A State of the Art Report on CSCW Technologies

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Abstract

This report provides a description of the state of the art with regard to Computer Supported Co-operative Work (CSCW) technologies as they relate to the DTI/EPSRC funded Integrated Co-operative Workspace project. A taxonomy of functions common to CSCW systems is presented and some exemplars of current commercial systems are described. The core functionalities of the ICW system are also explained and reference is made briefly to related research projects. A brief glossary of CSCW terminology is presented.

Keywords: Co-operative Systems, ICW, CSCW, Groupware
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1. Common CSCW Applications

**Shared diaries and calendars** are intended to provide support for the arrangement and organisation of meetings. Group members record their individual appointments and schedules in the electronic diary/calendar. When someone wants to arrange a meeting all available dates may then be discerned, possible automatically. The date and time for the new meeting may then be entered into all the required individual schedules. Problems can arise when no available times are forthcoming. Entries may be prioritised in order to allow high priority entries to override or suggestions may be electronically pencilled in to form the basis for negotiation. Individuals may object outright to having schedules arranged for them without consultation. There are also the related questions of privacy and security. The system may provide mechanisms for marking the details of entries ‘personal’ or of ‘restricted access’. Otherwise there will be a tendency for multiple diaries to be maintained and the success of shared systems depends in large part on their comprehensive patronage. Obviously, duplication and multiple diaries will render data-integrity difficult to maintain.

**Electronic mail** allows the transmission and reception of electronic messages which typically consist of various fields for specifying the recipient, subject matter and body of the message. Email systems typically provide an editing environment for the creation of messages and a viewing environment for reading mail. They will usually also provide means for managing messages in the form of storage, deletion etc. Apart from supplying a valid recipient address (which may be obtainable from a personal, organisational or global user directory), users do not need to concern themselves with the technicalities of transmission.

Email systems often offer a variety of functions to complement basic messaging. These include the ability to attach/insert files to messages, to broadcast to predefined or selected groups, to have receipt/reading of messages notified, to forward or reply to messages and to sort, search, save and print messages and attachments. Some systems also allow users to enter a ‘chat’ mode wherein direct communication is achieved with other users in a kind of text-based conference. More advanced functionality is provided by email systems which allow users to filter mail according to individual preferences. Structured message systems provide much more in the way of fields within the message according to which message/user behaviour can be directed (e.g. BeyondMail 2.0). The fields can be used, for example, to sort mail into particular directories according to subject, sender, priority or message type (e.g. memo/management edict etc). Email is often a central technology in so-called ‘workflow’ applications. **Voicemail** and **videomail** are extensions of the text-based mail system whereby sound or video messages replace or accompany textual messages.

**Forms** are essentially structured documents or messages. The structuring of the document into database-like fields allows operations and actions such as prioritising, filtering and routing to be based on field contents. The form itself may actually contain the rules which determine their own routing/scheduling etc. Forms may also be ‘typed’ for specific purposes so that only certain fields will appear, some of which may have default contents to lessen the burden on the sender in filling in the form. The structuring of documents and messages may be based around similar business type applications (e.g. tax return) or some abstract model of communication (e.g. Coordinator). Form based applications often also allow the user group to define their own document and message structures to meet their own needs and to allow for
changes in groupwork practices. Lotus Notes, Delrina Formflow and WordPerfect Office 4.0 are typical of forms-based systems, the latter two also incorporating a degree of workflow.

**Conferencing** capabilities have expanded with the development of high capacity data links and video compression techniques to allow real-time video and sound links between remote sites. These links can be used to arrange ‘meetings’ between distantly located sites in which participants are able to see each other as well as hear each other and exchange data without the need to travel. The ability to see the other party is considered important in introducing some of the features of face to face meetings into remote communications. However, there are associated difficulties arising from the characteristics of the video medium. For example, if the face is framed then certain gestures and postures (back channel information) will be lost to the communication. Desk to desk visual links are becoming commercially available (Intel - Proshare, IBM - Person to Person, HP - Mpower, Olivetti - Personal Communications Computer, Sun - VideoPix). Typical configurations employing one-to-one conferencing over token ring, ethernet and ISDN lines allowing for 256/240 display resolution at 15-36 fps, some allowing for a shared screen work area and file transfer.

**Scheduling**, as a component of workflow, is an aid to the effective planning of workgroup activities. Software with this functionality assists the team manager to plan work in a way which makes best use of parallel activities, while ensuring that coherence is maintained in the overall work plan. It typically enables individual workers to see their own task list and the team leader to check on the state and progress of the work. The use of such systems requires skill in ensuring that realistic targets are set. The danger is that the process becomes too rigid and unable to respond to changes as events unfold.

**Document routing**, another component of workflow (see below), involves the delivery and distribution of documents amongst group workers in a co-ordinated fashion so as to allow contributions to be made in a logical and sensible way.

**Bulletin boards** are a primitive form of workgroup computing whereby a shared computing resource, accessible via the PSTN or on a network, is used to store messages and files. Discussions may be arranged around topics of interest and anyone with access may read all messages on a particular topic left by others or add messages to the topic. The successful use of bulletin boards within an organisation relies on the patronage of all significant users. If users suspect that not all the intended audience will use the service, they are likely to choose an alternative means of communication. Commercial systems such as CIX, Compuserve and Compulink provide a wide range of topics and file transfer/gateway services. Lotus Notes has been heavily promoted on the basis of this functionality. However, its widespread acceptance for this purpose is not supported by the evidence of research.

