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Informative Planning: The Intelligent Use Of Information Systems In The Policy-Making Process

By

Micheal Batty
INFORMATIVE PLANNING: THE INTELLIGENT USE OF INFORMATION SYSTEMS IN THE POLICY-MAKING PROCESS

by

MICHAEL BATTY +

A paper to be presented to the UNCRD Expert Group Meeting on Integrating Information Systems/Information Technology in Local/Regional Development Planning, to be held from 31 October to 4 November in Singapore

+Department of Town Planning, University of Wales at Cardiff, Aberconway Building, Colum Drive, Cardiff CF1 3YN, Wales
ABSTRACT

Information systems have been applied in urban planning for over 20 years. Their use, however, has changed dramatically from large-scale, integrated systems whose structure reflected the process of strategic planning, to more routine, small-scale less ambitious systems in the present day. Here we argue that the most informative way of using the new technology is in the construction of many small information systems, each dealing with different aspects of the planning task, and being integrated with each other using emergent network technologies. Characteristics and examples of information systems are described, and a series of dimensions reflected in a typology of information systems introduced. The process of using such systems informatively and intelligently is then described. These issues are illustrated in the design of a simple library system consisting of maps describing the socio-economic conditions in the docklands area of south Cardiff (Wales, UK). This library is designed to enable users to ‘browse’ through a series of maps which are ordered in clear, hierarchical fashion. It is suggested that these are the sorts of system which are now eminently feasible, and provide a robust strategy for the most informative use of new information technology in planning and policy-making.
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THE AUTHOR

Michael Batty is Professor of Town Planning in the University of Wales at Cardiff.
INTRODUCTION

Even an occasional viewer of British television at the time of writing (September 1988) cannot fail to be struck by the impact of information technology in television advertisements. Viewers are urged to take advantage of widespread credit which is available using online banking in a variety of financial institutions. Cars, videos, cameras, every type of consumer durable in fact are advertised as having the current technological fix which no self-respecting viewer can do without. Perhaps the most bizarre advertisement in this electronic populism is one which exhorts viewers to purchase new furniture in a store in which salesmen sit at terminals, designing your 'future' kitchens, bathrooms and living-rooms, using interactive computer-aided design (CAD). The advertisement shows a young couple being advised by a salesman who is manipulating patterns and layouts using state-of-the-art CAD based on pop-up menus controlled by a mouse, with the immediate impression that this sort of expertise is widely available in the company in question.

Much of this kind of information system has limited functionality, that is, it is mainly concerned with rapid access and processing of large data sets through simple, albeit extensive accounting. Nevertheless, although the use of CAD packages in the customer environment is undoubtedly something of a 'gimmick', it does illustrate what is now possible at the most elemental level using information technology. The question immediately arises as to whether or not such technology is being used in areas and tasks which have a professional concern with data analysis and design,
and there is, in fact, widespread concern that this is not the case. In urban and regional planning practice, for example, the use of computers is still in its infancy, despite a 20-year gestation period, and the existence and knowledge of standard software such as the CAD package referred to above, is limited. Peters (1984), for example, writes that: "Even today, computers are not used at all in most planning applications. This is astonishing because a broad variety of facts have to be assembled in a plan, and data retrieval and preparation, exactly the type of work that is efficiently performed by a computer, are thus very important".

Information systems involving such data retrieval and preparation, have had a chequered history in urban planning. Large-scale systems devised during the heyday of 'systems planning', two decades or so ago, suffered the same fate as large-scale models: in brief, the organisation of such computer technology and its efficient use was difficult to develop (Brewer, 1973; Lee, 1973) in the corporate environment, and planning tasks were difficult to reconcile with such technology. By the mid to late 1970s, such technology had fallen into disrepute within planning practice, and only comparatively recently has information technology in the form of modest information systems-processing of routine data, such as that necessary to the control of development, become significant once again (Bardon, 1988; Klosterman and Landis, 1988). It is, however, also significant that the use of computers for more sophisticated planning tasks - forecasting and design for example - is less well-developed than it was two decades ago. The
kind of management system for planning proposed in the late 1960s is nowhere to be seen, at least in British planning (Cripps, 1969).

The dilemma facing professional activities such as planning does not involve the acceptance of computer technology for routine tasks, but for the use of this technology in less routine activities such as strategic planning. The basic idea of an information system as a piece of hardware and software necessary in the efficient storage, low-level processing and presentation or communication of extensive data is non-controversial. Controversy arises when information systems become large in scale, embodying functions or tasks which manifest the need to think in an expert technical manner. The problem of information system design then becomes one in which the specific operation and constraints of the particular planning organisation are crucial. There are many case studies which demonstrate that it is then that difficulties over balancing software with hardware and fusing this into an organisation's procedures - developing appropriate 'orgware' as it has been referred to (Nijkamp and de Jong, 1987) - become central.

Invariably, information systems must be tailor-made in some way, thus inhibiting the use of general software for large-scale applications. Prepackaged software which implies certain usage, and particularly that type of software emerging recently in the guise of geographical information systems (GIS), often embody a functionality, modest though it may be, which does not fit well to
any of the strategic roles of a planning organisation. Countless studies imply that information systems are only of real use when the functionality embodied within them is comparatively low-level. Kraemer, Dutton and Northrop (1981) in their extensive review of information systems in local government say: "...well-managed computers have real payoffs for government operations. Unfortunately, computer technology is not well-managed in most cities. As a consequence...computers generate problems that, while not extreme, are often pervasive".

The impression is frequently given that the application of any information system must be 'good' per se, but this ignores the enormous variety of such systems in both theory and practice. Moreover, looking at planning through the paradigm of information-processing or in terms of information systems as a framework for planning, is necessarily only a partial view. It is, however, emerging as the conventional view due to the popularity of information systems at present and their development as part of the all-pervasive spread of computer technology. But it must still be reconciled with more mainstream intellectual and practical views of planning as a legitimate professional activity. Once an information system begins to embody operations which are anything more than the lowest level of processing stored data, questions of hardware, software and orgware become centrally important, and must be informed by the type of intelligence which has guided planning since its emergence as a significant activity in the early years of the 20th Century.
The argument to be advocated here is based on the notion that planning must be 'informed' by information systems technology, but that scientific use of such technology can rarely be built into the functionality of such systems. The thesis which will be advanced is that information systems should be small-scale, manageable and that there should be many different varieties of system informing the planning task. Only in this way can the use of such systems become intelligent in that their use in any organisation will be predominantly guided by non-computerised functions and tasks. The intelligent use of such systems is a rather different matter from intelligent information systems whose functionality might embody elements of artificial intelligence. As Wyatt (1988) so clearly shows, intelligent planning is based on a great diversity of information technology which, in the present state-of-the-art, cannot be integrated in any large-scale fashion and is unlikely ever to be so. There have been some dramatic failures in the design of large-scale information systems in planning in the 1970s and more recently in other areas, for example in health authorities in the UK. The message of this paper is that informative planning depends upon small-scale systems, evolved and adapted step-by-step with possibilities for integration, but such integration being accomplished where necessary through infrastructure embodied in the organisation itself: this may be computer-based such as through networking but it is also likely to be through traditional modes of management.

Linking low-level information systems indirectly through networks which enable data and functions of such systems to be shared,
enables quite close control over the design and use of such systems. Although such systems may exist independently of each other, their integration through networking and their use in this way does require considerable expertise. Even the lowest level software packages such as those based on wordprocessing require a degree of expertise which involves training if their full potential is to be realised. It will be argued that the use of such systems requires a blend of expertise which must be acquired formally in that the intelligent use of such systems demands that even the casual user must know where and when to apply such systems. Expert systems are in some ways the prerogatives of the planner, and although such systems seem increasingly separate from other computerised systems, it is argued here that their major purpose should be as 'intelligent' front ends to other systems which make the use of those other systems 'user friendly' (Davis, Compagnoni and Nanninga, 1987).

In summary then, so far we have argued that small-scale systems, initially independent of each other and in the control of single users, should be the basis of informative planning. Their intelligent use depends upon the conventional sequence of tasks characterising any particular planning operation, and one of the main features of their development will be their embodiment in organisations which manifest intelligence. Accordingly, we will begin first by sketching the rudiments of information systems in terms of the basic model linking input and output through processing. Hardware and software need to defer to 'orgware' and the emergence of computers in all organisations will represent the
backcloth of their intelligent use. We then need to classify information systems within planning. A typology mapped onto planning tasks is indicated. The thesis that 'small is beautiful' in information systems design is then illustrated in an example of a low-key, small-scale information system which has more the characteristics of a data library through which users may 'browse', than a management system for making and monitoring plans. We will sketch the system we have recently developed for the Cardiff Bay Development Corporation which, we will argue, is one of many such systems which should be developed in planning agencies. It is clearly demonstrated that even the development of simple library systems such as these, utilises much of the technical expertise required in designing systems from scratch, so-to-speak. Indeed, one of the conundrums faced in using such systems for informative planning, is that anything more than the most modest development of such systems, requires a blend of computer and planning expertise which is rarely available. There are important consequences involving training resulting from such innovations (Sazanami, 1988), and these will be identified in our conclusions.

