Green IS/IT: An Overview of Historical Periods, Recent Research Initiatives and Theoretical Approaches

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Abstract: In this paper, we discuss historical periods and recent research initiatives and theoretical approaches to Green Information Systems and Technologies (GIS/IT). Having observed that the GIS/IT history is an insufficiently investigated topic, we used Information Systems History (ISH) research methods, such as periodization, contextualization and generalization. With the help of exploring existing variety of theories and initiatives, we provide clarification of evolution of the GIS/IT concept and explore areas in industry and research that are currently lacking insight. Our methodological diversification of the GIS/IT research assists not only in summarizing the current state of the GIS/IT but also in encouraging ideation and cooperation of the academics from different fields to produce novel outlooks on the GIS/IT.

1 INTRODUCTION

Among numerous studies concerning GIS/IT, presently, the GIS/IT history is an insufficiently investigated topic with blurred boundaries, unclear beginning and indefinite future. We suggest that investigating the history of the GIS/IT serves several purposes: (1) tracing the origin of the GIS/IT concept, (2) applying the Information Systems History (ISH) research methods, such as periodization, contextualization and generalization, (3) highlighting the GIS/IT significance in IS and other disciplines, and (4) summarizing current state of the GIS/IT research.

Our research considers disciplines of history, environmental science and information systems as well as includes resonance of the business and sociological studies. Firstly, we explain methodology we use and our view on the GIS/IT concept. Then, the historical periodization, contextualization, and generalization are used to shed the light on GIS/IT related matters. Investigating essential historical marks in the GIS/IT realm, we explain that historically, the GIS/IT is a modern incarnation of the technological and sustainable paths which can be traced in the history of the humanity far back in the past. Although it is impossible to give a completely thorough historical review of all matters pertaining to traces of sustainability and technology in the course of development of humankind, we picked the most relevant events from the history of IS and GIS/IT. The chosen historical pinnacles are frequently considered in scientific discussions, and thus, are likely to have considerably shaped and continue shaping the manner in which societal trends are developing. After that we give an insight of instances of GIS/IT in practice and research. Presenting cornucopia of initiatives in industry and society as well as theories and framework utilized in the GIS/IT research, we discover areas which are currently lacking insight. To conclude, we summarize findings based on periodization, contextualization and generalization of the GIS/IT in the history of the humanity and how crucial it is to ensure the presence of a multidimensional view of the GIS/IT notion nowadays. We also suggest proceeding consideration of GIS/IT via the historical lens with the multi-fold purpose of the investigation and diversification of views on the concept and popularization of the historical research methods in IS in general.

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2 RESEARCH METHODOLOGY

In this study, we employ historical research methods. Considering Information Systems History (ISH) as the point where IS meets history (Oinas-Kukkonen and Oinas-Kukkonen, 2014), we approach the GIS/IT history as a chronological account of sustainable ideas combined with practical and theoretical technological developments. To contextualize the present of GIS/IT, we refer to contextualizing relevant trends and tendencies in the past, thus conducting periodization and generalization of the history of sustainability and technology, the components of the GIS/IT history. By mapping these components to sources in the past, we employ historical research approach that will help retrieving an encompassing spectrum of what enabled appearance and growth of the present-day GIS/IT domain.

Considering concepts of sustainability and IS – the deep-rooted and considerably researched notions – as the causes which initiated appearance of the GIS/IT, we rely on assumption that "causes always have contexts, and to know the former we must understand the latter" (Gaddis, 2002). By contextualizing the past of these components, we broaden an existing understanding of these notions and, ultimately, we contribute to explaining the GIS/IT domain. Contextualizing the past is complex and an intellectually rigorous process (Lévesque, 2008), so with undertaking the historian lens to view the GIS/IT domain, we aim to "recover the lost world" (Gaddis, 2002) of what construes the initial point of combining technological and sustainable ideas. Referring to "manipulation of time, space, and scale" (Gaddis, 2002) that are suggested to place a subject of historical investigation in context, we show how passage of time divided in to periods has been modifying necessities of technological advancements and sustainable living and eventually shaped them into a modern concept of GIS/IT.

