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Multipath Routing Protocol by Breadth First Search Algorithm in Wireless Mesh Networks

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Abstract: *In this paper, we propose a multipath routing protocol in wireless mesh networks. In this protocol, the source discovers multiple paths to the destination using parallel layer based approach. This approach organizes the nodes and discovers multiple paths using breadth first search algorithm. From multiple paths, the primary path is elected using Expected Forwarding Counter (EFW) metric. We evaluate quality linked based in our approach using network simulator 2 (NS-2). Our approach discovers multiple paths effectively and the elected primary path is more reliable. The approach makes use of Expected Forwarding Counter (EFW) metric to elect the primary path. We have evaluated the protocol using NS-2. The results show that the proposed protocol attains more throughput and packet delivery ratio with reduced packet drop and delay.*

Keywords: *Breadth first search (BFS), Expected Forwarding Counter (EFW), Network simulator 2 (NS-2), Wireless mesh networks (WMNs).*

I. Introduction

The promising two-tier architecture constructed with multi hop transmission characteristic is termed as Wireless Mesh Networks (WMNs). This communication network includes radio nodes that are arranged in a mesh topology. The main components of WMN are Wireless Mesh Routers (WMRs) and Wireless Mesh Clients (WMCs). The WMRs are act like APs and it provides connectivity to the WMCs [1]. However, WMNs are constructed by means of several technologies, in that WiFi and WiMAX contributes more[2]. Infrastructure mesh, Client mesh and Hybrid mesh are the three types of Wireless Mesh Networks (WMNs)[3].

• Infrastructure/Backbone WMNs

The infrastructure mesh is constructed using more radio technologies. Infrastructure mesh is also known as backbone WMN as it endows backbone for clients. It also integrates WMN with prevailing wireless networks using gateway/bridge functionalities.

• Client WMNs

Link Quality Based Multipath Routing Protocol in Wireless Mesh Networks 369 Client meshing achieves routing in the current network and it provides configuration functionalities by providing end user applications to customers. Client meshing is responsible for accomplishing peer- to- peer networks among client devices.

• Hybrid WMNs

As the name implies, hybrid WMNs are the combination of both infrastructure and client meshing. This architecture access the network through mesh routers and provide routing functionalities, which is the function of client WMNs. Simultaneously, it makes use of infrastructure mesh, by providing connectivity to other networks. The wireless mesh network is the prominent technology to provide broadband wireless connectivity including urban, suburban and rural areas without requiring costly-wired network architecture. Transportation services can be controlled using wireless mesh networks. It is the adaptable solution for public safety such as police, fire department and emergency services [4].

1.1 Routing in WMN Network

There are several routing protocols exists for wireless networks, in that, some routing protocols are best fit for WMNs. The suitable routing techniques are classified into two types as, on demand routing and proactive routing. Apart from these categories, WMN routing protocols are further divided into two types namely source routing and hop- by- hop routing. This classification is based on how packets are routed along the paths. All these routing protocols have costs that they may differ in message overhead and process complexity [5].

1.2 Need for Routing

WMN offers an ideal Internet access to both fixed and wireless networks. As it provides transmission between mesh nodes and the Internet through mesh gateways, an efficient routing mechanism is necessary to facilitate both forward and backward data transmission.[6]

1.3 Issues of Routing in Wireless Mesh Networks

Implementing routing mechanism in Wireless Mesh Networks (WMNs) introduce more difficulties in the network. Some of them are described below [7]. Since, WMN offers multihop communication to transmit information, the routing protocols may suffer to discover reliable routing paths. As network size increases, complexity also increases to find a reliable path. If a route breaks due to network complication, finding a new route (i.e) recovery procedure is costly. The components of WMN such as mesh router and mesh client have different characteristics such as mobility and power constraints. These heterogeneity behaviors complicate the routing process [7]. Therefore, the routing mechanism should be able to address all these issues at the same time to provide an efficient routing mechanism.

In this paper the Proposed Work evaluates AODV-CGA (Reactive Hop-by-hop Routing), FBR (Proactive Field-based Routing) and GSR (Gateway Source Routing) routing protocols for achieving backward path routing. However, in their mesh network scenarios, the AODV-CGA protocol exhibits poor performance. FBR inherently does not scale to the network size, but for smaller networks, it seems to be a good fit. In [8], they formulate the logical topology formation, interface assignment, channel allocation, and routing as a joint linear optimization problem and their proposed MC-WMN architecture called TiMesh. The main drawback in this paper is more co- channel interference between some of the neighboring links in MC WMNs.

