New Support Technologies for Enterprise Integration

H. Ted Goranson[1], (Ed.), Roland Jochem[2], James G. Nell[3], Hervé Panetto[4], Chris Partridge[5], Francesca Sempere Ripoll[6], David Shorter[7], Peter Webb[8], and Martin Zelm[9]

[1]Old Dominion University, USA; [2]FhG-IPK, Germany; [3]National Institute of Standards and Technology, USA; [4]CRAN - Research Center For Automatic Control, France; [5]LADSEB-CNR-BORO, Italy; [6]Universidad Politecnica de Valencia, Spain; [7]IT Focus, UK; [8]BMT Defence Services Ltd, UK; [9]CIMOSA Association, Germany, tedg@sirius-beta.com

Abstract: see Quad Chart on page 2

1 INTRODUCTION

The following Quad-Chart (Table 1) summarizes the work of the group. It identifies the approach taken to resolve the issues and proposes several projects and ideas for future work for testing and enhancing the proposed solutions.

2 BACKGROUND

Enterprise modeling is a strange beast, because by its nature it synthesizes two major types of views: local views and a global one. Historically, modeling was a local activity, focused on individual processes and individual domains (activity, information, role, etc.). These process models, suitably constrained, were then aggregated in an ordered fashion to form a "model" of the whole enterprise, used for insight, analysis and optimization.

The original version of this chapter was revised: The copyright line was incorrect. This has been corrected. The Erratum to this chapter is available at DOI: 10.1007/978-0-387-35621-1_43

K. Kosanke et al. (eds.), *Enterprise Inter- and Intra-Organizational Integration*

Table 1: Working Group Quad-Chart

EI3-IC Workshop 4 ***Common Representation of Enterprise Models***	**Workgroup 2** ***New Support Technologies for Enterprise Integration***	**2002-February-20/22 Berlin, Germany**
Abstract: The workgroup focused on radical but practical strategies for greatly improving enterprise modeling and process modeling in an enterprise context. The group's work centered on improving user benefits in the context of common models, enterprise context and enterprise views. Major problems addressed were: multi-world views, soft modeling and meta-modeling theories. Several discrete research projects were proposed.		**Major problems and issues:** – Enterprise modeling encompasses two major types of views, local and global – These views tend to use different terminology, modeling methods, and ontologies; and occupy different space in virtual enterprises – Globally modeled things tend to be "soft" and non-deterministic – To engineer enterprises needs methodology to merge the soft and deterministic aspects – The infinity of tacit knowledge needs to be classifiable into apropos chunks
Approach: – Use the GERAM as reference and extend where necessary – Design focused, professionally facilitated workshops for a selected mix of experts – Seek participants with expertise in logic; situation, type, and graph theories; knowledge representation; agent systems; and international standards – Try to exploit prior research in relevant areas not normally encountered in the enterprise-modeling community		**Results and Future work:** Five to six projects were identified: – Soft modeling: such as, non-determinism, uncertainty, social and cultural dynamics, and tacit knowledge – Introspective modeling: so that models can control other models – Multi-world modeling: Domains such as legal, financial, and production contain conceptual discontinuities. – Multi-level modeling: Improve the interaction between process models and enterprise models – Meta-tools for modeling: to better accomplish multi-level and multi-world models – Additive abstraction: model the processes directly into the enterprise context

As time progressed, the discipline allowed for actual modeling of enterprises as a congruent activity with the aggregation of process models. Many in the field believe that the future of the discipline is in this power to explore both ways: tweak the enterprise model and see the implications at the process level, and the other way around.

But with this vision, one inherits a collection of superficially related problems associated with the different sorts of heterogeneity one finds in an enterprise. Some of these have been widely discussed and possible solutions are forthcoming:

- Different modeling methods
- Different ontologies
- Different corporate "zones" in a virtual enterprise (A "zone" may be a function like marketing, or a profit center or supplier.)
- To some extent, different roles and goals.

But there are a host of additional problems that real enterprises present, which are apparently hard to address but which would yield immense benefit if solved in some way. These are briefly discussed below. Suggested projects to address these problems follow.

2.1 Soft Modeling

A previous ICEIMT workshop addressed this set of problems. ["Ontologies as a New Cost Factor in Enterprise Integration" this volume] but substantially more about the problem is understood now.

Several kinds of "softness" exist in an enterprise, and must be accommodated in some way at the enterprise level. All of these share the quality of not being representable by deterministic models based on first order logic.

