Building a Green Archiving Model: Archival Retention Levels, Information Value Chain and Green Computing

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Abstract: Information and Communication Technologies (ICTs) affect the environment in various ways. Their energy consumption is growing exponentially, with and without the use of 'green' energy. Increasing environmental awareness within information science has led to discussions on sustainable development. 'Green Computing' has been introduced: the study and practice of environmentally sustainable computing. This can be defined as 'designing, manufacturing, using, and disposing of computers, servers, and associated subsystems - such as monitors, printers, storage devices, and networking and communications systems - efficiently and effectively with minimal or no impact on the environment'. Nevertheless, the data deluge makes it not only necessary to pay attention to the hard- and software dimensions of ICTs but also to the value of the data stored. We explore the possibilities to use information and archival science to reduce the amount of stored data. In reducing this amount of stored data, it's possible to curb unnecessary power consumption. The objectives of this paper are to develop a model (and test its viablility) to [1] increase awareness in organizations for the environmental aspects of data storage, [2] reduce the amount of stored data, and [3] reduce power consumption for data storage. This model integrates the theories of Green Computing, Information Value Chain (IVC) and Archival Retention Levels (ARLs). We call this combination 'Green Archiving'. Our exploratory research was a combination of desk research, qualitative interviews with information technology and information management experts, a focus group, and two exploratory case studies. This paper is the result of the first stage of a research project that is aimed at developing low power ICTs that will automatically appraise, select, preserve or permanently delete data based on their value. Such an ICT will automatically reduce storage capacity and curb power consumption used for data storage. At the same time, data disposal will reduce overload caused by storing the same data in different formats, it will lower costs and it reduces the potential for liability.

Keywords: archival retention levels, information value chain, digital archiving, green archiving, green computing

1. Introduction

The origins of an environmental approach to Information and Communication Technologies (ICTs) can be traced back to the beginning of the 1990s, when the reduction of the use of hazardous materials, the maximization of energy efficiency, and the recyclability or biodegradability of defunct products and factory waste became hot items in computing (Jacob & K.G 2012). The development of the World Wide Web, the emergence of social media and Big Data have led to a rising amount of data (Armitage & Roberts 2002; Segaran, Hammerbacher 2009; Manyika 2011). The infinite opportunities to process and publish data, global electronic communications, an explosion in devices located at the periphery of the network, including embedded sensors, smartphones, and tablet computers, aerial sensory technologies, software logs, cameras, microphones, radio-frequency identification readers, wireless sensor networks, a large-scale digitization of cultural heritage such as film, music, art, images, maps, and text, cause [1] the data storage capacity to double every 40 months (Hilbert & López 2011) and [2] an annual growth rate of 40 % in the amount of data, creating a 'data deluge' (Gantz & Reinsel 2012). This data creates new opportunities for analytics in human genomics, healthcare, oil and gas, search, surveillance, finance, and many other areas (Golden 2010). This data deluge is putting great pressure on the infrastructures of ICTs (Van Bussel & Henseler 2013).

ICTs affect the environment in various ways. Its production requires electricity, raw materials, chemical materials and large amounts of water, and supplies (often toxic) waste (Robinson 2009). Computers and peripherals are changed two or three years after purchase (Murugesan 2008). In 2006, global production of E-waste was estimated at 20-50 million tonnes per year (UNEP 2006). In rich countries, E-waste represents some 8 percent of municipal waste (Widmer, et al. 2005). It is the fastest growing municipal waste stream (EPA 2011). Most of this E-waste is not recycled, because those items tend to go out with the normal household waste and do not receive special treatment (Ladou & Lovegrove 2008). Some 80 percent of collected E-waste is exported to poor countries and ends up in landfills and informal dumps (Schmidt 2006). These dumping sites are poisoned and groundwater is polluted (Murugesan 2008). Green Computing has been introduced to

minimize environmental effects of ICTs, to save costs and for corporate social responsibility (CSR) (Harmon & Auseklis, 2009; Subburaj, et al. 2014).

