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THE COMPLEMENTARY DEVELOPMENT OF GIS AND INFORMATION TECHNOLOGY WITHIN A GOVERNMENT ORGANISATION

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Abstract

In a government organisation with a number of distinct business units, unmanaged introduction and diffusion of Geographic Information Systems (GIS) may result in duplication of effort, and ill-feeling among stakeholders, particularly those with a vested interest in the use of information technology (IT) in general, and GIS in particular. This is probably a result of an increased competition for the limited IT budget or a potential redistribution of power as perceived by the stakeholders. Actually, both IT and GIS groups play a complementary role in the overall IT development of an organisation.

Based on a recent study of the development of GIS in several State Government agencies in Australia, this paper highlights the services provided by the IT and GIS groups respectively in meeting an organisation's IT requirements, both infrastructure and business process. In a government setting, the process of IT and GIS development for which four contingencies have been identified, is driven by the strategic needs of the organisation. The management implications of bringing the organisation forward from one contingency to another in the process are discussed.

Introduction

Geographic Information Systems (GIS) development appears to be closely related to information technology (IT) development. However, GIS is often developed and managed by professionals other than those from the information technology services (ITS) department in an organisation. This paper attempts to shed light on the relationship between IT and GIS development. First, the issue is tackled theoretically. Then the concepts generated are compared with findings from three mini-cases of GIS development in State government agencies in Australia. The outcomes are discussed and conclusions are drawn based on these practical experiences.

GIS, Information Technology and Their Integration

In this paper, IT refers to the computer hardware, software (including applications), ancillary facilities, and the associated communication technology required to meet the information needs of an organisation. Weill, Broadbent & St.Clair (1994) classify IT into two groups, infrastructure and business process. Business process is that part of organisational IT needed to generate products or services to customers, while infrastructure is that part needed to provide "a stable base of reliable services to enable business process IT to be easily connected and changed". As more and more business process IT is decentralised to the business units, the role of the ITS department as a provider of IT infrastructure becomes more significant. Weill & Broadbent (1994) identify twenty-one IT infrastructure services that are provided by ITS departments in private organisations. Important examples of these services include *management, maintenance, support of large scale data processing facilities; management of corporate communication network services;* and in terms of traditional database management services, *management of firm-wide applications and databases* etc.

Geographic information is a type of management information needed to support decision making (Obermeyer & Pinto, 1994, p. 49). In general, GIS can be regarded as a kind of management information systems (MIS), and like other MIS, it is part of the larger IT of an organisation. This relationship between IT and GIS is more explicitly described when Chan & Williamson (1995) define GIS as comprising five elements: *data, information technology, standards, expertise,* and *the organisational setting*. In their definition, *information technology* refers specifically to the computer technology components required to meet an organisation's geographic information needs - a subset of the meaning of IT adopted in this paper.

Though GIS can be classified as a MIS functionally, technically speaking, it is unique enough to deserve special attention. It demands a special combination of skills and knowledge, namely, (1) proficiency in the substantive application areas such as mapping, asset management, or environment planning etc., (2) GIS skills, and (3) basic geographic and cartographic principles (Obermeyer & Pinto, 1994, p. 70). Huxhold & Levinsohn (1995, p. 7) identify three geographic and cartographic principles that are fundamental to the successful implementation of GIS: georeferencing, "the process of locating features within a model of the surface of the earth"; geocoding, "the process of attaching a geographic reference to nongeographic data"; and topology, "the branch of mathematics that defines the relationships between features". These principles are no stranger to professionals such as surveyors, planners, or natural resources scientists etc., but often are unfamiliar to personnel providing ITS to an organisation. This is why GIS often starts off as a local project within a certain business function of an organisation,

pioneered and developed by professionals (GIS group) other than the organisational ITS staff (ITS group). Therefore, GIS development should be managed by a specialised GIS group, irrespective of whether it is affiliated to the ITS group.

