Self Reconfigurable Wireless Mesh Network

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Abstract- Due to channel interference, dynamic obstacles, channel fading and/or applications’ bandwidth demands Wireless Mesh Networks (WMNs) experience frequent link failures during their lifetime. Multihop WMNs are equipped with multiple radio and multiple channels in every node. These failures cause severe performance degradation in WMNs. Expensive manual network management is required for their real-time recovery. This paper presents a Reconfiguration Algorithm (RA) which is also embedded with interference aware channel assignment that enables a multi-radio WMN to recover from local link failures to preserve network performance. The proposed method makes necessary changes in local radio and channel assignments in order to recover from failures, by using channel and radio diversities in WMNs. The method uses a default channel for transmission till the reconfiguration is done. Based on current channel and radio associations, feasible local configuration changes available around a faulty area are identified. Then, by imposing current network settings as constraints, RA identifies reconfiguration plans that require the minimum number of changes for the network settings. Based on the generated configuration changes and interference aware channel assignment, the system co-operatively reconfigures network settings among local mesh routers. The results show that the proposed algorithm improves channel-efficiency and throughput and has the ability of meeting the applications’ bandwidth demands.

Keywords- multiradio wireless mesh networks (mr-WMNs), self-reconfigurable networks, wireless link failures.

I. INTRODUCTION

Wireless mesh networking has emerged as a promising design paradigm for next-generation wireless networks. Wireless mesh networks (WMNs) consist of mesh clients and mesh routers, where the mesh routers form a wireless infrastructure/backbone and interwork with the wired networks to provide multihop wireless Internet connectivity to the mesh clients. Wireless mesh networking has emerged as one of the most promising concepts for self-organizing and auto-configurable wireless network-ing to provide adaptive and flexible wireless Internet connectivity to mobile users. This concept can be used for different wireless access technologies such as IEEE802.11, 802.15, 802.16-based wireless local area network (WLAN), wireless personal area network (WPAN), and wireless metropolitan area network (WMAN) technologies, respectively. Potential application scenarios for wireless mesh networks include backhaul support for cellular networks, home networks, enterprise networks, community networks, and intelligent transport system networks. Development of wireless mesh networking technology has to deal with challenging architecture and protocol design issues, and there is an increasing interest in this technology among the researchers in both academia and industry. There are many ongoing research projects in different universities and industrial research labs. Also many startup companies are building mesh networking platforms based on off the shelf wireless access technologies and developing demanding applications and services.

II. MOTIVATION

We first describe the need for self-reconfigurable mr-WMNs. Next, we introduce the network model and assumptions to be used in this paper. Finally, we discuss the limitations of existing approaches to achieving self-reconfigurability of mr-WMNs.

A. Why Is Self-Reconfigurability Necessary?

Maintaining the performance of WMNs in the face of dynamic link failures remains a challenging problem. However, such failures can be withstood (hence maintaining the required performance) by enabling mr-WMNs to autonomously reconfigure channels and radio assignments, as in the following Examples[1].

• Recovering from link-quality degradation: The quality of wireless links in WMNs can degrade (i.e., link-quality failure) due to severe interference from other collocated wireless networks. For example, Bluetooth, cordless phones, and other coexisting wireless networks operating on the same or adjacent channels cause significant and varying degrees of losses or collisions in packet transmissions. By switching the tuned channel of a link to other interference-free channels, local links can recover from such a link failure[2].

• Satisfying dynamic QoS demands: Links in some areas may not be able to accommodate increasing QoS demands from end-users (QoS failures), depending on spatial or temporal locality[3]. For example, links around a conference room may have to relay too much data/video traffic during the session. Likewise, relay links outside the room may fail to support all
Wireless mesh networks (WMNs) are being developed actively. They are deployed widely for a variety of applications, such as public safety, environment monitoring, and citywide wireless Internet services. They have also been evolving in various forms (e.g., using multiradio/channel systems) to meet the increasing capacity demands by the above-mentioned and other emerging applications. However, due to heterogeneous and fluctuating wireless link conditions, preserving the required performance of such WMNs is still a challenging problem. For example, some links of a WMN may experience significant channel interference from other coexisting wireless networks. Some parts of networks might not be able to meet increasing bandwidth demands from new mobile users and applications. Links in a certain area (e.g., a hospital or police station) might not be able to use some frequency channels because of spectrum etiquette or regulation. Their approach provides a comprehensive and optimal network configuration plan, they often require global configuration changes, which are undesirable in case of frequent local link failures. These methods to securing network programming are data dependent. This greedy change might not be able to realize full improvements, which can only be achieved by considering configurations of neighboring mesh routers in addition to the faulty link(s). They rely on detour paths or redundant transmissions, which may require more network resources than link-level network reconfiguration.

