AN INTERACTIVE FRAMEWORK TO DEVELOP AND ALIGN BUSINESS PROCESS MODELS

by

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Abstract

In the past few decades, the usage of Business Process Management (BPM) has enormously increased. Organizations are devoting resources towards development and use of BPM techniques and technologies to analyze, model, improve and implement business processes. The procedures currently used for collecting information to create business process models generally lead to misunderstanding or ambiguity between model and domain experts. We propose a framework to build business process models directly from users' inputs captured through interactive web-forms. It also allows the users to align processes with strategic business objectives, critical success factors, and key performance indicators. Further, processes can be tagged with appropriate maturity level, types and tiers. The framework includes a dashboard with real-time reports which helps decision makers to monitor organization's performance, make better decisions, and standardize/optimize processes across the organization. A comparison of the functionality available in different tools along with proposed framework is also presented.

Dedicated to my family and friends

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Abbreviations

BA	Business Architecture
BP	British Petroleum
BPA	Business Process Architecture
BPM	Business Process Management
BPMN	Business Process Model and Notation
BPMI	Business Process Management Initiative
BI	Business Intelligence
CSF	Critical Success Factor
CSS	Cascading Style Sheets
ETL	Extraction, Transformation, and Loading
GUI	Graphic User Interface
HTML	Hyper Text Markup Language
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
NPL	Natural Language Processing
OLAP	Online Analytical Processing
OLTP	Online Transactional Processing
OMG	Object Management Group
ROI	Return on Investment
RPST	Refined Process Structure Tree
SBO	Strategic Business Objectives

SBPMS Semantic Business Process Management System

SBVR Semantics of Business Vocabulary and Business Rules

SESE Single-Entry Single-Exit

SSO **S**ingle Sign-On

SQL Structured Query Language

SSAS SQL Server Analysis Services

SSIS SQL Server Integration Services

SSRS SQL Server Reporting Services

SWS Semantic Web Services

XML Extensible Markup Language

XPDL XML Process Definition Language

YAWL Yet Another Workflow Language

Chapter 1

1. Introduction

Over the last several years, companies and organizations have been increasingly adopting Business Process Management (BPM) technologies to analyze, model, improve and implement business processes. Consequently, there has been an increasing demand for techniques to create business process models efficiently. Several methods have been proposed but the existing procedures for collecting relevant information almost always lead to misunderstanding or ambiguity between model and domain experts. To this end, we have developed a framework aimed at generating effective and efficient business process models using input collected through asynchronous collaboration from all involved users. In this chapter, we first describe the underlying concepts which include Business Process Management (BPM), Business Process Model and Notation (BPMN) standards, the key concepts of the business process model, and Business Intelligence (BI). Next, we state the motivation behind our work and outline the benefits and contribution of this research on business processes and related activities.

1.1 Business Process Management (BPM)

The term BPM is used in different contexts by a number of communities, which include executives, business analysts, CEOs, business process consultants, business architects, software developers and Six Sigma and Lean practitioners [1]. According to M. Von Rosing "Business Process Management (BPM) is a discipline involving any combination of modeling, automation, execution, control, measurement, and optimization of business activity flow in applicable combination to support enterprise goals, spanning organizational and system boundaries, and involving employees, customers, and partners within and beyond the enterprise boundaries" [2]. BPM in general is an extensive area; the focus of our research is on building business process models and aligning them to strategic business objectives.

A business process is a chain of activities, events, and decisions that are performed to complete an organization's task, which involves some actors and objects [3]. The business process model is a diagrammatic representation or blue print of the business process. The business process models represent the processes of an organization, which can be analyzed and improved. Business Process Management (BPM) on the other hand, defines how work is performed in an organization in order to ensure consistent outcomes and in doing so provide various benefits such as reduced costs, faster execution time and fewer errors. Importantly, BPM makes the organization's workflow effective, efficient and adaptable to an ever-changing business environment. In fact, BPM manages the entire chain of events, activities, and decisions that add value to the organization and its customers [3]. It is a method that not only aligns business processes but also improves business performance at the same time [4].

Nowadays, companies are increasingly moving their business processes online by using BPM tools and technologies. This makes business processes easier to access and also facilitates extracting business logic from the business process models. BPM is used in various areas of the organization including human resources, finance and purchasing, management of customer relationships, sales and marketing, research and development. Several case studies demonstrate the successful implementation of BPM tools in the organizations. For instance, Munich Airport, the third best international airport in the world voted by the customers [5], used business process management solutions provided by iGrafx® [6] to better analyze and optimize their business processes. British Petroleum (BP) is one of the largest energy companies in the world that provides fuel for transportation, and energy for heat and light [7]. BP's Account Payable involves more than 10,000 vendors and 30,000 non-recurring transactions. They used Oracle BPM Suite to automate the processes and improve their invoicing and approval system. This process improved the data accuracy, increased the turnover and enhanced quality assurance. It reduced the cost of each transaction by 80% resulting in a 300% Return on Investment (ROI) [8]. The LEGO Group [9] is very famous for developing LEGO bricks for children to improve their creativity through play and learning. LEADing Practice[1] [10] used BPM to standardize their service model, revenue model, operational model and business processes. Some of the key benefits that the use of BPM and best practice brought to LEGO are listed below: [11]

- Better collaboration and information sharing
- Enhanced coordination
- Reduced level of complexity in processes

[1] LEADing Practice is an enterprise standards body that provide reusable and repeatable best practices.

- Improved process compliance, consistency, quality, efficiency and productivity
- Elimination of errors
- Build foundation for continuous improvement of the processes
- Reduced number of steps in processes

In BPM, we mainly focus on building business process models. These models provide a better representation of various processes that add value to the business of an organization. Consequently, organizations and companies are able to put the desired effort into the design, implementation, execution, monitoring and evaluation of business process models.

Creating business process models can be either an asset or liability for an organization depending on how the models are actually managed. For example, if an organization creates business process models for each process within the organization, this could yield hundreds of models, which would cost the organization considerably in terms of money, time, human and capital resources. Also, managing and maintaining a very large number of models can be cost prohibitive. Similarly, when business processes are not aligned to the organization's Strategic Business Objectives (SBOs), Critical Success Factors (CSFs), Key Performance Indicator (KPIs), and functions and do not offer value to the organization, it is futile to improve such processes. Additionally, business processes may become a liability when they are not standardized and, therefore, may include many redundancies. Similarly, business processes are a valuable asset when they are adequately represented and analyzed. These processes add further value when they strategically align with organization's objectives. In summary, when creating a business process model, the following points need to be kept in mind:

- Align business processes with strategic business objectives.

- Standardize business process models across the organization if the same process is exists in different areas.
- Optimize business process models to make the processes more effective and efficient.
- Improve process communication of and between different processes within the organization.
- Use BPMN (Business Process Model & Notation) standards while creating business process models.

1.1.1 Business Process Lifecycle

BPM involves automation, documentation, integration, monitoring and optimization of processes [12]. To accomplish these goals, the companies and organizations follow the conventional BPM lifecycle (Figure 1 [3]) namely:

Process Identification: In this phase, the business problems, related processes, and the processes that are strategically crucial for the organizations are identified. The outcome of process identification is process map/process architecture that presents the processes and their relationships.

Process Discovery: In this phase, the business processes are modeled in order to the capture current state (*as-is* model) of the business or organization [13]. The primary objective of this phase is to document the current state of the processes.

Process Analysis: In this phase, *as-is* business processes are thoroughly analyzed in order to identify the issues and weaknesses within each of the processes. The outcome of this

phase would be well-documented problems, which are then prioritized for correction based on time and resources required to solve them relative to their impact(s) on the organization.

Process Redesign: In process redesign, the necessary changes are made to the processes in order to solve the issues identified by the process analysis phase. For each process, possible alternatives are identified by performance measures and the best possible option is then selected to redesign the model. The outcome of the resultant redesign is the *to-be* model[2].

