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REDUCING WI-FI HANDOVER DELAY USING A NEW POSITIONING PROCESS

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ABSTRACT

Mobility has now a crucial requirement for wireless communication. Handover is one of the major tasks that are used to support continuous transmission for a mobile terminal into different radio coverage area. Optimizing the existing handover protocol requires integrating new functionalities. This work focuses on presenting and optimizing handover algorithm. We analyze handover time in wireless local area networks based on the IEEE 802.11b MAC protocol. In fact, scan phase is the main contributor to the handover time. Then, we propose a handover model which replaces a scan phase by a positioning process. This model is able to select the suitable access point (AP) based on the shortest distance far from the mobile terminal (MT). Proposed Handover allows a mobile user to reacting quickly to decide about to which access point to connect. Simulation results show that the proposed model provides gains in term of delays and Handover success in various scenarios

Index Terms— *IEEE 802.11, Handover, positioning, Latency.*

1. INTRODUCTION

This research introduces characteristics of WiFi (Wireless Fidelity) architecture and particularities of its mobility. Handover protocol has been attracting a lot attention from researchers in order to provide continuity of communication to mobile user. In order to reduce Handover procedure delay, some steps of handover must be revised. Classical procedure can then be optimised. Particularly, this work involves the impact of positioning component for handover protocol in a WiFi environment. It proposes fast handover protocol based on positioning process in order to minimize amount of time for handover procedure.

This paper is organized as follow. Section 2 presents the IEEE 802.11 environment. In section 3, we describe the classical handoff mechanism and we perform its constraints. Section 4 presents proposed Handover algorithms in the literature. In section 5, we detail our proposition to reduce handover latency. The simulation, analysis and synthesis are illustrated in Section 6. Section 7 concludes the paper.

Today, there are nearly pervasive WiFi delivers high-speed Wireless Local Area Network (WLAN) connectivity to millions of offices, homes, and public locations, such as hotels, and airports. The integration of WiFi into notebooks, handhelds and Consumer Electronics devices has accelerated the adoption of WiFi to the point where it is nearly a default feature in these devices [10]. WiFi is also characterized by easiness to deploy and less cost than cellular service. WiFi has the advantage to interoperate with others technologies as WiMAX.

2. WIFI OVERVIEW

The IEEE 802.11 architecture consists of a number of components. The Basic Service Set (BSS) is the basic building block in the architecture, and the members of a BSS communicate with each other or with the Internet hosts through access points. Multiple BSSs can interconnect with each other through a distribution system and form an Extended Service Set (ESS) [5]. The BSS consists of a number of mobile terminals. When MT is moving between different BSS, it needs to switch its AP which functions as a bridge permitting interconnection to the distribution System.

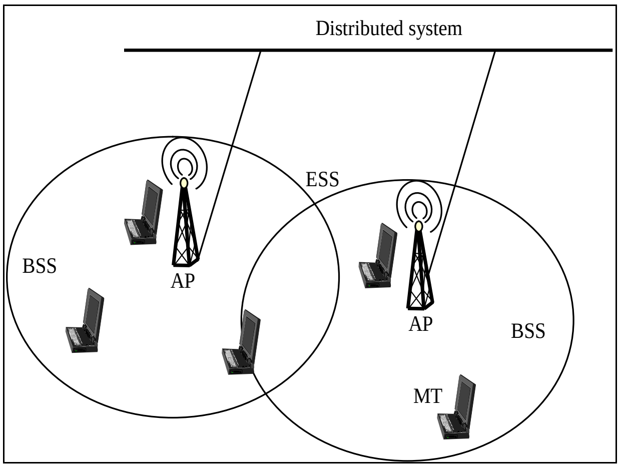

Figure 1. IEEE 802.11 architecture component

IEEE 802.11 specification focuses on the two lowest layers of the Open Systems Interconnection model (OSI model) that incorporate both physical and data link component. The physical layer consists of the radio and the radio's shared channel. The MAC layer maintains

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communications among 802.11 stations by managing the operation of the PHY and by utilizing protocols that support and enhance communications over the radio medium [1]. Figure 2 illustrates the basic WLAN architecture defined in the IEEE 802.11 standard.

