Domain Expert User Development: The SmartGov Approach

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Introduction

In a recent special issue of CACM [1] the approach of end-user development was presented and a number of articles tried to capture the benefits inherent in this approach and the broad range of issues that have to be tackled for end-user development to prosper.

End-user development (EUD) aims to empower end-users with the necessary tools to implement their own software. In this sense domain expert user development can be viewed as a special case of EUD. Domain experts can be considered to be a special case of end-users who possess the necessary knowledge of how the software should operate, what tasks it has to carry out, which business rules need to be enforced, validation checks to perform, etc. It has to be noted that in some cases domain experts will not use the produced software themselves, this software however will *indirectly* support their work, e.g. software developed by tax officers (domain experts) to be used by tax payers (actual end-users) simplifies the subsequent work of tax officers through minimization of errors, population of electronic data repositories etc.

Using a user-centred software engineering paradigm [2] domain expert users will work along with software developers to create specifications for the software to be implemented by the latter group. This process is usually iterative. Domain experts will be questioned by developers, developers will design a first prototype, the domain experts will most probably ask for changes, developers will come back with an altered prototype, etc. Since both user groups are usually involved in other assignments as well, this process can be time-consuming. Impedance mismatch problems [3], i.e. problems in the communication between the domain experts and the IT staff due to different backgrounds, perspectives and terminology result into additional delays within this phase. An alternative to this would be to help domain experts to create the software with a minimum or no involvement of IT personnel. This is the approach adopted in the SmartGov project[1]. In the framework of SmartGov a knowledge-based platform was developed that assists public sector employees with suitable domain expertise to generate online transaction services by simplifying their development, maintenance and integration with installed IT systems.

e-services and domain experts

According to the European Commission [4], transaction services (such as e-forms) although perceived as the future of e-government have not yet realized their full potential. E-forms have a significant role in e-government, as they are the basis for realizing most of the twenty public services [5] that all EU member states have to provide to their citizens and businesses. SmartGov delivers an intelligent e-forms development and maintenance environment and an associated framework for e-government services.

In the development of e-government services, domain experts play a central role. Domain experts know what data have to be collected and what data have to be presented, which are the laws and regulations that govern the electronic service and most importantly which business rules (including validation checks) pertain to individual data items or groups of data items. Unfortunately in most cases domain experts remain passive mediators of knowledge instead of undertaking a more active role.

The role of domain experts can be enhanced through a development environment that will assist domain experts not only to offer their knowledge, but also to take a more active part in the process. Such an environment has to provide its users with the necessary functionality to create electronic services in a friendly, intuitive manner. For that, the user groups involved in e-service development and maintenance and their profiles have to be outlined and their needs recorded.

According to the analysis carried out during the SmartGov project [6] the main stakeholders of e-services in the public sector are:

- Managers: The managers of the public sector who need to take a strategic view of the provision of services, and obtain high-level metrics (e.g. statistics, performance indexes etc.) from e-forms.
- Experts: The public sector domain experts who require e-forms to support their work (directly or indirectly) and who possess the necessary domain knowledge for the development of e-forms. Usually, they need to collaborate with IT staff during the creation of e-forms.
- IT personnel: The public sector employees (normally IT staff, clerical workers and in some cases external consultants) that provide and support the infrastructure necessary for e-forms, e.g. web servers, databases, etc.
- End-users: The end-users (either citizens and businesses or other public sector employees) that have to fill in e-forms and interact with the electronic services.

Currently, these stakeholders have significant problems in implementing electronic services. Apart from the organizational and cultural barriers [7], analysis also showed obstacles stemming from the following sources:

- Difficulty in actively involving domain experts in the whole process of the electronic service lifecycle. This is due both to viewing the domain experts as simple users and of not providing incentives in the form of acknowledging their role and expertise.
- Loss of valuable information during the transfer of knowledge from domain experts to IT personnel. Domain experts posses deep knowledge of the domain, however transfer of this knowledge from domain experts to IT staff is a *lossy process*, during which domain knowledge is translated to software specifications. These specifications, although necessary to build the required software, are of a low level of abstraction and cannot be used as help for end-

users, documentation for the service, or even for communication between domain experts, while the original form of the knowledge could serve well all these purposes.

- Complexity in creating e-forms and, most importantly, difficulty in encapsulating domain expertise in these forms.
- Lack of user-friendliness for the end-user in the form of online help, domain specific information, external references, examples, support of multiple access devices etc.