Process Implementation: In the implementation phase, all the changes that are required to move from *as-is* processes to *to-be* processes are implemented.

Process Monitoring and Controlling: In this phase, the business processes are monitored and controlled to make sure they meet the organization's goals and objectives [3]. When issues arise during monitoring and controlling, the process lifecycle is revisited.

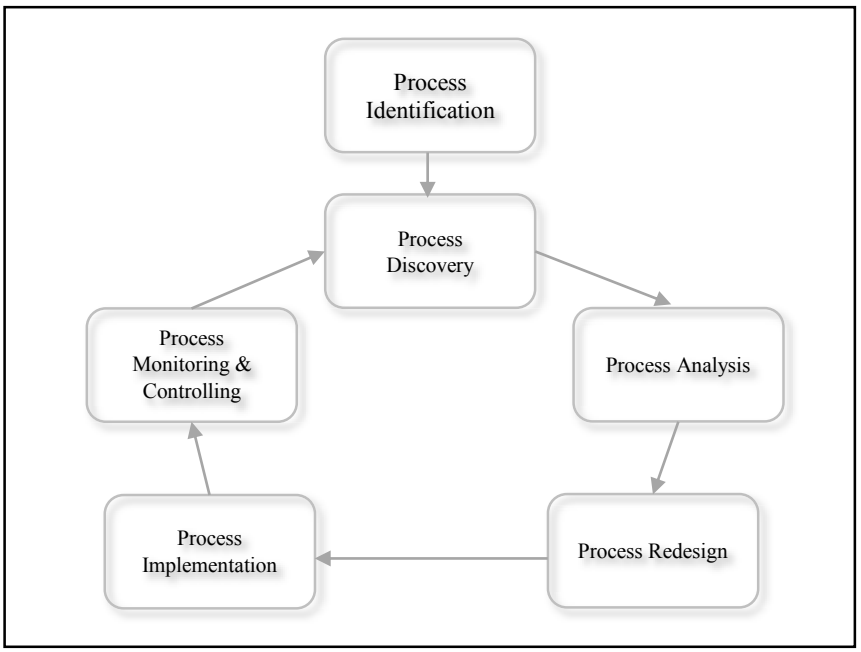


Figure 1: BPM lifecycle [3]

[2] Models that result from incorporating improvements in the current (*as-is*) model [73].

1.1.2 Business Process Model & Notation (BPMN)

The Business Process Model & Notation (BPMN) 2.0 has been chosen for our framework because of its adoption as a universal standard. This standard has been developed by the Business Process Management Initiative (BPMNI) [14] and is supported by the Object Management Group (OMG) [15]. The BPMN provides a graphical notation of a process in the business process model and as such helps organizations to improve their respective communications in order to better understand their respective business procedures [15]. Some basic BPMN shapes and notations taken from [16] are presented in Figure 2.

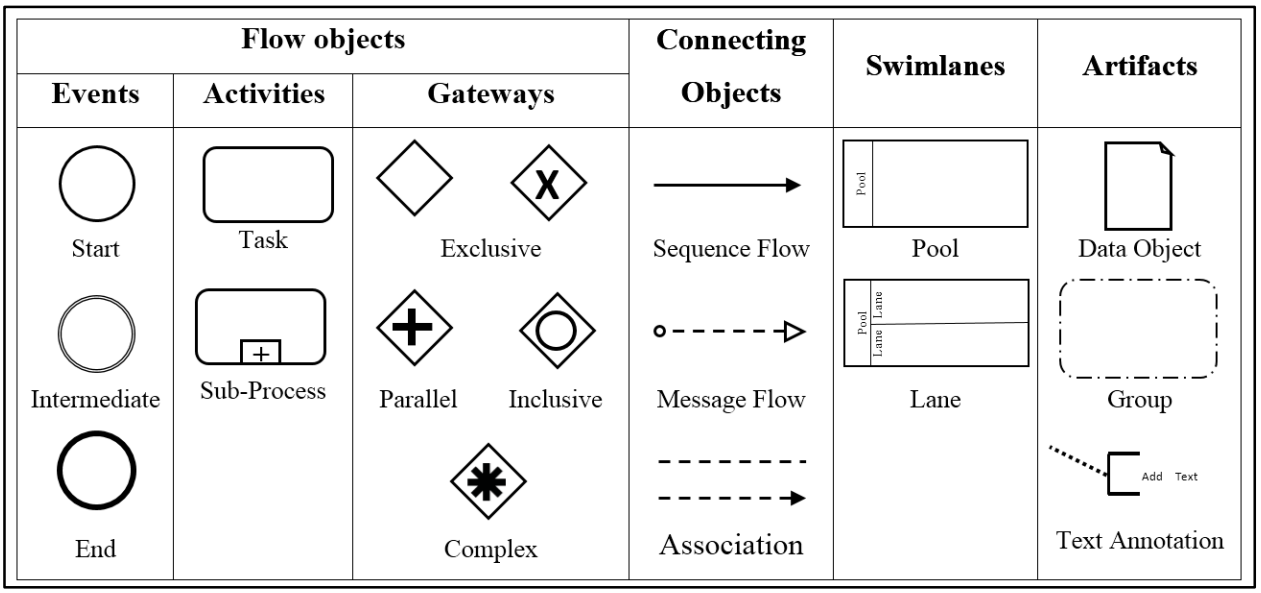


Figure 2: BPMN, main symbols [16]

Activity:

An activity could be a simple task or a sub-task that represents a unit of work that has been carried out by an actor[3]. A collection of sequence activities makes a process.

[3] Actor is a participant in an action or process

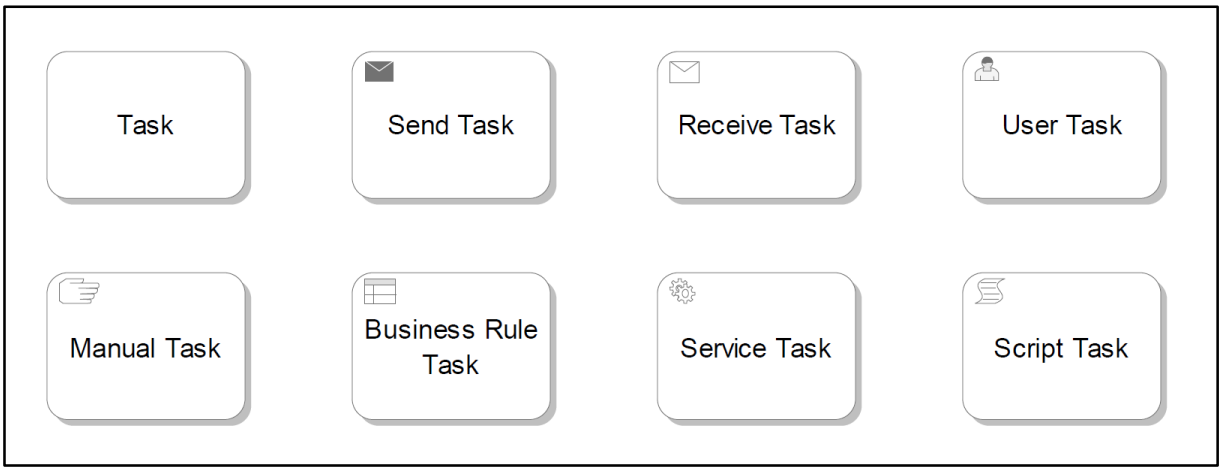


Figure 3: Task Type

- **Task:** It represents the work within a business process that cannot be broken down. There are different types of task as shown in Figure 3, which are explained below:
  - **Send task:** It sends a message to an external participant that is related to the process. When we use *send task* there should be a *receive task* to capture the message.
  - **Receive task:** It waits for a message to arrive from an external participant that is related to the process.
  - **User task:** It identifies the task, which is performed by the human with the help of software application.
  - **Manual task:** It identifies a task being performed without the help of any software application.
  - **Business role task:** It is used to apply a business role to the tasks in the business process model.
  - **Service task:** It displays a task that is being performed automatically by software that could be an automated application or a web service.

