WORKFLOW MANAGEMENT SYSTEMS:
THE HEALTHCARE TECHNOLOGY OF THE FUTURE?

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Abstract - **In recent years, healthcare institutions have had problems accessing and maintaining the large amounts of data they deal with. This paper identifies current approaches and technologies which relate to patient administration systems. It argues that, in the near future, WWW-based multimedia patient administration systems would become the norm for healthcare institutions. The development and acceptance of web-based multimedia patient administration systems is likely to aggravate the problem of healthcare institutions being flooded with large amounts of clinical data. A large amount of clinical procedures relating to patient management are repetitive and Workflow Management Systems (WFMS) can automate these repeated activities. We believe that the introduction of WFMS would enable healthcare institutions to face this challenge of transforming large amounts of medical data into contextually relevant clinical information. The central contention of this paper is that there is a dynamic connection between healthcare, workflow and internet technologies, which is being ignored. This paper further establishes that it is possible to build a virtual electronic health record database based on the client server architecture using current internet and object-oriented (OO) technologies**.

Keywords - **E-healthcare, business process reengineering, mobile computing, internet, client server architectures**

I. INTRODUCTION

This paper postulates that the World Wide Web is a suitable base for using workflow technologies in the context of healthcare. Major technologies (such as mobile computing, CGI, JavaScript, Java applets, Java servlets and Dynamic HTML) can be used to provide workflow over the internet. Applying this to mobile computing, the minimum design propositions for a web-based WFMS are then explored. We conclude that a healthcare-based Workflow Management System (WFMS), using Object Oriented (OO) technology, has to be distributed and heterogeneous and that the World Wide Web (WWW) is a suitable base for using workflow technologies.

II. MODERN HEALTHCARE SYSTEM

Two mornings a week Mr Tanaka Nobutsune, an 83-year-old retired farmer and resident of Yamada Village (Japan), rises to pray to Buddha and then does something quite different. He slips on a blood-pressure cuff and heart-rate monitor, which are attached to a machine. The screen commences its interaction with a good morning greeting. Mr Nobutsune inputs his answers to a series of questions (temperature, weight, etc) about his health.

Within seconds, his vital signs are sent via the WWW to the local public health clinic, where healthcare professionals are able to decide whether Mr Nobutsune would require an urgent visit by the doctor or if a routine appointment needs to be scheduled [1].

A. Hypothetical Healthcare System Scenario in 2010

To illustrate and validate the possibility of a healthcare-based WFMS, we have drawn up a hypothetical scenario of a futuristic healthcare system, which is described below in two parts.

Part I - Year 2005. Mr John Doe has just been admitted to the hospital. During the admission process, the nurse takes his NHS (the UK National Health Service) identification number and attaches a bar-coded wristband. This bar-coded wristband wirelessly transmits his vital signs to a wireless hand-held computer, which retrieves his Electronic Patient Record (EPR) file from the NHS data warehouse. The hospital staff now have access to John Doe's entire medical history, such as his previous and current medications. This assists the physician in patient diagnosis by ensuring that the right amount of medication is given to the patient and he does not have any drug reactions or allergies with the medication being prescribed. The patient is finally diagnosed and treated for hypertension. As a precaution, he has to wear the wristband continuously on a 24 hour basis**.**

Part II - Year 2010. John Doe is on a hiking trip in Scotland. Suddenly, he feels uneasy and cannot walk any further. His vital cardiac signs have crossed the normal threshold barrier. This triggers the bar-coded wristband to transmit all his vital signs details and his current geographical location to the NHS data warehouse, which in turn transmits them to the nearest hospital. The nearest hospital sends an ambulance over to pick him up. By the time John Doe arrives to the hospital, the cardiologist has already gone through his entire medical record and exchanged notes with his regular GP and the doctors who had treated him in 2005. John Doe undergoes an emergency heart bypass surgical procedure successfully. At the time of writing, a similar technology initiative (as described in part A) is currently in use at the West Park Hospital in Toronto [2]. The wireless technology described above is based on an IEEE Personal Communications article [3] and is likely to be a regular feature of any futuristic healthcare system**.**

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A broad model, which might have the potential to make the above hypothetical scenario of a healthcare system a reality by the year 2010, is introduced in an evolutionary manner below.

