USING ONTOLOGY TO DEFINE INFORMATION INTEGRATION ARCHITECTURE FOR GLOBAL SUPPLY CHAIN RISK MANAGEMENT

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ABSTRACT

The growing concerns about safety and security of global supply chains underscore the need for real time supply chain vigilance. This paper explores the link between interorganizational trust and supply chain risk, in particular how trust may be used to alleviate risk. A framework for designing trust based risk management systems is proposed. The information architecture for such systems is expressed as a high-level ontology representing classes necessary to capture, store, and retrieve relevant indicators of interorganizational trust.

INTRODUCTION

A supply chain (SC), or more accurately, a supply chain network, comprises of different firms engaged in mutually agreed upon contractual undertakings typically involving exchange of raw materials, goods, services, technological resources, and information. Increasingly, enterprises rely on globally distributed networks of manufacturers, growers, suppliers, and customers to successfully operate and stay competitive. SC arrangements often stipulate conversion, logistics (e.g., warehousing, transportation), or the selling of raw materials, sub-assemblies, and finished goods [3]. SCs, however, are more than the vehicles for exchange of physical inventories and information. They embody complex interactions and relationships between and among participating firms. Effective management of these relationships requires *integration* of information and key business processes from the end user through original suppliers. This paper proposes such information integration framework. It utilizes the concept of interorganizational trust as the basis for the design of information systems to monitor and mitigate supply chain risk. In particular, we focus on risk factors associated with SC safety and security. We use ontology of interorganizational trade and trust to identify and describe essential elements of the system.

SUPPLY CHAIN RISK & INTERORGANIZATIONAL TRUST

Global interconnectedness implies that a disruption or failure at one node or link in the company's supply chain can reverberate throughout the network with potentially serious operational and financial consequences. Supply chain risk has been defined as “any risk to the information, material and product flow from original suppliers to the delivery of the final product” [4]. Supply chain risks have been variously categorized. For example, some SC risks are associated with supply and demand coordination while others are related to disruptions of normal supply chain processes [6]. Sources of the former type of risks include unanticipated fluctuations in the supply and demand of raw materials, components, and finished products experienced by the sourcing firm, the supplier, or both. Examples of the later category of risks include natural hazards, economic disruptions through strikes and acts of terrorism, and unanticipated logistical problems. Chopra and Sodhi [2] provide a comprehensive list of risk categories and their drivers. Their categories include risks of supply chain disruptions and delays, systems breakdowns, forecast inaccuracies, and a number of other risks associated with inventories, capacity and procurement.

The role of interorganizational trust in mitigating risks in buyer-supplier relations was articulated by Luhmann [7] over two decades ago. He viewed organizations in a supply chain network as complex social systems. By establishing ground rules and expectations and through contractual arrangements, companies can effectively establish boundaries between their supply chains and the world outside. Establishing such subsystems with somewhat limited number of partners and possible interactions, allows firms to reduce complexity and uncertainty in their relations. Whereas trust based on interpersonal relationships often relies on vague, emotional propositions, Luhmann's conceptualization establishes a sound theoretical ground and practical basis for the role of trust in business relationships and dealings.

SYSTEM ARCHITECTURE

For most organizations, it makes sense to monitor activities and entities involved in their supply chain operations. Doing so not only enables them to avoid delays and disruptions but also to ensure the quality and integrity of their raw materials, products, and subassemblies. As we've discussed in the previous sections, such risks can often be mitigated through interorganizational trust. Although the notions of interorganizational and interpersonal trust are related, the former has emerged as an entirely different construct [9]. Whereas interpersonal trust involves two persons, a typical global supply chain may have several participating organizations, warehousing and transportation facilities, and countries. A typical supply chain is also dynamic in that the participating entities, particularly second and lower level suppliers and subcontractors are added and removed as necessary, often unknown to the sourcing organization. Thus, monitoring large, complex, and dynamic supply chains inevitably requires appropriate information systems to support data integration, analysis, and visualization. Figure 1 shows a high level view of the proposed architecture.

