Abstract—In this dynamic IT environment with increased global competition, enterprises must achieve greater business agility. As transactions and decision makings are made with information from both inside and outside the enterprise, enterprises are required to process more data on the World Wide Web in an interoperable manner. Semantic technology can be a useful tool to deal with this challenge. We have surveyed a number of articles predicting future technology trends and identified key dimensions for the future. We argue that semantic technology can be a key enabler for these dimensions and propose practical strategy for applying semantic technology to enterprises. A semantic web enterprise framework is proposed with guidelines for step-by-step implementation plans.

Index Terms—Semantic Enterprise Framework, Semantic Technology Adoption, Semantic Component Development Plan

I. INTRODUCTION

The economic, social, and technological developments trigger big changes in the business environment. The Internet has become an integral part of enterprise computing and continues to influence the business environment by providing both challenges and opportunities.

There have been two major trends dictating recent changes in the World Wide Web (Web): namely, Web 2.0 and Semantic Web. Web 2.0 is characterized by collective intelligence, mash-ups, social networking, and others that are associated with a new breed of Web applications and services. While there are numerous successful cases attributable to Web 2.0, Semantic Web has been denounced in many aspects as being too idealistic. But we believe that semantics, which is lacking in the current computing environment, is indeed a key feature that is required for intelligent services [1].

Semantic Technology (ST) is often understood as the activities and standards for the Semantic Web (SW) promoted by the World Wide Web Consortium. While SW is an important movement involving ST, we define ST as the technology pertaining to the use, storage, and management of semantics separate from the programs and the database instances. In this respect, ST is an enabler of a myriad of intelligent applications including the Semantic Web. In other words, Semantic technology is the key feature which contains architecture for interconnected communities and vocabularies for achieving interoperability. It also includes a set of interoperable standards for knowledge exchange [2]. However, there are still some ambiguities in the methods to realize semantic technology from the viewpoint of enterprise applications. And there are no clear and realistic approaches to reach the vision of Semantic Web in practical ways.

In this paper, we summarize major technological trends in future applications, and discuss how semantic technology can support these dimensions. Second, we review the recent criticism about the methods and approaches around semantic technology, and present a practical strategy for semantic technology adoption in the enterprise environment. Finally, we propose a semantic enterprise framework that supports the technological dimensions derived from the future trends. Also presented is a brief introduction of the development plan for each component of the enterprise framework based on our practical adoption strategy.

II. ROLE OF SEMANTIC TECHNOLOGY IN FUTURE TRENDS

Recently there have been quite a few predictions about future IT technologies and Web trends [3]-[5]. We derived the main directions of future technology from those predictions and the publishing trend of several important conferences related with semantic technology [6]-[7].

As shown in Fig. 1, the technological features that are demanded in future technology trends can be summarized into six dimensions: transforming the real-world into computable information, dealing with heterogeneity both at the data and systems level, ability to provide intelligent processing over complex information, enhanced modes of user interaction, sufficient computing power to support complex high volume transactions, and pervasive computing. Semantic technology is expected to play critical roles particularly in the following dimensions.

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A. Real World to Computable Information
To represent the various and complex objects in real world in machine-processable form, it is important to build up a computing foundation that supports a high level of abstraction. For example, sensor networks and other data collecting tools are expected to generate a vast amount of data at varying levels of granularity and perspectives. Without the ability to model and process these objects at an abstract level, it would be difficult even to comprehend the structure of the database let alone process them in a meaningful manner. Semantics provides a high level of abstraction that helps us map real world signals to manageable data object.

B. Dealing with Heterogeneity
We expect most of the creative new services of the future will come from integrating multiple systems and information resources. We need more flexible and powerful tools for dealing with heterogeneity than what are available presently. Heterogeneity is dealt with by standards and abstraction. As previously mentioned, semantics provides abstraction. Semantics can help to deal with data heterogeneity in much the same way it did to deal with mapping real world signals to computable objects. Furthermore, the usability of interoperability standards such as Web services can be greatly enhanced by supporting semantic description of the services and interfaces.

C. Intelligent Processing Using Enriched Information
Personalization and context-awareness are two of the most important aspects of intelligent future services. Learning and adaptation are also what we expect future systems would be capable of doing. All these require algorithms that identify patterns from a database, match them against the current situation, and decide on actions to take. Semantic technology includes various types of reasoning methods. ST can help in improving learning systems by providing the right level of abstraction as well as inference mechanisms. ST also includes data enrichment models and techniques; namely, RDF, RDF-S, and OWL. Pattern recognition and inference can be enhanced by providing semantics of the data involved.

