DESIGN AND IMPLEMENTATION OF MOBILE COMPUTING SIMULATOR

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ABSTRACT: - The Rapid progress in communications and wireless technology, especially in mobile computing, resulted in wide area of development in design, control and simulation of protocols that manage the wireless network. In this paper, a software simulator package has been designed, implemented and analyzed to simulate Internet Mobile Host Protocol (IMHP), Multicast Routing Protocol (MRP) and Handoff operation, which feature both route optimization and integrated authentication of all management packets.

The simulator coverage area includes three extendable subnets (LANs) with ten mobile hosts moving either randomly or manually over the network. The moving hosts have the ability of entering or leaving the network at any time. The designed simulator simulates all the predicted events that practically associated with mobile computing operation. In addition, the simulator stands for other events such as the rebooting or crashing in the network elements.

The simulated protocols are tested in terms of the speed of implementation, which computed throughout the designed simulator operation for both IMHP and MRP protocols. Also the effect of Handoff process on the mobile protocols implementation has been tested. The obtained results showed that the short cut route exhibits the fastest speed of implementation. Visual Basic programming language has been used in the design of this simulator.

KEY WORDS Internet Mobile Host Protocol, Multicast Routing Protocol, Handoff process.

INTRODUCTION

A different global computing paradigm has been evolved independently of the Web. Instead of connecting together all the LANs in the world, another way of extending the reach of a LAN is to move individual computers and other gadgets from one LAN to another, dynamically. A more interesting picture emerges when the various components of the

network can move about. This field of operation is referred to as the mobile computing [1]. In this paper, two types of mobile host protocols are to be adopted, these are; the Internet Mobile Host Protocol (IMHP) and the Multicast Routing Protocol (MRP), that features both route optimization and integrated authentication of all management packets. A software simulator is to be designed and implemented to simulate these mobile computing protocols. Visual Basic Language has been used in the design of this simulator, as it is an object-oriented language, which is the most suitable programming language for designing of simulation packages with friendly-graphical user interfaces.

The idea behind design of this simulator objected to find a rigorous software package that helps researchers in study and analysis in mobile computing area. This is because it is rather hard to find such a software package being available nowadays especially in Iraq. Researches in mobile computing fields are currently of increased attention. For example [2] built a software system to locate mobile users, connected to an in-building Radio Frequency (RF) wireless LAN. Also, in order to reduce Handoff latency and location management cost, [3].

Management scheme that combines hierarchical mobility management with the forwarding pointer scheme. However, [4] designed Cellular IP complement Mobile IP with support for fast, seamless and local Handoff control, and IP paging.

[5], has worked with mobility across heterogeneous systems, where mobile computers could become an important part of that heterogeneous environment in the future. In [6] and [7] authors are researched in the field of middleware systems and the trends and future of mobile computing.

2-INTERNET MOBILE HOST PROTOCOL (IMHP)

IMHP provides performance and operational transparency due to functionality in both the local and the wide area, and provides effective authentication today, while providing a good migration path to stronger authentication when available.

2.1 IMHP Architecture

The IMHP architecture includes four functional entities; mobile hosts, foreign agents, correspondent host, and home agents [8] and [9] as below.

1. Mobile Host (MH):-

The portable machine with wireless network hardware keeps a constant IP address, i.e. it is a normal host with additional software that allows it to move through the network in a manner transparent to the user and to software over the network routing layer within the host.

2- Foreign Agent (FA):-

Sometimes called 'Local Agent', the wireless base station that serves as the MH's temporary attachment point to the Internet. The FA has both a radio and a wired Internet connection, and is willing to forward packets between them. An FA may serve more than one MH at the same time; each local agent maintains a visitor list identifying all mobile hosts currently registered with this local agent.

3- Home Agents (HA):-

A stationary computer, home agent, is capable of forwarding packets to the FA to which the MH is currently attached. In other words, it is the router whom responsible for routing packets to mobile hosts with IP addresses in subnet. It remembers the locations of all MHs with addresses on that subnet.

There is a single HA for each subnet which supports mobile hosts, the home agent is a router connected to more than one network.

4-Correspondent Host (CH):-

It is any host on the Internet, mobile or non-mobile, with which a MH communicates. CH may be ordinary and send packets to MH's on a 'dog-leg' route (Triangle route) through its HA, or enhanced to use 'short-cut' routes direct to MH's FA, figure (1) depicts the IMHP architecture.

2.2 IMHP Operation Description

The operation description of IMHP has been focused on four processes as follows:

1-Handoff Process: - Operations done between MH and FA can be described by: 0: The FA periodically broadcasts beacons, 1: The MH replies with an attachment request, 2: The FA responds with an attachment grant.

2-Registration Process:- the operation of requesting for a registration to be done by the following steps, 3: After attaching, the MH sends a registration request to its HA, 4: The HA replies with a challenge packet to the MH, 5: The MH sends a signed reply, 6: If the reply is good, the HA sends a registration confirmation packet, 7: An HA function call tells the update layer of the new MH location; this triggers location updates to subscribe CHs, see figure (2).

3-Location Update Process:-

1: Normally routed packet intercepted. 2: Forwarded packet to MH. 3: HA triggers a notification message to the CH. 4: The CH asks the mobile host to name its home agent. 5: Receiving the reply. 6: Sending a subscription request to the HA. 7: The HA replies with a location update, which is then installed in the CH routing table, see figure (3).

4- Routing and Encapsulation Process:- Both CH's and HA's need to send packets to MH's by way of FA's. They cannot directly use the regular IP routing system, since it would send

packets with an MH's address to its HA. Simple encapsulation scheme is used. For this, in which an IP packet for an MH is placed inside another packet, with a special IP protocol number, addressed to an FA. A flag in each routing table entry controls encapsulation.

3-MULTICAST ROUTING PROTOCOL (MRP)

The main objective of this protocol is to provide an efficient mechanism for IP mobility [10], [11], [12], and [13]. Mobility support should be transparent to applications, and should provide adequate mechanisms for security. In addition, the protocol should provide smooth handoff, efficient routing in terms of end-to-end delays and consumption of network resources, and should conserve wireless bandwidth. Deployment of the protocol should be applicable to the Internet under reasonable assumptions. Note that these requirements should be achieved with least protocol complexity and least changes to the network infrastructure. A general requirement for IP mobility is to provide 'smooth' handoff in which can be measured by several criteria, such as delay, data loss and communication overhead during handoff. The efficiency of handoff depends heavily on the specific application. For example, audio in general is tolerant to loss, but has stringent delay requirements. Handoff delay is a function of the number of hops added to the data path during handoff. The aim is to reduce handoff latency for much of the operating conditions studied. One major drawback of the Mobile IP protocol is triangle routing, where packets from the correspondent node travel to the home agent before being tunneled to the mobile node. This approach has the following drawbacks:
(i) It consumes many network resources, (ii) It is more susceptible to network partition and (iii) It degrades the performance perceived by the end applications. Also, it further complicates the handoff. Routing efficiency may be measured as the number of hops traversed by data packets from the correspondent node (CN) to the mobile node (MN), as well as the overall network bandwidth consumed due to the mobility architecture. Since the MN may often be connected to the Internet via a wireless connection, such as radio frequency (RF) links, where link bandwidth and device power are scarce, mobility support protocols should be designed to conserve bandwidth and MN energy. Some approaches attempt to minimize delay and loss during handoff by multiple packet forwarding. Hence, these approaches are likely to waste more bandwidth than others are. Hence, the design protocol mechanisms aim to conserve network bandwidth in general, and reduce wasted RF bandwidth during handoff. In addition, the communication overhead should be reduced by the MN to conserve power.