**Application sharing systems** allow participants to share an ordinary single-user application (e.g. a word-processor or spreadsheet). The applications runs on one workstation. A controller (Sarin & Greif, 1985) interacts with the program as one user and sends the screen image to every participant’s workstation. The controller provides each participant with a telepointer (mouse pointer) so they can point into the shared space. The users’ access to the shared data is controlled through a floor-control mechanism (or chalk passing rule) (Greenberg, 1991).

**Argumentation systems** are also known as ‘problem exploration systems’ (Conklin, 1987). In this case the objects in the shared database are arguments or suggestions to the solution of a
complex problem. The arguments are linked together with relations such as question, support, objection etc. Through the process the participants build a hierarchical network of arguments and suggestions that may give a better understanding of the problem.

**Co-authoring and shared writing tools** range from simple multi-user editors (e.g. shrEdit), through more advanced word-processors with multi-user interfaces (Ellis et al 1991), to advanced document production systems (e.g. NLS/Augment (Engelbart, 1984) or OSCAR).

**Meeting room systems** differ from other systems in this category in their support for face-to-face meeting in specially designed meeting rooms with a large screen (e.g. video projector) and a number of workstations (Stefik et al 1987; Nunamaker et al 1991). The systems running on the workstation are usually very similar to the other systems in this category but some software is specially designed for meeting room systems.

**Screen sharing systems** are similar to terminal linking which was provided on old timeshare systems. The output of one screen is routed to other screens on other workstations (Engelbart & English, 1968). Many screensharing systems are interoperable between different platforms (e.g. Macintosh and MSWindows).

**Sketch pads and whiteboards** provide the participants with a 'shared workspace' in which to draw or write. In simple systems each user can only edit the objects created by him/herself. More advanced systems have shared access to the objects. (Beaudouin-Lafon & Karsenty, 1992).

**Message systems** consist of software which is E-mail-enabled. That is to say systems using E-mail as a transport engine for their services. In message systems users exchange copies of documents, forms or other task related objects. The co-operative work is supported through co-ordination or management of the workflow (Schmidt & Bannon 1992). E-mail enabled Groupware uses different techniques to augment the functionality of the message system. These are described below.

*Active or computational messages* are message objects containing guidelines and rules governing how they are to behave and react. The active message is like an application whose code is sent over the network and executes on the receiver’s workstation. It acts like an envoy who asks and gives information depending on the answer(s) from the receiver (Richardsen & Danielsen, 1989). The active message may also know its path through a system.

*Intelligent messages* are similar to active messages but, in addition, the intelligent message is able to make associations on behalf of the receiver. The associations made by the intelligent message can be made by presenting a summary of earlier communications, selecting interesting or relevant information in the receiver’s own information bases, or help the receiver makeup her/his mind (ibid.).

*Forms based systems* allow the user to fill in forms similar to paper-based forms. Like active messages, the form knows its way through the system (e.g. first to the manager, then to the pay-office) (Pankoke-Babatz, 1989).
Rule-based agents are user agents that process messages based on predefined rules. They may process messages based on the information in the header (To; or cc: fields) or by information in the body of the message. The incoming messages can be sorted into folders, urgent messages may notify the user, other messages may be sorted into project folders, meeting proposals etc. (Malone et al, 1987). Centralised rule-based agents may re-route messages, make backup copies, or maintain a progress log on a message on its way in a workflow. The agent may be user-programmable (semi-autonomous) or come with a set of static rules (autonomous) (Lai & Malone, 1988).

Structured or semi-structured messages contain a known set of fields. The rule-based agent or UA recognises each field in the different message-types, and knows how to handle them appropriately. A structured message can be the message-type ‘call for vote’, where each field represents an alternative choice (See Coordinator). The user agent presents the message to the receiver and sends back the result. A semi-structured message looks like the structured message, but some of the fields in the message contains unstructured text or other information. For example, call for meeting might include fields for 'time', 'place', and 'topic' along with an unstructured text giving more information concerning the meeting. (Malone et al, 1987).

Media Spaces consist of a computer-controlled video environment. The technologically created environment can consists of a audio/video link connecting two coffee rooms (The Palo Alto-Portland link (Bly et al, 1993)) or a computer controlled video network that gives users on different sites the ability to simulate navigation of a virtual hallway (See CRUISER).

Hybrid systems are the trend in CSCW systems. It has been recognised that multi-modal operation is a prerequisite for really effective groupwork. It is unacceptable and inefficient to perform some part of a task electronically and then have to perform some other part manually. Most commercial systems now combine a number of groupwork functions (see exemplars).

Virtual environments are computer generated synthetic environments where participants can move around, enter task specific spaces or rooms (e.g. an office or a meeting room). The virtual environment can be presented in a textbased system as in MUD (Multi User Dungeon "you are in a meeting room, at your left you see...") (See CyCo), the virtual environment can be representedas video spaces (See Cruiser) or in a 3D space (See DIVE).