2 THE INTELLIGENT USE OF INFORMATION

2.1 Information and Computer Systems

As Roszak (1986) so cogently argues, during the last 40 years information has become a 'Godword', thus acquiring exalted status. The reasons for this are known to us all. The basic function of computers is to store and manipulate or process data or information. But information as a word is more than any narrow
concentration on the idea of data. In psychology and other cognate sciences, the study of behaviour has been developed using the analogy of information-processing. Consequently, information systems have acquired a status independent of their application, and invariably, contemporary usage of such systems implies something more than the low-level processing of data. Information systems are conceived of as software rather than hardware and the tasks or functions to which such a system may be put, are referred to in computer-jargon as the 'functionality' of the system. Despite their status, most information systems have fairly limited functionality which mainly involves manipulating data in a statistical fashion or communicating such data efficiently. Higher level tasks such as design and decision-making, although potentially having some degree of automation through principles of artificial intelligence, are rarely present in information systems and are unlikely to be so.

It is not the purpose of this paper to debunk information systems in any sense but to emphasise that their intelligent use clearly demands such systems be considered in their most elemental, low-level form as comprising components of some meta-process. Here, a central distinction between the planning task and the organisational environment in which it is set, and the concept of information systems in their most modest form, will dominate the argument. Information systems will be considered as devices - hardware and software - which are able to store and retrieve, display and communicate in diverse ways a variety of facts involving not only numerical information, but text, voice and
pictorial information. Recent developments in computing, especially in the synthesis of computers and communications (C & C as the Japanese refer to it, or information technology in the UK), have enabled highly elaborate forms of computation, such as that associated with image-processing, automatic translation and such like. But the sort of functionality characterising planning which involves design and decision-making is likely to remain beyond such systems in the foreseeable future.

Roszak’s (1986) description of information as "...discrete little bundles of facts, sometimes useful, sometimes trivial and never the substance of things" is a useful working definition for the sorts of information systems to be considered here. Information systems clearly ‘add value’ to facts in terms of processing but are never able to integrate functions involving the use of these facts in a decision context. In this sense then, information systems in this paper are conceived of in a passive role in the planning process, informing the process assuming their intelligent use but never embodying routes for automating design, decision and action.

2.2 Information Processing and Planning

As soon as computers were developed, their main usage quickly became one of storing large amounts of data which could be retrieved quickly. The distinction between hardware and software only began to emerge in the late 1950s as computers became useful in routine and repetitive information-processing in business. In science, the stored program embodied instructions which related to
numerical solution or modelling, but such usage remained highly specialist with the scientific task dominating the way computers were used. The distinction between hardware and software became more important as computers became more available. The micro-revolution expanded computer memories dramatically enabling new kinds of data - voice, text and pictures - to be processed. Increasingly, the development of elaborate software to store and retrieve increasingly diverse types of information came to set software apart from hardware, and to give software development an independent status. Software engineering emerged and the need to develop appropriate software on appropriate hardware in particular organisations - the design of orgware - was recognised.

In this paper, we will continually refer to the distinction between hardware and software in terms of hardware involving information-processing as a model of the computer, and software involving such processing as a model of computing. We illustrate this idea in Figure 1 which indicates a model of an information system based on input, storage and output of data at its most elemental level, with increasing sophistication of the processing of information, as such systems are used to handle ever higher levels of task. Software then relates to the intelligent use of information systems in processing data in ways which involve some model of reality outside the immediate computer environment. Orgware involves the use of both hardware and software at even higher levels, involving ideas about how the organisation perceives its own tasks and roles in design and decision-making.
Figure 1: The Hierarchy of Processing in Information Systems
The most appropriate way to consider information systems in planning is at the most basic level as indicated in Figure 1. Planning clearly requires information systems which provide information which can be processed intelligently using methods and models, many of which will never be automated or computerised. It is so complicated a task environment that it is unproductive to begin thinking of information systems which might play an integrating role in planning itself. Such roles may emerge but the enormous variety of systems now available suggests that the linking or integrating process is planning itself and its organisation. Later in this paper, we will consider how the multiplicity of information systems available to planning might be integrated using network infrastructures and such like, but the assumption here is that informative planning should be based on a blend of both hard and soft, computerised and non-computerised information systems which can be used intelligently if computers are regarded as being useful only in their lowest-level form of information-processing.

2.3 The Role and Development of Computer Hardware

The information explosion is closely linked to the development of computer technology but it is not dependent upon it. Prior to the invention of the microprocessor or 'computer on a chip' in 1971, the two related processes of miniaturisation and automation, as well as the development of management and organisational structures, were generating more and more information and facts which could be, at least in principle, processed by computer. Futurologists such as Toffler (1970) and Bell (1973) painted their
portraits of post-industrial society without appreciating or anticipating that machines were only a decade or so away from being able to handle the increasingly complex information produced by an increasingly educated, informed, hence complex society. Clearly, computers have vastly accelerated the information explosion by providing a means to handle more and more data, more and more efficiently. Indeed, information systems terminology has grown out of the micro-revolution, notwithstanding the origins of the idea in management science and the systems approach. In fact in planning, the development of more conscious approaches such as the systems approach (Chadwick, 1971) were somewhat independent of the growth in computer technology, and the terminology of information is largely absent from planning theory based on systems and cybernetics. It is interesting to examine the use of computers in planning some two decades or so ago, where information systems were referred to as 'data banks' with virtually no other role than that of storage (Cripps, 1969).

Information systems are very much a product of the micro-revolution and their development has proceeded as a matter of necessity in using micro-computers for standard tasks such as wordprocessing. But the widespread availability of micros has also generated new innovations in information systems such as the spreadsheet, relational databases such as those embodied in software such as DBASE, and new forms of wordprocessing involving the extensive use of dictionaries, pictorial information and so on. There would appear to be no end in sight to this process of innovation in the hardware of computing. As long ago as 1964,
Moore, co-founder of the semiconductor firm Intel, observed that for a number of years past the number of circuit elements on a chip had been doubling each year. 'Moore's Law' which is based on the conventional wisdom of extrapolating this growth into the short and medium term futures, has been borne out (Forester, 1987; Noyce; 1979). There are no limits in sight as of now. Information systems running on micros are becoming more and more sophisticated as 8-bit are replaced by 16-bit and as 32-bit machines appear on everybody's desk. The speed of change is still daunting as new generations of hardware and software appear. We are already facing the prospect of highly sophisticated 5th generation computers which will enable a variety of unconventional processing in unconventional ways. Moreover, Manheim’s (1987) characterisation of the 'Third Computer Revolution' dominated by user-friendly decision support systems is in fact turning into a fourth such revolution, dominated by enormous opportunities for intelligent computing based on local and wider area networks.

Computers have now become part of the background to most kinds of employment. The ratio of computer terminals to students in Cardiff is in the order of about 5 to 1. Including micros, this ratio is about 3 to 1 in my own department, and there are now many organisations where computers vastly outnumber the number of employees. This kind of computer world is one where there is no sign of any convergence in the kinds of hardware available. Machines are being purpose-built for a variety of tasks and increasingly the machines with the most universal functionality are personal computers or home micros. Networking dramatically
increases the opportunity for specialised computing in that organisations no longer require their own specialist computing services. Indeed, one of the main arguments of this paper involving the notion that planning should be regarded as being a process informed by countless types of information system, is entirely consistent with this massive proliferation of both general and specialist computing devices. Before we look at the emergent infrastructure of this computer world, we must look at trends in software where the picture takes on a different kind of complexity.

2.4 The Software Revolution

A common assumption for at least the last five years, perhaps longer, is that software represents the cutting edge of the information revolution. It is assumed that over half, perhaps three-quarters, of all developmental work in information technology involves software. And there is an assumption that there is a greater diversity in types of software than in hardware, and that there is no sign of any convergence on common systems. Some convergence has occurred in the business world where IBM dominates the market for personal computers, but the emergence of more and more specialist computers acts against such trends. It is probably correct to say that as computers have become more and more available, their potential usage has become wider and wider, and more and more software products have come onto the market. At the level of computer languages for example, various archaic machine-like codes were supplanted by FORTRAN and COBOL in the 1950s. Then came BASIC which complemented the
scientific and business contexts with a broad educational bias. Structured languages such as PASCAL and C, based originally on ALGOL, emerged in the 1960s and 1970s with still no sign of any convergence on a common high level language.

The same has been true of operating systems. Here computer manufacturers have led the race with their own codes and while there has been some effort to devise general systems such as UNIX, there has been little convergence on common standards for computer programmers and users. Perhaps PC-DOS for micros has become the industry standard in personal computing but, even here, IBM seems to be suggesting that the newer ranges of micros will be provided with very different operating systems. One of the major problems which computer users face is in choosing hardware and software products. Short of actually testing every competing product in a variety of situations, it is enormously difficult to make intelligent choices. This is a problem which would appear unresolvable at present, and it has dramatic implications for the use of computers in areas such as planning. We will return to this later, by way of examples.

