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A new algorithm for optimization of quality of service in peer to peer wireless mesh networks

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Abstract

Nowadays, wireless mesh networks are known as important parts of different commercial, scientific, and industrial processes. Their prevalence increases day-by-day and the future of the world is associated with such technologies for better communication. However, the issue of improving quality of service for dealing with more complex and intense flow of data has been always a remarkable research problem, as a result of improved wireless communication systems. In this sense, objective of this study is to provide a new algorithm for contributing to the associated literature. In the study, peer to peer wireless mesh networks and the concept of service quality were examined first and then an approach for improving service quality in such networks has been proposed accordingly. In detail, the proposed an approach allows profiting data transfer capability by data packet and using this information for routing and preventing overcrowd in network nodes and finally, distributing the load over it. When middle nodes overcrowd, they withhold to send control messages of route creating or do that by delay. The proposed approach has been evaluated and the findings revealed that at least 10% of undue delays through network can be prevented while permittivity does not reduce, thanks to the approach. Also energy consumption within network nodes partially increases due to adding table and the search which can be overlooked.

Keywords Wireless networks · Peer to peer wireless mesh networks · Service quality · Optimization

1 Introduction

It is clear that lots of access points (APs) are required to obtain connection through one geographical area with scalability or distinct size [1–6]. Nevertheless, the more problematic issue is that DSL modems and cable modems cannot be easily applied in some areas or apartments because of observing issues associated with aesthetics, complexity in the architecture or arrangements done over it, and also problem of placing respective cables regularly [7, 8]. As general, such a case has led to recent research efforts on applying the technology of wireless mesh networks [9–15] as an alternative course of action in order to ensure access to the internet through some approaches like dynamic self-organizing, self-configuring, and self-modifying structure. In this context, WLAN technology is one of the most important technologies for creating possibility mobility through computer networks. The standard of WLAN technology is identified by Wi-Fi and/or IEEE 802.11 [16–20]. In very short time, that technology has been widely used for communication purposes over computer based systems. At this point, a remarkable technology: VoIP has been effective on

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decreasing the costs (bills) of telephone conversations/communications for both the communication companies and users. In big-size offices and enterprises, savings as a result of decrease in the cost have made it a trend to develop internal telephone system based on VoIP technology [21–26]. By creating wireless network based on the VOWLAN technology, profits of companies and enterprises have increased by two reasons: First, the employees moving throughout an enclosure are always available by VOWLAN earphones, so productivity and efficiency enhance in an environment as leading to an increased profit at the end. As second, costs can be decreased by establishing telephone conversations via IP standard that results again an increase in profit [27, 28]. Factories and enterprises that can benefit from VOWLAN technology are the places where workers or employees usually turnover in their work place and the hours they spend behind their desk constitute main proportion in comparison to the total work hours. Nurses at hospitals, teachers in the school environment, sellers at big stores, engineers operating and supervising construction projects, and factory workers are some remarkable examples for such workers or employees. Aside from the enterprises where personnel usually perform turnover in work place, there are also two other sections of market that can attract producers of VOWLAN technology for the future. The first market pertains to public places like airports, hotels, restaurants, exhibitions or congresses, train stations…etc. The second market is related to homes and small companies. By decreasing VOWLAN technology products, these two market sections will be gently given attention [29–31].

Nowadays, wireless networks have a particular importance. An increasing need to dynamism of works has made it possible to use equipment like a mobile phone, pagers, etc. over existing wireless networks. If users, companies or applications tend to have an access on their own needed information through mobile mode in every time, wireless networks are good solutions for dealing with that load. But in time, it is also important to have a good level of service quality in even more load and complex flow of information through the communication road. Therefore, it is too remarkable to as the following question: 'Which plans have been thought for increasing quality of services in wireless networks?' The response to this question can be a foreground for considering various kinds of wireless networks and the quality provision plans in these networks. Plans opening new worlds for thinkers and also newly developed technologies will make it possible to improve that research area and also take new step towards the developments for the modern sciences.

