

## **OPTIMIZATION AND RE-ENGINEERING OF INTERNAL GREEK BANKING PROCESSES USING BPMN MODELLING AND ADAPTIVE KPIS ANALYSIS**

GEORGIOS MPARDIS

Department of Electrical and Computer Engineering,  
National Technical University of Athens, Athens, 15773, Greece  
[gmpardis@medialab.ntua.gr](mailto:gmpardis@medialab.ntua.gr)

VASSILIS NIKOLOPOULOS

Department of Electrical and Computer Engineering,  
National Technical University of Athens, Athens, 15773, Greece  
[vnikolop@medialab.ntua.gr](mailto:vnikolop@medialab.ntua.gr)

THEODOROS KOTSILIERIS

Department of Health & Welfare Units Administration,  
Technological Educational Institute of Kalamata, Kalamata, 2400, Greece,  
[tkots@teikal.gr](mailto:tkots@teikal.gr)

IOANNA LYKOURENTZOU

Department of Electrical and Computer Engineering,  
National Technical University of Athens, Athens, 15773, Greece  
[ioanna@medialab.ntua.gr](mailto:ioanna@medialab.ntua.gr)

IOANNIS GIANNOUKOS

Department of Electrical and Computer Engineering,  
National Technical University of Athens, Athens, 15773, Greece  
[igiann@medialab.ntua.gr](mailto:igiann@medialab.ntua.gr)

VASSILI LOUMOS

Department of Electrical and Computer Engineering,  
National Technical University of Athens, Athens, 15773, Greece  
[loumos@cs.ntua.gr](mailto:loumos@cs.ntua.gr)

In the past few years, the mass production of IT services and processes required for businesses to operate efficiently, have had important advances or improvements. It is therefore, often essential to

use technology for the evaluation of business processes, while these become continuously more complicated. The work that is presented in this paper is focused on the modelling and optimisation of business processes that a Greek banking organization follows, during the process of a loan request. These activities are modelled and then monitored with the aim to localize time-consuming processes, which cause delays to the total procedure. The basic modelling methodology that was used was the Business Process Modelling Notation (BPMN). Key Performance Indicators (KPIs) were used in order to measure BPMN-based processes of the loan procedure and smart web-based analysis was effectuated, using clustering algorithms in order to extract statuses that had volume, quality or time problems within the complete business process.

*Keywords:* BPMN; Clustering; Process Modelling; Re-Engineering; Key Performance Indicators.

## 1. Introduction

Our work focuses on the optimization of the approval process a bank conducts during the application process of small business loans. When the customer requests a loan from the internal departments of a bank, its application has the capability to slide from stage to stage after its initial submission, until the loan's final decision is made. The information system that has been created has as a direct aim the quantitative and qualitative follow-up of the process in question, through the creation and management of indicators (KPIs) in each status. An important attribute of successful process improvement efforts is the close relationship to the organization's business goals and objectives.

Once the business goals are defined, the organization has to accomplish the following tasks:

- Select a framework that will enable the realization of the goals and objectives.
- Select a process improvement approach.
- Develop and document a process improvement plan.
- Execute the plan with all of the management attributes that accompany any project.

There is a strong belief<sup>21</sup>, that the most effective and efficient way to satisfy more than one standard is to implement them simultaneously rather than sequentially. Such an approach enables process developers to capitalize on the commonalities between those standards and use the strengths of one standard to offset the weaknesses in the other.

Process improvement is a major undertaking for any organization<sup>24</sup>. It requires these tasks:

- Analysis of existing processes
- Changing existing processes
- Developing new processes
- Deploying new and modified processes through the organization
- Training staff to use new or modified processes
- Sometimes abandoning comfortable, yet inefficient old processes

Most organizations select an approach that will enable them to implement the selected standard(s) and then measure the effectiveness of the new processes. The most fundamental approach is Plan-Do-Check-Act (PDCA) cycle<sup>23</sup>. In the PDCA cycle, the existing process is compared to the selected (or required) standard or model. Based on the detected "gaps," the organization develops a plan for process improvement, updates or changes processes, measures the improvement, standardizes the new processes, and finally implements them across the organization. The cycle repeats until all goals are

achieved. With this definition, we move away from the rigid implementation of each clause found in a standard. We take standards as guidelines that have been developed using engineering and management fundamentals and the experiences of the standards writers and successful organizations. Thus, the standards empower the users to understand the concepts, practices, and values associated with effectively managing, developing, and delivering products and services. Using the preceding definition, all standards and models considered in this paper will be considered as frameworks.

The methodology that will be used will be applied to the Greek Bank Loan Application Process. Focus is placed on the following four axes:

- (i) Reduction in the duration of implementation of enterprising process
- (ii) Reduction of implementation time
- (iii) Reduction of cost
- (iv) Improvement of quality

## **2. Bibliographic Reference**

Business process management (BPM) is a concept tightly engaged with IT and Management, for many years, under various names and labels<sup>5, 28</sup>. During the period of client-server domination over enterprise software development, BPM tools were called workflow management systems<sup>1, 11</sup>. Vast research efforts on this field led to the so-called workflow engines<sup>8</sup>, including a distributed nature of the workflow engine. Based on a process definition a BPM tool can route work between process participants, no matter if they were human actors or computer machines. During that period, the Workflow Management Coalition - WMC<sup>29</sup> was formed with the aim of standardizing the architecture and interfaces of typical workflow systems. After that initial period, the WMC shifted towards enterprise architectures, and problems related to enterprise architecture integration (EAI) as it is mentioned in<sup>7, 17, 30, 27</sup>. As automatic management of business processes was seen as one of the cornerstones of advanced EAI solutions, leading EAI vendors started putting BPM engines on top of their EAI suites. Today's advanced EA concepts revolve around the idea of service-oriented architecture (SOA)<sup>3, 19</sup>. Not surprisingly, BPM again is seen as an important building block of SOA. Since SOA focuses on standards, the industry has witnessed a "BPM standards war" with Business Process Execution Language (BPEL) emerging as a clear winner<sup>10, 20</sup>.

## **3. BPMN Modelling and Architecture**

The Business Process Modelling Notation (BPMN) is the new standard to model business process flows and web services. Its definition has evolved over the years with its beginning being described as a way to manage processes on an ongoing basis and offsets it from BPR's one-off radical changes<sup>2, 4</sup>.

Ovum<sup>22</sup> declared BPM as a change management and system implementation methodology to aid continuous comprehension and management of business process that interact with people and systems, within and across organization, solidifying BPM as a

management tools for business process in 2000. BPM's use went on to establish its usefulness<sup>9</sup> as not only a tool for designing, enacting, and controlling operational process, but more importantly the executive and administrative controls that can be enforced that make it a key component to business process modeling and administration. Van der Aalst<sup>26</sup> had given the most comprehensive definition of BPM as "supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information," further connecting BPM from modelers to organizations, their administration, and of course their highly valuable asset, their customers.

