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AN E-ORDERING AND E-INVOICING CLOUD SOLUTION

Abstract: This paper addresses a new cloud solution for e-Ordering and e-Invoicing solution. We faced several challenges in the process of the migration of the existing web application on the cloud, such as the reorganization of the proposed non-cloud model and the definition of the software modules that can communicate in a dynamic environment. In the design process we classified two kinds of software modules: static and dynamic. The classification is based on the level of required elasticity and scalability, as well as the activity that is associated with the corresponding module (tool). To finalize the implementation of this idea, we have developed indicators to determine the required conditions for the activation of additional cloud resources or the deactivation of the involved resources. The result of this design process is a new cost-effective solution with increased availability and performance compared to the non-cloud model. We also recognized the advantages and disadvantages of such a cloud solution, and discussed the characteristics that make our approach unique.

Keywords: cloud architecture, cloud computing, e-Invoicing; e-Ordering.

1. Introduction

Procurement is a fundamental business process of every company, organization or government institution, since its basic functionality is to use or offer various products, services and/or information. Electronic procurement provides the basic means to fulfill these processes, since it enables a faster, more meaningful and more integrated way to carry out corresponding purchases or sales. While electronic procurement represents a wide area of interest, the authors in this paper concentrate on electronic orders and electronic invoices as constituting parts of the post-award phase of electronic procurement.

E-Ordering and e-Invoicing are two basic processes in the e-Business area, since the essence of the business activity of a given company is the exchange of goods that another company provides. Therefore, each business process ends with a kind of an offer, order and invoice that defines the parameters of the exchange and its value.

Cloud computing, on the other hand, is a relatively new technology which has been in use in some kind of form for decades [Williams, Reese 2012]. For example,

virtualization is a technique for masking the physical characteristics of computers and computer related resources, thus enabling a uniform way for other systems, applications or end-users to interact with the mentioned resources [IBM White paper 2007]. It is arguably the biggest technology driver behind cloud computing existing for almost 40 years, with a long history starting in the mainframe environment and arising from the need to provide isolation among users [Crosby, Brown 2006], i.e. to enable a multi-tenant environment.

Modern computers are sufficiently powerful to use virtualization to present the illusion of many smaller virtual machines (VMs), each running a separate operating system instance [Barham et al. 2003]. Cloud computing introduces security, scalability and reliability into a group of centrally managed and virtualized physical machines. It offers scalability and elasticity on a large scale, and gives an illusion of limitless resources.

The overall research and development problem in this paper is the description of the design process to develop a cloud e-Ordering and e-Invoicing solution. We propose a solution that can efficiently utilize the cloud resources to achieve a scalable and elastic system in a multi-tenant environment for e-Ordering and e-Invoicing. The paper is organized as follows. Section 2 presents the related work that we found in the literature. In Section 3, we lay the background for e-Procurement, by emphasizing the e-Ordering and e-Invoicing. Section 4 describes the required transformations to migrate the existing web application solution to cloud based web services. We elaborate the pros and cons of the newly proposed model and its architecture in Section 5. Finally, Section 6 presents the conclusions and plans concerning our future work.

2. Related work

In this section we provide an overview of recent research in this field, and give an overview of the e-Ordering and e-Invoicing solutions available on the market for general use, most frequently in the form of e-Procurement or e-Purchasing. Today's global competitive market marshals new and innovative technologies into everyday processes. According to [Boss et al. 2007], procurement processes that take a longer time can be streamlined with cloud computing. The vast number of various researches proves that public procurement conducted through electronic means can be vital to create new jobs and generate the sustainable and long-term development of businesses, providing taxpayers and public services' users with best value for money [Carayannis, Popescu 2005].

Research of e-Procurement in Europe, [Bof, Previtali 2010], provides an investigative insight into various national models and their respective economic impact on both government and citizens' welfare. E-Procurement benefits are ana-lyzed through related technological and organizational changes, while also esti-mating

the advantages and disadvantages of public procurement through electronic means [Trkman, McCormack 2010].

These developments and trends are evaluated for e-Government services [Kiroski et al. 2012], especially e-Procurement and its sub phases, i.e. e-Ordering and e-Invoicing. They show that the most optimal path for modeling and developing a functional e-Ordering and e-Invoicing solution is to utilize all the benefits of cloud computing, particularly SaaS, being today's most utilized and popular form of cloud computing. The authors have previously established the major characteristics of the existing software solutions, measured their success in the implementation of the major software goals, and evaluated the level of completion of the objectives the system should possess. The main idea is to follow international standards regarding ordering and invoicing software, thus ensuring interoperability with most European platforms [PEPPOL]. In this paper we present the means to enable cloud functionalities of the improved model for the e-Ordering and e-Invoicing solution [Kiroski et al. 2011].

The ultimate goal of e-Purchasing through electronic means is to minimize the cost of producing, transporting and storing this kind of documents and to minimize the cost and expense of the procurement process. Estimates of decreased prices through electronic purchases go as high as an amazing 20 percent [Singer et al. 2009]. According to Pan-European Public Procurement OnLine [PEPPOL], if all public procurement can be accomplished through such a platform, annual savings will surpass 50 billion Euros [PEPPOL].

3. Background

Cloud computing as a concept was first introduced in the 1960s by John McCarthy using the phrase "computation may someday be organized as a public utility". This concept means that users are not required to understand fundamental principles of the service they use, they just need to have required skills to "plug in" when they want to use a service, and to "plug out" after their work with the service is done. This is similar to the way we use electricity or phones. The term "cloud computing" is derived from the synonym for Internet (cloud), and means using Internet to deliver or use computing services. Today, under cloud computing we define a solution able to deliver information technology as a service. This solution is shared by its very nature, and we are not interested in its comprising parts, but in the services it delivers as a whole. The parts that build a whole do not come from a single computer, and are not necessarily from a single organization – instead the only property that binds them is the software that defines them as parts of a single cloud.

"Cloud computing is creating a fundamental change in computer architecture, software and tools development, and of course, in the way we store, distribute and consume information. (…) cloud computing is only a different way to deliver computer resources, rather than a new technology" [Walker 2010].

To be able to explain cloud computing, we should look at virtual machines. A virtual machine (VM) is an operating system which does not exist in a physical context, and is created and run within another environment. This concept of virtual machines enables using single physical hardware to simultaneously run multiple operating systems, called "guests." The environment that enables running these guest operating systems is called "host" or "hypervisor", and most clouds are built around hypervisors which enable the static or dynamic provisioning of resources for different virtual machines. So we can say that virtualization is an enabler for cloud computing [Warr 2009].

