IS Design Science applied in SCM Support

Paul Grefen
School of Industrial Engineering
Overview

• IS Research @ TU/e
  • What is it we do?

• Design science research in IS
  • Seven characteristics

• An international design science project
  • CrossWork

• Analyzing CrossWork
  • Seven characteristics

• Conclusions
IS Research Cluster Structure

- Business Process Engineering
- Smart Mobility
- Health Care
- Business Process Intelligence
- Business Process Management
Business Process Management Cluster

Posted on November 7, 2012

The research of the Business Process Management (BPM) is conducted against the insight that operational performance is most effectively managed in many domains by a focus on cross-functional business processes and the application of information technology.

Mission of the BPM cluster

The mission of the BPM cluster is to be one of the world’s leading research groups that deals with analysis, design, execution, and improvement of operational business processes. Dominant research topics of this group are: process modeling, workflow management, BPR, discrete event simulation, process mining, and reference models.
Welcome to the Smart Mobility Cluster

Posted on November 7, 2012

Information systems for smart mobility support the intelligent routing of business objects in business processes. Business objects can be physical or non-physical (digital) artefacts. Business processes can be located inside a single organization or span multiple collaborating organizations, for instance transportation processes in the context of supply chains. Information systems for smart mobility build on well-established IT paradigms like Business Process Management (BPM) and Business Intelligence (BI).
Design Science in Information Systems
IS Research Framework (Hevner et al., MISQ, 2004)

**Environment**
- People
  - Roles
  - Capabilities
  - Characteristics
- Organizations
  - Strategies
  - Structure & Culture
  - Processes
- Technology
  - Infrastructure
  - Applications
  - Communications Architecture
  - Development Capabilities

**Relevance**
- Business Needs

**IS Research**
- Develop / Build
  - Theories
  - Artifacts
- Justify / Evaluate
  - Analytical
  - Case Study
  - Experimental
  - Field Study
  - Simulation

**Rigor**
- Applicable Knowledge
  - Refine

**Knowledge Base**
- Foundations
  - Theories
  - Frameworks
  - Instruments
  - Constructs
  - Models
  - Methods
  - Instantiations
- Methodologies
  - Data Analysis Techniques
  - Formalisms
  - Measures
  - Validation Criteria

**Application in the Appropriate Environment**

**Additions to the Knowledge Base**
### Design science research (DSR) characteristics

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>1: Design as an Artifact</td>
<td>DSR produces a viable artifact in the form of a construct, a model, a method, or an instantiation.</td>
</tr>
<tr>
<td>2: Problem Relevance</td>
<td>DSR develops technology-based solutions to important and relevant business problems.</td>
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<td>3: Design Evaluation</td>
<td>The utility, quality, and efficacy of a design artifact are rigorously demonstrated via well-executed evaluation methods.</td>
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<td>DSR provides clear and verifiable contributions in the areas of the design artifact, foundations, and/or methodologies.</td>
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<td>The search for an artifact utilizes available means to reach desired ends while satisfying laws in the problem environment.</td>
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<td>7: Communication of Research</td>
<td>DSR must be presented effectively both to technology-oriented as well as management-oriented audiences.</td>
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IT artifacts central in IS research

**IT artifacts:**

- **Constructs**
  - vocabulary and symbols
- **Models**
  - abstractions and representations
- **Methods**
  - algorithms and practices
- **Instantiations**
  - implemented and prototype systems
IS Research Cluster Structure Revisited

Attic:
Research Strategy
Driver: Positioning

First Floor:
Applied Research
Control: Relevance Cycle

Ground Floor:
Basic Research
Control: Rigor Cycle
The CrossWork Project
CrossWork Consortium

Profactor
UMIST
TU/e
Uni. Växjö
Uni. Linz
Magna Intier
MAN
AC
Atos Origin
Exodus
Automated support required for DVEs

- Collaboration gets more complex
  - Multi-party business process networks
- Collaboration changes more often
  - Maybe even on a per-customer-order basis
- We are talking about primary processes
  - You don’t want things to go wrong
- So we need automated support
  - For reasons of effectiveness
  - For reasons of efficiency
The start
Virtual Enterprise
Dynamic Virtual Enterprise
Dynamic Business Process Network
Project scope

- Prod. Spec.
- NoAE
- XW
- Design/Production
- OEM
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## DSR characteristics in XF: your opinion

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<th>Easiest to Follow</th>
<th>Hardest to Follow</th>
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<td></td>
</tr>
<tr>
<td>7: Communication of Research</td>
<td>XXXXXXX</td>
<td></td>
</tr>
</tbody>
</table>
Characteristic 1: Design as an Artifact
Artifacts in CrossWork

