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Full Length Research Paper

Future IT trends for GIS/Spatial Information Management

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In this decade, Information System are being spatially enabled to cope with the needs of users who always want to know their locations and location of other objects so that they can make spatial decisions which include determining their next direction and destination. However, there are dilemmas on how IT can be used to accomplish these needs in terms of what strategies to use, what models, techniques, and methodologies which should be adopted or followed. This paper looks at the Spatial IT, the technologies that impact on it, its applications and development and suggests ways of developing spatial IT so that future IT trends and development can benefit location oriented Information Systems.

Key words: Spatial IT trends, spatial information management, development approach.

INTRODUCTION

As developments follow the relentless progress of computing power towards smaller, faster and cheaper components; the number of computing-based devices outgrows the old models that held together companies that supply them. This has contributed to a major restructuring of the Information Technology (IT) industry. However, the old does not go away, it just gives up its central role to the new (Sharpe, 2002). This has been observed right from the time of mainframes, which shifted to minicomputers, and from minis to PCs. Another good example is the wireless communication devices, which are becoming increasingly ubiquitous and judging by the number of devices people are willing to carry around, it is clear that there is a desire to be able to communicate from just about anywhere (Marmasse and Schmandt, 2000), which calls for a lot of utilization of spatial information.

Therefore, as one develops IT tools, one should take note of location (geo-spatial) information, as it has become the center of attraction in many developments like Enterprise Location Services and Software (ELSS), which is about the use of location-specific information within information systems. Several technologies combine to make ELSS grow (Sonnen, 2005), and these include the Service-Oriented Architectures (SOA) (Channabasavaiah et al., 2003) and the automated location determination technology like GPS, cellular networks and radio frequency. Spatially-enabled IT Infrastructure, Open Standards, Spatial Data infra-structures (SDI), etc are becoming ubiquitous which underscore the need for a location ready SOA platform (Sharma, 2005; Sohir, 2005) and spatial IT. All these have provided avenues to share geo-information, which come from different sources.

This paper reviews the shift to spatial IT – diffusion and use of spatial information technologies especially Geo-Information System (GIS), and the opportunity it creates for organization and individuals to innovate in new products and services, the IT trends involved, and suggests ways for spatial IT.

The paper starts by examining the problem of handling location aspects in Information – Spatial Information Management (SIM); Technologies impacting on or efforts towards spatial IT where models, methods, and approaches which have been used or are being used to solve the problem of spatial information handling are investigated. This is followed by spatial IT development, future work and conclusion.

METHODOLOGY

The methodology used to come up with this paper followed a combined approach of reviewing recent information technologies which are impacting or contributing to GIS and spatial information systems development in general. This was followed by field research

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general. This was followed by field research to get the desired trends which information technology should take into consideration in order to meet the needs of the future spatial information systems. In summary, the approach we used is similar to meta-analysis (Hunter and Schmidt, 2004; Neil, 2006) which helped us to select existing studies, to decide and suggest methods to be adopted in developing spatial IT and to come up with explanations why spatial IT should take that trend.

SPATIAL INFORMATION MANAGEMENT

GIS is a general term for any information system which handles geographic or spatial data - data which describes objects from the real world in terms of (1) their position with respect to a known coordinate system, (2) their attributes that may or may not be related to position, and (3) their spatial interrelations with each other which describe how they are linked together or how one can travel between them (Burrough, 1986).

Thus, GIS is the science and tool of geographic information, it concerns itself with fundamental research issues of using and representation of digital geographic data. In this paper, we look at GIS as a computer system capable of capturing, integrating, storing, editing, analyzing, retrieving, generalizing, modeling, displaying, managing, and disseminating spatial information (Chrisman, 1997).

Spatial Information like all other information systems are always new and changing (Claver et al., 2000) and the issue of management is needed as from the very foundation of computer science in 1945 (Floridi and Sanders, 2002). It was information which needed to be managed in order to achieve goals as information has been considered as a 'utility' just like electric power (Malhotra, 2000).

The management of information systems (resources and strategies) in organizations is a top priority (O'Brien, 2001) as these are employed to play a vital role in efficient operations, effective management and strategic success of organizations. This is so critical especially for geo-information systems, which apart from having complicated data structure they are always set up and updated by more than one individual (Evans, 1997) due to the varsity amount of spatial data. Ma et al. *(*2000) further emphasizes that the use of information management approaches like data warehouse frees the information system organization from having to constantly program custom reports and queries.

