Effective Service Dynamic Packages for Ubiquitous Manufacturing System

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Abstract. This paper proposes a new integrated architecture for advanced manufacturing management with a Ubiquitous Management System (UMS) and a collection of adequate features to sustain it, where pragmatics on collaboration mechanisms prevails. The Market-of-Resources repository and its advanced brokering process will enable reliable interoperability, services dynamic packages and reconfiguration, as well as the (co-) management of production process, regardless information systems and using real-time collaboration mechanisms. This article contributes for building a logical model for UMS as well as an UML formalization for its supporting architecture

Keywords: ubiquitous manufacturing systems, pragmatics, dynamic packages, interoperability, integration, effectiveness.

1. Introduction

Some very recent statements by people with high level responsibilities in the world demark the real and actual sensibility for future industrial requirements. Several points of views see the solution mainly based on getting more production capacity, using more resources, better efficiency, etc. However some others defend that the problem is not related only with deficient capacity but more with the incapacity to quickly adapt and react to, and we would say to act in the environment of, continuous market dynamic changes. In the future scenario of manufacturing the relation between customers, suppliers and companies will be transformed on virtual dependencies and ubiquitous services. Maybe arises new stakeholders and new rules for the game. The needed resources will be managed by another resources and the supplier of some material behaves as customer from another in a transparent way. One doesn't have space but has production. One doesn't have production but offers services to it.

A new completely dynamic profile! The easiest way one adapts, we would say acts, the better he succeeds.

This announced dynamics requires not only agile and efficient management processes, but information systems high interoperability, reconfigurable networks of production units (cells, plants, companies, etc.) and efficient and effective integrated collaborative tools to support the human participation on the process under an unpredictable business environment. Although the actual information systems follow initial specifications, those specifications are not aligned with human needs but business requirements, instead.

So the scope of this paper is to present a model for Effective Service Dynamic Packages (ESDP) applied to Ubiquitous Manufacturing Systems (UMS) and a set of new features to sustain it. The way the human-to-human interact through the system is improved with pragmatics support and an advanced resources brokering mechanisms is implemented on top of a Market-of-Resources, as meta-organization environment, allowing their dynamic and quick reconfigurations.

This paper continues as follows. Related research work is reviewed in Section 2. In Section 3 we outline the Effective Service Dynamic Packages proposal, exposing its organizational, logical and technical models. The supporting architecture is explored in Section 4 and finally, Section 5 presents future developments and concludes the paper.

2. Related research work

Manufacturing systems and processes have been subject for several scientific research and publications, mainly concerned with: a) production processes and stakeholders relation; b) support systems and c) workers and underlying behavior, ethical, social and organizational questions. All of them aiming the optimization (less costs) and improvement (more gains) of the manufacturing offer.

Since there is an emergent infrastructure (cloud) where each member (machine, process, user, etc.) is able to find and to get what he needs, where no one knows precisely his precedent or dependent, it seems clear that the next generation of Manufacturing information systems infrastructure will have to support more than flexibility/agility and integration. It must support collaboration services (Jaatun, Zhao, Rong, & Zhang, 2009) and, we say, ubiquitous (computation too) services. To sustain this point of view, follows relevant work references in the area.

Dynamic Packages

The Dynamic Packages (or Dynamic Packaging) concept is not really new. It was (indirectly) explored on communication protocols of computer network OSI model, where the DTP - Dynamic Packet Transport protocol proposed an optimized transport protocol suitable to improve the use of the bandwidth, packets transmission, etc. (CISCO, 2000). This efficiency improvement might have inspired developers and architects to adapt the same concept to business (software and process) area.

Although explored in several business areas (Cardoso & Lange, 2007), the essence of the concept represents nothing but searching mechanisms, an information system oriented perspective, which allows services to be dynamically selected. Ferreira, Putnik, Cunha, & Putnik (2011) already explored the concept and proposed its enrichment with collaborative functionalities. According to them, the resources (for services) can be dynamically discovered and purposed, but there must be possible the human (user) participation (interaction) on the final decision. A similar perception can be applied to manufacturing business.