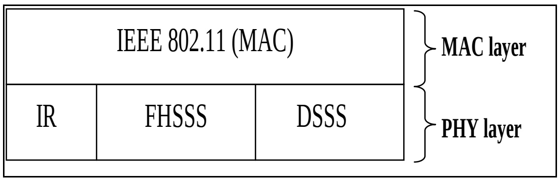

Figure 2. IEEE 802.11 architecture

3. HANDOVER SPECIFICATION

Handover term refer to different approaches to supporting mobility aspects. Distinctions between different propositions can be made according to the performance characteristics, diversity steps, state transitions, and control modes of handover techniques. Generally, Handover can be defined as the process by which an active MT changes its point of attachment to the network, or when such a change is attempted. Handover initiation is, generally, based on signal strength. The access network may provide features to minimize the interruption to sessions in progress [3]. The conventional Handover procedure comprises three phases namely Scan, Authentication and Association or Reassociation. Figure 3 illustrates Handover procedure as described in the IEEE Standard 802.11. It explains the basis handover model and its steps latencies [2]. More handover procedure details can be seen in [9].

3.1. Scan phase

In the scan phase, a MT tries to find a new available AP with the best signal quality. It selects channels to probe. Then, MT sends a probe request frame in order to obtain information from access point. For example, a MT would send a probe request to determine which access points (APs) are within range. When receiving a probe request frame, AP will respond with a probe response frame containing capability information, supported data rates, etc. The TM must explicitly scan each channel (11 channels in 802.11b and 802.11g, and 8 channels for 802.11a indoors) for potential access points. After probing all selected channels, the AP candidate is determined from the information received in the probe responses and their associated Signal to Noise Ratio (SNR).

In its simplest form, the scan phase can be completely passive. The MT switches to a candidate channel and listens for periodic beacon packets generated by access points to announce their presence (typically every 100 ms). However, the latency incurred by this approach can be quite long since the phase of beacon intervals is independent and a MT must therefore wait the full interval on each channel [8]. Scanning phase accounts for more than 90% of the overall latency. It is, then, considered as the dominating factor in handoff latency [1].

3.2. Authentication phase

Authentication phase depicts a process whereby the AP either accepts or rejects the identity of a MT. The MT begins the process by sending an authentication frame containing its identity to the AP. With open system authentication (the default), the MT sends only one authentication frame, to the selected AP which could accept or reject the connection through an authentication frame.

3.3. Reassociation phase

In Reassociation phase, we distinguish reassociation request and reassociation response. In fact, if a MT roams away from the currently associated AP and finds another AP having a stronger SNR, it will send a reassociation frame to the new AP. This last then coordinates the forwarding of data frames that may still be in the buffer of the previous AP waiting for transmission to the MT. An AP sends a reassociation response frame containing an accept notice to the MT requesting reassociation. Similar to the association process, the frame includes information regarding the association, such as association ID and supported data rates.

