Balancing of Heterogeneity and Interoperability in E-Business Networks:
The Role of Standards and Protocols

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ABSTRACT

To reach this interoperability visibility and common understanding must be ensured on all levels of the interoperability pyramid. This includes common agreements about the visions, political and legal restrictions, clear descriptions about the collaboration scenarios, included business processes and-rules, the type and roles of the Documents, a common understandable vocabulary, etc. To do this in an effective and automatable manner, ICT based concepts, frameworks and models have to be defined, that have to be known and understood, accepted and that have to provide additional e-benefits for all participating partners. In addition, ICT systems, tools and other instruments must be compliant with all the restrictions defined by the interoperability pyramid and they have to support the work properly and efficient, and last but not least they have to ensure trust and minimize e-business risks. Nowadays, many profitable and well working individual solutions on the market may be found. But there still is a gap for more general and well working interoperability solutions. This article shows the state of the Art in Research and Practice in building, managing and maintaining E-Business solutions under the focus to enhance interoperability based on standards, protocols and other helpful concepts, instruments and examples. To provide better understanding for non-specialists, also, the authors systemize the complex and interdisciplinary content and offer additional helpful explanations.

Keywords: *Advanced Web Technologies, E-Business Interoperability, Heterogeneity, Information Communication Systems, Standards*

INTRODUCTION

E-Business is embedded in an open environment with many participating business entities (people, enterprises, government institutions, etc.). Each of them should have a chance for free and open E-business, regardless of the volume and the type of business they are running, where they are sited, and independent of local time, etc. In front of such fair goals there were, are and will be many obstacles for E-Business varying from country to country, from enterprise to enterprise and from person to person. These obstacles may be simple described by the two words "total heterogeneity."

The areas of heterogeneity in E-Business may be classified by five categories, communication infrastructure, computing resources,

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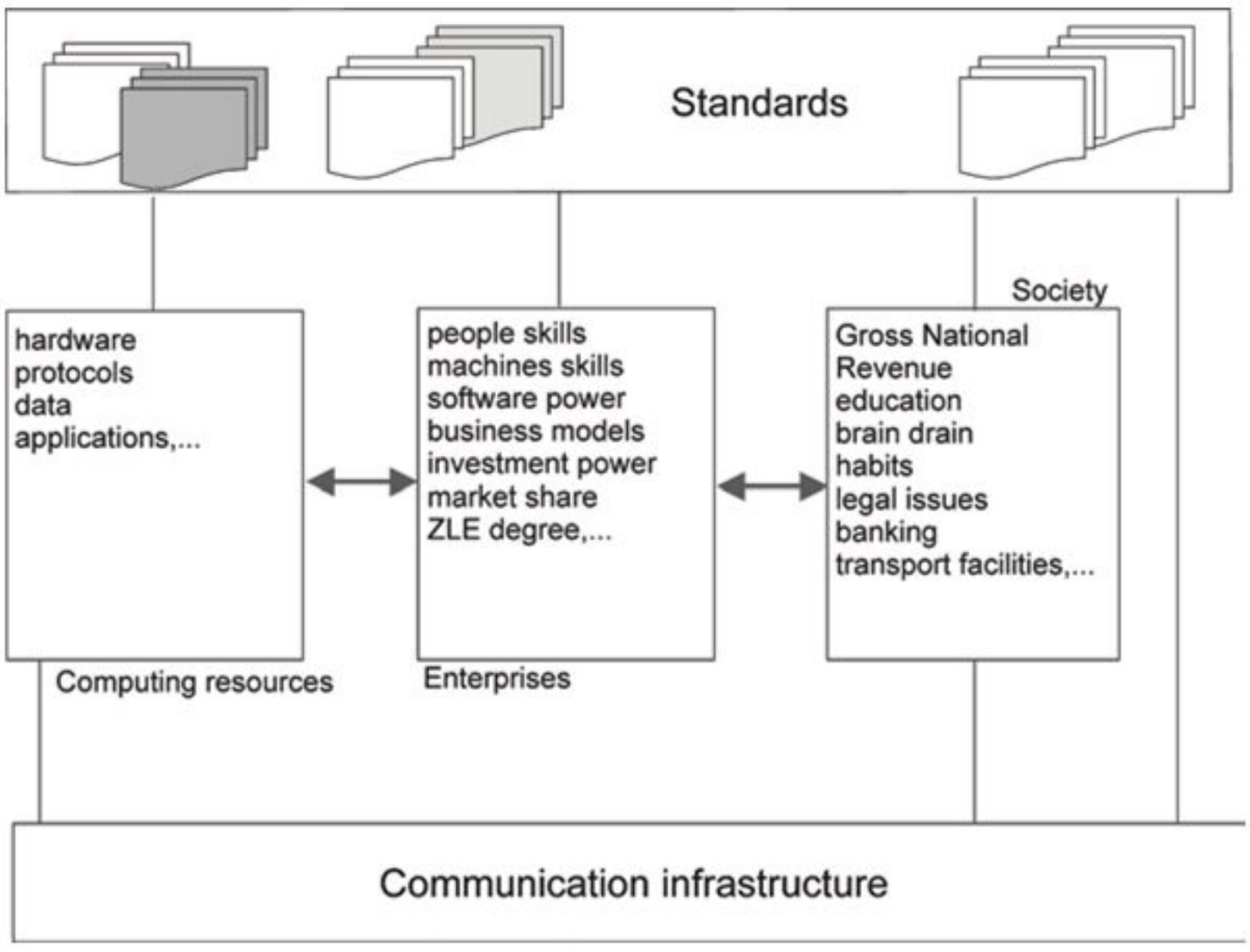
business entities (enterprises), society, and standards, and all are mutually dependent, as shown in Figure 1. E-Business standards are important and helpful but unfortunately, the real situation in E-Business is far too complex, that it can be solved by standards alone. Due to the heterogeneity in E-Business arena may arise many and unexpected events and problems which afford additional and even new concepts, models and solutions.

Thus let us address firstly communication and the heterogeneity of infrastructure. Much of Internet users may ask why is that? Internet protocols are well defined by their interfaces, including all rules known in advance, and they work, and may be confirmed by billions of Internet users. Thus, where is heterogeneity in communication? Let us remember "Birth of Broadband" document (ITU, 2003), the open document issued by ITU, that defined 512 Kb/s as entry speed over the network to be qualified as broadband. Many of the readers of this article will not get the point after all. They probably enjoy their Internet lives on GB backbone, but let us ask Ethiopians, for example, what they want, food or broadband?