Nondeterminism (including nonlinearity): Traditionally, a process is modeled precisely because it is deterministic, and one wishes to understand and engineer the revealed mechanics. But many typical enterprises are sufficiently complex that they include non-deterministic processes, or would like to either include such processes or model them if they could be managed in some way. The problem of modeling Nondeterminism has several dimensions that can be collected under the notion of "apparent determinism." In this notion, some key elements of the process appear deterministic at the enterprise level (for instance cost, quality or time constraints) but the details of the process get more unclear as one zooms down. This flies in the face of current approaches, which depend on ordered aggregation strategies. At some point in the decomposition, an explicit, semantically rich "place holder" of the non-deterministic causal dynamics needs to enter the picture. Such a placeholder would represent that you know something but not everything about an element, relationship or mechanism.

Uncertainty: Quite apart from the softness of nondeterminism (which concerns "how"), there is a an issue of uncertainty concerning "what." This appears at all levels, but often at the process level it is handleable by recourse to probabilities. This is because processes are usually repeatable and often have histories that can be incorporated statistically. But at the enterprise level, there are uncertainties of a more profound, disruptive and unpredictable nature, such as natural disasters. Most of the important of these cannot be usefully represented statistically. There needs to be a way to represent

and reason about objects or elements that are partially undefined or largely speculative.

Social/cultural dynamics: This is a broad class that appears in several forms and appears at all levels of the enterprise. It encompasses the phenomenon covered by the "soft" sciences: sociology, anthropology, psychology and the like. At all levels one often needs to understand and to some extent to engineer collaborative dynamics. At the process level this is usually seen as team dynamics: at the enterprise level, corporate culture. Also included are personnel qualification and certification within the collaborative fabric of the enterprise. But there is more. Increasingly, the enterprise is engaged in providing customer satisfaction through values that themselves are soft, such as product styling, lifestyle branding or direct social uplifting in a service or product interaction. These soft dynamics of customer motivations are a higher order of softness that needs careful consideration. Relating these motives to product features and process elements is a real challenge.

Tacit knowledge: The tacit knowledge problem is the most recognized of this class, which makes the lack of support at this late stage rather frustrating. Tacit knowledge is all the implied knowledge that parties share when they collaborate. It is a major bugaboo in modeling because the tacit knowledge is largely unrecognized and extraordinarily expensive to make explicit. Lack of doing so makes models and model transactions only an incomplete shadow of the real world. In many cases, the limits are fatal. (Note that current methods of managing the non-determinism involve the correct use of tacit knowledge to "convert" non-determinism into determinism.)

Effective softness through combinatorics or other modeling "holes": Tacit knowledge is one kind of information that is usually not captured by models, leaving them incomplete. But there is a whole class of other incompleteness that is a reality in modeling large enterprises. Unlike the three items above, the information is missing not because it is unrepresentable. But it just fell through the cracks, was overlooked, or some models contain errors, or some integration or translation process was misapplied, or the model is simply out of date. Or, even when the modeling operation is perfect, sometimes the combinatorials of the situation make it impractical to carry everything, so pruning occurs as a matter of expediency.

Whatever the cause, there are almost certainly large holes in the enterprise model of any reasonably interesting enterprise. One would hope that in the spirit of making things explicit, one could represent these "holes" in some way and reason over them. Perhaps the only utility is a fidelity metric measuring the accuracy and completeness of the model. But perhaps a greater facility for self-correction and guided completion might be affected.

2.2 Introspective Modeling

This is one area that is not well supported because of accidents in the history of how enterprise modeling developed. Process models were focused on specific tasks, usually tasks directly associated with the basic work of the enterprise. Such processes usually have "second order" processes associated with them, processes associated with monitoring and adapting the basic process for example. These can be likewise modeled and managed on a case-by-case basis.

But enterprise models combine all these. It is desirable to treat them all the same from one perspective just for consistency in aggregation and management. But they are of a different nature: basic processes do the work of the enterprise; while second order processes produce better first order processes. In fact, essentially all of the analyses applied through enterprise modeling are of this second order type. Their existence is the justification of doing enterprise modeling in the first place. And it is often the case that 25% or more of the processes in the enterprise are of this second order type.

This condition where they are treated the same but are different requires the quality of "introspection." Introspective models have some way of "understanding" other models and therefore themselves. Despite the basic requirement for introspection, virtually no major model techniques support it. This needs to be remedied.