Objective of this study is to consider the case of improving service quality and after investigating it from different aspects, the objective has been chosen as to provide an approach which may improve the service quality through some kinds of wireless networks under special conditions. In detail, the proposed an approach allows profiting data transfer capability by data packet and using this information for routing and preventing overcrowd in network nodes and finally, distributing the load over it. When middle nodes overcrowd, they withhold to send control messages of route creating or do that by delay. In order to understand more about success of the approach, it has been also aimed to ensure a simulation environment for evaluation.

Based on the topic and the objectives, the remaining content was organized as follows: The next section is devoted to a brief literature review so that it can be possible to have some pre-information about what has been done further in this research study. Following to that, the third section explains the proposed approach in detail, by considering its essentials and working mechanism through algorithmic steps. Next, the fourth section reports the simulation findings in terms of a direct evaluation and finally, the paper is ended with conclusions and a discussion about some future works.

2 Related work

In order to understand more about the performed research here, it is important to have connection with the associated literature. So, a general review on the literature can be done as follows, just before explaining more about the developed algorithm and the proposed solution approach in this manner:

Although mesh-based systems provide flexible and reliable infrastructures for distributing data, the need to apply data exchange method is not completely negligible. Pushing and pulling are two main methods for presenting video frames in peer to peer networks [32, 33]. Pushing-based method is more appropriate for limited uploading of applications in which there are several sources and many receivers. Unlike pushing method, pulling-based method is more useful when there are many sources but a few receivers. That means pulling-based systems are appropriate for limited download application. An efficient flow of Video on Demand method is based on pulling method that has been proposed in article [34] for serving great user population. The incentive of this distribution trend is N demands of video flow propagation in ever connected layer within a mesh-based peer to peer system, based on pulling method presented in article [35]. In article [36], one fluid trend, sharing file by help of bit torrent is presented by using pulling-based method and also measuring data delivering amount through mathematical analysis. Productivity magnitude of pulling method in article [32] has been measured only based on two function scales including delivery amount and distribution delay extent. Nonetheless,

permanent and intensive effect of different tensions on it has not been considered. Although Pull-based approaches impose high network overhead to the network, but no evaluation on it is performed. So few works evaluated pull-based method in P2P systems and all of them considered few performance metrics with no churn event in the system. In addition, in a study introduced a hybrid push–pull approach and compared it with pull-based method [37]. Hybrid method is almost a new solution based on both pull and pushes techniques that are introduced to provide better performance in data exchanging. Each peer pushes just received video frames to some of its neighbors randomly. Therefore, although push-based method drastically decreases the end-to-end delay in both mesh- and tree-based systems, it imposes a large number of duplicated video frames in mesh-based systems due to blindly forwarding of frames which results in considerable waste of bandwidth [38]. On the other hand, pull-based method diminishes the number of duplicated video frames dramatically, while it increases the end-to-end delay. Each peer in a pull-based system sends its Buffer Map Status (BMS) in a specific interval time. Each neighbor, which receives this BMS, compares it with its local buffer status and sends a request message which includes the list of missed video frames in its buffer to its neighbor. Neighbors who receive these requests will send requested video frames immediately based on their upload policies. In the recent years, different hybrid push–pull-based methods are introduced to exploit the efficiencies of both pull and push techniques [39]. However, their proposed methods usually inherit existing problems in them. To examine these hybrid methods is out of the scope of this study. In near future, this study will analyze the efficiencies of the most important recent proposed hybrid push–pull methods in same conditions. Actually, most of the recently studies, especially those which used network coding [40] for efficient video streaming, employs pull-based method for video dissemination over mesh-based P2P systems [39, 41]. As a result, this research determined to examine the real efficiency of this method for mesh-based P2P live video streaming in various network conditions. Moreover, peer churning is one of the most important challenges and as an open issue in all P2P systems [33].

