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The Impact of Mobility Prediction on the Performance of P2P Content Discovery Protocols over Mobile Ad-Hoc Networks

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Abstract

Content discovery is one of the fundamental issues that determines the architecture and performance of content distribution networks based on peer-to-peer (P2P) networks. To administrate the costs and discoveries, peers of a P2P network communicate with each other by one or more overlay layers. The condition of node's relations in overlay networks, have a great impact in efficiency of networks. Therefore the suitability of an overlay network is so important. So it should be proposed some techniques to create the overlay layer in the best possible. Hence, this paper proposes a new method for designing an overlay layer that can improve the efficiency of it .For this purpose, It will be applied one of the mobility prediction patterns and change the Gnutella protocol. After evaluation, simulation results clarified the significant role of mobility prediction on performance of P2P content discovery protocol over mobile ad-hoc networks.

Keywords:*Content Discovery, Peer-To-Peer, Mobile Ad-Hoc Network, Mobility Prediction*

1. Introduction

Mobile Ad-hoc Networks (MANETs) consist of a collection of wireless mobile devices dynamically forming a temporary network without the use of any existing infrastructure or centralized administration .In such a network, each node acts as a host or may act as a router [16] one of the major issues in Mobile Ad-hoc Networks is dynamic topology due to the mobility of the nodes [33].

On the other hand, Peer-To-Peer (P2P) networks are set of computers that connect in overlay layer and aim to share information among a large number of users without assistance of explicit servers [7]. A peer-to-peer (P2P) overlay network is a logical network on the top of physical layer which can be in every type of networks, wired or wireless.

In P2P networks, the relation among peers lead to creating a network in application layer which is called an overlay network [42]. The ways in which each peer communicate with other peers in P2P networks are classified into two groups: structured and unstructured [13]. In unstructured networks, there are not any special

rules for assigning neighborhood among nodes, and there is no predefined place for holding data. On the contrary, in structured fashion, the manner of assigning neighborhood among nodes and the place of data are clearly defined based on a specific routine.

One of the most important applications in P2P networks is content discovery. In unstructured networks, controlled or uncontrolled flooding method is used for this. It means, flooding query message in the networks is used to find desired content which lead to a high traffic in the network. This traffic is the main problem of unstructured overlay networks [43]. On the other hand, because of following a predefined procedure in structured P2P networks, the cost of leaving and joining nodes and also maintaining an overlay network is very high [21]. But by using different kind of DHT (Distributed Hash Table), it can be presented better and more efficient algorithms for route finding and content discovery [21]. Some unstructured content discovery techniques are FreeNet [42], Gnutella [14] and Random Walk [32] and some structured content discovery techniques are Chord [21], CAN and Pastry [42].

The overlay organizes the computers in a network in a logical way so that each node connects to the overlay network through its neighbors [25]. But the main issue in overlay network is node's communications which have a significant impact on the performance of p2p networks [36].

P2Pand MANETs have many similarities in nature, including being self-organized and decentralized and having dynamic topology. However, there are differences between them too [7, 15, 27, 51]. For instance, topology in MANETs is more dynamic than that in P2P networks due to node movement in MANET. In addition, MANETs encounter limitations such as low computing capacity, radio transmission range and consumed power.

The similarities between P2P networks and MANETs, the significance and simplicity of MANET deployment and wide applications of P2P have opened a new research field that attempts to apply overlay structure of P2P networks in the application layer of MANETs.

There are papers such [41] which have tried to apply P2P content discovery protocol over MANETs. Authors in [17] propose a content discovery framework for evaluation performance of these protocols over MANET with different mobility models. Results of this paper revealed the impact of mobility on the performance of content discovery protocols with metrics such as Hit rate, Response time and Energy consumption. Furthermore, higher performance of unstructured content discovery protocols than structured ones was revealed. Since, focusing on comprising an unstructured overlay with mobility parameter consideration over MANET is critical and justifiable.

Hence, this paper has focused on Gnutella, one of the unstructured content discovery protocols and has tried to justify it for MANET by applying some modification in neighbor selection for forwarding a query. It means a peer for forwarding a query selects the neighbors that it has the higher stable links with them. For finding such neighbors, this paper uses a mobility prediction method for calculating stability of the links between a peer and its neighbors. Since, this paper can be categorized in location aware or underlay aware P2P network which underlay parameter effect on overlay network.

Finally after simulation of proposed protocol, effective metrics for increasing the efficiency of peer-to-peer content discovery such as Hit Rate, Response Time, Search Delay and Energy Consumption are examined and will compare with previous protocol.

Simulation results show that by using new protocol can increase the efficiency of P2P content discovery protocol.

This article is organized as follows: first previous studies on the evaluation of P2P networks over mobile ad-hoc networks and the effect of mobility prediction on the performance of Mobile Ad-Hoc networks are reviewed. Then, P2P applications and their various architectures are explained. Finally,Gnutella will be changed by using mobility prediction method and will be evaluated by four efficiency parameters and the results of simulation will be analyzed.

2. Related Works

The issues of P2P and mobility management have been extensively studied separately. But there has been little work on using mobility management or prediction on P2P networks and its applications.

MA-Chord [39] is a modified version of Chord for MANET. It combines Ad hoc On-Demand Distance Vector (AODV) and Chord overlay routing. To exploit physical locality in its overlay, it uses Random Land marking 49], instead of having fixed land mark nodes.