III. WORKFLOW

Today the World Wide Web continues to be the most widely used and rapidly growing internet application. The internet, in conjunction with other related technologies, has been the focal instrument in orchestrating massive changes in healthcare and in the workplace. The internet and its applications have also influenced directions in software development. An increased number of software developers have started to engineer internet based client-server models. This is a major shift from the intranet-based client-server networking model.

Workflow involves the automation of a business process in order to support and complement the transition of information and tasks between organisational actors. Workflow becomes important in those sectors or industries that have to deal with vast amounts of information and, in particular, where timely receipt of information is of the essence. The healthcare domain is one such arena which fits the above bill. The difference in the rate of dissemination of information can be the crucial difference between life and death. Research regarding the driving forces behind the e-healthcare workflow domain is therefore crucial.

Workflow Management Systems in the healthcare context may have tremendous potential as they can deliver an array of services - at significantly lower cost - while enhancing the quality of the service. At a basic level, WFMS can automate complex administrative procedures, leaving clinical staff with time for real, potentially life-saving, clinical procedures. WFMS have the potential to enhance both efficiency and effectiveness in healthcare. Workflows involve automation of complex procedures that include both clinical and administrative tasks, thereby improving productivity.

A. Workflow and the Internet

The Workflow Management Coalition has published a white paper on the impact of workflow in conjunction with internet technologies [4]. They believe that, taken together, workflow and the internet have the potential to bring about surprising results. The coalition believe that this is possible as significant changes will be realised by associating the "unprecedented information communication capabilities of the Internet with the strategic business processes automation and integration capabilities of workflow engines" [4].

They believe that this would subsequently lead to an acceleration of productivity improvement within information-related activities, which would allow new forms of work to flourish. These new work forms include virtual enterprises which are formed for the duration of a specific project and

which bring together collaborating organisations regardless of their physical location worldwide.

There has been a shift in the way the internet is being used. Initially the internet was primarily used by individuals, for correspondence (email, newsgroups) or to visit different sites on the net. The internet is now being seen as a medium, which is supporting development of electronic commerce between individuals and companies [5]. The success of Java (an object-oriented portable language) helps in confronting the heterogeneity problem and is leading the way to a generic computer-connectivity technology of the future. We believe that internet technologies have a critical role to play in E-healthcare systems of the future and that WFMS can accelerate their contribution to telehealth.

B. Mobile Computing and Workflow

The success of second-generation wireless networks has led to an explosion in the use of wireless applications to transfer voice and data services. This, in turn, has raised the possibility that future wireless networks might support cost-effective broadband multimedia services [6]. Technologies such as Wireless Application Protocol (WAP) have enabled patients and doctors to remain in closer contact. There are successful WAP-based products (such as LifeChart.com) through which doctors can monitor online their patient's condition, and take care of their healthcare needs (eg. view test results and prescribe medication) [7].

Another example of the use of WAP is *WirelessMed*, through which UK Doctors have wireless access to clinical data on Medline, the largest US government database comprising more than 12 million medical references (which supports download speeds of up to 400-words in few seconds). Another example of WAP-enabled healthcare products is *MedicinePlanet*, which aims to bring local health information (local health news, current health alerts, details on local healthcare system) to travellers using mobile phones [7]. WAP technology is facing strong competition from other medical wireless systems based around PDA (Personal Digital Assistant) platforms, which support downloads of a standard patient image in 10-15 seconds [8].

The main disadvantages of mobile computing (limited battery and processor power) should diminish [3] as new technologies, allowing higher bandwidths, are introduced onto the market. Workflow-based applications, in conjunction with mobile computing technologies such as WAP and PDA, have the potential to transform the delivery of healthcare information.

