Enterprise Information Systems State of the Art: Past, Present and Future Trends

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David Romero
Tecnológico de Monterrey

François B Vernadat
University of Lorraine, France, Metz

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David Romero[1], François Vernadat[2]

[1]*Tecnológico de Monterrey, Mexico; david.romero.diaz@gmail.com*
[2]*European Court of Auditors, Luxemburg; Francois.Vernadat@orange.fr*

Abstract. This state-of-the-art paper is intended to set the scene for a special issue of the Computers in Industry Journal on "Future Perspectives on Next Generation Enterprise Information Systems". It gives a brief history of Enterprise Information Systems (EISs) and discusses various aspects of EISs, including EIS design and engineering, the impact of enterprise modelling, enterprise architecture, enterprise integration and interoperability and enterprise networking on EISs before concluding.

Keywords: State-of-the-Art, Future Trends, Enterprise Information Systems, Enterprise Architecture, Enterprise Integration, Interoperability, Enterprise Networking.

1. Introduction

Enterprise Information Systems (EISs) are nowadays essential components of any enterprise system. According to systems theory (Le Moigne, 1977; von Bertalanffy, 1976), any complex system is made of three fundamental sub-systems: (1) a *physical sub-system* (i.e. the operative part made of physical components including human and technical agents as well as material and physical flows), (2) a *decision sub-system* (i.e. the control part where organisation, planning, decision and monitoring actions are made) and (3) an *information sub-system* (i.e. the data-processing part dealing with information flows as well as process, storage and retrieval actions on data, information and even knowledge). In complex systems, each of these sub-systems can itself be viewed as a complex system possibly made in turn of the three sub-systems.

Indeed, *Enterprise Systems (ES),* which are large socio-technical-economic systems, are themselves complex systems and, as such, comprise these three fundamental components. The situation can even be more complicated in the case of networked enterprises or large manufacturing supply chains made of several business entities (e.g. suppliers, manufacturers, assemblers, retailers…) and which become *Systems of Systems (SOSs)* as defined by Ackoff (1972) and analysed by DiMario (2010) in the context of collaborative systems. The focus of this paper remains on the information part of enterprise systems, be they manufacturing and production systems of goods, service enterprises or administrative organisations.

Enterprise Information Systems (EISs) can be defined as "software systems for business management, encompassing modules supporting organisational functional areas such as planning, manufacturing, sales, marketing, distribution, accounting, financial, human resources management, project management, inventory management, service and maintenance, transportation and e-business" (Rashid and Hossain, 2002). They are made of computers, software, people, processes and data.

According to Xu (2011), EISs have emerged in the last decades as promising tools used for integrating and extending business processes across boundaries of business functions, at both intra- and inter-organisational levels, in a worldwide economy with increasing global business operations. In this context, the development of Information and Communication Technologies (ICT), including Industrial Informatics (e.g. Industry 4.0), and the technological advances in EISs have provided a viable solution to the growing needs of information integration in both manufacturing and service industries, supporting the operations of global supply networks. This also applies to government and non-government administrative organisations. Furthermore, EISs have progressed in a constant interaction between changing business requirements, technological and organisational maturity and software vendors' capabilities (Wortmann, 1998).

The aim of this paper is to provide introductory reading for a special issue of the *Computers in Industry* Journal on "Future Perspectives on Next Generation Enterprise Information Systems". It provides a state-of-the-art discussion on essential aspects of EISs and addressing some future trends. It first presents a brief history of EIS, then a discussion on EIS design and engineering aspects, followed by an analysis of the impact of Enterprise Architecture, Enterprise Integration, Enterprise Interoperability and Enterprise Networking (EAI2N) disciplines on EISs before concluding.

2. Enterprise Information Systems (EIS) History

Enterprise Information Systems (EISs) history started with the introduction of computers in industry in the early 60's, using their computing and recording capabilities to automate manual tasks and to replace paper-based systems such as book keeping. The first generation of EISs mostly consisted of stand-alone functional information systems, e.g. intensive data processing systems (for instance for human resources data, accounting data, finance data, invoicing…). Gradually, as the sophistication of computers, computer networks and database systems increased, EISs begun to take a more active role in supporting business processes, information flows, reporting and data analytics in organisations. In the late 60's, EISs took over the control of bills-of-materials processing, inventory systems and forecasts. Afterwards, in the 70's, the first *Management Information Systems (MISs)* appeared while other EISs started to support Material Requirements Planning (MRP) and a decade later, in the 80's, Manufacturing Resources Planning (MRP/II). The 90's gave born to Enterprise Resource Planning (ERP/I) packages, integrating databases and operational business functions in the back office and including support for human resources and quality management. In the 2000's, ERP solutions moved beyond enterprise boundaries to evolve to ERP/II, supporting the 'extended enterprise' and enabling inter-organisational collaboration embracing supply, design and engineering business functions (Møller, 2004). Nowadays, ERP/III aims at creating a 'borderless enterprise', supporting collaboration within the enterprise business functions and across the supply chains, including customers and the sales side of the marketplace (Hurbean and Doina, 2014).

Because documenting in detail this section with relevant bibliographical references would amount to hundreds of citations, which is not the goal of this paper, essential readings in relation to this brief history of EISs can be limited to Xu (2011) for a general state-of-the-art discussion on enterprise systems, Orlicky (1975) on MRP, Davenport (1998), O'Leary (2000) on ERP and ERP/II, and Hurbean and Doina (2014) on ERP/III.

However, deeper attention with respect to the EIS history can be devoted to six particular types of enterprise information systems: Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Manufacturing Execution Systems (MES), Customer Relationship Management (CRM), Product Lifecycle Management (PLM) and Business Intelligence (BI).