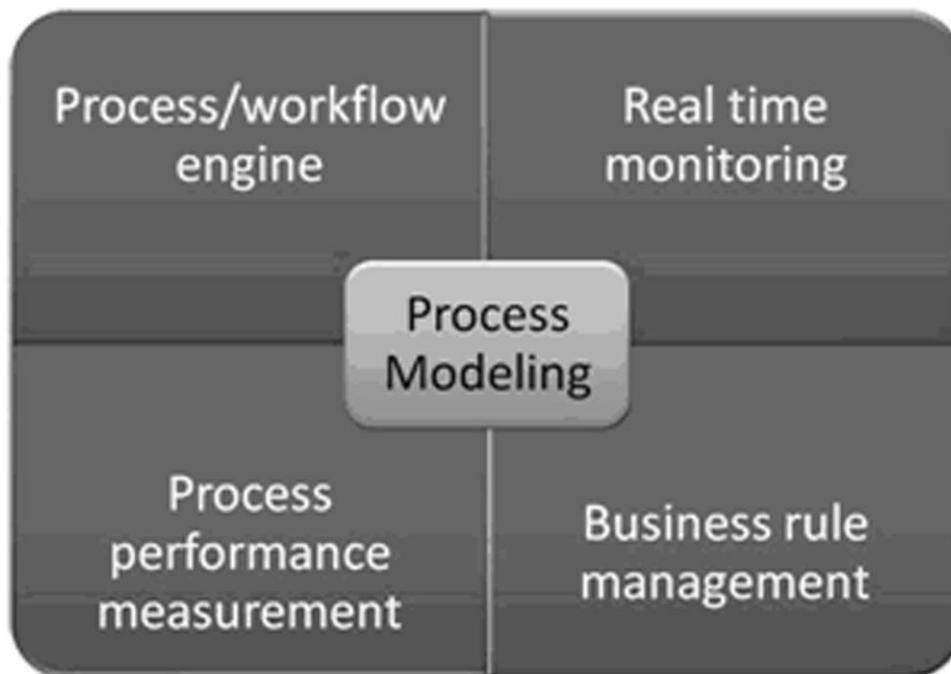


Fig. 1. Process Modelling Mix

The use of BPMN as the formalization language for contract-business processes is based on many features that make it advantageous to other similar languages such as UML, activity diagrams, and format colored Petri nets. BPMN offers flexibility because it uses two levels of information representation, graphical notation that makes it simple to understand and the use of BPMN constructs to define a set of attributes that allow it to be specific.

The ability to define attributes and user-specific activities and procedures makes BPMN the preferred option. The language's graphical nature makes it easily

comprehensible by both modelers and users. Maintaining this easily understandable format, BPMN's non-graphical attributes allow modelers the ability to map to Business Process execution languages.

#### **4. Loan Process Flow in a Greek Bank**

The specific BPMN diagram is completed by seven separate pools. A Pool represents a Participant in the Process. A Participant can be a specific business entity (e.g., a company) or can be a more general business role (e.g., a buyer, seller, or manufacturer). Graphically, a Pool is a container for partitioning a Process from other Pools, when modeling business-to-business situations, although a Pool need not have any internal details (i.e., it can be a "black box").

- In the first pool, the bank's client is modeled and the process of various loan applications is formatted.
- In the second pool, the Bank System pool, the loan application processing and approval procedure is designed. The orchestration pool acts as a central management entity of all other pools, made up of those responsible for the overall organization and communication.
- In the third pool, employee 1 pool, the bank employee responsible for the pre-approval phase is modeled.
- In the fourth pool, employee 2 pool, the employee that handles the pre-check phase is modeled.
- The fifth pool, Registration pool, is modeled for the user responsible for the registration of new application and communication with the bank pool via web service.
- The sixth pool, ACAT POOL, is completed by the bank's automated evaluation system that corresponds with the bank pool using the web service.
- The seventh pool, consists of a mail system that the bank system pool uses to correspond with clients

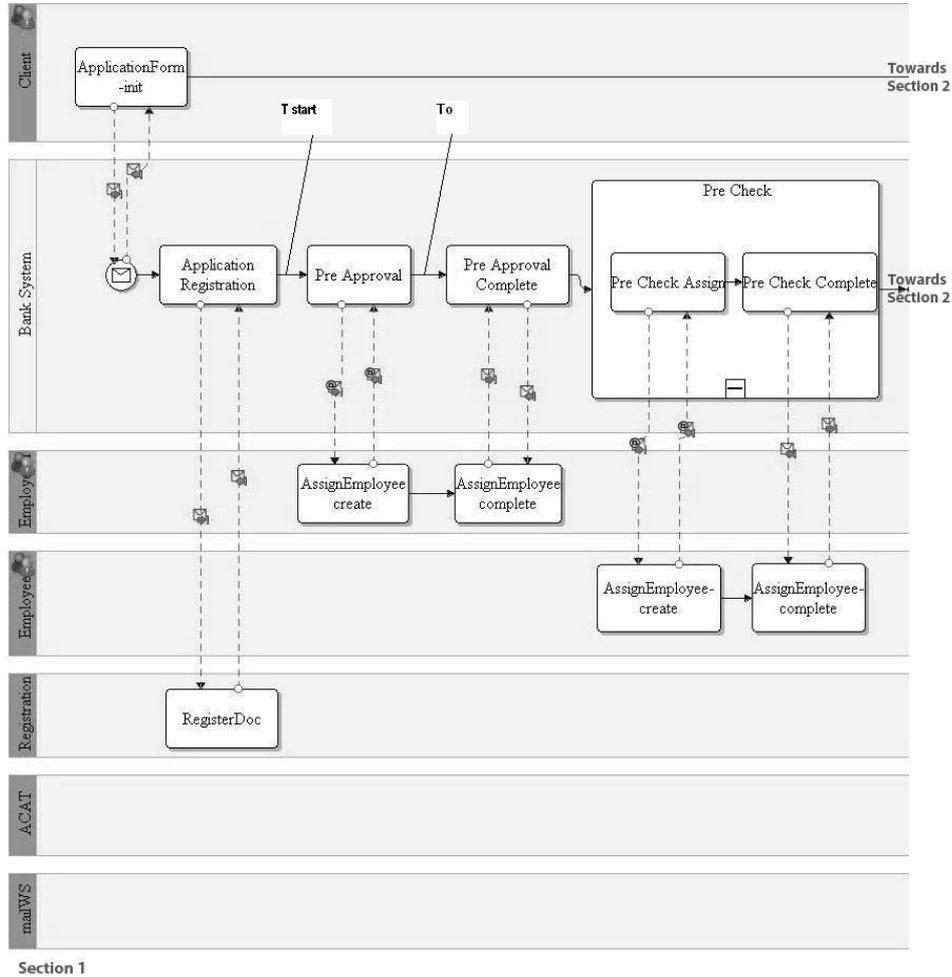


Fig. .2. 1<sup>st</sup> Section BPMN Model for Greek Bank Loan initiation

The client, from the client pool, completes an Application form on the internet. In this way, a request for a loan product from the Bank is initialized. The Bank system pool, after receiving the application request, communicates through web service with the RegisterDoc pool in order for the client's application to be archived. At this time, (Tstart), the application enters the "Pre-Approval" phase. This phase is conducted by the Bank employee, Employee 1. The moment the "Pre-Approval" phase is completed (To), the application is then forwarded to the "Pre-Check" phase, where the employee in position Employee 2 completes this step.