The energy consumption of ICTs is growing exponentially as a result of the data deluge, just like energy costs. From 2000 to 2005 power consumption of data centers doubled, while power consumption worldwide grew by 16.7 percent per year (Koomey 2008). From 2005 to 2010, power consumption of data centers alone jumped with 56 percent (Koomey 2011; Cook 2012). This increase in energy consumption results in increased greenhouse gas emissions. According to Dubey & Hefley (2011), each PC or laptop in use generates about four tons, each server about eight tons of carbon dioxide every year, although there are many possibilities to lower those emissions (Boccaletti, et al. 2008). In 2008, storage networks were responsible for 15 percent of total ICT energy costs (HP 2008). This percentage has, in our estimate, doubled in 2011, given the increasing need for data storage as a result of multiplication of data, social media, and fear of not being compliant (Van Bussel 2012a). Studies have shown that power costs can approach 50 percent of the overall energy costs for an organization (Harmon & Auseklis 2009). In January 2013, an average in-house server in the USA costs $ 731,94 in electricity (Hammond 2013).

2. Research questions, objectives, and methodology

The data deluge threatens to drown all positive effects of Green Computing. It becomes necessary to curb data storage. We need to pay attention to data value (over time), to implement data value appraising methods and tools, and to completely and permanently delete data that has lost its economic, social, cultural, financial, administrative, fiscal and/or legal value.

2.1 Questions

We have defined two research questions for this paper:

[1] Can a Green Archiving model be constructed when combining Green Computing, information and archival science?
[2] Does this Green Archiving model [a] increase awareness for the environmental aspects of data storage; [b] reduce the amount of stored data, and [c] reduce power consumption for data storage?

2.2 Objectives

The first objective of this paper is to develop a Green Archiving model to [1] increase awareness in organizations for the environmental aspects of data storage, [2] reduce the amount of stored data, and [3] reduce power consumption for data storage. The second objective is to test the viablility of this model in two exploratory case studies to see if reducing the amount of data reduces power consumption for data storage. The Green Archiving model integrates Green Computing with theories of information and archival science: Information Value Chain (IVC) and Archival Retention Levels (ARLs). Green Archiving does not yet have the aim to directly reduce environmental impact, but intends to raise awareness of the environmental effects of ICTs (like increased greenhouse gas emissions) and to define solutions for the rising amount of data and the constantly rising costs of energy. Operationalizing the Green Archiving model, organizations curb power consumption, lower needs for storage capacity and develop 'low power' ICTs (Forrest, Kaplan & Kindler 2008). That way, Green Archiving reduces the environmental impact of ICTs and contributes to energy efficiency and cost effectiveness (Barosso & Hölzle 2007; Schwarz & Elffers 2010; Orgerie, et al. 2014). In new research, we are designing case studies to measure the environmental effects of the Green Archiving model. Green Archiving is a new subject and is not extensively studied within the context of information and archival science.

2.3 Methodology

Our exploratory research was a combination of desk research, qualitative interviews with information technology and information management experts, a focus group and two exploratory case studies. We researched scientific literature with an IT, information management and archival science perspective. We collected literature with a key word search in Google Scholar and in the Digital Library of the University of Amsterdam (indexes on IT, information science / management, archival science / management). The key words used in this search were: 'Green Computing', 'Green IT', 'IT power use', 'IT power costs', 'information value', 'archival appraisal', 'archival disposal' and 'environmental awareness'. The findings of this desk research were used, complemented and criticized in: [1] individual, semi-structured interviews with ten IT,

information management and archival science experts (three scientists, two consultants, three CTO's, and two storage industry specialists); [2] a focus group, consisted of six (different) experts (two Green Computing consultants, two information managers and two storage managers). We used the information acquired through desk research, interviews and focus group to develop a provisonal Green Archiving model. This model was than tested for validity in two small exploratory case studies.

