

Intelligent Business Process Management

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Abstract— Business Process Management (BPM) became the defacto standard for automating and managing an organization's business processes. BPM also provides the opportunity to analyze the activities and Key Performance Indicators (KPIs) while suggesting process improvements via process re-engineering. The inefficient rate of the current process re-engineering method is causing organizations to lose its opportunities to their competition. With the explosion of real time analytics capabilities, BPM has untapped potential for rapid feedback cycles thus improving the process and capturing the eluded opportunities. The purpose of this paper is to provide extensions to the current BPM solutions to become intelligent by self-improving and self-re-engineering using the underlying data science insights. Intelligent Business Process predicts the bottlenecks in the process instances and task allocations and then prescribes alternatives, while Intelligent Business Human Activities learns the human decisions for each process instance and predicts the human input. This allows the BPM activity to be automated, contributing to prolonged efficiency and productivity.

Keywords— *Business Process Management, iBPM, Data Mining, Machine Learning, Process re-engineering, process, IHT, BAM, BPMN*

I. INTRODUCTION

Every business involves process, which is the way things are performed within an organization. The process is what differentiates an organization from its competition. Business Process Management (BPM) automates the business processes to achieve efficiency, effectiveness, productivity, and agility, to boost quality and speed up delivery in order to improve customer satisfaction.

Today's businesses need to adapt quickly to changing circumstances and hence the underlying technology supporting the business needs to be agile enough to support business agility. In essence, BPM is evolving to being more dynamic from the traditional static models. Traditional BPM should leverage the innovations in technologies like Social Media, Internet of Things (IoT), Big Data Analytics, Machine Learning, Automation, Digital, etc. and become an intelligent process capable of re-engineering itself.

II. DEFINITIONS

A. Business Process management

Business Process Management is the complete set of end to end activities required to complete a transaction. These processes are a set of activities and transactions that an organization conducts on a regular basis in order to achieve an objective.

B. Machine Learning

Within the field of data analytics, machine learning is a method used to devise complex models and algorithms that lend themselves to prediction. These analytical models allow researchers, data scientists, engineers, and analysts to produce reliable, repeatable decisions and results and uncover hidden insights deriving from historical relationships and trends in the data

C. Automation of Human Decisions

Intelligent Human Task (IHT) activities would capture the human decisions (Accept/Reject, Yes/No, input dollar amount, etc.) based on the instance data at that point of time that is contributing to the decision. IHT builds a predictive model using the historical data and shows user the predicted decision until the confidence is gained. Once appropriately confident, IHT would become an automated task and proceed to next activity based on predicted decision.

D. Business Process Reengineering

Process instances are monitored for the bottlenecks in the process using data like instance data, environment data, logs and Business Activity Monitoring (BAM) insights to predict activities that are bottlenecks to instances and then alerts the owner. This gives opportunity for owners to react in real-time. Intelligent process however, identifies the specific data elements which are influencing/causing the bottlenecks and reports to the business owner, so the owner can reengineer the process with deep understanding at hand. The intelligent business process predicts the possibility of breaching Service Level Agreements (SLAs) and intelligently assigns the task to a group or person which improves the KPIs.

III. BPM PROJECT IMPLEMENTATION

A project was implemented for a governmental client to establish a business on a collaborative partnership among business, enterprise, and technology stakeholders at all levels of the client. In the legacy acquisition environment, business units that support acquisition have created process variations to complete the procurement life cycle for the products and services they provide. As a result, the client has inconsistent business processes and inconsistent quality in the area of acquisition planning. There is a pressing need to improve the Acquisition Planning Business Segment, which spans an entire organization. This project fully automated the acquisition planning process and provides acquisition professionals and management with the ability to better leverage acquisition data. The main business goals of the project defined by the client were to streamline and shorten the current processing time, from receiving requirements to Approval.

Achieving this business goal is critical to this client’s mission. To help the Approvers to take the decision, Human tasks/User Input Tasks need to become intelligent by self-learning from the past acquisition data. Processes need to become intelligent in order to produce insights to quick re-engineering.

IV. EXPERIMENTAL AND COMPUTATIONAL DETAILS

Many organizations started the digital transformation by adopting the BPM tool to improve the customer satisfaction and its return on investment. In the world of Cyber Physical Systems, data is produced and there is need for the BPM systems adopt to data driven approaches. Traditional BPM was designed to automate the business processes. BPM itself is a discipline for continuously improving cross functional, horizontal business processes that deliver value to customers and other external stakeholders. BPM also draws from other methodologies for continuous improvement, like Six Sigma and Lean. BPM software (BPMS) is a software suite for designing, automating, monitoring and improving a collection of interrelated business activities that form an end-to-end business process.

Each process is generating the transactional data, process instance data, and activity history data. With help of Machine Learning principles and the data that was collected in the processed instances, processes should self-learn the next best possible activity in the process with minimal manual intervention while also proactively identify the bottlenecks in the process and the data that is responsible for the behavior help to re-engineer the process.

