a feasible scheme for the design of integrated energy internet platform.

2. Integrated energy service platform scheme

The overall architecture of the integrated energy service platform is shown in figure 1. The overall architecture covers four layers of applications for the internet of things. It includes physical perception layer, network transport layer, data and service cluster layer, and platform application layer. Fog computing and edge computing together to provide network, computing, storage, applications and
other core application computing capabilities. In order to produce network services with faster speed, less traffic and lower cost, intelligent energy gateway is often used in engineering applications to realize the above functions.

At the physical perception layer, intelligent terminals of various energy Internet of things are used to collect operational data covering energy production, energy transmission, energy storage and energy consumption. The system adopts Internet of things technology such as fog computing to strengthen the unified monitoring capability of distributed energy, energy stations, end users and other links. The terminal layer includes data acquisition terminal, communication management machine and field communication network. At the network transport layer, the data collected by various terminals is transmitted to the data processing layer of the platform layer. The means of communication include cable communication, wireless communication, satellite communication and so on. At data and service cluster layer, the system will carry out data processing, basic services, application services and other businesses. At platform application layer, PC terminal, mobile application terminal and large screen system equipment for the system to provide specific business display.

Figure 1. Integrated energy service platform scheme

3. Intelligent energy gateway data preprocessing in fog computing architecture
The comprehensive energy service platform scheme is introduced above. In order to verify the effectiveness of fog computing in network transmission, this chapter designs a two-network fusion intelligent gateway. The basic functions of fog computing positioning and data preprocessing are realized, and the goal of reducing the network bandwidth pressure caused by real-time upload of sensor data. Comparative analysis of traditional and proposed intelligent energy schemes is shown in figure 2.

3.1. Fog computing data preprocessing
The core service function of fog computing is the processing, storage and calculation of sensor network data. In this paper, abnormal data elimination and effective data fusion are considered. Multi-sensor data preprocessing refers to the comprehensive processing of data observed by the same target by multiple sensors. Therefore, the elimination and data fusion of abnormal data in fog calculation have the following advantages:
1) **Fill in the missing data.** The missing data can be filled by the load of several same days and the data weighting processing method.

2) **Data is processed vertically.** Considering that the load at the same time of similar day has similarity, when the load difference at the same time of similar day is too large, the data can be modified for a second time.

3) **Horizontal processing of data.** In the data analysis, the load data at the previous and later times are used as the benchmark. If the load change at the previous and later times exceeds the maximum load change threshold at the previous and later times, the load data can be finally revised.

In addition, the input samples can be normalized during data preprocessing. Avoid input vectors that are too different in order of magnitude to affect the effect.

\[
\bar{x}_i = \frac{x_i - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}} \tag{1}
\]

\(x_{\text{max}}\) and \(x_{\text{min}}\) represent the maximum and minimum values of the load in the training sample set. \(x_i\) is the actual load data and \(\bar{x}_i\) is the normalized load data. After normalization, the data is converted to the interval of \([0,1]\). Finally, the following formula is used to convert the data to the real value.

\[x_i = (x_{\text{max}} - x_{\text{min}}) \times \bar{x}_i + x_{\text{min}} \tag{2}\]

3.2. **Edge data mining technology**

Edge data mining technology utilizes the existing artificial intelligence, pattern recognition, statistics and other technologies. This technology can discover new patterns and patterns in massive and complex data, and thus discover its potentially valuable information. The functions of classification, clustering, correlation and prediction can be realized.

The input of edge data mining can be represented by a set of ordered sequences \((X, s)\) or \((X, d)\), where \(X\) represents a set of samples, and \(s\) and \(d\) are the criteria for measuring the similarity or divergence between samples respectively. The output of clustering system is one partition at a time, and it satisfies

\[C_1 \cup C_2 \cup \cdots \cup C_k = X \tag{3}\]

\[C_i \cap C_j = \emptyset, i \neq j \tag{4}\]

In equations (3) and (4), \(C\) is the system cluster, which can be described by some characteristics, respectively:

1) The data relation in space vector is used to represent a class of nodes.
2) Nodes in the cluster tree are used to represent a class graphically.
3) Nodes in the sample attribute are used to represent a class logically.

![Figure 2. Comparative analysis of two intelligent energy schemes.](image-url)
4. Software and hardware design of smart energy gateway in fog computing architecture

The intelligent energy gateway hardware studied in this paper adopts ARM9 300MHz processor. Meanwhile, the gateway is equipped with industrial touch screen and multi-type data interface. The gateway can conveniently process and forward CAN, 485, 232 and other data through Ethernet, GPRS and WIFI, so as to realize the interconnection and interworking of multi-type energy-using devices.

In terms of software functions, smart energy gateway adopts C++ language to describe the basic functions, and has the characteristics of cross-platform and expansibility, etc. The typical level diagram of the development system is shown in figure 3.

![Figure 3: Intelligent gateway system hierarchy diagram.](image)

The maximum number of intelligent energy gateway supporting collection terminals is 1024. TCP/UDP is adopted to communicate between the terminal and energy consuming equipment. The smart energy gateway software and hardware parts are respectively shown in figure 4. Smart energy gateway is based on fog computing architecture, which can provide data support for the design, develop and application of integrated energy service.

![Figure 4: Intelligent energy gateway software and hardware parts.](image)
5. Conclusion
In this paper, an intelligent energy gateway design method based on fog computing technology is proposed. Firstly, the construction concept of comprehensive energy internet platform is put forward, and the construction goal, architecture and function of the platform are expounded. Secondly, the key technologies of intelligent energy gateway under the framework of fog computing are summarized, which provides a feasible scheme for the design of integrated energy internet platform. Finally, the design results of integrated energy gateway software and hardware parts are given. The rationality and effectiveness of the scheme under the framework of fog computing are proved.

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