Personal Networks Enabling Remote Assistance for Medical Emergency Teams

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Abstract. Personal Networks provide the technology that is needed to interconnect the various private networks of a single user (home network, car network, office network, Personal Area Network, and others) seamlessly, at any time and at any place. This can be useful in many business sectors. In case of medical emergencies, it can provide a means to enlist remote assistance from peers wherever they are in the world at that particular moment. To illustrate this, we have analyzed the use case of a medical emergency surgery and have built a demonstrator.

Keywords. Personal Network, medical emergency team, Personal Area Network, Mobility Provider, Personal Network Gateway.

Introduction

Operating theatres are called like that because, in early times, students and other specialists could attend medical operations live, in an operating room with stands around the table (see Figure 1). Because of modern demands on hygiene, today's surgeries are heavily protected environments with few facilities for physical communication with the outside world. Especially in cases of medical emergency, when there is little time to prepare the operation, this limits the amount of assistance the medical team can call upon.

Figure 1. Surgery performed in the operating theatre of old St. Thomas Hospital, London, about 1775. Students and peers are physically present in the room to ask questions or to give helpful advice.

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Personal Networking technology can provide a means to enlist remote assistance from peers wherever they are in the world at that particular moment. Depending on the available networks and equipment, the peers can have voice, data and video communication with the operating room, and also remotely control the cameras that record the treatment.

This paper first discusses the general concept of Personal Networks, its various application domains, the current state of the technology and the research challenges ahead. In the second section we treat the use case of the medical emergency team in more detail and describe a demonstrator that we have built. In the final section we summarize the main conclusions and provide an overview of the user studies we are currently performing.

1. Personal Networks

1.1. The concept of Personal Networks

Personal Networks (PNs) is a concept that has been introduced only recently [1, 2]. It is based on the following trends:

- People possess more and more electronic devices, such as mobile phones, laptops, Personal Digital Assistants (PDAs), digital cameras, MP3 players, gaming consoles, digital video recorders, set-top-boxes, broadband modems, media centers, TV screens, desktop PCs, tablet PCs, PC accessories, navigation systems, DVD players, and white goods.
- More and more electronic devices have networking functionality that enables the device to share content, data, applications, and resources with other devices, and to communicate with the rest of the world.
- In the various private domains of the user (home, car, office, workplace, etc.) clusters of networked devices ("private networks") appear that indeed share content, data, applications, and resources with each other, and communicate with the rest of the world by means of a common gateway, for instance the broadband modem [3].
- With increasing wealth, people are becoming more mobile and carry an increasing number of (portable) electronic devices with them. Often these devices can relatively easily be connected to the public mobile network, but local interaction between them is still rather limited. In the near future, however, it is expected that these devices will form a Personal Area Network (PAN) with the help of recently developed Wireless Personal Area Networking (WPAN) technologies such as Bluetooth [4].

A PAN can therefore be defined as a network of devices in the personal operating space of the user. A schematic representation of a PAN is given in Figure 2. The user is carrying a laptop, a PDA, a mobile phone, a wireless headset and a digital camera. The devices are networked with each other by means of high-data-rate WPAN technology (>200 kbps) [4], here depicted as "802.15". The mobile phone, the laptop and the PDA can also communicate to the rest of the world by means of Universal Mobile Telecommunications System (UMTS) technology or Wireless Local Area Network (WLAN) technology. This configuration enables e.g. pictures taken by the digital camera to be emailed by means of the email client on the PDA and the UMTS connection of the mobile phone.

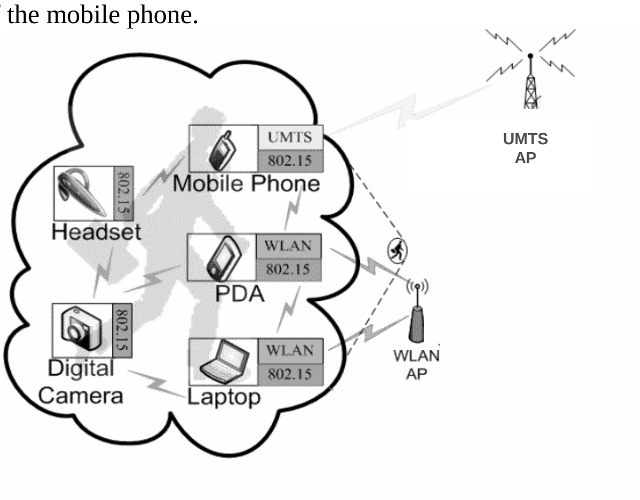

Figure 2. Example of a Personal Area Network.