There are clear distinctions within the development of software between systems and applications, and between general purpose and specific softwares. With respect to general purpose software, there have been major developments in data base, spreadsheet, accounting, mapping and drawing as well as related basic information-processing packages during the last decade. In many of these packages which have different degrees of 'user-
friendliness’, there is limited functionality in that they are often designed so that the end user can develop and adapt the package in various ways. For example, spreadsheets which have emerged in more and more sophisticated ways since VISICALC was first invented, now enable users not only to design their own functionality but to present their data in processed or original form in diverse ways using high-quality graphics. The same is true of the newer generations of wordprocessing package which contain dictionaries, spell-checks and even in some prototypes at present, grammatical checks which embody quite sophisticated linguistic theory.

Although the general picture is one of increasing variety of software, the existence of general software such as databases, statistical packages and so on does present many opportunities for planning applications. The recent book by Brail (1987) on microcomputers in urban planning contains many applications of spreadsheets to various applications such as population and land use-transportation modelling. Campbell (1988) has used LOTUS 1-2-3 as the basis for geographical information systems, developing the spatial location properties of such systems using the two-dimensional graphics available in the package. Yapa (1988) has linked a variety of standard software such SPSS-PC for statistical analysis and AutoCAD for design, using linker programs written in BASIC as part of a more general computer-aided regional planning process. And Harris (1987) has proposed an eminently feasible package for microcomputer-based planning in small cities in the Third World, consisting of standard prepackaged software
blended with more specific programs based on applications of design and forecasting models, such as MEPLAN developed by Marcial Echenique and Partners (Echenique, 1988).

Statistical packages such as SPSS and MINITAB are now widely available in user-friendly form for the whole continuum of computers from mainframes to micros. But as the applications area narrows to more specific planning tasks, the generality of the software also narrows and the bias towards more specific functionality increases. There are few packages in general use apart from MEPLAN involving land use modelling, while transportation model packages, too, are mainly tailor-made to the particular context (Young, 1988). CSIRO in Melbourne, Australia, are one of the only groups to have developed software which is both general enough for widespread application in planning and specific enough to fit context-dependent planning tasks (Newton, Taylor and Sharpe, 1988). Developments in geographical information systems represent an interesting and problematic middle ground. Systems such as ARC/INFO have been developed with high generality of application in mind, but their functionality is exceptionally narrow involving spatial analytic and resource applications (Burrough, 1986) which rarely fit the context of public planning in a local government context. In fact, it would appear that this context requires much more general low-key information-processing systems in which functionality is embodied in their linkage and use rather than in the computer software per se. The examples of computer-aided planning in Sri Lanka developed by Yapa (1988) are typically representative of this context.
2.5 Computers in Planning Organisations: The Design of Orgware

Models of the development and use of software such as those already mentioned, particularly those pioneered using microcomputers, usually involve the simplest possible organisational environment based on a single user, interacting directly and immediately with a single computer, running a computer program concerned with a single task. This, of course, is the model of 'personal computing' upon which much of the general purpose software so far developed, has been predicated. Indeed, the ability to develop general purpose software is assured only if hardware, software and orgware are tightly bound together in the relationship of one machine, one program, one user. This model clearly works well, but it is impossible to generalise to organisations composed of several or many users and tasks.

Although most of our examples depend upon a total convergence of hardware, software and orgware, general purpose software has been developed for large organisations but only for the most routine, rigidly hierarchical and highly controlled tasks. Systems involving ordering, scheduling, pricing and communicating routine information which is continually changing, are quite well-developed. Indeed, the typical examples of electronic populism banking, electronic funds transfer, electronic point of sale systems and so on - referred to at the beginning of this paper, are cases in point. In fact, information systems and related computer applications which characterise planning always involve more than a single user, and it is often difficult to generalise about such systems. Hardware and software are usually clearly
defined, but the way in which such systems are used and embedded within the organisation - the principles involved in the design of orgware - are the least defined in this continuum. This is what makes case studies of the development of planning information systems, especially in a strategic context, so difficult to compare and generalise from (Sazanami, 1986; 1988).

Most information systems in planning are likely to involve many users, all having different professional roles and involved in different tasks, many of them non-routine. Designing successful information systems in such contexts requires great expertise in design, and a thorough understanding of organisational needs, and possibilities. Examples of large-scale information systems such as online banking etc. which appear to work well, are of little help. Frequently, the planning organisation does not have a particularly clear view of its own goals and tasks, and there is usually great uncertainty and volatility in the task environment. For example, even in the design of information systems such as those involving the control of development in physical planning, such basics as to the number and type of professionals and other participants in the process who should have immediate access to such systems, is unknown. Because information systems technology enables professionals who have often never sought to use the information in question, to participate in interpreting such information, issues as to the number of users may always remain uncertain. Systems may fail if these issues are not perceived correctly; or the systems which are implemented will not enable the organisation to realise its or the system's potential. Most
failures of technology in practice, in fact, appear to be organisational rather than technical whatever types of computer system are involved (Brewer, 1973; Kraemer, Dutton and Northrop, 1981).

Basic principles of orgware design are in their infancy but some clues as to good design might be identified. In all organisations, rapid access to computer systems is usually required. This inevitably means interacting with the computer environment in a one-to-one fashion as an individual, so that information-processing can, to all intents and purposes, begin immediately. This implies that responses from the system must be virtually immediate or at least the query must be immediately accepted by the system even if the response occurs later. Systems must thus be interactive and user-friendly. It is therefore likely that the development of expert systems in planning will involve adding 'intelligent' or at least user-friendly interfaces to computing packages and programs.

In the past, information systems have always been remote prior to fourth generation computers, and these conditions involving interfacing users with computers were rarely met. It might now appear that the image of computing as a religious cult centred on a remote machine, tended and isolated by programmers as high priests, has gone forever. Interactive computing has removed this. But there remains a mystique surrounding highly trained staff who are required to operate the very large systems which still characterise much computing in planning. Such systems are
highly vulnerable to change in their staffing and often acquire a life of their own as more and more specialist effort is put into them. Indeed, such systems usually embrace planning functions which are rarely well-defined, thus adding further ambiguity to the role of big systems.

In summary then, computer systems in planning can now be designed from the ground up, so-to-speak, in a simple, robust manner. It is safer to keep systems personal, building tight loops of hardware and software around individual users and computers; and then developing linkages through shared functions - data, programs, processed information and so on. To develop really robust, informative and evolving systems for planning, integration should be mainly based outside the software per se through the infrastructure of networking and other forms of communication. This implies a redundancy within the technology which enables the organisation always to operate if parts of the technology fail.

2.6 Interacting Computers in the Networked Organisational Environment

Only quite recently has the ability to link computers together become a reality. Traditionally, interactive computing has been based on terminals linked to a remote central computer arranged in the form of a star network. This model is being rapidly replaced by local area networks in which users can access a variety of computers connected to the network. Local area networks can be embedded in wide area networks which in turn can link to much larger-scale network infrastructure enabling regional, national,
even global communication. Microcomputers can also be networked and state-of-the-art workstations, often based on microcomputers, can thus be linked in a variety of ways enabling local as well as remote information-processing.

The specialisation realised through such networking can be daunting. Organisations can be built around such structures which enable the kind of computing indicated previously in Figure 1, to be instantly available to every user from a desktop terminal. Local processing using standard software such as spreadsheet, wordprocessing and other data base packages can now be developed on terminals which also access the hierarchy of networks, each of which in turn provide access to ever more powerful and specialised computers. In some senses, the sort of wired society reflecting this synthesis of computers and communications, is replacing the very notion of the computer as a universal machine: it is the overall infrastructure itself which enables all computers to be linked, and a kind of global computing to be possible. For example, in the case study we show later, micros, minis and mainframe computers are linked to enable an information system to be constructed. This relies on a variety of remote processing and remote access to data using local area networks as well as the British Joint Academic NETwork (JANET) which links any academic user to any other in the UK; and internationally to networks such as BITNET and EARN (European Academic Research Network) in Continental Europe.
Principles for designing an appropriate orgware for planning agencies, although rudimentary, are beginning to emerge. With even the simplest of networks linking constellations of micros, data can be shared as can software by locating such information at key points on the network so users can call it up from their own personal computers. One of the most attractive features of this emergent power of networking is that it can be developed in a simple, robust fashion. In computer-free environments which wish to develop information technology, there is much to be said for proceeding with the simplest possible low-level information-processing on stand alone personal computers running robust, general software. Linking these together, once users become computer-literate, is then possible. Proceeding from the top down may also be necessary in that many organisations require larger-scale systems to begin with. To link these to users will involve a hierarchy of networking. Distributed computing can also be developed for specialist software. Webster's (1987) idea of distributed GIS systems in which software functions and data are available at different sites linked by ring or line (ethernet) networks is now possible. The example we show later involves using micro, local, wide area and national networks to enable data to be extracted and maps to be stored in the modest library information system to be constructed.

