Abstract—This paper aims to present the Cloud-Marketplaces approach that delivers a new paradigm to e-marketplaces. The proposed Cloud-Marketplaces architecture is a combination of the Cloud Computing paradigm and Service-Oriented Architecture (SOA), and decouples the traditional e-marketplaces into E-marketplaces and Community Services Clouds. The new e-marketplace architecture is being experimented in a real business scenario, and the case study of Vortalway, an industrial-based research project conducted by a major international e-Marketplace, is presented with the description of three pilots. The paper concludes that despite the Cloud-Marketplaces paradigm is technically a sound concept, besides the engineering and technological issues, it poses interesting challenges regarding business models.

I. INTRODUCTION

It is acknowledged that existing e-commerce platforms do not provide an adequate foundation for Business to Business applications [9]. Hence, their architecture, business processes, interoperability and the integration to back-end systems is usually very poor if done at all. Lack of interoperability between e-marketplaces, is also making cross-platform information flows and commercial transactions impossible [5][6][10]. This paper proposes a conceptual approach for overcoming some of the shortcomings of earlier researchers’ and practitioners’ approaches. In the advent of new computing paradigms like Service-Oriented Architecture and Cloud Computing, the challenge of this research work is, Can Cloud Computing paradigm sustain a new way to develop e-marketplaces platforms and their businesses, particularly as some of their services are sometimes offered as Software as a Service (SaaS)? This paper presents current research on the concept of the Cloud-Marketplaces, aiming to deliver a new paradigm to e-marketplace vendors. The Cloud-Marketplaces architecture is proposed and a description of the application on scenarios experimented in real business scenario, in the case study of Vortalway, is presented. Section 2 reviews the current state of play of e-marketplaces and their main challenges in Cloud Computing and SOA paradigms. Section 3 lays out the Cloud-Marketplace concept for the development of new transactional and collaborative e-marketplaces, based on SOA, and Cloud Computing. Section 4 presents the Vortalway case study, describing three pilots which aim to contribute to the validation and implementation of the conceptual model. Finally, Section 5 concludes, with some words on the relevance and applicability of the Cloud-marketplace approach and the challenges to its development.

II. STATE OF PLAY FOR E-MARKETPLACES

An e-marketplace is a virtual space in an electronic network, an inter-organizational information system that allows the participating buyers and sellers to exchange information about prices, product offerings, and an Internet-based electronic commerce platform that matches multiple buyers and suppliers in transactions along with traditional project-based collaborative functions [1].

Despite the widespread use of e-marketplaces with transactional and collaborative functions, there is today a plethora of electronic formats, product descriptions, and classification schemes, seeking to provide guidelines for the exchange of data between transacting agents, and regarding e-procurement especially, the challenge of having electronic catalogs (e-Catalogs) among buyers and suppliers [8]. Apart from the need for standardizing processes and messages for conducting business electronically, the adoption of additional standards is necessary for unifying the manner in which products and services are described in projects in a digital format. Besides the e-Catalogs issues, e-procurement presents several additional technical challenges that create interoperability concerns regarding electronic marketplaces at the European and global scales, and that are being addressed by several R&D and industry initiatives. For example, European public tendering procedures require that companies submit certificates and attestations to prove that they comply with selection and exclusion criteria. Electronic business certificates that are interoperable are thus one of the major challenges [3]. Electronic signatures interoperability is also an important issue, despite the availability of technical standards, such as X.509v3 for electronic certificates. However, even though electronic signatures are relatively widespread today, in practice certification authorities do not recognize each other in every case, thus creating identification hurdles. Other less challenging issues are ordering and e-invoicing, as the ongoing standardization work in CEN/ISSS WS/BII [3] is becoming mature, and these business documents are now standardized and XML-based (at least for system to system communication).

E-marketplaces architectures have been embracing new technological developments like the emergence of Service-Oriented Architectures (SOA) [10]. The World Wide Web Consortium (W3C) refers to the SOA as “a set of components which can be invoked, and whose interface descriptions can be published and discovered” [16]. Also, and according to Microsoft, the goal for SOA is a worldwide mesh of collaborating services that are published and available for
services architecture from merely the technology perspective, but also proposes a normalized Service Oriented Environment (SOE) offering services’ description, registration, publication, and search functionalities. Placing emphasis on interoperability, SOA combines the capacity to invoke remote objects and functions, i.e., the services, with standardized mechanisms for dynamic and universal service discovery and execution.