• Not a single artifact, but a compound of
  • Constructs
    – Instant Virtual Enterprise concept
    – Dynamic Business Process Network concept
  • Models
    – CrossWork system architecture
  • Methods
    – Algorithms in system modules
    – Business process design practices
  • Instantiations
    – Prototype CrossWork System
Constructs: IVE & DBPN
Model: system architecture

front-end: DVE construction

back-end: DVE operation
Method: algorithm for system module

1: procedure AGGREGATE(P, X)
2:     l := lca(X)
3:     if l ∈ X then
4:         agg := children*(l)
5:     else
6:         C := \{c ∈ children(l) \mid X \cap children*(c) \neq \emptyset\}
7:         aggC := \bigcup_{c \in C} children*(c)
8:         if type(l) = SEQ then
9:             C' := \{c ∈ children(l) \mid \exists a, b ∈ C : a < c < b\}
10:            aggC' := \bigcup_{c' \in C'} children*(c')
11:            agg := aggC \cup aggC'
12:        else
13:            agg := aggC
14:        end if
15:     end if
16:     return agg
17: end procedure
Instantiation: prototype system (UI)
Characteristic 2: Problem Relevance
Changing product characteristics

- Rapidly growing product complexity
  - Inherent complexity (television sets)
  - Hybrid products (cars, financial products)
  - Combinations of products and services
- Rapidly increasing number of varieties
  - Complex sets of customer-chosen variables
  - Up to complete mass customization (PCs: Dell)
- Rapidly shortening life-cycles
  - Quicker generation succession (cars)
  - Quick technical end-of-life (PCs)
  - Quick economical end-of-life (GSMs)
Changing producer characteristics

• Focus on core competence
  • Be (second) best in class or drop out
  • Outsource non-core processes
  • Engage in co-makerships
  • Be lean and mean

• Play on a global level
  • Collaborate around the planet
  • Offer regionally customized products

• Must be prepared to change
  • Internally – and –
  • In network collaborations
Static chain
Dynamic chain
Comakership
Service outsourcing
Complex business network
Gartner Reveals Five Business Process Management Predictions for 2010 and Beyond:

• By 2013, dynamic BPM will be an imperative for companies seeking process efficiencies in increasingly chaotic environments.

• By 2014, business process networks (BPNs) will underpin 35 per cent of new multi-enterprise integration projects.

• Dynamic Business Process Networks will be essential in future business – and they need automated support.
Where is dynamism in collaboration going?

- nothing
- some things
- everything

- never
- sometimes
- always

Frequency vs. Intensity
Characteristic 3: Design Evaluation
CrossWork case studies

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MAN case study example process

Preparation

Motor pump

Grommet

Tank body

Dispenser

Sealing ring

Assembly
Evaluation process (part of relevance cycle)

• Characteristic: The utility, quality, and efficacy of a design artifact are rigorously demonstrated via well-executed evaluation methods.

• In practice, this is hard:
  • Based on limited set of constrained case studies
  • Prototype cannot be exhaustively tested
    – Too complex functionality
  • Targeted user group has limited availability
  • Evaluation period is small part of project
    – Focus is on construction of solution (funding !)
Characteristic 4: Research Contributions
CrossWork contributions

- Not extremely ‘tangible’, as artifact is not a single object (but an ‘ensemble’)
- New approach to the semi-automatic design of process-oriented IVEs
- New approach to the automatic execution of processes in these IVEs
- High-level system architecture
- Algorithms implementing core functions
- Indication of feasibility / usability
Characteristic 5: Research Rigor
## Structured requirements engineering

<table>
<thead>
<tr>
<th>Req.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1</td>
<td>Given a global (IVE-level) business goal ( gg ), the system can semi-automatically decompose ( gg ) into a structure of local (organization-level) business goals ( slg ).</td>
</tr>
<tr>
<td>RQ2</td>
<td>Given a structure of local business goals ( slg ), the system can semi-automatically identify a set of organizations ( so ) in a business market such that the organizations in ( so ) together have the capabilities required to reach ( gg ) by implementing each of the local goals in ( slg ).</td>
</tr>
<tr>
<td>RQ3</td>
<td>Given a local business goal ( lg ) and an organization ( o ), the system can semi-automatically obtain the specification of one or more external level local business processes of ( o ) that implement ( lg ).</td>
</tr>
<tr>
<td>RQ4</td>
<td>Given a set of local business processes ( slp ), the system can semi-automatically compose the local processes in ( slp ) into an IVE-level business network process (BNP).</td>
</tr>
<tr>
<td>RQ5</td>
<td>Given a BNP ( bnp ), the system can validate process execution characteristics of ( bnp ) without actually enacting it in an IVE, where validation is interactively performed by a business process engineer.</td>
</tr>
<tr>
<td>RQ6</td>
<td>Given a BNP ( bnp ), the system can automatically map ( bnp ) to the distributed DBNPM system of an IVE.</td>
</tr>
<tr>
<td>RQ7</td>
<td>Given a BNP ( bnp ) mapped onto the DBNPM system ( ds ) of an IVE, the system can automatically enact ( bnp ) on ( ds ), where enactment includes providing end user interaction functions and process manager monitoring functions.</td>
</tr>
<tr>
<td>RQ8</td>
<td>In the enactment of a given BNP ( bnp ), the DBNPM system facilitates interaction with legacy (back-end) systems of the organizations enacting ( bnp ).</td>
</tr>
</tbody>
</table>
The start