- **Script task:** It is a type of task that is executed by a business process engine. It represents code that can be executed on a process engine. When the task starts, the script executes and when the script finishes the task finishes as well.

- **Sub-process:** Another process displayed in collapsed view and hides its details. It can be expanded to show more details.

Gateways:

They are used to control how sequence flows interact, and also help in organizing the process control flows. There are different kinds of gateways: exclusive, inclusive, parallel and complex.

- **Exclusive:** A gateway that allows the sequence flow to have two or more paths within the process but only allows one outgoing pathway to be taken.
  - **Data-based Exclusive Gateway:** A gateway that only allows one outgoing pathway to be taken based on the business condition. It is also used for merging purposes.
  - **Event-based Exclusive Gateway:** A gateway that allows one outgoing pathway based on an event that happens within a process.
- **Parallel Gateway:** A gateway that defines and/or synchronizes multiple parallel paths. The "+" sign is used to identify this gateway.
  - **Parallel event-based gateway:** A gateway that allows outgoing pathways to proceed based on events that happen in parallel within a process.
- **Inclusive Gateway:** It is a decision gateway that is, where more than one outgoing pathway are allowed. This gateway is identified by using an "O" sign.

- **Complex Gateway:** It is a type of gateway that defines advanced behaviour in a process. It can be used for both splitting and merging of activities in the business process models.

Event:

An event indicates that something has happened during a business process. The most commonly used events are start, end, and intermediate event.

- **Start Event:** It indicates initiation of a process. They are used at the beginning of the process and do not have any incoming sequence flow. There are different types of start events shown in Figure 4.

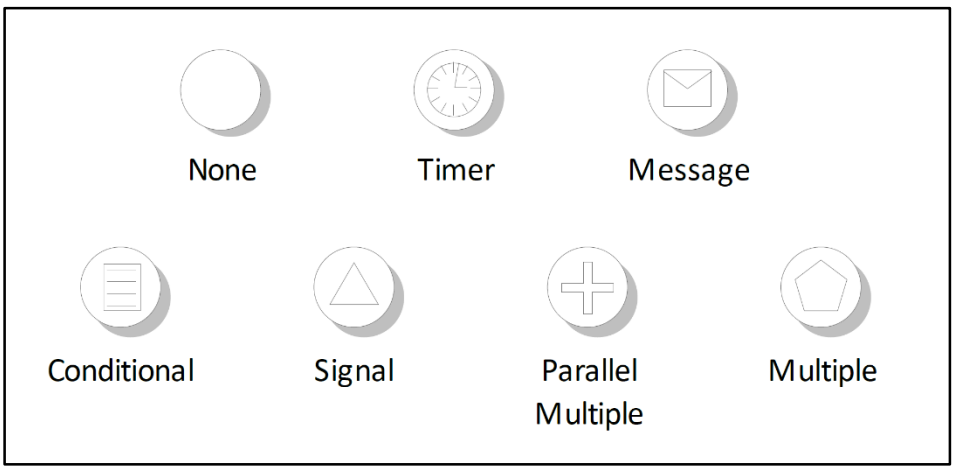


Figure 4: Start events

- **Intermediate event:** It occurs between the start and end of the process and also can be used to throw or catch an event trigger. There are different types of intermediate events as shown in Figure 5, and explained later.

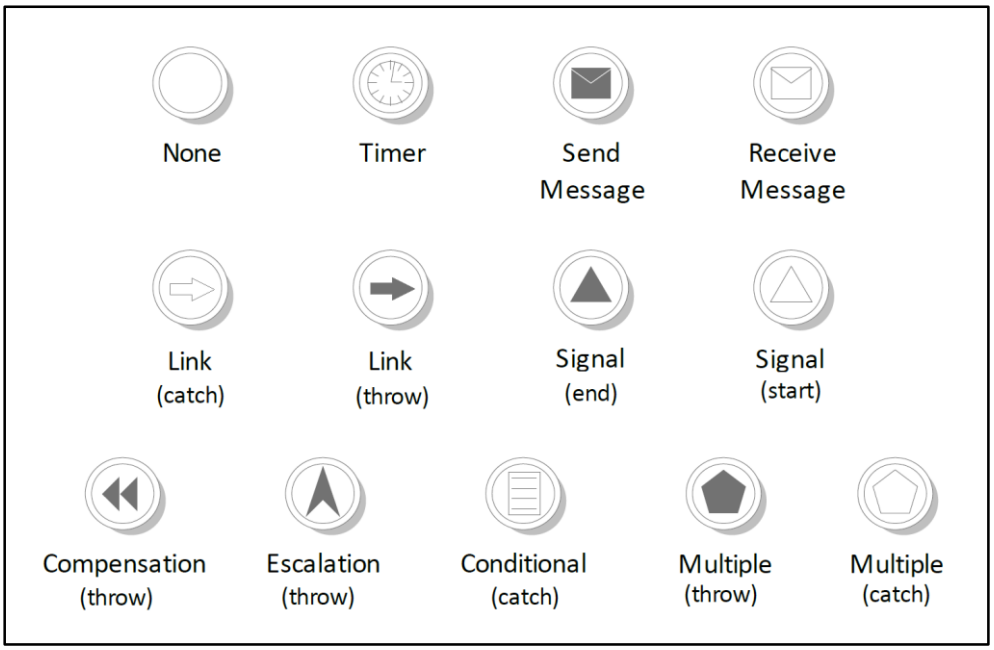


Figure 5: Intermediate events

- **End Event:** It indicates the end of a process. A process can have more than one end event. These events do not have any outgoing sequence flow.

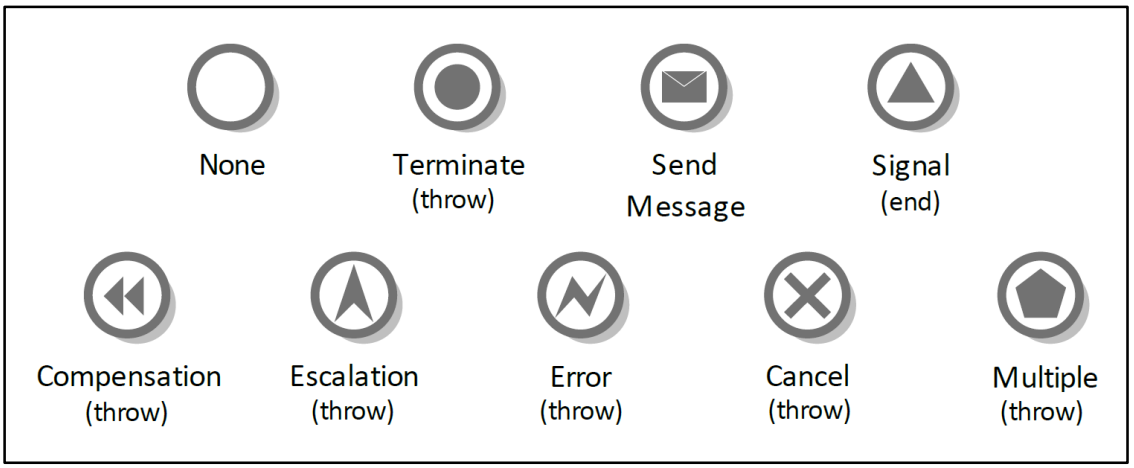


Figure 6: End events

  - **Timer:** indicates waiting in the beginning or middle of a process for a specific condition of time to be true in order to continue the process.
  - **Receive Message:** starts or continues a process upon receipt of a message.