A Personal Network (not to be confused with a Personal Area Network, or PAN), is envisaged as the next step in achieving unlimited communication between peoples electronic devices. A PN provides the technology needed to interconnect the various private networks of a single user seamlessly, at any time and at any place. Such private networks are, as mentioned before, home networks, car networks, company networks, PANs, and others. Often, a user wants to remotely access content, applications, or resources that are located in one of his private domains. For example, a business man who is at a conference wants to take pictures of the various demonstrators without having to worry where the pictures should be stored: on the memory card of the camera, the hard disc of the laptop, the content server in the office, or the desktop computer at home. A PN should solve the current limitations that inhibit (user-friendly) access to the personal devices that are not physically close to the user at the moment of need.

A schematic view of a PN is given in Figure 3. In the figure, the clouds represent the various private and public infrastructures involved in creating a PN. The PN itself is drawn as an overlay over the multiple domains that should hide the underlying network and business complexity from the user. At the heart of the PN is the core-PAN, which is physically associated with the owner of the PN. The core-PAN consists of networked personal devices carried by the user. Depending on the location of the user, the core-PAN can interact with devices in its direct environment or with remote devices in the user's other private networks to create a PN. A key element of the core-PAN is therefore the PN Gateway (PNG). The PNG is the device that contains the functionality needed to create a PN from the core-PAN and the other private networks. This functionality might include, amongst others, local storage, local intelligence, and multiple wireless (mobile) access network interfaces. The PNG can be a single dedicated device, or added functionality of other devices in the core-PAN. In the example of Figure 2, the PNG functionality is distributed over the laptop, PDA, and mobile phone.

Another important factor for enabling a fully functional PN will be the Mobility Provider (MP) [5]. The MP is not a device or a specific application, but a new business role. It is basically the service provider offering the PN service and providing an operational environment to manage user, service, content and network related issues. For that purpose the MP might use a service platform like that described in ref. [6], which communicates with the PNG and offers service control functions that enable end users to easily gain and maintain access to services, while roaming between different interconnecting public infrastructures. For other service providers, the MP can act as a one-stop shop for providing their services to the PN. The MP could also take care of the billing, depending on the subscriptions with the various network and service providers, and on the authentication of the devices and content belonging to the PN.