A special chord algorithm, spiral chord was proposed in [54], for discovering resources currently available efficiently. Spiral chord could put forward an identifier (ID) assignment technique based on spiral space-filling curve to integrate location-awareness with cross-layering. Location awareness could aims at alleviating the mismatch of physical network topology and overlay network topology, and requires close-by IDs in logical ring of neighboring peers, while cross-layering aims at speeding up resource lookup operations, requires faraway IDs of neighboring peers.

Authors in [19], proposed a novel framework to evaluate the effect of mobility and its models on the resource discovery. By using several metrics, this framework was capable of evaluating the effect ofmobility on the underlay structure and subsequent changes on the overlay structure. The results obtained from extensive simulation, had clarified the significant role of the mobility models on the performance of P2P content discovery protocols. These results were supported by mathematical analysis.

In another work [18], authors proposed an adaptive method to optimize Random Walk unstructured content discovery protocol over MANET. First, they modeled this protocol using G-Network which is a queuing system with two types of customer, negative and positive. Then, they optimized this protocol by Gradient descend technique based on a cost function which consist of three parameters. Two of these parameters were Hit Rate and Response Time which are derived from content discovery protocols performance metric. The other parameter was Energy Consumption which is one of the most important performance metrics in MANET.

In [37], authors presented an evaluation framework which could evaluate challenges in VANET and their impact on performance of content discovery protocols including structured or unstructured ones. This evaluation was based on simulation and mathematical modeling. For mathematical modeling, Generalized Random Graph had been used. Results of evaluation had clarified a higher performance on unstructured protocol and also impact of movement pattern and environmental characteristic of VANET on performance on content discovery protocols. Furthermore, based on evaluation results, some modifications in the manner of comprising overlay network

had been presented. This modification could emphasize matching of overlay networks and underlay networks and also using traffic flow of vehicles in comprising overlay links. Positive impact of this modification had been shown by simulation and mathematical modeling.

3. Mobility Prediction in Mobile Ad-Hoc Network

Mobility prediction, i.e., estimating the trajectory of future positions of the mobile nodes in Mobile Ad-Hoc networks. In [13, 17] mobility prediction methods for mobile ad hoc networks classified into three categories as follows:

A. Movement history based prediction methods, which predict the "future" location of a mobile user based on his movement history (i.e., previous user movement patterns.)
B. Physical topology based mobility prediction methods, which base their prediction on the use of the characteristics of MANET's physical topology and therefore, require the use of a Global Positioning System (GPS) to obtain exact node location and mobility information.
C. Logical topology based mobility prediction methods, which choose a logical topology of the MANET (e.g. a clustering structure) over which they apply their prediction process.

By exploiting the fact that in real world situations, usually, a mobile node's movement is not completely random but the node travels in a predictable manner, it can be predicted the future state of the network topology. By predicting the future state of the network topology, the route reconstruction can be done effectively prior to route breaks and without generating excessive control overhead.

4. Content Discovery Protocols

One classification of content discovery protocols[1] divides them into two categories of structured and unstructured categories. In unstructured protocols, there is no specific rule to define the location of stored data and network topology. They use query flooding to search .Gnutella and Random Walk are two significant protocols of this type [3,15].but in structured protocols, the neighborhood connection between nodes and the location of stored data are clearly defined. Chord is one of the most well-known structured protocols has been presented in [19] [37] in details.

The protocol which is discussed in this paper due to the special characteristics of the low cost of nodes for joining and leaving the network in unstructured P2P is Gnutella that will be introduced completely below:

Gnutella is a very popular distributed file sharing protocol. The number of nodes participating in the network was estimated at about 50,000 in 2001 [24], when P2P was still a nascent technology. The current widely deployed version is 0.6 [34], which is a two-tiered hierarchy of peers, termed servants, collaborating to share files and forward protocol traffic through the network. Gnutella is an open standard and, as such, lends itself well to study and simulation in academic circles.

Unlike the Napster network [35], which employed a central server to mediate communication between peers, Gnutella is a distributed network. When first connecting

to the network, new nodes (known as servants) contact a "bootstrap" server to obtain the addresses of a few connected peers. However, further communication is handled through the P2P overlay without relying on servers. Once the new node has the addresses of existing nodes, it attempts to connect to them by sending Gnutella connect messages [29]. Two connected nodes are called neighbors. Several connection attempts may be necessary because nodes may not be willing to accept new connections or may have left the network. Once at least one connection has been established, the new node begins sending periodic Gnutella ping messages. These probes not to be mistaken for Internet Control Message (ICMP) ping messages are used to search for other nodes willing to accept new connections. They are sent by the new node to all its neighbors, which, in turn, flood them to all their neighbors. This recursive flooding continues until the ping's time-to-live (TTL) field, which is decremented at each hop, reaches zero. Along the way, any node receiving a ping and willing to accept new connections responds with a pong message. The pong back-propagates to the originator of the ping, which may decide to attempt a connection with the pong's sender [38].

In order to locate content shared in the Gnutella network, nodes must send query messages. Queries contain the search criteria (e.g., a file name) and are flooded similarly to ping messages. When a node receives a query that matches a resource it shares, it responds with a query hit message, which is back-propagated to the query originator. The originator may then decide to download the file from the node that sent the query hit. This is done directly, through an HTTP-like protocol [29], and the traffic does not pass through the P2P overlay network. Incidentally, this download activity represents a large proportion of the traffic on Internet [8].

