INCIDENT NOTIFICATION PROCESS AS BPAAS FOR ELECTRICITY SUPPLY SYSTEMS

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Abstract

Business Process Management (BPM) systems have been deployed in many large organizations to improve their business effectiveness and efficiency. Cloud based BPM systems have provided SMEs using BPM in a pay-per-use manner. Previous work has focused on looking at cloud based BPM from the perspectives of distribution of data, activity or/and business engine and related issues, such as scalability of system, security of data, distribution of data and activities. To achieve business agility business process collaboration needs to seamlessly connect local BPM systems and cloud based BPM systems. In this paper we look at BPM in the cloud from a new user perspective, how process models can be handled in the cloud for the fast pace of change of business collaborations. The paper proposes a distribution solution in which at the design time, the shared process model can be discovered from a process repository, and adapted to local needs; at run-time a process is distributed. A real world case is used to explain our design and implementation. Collaborative process for incident notifications is built to work across different organizations.

Keywords: Business Process as a Service, Incident Management, Business Process Mashup, Cloud Computing, Service-oriented Computing.

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1. INTRODUCTION

Industrial incidents are inevitable. Those related to our everyday life, such as power outages like the 2012 blackout in India (BBC News, 2012), will usually have strong adverse impact on the society and economy. These impacts are commonly measured as direct and indirect economic cost (La Commare & Eto 2004), (Lineweber & McNulty, 2001) where the latter is often large. For example, apart from enormous economic recovery costs, the nuclear accident at Fukushima has resulted in radical community reaction due to the lack of effective communications from main stakeholders (Secretariat, 2012).

The process of handling incidents, and specifically notifying stakeholders thereof, is a typical situational application that is not expected to occur often. Incidents generally involve multiple parties and to reduce the impact of the incidents, joined effort is needed. The *situational applications* handle business needs within a short period for a small group of users while the traditional BPM systems are supporting mission critical and core business of the organization (Balasubramanizm *et al.* 2008), (Pahlke, Beck & Wolf, 2010), (de Vrieze, Xu & Xie, 2010). In this paper, we therefore look at cloud based business process management for situational applications which are beyond traditional BPM systems.

The Internet as a conduit for information exchange has fundamentally changed how business is conducted. Cloud computing has enabled users to use computing resources in a pay-per-use manner and perceiving these resources as unlimited. At the cloud computing age, business process management systems have also adapted themselves into cloud environment. Business Processes as a Service (BPaaS) as a relative new concept, could be any type of business process that is delivered based on a cloud provisioning model. BPaaS can be seen as a new trend for Business Process Management (BPM). BPaaS can therefore classified differently according to the cloud based setting, i.e. Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Business process service can be further classified as a SaaS based Business Process Service, a PaaS based Business Process Service, and an IaaS based Business Process Service.

SaaS based Business Process Services provide the process oriented capabilities as a readymade solution that is more appropriate to smaller organizations. In this approach the customers use a cloud based BPM solution as a pre-configured system where all business processes are predefined or only slightly modified based upon simple configuration variables. SaaS based BPM allows for customers to forgo the need of specialist administration and up-front investments in soft and hardware.

When existing BPM systems migrate to cloud based platform services, business process engines run on cloud side, providing a sort of PaaS capabilities for all cloud users. Individual users specify their business logic and the specification, which are uploaded to the business process engine in the cloud for execution. The PaaS cloud provider provides execution, reliability and storage capabilities. The services of business process management for users are provided in a pay-per-use manner. Organizations that choose PaaS BPM do not have to buy expensive hardware and BPM software. No maintenance of the BPM platform is required. Multiple organizations share same business process management platform, each tenancy is responsible for its business logics or business process models though.

When existing BPM systems migrate to the cloud based infrastructure services, for the organization the only change is the hardware where the BPM systems runs. The organization still owns the business process management system, business process logics, process activities, and data. However, the organization does not need to do maintenance and updating of hardware, which is taken care by infrastructure cloud provider.

Due to the fear of losing or exposing sensitive data, cloud based BPM is at this time not widely adopted, and often only used on small scales. In this paper, we explore how cloud based BPM can be useful for enterprise needs. Especially we look at how a cloud based BPM can be applied for industrial incident management. The incident notification process is normally a collaborative process because industrial incident management most of time involves multiple parties. This kind of ad-hoc notification process is not supported by existing BPM systems.

The remainder of this paper is organized as follows, Section 2 discusses related work. Section 3 presents an incident notification case in the Spanish electricity system. Section 4 analyses the requirements and design principles of the incident notification system. Cloud based business process applications and new distribution patterns are discussed in Section 5. Design and implementation are discussed in Section 6. Service improvement and benefits analysis of our solution is presented in Section 7. We conclude our work and point out our future research in Section 8.