3 A new approach for optimizing quality of service

In this section, the new approach for optimizing quality of service was explained in general. The next paragraphs are devoted to some information for essentials and details of the algorithm and the followed solution approach.

3.1 AODV routing algorithm

AODV (Ad hoc On Demand Distance Vector Routing) algorithm is known as a ‘distance vector algorithm’ that has been developed for working in mobile environments and in which limited bandwidth and i.e. little life of car battery have been seen in the environment (in calculation related to the optimum route) [42–47]. One of the other uncommon features of the method is that it is implemented through On-Demand algorithm, that is the routes arriving some points of destination are determined only when one want to send a package to that destination. Figure 1 shows an initial mode of a typical mesh network in which data will be dispatched from node A to node E (these nodes are shown as colored).

3.2 Route detection

In order to illustrate algorithm, let’s consider the particular network (Fig. 2) in which the node A want to send package to the node B. In AODV algorithm, each node has one table including a key corresponding to the destination address and each record of this table contains data about destination to which neighbor one should dispatch that package. Suppose A searches its table and cannot find any element parallel to E. Now it should detect a route toward E. Such a feature (the routes are found only if necessary), has called as ‘On-Demand’ feature of the algorithm. Figure 2 shows one step of routing for sending data from A to B in which node A receives route information from its neighbor nodes.

Here, the node A creates one particular package called ‘Route Request’ and propagates it in pervasive mode in order to find the location for the node E. The related package arrives at B and D (as indicated in Fig. 2). The package case of ‘Route Request’ is as follows: this package includes destination address and origin address and identifies who search whom. In detail, Fig. 3 presents a typical protocol packages format of the AODV.

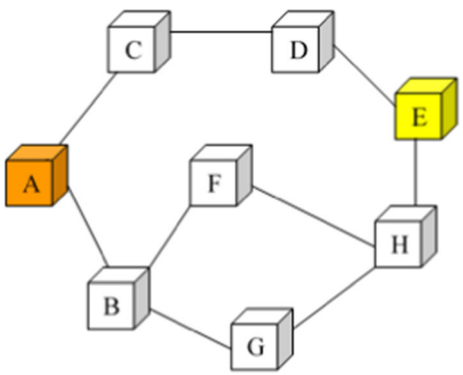

Fig. 1 An initial mode of a typical mesh network

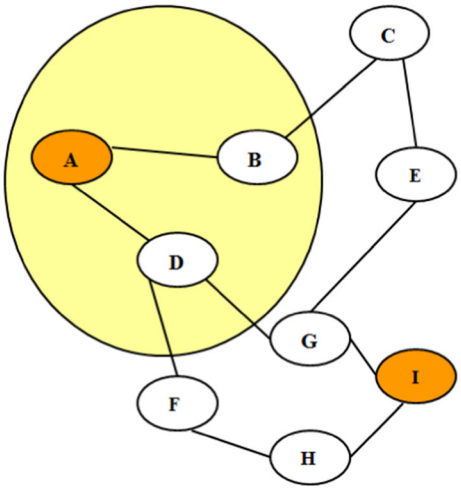

Fig. 2 One step of routing as beginning the route from node A to B

Unlike the other algorithms of origin routing, AODV algorithm does not place route in package header. In contrast, when each node receives an RREQ message, if it has the last node path in its table, it propagates the REEP message from the table it previously checked. Otherwise, it propagates RREQ message. Certainly, RREPs can be sent back to the RREQ sender node. One sequence number in RREQ message may be used, in order to inform the middle node whether the route it knows is newer than dispatched demand. Similarly, RREQ massage may be provided via a middle node only if RREQ sequence number is smaller than the known sequence number [48–50].