3.1. Cloud computing model

Cloud computing is becoming a phrase everyone uses, whether it is appropriate or not. This is due to the fact that cloud computing is related to the use of thin client as an interface to the software, virtualization as a mean to build a hardware cloud, Internet as a network used to connect to resources, and so on. For the purposes of this study we will use the model definition proposed by the US National Institute of Standards and Technology (NIST) [Mell, Granse 2011]. This model defines five essential characteristics, four deployment models and three service models.

To be able to categorize a service as a cloud computing service, we need to be sure that it behaves in a certain way and has some characteristics that are unique to cloud computing. The essential requirements of cloud computing are as follows:

- *On-demand self-service*: users can utilize applications, resources, network, storage, etc., at any time and from anywhere on Internet. Interaction is automated and does not require a human operator on the other side. This characteristic makes cloud computing comparable to any public utility, such as electricity, telephone, etc.
- *Broad network access*: the capabilities provided by cloud computing are available over the network (in most cases Internet) by using a wide variety of thin or thick client platforms (PDAs, smartphones, laptops, etc.).
- *Resource pooling*: computing resources are pooled, which means that a collection of resources is made to behave like a single pooled resource, thus increasing their reliability, flexibility and efficiency [Wischik 2008]. Pooled resources are able to serve multiple consumers using a multi-tenant model, where different physical and virtual resources are dynamically assigned and reassigned to satisfy consumer demand. The consumer is not aware of the exact location of the resources he/she is currently using. Resources provided this way may include storage, processing power, memory, network bandwidth, and virtual machines.
- *Rapid elasticity*: a characteristic closely related to resource pooling, which means that computing resources must be rapidly and elastically provisioned, to be able to quickly scale out when used, or scale out when released. The consumer has an

illusion of unlimited resources which can be purchased in any quantity and at any time.

- *Measured service*: a charge is made according to the measured amount of usage. Cloud systems are able to automatically control and optimize resource usage appropriate to the type of service. Resource usage is monitored, controlled, reported and available for inspection by both the provider and consumer of the service.

3.2. Cloud deployment models

Deployment models for cloud computing primarily concern providers giving infrastructure services, since they describe hardware cloud infrastructure. There are four deployment models, depending on the ownership and architecture of the cloud:

– *Private cloud*: exist behind corporate firewall and are intended to be used by limited, pre-determined audiences, or they exist off-premise where cloud service providers deliver secure computing environments. By using a private cloud, enterprises are able to deploy resources to environments which meet business or application needs, without any concern for reliability or security [VmWare White Paper 2009].
– *Community cloud*: cloud infrastructure is not owned any more or used by a single corporation. Instead it is shared and used by several organizations, all having similar concerns, like mission, security requirements, policy, or compliance considerations. It is managed by sharing organizations or a third party, and exists on- or off-premise.
– *Public cloud*: accessible over the Internet and intended to be used by the general public, and usually do not provide the same level of reliability and security as required for business applications. These clouds are generally used for temporary development environments or web hosting services.
– *Hybrid cloud*: cloud infrastructure is composed of two or more clouds, whether they are private, public or community clouds. These composed clouds remain unique entities, but they are bound together by standardized or proprietary technology that enables application portability, like cloud bursting for load balancing between clouds or VMware vCloud Datacenter services.

3.3. Cloud service models

Service models provided with cloud computing are defined by the needs of their consumer, assets they provide and their characteristics. The three levels of cloud computing services include:

1. *Infrastructure as a Service* (IaaS) – the consumer is provided with processing, storage, networks and other computing resources, and he/she is able to deploy and

run arbitrary software. The roots of the IaaS are in hardware virtualization, and use some of its key characteristics and concepts. IaaS key concepts include:

- *Cloud bursting* − dynamic deployment of a software application that runs on internal organizational compute resources to a public cloud to address a spike in demand.
- *Multi-tenant computing* – a single instance of the software running on a server is serving multiple client organizations.
- *Resource pooling* – multiple resources are "pooled" and used as a single pool of resources.
- *Hypervisor* – low-level code application responsible for inventorying hardware resources and allocating them on demand.

2. *Platform as a Service* (PaaS) − the consumer is provided with programming languages and tools so as to be able to create and use various applications. PaaS gives its consumers an illusion of infinite resources, since it enables them to use an expanding quantity of resources without requiring additional actions on the consumer's part. The main features provided with PaaS should include:

- *Application development framework* – most preferred is a robust development framework not limited by a specific vendor.
- *Ease of use* – PaaS should provide for user friendly development tools which support some standard IDEs.
- *Business process modeling tools* – required for building the business process model around which the application will be built.
- *Availability* – the platform must be available anywhere and anytime.
- *Scalability* – the platform should give the illusion of infinite resources, and implement elasticity to satisfy consumer needs.
- *Security* – the platform must provide for security in the application development and deployment, and support single sign-on, so as to be able to interact with other on-premises or cloud applications.
- *Inclusion* – the platform should provide the ability to include, embed and integrate other applications, whether they are built on the same platform or not.
- *Portability* – the platform should allow consumers to move their applications from one IaaS provider to another.
- *Porting tools* – needed to support moving on-premises applications to the cloud.
- *API* – a well thought-out and documented API will enable software developers to perform tasks such as user authentication, working with databases, storing and retrieving files, and so on.

3. *Software as a Service* (SaaS) – the consumer is provided with provider's applications running on a cloud infrastructure. It represents the cloud computing from the end-user's point of view, used in everyday work, such as Gmail, Google Docs or Netflix.

By comparing the differences between the three levels of cloud computing and traditional, on-premises computing can be carried out through deducting which resources or services are executed by customer and provider.

Levels of service provided with Cloud computing are interdependent with each other, and hierarchically aligned, as shown in the hierarchy in Figure 1 [Intel White Paper 2009].