2. Related Work

Related work is addressed from two aspects: the aspect of process-oriented solutions for incident management and the aspect of cloud based BPM.

In our previous research, we have designed and implemented business process mashup for incident notification in a cloud environment. Paper (Jiang *et al.* 2012) looks at data as a service in a cloud environment. Our research includes the design and implementation of a business process mashup engine (de Vrieze *et al.* 2011) and lightweight business process modeling language (Xu *et al.* 2010) (Xie, Xu, & de Vrieze, 2010). Special attention is paid to the end-user aspect which is orthogonal to extending our designs for cloud based BPM.

In recent years a good amount of work on providing BPM capabilities in the cloud has appeared. It specially attracts SME (Small and Medium Enterprise), as they now can use scalable BPM services in a pay-per-use manner without incurring large maintenance costs (Buyya, Yeo, & Venugopal, 2008). Major IT vendors have begun to provide cloud based BPM services, such as Salesforce's Sales cloud, Market cloud (Salesforce, 2012), IBM's Blue Works (IBM,2013), Vitria's M3O (VitriaCloud,2013), and a solution based upon Amazon EC2 cloud (Amazon, 2013). These services are at different cloud levels.

There is also academic research on cloud based BPM. Han et al. (2010) present a design architecture for cloud based BPM with user-end distribution of non-compute-intensive activities and sensitive data. An analysis of optimal distribution of activities and data for synthetically utilizing is given from both user side and cloud side resource perspectives. Santos et al. (2012) and Anstett et al. (2009) discuss how to transfer a business process into the business processes for both user and cloud sides.

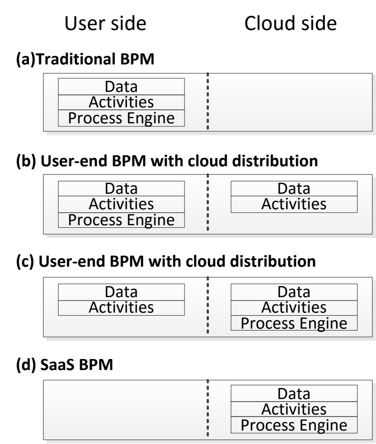

Figure 1.Cloud Based BPM Distribution Patterns Based on (Han et al. 2010), (Santos et al. 2012)

The previously mentioned papers (Han *et al.* 2010), (Santos *et al*. 2012) present a PAD (Process engine, Activity execution and Data) storage model that has been used to classified four types of BPM: traditional standalone BPM, user side BPM with cloud side distribution, cloud based

BPM with user side distribution and SaaS based BPM. In traditional BPM process engine, activity execution and data are local to organization of the user (see Figure 1 (a)).

For a SaaS based BPM, process engine, activities, and data exist in the cloud (Figure 1 (d)). For the user side BPM with cloud side distribution, it means that a process engine, activities and data (P, A, and D) are still running at the user side, and only distribute some compute-intensive activities and those parts of the data that are compute bound to it are distributed to the cloud to take advantage of stronger capabilities and better performance (see Figure 2 (b)). For cloud based BPM with user-end distribution, the process engine is in the cloud and the process models are enacted there, but activities can be run at the user side for sensitive, or local, data (see Figure1 (c)).

3. SUPPORTING CASE

In order to demonstrate how the proposed solution can be used to support incident management we provide a case study addressing power outages (i.e. `blackouts') in the Spanish national electricity system.

3.1 SPANISH ELECTRICITY SYSTEM AND KEY STAKEHOLDERS

A national electricity system is generally formed with of high-voltage electric power transmission network and grid connecting power stations and substations to transport electricity from where it is generated to where it is needed. In an industrial perspective, there are number of stakeholders in the system (see Figure 2): generators, distributors (also called network owners and operators) and suppliers, market operators, and system operators. The system operator is responsible for operating the nation's power transmission system and electricity grid. Red Electrica de Espana in Spain is the system operator and OMEL is the market operator (REE, 2012). Note that a utility company like Gas Natural Fenosa is both a generator and distributor in the system.