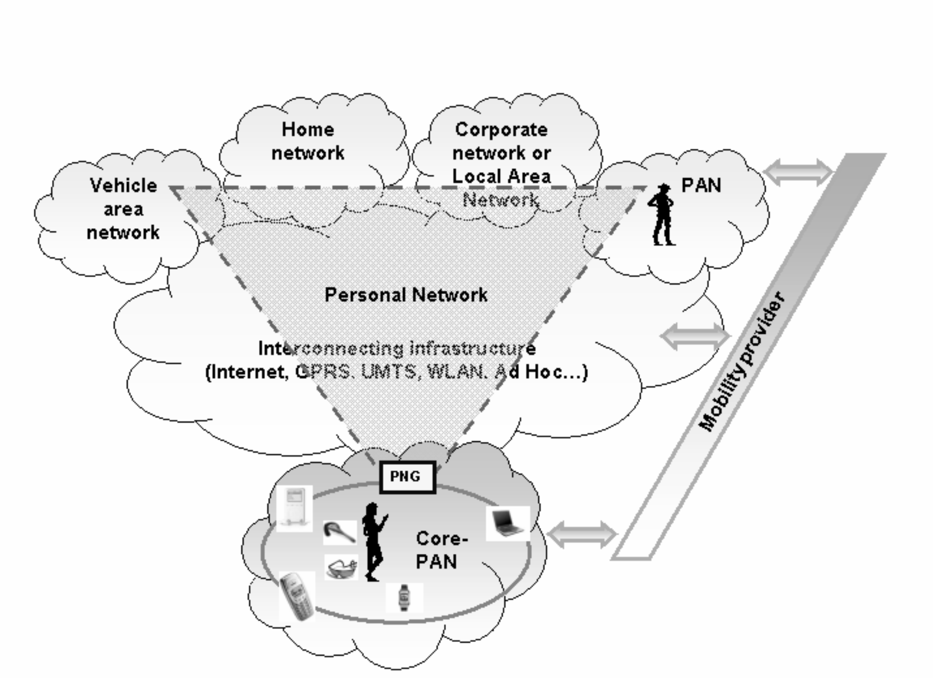

Figure 3. A Personal Network (PN) is a personalized overlay over multiple network domains. The Mobility Provider offers the PN service. The PNG connects the core-PAN to the other private networks, thus creating a PN.

1.2. State of the art, research challenges, and application domains

The goal of the Freeband Personal Network Pilot 2008 project (PNP2008) [7] is to develop the concept of Personal Networking. The generic research question is how to create a PN to support, in a meaningful way, users in their private and professional activities. This involves investigating the desired user experience and finding solutions to a range of technical problems, but also business problems. These research and development challenges basically arise from the fact that current networks often support user mobility within a single network domain (a single cloud in Figure 3), but not between the different network domains. Users can therefore not switch between the different networks whilst automatically retaining their session and information. Furthermore, in PNs we no longer have single terminals wanting to establish co-operation with the other infrastructures (like in current cellular systems or WLANs), but very dynamic and heterogeneous mobile PAN networks. Finally, there are no suitable business models in place for PNs, because current business parties are usually dedicated to a single network or application domain.

A PN should result in a distributed personal environment, consisting of clusters of geographically dispersed devices, that dynamically changes according to the context and needs of the user. It offers users access to their personal applications, devices and content depending on the role of the user (employee, private person, member of a community, etc.). Therefore, a PN should not only be non-specific to the underlying network domains, but also to the application domains. In ref. [8] we have studied the value that PNs can add to various business market sectors, based on the sectors' need for integration of dispersed resources, the level of complexity a PN can hide for their employees, the number of different contexts in which the employees are acting and that the PN can adapt to, and the size of the market. We found that PNs should be especially attractive to the construction sector, the transportation sector, the manufacturing sector, the health care sector and the emergency services sector. In the first year of the PNP2008 project we have decided to develop the concept of PNs in more detail for the latter two sectors. This resulted in a demonstrator that will be described in the following section.

2. Use case and demonstrator

2.1. Use case

Healthcare professionals indicate that information and communication is crucial to their functioning. The information should be complete, covering all subjects, and if possible be available in the doctor's office whenever needed. Doctors especially need a wide range of data from different perspectives and supplied by several parties. Some examples are the patient's history, transfer data by nurses and other doctors/specialists, and information on medication. Currently, however, this information is often not available when and where it is needed. It can be concluded that in the healthcare sector ICT is not yet supporting the complex internal and intramural work processes sufficiently and does not yet ensure adequate information and communication. Personal Networks might be a very helpful tool in this situation. This can be illustrated by the following use case.

In medical emergency operations, the medical staff involved has only limited time to make a diagnose and to collect all the information needed. Quite often, therefore, the operating surgeon has to consult a colleague by physically leaving and re-entering the operating theatre, which is fairly time consuming because of the tight hygiene regulations. A PN consisting of the PANs of the surgeon and the peer, extended with the appropriate cameras and screens in the vicinity of the people involved, might improve the communication significantly. This use case is the basis of the first PNP2008 demonstrator, as described in the following section.

Other stages in medical emergency cases desire communication of voice, data, and video that can also be improved by the use of PNs. A medical emergency often consists of the following stages:

1. The emergency call center is contacted by a bystander
2. Medical emergency team is notified
3. The ambulance is on the way

4. The ambulance is on the spot
5. The ambulance doctor contacts the intensive care doctor for an expert opinion
6. The ambulance is on the way back to the hospital
7. The patient is transferred to the emergency room
8. More diagnostic measurements are done
9. The patient is operated

PN technology can also be useful in stages 3-6. The PN then consists of the PANs of the ambulance personnel, the ambulance network, the PAN of the intensive care doctor, and the hospital network. When the ambulance is on its way, updated status reports and the medical background of the patient can be automatically and continuously exchanged between the ambulance and the hospital and the personnel involved. At the spot, the first diagnosis can be discussed with the intensive care doctor, who also has a video connection to the scene via the cameras of the ambulance. Any data measured by medical equipment on the spot is directly communicated to the doctor and the hospital, where the data can be processed by various intelligent systems, and immediate medication be suggested to the ambulance personnel. It can then also be decided, for example, to transport the patient directly to an academic hospital instead. On the way back to the hospital, the patient is continuously monitored, and the information is shared with the hospital and the surgeon.

