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Abstract

The integration of sustainable thinking and performance within day-to-day business activities has become an important business need. Sustainable business requires information on the use, flows and destinies of energy, water, and materials including waste, along with monetary information on environment-related costs, earnings, and savings. Creating this holistic view of economic, social and environmental information is not a straightforward mission from an IT perspective, and implies tackling several challenges such as information granularity and overload, the different projections of the same factual information, and the heterogeneity of information systems. In this paper, we propose an entity-centric approach to Green Information Systems to assist organisations in forming a cohesive representation of the environmental impact of their business operations at both micro- and macro-levels. Initial results from a Small Medium-size Enterprise case study are discussed along with future research directions.

Keywords: Green Information Systems, Linked Data, Entity-Centric, Data Integration.

1 Introduction

Sustainable development is an important business issue, affecting new products and services, compliance, cost reduction opportunities, reputation, and revenue generation. Information Technology and Information Systems will play a key role in the delivery of sustainable business benefits both internally and across the enterprise. The potential for the use of IT/IS to reduce Greenhouse Gas (GHG) emissions has been estimated at approximately 7.8 GtCO2 of savings in 2020, representing a 15% emissions cut in 2020 and 600 billion ($946.5 billion) of cost savings (Webb, 2008). IT/IS can provide business solutions that can alleviate at least five times the GHG footprint of IT/IS itself (Enkvist et al., 2007). There is an imperative for IT/IS researchers, organisations, and professionals to deliver on this potential. Indeed, it is the focus of an emerging field of research called Green IS (Watson et al., 2010) that targets the utilisation of information systems to support sustainable business.

Many organisations think sustainable business requires a significant transformational change programme, yet the ultimate goal is to embed sustainable practices into business-as-usual activities. In addressing sustainable information needs, organisations are facing both business and technical challenges that are complicated by the inherent breadth of information, which spans the full value chain of an enterprise. While organisations are fighting a data deluge within their information systems (Cukier, 2010), there is a significant lack of information on sustainable business concerns. A 2010 survey of more that 600 Chief Information Officers and Senior IT Managers highlights that few organisations are performing well at measuring the effectiveness of their sustainable business efforts (O'Flynn, 2010). The paucity of sustainable information within organisations is a significant challenge and one that needs to be addressed if efforts such as Green IS are to deliver on their potential. Organisations will need to consider Green IS to be as mission critical as other operational IS such as finance or production.

The goal of this paper is to contribute a clear understanding of the practical challenges facing Green IS systems and how these may be overcome with an entity-centric approach to Green IS design. We begin by outlining the challenges with deploying Green IS systems. Next, we describe an entity-centric approach for Green IS. Finally, we present the findings from the application of the proposed approach within a Small-Medium size Enterprise. The paper concludes with a brief discussion for further research directions.

2 Challenges with Green IS

Creating a sustainable business requires an enterprise-wide perspective on the use, flows and destinies of energy, water, and materials including waste, along with monetary information on environment-related costs, earnings, and savings. Creating a holistic view of economic, social and environmental information for an organisation is not a straightforward task, the complexities of real-world organisations are reflected within their information systems and significant challenges exist.

Information Granularity and Overload: With the relative immaturity of sustainable practices within organisations, use of metrics is an emerging area (O'Flynn, 2010). The development of effective metrics is complicated by the fact that sustainable business is an enterprise-wide issue, which spans the complete value chain. Determining the granularity for effective information is not well understood and research is needed to define the appropriate level of usefulness (Watson et al., 2010). The appropriateness of information will also be highly dependent on the stakeholders and the task or decision at hand. Corporate-level energy consumption for the organisation is useful for high-level decision making, however it is less useful for optimising energy usage for a single production line. In the same way, micro-level production line energy consumption is less effective for macro-level corporate decision making when viewed in isolation. Green IS will need to be flexible to provide the appropriate level of information for the given situation.

Data Integration: Organisations use multiple information systems to support their multiple business processes. While some organisations have managed to ensure these systems are interconnected, a significant number have not. Green IS will need to link systems that have never been connected before, while overcoming the high cost associated with data integration projects.

Many Versions of the Truth: Each information system within the organisation has been designed for a specific mission, and the data and information within the system will be biased toward the mission goals of the system - accounting systems will be biased towards particular accounting principles, supply chain management will be biased toward inventory management. In addition, the temporality of information can be generated and made available in different sequences, with financial systems working on quarters, and energy systems working in real-time. Multiple systems mean multiple versions of the truth, and multiple interpretations of the truth within the organisation. While reaching a single version of the truth may be technically feasible, in many cases it will not be practically achievable without significant re-design of existing information systems. Therefore, Green IS will need to accommodate the re-purposing of the information in terms of structure and temporality; flexibility is also needed when dealing with conflicting versions of the truth.