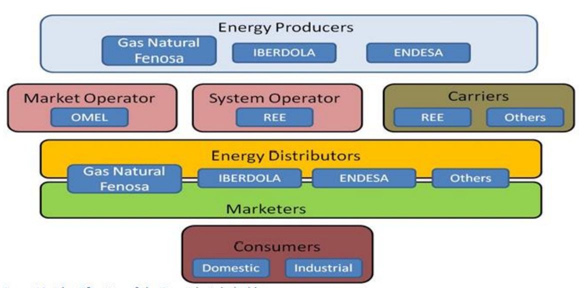

Figure 2.Stakeholders in Spanish Electricity System

The electricity transmission starts from power stations where energy is generated from various sources by generators. The production is later transformed to a high-voltage and transported to the system operator through the transmission network. After that, it is transmitted from power substations owned by distributors, through an output line substation, to a transforming center and is finally transformed to the needed voltage level for different consumption needs at the supplier level. Since electricity cannot be stored in large quantities, the whole process must work continuously without any interruptions. This becomes even more difficult when power is generated intermittently from renewable sources. Moreover, the system also needs to be balanced to make sure that the demand is met by supply at the same time.

Incidents and Issues in the Electricity System. The whole electricity system is complex so incidents can occur anywhere and anytime in the process of electricity transportation. These incidents, ranging from signal errors, cabling problems to serious substation overloads, will affect energy supply, lead to power cut or even generate huge impact to the community and economy. Incidents have to be coordinated at system level which involves the system operator and all energy distributors as the latter may use each other's network towers and substations to service their clients in affected regions. On the end-user side, larger industrial users are connected directly to the high voltage network. Because of the interruptible contracts (Baldick, Kolos, & Tompaidis, 2006) they must be notified of disruptions. However, domestic users normally interact with (electricity or power) marketers. The distributors, system operators, and distributors do not have the contact details of the domestic users. In the current systems domestic users are not notified of disruptions.

The problem lies in here: energy distributors, operators, and marketers face different markets and different responsibilities. They operate separate businesses and contain different customer and operational data. For the daily operation, there is no need to share certain data. However, when incidents/interruptions occur, there is need to notify not only industrial users, also domestic users.

4. REQUIREMENTS AND PRINCIPLES

Incidents can be singular acts, but can also consist of a number of related (sub-) incidents that each contribute to an incident. The notification of incidents or interruptions may thus need to involve different partners and their information systems. The function of the incident notification is important for consumer satisfaction of electricity supply, but does not belong to daily operations for any involved partners. It is used only for a few weeks. It is also very hard to predict when the incidents may happen. In any case incidents should not occur often for a single distributor view. However, on a country level, minor incidents could occur rather frequent, i.e. at least once per month.

To improve domestic customer satisfactions of the power supply services, this research is driven by the energy distributors. The energy distributors are looking for a solution which does not offend (electricity or power) marketers who possess the contact details of domestic customers, but may not have proper IT knowledge to quickly build and maintain an application which is not a daily operation for the marketers (there is a large variation in size of the marketers).

The proposed solution needs to collect data from different partners. There is no individual partner to take responsibility for it. The first priority is to identify what is the best way to create, deploy, and maintain the application. The owner(s) of the application should be a permanent stakeholder such as the market operator rather than those on fixed term contracts like marketers as their contracts may not get renewed. The system needs to be designed to allow for implementation with minimal maintenance required. At the same time local modifications must be possible to allow for marketer driven enhancements and innovation.

To meet the objective of combining data from various systems the proposed solution must work with many different systems from different partners which could use varying technologies, standards, data formats etc. Reliability of the proposed solution is an important factor that must be ensured. The proposed solution needs to be ready to create notifications as soon as a problem is detected. The solution should be rarely used but it must be tested regularly to ensure its reliability especially after changes are made to ensure they have not affected its operation.

Costs of the solution and the notification methods used are also a key factor and these will be considered when specifying the solution. Due to the nature of the problem (power loss) at least some of the notification options should work without general availability electricity. In some cases there maybe advance notice of the outage, e.g. work will begin on substations between 12am and 2am and power will be unavailable throughout, and notification systems that require electricity can be used before the power outage. During power outages, especially when advanced notice was not possible, options that do not need electricity should be considered to notify affected customers. However options that require power can still be considered as affected customers may visit places with power and see the notifications there. As the duration of the problem increases the amount of notifications used should ideally also increase.

The requirements can be listed as follows:

- The system must integrate data from different owners and from different systems.
- A list of affected streets addresses should be obtained.
- A list of the affected customers for one company should be obtained.
- The list of the affected customers should be checked.
- All data processing must be done in line with data protection laws.
- The information about the streets affected, the problem and forecast must be published on the marketers' website in order to allow customers without mobile, to have access to the information.
- All customers must be informed about the problem, not only the most important.
- All customers in the area affected must be informed as soon and accurately as possible about the incident with appropriate information on causes and timeframes.
- The information must be sent by mobile text.
- In case the problem cannot be solved in the estimated time the system must send the up-to-date information with the new forecast.

