A Methodology for 4G Mobile Networks using Vertical Handoff Approach
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Abstract—The requirement of high bandwidth and greater mobility in the next generation mobile network can be fulfilled with the combination of both the technologies and this can only be achieved with the help of vertical handoff. The selection of vertical handoff technique is very important because it affects the quality of service in the network. The objective of this paper is to provide an intelligent and accurate decision making algorithm which is based on different input parameters.

Key words: Reasoner, Processor

I. INTRODUCTION

There are varieties of wireless access network presently available some of them like Wireless Local Area Network using WiFi and adhoc network and other is Wireless Metropolitan Area Network using WiMax standard. Handoff is the process of maintaining a mobile user connection active while it moves within a wireless network. Mobility of a user can be maintained by two different handoff strategies. The first one is Horizontal Handoff and second one is Vertical Handoff. In horizontal handoff, handover is between two base stations which is using the same wireless access network technology. In vertical handoff, handover is between two network access points that using the different wireless access network technology. The vertical handoff process involves three steps namely source information, reasoner for decision making and the processor for handoff execution. [1]

In the next generation wireless network the most important use of vertical handoff is to integrate vertical handover between wireless local area network (WLAN) and cellular network. Both these technology exist in the wireless network and many devices having the interface to support WLAN and cellular network both. The features of both the technologies are complimentary to each other. WLAN can cover some specific places like college campus, commercial building and provides greater bandwidth with low cost but the mobility is limited whereas the cellular cover a wide area and provide greater mobility but low bandwidth and high cost. So the requirement of high bandwidth and greater mobility in the next generation mobile network can be fulfilled with the combination of both the technologies and this can only be achieved with the help of vertical handoff. The selection of vertical handoff technique is very important because it affects the quality of service in the network. The objective of this paper is to provide an intelligent and accurate decision making algorithm which is based on different input parameters.

II. ARCHITECTURE AND COMPONENTS DESCRIPTION

[3] The proposed architecture consists of Sources Information on the mobile device and also in the fixed network and the Processor and the Reasoner components on the mobile device. Traditionally, the handover decision could be taken entirely by the network which is called Network Controlled Handoff (NCHO). But in the next generation technology the handoff decision entirely based upon mobile device which is called Mobile Controlled Handoff (MCHO). [4] There also exist some approaches which combine both of these strategies. The later is more useful in the next generation mobile network because it uses IP based mobile service. We choose to take handover decision on the mobile device because most of the sources are located on the mobile device and we do not use Mobile IP for handling mobility. Moreover, this mobile controlled handoff supports the mobile device to take such decision and for this it does not need to depend on the external entities for the handover decision.

A. Source Information Parameters (Mobile End):

1) Location
Coordinates of the device’s current geographic location as obtained from the GPS receiver. [6] It has been observed that the availability of and the Quality of Service provided by the mobile networks depends on the location.

2) Device Information
For a given mobile device, its model, CPU type, CPU clock speed (MHz), remaining battery level could be obtained using the OS API calls. For a given device, power required for creating and transmitting data, CPU type and clock speed influence the QoS of the network. Battery level could be combined with the user’s power saving preferences.

3) User Preference
[10] A list of all the mobile network providers, network names, and network technologies a user can subscribed from the list. A list of all the device services ranked according to their importance to the user. User’s power preference (Yes/No) indicating whether should consider/or not power usage during network selection. All the above information could be obtained from the user using the user interface.

B. Source Information Parameters (Network End)

1) Availability At The Location
The prediction of the Quality of Service network source are based on the historical data combined with learning mechanisms. The information obtained from the host source is an input for Quality of Service prediction of network source. However, Quality of Service predictions source does not depend only on the information provided by the host source, but also use a variety of other information.

C. Quality of Service Prediction
All the available networks as specified by provider names, network names and technologies along with their coverage ranges and availability at a given location and predicted QoS. This information is useful to know the available...
networks for handover along the user’s mobility path and preference.

