

The European Journal of Surgical Oncology and the Internet II—World Wide Web standard networks and clinical applications

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Applications of intranets

In the first of these articles, we described some of the key concepts and components of World Wide Web derived private networks. In the second article, we consider the practical applications in medicine, education and scientific journal publishing.

Time management and resource planning

Web-enabled networks offer considerable utility to medical institutions and to doctors. Web technology promises to increase efficiency and to reduce paperwork by making information rapidly and widely available in a common format at low unit cost. One simple example of such an application for an intranet in a hospital would be the publication of the internal telephone directory and of staffing lists. Such databases can be updated immediately and accessed on an intranet, without the delays of a printed version. Cost and efficiency savings over printed paper systems may be considerable.

Intranets may also be useful for the co-ordination of activities between individuals and departments. Applications include timetabling, seminar and workshop scheduling and resource planning. Much of the information in the professional diary has utility to other authorized users. This might include the timetable of clinical commitments and work schedules of each doctor, the timing of meetings, teaching schedules and planned absences. Most usefully, intranet diary entries may be linked to relevant documents and other information, such as the minutes of a meeting or directions to a venue, without the need for transmission, storage and retrieval of paper documents.

Other examples of administrative information of direct utility to doctors include the telephone directory, nursing and medical care protocols, codes of practice and standing orders for procedures, newsletters and notice boards.

Electronic mail

Electronic mail (E-mail) expedites communication, by virtue of its speed, ease of use, simplicity of format and low cost. Each user of E-mail has a unique personal address, often

linked to the host organization. The address identifies a mail box rather than the physical location of the addressee, unlike most conventional mail. Thus, dar2@le.ac.uk identifies the Associate Editor's mail box on the Leicester University computer (le) in the academic domain (ac) in the United Kingdom (UK). The mail can be read by the recipient from any computer terminal which will access the host computer's mailbox. E-mail long predates intranets, extranets and the World Wide Web (WWW), but its utility has been substantially increased by its incorporation within Web browser software. Thus, an E-mail address which is displayed on a Web page can be reached by pointing and clicking without the need to retype the address. Within a Web-enabled network, E-mail is an important function which can obviate the need for much paper communication.

Hospital information systems

The larger a paper-based organization becomes, the greater the inertia and inefficiency in its information management. The adoption of computers and networks into paper-intensive health care organizations has been piecemeal and erratic over decades, with incompatibilities, lack of interoperability, and excessive costs. Many hospitals are already equipped with one or more administrative computer networks, which are often complex and incompatible, including patient administration (PAS) systems, pathology and radiology databases and clinical audit systems. Each requires separate training and maintenance skills, and separate data entry with attendant inefficiencies and costs. Web technology should allow consolidation and integration of diverse information systems.

Clinical data systems

Patient-sensitive data fit several categories. These include patient registration and administration (PAS) data, such as clinic bookings, admission and discharge records; patient medical records, such as remain paper-based and handwritten; and patient-specific medical data, such as pathology, biochemistry and pathology records, which are commonly computerized. Nursing records form a major additional component of clinical data sets.

The format of clinical medical records lends itself

naturally to the structure of the Web page. We can conceive an electronic format whereby each patient registration set is in effect presented as a Web page. Each would 'hot link' to the various components of the patient data set, such as pathology results, and to the stored images of written documents relating to patient care. One example of a Web-enabled, intranet-supported clinical records system under development is the Electronic Medical Records System (W3-EMRS) based on Web technology,^{w4} and similar models could be conceived for clinical oncology.

Electronic medical records are unlikely to supplant paper-based notes entirely. Nevertheless, benefits may be gained from the electronic storage and networking of clinical information. Advances in archiving systems, for example writable CD-ROM technology, document image storage systems and high capacity disc drives, now allow cost-effective permanent data storage and access. These benefits include the administrative savings from reducing the number of repetitive registration data entries, and the clinical benefits of audit, trials, epidemiology and treatment data. Other benefits include the speed of transmission of records between remote sites, and the simplification of access to the data contained within complex medical records.

Drug development

Industry and commerce provide many examples of practical benefits to be obtained from intranets.^{w1 w3} For example, the transmission of pharmaceutical research data on intranets speeds up drug development. Intranets allow the huge volumes of data associated with new drug modelling and peptide and nucleic acid sequence comparison, to be exchanged such that drug development times are substantially reduced. Pharmaceutical company intranets may be used to publish reports, white papers, meeting schedules and research data in a form which is immediately available to thousands of employees. Such networks also allow manipulation and analysis of raw data at remote sites, and collaborations with other companies, regulatory bodies and university groups.