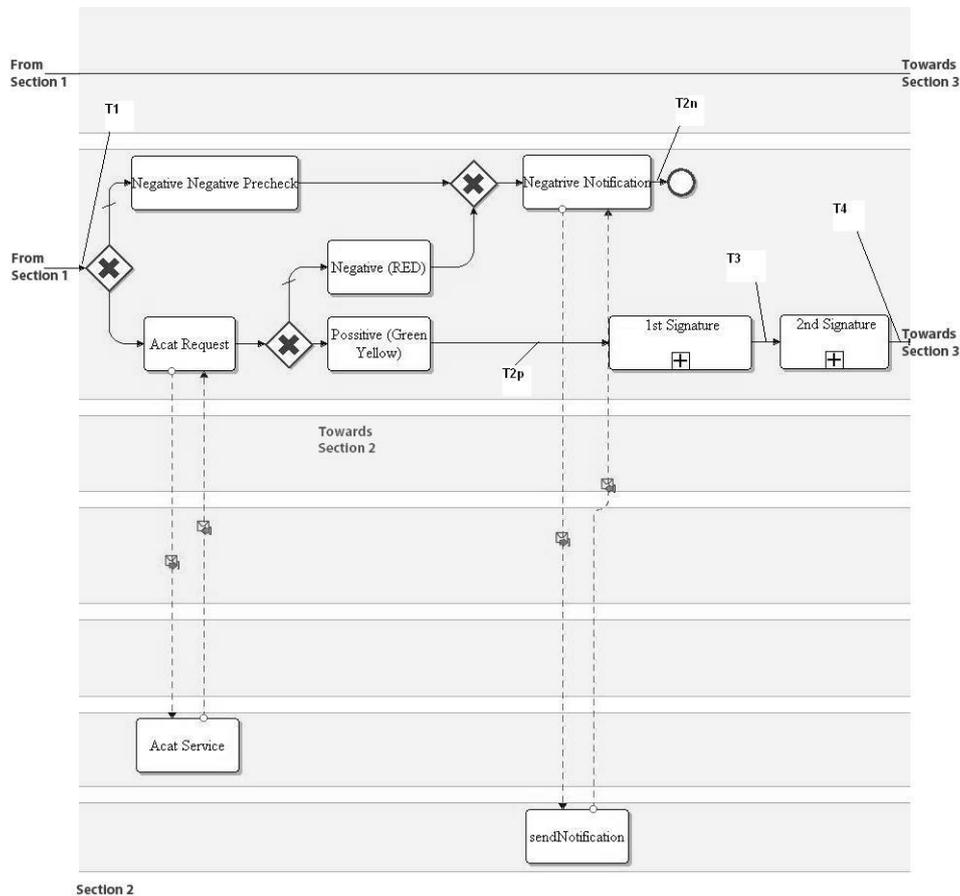


Fig.3. 2<sup>nd</sup> Section BPMN Model for Greek Bank Loan initiation

From there (T1), the application is either approved, where the application will continue on to the automated evaluation process, ACAT, or will be denied and therefore continue on to automatically generate a letter of rejection that will be sent to the clients email, (T2n) . The ACAT system is made up of an automate evaluation system belonging to the Bank, which checks the credibility status of each uses and automatically designates one of three statuses to each application, (Red, Yellow, Green). In the context of this specific project, the ACAT results were provided. Application with a Red status was sent to T2n, therefore a rejection email was sent. Application with a Green Yellow status, T2p, advanced to the first signing, T3. After the first signing, the application continues to the second signature, T4, where the final evaluation takes place, Approval or Rejection.

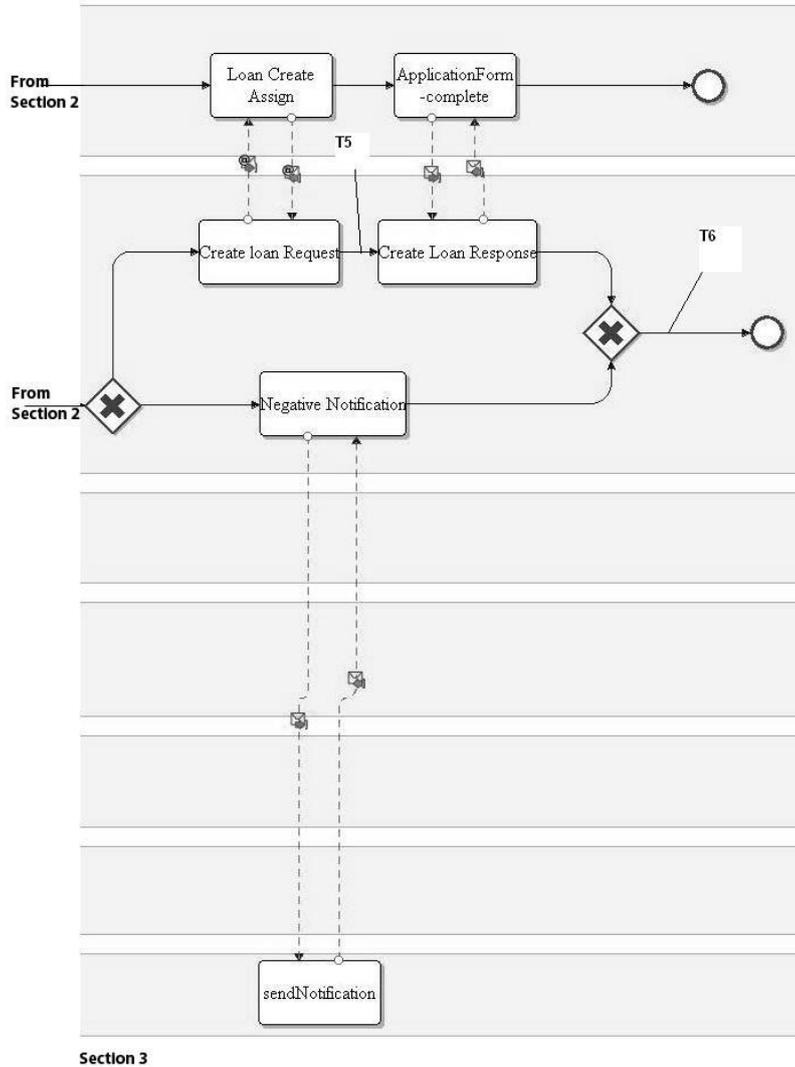


Fig.4. 3<sup>rd</sup> Section BPMN Model for Greek Bank Loan initiation

After the final signature, the bank branch informs the client in regards to their application status, T5, and the process is completed at point T6. The modeling of the whole of activities is actualized using Intalio designer. Intalio|Designer<sup>12</sup> is built on top of the popular Eclipse platform. It is a collection of Eclipse plugin, and runs on any of the many operating systems supported by the Eclipse workbench, including Linux, Mac OS X, and Microsoft Windows. Intalio|Designer has a very modular architecture, with core modules being part of Intalio|BPP Community Edition. Intalio|Designer provides an environment where deployed processes are just one click away, literally. Once a BPMN process has been modeled, bound to external systems and linked to workflow tasks – all activities

performed through intuitive graphical metaphors and simple wizards -- a single click validates the process, generates the code, checks for all dependencies, deploys all artifacts onto Intalio|Server. Intalio|Server<sup>13</sup> is a native BPEL 2.0 process server based on the J2EE architecture and certified for a wide range of hardware platforms, operating systems, application servers, and database servers.

The proposed system will help in the synchronized selection and effective correlation of all information, so as to result in the creation of a centralized knowledge base, through the dynamic depiction of important KPI Networks. The key, for the successful system application for web-KPI monitoring, is the equitable choice of measurement indicators of record and their corresponding statistical significance, in order for these to reflect the strategy and the objectives of Piraeus Bank, via the central Loan methodology. The system will provide information and knowledge so much for time indicators of lending flows (Timestamps KPIs) as for, Quantitative indicators (Volume KPIs) and Qualitative indicators (Quality KPIs). The correlation of the three categories, that will be achieved via the proposed system, will produce a dynamic system of Decision-making (Decision Support System) where the user will be able to make decisions based on the connected KPIs.