V. INTELLIGENT HUMAN TASKS

A. Component Theoretical Paradigms Used for the Model Derivation

The data that is presented to the user for making decisions is used to derive the input features for the model. User action for each instance becomes a target variable. Classification/Regression models will be built based on the output variable which can be either qualitative or quantitative variable. The model performance is evaluated continuously.

B. Business Process Management Notation (BPMN) Semantics for Intelligent Human Task

BPMN 2.0.2 introduces an extensibility mechanism that allows extending standard BPMN elements with additional attributes. Figure 1 shows a snippet of the extension on the User task BPMN element by adding properties to make it intelligent Human Task.

Figure 1. BPMN Semantics xml

```
<userTask name="edit 1st level ticket" id="_1-77">
  <potentialOwner><resourceRef>
    tns:FirstLevelSupportResource</resourceRef>
  </potentialOwner>
  <!-- After reaching the confidence level, Administrators will
  mark this field as true.-->
  <autoApprove>false</autoApprove>
  <!-- Available Features that can contribute to take the decision.-->
  <AvailableFeatures></AvailableFeatures>
  <SelectedFeatures></SelectedFeatures>
</userTask>
```

With the extended human task, Process Model Administrators will be able to select the features in combination with functions (date difference, Avg, Sum etc.) from available data features. These selected features will be used to build ML model to predict the user response.



Figure 2. Designer View of the extended User Task Configuration.

C. Model Building

Figure 3 shows a prototype classification model using the Gradient Boosting model (GBM) to predict user action on a case decision (Approved/Rejected). The data that is being used is generated from processed instances along with user actions. R programming is used to build the model and exposed as a service part of the intelligent human task execution environment.

The model can also output the influencing features and the predicted response with the confidence/probability associated with it.

Figure 3. GBM Classification Model

```
library(gbm)
gbm_model=gbm(planstatus~.-planid-planitle, data=acqi_final_1,
distribution = "bernoulli", n.trees = 250, shrinkage = .01,
n.minobsinnode = 20, verbose = T)
summary(gbm_model)
gbmTrainPredictions=predict(object=gbm_model,
newdata=test_data,n.trees=250,type= "response")
head(gbmTrainPredictions)
head(data.frame("Actual" = test_data$planstatus,
"PredictedProbability" = gbmTrainPredictions))
```

D. User View of Decision Task

Figure 4 shows an example window wherein the Approver can click on the Suggested Solution based on the provided Analytics link. Upon clicking this link, the user will see the predicted outcome and the confidence associated with the decision produced by the Machine Learning task. The window will also show the influencing features and their values for the instance.

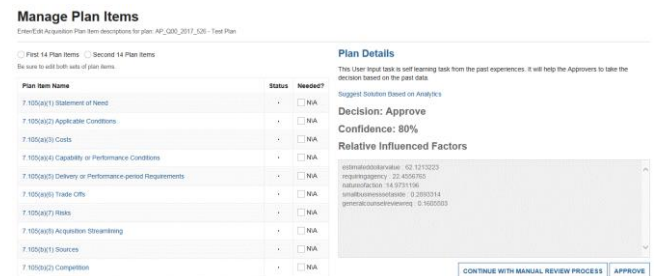


Figure 4. End-user View of Decision Task with Confidence

After earning confidence over time, Administrators can configure the User Task to auto approve the task based on outcome of the predictive analysis result with a limit on threshold.

VI. PROCESS RE-ENGINEERING

Identifying the bottlenecks/inefficiencies on company's processes is not an easy exercise and can't be accomplished without dedicating time and effort. It's important to have continuous process improvement, which is dynamic and can constantly re-evaluate the results. Constantly monitoring and evaluating the processes will give the necessary information to make any adjustments. Business activity monitoring (BAM) will provide the metrics to evaluate the runtime behaviour of different business processes. It does not provide the data insights to Subject Matter Experts (SMEs) to determine which data set is causing the bottleneck in the process.

A. Model Building

Instance data and the each activity processing times are captured for building multiple regression models. A Gradient Boosting model is built for each of the activities using R programming language. These models would predict the response times for each activity and alerts process owner with list of bottleneck activities along with the data set that is causing the bottlenecks. SMEs can use these data insights to re-engineer the process with quick and efficient feedback loops.

