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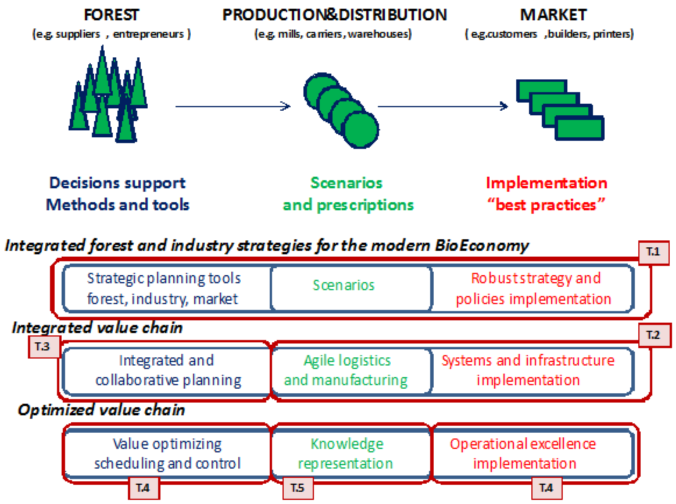
Abstract. Canadian academic researchers, in collaboration with FPInnovations managers and researchers are proposing to build an NSERC Strategic Research Network on Value Chain Optimization (VCO) that aims to provide the industry and policy makers with new advanced planning and decision support systems to design and deploy optimized forest bioeconomy networks. New value propositions are to be evaluated from a global value chain perspective. The decision-making processes, from strategic to operational, as well as the implementation processes are to be studied within the NSERC VCO Network. Designs of innovative, agile and integrated logistics and manufacturing systems are also expected. The research is to be organized around five themes which are numbered T1 to T5 in the figure below.



Themes T1 to T4 develop a hierarchical approach to value chain optimization. Theme 5 addresses a broader comprehensive knowledge representation (Knowledge representation for agent-based and sector modelling). At each thematic level, we ask the following two questions: i) how can we create the maximum possible value from the forest value chain as defined at this level, and ii) how can we redesign the forest value chain to enable the creation of more value from Canada's most significant natural resource. Throughout this, our major focus is meant to be on the value chain and the network of values and not just its links. The focus of this paper is on theme T5. It stresses on the need for gaining a common representation and understanding of the different components of the value chain as this will permit evaluating forest and industry strategies, supply chain configurations and planning approaches using simulations. Agent-based modelling (ABM) is favored to facilitate the assessment of different scenarios, however, the information and knowledge sharing (IKS) in a collaborative modeling context remains an issue. This paper discusses the need for collaborative modelling and simulation of the FPVC, and surveys the literature about the most significant standardization initiatives for IKS and ABM platforms with focus on the FPVC. Then the key findings are explained, and a roadmap toward defining a standard for value chain modeling is proposed. Finally, the results of an assessment of the perspective of Canadian researchers on the required standards are presented.

Keywords. Information and knowledge sharing, standardization, value chain, agent-based modelling, forestry.

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1 Introduction

Canadian academic researchers, in collaboration with FPInnovations, a national forest research institute, are proposing to build a strategic research network on value chain optimization (VCON) that aims to provide the industry and policy makers with new advanced planning and decision support systems to design and deploy optimized forest bioeconomy networks. New value propositions are to be evaluated from a global value chain perspective. The network should develop and maintain virtual business test-benches providing data sets and rich business contexts to aid demonstration of the potential benefits of the different integration and synchronization methods. It has favored an agent-based approach to facilitate the assessment of different scenarios, however, the sharing of information and knowledge in a collaborative modeling context remain a key theme. This paper is focused on this issue. It surveys the literature about the most significant standardization initiatives for IKS and ABM platforms with focus on the FPVC, and it proposes a roadmap towards defining a collaborative knowledge-based platform (CKBP) to support researchers within the VCON.

The paper is organized as follows. In Section 2, the collaborative design of planning systems within the forest products industry is discussed. Section 3 presents the literature review It begins with an overview of the components of a typical architecture for information and knowledge exchange in value chain followed by a review of the most significant standardization initiatives and ABM platforms in value chain. Then, the focus is on the standardization initiatives and ABM platforms that were specifically developed for the forestry. This section terminates with a summary of the key findings. Section 4 presents the proposed roadmap.. Finally, section 5 presents the results of an assessment of the perspective of Canadian researchers on the required standards.

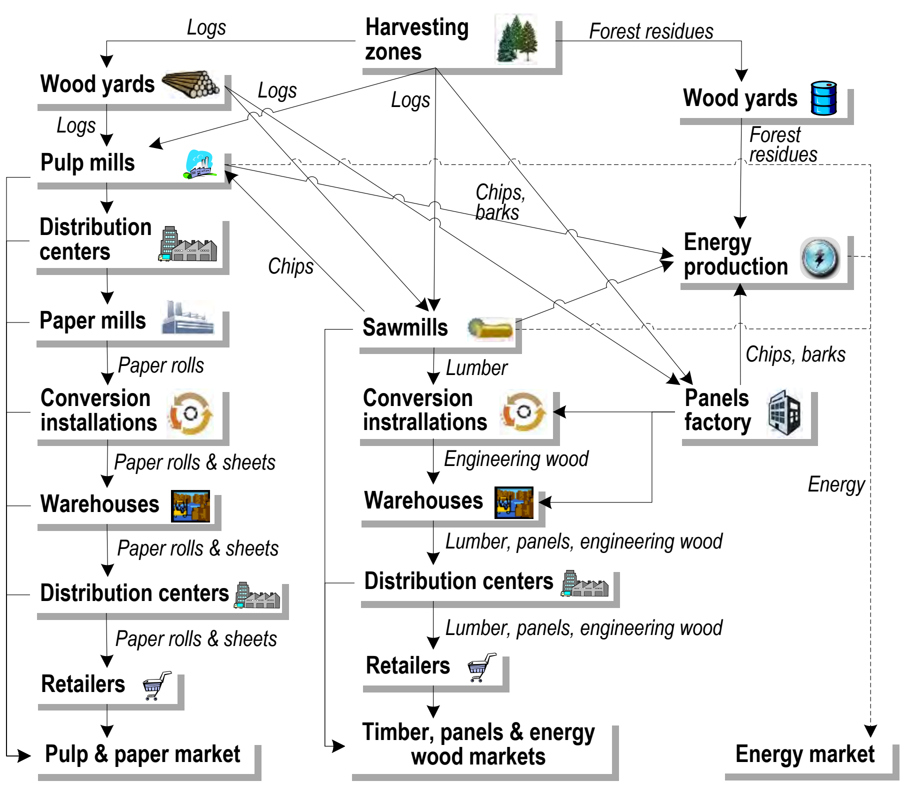

Fig. 1. Value chain of the forest products industry

2 Collaborative Design of Planning Systems within the Forest Products Industry

To transform a tree in forest products and then to deliver them to a customer requires the intervention of several actors (e.g., person, organization, business unit and network. See Figure 1). These actors must ensure all the necessary activities for the management of the forest, deployment of a network of roads, transport of trees, logs and residues, first and second transformations, and distribution and recovery. They must maximize their profits in respect of the social and environmental constraints. Besides the physical assets and inventories, there are all the knowledge resources and product/service designs groups provided by firms and research institutions. The coordination and the planning of the use of all these resources strongly contributes to the improvement of the competitiveness of the companies involved in the value chain [1]. As defined by the management study guide, coordination is "the unification, integration, synchronization of the efforts of group members so as to provide unity of action in the pursuit of common goals". On the other hand, resource use planning is a problem that is known with its different scales or hierarchical nature. Hierarchical planning of the FPVC is characterized with its top-down and bottom-up effects (see Figure 2). These effects are known to pose a real challenge to value chain planning in general. However, what makes it more challenging here is the fact that the forest is a natural resource, the management of which is known with the socioeconomic as well as ecosystem processes it encompasses and is characterized by complexity, seasonality, uncertainty, information deficits and asymmetries, etc [1][2]. Besides, the fact that most of the wood comes from Crown timberlands gives the government and local units important roles in the planning of the use of the forest resources.