II. Related Work

The three protocols for routing from the Internet to mesh nodes in static and mobile scenarios. These protocols all represent different classes of routing strategies. Based on their findings, they proposed and evaluate enhancements of a routing protocol GSR is scalable; it delivers the best trade-off between packet delivery ratio, routing overhead, and scalability to the\ network size. Mohsenian-Rad et al [8] have proposed the TiMesh MC-WMN architecture by formulating the logical topology design, interface assignment, channel allocation, and routing as a joint linear mixedinteger optimization problem. And this model formulation takes into account the number of available NICs in routers, the number of available orthogonal frequency channels, expected traffic load between different source and destination pairs, and the effective capacity of the logical links. This scheme balances the load among logical links and provides higher effective capacity for the bottleneck link(s). The available NICs and frequency channels are also better utilized. The TiMesh also offers better fairness among different flows. Yong Ding et al [9] have proposed two heuristic multipath discovery algorithms namely iterative path discovery (IPD) and parallel path discovery (PPD) to find multiple independent paths from senders to the receiver for each Video on Demand request. The proposed algorithms considered wireless interference in the multipath discovery, so it was able to balance the video streaming traffic both spatially and on different channels in the network. Based on the multipath discovery algorithms, then they have proposed a joint routing and rate allocation algorithm to find the routes and rate allocation with the goal of minimizing the network congestion. Chun-Wei Chen et al. [10] have proposed a Gateway Zone Multi-path Routing protocol called GZMR. Their protocol use nodes around the gateway to form a gateway Cooperative Zone and ceases the routing control messages flooding outside the zone. Border nodes in the zone can help replying gateway information to reduce route discovery delay and can solve gateway-congested problem.

The reducing routing overheads and multiple paths from source to the gateway can help reducing average end to-end delay and improving the packet delivery in wireless mesh networks. They do not consider some important metrics such as node stability and residual power to determine gateway cooperative zone and border nodes. Jack W. Tsai and Tim Moors [11] have proposed an interference-aware multipath selection technique for reliable routing in wireless mesh networks. Initially, they have investigated using interference minimization to provide reliable data delivery. They have defined weight function based on the ETT metric and interference minimization known as WIM. They have provided heuristic for multipath selection that will exploit the frequency diversity offered in a multi-radio, multi-channel network. They have focused on improving resilience against random link failures by factoring in the interference between multiple paths that could adversely affect redundant data delivery.

III. System Design

The system design has been in two phases-logical design and physical design. In the logical design, the user specification for the proposed system were formulated, i.e. features like input files, transferring files etc. also procedures were designed in a manner that would meet the project requirement. Physical design follows the logical design phase, in this phase, emphasis is put on how the requirements are to be achieved in terms of hardware equipment's and procedures were formulated. The method of inputting data to the system and to process them so as to produce the desire output was decided after the advantage and disadvantages of each available alternative.

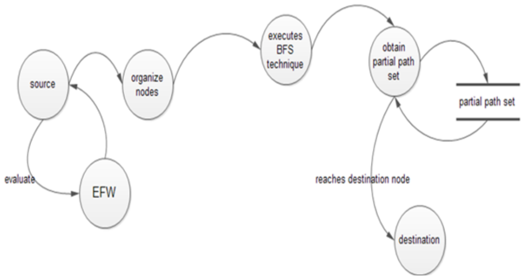

Fig.1 Data flow diagram for iteration

Data flow models are an intuitive way of showing how data is processed by a system. At the analysis level, they should be used to model the way in which data is processed in the existing system. The notations used in these models represents functional processing, data stores and data movements between functions. Data flow models are used to show how data flows through a sequence of processing steps. The data is transferred at each step before moving on to the next stage. These processing steps or transformations are program functions when data flow diagrams are used to explain a software design.