3.3 Proposed algorithm

Considering the explanations so far, details regarding the proposed method can be explained in detail as follows: The method proposed in this research is based on required parameters to supply service quality in peer to peer wireless mesh networks. The first part of this solution is realized as independent of AODV routing protocol and any type of protocol in a way that when each node has a package for sending, accompanies its own data with that package, then the nodes that receive this package (load data of origin node), save this data in a table. So all nodes will have one table in which they have saved load data. Another data that each node should save within itself is total network situation, in such a case that each node should change total network situation when the table changes. The total network situation is an average of loads saved in this table. Because of different routes among nodes and also non synchronization of nodes, various nodes may be different but it does not matter. Each node has its own view regarding network and makes decision based on its unique information about network.

The second part of the solution is related to AODV packages. When each node receives one package in kind of AODV Route Request, compares its own situation to the total network situation in a way that divides its own load situation by the total network situation and do an appropriate function with due attention to this proportion. If this proportion was less than one, it means that node situation is normal and node sends package as usual. But if this proportion was more than one, it indicates that node is overloaded and does one of the two following reactions based on this extra proportion; if this amount was very big removes Route Request package, and if this amount was not very big dispatch the package with delay. Also it uses related information in itself routing, so that finds its neighbor nodes which have the better statistics. Identifying neighbor nodes is very simple and it can be even done by accounting how many steps the package has taken.

The algorithmic steps of the proposed method can be expressed generally as follows (Fig. 4):

- *Step-1: Send messages correction*: Each node as a source wanting to send data, adds a weight field to their sending packets. The weight is transferred by data

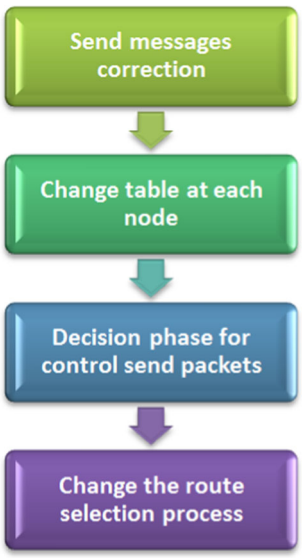

Fig. 4 Flow chart of the proposed algorithm

Fig. 3 AODV protocol packages format

packets within the network and stored in the table of each node. The sender node's weight should be stored in the node table as the intermediate routers to be used if needed.

- *Step-2: Change table at each node*: Table in each node which is for neighbor selection in suggested algorithm, will be updated during the short time: This issue occurs when as number as the number of cells of the table, we have data from different nodes and a new packet arrives. In this case, these data further will situate the existing data rotatory.
- *Step-3: Decision phase for control send packets*: In this step, when each node received a route request control packet, compare its load amount with global situation of network, so divide load amount of itself on load amount of the network and regarding this ratio perform suitable task.
- If this ratio be less than 1 it means node situation is normal and the node send packet as usual; but if this ratio be greater than 1 it means node hasn't suitable situation and with respect to amount of it perform one of following reactions: if this amount be very large it drop route request packet and if this amount isn't very large, forwards this packet with delay.
- *Step-4: Change the route selection process*: In the proposed algorithm, path selection is based on quality of service maintenance. To this end, nodes must be chosen from the neighbors of a node to the next node that as estimated has the least load, the lowest cost or the most benefit. As a result, three cases can be considered: mention only load of a node as the criterion of deciding. Second case is when we mention absolutely to other parameter except load amount of nodes like number of neighbors, node's energy and so on. Third case is when another criteria mentioned in deciding.

4 Simulation and evaluation

It is important to have more information about success of a proposed method in terms communication. Because of that, an evaluation including simulation and measurement phases have been done for understanding more about success of the method in this study. Simulation software used in this manner is NS simulation software version 2.29. This software is very efficient and reliable for network simulating and measuring and is confirm by universities and scientific communities.

An example scenario has been followed in order to understand about performance of the proposed approach-algorithm. The number of traffic flows is constant in the proposed scenario and number of nodes changes from 30 nodes to 80 nodes every time 10 nodes. Certainly, network efficiency decreases to some extent due to network nodes increase which in turn leads to node interference. In the scenario, the traffic flow number equals to 5 which is UDP type with CBR constant rate.