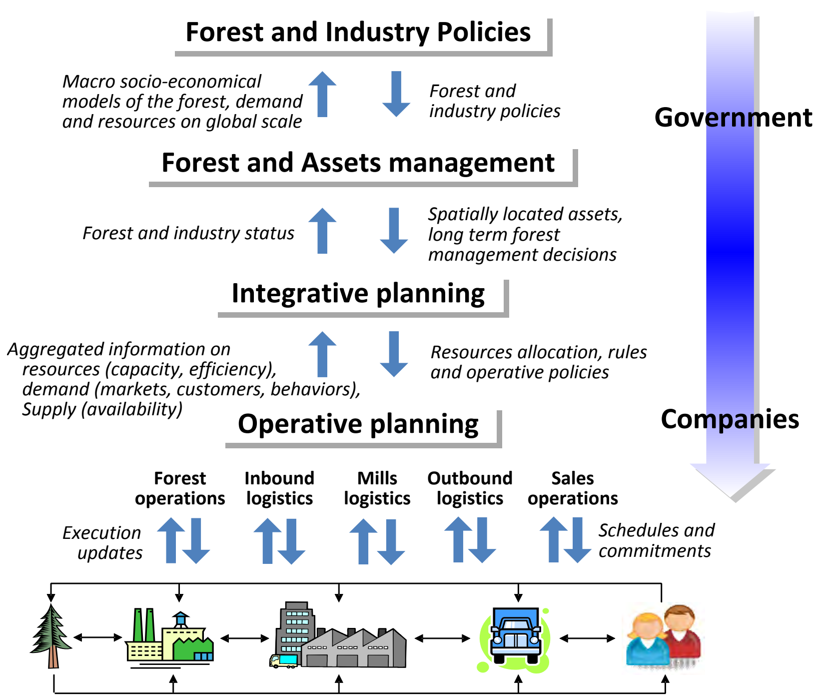

Fig. 2. Decisions scales for the planning of FPVC

From the above discussion, it is clear that in order to solve this planning problem and facilitate future research and managerial practice, the adoption of a highly flexible framework for integrated and collaborative modeling and simulation becomes a necessity. This framework should enhance (i) the cooperation of different and multidisciplinary models, and (ii) the seamless IKS throughout these models [3][4][5]. To better understand what is really meant by IKS, it helps to visualize the value chain like a layered structure as shown on Figure 3: the data resource layer (the foundation) supporting the information engineering and knowledge environment layer, in turn, supporting the business strategies layers. Data resources are analyzed to develop information. Information exchange supports the knowledge environment (by creating new knowledge or assist knowledge exchange). Knowledge is used in resolving complex business problems, or in gaining successful business ideas.

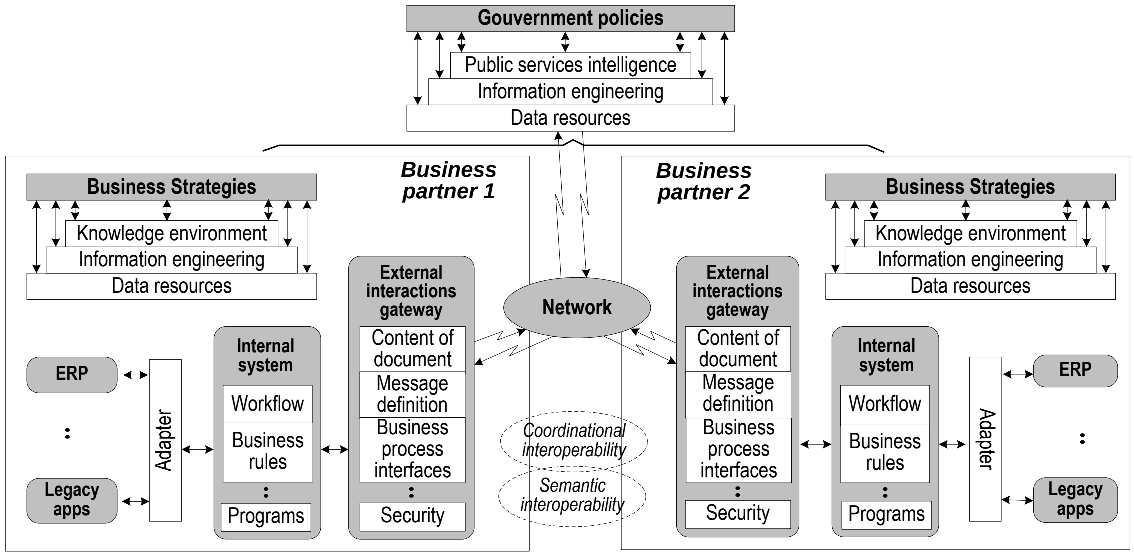

Fig 3. Architecture of a B2B interaction framework and a layered view of the value chain (adapted from [6])

3 Literature review

This section aims at reviewing independent and industry-specific standardization initiatives and ABM platforms used in value chain. Industry-independent standards are not specific to any industrial sector. Furthermore, most of the standards presented below emerged through joint effort of members of well-known organizations. The members form a non-profit association, and the standards are based on their consensus. Such standardization process is known as "consortium standardization" as opposed to formal, project-based, and industry standardization [13]. But first, we find it more convenient to take a broad view of the components involved in the typical information and knowledge exchange architecture in value chain.

3.1 Overview of the components in a typical architecture for IKS in value chain

IKS can occur when two business partners interact. Figure 3 depicts the typical architecture of a B2B interaction framework. Notice that the terms "framework" and "standards" are used interchangeably in the e-business literature. Basically, the interactions occur in three layers: communication, content and business process layers. For example, in Figure 1, Sawmill and Pulp mill need to agree on their joint business process (e.g. contracts, delivery mode). Sawmill needs also to "understand" the content of the purchase order sent by Pulp mill. Finally, there must be an agreed upon communication protocol to exchange messages between Sawmill and Pulp mill. If the communicating partners use different communication protocols, then a gateway should be used to translate messages between heterogeneous protocols. The content layer provides languages and models to describe and organize information in such a way that it can be understood and used. At this layer, companies interact through business documents that communicate a semantically complete business thought: who, what, when, where and why (the 'what' is typically the product). Business documents are composed of three types of components: core components, domain components, and business information objects. A core component is a syntax-neutral description of semantically meaningful business concepts (e.g. "Date of Purchase Order", "Sales Tax", and "Total Amount" could be core components for parts of a purchase order). Domain components and business information objects are larger components stored in the domain library and business library, respectively. For example, a "Purchase order request" business document guides how products, dates and currencies are presented. This is achieved by schemas provided by the e-business frameworks for validating the contents of business documents [6][7]. The objective of interactions at this layer is to achieve a seamless integration of data formats, data models, and languages. Information translation, transformation, and integration capabilities may be needed to provide reconciliation among disparate representations, vocabularies, and semantics. Finally, the business process layer is concerned with the conversational interactions (i.e., joint business process) among services. The objective of interactions at this layer is to allow autonomous and heterogeneous partners to come online, advertise their terms and capabilities, and engage in peer-to-peer interactions with any other partners.