The need for Spatial Information Management (SIM) can be evidenced with Google Earth; Microsoft's MapPoint.Net; O'Reilly's Where; Intergraph's reorganization around "SIM"; Oracle Locator and Spatial; ESRI's ArcGIS; US Census' MAF/TIGER integration; new platforms, new vendors, new users and the many conferences on mobile commerce and location-based services (Batty, 2004; Alperin, 2005; Busgeeth and Rivett, 2004). These changes are so diverse, they do not even seem related, but they are (Sonnen, 2005); that is, they take advantage of the vast spatial information available, which reflect the increased importance of location in information systems and services (Strader et al., 2004).

An example is the application of Google Satellite Mapping services to trace and location rapid infrastructure developments in countries where it is difficult and expensive to produce updated maps to match with rapid changes in construction using traditional methods like Photogrammetric approaches. Figure 1 shows how a Ugandan construction company is using spatial IT to help direct its clients and material suppliers to the new construction site.

Figure 1 shows Kin apartment construction site in Najjeera, in Kira Town council - Wakiso district on the outskirts of Kampala (Uganda) captured using Google.

TECHNOLOGIES IMPACTING ON AND EFFORTS TOWARDS SPATIAL IT

There are various technologies like internet, web services, image capture and communication, low cost spatial data collection tools, grid computing power, among others, that are pushing towards spatial IT and as a result they are acting as vehicles through which spatial IT development is taking place. With these technologies in place, several efforts such as Enterprise integration, Decision Support System, Personal Digital Libraries and Collections, Location Based Services and Location-Tracking Trends, among others are spatially enabling their services.

The internet and on-line databases

The impact of the Internet on geo-spatial applications like other areas of IT continues to accelerate (Brodeur, Bédard et al., 2000; Renschler 2003). Increasingly sophisticated applications can be accessed via the Web anywhere in the world, and more data are now accessible online (Scharl, 2007). It is the Internet's capabilities as a pervasive network, connecting computers globally which is impacting on spatial IT by enabling access to spatial databases interactively anywhere in the world (Batty, 2004; Herold et al., 2005). This has created many interesting opportunities, such as the ability to use external databases of various types such as oceanographic, weather, property, demographic, and road databases that include information relevant to routing and marketing purposes.

The presence of spatial information on the Internet (Pastalkova et al., 2006; Chang, 1997) is changing the way the geo-communities think about data. It has contributed to our understanding how to get map-based information into and out of a computer and how to extract data in relationship to other data which speeds comprehension and adds new insight. As this functionality

Figure 1. Satellite View of Kampala using Google Earth Data http://www.nationsonline.org/oneworld/map/ google_map_Kampala.htm (accessed 16 May 2009).

becomes available and accessible to others, the demand for data is growing due to the fact that humans are a species with a strong preference to processing information visually.

Many organizations are providing map-based and enabled information on the internet and spatial data are increasingly being stored in databases on-line, making access more like an on-line transaction processing (OLTP) application (Skog, 1998; Batty, 2004; Sharma, 2005; Sohir, 2005).

Web services

Web sites are being developed which can directly handle spatial information, such as ESRI's ArcXML, which provide ArcWeb Services, Microsoft's web service provides spatial functionality including maps, driving directions, distance calculations, proximity searches, and other location intelligence. Others include MapQuest and Microsoft MapPoint each handing millions of spatial transactions per day (Microsoft, 2007; Batty, 2004). In addition, the Open Mobile Alliance incorporates what was formerly the Location Interoperability Forum work and is focused on standards related to location services based on mobile phones.

Other organizations have applications that conduct routing based on the street data contained within their geodatabase (Fleischmann et al. 2004). Combing this with traditional client-server GIS applica-tions, functionality continues to be added to commercial routing applications, and one of the big steps is the incorporation of real-time traffic information for calculating routes (Batty, 2004). The combination of the above technologies with a variety of standards including the ones explained in section "Spatial Data Standards" below for spatial web services and data interchange, the barriers to widespread use of spatial is now more business and organizational in nature than technical.

Spatial data standards

A number of standards do exist including ISO, OpenGIS, GYPSIE, NIMA, Spatial Data infrastructures (SDI), Geospatial Data Clearinghouse, Proprietary protocols, GIS-network integration, etc (Evans, 1997; Sohir, 2005; Musinguzi et al., 2004). The OpenGIS standards based on eXtensible Markup Language (XML) (Evans, 1997) and Geographical Mark-up Language (GML), for example, have gained the support of major GIS vendors. This technology now enables interaction with remote online databases in different vendor formats across the Internet.