USING ONTOLOGY TO MODEL THE SYSTEM ARCHITECTURE

An ontology is a shared conceptualization and an explicit and formal specification of the phenomenon that we want to represent [5]. Ontologies have been used in various application domains to formally specify the concepts and the relationships between them. The concepts in ontology can be represented as classes containing essential properties and behaviors. Other ontological features describe relationships between classes and clarify or constrain properties and behaviors. Independent ontologies or ontological modules can be merged or reused if they are designed using the standard knowledge-based formalisms. Essential features of such standard ontologies include the following [8]: primitive concepts expressed using their necessary conditions; defined concepts with necessary and sufficient conditions; properties that relate the concepts - properties can be part of the subsumption hierarchy; axioms describing concepts as either disjoint or implying other concepts; and restrictions.

Using ontological methods to specify software architectures can offer benefits including the following [1]: (1) Ontology and related tools provide support for documenting architectural decisions and the flexibility in modifying, extending, and using them to create on-demand views and what-if analyses. (2) A common vocabulary with precise meanings and definitions helps develop and communicate shared understanding of the system components. (3) Ontologies facilitate reuse through the use of data languages that facilitate expression of constraints in first order logic, which in turn helps build standardized content that can be shared and reused globally as domain specific dictionaries. (4) The use of semantic Web standards such as RDF, OWL, and XML Schema facilitates semantic interoperability and federation among globally distributed knowledge sources.

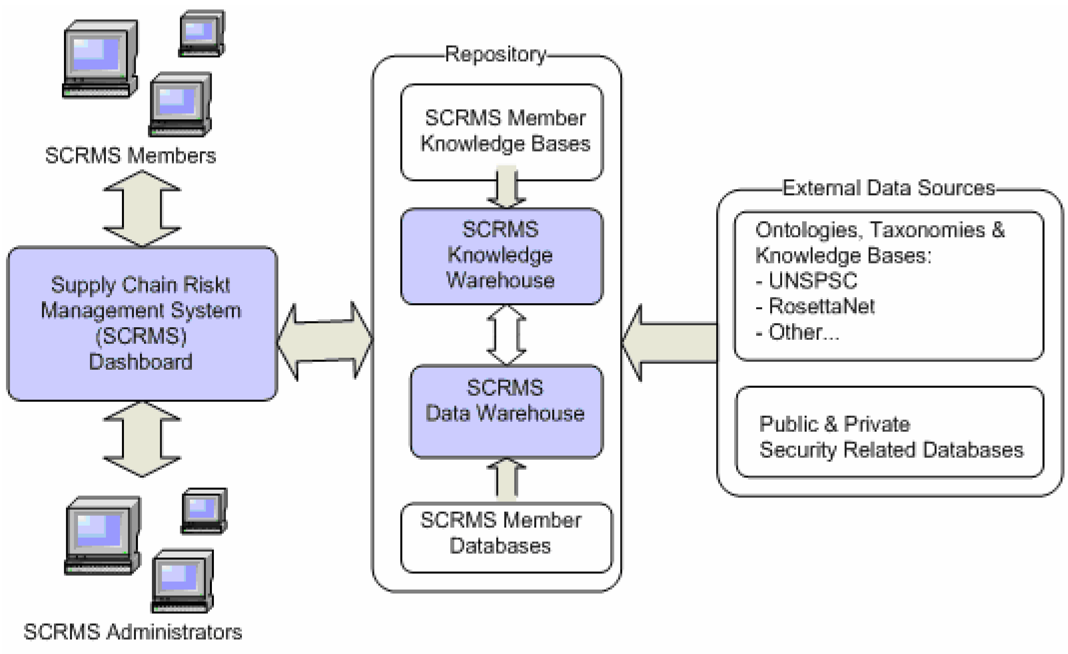

Figure 1: Supply Chain Risk Management Architecture

The literature identifies several antecedents and indicators of interorganizational trust. Appropriate measures of trust may be operationalized based on specific objectives of a system. These measures may then be used to identify master data elements for structured data, information, and knowledge that need to be maintained by the system. The proposed system is intended to capture, sore, analyze, and retrieve organizational data relevant to supply chain risks of delays, disruptions, quality, and safety. We used ontological concepts to represent information architecture of the system.

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