PROTOCOL ANALYSIS IN WIRELESS MESH NETWORK

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ABSTRACT

The wireless mesh network (WMN) has been an emerging technology in recent years. Because the transmission medium used in networking backhaul access points (APs) is radio, the wireless mesh network is not only easy and cost effective in deployment, but also has good scalability in coverage area and capacity. Routing protocols are critical to the performance and reliability of wireless mesh networks. Traditional routing protocols send traffic along predetermined paths and face difficulties in coping with unreliable and unpredictable wireless medium. . Routing protocol design is critical to the performance and reliability of wireless mesh networks. Traditional routing protocols send traffic along pre-determined paths and have been shown ineffective in coping with unreliable and unpredictable wireless medium. This paper proposes various protocol challenges and the comparative studies of various Protocols such as Simple Opportunistic Adaptive Routing protocol (SOAR), MAC, MPR, GPR etc on the basis of various parameters.

Keywords: Wireless Mesh Network, Protocols

1. INTRODUCTION

The wireless infrastructure is self-organizing, self-optimizing, and fault tolerant. It can extend IP connectivity to regions otherwise unreachable by any single access technology. Many companies, such as Nokia, Microsoft, Motorola and Intel, are actively promoting wireless mesh networks as a full IP solution. WMNs combine concepts from a diverse set of existing and emerging wireless technologies, including cellular technologies, ad hoc networks, and sensor networks. The application of research results from these areas could greatly contribute to the development, implementation, and growth of wireless mesh networks. The multi-hop wireless nature of a WMN demands a different approach to routing from conventional wireless access networks. It has much more in common with the ad hoc and sensor network fields. However, the overall properties of the individual nodes and the overall network are very different in many ways. Therefore, it is unclear exactly how applicable these approaches are to a WMN. Wireless mesh networks (WMNs) consist of wire line gateways, mesh routers and mesh clients, organized in three-tier architecture as shown in Fig.1. A mesh client network can be formed in an ad hoc manner and connected to one or more mesh routers. The mesh routers in fixed sites comprise a wireless mesh backbone to provide relay service to the mesh client networks and other access networks such as cellular networks, wireless local area networks (LANs), etc. Due to the self-organization nature of WMNs, it is desired to apply distributed MAC to achieve efficient resource utilization. Without central coordination, distributed MAC is more challenging than centralized MAC as contention and hence transmission collisions are generally inevitable. There are extensive research results on distributed MAC over mobile ad hoc networks in the literature. Recent studies show that traditional routing faces difficulties in coping with unreliable and unpredictable wireless medium. Motivated by these observations, researchers developed opportunistic routing protocols for wireless mesh networks. Opportunistic routing exploits the broadcast nature of the wireless medium and does not commit to a particular route before data transmission.

2. RELATED WORK

Sonia Waharte & Raouf Boutaba & Youssef Iraqi & Brent Ishibashi proposed that Wireless mesh networks present a promising solution by extending network coverage based on mixture of wireless technologies through multi-hop communications. WMNs exhibits not clearly observable boundaries outside of which nodes are always run able to communicate [1].

V. Loscrì said that the MAC protocols have been proposed for wireless mesh networks (WMNs) and, specifically, this paper analyzed the coordinated distributed scheduling scheme (CDS) of the mesh deployment of the IEEE Std 802.16 for tree topologies [2].