All this network infrastructure which is emerging suggests that the physical infrastructure of communications is converging with organisational infrastructure. The idea of the intelligent building is based around such local area networks (Gouin and
Cross, 1986) and larger-scale wide area networks are beginning to appear across whole towns. There are few design principles as yet for such systems and our understanding of their impact on tasks that users can develop, is extremely rudimentary. Nevertheless, the ability to specialise with respect to types of information-processing is a clear consequence of these developments. Data is expensive and in particular, the maintenance of data is also time-consuming and costly. It is clear that such data should be located remotely from users, and that users should have the power to download to their individual workstations from remote sources. The same is true of software. Its maintenance can be equally problematic, although once tasks begin to be organised around computer networks, the licensing and cost of acquisition can become very complex. In Figure 2, we sketch the kind of computing environment which might face a typical user with respect to interacting through a personal workstation. What is clear is that the sort of picture illustrated here cannot be developed overnight: it has to evolve, and it requires an ability to reorganise tasks which depend upon a hierarchy of levels of information-processing.

This then is an illustration of how 'informative planning' can evolve. Essentially our definition of this style of planning assumes that users are online, that computing involves a hierarchy of tasks from the simplest which involve local processing to the grandiose which involve specialised computers somewhere on the network. If the systems fail, users would be left with stand alone terminals on which they can accomplish the most basic of
WAN - Specialist Processing Scanning, Printing, Plotting & Mass Storage

Figure 2: Organising Information Processing in a Hierarchy of Networks
tasks. Informative planning is not based on a process involving organisational or scientific design, decision or problem-solving for this style assumes that the process of planning is organised accordingly. In essence, informative planning represents a style of working with computers and information systems which utilise the emergent power of a computer world in a fashion which is robust, simple and effective.

3 INFORMATION SYSTEMS: TYPOLOGIES AND APPLICATIONS

3.1 Constructing a Typology of Information Systems

So far we have argued that information systems as reflected in the basic computerised or non-computerised functions of input, storage and output, represent the most robust systems to develop. Once extra functionality is added reflecting analysis, forecasting, design and other tasks, such information systems take on a complexity that makes their successful implementation uncertain. These elements are reflected in Figure 1. The argument then proceeds to suggest that additional functionality should, if possible, be developed in a variety of information systems connected in network fashion as illustrated in Figure 2. This argument, however, does not reflect the way large-scale information systems have been developed, largely because the technology of networking has only recently appeared, but also because planning itself has always been theorised as a comprehensive, integrated activity. In practice, this has never been the case and it would seem appropriate to use this fact as a guiding principle in future information systems design and application.
Nevertheless, it is important to recognise differences between information systems, and a typology of such systems is worth developing with respect to planning, notwithstanding the difficulties of doing so (Clarke, 1986). We can define five dimensions relevant to such systems: the tasks involved in planning, the time scale over which such systems might be constituted, the scale, both spatial and nonspatial, relevant to such systems, the functions involved in planning, and the users with respect to their roles in planning - these are all key issues which are reflected in information-processing. We will deal with these issues in turn.

The task environment within which planning resides is based on a number of traditional activities. Government agencies particularly are empowered to make plans, to implement them, and to monitor developmental change. Making plans is usually considered as a strategic function of any agency, as a non-routine but nevertheless periodic activity which can be highly analytical. Implementation is usually a process which involves many agencies other than planning, although the monitoring of such implementation and certainly development is conceived of as a more routine function (Batty, 1988). In British planning practice, plan-making and development control, the non-routine and routine functions respectively, represent the main tasks, with implementation residing in other agencies; frequently however, analytical functions are associated with separate agencies such as those concerned with research and intelligence, and these functions typically involve information. In developing countries,
most planning tasks are conceived in non-routine, strategic terms
thus involving information systems which embody higher-level
information-processing (Sazanami, 1986).

A fourth function which has emerged quite strongly during the last
decade involves communication. Traditionally, public
participation has been the the modus operandi of communication
between planning agencies and the public-at-large, but
increasingly planning is being viewed as a process of bargaining,
negotiation and argument at all levels. Quite clearly, computer
systems can be used to display arguments for various proposals,
and information systems are emerging which link technical experts
to decision-makers, decision-makers and technical experts to the
public-at-large, private sector interests, community groups and so
on. In fact, one of the main uses of expert systems would appear
to lie in the creation of user-friendly environments linking data
on plans, proposals, goals, objectives and such like diverse
information, to this whole spectrum of potential users. Openshaw
(1986) has suggested that this style of communication could be
built as a 'planning machine' in contrast to other forms of
'machines' which enable analysis, design and such like. In one
sense, such communications functions have been around for several
decades, although the prospect of their successful implementation
is quite recent. Negroponte's (1970) 'architecture machine', for
example, consisted of using teletype terminals in the community so
that users of buildings could interact with architects over
building design and critique. Other more public information
systems are beginning to gain common usage, and the prospect of developing better public understanding and participation through information systems is now firmly on the horizon.

Notwithstanding the dramatic speed of change in the computer industry itself, most information systems are not conceived in terms of continual development or evolution. Information systems are usually developed with a functionality in mind which is not capable of being developed. This is certainly true of large scale systems in planning, such as the Local Authority Management Information System (LAMIS) pioneered in the late 1970s by ICL (Masser, 1988). Many such systems can be updated with respect to data inputs: for example, development control systems (Farthing, 1986a) are systems which are based on continual, perhaps daily updating, but their functionality is usually fixed. Most systems become obsolete fairly quickly in the rapidly changing environment of computing where new hardware and software enable ever more powerful and sophisticated functionality to be developed. Somewhat ironically perhaps, the more general the information system, the more flexible it is to incorporate time in its development, but such systems are invariably the most simple where a flexible but limited functionality can be evolved. Clearly, issues of time mainly reflect distinctions between routine and non-routine applications, and systems developed along this dimension are usually quite different.

Scale of application relates to both the spatial scale on which the system is focussed, as well as the degree of comprehensiveness
of the information involved. There is a key distinction spatially between larger scales involving districts upwards, and smaller scales involving a more detailed geometry of the environment. These are best reflected in the way data is displayed spatially. Larger scale systems involve rather abstract representations of space such as those found in thematic mapping: here precise geometry is largely irrelevant, topology is the main focus. This is in contrast to more detailed scales where the geometry of form is crucial. These so-called cadastral information systems involve much functionality concerning geometry in 2-, sometimes 3-dimensions. The distinction is best seen between geographical information systems (Newton and Crawford, 1986) and property register systems (Zwart, 1986); the former, although often embodying a functionality which can produce detailed geometry, are mainly used in applications where geometry is not important, in contrast to property systems where site boundaries and such details are central. Interestingly, development control combines both thematic and cadastral issues, and this might suggest that GIS systems are good candidates for systems involving such control. However, much of the functionality of GIS systems is irrelevant to planning tasks involving such control.

The fourth dimension which is clearly reflected in the previous three involves the functions that an information system must contain. The basic function of information storage which involves efficient and rapid procedures for the input and output of such data should not be underrated. Information systems embody a logic of organisation which if imposed upon some planning tasks can
provide a discipline essential to effective planning. However, most information systems contain more than this. Analytical processing of data involving the statistical and geometrical properties of data represent such middle-level functions. Few systems go much further than this, although systems embodying forecasting and design have been developed, most rather unsuccesfully (Kraemer, Dutton and Northrop, 1981). Information systems in the resource management area have had a strong influence on the development of GIS and, in many cases, such GISs contain a rudimentary design-decision logic involving overlay map procedures which indicate the potential for urban and other development. In fact, this is what makes most GIS systems unsuitable for urban planning in that this functionality is largely irrelevant to the sorts of tasks central to the planning process.

Storage, analysis, forecasting and design are all functions that a planning information system must embody or relate to, and a fifth - monitoring and implementation - must be considered. Existing information systems could be classified according to these types of function, although it is much more likely that actual systems combine more than one of these to varying degrees. The last category against which these systems might be classified is according to the type of user. We have already noted the distinction between professional/non-professional and expert/non-expert users. Computer experts of various sorts ranging from systems programmers to applications programmers comprise those with the greatest computer expertise in the design of systems.
Invariably these will be complemented by planners with computer expertise who represent the interface between the planning team and the systems experts. There is a major communications function here, just as there is between other professionals and decision-makers with political significance in the organisation. Users external to the organisation may be major recipients of information in both a positive and negative sense: business users, for example, wanting positive advice and information about development change, casual users, community groups etc. wanting information concerning proposals which are generating conflict in the community, and so on.

All five elements we have identified cut across each other in that there are correlations between tasks, time, scale, functionality and user roles. A full concatenation of these dimensions against each other would not appear very useful at this stage because of the non-mutually exclusive nature of the elements. Nevertheless, these categories not only define issues that are important in existing information systems, but also define issues in designing better systems. These enable the constraints on feasible systems to be clearly identified and costs and benefits to be assessed. In fact, the cost of such systems is another important element, so significant in fact that we will address this issue directly in the following section.

3.2 The Economics of Information Systems

Cost is, of course, crucial in the design of such systems in that cost constrains what is possible and often what is successful.
Design according to cost yardsticks always involves a compromise, but in information system design, the tighter the cost constraints, the more likely the system is to be feasible in that the cheapest such systems - one machine, one user, one program - are inevitably the most robust. The difficulties emerge when what is possible is matched against what is required, and it must be recognised that there are some situations where non-computer information systems may be the only course possible. The environment surrounding such design is, like many decision contexts, somewhat lumpy and uncertain.