4-HANDOFF OPERATION

Initially, the MN is assigned a multicast address 'G'. The CN sends its packets to G. To establish the delivery tree from the CN to the MN, the MN sends a source specific (CN, G) join message towards the CN, the MN moves and connects to another location; it joins (CN, G) through the new location. The join is forwarded upstream (according to the multicast routing protocol) towards CN. When the join reaches the nearest point of the multicast tree, the join process is complete and the packets start flowing down the newly established branch towards the MN. Upon receiving data packets from the new location, the MN issues a prune message to the old location. The prune message tears down the branches that no longer lead to the MN [11]. In general, at any instant of time, the MN should accept packets from only one \location. However, during transient movement, the MN may be joined to G through multiple locations. The dynamics of joining and leaving/pruning G during handoff directly affect handoff latency and smoothness. To allow a smooth handoff, the MN should not prune the old location until it starts getting packets from the new location. This has been illustrated in figure (4). To further ensure smoothness and to conserve RF bandwidth, mechanisms should be designed to reduce join and leave latencies, this handoff operation can be perform in the tree using mixed direction horizontally (and, or) vertically.

5- SIMULATION ENVIRONMENT AND ASSUMPTIONS

The simulation environment that has been assumed throughout design and analysis of the mobile computing protocols simulator involved consideration of ten wireless MH's, moving in a mobile LAN area with flat. The approximate simulation time of the overall software package is about 250 second. Also, the transmission channel capacity is assumed about 54 Mbps, according to typical situations, which are available nowadays. The source node is assumed to start transmitting of the packets after protocol procedure is proceed, and then they will be received by the destination node. However, the size of the information packet and its format are out of the scope of this work. On the other hand, the pattern of mobility in the network is considered to be issued on a random basis, in order to reflect the actual situation that may happen during the use of mobile devices, as when and where of the moving of any mobile device on the network can't be predicted, it is a decision that belongs to the user of the mobile device only. Accordingly, in the simulation of the IMHP, the location of the mobile host can be chosen either randomly or manually (under the user control). This protocol allows the mobile hosts to move between cells (i.e. subnet areas). The movement in the simulation of the MRP is random also, but with uniform speed. Regarding the physical link, or the data transmission medium, it is assumed that the packet transmission

is not associated with any bit errors (i.e. error free communication channel), because treating the digital communications topics is out of the scope of this work.

6-SIMULATOR DESIGN DESCRIPTION

The designed simulator consists of two main parts, IMHP and MRP. The former consists of two branches, see figure (5). Each part of the simulator has been, firstly, designed and implemented independently, then all parts are combined to be executed align, however, some of them are related to others by special protocol mechanisms. The designed simulator consists of two part; IMHP and MRP, where the first one consist of two branches, one of them simulates the IMHP protocol focusing on the operation description of this protocol. While the other simulates different case studies on this protocol. The part that simulates MRP describes the operation of the protocol.

6.1 IMHP Simulation

The protocol consists of registration and authentication processes for the IP address of the MH or (FA IP if the CH not to be enhanced i.e., CH cannot follow MH current address). Different 'unpredicted', or suddenly happened, situations are taken into consideration throughout the simulation process, before the authentication process in HA or subscription process in CH completed, such as; crashing in nodes, reboot in HA, and CH, and authentication failure in HA.

6.1.1 IMHP Operation Simulation: - After MH receives the beacons from FA, it will send an attachment request to FH and stay waiting for a reply, the reply is an attachment grant, which will be granted to the MH if the FA is not overloaded. If it is overloaded then the MH stay waiting for service until the FA be able to serve it. After the attachment grant, the FA sends a registration request to HA; HA will send two bytes challenge number to MH, and to ensure secure connection, the MH resends the challenge number with secret key in addition to the FA's IP number. HA saves this information, if it isn't fail, and sends acknowledge message to MH, however, HA failures making it send denial packet to MH, and waiting for beacons from FA. Sending item will be bounded by source node, either CH or MH, and forwarding to HA as a triangle route then forwarding to the destination node MH or CH respectively, if short cut route is used. HA informs CH that MH is mobile, in order to use the current address by notification message. Enhanced CH asking HA about the current address of the MH; this question will be forwarded to MH by HA, then MH sends his current address to CH, during this time CH sends subscription request to HA, and depending on the replay message of HA, it will save that current address in CH routing table. The information in the sending item will be forwarded to the destination without going through HA, that is the short

cut route. In the case of CH haven't enhance facilities making continuity of transition by the old triangle route; HA crash making its routing table empty, then HA will depend on the re-subscription process sent by CH, in order to continue sending by short cut route; Whilst CH crashes are making CH routing table empty and then the connection will be by the triangle route.

6.1.2 IMHP Case Studies Simulation: - Firstly the user must chose the existing mode (incoming or outgoing), and the distribution mode (randomly or manually). The number of MH's that would be distributed in the three subnets should be assigned also, and this number should not exceed 10 MH. Three subnets are considered in order not to increase the simulator complexity. After pressing the 'apply' command bottom, there would be a checking on the number of MH's in the area; if it is zero and the existing mode is 'outgoing', the simulator will display a help menu to change the existing mode because there is no MH in the area. Therefore, first existing mode should be 'incoming'. Depending on the number of MH's the distribution will be done, 'random' choice making the MH's being distributed in the three subnets area independently at random locations. If a MH is in subnet 1 (area 1), it will be connected to the destination CH by the direct path (MH-FA1-CH) in short cut route, while if it is in another subnet such as 2or 3 it will need the HA's (routers) to connect it, in case of subnet 2, using the path (MH-FA2-HA2-HA1-CH). When all assigned hosts being distributed in the subnets areas, the operation terminates and waiting for another try. In the manual distribution, the locations of MH's would be specified according to the mouse click on the subnet area. In case of the operation in the 'outgoing' mode, a dialog box that asks about the number of the hosts to be going out would appear. If the number is larger than the active hosts in the range, then the simulator will reject the number and asking to try again. In random outgoing mode, some random hosts will hide and the path that connects the MH with the CH will be disconnected. The same situation can occur in the manual outgoing mode; however the choice of the MH's is controlled manually.

6.2 MRP Simulation

In the Multicast Routing Protocol the simulator shows a tree structure provides location independent group addressing, where the first level of the tree represent the terminal (CH or MH) that the MH needs to connect to it, and it's parent node distributes as a binary tree to many levels depending on the network size. The leaf of this tree is considered the access point (or Base Station BS) wherever the MH is connected to it. Movement can be done either randomly or manually using the mouse. In random movement, the location of the MH would be limited in a random subnet area. When the MH being connected to the BS of a given subnet area, it will join the path of the CH (terminal) and prune with all other paths

related to BS in the other subnet for the same destination. The handoff operation has been simulated also, which keeps continuous transmitting and receiving of data between terminals, however, the time taken by the handoff process should be as short as possible. In this regard, the MH must not leave the oldest BS until it start receiving packets from the newest one. The Handoff process can be performed between two subnet areas. For example, if the MH is in subnet1 and joins to BS1, when pressing moving bottom the MH will move around this area as a mobile terminal, and receives packets by this BS; however if the MH goes out of subnet1, during his moving, it will be connected through subnet2 by receiving beacons from the nearest BS, and then after first packet being received by the MH in the new subnet, the MH will leave the oldest BS and prune the oldest path from BS1 to CH. Practically, the moving device may stop movement at any time, even throughout the handoff process. Hence, this simulator has been designed such that the movement of the MH can be stopped at any time also. The different operations that happen throughout the Handoff process, such as join, leave and prune, would be displayed to the user as control messages.

7- SIMULATOR IMPLEMENTATION

Several Graphical User Interfaces (GUI) have been designed in order to assist implementation and operation understanding of the designed Mobile Computing Simulator. The first main interface is shown figure (6). It is the home page of the simulator, on which pressing 'next' bottom will display another GUI that asks the user to navigate into one of the implemented protocols, see figure (7). By this interface, the user may choose one of the mobile computing protocols, either the IMHP or the MRP.

In each of the designed interfaces, different facilities are designed such as saving, printing, or opening any file inside the computer. In addition each interface provides free choice to the user to exit at any time or return one step back to the last interface, or even return to the home page.

7.1 IMHP Implementation

Referring to the interface shown above, if the user chose the IMHP, that will displayed in figure (7) would appear. In this interface, the user should specify whether he wants to navigate through the operation of this protocol, or he wants to try some case studies on this protocol; the choice can specified by pressing the suitable bottom.