- **Send Message:** sends a message in the middle or end of a process path.
- **Conditional:** starts or continues a process only if a certain condition is true.
- **Signal (start):** receives signals in the beginning or middle of the process model. It is a form of communication within pools, across pools and across process models.
- **Signal (end):** is a form of communication within pools, across pools and across process models. It sends signals in the middle or end of the process model.
- **Link (catch):** facilitates the process of creating a diagram. It is used in the long diagram as an entrance point. It does not have any significance on how the process is performed.
- **Link (throw):** does not have any significance how the process is performed and is used as an exit point in process models. It also facilitates the process of creating process models.
- **Multiple (catch):** summarizes multiple event types with a single symbol. It is used in the beginning or middle of the process model.
- **Multiple (throw):** summarizes multiple event types with a single symbol. It is used in the middle or end of the process model.
- **Parallel Multiple:** is used at the start of the process like *Multiple Event* to summarize multiple event types with a symbol. The main different between *Parallel Multiple* and *Multiple* is that *Parallel Multiple* will be triggered only if all of the event types are satisfied.
- **Compensation (throw):** allows to undo the action which was completed in the process. For example, cancelling a flight. It is used in the middle or end of the process models.

- **Escalation (throw):** shows the communication between sub-process and parent process. It is used in the middle or end of the process models.
- **Terminate:** stops the entire process.
- **Error (throw):** handles errors in the end of the process models.
- **Cancel (throw):** cancels and rolls back the transaction in the end of the process models.

Connecting Objects: It can be a sequence flow, a message flow or an association.

- **Sequence Flow:** indicates the ordering of activities using a headed arrow to connect the activities together.
- **Message Flow:** shows the flow of messages among two entities within a business process model.
- **Association:** shows the association of text or artifact to the Flow Objects.

Swim-lane: It includes the following:

- **Pool:** shows the participant[4] who performs the business process model.
- **Lane:** is a subset of the pool and is often used to display the user role/actor.

Artifact: It includes the following:

- **Data Object:** shows the usage of documents and data in a process.
- **Text Annotation:** adds further information to the model.
- **Group:** groups elements which are related together.

[4] Process Participant: Is person who performs the activity within business process.

1.1.3 Business Process Model

Business process model is a diagrammatic representation of the business process. It allows documentation, analysis, automation and implementation of the process. Figure 7 illustrates an example of a model using BPMN shapes and notation described earlier.

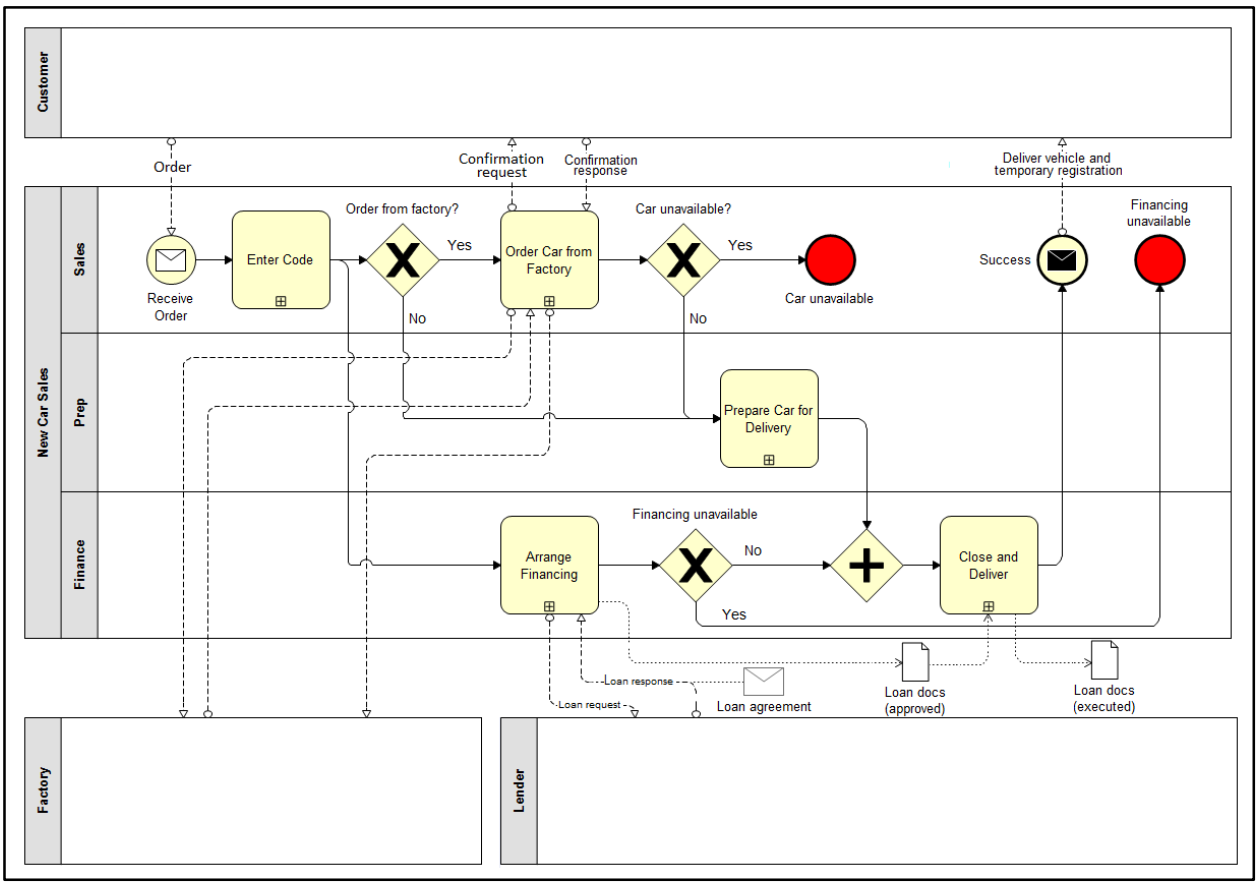


Figure 7: Car purchase process [17]

Before starting to create a business process model, the following information must be gathered [18].

- What we want to achieve by creating this business process model?
- When the business process starts and ends?
- All of the activities that are part of the business process.

- The order in which these activities are performed to complete a business process.
- The participant responsible for each activity within the business process.
- The documentation that is exchanged in order to complete the business process.

Once this information is collected, the business process model can be created using BPMN standards.

1.1.4 Role

As stated in [19], the role is a set of activities that someone performs to complete a business process. Two common roles are:

Business Process Analyst: is a person who analyzes and creates the business process model [3] and knows BPM and project management very well [19]. Generally, the process analyst does not understand the business process in detail. Therefore, domain experts help the analysts build the business process models.

Domain Expert: is a person who has knowledge about process or activity. Process manager or process owner who works in close collaboration with a person who performs the process [3] can be also called domain expert.

1.1.5 Business Process Management (BPM) Tools

Software products that support the acquisition, modeling, analysis, simulation, evaluation and deployment of business processes are BPM tools [20]. The software that business process analyst uses to create business process models include HP Process Automation [21], iGrafx® [22], Visual Paradigm [23], Oracle Business Process Management Suite [24], Bizagi BPM Suite [25], IBM BPM [26], Tibco ActiveMatrix [27], and Bonita BPM [28].

People use different tools for building business process models because of their specific requirements and needs, for example, some organizations prefer to use software obtained and developed by the larger corporations like Oracle, IBM, etc. because they provide training for the employees, availability of technical support and ensure superior security. A disadvantage of such software is that new functionality may be difficult to add. Consequently, many organizations choose to use open source software for building business process models. The capabilities and limitations of these tools are explained in Chapter Two.

1.2 Business Intelligence (BI)

We have decided to use BI for data visualization because it gives the users the ability to convert raw data into meaningful information which provides historical, current and predictive views of business operations within an organization [29]. BI software is a collection of decision support technologies which assist CEOs, business executives and managers alike to make better, accurate and faster decisions.

