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Can the current generation of wireless mesh networks compete with cellular voice?

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Abstract

Wireless mesh networks are being deployed to provide broadband wireless connectivity to city-wide hotspots. The typical architecture in these deployments thus far is a single-radio architecture: mesh nodes carry only one radio, which is used both to receive the traffic from the clients and to relay this traffic through the mesh to the wired Internet gateway.In this paper, we study the performance of a representative single-radio mesh network both in a live setup and in a laboratory environment. We characterize the performance of different applications (e.g. VoIP), and study some key challenges of mesh networks such as the fairness in bandwidth allocation and hidden node terminal. Finally, we compare the results of the study with traditional cellular networks, and discuss various options to enhance the performance of wireless mesh networks in the future.

Keywords: Wireless mesh; WiFi; VoIP; Performance; Multihop; Measurements

1. Introduction

Many cities in the US, and quite a few outside, are either committing to, or studying the possibility of deploying a city-wide WiFi coverage using wireless mesh networks. San Francisco, New York, Philadelphia are in the planning stages, while smaller cities have already deployed networks which attempt to provide broadband wireless access ubiquitously. The goals in setting up these wireless mesh networks are multiple, and include providing broadband access to underserved communities or supporting emergency services. However, one of the main reasons is to reduce the cost per bit of the wireless access, in order to support applications which reduce the expenditures of a city.

The hope is that a lower cost per bit would provide the incentive to use applications on the go, thereby increasing the productivity of city employees. Alternatively, if the network is operated by a provider, the lower cost per bit would provide the margin to compete for mobile applications with cellular operators. Metropolitan wireless mesh networks are seen by some investors as a potential disruptive technology for legacy cellular operators. A wireless mesh network combined with a VoIP handheld device could become an alternative to the cellular handset.

Many vendors are proposing infrastructure products and solutions to provide wireless broadband connectivity over extended areas [9,38,39,43]. It is however, a testament to the uncertainty of the business model to see such a balkanized market with no clear technology consensus. The market is pulling in different technological directions, hoping that one will prove profitable.

The current generation of mesh networks is based on a single-radio architecture. This architecture is the only technology that can provide the required coverage at the current budget envelope. The market leader in volume for this architecture is Tropos Networks. In this paper, we study the performance of such single-radio mesh networks

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and compare the cost benefit of using such architecture with that of a cellular network.

We study the VoIP performance in an actual, fully deployed network, and show that, at the price point currently supported by the business model rules of thumb, a single-radio wireless mesh network is unable to provide satisfying VoIP service, let alone compete with a cellular infrastructure.

Subsequently, we study in the lab the performance of a mesh network of a single-radio platform against some key performance metrics. We will show that issues of unfairness arise quickly, and that, even in the lab, the performance proves disappointing.

Finally, we compare and evaluate the deployment feasibility of a single-radio mesh solution against other cellular technologies in regards to data and voice capacity, coverage, and cost of deployment. Our evaluation shows that this generation of single-radio mesh networks cannot currently rival with cellular networks.

The remainder of the paper is organized as follows. Section 2 introduces the single-radio WiFi mesh architecture. Section 3 describes our research approach. Section 4 presents the results and analysis and in Section 5 we compare mesh networks to the current cellular offerings. In Section 6 we describe the related work, and finally, in Section 7 we draw conclusions.

2. Deployed single-radio WiFi mesh architectures

The wireless mesh network is composed of three basic elements: an 802.11 WiFi client, an access point (AP) and mesh routers. The users connect to the network AP with the 802.11 WiFi client, such as a laptop, PDA or a VoIP phone. The mesh routers forward the traffic over potentially multiple wireless hops in between the AP and the wired Internet gateway. The mesh routers form the backhaul of the mesh network (see Fig. 1).

The most common commercial solutions deploy a single-radio mesh node, where both AP and backhaul functionality are merged on the same platform. The single-radio architecture uses the same-radio frequency for wireless access and backhaul. The same node functions both as an access point to the end-user clients and as a relay for the traffic to the gateway. Single-radio architectures were chosen mostly due to their lower price point [47], and to their implementation and deployment simplicity in an emerging market.

Many metropolitan wireless mesh deployments are currently based on this architecture, usually with Tropos hardware, such as those from Earthlink in Philadelphia or Google in Mountain View [24]. The single-radio architecture is substantially cheaper than dual or multi-radio architectures. On the other hand, multi-radio architectures offer better performance, as the backhaul traffic typically is in a different frequency band as the access traffic, and does not interfere with it. For a performance benchmark of multi-radio mesh equipment, please refer to [28].

In a mesh network the nodes might be several hops away from the wired gateway, as depicted in Fig. 1, and the nodes might need to use other nodes as relays. Therefore, not only does the backhaul traffic interfere with the access traffic, it also interferes with itself. As more mesh

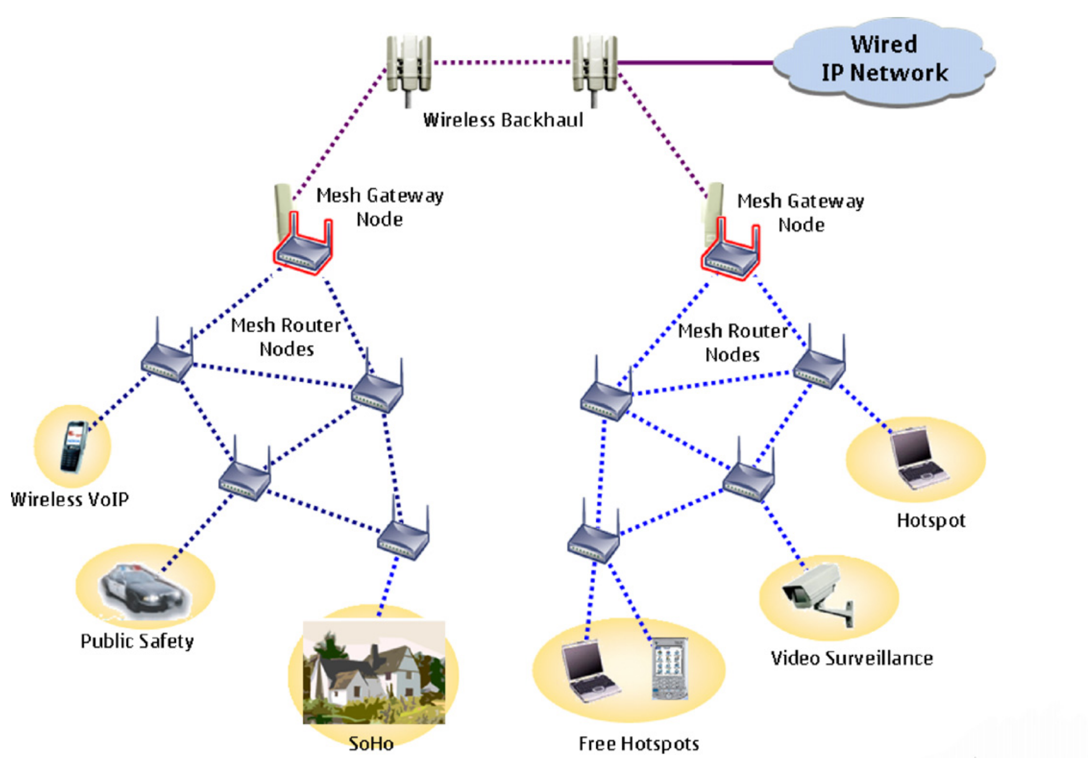

Fig. 1. WiFi mesh in an outdoor scenario.