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FRAMEWORK FOR A BUSINESS INTEROPERABILITY QUOTIENT MEASUREMENT MODEL

Por

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Abstract

Over the last decade the context of Interoperability has been changing rapidly. It has been expanding from the largely technically focused area of Information Systems towards Business Processes and Business Semantics. However, there exists a need for more comprehensive ways to define business interoperability and enable its performance measurement as a first step towards improvement of interoperability conditions between collaborating entities.

Through extensive literature reviews and analysis of European Research initiatives in this area, this dissertation presents the State of the Art in Business Interoperability. The objective of this dissertation is to develop a model that closely captures the factors that are responsible for Business Interoperability in the context of Collaborative Business Processes. This Business Interoperability Quotient Measurement Model (BIQMM), developed in this dissertation uses an interdisciplinary approach to capture the key elements responsible for collaboration performance. Through the quantification of the relevance of each element to the particular collaboration scenario in question, this model enables a quantitative analysis of Business Interoperability, so that an overall interoperability score can be arrived at for enhanced performance measurements.

Finally, the BIQMM is applied to a business case involving Innovayt and LM Glassfiber to demonstrate its applicability to different collaboration scenarios.

Sumário

Durante a última década no contexto da interoperabilidade vem mudando rapidamente. Tem vindo a expandir em grande parte da área tecnicamente foco de Sistemas de Informação para Processos de Negócios e semântica do negócio. No entanto, existe uma necessidade de formas mais abrangentes para definir a interoperabilidade de negócios e permitir a sua avaliação de desempenho como um primeiro passo para a melhoria das condições de interoperabilidade entre as entidades colaboradoras.

Através de extensa revisão da literatura e análise de iniciativas europeias de investigação nesta área, esta dissertação apresenta o estado da arte em Business Interoperability. O objetivo deste trabalho é desenvolver um modelo que melhor capta os fatores que são responsáveis por negócios de interoperabilidade no contexto de processos colaborativos de negócios. Este Business Interoperability Quotient Measurement Model (BIQMM), desenvolvido nesta dissertação utiliza uma abordagem interdisciplinar para capturar os principais elementos responsáveis pelo desempenho de colaboração. Através da quantificação da relevância de cada elemento para o cenário de colaboração especial em questão, este modelo permite uma análise quantitativa de Interoperabilidade do comércio, de modo que uma pontuação global de interoperabilidade pode ser alcançado por medidas de desempenho aprimorado.

Finalmente, o BIQMM é aplicada a um caso de negócios envolvendo Innovayt e LM Glasfiber para demonstrar a sua aplicabilidade em diferentes cenários de colaboração.

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Abbreviations

AIF	Athena Interoperability Framework
B2B	Business to Business
BIP	Business Interoperability Parameter
BIQMM	Business Interoperability Quotient Measurement Model
DRM	Digital Rights Management
ECOLEAD	European Collaborative networked Organisations LEADership initiative
EDI	Electronic Data Interchange
e-GIF	e-Government Interoperability Framework
EIF	European Interoperability Framework
ICT	Information Communication Technology
IDABC	Interoperable Delivery of European e-government services to public Administrations, Businesses and Citizens programme
IDEAS	Interoperability Developments for Enterprise Application and Software
IP	Intellectual Property
IPR	Intellectual Property Rights
IT	Information Technology
LMFO	LM Funding Office
OPAL	Object, Process, Actor modelling language
OWL	Web Ontology Language
SOAP	Simple Object Access Protocol
SSO	Standard Setting Organizations
UDDI	Universal Description, Delivery and Integration
VBE	Virtual Business Enterprise
VO	Virtual Organization
WSDL	Web Services Description Language
WS-I	Web Services Interoperability

1. Introduction

1.1 Context

Companies can rarely afford to conduct meaningful transactions without having close interactions with other organizations and entities. They often need to form innovative networks of value creation where they can bundle core competencies from different partners. The requirements for collaboration vary from industry to industry and depend on collaboration objectives. Sometimes, the closeness of coupling can be extremely high and result in the formation of Virtual Organizations, where two or more organizations can come together to have a common strategy and behave like a single entity. On the other hand, organizations can also collaborate in a competitive scenario, competing against each other but at the same time coordinating to benefit their common interests. Also, organizations that have customer supplier relationships require not only transactional interactions but also more strategic planning and collaboration to optimise their efficiencies.

Regardless of the type and degree of collaboration required, it is the single most important factor towards the successful conduction of business. And the core to conducting successful collaboration is the interoperability between organizations. By conforming to standardized interoperability frameworks organizations can seamlessly collaborate, share information, collectively create knowledge and smoothen business processes. Although the research community sees networked organizations as an undisputable reality, companies find it very time-consuming and difficult to establish electronic business relationships with a large number of business partners, and the sheer complexities involved make interoperability difficult to achieve. The major challenges hindering the establishment of interoperability are enumerated:

Lack of trust: The lack of trust between partners poses a challenge to collaboration where reciprocal benefits is one of the prime motivators. For example, in a buyer supplier relationship both collaborators focus on squeezing prices and a greater transparency can sometimes lead to lowering of bargaining power. [Hoyt/Huq 2000]

Isolated semantic islands: Despite the advent of internet technologies, decades of isolated business models have left semantic islands with their own standards and services. Integrating these into a global interoperability framework can be difficult since existing businesses can

face disruptions and tremendous inertial forces would be needed to be circumvented. [Kling et al. 1996]

Responsibility Gap: Inter-organizational networks have spaces between businesses for which the responsibility have not been elaborately assigned. Issues for business networks such as network outages, disruptions of syntactic or semantic data integrity or system updates can lead to conflicts. [Kumar/Diesel 1996]

Lack of resources: Often resources required for integration exceed the capabilities of internal IT. External agencies providing those resources could be too expensive for the collaborators. Hence there is a need for interoperability not only to be easily available but also cheaply realisable. [Dai/Kauffman 2001] This is where standardization and frameworks by Standard Setting Organizations and public bodies especially in the area of IT can play a major role to curb inefficiencies and reduce the cost of interoperability.

Trust and intellectual property: The intellectual property of collaborative process design and the exchange of information needs to be protected from competitors and shared with partners. Lack of security can be a strong hindrance to interoperability. Fail safe operations and protection against unauthorized access must be guaranteed.

Many-to-many relationships: While collaboration with one partner is a starting point, information flows need to be optimised across several tiers and several partners which is a much more challenging task. [Le 2002] The ability to quickly and inexpensively integrate a lot of processes and supply chain partners is a key benefit from cooperation processes [El Sawy 2003].

These challenges need to be overcome to ensure Business Interoperability can be easily attained within various collaborative scenarios. Hence it is important to have an integrated approach to Interoperability and view it as a sum of different interoperability levels encompassing technological, organizational and managerial issues.

1.2 Objectives

To strive towards the aim of creating an optimal interoperable ecosystem, it is critical to analyse the barriers to effective collaborations. For companies to foster connections and establish smooth workflows with other entities, all hindrances to collaborations must be removed. Knowledge and information flows should be seamless, with a platform for sharing of knowledge and innovation that is highly interoperable and at the same time customizable to different needs.

Interoperability in the context of collaborating organizations need to be viewed in a much broader sense than traditionally done. Interoperability has been focussed within the realms of IT and technology. Although IT plays a key role in making business interact seamlessly, such an information exchange infrastructure, it is meaningless if the other core aspects of business collaborations are not interoperable. Hence the concept of Business Interoperability goes much beyond IT into organizational aspect of businesses and encompassing a culture for people to people interactions.

Smoother workflows also mean that business processes originating in one organization can seamlessly flow into a collaborating partner organization without getting caught into bureaucratic hurdles. Systems for conflict resolutions and Intellectual Property Management can further ensure business interoperability.

The aim of this dissertation is to conduct intensive literature reviews to identify key interoperability parameters. Identification of Business Interoperability Parameters (BIP) is the first step towards assigning directions for further work to ensure development of successful business interoperability frameworks. The dissertation also aims to develop a Framework for Interoperability Quotient which will attempt to quantify interoperability scenarios between two collaborating organizations.

Further, through a case study in the area of collaborative innovation, this dissertation will attempt to apply the Interoperability Evaluation model to assign interoperability scores to the collaboration between an Innovation Consultancy, Innovayt and a leading Danish wind turbine blade manufacturer, LM Glasfiber.

1.3 Organisation of the Dissertation

Chapter 2 of the dissertation discusses the various approaches to Interoperability and analyses the literature existing in this area. It tries to define Business Interoperability and differentiates it from the concept of Business Networkability. Further, it tries to discuss the paths to achieving ICT interoperability and discusses the process of standardization and role of Standard Setting Organizations towards this end. It discusses IPR management issues and Semantics within the context of interoperability. Finally chapter 2 concludes with an assessment of the impact of interoperability initiatives and the potential gains that interoperability could have.

Chapter 3 makes an assessment of European Initiatives and Projects with regards to advancement of Business Interoperability. It briefly discusses the results of the Athena Interoperability Framework and its impacts. Then it discusses the IDABC European E-government services programme which aims towards the ambituous goal of a pan European e-government interoperability and the European Interoperability Framework (EIF) that provides a technical approach to achieving it. Finally it discusses the ECOLEAD project and its results especially with respect to the Virtual Organization Performance Measurement.

Chapter 4 discusses the results of this dissertation and details the developed model for interoperability quotient evaluation.

Chapter 5 applies the developed model to analyze the interoperability quotient of the LM funding office collaboration between LM Glassfiber and Innovayt. Through a detailed interview of the key stake holders from Innovayt, an analysis of Business Interoperability is performed.

Chapter 6 concludes the work done in this dissertation and plans a roadmap for future work in this area.

1.4 Research contribution of this dissertation

This dissertation firstly aims to review the existing work in the relatively new field of Business Interoperability. In the subsequent sections, the major approaches to interoperability have been analysed and a literature review of the state of the art in this area has been incorporated. This thesis has also carried out a review of major European Initiatives and Projects that promote interoperability and have influenced the writing of this dissertation.

The key research contribution of this dissertation is the introduction of a highly interdisciplinary approach to business interoperability. While most traditional approaches to interoperability have been focused on information systems, some recent approaches have incorporated business processes and semantics within its domain. While most of these approaches use information theory and IT based tools to address the issues, it was felt that several other key issues that affect the performance of collaborative situations and hence inter-organizational interoperability, cannot be solved by just these approaches. Successful business collaborations require efficient business strategies that address potential conflict of interests, an interoperable work culture, clarity on IPR management, and several other issues that need to be addressed for ensuring a smooth overall interoperability. Hence expertise from several disciplines, including Management, Law, Sociology, Psychology, and Engineering need to be engaged before a comprehensive model for assessing and addressing interoperability is evolved.

Another key contribution of this dissertation is that, for the first time, it attempts to create a Business Interoperability Quotient Measurement Model (BIQMM) that can quantify interoperability parameters and give overall interoperability quotients. This approach could be a key component of a comprehensive performance measurement system. Also this model recognizes that different organization have very different issues when it comes to interoperability. Hence this model attempts to ascertain the relevance of each identified interoperability parameter to the particular collaboration scenario, thereby giving more importance to more relevant issues. Thus this model can also act as a key agent for identifying key areas where interoperability needs to be strengthened.

Although the performance measurement methodologies has the potential to be further improvised and detailed in future works, this dissertation has clearly expanded the horizon with regards to our understanding and evaluation of Business Interoperability.

2. Literature Review and Analysis

2.1 Existing Approaches to Interoperability

While Research in Interoperability has been in focus for decades, it is majorly in the past decade that interoperability has been approached beyond the traditional area of IT Systems.

Some of the approaches have been described below:

Networked organisations and value model research:

While the networked organization stresses on nodes and linkages between organizations where it lacks is in analysing the comprehensive nature of these linkages. Some of the relevant works in this area include transaction cost theory [Williamson 1989], organisational theory ([Sydow 1992], [Snow et al. 1992]), new institutional economics ([Malkin 1995]; [Williamson 1998]), coordination theory [Malone/Crowston 1994], business networks and information management [Malone 1987], [Klein 1996a,Wigand et al. 1997]). Networked organisations and value model research explain the emergence and success factors of new types of networked organisations, but tend not to focus on business interoperability and lack supporting management techniques ([LI 2005]).

Standards:

[Benjamin et al. 1990] reported that insufficient availability of standards has been the most important barrier to inter-organisational integration. Up to date standards are mostly available for communication services and on the syntactical level [Bussler 2003]. This also applies to WS-I Organisation (Web Services Interoperability Organisation, http://www.ws-i.org) which is chartered to promote interoperability across platforms, operating systems and programming languages by Web Service standards, including Simple Object Access Protocol (SOAP), Universal Description, Discovery and Integration (UDDI) and Web Services Description Language (WSDL).

Various initiatives have been launched to extend XML-based standards to comprise standardization on the semantic level either by industrial associations – e.g. RosettaNet Partner Interface Protocols (PIPs) in the hightech industry, ChemXML as part of CIDX in the chemical industry, the Universal Product Code (UPC) or the European Article Number (EAN) in the retail industry – or by independent providers such as Dun & Bradstreet for company

identifiers. Standards on the pragmatic level are available within companies, but solutions which span across multiple organisations, such as Bolero.net which creates trust among business partners by establishing business agreements and legal frameworks, are rare. Besides the neglect of semantical and pragmatical issues in existing standards, referred to as the 'organisational gap' by [Kubicek 1992], the enforcement and the overlapping between standards remain a problem.

Existing frameworks and standards cover mostly the technical aspects by suggesting standards for presenting, collecting, exchanging, processing and transporting data. Research on networked organizations and value models address strategic and organizational issues. However a systematic analysis of business and management issues with respect to interoperability of organizations is lacking. Also an integrated approach to business interoperability beyond IT interoperability is significantly required.

Interoperability frameworks:

A number of initiatives have tried to systemize and classify the different interoperability aspects into comprehensive interoperability frameworks, among others the e-Government Interoperability Framework (e-GIF), the Levels of Information Systems Interoperability framework (LISI) or the European Interoperability Framework (EIF). Generally, the initiators of these frameworks have been practitioners or public administrations which are pursuing the goal of standardizing across distributed organizations and avoiding technology vendor lock-in. These interoperability frameworks distinguish different layers of interoperability and describe artifacts or standards for each of these layers. With the exception of the EIF, they distinguish the infrastructure, data/message and functions/ services layer. In addition, the EIF introduces organizational aspects of interoperability, e.g. the definition of business goals and the modeling of business processes to enable different organizations to work together. In addition, most frameworks introduce either explicitly or implicitly an evolutionary perspective and suggest a linear advancement from lower to higher levels of interoperability. [Peristeras and Tarabanis 2006] relate existing interoperability frameworks to theoretic concepts from linguistics and semiotics and derive the Connection, Communication, Consolidation, Collaboration Interoperability Framework (C4IF) for information systems interoperability. A more holistic approach is taken by the Business Interoperability Framework suggested by [Legner and Wende 2006] who explicitly introduced organizational and management- related layers. On the basis of contingency theory, the authors argument

that the maximum level of interoperability is not necessarily the optimal one and identify organizational and environmental contingencies (e.g. industry dynamics, e-business maturity) impacting this optimal level of interoperability. [Legner and Lebreton 2007]

Interoperability Developments for Enterprise Application and Software (IDEAS) was a European commission funded project under the Framework Program 5, which was completed in 2003 and aimed to create and to manage a Working Group to elaborate a strategic roadmap in the domain of enterprise application and software interoperability. It stated that in order to achieve meaningful interoperation between enterprises, interoperability must be achieved on all layers of an enterprise. This includes the business environment and business processes on the business layer, the organisational roles, skills and competencies of employees and knowledge assets on the knowledge layer, and applications, data and communication components on the ICT layer. In addition, semantic descriptions can be used to create the necessary mutual understanding between enterprises that want to collaborate.

The Athena Project was subsequently also funded by the European Commission under the Framework Program 6 aimed at adopting a holistic perspective on interoperability in order to analyse and understand the business needs and the technical requirements, and a multidisciplinary and model-driven solution approach to solving the interoperability problems. Its results have been significantly used in the drafting of this dissertation. It focussed on 3 core areas:

- Enterprise modeling which define interoperability requirements and support solution implementation
- Architectures and platforms which provide implementation frameworks
- Ontology to identify interoperability semantics in the enterprise

These European initiatives have been further detailed in chapter 3.

2.2 Existing Research Contribution

The majority of the existing work in this area can be classified as being either of exploratory or of constructivist nature. Whereas the exploratory research stream relies on case studies or surveys in order to investigate either the current state of interoperability in a specific industry or the use of interoperability solutions to improve this state, the constructivist approach proposes architectures, models and methodologies for achieving higher levels of interoperability.

