A Modified Location Aided Routing Protocol for UWB MANET

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***Abstract*—** The Mobile Ad hoc Network (MANET) is a conventional ad hoc network; nodes within the network are mobile, where each node is equipped with a transmitter and receiver, antenna, and a local battery. Each node may operate as a router to relay message from sender to receiver. Nodes within MANET are organized in different manners, they can be hierarchical or flat, they can move in any direction and speed, and communicate to each other by means of wireless routing protocols.

Now it is the time for Ultra-WideBand (UWB) to be given more attention due to its great capability in high data rate, large Band Width (BW), and low power consumption. Currently, hosts are equipped with UWB system in order to achieve short range communication and exploit the previous mentioned advantages, besides UWB has the ability to measure distance between hosts accurately. As a result, researchers have been encouraged to design new routing protocols for UWB networks to make it suitable for hosts to exploit features of UWB, but still needs more and more work to overcome drawbacks of network such as network overhead, power consumption, unreliable route, etc…

The goal of this work is to design and implement a new routing protocol for UWB network; the new scheme aims to increase the life time of network, reduce network overhead, and achieve route reliability. The new protocol is based on LAR scheme 1 and exploits the request zone technique by defining several request zones in advance in order to find route to destination.

QualNet is used as environment to develop and implement the new protocol. Results from simulator indicate that the new protocol outperforms the comparable protocols (AODV and LAR1); it enhances the life time of network, reduces the network overhead, and increases the throughput as discussed later in this research.

***Keywords*—**MANET, UWB, Routing protocol, LAR.

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I. Introduction

WIRELESS Local Area Networks (WLANs) provide wireless access to different types of mobile hosts such as personal digital assistants (PDA), laptops and cellular phones. These nodes are equipped with short range transmitters and receivers, and antennas which may be omnidirectional (broadcast), highly-directional (point-to-point), or some combination of the two [1].

In a WLAN environment, routing protocols then enable nodes to relay data packets if they are within transmission range, or if they can communicate directly. If they are away from each other, intermediate nodes are required to establish a multihop route between the sender and receiver. The wireless routing protocols that provide this key functionality, in general, are classified as either topological based or position based.

- Topological based routing protocols use the existing information about links in network to flood (or forward) packets. There are two main routing strategies classified as topological based; proactive [2] that maintains routing information for each node in the network and stores this information in routing tables, such as Destination-Sequenced Distance Vector (DSDV) [3], Cluster-head Gateway Switch Routing (CGSR) [3], Wireless Routing Protocol (WRP) [4], and Optimized Link State Routing Protocol (OLSR) [5]. The second type is reactive routing protocols which maintain a route on demand, such as Ad hoc On-Demand Distance Vector (AODV) [6], Dynamic Source Routing (DSR) [7], Temporally Ordered Routing Algorithm (TORA) [4], and Associativity-Based Routing (ABR) [3]
- Position based routing protocols exploit positional information to direct flooding towards the destination in order to reduce overheads and power consumption, Location Aided Routing Protocol (LAR) [8], GRID [9], Compass [10], and Greedy Perimeter Stateless Routing (GPSR) [11] are examples of position based routing protocols.

Ultra-WideBand (UWB) [12][13] is a radio technology that has been proposed for use in Personal Area Networks (PAN) and appears in the IEEE 802.15.3a draft PAN standard. UWB systems consume very low energy levels, and can be used in short-range, high-bandwidth (BW) communications systems where the BW > 500 MHz, at 20% of the center frequency. UWB is defined to operate between 3.1–10.6 GHz and is restricted to a maximum allowable power spectral density of 41.3 dBm / MHz corresponding to average transmitted power of 0.5 mW. Therefore, UWB provides relatively short radio range but given the spectrum available very high data rates in excess of 100 Mbps can be achieved, (with bit rates of 55, 110 & 200 Mbps [14]).

UWB is best used for ad-hoc and sensor networks [15], it is used as part of location systems and real time location systems such as hospitals and healthcare, short broadcast time, "see-through-the-wall" precision radar imaging technology [16], and replacing cables between portable multimedia Consumer Electronics (CE) devices and in the next-generation of Bluetooth Technology devices [17].

The two most common UWB signal structures are impulse UWB (IR-UWB) and multicarrier UWB (MC-UWB) [18].

Impulse UWB signals [18] (e.g. nanosecond long Gaussian pulses) is used in indoor applications where it does not use a modulated sinusoidal carrier (or carrierless) to transmit information; instead, information is sent through a series of baseband pulses, the duration of these pulses is so short, and so, this typically results in a bandwidth on the order of gigahertz.

Multicarrier UWB signals [19] (e.g. Orthogonal Frequency Division Multiplexing, OFDM) use a set of subcarriers that must be overlapping. A major advantage of multicarrier UWB signals is their ability to minimize interference because the subcarriers can be chosen to avoid interfering with bands used by other systems sharing the spectrum.

MC-UWB [20] (or frequency domain UWB) transmitted signal s(t) has the following complex baseband form.

$$s(t) = A \sum_{r} \sum_{n=1}^{N} b_n^r p(t - rT_p) e^{(j2\pi n f_0 (t - rT_p))} \quad (1)$$

Where N is the number of subcarriers b_n^r is the symbol that is transmitted in the rth transmission interval over the nth subcarrier, Tp is signal duration, and A is a constant that controls the transmitted power spectral density and determines the energy per bit. The fundamental frequency is

$$f_0 = \frac{1}{T_p} \quad (2)$$

The type of application determines which part of the spectrum UWB uses. UWB transmission has been limited to a range from 3.1 to 10.6 GHz, specifically to avoid interference with GPS and other essential services operating below 3.1 GHz.

