Towards a Framework for Enterprise End-User Development Initiatives: A Design Science Research Investigation

Emergent Research Forum Paper

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Abstract

This paper presents an overview of a recently instigated research program aimed at devising a systems development and implementation framework for enterprise end-user development (EUD) initiatives. This research aims to investigate use-case scenarios, business process requirements, infrastructure requirements, implementation tactics, and technology governance issues related to the effective implementation and adoption of enterprise EUD technologies. We plan to investigate the efficacy of novel model-based systems design approaches as well as collaborative design processes among end-users and system developers as viable methodologies for EUD implementation. Principles and processes from design science research are being utilized to provide a roadmap for the research program. This paper outlines the study's research design and its expected research outcomes. The outputs of this research have the potential to advance an understanding of development methodologies and implementation strategies for EUD-based self-service technologies, and facilitate the effective adoption and institutionalization of EUD initiatives in organizations.

Keywords

End-User Development, EUD, Design Science, Participatory Design

Introduction

The development of software applications functionality and data integration workflows is a complex undertaking traditionally entrusted to corporate IT departments and technology professionals in organizations. However, with the ever rising quantity and assortment of cloud applications, connected devices, and unstructured stream data, business users with some technical skills are increasingly taking it upon themselves to use lightweight programming technologies and software readymades to develop new applications and integrate their applications with relevant back- or front-end systems that they use. These types of user are often called citizen integrators (or citizen developers) (Pezzini, 2014), and the activities in which they assume a central role in creating or modifying software artefacts can generally be classified as end-user development (EUD) (Lieberman et al., 2006; Paternò, 2013).

While corporate EUD programs and enabling technology platforms are key current trends in enterprise technology initiatives (Cearly et al., 2015; Overos, 2014), there is a significant lack of empirically based academic research with insights about key success factors for the effective adoption and institutionalization of such initiatives in organizations. The research program summarized in this paper was instigated with the aim of addressing this research gap.

This paper provides an overview of our research program aimed at devising a systems development and implementation framework for enterprise EUD initiatives. Toward this, the paper presents a brief overview of the current research on EUD and highlights gaps in the extant literature. This is followed by an
outline of our program’s research design comprising a mixed methods approach with empirical as well as applied investigation components, all being guided through design science research principles. Finally, the paper highlights some expected outcomes from the investigation and their significance to research and practice.

**Extant Research on End-User Development**

End-user Development (EUD) can be defined as “a set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create or modify a software artefact” (Lieberman et al., 2006). End-user development comprises various lightweight programming activities that differ from traditional programming by software developers in that the aim of the end-users is “to achieve the result of a program, rather than the program itself” (Ko et al., 2011). The goal in EUD based activities is to build a new application or to modify or extend an existing application for one’s own use rather than creating an application for other people to use.

According to many academic and industry researchers, the number of applications developed through EUD based tools and techniques will keep rising (Burnett & Scaffidi, 2013; Finley & Knipp, 2011; Paternò, 2013). As a critical trend in personal and enterprise computing (Finley & Knipp, 2011; Chudnovskyy & Gaedke, 2012; Lewis, 2010), EUD continues to gain traction as many interactive software applications are being crafted not by professional software developers but by people with specific domain expertise (Paternò, 2013). Key enablers for EUD include the availability of customizable applications and simplified development toolkits in the form of visual interactive systems (VIS), as well as evolving cloud ecosystems that provide web data services and software functionality through content feeds and application programming interfaces (APIs) (Ahmed & Ruhi, 2013; Ruhi, 2014). In the enterprise environment, advancements in service-oriented architecture (SOA) has also further facilitated the development of applications by tech-savvy employees (Finley & Knipp, 2011).

As a corporate initiative, EUD has the potential to produce many benefits. EUD based tools can help enhance the productivity of end-users by allowing them to gain more control over their computing environment (Klann, 2003; Paternò, 2003). This can also translate into greater utilization of technologies that may otherwise not be used effectively due to inadequate end-user adoption or perceived gaps in the functionality of the solutions (Spahn et al., 2008; Sutcliffe, 2005; Xiaoxiang et al., 2008). By nurturing a conducive EUD environment internally, the organization can enable the production of agile business applications and subsequently enhance their business process architecture, decision-making capabilities and innovation posture (Spahn et al., 2008; Kierkegaard & Markopoulos, 2011).

