REVIEW OF THE ACCESS NETWORK SELECTION ALGORITHMS ON WI-FI OFFLOADING IN LTE NETWORKS

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ABSTRACT: Currently, global mobile data traffic is booming and shows no sign of slowing down as increasing speed impacts more use of mobile data in the future. The consideration of speed rates mobile communication is due to the growing use of very large amounts of data traffic, which this is a major obstacle faced by the telecommunication service providers to meet the growing demand. Therefore, the problem of data explosion on the mobile phone network is solved using Wi-Fi offloading. In this study, a comparison of the access network selection algorithm in the Wi-Fi offloading process and the LTE network is conducted. The outcome of this review shows the findings of network selection factors and handover strategies on Wi-Fi and LTE networks. As a result, the hybrid ANDSF model is the state-of-the-art and machine learning and computing is suitable method use for access network selection.

KEYWORDS: *Wi-Fi Offloading; Network Selection; LTE; Radio Access Technology; Signal Threshold*

1.0 INTRODUCTION

According to Cisco [1], Wireless networks and smartphone makers are gearing up to launch the world's first 5G (fifth generation) networks early next year. Global mobile data traffic is growing and shows no sign of slowing down as increasing speed impacts more use of mobile data in the future.

The consideration of these speed rates is the increasing use of very large amounts of data traffic, which this is a major obstacle faced by the cellular telephone service providers to meet the growing demand. Wi-Fi (Wireless Fidelity) offloading is envisioned as a promising solution to the mobile data explosion problem in cellular networks [2].

The importance of this research is to find out the existing algorithms in the selection of Wi-Fi networks with LTE (Long Term Evolutions) since the problem of Radio Access Technology (RAT) in 5G that is the Next Generation Communication in Wi-Fi networks continues to increase. Quality of Service requirements (QoS) constantly improve to provide customers with better QoE (Quality of Experience). The handover method will, of course, change according to the technology.

The scope of research focuses on the problem of selecting Wi-Fi network access with LTE networks in 5G. The contribution of this review is the access network selection factors and handover strategies on Wi-Fi and LTE networks are obtained. The use of the hybrid ANDSF model is the method of choice and at the cutting edge research. The use of machine learning and computing is the most suitable adaptive choice for network selection in the future [3].

2.0 NETWORK SELECTION

A significant number of mobile users cannot be served by a single network radio access technology that concurrently offers cheap cost, low energy consumption, low latency, high bandwidth, and high throughput data services. On the mobile terminal, network selection is suggested for selecting and switching wireless interfaces in heterogeneous networks.

At the beginning of the implementation of Wi-Fi offloading technology, the algorithm used for network selection uses Wi-Fi hotspot to keep mobile devices connected. This algorithm has the lowest threshold in signal strength and works with a minimum limit of 0. As a result, if Wi-Fi is active, the algorithm cannot switch the network to a cellular signal. Users must turn off the Wi-Fi application manually.

2.1 Network Selection Factors

The Network Security Services (NSS) is a collection of cryptographic computer libraries designed to support cross-platform development.

Using a NSS, a user equipment (UE) can choose the best access network from various networks, such as cellular and Wi-Fi networks. The best RAT among the various networks is selected using a variety of alternatives and methods, but not all the same considerations should be considered. The received signal strength (RSS), rather than the data rate or congestion, is the specific factor used to identify the optimal RAT.

In [4], a strategy for selecting network-cooperation-based radio access technology between Wi-Fi and high-speed downlink packet access is find out. This selection schema is done using the RAT suitability with the high speed downlink packet access (HSDPA) algorithm.

2.2 Strategy of Handover

A crucial technique for maximizing the use of radio resources between various wireless access networks is vertical handover (VHO)[5]. Formal handover based on RSS is appropriate for horizontal handover (HHO) but not for making a VHO choice [5]. As a result, numerous research projects have investigated using the characteristics of heterogeneous wireless networks. According to the research in [6], a signal-to-noise ratio (SINR)-based VHO has a greater throughput for the terminal and network than RSS-based HHO.

The policy enabled VHO method was introduced in [7] and considered many variables using a cost function. They are presented in [8] as an improved approach, the multi-criteria VHO algorithm. In [9], a VHO algorithm was presented that focused on RSS and bandwidth as the main variables. The drawbacks of these algorithms include the potential for ping-pong effects if a trade-off between various performance measures is not considered.

Devices able to construct a network map and get information about various access networks. Such additional information is essential to the handover process for each accessible access network. According to simulations in [10], it chose the best network compared to the traditional trigger method. To the selected network, the switching is initiated at the right moment. Additionally, this technique considerably reduces the energy consumption of multi-radio equipment. This clever technique allows seamless handoff and improve the continuity of ongoing sessions.

