End User as Application Developer for Decision Support

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ABSTRACT
This paper discusses a new generation end-user centred information service view, for developing decision support applications. The tailorable solution allows specific applications to be designed by end-users, where integrity is assured by the architecture’s control in knowledge-based systems. In the development approach, the end-users at different level engage in interaction for secondary application creation. This initiative reinforces a shift from the traditional IS development process to a new provision where end-users can actively participate for a secondary application design. A secondary application design can be seen as a secondary activity for tailoring applications by the end users so that it fits within their context. However, the achievable boundaries of the architecture and the interplaying roles of end-users for the secondary design are still emergent and increasingly of interest to researchers. This paper describes a process by which ‘end-users-as-designers’ engage in the secondary design or redesign processes of decision support applications in a rural industry context.

Keywords: end-users, DSS, tailorable design.

INTRODUCTION
Over the history of information systems (IS), technology’s increasing usability has shifted the role of the end user towards system design and tailorability (Hovorka and Germonprez, 2008; Gammack, Hobbs, and Pigott, 2007; Germonprez, Hovorka, and Colloy, 2007). However, end-user participation for developing or tailoring systems has not been fully understood (Hovorka and Germonprez, 2008). Specifically in consideration of how far end users can go towards major technological modifications for the secondary design, under different business conditions.

This paper describes a new information service development view that enables end-users to actively participate in their applications development. The developed software platform promotes a shift in the traditional concepts of IS development, especially for the decision support systems (DSS) development paradigm. The tailorable solution allows specific applications to be designed by end-users, where integrity is assured by the architecture’s controls in knowledge-based systems. The industry end-users at three levels (i.e. management users, domain experts and general users such as primary producers) interplay for the creation of secondary applications in the proposed solution environment. As secondary application development by end-users is an emergent practice, the interplaying roles and their boundaries are still developing. This interplay is increasingly of interest to researchers. Therefore, the paper describes a process by which ‘end-users-as-designers’ engage in design or redesign of decision support applications.

For DSS developments, particularly in a rural industry context, researchers or solution developers often use their theoretical knowledge, rather than accessing primary producers’ practical knowledge for problem solving. This has potential to cause mismatches in problem conception and relevant knowledge communication (Cox, 1996; Kerr, 2004; McCown, 2002). Fountas, Wulfsbohn, Blackmore, Jacobsen and Pedersen (2006) reported that primary producers, based on their experience and familiarity with their farm, most likely use information in ways not fully appreciated by researchers or solution designers. These instances suggest that there is a need for an approach where design options will be updatable and re-configurable to accommodate end user’s local changes and contingencies. Although the end users have recently been given greater control in the system usage than previously in offering more user-friendly options in the released software (Kreie, Cronan, Pendley and Renwick, 2000), the specific issues for end users in developing applications are not straightforward in the business context. There are some recognised issues with end-user development in general, namely: completeness of problem identification; decomposition of the problem; and sometimes the system outcomes are inappropriately driven by the end user’s probabilistic reasoning (Wagner, 2000). Non transferability and information sharing are also problematic with ad hoc software development. For instance, Lambert and Elix (2003) described requirements of transferring knowledge for extension professionals to facilitate sustainable rural practices. The
roles of extension professionals include transferring the latest scientific knowledge and research based findings to the primary producers (i.e. farmers) to help them achieve their business goals (van den Ban, 1999). Furthermore, van de Fliert (2003, p. 29) stressed the importance of enhancing farmer capacities in latest “ecological knowledge, observational, analytical and experimental skills, and inclination towards collectivity to allow farmers to make better, informed decisions”. In order to resolve these issues of DSS development by end users, in the case of working primary producers, it is necessary for a more human-centric and tailorable approach that can provide development of a quality application for their specific problem area.