Although the approach taken up, tackled all of the above-mentioned problems, this article focuses on the role of domain experts and the functionality provided to them in order to transform the whole process of creating electronic services.

The SmartGov approach

Domain expert user involvement

Based on the SmartGov approach the development of a new electronic service starts with the definition of the data the electronic service requires, the rules for verifying them, the back-end processing that should take place and the possible output. In all these tasks, domain expert users play a central role.

Domain experts know what data have to be collected and are required for the execution and efficient operation of the service. This knowledge is derived from the laws and directives that underlie the service and govern its operation. In the approach taken, this implicit knowledge can become explicit in the form of documentation and data validation rules. Usually domain experts are reluctant in providing this knowledge for fear of losing the power associated with it. Requirement analysis recorded incentives that if employed, they could encourage domain experts to participate and share their knowledge. Since in public administrations the main reward for public servants was the enhancement of their status and prestige that would consequently assist the advancement of their career, any approach aiming to make domain knowledge explicit and concrete has to support this aim. To this end, domain experts have to be accredited as authors of specialized knowledge and the management of the public administration has to be able to detect them among the public servants. The provision of a centralized knowledge base can help to that, and also allow the association of validation rules with the pertinent electronic service objects, offering context-sensitive documentation for developers and end-users and a means to retrieve objects that are affected by changes in laws and directives. This approach is supported by a platform providing the necessary tools for domain experts and developers to implement electronic services.

The SmartGov platform

The SmartGov platform offers functionality for managing knowledge and validation rules, creating objects, designing forms and services and deploying them. The central concept in the SmartGov platform is that of *Transaction Service Elements* (TSEs). TSEs are effectively widgets that may be used as electronic service components. However, in contrast to user interface widgets these building blocks have more than their visual appearance: they can contain metadata and domain knowledge. Metadata may encompass the object's type, range of values, validation checks, multilingual labels, and on-line help, while domain knowledge includes information about the relation of the object to other elements, legislation information, documentation etc.

The platform contains a toolbox of predefined TSEs that can be used by domain experts as a basis for implementing electronic services. Furthermore, widgets or even parts from existing services along with the associated knowledge and rules can be reused in new services.
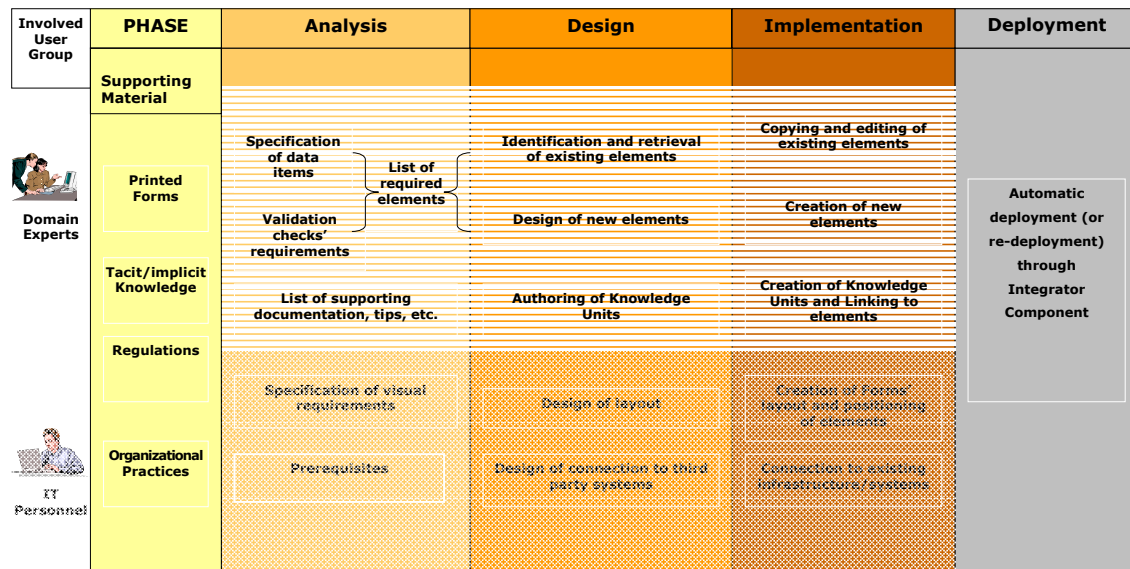
Involved User Group	PHASE	Analysis	Design	Implementation	Deployment
	Supporting Material				
Domain Experts	Printed Forms	Specification of data items	Identification and retrieval of existing elements	Copying and editing of existing elements	Automatic deployment (or re-deployment) through Integrator Component
		List of required elements		Creation of new elements	
	Tacit/implicit Knowledge	Validation checks' requirements	Design of new elements		
		List of supporting documentation, tips, etc.	Authoring of Knowledge Units	Creation of Knowledge Units and Linking to elements	
	Regulations				
IT Personnel	Organizational Practices	Specification of visual requirements	Design of layout	Creation of Portex layout and positioning of elements	
		Prerequisites	Design of connection to third party systems	Connection to existing infrastructure/systems	