There is fewer multipath cancellation effects with UWB signals because Multipath cancellation happens when a multipath signal arrives at the receiver partially or totally out of phase with the direct signal, which produces a reduced amplitude response. With short duration pulse signals, direct signals come and go before indirect signals arrive.

The main disadvantage of UWB is like other RF technologies, suffers from trade-offs in signal-to-noise ratio versus bandwidth [21].

UWB radios can provide relatively good accuracy in line-of-sight (LOS) short baseline conditions, performance degrades with distance and even more so with non-line-of-sight (NLOS) measurements. UWB power levels must be low enough to ensure that operation would not cause performance degradation in existing devices [21].

UWB high-data-rate (HDR) signal formats proposed within the IEEE 802.15.3a Task Group are the impulsive direct-sequence UWB (DS-UWB) and the nonimpulsive multiband orthogonal frequency-division multiplexing (MB-OFDM) [22].

For the UWB low data rate (LDR) IEEE 802.15.4a standard, the signal format is the impulsive time hopping (TH) UWB [23].

This paper proposes a new routing protocol for the UWB MANET and is based on the conventional Location Aided Routing protocol, scheme 1 (LAR1). The new approach proposes a dynamic and static request zone at the same time, in order to consider power as a metric when a route is selected.

Three regions of request zones are assigned; the first zone represents a rectangle where the source and destination lie in opposite corners of the rectangle, see Fig. 1.

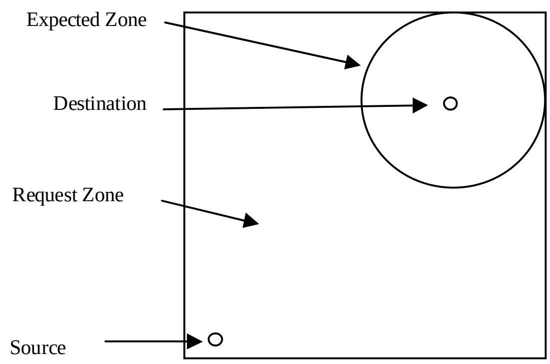

Fig. 1 LAR, scheme 1.

The second and third zones, see Fig. 2, represent rectangles with dimensions that are dependent on the dimension of the first zone, (this is explained later in more detail).

In order to achieve reliability and increase the probability of finding route, when each node within a request zone receives a Route Request (RREQ), they respond by transmitting a Route Reply (RREP) according to the following criteria:

- In each region, a threshold value of residual battery power is assigned
- The threshold of region 1 (Th1) is greater than that of region 2
- The threshold value of region 2 (Th2) is greater than that of region 3.

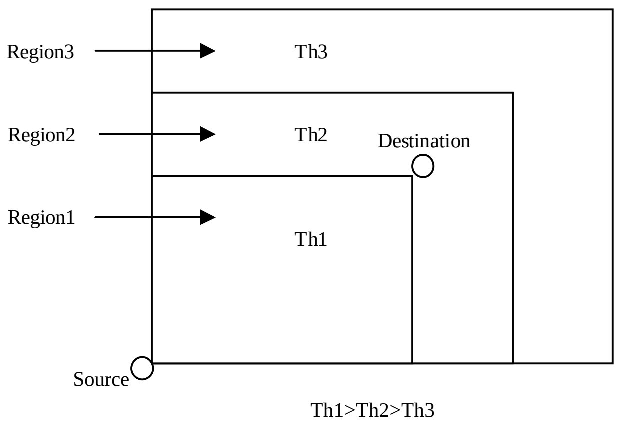

Fig. 2 Request zones

The basic operation of the protocol is as follows:

The initial RREQ is flooded over the request zone. When a node within one of the three zones receives a RREQ, it checks the header of RREQ for the threshold and dimensions of each region (it should be noted here that positional information is known by all nodes). If the node is within one of the zones, and has a residual battery power above the threshold of that zone, it forwards the RREQ and so on until RREQ reaches to destination which replies to the first received RREQ using the reverse path.

The rest of paper is organized as follows: section 2 summarizes related work, section 3 presents the proposed routing protocol, section 4 presents simulation results, and the summary in section 5.

II. Related Work and motivation

The new routing protocol exploits the advantages of LAR1 routing protocol besides power issue in Location-Aware routing Protocol with Dynamic Adaptive of Request Zone protocol (LARDAR). Below are more details about LAR1 and LARDAR.

A. Location Aided Routing Protocol (LAR)

Location Aided Routing (LAR) [24] is an on-demand routing protocol. LAR uses the modified Dijkstra's Algorithm to find the shortest path; it relies on a flooding-based route discovery procedure which causes a huge amount of routing overhead. Destination lies in a circular region of certain radius centred at a position at certain time, known as the Expected Zone, which indicates which zone of the network should be reached by RREQ packets. Global Positioning System (GPS) enabled terminals to know its own position and speed, while dissemination is performed by piggybacking location information in all routing packets.

There are two proposed schemes of LAR: [25]

First assumption (LAR1) defines request zone that includes sender and receiver on opposite corner of a rectangle as shown in Fig. 1. The rectangle dimensions are estimated according to the receiver average speed at a certain time. Nodes within this zone respond to the RREQ of sender by forwarding the RREQ to their nieghbors. This scheme reduces network overhead but causes delay.

Another LAR scheme (LAR2) is proposed depending on the calculated distance between source location and the estimated position of destination. Each node receives the RREQ calculates the distance toward destination, if the distance is less than of the distance from the previous sender node to destination, it forwards the packet. In this scheme, intermediate receiving node may be the closest node to destination, and so the algorithm reaches a dead-end.