IV. E-HEALTHCARE

The European healthcare-IT share of the market has been estimated at 14 billion Euros per annum [9]. This represents 6% of the European IT market and 2% of the overall European Healthcare market.

This market is expected to double in size within the next five years [9]. A key trend in E-Healthcare is that large numbers of new consumers expect to have a proactive role in management of their health. Interest in health and medical information sites is now ranked in the top three of citizens' interest in online services.

Despite the presence of a multitude of elements which affect E-healthcare and its sub-domains, such as telehealth and telemedicine, it is possible to reduce these elements to three fundamental areas: technological, business and social [10]. In order to successfully exploit the social and economic benefits that are emerging as a result of E-healthcare, it is important to fully understand the developments in technology, social considerations, government fiscal policy and business objectives [11,12].

E-Healthcare is fast becoming an important issue, as managers are under increasing pressure to provide cost-effective healthcare. Workflows and associated internet technologies are being seen as an invaluable means to cut administrative expenses. One way to provide cost-effective healthcare, without compromising on quality, is to use IT implementations such as workflow tools which are designed specifically to automate the electronic paper flow in a managed care operation - thereby cutting administrative expenses [13].

A. EPR and E-Healthcare

WFMS can cut administrative expenses and improve communication by focusing on the EPR system. One of the big drawbacks of telemedicine is that most systems force the caregiver to look at medical issues in isolation. More detailed information (for example, the patient's medical history) might help in arriving at a better-informed medical diagnosis [14].

TABLE I
IMPLEMENTATION LEVELS OF THE UK NHS EPR SYSTEM

EPR Level Benefits	Overview
Level 1	Partial Patient Administration System (PAS).
Level 2	PAS outpatients, waiting list and case note tracking, contracting nursing, Accident & Emergency (A&E)
Level 3	Virtually full order communications / results reporting, some clinical systems, care planning and multi-disciplinary care
Level 4	Electronic prescribing, some development of clinical decision support, initial implementations of workflow & imaging systems
Level 5	Availability of full electronic patient records, extensive clinical decision support, workflow and imaging, case notes no longer stored on paper
Level 6	Full multimedia Information Management & Technology (IM&T) support of clinical process, available to clinicians at point of delivery of care, includes patient scans, graphs, x-rays, drawings, photos, video

Initial web-based multimedia patient records systems have been developed which allow telecaregivers remote access to a patient's entire medical history [14]. We believe that in the future, web-based multimedia patient administration systems will be the norm for healthcare institutions. A similar concept has been put forward by the NHS in the UK, which states that it is possible for a healthcare institution to adopt an Electronic Patient Record (EPR) system at six varying levels of implementation [15,16]. Each higher level of implementation will give value added services in a healthcare context. The demand for fully-fledged WFMS starts at level 4 and is realised at level 6. Table I summarises the advantages that healthcare institutions can obtain at each of the six implementation stages [15].

V. ELECTRONIC HEALTH RECORDS

If a virtual Electronic Health Record (EHR) system becomes a reality, all the data contained within it would not reside in one place, but at a number of sites, possibly at different levels. The advantages of a virtual EHR system would include a substantial reduction in minimum system requirements in creating and maintaining large data warehouses and repositories, thereby reducing costs. In the future, healthcare organisations would stand to gain by adopting EPR systems as this would ensure that staff are in a position to spend more time for direct patient care, rather then on administrative activities.

These virtual EHRs would reside on a virtual database server, which would act much like a data warehouse and which would house all the electronic health records. Any authorised person, after due user identification, would have access to the database. Their rights would be based upon their status (administrator, nurse, doctor). To the user, the database would appear to house all the data at one place but the implementation would be carried out separately for each sub-component (laboratory, document imaging, radiology, pathology, anaesthesiology).

