CONCEPTUAL FRAMEWORK OF SUPPLIER DISCOVERY VIA ONTOLOGY-DRIVEN SEMANTIC REASONING

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Abstract

Due to market's demanding needs of high quality and low cost products, global manufacturers must be competitive in forming and operating dynamic supply chains from raw material sourcing up to global retailing and marketing. This paper proposes a conceptual framework of ontology-based supplier discovery system that connects buyers with suppliers by employing manufacturing ontology and semantic matchmaker. The system consists of capturing of buyer's requirements and supplier's capabilities, manufacturing ontology, semantic matchmaker and registry. The proposed conceptual framework for supplier discovery helps overcome the challenge that the manufactures are facing in forming a global collaboration chain and also provides the fundamental principle for operating the formed supply chain.

Keywords
Supplier discovery, Global supply chain, Semantic reasoning and matching, Manufacturing ontology

1. INTRODUCTION

Due to market’s demanding needs of high quality and low cost products, global manufacturers must be competitive in forming and operating dynamic supply chains from raw material sourcing up to global retailing and marketing. However, heterogeneous characteristics of suppliers prevent manufacturers from discovering and scouting right suppliers, and forming a competitive collaboration network.

Supplier discovery consists of two processes in general, (1) collecting supplier’s contact information, and (2) evaluating supplier’s manufacturability to ensure that the supplier can fulfill the production requirements. Traditionally, a buyer collects supplier’s contact information via newspaper advertisements, magazines, exhibitions or intermediate brokers. Supplier’s manufacturability is evaluated by supplier itself and then extra activities such as plant visits, financial reports analysis and vendor surveys are followed. The traditional way of supplier discovery was effective before the digital economy era when the customers were not sophisticated, the manufacturers made everything in-house from raw materials to end products which required a few suppliers to collaborate with. It has a few shortcomings in nature; it takes a long time to discover suppliers manually, and the search space is usually limited to a certain geographical zone.

However, as the customers become more demanding and sophisticated with ever shortened life cycle of products, the supply chain needs to be highly flexible and responsive to unexpected changes. This required internet-based supplier discovery services, including discovery of suppliers based on product catalogue and/or keywords search. Although internet-based approaches are better in time and space than the traditional methods; the keyword search does not consider the manufacturability and capability of suppliers. Therefore, the internet-based services still requires a considerable time and cost since most of the evaluation processes are conducted offline and retrieve several irrelevant results.

Instead of providing services based on keyword search, a growing number of modern systems begin to enable more powerful semantic search based on ontology that consists of domain knowledge and rules. [1]. The objective of this research is to propose a conceptual framework to resolve the aforementioned problems by introducing supplier discovery services via manufacturing ontology.
2. DEFINITION OF SUPPLIER DISCOVERY
Supplier discovery is different from supplier selection in that the latter focuses on selecting a supplier from the list of ‘found’ suppliers. In general, once a set of suppliers are discovered, B2B transactions are conducted for the actual products/services followed by the delivery throughout the logistics activity. Compared to well defined “B2B transactions” and “Logistics,” “supplier discovery” has yet to be studied. Due to the lack of clear definition, no shared concepts exist in the field of supplier discovery.

As illustrated in Figure 1, supplier discovery is an activity of finding a new supplier for a product/service of interest. The buyer needs to discover new suppliers either (1) for a new product/service development, or (2) for diversification of the source of raw materials for an existing product/service.

![Figure 1 Definition of supplier discovery](image)

For the first case, the discovered suppliers have never been contracted, or have been contracted for other products/services. As the concerned products have never been manufactured, even the suppliers contracted in the past become candidates to be discovered. For the second case, the scope of supplier discovery is basically the same as the first case. This should not be confused with the case that the buyer selecting the supplier that provides the raw materials in the most favorable manner. In conclusion, supplier discovery is basically the activity of finding a set of suppliers that never been pre-contracted for producing a particular product (regardless of a new or an existing product).

3. CONCEPTUAL FRAMEWORK OF SUPPLIER DISCOVERY
As illustrated in Figure 2, supplier discovery is conducted via several activities: (1) Suppliers register their capabilities information (non-technical & technical) in a form of ontological instance into the open registry; (2) A buyer submits his/her requirements including technical (drawings, manufacturing operations and processes, equipment and facility, required tools, etc.) and non-technical requirements (financial aspects, contract history, reputation and delivery tardiness, global certificates, etc.); (3) The matchmaker will then conduct ontology-driven semantic reasoning. (4) In response, the manufacturing ontology and the Semantic Web Rule Language (SWRL) create semantically related terms and return them to the semantic matchmaker. A domain specific manufacturing ontology related to resources and operations is developed in the form of concept definitions and their interrelations (taxonomies) for semantic reasoning. In this case, an upper ontology for description of manufacturability and capabilities of suppliers is used as a preliminary reference to the establishment of such a domain specific ontology. (5) The semantic matchmaker composes a compound query and sends it to the registry; (6) In response, the registry returns a list of suppliers discovered based the compound query to the semantic matchmaker, (7) Finally, all the discovered suppliers are evaluated in terms of non-technical information and technical information so that they are ranked and recommended to the buyer.