Another heterogeneity issue of E-Business is growing by social discrepancies between societies, people living in different countries, and other social circumstances that may differ a lot. The deeper view of these aspects regarding developing economies can be found in Travica et al. (2007) and Roubiah et al. (2009). Such analyzes that focus on undeveloped world are hard to be found. Heterogeneities of computing resources, data, business processes and existing standards will be discussed later.

Keeping the total heterogeneity in mind we aim to get a common understanding and an overlook about the instruments and ways to achieve an interoperable and efficient E-Business Thus we provide a systemization aid which shall help to separate and to discuss the manifold problem fields of E-Business, its concepts, projects, models and solutions. Each of the four areas: E-Business as a Market, Understanding and Advanced Modeling E-Business, E-Business Standardization and last not least Converting, Customizing, and Enhancing in E-Business, represents one special aspect of the phenomena E-Business. These aspects should not be seen separate because EB-solutions, theoretical and

Figure 1. The total heterogeneity of E-Business arena



all the more practical ones need knowledge and instruments from some or even from all of these aspects.

All aforementioned aspects highly relay on technological enablers also. Some of important that we must take into account are XML and E-Business Integration Standards based on it, UBL, Web services, Semantic Web technologies, such as RDF, OWL, OWL-S, Web Service Modeling Ontology, etc., Agents and Multi-Agent Systems, Social Networks, Internet of Things, Security and Trust Technologies, etc. These technologies supported a significant progress in E-Business interoperability, but also set up many new research challenges, some of them can be found in (Kajan, 2011; Kajan, Dorloff, & Bedini, 2012). In fact, many arguments and forecasts in this article are based on research efforts and results presented in these two books.

The main purpose of this study is to provide a systematic overview of multi-faceted E-Business environment with the special emphasis on Standards and advanced technological enablers. This study proceeds as follows: Next section gives a systematization attempt in order to recognize multiple faces of E-Business phenomena, resulting with four aspects: (1) market, (2) understanding and advanced modeling, (3) standardization, and (4) converting, customizing and enhancing. It is followed by the first insight in evaluated issues, findings and outstanding research needs concentrated on these four aspects of E-Business environment. Two final sections concentrate on technological impact on the development of full E-Business interoperability and overview some visions from the past and gives our own.

MULTIFACE OF E-BUSINESS ENVIRONMENT

The starting point of each E-Business is the market, its needs, structures, mechanisms and conditions. E-Business as a market means to focus on the actors on these markets (public, private, wholesaler, industry, craftsman, provider..), their targets and business models, their demands and offers, the exchanged products and customer-services, the basic business relations (B2B, B2G,C2B, etc.), the characteristics of the market (open, restricted, controlled, network, hierarchy, etc.), the pricing concepts (types, models, restrictions.), the geographical scope, the logistic concepts, the contracts as well as additional technical, legal, political and even cultural aspects and in consequence, there is no one best E-Business concept. An E-Business concept has to be defined either individually or in generally dedicated to "often to find" market scenarios before it can be modeled and automated, and has to be adapted permanently due to changing markets, unexpected customers needs, changing business models and conditions. So a crucial prerequisite to achieve useful and applicable E-Business solutions is to understand and to analyze the targets and environment of the special E-Business to be modeled and developed, including the main problems, parameters, objects, its attributes, and the relationships inside the market and to its environment. This is a complex task, and affords competencies of different experts and disciplines and last not least of the people knowing how to make their business.

Let us regard the second aspect: Understanding and Advanced Modeling E-Business. E-Business systems, especially ICT-Systems are very complex, and by this for the understanding, developing and fostering E-Business solutions the knowledge of different experts is needed, who have to work together in an effective, coordinated and intelligent manner. As each new or modified E-Business concept, model or artifact generates additional knowledge and data, the problem arises to manage this high quantity and diversity of information, storing and filtering it and all the more explaining its meaning and relevance to the different participants of the E-Business. Further problems in understanding E-Business may arise in respect to E-Business between people from different cultures countries, languages, religion, social levels and lifestyles. Their expectations in products and services, quality prices may differ and so their behavior.

Another big challenge is to describe the demands and offers, products and services in a precise and automatable manner, and to exchange and classify them according to the needs of the trading partners. Handling this is not only a technical but all the more a semantic and social and cultural challenge. In consequence we need inter alia interdisciplinary concepts, frameworks and instruments including meta models, vocabularies, ontologies and other ICT-artifacts as well as people with special knowledge and competencies like translators, mediators, providers and other E-Business experts.

E-Business Standards are one of the main enablers of E-Business. Well elaborated and proved they may enhance the speed and efficiency of E-Business, allow a high degree of automation, can reduce the costs for the processing and lead to more market transparency. E-Business Standards help to avoid inefficient "peer to peer" solutions which often are not compatible and not reusable. They may cause long lead times, incorrect and inconsistent data and in consequence also insufficient customer service. In addition "peer to peer" solutions produce high costs for adapting formats, for correcting mistakes and as a consequence may cause insufficient customer service and last not least loss of sales and even customers.

Developing the "right" E-Business-Standards has to deal with a dilemma. The more people use a standard the more efficient and effective it can be. But then again the more general a standard is designed, the less it will fit to the needs of special industries, markets or product groups.

There exist many types of E-Business Standards. In private E-Business and mainly in E-Procurement, there are E-Business-Standards for Identification (products, services, enterprises, and physical resources like vehicles, packages, etc.), for Product Data Exchange (E-Product Catalogs), for Business-Transactions (Exchange of Business Documents and related Protocols), for Process-Descriptions and Collaboration, for Trust and Security and other aspects. For each type of Standard often exist variants and versions developed by different types of organizations and they may also address different markets and industries.

Many E-Business Standards are used in industry and trade and in E-Government and public administrations as well. Public used Standards additionally have to focus especially on trust, security and compliance and, what is very important, have to accord with existing political and legal rules on the national and even international level. These public standards often aim to regulate the administrational work in a unique and controllable manner but can also reduce the variety of documents, simplify procedures and can reduce the needed amount of personal resources inside a community, an economic area and even worldwide. CEN, the European standardization body, actually develops an E-Procurement standard mainly based on two EU-Projects (PEPPOL, http://www.peppol.eu and BII, http://www.bii.org) These Standards shall support public administrations and the interacting enterprises in Europe along the whole supply chain, invoicing included. The standards themselves aim to be compatible with international standards like ISO, UN/CEFACT and others.

