Towards an Architecture for Electronic Notifications Services on the Cloud: A Model Driven Approach

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Towards an Architecture for Electronic Notifications Services on the Cloud

A Model Driven Approach

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Abstract—**Cloud computing technology is being adopted by organizations driven by their need to reduce operational costs, and to deliver scalable and flexible services. Solutions deployed on the cloud are a great point of interest in the commercial and governmental area for e-commerce transactions. Here, electronic invoicing applications play a key role in commercial activities, being a branch of vital importance for the business activities. In order to accomplish certain tasks (e.g., collection of overdue invoices, notifications about payment plans) technological solutions have been proposed. Then, it is important to establish architectures that support developers in creating notification solutions in order to send messages about issues of interest for organizations in a proper manner. Moreover, due to the constant changes of laws, a model driven approach can help as a flexible and maintainable option for these solutions. Therefore, this paper proposes an architecture for the creation of electronic notifications, which allows a good communication between organizations and their clients. In this context, a case study is presented in order to demonstrate the instantiation of the proposed architecture in a real scenario.**

Keywords-cloud computing; web service; e-invoicing; notification; SMS; mail.

I. INTRODUCTION

Nowadays e-business plays a critical role in the maintenance and management of business information along the supply chain [1]. It covers a broad field, from which several activities are derived; these include the world of e-invoicing. In this context, the Electronic Data Interchange (EDI) was firstly implemented between companies, and later, it was used to transmit electronic invoices between individuals, companies and government offices. Therefore, it has become the backbone of electronic commerce. Also, the need to transmit information has allowed that so many countries use cloud computing as a platform to deploy invoicing services to the population [1]. The nature of the electronic invoicing allows to send, receive and process invoices without manual intervention [2]. According to Muller [3], an electronic invoice is a modern, reliable, cost-effective and essentially paperless method of managing and processing invoices generated by a business, which has been implemented in many countries. Moreover, it is a document that meets the legal and regulatory requirements that constitutes a proof of sale. Therefore, it guarantees the authenticity of its origin and the integrity of its content [4]. Also, it has the same accounting benefits as a traditional commercial invoice.

Overdue accounts and clients with arrears in payments are a headache for many companies and organizations. Therefore, one of the most important objectives of an organization is the timely collection of past due portfolio, which is a process that requires an efficient planning, which allows the successful benefit of the liquidity and solvency of a company, business or organization. Thus if this concern is not a priority for companies, this generates losses of money, time and effort [5]. However, there are few companies that have a system of electronic notifications to inform customers about their situation related to their debts and overdue bills. Those solutions are restricted to the specific requirements of the enterprises, therefore if a requirement changes, the e-notification infrastructure needs to be re-implemented.

On the other hand, the use of web services and cloud technologies allows companies to incorporate new technological solutions at lower cost, focusing their development on the core of their business. Also, they add value aspects; maintaining the investment of the ERP or the legacy systems. Another feature is to integrate business processes with partners at lower cost when sharing their information independently of their own technologies [6].

According to Booth [7] a web service is "a software system designed to support the interoperable interaction of machine-to-machine through a network. It has an interface described in a machine-processable format (WSDL specification). Other systems interact with the web service in the manner prescribed by its description using Simple Object Access Protocol (SOAP) messages, usually transmitted via HTTP with an XML serialization along with other standards related to the Web.

Similarly, cloud computing, has been defined by the National Institute of Standards and Technology (NIST), as "a model to allow ubiquitous, convenient and on-demand network access to a shared pool of configurable computing resources that can be provisioned and released quickly with minimal management effort or intervention from the service provider" [8].

Using a service-oriented cloud infrastructure has some advantages, such as the interoperability in independent programming language technologies, along with the means of transporting data provided by the HTTP protocol.

Currently, organizations are choosing to use development approaches different from traditional ones, this is the case of Model Driven Architectures (MDA). This framework allows developers to focus on design at a high level, without considering technological restrictions or specific implementations. It also allows a high maintainability against technological changes, facilitates portability, among others

[9]. Likewise, MDA is related to the use of models in software development, model-driven architecture establishes certain types of models. In MDA, the concepts of Computation Independent Model (CIM), Platform Specific Model (PSM) and Platform Independent Model (PIM) are handled. The CIM shows a business domain model; while the PIM shows a software solution model which does not contain details about the platform. Similarly, the PIM shows the detailed model on the platform to be implemented [10].

