Proceedings

International Conference on Industrial Informatics

INDIN 2003

August 21-24, 2003, Banff, Alberta, Canada

Rainer Unland, Mihaela Ulieru, Alfred C. Weaver (editors)

Table of Contents

IEEE Catalog Number 03EX768
ISBN 0-7803-8200-5
Library of Congress 2003112578

Preface

2003 defined a milestone in the development of IEEE IES since it was this year that a new, highly exciting conference was launched in an extremely inspiring environment (Banff, Rocky Mountains, Canada). Moreover, this conference was also the starting point and (future) accompanying event for the launch of a new journal on this topic, edited by IEEE IES.

Although there had only been little time to prepare, organize and publicize the conference it was highly successful and well-accepted. It had offered an exciting mix of visionary state-of-the-art keynotes, application-oriented tutorials from distinguished experts in their field, high-quality research papers and workshops on hot topics in this area of research. Altogether more than 100 papers were submitted from all over the world and carefully reviewed. Many of these papers did not make it to the final program which was often not an indicator of missing quality of these papers but of the extraordinary quality of the conference.

Industrial Informatics is a new term coined by the founders of the conference. Its semantics was one of the hot issues on this conference. There were a number of working definitions from which I would like to take a slightly modified one proposed by Jim Christensen:

"Industrial Informatics (II) is the application of information technology (IT) to the solution of economically [and/or technically] significant problems in the primary (agricultural and extractive) and secondary (processing and manufacturing) industries."

According to this definition the main conference presented papers on different topics in the four following main areas:

- e-Factory: Integration of Control, Communication and Information Technologies
- Methodologies and Tools
- Security and Safety
- Intelligent Production Systems

The main conference was accompanied by a number of tutorials and workshops which perfectly rounded off the conference. These proceedings comprise abstracts or full versions of the keynote speeches, the papers of the main conference and the best ones from the workshops. I hope that it will be an inspiring adventure for you to go through these papers and learn from the ideas and views presented by them.

Last but not least it is a pleasure for me to thank the many people who have helped to make this event possible. They were already mentioned in the Welcome Addresses, thus, I will not repeat their names here. However, I would like to especially say Thank you very much to Frank Büscher and Kim Gregg and her daughter Amanda, who have worked hard many nights and weekends overtime to make these printed proceedings possible. Your contributions are really highly appreciated.

Essen, November 2003

Rainer Unland (University of Duisburg-Essen, Germany)
Editor and International Program Committee Coordinator

Welcome Message from the General Chair of the First IEEE International Conference on Industrial Informatics (INDIN '03)

The idea of INDIN'03 was sparked at IECON02 in Seville, from the momentous encounter of the IEEE-IES Gurus (plotting at the time the genesis of a new IEEE Transactions - on Industrial Informatics) with the organizers of the first International Workshop on Holonic Enterprises (who were planning its sequel). A perfect opportunity to baptize this new IEEE Conference meant to embrace the timely convergence of several streams reflecting today's trends in industrial informatics:

- The initiative of the IEEE-IES to create a forum for the exchange of R&D ideas reporting new developments in industrial ICT (Information and Communication Technologies).
- The collaborative efforts of several international R&D Consortia working under the IMS (Intelligent Manufacturing Systems) umbrella, targeting ICT advances aimed at improving manufacturing production (Holonic Manufacturing Systems; Plant Automation Based on Distributed Systems; IMS Network of Excellence, etc.)
- The progress in industrial application of the most advanced computational intelligence techniques – carried on by the BISC (Berkeley Initiative in Soft Computing) Special Interest Groups
- The latest trends in the development of adaptive, evolvable, autonomous synergetic hardware-software integrated computing tools defining, and defined by the new area of autonomic computing
- The efforts carried on by FIPA (the Foundation for Intelligent Physical Agents) to standardize the development of intelligent software technologies – Multi-Agent Systems – that enable, among others, cloning of 'societies' in Cyberspace capable to back mankind in several endeavors

Now, here we are, nine months later after conception, delighted and amazed to see our common dream come true due to your involvement, creativity and dedication to one of the most significant research areas driving our World today!