The principles and rationale behind our design are cloud principle, web principle, service-orientation principle, and reusability principle

Cloud computing provides business users the opportunity of offering different services in different forms for different requirements, i.e. SaaS for end users, PaaS application developers and IaaS for provisioning. Internet-based data management and computing facilities are the most popular functionalities delivered as cloud services. It also provides a scalable multi-user virtual community delivering cloud services, which use the Internet for controlled sharing and collaboration. Providing cloud services also move the maintenance pressure from individual partners.

A Web-based system is easy to extend; in principle every partners should be able to contribute effortlessly to the system either as a provider or consumer of information. The usage of the proposed solution must be as simple, smooth, and unrestricted.

The solution should support the collaborative process from several computing power to run a single task, transparently and coherently. The system also allows the transparent distribution of components over the network so that executing processes running in middle ware can be scaled across numerous physical servers which span across organizations over a cloud environment.

The cloud based BPM solution allows the integration of heterogeneous proprietary and legacy solutions through standards based common interfaces where they exist. Interoperability on the Web is platform and vendor neutral allowing all providers and requesters of information to participate on level playing field.

Service-orientation provides a broad design paradigm that provides separation of concerns on internet scales. It uses services as the basic building blocks of functionality. Service-orientation provides a way to think about the design of a solution in terms of services, service-based development and the outcomes of the services. The cloud based BPM solution aims at enhancing efficiency, agility, flexibility and productivity by positioning services as the primary functional elements.

The reusability principle involves the concept of reusability. In the process modeling field workflow patterns are regarded as reusable elements. A subset of workflow patterns has been adopted as basis of our process patterns and process templates (Xu *et al.* 2010) (Xie, Xu, & de Vrieze, 2010). Process patterns, process templates, process fragments, reference models, best-practice models, and further example models are provided in association with the process modeling language; these are all reusable.

Each involved partner can select a suitable process model which can be modified according to the situations. The process model can be downloaded from the process model repository and the improved process model can also be uploaded to the process model repository. The repository provides additional features such as tagging, liking and sharing to encourage discovery and reuse.

5. Cloud based Solutions for Situational Business Process Applications

When the main components of BPM systems are identified as PAD: Process engine, Activities, and Data in papers (Han *et al*. 2010), (Santos *et al.* 2012), (Anstett *et al*, 2009) different bases cloud BPM solutions can be seen in Figure 1. Business process models have been seen as an important organization asset and they are related with data and activities. Many times they could be independent with process engine. They provide business logic to process engine when, where, how and whom should process certain activities. In traditional BPM system, business process models do not change often after the BPM system deployed. However, building business process models rapidly is a key factor for implementing situational process applications. Therefore, we add business process model as an important component of BPM services after PAD and the ownership of each components. The cloud based distribution patterns of business process services is extended accordingly in Figure 3.