Common functions of business intelligence technologies are online analytical processing, process mining, reporting, complex event processing, data mining, text mining, analytics, benchmarking, predictive analytics and prescriptive analytics [29]. Some key terms related to business intelligence taken from [29] are briefly explained below:

Online Analytical Processing (OLAP): OLAP enables users to easily and quickly retrieve information from data. OLAP systems present data using dimensions, measures, hierarchies and cubes. This approach makes it easier for the users to slice and dice information along multiple dimensions. The cube contains preprocessed calculated fields which make the rendering of reports faster.

Key Performance Indicator (KPI): It is a measurable expression used for achieving the desired level of results by making the objectives and goals quantifiable. KPIs provide a very fast way to determine the health of the essential aspects of the organization. Data visualization is used to convey the indicator's status at a glance.

Online Transactional Processing (OLTP): OLTP records business interactions as they happen. OLTP supports the day-to-day operations of an organization which when aggregated provide the history of an organization. These daily transactional data contain the raw numbers which are necessary to calculate the measures for online analytical processing.

Extract, Transform and Load (ETL): ETL is the process of extracting data from different sources, and perform data cleansing which is required to transform the data into a standardize format. This data is then loaded into a data warehouse.

Data warehouse: It is a repository of information that are gathered from various sources and stored under unified schema, at a single site. The data in warehouse are historical data and it is

used for analysis and forecasting purposes [30]. According to William H. Inmon [31] a data warehouse is subject oriented, integrate, time variant and non-volatile collection of data which assists decision makers.

1.2.1 Microsoft SQL Server

Microsoft SQL Server suite has been used to create reports. The suite includes, SQL Server Integration Services (SSIS), SQL Server Analysis Services (SSAS) and SQL Server Reporting Services (SSRS) which are briefly explained below.

SQL Server Integration Services (SSIS) : It is a component of Microsoft SQL Server that is used for data migration. It provides an ability to fetch data from various sources like (Notepad, Excel, SQL Server, etc.), apply transformation techniques like (data conversion, apply aggregation function, merge data, sort, etc.) and load data to the specified destination. [29].

Microsoft SQL Server Analysis Service (SSAS): SSAS is a data mining and OLAP tool. It is used to build *Cube* (multidimensional structure) that stores complex aggregations and pre-calculated measures [29].

SQL Server Reporting Services (SSRS): It provides ready to use tools and services to help create, deploy and manage reports. It includes programming features which enable the users to generate customized interactive graphical, tabular or free-form reports from relational, Extensible Markup Language (XML) based, multidimensional data sources. Reports include rich data visualization, including charts, graphs, maps, tables, gauges, spark-line, indicators and much more [29].

BPM and BI techniques are used to gain competitive advantage. They allow to relate process performance indicators and key performance indicator for better decision making [32].

1.3 Motivation & Problem Statement

In order to analyze and improve an existing process, it is essential to have an understanding of the process from end to end. This can be achieved by creating a diagrammatic representation of all activities, events and decisions which constitute the process [33]. Ideally, this should be done by the person who is knowledgeable about all activities within the process. In reality, such a person generally lacks the essential skills required to design a model. So modeling experts are engaged to create and validate business process models together with the person who is either somewhat familiar with the process or knows the process very well [34].

The current procedures used by most organizations for collecting information to create business process models generally lead to misunderstanding or ambiguity between model and domain experts which is very expensive and time-consuming. As stated by Herbst, the information to collect for the *as-is* model in a workflow[5] project could require 60% of the time allocated to the overall project [35].

To solve this problem, we propose a framework to create business process models more efficiently and effectively which is explained in more detail in next section. The proposed framework does not only automatically create business process models from users' inputs, but it gives the users the ability to align those processes with organization's strategic business objectives, critical success factors, KPIs, and functions. In addition, ongoing maintenance of

[5] Workflow: shows a sequence of steps that consists of work process in an organization. It usually involves numerous of employee in an organization.

the created model also becomes more efficient. Further processes are tagged with relevant tiers and assigned desired maturity level to guide the development and resources allocated by decision makers.

1.3.1 Proposed Framework

Our proposed framework enhances the communication between process analysts and domain experts, and provides an approach to verify as well as validate the process of entering the business process steps. The framework provides a user-friendly interface which allows the users to add events, tasks and decisions in the sequence order that they appear within a process instead of a lengthy document explaining the overall processes. The users are able to specify the roles related to each process and activities. The framework creates the business process map in XPDL[6] (XML Process Definition Language) [36] file format for each process which is subsequently translated into business process models. Specifically, the framework allows the users to perform the following tasks:

- Submit information about the processes.
- Submit additional process requirements, especially when the process changes.
- Provide feedback for existing processes.
- Report bugs on the business process models.
- Add and specify relationships between an Organization's SBOs, CSFs, KPIs, functions, and processes.

[6] XPDL: XML Process Definition Language is a standard format by WfMC (Workflow Management Coalition) defines an XML schema to specify the business process models [36].

The analysis section of the proposed framework provides a dashboard with aggregated information about the processes and drill down/drill through reports which contain information at a finer granularity. Among other things, the analysis module displays the following information:

- Overview of organization's strategic business objectives, critical success factors, KPIs, functions and business processes together with their relationships.
- Maturity level of functions and processes
- Type of processes
- Number of approved business process models

1.3.2 Benefits and Contributions

Reviewing the existing literature identified a number of issues such as limited involvement of domain experts during the creation of business process models, processes are not aligned with strategic business objectives, several unrealistic assumptions and laborious tasks to assemble the relevant information. Our proposed framework addresses a number of these concerns. Some of the benefits and contributions are listed below:

- The framework allows specification of the relationship between an organization's strategic business objectives, critical success factors, KPIs, functions and business processes within all areas of the organization together with interactive reports demonstrating the relationship.
- Flow objects can be stored with their respective departments and roles. It helps to identify the number of tasks performed by each role. For example, if an organization

changes/deletes a role, the interface clearly shows the associated tasks which would be affected.

- Constraints are enforced to create BPMN compliant models.
- Information can be gathered via asynchronous collaboration, which allows multiple users from different locations to work on a specific process simultaneously.
- Current and desired maturity level can be tagged to functions and business processes. This helps to display number of functions and processes that have not yet reached their desired maturity level.
- Processes can be tagged with process tier (strategic, tactical & operational) and process type (management, core & support). This classification helps in prioritization of the work. For example, change to a process in strategic tier may receive a higher priority as it affects the entire direction of the organization. Similarly, if a process type is core then it has direct relation with the services and products that bring value to the organization.
    - Classification reduces the complexity of the work as it provides a clear picture of the area of interest by assisting in better understanding of the relationships. It also relates processes to the right accountability level.
- Platform independence.
- The XPDL generated file allows easier data transfer to other software.
- Feedback and errors can be added for each business process model.
- Real-time dashboard provides aggregated reports with drill down capabilities.

- Modular design allows easy extension and removal of a component. For example, a report component can be removed from the framework without breaking other components. Similarly, the reports built in SSRS could be changed to another visualization technology without affecting other components.

1.4 Thesis Organization

This thesis consists of five chapters. In Chapter One, we described the underlying key concept such as Business Process Management, Business Process Model and Notation standards and Business Intelligence. We also described the motivation behind our work highlighting the benefits and contribution of this research. Chapter Two presents related work in the area of business process management. Chapter Three describes the architecture design and implementation of our proposed framework. Chapter Four presents various use case scenarios to demonstrate the functionality of the proposed framework and its advantages over existing tools. In Chapter Five, we conclude the thesis by recommending future directions that we believe can be taken to extend this work.

Chapter 2

2. Related Work

Due to the increased adoption of business process management, extensive research has been done in this area. In the first section of this chapter, we provide the history of BPM and outline methods for generating, extracting information and improving business process models as proposed in literature. We also describe relevant work done in the area of business architecture and strategic alignment of processes. We conclude by providing an overview of several tools, followed by a summary of the chapter.

