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An Enterprise Operating System for the Sensing, Smart, and Sustainable Enterprise

D. Chavarria-Barrientos*, D. Chen, R. Funes***, A. Molina*, F. Vernadat******

**Tecnologico de Monterrey, Escuela de Ingeniería y Ciencias, Mexico City, Mexico (e-mail: dante.chavarria@itesm.mx, armolina@itesm.mx).*
***IMS, University Bordeaux, Talence, France (e-mail: david.chen@ims-bordeaux.fr)*
**** Lovis Company, London, England (e-mail: rafael.funes@lovis.email)*
***** LGIPM, University of Lorraine, Metz, France (e-mail: vernadat30@gmail.com)*

Abstract: To be competitive in the digital era, enterprises need to become sensing to be aware of their context, smart in taking decisions, and sustainable regarding social, environmental, and economic issues. Reference models can guide the enterprise engineering process in such direction. However, the implementation of the enterprise models, generated with reference models, depends on the integration of enterprise resources, which is not always possible due to the diversity of tools and applications needed within each business process. This paper proposes an Enterprise Operating System (EOS) to effectively handle the execution of enterprise models by integrating a diversity of functionalities. The goal of an EOS is to manage the resources (i.e. humans, applications, and machines) of an enterprise to fulfil its operations. The Sensing, Smart, and Sustainable Enterprise Reference Model (S^3E-RM) is proposed to guide the implementation of the EOS. This reference model uses the viewpoints defined in the Reference Model of Open Distributed Processing (RM-ODP), i.e. enterprise, information, computation, engineering, and technology viewpoints. The EOS presented has been successfully applied in more than 27 industry sectors, including government.

Keywords: Enterprise Operating Systems, Digital Enterprise, Sensing Enterprise, Enterprise Reference Model, Enterprise Engineering, Enterprise modeling.

1. INTRODUCTION

In the digital era, thanks to advances in Information and Communication Technologies (ICTs), such as big data analytics, cloud computing, social computing, and cyber-physical systems, enterprises become part of the hyperconnected world to improve their business operations. Enterprises can become digital systems that use their sensing possibilities to be aware of their context and use knowledge to take smarter decisions that lead to sustainability. This vision of the enterprise is referred to as the S^3-Enterprise (Sensing, Smart, and Sustainable) (Weichhart et al., 2016). Although this vision promises that enterprises have the necessary capabilities to compete in the digital era, tools and methods are needed to guide the evolution of nowadays companies and the creation of new S^3- Enterprises.

Enterprise engineering is the discipline in charge of studying the methods and tools to design and maintain an integrated state of the enterprise (Kosanke et al., 1999). Within the field of enterprise engineering, enterprise models were created to capture enterprise content, structure and requirements to improve integration. The creation of particular enterprise models can be eased using reference models. The reference models provide reusable structures common to many enterprises. Reference models have been used to analyze, create, and design particular models for the S^3-Enterprise (Chavarria-Barrientos et al, 2016).

Today, enterprise models are built for the purpose of analysis, understanding, and design. The next step after enterprise modeling is to be able to execute these models to really facilitate the processes, decisions, collaborations, and interoperations occurring within the enterprise or the Collaborative Networked Organization (CNO) (Camarinha-Matos et al., 2009). For such purpose, there is a need for Enterprise Operating Systems (EOSs) that act as an interface between enterprise resources that perform business processes and enterprise managers that decide how the processes will be executed (Chen et al, 2015).

This paper presents a proposal for an Enterprise Operating System that allows the execution of enterprise models. The vision of the EOS is described in section 2. Related developments are identified. Then, an EOS is presented (section 3) as a proposal to fulfil such vision. The methodology and tools used to leverage its use are explained. Finally, the evaluation of such an EOS (section 4) and conclusions (section 5) are stated.

2. THE VISION - ENTERPRISE OPERATING SYSTEM

An EOS is a system capable of monitoring enterprise resources and operations in order to dynamically allocate resources to required activities (AMICE, 1993; Chen et al., 2015). The goal is that diverse resources connected by the EOS work as ‘one’. According to the conceptual architecture

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presented by Youssef et al. (2016), an EOS contains five major components.