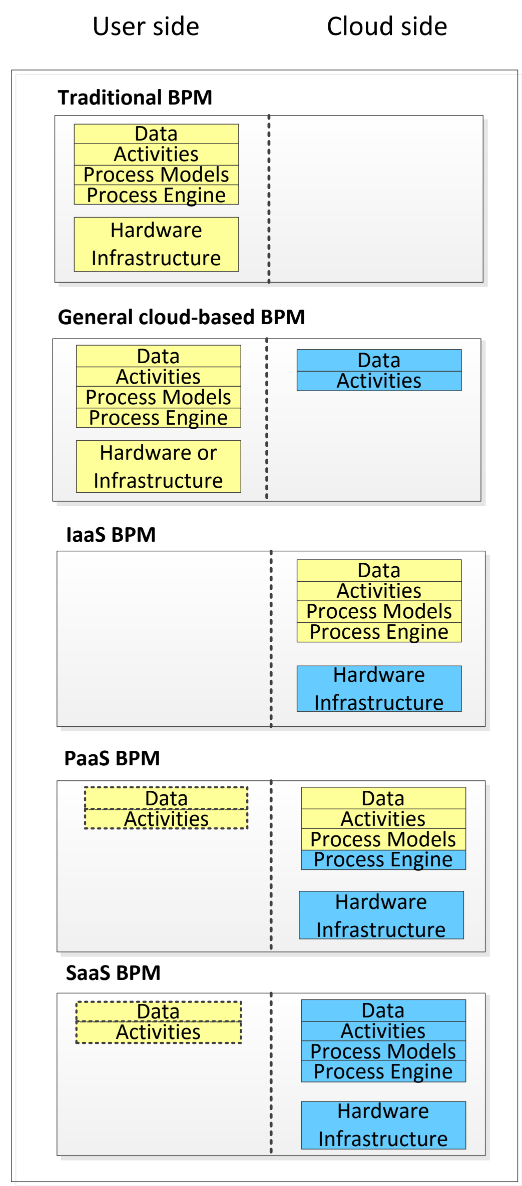

Figure 3.Cloud Based Business Process Management Services Distribution Patterns

Four main kinds of cloud based business process services are classified as general cloud-based business process services, IaaS based business process services, PaaS based business process services, and SaaS based business process services. The color of the box represents the ownership of each component. The components in a blue box mean that the components belong to a cloud provider; the components in a light yellow box mean that the components belong to each user/organization. The box with dish line indicates the optional.

As traditional BPM, the organization possesses the data, activities, process models (or business logics), process engine, and hardware and infrastructure which runs its BPM systems.

General cloud-based business process services just like the traditional BPM. The organization takes control of the BPM but also takes advantage of cloud computing and storage power for some compute-intensive activities and large data. Therefore the part of data and activities are in cloud.

In IaaS based BPM users migrates their systems from the local computing resources into cloud computing resources without any changes of the process models. Although data, activities, process models and process engine are running in the cloud, the individual organization holds the ownerships of them. The cloud provider provides BPM platform, and hardware and infrastructure for multiple organizations in the Paas BPM pattern. The each organization has itself data, activities, and process models running at the provider side. Some sensitive data and activities may still keep at the user side. The PaaS based BPM allows users/individual organizations to build change or extend their process models for their different needs.

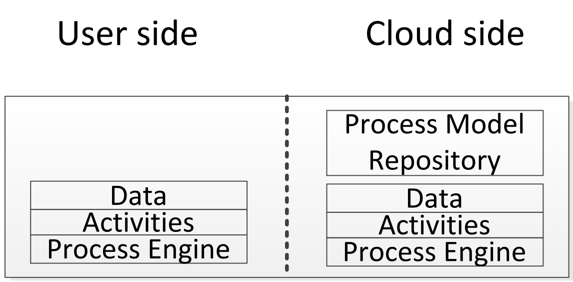

Figure 4 Hybrid Distribution Pattern for Incident Notification Services

A SaaS BPM, in which a BPM system is offered as a software service. Instead of having to buy hardware and software, the system is used in a pay-per-use manner. This cloud based solution can easily deal with scalability of the system, so that additional resources can be instantiated relatively easily in peak load situations. When the rush is over, the additional resource can be released. However, the fear of losing or exposing sensitive data in the cloud, the current cloud based BPM is adopted by some small scale of business department, e.g. adopting Salesfource for a sales department. Some of data and activities can belong to the users and running at the cloud. Another data and activities run at the cloud side. SaaS based BPM includes a fixed/semi-process model with limited flexibility.

In our solution for the incident notification in Figure 4, business process oriented mashup engines are distributed in the cloud and different partners. The process mashup engine is deployed by all distributors and marketers. It ensures that all involved partners can flexibly deal with incidents as they appear. The engine can also be used for different situational applications. Therefore, we include process mashup engine at both cloud and user sides. A process model repository is provided in the cloud together with a process editor at the client that joins both local and shared information. This cloud based editing (even in the local editor) uses social web features to promote collaboration and sharing of best practice models. Users can select a suitable process model from the process model repository to adjust for their own usage. The process editor can be used to view, test, and learn how the process model works, and can even be populated with historical data (if available).

6. Design and Implementation

Our lightweight process modelling language in (Xu *et al.* 2010), (Xie, Xu, & de Vrieze, 2010). is designed for business users who have a professional background knowledge and understanding of the tasks and processes they are trying to support, but who are not professional software developers (or modelers). These users cannot be expected to have received significant training in programming, modeling nor system design either. Because of the popularity of BPMN (Business Process Modeling Notation), we adopted BPMN symbols. Figure 5 shows the collaboration process model of the incident notifications. The problem case starts when there is a disruption in the electrical transmission grid which is the responsibility of Red Electrica de Espana (REE). This problem can affect one or several distribution substations. Almost instantly, both REE and the distributor substations are informed automatically of the failure by their operational systems called SCADA. The process can follow two paths.

