Always Best (dis-)Connected: Challenges to Interconnect Highly Heterogeneous Networks

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Abstract. Wireless networks enable mobility, multihoming, and Delay Tolerant Networks. In such networking environments, the principles of the Internet, i.e., the end-to-end principle and the combination of location and identification in IP addresses, cannot be applied. In this paper, we propose a scalable application centric approach for mobility and multihoming that is able to interconnect highly heterogeneous networks where the networks may belong to different networking paradigms, e.g., IP based and Delay Tolerant Networks. Applications and users that aim to communicate, form communities. Community members might together have several network technologies available, and the community layer manages internetworking information for the members to seamlessly integrate these. Networking adaptation layers are used to provide a common interface for the different networks to the community layer. Addressing is based on names, cryptographic identifiers, and network locators and such that identifiers can also be created in infrastructure-less and disconnected situations.

1 Introduction

Mobile devices with multiple wireless networking capabilities, like IEEE 802.11, 3G and Bluetooth, have become mainstream devices in the recent years, and their popularity will increase also in the future. Applications running seemingly smoothly over these different networks give the impression that the Internet architecture is well suited for future wireless and mobile computing. Unfortunately, this impression is not correct. Basic mobility support required a patch to the Internet architecture, i.e., Mobile IP. Mobile IP enables the user to be reachable via the same IP address while roaming, through the help of a Home Agent. Since the Home Agent is a part of the network it conflicts with the fundamentals of the Internet architecture, i.e., the end-to-end principle. The basic problem that causes this conflict is the fact that IP addresses are used as locators and identifiers at the same time. The combination of identification and location causes also substantial problems for seamless integration of different networking technologies at the end host, i.e., for multihoming, because each network interface requires its own IP address. There are several ongoing efforts in the IETF to develop new patches to the
Another challenge to the Internet architecture is introduced by Mobile Ad Hoc Networks (MANETs) and Delay Tolerant Networks (DTNs). DTNs are infrastructure-less networks, which are so sparse that end-to-end connections cannot be established. Therefore, DTNs apply the store-carry-forward principle, i.e., nodes carry messages for some time until they meet other nodes that can be used to forward the message one hop. Obviously, such an approach is contradicting to the end-to-end principle and IP cannot be used in DTNs. Thus, DTNs represent a new networking paradigm and are clearly separated from MANETs. MANETs are also infrastructure-less networks, but they obey the end-to-end principle and are based on IP. In MANETs, it is assumed that route breaks caused by mobility can be quickly fixed through discovery of new routes and re-routing. We believe that the strong separation between MANETs and DTNs is wrong, because both network types are infrastructure-less and are used either due to necessity, i.e., no network infrastructure exists, or due to the explicit choice of the user. Examples for the first case include sensor networks for wildlife and environmental monitoring, emergency and rescue operations in areas with destroyed infrastructure, and also military applications. Examples for the second case include Vehicular Networks which do not want to rely on cellular networks like 3G due to the unacceptable end-to-end delay between neighbouring vehicles, and social content distribution networks that either want to save money (roaming costs) or want to establish a network that nobody can control, like floating content [1]. The question whether MANETs or DTNs should be deployed in a certain setting depends on the density and mobility of the nodes. MANETs might become quickly partitioned and nodes in DTNs might be close enough to each other to form a MANET with end-to-end connection. Multihoming and a seamless integration of the different networking paradigms would enable applications that are always best (dis-)connected in highly heterogeneous networks. Therefore, full advantage and resource optimisation of available communication capabilities from underlying layers could be obtained for applications and services in any network (dis-)connected node.

The contributions of this work comprise the identification of the challenges introduced by mobility, multihoming and different network paradigms and a proposal to address these challenges. One of the main characteristics of our proposal is that it is application and user centric compared to related network centric solutions.

The rest of the paper is structured as follows. In Section 2 we detail the challenges that mobility and multihoming over highly heterogeneous networks present. The state of the art in mobility, multihoming and heterogeneous internetworking is discussed in Section 3. In Section 4 we present our proposal for solving the aforementioned problems. Section 5 concludes the paper, discussing the differences between the proposed approach and related work, and pointing out our future work.

2 Challenges

The proliferation of wireless technologies has broken many of the assumptions made in the design of the current Internet. On the one hand, the Internet was designed with a much more reliable wired network in mind, so some protocols as TCP may be inefficient