Resolving Network Congestion and Enabling Flexible Traffic-Splitting in Heterogeneous Wi-Fi Networks through a Traffic-Splitting System

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Abstract

This research focuses on developing a Traffic-Splitting system for heterogeneous wi-fi networks to address the issue of network congestion caused by the exponential growth of mobile traffic. The system comprises a Traffic-Splitting client installed on mobile terminals and a Traffic-Splitting server on the Internet side. The Traffic-Splitting client collects network state information and user state information from the mobile terminal and transmits it to the Traffic-Splitting server. The Traffic-Splitting server analyzes the aggregated data and provides Traffic-Splitting control information to facilitate the Traffic-Splitting process for users. The Traffic-Splitting client performs flow splitting based on the received control information, current network and user states, and adjusts the Traffic-Splitting strategy to accommodate changes in the network and user conditions, thereby achieving effective flow splitting in the heterogeneous wi-fi network. This solution not only solves network congestion issues but also enables Traffic-Splitting to WiFi networks, thus optimizing mobile user experience.

Keywords: Traffic-Splitting system, Heterogeneous wi-fi network, Network congestion, Traffic-Splitting, WiFi network

Introduction

In today's digital era, the demand for mobile data services is experiencing an unprecedented surge. With the widespread use of smartphones, tablets, and other mobile devices, the volume of mobile traffic has been growing rapidly, leading to significant challenges in managing network congestion. To address this issue, researchers and industry professionals are exploring innovative solutions to optimize the utilization of wi-fi networks and enhance user experience. One promising approach is the development of a Traffic-Splitting system for heterogeneous wi-fi networks.[1] The management decision of electricity demand forecasting to Electric Power Network Planning and economic department accurately has important directive significance. Electricity demand forecasting is carried out on the basis of research

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different user electrical characteristics, electric power enterprise can be helped to understand user individual demand for services better, for following power network development and electric power demand side response policy making provide data supporting.

Along with the sustainable development of Chinese society economy and the continuous adjustment of the industrial structure, power consumer just presenting diversified development trend by electrical characteristics, the variation of user power utilization characteristic proposes challenge to traditional electricity demand forecasting method.[2] Meanwhile, along with the construction and development of intelligent grid, electric power enterprise inside defines gradually and comprises production data, marketing data, and relevant socioeconomic data etc. is that the power consumption the taking into account user power utilization characteristic prediction that becomes more meticulous provides data basis in interior intelligent adapted University data.

Figure 1 depicts a framework showcasing diverse wireless connectivity methods, enabling the gathering of extensive data from wireless devices. This data is then processed and utilized by machine learning algorithms to extract patterns, facilitating informed decision-making. The aim is to optimize operational parameters and enhance the quality of service (QoS) and quality of experience (QoE) in the network.