Today, the use of W3C’s web services is expanding rapidly as the need for application-to-application communication and interoperability grows. Web services are implemented in XML (eXtended Markup Language). The network services are described using the WSDL (Web Services Description Language), and the SOAP (Simple Object Access Protocol) is the communication protocol adopted. The registration of the services is in the UDDI registry (Universal Description, Discovery, and Integration). The Web Services Interoperability Organization, WS-I, is an organization supporting Web services interoperability across platforms, operating systems, and programming languages, and that has been developing efforts for the convergence and support of generic protocols for the interoperable exchange of messages between Web services [19].

Less clear has been how Cloud Computing can impact on e-marketplaces. Cloud Computing involves a set of key technologies to address resource sharing based on business requirements. Cloud Computing can be seen as an evolution over the traditional hosting and application service providers, though more aligned with the service-oriented environments, and less with client-server architectures [15] [18]. Cloud Computing follows two key enabling technologies that play very important roles in this revolutionary phase: Virtualization Technology and SOA. The virtualization technology handles how images of the operating systems, middleware, and applications are pro-created and allocated to the right physical machines or a slice of a server stack. The SOA is used for addressing componentization, reusability, extensibility, and flexibility.

Within the Cloud-Computing paradigm, there are some variations on what service is included. The most common reference is the Cloud Software as a Service (SaaS), which is the capability to use the provider’s applications running on a cloud infrastructure [15]. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email, Google Docs, etc.). There is no management of the underlying cloud infrastructure (network, servers, operating systems, storage, or even individual application capabilities), with the possible exception of limited user-specific application configuration settings.

III. EVOLUTION TO CLOUD-MARKETPLACES

The basic assumption of the Cloud-marketplaces is that integrating all platforms into a single e-procurement ecosystem will provide added value to the final user i.e. suppliers will have wider access to opportunities without having to look up into all the possible platforms and buyers will have more options to choose from. At the same time it’s usually the case that various platforms provide specialized services, which are the added values for its users. Hence, it will be interesting for platform providers to share such specialized services to other platforms for the mutual benefit of the users of both platforms will increase the added values of all the collaborating platforms.

The proposed evolution to e-marketplaces is here designated as Cloud-Marketplaces, which is a combination of the Cloud Computing paradigm and Service-Oriented Architecture (SOA), and decouples the traditional e-marketplaces into E-marketplaces and Community Services Clouds (Figure 1). E-marketplaces define the working environment in which buyers, sellers, and economic agents can transact and collaborate. Therefore, the e-marketplace will be where users configure and interact their procurement, transactional, and collaborative business environments and platform functions. From the e-marketplace service provider perspective, each client, remotely and through the Internet, can have as many e-marketplaces as they need, and each client or each economic agent is likely to have its own e-marketplace.

Since there is a need for disparate working environments for the procurement, transactional, and collaborative processes, according to companies’ requirements, markets, or projects, the approach is to “virtualize” the e-marketplace [14].

The Community Services Cloud manages the back-end of the services made available on the E-Marketplaces. It sets the rules, profiling, authentication, security, generic and specific functionality, in a federated environment managed in a service-oriented basis. It also shall be responsible to guarantee interoperability between the various E-Marketplaces, being a connecting hub, along with sustaining interoperability with external e-marketplaces [12]. The envisaged architecture is also conceived to support integration with other cloud-based applications, which can occur in two different approaches [17].

Firstly, on a Service Consumer approach, part (or all) of the applications of the E-marketplace are provided in an embedded way to other cloud-based applications and systems (e.g. other e-commerce applications). In this approach, the platform can also incorporate in an embedded way other cloud-based applications from other software vendors or suppliers. Secondly, on a Service Provider approach, with clients having the ability to design customer specific services, which are not on the scope of the services provided by the E-marketplace. An important concept in the envisaged Cloud-Marketplace platform is how communication flows occur between the Community Services Cloud and the E-marketplaces.

