
The *European Journal of Surgical Oncology* and the Internet I—Clinical networks: technology, definitions and structures

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Introduction

The *European Journal of Surgical Oncology* is exploring strategies for integrating scientific publication with the opportunities provided by the World Wide Web (WWW). For many readers, the Internet and the World Wide Web will still be relatively unfamiliar territory. The speed of change and the ceaseless flow of new technologies and terminologies may cause considerable confusion to the casual observer. In order to help our readers to understand and to make the best professional use of this new medium, the Journal proposes to publish educational articles about relevant developments on the Internet from time to time.

The advantages and opportunities of the Internet for scientific and professional communities are now well established.^{1,2} Standard technologies, software and protocols are changing the ways in which individuals can communicate and cooperate. New software systems in the early 1990s have transformed the ease of use of the Internet and have created the World Wide Web, the most visible and widely used component of the Internet. The Web has its origins in scientific publishing. The idea of the Web grew out of work at CERN in Geneva. By early in 1990, the original Hypertext Transfer Protocol (HTTP) and Hypertext Markup Language (HTML) tools which allow the Web to function were defined.

The same formats which allow public communication on the Web can also improve private communication within and between organizations. In two articles, we aim to show how the general technology of the WWW can be adapted to more parochial professional network applications. WWW-based systems are now being applied to the internal computer networks of large and small commercial and public organizations, including hospitals and universities.

In the first article, we introduce and define the concept of Web networks and their components. In the second article, we discuss possible applications, including those in scientific journal publishing.

Terms and definitions

The *Web page* is the basic component of information presentation on the Internet. It comprises the navigational

aids (for example, forward and reverse buttons) and information (network addresses) which allow the user to move with ease through the structure of the network. The information capacity of a page is limited to the capacity of one or a few computer screens. Thus, large data sets need to be organized over a number of pages. The core method of connecting between pages is *the hypertext link*, whereby highlighted words and phrases are invisibly linked to the network addresses of related data. 'Point and click' browsing takes the reader to the relevant link, which may be within the same computer database (or Web site), or anywhere else worldwide on the Internet.

An *intranet* is a private internal computer network based on Internet (TCP/IP) and WWW (HTTP) protocols and formats. It allows the exchange of many forms of data, including image and data files, diagrams and charts, printed documents, voice, audio and video transmission. It may be physically and geographically discrete, as within a single building, locality or campus. In this case, it may comprise a Local Area Network (LAN) of wiring and infrastructure, for security, efficiency and high data carrying capacity. Alternatively, an Intranet may be geographically dispersed over a public communications network among users who share a common function or purpose, in which case the internal security of the network is sustained by software systems and codes.

Intranets have been widely adopted in commerce for a number of reasons. Modified Internet software and components based upon open standards impose simplicity and consistency on diverse and otherwise incompatible systems. They can be added retrospectively onto existing computer systems. They transform many data communication, archiving, storage, updating and retrieval processes. Systems developed on different sites, at different times, running on different computer and network systems can still work together and be integrated. There is no dependence upon a single vendor of system and support products; and the size and competitive nature of the technical base continually drives up the functionality of the key technologies whilst their cost is reducing.

An *extranet* is a private multisite network designed to WWW formats between organizations who share a common purpose but who need to restrict access to the information therein. It may comprise a number of linked intranets, or

it may be a central intranet with a number of remote users and terminals. Examples might include the links between a health insurance company and its affiliated hospitals, or a journal and its subscribers.

The intranet and extranet definitions are not mutually exclusive. Both forms of network will change in time and place as their functions and users are changed, such that the definitions will blur. They will often be linked with the public Internet, both to allow the internal users access to the benefits of the WWW, and to publish electronic information for the benefit of external electronic visitors, such as customers, to the organization. The local Web-enabled network will thus be defined according to the levels of control and access allocated to different users and to the needs of different components and individuals within it.

The structure of intranets and extranets

The linking of two or more computers with the facility for communication between them creates the opportunity for a network. Each terminal on any network subserves two functions, data submission and retrieval. In older systems, network terminals were dumb, in that they were merely a window to the central computer. In modern systems, each terminal is usually a personal computer (PC) which can be used independently of the main server. Most PCs can be networked, by using wire or radiotelephony connections, and by using appropriate software. The networking of computers may be non-hierarchical, in which case each machine has equal importance in the network. Alternatively, it may be fully distributed, with client machines serviced by a central computer, known as the central server of the network. Modern personal computers are now so powerful that with minor modifications they can subsume the role of a central server once filled by much larger and more expensive machines.