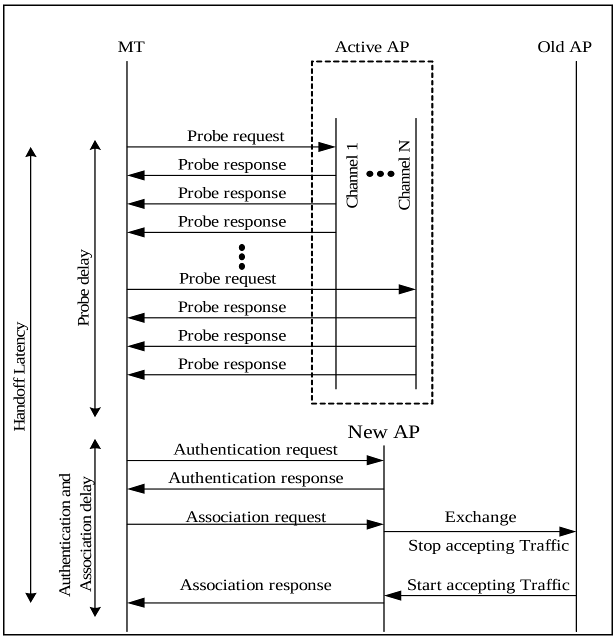

Figure 3. Handoff latency in IEEE 802.11 Networks [2].

4. RELATED WORK

Handover should maintain connectivity to mobile terminal as it moves from access point to another. Important issues related to handover include selection of optimised access point, initializing handover, handoff delay and routing. Different approaches have tried to optimise handover procedure in WiFi network to reduce handover time incurred by probing, authentication and association phases.

Some researchers propose an authentication phase that is designed to reduce the authentication delay during a WiFi handover process.

Details of this approach can be found in [4, 5]. We are interesting here of research that try to reduce a scan phase. In fact, Syed S. Rizvi and all [11] verify that the active scanning can reduce the overall handover time at MAC layer if comparatively shorter beacon intervals are utilized for packet transmission. In [11], mathematical model is proposed to be used to effectively reduce the handover time of WLAN at MAC layer. Simulation results verify that the utilization of probabilistic approach with the active scanning yields lower latency for each detection and search phases. Both simulation and numerical results of this paper demonstrate that the reduced handover time at MAC layer provides better load balancing, high throughput, and minimum frame transmission delay. The solution proposed in [2] consists of transmitting Probe requests which the scanning channels, stops once a Probe response indication is received with an adequate SNR. An SNR threshold level has been defined to select AP that provides QoS guarantee. Simulation results show that the proposed model reduce handover time by 22,28%. In [6] the handover was split into three phases, typically performed in sequence: detection, search and execution. Proposed approach has shown that the detection phase can be reduced to three consecutive non-acknowledged frames when stations are transmitting. A shorter beacon interval reduces the detection. The idea in [7] is to monitor continuously the signal quality of all access points in range. In this way terminal makes decisions based on signal levels received from all access points. If any available AP provides a significant better signal quality or the actual associated AP has too weak signal level to serve the MT with a specific link quality, it is necessary to initiate a handover process. The whole handover process is under control of the mobile node that is capable of performing fast handovers. In [8] a technique called SyncScan is described. This technique requires synchronizing short listening periods at the MT with periodic transmissions from each AP. SyncScan algorithm is implemented using commodity 802.11 hardware. Proposed scheme allows better handover decisions and seek to reduce the time spent in the channel scanning phase when a handoff occurs. In fact, implicit time synchronization is proposed to reduce the key cost of discovering new wireless access points. By synchronizing the announcement of beacon packets, a client can arrange to listen to other channels with very low overhead. As a result, handoff using this SyncScan approach is an order of magnitude quicker than using the conventional approach.

5. HANDOVER USING POSITIONING PROCESS

In wireless environment, supporting continuous communication with QoS guaranties is hard to attempt. This is due to fluctuation of network conditions, long time of signalling requirement. When moving into different radio coverage area, Mobile Terminal must find a new access point with which to associate. The access point should provide sufficient signal strength. We propose in this work to choose a nearest access points in order to increase handover success. In consequence, a scan step is eliminated. A positioning process offer advantage of focusing the choice of the access point candidate to which a terminal has a shortest distance. The positioning process is responsible for measuring distance between terminal and each access point. The positioning component calculates distance between mobile terminal and access point. It generates different distances in order to choice the nearest access point far from MT.

In this section, we outline the implementation of the positioning process in the MAC layer of a TM. We explain a modular architecture proposal of our contribution in the MAC layer, based on receiver, transmitter component and positioning process. Figure 4 details interaction between different processes using various types of handshaking signals.

