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Improving P2P streaming in Wireless Community Networks☆

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ABSTRACT

Wireless Community Networks (WCNs) are bottom-up broadband networks empowering people with their on-line communication means. Too often, however, services tailored for their characteristics are missing, with the consequence that they have worse performance than what they could. We present here an adaptation of an Open Source P2P live streaming platform that works efficiently, and with good application-level quality, over WCNs. WCNs links are normally symmetric (unlike standard ADSL access), and a WCN topology is local and normally flat (contrary to the global Internet), so that the P2P overlay used for video distribution can be adapted to the underlaying network characteristics. We exploit this observation to derive overlay building strategies that make use of cross-layer information to reduce the impact of the P2P streaming on the WCN while maintaining good application performance. We experiment with a real application in real WCN nodes, both in the Community-Lab provided by the CONFINE EU Project and within an emulation framework based on Mininet, where we can build larger topologies and interact more efficiently with the mesh underlay, which is unfortunately not accessible in Community-Lab. The results show that, with the overlay building strategies proposed, the P2P streaming applications can reduce the load on the WCN to about one half, also equalizing the load on links. At the same time the delivery rate and delay of video chunks are practically unaffected.

1. Introduction

Wireless Community Networks (WCNs) are infrastructures built by the people for the people [1], with a bottom-up approach bringing broadband services to communities, rural and urban as well. They have become an important reality in the landscape of telecommunication and ICT services, and in some cases involve hundreds or thousands of nodes and people.[1] They spread over large regions and some effort is currently spent in planning a sort of interconnecting federation [2]. The continuous growth of these networks and the services experimented on them represent a major swerve from the dominating paradigm of consolidation and centralization of the Internet. The increasing traffic generated by their users requires careful studies on the resources involved and the performance achievable by applications, with a special focus on services that have been ostracized in the commercial Internet. Among these, P2P applications, divested from their illegal aura, suite very well the WCN

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[1] Notable examples in Europe include: the Guifi.net community in Spain (http://guifi.net/); AWMN Community,the Athens wireless metropolitan network (http://awmn.net/content.php); the Ninux networks in Italy (http://ninux.org); the Funkfeuer free networks in Austria (http://funkfeuer.at/index.php?id=42&L=1).

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philosophy (delivering user-generated contents to other users) and also its internal, distributed structure, and can constitute killer-applications. Indeed, a P2P distributed architecture realized through a mesh overlay can exploit the WCN link characteristics like symmetric bandwidth and high throughput. On the contrary, applications based on the client-server approach cannot scale without a large amount of centralized resources because they do not take advantage from the underlaying network structure.

One of the P2P applications that raises most interest in a WCN is live streaming, which can have a relevant impact on the community. Live broadcasting of community user ideas and events fosters the opinion exchange within the community and can be a means for information propagation in a way much more tied to the citizens with respect to what traditional media do.

Even if the P2P architecture is distributed, the application must manage network resources accurately to avoid starvation and to properly balance the load in the underlying physical network. Our early works [3] and [4] report the feasibility of P2P live streaming in WCNs, but also highlight possible limitations affecting these kind of networks, and describe possible tuning needed to maximize the distributed content quality while limiting the network load.

This paper extends the work in [4], proposing and evaluating strategies for the management of the overlay topology and the content distribution in P2P live streaming. The key contributions of this paper can be summarized in the following bullets.

- The proposed strategies are aware and respectful of the network resources in a WCN, and autonomously adapt to them to achieve optimal performance with minimal resource use and maximal fairness.
- Several tests are performed on Community-Lab [2]. Community-Lab is a WCN testbed made up of real community network nodes, it allows the execution of experiments on different European WCNs testing the behavior of real-world application. Measures and consequent conclusions taken on Community-Lab are particularly relevant as proof of concept of the feasibility in real WCNs, and give high confidence on the final reception quality of the content distribution.
- Additional tests have been run on Mininet [5]. Mininet is a network emulator we adapted to emulate actual WCNs. Our adaptation relays on the statistical data we collected from the Ninux WCN. This emulator allows the analysis of complex techniques like cross-layer optimization that are not feasible in Community-Lab.

The rest of the paper is structured as follows: Section 2 reviews the relevant literature and explains the goal of this paper; Section 3 describes P2P architecture and strategies and PeerStreamer, the platform we use for our tests; Section 4 is devoted to describe the strategies we propose to create an optimal overlay; Section 5 summarizes what are, at the application level, the strategies adopted to schedule video chunks transmissions; Section 6 presents the tools and infrastructures we use for testing our strategies; Section 7 reports the results we obtained from the tests and, finally, conclusions are given in Section 8.

2. State of the art and contribution of the paper

Cross-layer optimization has been shown to be a key factor for real-time content distribution in wireless mesh networks [6,7]. However, the approaches described in [6,7] rely on advanced MAC/PHY protocols (such as IEEE 802.11ae) and the resulting algorithms have currently not been implemented. The multicast distribution on wireless mesh networks (WMN) is addressed in [8] and [9], but the suggested solutions rely on proposed advanced features for the data-link layer. [10] presents a collaborative algorithm for video streaming and cross-layer optimization, but it requires that all the WMN, including the user number and the load, is under full control. Video streaming in WMN is also addressed in [11] which reports a study on video streaming quality using different interference-aware metrics.

Only 4.5% of the papers analysed in [12] validates their findings with experiments, and repeatability is an issue. In previous works [3] and [4] we tested PeerStreamer on WCNs and we highlighted the need of a network aware strategy to create an efficient overlay that can cope with packet loss in WCNs. The repeatability of the tests performed is granted by the open source nature of PeerStreamer and the real world testbed Community-Lab.

Building efficient overlays is a well studied topic, and efficient distributed algorithms to build unstructured peer overlays already exist [13,14]. These algorithms focus on placing the peers with more network resources close to the source to enhance the content distribution performance. They behave well on the Internet, where network resources are not equally distributed. However, they do not take into account the network load and the fairness. Other works like [15] and [16] build efficient overlays based on network coordinates. Again, these methods are tailored for the Internet, hence they do not take into account network load and link fairness.

As already mentioned the application we use is based on PeerStreamer, an open source P2P live streaming platform briefly described in Section 3. The architecture of PeerStreamer is described in [17], while its capability to adapt to different network scenarios is studied in [18]. Additional details and related literature can be found on the home page of PeerStreamer .[2]

2.1. Goals of this paper

Compared with the discussed literature, this paper takes a different global perspective, which is enabled by two facts. First of all we exploit the PeerStreamer platform that enables the customization, including cross-layer optimization, of P2P streaming and its adaptation to specific environments. Second, we exploit the knowledge of mesh networking and routing protocols to introduce simple, but smart solutions that enhance the streaming performance and fairly uses network resources.

The goals and contributions of this paper are thus unfurling in two directions. First of all we demonstrate the feasibility of a traditional “killer application” as live video streaming in a fully distributed fashion without any support from

[2] http://peerstreamer.org .