



## IST-2000-25153

### Deliverable D3

### Specification and needs of the Clinical Testbeds

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**Abstract:** This deliverable describes the three clinical testbed demonstrator sites of the 6WINIT Project. These sites provide a means of validating the technical 6WINIT solutions and of the potential benefits of using wireless IPv6 services. In this deliverable each site has provided a description of the healthcare setting, the clinical challenges to be addressed and the clinical applications that will be used to profile 6WINIT. The deliverable also includes an initial outline view of the technical strategy for implementing the 6WINIT solutions and considers any relevant networking and security issues.

**Keywords:** Health informatics, Computerised medical records, Distributed systems, IPv6/IPv4 Transition, IP Security, Mobile IPv6

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## Executive Summary

The 6WINIT project aims to validate the introduction of the new mobile wireless internet in Europe.

Three clinical sites have been chosen to represent the early marketing targets within the healthcare domain as demonstrator sites:

- John Paul II Hospital, Krakow, Poland
- Eberhard-Karls University, Tübingen, Germany
- Whittington Hospital, London, UK

These sites were chosen partly because they have a longstanding relationship with three of the technical partners in the project (UCL, RUS and UMM respectively), and partly because the applications they proposed were useful tests of the type of services which could be provided well in the mobile environment.

Each site has now confirmed the clinical applications that are best suited to the technology, of interest clinically, and feasible to deploy within 6WINIT. They have begun to identify the changes needed to deliver these on the IPv6 mobile network. They have also identified some aspects of the technical approach and network infrastructure that are likely be similar between the sites.

This deliverable describes the clinical demonstrations that will be mounted at each of the three sites. It includes a description of each demonstration scenario, the clinical applications that will be demonstrated, the clinical setting in which they will be used, the requirements for and the anticipated benefits of the 6WINIT solutions at each site. A common framework of headings has been used for all three site descriptions.

The sites have each provided a description of the legacy-computing environment at each location and outlined the requirements for adapting it during the project to meet the needs of each IPv6 demonstration, including any relevant security issues.

This Deliverable is intended as a means of sharing information about the three sites with the technical partners in the 6WINIT Consortium and with other relevant projects in the IST programme.

All of the sites are now starting to develop or refine the clinical applications to make them suitable as demonstrators, and to establish the necessary network and server infrastructure to run the IPv6 services. A description of that work in progress and of the definitive intended technical architecture at each site will be the focus of Deliverable 7, due for publication in December 2001.

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# 1 JOHN PAUL II HOSPITAL CLINICAL SITE

## 1.1 Description of the Healthcare Site

### JOHN PAUL II HOSPITAL, KRAKOW, POLAND

- Employs 170 physicians including 4 professors, 5 associate professors, 25 physicians with PhD, 435 nurses, 93 technicians, 26 dieticians and 21 pharmacists; all staff 1500 persons.
- Admits annually over 11 500 patients, and provides services to over 90 000 patients
- Provides annually 60 000 ambulatory consultations
- Performs annually about 2 000 open-heart operations and about 60 heart transplants
- Performs annually 1 000 thoracic procedures and operations
- Has 15 day and day-and-night wards including 4 clinical wards and 40 specialised laboratories
- Performs annually about 40 000 imaging examinations, functional examinations and endoscopies
- Performs annually about 7 000 procedures in intervention cardiology
- Implants annually over 500 cardiac pacemakers
- Performs annually almost 800 000 laboratory tests

Recently introduced programmes aim to improve access to advanced diagnostic evaluation and therapeutic procedures in the entire 24 hours, and to enhance the quality of medical services.

The programmes are as follows:

- Day and night intervention in cardiology and cardiac surgery
- Treatment of acute chest diseases
- Emergency medicine
- Early detection of public health diseases using unique diagnostic equipment
- Prophylactics of cardiovascular and respiratory diseases
- Prophylactic vaccination
- Medical care for business companies
- Information technology in health care in co-operation with the consortium - Kraków Centre of Telemedicine and Preventive Medicine
- Continuing hospital care based upon telemedicine
- Advances in medical technology
- Monitoring of the quality of medical services and study of patient satisfaction

### MEDICAL UNITS IN THE JOHN PAUL II HOSPITAL

Medical units
I Ward of Lung Diseases
II Ward of Lung Diseases
III Ward of Lung Diseases
IV Ward of Lung Diseases
Ward of Thoracic Surgery

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Ward/Department of Cardiovascular Surgery
Ward/Department of Cardiac and Vascular Diseases
Ward/Department of Coronary Disease
Ward/Department of Electrocardiology
Ward of Children's Infectious Diseases
Ward of Neuroinfections
Ward of Viral Hepatitis
Department of Haemodynamics and Angiocardiology
Centre for Diagnosis and Rehabilitation of Heart and Lung Diseases
Central Clinical and Research Laboratory
Ambulatory Consulting Unit for Cardiac Patients
Ambulatory Consulting Unit for Patients with Lung Diseases
Ambulatory Consulting Unit for Children's Diseases
Provincial Consulting Unit for Patients with Viral Hepatitis
Rehabilitation Unit
Provincial Centre of Oxygen Home Therapy

#### CARDIOLOGY AND CARDIAC SURGERY

- Department of Cardiovascular Surgery
- Department of Cardiac and Vascular Diseases
- Department of Coronary Disease
- Department of Electrocardiology
- Department of Haemodynamics and Angiography
- Ambulatory Consulting Unit for Cardiac Patients

Teams of highly qualified cardiologists and cardiac surgeons in co-operation with other specialists diagnose and treat coronary artery disease, arterial hypertension, acquired and congenital defects of the heart and vessels, cardiovascular complications in pregnancy.

Unique methods are used to treat myocardial infarction, myocarditis and cardiac arrhythmias. Interventional cardiology includes arteriography, aortography, coronary arteriography, permanent external pacing, pacemaker implantation, coronary and peripheral artery angioplasty with stent implantation, laser myocardial revascularisation, myocardial biopsy, complete invasive electrophysiological studies. Hospital performs operations for aneurysms, coronary and peripheral bypass grafting and cardiac operations using minimally invasive and endoscopic techniques. The hospital performs heart transplantation and provides continuing care for patients with heart transplants.

#### INFECTIOUS DISEASES

- Ward of Neuroinfections
- Ward of Children's Infectious Diseases
- Ambulatory Consulting Unit for Children
- Ward of Viral Hepatitis
- Regional Consulting Unit for Patients with Viral Hepatitis

Adults are diagnosed and treated for viral hepatitis and other acute or chronic liver diseases. Paediatricians diagnose and treat acute and chronic diseases of the liver, biliary tracts,

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gastrointestinal tract of infectious aetiology, infections of the urinary tract and generalised infections, infectious diseases of childhood and parasitic infections.

The hospital also provides treatment for encephalomyelitis, meningomyelitis, and infections of the peripheral nervous system, neuroinfective complications of infectious diseases, post-vaccine complications, convulsions of unknown aetiology. Hospital also gives advice on prophylactic vaccination. In co-operation with kinesitherapists we carry out comprehensive rehabilitation of children.

#### DIAGNOSTIC SECTOR

- Centre for Diagnosis and Rehabilitation of Heart and Lung Diseases
- Central Clinical and Research Laboratory

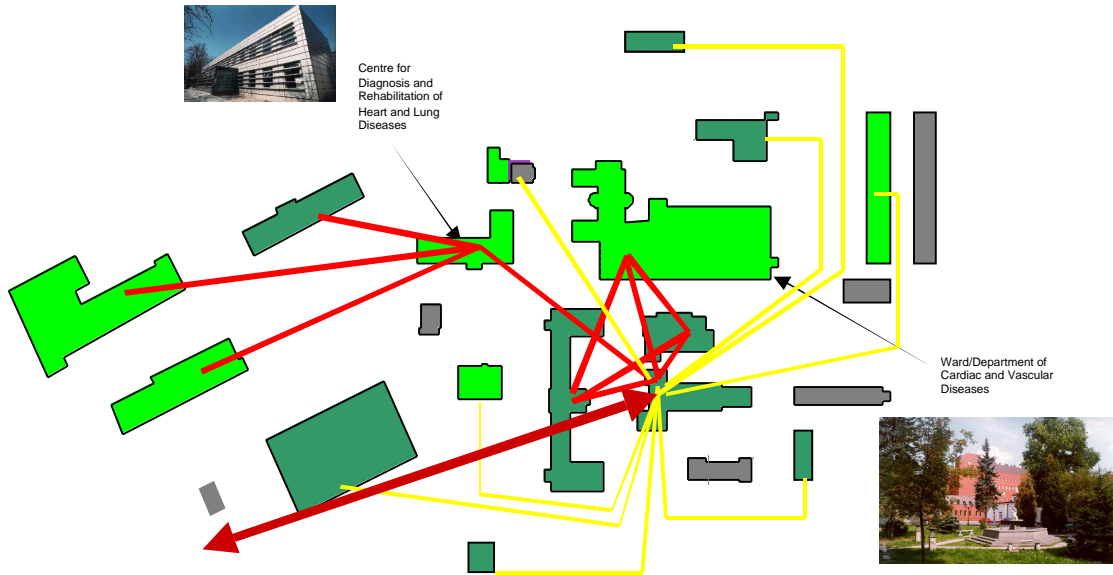
Diagnostic Centre offers a full day-and-night panel of analytical, biochemical, haematological, serological and microbiological tests. Hospital uses molecular biology techniques and flow cytometry. Laboratory tests are performed for in- and outpatients. Teams of cardiologists and radiologists perform cardiac and vascular examinations, including intracoronary ultrasonography.

Reliable imaging techniques in the digital system are used for diagnosis. Diagnostic Centre performs examinations of the whole body using the newest, unique on the European scale, devices: nuclear magnetic resonance, spiral computerised tomography, scintigraphy and 3D ultrasonography. Pulmonologists perform endoscopy of the bronchial tree and functional examinations of the lungs using body plethysmography. Hospital offer a “one day” comprehensive programme of diagnosis.

### 1.1.1 Location

The picture introduced below represents physical relationship between main buildings placed on the JPII Hospital area. Two units that are involved in 6WINIT, i.e. Centre for Diagnosis and Rehabilitation of Heart and Lung Diseases and Ward/Department of Cardiac and Vascular Diseases are pointed to by arrows and provided with the photos of the buildings that hosts them. The distance between two buildings is about 50m. They are connected by hospital network (622 Mb/s - backbone).

ACC Cyfronet, the supercomputer and networking centre is situated about 3 km away from JPII hospital. The third party, Department of Computer Science, is located closer to ACC Cyfronet — about 1 km. On the following picture pink circle represents JPII hospital, the blue one ACC Cyfronet and the red one Dept. of Computer Science.



All the partners are connected to each other with fast ATM connections operating on fibre-optic links. The exact network infrastructure that connects those three sites together will be described more precisely later in this document.



### 1.1.2 Parties

6WINIT solutions developed at the demonstrator site refer to the three main groups of people.

The first group involves specialist doctors. They will take advantage of NetRAAD application that is used to store and present medical data. One of their roles in the patient care process is to evaluate the results of patients' examinations. With 6WINIT solutions they will be able to offer their assistance from any place all over the world, especially from their homes, at any time. 6WINIT advances will provide them with an appropriate level of quality of service and security mechanisms necessary for reliable diagnostics and treatment. It is planned that during the demonstrator phase about 10 doctor specialists will be using 6WINIT conveniences.

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The second group of people dedicated to the evaluation of 6WINIT offerings is general practitioners. GPs will be able to make an appointment on behalf of their patients with a doctor specialist or for a particular specialist examination. They will be given the possibility of consulting the results of examinations, too. 6WINIT techniques enlarge accessibility of these operations making GPs possible to perform these tasks even from the patient's home. Again, IPv6 and new wireless techniques will ensure suitable security and quality of service mechanisms obligatory in medical care affairs. All of these activities will be accessible through *Internet System for Offering and Reservation Medical Services* provided by the Department of Computer Science.

It is assumed that several GPs will be involved in testing 6WINIT solutions.

At last the patients will consume 6WINIT solutions. Indirectly, all the improvements that 6WINIT offers to specialist doctors and general practitioners obviously engage the patients. They will be provided with easy access to medical booking services through network applications. At the moment, it is hard to state how many patients will be engaged in the solutions. Some work will be undertaken to popularise them among patients.

## **1.2 Description of the Clinical Setting**

### **1.2.1 Introduction**

In the 6WINIT Project from the John Paul II Hospital side will be involved the group of high trained medical staff from cardiac surgery and diagnostic centre. They covered full medical specialities needed for patient services in pilot locations. They are also trained for clinical computer system use in different hospital locations. They have got same experience with mobile computers and wireless communications.

### **1.2.2 Health Information**

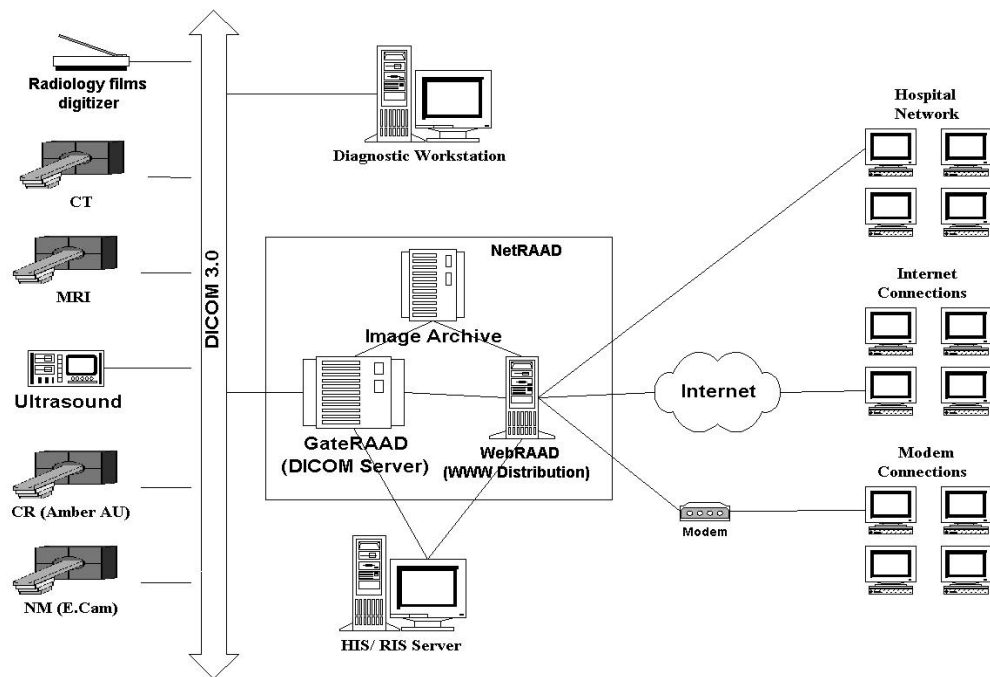
In the John Paul II Hospital, all medical and non-medical information is stored in paper form according to legal regulations. Even if there are computer systems at the same location all information should be printed out and signed by the responsible physicians.

Medical documentation is transferred from hospital wards after one or two days after patient discharge to the central archive where it is stored. Central Medical Archive is fully computerised, so it is easy to find any documentation if it is needed. For education reason medical students could have access to the archive though the computer system.