D. Processor

The role of the Processor is to get information from the sources and the fixed network and provide this information to the reasoner to be able to make a network selection decision at a given time and location. After the first activation of the mobile device, processor obtains the user’s information from the user information source, current location and time from the location and time source, device information from the device source and provides this information to the quality of service prediction source to get a complete quality of service prediction information according to the user location. The quality of service prediction information is useful at a given location and time for current quality of service predictions. After the first activation of the device, processor also subscribes to the user preferences source, device service and communication source. The information obtained from these sources and the current network predictions together form the current information. The current information is updated according to the changes received from other sources. Processor sends the current information with the relevant changes to reasoner for the further processing.

E. Reasoner

The Reasoner is an event driven component and is responsible for the selection of one of the available networks for the handover from the current network, by considering user preferences, device requirements, device perception and its quality of service at different level. To be able to make use of the available information, reasoner uses the following set of objectives for optimizing the selection of the network:

- Maximize user’s network preferences.
- Consider user preference on power consumption issue.
- Maximize device throughput requirements.
- Minimize device delay requirements.

III. METHODOLOGY

In the future mobile networks must be able to coordinate different services within a network environment. For example, a widely deployed third generation (3G) cellular network is used for voice and data service with much faster speed than previous 2G cellular network ex: general packet radio service (GPRS). But in the next generation mobile network the data rate and quality of service is the most important issues. To obtain the requirement of bandwidth and high data rate the well known technology IEEE 802.11 is to be coordinated with our mobile network. For this we have to introduce a new concept of vertical handoff. In this paper we are trying to provide components of a vertical handoff decision algorithm that provide access network selection at a mobile node. A performance study shows that our proposed vertical handoff decision algorithm is able to determine when a handoff is required, and selects the best access network that is fulfill the network conditions, quality of service requirements, user preferences, and service cost.

IV. FUZZY LOGIC ALGORITHM

In my proposed algorithm for handoff between 4G networks and WLANs by combining the RSS measurements either with an estimated lifetime (expected duration after which the mobile station will not be able to maintain its connection with the WLAN) or the available bandwidth of the WLAN candidate.

In the first scenario, when the MS moves away from the coverage area of a WLAN into a 4G cell, a handoff to the 4G network is initiated. The handoff is triggered under the conditions that (a) RSS average of the WLAN connection falls below a predefined threshold, and (b) the estimated lifetime is less than or equal to the handoff delay. The MS continuously calculates the average RSS using the moving average method.

\[ \text{RSS}(k) = \frac{1}{W_o} \sum_{i=0}^{k} \text{RSS}(i) \]

RSS(k) is the calculated average of RSS at time instant k. \(W_o\) is the window size of a slope estimator, a variable that changes with the velocity of the MS.

In the second scenario, when the MS moves towards a WLAN cell, the handoff to the WLAN is initiated if (a) the average RSS measurements of the WLAN is larger than a threshold and (b) the available bandwidth of the WLAN meets the bandwidth requirements of the application.

Since the lifetime metric and bandwidth are considered, the algorithm adapts to the application requirements and the user mobility and also the number of unnecessary handoffs is reduced. There is an improvement in throughput for the user, because of the MS’s ability to remain connected to the WLAN as long as possible. However, Packet delays can be increased with an increase in the life time, due to the deterioration of the channel condition, as the MS moves towards the boundary of the WLAN. This issue can be critical for delay sensitive applications and degrade their performance. Along with RSS five more factors play an important role to decide handoff which is 1) available bandwidth, 2) Battery life, 3) Speed of mobile, 4) Coverage area 5) No. of users.

V. FUZZY LOGIC

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multi-valued logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of FL. Even in its more narrow definition, fuzzy logic differs both in concept and substance from traditional multi-valued logical systems.

In Fuzzy Logic Toolbox software, fuzzy logic should be interpreted as FL, that is, fuzzy logic in its wide sense. The basic ideas underlying FL are explained very clearly and insightfully in the Introduction. What might be added is that the basic concept underlying FL is that of a linguistic variable, that is, a variable whose values are words rather than numbers. In effect, much of FL may be viewed as a methodology for computing with words rather than
numbers. Although words are inherently less precise than numbers, their use is closer to human intuition. Furthermore, computing with words exploits the tolerance for imprecision and thereby lowers the cost of solution.