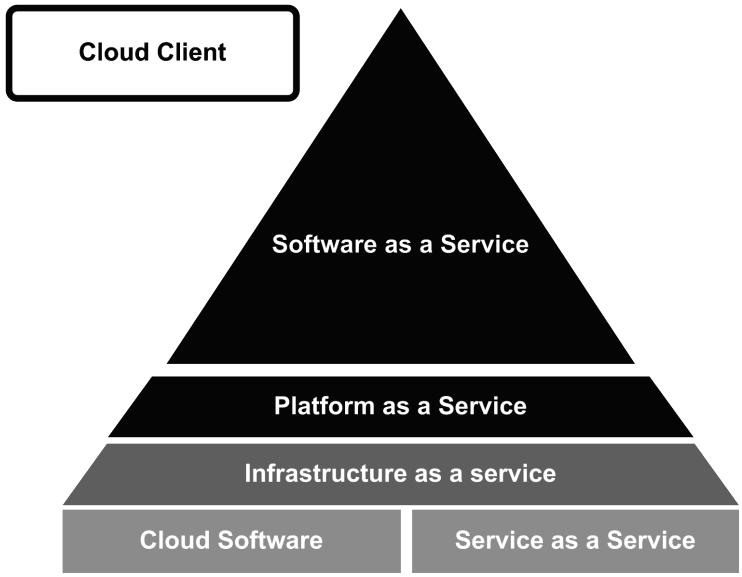

Figure 1. Cloud computing service model taxonomy

Source: own elaboration.

Apart from the service levels, this taxonomy includes:

– *Cloud software* – unique software used to build and run cloud services.
– *Cloud client* – client-centric services and software intended for cloud execution
– *Service as a Service* – service subscribed to and used as a component of SaaS, IaaS or PaaS offerings.

3.4. Advantages and disadvantages of cloud computing

Since cloud computing is a relatively new technology, it brings new concepts which make it more attractive both to service providers and service consumers. After providing a review on characteristics, services and deployment models, we present an insight into the benefits and weaknesses of cloud computing. Both the upsides and downsides come from the fact that everything is "in the Cloud" [Warr 2009; GTSI Corporation White Paper 2009].

The advantages of cloud computing include:

– *Elasticity and scalability* – resources provided in the cloud are scalable with the needs of the service consumer, and allow using more resources when the con-

sumer needs them, and fewer resources when there is no need of them. This resource scaling is fast, adaptable and automated, so consumers do not need to interact with human administrators when requiring resources.
- *Simplicity* – using cloud services can simplify business operations, in the way that it enables simple atomic services to run in the cloud, in some cases even without consumer interaction. Required technological knowledge is kept at a minimum, and resources are used just as any other utility.
- *Cost-effectiveness* – using cloud services does not require technical staff, or additional hardware resources. Different Service Level Agreements enable consumers to decide the service level they require, letting them pay for using the service on occasional basis, or even on a transactional basis.
- *Business agility* – cloud computing enables companies to quickly start using a service, scale the used resources according to actual needs, forge links to other cloud services, or stop using them altogether.
- *Resiliency* – clouds are built from a large number of inexpensive hardware resources, and cloud software enables them to host applications in virtualized environments, thus lowering the chances to lose connectivity, functionality or even data in cases of failures in the cloud.
- *Access* – the only requirement, which enables accessing the environment with high performance computation capabilities is a network connection to the cloud.

The same nature of the cloud computing that provides these advantages, on the other hand, is responsible for the disadvantages of cloud computing. These are listed as follows:
- *Performance* – in the cloud, all virtual machines and applications are competing for the same pool of hardware resources. The same characteristic that enables more optimal usage of hardware resources in the cloud, provides for increased hunger for resources in peak usage times. Clouds provide the illusion of limitless resources, but in reality, "there is no free lunch".
- *Security* – security is the main problem encountered in every Internet application. This problem is even bigger, since some service models include development platforms or even hardware resources in the cloud, requiring not only secured message exchange, but securing the entire cloud working environment.
- *Redundancy* – represents the other face of resiliency, since no hardware is infinite, and providing redundant data center may double the price of the required resources for storing data. An additional concern is that a cloud service hosted on the other side of the world may become temporarily unavailable due to connection problems.
- *Cost* – although it is cost-effective, cloud computing may become costly if resource usage is not monitored. Resources provided by automatic scaling may exceed the projected budget and turn a big profit into an even bigger expenditure.
- *Adequacy* – every application is not appropriate to be hosted in the cloud. There is data not worthy to be put in the cloud, and there is also data containing customer-sensitive or competitive information not suited for cloud usage.

4. Modeling the cloud solution

In this section we describe the required transformations to migrate an existing solution from a web application to an IaaS cloud-based solution. The cloud-based modular approach is used to realize e-Ordering and e-Invoicing software modules and tools. A new idea is introduced to enable elasticity and scalability based upon used resources, i.e., virtual machines (VMs), in a multi-tenant cloud environment.

4.1. Process modeling

We have previously established that the development process for a cloud computing e-procurement solution should utilize model driven development, since we have no knowledge in advance which platform it will use, and it will give our solution the required agility and not restrict it to one platform or technology.

The great importance of using model driven approach is probably best described by Frankel [2003] about the breakthrough concept of Web services, that information and services can be presented and accessed over the Internet and the goal is to use web service implementation technologies and an environment in which individual web services can be produced in a way that is as independent of these particular technologies as possible. The model requirements in a model-driven approach are clearly identified on separate levels, with corresponding tools for model organizing and storing, tools for checking and generating more detailed models, and tools for reengineering models from existing descriptions or source code. Thus we can focus on creating models conceptually close to application domain. Using the model we can capture not only the final outlook of the solution, but also the basic principles of the business process and workflow involved in creating the desired outcome. By using the business process model we can represent all the processes involved in purchasing goods and services, so we can analyze and improve them.

Frankel [2003] also uses the concept of business service, "which might be presented as a Web service, a Web page, a fat-client application screen, a service for a wireless handheld device, or a Java API". After establishing business services, composed of lower-level business functions and information entities, we will be able to decide to use different programming tools and technologies to develop our solution. This concept is illustrated in Figure 2.