2.3 Access Network Selection Algorithms

The access network discovery and selection function (ANDSF), which manages changeover operations between 3GPP and non-3GPP networks, has been designed by 3GPP to allow users' equipment (UEs) to find nearby non-cellular wireless access networks [11], [12]. Based on recent geographic data gathered from UEs, the primary purpose of ANDSF is to identify nearby access networks that are open for use. Additionally, ANDSF oversees prioritizing the available access networks following operator policies.

3.0 RESULT OF NETWORK SELECTION ALGORITHMS

A mobile device selects one of the available femtocells as traffic offloading is an essential operation in Long Term Evolution (LTE) networks. Several network selection strategies based on multiple attribute decision-making (MADM) methodologies have recently been implemented for LTE traffic dumping [13], [14]. To determine the priority scales of individual judgments, the Analytic Network Process (ANP), a MADM technique, configures the decision-making problem as a network of attributes. This method has received very little research attention for network selection in cellular networks.

In [14], the utility value of each network attribute is first determined using utility functions for various services. The objective and subjective weight of network features are then determined using the entropy approach and the fuzzy-analytic hierarchy process (FAHP). FAHP is also utilized to determine the user preference ratings of services for candidate networks. The score of each candidate network is then determined using the following methods: simple additive weighting (SAW), multiplicative exponent weighting (MEW), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [13]–[16]. To balance the user's payment with the service quality measured by the file transfer deadline [17].

In order to increase the overall system throughput in an LTE-Wi-Fi system with offload capabilities, the optimal RAT selection problem is considered in [18]. In [19], they offer an online Radio Access Technology (RAT) selection algorithm utilizing the Relative Value

Iteration Algorithm (RVIA), which is motivated by the Post-Decision State (PDS) paradigm to discover the optimal policy under unknowable statistics of system dynamics [19], [20]. The adaptive multi-criteria vertical handoff (AMVHO) decision technique increases the precision of the vertical handoff choice for heterogeneous radio networks[8]. This approach uses a modified Elman neural network (MENN) and a fuzzy inference system (FIS). The MENN assists in making predictions for the FIS's key variable, the after-handoff network's user count. A vertical handoff (VHO) strategy based on WLAN is first presented in [21] and is used in their suggested model.

In [22], [23] discusses ways to offload Wi-Fi in Long Term Evolution (LTE) cellular networks where performance demands are more significant than what the LTE access can provide. The performance of each access technology is then compared using various network performance measures. An enhanced signal-to-noise ratio (SNR) threshold-based handover solution and 3GPP standard extension for access coverage are described in detail. The Network Discovery and Selection Function (ANDSF) framework for Wi-Fi offloading are suggested when multiple radio accesses are available.

In [24], it has been suggested to shift data traffic from the present LTE-advance system or the upcoming 5G system from licensed frequency to unlicensed spectrum used by Wi-Fi systems. A Listen-Before-Talk (LBT) strategy is used in the current LTE-Wi-Fi coexistence standard to ensure that the LTE system senses the medium before a transmission. The data rate, service cost, lag time, and power usage have all been considered [24]. The permanent matrix is computed to derive a "network satisfaction value".

Machine learning methods are used to obtain and analyze operator data from three LAA cellular operators. In three steps, the effect of the phenomena on LTE, LAA, and Wi-Fi components is shown. First, the variation in PCI scenario predictions of network performance accuracy is examined. Second, the effectiveness of numerosity reduction approaches utilized in data-driven cell selection is assessed in both PCI situations. In the third step, network measurements and operator data analysis are compared. In-person tests are carried out at the same PCI and several PCI sites to examine variations in real-time network performance. Multiple traffic categories are taken into consideration as a managed LTE-Wi-Fi coexistence environment is built. Finally, a class-weight-based approach to PCI scenario detection is suggested [25].

The cellular network service providers use a variety of RATs to expand the capacity of their networks; these networks are known as heterogeneous networks (HetNets). User equipment (UE) often chooses an access network in a HetNet based on the priority list of the network service provider since it is possible choosing an access network based on the priority list and not effectively use the available network resources. Therefore, in [26], they emphasis employing metrics for throughput, latency, and received signal strength indicator (RSSI) to continuously monitor the state of a HetNet. They provide access network selection and switching methods based on these metrics. A Relative Value Iteration Algorithm (RVIA)-centric Q-learning approach provides an online algorithm for selecting the best RAT [20].

In [18], [19], [27] suggests a new user association algorithm that considers joint node and mode selection. A fairness-oriented carrier selection (F-CS) method is additionally presented for use in performing carrier selection for LTE-U users, and it is based on the F-CSAT mechanism [28]. Based on the journals we reviewed, we grouped the types of algorithms that classify the limits of SNR values and other parameters in the network selection process. Table 1 is the result of our review. This review is only for Wi-Fi to LTE networks.