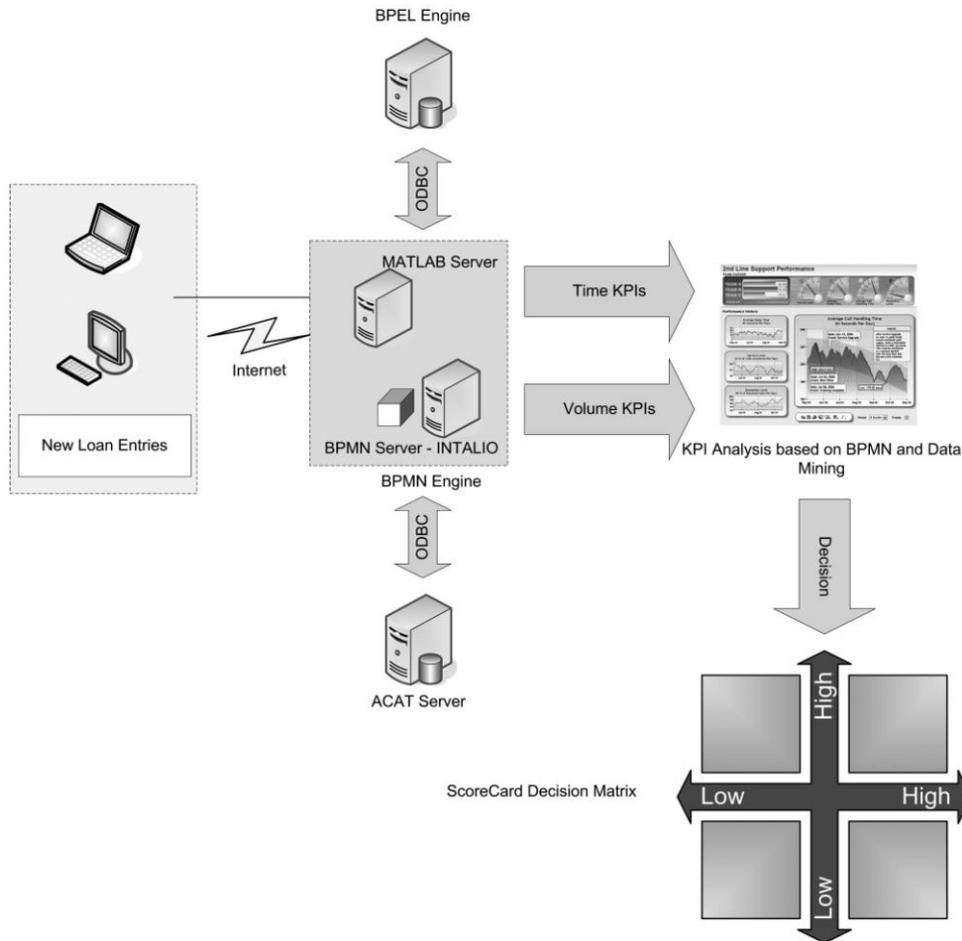


Fig.5. Greek Bank Loan Business Flow Technical Topology

The total of available information as well as the access in all the sub-systems of the new web-KPI system of Piraeus Bank will be achieved by a specific Web Portal which will be accessible via the Bank's Intranet by all users, according to the rights of use and access that the Bank has designated. The breadth of information is explicitly sufficient that it does not emanate only from one system, but is found to be collected from various external sources and relevant databases. More specifically, according to the actualized architectural structure (Fig.5) of the information systems of the Bank, the information that is used for the catering of currently-used system web-KPI is found mainly in external DB systems of the Bank and the ACAT database system, from where a credibility status of the application is generated automatically, according to the Bank's internal Data warehouse system. The core of the system is the central Business Logic server, based on Matlab with the BPMN Intalio Server Engine. As soon as a loan request is made, the BPMN model generates some BPEL outputs that are analyzed by the Business Logic middleware (Matlab) according to some specific Key Performance Indicators that are

explained below. The KPI analysis creates a dashboard of results and some graphs in order to assess the KPI performance and produce some reasonable decision, based on the k-means clustering algorithm, as first presented and introduced by Chernoff, H. and McQueen, J. <sup>6, 18</sup>.

#### **4.1. Dynamic Monitoring and Metrics (KPIs)**

For the modelling and the assessment of the Loan process effectiveness and in order to model in the best way the analyzed simulation results, some specific Key Performance Indicators were derived. The KPIs were divided into three distinct sections. Section A comprised of Time-relevant KPIs, Section B comprising of Volume-related KPIs and Section C was a combination of the two above to create some Quality KPIs. The calculations were based on the BPMN model that was generated (Figs. 2-4) and simulated on the BPMN workflow engine, using BPEL language and back-end database system.

#### **4.2. Timing KPIs**

Four Time-related KPIs (Table 1) were used, in order to measure the time delays in between several statuses in the overall BPMN model. The time measurements were executed on the workflow engine, using BPEL coding and a MySQL database in order to store and analyze the timestamps. TA represents the overall approval time for a specific application (i) in a specific branch of a Bank (j). A summation series was used to measure the overall delay from the initial loan request (T0) up to the final contract status for a loan request. TR represents the overall rejection time for a loan application that due to problems is rejected by the bank employee; TD represents the application queue delay metric that represents the fractional delay factor between two important process flows: 1) the process of creating a loan request after the application is being approved over the two signatures processes. This fractional time indicator will measure and compare at the same time the two most important and time consuming processes in the loan request procedure. Finally, the TC metric will measure the final contracting time for every application. The combination of the contracting time with the overall delay and the delay metric, will reveal the cause of any specific delay in the overall process and indicate the employee that should speed up its individual performance.

Table 1. Time Key Performance Indicators

Description	Time KPI
Overall approval Time ( $T_A$ ) per Application (i) per Bank (j)	$\sum_{i,j} [T_A]_{i,j} = \sum_{i,j} ([T_{2P}]_{i,j} - [T_0]_{i,j}) + ([T_5]_{i,j} - [T_3]_{i,j}) \quad (1)$
Overall rejection Time ( $T_R$ ) per Application (i) per Bank (j)	$\sum_{i,j} [T_R]_{i,j} = \sum_{i,j} ([T_{2N}]_{i,j} - [T_0]_{i,j}) \quad (2)$
Application Queue Delay Metric ( $T_D$ ) per Application (i) per Bank (j)	$\sum_{i,j} [T_D]_{i,j} = \frac{\sum_{i,j} ([T_5]_{i,j} - [T_4]_{i,j})}{\sum_{i,j} ([T_6]_{i,j} - [T_{2P}]_{i,j})} \quad (3)$
Contracting ( $T_C$ ) per Application (i) per Bank (j)	$\sum_{i,j} [T_C]_{i,j} = \sum_{i,j} ([T_6]_{i,j} - [T_5]_{i,j}) \quad (4)$

### 4.3. Volume KPIs

Regarding the volume metrics, four Volume-related KPIs (Table 2) were used, in order to measure the volume delays in between several statuses in the overall BPMN model. According to Fig.6, the basic metric unit is the application of a loan. According to the assessment procedures, the application may be rejected, or even blocked in a later stage of the overall process.

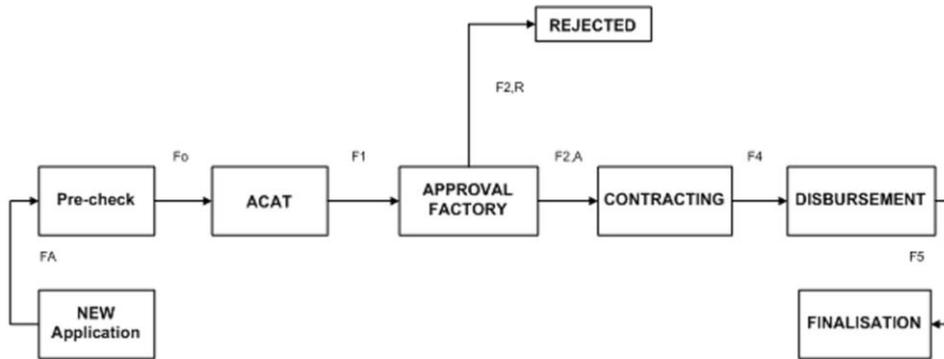


Fig. 6. Volume KPI Metrics Topology for a Loan Process

Volume KPIs were constructed to measure and count the overall numbers of applications. FA represents the initial application pool of a specific branch (j). FPR denotes the per cent fraction of the pre-checked applications over the initial one. This will give a first quality indication on the efficiency of the application procedure. FR is the percentage of the rejected applications and FC denotes the final loan contracts that were processed by some successful applications. Volume KPIs will be combined with the time metrics in order to produce good quality KPIs to assess the quality of the loan procedures and by definition the quality of the employees taking part in the processes in various statuses and parts of the BPMN model.