Additionally, the techniques of Model Driven Engineering (MDE) have been included in this architecture, in the abstraction model of the solution, making it more flexible and maintainable against changes, because they would be reflected in the model.

Nowadays, there are different types of notification systems that alert end customers, with the purpose of informing them about certain aspects related to e-invoicing. It includes solutions for notifications with digital media on electronic invoicing, electrical energy applications, gas provision, health care, accounting services and proposals for frameworks for internet services.

In a previous systematic literature review [11], we have concluded that there are not approaches focused on this problem in a way that easily accomplish the objectives of this study, as is the case of our system that seeks to create an architecture where MDA advantages are involved (e.g., flexibility, scalability, maintainability); and in which notifications to clients that have expired invoices, are sent using cloud computing. Where the cloud model helps to organizations in improving their activities and governments in having several resources for having updated information.

For this reason, this paper presents a first approach towards an architecture for the development of an Electronic Notifications Platform (ENP) with web services, for overdue invoices of organizations. This solution integrates conceptual models and apply techniques based on MDA, cloud computing, web services, informatics security, communication protocols, and shipping gateways. Also, this platform is deployed on a private, public or hybrid cloud, using the Software as a Service (SaaS) model, depending on the infrastructure of the organization or its requirements of availability, performance among others.

The structure of this paper is as follows: section 2 presents the related work, then in section 3, the architecture of the ENP is proposed. Section 4 shows the MDA approach used for the development of the ENP, while section 5 presents the XML standard for communications. Section 6 shows the aspects to be considered to implement the architecture. Section 7 is a study case to analyze the impact of the proposed architecture; and finally, conclusions and future work are described on section 8.

II. RELATED WORK

There are several solutions that cover specific areas of electronic invoicing, using the appropriate technologies and approaches for each case. For example Suwisuthikasem [12] presents an e-invoicing tax management system that allows the integration of the taxpayers with the electronic platform of the government, which uses the XML, WSDL, UDDI and SOAP standards. The results of this paper show that the needs of the taxpayers are met while a more efficient tax control for the collection agency is present.

In Matus [13] a private solution is proposed, which follows the Software as a Service (SaaS) model. This solution allows the emission of electronic vouchers by taxpayers to the government platform. This development follows a web engineering methodology based on the Unified Modeling Language (UML), providing security in the transmission of data through a secure communication channels like Hypertext Transfer Protocol Secure HTTPS and Secure Socket Layer SSL for Simple Object Application Protocol requests SOAP made to the government platform. Where the results show that despite demonstrable savings, elimination of errors, accelerated cash flow, enhanced competitiveness and efficient supply chains, it still being a marginal issue with a wide space for further investigation.

In a similar way, Kaliontzoglou [14] proposes an open system of electronic invoicing based on XML, cryptography for XML and web services, which complies with the requirements of European directive 2001/115 / EC. Said system proposes an authentication of origin, which uses digital signatures together with smart cards. Regarding the integrity of the information, this is achieved through the use of cryptographic hash functions. The non-repudiation of origin and destination is achieved with digital signature of advanced electronic signature XML (XAdES) and timestamps. The XML encryption syntax is obtained by following the recommendation W3C [15].

Similarly, Spanic [2] proposes an e-invoices system, providing multiple services to different users. The system is able to transfer e-invoices between large companies through EDI of their ERP, and provide web services related to SMEs (small and medium enterprises). However, these approaches do not propose an architectural way to achieve the notifications delivery to companies' customers. Also, these are organizational specific implementations and do not make use of innovative development methodologies nor exploit the advantages of web services or cloud computing.

Radeski [20] proposes an electronic invoicing model, where the main objective is to build a system that is aligned with EU references. The model uses a combined approach to solve the problem of signatures of electronic documents. According to this model, the companies will only apply the basic electronic signature to their electronic invoice data and the models will be in charge of improving the signed data received in an electronic signature file format, placing the time stamps and the status information of the certificate.