Figure 1 depicts the design and system architecture of a proposed web-based WFMS for oncology. The client's system (doctor or cancer specialist) would access the virtual electronic health record database by using a web-enabled WFMS [Step 1]. A secure sockets layer (SSL) protocol would provide support for client's authentication and for the security of information being transmitted [Step 2]. The cloud represents a *"master"* (the internet) which would be used to locate the closest repositories which support the virtual electronic health record database [Step 3].

The web-based server would invoke the workflow management system to interact with the client and ascertain the request [Step 3]. The WFMS will interact with the concerned sub-components which house the patient's electronic health records [Steps 4 and 5]. As such, there could be multiple repositories all over Europe.

Once all the requisite information is collected, it would be transmitted back to the original repository, which had made contact with the client. However, all the information transmitted would be sent to all parties concerned with the

care of the patient. In this case, it would go to the GP (General Practitioner) and cancer specialists [Steps 6 to 10]. This will have a two-fold effect; firstly, all the caregivers would be kept informed and, secondly, there would be a record of all the people who access the database.
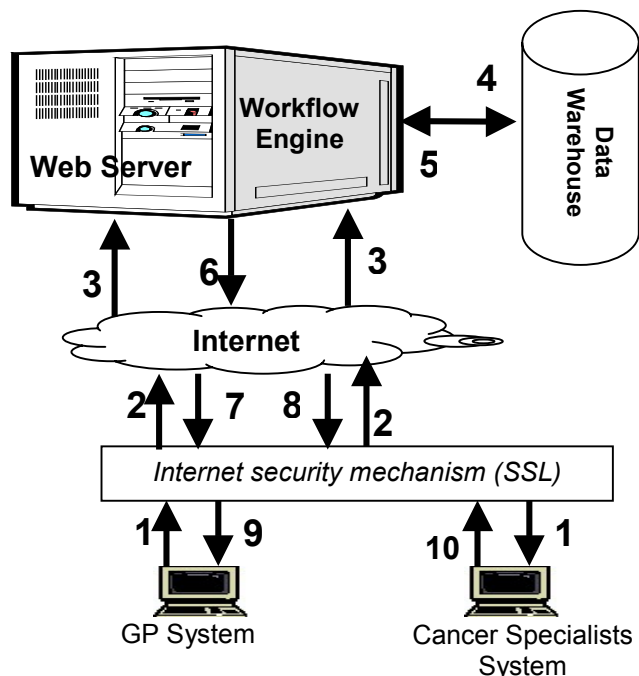

Fig. 1. Proposed web-based WFMS.

Many of the issues discussed in this paper have been put forward from a theoretical perspective. This does not mean that the technologies discussed do not have any practical applications. The innovations presented in the paper have been implemented on a stand-alone basis or in conjunction with other technologies. However, the innovations discussed have not been combined and implemented as one entity. Since the same architecture is being used for other purposes, such as E-commerce, there is no reason to believe that the same architecture could not be effective for a wireless workflow healthcare system.

VI. CONCLUSIONS

This paper argues that WWW-based multimedia patient administration systems would become the norm for healthcare institutions. The development and acceptance of web-based multimedia patient administration systems is likely to aggravate the problem of healthcare institutions being flooded with large amounts of clinical data.

We believe that the introduction of the WFMS paradigm would enable healthcare institutions to face the challenge of transforming large amounts of medical data into relevant contextual clinical information. WFMSs can automate complex administrative procedures, saving time for clinical procedures, thereby improving productivity and saving lives.

Healthcare can be used as an ideal vehicle to introduce workflow technology. A healthcare WFMS of the future would have to cope with heterogeneity in terms of different networks, protocols, operating systems, and hardware and application platforms. These paradigms constitute major areas of research in their own right and there is no comprehensive solution in sight. We conclude that much work still needs to be done in this area in order to ensure a commercially viable healthcare WFMS.

Web-based multimedia patient administration systems in conjunction with internet and workflow technology has the potential of orchestrating massive changes in healthcare, a potential which unfortunately has been ignored for too long by healthcare researchers and practitioners.

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