Ad-hoc Technology in Future IP based Mobile Communication Systems

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Abstract
In this paper we outline our future research activities in the field of ad--hoc communication systems for IP based services. We summarize why omnipresent technologies fail to support ad--hoc technology and give the motivation for our own approach. We identify different ad--hoc scenarios and emphasize the required research activities. We provide an overview of our intermediate results and explain how our results can be obtained by the WWRF working group.

Keywords: ad--hoc networks, IP services, video measurements, H.26L, wireless link measurement, IEEE802.11a

1 Subject Area

The focus of our future work is to investigate the feasibility of ad-hoc technologies for future IP based wireless and mobile[1]networks. For our work we have identified three different network structures. The network types are given in Figure 1, 2, and 3.

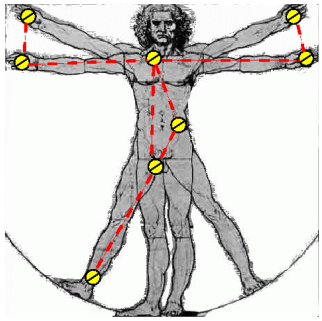

Figure 1: Personal area network scenario.

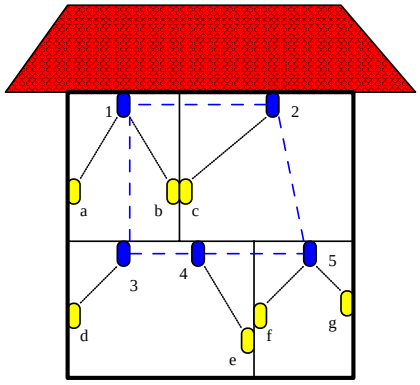

Figure 2: eHome scenario.

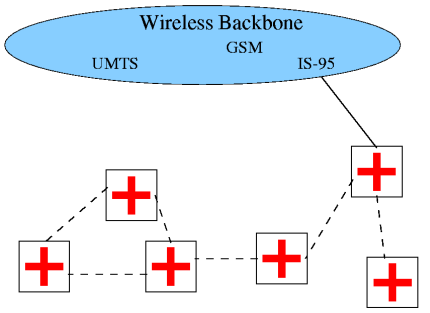

Figure 3: Firefighters/Mobile internet scenario.

In Figure 1 a personal area network (body network) is given. For this scenario all wireless terminals have the same air interface. The eHome scenario is depicted in Figure 2. Here we differ two types of terminals: the wireless terminals with battery and the wireless terminals with wired power supply. The terminals with wired power supply form the IP backbone network. Each of the battery driven wireless terminals will connect to such a terminal. The last scenario we refer to as the

[1] In the following the terms mobile and wireless are used interchangeable.

Firefighters or Internet scenario. Here we assume that a subset of terminals is connected to an overlay network (e.g. UMTS) and also with other wireless terminals via the multi--hop network. Terminals without the connection two the overlay cell will hop over their neighbored terminals to a station that has to types of air interfaces. For all these scenarios the solutions in terms of routing, medium access, handover strategies, quality of service support, etc differ dramatically. We will define our objectives and the required research in the following section.

2 Objectives of the Required Research

We identify the following items for our future research in the field of ad-hoc communication for IP services (see Figure 4). The proof of concept is done by simulations and testbeds.