The quality of an E-Business Standard is crucial for its benefits and seamless application. It depends mainly on factors like the type of developing standardization body (legal authorized, free built consortium), its interests, developing methods and competencies, the openness and participation of relevant stakeholders, the availability of a well understandable documentation and helpful examples for the users, stability, controlled versioning, an acceptable low price, a rigid concept of adjustment, and so on.

A central problem for the users is to choose the "right" standard from so many. Quality metrics may be one guide, but often they do not exist, and the enterprises normally don't have the experts to analyze and compare the standards. Another crucial problem for potential users of E-Business is to prospect the benefits and amounts of a standard in particular if it shall be implemented and used in a special market and even for special products. Last not least dif-

ferent types of standards should fit together, for example a standard for the exchange of product data, like BMEcat (http://www.bmecat.org) with a Product-Classification-Standard, e.g., Ecl@ss (http://www.eclass.de/).

Enterprises may be profitable, if they address the individual needs of their customers, if their products and service are of a good quality and if their processes, procurement and logistics included are lean and efficient. They also should be able to react quickly on changing market situations, on attacks of the competitors, on legal changes and other variables. Standards can help make processes more efficient, but they also can restrict the flexibility and agility of enterprises.

Here we come to the fourth aspect. Beside Standards we need more flexible and specialized E-Business-Solutions for such areas, where standards are not usable or alone don't fit. We talk about higher sophisticated approaches like Service based concepts, agents, converters, configurators for products, services etc. These concepts and corresponding instruments will allow more flexibility, reusability, offer intelligence and individuality for the enterprises. They sometimes can effectively be combined with concepts of standardization and process reengineering.

Converting means to map concepts, processes and especially data structures of diverse interacting enterprises. There exist different converter structures as peer to peer, circle, star or a mix of. With the upcoming of XML language the exchange of data schemas has become much more concise, easy and understandable. Nevertheless, especially semantic mappings often based on taxonomies and ontologies are still a high challenge. Mappings are needed not only for documents but also for processes, vocabularies, registries, data types and the exchanged content itself. In addition, ontologies are a proper instrument to describe, map and harmonize diverging knowledge and data of different domains. These mappings there are no more restricted to defined and structured data but can also be applied to other forms of information and knowledge.

A promising approach to develop efficient and flexible E-Business solutions may be the combination of Service-Computing, Business-Process Modeling and the Agent-Concept. Services can be described as autonomous and reusable Software-modules that may be combined to service packages, which then can be tailored to the customer needs. Software Agents can be modeled to deliver the needed services. They can search, identify and select the products and services according to defined rules and even may be able to react on changes of the strategy, actions of the competitors, changing market factors like prices and so on.

ISSUES, FINDINGS, AND RESEARCH NEEDS

E-Business as a Market

Although this important topic is not in the central focus of this article, there are several issues that touch this aspect discussing interesting facets like supporting customer's decisions and ensuring service quality, and trust between business partners, as well.

Supporting customer decisions is a complex and interdisciplinary problem. To understand the background and parameters that lead to buying decisions is an old research field in economics and here in the field of consumer marketing. Buying over the Web is a special type of shopping. It offers additionally Web-based concepts and instruments to access the products bids even from home, as well as Web-typical buying benefits such are more transparency, easiness, quickness but also comparability and frequently changing prices due to the harder competition. But there are also new risks related to more complex legal backgrounds, the intangibility of products, new and nontransparent paying procedures and other fraud risks due to the openness and internationality of E-Commerce. To handle this more properly additional research in the field of customer decision making is needed. To support customers in their buying decisions on the Web there is a need inter alias to identify the type and relevant attributes of

customers (like professional, newcomer) and the sellers (e.g., manufacturers, wholesalers, local or international, etc.) and also of the offered products and services (cars, food, software testing, etc.). Moreover valid models about the customer's behavior and over advanced possibilities to measure and even influence the buying behavior of costumers are also required.

Looking back on our discussion many corresponding research fields are still left open, for example, building types of actors, products and services, developing and validating models and metrics for measuring customer behavior, measuring the quality and satisfaction of the customers with their decisions, the use of knowledge support by providers and so on. Here it could be useful to interact with experts from different disciplines (IT-experts, economists, psychologists, etc.) to get deeper insights and to learn from each other.

Customer-Service is one of the most important instruments in E-Business. But there does not exist a common understanding of Service and of Service-quality in the marketing related literature, all the more this word Service will be quite differing understood in the disciplines of economy and ICT. Thus, there is a need to clarify the definition and facets of service, before thinking about selling or buying services. A sound overlook about the variants and complexity of Service descriptions, which can vary, e.g., by the domain, the structure and components of the service, its relevance and the degree of service-management may be found in Conger (2012). Especially the impact of ICT and the Web changed the understanding about service from the more physical logistic and marketing aspects to ICT modeling aspects. So, one interesting future research field could be comparing service definitions from different disciplines. It may include analysis of best practices in special domains (Logistics, SW-Business, and Marketplaces), linguistic analysis of definitions and elements of service, comparing existing models of service quality, creating classification systems for services, and so on.

Trust is an essential prerequisite for fair, effective, profitable and long lasting EB-relations. Trust Management in E-Business, means the process of establishing trust amongst the parties involved. Trust has many facets: trust in business partners (organizations, persons, roles, quality, governance, etc.) and their accountability, trust in the transparency and reliability of business conditions and regulations, trust in information and communication systems including the underlying networks, business models and methods, as well as trust in the behavior and competencies of their owners, managers and operators and so on. Trust can be carried out by ethics, governance, trustworthy business people, transparent win-win cooperation and supply chains and especially in E-Business by developing trust dedicated ICT approaches, models, methods, technologies, etc.

Trust depends inter alias on the personal characteristics of the business partners, their roles, their risk awareness, their personal backgrounds as well on other scenario driven factors like: position as a seller or buyer, professional buyer or consumer, experienced buyer or newcomer; big or small business volume, bad or good experience with the business-results, prepared or just spontaneous buy, ICT support for the buying process or unsupported buying, buying new products or repeated buy; complexity of the products and services and especially in E-Business the descriptiveness of products and services and so one.