Delivery package to 50 node numbers ratio by the proposed algorithm is shown in Fig. 5a. It is only once simulation operation. As it can be seen from the Figure, all packages have been delivered in mostly seconds, but package downfall is only observed in about second 27 when delivery package ratio comes to 92%. Figure 5b also shows a graphic regarding throughput for 2 video flows versus time.

In addition to the findings so far, the proposed algorithm can be also evaluated with some similar algorithms. When it is compared with some alternative algorithms like P2P Mesh, WMN-Balance, Favorable peer support, and the Opportunistic P2P, it can be seen from Fig. 6 that the rate for number of flows by the proposed approach-algorithm is always better than P2P Mesh, and WMN-Balance. When compared with Favorable peer support, and the Opportunistic P2P, it is possible to indicate that the performance of the proposed approach is between these alternative solution approaches. Even at a certain point, they provide similar performance in terms of flows.

When the end-to-end delay (in seconds) is evaluated in the context of the comparison, it is possible to indicate that the proposed approach provide better performance according to all other alternative approaches of P2P Mesh, WMN-Balance, Favorable peer support, and the Opportunistic P2P (Fig. 7). Moving from the findings, it can be understood that the proposed method may improve package delay up to 10% and ensure better situation for the network traffic load. Thus, package removal may be intercepted very well, thanks to the proposed approach-algorithm in this research study.

The algorithm proposed in this study is an easy-to-apply and a direct method for ensuring desired service of quality. Further analysis may include modelling the problem in more detail and even using some heuristic, combinatorial optimization oriented ways as such solutions are also popular in the literature [51–56].

5 Conclusion and future work

In this paper, the concept of service quality in peer to peer wireless mesh network was studies and consideration was given for how to improve this with due attention to important parameters. The proposed algorithm has enjoyed the feature of 'data piggy-backing' by nodes as fulfilling nodes need to some information about network load, nodes