The Conference, which reflects mainly the IEEE-IES vision on the emerging trends in Industrial Informatics, is strongly backed by dedicated workshops and panels reporting advances in each of the individual streams. By bringing these great minds and ideas all together into this unique bouquet we aimed to create a synergetic environment for the exchange of ideas on developing integrated IT solutions capable of acting as powerful infrastructures for today's industrial needs.

In 2002 I led, together with the R&D leaders of Schneider Electric, the first International Workshop on Holonic Enterprises that was aimed at merging the forces working towards the development of infrastructures supporting the creation and deployment of collaborative organizational structures for holonic manufacturing production, ranging from supply chain management to the machine production level. On that occasion I became aware of the powerful technologies and solutions dedicated to the safety and reliability of production that were being made available to the broader communities of interest by the latest research results in this area. Given the challenges facing our World today, I have decided to organize INDIN'03 under the slogan ***e-Logistics for a Fail-Safe World*** in an attempt to transfer the powerful technologies developed in the industrial arena to address critical aspects threatening the safety and security of mankind today. Merging agent technology with industry's best practices inherited from global production and supply chain coordination and latest advances in computational and computing technologies, INDIN'03 aims to enable the development of powerful techniques for the ad-hoc creation of organizational structures capable of addressing emergency response needs promptly in order to support the global efforts in keeping our world a relatively fail-safe environment.

In order for our efforts to be effective and ecological there is a growing awareness that technological development must be backed by a strong value set defining a solid ethical framework as foundation and direction for our work. We are deeply honored and encouraged in this regard by the powerful response received from the leading research forces that enriched the INDIN'03 program with specific keynote addresses and tutorials that go beyond the usual task of coining the milestones in today's research in order to set the vision for the future on critical aspects ranging from values and leadership in the IT-driven world to the impact of IT on today's industry and society in general. The enormous amount of complex and conflicting information bombarding our world today is taking our focus away from the critical issues that need to be addressed, and this by itself looms as a serious threat to the quality of our lives.

There are many questions, and not so many clear answers. What drives mankind today? What do we value as a society? What ingredients are essential for the industrial success portion to be most effective and in tune with mankind's overarching goals? David Johnstone, Soren Brier and Francis Hartman shed light on these crucial aspects of today's emerging industrial IT development. Lotfi Zadeh, Hojjat Adeli and Bill St. Arnaud reveal

particularities driving the trends in IT development in areas ranging from intelligent search engine development to wavelets and grid computing. The true essence of our INDIN slogan is revealed through the virtual logistics technologies exposed by Tharam Dillon and Elizabeth Chang while Alan Martel addresses the status quo here at home in the manufacturing industry and beyond. Essential technological aspects related to industrial standards and methodologies are deepened by our tutorial presenters in comprehensive expositions focusing on industrial control with a special report on risk analysis from the BISC group.

As General Chair of the First IEEE International Conference on Industrial Informatics I am excited and grateful to have brought together this harmonious, rich blend of academic and industry leaders into an innovative forum for discussion and exchange of ideas. I am deeply honored to be in the privileged position of welcoming you all in the beautiful and peaceful environment of Banff National Park. I envision that INDIN'03 is the historic start of a series of future INDIN events that could be destined to become an annual tradition in maintaining the fruitful conversation on the most crucial ICT R&D areas supporting today's global dynamics. Through innovative solutions and creative thinking we can foster a better quality of life for ourselves, and protect this quality of life as our legacy for the generations to come!