If the user chose the 'IMHP Operation Description' bottom, then he would navigate into the successive steps of implementing this protocol, and all necessary declarations that explain type of used lines and symbols would be appear, type of adopted route (i.e. triangle or short

cut routs), transmitting progress, protocol procedure, and all other control messages. Some of these successive interfaces are shown in figures (9) to (14).

7.2 IMHP Case Studies

In this part of the simulator, the user can control the design of the mobile network that he may want to analyze or investigate. When the user chooses the case studies icon, an interface would appear that asks him to specify the number of mobile hosts to be distributed in the network. The maximum permitted number is ten hosts. In addition, the user should specify the type of the operating mode, i.e. is it an incoming mode or outgoing mode. The first one means the number of hosts that to be enter to the network, while the outgoing mode means the hosts that want to go out of the network, hence the outgoing mode cannot be chosen only if there are hosts already exist in the network.

Moreover, the user should specify the distribution mode; it is either random or manual. In the first mode, the distribution of the mobile hosts in the network is performed randomly, while in the second one, the user specifies the location of each mobile host manually. When the user specifies all these parameters, then by pressing 'Apply' bottom the simulator starts displaying the designed network. In figure (15) the displayed interface shows that 10 MH are chosen as 'incoming' to the network and to be distributed randomly. In figure (16), when the 'outgoing' mode is chosen, a dialog box appears that asks the user to specify the number of mobile hosts to be outside the network. For example, if '4' is specified, then as in figure (17) there were only six MH's distributed in the network.

7.3 MRP Implementation

Referring to figure (17), if the user presses the Multicast Routing Protocol (MRP) bottom, then the simulator will transfer to the simulation of the MRP protocol. Firstly, the simulation parameters should be specified. These include specifying whether it is required to see the protocol operation or the Handoff process implementation. If the MRP operation was required, then the operating mode, either manual or random, should be specified. This is shown in figure (18) where the 'joining' process is performing. In figure (19), the manual operation of the protocol is displayed.

7.4 Handoff Simulation

The Handoff process simulation is described in the following figures. Firstly preparing for the Handoff process is displayed in the interface shown in figure (20). If the mobile host is considered to be moving at the area of base station 1, figure (21), then it moves towards the subnet 2 area. So a handoff process should control its movement in order that its connection do not terminate.

The Handoff process starts as a continuous procedure between the two base stations, as shown in figure (22). Then the mobile host sends a 'Leave' message to the base station of subnet 1, figure (23), and then it will ask for a receiving packet from base station of subnet 2, which is shown in figure (24). Finally, its connection to the first base station is completely terminated, and its communicating stays only with the second base station, see figure (25).

8- SIMULATOR TESTS

In these tests, the short cut and triangle routs of the IMHP are to be compared from the speed of implementation point of view. The effect of Handoff process on the speed of the implementation of the two protocols has been investigated also. The calculations of the speed of implementation are based on the following measurements that calculated by measuring the simulation time throughout the running of the designed simulator: The simulation time required to transmit a given unit of transmitted information using the short cut route was 74 sec, and using the triangle route it was 82 sec. For both types of the routes, the Handoff process requires 4 sec in order that the mobile host goes from a given subnet to another one. Of course, such simulation times seem to be rather large compared to practical field values and considerations. However, this due to the fact that the simulation has been implemented on an ordinary PC of 2GHz processor speed and 256 MB RAM. Whilst, practically the mobile networking processors are special devices of very high speed. Accordingly, the simulation time is calculated for different amounts of transmitted information units, and the short cut and triangle routs implementation speeds are compared during the same periods. The results are shown in figures (26) and (27) for short cut and triangle routes respectively. In each figure, the effect of Hand off process delay has been displayed. On the other hand, the four cases, i.e. both routes with and without Handoff effect, are compared in figure (28). It is clear that the best choice is the short cut route, where the Handoff delay adds extra time cost on the required simulation time.

9- CONCLUSSION

A mobile computing simulator has been designed and implemented using Visual Basic programming language that has good flexibility helps the designer in the design of sophisticated software packages. On the other hand, the graphical user interfaces facility guidance of the user to assist understanding the how of mobile protocols operation. Also, it is worthy to note that the speed of the implementation should be high enough to make efficient use of the network, which requires high speed FA and HA computers. Furthermore, it is possible to extend the designed simulator to simulate for WAN mobile network, by extending

its coverage area and developing the software to stand for active IP address in the other coverage areas, also the selection of which BS connect to the MA through roaming process depends on Queuing Algorithm in order to become smooth handoff operation which can be perform as a new idea for future work.

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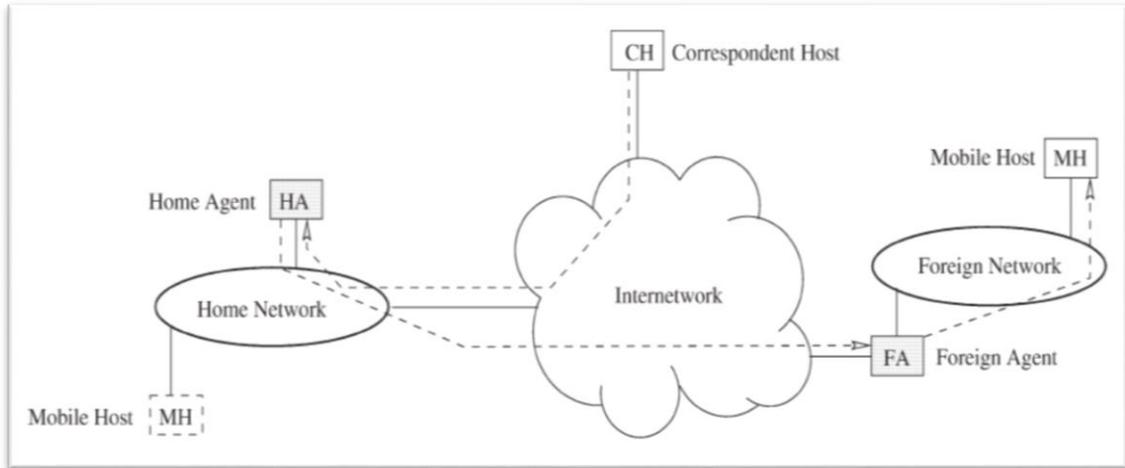
Figure (1): IMHP architecture.
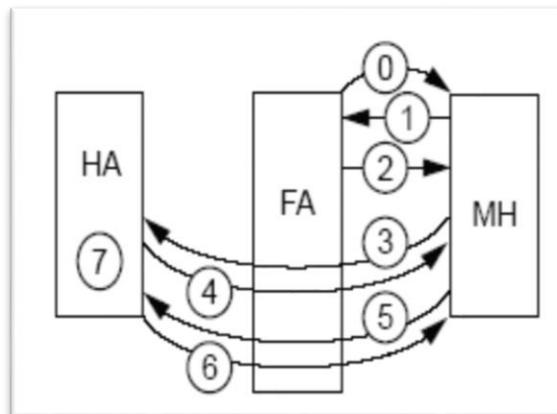
Figure (2): MH Hand-off and Registration Process
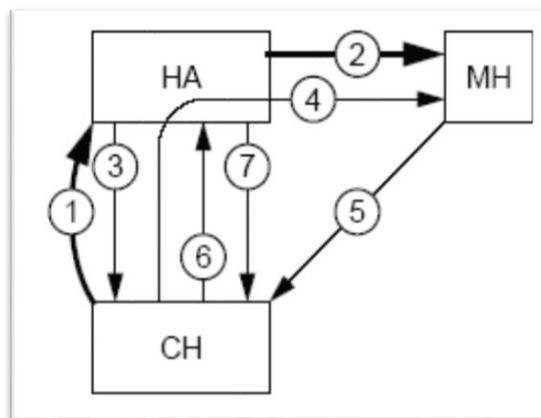
Figure (3): CH updates CH acquisition of direct route.
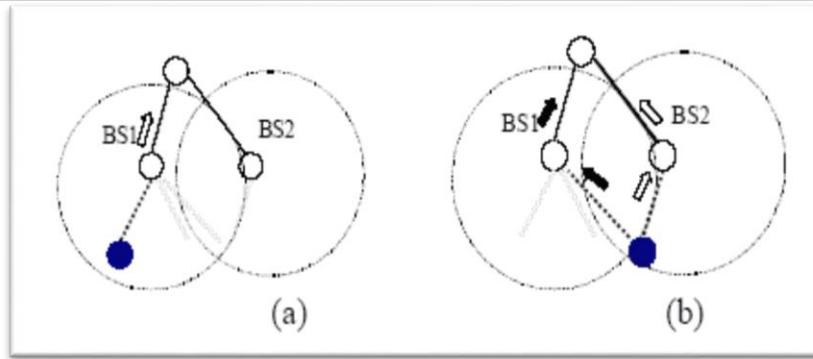
Figure (4): Smooth handoff between neighboring cells.
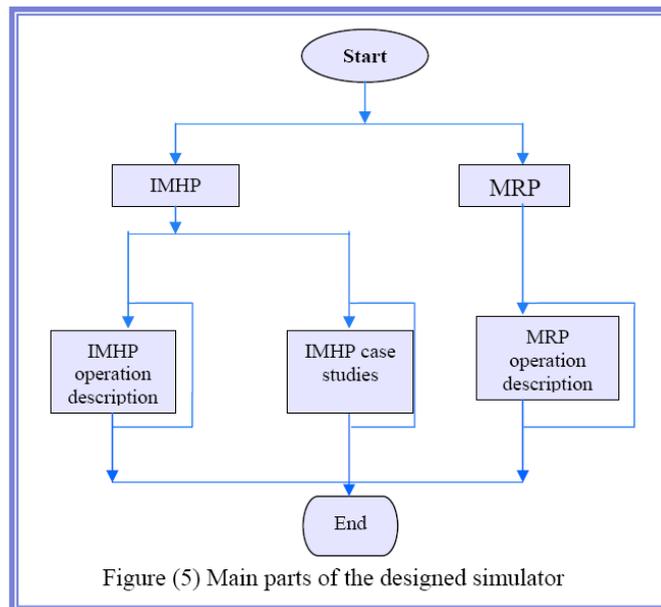
Figure (5) Main parts of the designed simulator