3. Theoretical discussion

3.1 Green computing

Green Computing (Brooks, et al. 2012) is defined by Murugesan (2008, p. 25-26) as 'the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems - such as monitors, printers, storage devices, and networking and communications systems - efficiently and effectively with minimal or no impact on the environment'. There are four paths along which the environmental effects of computing should be addressed: green use, green disposal, green design, and green manufacturing (Murugesan 2008). Green Computing can also develop, according to Donnellan, Sheridan and Curry (2011), solutions that align IT processes with the principles of sustainability and stimulate innovative technologies to deliver green benefits across an organization. In that way, end user satisfaction, management restructuring, regulatory compliance, fiscal benefits, and return on investment (ROI) can be addressed. In the opinion of Visalakshi, et al. (2013, p 64), Green Computing may be 'simple, plain, common sense'. Analyzing literature, interviews and focus group discussion, we discern six components of Green Computing research: [1] product longevity (Visalakshi, et al. 2013; Agarwal & Nath 2011), [2] software and deployment optimization (Ahamad & Ravikanth 2012), [3] power management (Murugesan 2008; Visalashki, et al. 2013), [4] materials recycling (Visalashki, et al. 2013; Kwon, et al. 2006), [5] telecommuting (Thompson 2009), [6] low power IT (Ahmad & Ranka 2012; Lee, et al. 2013). The components [2], [3] and [6] are important for reducing power consumption for data storage.

3.2 Archival retention levels en information value chain

Information and Archival science are interdisciplinary fields concerned with the analysis, collection, classification, storage, retrieval, dissemination, appraisal, disposal and preservation of data. They use methods and techniques to appraise and select organizational data for long-term (or indefinite) preservation or to permanently delete appraised data (Shepherd & Yeo 2003; Xie 2013; Smallwood 2013). This appraisal is based on the 'value' of organizational data over time, be it economic, social, cultural, financial, administrative, fiscal and/or legal value (Cook 2013). Appraisal results in retention schedules, which assure that all data is retained and disposed according to their quantified 'value': the time (in years) that data should be retained, according to considerations of organizational risks and assigned economic, social, cultural, financial, administrative, fiscal and/or legal value. Minimizing risks (especially those of litigation) also means systematic disposal immediately after the expiration of the assigned retention period (Shepherd & Yeo 2003; Robek, et al. 1995). Two theories of archival science offer tools for appraising data: the theories of Archival Retention Levels (ARLs) (Den Teuling 2001) and Information Value Chain (IVC) (Van Bussel 2012ab). The first theory concerns itself with designating ARLs in organizations to store and retain data that is unique, authentic, relevant and contextual. ARLs define detailed functional (organizational) responsibilities for the retention, storage and archiving of unique and authentic data (Smit 2012). Data value is appraised according to the organizational level that is responsible for the collecton, analysis, processing and storage of that specific data. This organizational level is the designated ARL. At the ARL the data are retained as long as the retention schedule permits. This schedule makes the economic, social, cultural, financial, administrative, fiscal and/or legal value of the data (retained at every ARL) explicit and defines its archival value: a time (in years) after which the data should be disposed of. Identical data retained elsewhere within the organization and without a new business objective (duplicates) can be deleted permanently and immediately. In digital environments, duplicates are stored in different forms and places and in various business processes (Paul & Baron (2007)), not being the designated ARL. In hospitals, an average organization's duplicate rate in 2009 was typically between 5-10% (McClellan 2009). It is (non-scientifically) estimated that in 2013 in most organizations 30% of all files are duplicates, without a new business objective or value (Proofpoint 2013). Using ARL checklists can seriously reduce the amount of data stored, which has direct effects on costs and needed storage capacity. The organizational use of ARLs can be seen as contextual data deduplication. The IVC theory defines the utilization of the informational and evidential value of data in business processes to improve the management of trusted data and the performance

of business processes (Van Bussel 2012ab). The IVC includes all processes of information management and manages data generation, data identification, data capture, data storage, data processing, data distribution, data structuring, data publication, data (re-) use, data appraisal, data selection, data disposal, data retention, data security, data auditing and data preservation. For the purpose of this paper, only the processes of data appraisal, data selection and data disposal are important. In the data appraisal process the short- and long-term (or indefinite) data value is defined in order to retain and preserve data for later (re-)use. As stated above, this data appraisal defines the archival value and results in a retention schedule. In the data selection process, data is collected and set aside according to its retention schedule. In the data disposal process, this set aside data is completely and permanently deleted (Shepherd & Yeo 2003). Organizational retention schedules are used to operate those processes. Almost 75 percent of all data in an organization can be permanently deleted over time (Archieflandsverordening 2007).

