

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, office network, Personal Area Network, and others) seamlessly, at any time and in any place. This can be useful in healthcare. 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. We illustrate this concept with a case scenario and a demonstrator model for an emergency surgery situation.

INTRODUCTION

In medicine peer to peer consultation is often used for deciding on the best and most appropriate treatment for an individual patient, e.g. a patient undergoing an operation. Advances in information and communication technologies (ICT) have extended the opportunities and boundaries for this in clinical practice. In particular Personal Networking technology can provide a means to instantly enlist remote assistance from peers irrespective of their global location. Depending on the available networks and equipment, peers can have voice, data and video communication and may even remotely control equipment, e.g. within the operating room.

This paper discusses the general concept of Personal Networks, its various application domains, the current state of the technology and the research challenges ahead. We detail this concept and potential applications with an emergency scenario. Finally, we summarise the main conclusions and provide an overview of the user studies we are currently performing.

PERSONAL NETWORKS

Personal Networks (PNs) are a recently introduced concept^{1,2} and are based on the following trends:

- People possess more and more electronic devices that have networking functionality. These enable the devices to share content, data, applications, and resources with each other.
- In the various private domains of the user (home, workplace, etc.) clusters of networked devices (“private networks”) exist that share content, data, applications, and resources with each other, and communicate with the rest of the world by means of a common gateway, e.g. broadband modem³.
- People are more mobile and carry an increasing number of (portable) electronic devices with them. Often these devices can be connected relatively easily to the public mobile network, although 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 Bluetooth⁴.

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 1. 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

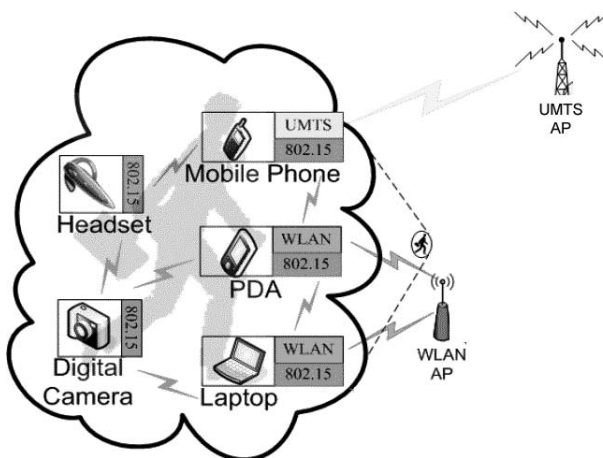


Figure 1. Example of a personal area network

PDA = Personal Digital Assistant, UMTS = Universal Mobile Telecommunications System, WLAN = Wireless Local Area Network

of Universal Mobile Telecommunications System (UMTS) technology or Wireless Local Area Network (WLAN) technology. This configuration enables for example 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.

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 the electronic devices of an individual. A PN provides the technology needed to interconnect the various private networks of a single user seamlessly, at any time and in any place. Such private networks are, as mentioned before, home networks, work networks, company networks, PANs, and others. Often, a user may want to remotely access content, applications, or resources that are located in one of his private domains. As an example, a doctor attending a medical conference may want to show a colleague photographs of an interesting case he has dealt with. However he does not want to have to worry about where he has stored the pictures - on the memory card of the camera, the hard disc of the laptop, the content server in the office, or his desktop computer at home - to be able to access them. A PN aims to solve this current limitation that inhibits (user-friendly) access to 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 2. 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

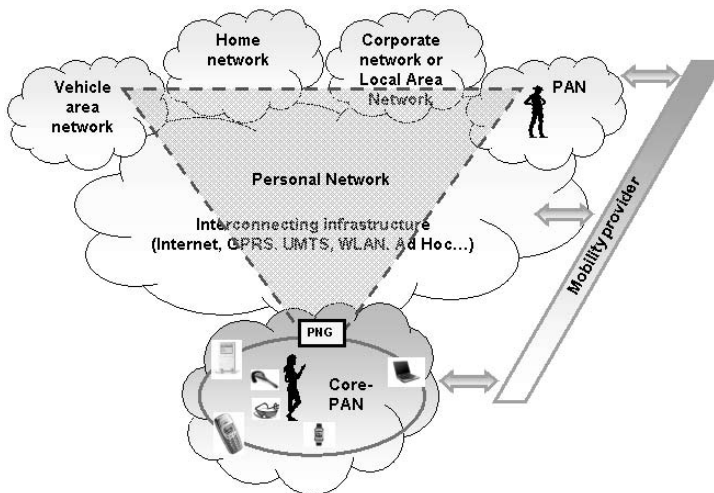


Figure 2. A personal network (PN) is a personalised overlay over multiple network domains

The Mobility Provider offers the PN service. The Personal Network Gateway (PNG) connects the core-Personal Area Network (PAN) to the other private networks, thus creating a PN.

GPRS = General Packet Radio Service, UMTS = Universal Mobile Telecommunications System, WLAN = Wireless Local Area Network

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 have 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 the 4GPlus Project⁶. This 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 billing, depending on subscriptions with the various networks and service providers, and on the authentication of the devices and content belonging to the PN.