2.1 Enterprise Resource Planning (ERP)

From a historical Information System (IS) application perspective, ERP/I comprised several integrated modules, including logistics, procurements, sales, marketing, human resources and finance, supporting intra-organisational collaboration. According to Callaway (2000) and Møller (2004), ERP/II, also known as extended ERP (eERP), offers the following Web-enabled modules: *e-Commerce* – including electronic catalogue, on-line purchasing and status checking facilities; *e-Procurement* – automating the business function from on-line ordering, order status, ship notice and electronic payment and invoicing; *Supply Chain Management (SCM)* – featuring collaborative production planning and control functionalities; *Customer Relationship Management (CRM)* – allowing customer identification and service management; *Business Intelligence (BI)* – supporting decision making with data collected from the corporate datawarehouse; *Advanced Planning and Scheduling (APS)* – optimising the production capacity based on the forecasted orders, inventories and manufacturing capacity; *Corporate Performance Management (CPM)* – introducing dashboard functionalities to assess and analyse the health status of business functions; *Human Resources Management (HRM)* – featuring payroll, attendance, performance appraisal, benefits administration and recruitment support; *Product Lifecycle Management (PLM)* – enabling effective management of the full product (data) definition an extended enterprise context; and *Supplier Relationship Management (SRM)* – working with the supplier base as an analogy to the CRM. Next Generation ERP, or ERP/III, will encompass the integration of 'social media' with new 'marketplace intelligence' and analytics into the ERP/II. These new ERP/III functionalities, or extensions of existing ones, with even new modules, will help on the one hand to extend enterprise analytics beyond internal recorded events in a datawarehouse (business intelligence) to external information (market intelligence) stored in a kind of larger and augmented datawarehouse known as 'Big Data'. The benefits will be that decision makers can be provided with a more complete picture of the ongoing corporate performance and, on the other hand, 'social media' will create new and more direct marketing, communication and sales channels with customers (Hurbean and Doina, 2014).

Furthermore, from a historical Information and Communication Technologies (ICTs) perspective, ERP/I evolved from MRP/II enabled thanks to the advances on Database Management Systems (DBMS), computer networks, client-server architectures, technologies focusing on data and applications integration and automation (such as Enterprise Application Integration (EAI) platforms) as well as from the progress of Workflow Management Systems (WfMS) and technologies concentrating on intra-organisational business processes integration and automation. A decade later, the transition to ERP/II, and therefore to inter-organisational business processes, was allowed in a first instance by the advent of data exchange technologies such as EDI (Electronic Data Interchange) or ebXML and more mature WfMS technologies named Business Process Management (BPM), followed by IT architecture frameworks for business processes integration and interoperability along with more progressive and open data exchange technologies such as XML and Web Services to support the extended enterprise. Finally, the ERP/III is now becoming a reality thanks to a set of rapidly evolving and enabling technologies of the 'borderless enterprise' such as mobile, social media, SOA (Service Oriented Architecture) and other Web-enabled tools and Internet computing technologies. Moreover, within the ERP/III generation it is important to distinct three forms of ERP adoption, starting from the traditional on premise solution hosted at the enterprise ICT-infrastructure, followed by the such called 'cloud ERP' offered as a cloud application service under the Software-as-a-Service (SaaS) paradigm and the 'hybrid ERP' delivered as a combination of licensing options with on premise solution offerings.

2.2 Supply Chain Management (SCM)

Even though SCM origins can be traced back to the 40's at the intersection of industrial engineering and operations research, it was during the late 70's and 80's with the emergence of MRP and MRP/II that was born the *computer-based SCM*, with an initial scope for product information management and focus on inventories, production cost and capacity and throughput control for quality assurance and cost management (SCM/I). During the early 90's, the SCM/II extended its scope to include market information and focus on orders management for improving product availability, and before the decade ended the SCM/III including customer information for enhancing customer satisfaction (response/lead time). Across the 2000's and at the present time, the SCM/IV and beyond has become a powerful information management and control system for demand management, acquisition of raw materials and parts, transformation of raw materials and parts into finished products, finished products distribution to either retailers or customers and reverse logistics for products repair, remanufacturing and/or recycling (Martin and Towill, 2000; Muzumdar and Balachandran, 2001; Folinas et al, 2004; Ballou, 2007). Besides the SCM timeline, *computer-based SCM* can be divided in four generations: (1) core-logistics activities supported by the MRP and MRP/II, (2) coordination of inter-organisational business processes enabled by the ERP/I, (3) inter-enterprise business exchange facilitated by the ERP/II and (4) the establishment of dynamic networks between virtual organisations thanks to the ERP/III (Folinas et al., 2004; (Hurbean and Doina, 2014). Looking backward, it can be said that *computer-based SCM* has become more than a database and a process manager but rather a decision support system to help managers to make decisions effectively. Beholding the future, beyond the ERP and EDI, SOAP (Simple Object Access Protocol) and XML protocols for data exchange in the supply chain, next generation computer-based SCM systems and e-platforms will be based on SOAs enabling data exchange with Web services, data enrichment via new tagging technologies for assets identification, tracking and monitoring, and wireless communication technologies, all supporting accurate and real-time information provision for decision making.

2.3 Manufacturing Execution Systems (MES)

In the later part of the 70's and early 80's, MRP and MRP/II provided manufacturing enterprises with three main capabilities: material planning, material control and production definition. However, when it came to real-time management and control of the production, MRPs and ERPs felt short in the task of recording and reporting every single transaction on the shop-floor in real-time for proper manufacturing execution management, creating a niche for the birth of the *Manufacturing Execution Systems (MES)*. The first generation MES were developed in the 80's to support data collection, centralisation and processing for supporting manufacturing planning, scheduling, traceability, quality assurance and reporting by providing real-time data visualisation for operators and management. Later in the 90's, as *Computer-Integrated Manufacturing (CIM)* evolved, MES/II became real dynamic and integrated information and control systems driving the execution of manufacturing operations using real-time data to control production operations from point of order release into manufacturing to point of product delivery. Nowadays with the advent of Industry 4.0 and personalisation/mass-customisation paradigms, next generation MES (MES/III) will focus even more in plant management working with increasingly detailed manufacturing and planning units in order to enable higher levels of flexibility in production systems, so facing in a natural way new data and applications integration and interoperability challenges between the aimed smarter production systems and smart materials and machines.

2.4 Customer Relationship Management (CRM)

Computer-based Customer Relationship Management (CRM) has its origins in the early 80's with "database marketing" and "contact management". Its aim is to record and analyse customer information in a passive way. It was till the early 90's that *computer-based CRM* had its first real push into the sales force by becoming a two-way street in where the recorded and analysed customer information started to be used to improve customer service (e.g. loyalty programs) in addition to sales. Beyond the 2000's *computer-based CRM* became an enterprise information system supporting sales activities, automating marketing campaigns, and providing service ticketing and case management. In parallel, its delivery mechanism evolved from an on premise solution based on a client-server architecture to new SaaS and mobile delivery mechanisms based on SOA, with increased datamining and reporting capabilities.