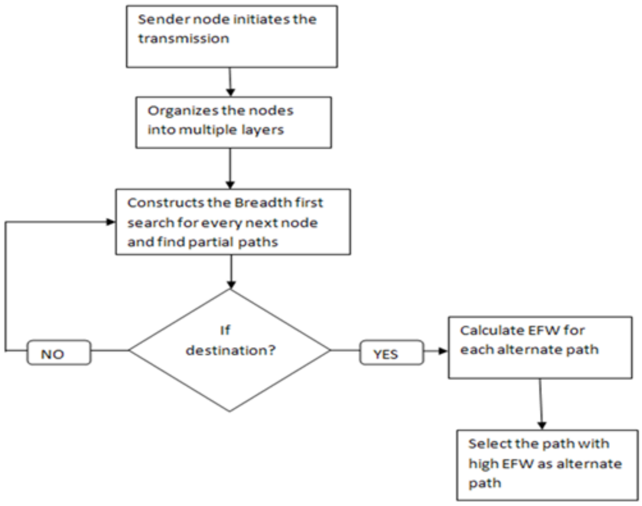

Fig.2 Block diagram of Breadth first search

The implementation phase of any project development is the most important phase as it yields the final solution, which solves the problem at hand. The implementation phase involves the actual materialization of the ideas, which are expressed in the analysis document and developed in the design phase. Implementation should be perfect mapping of the design document in a suitable programming language in order to achieve the necessary final product. Often the product is ruined due to incorrect programming language chosen for implementation or unsuitable method of programming. It is better for the coding phase to be directly linked to the design phase in the sense if the design is in terms of object oriented terms then implementation should be preferably carried out in a object oriented way. The factors concerning the programming language and platform chosen are described in the next couple of sections. There are three major implementation decisions that have been made before the implementation of this paper.

IV. Multipath Path Discovery Algorithm

The WMN can be denoted by a directional connectivity graph as G(V,E) , whereas V represents the set of mesh routers and E denotes the set of undirected edges in the network. The undirected edges 1 2 1 2 (e , e)ÎE if d (e , e)£ R whereas, 1 2 d (e , e) is the Euclidean distance between 1 e and 2 e and R denotes the radio transmission range.

Parallel Layer based Approach

Let S and D be the source and destination respectively. Let T be the current topology of the network. Our approach discovers multiple paths between the source and the destination using parallel layer based approach. Initially, the source arranges the nodes that are in V into multiple layers. The nodes are categorized into multiple layers based on their distances from the destination (D). During the discovery of multiple paths, our approach executes breadth first search for all iterations. The search starts from S, which is in outer most and attains partial paths that connect nodes in the lower layer. The partial paths that are obtained in the search are stored in P, which is the set that contains all possible partial paths that connects the destination. This process is iterated until the destination node is reached. The search process is described in Algorithm.

Algorithm-1

Let P be the set that contains partial paths

Let T be the current topology of the network

Step-1 Execute Breadth First Search in T

Step-2 Store the obtained partial paths in P

P = {p1, p2}

Step-3 Repeat step-2 and 3 until it reach the destination

Figure-3 describes the parallel layer based approach. In that, S and D denote the source and destination respectively 1, 2 … 11 represents mesh nodes. While discovering multiple paths in the network, the source executes breadth first search. During its first iteration, it founds partial paths as

P1 = {S −1, S − 2, and S − 3} and this iteration is denoted in red color. In second iteration,

P2 = {2 − 5,1− 4, 3− 6,3− 7}, which is represented in brown color. Again, in third iteration is colored in green,

P3 = {5 −12,4 −8,6 − 9,7 −10}. Finally, the fourth iteration is mentioned in blue color,

P4 = {11− D,8 − D,9 − D,10 − D}. Thus, the iteration process is repeated until the source finds paths to the destination. By summing up P1, P2 , P3 and P4 , we attain the multiple paths from source S to destination D .

$$P=P1+P2+P3+P4 \quad (1)$$

Now, the available multi paths (M) can be summarized as follows,

$$M = \begin{Bmatrix} M1 = S-3-7-10-D \\ M2 = S-3-6-9-D \\ M3 = S-1-4-8-D \\ M4 = S-2-5-11-D \end{Bmatrix} \quad (2)$$

This S-D pair contains four alternate paths between the source and destination. Among these available paths, the primary path can be elected based on EFW metric and it is described below

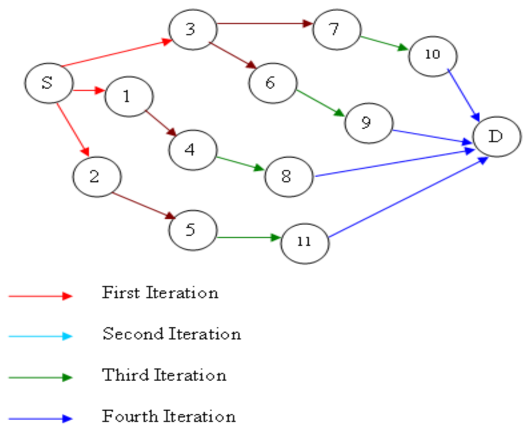

Fig. 3 Parallel paths Primary Path Selection

We obtain multiple paths for any source and destination pairs using layer based multipath selection approach as discussed in the availability of multiple paths, the primary path is elected using Expected Forwarded Counter (EFW) metric proposed by Stefano.