Using Model Driven Software Development is common to software intended to operate in the web environment, and this approach enables choosing a software platform at the designer's convenience. Another benefit is that it enables business interoperability between parties using different software for their document exchange. The European Committee for Standardization (CEN) [European Committee for Standardization 2013] "is a business facilitator in Europe, removing trade barriers for European industry and consumers. Its mission is to foster the European economy in global trading, the welfare of European citizens and the environment. Through its

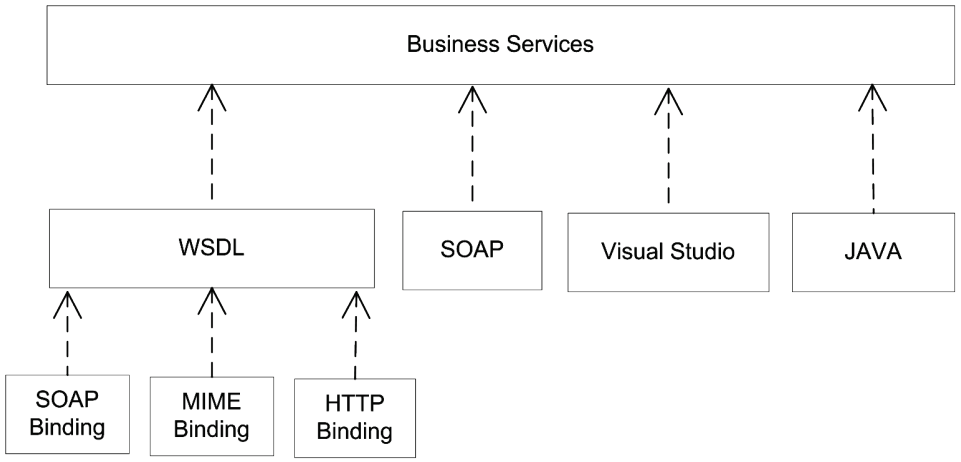

Figure 2. Maximizing reuse over different technology stack

Source: own elaboration.

services it provides a platform for the development of European Standards and other technical specifications".

The CEN Business Interoperability Interfaces (BII) specification is meant to facilitate an effective public procurement solution with a focus on cross-border interoperability and closing the gap between systems built on UN/CEFACT and OASIS/UBL 2.0. CEN/BII profiles can be used to create interoperability between the users of the two standards. Models built using profiles provided in the CEN/BII specification tend to achieve the development of standardized solutions which will enable borderless public e-procurement process in Europe. The whole e-procurement process is divided into five groups (Publication, Tendering, Sourcing, Ordering and Billing, and Support), each of them containing several profiles, where each profile involves one or more business processes. These processes are shown in Figure 3.

Each process gives a description of the business partners involved in the process and their corresponding roles in the given process. Business processes use Collaborations to describe the actions required to complete the business process. These collaborations involve the business partner's roles, and define needed pre-conditions, one or more possible post-conditions and the transactions required, thus drawing out all possible outcomes, both positive and negative, required to complete the collaboration. CEN/BII profiles also provide a detailed description of all transactions involved in the profile which present message exchanges between business partners. Complete documentation and business profiles can be found in [Kiroski et al. 2011].

The Pan-European Public Procurement Online [PEPPOL] is an initiative sponsored by the European Commission which aims at enabling cross-border public

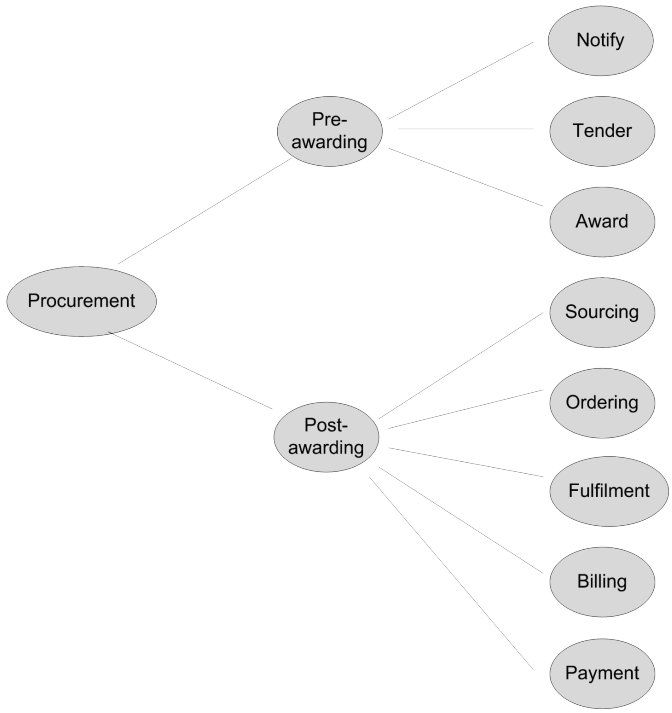

Figure 3. Business processes used to describe CEN/BII profiles

Source: own elaboration.

procurement, and allowing participants from European countries to compete in a single European market. This vision should be fulfilled by linking existing national platforms for public procurement, and will enable any European supplier to respond to any European public tender and complete the procurement utilizing the existing national infrastructure. The estimates are that using full electronic procurement for all public tenders could annually save more than 50 billion Euros.

In order to achieve these goals, the PEPPOL project uses business profiles provided by CEN/BII, and defines additional elements to complete the business processes described by the profiles. The PEPPOL goals are to provide a number of components involved in the public procurement process, such as those illustrated in Figure 4.

- e-Signature – a project intended to create interoperability between different national schemes, which will enable entities from different countries to uniquely identify certificates issued by other countries, and enable tender submissions across borders.
- Virtual Company Dossier – this dossier will enable replacing paper certificates with electronic attests, thus removing the necessity for providing qualification documents for every tender separately.

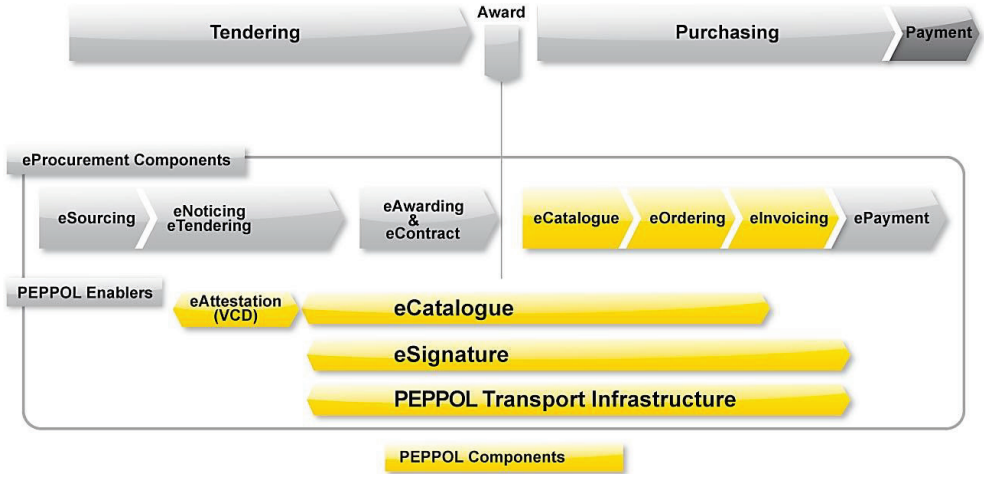

Figure 4. PEPPOL components

Source: [http://www.peppol.eu/work_in_progress].