Interoperability at this higher level is a challenging issue because it requires the understanding of the semantics of partner business processes. A brief overview of the different components encountered in a typical architecture for IKS in VC is provided in Appendix A.

3.1.1 Industry-independent standardization initiatives for information and knowledge sharing

EbXML

ebXML (E-Business XML, www.ebxml.org) is a modular suite of specifications edited by OASIS (Organization for the Advancement of Structured Information Standards, www.oasis-open.org) and UN/CEFACT (United Nations Centre for Trade Facilitation and Electronic Business). It provides a standard method to exchange business messages, conduct trading relationships, communicate data in common terms, and define and register business processes. ebXML does not use its own e-business vocabularies to describe business documents. Instead, ebXML documents are assembled from core components. In addition to the core components, the underlying architecture of ebXML comprises the following elements: a messaging service, registry/repository, business process specification schema, collaborative protocol profile/agreement, and core components. ebXML enables the implementation of Web Services protocols, such as WSDL (Web Services Definition Language), UDDI (Universal Description, Discovery and Integration) and SOAP (Simple Object Access Protocol). Notice that Web Services are application programming interfaces designed to support machine-to-machine interaction over a network. Finally, according to Chituc et al. [8] "Opinions on ebXML potential are mixed. While it serves as starting point in some applications, there are authors who do not bet much on its future".

RosettaNet

RosettaNet (www.rosettanet.org) is a non-profit consortium of major companies (more than 400 of the world's leading information technology, electronic components, semiconductor manufacturing, and solution provider companies) working to promote open e-business. RosettaNet has published several specifications to facilitate e-business in the high-technology industries. The most important part of RosettaNet is the business process specifications called PIPs (Partner Interface Processes). Currently, RosettaNet covers over a hundred PIPs and associated business documents. RosettaNet also provides a messaging specification called RNIF.

3.2 Standardization initiatives for IKS related to the forest industry

PapiNet

On the papiNet website (www.papinet.org), papiNet is presented as "a set of common electronic formats and terminology for the paper and forest products industry, designed to facilitate system-to-system real time exchange of information between buyers and sellers". It was formed in 2000 by 23 members of CEPI (Confederation of European Paper Industries) and GCA (Graphic Communications Association). Today, the papiNet consortium includes more than 40 members (such as International Paper, StoraEnso and Time)., and Several segment user groups have been formed in order to agree upon business rules, processes and data to be used in a specific paper market segment (Carton board, Fine paper, Label stock, Packaging, Publication paper, Pulp, Recovered paper, Transport & logistics, WoodX, Forest Wood Supply, XBITS for books).(Book)). The scope of those groups is to agree upon business rules, processes and data to be used in a specific paper market segment, basically a template.

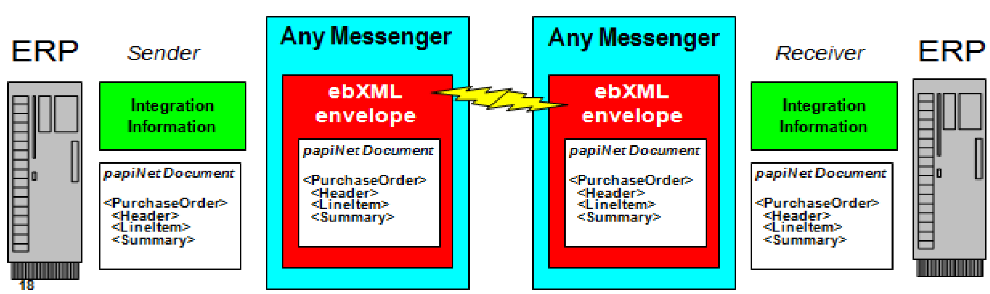

Fig. 4. papiNet interoperability (source: www.papinet.org)

papiNet provides specifications for 36 business documents and related business processes, available in three categories: Basic order fulfillment, Supply chain management, and Product quality (invoice, dispatch note, stock status, stock adjust, order, call-off, etc). Finally, papiNet uses the ebXML messaging service as an envelope for the documents, and offers a Trading Partner Agreement (TPA) template. TPA documents capture the essential information upon which trading partners must agree in order for their applications and business processes to communicate, including participation roles, communication and security protocols, and a business protocol (valid actions and sequencing rules, etc).

ELDAT

ELectronic DATa is Germany's widely valid data interface in the wood trade, with which the information between the partners is exchanged and standardized in such a way that they can be worked on by means of electronic data processing; this standard serves for the exchange of product data of raw wood (logs) and contractual data between forest owners, wood consuming industries (especially mills and pulp industry), wood traders, and carriers in the German wood market. The standard is conceived for file-based exchange using comma-separated text files or XML files. The data model consists of a dozen entities with a huge number of attributes, combined with an extensive controlled vocabulary. Unfortunately no interesting reference to this standard could be found in the literature. ELDAT is a mutual initiative of the forest companies under the backing of the technical research for silviculture and forest management institute (KWF).

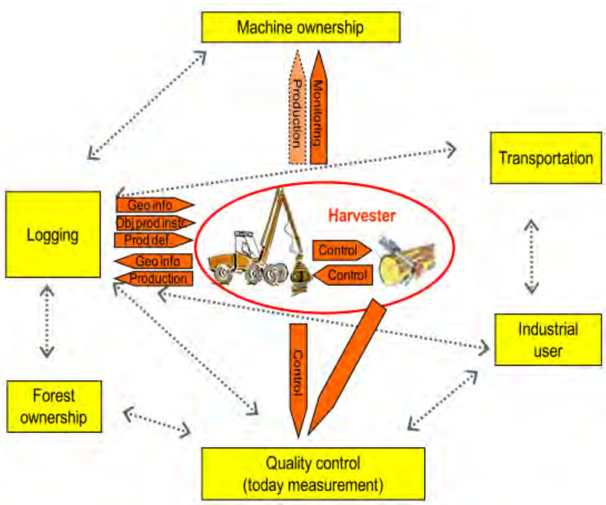

Fig. 5. Illustration of how standardized messages are used in different information flows using the StanForD standard. The dashed arrows illustrate information flows that are based on other data standards as for example papiNet (source: www.skogforsk.se)

StanFarD

StanForD (Standard for Forestry Data and Communication, www.skogforsk.se) focuses on managing bucking or merchandising computers on-bard forest machines and on managing data communications in forestry (control, reporting and monitoring/follow-up of logging production on harvesters and forwarders). It comprises a data standard, a file-structure standard, and a Kermit-based communications protocol or data recorder to the merchandising computer is also included. The Forestry research institute of Sweden (Skogforsk) coordinated the standard with the help of manufacturers and Swedish forest enterprises. The next version of the standards (planned for release in autumn, 2010) is expected to provide an XML interface, and the definitions for messages of the following types: production instruction, object instruction, species group instruction, object geographical instruction, forwarding instruction, harvested production, harvesting quality control, total harvested production, forwarded production, forwarding quality control, object geographical report, and operational monitoring. Figure 5 illustrated the use of some of these messages. StanForD is of high interest within the Indisputable Key project (a European initiative that aims at developing methodology, technology, and knowledge to increase in the utilization of production resources in the FPVC) since, with minimal update, it can serve to keep track of the logs through the supply chain.