B. Location-Aware routing Protocol with Dynamic Adaptive of Request Zone (LARDAR)

LARDAR [26] is a location-based routing protocol. It uses a) the destination's position to form a triangle or rectangle request zone in order to reduce the traffic, b) dynamic adaptation of request zone technique in order to adapt the precision of the estimated request zone and reduce the searching range, and c) increasing-exclusive search approach to redo route discovery by a progressive increasing search angle basis when route discovery failed and reduce routing overhead.

LARDAR utilizes the GPS information of destination node’s location, timestamp (location information obtained time), and velocity which can be calculated using the traveled distance and the time needed for traveling that distance.

LARDAR improves the drawbacks of LAR and Distance Routing Effect Algorithm for Mobility (DREAM) [2]. It utilizes the location and expected zone in LAR, location update frequency of DREAM, and uses energy aware and geographical informed neighbour selection to reduce network overhead which is the number of control packets transmitted.

In LARDAR, increasing the angle of the triangle-zone shape depends on some factors; it can be improved by genetic algorithm. When the expected zone is extended, source forwards RREQ with the same sequence number, when intermediate nodes receive the RREQ again, they discard it. This could be a problem; these nodes could be the only ones that can relay RREQ to the other nodes within the extended zone.

LARDAR saves power and lengthen system lifetime.

C. Power-Aware Routing

Since mobile hosts depend only on local power supplied by batteries, power aware is an important issue which must be taken into account when designing wireless routing protocols. Energy efficient issues, in general, are: Transmission Power Control, Minimum Power Routing, Power-aware route selection, and Battery-Cost-Aware Routing. [27]

Several routing techniques uses residual battery power as metric to select next hop or detecting link failure, such as Minimal Battery Cost Routing (MBCR) [28] which uses battery power evenly depending on a cost function in order to select next hop node, the cost function considers only the total cost while the route can include a node with little energy while the other nodes have a plenty of energy. Min-Max Battery Cost Routing (MMBCR) [28] which considers nodes' lifetime and avoid nodes that will exhaust soon when selecting next hop, it prolongs the lifetime of an individual node by introducing a new path cost, but it can set up the route with an excessive hop count and then consume a lot of total transmission energy because it takes into account the remaining energy level of individual nodes instead of the total energy. Max-Min Battery Capacity Routing (CMMBCR) [28] which tries to make balance between MBCR and MMBCR, the basic idea behind CMMBCR is that when all nodes on route have remaining battery capacity above a threshold, a route with minimum total transmission power among all routes is chosen. It maximizes the lifetime of ad hoc mobile networks, but algorithm is very complex. AODV with Break Avoidance (AODV-BA) [29] that can avoid route breaks; intermediate node that detects the breakage re-establishes a new route before the route breaks. The detection of link breakage based on threshold value which are: received radio, the residual battery power, and the density. Energy-Aware AODV (EAAODV) [30] where each node receives RREQ checks its residual battery power, if it is above a threshold, it forwards the RREQ, and otherwise, the node ignores it. And Power Aware On-Demand (PAOD) [31] where the selection criterion is based on two thresholds; each node compares its residual battery power to these levels. When the residual battery power reaches to a certain level (link is going to be failed), an action is done.

III. ROUTING PROTOCOL

The new proposed routing protocol exploits functionality of LAR1 to improve route reliability and decrease power consumption.

A. Routing Strategy

Three regions are assigned, and each region has a certain threshold value of power. Each node within its region and has a residual battery power greater than the threshold responds to RREQ by retransmitting it as shown in Fig. 2.

The threshold values should be within the maximum available power and minimum received power which is calculated as follows:

$$Pr = Pt - N \quad (3)$$

Where: Pr is received power, Pt is the transmitted power, and N is thermal noise. Whereas thermal noise is calculated according to the following equation [32]:

$$N = T * k * B * F \quad (4)$$

Where T is noise temperature in Kelvin of the input termination and equal to 290 K which is the standard temperature, K is Boltzmann constant (= 1.379 x 10-23 Joules/Kelvin), B is bandwidth of carrier signal in Hz, and F is a constant called the noise factor [33].

When source node wants to send data packets to destination, it forwards RREQ based on the current information about location and velocity of destination. First it establishes the expected zone based on the previous information stored in its routing table about the destination, this information includes the speed and position at certain time, source node assumes the destination in the center of circle where the radius is calculated according to the speed and time equation whereas the radius is the speed times the period of traveling, this period is the difference between the current time and the time when that information is updated in routing tables. Then the source establishes the first request zone as shown in Fig. 1, then it calculates the dimensions of the other two zones where the dimensions are proportional to the dimension of first zone as shown in Fig. 2. And then the source forwards the RREQ including in the header extra information which are the dimensions of each region, threshold values assigned to each region.

If RREP is not received within a certain time, RREQ is reinitiated again; Fig. 3 shows the process of initiating RREQ.

```
Define Request Zone
Initiate RREQ
Wait certain time for RREP
      If RREP is received
Establish route and send data packets
      Else reinitiate RREQ
```

Fig. 3 Initiating RREQ

When intermediate node receives RREQ for the first time, it checks its position by GPS and RREQ’s header for zones’ information (dimensions) and threshold values, if node is within the three regions, it compares its residual battery power to the threshold assigned to its zone, if it is greater than the threshold, it forwards the message to its neighbors. Fig. 4 shows the process, otherwise, It ignores the RREQ.