5. Proposed Protocol

As mentioned previously, in the Gnutella protocol to perform some operations such as content searching, file sharing, messaging, query and so on one or more overlay networks are placed as an application layer on the physical layer (underlay layer).

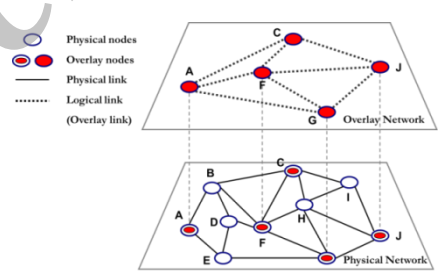

Figure1. Interaction between overlay and physical layer

According to the figure1 and by considering a wireless link between A and F nodes in a condition that the two nodes are in the transmission range of each other, It must be determined whether sent packets from A by the link (A-F Link) will reach F or not. In other words, the link will remain stable until the arrival of the packet to the destination or not. For this purpose,Link expiration time must be predicted. By anticipating link expiration time,they can be configured before disconnecting the links. As a matter of fact, a threshold is considered and if the P probability is larger than the threshold, mentioned node (destination node) is selected and a path between them will be formed

and in a condition that this probability is smaller, no path will be formed for sending the packet.

The method is in a way that the neighbors of node A (E, D, B) send their X and Y locations to each other periodically. This way the neighbors table will be achieved and their X and Y have been valued, as well. Also it has been considered two time periods, T_{old} and T_{now}. Now, according to equation (1) The sent time of a packet will be calculated and also by equation (2) the speed of a packet by using neighbors table. Hence, predicted distance will be determinable for each node based on equation (3), that is to say the latest time that are aware of the node.

$$T = T_{now} - T_{old} \quad (1)$$

$$V = \frac{A - A'}{T_{x+1} - T_{old}} \quad (2)$$

$$X = (T_{now} - T_{old}) \times V \quad (3)$$

Thus the probability rules are used and calculate that in which condition the sent packet can be used. Assuming that in the ad hoc network, the transmission range is equal to 100, and Hop Count < 2 is good and safe, according to equations (4) and (5):

$$X_g = 2 \times TransmissionRange \quad (4)$$

$$P = \begin{cases} \frac{1}{X_g - X}, X < X_g \\ \frac{1}{(X_g - X)^2}, X \geq X_g \end{cases} \quad (5)$$

When node A wants to send data packet, a random number between 0 and 1 is chosen. Then, according to equation (5) for each neighbor, it calculates the P probability amount. If the random number was greater than P probability, it means that the A-F direction would be a safe route and send the data packet. Otherwise, after calculating the probability (p) for each of the existing directions between intermediate neighboring nodes and comparison of the destination node with the random number, if the random number is less than the amount of P, it would be likely to mean that the path between them is not a safe path for sending a data packet will not send the packet. Provided protocol by the techniques of mobility prediction is called the Gnutella+ protocol which is the modified mode of the Gnutella protocol.

Based on the above code pieces, the simulation was started from 0 to 50 nodes. At each hop of the simulation, each node send their own x and y locations to each other periodically. At the beginning the onset of the process zero ($T_0 = 0$) was considered and by subtracting it from the current time($T_{now\_} T_{old}$), the time passed since the last packet sent by the source node was obtained and it had been called T. By multiplying T by transmission rate of data packet, value of X which is the distance between two neighboring nodes is calculated. Taking into account that the transmission range is equal to 100 and assuming a path length hop count < 2 a good and safe way, the threshold value was achieved.

By multiplying T by transmission rate of data packet, X value which is the distance between two neighboring nodes is calculated and also probability laws are implemented for sending the packages in a secure way. If the value of $X_g\rangle$ X, the probability of packet transmission is calculated by using $\frac{1}{(Xg-X)}$ equation, if the value of $X>X_g$, the probability of a packet is calculated from $\frac{1}{(X-Xg)^2}$ equation. Then, regarding to the fact that if $X <X_g$, the path between two neighbors path is an unsafe path and if $X>X_g$, the path between them is a good and safe one, then it will be made decision for sending the packet.

6. Network Characterization

To simulate, one of the most common network simulators, i.e. NS-2 is used. This simulator can simulate MANETs and P2Ps under different scenarios. Each scenario has been run 20 times for each protocol. Conducted by NS-2 simulations to evaluate the performance of P2P content discovery metrics for different number of nodes (starting from 50 nodes and add their number to 70 nodes), 70 separate simulations have been done that the result of analysis of the 70 simulation is presented in 14 diagrams.

Table 1 to 3 summarizes the parameters used in the default simulation scenario. As it was mentioned earlier, two protocols of Gnutella and Gnutella+ have been simulated. In both of them these are assumed that each node has a maximum of five neighbors. TTL of messages is set to 4 and ping messages are sent every 10 seconds. For each average speed (i.e. speed of 0 to 20 have an average of 10) 5 separate simulations were performed with different scenarios and Then output files of the simulation analyzed and A report file containing the processed data from the simulations have established.