But we must not confuse dynamic packaging with Dynamic Manufacture and Packaging, where predetermined proportions of some components are dynamically mixed in order to obtain a final product and then packaged to deliver to the customer. Also, we must not confuse it with Dynamic Manufacturing Environment where the control of the incoming materials, the manufacturing process control and the customer satisfaction are correlated trough the use of Quality Function Deployment (QFD) techniques and Knowledge Based Expert Systems (KBS) (Pearsall & Raines, 1994).

Considering this and seeing that manufacturing is evolving toward digitalization, we fill that future manufacturing, ever more information and knowledge oriented (Lan, Ding, Hong, Huang, & Lu, 2004), will needs to quickly reconfigure the production processes (schedules, machines availability and capacity, supply of material, human resources, etc.) since the agile, dynamic, integrated and distributed (virtual) network of companies, to which it will belong, regulated by a global and dynamic business model, will require it. In this situation the Dynamic Packages behavior needs to offer not only a set of possible resources or services (discovered by advanced brokering engines) but also to assure the contract between them towards the deadlines of products delivery.

Ubiquity, Open, Virtual and Cloud

Ubiquity	Virtual Enterprise	Open Manufacturing
Virtual Ubiquity	Open source	Virtual Organization
Virtual Hardware	Open Access	Virtual Capacity
Virtual Computing	Virtual	Virtual Development

We are convinced that there still exist some misplaced interpretations of emergent concepts of ubiquity, virtual and open. This misplacement becomes stronger with cloud computing architecture and related paradigms. Paraphrasing Dave Malcolm (2009), the interest in cloud computing is rampant across the entire IT industry and everyone has a different perspective and understanding of the technology.

Dynamic computing infrastructures, IT service-centric approach and self-service based usage model, are some of the announced supporting features of the cloud which makes clear that its main goal is to increase the capacity or add capabilities on the fly, without investing in new infrastructure or new software (Miller, 2008).

Running away from hardware virtualization, the services oriented architecture (SOA) and their web services brings virtual services (does not matter who and how are executed) and virtual development (Coppinger, 2007) at the top of "clichés" which need to be always available (ubiquitous) and able to be used according to their specifications (opened). Therefore manufacturing as a traditional evolving business activity must be integrated on this "infrastructure" just to take advantage of its potential.

The Open Manufacturing initiative (Christodoulou, 2011) already appeared to care these misplacements. It intends to reduce possible barriers to manufacturing innovation, focusing on procurement contract, grant, cooperative agreement, or other transaction supports. Again, we must not confuse the previous with the Open Access or Open (manufacturing) Source software which generally means no barriers to use and transform.

The Virtual Organizations are considered to be a mechanism to achieve significative returns increasing based on firms networks effects. The firms' network effects are directly related with network structure level and network technology level.

Considering the ubiquity and agreeing with Ferreira et al. (2010), the e-Business models forced enterprises to undertake important steps to their reorganization, both inside and outside the company. If the initial factor for this adaptation was the web, now it happens again with the Cloud (towards u-Business, the ubiquitous business). Cloud means no rigid structure and continuous reconfiguration. However, it is very difficult to archive real and useful collaboration between several (unknown) stakeholders, where the initial planning conditions can be changed, any time and for any reason.

So, Ubiquitous Manufacturing System (UMS) is represented, actually, as two qualitatively different paradigms. The first paradigm of UMS employs the ubiquitous computational systems to improve efficiency of the existing (organizationally "traditional") manufacturing systems, while the second paradigm implements UMS architecture and organization as a mapping of the concept of ubiquitous computational systems, not necessarily employing the ubiquitous computational systems in order to improve, not only the efficiency but, the effectiveness of the manufacturing system (G. Putnik, 2010).

We already see Virtual Ubiquity, but fortunately (or not) only for commercial companies' names.

Supporting Technologies

In ICT perspective we are facing a new era of architectures and paradigms. In nowadays services (web) are seen as the basic and main processing unity, as happened before with functions, modules, objects, components, etc. Services, inherent to Services Oriented Architecture (SOA), appeared to respond to portability (based on standards), processing autonomy (signatures), availability (discovered with UDDI) and interoperability (XML) properties of the new architecture systems.