2.5 Product Lifecycle Management (PLM)

Computer-based Product Lifecycle Management (PLM) systems have their origins in the late 80's with the first 'Engineering Databases' (EDB) as information systems managing and integrating product engineering data in a single repository coming from e.g. Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) systems. Later on at the early 90's, EBDs evolved to 'Engineering Data Management' (EDM) systems by adding the functionalities to structure engineering processes (e.g. WfMS). By the mid 90's, with the integration of non-engineering product data (e.g. marketing and sales) from the ERP, 'Product Data Management' (PDM) systems were born, supporting bills-of-materials (BOM), engineering change, CAD vaulting and document management. Around 2000's, PDM systems became integrated information systems supporting product data management across the whole product lifecycle, being renamed to 'Product Lifecycle Management (PLM)' systems. PLM systems evolution continues by extending its capabilities for collaboration environments (e.g. BOM exchange, team collaboration, 2D & 3D viewing/mark-up, component and catalogue sourcing) as well as for better product information traceability during its whole lifecycle (e.g. closed-loop PLM, IoT enabled PLM).

2.6 Business Intelligence (BI) & Analytics

Business Intelligence (BI) has a humble origin in the 80's as a reporting type of application. Modern BI was later born in the 90's as data warehousing solutions, Extract, Transform and Load (ETL) tools, and Online Analytical Processing (OLAP) software to cut the time to access and analyse data. First generation BI solutions had then two basic functionalities, producing data and reports (e.g. statistical analysis of data) and organising them for proper visualisation (e.g. graphical visualisation of results). Around 2000's, a second generation of BI solutions has achieved faster processing capabilities and has adopted new data analysis and visualisation methods (e.g. data, text and process mining, complex event processing, descriptive, predictive and prescriptive analytics). Nowadays, as data volumes continue to grow, new analytic technologies such as 'Big Data' are emerging to transform BI, and therefore the world of decision support systems, by enabling advanced analytics. Moreover, as 'Big Data analytics' continue to mature based on inductive statistical methods, Big Data starts to differentiate itself from 'BI analytics' mostly based on descriptive statistical methods.

3. EIS Design and Engineering

The ecosystem of a typical enterprise is usually made of dozens and even hundreds of information systems, depending on the enterprise size. These information systems can be stand-alone, interfaced with some others or tightly integrated with information systems inside or outside the enterprise. They can concern various functional domains of the enterprise as it was mentioned in the earlier sections of the paper. Some of these systems are based on software products or packages bought from the marketplace, others have been fully developed with programming languages and database technology and others are shared with other business entities or partner companies and may not be hosted in the data centre of the enterprise. Depending on their nature, EISs can be classified as transaction-oriented, database centric, form-based, workflow-driven, Web application, enterprise portal or Web site applications.

Information system design and analysis methods have their roots primarily in functional analysis on one hand and information flow and object analysis on the other hand. Ancestor methods are the Structured Analysis and Design Technique (SADT) of D.T. Ross (1977) for functional decomposition (renamed IDEF0 in the IDEF method) and the Entity-Relationship (ER) method of P.P.S. Chen (1976) for information modelling. The ER model and its extensions (such as IDEF1x, MERISE, NIAM...) have been used for a long time, and can still be used, to design the conceptual schema of application databases. In the meantime, they have been challenged by the Business Process Modelling (BPM) methods on the one hand and the Object-Oriented Approach (OOA) on the other hand that appeared at the beginning of the 90's and have transformed software engineering design and analysis methods.

For traditional EIS development, the state-of-the-art is first to perform a business analysis phase to analyse the business environment and the functional requirements. A process modelling approach is used to model business processes, preferably with BPMN (Business Process Modelling Notation) supported by the Object Management Group (OMG, 2011) but any other process modelling technique can be used (such as IDEF3 of the IDEF method). Then, a deeper analysis of the functional requirements is made using relevant diagrams from the set of diagrams provided by the Unified Modelling Language (UML) such as Use Cases, Activity Diagrams, Communication Diagrams, State Diagrams or Sequence Diagrams (OMG, 2005). Finally, an object structure, for the interfaces, the code and the database to be implemented is specified using the Object Class Diagrams of UML. If the information system is a traditional 3-tier application (i.e. made of a data layer, a business layer and a presentation layer), it can then be developed in Java in a Java environment (e.g. Oracle WebLogic or IBM WebSphere) or C# in a Microsoft.Net environment or any other programming languages, possibly using the SQL language for the relational database (e.g. Oracle or MS SQL Server or MySQL or the like). Open source platforms exist, especially in the Java world (e.g. Apache Tomcat, JBoss, etc.). Details on several modelling techniques commonly used in traditional IS development can be found in Bernus et al. (2005).

Another way of developing complex EISs, made of many modules in which reuse of pieces of code encapsulating well-bounded units of functionality is need, is to use the Service-Oriented Architecture (SOA). A SOA is a collection of services. If these services can be accessed via a URI (Unified Reference Identifier) similar to a URL (Unified Reference Locator), they are called Web Services (Khalaf et al., 2005; Singh, 2005). Web services are self-contained, self-describing, loosely coupled and modular software components that communicate via XML-based interfaces and using Internet protocols (e.g. TCP/IP, HTTP/HTTPS and SOAP). Web services are described in terms of WSDL (Web Service Description Language). WSDL is an XML-based syntax for describing a Web service and expressing the interface to a given Web service (W3C, 2001). A specific design and analysis approach, recently proposed to cover the whole SOA life cycle development, supported by OMG and which should become an industry standard, is SoaML (OMG, 2012).

When there is a large number of Web services that have to communicate with one another and these Web services are distributed over many computer servers, specific platforms based on message-oriented middleware (MOM) technology can be used. These are called *Enterprise Service Buses (ESBs)* (Chappell, 2004). ESBs have replaced former platforms called object brokers used in object-oriented platforms such as OMG CORBA or OSF/DCE. ESBs make possible the development of loosely-coupled IS integration architectures of SOA applications as opposed to previous platforms that followed object brokers in the 2000's and were called Enterprise Application Integration (EAI) platforms. EAI solutions were complex proprietary solutions working as a central hub able to connect a large number of enterprise information systems (built-in or packaged solutions) by means of connectors, i.e. specialised interfaces for various kinds of systems and technologies (Linthicum, 2000; Lee et al., 2003).

To facilitate the work of IT architects and IT developers in designing and developing integrated EISs, either by means of EAI technology or by means of SOA/ESB technologies, enterprise integration patterns have been specified and can be reused and customised for particular situations. The interested reader is referred to the book of Hohpe and Woolf (2004), which remains a reference on the topic.