Document Imaging involves the management of paper-based documents in electronic form. It is often important for organisations to keep copies of original documents, such as application forms, and there is often also a requirement to integrate this storage with that of other electronic media in order to be able to handle all forms of information using the same system. Electronic images may be received via FAX, mail or may be scanned into the system. Such facilities are often accompanied by OCR technology so that document images can be converted into a form which can be processed by text-based software.

Document management refers to various types and collections of features including those mentioned above. In general document management features will enable a variety of media types and document formats to be stored, searched, processed and exchanged.
Decision support systems include such facilities as argumentation tools, for recording decisions and the arguments that led to them so that, for example, a design rationale is available for inspection by anyone involved in implementation, meeting rooms, which are designed to support face-to-face meetings by providing computer facilities which provide individual use or access to shared resources on a group or sub-group basis, and shared drawing surfaces for synchronous, remote design meetings, for example. As well as access protocols, the latter function is usually accompanied by other channels of communication such as voice and video.

Workflow automation is the execution, co-ordination and control of rule-based procedures with pre-defined objectives. It involves managing a task or series of tasks, consisting of multiple steps, and usually many people, to achieve a defined end result, such as the approval of a loan application, within the desired time frame. The groupware architecture of workflow systems is designed to map onto organisational structures and procedures so as to partially automate processes, such as the routing of documents, which would normally be undertaken manually. Obviously, systems vary from being ‘passive’, basically document routers, to the full workflow system which models organisational intelligence in its knowledge base. Additional features offered by some workflow systems are password protection, electronic signatures, audit trails and report output directed to spreadsheet/graphics package.

The development is providing a rich market for consultancy since it is recognised that merely automating existing processes misses out on the potential gains of radical process ‘redesign’ with the integration of new technology. Staffware and Workflo typify this kind of development but there are said to be about a hundred such packages available world-wide.

Multi-Media Where the computer is used to integrate and control diverse electronic media, such as computer screens, videodisk players, CD-ROM disks, and speech and audio synthesisers. Making logical connections between these elements and providing interactivity with the user creates hypermedia. Multi-media databases allow for the storage of multi-media binary large objects (BLOBs) as a field in a database record. As with any other data type, such objects may be archived, restored and recovered through the normal DBMS mechanisms. BLOBs may have the type text or byte. Text BLOBs may contain character data such as memos, chapters of a book, contracts etc. Byte BLOBs are binary data streams that can contain any object such as a spreadsheet, graph, object-code module, voice pattern or any digitised data. A user may be connected to a database via a network. Thus, multi-media objects may be accessed and manipulated in local or remote databases.

With multi-media databases, an organisation is not restricted to textual data storage. Information may be stored and accessed in the most appropriate medium, theoretically allowing for a far more diverse approach to communicating information between users of such information.

Multi-media applications vary along several dimensions. Technically, they range from specially prepared packages which run on stand alone machines using standard input/output devices, through systems using sophisticated virtual reality devices such as data gloves, head-up displays etc., to networks which carry a variety of different media as described above, which collectively provide electronic conferencing, electronic mail, access to large banks of textual and visual material such as slides of famous works of art, computer-based learning
materials and so on. Another dimension along which multimedia systems vary is the kind of learning experience they potentially provide. They can provide a variety of instructional styles ranging from a linear presentation of concepts similar to a linear text, but with pictures, video, sound and animation to highly flexible hyper environments, which encourage users to develop their own pathways through material.

The 1990s are witnessing world-wide development and utilisation of interactive multimedia(IMM). The Higher Education sector in the UK is a prime example of an area of activity in which the application of IMM is seen as a priority in its future development, and substantial funds are being invested in the development of campus-wide multi-media information and learning systems to assist in course delivery.

**Enterprise Information Services (EIS)** These aim to provide flexible mechanisms to interrogate and modify organisational information stored in a variety of underlying databases. In the case of the EIS currently being developed by Nexor, this information is represented using an object oriented class hierarchy and is divided into four fundamental types:

- **Schema** which describes the classes of objects understood by the EIS. The EIS schema may be supplemented to include new types of object.
- The actual **objects** within the system such as people, roles, workgroups and rooms.
- **Relationships** between objects such as an "is the manager of" relationship between two person objects or an "is playing " relationship between a person object and a role object.
- **Constraint Rules** which restrict the values which may be taken by the attributes of the objects.