Figure (6): Home Page of the Mobile Computing

Figure (**7**)**:** Interface of the given protocol choice.
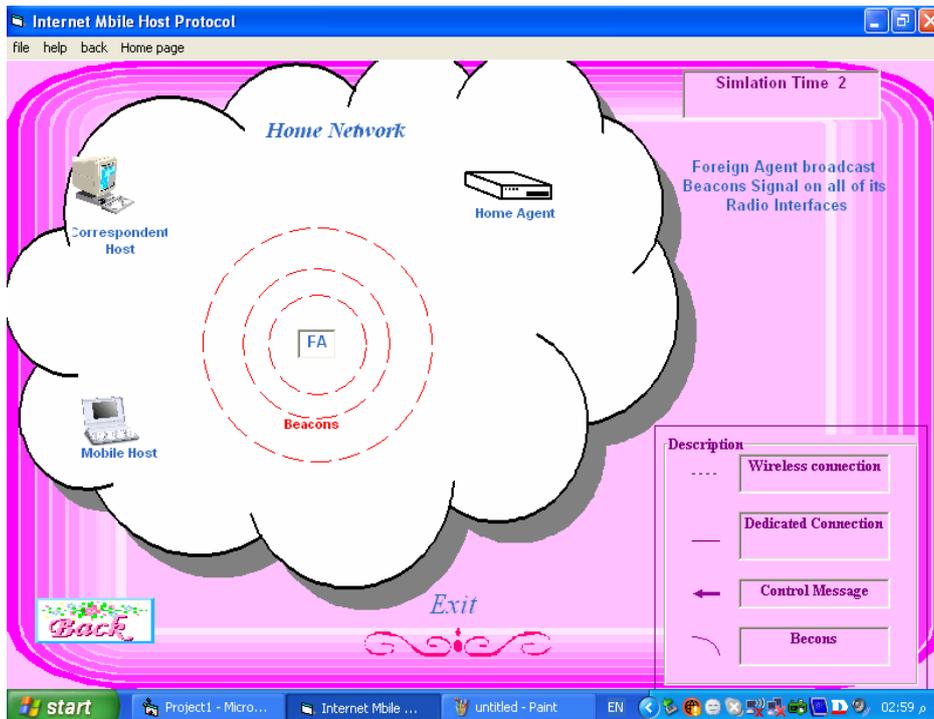
Figure (9): Beginning of Beacons of IMHP protocol.
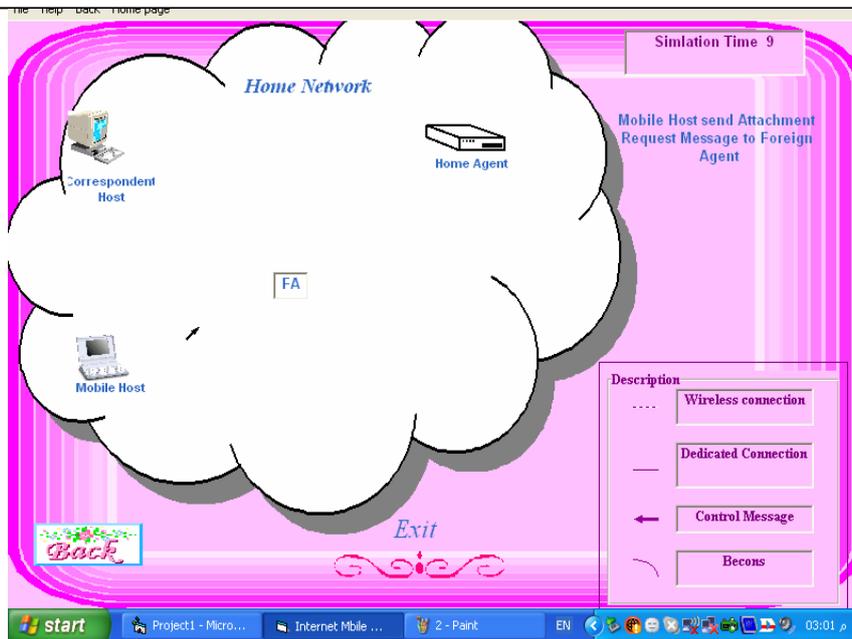
Figure (10): Attachment request sent to HA.
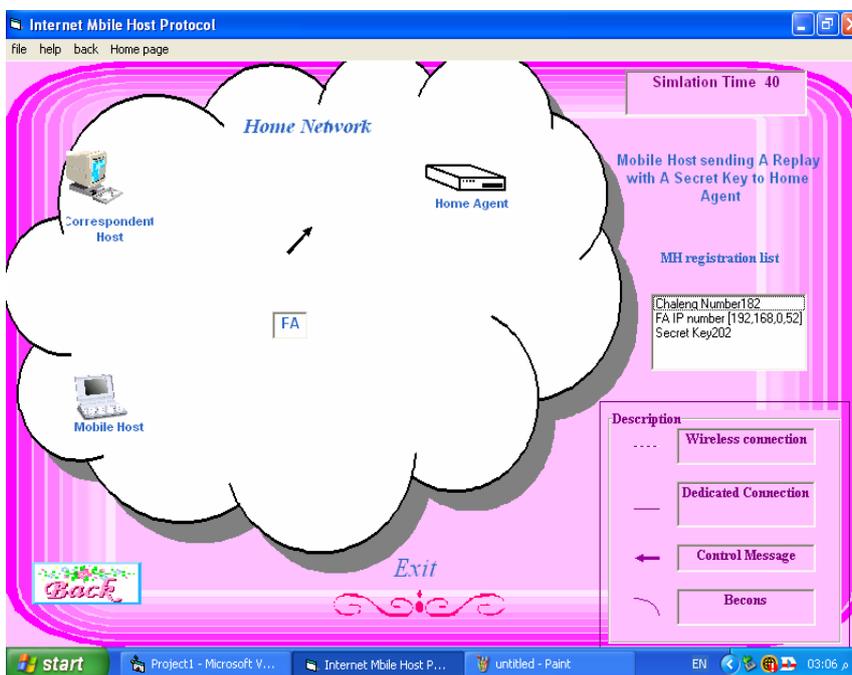
Figure (11): MH list that sent to HA, contains secret key, HA challenge number and FA IP address as a request for registration.
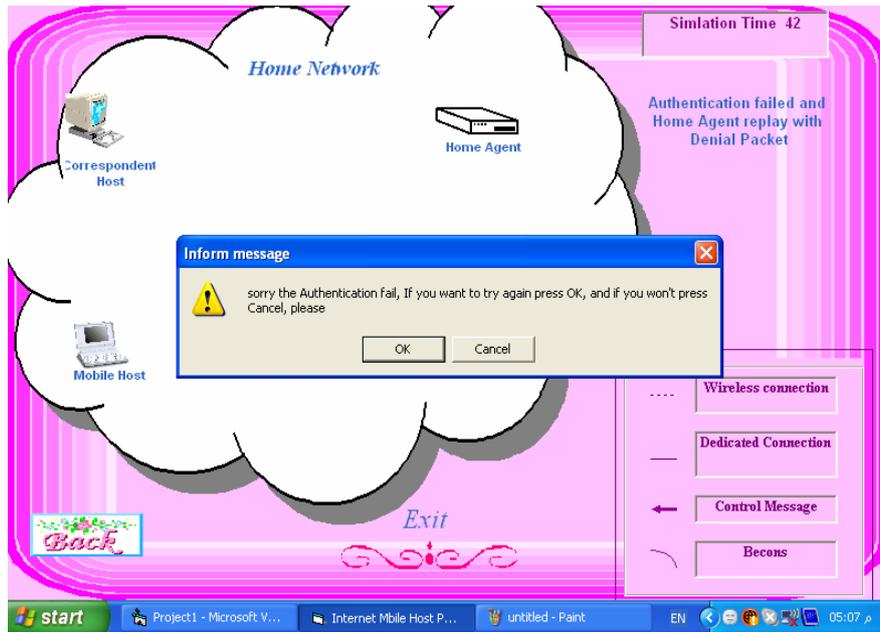
Figure (12): HA Authentication failure, a case that happened randomly.
