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A week in the life of three large Wireless Community Networks

Leonardo Maccari, Renato Lo Cigno *

DISI, University of Trento, Italy

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ABSTRACT

Wireless Community Networks (WCNs) are created and managed by a local community with the goal of sharing Internet connection and offering local services. This paper analyses the data collected on three large WCNs, ranging from 131 to 226 nodes, and used daily by thousands of people. We first analyse the topologies to get insights in the fundamental properties, next we concentrate on two crucial aspects: (i) the routing layer and (ii) metrics on the centrality of nodes and the network robustness. All the networks use the Optimized Link State Routing (OLSR) protocol extended with the Expected Transmission Count (ETX) metric. We analyse the quality of the routes and two different techniques to select the Multi-Point Relay (MPR) nodes. The centrality and robustness analysis shows that, in spite of being fully decentralized networks, an adversary that can control a small fraction of carefully chosen nodes can intercept up to 90% of the traffic. The collected data-sets are available as Open Data, so that they can be easily accessed by any interested researcher, and new studies on different topics can be performed. In fact, WCN are just an example of large wireless mesh networks, so our methodology can be applied to any other large mesh network, including commercial ISP networks.

1. Introduction

A Wireless Community Network (WCN) is a wireless mesh network created by a local group of users to have an alternative, self-managed, community-based networking infrastructure. A WCN serves two purposes: It allows inter-user interactions (messaging, talking, sharing, etc.), and it brings Internet connectivity where it is not present. WCNs are flourishing. Many European cities feature WCNs with hundreds of nodes: in Athens a single WCN includes more than 2400 nodes, while in Spain, the Guifi network is a composition of WCNs that counts more than 23,000 nodes and growing. Thousands of nodes connecting tens of thousands of individuals, families, associations, public offices with a non-profit approach and a community-based organization. After an initial interest in their early steps [1], WCNs have lately re-attracted the attention of academia and research funding [2,3], and they are becoming a strong asset in reducing the digital divide and pushing broadband access from the bottom up.

The goal of this paper is to analyze the main features of three large European WCNs, with particular focus on routing aspects and on centrality and robustness metrics.

1.1. Contribution

This paper extends the initial findings on a small portion of the data presented in [4], leveraging the analysis, the metrics and theoretic contributions published in [5,6]. It offers an original combination of insights not present in the existent literature. First of all, three different large networks are monitored for an entire week, exploring their stability and different characteristics and finally providing a novel comparative analysis of the three networks.

* Corresponding author.
E-mail addresses: leonardo.maccari@unitn.it (L. Maccari), renato.locigno@unitn.it (R. Lo Cigno).

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Second, WCNs do not strictly focus on Internet connectivity, as the large commercial networks analyzed in the literature. Instead, the participants of a WCN perceive the network as an alternative communication media that offers a higher degree of privacy and neutrality. For this reason they try to use the internal services of the network as an alternative to external commercial services. In the light of the recent world-wide discussions on privacy, neutrality and forced disconnections, WCNs represent successful networks based on a somehow revolutionary societal approach. For this reason it is particularly important to study their development, describe their features and verify how much they match the expectations, even raised by mainstream media.[1] One of the contribution of this paper is the analysis of the robustness and of the centrality metrics of WCNs, that give an unbiased overview of how much these expectations are matched by the real networks.

Third, we focus on specific issues that have been ignored by previous works, as the analysis on the choice of Multi-Point Relays (MPRs) in the Optimized Link State Routing (OLSR) protocol. MPRs are key nodes used in the OLSR protocol that have been largely debated in literature, most of the times using a theoretical or simulative approach. We believe this is the first attempt to evaluate on real topologies how MPRs could impact the performance not only in terms of signalling, but also in terms of accuracy in finding the best routes.

Finally, and contrarily to the majority of the works in literature, we release all the data we have collected and the software we developed to encourage more researchers to investigate on this topic, so that new comparative research can be based on this work. We will continue to monitor the three networks and, if possible, to extend the monitoring to new ones and enrich the public dataset with new features.[2]

1.2. Related work

Several works describe the features of wireless mesh networks. In some cases, detailed analysis were made on small wireless networks [7,8], in some other cases large networks providing Internet access were analyzed [9–11]. Nevertheless, there is a great difference between a commercial access network and a large WCNs, that offer some unique challenges [12] and displays some unique features.

Recently the topological properties of Guifi have been studied [13], and in a previous work [4] we analyzed some feature of the Ninux network. This paper goes beyond the state of the art and focuses on some currently unexplored specific issues.

Among these, we will study the centrality metrics applied to WCNs, and, specifically, group centrality metrics. These are metrics that have been largely used in social science, but have been applied to wireless networks only recently [14,15], but never to networks of the size as the ones we consider.

Finally, many works in literature addressed the problem of finding the optimal MPR set for a network both in the past [16] and in recent times [17–19]. Most of these works are based on geometric evaluations or simulations, and to our best knowledge, there is none estimating the impact of different MPR choice strategies in real large topologies as we do in this work.

2. Overview of the networks and of the measurements

The three networks we consider are Funk Feuer Wien and Funk Feuer Graz in Austria and Ninux in Italy; FFWien, FFGraz, and NNX for short. They have different management structures and "philosophy", but they all exploit the OLSR routing protocol to maintain the network topology and compute routing.

2.1. Nodes' configuration

The majority of the nodes use either one of two solutions: (i) boxed indoor equipment, or (ii) commercial devices for outdoor use.

In the first case devices such as the TP-Link TL-wr841nd[3] are modified using outdoor antennas, powered over Ethernet and enclosed in a plastic box. This is a low cost solution, easy to deploy since it relies on omnidirectional antennas that do not need to be aligned. The drawbacks are short ranges, higher interference, and a lower throughput.

In the second case devices such as the Ubiquiti *nanostation*[4] are used. They have embedded panel antennas with a beam-width of 40° or parabolic antennas with a beam-width of 10°. This second solution needs more expertise to be installed, but guarantees longer ranges and higher bit rates. Using directional antennas, it is often necessary to install more than one device to connect to neighbor nodes. Each device is connected to the others via Ethernet; this configuration is called a *super-node*. A super-node implements cross-AP routing and maintains a large horizontal 'virtual' coverage angle while featuring long ranges and high bit rates.

The communication technology used is a mixture of IEEE 802.11 g/a/n standards with preference for 802.11n to achieve higher bit rates and use the 5 GHz frequency that is generally less crowded of consumer devices.

Each WCN or user, decides what is the best Operating System (OS) for the nodes, and the choice depends on many factors. As a general rule, using the OS shipped with the device has higher stability and better performances due to a better integration with the hardware. As a drawback it may not allow the users to modify the routing protocols or use the ad hoc mode.

2.2. The OLSR routing protocol

Some comprehension of the OLSR protocol is needed to better understand the remaining of this paper. Since OLSR is well known and described in the literature [20], we give

[1] See, for instance, recent coverage from the New York Times "*U.S. Promotes Network to Foil Digital Spying*" http://nyti.ms/1r6yltT.

[2] A preview of the software developed and data-sets collected for this work are available at http://disi.unitn.it/maccari/CN.

[3] See www.tp-link.com/en/support/download/?model=TL-WR841ND.

[4] See www.ubnt.com/airmax.