Figure 1. The SmartGov approach of e-service development

Domain experts can identify and copy parts previously created for other electronic services that suit similar or even the same purpose. Identification of such parts is not carried out so much based on visual similarity but rather on semantic analogy. The domain expert can change anything ranging from the visual part to the associated knowledge and the validation checks. During the SmartGov platform requirements analysis phase, common validation check types have been modeled and included as templates in the platform.

This approach (Figure 1) along with a simple, easy to use interface (Figure 2) assists in overcoming the obstacles encountered in traditional approaches. Figure 2 depicts the TSE editor screen, which is accessible after logging on to the SmartGov platform. In this screen, the platform displays the last tasks carried out as well as the list of services the active user's work group has undertaken. Through the main menu on the left, the user can access basic functionality for editing services and service elements as well as for knowledge management.

Figure 2. Transaction Service Editor Screen

The effort required for creating electronic forms is reduced by exploiting the *reusability* inherent in the development of electronic services. Once a domain expert creates a TSE, it can be used (instantiated) as many times as needed; each instance inherits all the linked knowledge, validation checks, etc. To enhance reusability the user can create groups of TSEs, with cross-validation checks, and copy them (through the instantiation paradigm) as an integral unit between services. One such example is that of personal details field group. Almost all electronic services have a part for entering user details, such as name, surname, address, email, telephone and fax. These fields can have checks to test their validity, knowledge units like help, etc.

For example, during the pilot application phase a first pilot service was developed that displayed the tax clearance results of a citizen's tax declaration form. A second pilot service built was that of the e-VIES. This service is used by freelance workers and companies that perform trade of goods and services within the European Union in order to declare the amount of cross-country trade. Although the two services cater for different user groups and different functions, still the first half part of both services is identical, namely that of personal details declaration. Using the TSE Group Editor option of the SmartGov platform, developers of the second service were able to instantiate a copy of personal details part of the first service including all linked Knowledge Units and validation checks and re-use it without any further modifications in the second service.

Since most services within the same public administration share a large proportion of common parts in both the front-end and the back-end, this notion of reusability can reduce development effort and promote uniformity across different services.

One crucial aspect of the development process so far was that the domain experts were giving their knowledge as part of analysis process carried out by IT staff, without this being acknowledged. The platform enabled domain experts to directly enter their knowledge to be used in electronic service; the fact that their contribution was recorded and acknowledged (they were listed as *authors* of the elements they created), was found to help them overcome their reluctance to provide knowledge.