III. A PRACTICAL SEMANTIC TECHNOLOGY ADOPTION STRATEGY
Semantic technology is expected to be an important factor which enables the future services and applications. However, the approaches so far have tried to solve problems on a too ideal point of view. These approaches have failed to produce concrete results. Therefore it is extremely important to have a feasible strategy for semantic technology deployment that will bring tangible value to the enterprise.

A. Roadblocks to Semantic Technology Adoption
Semantic Web, which has been the most visible organized effort for semantic technology, has not been able to live up to its potential. There are very few successful business cases for Semantic Web. Its approach is too ideal. As a result, many people question the effectiveness of semantic technology.
Table 1. Differences between Conventional Approach and Practical Approach

<table>
<thead>
<tr>
<th>Conventional Approach</th>
<th>Practical Approach</th>
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<tbody>
<tr>
<td>Focus on what we don’t have upper ontology</td>
<td>Focus on what we have transactional data</td>
</tr>
<tr>
<td>Focus on inference</td>
<td>Focus on data</td>
</tr>
<tr>
<td>Complex concept hierarchies</td>
<td>Simple usable concepts</td>
</tr>
<tr>
<td>FOL vs F-Logic vs DL</td>
<td>Low degree of inference</td>
</tr>
<tr>
<td>Satisfy scientific constraint</td>
<td>Satisfy business value</td>
</tr>
<tr>
<td>completeness, decidable, …</td>
<td>performance, feasibility, …</td>
</tr>
<tr>
<td>Professional Knowledge</td>
<td>Collective Intelligence</td>
</tr>
<tr>
<td>A few experts building a knowledge base for everyone to use</td>
<td>Harvest knowledge embedded in pre-existing enterprise databases</td>
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Especially, Iskold observed in [8] that Semantic Web has remained an academic exercise because of the limitations of classic approaches over technological, scientific, and business challenges. Furthermore, there exist concerns that applying semantic technology could make systems difficult for end-users; heated discussions about technology-centric issues such as description logics, artificial intelligence, and natural language processing are barely comprehensible to most people [9]-[10], and will surely turn away users, developers, and decision-makers, if not backed up with clear evidence of business value.

As for the construction of semantic contents, namely, ontology, majority of projects have focused on complex concept hierarchy or upper ontology, mathematical propositions, and reasoning. They have been trying to achieve the ideal goal of having machines completely understand as we humans do. Hence, it has been difficult to develop a working system even with only a moderate amount of semantics.

B. Practical Semantic Technology Implementation Methodology

We believe the key points for the success of semantic technology are to support the requirements of intelligent applications to the degree of being practically feasible. We propose a two step process in implementing semantic technology. First, data-ready, and then, service-ready.

Semantics is about meaning, and meaning is embedded in data. Many semantic projects have failed because they focused on intelligent processing without having enough semantic contents to work with. You must have a well structured database that can be manipulated and inferred upon. Being data-ready involves having clean data, well-defined and understood metadata, explicit representation of relationships between entities not only at the schema level but also at the instance level. For this purpose, a thorough analysis of information requirements against current legacy data should be preceded. The analysis over data forms the basis of defining usable formal vocabularies, concept hierarchies that are not necessarily too deep, and essential including integrity constraints. These results modeled and stored in a structured way make the system data-ready.

Data-ready systems evolve into the service-ready systems. Service-readiness involves system-level interoperability, mash-up support, ability to navigate through and answer queries over the aforementioned database. Inference is one form of processing of data. Simple inference can be done using database query languages such as SQL, while some services may require more powerful inference capabilities. The system architect must weigh scalability and performance against complex algorithms. Service-readiness can be evaluated on the basis of interoperability, functionality, robustness, and scalability.

Table 1 summarizes the differences between the conventional approach and our proposed approach.

IV. SEMANTIC ENTERPRISE FRAMEWORK AND ITS DEVELOPMENT PLAN

Intelligent semantic services like u-learning, customized content delivery, and context-aware services consist of several technology components. We present our semantic system framework and its components.

Fig. 2 shows a high-level organization of system components for semantically-enriched services. They can be categorized into three layers: foundations, semantic components, and collaborative components. As we mentioned in chapter 3, enterprises should approach semantic technology in a practical point of view. Similarly, each component in semantic enterprise framework needs a feasible development plan which is composed of short-term, mid-term, long-term plans.

A. Foundations

The first level of semantic enterprise framework consists of fundamental technology, which utilize the resources that the enterprises already have and form basis of intelligent services.