Nevertheless, it is a relatively straightforward matter to identify the sources of cost in information system design. Data itself can manifest many different levels of cost, as can the construction of the system. Hardware is comparatively easy to cost, software is more difficult, especially if dominated by specialist and purpose-built applications; training, too, must be considered and, of course, there are time constraints relating to the function of the agency, the types of plans being prepared and so on. We will begin by identifying the costs of data. Much data required in planning comes from secondary sources, usually various types of census. Increasingly, such data although largely collected by government, is only available at a cost, which not only reflects its storage and transmission across networks, but the desire by government to at least cover the original costs of collection, perhaps even to make a profit.
Primary data on the other hand is easier to control, in that this is data collected by the planning agency itself: data which is collected in a one-off local census fashion, or data such as that on development which is available to the authority on a routinised basis, through planning applications for example. There is a third and increasingly important source of data: this involves either primary or secondary data collected by another agency or firm which is then processed before being passed on to potential customers. This is the type of data which is often only accessible in this manner. The classic example is household or individual data relating to income, housing, other domestic acquisitions and characteristics which are typically used and/or compiled by credit card companies. As the network society continues to elaborate, it is increasingly possible to collect data remotely, process it with respect to some obviously useful task, thus adding value to it, then be in the market for trading such information. Market researchers have always specialised in this activity but increasingly, large retail conglomerates, land and property companies, and other government agencies, see niches in the market for trading their own data which is being collected as a matter of course in their own activity. For example, the information system we will present towards the end of this paper involved both public and private data which in itself was costless, but once it was passed over a network, it acquired value and became marketable.

The cost of programming time and other system costs involving the setting up of information systems can be considerable. Even the
most personal and robust of information systems - running DBASE III on an IBM-PC to store information on planning applications which can be sorted quickly, for example - incurs costs in the setting up of the hardware and demonstration of the program. Such costs will depend upon the scale and nature of the system being implemented but this world of new technology is so volatile, and the tasks involved so uncertain, that costs can easily inflate to levels which would have seemed inconceivable at the onset of the project.

The cost of hardware is the easiest to assess, although even here the development of networking and the existence of hardware-software packages (the so-called turnkey systems) can generate hidden costs. Hardware has to be maintained and although incredibly robust, does involve technical expertise which cannot be held in-house and has to be brought in to service and resolve failures in the system. The cost of software is equally problematic. Specialist software packages in areas such as CAD and GIS in themselves can often exceed the cost of the hardware by several orders, while the licensing arrangements on software place severe limits on who is able to use such software in which particular places and on what particular machines. Increasingly, experience in urban planning suggests that purpose-built software is more useful, easier to develop and less costly than elaborate software packages which can only be run in particular ways and have little capability for expansion or adaptation. The same sorts of issues are reflected in the costs of training. Software vendors usually include training and maintenance in their
specialist packages but training is in operating the package, not in understanding exactly what is being processed. All the experience so far suggests that computer applications should evolve around individuals, from the ground up, being built robustly into an organisation’s infrastructure and not restructuring the organisation to the dictates of the software.

Time itself is also a constraint on what is possible but all these factors, if properly balanced, should determine feasible courses of action. The best policy would be to begin with small personal applications centred around individuals. The use of spreadsheets as demonstrated by Brail (1987) amongst others provides a useful way into information systems thinking. Networking of micros in the first instance involves shared data and software as well as wide access, and experience certainly in an academic context where the task environment is somewhat different of course, illustrates a high level of success. Ottensmann (1985) suggests how such strategies might be transferred to public agencies. In developing a strategy for a planning agency, it is possible to take existing programs which run remotely, in batch processing mode on remote machines, and transfer these to spreadsheet or data base software or to translate them to the dialects available on the hardware itself. This, in itself, might provide a major learning opportunity for appropriate agencies.

Bigger systems are much more problematic, but frequently small robust systems do not appear to meet the needs of the agency in question. Purpose-built systems are often necessary but the
principle of beginning on as small a scale as possible is still applicable, given present experience with large-scale systems. Recent estimates, for example, of the time spent developing software in the UK business sector, indicate that three-quarters of all the time spent is in adapting and maintaining ancient (by computer standards) programs, often still written in COBOL or similar archaic languages, running on machines entirely inappropriate to the tasks in hand. Another well-worn statistic reflects on the need to train at the most elementary level. 50 per cent of all the micros used in British business stand unused or 'underused' because of the inability of the user to match software to the tasks of the organisation. If the tasks are such that the only solution is large-scale computerisation involving importing huge specialist information systems into a non-computer literate organisation, common sense alone suggests this should be gradual, slow and painstaking. Anything else is a recipe for disaster, a lesson that has been learnt time and time again wherever 'big' computerisation has been attempted.

3.3 Applications in Urban Planning

The typology we have suggested in this part of the paper is unsuitable as a device for exhaustive classification but it is useful in indicating certain features which dominate existing software. Here we will conclude this discussion by presenting some examples of information systems used or of potential use in urban planning so that some clear trends can be identified. The smallest scale applications possible involving standard, widely available software have been developed around single or no more
than 4 or 5 users, on microcomputers. Spreadsheets are popular in these applications but the major use so far has been for simple problems of classification and sorting, as well as simple methods of development control. In essence, planning practitioners are using such information systems more in the manner of automated diaries or record cards with an emphasis on sorting, rather than in any strategic planning applications. Where spreadsheets have been suggested for non-routine strategic purposes, these have mainly been developed as exemplars (see Brail, 1987), although as such spreadsheets continue to elaborate in terms of possible functionality and graphical presentation, some very powerful strategic planning applications become possible (Harris, 1987; Banister, 1988).

Mapping systems and Population Census data sorting and display are quite well-developed in practice using middle-level information systems constructed from several standard program packages, for example, SASPAC (Small Area Statistics PACkage). Such systems have limited functionality and the emphasis is on efficient storage, rapid processing and clear display (Challen, 1982). High quality maps are often required and the GIMMS (Geographical Information Mapping and Management System) cartographic package is widely used to produce such products. In fact, geographical information systems per se have not found much use in planning practice. The kind of spatial analysis which packages allow, is often of more academic than practical interest, while strategic planning uses are limited to problems of site selection via overlay analysis (Dangermond, 1983). GIS systems represent an
interesting mix of precise data manipulation alongside rather broader scale design and decision functions. In urban planning, they are suitable for a very limited range of problems which occur in rather specific contexts. GIS often have excellent mapping capability with many useful operations involving map geometry at both thematic and cadastral levels. Some are based on relational data base theory which enables the complete association of spatial and nonspatial data. However, the main use of such systems is likely to remain in the resource area from whence they have originated (Yeh, He and Chen, 1987). The problem of applying such systems in urban planning is that much of their functionality is likely to be unutilised, thus implying that narrow, deeper perhaps purpose-built systems are more appropriate. Nevertheless, GIS systems present the clearest specifications of spatial information systems to date and as exemplars, they are exceedingly useful (Burrough, 1986; Teicholz and Berry, 1983; Scholten, 1988).

Routine spatial information systems in planning are more likely to involve narrower and more primitive functionality than GIS. Property information systems based on registers which can be displayed as cadastral maps, and development control systems which must be relational in linking topic-based data to sites, require functionality which is more similar to accounting than spatial analysis, but often requiring the sorts of graphic display characteristic of GIS. In Britain, for example, this is the area of application where such systems are being built from combinations of simple micro-based accounting packages, to large-scale turnkey systems designed exclusively for development
control, for example. The Wootton-Jeffries PLANET suite and ICL's PLANAPS (see Farthing, 1986a; 1986b) are proprietary systems, purpose-built for the task in hand, while in-house packages based on primitive accounting using wordprocessing are even to be found (Haslam, 1982). The particular feature of these applications and tasks involves their routine nature, and it is this which accounts for the comparatively wide use of computerised information systems. Accounting, sorting, classifying in diverse ways, as well as rapid access to particular records and their display in spatial terms are the key features of such operations. Rarely is there any requirement for spatial analysis and certainly there is no requirement for strategic capability. In fact, the main rationale for adoption in planning agencies is one of improving productivity in the development control process, not enabling better decision-making insofar as better is not equated with faster (Farthing, 1986a).

The use of information systems in routine operations in planning agencies is somewhat similar to that in office automation 5 years or so ago. There was a phase in the introduction of wordprocessing when such systems were mainly purpose-built, turnkey installations. This quickly gave way to simpler, less sophisticated systems on micros which in time have become much more user-friendly. There is still the possibility that wordprocessing may revert to purpose-built hardware-software packages, although this seems unlikely. In development control, purpose-built systems are giving way to packages operating on any set of microcomputers. However, the use of completely generalised
software such as spreadsheets in this area ultimately depends not on the spreadsheets or similar database packages themselves, which are ever more powerful, but on the ability of planners to recognise their potential application. This, of course, depends on awareness and training.