While Humski [16] proposes an e-invoice system named FER. The system characteristics include that it is based on a scalable, open and modern 4-corner architecture which is applicable in real business environment; it is also able to transform invoices between some of the most used XML-based e-invoice standards and enables automatic generation of a payment order. Additionally, a business analyses process with data warehouse. However, the scope of these studies is limited to specific situations, which do not allow their deployment as a service in the cloud.

Currently, there are notification systems with multiple application areas. Rodney [17] presents an automatic power meter reading system, which allows to manage all the meter readings from each consumer unit, computing the billing costs and publishing e-invoicing notifications to its respective consumer through SMS, email, web portal and printed postage mailing.

Similarly, Muhammad [18] presents the design and development of an billing automation system for gas consume. This solution allows for domestic and industrial use, communicating the consumption of each gas meter to the regional billing office, where the values to be paid are calculated and the e-invoice is transmitted to the consumer.

In another context, Vanitha [19] presents an architecture and implementation of a system called "Medbook", which provides patients and healthcare providers with an exchange of information, notifications on electronic health records (EHR), billing activities and consultation. With regard to technologies, it uses the Jelastic service. This architecture is based on Software as a Service (SaaS) and for its implementation in an Infrastructure as a Service (IaaS).

Likewise, Papadopoulou [20] presents a framework for the design of an Internet billing services environment, which includes the principles of relationship marketing, advertising and sales. It sends notifications to the issuer of the invoice and to the client, with the information about the payment.

Finally, Omosebi [21] presents a platform in the cloud using OpenStack to provide accounting and billing services that can be used to qualify, charge and bill consumers, having automatic notifications and alerts for the customers. However, these studies do not address the dispatch of notifications focused on past due portfolio recovery. This study only focuses on specific solutions, without the possibility of using them openly by multiple companies, in contrast with the use of cloud technologies such as web services.

The aforementioned solutions on notifications of electronic invoicing based on overdue invoices, together with the use of cloud technologies, play a very important role in the recovery of the portfolio, being a point of great interest [5]. These documents approach specific areas of electronic invoicing, such as: the use of technologies, development focused on custom made systems, tax management, systems for the transfer of invoices and taxes, the platform for issuing electronic vouchers to the government; making use of standards such as XML, SOAP; giving a focus on certain security cases with HTTPS, SSL, among others.

However, as far as it is known, there are no studies that address the area of notifications of electronic invoicing over past due portfolio using cloud technologies. Therefore, it is show that these solutions are not focused on what this document proposes: a solution for the development of an overdue electronic invoice notifications platform through the use of web services and cloud computing, incorporating MDA to obtain benefits of this framework, allowing automatic platform´s source code generation, based on previously defined context models.

III. PROPOSED ARCHITECTURE

This architecture is structured by the ENP platform and the elements that interact with it. In this way they have been considered: Cloud, Server - Electronic Notifications Platform (ENP), Architecture communication and ENP Clients.

A. Cloud

The deployment in the cloud is done by using a public deployment model, which is characterized by offering resources to multiple customers or companies. Also, the sharing of resources allows significant cost savings for the companies. In this way, the aim of this solution is to provide technological resources, storage and software in a SaaS model. Therefore, the service provided with notifications and alerts must be fully available, with the possibility of growing and expanding the service to more companies through a high degree of flexibility. Likewise, this feature is an advantage when there is an overflow of services due to possible sales spikes by companies at certain dates of the year, which in the end become invoices to be notified [22].

B. Server - Electronic Notifications Platform (ENP)

Since the ENP is purposed for an electronic business and it is designed as a SaaS service model, then the main objective is to facilitate the connection of information between the parties involved [23]. Because of this, the use of Web Services has been chosen, this being a technology that uses a group of protocols and standards established by OASIS and W3C.

Thanks to the use of open standards, it is possible to have interoperability between heterogeneous software systems that each company may has (different formats, hardware and software platforms). The web services respond to SOAP requests, the same ones that are linked through the definition of a WSDL (Web Services Description Language), this is based on a universal format such as XML (Extensible Markup Language) providing several features such as extensibility, neutrality and independence to hardware and protocols [23] Also, other advantages of the protocol can be found such as the existence of interoperability due to the use of XML and that it is easily scalable by the use of HTTP, among others.