Finally, the last class of EISs that have become very common in most enterprises and that need to be integrated with the rest of the IS ecosystem are Web applications and especially Web dissemination systems (e.g. Intranet, Internet and Extranet sites) as well as collaborative sites. These are applications to be accessed via a Web browser. They usually rely on a Web Content Management (WCM) system and/or an Enterprise Document Management (EDM) system depending on the types of contents to be shared and disseminated. Dissemination systems are usually built on Enterprise Portal (EP) technologies (e.g. Drupal, Liferay, Oracle WebCenter, Microsoft SharePoint, SAP Portal or IBM WebSphere Portal, to name a few) while collaborative sites are built on collaboration platforms (e.g. Microsoft SharePoint, EMC eRoom or IBM Sametime, to give some examples). This kind of information systems requires specific skills and techniques for its design and development (for instance, regarding Look & Feel and page layout design, content organisation, content navigation and user experience, services offered, etc.).

For further future perspectives on *EIS Design and Engineering*, please refer to Weichhart et al. (2016) on "Challenges and Current Developments for Sensing, Smart and Sustainable Enterprise Systems", Bernus et al. (2016) on "Enterprise Engineering and Management at the Crossroads", Lapalme et al. (2016) on "Exploring the Future of Enterprise Architecture: A Zachman Perspective", El Kadiri et al. (2016) on "Current Trends on ICT Technologies for Enterprise Information Systems" and Hinkelmann et al. (2016) on "A New Paradigm for the Continuous Alignment of Business and IT: Combining Enterprise Architecture Modelling and Enterprise Ontology", all papers are part of this special issue.

4. EIS and the Enterprise Architecture Discipline

4.1 Enterprise Architectures: Past and Present

Enterprise Architecture (EA) is defined by Gartner (2016) “as a discipline for proactively and holistically leading enterprise responses to disruptive forces by identifying and analysing the execution of change towards desired business vision and outcomes”. EA knowledge can be systematised using so-called Enterprise Architecture Frameworks (EAFs). EAFs have been developed in parallel by two distinct communities: (1) the *Enterprise Integration (EI)* movement of the Industrial Engineering community, predominantly interested in manufacturing systems engineering to achieve seamless information, control and material flows across the enterprise and the supply chain, and (2) the *Information Systems (IS)* community focusing on development methods, mainly concentrating on the development of software systems, but acknowledging that software is only one part of the enterprise’s information system.

The first community, on Industrial Engineering, initially defined the EA scope as the design and construction of manufacturing systems, integrating manufacturing operations and manufacturing control. However, soon this scope limitation appeared to be too restricted and it was extended to the complete enterprise (covering all functions of the physical architecture, the control architecture and the human architecture). Also, because an enterprise typically extends beyond its organisational boundaries, the scope included the complete supply chain, noting that some enterprises are not even organisationally bound such as Virtual Enterprises (VEs) or Collaborative Networked Organisations (CNOs). During the 80’s and the 90’s, the manufacturing and industrial engineering communities have adopted fundamental systems engineering concepts and methods, such as system lifecycle, recursion of systems lifecycle relationships and systems modelling, to name a few. Various schools have codified these concepts in the form of architecture frameworks (Bernus et al., 1996). The prominent examples include: the Purdue Enterprise Reference Architecture (PERA) (Williams, 1992), the Computer-Integrated Manufacturing Open System Architecture (CIMOSA) (ESPRIT Consortium AMICE, 1993; Kosanke et al., 1999) or the GRAI-GIM method (Doumeingts et al., 1992). These EA frameworks have been surveyed by Vernadat (1996) and Noran (2003). The generalisation of these and similar frameworks was formalised as ISO 15704:2000 (ISO, 2000), also known as GERAM, which stands for ‘Generalised Enterprise Reference Architecture and Methodology’, yielding a set of concepts that enterprises could use to systematically address the complex design and implementation process of manufacturing or service enterprises (GERAM, 1999).

The second community, on IS development, created a number of frameworks after the pioneering work on the Zachman Framework (Sowa and Zachman, 1992; Zachman, 2011). Among these, one can mention: ARIS (Scheer, 1992), the Open Group Architecture Framework (TOGAF) (The Open Group, 2011), the Federal Enterprise Architecture (FEA) framework (FEA, 2013), the Department of Defence Architecture Framework (DoDAF, 2010) or, more recently, ArchiMate (The Open Group, 2012), which tends to be a synthesis of ideas coming from previous EAFs (Lankhorst, 2009).

Other international standards have also been developed to codify some additional important concepts regarding architecture descriptions from the software engineering perspective, e.g. ISO 42010: 2011 (ISO, 2011).

Given the fact that ISO 15704 lists the necessary components of an EA framework, it is possible to use it to assess the state-of-the-art of these components and practically all important EAFs have been mapped onto GERAM to assess their completeness (Noran, 2003). So, from the point of view of scope, current EAFs appear to be complete enough to represent, analyse and design current and future states of an enterprise of any kind. Therefore, EAFs have specifically been designed to be holist, stable as well as business model and technology independent and they include a list of necessary components to implement a specific EA. These components include: *modelling languages* suitable for developing the necessary models from the viewpoints of the stakeholders in terms of their specific concerns and, in general, to address their concerns, *ontologies* that define the precise meaning of modelling languages (i.e. domain ontologies expressed as terminologies in form of meta-models or by the addition of axioms as ontological theories), *reference models* that can be used as customisable templates or reusable models (i.e. typical partial solutions), *enterprise modules* (i.e. typical technologies and human roles models), *enterprise engineering methodologies* designed to help address transformation problems and *enterprise modelling tools* that can be used as repositories for models, views of these models for stakeholder and in general all architecture descriptions.