There are several key gaps in existing research on end-user development that this proposed research aims to address.

In terms of composition environments that facilitate the creation of EUD applications, model-based approaches that have been recommended for the design of visual interactive systems have not gained much traction with non-IT professionals, and their adoption has been primarily limited to professional software application developers (Costabile et al., 2006; Paternò, 2013; Spahn et al., 2008). Furthermore, the tools and techniques offered in EUD tools for data mapping and workflow integration are still rather complex and not suitable for end-users without adequate programming knowledge (Chudnovskyy & Gaedke, 2012; Mørch & Zhu, 2013). One reason for these problems is that the methods followed during the development of EUD composition workspaces still largely rely on the expertise of professional software engineers and application developers whose programming focus during design-time does not necessarily reflect the evolving needs and requirements of end-users during use-time (Maceli & Atwood, 2011). Active user participation of domain experts in the software development process has been advocated by many researchers as a means to bridge this critical gap between design- and use-time, and various participatory design techniques have been suggested to help with requirements gathering, use cases and tasks analysis, and user-interface design issues for EUD software (Ardito et al., 2012; Costabile et al., 2006).

From a technology governance perspective, organizations interested in making their employees more productive through EUD applications are also concerned about various risks to their business. For
instance, a key issue in enterprise EUD environments is to formulate and institutionalize quality assurance mechanisms that ensure the reliability of the produced applications as well as their compliance with company policies (Kierkegaard & Markopoulos, 2011; Mehandjiev et al., 2006). Therefore, it is important that corporate EUD programs not only focus on providing useful and user-friendly development tools, but also have formalized citizen developer governance policies (Bader et al., 2012) to monitor EUD activities for various risks such as data loss, compromised process integrity and susceptibility to security threats (Finley & Knipp, 2011).

The proposed research addresses the gaps outlined above through devising and demonstrating a detailed methodology that combines participatory design principles for EUD environments as the basis for developing and implementing EUD toolspaces and service front-ends. Such a methodology is expected to provide a holistic means to capture business value propositions, use-case scenarios, business process requirements, infrastructure requirements, implementation tactics, and technology governance issues related to enterprise EUD initiatives. Further details about the research design and methodology are provided in the next section.

**Research Design & Methodology**

Our research program comprises a mixed methods research design with empirical as well as applied investigation components. Design science research is adopted as the underpinning methodology, and its processes and principles are being used to guide the investigation phases over the duration of the research program. As a growing research paradigm in information systems, design science research is well suited to this research context since the aim is to develop a technology based solution to a business problem (Hevner et al., 2004; Kuechler & Vaishnavi, 2008).

*Figure 1* depicts the research design showing the various phases of the research program and their underlying activities and products. It juxtaposes the components of the research program with the typical outputs expected and the recommended process model steps in design science research projects (Vaishnavi & Kuechler, 2004). As shown in the figure, the research program is organized to be completed over three phases. Each of these phases is outlined in the following sections. It should be noted that while each phase is delineated herewith for purposes of clarity, together the phases form an integrated program largely corresponding to the awareness, suggestion, development and evaluation phases in a typical design science research project (Gregor & Hevner, 2013; Kuechler & Vaishnavi, 2008).

**Phase 1: Empirically Based Meta-Ontology Model & Issues Identification for EUD Information Systems**

The empirical investigation component in this research aims to identify opportunities and challenges with enterprise EUD technologies and initiatives, as well as to help devise methods and procedures for creating EUD information systems. Toward the latter, this research program will utilize ontological engineering as a primary method to develop a model for EUD information systems. As an emerging paradigm, ontology based software engineering (OBSE) is regarded as a promising instrument for knowledge transfer between software projects and application development cycles (Bachmann et al., 2007; Hesse, 2002; Seedorf & Schader, 2011).