Each computer on a network needs a linkage device to the network. Computers may be linked to the LAN on which the Intranet is running by one of two methods—either a permanent, high-bandwidth connection such as Ethernet, or as a dial-up connection via modem or ISDN. The linkage device may be built into the computer or connected externally. Dial-up connections through modems, such as are available to most home users, tend to offer much lower data rates, typically in the range 28.8k–64k bits/s. Modems convert computer-generated digital signals to analogue form for public network transmission. This constrains the volume of data that may be transmitted. They are best suited to text rather than to data-intensive image transmission, and for low volume, home or mobile connections, including links through mobile digital phones to the public radiotelephony networks.

Conventional analogue telephony is universally available but slower and less secure to use than dedicated circuits. ISDN increases the data capacity of public telephony to around 100 kbits/s on conventional copper cable networks by using two lines for data transmission. Fibre-optic cables have a much higher digital data transmission capacity, of between 10Mbit/s and 100Mbit/s. This allows the transmission of digitized images such as video, or X-ray

films. Such cables form the backbone of many national transmission networks in Europe. Other high capacity dedicated networks include the British Joint Academic Network (JANET). Buildings such as hospitals, offices or research laboratories are now usually fitted with dedicated cables to allow large volumes of secure data and imagery to be transmitted on internal LANS.

Software for intranets and extranets

A new lexicon of terms and names is associated with Web-enabled net software. The browser is the key software application which links the user to the Web. The two common browsers are Netscape's Navigator and Microsoft's Internet Explorer. These are similar in concept, in appearance and in use. Software standardization across different types of computer is a key feature of the simplicity and hence the popularity of the Web. HTML is the common language of the Web, allowing point and click movement through the Web. Documents can now be written automatically into HTML in modern word-processing packages, thus allowing users without programming skills to publish interactive web pages on their own networks.

JAVA and Active X are examples of proprietary standard languages which facilitate interactive applications (or applets) and subroutines on the Web. Thus, for example, an applet on an oncology page might be a nomogram to calculate the optimum dosage for a cytotoxic drug.

Data structure on the Web-enabled network

Data published on a network may be either static (read-only) or dynamic (interactive). In the former case, the page publisher will post the information which the visiting browser may read. In the latter case, the visitor may also wish to modify the database, as, for example, an outpatient clinic booking clerk updating attendance records. Whatever the form and use, Web data must be organized in a disciplined, hierarchical and preplanned fashion, so that a reader or searcher can move through the database and the Web pages in a simple and efficient manner.

Thus, for example, a hospital may choose to organize its patient database on WWW lines. Each patient may thus be allocated a Web record, in which the top page contains the person's registration data set and list of attendances or admissions. Each admission might then generate its own Web page, which may comprise a summary of the admission, with hot links to the pathology and X-ray databases for results of investigations. Further hot links may connect to other relevant information, for example about a rare condition. To extend the analogy, a primary care practitioner

outside the hospital may have authorized access to the web pages of his or her own patients, thus developing the hospital's Intranet into a local professional extranet.

Search engines

Intranets and extranets may contain vast amounts of regularly changing information. Consider, for example, a database of a Health Insurance Company, or the patient registration data of a hospital. The utility of these data will be easily lost if they are not properly organized and accessible. Searching for information may be time-consuming and inefficient. The search engines of the public Internet are high-capacity computer systems which visit every page on the network and catalogue every significant word and phrase with its Web page address. Examples include Yahoo, Lycos and Alta Vista. Thus, a search for a word or phrase yields a structured list of every Web page on which the item appears, with hot links to that page. A search can be conducted very rapidly, and may reveal unexpected connections. Search engines using similar strategies have been adapted for use in closed networks and on individual personal computers.

Network co-ordination software

The efficient operation of all networks imposes particular demands on data management, to ensure that information is correctly updated and available at all points on the system, that security is maintained, that structure and order is imposed on the data, and that discipline and hierarchy are maintained. Software packages which help co-ordinate multiple users on networks, or 'collaborative' computing, predate the Internet. Pre-eminent among these has been Lotus Software's 'Notes' package. The WWW model appears to offer considerable advantages in data management and ease of use over earlier collaborative systems. Software on the central server co-ordinates the operation of the Local Net and its electronic security systems. It also ensures interoperability with the Web browsers used on each terminal. Each peripheral PC on the network will contain Web browser software which enables it to interact with the central server.

Security

Security of access and design also defines intranets and extranets. The intranet server must be set up to deny access to unauthorized users to confidential and internal information. This separation may be by physical isolation of data circuits, or by software controls, known as a firewall. The intranet also requires supervision. This is usually the task of the locally designated webmaster, an employee with overall responsibility for the structure, the operation and the security of the intranet.