Semantic Enterprise Information Architecture: It converts existing information architecture into semantic architecture by adding semantic information. In short-term and mid-term plan,
Fig. 2 Semantic Enterprise Framework consists of core components which enable future services

Semantically enriched business data are to be built by analysis over existing data. Simultaneously, interoperability between systems should be obtained. A vision for long-term development plan contains the building of SSOA(Semantic Service-Oriented Architecture) and strengthening business agility to cope with dynamic environment.

Semantic Infrastructure:
Intelligent services require various technical backgrounds; i.e. network protocol, grid computing, standards for data representation, etc. Short-term and mid-term plan concentrate on data standardization and instance collecting on various domain. In long-term plan, connected environment between devices should be established for Real World Web environment.

Reasoning:
A set of techniques are used to retrieve new information from existing information. In the short-term plan, we should develop efficient methods for traversing the simple graph model and probabilistic reasoning. In mid-term and long-term plan, reasoning techniques would support multi graph model, Description Logic and its extensions.

Privacy & Security:
The introduction of semantic web in future computing environment will change the way of services. As services are evolving more intelligent and personalized, the importance of user’s private information like profiles and usage logs is getting larger. Nevertheless, the current state-of-the-art techniques of Semantic Web do not fully cover the potential problems about privacy and security issues. Service providers should protect privacy and guarantee the secure process in personalization. We suggest the plans about for which can prohibit leaking the personal information. Short-term plan concentrates on modeling and implementation about privacy control based on policy and gradually develops system to process it. Long-term plan introduces the concept of private workspace considering social network environment.

B. Semantic Components

Semantic components layer consists of the components which introduce semantics into user application based on foundation components.

Search & Recommendation: It builds an environment which user can access to ‘Right Information’ easily using semantic information. In short-term plan, enterprises should focus on how to use tags and contents metadata for search engine. In mid-term and long-term plan, improving in quality of search result by analyzing semantics of metadata and social search should be concerned. Search domain is not limited in text documents but can be extended to multimedia data.

Context-Awareness: Users, contexts, and all other objects related to service need to be modeled in context-aware system. Context-awareness means an environment supporting relevant action from reasoning based on the former model. In short-term plan, we recommend to start from modeling simple objects and service scenarios. Then, complex objects which needs
statistical or uncertain model should be manipulated in mid-term and long-term plan. It is recommended to consider reasoning method relevant to each model and interface which processes interaction with users effectively.

**Collective Intelligence:** It means creating useful knowledge by contribution of many people including experts and non-experts. In short-term plan, we suggest to construct an environment which many people can participate in social network. In mid-term and long-term plan, systems need to evolve into pervasive computing environment to collect more information using various devices. Converting collected information into machine-understandable form is also needed.

**Personalization:** Service providers should offer users the contents which are relevant to users’ situations and intentions. Short-term plan of personalization exploits individual profile and usage that are collected from servers. Mid-term and long-term plan utilize extended data that are collected by analysis of existed contents like UCC(User Created Content) and additional information from various devices. During this process, it also needs to consider privacy problem.

**C. Collaborative Components**

Collaborative components are extensive combinations of semantic components. Systems and users can interact with each other through this layer.

**Social Network:** It is an environment to utilize collective intelligence by connecting people who share common interest through various channels. In short-term plan, enterprises need to attract user participation by providing various contents and channel. In mid-term and long-term plan, we propose that enterprises should support semantic connection between communities and link social networks to real life.

**Mash-up & Service Adaptation:** It means an environment for combining various services into new types of services easily. Data and system flexibility is needed for mash-up in short-term. In long-term time, assuring ability of dynamic binding and composing services which are relevant to a situation is getting more important.

**Device Independence & Multi-modal UI:** An device-independent system will be used for an interaction with user through integration between semantics of UI which is supported by various devices. Defining user actions from UI and designing flexible structures are focused in short-term. From mid-term to long-term, how to send user's intention to systems and notify the results to user efficiently in wearable computing and sensor network environment will be important issue.

V. CONCLUSION

It is difficult to define and utilize the semantics of data in computing environment so far. However, it is essential for enterprises to provide intelligent services tailored to consumers’ contexts and preferences. Therefore, many enterprises are applying semantic technology to their business applications. For example, customer’s context is very important to provide personalized services. By applying semantic technologies, enterprises can obtain the customer’s context information from transactional data.

Although there are a variety of researches about Semantic Web and Semantic technology, actually the results of conventional approach have been focused as being too idealistic. Because of the gap between the ideal and the real, many people have questioned whether the Semantic Web can benefit the enterprise and give value to the consumers. We believe these goals have not been met but can be by taking incremental steps.

The use of semantic technology in practical perspective does not need large amounts of time and effort. We also expect that our research can contribute to building and utilizing the knowledge gradually with semantic technology in near future.

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