Expected Forwarded Counter (EFW)

The EFW metric enhances the Expected Transmission Count (ETX) metric. It associates the link reliability measurement of ETX with forwarding behavior of relaying nodes to assure high throughput requirements. EFW introduced the forward probability estimation technique in view of the fact that packets may drop even after the reception of successful ACK packets.

Let L_i and L_j be the links formed between nodes i and j . , $P_{Li,}$ P_{Lj} and $P_{Lj,}$ P_{Li} represents the packet loss probability of the link in forward and backward direction respectively. Then the transmission probability of link
(L_i , L_j) is formulated as below

$$T(L_{i,L}j)=(1-P_{Li,Lj})*(1-P_{Lj,Li}) \quad (3)$$

whereas, T($L_{I,}$ L_j) denotes the transmission probability of the link and j is the relaying node. Assume, j Li L D be the dropping probability then its forwarding probability (F) is denoted as,

$$F = 1 - D_{Li,\ Lj} \quad (4)$$

From the computation of transmission probability and forward probability we can easily derive successful transmission probability ($S_{(Li\ ,\ L\ j}$) of link L_i and L_j as follows

$$(S_{(Li\ ,\ L\ j}) = T(L_{i,L}j)* 1 - D_{Li,\ Lj} \quad (5)$$

$$EFW = \frac{1}{S_{(Li,Lj)}} = \frac{1}{(1-P_{Li,Lj})\ \ (1-P_{Lj,Li})} \bullet \frac{1}{1-D_{Li,Lj}} \quad (6)$$

In the above equation, the first part denotes the reliability of physical and MAC layers, the latter part contribute to the reliability of network layer. In equation (4), we have defined the forward probability (F) as a function of dropping probability of a relaying node. This forward probability function is evaluated at MAC layer. The broadcasting nature of wireless networks facilitates straight forward method for estimating forward probability. Due to this characteristic, every node can overhear the transmission of other nodes within its transmission range R. In network, the value of F is computed as follows,
(i) Each node in the network is in monitoring mode
(ii) While deploying the nodes in the network, every node transmits HELLO message to all its neighbors and construct neighbor table (NT)
(iii) The NT includes node ids of neighbors and number of packets that are forwarded successfully (F). The format of NT is shown below

Table.1 Header of Neighbour table

Node ID	Neighbour Node ID	Sequence Number	Tranmitted packet

(iv)Transmitted packet is calculated from

$$F = \frac{N_{fwd}}{N_{ack}} \quad (7)$$

N_{fwd} is number of forwarded packets
N_{ack} is number of acknowledgement packets
(v) During the evaluation of S , the N_{fwd} is incremented only if the node hears the transmission of packet that was previously acknowledged.
(vi) If the node does not hear the neighbor transmission even after t_{fwd} then it increment only the value of N_{ack}

Path Selection

When the source obtains multiple paths to the destination, it evaluates EFW metric for each alternate paths. After this estimation, the source elects the path that has higher EFW value as a primary path. Through this path, the source transmits data to the destination. In this the path M1 has higher EFW value and it is chosen as the primary path. The selection of primary path is symbolized in figure-4.

Algorithm-2

Let T be the initial topology
Step-1 The source arranges the nodes in multiple layers
Step-2 The source performs breadth first search to find partial paths
Do
Breadth First Search on T
Until (T= Destination)
Step-3 The source estimates EFW metric for each alternate path
Step-4 It selects the path with high EFW value as a primary path
Step-5 Through this path, the source transmits data to the destination