The growing recognition of developing end user enabled or tailor able services revealed a new appealing problem area in which the main challenges are to define interplaying roles of end users and the primary designer. A line should be drawn between the roles for both primary design activities for the professional designers (for building the main architecture for service creation); and secondary design activities by the end users (for building secondary applications from the main architecture in their local context). This secondary design should offer a less knowledge intensive or have less technical processes for end users. The aim is to address this issue in the domain of tailorable design theory by defining the roles of end users in developing DSS applications. In the proposed approach, the end users are the ones who select the parameters based on their own specific problem situations, for building applications. As such end users exercise their own choices to outline a relevant problem scenario, in the main architecture for building secondary applications. The intention is to fulfil the dynamic requirements (i.e. within rapidly changing situations) of application development for decision support which has not been met by the conventional technologies. Previous publications from this project include, Miah, Kerr and Gammack (2006a), describes the initial development methodologies; Miah, Kerr and Gammack (2006b) describes an ontology design from the problem domain; Miah, Kerr and Gammack (2009), describes a technical foundation of such solution approach; and Miah, Kerr, Gammack, and Cowan (2008), describes developing a knowledge acquisition method for the problem domain. Beyond this line of works, the aim of this paper is to look at the entire solution architecture from an angle of tailorability, by defining the implemented relationships between the primary and secondary design activities, specifically highlighting the processes of end user’s design activities.

Arnott and Pervan (2008) emphasised the design science approaches for DSS development, as an alternative to the natural science approach which is dominant for IS development. The research investigated design science approaches as an alternative methodological standpoint aiming to find out relevance of the theories for user centric IS solution development, where the roles of the user in the secondary design are to be addressed. In the design science paradigm, researchers create system artefacts that provide not only solutions for identified organisational problems, they also create new dimensions in the design (Hevner, 2008; Baskerville, 2008). Hevner, March, Park, and Ram (2004, p.1) described “the design science paradigm seeks to extend the boundaries of human and organisational capabilities by creating new and innovative artefacts”. McKay and Marshall (2007) argued that the IS design should be evaluated from three viewpoints: product, process and practice, because IS design is one of the complex tasks where several roles of users and different possible problem situations are to be processed or designed. Therefore, using a philosophy where the underlying knowledge representation is relational, constraints that are tailorable with regard to end-users subjective preferences, while also allowing different variables to be optimised as business conditions change. Hevner et al’s (2004) seven guidelines provide supportive instructions for defining problem space, outlining and implementing design, and evaluating the design artefact for the appropriate communication of research. The view from this method provides clarity for designing, constructing and evaluating artefacts, which offers support for technical artefact design excluding the other relevance. Therefore, this research relies on the combination of product, process and practice views in the solution design, where different levels of end user’s interplay and their roles for the secondary application design. This view guides this research to investigate a representative problem space of decision-making in a real industry.

This paper is organised as follows. The next section presents a background of end user development in information systems. The subsequent section presents literatures on end-users as designers. The next section presents the primary and secondary design activities. Then, the ‘tailorable design environment’ section describes process of the end-users activities in the design environment as a proposed solution. Finally the last section contains a brief discussion and summary of the design work.

BACKGROUND OF END-USER DEVELOPMENT

In end user development, an end user “....decides what applications he or she needs, determines how the applications will function, customises the software for the applications” (Nickerson, 1998, p. 384). However, end-user development involves users and professionals who build or use applications directly to solve problems or enhance business productivity (Turban, Aronson, Liang, and Sharda, 2007). In this approach, people are able to understand the technologies, the specific decision-making situations and the design requirements for their own solution development. It is recognised that there are advantages of using these types of systems as well as risks associated with them. Turban et al. (2007) suggested that locally developed end-user applications can have advantages such as short development time,
elimination of formal requirement specifications, reduced implementation problems and low cost. Gammack (2002) also suggested that user-developed applications include better access to contextual information and improved information quality, which leads to improved end-user productivity and performance in their business. In addition, end users are now more empowered and involved in system design than previously. It reveals that tailorability in system design, as a form of empowerment, helps increase a technology’s usability (Germontprez et al., 2007). In the proposed approach, end-user application development does not only provide design ability to produce the end-user’s target solution, but also opens a learning platform for dealing with end user’s particular business information.