In large and diverse organisations, the organisational information may be stored in a variety of formats in a variety of types of data stores. A major role of an EIS is to provide translation between these various data formats, providing consistent responses for enquiries in a given format where the response may require access to data from a source containing the required data in a different format. The user of an EIS would typically use the interface provided by an Enterprise Browser to initiate queries to be processed by the EIS. Some example data sources are listed as follows:

- **Directory Services** - Directory services such as those based on the X.500 standards and the Domain Name System(DNS) provide a global repository of enterprise information.
- **E-mail** - E-mail( using standards such as X.400 and the Simple Mail Transfer Protocol(SMTP) systems can apply enterprise information to provide , for example, address book and distribution list functionality.
- **World Wide Web** - The World Wide Web(WWW) is a globally distributed hypermedia system which includes gateways to other systems such as X.500 and Archie
- **Anonymous Ftp** - Anonymous Ftp allows remote access to publicly available computer software and documents form numerous computer hosts throughout the Internet.
- **Archie** - Archie provides a database of the contents of anonymous Ftp sites.
- **(ODP) Trader** - Distributed applications use traders as a rendezvous mechanism. Applications offering a service register with the trader and clients requiring a particular service search for it in the trader. An EIS may integrate many individual traders to form a single globally federated trading domain.
- **Finger** - finger allows simple remote retrieval of information about computer users.
- **Network Management** - Allows for remote interrogation and control of network hosts using such standards as the Simple Network Management Protocol(SNMP) and CMIS.
USENET News - A globally distributed bulletin board system.

Network Architecture

Host/terminal architecture is typical of mainframe set-ups. A powerful central machine performs all of the processing for all users and applications and provides character-based input and output to terminals or terminal emulators.

Peer to peer networks have no central server but distribute resources among the nodes on the network. Each node may access resources on or attached to other nodes.

Client/Server systems have a central server where much of the intensive processing is performed but each node runs client software for each application which provides the (usually graphical) user interface. Since the server is not actually transmitting graphical data, the bandwidth of the communication medium can be relatively low. The graphical aspects of the application’s data are constructed at the client end.

2. Exemplars

Lotus Notes is the most successful groupware product to date (at the time or writing, approximately 500,000 copies are in use). It is marketed as an application design environment, as a medium for the supply of services and as a carrier for a range of third party add-ons. Its success has come mostly from the first of these. However, Lotus hope that the latter characteristic will mean that Notes will follow MS Windows in becoming a software platform for a wide range of applications developed by other specialist software companies.

Notes is a forms-based system designed to allow organisations to design their own office applications. It offers the ability to capture, organise and communicate text, data, images, sound, graphics and video information. It is based on a client/server architecture where the server maintains all databases, any of which can be uploaded by clients.

Version 2.1 runs the server software on a PC under OS/2 with Presentation Manager or MS Windows clients (<= 10). Version 3.0 has extended the server base to UNIX, Novel NLM and Windows NT and Apple Macintosh client capability has been added, with NetBIOS, Appletalk, TC/PIP, IPX/SPX, X.25, SNA and Banyan Vines network protocols being supported.

The server provides an object store providing shared access to information objects, messaging and directory services for routing information between users and databases, network drivers and an application programming interface that developers use to access information storage and retrieval services. Database entities are documents (completed forms), forms (user-defined sets of fields on a static background), fields (containing data or instructions, displayed in views) and views (user-defined lists of documents in columnar format). Databases are replicated among servers to provide data sharing. Data integrity, version control and race conditions are handled automatically.
The Notes client comprises three components via which end users see and work on the database. Databases are identified, organised and replicated via the 'workspace'. Documents are created and responded to via the 'editor'. 'Views' are as for the server.

Designing a Notes application is a matter of creating a new database consisting of fields, forms, views, filters, icons, help and policy documents, access control, routing and "@functions".

Notes does not include diary, calendar or scheduler functionality and Wordperfect Office 4.0 is said to be a close rival offering these workflow features, as well as the ability to support gateways to other platforms including SNA, MHS and SMTP. However, the philosophy here is one of providing what functionality is envisaged as necessary rather than relying on add-ons or macro programming and makes Office 4.0 inherently less flexible.

XSoft’s InConcert is a typical commercial workflow product, designed to support all open systems software by not presupposing the use of any other product. It is said to be fully scalable and easily customisable. A process or 'job' is represented in a template stored in a relational database, such as Oracle. The template determines the way in which InConcert will allocate task assignments and route and schedule documents and applications for the performance of specific tasks. Information concerning the job is available via built in query, SQL or other reporting facilities. A desktop icon allows all users to monitor the current process.

A workflow process is created graphically using a 'workflow editor'. Tasks are defined by dragging and dropping icons representing all kinds of objects, including voice, video, structured graphics, images and text. Behind the object lies information about where the content is located on the network and which application should be launched with respect to that object. When a user highlights a task icon, a collection of document icons related to the task are presented on the screen. Selecting one of these retrieves the document and launches its application so that the user may work on it. When the task is signalled as complete, the system initiates the next appropriate action. Version control can be built in to the workflow.

ICL market a range of groupware products under the name of Teamware. These include TeamMail (email), TeamCalendar (scheduling), TeamLibrary (multimedia database) and TeamForum (BBS/conferencing) which make up the TeamOffice package and TeamNet (physical/logical network facilities), TeamConns (enterprise network functions), TeamCare (remote s/w installation and management), TeamFlow (workflow) and TeamTools (client/server development environment). All components are activated from the tools menu of a Windows application.

In the TeamOffice package, TeamMail is a fairly basic email facility with recipient, subject and attachment fields provided in the create-message function. Messages can also be configured for priority, sensitivity, alert on delivery/error, confirm delivery, defer until and reply requested characteristics. X400 and MEMO gateways allow connection to any other email system and FAX is supported.