One of the biggest challenges is to address interoperability concerns regarding electronic marketplaces at the European
Figure 1 – Vision of a Cloud-marketplace Ecosystem

and global scales, without forcing the platform providers to adopt any single standard, but to work in collaboration with least possible changes/efforts in their existing platforms. Procurement is a complex system, comprising of various phases with huge amount of data exchange in each processes, and thus understanding various standards for business process modeling, data messages, transactions etc. is a major challenge.

IV. THE VORTALWAY CASE STUDY

One of the first Cloud-Marketplace available in the market has been developed and implemented by Vortalway, an industrial pilot project that has been conducted by Vortal, a Portuguese leading e-marketplace company and third largest e-marketplace in Europe. Vortal has currently over 25,000 companies connected to its platform, covering the markets of Public eTendering, Construction, Health, Energy & Utilities, Industry and Office & Supplies, mainly in Portugal, but entering now in Spain and UK geographical markets. In 2010, 3.7 billion Euros worth of transactions were carried out on its platforms.

The Vortalway system can act as both a service provider and a consumer. As provider, it exposes a number of atomic or aggregated services that can be used by other service consumers and applications. As a consumer it can incorporate services exposed by external providers into its own applications or use them to make other composite services. To manage the services deployment and interactions, a logical component of the Vortalway’s baseline architecture, called Vortalway Service Platform (VSP), is used as a central point of mediation between the platform’s consumers and providers, providing an interoperable and manageable service consumption environment. VSP is important to achieve interoperability between providers and consumers since it will be responsible for data adaptation and protocol transformation as necessary. At the same time, it will provide a centrally manageable environment in order to ensure that the QoS is maintained as per the agreement between the various parties.

The overall operation scenario of Vortalway involves a number of clouds. Vortalway itself consists of a private cloud and a public cloud, and the overall platform has the ability to interact with independent third-party clouds, which in aggregate can be designated as a Cloud-Marketplace Ecosystem. Each cloud makes use of standard service consumption gateways and service provider interfaces for consuming and providing service, respectively. The standard interfaces are the points through which cloud service consumers access and monitor their contracted services. The interface covers Service Level Agreements (SLA) negotiation, service access, service monitoring, and billing. This interface is also the interface through which a cloud service developer interacts with a cloud service provider to create a service template that is added to the service catalog. In the case of Vortalway the service interface is a Web Service. Vortalway basically handles the case of SaaS, which is easily achieved by using the standard interfaces explained above. Note that Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) can also be handled similarly by adding more connection points. For instance, if IaaS is to be implemented, then add the connection points at the data layer and expose the accessible interface as web service.
In Figure 2 we provide a scenario of solution showing how a new platform can be integrated in the overall procurement platform. All VortalWay services are deployed as web services for ubiquitous access by any platform. In Figure 2 we see three phases i.e. submission of platform profiles and transformation functions; Notification; and Tendering. The new platform makes use of a service to submit its profiles specification in order for the centric application start understanding them. Then without any major changes in the existing business process, during the contract notice submission, services invocation is made to submit the profile in the ecosystem. With this publishing now the opportunity becomes accessible for all platforms in the ecosystem. Then in the tendering process, again the submission process makes use of service to pass the proposal to the ecosystem. The Enterprise Service Bus (ESB) handles the correct routing of the proposal to the originating body.

This prototype example depicts that any existing platform will be connected to a number of other platforms in the ecosystem of e-procurement platforms with least changes in their business process. Also, note that this approach requires no change in the data models being followed by the platforms. The Vortalway Cloud-Marketplace Ecosystems concept is being tested in real-life context pilots, validating it in different operational scenarios e-commerce processes, and this paper describes 4 of these piloting scenarios.

A. INCM Integration Pilot

According to the Portuguese Law, a user in addition to publishing the public tender in his platform he must also publish it in INCM. To ease his experience, the goal is to spare the user from logging in on INCM and the submission is posted on both platforms.

Thus, consider that a user wants to publish a public procurement procedure in Vortal’s platform. Since, its obligatory by Portuguese law to first publish the announcement in “Diário da República” through the INCM platform, the user have to leave Vortal’s platform, log in to INCM platform, submit the announcement and, if successful, with the code assigned (for the announcement) re-authenticate in VORTAL platform and finish the announcement. But now with the INCM integration pilot, the user doesn’t need to leave the Vortal’s platform environment.