According to our analysis, the most proposed method by the researcher uses the hybrid method for LTE networks. Some researchers carry computational and machine learning methods. Computing provides algorithms that are more flexible and gives better performance. The research gap in selecting Wi-Fi networks with LTE can be seen in Table 1. From this table, researchers determine the next research step. 5G technology requires high speed data transmission. Therefore, the research direction refers to throughput as a future limiting parameter of network selection algorithms. With artificial intelligence (AI) technology advancing, deep learning and machine learning is unbeatable in making decisions.

The 5G system adopts the New Radio Access Technology. This technology develops the existing LTE using OFDM (Orthogonal Frequency Division Multiplexing) techniques. Using the new radio spectrum will be challenging to access the required high speed. Meanwhile, Wi-Fi technology is also undergoing evolution. The Wi-Fi 6E standard uses the triple band of 2.4 GHz, 5 GHz, and 6 GHz. Thus the network selection between Wi-Fi and Next-Generation mobile telephone cellular will continue to evolve.

Table 1: Comparison of network selection algorithm

Algorithms	On the Spot	Fix SNR Threshold	ANDSF modelled based on Cell ID	ANDSF modelled based on Position	Hybrid ANDSF model	Mechanism
NetANPI [13]					√	MADM
FAHP [14]					√	Service characteristics and user preferences
DAWN [17]					√	lowest payment
Optimal Radio Access [18], [29]		√	√	√	√	CALC–OPT–POLICY–UC
AMVHO [8]					√	FIS, MENN
Modelling & Simulation [21]		√				WLAN-first
Performance-Centric [22], [23]	√	√	√			Performance-Centric
Listen-Before-Talk (LBT) [24]				√		Fair coexistence
Incertitude [16]					√	A triangular fuzzy
Machine learning [23], [25]					√	Game theory
Physical Cell Id [25]			√			Comparison of data with network measurements
Access and switching [26]				√	√	RSSI, throughput, & delay metrics.
RVIA [19], [20]					√	Maximizing throughput
User association [18], [19], [27]		√		√	√	Matching Game
Fairness-oriented Carrier [28]					√	Access fairness

Figure 1 shows the graph of comparison for network selection algorithms studied by most researchers in this field. It is shown that the Hybrid ANDSF algorithm is mostly studied and used for network selection. This is proven that Hybrid ANDSF is the state-of-the-art for network selection in wireless sensor networks.

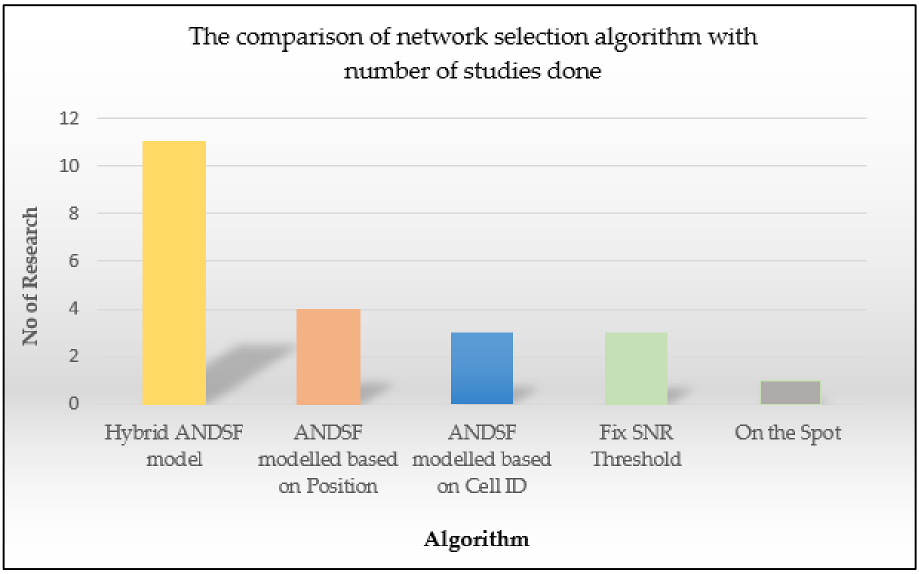

Figure 1: Graph of comparison for network selection algorithm most under studied by researchers

4.0 CONCLUSION

According to our analysis, the most proposed method by the researcher uses the hybrid method for LTE networks. The use of the Hybrid ANDSF model is the method of choice in the latest research. Computing provides algorithms that are more flexible and gives a better performance. The use of machine learning and computing is the most suitable adaptive choice for network selection in the future Next-Generation Telecommunication.

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