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A META-METHODOLOGY PROTOTYPE FOR COLLABORATIVE NETWORKED ORGANISATIONS

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The benefits of using various forms of Collaborative Networked Organisations (CNOs, or Collaborative Networks - CNs) to create agile virtual organisations, shop floors and laboratories, or to bring together professionals worldwide in virtual communities are commonly acknowledged in the academic and industrial communities. However, the advancement of the CN domain to a discipline *status essentially depends on the structuring of presently scattered and overlapping CN knowledge into a consistent framework, conveying a commonly agreed upon paradigm. The methodological aspect of this structuring effort can be greatly assisted by a* meta-methodology *integrating existing and emerging knowledge relating to the creation and operation of various concrete CN manifestations. This paper describes a milestone in the quest for a meta-methodology guiding the life cycle of CNs and their materialisations by explaining the final refinement and conclusions to a cyclic and reflective action research approach, which has resulted in the establishment of an implementable meta-methodology prototype for CN(O)s.*

1 INTRODUCTION

The current move towards market globalisation supported by pervasive computing and Internet-based information and communication technologies (ICT) has led to a significant proliferation of the practical manifestations of collaborative networked organisations (CNO)[1], such as virtual organisations (VO) and shop floors, professional virtual communities (PVC), value constellations, collaborative virtual laboratories, etc. It is nowadays clear that inevitably, organisations worldwide need to come together in order to complement their individual competencies when bidding for, or executing large projects. However, this action alone is not enough to ensure success. At a minimum, a CNO manifestation such as a VO has to form promptly, be agile and be based on sound underlying principles such as trust, common practices and infrastructure, interoperability, etc. Such requirements have deep organisational, cultural and technological implications. Collaborative business ecosystems (Camarinha-Matos, 2002), breeding / nesting environments or company

[1] also referred to as collaborative networks (CN) (Camarinha-Matos and Afsarmanesh, 2004)

networks (Globemen, 2000-2002) enable a prompt formation of CNOs; however, at present they are not properly supported by effective and integrated modelling techniques, including social and human aspects (Camarinha-Matos and Afsarmanesh, 2003). In this sense, a *meta-methodology*[2] helps integrate knowledge relating to CNO creation and operation methodologies and can suggest a customised set of steps to create and operate a CNO materialisation for a particular project type.

This paper describes a milestone in the search for a meta-methodology able to guide the life cycle of CNs and their various possible forms. The design of the research approach adopted is presented in (Noran, 2004d). The testing and validation of the successive prototypes have been performed in cyclic field tests described in detail in (Bernus et al., 2002) and (Noran, 2004c). This paper completes these research cycles by explaining the evolution, final refinement and conclusions resulting in an implementable meta-methodology prototype for CN(O)s.

2 META-METHODOLOGY PRIMER

2.1 Research Question, Strategy and Design

The main question of this research was whether a methodology describing how to construct customised modelling methods for CNOs (and their forms) may be built, and what factors may influence such an endeavour. This topic has provided an opportunity to employ Action Research (AR) (Galliers, 1992; Wood-Harper, 1985)) which allows for practical problem solving, and for generating and testing theory (Eden and Chisholm, 1993; McKay and Marshall, 2001).

The research was based on two cycles containing simulation, lab / field testing and reflections leading to theory extension (Checkland, 1991). The researcher saw himself as a facilitator and systems expert in an anti-positivist stance, guided by an interpretivist paradigm, seeing humans as voluntaristic and organisations as dynamic entities. The theoretical model adopted was ISO 15704 Annex A - GERAM[3] (ISO/TC184, 2000). The research strategy (design decisions, research stance justifications and methods adopted) is described in (Noran, 2001), while the initial conceptual development of the meta-methodology is presented in (Noran, 2004d).

