Supplier Discovery and Assessment Based on Ontology Models for Mold Manufacturers in Korea

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ABSTRACT

Recently, mold manufacturing companies in Korea try to reinforce their competitiveness and find collaboration partners from overseas. In order to find their collaboration partners, companies participate in various kinds of expositions and conferences, or sometimes use business agents and websites. After revitalizing internet, many companies try to find their collaboration partners via supplier discovery websites such as alibaba.com, mfg.com, and so on. These websites provide general information or engage in business contracts between buyers and suppliers by human force. In such cases, the website users have to pay a lot of money for their membership and contracts. This will be a big barrier for Korea mold manufacturers as well as others to use such websites. Therefore, in this paper, we suggest a web-based business supporting system, referred to as an Excellent Manufacturer Scouting System(EMSS), which is developed to support core business functions including supplier discovery, negotiation, and collaboration between overseas buyers and domestic suppliers. In order to discover collaboration partners, EMSS has been developed based on ontology models including matching algorithms which can analyze a demand of collaboration partners. Ontology models and matching algorithms can reflect companies' preference and qualitative tendency. In order to evaluate quantitatively, EMSS has assessment models to verify collaboration partners who are candidates of collaboration. Suggested models, algorithms, and EMSS are novel in the area of supplier discovery and assessment especially from the manufacturability point of view.

1. INTRODUCTION

Nowadays, many manufacturers try to reinforce their competitiveness by considering collaboration and outsourcing for their core service and capacity. Especially, manufacturer wants to make global collaboration network which is most important strategy via outsourcing for their future. In such situations, SMEs (Small and Medium Enterprises) should secure their partner or collaborative company for the relative advantage against a developing country such as China, Indonesia, Vietnam, and so on [1]. Recently, a target of global outsourcing has been changed from non-core services such as human force for back-end business operations to a higher value-added business such as knowledge outsourcing. Thus, collaboration style for global outsourcing has been changed from ad hoc buyer-supplier relationship to a strategic partnership (i.e., long term exclusive relationship) as illustrated in Figure 1.

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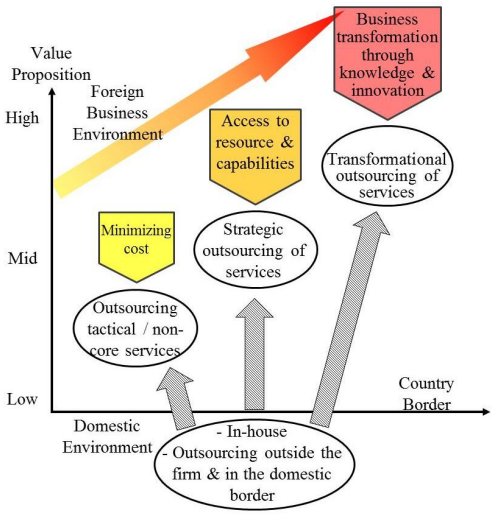

Figure 1. Change of the collaborative approaches [2].

Also SMEs should notify their core capacities to customer such as global enterprises. In order to choose the new partners, companies should spend their resources in participating an industry exposition, conferences, commercials, and so on. However these legacy methods have a limited search range. And sometimes they use a business agent and website for scouting their buyers and suppliers, since supplier discovery websites are possible to connect overseas customer such as alibaba.com, mfg.com, and so on. These websites only provide general information or they engage in business contract between buyers and suppliers by human force. If some user wants to use matching service via those websites, user should pay a lot for the membership and contract. Also these websites have another problem which is not considering about inherent factors such as reputation, capability, and potential power. In order to solve these situation, and for efficient search of collaboration partner, we suggest a web-based business supporting system, referred to as an Excellent Manufacturer Scouting System(EMSS), which is developed to support core business functions including supplier discovery, negotiation, and collaboration between overseas buyers and domestic suppliers. In order to discover collaboration partners, EMSS has been developed based on ontology models including matching algorithms which can analyze a demand of collaboration partners. Ontology models and matching algorithms can reflect companies' preference and qualitative tendency. In order to evaluate quantitatively, EMSS has assessment models to verify collaboration partners who are candidates of collaboration. Suggested models, algorithms, and EMSS are novel in the area of supplier discovery and assessment especially from the manufacturability point of view.