In accord with the recommended historical research practices (Oinas-Kukkonen and Oinas-Kukkonen, 2014), we constructed a thematic discussion on GIS/IT with an emphasis on chronology and periodization. Observing continuity and periods of time crucial for GIS/IT, we used existing periodization approaches to identify coherent phases and important turning points of the GIS/IT history. Making generalizations and conclusions, we utilized periodization not only to outline chronology of events but also as a medium for sense-making of the GIS/IT phenomenon.

We recognize that there are several outlooks on GIS and GIT concepts, so, in this study, we emphasize treating the GIT as part of the GIS. Typically, the notion of GIT addresses energy consumption and waste associated with the use of hardware and software, which tends to have a direct and positive impact, such as improving the energy efficiency of hardware and data centers, consolidating servers using virtualization software, and reducing amount of the leftover material associated with obsolete equipment (McLaren et al., 2010; Watson et al., 2008). However, limited to the IT function without leveraging the potential of IS to decrease enterprise-wide environmental impacts, the GIT practices alone cannot solve the environmental challenge (Recker, 2016).

Conversely, GIS has been noted for a potential to enable changes to practices, decisions and business process. It is broadly defined as the composition of structures that assist individuals and organizations to make environmentally sustainable decisions conveniently and effectively, enable and effectuate environmentally sustainable work practices (Recker, 2016; Watson et al., 2008). GIS is distinguished as the study and practice of IS-enabled organizational process reengineering with green objectives that improve environmental and economic performance, advance cooperative knowledge management (Watson et al., 2008), and create positive impacts indirectly. A combination of these views on GIS and GIT constitutes our approach to GIS/IT as the subject of research.

We suggest that the GIS/IT periodization, contextualization and generalization, can be further incorporated into other historical research methods, such as the seven step approach (Mason et al., 1997) and account for other ISH research practical recommendations suggested by Oinas-Kukkonen and Oinas-Kukkonen. We expect that this rather unconventional research approach in the IS discipline will bring out importance of the "green" and sustainable topics in the IS scientific community as well as explain meaning and significance of the GIS/IT to the researchers in other fields.

3 HISTORICAL PERIODIZATION OF GIS/IT DEVELOPMENT

Combination of computer science, management and organization theory, operations research, accounting (Davis and Olson, 1985), and development of technology initiated appearance of Information

Systems research field in 1960s, initially referred to as "Management Information Systems" (Hirschheim and Klein, 2012). Since then, the IS field has been growing and changing together with the disciplines it was initially composed of. To contextualize evolution of the IS field, we refer to the Four Era periodization by Hirschheim and Klein (2012) and we map evolution of the GIS/IT to these stages.

The First Era (from mid 1960s to mid 1970s began when the first IS departments appeared in organizations. This phenomenon was largely driven by the need to automate the basic business processes to consolidate basic data processing (Hirschheim and Klein, 2012). This era is also marked by appearance fo the Third (1964 – 1979) and Fourth (beginning 1979) Generation computers (Butler, 1997). Although the term "sustainability" had been coined by this time, the significance of sustainable development of human kind had been recognized and the overall environmental consciousness has increased, there was still no significant GIS/IT practices implemented.

The Second Era (from mid 1970 to 1980s) was marked by introduction of personal computers, attempts to develop massive parallel CPUs and artificial intelligence, and competition for the leading position in IS hardware (e.g. Japanese "Fifth Generation Computer project"; the US Microelectronics and Computer Technology Corporation (MCC), the UK's Alvey initiative, and the European Strategic Program of Research in Information Technology (ESPRIT)) (Butler, 1997). At the same time, further association of building sustainable society with the increasing environmental consciousness was taking place. The highlight of the period was establishment of the World Commission on Environment and Development (WCED) (the Brundtland Commission) by the UN to craft long-term environmental strategies for the international community (UN, 1987). *Our Common Future* report (1987), written by the Commission, emphasized meeting needs of the poor without increasing environmental problems (UN, 1987).

The Third Era (from mid 1980s to late 1990s) is the period of emerging departmental computing and decentralization. Large scale computer networking took over private and public networks, and the Internet emerged to assist with open architecture networking (Hirschheim and Klein, 2012). For the first time in history, GIS/IT programs, standards and initiatives started appearing at this point (e.g. Energy Star and TCO Certification (1992), The Uptime Institute Inc. industry standards (1993) (Visalakshi et al., 2013; Raza et al., 2012).