Interoperability research is closely linked to the topic of standardization, since the ultimate goal of standards is to ensure interoperability and integration of different systems. However, interoperability research focuses particularly on those fields where compatibility is still low, i.e. areas with lacking or conflicting standard developments or with lacking uniform implementation of standards. This is reflected by the fact that the majority of publications explore interoperability in a specific industry domain, namely [Legner and Lebreton 2007]

- Public sector (e.g. [Kaliontzoglou et al. 2005], [Roy 2006], [Guijarro 2007], [Otjacques et al. 2007])
- Health care (e.g. [Egyhazy and Mukherji 2004], [Eckman et al. 2007])
- Manufacturing (e.g. [Lin et al. 2004], [Brunnermeier and Martin 2002])
- Telecommunications (e.g. [Bose 2006], [Moseley et al. 2004]).

Due to slower adoption pace of standards and high adoption costs, interoperability research increasingly comes up with innovative ways of achieving compatibility on the information and process layer thus intending to minimize set up costs. [Yang and Papazoglou 2000] have been first to describe a comprehensive multi-layer architectural framework for interoperability in integrated value chains. This framework comprises a set of business components, processes and workflow applications specified for a specific ‘vertical’ industry. The authors discuss a common business object language for describing workflows, ontologies for digital content and services as well as componentization of legacy assets. In the meantime, consensus is being reached on the critical role of open web service standards and service-oriented architectures in fostering interoperability in heterogeneous environments. [Legner and Lebreton 2007]

Information mediation is used to detect and resolve semantic heterogeneity at the information level. It is based on the idea of specifying semantic aspects (i.e., the concepts behind exchanged messages) independently from their physical representation. Ontology based information mediation builds on an ontology specifying the conceptualization of a domain and thus creating a shared vocabulary in a community of interest.

Information mediation concepts are further enhanced and applied to various domains. For instance, Fodor and Werthner (2004) suggest a web services infrastructure for business-to-business integration between tourism organizations by means of an ontology-based mediation. Madnick et al. (2003) sketch a mediation approach for semantic integration and ontology framework for the specific problem of corporate entity aggregation.

Web services are self-contained, self-describing and modular, and they can be published, located and invoked across the web. They perform functions that can be anything from simple requests to complicated business processes. Since web services are based on open internet standards and enable flexible integration across heterogeneous technologies and platforms, their use is suggested in order to achieve cross-organizational coupling of business processes.

Research has been mostly focusing on cross-organizational workflows (e.g. [Zur Muehlen et al. 2005]). In this context, while [Zhang 2004] develops a prototype e-Procurement system using web services composition, [Liu et al. 2005] demonstrate how future B2B architectures allow the conceptualization and implementation of an inter-enterprise workflow supported supply chain management system for a large Chinese motorcycle corporation.

Today, two key cited approaches for achieving interoperability across large scales are the Model Driven Architecture and the Service Oriented Architecture [Goncalves et Al. 2006]. Model Driven Architecture makes available an open approach to write specifications and develop applications, separating the application and business functionality from the platform technology. The service-oriented architecture (SOA) establishes a software architectural concept that defines the use of services to support the requirements of software users, making them available as independent services accessible in a standardized way.

2.3 Defining Business Interoperability

Interoperability is often discussed in the context of technical integration related to platforms, network devices and communication protocols, as well as syntactic and semantic data formats [Peristeras and Tarabanis 2006]. This is reflected by the most cited definition of interoperability by [IEEE 1990] which characterizes interoperability as 'the ability of two or more systems or components to exchange information and to use the information that has been exchanged'. Over the last decade, internet and web service technologies have significantly fostered interoperability at the transport and communication level [Alonso et al. 2003].

But with the broader use of these technologies, a multitude of interoperability issues have to be solved at higher levels in order to allow for seamlessly integrated collaboration. Whereas many authors have underlined the need for aligning the semantics [Zhang 2004], some of them consider interoperability in the broader context of value chain integration. [Yang and Papazoglou 2000] mention business process compatibility, adaptability of business processes, leveraging legacy assets, support for business transactions and network security services as important factors driving interoperability in the context of e-commerce and integrated value chains.

While the technological interoperability research stream intends to solve the issues related to the electronic integration in heterogeneous, distributed environments, business interoperability research intends to determine how and to what extent the potential of these concepts can be reclaimed for realizing seamlessly integrated value chains.

Business interoperability involves specific characteristics of the inter-organisational design of a company's external relationships. It extends from the more technically focussed notion of interoperability to cover organisational and operational aspects of setting up and running IT-supported relationships. Business interoperability builds on the concept of networkability [Wigand et al. 1997, p.11,Österle et al. 2001b, p.5] which is a continuation of coordination theory and sees coordination as the management of relationships of dependence. Figure 2.1 from Athena Project depicts the hierarchical nature of business interoperability, that most architectural and model based approaches to the subject stress at. This figure shows that any model of business interoperability would comprise of the strategy at the highest level, followed by business processes and the Information System Architecture coming at the lowest

level. Business interoperability requires the multi-layered collaboration with each level complementing the other for the smooth functioning of the overall collaboration.

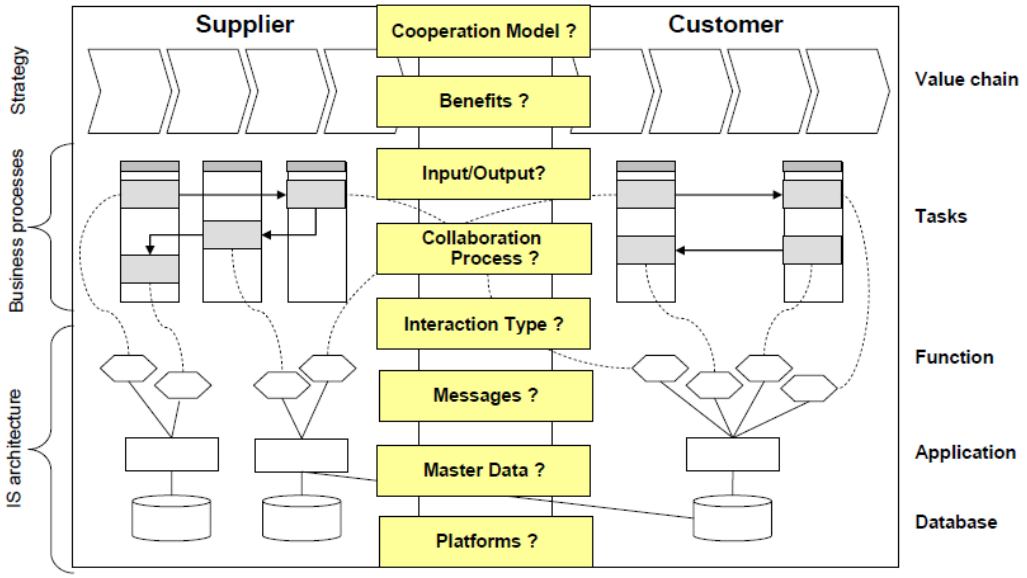

Figure 2.1 Different Aspects of Interoperability (Source [Athena 2006])

Business Interoperability aims to improve the effectiveness and ease of conduction of business between two or more business collaborators. These collaborators could be any organizations governmental or private. However, some of the different issues that may be involved while defining business collaborations are:

- Defining the cooperation model and identifying target partners,
- Defining consistent business goals,
- Formalizing these goals (e.g. by contracts and service level agreements),
- Aligning business process with partners,
- Making technology and platform choices,
- Coupling the supporting information systems between the business partners

The ease of performing the above tasks, along with a consistent approach would contribute towards the collaborations being more interoperable. Hence interoperability can be viewed as relying intensely on networkability at different levels. However collaborative scenarios can

differ greatly from industry to industry and depend greatly on the objective of the collaboration.

Optimal Interoperability

It is inappropriate for the measurement of interoperability to be based on closeness of collaboration, sophistication of technology or automation of processes. While evaluating interoperability, it is critical to keep in mind that highest levels of interoperability are never the optimal. Assessing the optimal levels of interoperability is not always simple. The assessment should firstly analyze if an increase in deployment of standards, tools, policies, could further increase productivity and collaboration efficiency. If changes to procedures, or the deployment of newer technologies has the potential to improvise efficiency and produce tangible results, then the current levels of interoperability is not optimal.

However, a cost benefit analysis is also a necessity before deciding on the optimality of interoperability. If the adoption of a new technology is prohibitively expensive, or does not justify the gains in terms of convenience, then the current scenario though not ideal could be considered optimal. However, a change in external conditions, in this case, a lowering of technological cost could render the scenario non-optimal.

In the hightech industry, the supply chain between Original Equipment Manufacturers (OEM), contractors and component manufacturers is tightly integrated. Companies like Cisco or HP adhere to process standards (e.g. RosettaNet) and use collaboration platforms (e.g. Viacore) which ease electronic collaboration within their value chain. The limited number of manufacturers and the complexity of product specification require that tight integration with an extremely high level of interoperability is critical for the industry's performance. Rapid changes in product specifications can be easily propagated across the value chain through an efficient IT infrastructure.

However, this high degree of interoperability may not be relevant to other business scenarios or in some cases may even not be optimal. For example, information systems in the tourism industry especially related to hotel bookings cannot be so tightly integrated as tourism agencies want to target the maximum reach of hotels and lodges. Hence multiple information systems including emails, websites, faxes or even phones are used to transmit booking information to hotels and updating of vacancy and promotional offers. Implementing tightly standardized IT infrastructures is not feasible at a global scale.

2.4 Clubbing Inter-Organizational Networks by Similarity of Interoperability Requirements

Organisations usually participate in several networks simultaneously, e.g development and procurement communities, strategic marketing partnerships, several specific value chains with different products and/or services. Each of these relationships require different degrees of collaboration and the nature of business interoperability requirements of one may be completely different from another. Some attempts towards classification of interoperability scenarios on the basis of similarities in interoperability requirements have been attempted by [Athena 2006].

According to it, four operative coordination areas can be distinguished in a typical organization, that show low dependencies between each other, but a high level of dependency within each area. These four areas represent different cooperation models, pursue different economic goals, implement different types of network, are characterised by widely divergent cultures, link different partners, have interdependencies based on different resources and use different information systems for coordination purposes. [Fleisch/Österle 2000b],

Supply Chain Management

It's goal is to handle operative planning and execution processes as efficiently as possible. It tries to utilise the effects of economies of scale in order to achieve profit. Supply chain management is characterised a large integration depth in the coordination of its well structured processes and prefers the forms of coordination of an internal and/or stable network. Business processes as well as IT infrastructure are optimized towards automation and standardization.

Relationship Management

Its goal is to win customers and/or suppliers and to gain their loyalty. Relationship management tries to cover as wide a spectrum of customer requirements as possible in order to utilise the effects of economies of scale. Partners in this area are above all customers with whom a market-like relationship exists.

Innovation

It's goal is the rapid creation of new products, which requires a dynamic environment in the early phases. As a project advances in maturity a business unit usually coordinates with a

large number of different partners and, depending on the task in question, follows the rules of different forms of coordination.

Infrastructure

It distinguishes itself from supply chain management in terms of content, which does not necessarily show a high degree of repetition (e.g. preparation of a corporate balance sheet), and its transactions may be complex in nature (e.g. outsourcing of IT). There is a high level of dependency between the infrastructure partners which calls for the relationship to be stable.

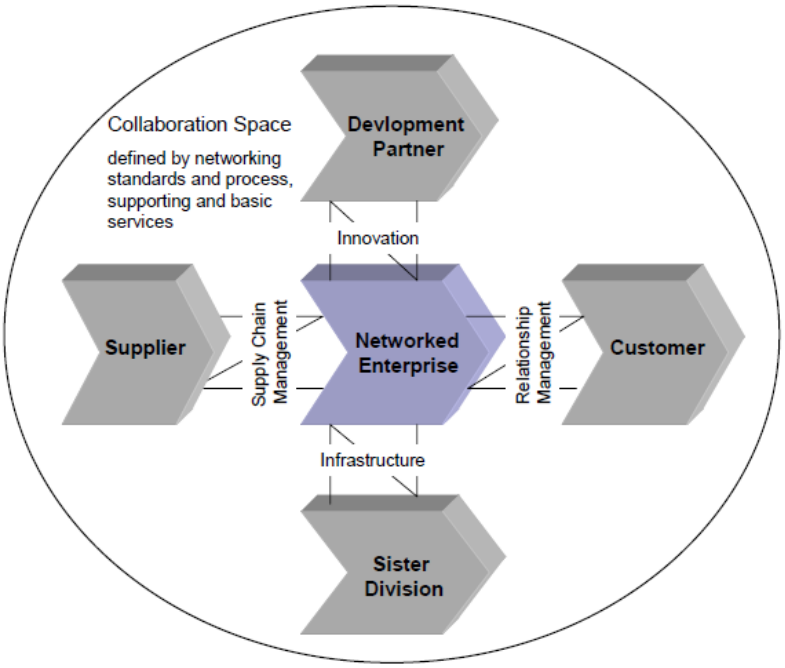

Figure 2.2 The Networked Organization (Source [Athena 2006])

A typical networked organization could involve interactions or collaborations with several different partners, involving different coordination areas. Hence each of these collaborations will have different interoperability requirements. Interoperability requirements for collaborations falling under one of the four identified areas will show a high degree of correlation. For example, all collaborations related to innovation will require a high degree of flexibility. Hence the implementation of extremely standardized procedures and automated systems would not be possible and the interoperability infrastructure would need to be designed for allowing increased adaptability as is characteristic of innovation environments.

2.5 Business Networkability

Business Networkability is the internal and external ability to cooperate as well as the ability to rapidly and efficiently establish, conduct and develop IT-supported business relationships. ([Alt et Al. 2000]) It is closely associated with Business Interoperability since Networkability is one of the crucial requirements for systems to be interoperable. However assuming that networkability in itself guarantees interoperability is not justified since networkability is only one crucial component of interoperability. It denotes the ability of two organizations to establish connections at different levels but does not guarantee that those connections would by themselves lead to efficient business processes. Hence, business interoperability can be more closely related to collaboration performance measurement and enhancements, instead of just the ability to connect, which networkability stresses upon.

However, due to the existing literature on networkability being highly relevant to the ongoing research in the field of Business Interoperability, it is being mentioned in this dissertation.

Networkability consists of different aspects which create dependencies among the business partners. Networkability, is a continuation of coordination theory, which defines coordination as the management of dependencies.

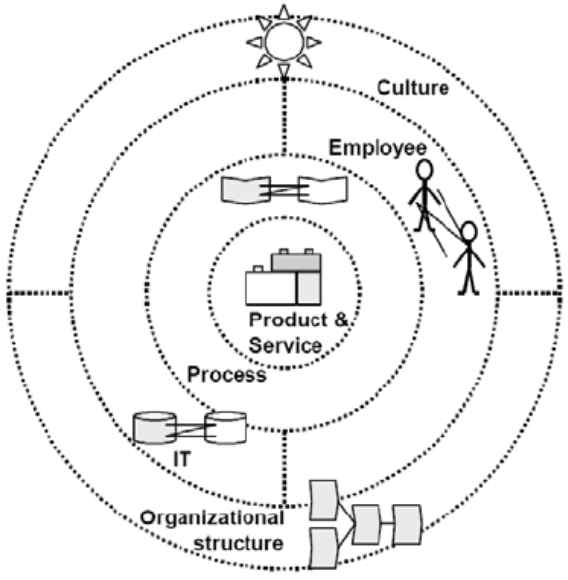

Figure 2.3 Design objects of Networkability (source [Alt et al. 2000])

The different design objects of Networkability as defined by [Alt et al. 2000] are listed below:

Products and services: Networkable products and services can be altered quickly and inexpensively for specific partners or be integrated with other products. Examples of networkable products and services involve personalization, use of status information or use of partner's article numbers.

Process: Networkable processes can quickly and inexpensively establish and conduct a relationship of coordination with corresponding processes. Automatic requests for various catalogs or automatic orders when stock levels fall below an agreed safety level are examples of this.

Information systems: Networkable information systems (IS) can be linked up to other IS quickly and inexpensively and support communication on the system level. This especially applies to setting up an EDI link with a business partner.

Employees: Networkable employees are the essence of personal networks. They are oriented to the customer, understand the relevance of win-win situations and are also assessed according to the way in which they maintain and look after relationships between partners.