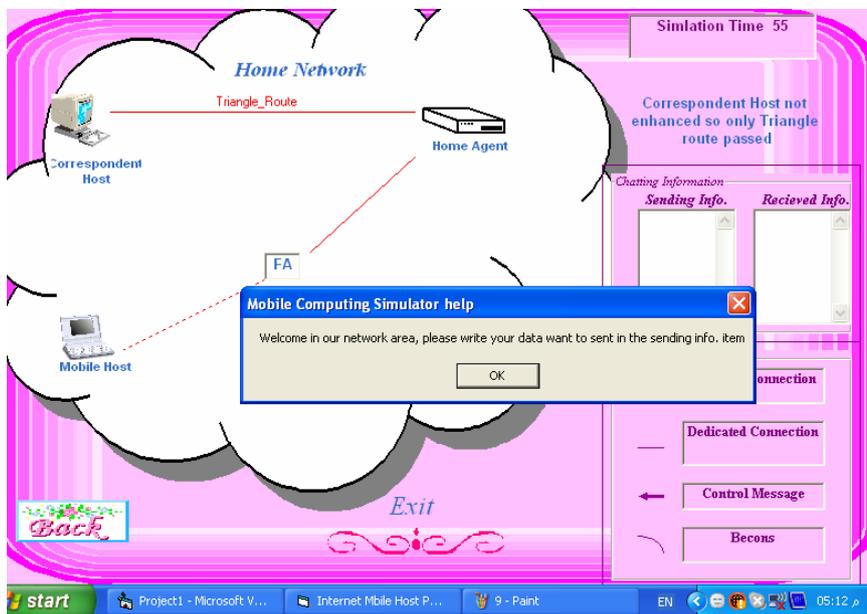
Fig (13): IMHP triangle route transmission stopped here and no need to continue by short cut route.
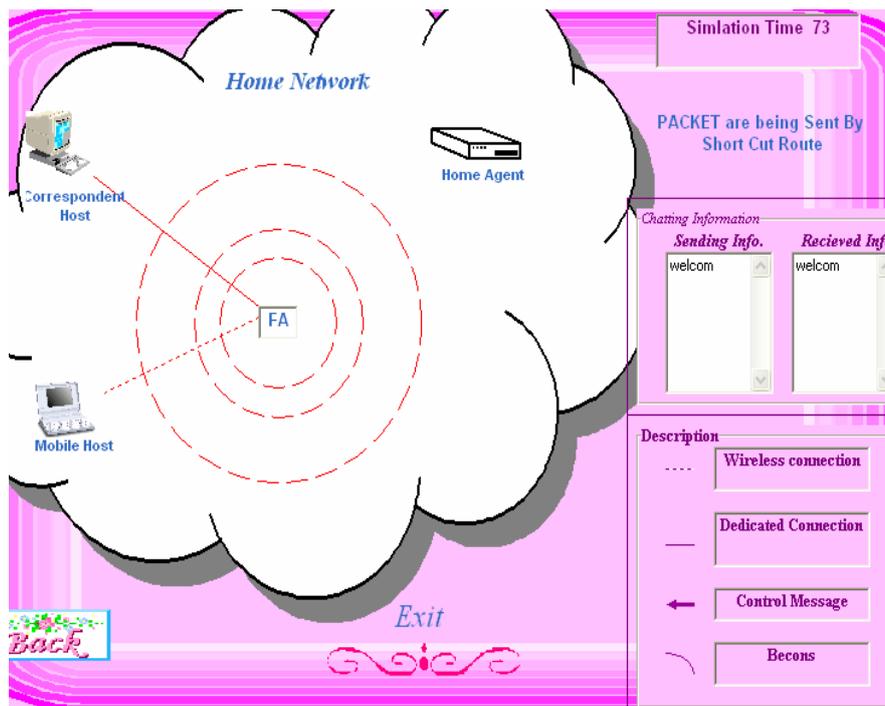
Figure (14): Short Cut route of IMHP.
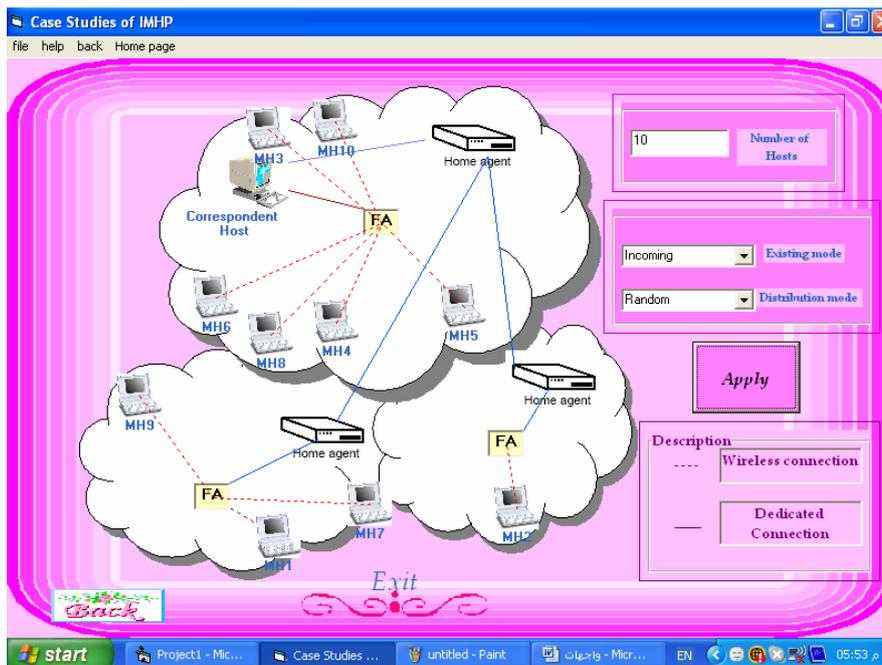
Figure (15): Random distribution of 10 incoming MH's.
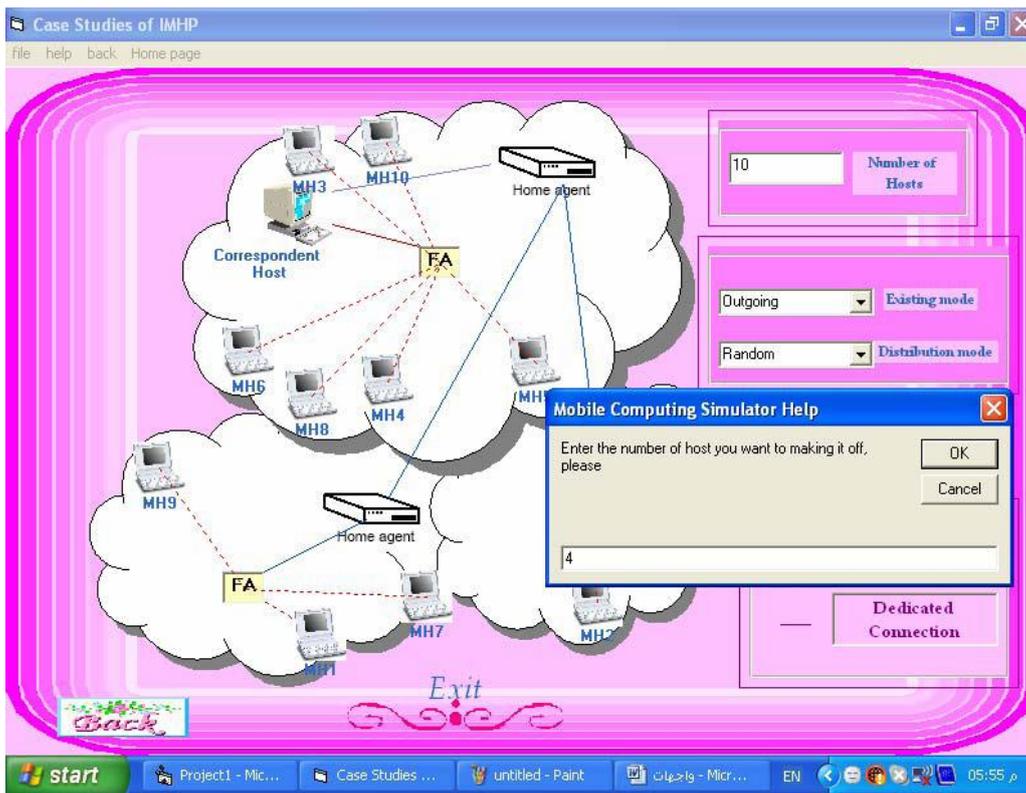
Figure (16): Specification of the number of MH's to be outgoing.
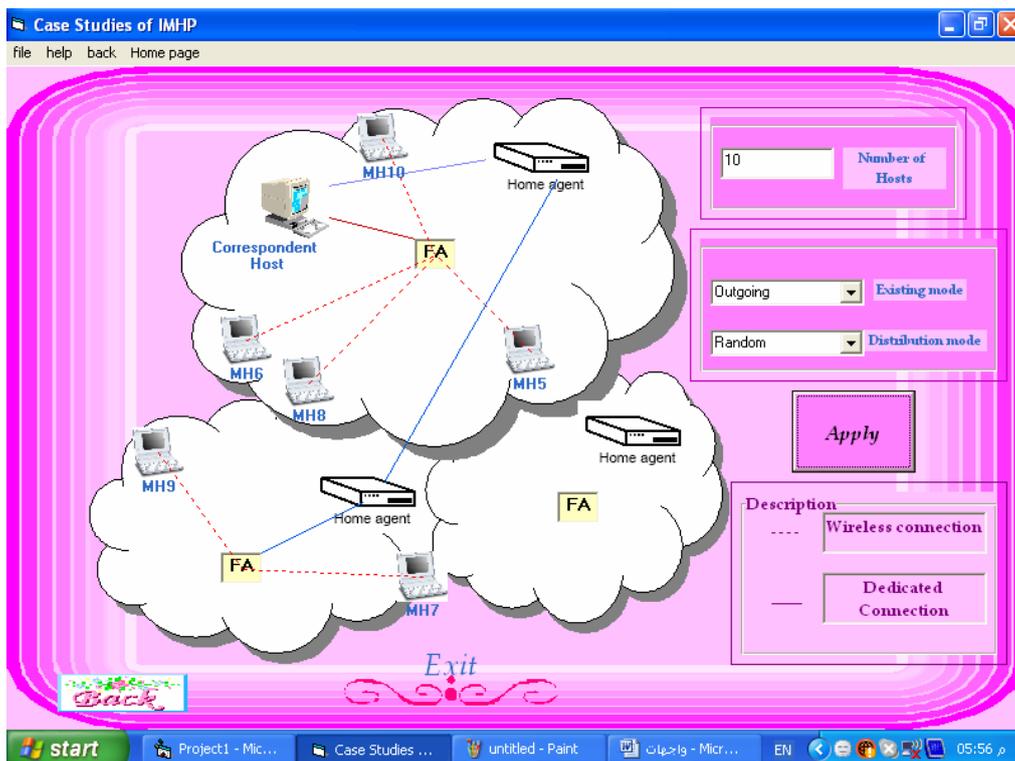
Figure (17): Four MH's are outside the network.
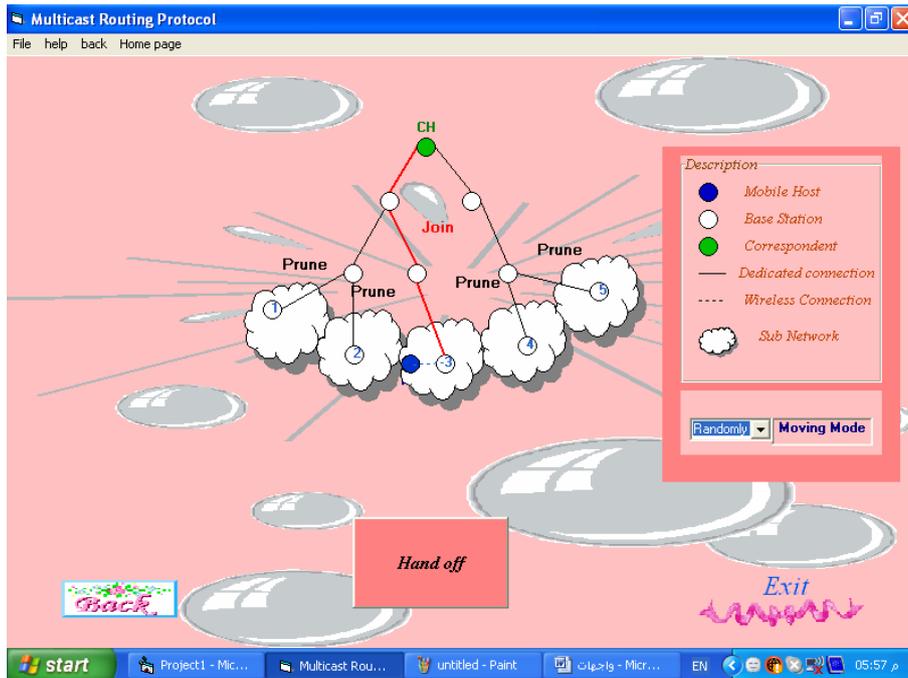