Comprehensive medical information and decision support systems

The demand for evidence-based medicine imposes new pressures on professional practice to keep abreast of the growth in specialist knowledge and of media articles relating to a particular field. Immediate access to the information on the public Internet and on specialist intranets may facilitate the clinical consultation. One use of this process is in decision support, wherein patient specific data entered into computer programs is used to aid diagnosis and to optimize treatment.^{w4} We may thus expect to see the emergence of professional knowledge-based systems founded on the Web which will offer sufficient speed of access and utility as to become a natural extension of professional practice.

Internet technologies can provide diverse educational materials and formats, including text, sound, images and video, through one simple interface. Such systems are particularly useful for distributed health care away from

centres of expertise. They find applications for shield medical workers, for the health services of developing countries, for doctors in training, and in continuing medical education. The ease of production of Web pages and databases allows educational material to be produced from diverse sources, including individual educators, universities, publishing houses, public service bodies, government agencies and charities. This facility anticipates a major growth in such resources.

Applications of extranets

Once an intranet has been established, its interconnections will grow, so that an extranet emerges. Extranets may be purpose-built, or they may emerge as private networks of networks within the Internet. Information links expand inexorably into new fields on the Internet. The technology is already in place to ensure that this will happen, the principal constraint on the uncontrolled growth of extranets being the ability to control, organize, access and utilize the information therein.

Extranets will find many uses in health care systems where administrative needs extend outside one hospital site. There may be natural links to other hospitals in a group, to primary practitioners in a health care district, or to local administrative and administrative agencies, or to commercial suppliers such as health insurance organizations, medical equipment manufacturers and pharmaceutical companies. In the short to medium term, we may expect useful healthcare extranets to emerge locally, regionally, nationally and internationally, for administrative, academic, educational and commercial purposes, and we may consider examples in each category.

Local and regional links

Dispersed health care services should benefit from Web-enabled networking. Many hospital services and management centres are distributed over several geographical sites in a city or locality, or may comprise smaller community or satellite units linked to a central hospital. The benefits of networking these units is clear for administrative purposes. The extension and linkage of computerized hospital-based patient administration to family doctors and primary care agencies would be a natural development. The exchange of non-sensitive data with local family practitioners, which might include waiting list times, booking of services, the availability of specialists for consultation, local post-graduate education programmes and local treatment protocols for common diseases (to reduce the costs and need for hospital referral and consultation).

District extranets will link naturally together, creating regional networks. Hospitals are often grouped in regions, with shared administrative interests and processes, as is the case in the UK's National Health Service. Groups of hospitals may share in the financial economies of scale from sharing common suppliers or services, and from clinical

economies of scale derived from regional specialist referral centres.

National and international links

Much of the information generated within the health system needs to be collated and distributed for political, economic and public health reasons. Conversely, information and instructions need to be disseminated from centralized agencies such as the National Departments of Health. Electronic networking of health service data seems likely to offer considerable benefits to medical policy-makers.

Within the health service context, international networking may find important applications. These might include: the issuing of public health information, such as about communicable diseases; the exchange of data for health economists; the harmonization of standards of practice; employment practice, for example in relation to Europe-wide job mobility for health professionals.

Network applications in medical education and research

Undergraduate and post-graduate teaching systems

Computer networks may radically change the delivery and consumption of higher education. In the hospital context, this may allow greater geographical devolution of medical teaching from the university centres, and the enhancement of distance-learning systems for students at dispersed and remote hospitals. This may cross national boundaries. For example, students in one country may register for courses run by centres of excellence anywhere in the world. The concept of the British Open University anticipates such an educational model.

Networks may contribute greatly to undergraduate and post-graduate teaching within and between educational institutions, so a student no longer need register with one university or professional college, but may move between curriculae with ease. As students gain greater access to computer networks, so these may be developed to provide supplementary course material, including audiovisual material; links to library and reference materials; and the decentralization of educational establishments to peripheral health centres, campuses and private homes.

Continuing medical education (CME)

CME is now a major issue in professional development, and one to which the *European Journal of Surgical Oncology* attaches great importance. The public Internet and closed, professionally accessible extranets, offer limitless opportunities for distributed multimedia learning. Distributed learning may be undertaken at home or at work, and offers considerable efficiencies over centralized teaching systems in cost, time and travel. For example, the publication of a post-graduate lecture on the Net can reach a much wider audience than may attend the public presentation, and over a longer period of time. Extranets are a natural extension of the distributed learning systems

which have been developed in recent years for doctors in training, such as the STEP programme of the Royal College of Surgeons of England,^{W5} and will take advantage of all multimedia functions, including sound and video.