The Freeband Personal Network Pilot 2008

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 2), 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 cooperation with the other infrastructures (as 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 change 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 a previous study⁸ we have evaluated the value that PNs can add to various business sectors, taking into account a number of different variables. We found that PNs should be especially attractive to healthcare and emergency services. As a consequence in the first year of the PNP2008 project we decided to develop the concept of PNs in more detail for these two sectors. This resulted in a demonstrator model that is described below.

CASE SCENARIO AND DEMONSTRATOR

Case Scenario

It is well-recognised that accessibility to patient information and communication between healthcare professionals are crucial to the optimal management of individual cases. Patient information may be provided from several different sources, e.g. general practitioner, hospital physician, nurse, laboratory, pharmacy etc., and be in a variety of formats e.g. text documentation, laboratory results, X-ray images, etc. However irrespective of the source, the information should be complete, comprehensive and available at the point of care whenever needed. Currently this situation rarely exists as healthcare ICT is not yet sufficiently mature to adequately support the complex work processes of healthcare professionals. Personal Networks might be a very helpful tool in this situation. This can be illustrated by the following case scenario.

For medical emergency operations, medical staff frequently only have a limited time to make a diagnosis and obtain relevant information. In such a situation it is conceivable that a surgeon will want to consult a colleague during the operation, but will be unable to leave the operating room because the patient is unstable or requires a life-saving procedure, e.g. controlling haemorrhage. In this situation a PN consisting of the PANs of the surgeon and the peer, supplemented by appropriate cameras and monitors/screens in the operating theatre, might significantly improve communication between the two. This scenario is the basis of the first PNP2008 demonstrator, which is described later.

PNs may also be useful in improving communication by means of voice, data, and video in other key stages of the management of medical emergencies. This can be better appreciated by considering the stages involved in an emergency team being sent to deal with a patient who has fallen in a frozen lake:

1. Bystander contacts emergency call centre
2. Medical emergency team is notified
3. Ambulance is dispatched
4. Ambulance arrives at the lake

5. Ambulance doctor contacts the intensive care consultant for an expert opinion
6. Ambulance transfers patient to the hospital
7. Patient is transferred to the emergency room
8. Patient is assessed and diagnostic investigations performed
9. Patient is taken to the operating room to be rewarmed with the aid of cardiopulmonary bypass.

PN technology could be particularly 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 consultant, and the hospital network. Whilst the ambulance is travelling to hospital, an updated status report including the patient's vital signs can be automatically and continuously exchanged between the ambulance and the hospital personnel. At the emergency scene, the initial diagnosis and assessment can be discussed with the intensive care consultant, who has a video connection to the scene via the ambulance cameras. Any data recorded from the patient can be directly communicated to the hospital and management recommendations be sent from the hospital consultant to the ambulance personnel. A decision can be made for example to transfer the patient to a hospital with cardiac surgery facilities if the patient is thought to require warming on cardiopulmonary bypass. Whilst the patient is being transferred to the hospital, the patient is continuously monitored, and data can be continuously shared with the hospital staff including if necessary the cardiac surgeon.

Demonstrator

The case scenario to which the demonstrator refers is based on step 9 of the medical emergency case described above. 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),

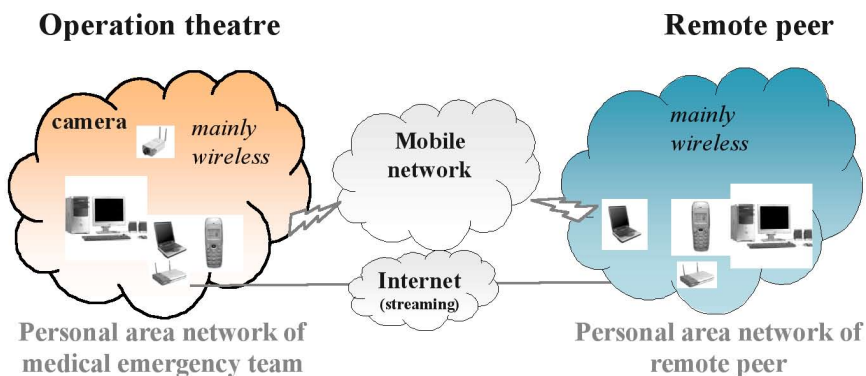


Figure 3. Schematic overview of the demonstrator set-up

and the local network of the peers (containing any type of screen). This setup is drawn in Figure 3.

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 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 others 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 principle 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 optimal interaction.

The architecture of the demonstrator can be briefly described as follows. The emergency room has a WLAN, 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 standardised 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 service¹⁰. There exists an open standard for Push-to-Talk over cellular networks, but this is not yet implemented 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 for example 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-RPC¹²), 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, for example, the Mobility Provider. In both PANs involved, the PNG functionality is distributed over the mobile phone and the laptop or PDA.

DISCUSSION

For business and personal use, many people would like to be able to access any electronic device that resides in their personal domain. Currently, 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 readily available at present. A Personal Network should provide the technology needed to interconnect the various private networks of a single user seamlessly, at any time and in 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 healthcare sector and particularly for emergency services. We have shown some of this added value with a demonstrator based on an emergency scenario where the emergency team 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 for 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 task, but has strong industrial potential, since it would enable a whole new class of applications.

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