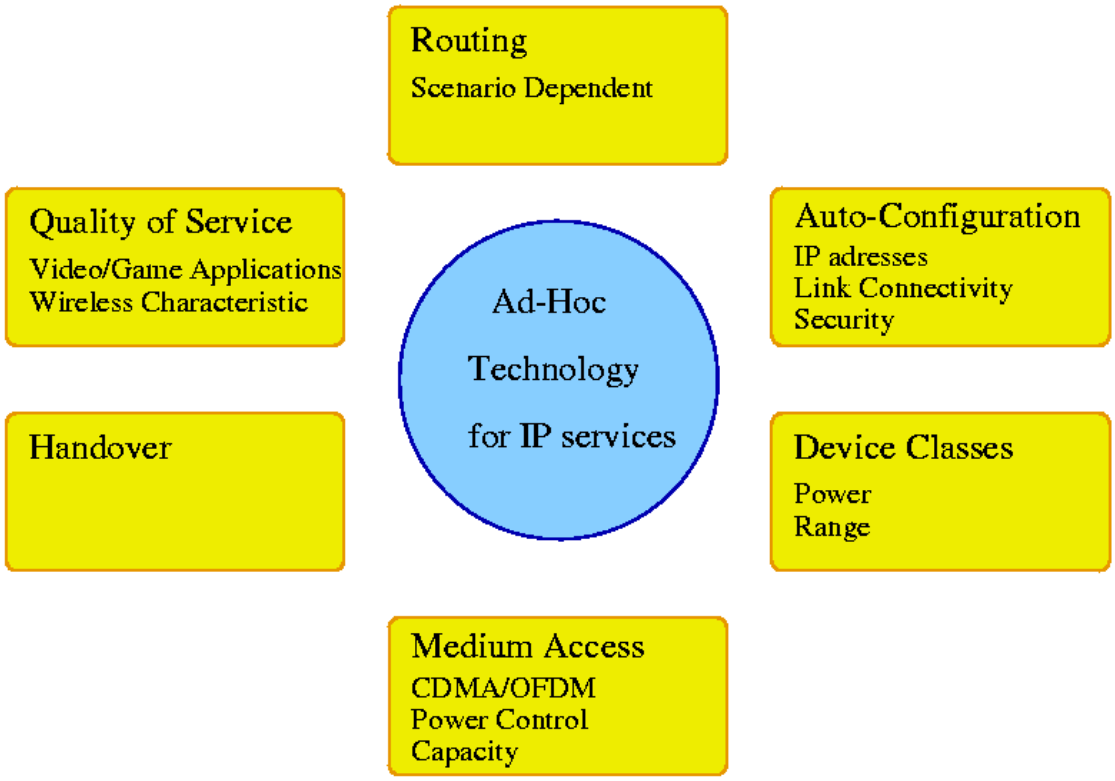

Figure 4: Required research in the field of ad--hoc technology.

Routing

A lot of work was done in the field of routing in ad-hoc networks [1,2,3,4,5,6]. But for the different ad-hoc scenarios (see Section 1) the routing protocol differs dramatically. While the routing protocol for the eHome scenario can assume fixed wireless terminals (leading to a small dynamic for the routing), the terminals in the firefighters scenario are highly mobile (leading to a high dynamic for the routing). This leads to the assumption that different routing strategies have to be applied. Quality of Service In wireless communication the problem of quality of service support is well known. The reason for this problem is based on the variability of the wireless link and the stringent requirements of the overlying applications. Therefore we identify the measurements of the wireless link and the application as one item for our further research.

Auto-Configuration

If we focus on IP services over ad-hoc networks we have to support the assignment of IP addresses. Protocols like DHCP will not work in an ad-hoc environment. Furthermore there

has to be the possibility to achieve link status information on layer two. This allows gathering informations about neighboring terminals without the knowledge of their IP address.

Device Classes

The routing process depends on the device class of a wireless terminal. Terminals with batteries are not well suited for the multi--hop routing, because they are consuming the resources. The device classes are based on power, range, air interface, costs, etc.

Handover

In case heterogeneous wireless terminals (e.g. Bluetooth and IEEE802.11) have to be supported, the handover procedure becomes very important.

Medium Access

Creating ad--hoc networks using the IEEE 802.11 technology implies some well known difficulties [7]. Two solutions are possible: 1.) To tune the IEEE802.11 technology (RTS and CTS interval) and 2.) To develop a new MAC scheme based on CDMA/OFDM.

3 State of the Art in the Area and Possible Approaches

acticom started to create its own ad-hoc testbed. The testbed was based on the IEEE802.11b technology. In Figure 5 the structure of the testbed is given. Sony Vaio C1VF are wireless terminals that are connect with each other via a multi--hop network and one Sony Vaio SR21 as a wireless bridge to the Internet. Each wireless terminal is able to establish a video conference with one member of the group or with a fixed terminal in the Internet. Because AODV [2,3,4] and DSR [5,6] routing protocols failed to support the requirements of real time services such as video, we implemented our own quality of service aware routing protocol.