The process is keeping running until RREQ reaches its destination.

```
If RREQ received for the first time
    Check region
    If within regions 1, 2, or 3
        Check threshold
        If greater than dedicated threshold
            Node adds its address
            Forward RREQ
        If not
            Ignore the message
    If outside regions 1, 2, or 3
        Ignore the message
If RREQ is already received
    Ignore it
```

Fig. 4 Handling of RREQ

When RREQ is received by destination, it forwards RREP to source using the selected reverse path. Fig. 5 illustrates the process.

```
If RREQ is received
    Initiate RREP and forward it using reverse path
```

Fig. 5 Handling of RREQ by destination

Each node has routing tables that stores routing information which is updated whenever it receives control packet. When RREP is received by intermediate node that is located on the reverse path, it updates its routing table according to the information included in the header of the received RREP, and then it forwards the RREP towards the source. Fig. 6 shows the process.

```
If RREP received
        If node address appears in header of
        RREP
    Update cache
    Forward RREP
  If not
    Ignore it
```

Fig. 6 Handling of RREP

IV. Network Environment and Simulation Results

The proposed scenario considers a network of 20 hosts where the positions of nodes are selected randomly based on the standard normal distribution, the scenario represents an outdoor network, each host has a certain level of battery power which is selected randomly, and nodes in this network scenario are static. and threshold values are selected to have reasonable values regarding the maximum and minimum battery power of nodes which ranges from 1.0 mAhr and 0.1 mAhr. Lower values are selected rather than the real one whereas selecting large values will not affect the results, but the statistics graphs will not show the difference in power consumption, for example, when power values of batteries are big while the consumed power is low, the graphs will not show the effect of modified routing protocol.

Using frequency of 3.5 GHz (within the UWB frequency range) and substituting into equations 1 and 2 yields in received power of 0.33mA, And so, the threshold values should be within the range: 1.0 > Th > 0.33 (received current).

Each node is equipped with GPS system which imposes an outdoor scenario, besides an UWB system that uses 0.5 milliWatt as transmitted power, frequency of channel is 3.5 GHz (range of frequency available is 3.1 – 10.6 GHz), SNR sensitivity is 1.0; which is acceptable ratio to enable receivers to detect incoming signal, temperature is 290 Kelvin which is the standard temperature, bit rate is 55 Mbps which is the (the minimum bit rate) and the range is up to 20 m as the minimum bit rate is used which are the typical values [14].

Number of zones is three, where the dimensions of second zone equal to 50% of the firs zone (requested zone), while the dimensions of third zone equal to 30% of the requested zone.

Constant Bit Rate (CBR) is selected to be used as traffic generator; it is a UDP-based client-server application which sends data from a client to a server at a constant bit rate, whereas 100 packets will be forwarded by source to destination, each packet is 512 bytes in size; all these values are applied to QualNet simulator.

A. *Static Mode Results*

This section shows the results of modified protocol in compare to LAR1 and AODV in static mode (nodes are fixed). As shown in Fig. 7, modified LAR1 has the minimum power consumption (system aggregation) in transmission mode and LAR1 has the maximum amount, while AODV has an intermediate value between them. This is an indicator that modified LAR1 protocol generate less RREQ packets than the other two protocols because the only nodes which have residual battery power over than the threshold can forward the RREQ and data packets as well despite the fact that the flooded area of modified LAR1 is greater than that of LAR1, which indicates that the modified LAR1 increases the life time of the network as a whole in case of transmission mode.

Fig.s 8 and 9 show the broadcast packet sent and received to channel respectively. They represent the amount of received and transmitted RREQ packets, which is a meter to network overhead; whereas the modified LAR1 has the minimum value of both received and transmitted signals, LAR1 has the maximum value, and AODV has an intermediate value. An explanation of the result is that the requested zone of LAR1 does not cover the destination and so source resorts to flooding over the whole network as a method to find route to destination, this means that RREQ is retransmitted more than once by the same some nodes (nodes within the requested zone), AODV uses flooding directly to cover the whole network, and so it ignores the retransmission

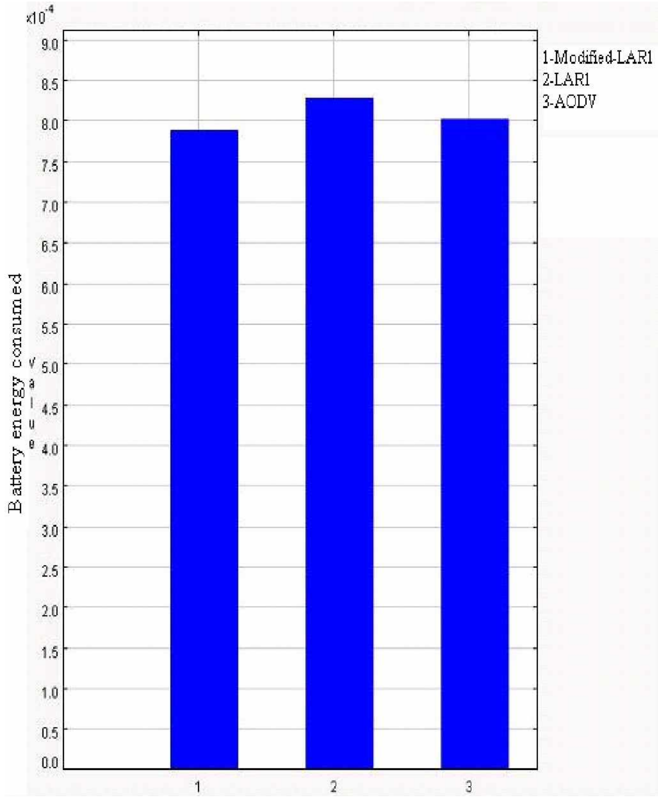

Fig. 7 Battery energy consumed in transmit mode (static mode).