Regarding to the database, it has been considered the use of MySQL, since it is a relational database management system of Open Source type and with GPL license. It is one of the management software with the best performance to currently execute the operations, it has a low cost in requirements thanks to its low consumption of resources, likewise it has a low probability of corrupting data.

Additionally, it has been implemented the use of an ORM (Object-Relational mapping) as Hibernate. This has several benefits at the time of implementation, since it offers an 100% object-oriented paradigm. Also, it provides an agile and fast development, with much fewer errors in execution time, allowing modeling of entities to be transformed to SQL statements [24].
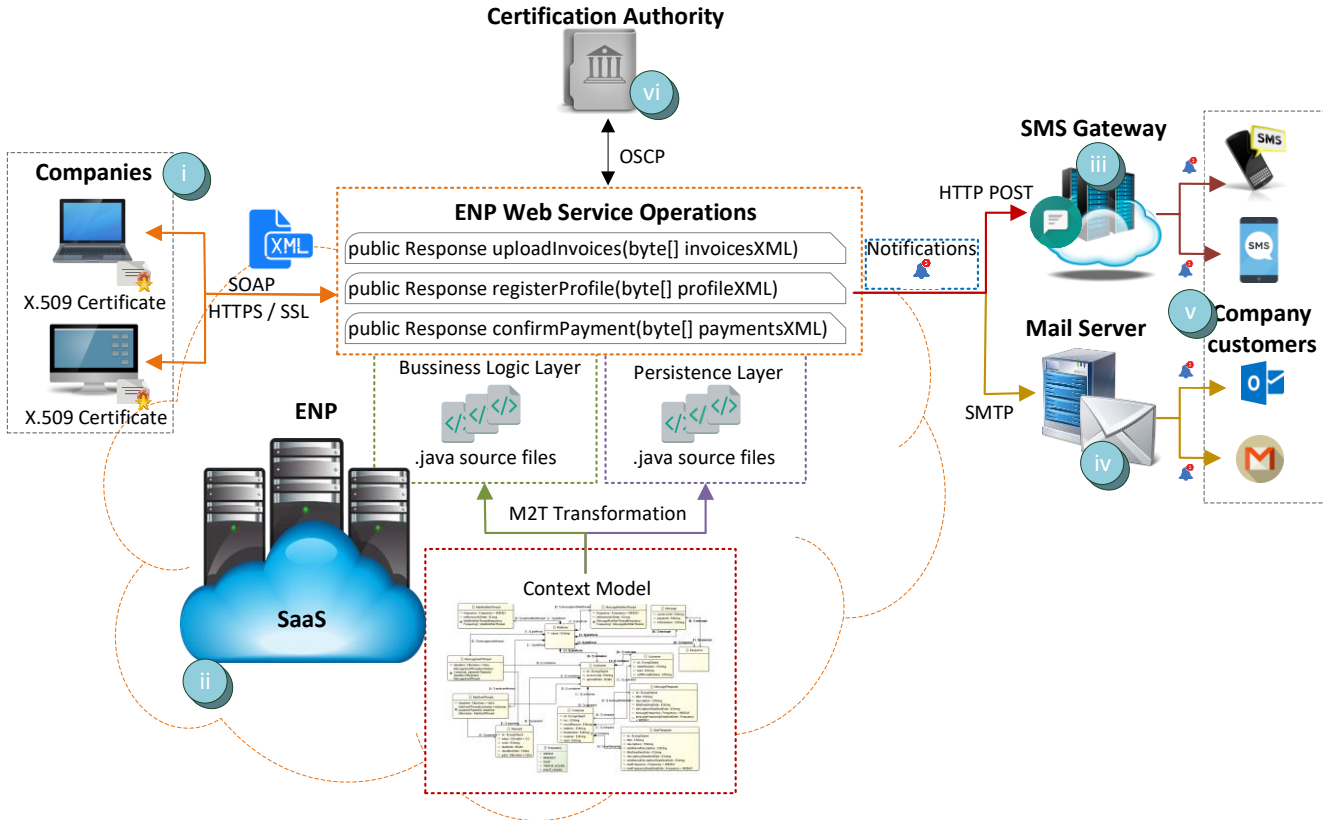
Figure 1. Electronic Notifications Service Architecture

In an internal view of the server, a structure layer has been considered for processing, where the MDA approach has been applied, which allows the generation of the persistence and business logic layers. Therefore, development processes can be streamlined, as well as maintenance against changes in the domain, achieving so platform independence, allowing the portability of the model towards specific implementations, according to the specific needs of each web service provider.