Organizational structure: Networkable organizations can be adapted quickly and inexpensively to new market requirements. Examples of this are the rapid creation of temporary inter-company teams, the relocation of business processes or the joint execution of processes (formation of so-called shared services).

Culture: Networkable company cultures promote cooperation by being open to change and by basing cooperation between business partners on a relationship of trust instead of mutual checks (on costs).

2.6 Path to achieving ICT Interoperability

ICT interoperability forms the core of all interoperability frameworks and is the most developed interoperability area in terms of research and standards. There exists well defined standards for data exchange in a large variety of industries.

There are 3 major approaches to ICT interoperability. [Ray and Jones 2006]

In the first approach, a point-to-point customized solution is developed for each pair of partners. This approach is expensive in the long run because each pair of software systems needs a dedicated solution.

In the second approach a dominant collaborator (such an Original Equipment Manufacturer) mandates that all partners conform to a particular, usually proprietary solution. This has been the practice, for example, in the automotive sector. While this is a cost-effective solution for the dominant collaborator, it causes nightmares for the partners because they are forced to purchase and maintain multiple, redundant systems if they want to do business with several other partners.

In the third approach, neutral, open, published standards form the foundation of the infrastructure. The nightmares associated with the second approach are eliminated because partners can buy any software they want, provided the vendors implement the standards. Furthermore, standards also offer stability in the representation of information, an essential property for long-term data retention.

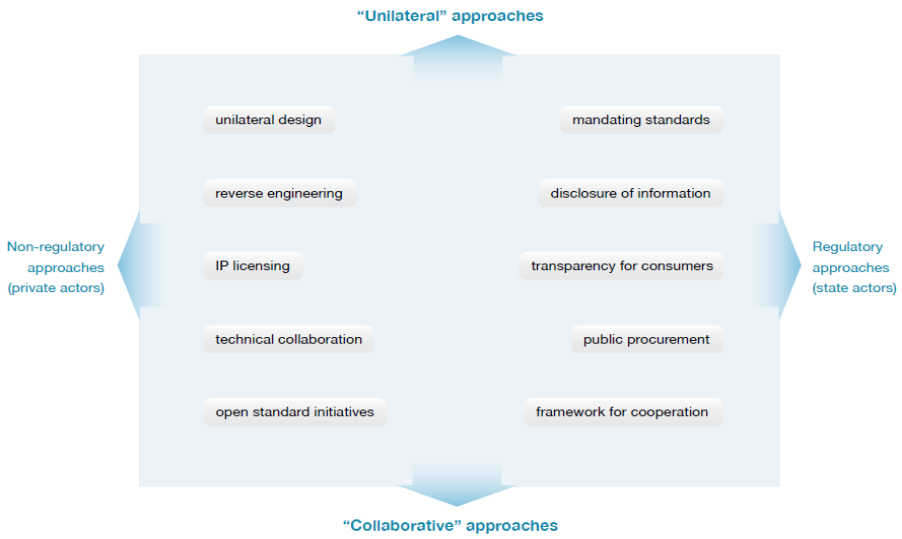

Figure 2.4 Paths to achieving ICT interoperability (Source [Gasser and Palfrey 2007])

The creation of ICT Interoperability standards can follow several paths as depicted in figure 2.4. The several initiatives or paths have been organized, from top to bottom, on the basis of unilateral approaches, such as those initiated by a dominant market player at the top, (for example, Adobe PDF for document sharing) to collaborative initiative at the bottom, (for example XML standards). Also these initiatives can be either regulatory in nature with the state being a stakeholder, thus making conformance mandatory(right side), as in the case of banking sector, or it could be non-regulatory, providing convenience and market incentives for adoption(right side). Some of the most widely used approaches include making open standards, joint technical collaborations, and IP licensing by a dominant technology holder.

The different paths to achieve interoperability can lead to different kinds of interoperability. These can basically be categorized as informal and formal interoperability.

Informal approaches are when interoperability is not planned but evolve based on market conditions. These include unilateral approaches where a major market player opens up standards for others to use. For instance, a Web service provider like Facebook or Google voluntarily creates an open API that allows many others to interoperate with their services without the need for further approval or cooperation. The opposite approach is reverse engineering, as when RealNetworks through their Harmony technology attempted to make its Digital Rights Management(DRM) scheme compatible with the iPod over Apple's vigorous objections. Somewhere in the middle is widespread intellectual property licensing, which Microsoft has done with their PlaysForSure initiative in licensing Windows Media DRM to several online music stores. [Gasser and Palfrey 2007] These approaches to technical interoperability have the advantage of quick time to market and the ability to make improvements in technology systems without a great deal of coordination among many firms.

Another informal approach is Mashups where several technologies are combined together. This is an adhoc approach to interoperability and can lead to complications as technologies evolve. But this can be a quick solution in the short term while formal approaches are evolving.

Formal approaches on the other hand involve creating open standards for industry. This can have the involvement of governmental agencies but is generally done by Standard Setting Organizations (SSO) which include major market players. Most SSOs promote the adoption of open standards - where the term "open" implies that technical specifications are widely, perhaps even freely, available to potential implementers.

While achieving interoperability is desirable to the society at large and goes a long way towards fostering innovation, its adoption is not always easy. Other than technical challenges, interoperability can also have other strategic barriers. It can pose a dilemma for individual firms hoping to benefit from SSO participation. While openness increases the probability of coordination on a particular standard (and hence its total expected value), it can also increase the intensity of competition, making it harder to capture that value once the new specification and standard is introduced. As a result, SSO participants are often tempted to take actions that "close off" a standard when those actions also give them a competitive edge in the standards-based product market. To put it crudely, SSO participants usually want all of the technology needed to implement a standard to be open, except for their own.

On one side, proponents of the open source model are working to create a set of legal institutions that make it impossible for firms to capture value through IP licensing. On the other side, some firms are actively "gaming" SSOs in an effort to ensure that industry standards will eventually infringe on their own patents. Meanwhile, SSOs and policy makers are stuck in the middle trying to devise a framework that balances the legitimate interests of the various interested parties. This is where governmental involvement as an unbiased orchestrator is crucial.

2.7 IPR Issues

The term “intellectual property” encompasses patent, trademark, and copyright protections. Patents give an inventor the right to exclude others from using their invention for a specified period of time [Graham and Mowery 2004]. From a policy perspective, the role of a patent system is to create incentives for innovation by providing a legal solution to inventors’ appropriability problems. This incentive will clearly be especially important for firms that cannot easily access or acquire the complementary assets required to profitably commercialize their inventions. As a result, patents play an important role in promoting vertical specialization in research and development by limiting the hazards faced by specialized technology developers with business models that call for selling inputs rather than implementations.

On the other hand, any administrative process granting potentially valuable property rights will almost certainly create some rent-seeking behavior. Over the last two decades, there has been a notable increase in the number of U.S. patent applications. The majority of these applications have been granted, which has led to an increase in the scope of patentable subject matter and arguably a decline in average patent quality. [Jaffe and Lerner 2004]

Patent proliferation means that more parties now have the right to impose a “tax” on implementation. The shift towards open innovation with a large number of collaborating entities requiring access to patented technologies, has created an environment where organizations holding frivolous patents get a good opportunity to collect “taxes”.

To avoid these patent squatters, it is important for patent applications to be rationalized and this requires a high degree of governmental proactiveness to change patent granting procedures. Standard Setting Organizations (SSOs) while creating open standards for increased interoperability, have made it mandatory for related industries to disclose essential IPRs. Between 1995 and 2005, there were a number of legal disputes over the appropriate use of IPRs in the standard setting process. The two most significant examples, Dell and Rambus, both involved allegations that they failed to disclose essential IPRs—in violation of SSO policy—and then sought to license the undisclosed technology to potential implementers. These cases and several others have led to a growing interest among legal scholars in the antitrust and intellectual property issues associated with standards creation. [FTC 2002]

Usage of IPRs by collaborating entities can be done in different ways. Open strategies, such as IPR contributions, anticipatory standard setting, and defensive patent pools encourage value creation by enhancing the availability of the underlying technology. Closed strategies, include licensing or hold-up, and use of IPRs as a mechanism to capture a share of the value of the innovation.

The effect of IPR laws on promoting interoperability can be both positive as well as negative. Poorly scrutinized and rather opaque software patents may impede the progress of mashups, since it is increasingly difficult for web service developers to predict the potentially devastating liability risks for patent infringements. Patent laws can be used to hinder — or at least increase the expense of — the development of interoperable technology. In contrast, IP licensing by single companies, in bilateral co-operation, or in multi-player settings, are important forms of private coordination in which IP law has been used to contribute to higher levels of interoperability.

However, Firms are faced with the dilemma that on one hand they wish to learn from their partners, however, on the other hand they want to retain their own core proprietary assets and thus prevent leakage of critical know-how. [Kale et al 2000] This may constrain the process of collaboration by limiting, for example, the extent of information and knowledge transferred and shared within partnerships, thereby hindering the interaction of different bodies of knowledge which generate innovation in the first place. This may be particularly important as companies increasingly compete on knowledge and competencies as they risk losing their competitive advantage. On the other hand, it is through collaborations alone that access to vital intellectual assets are available. Hence the existence of a robust intellectual property regime is critical to improving confidence in partnership and avoidance of conflicts.

While institutions will need to become much more selective in their efforts to protect existing stocks of knowledge, a more rational IPR regime will encourage them to use and share their stocks of knowledge to improve knowledge flows and the innovation process.

2.8 Semantics in the context of ICT Interoperability

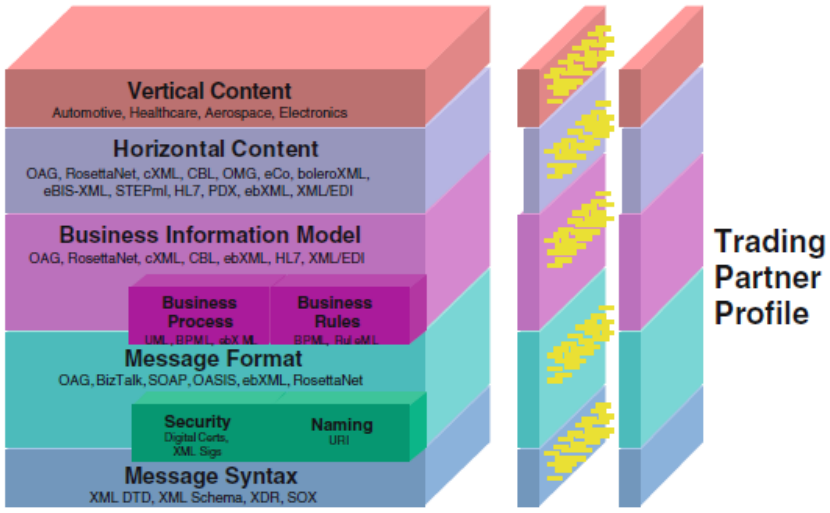

Figure 2.5 ICT Interoperability Stack [Ray and Jones 2006]

Interoperability standards, like communication standards, come in layers (see Fig. 2.5). All the layers in this interoperability stack must be implemented correctly for interoperability to be achieved. The greatest challenges remain at the top of this stack.

One of the most popular standardization effort is the XML which appears in almost every layer of the stack. XML is a markup language that can be used to tag collections of data with labels. As part of a standardization activity, communities can agree on the names for these labels. However, XML standardizes syntax; it was never designed to even capture, much less standardize, semantics. This is not necessarily an obstacle for a tightly knit community that operates within a common context, such as the automotive sector or the financial sector. Within a given sector, the meanings associated with a tag are shared and well understood by all. Serious problems can arise, however, in moving data from one sector to another, such as automotive to financial. Without explicit, rigorous definitions of the meaning of terms, misunderstandings are sure to arise. Humans can resolve such misunderstandings; computers cannot. Consequently, the process of achieving interoperability remains a highly manual process, with computers executing only the most basic steps in this process.

Semantic mapping

Although conceptual views and engineering views serve different roles, they are not used in isolation. Intermodel relationships between elements from these views link the relationships

between an activity or entity expressed in business terms and an engineering means of implementing that activity or representing the entity.

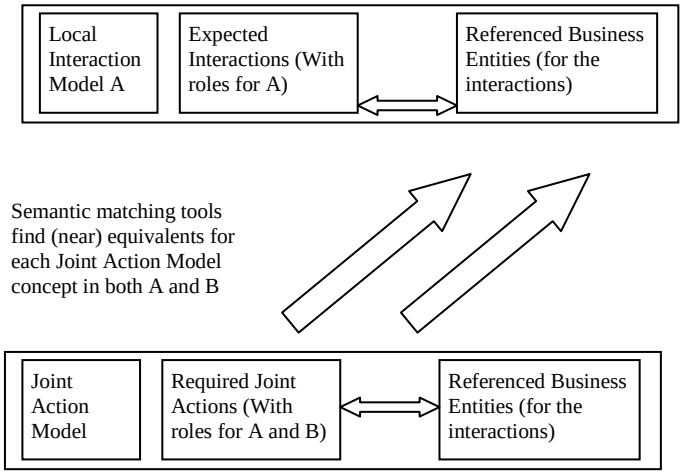

Figure 2.6 Conceptual View of semantic Mapping [Ray and Jones 2006]

Given a sufficiently detailed semantic mapping, it is theoretically possible to build a tool that generates translations corresponding to the mappings. To achieve arbitrary transformations of syntax, structure and interactions to the lowest levels of abstraction requires that all the information be formalized. Generation of message converters is then reduced to a search problem: find the composition of available components that can transform the input available into the desired output.

Web Ontology Language (OWL)

The Web Ontology Language (OWL) is used by applications that need to process the content of information instead of just presenting information to humans. OWL facilitates greater machine interpretability of Web content by providing additional vocabulary along with a formal semantics. OWL has three increasingly-expressive sublanguages: OWL Lite, OWL DL, and OWL Full (http://www.w3.org/2004/OWL/). OWL builds on RDF and RDF Schema (http://www.w3.org/RDF/) and adds more vocabulary for describing properties and classes.

Those properties include relations between classes, cardinality, equality, richer typing of properties, characteristics of properties, and enumerated classes. OWL uses both URLs for naming and the description framework for the Web provided by RDF to add four capabilities to ontologies: the ability to be distributed across many systems, scalability to Web needs, compatibility with Web standards for accessibility and internationalization, and openness and extensibility.

Existing ontology languages (such as SHOE[3], DAML+OIL[1], or OWL[2]) are of a general purpose nature and therefore give to the user great freedom and, conversely, low domain specific guidance. Enhancing domain specificity of ontology building tools will support domain experts in their challenging tasks. Domain specificity can be achieved with two different approaches. One is to provide a core domain ontology, containing the most general concepts that characterize a given domain. Then domain experts can start building the ontology in a top-down fashion, by refining such concepts. Another approach is to enrich the constructs of the ontology language with primitives that provide a guidance for the user when representing the domain concepts. The two approaches are not mutually exclusive. ([Missikoff et al. 2004])

2.9 Impact of Interoperability

Very few publications address the impact of interoperability on businesses. The first major analysis was performed by [NIST 1999] and [Brunnermeier and Martin 2002] and investigates the costs of lacking interoperability in the US automotive industry. In the report, the sequel costs of low interoperability are estimated at 1 billion dollars per year for the US industry, from the car manufacturer to the smaller third and fourth-tier suppliers.

[Gallaher et al. 2004] assess the costs of lacking interoperability in the US capital facilities industry. In their macro-economic study, the authors encompass the total life-cycle of facilities, from the design phase to the facility management phase. The scattered structure of the facility industry encompasses a network of thousands of stakeholders (among others, architects, construction companies, facility managers and service providers). The authors find out that the main 'victims' of interoperability are not the stakeholders developing or constructing the facilities (which have already some rudimentary data exchange procedures). 60% of the total interoperability costs, 9 billion dollars (for a total $15.8 billion/year) are carried by the owners and operators of houses and commercial buildings which do not have adequate information exchange workflows and standards with the designers and constructors.

Apart from the EU-funded projects ATHENA and INTEROP, case studies dealing specifically with the business aspects of interoperability are rare. [Nelson et al. 2002], for instance, investigate the impact of RosettaNet on its users in a given business relationship. They explore the relative advantage of using RosettaNet, i.e. 'the extent to which a potential adopting organization views the innovation as offering financial and operational benefits over previous ways of performing the same tasks'. As the objective is to compute the return on investment of applying interoperable standards, this case study on RosettaNet also includes quantitative results. Their analysis shows a significant reduction of transaction costs for both manufacturer and distributor, as well as improvements in throughput and cycle time.