Calgary, July 2003

Mihaela Ulieru,
General Chair IEEE INDIN'03

ACKNOWLEDGEMENTS

This conference would not have been possible without the enthusiastic support of a number of dedicated people who went far into the impossible to make this event happen. My most grateful thoughts go to Alf Weaver, Kim Gregg, Rainer Unland, Frank Büscher, Robert (Bob) Begun, Aleksander Malinowski, Carlos Couto, Margaret-Anne Stroh and George Davidescu. They were always available for me keeping things rolling as smoothly as possible in the most stressful times. Highest gratitude goes to Brian Unger and iCORE, our first sponsors, for their generosity and for their kind support of several students. Special thanks to Okyay Kaynak and IEEE-IES without whose constant advice and support this event wouldn't have been possible.

I especially acknowledge the efforts of the workshop organizers (Armando Walter Colombo, Ashok Deshpande, Eckehardt Klemm, Axel Klostermeyer, Arndt Lüder, Masoud Nikravesh, Duc Truong Pham, Huaglory Tianfield, Rainer Unland) for the excellent job done in bringing new trends to the awareness of the research community and by attracting excellent papers and presenters who gave the unique essence to our conference.

Mihaela Ulieru
General Chair IEEE INDIN'03

A Welcome Message from the President of IEEE Industrial Electronics Society

On behalf of the IEEE Industrial Electronics Society, I would like to welcome you to the first of a new conference series that the IEEE Industrial Electronics Society is initiating, under the title "IEEE International Conference on Industrial Informatics."

During the second half of the last century, we have witnessed significant changes in industrial automation. The 1960s were the era of power semiconductor devices (thyristors and power diodes) in the main circuits and analog integrated (operational amplifiers based) control circuits. In the following two decades, the advances in semiconductor technology greatly changed the scene of industrial installations, digital techniques became the norm, with increasing applications of microprocessors. IEEE Industrial Electronics Society was always ahead of these developments, changing the emphasis in the acitivies of the society as appropriate. In 1980s, IEEE Transactions on Industrial Electronics was the main outlet for archiving research results in the topic of microprocessor applications in industry.

During the last decade, we have been experiencing a new paradigm shift, namely the profiletarion of information technology in industrial environments. As industrial systems become more intelligent, automated, and distributed, and as monitoring and control shift to the networked environments and the Internet, the information technology components become of primary importance. As a consequence, Industrial Informatics is rapidly emerging as one of the fastest growing and most promising new technological developments for the next generation and beyond. With this thoughts in mind, IEEE Industrial Electronics Society has initiated this new conference series to be held annually in very close cooperation with industry. It aims to bring together experts from industry and academia working towards the development of enabling control, information and communication infrastructures supporting the deployment of an integrated coordination backbone for global collaborative enterprises with dynamic, flexible, agile and reconfigurable organizational structures.

I would like to take this opportunity to thank everybody involved in the organization of the event for having brought together an outstanding technical program. I hope that the international atmosphere of INDIN 2003 will inspire new friendships among scientists and the engineers of the world to the benefit of all mankind in the years ahead.

Yours truly,

Okyay Kaynak
IES President

Welcome Message from the PC-Chair of the First IEEE International Conference on Industrial Informatics (INDIN '03)

Welcome to INDIN'03, which is sponsored by the IEEE Industrial Electronics Society and technically co-sponsored by the Alberta Informatics Circle of Research Excellence (iCORE), Schneider Electric (Germany), Rockwell Automation (USA) and Phoenix Contact GmbH & Co. KG (Germany).Under the direction of our General Chair Dr. Mihaela Ulieru, INDIN'03 has been organized as a response to the increasing importance of information technology in industrial processes.

David Hughes, editor of *Aviation Week and Space Technology*, said in a 1998 editorial that "Information technology is becoming a key part of everything the aerospace and defense industry does for a living, and as the century closes it is computers and software that hold the keys to the future. The [aerospace] industry is being transformed from dependence on traditional manufacturing into something that looks more like IBM and Microsoft with wings."