C. Architecture communications

Figure 1 shows the detail from the flow of processes in the operation of the ENP, using the numbering shown in it.

The protocol used for communications between the client and the server is SOAP over HTTP. The body of the requests made to the server consists of XML format files, which follow a previously defined standard to structure the information necessary for each operation available in the web service

Requests for web services are made asynchronously. The ENP (ii) processes the information of each request in a stateless session, whose life cycle begins with the request and ends upon completion of the processing. On the other hand, the ENP keeps the execution of threads in parallel, which are scheduled to run in background at the established notification frequencies, consulting the database for the payments whose notification is pending and dispatching it to the SMS gateway (iii) and Mail Server (iv).

It has been considered necessary to establish pre-defined notification frequencies (eight hours, twelve hours, daily, biweekly, weekly). In this sense, it is necessary to use threads, allowing the configurable execution of each thread, assigning the corresponding notification frequencies. In this way, it is possible for each thread to carry out its notification process and to stop for the established time, to then resume the notification work.

In this way, the email and SMS notifications process are given by executing an independent thread for each notification frequency.

During the processing activity time of each notifier thread, the outstanding payments of the companies are consulted in the database, along with the contact information associated with the client of each pending payment, and the sending of the email and SMS notifications is carried out.

Communications are done through a secure communications channel using the Secure Socket Layer (SSL) protocol, making it possible for encryption and bidirectional authentication in Hypertext Transfer Protocol Secure (HTTPS), that is, client - server and server - client, using X.509 certificates issued by Certification Authorities (CA).

Mail notifications are made using the Simple Mail Transfer Protocol (SMTP) protocol. For sending SMS notifications a commercial gateway is used, that provides the service of sending messages using HTTP requests of type POST for each request of sending.

The client (i) initiates the secure link by guaranteeing the origin of the connection to the server, this through the verification of the certificate in its trusted store. The server (ii) also verifies the certificate validity from the incoming connection, corroborating via Online Certificate Status Protocol (OSCP) with a trusted certifying entity CA (vi), guaranteeing the authenticity of the connection.

Additionally, a verification of the authenticity and integrity of the data received is carried out by means of the electronic signature attached to said data. This electronic signature must follow the XadES_BES standard [15]. It will also be possible to determine if the organization that is making the request has authorization to process the data attachment.

When the server (ii) makes a notification by SMS, makes a POST request to the SMS gateway (iii), including user credentials of the gateway, destination data and the attached text message. On the other hand, when the server (ii) makes a mail notification the SMTP protocol is used, allowing the notification to be sent from the mail server (iv) to the recipient of said notification (v).

D. ENP Clients

On the company's side, an ERP computer system has been considered, which should generate the different standards proposed in XML to send notifications of payments, send or update data and company templates and confirmations of payments, disabling these notifications. Likewise, the link to the WSDL must be made to obtain all the benefits provided by the web service, which will be available for the use of the different companies that request the notification service.

IV.   MDA APPROACH

In the development of web services, the technology used should be considered secondary, with the information and services that will be available for the treatment of said information being a paramount. The use of the MDA approach allows the increasing of the productivity of the developers by establishing an environment where efforts can be concentrated in the modeling tasks, independently of implementations in specific technologies.

MDA allows to design web services at a more abstract level than implementations for specific technologies. The web services developed with MDA present greater flexibility and agility in the aspect of technological changes, as well as a higher level of quality and robustness due to the more formal and precise domain specification [25].

On the other hand, MDA allows to support software systems throughout their life cycle for the benefits that it entails: the same PIM can be used several times to generate models in different PSM platforms; several views of the system or several levels of abstraction can be expressed in design; improvement in the portability and interoperability of systems at the model level; preservation or uniform evolution of business logic in the face of technological changes or evolutions; prevention of manual development prone to errors; ease of migration towards implementations with other technologies [26].

An MDA approach has been considered for ENP development, given the characteristics and benefits of its use. This allows to apply the domain of this study according to the specific needs of each organization, independently of the platform or language to be used for its implementation, allowing the generation of source code automatically through transformations.