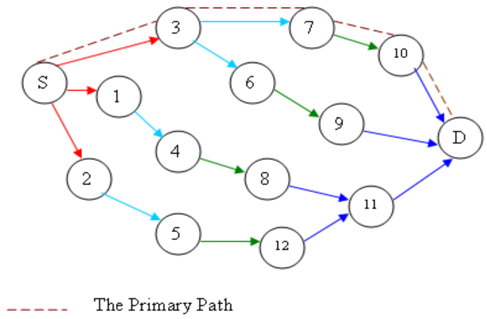

Fig.4 Primary path selection

V. Materials And Methods

NS2 consists of two key languages: C++ and Object-oriented Tool Command Language (OTcl). While the C++ defines the internal mechanism (i.e., a backend) of the simulation objects, the OTcl sets up simulation by assembling and configuring the objects as well as scheduling discrete events (i.e., a frontend). The C++ and the OTcl are linked together using TclCL. Mapped to a C++ object, variables in the OTcl domains are sometimes referred to as handles. Conceptually, a handle (e.g., n as a Node handle) is just a string (e.g., _o10) in the OTcl domain, and does not contain any functionality. Instead, the functionality (e.g., receiving a packet) is defined in the mapped C++ object (e.g., of class Connector). In the OTcl domain, a handle acts as a frontend which interacts with users and other OTcl objects. It may defines its own procedures and variables to facilitate the interaction. Note that the member procedures and variables in the OTcl domain are called instance procedures

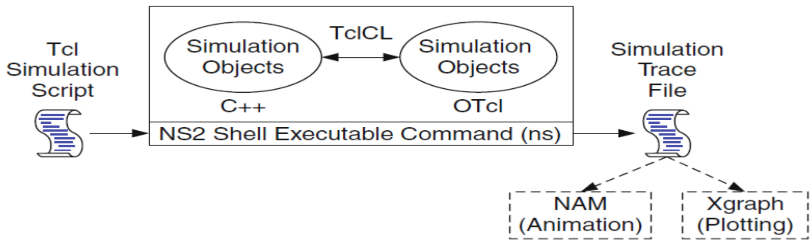

Fig.5 Network Simulator components

(instprocs) and instance variables (instvars), respectively. Before proceeding further, the readers are encouraged to learn C++ and OTcl languages. We refer the readers to [14] for the detail of C++, while a brief tutorial of Tcl and OTcl tutorial are given in Appendices A.1 and A.2, respectively.

VI. Results And Discussion

Multi npath routing protocol by BFS technique we evaluate link quality and reliable primary path from partial path set.Here in this proposed work we sequential modules are Network creation and routing, Analysis of AODV routing protocol, Implementation of link quality based multi path routing technique , Performance and analysis.