That same statement is true about a host of enterprises other than just defense. Not only are new manufacturing systems computer-controlled, they are controlled by networked computers which, increasingly, are globally connected by public or private internets. Thus as industrial systems become more intelligent, more automated, and more distributed, and as monitoring and control shift toward use of the Internet, industrial informatics becomes a topic of paramount concern for both academic and industrial practitioners.

INDIN'03 supports five technical tracks:

- TIP – Intelligent Production Systems
  - Intelligent production and supervision; holonic enterprises; collaborative factory automation; dynamic planning and scheduling; standards; applications.
- TEF – e-Factory: Integration of Control, Communication, and Information Technologies
  - Real-time control; wireless sensors and actuators; information infrastructures; communications technologies; seamless integration; standards; case studies.
- TEL – e-Logistics, Systems Interoperability and Human Machine Interface
  - Enterprise integration; workflow coordination; intelligent infrastructure; virtual enterprises; multimedia; Internet-enabled monitoring and control; novel applications.
- TSS – Security and Safety
  - Data security; safety systems; privacy, security, and authorization for data access and control; security standards for global enterprises; security for healthcare system.
- TMT – Methodologies and Tools
  - Re-engineering; distributed simulation; interoperability; coordination; formal techniques; fuzzy logic; artificial intelligence; algorithm/protocol design and analysis.

I am pleased to report that INDIN'03 has accepted 35 technical papers in these five technical tracks, confirmed eight keynote addresses by leaders in the industrial informatics industry, and arranged for four tutorials on topics of current interest. The program committee hopes that your attendance at INDIN'03 will provide a forum for technical information interchange, an opportunity to meet academic and industry colleagues, as well as an opportunity to explore the beautiful venue of Banff.

The IEEE Industrial Electronics Society (www.ieee.org/ies) is especially pleased to be the sponsor of this conference. Industrial informatics represents a golden opportunity for our society to expand from its traditional roots in power electronics and control systems into the next generation of automated, distributed, computer-controlled and Internet-connected systems. IES was the IEEE's first society to embrace the application of microprocessor technology to industry problems, and I believe that the current situation offers us a parallel opportunity to become the premier IEEE society with regard to innovation, development, implementation, measurement, adaptation, and utilization of information technology as applied to industrial electronics, manufacturing, monitoring, and control. INDIN'03 is our first conference with this specific theme, and we hope it will be the first of a continuing sequence of meetings on these most important subjects.

We thank you for your interest in and attendance at INDIN'03, whether in the role of author, keynote speaker, tutorial speaker, or organizer. The success of the conference depends entirely upon the intellectual contributions of its participants. We are extremely grateful that you have chosen to share your intellectual capital at INDIN'03.

Alfred C. Weaver
Department of Computer Science
University of Virginia
151 Engineer's Way
Charlottesville, VA 22904 U.S.A.
weaver@virginia.edu

Keynote

Web Service Integration in the Extended Logistics Enterprise

Elizabeth Chang
School of IS,
Curtin University,
Perth, WA,
Australia 6845
change@cbs.curtin.edu.au

Tharam S. Dillon
Faculty of IT
University of Technology,
Broadway, NSW,
Australia 2007
tharam5@it.uts.edu.au

Alex Talevski
Dept. of CS&CE,
La Trobe University,
Bundoora, VIC,
Australia 3083
alex@cs.latrobe.edu.au

Abstract

Transportation and warehousing logistics are activities that require strong information systems and computer support. This IT support has expanded with the advent of e-commerce. This has led to the development of e-commerce based systems by companies such as FedEx and UPS which allow their customers to track and monitor the fulfillment of their service on the Internet, provided the goods are being handled by the one corporation, with an integrated system. However, with the advent of B2B (Business to Business) and P2P (Partner to Partner) e-commerce, there has been an increasing tendency to set up consortia that represent several players in a given field. Such consortia consist of companies or organizations in a given field that get together and produce a single site in order to increase traffic through the site compared to other competitor sites and/or extend beyond their region of operation.