- e-Catalogue – intended to provide product information, a detailed description and pricing. Using electronic catalogues will speed up the whole tendering process since it could be reused for different procurements.
- e-Ordering – a process concerned with issuing electronic orders by the buyers and the receipt of an order by the supplier.
- e-Invoicing – deals with payment claims for provided goods and services delivered, received or consumed as a result of a contract between the buyer and the supplier.
- PEPPOL Transport Infrastructure – an interconnected e-procurement infrastructure based on common IT standards, which will enable interchanging documents between various member states. It will enable government entities and the business sector to exchange business documents with provided security and reliability.

4.2. Model modifications and improvements

We previously established the major characteristics of the existing software solutions, measured their success in the implementation of the major software goals, and evaluated the level of completion of the objectives we established the system should possess. We also established that we will follow international standards regarding ordering and invoicing software, and thus ensure interoperability with most European platforms. According to these objectives, we will describe the modifications and improvements we introduced over the CEN/BII model.

During our research [Kiroski et al. 2011], we noticed that the CEN/BII model, although robust and encompassing, has a lot of redundant business profile's content. This is not a big problem when designing a solution according to specific requirements while using a specific business profile. But there are situations when this lack of segmentation can seriously increase the effort required to modify both the model and solution:

- New features are to be added to the solution, requiring complete replacement of the business profile .
- Modifying the solution in such a manner, so that it no longer corresponds to the business profile it uses, requires adding or removing fields from the data model.
- Introducing completely new, or replacing existing CEN/BII profiles.

In all these situations the quantity of work required to make such modifications can be minimized if completely segmented business profiles are used which do not include collaborations or messages used by another business profile. We called these profiles Basic profiles. They include:

- *Basic Order* − the Buyer makes and submits an order. The order is received and processed by the Seller.
- *Order Response* − the Seller receives and processes an electronic order. He/she accepts or rejects the order in question and sends the response to the Buyer.
- *Basic Invoice* − the Supplier sends an electronic invoice that can be received and processed by the Customer. An invoice containing VAT information must comply with the VAT rules of the country where the Supplier is registered. The invoice content enables the Customer's system to route the document to a specific person, department or unit within the organization; this may be required for authorization etc. The invoice content facilitates the automatic validation of legal and tax values, tax accounting and payment.
- *Invoice Dispute* − the Customer processes an electronic invoice sent by the Supplier, and notifies the Supplier of inconsistencies in the invoice. The authorized user on the Supplier side can take actions to correct the invoice in question, either by issuing a credit statement, or a completely new invoice with corrected information.

In the CEN/BII model, there are a great number of profiles surpassing the scope of our solution, but also not every profile is intended to be used according to our requirements – for example, profiles including the creation and modification of online catalogues do not take into consideration the same catalogues in the ordering process. Another issue is that CEN/BII profiles do not include the possibility of completely revoking already submitted invoices or orders. To address these issues we created three new Basic profiles:

- *Basic Order using Catalogue* − the Buyer uses the catalogue to make an order and submits the order. The order is automatically rejected or accepted by the Seller's system depending on two things: all the ordered items are in the catalogue, and the quantity per ordered item is smaller than the quantity per catalogue item.

- *Revoke Invoice* − the Supplier creates a notification that he/she cannot deliver goods or services as stated in the referenced invoice. This notification is sent to the Customer and the invoice in question is stored. If the referenced invoice was created on the basis of a previously created order, the order in question is nullified in the Supplier's system, and notification of its nullification is sent to the Customer to be processed.
- *Revoke Order* − the Buyer creates a notification that he/she has no longer the need for, or cannot purchase, the goods or services as stated in the referenced order. A request is sent to the Seller and if the contract conditions allow it, and the higher authorities on the Seller's side approve it, the referenced invoice is revoked and the previously placed order is nullified. A notification of the order's nullification is sent to the Customer to be processed.

After establishing our seven basic profiles, we discovered that all possible scenarios regarding purchasing process can be covered by arranging the initial seven basic profiles into five new, advanced profiles. Two of the advanced profiles involve only the ordering process (Advanced ordering using catalogue, Advanced ordering without catalogue), one involves only invoicing (Advanced invoicing), and two involve both invoicing and ordering, thus enabling complete coverage of the process of purchasing goods or services (Procurement without catalogue, and Procurement using catalogue). It is noticeable that some profiles include common Basic profiles, but it was necessary to introduce them since they also differ from each other. The following are brief descriptions of the five Advanced profiles:

- *Advanced Ordering using Catalogue* − the Customer uses a catalogue to make an order and submits it. The order is accepted or rejected by the Seller's system automatically depending on two things: all the ordered items are in the catalogue, and the quantity per ordered item is smaller than the quantity per catalogue item. After receiving positive feedback from the system, the Buyer creates a notification that he/she no longer has the need for, or cannot purchase, the goods or services as stated in the referenced order. If their mutual agreement allows it, and if there is no further document exchange, the Seller can accept or reject the revoke request. In the case of a positive answer, notification of the order's nullification is sent to the Customer to be processed.

  This profile consists of the following Basic profiles:
- Basic Order using Catalogue.
- Revoke Order.

– *Advanced Ordering without Catalogue* − the Customer makes an order and submits it. After receiving an order, the Supplier views the order and accepts or rejects it, and sends this response to the Customer. A contract between two parties is established. The Buyer creates a notification that he/she no longer has the need for, or cannot purchase, the goods or services as stated in the referenced order. If their mutual agreement allows it, and if there is no further document exchange,

the Seller can accept or reject the revoke request. In the case of a positive answer, a notification of the order nullification is sent to the Customer to be processed.

This profile uses the following Basic profiles:

- Basic Order.
- Order Response.
- Revoke Order.

– *Advanced Invoicing* − the Supplier sends an electronic invoice that can be received and processed by the Customer. The invoice content enables the Customer's system to route the document to a specific person, department or unit within the organization; this may be required for authorization etc. The Customer processes an electronic invoice sent by the Supplier, and notifies the Supplier of inconsistencies in the invoice. The Supplier resolves the dispute and sends the corrected document(s) to be processed by the Customer.

Advanced invoicing uses the following Basic profiles:

- Basic Invoice.
- Invoice Dispute.
- Revoke Invoice.