XW
Separation of concerns

- What
- Who
- How
- With
The three-level framework

External level

Conceptual & internal levels

- **What**
- **Who**
- **How**
- **With**
Modularity of functionality

Product

Goal
Decomp.

Team
Format.

Team

Workflow

WF
Compos.

WF
Prototyp.

WF
Verificat.

Infrastructure

Process
Enactm.

Legacy
Integrat.
Characteristic 6: Design as a Search Process
• Search for usable ingredients
  • Use established knowledge (part of rigor cycle)
  • To manage the complexity of the design
    – Compound, multi-faceted artifacts
  • Modify where necessary
    – Often easily possible because not physical
• Typically no search for alternative designs
  • Too costly
    – Effort-wise (= finance)
    – Time-wise (= finance + context)
• But would be very interesting
A bit busy in SOC Avenue ...
A bit of a gap …
CrossFlow: Three-level Framework

- **Service Consumer**
  - **Conceptual Process**
  - **Map**
  - **Internal Process**

- **Service Provider**
  - **Conceptual Process**
  - **Map**
  - **Internal Process**

- **External Process**
  - **Project**

Diagram shows the flow between service consumer and service provider through conceptual processes, maps, and internal processes.
Characteristic 7: Communication of Research
Communication: project deliverables

Contract No.: 507590
Acronym: CrossWork
Project Title: Cross-Organisational Workflow Formation and Enactment

Consortium:
- UNIVERSITY OF MANCHESTER (UMAN)
- PROFATOR PRODUKTIONSFORSCHUNGSGMBH (Profactor)
- TECHNISCHE UNIVERSITET EINDHOVEN (TUE)
- VÄXJÖ UNIVERSITET (UNI Växjö)
- JOHANNES KEPLER UNIVERSITAT LINZ (JKU)
- EXODUS SA. (Exodus)
- ATOS ORIGIN (Atos)
- MAGNA ENGINEERING CENTER KONSTRUKTIONS GMBH (Intier)
- OD. TECHNOLOGIE- UND MARKETINGGESELLSCHAFT mbH (AC)
- MAN NUTZFAHRZEUGE OSTERREICH AG (MAN)

Document Title: CrossWork Global Architecture
Document No.: D4.1 v2.0  Due Date: 31.07.2006  Delivery Date: 31.07.2006
Contract Start Date: 01.01.2004  Contract Termination Date: 31.12.2006

CrossWork Global Architecture
Work Package 4: Software Design
Task 4.1: Agent System Architecture

Document author/organisation: Paul Grefen (editor, TU/e)
Partners owning: All / Consortium
Partners contributed: All / Consortium
Availability: Confidential
Circulation: Consortium, Project Officer EC, Reviewer EC

Funded by the European Community under the 6th Framework Program
Thematic Priority 2 - Information Society Technologies (IST)
Structural Matching of BPEL Processes

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Abstract

BPEL has emerged as the industrial standard language for modelling behavioral aspects of web services. To support business partners in dynamically and flexibly binding their services together, different BPEL processes need to be efficiently matched. This paper identifies and defines various types of structural matching for BPEL processes. The matching definitions are based on heuristics: they take behavioral interaction aspects of the compared services into account, but abstract from irrelevant syntactical differences. Since the definitions are structural, they can be efficiently computed, and thus are useful to support dynamic and flexible binding of services. The approach is illustrated with an example from an existing business scenario.

1 Introduction

Web services [1] enable organizations to cooperate with each other in a dynamic and flexible way. Organizations can publish services they offer at public repositories, maintained by brokers. Potential business partners can search these repositories and contact the retrieved potential partners for doing business. This approach is supported by the publish-find-bind mechanism which is key part of any web service architecture.