A new form of collaboration is likely to develop in the near future leading to the concept of an extended logistics enterprise. This extended logistics enterprise provider assembles a number of companies (or Partners) that are physical logistic providers into strategic alliances that allow sharing of their facilities.

This paper deals with the concept of the extended logistics enterprise and explores the software engineering issues underlying the development of such complex systems.

Keywords

Extended Logistics Enterprise, Systems Interoperability, Web-Service Integration

1. Introduction

The term enterprise application defines a class of applications that automate key business functions, such as managing supply chains and customer relationships. Custom enterprise applications constitute the majority of worldwide software systems and development. The Enterprise Application Market (EAM) has been predicted to grow to US$78 Billion in 2004, where the fastest growing businesses are considered to be E-Business Relationship Management (ERM) and Supply Chain Management (SCM) both representing more than 15% of the market share respectively. The development of an extended logistics enterprise is therefore of considerable economic importance.

The advent of the web and its intrusion into business, commerce, government and health have provided mechanisms for binding organizations together, for carrying out sales over great distances and at any time. It has created new modes for marketing and enabled partnerships previously inconceivable within a wide array of business as well as other human activities. A consequence of this connectivity and information richness is that one is faced with an increasingly dynamic business environment and marketplace. This has created the need for new business paradigms and organization forms that transcend the previous static, closed, competitive models and move to flexible open re-configurable, often collaborative models that are able to respond to the business environment dynamics inherent within the networked economy. This new paradigm is referred to as "extended enterprise". A key factor in the success of such extended enterprises is the creation of the underpinning information infrastructure to carry out the required services.

- Services and interfaces
- Underlying architectures
- Data and document formats

Some business-oriented problems include
- Business processes
- Business requirements and wants
- Standards (laws, languages, documents, specifications etc.)
- Customer needs

Even worse, the problem becomes a multidimensional one when integrated solutions must cope with non-functional requirements such as security, availability and transactions, to name just a few.

Existing solutions of partner to partner integration of less complexity have utilized one of the four approaches below:

- Server side redirection
- Message based information sharing
- Third part message brokers or business connectors
- XML based technologies.

1.1. Server side redirection

Server side redirection is employed by many large organizations to redirect users between their partner organizations. The advantage of this approach is that it is simple and has a low cost implementation.

The disadvantages are:
- One partner's trusted user is not a trusted user at the other site - thereby resulting in one or more login processes
- No collaborative business processes are taken into account
- Loss of customers' session information takes place
- If the remote site's designated URL changes, the customer is left on their own to find out where they are.

1.2. Message Based Information Sharing

- Has high setup and maintenance costs
- Uses VANs, which are expensive to set up and use
- Uses a document format that cannot be easily read by a person
- Only data can be transferred no process is considered.
- Experiences document translation difficulties because of industry-specific variations on standard EDI documents

1.3. Third Party Message Brokers

Third Party Message Brokers & Business Connectors are similar to each other. They differ only in architecture and the way they process the messages.

Advantages of using these technologies include:
- No implementation costs or complexities involved (off-the-self packages)
- Well tested methods in handling information exchange

The Disadvantages are:
- Cannot handle dynamic or changing business process (which is true in many companies including the systems of the business partners)
- Any changes in the business require time consuming re-adjustment to the Message Broker/Business Connectors
- Unfriendly or incompatible technologies compared to existing legacy software at the companies.

1.4. XML approaches

A purist XML approach would involve replacing all databases (such as Relational Databases) with XML databases with query of this database either using DOM programming or XQL Query Language but this would involves replacing all existing largely relational databases in XML format which from a commercial viewpoint would not be an acceptable solution. In addition it would require definition of a standard markup language for that domain which is time consuming involving many parties and vendors.

XML Data Middleware utilizes XML to provide the glue for the organization to organization information exchange. Thus data from one organization is transformed from its own format into XML before transmission to the other organization and then the second organization re-translates the XML message into a format compatible with its own system.