### **1.2.3 Clinical Applications**

NetRAAD (Network Radiology Acquisition, Access and Distribution) makes the required information available on demand and independent of location. It is a PACS imaging system compliant with the DICOM standard, which can be used by radiologists as well by physicians. NetRAAD can store any data recordable in the binary form. These can be static images (e.g. x-rays, CT), motion pictures (e.g. movies presenting the laparoscopic operation), sounds (e.g. voice comments to the examination or image) etc.





The population of the NetRAAD repository is handled by scanning film, direct connection to diagnostic modalities or sending data from the client workstation directly into NetRAAD storage, which provides data to clients with access to the repository server via the hospital network (intranet, internet or modem). Client access is via a platform independent (Windows 95/98/NT, Apple, X-Windows) web browser (Netscape Navigator, Microsoft Internet Explorer). A registered user working with NetRAAD may search for and display patient examination and image data. All images are displayed in separate windows to allow for viewing multiple images and patient data simultaneously. Viewing of multiple images allows for referencing historical information on a condition and comparison of similar conditions in other patients. NetRAAD provides easy mechanisms to use external medical image browsers (Osiris, DICOM Eye etc.) Access to data within a repository is controlled by a set of access rights, which are assigned to each piece of data. A special student user group is defined which allows access to medical information for educational purposes, but restricts access to patient personal information. NetRAAD also supports the SSL protocol in order to provide secure data transmission between the server and users' workstations. This system can save time providing easy to use teleconference consultations. Images and markups are displayed to conference participants simultaneously. Conference participants can communicate via text or voice. The system allows easy integration with existing hospital information systems (HIS, RIS). NetRAAD supports e.g. HL7 communication standard. The NetRAAD server utilises any SQL compliant relational database. Commercial off-the-shelf software utilised for implementation minimises the cost of implementation, training and administration and maximises performance, scalability, stability and upgradability.

The ISOReMeS authorization is based on LDAP (Lightweight Directory Access Protocol) and on Java ACL. This solution allows control to access to each piece of data in the system, which in combination with a centralized user authorization and authentication management makes even very complicated rights definition possible, all through a user friendly interface based on any Internet browser. As the system is not yet implemented entirely it is difficult to consider the weaknesses. We can state that security is the one of the strongest points of the system.

#### 1.2.4 Other Information Services

The hospital network allows for registered users access to the Internet and electronic mail applications. It is also possible to access MEDLINE databases and the Hospital Intranet with organisational information (phone books, pharmacy information, laboratory tests). There is also some more specific software (MAC computers - Nuclear Medicine) for diagnostic reasons and clinical Siemens and ACUSON workstations. Most of the computers also have MS Office software.

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## 1.3 Description of the Technical Setting

### 1.3.1 Overview

John Paul II Hospital uses INFO-MEDICA, a complex software solution from ComputerLand company. It is client-server architecture application based on an Oracle database for use on a Windows platform. It consists in many integrated modules that collaborate on shared data in one environment – Hospital Information System.

Every hospital wards have access to the system through very fast computer network (ATM). Some of the wards can do teletransmission from operation theatres to conference rooms and even to other hospitals – by MAN or WAN. The other main software it is:

- Siemens - ACOM-Net
- Siemens - ACOM-Web
- Siemens – Cathcor
- UHC- NetRaad
- Other DICOM 3 interconnected sub systems
- Administration software

The hospital uses a few operating systems like:

- WINDOWS NT SERVER
- NOVELL NetWare 5.1/4.11
- Linux 2.2/2.4
- SUN OS 5.6

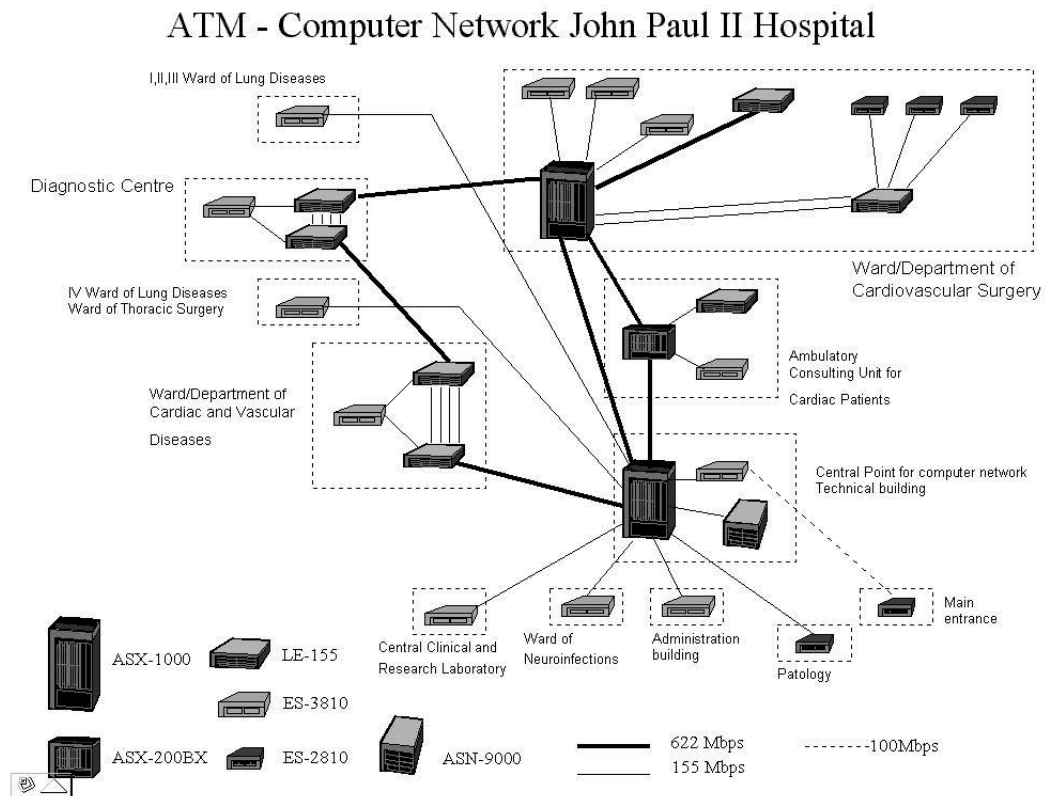
All software is used very extensively by approximately 600 trained users.

In the Hospital there is a complete administrative system implemented. Few medical applications are in the stage of implementation. Until now, a radiology system NetRaad based on WEB technologies has been implemented and another solution from Siemens –Acom-WEB is being tested.

### 1.3.2 Networking

During 1999 a modern ATM Network, allowing transfers of 622 MB per second, was installed in the Hospital. Network active elements are based on FORE (present Marconi) switches: backbone 2 x ASX 1000, 2 x ASX 200 BX. In the buildings is Cat 5 structured cabling (LUCENT). The main reason for constructing such a big infrastructure was to run software from companies like Siemens (Acom-Net), Net-Raad and many others. For security reason critical network segments have full redundancy. The hospital is connected to MAN by fibre optic cable and ATM 155 Mb/s link. All buildings are interconnected and most of station has got Internet access.

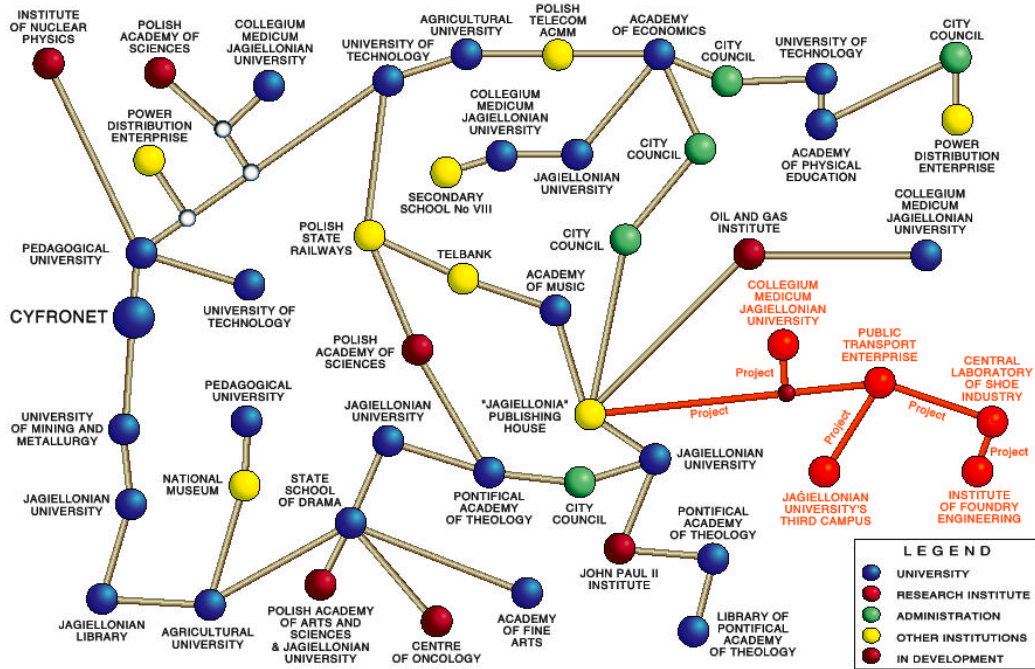
The hospital consists of 12 buildings in the area of 1,5 square kilometres in one campus and all the departments use common INTRANET system. All networked devices are managed by a HP OpenView network node manager. Network is prepared to connect 2000 devices including computer station, medical equipment and other electronic staff. There are 7 IP routed VLANs for different purpose.



The hospital internal network is provided with direct connection to Kracow MAN.

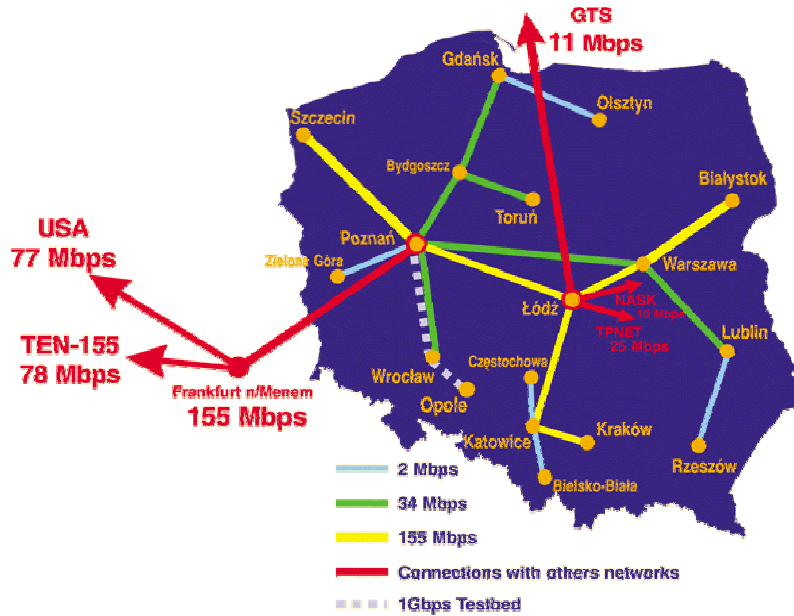
CYFRONET, appointed by the State Committee for Scientific Research (KBN) as the leading unit for the Kracow Metropolitan Area Network and officially authorised by the Ministry of Telecommunications for the network activities, functions as the main network node in southern Poland. The Kracow MAN provides and supports access to interurban and international communications over three wide area networks: high-speed POL-34 (155 Mb/s) with direct connection to the European TEN-155 (155 Mb/s), Polpak-T, and NASK. CYFRONET has designed a fibre-optic infrastructure within the city of Kracow. It is several dozen kilometres in length and links almost all universities and research institutes as well as the state and local administration units, schools, and commercial organisations. New fibre-optic connections are planned and in development. Moreover there are some dozen of leased lines in use. Dial-up connections are also enabled for network users. CYFRONET is involved in establishing, developing, and maintaining the computer networks in southern Poland (now, in the cities of Zakopane and Tarnów).

The modern telecommunications equipment, mainly manufactured by Cisco Systems, together with two HP network servers (HP 9000 N4000 – two PA-8600 processors, 4 GB of operating memory, 584 GB of disk space and HP 9000/800 K570 – two PA-8200 processors, 1 GB of operating memory, 56 GB of disk space) and a few workstations of HP and SUN have been installed. CYFRONET performs a variety of Internet services like e-mail, telnet, ftp, news, www, and W3cache. The Centre is also active in developing virtual networks and maintaining regional domains. Introducing and developing the new multimedia services is very important for Kracow MAN nowadays. The Centre has already succeeded in realisation of some remote video transmissions and teleconferences. The Kracow MAN is also the base for the VTLS integrated system of library services (the academic Kracow Library Consortium).



**Cracow MAN Fiber-Optic Infrastructure (January 2001)**

The Kracow MAN connection to the Polish and world resources through the Polish backbone network POL-34 is presented below:



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### 1.3.3 Security

#### National/regional regulations

Polish Law concerning this problem precisely defines procedures that should be carried out to protect personal data (including name, address and all medical information) from being accessed by unauthorised persons. Each organisation that processes such information must:

- have written permission from each person whose data is being processed,
- designate a person responsible for security policy and data protection,
- not use data for other purposes than specified.

#### Local security policies

There is a Security Officer in the IT Department responsible for electronic data security policy in the Hospital. He is to protect all computer hospital systems from unauthorised access. The general rule is “what is not permitted is not accessible”, so accounts in the systems are created only for persons that really have to be able to access information.

#### Technical infrastructure

From the outside Hospital Computer Network is protected by firewall software running on SUN server with SOLSTICE Firewall-1.

#### Access control

Each system has its own users and groups database with access permission defined. As there are only few such systems, the administration is not very complicated. The problem is that some of these systems do not implement the access control required – e.g. they can only define access for a given patient data with no distinction which particular medical data can be accessed.

#### User authentication

User authentication is currently based on a standard login/password mechanism. It is performed for each system/host separately without any synchronisation between them. We are going to implement global authorisation mechanisms based on LDAP and chip-cards in the future.

## 1.4 Technical Overview of the Demonstrator

### 1.4.1 Computing Environment

One of the applications used for 6WINIT Project system is NetRAAD (clinical system). Network equipment in two buildings will be designated for purpose of the 6WINIT.

A Compaq computer based on Intel PC platform will be used as a main server in NETRAAD system. The appropriate machine parameters are chosen to achieve high performance and effective query processing. The system contains Intel Pentium II 266 MHz CPU, 64 MB RAM memory and 3GB HDD storage capacity.

The HTTP protocol version supporting IPv6 will be run on the Linux operating system, thus it would be necessary to allocate another machine to support JukeBox storage media manager, because the Linux system lacks JukeBox drivers.