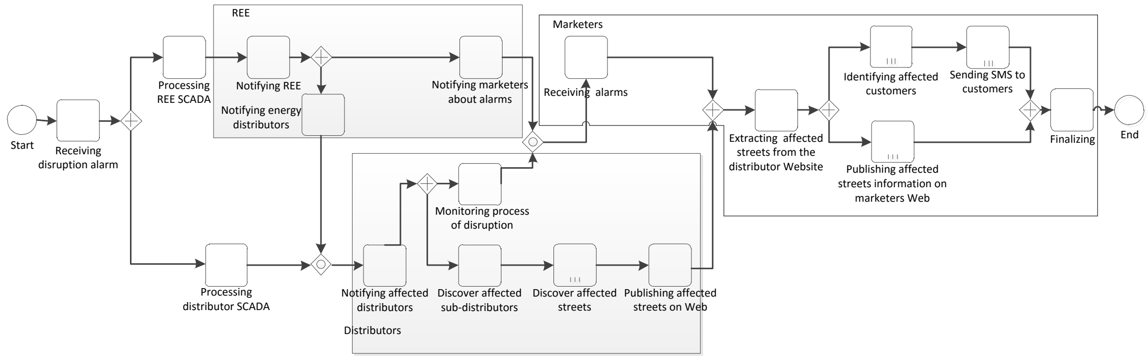

Figure 5. Collaborative Process Model of Incident Notification

There are two different ways in which the incident notification system can be triggered. In the first way, when the affected distributors are alerted about the failure, the distributors should obtain an approximate forecast about the time that the problem should be repaired. There are two operational systems BDI and SGC that in this case provide the information needed for acquiring the list of affected streets by blending those sources with the list of affected substations. At this stage, the distributor is able to publish the information on its web site. Only when this path is completed can the other processes could be completed.

Regarding to the other way, REE is alerted by its SCADA system about the disruption. Then, REE informs all the distributors, which can include the distributor-substation owner. Subsequently, distributors inform their respective marketers. At this stage, they have to wait until the affected-street-to-marketers list is published on the distributor web site.

Once the information related to a current incident has been released, marketers should extract the information of the all customers affected by combining the information extracted from the distributor system with their own customer data. Finally, the information will be released on their own marketers' website. Furthermore, the customer should receive a SMS or/and facebook/twitter message with the information about the problem and the repair forecast.

In our approach, we use a business process oriented mashup engine. The business process oriented mashup engines are deployed for all distributors and marketers. It insures that all involved partners can flexibly deal with appeared incidents and it can also be used for other situational applications.

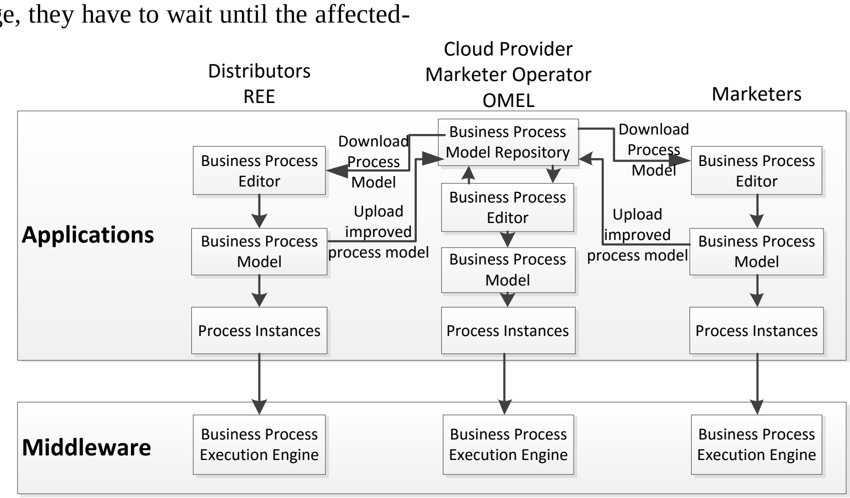

Figure 6 Architecture of Cloud Based Incident Notification Process

Figure 6 shows the architecture of the incident notification system. The information needed from both distributors and marketers is not big in terms of data size. But, where the information from the distributors' side is not commercially sensitive data, the data from the side of the marketers is.

Therefore, it is necessary to the part of the processing that uses customer data at the marketer side, and therefore to have the marketers to run a business process engine. For the incident notification purpose, the marketers could download a common process model from the process model repository on the cloud. Based on the downloaded process model, the marketers can modify the process model to adopt different notification channels, for example, beside to send SMS messages, Facebook messages are also sent. The marketers can use a local process editor to allocate the data (affected customers' mobile phone number, Facebook ID, or Twitter ID) and run the business process at local process-oriented mashup engine.