Currently, this collaboration approach is only supported for black-box services, i.e. services having input and output parameters and optional pre and post conditions [10, 22, 24, 27, 31]. Such black-box services do not provide any information on the internal operation of the service. WSDL [7], in combination with languages like OWL-S [25] and WSMO [28], has emerged as standard language for modelling black-box services.

However, due to business trends like mass customization and end-to-end business optimization [13], services also need to expose some details of the internal process in a process view [6, 11, 15]. Service consumers can use the process view to monitor and control the progress of service execution [16]. BPEL [2] is emerging as standard language for modelling behavioral aspects of services, i.e. their business protocols, and is therefore a good choice for representing such process views.

To support this service integration approach, partners should be able to search for services exhibiting a certain desired behavior. The retrieved services need not match the service request exactly, for example, an organization may be willing to adjust its intended way of working if it finds a cheap service whose behavior differs slightly from the specified behavior. Thus, multiple services with different behaviors can be relevant for a certain request. Retrieved services should be ranked according to their degree of similarity with the service request.

Matching behavioral aspects of services can be done in various ways. One approach is to match the behavior (for example state spaces) of different processes [19]. However, this requires a formal semantics, which is lacking for BPEL. Different formalizations have been proposed [12, 20], but it is unclear which one is intended by the informal BPEL standard. Another serious drawback of this approach is that due to parallelism, the state space can increase exponentially in the size of the process definition (called the state explosion problem). Thus, this approach is not scalable and only feasible for simple processes.

Another way to support matching is to look at BPEL syntax only. However, drawback of such an approach is that different syntactic constructs typically mean the same. So two processes may not be matched even though they are equivalent. For example, BPEL allows sequential behavior to specified using sequence nodes or using if/else. As another example, any BPEL process is equivalent to the same process with an overarching sequence node added on top.

Therefore, a more sophisticated, yet efficient approach for matching BPEL processes is needed. The goal of this paper is to define an efficient approach for matching BPEL processes that takes into account relevant behavioral interaction aspects of BPEL processes, but abstracts from irrelevant syntactic structures and from internal computational
Internet-Based Support for Process-Oriented Instant Virtual Enterprises

The ever-increasing complexity of contemporary products and services demands business supply chains that ultimately involve a large number of autonomous organizations. Competitive markets require these chains to be highly agile, effective, and efficient, which organizations can achieve by forming dynamic virtual enterprises within supplier networks, which we call instant virtual enterprises (IVEs). We present the CrossWork system, which helps these organizations create and operate IVEs by providing automated, Internet-based support for the composition, setup, and execution of global business processes. In this article, we use the automotive domain to illustrate the system’s optimal use.

In the past, businesses often operated in stand-alone mode or relied on rather static networks of cooperating organizations. Today, competition has become fiercer, fueled by relatively recent developments such as the globalization of business, shortened time-to-market requirements, and increased market transparency. Products and services to be delivered to customers are, on one hand, quickly increasing in complexity and, on the other, subject to increasingly frequent modifications and replacements. To comply with these market settings, organizations must shift their priorities to flexibility and the ability to change if they want to survive. Therefore, dynamically established cooperation among organizations is becoming much more of a requirement to meet market demands.

Accordingly, we have seen the emergence of new business models focused on new business abilities that rely on intensive collaboration between autonomous business entities based on dynamic partnering. We call this model the Instant Virtual Enterprise (IVE) – a temporary business entity executing dynamically composed, global business process to achieve a specific business goal. Compared to a traditional virtual enterprise (VE), an IVE is more dynamic and must rely more on its members’ existing business processes. It’s more dynamic in the sense that its life span typically is on the order of
Dynamic Business Process Formation for Instant Virtual Enterprises
Conclusions
Observations

• Typing our research
  • Yes, it is typically DSR
  • In its essence
  • Creating artifacts to solve problems

• Keeping to the methodology
  • Is required to ensure quality of process (+ artifacts)
  • Is hard because of
    – Complex nature of artifacts
    – Context of research project (e.g. IST project)
  • Is not ‘common practice’ (yet ?) in IS DSR
Iteration in IS Research Framework

Environment
- People: Roles, Capabilities, Characteristics
- Organizations: Strategies, Structure & Culture, Processes
- Technology: Infrastructure, Applications, Communications Architecture, Development Capabilities

Relevance
- Business Needs

IS Research
- Develop / Build: Theories, Artifacts
- Justify / Evaluate: Analytical, Case Study, Experimental, Field Study, Simulation

Rigor
- Assess
- Refine

Knowledge Base
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Application in the Appropriate Environment

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