2. MANUFACTURER SCOUTING SERVICE

2.1. ONTOLOGY IN THE CONTEXT OF MANUFACTURING DOMAIN AND WEB SERVICES

An ontology is a 'formal and explicit specification of a shared conceptualization' that is used to model a domain of interest, and to support reasoning[3]. Many researchers have proposed to utilize the concept of ontologies in the context of manufacturing domain. And other researchers have approached the manufacturing resources model as a web service consisting of three parts: service profile, service model, and service grounding[4-5]. National Institute of Standards and Technology (NIST) developed Process Specification Language (PSL) for description of basic manufacturing and business processes. PSL aims to overcome interoperability issues in the enterprise processes by integrating processes throughout the manufacturing process life cycle: production planning, workflow management and project management. However, it lacks in specificity to represent manufacturing capabilities required for supplier's capabilities of semantic web-based discovery. Extend OWL-S developed for semantic representation of web services including manufacturing operation[6]. In their model, manufacturing operation is represented by defining sub-classes such as material removal operation and hole making. This augmentation of sub-classes may reduce the overall flexibility of the ontology. Moreover, this ontology assumes that a service profile is a description of the aggregate capability of a shop at its largest. However, in the context of supplier discovery, representing the company's entire manufacturing resources is necessary. MSDL (Manufacturing Service Description Language) is the representation of manufacturing services[7]. It is an upper ontology that provides limited basic concepts to address a broad range of objects in the domain of interest. Naturally, an upper ontology has sufficient flexibility and extendibility for further specification.

2.2. MANUFACTURER SCOUTING SERVICE

In general, manufacturing companies spend their resources and time to find a new collaboration partner by means of participating in various industrial expositions or conferences. In order to reduce costs, they have used various manufacturer scouting services for searching and scouting their buyers or suppliers. Manufacturer scouting services are one of business and information system such as an mfg.com, and alibaba.com. Alibaba.com [8] is a well-known e-marketplace specialized in manufacturing industry. It focuses on the service on commercial transactions such as product lists, product search, supplier search, buyer search, intermediary services, and so on. However, it does not provide matching services and evaluation services for buyers and it only provide a simple search service by using keywords. Therefore, buyers have to evaluate suppliers by themselves. Furthermore, the quality of search service is not good enough to find right suppliers effectively because of its limitation of keyword searching. EC21.com [9] focuses on not only manufacturing industry but also other industries such as agriculture and service industry. Its services are similar with those of alibaba.com. But EC21.com provides company's homepage and catalog services. However, such additional services are insufficient for practical support for matching buyers and suppliers. Mfg.com [10] provides not only search services but also matching services and negotiation service between buyers and suppliers in manufacturing industry such as molding, forge welding, assembly, and so on. Buyers can find a suitable supplier easily and conveniently by using it. However, the level of services provided depends on the membership fee monthly paid. Furthermore, because the discovery process is performed by human, it is inefficient in terms of cost and time. We also cannot get accurate evaluation results, reflected by human's subjectivity. In sum, legacy e-marketplaces provide limited search services based on keyword search methods, and they do not provide matching and evaluation services except for mfg.com. Even mfg.com employs a manual evaluation mechanism. Thus, it is required to build more effective searching mechanism based on a semantic search rather than simple keyword search. In addition, an automated evaluation method of core capabilities of manufacturing companies should be developed. Furthermore, the discovering services are required to be incorporated with post-discovering services devoted to negotiation and collaboration. EMSS proposed in this paper meets these requirements. Recently, research of semantic searching is still in a development process. But there are no applications for specific domain and semantic search based on the ontology. In 2010, NIST (National Institute of Standards and Technology) [11] started research on a feasibility study about core capability of manufacturing.