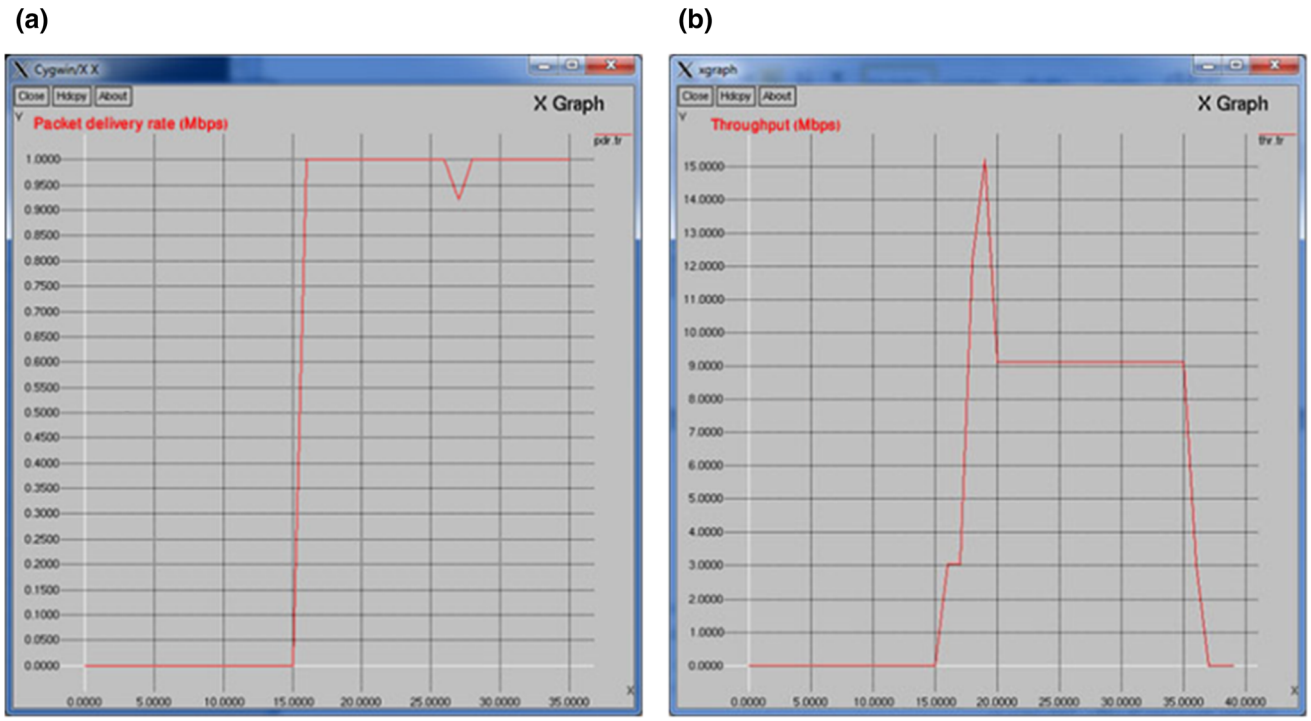

Fig. 5 **a** Package delivery to 50 nodes ratio versus time. **b** Throughput for 2 video flows versus time

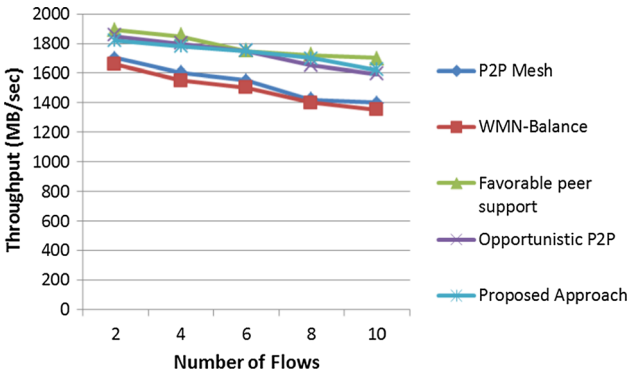

Fig. 6 Comparing throughput of some algorithms and the proposed approach

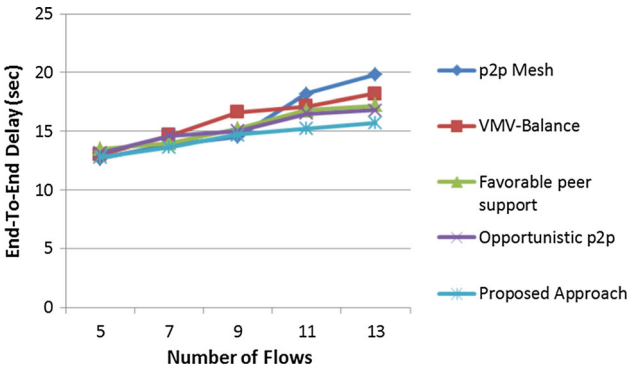

Fig. 7 Comparing delay of some algorithms and the proposed approach

energy, and their neighbor number. Each sender dispatching the package places its own data on it and nodes along route use this data and update their own table. Every node using this data can make two decisions: one that to which neighbor nodes it sends data, and the other whether it dispatches route information to other nodes given total network situation or that it can do it by delay to decrease network traffic. It is important that the proposed method may improve package delay up to 10% and also make better situation regarding network traffic load. So package removal may be intercepted very well. That is case while the important parameter like permittivity within network does not decrease and it is critical issue in itself.

In addition to the performed research, there are also some future works planned. In this context, there will be some additional experiments to evaluate the proposed algorithm more. Also, developments on the algorithm to have newer, improved versions have already been planned. It is certain that the associated literature is always open for new algorithms so it is a need to provide new versions of the algorithm with improved features. As the final future work plan, there will be also future research on combining some artificial intelligence techniques with the proposed algorithm for improving the abilities of the algorithm by considering possible advanced network structures of the future. That research may include use of some control oriented techniques like Fuzzy Logic or optimization based algorithms to search for optimum parameters for better

performance or creating adaptive algorithmic characteristics.

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