eFIDS

eFIDS (e-Forestry Industry Data Standard, www.oasis-open.org/committees/.../eFIDS-Description.html) is a standard designed to provide the basis for the implementation of a range of e-business applications. It has been developed within the UK by a number of leading organizations within the forestry industry and there has been wide consultation on its applicability. Full use has been made of the promotional activities of government development agencies such as Scottish Enterprise as well as the trade associations such as UKFPA (United Kingdom Forest Products Association) and other forestry groups such as ConFor (The Confederation of Forest Industries within the UK, www.confor.org.uk). OASIS (see above) continues to develop eFIDS as an international standard. The schema provides an XML framework that allows a variety of trading documents and their corresponding data to be used between various parties, but it does not define the documents themselves (For example, there is no XML element called "Delivery Note" but there is an element whose function is to contain the descriptor for a Delivery Note). The most recent version of this standard includes the following use cases: dispatch data (round timber) from supplier to buyer, weighbridge data from buyer to supplier, conventional invoicing from supplier to buyer, self-billing invoicing from buyer to supplier, dispatch/weighbridge data from 3rd party weighbridge to buyer/seller, any weighbridge to 3rd party (e.g. hauler to any of above) (www.forestryscotland.com).

GIS DTS

GIS DTS (Geographic information systems data transfer standard (GIS DTS, www.oasis-open.org/committees /forest/ charter.php) is another OASIS standard. It is meant to facilitate geographic information exchange between different systems used in the forest industry. GIS are used by the forestry industries to help manage forestry related information and plan complex harvest area. However, over the last 15-20 years, several GIS systems have been adopted, with different methods of data storage being used. GIS DTS works with different GIS systems and does not require any specific data storage format, though some basic compliance to the GIS DTS is necessary. New GIS and database systems being designed for use in the forestry industry should take note of this standard, and have data models built in a compatible way.

Other standards

Two other forest-specific standards were referred to in the literature. There were local standard (VIOL standard Kommstandard in Scandinavia, and FHPDAT in Austria). Unfortunately, we were not able to find any English text describing these standards.

Finally, Appendix B presents a survey of different standardization initiatives related to other industries.

3.3 Standardization initiatives for IKS related to other industries

Few studies on industry specific standardization initiatives could be found in the literature. In fact, the only reviews of industry-specific standardization initiatives we found were in [7] and [8]. These authors briefly reviewed several standards and attempted to analyze their interoperability aspect, limitations and challenges. We merely draw attention to their existence by naming them: CIDX (www.cidx.org; Chemical industry) – PIDX (committees.api.org/business/pidx; Petrolium industry) – AgXML (www.agxml.org; Grain and grain processing – AIAG (www.aiag.org; Automotive industry) – TexWeave (www.texweave.org; Textile supply chain integrated networks) – RAPID (www.rapidnet.org; Agriculture) – Odette (www.odette.org; Automotive industry) – STAR (www.starstandard.org; Standards for Technology in Automotive Retail). All these standards are made openly available to the public by consortiums formed by industry members and organizations. The general approach to development can be described using the following steps: (i) identifying of the business processes that, if electronically-enabled, would improve business-process efficiency and effectiveness, (ii) determining the data requirements of those business processes, (iii) define and maintain evolving XML schemas and related guidelines that support the data requirements, (iv) building commitment from participants to integrate XML-based messaging into their business processes and provide a forum for understanding that process. In general, there are 10 to 40 members per consortium, and the number of documents per standard varies between 17 to 60 documents. Related business processes guidelines are also provided. Finally, all the mentioned standards are XML-based however not all of them offer messaging, envelope and security specifications.

3.4 Industry-independent ABM frameworks

An agent is an abstraction to represent complex entities and it is the main building block to form a multi-agent system (MAS). Thus, an ABM is usually implemented as MAS. Flores-Mendez [9] stated that "Agent Infrastructures deal with the following aspects: (i) Ontologies: allow agents to agree about the meaning of concepts; (ii) Communication protocols: describe languages for agent communication; (iii) Communication Infrastructures: specify channels for agent communication; and (iv) Interaction Protocols: describe conventions for agent interactions". Accordingly, assuming this view of MAS infrastructure, we can assert that standards are needed for the four aspects that MAS infrastructure deals with. The research on agents, MAS and their infrastructure has been on the rise over the last two decades. Already, since the early 1990's, several authors elaborated literature reviews about MAS architecture standardization [9][3][13]. Many standardization initiatives were reported by the literature such General Magic, the KAoS (www.ihmc.us/research/projects/KAoS/), HMS (hms.ifw.unihannover.de/), and CoABS (www.objs.com/agility). The most prominent efforts may be those developed by OMG, and FIPA. Some details about these two initiatives are provided below. In general, these efforts focused on the interaction aspects of agent technology. In fact, many of the industry-independent standardization initiatives focused on key challenges facing commercial agent developers as they were bringing this technology to market. A particular interest was given to agent mobility (the ability to migrate in a self-directed way from one host platform to another). The agents communicate using languages that could hardly convey meanings; instead they convey objects with no semantics like in classical object middleware. As it is shown below, the advent of the web has forced these standardization initiatives to realign their specifications.

The OMG initiatives

The OMG (Object Management Group, www.objs.com/agent) is an international computer industry consortium that develops enterprise integration standards for modelling, middleware and data warehousing and a wide range of industries including healthcare and manufacturing. The well knowing Unified Modeling Language (UML) is OMG's most-used specification for modeling business processes and data structures. Within OMG, there is a special interest group that aims to extend OMG's object management architecture to better support agent technology, to identify and recommend new OMG specifications in the agent area, and to recommend agent-related extensions to OMG specifications and to promote standard agent modeling techniques. As such, OMG's effort was more a bottom-up activity. Another group within OMG (OMG Ontology Working Group) is working on aligning the domain modeling activities of OMG with the Semantic Web, the extension of the web, with related ontology development projects such as DARPA DAML (DARPA Agent Markup Language, www.daml.org) and IEEE SUO (IEEE Standard Upper Ontology working group, suo.ieee.org). The semantic Web (semanticweb.org) is a group of methods and technologies to allow machines to understand the meaning - or "semantics" - of information on the web.

The FIPA initiatives

FIPA (Foundation for Intelligent Physical Agents, www.fipa.org) is "an IEEE Computer Society standards organization that promotes agent-based technology and the interoperability of its standards with other technologies….FIPA was originally formed as a Swiss based organization in 1996 to produce software standards specifications for heterogeneous and interacting agents and agent based systems". FIPA's effort was more a top-down activity. Its approach to MAS development was based on a "minimal framework for the management of agents in an open environment." This framework is described using a reference model (which specifies the normative environment within which agents exist and operate), and an agent platform (which specifies an infrastructure for the deployment and interaction of agents). At the IEEE Computer Society, it is believed that standards for agents and agent-based systems should be moved into the wider context of software development; "In short, agent technology needs to work and integrate with non-agent technologies". To this end, FIPA has been accepted to become part of the standards committees. Many of the ideas originated and developed in FIPA are now coming into sharp focus in new generations of Web/Internet technology and related specifications.

The ODD protocol

The ODD (Overview, Design concepts, Details) is a standard designed as a general protocol for communicating individual-based and agent-based models. As such, it is concerned with a different perspective of ABM with regard to the OMG and FIPA standardization initiatives described above. It consists of a narrative description of the various elements of an ABM, contributing to a more rigorous formulation phase [20]. Each model is described using three blocks (overview, design concepts, and details), which are subdivided into seven elements: Purpose, state variables and scales, process overview and scheduling, design concepts, initialization, input, and submodels. ODD has been formulated and tested by 28 authors from seven different countries, and it is gaining diffusion in ecology and in social science.