3. EXCELLENT MANUFACTURER SCOUTING SYSTEM (EMSS)

3.1. SUPPLY CHAIN FORMATION AND SUPPLIER DISCOVERY PROCESS

EMSS serves manufacturing services that plays a role of a matchmaker between buyers and suppliers. EMSS helps globally located buyers to discover and evaluate outsourcing partners, and provides potential suppliers with business opportunities. Figure 2 shows overall procedure for supply chain formation via partner selection using EMSS, that consists of three stages including 1) discovery, 2) negotiation, and 3) collaboration. In the stage of discovery, which is the scope of this paper, EMSS provides a buyer with candidate suppliers that conform to its requirements of manufacturing capabilities, quality level, etc. The buyer makes the final selection of its supplier in the stage of negotiation, and then orders are placed to the selected supplier for making products or services in the stage of collaboration. It is assumed that a web-based collaboration system, referred to *i*-MFG, is employed in the collaboration stage. *i*-MFG was developed by a government-led project in Korea, and it serves various functions for collaboration[12-15].

Supplier discovery process of EMSS includes 1) filtering, 2) matching, and 3) ranking, At the filtering phase, EMSS filters out inappropriate suppliers from registered suppliers, based on non-technical criteria such as general information, exportation experience, customer portfolio, etc. Non-technical information is usually expressed as a string type of text. Therefore, a text-based keyword matching method incorporated with a binary search is applied to find out suppliers that meet the non-technical requirements of a buyer. For example, if a buyer wants to find a supplier located near a harbor, EMSS finds out suppliers of which profile shows some related keywords such as 'near harbor' or the names of principal harbor cities. Other suppliers are eliminated from the search space. At the matching phase, EMSS selects some suppliers that meet the technical requirements of a buyer. Be-cause technical requirements are usually described by various terminologies in isolation; their true meanings may not be uniformly interpreted. Thus, EMSS employs an ontology-based method for semantic interpretation of technical requirements. In the final step, i.e., ranking phase, EMSS evaluates capabilities of selected suppliers, based on additional non-technical criteria. Their ranked list is reported to the buyer, and the buyer goes through a negotiation process with the recommended suppliers.

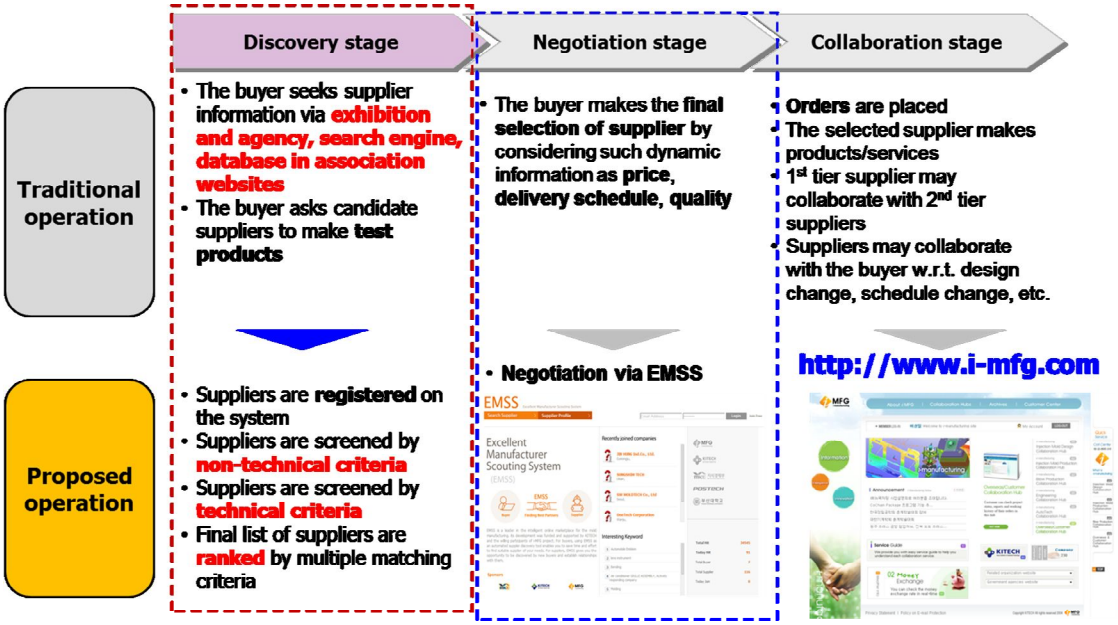

Figure 2. Overall procedure for supply chain formation.