III. ARS ARCHITECTURE

We first present the design rationale and overall algorithm of ARS. Then, we detail ARS’s reconfiguration algorithms. Finally, we discuss the complexity of ARS.

A. Overview

ARS is a distributed system that is easily deployable in IEEE 802.11-based multi-WMNs. Running in every mesh node, ARS supports self-reconfigurability via the following distinct features:

• **Local reconfiguration**: Based on multiple channels and radio associations available, ARS generates reconfiguration plans that allow for changes of network configurations only in the vicinity where link failures occurred while retaining configurations in areas remote from failure locations.

• **QoS-aware planning**: ARS effectively identifies QoS-satisfiable reconfiguration plans by: 1) estimating the QoS satisfiability of generated reconfiguration plans; and 2) deriving their expected benefits in channel utilization.

• **Autonomous reconfiguration via link-quality monitoring**: ARS accurately monitors the quality of links of each node in a distributed manner. Furthermore, based on the measurements and given links’ QoS constraints, ARS detects local link failures and autonomously initiates network reconfiguration.

• **Cross-layer interaction**: ARS actively interacts across the network and link layers for planning. This interaction enables ARS to include a rerouting for reconfiguration planning in addition to link-layer reconfiguration. ARS can also maintain route discoveries and recovery algorithms that can be used for maintaining alternative paths even in the presence of link failures.

**Link Failures**: Channel-related link failures that we focus on are due mainly to narrowband channel failures. These failures are assumed to occur and last in the order of a few minutes to hours, and reconfiguration is triggered in the same order of failure occurrences. For short-term (lasting for milliseconds) failures, fine-grained (e.g., packet-level or in the order of milliseconds) dynamic resource allocation might be sufficient [10], [11], and for long-term (lasting for weeks or months) failures, network-wide planning algorithms can be used [12]. Note that hardware failures (e.g., node crashes) or broadband-channel failures (e.g., jamming) are beyond the scope of this paper.

**C. Limitations of Existing**
connectivity during recovery period with the help of a routing protocol.

IV. SYSTEM IMPLEMENTATION

![Diagram of ARS Implementation and prototype](image)

**Fig. 1:** ARS Implementation and prototype

Fig. 1(a) shows the software architecture of ARS. First, ARS in the network layer is implemented using net filter, which provides ARS with a hook to capture and send ARS-related packets such as group-formation messages. In addition, this module includes several important algorithms and protocols of ARS: 1) network planner, which generates reconfiguration plans only in a gateway node; 2) group organizer, which forms a local group among mesh routers; 3) failure detector, which periodically interacts with a network monitor in the device driver and maintains an up-to-date link-state table; and 4) routing table manager, through which ARS obtains or updates states of a system routing table. Next, ARS components in the device driver are implemented in an open-source MADWiFi device driver. This driver is designed for Atheros chipset-based 802.11 NICs and allows for accessing various control and management registers (e.g., longretry, txrate) in the MAC layer, making network monitoring accurate. The module in this driver includes: 1) network monitor, which efficiently monitors link-quality and is extensible to support as many multiple radios as possible; and 2) NIC manager, which effectively reconfigures NIC’s settings based on a reconfiguration plan from the group organizer.

V. CONCLUSION

The mesh network architecture addresses the emerging market requirements for building wireless networks that are highly scalable and cost effective, offering a solution for the easy deployment of high-speed ubiquitous wireless Internet. In addition to 802.11s, other IEEE Working Groups are currently working to provide mesh-networking extensions to their standards (e.g., 802.15.5, 802.16a, and 802.20). This presents an autonomous network reconfiguration system (ARS) that enables a multiradio WMN to autonomously recover from wireless link failures. ARS generates an effective reconfiguration plan that requires only local network configuration changes by exploiting channel, radio, and path diversity. Furthermore, ARS effectively identifies reconfiguration plans that satisfy applications’ QoS constraints, admitting up to two times more flows than static assignment, through QoS aware planning. Next, ARS’s online reconfigurability allows for real-time failure detection and network reconfiguration, thus improving channel efficiency by 92%. Our experimental evaluation on a Linux-based implementation and ns2-based simulation has demonstrated the effectiveness of ARS in recovering from local link-failures and in satisfying applications’ diverse QoS demands.

VI. REFERENCES