Another basic concept in FL, which plays a central role in most of its applications, is that of a fuzzy if-then rule or, simply, fuzzy rule. Although rule-based systems have a long history of use in AI, what is missing in such systems is a mechanism for dealing with fuzzy consequents and fuzzy antecedents. The fuzzy logic mechanisms has provided by the calculus of fuzzy rules. The calculus of fuzzy rules serves as a basis for what might be called the Fuzzy Dependency and Command Language (FDCL). Although FDCL is not used explicitly in the toolbox, it is effectively one of its principal constituents. In most of the applications of fuzzy logic, a fuzzy logic solution is, in reality, a translation of a human solution into FDCL.

We can use Fuzzy Logic Toolbox software with MATLAB technical computing software as a tool for solving problems with fuzzy logic. Fuzzy logic is a fascinating area of research because it does a good job of trading off between significance and precision—something that humans have been managing for a very long time.

In this sense, fuzzy logic is both old and new because, although the modern and methodical science of fuzzy logic is still young, the concepts of fuzzy logic rely on age-old skills of human reasoning.

Fuzzy logic is a form of many-valued logic in which the truth values of variables may be any real number between 0 and 1, considered to be "fuzzy". By contrast, in Boolean logic, the truth values of variables may only be 0 or 1, often called "crisp" values. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific (membership) functions.

The term fuzzy logic was introduced with the 1965 proposal of fuzzy set theory by Lotfi Zadeh. Fuzzy logic has been applied to many fields, from control theory to artificial intelligence. Fuzzy logic had however been studied since the 1920s, as infinite-valued logic—notably by Łukasiewicz and Tarski.

A basic application might characterize various sub-ranges of a continuous variable. For instance, a temperature measurement for anti-lock brakes might have several separate membership functions defining particular temperature ranges needed to control the brakes properly. Each function maps the same temperature value to a truth value in the 0 to 1 range. These truth values can then be used to determine how the brakes should be controlled.

Fig. 1: Fuzzy Logic Temperature

In this image, the meanings of the expressions cold, warm, and hot are represented by functions mapping a temperature scale. A point on that scale has three "truth values" — one for each of the three functions. The vertical line in the image represents a particular temperature that the three arrows (truth values) gauge. Since the red arrow points to zero, this temperature may be interpreted as "not hot". The orange arrow (pointing at 0.2) may describe it as "slightly warm" and the blue arrow (pointing at 0.8) "fairly cold".

A. Forming a consensus of Inputs and Fuzzy Rules

Since the fuzzy system output is a consensus of all of the inputs and all of the rules, Fuzzy logic systems can be well behaved when input values are not available or are not trustworthy. Weightings can be optionally added to each rule in the rulebase and weightings can be used to regulate the degree to which a rule affects the output values. These rule weightings can be based upon the priority, reliability or consistency of each rule. These rule weightings may be static or can be changed dynamically, even based upon the output from other rules.

B. The Fuzzy Logic Process

1) Fuzzify all input values into fuzzy membership functions.
2) Execute all applicable rules in the rulebase to compute the fuzzy output functions.
3) De-fuzzify the fuzzy output functions to get "crisp" output values.

VI. CONCLUSION

Vertical mobility has been a topic of research for over a decade now, and it is deployed in commercial products and field tests. Yet, the popularity of seamless services has not taken its place in the everyday life of consumers in the same way that talking to a mobile phone or using Internet from a home PC. While there is some doubt if vertical mobility will ever have significant enough revenue creating ability for operators, the future challenge is to "put into action" services and applications that utilize vertical roaming with both technical and economical excellence. These services need to be enabled and introduced in mobile handsets with viable and tailored applications in order to see their full benefits. The challenge is about enabling better mobile applications through holistic plug-and-play connectivity and "always best connected" paradigms.

REFERENCES


