System Requirements: Products, Processes and Models

Report Workshop 3/Workgroup 1

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Abstract: see Quad Chart on page 2

1 INTRODUCTION

The work of the group is summarized in the following Quad-Chart (Table 1). It identifies the approach taken to resolve the issues in domain of interoperability of both processes and models and proposes a concept for planning such collaborations. In addition it states some ideas for future work for testing and enhancing the proposed solutions.

1.1 Problems and Assumptions

The workgroup discussed how to satisfy customer expectations for high quality, low price, fast delivery, agilely produced, and environmentally clean products. The core concept toward creating the approach and recommending future work is to be based on best practices of systems engineering.

Some benefits for enterprises to have this capability are:

- Reduced need for physical prototyping because engineers can evaluate product and production system operation using electronic-simulation techniques, including interference, and safety aspects.

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

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Table 1: Working Group Quad-Chart

EI3-IC Workshop 3 ***Interoperability of Business Processes and Enterprise Models***	**Workgroup 1:** ***System Requirements and Models and Processes***	**2002-February-6/8 Gaithersburg MD, USA**
Abstract: Enterprises use stovepipe tools that limit interoperability, traceability, consistency, and complicate data sharing and impact satisfying customer expectations for high quality, low price, fast delivery and environmentally clean products. Focus of the workgroup in creating the approach and recommending future work is based on best practices of systems engineering and the holistic integration of people, processes and systems & technology.	**Major problems and issues:** – How to define interoperability of processes and models? – How to model interactions between all activities of the enterprise -, production-, and product life cycles? – How to achieve concurrent use of product design and production system eng. data; focus on design optimization through electronic prototyping and production simulation for decision support during operation? – How to provide synthesis of data dictionaries?	
Approach: – Use GERAM life-cycle concept to identify relations between different processes and models – Use systems engineering approach in designing, manufacturing and supporting a product/system including the enterprise as a component of the system – Identify interoperation needs among and between product, process, and enterprise life cycle structures – Identify interoperation problems and propose solutions – Propose interoperability measurements (quality, cost, time) – Analyze existing standards like Systems Engineering, EPISTLE, Application Integration Frameworks – Find a way to go from architectures and frameworks to a software strategy for interoperability	**Results:** – Interoperability: on-time transfer of understood information between processes. – Distinguish between enterprise processes, product processes and production processes. – Metrics for interoperation quality: number of conversations needed--not needed--to get understanding with minimal or no loss, delays, synchronization success **Future work:** – Define product design, system engineering and operational processes such that their process data can be used for both design optimization and production decision support. – Analyze and model exchange of information during product and production process design with emphasis on human-oriented information exchange – Define set of required standards – Identify elements of an enterprise-wide data framework and provide methodology for its creation.	

- More timely access to information from production, use, and support functions for product-definition processes.

- Optimized parallel processes to enable solutions for the overall production system or for general problem (such as a battlefield) solutions.
- Improved production processes due to use of more efficiently coordinated knowledge and business rules.

But to scope the effort, the workgroup decided to accept certain existing assumptions:

- An enterprise-reference architecture embodying life-cycle concepts would provide a basis for starting the analysis (ISO 15704, 1999, pre EN ISO 19439, 2002).
- An enterprise-wide or greater viewpoint will be used.
- Analyses will be done using the principles of systems engineering--the system-design type, not the computer-systems type.
- Interoperability will refer to information transfers among enterprise processes. Specifically, the parts of the processes that send, receive, interpret, and respond to information. This could include interoperation enablers such as humans, resources, machines, and material.
- Integration at the process-model and resource-model levels is the correct approach, as opposed to integrating applications, services or product data flows. This mirrors the implicit common denominator of the enterprise-modeling community. Moreover, the group asserted that for practical advance in virtual enterprises, existing model and model integration paradigms must apply (Vernadat, F.B. 2001, ISO 18629, 2002, ISO 15704, 1999 (see Annex for GERAM)).

2 THE APPROACH

Following general convention, the group assumed an architecture consisting of virtual enterprise components that may be companies or relatively independent operations of a company. Each component is composed of processes, resources, and products. Each of these things, since they have structure and have order; that is, lower entropy; contain information. All have information ports into and from which information flows hopefully effecting communication or a form of understanding. Some of these process components are automated objects, some are exclusively human, and humans operate some of the components. Some of the information exchanges are explicit, well-formed messages, perhaps from machine to machine.