In this paper we propose a framework that forms the basis for the integration and reconfiguration of supply chain enterprise applications and web-services. In following section we discuss the architectural requirements of distributed supply chain application, section three outlines the proposed

middleware technologies, which increase the effort required to integrate and deploy semantically compatible and interoperable components across multiple middleware platforms. Although current component middleware solutions provide technological support for component connection and interaction, current middleware technologies do not yet provide complete end-to-end solutions that support enterprise application development in diverse environments. Simply using middleware to integrate disparate enterprise applications has proven to be insufficient. For instance, this type of simple integration approach does not consider issues such as integration of different data models, workflow engines, or business rules, to name a few.

To solve this problem we propose a distributed Meta model driven framework. The presented framework explicitly identifies an enterprise application, its interface and the services that it provides and how these services are integrated into other heterogeneous applications dynamically. Through its interfaces an enterprise application exposes both its provided and required services. In this way it is possible to make changes to any of the connected enterprise applications internals as long as the changes continue to adhere to the interface contract. An interface contract specifies the pre-conditions that must be met by a client prior to invoking a server operation and the post-conditions that it will receive as a return from the server. The enterprise application META data model as illustrated in (Fig. 2) is an explicit representation of an enterprise application, its interface and its provided and required services. We can call this the enterprise application service specification (EASS). We have used the Unified Modeling Language (UML) to illustrate our framework. However, in future it may be necessary to define a different notation system.

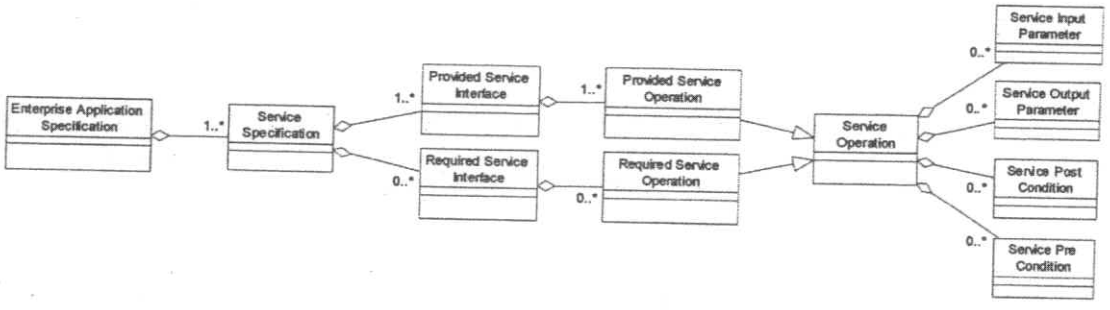

Fig. 2 UML Meta model for enterprise application service specifications

3.1. Interfaces

An interface is a collection of operations that specify a service provided by a web-service. Interfaces are seen as a provider and a consumer [12]. The concept of required and provided interfaces is essential to enabling software plug and play. It is possible to replace or modify a web-services' internals as long as the implementation adheres to the interface contract. An interface contract specifies the web-service interface, its exposed attributes and operations, the interaction protocol and the pre and post-conditions that must be met in order for a enterprise applications to interoperate. Each enterprise application will expose multiple web-services and each web-service will expose one or more provided interfaces and zero or more required interfaces.

A web-services provided and required interfaces can be obtained by querying a central Meta data repository or the web-service itself.

3.1.1. Provided Interfaces expose the underlying provided operations and attributes that represent the services that a web-service provides. Services are operations that can be accessed through the provided interface by the client. The results of a call to a provided operation should be documented as post-conditions of that operation.

3.1.2. Required Interfaces. A web-service may also request a list of services that it requires in order to perform. A web-service may request either operations or attributes through its required interfaces. The requirements of a web-service whether attributes or operations should be documented in the components pre-conditions. If these requirements are not met a

attribute [15]. Attribute adaptors are not discussed in this paper.