2.1 Business Process Management (BPM)

In the few past decades, the BPM has been increasingly adopted by organizations. BPM enhances collaboration and communication among IT and other business areas within an organization in the process of development, implementation and optimization of business processes. BPM is not a new concept, as most of the organizations have used process improvement or process management, business process reengineering, Six Sigma, etc. [37] to optimize their operations. Lusk et al. [38] state that BPM and related tools evolved as results

of customization, innovation, increased one-to-one customer focus, and business growth that has been caused by consolidation.

According to Scheel et al. [39], business processes evolved in four phases. The first phase started with Sun Tzu's *The Art of War,* an ancient Chinese military book in the 5th century BC, which describes military tactics and strategies [39]. This book is one of the most important references in competition strategies and strategic management. It provides necessary clues to the organization directors and managers in the process of development and implementation of strategies in situations where they are unable to find allied relations [40]. Hundreds of years later, Adam Smith showed benefits of the division of labour which later influenced Frederick Winslow Taylor to introduce the initial principles of scientific management. The second phase, optimization of process [41], began around 1950 when the digital communication infrastructure started to influence business processes. It has completely changed the way organizations and companies conduct their business and perform tasks. Process optimization led to digitalization and visualization of the business process which forms the third and fourth phase, respectively. Now the business processes are implemented and executed by using technology and information systems [39]. The historical evolution of processes are illustrated in Figure 8 [39].

Many techniques and methods have been proposed in the area of BPM and especially business process models. We have divided these into three categories: generation, extraction of information, and improvement of business process models. These techniques are discussed in the following sections.

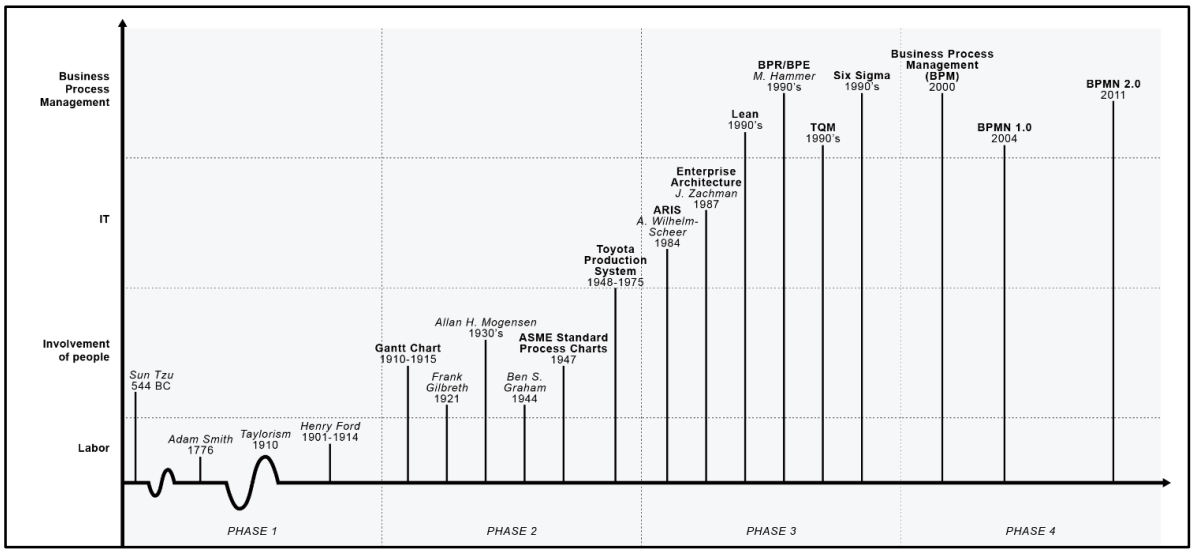


Figure 8: The historical evolution of processes over the course of time [39]

2.2 Generating Business Process Models

In an organization, the model experts build business process models using software and tools like HP Process Automation [21], iGrafx® Flowcharter [22], Visual Paradigm [23], Oracle Business Process Management Suite [24], Bizagi BPM Suite [25], IBM BPM [26], Tibco ActiveMatrix [27], Bonita BPM [28] etc. Extensive research has been done to identify approaches which make the process of building business process models easier.

Redding et al. [42] proposed an approach to generate business process models from object behaviour models. To complete the transformation procedure, three steps were performed. First, a *heuristics net*[7] was generated from an object model. Then the *Petri net*[8] was created which later on transformed into YAWL[9] (Yet Another Workflow Language) process models. This approach could be useful only to transform object behaviour models to business

[7] Heuristics net: Is a set of transactions and is used as "tasks" in [42].
[8] Petri net: In BPMN standard "Petri nets offers graphical notation for stepwise processes that includes choice, iteration and concurrent execution." [75]
[9] YAWL is powerful workflow language [74].

process models. Further, it covers the control flow of objects but does not cover resource allocation and data flow.

An automated approach towards generating BPMN (Business Process Management Notation) models from document description was proposed by Friedrich et al. [43]. NPL (Natural Language Processing) and BPM have been combined to achieve this goal. First, the sentences which contain information about the process were analyzed. Later, the text within sentences was analyzed and at the end, the models were generated. A set of 47 text-model pairs from industry and textbooks were used, and the generated models were on average 77% correct when compared with human created models. During the creation of these models, it was assumed that the process descriptions were sequential, do not contain questions, and the description documents have less irrelevancy about the processes. However, process description generally contains questions and irrelevant information about the process. Thus, using this method requires text preparation to meet the unrealistic assumption.

Other related work with reference to creating process models includes:

- Visualization of Use Case sets as BPMN processes [44].
- Generation of business process model for a set of given reference object life cycles [45].
- Construction of simple artifact-based business processes [46].
- Introduction to a set of extensions for BPMN model generation [47].

In above list, researchers generated process models from object behaviour models [42], document description [43], and reference object life cycles [45]. Daniel and Kurt [44] described an approach to visualize dependencies for use case sets. By using pre-conditions, post-

conditions and triggers, BPMN models were created to show the relationships between various use cases. They assumed that all use cases would be in a semi-structured and tabular form which is not the case in reality.

Jochen et al. [45] proposed a technique to generate a process model from object life cycle[10]. This was done in three steps. First, a set of actions was created. Second, the order of those objects was determined and actions were combined into process fragments. Finally, the process fragments were connected to create process models. An alternative approach was presented by Christian et al. [46] to automatically create workflow schema that satisfies a specified set of conditions. The model-based workflow that represents the main business objects were used in this research.

Decker and Barros [47] introduced a set of extensions for BPMN model generation which had reusable control-flow, but with certain limitations. Instead of tasks, events, gateways and complex interactions were used in the process models. All decisions and events with no messages had to be assigned to the pools. This approach has not been completely validated and was referred to as part of future work.

In this section, we reviewed various techniques and methods proposed by researchers to generate business process models. A common shortcoming of these approaches and methods is that the domain experts are not involved in the process of creating business process models. Also, the processes are not aligned with strategic business objectives of the organization and do not have the capability to assign process tier (strategic, tactical & operational) and process

[10] Object life cycle: is a model which captures permitted state transitions and states for a specific object type [76].

type (management, core & support) to business process models. In next section, we review the process of extracting information from business process models.

2.3 Extracting Information from Business Process Models

In this section, we present a reverse perspective, that is, the approaches to extract information from existing business process models.

Meyer and Weske [48] presented an approach to extract data objects and their status from business process models. In this approach, the labels[11] of activities were first analyzed in order to determine the actions and objects within business process models. Next, the input and output objects were specified. Finally, the redundant data objects were combined in order to improve readability of the models. This approach is very useful when organizations want to move from documentation of processes to their execution. It also assists the organization to validate process models with the data objects that are extracted.