Concerns about data security have been a major factor in determining the rate of introduction of computers into medical organizations. Much information of a confidential

and personal nature concerning both patients and health care personnel remains unsuitable for network transmission under current perceptions of computer security, and in accordance with social and political demands for confidentiality in health care computing.

We must therefore distinguish between information of a general administrative nature and sensitive medical record information. The latter raises important issues of patient confidentiality. Health providers are wary of transmitting patient records across computer networks because of legitimate concerns about data security. These attitudes may change if and when the safety and security of confidential data across publicly accessible telephone networks can be guaranteed. The technical problem is not the guarantee of security *per se*, but rather the trade-off between a given level of security and interoperability. The problem can be minimized with careful system design however, though not completely eliminated.

Moving data from behind an intranet firewall out to an extranet causes additional security problems. It is possible to design an intranet/extranet system with an acceptable level of privacy for sensitive data. However, higher levels of security impede interoperability between networks. The encryption technology which provides data security across open lines has yet to agree a set of universal standards. Various tunnelling protocols provide secure virtual private networks (VPNs) between authenticated users.

Virtual reality and the Web

The simple two-dimensional Web page format for information presentation, albeit with enhancements for hypertext links, video motion pictures and sound, has limitations. Many complex data sets are best understood as graphical imagery, including three dimensional formats. The technology of Virtual Reality also offers opportunities for data modelling. A new protocol, Virtual Reality Modelling Language, VMRL, has been created, for WWW and intranet use. Such developments may have a significant impact upon medical teaching and 3D medical imaging. Three-dimensional graphics may also aid use of the network. Thus, for example, a user of an intranet site may move through a three-dimensional world, entering resources, databanks and libraries through virtual doors and corridors. Such applications are not merely frivolous, but can aid the efficient use of the Net and the interpretation of complexity.

Summary

The *European Journal of Surgical Oncology* has been an early exponent of intranet technology in the publishing process. Documents are now prepared and manipulated within the publishing house, and can be posted on the Journal's Web site in the public domain, at which point they are accessible on the open network of the WWW. Many aspects of the publication process remain manual, including manuscript submission and refereeing. We may expect to move to a more electronic preparation medium in due course. In parallel with this, our readers may expect

to see a rapid introduction of network technologies into their own working environments over the next few years. In the second article, we will consider the practical applications of Web-enabled networks in professional practice.

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

References

1. Rew DA. <http://www.hbuk.co.uk>—the *European Journal of Surgical Oncology* and the Internet. *Eur J Surg Oncol* 1996; 22: 563–8.

Relevant WWW sites

(prefixed by <http://www.>)

W1. glaxowellcome.co.uk

W2. biochem.ucl.ac.uk

W3. relay.co.uk

W4. healthgate.com

W5. rcs.ac.uk

Answers

(to self-assessment exercise on p. 564)

1. The first part of the question is correct. It is, however, also applicable to confocal microscopy and thus enables subcellular structure and organization of individual cells to be studied.
2. That is correct. Also, such cells cannot be recalled and restudied. However, sub-populations can be isolated by cell sorting techniques.
3. This development has great versatility and can be used to analyse cell aspirates, smears, fluid collections as well as tumour specimens. In particular, it is being used to assess cytotoxic drug assays *in vitro* and fluorescein *in situ* hybridization (FISH) markers for chromosome analysis.
4. This is not correct. Laser scanning cytometry covers those aspects of biological assessment carried out by routine flow cytometry. For example, it can establish DNA ploidy, determine S-phase fraction, expression of oncogene, etc.
5. This is not always the case. Although most instances have been described in patients with upper and lower gastrointestinal cancers or in women with gynaecological cancers, extra-abdominal sources have been documented (e.g. lung).
6. On the contrary, Sister Joseph's nodule may be the presenting clinical sign in a substantial number of patients (up to 30%). Confirmation of diagnosis can be made by fine needle aspiration cytology and should lead to a thorough search for the occult primary cancer.
7. That is not correct. William Mayo first described this clinical feature in 1928 in the Proceedings of the Staff Meetings in the Mayo Clinic. However, Sister Joseph, a much valued surgical assistant of William Mayo, first drew Mayo's attention to her observations.
8. Umbilical metastases were recognized well before Mayo's publication. Several articles were published in the mid 19th century, the earliest being attributed to Walshe (*Nature and Treatment of Cancer*, Vol. 92, London, 1846).