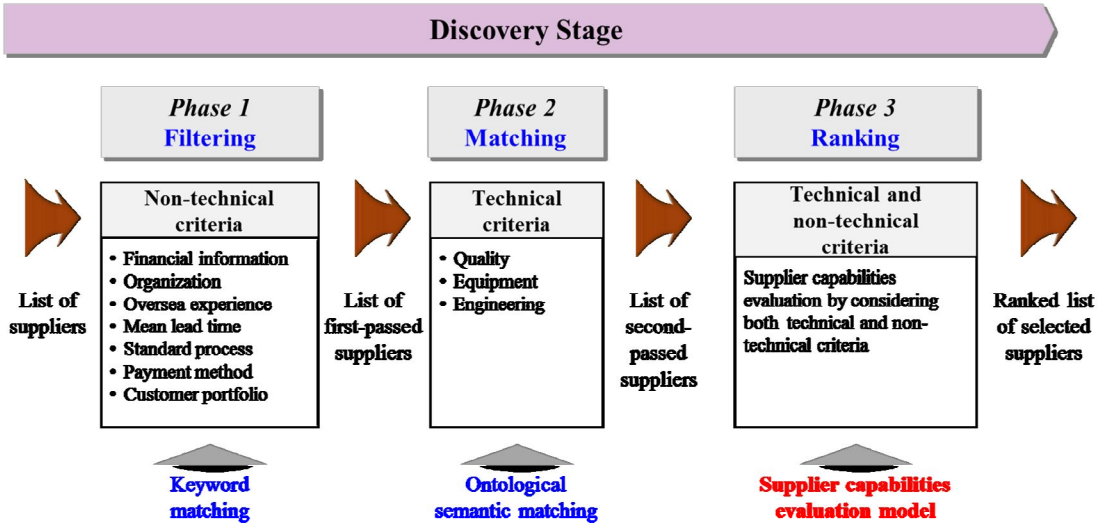

Figure 3. Supplier discovery process in EMSS.

4. COLLABORATION ONTOLOGY IN EMSS

4.1. SUPPLIER DISCOVERY FRAMEWORK

Collaboration ontology is developed to represent the supplier's capability information and the buyer's requirements. The framework includes ontology building, reasoning and semantic matching as illustrated in Figure 4.

1) In order to be used for reasoning, collaboration ontology is pre-built. Ontology is built in the form of Web Ontology Language (OWL), and OWL Rules Language (ORL).

2) Supplier's potential capability is reasoned from classes, properties, reasoning rules, and instances. OWL includes classes and properties, ORL is used for rules, and Resource Description Framework (RDF) for instances. Reasoning tool auto-mates the reasoning process and it stores the ontology model and its reasoned in-stances in the 'triple instance store'.

3) Finally, the buyer's requirement is semantically matched with supplier's capability information using query language.

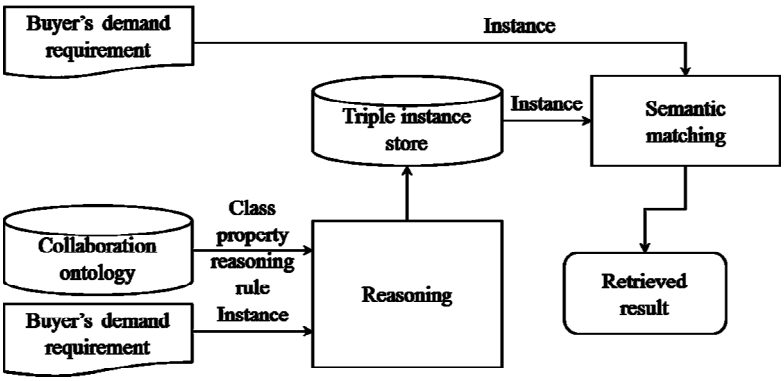

Figure 4. Supplier discovery process in EMSS.