Tomas et al. [49] proposed a method to extract vocabulary from the business process models. The algorithm is composed of three stages. First, the business expressions and objects are extracted from models and stored in datasets. Second, the Semantics of Business Vocabulary and Business Rules (SBVR) *noun concept*[12] entries are formed from previously extracted business objects and SBVR *fact type*[13] entries are formed from business expressions. SBVR is a standard adopted by OMG [50], and its purpose is to express business knowledge that is understandable by computer and human in a controlled natural language [51]. Lastly,

[11] Label refers to the text that indicates the action of an activity.
[12] *Noun Concept:* It is a SBVR concept that is divided into *Individual Concept* and *General Concept*. *Individual Concept* corresponds to only one object and *General Concept* classifies objects based on their common properties [49].
[13] *Fact Type:* It is a SBVR concept that indicates the type of relationship among two or more noun concepts [49].

the validation of the SBVR business vocabulary is performed by domain experts. This algorithm is very useful in a large BPM project where numerous business process models are involved and can be helpful for integration these models. One of the issues in this algorithm is the process of manually identifying verbs, nouns and adjectives in the first stage, and then forming business expressions.

Leopold et al. [52] developed a method to create natural language text from BPMN process models. A set of 46 process models from different areas was used. The generated text was found to be similar to that created by human. This text could assist the domain expert to better understand the business process model and could also be used for training purposes. The results indicated that 66 percent of generated text was correct. However, these results may be biased because the participants were well conversant with process modeling. The proposed pipeline architecture components are listed below:

- Extracting the linguistic information from the elements of the process model.
- Building a tree structure for every pool in the process model.
- Inserting bullet points and paragraphs depending on the tree structure.
- Generating intermediate messages for each node of the tree.
- Transforming intermediate messages to grammatically correct sentences. All the messages were combined, and suitable words were then inserted into the sentences to make them readable.

In this section, we reviewed methods that extract data objects [48], vocabulary [49] and text [52] from the business process model. A common shortcoming of these methods is that the process of extracting information is not fully automated. Also, some of the results might be biased because the participants involved in the collection of results were aware of process

modeling. Therefore, the results might have been different if the users were not conversant with process modelling.

2.4 Improving Business Process Models

In the previous two sections, we discussed techniques used to generate and extract information from business process models. In this section, we present techniques to improve business process models and other related methods proposed in the literature.

An automated layout algorithm for BPMN (Business Process Management Notation) was presented by Kitmann et al. [53]. The algorithm was implemented in Java with GUI (Graphic User Interface) which allows specifying the input and output files. The algorithm takes BPMN models in eRDF[14] format as input and improves the layout of the models, but not description of the process.

Another technique which automatically detects the difference between business process models and textual descriptions was presented by Van Der Aa et al. [54]. The proposed approach uses natural language processing methods. First, a linguistic analysis is performed on the textual description and activity label of the models. Then the similarity between sentences and activity is determined to find the optimal correspondence relationship. Finally, relationship is assessed to find any inconsistencies between the textual description and business process models. The 46 models and text descriptions used in this approach were from academic, industrial, textbook and public sector resources. This approach successfully identified the

[14] eRDF is a file format used by Oryx Editor. Oryx Editor is a web-based modeling tool that supports business process modeling in BPMN.

inconsistencies between business process models and textual description with a very low number of false results.

Wetzstein et al. [55] explained how ontology and semantic technology could be used in each phase of the BPM lifecycle. The main goal of Semantic Business Process Management (SBPM) is to combine semantic technology like ontology and SWS (Semantic Web Services) in order to improve automation in BPM lifecycle. The authors identified the requirements, which is needed in each BPM lifecycle phase for a SBMP System (SBPMS), and described the benefits of using semantics. The authors claim that by using semantics technologies, more automation can be achieved in BPM lifecycle. Unfortunately, the authors did not specify the technology needed for implementation of the proposed requirements.

Dijkman et al. [56] presented three similarity metrics to retrieve process models from a repository that closely matches the given process model. First, they measured the similarity based on properties of elements such as labels and other attributes within the business process models. Second, the similarity is measured based on properties of elements and the relationship between these elements. Third, the similarity is measured based on the behaviour. The proposed metrics were tested in two different datasets with the conclusion that the results which were finding similarity between given model and models in the repository were better than those obtained from the text-based search engine.

Pittke et al. [57] proposed an approach that recommends the most relevant name for the elements within process models. The proposed approach consisted of two steps. First, a list of recommended names was created by applying three layers of context. In the first layer, all business objects and actions within a process model were considered as a recommendation name. In the second layer, all the process models within the repository were taken into

consideration, and the missing actions or business objects were inferred from them. In the third layer, the general text was searched for the missing element. In the second step, the recommended names were ranked according to the suitability of the chosen process models. In order to demonstrate the capabilities of this approach, an evaluation was conducted using test data, evaluation design, evaluation metrics and prototype implementation. The results showed that this approach created meaningful recommended names.

Other related work proposed in literature for process models includes:

- Identifying data-flow errors in BPMN process models [58].
- Creating glossary for process modeling automatically [59].
- A prototype to layout BPMN process models [60].
- A method using constraints to layout business process model [61].

Stackelberg et al. [58] proposed an approach to identify dataflow errors in business process models. A set of transformation rules were developed that represents dataflow errors in business process models. To detect the dataflow errors, data dependent and flow elements of process models were transformed into unfolded Perti Nets. To validate this approach, an evaluation was conducted and the results showed that this approach successfully detected dataflow errors.

Peters and Weidlich [59] introduced an approach to generate a glossary from existing business process models, which could be used to assist in label suggestion. The formulas used in this approach were explained well but the way in which those formulas were used was not clear. There was also an assumption that the process models have high-quality labels. Therefore, the generated glossary might yield different outcomes with low-quality labels.

Philip et al. [60] presented a tool, which automatically helps to layout BPMN models. The proposed tool consists of six main features: a) automatic layout, b) model design, c) division and links, d) free navigation and zoom, e) import and export and f) undo/redo. The sub-processes were considered as an object flow, which allowed to layout the sub-processes in the whole model.

Thomas et al. [61] proposed an automated layout algorithm by using constraints. A three-phase approach was followed to achieve this goal. In the first phase, the gateways were split such that, one covered all the incoming edges and the other all the outgoing edges. Likewise, for activities and events multiple outgoing and incoming edges were separated into another gateway. In the second phase, the business processes were decomposed by using Refined Process Structure Tree (RPST) algorithm into Single-Entry Single-Exit (SESE). Therefore, each process had a single start and end point. In the third phase, the layout of business process models was computed based on SESE. An evaluation was conducted and all constraints in the algorithm were met. The algorithm was tested with small business process models.

Organizations create workshops and train process experts with new techniques in order to improve business process models. Several proposed algorithms and methods to assist in this area were discussed in this section. Some of the approaches reviewed did not specify the technology and implementation details. Also, there were several unrealistic assumptions made in implementation.

2.5 Business Architecture (BA)

Business Architecture (BA) helps the alignment of business processes with strategic business objectives of the organization. BA allows an organization to establish a shared vision, level of transparency, and common vocabulary [62]. The benefits that business architecture bring to organizations include:

- Aligns business process with organization strategic business objectives
- Creates a transparent process prioritization by showing the relationship between different areas of an organization.
- Brings clarity, consistency in vocabulary across business units.
- Eliminates process redundancy and brings standardization

Business Process Architecture (BPA) groups the processes in various subsets, each being responsible for a specific business case [63]. It is not only the processes that change within the organization, the relationship among them changes as well. The changes in an organization can happen at many levels and at various rates. In order to manage these changes, the organization needs to be knowledgeable about the core, support and management processes within their business [3]. Core processes generate or add value to services or products of an organization. Support processes do not add value, but they facilitate the execution of the core process. Further, support processes provide the resources, which are needed to operate the core processes. Management processes are used to plan, monitor, control and communicate between the core and support processes [3]. Figure 9 shows a customer order fulfillment process, in which these processes are identified. The processes require adequate allocation of resources for analyzing, redesigning, monitoring and maintaining the business processes model. An

organization does not need to create business process models for all their processes because of cost implication. Instead, it is more beneficial that an organization focuses on carefully selected processes which are strategically important and those which are problematic for its customers and/or stakeholders. In other words, the focus of the organization should be on processes that bring value, are strategically important and those that are troublesome. Applying BA can clearly illustrate the processes that are strategically important for an organization.