END-USERS AS DESIGNERS

Many researchers define the term ‘end-user’ in the context of application development. For example, Wagner (2000) describes end-user developers as professionals or managers whose primary function is not information system development but involvement in lower-end development environments according to their own knowledge and interests. Kreie et al. (2000, p. 145) defined end-user as a “person who adopts and uses information technology to develop applications”. Bell (1992) explained end-users as an actual user of the system who should be regarded as expert, developer or computer professional who can attempt to build-up and install systems in various contexts of use, because “ultimately users know their context best” (Bell, 1992, p. 51). These views imply that a shift of design activities from developer to end user has become increasingly significant in IS development. This principle also has been described in the phrase ”user-as-designer” in many literatures (for example in Gammack, 2002; Lytje, 1997; Gill, 1991; 1998).

In the DSS development context, many researchers found that end-user developed applications have had substantial issues. Table 1 shows findings on end users development.

<table>
<thead>
<tr>
<th>Main issues</th>
<th>Specific findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>limited options of end-user design control; low quality development; inappropriate methodology used in application development; not interoperable; and uncontrolled vocabulary</td>
<td>• lacking in traditional system development approaches and using system development professionalism (Gammack, 2002); • issues in system reengineering and third party knowledge engineer’s involvement in system development (Gammack, 2002); • low quality of system development and inappropriate design methodology (Wagner, 2000); • threats in data security, data integrity, solving the wrong problem, compatibility issues (McGill, 2002); • requirement for skills in basic database, file management, editing for end users (West, 2000); • requirements for system analysis and design training (Kreie et al., 2000); • risks associated with end user’s spreadsheet development (Janvrin and Morrison, 2000); • requirements of controlled vocabulary (Qin and Paling, 2001)</td>
</tr>
</tbody>
</table>

Table 1: Issues in end-users developed applications

Shifting design burden and the relevant decision-making responsibilities towards end-users, allows faster and more contextually subjective reflections as outcomes. However, placing end-users in central active roles in IS development leaves many concerns in the problem context. Firstly, end users need to have similar language to communicate in their secondary application design. For example, a developer can build a database establishing technical meanings but the meanings may not be suitable for end users in their context of use. It implies that all system components should have a common language to be understood by all levels of end users. Secondly, the architecture should differentiate end user’s design activities from co-designing; this is because theoretically secondary application design is not co-design. The original design architecture should be built by a developer or professional designer and must have specific limitations for end users to constrain them in a well balanced framework. However, the question is how can we establish a scale of end user’s knowledge intensiveness for the group of end-users in their specific design participation? Because, what is important is end-user engagement in the different levels of the problem domain are needed to ensure a balanced interplay of workable application creation, which will be vital in their specific business context. These significant issues need to be addressed by researchers. Therefore, the intention of this research is to focus on a human-centred tradition of systems development that may recognise both issues.
This solution development emphasises an infrastructure in which secondary applications can emerge in relation to current needs. The infrastructure is developed through less knowledge intensive activities while attempting to specify rigid and context boundaries and local definitions for end-user groups. This view complements current approaches by recognising of the inevitability of such systems in future (i.e. Germonprez et al., 2007; Hovorka and Germonprez, 2008). So that end user will progressively become responsible for major activities in the applications development.

PRIMARY AND SECONDARY DESIGN ACTIVITIES

A tailorable technology contains a dynamic design environment that has “recognizable components and conventions” for enabling users to tailor the technology through its features (Germonprez et al., 2007, p. 360). Accordingly, the proposed tailorable solution environment allows specific applications to be designed by end-users through the selection of the system components, with the architecture controlling its integrity. In this instance, the active design environment remains in its original form (i.e. in its primary design state) for any action of tailoring, as the end user becomes a designer of the secondary state (Germonprez et al., 2007). The secondary design state is termed as a secondary application design in this research. Therefore, there are two main phases in dealing with a tailoring technology: First phase is to outline primary combined technology (which is the tailorable design environment that can accommodate domain knowledge in terms of useful components for building application) for the end user; and the second phase is when the primary technology takes place for end users creation and interaction with them for their own application development. In addition, the primary technology recognizes end users as intentional users to tailor the system through its features that suits their specific business contexts.

