Research Issues in QoS Provisioning for Personal Networks

Weidong Lu, Anthony Lo, and Ignas Niemegeers

CWPC, Delft University of Technology, Delft, The Netherlands
{W.Lu,A.Lo,I.Niemegeers}@ewi.tudelft.nl

Abstract. This paper outlines our ongoing research in providing personal networks (PNs) with QoS support. Research challenges and directions for the QoS provisioning in heterogeneous and dynamic PN environments are presented in two interrelated aspects: the traditional end-to-end QoS provisioning and the QoS support in PN self-organization.

1 Introduction

Personal network (PN) [1] [2] as a user-centric enabler for future wireless communications, starts from the user and extends the user's personal area network (PAN) to a global coverage of his personal devices and services in his home, car and office etc. as well as other foreign networks and services regardless of their geographical locations. Figure 1 illustrates an network abstraction of a PN. The PAN depicted in the thick circle is called Core-PAN, which is intimately associated with the person and is regarded as the heart of the PN. The extension of Core-PAN to different networks and services is made available via either ad hoc networks or infrastructure-based networks including UMTS networks and the Internet with wireless access points (APs) as depicted in Figure 1.

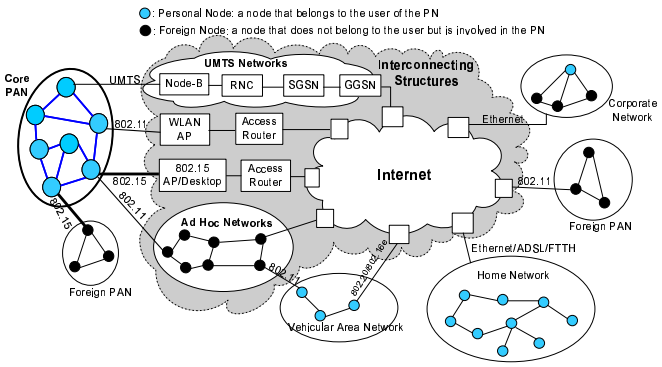

Fig. 1. A network abstraction of a personal network.

The need for provisioning of QoS for PNs inherits from the IP networks for providing real-time multimedia services. Furthermore, QoS provisioning in PN

becomes more challenging and complex due to the heterogeneity and dynamism characteristics of PNs. The *heterogeneity* of PNs lies in that mobile devices in a PN are heterogeneous in functionalities, computational and battery capacities and may be equipped with heterogeneous wireless technologies with different coverage ranges. Networks that are involved in PNs are also heterogeneous including ad hoc networks, wireless access to the Internet, the Internet and UMTS networks etc. Moreover, heterogeneous devices, wireless technologies and networks are complementary to each other and could cooperate with each other in a PN to best meet the user's demands and QoS requirements of applications. The *dynamism* of PNs inherits from ad hoc networks where mobile nodes move around and communicating with each other. However, the dynamics become more severe in PNs due to the mobility and cooperation in heterogeneous PN environments. For example, communications in a PN may switch between different interfaces, devices and networks frequently to achieve the best performance.

2 Research issues in QoS Provisioning for PNs

In this section, we will discuss the challenges that the heterogeneity and dynamism may pose to the QoS provisioning for PNs from the following two aspects. We will briefly address some challenges in end-to-end QoS provisioning and focus on the discussions of self-organization, a new form of QoS in PNs.

End-to-end QoS Provisioning. The end-to-end QoS provisioning in wired networks and self-organized ad hoc networks has been studied extensively over the years. However, several issues are still challenging for PNs. First is the unification of QoS parameters for heterogenous networks and QoS domains. Second is the end-to-end admission control and resource reservation in the heterogeneous and dynamic PN environments involving ad hoc networks, wireless access to the Internet and the Internet itself. Third is the QoS routing, a multiple constraints routing that dynamically determines the network path which satisfies the given constraints. The static QoS routing problem has been solved in practise but the QoS routing in dynamic PN environments is still under investigation.

QoS Support in Self-Organization of PNs. In addition to the traditional end-to-end QoS provisioning, new issues in QoS delivery for PNs lies in the self-organization of a PN, which refers to as the process in which the internal organization of the PN and the establishment of communications among nodes inside the PN are performed automatically and without or with minimal human intervention. Typical self-organization functions include device discovery, address-autoconfiguration and duplicated address detection (DAD), route discovery, mobility management, resource discovery, and context discovery, etc [3]. Self-organization functions need to be performed in a timely fashion to adapt to the dynamics of PNs.

Discovery functions play important roles in self-organization of PNs. Devices discovery and route discovery are related to the formation of PANs and PNs. The

latency introduced in these discovery processes may be very high. For example, the device discovery latency of Bluetooth technology is in the range of 3 to 10 seconds. Mechanisms need to be investigated to minimize the latency of discovery functions so that the formation of a PN is accomplished promptly. In addition, context discovery (context awareness) facilitates the cooperation in Core-PAN to achieve better QoS. For example, every mobile node in Core-PAN should be aware of the status of ongoing connections inside Core-PAN by context discovery. When there is no ongoing session, mobile nodes could turn to sleep mode and perform device and route discovery less frequently to save energy. On the other hand, when there is any ongoing communication, mobile node need to be active and perform discovery functions frequently to search for possible alternative route to the Internet so that when the QoS requirement can not be meet on one path, for example due to handover or link failure, alternative path can be selected to forward packets. The context of Core-PAN could also be its location and mobility. Mobility, for example, can be utilized to determine the proper gateways and interfaces to be selected to setup communications. If the mobility of Core-PAN is high, it is preferable to choose long distance UMTS connections to setup communication instead of short range 802.15 or 802.11 technologies.

Another key function in self-organization is mobility management which allows mobile nodes such as nodes in Core-PAN remain reachable while moving around. The network layer mobility solution, Mobile IP, is considered appropriate to provide mobility across heterogeneous networks. However, handover processes, especially vertical handovers between heterogeneous wireless technologies and networks may still result in a significant degradation of QoS. In order to solve this problem, end-to-end resource reservation need to be re-established on the new path after handover using QoS signalling such as RSVP. Moreover, mechanisms need to be investigated to minimize the handover latency in the dynamic PN environments. For example, to minimize the delay caused by the simultaneous movement of both ends during communications.

3 Conclusions

This paper discussed research issues in provisioning of QoS for PNs from two aspects: traditional end-to-end QoS in heterogeneous and dynamic PN environments and the self-organization of PNs which is a new form of QoS. In the future, we are going to investigate and provide new solutions for the research issues highlighted in this paper for QoS provisioning in PNs.

References

1. I.G. Niemegeers and S.M. Heemstra de Groot: Research Issues in Ad-Hoc Distributed Personal Networking. Wireless Pers. Commun. 26, August (2003) 149–167
2. Martin Jacobsson et al.: A Network Layer Architecture for Personal Networks, in IST MAGNET International Workshop, Nov. (2004)
3. W. Lu, A. Lo, and I. Niemegeers: On the Dynamics and Self-organization of Personal Networks. IST MAGNET International Workshop, Nov. (2004)