2.2 Initial Meta-methodology Concept

The initial core concept of the meta-methodology comprised three main steps:

- identify entities relevant to the specific enterprise engineering task;
- construct a business model showing these entities *and their relations* in the context of their life cycles;
- 'read' the life cycle diagrams of the entities to be designed (e.g. CNO, VO) phase by phase, noting the relations of each phase with phases of other entities and constructing a list of activities expressing these relations.

These steps can also be found in the final meta-methodology concept (**Figure 1**). Note that the main meta-methodology deliverable is a functional model of types of tasks, built following the business model relations affecting the life cycle phases of the entity being designed and according to the AF elements selected from the Structured Repository (SR). The AF element selection and the further detailing of the functional model (down to a level executable by a human, a machine or a combination thereof, e.g. as an *agent*) are performed according to the *domain*

[2] a method (containing e.g. steps, rules and element repositories) on how to design a method.
[3] Generalised Enterprise Reference Architecture and Methodology

knowledge of the user, injected during meta-methodology application[4].

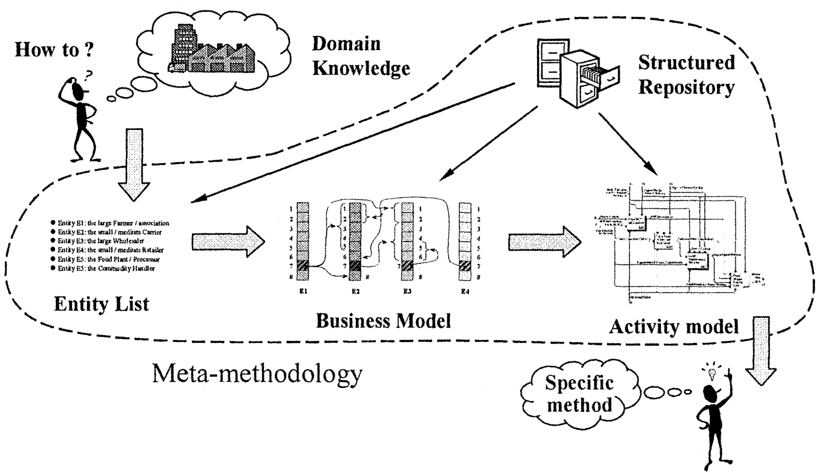

Figure 1. Meta-methodology concept

2.3 The Main Research Cycles

Simulation

The Enterprise Architecture (including CNO) area of research comprises substantial field testing turn-around times. Thus, such tests must be carefully prepared. The concepts to be tested must be mature, so as to obtain meaningful and potentially convergent results. Maturing can be efficiently obtained by simulation[5]; therefore, the preliminary meta-methodology prototype has been used to simulate the creation and operation of a virtual transport enterprise called FP-VITE, using an existing reference model (Chalmeta, 2000) and common architecture framework (AF) elements. This simulation has confirmed the feasibility and *usefulness* of the meta-methodology (Noran, 2004b), has refined its content and has uncovered the need for a Structured Repository (SR) holding the necessary AF elements.

A First Field Testing / Case Study

In this instance, the application of the meta-methodology has yielded a design (and partly operation) method for a Breeding Environment (BE) and the Service Virtual Enterprises (SVEs) created by it (Hartel et al., 2002). The lead partner(s) wished to retain control of the identification and the concept of the SVEs created, with the rest of the SVEs' life cycle phases covered by the BE. The audience (management and technical personnel) was partly familiar with the IDEF[6] family of languages and with a reference model developed by the Globemen[7] consortium.

The application of the meta-methodology has resulted in a multi-level IDEF0[8]

[4] e.g. via user's answers to questions on the scope of change, language / tool proficiency, etc
[5] note that the model thus obtained can only be checked for *internal* validity (Trochim, 2000)
[6] Integration DEFinition family of languages (Menzel and Mayer, 1998).
[7] Global Engineering and Manufacturing in Enterprise Networks (Globemen, 2000-2002)
[8] Integration Definition for Function Modelling (NIST, 1993)

model of the design methodology for the BE and the SVEs created by it, based on the Globemen reference model (due to the audience proficiency). The meta-methodology has also recommended to model the decisional aspect of the partners, BE and potential SVE(s) using GRAI[9] Grids and applicable reference models (Olegario and Bernus, 2003). More details (which are beyond the purpose of this paper) are available in (Bernus et al., 2002).

