VIRTUAL PROJECT TEAMS : AN EMERGING PARADIGM

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ABSTRACT

The rapidly developing technological paradigm of networked computing is offering new opportunities for increasing productivity in a wide range of business environments which include planning and design. It is becoming clear, however, that application of new technology, in the absence of organisational restructuring or 're-engineering' may not deliver the expected benefits. In this paper we explore examples where new communications and information technologies have been used to support the creation of virtual project teams or virtual offices where traditional forms of activity are replaced by new (electronic) modes of operation. It represents but one facet of the revolutionary changes washing over contemporary society where there are continuous challenges to what is technologically possible, economically feasible and organisationally desirable.

INTRODUCTION

In the introduction to **Desktop Planning** (Newton *et al.* 1988 p.1) it was suggested that:

*"It is now **technologically** possible for practitioners in local, regional and national organisations to effectively plan-at-a-distance — from their own desks"*

Here the focus was primarily on the capacity of computers to deliver an increasing array of information, knowledge and decision support to individuals at their desktops. Communications was present in the 'system', but tended to be somewhat peripheral and low speed. Digital information was transferred primarily on disk via courier.

Several years later, in the introduction to **Networking Spatial Information Systems** (Newton *et al.*, 1992, p.1), some of us ventured that:

"Networking spatial information systems, by the end of the 1990s, will have moved from the status of field trial to that of established practice. Multi-user, multi-media databases will be interactively accessed via regional, national and global broadband networks. Large textual and graphics files will be electronically couriered as routine practice. Videotelephony and videoconferencing will be enhancing the wide area networking of

spatial information systems. In short, organisations will have the ***technological freedom****, as never before, to re-shape the geography of their operations, to determine which activities are undertaken where.*"

Networked computing is at the heart of a paradigm shift that has begun to penetrate all sectors of industry, including the architecture, engineering and construction (AEC) and the planning sectors. Towards the end of the 1980s, local area networks (LANS) had emerged providing the capability of information exchange between PC/workstations, but typically confined to a single office building or 'campus'. This meant that information (data, software etc.) held on one machine could be accessed from another — and used in real time as if it was resident locally. The framework for information sharing, distributed computing, virtual work teams and virtual organisations was beginning to emerge. What was missing was the communications network capable of linking LANs located in different parts of a city, state, country or for that matter, the world. The wide area networks (WANs) of the 1990s enabled LAN-to-LAN connectivity without (necessarily) a decline in speed of information transfer (currently 10 Mbps on commercial networks) and provided the platform for the full range of telematic services and applications that will enable the emergence of *virtual project teams* which come together electronically to contribute to the planning, design, construction and fit-out of major building and construction projects.

Table 1: Transition to an Information Society

	Societal transitions Industrial	→ Informational
Industry location	Centralised	Centralised with decentralisation/dispersed
Industrial process	Mass production	Flexible specialisation
Economic engine	Machines	Human knowledge
Product	Uniform	Personalised
Market force	Supply led	Demand led
Work conditions	Formal	Team
Dominant mode of interaction/type of information transfer at work	Hierarchical line management	Information networks
Market orientation	Regional/National	Global
Commuting pattern	Focussed	Dispersed
Transport network, mode	Radial public, rail	Extensive grid private, car
Planning paradigm	Prescriptive planning	Performance-based planning

In an era of rapid technological change there are, however, dangers of being 'seduced by technological wonder' (Schnaars, 1989); that is, a tendency to become over-imbued by the technology itself and lose sight of the applications to which the new technology can be put and the market it is intended to serve and the practicalities of that market. As *participants* in an era of rapid technological and societal change, future rates and directions of development are often difficult to discern and frequently become apparent only with the benefit of hindsight. So it is as we look back over the past century, we can chart the transitions that have taken place in our economy and society (see Table 1; also Brotchie *et al.*, 1995). The *from → to* transitions listed are truly revolutionary.

In this paper we use the *from → to* strategy in an endeavour to outline the paradigm shift that is now discernible in certain facets of design. At present they are far from representative and are clearly 'leading edge' — and in that sense are indicative of what is likely to occur more widely in the future, if current models of innovation diffusion are applicable.