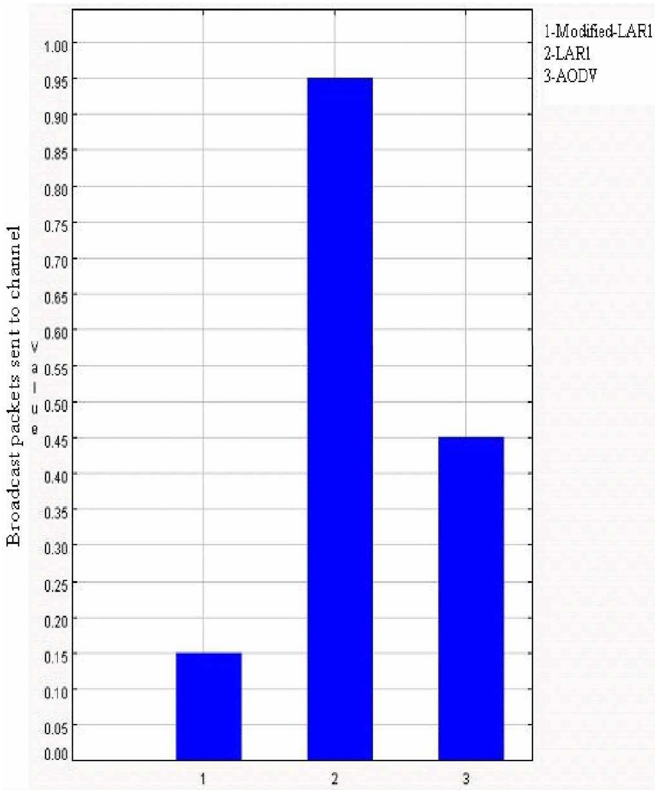

Fig. 8 Broadcast packets sent to channel (static mode).

of RREQ as in LAR1, while in modified LAR1, the requested zone is extended to three regions instead of one, the new requested zones cover the destination, and so no need to resort to flooding, on the other hand, not all nodes forward the RREQ, because only nodes which have residual battery power over a predefined threshold value forward the RREQ. As a result, modified LAR1 forwards less number of RREQ, which affects the number of received RREQ as well, and so not only it reduces network overhead, but it also reduces power consumption.

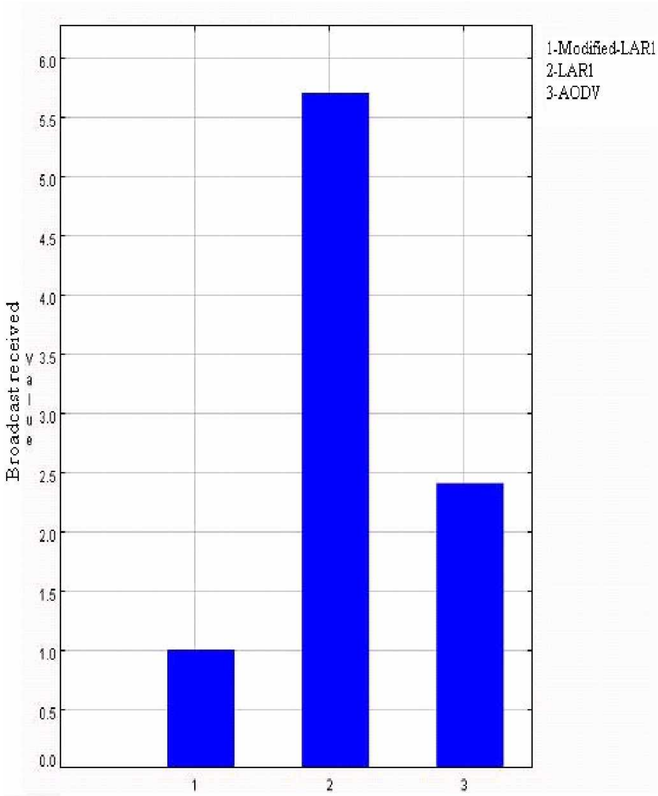

Fig. 9 Broadcast received (static mode).

Fig. 10 illustrates the throughput of the three routing protocol, it shows that the throughput is equal for all of them; data packets are transmitted and received by the same amount, and so the difference is in control packets especially RREQ, that means the lower amount of consumed energy in either transmit or receive modes does not affect the throughput and it is not cause of data packets, on the contrary, it is at the expenses of RREQ; because not all node participate in forwarding the RREQ, only the nodes which have residual battery power greater than the threshold can forward it.

