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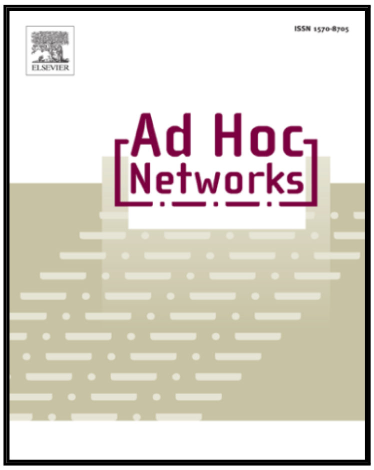

MeNTor: A Wireless-Mesh-Network-Aware Data Dissemination Overlay based on BitTorrent

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MeNTor: A Wireless-Mesh-Network-Aware Data Dissemination Overlay based on BitTorrent

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Abstract*—IEEE 802.11s introduces MAC-layer extensions to enable vendor-independent and inter-operable WLAN mesh networks. Featuring automatic device interconnection and routing, 802.11s networks provide a higher scalability, flexibility, and robustness compared to common centralized WLAN infrastructures. As logical Peer-to-Peer (P2P) networks exhibit many of the characteristics of physical WLAN mesh networks on the application layer, it is obvious to consider solutions where both technologies interact to leverage robust distributed wireless applications, such as collaborative data distribution and synchronization in future smart cities. Envisioned scenarios include the administration and update deployment to specific device groups or the distributed caching and delivery of on-demand multi-media content to selected end points within a city-area wireless mesh network. Nevertheless, common P2P protocols, such as BitTorrent (BT), do not consider the structure of the physical underlay as they were primarily designed to be used over wired communication networks, such as large parts of the Internet. Hence, the default BT peer selection mechanism does not adapt to the network topology and varying medium utilization in wireless multi-hop networks. We present *MeNTor*, a set of optimizations to enable underlay-aware BT peer selection in WLAN mesh networks. It relies on cross-layer integration of default 802.11s information, only requiring minor extension of the BT application layer without introducing any MAC-layer modifications or traffic overhead. Our solution was evaluated in a 25-node real-world mesh test bed, using 10 different seed/leecher placements and comparing 18 parameter combination variants of *MeNTor*. Results show that average download times can be reduced by 30–40 %, depending on the seed/leecher placement and parameter combination variant. Finally, we recommend the variant that performed best across all scenarios as prospective default configuration.

***Index Terms*—WLAN, Wireless Mesh Network, IEEE 802.11s, HWMP, Airtime Link Metric, P2P, BitTorrent, Peer Selection, Cross-Layer Optimization.**

I. Introduction

Leveraged by the increasing variety and affordability of wireless consumer devices, complex wireless networks can be established to provide distributed communication services. The widespread IEEE 802.11 WLAN (Wireless Local Area Network) standard family [1] is already omnipresent in today's home networks, office environments, and public facilities. However, currently prevalent WLAN deployments are based on central Access Points and thus are limited in terms of economical extensibility and scalability. On the contrary, decentralized mesh networks are characterized by their flexible and fail-safe network topology [2]. While already having entered the commercial sector as affordable solution for improved wireless coverage in the home by using only a handful of nodes, WLAN mesh networks will be one of the key technologies for high-bandwidth wireless access networks, backbones, and service infrastructures in upcoming smart city scenarios [3]. The standard amendment IEEE 802.11s introduces mesh forwarding and routing capabilities to the WLAN MAC layer as opposed to other solutions, which rely on IP-layer routing [4]. Nodes within radio range automatically interconnect and establish paths to selected destinations. Thereby, path maintenance follows a radio-aware cumulative link metric that takes the properties of the wireless medium and MAC protocol into account. Thus, the network becomes more robust to changes in node availability, density, and varying channel conditions. For interoperability, 802.11s defines the *Hybrid Wireless Mesh Protocol* (HWMP) and the *Airtime Link Metric* (ALM) as default protocol/metric combination for path selection.

P2P technology on the other hand is used to develop distributed, scalable, and failure-resilient network applications. It overcomes the drawbacks of centralized client/server communication, which inherently includes a Single Point of Failure [5]. P2P protocols are implemented as logical overlay on top of a given physical underlay network. Regarding robustness and scalability, they share many similarities with wireless mesh networks and appear particularly suitable as candidate technology above a mesh underlay [6].

It is obvious to consider solutions where both technologies interact to leverage robust distributed wireless applications, such as collaborative data distribution and synchronization in future smart cities [3]. Envisioned scenarios include, among others, the administration and selective update deployment to specific device groups within a city-area wireless backbone or access network. When aiming at a flexible wireless infrastructure that also provides information services, another use case is the distributed caching and efficient delivery of on-demand content to outdoor multi-media panels and digital billboards.

While such city-area and public facility mesh networks can be assumed as rather static deployments without node mobility, they still exhibit considerable dynamics in terms of link quality, medium utilization, and node availability. On the one hand, link quality mainly depends on the physical-layer channel conditions affected by path loss, shadowing, external interference, or weather effects. On the other hand, communication performance also largely depends on the network utilization and traffic pattern which influence airtime consumption, medium access arbitration, and collision probability. Moreover, underlay structure might change due to a roll-out of additional devices for network extension or if nodes fail

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