Human-to-human communication contains much tacit information. Models capture the mechanics of the process within each component. And because models also capture the "process" of component-to-component interaction, those models define the structure, the nature, and timing of the information exchanged.

More specifically the group agreed on the following facets for the approach presented in Table 1 to better enterprise interoperability:

- Exploit the many concepts of GERAM that will guide the analysis and modeling of enterprise components.
- Use a wide-scope, systems-engineering approach to avoid islands of improvement.
- The group was reminded of the history of ICEIMT, in which certain solutions, once in place, have tended to block facile transition to further improvement. Also, the mentality required to solve some of these problems is greater than the mentality used to create them. Aware of this difficulty and aware that the problems probably were created unintentionally, the group agreed to use extra care to avoid such de-enablers.
- Using an enterprise viewpoint, identify interoperation needs among product, process, and other enterprise structure, and infrastructure.
- This is more rigorous than simply saying that everything has to talk to everything else. There probably are far fewer things that need to interoperate than there are things in the enterprise.
- There also probably is more information issued by enterprise things than information used, thereby taking up valuable bandwidth and compounding the interoperation problem.
- Propose a set of metrics to measure relative interoperability.
- These metrics will serve to add credibility to user-executives that must decide whether or not investment in this domain is worthwhile. The solution to these problems needs to be advocated aggressively at the executive level. Improvement will only accrue if the problem is addressed as the problem of becoming a "lean" enterprise is addressed. That is, continuous improvement over a long term.
- In formulating a standards approach, which becomes versed in the key enterprise and system analysis, numerous standards that have been issued recently will be analyzed (ANSA/EIA 632, 1999, IEC 62264, 2002, Epistel, ISO 15704, 1999, ISO 15745, 2002, ISO 15926, ISO 1600 (2002), pre EN ISO 19439, 2002).

3 THE NATURE OF INTEROPERABILITY

The group tried to reach consensus on various concepts relating to improving enterprise interoperability. We agreed that we are talking about interoperability among enterprise processes. Processes contain activities that use enablers such as buildings, humans, machines, information, and material. Each process has information ports to transmit or receive information. These ports are sensors of some sort, and the information that passes through them can range from one bit to huge STEP files, to spoken words. There needs to be medium transducers to convert from a form of information used in one process to the form used in the other one.

We felt that we needed to understand the distinction between process data and product data, whether it should be treated differently, and if new representation methods or standards are required in interoperability analyses. Product data is an easier thing to represent because it is mostly nouns describing attributes of a product. Process data is mostly verbs that are functional, behavioral and time related in nature.

The product, process, and enterprise complex of information must be managed by a systems-engineering discipline that helps to manage the disparate enterprise and process system data and human interfaces available anywhere that could impact end product or system operation. Humans are required in this information system to help manage and coordinate knowledge and business rules. This could provide the capability to realize some significant benefits to the enterprise.

This data, when integrated, provides capability to trade off parallel processes to optimize product creation, factory throughput, or problem solution such as a battlefield scenario. Information generated during one part of a product-life cycle has little chance of interoperating with information used or generated by a process in another part of the product-life cycle. This is because users select tools in the different processes that optimize the output of that particular process and does not pay conscious attention to the information needs in the remainder of the enterprise. So there is a need to consider, in addition, information transfers among the product and process mix regarding design, producibility, and supportability tasks to maximize process interoperability and, hence, enterprise flexibility and agility.

In simulations, both of these data sets need to be available in a format usable by simulation applications. With necessary data at the correct time, we can simulate with good accuracy. Electronic prototypes for simulations are useful to demonstrate such phenomena as: producibility, interference, assembly, tolerance, test, and operation safety. Vendors can use such integrated information to visualize how their part is used in the end system. To accomplish effective simulation, users would need data from computer-aided design and computer-aided engineering systems. These information sources may be disparate and quite distributed, but they must interoperate.

We could also create an integrated, configuration-management model in the end system with parts not organized by system but in space by a Cartesian, (X, Y, Z) coordinate system, or a polar (r, θ) system.