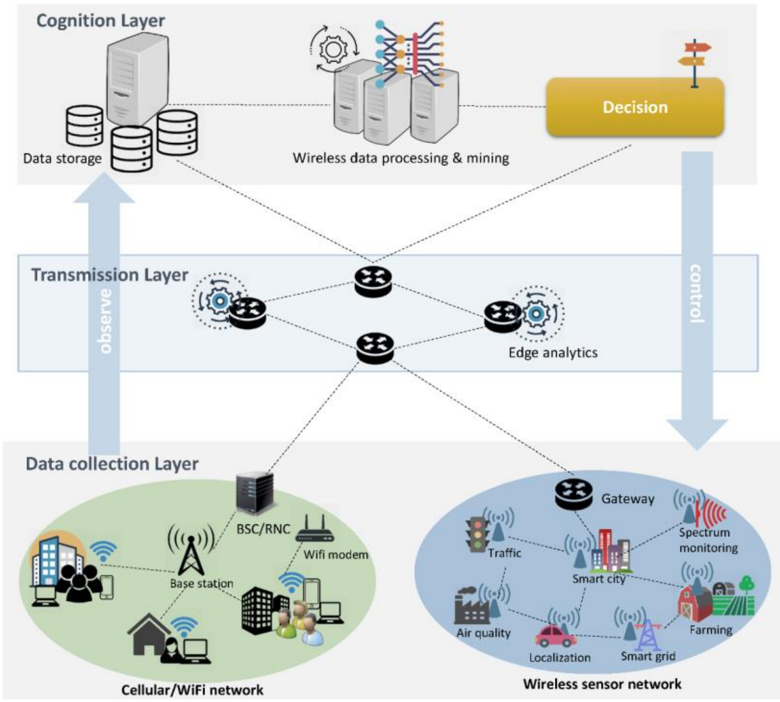

Figure 1. Structure for wireless large-scale data analysis

But, due to the feature such as intelligent adapted University data class is many, the scale of construction is large, dimension is high and formation speed is fast, traditional electricity demand forecasting method

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is had some limitations at excavation mass data message context, is difficult to power consumption relation factor and the Changing Pattern of accurate assurance user.

Under large data environment, how studying use electrical characteristics and the power consumption relation factor of user, and predict its power consumption, is the challenge of pendulum in face of researcher. At present, most electricity demand forecasting methods can be classified as three classes: based on seasonal effect in time series Forecasting Methodology, user side predicted method, and econometric forecasting method.[3] But, these methods or too rely on the quality of data available, or need human intervention be carried out when discriminating user power consumption influence factor, the profound incidence relation be hidden in after electrical energy demands change cannot be excavated, for the user power utilization amount prediction under large data environment, there is larger limitation.

The identification of user power utilization relation factors and the development of an electricity demand forecasting method under the large data environment have become critical research areas in the power industry.[4] It is essential to understand the power consumption patterns and characteristics of different users to improve the accuracy of demand forecasting, enable effective network planning, and facilitate policy-making regarding demand-side response strategies. However, with the dynamic changes in the economic landscape and industrial structure, traditional forecasting methods face challenges in accommodating the diverse development trends and variations in user power utilization.

Moreover, the emergence of intelligent grids has brought about significant advancements in data collection and analysis. Power enterprises now have access to vast amounts of data, including production data, marketing data, and socio-economic data. Leveraging this wealth of information to predict power consumption based on user power utilization characteristics has the potential to enhance forecasting accuracy.[5] However, the sheer volume, complexity, and velocity of data in intelligent grids pose challenges for traditional forecasting methods, making it difficult to accurately identify power consumption factors and track changing patterns in user behavior.

In the current landscape, existing electricity demand forecasting methods demonstrate limitations. Time series forecasting methods heavily rely on the quality and availability of data, while user-side prediction methods require human intervention to discern power consumption influence factors. These methods often fail to uncover the underlying complex relationships hidden within the changes in electricity demand. Consequently, there is a significant need to develop advanced methodologies that can overcome these limitations and enable accurate predictions of user power utilization in the context of large data environments.[6] This research aims to address this gap by proposing a Traffic-Splitting system for heterogeneous wi-fi networks. The system consists of a Traffic-Splitting client on the mobile terminal side and a Traffic-Splitting server on the Internet side. The client collects network state information and user state information and reports it to the server. The server integrates and analyzes the collected data to provide Traffic-Splitting control information, while the client performs flow splitting based on this information and the current network and user state.