Looking into the future, there are three major interrelated drivers that should impact EAF evolution:

(1) *Advances in technology,* including design, manufacturing, service provisioning, logistics and information technologies as enablers and advances in management and control theory of enterprises, networks of enterprises, programmes and projects, logistics, planning and scheduling, etc. Due to the scope of this special issue on "Next Generation Enterprise Information Systems", a special mention on the advances in supporting EIS technologies and IT reference architectures is required. EISs have first moved from application-centric database silos to statically designed integrated ERP databases and ERP application suites and more recently to distributed service-oriented solutions (SOA) that can dynamically create and maintain 'just enough' integration of information, control and material flows. Moreover, a number of relevant technologies are set to transform the EIS field. These include the recent surge in the use of *Cloud Computing* to increase some 'ilities' (i.e. Anything-as-a-Service (Xaas): Software, Platform and/or Infrastructure), but with new challenges associated such as cybersecurity. Other technologies, such as the ones behind the so-called *Big Data* movement, are at their highest hype of expectations, but how to effectively utilise the ability to access and analyse very large and heterogeneous datasets in real-time is but in few cases still an open question. Furthermore, the *Internet-of-Things (IoT),* also in its infancy, offers different expectations with regards to the opportunity to built-in intelligence in various small devices, being 'technological innovations' in terms of creating new or extending the abilities of existing devices or 'business model innovations' by enabling new forms of creating and capturing value. While technology development continues to progress and creates a large variety of sensors and actuators (e.g. intelligent things), the ability to have an extraordinary richness of data creates also the challenge of how to turn such data into useful information. In this sense, IoT is, or will be, able to exploit machine intelligence and robotics algorithms that have already been known for some time. However, in the context of very large number of devices, the algorithms currently in use will eventually hit a complexity barrier, and there will be a need for new methods to deal with this complexity.

(2) *Advances in business models,* driven by opportunities opened up by (new) digital technologies, can influence the field. Some important developments are along e-commerce (e.g. B2B: Alibaba and B2C: Amazon, iTunes, Spotify) and social media (e.g. Facebook), which have been a great success for those who knew how to exploit the digital technology to access the expanded market and utilise multi-channels for marketing and selling goods and services. The use of service orientation on the business level, and supported by (new) digital technologies, has created the ability to run services at a much lower cost than previously. A new arrival in the business model innovation arena is what is often termed the 'sharing economy' (e.g. Airbnb, Uber) enabled by mobile technology and digital platforms. When it comes to the manufacturing industry, the combination of industrial and digital technologies and business model innovations have created the Industry 4.0 vision, of a distributed global and virtual manufacturing factory of the future. Dangers in the business model sphere exist too, due to the lowering of the cost of entry, potentially creating economically unstable business models, with unexpected or adverse social and/or environmental effects.

(3) *Advances in global economic and financial systems and legal frameworks,* including politics and policies. Although not the topic to be further discussed here, it is important to mention that technology innovations and business model innovations are stretching the limits of current legal, financial, political and social systems. From the point of view of this special issue, the only remark is that not all technologies and business models that are possible is desirable and policy makers need to try to achieve some level of global consensus on regulating these developments.

4.2 Enterprise Architectures: Future Trends

Next Generation Enterprises will face the challenge to survive in an ever changing environment. To support the transformation of the enterprise according to new business demands, legal regulations or changing market situations, a holistic perspective on the *Enterprise Architecture (EA)* has to be taken according to Ernst and Schneider (2010). In this context, the vision of an enterprise is shifting from the Traditional EA, which is modelled as a framework-centred, tool-driven, technology-centric and business-constraint, to a Digital Architecture or *Next Generation EA (NGEA),* which includes the latest digital capabilities such as: social Web, SOA, big data analytics, omni-channels, cloud computing, virtualisation, Internet-of-Things and so on (Palli and Behara, 2014). For example, in a NGEA, *Business Architectures* will emphasise on cross-business processes instances that can be quickly altered to address enhancements or fine-tuning and in where changes will no longer be referred to as exceptions, because expectations denote a deviant or abnormality and in an ever changing environment adaptation or change will be normality (Tanuj and Amol, 2008). *Information Architectures* will be oriented to big data, as well as to descriptive, predictive, prescriptive and inductive analytics and social business intelligence. *Application Architectures* will focus on reusable components, including portals, mashup servers, RSS feeds, database servers, mapping servers, gadgets, user interface components and legacy Web servers in order to integrate these elements to form an edge application in which multiple services and components are overlaid or mashed together (Hutchinson et al., 2009). Lastly, *Technical Architectures* will have a strong service orientation (e.g. Service-Oriented Architecture (SOA), Service-Oriented Computing (SOC)) aimed at providing platform-, language- and operating systems- independent middleware solutions based on Web services and XML-based approaches to support interoperability and integration of systems, applications and data sources by means of services paradigm, compromising the infrastructure needed for specifying service properties (Web Services Description Language (WSDL)), interaction between services (Simple Object Access Protocol (SOAP)), services invocation (Web Services Invocation Framework (WSIF)), services registry (Universal Description, Discovery & Integration UDDI)), tunnelling through firewalls (Web Services Gateway (WSG)) and scheduling (Web Services Choreography Language (WSCL)) as promoted by Internet Computing (Singh, 2005).

For further future perspectives on *Enterprise Architectures*, please refer to Bernus et al. (2016) on "Enterprise Engineering and Management at the Crossroads", Lapalme et al. (2016) on "Exploring the Future of Enterprise Architecture: A Zachman Perspective", and Hinkelmann et al. (2016) on "A New Paradigm for the Continuous Alignment of Business and IT: Combining Enterprise Architecture Modelling and Enterprise Ontology", all papers part of this special issue.

5. EIS and the Enterprise Integration Discipline

5.1 Enterprise Integration: Past and Present

Enterprise Integration (EI) in its broad sense is surely a technical but first of all an organisational challenge. It requires Enterprise Modelling (EM) and EA disciplines in order to analyse functional, information, resource and organisation aspects that need to be integrated. EI is concerned with "facilitating information, control and material flows across organisational boundaries by connecting all the necessary functions and heterogeneous functional entities (e.g. information systems, devices, applications and people) in order to improve the 3 C's (communication, cooperation and collaboration) within the enterprise so that the enterprise behaves as an integrated whole, therefore enhancing its overall productivity, flexibility and capacity for management of change or reactivity" (Vernadat, 1996). Thus, EI happens any time that two or more enterprises need to coordinate their business or to work together as a single entity. It is the case, for instances, in the event of enterprise mergers or acquisitions, when rationalising a business to increase its efficiency or productivity or when adding partners to an extended enterprise organisation that must last over time. It therefore requires at least alignment but in many cases tight or full integration of business processes and associated resources and information systems (Petrie, 1992; Gold-Bernstein and Ruh, 2005; Molina et al. 2007). EI has become an important issue for many enterprises in order to extend their business processes through integrating and streamlining processes both internally and with partners in the supply chain (Panetto and Molina, 2008). Furthermore, EI deals with strategies, methods, models and tools, which aim at consolidating and coordinating databases and applications.