Trust related Research needs in E-Business are manifold. They inter alias depend on the discipline, the scenarios and the focus of the researchers. Focusing on consumers buying over the Internet via portals research fields may be to measure, interpret and influence the risk perception of customers as well to analyze the effects of special trust producing factors and applied instruments regarding changes over time as well as more sophisticated Trust related models and instruments.

Additional Trust and E-Business related research may be found in the field of professional industrial buying, focusing on E-Sourcing and E-Procurement. Here some of the mentioned research needs also exist. But there are additionally research ones in the field of Supplier

Relationship Management (SRM), the organizing and managing of Buying center and their Trust related ICT Support. The aforementioned factors (personal characteristics and role of the buyer, risk perception, buying scenarios, experiences with the supplier or product, etc.) should be taken into account also. An interdisciplinary approach by combining the research of economists (Decision theory, Behavioral analysis, SRM and CRM concepts) especially in the field of E-Procurement and approaches of ICT driven researchers (Structure and content of buying portals, search and buy behavior on the Internet etc.) seems to be promising.

E-Business Standards

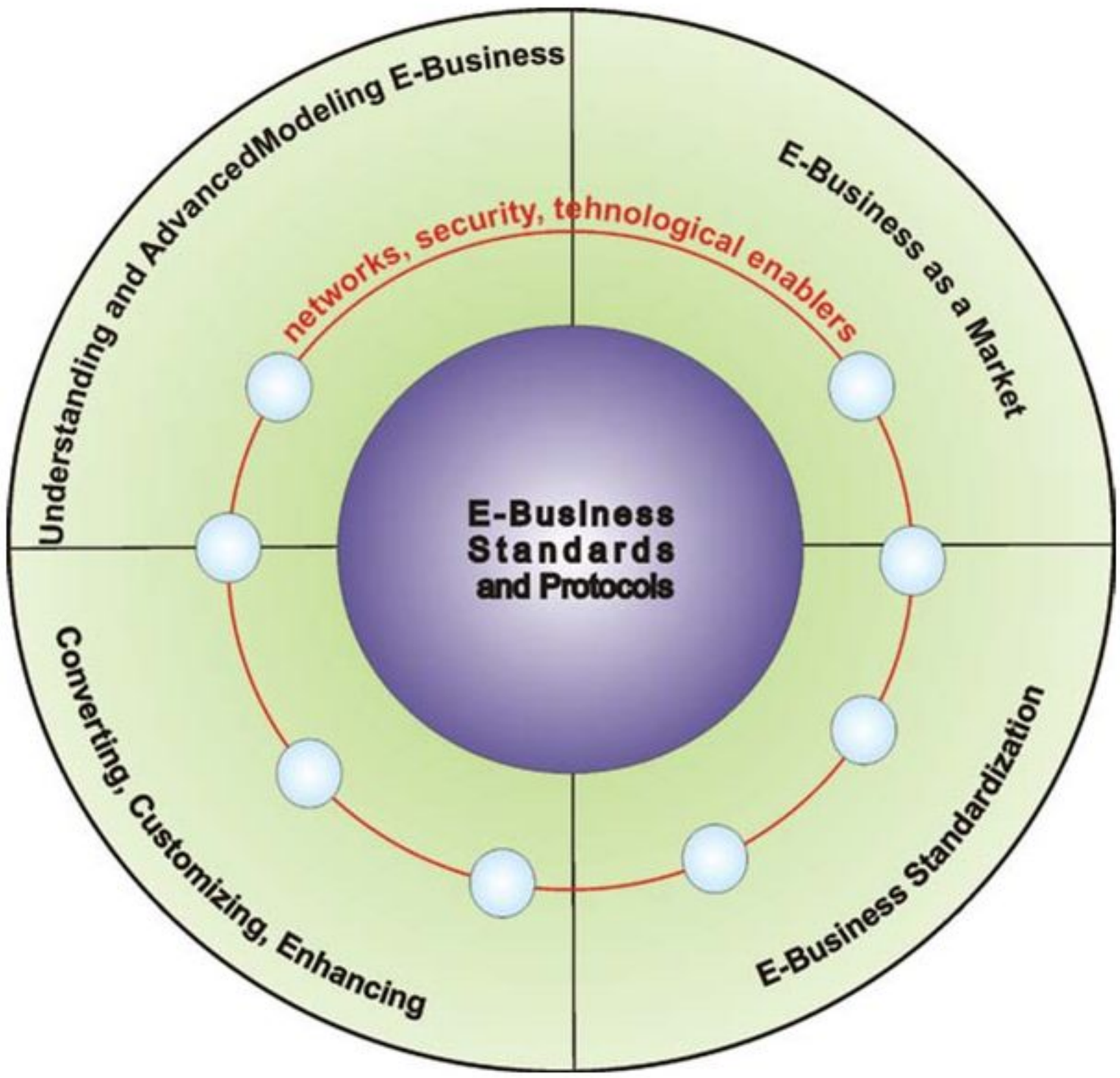
Due to its importance Standard-related topics can also be found at the other three aspects of Figure 2 related to networks and technical infrastructure as well. Not each "standard" fits the needs of the trading participants or markets and so they may not be useful for all of them. Let us compare the interests of a government, of a big buyer and a seller. The government argues with the cost reductions and lower lead times nationwide, the buyers want a transparent markets and information where they can get the products they need and this worldwide and often much cheaper (MRO Products, auctions). The sellers want to be present on the E-markets but what they don't want is to become comparable in matters of price and quality of their products and services. On customer driven markets they often are forced to produce and maintain E-Catalogs and to classify their products based on given E-Business Standards and to accept the costs for that.

Depending on the role of the participants and their business concept, the type of the product and services exchanged, and the amount and risks for implementing and using e-Business standards, these standards may be welcomed but also may be denied. In practice not the best modeled standard will win but those which promise the highest profit for business partners. Sellers often want a unique selling position so they will accept standards which lower their costs, e.g., Document Standards, but they also want to be free in changing products offered, its prices and so on without having additional costs. In consequence a standardized Information-Hub - e.g., based on the UBL Information structure - that harmonizes centrally all "core" information, but leaves freedom to each enterprise beyond the Hub is proposed. By this, some sorrows of the sellers may be reduced. However, there are a lot of problems left that have to be elaborated and solved. Under the aspect Conversion and customization- additional concepts and proposals are given. For SMEs the selection and implementation of an E-Business Standard may be too complex, therefore they need help from the government and from experts like service providers.