In summary, most developments of information systems in planning so far are based on routine tasks - monitoring/development control, display such as mapping, data analysis and classification - in short on communicating more efficiently and more rapidly, rather than providing better techniques for design or decision. The scale of such systems tends to be local rather than regional or beyond, functionality is limited and users tend to be administrators rather than planning professionals, although systems professionals might be much in evidence. This is consistent with smaller, integrated systems and larger, more partial systems which might be integrated through user communication via networks rather than through integrated software. This is not the age of large-scale systems in planning: a history of bigger followed by smaller parallels the very history of computers and computing itself and it also fits contemporary perceptions of planning tasks which view plan-making, monitoring, implementing and communicating as partial rather than comprehensive, complex and intensive rather than simple and extensive.
4 PROCESSES OF INFORMATIVE PLANNING

4.1 Conceptions of the Planning Task

Urban Planning was first institutionalised in the early years of the 20th Century in both Britain and the United States. Since then, it has evolved quickly and dramatically, its focus changing quite radically especially during the last twenty years. Its original focus in Britain at least, if not everywhere, was based on solving problems of environmental or public health caused by rapid urbanisation in the 19th Century. This social concern was articulated in terms of physical solutions involving the establishment of space and design standards coupled with sets of rather blunt instruments designed to both constrain and direct urban growth.

Until the mid years of the century, this model was elaborated into a comprehensive concern for the physical structure and environment of whole towns and regions. This rudimentary technical method based on Geddes' (1923, 1949) hallowed concept of 'Survey-Plan' became the basic structure on which physical plans came to be prepared. Although the concept of information has only emerged as an important feature within planning since the 1940s, and although computers were but a dream when Geddes first stated his method, planners in practice considered information or data to be the key starting point in planning articulated through the 'Survey'. As Geddes (1923) said "...the survey prepares for and points towards the plan". In the interwar years, this model came to be elaborated in the cliche 'Survey-Analysis-Plan' and by 1960 it had become 'Survey-Analysis-Synthesis-Plan' in recognition by
professional planners that detailed analysis had to be synthesised with professional intuition in devising plans to solve the problems revealed by survey.

There is an interesting parallel between the functionality of GIS systems and this early model of the planning process. Planning as it was institutionalised in a comprehensive fashion in Britain in the 1940s was being developed in an emergent climate of rapid urban growth. Selecting sites for such growth became an important issue, as was best represented in the location of new towns. In parallel with developments in landscape planning, methods for generating plans by filtering out physical constraints on development were virtually institutionalised into the practice of planning. Sieve mapping and its development into potential surface analysis represents the sort of functionality now available in GIS systems, for example in systems such as ARC/INFO. This sort of functionality was important 40 years or so ago, and it is still important in some developing countries (Sazanami, 1986) but it no longer has any major place in planning in Britain; this makes the focus of many GIS systems difficult to embed into contemporary urban planning.

In the 1960s, the planning process was consciously developed into a model based on explicit problem-solving. The uncertainty and complexity of making plans and implementing them came to be embodied in an elaborate and complex model of the process: goals were to be defined, alternative planning strategies were to be generated, plans were to be evaluated against goals, the best
being chosen for implementation, and the whole process was considered to be continual and cyclic so that planners might 'learn' about the problem as they gradually 'converged' on the best solution. This was the era of the systems approach (Chadwick, 1971) in which computers and information were seen as essential tools and concepts in handling the sort of complexity characterising planning.

Several types of analogy were made between planning and systems. Cities were considered as systems which were to be 'controlled' by planning. Much of the emphasis was on control (McLoughlin, 1973) rather than upon understanding cities as systems which was the prerogative of other disciplines and professions, and there was high confidence that explicit mechanisms and procedures could be devised to ensure such control. Information and ideas were considered the life blood of systems, such systems being regarded as consumers of vast amounts of information - 'informavores' as Miller (1983) has so aptly referred to them. Planning was also considered in analogy to problem solving, and to optimisation in management and operations research (Harris, 1971). In all these conceptions, it was assumed that planning was to be comprehensive in that the systems of interest were so strongly interconnected that any analysis based on the parts was bound to be less than adequate (Batty, 1985).

Information systems first made their appearance in urban planning in the early 1960s, particularly in land-use transportation studies. Information systems were conceived of in their primitive
role as data banks, embedded into the comprehensive planning process. Information regarded as central to systems theory represented the material of complexity which had to be managed and controlled. This followed one of the central tenets of systems theory, Ashby's (1964) law of requisite variety, which suggested that to 'kill variety' or manage complexity, one required a control process of equal complexity or variety. Computers, information systems and all the technology one could muster were central to the quest to meet complexity head on with equal complexity. As early as 1965, there were formal developments in planning which suggested that strategic planning required elaborate computerised information systems (Jay, 1965). Such systems were to be integrated with the strategic planning process in grandiose fashion, a far cry from the more modest, routine systems which characterise present day planning. Development control was one of the last areas of planning to which the new technology was to be applied; indeed, such functions were never even mentioned in the mainstream, apart perhaps from McLoughlin's (1973) view that it was in such control that the systems approach would find its real potential.

During the 1970s, the model of planning changed yet again. Comprehensiveness was extended to embrace the whole range of corporate functions in government, through ideas of corporate planning and management. Information systems which were central to such ideas for common areas between such functions were often seen most clearly in terms of common information. But by then planning, in Britain at least, had begun to fragment. In essence,
growth had begun to disappear. Traditional physical intervention, for example, in inner city areas was beginning to be regarded as something of a catastrophe, economic problems began to loom at every level of planning, and the techniques and ideas which had seemed to promise so much were manifestly silent about the emergence of these new crises. In fact, this was the beginning of a recognition that systems planning was correct in emphasising complexity as the interdependence between various problem areas, but was simplistic in its articulation of such problems. The traditional planning model based on Survey-Analysis-Plan came to be abandoned in favour of deeper study and analysis of more limited problem contexts.

The articulation of planning as a comprehensive but simple affair turned into one which, for reasons of practical expediency, could only be considered as a partial but nevertheless complex activity. The technocratic problem-solving model disappeared in favour of more overtly 'political' ways of making plans based on bargaining and negotiation. Planning was no longer the prerogative of a single, comprehensive all-knowing agency, but a proliferation of agencies associated with proliferating urban problems. The quest for pragmatic solutions became the order of the day. In the 1980s, planning has become a coordinating activity, linking public to private sectors as well as an entrepreneurial one concerned with creating opportunities for urban development and change, as well as engineering local economic growth itself. Strategic planning has all but disappeared (Breheny and Hall, 1984).
It is into this vacuum that new developments in information technology have emerged. In British planning practice, information technology is now regarded as having greater importance in good office management, in raising ‘planner productivity’, and perhaps in communicating data and ideas more effectively. The development of large-scale information systems is regarded with considerable suspicion for the experience has been that any kind of large-scale approach to urban planning has in the past been fraught with problems. Only in areas of routine activity are large-scale systems considered. Nevertheless, the existence of large-scale systems with considerably greater potential than was ever available a decade or more ago, is beginning to force urban planners to think again about possibilities for strategic action. But the strategy implied in this paper - that information systems should be developed in a tight, small-scale fashion at first, with integration taking place between rather than within systems, remains the most feasible way of using information technology in practice.

4.2 Planning as Intelligent Information-Processing

We are now in a position having discussed the way in which planning theory and practice have responded to information technology, to develop some rudimentary principles for using information systems intelligently within the planning process. Clearly, the planning task should guide the design and use of information systems for this has been the modus operandi of planning for the last 40 years. Planning is regarded as being quite separate from information systems design, and most planning
tasks cannot be considered from the information systems viewpoint; that is, most functions in a planning agency cannot be embedded within an information system, thus limiting information systems in planning as having any strong integrating role. Many small information systems should characterise the effective use of this technology, not single, comprehensive integrated systems.

The model of information-processing however is a very general one, and it has become supremely important in many scientific areas which have given it high status. In one sense, it is the model used in studying the working of the brain, and it is central to the development of artificial intelligence (AI). Expert systems, for example, combine ideas from AI with those based on information systems design, resulting in appealing and persuasive programs for human problem-solving. Information systems ideology is as dangerous as any extreme form of thinking, especially in its application to problem areas which by their very nature are problems whose solutions involve compromise, and the reduction of conflict. In short then, the various conceptions of the planning task indicated above should guide the design of information systems in the explicit recognition that activities such as prediction/forecasting, design and decision all involve qualitative as well as quantitative synthesis which cannot be integrated within any information systems structure.

This then is a first principle in developing systems for informative planning: planning involves a blend of analysis and synthesis which can be informed by various functions which can be
embedded in turn in computerised information systems, but only represent a small fraction of the qualitative knowledge required in planning. In Roszak's (1986) terminology, planning is a blend of ideas and information, in the light of the opinion that "....information does not create ideas; by itself it does not validate or invalidate them". A second principle suggests that planning is so complex a task, or rather set of tasks, that it is most unlikely that it can ever be informed by only a single information system. Indeed, in the present practice of planning, its fragmented, partial nature simply prohibits the effective use of a single system. Moreover, as we have implied continually throughout this paper, information systems are not necessarily computerised, and much of the value in their development in computer terms is in the clarity which they might impose on the development and use of non-computerised systems.