VIRTUAL PROJECT TEAMS

Virtual design represents that part of the design process where there is a substitution of physical access to people, places and information sources with electronic access. It is predicated upon a number of developments, including that of *distributed computing* and the emergence of a *critical mass* of nodes (activity/data centres, working groups etc) capable of being inter-connected.

In addition to the technology drivers of broadband communications and distributed computing, there are a range of other forces which are effecting a shift in attitude among firms in the AEC sector in relation to how and where construction project teams are formed. Foremost among these is the *internationalisation* of construction. Design and construction firms in advanced industrial countries are actively competing for projects outside their traditional market areas and increasingly off-shore. The logistics associated with providing support (technical plus human resources) are enhanced when head office capability can be electronically accessed and transferred as needed to the distant design or construction site. Organisations are also restructuring their *modes of operation.* There is a clear shift in industry towards flexible specialisation, strategic alliances and inter-firm collaboration (Figure 1). To a large degree the AEC sector has tended to operate in this fashion for much of its modern history with construction projects frequently representing an alliance of different firms, each contributing their particular skill (architecture; civil, mechanical, electrical engineering; hydraulic services; construction contractors; project managers, etc). Until recently, however, collaborative work in design and construction had *traditionally* meant that participants tended to work in geographic proximity to one another (frequently requiring physical relocation of staff from the various firms to the project site) or else suffer the consequence of working at a distance and the associated delays in travel and document transfer. High speed, wide area networking now provides for the transformation of such firms into a virtual organisation or virtual project team, bound together financially, legally and electronically for the duration of particular projects.

CAD conferencing systems are now being used to support distributed computer supported co-operative work (CSCW) in design and construction. Fully described in Newton *et. al* (1993, 1994, 1995) the system facilitates three levels of CAD operation: file transfer, networking CAD and CAD conferencing. Key features of the system include window sharing (permitting CAD drawings to be viewed and manipulated simultaneously by 'local' and 'remote' members of the virtual AEC project team), whiteboarding and live videoconferencing.

The system is now being used to support a variety of design and construct projects via high speed (2 Mbps and 10 Mbps) wide area virtual private networks.

Conceptual Planning and Design. A phase when there is the greatest shortage of information; capable of being redressed through videoconferencing and whiteboard sketching (Figure 2) — brainstorming among experts in design who may live in difference cities (or countries); Internet access to virtual global libraries of information; connection to state and local government information systems to query information on zoning, location of infrastructure and services etc.