Table 2. Volume Key Performance Indicators

Description	Volume KPI
Total Applications Processes ( $F_A$ ) per Bank (j)	$\sum_{j \in N} [F_A]_j$ (5)
% of Pre-Check Efficiency ( $F_{PR}$ ) per Bank (j)	$\sum_{j \in N} \left( \left[ \frac{F_O - F_A}{F_A} \right]_j \right)$ (6)
% of Rejection ( $F_R$ ) per Bank (j)	$\sum_{j \in N} \left( \left[ \frac{F_{2R}}{F_1} \right]_j \right)$ (7)
% of applications actually processed by contracting ( $F_C$ ) per Bank (j)	$\sum_{j \in N} \left( \left[ \frac{F_4}{F_{2A}} \right]_j \right)$ (8)

#### 4.4. Overall Quality KPIs

Quality KPIs evaluate the combination of the delay metric and the volume metric. According to Table 3, three quality metrics were produced, that will take part in the decision process according to some clustering algorithms. Q1 represents the % ratio of accepted applications over the acceptance time. Denotes the quality of the loan acceptance “speed” and should be higher than the rejection quality metric, in order for the branch to have a positive ROI. Q2 represents the % ratio of rejected applications over rejection time. A small value denotes problematic employee performance (low number of loan application requiring big time intervals to be rejected) whereas high number also must be examined since the rejection status would be very “quick” to be analytic. Finally,

Q3 denotes the overall quality metric of the loan process, by a multiplication of the basic time delay metric (TD) and the number of final contracts from the successful applications. A high number denotes a rather problematic process with many loans but huge delays. An average number should be the target for any branch but combinations will be made in order to correlate the workflow simulation results.

Table 3. Quality combined KPIs

Description	Combined Quality KPI
Ratio of applications Accepted per Acceptance Time (Q <sub>1</sub> )	$Q_1 = \sum_{j=1}^n \left( \frac{F_{2A}}{T_A} \right)_j \quad (9)$
Ratio of applications Rejected per Rejection Time (Q <sub>2</sub> )	$Q_2 = \sum_{j=1}^n \left( \frac{F_{2R}}{T_R} \right)_j \quad (10)$
Total Quality Application Metric (Q <sub>3</sub> )	$Q_3 = \sum_{j=1}^n \left( F_5 * T_D \right)_j \quad (11)$

Based on the above metrics, the overall model was simulated using the Intalio workflow engine, the BPMN model and BPEL code. The various statuses and timestamps were stored in a relational MySQL database, in order to be accessible for analysis and clustering application.

## 5. CASE Study to the Greek Banking Sector

### 5.1. Bank Loan Workflow Simulation

The simulation used over 320 loan applications in 34 different branches all over Greece. The results were stored in a central database, as mentioned and analyzed using matlab and BPEL code. In Table 4 we can see a snapshot of the simulation of the loan application 19365 in the bank with code 2254 for a specific client (4208888). The branch was based in Athens. As it can be observed, various employees are taking part in the process (F823, N019, etc) and each one with a time. The difference between the various timestamps, give the values for the time KPIs inputs, The ACAT process is the fastest, because it is generated by a computer. All other statuses are generated by employees. Volume KPIs are stored by calculating the average numbers of the initial loan application volumes. The example below is completed with a final approval for a loan that took approximately 8 days. This is a big number and a low performance for the specific bank. As it can be seen, the biggest delay was caused by the 1st signature appointment.

Table 4. Loan Applications for one Bank (j=2254)

Application Code	Timestamp	Status	Descr_Status	User	Bank Code	Client
19365	2007-07-03-15.14.39	0	In Progress	F823	2254	4208888
19365	2007-07-04-15.39.17	1	Pre-approval	F823	2254	4208888
19365	2007-07-05-08.58.59	12	Pre-Check	N019	2254	4208888
19365	2007-07-05-08.59.11	14	ACAT Process	N019	2254	4208888
19365	2007-07-05-08.59.49	15	YELLOW (ACAT)	ACAT	2254	4208888
19365	2007-07-11-15.43.52	2	Assessment (1 <sup>st</sup> signature)	F146	2254	4208888
19365	2007-07-11-15.43.57	18	Towards 2 <sup>nd</sup> signature	F146	2254	4208888
19365	2007-07-11-15.44.10	19	2 <sup>nd</sup> signature	F146	2254	4208888
19365	2007-07-11-15.44.19	9	Approval	F146	2254	4208888

This delay can be seen in Table 5 below, where all KPIs were calculated for the above Bank and for other 4 branches of the same bank. For the above branch (j=2254) TA metric has a value of 34,51 indicating an overall delay in the process. This is also the reason why all three quality metrics have rather average values. Branches 2277 and 2081 have a very good performance in terms of delay and volume efficiency.

Table 5. KPI Table for several loan Applications for j=5 branches

Bank j	Timing KPI (hrs) ( $T_A, T_R, T_D, T_C$ )				Volume KPI (%) ( $F_A, F_{PR}, F_R, F_C$ )				Quality KPI ( $Q_1, Q_2, Q_3$ )			Client Loan Apps (i) per day
2254	34,51	11,58	0,58	0,31	21	0,95	0,15	0,91	0,5	0,25	10,44	21
2277	27,54	9,58	0,64	0,28	35	0,91	0,19	0,98	0,65	0,31	19,84	35
2081	19,59	5,57	0,54	0,21	32	0,95	0,13	0,93	1,42	0,53	15,12	32
2105	31,14	8,45	0,38	0,55	45	0,88	0,076	0,94	1,28	0,59	14,82	45
2189	29,45	14,54	0,45	0,47	15	0,97	0,12	0,98	0,47	0,13	4,95	15

The above results can be seen in the graphs below. The 1st branch has indeed a problem and by using drill-down procedure, we can identify the employee F146 had huge delays in serving the signature requests. According to Fig 7 (i), branches 2, 3, 4 had the best performance in terms of the first two time metrics and the relevant volume of the initial applications.

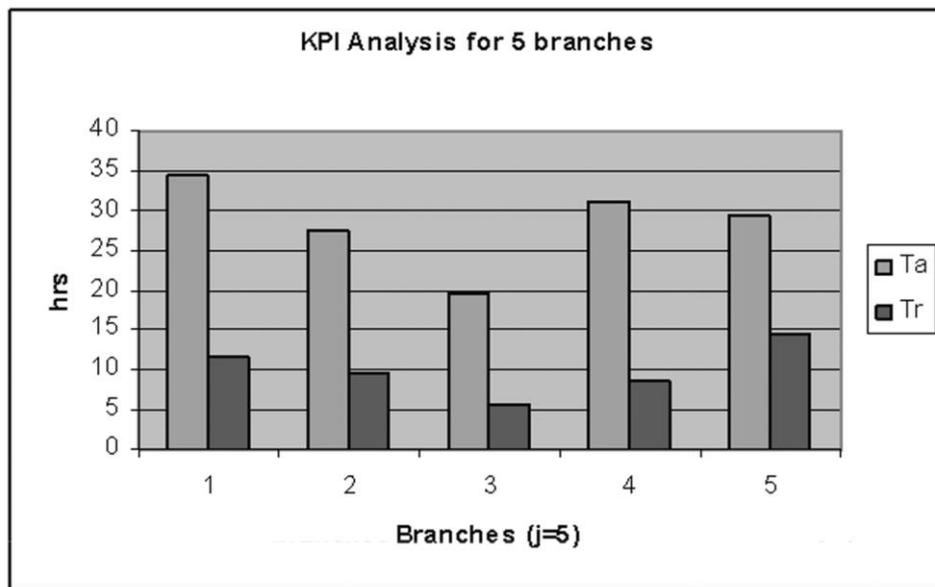


Fig. 7 (i). Time KPI Metrics Ta and Tr for 5 branches

According to Fig 7 (ii) the other two time metrics differentiate the last 2 branches. TC having higher values denotes that clearly there is a big delay in the contracting stage. This is assured by the low value of TD (quick signature process, low contracting process).