Figure (18): Random mode of the MRP operation.
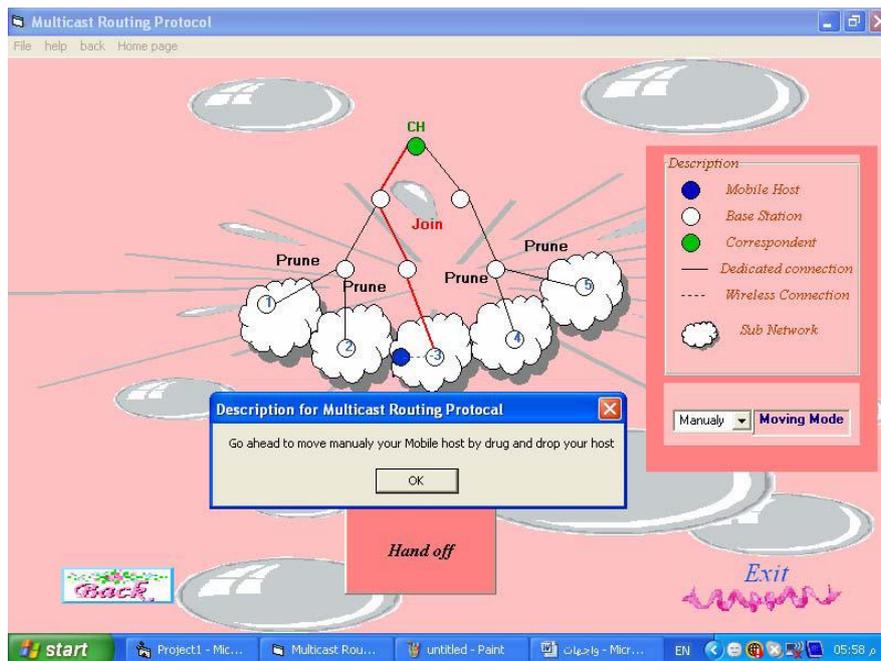
Figure (19): Manual mode of the MRP operation.
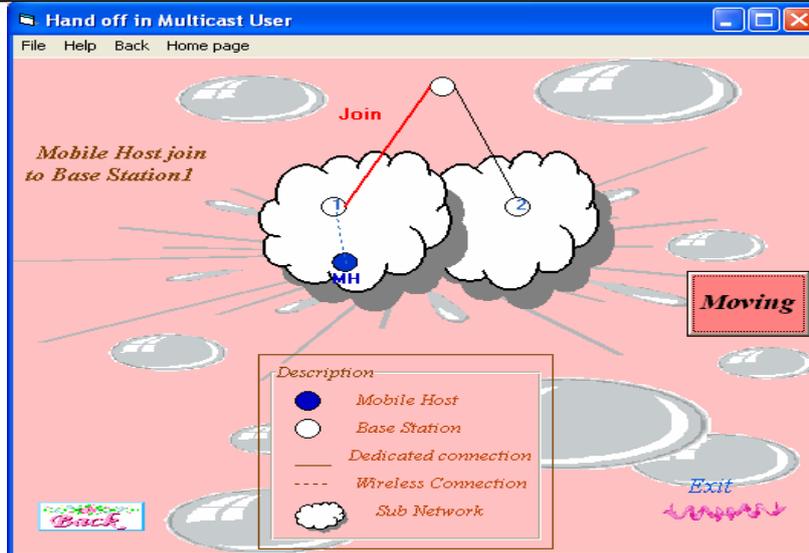
Figure (20): Environment for Handoff process.
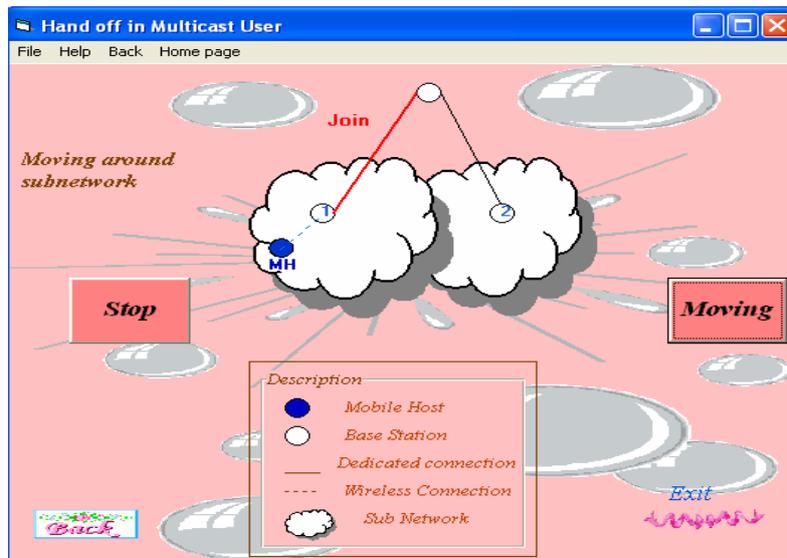
Figure (21): MH moves in area 1, then towards area 2
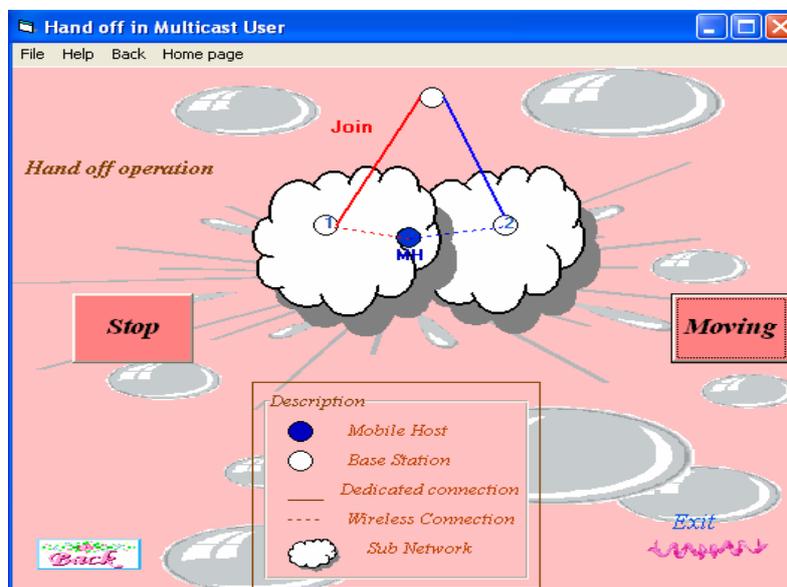
Figure (22): Starting Handoff process between base stations 1 and 2.
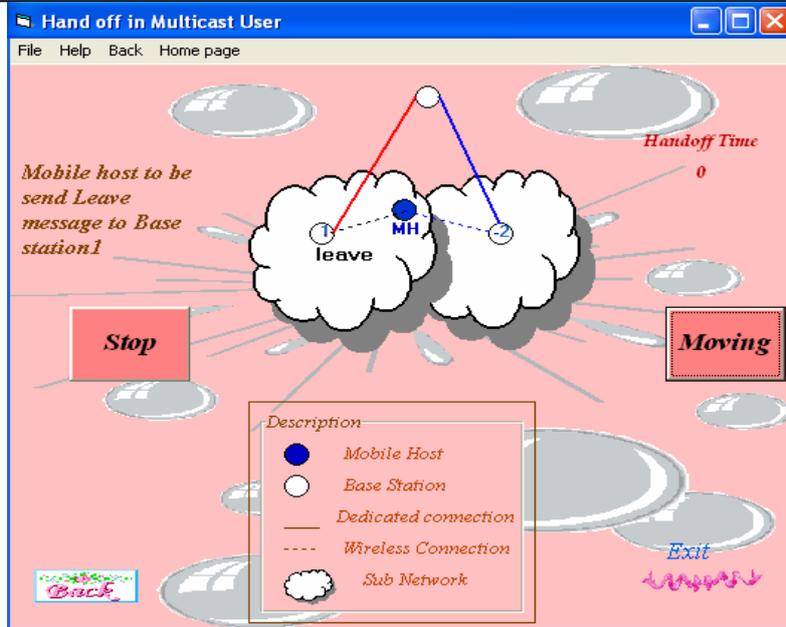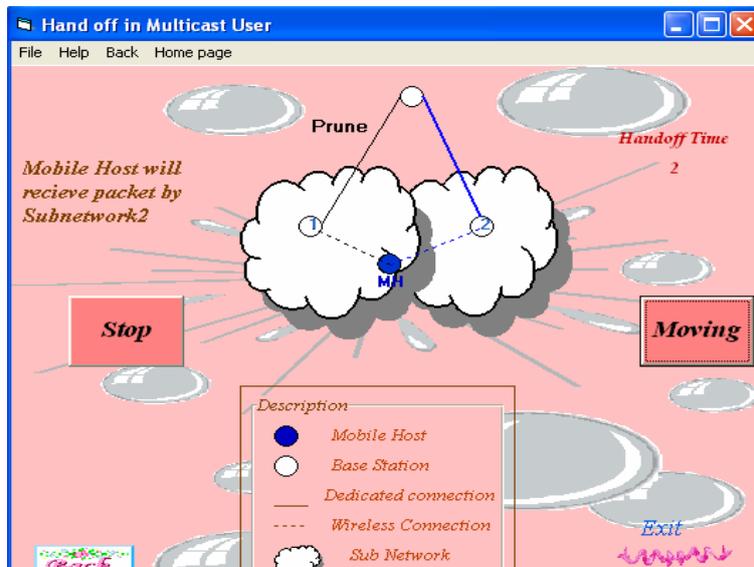
Figure (23): MH sending' Leave' message to base station1.