The domain of electronic notification systems to which this study applies may be subject to change, so the MDA approach allows the extension of the capabilities of the ENP, along with an already established model; therefore, saving effort and time.
In this study, a Model to Text transformation (M2T) has been applied, which allows generating the source code files in the JAVA programming language corresponding to the business and persistence layer of the ENP, based on the PIM, as shown in Figure 2

V.   XML STANDARD FOR SERVICES CONSUMING

The web services exposed by the ENP will process the requests that are made from ERP systems of each company. For this purpose, it is necessary to define a standard that will be used to structure the information of said requests allowing consuming the operations arranged in web services: register or update company information, receipt of vouchers for notification and confirmation of payments.

XML offers great advantages in communications between software systems. Since XML is a text-based meta-language, it allows to create structures that describe information with defined semantics. It is also a platform independent method to describe data that is readable by humans and machines (unlike binary encodings). Since it is expressed in a textual format it is independent of the language. Additionally, it allows to express the structure and
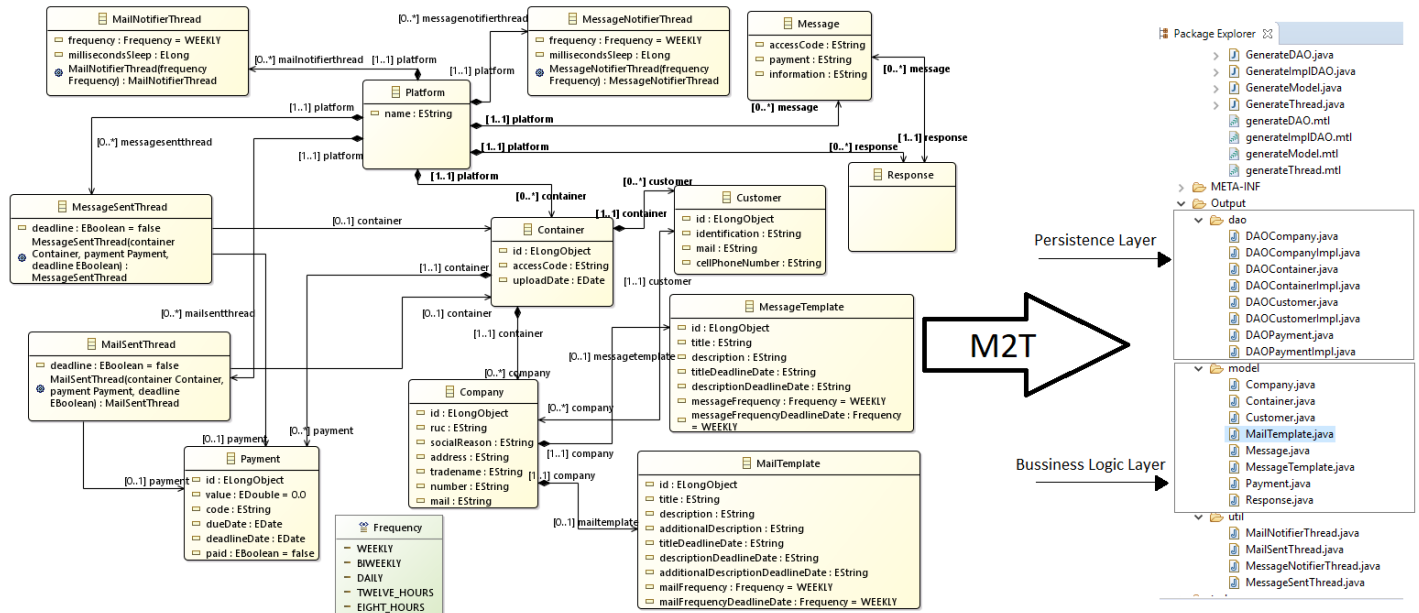
Figure 2: M2T transformation

relationships within the data using a Document Type Definition (DTD) or an XML Schema, allowing to validate that the data in XML is correctly structured to consume the operations of the web services [27]. Considering these benefits, an XML standard has been defined for each of the mentioned operations. As an example, a fragment of the register or update company information operation is shown in Figure 4.