Based on the two groups of IT as identified by Weill et al. (fourth paragraph), when a GIS remains a local stand-alone project that requires minimal access to corporate databases, it is just like an additional set of business process IT developed on top of infrastructure IT. It is more the concern of its developer - the professionals and business managers - than that of top management or ITS group. However, the moment it is deemed necessary to integrate the GIS with the mainstream corporate IT to be shared by other business units, GIS can take on the roles of infrastructure and business process, just like IT (Chan & Williamson, 1995). As business process IT, GIS provides spatial data manipulation functions such as overlaying, buffering, network analysis etc., and specialised application or modelling programs to support an organisation's daily business. As infrastructure IT, GIS provides the skills and a common spatial framework on which these databases can be georeferenced and geocoded for future spatial analyses. It also provides specialised database management techniques based on sound surveying and cartographic principles to provide up-to-date geographic data for decision making. In its simplest form, GIS can generate a map as a common backdrop for displaying and analysing existing datasets.

GIS Development

Ideally, business and ITS managers should plan their work according to organisation goals, while aligning with each other (Keen, 1991, p.227; Walton, 1989) and with top level policy (Keen, 1991, p.189). If GIS is considered essential to the organisation, it should also be included in the process. To facilitate such an integrated business/IT planning process, Keen (1991) suggests a reach and range framework to define the business functionalities of the corporate IT platform. According to Keen, the corporate IT platform "is a shared information services delivery base", i.e., the IT infrastructure (including GIS); reach is "the locations a platform is capable of linking"; range refers to "the degree to which information can be directly and automatically shared across systems and services" and so, defining the IT or GIS services that can be shared across platform.

Based on this framework, a relationship between GIS and IT development can be described. IT infrastructure provides the reach, determining the extent GIS is physically linked in the organisation, and the range of supporting services, allowing GIS services to be freely shared by the business units. Simultaneously, GIS infrastructure enriches the range (of services) of the IT infrastructure by providing: 1) spatial data management capabilities in addition to the traditional database management capabilities across organisation; 2) a common geographic data framework to support consistent geocoding, georeferencing, and spatial analyses involving all databases that are linked by the IT infrastructure. However, this relationship will exist only when GIS is integrated with corporate IT. Therefore, unless a GIS group is developing a stand-alone GIS, it should maximise the chance of successful implementation by considering the constraints and opportunities inherent in the larger corporate IT.

Based on the reach and range framework, we also can identify different contingencies of GIS development as illustrated in the matrix in Figure 1. In this matrix, there are two scenarios of GIS range along the x-axis - discrete and integrated, and two scenarios of GIS reach along the y-axis - local and corporate. Strictly speaking, the x- and y-axis are both continua of the range and reach scenarios, representing an infinite combination of contingencies. However, for illustration purpose, four contingencies of GIS development are highlighted here:

- local discrete - GIS exists as stand-alone systems in one or a couple of business units;
- corporate discrete - GIS exists as stand-alone systems in many business units corporate-wide;
- local integrated - GIS exists as a system integrated with the local IT system of a business

unit;
- corporate integrated - GIS exists as a system fully integrated with the corporate IT, infrastructure and business process.

As the reach and range framework is originally developed for IT, it is expected that the matrix and the four contingencies are equally applicable to IT development.

The matrix can be a useful planning tool. It allows an organisation to map the states of IT/GIS development, and to plan the path needed to bring IT and GIS from their current state of reach and range to the planned state according to the strategic goals.

Though the above concepts concerning IT/GIS development are derived from the commercial sector, it will be interesting to see if they apply to the government sector in practice. Such an opportunity arose during a recent visit to several State Government agencies in Australia to study their GIS development. Three cases are documented below to briefly illustrate the actual situations regarding the concepts described above, i.e., 1) alignment of GIS with strategic goals of an organisation, 2) the relationship of IT-GIS development, 3) the four contingencies of GIS development. To avoid possible embarrassment to the agencies and the staff concerned, the agencies are identified by a codename respectively: Xcase, Ycase, Zcase. Other than that, as far as the authors can ascertain, the information provided reflects the actual situation.