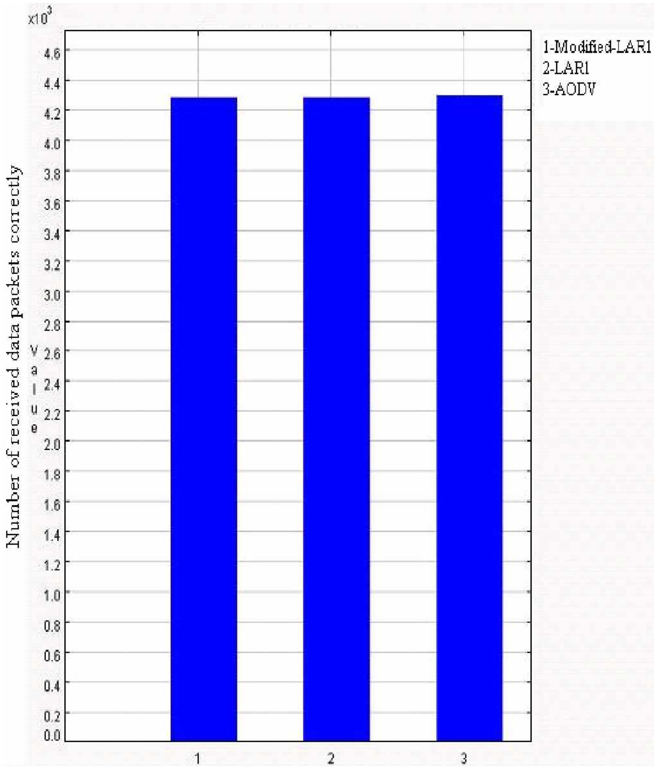

Fig. 10 Throughput (static mode).

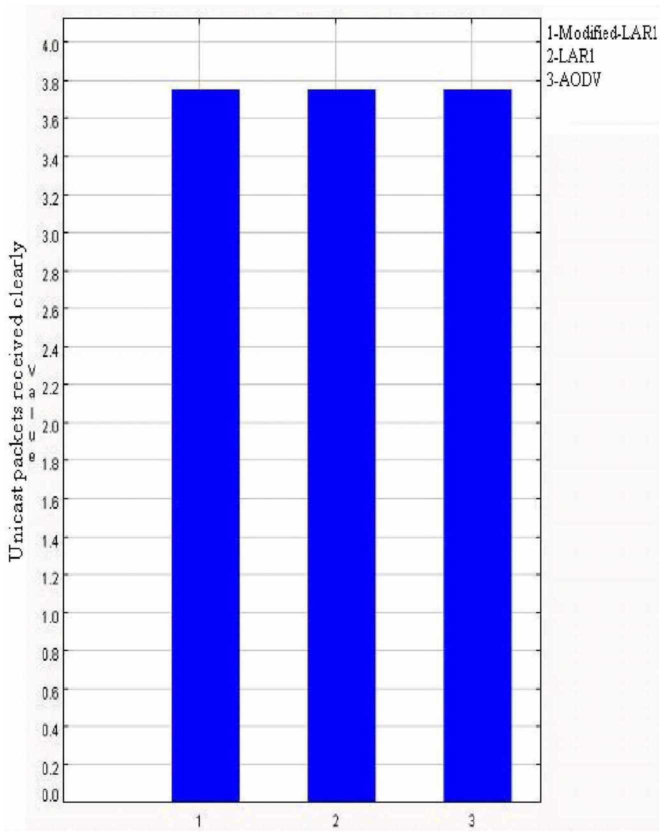

Fig. 11 Unicast packets received clearly (static mode).

Fig. 11 indicates the amount of packets received clearly, in other words, how much the system is reliable; the figure illustrates that the three protocols have the same value of reliability; because nodes are distributed randomly over the network and power values are assigned randomly as well, the selected route in all cases is the same, or at least the nodes on the active route have enough battery power to recognize logic 1 as logic 1 and logic 0 as logic 0. The effect of reliability appears in dynamic mode as nodes move, and so not the same nodes are selected in the active route for different routing protocols.

B. Dynamic Mode Results

This section shows the results of modified protocol in compare to LAR1 and AODV in dynamic mode (nodes are moving). Fig. 12 shows the energy consumed in transmit mode when nodes are dynamic. We notice that the modified LAR1 has the maximum power consumption in transmission mode and AODV has the minimum amount, while LAR1 has an intermediate value between them; regarding modified LAR1 protocol, as nodes move randomly in every direction and the restrictions of selecting nodes that will forward RREQ besides the confined area of flooding, this makes it difficult to find suitable route quickly, on the opposite side, AODV uses flooding over the network, which makes it easy to find route to destination, while LAR1 is only restricted by the confined area. Nevertheless, the three results are close to each other as discussed later on regarding fig. 5.15 (throughput).

Fig.s 13 and 14 show the broadcast packet sent and received to channel respectively. It represents the amount of received and transmitted RREQ packets, which is an indicator to network overhead. These two figures confirm the previous results whereas most of the time and power consumed in transmitting and receiving are due forwarding and receiving data packets rather that control packets.

The two figures show that the modified LAR1 has the minimum value of both received and transmitted signals, LAR1 has the maximum value, and AODV has an intermediate value. An explanation of the result is that the requested zone of LAR1 does not cover the destination and so source node resorts to flooding over the whole network as a method to find route to destination, this means that RREQ is retransmitted more than once by the same some nodes (nodes within the requested zone only), AODV uses flooding directly to cover the whole network, and so it ignores the retransmission of RREQ as in LAR1, another point is that RERR packet could be generated as nodes may have not enough power to transmit and receive all the time which forces the source to generate more RREQs to find new route to destination. While in modified LAR1, the requested zone is extended to three regions instead of one, the new requested zones cover the destination, and so no need to resort to flooding, On the other hand, not all nodes forward the RREQ because only nodes which have residual battery power over a predefined threshold value forward the RREQ. As a result, modified LAR1 forwards less number of RREQ, which affects the number of received RREQ as well, and so it does not only reduce network overhead, but also reduces power consumption

Fig. 15 clarifies the throughput of the three routing protocol, it shows that modified LAR1 achieves the highest throughput of the three protocols; that is, nodes which are selected in active route have enough power to receive and transmit packets, and so it achieves the highest throughput, and this is an explanation of the previous results in the last four figures (why the modified LAR1 consumes more energy in transmit and receive mode).