The Fourth and most eventful Era in both IS and GIS/IT fields began in late 1990s with commercialization of the Internet and enhancement of organizational methods of communication and business strategies. Virtual organizations started dominating over "bricks-and-mortar" business model, while intranets and extranets reengineered business processes, consolidated operations and built networking. Simultaneously, mobile and wireless technologies extended the formal workplace and develop ubiquitous computing environments and enabled constant enhancement of GIS/IT applications and solutions. Moreover, improved search engines (e.g. Google) disrupted the research process, while the growth of social media and networking modernized work and interaction (Hirschheim and Klein, 2012) as well as promoted spreading environmentally conscious trends. More industrial standards for environmental care supported by institutions and individuals were established. Businesses and other organizations have started modifying their current processes and strategies related to GIS/IT. Academic research gained a critical role in addressing environmental issues, investigation of theoretical and practical frameworks for organizational, societal and individual needs.

Having paralleled the IS eras and GIS/IT development, we observe that during the First and Second IS Eras GIS/IT existed only in the form of conceptual, ethical, social and political notion turning into more practical concept in the Third and Fourth eras. Overall, the continuity in the IS history due the evolution from MIS to pervasive IS corresponds to the continuous development of GIS/IT. Next we analyze furhter how GIS/IT is approached by practitioners and by academics.

4 GIS/IT INITIATIVES IN INDUSTRY AND GOVERNMENT

Partly the Third Era (1992–1993) and extensively the Fourth Era of IS (since 1999) are marked with implementation of numerous GIS/IT initiatives. GIS/IT can guide companies and corporations in handling toxic, hazardous materials and e-waste, managing energy consuming facilities, and designing products and business processes in environmentally friendly manner (Butler, 2011), ultimately improving organizational image, branding and generating more revenues (Chou and Chou, 2012). Hence, governmental and industrial programs, benchmarks

and rating tools were created to support and rate success of organizational GIS/IT practices. Several works summarize well-known programs, practices, and certifications acknowledged earlier in GIS/IT research (Gandomi and Amin, 2014; Visalakshi et al., 2013; Raza et al., 2012) highlighting their missions related to GIS/IT advancement. Each of these organizational initiatives is historically important for the GIS/IT devolvement and modernization. Starting from local optional programs (e.g. Energy Star by the US Environmental Protection Agency, Certification program by the Swedish organization TCO Development), more initiatives developed later resulting onto world-wide programs (e.g. The Uptime Institute Inc. industry standards, Standard Performance Evaluation Corporation (SPEC) benchmarks, Electronic Product Environmental Assessment Tool (EPEAT) by Green Electronics Council, Climate Savers Computing Initiative (CSCI), Green Grid) and governmental entities and regulations (e.g. the US statewide recycling programs and institutions including Electronics TakeBack Coalition, American Recovery and Reinvestment Act (ARRA), Coalition for American Electronics Recycling) enforcing “green” industrial standards. Thus, initially beginning as auxiliary programs, GIS/IT standards turned into business requirements for organizations to remain competitive and appealing to customers.

Apart from organizational and industrial standards, there are also programs and initiatives for recognizing individual skills and expertise related to GIS/IT. Although they still fall both qualitatively and quantitatively behind those crafted for organizations, the instances of certifications to recognize personal knowledgeability are present in the sphere of the GIS/IT. Simultaneously with the organizational benchmarking, universities and professional certification programs worldwide educate individuals about building and maintaining GIS/IT. Existence of these certifications pinpoints that education and training of the individuals is a valuable contribution towards the overall development of GIS/IT. Visalakshi et al., (2013) highlighted the following certification programs for individuals:

- Certified Green Computing User Specialist (CGCUS), Certified Green Computing Architect (CGCA) and Certified Green Computing Professional (CGCP) by Green Computing Initiative (2007)
- Certificate in GIT by BCS Professional Certification (formerly Information Systems Examinations Board (ISEB))
- Computer Professional Education Program (CPEP) with the Green Technology Strategies Certification by the Australian Computer Society (ACS) (2009)
- CompTIA Strata GIT (discontinued in 2013) Certification (2010)
- Singapore Certified GIT Professional by the Singapore Infocomm Technology Federation (SiTF) (2012)

Although the specifics of the certifications vary, their main ideas are to educate IT practitioners what the core environmental goals are, which sustainable regulations and practices are most commonly implemented, and how to optimize business processes to reduce carbon footprint.