The Second Field Testing / Case Study

The second field testing has involved the application of the refined meta-methodology to the creation of a VO in the tertiary education sector (Noran, 2004a). Several schools of a Faculty within a University have formed a VO to capitalise on their shared knowledge, present a unique and stronger image to prospective students, industry and government, and thus improve their competitive level. The current (AS-IS) state of the schools was not fully understood by stakeholders. The future (TO-BE) state was to be obtained by evolving the AS-IS state, rather than by radical change. The audience of the meta-methodology deliverables was neutral in respect to a particular modelling formalism or reference model.

The main deliverable of this field testing was a customised VO creation method functionally expressed in IDEF0, supplemented by models of additional aspects (such as decisional and organisational, using GRAI Grid[10]) and by low detail models and guidelines for project management, human resources and organisational culture aspects. More details on this field testing are available in (Noran, 2004c).

3 THE META-METHODOLOGY EVOLUTION

3.1 Evolution of the Meta-methodology Steps

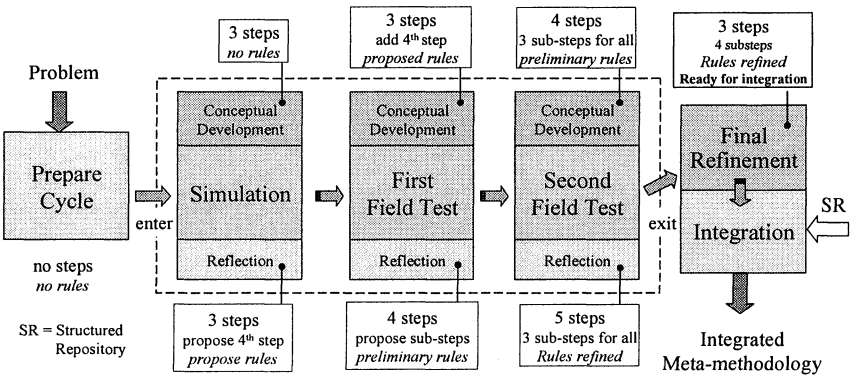

Figure 2. Evolution of the meta-methodology steps (Noran, 2004b)

As can be seen in **Figure 2**, in the initial conceptual stage of the first iteration (simulation), the meta-methodology contained three mandatory steps. Subsequent reflection has proposed an additional step (modelling of other aspects besides functional) and has uncovered the need for applicability rules, levels of modelling detail and representing management in life cycle diagrams.

[9] Graphs with Results and Activities Interrelated (Doumeingts et al., 1998)
[10] the use of IDEF0 and GRAI was warranted in view of the audience's formalism neutrality and ease of comparison with the first field testing and with the simulation

Conceptual work in the second iteration has added this step, has attempted to attach rules to the steps and has uncovered the need to *refine* the entity list obtained in step one, concurrently with step two. Subsequent reflection has proposed *sub-steps* to identify other aspects to be modelled using views contained in the modelling frameworks (MFs) of the AFs in the SR (e.g. Function, Information, Organisation, etc present in the MFs of GERA[11], Zachman[12], etc) and suitable formalisms / tools.

Conceptual work in the last cycle has proposed to shift modelling of additional aspects (e.g. decisional structure) into separate meta-methodology steps. However, subsequent reflection has found that these new 'steps' are in fact mere applications of other existing meta-methodology steps and thus, the modelling of additional aspects should become a *sub-step of all* main meta-methodology steps.