Clinical trials data collation

Many aspects of the organization and administration of clinical trials lend themselves to networking, including planning, information exchange, the recruitment of clinical participants; anonymized patient registration; and the dissemination of results. While confidential diagnostic and treatment data are not yet considered appropriate for network transmission and dissemination, every patient and clinical episode generates information about cancer epidemiology, treatment and outcomes. The core information is usually stored on paper or microfiche, by individual clinicians and units. The global utility of this information is lost because the volume, format and problems of access prevent its interrogation by epidemiologists, researchers and clinicians.

Web technologies with appropriate security protection will simplify the interrogation of these data. Such systems, extended to oncology data, would allow pan-national registration of anonymized clinical data sets on large numbers of patients, for example, providing new insights into the outcome of complex therapeutic strategies, and overcoming many of the problems of organizing randomized controlled trials.

Journal publishing

Networking offers particular attractions in the production and dissemination of a specialist international journal such as the *European Journal of Surgical Oncology*. In the context of scientific journal publishing, intranets may be considered to include all components of the editorial and production process. Such applications may extend throughout the production process, allowing a seamless and rapid flow of information through the system, including manuscript submission by authors, manuscript transmission to referees, manuscript amendment and copy-editing by editorial staff, and manuscript publication in paper and electronic form.

The implementation of intranets and extranets

The costs of implementing a simple intranet are now marginal, in terms of the purchase of computer hardware and software. However the running costs may be disproportionate, unless care is taken with project design from the outset. Potential problems include the management of user access; document version control; server and communications infrastructure scalability as the system grows; security and interoperability; accountability for accuracy of sensitive material; and system availability requirements. Plans must be laid for an alternative resource if the server breaks down, for reducing dependence on vital equipments, and for the data recovery strategy in the face of damage or catastrophic failure. All of these problems multiply geometrically as the system expands.

The key challenges in the implementation of an effective intranet in professional medical practice, as elsewhere, relate to the potential users and to the human factor. Networks require a change in working practice from paper based media to the computer screen. This process is as much about attitudes as about economics, hardware and software. The key advantage of Web-based technologies is the simplicity and commonality of the interfaces and the ease of exploration and mobility within the network. These critical features minimize training and adaptation times and costs, and the skills for the general user are directly transferable to the public Internet. The rapid growth of the Internet will in any case ensure increasing familiarity with Net software, hardware and terminology among general and professional users.

Conversely, successful implementation requires that the new, Web-based systems remain as close to current working practices as possible. The design of professional information networks must thus involve the clinical end-user. Thus, to be used and to be useful, closed and open networks must be readily available at the points of use, with the ease of access and speed of response of internal and external telephone networks. Rapid development of the Internet's hardware and software infrastructure will ensure that current difficulties over access and speed of use will diminish with additional capacity on the Internet. With this will be a growing maturity in use.

Conclusions

The information revolution still has a long way to run, but its direction and irreversibility are now beyond doubt. Its impact on professional practice has yet to be fully absorbed,

but it will certainly modify and enrich the work patterns of surgeons and oncologists over time, and improve the efficiency of information exchange in the health services. Intranets and extranets are the framework upon which change now seems likely to be implemented, as the constraints on communication between professionals imposed by time and place are further eroded.

Information networks in oncology will increasingly influence patient care. Better data interrogation, management and exchange may help to reveal new or hidden patterns in current treatment modalities, and should aid the development of new treatments in laboratories and in clinical trials. Professional recognition of the beneficial potential of WWW standard networks may hasten their introduction into European Oncological practice.

References

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 The Internet: bringing order from chaos. *Scient Am* 1997; **276**: 41-73.

Relevant WWW sites

- (prefixed by <http://www.>)
 W1. glaxowellcome.co.uk
 W2. biochem.ucl.ac.uk
 W3. relay.co.uk
 W4. healthgate.com
 W5. rsc.ac.uk

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Scholarships

The European Society of Surgical Oncology announces two scholarships of BEF 50.000 each

The scholarships are intended to support a 2 to 3 week visit to a European institution for a professional education and/or training within a field relevant to surgical oncology. Participation to a course relevant to education within the field of surgical oncology can also be supported. Congress travel will not be included.

The application should contain the following: motivation; information about current position and professional education plan; a letter of recommendation from Head of the Department; letter of invitation from the host institution or course curriculum; and statement of research activities and publication.

The applicant should be a member of ESSO. Priority will be given to junior doctors seeking education and training within developing fields.

Applications should be sent to: Associate Professor Lars Holmberg, Department of Surgery, University Hospital, S-751 85 Uppsala, Sweden. Fax: +46 18 556808.