TeamCalendar is a tool for scheduling personal, group and resource appointments. Dates can either be entered directly or free time requested. The calendar can be viewed in a variety of different formats and access rights can be set according to identity.
**TeamLibrary** offers a partitionable document store which can be accessed from within Windows applications, File Manager or through TeamLibrary itself. Documents are organised into folders according to subject and may be searched for by date, subject, keywords or on text. Access control features are included.

**TeamForum** is essentially a bulletin board system allowing files and messages to be posted for reading by others for the creation and management of topic-based discussions.

**TeamOffice** runs on a variety of hardware and O/S platforms in a client/server environment.

### 3. ICW Technologies

**Document Management (IDOC - Fretwell Downing)**

Information is one of the major assets of any organisation and much time, effort and money is invested in its acquisition, organisation and distribution. The efficient management of information has always presented a variety of problems for IT. Even in the days of text-based, centralised, information systems, issues concerning the organisation of data for shared access, duplication and version control arose. Now that the trend is towards enterprise-wide access to distributed, multi-media, information sources, across departmental and divisional boundaries, the challenges facing systems development are considerable.

The functions of a document management system will vary with the strategy adopted for its implementation. Some applications will be motivated by the simple need to manage the storage and retrieval of electronic documents, perhaps to replace or ease the migration from an out-dated or paper-based system. Others may be part of a more radical change in the business process to be tightly integrated with messaging, conferencing and workflow and other groupwork-oriented applications (ICW is of the latter type).

In the context of ICW the boundaries between software components in terms of their functionality is blurred to some extent and document management functions are capable of being and are likely to be distributed between software components. However, IDOC is the component which has been developed specifically for this purpose and has its developmental roots firmly in this domain of functionality.

IDOC began life around 1986 as "Oracle Libraries" - a libraries book archive management system which included functionality for the management of circulation, acquisition of books and borrowers records. It consisted of a Forms/VT200 (or block character) interface to an Oracle Database. In 1992 it emerged as "IDOC" with a multimedia, OPAC (On-Line Public Access Catalogue) PC/MicroSoft Windows client, capable of rendering a variety of media types. At this time IDOC was marketed as a document management system with or without the libraries archive functionality and was answering the demand for 'desktop integration' in the handling of multimedia documents. Computer-aided learning applications, for example were able to make use of the presentation of multimedia capabilities of IDOC and British Airways press office used IDOC to handle customers’ multifarious document types and applications. Documents could be catalogued in the underlying Oracle database from within ordinary Windows applications.
A great many document management products were being developed from imaging software, designed to reduce costs in structured workflow by handling documents in electronic form. However, an increased interest in CSCW and groupware, particularly *ad hoc* workflow, presented somewhat different priorities for the support of groupworking and the aims of desktop integration and group productivity were instrumental in subsequent IDOC developments towards the provision for management of personal/individual information via folders, password protected login and individual searches. The adherence to an underlying database technology such as Oracle ensured the potential for enterprise-wide access.

The latest release of IDOC (WODIAK) developed within ICW was written in Visual C++ and boasts an MDI (Multiple Document Interface). The search algorithms feature ranked-relevance searching. The open-systems capabilities provided by Oracle and SQL have been enhanced to include software extensibility via a flexible OLE 2 interface with tailorable software interface components (DLLs - Dynamic Link Libraries) to OLE 2-compliant clients. The next phase of development will see the provision of a MAPI communications interface between enterprise-wide (MAPI-enabled) clients to better support and control *ad hoc* workflow (this email capability already exists at server level) and the support of all WODIAK functionality over the Internet and other commercial and corporate networks. In addition, the search and retrieval standard Z39.50 will be incorporated in the client software.

Comparable products include:

- Keyfile 2.3
- PC DOCS OPEN 2.0
- Saros Document Manager 1.01
- SoftSolutions 4.0
- Ongo DMS

The future: There is every indication that, just as electronic mail has started to be seen as an infrastructure technology and is being subsumed as part of or bundled with the operating system (Windows for Workgroups) or hardware (HP/OpenMail), document management, or at least its engines, will go the same way. Developments between Novell and Xerox and Saros and Microsoft would seem to support this view.

**Enterprise Information Systems (EIS - Nexor)**

The information that an organisation makes use of exists not only in various media types and data formats but may also reside in a variety of locations and sources, each with its own access mechanism. Making efficient use of such disparate sources is consequently made difficult owing to the need to change access routes to suit each particular information source. The Enterprise Information System is designed to provide a unified access route to any information source of interest to any of the client applications.

The EIS consists of a central server hub and a number of ‘channels’ to other information seeking/serving applications. The central server contains a canonical schema for representing any kind of information object. Any request for information from any of the attached applications (say, a mail tool) is converted by its specific channel into the canonical schema format. The server then decides where to locate the requested information (e.g. an X.500
database) and passes on the request via the specific channel of the information source application, which converts the request into a format recognised by the providing application (i.e. X.500). The information (say, an email address) is then converted by the X.500 channel into the canonical schema and then converted and passed back to the requesting application (email) via the email channel. In this way, all the enabled applications have access to all of the connected information sources but only ever see that information in a recognised format. The differences in location and data format are transparent at the client level.