To determine the position of TM in a 2D space, we used our new geometric approach to Mobile position in wireless LAN reducing complex computations [12]. This new geometric oriented algorithm is based on three distances measurements to determine the position of a mobile object. Provided that all operations in our proposed algorithm are additions, subtractions and multiplications based, the implementation is simplified which reduces complexity.

The proposed method converges and provides with a good accuracy the position of MS using a very reduced number of iterations (K<10). Hence, the major advantages of our algorithm are: implementation simplicity, and low computation overhead.

The following figure illustrates the system architecture; we divided location process to 4 parts: a process location algorithm, the square root component, divider block and buffers to store data

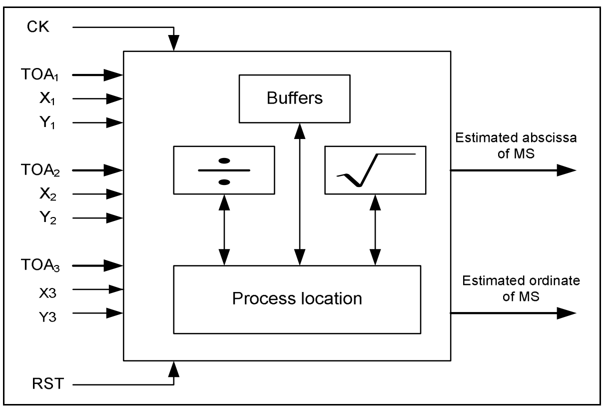

Figure 4. Top level structure of the Location circuit

Developed algorithms give information to allow mobile terminal to select an access point in an optimal way.

These algorithms explain also a complexity of implementing positioning process with VHDL description language. In fact, positioning process necessitates functions to the extraction and the manipulation of traffic parameters. It needs also functions to compute terminal position. Complex models including arithmetic operators as addition, division and multiplication are, then, required to be employed.

The equations for the x and y position of the mobile was modeled using VHDL. The numeric_std package was used to construct the VHDL model that was readily synthesized into a low power digital circuit. The input signal of the model are the x, y positions of the three APs, i,j,k in meters, and the signals TOA from the individual AP to the TM in nanoseconds. The input signal assignments are xi, yi, TOAi, xj, yj, TOAj, xk, yk, TOAk

After calculating its coordinates (x, y) and using a simple calculation of Euclidean distances, the MT can easily compare the distances which separate it from different available AP. The shortest distance corresponds to the AP closest to the MT. This closest AP will be then chosen to establish a new connection

The following figure shows the selection of the closest AP based on Euclidean distances

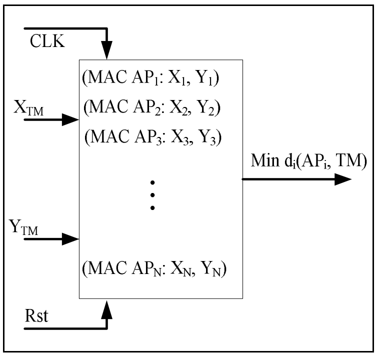

Figure 5. Min di (APi, MT) determination

The input signal of the model are the x, y positions previously computed of the TM in meters, and the signals CLK and Rst as operating clock and initialization circuit respectively. The output signal is the shortest distance from N distances and therefore the selected AP to establish the new connection.

6. RESULTS AND OBSERVATION

6.1. Basis model

A MT broadcasts probe request over three channels. On each channel, it expects to receive responses from three access points. Response frames as well as their SNR are buffered and then used to select the AP that satisfies the mobile requirements

Figure 5 gives an example of an active scan simulation. It shows also probe response frames identification, addresses extraction and SNR measurement. The rest of the handoff process reposes on authentication and association phases while each one a frame is sent to the selected AP and a response is received.