For the distributors, the incidents or interruptions can be caused or observed in different parts of the organization. Therefore, after download a sample process model, the model can be modified according to the situation. The process can keep monitoring the process of the repair and information is consistently published on the Web using the local process engine. The implementation process model is presented in Figure 7.

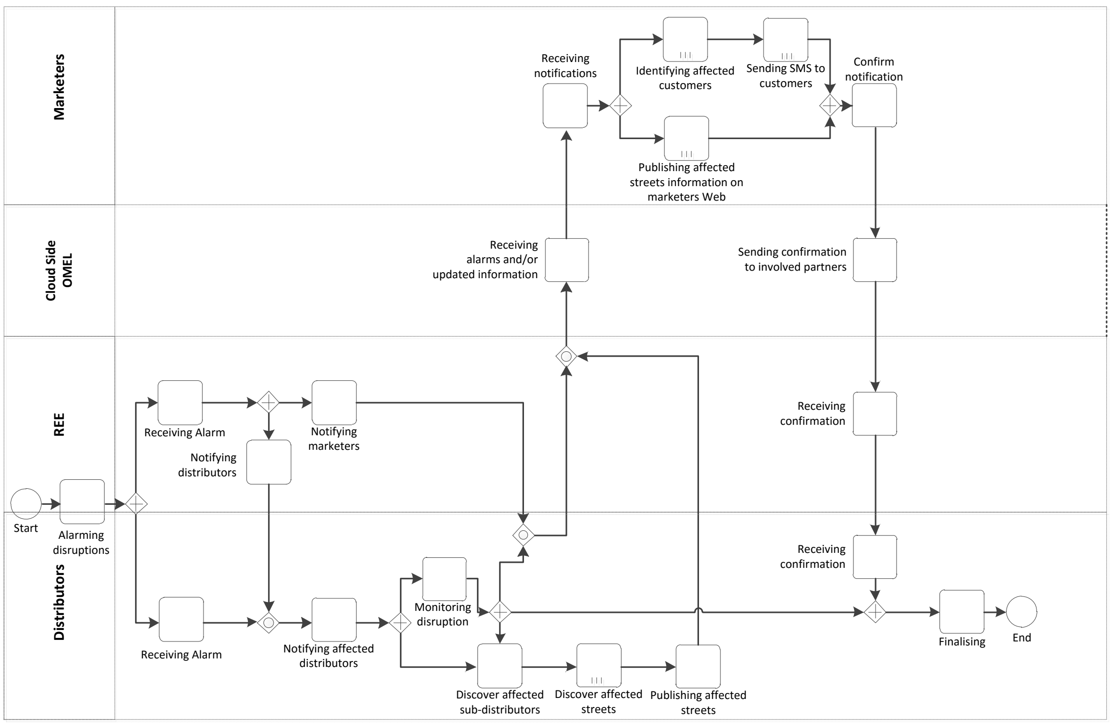

Figure 7. Cloud Based Incident Notification Process Model

The cloud provider mainly concentrates to maintain the process model repository and to provide some common web services. It also provides a process editor and a process engine for users testing the process model. The users are certainly able to upload their data for running their processes in case of the local process engine is out of order. A collaborative process which runs in the cloud can be supported for special cases, e.g. monitoring the collaborative process.

7. Service Improvement

As a prime example of this kind of incident, on 23 July in 2007 the Collblanch substation, owned by REE, suffered a fire. Around 320,000 people were affected by this incident, having energy cuts of between 6 to 60 hours. A lack of information for the population resulted in disturbances on Barcelona's streets. The population's dissatisfaction was felt by the Government and both companies implied REE and ENDESA. The fine was exemplary. Around 40 million Euros was demanded by the judge, and 21 million Euros by the Generalitat (Catalonia government). In addition, the National Energy Commission punished both companies. However, it is difficult to know the total amount of money spent on the incident and the impact concerning the customers' switch to other companies (Sanchez, 2007).

The current industrial recommendations for the SLA of call centre: Average handling time (AHT) should be between 4.5 and 6 mins. Agents wrap time: 10 seconds, means how long they can rest after a call. Speed of answer:

80% answered within 20 seconds and 90% answered within 10 seconds. A regional call centre has a staff of 1,200 (in total, including managers and shifts) and they take 70,000 calls a normal month. It indicates 2300 calls a day. For 12 hours call in a normal working time, the average call per minute is 3.24.

For an incident like we mentioned above. If we do not change the average handling time, the call rate changes from 0.054 calls per seconds into 8 calls per seconds or more. According Erlang C traffic model (Zeng, 2003), it means that the call centre needs over 2,300 staff when an incident occurs. If the call rate change into 8 calls per seconds and the average handling time is 2 mins longer, over 4,300 staff are needed to handle the calls.