– *Procurement without Catalogue* − the Customer creates and sends an electronic order without using the Supplier's electronic catalogue. The Supplier sends an electronic Order Response, stating whether the order is accepted or rejected in full. The order response can be received and processed automatically by the Customer or a representative acting on his behalf. The Supplier sends an electronic invoice and, potentially, an electronic credit note that can be received and processed by the Customer. In the case of an error in the invoice, the Customer sends an electronic dispute that can be received and processed by the Supplier.

a. Due to an unanticipated chain of events, the Buyer must revoke the already submitted order. He/she sends the revoke request to the Seller. The Seller accepts or rejects the revoke request. If the request is accepted, the Creditor revokes the already created invoice. He/she sends the revoke notification to the Debtor. The revoked invoice is stored, and the order is deleted. This profile includes Revoke Invoice and Revoke Order.

b. Due to an unanticipated chain of events, the Creditor must revoke already created invoice. He/she sends the revoke notification to the Debtor. The revoked invoice is stored, and in the case of the existing order connected to the invoice, the order in question is deleted.

Procurement without Catalogue consists of the following Basic profiles:

- Basic Order.
- Order Response.
- Basic Invoice.
- Invoice Dispute.
- Revoke Invoice.
- Revoke Order.

– *Procurement using Catalogue* − the Customer sends an electronic order generated using the Supplier's electronic catalogue that can be received and processed by the Supplier's system. The Supplier's system sends an electronic Order Response, stating whether the order is accepted or rejected in full. The Order Response can be received and processed automatically by the Customer or a representative acting on his/her behalf. The Supplier sends an electronic invoice and, potentially, an electronic credit note that can be received and processed by the Customer. In the case of an error in the invoice, the Customer sends an electronic dispute that can be received and processed by the Supplier.

a. Due to an unanticipated chain of events, the Buyer must revoke the already submitted order. He sends a revoke request to the Seller. The Seller accepts or rejects the revoke request. If the request is accepted, the Creditor revokes the already created invoice. He/she sends a revoke notification to the Debtor. The revoked invoice is stored, and the order is deleted. This profile includes Revoke Invoice and Revoke Order.

b. Due to an unanticipated chain of events, the Creditor must revoke the already created invoice. He/she sends the revoke notification to the Debtor. The revoked invoice is stored, and in the case of the existing order connected to the invoice, the order in question is deleted.

This profile uses the following Basic profiles:

- Basic Order using Catalogue.
- Basic Invoice.
- Invoice Dispute.
- Revoke Invoice.
- Revoke Order.

Using these seven Basic and five Advanced profiles will enable us to define and describe all the possible scenarios involving the ordering and invoicing processes. At the same time we will be able to accommodate or create new Basic profiles. The fact that our Advanced profiles are completely created out of the Basic profiles will also be beneficiary, since it will require only minor changes or improvements to adjust to the new requirements.

4.3. Modeling the cloud solution

Implementations of an e-ordering and e-invoicing solution through the traditional provision of web services cannot offer sustainable performance since the predicted system may require a huge amount of unpredictable resources only in appropriate small periods during the peak period (such as the end of one year and the beginning of the another), while most of the time this system requires fewer resources that are predictable. Using the server-cluster architecture to create scalable and highly available solutions [Ho et al. 2007] will only partially solve a performance peak problem since it is hard to be managed and administered. On the other hand, the

software solution has to be prepared for scalability. The solution presented in previous sections can be hosted on a classic, third generation system architecture, showed in Figure 5.

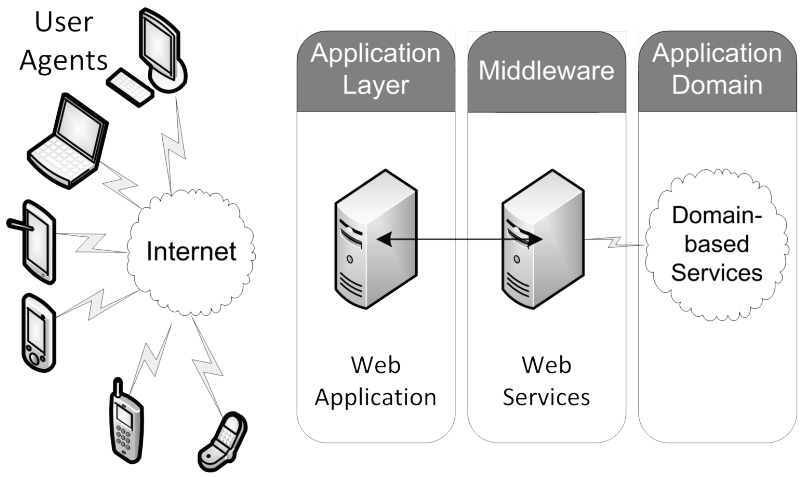

Figure 5. Third generation architecture, using web services

Source: own elaboration.

The third generation e-Assessment system architecture consists of three subsystems, Application Layer, Middleware and Application Domains. We can notice that there are no mechanisms for providing support in the case of increased usage, hardware or network problems, and so on.

Cloud computing, as a new technology trend in providing computing resources in addition to software in the form of a service [Armbrust et al. 2010]. Cloud providers offer the on-demand illusion of infinite elastic resources using virtualization [Mell, Grance 2011]. Cloud computing addresses a set of services providing scalable, QoS guaranteed, normally personalized, inexpensive computing platforms on demand [Wang et al. 2008]. The cloud billing model is similar to the basic utilities billing models, i.e. it is proportional to the amount of usage. Therefore cloud computing is suitable for small and medium business enterprises, especially in the present economic crisis. However, cloud computing degrades the SOA web service performance to 71 to 73% compared to the traditional "bare metal" web service hosting infrastructure with the same hardware resources [Ristov et al. 2012].

Small and medium enterprises can benefit if they migrate their e-ordering and e-invoicing systems into the cloud, since the cloud is capable of offering excellent flexibility and scalability of resources, storage space, computational power and network access, and most importantly, at a lower cost.

Cloud computing lowers the disk space requirements, and enables newest software versions and monitoring of the installation progress in each of the cloud service models, (IaaS, PaaS and SaaS).

Moving the proposed e-ordering and e-invoicing solution into the cloud requires the reorganization of system modules into two groups: static and dynamic. The static group is composed of tools not requiring increased computing power, as these tools are not utilized on a regular basis and will not be accessed by each and every user. The dynamic group, on the other hand, refers to e-orders and e-invoices creation tools and the common activities related to them, as shown in Table 1.