3.2 The Structured Repository Attached to the Meta-Methodology

Figure 3 illustrates the evolution of the SR. Its initial form was that of a repository containing elements grouped by categories, with attached 'IF / THEN' applicability rules that needed sequential testing by the meta-methodology user. Subsequent reflection has identified potential scalability problems and the need for additional AF elements (e.g. reference models), generic modelling languages / tools (non AF-specific) and additional attributes to rank AF elements by various criteria.

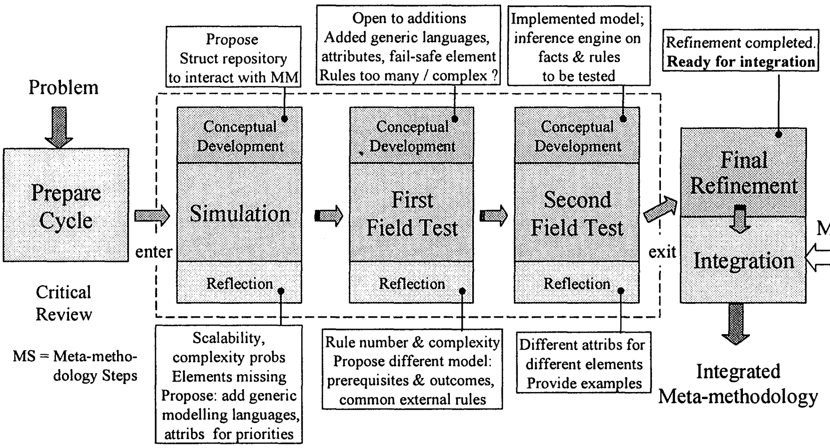

Figure 3. Structured repository evolution (Noran, 2004b)

Thus, subsequent conceptual work has added the proposed SR elements and high-level modelling elements (English text, rich pictures) for additional representations. However, the reflection ending this cycle has found flaws in the SR structure and has recommended that selection rules be common to the entire SR.

Therefore, the second field test has redesigned the AF elements in the SR to contain *prerequisites* and *modelling outcomes* (**Figure 4,** left), thus enabling their selection by external rules matching outcomes with user requests, and prerequisites with outcomes of other elements; the resulting SR structure was simple and scalable.

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[11] the Generalised Enterprise Reference Architecture, a component of ISO15704 Annex A
[12] the Zachman Architecture Framework (Zachman, 2000)

4 FINAL REFINEMENT: THE PROTOTYPE

4.1 Meta-methodology Steps

In the final reflection and refinement phase, the number of steps and sub-steps and their content has been defined as follows:

Step1: *Identify a list of entities relevant to the EA project.* If one or more projects are set up to build the target entity (entities), consider including them;

Step2: *Create a business model showing the relations between the life cycles of the identified entities, while re-assessing the need for the presence of each entity in the diagram, and the extent of the life cycle set to be represented for each entity;*

Step 3: *Reading the life cycle diagram of the target entity, phase by phase, create a set of activities that describe the relations of the target entity with other entities.* For several target entities, determine the order in which they are created (from the relations in the diagram) and create the activity model in that order;

The meta-methodology sub-steps (applicable to all the main steps) are as follows:

Sub-step1: *Choose whether to represent only the present (AS-IS), the future (TO-BE), or both states (separately or combined).* The logic for this sub-step can be embedded in the SR, which can make recommendations if supplied with the step number and with answers to additional questions;

Sub-step2: *Choose aspect to model, depending on the meta-methodology step.* This sub-step can also be performed by the SR, which can resolve dependencies as well (e.g. the need to model aspect A, in order to be able to model the required aspect B);

Sub-step3: Choose modelling formalism (and tool) depending on the aspect selected and on modelling best-practice criteria. These criteria can be embedded in the SR.

4.2 Structured Repository

The refined form of the SR prototype has the structure shown in **Figure 4**.