The EIS has been developed in close integration with other standards-based products such as xtp - an X400 messaging implementation, extending and enhancing pp which is public domain, xtquippu - an X.500 directory services product, based on another public domain application quippu and various user-agents (xtdua, xtmua) for these services conforming to X-windows, Motif and MicroSoft Windows interfaces. There is now also an MS Windows user-agent for the EIS known as the Enterprise Browser, developed under ICW.

On the electronic mail side, one the problems for organisations is the non-interworking of the various proprietary 'standards' such as Msmtp, DaVinci, LANmail, ccmail etc. For example, attachments are not dealt with in a standard manner. Different divisions within an organisation may use different packages and the aims of enterprise-wide groupworking can thereby be thwarted. X.400 provides one route for interfacing incompatible mail systems with one another. This problem is also being addressed elsewhere, for example via VIM (Lotus) and (MAPI) Novell - application programmable interfaces to provide a standard interface to email services, but these themselves are not compatible. The purchaser is again locked into proprietary standards.

On the directory services front, it is harder to make an argument for X.500-based products and the market is immature. On the face of it, X.500 has the potential, if universally adopted, to provide a 'global telephone directory' containing multi-media information about anyone or anything desired. One of the problems is that international standards tend to be seen as overly complex by trying to cover all eventualities. This is a disincentive in itself but also tends to put standards-based products behind the competition, in terms of take-up, owing to the consequent increase in development overhead and time and financial costs involved in conformance testing.

However, as the various parts of an organisation extend their electronic interconnectivity, incompatibilities between different information resources become painfully obvious and the usefulness of unifying technology such as xtp, xtquippu and EIS immediately recognised. Again, providers are aware of the potential in this direction. For example, Novell is developing its own directory services solution. But again, this will not be X.500 conformant with the consequent detriment to open-systems advancements. In the Internet environment, the Internet Engineering Task Force - an informal development group, are making extensions to the Domain Name Service to include personal information and IETF developments have been widely adopted in the past.

"The beauty of standards is that there are so many to choose from". This is clearly one of the problems for an attempt at unifying technology. While some are striving to unify others are diligently diversifying and creating more to be unified. Another obstacle is the need for security. Organisations will not invest in technology which is at all liable to render sensitive or personal information open to attack by malevolent outside agents. X.500 can provide security
via 'public key encryption' - a method whereby part of the encryption key is public and part is granted by the information provider but there is a certain amount of controversy over encryption, for example, the question of who should hold the keys. The U.S. government wishes to have implemented an encryption scheme known as 'Clipper' whereby the U.S. administration gets to hold all the 'back-door' keys. Understandably, the networking community are somewhat sceptical of this proposal and are more in favour of schemes such as PGP (Pretty Good Protection) - a reputedly, very secure, public domain solution.

Other vendors in this arena include Rettix - X.400 source code and development kits, Isocorp - end-user X.400 software and Digital, Sun and IBM in the public contracts area.

**Process Management (ProcessWise: ICL)**

ProcessWise grew out of the IPSE 2.5 project which was part of the U.K. Alvey Programme. Initially, the target domain for process support was that of software development but it became apparent that process support tools are valuable in areas outside software development as a means of improving the quality and timeliness of process outcomes. This project finished in 1989 but the development of the process support environment PSS was continued by STC Technology Ltd, one of the Alvey collaborators, and more recently by ICL. PSS departed from the established practice of typical process support tools in that it offered a process modelling/programming approach as opposed to simple process language or database support for process analysis and development.

PSS was designed to incorporate the functional, behavioural and organisational aspects of processes, thus describing respectively what activities produce what objects, when actions are carried out and which agencies carry out which activities. The activity of process modelling/programming is seen to be that of constructing detailed, executable process descriptions. The objects that are manipulated are the documents pertinent to a particular process and the modelling language enables the programmer to express all of the operations that are applicable to these objects by the tools and agents involved in the process.

The involvement of the process participants is expressed in the process program. It is realised at process execution time by the participants logging into the system from their workstations. Each participant sees a view of the process which is relevant to the role being played in the process. A participant playing a number of roles may have access to a number of views. The contents of the view are determined by the process program and reflect its state.

The language used in PSS is PML (Process Modelling Language) which provides, in common with standard programming languages, a set of simple primitives which the programmer can combine to produce more complex structures. Despite its origins in the concepts of knowledge representation, PML is seen to be more amenable to imperative rather than declarative programming paradigms. PML incorporates several features which make for the easy encoding of processes:

- **Concurrent threads of execution** - providing a convenient abstraction which simplifies the program design task.
- **Dynamic thread creation** - which can capture the unpredictability with which new activities can start in a process.
- **Subtyping** - allowing operations to be defined which can be applied to objects of different but related types.
- **Persistence** - relieving the programmer from any concern as to whether data is held in primary or secondary memory.
- **User interface** - allowing the user to define a simple relationship between the state of a process thread and the display its owner sees.
- **Tool Interface** - The ability to start and then transfer data to and from tools that are running outside PSS, while the process program controls and co-ordinates their operation with the state of the process.