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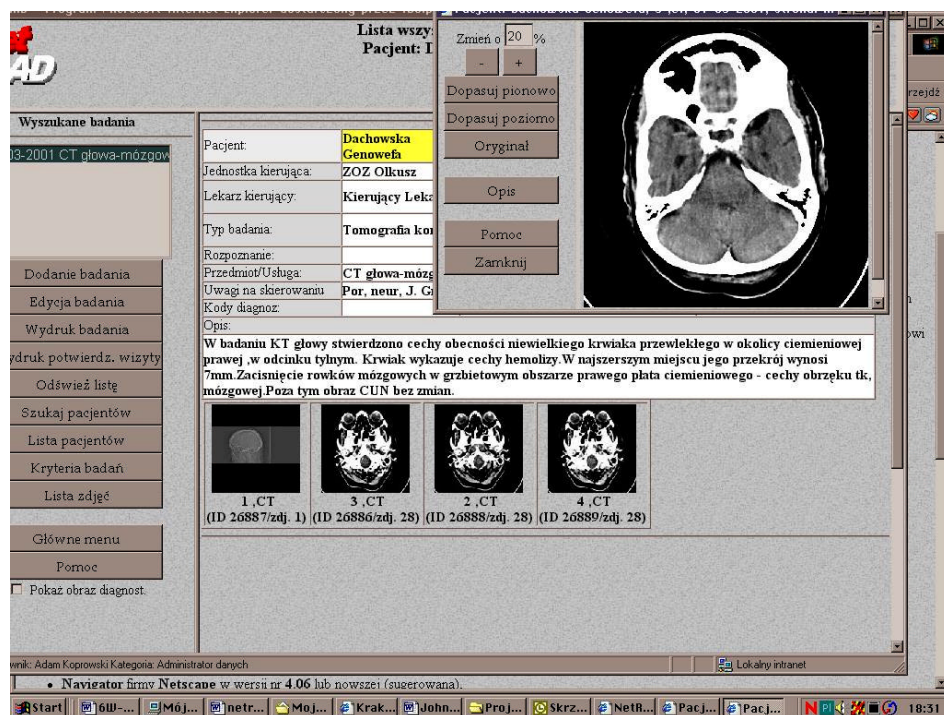
There are 15 PC workstations dedicated for NetRAAD as client machines with the following configuration:

- Celeron 466 Mhz, 64 MB RAM, 5 GB HDD
- 15" Monitor, Network Card Ethernet - 100 Mb/s
- Operating system WINDOWS 9x/NT.
- INTEL PENTIUM II 266 Mhz, 128 MB RAM, 10 GB HDD
- 15" Monitor, Network Card Ethernet - 100 Mb/s
- Operating system RedHat Linux – 6WINIT – server

The ISOReMeS system is currently developed on Sun Ultra Enterprise 3000 equipped with 3 processors 400 MHz and 512 MB RAM. The database used by the system is placed on HP-9000/899/K570 with HP-UX OS. This computer is armed with 128 processors, 40 GB RAM, and 200 GB hard discs. In the target configuration the latter computer will not only host the database but will be populated with the system as well.

### 1.4.2 Healthcare Information and Communication

To the demonstration will be involved medical data from NetRaad application. This software is dedicated for clinician who wants to look into multimedia medical records. Below example screenshot for the application



A registered user working with **NetRAAD** may search for and display patient examination and image data. All images are displayed in separate windows to allow for viewing multiple images and patient data simultaneously. Viewing of multiple images allows for referencing historical information on a condition and comparison of similar conditions in other patients. NetRaad Software is used by all medical staff for diagnostic reasons especially for thoraco surgery and heart surgery.

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The second system we will use in demonstrations will be ISOReMeS. This very sophisticated system using EJB as its core is based on the Sun iPlanet Application Server. It combines characteristic of a publicly available Internet portal and an application which is able to serve confidential medical information for authorized users. The information available will include health care in generally, examinations and operations offered by the hospital and other hospital specific information and advertisements.

E-registration will be also possible and it will be addressed to GPs and to patients individually. The system has automatic notification support; patients will be informed about important events concerning them (e.g. availability of examination results, examinations cancelled due to equipment breakdown or doctor's illness) in the way they prefer (e.g. email, SMS). Hospital staff, administration, management and technicians who take care of equipment are the other users of this system.

The screenshot displays a web application interface for medical services. At the top, a blue header reads 'System oferowania i rezerwacji usług medycznych'. Below this, there are three main sections: a search bar labeled 'Szukaj Badania', a 'Programy Badań' section, and a 'Badania' section. The 'Programy Badań' section contains a list of programs, with the first one, 'Edukacja zdrowotna oraz działania profilaktyczne w zakresie chorób układu krążenia', selected. The 'Badania' section provides detailed information for this program, including its name, price (0.0 PLN), and a description of the program's goals and target audience.

Nowadays the whole system is implemented basing on IPv4 and wired network. We are planning to move it on IPv6 and allow access from mobile and wireless terminals from both inside and outside of the Hospital.

## 1.5 Technical Challenges to be Addressed

Jobs related to creating an IPv6 network began with negotiations with the organisation that is responsible for assigning addresses. In Poland, ICM in Warsaw is such an organisation. For our purposes, the following IPv6 addresses pool has been assigned: 3ffe:8010:57::/48. These addresses are test addresses and after a certain period RIPE would be taken away. Thanks to ACC Cyfronet efforts and their application to European RIPE, the IPv6 target addresses have been granted. These addresses further will replace tested addresses that are used now. From the granted



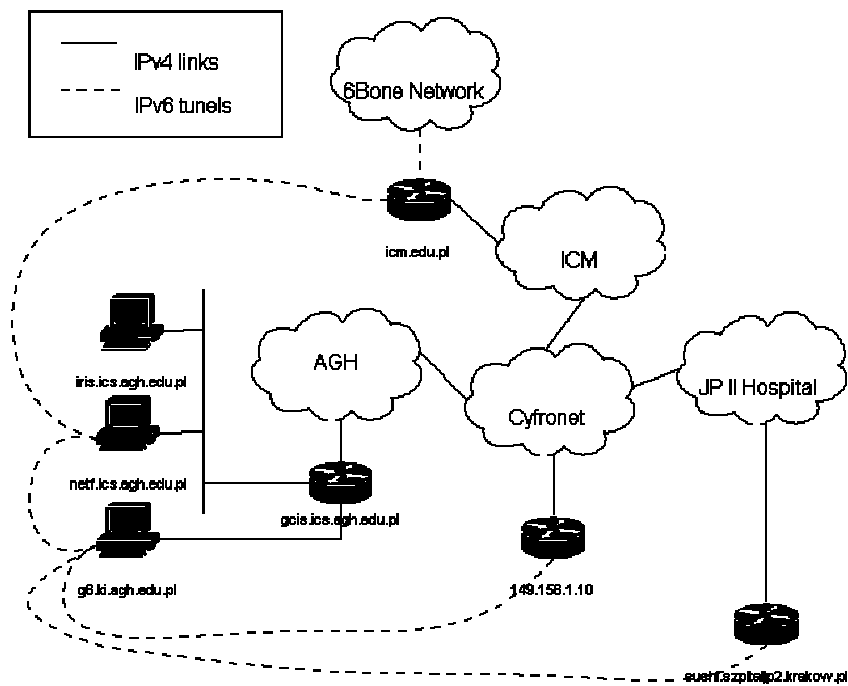
address pool some of them have been assigned for local network (149.156.97.0/24 in IPv4 addressing).

In order to get access to 6BONE, it was necessary to set up a tunnelling connection for IPv6 traffic between ICM and DSRG. The necessity of tunnelling IPv6 traffic results from the fact that none of the routers located between ICM and DSRG supports IPv6 routing. The tunnel allows forwarding IPv6 traffic to ICM and hence to whole Poland 6BONE network. Moreover, because of existing IPv6 connections between ICM and world's 6BONE network, there are IPv6 links from DSRG to world's 6BONE network. The network in UMM bounds is also based on tunnels. Currently there are connections between IPv6 networks in UMM DSRG, Cyfronet and John Paul II Hospital.

None of the CISCO hardware routers used in standard service support IPv6. On two routers (2501, 2514) an experimental IOS v. 12.2 software supporting IPv6 routing has been installed.

Future work includes the systematisation of the DNS configuration for IPv6 hosts; registration of the subdomain containing IPv6 hosts in agh.edu.pl domain; and registration of Reverse-DNS in ICM.

We also plan to set up dynamic BGP4+ routing between ICM and DSRG (testing purposes) with a redundant BGP4+ tunnel between DSRG and IPv6 network in Szczecin



The configuration depicted above conveys the present state of IPv6 network meant for holding tests of IPv6 applications. The described configuration does not make use of all available features of IPv6 implementation for the reason of encapsulating IPv6 traffic into IPv4 traffic.

The configuration is based on tunnels. The target will be replaced with topology with separate VLAN network, thus it would not be necessary to encapsulate IPv6 traffic into IPv4. It would be possible also to use all features of IPv6 implementation such as QoS or MobileIP.

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Concerning clinical applications, we are planning to adapt two of them, that is NetRAAD (the system for storing and accessing multimedia patient records) and *Internet System for Offering and Reservation Medical Services (ISOReMeS)*. To complete the task, the existing hardware and software architecture has to be adapted to IPv6 requirements. In the case of NetRAAD, the work progress is such that the application will be accessible for testing purposes over IPv6 within a few weeks. ISOReMeS is still implemented thus the adaptation to IPv6 is tightly integrated with an implementation process. Considering the fact that ISOReMeS core components are based on SUN's Java, the full IPv6 integration will be possible only when SUN issues an IPv6 compatible Java virtual machine.

In a current development stage ISOReMeS uses terrestrial connections and has been designed particularly for this kind of connection infrastructure and for end-user devices such as PC computers. Finally, the system is targeted to be adapted into wireless environments and other kinds of end-user devices. In the second stage the system will be ported onto a WLAN (IEEE 802.11b) infrastructure. This modification impacts on the lower layer protocols with which the clinical application doesn't directly interact. End-user devices applicable in such an environment are e.g. palmtops, so only little modifications might be required. The next development stage is associated with fitting the system into GPRS and UMTS. Such a prerequisite require much more work referred to a vast end-user devices diversity used with these communication standards. The system will have to be able to adjust the way the information stored by the system will be presented to requirements established by end-user devices characteristics.

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## 2 UNIVERSITÄTSKLINIKUM TÜBINGEN CLINICAL SITE

### 2.1 Guardian Angel System – GANS

Deploying their "Guardian-Angel-System" - GANS - in 6WINIT UKT-RUS want to show the transmission of potentially high-bandwidth multimedia and vital data from an ambulance car to a hospital. In the hospital is a receiving centre, where experienced doctors will immediately help the colleague outside to manage the problems of the emergency patient.

In the project this patient will be a modern realistic patient simulator system.

Although not part of 6WINIT, in the project UKT will also explore possible interworking scenarios between the standard information system of UKT and GANS/6WINIT.

Exploiting also results from other 6WINIT workpackages (WP5 and WP6) and possibly RUS' IST project MobyDick, UKT-RUS will develop a series of scenarios of increasing complexity with respect to networking.

### 2.2 Description of the UKT Healthcare Site

#### 2.2.1 Overview

The Universitaetsklinikum Tuebingen (UKT) is a big university hospital with 17 faculties and 38 departments. All aspects of medical care are provided. The hospital has 1.500 beds. We treat 60.000 patients on the wards and 220.000 patients in an ambulant care setting. With 1000 scientific employees the medical faculty is the biggest of the associated Eberhard-Karls-University Tuebingen. There are about 2.800 medical students.

#### 2.2.2 Location

There are two groups of buildings. One in the city and one on a little hill above the city. The main hospital is on the hill, including the patient-simulator-centre (TuPASS) and the intensive care units (ICU). This will also be the site for the GANS centre to provide assistance to the ambulance. The other buildings will not be involved in the 6WINIT application.

#### 2.2.3 Parties

The 6WINIT application will be used by the team providing acute management help to the colleague in the ambulance. The other user will be in the ambulance car outside the hospital. There could be several ambulance vehicles equipped with the mobile system.

In the development of the project, the remote ambulance might at first be located "next door" in the hospital, until the applications for mobile transmission are set up.

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## 2.3 Clinical Setting - Demonstrating the Benefit

### 2.3.1 Clinical or Educational Services

Through the application of 6WINIT Live-telementoring solution (GANS) the emergency physician in the ambulance car will never be alone. Until now, the emergency physician outside is one of the loneliest fighters in healthcare. If he has a problem he can't solve, or if he is unsure about decisions or measures, no one will ever help him. Doctors working alone in the ambulant care setting are at least able to call the ambulance if they have trouble. But the ambulance car doctor is always the last in the row. This is even worse concerning the fact that a lot of ambulance doctors are quite junior. The 6WINIT solution will be a little revolution for the pre-clinical care setting. Finally it will be possible for the doctor to call an experienced colleague at the hospital and discuss the management of his patients problems.

Of course this will need some adaptation work for the involved personnel.

The proof-of-concept will be carried out in multiple study sessions with emergency physicians using the system in its various versions, while treating patients with many different life-threatening problems (patient simulator-system of UKT). There will also be studies to look at work flows by associated work psychologists.

## 2.4 Clinical and Organisational Acceptance

As the application is new to the emergency system, there will be a great need to explain the system to the users (pre-clinical emergency physicians and the paramedics). Some will not like the system because they never had it and "of course" never needed it. But most of the people will embrace such a system, because it provides a high-fidelity back-up for them during critical situations. On the other hand should the system be self-explanatory and fail-safe in the usage. If these requirements are met, there shouldn't be a great problem to implement it in the real world ambulances. As the emergency doctors and paramedics are used to handle many different devices, it should be easy for them to use the 6WINIT-GANS-System.

In addition the German Air Rescue (DRF) wants to implement the system in its aeroplanes and helicopters.

## 2.5 Description of the Technical Setting

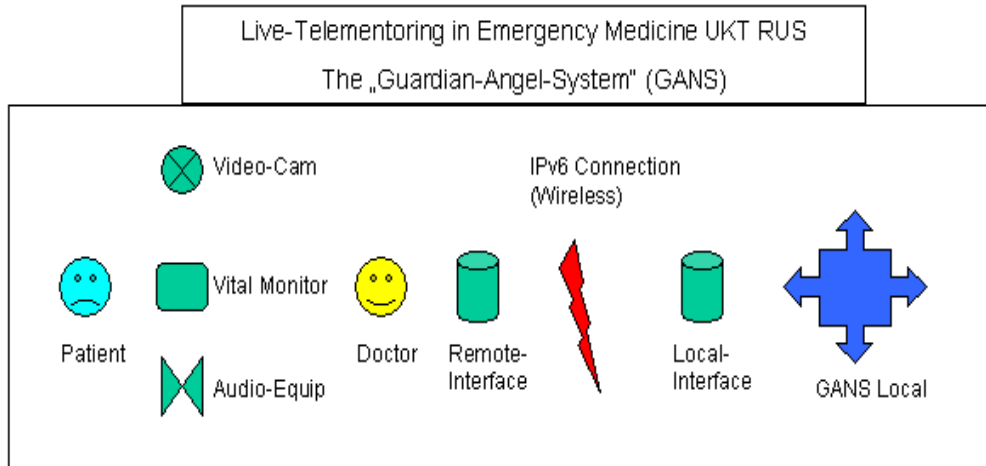
Within the timeframe of 6WINIT, there will be four generic versions of the set up of the GANS application. These four versions will be implemented following the evolution of the network capabilities in 6WINIT. The versions are described below.

### 2.5.1 General Application:

The patient is connected to a vital signs monitor (ECG, blood pressure, oxygen saturation etc.). There will be at least one video camera to give pictures of the patient treatment scenario. The audio signals will be recorded by at least one microphone. Also the picture and voice of the remote doctor may be involved. These data streams are connected to the remote interface unit, which will perform all necessary transformations to the IPv6-protocol. Then comes the transmission process which is different from version to version (see below). At the other end is

the local interface unit, which transforms the received IPv6 into data streams to make them visible to the local doctor in the GANS-Centre. Of course the transmission can be bidirectional.