After probing all selected channels, the next access point is determined from the information received in the probe responses and their associated Signal to Noise Ratio (SNR). The following algorithm details the process described above.

Algorithm: Full-scanning algorithm.

For each channel to probe do
Broadcast probe request on this channel
Start probe timer
while True do
Read probe responses
if MinChannelTime expires, ***then***
break
end if
if MaxChannelTime expires, ***then***
break
end if
end while

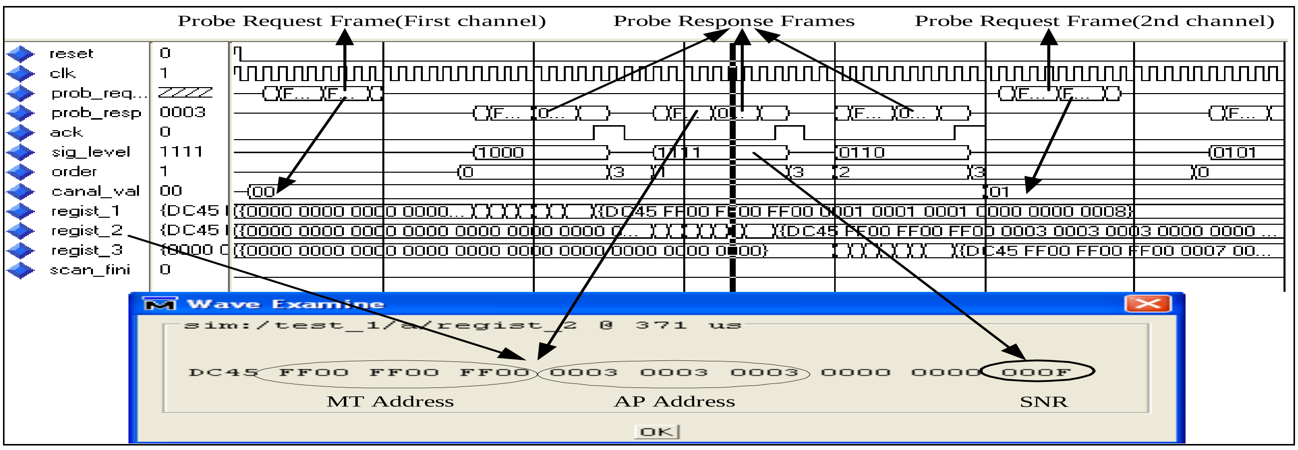

Figure 6. Simulation of the Scan Phase on the first channel (basis model).

6.2. Handoff with positioning process.

This work lies in the development, implementation and discussion of handover protocol. It shows performances of handover procedure in WiFi environment based on positioning strategy. In fact the proposed model is fixed to reduce handover time. Parameters values used to validation are selected according to typical cases. Performance evaluation is given by simulation. Our approach of handover is transposed on a concise description which support different scenario in WiFi environment. Handover algorithm is integrated on the MT. It is implemented in an FPGA environment with simulation and synthesis tools. The efficiency of this description for several network situations evaluates the Handover algorithm performances.