Cases of GIS Development

Xcase

The first agency is Xcase which is responsible for the supply of mapping data, both paper-based and digital. It has a total staff size of about 400 and an recurrent annual budget of over A$21 million (1992/93). Though staff were already experimenting with digital facilities in 1974, the organisation was not committed to a digital environment and as a result, not much progress was made. In 1985, the present agency was officially established by an amalgamation of two existing Offices and later was headed by the present Director in 1987. Since, 1980/81, there was a continuous scaling down of budget and staff size of both the present agency and its parent Offices . In addition to being located away from the State capital, there appeared to be a feeling of isolation. By 1987, the morale of the staff was low and many were disillusioned of their future with the completion of the state-wide cadastral pattern developed from orthophotographs. The new Director who was conscious of the needs of the agency and its staff, and had experience with GIS, decided to adopt the technology as part of the long term strategy of the agency. At first, there was limited support for the new vision. Many staff, apart from the GIS pioneers, were not familiar with use of computers and could even be considered techno-phobic. Use of information technology in the agency was limited. With the appointment of a supportive business manager, a systematic effort was made to better align the views of managers and staff with the help of GIS pioneers. The effort involved promotion by merit, training staff in the new technologies, and encouraging staff to interact with clients to find out their needs. More significantly, with the help of rigorous cost-benefit justifications, politicians were convinced to inject capital for the development of Statewide digital geographic (including cadastral and topographical) databases. Staff could then see the benefits of change, particularly the adoption of GIS, and so, a vision driven, customer oriented, IT/GIS embracing culture was developed. Spearheaded by the Director, IT developed hand-in-hand with GIS. The ITS and GIS groups jointly managed the GIS, providing both infrastructure and business process services to the various business units of the agency. The ITS group provided the following infrastructure services:

- Local Area Network that provides wide bandwidth to support transfer of large volume (typically 35GB) of geographic data.
- Economical data storage for large amount of data.
- Hardware support for specific requirements of certain specialised software, e.g., for handling remote sensing data.
- Software support of proprietary GIS software adopted for managing the cadastral database kept on mainframe.
- Vendor liaison, especially concerning software and hardware maintenance.
- Management of attribute data.
- System administration and special data management advice, e.g. proper subdivision of the State's complete cadastral coverage into tile/coverage according to data quantity.
- Data movement to and from clients.
- Special data management services such as updating of clients' cadastral databases.

The GIS group, apart from providing business process services such as value-adding to existing databases to meet the needs of clients, also provided the following infrastructure services:

- Creating, up-dating/up-grading of all the digital geographic databases.
- GIS software support other than the one supported by the ITS group.

In recent years, Xcase became part of a larger department created for land management and environment conservation. Xcase was one of the business units with an integrated GIS. With the help of in-house GIS experts, the department produced an IT strategy to coordinate development of the IT/GIS capabilities available to better achieve its business objectives.

Ycase

The second agency is Ycase which is responsible for land administration, and general supply of land ownership data, both paper-based and digital, for about three million legal parcels. It has a

total staff size of about 700 and an recurrent annual budget of over A$52 million (1994/95). It started examining the use of information technology in the early 1970s and a working MIS was introduced in 1983. All along, both previous and present Directors of the agency recognised that the system they were running was essentially a GIS, involving both geographic and attribute data. In 1988, surveyors from the Charting Branch got funding to start a pilot GIS project to investigate if providing a computer cadastral index to the land ownership information was feasible. However, before a full GIS for business application could be developed, the agency needed an accurate State-wide digital cadastral database. In the mid-80s, with an interagency agreement, the development of such a database, also called a Land Information System, was to be coordinated by a separate body. In the mean time, apart from supporting the development of the cadastral database, resources of the Ycase were heavily committed to continually introducing new MIS and the associated changes in business processes needed to reduce reliance on manual labour and backlog of data up-dates, and generally to improve services to the public. Therefore, development of the GIS progressed slowly over the years. Though as a core agency project, the pilot project had to have the involvement of ITS staff, the surveyors controlled the project quite independently. With the completion of the digital cadastral database by a separate state agency in the last couple of years, arrangement was in place for the two agencies to work together to develop a GIS that served their needs. Perhaps, later on, when the GIS is mature enough for agency-wide introduction, the GIS and IT groups can work closer together in the managing the GIS.

Zcase

The third agency is Zcase which is responsible for managing 16,900 km of road and the associated traffic systems in the State, with emphasis on road safety and transport efficiency. It has a total staff size of over 8000 and an recurrent annual budget of over A$706 million (1992/93). In the late 1980s, middle and lower management of different business units were increasingly aware of GIS, and their demand to use GIS to provide a graphical interface to query the large management databases grew significantly. In response, the general manager of ITS justified a case for a corporate licence of a proprietary GIS software with associated training for a small number of people. At that time, the immature technology and difficult commands resulted in great user resistance. A few took on the challenge and became the GIS core group. Three years on, managers separately responsible for assets management and maintenance, route and network planning, road safety and road use, road performance measurement, road funding allocation and environmental management etc. acquired other pc-based GIS products. Though GIS matched the corporate business information needs, there was no consensus on a standard GIS within the agency. A management consultant brought in in 1991 was unable to overcome the problem.