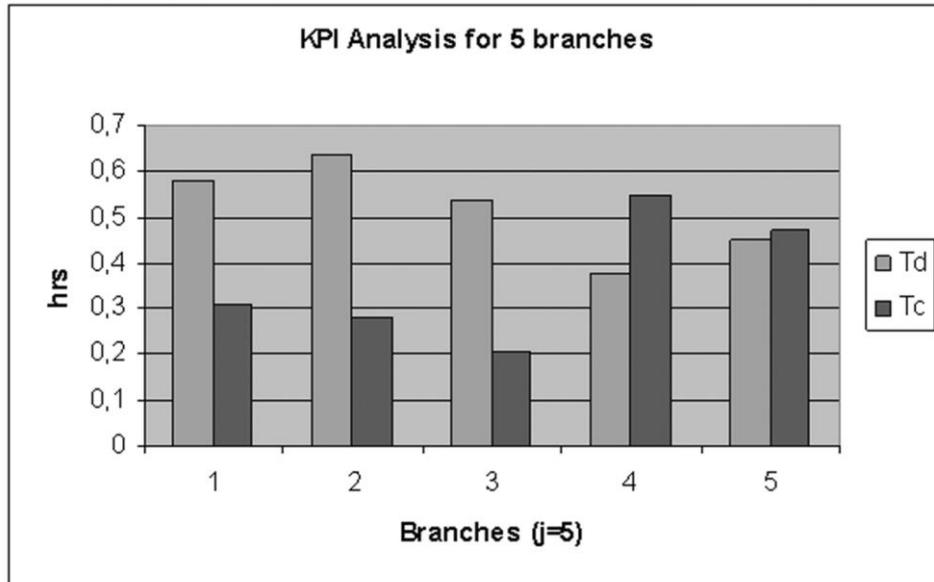


Fig. 7 (ii). Time KPI Metrics Td and Tc for 5 branches

Also, having high acceptance time and relevant low rejection times (Table 5,  $j=2105, 2189$ ) it can be said that the employee responsible for the overall delay is the one seating in the contracting stage. The rejection stage is rather good for the branch  $j=2105$  but for the second branch ( $j=2189$ ) the overall delay is also caused by the employee sitting just before the rejection stage (Pre-check status). The above comparative statistics are very important in order to reach a decision for a future optimization or re-engineering of the process, or even to design specific seminars for the employees that cause those performance problems. The decision cycle is even more compact, if specific clustering algorithms are incorporated in the overall analysis procedures<sup>14, 15</sup>.

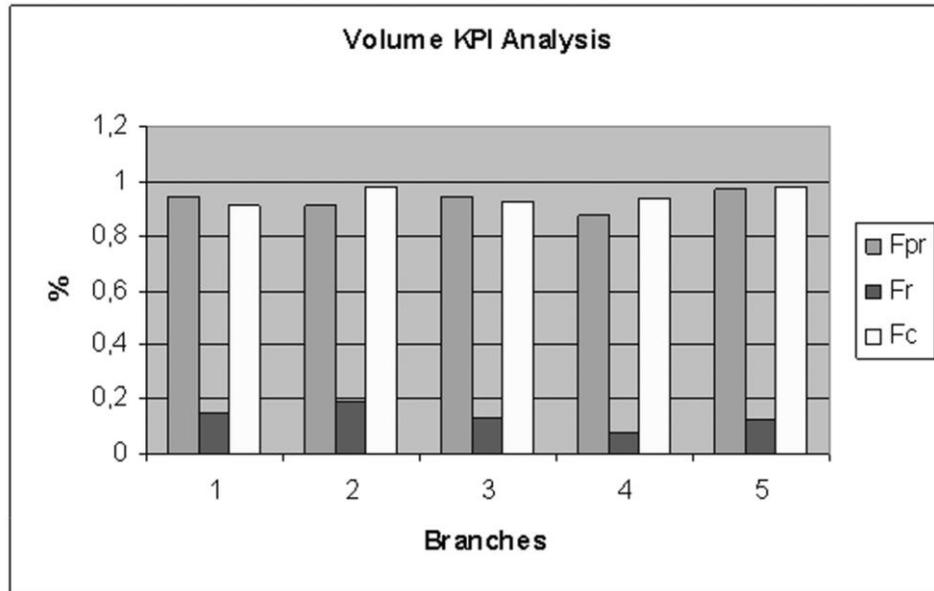


Fig. .7 (iii). Volume KPI Metrics Topology for a Loan Process

## 5.2. Quality KPIs Clustering and Decision Making

Clustering is an important tool in data mining and knowledge discovery and many algorithms exist in order to apply clustering approach to a set of data. The ability to automatically group similar items together enables one to discover hidden similarity and key concepts, as well as to summarize a large amount of data into a small number of groups. However, a drawback of such algorithms is that they tend to be computationally expensive. K-means is the simplest and most commonly used algorithm employing a squared error criterion as in McQueen<sup>18</sup>. Several variants of the k-means algorithm have been reported in the literature<sup>16</sup>. Some of them attempt to select a good initial partition so that the algorithm is more likely to find the global minimum value. Another variation of the k-means algorithm involves selecting a different criterion function altogether. Thomassey<sup>25</sup> used clustering and decision trees for sales forecasting. In this paper the k-means clustering algorithm was used for process performance assessment for re-engineering services provision.

According, to Fig 8(i) k-means was executed on the database outputs (the same data for the KPIs), using the BPEL simulation code. Applying the algorithm to the first two quality KPIs and for a number of approximately 16 branches from different regions in Greece and measuring the average centroid Euclidean (Ed) distance ( $\mu$  norm) and average cluster dispersion (Cd) for every xi points of number N in the grid, tight clusters came up, indicating a correlated performance of some specific branches.

$$C_d = \left( \frac{1}{N} \sum_{i \in d(N)} \vec{E}d|\mu|_i \right) \quad |\mu|_i = \sum_{i \in d(N)} \left| \vec{x}_i - \vec{\mu}(d) \right| \quad (12)$$

Tight centroid dispersion indicates good alignment of 5 branches that are in the same region and have the same quality KPIs. This denotes a good spatial performance, in terms of geographical data and branch positioning. This alignment will help the decision process to identify correlated KPIs and analyze those metrics in order to optimize the overall performance of a geographical group of branches.