Although offering new opportunities, web services demand new requirements as well. Since built in technology standards, they reduce significantly the required middleware for interoperability between heterogeneous systems. In business perspective, web services improved interaction inside the company as well as between others companies, their customers and suppliers. Paraphrasing Ari Bixhorn, from Microsoft[1], "The result is less information-technology complexity and significant cost savings".

Moving the same reasoning to manufacturing, manufactures can now easily communicate with all stakeholders, enabling better customer support and faster time-to-market alignment. In summary, better product collaboration and consequent cost reduction.

Since SOA and web services enabled loose coupling as well as reusability and orchestration or governance architectures and services, they sustain their dynamic behavior and consequent response. The relation between partners is no more rigid point-to-point but, arbitrary, with several available services providers and consumers. Paraphrasing now Miko Matsumura[2], web services "is a way to map the capabilities of the network to the parameters of the request", given clearly focus to results and ignoring delivery details. So any common "No" result must be replaced by suggestions of alternatives.

[1] Ari Bixhorn is the Director of Web Services Strategy for Microsoft Corp.

[2] http://www.infravio.com

As consequence of the webization of applications and process and the generalization of services implementation it is need now to orchestrate their utilization and establish their quality, even known that their supporting technology assures their interoperability and composition. It is necessary to find the answer to the question “how to compare services?”.

To describe such properties we need to back again to ontologies and their capacity to semantic support. Thus it is possible to enrich services specification with more meta information, where semantic can be included. Web Services Modeling Ontologies (Bruijn, Fensel, & Keller, 2005) and Semantic Annotation for WSDL and XML Schema (Kopecký, 2007) are some efforts on that. “…by having a BOM Web service, any application on the manufacturing floor that is loosely coupled with the service has only to go to the Web service, rather than the BOM program installed at each application…” (Ahmed Mahmoud, Dell Vice President of ITGM- Information-Technology Global-Manufacturing)

The context now has several services, several enterprises and naturally several distinct architectures, so the need to integrate them is evident. Having this, an architecture which allows the interoperability between any application (or service) from any architecture model is a very intended purpose and critical goal which SOA tried to overcome. But to get that, web services need to be enhanced (T. Erl, 2007) and due to the dynamic behavior of this architectures (services availability and competence change easily) the overall architecture must react (to events) and behaves as an Event Driven Architecture (EDA), or better, as a Context-Aware Architecture (CAA), as suggested for ontologies (Kopecký, 2007), never ignoring that events are not all predictable (Hoof, 2006).

In this manufacturing system proposal we will need also to classify services and resources, since they must be cataloged in Market-of-Resources for posterior analyses under brokering and dynamic reconfiguration processes.

Lana (2004) already proposed a web manufacturing system to rapid product development based on rapid prototyping. However, since it is essentially a system oriented perspective, the collaborative features don’t allow real-time participation and the dynamic reconfiguration is not specified as requirement. Sua (2005) proposed a Virtual Fab with a flexible and dynamic manufacturing service for virtual environment characterized by separation, transparency, simulation, and customization which does not represent our model of virtual enterprises. (Mostafaeipour & Roy, 2011) explored e-Manufacturing with an Intelligent Management System, an integration proposal for existing manufacturing supporting software (CRM, ERP, SCM), being the middleware supported by web-based techniques, as is the case of the “intelligence” which is supported by agents. Focused on system autonomy, the dynamic reconfiguration and user participation on final decision are not specified.

On emergent corporate networks of Enterprise 2.0 (Newman & Thomas, 2009), a new buzz phrase promoting collaboration technologies (social networks, blogs, wikis and mashups) and software as a service (SaaS), the human represents the critical part on discussions, analyses and decisions. Thereby, tools for their communication and direct collaboration are critical requirements on new Multimodal and Rich Internet Applications and mobile devices are the main targets platforms for system architects and system developers. Information dissemination and disparate information consolidation have now real new tools.

Brokering and Market-of-Resources

Brokering is, by literature, a process executed by a broker who, in essence, means an act an agent does for other. However we intend to move its meaning to search and management area. According to (G. Putnik, 2001) a brokering process in manufacturing is much more than a search engine or information retrieval process. It is responsible for resources (cells, machines, persons, materials, etc.) selection, resources integration and scheduling, resource (dynamic) reconfiguration, resource monitoring, control and reliability analysis.