Three levels of integration can be identified in an enterprise as defined by CIMOSA (ESPRIT Consortium AMICE, 1993) and which still hold: (1) *Physical Integration*, or communication level, which deals with systems interconnections and data exchange (interconnection of physical devices, computers and database systems via computer networks), (2) *Application Integration*, or cooperation level, which deals with interoperability of software applications and database systems in heterogeneous computing environments and, on top, (3) *Business Integration*, or collaboration level, which deals with co-ordination of functions, processes and people that manage, control and monitor the operations of the enterprise.

Integrated information systems can be divided into three main classes: (1) *Interfaced systems* representing the weakest (but still widely used) form of integration because systems can only exchange data using predefined exchange protocols and data schema (e.g. Comma-Separated Value (CSV) files over FTP (File Transfer Protocol), XML files via TCP/IP and SOAP, SQL schemas over DBlink in the case of Oracle applications, etc.), (2) *Tightly-coupled systems* integrating all data sources by creating logical mappings between them using standardised hard-coded interfaces and predefined global schemata and requiring so-called integrating infrastructures such as Enterprise Application Integration (EAI) platforms (Linthicum, 2000) and, in between, (3) *Loosely-coupled systems* coordinating autonomous component data sources and software applications with a set of federated schemas and open data exchange formats and protocols, preferably XML formats and using, for instance, Enterprise Service

Buses (ESB) for message routing (Chappell, 2004). The latter case equates to interoperable enterprise information systems discussed in the subsequent section. Of course, there could be many intermediate gradations of IS integration between these two extrema (i.e. interfaced and tightly-coupled).

Furthermore, during the First International Conference on Enterprise Integration Modelling Technology (ICEIMT) held in 1991, it was established that there are three main approaches to integrating enterprise information systems on the basis of their models (Petrie, 1992): (1) the *Master Model approach* (in which a single reference model is used from which all other models and instantiations are derived – see for instance the ARIS architecture), (2) the *Unified Model approach* (in which a supra meta-model is used to make the translation between the models of the EISs to be integrated – see for instance the CIMOSA architecture) and (3) the *Federated Model approach* (in which the loose coupling occurs as needed using late binding and a formal mechanism, such as ontological mechanisms – see for instance the TOVE (Toronto Virtual Enterprise) approach (Fox, 1992)).

With the recent advent of new technologies such as XML, Web services and SOA, EI now intends to integrate any form of data in enterprises and networks of enterprises and aims at providing a uniform interface for information access, manipulation and integration across multiple data sources. Nevertheless, these new EI technologies/approaches are still based on similar principles of loosely-coupled systems and face comparable challenges such as 'scalability' and 'semantic' problems than other IT disciplines (Zhou et al., 2006).

5.2 Enterprise Integration: Future Trends

In the future, integration of enterprise systems will remain desirable and even mandatory in many cases, but a real question for EI is when should this integration be created: at design-time or at run-time? As technologies and business models develop, it is expected to have more 'run-time integration', i.e. while operations are executed, therefore requiring less 'design-time integration'. In other words, the trend is to build ever more loosely-coupled systems and less rigid and pre-defined solutions, thus better sustaining e-business agility and rapid enterprise evolution.

Another trend is to be able to build more collaborative enterprise information systems, i.e. federated information systems that can support collaborative work or that can cooperate with one another. They can, for instance, support geographically distributed product design processes in a multi-national group or cope with reconfiguration of an enterprise network forced by dynamic adaptation to rapidly changing market conditions. Again, this calls for high agility of the enterprise systems and non-monolithic integration solutions. Novel models of collaboration schemes and new collaboration protocols must be devised as new collaboration situations are ever faced. This leads to another question: How much my EISs must be open to partners or stakeholders while protecting the security of my data or my intellectual property rights?

The advent of Cloud Computing (Mell and Grance, 2009) is also drastically changing the EIS scene. Indeed, many manufacturing companies are going to have part of their data and information on some local systems in their premises but have ever more data in the Cloud to use software facilities either provided as SaaS (Software as a Service) solutions (such as product design and engineering packages or ERP modules) or provided by partners (e.g. networked enterprise private Cloud). For small and medium-sized manufacturing enterprises, the trend within a decade is to have outsourced their data centre and pay per use for the software they use and the data they store. This leads to the usual questions: Where are my data stored? Who can access them? How confident can I be in Cloud services or Cloud solution providers?

Because cooperation and exchanges are intensifying among firms and with their partners and suppliers, forcing to interconnect or integrate various information systems, another trend for EIS design and operation is to integrate the concept of 'trust' in addition to the concept of collaboration in their new EA frameworks. Indeed, organisational trust is an essential concept that has to be measured and managed because it can drastically influence the degree of EIS integration in horizontal relations, the quality of the collaboration, the type of alliances and the nature of IT solutions implemented in interfirm cooperation (Rindfleisch, 2000; Shi and Liao, 2015). This raises new questions for top managers in terms of strategic decisions at the organisational level of EI.

For further future perspectives on *Enterprise Integration,* please refer to Panetto et al. (2016) on "New Perspectives for the Future Interoperable Enterprise Systems", El Kadiri et al. (2016) on "Current Trends on ICT Technologies for Enterprise Information Systems" and Agostinho et al. (2016) on "Towards a Sustainable Interoperability in Networked Enterprise Information Systems: Trends from Knowledge and Model-Driven Technology", all papers are part of this special issue.

6. EIS and the Enterprise Interoperability Discipline

6.1 Enterprise Interoperability: Past and Present

While integration, according to the Webster dictionary, is about "*to unite or to make complete*", interoperability is defined as "the *ability of a system to use the parts of another system".* While integration is a goal, interoperability appears to be a means.

According to Chen et al. (2008), *interoperability* denotes "co-existence, autonomy and a federated environment", whereas *integration* refers to "coordination, coherence and uniformisation". In this sense, *Enterprise interoperability (Ei)* is concerned with "the communication between information systems, devices and applications. This is the ability of peer entities involved in a communication to exchange information on the basis of mutual understanding and to successfully use functionalities or services of the other" (Vernadat, 1996).

Interoperability can then be considered either as a capability, requirement or constraint of enterprise systems that impacts the seamless communication between (enterprise) information systems, devices and applications. It does not apply to humans (humans cooperate, collaborate or work together but cannot be said to be interoperable). Interoperability capabilities are essential to build integrated enterprise systems but interoperable enterprise systems are not necessarily integrated. In fact, enterprise interoperability equates to loosely-coupled enterprise integration as defined previously (Vernadat, 2007).