Table 1. Proposed reorganization of Tools and Modules regarding the involved activities

Type of Activity	Cloud Modules	Related Tools
Static	Administration Module	User and web site administration tool Backup and recovery tool
	Content Module	Tool for creating and managing catalogues Customization tool
	Usability Module	Workflow establishing tool Reporting tool
Dynamic	Basic Operations	Order creation and editing tool Invoice creation and editing tool Search and view tool
	Advanced Operations	Invoice dispute tool Resolve dispute tool Invoice revoke tool Order revoke request tool Resolve revokes tool

Source: own elaboration.

In addition to clustering the proposed solution tools into static and dynamic groups, there is another modification. Further analysis showed that the intended tools can be implemented in five different modules, created according to the static or dynamic nature of the proposed tools, and also as a means to logically group them, thus allowing improved functionality, security, and access control. Such implementation of the modular solution can be found in [Ristov et al. 2013], while the practical implementation for e-ordering and e-invoicing software is shown in Figure 6.

For the proposed solution, static modules are:

- **Management module** − intended for Administrators and partly for Managers, since the main activities involve occasionally used tools for user administration, web site administration, and backup and recovery tools.
- **Content module** – used by Employees to create and maintain Catalogues, and also a tool for forms' customization.

- **Usability module** – consisting of a Workflow establishing tool and Reporting tool, used by Managers and Employees to automate document creation and for reporting activities.

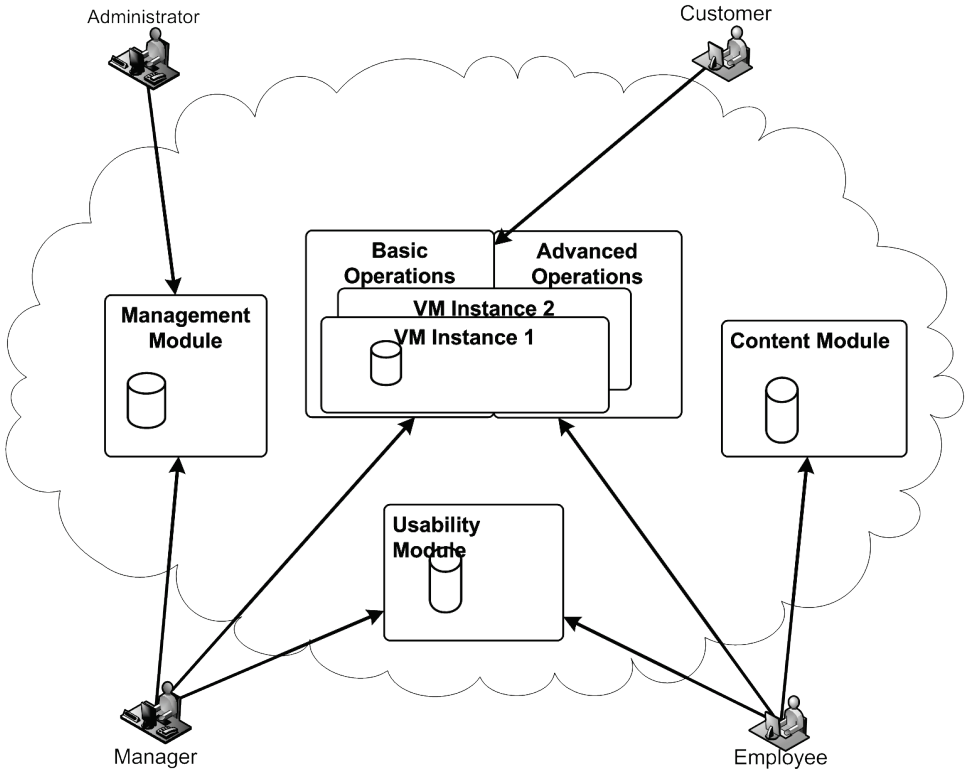

Figure 6. Cloud-based modular approach to e-Ordering and e-Invoicing tools and modules

Source: own elaboration.

Dynamic modules which require more resources at peak times and provide critical functionalities of the solution, are as follows:

- **Basic operations module** – used by Managers, Employees and Customers alike, in order to create, edit and delete orders and invoices. It also provides a search and view tool for created orders and invoices.
- **Advanced operations module** – this module involves advanced activities with invoices and orders, such as disputing invoices and revoking invoices and orders, mostly by Employees and Customers. It also enables Managers to resolve disputes, and decide about revoke requests.

The proposed model is capable of utilizing features and characteristics offered as a solution for each cloud service layer, from IaaS to SaaS. The model for the

Table 2. An overview of cloud-based e-Ordering and e-Invoicing solution benefits

Elasticity and Scalability	Underlying infrastructure in the proposed cloud platform is based on virtual machines, all sharing common resource pool, enabling automated utilization of more resources in peak times, and fewer resources (which will be routed to other VMs hosted in the Cloud) when there is no more need for them. Enabled through use of data clusters, IIS-based load-balancing, etc.
Simplicity	Basic services can be provided as individual services/applications: – user access management, – orders, – catalogues, – invoices, – automated purchase lifecycle, – document export and import. Enabled as a simple web service or an complete web application at the discretion of the software user.
Cost-effectiveness	Management and maintenance of the e-ordering and e-invoicing solution will be the responsibility of the provider, requiring no technical staff on behalf of the service consumer. Different Software Level Agreement: – web based solution available for purchase, – paying for using the service on periodical bases, – per-transaction fee.
Business agility	Software use lifecycle is provided in a few quick steps: – companies and individuals will be able to apply to use the service, – administrator will be able to register new clients in the roles of managers and employees, – managers will be able to register new customers, as well as grant or revoke special permissions to employees, – revoke order shall also permit requests to nullify the contract for using the service. Administrators will be able to disable Clients, i.e. Managers and Employees. Backup and recovery tool will enable downloading of documents in exported form.
Resiliency	e-Ordering and e-Invoicing solution is intended to run in Virtual Machine on a cloud platform. One possible platform includes (but is not limited to) the following server setup: – MS SQL Server 2008, – MS Windows Server 2008 R2 , – MS IIS 7.0, – platform and servers to be used enable load-balancing and failover clustering, and all virtual machines, together with operating systems, servers, and data, shall be stored on HP P2000 storage with multipath I/O.

Source: own elaboration.

e-ordering and e-invoicing system presented in this paper can be hosted onto the cloud and use seemingly infinite cloud resources dynamically to reduce costs and to provide better performance. An overview of the improvements and advantages introduced through a cloud-based solution is provided in Table 2.