And also research needs are manifold – first of all framework should be harmonized, its levels and recommended standardization concepts on each level. A very complex level is the process level, where recommendations often only can be given for a special industry (e.g., telecommunication) or a special application area like E-Procurement (see PEPPOL/BII two Projects of CEN, the European standardization organization). But also mappings on the data schema level are very complex from both the technical and the semantic view. Here ontologies and high sophisticated mapping tools based on XML perhaps could help.

One crucial aspect in E-Business Standardization is the quality and interoperability between existing and upcoming E-Business Standards and its versions. This problem may be reduced if the SDOs (Standard Developing Organizations) in spite of possibly different interests and authorization would harmonize their developing and dissemination processes, instruments and metrics. Harmonization should be ensured for the whole lifecycle of a standard, therewith they stay actually, will become properly adapted to changing demands, are compatible with referenced codes and adjacent standards, are well documented and offer sufficient support for their users. An interesting approach offers BOMOS framework (Folmer, 2012). It supports interoperability in the areas of Semantics (Messaging), Mechanism (Web

Figure 2. Four aspects of E-Business phenomena



Services), Communication mechanism (Internet), includes an activity model distinguishing different types of tasks (strategic, tactical and operational, implementation and communication) as well as a proposal for the organization structure and the processing of the development of standards. Further work is needed, e.g., by improving the support for the users, offering examples for different scenarios, offering additional support for the adoption of existing and upcoming EB- Standards, supporting mappings between standards etc.

Understanding and Advanced Modeling of E-Business

This aspect deals with semantic interoperability, ontology based knowledge exchange and advanced modeling of efficient and effective Business-Processes. Semantic interoperability means "that cooperating parties allocate the same meaning to the data that is exchanged" as defined in Folmer (2012). In reality this is difficult to get, because the cooperating parties can differ in aspects like domain, language, culture, social level, organization, application field, etc. Even more there is high probability to have data, that should be exchanged, in semantic conflicts caused by discrepancies at the schema level (Kim & Seo, 1991), naming conflicts that come from arbitrary assigning names to schema elements (e.g., entity classes, relationships, attributes, etc. (Sheth & Kashyap, 1992), entity identifiers, schema isomorphism, etc. The detailed description of semantic conflicts and their sources at data, as well at business process layer may be found in Kajan (2010).

One promising approach to formalize semantics and to harmonize semantic different areas is the application of ontologies using the shared vocabulary for a domain, having in mind that participating business entities have agreed in on such a vocabulary in advance. Nowadays

ontologies have been applied in several domains and exist in different formal representations like vocabularies, taxonomies and even as axiomated logic theories and automatic reasoning. The exchange of knowledge and structured data is essential for reaching semantic interoperability. A special added value may be created when the transfer of semantic harmonized content is supported by cooperating agents. There are many software tools supporting semantic harmonization based on ontologies, but as Zelewski points out (Zelewski et al., 2012), "the potential of software tools for ontologies should not mainly be limited to offer editing functions, but also functions for the graphic visualization of the taxonomical connection of all classes and instances and for the specifying of rules of inference and integrity." Especially, "the combination of case-based reasoning with ontologies could be promising for the management of complex projects in e-business."

One promising E-Business approach to reach more interoperability and also a more effective, agile and flexible E-Business solution is to combine of Service-Computing, Process Modeling and the Agent Concept (McDowall & Kerschberg, 2010; Unland, 2012). In this approach Service-Oriented Computing (SOC) services are the bricks to build low-cost applications, especially designed for use in open and heterogeneous fields like E-Business. Here agents act as autonomous, problem-solving, and goal-driven computational entities with the ability to behave in a social manner and proactive with the aim to achieve given goals in a special field that may be restricted by rules and constraints. A combination with E-Business Standards is a new and promising approach. By this, future research needs are manifold. They include the design, prototyping, implementation and evaluation of such systems in different E-Business domains, developing the needed ICT infrastructure for such systems including grid computing and the cloud concept. Most important for the acceptance of such solutions is the reduction of complexity and the proof that such systems can work economically and without greater risks.

Converting, Customizing, Enhancing

This aspect deals with concepts and solutions that support the mapping of data schemas, classifications and discusses data and process mediation, and the information management problems and challenges and arising through the use of the Web 2.0 features, as well.

In E-Business at minimum three standards are needed - standards for the exchange of product data, for the classification of products and services and for the exchange of business documents like orders and invoices. These three types of standards should be compatible with each other. The problem arises a lot due that are so many and to have it the worst, many of them are existing in different versions. In consequence their mapping and harmonization is a very complex and not yet solved challenge.

Mapping data schemas is on the research focus over the years, the overview of which may be found in (Rahm & Bernstein, 2001; Shvaiko & Euzenat, 2005). Current approaches in schema mapping and matching focus on a pairwise comparison of schemas. Here exist many interesting concepts, solutions and SW-Tools. Nevertheless solutions that automatically can map, for example, data schemas of e-Business Standards like BII/UBL and BMEcat, without additional intensive manual interactions still cannot be found. An interesting approach that integrates a set of input schemas into one comprehensive representation, named unified data model, which covers all aspects of the imported source schemas in detail is given in Dietrich and Lemcke (2012). This unified data model will grow with the number of imported schemas and by this it will become too complex to be understandable by the users. In consequence, a canonical data model has derived which represents the most common structure of all schemas included in the unified model. The approach supports intra-enterprise and inter-enterprise integration.

The *electronic exchange* and the *classification of product and service data* are essential for a seamless and efficient E-Commerce. But

there exist many classification systems (Hepp et al., 2005), which vary in the structure of the classification structure (net vs. tree), the number of product-description levels (one too many), in the existence of product-attributes (yes or no), in the kind and number of product attributes and in the way the content is managed and validated. Recently, a new approach, based on an advanced tree concept, which uses attributes for products and allows inheritance and polymorphism as well has presented (Wilkes et al., 2012). By this, the administration of the high quantity of classified product-data will become easier, and the amount for the content administration may be reduced dramatically. The approach includes two parallel classifications, one is technical and the other aspect oriented and by this reusable packages of products and services can be modeled. All this have got applied to the ecl@ss classification and BMEcat system which now may be used together and worldwide.

This object orientated concept allows to overcome many known drawbacks and moreover offers new modeling capabilities and opens new application fields as there are: defining and attributing groups of products, inheritance based grouping of products, which would lead to a enormous smaller data base, building relations between products in the classification, which can make content editing checking and harmonizing easier, describing more complex products and services and even integrating interfaces description in product and service systems. Open research fields are to apply this concept in real classification tasks and in special domains.