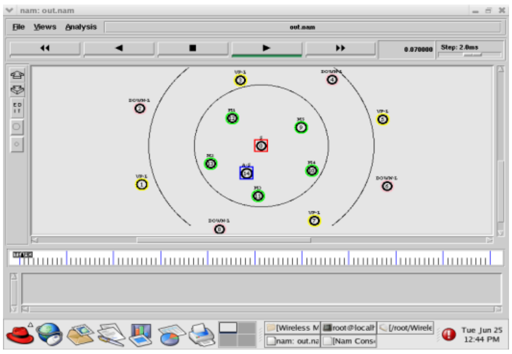

Fig. 6 Multi path routing

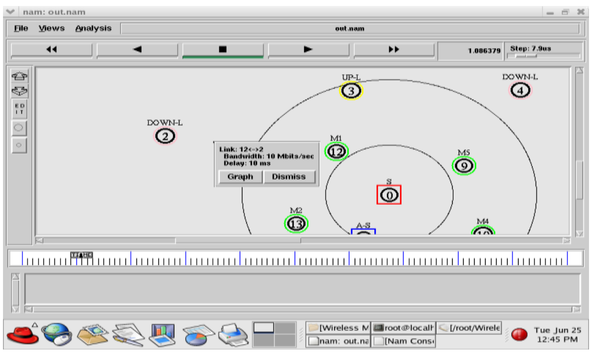

Fig.7 Data transmitted packet

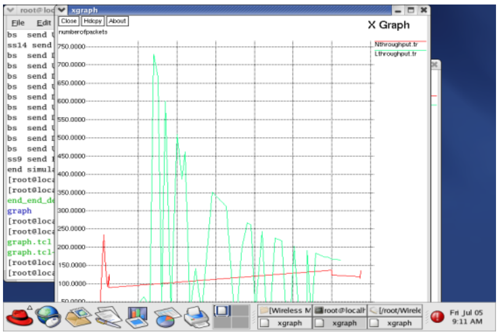

Fig.8 Throughput graph

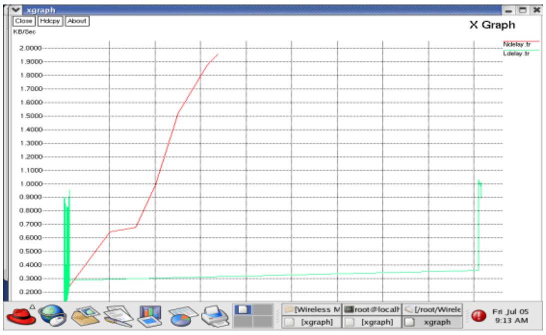

Fig.9 Delay graph

VII. Conclusion

In this paper, we proposed multipath routing protocol by BFS Algorithm in Wireless Mesh Networks. In this protocol, the source discovers multiple paths to the destination using parallel path based approach. This approach organizes the nodes into multiple paths for every iteration; it executes the breadth first search approach to find partial paths. The obtained partial paths are stored in partial path set. This process is repeated until it reaches the destination. By bringing together all partial paths, the source obtains multiple paths to the destination. From multiple paths, the primary path is elected using primary path selection approach. The source uses the primary path to transmit data packets to the destination. The approach makes use of Expected Forwarding Counter (EFW) metric to elect the primary path. We have evaluated the protocol using NS-2. The results show that the proposed protocol attains more throughput and packet delivery ratio with reduced packet drop and delay.

References

[1] Hassnaa Moustafa, Usman Javaid, Tinku Mohamed Rasheed, "A Panorama onWireless MeshNetworks: Architectures, Applications and Technical Challenges". Proceedings of Wimeshnets 2006, Waterloo, Canada, 2006.

[2] Md. Arafatur Rahman, Farhat Anwar, and Md. Saiful Azad, "Integrated Metric-Ad Hoc On-Demand Distance Vector: A Routing Protocol over Wireless Mesh Networks" Journal of Computer Science, vol.5, No.7, pp.511-518, 2009.

[3] Ian F. Akyildiz, Xudong Wang, "A Survey on Wireless Mesh Networks", IEEE Radio Communications, pp.525-530, 2005

[4] Bruno, R., Conti, M. & Gregori, E, "Mesh networks: commodity multihop ad hoc networks", IEEE Communications Magazine 43, pp. 123-131, 2005

[5] Yaling Yang, Jun Wang, Robin Kravets, " Designing routing metrics for mesh networks" IEEE- WiMesh, 2010.

[6] Baumann, R., Heimlicher, S., Lenders, " Routing Packets into Wireless Mesh Networks", Third IEEE International Conference on Wireless and Mobile Computing Networking and Communications, WiMob, 2007

[7] Akyildiz, I.F., Wang, X. & Wang, W. "Wireless mesh networks: a survey" Computer Networks 47, pp. 445-487, 2005.

[8] Mohsenian-Rad, A.H. & Wong, " Joint logical topology design, interface assignment, channel allocation, and routing for multi-channel wireless mesh networks", IEEE Transactions on Wireless Communications 6, 2007

[9] Yong Ding, Yang and Li Xiao, "Multi-Path Routing and Rate Allocation for Multi-Source Video On-Demand Streaming in Wireless Mesh Networks" IEEE INFOCOM-2011

[10] Chun-Wei Chen and Eric Hsiao-Kuang Wu, "Gateway Zone Multi-path Routing in Wireless Mesh Networks", Proceedings of ACM 4th international conference on Ubiquitous Intelligence and Computing, (UIC '07), Pages 350 – 359, 2007

[11] Jack W. Tsai and Tim Moors, "Interference-aware Multipath Selection for Reliable Routing in Wireless Mesh Networks", IEEE International Conference on Mobile Adhoc and Sensor Systems, (MASS 2007), 2007.

[12] Stefano Paris, Antonio Capone, Cristina Nita-Rotaru and Fabio Martignon, "A Cross-Layer Reliability Metric for Wireless Mesh Networks with Selfish Participants", ACM SIGMOBILE Mobile Computing and Communications Review, Volume 14, Issue 3, Pages 1-3, July 2010

[13] Network Simulator, http://www.isi.edu/nsnam/ns

[14] "WiMsh: a simple and efficient tool for simulating IEEE 802.16 wireless mesh networks in ns- 2", Proceedings of the 2nd International Conference on Simulation Tools and Techniques,2009.