Introspection is required for system optimization that is managed just like the basic (first order) processes are. It is required for well-behaved state and configuration management. It is probably required for scalable approaches to trusted, secure system. It is certainly required for any measure of autonomous self-correction.

2.3 Multiworld Modeling

The multiworlds problem is also new to enterprise modeling, and also is overlooked because of its origin in focuses on local domains. When one models a shop floor, one can assume that all the behavior conforms to the same fundamental laws. For instance, physics applies. The same basic corporate policies and external regulations apply. There will still be lots of "soft" stuff missing, but it will all be missing from the same world.

Enterprises are not so well behaved. Enterprises are not logical machines; they have large components from different domains that interact as a system, and not all these domains exist in the same "world." Some of those that differ actually have different causal mechanics, different "physics" if you will.

For example, in the legal world, truth operates by different rules. In that world, many "truths" vary from fact-based reality and much of the activity of

those people in the enterprise is to tolerably maintain that distance for the benefit of the enterprise. (The workgroup did not have time to harmonize the diverse definitions of the use of the word "truth," so it is in quotes here. The different opinions concerned long-standing arguments over whether truth is based in nature or is a fabricated quality. That the truth about "truth" was unattainable is submitted as an example of the problem phenomenon. For readability, the term should be understood as quoted below.)

Here is another example, the so-called "black pot" defense. A man borrows a pot from his neighbor and returns it broken. His neighbor sues. The lawyer argues 1) my client never borrowed the pot; 2) it was broken when my client got it; 3) it was not broken when my client returned it. In many legal systems, these assertions can be made in a non-exclusive manner. (Incidentally, this is a primary reason why expert systems have not been applied in the legal domain, as they have, say in medical diagnosis.)

In addition to parallel truths and truths that are non-fact-based but based on constrained proofs, one has other peculiarities of the legal world. There are lots of artificial concepts, actors and relationships that have no "real world" counterpart. These include ownership, intellectual property, rights, liabilities and value. One needs to model not only these notions, but also the processes we use to know and use these notions.

All of these are accommodated to a crude extent in ordinary process models, appearing as constraints and attributes. But that is not how they are managed in the legal world. And to model the enterprise in a truly holistic way, that world must be included. And the legal world is just the tip of the other worlds iceberg. Everyone has a favorite horror story of something that made sense in the financial corner of the enterprise, but when "integrated" into operations required processes to act in a way that was obviously harmful, or counterproductive or downright stupid.

Marketing and human resources have some of these otherworlds distinctions. And in their cases, it is complicated by also involving soft elements as well.

Clearly, there are some solid overlaps of worlds: human resources and legal worlds share the same rich causal notions of rights. Legal and financial worlds share the same rich causal notions of ownership value. But there are other areas of mismatches. These are not a matter of different modeling methods, nor a simple matter of semantic confusion. These are "discontinuities" in the basic causal structure of the worlds, meaning that there cannot be a "smooth," coherent system of models that covers all spaces. Obviously, these discontinuities can make big trouble when introspective control is applied: for instance a financial collection of processes changing physical operations and missing some clear "reality" of those processes resulting in the horror stories noted above.

Most of the group recognizes that this is a very hard problem. The intent in raising it is not to suggest a solution. No reasonably inexpensive or practical solution may exist. Rather, the group would like to suggest a lightweight mechanism that raises a flag when such causal discontinuities occur. The flagging of a problem would throw the issue to intervention by a human team.

The workgroup was not unanimous in understanding the problem this way as already noted. An alternative view suggested that there can only be one truth, one real world. The problem is not so much about the world, but about what we know or believe about the world. Engineering activities using traditional physics will probably assess the various possible ways in which the current state of affairs may have come to pass. There is only one way in which the world is – so we may have to hedge our bets as to which way that is and accommodate a range of possibilities.

In this perspective, the "black pot" example trades on the difference between what the law "believes" and what the lawyer believes. The notion of artificial concepts, actors and relationships opens one up to questions about how we come to know and use things that are not 'real' and so cannot have any causal relationship with the real world. So the multiworlds problem is that they seem like different worlds to the people 'living' in them. Further analysis may show that there is no consistent way of looking at them all.

In any case, there was unanimous agreement that despite the different definitions, the problem either does exist or appear to exist in a way that has the same effect.

2.4 Multilevel Modeling

There is another problem in the enterprise that superficially is related to the multiworlds problem. It is better behaved in internal "physics," and in fact relatively easy to describe, but it seems to be a deceptively thorny problem in aggregating models at various levels from bottom to top.