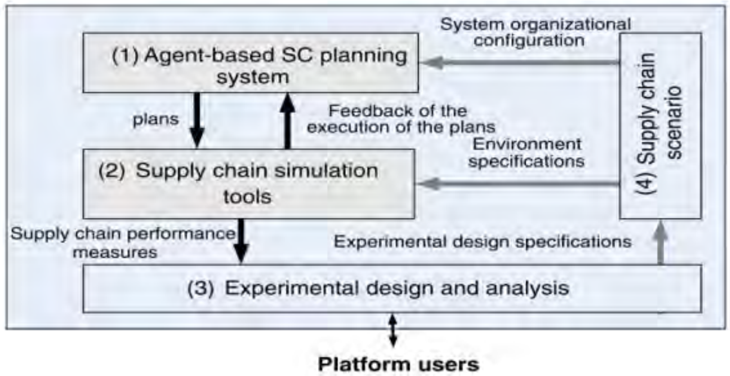

Fig. 6. General overview of the FEPP experimentation platform

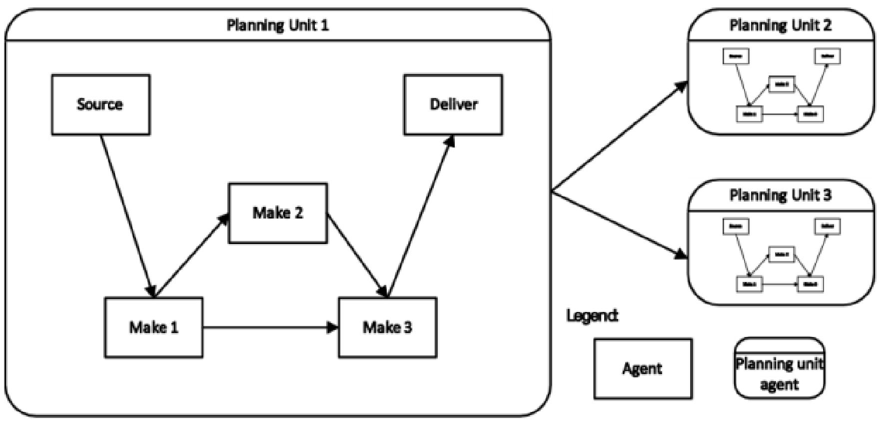

Fig. 7. Components of a specific implementation of a supply-chain configuration

3.5 ABM frameworks related to the forest industry

FEPP

FEPP (FORAC Experimental Planning Platform, www.forac.ulaval.ca) is composed of agents that interact with each other in order to solve the global lumber supply chain planning problem. It addresses two relevant issues for the FPVC: (i) capacity to plan and coordinate operations across the supply chain and (ii) capacity to analyze the dynamics and performance of different supply chain scenarios by means of simulation [10]. From a functional point of view, the platform is made of an advanced planning and control system exploiting agent-technology. Users, through the use of various dedicated graphical tools and interfaces, can develop the various supply-chain scenarios to be tested and analyzed. (See Figure 6).The configuration of the platform follows an organizational design approach that consists in the division of the supply chain into business units. In turn, this division into business units is based on the natural heterogeneity of the production process. In other words, the overall problem is split into several smaller sub-problems, each of which results in the managerial problem of a single organizational unit. Consequently, every agent is modelled after a specific organizational problem (Figure 7). This gives each agent the ability to solve a smaller scale problem using adapted tools. The collaboration, or the cooperation, of all agents present in the supply chain solves the value creation network global problem. Many functions are shared by all agents. For example, they can interact with each other or perform tasks when necessary and by definition, they are autonomous. Moreover, by the way in which the FEPP is conceived, each agent can be represented as a modular block that can be assembled with others to model a supply chain. Several conversation protocols and agent behaviors have been implemented in order to produce optimized solutions in various situations.

Figure 8. SOFIA platform (integrated view) (source: Nikitin et al., 2010)

<u>*SOFIA*</u>

SOFIA (Seamless Operation of Forest Industry Applications, www.cs.jyu.fi/ai/OntoGroup) is a logistic control platform for B2B mediation tailored to the forestry sector of Finland [12]. It is designed to optimize logistics on the contractor site (for harvesting and transportation SME's); it improves contractor's order management by integrating heterogeneous order base from different order makers. The platform will serve as an integrator of information systems provided from different wood buyers and forest owner associations. The orders coming from different systems will be gathered to one integrated view allowing the contractor to apply logistics optimization tool and decrease useless overheads in operation (see Figure 8). SOFIA platform design will not change existing systems of customers, but rather plug to them, and will contribute to the development of the flexible forestry service market. With this platform, the authors aim at building a strong national level network of forestry companies and organizations in order to get support and promote the new vision of flexible contracting for SMEs. Also, they intend to ensure sustainable ICT infrastructure for logging and transportation SMEs. In fact, the SOFIA platform is developed on top of UBIWARE; "a generic domain-independent middleware platform that is meant to provide support for integration, interoperability, adaptation, communication, proactivity, self-awareness and planning for different kinds of resources, systems and components." UBIWARE integrates several technologies including semantic web, agent technologies, ubiquitous computing, service-oriented architecture, and Web X.0. (e.g. data information and knowledge, software and services, humans, hardware and processes)." The UBIWARE platform is based on integration of several technologies: Semantic Web, Distributed Artificial Intelligence and Agent Technologies, Ubiquitous Computing, SOA (Service-Oriented Architecture), Web X.0, etc. It fulfills the Global Understanding Environment (GUN) concept where "various resources can be linked to the Semantic Web-based environment (introduced in section 2.3) via adapters (or interfaces), which include (if necessary) sensors with digital output, data structuring (e.g. XML) and semantic adapter components (XML to Semantic Web). Software agents are to be assigned to each resource and are assumed to be able to monitor data coming from the adapter about the state of the resource, make decisions on behalf of the resource, and to discover, request and utilize external help if needed. Agent technologies within GUN allow mobility of service components between various platforms, decentralized service discovery, utilization of FIPA communication protocols, and multi-agent integration/composition of services." For more details on the UBIWARE platform the reader is referred to [21].

<u>*Other ABM of forest industry using industry-independent platforms*</u>

Several other attempts were made by researchers to apply ABM to investigate the FPVC problems using commercial or free of charge simulation frameworks. In [14][15], Vanclay proposed the FLORES framework for spatially-explicit modelling of the human-forest interaction, at different levels of detail. This framework is intended for policy makers and their advisors to envisage the efficacy and consequences of any initiatives (policies and incentives) to promote sustainable forestry and better land use. FLORES was built using the Simile modelling environment (www.simulistics.com). Purnomo et al. [16] used CORMAS (cormas.cirad.fr), a multi-agent simulation platform specifically designed for renewable resource management systems, to examine several scenarios of sustainable forest management involving multi-stakeholders (central and local government, communities, NGOs, etc). Caridi et al. [17] assessed the benefits brought by MAS connected to the CPFR (Collaborative Planning Forecasting and Replenishment) Process where trading partners work off a common forecast. The simulations were carried out using SIMPLE++ (www.tecnomatix.com), a general purpose system for the object oriented, graphical, and integrated modeling, simulation, and animation of systems and business processes. More recently, in his PhD dissertation [18], Schwab presented CAMBIUM, an agent-based forest sector model for large-scale strategic analysis. Basically, CAMBIUM models the interdependencies and feedback loops between resource inventory dynamics and changing market conditions for finished products using an intermediate layer of autonomously interacting forest industry agents. It is used as a decision support tool for assessing the effect that changes in product demand (due to market dynamics) and in resource inventories (due to natural disturbances) can have on the structure and economic viability of individual companies and communities. Schwab used Repast_3 (repast.sourceforge.net/repast_3); a free and open source ABM toolkit. Finally, in [19], Pérez and Dragićević used ArcGIS to test different management strategies based on an existing agent-based model for simulating mountain pine beetle tree mortality patterns in order to evaluate influence of different forest management practices to control insect outbreak. In fact, ArcGIS was coupled with Repast (the ABM toolkit) using an extension. Because the agent-based model was enabled to include real-time GIS data feeds, it was possible to simulate and visualize lodgepole pine stands' mortality patterns unfolding at different time steps.