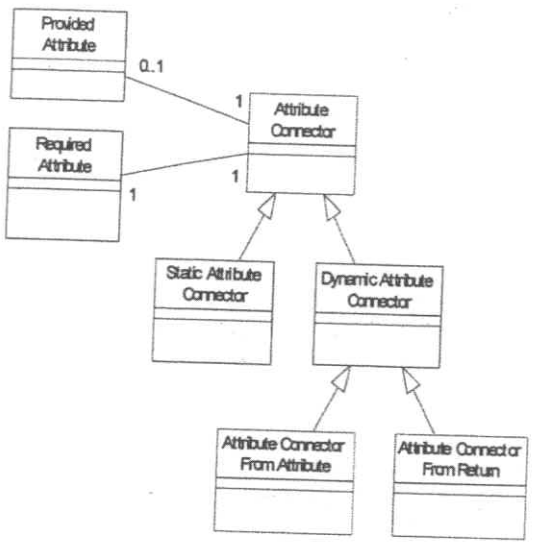

Fig 4. UML Meta model for component attribute connector

3.4. Composition – Operation Connectors

Collaboration defines elements that work together to provide some cooperative behavior. Therefore, collaborations have structural as well as behavioral dimensions. A given class might participate in several collaborations. Thus, compositions are groups of interconnected web-services or other compositions that are composed together using operation glue in order to perform a particular task (Fig. 5).

Like attribute connectors, operation connectors are used to glue required and provided operations together. Once glued, a required operation always calls the provided operations that it is glued to. Two operation connector types exist. Operation connectors can be used to connect required component operations to provided ones or to a static return value as provided by the user. Operation adaptors may be used when a provided operation has an incompatible return type or parameters and needs conversion. If required an attribute adaptor may be used to convert both the return type and operation parameters to what is required [15]. Operation connectors are not discussed in this paper.

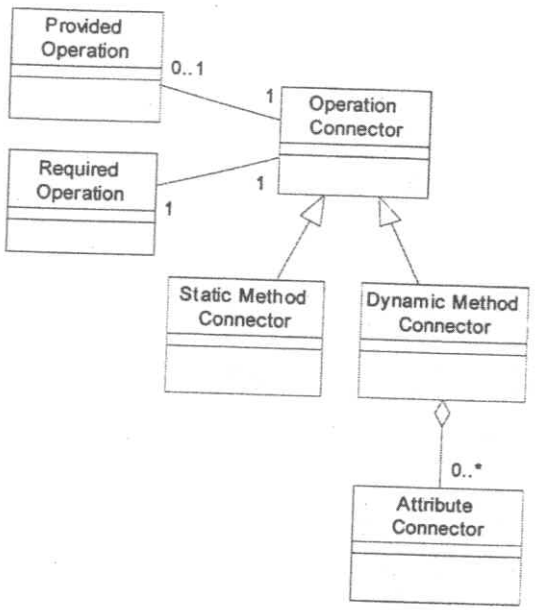

Fig 5. UML Meta model for component operation connector

4. Conclusion

Due to the complexity of integrating heterogeneous enterprise applications and their services while maintaining complicated non-functional requirements, the lack of a framework for expressing component collaboration makes such service oriented programs more difficult to integrate, reconfigure and evolve. Furthermore, in order to take the notion of web-service integration further we need to develop a model of inter-enterprise workflow that is capable of incorporating web-services. This paper presents a framework for web service integration in an extended logistics enterprise. Currently, a prototype system to test these ideas in being implemented and can be viewed on www.ipowerb2b.com.au.

References

1. W. Brenner, R. Zarnekow and H. Wittig (Eds.), "Intelligent Software Agents: Foundations and Applications", Springer-Verlag, Berlin, Heidelberg, 1998.
2. Aglets, URL: http://www.trl.ibm.co.jp/aglets/.
3. Voyager. URL:http://www.objectspace.com/voyager/
4. FTP software agents, URL: http://www.ftp.com/
5. Odyssey, URL: http://www.genmagic.com