Open Issues in Wireless Mesh Networks

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***Abstract*—Thanks to their capability of self-organization, Wireless Mesh Networks (WMNs) reduce the complexity of network deployment and maintenance. Despite their numerous advantages, many research challenges remain and problems still to solve. In this short paper, we present our main research topic focused on mobility management issues and routing performance measurements in WMNs.**

I. Wireless Mesh Networks

Wireless Mesh Networks (WMN) [1] are an emerging class of wireless networks, able to organize and configure themselves dynamically. WMNs define two types of nodes: Wireless Mesh Routers (WMRs) and mesh clients. Depending of these nodes' functionality, a WMN can be classified into different architectures. The most commonly used is the *backbone architecture*, where WMRs form an infrastructure (backbone) and offer access network for mesh clients. Compared to conventional networks, this architecture allows improving flexibility, efficiency, and coverage, while reducing the complexity of deployment. Furthermore, WMNs improve significantly the performance of ad hoc networks, and wireless local area networks.

Numerous academic research testbeds ([2], [3]) and industrial implementations ([4], [5]) have been set up to carry out research and development for WMNs. Nevertheless, despite numerous advantages and an important amount of work already performed, real experimentations prove that WMNs' performance is still poor and needs to be improved. Among the various important issues to be tackled, our interest focus on the following:

- *Mobility*: Mobility management is a very important issue in current networking, since users are more and more mobile due to the widespread of wireless technology. Despite considerable efforts, mobility management in WMN remains an open issue. Several high performance solutions can be found in the literature ([6], [7]), however, they all have the same requirement that refrains them from being widely adopted: they involve clients' equipment to support mobility. In contrast, one of our requirements is to detect efficiently clients' mobility, and keep alive established connections, with no modification or additional software on the client side.
- *Routing*: Usually, in wired networks, routing protocols use the hop-count shortest-path metric, which is appropriated perfectly. Nevertheless, this metric cannot be used for WMNs [8]. A myriad of routing protocols propositions have been published on new routing metrics able to correctly model the wireless link behavior. Most of them are based on cross-layer approaches including power control features, but often relying on strict theoretical assumption. The very few existing real implementations of cross-layer routing protocols, do not take into account power control and mobility management [9]. For this reason, we aim at performing extensive measurements, in different scenario-tests on our testbed [10] in order to gain a deep understanding of the inner behavior of the protocol stack in the wireless context, and explore the metrics that are the best fit for real wireless networks.

II. Our Ongoing Research Work

As we have seen in the previous section, our goal is to improve mobility management mechanisms and routing performance in real wireless mesh networks environment, by means of real measurements on MeshDVNet ([10], [11]), a WMN testbed developed and deployed at LIP6. MeshDVNet is built on a backbone architecture, which offers a wireless connection to clients and allows them to communicate with no pre-necessary installation.

A. Mobility management

The mobility management problems consist of clients' localization and clients' management issues. Compared with an infrastructured configuration like in Wireless Local Area Networks (WLAN), where Access Points (As) are all wired together, WMRs are disposed in a total distributed architecture, where each WMR can communicate directly only with its neighbors. Thus, clients' management became more complicated. In fact, to set up a communication, a WMR needs to localize rapidly and with minimum overhead client's position (*i.e.*, the WMR to which the client is connected), which is not a simple task in a distributed backbone topology. Moreover, when mobile client moves from one WMR to another, during an active communication, the old WMR needs to be able to detect this change rapidly and forwards all traffics to the new WMR in order to minimize packet losses. Basically, clients can interact with the backbone and inform the new WMR of their old position (WMR) after a move. However, this approach is contradictory to our main objective, which consists to manage clients' mobility efficiently without changing the client part.

In this context, a first contribution we have proposed is the EMM (Enhanced Mobility Management) approach ([12], [13]). EMM is based on the utilization of clients' Neighbor Discovery Protocol (NDP) cache. With EMM, WMRs inject a particular entry in the clients' cache, which is used when clients move. In fact, this entry allows WMRs to recognize where their new client was previously associated.

However, EMM allows only the new WMRs to know where a client was previously associated and where it is currently associated (a kind of local localization). Thus, when a WMR needs to localize a non-local client (for possible communication with its local client), it needs to flood the backbone to perform a lookup, which increases the overhead. A solution can consist in using a central location server, where WMRs would save the position of their local clients. This approach can block the whole network if central server crashes. Moreover, all clients' position requests are sent to this server, which can create congestion, limiting the scalability of the solution.

The previous limits and issues, gives us the motivation to pursue active research on efficient mobility management in WMNs. Our challenge is to propose solutions characterized by:

- *Reduced overhead*. Compared to the flooding solutions, clients' position needs to be obtained on unicast.
- *Scalability*. Meaning that the system functions correctly even with large mobile clients count.
- *Load Balancing*. Each WMR of the backbone should manage an equal share of clients.
- *Transparency*. Not introducing modifications or additional software on the client side.

In order to satisfy the above requirements, we explore new clients' localization service based on Distributed Hash Tables (DHT). Distributing the clients' position (storage and access) over multiple nodes (WMRs) clearly offers improved performance and efficiency of the system.

Nowadays, the Internet is organized as a client/server system, and DHTs are used either on top of it as overlays, or as underlay for self-organizing networks ([14], [15]). Hence, it is an interesting challenge to change this paradigm and use DHTs for basic network services, as for client localization. Some works in literature have investigated this domain and tried to adapt the DHTs for mobile ad hoc networks ([16], [17]). These studies are a good background for our work. In order to evaluate performances of our approach, we expect comparing DHT solution against existing approach such as MobileIP, OLSR and other mobility solutions available.

B. Routing Performance

Despite the large amount of works performed in theory and simulation, very few cross-layer metrics are explored in reality. Thus, to study deeply the dynamics of real wireless testbed, and to understand the behavior of the protocol stack in the context of WMN, we performed tests on MeshDVNet, showing that cross-layering effectively improves performances [18]. We continue on this way in order to deepen our knowledge in cross-layer metrics by measuring and analyzing behavior of different routing protocols with different metrics. For instance:

- OLSR (Optimized Link State Routing) routing protocol vs. DSDV (Destination-Sequenced Distance Vector)
- Cross-layer metric vs. hop count metric

III. Conclusion

Despite the improvements that can be achieved using the distributed hash tables on wireless mesh networks, merging this two technologies is a real challenge. Due to the irregularity of radio coverage on the relationships between WMRs, caused by various obstacles such as walls, furniture and moving nodes, it is difficult to maintain a stable DHT with correct information. Further, the radio instability affects also the routing infrastructure. In order to understand the behavior of routing protocols, algorithms, and metrics, it is very important to have real measurements.

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