These organizations are working with leading software and hardware companies to identify and publish formats for interoperability, a great benefit to users (Skog, 1998 [0]), and how it can be done between organizations and individuals (Evans, 1997; Erdi and Sava, 2005; Musinguzi et al., 2004).

With these standards in place and being accepted and followed by different geospatial developers, the limit are now only development of spatial IT to accelerate the use of geospatial information system.

Enterprise integration

For many organizations, integration is still a major challenge in GIS projects. According to Aberdeen Group and others (Channabasavaiah et al., 2003; Jhingran et al., 2002; Halevy et al., 2005) on average 40% of IT budgets is spent on integration, and as much as 70% in some cases. The bulk of this effort focuses on integration between a spatial system and various non-spatial systems. For example, in utilities, integration between the GIS and work management, asset management, outage management, and customer information systems is typically a higher priority than integration between different spatial systems.

Thankfully to the new trend towards, adoption of enterprise application integration software (Sharma, 2005; Sohir, 2005) which has continued to increase and provides several significant benefits compared with traditional point-to-point interfaces. This is helping the people working towards spatial IT to focus on IT to enable and support geospatial information systems than dividing the effort on the data integration.

Low cost spatial data collection tools

The development of lower cost, and widely deployed, automated data creation and collection methods such as radio frequency (RFID), automated meter reading, digital imaging cameras, airborne or terrestrial LIDAR, and remote sensing satellites is leading to an exponential explosion of data that must be managed. The availability of such data, coupled with advances in visualization and geometric modeling technology have made it possible for desktop or browser based applications to incorporate sophisticated techniques such 3-D, terrain, engineering, or scientific analysis and visualization (Sharma, 2005 [0] which are vital to the development of Spatial IT.

Location based services and location-tracking trends

There are a growing number of ways that on-line services can tell where you are and adapt appropriately. GPS is the most obvious, but there are also ways that the mobile telephony providers can work-out location. Most new cell phones are location-enabled, either using GPS or other mechanisms, such as E-OTD (Enhanced Observed Time Difference), which does not require special hardware in the handset, but uses a system based on triangulation from cell phone towers (Batty, 2004). In the United States, the move toward location-aware mobile phones was driven by the federal government's E911 (enhanced 911) mandate.

The mandate stated (in overview) that most new mobile phones, activated by the end of 2003, were to be location-aware such that by the end of 2005, cell phone makers had to ensure that 95% of handsets in operation are location-aware (Federal Communications Commission, 2006). Also, researchers have already experimented with ideas such as leaving messages for other people attached to certain places, all enabled by on-line location services (Sharpe, 2002).

In addition to GPS, several interesting location-tracking technologies are under development. Many of these can be categorized as local positioning systems (LPS).

These systems use sensors to track "tags" within a localized area. LPS uses a variety of sensing technologies, including Ultra Wideband (UWB) radio, microwave, and WiFi. Such technologies are of primarily interest for accurately tracking location indoors, which some GPS cannot do. Accuracy of these systems can be a few inches in real time.

There are also micro-GIS-type applications, which provide a foundation for a whole new category of applications known as sentient computing. Sentient applications can sense the real world around them and automatically interact with people or other systems. Spatially enabling modules of Enterprise Resource Planning (ERP) or Supply Chain applications is another happening trend. Organizations have moved beyond Asset Mapping Facilities Management (AM/FM) and now are applying spatial information to Human Resources, Finance, and Logistics. This has enabled organizations to see where raw materials are produced, where they are assembled, where they are inventoried, and where the customers are, so that deliveries can be made. This has benefited many organizations looking to improve their efficiency (Skog, 1998 [0]) and it is pushing spatial IT to the next level as demand continues to grow.

Image capture and communication

Digital image capture has now entered the mainstream IT application, with revenue from digital camera sales exceeding film camera sales in North America in 2005. The technology has been made small enough to fit in a phone or wristwatch, and there is a massive growth in image-based communication as the mobile phone industry rolls out MMS (multimedia messaging).

With imaging technology becoming cheap and ubiquitous it has become much easier to capture and share information, and this has promoted the uptake of many products (Sharpe, 2002). Thus solving one of the barriers (capturing the information digitally) to greater use of products such as white boards that let people work together more informally.