Our first version of a meta-ontology of EUD information systems is primarily being developed through a systematic literature review. As a means to enrich the meta-ontology being created in this phase of research, we are also conducting an extensive exploration of EUD tools and applications offered by different industry vendors and service providers in the platform as a service (PaaS) marketplace. These steps will help provide an initial description of EUD systems’ structure and semantics using common industry standards. In developing the meta-ontology, we are utilizing the OWL (Web Ontology Language) W3C recommended standard for ontologies (W3C, 2004; W3C, 2012).
After developing a common high-level vocabulary in the EUD meta-ontology, in the second stage, we will commence the empirical phase of research which will utilize a combination of qualitative and quantitative data collection and analysis techniques. A series of interviews and surveys will be conducted among various individuals with prior experience in EUD technologies and initiatives. Purposive sampling techniques will be used to gather empirical data from multiple organizations and from individuals with different roles including domain expert users, business process owners, IT staff, software engineers, data integrators, and interface design experts.

The themes from the findings of the empirical investigation are expected to help identify and shed light on various issues related to corporate EUD technologies including their value proposition, infrastructure requirements, implementation tactics, and technology governance issues associated with their deployment. Furthermore, many of the themes and concepts from the findings will help enrich the initial meta-ontology of EUD information systems being constructed in this first phase of the research program.

Overall, the first phase of this research program highly aligns with the awareness stage in design science research, and the findings from this phase are expected yield a substantive foundation for actionable knowledge to facilitate the implementation of enterprise EUD technologies.
Phase 2: Participatory Design of Business Domain Ontologies for EUD Systems

The primary objective of this phase of research is to investigate multiple business domains for enterprise EUD initiatives and ascertain specific requirements and tactics for these domains. Towards this, we will create ontologies for EUD systems with source schema for these specific business domains and subsequently map them to the meta-ontology from the previous phase. In this way, we will also be able to validate various aspects of the meta-ontology created in the previous phase.

For this phase of research, we will engage multiple potential case-study organizations experimenting with EUD initiatives in application domains such as business analytics self-service, social media curation for online marketing, and application integration with government open data sources.

Each business domain will be represented by a case-study organization and employees from these organizations will be recruited to collaborate and contribute in a participatory design process for the EUD system. Many researchers have recommended participatory design as best practice for enterprise EUD technologies and initiatives (Fischer & Giaccardi, 2006; Paternò, 2013; Spahn & Wulf, 2009). Such design processes can help enhance the functionality of EUD tools by allowing software developers to offer their programming expertise and enabling end-users to draw upon their own domain expertise and creativity.

In terms of execution, the participatory design process in this research will be implemented using the software shaping workshops (SSW) approach (Costabile et al., 2006; 2007) whereby different types of EUD stakeholders are involved in the design of software environments that are appropriate to their roles and are suitable for their specific activities with the technology (Costabile et al., 2007). Based on the SSWs conducted, each business application domain will be modeled individually as a custom ontology. As the EUD environment from each domain is modeled, the specific concepts from each environment will be tagged with relevant semantic identifiers from the meta-ontology created in the first phase of the research program. The concepts from each EUD environment hence become specific examples of the concepts in the meta-ontology. Once all business domains have been explored, a cross-case analysis will be performed to ensure that relevant cross-case global EUD concepts are represented in the meta-ontology.

The process of alignment among specific domain ontologies and mapping between the meta-ontology and the domain-specific ontologies will be supported through various semi-automatic ontology mapping tools and techniques such as PROMPT (Noy & Musen, 2002) and MOMIS (Mediator Environment for Multiple Information Sources) (Beneventano et al., 2003).

In terms of its linkage to design science methodology, this second phase of the research program aims to provide a tentative design for an EUD information system, and it corresponds with the suggestion stage in design science research. In terms of research outcomes, this phase of the research program is expected to provide a corroboration of the meta-ontology created in the preceding phase, and to also provide insights about the efficacy and viability of using software shaping workshops as a methodology for model based design of EUD information systems. Furthermore, the outputs from this phase will be directly utilized in the next phase of the research comprising the complete design and validation of a proof-of-concept EUD system.