For the whole project the patient will always be the realistic patient-simulator of UKT.



**Figure 1: The 6WINIT UKT-RUS Guardian Angel System – GANS**

The following Figure 2 below is showing the GANS elements in a local scenario:

- Patient Simulator: pictures in the left upper and lower corner
- Life sign monitor for vital data: right upper corner in the picture in the left lower corner
- Experts - locally in the control room - are shown in the right lower picture

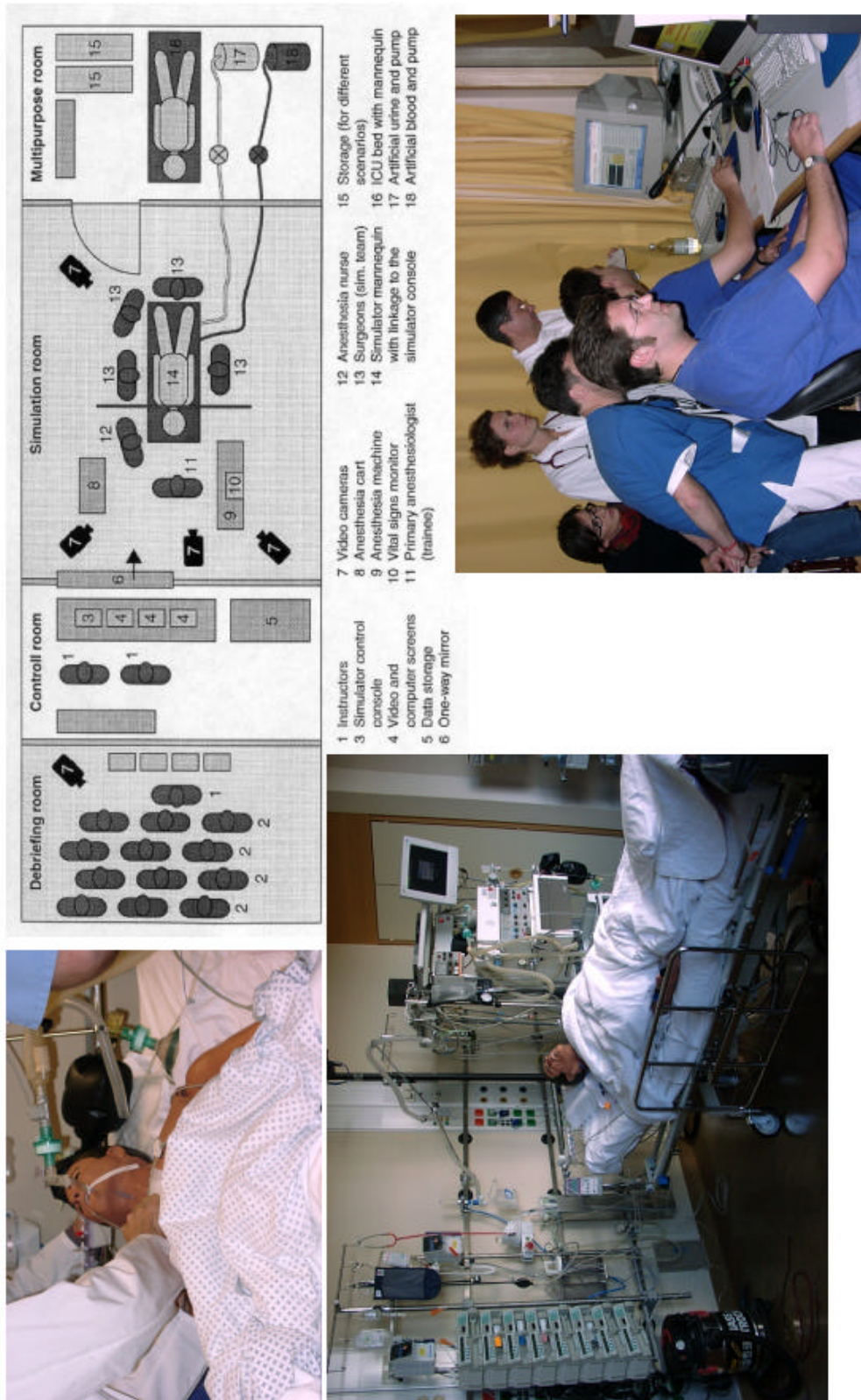


Figure 2: The 6WINIT UKT local scenario

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In the following, four generic versions of 6WINIT GANS are described in reverse order of implementation:

Final Version 4:

In the final stage of the project. The car will be driving around in an area where there will be wireless network support (GPRS or even UMTS). The GANS-Centre will be located at the intensive care unit (ICU) at UKT. The patient will experience serious complications, which will be tried to resolve via live-telementoring from the GANS-Centre in the hospital.

Version 3:

- a) The patient will be in the ambulance car, but the car will not be moving. The transmission will be wireless. This will omit the problems of the seamless moving wireless connection.
- b) The patient will be in the ambulance car, but the car will not be moving. The transmission will be hard wired. This version will demonstrate the management of the data streams and the handling of the system under the restricted room possibilities in the ambulance car setting. The main focus will be on the remote data connections (example: Bluetooth)

Version 2:

The patient will be in the simulator centre at UKT. The GANS Centre will be reached by wired IP. The GANS can be located at UKT or at RUS. This version will demonstrate the possibilities of the remote management in general.

Version 1:

The patient will be in the simulator centre at UKT. The GANS will be next door. The connections could be hardwired or IP. This version is a prototype demonstrator to find out which data streams are needed in which quality to provide an effective live-telementoring for remote doctors in trouble. The types of data streams (from a medical perspective) will be defined in this version.

## 2.5.2 Networking

At present RUS and UKT networks are "standard parts" of their respective "home networks" which in turn are eventually connected via DFN-G-WiN to GEANT. This possibly will allow the inclusion of other 6WINIT partners into trials and demonstrations.

RUS so far has a limited deployment of a 802.11b WLAN. It is preparing its connection to the 6Bone, and is preparing the usage of the GPRS service of Deutsche Telekom AG (DTAG). RUS, as part of IST MobyDick, is closely following the evolution of "All-IP over UMTS"; there may be a possibility to test the 6WINIT/GANS scenario in a UMTS TDD mode installation in France or Germany.

UKT and RUS should/will evolve/speed up their 802.11b WLAN and IPv6 (6Bone) infrastructures as soon as possible.

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For 6WINIT it would be sufficient for UKT to have an operational 802.11b WLAN connected to the UKT intra/Internet; the ambulance car could operate in DTAG GPRS cells. On arriving at the hospital, the GPRS connection would possibly change into a 802.11b WLAN one.

### 2.5.3 Security

At present at its "edges" RUS and UKT are using standard firewall technologies. As we are using only a simulated patient, in 6WINIT this type of scrutiny measure will be probably sufficient. Nevertheless, preparing for real deployment on GANS, UKT will expand this chapter of this working document possibly to be conformant with existing or future security policies of its organisation.

## 2.6 Technical Overview of the Demonstrator

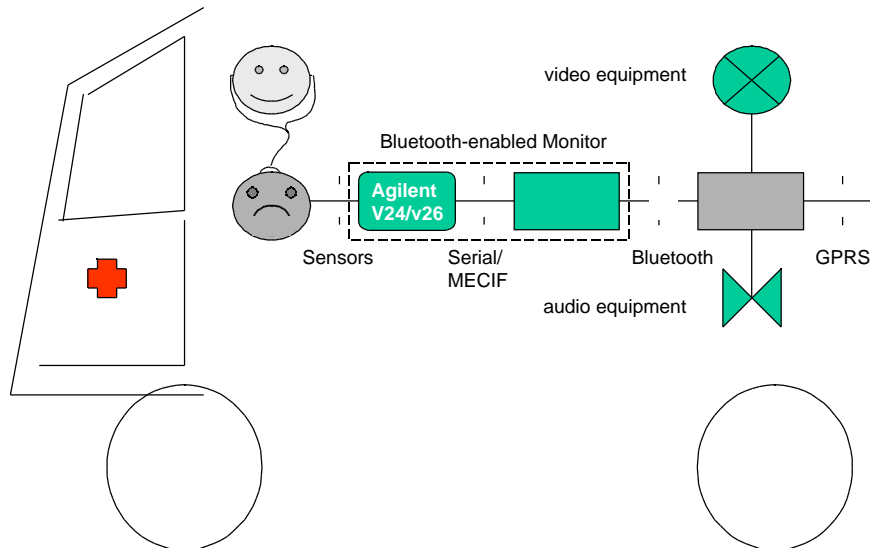
### 2.6.1 Computing Environment

Within 6WINIT the GANS application will be isolated from other application in the hospital. A possible integration with the clinical information system is for further studies.

The UKT network will be only used to transport signals from the GANS centre to the outer world and back (clinical network, University of Tübingen network, DTAG GPRS service, ambulance car).

- Servers will be preferable LINUX based or Windows 2000.
- End systems will be preferable Windows 2000 based.
- The "Clinical Workstation" will be an Agilent patient monitor system V24/V26. Using the so-called MECIF application protocol the vital data are transferred via a serial line to a Bluetooth-equipped notebook: The following figure describes the set-up in the ambulance car.





**Figure 3: UKT-RUS Guardian Angel System - GANS set-up in an ambulance car**

### 2.6.2 Healthcare Information and Communication

As shown in Figures 1 and 2 the information transferred in the GANS application are

- vital data
- audio – two-way
- video – one-way

It will be part of the development and evaluation procedures to assess the usefulness of - especially the video component under the given bandwidth constraints. For example, as shown in Figure 2- the doctor examining the patient - even a coarse picture of the situation may inform the experts in the hospital, that audio communication is not indicated at this very moment.

Figure 4 below shows the screen and panel of the Agilent V24/V26 as presently installed at RUS.

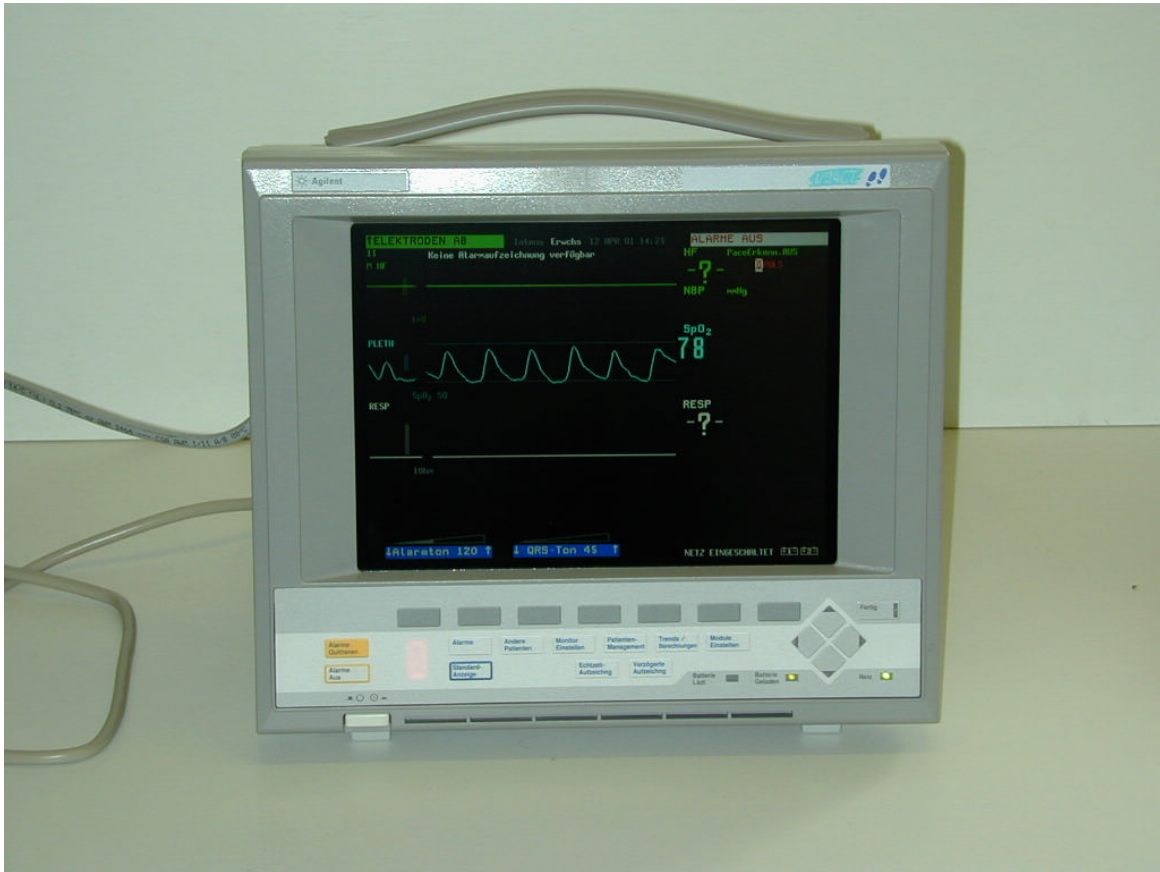


Figure 4: Screen and panel of the Agilent V24/V26

## 2.7 Technical Challenges to be Addressed

### 2.7.1 The GANS application

Formally not a part of 6WINIT, GANS is developed in a separate but co-ordinated effort. In order to be easy to maintain and to extend in a possible future production deployment, the GANS application is supposed to be based on standard components. The initial GANS design is using the Sun Java Media Framework (JMF) for the data part, see Figure 5 below. The control part design is still under consideration but will probably be based on an application server such as the Inprise application server.

RUS will provide initial prototypes both for the vital data and A/V part to UKT in order to test and assess the achievable quality; such prototypes can be also used in 6WINIT-wide tests and demonstrations.

RUS is following the question of "Java and IPv6" both in 6WINIT and MobyDick.