In order to build a framework, detailed tasks are needed: (1) a markup methodology of representing supplier’s capabilities and buyer’s requirements, (2) a manufacturing ontology that provides the shared understanding of manufacturing domain, (3) a matchmaker that computes similarity between buyer’s requirements and supplier’s capabilities, and (4) a registry to store supplier’s capabilities profile.
3.1 Markup methodology
The markup methodology for capturing buyer’s requirements and supplier’s capabilities is developed with reference to the manufacturing ontology. First, the information on supplier’s capabilities and buyer’s requirements needs to be conceptualized as entities and their relationships. To conceptualize the information, the five steps should be followed: (1) collect the related terms, (2) organize the collected terms, (3) clarify terms to produce informal concept definitions, (4) diagram terms and their relations to ensure its validity, and (5) formalize concepts. In fact, Ameri & Patil (2010)[2][3] utilize Request-for-Quote (RFQ) and Request-for-Proposal (RFP) to collect buyer’s requirements and supplier’s capabilities, and then conceptualize them, as illustrated in Figure 3.

3.2 Manufacturing ontology
Manufacturing ontology enables automatic discovery, invocation, composition and interoperation by providing shared understanding of manufacturing domain. According to ontology development
guidelines [4], the first step toward building ontology is to determine which terms and synonyms to be included. This will define a set of classes, properties, relations between the different entities, and axioms and rules. In this case, an upper ontology is used as a preliminary reference to the establishment of such a domain specific ontology. We refer to Manufacturing Service Description Language (MSDL)[2] as an upper ontology. Figure 4 illustrates core classes of MSDL.

Rules can be defined with tableau reasoning method or rule-based reasoning. While, tableau reasoning is about subsumption, instance check and entailment[5][6], the rule-based reasoning supports not only inferencing with forward chaining or backward chaining, but also supports automatic and semantic search. New knowledge can be acquired using rule-based reasoning chaining, for example Semantic Web Rule Language (SWRL), which enables the manufacturing ontology to be augmented itself by updating inference and knowledge using. The example of rules is illustrated in Figure 5.

3.3 Semantic matchmaker
Instead of exact syntax matching, an ontology-based matchmaker performs semantic reasoning referring to ontology. Mappings between terms from different set of instances are done via weighted metrics optimized to treat heterogeneous data. Semantic similarity measures the degree of how two concepts resemble each other [7]. The four different types of algorithms are available to calculate semantic similarities: (1) edge counting, (2) feature matching, (3) probability of occurrence, and (4) a hybrid combination of the above ideas. In this research the hybrid approach will be employed to realize semantic matchmaking.

3.4 Registry
UDDI is a remotely searchable registry that maintains information about providers, services and businesses, as well as technical information for requesting and/or receiving services. Briefly, UDDI provides a simple data structure based on key-value pairs to express technical specification about ‘services’. Each UDDI registry entry uses four core data types: businessEntity, businessService, bindingTemplate and tModel(i.e. technical model)[8]. As UDDI is incompatible with expressing semantic descriptions about manufacturing services, an extended UDDI is required. It contains OWL-based service descriptions and new description logic to perform semantic matchmaking based on descriptions.

4. PROTOTYPE OF THE PROPOSED CONCEPT
As the sample instance for supplier’s capabilities is shown in Figure 6, “Raw material”, “Production process”, “Production facility” and “Certification” are classified into technical information, while “Industry”, “Main Product” and “Location” are classified as non-technical information. Both type of information will be used to match supplier’s capabilities with buyer’s requirements.
Figure 7 illustrates similarity measurement by using two methodologies: WordNet-based similarity and feature matching-based similarity. WordNet [9] is a popular tool to measure semantic relatedness, which organizes lexical information according to word meanings. This can be used in conjunction with ontology [10] to reason about the relationships between different words. The feature-based method compares the common and uncommon features between concepts.

Once the entire system is implemented, a set of suppliers can be discovered with a set of requirements via ontology matching. As illustrated in Figure 8, the requirements are composed of number of criteria, such as global experience, manufacturing process, product parts, and so on. For example, when a buyer intends to find a capable supplier in manufacturing front bumper molds and door trim molds, the implicit knowledge in the ontology is used. A supplier with certain machines and certifications is perceived as a capable manufacturer. Similarly, when a buyer requires oversea experienced suppliers, this can semantically be inferred from the supplier’s portfolio, assuming that ontology states that customer portfolio can be replaced for oversea experience. Such ontology with implicit domain knowledge is necessary for effective semantic search of suppliers.

5. SUMMARY
The existing internet-based supplier discovery services have not addressed major issue within in supplier discovery practice, thus making the supplier formation less flexible, high cost and time consuming. The proposed ontology-based system will consider implicit knowledge of domain using manufacturing ontology and evaluate the manufacturability of supplier by considering both non-technical (finance, reputation, location, experience and etc.) and technical requirements (equipment, license, process, product and etc.) for matching. To help understand the concept of ontology-based supplier discovery system, the definition of supplier discovery was elaborated. In addition, the overall framework of the system was illustrated in terms of seven activities and four different tasks: (1) Markup methodology (both buyer and supplier), (2) Manufacturing ontology (3) Semantic matchmaker and (4) Registry. Finally we drew scenarios to test how the ontology matching is conducted with a prototype scenario. Ongoing research focuses on developing a prototype in the molding industry. To this end, buyer’s requirements and supplier’s capabilities information have been collected from SMEs. The upper ontology (MSDL) was then extended to accommodate molding-specific domain knowledge. Along with the ontology, the matching algorithm and semantic registry will be implemented accordingly.
REFERENCES