The main aim of the primary design is to create an environment that employs a design template to build DSS applications. The primary development activities comprise two distinct phases in a participatory research environment. In the first phase of development, an initial template of DSS application was outlined from the knowledge of the problem domain. Then the application template was reviewed with industry standard conditions and it must fulfil the decision-making requirements to the satisfaction of the decision makers at entry level (Miah et al., 2006a). In the second phase, practical knowledge (knowledge components) from the developed template was used to outline a generic ontology repository that is the key part of the design environment. This design environment holds the features for selecting, adding, updating, modifying, and deleting the knowledge components. Therefore, this tailorable design environment enables end user application creation through the interaction of the applications development.

The solution approach provides a dynamic space for different end users for outlining the secondary application. As mentioned earlier that the primary design provides functions for three key roles of the end users. Management end users can define the scope and allocate resources whereas the domain end users convert the problem domain into system components that can be useful for the general end users. The role of the general end users such as a primary producer can apply their own subjective judgement for building the specific decision support applications in the context of its use. A primary producer can build different applications as many as they need due to their changes needs. They can store their developed applications and the generated outcomes from the developed applications for further comparisons and analysis for their business progress. Germonprez et al. (2007, p. 352) defined that tailorable technologies “enable end users to select and integrate technology features in the ongoing creation and recreation of unique information systems that match their concerns and activities”. In the proposed approach, end user’s creation and interaction can be viewed through the modelling of their specific problem domain for building DSS applications as required.

TAILORABLE DESIGN ENVIRONMENT

According to the requirement of users’ involvement in the problem space identified in this study, the proposed design environment recognises different classes of end user roles in secondary application design within the industry. The design environment incorporates three functional processes. The first one is an authorization layer for the management end users (i.e. managers) who allocates resources and assigns one or more domain experts for DSS application development. The second layer for knowledge acquisition is where the domain end users (i.e. domain experts) develop decision-making rules from the relevant knowledge of the problem domain. The final layer is DSS development for general end users (i.e. primary producers) who builds the business specific DSS using the decision rules created by the domain end users.

The two main obligations, knowledge acquisition from the problem domain and DSS building options for the end users, are essential functions in the solution architecture. Management end users are required to incorporate these two functions for application design. In this case, there are a limited number of resources available within the rural industry, and these resources need to be allocated to individual projects. At the administrative level for management end user, formal project technical support for initialising a DSS project is assigned, so that appropriate assignment of administrative
responsibilities across the projects is assured. Figure 1 presents the overall system design architecture for the three functional processes, representing each end user layer. The following sections describe the processes in these layers.

Figure 1: The overall system design architecture in which end users can build their problem specific DSS applications.

Processes for Management end users
Management end users layer was developed for several purposes including policy making, allocating resources, deciding on the scope of the DSS project, and assigning the domain experts, who will undertake the DSS application development. Managers within the business industry understand what is needed for this type of secondary application development. Within this layer, they have super-user access over the system (i.e. they can access and monitor the entire development activities by the domain experts and general end users). Managers know the expertise sources for a given knowledge domain, and can even allocate the same project to more than one expert, so that a better or more acceptable solution can be found competitively. The layer also associates mandated DSS project documents, resource documents, industry repositories and other relevant documents in a central location. Access to the second and third layers is via this level.

Domain end users processes
The second layer of the architecture was developed for domain experts (i.e. domain end users who convert the knowledge components). It is at this level that the ontology repository relevant to any specific decision situation can be created. The function under this layer is important for the domain experts because they act within the host administration for
knowledge acquisition for the target problem domain. Extension professionals may act as domain experts if managers assign them, and their recognised position in the organisation (i.e. in rural industry context) qualifies them to detail a specific knowledge domain. They interact with general end users such as primary producers, and have a high level of knowledge about the decision-making situations such as farming conditions, as well as the decision criteria (for example, industry regulations) that end users have to work with. As mentioned previously, one of the main goals of the domain experts (in their capacity as extension professionals) is to transfer the most useful scientific knowledge to the end users for their best practices. They also have the training and relevant experience on application development for DSS, or can access this internally.