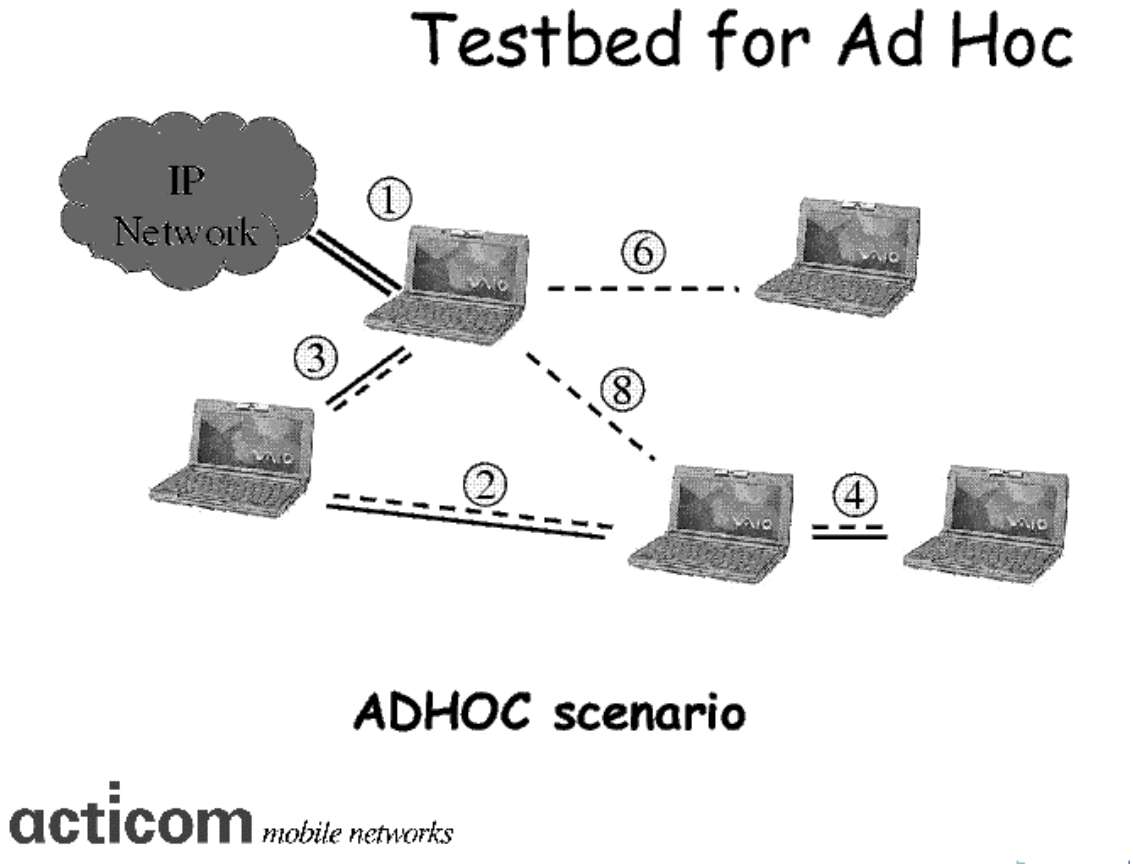

Figure 5: Testbed for ad--hoc networks.

In Section 2 we claimed that we need a good understanding of the wireless link. For the IEEE 802.11a technique based on multi-mode modulation and OFDM the wireless link characteristic becomes even more difficult. In Figure 6 the data rate versus the distance

between sender and receiver for the IEEE802.11a technology is given. From the point of an ad-hoc network this characteristics seems very promising. It is well know that multi-hop systems can save a huge amount of energy. Together with the behavior depicted in Figure 6 multi--hop achieve even higher data rates. In the future we will perform comprehensive measurements of the IEEE802.11a wireless link.