Phase 3: Proof-of-Concept Design & Validation of a Domain-specific EUD VIS

The final phase of this research program will entail an application of the ontology models created in the previous two phases and utilize these models to design a proof-of-concept EUD visual interactive system (VIS) consisting of end-user development tools and components for a specific business domain application. A successful proof-of-concept will not only be used to functionally demonstrate the components of a useful EUD VIS, but also help establish the effectiveness of the methods and procedures used in the preceding phases of research.

This phase of research will entail the specification and implementation of a proof-of-concept EUD VIS based on the requirements and specifications for EUD systems for one specific business domain explored in the previous research phase.
In the first stage of design, a model-based approach will be utilized to support the specification of a domain-specific EUD system (from the previous phase). A model-based approach for system design would allow the use of meaningful abstractions and help avoid low-level details (Fogli & Provenza, 2011; Paternò et al, 2009). Toward this, we aim to use the MARIA (Model-based language for Interactive Applications) (Paternò et al, 2009) user interface description language (UIDL) to specify the tangible user interface for the prototype EUD environment. Using MARIA, we will formulate data models and event models to specify the interactive application architecture for the EUD environment.

In terms of the actual implementation of the toolspace and service front-end, the prototype EUD environment will be developed using HTML 5 W3C standards and the open-source RAML (RESTful API Modeling Language) standard. Various HTML 5 APIs including drag & drop, server-sent updates, and web workers will be utilized to create widgets for the EUD workspace. RAML will be used to create interfaces among components, connectors, and data elements in the EUD toolspace and to orchestrate backend services.

Following the implementation of the EUD prototype, in the final stage of this research phase we will conduct evaluations of the developed prototype against various usability and utility heuristics for visual interactive systems (Fischer, 1993; Johannessen & Hornbæk, 2014; Nielsen, 1996) as well as specific design guidelines for EUD systems (Repenning & Ioannidou, 2006). This heuristics based evaluation will be complemented by an empirical validation of the prototype by end-users who were involved in the participatory design process for the EUD business domain application. Multiple end-users with different roles and with varying degrees of technology competence will be invited to participate in the usability study comprising open-ended and scenario-based approaches to explore the EUD system.

Phase 3 in the proposed research program constitutes the development and evaluation stages in design science research methodology. Through the completed design of the proof-of-concept EUD VIS and its evaluation by potential domain expert end-users, we aim to ascertain the viability and usefulness of our global and domain specific ontology models from the preceding phases, and provide the tools on an open-source basis to interested industry organizations. We also plan on providing a live demonstration site for the academic and practitioner community for testing and commentary.

**Expected Research Outcomes**

The overarching goal of this research program is to devise a systems development and implementation framework for enterprise end-user development initiatives. Towards offering recommendations for effective implementation and adoption of corporate EUD initiatives, this research program aims to explore use-case scenarios in various business domains such as business analytics, social media curation, and government open data initiatives in order to formulate local ontologies with source schema for these specific business domains. Subsequently, these domain ontologies will be mapped to a global shared ontology for information systems that can facilitate enterprise EUD initiatives. Ultimately, these ontologies will be utilized to build and evaluate a proof-of-concept visual interactive system for EUD within a specific business domain different from those used in the initial exploration to test and validate the efficacy of the ontological framework.

Our research has several potential theoretical contributions. Recent systematic studies and research surveys in the EUD field have impressed upon the need for new approaches in systems modeling to enable high-level abstraction for EUD tools and components, as well as the need to research collaborative design processes among end-users and system developers as the basis for EUD implementation (Burnett & Scaffidi, 2013; Paternò, 2013). This proposed research aims to answer that call.

In terms of contributions to practice, the ontology based frameworks and the proof-of-concept from this research program are expected to advance an understanding of business process requirements that can be satisfied through the use of self-service enterprise technologies, and aid in the development of application toolkits targeted at citizen integrators and end-user developers. Holistically, the outputs of this research program have the potential to help organizations harmonize high-control systematic technology projects
being approached formally in a top-down fashion alongside high-speed adaptive technology projects being led by individuals or lines of business in a bottom-up fashion. Furthermore, our research findings will provide insights on key success factors for the effective adoption and institutionalization of end-user development initiatives in organizations, and subsequently help these organizations enhance their decision-making capabilities, improve their business process architecture, and enhance their decision-making capabilities and innovation posture.

REFERENCES