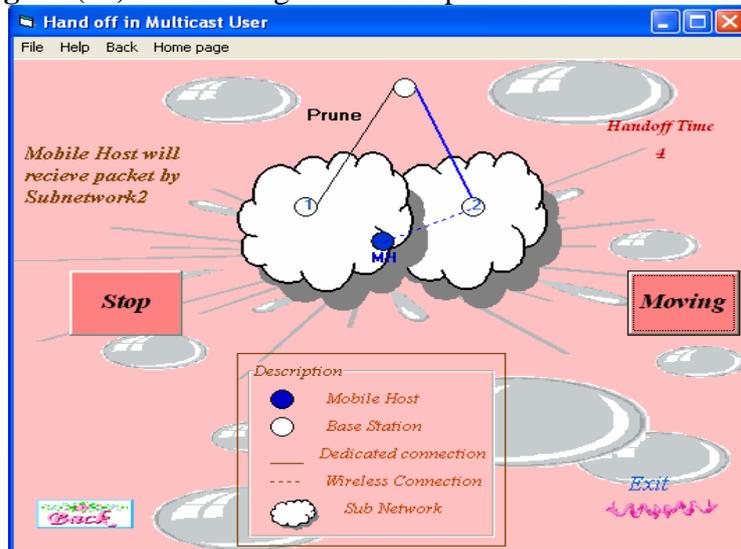**Figure (24):** MH asking for receive packet from base station 2.