Rules for Sub-Step 1: Modelling of AS and TO-BE states

These rules decide whether to model the present and / or the future (see **(1)**) and *how* to do it (separately or in a combined form, as shown in **(2)**):

(1) IF ((TO-BE_obtainable_from_AS-IS) OR (AS-IS_not_understood))
THEN (model_AS-IS)

Thus, *if the future state can be evolved from the AS-IS, or if the present state of the participants is not fully understood, then model the AS-IS state.* The IF / THEN structure can be simulated using modules similar to the formalism and tool elements, where the outcomes are the IF part, the module content is the THEN part, and prerequisites are any dependencies. E.g. - when should several TO-BE be modelled?

```
        module several_TO-BE {          // the THEN part
            type rule_simulator         // this is a rule simulator module
(2)                 prerequisites (separate_AS-IS_TO-BE) // dependencies
                    outcomes (undecided_TO-BE) } //  IF part
```

Rules for Sub-Step 2: Aspects to Model

The aspects (or views) of the MFs present in the SR may be modelled as outcomes in relation to the various life cycle phases, which are then matched against outcomes required by different meta-methodology steps. Thus, the MFs may contain functional, decisional, information, resources, organisation, behaviour, performance, culture, economic, infrastructure, etc aspects. However, some aspects are merely specialisations, or variants of others and therefore, their representation may contain prerequisites calling for the 'parent' aspect to be modelled as well. The selection of additional aspects necessary in each meta-methodology step is the result of the interaction of the user with the meta-methodology steps and SR (refer **Figure 4**).

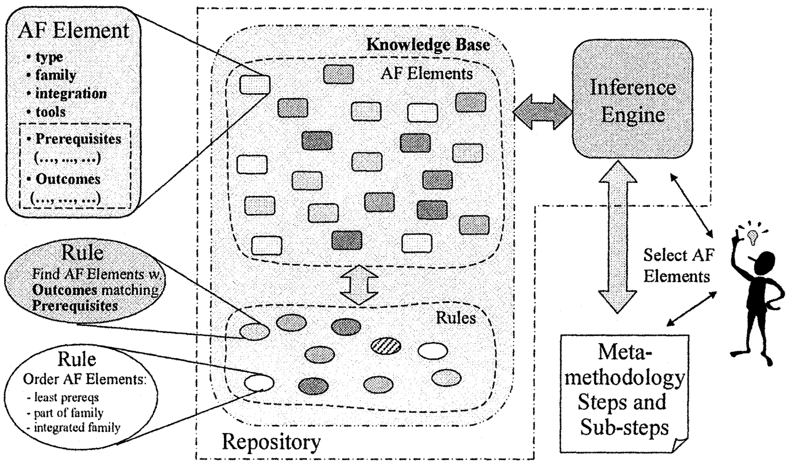

Figure 4. Structured Repository organisation and interaction with the user

Rules for Sub-Step 3: Choice of Formalisms

The criteria for formalism and tool choice can include: formalism previously used in the same modelling project, formalism being part of a family, integrated family of the formalism, tool support, availability and cost, staff literacy in that tool, etc.

5 CONCLUSIONS AND FURTHER WORK

The meta-methodology prototype has an open character. The SR knowledge base can be upgraded with new members, and the element representation in the SR and its rules may be changed to reflect various approaches to enterprise modelling. Interestingly, the open character of the meta-methodology makes it applicable to other EA tasks, or with suitable modifications, *to any task*.

Further testing and refinement is needed to completely define the SR, including the rules of selection for non-trivial aspects for the meta-methodology steps. The meta-methodology environment needs to be formalised (e.g. based on a metamodel) in order to achieve a complete integration, facilitating the envisaged implementation of the meta-methodology as a decision support system (Noran, 2004b).

The levels of refinement and usability of the meta-methodology prototype described in this paper essentially depend on further testing in case studies and regular updates with state-of-the-art knowledge in the EA domain.

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