The INCM integration application will handle the flow between the Vortal and INCM platforms. Let’s suppose the user wishes to make an announcement then the user is forwarded to announcement work area in INCM platform. After the submission of the announcement, the user is forwarded back to VORTAL’s platform without losing session and maintaining the INCM the announcement identifier as generated in INCM platform (Figure 3).

This pilot involved external service provider i.e. INCM, so understanding their web services and complying with the frequent changes was a challenge that we had to face during the realization of this pilot. We had the challenge to establish a channel for exchange of information in line with the new requirements of document integration with the INCM, so that all actions / processes to be made possible with the DRE (creation, correction, publication of acts of ads) are processed in platform according to requirements legally defined. Other challenge was to map the contracting authority with the Vortal’s profile and INCM profile with relation to the VAT number of Contracting Authority.

The solution that we have formulated is based on the baseline architecture, where the communication takes place through webservices. Marketplace application makes use of community application to authenticate the user and provides
the authorization based on the claims of the user context. Now the information contained in the claims obtained during authorization will be used for authenticating the user in INCM platform, thus avoiding the need for the user to login in INCM platform too. Marketplace communicates with INCM through web services to provide/receive necessary information for creation of announcements. The generated announcement ID in INCM when the announcement is completed is received by marketplace and will be used to identify the announcement during further steps of procurement.

B. Centric Model Pilot

The objective of centric model pilot is to allow different e-platforms with their own standards to communicate with each other. VortalWay acts as a mediator between all the registered platforms for transformation between the platform’s formats and pass information accordingly. The main objective of this pilot is to develop an application that acts as a centric hub for various platforms to receive opportunities and proposals irrespective of their own standards. In general, the idea is to allow a user registered in a platform have an access to the opportunity that originates in some other platform, without adding any burden to either of the platforms to understand the data model of origin or destination. The scope of this pilot includes the complete flow of the pre-award phase thus also allowing the proposals to flow between platforms.

Hence, consider that there are two e-procurement platform: Vortal and Platform A. Since these two platforms are independent from each other and follow their own standards they are not interoperable with each other at all. So initially opportunities and proposals are constrained within the domain of respective platforms. Users registered at Vortal cannot have access to the opportunities published in Platform A and vice versa. If a user is registered at both the platforms then (s)he can have access to opportunities by logging in separately at two platforms.

Now, let us suppose both the platforms are registered in VortalWay Centric Model application. When an opportunity is created in Vortal, centric model application performs the necessary transformation on the opportunity making it understandable for Platform A. This will allow the registered users in Platform A have access to the opportunity originally created in Vortal, without having to login to Vortal’s platform. And similarly if the opportunity originates in Platform A users of Vortal platform will have access to the new opportunity. Note that both Platform A and Vortal didn’t have to undergo any changes to achieve this integration. Thus, Centric Model pilot provides access to more opportunities to the users in a very easy way without adding any overhead to the platform owners.

The biggest challenge for this pilot is implementation of the transformation engine, which handles the transformation of the opportunities and proposals based on the origin and destination. Since, profiles for e-procurement are complex in nature, understanding the elements of each of the profiles and defining mapping rules between various formats was a big challenge that we had faced to develop this module. In the current version of centric model, it can transform between three formats: PEPPOL, Vortal and a generic standard. Any platforms following any of these standards can be integrated to the centric model and eventually with each other with a single step of platform registration in the database.

In the final version of VortalWay, it supports three different formats for two types of profiles. Profiles that are supported are Contract Notice and Proposal (called as Tender in PEPPOL). Three platforms that VortalWay supports are NextWay which follows the data model of Vortal, PartnerA which follows a data model defined based on the guidelines provided by EU for public procurement contract notice and PartnerB which follows the data model as followed by PEPPOL i.e. UBL. It is to be noted that we have taken into consideration of only the subset of standard models like Vortal and UBL, for the proof of concept, but taking into consideration of the fact we provide enough information in each of the supported information. The transformation process of centric model is depicted by Figure 4.