Another relevant area here is *data and process mediation*. *Mediators* were introduced twenty years ago (Wiederhold, 1992) as an architecture that may be used to solve integration of heterogeneous data sources. Since then, such mediation is one of the hot research topics, where many mediator-based frameworks have been proposed. Examples include, but not limited to, PSM (Mrissa et al., 2007) and WSMX (Zaremba & Vitvar, 2008). Recent effort done by US NIST and associates (Vujasinović et al., 2010) proposes a simplified way. Instead of development of domain ontologies during implementation of particular standard, authors proposed a shortcut that should be applied by SDOs during standard development in a domain. The proposed scenario takes three steps: (1) creation of reference ontology for a domain; (2) semantic annotations of message elements, and (3) definition of reconciliation rules.

A challenge is to develop concepts and solutions for the search, evaluation and integration of knowledge via Web 2.0 features, known as *Crowdsourcing*. Crowdsourcing applied on social networks tries to find and incorporate the knowledge and skills of globally distributed experts and wants to convert it into new knowledge with added value (Vukovic & Bartolini, 2012). Global enterprises and entrepreneurs nowadays are embedding crowdsourcing into their business processes to leverage scalable workforce online, including variable pricing schemas for tasks and reduced opportunity costs. Examples for application fields of Crowdsourcing are submitting ideas on new features (e.g., Dell's IdeaStorm), development of products (e.g., TopCoder), providing product support (e.g., FixYa, CrowdEngineering) and solving business and research challenges (e.g., InnoCentive). As a result, numerous enterprise crowdsourcing models emerged based on the type and complexity of the requested task, type of crowd engaged (e.g., internal, external, or hybrid), and type of the incentive. There still exist some platforms supporting specific activity types, like software components (TopCoder), mechanisms for setting up and maintaining crowd networks.

The main problem in Crowdsourcing is that there exist so many solutions but there are no harmonized concepts and interfaces for the integration of all this activities. This opens a broad field for future research. Firstly, there is a need for developing a principle way of conceptualizing them. Other challenges can be found for enterprise crowdsourcing in the categories: technical, sociological, quality, governance and ethical. Technical challenges refer to the integration of human computation in existing business processes, the standardiza-

tion of human computation (crowdsourcing) protocols, which in turn raises the security and governance. Other challenges may be the management of crowdsourcing systems, inter alias price modeling, ensuring security and trust, organizing, searching, filtering, harmonizing and distributing the manifold information of the experts, assuring copyrights and much more.

A promising approach to retrieve information semantically defined from different and heterogeneous databases offers a new class of enterprise data integration application, called *Data Mashup* (Yu et al., 2008; Di Lorenzo et al., 2009). It relies on the SOA paradigm and permits integrating data "on the fly" even in real time. In practice the relevant source information often resides in a mix of relational databases, applications and legacy mainframe systems. For an average Domain-Expert it is nearly impossible to understand and handle all the ICT procedures which are needed to derive the right data from the manifold existing sources and to build new and valuable information packages. Even, if only referring to Relational Databases, the needed information cannot be simply retrieved by applying a query language, because APIs may control the rules and logic of the underlying "business objects" and hence complex programming work is needed to get the needed Data.

A new and promising Data Mashup approach based on a combination of declarative description of ontologies and on Web Services has given in (Barhamgi et al., 2012). In this approach Data Mashup creators need only to specify declarative queries based on domain ontologies, and the Data Mashup system should resolve most of the outstanding problems automatically. A special strength of this approach is the possibility to restrict the use of extracted date in a formalized and standardized way, accepting constraints which may be given by law, organizations and even individuals. The authors refer to an XML-based W3C standard policy definition language that allows organizations to publish their privacy policies and data practices in a computer-readable format (http://www.w3.org/P3P/). It will be used to describe what type of private data the site collects, for what purposes the data is collected and how it uses this private data. As a resume, this approach offers new promising research fields such as (1) privacy management for individuals and organizations including: storing, administration, updating, and retrieving and systemizing of given permits along the E-Business live cycle based on ontologies; (2) applying the Data Mashup concept to social networks; (3) applying the Data Mashup for the mapping of data schemas, etc.

Closely related to Data Mashup is the concept of *Linked Data* (Bizer et al., 2009; Oren et al., 2008). The concept is based on rules, known as *linked data principles*, for publishing data on the Web in a way that all published data becomes part of a single global space. It allows identifying real-world entities (things) such as products, services, customers, etc. Metadata about these things are usually expressed in the form of RDF triples. The concept has two major obstacles: converting proprietary data into RDF is a technical challenge, keeping privacy and security of data is an organizational and technical challenge, as well.

THE IMPACT OF TECHNOLOGY: PAST, PRESENT, AND FUTURE

The idea to build a distributed open network consisting of ICT Systems that may communicate with no boundaries was born in the middle of 1980s (ISO, 1984). Despite OSI failure due to its robust specification and expensive implementation, OSI era made a significant movement from proprietary to open systems. Several factors influenced OSI failure, which may be summarized as bad timing, bad technology, bad implementations and bad politics. The idea of exchanging business data between applications is nothing new and has been implemented since 1970s. The framework used was Electronic Data Interchange (EDI) based on international standards X.12 and UN/EDIFACT both aimed to minimize the cost, effort, and time for processing paper-based business documents. Despite

its standard-based specifications, EDI failed for the same reasons as OSI. In contrast, today we have a plenty of Web technologies, which may be categorized by actors that communicate via some set of available technologies, as follows.

Human networks rely on so-called Web 2.0 technologies. These include blogs, crowdsourcing, folksonomies, mashups, social networks, RSS feeds, etc. The business impact of these technologies is widely recognized taking into account various aspects, such as e.g., aforementioned aspects of crowdsourcing and Mashup to E-Business interoperability, but also in terms of knowledge management, rapid application development, CRM, collaboration, etc. (Andriole, 2011). Lee emphasized that the power of Web 2.0 does not rely on its software tools and techniques, but on the data that Web 2.0 may bring within (Lee, 2011). He pointed out the six new business models behind Web 2.0 technologies, in which use of these technologies are primary tools to make revenue and survive on the market. In Bonchi et al. (2011) special emphasis has given to data mining from social networks in order to improve business through Social CRM, recommender systems, collaboration with customers, production forecasting, expert finding, churn (loss of customers) analysis, etc. An example of exploring social network data to hire skilled people is the recruitment process (Tétreault et al., 2011). The Combine, as the system is called, is used to hire ICT-skilled people, collecting data from Social networks and applying ontologies in order to help recruiters to find the best match for their current stuff needs.