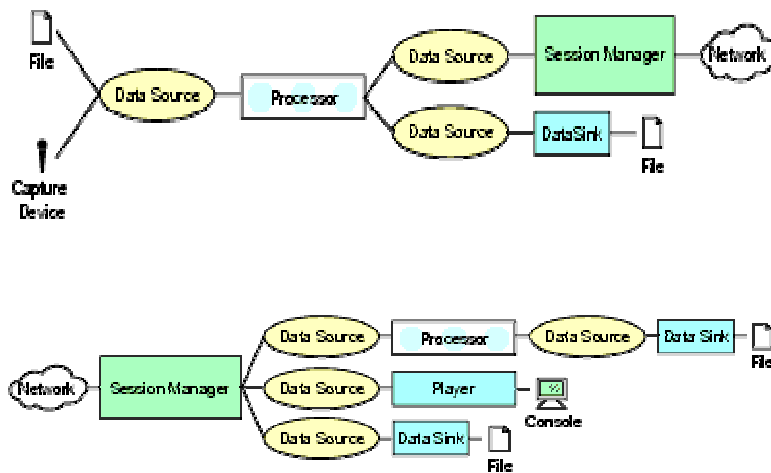
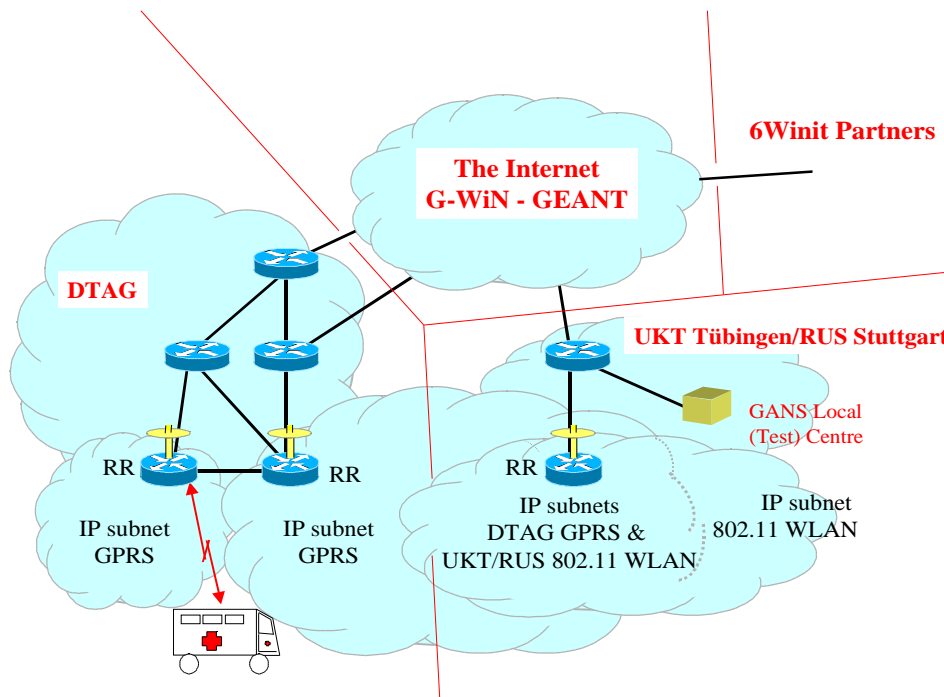


Figure 5: Java Media Framework structural elements

## 2.7.2 Networking

The following Figure 6 shows the final target scenario for 6WINIT-GANS.



**Figure 6: The 6WINIT-GANS ambulance car on the move - (radio access networks simplified)**

The realisation of this scenario does require at least the following steps:

- IPv6 basic infrastructure set-up at RUS-UKT
- Experimentation with IPv6 together with other 6WINIT (and possibly MobyDick) partners
- Experimentation with Mobile IPv6 - applications, end-systems, servers, gateways
- Clarifications concerning the nature, availability etc. of the DTAG GPRS service
- Capabilities of IPv4 of DTAG GPRS service to carry/tunnel any IPv6 hand-over scenarios

## 2.8 References

- [1] Agilent Technologies: Agilent Component Monitoring System and V24 and V26 . RS232 Computer Interface Programming Guide (Option #J13)
- [2] Darlagiannis V., Ackermann R., El-Sadick A.,m Georganas N., Steinmetz R.: Suitability of Java for Virtual Collaboration. Proc. Net.Object Days 2000, Erfurt, Germany, Oct. 2000
- [3] Shirmohammadi, L. Ding, and N.D. Georganas, "[An Approach for Recording Multimedia Collaborative Sessions: Design and Implementation](#)", Journal of Multimedia Tools and Applications (accepted, to appear).
- [4] Yongzheng Liang: Report on the JMStudio Prototype RUS . 30.03 2001
- [5] Jürgen Scheerer: Report on the Agilent V24/v26 vital data transmission and presentation. RUS. May 2001 (to appear)

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## 3 NORTH LONDON CLINICAL SITE

### 3.1 Description of the Healthcare Sites

#### 3.1.1 Overview

The London 6WINIT Clinical Demonstrator comprises a set of primary and secondary care sites in north London working in partnership with University College London. The eventual shape of the demonstrator site will comprise the following healthcare settings.

- The Department of Cardiovascular Medicine at the Whittington hospital
- 2-4 community-based cardiology clinics
- Several GP practices in north London
- Several community pharmacies in north London

#### CHIME

The UCL Centre for Health Informatics and Multiprofessional Education (CHIME) was established in 1995 to develop and integrate initiatives in health informatics, education and health services research. The informatics research activities of CHIME are in clinical information management and systems, decision support and telemedicine, community genetics and educational computing. CHIME staff have played leading European roles in research and development of health information systems architecture and prototyping and evaluation of novel systems for health care records, over the past nine years. They are also members of relevant national and international standards bodies.

#### The Whittington Hospital

The Whittington is a community based teaching hospital in north London, serving a busy and cosmopolitan part of the capital city. It was once the largest in Europe. Through reciprocal links with University College Hospital it is able to offer a comprehensive and expanding range of patient care services. The hospital has a close relationship with University College London for medical student and postgraduate education, and with Middlesex University for the training of nurses and other health professionals. The consultants have close working relationships with local GPs, and the hospital provides support for many GP educational activities.

The Department of Cardiovascular Medicine provides care for around 1,800 emergency inpatient admissions, almost 7,000 outpatients and co-ordinates around 20,000 cardiac investigations per annum. The department's close working relationship with the Middlesex Hospital (within the UCL Hospitals group) for tertiary referrals embraces cardiovascular medicine and cardiovascular surgery, and incorporates peripheral vascular as well as cerebrovascular disease.

#### North London General Practices

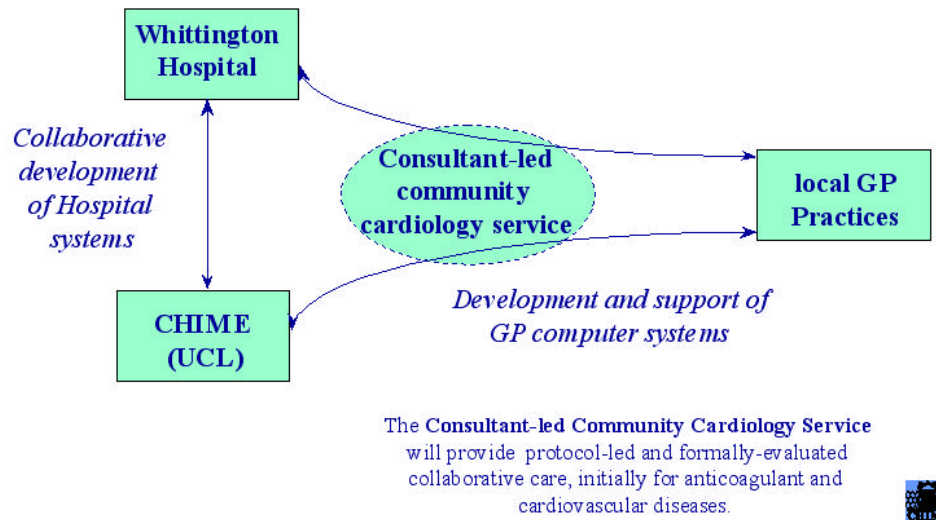
Several GP practices will be recruited during the project to pilot Internet-based access to the CHIME clinical applications. These are likely to be group practices comprising 2-5 doctors working with one or more nurses and other clinical staff, providing a wide range of primary care services to a local population of around 5,000 – 10,000 patients each. UK primary care services now include a wide range of protocol-based disease management and screening clinics.

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### Community Pharmacies

A selected group of north London pharmacy sites will also pilot the use of the 6WINIT components, in order to collaborate in the seamless but co-ordinated delivery of patient-centred care.

### 3.1.2 Location



**Figure 7: Partner sites in the London 6WINIT Demonstrator**

### 3.1.3 Parties

The Department of Cardiovascular Medicine has three consultants and seven junior medical staff supported by several cardiac technicians and specialist cardiac nurses trained in anticoagulation and in resuscitation. A Consultant in Community Cardiology is facilitating the development of a seamless cardiology service from the patient's home through primary care to secondary care and to tertiary care.

The main users of 6WINIT-enabled clinical applications will be:

- doctors, nurses and technical members of the Department of Cardiovascular Medicine, working inside the Whittington Hospital, ideally from any location on the hospital's intranet;
- the Consultant in Community Cardiology working from GP practices and patients homes in the north London area;
- specialist nurses running particular clinics such as anticoagulation management, which are partly located outside the hospital in community health centres;
- several local GPs, working in group practices within the north London area;
- several community pharmacists specifically providing anticoagulation management;
- several selected patients who have had training in self monitoring and self management of anticoagulation.

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## 3.2 Description of the Clinical Setting

### 3.2.1 Introduction

The clinical focus of the London Demonstrator is in cardiology, and more specifically for outpatients (ambulatory care patients) requiring anticoagulation therapy or the investigation and management of acute chest pain symptoms.

The plans for the clinical demonstrator are built on the shared use of an electronic health record server that has been developed by CHIME (UCL) over several years on the basis of EU Health Telematics R&D project results and CEN standards.

The Whittington Hospital cardiology department already undertakes world-leading research in fields such as anticoagulation. The anticoagulant advisory system, written in Access Basic, is not available on-line to the wards. The intent of the 6WINIT demonstrator is to facilitate on-line access to a new electronic advisory management system and to minimise the need for both manual and electronic entry.

Chest pain clinic services are increasingly coming under National Health Service and public scrutiny, following the publication last year of a National Service Framework (NSF) for cardiovascular health care. This framework specifies how care should be shared between primary and secondary care, what kinds of care processes should be performed including criteria for diagnostic procedures and treatment recommendations. There is now a national challenge for hospital trusts and GP practices to collaborate in defining local care pathways and in collecting and sharing the appropriate data sets to reflect the NSF guidance. The intent of the 6WINIT demonstrator is to develop a hospital focused care pathway application, and to provide web-based views of patients cardiovascular record to GPs, other community health professionals and to patients.

### 3.2.2 Health Information

Anticoagulant care is presently delivered by specialist nurses in a hospital clinic, using a Microsoft Access Basic stand-alone decision support application. This has been used successfully for several years, and has largely eliminated the need for clinic paper records to be kept except as printouts for the patient or GP. However, the legacy anticoagulant advisory and management system still has relatively restricted access. The results of the routine INR blood test are entered on paper records in the laboratory and brought physically by the patient to the anticoagulant clinic where they are entered in the system.

Heart disease (angina and myocardial infarction) care is presently based on the paper hospital record folder, which is shared across all departments and includes reports and correspondence. Nursing and medication administration records are maintained separately on paper for inpatients.

The Department has an electronic clinical record (including referrals, diagnoses, management plans and outcomes) of all patients treated for angina or myocardial infarction, accumulated over the past ten years. Experience has shown that this database is a valuable resource of background information when patients develop new cardiac symptoms, but access to this is limited to two physical settings inside the Whittington, and not at all in potential emergency community settings where it would most urgently be needed.



Diagnostic investigations inside the hospital are largely performed using equipment from General Electric / Marquette. Most of this is acquired from electronic devices that are connected with specialist interpretation and reporting applications. Some limited integration occurs, but a new integration database and web-based application has been developed by GE Medical Systems (Europe) and will be installed during the next year.

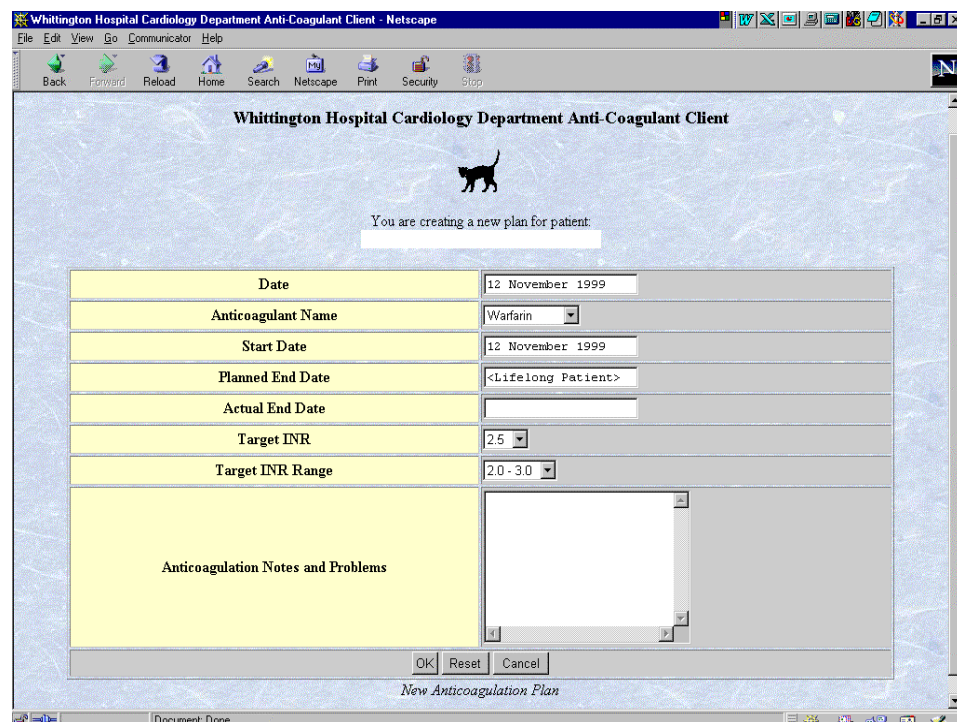
General practitioners and practice nurses have increasingly adopted computerised templates to facilitate structured data entry and systematic clinical care in the management of many chronic illnesses. These have often been defined by individual practices, and there has only recently been a concerted effort for practices to standardise these on a locality or district basis.

Communication between sites, e.g. for referral and discharge, are supported by letters and summary reports on paper.

### 3.2.3 Clinical Applications

#### Anticoagulant services

New web-based clinical applications interfacing with an electronic healthcare record server will provide clinicians with access to patient records, to protocol-based management guidance and to decision support services. The first of these, an anticoagulant application, has now been written, and is undergoing final off-line clinical evaluation before going live in a few weeks. An example screen is shown below.



**Figure 8: Anticoagulant Client - authoring a new treatment plan**

Plans for new ischaemic heart disease applications are described in the next section.



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Each clinical site has existing clinical and administrative applications, usually accessed via the local area network, the use of which is not expected to change through 6WINIT activities.

### 3.2.4 Other Information Services

Clinical teams in hospital and general practice have recently been provided with Internet and e-mail facilities via *NHSnet*. Few users had prior access to these services, and user training is therefore now an important issue. These services will not be open to modification through 6WINIT, and client access to new record server applications from inside the main healthcare sites via IPv6 will need to be interfaced to the existing networks.

The use of on-line knowledge databases, such as Medline, is still limited to enthusiasts. However, this use of such health informatics services is set to expand rapidly, and CHIME will report on evolving requirements for such services in future reports.

## 3.3 Clinical View of the Demonstrator

### 3.3.1 Clinical or Educational Services

Management of chronic illnesses and conditions such as stroke, diabetes, asthma and coronary artery disease represent a major and growing challenge to healthcare services throughout the world. Mobile devices are needed to measure, communicate, inform and support individual patient decisions and choices based on clinical guidance. This will permit chronically ill patients to benefit from healthcare support by multi-professional teams at unpredictable times and places and will enable them to lead as full a life as possible. There is evidence that the greater the patient's involvement in the management of their illness, the better their compliance with treatment and the clinical outcomes achieved.

The north London demonstrator vision is to deliver the seamless shared care of patients with cardiovascular illness, in a managed care environment. Patients requiring anticoagulation will have their therapy commenced in the hospital outpatient clinic, informed by background information from their GPs record, guided by electronic protocols and decision support systems. Once stabilised, their care will be transferred into the community and managed under the same protocols with their GP having appropriate access to the hospital records. The care of all patients under anti-coagulation will be subject to clinical and management audits, through interrogation of their federated health care records.

