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P2P multicast for pervasive ad hoc networks☆

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Abstract

During the last few years, the proliferation of miniaturised devices with networking capabilities has provided the technological grounds for pervasive networking environments. It is not visionary to foresee a world of pervasive devices embedded in the environment interacting between them, and with those carried by users, via wireless communications. In addition, fostered by the diffusion of small-size, computational-rich mobile devices, the way content is generated, and accessed is changing with respect to the legacy-Internet paradigm. An ever-increasing share of the Internet content is generated directly by the users, and shared on the network (following the User-Generated Content model). While today the legacy Internet is still used to share user-generated content, it is reasonable to envision that pervasive networking technologies will represent the natural platform to support this new model. This will result in content being distributed on users' devices rather than on centralised servers on the Internet, and in users creating ad hoc networks to share content. The p2p paradigm is particularly suitable for this scenario, because communications will occur directly among users, instead of being necessarily mediated by centralised servers. Motivated by these remarks, in this work we focus on p2p *multicast* services over ad hoc networks aimed at sharing content among groups of users interested in the same topics. Specifically, starting from a reference solution in legacy wired networks (Scribe), we design a cross-layer optimised protocol (XScribe) that addresses most of the Scribe problems on ad hoc networks. XScribe exploits cross-layer interactions with a proactive routing protocol to manage group membership. Furthermore, it uses a lightweight, structureless approach to deliver data to group members. By jointly using experimental results and analytical models, we show that, with respect to Scribe, XScribe significantly reduces the packet loss and

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the delay experienced by multicast receivers, and increases the maximum throughput that can be delivered to multicast groups.

Keywords: Multi-hop ad hoc networks; P2p multicast; Cross-layer; Experimental evaluation; Modelling

1. Introduction

1.1. Background and motivations

The hardware and software progresses of the last ten years have provided the basic elements (wearable computers, wireless-network technologies, devices for sensing, and remote control, etc.) for the deployment of pervasive computing and communication systems. We are actually progressing towards Mark Weiser's vision, in which the environment is saturated with devices that have computing and communication capabilities, interacting among them and with the users. Besides this, the computing and networking capabilities of current mobile devices (PDAs, WiFi phones, etc.) are changing the way content is generated and accessed with respect to the legacy-Internet architecture (mostly based on the client-server model). Following the User-Generated Content model, users generate the content on their own, and share it over the network. The increasing popularity of services like YouTube, flickr, blogs, and grassroot journalism are just a few examples of this trend. Even though these services are currently implemented through the legacy-Internet architectures, a pure p2p communication model is more suitable to support this way of accessing information. Currently p2p systems are widespread on the Internet, and this trend will be even greater in pervasive networking environments. By progressing along these directions, we can envisage that in the ubiquitous Internet the content will be available everywhere, distributed among all networked devices, while the role of centralised Internet servers will diminish. The users will mine the network for relevant information and data, starting from nodes physically close to them.

This different method to access the information will have a strong impact on the network organisation. In a pervasive networking environment, the infrastructure-based wireless communication model will often not be adequate. Rather, self-organised networks will provide a more efficient and flexible solution for accessing network services and retrieving data from the network. We can thus envisage that the network structure will evolve towards a model in which dynamic, content-rich, ad hoc networking clouds will co-exist and be integrated with legacy-Internet backbones. A big share of the traffic will be generated and accessed via p2p communication models directly within the ad hoc networking clouds, without relying on the legacy infrastructure. Thus, since in this environment content management will be of primary importance, increasing attention is being devoted to design efficient p2p solutions for ad hoc networks. Specifically, during the last few years, there has been increasing interest in integrating legacy p2p systems and multi-hop ad hoc networks (see, for example, [1,2]).

One of the main obstacles to this integration is the fact that p2p systems are typically based on opposite assumptions with respect to those really held in ad hoc networks. Legacy p2p systems are designed to scale up to thousands of nodes. Furthermore, the networking