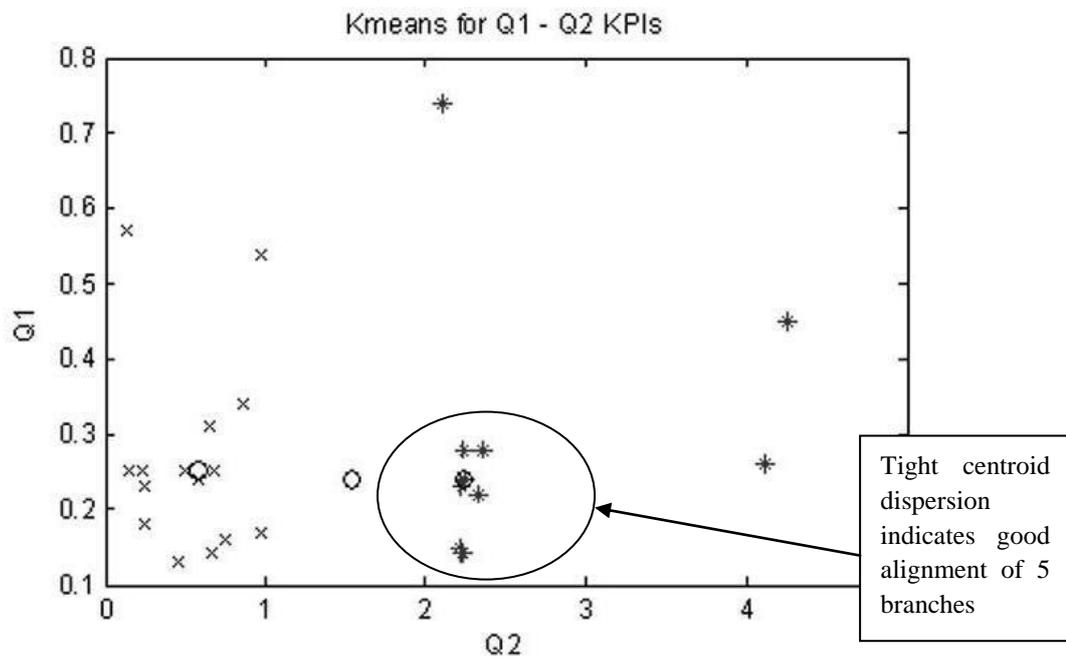


Fig. 8 (i). K-Means Clustering of Q1 and Q2 quality KPIs

Similar results can be conducted from Fig. 8(ii), 8(iii) and 8(iv).

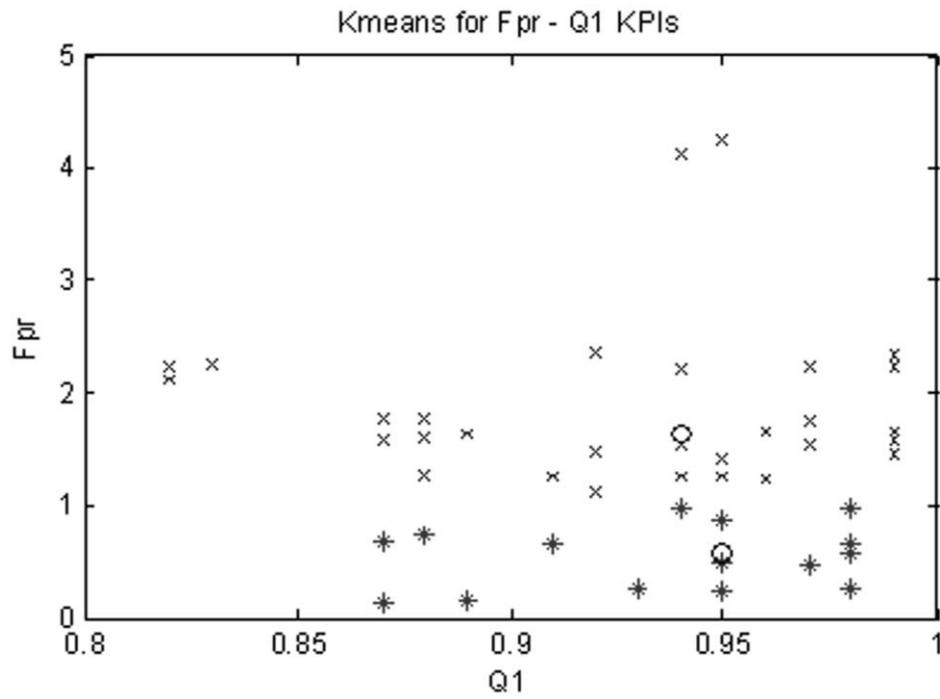


FIG.8 (ii). K-Means Clustering of Q1 and Fpr quality KPIs

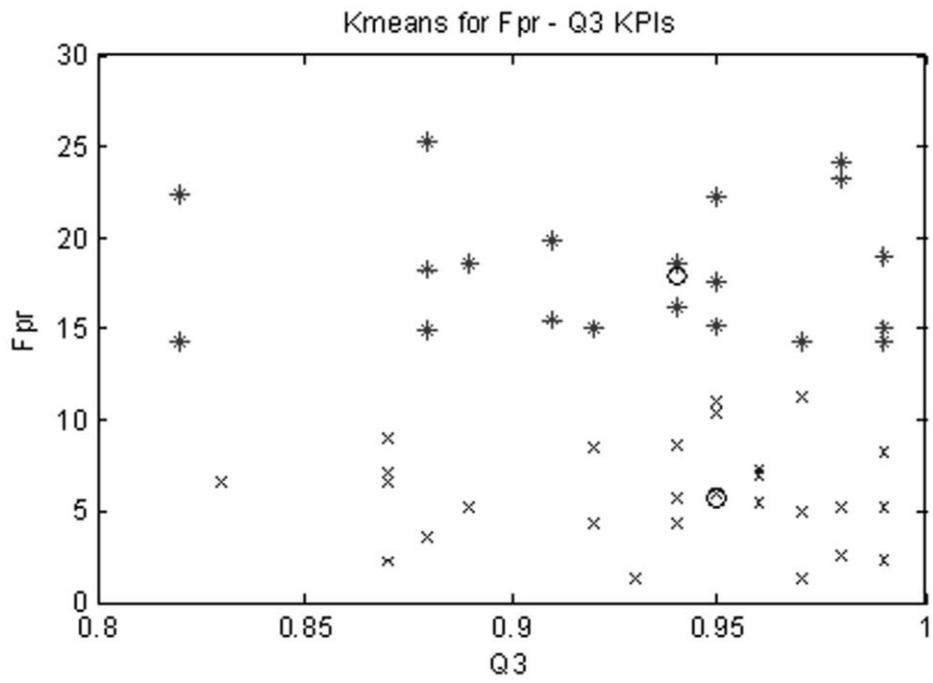


Fig.8 (iii). K-Means Clustering of Q3 and Fpr KPIs

In Fig 8 (iv) a semi-tight centroid dispersion indicates an alignment of 7 branches with good KPI performance.