Fig. 16 represents the reliability of protocol; it indicates the amount of packets received clearly. The figure illustrates that the modified LAR1 protocol has the highest value than the other two protocols, which means that it is the most reliable compared to LAR1 and AODV routing protocols. This is because of the strategy of route selection; where nodes of higher power is selected rather than low power nodes, which maintains the route and enable active nodes to receive data packets clearly, i.e. logic 1 is received as logic 1 and logic 0 is received as logic 0.

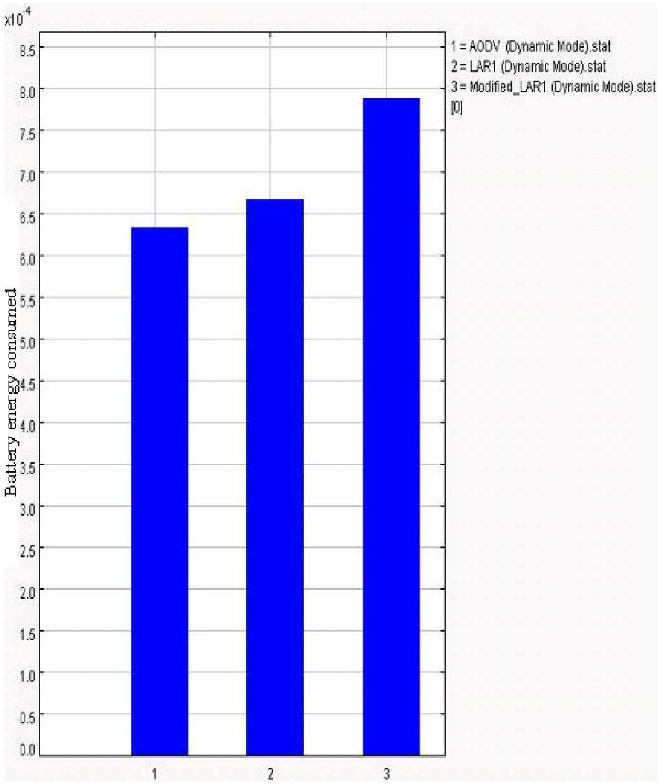

Fig. 12 Battery energy consumed in transmit mode (dynamic mode).

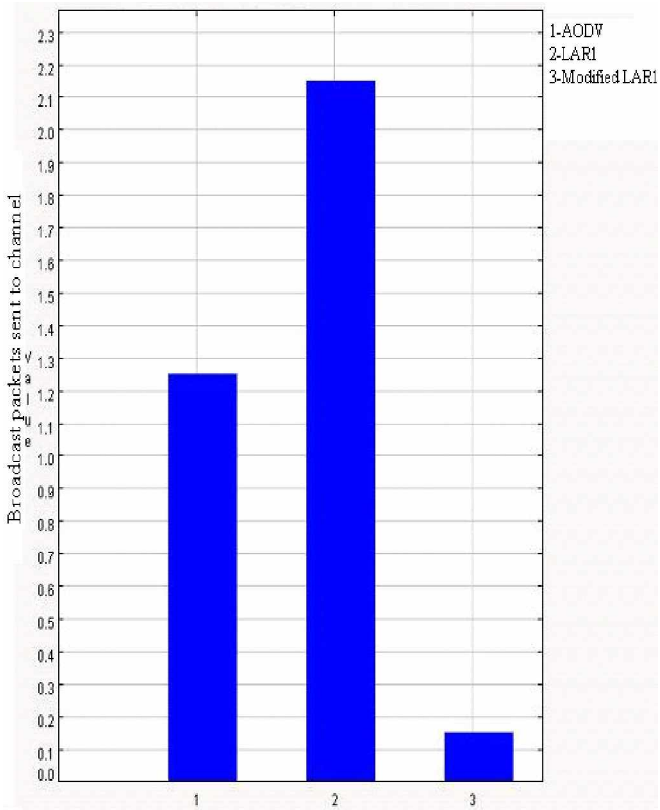

Fig. 13 Broadcast packets sent to channel (dynamic mode).

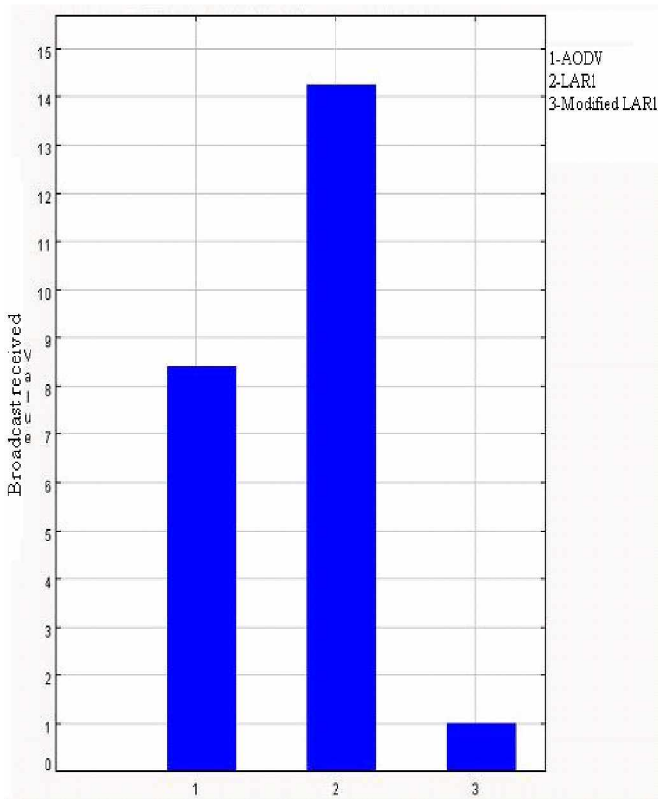

Fig. 14 Broadcast received (dynamic mode).