Table 1. Simulation Parameters

Items	Values
Simulator	• NS-2
Terrain Size	• 2,000m^2
Node Speed	• 0 to 80 m/s
Node Number	• 50 or 70
Simulation Time	• 500s
Pause Time	• 50s

Structured 2. Underlay Characteristic

Items	Values
MAC Protocol	• Cisco 802.11 B/G Minipci Card
Routing Protocol	• AODV
Mobility Model	• Random Waypoint

Table 3. Overlay Structured Characteristics

Items	Values
Channel Error Rate	• 0.5
Percentage Of Online Node From Beginning Simulation	• 50%
Number Of Files	• 5000
Number Of Queries	• 1000

In the next section, the most important metrics to increase the efficiency of P2P content discovery protocols such as Hit Rate; the number of queries that are responded successfully in P2P networks. [9], Response Time; is the amount of time that a node should keep waiting for receiving the required response to its query. [9], Search Delay; the amount of search latency per node [2] and Energy Consumption; the average energy consumed per node [9] will be examined and analyzed.

6.1 Overlay Structured Metrics

Our classification of used simulated metrics, divides them into two categories of public and effective categories as shown in figure 2. In the following parts, each of the categories is discussed in details. It has been tried to present each metric by an equation for easy realization.

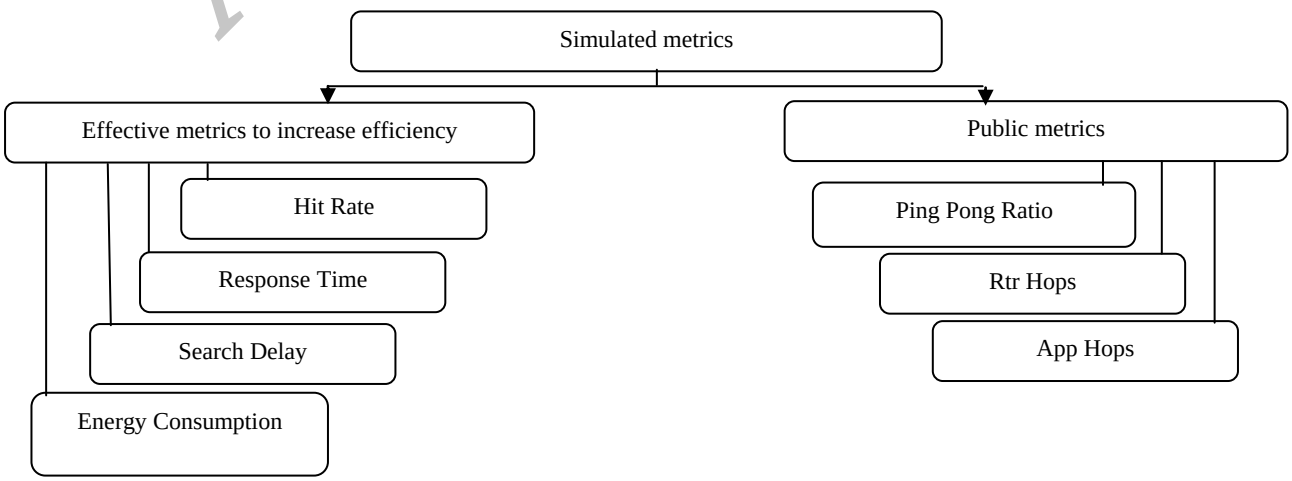

Figure 2.Classification of simulated metric

Ping-Pong Ratio:

Ping-Pong ratio is delivery rate of data packet to destination that shows the percentage of receiving packets by destination. In order to calculate it, It can be used from bottom equation:

$$Ping-Pong\ \ Ratio=\frac{\sum_{t=0}^{T} PktRcvd}{\sum_{t=0}^{T} PktSent} \tag{6}$$

Router Hops (Rtr Hops):

Router hops or briefly Rtr Hops is percentage of packets where routed in physical layer. In other word, it shows average of hops which passes a packet data to reach destination. By increasing the number of peers in network and followed it, by increasing the number of possible hops between two peers, also Rtr hops increases. In order to calculate it, It can be used from bottom equation:

$$RtrHops=\sum_{t=0}^{T} number\ \ of\ \ hops\ \ between\ \ two\ \ peers\ \ in\ \ physical\ \ layer \tag{7}$$

App Hops:

Application hops or briefly App Hops is percentage of packets where routed in application layer. In other word, it shows average of hops which passes a packet data to reach destination. since in p2p networks, there are one or more overlay layers as application layer over physical layer and relation between two neighborhood peers are direct and without any mediated node, App Hops is less than Rtr Hops.($\sum_{\text{App Hops}} < \sum_{\text{Rtr Hops}}$).In order to calculate App Hops , It can be used from bottom equation:

$$AppHops=\sum_{t=0}^{T} number\ \ of\ \ hops\ \ between\ \ two\ \ peers\ \ in\ \ application\ \ layer \tag{8}$$

Hit Rate:

Definition of hit rate is the number of queries that are responded successfully in P2P networks. Hit Rate, is calculated as follow:

$$HitRate = \frac{\sum_{t=0}^{T} success\ \ queries}{\sum_{t=0}^{T} success\ \ queries + \sum_{t=0}^{T} lost\ \ queries + \sum_{t=0}^{T} fault\ \ queries} \quad (9)$$

Response Time:

Definition of Response Time is the amount of time that a node should keep waiting for receiving the required response to its query. The time contains the amount of time needed for query transmits in the network, discovering the target content, and returning the response back to the user. Also Response Time is calculated as follow:

(10)

$$\text{Response Time} = \sum_{t=0}^{T} \Big(Time\ \ for\ \ query\ \ transmit + Time\ \ for\ \ content\ \ discovery + Time\ \ for\ \ returning\ \ response\ \ to\ \ user \Big)$$

Search Delay:

Search Delay is the amount of search latency per node that indicate that how long it takes for the flow of a data bit over a network from source node to a destination node. In fact, the average of search delay is the average amount of time that a data packet spends per second to reach to the destination.