Service networks have been invented in order to meet dynamic nature of E-business (Papazoglou et al., 2007; Yu et al., 2008). It is based on Web services, autonomous, platform-independent entities that can be described, published, discovered and loosely coupled. Despite that initial Web services stack, consisting of standard WSDL, UDDI and SOAP specifications exists over decade many research and standard efforts have done or yet underway to bring service networks into full potential. These efforts may be classified into several categories such as integration with business process modeling (Dorn et al., 2011), choreography and orchestration of Web services, usually supported by semantic technologies (Zaremba & Vitvar, 2008; Ardissono et al., 2012), security, enhancing with Web.20 capabilities, such as social networks (Maamar, 2011) or enterprise Mashup (Liu et al., 2011; Bahramgi et al., 2012), etc.

Semantic networks are based on semantic technologies (Ding et al., 2002) that allow knowledge-to-knowledge communication between business peers. These networks are usually referred as Web 3.0. Research efforts on semantic networks are focused on various aspect of the development and deployment of semantic technologies, the overview of which may be found in Kajan (2011) and Kajan, Dorloff, and Bedini (2012). In order to emphasize these that are concentrated on mixing semantic networks with other technological networks we just mentioned adding semantic to Web services (Martin et al., 2007) or to social networks (Gruber, 2007; Bojrãs et al., 2008; Skopik et al., 2011).

Network of things, an emerging concept of technology development that will allow machine-to-machine communication over the Internet, usually referred as Internet of Things (IoT), in an extension also named as Web of Things (Mathew et al., 2011). Despite that IoT term has been released officially by ITU in 2005, there are several visionary papers that predict such a technological environment (e g., Kleinrock, 1997; Kindberg et al., 2001). By this, the virtual world will be extended by a number of more complex physical objects acting in special environments. Collaborations are no more restricted to E-Business as is, but in future real-time collaborations will take place between human beings, computers and facilities cooperating in different domains and environments. The economic and informational orientated world will be integrated with the world of Engineering and Logistics. In consequence there will arise many useful and often mobile applications in surgery, health care for elderly people, transport and tourism, entertaining, smart services, etc. This enhances the still

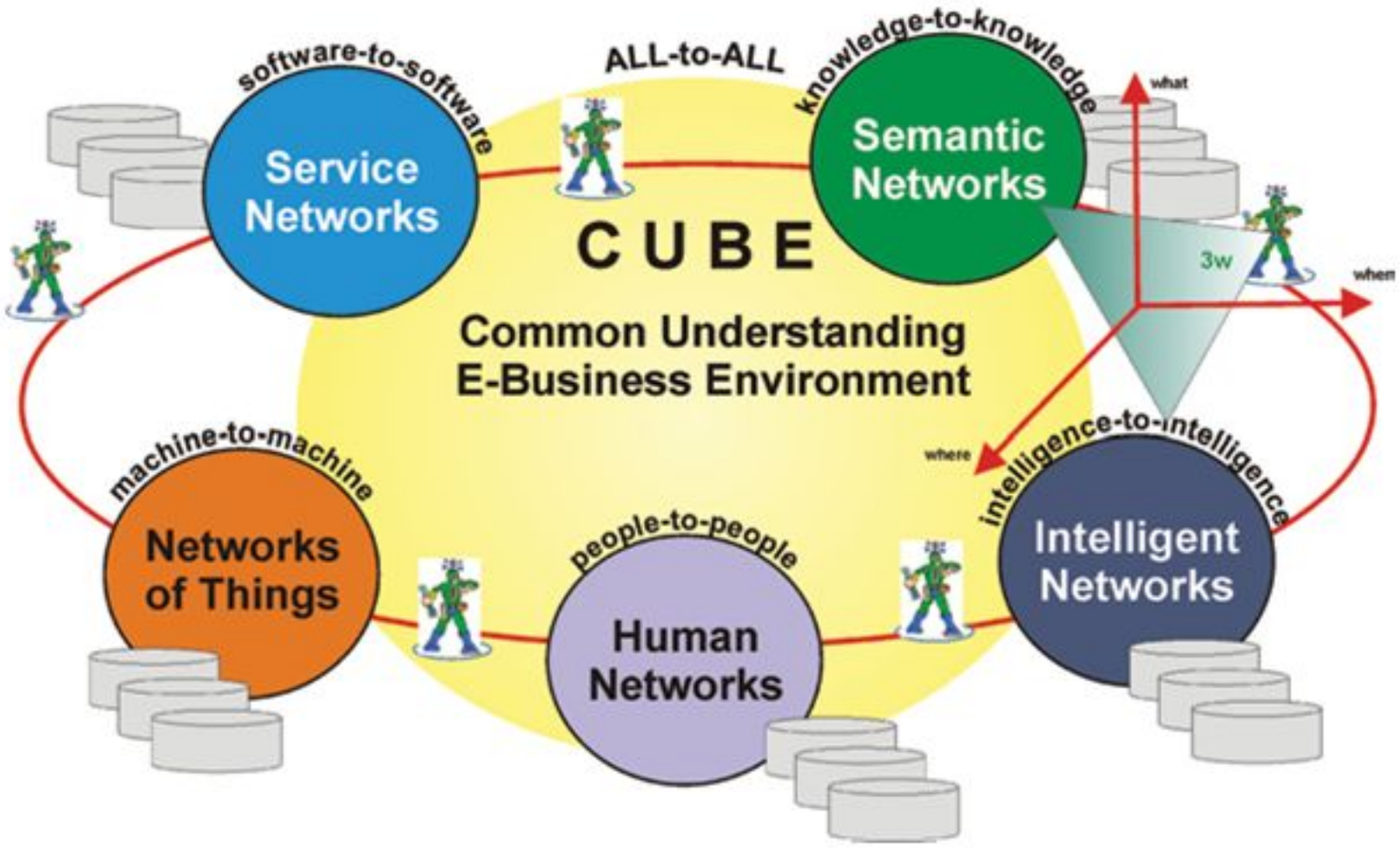
high heterogeneity of digital life and brings up new interoperability challenges – drastically more objects to be identified and characterized, seamless connections between the Internet and radio networks, more complex feedback controlled systems, the need for more powerful and frameworks, concepts, models and monitoring systems. Because of this heterogeneity, the restricted ability to control such complex interactions may become critical and new risks may arise. A big challenge will be to ensure visibility, common understanding and interoperability on all levels. In consequence, additional and even new Standards and regulations on all levels of the Interoperability framework will be needed.