4. A 'green archiving' model

The theoretical discussion allows us to combine the components of Green Computing, with the data reducing components of the two archival theories. We were able to develop a Green Archiving model that can be used [1] to reduce the amount of stored data, [2] to reduce power consumption for data storage and, ultimately, [3] to reduce greenhouse gas emissions and E-waste in realizing all components of Green Computing. This paper concentrates on the aspects [1] and [2] of the model. Aspect [3] of the model will be part of further research. Participants of the interviews and the focus group remarked that the model could be used to increase awareness in organizations for the environmental effects of the use of ICTs. In their professional experience, they encountered an extremely low organizational awareness of the environmental effects of ICTs. We tend to agree with this remark: we could not use the results of an online questionnaire because the response was extremely low. The lagging paticipation in that survey could be a result of very low awareness of the problem, but we could not confirm this. In the case studies, we also tried to confirm if the model could be used to increase organizational awareness of the environmental effects of ICTs. The model of Green Archiving we developed is shown in figure 1.

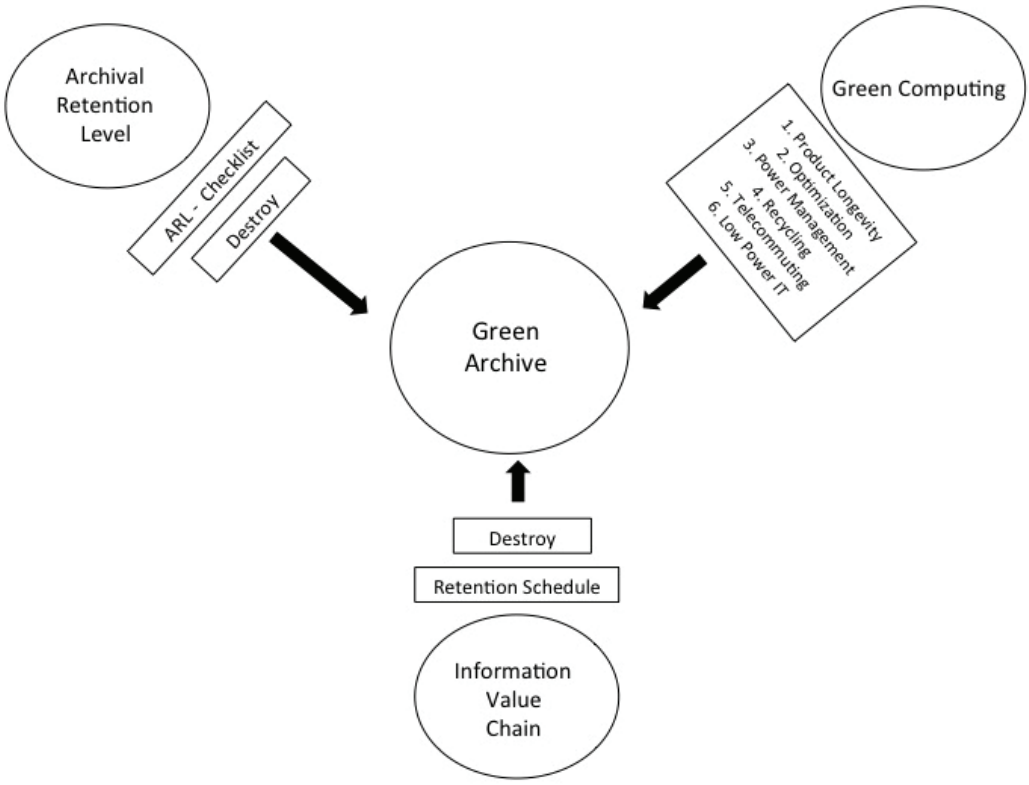

Figure 1: Green archiving model: combination of green computing, ARL and IVC

5. Exploratory case studies

5.1 Purpose

The purpose of the case studies was to ascertain that de model was viable and that it could be used in organizations to [1] increase awareness of the environmental effects of ICTs, [2] reduce the amount of data, and [3] curb power use for data storage. These exploratory cases only provide us with provisional results, that need to be confirmed in further research.