Energy Consumption:

Energy consumption is the average energy consumed per node. Remaining energy is total of remaining energy in nodes after all simulations.

$$\text{Remaining Energy} = \Big(\text{Primary Energy} - Consumed\ \ Energy \Big) \quad (11)$$

7. Validating and Evaluating Simulated Metrics

In this section,the peoposed metrics whose are effective for peer to peer content discovery protocols such as Ping-Pong Ratio,Rtr Hops,App Hops,Hit Rate,Response Time,Search Delay and Energy Consumption are evaluated and examined.

7.1. Ping-Pong Ratio, Rtr Hops and App Hops Metrics in Gnutella and Gnutella+

As previously mentioned the Gnutella protocol uses flooding method for sending its own data packet. For two nodes which are considered as neighbors and are going to send a data packet to each other, at first the Ping message has sent and in response, the Pong message is back in order to establish a connection between two nodes.

Increasing the number of nodes in the network, causing congestion and overcrowding of existing routes in order to achieve the desired node and the nodes within a single package to be sent to the destination node, So many messages must be sent to only those messages Ping Pong messages received his answer would have been a neighbor of the source node.

Therefore, as shown in Figure (3) as the speed increases, the Ping-Pong rate reduces. Also as the Gnutella protocol is a P2P content discovery protocol and there is a physical layer in it which forms peers neighborhood connection, by increasing the number of nodes in the physical layer, as the speed increases, the Ping-Pong rate reduces. Another reason for such a decrease is that whereas the two nodes intending to send Ping-Pong message to each other may not be a direct neighbor and might be far two hops from each other, it is needed for a Ping message to pass some hops in order to reach the destination and mutually the Pong response need to back some hops, as a result Ping-Pong rate decreases with increasing speed.

According to Figure 3 it can be concluded that the proposed Gnutella+ protocol could enhance the Ping-Pong rate due to the improvement in routing overlay layer which itself is due to the direct connections of overlay layers in comparison with the lower layer.

Also as shown in figure (4), as Rtr Hops shows routing percentage of the packets at physical layer and by considering the Gnutella protocol a peer-to- peer content search protocol in which neighborhood connections of peers in the lower layer (physical layer) might form indirect and takes a few hops far from each other, by increasing the speed and the number of peers, Rtr Hops value reduces.

On the other hand, by taking into consideration that App Hops shows routing percentage of the packets at the application layer, and relying to the fact that the application layer is the same overlay layer which is placed on the physical layer and has direct neighborhood connection instead of having indirect connection with the presence of an intermediate, It is concluded that the routing of packets at the application layer is better than routing packets at the physical layer due to more direct connections of neighboring nodes in the physical layer.

According to figure (4) and (5) and those in the previous section and the diagrams, it can be concluded that the proposed Gnutella+ protocol could enhance the rate of Ping-Pong. This enhancement is due to the improved routing overlay layer and better direct connections than the lower layer. Also because Ping-Pong messages' rate is better in the Gnutella+ protocol and routing process is easier at overlay layer in comparison with the physical layer, it can be expressed that the proposed protocol is improved compared to the previous one.

7.2. Hit Rate metric

Figure (6) shows the amount of Hit Rate in the Gnutella and Gnutella+ protocol. Regarding to the fact that Hit Rate demonstrates the number of responded queries in a successful manner in a peer-to-peer network and considering that in the Gnutella network, queries are transmitted in a flood way and they have to pass all the neighbor nodes in order to reach the destination node, the amount of Hit Rate decreases. As a query may not fully and successfully reach its destination and lost during the sending path or the query may be sent wrong from the beginning.

If the queries are sent through the physical layer, by increasing the number of nodes and speed, the amount of Hit Rate decreases due to indirect and mediated communication nodes. After applying mobility prediction technique on the Gnutella protocol, the amount of Hit Rate modifies slightly and a greater number of queries on the network are answered successfully. It should be noted that in unstructured peer to peer protocol, increasing the speed will not significantly impact Hit Rate amount and the initial decline observed in the figures is due to the direct transmission of the queries which are sent without any intermediaries through overlay layer.

7.3. Response Time Metric

Figure (7) shows the amount of Response Time in the Gnutella and the Gnutella+ protocols. There are a lot of factors which play prominent roles in Response Time. Among these factors, time period between query generator and its response are not able. In addition, geographical distance and quality of the path are of effective factors, as well.

Indirect relationship consisting peers mediation in the physical layer and increasing the number of peers in the network results in a drop in network performance and also followed by a drop in response time. While, in the Gnutella+ protocol by taking advantage of mobility prediction technique and query transmission by an overlay layer, due to more efficient and direct communication of this layer, a modified query response time will be achieved.

It should be noted that in the case of broken links, there would be no response time whether the query is performed at the physical layer or overlay layer. However,This process can be prevented by taking advantage of the mobility prediction technique and using the proposed Gnutella+ protocol and sending continues Ping messages to find out the existence of a link.