Considering this, the brokering will need high capacity to discover (search) resources as well high capacity and agility (dynamic behavior) to react to environment (Market-of-Resources) changes.

The main scientific contributions for brokering are focused on knowledge discovery. Accuracy and efficiency are well explored with agents, web services and matching algorithms technologies. Paraphrasing (Ferreira & Putnik, 2008), the "possibility to get useful information depends on the capacity to retrieve, search and interpret it". Selecting and ranking several results using collaborative-filtering (Silvia & Amandi, 2009); knowledge-based inference (Middleton, Shabolt, & De Roure, 2004); case-based reasoning and multi-criteria decision making of (Alptekin & Büyüközkan, 2011); data-mining over relational databases (Chaudhuri & Dayal, 1997); integrating data using patterns and markup languages (Hohpe & Woolf, 2004); adapting context-based multimodal adaptive systems (Höpken, Scheuringer, Linke, & Fuchs, 2008); etc. are all relevant initiatives. However, they only can "infer" new information from existing data, being the human perspective (information) impossible to get in this way.

The Market-of-Resources is a meta-organizational environment. It is an independent organizational entity (company) in the meta-organizational relationship with other independent organizational entities (companies), which form networked and virtual organizations, with the function of enabling their dynamic reconfigurations, through radical reduction of reconfiguration transaction costs and knowledge and intellectual protection (trust included) (G. D. Putnik & Cunha, 2005).

Communication, Collaboration and Pragmatics

Whenever two entities (systems, persons, applications, etc.) need to communicate there must be present the triad: transmitter, receiver and a channel to transmit the message. To collaborate they need the same communication model as well as mechanisms (tools) to work together. As Weaver (1949) sustained, after the confidence, the syntax for technical (accuracy), the semantics (meaning) for precision and the pragmatics (use) for effectiveness of the language (Morris, 1938), are the main critical factors for communication success. The same happens with the new collaboration tools.

But future communication tools (web, mobiles devices, etc.) and adhering information society show clearly that persons are rather easygoing, better related and share easily their point of view on decisions. However, this kind of relations needs to follow the functional specifications of actual software applications. Although the applications were developed to facilitate the human job and reduce his dependency, they cannot be fully functional to him, since the human behavior is very unpredictable. It can be easier to interact with someone but it is almost impossible to transmit a personal context interpretation, if one needs so.

Considering this, the emergent social collaboration tools are suitable to be integrated or adapted on future information systems. Since we consider critical to support direct human participation, pragmatic features will allow more collaboration and human interest alignment.

The fundamental, qualitative, differences between the pragmatics, semantics and syntactic, are virtually the best described by Carnap (1942), based on their degree of abstractness in relation to complete signs and semiosis:

"If in an investigation explicit reference is made to the speaker, or, to put it in more general terms, to the user of language, then we assign it to the field of pragmatics. . . If we abstract from the user of the language and analyze only the expressions and their designate, we are in the field of semantics. And if, finally, we abstract from the designate also and analyze only the relations between the expressions, we are in (logical) syntax." (Carnap, 1942, p. 9)(cited in (Recanati, 2004)).

So, the attempt to instruct new information systems with pragmatics in communication, will sustain their alignment with real customer's needs. The Pragmatic Web was the first technological tentative to instruct pragmatic aspects to existent syntactic and semantic web. However was not but some more meta-information to describe the meaning of the existent contents.

Different others experimental initiatives proposed collaboration mechanisms under semiotic frameworks but all of them tried, in a nutshell, to integrate existing technologies to get more advanced features and facilitate the human integration (use) in the system.

An ubiquitous system needs, besides the technological ubiquity support, a mechanisms to assure the customer's satisfaction, that is the system interoperability on the communicational level too. In complex and unpredictable scenarios, the user and the system need to be aligned and cooperate (collaborate) towards effective solutions.