Decision support system and SDI

The GIS plays a vital role in the Decision Support System (DSS) as they move towards meeting the need to share geographic data among all users. With GIS incorporated into DSS, it enhances decision-making and produce significant savings for data collection and use by reducing the effort and money wasted in the duplication of data production.

This has led to building SDI (Sohir, 2005; GSDI, 2005), which facilitate the accessibility to the data and bring it to the user at anytime. The goal of this SDI is to reduce duplication of effort among agencies, improve quality, reduce costs related to geographic information management, to make geographic data more accessible to the public, to increase the benefits of using available data, and to establish key partnerships with states, counties, cities, tribal nations, academia and the private sector to increase data availability (FGDC, 2005; Musinguzi et al., 2004)

Personal digital libraries and collections

The development of Personal Digital Libraries and Collections (PDLC) which can be used in spatial IT has been growing due to two major trends (Neil, 2005):

1. The exponential increase in computer processing power often referred to as "Moore's Law" where there is roughly a doubling of the number of transistors on integrated circuits every 18 months for the same unit cost (Neil, 2005). In the server environment this has lead to incredible functionality gains and a re-definition of IT (Skog, 1998). This technical trend of rapidly increasing computing power is substantially reinforced by a similar trend over time in the volume and cost of computer storage. These developments are placing remarkable levels of computing power and storage within reach of individuals. Already, personal digital stores of a terabyte or more are almost within reach.
2. The increasing consumer digital creativity and an appetite for digital content, which has been dubbed "Generation C". The Generation C phenomenon refers to a perceptible consumer shift from consumption to personal creation, customization, and co-production of digital content (Neil, 2005). Similar to the past "democratization" of computing with the shift from centralized mainframes to personal computers, there appears to be an emerging democratization and personalization of digital content creation. There is growth in personal online journals, personal journalism operating on a mass scale, and interpersonal links such as picture, video and music sharing. It forecasted that there will be increased consumption of "amateur" content and that amateurs will have better links to professional producers/ publishers to send electronically content they have made themselves (Spectrum Consultants, 2004), for example text, photos, and video clips of breaking news from dangerous and hard to reach places on big television networks like BBC, CNN, Aljerza, Sky Net, CCTV, etc are got from communities not from mass communication professionals.

The overall effect of these trends is that people are able to create, capture and store an ever-increasing amount of digital information about or for themselves, including emails, documents, portfolios of work, digital images, and audio and video recordings, and can edit, share, and distribute them easily over the net via blogs, personal web pages, peer to peer networks, or shared services.

As noted by the Microsoft MyLifeBits research project, that it is both theoretically and practically possible to envisage capturing all aspects of an individual's life digitally due to the evolution of digital storage and capture devices. MyLifeBits uses a combination of continuous digital capture via devices such as video cams and retrospective digitization of analogue sources (MyLifeBits, 2005).

Grid computing power

Oracle, Google, Amazon, Yahoo, Salesforce.com and others have spearheaded another trend of enterprise grid computing using low cost hardware and software that enables virtualization and dynamic provisioning of resources. Google, for example, has shown that this infrastructure is excellent for building scalable, and highly available, geospatial services that provide a rich user experience. While Oracle's product strategy is led by the vision that infrastructure resources managed in a grid will progress to the point that computing and storage capacity are delivered on demand like a utility. Applications in a grid will advance so that business and application logic are as massively connected and referenced as static web pages are on the Internet today; enabling frictionless, automated, global business between trading partners. Eventually, a global information grid will impart every bit of digitally represented information anywhere the same values we take for granted with relational databases as if all information resides in a single virtual database. All inherent relationships between information will be revealed, and anyone with appropriate authorization will have instantaneous access to all relevant information regardless of representation, location, or access method (Sharma, 2005).

SPATIAL IT DEVELOPMENT

As the world is already moving towards designing and developing spatially enabled IT and artifacts, the basic characteristics of Information Systems (IS) which is handled should be true, up-to-date, standard, flexible, unrepeated, in desired form and sufficient to the needs and their share ability (Erdi and Sava, 2005). And the issues to consider should include methodology, technology, standards, platform, etc.

Methodology approach

Both diverse academic disciplines and diverse (national) research communities contribute to IS research (Niehaves, 2005). Against the background of this diversity, we should be willing to allow IT research to follow a multimethod research approaches so that it can benefit from such a variety of approaches and contributions. In the process it will help to see IT and IS-related phenomena from different points of view (Mingers, 2001; Weber, 2004). Among the issues which should be put into consideration is the differentiation between Behavioral Science Research (BSR) and Design Science Research (DSR).