5. Discussion of results

This paper tackles the modeling and performance analysis of a new e-ordering and e-invoicing solution. The results of the research on these fields produced in the last three years are described in the next sections.

5.1. Benefits

The procurement process is one of the fundamental activities regularly executed in every organization, whether it is a private company, or a public institution. The benefits resulting from a cloud solution for e-invoicing and e-ordering are:

1. A complete and comprehensive benchmark for e-ordering and e-invoicing solutions.
2. Findings regarding world trends in offering this kind of solution.
3. The proposed categorization and evaluation methodology can give meaningful direction and help in developing better solutions.
4. Guidelines for designing and developing a solution that will be compliant to the SAAS idea, to develop the solution so it can be used as a Plug-In module for different kinds of software, and to implement interoperability to make it available for wider use.

Finally, working on the new, improved model for e-ordering and e-invoicing will provide the following benefits:

1. Help in designing a solution interoperable with primarily European platforms, so as to enable software users to cooperate with international companies and to compete for international public tenders.
2. Introducing Model Driven Software Development in the definition of the model.
3. Bringing new quality into e-ordering and e-invoicing software through the use of a modular approach which will help in making it more attractive and useful to the end users.
4. New Basic profile involving an electronic catalogue as a means for the automatic creation of orders and invoices.
5. Introducing the Revoke option, if agreed by all the concerned parties and permitted by their contract.
6. Developing and implementing the new Basic profile requires far less effort than reworking the entire process, and combining the Basic profiles can facilitate the creation of long workflows and processes.

5.2. Disadvantages

Due to the wide application area of a system for e-ordering and e-invoicing, it will require process adjusting enabling electronic purchasing in each organization. The non-existence of such a solution shall require an additional initial effort into its development. On the other hand, the necessity for interoperability with existing platforms on an European and global level, shall necessarily define the way in which such a system should be designed.

Although this model for an e-ordering and e-invoicing cloud-based solution offers significant benefits both for business and individuals, its architecture implies additional effort in resolving the following challenges:

1. *Interoperability* – realization of the solution in order to integrate with existing platforms.
2. *Portability* – designing software capable for migration between platforms and service providers.
3. *Security* – implementing security mechanisms and best practices in order to guarantee data security, integrity, and confidentiality.
4. *Data privacy* – catalogues, orders and especially invoices, represent sensitive data with the need for restricted access.
5. *Law compliance* – validity and legality of electronic documents, especially invoices must be compliant with the governing laws for both parties' countries .
6. *Total Costs* – although cloud solutions are cost-effective, total costs may incur over-expenditure in cases of excessive use.

5.3. Comparison to other solutions

The cloud virtual environment behaves differently with the same load at different times, depending on the number of active VMs on a particular cloud node and the total number of active VMs in the whole cloud [Koh et al. 2007]. Ristov et al. [2013] determined that the virtualization in cloud computing degrades almost 30% of the SOA (Service Oriented Architecture) web service performance, compared to the traditional "bare metal" web service hosting infrastructure with the same hardware resources. The real challenge is how to mitigate this relatively huge performance degradation and performance discrepancy.

Migrating the existing third generation system architectures on the cloud and thus using the cloud features of scalable and elastic theoretically unlimited resources can even increase cost, rather than decrease it.

The most common cloud providers such as Microsoft Windows Azure, Google Compute and Amazon EC2, offer different types of VM instances. Although the prices and SLAs (Service Level Agreements) are different for each cloud provider for the same resources, their pricing models have a common issue, that is, the price increases linearly while scaling the resources [Amazon Ec2; Google Compute

Engine; Microsoft Windows Azure]. But many authors show that the performance is not scaled the same as the resources (and the price).

Gusev et al. determined that Multi-VM environment (many VMs with a single CPU core) provides up to 10 times better performance compared to the Single-VM environment (one huge VM allocated with all cores) [Gusev 2013]. Therefore, scaling the number of VMs (and balancing the load among them) is a better solution than scaling the resources in a single VM instance. The former solution is more reliable and available because the system will continue to work if some VMs fail. Introducing a resource broker in our solution reduces the number of active VMs, thus reducing the overall cost of the solution and making it a green cloud solution.

6. Conclusion and future work

E-Ordering and e-Invoicing are the most important parts of an e-Procurement business process. In this paper, we presented the design of an IaaS cloud e-Ordering and e-Invoicing model. The final goal is to efficiently and effectively utilize the cloud using scalable, elastic and theoretically unlimited computing and storage resources.

We have realized a new cloud solution by identifying and organizing static and dynamic software modules. Dynamic modules can activate various virtual machines, forming an efficient solution.

Future work will be based on the experimental research of the performance of this solution and compare with several other solutions.

Our proposed cloud model focuses only on a part of e-Procurement, i.e. for e-Ordering and e-Invoicing. We will continue with our research to propose a comprehensive cloud model for the whole e-Procurement business process. While proposing the cloud model for a partial e-Procurement solution, we are confident that the proposed model can also be beneficial in other application domains, such as assets management, content delivery networks, computing, etc.

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E-ZAMÓWIENIA I E-FAKTUROWANIE. ROZWIĄZANIE TYPU *CLOUD COMPUTING*

Streszczenie: Artykuł omawia nowe rozwiązanie typu *cloud computing* dla systemów e-zamówień i e-fakturowania. Mamy do czynienia z kilkoma problemami w procesie migracji istniejących aplikacji internetowych w chmurze, takimi jak: reorganizacja proponowanego modelu *non-cloud* oraz definicja modułów oprogramowania, które mogą komunikować się w dynamicznym środowisku. W procesie projektowania wyróżniono dwa rodzaje modułów oprogramowania: statyczne i dynamiczne. Podział ten opiera się na wymaganym poziomie elastyczności i skalowalności, jak również na powiązaniu z odpowiednim modułem (narzędziem). Implementując swoją propozycję, autorzy opracowali wskaźniki do określenia wymaganych warunków do aktywacji dodatkowych zasobów w chmurze lub dezaktywacji już używanych zasobów. Wynikiem tego procesu jest konstrukcja nowego, efektywnego kosztowo rozwiązania o zwiększonej dostępności i wydajności w porównaniu z modelami typu *non-cloud*. W pracy wskazano zalety i wady rozwiązania opartego na chmurze oraz omówiono cechy, które powodują unikalność zaproponowanego podejścia.

Słowa kluczowe: architektura chmury (*cloud*), przetwarzanie w chmurze (*cloud computing*), e-fakturowanie, e-zamówienia.