4.2. ONTOLOGY FOR CAPABILITY INFORMATION OF SUPPLIER

Since the quality of the semantic search is directly determined by the richness of the representation, an ontology plays an essential part in this framework. The collaboration ontology is built using the formal representation language OWL, the most expressive semantic markup language [16]. Each ontology concept is represented as a class, using owl:Class. An OWL class is characterized by relationship-type properties using owl:ObjectProperty, or by data-type properties using owl:DatatypeProperty. Figure 5 shows a supplier ontology in which classes represent supplier's capability information consisting of manufacturing capability and non-manufacturing capability. For example, tool, process, part and product classes are used for reasoning regarding manufacturing capability, while patent, location, and customer classes are used for reasoning regarding non-manufacturing capability [17-18].

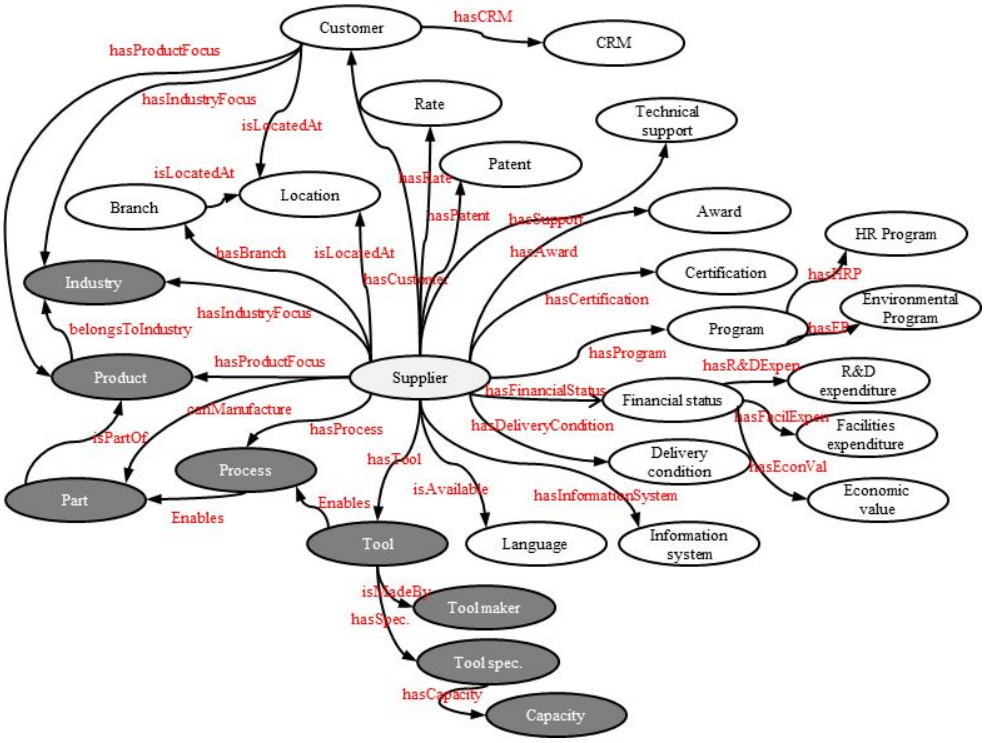

Figure 5. Supplier discovery process in EMSS.

4.3. ONTOLOGY FOR REQUIREMENT OF BUYER

Figure 6 shows a buyer ontology in which classes represent buyer's requirements consisting of product requirement and supplier requirement. For example, process, part, and product classes are used for reasoning regarding product requirements, while supplier requirement classes are used for reasoning regarding supplier requirements. Table 1 describes explicit meanings for exemplary supplier requirements.

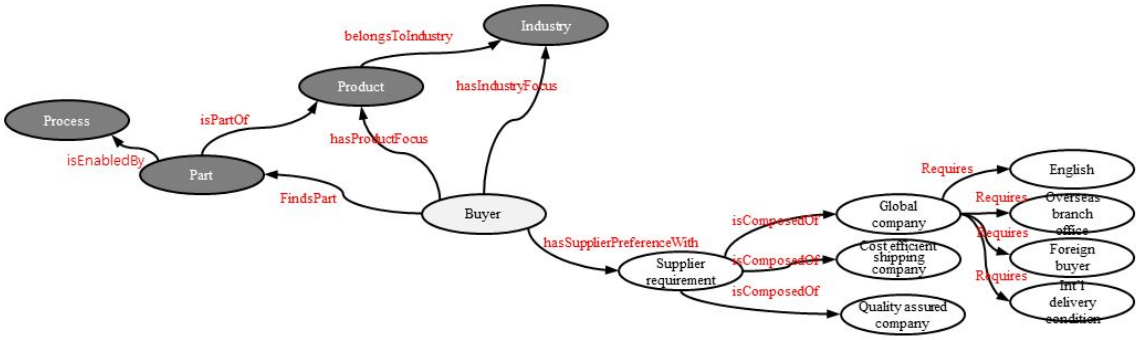

Figure 6. Supplier discovery process in EMSS.