Related Work

In recent years, the rapid development and widespread adoption of mobile terminals have led to the exponential growth of mobile Internet services. Mobile Internet, utilizing mobile devices as carriers and broadband mobile networks as platforms, offers personalized services to a vast number of mobile subscribers. It is considered the next frontier of internet economy development. Predictions indicate that in 2014, on average, each mobile subscriber will generate around 7GB of mobile data traffic, with the total traffic produced by all mobile subscribers being 39 times that of 2009. With this upward trend, the existing wi-fi cellular networks, including 3G and LTE networks, are unable to meet the increasing demand for mobile traffic. Mobile operators are faced with the challenge of exponentially increasing operating costs without a proportionate increase in income from mobile data services. This situation calls for a low-cost and effective networking solution.[7]

The International Organization for Standardization 3GPP (Third Generation Partnership Program) has developed international standards for the merging of 3G and WLAN (Wi-fi Local Area Network). These standards include close coupling and loose coupling schemes. However, these technologies have limitations. They involve integrating and transforming existing cellular networks with Wi-Fi networks, resulting in high construction costs, long implementation cycles, and increased complexity.[2] Additionally, these technologies heavily rely on existing cellular networks, lacking scalability and flexibility. The flow of data from Wi-Fi networks is routed through the core network of the cellular network rather than directly accessing the internet, which fails to effectively solve congestion issues within the cellular network.[8,9] These technologies focus primarily on the network side and do not consider the impact of user requirements. They do not offer differentiated traffic routing based on user needs. For instance, high real-time business requiring low latency and delay variation, such as voice calls, cannot be efficiently redirected to Wi-Fi networks. As a result, these technologies do not adequately address network congestion problems, and the instability of Wi-Fi networks may degrade the quality of real-time business. Furthermore, these technologies do not consider the current state of mobile subscribers, leading to suboptimal user experiences.

To explore alternative solutions, one another resource allocation system and method for multi-net cooperative transmission in a heterogeneous wi-fi environment. This system splits network-side business streams into multiple subservice streams and transmits them to corresponding identification equipment terminals via multiple wi-fi access networks. The identification equipment terminals receive and forward the subservice streams to receiving terminals, where they are merged back into a single business stream.[6] However, this technology is complex, requiring the addition of new units on the

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network side, which entails transforming existing cellular networks and poses technical challenges. Additionally, it mainly focuses on traffic routing for mobile operators, lacking flexibility and scalability for internet services. Furthermore, it only addresses the transmission issues of a single business stream and does not provide solutions for multiple business streams or consider the dynamic state of mobile subscribers, leading to potential user experience issues.[10]

Research Objective

The objective of this research is to design and implement a Traffic-Splitting system for heterogeneous wi-fi networks that can effectively address network congestion caused by the rapid growth of mobile traffic. The specific objectives include:

1. Developing a Traffic-Splitting client for mobile terminals to collect network state information and user state information.
2. Designing a Traffic-Splitting server to analyze and integrate the collected data for Traffic-Splitting control.
3. Implementing flow splitting based on the Traffic-Splitting control information, network and user states, and adjusting the Traffic-Splitting strategy dynamically.
4. Evaluating the performance and effectiveness of the Traffic-Splitting system in mitigating network congestion and optimizing Traffic-Splitting.

Heterogeneous Wi-Fi Networks through a Traffic-Splitting System

The proposed system aims to enable the seamless integration and efficient management of heterogeneous wi-fi networks. It consists of two main components: the shunting client located on the mobile terminal side and the point streaming server on the network side, connected to the internet. The shunting client collects network and user state information and reports it to the point streaming server. The shunting server integrates a large amount of mobile terminal network and user state information, performs data analysis, and provides flow-dividing control information to the shunting client. Based on the control information received from the point streaming server, the shunting client dynamically distributes network traffic based on the current state of both the network and the user. It also adjusts its distribution strategy according to changes in network and user conditions, thereby facilitating effective shunting in a heterogeneous wi-fi network.