Notice that Appendix C presents an overview of some other industry-independent initiatives for VC-ABM frameworks that are not related to forest sector.

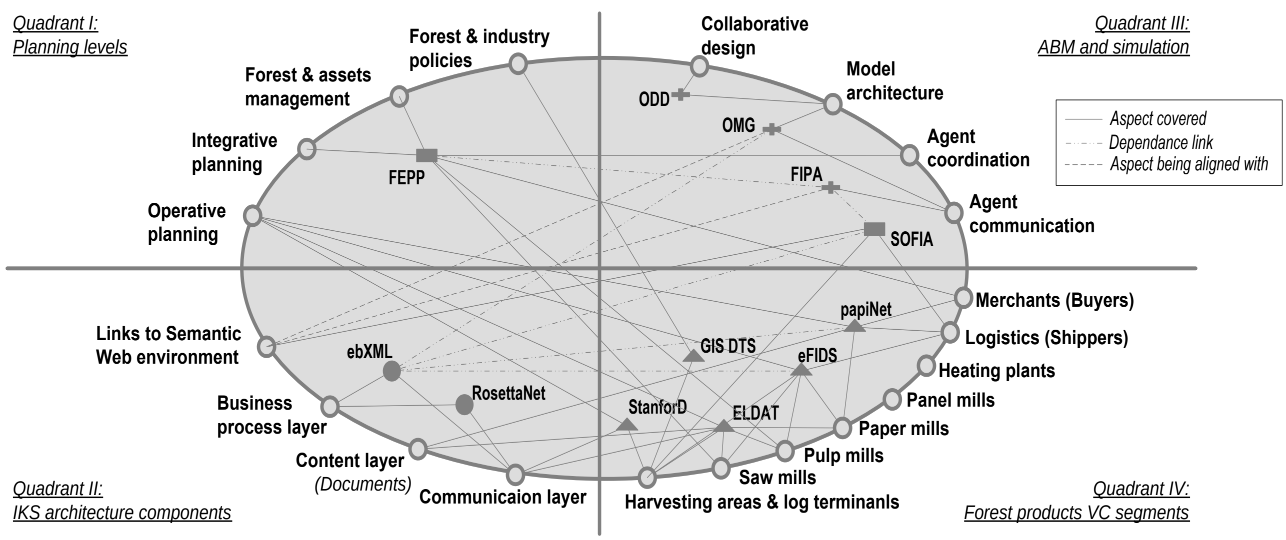

Fig. 9. Comparison of different standards/frameworks

3.6 Key findings

All the standards described above emerged from non-profit consortiums. Figure 9 depicts a comparison of these standardization alternatives based on the authors knowledge and understanding, It attempts to position the different standards with respect to each other and to emphasize the links they have with a number of aspects organized in four quadrants: FPVC segments; IKS architecture components; Planning levels or functions; ABM and simulation. One can pretend that the ideal standardization initiative should be linked to all these aspects and should correspond to the center of the circle and at equal distance from all the aspects. Unfortunately, Figure 9 shows that most of the standards are situated close to the perimeter of the circle, meaning that they are too specialized and limited in scope. Many standards from the right-side quadrants rely on the ebXML framework to build their messaging layer. ebXML enables the transfer of documents between two or more parties. For instance, the papiNet has a number of independent documents, one per message type (invoice, despatch note, stock status, stock adjust, order, call-off, etc...) and it does not have a single, flexible document or schema to transit multiple message types. In fact, papiNet does not address semantic conflicts; it simply avoids them. Thus, each new application of the papiNet standard is much more likely to require schema amendments or extensions. For more flexibility and better connectivity and interoperability, Figure 9 shows that the trend is to link to semantic web environment. Finally, it appears that standards makers did not tackle ABM description and models communication. In a collaborative design context, a standard of this aspect (such the ODD framework) would be of great help.

4 A Roadmap Toward Defining Canadian Standards For Value Chain Modelling

Figure 10 gives an overview of what could be the structure of the CKBP to support researchers within the VCON. It links together a number of models via the internet with one-way or two-ways links. Communication agents may be used. Some models correspond to MASs while others correspond to single agents. The models emphasize or could be concerned about different static and dynamic aspects of the value chain (e.g., products, processors, processes, customers, suppliers, transporters, business units, planning units), its business flows (information, product and financial), but also flows of the virtual artifacts used for local planning and coordination/ synchronization of the resources-use at all operational, tactical and aggregated levels. Therefore, different decision makers operating on different scales and responding to decisions made on other scales (as in Figure 2) could be simulated. What is important, here, is the interactive decision-making across various levels of authority or governance that can be portrayed, analyzed, then used, somehow, to improve the cross-scale and cross-sectoral coordination. Constant assumptions about the responses at other scales or at other levels (vertically or horizontally) of the value chain could be avoided. Seen from another perspective, this CKBP is a spatially-explicit ABM that is used as a communication tool between researchers (knowledge resources and product/service designs groups). It is a unifying translational architecture for dynamic knowledge representation removing barriers to multidisciplinary collaboration.

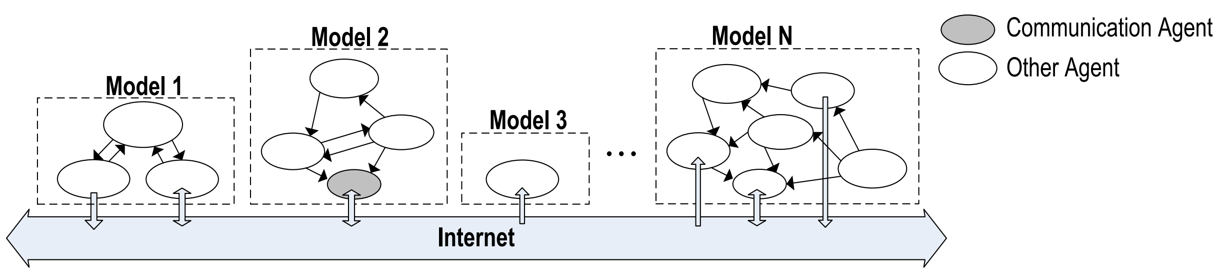

Fig. 10. Illustration of the structure of a collaborative knowledge-based platform (CKBP)

A basic condition for the creation of the CKBP is the development and adoption of standards approaching the ideal standard described in the previous section. In this preliminary version of the roadmap towards defining this standard, we highlight a range of key issues and future challenges for some of the aspects appearing in the four quadrants of Figure 9:

1) Regarding the aspects of “Agent communication” and “Links to semantic web environment”, an automated approach to semantic interoperability needs to be developed. Semantic interoperability ensures that agents of heterogeneous behavior have a common understanding of the meanings of the requested services and data. It should be supported by a well-defined ontology [11]. Ontology and semantic interoperability define for researchers a common vocabulary to share common understanding of the structure of information among people or software agents, enable reuse of domain knowledge, make domain assumptions explicit, separate domain knowledge from operational knowledge, and analyze domain knowledge. The approach should be supported by web services and it should be automated because of the dynamic and rapidly evolving environment modeled by the CKBP.