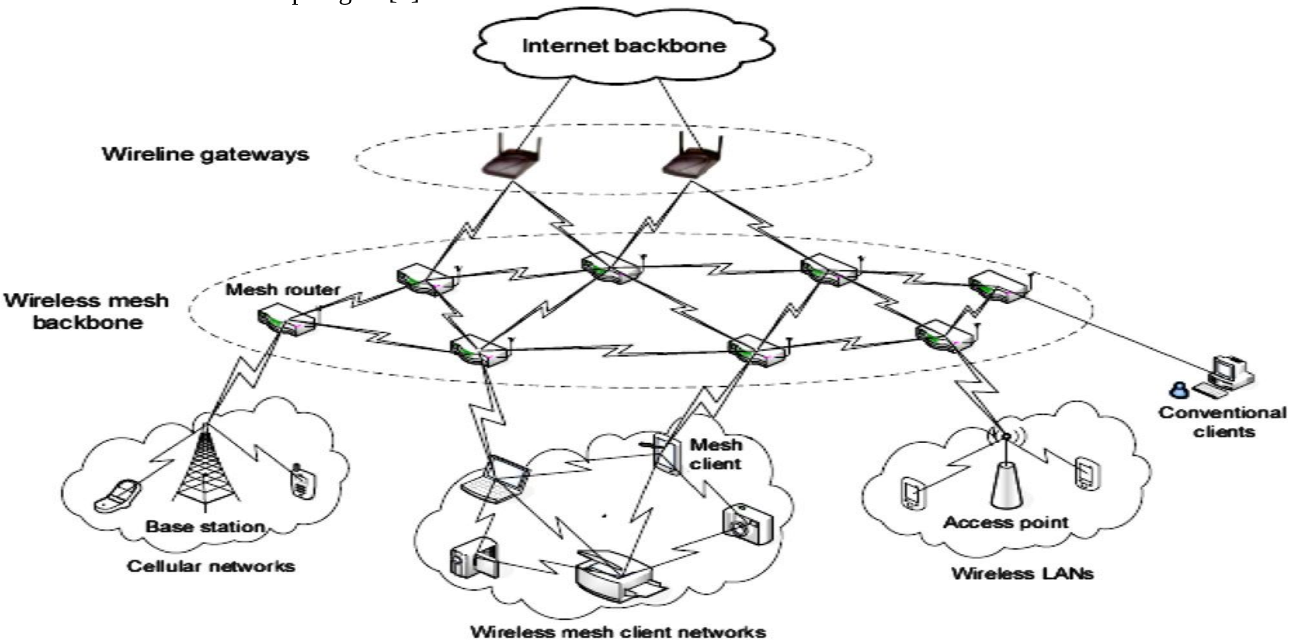

Figure 1 An illustration of wireless mesh network

Eric Rozner Jayesh Seshadri Yogita Ashok Mehta Lili Qiu developed SOAR, a novel opportunistic routing protocol. SOAR effectively realizes opportunistic forwarding by judiciously selecting forwarding nodes and employing priority-based timers. The joint design of routing and rate limiting as in SOAR is useful, and may be useful to the design of other opportunistic routing protocols. SOAR can easily accommodate other default path selection metrics. The performance of SOAR could further improve with enhanced default path selection [3].

Ning Xiao, Ling Ding, Minglu Li, and Minyou Wu presented a novel opportunistic routing protocol, called GPR. It uses the geographic information of source-destination pair to get candidate subset. GPR cooperates with the mac layer to prevent duplicate transmission or packet loss because nodes make the transmission decision incorrectly. We use simulations prove that the throughput of GPR can increase over 300% than reference method. The simulations also verify that GPR is scalable as the network scale increases [4].

Raffaele Bruno, Maddalena Nurchis presented the wireless diversity-based routing paradigm by illustrating the main features, discussing the key challenges and presenting some of the most representative existing solutions. They discuss the key issues with a special attention to the ones most related to the wireless mesh scenario and focused on the impact of traffic patterns opportunistic and coding-based approaches. Wireless mesh networks are expected to provide advanced communication services supporting real-time traffic. In this perspective, it is clear that stronger guarantees must be offered to network users also in terms of maximum delay and/or delay variability. Moreover, the distinction among different types of traffic flowing across a network is not confined only to delay-tolerance. In a wireless mesh network, a traffic flow can be headed to a node either within the network or belonging to an external network, which imposes a differentiated traffic management for intra-mesh and extra-mesh traffic. Hence, diversity-based routing protocols should be designed to adjust their forwarding policies to meet the different traffic requirements [5].