In the context of the Athena project, based on a comprehensive review of these case studies, [INSEAD 2006] proposes an impact analysis model to quantify the value created by improved interoperability. The authors differentiate between operational (direct, quantifiable) impacts and strategic impacts. The operational assessment builds on transaction costs theory to assess the value created. The resulting interoperability impact assessment model (IIAM) identifies three different transaction cost types that are, to a greater extent, related to business interoperability: connectivity costs, coordination costs and control costs. An application of

this cost scheme is enabled thanks to the separation between day-to-day costs (execution, monitoring) and more strategic connectivity costs depending on the technical and human investments in a business relationship.

The following table lists out interoperability impacts for a few cases:

Table 2.2 Studies on the economic impact of interoperability [Legner and Lebreton 2007]

Case (Source)	Interoperability issue	Solution proposed	Impact assessment	Managerial insights
Automotive industry, product development (NIST 1999, Brunnermeier and Martin 2002)	Lack of compatibilty of CAD file formats lead to mistakes and to additional engineering work	None, except standardization of data formats	Lack of standardization costs 1 billion dollar per year to the US car manufacturers	Data processing costs represent the greatest fraction of these interoperability costs
RosettaNet (Nelson et al. 2002)	Incompatibility of exchange formats, important setup costs for setting 1:1 relationships	XML-based IOS standards (e.g. RosettaNet)	Payback within less than two years for both partners (manufacturer and distributor), reduction of transaction costs and cycle time	Firms adopt XML standards when gap between old technologies and opportunities of new ones is significant
Automotive industry, inventory management (Danziger et al. 2004)	Lack of standardization on the exchange of inventory data preempts suppliers to set up automated connections to the inventory systems of their customers	Inventory visibility solution (connector) based on an industry standard	Savings of 250 million dollar per year for the three US American car manufacturers	A great fraction of the costs is carried by small and medium-sized suppliers. Savings on working capital costs (on inventories) represent the greatest fraction of the value created

Capital facilities industry: Communication of product and project data (Gallaher et al. 2004)	Same as (NIST 1999)	None, except standardization of data formats	Lack of compatibility of data formats and the unavailability of CAD files cost 15.8 billion dollar per year to the capital facilities industry	60% of the costs are carried by facility owners/operators and not by constructors and architects.
Health care: Case management (INSEAD 2006)	2 months lost during the recovery from breast cancer because no coordination mechanism exists	Introduction of governance structures and processes within the decentralized network; Set up of a collaboration platform between physicians	2500 Euros per patient cured (phase 1 without technological support)	Organizational improvements can already reduce transaction costs without advanced technological means. Collaborative platform required to further improve process efficiency but hampered by law
Car configuration (Klein et al. 2007; (INSEAD 2007)	Multi-brand car dealers need to manually re-enter data for each OEM's car configurator for brandspanning comparisons	Ontology unifying OEMspecific product model + web service-based platform to integrate OEM car configurators	Additional revenues.50 Euro per car sold. Salesforce spend less time on data processing but more on acquisition	Political factors may preempt the publication of processable product data although the technological issues are already solved
Furniture manufacturers (Grandin-Dubost et al. 2007)	Late and wrong deliveries from typing errors in the ordering process	Online catalogue with integrated ordering functions, improved process integration between manufacturer's services	Savings of 20 Euros per order (integration and maintenance costs not included).	Intraoperability plays a great role in achieving the benefits of interoperability

3. European Interoperability Initiatives

3.1 Athena Interoperability Framework

Launched as a three-year project in 2004 with sponsorship of the European Commission, ATHENA (Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Applications) is the flagship project in the interoperability research portfolio. ATHENA aims to provide comprehensive and relevant results in the field of enterprise application interoperability and initiate an interoperability community in the form of the Enterprise Interoperability Centre (EIC).

ATHENA not only focuses on IT issues such as information, application, and platform interoperability, but also on business processes, seeking to establish an integrated set of research solutions, supplemented with through business and economic research.

According to [Athena 2006], Business Interoperability is defined as "The organisational and operational ability of an enterprise to cooperate with its business partners and to efficiently establish, conduct and develop IT-supported business relationships with the objective to create value."

Whereas the IDEAS framework focused on structuring the interoperability issues (into business, knowledge, semantic, architecture and platform issues), the Athena Interoperability Framework (AIF) focused on the solution approaches. A common characteristic of the ATHENA solutions are the fact that they are model-driven. The solutions focused on modelling the interactions and information exchanges that occur in collaborations, both on a business level and a technical level.

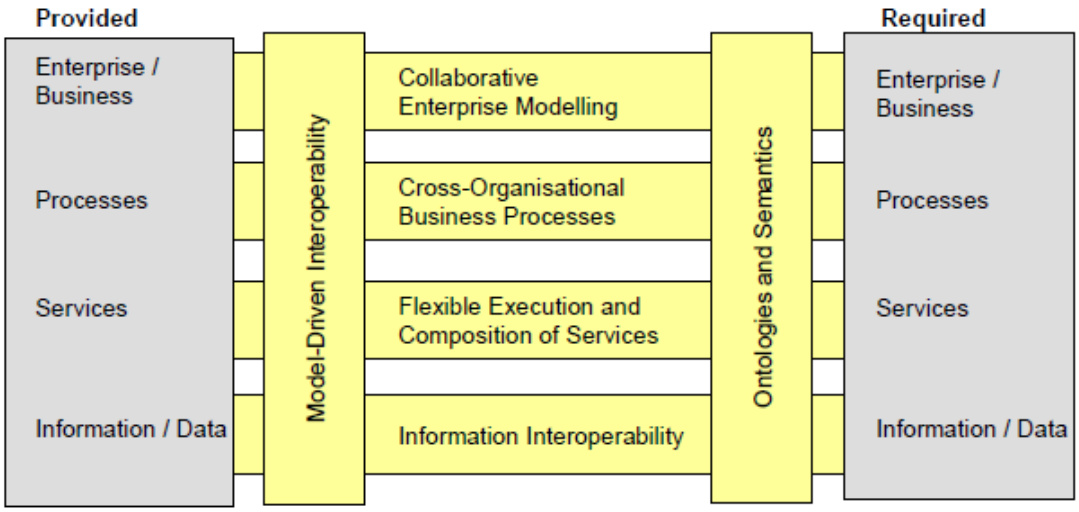

Figure 3.1 AIF conceptual Framework

The AIF provides a reference model in which the modeling solutions coming from different research areas can be related. The above figure is a simplistic view of the AIF reference model that indicates interoperations taking place at various levels ie. Enterprise/Business, Process, Services, and Information/Data. For each of these levels ATHENA prescribes a model-driven interoperability approach where models are used to formalise and exchange the provided and required artefacts that must be negotiated and agreed upon. ATHENA defines a set of metamodels and languages that can be supported by tools and methods to construct the models in question. (Table 1)

Table 3.1 ATHENA solution space – metamodels and languages

Modelling	**Solution**	**Type**	**Description**
Collaborative enterprise modeling	POP	Metamodel	The POP metamodel [Athena D.A1.3.1 2005] defines a core set of enterprise language constructs in the modeling dimensions Process, Organisation, Product (POP) and other dimensions like System and Decision to be defined in an enterprise model. The POP metamodel acts as a flexible intermediate language to facilitate model exchange between different enterprise modeling tools.
Cross-organisational business processes	CBP	Metamodel	The CBP (cross-organisational business process) metamodel [Athena D.A2.2 2005] defines language constructs for modeling cross-organisational business processes using the concepts of view process and private process. A CBP defines the interactions between two or more business entities which links together view processes. A view process combines different (internal) private processes to an abstract level that enables companies to hide critical information from unauthorized partners.
Flexible execution and composition of services	PIM4SOA	Metamodel	The PIM4SOA (platform-independent model for service oriented architecture) metamodel ([Athena D.A6.4 2006], [PIM4SOA 2006]) defines language constructs for modelling information, software services, software processes and quality of service. This model can be used to represent SOA solutions in a platform-independent way, integrate different technology platforms, and bridge the gap between the enterprise layer and the technical layer .
Information interoperability	XML, XSD	Format, Schema	During the last few years there has been a trend towards the use of XML for exchanging documents and messages. The XML Schema Definition Language (XSD) [W3C 2004], is seen as a key enabling technology for achieving information interoperability. The ATHENA solutions builds upon this foundation.
Ontologies and semantics	OPAL	Modelling language	Today ontology languages present a syntax which looks not “natural” and are lacking of built-in primitives (i.e., modeling notions) domain experts are familiar with. The OPAL (Object, Process, Actor modelling language) [Athena D.A3.1 2005] offers a number of modeling notions useful in the eBusiness domain, but general enough to be used in diverse business sectors (such as automotive, tourism or banking).

Source: The ATHENA Interoperability Framework 2006

Enterprise/business Level

Interoperability at this level should be seen as the organisational and operational ability of an enterprise to factually cooperate with other, external organisations in spite of different working practices, legislations, cultures and commercial approaches. Collaborative Enterprise modeling is supported by the POP metamodel. [Athena D.A1.3.1 2005]

Process Level

Interoperability of processes aim to make various processes work together. A process defines the sequence of the services (functions) according to some specific needs of a company. In a networked enterprise, it is also necessary to study how to connect internal processes of two companies to create cross-organisational business process. This is supported by the CBP (cross-organisational business process) metamodel. [Athena D.A2.2 2005]

Service Level

Interoperability of services is concerned with identifying, composing and executing various applications (designed and implemented independently). Services are an abstraction and an encapsulation of the functionality provided by an autonomous entity. Modelling flexible execution and composition of services can be supported by the PIM4SOA (platform independent model for service-oriented architecture) metamodel ([Athena D.A6.4 2006], [PIM4SOA 2006]).

Information/Data Level

Interoperability of information/data refers are related to the management, exchange and processing of different documents, messages and/or structures by different collaborating entities.

Ontologies and Semantics

To overcome the semantic barriers which emerges from different interpretations of syntactic descriptions, precise, computer processable meaning must be associated with each concept using ontologies and semantics. The OPAL (Object, Process, Actor modelling language) [Athena D.A3.1 2005] offers a number of modelling notions to more precisely define the meaning of concepts. This allows us to relate concepts at the different levels (ensuring consistency amongst the levels) and relate concepts at the same level e.g. supporting information interoperability.

3.1.1 Problem Space Definition by Athena

An enterprise model represents the fundamental structure of an enterprise and comprises the main sets of concepts to model and build an enterprise.

[ATHENA 2005b] identifies heterogeneity, need for flexibility and complexity as three core challenges when seeking to achieve interoperability among the partner companies in collaborative enterprises. It identifies the following levels for addressing these challenges:

• *Knowledge:* approaches, methods and skills needed for innovation, problem solving and work performance, the shared language and frames of reference needed for communication, etc.

• *Process:* the planning, coordination and management of cooperative and interdependent activities and resources;

• *Infrastructure:* the information formats, software tools, and interoperability approaches of the participating companies.

The problem space identified by [ATHENA 2006] is defined which forms the basis of its enterprise modeling.

Table 3.2 Athena problem space

	Knowledge	**Process**	**Infrastructure**
Heterogeneity	Communication: establishing common languages and meanings across companies and disciplines	Process diversity: negotiating different rules and procedures between the partners	Interoperability across companies' knowledge spaces and enterprise architectures (Business, Knowledge Software)
Complexity	Integrate capabilities: form effective teams across different local cultures; align views with contents and context among and between stakeholders and people	Work management and planning, task assignment, coordination and monitoring of activities and tasks across projects, partners and networks, dealing with uncertain interdependencies among several concurrent activities	Enterprise architectures: managing project and systems portfolios; providing new model driven approaches for solutions design and development; avoiding featuritis (unmanageably complex systems)
Flexibility	Learning: partners must be able to improve practice based on common experience from the Collaborative Enterprise	Supporting both structured and ad-hoc work (with evolving plans); Handling unforeseen exceptions	Customised and personalised support; Rapid formation of Collaborative Enterprises, allowing partners to join along the way.

[ATHENA 2005b] states that the unique nature of each collaborative enterprise, and the dynamic set of partners, seldom makes it economically viable to integrate information systems through developing new software interfaces. Instead, we need an open, model-supported and model-driven infrastructure for collaborative concurrent modelling and execution, supporting shared understanding, work management and learning, and allowing interoperability to emerge from work, rather than being a prerequisite for cooperation. Enterprise models, articulating who performs which tasks when and why, are powerful resources to understand and master complexity.

3.1.2 Review of Athena framework and its implications

The Athena Framework builds on the previous IDEAS framework and advances the development of models for a holistic approach to achieve interoperability. The IDEAS network identified the need for a structured approach to collect, identify and represent the current state of the art, vision statements, and research challenges. It defined a framework for capturing and inter-relating this information from many perspectives called the IDEAS Interoperability Framework. The IDEAS framework describes that interoperability must be achieved on different levels (business, knowledge and ICT) between two co-operating enterprises.

The originality of the ATHENA project is to take a multidisciplinary approach by merging three research areas supporting the development of interoperability of enterprise applications and software. The three areas are:

1) Enterprise modeling which define interoperability requirements and supports solution implementation

2) Architectures and platforms which provide implementation frameworks

3) Ontology to identify interoperability semantics in the enterprise.

The ATHENA project has the following two major characteristics:

1) *Generic and extensible solution approach to interoperability:* The AIF has a wide applicability over a wide variety of scenarios having different interoperability. This makes the AIF unique over most previous works, since most solutions based research with application potentials in the past have been confined to a specific industry scenario.

2) *Holistic, Solution Based approach:* The AIF has successfully integrated research work from the Athena project in the three research areas mentioned above, to arrive at a holistic integrated model to solve interoperability issues at both Enterprise Level as well as the ICT level.

Implications to this dissertation

This dissertation has been particularly influenced by the holistic, interdisciplinary approach to interoperability that has been taken by ATHENA. The objective of this dissertation was to develop a model that captures all the key elements of interoperability particularly in a dyadic collaborative relationship. The key areas of Enterprise Modelling, Architectures and Platforms, and Ontology, being integrated in the AIF helped influence the interdisciplinary approach to interoperability that this dissertation advocates.

However, this dissertation believes that the ultimate aim of business interoperability is the smooth collaboration between two organizations. Hence there do exist several other parameters that are critical for achieving the ultimate aim of smooth business collaborations. These include the relatively abstract but critical concepts of Business Strategy, Conflict management, IPR issues, work cultures amongst others that have not been addressed by Athena.

While Ontologies and Business processes are areas where specific and well defined approaches are possible, and information processing can be more easily implemented, the other key areas require a completely different approach. Hence the ultimate Interoperability framework needs to encompass a much greater level of interdisciplinary research encompassing fields of management, social science, human behavior, psychology, organization theory, in addition to the current application of information theory and business process design.

This dissertation has attempted to expand Athena's approach to incorporate and identify key factors that affect Business Interoperability while at the same time acknowledging that the relevance of each of the identified factors would vary depending upon the collaboration situation and scenario.

3.2 IDABC European E-government Services programme

The IDABC programme (Interoperable Delivery of European e-government services to public Administrations, Businesses and Citizens programme) was launched in 2005. It uses the opportunities offered by information and communication technologies

- To encourage and support the delivery of cross-border public sector services to citizens and enterprises in Europe.
- To improve efficiency and collaboration between European public administrations.
- To contribute to making Europe an attractive place to live, work and invest.

To achieve its objectives, IDABC issues recommendations, develops solutions and provides services that enable national and European administrations to communicate electronically while offering modern public services to businesses and citizens in Europe.

The programme also provides financing to projects addressing European policy requirements, thus improving cooperation between administrations across Europe. National public sector policy-makers are represented in the IDABC programme's management committee and in many expert groups. This makes the programme, a unique forum for the coordination of national eGovernment policies.