Moreover, creation of these courses and certifications from 2007 onwards indicated growth in demand of having a registered approval of the individual knowledge and skills at managing GIS/IT. As these certifications aim to provide more career opportunities for their holders, it indicates that GIS/IT expertise has developed as a separate valuable human resource skill. From being solely a point of interest, GIS/IT has become a necessary skill for employees responsible for the corporate social responsibility and procurement or infrastructure. Unfortunately, there are a few drawbacks associated with these certifications. Firstly, some of the certifications were not long-living and have already been discontinued (e.g. CompTIA Strata GIT). Moreover, the certifications’ ultimate purpose of contributing towards cultivating eco-friendly individual and organizational attitudes may not always be pursued. For instance, Organization for Economic Co-operation and Development (OECD Working Party on the Information Economy, 2009) noted that initiatives often neglect actual implementation, since only 20% of over 90 government and industry initiatives surveyed were recognized to have the measurable targets (with government programs including targets more frequently than business associations). Hence, constant revisions and further development of the similar initiatives is required.

5 GIS/IT THEORETICAL APPROACHES

Appearing in late 2000s during the most recent part of the Fourth Era of IS, in academic investigation (Tushi, Sedera and Recker, 2014), the GIS/IT research field needs directions, explanations of relevant theoretical foundations, studies, conceptualizations and proposals (Lei and Ngai,

Table 1: Examples and classification of GIS/IT theories.

	GIS/IT application	Theories
Organizational	-Explaining influence of internal and external motivational drivers such as managerial attitudes and subjective norms on emergence GIS/IT initiatives in organizations	Theory of Reasoned Action (Sarkar and Young, 2009), Institutional Theory (Butler, 2011; Sarkar and Young, 2009), Motivation Theory (Molla and Abareshi, 2012; Molla and Abareshi, 2011), Resource Dependence Theory (Datta, Roy and Tarafdar, 2010), Theory of Absorptive Capacity (Cooper and Molla, 2012), Organisational Theory (Butler, 2011), Belief–Action–Outcome (Gholami et al., 2013), Diffusion of Innovation (Bose and Luo, 2011; Nedbal et al., 2011)
	-Providing insights on incorporating GIS/IT in organizational context	G-Readiness Framework (Molla et al., 2008), Implementation Framework (Mann, Grant and Singh Mann, 2009), Strategic GIT Alignment (Erek et al., 2011), Balanced Scorecard (Jain, Benbunan-Fich and Mohan, 2011),Socio-Technical System Theory (Seidel, Recker and vom Brocke, 2013), Energy Efficiency and Low Carbon Enabler GIT (Uddin and Rahman, 2012), Process Virtualization Theory (Bose and Luo, 2011)
	-Theorizing processes of introducing, assessing and evaluating GIS/IT initiatives, implementation stages, performance and integration possibilities (outsourcing) at different the organizational levels and across departments	Technology–Organization– Environment Theory (Lei and Ngai, 2013; Bose and Luo, 2011; Nedbal et al., 2011), Value Model (Chou and Chou, 2012), Transaction Cost Theory (Nedbal et al., 2011), Theory of Practise (Ijab, Molla and Cooper, 2011), Business Transformation (Elliot, 2011), GIS Lifecycle (Ijab et al., 2010), Functional Affordance (Seidel, Recker and vom Brocke, 2013), Natural Resource Based View Theory (Rahim and Rahman, 2013; Dao, Langella and Carbo, 2011).
Social	-Exploring initiatives, motivations, beliefs, driving political (public concerns, regulatory forces) and economic factors (cost reduction, differentiation), actions for acceptance and role of mobile technologies in adoption of GIS/IT in the society.	Actor Network Theory (Aoun, Vatanasakdakul and Cecez-Kecmanovic, 2011; Bengtsson and Ågerfalk, 2011), Motivation Theory (Koo, Chung and Lee, 2013; Molla and Abareshi, 2012; Molla and Abareshi, 2011), Reference Group Theory (Koo, Chung and Lee, 2013), Stakeholder Theory (Cai, Chen and Bose, 2013), Political–Economic Framework (Cai, Chen and Bose, 2013), U-Commerce Framework (Pitt et al., 2011), Belief–Action–Outcome Framework (Melville, 2010)
Individual	-Examining beliefs, behaviors, and goal-setting initiatives of GIS/IT users; -Observing how GIS/IT encourages sustainable measures.	Theory of Reasoned Action (Chow and Chen, 2009), Theory of Planned Behavior (Chow and Chen, 2009), Extended Model of Goal-Directed Behavior Theory (Loock, Staake and Thiesse, 2013)