At present, enterprise modeling assumes that the world effectively consists of two levels: that of processes and that of process assemblies that at some point can be perceived as an enterprise. Strictly speaking, an enterprise can be seen as a large process, which can be successively subdivided into subprocesses until an intuitively atomic level is reached. So far as the other way, any reasonable collection of processes can be thought of as an enterprise. And these sub-enterprises can be combined. In fact, most approaches to virtual enterprises use this assumption.

Alas, the real world disappoints again. Actually, enterprises are not at all homogeneously behaved at all levels. The way that manufacturing cells are managed and measured is fundamentally different than the way a plant is.

The way that a design team is managed and measured is a different thing altogether from how a company is. This is partly an effect of scale, and partly a result of the forces that come to bear: for instance, a company is directly responsible to financiers, while the effect of financier metrics at the design team level is substantially filtered and transformed.

In reality, there are "levels" at which the dynamics and metrics of the system change in substantial ways from those below and above. These levels, their number and placement, will vary according to situation. Often, these differences are hidden in the tacit knowledge of company policies, which is why we are discovering the existence of these layers as virtual enterprises become more common.

The aggregation methods used in composing enterprise models have to be more specific than mere agglomeration. This is especially the case as virtual enterprise paradigms become more used, and as EVA (economic value added) metrics are applied at the lower levels turning them into selfish profit centers.

2.5 Meta-tools for Modeling

All of the above led the workgroup to consider the general class of meta-tools. This is a broad category, created only for the discussion. It includes:

- Tools to model the enterprise of enterprise modeling. The observation was made that if modeling is so good, why don't we use it ourselves?
- Tools that would become some of the reusable "second-order" tools noted above. Good candidates are automatic syntax analyzers and generators, tools to explore new model paradigms, and "interlingua" tools that would map between syntax and semantic variants.
- Formalisms and theories that are already mature but which have not been well applied to the modeling problems described above. Examples are situation, type and category theories.

Very near term actions were fleshed out for the use of an extended workgroup. These involved exploring tools which can model other tools, and using the CIMOSA web site to expose some of the relevant theories to the modeling community.

3 SUGGESTED ACTIONS AND PROJECTS

The discussion of the workgroup was centered on a number of high value problems. These were considered in turn, and specific actions identified for tests, research or further discussion. Each of these is presented below, in no particular order.

In each case, practical implementation was a guideline, with revolutionary capability as a goal. The group felt that rather than reinvent what exists, a new capability should be easily "insertable" into existing tools and methods. Many of the projects noted below address rather difficult problems.

The general feeling was that a complete near term solution to many of these problems is unachievable. But some tracking and notation of the inadequacy would be a real step forward. For example, the "many worlds" problem of below is certainly not practically solvable. It involves harmonizing incompatible causal mechanics. If a facility merely indicated that there was a problem with some indication of its nature, which would be of significant use.

3.1 Project 1: Soft Modeling

Problem: This project develops a roadmap for graceful implementation of soft modeling within existing and emerging modeling techniques. Both process and enterprise models will be addressed.

Approach: Projects 1 through 4 are proposed with the same approach, though they should be run independently, in parallel.

The project is suggested as a direct follow-on to the ICEIMT, using the same administrative processes. International experts will be identified for focused, facilitated workshops. These will be much longer (four–five days). The participants will be paid to produce position papers and attend. Professional facilitation will be provided.

In other words, for these projects, no new research is planned, merely the exploitation of prior research in relevant areas not normally encountered in the enterprise modeling community.

Disciplines of interest will be logicians, and theorists in the category, situation, type and graph theories, Experts in knowledge representation in agent systems will be included, as will leaders in the relevant standards efforts.

Expected Benefits: Major national research establishments are aware of the problem, but are unsure of the expected benefits and promising approaches. The benefit of a well-structured research roadmap should mobilize pent up interest and produce some early, leverageable results.

3.2 Project 2: Introspective Modeling

Problem: This project addresses the problem of models which monitor, measure and change models in the enterprise modeling context. It focuses on developing a set of priorities for implementation, an ordered list of the ex-

pected difficulties and benefits, and an indication of leverageable technologies.

Approach: (See Project 1)

Expected Benefits: As with project 1, the benefits of a research roadmap should bring light to a cloudy area. A well-defined roadmap is probably too much to expect from this project, given the diversity of communities involved. But there are likely many ready solutions that might be adapted, once the proto-roadmap is produced.