Similar managed care scenarios will be developed over time for patients suffering from angina, ischaemic heart disease and cerebrovascular disease, with a particular emphases on protocol-based therapy guidance and on secure distributed access to views of patient records.

Recently the Whittington has pioneered the use of "Integrated Care Pathways," presently paper based mechanisms for automating the path of the patient across departments in the hospital as activities are performed and as a disease changes in nature. There is undoubted utility in making these forms computer based, not least because they are currently not particularly readable.

It is well known that patients can acquire considerable expertise in managing their own health if they are given useful material with which to educate themselves. There is a compelling argument for the benefits of such "passive" decision support (advice that is not patient specific). In the longer term middleware record service components will relate parts of a patient's record to

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relevant advice topics, delivered through a combination of web-based stations and touch-screen kiosks.

Patients will be recruited from the Whittington Hospital anticoagulant clinics and general cardiology outpatients, and will ideally include all patients attending outpatient clinics with the relevant diagnoses. The exact numbers of patients cared for through these applications cannot yet be confirmed, but is likely to be a few hundred within the first year.

### 3.3.2 Information Flows

The long-term aim of the north London cardiovascular demonstrator is to provide access to the patient information collected around the Whittington Hospital and particularly within the cardiology department so that authorised clinical personnel can get access to it from wherever they are working. Staff often need to roam within the hospital, being at times within their principal department and at other times doing clinics or ward rounds. A specifically appointed community cardiology consultant has already commenced a set of district clinic sessions and the number of locations for these is set to expand across north London. Specialist nurses also work from a range of community-based health centres, from which they will need access to the main cardiology patient records.

GPs and community teams will need to access hospital based records, and to take advantage of shared care records and protocols, from any point of care including a patient's home or any other emergency setting such as the roadside. The London 6WINIT demonstrator aims to offer secure mobile access to a web-browsable record for community healthcare professionals in such urgent situations.

Patients requiring careful management of symptoms, physiology or function will need to communicate changes in monitored readings to their clinical team and obtain management advice, possible via decision support systems. The latest generation of PDAs with a secure mobile link to the Whittington's (web-based) EHCR services would allow the delivery of this kind of patient care.

The main objectives for the clinical data integration in London are therefore to:

- provide a seamless service across primary, secondary and tertiary care and for self-management, based on a shared electronic health record;
- enable patients and emergency health providers to access patient records from a potentially mobile setting;
- interface seamlessly with current (feeder) systems within and without the hospital setting;
- support the continuing development of end-user applications e.g. for anticoagulant control and chest pain management;
- give multimedia access to electronic medical libraries and repositories of best practice;
- support the development of educational and behavioural change material;
- support clinic and department management;
- receive and process data from cardiology equipment.

Patient care will require the access to a summary record, planning and reviewing of investigations, access to decision support advice and treatments given including medication. The details of the clinical data sets, data types and templates to be incorporated into the cardiovascular EHR are still being defined. However, it is expected that in the first instance data will be character-based together with a limited number of static images such as graphs, ECG images,

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radiology images. Mobile PDA access to clinical applications is desirable, but might initially be limited to access from outside the hospital and GP premises to avoid radio signal conflicts with medical equipment.

### 3.3.3 Clinical Applications

The set of clinical applications presently in scope for development over the next two years include:

- anticoagulant clinical management system
- angina and myocardial infarction (acute chest pain) clinical management application
- atrial fibrillation specialist systems
- cardiology investigation and monitoring reports (derived from Marquette/General Electric diagnostic equipment and applications)

These will be delivered as a set of web based applications running from a single web server, which also hosts a set of record services, directory services and probably authentication and access control services. Many of the core services have been developed and tested, and what remains to be achieved is the specific clinical information modelling to reflect the needs of each clinical speciality, the design of individual web screens, and the development of decision-making components that enact elements of an overall clinical protocol.

Security features such as encryption and token and certificate-based authentication are required, and advice will be needed from the 6WINIT partners on suitable components to provide these within an IPv6 networking environment.

As mentioned above, application 1 is completed and ready to go live. Application area 2 above will specifically be targeted for delivery to mobile users, such as GPs in patients' homes and patients themselves. The requirements for this access will be for ubiquitous and portable access, rather than access whilst "on the move". Future use by the classical emergency services such as ambulance staff, who might need seamless and continuous access whilst physically moving, is not envisaged during the lifetime of the 6WINIT project at the London site, although such use would be ideal in the longer term.

## 3.4 Example Use Cases

The London demonstrator has the goal of delivering ubiquitous secure access to electronic health record (EHR) information.

The following Use Case scenarios summarise the likely principal interactions between end-users of the 6WINIT solutions and the clinical applications/record server of the London demonstrator site. Each case is described in general terms, since the actual users may only be confirmed once the technical architecture and deployment setting has been confirmed at a consortium level.

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### 3.4.1 End Users and Their Activities

End User	Locations	Activities
<b>Health Care Professional:</b> e.g. Doctor Nurse Medical Secretary	Hospital clinic or ward, including intensive care units; GP surgery or health centre; Patient's home; In their car or at roadside	<b>Review</b> patient records, including: out-patient clinic consultations, medical history taking, clinical examinations, laboratory test requests & results, radiology requests & results, biosignal requests & results, angiography records & diagrams, operation notes, anaesthetic records, nursing observations, dietary history, education by specialist nurses, outpatient clinic letters, discharge summaries. <b>Revise</b> data sets and templates for research or clinical care purposes. <b>Audit</b> the clinical care of patients or groups of patients.
<b>Patient</b>	Home, office, in transit	<b>Review</b> personal record, annotate personal record
<b>Administrator</b>	Hospital office or GP surgery office	<b>Register</b> new patients, amend patient registration details. <b>Arrange</b> admissions, clinic appointments.
<b>Personnel Officer</b>	Hospital office or GP surgery office	<b>Register</b> new clinical staff, amend staff details.
<b>Hospital Manager</b>	Hospital office or GP surgery office	<b>Analyse</b> the overall management, costs and clinical care of patients or groups of patients.
<b>Computing Department Information Scientist</b>	Hospital IT department, clinic or ward; GP Surgery	<b>Register</b> new clinical staff, amend staff details. <b>Register</b> new patients, amend patient registration details. <b>Revise data sets and templates</b> for research or clinical care purposes. <b>Analyse</b> the overall management, costs and clinical care of patients or groups of patients.

### 3.4.2 Use Case Diagrams

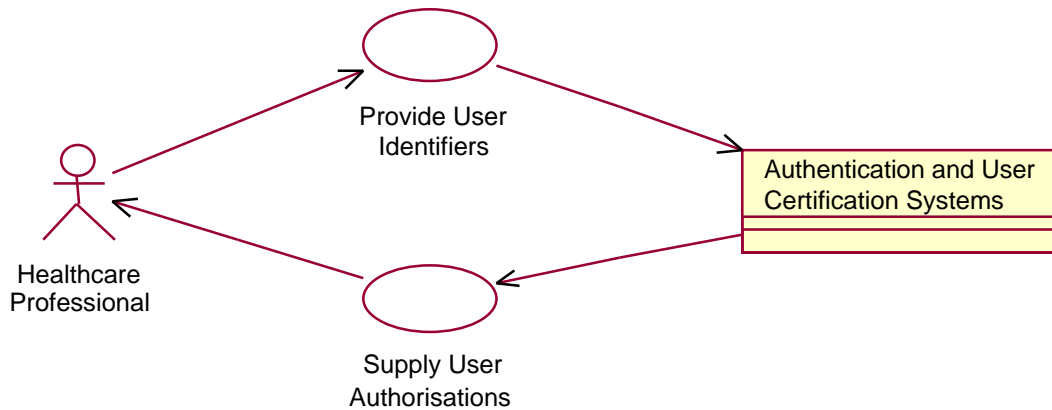
*Request/response*

An end user for this scenario may typically be a doctor or a nurse providing care to a patient, or a medical secretary generating out-patient clinic letters or discharge summaries. A further set of users are hospital management staff, who will wish to review individual patient record information for financial (e.g. billing) purposes, or aggregate data for clinical audit or quality assurance purposes. An additional special case of this scenario is when a patient will wish to view their own healthcare record, which must be permitted through their own level of access rights.

Each end-user will typically wish to:

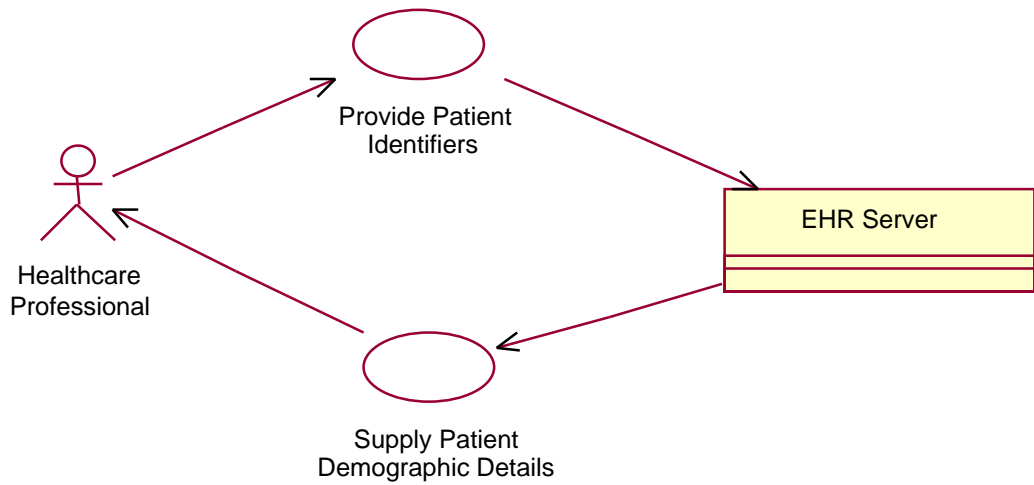
- log in to their computer workstation, and thereby declare their appropriate level of authorisation to EHR services;
- select a patient by providing identification information (such as their surname and first names) and receive confirmation of the patient by seeing a fuller demographic data set;
- review the contents of the patient’s healthcare record through a series of drill-down and drill-up requests for record entries.

NOTE: In each of the use case diagrams (a) to (c) the user Healthcare Professional could be replaced by a Healthcare Manager or a Patient.



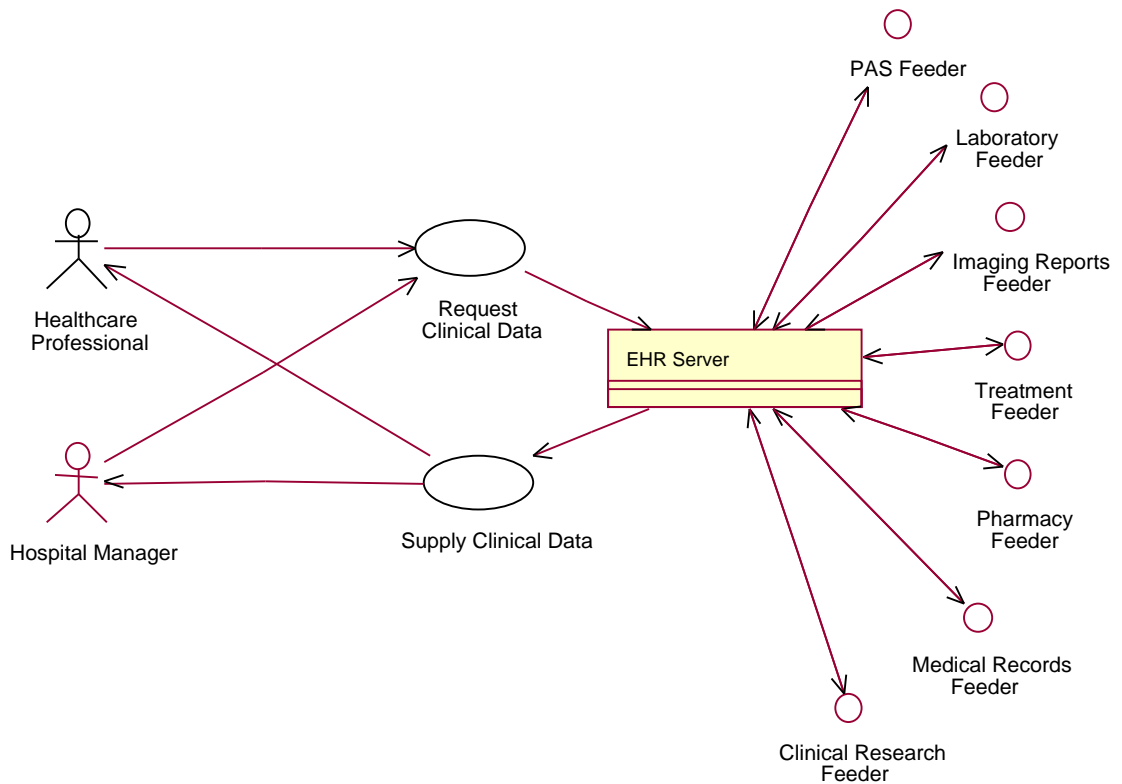
**Figure 9: Request and Response Use case**

**(a) Logging in to the EHR Server**



**Figure 10: Request and Response Use case**

**(b) Identifying a Particular Patient**



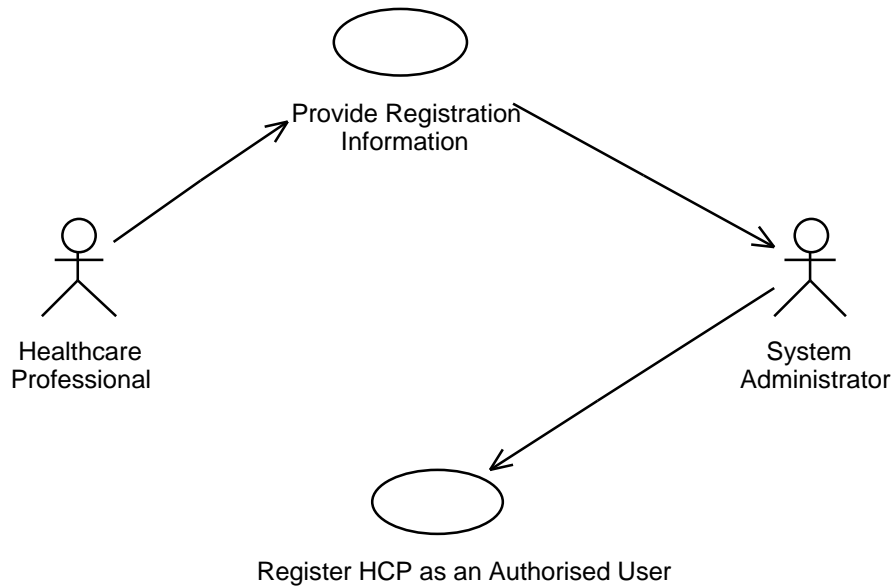
**Figure 11: Request and Response Use case**

**(c) Requesting and Retrieving Parts of that Patient's record**

User Registration

Given the broad range of feeder sub-systems that will be accessible through an EHR federation, the process of user registration will need to be carefully managed. The process of defining named end-users and of associating them with a default set of authorisations, may be handled by the hospital's computing department or personnel department.