Table 1. Explicit meanings of supplier requirements.

Supplier requirements	Explicit meanings
A global company	A supplier can be interacted in English, has overseas branch offices, has transaction experiences with foreign buyers, and can deliver products abroad
A company with delivery competitiveness	A supplier is located close to airport/port, has various delivery conditions, and has achieved high delivery performance
A company that provides assured quality	A supplier has high market share, has transaction experiences with principal customers, has received certifications by principal customers, has received quality awards

4.4. ONTOLOGY FOR MATCHING BUYER WITH SUPPLIER

Semantic matching of buyer's requirements with supplier's capability information is required to solve the issue of buyers and suppliers using different level of details in their descriptions. In this framework, Buyer's product requirements and the supplier's manufacturing capability, and the buyer's supplier requirement and the supplier's non-manufacturing capability are semantically matched. Figure 7 presents an exemplary concept diagram which is 'how to match buyer's product requirements with supplier's manufacturing capability information'. First, all the manufacturing capabilities of the supplier, such as bumper mold, are reasoned via the described processes. Subsequently, buyer's product requirements are matched with the supplier's manufacturing capability. In this framework, the bumper mold instance in the buyer ontology is matched with the front bumper mold instance in the supplier ontology, because they have the identical instances.

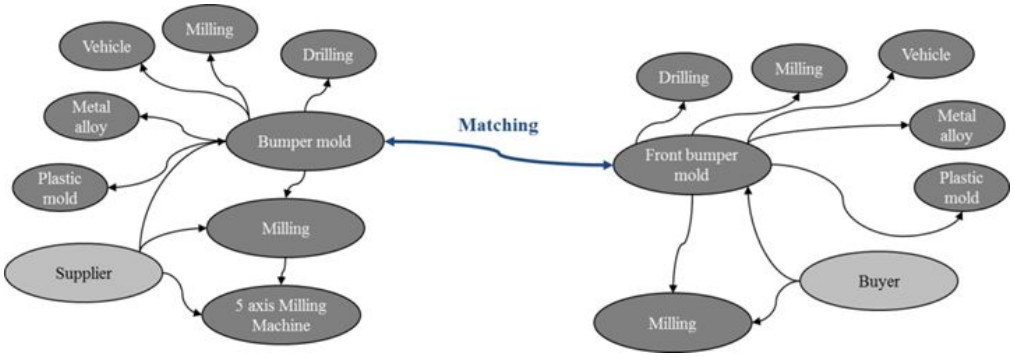

Figure 7. Concept diagram for semantic matching.

5. MANUFACTURABILITY ASSESSMENT IN EMSS

EMSS is equipped with an assessment model of manufacturability to evaluate capabilities of selected suppliers. Supplier's manufacturing capability is hierarchically decomposed into following performance criteria; 1) service and customers, 2) facilities and human resources, 3) quality assurance, 4) contract and delivery, 5) financial status. Figure 8 shows the hierarchical structure. Each performance criterion has various sub-criteria to quantitatively rate the candidates. The sub-criteria are also decomposed into next-tier sub-criteria, if necessary. However, qualitative criteria such as strategic policies and mission statements are excluded from automatic calculation for rating, but they are evaluated in the measure of "yes" or "no".