3. PROTOCOL CHALLENGES IN WIRELESS MESH NETWORK

3.1 Coding-based routing

The basic principle behind network coding is that routers can combine the information to be transmitted so as to deliver multiple data packets through a single transmission. More precisely, let us denote as native packets the original non-coded packets that are initially generated by the source node. Then, a coded packet is a combination of the native packets, which the destination node can decode to reconstruct the set of initial packets. Potential advantages of network coding were first demonstrated in the pioneering considers multicast transmissions in wired networks. In this paper it is shown that net-work utilization can be enhanced if network nodes do not act as classical switches, i.e., routing or replicating packets, but as encoders that mix the information they receive from all the input links and send it to all the output links. The authors demonstrate that network coding allows achieving the multicast capacity, which is the maximum rate at which a sender can communicate common information to a set of receivers. Moreover, Li et al. show that linear coding is sufficient for the above condition to hold, while Ho et al. demonstrate that this is true also when nodes pick random codes. Network coding benefits are not confined to multicast transmissions in networks with point-to-point links. Network coding techniques naturally extend to wireless networks by taking advantage of the broadcast nature of the wireless channel. In wireless networks, nodes can overhear neighbors' transmissions. Hence, each node may be able to collect many packets to code together, thus increasing the efficiency of the forwarding process in many cases. To better explain the performance gains obtained by employing network coding techniques in the context of wireless networks, in the following we illustrate a simple coding example. To this end, let us consider the chain topology depicted where node A wants to send packet pA to node B, and node B wants to send packet pB to node A. In this case, intermediate node R must forward both packets received by node A and node B because they cannot directly communicate to each other. Thus, with legacy routing, four transmissions are needed in order to deliver one packet to both destinations. On the other hand, as shown in Fig. 2, network coding allows node Rto broadcast a single coded packet, say pX, generated by applying the XOR operator to the native packets (i.e., pX=pA.pB). Then, node A can easily recover packet B since it locally stores a copy of packet A and pA.pX=pB.

3.2 How to code packets together?

Computational complexity is a crucial issue in network coding, and selection of coding techniques must consider the impact both in terms of encoding and decoding complexity, and in terms of minimum number of coded packets needed to recover the original flow. In the example presented above, coding is performed through XOR operations, which are easy to implement. However, the most frequently used approach for encoding packets is through random linear codes. Specifically, given a set of k native packets p1,...,pn, the coded packet p 0 can be created asp 0 ¼ Pk j¼1 cjpj, where cj are random coefficients extracted from a certain finite field Figure no.1.Random linear codes have some nice properties. First of all, checking for independence between coded packets requires only simple matrix algebra, and decoding can be done inverting the matrix of coding vectors. Furthermore, a linear combination of coded packets is also a linear combination of the corresponding native packets, which greatly simplifies the re-encoding process at intermediate forwarders. Several theoretical studies on properties of random linear coding have been conducted, demonstrating the potentiality of this technique, both in lossless and in lossy environments.

3.3 When coded packets should be generated?

Many factors affect the selection of the time at which coded packets should be generated. In general, a coded packet should be created only when there is a coding opportunity, i.e., the node has enough packets to code together. However, a node may have packets to send but no coding opportunities, thus it may decide either to forward native packets or to further delay transmissions waiting for receiving additional packets. Clearly, this design choice represents a trade-off between delay and achievable coding gain. Note that also buffer constraints must be taken into account to decide how long packets useful for encoding should be stored by each node. Furthermore, the coding algorithm should ensure that inter-mediate nodes have received enough coded packets to decode their corresponding native packets. For instance, intermediate nodes may want to reconstruct native packets to refresh the packet stream by replacing coding coefficients and re-encoding incoming packets. In addition, coded packets may include packets from multiple flows, and intermediate nodes may want to decode incoming packets to avoid that data is forwarded to areas where there are no interested receivers. Thus, the broadcast rate of coded packets should be adjusted to ensure that the decoding probability is sufficiently high not only at intended destinations but also at intermediate forwarders. Finally, transmissions of coded packets can also be driven by a trade-off between the desired level of data redundancy and the achievable coding gain. Specifically, coding is generally used to minimize the total number of transmissions needed to carry packets across each wireless hop. However, in case of high loss rates, it may be desirable to increase redundancy by injecting more coded packets in the network, so as to ensure that the next hop forwarders receive enough packets to be used during the decoding process, even at the cost of increasing the number of transmissions required to communicate the same information. Several solutions exist to deal with the various issues described above, and to fully exploit the coding benefits. We believe that the key characteristic pertinent to network coding that can be used to discriminate between coding-based routing schemes is the set of rules employed to decide which packets code together. To this end, the distinction between the two complementary approaches of intra-flow network coding, represents an essential principle for the network coding classification.