If ones think that the main problem is a technical question, we think that two others dimensions need to be considered: a) the *linguistic* (Fromkin, 2000) used on the communication and b) the *human behavior* during the process. Thereby some more than technical arguments sustains the deficient alignment between Information systems, business and their user (human). Agreeing with (Ferreira et al., 2011) the human agency represents the strongest argument to depart systems from human satisfaction, since the systems do not support them.

For instance, the user does not always succeed his transmitted message and inversely, a transmitted message does not always mean communication. One cannot always interpret the intended meaning of the message transmitted. The ability to understand another speaker's intended meaning is called *pragmatic competence* (e.g. see (Mey, 1993)). So, having the capacity to communicate cannot be enough.

In another perspective, what happens if the context changes or the user move its interest to different results? The communication may had been perfect and well interpreted but now the intended results changed. This is common to human behavior.

In these and others situations, the system must give alternatives or allows interaction with the user. The system will (surely) need more information and the user will (surely) need different results. The effective manufacturing systems will work around this paradigm. All participating systems must be interoperable enough to allow agility and competence and work far away enough from the mechanical idiosyncrasy of common information systems.

3. Effective Service Dynamic Packages

This section presents the Effective Service Dynamic Packages (ESDP), an architecture proposal to handle effective service dynamic packages for Ubiquitous Manufacturing Systems, under Virtual Enterprise Organization model with high reconfiguration dynamics. It mainly supports: a) ubiquity, b) real-time collaboration for human-to-human interaction and c) dynamic reconfiguration.

ESDP Organizational Model

The traditional manufacturing process is not prepared to be supported by a Ubiquitous Manufacturing System (UMS), where the dynamic reconfiguration of processes and resources is required. Moreover, this new system to be effective must deal with dynamic and loosely coupled services, enabling enterprises with the sufficient agility to act quickly to effectively interact with dynamic environment.

This new "organization" will have traditional customers, providers and managers, but all of them advanced users, supported by specific information systems. There systems will be completely integrated with UMS and the *broker* and *Market-of-Resources*, the new stakeholders in the process, which will care of enabling the interoperability and resources ubiquity (anytime and anywhere availability) (Figure 1).

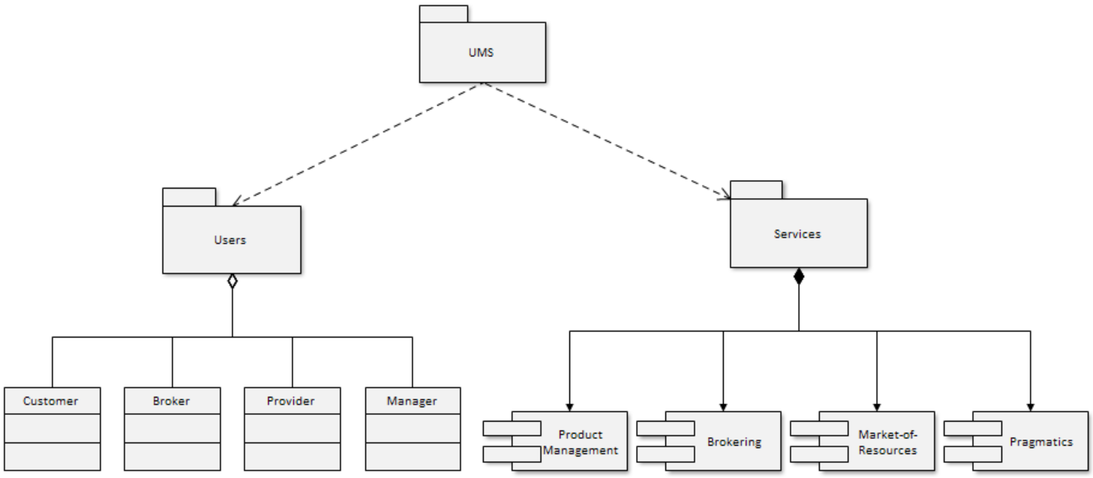

Figure 1 – UML ESDP Organizational Model

As we saw previously, the Open Manufacturing initiative (Christodoulou, 2011) tried to deal with manufacturing innovation obstacles. However, the ESDP goes a step further since it tries to be opened on usability, available on ubiquity and reconfigurable on dynamics. Effectiveness, indeed!