System implementation

The implementation of the SmartGov platform was based on open standards and technologies. Figure 3 depicts the architecture of the SmartGov development and deployment environments, along with the underlying technologies. Both environments are based on Apache Tomcat and on open technologies such as JSP, Java and XML. As illustrated the development environment includes an authorization and personalization component, management modules for all ingredients of e-services as well as an Integrator component, which compiles and deploys the service (service logic and default authorization). In the deployment environment each service has its own authorization component to enable end-users log-on. Deployed services can communicate with back-end systems through the Information Interchange Gateway [6].
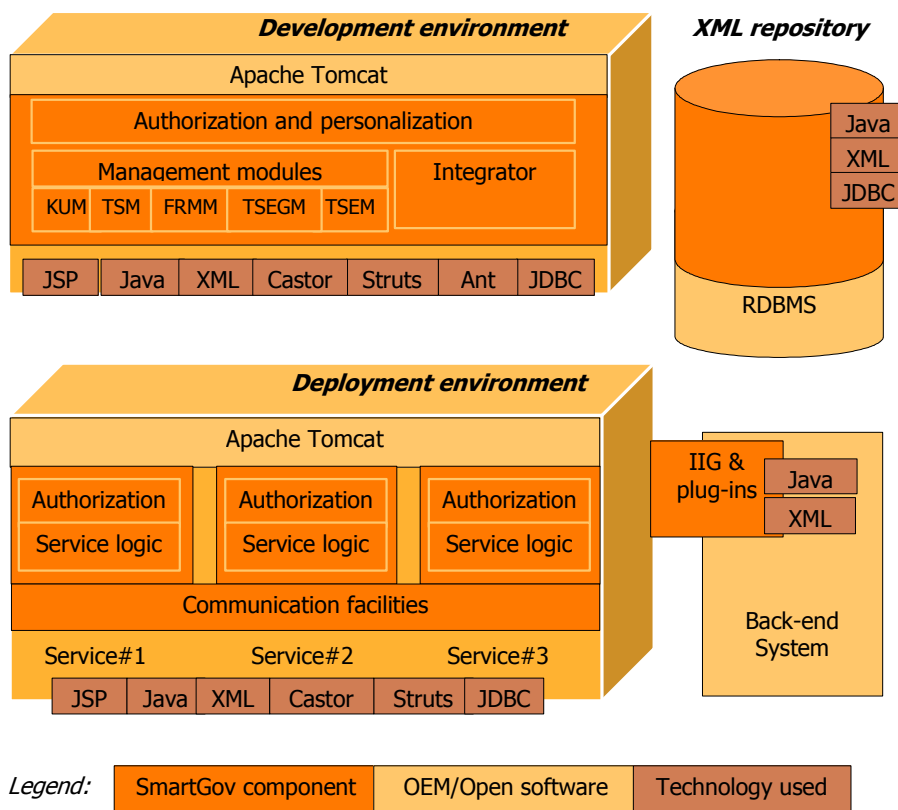
Figure 3. Technologies employed in the SmartGov platform

System evaluation

The SmartGov platform was evaluated at the sites of the two user partners participating in the project: the General Secretariat of Information Systems at the Greek Ministry of Finance and the City of Edinburgh Council. In the first case the domain expert users were accountants but also had computer experience whereas in the second case the domain expert users were occupational therapists with limited computer experience. The evaluation of the platform was categorized into three main components:

Technical acceptability: A usability engineering technique was employed to assess the platform against the user requirements collected in the initial phases of the project. The conformance to user requirements analysis showed that the overall total of user requirements met either fully or partially was 78%, with more than 80% of the compulsory requirements being met.

Usefulness: This was concerned with utility and usability issues relating to how the SmartGov platform performed and was perceived by the real users in their native environment. In this a holistic view of the platform in-situ at the two pilot sites was taken, detailing the use of the development environment by the Public Authority Staff to create the online pilot services. The results of this evaluation of platform usefulness were generally positive in that the majority of the success criteria were met, taken across the two pilot sites as a whole. However there was a disparity between the two sites, which can be seen in the separate results for each site. This disparity was due to the fact that the service developers in CEC had limited IT experience, whereas in GSIS, the individual service developers had a high level of IT expertise. Overall, although the learning curve for occupational therapists was greater than for accountants, both user groups were very positive in their comments in regards to the usefulness of the platform as a system for creating electronic services and for sharing knowledge both with peers and with end-users.

Social/organisational acceptability: This focused on a cost-benefit analysis of the platform in order to estimate the overall added value of SmartGov. The cost-benefit analysis carried out by consortium partner Archetypon, suggests that the platform could provide added value.

A detailed report of the trials and evaluation results can be found in [8].

Conclusions

The SmartGov platform implements an innovative approach in the development of electronic transactional services for the public administration domain. In regard to the applicability of this approach in other domains, we feel that this approach is most efficient in contexts where the e-service is based on a set of complex principles such as laws and directives and where there exist many services. The presence of a complex background increases considerably the effort needed to implement and especially to maintain electronic services if a traditional development approach is followed. Such environments are usually encountered in public administrations, which base their operation and therefore their services on a number of laws and directives, which are additionally subject to frequent modifications. In environments such as electronic business, the implementation of the transactional service may not be based to the same extent on domain expertise, on laws and directives, rendering traditional development approaches as efficient as the proposed SmartGov approach.

SmartGov's most important contribution in the development procedure of e-services is the active involvement of domain expert users. Domain experts are a special case of users, being the persons who possess deep knowledge of a certain domain. To this end, it is imperative to activate them during the development of electronic services. The approach taken in the SmartGov project showed that with appropriate incentives and tools, their role in the design and implementation of the services can be enhanced and they can become to a great extent developers of their own services.

Acknowledgements

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