5.2 Dutch Music Institute (Nederlands Muziek Instituut)

We organized our first case study in the Nederlands Muziek Instituut (Dutch Music Institute), a small organization that operates as national heritage centre for musicians and composers. We ascertained that environmental awareness was extremely low and that all components of the model were unknown. The information managers had never heard of Green Computing. The management of the organization was not informed about the environmental effects of ICTs. That may be a result of the fact that the Institute used the ICT infrastructure of the Koninklijke Bibliotheek/National Library of the Netherlands (The Hague) for its storage network. The Institute never discussed energy use and power costs for their two terabytes (TB) of data storage capacity with their hosting partner. Within the Institute, ARL Checklists were not in use, but it was acknowledged (after being instructed about their purpose) that its use would reduce the amount of duplicates within office automation. Because the storage capacity for office automation was not known, it was not possible to quantify this effect. In addition, the Institute didn't use retention schedules for its digital collection and its business processes. All data was retained. We could only confirm that the Green Archiving model was a viable model to check and increase environmental awareness. We could not estimate the effects of the model for the reduction of the amount of data or the reduction of power consumption.

5.3 Dutch international trade organization

The second case study was in a small international trade corporation in Maastricht (The Netherlands), working with subsidiaries in Europe, Asia and South America. The case study data were collected in [1] a scan of the ICT infrastructure of the corporation using the model, and [2] a pilot study by the corporation's IT department on the effects of ARL Schedules. In [1] the Green Archiving model was enthousiastically received. Green Computing was well known within the IT department, but only the components Optimization and Power Management were implemented. The results of this implementation of these components were comparable to those described by Dubey & Hefley (2011). The IT department admitted that it should be more aware of other Green Computing components. CSR was extremely important for the corporation and implementing other components of Green Computing would be a significant contribution to CSR. The IT department planned to look into the possibilities of Telecommuting and Product Longevity. When we did the exploratory scan, the organization didn't use ARL checklists, but (for this case study) agreed to experiment with them in its corporate headquarters. After a scan of the company's file systems, the IT department estimated that almost 35 % of their IT storage capacity of 18 TB was used for duplicate files. It acknowledged that the use of ARL checklists would have a significant effect on the IT storage capacity. Retention Schedules were used only for the data stored in their document and records management applications, but the IT department acknowledged that both applications were not yet generally in use. Rigorous use of those schedules would certainly have an effect on the IT storage capacity, but the IT department could not quantify those effects yet. In [2] the IT department concluded that the use of ARL checklists would diminish global data storage capacity with 30 percent. 37 percent of the company's data storage capacity was used for duplicate files. Reducing the amount of data resulted in less power consumprion for data storage. Energy costs for data storage diminished with 25%. The company planned a pilot for 2014 to measure the global effects of rigorous use of retention schedules. We concluded that the Green Archiving model seemed to be a viable model for organizational use.

6. Conclusions and future work

In this paper, we have developed a model for Green Archiving by combining Green Computing with the theories of ARLs and IVC (research question 1). Both cases confirm that the model can be used for increasing environmental awareness (research question 2 [a]). The second case study showed that the model could be used to reduce the amount of data (30 percent, using ARLs only) (research question 2 [b]) and to reduce the power consumption for data storage (resulting in a cost reduction of 25 percent). It seems that the Green Ar-

chiving model is a viable model to study possibilitities to create environmental awareness, to reduce the amount of stored data and to curb power consumption in organizations. These exploratory case studies only provide us with provisional results. They need to be confirmed in further research. We are planning extensive case studies to research the environmental effects of Green Archiving and the scientific viability of our model. The ultimate goal of this research project is the development of a low power ICT that will automatically appraise, select and preserve or permanently delete data. Such an ICT will automatically reduce storage capacity and curb power consumption used for data storage. At the same time, data disposal will reduce overload caused by storing the same data in different formats, it will lower costs and it reduces the potential for liability.

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