3 An Entity-Centric Approach to Green IS

Information systems are built around business processes and work flows across various levels of an organisation. The objective of these systems is to automate processes by capturing and processing relevant data usually in a structured form. An entity-centric approach focuses on the concepts that define particular areas of interest in an organisation, for example, business entities like employees, products, customers, intellectual property, assets, etc. Information systems built along this methodology collect information associated with specific entities from within organisational boundaries as well as the outside world. Post collection they provide functionality to manipulate and consume information through either application or user interfaces.

Customer Relationship Management (CRM) and Vendor Relationship Management (VRM) systems are two examples of entity-centric IS. A typical CRM will support customer management by providing customer-centric services ranging from channel management to sales force automation. The wide-scale integration of customer data needed by these systems is complex and comes at significant cost to the enterprise (Karakostas et al. 2005 & Chalmeta, 2006). The need for Green IS to integrate data for multiple entity types (i.e. customer, product, building, etc) will further increase their complexity. In order to simplify the implementation for entity-centric Green IS we propose the use of an Entity-Attribute-Value (EAV) model. The EAV model is appropriate for the heterogeneous and dynamic conditions found within modern organisations and facilitates rapid prototyping and iterative refinement (Nadkarni et al. 1999).

The impact of Green IS toward sustainable goals can be realised by associating sustainable information with individual entities. This facilitates tracking of socio-environmental indicators at various levels of detail and allows organisations to set respective goals for entities and incrementally improve over time. An output-driven entity-centric approach provides three benefits in building a sustainable business information platform:

1. Focusing on one entity at a time allows the infrastructure to be built around the incremental integration of relevant KPIs.
2. Concentrating the choice of KPIs to those that are directly related to environmental concerns helps to form a cohesive view impacts associated with an entity.
3. Incorporating these cohesive views into a near real-time tool allows employees and groups within the organisation to understand the actions required to reduce the overall environmental impacts associated with familiar business entities.

Following a pay-as-you-go methodology for data integration it is possible to incrementally enriching entity profiles. This iterative process facilitates communication with the business organisation

throughout the development process, which has as great an impact on outcomes as properties of the technology itself (Tora, 1996).

4 Small-Medium size Enterprise Case Study

In order to analyse the benefit of an entity-centric Green IS system, a recent case study was conducted in a Small-Medium size Enterprise (SME). The enterprise's 140 employees' day-to-day work is focused on producing research and software outputs. The SME's management recently decided that a sustainable business platform would be of value to the organisation. Besides environmental concerns, the platform needed to be extensible to allow economic and social measures to be added in the future to support a holistic Triple Bottom Line (Elkington, 1998)). Focusing the platform around output-driven business entities has assisted development, with specific benefits in the holistic representation of the entities' impact and the use of tools and plug-ins to incorporate sustainable information into everyday decision-making.

4.1 Key Performance Indicator Integration

Discussion with the enterprise on sustainable Key Performance Indicators (KPIs) for entities occurred in stages, during iterations of the project. Five types of sustainable KPIs were identified for business entities covering travel, power, print, commute, and paper usage. Sustainable KPIs were scattered throughout a number of systems and processes within the SME. To integrate these information systems fully would have taken months of planning. Instead, by iterating the platform over business entities one at a time, integration efforts were concentrated on linking relevant sustainable KPIs. This provided a feasible methodology for consolidating data, with the first implementation of the platform available within weeks of commencement. Depending on how the source information system captures data, the values for sustainable KPIs are either estimated or actual. The sustainable KPIs for each entity, along with the corresponding source information systems are detailed in Table 1.