3.3 Project 3: Multiworld Modeling

Problem: This project concerns identifying the basics of the multiworld problem as described above. No immediate solution is expected, instead a thorough elucidation of the problem.

Approach: (See Project 1)

Expected Benefits: The benefits of this project are patterned after the two above. Of the three, this will be least mature in terms of a well ordered research plan. But immense value is expected from a clear understanding of the problem itself. As with modeling in general, a model of the problem will produce immediate insight into pitfalls for the entire community of enterprise modelers, giving them a virtual "placeholder" for problem areas that will require intervention by human teams.

3.4 Project 4: Multilevel Modeling

Problem: This project begins progress toward an ordered understanding of the multilevel problem described above. The group supposes that an understanding of this problem is a necessary step in applying enterprise modeling in interesting virtual enterprise cases.

Approach: (See Project 1)

Expected Benefits: The project is expected to result in a demonstration agent system (perhaps open source) that exhibits multilevel evolution. This system will emulate levels seen in common types of virtual enterprises. This problem is expected to one, which many clever enterprise modeling centers will jump on once first results are demonstrated. Quite possibly, the solutions that emerge will be in reaction to the result of this project instead of directly building on it.

3.5 Project 5: Additive "Abstraction"

Problem: This project addresses a need not described above.

The basic problem is that enterprise modeling at present is a two-step process: processes are modeled, and then they are aggregated. Each is a lossy step, involving abstraction.

The workgroup believes that these two steps produce a rather profound loss of relevant behavior because abstracting for effective individual processes probably is in a different "direction" than for enterprise registration.

The project intends to produce a roadmap toward a process humorously called "additive abstraction," or contextualization. In this approach, processes are modeled directly into the enterprise context, immediately inheriting the information needed for the local process owner to see relevant characteristics of the enterprise.

This will certainly result in more complex process models than the "direct" process models of today. But the expectation is that they will be more useful in the enterprise context.

Approach: Of the projects in this report, this is the only one suggested as a "traditional" project, with a dedicated project team chartered with producing a prototype system.

International involvement is suggested, in part to tap the large but distributed knowledge base. But the international scope is also intended to bypass the long, languid process usually resulting from normal national and European Union channels. Academics will be involved for their expertise, but the prime mover is suggested to be a lean and mean commercial prototyper.

The open systems process is suggested for maximum technology transfer and visibility. The project will explore four inter-related concepts: speech acts, metaphor, narrative and "explanation."

Speech acts are a formal parsing and ordering of the information exchanged between active entities. This is a well-studied area when the information is well-behaved and the entities "understand" each other well, but the approach will be extended for the four cases addressed in the projects above.

The resulting speech act performatives will guide the exploration into metaphor. The use of metaphor is expected to be an aid in contextualizing the information. The focus of the exploration into metaphor will be on notations that convey certain contextual patterns while making that context clear to non-specialists.

Both the performatives and metaphoric context will suggest means for building structured narrative. This narrative is expected to provide the structure for an annotation strategy that will provide the explanations desired.

The target application is as a structured annotation language to add to existing modeling environments. The notion is to allow existing methods to support what they already do, and revert to attached annotations for those areas (soft, multiworld...) which they do not. The project will focus on this

annotation language to incrementally improve the information and context captured in a structured computable way.

Multimedia delivery and presentation methods will be explored.

Expected Benefits: The direct benefit of this project will be to define a new approach to modeling: for enterprise models rather than composable process models. This is expected to hit a sweet spot in the cleverness of the community and produce a rash of new modeling approaches. Direct input to the developing Process Specification Language and Unified Enterprise Modeling Language programs is expected.

3.6 Project 6: Definitions

Problem: This project works toward definitions of enterprise and behavior in the expanded context identified by the workgroup. The impetus for the project grew out of an unexpected difficulty the group had in closing on such definitions. The fundamental problem seems to be a matter of the simultaneity of purposes: enterprise view to optimize the system through processes, and process view of enterprise characteristics to improve the enterprise through incremental action.

Approach: This is proposed as a virtual, web-based project. It will leverage the many people already funded to work in this general area. The only costs will be professional facilitation, which need be substantial because of the continuing need for focusing and refinement.

Draft, web-based results and email-based discussion will feed the process. Total convergence on consensus positions is not expected. Consensus will be encouraged where possible. Otherwise, a crisp description of contrary positions is sought, together with underlying analysis of the philosophies behind the differences.

Expected Benefits: The result of this project will be directly fed to standards efforts, producing and expected greater understanding of the unique challenges of common enterprise model representation.