2013; Nanath and Pillai, 2012). Empirical GIS/IT studies between 2007 and 2013 (examined by Tushi, Sedera and Recker (2014) collected data at the organizational level (Cai et al., 2013; Molla and Abareshi, 2012; Nanath and Pillai, 2012; Cater-Steel and Tan, 2011; Molla, 2009; Molla et al., 2009) from both organizations and individuals (Ansari et al., 2010), and from individuals (end users) (Chetty et al., 2009; Chow and Chen, 2009; Sarkar and Young, 2009; Chetty et al., 2008; Woodruff et al., 2008). Theoretical analysis (Tushi et al., 2014) reveals (1) core topics (e.g. what GIT is, how it is causing problems to the environment, how IT can be transformed into GIT), (2) periphery topics (e.g. GIT life cycles, motivations and initiatives), and (3) topics beyond the scope (addressing awareness, cost of implementation, current challenges, future development, readiness and capability of organization to face GIT, literature reviews of the GIS/IT). To form a richer understanding of dominant types of studies in the GIS/IT research, we classified previously identified by Tushi, Sedera and Recker (2014) prevalent theories and frameworks into several general IS theory types outlined by Oinas-Kukkonen (Oinas-Kukkonen, 2015). This generalization distinguishes individual user behaviors, social behaviors (of both individual users and groups/networks of users), and organizational behaviors. Applying this classification (see Table 1) provides an insight on which levels of analysis environmentally-oriented behaviors have been most commonly addressed and reveals the ones lacking scientific insight in GIS/IT literature.

Classification discloses that most of existing theories and frameworks (23 in total) assist organizations in implementing, utilizing and evaluating GIS/IT initiatives. Meanwhile, the theoretical approaches for individuals (3 total) and social groups (7 total) are scarce. Thus, the GIS/IT research should devote more attention to creating

GIS/IT theoretical and practical solutions beyond the scope of the organizational and job-related contexts.

6 CONCLUSIONS

We utilized historical methods contextualize and generalize GIS/IT concept which up-to-date has only been looked at as exclusively novel creation of the recent stage of the technological age. By placing it in the context of the related sustainable and general IS trends, we highlighted its importance for the society in different historical periods. Thus, together with underpinning the significance of the GIS/IT, we expanded utilization of the historical research methods in IS research. Historical periodization, generalization and contextual analysis of GIS/IT initiatives shed the light on inseparability of sustainable environmental concerns and technological development. Periodization exposed evolution of ideas about sustainability and IS which culminated with the emergence of the new currently developing division of research – the GIS/IT. Summarizing current theoretical and practical initiatives of the GIS/IT, we emphasized the potential and need to continue developing this concept.

Besides exploring development of the sustainable trends in parallel with constant technological advancement from the IS perspective, we applied historical research methods to summarize a wide range of GIS/IT related standards and programs created for organizations and individuals. Our assessment suggests that while both types of the initiatives are crucial and impactful, the ones crafted for individuals have been scarcer and less advanced. Similarly, in research and science, GIS/IT has been studied more often on organizational and social levels than on the individual one. Therefore, we highlight the need to generate more practical and theoretical GIS/IT solutions and studies targeted specifically for individuals. Finally, our periodization, contextualization, and generalization set the scene the further more meticulous GIS/IT Historical Research.

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