In Erlang C traffic model, *m* specifies the number of staff in the call centre, *u* represents traffic intensity: $u = \lambda.T_S$ where λ is the average call arrival rate and T_S indicates the average call duration.

$$E_c(m,u) = \frac{\frac{u^m}{m!}}{\frac{u^m}{m!} + (1-p)\sum_{k=0}^{m-1}\frac{u^k}{k!}}$$

Table 1 presents our simulation results. There are three data groups. The first data group targets service level objective 60%, answer time is 240 seconds 4 mins, talk time is 300 seconds (5 mins), for processing 4 call rate per seconds (240 call per 10 mins) needs 1240 staff members; for processing 10 calls rate per seconds (600 calls per mins) needs 3100 staff members.

The second data group, if the talking time changes into 400 seconds (about 6 mins), for processing 4 call rate per seconds (240 call per 10 mins) needs 1640 staff members; for processing 10 call rate per seconds (600 call per 10 mins) needs 3690 staff. The third data group, we increase the taking time and reduce service level objective.

Number of staff	Call rate	Talk Time[s]	Wrap time [s]	Target answer time [s]	Service Objective [%]
1240	4	300	10	240	60
1333	4.3	300	10	240	60
1488	4.8	300	10	240	60
1550	5	300	10	240	60
1612	5.2	300	10	240	60
1736	5.6	300	10	240	60
1860	6	300	10	240	60
1922	6.2	300	10	240	60
2077	6.7	300	10	240	60
2170	7	300	10	240	60
2325	7.5	300	10	240	60
2480	8	300	10	240	60
2790	9	300	10	240	60
3100	10	300	10	240	60
1640	4	400	10	240	60
2050	5	400	10	240	60
2460	6	400	10	240	60
2870	7	400	10	240	60
3280	8	400	10	240	60
3690	9	400	10	240	60
2040	4	400	10	240	60
2550	5	400	10	240	60
3060	6	400	10	240	60
3570	7	400	10	240	60
4080	8	400	10	240	60
4590	9	400	10	240	60

Source: Fictitious data, for illustration purposes only

Table 1. The results of Erlang Cmodel simulations

So for an incident like we mentioned above, 320,000 people were affected. 600 calls per 10 mins is easily achieved. Therefore, the benefits of our solutions are obvious. First, it provides a centrally-organized notification process. Log files can be used as evidence for the future identifying of responsible partners in the case that customers are not notified. The distributors do not have access to contact details of domestic customers, but they are held responsible for informing customers by the government. This notification process depends very much on the efforts of the marketers. There is no effective mechanism for monitoring the marketers' notification efforts.

Besides solving the notification problem, as a second benefit, incident or interruption notification process models can be shared among distributors, REE and marketers. An improved process model can be uploaded by each partners and managed by the market operator OMEL. Third, the (Web) services related to the incident notification process can also be shared to improve performance. Multiple process mashup engines run at different sides, which also allow them to function as backups for each other. In general, a process-oriented solution will be able to significantly to reduce the communication time of domestic user awareness of the incident and related information.

8. CONCLUSIONS

Cloud-based BPM systems bring many benefits to business users. They provide a good opportunity for organizations which seek saleable and flexible solutions. Cloud-based BPM systems are not likely to replace all local BPM systems. To achieve business agility business process collaboration needs to seamlessly connect local BPM systems and cloud-based BPM systems. In this paper, we extend the PAD (process engine, activity, and data) model (Han *et al.*, 2010). A new user perspective is taken, i.e. not only process engine, activity and data can be distributed; in our new mode, business process models can also be distributed and adopted for different purposes. This extension is a big step for PaaS BPM. We have use incident notification process to verify our design.

Effective incident management can be considered as a more cost-effective solution to reduce the negative impact on the community and economy after an industrial incident occurs. From the end-user perspective, this relies on instant situation awareness and response. The core concept of the architecture is that it uses verified incident notification process models and a business mashup engine to help organizations respond to emerging situations triggered by incidents more intuitively. The architecture also supports on-demand and flexible situational applications which are used to address timely and immediate customer needs. The case study has demonstrated how the framework facilitates in solving a real world problem effectively. Whilst the implementation was based on the Spanish electricity supply system, it can also be applied to other national electricity supply systems especially for the European Union countries in compliance with Act 17/2007. Moreover, the situational application shown in the case study focuses on electricity incident management which can also be extended to other incident management areas where immediate collaborations based on data sharing and access are needed.

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