		Business Entities				
		SME	**Unit**	**Project**	**Employee**	**IP**
Sustainable KPIs	**Travel**	Actual	Actual	Actual	Actual	Actual
	Power	Actual	Estimate			
	Print	Actual	Actual	Actual	Actual	Actual
	Commute	Estimate	Estimate			
	Paper	Actual				
Information Sources	**Travel System**	✓	✓	✓	✓	
	Print Server	✓			✓	
	Spreadsheets	✓		✓	✓	
	Content Mgmt System	✓	✓		✓	✓
	Website	✓		✓	✓	
	Surveys	✓			✓	

Table 1: Carbon emissions calculation and data sources for entities

An entity centric approach not only assists in simplifying integration, but also in the expressiveness of the resulting information. In the SME, management makes decisions about where to divide money and resources based on the performance of their business outputs. It is, therefore, essential that they have a holistic understanding of these outputs in order to measure the overall costs and benefits to the institution. Because an entity-centric approach focuses on business outputs one at a time, it allows for an overall comparison between individual entities, with little concern for hidden factors. Figure 1 shows how each measure of an entity's impact can be compared side-by-side, while Circle 1 allows

the user to pivot between or select multiple entities for comparison. Selection of any of the listed KPIs takes the user to a mode of Figure 2, which allows for expressing more detailed information.

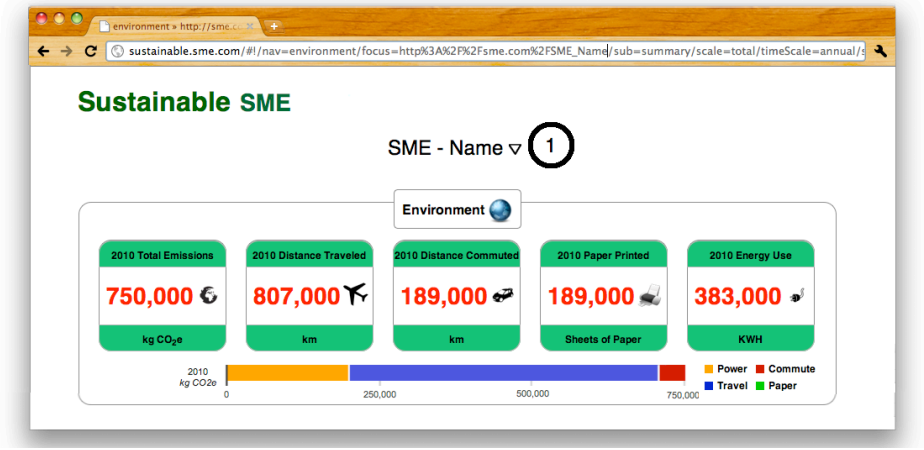

Figure 1: Entity-Centric KPI Overview

4.2 Motivating Sustainable Actions

In addition to a simpler and more expressive integration of data, the entity-centric approach assisted in decision making via four specific areas related to the SME's travel, paper, commute, and power KPIs:

1) Real-time direct action items that employees can respond to while in the planning stages of emission-producing activities.

2) Daily direct action items that employees can respond to after reviewing their previous day's activities.

3) Monthly direct action items that employees can respond to by understanding the extrapolated effects of their daily activities.

4) Monthly indirect action items that employees can respond to by understanding the effect of their day-to-day activities as averaged over the enterprise.

The platform includes a tool to communicate this information via a multi-level model that makes use of the entity-centric infrastructure. In each mode of the interface, illustrated in Figure 2a, the user can see the relative impact of individual KPIs (circle 1), see trends within and between KPIs over time (circles 1 and 2), and compare entities within a category (circles 2 and 3). In addition, pivoting over entities is possible, as well as choosing multiple entities with which to compare (circle 4). Note in Figures 2a and 2b, that there was incomplete data in 2007 through 2009.