If query transmission is at the overlay layer, cost of fixing path, being aware of the link and consequently response time will be boosted in comparison to the situation that query transmission is implemented only in the physical layer.

Eventually it was concluded that the Gnutella protocol, increasing the number of nodes will increase the number of sent queries and as a result the network traffic will increase as well. Besides, increasing the number of nodes, presence links at overlay layer will be reduced and as a result levels of Response Time decreases, too. According to Figure (7), after presenting the Gnutella+ protocol an improvement in Response Time are also observed.

7.4. Search Delay Metric

Because following a rise in the number of peers in the network, it is possible that the distance between two indirect neighboring nodes to beaded and consequently followed by an increase in response time. By an enhancement in the Gnutella protocol and introducing Gnutella+ one the response time will be decreased and an improvement in peer to peer content searching will be the result. Because in this protocol, there is an overlay layer on the sub layer that its neighborhood connections will be answered without any intermediates immediately and in least period of time.

Figure (8) shows the amount of two Gnutella and Gnutella+ protocols. Noting that search delay, the time that a packet spent in a second for reaching a destination, in other

words, time differences between the first data reaches the destination packet from the first data sent to a destination and considering the indirect connection by the mediation of nodes at the physical layer, response time will be increased by increasing the number of peers and the speed.

7.5. Energy Consumption Metric

Figure (9) shows the amount of Energy Consumption in the both Gnutella and Gnutella+ protocol.As several attempts might be taken in order to make the connection between neighboring nodes in the network and also existing nodes may not be willing to accept connections or want to leave the network, when a data packet is sent or a query occurs in the network, periodically Ping messages are sent by the Gnutella. These messages are sent by a new node to all of its neighbors and the neighbors also send the messages to other neighbors in such a flood method.

Considering that this reversing flood transmission continues until TTL field reaches zero which has an initial value and is decremented one unit in each hop. Thus, in each transmission Ping message hop, by decreasing the amount of TTL, some energy is consumed and since the residue energy is the difference between the initial energy level from consumed energy, its value will be diminished in each hop.

If sending a query is performed at the physical layer, as two nodes may be separated several hops and for taking any hops some of their energy reduces before reaching query message to its destination their energy is completely gone, i.e. the query may lost during transmission, energy consumption increases. After improvement of the Gnutella protocol and presenting peer to peer content search protocol in the platform of ad hoc network called the Gnutella+, according to overlay layer which has direct neighboring connections without any intermediate, the amount of energy consumption is improved.Finally, compared to the Gnutella protocol, there is a reduction in energy consumption at the Gnutella+ protocol and rise trend in energy curve grows with a less steep. As each node knows its limitations for data connections, this conclusion can be made that the Gnutella+ protocol is acted much better than the Gnutella and makes node lifetime longer. Moreover, there is a direct relationship between Hit Rate and Energy Consumption. By increasing the number of nodes, an increase in energy causes acceleration in Hit Rate amount as network traffic has been increased.