It has identified the following six objectives for the European Community with regards to achieving interoperability in public sector: ([IDABC 2008])

1. Develop a European Interoperability Policy;

Specific Objectives	Expected Results
Increase in cooperation among Member States and EU institutions to create synergies and leveraging effects Increase in policy drive Enhance the dialog with industry stakeholders	A European Interoperability Strategy (EIS) Communication of the EC to the European Parliament and Council of the EIS Guidance and promotion by CIOs of the EIS Better responses from industry to meet the

	needs of administrations

2. Enhance consideration of ICT dimensions within EU legislation;

Specific Objectives	Expected Results
Consider ICT aspects when designing EC legislations and increase in support to EU policies.	Smooth implementation of EC legislation Identification of the needs for services and tools in time so that requirements are fulfilled when the legislation come into force Understanding of ICT aspects of EU policies
Facilitate the development of PEGS (interoperability of citizen IDs across Europe)	Coverage of PEGS related issues

3. Foster the use of common frameworks;

Specific Objectives	Expected Results
Use of a coherent set of common specifications, guidelines, methodologies and strategies	Common context in which MS, and community institutions can discuss cross-border and cross-sectoral interoperability Coverage of PEGS related issues Up to date set of framework and methodology Concrete specifications, methods, etc. when needed

4. Increase the use of common services;

Specific Objectives	Expected Results
Enhance the availability of high quality common services and infrastructures	Improved services and infrastructures Continuity in the common services delivery Professional delivery of a coherent services portfolio
Create new common services	Increased availability of services that meet the needs of sectors and MSs Delivery of new services in time

5. Increase the use of reusable generic tools;

Specific Objectives	Expected Results
Enhance the availability of high quality common services and infrastructures	Improved services and infrastructures Continuity in the common services delivery Professional delivery of a coherent services portfolio
Create new common services	Increased availability of tools that meet the needs of sectors and MSs Availability of new tools in time

6. Provide accompanying measures to support the overall action.

Specific Objectives	Expected Results
Organise the exchange of information and share of best practices Improve the coordination function Increase the visibility of common services and of reusable generic tools Strategic and support activities	Increased awareness of best practices Reuse of best practices More synergies and less duplication of activities More harmonious and coherent approaches Common understanding among stakeholders More cross-sectoral cross-border collaborations when systems are being designed Increased awareness of common services by potential users when designing PEGS Consideration of common services Improvement of the programme

3.2.1 European Interoperability Framework

European Interoperability Framework (EIF) is an interoperability framework to support the delivery of pan-European eGovernment services to citizens and enterprises. This framework intends to address information content and recommend technical policies and specifications to help connect public administration information systems across the EU. It is a reference document on interoperability for the IDABC programme.

The objectives of the European Interoperability Framework are:

• To support the European Union's strategy of providing user-centred eServices by facilitating the interoperability of services and systems between public administrations, as well as between administrations and the public (citizens and enterprises), at a pan-European level.

• To supplement national interoperability frameworks in areas that cannot be adequately addressed by a purely national approach.

• To help achieve interoperability both within and across different policy areas, notably in the context of the IDABC programme and any other relevant Community programmes and initiatives.

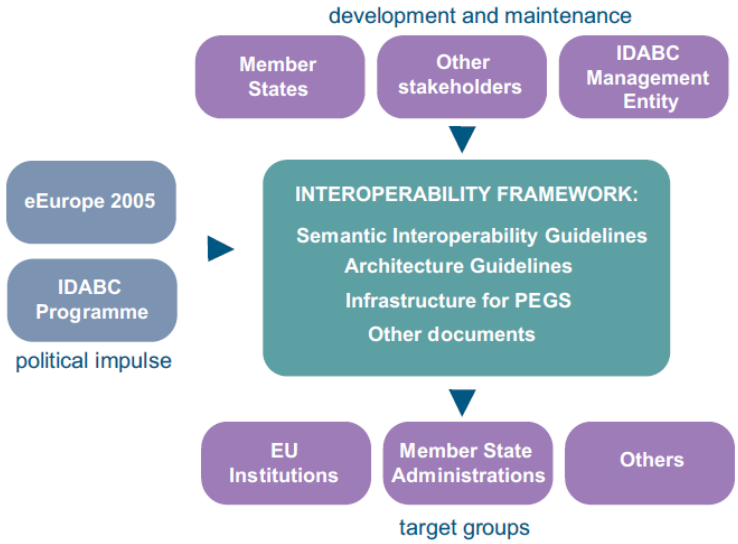

Figure 3.2 Context and actors for the EIF

Figure 3.2 explains the key stake holders involved in the implementation of the EIF. The context for implementation of the EIF is majorly the eEurope 2005 and the IDABC programmes. It includes Architecture guidelines and Interoperability guidelines for the implementation of several European wide interoperability e-goverance projects.

Types of Interactions for e-Governance

In the most general form of interoperability, the following three interaction types that cover most of the current trans-border eGovernment services can be defined:

• Direct interaction between citizens or enterprises of one particular Member State with administrations of other Member States and/or European institutions.

• The exchange of data between administrations of different Member States in order to resolve cases that citizens or enterprises may raise with the administration of their own country.

• The exchange of data between various EU Institutions/Agencies or between an EU Institution/Agency and one or more administrations of Member States.

Interoperability Dimentions

Three dimentions of Interoperability have been considered in EIF:

Organisational Interoperability

This aspect of interoperability is concerned with defining business goals, modeling business processes and bringing about the collaboration of administrations that wish to exchange information and may have different internal structures and processes. Moreover, organisational interoperability aims at addressing the requirements of the user community by making services available, easily identifiable, accessible and user-oriented.

Semantic Interoperability

This aspect of interoperability is concerned with ensuring that the precise meaning of exchanged information is understandable by any other application that was not initially developed for this purpose. Semantic interoperability enables systems to combine received information with other information resources and to process it in a meaningful manner. Semantic interoperability is therefore a prerequisite for the front-end multilingual delivery of services to the user.

Technical Interoperability

This aspect of interoperability covers the technical issues of linking computer systems and services. It includes key aspects such as open interfaces, interconnection services, data

integration and middleware, data presentation and exchange, accessibility and security services.

Key Recommendations

When implementing a national interoperability framework the emphasis is obviously on "interoperability". The EIF recommends standardisation in technology and harmonisation in legislation as two major ways to achieve this.

Other key recommendations of the EIF are:

• *Use open standards:* For establishing an IT platform that is extensible and compatible with future expansions, the use of open standards has been recommended. The software source codes when open, not only enable future modification but enable a larger participation for the development of future modules. In contrast proprietary systems often face issues of vendor lock-in.

• *Incorporate existing standards in a larger context:* Reinventing is not always the best solution, and as far as possible, existing standards should be tried to be utilized in a larger context. This would enable a much easier integration with existing systems and would not cause large scale disruption in operations during implementation.

• *Stimulate re-use of proven standards:* Proven standards that have been utilized for several years have already evolved into robust systems. Their reuse would not only reduce interoperability costs but reduce the chances of major failures post project.

• *Redesign administrative processes and make the best use of the available technology:* This involves making services more user-centred. When administrative processes are designed for maximizing the benefits that Information Systems can offer, the end users will find the entire process much less bureaucratic and easy to interact with.

• *Keep administrative systems independent of proprietary technology:* Proprietary technology promotes vendor lock in and increased dependence on one particular vendor. The severely limits the future expansion possibilities.

• *Coordinate and manage the eGovernment initiative:* The e-government initiative must be centrally coordinated and managed to insure that the several departments of different governments are well integrated and avoidance of isolated islands of interoperability.

• *Free and Easy availability of XML schemas:* Centrally agreed XML schemas may be provided free of charge throughout the public sector. This form of re-use reduces cost and the need to develop separate mechanisms for interchanging data.

• *Updated tracking of developments:* Keeping track of developments in the wider community is necessary. For instance, changes in privacy legislation may impose requirements to the provision of some eServices.

• *Reduction in data Collection:* The amount of data to be collected must be reduced by using well-defined data dictionaries and data structures which reduce duplicity of data collection.

• *Security:* Ensure information security by preventing unauthorised access to systems and, in the case of highly confidential information, securing each record (or even each component) individually.

• *Enable wide access:* The maximum possible access must be ensured through the use of user-friendly interfaces, access for the disabled, foreign language support, amongst other measures for wider dissemination.

3.2.2 Relevance of IDABC and EIF to this dissertation

The IDABC initiative is a classic example of the large scale need of interoperability in several key areas. There are several key differences between the approach towards interoperability by the EIF and the objectives of this dissertation. While the EIF aims to develop a framework and guidelines for the large scale adoption of interoperability across several entities and governmental organizations and departments, this dissertation explores the dyadic interoperability issues between two organizations. While the EIF is focused on the e-government domain, this dissertation aims at developing a model for more generic applications across a wide variety of industry domains. Also, while the EIF concentrates more on organizational systems and information system architecture, this dissertation aims to further expand the scope of interoperability to include more aspects.

However, the EIF makes several technical specifications which can have applicability in a much larger area, for example IT system planning for large organizations. The EIF also shows that centralized planning and distributed execution go hand in hand for ensuring implementation of large scale interoperability.

3.3 ECOLEAD Project

Ecolead was a Project funded by the European Community under the "Information Society Technology" Program. It was a 3 year project that was initiated in 2004.

European Collaborative networked Organisations LEADership initiative, ECOLEAD, aimed to create strong foundations and mechanisms needed to establish an advanced collaborative and network-based industry and society in Europe. It visualizes, "In ten years most enterprises will be part of some sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations in response to fast changing market conditions." [ECOLEAD website]

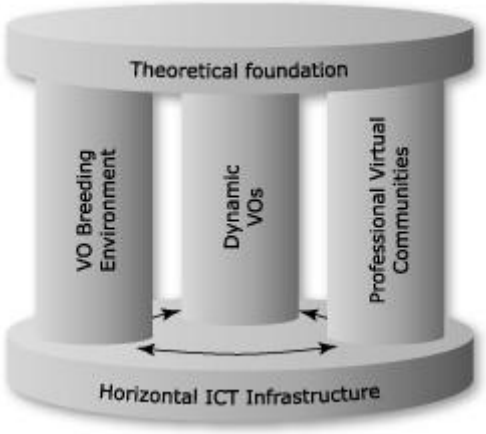

Figure 3.3 Components of ECOLEAD Project

ECOLEAD believes that a substantial impact in materializing networked collaborative business ecosystems requires a holistic approach. It states that due to the area's complexity and the multiple inter-dependencies among the involved business entities, social actors, and technologies, substantial breakthroughs cannot be achieved with incremental innovation in isolated areas. On the other hand, project plans must remain manageable. Thus ECOLEAD addresses the fundamental and inter-related focus areas, which form the basis for dynamic and sustainable networked organizations: the VO Breeding Environments, Dynamic Virtual Organizations and Professional Virtual Communities, as shown in figure 3.3. In addition to these three vertical focus areas, the holistic approach is reinforced and sustained on two horizontal areas: the theoretical foundation for collaborative networks and the horizontal ICT infrastructure. The horizontal activities support and affect all three vertical focus areas. The existence of an invisible, low-cost ICT infrastructure is a pre-condition for the establishment of truly dynamic collaborative networks. ECOLEAD aimed to impact industrial

competitiveness and societal mechanisms, by providing means to effectively exploit opportunities derived from the deployment of VOs, and by designing and enabling new professional work paradigms, capable of enacting a knowledge-based society.

Results

The ECOLEAD project results were aimed at existing and future Virtual Organizations Breeding Environments (VBEs), professional associations, universities, research institutes, ICT industry, consultancy companies and SMEs. ECOLEAD developed the following tools to help in the creation and management of virtual organizations:

1. **Dynamic VO creation assistance tool** which supports the rapid creation of a virtual organization utilizing trust, competency, business process, past performance information of candidates and their ability to rapidly create ready-to-do businesses.

2. **VO collaboration and performance measurement tool** that records past collaboration performance of each single member in order to be able to select the right organization needed to create a VO.

3. **Contract negotiation wizard tool** that allows the rapid definition of the dues and the rights of the organizations which are going to join together in the VOs;

4. **VO management e-service tool** that effectively manages an operating VO by means of e-services in ASP modality with a very low impact in the single organization ICT structure.

5. **Collaborative problem solving support e-services tool** that improves the profitability and quality of VBE members allowing to start problem solving processes addressing daily troubles and inefficiencies they experienced.

6. **Advanced collaboration platform for PVCs tool** provides the necessary support in order to allow the cooperation of single professional humans, bringing in the business arena, their personal and specific competencies.

The above-mentioned ECOLEAD's results are intended to act as drivers for the adoption of ICT solutions by SMEs while networking through VBEs. These tools support SMEs' vital business processes since the VBE joining time.

3.3.1 Virtual Organization Performance Measurement (VOPM)

Ecolead defines VOPM as the systematic approach to plan and conduct the collection and monitoring of data for performance indication of the collaborative activities and aspects in a Virtual Organization (VO).

This data collection and monitoring is aligned to certain Performance Indicators (PIs) that are derived from defined objectives of the VO. The indicators are focused on the collaborative activities and aspects which means that they concentrate on the exchange between partners and their contribution to the overall performance of the VO.

Aspects for Performance Measurement

Ecolead's VOPM performs the performance measurement on the following aspects:

- Financial data, especially cost, keeping of budgets and revenues.
- Data on the accomplishment of the (non-financial) planning, especially the on time accomplishment of the tasks and milestones in the Work-Breakdown-Structure (WBS).
- Data on the effectiveness, efficiency and stability of processes including collaboration process

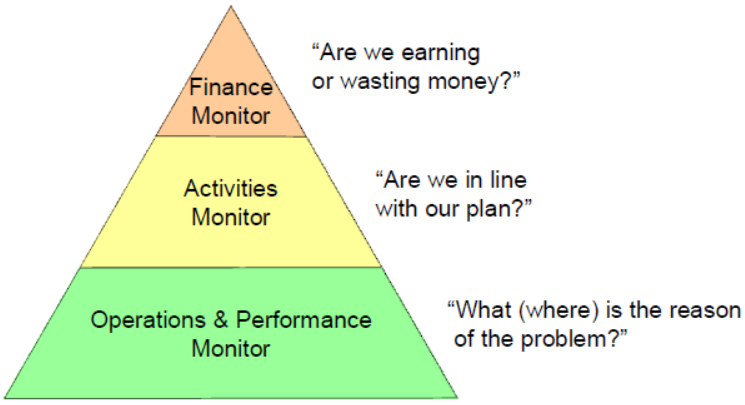

Figure 3.4 Main Aspects of Performance Measurement in ECOLEAD

According to these requirements the main scope of measurement will be:

· Cost and revenues

· Quantitative output

· Quality

· Time

· Collaboration performance (as a VO specific part of the operations performance)

Besides these main aspects there could be a need for additional data like customer satisfaction.

3.3.2 ECOLEAD Project Impacts

Ecolead claims to have the following impacts to the following market segments:

Impact to ICT solution providers

Most successful ICT companies find it difficult to effectively meet SME requirements. The intrinsically small dimensions, the loose availability of financial resources, the fear of facing to innovation, the adopted organizational structures and several other limitations, frequently become insuperable walls, barriers, between SMEs and enterprise ICT solutions. Ecolead aimed to circumvent it by interfacing and integrating pre-existing IT systems, harmonizing business models and processes, customizing and tailoring user interaction to support very different degrees of education and professional skill sets, and representing and sharing heterogeneous knowledge models.

The ECOLEAD projects aimed to have the following potential benefits for ICT providors:

1. They can use VBE members and service centres, as partners to propose their collaborative solutions, without the time pressure of an urgent business opportunity to support.

2. They can use the VBE methodologies and tools as knowledge base on which to found the development of cross-organisation software applications.

3. They can use the VO management performance indicators as the relevant business parameters on which to constantly measure and simulate the behaviour of a collaborative solution.

4. They can use the VOs management monitored information as the real life data testifying the actual development and implementation of a business opportunity.

5. They can use the advanced collaboration platform for PVCs as the human (and competency) centred cooperation environment which often is required to support a complex cross-organisation application.

6. They can use the technology-independent ICT platform as the reference model and the basic middleware to dominate the heterogeneity of existing ICT solutions in Computer Network Operations (CNOs).

7. They can use the theoretical foundations as the elements necessary to fill the conceptual gap between one-enterprise and multi-organisations software solutions.

Impact to SMEs

The global market today, pushes the SMEs into cooperation with other SMEs and also with big companies in the collaborative network paradigm. But collaboration requires, very frequently, a preparedness that usually is missing in most SMEs. In fact, the need for cooperation is usually not compatible with the traditional mindset of SMEs and their patrons. Facts like insufficient preparedness of people or resources and the inability to have a quick access to monetary resources, frequently force the SMEs to miss business opportunities which require the rapid establishment of a collaboration framework amongst them. ECOLEAD intends to provide a complete cooperation kit for SMEs which will speed up, enable and support the building of VOs between SMEs and thus secure the successful existence of new economic entity. This is even more relevant since SMEs are usually ready to pay just for applicative services which could either cut expenses or increase revenues, but are not in a position to directly pay for infrastructures and invasive ICT solutions. Hence ensuring a smooth 'entrance' in the VBEs is a key success factor.