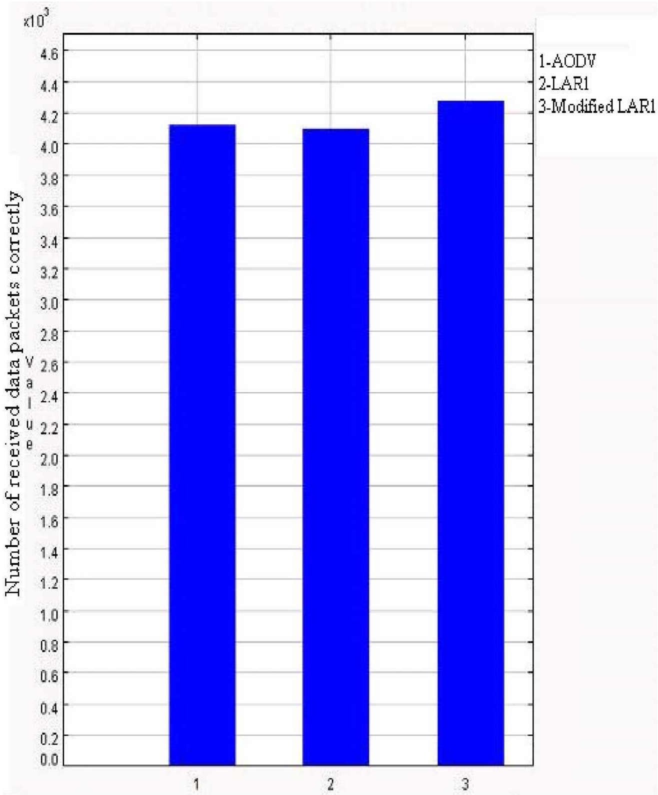

Fig. 15 Throughput (dynamic mode).

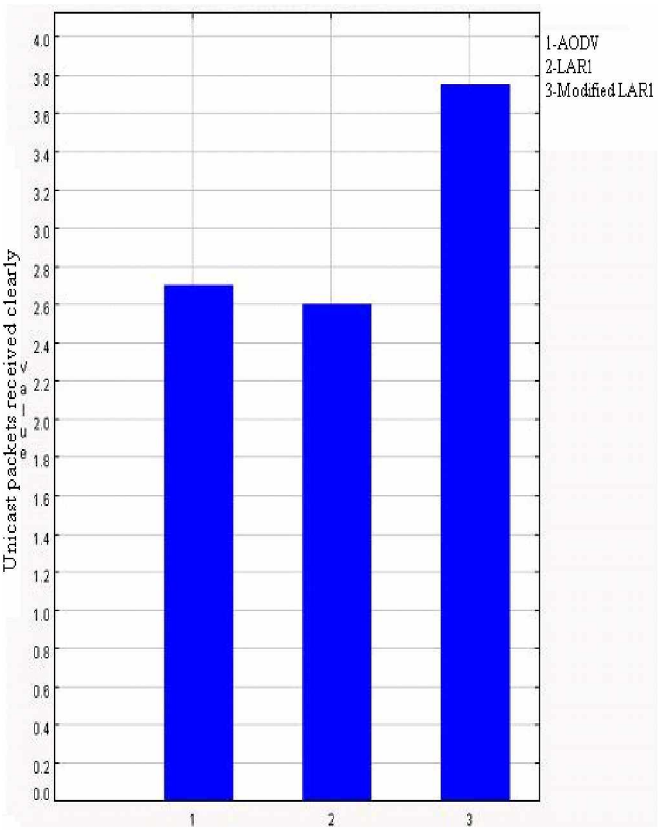

Fig. 16 Unicast packets received clearly (dynamic mode).

Fig. 16 represents the reliability of protocol; it indicates the amount of packets received clearly. The figure illustrates that the modified LAR1 protocol has the highest value than the other two protocols, which means that it is the most reliable compared to LAR1 and AODV routing protocols. This is because of the strategy of route selection; where nodes of higher power is selected rather than low power nodes, which maintains the route and enable active nodes to receive data packets clearly, i.e. logic 1 is received as logic 1 and logic 0 is received as logic 0.

V. Conclusion and Future Work

In this paper, a new routing protocol for UWB MANET is proposed which exploits functionality of conventional LAR1 in order to improve route reliability and decrease power consumption of nodes and overhead.

In the proposed protocol, only nodes located within the assigned region respond to RREQ by detecting its position by GPS, determine the zone they belong to and the its threshold by detecting RREQ's header; if the previous conditions are valid then the node forward RREQ to its neighbors.

The modified LAR1 protocol performs well in static and dynamic modes, it outperforms both AODV and LAR1 protocol at all levels (network life time, network overhead, reliability); the key factor for the above results is the selection criteria of nodes; where nodes of residual battery power above a threshold can participate in active route, which guarantees route reliability, network life time, and high throughput, besides the extension of the confinement flooded area by dividing the resulting requested zone into three zones of different dimensions and assigning a threshold value to each zone.

Results of dynamic mode are better than results of static mode. In dynamic mode, nodes are moving in every and any way, and so any protocol may stick if a node of low battery power is selected in active route, running out the node's power will cause a link failure and affect the performance of routing protocol, modified LAR1 does not stick in such problem as nodes of residual battery power above a threshold are always selected, which guarantees a high performance even in dynamic mode.

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