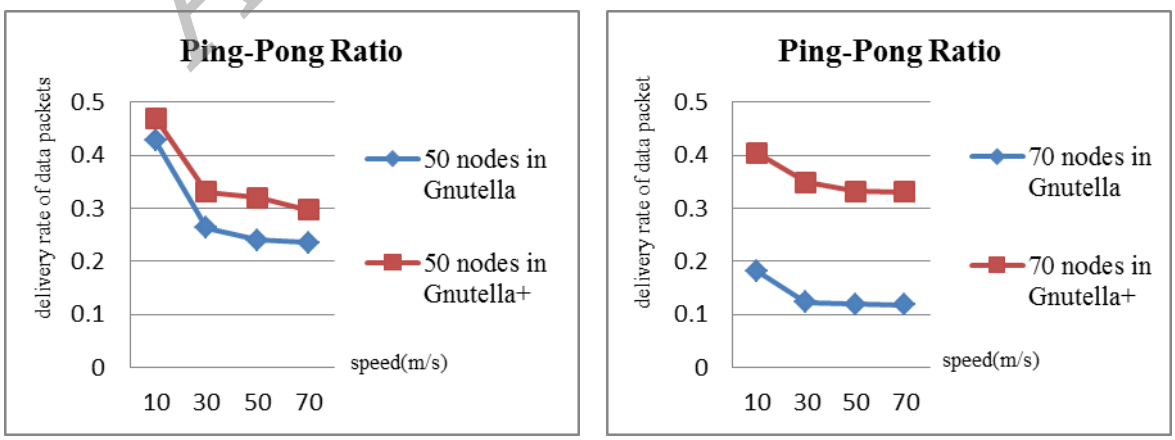

Figure 3. Ping–Pong Ratio

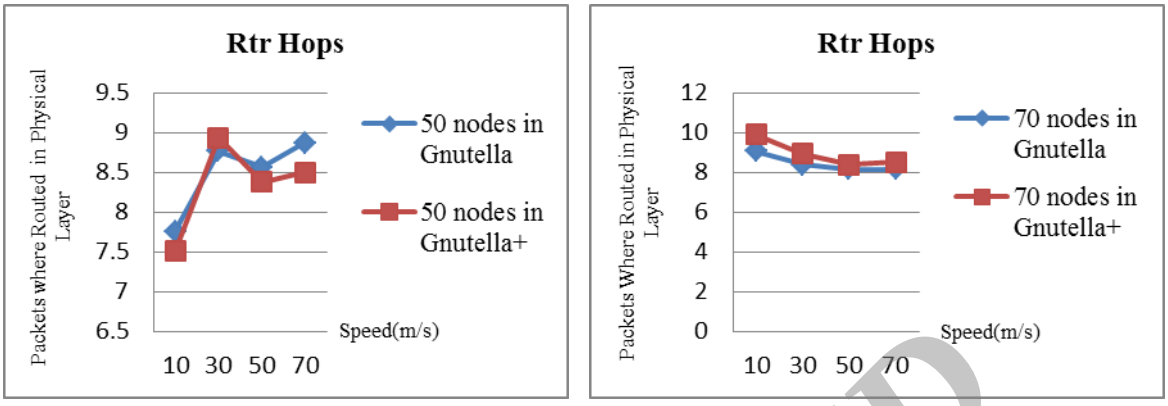

Figure 4. Rtr Hops

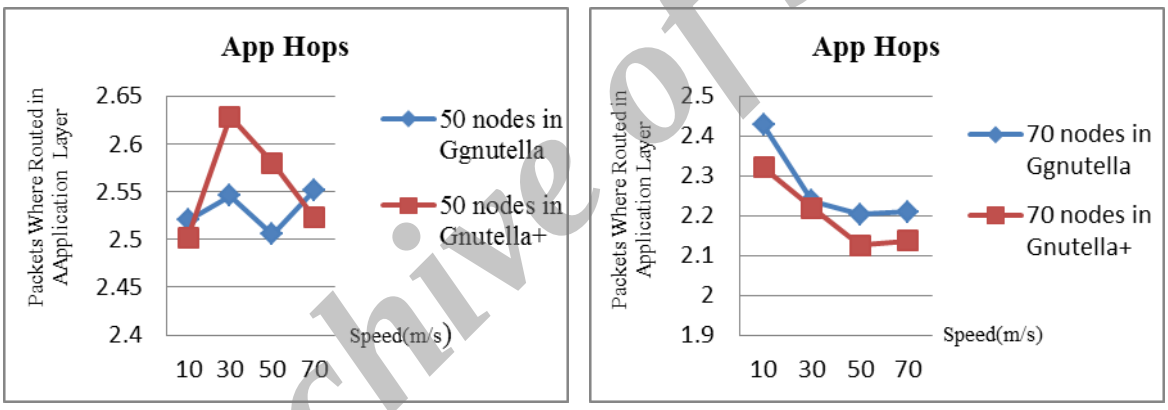

Figure 5. App Hops

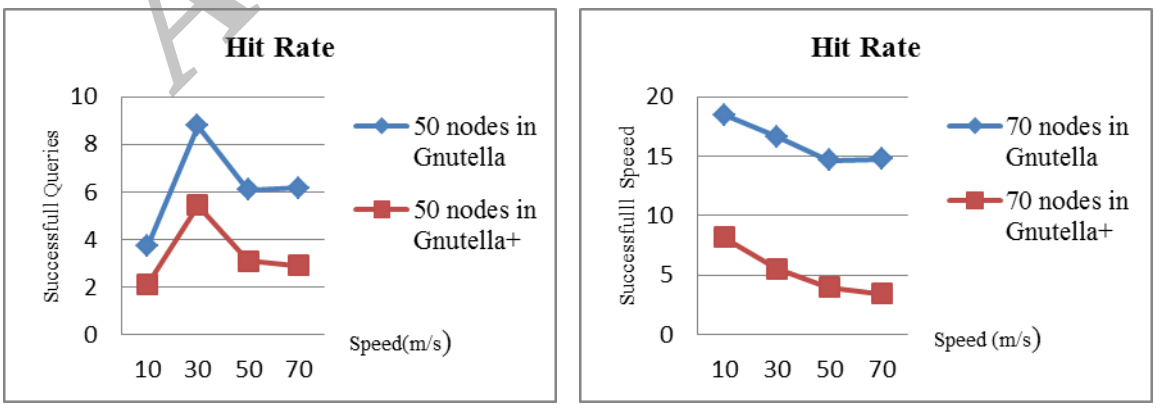

Figure 6. Hit Rate

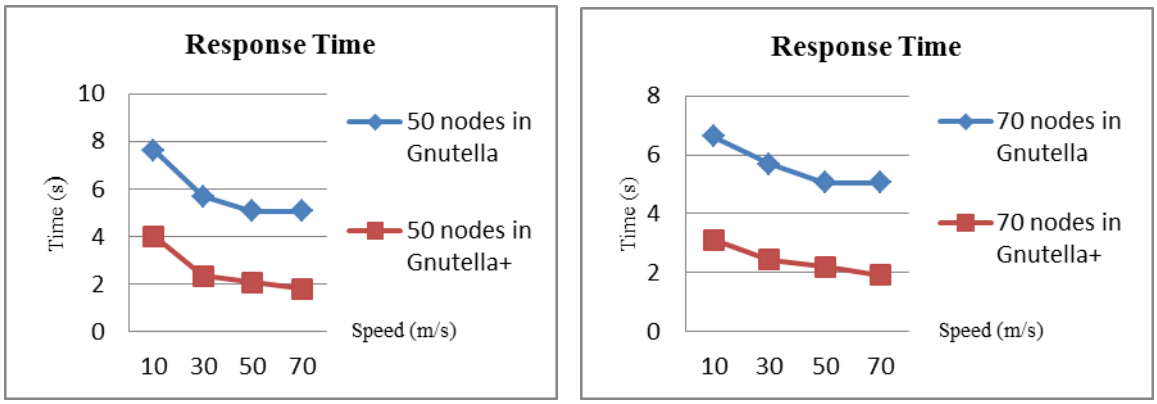

Figure 7. Response Time

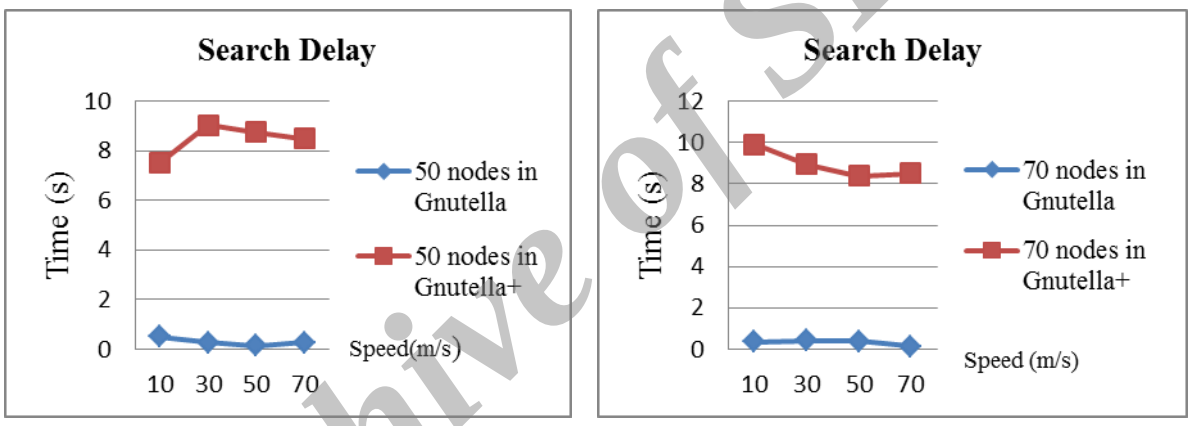

Figure 8. Search Delay

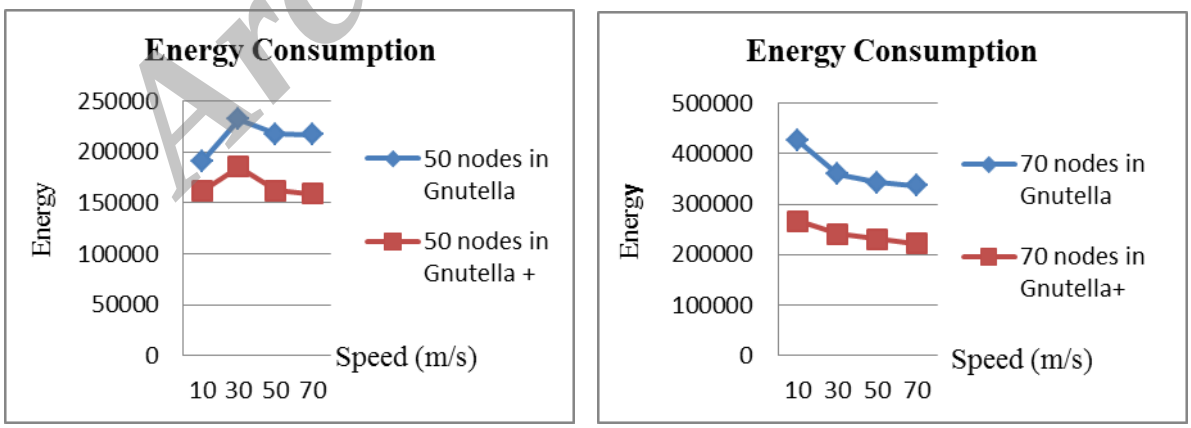

Figure 9. Energy Consumption

8. Conclusion

This paper proposed a location aware unstructured content discovery protocol over MANET. Considering transient topology of MANET, awareness of location of peers can improve performance of P2P networks over it. Furthermore, mobility prediction can help peers to select neighbors which are more stable during discovery process. This stable communication among peers leads to higher performance. But, awareness of location need using positioning system like GPS. Such systems, today, can be found in many of portable computing devices.

By implementing analysis procedure on various scenarios based on the number of various nodes and different speeds, this conclusion is made that proposed Gnutella+ protocol compared to the previous one is more effective in sending an application package, asking the path and sending queries in flooding method and has caused an efficient lifetime. In addition, following the advantage of high efficiency due to the reduced energy consumption, a reduction in the network delay is also provided by this protocol.

Finally, after analyzing effective factors to increase the efficiency of peer-to-peer content search protocols in ad-hoc network platform, These results were obtained that the criteria such as Response time and Search Delay which apply their main activities on overlay layer, has the largest influence in increasing the efficiency of peer to peer content search and From the other point of view, criteria such as Hit Rate and Energy Consumption due to indirect and mediated connections of neighboring nodes in underlay layer has minimum impact on increasing the efficiency of peer-to-peer content search protocol**.**

As future work, authors decide to extent proposed method to structured content discovery protocols and furthermore, use of more detailed mobility prediction techniques for selecting next hop for forwarding a query.

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