VBE (Virtual Organizations Breeding Environment)

At the moment, there are only a few examples of VBEs globally, which are based on the ECOLEAD project concept, nevertheless VBEs have the most promising potential for enabling SMEs to collaborate and most of the results of the project are addressed to them. A number of examples of SMEs services centers (industrial associations, district service center, technological implantation services, and so on) already exist, and they are very close to acting and behave as VBEs. These potential VBEs have the mission to support the overall well being of their associated SMEs. Most of the VBEs were started with public funding but need to be sustainably supported economically by their associates, and this will be realized only if the VBEs are able to provide members with high value added services.

Consultancy Companies

SMEs must deal with the need to be ready for changes and be able to face new challenges (like collaboration and collaborative processes). They are not always having the required know-how to take tactical decisions. Often in some situations, they require the help of external persons, acknowledged as experts in the domain, in order to support the decisional

processes. The management consultants in the VBE environment, in order to re-organize the business processes, could adopt tools like the Collaborative problem solving support e-services, which were born as consultancy instruments. These consultants are vital to promote the VBE/VO concepts to the SMEs which could in turn be a vital source of business for them.

Analysis

The ECOLEAD project recognizes the fact that for small SMEs to sustain, they need to utilize their agility combined with the ability to form quick collaborations with other SMEs to compete effectively with larger organizations. The project results are aimed at aiding the creation and management of Virtual Organizations and develop tools that will help in the management of these virtual organizations. However, the key challenge in itself is to ensure the creation of cross functional, efficient and interdisciplinary VBEs that would enable SMEs with different functional competencies to collaborate. For the optimal creation of VOs, SMEs should have the opportunity to partner with the best in the world. Hence VBEs should be either few and global in nature or have internetworkability to allow SMEs from one VBE to collaborate with SMEs from other VBEs. Hence a comprehensive policy for the establishment of VBEs aided by national legislations need to be further evolved.

3.3.3 Relevance of Ecolead to this Dissertation

The Ecolead project aimed to create several tools for the creation and management of VBEs. This is intended to be greatly beneficial to SMEs being a part of the VBEs implementing ECOLEAD results. Several of the tools developed by ECOLEAD aimed at addressing the interoperability issues that this dissertation aims to address. The VO creation assistance tools addresses the business interoperability requirements with regards to management of external relationships and selection of ideal collaborations. The Contract Negotiation Wizard tool helps to address the interoperability issues regarding proper allocation of IPRs.

The collaboration performance measurement tools to some extend address the measurement of business interoperability primarily aimed by this dissertation. However it tries to measure performance more in the context of virtual organization as compared to interoperability measurement in a dyadic collaborative environment that this dissertation attempts.

4. Results

The ultimate objective of this dissertation is to identify key aspects of Business Interoperability and to devise an analytical framework for the assessment of Business Interoperability Quotients.

4.1 Measuring Business Interoperability Parameters

Based on the extensive review of existing models and frameworks, eight Business Interoperability parameters (BIP) have been identified. While the relative importance and relevance of each of these parameters would depend on the collaboration environment, all of the identified parameters play a role in evaluating overall collaboration interoperability.

Business Interoperability Parameters
Business Strategy
Management of External Relationships
Collaborative Business Processes
Organizational Structures
Employees and Work Culture
IPR management
Business Semantics
Information Systems

Figure 4.1 Identified Interoperability Parameters

The above mentioned business interoperability parameters are exhaustive and cover different levels and aspects of business collaborations. They can be utilized to measure and quantify the overall business interoperability between two organizations so that an Interoperability Index can be arrived at which would lead to the computation of an Overall Interoperability Score. These parameters are further described by certain sub-parameters as detailed later. For making these computations, for each of these BIPs and their sub-parameters, some key values need to be assigned, which would enable the calculation of the Interoperability Index:

Parameter Relevance Value (r_i)

Each of the BIPs assume different relevance in different collaboration scenarios. It is necessary for assigning a value which signifies how important is the specific BIP. For example the relevance of Employees and Work Culture is less important in purely transactional collaborations between a seller and a buyer than for collaborative research assignments. The relevance value is assigned a score between 0 and 10.

0	1	2	3	4	5	6	7	8	9	10
Irrelevant	Trivial	Preferable	Desirable	Beneficial	Substantial	Important	Significant	Crucial	Critical	Vital

Figure 4.2 Scale for gauging relevance

Sub-Parameter Relevance Value(r_{ii})

The Sub-parameter reference value demonstrates the relevance of each sub-parameter with respect to that particular parameter. It is also graded on a scale of 0 to 10 shown in figure 4.2. However the Parameter Relevance value(r_i), indicating the relevance of that BIP to the overall interoperability, needs to be assigned separately and is not derived from r_{ii} values. This is because; the presence of even a single critical sub-parameter could render the relevant BIP highly critical, although its other sub-parameters may not be so significant. Hence an average value for r_i calculated on the basis of the other sub-parameters may not be optimal. Hence the BIQMM design required assigning the values of r_i and r_{ii} separately through the assessment performed.

Sub-Parameter Score (v_{ii})

Each Sub-Parameter needs to be assigned a value between 0 and 10 which signifies how sufficient is the existing interoperability with respect to what is desirable for that particular sub-parameter. While assigning the value, it is necessary to evaluate the sufficiency of existing interoperability arrangement and not the sophistication of interoperability tools employed since the highest level of interoperability may not be the most desirable. The final parameter score V_i for the particular BIP is the weighted average of v_{ii} with r_{ii} being the weights.

Table 4.1 Interoperability Index

No	Business Interoperability Parameters	Relevance	Score
1	Business Strategy	r_1	$V_1=\sum r_{1i}\, v_{1i} / \sum r_{1i}$
2	Management of External Relationships	r_2	$V_2=\sum r_{2i}\, v_{2i} / \sum r_{2i}$
3	Collaborative Business Processes	r_3	$V_3=\sum r_{3i}\, v_{3i} / \sum r_{3i}$
4	Organizational Structures	r_4	$V_4=\sum r_{4i}\, v_{4i} / \sum r_{4i}$
5	Employees and Work Culture	r_5	$V_5=\sum r_{5i}\, v_{5i} / \sum r_{5i}$
6	IPR management	r_6	$V_6=\sum r_{6i}\, v_{6i} / \sum r_{6i}$
7	Business Semantics	r_7	$V_7=\sum r_{7i}\, v_{7i} / \sum r_{7i}$
8	Information Systems	r_8	$V_8=\sum r_{8i}\, v_{8i} / \sum r_{8i}$

Overall Interoperability Score (I)

This signifies the overall level of Business Interoperability that exists between two collaborative scenarios and is derived from the above interoperability index. It is in the range of 0 and 10.

$$I = \sum r_i\, V_i / \sum r_i$$

Note: small letter denotes that the variable has been assigned a value, while capital letter indicates that the variable's value has been calculated.

4.2 Identifying Business Interoperability Parameters and Evaluating Sub-Parameters

Business Strategy

The highest level of interoperability between collaborating organizations should be reflected in their overall business strategy. There should be pronounced clarity on the objectives and the scope of collaboration at the highest strategic decision making levels. Conflicting interests should be addressed in an open manner so that the mutual interests of both collaborating partners should be identified and respected.

For example, in a Customer-Supplier relationship, collaborations could be aimed at reduced inventories, better planning and efficient forecasting of demands. These objectives are aimed at mutual benefits and do not result in conflict of interest amongst the partners. However, the efficiency of this collaboration would necessitate greater transparency. However, the interests of both the partners are in different directions when it comes to negotiations on prices and a greater transparency may lead to reduced leverage on price negotiations for a partner. Hence such conflicts that could hamper business interoperability can be resolved if there is a well defined business strategy and both partners recognize and agree on the strategic advantages and understandings of the collaboration for them.

Questions for assessing interoperability sub-parameters with respect to Business Strategy

Clarity in Strategic Goals	Are there any conflict of interests in the collaboration? Has it been adequately resolved?
Impacts of collaboration breakdown	Has there been a formal commitment to the duration of collaboration? How detrimental would it be for the organization in case of premature termination of the collaboration? Are their sufficient safeguards to prevent this termination or backup plans in case it occurs?

Management of External Relationships

Management of networks figures among the most important success factors highlighted by many authors. Cooperation management starts with planning and defining the cooperation, e.g. selection of partners, and covers all aspects of realization, implementation and monitoring

of the cooperation, such as cooperation contracts, managing conflicts, change management and communication. When the cooperation is finished, management includes obtaining feedback, learning from good as well as bad experiences and keeping good relationship with the cooperation partners.

Questions for assessing interoperability sub-parameters with respect to Management of External Relationships

Partner Selection	Is there any mechanism for identifying the best partners available? Are you certain that the collaboration partner is one of the best suited for your needs?
Partner Assessment	Do you have any mechanism for evaluation of the quality of selected partners and their appropriateness for your organization? Do you have well developed guidelines for performance measurements and use it for gauging partner performances?
Cooperation Contracts	Do you have clear, well defined cooperation contracts with your partner which spells out conditions and liabilities and reduces chances of conflicts?
Conflict Resolution	Do you have frequent occurrences of conflicts? In case of conflicts, do you have mechanisms for quick resolution?
Communication	Do you have barriers to free inter-organizational communication?

Collaborative Business Processes

In B2B relationships, partner responsibilities are often unclear and performed ad-hoc, which result in conflict of resources and coordination efforts. Business interoperability builds on the vision that companies can quickly and inexpensively establish and conduct a relationship of coordination with corresponding partner processes. Automatic orders when stock levels fall below an agreed safety level are examples of this.

Responsibilities between business partners must be well clarified and well specified in collaboration arrangements. [Athena 2006] states that since cross-organisational business process design tends to be complex and not very practicable, its BIF builds on the concept of "Public Processes". Public processes define the inputs and outputs in cross-organisational

business processes in the sense of loosely coupled interfaces, thereby hiding all private details to the business partners.

The European Interoperability Framework states that since it is unrealistic that national administrations will harmonise their business processes because of pan-European requirements [IDABC 2004, p.18], it suggests to identify and document the "entry and exit points" of cooperation processes. Through these "business interoperability interfaces" (BII) the administrations will be able to cooperate with administrations of other Member States.

Besides the problem of aligning business processes from different organisations is the problem of lack of transparency. Experiences from e-business projects show that even minimal process visibility (e.g. status information or notification in the case of an exception) often provides business benefits to a business partners.

Questions for assessing interoperability sub-parameters with respect to Collaborative Business Processes

Responsibility Sharing	Is there a clear division of responsibility between you and your partner?
Clarity in business processes	Are business processes for collaborative work well defined and responsibilities well allocated? Is there a smooth transition of information from one organization to another?
Visibility	Is the status of processing within one organization easily visible to the collaborating partner?

Organizational Structures

Different organizations have different organizational structures ranging from mostly flat, to a strictly hierarchical structure. Also while some organizations have dynamic project based teams, which assemble and dissemble as the project progresses, other organizations believe in departmentalizing work and distributing the project work amongst the different departments. While different organizational structures may be more appropriate for different organizations, interoperability may be an issue when two organizations are collaborating, which have completely different organizational structures. As organizational complexity grows,

hierarchical structures are adopted with well defined business processes. On the other hand, small organizations do not feel the need for strict organization and use the inherent flexibility to their advantage. Hence it is important for an inter-organizational mapping so that different organizational structures do not cause communication barriers and agents in one organization are aware of their counterparts in a collaborating organization.

Questions for assessing interoperability sub-parameters with respect to Organizational Structures

Cross-Organizational Role Mapping	Is there a clarity within the organization for responsible person to contact from collaborating organization for various different types of issues? Are there significant delays for obtaining information from collaborating organization on account of uncertainty on whom to contact?
Contact Points	Are there sufficient contact points at different levels which would enable the different organizational structures to seamlessly collaborate?

Employees and work culture

Networkable enterprises promote cooperation by being open to change and by basing cooperation between business partners on a relationship of trust instead of mutual checks. In practice, collaboration cannot be neither ordered nor imposed on someone. This emphasises the importance of change management in order to implement a business solution which will be accepted by the employees in all the companies involved. Communication and trust can be seen as key elements. Mechanisms to reach this state are openness, identification and control of goal conflicts as well as trust creating measures.

As organisations tend to expose their internal complexity to their business partners, partnership management becomes more important with an increasing number of external relationships. As a result, a clear communication route between the partners, which is not overly dependent on key individuals, is necessary.

Questions for assessing interoperability sub-parameters with respect to Employees and Work Culture

Linguistic	Does the collaborating partner's employees use a different language than

Barriers	yours? If yes, does it cause problems with normal communication of employees?
Motivation	Based on your experiences are your collaborator's employees as motivated about the work as are yours or vice versa? Are employees from both the organizations incentivized and encouraged to take leadership roles and initiatives for improving ongoing collaborative projects?
Responsibility	Do employees of both the organizations take responsibility for tasks or do you notice a 'passing the buck' syndrome where there is a tendency to push responsibilities to the other organization?
Honesty	Do you believe that employees of both the organizations share the same level of honesty and openness, especially when dealing with the other organization?
Efficiency	Are your collaborator's employees as efficient as yours in terms of required training, performance, working speed?

Intellectual Property Right Management

This is especially relevant on knowledge based collaborations where an appropriate mechanism of sharing Intellectual Property Rights, needs to exist. IPR related conflicts can severely affect trust and efficiency of innovation projects. Rationalising of IPR applications and convergence on IPR sharing agreements is important to achieve interoperability on IPR issues.

Questions for assessing interoperability sub-parameters with respect to Intellectual Property Right Management

Background IPR Protection	For the collaborating scenario, does your collaboration agreement clearly spell out existing IPRs to be provided by each partner and its conditions of use? Is the compensation for the same clearly agreed upon?
Foreground IPR	Has potential IPRs arriving out of this collaboration been identified and its use and sharing of rights been agreed upon?

Conflicts	Is there any conflicts related to IPR sharing or use within the collaboration?

Business Semantics

Among the key issues in aligning business processes, figures the problem of different terminologies in every organisation. A prerequisite for inter-organizational collaboration is a common understanding of the structure and significance of the information to be exchanged. This is traditionally been true for transactional collaborations, like the banking sectors but standardization of business semantics has now been found much helpful in several other areas such as tourism, media, with much greater usage of information systems in these areas.

Usually, in case of usage of differing terminologies, information systems use different internal representations of the relevant business objects which require mapping and transforming data. While this usually involves an ad-hoc approach, setting of industry standards goes a long way in promoting interoperability.

Hence while aiming towards common standardized business semantics is important, at the same time development of semantic conversion technologies is also necessary to offer practical solutions in the short term.

Questions for assessing interoperability sub-parameters with respect to Business Semantics

Conflicting terminologies	Do you and your collaborator use different terminologies with regards to the business area that you both operate on?
Semantic Conversion	Do you have standardized tools or processes to undertake the process of semantic conversion so that differing terms in different organizations do not create operational difficulties?

Information Systems

Information Systems interoperability is the most basic of all interoperability requirements since most transactions and information exchanges today take place through electronic networks.

Initially, portal solutions are set to represent the dominant collaboration strategies as they have the lowest integration requirements. In the medium- and long-term, companies will prefer to network by means of business collaboration infrastructures due to the higher efficiency potentials.

When setting up electronic links with business partners, companies often struggle with bilateral discussions. The lack of scalability to a broader number of business partners has hindered the diffusion of interorganisational systems so far. Until now, standardisation has only partly been successful in creating this common terminology, since many standards, including XML and core Web Service standards relate only to the syntactical layer. In the future, service-oriented architectures [Papazoglou 2003] could promote semantic integration by providing standardised interfaces which follow industry norms.

An additional factor in B2B relationships is the necessity to conduct transactions over the internet that meet user's privacy and security requirements as well as existing e-business legislation. This typically involves questions of authorization, authentication, encryption etc.

Questions for assessing interoperability sub-parameters with respect to Information Systems

Data Exchange Tools	Do you have a suitable tools for ease of exchange of Data and files?
Speed	Is the information system that you rely on fast enough for quick communication?
Application Interoperability	Are there specific/standard translators or conversion applications that are used to access data between your organizations?
Security	Do users have the confidence to securely transmit confidential information and perform secure operations across the two organizations?

4.3 Business Interoperability Quotient Measurement Model (BIQMM)

The primary objective of this dissertation was to develop a model that would allow the measurement of Business Interoperability based on a holistic approach to the topic. This model has identified 8 major BIPs which represent the different levels of interactions that collaborating entities could engage in. The model has further identified sub-parameters to enable performance measurement for each BIP.