So the UMS effectiveness derives from the association of several interoperable services or components. The advantage for traditional Management Manufacturing Systems comes from the dynamic and advanced Brokering service; from the innovated repository Market-of-Resources, where any type of resource need to be registered and to register; and Pragmatics which responds for human-to-human interaction support.

Conceptually, this proposal represents further developments than other initiatives for manufacturing management. This model promotes a set of services and suitable technological features which allow their real-time governance, composition, selection, taking in consideration the user perspective.

Logical Model

Following the organizational model, the ESDP architecture comprises the following logical components: a) Product Management (PM), b) Brokering Engine (BE), c) Market-of-Resources (MoR) and d) Pragmatic Engine (PE). Figure 2 represents its UML architecture logical model.

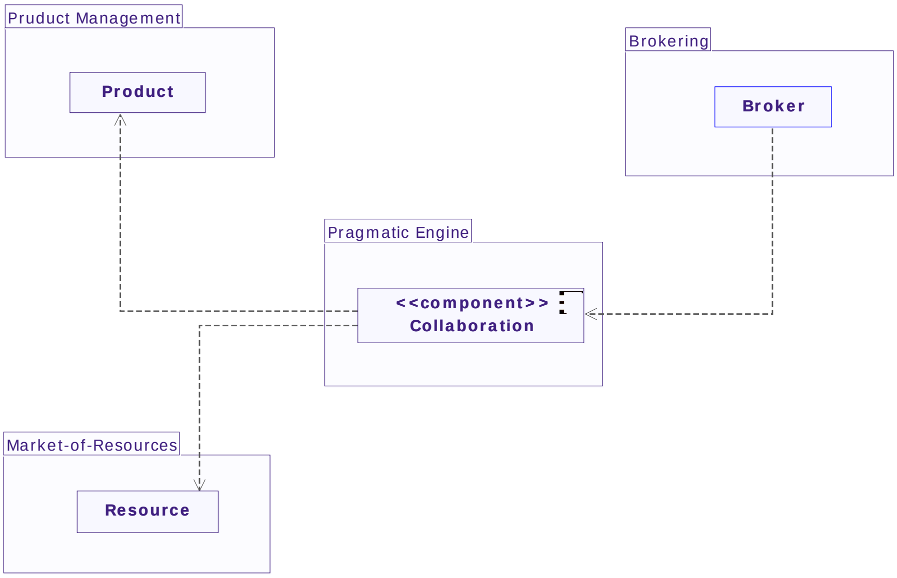

Figure 2 - UML Architecture Logical Model

The Product Management (PM) logical component acts as a traditional manufacturing management system, supporting the complete product life cycle. On the other hand, the Brokering Engine is the logical component responsible for the resources (services) dynamic selection and orchestration, that “best fit” product development requirements or expectations. It is responsible for reconfiguration management, assuring the permanent alignment among the Virtual Enterprise and the product development, as well. These resources are registered on the Market-of-Resources logical component which behaves as a repository to store, to catalogue (classify, qualify, ranking, etc.) and to regulate all kind of resources (cells, materials, plants, etc.). The human-to-human synchronous collaboration (video, audio, etc. and related auxiliary tools) which allows the natural involvement of the user on the co-creation/co-design (co-management) processes with other agents (humans) is the responsibility of the Pragmatic Engine logical component.

4. ESDP Architecture

The ESDP global architecture (Figure 3) will be structured according to N-Tier pattern and functionally according to SOA/ESB and EDA patterns (Thomas Erl, 2009; Team, 2010), having multiple loosely coupling layers interacting and cooperating towards the system requirements satisfaction. The first tier – *Presentation* – prepares the results to be presented in the applications and supports *Collaboration* and *Pragmatics* mechanisms (co-creation). Almost all brokering process, its rules, algorithms and methods as well as the global system rules (profiles, authentication, security, etc.), will be implemented on the second tier of the architecture – *Business*, with a static collection of business services and a dynamic set of rules and process. SOA prevails on this level. All necessary interaction with the Market-of-Resources (resources repository) will be supported by the third tier – *Resources* – as well as any general databases interactions.