Simultaneously, Zcase's IT policy was being restructured. The officer-in-charge of the exercise saw the value of GIS and fought the case of an integrated GIS at CEO level. Ultimately, an internal cost-benefit justification helped gain approval to set up a team to implement GIS across Zcase. In 1994, a four-member GIS management implementation team was created under the ITS group to oversee implementation of the selected system corporate-wide. To overcome staff resistance in the process, a value management study was conducted with the help of experts to ensure that all necessary functions were provided to meet end user needs. It gained over 90% support and was found to be a valuable tool to facilitate change.

The ITS group of Zcase initially did not understand GIS, considering it as gimmicky. In general, it was not interested in the project and provided only hardware support. The GIS team got on with its work, largely with the help of contractors. The division of labour between the GIS and ITS groups was as follows. The ITS group provided hardware support, general training and Oracle support on a pay-as-you-use basis. The GIS group provided:

- GIS software and hardware support.
- Application development services.

All geographic data issues - maintenance, updating/upgrading, distribution of up-to-date data.
- Help desk service and general GIS training.
- Management of contractors for access of oracle data for use in GIS.

In early 1995, on the recommendation of one of the directors, the project team was placed under a different section in the agency, within a common geomatic environment of surveying, mapping, and property management. Later on, the Chief Executive commissioned a third party evaluation of the implementation of the corporate GIS project, which was found to be a success. The project delivered GIS software, hardware, geographic data, training and applications to users throughout Zcase. Based on the recommendations in the report, the implementation team was given two years to get GIS fully operational and decentralised to regions. It was also required to operate on a self-sufficient basis through provision of services to regions and other clients.

In the mean time, senior management was keen to encourage business units to get quality accredited to ensure that Zcase got value for the money from its investment in management and technology. Special badge presentation gatherings were organised to recognise openly the achievement of those who got the status. Senior management was keen to improve the productivity of the agency through conscientious cultural change. The GIS groups in headquarters and in regions are expected to be accredited in time.

Discussion

By studying the cases described, it is possible to observe several points about GIS development in government that echo and supplement the concepts described at the end of the "GIS Development" section. First, successful introduction of GIS does not necessarily require the direct involvement of the ITS group. However, the IT infrastructure made available by the ITS group is crucial for the rapid delivery of GIS to the business units. Further, the past experience of the ITS group in introducing new MIS may help GIS introduction later on. Second, GIS must meet the business needs of a government agency and aligned with the strategic goals of top management. Third, the four contingencies of GIS development are found to apply equally well to government agencies. In addition, it is found that there can be significant cultural change when bringing a GIS from a discrete to an integrated environment. Top management's input and support is indispensable to see the change through.

IT-GIS Development Relationship

In the process of GIS development, the relationship between the IT and GIS groups varies from case to case. In Xcase, spearheaded by the Director, IT and GIS developed hand-in-hand, and the ITS group had taken up most of the GIS infrastructure services. In Ycase, ITS had minimum involvement with the GIS project. This was probably due to the early stage of GIS development and the heavy commitment of the ITS group to introduce new computerised MISs into the agency. However, it is noted that with the IT infrastructure already in place and the agency's extensive experience in introducing new MIS, the GIS group can benefit significantly from the involvement of ITS.

In Zcase, the working relationship fluctuated over the years. At first, ITS group brought in the first GIS software. One of its member strongly supported an integrated GIS during the review of the IT strategy and ultimately got the GIS group under ITS group. However, ITS staff basically did not understand GIS and the GIS group was left to work independently, with the help of contractors. This illustrated that ITS's direct involvement is not essential. However, the existing IT infrastructure and ITS's infrastructure services are essential to bring GIS to its users within an implementation period of fifteen months. Both groups had paid a price for their minimal cooperation. The ITS group lost the influence that it could have over GIS development, while the GIS group had to provide GIS infrastructure services that could have been provided by the

ITS group.