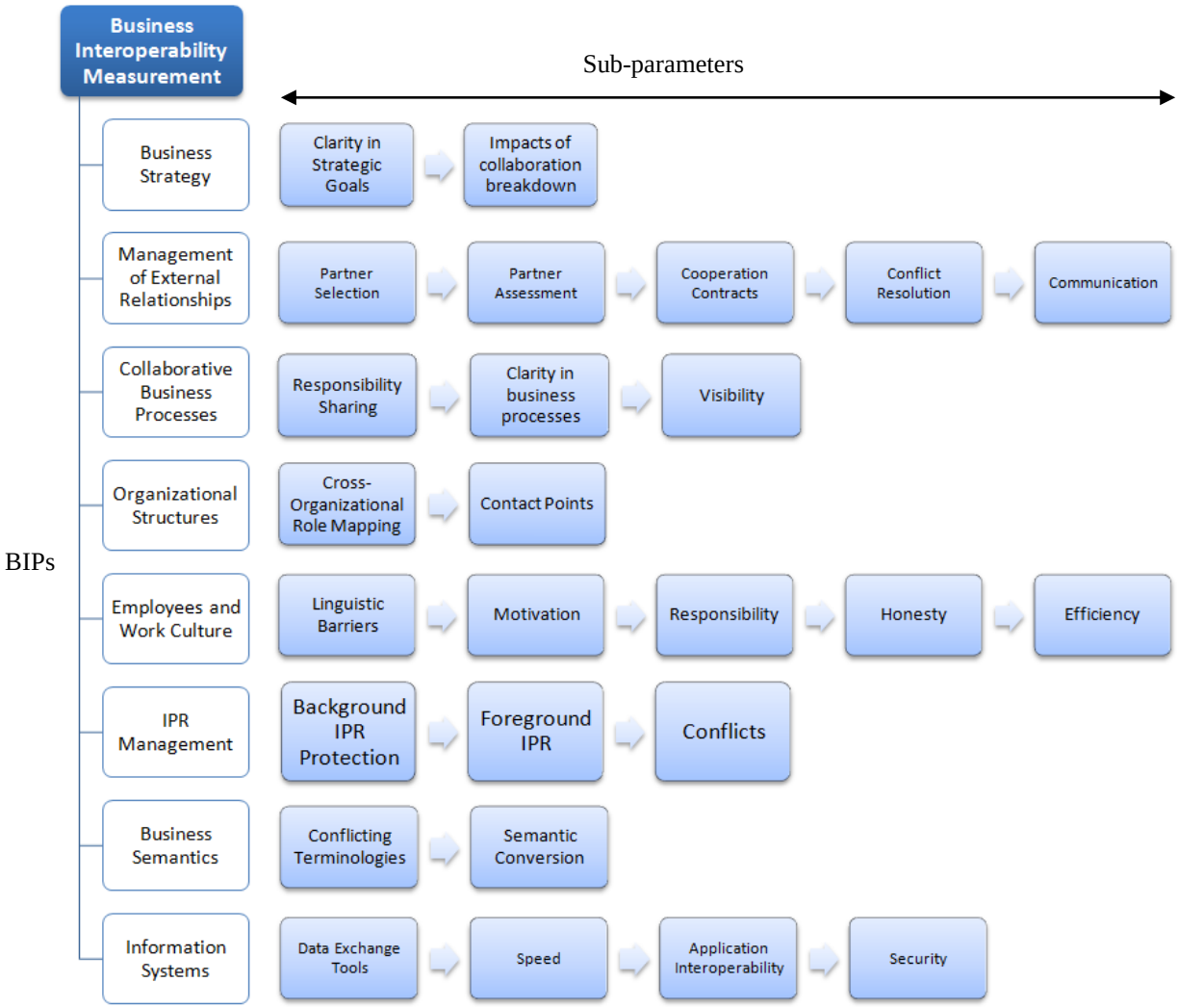

Figure 4.3 Interoperability Quotient Measurement Model

The model is designed to focus on the measurement of interoperability and assign it a score with respect to optimal interoperability. That is why it is critical to assess the relevance of each of the eight indentified BIPs and respective sub-parameters. For example, a collaboration between two companies involving a key secret research project would find responsibility and honesty as critical requirements for the involved employees from both companies. Hence the

BIP, “Employees and Work Culture”, would be given a high relevance score as compared to a collaboration involving an automated data sharing. Thus the successful implementation of this model necessitates a precise assessment of both the relevance and performance of each BIP. The questions developed to gauge the performance of each attribute of a BIP in the previous section, will guide the analysis of the correct collaboration situation.

Technical and economical assessment approaches that are based on a static idea of collaboration relationship have limited value. [Grilo et Al. 2008] Dynamic approaches that take into account the past trend, and hence the future increase in interoperability requirements, are more capable at judging the present state of interoperability ‘preparedness’. Hence while using the BIQMM, these dynamic factors need to be taken into consideration.

Interdisciplinarity

The interoperability model encompasses several disciplines as it moves from the more technically focused area of Information Systems, upwards towards Business Strategies. The various fields of relevance are listed:

Table 4.2 Disciplines involved in BIQMM

BIP	**Discipline(s) involved**
Business Strategy	Strategic Management
Management of External Relationships	Management
Collaborative Business Processes	Business Process Management, Information Mangement
Organizational Structures	Organizational Management, Value Networks
Employees and Work Culture	Ethics, Sociology, Psychology, Behavioural Science
IPR management	Law, Innovation Management
Business Semantics	Information Technology, Language, Semiotics
Information Systems	Information Technology, IT Networking

The interdisciplinary approach to using this model for interoperability evaluation makes it further difficult for analysis or application to a particular business case. While this dissertation

makes a first attempt to identify the various BIPs and has attempted to highlight key attributes, there exists immense possibilities for further refining and detailing of the attributes identified. Also any implementation of this model must involve key participants from the participating organization who have an overview of the collaboration situation. In case the organization is particularly large, the analyst may identify key representatives from different departments for the evaluation of BIPs more relevant to their area of working.

5. Case Study for evaluating BIQMM

The Case Study involves the LM Funding Office, which is a joint initiative between Innovayt and LM Glasfiber.

Innovayt is a small Danish consultancy specialised in innovation and public funding. It assists companies and public bodies with their work on concrete projects and funding applications. It has offices in Lyngby, Denmark and Braga, Portugal. The core competencies of the company lie in public funding programs, in particular the realization of innovation ideas from corporate clients on tools for optimizing innovation activities and project portfolios related to technological innovation.

Innovayt helps private and public sector clients with:
- Development of innovation strategies for core business areas
- Inspiration, screening and validation of innovation projects
- Funding and grants for innovation projects
- Building and strengthening innovation capability
- Analysis and program management for public organizations.

Innovayt has cumulated more than 35 years of first-hand experience with respect to European R&D Framework Programs including;

- Brussels-based work with EU R&D and Innovation – Ranging from policy negotiation, proposal writing, project evaluation to project implementation.
- Experience with establishing pan-European partnerships and cooperation on product development between companies and R&D organizations.
- Work with companies on technology and product development – ranging from low tech to high-tech companies.
- Market-leading insight into political preparation and policy process surrounding EU R&D funding. One Innovayt partner took up central responsibilities in the negotiation of FP7 and other innovation related funding programs.

- Unrivalled knowledge of FP7, both from a political and practitioner's perspective – including content of programs, rules of participation, application, and simplification measures, IPR and horizontal issues of EU research cooperation.

LM Glasfiber is the largest manufacturer of wind turbine blades in the world with a market share of 25%. LM Glasfiber has manufactured more than 120.000 blades since 1978 corresponding to a capacity of more than 37 GW - contributing to saving nature more than 70 million tons of CO2 each year. It has manufacturing facilities in several countries.

LM Glasfiber employs approximately 7,200 employees worldwide. The company is headquartered in Kolding, Denmark and has a global business office in Amsterdam, the Netherlands. LM Glasfiber has built production and service facilities in the major wind energy markets – 14 locations in 8 countries (Denmark, Germany, Spain, USA, Canada, India, China and Poland). In addition to this; the company has a global network of R&D Centres in Denmark, the Netherlands and India.

Figure 5.1 Global Presence of LM Glasfiber

LM has achieved a strong position in a business distinctive for international growth via a consistent focus on research, product development, quality and customer service. LM Glasfiber conducts extensive R&D in close collaboration with both customers and leading research institutions. Their objective is to develop new technology that makes wind turbines more efficient and extends the service life of both the turbines and the blades.

LM Funding office (LMFO)

The initiation of LMFO as a permanent activity in LM Glasfiber's organization, through a new organizational unit to be located within LM's corporate finance setup, signals the determination of LM to fully exploit possibilities in soft funding sources for all its business areas and geographical locations. Soft funding in this context refers to grants and public programmes, instruments, and incentive schemes representing financing and more favourable terms than offered by private capital markets.

Through collaboration with Innovayt on LMFO, LM gains access to Innovayt's unique expertise within the European regional and national soft funding landscape. In addition to coordination and drafting of individual funding applications, Innovayt will provide continuous support for funding activities, in particular with regard to structured and regular intelligence on funding opportunities and support for project screening and project management.

In addition to LM's own resources, LMFO is based on external expert assistance for funding activities, with Innovayt as the chosen European partner for this role. Innovate will designate permanent staff for the assignment, including a project leader to undertake day to day management of the assignment, as well as a project responsible in order to see the assignment and conduct senior contact with LM.

Economics and risk sharing mechanism

The risk sharing mechanism agreed between LM and Innovayt for LMFO is designed to enable an overall guarantee for self-financing – through funding revenues secured for LM – of all LM's cost for external services for the running of LMFO. The risk sharing mechanism details an arrangement where LM pays an additional win-bonus to Innovayt for funding secured above DKK 1,600,000. Conversely, in the (unexpected) event where total funding secured for LM during the agreement period does not exceed DKK 1,600,000, Innovayt will refund to LM an amount equivalent to 50 percent of the difference between funding secured and DKK 1,600,000.

The overall consideration behind the risk sharing mechanism, besides making the arrangement more economically attractive to LM, is to align interests so that both parties have a clear interest on cooperating on only the best ideas and constantly maintain the highest professional standards.

5.1 Responsible Staff interviewed at Innovayt

For assessing the interoperability quotient of the collaboration from the perspective of Innovayt, two of its key staff involved in this collaboration were invited for an open discussion. The interoperability framework presented in this dissertation was explained to them. The questionnaire presented in Annex 1 was presented to them.

It was felt that to arrive at a realistic picture of the collaboration scenario, they would be required to reflect deeply on their past experiences with their collaboration. Also, it was felt that rather than separately interviewing them, a joint discussion on the various points covered in the questionnaire and arrival at a BIP score by consensus would be much more meaningful. This is because, while one of the participants is a senior partner at Innovayt and would be more aware of the strategic issues, the other participant would be more aware of issues faced while working practically at lower levels of the Business Interoperability Framework.

The profiles of the two participants were:

Morten Kröger, Partner (LMFO Project Responsible)

Morten has more than 12 years of EU Framework Program and general fund-raising experience. He served 9 years at a Danish regional innovation and development agency in Brussels – 6 years as head of office and Director. His experience includes policy formulation in expert groups, policy and industry advisor, formulation and implementation of FP research projects of all modalities.

Morten serves as R&D project evaluator for the EU Commission and EUREKA and on the commission's FP7 SME Advisory Group. In addition, Morten has formulated and implemented several regional FP incentive programs with successful results. Through his work in Brussels and at Innovayt, Morten has in-depth knowledge of most European Instruments and themes. He holds an MSC in Political Science from Aarhus University and a MAP from INSEAD in France.

Kristoffer Riis Pedersen, Project Developer (LMFO Project leader)

Kristoffer has 2 years experience with soft funding instruments and the drafting and coordination of applications. He has taken responsibility for, inter alia, applications within the field of automation and process machinery, as well as numerous projects within renewable energy.

In addition, Kristoffer has a record as an independent entrepreneur assisting companies on ideation in the context of innovation projects, and has assisted faculty on numerous academic projects on related topics during his postgraduate studies.

Kristoffer's areas of expertise are application writing and coordination, project management, innovation, and analytical tools for ideation and innovation management.

5.2 Results of the discussion

The response of the participants on the various BIPs are summarized below.

1. **Business Strategy**

- Clarity in Strategic Goals

Are there and conflict of interests in the collaboration? Has it been adequately resolved?

There are no conflict of interest and this is a mutually beneficial partnership. Innovayt has given an undertaking not do business with LM's competetitors in the wind turbine blade manufacturing industry, since it has access to LM's classified information in this area and this could lead to potential conflict of interests.

$r_{11} = 8$, $v_{11}=9$

- Impacts of collaboration breakdown

Has there been a formal commitment to the duration of collaboration? How detrimental would it be for the organization in case of premature termination of the collaboration? Are their sufficient safeguards to prevent this termination or backup plans in case it occurs?

The collaboration arrangement is reviewed every year. Since LM is a big business partner for Innovayt, a termination of the collaboration would have an affect but would not affect its other clients or its core business capabilities. A risk sharing arrangement has been made for having a deeper and sustainable relationship with LM.

$r_{12} = 5$, $v_{12}=8$

Remarks: Innovayt stands to gain from handling most of LM's proposal applications and subsequent increase in its business while LM gains from more efficient management of public funding. It's a win-win situation for both and strategically the relationship is based on solid terms with potential conflict of interests well addressed.

$r_1 = 7$, $V1=(r_{11}v_{11} + r_{12}v_{12}) / (r_{11} + r_{12}) = 8.6$

2. **Management of External Relationships**

- Partner Selection

Is there any mechanism for identifying the best partners available? Are you certain that the collaboration partner is one of the best suited for your needs?

LM is one of the largest global companies involved in wind turbine blades and is involved in a large number of research projects. Along term relationship with LM brings good business to Innovayt.

r_{21} = 3, v_{21}=8

- Partner Assessment

Do you have any mechanism for evaluation of the quality of selected partners and their appropriateness for your organization? Do you have well developed guidelines for performance measurements and use it for gauging partner performances?

Innovayt ensures that the innovation projects it handles conform to a degree of technical expertise through independent expert's evaluation of each project prior to take up. LM being our client, its own performance on projects post funding approval is not such a critical concern for us, as our performance is for them.

r_{22} = 5, v_{22}=7

- Cooperation Contracts

Do you have clear, well defined cooperation contracts with your partner which spells out conditions and liabilities and reduces chances of conflicts?

Yes we have a well defined cooperation agreement, which clearly lists out conditions and liabilities.

r_{23} = 6, v_{23}=9

- Conflict Resolution

Do you have frequent occurrences of conflicts? In case of conflicts, do you have mechanisms for quick resolution?

We have not had any major conflict in the past.

r_{24} = 5, v_{24}=9

- Communication

  Do you have barriers to free inter-organizational communication?

  We have direct access to the R&D manager at LM and don't suffer from inter organizational communication problems. LM regularly conveys its research strategies for us to efficiently make an effective research plan for them.

  r_{25} = 8, v_{25}=8

Remarks: We being a consultant offering innovation funding management services, do not require very careful performance measurement of LM. However we do maintain a minimum standard for the quality of research projects we handle.

r_2=3, V_2=8.2

3. **Collaborative Business Processes**

   - Responsibility Sharing

   Is there a clear division of responsibility between you and your partner?

   Our role as providing management of funding opportunities for LM's innovation project portfolio is well defined. However occasionally we do not get proper background information from the client and have to end up using extra resources for the same. A greater clarity in responsibility definitions would be beneficial.

   r_{31} = 8, v_{31}=4

   - Clarity in business processes

   Are business processes for collaborative work well defined and responsibilities well allocated? Is there a smooth transition of information from one organization to another?

   Inputs from LM's marketing department regarding future research areas is sometimes delayed or not clear, however a proactive approach by Innovayt has enabled us to finally obtain relevant information in time to offer efficient services.

r_{32} = 9, v_{32}=3

- Visibility

Is the status of processing within one organization easily visible to the collaborating partner?

Not generally, but its need has not been felt as long as deliverables from both sides are exchanged as per schedule.

r_{33} = 3, v_{33}=3

Remarks: More clarity on responsibilities could be desirable.

r_3 = 8, V_3 = 3.4

4. **Organizational Structures**

- Cross-Organizational Role Mapping

Is there a clarity within the organization for responsible person to contact from collaborating organization for various different types of issues? Are there significant delays for obtaining information from collaborating organization on account of uncertainty on whom to contact?

Since we primarily deal with the R&D manager and the Marketing Management at LM, there exists a clarity on whom to contact.

r_{41} = 3, v_{41}=8

- Contact Points

Are there sufficient contact points at different levels which would enable the different organizational structures to seamlessly collaborate?

Our's is a small organization so multilevel contact points are not really relevant.