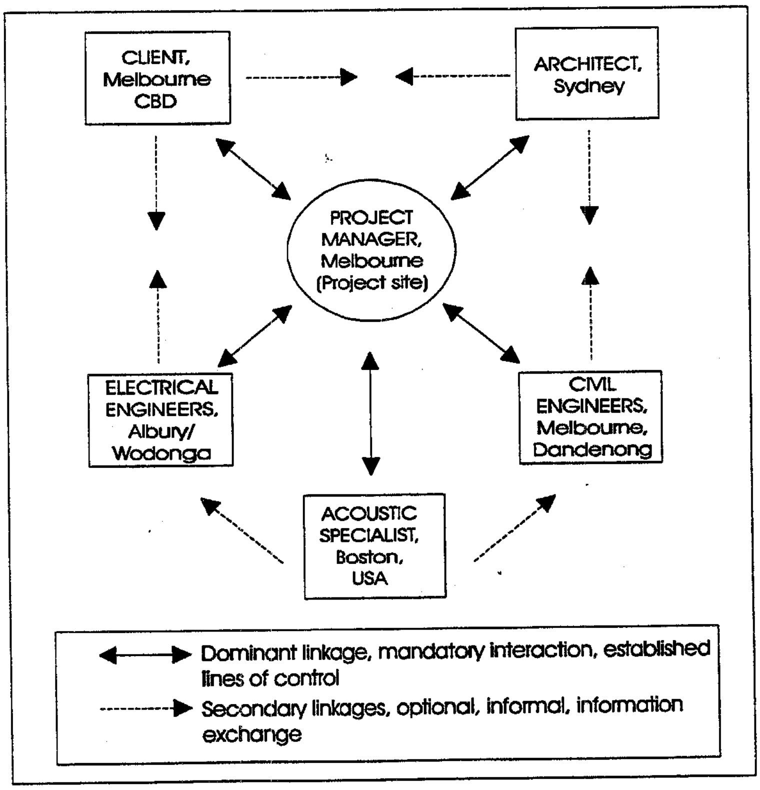

Figure 1. Virtual Project Team

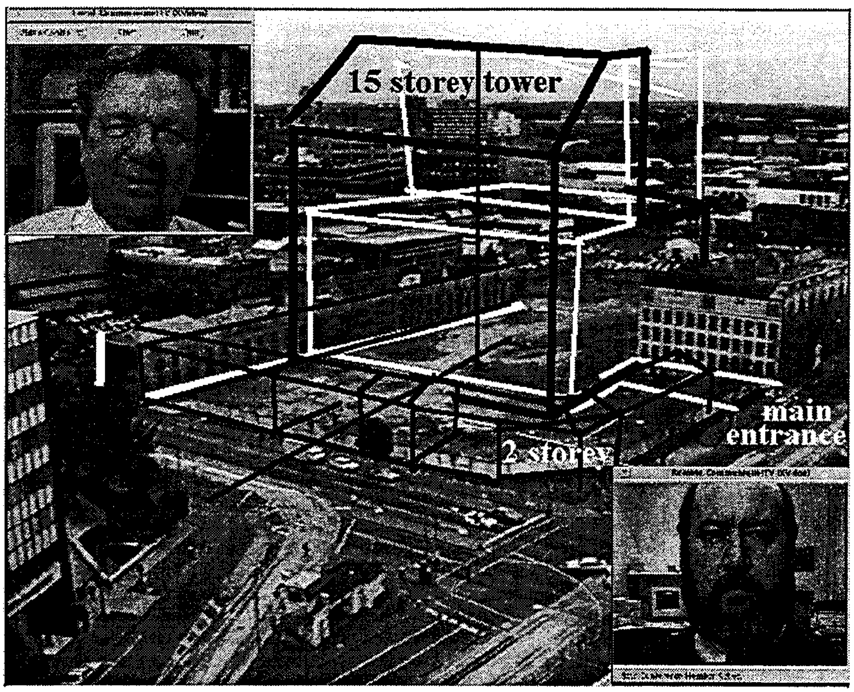

Figure 2: Conceptual Design via CAD Conferencing

Design and Documentation. A key phase in the value-adding chain and one which is the most information-intensive. Conflicts in design between the various AEC practitioners and the subsequent need for re-work represents a major cost factor which is magnified when not identified prior to construction. CSCW is likely to be most highly focussed on networking CAD, whereby members of the virtual project team engage in real-time electronic comparison and manipulation of CAD layers etc (see Figure 3).

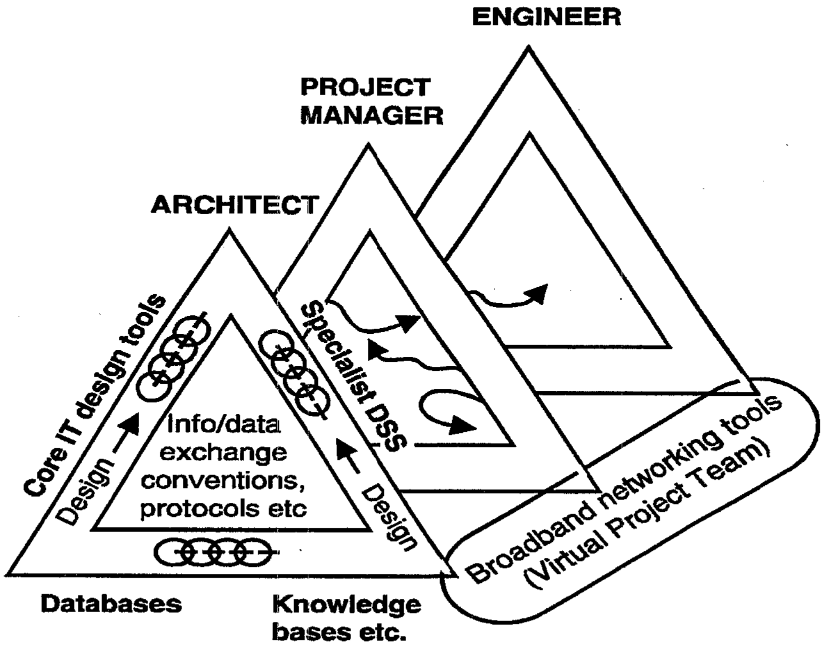

Figure 3. CIT in Design and Construction (Integrated Project-based Systems)