3.4 Hybrid routing

From the above discussion we can conclude that opportunistic forwarding and network coding are two complementary means of taking advantage of the broadcast nature of wireless channel, as well as to exploit the multi-user diversity of typical wireless environments. It is also intuitive to anticipate that coupling these two approaches into a hybrid paradigm may permit to obtain sig nificant improvements, originated by joining advantages of both techniques. Moreover, this coupling can offer an implicit solution to some limitations of the two paradigms. For instance, one of the main issues of opportunistic routing is the scheduling overhead for node coordination. Classical opportunistic forwarding deal with this issue by introducing node prioritization and forwarding de-lays, or exchanging state information between candidate relays. In contrast, network coding may provide an elegant method to partially eliminate this complexity. In principle, nodes do not need to know exactly which packets are stored by each neighbor and which packets are sent by the other forwarders. Indeed, packets have to be sent, and then any set of different coded packets is sufficient to recover the original set. Hence, every forwarder may autonomously generate its own coded packets, since any of them contains information about several native packets, and it may con-tribute to the flow progress towards the destination.

3.5 Opportunistic routing

Intuitively, the main benefit of opportunistic-based routing is to leverage transmission opportunities that unexpectedly reach far nodes, taking advantage of any transmission progress while mitigating the negative impact of failed transmission attempts. More-over, this strategy allows the destination node to receive packets that have been forwarded by different relays, thus traversing different network paths, fully exploiting the multi-user diversity property. In contrast, legacy routing would require retransmitting any packet that does not reach the next hop for which it was in-tended, as well as the preliminary construction of one or multiple network paths connecting the source-destination pair.

Table 1: Comparative study of routing protocols in Wireless Mesh Networks

Protocol	Routing	Scheduling	Node Priority	Duplicate Suppression	ACK strategy	Prototype
EXOR	Opportunistic	Yes	ETX-based distance to destination	Batch map and prioritybased forwarding timers	Batch map	MIT Roofnet
SOAR	Opportunistic	Yes	ETX-based distance to destination + ETX-based proximity to minimum-cost path	Overhearing and prioritybased forwarding timers	Hop-by-hop network-layer selective ACKs	No
OpRENU	Opportunistic	Yes	Residual network utility	Priority-based link-layer ACKs	Link-layer ACKs	No
COPE	Legacy with Pseudo broadcast transmissions	-	-	-	Link-layer ACKs	20-Node indoor testbed
OMNC	Opportunistic	No	ETX-based distance to destination	Packet innovativeness + overhearing of a new generation + ACK overhearing	End-to-end ACKs	Emulation Testbed
codeOR	Opportunistic	No	ETX-based distance to destination	Packet innovativeness + hop-by-hop ACKs	End-to-end ACKs	No
XCOR	Opportunistic	Yes	ETX-based distance to destination + ETX-based proximity to minimum-cost path	Overhearing and prioritybased forwarding timers	Reception reports	No

4. FEASIBLE SOLUTION THROUGH WMN PROTOCOL STUDY

This paper, examined the key challenges associated to the design of routing algorithms that use opportunistic forwarding and network coding to take advantage of the multi-user diversity and the broadcast nature of the wireless medium. To this end, we have presented taxonomy of existing solutions relying on these novel routing paradigms, and we have analyzed their most representative features, relative strengths and weak-nesses. From this overview, it is easy to identify some common functionalities and mechanisms that can be considered as basic building blocks for each solution. Wireless diversity-based routing paradigm by illustrating the main features, discussing the key challenges and presenting some of the most representative existing solutions. Although very promising results have been obtained in terms of throughput and reliability improvements, many research issues are still open. Considering protocol there routing style scheduling strategy incurred some key issues with a special attention to the ones most related to the wireless mesh scenario.

4.1 Systematic analysis of coding and opportunistic gains:

Existing studies usually point out the advantages of the proposed solutions with respect to others developed with the same purpose, considering a specific tested or a simulation environment created for the evaluation. However, higher performance improvements could be achieved by clarifying the impact of opportunistic, coding-based and hybrid routing primitives on more general scenarios. The motivation behind this requirement is that each of the above paradigms implies a different balance between design trade-offs and achievable gains. Therefore, a more systematic study is necessary to quantify the impact of different design approaches on various net-work settings. For instance, many theoretical research papers have shown the capability of the network coding paradigm to achieve the maximum flow capacity in arbitrary random networks, whereas analogous results are not available in the opportunistic nor in the hybrid area. Thus, an important direction for future work is the characterization of limitations, trade-offs and gains provided by the approaches described in this survey, with particular attention to the design parameters that mainly affect these results. This analysis will also be useful to reveal the capacity bounds achievable with each technique in different network scenarios.