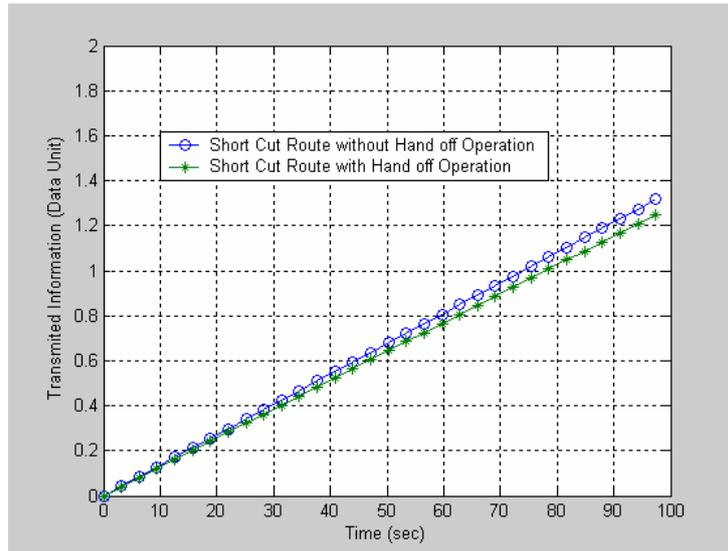
Figure (25): MH is connected to base station2.

Figure (26): Implementation speed of the short cut route in IMHP.
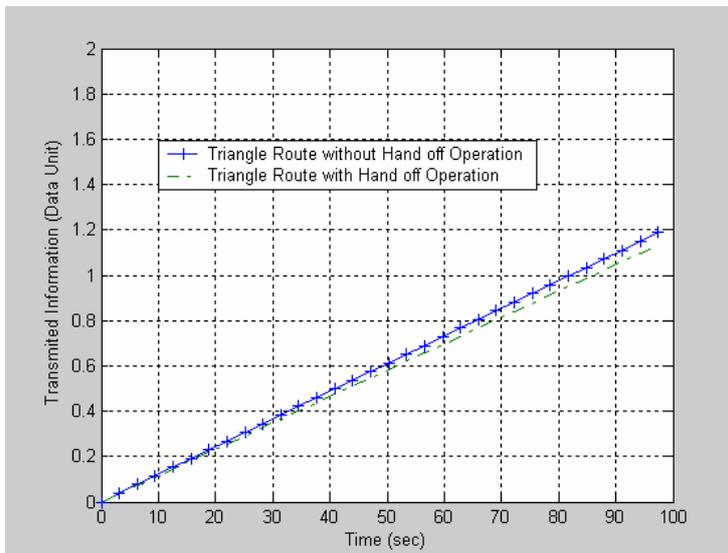

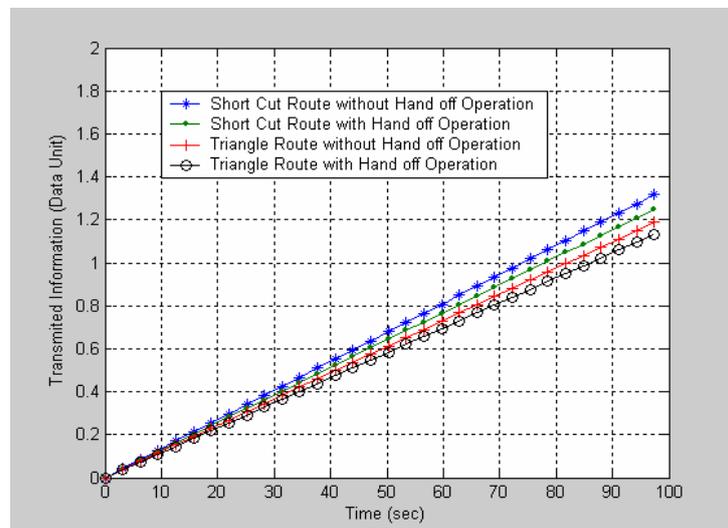**Figure (27):** Implementation speed of the triangle route in IMHP.

Figure (28): Speed of implementation comparison for IMHP routes.

تصميم وتنفيذ محاكي الحاسب النقال

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الخلاصة

إن التقدم الكبير في التكنولوجيا اللاسلكية وخاصة الاهتمام بالشبكات النقالة, أنتج جهود مكثفة في البحوث التي تطور بروتوكولات الحاسبات النقالة مثل بروتوكولات إيجاد المسار وتعدد البث وبروتوكولات الإدارة المختلفة.

في هذا العمل تم تصميم وتنفيذ محاكي برمجي رصين باستخدام لغة بيسك المرئية. يقوم بمحاكاة مجموعة من بروتوكولات الحاسبات النقالة المهمة وهي بروتوكولات MRP, IMHP وكذلك عملية المناولة. وصممت واجهات صورية متقدمة لتوفير استخدام طيع للمحاكي يساعد في فهم تكنولوجيا الحاسبات النقالة إضافة إلى تحليل وتقييم أداء البروتوكولات المصممة، المساحة التي يغطيها المحاكي تتضمن ثلاثة شبكات ثانوية يتحرك فيما بينها عشرة أجهزة نقالة عشوائيا أو يدويا ويمكن لهذه الأجهزة الدخول والخروج من والى الشبكة في أي وقت.وتم محاكاة كل الاحتمالات العملية المرتبطة بعمل الحاسبات النقالة بالإضافة إلى إن المحاكي المصمم يأخذ بنظر الاعتبار الإحداث الغير متوقعة مثل إعادة التشغيل والتوقف الفجائي في عناصر الشبكة. اختبارات ومقارنات موسعة تم تنفيذها وأظهرت النتائج التي اعتمدت سرعة المحاكي لكل من البروتوكولين على حدة ويتأثير عملية المناولة على كل منهما بان المسلك الأقصر وبدون مناولة هو الأسرع من بين باقي الطرق المتاحة في الشبكة.