Domain end users may have access both to the source of scientific knowledge and business process aspects. As such, they are responsible for knowledge organisation and rules creation for secondary design in the proposed approach. In this case, this design environment shifts the traditional knowledge engineer’s roles to the domain experts. Domain experts know the extent of their own domain knowledge, relevant problems and important variables in the decision-making process. They are also familiar with the knowledge flow that is required for the articulation of decision making.

**General end user’s processes**

In the end user’s layer, primary producers can select the decision parameters relevant to their specific farming situation. This is how they can outline a specific problem scenario for obtaining decision support. In a case of this research, decision-making parameters were collected for milk protein (one result variable) in the dairy industry context. Primary producers then insert current values for the parameters according to their local context. The specific DSS application produced by end users then calculates and displays the difference between the optimal level and the current level for each parameter, so that the producers can decide what factors need to be improved. The developed secondary application also provides specific expert advice for improving farming practices. Finally, the secondary application produces an assessment report that details the farming conditions and where improvements can be made.

The following table (Table 2) summarises the activities of the different end user’s access levels.

<table>
<thead>
<tr>
<th>Administrators activities</th>
<th>Domain expert activities</th>
<th>Primary producers/business operators activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assign a new DSS development project, allocate resources and scope to the experts</td>
<td>establish a meaningful knowledge base in the adopted problem domain defined by domain experts as such extension professionals</td>
<td>tailor decision-making requirements to a farmer’s specific situation as defined by the primary producers</td>
</tr>
<tr>
<td>Set priority of the project for experts</td>
<td>identify specific parameters influencing decision</td>
<td>allow farmer’s own choice of parameters to selection</td>
</tr>
<tr>
<td>Monitoring all projects, its progress, its performance and expert’s activities.</td>
<td>specify relationships between the parameters and output variable levels</td>
<td>give primary producers more specific expert outcomes on their current farming status</td>
</tr>
<tr>
<td></td>
<td>set up mathematical relationships for estimating required level in production to compare with current status</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2: Different activities supported by the design environment according to the rural industry authority**

**DISCUSSION AND CONCLUSION**

This paper described the processes for secondary application design by end users of different levels in a rural industry context. End users such as primary producers can apply their own subjective judgement for their application development in the context of its use. However, when specifically considering general end users task from a management perspective, it needs to be coupled with a domain expert’s knowledge acquisition through the protocol of knowledge transferring and the monitoring of the development activities. For instance, managers can achieve their own objectives throughout the automated process of accessing the settings. Domain experts can configure the systems by adding knowledge components and setting decision-making rules. Finally the primary user/producers can use such a template for outlining their problem scenario (by selecting relevant parameters) for building their own DSS applications. As such the proposed architecture provides tailorable features for accommodating roles of different end users. This development view discourages the traditional reality of IS development where multiple design states are included with preset or defined
intermediary requirements. This study conceptualised objectives of the novel design process by learning the roles of end users interplay for the secondary design in the primary design-environment. These are:

- employed end user friendly features in the design environment
- defined access layers for different end users
- limit customisable functions for secondary design with solution standard defined in the design environment
- defined validity check of the secondary application developed by end users
- maintained up-to-date database or updated domain oriented information for application

From the system evaluation with the target end users, the research found that the achievable goals of this design can be met by having simpler and easier user interfaces of the architecture, adequate problem solving methods in place (i.e. decision-making rules) and using updated knowledge in the repository.

A limitation of the research is that as a “proof of concept” demonstration, the design environment prototype was developed only to a level consistent with stakeholder evaluation of the conceptual design. Although developed within a single industry case domain using a specific ontology, the design environment architecture and the development approach itself are deliberately tailorable and therefore further research could examine this more closely in any other problem space.

REFERENCES