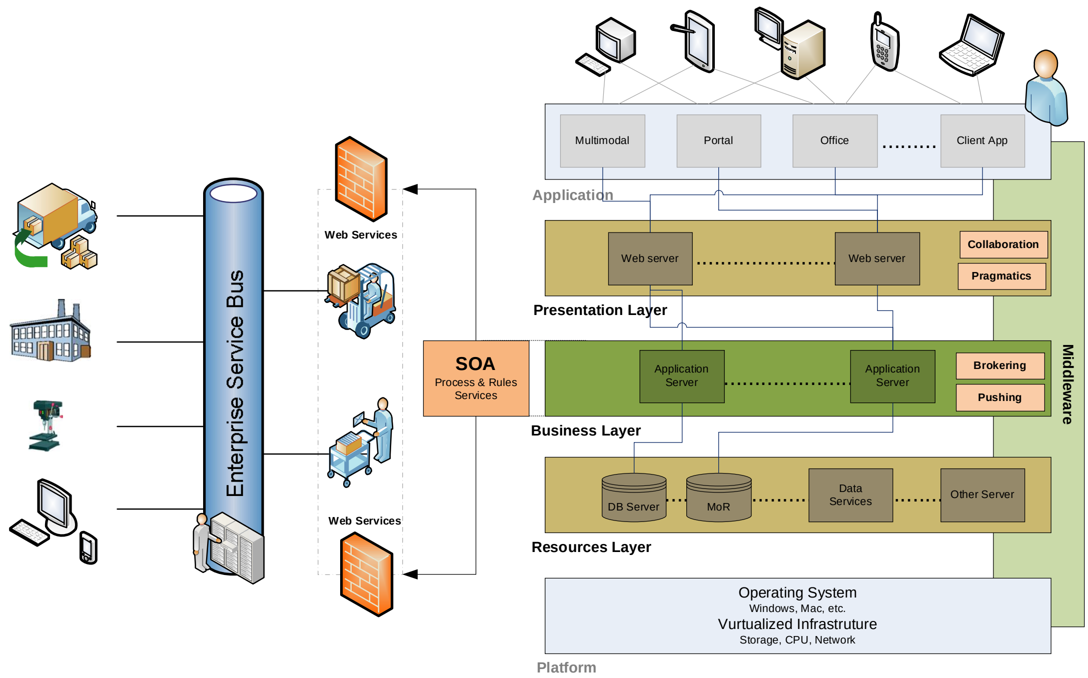

Figure 3 - ESDP Global Architecture

Technologically this architecture must support real-time collaboration (conversation) as well as asynchronous processing and information systems interoperability, enhancing the human interaction process which “behaves naturally” in the decision making on the resources (service) brokerage processes. This allows user to construct his proper resources planning considering his perception and contextual interpretation.

As previously described, the architecture will be layered, will support events (event-driven to assure reconfiguration and agility), and assure interoperability with services discovery and composition (service-oriented) following the Enterprise-Service-Bus pattern.

For brokering process there must be Web Processing Services (OCG, 2011) intervention, collaborating on dynamic resources selection from the Market-of-Resources.

Functionally, the architecture will be mainly supported by technological standards.

5. Conclusions and Future Research

The continuous emergence of new technologies and globalization of business activities requires continuous transformations on production processes and capacities towards efficiency and effectiveness.

From recent statements, the advanced manufacturing is a serious concern of world leaderships and several strategies are taking towards that. As they say, the technology needs to be more efficient but the processes need to change to get advantages of it. The proposed architecture in this paper responds well to these guidelines.

A new integrated architecture for advanced manufacturing management with a ubiquitous management system is proposed, and a set of new features to sustain it is established. An improved way to interact with the system on human-to-human pragmatic behavior is enabled and an advanced brokering mechanism to select and manage resources of Market-of-Resources is designed.

The architecture follows the SOA and ESB patterns, assuring the required interoperability and reconfiguration. The loosely coupled web services avoid the technological dependency and so, portability and expansibility of the system will be granted.

Further research will be focused on human interaction and the new collaborative tools inherent to the new enterprise and business model and on validation of the proposed model in the networked laboratorial and industrial environments.

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