Figure 5. GBM Regression Model

```
time_df$timestamp1= ifelse(is.na(time_df$timestamp.y),
time_df$timestamp.x,time_df$timestamp.y)
time_df1=subset(time_df,select=c('ae_p_id','actiontypename',
'timestamp1'))
time_df1 = time_df1[-c(167, 168),]
e<-spread(time_df1,key='actiontypename',value= timestamp1')
head(e)
e$timediff = e$Complete - e$Start
Legacy_Plan_data= merge(Legacy_Plan_data,e,by='ae_p_id',all.x
=T)
head(Legacy_Plan_data)
model_data=subset(Legacy_Plan_data,
Legacy_Plan_data$actiontypename=='Complete',c('ae_p_id','time
diff',cols))
model_data = model_data[!names(model_data) %in%
c('v27','v28','v29', 'v30', 'v31', 'v32', 'v33', 'v34')]
head(model_data)
model_data$timediff=ifelse(is.na(model_data$timediff),0,
model_data$timediff)
fac_cols=c("v1","v2","v3","v4","v5","v6","v7","v8","v9","v10","v
11", "v12","v13","v14","v15","v16","v17","v18",
"v19","v20","v21","v22","v23","v24","v25","v26")
model_data[fac_cols]=lapply(model_data[fac_cols], factor)
sapply(model_data, class)
train_index=sample(seq(nrow(model_data)),70*nrow(model_data)
/100)
gbm_model=gbm(timediff~.-ae_p_id,distribution= "gaussian",
data = model_data[train_index,], n.trees = 100, interaction.depth
= 1, shrinkage=0.001, bag.fraction=0.5, train.fraction=1.0,
cv.folds=0, keep.data= TRUE,verbose = TRUE)
summary(gbm_model)
```

VII. RESULTS AND DISCUSSION

A. Intelligent Human Task Model and Significance

As shown in Figure 6, the user will see the predicted outcome that is which factors have more relative influence and the confidence associated with the decision. The classification model algorithm will produce the Relative Influence of the data and model (Table 1). Based on the variable influence and model, Machine Learning task will predict the probability of the decision.

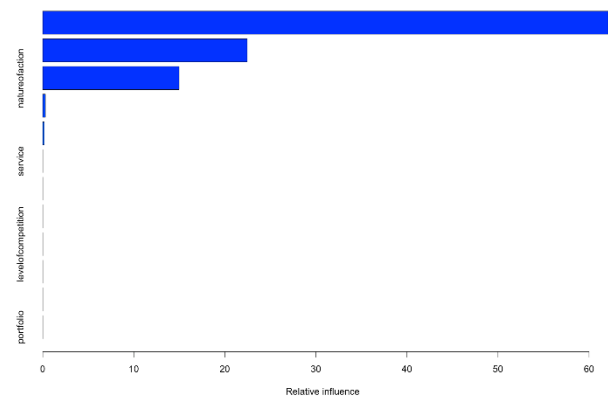


Figure 6. Comparison model of Factors and Relative Influence

Table 1. Comparison Data of Factors and Relative Influence

Factor	Influence
estimateddollarvalue	62.1213223
requiringagency	22.4556765
natureofaction	14.9731196
smallbusiness	0.2893314
generalcounselreviewreq	0.1605503
compition	0
service	0

A. Process reengineering

Similar to the Classification model, for process reengineering, used the Regression model to identify the data which is causing the bottlenecks in the process (Figure 7). This model shows the Subject Matter Experts (SMEs) the influence of each specific variable upon which the Subject Matter Experts (SMEs) can take the appropriate action to avoid the bottleneck in the process model. Model shows the data set with their relative influence instead of just metrics on the process bottlenecks.

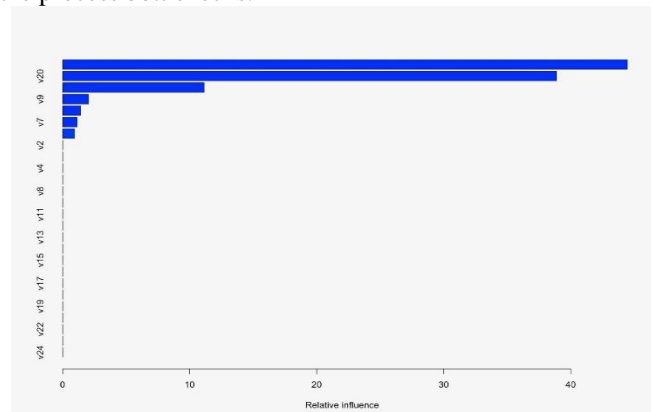


Figure 7. Comparison model of Data and History Relative Influence

Table 2. Comparison of Variables and Relative Influence

Factor	Variable	Influence
estimateddollarvalue	V26	44.4550887
requiringagency	V20	38.8779242
natureofaction	V25	11.1354436
smallbusinesss	V9	2.0417347
generalcounselreviewreq	V1	1.4103369
compition	V7	1.1336097
service	V5	0.9458622

VIII. CONCLUSION

By enhancing the BPM capabilities using the data science techniques, we are now able to improve the process efficiency by converting interactive activities to automated tasks and data level insights for process re-engineering. With proof of concept, we are able to show that BPM processes can be quickly adjusted/upgraded to the market/data changes. Having specific details on data influence for each activity and

overall process will help customer to meet the Service Level Agreements (SLAs) and to achieve their optimal business mission.

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