2) Regarding the aspects of "Agent coordination" and "Business process layer", coordinational interoperability should be achieved. Coordinational interoperability deals with the interaction between agents operations; it imposes discipline on the interaction between the agents (for preserving temporal as well as functional properties). Discipline is also needed between the researchers developing the agents. Common policies, contracts and protocols to which the agents subject their activities are needed.

3) Regarding the aspects of "Collaborative design" and "Model architecture", structured thinking and notational interoperability are needed. A unified framework for systems thinking and modelling during the analysis phase would save valuable time for the researchers during problem structuring, dynamic modelling, scenario planning and modelling, implementation and organizational learning, etc. On the other hand, notational operability is required in order to surmount disagreements among the objects (Agents, software tools, databases) on the structure, representation or interpretation of the data. Here, a starting point could be the ODD standard. We believe that this standard could make models description and understanding much easier in the context of collaborative design.

4) Regarding the aspects in quadrant IV, all the segments of the FPVC should be detailed and modelled. More internal factors (manufacturing capabilities, human resources, etc) and external factors (environmental change, macroeconomic matters, technological change, legislation, socio-cultural changes, changes in the marketplace, etc) should be included in the models. The FEPP platform appears to be very promising. Also, a standard registry describing all these models should set up and maintained up-to-date. It should be very helpful to the researcher to engineer their models and scenarios.

5) Regarding the aspects in quadrant I, links to GIS data should become a standard. GIS data should be integrated into the design process of models and solutions at all the planning levels.

We think that the above mentioned key issues and future challenges should become very high priorities for research in the academic, government and industry research communities in the near future.

5 Perspective of Canadian researchers

We examined the perspective of a number of Canadian researchers on standardization issues in their work. In all, 6 peoples were selected based on their involvement in research on VCO including 3 academic researchers from 3 different research group (2 people from each group) throughout Canada (Québec, Ontario and British Columbia) and two representatives from FPInnovations. First, the participants were introduced to the context of this work and briefed about the proposed roadmap then they were requested to respond to the following two key questions:

Q1 – What are the biggest challenges that they face in their efforts to collaborate with other research groups in order deliver on their mission?

Q2 – How can effective steps taken against the 5 key issues raised in the roadmap (automated approach to semantic interoperability; coordinational interoperability; structured thinking and notational interoperability; modelling of the all the segments of the FPVC; GIS data integration) give more depth to their work and contribute to not only disseminate their results and findings but also their models, solutions, and software components?

It was possible to reach 4 persons. A summary of the interviews is depicted in Table 1.

Table1 Overview about industry-related standard (excluding forestry)

Participant	*Responses to questions #1and #2*
***Steven Northway** from the Faculty of forestry, University of British Columbia. His group developed the architecture and design of the International Forest and Forest Products*	***Question 1*** • There is a need for a technique that can help build models in much richer way especially for strategic modelling. • We need to make sure that collaborators are aware of how fine are the different descriptions of the products or forests from one model to another (granulometry issue). For example, there is a time issue when the models (generated descriptions) or the

trade model (IFFP) that is used to explore critical forest policy issues such as plantation development and illegal logging. Basically, the IFFP is a JAVA program/servlet that will: (1) translate text files, describing the problem, into a LP formulation, (2) initiate the LP solver and (3) translate the solution into HTML reports.	data were not generated for the consistent time steps. Another example is the geographical extend (for instance, models built on provincial basis may use different jurisdiction or different ecosystem basis). • In general, our problems are well defined but we lack data (data not detail enough to drive the decision). ***Question 2*** • There is no doubt about the fact all the five points are very important. The will lead to better models and better collaboration. • We might need to start with the first 3 points. • The first point (semantic interoperability) is especially very important. "If you get the first point you cover a lot of things…".
Francis Fournier *is highly involved in FPInnovation's Transformative technologies research program developed with industry and government partners.*	***Question 1*** • There is a lack of tools (decision-making solutions needed by the manufacturer) for some link of the forest products value chain. At FPInnovations, they started to link together their software tools in order to built an operational tool than ca be used to generate more complete answers. • There are many software tools already available or that are being developed. The exchange of data between the software is really a challenge. For instance, the government holds inventory data in a very specific format and highly aggregate so these data cannot be used at an operational level using their decision-making tools.. ***Question 2*** • The different action steps brought by the roadmap are properly aligned with the needs of their research program. • At FPInnovations, the different software are stand alone applications. However, when two applications need to talk to each other, they do that via a bridge (a specific software component) built for them. It is clear that a standard semantic language would greatly standardize the bridges. • However, Francis is questioning the will of the different parties to share data and models.
Jonathan Gaudreault *is researcher from FORAC, Laval University, involved in distributed search for supply chain coordination using agent technology.*	***Question 1*** • The inconsistency in the hypotheses and the data between different groups is the main challenge. • For now, they do not attempt to integrate models by different researchers because they are aware of the huge efforts needed in order to learn about the hypotheses that were made, how to validate them and how to modify the models in order comply with the hypotheses. Also, the data could be inconsistent. ***Question 2*** • All the different action steps brought by the roadmap are interesting. However, we need to think where to position the actions along the value chain as some actions could be more important than other depending on where we are in the value chain. For instance, too many research efforts were devoted to model the forest resources or some wood transformation processes however very few attempts were made to model the market or the customer demand and preferences.
Jean-Marc Frayret *is a professor at École Polytechnique de Montréal. He has research projects in (i) operations and supply chain management and in (ii) distributed decision making integration in manufacturing networks. He applies the tools of operations research and multi-agent systems to design advanced planning and*	***Question 1*** • It is relatively easy for professors to work together and exchange ideas. The professors are looking to integrate their decision tools rather than their models. • The real challenge is not in the seamless exchange of data between models but in how we built the models so to avoid gaps of variables that were not considered by any of the models. • Currently, he is focusing on solving specific problems for some enterprises but definitely he believes that there will be a need to standardize blocs of models and integrate models in order built tools for large simulation. ***Question 2*** • In general, the proposed roadmap is driving the researchers in the right direction.

scheduling systems.	However, we should be aware that it implies huge efforts. • There are precedence relationships between the 5 key issues raised by the roadmap that should be clearly defined and strictly observed. • The standardization should be made at the semantic base. It would be very interesting if future models are built using the same semantic basis. • We can think of future agents that are enabled to use a standard semantic in their decision making abilities and for coordination between each other.

6 Conclusion

The paper presented literature review about information and knowledge sharing in the context of collaborative and agent-based modelling of the FPVC. Then, a preliminary version of a roadmap towards defining a standard to be used in a collaborative knowledge-based platform to support researchers within the VCON was proposed. The research and development needs defined by this roadmap fit in the general trend toward internet-based computing (also referred to as cloud computing). When asked to give their perspective about the proposed roadmap, the researchers (3 academic researchers and 1 representative from FPInnovations) unanimously stated their support to the identified research priorities.