Our third principle involves the coordination of a multiplicity of information systems. The emergence of computer networks and the design of office environments built around such networks provides the obvious basis for communication between diverse systems. Beginning with highly decentralised hardware running separate systems or from the traditional highly centralised mode of computing in many planning agencies, networks can be designed which enable enormous opportunities for communication to be realised. In fact, networks are hidden from users and for much of the time, users need never be aware of potential opportunities for decentralised computing. In this way, organisations can evolve their means of coordination as users become aware of each other
and learn about the possibilities of integrating various tasks.

Hardware and software need to be coordinated, of course. In particular, the existence of standard software residing at some point on the network accessible to all users, implies some form of hardware standardisation. With respect to data which is also likely to be located so that many users can gain access to it, standardisation of hardware is less important. Data itself has to be standardised but this is usually easier with respect to its format and the way it is stored, than standardisation of software which often implies knowledge of a machine's internal architecture. It is difficult to generate rules or principles more detailed or explicit than these. Every situation is different, and the use of information systems is bound to reflect the details of organisational design as well as the context of planning in particular localities. Hierarchical principles of data and information system access may be appropriate or they may not; much will depend upon resources, attitudes and the historical pattern of computer use and development in the particular organisation.

What is possible is to indicate where information systems might be appropriate and how they might be coordinated in a typical (British) planning agency. In Figure 3, we show how the functions of plan-making, monitoring and control, implementation and communication might be structured in archetypical form. Clearly, common facilities for input and output of data form the central core of such coordination. What Figure 3 does not show is how
such functions might relate to the broader organisation within which the planning function is located. This picture, however, is the nearest we can get to a generalised blueprint for how hardware, software and orgware can be developed together for a set of typical 'planning' tasks. In the next and last substantive section of this paper, we will show how one of the multiplicity or information systems planning requirements can be developed in the light of the principles and issues raised so far.

5 INFORMATIVE PLANNING BASED ON RUDIMENTARY INFORMATION SYSTEMS

5.1 Hierarchies of Information Systems
Planning which involves information from a multiplicity of systems, will also involve some ordering of those systems with respect to their roles, the degree of expertise required in their operation, limits on their access to users and other constraints imposed by the organisation. A hierarchy of information systems is likely to exist, with the most complex, expert-orientated systems available only to a few experts on the upper levels, and widely available systems based on standard software at lower levels. Higher level systems are likely to contain or link to functions which have specialist analytic characteristics such as forecasting and design, while lower level systems which are likely to be considerably more numerous, will contain standard functions with more general applicability, and easier to comprehend functionality. To define these systems in a hierarchy of levels does not mean that these levels are necessarily integrated with each other, nor does such a hierarchy imply that smaller lower level systems are contained or nested within larger higher level
Figure 3: The Coordination and Communication of Information Systems Between Typical Planning Tasks
systems. Nor is there likely to be a perfect correlation between level in the hierarchy and the degree to which information systems are purpose-built. Indeed, in the example which follows this section, a relatively low-level information system, more akin to a library than an instrument of analytic classification, is purpose-built but from more general software by applications programmers with some professional planning expertise.

It is envisaged that all such systems would be online, that is, be available interactively. If networked, then all systems would in principle be available from all workstations. Various types of experts and users would be peppered up and down the hierarchy and across the network, but access to the various systems would depend on precise roles, hence tasks. To design such a network which would clearly involve distributed computing and decentralised storage, the system design itself could be as complex as that of planning a transportation system for a small town. Although the network would be invisible to casual users, its efficiency is likely to depend upon both the types of machine and workstations connected to it, and the spatial layout of its various components.

A typical user accessing such a network would either log onto a terminal which would automatically boot up to present a menu of possible applications programs or would simply display its local prompt thus requiring some knowledge by the user as to the various possibilities available in and from that particular workstation. Moreover, workstations would enable a variety of local as well as distributed processing. Users may use such terminals as
microcomputers independent of the network or use the network to retrieve standard software and data located at remote sites, thence continuing entirely in local processing mode once data and software are within the local memory. In this sense, the network is only of use in transferring information, not in any form of higher level processing. The design of such a system will depend upon various tasks and roles peculiar to the organisation, and users will only be able to access those systems which they are likely to be able to use from given terminals. Characteristics of such systems however are likely to be such that they will be littered with HELP facilities, and perceptive users are likely to be able to work their way through what is available whatever their status in the organisation.

We have already attempted to define a typology of information systems relevant to planning tasks, but it is also worthwhile defining these systems by their level of complexity and expertise of operation. At the base of the hierarchy lie what might be referred to as public information systems, which simply display major characteristics and information about the planning task environment, the kinds of facilities computer or otherwise available, the organisation's personnel, bulletin boards and so on. There may be some structure to these systems, in particular between those which serve individuals within the organisation and those outside it. These systems are a little like libraries of information, and those which are available to the public for information and even participation would consist of data and facts relating to planning problems and proposals of direct concern to
potential users. There may even be some expert-like system interfaces dealing with queries from users.

These lowest level systems relate up to the next level involving **specialist library systems**. Such systems will consist of already processed data; that is data processed even perhaps by decision-makers and politicians. Examples consist of map libraries, numerical information in tabular form, even 'factual' summaries of problems and issues prepared by experts. Although any form of processing adds value to the data and that value will inevitably reflect the perceptions and priorities of the experts who have created it, these libraries involve data that is clearly going to be reused and reprocessed in the plan-making, monitoring, implementing or communicating roles of the planning agency. Our example below will be based on such a system.

Moving to the next levels, there are likely to be information systems with limited analytic functionality and systems with extensive analytic capabilities. The former **simple analytic systems** are likely to involve elementary statistical manipulations, classifications across various dimensions, and the creation of presentable outputs which enable less expert users to make interpretations and draw conclusions. **Advanced analytic systems** take statistical analysis one stage further. At this level, such systems are likely to draw on other systems, that is, involve fusing data and information from one system with the analytic capabilities of another. Modelling systems may be involved at this level. Both these types of system produce
information which can be 'dumped' into libraries at lower levels, and there may well be ancillary software which is involved in creating appropriate specialist and general library systems from information produced at this level.

Two broad classes of system occupy the higher levels in the hierarchy. The first class consists of information systems involving routinised operations such as monitoring, development control, implementation and so on. We have looked briefly at development control systems and once again such systems produce information which can be stored in libraries at lower levels. The second class of system involves predictive and prescriptive functions in planning centred around forecasting and design. In this area, information is used and created but, strictly speaking, these activities cannot be considered as being embodied in information systems per se. Indeed, one of the most controversial features of geographical information systems is their functionality which suggests certain solutions to physical resource problems or design issues. Prediction and prescription are so theory-laden and qualitatively complex that it would only be the most foolhardy who could suggest they be incorporated within information systems. And as we have argued earlier, it is likely that on a strategic level where information systems are required, these activities will determine the form of those systems at lower levels (Batty, 1979).

Libraries can be used in many ways: for selecting information to study in depth, for browsing and acquiring a general 'feel' for a
particular situation, for searching out a problem and its associated structure or lack of it, and so on. These functions and activities will characterise the libraries we have referred to above, but to illustrate their use, we will now turn to an example, involving the construction of a specialist information library in our own local area, thus demonstrating its role in the planning process, how it can be used, and the issues involved in its construction.

5.2 Library Information Systems: The Development of a Map Browser
There are few examples in planning to date involving the use of several information systems which are well documented. Indeed, information systems are such practical instruments that a good deal of their use and operation goes unreported. The occasional exceptions are extremely valuable (Kraemer, Dutton and Northrop, 1981; England et.al, 1985; Sazanami, 1986; 1988). Here we will briefly recount the principles involved in constructing a simple library system containing data relevant to a socio-economic profile study of the southern area of the town of Cardiff in South Wales. This study was commissioned by the Cardiff Bay Development Corporation, an agency set up to regenerate the docklands area of south Cardiff by bringing in private capital to effect the transformation. The agency is similar to a task force commissioning technical work and acting as a forum for discussion and action, hence requiring high quality information in their decision-making.
The Corporation required us to produce a rapid picture of socio-economic conditions in south Cardiff in an area which contained some 15,000 jobs, 6,000 population and covering an area of about four square miles (Alden, Batty, Bracken and Longley, 1988). Although other agencies involved in planning have responsibility for the area - the local authorities of the City and the County, the Welsh Development Agency, the Land Authority for Wales - the Corporation did not have immediate access to their data bases, and thus our project involved collecting such information from local agencies and synthesising this with publicly available secondary sources.

The project involved two main phases: first, data had to be collected and merged with secondary source data extracted from remote sources across computer networks; and, second, once processed, data had to be assembled in a library of maps and statistics, constructed in a manner to facilitate 'leisurely browsing'. The first stage involved a whole series of computer operations and software ranging from map digitisation to statistical classification, and involved expertise in computer cartography and the use of specialist information systems software to retrieve census data. The second phase in constructing the map library was largely a programming task requiring expertise in information systems design, sorting and search procedures.