NOTE: In the diagram below the Healthcare Professional could be replaced by a Departmental Administrator or Personnel Officer.

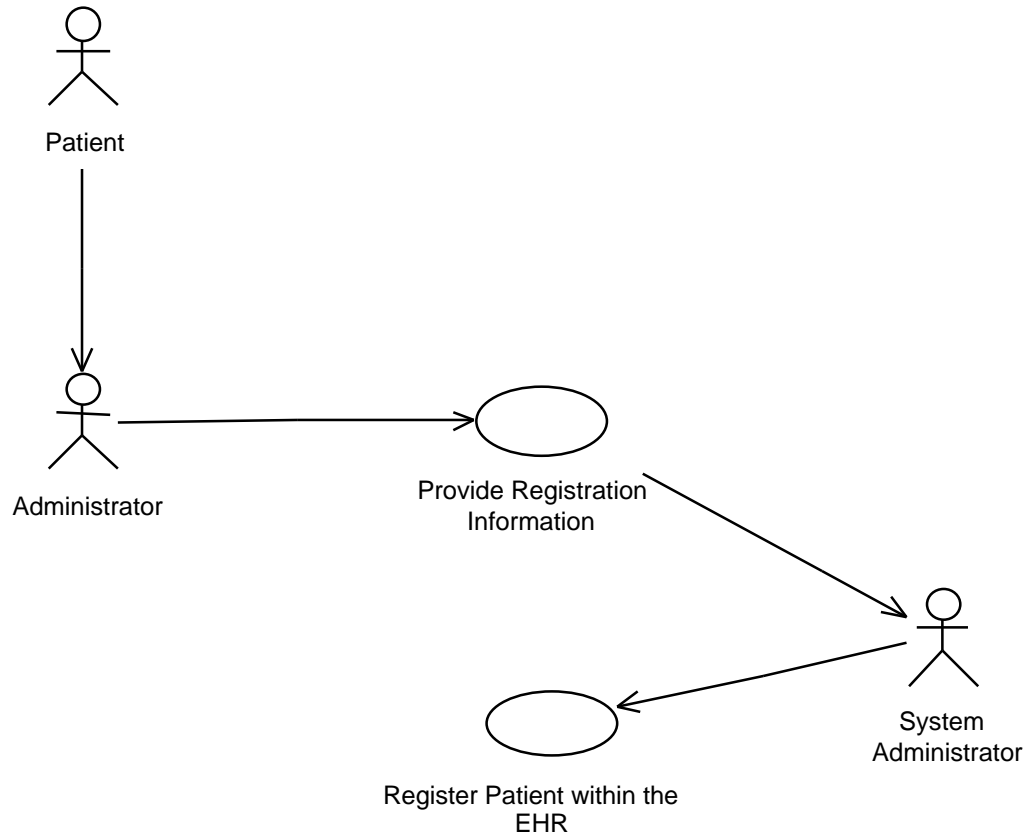


**Figure 12: User Registration**

Patient Registration

Each patient whose records are contributing to the EHR federation at any healthcare enterprise will need to be uniquely and unambiguously identifiable by the EHR server. A mechanism is required for this, although it may initially draw on existing patient master index systems, in order to allow the federation to incorporate multiple sites.

NOTE: In different settings a wide range of different end-users may be involved in the process of patient registration. The diagram below is therefore an example case.



**Figure 13: Patient Registration**



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### 3.5 Functional Requirements

The requirements listed below, adapted from background work by UCL on the design and implementation of electronic health record servers, reflects the functional requirements of an open distributed system providing secure and ubiquitous access to patient health information. These requirements primarily relate to the computing environment in which the server is deployed, including network connections and security features, and omit the fine-grained requirements for handling health record data itself.

#### General Functional Requirements

The EHR Server must facilitate the creation of a single logical electronic healthcare record for each patient within one or more healthcare enterprises, by enabling distributed and legitimate access to the set of patient-related clinical data held by or available to those healthcare enterprises.

The EHR server should contain the necessary features to facilitate safe exchange of patient records and record components between information sources holding patient information.

The EHR server should be capable of accepting and responding to requests for patient records from end-user applications.

The EHR server should be capable of generating an output to the end-user application corresponding to the original request.

The EHR server should be capable of managing requests from more than one client application.

The EHR server and server-side applications must be capable of receiving and responding to end user client applications from a diversity of locations and physical devices, via a any appropriate communications connection.

The EHR server should make information accessible to end user applications in a safe and secure way.

The EHR server should provide features allowing it to be configured directly.

The EHR server should aim for 100% availability.

#### General interface requirements

Mechanisms must exist whereby an authorised user can modify, in a safe, secure and friendly manner, the clinical object definitions, patient indices, end-user authorities and access-control frameworks held by the EHR server.

The EHR server interfaces should allow the 'registration' of feeder systems to be managed.

The EHR server interfaces should support connection between multiple applications and the server.

The EHR server interfaces should allow the 'registration' of end-user applications to be managed.

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The EHR server must be able to manage patient identifiers, allowing for these to change over time.

Security

Personal health information held in a computerised form must be secure, private and confidential. The server design must enable an institution to comply with national and EU mandates and directives on the protection of healthcare data. This relates to the ownership of, responsibility for, and access to distributed EHR data.

EHRs should be created, processed and managed in ways that optimally guarantee the confidentiality of their contents and the legitimate control of patients over them.

Encryption services must be used for EHR data sent over open or uncontrolled networks.

Integrity and Availability

Healthcare records must be accurate and complete, available at all times at any appropriate points of care, and retrieved within a time appropriate to the clinical context.

EHR data must be a legally acceptable: admissible as evidence in legal proceedings, as well as authorising the validity of prescriptions and other orders.

It must be possible for an authorised user to create or update a record entry, but impossible to alter or erase an original entry. Data should be updated by addition of correct information and labelling of old information as inaccurate or incomplete rather than by overwriting.

The patient or their representative must be able to view any or all of the personal health data that forms part of their healthcare record.

The EHR server must have the facility for keeping a "Third Party Disclosure Register" so that subsequent updates or corrections can be notified to them.

Access control

Appropriate technical and organisational measures must be implemented to protect Personal Data against accidental or unlawful destruction or accidental loss, alteration, unauthorised disclosure or access, in particular where the processing involves transmission over a network, and against all other unlawful forms of processing.

The EHR server should support a multi-level access rights framework, in which levels may be defined according to profession, position, speciality or function, and which may only be valid for individual patient records and/or for certain periods of time.

Only persons with the appropriate rights to do so should be in a position to amend or create record entries.

The EHR server must accommodate the over-riding of normal access rights in an emergency situation. Such emergency exceptions must be explicitly documented within the server itself to support subsequent investigation.

If the record is to be used by a large number of professionals for different purposes it must be possible to withhold certain information from general viewing.

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Patients should be made aware of which professional groups have access to their healthcare record. Research utilising healthcare records should have informed consent as the guiding principle: the design and purpose of the research should be available to patients.

The EHR server interfaces should provide the means to manage/set-up access control.

User Authentication

Authentication mechanisms should be facilitated. There must be a watertight method to identify and to authenticate the author of an entry or of a request for a record extract.

End-users should require authentication only once for each session.

End user authentication should not require specific user profiles to be permanently maintained on portable connection devices (e.g. PDA, laptop), but utilise trusted third party (PKI) services that are not compromised if the portable device is lost or stolen.

The EHR server interfaces should allow access to be controllable, e.g. on a 'time and station' basis.

The EHR server interfaces should allow 'time-out' to be configured, e.g. on a station basis.

Audit trails

Effective audit trails are required to ensure that it is possible to find out who was given access to EHR data and when.

The EHR server should contain the necessary features to enable an audit trail of the creation and amendment of patient information.

The EHR server interfaces should have provisions for logging the exchange of information between the server and the end applications.

The EHR server interfaces should allow audit trail logs to be examined by an administrator.

Performance

It is essential that response times are reliable and have consistent characteristics. The time necessary for the server to translate the request from a client into a query to one or more feeder systems should not (e.g.) take more than one second

The time necessary for the EHR server to translate the response(s) from the feeder system(s) into a response to the client application should not (e.g.) take more than one second.

The EHR server interfaces should provide the capability for the transmission of any conceivable multimedia data (for instance containing moving image data.)

Exceptions and Errors

Healthcare records must be available at all times at any appropriate points of care. If parts of the record are lost, damaged or unavailable (for any reason) this fact must be made apparent to the end-user. Appropriate backup facilities must exist to enable continued access to EHR data when the server is "down" or fails.

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The EHR server should be capable of detecting data conflicts or errors and notify the end-user application and administrator.

### 3.6 Demonstrating Benefit

The main change in the health care delivery pattern through 6WINIT services will be the distribution of care to sites outside the hospital, and probably to new parts of the hospital.

Proof-of-concept validation of the 6WINIT solutions will be the reliability of the connection to the web based applications from a range of client locations and devices, and the overall performance of the network in terms of speed. It will be important to end users, managers and to the NHS that user authentication and system security is demonstrably robust and confirms to national policies.

End user satisfaction, for health professionals and for patients, can be demonstrated through questionnaires. Specific problems can be monitored via incident reporting systems. In particular, it will be important to show that distributed access to health information is feasible, scalable, and is of an acceptable quality to support clinical practice.

However much of the clinical benefit of the new systems will relate to the qualities of the applications themselves, which may not in itself be of interest to the 6WINIT technical partners. Advice will be needed from other partners about the aspects of each site that have technical or potential marketing value that can be highlighted in the evaluation. Once this is clear, a draft framework for end user evaluation will be proposed.

### 3.7 Clinical and Organisational Acceptance

If we assume that the demonstration is technically successful, and that the end users involved are happy with the information services provided, there are still a number of factors, unrelated to the networks, that will influence the broader roll-out of 6WINIT solutions within the healthcare domain. These are mainly in relation to culture changes introduced by distributed information services, but also to compatibility with any relevant aspects of the NHS technical approach:

- the demonstrable security and reliability of access to patient record information
- conformance to NHS security policies
- interoperability with the present version of *NHSnet*
- impact on the procurement strategy for the replacement of *NHSnet* in 2002
- congruence of ideas with the NHS ERDIP (electronic records demonstrator programme)
- the practical usability of PDAs in place of workstations and laptops, at least for emergency access
- clinical acceptance of the idea of shared (multi-site and multi-agency) records
- clinical acceptance of care pathway structured healthcare
- patient attitudes to their records being shared across sites, including consent for disclosure
- patient attitudes to accessing their own health record

These factors will be considered further by members of the London site, but input from other consortium members is most welcome.

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## 3.8 Description of the Technical Setting

### 3.8.1 Overview

#### Whittington Hospital

The Whittington Hospital has a Patient Administration System implemented and maintained by HBOC. Additional modules of the system support the administration of ADT and outpatient clinics. Laboratory results are available on wards and clinics.

#### Cardiology Departmental Applications

At present the cardiology department has several heterogeneous computer systems with relatively limited inter-operability:

- an outpatient system collecting information which includes outpatient diagnoses;
- an inpatient system which is used to a limited extent for logistic rather than technical reasons;
- a diagnostic system for echocardiography, 24-hour tapes and exercise tests;
- an anticoagulant advisory (decision support) and patient management system;
- a coronary artery disease system (incorporating some decision support features) which is presently being brought into clinical use and will be evaluated;
- a Marquette/General Electric/Helliger system which embraces:
  - an expert and advisory system for ECG interpretation;
  - an ICU system with six monitors;
  - a CCU system with six monitors and a central station;
  - an exercise test system;
  - a 24-hour tape system;
  - ECG machines.

All ECGs recorded in the Hospital, whether for inpatients, outpatients or in the Accident & Emergency Department, are recorded electronically and stored. Although access to previous individual records is therefore available, the access is laborious and not instantaneous. A new web-based product from GE/Marquette is about to be installed to enable distributed access to these diagnostic and monitoring data, but will not in itself be integrated with other departmental systems or the patients electronic health record.

#### GP practices' Applications

The selected GP sites will all be group practices in dedicated clinic premises, using either GP-CARE or EMIS. Both are very comprehensive clinical and practice management systems, accredited to the latest national conformance standards, and incorporate EDI links to hospitals for pathology test reporting and to health authorities for patient list management and billing.

GP-CARE is a Microsoft Visual Basic application developed at CHIME, and therefore can be regarded as an "open" system for data interfacing purposes. EMIS is a commercial MUMPS based system, and although the vendor has participated in many NHS R&D projects this has only been through funded activities. The system has a limited export interface but for the purposes of 6WINIT might be regarded as a "closed" legacy system.

Pharmacy Applications

Community pharmacists use one of a range of proprietary dispensing and stock control/ordering systems, which for the purposes of 6WINIT might be regarded as “closed” legacy systems. More information on the specific systems in use will be available later once the individual sites have been chosen.

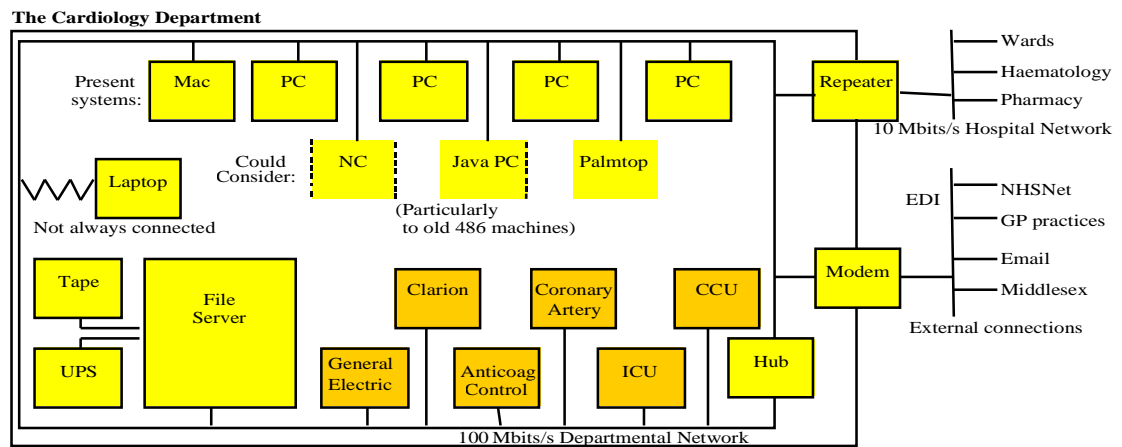
**3.8.2 Networking**

Hospital Wide

The Whittington Hospital runs a Novell local area network, provided and maintained by HBOC. Some departmental common services are administered via Novell Groupwise, and local departments often have one or more Windows™ NT servers. The hospital’s Intranet is connected to the wider NHS (national) Intranet (*NHSnet*). Present IT plans include the broad roll-out of PC workstations and Intranet connections to replace terminal-based stations, to enable clinical staff to access Intranet, Internet and e-mail services. This also gives rise to a major training challenge in which the hospital IM&T department is actively engaged.

Departmental Network

The departmental workstations are connected via a Local Area Network to the Whittington HIS. The new web based anticoagulant system is presently installed on a Windows™ NT sever located in the department and connected to the main hospital Intranet. The anticoagulant system is used within the hospital outpatient department and also (via laptop computers) in community clinics. A schematic diagram of the departmental network is given below.