VI. CASE STUDY

An implementation of the proposed architecture has been developed according to the technological issues and considerations. For this a prototype was integrated in a micro company. This company provides SaaS for electronic invoicing; however, they do not have an automatized mechanism for suitable communications for notification to their clients regarding debts. In this sense, for two months investigators have applied interviews to company personal, complementing with direct observations on daily workflow. [28].

After the implementation of the ENP, the employees confirmed with interviews some key aspects for validating the study. Labor charge has decreased generating greater reliability and efficiency because of the automatization. The proposed model for register the company data and upload the invoices allows populate and customize data according to the company requirements. Finally, the lot payment confirmations provided by the platform covers the collection

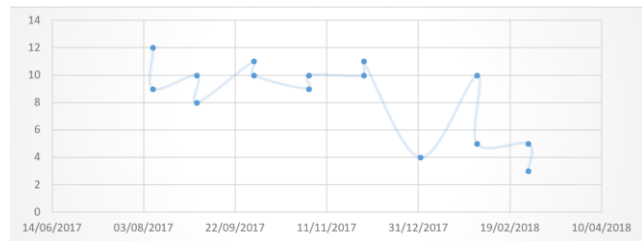process allowing a better integration with company ERP systems.

Figure 3. Trend of days elapsed in payments.

As results of the case study, Figure 3 shows the descending trend on number of days elapsed from notifying clients to the receiving the payment. The company has shown improvements on time saving since the sending of notifications about due payment. In the same way, investigators have observed more agility and less personal effort. Mistakes has been reduced and notifying associated costs were lower.

VII. ASPECTS TO BE CONSIDERED

The operations provided by the web service are performed asynchronously. The server response consists on Object Java Objects Plan (POJOs) that contain a list of messages, warnings or errors that could have occurred during the processing of the operation and may include information about the invoice and payment number in question if it is necessary.

The ERP client will be able to access the web service operations to register the information of the company and preferences about the notifications. They can also upload invoices that wish to notify to the clients, including contact information for the dispatch of email notifications and text messages. Finally, the payments can be confirmed when they have been made, so the system is constantly updated, furthermore concluding the process.

For all these operations, the standard established for each purpose is followed. Customers will not be able to upload their invoices or confirm payments if they have not previously registered their company information.

Parallelism is used for mail and message notifications, setting notification threads that act according to the time established in the preferences of each company. In each unit of work of the notification thread, the payments that are pending to be notified are verified in the database.


```xml
<?xml version="1.0" encoding="UTF-8"?>
<companyProfile>
  - <contactInformation>
        <ruc>0104638507001</ruc>
        <razonSocial>Edgar Andres Garcia Clavijo</razonSocial>
        <direccion>Popayan y Habana</direccion>
        <nombreComercial>GSOFT</nombreComercial>
        <telefono>2800416</telefono>
        <correo>collection@gsoft.ec</correo>
    </contactInformation>
  - <mailTemplate>
      - <overdueBill>
            <title>Overdue bill!</title>
            <description>GSOFT regrets to inform that the payme
            <additionalDescription>You have the following payme
            <notificationFrequency>DAILY</notificationFrequency>
        </overdueBill>
    </mailTemplate>
  - <SMSTemplate>
      - <overdueBill>
```

Figure 4. XML Standard Fragment

VIII. CONCLUSIONS AND FUTURE WORK

This study proposes an architecture that mark a milestone in the area of systems for sending notifications of payments on electronic invoices using cloud computing technologies, allowing companies to improve their portfolio recovery and maintain closeness with their customers.

The technologies and protocols mentioned in this study have been considered in such a way that this architecture could be implemented in worldwide public or private solutions.

As future work, it is proposed the extension of the system's capabilities, such as sending PUSH-type notifications, possibly using the Extensible Messaging and Presence Protocol XMPP protocol, Also, the architecture could be improved by the incorporation of a secure collection gateway that allows the company´s clients to make an online payment in a secure way, once notifications are received. Also, it is necessary to evaluate empirically the solution from several viewpoints (i.e., users, organizations, software architects).

IX. ACKNOWLEDGMENT

This research is supported by the research project DIUC XVII "Fog Computing applied to monitor devices used in assisted living environments; Case study: platform for the elderly people".

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