These two phases are illustrated in Figure 4, which shows the enormous variety of computers, networks and software expertise required to produce what is an extremely simple map library. The
best way to proceed is to explain the elements in Figure 4. A major source for the project involved the 1981 Population Census which is available at the South West Universities Regional Computing Centre (SWURCC) in Bath. This data at the level of enumeration districts (EDs), of which there are 73 covering south Cardiff, can be extracted in various forms using the SASPAC software mentioned earlier. The data can be transmitted to Cardiff using the national JANET network which links all UK universities to one another. Macros written by systems programmers in Cardiff enable this data to be brought to any of the VAX machines on one of the local area networks in the University of Wales at Cardiff.

To create maps to display this data requires two different machines and several types of software. The EDs in the Cardiff Bay area were digitised using locally written software available in a suite called MAPMANAGER (Bracken, Holdstock and Martin, 1987) which in itself is an elaborate geographical information system. This software is written for an IBM-PC in Microsoft BASIC and some assembler code, and the entire map digitisation, checking and display is carried out offline on a microcomputer. The data files are then assembled and formatted so that they can be input to the main map creation software used which was GIMMS. The data was transferred from the PC to a VAX on the LAN, on which the GIMMS software was mounted. This software matches the numerical spatial data input, in this case Census data at ED level, to the digitised map data and enables the user to create a variety of presentable maps. These maps can be created interactively and
Figure 4: The Constellation of Hardware and Software Used in Creating the Map Browser

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stored as plot files to be displayed or plotted at a later date. The same process was also used to create maps from a recent (1988) employment survey for Cardiff Bay which was also to be combined with the Census maps in the map library.

A huge variety of software was involved in creating these maps: operating systems PC-DOS, VAX/VMS, the ICL Estriel OS at Bath, as well as high level languages MS-BASIC, FORTRAN 77, and the complete packages SASPAC, GIMMS and MAPMANAGER. File transfer software such as KERMIT from PC to VAX, and non-specified systems software enabling file transfer over JANET from Bath to Cardiff was used. At least 4 experts as well as the author were involved in using this software to create the maps, and at least the same number were available at Cardiff and SWURCC to resolve any problems with local and remote software. This, of course, excludes the authors of the standard software packages and file transfers. This might seem a large number to create such simple maps, but the state-of-the-art is such that this process has only become feasible within the last 5 years.

5.3 Structure of the Map Browser

Hard copy of the maps created was used in the socio-economic profile report. But it was also decided to construct a 'map browser' which was to be available online both as a demonstration package, and a genuinely useful tool to learn about the socio-economic structure of the area in question. 53 maps were available in the library and these can be plotted on a variety of graphics display devices. The maps are classified into four
types: those dealing with the spatial definition of the area in question, and three other sets involving the employment, housing and population characteristics of Cardiff Bay. The browser was constructed as a hierarchical menu system, users being able to search through menus at three levels of detail until the map they required to view was reached. The three levels in the hierarchy deal with sectors of activity, classes of activity and finally, types of activity, nested in the hierarchy shown in Figure 5.

When a user logs on, the command $INFO reveals a number of options possible with the work station in question, one of which $DEMO enables the user to access the map library.

Users are able to explore the structure of the library without viewing any of the maps. In fact, users are first advised to do this so that they may get some 'feel' for the system in question. Users are able to move up and down the hierarchy following the menus as they are shown in Figure 6. It is particularly important that users become acquainted with the transmission between menus and maps because this involves switching the screen from graphic to alphanumeric mode, and thus, at an early stage, users are advised to select a map and go backwards and forwards flipping the screen from one mode to another using the control sequences for the terminal in question.

The complete menu system is illustrated in Figure 6. In the master menu, users can choose to look at base maps to gain some knowledge of the Bay area and its spatial subdivisions, or can choose between the sectors of employment, housing or population.
There are 5 classes of employment: four of these - industry, unemployment, travel to work employment, and activity rates - are based on Census data collected at residence, while employment at workplace is based on a recent special survey conducted by the Corporation. There are four housing classes involving social class of household, house condition, tenure and mobility, all recorded at place of residence. Finally, there is only one population class, namely the age structure of the population. As Figure 6 illustrates, at each level of the hierarchy there are expansion slots for data not yet available, data which in a developing situation would be provided from other types of information system and planning function in due course.

A typical search or 'browse' through the complete hierarchy is demonstrated in Figure 7. This shows the sort of map which resides in the library, and also indicates the kind of guidance produced once the user logs on. In fact, a more experienced user can get rid of any information already known or displayed by breaking out of the graphic display back to the menu or submenu in question. The organisation of the menu system is such that moving back up the hierarchy involves a sequence of movements, one level at a time. In Figure 8, we show a series of maps residing in the system and their position in the hierarchy. The maps produced are all to a standard layout and once one is understood, all the others follow easily. It would take about 2 hours to explore the system thoroughly, but probably longer if all the maps were to be viewed. In this sense, users are advised to use the system more than once. Finally, it is possible at any stage to take hard copy
Figure 5: The Hierarchy of Activity Sectors, Classes and Types
of the graphics screen assuming one is working from a terminal to which a hard copy device is attached. We usually run this system from a medium resolution (512 x 390 pixels) device attached to which is an ink-jet printer. To print a map, takes about 2 minutes. The time taken to display the map itself depends on the graphics device and how many other uses are logged into the MicroVax II machine on which the system is mounted. With 3 or 4 users, each map takes about 1 minute to display from the plotfile. Screen dumps would clearly be quicker, but the system does not allow this.

There is considerable potential in the system for expansion. Embedding numerical data and its display alongside the associated maps would be straightforward. Extending the system to create maps, hence allowing the user to explore his or her own spatial analyses of the data, is not difficult but it would be very time consuming. To create a map using GIMMS requires first selecting map type and data, and putting this into GIMMS format. This would be fairly fast but the subsequent creation and display of a map could take up to 3 minutes. This would move the system onto rather a different level, that involving simple analysis, but it would let users construct derived variables such as location quotients and various ratios from the raw data, and map these. A pictorial record could be kept and a library thus created in this manner.

Other extensions of the system to improve its capability might involve colour plots: at the moment, the maps are created with
Figure 7 : A Typical Search through the Hierarchy to View a Map
Figure 8: Typical Maps Generated in the Course of 'Browsing'
black and white reproduction in mind, but this is only because the simplest graphics device on which the system runs is only capable of displaying two colours. This type of library could be linked to similar types. In fact, the potential exists to design libraries based on different sectors of activity which draw on the same basic maps and data. A good deal of the software involved in creating libraries involves designing user-friendly screen displays, and efficient methods for searching the hierarchies created. The development of expert systems is close in spirit to these ideas, especially as the knowledge contained in such systems might parallel that used here.

Finally, a word on the costs involved in creating such systems is necessary. Much of the local processing time involved in digitising is effectively free computer time, but the use of the local area network, the time used on the VAX computers, and the use of JANET to access data on the ICL 3980 machine at Bath are all chargeable. There are also copyright charges on the Census data processed and although these are fairly modest for university and other government users, they can nevertheless be significant. A cost-benefit analysis of developing these maps using traditional versus computer methods is not a relevant issue because maps such as these and the display in library form is not possible any other way. In short, the creation of these maps is the main source of costs rather than their use in the library system.
CONCLUSIONS

Many issues have been raised in this paper which are instrumental in the development and intelligent use of information systems in planning. The first point relates to the simplicity and robustness of information systems design. The technology is now available to generate relatively large numbers of simple systems which can inform various planning tasks in diverse ways. Information systems are best constructed around the notion of low-level processing such as the library system for Cardiff Bay, described above. Elaborate integrated systems are more problematic and the greatest care that has to be taken in information system design for planning, relates to the in-built functionality of such systems. The greater the functionality of such systems, the more likely there are to be differences and conflicts between conceptions of what is required in planning and what the information systems dictate be required.

Linking or integrating information systems should revolve around the orgware of any planning agency. Increasingly, organisations are developing local area networks which enable many users to communicate with one another and use standard software. Integration can thus be effected across networks. Whether or not information systems should be based on generally available standardised software, or whether they should be purpose-built, will depend upon the tasks in mind and the expertise available. Professionals trained to some degree in information technology will always be required. It is now possible to build simple, effective information systems tailored to the task in hand at
relatively low cost, but assuming the experts involved are thoroughly familiar with both the planning task and the hardware and software available (Batty, 1988).

The central issue in planning is how information systems can be used intelligently and effectively. In this sense, a good deal of the functionality of elaborate systems such as GIS is unnecessary, largely because that same functionality developed separately in computer techniques is always superior. Overlay analysis is a case in point. Information systems must always defer to the demands of the policy process for much more is known about the specification of the planning task in professional, political and organisational terms than can ever be built into the functions of an information system. More case studies are required of good practice in the design and use of information systems especially if planning is to continually improve its use and management of information. But experience already suggests that smaller, more robust systems are much more successful than bigger, integrated ones. As we move towards an environment which is entirely underpinned by information technology, this in itself will ensure that a multiplicity of small, robust information systems will come to be the norm.
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