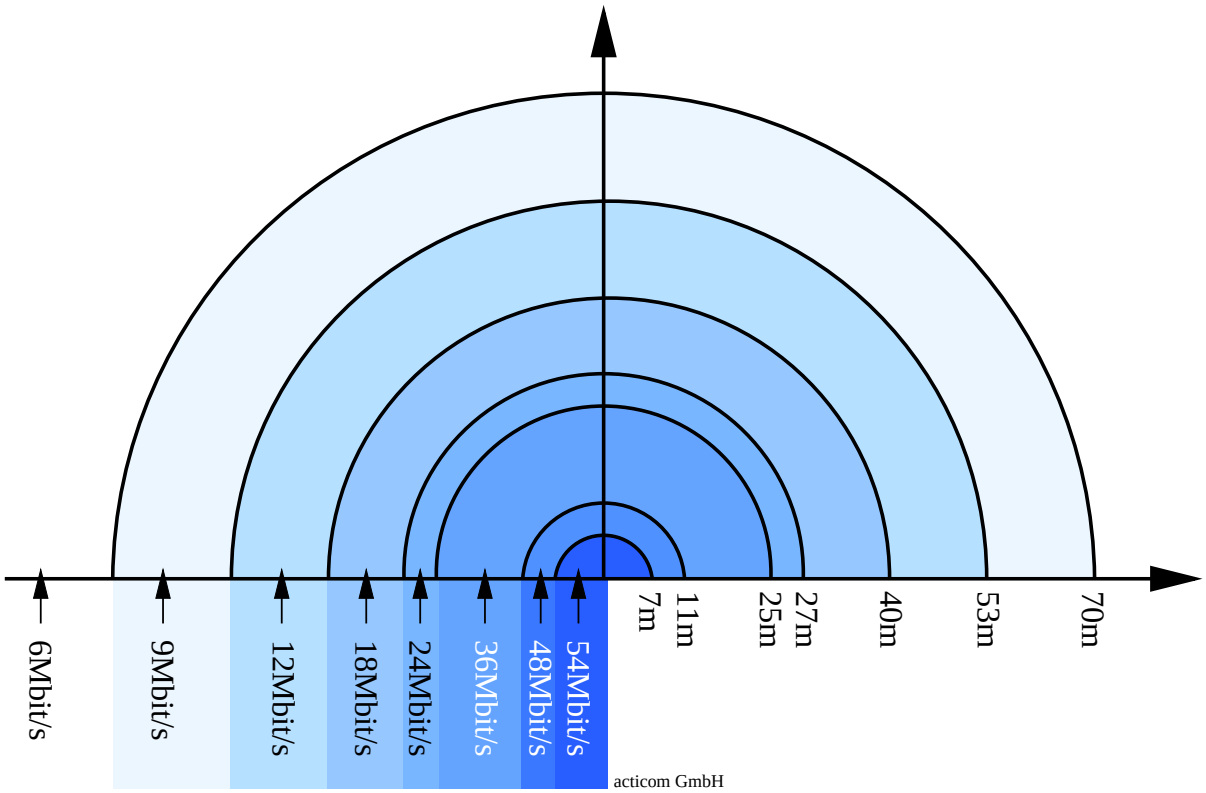

Figure 6: Data rates versus the distance between sender and receiver for the IEEE802.11a technology.

A disadvantage of multi--hop systems based on IEEE802.11 is that with more wireless terminals in the range the throughput decreases because of the RTS/CTS mechanism. To achieve both high data rates and power saving the RTS/CTS mechanism has to be tuned or a new MAC scheme has to be found. The tuning process of IEEE802.11 or the research for a new multi--hop MAC schemes is for further research.

If we want to support heterogeneous quality of service over the multi-hop network we need a good understanding of the application types. One of the tightest quality of service requirements has to be fulfilled for video services [8]. Therefore we investigate the characteristics of H.26L video sequences. It is claimed that H.26L has a larger compression gain that other encoding schemes like MPEG-4 or H.263. In Figure 7 H.26L video frame size [byte] versus time (eight seconds) for three different quality levels (low/medium/good) of the video sequence *Coastguard* is given. For future research we will investigate different types of video sequences with the H.26L encoding.