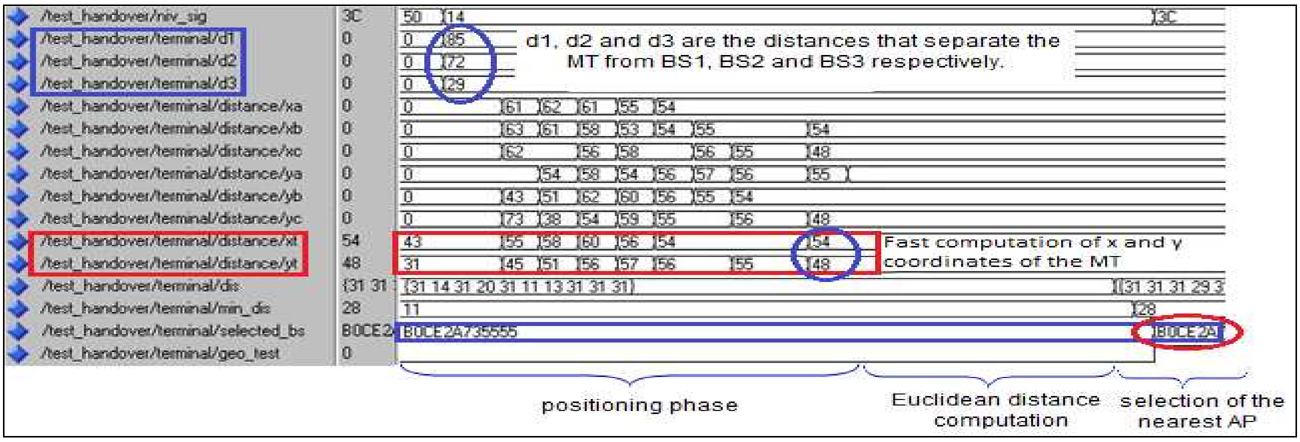

Figure 7. New Handover mechanism based on positioning phase

6.3. Comparison

With the basic model a mobile station broadcasts probe request over three channels. On each channel, it expects to receive responses from three access points. Response frames as well as their SNR are buffered and then used to select the AP, which satisfy the mobile requirements. Fig 5 gives an example of an active scan timing diagram. It shows also probe response frames identification, addresses extraction and SNR measurement. The rest of the handoff process reposes on authentication and association phases while each one a frame is sent to the selected AP and a response is received.

However, with positioning process, optimal handoff latency is improved by replacing the phase of the with a fast positioning process.

Simulation results show that the proposed model allows the reduction of almost 60% of the basic handover. The following figure shows the number of clock cycles required for each model.

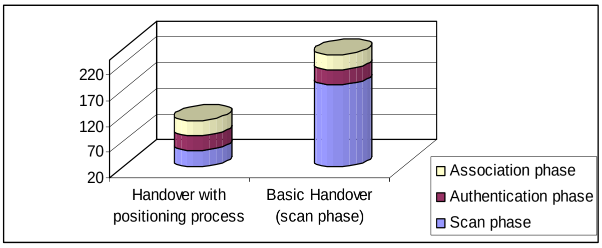

Figure 8. Handoff latency for new and basis models.

6.4. Synthesis results

During the synthesis step, we have exploited FPGA xilinx virtex 5 environment. This environment allows implementing communication systems on programmable circuits. The advantage of using FPGAs circuits is mainly the system re-scheduling. For our application, RTL synthesis is achieved using the ISE 10.1 of the Xilinx FPGA virtex 5 environment. Synthesis results, of the two approaches, are shown in table 1. These results should be exploited in order to study their impact on the support of the technological parameters specified in IEEE 802.11.

Table 1. Comparison of different handoff mechanisms

	Number of Slices	Number of Flip Flops	Frequency (MHz)
Basis Handoff	782	604	132
Proposed model	507	463	187

7. CONCLUSION

This paper shows a model that focuses on reducing handover time consumed by the channel scanning phase. Therefore, we presented a work for designing, simulating and synthesizing a positioning approach that replaces a scan phase. We discussed how a positioning approach can decrease handover during.

Implemented positioning IP reduces handover latency by finding out distance between mobile terminal and various access points. Results presented in this paper show that MT can select the optimal access point with low time. Component is designed and characterized by using a hardware design flow. The description was made with the high description language VHDL. ModelSim was used to check the behaviour of the system at the RTL level. It permits to determine the latency in terms of clock cycles. Synthesis was undertaken using the ISE 10.1 of the FPGA environment xilinx virtex 5, in order to evaluate the performance of the circuit in terms of surface area, critical time and frequency operandi.

The approach explained in this work has limitations that may not be apparent in indoor network, but are inadequate outdoor for network.

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