2.2. Demonstrator

The use case to which the demonstrator refers is based on step 9 of the medical emergency case of section 2.1. In this case, the PN consists of the PANs of the surgeon and his remote peers (containing various mobile devices), the local area network of the emergency room (containing controllable high quality cameras), and the local network of the peers (containing any type of screen). This setup is drawn in Figure 4.

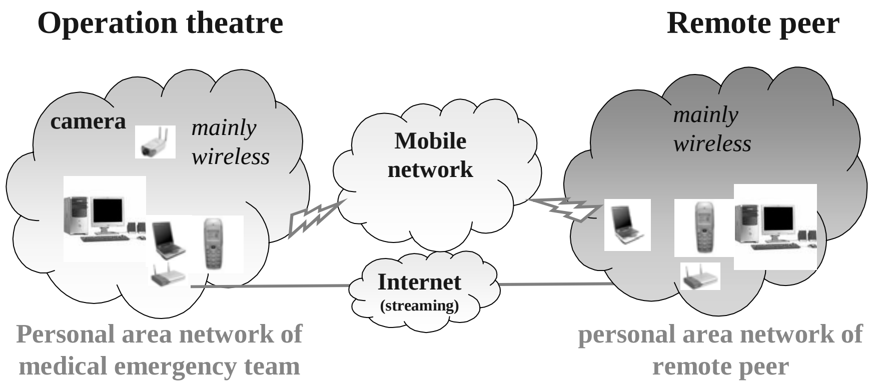

Figure 4. Schematic overview of the demonstrator set-up.

We assume a medical emergency team working in the operation theatre. A number of controllable digital video cameras are recording the scene. The cameras and the streaming server become part of the surgeon’s PAN as soon he enters the operating theatre. The surgeon controls the streaming server with his mobile phone or another device in his PAN that, for instance, enables him to operate the cameras by means of voice recognition. The surgeon is then in control of the recording, i.e. he decides what is recorded and when. On demand the surgeon is also able to deliver the live streaming content to the outside world. In this particular case the surgeon wants to consult a few peers around the world about a patient he is operating on. A previously constructed list of peers is then used (based on their phone numbers) to make an invitation phone call. The invited peers receive an SMS message with the invitation to join the group. The surgeon receives the confirmations indicated by, for instance, highlighted list items. From that moment on the medical emergency team and the remote group members are able to talk to each other.

After briefly describing the problem at hand, the operating team sends a message to the peers containing a web address and login details. The group members can then access the live streaming video by temporarily absorbing any local device with a screen into their PAN (e.g. their home TV screen) and using the web address. Based on this web address, the video (with audio stream) could in principal be received on any screen devices connected to the Internet. The invited group is now able to discuss the problem with the surgeon watching live video images. Moreover, the surgeon can delegate the control (pan, tilt, zoom) of one or more cameras to one of the invited peers to have an optimal interaction.

The architecture of the demonstrator can be briefly described as follows. The emergency room has a wireless local area network, based on the IEEE 802.11a standard, that is connected to the Internet by means of a router/gateway. The wireless network consists of a high quality networked camera with a stream server and a control interface. It also contains a PC that can play the camera image and that registers the camera so that it can be automatically discovered by other devices that enter the theatre. This PC can also be used to collect other health data of the patient. The PAN of the surgeon consists of a GPRS and Bluetooth enabled mobile phone and a Bluetooth and IEEE 802.11a enabled laptop or PDA. The laptop/PDA is used to discover the camera (by using the Zeroconfig autodiscovery and –configuration protocol standardized by the Internet Engineering Task Force (IETF) [9]). The phone is used for inviting group members and setting up a group conversation by using a Push-to-Talk service [10]. There exists an open standard for Push-to-Talk over cellular networks, but this is not implemented yet by most operators. We therefore use proprietary software, licensed by SPING B.V. [11], that enables Push-to-Talk over GPRS. For Push-to-Talk an extra server is needed that is deployed and maintained by e.g. the Mobility Provider. Via the Bluetooth connection between phone and laptop, the camera can be controlled and the camera details (web address, login details) can be retrieved and sent to the message server. This message server is based on the Simple Object Access Protocol and Remote Procedure Call (SOAP-RPC [12]), and is also to be deployed and maintained by the Mobility Provider.