BSR has its origin in natural science; uses problem understanding paradigm; with objective to develop and justify theories which explain or predict organizational human phenomena surrounding the analysis, design, implementation, management, and use of information systems (Hevner et al., 2004). While DSR originality from engineering and sciences of the artificial intelligence; it uses problem solving paradigm; with objective to create innovations that define ideas, practices, technical capabilities, and products through the analysis, design, implementation, management, and use of information systems (Hevner et al., 2004).

While BSR focuses primarily on developing and justifying theories on human-computer-interaction, DSR seeks to create IT artifacts intended to solve organizational problems. Following this approach, acquiring knowledge about IT and IS in an organizational context requires the application of both research paradigms (Hevner et al., 2004).

Thus, BSR and DSR can be regarded as two complementary elements of the IS research cycle. Starting from pre-scientific observation of IS and IT usage in practice, theories about IS-related issues are developed by behavioral science researchers. These theories are intended primarily to explain and predict human behavior, information system functions, and issues interrelated with both of these aspects. Through a process of justification, these theories are considered to be true or valid. Thus, they provide a basic understanding of the (real world) problem situation described in the first instance. This understanding provides the basis for the design of IT artifacts which address a given problem situation. By actually applying them, these IT artifacts are intended to become useful in terms of problem solving (Niehaves, 2005). This should be followed as we develop IT for spatial information management.

Disruptive technology

As we develop spatial IT we should put into consideration the big thing for software development that is the ease-of-use and implementation, as opposed to the addition of more and more features. Customers really want and are willing to pay for these capabilities, especially customers in the spatial industry (Batty, 2004).

In fact, the spatial industry is ripe for some disruptive technology, as described in Clayton Christensen's book titled “The Innovator's Dilemma” Batty, 2004). Christensen describes examples in which technologies that were regarded as too "low-end" have improved in functionality and performance to meet the needs of the mainstream. This means that these technologies can take-over from the previous generation of more complex solutions at a much lower price point. An example of disruptive technology is Microsoft MapPoint, which is a customized package, where a large percentage of traditional GIS product users only use a small subset of GIS functionality, for example viewing, doing simple queries, and printing. For such users, MapPoint, or a similar product, may be a very attractive option.

Standards, platform and development issues

The development of spatial IT, projects should not follow the confusion between knowledge and information, which has caused managers to sink billions of dollars in IT investments that have often yielded marginal results (Malhotra, 2000). There is disconnect between IT expenditures and the firms' organizational performance; this is attributed to an economic transition from an era of competitive advantage based on information to one based on knowledge creation which need to be incorporated in spatial IT as they are basis for location decision making.

These IT related projects should be concerned with bringing about changes in the way work is performed in the organization through more efficient or better information handling, otherwise there are no business benefits and value created from the new IT facilities (Tiernan and Peppard, 2004).

Projects in the context of Spatial IT should actually be thought of as creating IT services and not just the systems and IT facilities (Sharpe, 2002). As exemplified by Oracle which has for many years, invested in providing an integrated content store, a robust and standards based application development and deployment platform, and an integrated suite of applications designed for implementing flexible business flows and access to valuable information when and where it’s needed. Such infrastructure makes it easier for domain experts to solve business problems.

FUTURE WORK

The future of Spatial IT is on the expanding geo- technology and its combination with ubiquitous wireless networking, where highly accurate and pervasive location-tracking technologies are radically changing the industry. These technologies will be able to provide much larger quantities of highly accurate spatial data in real time, and ability to know where tracked items are at all times. As such, one will be looking at the development of geo-spatial integration model which will be able to compare geo-spatial data being created by GIS so that it can be incorporated in the development of spatial IT artifacts. This will make spatial information management to evolve as IT platforms evolve.

Conclusion

The fundamental goal of IT is to provide the best information, at the lowest cost and highest quality of service. In this paper, we have looked at the trends towards handling spatial information and provided a review of current trends in applications that exploit spatial information. This helped to show how IT development trends are moving towards including location in the way they handle information so that they meet the needs of the public.

The paper further details how spatial information management is no longer a specialized application, but has a broad relevance to general business applications. Thus, integration of spatial information with the IT infrastructure brings location intelligence to more business applications resulting in better information, and agile decision-making. It also allows domain experts to focus on solving the business problems; a case in point is where spatial technologies like those developed by Google are being used in developing countries to accomplish different needs like location of construction sites by local companies whose strength is in building construction not spatial IT.

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