Intelligent networks, another emerging concept that will allow intelligence-to-intelligence communications, usually referred as Web 4.0. In the center of this concept are intelligent software agents, resident or mobile, armed with various AI skills and capable to act as independent self-proactive software artifacts. Since Kasbah, the first e-commerce agent marketplace (Chavez & Maes, 1996), up to day, research on agents, multiagent systems and agent communication languages is taking mush interest in the research community, good overview if which may be found in Wooldridge (2009) and Unland (2012). Such agents are capable to build not only intelligent networks, but also to make a "self-active glue" that will be able to dynamically connect necessary pieces coming from other networks using their capabilities to decide when and what to do, and where to go in case of mobile agents, as we shown in Figure 3 as *3w coordinate space*.

Despite of many obstacles that we mentioned in the beginning as total heterogeneity, such huge and reach technological development allowed significant improvements in E-Business development. Many enterprises went the whole way since era of closed systems, when only isolated islands of information existed, until today, with many technological enablers existing and offering new opportunities to generate added values to enterprises. Nevertheless not all companies, especially SMEs, could use these opportunitiesdue to required high investments that they were unable to cover. With current technological achievements SMEs will have better chances to participate. To summarize and understand what we may have today, let us analyze the main technological opportunities.

Many "standardized" E-Business frameworks, based on Web technologies, and their implementations are existing today (Medjahed et al., 2003; Lamphataki et al., 2009; Bedini et al., 2011). But, the openness of such environments are limited to particular frameworks de-

Figure 3. "The Solar System" of Web technologies



ployed, and may be additionally decreased due to "so called additional features" that vendors like to offer in order to get new pies of market cake. Let us name such E-Business communities as Framework-related Communities.

Another opportunity to enterprises is to choose a particular technology stack and make the business with others that have chosen the same Technology-related community, e.g., someone may decide to use Semantic networks and, if there is a business environment where participants may agree on shared ontologies, it may be a good choice. However depending on the underlying business model it may choose another technological environment.

Due to their technical choice and restrictions both aforementioned communities only have limited opportunities and also a limited number of potential participants. This leads us to (vision) the development of a Web with full potential, where different axis of Web development may results with new Web, sometimes referred as Web 4.0, or Web 5.0, depending on how much functionalities and open they will bring. In context of Figure 3, we mean connectivity of formerly isolated islands of technologies into preferable one distributed and Common Understandable E-Business Environment (CUBE) that will allow open communications between actors more easily and with less limitation. When this will happen we can say that a new "Web star" is born as a core of a CUBE.

VISIONS AND FORECAST: FROM MEMEX TO CUBE

Let us imagine what a non-technically educated reader of Atlantic Magazine might think when he read the article about memex long time ago, back in 1945, twenty years before the 1st ARPANET node was born (Bush, 1945). Vannevar Bush expressed the vision of memex as "*Consider a future device for individual use, which is a sort of mechanized private file and library.*" He coined a random name memex and explained in detail what he had in mind. Any reader of this article will probably say: That is my personal computer. But, aforementioned reader in 1945 probably imagined that the article was dedicated to UFO phenomena, and that aliens will show such a communication device to the living world of the Planet Earth.

Today, we know this vision was true and much more visions in the meantime were materialized into concrete ideas, plans and finalized by technologies that work and made human life easier and richer. Authors of this article made their first software programs in 1960 and 1970s using Hollerith code and punched cards, a programming environment that our younger colleges and students have never seen. In the meantime, many Internet pioneers moved us into the future. For example, Claude Shannon set up the information theory, Paul Baran did the same by the packet communication theory, Leonard Kleinrock sent the first 2-bytes long message "lo" from UCLA to Stanford University. In 1999, Los Angeles Times paid attention to that occasion and total contribution of Leonard Kleinrock to the Internet development, classifying him into top 50 people over the world that influenced business development in 20th century. But it could not be possible without Web and its inventor, Sir Berners-Lee.

The Web 2.0 still is a network platform, which offers a lot of information exchange and collaborations possibilities via connected ICT systems and devices, together with Web of Services offers Software as a Service which is getting better the more people use it, it consumes and remixes data from multiple sources and thus generating network benefits through participation. Intelligent networks and communication go a step further. They try to solve problems with the help of worldwide acting experts and try to find, harmonize and explore their distributed knowledge, which may be represented in different semantics and formats to solve common problems. A vision may be to bring all the knowledge of the deciders and experts together that may help to us to avoid a climate disaster. We surely can use the concepts and instruments of the existing Web 2.0 but we need more and higher sophisticated frameworks, methods knowledge and experi-

ence, e.g., enhanced and distributed decision support systems, evaluating information with help of Fuzzy Analysis or (Data) Information or Knowledge mining, extended models of the behavior and advanced risk analysis in networks, including research from Brain-Informatics and psychology, Recommender systems helping the users to e.g., evaluate the results and risks of an agent based search results (Liu et al., 2011; Rios & Aquileira, 2010). Other aspects are the laws and rules in such networks, the structures, costs and benefits for the whole network and for each participant.

Thus lets us go back to technological development needed to establish an open e-business. A vision of Tim Berners-Lee given in the foreword of the book about Semantic Web (Fensel et al., 2003, p. xxii): "Now we can imagine the world of people with active machines forming part of the infrastructure. We have only to express a request for bids, or make a bid, and machines will turn a small profit matching the two" is already realized with many research prototypes and small communities and relevant parts of this are successfully implemented and used in the field of E-Procurement.

"Web 4.0 will come later and it is about connecting intelligences in a ubiquitous Web where both people and things reason and communicate together" (Davis, 2008). Vagan Terziyan working on and predict appearance of Web 5.0, "it is about connecting models in a global understanding environment, which will be such proactive, self-managed evolutionary Web of Things, People and Abstractions where all kind of entities can understand, interact, serve, develop and learn from each other" (Terziyan et al., 2009).

Memex device has never been produced and appeared in practice with that name, probably the Common Understanding E-Business Environment will also not be appear with that name, but probability and reality of having such an environment with desired capabilities in the near future is many, many times greater that vision of memex had at the time of appearance. Let it be our vision.

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