The PSS system is composed of three architectural elements: The Process Control Engine (PCE), the UI servers and the tool servers. An instance of the UI server is run on each participant’s workstation. The act of logging in connects the server to the PCE. A high-level protocol is used to communicate the contents of the display to the workstation and the participant’s actions back to the PCE. A similar login is performed by the tool server. A tool server executes in the environment appropriate to the tools it will support. PCE implementations exist for SUN 3, SUN 4 and ICL series 39 machines. UI servers have been written for NeWS and X-Windows running on SUN workstations and for Microsoft Windows running on PCs. Tool servers exist for SUN 3, SUN 4, PC and series 39 environments. Standard communication protocols are used to connect the servers to the PCE.

Process support in the form of executable process models can improve process enactment by:

- Removing unnecessary human activities.
- Ensuring conformance to process specification.
- Improving the user-interface.
- Producing better management information.
- Supporting local variants of the process.

The ProcessWise suite of software now provides for process modelling via a graphical UI (ProcessWise Workbench), process enactment (ProcessWise Integrator) and tools for generating the PML for a particular process from the output of the Workbench and tools for implementing the Incremental Development Route as set out in the Methods handbook. In all cases, process-orientated software is tightly co-ordinated with the process management methodologies described therein. Unlike many other commercial products in the process management arena, ProcessWise is geared towards *ad hoc* workflow situations.

### 4. Related Projects

**Configurations of Video Links as an Adjunct to Shared Tools**

* A three year investigation, running until November 1995, funded by the JCI

Modern work environments are increasingly designed around the electronic coordination of teams of individuals, whether it be on the factory floor or in the board room. Coordination requires effective communication which, in turn, requires that the opportunities for communication are timely and appropriate for the task in hand. Many companies are now
investing heavily in video technologies on the assumption they will fulfill the necessary criteria and probably some others besides.

Psychological investigations of the utility of video telecommunications began in the early nineteen-seventies and have continued sporadically ever since. The tremendous individual differences in behaviour, for the experimental tasks chosen and the metrics deployed, have made consistency and replicability of findings difficult to achieve. The result has been, for some considerable time, a discrediting of the potential of video simply by association with the problems of these investigative strategies. For this reason, the primary thrust of the current work is to develop measures of behaviour in such settings and to demonstrate their utility.

Work to Date

A Methodology and Computer Tool

Interpersonal interaction is a tremendously rich, subtle and, in many ways, intangible activity. Almost inevitably, analysts are drawn to video-taped recordings of the interactions they wish to study. Video data is a mixed blessing: without the inherent complexity of video data, the dynamic characteristics are difficult to obtain and yet with it, the character of that interaction is easily obscured.

The multi-strand approach of the project required a rigorous and sound method for accommodating several different types of time-series data. A computer tool has been developed to address this problem, using a simple category system that offers to unify any class of observation made by an observer with any other. The tool consists of a small HyperCard stack, designed to exploit the power of the SPSS data processing software. The key step in this approach is translation of separate sets of linear data into a vector state-space.

Experimental Work

Three studies of dyadic interaction have been carried out. Two have involved a role-playing negotiative exercise, designed to exploit social dimensions of communication. The first of these compared a face-to-face environment with two, remote and electronically-mediated communication suites, one offering a high quality, large-format video link with sound, and the other an audio-only link. The electronic elements for this study were limited to the remote conditions, and involved no computer resources. Some measures of the talk in interaction, such as the number of words uttered, and questionnaire data, based on the ‘media richness’ literature, failed to differentiate amongst these environments.

The second study was a refinement of the same task, without a face-to-face condition, but with controls for the gender and prior familiarity of those who took part. Also, whereas the first was based on paper-only information, the second used a live computer link, offering a synchronised shared screen image. Although both participants were offered identical information through the computers provided, they were given the opportunity to make notes to support their particular negotiative stance prior to the interaction.

This study produced several findings of interest. Verbal protocol analysis revealed differences in the number of specific queries about the argumentary contentions made. The audio condition produced fewer instances of this category of talk than the video condition. Also,
questionnaire data revealed significantly lower agreement with the statements referring to the 'social salience' of the participants. For example, using 100mm line scales, "I could readily tell when my partner was concentrating on what I was saying" elicited agreement ratings of around 50 in the audio condition, compared with 90 in the video condition ($t(14) = 5.46, p = 0.0001$).

Using the Action Recorder tool, the video tapes were analysed to expose the duration and frequency of glances directed at the computer, the video monitor and the self-produced paper notes. Although the information about duration of glance reveals that the video monitor was "referred to" less (mean=11.04 seconds per minute, s.d. 5.87) than the other two possible foci (computer: s/min=28.66, s.d. 10.77; notes: s/min=19.16, s.d. 10.45), frequency data reveal that just as many glances are on average directed to each of the potential foci (video : frequency per min = 5.27, s.d.1.85; computer : n/min = 5.30, s.d.1.90; notes : n/min = 4.85, s.d.1.17).

**Business Facilitation Systems (BFS)**

The original concept of the Business Flight Simulator, as the BFS was originally called, was to act as a general purpose management education and training tool for use both in business schools and in industry. This concept continues to be valid. However, corporate organisations have been much more interest in actually using the BFS either to address real business problems (e.g. as a form of synchronous or asynchronous electronic meeting support). or as a demonstrator of how a specific organisation could gain business benefits from the integrated use of a variety of groupware products.