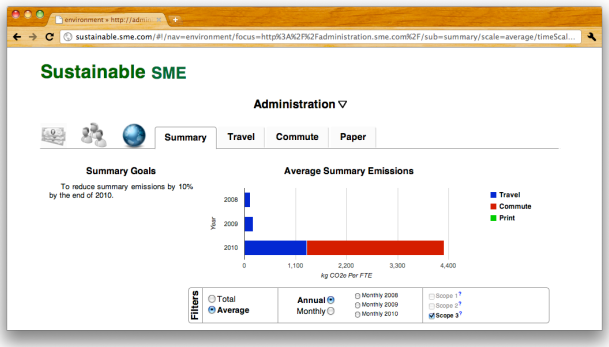

Figure 2a (left): Main Interface

Figure 2b (top): Pivoted to Admin Unit

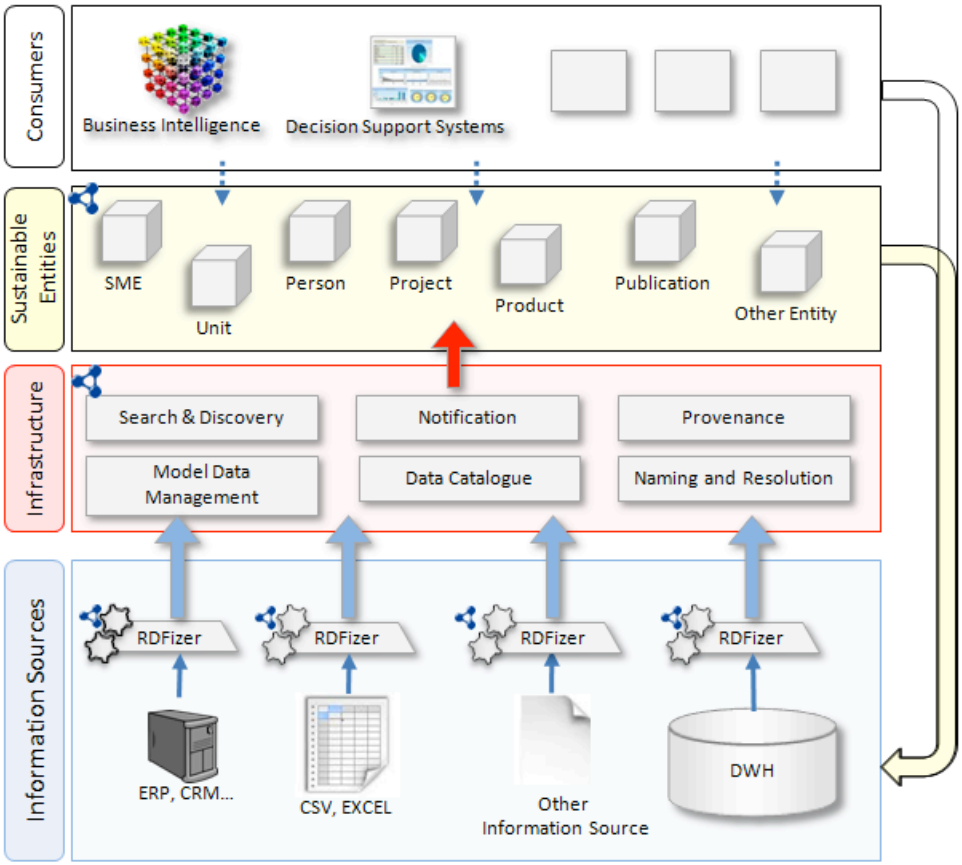

Figure 3. Architecture for entity-centric sustainable IS

5 Information System Architecture

The challenges with Green IS are approached from the technical perspective by a flexible IS architecture as illustrated in Figure 3. The architecture weaves the data sources that exist in an organisation by employing Linked Data technology to make a dataspace out of the multiple data silos that usually complicate the consolidation of scattered entities inside an organisation. By linking these data sources, a holistic view of sustainable performance was achieved.

Linked Data is a technology that facilitates information sharing and integration by building upon the current web architecture and new open standards developed for the Semantic Web. Linked Data assumes (1) The use of a Uniform Resource Identifier (URI) as a unified naming scheme for entities; (2) The use of HTTP as the mechanism to look up those entities; (3) The retrieval of information in useful formats for both humans and machines such as the Resource Description Format (RDF); and (4) Linking entities together by the use of their URIs (Berners-Lee, 2006).

The entities involved with the SME's software and research outputs are each managed in separate information systems, as described in Table 1. By choosing one entity at a time, the choice of information sources was restricted to a tangible subset - namely those containing environmental indicators emitted by the entity in question. Once data is chosen and filtered and converted to the open RDF format, various support services are responsible for properly consolidating, organising and updating the data. Through this architecture, entities that have been previously scattered and difficult to retrieve, become accessible with standard formats and mechanisms, allowing them to be included in an organisation's sustainable business strategy, and most importantly, linked into its daily operational systems.

6 Conclusions and Future Work

Green IS will need to support an organisation's sustainable business efforts at all appropriate levels, providing timely, accurate, and useful information. In this paper we propose an entity-centric approach to Green IS to assist organisations in forming a cohesive representation of the environmental impact of their business operations at both micro- and macro-levels. A case study is being conducted within an SME using the proposed approach to enable near-real time information provisioning so that the environmental impacts of the SME's business activities can be understood in a holistic manner. The resulting system allows employees and groups within the SME to understand their overall environmental impact, allowing them to incorporate sustainable business concerns within their micro-level day-to-day activities and decisions. The tool also allows senior management to understand the macro-level sustainable business concerns of the organisation. Future research will focus on studying the suitability of entity-centric information for reducing the environmental impacts of business activities at micro- and macro-level by embedding the platform into business processes.

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