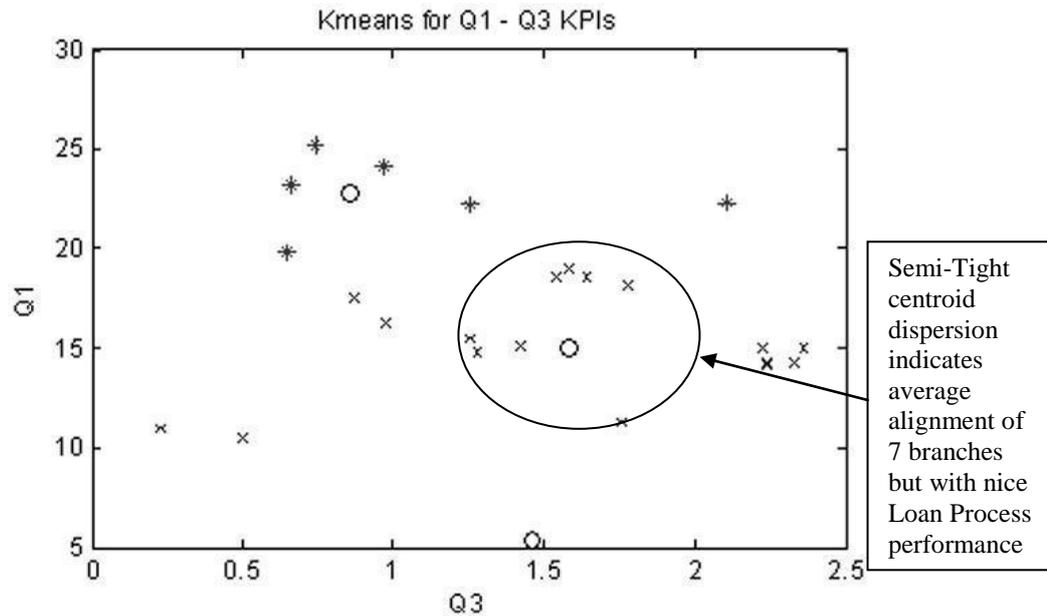


Fig.8 (iv). K-Means Clustering of Q1 and Q3 quality KPIs

Using Table 6 and measuring Cd for a number of k-means executes on specific targets of branches, a efficient ranking of clusters was obtained, in order to rank the performance of specific banks according to their region. The highest Cd value indicates more aligned branches and according to the centroid value, the possibility of re-engineering or optimization can be deduced.

Table 6. K-Means results for 6 branches

No. Branches	Quality KPI			Centroid Dispersion
	$(Q_1,$	$Q_2,$	$Q_3)$	$Cd$
14	1,31	0,14	15,45	2,4
20	0,98	0,25	12,54	8,54
5	1,12	0,87	21,45	3,54
12	1,42	0,54	3,58	14,85
21	0,89	0,65	12,54	24,98

## 6. Conclusions and Further Work

In this paper, the BPMN approach was used, in order to model and measure a process performance. Through the application of BPM and the use of process-oriented IT systems (BPM systems using BPEL code) quality and bank performance of loan processes has increased substantially.

The most important effects of the procedure presented in this paper, are the following:

- (i) Cycle time has been reduced. This is mainly due to the fact that waiting time has almost disappeared. As soon as a certain process step is finished the case is automatically moved forward by the BPM system using BPEL code.
- (ii) Output per employee has increased. All process steps that can be performed by a BPEL machine (without losing quality) are executed by the IT system. For instance, prior to automation, employees had to use long checklists for certain processes to ensure the process was carried out correctly.
- (iii) The processes have been improved (partial re-engineering) as part of BPM and the use of specific KPI analysis and clustering algorithms (k-means)

In general, the importance of using simple models to describe, simulate and assess business processes is increasing in the field of financial institutions. However, the various systems available do not always offer cost-efficient integration mechanisms for BPM systems. Almost every BPM system available has its own reporting and performance measurement concept. Some of them are rather rudimentary whereas other systems are provided with broad and user-friendly analysis functions.

## References

1. G. Alonso, D. Agrawal, E. Abbadi and C. Mohan, Functionality and Limitations of Current Workflow Management Systems G. Alonso, *IEEE Expert* **12** (1997).
2. F. Armistead and S. Machin, Implications of business process management for operations management, *International Journal of Operations & Production Management* **17** (9) (1997) pp. 886-898.
3. K. Banke and D. Slama, Enterprise SOA: *Service-Oriented Architecture Best Practices*, (Prentice Hall PTR, 2004).
4. F. Bodart, A. Patel, M. Sim and R. Weber, Should The Optional Property Construct Be Used In Conceptual Modeling? A Theory and Three Empirical Tests, *Information Systems Research* **12** (4) (2001) 384-405.
5. BPMI.org, OMG. (2006). Final Adopted Specification, <http://www.bpmn.org/>.
6. H. Chernoff, Cluster Analysis for Applications (Michael R. Anderberg), *SIAM Review* **17** (3) (1975) 580-582.
7. F. Cummins, *Enterprise Integration: An Architecture for Enterprise Application and Systems Integration*, (John Wiley & Sons, 2002).
8. J. Eder and E. Panagos, Towards distributed workflow process management. In C. Bussler, P. Grefen, H. Ludwig, and M.-C. Shan (Ed.), in *Proceedings of the Workshop on Cross-Organisational Worklow Management and Coordination*, (San Francisco, CA, USA, 1999).
9. J. Elzinga, T. Horak, Chung-Yee-Lee and C. Bruner, Business process management: survey and methodology, *IEEE Transactions on Engineering Management* **42** (2) (1995) 119-128.

10. X. Fu, T. Bultan and J. Su, Analysis of interacting BPEL web services in *Proceedings of the 13th international conference on World Wide Web*, ACM, (New York, NY, USA, 2004).
11. D. Georgakopoulos, M. Hornick and A. Sheth, An overview of workflow management: From process modeling to workflow automation infrastructure, *Distributed and Parallel Databases* **3** (2) (1995) 119-153.
12. Intalio. (2009). Intalio Designer, <http://www.intalio.com/products/designer/>
13. Intalio. (2009). Intalio Server, <http://www.intalio.com/products/server/>
14. V. Kabilan, and P. Johannesson, Semantic Representation of Contract Knowledge using Multi-Tier Ontology, in *Proceedings of Semantic Web and Databases workshop*, (Berlin, Germany, 2003).
15. P. Küng and C. Chagen, The fruits of Business Process Management: an experience report from a Swiss bank, *Business Process Management Journal* **14** (8) (2007) 477-487.
16. J. Lai, T. Huang and Y. Liaw, A fast k-means clustering algorithm using cluster center displacement, *Pattern Recognition* In Press, Corrected Proof (2009).
17. D. Linthicum, *Enterprise Application Integration*, (Addison-Wesley Information Technology Series, 1999).
18. J. MacQueen, Some Methods for classification and Analysis of Multivariate Observations, in *Proceedings of 5-th Berkeley Symposium on Mathematical Statistics and Probability*, Berkeley, (University of California Press, 1967), pp. 281-297
19. P. Massuthe, W. Reisig and K. Schmidt, An operating guideline approach to the SOA, *Annals of Mathematics, Computing and Teleinformatics* **1** (3) (2005) 35-43.
20. J. Matjaz, S. Poornachandra and M. Benny, *Business Process Execution Language for Web Services 2nd Edition*, (Pact, 2006).
21. A. Oberweis, Workflow management in software engineering projects. In *Proceedings of the 2nd International Conference on Concurrent Engineering and Electronic Design Automation*, (Bournemouth, United Kingdom, 1994), pp. 55-60.
22. Ovum, Business process management – a systems solution to crisis (2000), <http://www.ovum.com>
23. W.A. Shewhart, *Economic Control of Quality of Manufactured Product*, (Van Nostrand Reinhold, Princeton, 1931).
24. H. Smith, P. Fingar, *Business Process Management (BPM): The Third Wave*, (Meghan-Kiffer Press, 2003).
25. S. Thomassey and A. Fiordaliso, A hybrid sales forecasting system based on clustering and decision trees, *Decis. Support Syst.* **42** (1) (2006) 408-421.
26. W.M.P. Van der Aalst, Business process management - a personal view, *Business Process Management Journal* **10** (2) (2004) 135-139.
27. F. Vernadat, *Enterprise Modeling and Integration: Principles and Applications*, (Chapman and Hall 1996).
28. S. White and D. Miers, *BPMN Modeling and Reference Guide*, (Future Strategies Inc., FL, USA, 2008).
29. Workflow Management Coalition, Workflow Management Coalition – Terminology & Glossary. Technical Report WFMC-TC-1011, (Hampshire, United Kingdom, 1999).
30. R. Zahavi, *Enterprise Application Integration with CORBA Component and Web-Based Solutions*, (Wiley, New York, 1999).