R_{42} = 4, v_{42}=8

Remarks: We do not face organizational issues with regards to differences in organizational structures.

r_4=2, V_4=8

5. **Employees and Work Culture**

- Linguistic Barriers

Does the collaborating partner's employees use a different language than yours? If yes, does it cause problems with normal communication of employees?

While most of our employees speak Danish, some of the employees at our Portuguese office speak English. That sometimes causes an issue with handling client documents written in Danish. However we get it translated. All employees at LM speak English in addition to Danish, so we do not have major linguistic barriers.

r_{51} = 5, v_{51}=8

- Motivation

Based on your experiences are your collaborator's employees as motivated about the work as are yours or vice versa? Are employees from both the organizations incentivized and encouraged to take leadership roles and initiatives for improving ongoing collaborative projects?

Innovayt's employees are trained to take more initiative and be proactive in getting the work done. LM being a much larger organization is more bureaucratic.

r_{52} = 7, v_{52}=5

- Responsibility

Do employees of both the organizations take responsibility for tasks or do you notice a 'passing the buck' syndrome where there is a tendency to push responsibilities to the other organization?

Normally employees of both organizations take responsibility for their respective tasks, but sometimes we do have to take extra responsibility when we don't receive the proper inputs from LM especially with regards to marketing strategies.We believe that it could be improved through organizational efficiency at LM's side.

r_{53} = 6, v_{53}=5

- Honesty

Do you believe that employees of both the organizations share the same level of honesty and openness, especially when dealing with the other organization?

Yes we do, and that is the basis for our strong relationship.

r_{54} = 8, v_{54}=8

- Efficiency

Are your collaborator's employees as efficient as yours in terms of required training, performance, working speed?

Yes, we both have on the whole, very efficient employees.

r_{55} = 5, v_{55}=9

Remarks: While both companies share efficient employees, a more bureaucratic culture at LM on account of its larger size reduces its speed as compared to a smaller Innovayt where employees are empowered take decisions and trained to be proactive.

r_5= 6, V_5= 6.9

6. IPR management

- Background IPR Protection

For the collaborating scenario, does your collaboration agreement clearly spell out existing IPRs to be provided by each partner and its conditions of use? Is the compensation for the same clearly agreed upon?

We do not use our client's IPRs although we do have access to them. Our confidentiality agreement makes us committed to maintaining its secrecy.

r_{61} = 2, v_{61}=5

- Foreground IPR

Has potential IPRs arriving out of this collaboration been identified and its use and sharing of rights been agreed upon?

We just provide consultancy services and our collaboration does not generate any IPR.

r_{62} = 3, v_{62}=6

- Conflicts

Is there any conflicts related to IPR sharing or use within the collaboration?

No

r_{63} = 2, v_{63}=7

Remarks: Innovayt is not involved in using or generating any IPR for the client. However the nature of its work gives it access to client's IPRs which is maintained confidential.

r_6= 2, V_6= 6

7. **Business Semantics**

- Conflicting Terminologies

Do you and your collaborator use different terminologies with regards to the business area that you both operate on?

No

R_{71} = 1, v_{71}=8

- Semantic Conversion

Do you have standardized tools or processes to undertake the process of semantic conversion so that differing terms in different organizations do not create operational difficulties?

No

R_{72} = 0, v_{72} = 3

Remarks: We usually use standardized common English terms and do not face this issue.

r_7 = 1, V_7 = 8

8. **Information Systems**

- Data Exchange Tools

Do you have a suitable tools for ease of exchange of Data and files?

We normally use emails for all our collaborations including file exchange. Although we are realizing that managing files is becoming cumbersome through email. We are thinking of moving towards using a web 2.0 based collaborative web application for project management and file sharing.

$r_{81} = 8$, $v_{81}=3$

- Speed

Is the information system that you rely on fast enough for quick communication?

Our servers are in Denmark. While we get decent speeds in Denmark, we connect to them from Portugal using VPN which is very slow. We are trying to solve this issue.

$r_{82} = 9$, $v_{82}=3$

- Application Interoperability

Are there specific/standard translators or conversion applications that are used to access data between your organizations?

No

$r_{83} = 3$, $v_{83}=2$

- Security

Do users have the confidence to securely transmit confidential information and perform secure operations across the two organizations?

While we use emails for exchanging sensitive information, we do not have any reason to believe that our emails are not secure.

$r_{84} = 3$, $v_{84}=5$

*Remarks:*The information system used for collaboration is very basic and insufficient for the requirements of constant data exchange. Although, the requirements for the immediate future in terms of information system requirements will not be phenomenal, but usage of

collaborative tools or web based applications for management and display of funding opportunities, could improve client satisfaction and be an alternative to the cumbersome process of managing emails.

r_8 = 8, V_8=3.1

5.3 Analysis

Innovayt is a small agile company interacting with the R&D division of an immensely large multinational firm. This relationship has been analyzed using the BIQMM with the intention of gaining an in depth quantitative and qualitative assessment of the interoperability scenario between them. This analysis is made with the intention of not only assigning scores to how interoperable the two companies are but also highlighting the key areas where interoperability needs to be enhanced in the short and medium term, to avoid key bottlenecks to achieve the overall strategic aims of the collaboration. The business interoperability scores are presented in table 4.2.

Table 4.3 Business Interoperability Index for LMFO

i	**Business Interoperability Parameters**	**r_i**	**V_i**	r_{i1}	r_{i2}	r_{i3}	r_{i4}	r_{i5}	v_{i1}	v_{i2}	v_{i3}	v_{i4}	v_{i5}	**Comments**
1	Business Strategy	**7**	**8.6**	8	5				9	8				Revelant and Satisfactory
2	Management of External Relationships	**3**	**8.2**	3	5	6	5	8	8	7	9	9	8	Not very relevant
3	Collaborative Business Processes	**8**	**3.4**	8	9	3			4	3	3			Not satisfactory
4	Organizational Structures	**2**	**8**	3	4				8	8				Not important
5	Employees and Work Culture	**6**	**6.9**	5	7	6	8	5	8	5	5	8	9	Satisfactory
6	IPR management	**2**	**6**	2	3	2			5	6	7			Not relevant
7	Business Semantics	**1**	**8**	1	0				8	3				Not Applicable
8	Information Systems	**8**	**3.1**	8	9	3	3		3	3	2	5		Not Satisfactory

$I = \sum ri\ Vi / \sum ri = 214.2 / 37 = 5.78$

With an overall Interoperability Score of 5.78 out of 10, Innovayt and LM Glasfiber have a reasonably interoperable relationship with some deficiencies. However Innovayt is a very small company and has a very specific collaboration objective with LM. This makes it fairly easy for it to maintain a relatively high degree of Interoperability. However as the collaboration grows coupled with the growth of the size of Innovayt itself, a greater emphasis needs to be placed into making the relationship more interoperable.

More detailed analysis of the BIQMM follows.

BIPs with low relevance

The following BIPs were found having low relevance in this collaboration scenario:

1. *Management of external relationship* – For Innovayt, LM is a client with significant business potential. However relationship with LM does not involve major functional implications or risks. Hence innovayt does not need to be extra cautious over the selection of its clients.

2. *Organizational structures* – The small size and the consequent agility that Innovayt possesses, does not make serious implications for the organizational structure of its partner organization, since the agility allows it to flexibly interact with different levels of LM's organizational structure.

3. *IPR Management* – Since Innovayt does not use any of LM's background IPR, nor generates foreground IPR, this is not such a relevant BIP.

4. *Business semantics* – Business symantics assumes relevance when codification or terms and vocabulary play a key role in the collaboration. In this case, semantics is not such a critical factor, neither in the operational processes nor in information system usage.

BIPs with high relevance

Based on the detailed discussions with the participants, the most relevant BIPs are:

1. *Business Strategy:* As with most collaborations the overall collaboration objective and related business strategy forms a key element of Innovayt's collaboration with LM Glasfiber.

2. *Collaborative Business Processes:* For a consultancy, engaged in management of a vast variety of information, processing of several project ideas, analysis of different funding opportunities, engaging with different departments of LM; a smooth, well planned collaborative process is not just beneficial but even necessary for avoidance of chatotic failures, overloading, delays and missing deadlines.

3. *Employees and Work Culture:* In a consultancy, most tasks are performed by Knowledge Workers. Hence the importance of proper Employees and Work culture is

naturally high. The employees at both the companies should be able to smoothly communicate and share information as and when necessary.

4. *Information Systems:* As with most collaborations, Information System is a very important part of information exchange between LM and Innovayt. Although the complexity of Information Systems required for this collaboration is not extremely high, it nevertheless is an important component for efficient collaboration.

The interoperability with regards to "Business Strategies" and "Employees and work culture" was found to be satisfactory. The key BIPs where interoperability was found to be deficient was:

1. *Information system :* IS interoperability is an area of concern since reliance on emails alone, as practiced as of now, for exchange of files and information is unviable as the collaboration load increases. Adoption of more efficient project management tools and file exchange applications are recommended. Key requirements identified were:

    a. Collaborative project management application

    b. A File management system with revision handling capabilities

    Several commercial web based applications are available for implementing the above mentioned requirements. They are available, both as open source applications and commercial applications. An early implementation with due consideration to the level of security desired, is advised.

2. *Collaborative Business Processes*: Another key area of concern is demarcation of responsibilities by coordinated actions from Innovayt and LM management. While Innovayt's employees are flexible and are managing to cope with a not so well defined business process, efficiency gains from a more efficient business process, especially at LM's side, would have long term benefits for both the organizations. When involved in projects, allocation of responsibilities to the concerned departments with regards to providing proper background information to Innovayt would ease Innovayt's tasks and improve the quality of deliverables to LM.

6. Conclusions and Future Work

This dissertation has reviewed the latest progress in academic and industrial circles with regards to the relatively new and emerging field of Business Interoperability. It stresses on the interdisciplinary nature of business interoperability and emphasizes that Interoperability should not be merely seen in the context of Information System but across a cross disciplinary hierarchy of business organization.

This dissertation discusses the relevance of Interoperability and gathers relevant literature that studies the impact of interoperability and its potential benefits. It discusses the concept of Networkability and the connections it has to the field of Business Interoperability. The literature review also details on the issues that affect the lower levels of Business Interoperability, namely, information systems, semantics and IPR.

The dissertation further discusses some European Initiatives for the development of the field of Business Interoperability. The development of this dissertation has been immensely influenced by the two European projects Athena and ECOLEAD. IDABC, the European initiative towards e-governance, has also been discussed along with a discussion on its key technical framework, the EIF.

Finally, key factors or areas responsible for the assessment of Business Interoperability have been identified in this dissertation. These Business interoperability parameters (BIPs) have been used to develop a Business Interoperability Quotient Measurement Model (BIQMM) that enables the qualitative and quantitative assessment of the business interoperability in a dyadic collaborative relationship.

This BIQMM has been demonstrated by its application to a case study involving two companies, Innovayt and LM Glasfiber. While the collaboration between the two companies is relatively less complex, this demonstrates the applicability of the BIQMM across a large segment of business and organizational collaboration scenarios regardless of collaboration complexity. BIQMM has the capabilities to be applied to far more complex scenarios.

However Business Interoperability is a relatively new field and there is enormous scope for future work in the area. The interdisciplinary nature of the BIQMM, made further development on the analysis of each BIP, beyond the scope of this dissertation. However

further works on developing quantification and evaluation methods for different BIPs could further strengthen and improvise the applicability of BIQMM in different business scenarios.

While, this dissertation broadly recognizes that the relevance of different BIPs is directly linked to the collaboration environments and objectives, more work needs to be done towards more intensive quantification of business interoperability parameters and further research and studies need to be performed for establishing these relationships over diverse industry segments and scenarios.

While collaborations between two entities have been studied, integrated value chains or value networks encompassing a number of relationships between the actors have not been investigated as yet, mainly because these inter-organizational relationships are complex in nature, since they involve not only the interactions between the actors but also the competitive and political environment in which the interactions are occurring. Further studies in this area is intended to be carried in future.

While the benefits from improving the degree of interoperability in a value chain present a compelling picture, local improvement does not automatically mean that the entire chain will significantly benefit from it. Even if increasing interoperability is a zero-sum or a positive-sum game, there might be instances in which implementing interoperability solutions may not be desirable for one or more partners in the value chain. Clearly, when these instances occur, external coordination mechanisms or other types of value-sharing solutions become necessary to align incentives among firms and promote the diffusion of interoperability solutions along the chain. Additional research is therefore necessary and planned to explore how firm-level, dyadic and value chain interoperability relate.

The impact of interoperability improvements on the strategic positioning of a company needs to be further researched. In this context, it would be very valuable to know whether superior interoperability levels contribute to the creation or extension of a competitive edge.

As further research progresses in the area of Business Interoperability, it is hoped that these models and frameworks are translated into large scale business interoperability services that would substantially ease business collaborations and related collaboration costs.

Annex 1 – Questionaire for implementing BIQMM

Business Strategy			
Clarity in Strategic Goals	Are there and conflict of interests in the collaboration? Has it been adequately resolved?		
Impacts of collaboration breakdown	Has there been a formal commitment to the duration of collaboration? How detrimental would it be for the organization in case of premature termination of the collaboration? Are their sufficient safeguards to prevent this termination or backup plans in case it occurs?		
	Remarks:	r1=	V1=
Management of External Relationships			
Partner Selection	Is there any mechanism for identifying the best partners available? Are you certain that the collaboration partner is one of the best suited for your needs?		
Partner Assessment	Do you have any mechanism for evaluation of the quality of selected partners and their appropriateness for your organization? Do you have well developed guidelines for performance measurements and use it for gauging partner performances?		
Cooperation Contracts	Do you have clear, well defined cooperation contracts with your partner which spells out conditions and liabilities and reduces chances of conflicts?		
Conflict Resolution	Do you have frequent occurrences of conflicts? In case of conflicts, do you have mechanisms for quick resolution?		

Communication	Do you have barriers to free inter-organizational communication?		
	Remarks:	r2=	V2=
Collaborative Business Processes			
Responsibility Sharing	Is there a clear division of responsibility between you and your partner?		
Clarity in business processes	Are business processes for collaborative work well defined and responsibilities well allocated? Is there a smooth transition of information from one organization to another?		
Visibility	Is the status of processing within one organization easily visible to the collaborating partner?		
	Remarks:	r3=	V3=
Organizational Structures			
Cross-Organizational Role Mapping	Is there a clarity within the organization for responsible person to contact from collaborating organization for various different types of issues? Are there significant delays for obtaining information from collaborating organization on account of uncertainty on whom to contact?		
Contact Points	Are there sufficient contact points at different levels which would enable the different organizational structures to seamlessly collaborate?		
	Remarks:	r4=	V4=
Employees and Work Culture			

Linguistic Barriers	Does the collaborating partner's employees use a different language than yours? If yes, does it cause problems with normal communication of employees?		
Motivation	Based on your experiences are your collaborator's employees as motivated about the work as are yours or vice versa? Are employees from both the organizations incentivized and encouraged to take leadership roles and initiatives for improving ongoing collaborative projects?		
Responsibility	Do employees of both the organizations take responsibility for tasks or do you notice a 'passing the buck' syndrome where there is a tendency to push responsibilities to the other organization?		
Honesty	Do you believe that employees of both the organizations share the same level of honesty and openness, especially when dealing with the other organization?		
Efficiency	Are your collaborator's employees as efficient as yours in terms of required training, performance, working speed?		
	Remarks:	r5=	V5=
IPR management			
Background IPR Protection	For the collaborating scenario, does your collaboration agreement clearly spell out existing IPRs to be provided by each partner and its conditions of use? Is the compensation for the same clearly agreed upon?		
Foreground IPR	Has potential IPRs arriving out of this collaboration been identified and its use and sharing of rights been agreed upon?		
Conflicts	Is there any conflicts related to IPR sharing or use within the collaboration?		

	Remarks:	r6=	V6=
Business Semantics			
Conflicting Terminologies	Do you and your collaborator use different terminologies with regards to the business area that you both operate on?		
Semantic Conversion	Do you have standardized tools or processes to undertake the process of semantic conversion so that differing terms in different organizations do not create operational difficulties?		
	Remarks:	r7=	V7=
Information Systems			
Data Exchange Tools	Do you have a suitable tools for ease of exchange of Data and files?		
Speed	Is the information system that you rely on fast enough for quick communication?		
Application Interoperability	Are there specific/standard translators or conversion applications that are used to access data between your organizations?		
Security	Do users have the confidence to securely transmit confidential information and perform secure operations across the two organizations?		
	Remarks:	r8=	V8=

Overall Interoperability Score (I) = $\sum$ ri Vi / $\sum$ ri

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