- Enterprise Resource Management (ERM): dynamically monitors the status of enterprise resources. It searches and allocates suitable resources to business operations.
- Enterprise Process Management (EPM): executes and coordinates business processes defined by business managers and EOS internal processes.
- Enterprise Information Management (EIM): manages, protects and supports information and data exchange between the resources connected to the EOS.
- Presentation Management (PM): is a set of services with appropriate interfaces that allow enterprise resources (i.e. humans, applications, and machines) to connect to EOS and receive/send information.
- Interoperability Management (IM): is a set of services that provide necessary mapping between heterogeneous resources to make them interoperable through EOS.

Although the term EOS appeared in the last decade, the concepts and objectives that it implies have been developed before. The EOS concept appeared at the end of the 80's in the form of an Integrating Infrastructure (IIS), within the CIMOSA architecture (AMICE, 1993). After that, in the 90's, CEN TC310 WG1 elaborated ENV 13550 EMEIS (Enterprise Model Execution and Integration Services) to express capabilities of environment for developing executing and integrating enterprise models on an open IT-based platform (Chen and Vernadat, 2004).

Enterprise IT infrastructures have been proposed since then (e.g. OMG CORBA, OSF DCE or more recently Enterprise Service Buses) to support integration and interoperability of enterprise applications. However, they do not implement enterprise models enactment. Then, the direct model execution was proposed by E2E under the concepts of OMG MDA (Model-Driven Architecture), enterprise models are executed without transforming them to code.

Developments related to EOS include the ERP (Enterprise Resource and Planning) systems connecting MES (Manufacturing Execution Systems). An example is the open ERP ODOO (https://www.odoo.com), which implements several types of business applications, e.g. customer relationship management, finance, Web services, product lifecycle management, etc. However, an EOS must also impact processes at the strategic level of the enterprise.

Existing works cover certain requirements stated in the vision of the EOS. Each of them with different focuses. Although it was a step in the development of EOS, new studies must include more EOS characteristics. Examples of works that help in directing such developments are the framework proposed by Oztadzadeh and Rahmani (2010), which is based on the Zachman Framework, and the conceptual and technical architectures described by Youssef et al. (2016). Youssef's architecture was tested using simulation in a banking and finance environment.

Although the vision of the EOS and traditional ERP systems is similar, the philosophy and approach implemented by each of them are different. ERP application is hardly interoperable with a software application coming from a different vendor; while EOS aims at supporting interoperability of heterogenous applications. Furthermore, ERP is usually rigid and expensive; while EOS is flexible by allowing the implementation of applications in an incremental manner. Finally, the inclusion of EOS aims at developing a business ecosystem to provide a variety of enterprise applications just like what happened with IOS and Android in smartphone domain.

3. LOVIS ENTERPRISE OPERATING SYSTEM

LOVIS (http://lovis.company/) is a company that helps its customers improve their business value by aligning the business processes to the strategy and supporting them with cloud-based business technology. One of the products offered is an Enterprise Operating System, LOVIS EOS, that aims at substituting the traditional ERP systems.

After listening carefully to its clients, the LOVIS company identified eight characteristics as the requirements that make an EOS unique among other enterprise applications (i.e. classical ERP solutions):

- Reflect reality. Nowadays, many enterprises adjust the inputs to their enterprise applications to match system requirements. As a consequence, data capture becomes complex and the data analytics made is biased. In contrast, an EOS must be designed to capture the reality of the enterprise.
- Universal enterprise software. An EOS software must be the same for all countries and industries but configurable to special needs. Thereafter, the communication among different supply chains is made easier, allowing the creation of CNOs.
- Ready to use, configurable, and scalable. Current enterprise applications need specific code development each time a client requires to expand, modify, or include a functionality during the implementation. An EOS is ready to operate from the first day and it adapts to the enterprise logic without programming.
- Non-stop natural workflow. To provide reports or synchronize processes, some enterprise applications need to be stopped, causing reworks and delays in business operations. An EOS must be designed for non-stop operation so that business processes, such as accounting, can be derived at any time and immediately.
- Online & Real-time Transactional Operation. To get valid and up-to-date information at any time, each transaction must be made into the application by the person that is in charge of it and in the moment that it happens. So, the information that reflects this transaction enters the database naturally, it is validated and its effects are applied upon all related transactions.