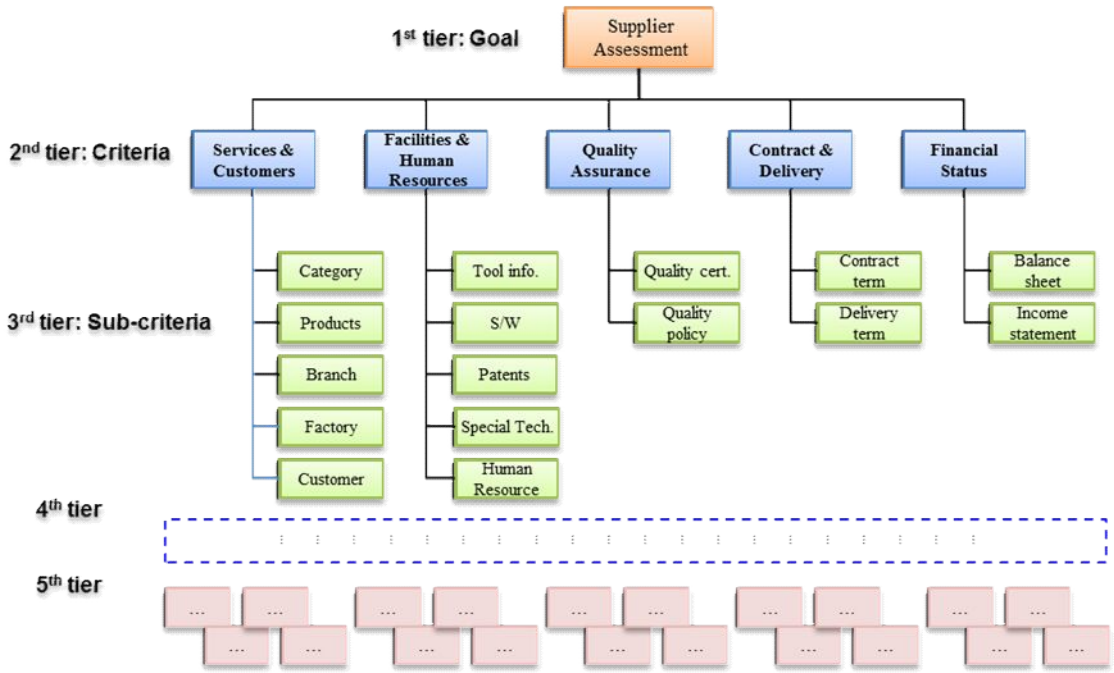

Figure 8. Hierarchy of assessment criteria.

There are four assessment types in the evaluation method as illustrated in Table 2. Pass-type means that some indices or sub-indices are not necessary to be assessed such as address, location, and name of the company. However, sometimes a buyer wants a specific location of a supplier, such as Korea, Malaysia, or US. In this case, those indices can be evaluated by using Y/N-Type means that indices or sub-indices satisfy the buyer's requirement (yes) or not (no). Score-Type means that indices or sub-indices are evaluated as a certain value of score, which shows a relative ranking such as product quality, tolerance limit, and so on. Buyer-Type means those indices or sub-indices need a qualitative assessment. They are composed in text or sentences such as strategy, future plan, company vision, etc. In this case, suggested evaluation model only shows the contents instead of proceeding the evaluation process in order for the buyer to refer to the suppliers initiatives.

Table 2. Four Assessment Types in the Suggested Evaluation Method.

Assessment Type	Description
Pass-Type	Indices unnecessary to be assessed
Y/N-Type	Indices assessed satisfied(yes) or not(no)
Score-Type	Indices assessed quantitatively in score
Buyer-Type	Indices assessed qualitatively by the buyer

6. CONCLUSIONS

We suggest EMSS that is a manufacturer scouting system via web-based for buyers and suppliers who find partner. EMSS consist of collaboration ontology for matching between buyer with supplier, and manufacturability assessment module to evaluate supplier's capability. Until now, other supplier discovery methodologies focus on matching product requirement. However proposed collaboration ontology considers supplier requirements as well as product requirements. Also, supply chain is expected to be stable and agile, since the framework helps to discover suppliers that may be previously unknown. And proposed manufacturability assessment methodology can evaluate core manufacturing capability. Proposed evaluation model is important for evaluating core manufacturing capability.

However, there are still many things to study for further research. Firstly, to reflect industry realities, we will extend the ontology by capturing the supplier's capability information systematically. Secondly, we need a comparison study between expert and suggested evaluation model. Thirdly, for verifying the evaluation method, we need to compare with another evaluation model.

ACKNOWLEDGEMENTS

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