**Figure 14: Overview of the Present Cardiology Departmental IT Systems**

GP Practices’ Networks

The general practices selected for pilot demonstration will be using one of two GP computing systems: GP-CARE or EMIS. Both have recently migrated to Windows™ NT networks, usually with a central file server running clinical applications and a communications server (often the

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primary domain controller) providing access to *NHSnet* services (e-mail, NHS Intranet and Internet) via a managed router (from BT) and ISDN connection.

#### Pharmacy Networks

Community pharmacists often have more limited computing facilities, sometimes with only a standalone computer. Plans for linking these sites might presently be limited to dial up connection via a PSTN line, or the use of a mobile connection. The connection of pharmacists is not presently part of the *NHSnet* strategy.

#### NHSnet

At present, networking services for the UK National Health Service are based around the private network, the *NHSnet*. *NHSnet* is a managed service, with connection controlled by Code of Connection, expressed in the case of GPs through an interim Acceptable Use Policy. The *NHSnet* is currently provided under a series of Framework Contracts, in which BT and Cable and Wireless offer networking services, and BT Syntegra offer a managed messaging service. Currently all Health Authorities and over 90% of Trusts have connections to *NHSnet* (although in many Trusts these are single point connections which do not reach the end user). As part of the Project Connect programme, over 70% of GP practices are now connected to *NHSnet*.

*NHSnet* includes an X.400 e-mail service to most clinical staff, and a nation-wide directory of e-mail addresses (available only within the *NHSnet* to authorised users). NHS managers and Information Authority staff also have SMTP mail. EDIFACT messages are used for communication between hospitals, GPs and health authorities, mainly for management purposes: the electronic exchange of these is now migrating from Kermit-based to X.400 mail attachments.

Local services are the responsibility of local health organisations, although it is usual for these to take advantage of the nationally-agreed contracts. Individual organisations are responsible for delivering and managing their own Local Area Networks. At present, there are no nationally-agreed product tools for the NHS. Typically, local organisations are responsible for their own decisions in areas such as e-mail and Office systems.

UCL's experience of interfacing with *NHSnet* to date has identified problems with multiple firewalls, managed locally by each Trust HIS provider and by BT nationally. It has proved difficult to request the addition of specific new IP addresses to the permissions list held by BT, and it is not known whether any facility exists for interfacing *NHSnet* to IPv6 networks.

### 3.8.3 Security

#### 3.8.3.1 National security policy

The National Health Service has formal published security policies, relating to general health service information systems and specifically the code of connection for *NHSnet*. (Copies of these are available from CHIME on request.) More recently the NHS has agreed to adopt ISO/IEC 17799:2000 as the basis for security management; some NHS specific extensions may be determined later. Local Trusts and GP practices will therefore be migrating to this over the next year or two.

GP practices have been encouraged to agree to a local policy, but in practice have usually agreed to use a generic one provided by their system supplier. (A copy of the GP-CARE recommended

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policy is available from CHIME on request). The practical implementation and monitoring of the policy across practices is variable.

### 3.8.3.2 Technical infrastructure

#### Whittington

Staff are authenticated via Novell Directory Services which also manages their access profiles (to applications and servers within the hospital network). Authentication is presently via passwords only. Mobile users can take advantage of a dial-up portal to access the Hospital's Intranet from outside. A laptop computer has been specifically configured for mobile use by the anticoagulant specialist nurse, and requires token based authentication to comply with *NHSnet* code of connection requirements.

#### GP Practices

The local GP systems are protected via Windows™ NT standard user password authentication. In addition, national accreditation requirements include password protected screen savers on all workstations, regular password change, user and group level system function definitions. All workstation IP addresses are registered with the router and access to both the *NHSnet* and Internet are limited to authorised users.

#### Pharmacies

This will be identified later, and may need to be provided by the 6WINIT partners from scratch.

## 3.9 Technical Overview of the Demonstrator

### 3.9.1 Computing Environment

The clinical information systems being demonstrated in north London are based on an innovative Electronic Health Record (EHR) server developed by CHIME through three frameworks of EU Health Telematics R&D programmes.

The demonstrator is utilising the following UCL components:

Object Dictionary Client and services (as a means of facilitating feeder system sign-up and of navigating a federation environment)

Federated Healthcare Record services (as a scalable run-time EHR environment supporting distributed access to record components from new and legacy feeder systems)

Persons Look-up services (for patient demographic information and staff identifiers)

Expert Advisory (Decision Support) services (to calculate the patient's next treatment regimen and next monitoring interval)

Web-based applications (to provide end-user clinical views and functions)

All of the main components are or will be written in Java™. The federated access to distributed clinical databases will be managed through a set of directory services accessed via the Java Naming and Directory Interface (JNDI). The components are deployed within a middleware

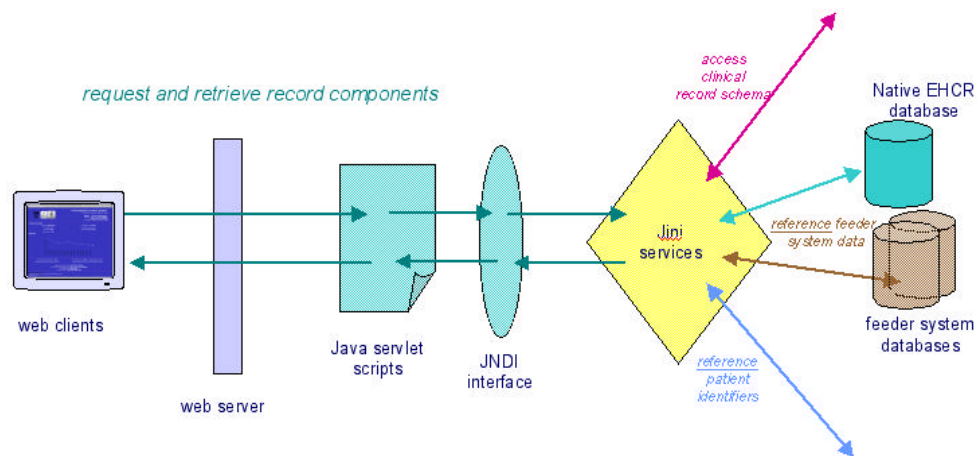


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environment managed through Novell Directory Services and JINI™, an open standard service-integration technology. This overall approach will allow the ongoing development of flexible and portable applications with high-level graphical user interfaces to be made where such applications can inter-operate across diverse architectures and infrastructures. The services are presently deployed on a Windows™ NT server, but alternatives including Linux™ can be considered. IPv6 web server and servlet runner applications will be required.

As well as accessing distributed feeder systems, the UCL EHR services incorporate a principal record database, ObjectStore™ (from Object Design Inc.), that can be used as a local cache and provides a robust repository for data originating from feeder systems that are to be decommissioned. An Oracle version of the record server is also being developed.

New web-based clinical applications are being written, using Java™ servlets, to provide end user access to the patient records held within the EHR server. The anticoagulant system is about to go live, and new applications for the management of acute chest pain are being designed for deployment during the 6WINIT project lifetime. At present these applications exclusively use HTTP for client-server communication.



**Figure 15: Components within the existing EHCR system to be utilised within the London 6WINIT Demonstrator**

Users should ideally be able to access these applications from:

- Windows™ workstations inside the Whittington Hospital
- Windows™ workstations inside the GP practices
- pharmacists, nurse specialists, patients via laptop (Windows™) and from a non-fixed point of dial up connection
- doctors, patients and nurse specialists via mobile PDA.

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### 3.9.2 Healthcare Information and Communication

The set of middleware components intended for this demonstrator will provide:

- a comprehensive, multi-media, multi-professional electronic healthcare record system
- the secure and seamless federation of disparate record systems within and between sites
- clinically-oriented tools to facilitate the creation, navigation and analysis of patient records
- integrated terminology, protocol and decision support services
- links to a range of clinical knowledge and educational databases

#### Anticoagulant application

This application provides a set of HTML web clients to enable the management of anticoagulation therapy by clinical staff (or patients) trained to monitor this. The overall application includes forms to deal with requests for and the display of existing data, and also with data entry. The system incorporates drug dosing decision support and recommends monitoring intervals between blood tests. It has been written to replace a legacy application, and will be the first live clinical application to test the EHR server. This application will shortly be accessed by the first community pharmacist, and it is hoped to include other pharmacists, GPs and patients as users within the next 12 months.

#### Acute Chest Pain Management

A new application is being written to provide clinicians inside and outside the hospital with access to the record of patients having acute chest pain (heart disease) symptoms, together with management guidance. The primary clinical application will be hosted on the same ER server as the anticoagulant system, and share the same core middleware services. The intention is for this application to be accessed on workstations only, inside the Whittington Hospital and selected GP practices.

#### Mobile views

It is presently proposed to create two views of the chest pain patient record, one for emergency care (a summary) and one for patients who wish to view their own record. For this we hope to utilise 6WINIT mobile networks and PDAs supplied through consortium partners. The emergency view is expected to be a helpful demonstration of secure mobile use of the 6WINIT networks, and is a high-profile strategic goal of the UK Department of Health.

## 3.10 Technical Challenges to be Addressed

### 3.10.1 Location of EHR server

Because of the complexity of providing external access to information services and applications from inside the Whittington Intranet (or indeed any other *NHSnet* site) CHIME presently intends “cloning” the Whittington EHR server within the University network at CHIME. This 6WINIT EHR server will contain an identical suite of clinical applications and services to the live clinical server, but using anonymised or pseudonymised patient data. This demonstration server will be

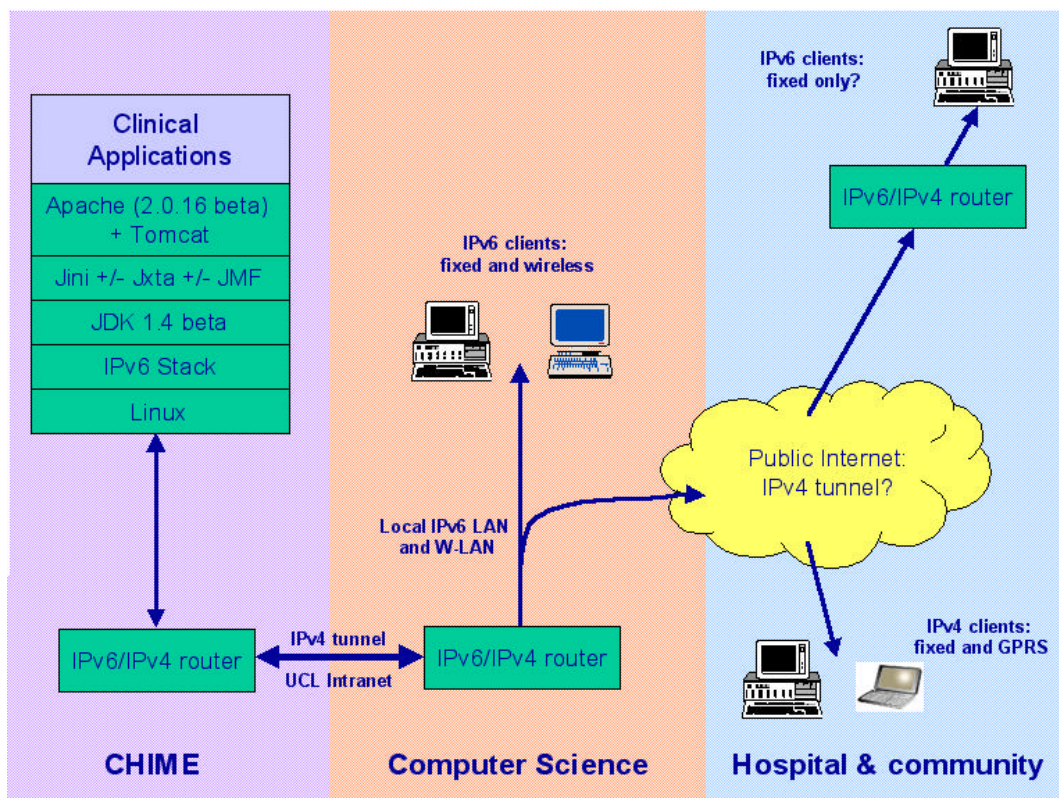
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sited on a localised IPv6 network within CHIME and tunnelled over IPv4 to the IPv6 network at the Computer Science Department of UCL, and from there to other IPv6 network nodes including wireless services. This will hopefully enable IPv6 solutions to be deployed more easily by the 6WINIT partners to provide patient and community users with demonstrator access to the web server applications. However, NHS legal constraints would prevent such an approach scaling up to a live or large-scale demonstrator, and alternatives including an *NHSnet* hosted solution should be investigated for the longer term.

Because of *NHSnet* firewall permissions problems, we will need to ensure that users inside the *NHSnet* can gain Internet access to the 6WINIT EHR server.

### 3.10.2 Server Applications

The server operating system and IPv6-enabling applications are shown on the diagram below which depicts the 6WINIT EHR server hosted at CHIME, tunnelled to the UCL Computer Science department and connected to a range of possible client locations.



### 3.10.3 Security

The use of pseudonymised data originating from the University network has minimal security requirements in comparison with real patient electronic health records originating from one or more healthcare settings. However, the London demonstrator should aim to incorporate a complete and realistic set of security components as far as possible, in order to give health service (and wider) credibility to the 6WINIT solutions.

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The issues that need to be tackled are:

- end-user strong authentication, using token based or biometric techniques, using TTP services;
- encryption for transfers over public networks;
- reliability of connection;
- stability of connection, despite user mobility, within one GPRS cell; (seamless wandering across GPRS cells is not required for the London demonstrator).

Several other security, access control and audit trail requirements listed in Section 3.5 above are being incorporated into the EHR server itself.

## 4 ACRONYMS AND ABBREVIATIONS

<b>Acronym</b>	<b>Meaning</b>
6WINIT	IPv6 Wireless INternet IniTiative
API	Application Level Interface
CCU	Coronary Care Unit
CEN	Comit, Européen de Normalisation
CHIME	Centre for Health Informatics and Multi-professional Education
DNS	Domain Name Server
ECG	Electrocardiogram/graphy
EHR	Electronic Healthcare Record
EPR	Electronic Patient Record
GANS	Guardian ANgel System (UKT-RUS)
GB	Gigabyte (10 <sup>9</sup> bytes)
GPRS	General Packet Radio Service
HTML	HyperText Mark-up Language
HTTP	HyperText Transfer Protocol
ICU	Intensive Care Unit
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IPSec	IP Security Protocol
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
IST	Information Society Technologies
JPEG	Joint Photographic Experts' Group
LDAP	Lightweight Directory Access Protocol
MAN	Metropolitan Area Network
Mb/s	Megabits per second
NHS	National Health Service (United Kingdom)
PCM	Pulse Code Modulation
PDA	Personal Digital Assistant
PKCS	Public-Key Cryptography Standard
PKI	Public Key Infrastructure
QoS	Quality of Service

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RFC	(Internet) Request for Comments
RSA	Rivest-Shamir-Adleman (encryption algorithm)
RUS	Rechenzentrum Universität Stuttgart
SSL	Secure Socket Layer
UCL	University College London
UKT	Universitätsklinikum Tübingen
UMM	University of Mining and Metallurgy (Kraków, Poland)
UMTS	Univeral Mobile Telecommunications System
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
W3C	World-Wide Web Consortium
WAP	Wireless Application Protocol
WLAN	Wireless Local Area Network
WML	Wireless Mark-up Language