According to the European Interoperability Framework (EIF, 2011) or others (Chen et al., 2008; Kubicek et al. 2011), and as it has been done for Enterprise Integration, three layers of interoperability can be defined: (1) *Technical Interoperability,* or syntactic interoperability, at the lowest level, covering the 'plumbing' technical issues of linking systems, devices, applications and services, including aspects such as communication protocols (TCP/IP), interconnection services, specific data formats (XML or SQL), data integration and middleware (ESB), data presentation and exchange, accessibility and security services; (2) *Semantic Interoperability,* defining the 'meaning' and the use of data/messages, allowing data/messages to be received, combined and processed in one system, sent to another system by which they can be automatically recognised and further processed. The state of the art in industry is either to enrich data and messages with metadata, refer to common thesauri or managed metadata stores (like Microsoft SharePoint) or use ontological definitions of data objects or concepts to be exchanged using Common Logic (CL) representations or languages such as the Web Ontology Language (OWL), designed to represent rich and complex knowledge (W3C, 2012) in association with the Resource Description Framework (RDF) for Web data interchange (W3C, 2014); and (3) *Organisational Interoperability,* focusing on organisation and business process alignment, automated processing of sub-functions into one single inter-organisational automated workflow through the use of a common service architecture (e.g. SOA) and the previous mentioned interoperability lower layers. Organisational interoperability has been investigated in more details in the context of government organisations by Kubicek et al. (2011). A fourth layer can be added on top of the EIF to deal with *Legal Interoperability* issues when legal alignment of procedures, rules, directives, regulations or laws is necessary (EIF, 2011).

6.2 Enterprise Interoperability: Future Trends

Technical interoperability will continue to be a key technology for enabling advanced and open IT application cooperation but also Machine-to-Machine (M2M) communication in the era of the 4th Industrial Revolution. Its evolution will heavily depend on advances in ICT technologies (e.g. wireless and high broad-band networks, interconnection services, data integration and middleware, messaging formats or broker technologies, open interfaces, etc.).

Regarding *semantic interoperability,* currently most of the formal ontology development languages used are first-order logic based (description logic based languages, e.g. RDF/RDFS and OWL, and Common Logic based languages, e.g. Common Logic Interchange Format (CLIF), Knowledge Interchange Format (KIF), Knowledge Frame Language (KFL), etc.). According to Usman et al. (2013), although RDF and OWL are more widely used, common logic based languages have more expressive power and provide better inference capabilities. This is the reason why they have chosen KFL to develop their Manufacturing Reference Ontology (MRO), which paves the way on how to build key components in future interoperable (manufacturing) systems.

On top of this, paradigms such as *Pervasive* or *Ubiquitous Computing* are enabling an *Internet-of-Everything (IoE),* creating new connections between and among people, processes, data, things and even services. In this future *Internet-of-Things* (or of-Everything), interoperability will be the key for unlocking its full potential; failing to do so, will leave the IoE limited in its use for industry and society (Zdravković et al., 2014; Panetto & Molina, 2008). So, some of the standard and short-term potential solutions to enable the IoE are the use of ‘open standards’ and ‘open APIs’ (Application Program Interfaces), being the key for their openness and collective adoption. Another possibility for the long-term is to enable interoperability as a property of ubiquitous systems society (Zdravković et al., 2014). Nevertheless, achieving universal interoperable systems of systems will not come that easy, since it opens up systems to vulnerabilities, bringing challenges to cybersecurity such as identify and privacy management.

For further future perspectives on *Enterprise Integration*, please refer to Panetto et al. (2016) on “New Perspectives for the Future Interoperable Enterprise Systems”, El Kadiri et al. (2016) on “Current Trends on ICT Technologies for Enterprise Information Systems” and Agostinho et al. (2016) on “Towards a Sustainable Interoperability in Networked Enterprise Information Systems: Trends from Knowledge and Model-Driven Technology”, all papers are part of this special issue.

7. EIS and the Enterprise Networking Discipline

7.1. Enterprise Networking: Past and Present

Cooperation in *Collaborative Networked Organisations (CNOs),* or *Networked Enterprises,* goes beyond providing support for human interaction by means of *Computer Supported Cooperative Work (CSCW)* (Wilson, 1991; Grudin, 1994), coordination of business processes based on *Workflow Management Systems (WfMS)* (Chen and Hsu, 2001) and integration of data from different databases, applications and legacy systems through *Enterprise Application Integration (EIA)* approaches (Linthicum, 2000; Lee et al., 2003). The anatomy, reference models and architectures of Collaborative and Networked Organisations have been analysed by several authors (for instance, Camarinha-Matos and Afsarmanesh, 2008; Jagdev and Thoben, 2001; Molina et al., 2007).

CNOs operations require extensive and advanced functionalities for supporting different types of digital transactions and collaborative environments, via information systems and computer networks, such as people to collaborate and negotiate, systems/services to execute and adapt, knowledge and information at all levels to be exchanged and retrieved, computing and human resources to be discovered and shared and (business) processes to be interconnected and synchronised (Rabelo, 2008). In this context, current *Collaborative Business ICT Infrastructure* solutions are required to evolve from a focus on efficiency and full automation to collaboration flexibility and human intervention (participation), from monolithic, rigidity, dependence and predeterminism to composable, self-adaptability, autonomous and smart services of software deployed in several repositories and seen as utilities, and from a homogenous environment and software packages to a computing environment of *Software-as-a-Service Utilities (SAAS-U)* (e.g. software, platform, infrastructure) (Camarinha-Matos and Afsarmanesh, 2004; Rabelo, 2008).

At the present time, some architectural approaches and technologies to support *Collaborative Business Infrastructures (CBIs)* development include SOA paradigm and Web services technology (Singh and Huhns, 2005), where all functions, or services, are defined using a description language described in a machine-processable format (e.g. XML), so platform-independent, and have evocable interfaces by any client, that are called to perform business processes. Following the SOA principles, and aiming at supporting flexibility in CBIs, future collaborative ICT-infrastructures should enable a distributed open bus composed of many federated services which are accessed on-demand to support ad-hoc collaboration. SOA can then be considered a suitable approach for development of CBIs, allowing scalability, modularity, granularity, reusability, independence of platform and technology, and on-demand usability features (Rabelo, 2008). Furthermore, *SaaS-U models* are another paradigm offering access to utility solutions for cooperation such as software, platforms and infrastructures under subscription-based, remotely hosted and delivered over the Internet, without the need of complex ICT-infrastructure implementations, creating accessibility, especially for Small and Medium-sized Enterprises (SMEs), to digital ecosystems such as CNOs (Rabelo, 2008).