In the design phase, on-line connectivity between core software (e.g. CAD), specialist decision support systems which conform to world-best-practice (e.g. related to thermal modelling, building code expert systems etc) and related databases (e.g. materials performance; embodied energy, building quantities etc) will be increasingly required in an era of building and construction that is shifting from prescription to performance, from regional to global. Connectivity to on-line multi-media building products databases will also permit a wider search and evaluation of building elements and their performance attributes with subsequent transfer into CAD drawings, building specifications, quantity estimation and costing software with materials ordering direct from factory or warehouse via EDI. Retailing and the associated travel and face-to-face contact it entails can be expected to diminish in significance.

Construction. With the advent of the fast-tracking of construction projects, the time compression required for design and documentation can benefit from use of on-line systems among the AEC consortia. Another common occurrence during construction involves regular visits to the work site by members of a project consortium. In the course of discussions or as the result of an inspection, need may arise for a practitioner (e.g. architect) to access the CAD files resident on his or her workstation which is 'remote' from the building site. Via a 'remote terminal session', architects can, from a workstation at the construction site log into their own machines, run their own CAD packages (which may be different to that operated by the project manager on site) with their own files, but redirect the window display back to the computer screen at the construction site. This means that no files are exchanged, security and intellectual property rights are maintained (if this is an issue), and yet the visiting practitioner can interactively show screen output from his or her remote CAD package, moving about the drawings and making changes as required. Should hard copy be needed, then capture of the redirected screen output at the work site could be undertaken — providing a 'dumb' screen raster image which could be printed or marked up, but lacks the 'intelligence' to allow others to recreate the original mixture of CAD layers and CAD entities.

Building Fit-Out. The ability to reduce fit-out time and bring forward building handover can deliver cost savings to the client. Again, access to on-line databases of fittings and furnishings will facilitate preparation of interior designs, as will recourse to rendered 3–D models of rooms, their colour finishes and their furnishings (i.e. a virtual fit-out and furnishing is undertaken as a preliminary first step). During fit-out, videoconferencing between the site and the project managers and/or client's offices can be used to transmit images of the interior of the building as fit-out progresses.

Building Operations. The commitment of all design and documentation to digital media permits the provision of a set of 'as-built' drawings (including relevant multi-media files of building elements, fittings, fixtures, services, and furnishings – viz containing details related to maintenance etc) as the basis for an asset management system for the building.

The benefits to be gained from networking during design and construction are many (see, for example, Newton and Zwart, 1992), none the least of which are savings in project costs. The estimated percentage savings on commercial building projects approximately double as the project size/value increases by a factor of ten. Under an achievable scenario whereby the project is foreshortened by one twelfth of the normal time taken for design and documentation, estimated savings could range to 0.5% for projects of $M5 to $M100. When applied to all large scale industrial, community, civil engineering, residental as well as commercial projects currently underway across Australia, aggregate savings are estimated to exceed $M120 under this conservative scenario.

FUTURE WORK

Much more work needs to be done to advance distributed collaborative interactions of the type described above, including:

- developing user-friendly software to assist with the many and varied system operations. This will focus primarily around developing (multi-media) human-computer interfaces with which the operators feel comfortable.
- understanding the social dynamics of interactive group activities. This requires a multi-disciplinary input from researchers in the cognitive sciences, computer sciences and social sciences.
- developing standard terminology to be used for information exchange in an effort to minimise ambiguity and misunderstanding. Development of intelligent agents capable of language translation will be of central importance.
- systems capable of handling the difficult procedural and informational issues which arise in the interactions between multiple tasks performed by multiple groups.

CONCLUSION

Substitution of leading edge practice for traditional practice will continue to occur in the planning and design professions where value adding can be clearly demonstrated. Substitution of computers and networks for labour-intensive and travel-intensive activity is clearly evident in relation to the more routine activities in all sectors of industry. The challenges are greater, both technologically and organisationally in relation to the non-routine aspects of work where geographic propinquity and face-to-face contact remain highly valued (e.g. for brainstorming activities where telematics remain deficient; establishing rapport and trust among a team etc – Handy, 1995). However, in this area too, we are likely to be surprised.

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