Alignment with Strategic Goals

In all three cases, there was either an obvious or proven business need for the agency to use GIS. At the same time, adoption of GIS also aligned with the strategic intent of the organisations. In Xcase, the Director's belief in GIS as a means to modernise the agency was the indispensable driving force behind development of the corporate GIS. In Ycase, its previous and present Directors were convinced that conceptually, the system being run by the agency was essentially a GIS. This belief has kept the pilot GIS project as an on-going core agency project since 1988. In Zcase, top management had minimal knowledge of and commitment to GIS. However, their strategic goal was to boost productivity. In the course of realising the goal, IT strategy (incorporating GIS) was restructured and a Total Quality Management policy was adopted. Once they were convinced that an integrated GIS was essential to core business, and was in-line with their strategic intent, they had used various means to ensure the successful introduction of a coordinated corporate GIS. In short, alignment with the strategic goals of top management is indispensable to keep the momentum to drive GIS forward. It also helps to get top management's involvement at time of difficulties, as to be elaborated later on.

Four Contingencies

Examples of the four contingencies of GIS development can all be found from the cases. Ycase, being at the pilot GIS project stage of development in the Charting Section, is typical of the local discrete contingency. If the support of top management continues, it may well move directly towards the corporate integrated contingency. Zcase, starting from an essentially local discrete contingency, went through a phase of uncoordinated GIS development in various business units typical of the corporate discrete contingency. Its effort to integrate its GIS development may eventually bring it to the corporate integrated contingency but it is not quite there yet at the time of the visit. Xcase, with its GIS servicing all business units in an integrated manner, is typical of the corporate integrated contingency. Further, as a business unit under a larger department for land management and environment conservation, Xcase and its parent department serve as an example of local integrated contingency in which Xcase has the locally integrated GIS in a department that does not yet have one.

The concept of a reach and range matrix showing the possible contingencies of GIS development is useful for strategic planning purposes in a government environment. The matrix allows a GIS planner and its clients to map where their organisation is located, and more importantly, where the organisation aims to strategically locate itself. If a more refined analysis is needed, the detailed levels of GIS/IT development that can be achieved can be plotted along the reach and range axes instead, and both GIS and IT can appear on the same matrix. By having a map of GIS/IT development showing where one is, and where one wants to go, it is relatively easy to agree on the best route (strategy) to follow to achieve the strategic goals.

Cultural Change With Top Management Involvement

The cases also bring out an additional point that has not been discussed above: it is usually stressful, time consuming, demanding on resources and management skill, to integrate a GIS with corporate IT. Even with the support of the Director, Xcase had taken almost a decade to change its culture, convincing its staff to use GIS to meet core business objectives.

Zcase which is a larger organisation, has gone through a fragmented phase of GIS development. Its original simple GIS grew into several stand-alone GIS. Recognising the problem, top management acted decisively to remedy the situation. They were unsuccessful initially because the feelings for the utilisation of individual GIS products had been allowed to grow deep among the GIS user groups. However, with input of time and resources by top

management into project planning, and the use of change facilitating tool - value management study - a coordinated GIS was successfully introduced into Zcase, on time and within budget. Afterwards, they continued to monitor progress and set targets to ensure that the GIS would develop into a fully integrated and functioning corporate system. Their expectations and involvement to improve productivity reshaped the norms and values of the staff, and as a result, kept GIS development on track.

Conclusions

Theoretically, IT and GIS should develop hand-in-hand. Actually, in a government setting, the different attitudes and needs of the ITS and GIS groups can result in varying involvements of the ITS group. Contractors can provide the services needed by the GIS group in case support is lacking. What the GIS group relies on most for a fast and effective introduction of a corporate GIS is a good IT infrastructure made available by the ITS group. In addition, success also depends on how the organisation and its staff view the introduction of GIS. If it meets the strategic and business needs of the organisation and if the culture of the organisation is conducive, the process will be relatively smooth. Otherwise, it can be stressful and traumatic. In the latter case, if the resistance comes mainly from the staff, involvement of top management is indispensable to overcome the problem.

A reach and range matrix for GIS development is suggested in this paper as a starting point to help government organisations plan for their GIS development. As an illustration, four contingencies are described, providing a framework to allow organisations to assess where they are, and plan where and how they want to go in the process of integrated IT and GIS development.

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