One example of an advanced CBI development can be found in (Rabelo et al., 2006; Rabelo and Gusmeroli, 2008; Rabelo et al., 2008), where an open, distributed, scalable, transparent and security-embedded collaborative service-oriented infrastructure was tailored to support CNOs in the modelling and execution of collaborative tasks, accessed on-demand and paid-per-use. Another advanced CBI example can be found in (Facca et al., 2009). It presents an enterprise collaboration and interoperability platform developed based on a service oriented architecture, SaaS-U paradigm and semantic technologies (e.g. Semantic Web services) to enable provisioning of services to enable enterprises to participate in CNOs by means of enterprise collaboration services (preparation, formation, collaboration management and operation services, dissolution and basic human interaction services) and information exchange through enterprise interoperability services (model-driven, enterprise modelling, business processes, semantic mediation and data interoperability service).

Furthermore, for representing some standard networking platforms nowadays being developed by ICT vendors, three types of platforms can be mentioned: (1) *Unified Communications Networking platforms*, including applications and services for instant messaging (chat), unified messaging (integrated voicemail, e-mail, SMS and fax), voice (IP telephony), rich media conferencing (audio, Web and video), collaboration tools (desktop and data sharing), collaboration clients (desktop and applications virtualisation) and many other functions; (2) *Collaborative Workspaces*, or shared workspaces, allowing asynchronous (e-mail, tasks, shared file system) and synchronous (video, voice messaging, shared whiteboards) electronic communications and groupware (calendaring, project management, online proofing, workflow systems, knowledge management systems, enterprise bookmarking, online office suite, client portals); and (3) *Enterprise Social Networking platforms*, also known as Enterprise 2.0, enabling social software systems to organise social relations of groups and content by supporting functionalities such as chat, forums, wikis, blogs, collaborative real-time editors and social bookmarking.

7.2. Enterprise Networking: Future Trends

A number of advanced ICT's have emerged in recent years to offer possible architectural solutions for CBI's (Rabelo, 2008). For example, *Pervasive* or *Ubiquitous Computing* integrates 'computation' into distributed environments and everyday objects, enabling a given client application to create its required information-processing environment under the *AAA paradigm* (Anywhere, Anytime, Anybody / Any type / Any device) (Singh et al., 2006)). *Peer-to-Peer (P2P) networks* offer the possibility to increase the computing power and bandwidth of computer networks by making their nodes work simultaneously as 'clients' and 'servers' to enhance their reliability and efficiency to publish, advertise, search, exchange and share information, applications and services (Parameswaran et al., 2001). *Grid Computing*, as an ICT infrastructure based on a P2P architecture, allows flexible, secure and coordinated resource sharing among dynamic collections of individuals, resources and organisations by means of computing resources virtualisation, facilitating resources rationalisation among entities (Foster et al., 2011). In addition, *Multi-Agent Systems* (MAS) (Ferber, 1999), as a form of distributed Artificial Intelligence (AI), offer the possibility to create collaborative systems composed of one or several intelligent computing processors or agents that interact with each other asynchronously and with autonomy, with other sources of knowledge and with other systems, to solve complex problems that are intrinsically dynamic and distributed (Acampora and Loia, 2007).

For further future perspectives on *Enterprise Networking*, please refer to Weichhart et al. (2016) on "Challenges and Current Developments for Sensing, Smart and Sustainable Enterprise Systems", El Kadiri et al. (2016) on "Current Trends on ICT Technologies for Enterprise Information Systems", Panetto et al. (2016) on "New Perspectives for the Future Interoperable Enterprise Systems", Agostinho et al. (2016) on "Towards a Sustainable Interoperability in Networked Enterprise Information Systems: Trends from Knowledge and Model-Driven Technology" and Hinkelmann et al. (2016) on "A New Paradigm for the Continuous Alignment of Business and IT: Combining Enterprise Architecture Modelling and Enterprise Ontology", all papers are part of this special issue.

8. Conclusions

A brief history of *Enterprise Information Systems (EISs)* has been developed in this state-of-the-art paper, including different discussions about their essential aspects and addressing some of their future trends further developed by the contributing authors to this special issue of the *Computers in Industry* Journal on "Future Perspectives on Next Generation Enterprise Information Systems" (see El Kadiri et al., 2016; Weichhart et al., 2016; Panetto et al., 2016; Agostinho et al., 2016; Hinkelmann et al., 2016; Bernus et al., 2016; Lapalme et al., 2016). Furthermore, the discussions addressed past and present aspects of *EIS Design and Engineering* moving towards future Hybrid Cloud-based Interoperable and Networked EISs, classic and contemporary *Enterprise Architectures* and their evolution to Service-Oriented Enterprise Architectures, *Enterprise Integration* and *Interoperability* approaches and services to support Future Internet Enterprise Systems and the Internet-of-Everything, and *Enterprise Networking* collaborative business infrastructures enabling cooperation for a diversity of collaboration forms (e.g. extended-, networked-, virtual- enterprises).

Moreover, the development of new *EISs* and *Enterprise Integration* seem to be never-ending processes, because the enterprise continues to evolve in its ever-changing environment as a result of adaptation to external forces, advances in technology, emerging business models, new legal regulations and/or optimisation of internal solutions; making what is today a fully integrated system, the partly integrated system of tomorrow. In this context, the *Enterprise Architecture discipline* will be there to assist the enterprise in the process of translating its business vision and strategy into 'enterprise change' by identifying, communicating and planning for enabling its business, information, application and technical architectures to evolve to the desired future state and achieve again the goal of business-IT alignment.

Likewise, as world-wide economies (globalisation), and in particular organisations, people, processes, data, things and services become more connected/networked (the Internet-of-Everything), *Enterprise Interoperability* and *Networking* services will need to become a 'commodity' in order to support the building of a hyper-connected world and the seizing of its opportunities for industry (e.g. Industry 4.0) and society (e.g. smart cities). For facing this challenge, nowadays 'interoperability service utilities' are being envisioned as the support for enabling systems of services to deliver basic interoperability to enterprises and other entities as well as cloud-based collaborative services for enabling cooperation among networked enterprises.

Finally, as cloud computing paradigm continues to grow, cloud-based enterprise information systems will reshape the way that enterprises acquire and use software, platforms and infrastructures for designing and engineering their *Enterprise Architectures* for interoperability and collaboration in a networked economy.

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