The system supports shunting between different types of wi-fi networks, such as cellular networks and WLANs, as well as shunting within WLANs. The shunting client comprises several components to facilitate its functionalities. The User Status Collection Device gathers user state information, including

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the user's current location, movement speed and direction, and their usage patterns on mobile devices. This information is stored in the shunting client's streamed data storehouse. The Terminal System State Collection Device collects system status information of the mobile terminal, such as available memory, CPU resources, and remaining battery life. Similarly, the Network State Collection Device captures the current network state information of the mobile terminal, including signal strength, data transmission speed, and packet loss. Both the terminal's status and network state information are stored in the streamed data storehouse of the shunting client. The Diffluent Information Sending/Receiving Device extracts various information, including user state information, terminal system state information, network state information, and user inquiries, from the streamed data storehouse of the shunting client. This device sends this information to the point streaming server on the network side and simultaneously receives flow-dividing control information from the server. The control information includes distributing strategy information. The Data Analysis Engine is responsible for analyzing the data in the streamed data storehouse of the shunting client. It analyzes user state information, terminal system state information, network state information, and the flow-dividing control information provided by the point streaming server. The analysis results are stored in the streamed data storehouse of the shunting client. Additionally, the Distributing Strategy Configurator receives the distributing strategy information from the point streaming server and allows mobile subscribers to configure their own distributing strategies.

The Flow-Dividing Control Module processes data from various mobile applications, taking into account the flow-dividing control information provided by the point streaming server and the current user state, terminal system state, and network state information. It manages the shunting and data buffering of different mobile application data. The Data Buffer is responsible for buffering the data of various applications according to the instructions from the shunt controller, ensuring smooth shunting and providing the best consumer experience. The Flow-Dividing Control Module continuously monitors the current applications and data transmission queues, determining whether an application is suitable for shunting. If it is suitable, the module further examines the user's current state and the terminal's system mode to confirm if shunting is feasible. It then searches for the optimal WLAN network based on the application's quality of service requirements. If a suitable network is found, the client executes WiFi shunting. The client continuously monitors the network, terminal, user, and application states. If any state changes and shunting is no longer applicable, the WiFi shunting is terminated. The Diffluent Information Sending/Receiving Device on the point streaming server side classifies the received information based on its type. If the information is state-related, it is categorized and stored in the streamed data storehouse. On the other hand, if it is an inquiry request, the server analyzes factors such as the user's position and their usage patterns to determine the optimal WLAN network for the user. The server then retrieves the relevant business information and sends it back to the shunting client.

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Moreover, the point streaming server includes a streamed data storehouse to store various streamed data information, including user state information, terminal system state information, and network state information. This storehouse acts as a repository for the data analysis engine, which extracts and analyzes the collected information from mass users. Through data mining techniques, the analysis engine generates WLAN network chart information, allowing it to provide flow-dividing control information. The results of the analysis are stored in the streamed data storehouse for future reference.

Additionally, the system incorporates a network management interface that serves as a direct interface between the management server and the cellular network and WLAN. This interface enables the server to obtain internal state information from each network, allowing for more accurate shunting. By leveraging this network management interface, the system can optimize the distribution of network traffic and enhance overall network performance. In summary, the proposed system for heterogeneous wi-fi network shunting consists of a shunting client and a point streaming server. The shunting client collects user state, terminal system state, and network state information, while the point streaming server receives and processes this information. The server generates flow-dividing control information, which is sent back to the shunting client to facilitate the efficient distribution of network traffic. The system supports shunting between different wi-fi networks and within WLANs. By analyzing the collected data and considering factors such as user behavior and network conditions, the system aims to provide an enhanced user experience by optimizing network resource allocation and reducing congestion.

Conclusion

In conclusion, this research presents a comprehensive Traffic-Splitting system for heterogeneous wi-fi networks to address the challenge of network congestion resulting from the rapid increase in mobile traffic. By utilizing a Traffic-Splitting client and server architecture, the system collects and analyzes network and user state information to enable efficient flow splitting. The system effectively splits mobile user traffic to WiFi networks, reducing congestion in cellular networks and enhancing user experience. Additionally, the proposed solution offers a flexible and lightweight approach, overcoming the limitations of high construction costs and low flexibility observed in existing methods. The research contributes to the development of a rapid and deployable solution for managing mobile traffic in heterogeneous wi-fi networks.

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