4.2 Impact of traffic patterns:

To the best of our knowledge, opportunistic and coding-based approaches proposed so far do not take into account the variety of possible traffic patterns and characteristics. The strong assumption behind their design is that an application can tolerate a certain delay in exchange for through-put gain. In other words throughput improvement has been considered the main objective in this research field, while only a little attention has been directed to delay reduction. However, wireless mesh networks are expected to provide advanced communication services supporting real-time traffic. In this perspective, it is clear that stronger guarantees must be offered to network users also in terms of maximum delay and/or delay variability. Moreover, the distinction among different types of traffic flowing across a network is not confined only to delay-tolerance. In a wireless mesh network, a traffic flow can be headed to a node either within the network or belonging to an external network, which imposes a differentiated traffic management for intra-mesh and extra-mesh traffic. Hence, diversity-based routing protocol should be design to adjust their forwarding policies to meet different traffic requirements.

4.3 Cross-layer solutions design:

Generally speaking, the local situation of a node provided by lower layers represents fundamental information during routing/coding processes. Clearly, designing diversity-based routing protocols by abstracting from MAC layer details seems to be hard and highly inefficient. On the contrary, a cross-layer design involving MAC/routing interactions appears to be more convenient, since routing strongly relies on MAC-related R. Bruno, M. Nurchis / Computer Communications 33 (2010) 269–282 281 aspects. For instance, transmission rat and routing metrics definition, as well as congestion-aware access methods for broadcast frames, and several other protocol features can greatly benefit from the cross-layer interaction, which permits several optimizations. Thus, cross-layer interaction should be considered as a key attribute in the development of cooperative routing protocols.

5. CONCLUSION

Routing in multi-hop wireless networks has always been a challenging research avenue. Previous works in this area have focused on ad hoc networks. However, the disparity between mesh and ad hoc networks is significant enough to question the suitability of ad hoc routing protocols for mesh networks. In this paper, the characteristics of wireless mesh networks have been discussed and compared with the properties of other wireless networks. Existing routing protocols have been categorized according to these properties. We argue that new routing protocols specifically adapted for WMNs are needed. A set of design questions have been raised, relating to WMN routing. These questions require further investigations, and consideration in the development of protocols for WMNs. We hope that this paper will help in shaping future research in this area by providing a more concise view and problem definition, design requirements and constraints, and suggestions for possible research directions.

REFERENCES

[1] Sonia Waharte & Raouf Boutaba & Youssef Iraqi & Brent Ishibashi, Routing protocols in wireless mesh networks: challenges and design considerations, Published on 6 July 2006, Springer Science.

[2] V. Loscrì, MAC protocols over wireless mesh networks: problems and perspective, Journal of parallel and distributed Computing, University of Calabria, Italy, 7 May 2007

[3] SOAR: Simple Opportunistic Adaptive Routing Protocol for Wireless Mesh Networks, University of Texas at Austin, 2009

[4] Ning Xiao, Ling Ding, Minglu Li, and Minyou Wu, Geographic Probabilistic Routing Protocol for Wireless Mesh Network, Computer Science Department, Shanghai Jiao Tong University, Shanghai 200240, China

[5] Raffaele Bruno, Maddalena Nurchis, Survey on diversity-based routing in wireless mesh networks: Challenges and solutions, Italian National Research Council (CNR), Institute for Informatics and Telematics (IIT), Via G. Moruzzi 1, 56124 Pisa, Italy

[6] B. Awerbuch, D. Holmer, and H. Rubens. Provably secure competitive routing against proactive Byzantine adversaries via reinforcement learning, In JHU Tech Report Version 1, May 2003.

[7] M. Conti, S. Giordano, Multihop ad hoc networking: the reality, IEEE Communications Magazine 45 (4) (2007) 88–95.

[8] I. Akyildiz, X. Wang, W. Wang, Wireless mesh networks: a survey, Computer Networks 47 (4) (2005) 445–487.

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