The architecture of the peer’s networks is very simple. The peer has a PAN containing a similar mobile phone and laptop/PDA. The mobile phone is used for the Push-to-Talk session, and the IEEE 802.11a enabled laptop/PDA is used for discovering a screen with a video player nearby and for receiving the camera instructions from the mobile phone. The screen might be connected to the Internet by its own broadband connection (the home network or the hospital network). In that case the camera images can be routed to the screen via the broadband fixed network. If the screen is stand-alone, the images might be streamed via the much slower GPRS and Bluetooth connection. In that case, some content adaptation should be performed by, e.g. the Mobility Provider. In both PANs involved, the PNG functionality is distributed over the mobile phone and the laptop or PDA.

3. Conclusions and future work

People want to access more and more electronic devices that reside in their personal domains. At this moment, these devices form networked clusters that can be relatively easily connected to the public network. However, context aware interaction between these clusters and with remote personal content and applications is not possible yet. A Personal Network should provide the technology needed to interconnect the various private networks of a single user seamlessly, at any time and at any place.

A PN is not really an end-user application, but merely a sector non-specific service enabler. We found that PNs should be especially useful for stimulating voice, data, and video communication in the construction sector, the transportation sector, the manufacturing sector, the health care sector and the emergency services sector. We have shown some of this added value with a demonstrator that is based on the use case of a medical emergency team that can communicate with remote peers by using a PN. Further evidence will be acquired by conducting a number of user studies, in which we will interview a number of medical specialists and have the demonstrator tested by them on usefulness and usability.

Ultimately, PN technology should enable a truly user-centric ambient communication environment in a highly heterogeneous world of devices, operators and network technologies. This is a challenging research task, but it has a strong industrial potential, since it would enable a whole new class of applications.

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References

[1] G. Niemegeers and S.M. Heemstra de Groot, Research issues in ad-hoc distributed Personal Networking, *Journal on Wireless and Personal Communication* **26** (2003), 149-167.

[2] I.G. Niemegeers and S.M. Heemstra de Groot, From Personal Area Networks to Personal Networks: A user oriented approach, *Journal on Wireless and Personal Communications* **22** (2002), 175-186.

[3] F.T.H. den Hartog, M. Balm, C.M. de Jong, and J.J.B. Kwaaitaal, Convergence of Residential Gateway technology, *IEEE Commun. Mag* 42 (2004), 138-143.

[4] T. Cooklev, *Wireless communication standards*, Standards Information Network IEEE Press, New York, 2004.

[5] N.H.G. Baken, E.F.M. van Boven, F.T.H. den Hartog, and R. Hekmat, A four-tiered hierarchy in a converged fixed-mobile architecture enabling Personal Networks, *Proc. FITCE 2004*, Ghent, 2004, also in *The Journal of The Communications Network* **3** (2004) part 3.

[6] D.-J. Plas, M. Bargh, J. Laarhuis, J. van Vugt, J. Brok, and H. van Kranenburg, The 4GPLUS project; overview and main results, *Proc. of ECUMN 2004*, Porto, 2004.

[7] Pnp2008.freeband.nl .

[8] A. de Vries, J. Kort, M.S. de Jonge, and L.L.M.L. Kuiper-Hoyng, Professional target groups for a Personal Network, *Deliverable 4.1 of the PNP2008 project*, 2004.

[9] www.ietf.org/rfc/rfc3927.txt .

[10] Push-to-Talk on a mobile phone, GSA opinion paper, www.gsacom.com/downloads/pdf/gsa_opinion_paper_015.php4 .

[11] www.imfree.nl .

[12] www.ietf.org/rfc/rfc3288.txt .