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APPENDIX A: Overview of the components in a typical architecture for IKS in VC

Table A.1 Overview about of the components in a typical architecture for IKS in VC

Technical term / Description / References
Business process (or Workflow process)
A collection of activities related by data and control flow relationships. An activity is typically performed by executing a program, enacting a human/machine action, or invoking another process (called sub-process). Programs, persons, machines, and data used to perform workflow processes are called workflow resources.
Description of all the details of a certain business operation flow, including the transaction flow, document schemas, rules and restrictions. Business processes specify activities to be carried out in a given order, for example, when a business document should be sent and how and when it should be answered. The frameworks define these using diagrams and/or textual descriptions.
Nurmilaakso et al. (2006), Medjahed et al. (2003).
Business document
Business document specifications define the structure and contents of business documents exchanged in a commonly understood fashion. For example, a "purchase order request" business document guides how products, dates, financial amounts and currencies are presented. This is achieved by schemas provided by the e-business frameworks for validating the contents of business documents.
Business documents are used for interactions at the content layer. A business document is a set of information components that are interchanged as part of a business process. Business documents are composed of three types of components: core components, domain components, and business information objects. Core components, stored in the core library, are information components that are re-usable across industries. Domain components and business information objects are larger components stored in the domain library and business library, respectively.
Nurmilaakso et al. (2006), Medjahed et al. (2003).
Business Messaging
Messaging specifies the envelope for the business document as well as the packaging, security, and transportation standards to be used (general information exchange standard).
Web service
"A software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically Web Services Description Language WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards."
en.wikipedia.org

SOAP *SOAP, originally defined as Simple Object Access Protocol, is a protocol specification for exchanging structured information in the implementation of Web Services in computer networks. It relies on XML for its message format, and usually relies on other Application Layer protocols, most notably Remote Procedure Call (RPC) and Hypertext Transfer Protocol (HTTP), for message negotiation and transmission.* *As a layman's example of how SOAP procedures can be used, a SOAP message could be sent to a web-service-enabled web site, for example, a real-estate price database, with the parameters needed for a search. The site would then return an XML-formatted document with the resulting data, e.g., prices, location, features. Because the data is returned in a standardized machine-parseable format, it could then be integrated directly into a third-party web site or application.* *en.wikipedia.org*
XML *XML is a meta-markup language for expressing structured documents, and it defines the syntax in which other specific markup languages can be written (An XML document consists of nested data items called elements which can have sub-elements and attributes). However, the applications do not understand each other by only having information in an XML document; it only provides a way to access information.* *Nurmilaakso et al. (2006)*

APPENDIX B: Standardization initiatives related to other industries

Few studies on industry specific standardization initiatives could be found in the literature. In fact, the only reviews of industry-specific standardization initiatives can be found in Chituc *et al.* (2008) and Nurmilaakso *et al.* (2006). Thus, the results presented in Table below are based on the work of these authors. We very briefly present each standard and we attempt to analyse its interoperability aspect, its limitation and its challenges.

Standard / Description / Industrial sector / Published specification / Interoperability aspect
CIDX www.cidx.org *A consortium formed by about 50 members form the chemical industry. In 2009, CIDX transitioned its standards and operations to the Open Application Group (OAGi) and the American Chemistry Council's Chemical Information Technology Center (ChemITC)* 60 business documents and relates Business process guidelines, messaging, envelope and security specifications. Also, the standard provides various implementation tools. XML-based.
PIDX committees.api.org/business/pidx *A consortium formed by the American Petroleum Institute and about 20 members of the petroleum industry.* *17 business documents and related business processes. Also include messaging specifications.* *XML-based e-business. To tackle semantic interoperability, PIDX is pursuing efforts towards developing a Petroleum Industry Data Dictionary meeting the needs of this industry.*
AgXML www.agxml.org *An organization of grain and processing companies, and related entities, committed to develop standards for the efficient and effective communication of information electronically through the entire agribusiness supply.* The general approach to development is as follows: - Identify business processes that, if electronically-enabled, would improve business-process efficiency and effectiveness. - Determine the data requirements of those business processes. - Define and maintain evolving XML schemas and related guidelines that support the data requirements. - Build commitment from participants to integrate XML-based messaging into their business processes and provide a forum for understanding that process.
AIAG (Automotive Industry Action Group) www.aiag.org *This is one among several initiatives are available for the automotive industry, aiming at developing tools, standards, guidelines, and recommendation for improving the flow of goods, services, product data and business information through*

the automotive supply chain.
TexWeave www.texweave.org **Standardization and Interoperability in the Textile Supply Chain Integrated Networks** *A CEN/ISSS standardization initiative aiming at providing an interoperability framework for textile/clothing sector based on standardized electronic document exchange, using XML-Schema and the Internet, and at fostering its adoption in business communities. The results achieved so far comprise business models for fabric and clothing supplying, XML templates for document exchange, and a common dictionary.*
RAPID http://www.rapidnet.org *A standard by a not-for-profit organization formed by leading agricultural companies supporting the agriculture community to take advantage of new developments in electronic communication. It makes us of EDI, XML, Bar Coding, Sales Reconciliation Format, unit measure conversion, and endorses Web services interoperability profile concept. Some XML transaction schema files were developed in collaboration with CIDX. It provides a Data Dictionary.*
Odette www.odette.org *Odette International is an organisation, formed by the automotive industry for the automotive industry. It sets the standards for e-business communications, engineering data exchange and logistics management, which link the 4000 plus businesses in the European motor industry and their global trading partners.*
STAR (Standards for Technology in Automotive Retail) www.starstandard.org *Several initiatives are available for the automotive industry, aiming at developing tools, standards, guidelines, and recommendation for improving the flow of goods, services, product data and business information through the automotive supply chain, such as: the AIAG, STAR, and JAPIA (Japanese Automotive Parts Industry Association), Odette and JAMA (Japanese Automotive Manufacturers Association) jointed their forces to build a global Joint Automotive Data Model (JADM) that will be the foundation for enabling common, consistent business vocabularies at the data level, allowing various business domains to retain their existing infrastructure and BPs.* *A first version is expected to be released during 2007.*

APPENDIX C: Other industry-independent initiatives for VC-ABM frameworks

Group initiative / Description
KAoS *An important standardization effort is pursued by researchers of the Knowledge-able Agent-oriented System [3] architecture. This system, which is also known as KAoS, is described as ``an open distributed architecture for software agents." The KAoS architecture describes agent implementations (starting from the notion of a simple generic agent, to role-oriented agents such as mediators and matchmakers), and elaborates on the interactive dynamics of agent-to-agent messaging communication by using conversation policies.*
General Magi *General Magic is a commercial endeavor researching mobile agent technology for electronic commerce. Conceptually, this technology models a MAS as an electronic marketplace that lets providers and consumers of goods and services find one another and transact business. This marketplace is modeled as a network of computers supporting a collection of places that offer services to mobile agents. Mobile agents, which are entities that reside in one particular place at a time, have the following capabilities:* • *they can travel, to move from one place to another* • *they can meet other agents, which allows them to call one another agent's procedures* • *they can create connections, to allow an agent to communicate with another agent in a different place* • *they have authority, which indicates the real-world individual or organization that the agent represents* • *they have permits to indicate the capabilities of agents*

HMS (Holonic Manufacturing Systems Consortium) hms.ifw.uni-hannover.de
CoABS (Control of Agent-Based System)
DARPA (Agent Markup Language (DAML)) www.daml.org
CAG (Collaborative Agents Group) sern.ucalgary.ca/cag/