Unlike conventional electronic meeting systems (EMS), our use of pre-prepared Lotus Notes databases and other data sources provides direct access to the "organisational memory". The partnership with many UK-based innovators in groupware means that the BFS will integrate, at the desktop, a wide range of technologies from videophone to voice mail, as well as a range of data sources (internal/external hard/soft).

The focus in BFS design has been on business processes and on linking the business process to different combinations of groupware tools. The tools we are currently working on include building some generic ‘templates’ for standard business process, e.g. ‘electronic board meetings, collaborative discussions, setting of key targets and actions planning, targeting and sales prospects and computer systems development. The aim is to populate these templates with real data from ‘test site’ companies. This is already showing how data can be ‘brought to life’ by reformatting it within a multimedia environment, making it accessible to a group separated over space and time while allowing the data to be the topic of discussion.

**VIRTUOSI - Support for Virtual Organisations**

VIRTUOSI is a project within the DTI/EPSRC Computer Supported Co-operative work (CSCW) programme. Its aim is to promote research into the use of computer systems to support groups of people working together in industry or commerce. The organisations that form the project consortium are British Telecommunications plc (the lead partner on the
The VIRTUOSI project explores the use of virtual reality to allow multiple users to perform synchronous, co-operative work across geographically dispersed locations. This project, which is part of the DTI/SERC Computer Supported Co-operative Work (CSCW) programme, has a total budget of approximately £2.5m over three years, with a DTI/SERC contribution of about £1m. VIRTUOSI will allow people to join discussions and problem-solving activities at home or in different offices or factories across the world.

Virtual reality technology from the UK company, Division Ltd, contributes to the core framework of the project, providing powerful tools to allow users to interact within the virtual environment. A strong theoretical basis will be provided for the project by Nottingham, Lancaster and Manchester Universities. These Universities are all involved in UK and European research projects to establish the fundamental principles for interacting and co-operating in virtual environments that will be set up across future information superhighways. In addition to developing models and systems, they are also involved in capturing user requirements and assessing the effectiveness of the two application pilots.

Two pilot applications are being developed by the project. One is concerned with improving communication between a number of BICC Cable factories throughout the world. The aim is to enable managers and workers to share expertise as easily as if they were in a single factory. For example, technical experts on one continent will be able to "visit" shopfloor staff on another continent to co-operate on resolving technical and production issues at the remote factory.

A compact 3D representation of the total organisation is generated on the screen of the desktop computer. Users are able to move around within this visualisation to locate individuals and sources of expertise at the remote sites. The system then integrates video windows and computer based data into this virtual world while setting up a conference call to the participants.

The other pilot service is based in the textile and clothing industry and allows co-operation between a number of small and medium enterprises involved in the design and manufacture of fashion garments. This application is part of Nottinghamshire County Council’s programme to support industry in its area and to provide competitive advantage to its users.

Designers are able to use virtual reality techniques to create a visualisation of a garment. The designer can discuss the design with remote buyers who can also see the garment being worn by a model on a virtual catwalk. Users can make changes and view the effects during their discussions and the details of the design are transferred immediately to the factory for manufacture, once agreement has been reached. The work on this application is supported by a consultant to the project based at Nottingham Trent University who provides expertise on computer support and visualisation techniques in garment design.
Both BT and GPT Ltd are involved in developing the telecommunications aspects of the project. GPT's contribution is supported by GEC Marconi Hirst Research Laboratories which has considerable experience in virtual reality applications.\textsuperscript{1}

\textsuperscript{1} Additional information on DTI/EPSRC and related projects can be found at http://www.demon.co.uk/jrac/cscwdir.html
5. Glossary of Abbreviations

API: Application Programmable Interface (e.g. the Common ISDN API is a standardised interface between the telecommunication application program and the protocol software)

DBMS: Data Base Management Systems

MAPI: Messaging API

CMC: Computer Mediated Communication

CSCW: Computer Supported Co-operative Work

CODEC: Compression and decompression (Several standards for video compression exists e.g. CCITTs H.261 (also called Px64), MPEG (Moving Pictures Experts Group), Cinepak etc. (Halfhill 1993) See also compression-FAQ in Usenet News comp.compression)

MHS: Message Handling System

SMTP: Simple Mail Transfer Protocol

UA: User Agent


Relaxed WYSIWIS: The participants working on the same objects may have different views into the shared space.


VIN: Vendor Independent Messaging

GDSS: Group Decision Support System

GSS: Group Support Systems

ISDN: Integrated Services Digital Network (A new standard for telecommunication that will replace a major part of the world wide telephone system with a system that supports both voice and data communication. Supports digital end-to-end connections (Tanenbaum, 1989)).


PIM: Personal Information Manager (not Plug-In Module)

OCR: Optical Character Recognition.

OIS: Office Information Systems

FAQ: Frequently Asked Questions

ftp: File Transfer Protocol (anonymous ftp is a service whereby files can be transferred or downloaded from a server without the need for a user account.

fps: frames per second. (10-15 fps is usually considered as the low end to acceptable viewing quality)
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