A scenario of creation of contract notice in NextWay and being delivered to different platforms including mobile application is depicted by Figure 5. In this figure NCN and NR means NextWay Contract Notice and NextWay Reply respectively, while PCN, PartnerCN, PR, PartnerR denote the Contract Notice and Reply formats of the partner platforms. MCN is the Contract Notice for mobile applications.
C. Virtual Storefront

The main objective of this pilot is to allow the suppliers to provide their product/service and to receive more relevant opportunities. Suppliers can submit the catalogues by following their own data model thus making virtual storefront application capable of integration of varying catalogues standards. The matching engine module of virtual storefront will help the suppliers to easily filter the opportunities that are more relevant to their business scope and the buyers to receive proposal from more relevant suppliers. Figure 6 depicts the general workflow of virtual storefront pilot.

Now, supposing that the supplier responds to an opportunity by using products from his catalogues. In future the percentage of relevance to contract notices that are similar to the ones that the supplier responds should be higher, because of supplier’s tendency to respond to a certain types of opportunities. Virtual Storefront implements such a learning mechanism which will update the certainty percentage based on supplier’s involvement in the proposal submission phase.

One of the biggest challenges faced in the implementation of this module was the formulation of matching algorithm. Since, we have taken into consideration of both the classification code matching and textual matching, we had to formulate two different algorithms to calculate the match index based on CPV code and similarity of the text in description. Other challenges that we had to face was regarding the processing of various catalogues (often received in excel file). The catalogues were to be converted into some platform specific formats and represent in XML. Then the transformation rules had to be defined to transform such catalogues into a standard format developed for VortalWay. This process involved the understanding of various formats like VorCat (Vortal’s standard), UBL (PEPPOL’s format) and BMECat (format used in Scandinavian nations) and writing mapping rules (in XSLT) for transformation.

In the current version of the VortalWay pilot it supports two catalogue formats viz. subset model of the catalogue data model defined by UBL (henceforth called PartnerA) and subset of BEMCAT data model (henceforth called PartnerB). VCat is the intermediary catalogue format designed to store only the necessary information for the matching process. Figure 7 shows the transformation process available in VortalWay. Note that all the contract notices can include the catalogue details, which are called buyer’s catalogue and have the description of the products that they want to purchase. So, contract notices which are firstly transformed to PEPPOL format as shown in Figure 4 is also transformed to VCat format.

Generated VCats are used to calculate the matching between the supplier and buyer catalogues to find the more relevant opportunities for the supplier. The matching is based on the CPV classification of the product and description text. Thus for any platform the occurrence of Contract notices or
Catalogues will trigger the calculation of the match percentage between them.

The attributes under consideration for calculation of match index are product classification CPV code and description. Since, these two attributes represent different information about a product, we have treated them separately. We calculate the overall certainty by:

\[
\text{Certainty} \% = (\text{cpvCertainty} \times \text{cpvWeight}) + (\text{descriptionCertainty} \times \text{descriptionWeight})
\]

CPV certainty is based on the comparison between the CPV codes of the products, while description certainty is based on the comparison of textual description provided for the products. For further understanding the algorithms for cpvCertainty and descriptionCertainty reader is advised to follow the documentation in the code. Similarly Virtual Store front also implements learning engine to update the matching between catalogues and opportunities based suppliers responses to the opportunities. The Learning engine increases the match percentage for the particular catalogue-contract notice pair, when the supplier responds to the opportunity. This will help the supplier to get better match results in future.

V. CONCLUSIONS

The proposed Cloud-Marketplaces approach aims to deliver a new paradigm to e-marketplace vendors. The envisaged Cloud-Marketplaces architecture is being experimented in real business scenario by Vortalway, an industrial-based research project conducted by a major international e-Marketplace. The project, that is in its roll-out phase, has delivered e-sourcing, e-commerce and e-procurement full functionality to Vortal’s electronic platform, offering which is envisaged as being strategic considering their business options to move to other countries in Europe, and to covering disparate vertical markets like public administration, construction, health, etc.

Nevertheless, the implementation of the Cloud-Marketplaces paradigm, besides the engineering and technological issues, poses interesting challenges regarding business models. The new possibilities brought by the new architecture do also require such new business models that move away from traditional fee or transaction-based revenue mechanisms, which is also currently being researched.

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