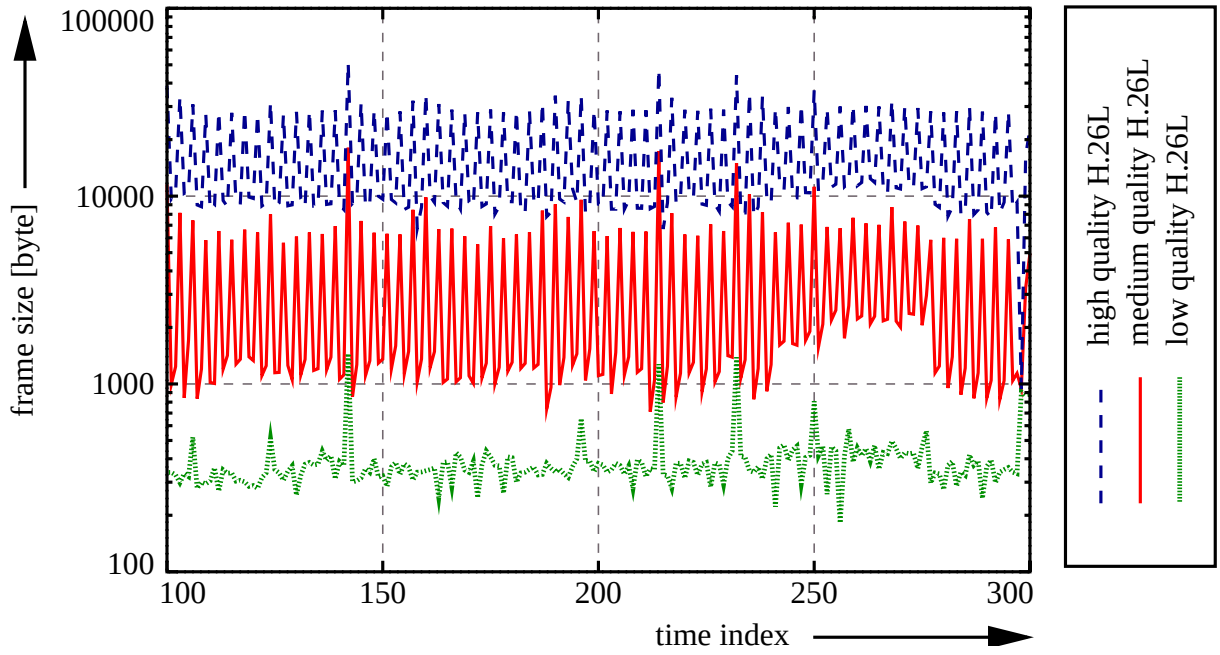

Figure 7: H.26L video frame size [byte] versus time (eight seconds) for three different quality levels (low/medium/good) of the video sequence *Coastguard*.

4 Expected Results and Time Frame

Testbed

With our testbed we want to identify the problems that occur with omnipresent technologies. The results will help us to design a better (in terms of capacity for given quality of service set) ad-hoc networks.

Measurements of H.26L Video Streams

This work has been already started. First results will be available in July 2002 at the acticom web server. The goal is to offer the WWRF group a sophisticated source model for their further work. Simulation engines will be created for the NS and the PTOLEMY simulation tool.

Measurements of 802.11a Wireless Link

This work will start in April 2002. First results are available at the end of 2002.

Modelling of 802.11a Wireless Link

After the measurements we will even provide a link model of IEEE802.11a for simulation purposes.

Device Classes

A first definition for the device classes has been made. In the future work we will match or add the parameters in the device classes.

Auto--Configuration

We want to solve the problem of assigning IP addresses to the wireless terminals. Therefore we need a mechanism to detect whether a layer two connection is available or not. This work will start in May 2002.

Routing

First results have been obtained as given above. The routing protocol will be improved over the next years.

Medium Access Control

The work to tune the RTS/CTS mechanism will start in July 2002. The development of a new MAC scheme based on a CDMA/OFDM air interface has been started.

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