Interoperability needs to be analyzed to the transaction level to ascertain a transaction's nature and to define requirements for needed infrastructure capability. This includes analyzing timing, nature, and context of messages.

4 INTEROPERABILITY METRICS

To evaluate how well interoperability is going the group felt we need some metrics to report the quality of an instance of interoperability. The key aspects of interoperability are:

- Number of conversations needed (or not needed) to get understanding or desired behavior
- Synchronization of message; that is, did it occur just-in-time, with the correct information

From here, the metrics discussion migrated to exchange characteristics to improve interoperability. Basically, the source of the information must be trusted. While this is somewhat of a soft issue, trust can be statistically predicted using the success of prior transmissions from the same source. We also can use concepts such as a product's trustworthiness--communicated from prior use, use by other users, product reviews, and the producer's reputation for trustworthiness.

5 SYSTEMS DESIGN

Given the need for interoperability what can be done to improve the interoperability process in enterprises? The group felt that good system design techniques should be applied to the problem.

- Define the entire system
- Design (consciously) the entire system so that it is more interoperable
- Use ANSI/EIA 632 (1999) Process for engineering a system

Other good engineering design axioms apply to this problem. Basically the group recommends that rather than design processes in human-logical chunks, partition the system for interoperability. For example the following axioms may help (Suh, 1990). Partition the system such that:

- Amount of information transferred is smallest at the partition interfaces
- All the functional requirements for a process design must be independent of each other
- Try for a design that requires a minimum of information to execute each function

6 JOINED MEETING OF WORKGROUPS 1 AND 2

Of most importance to me was the joint discussion between our two workgroups outputs that highlighted the key issues between small stand-alone point solutions and the bigger interoperability problems

The group considered a holistic integration of lifecycles for the enterprise, products, and processes. However, the viewpoints and the nature of the information that each group needs to use are different. For Group 1, looking at wide-angle-strategic things and product representation, the type of information is mostly noun oriented, while for group 2, considering mostly process models, thinks in terms of concepts that are largely verb-oriented. Group 1 views the enterprise from the top downward and Group 2 views it from the bottom upward.

That, in itself, is not a problem. The problem arises in the orientation—verb-oriented concepts are difficult to merge or integrate with noun-oriented concepts. Group 2 had investigated taking the complexity out of the models by removing elements and information relative to the ontology. Then there would be a light-weight mechanism backed up with the heavy-weight ontology stuff. This approach would alleviate the problem that enterprise models have—a high cost and limited reusability. An approach such as this would appeal to users, especially small-to-medium sized enterprises.

The problem of matching model composition poses problems for the simulation benefit seen by improving interoperability. Simulation requires us to amass large quantities of information at the correct time from various sources—namely from the modeling domain of groups 1 and 2. We need all of the information to capture enough meaning, the semantics, plus at the same time resolve different methods and rules for representing that meaning, the syntax. Group 2 is designing an example by creating an information artifact and forcing the artifact to combine noun and verb techniques into a singularity of meaning.

An approach to the solution is to develop a generalized method for integrating or federating the business-process-application level to the lower-tier information systems of the enterprise, the application software. At present, software vendors do not have the same view as process builders and entities are not the same granularity, nor, as stated before, do they focus on the same parts of speech. The integrating issue in matching this up is probably the ontology. Modeling in the past captured data and relationships, not the meanings. The ontology can provide the meaning. Ontologies were discussed in detail in the Workshop 2 Workgroup 1 report.

7 PROPOSED RESEARCH PROJECTS

The following research issues have been identified, which should read to be proposals rather than questions.

- How to combine the noun and verb oriented models into a singularity of meaning quickly enough to allow sophisticated simulations of enterprise integration?
- What do we need to do with the models or the processes to allow interoperability?
- Can we define better the model matching challenges: smaller to bigger, bigger to smaller, and models employing different languages?
- Can we define an enterprise system design theory for interoperability?

8 CONCLUSIONS

WG1 and WG2 discussed in a joint session the information objects mismatch issue between verbs and nouns. Agreement reached that WG2 must assess the broad needs of WG1 holistic integration framework before demonstrating a small pilot production application to test the reusability of what they develop. It was suggested that we need a generalized method for mapping business application levels to software information systems levels.

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