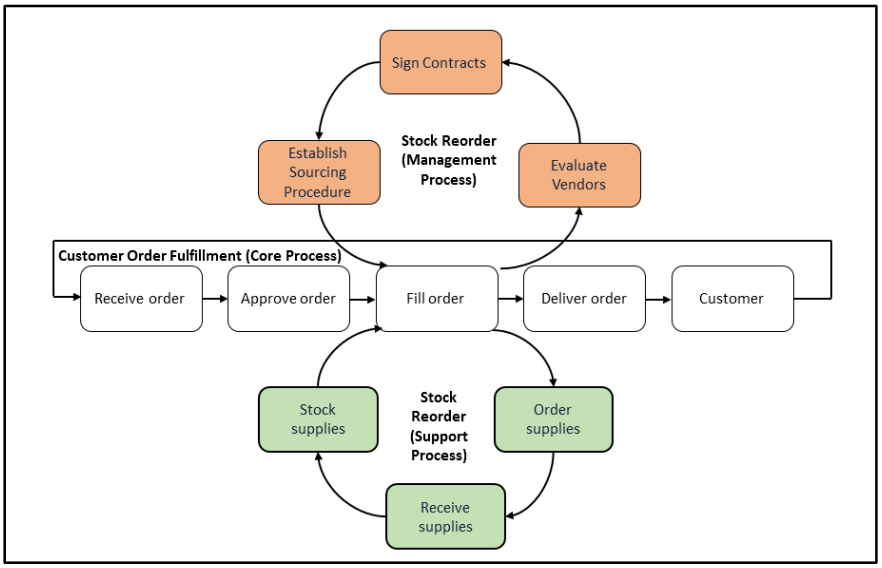


Figure 9: Core, management, and support processes [64]

Classification reduces the complexity of work as it creates patterns which provide a clear picture of the area of interest and also supports in better understanding of the relationships. Earlier in this section, we discussed one type of process classification (Core, Management and Support). Now we define process tiers that classify the processes into three categories (Strategic, Tactical and Operational) [65] with the examples shown in Figure 10.

- **Strategic**: This tier affects the whole organization and consists of long-term, complex decisions made by senior management and executives. It includes processes relevant to mission, vision, business planning, budget, etc.

- **Tactical**: In this tier, decisions are less complex and performed by middle managers. It includes processes related to administration, policies, rules, etc.
- **Operational**: In this tier, operational managers make day-to-day decisions. The decisions are very simple and routine for example operational administration, operational reporting, etc.

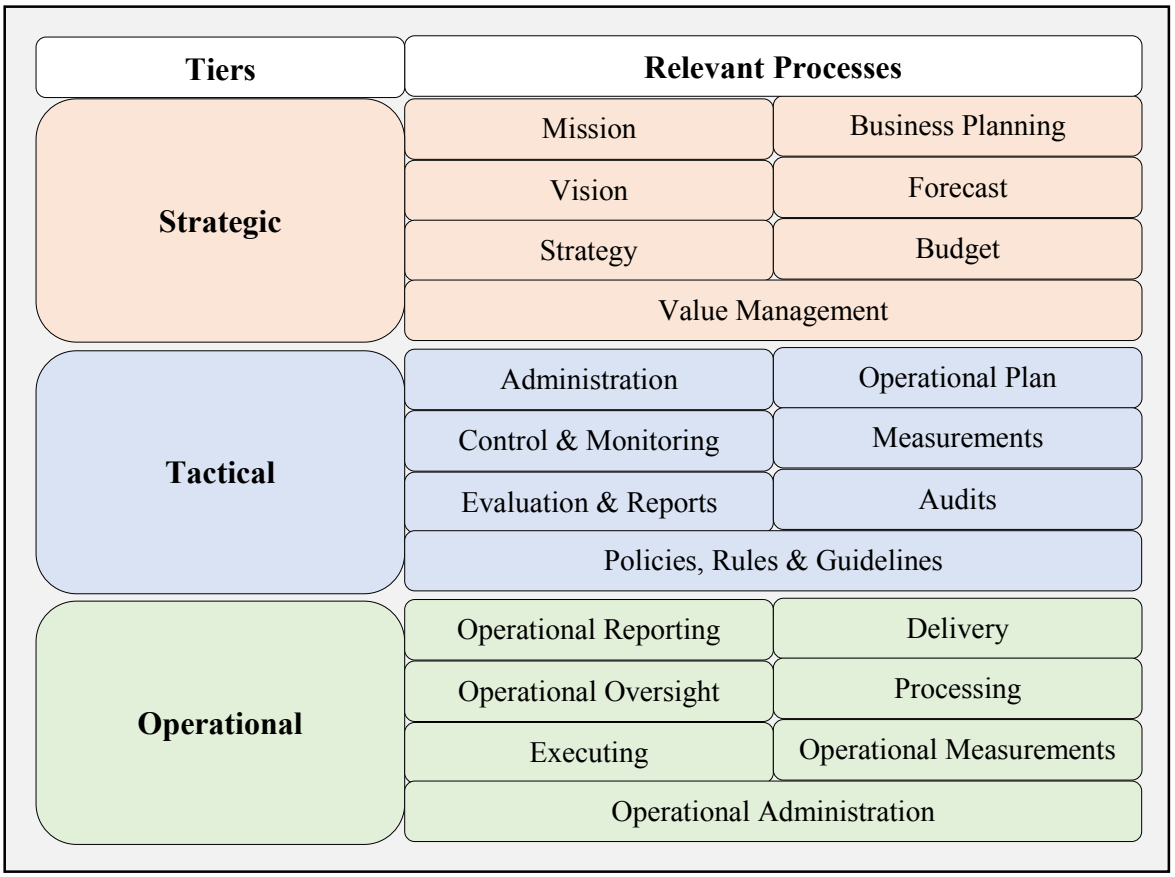


Figure 10: Example of "Enterprise Tiers" and relevant process context [65]

Example of strategic, tactical, and operational tagging of the processes is shown in Table 1. Processes that affect the whole organization are tagged to strategic tier, for example, develop and manage strategies process. Processes that are less complex are tagged to tactical tier, for example, manage IT knowledge process or develop product and services process.

Finally, processes that are day-to-day routine are tagged to operational tier, for example, manage taxes process *[65]*.

Tier	Business Process
Strategic	Develop and manage strategies
Tactical	Manage IT Knowledge
	Manage treasury operations
	Develop product and services
	Develop and maintain information technology solutions
Operational	Control & Monitoring

Table 1: Examples of processes classified by tier [65]

2.5.1 Strategic Alignment of Business Processes

As mentioned earlier, Business Architecture helps decision makers to better understand the current processes and their relationship with each strategic business objective and goal thereby leading to standardization and optimization of the process. As described by Paul A. Strassmann "Alignment is the capacity to demonstrate a positive relationship between information technologies and the accepted financial measures of performance" [66]. BPM alignment focuses on accelerating automation and reusability, which requires the CEOs and managers to have a better understanding of alignment and how to develop it [32].

Koliadis et al. [67] proposed an approach for aligning services capabilities to the business process. The authors described the relationship between effects and goals that display how requirements are related to processes. A set of 22 questions that can be used in building process architecture and functional evaluation were presented. Another approach was proposed by Zirpins and Piccinelli [68]. The alignment of services to processes was explained by using

role-based and capability relationship. One of the main advantages of this approach was the possibility of capturing change strategy, and separate application and definition from such strategy. Evan et al. [69] proposed a framework which shows strategic alignment within an organization. The framework provided a set of methods that correlated models to strategic plans, optimization objectives and functional goals.

In summary, the benefits of strategic alignment of business processes include [32]:

- Elimination of redundant steps which are system driven or regional
- Integration and standardization of processes across the organization units
- Automation after removing redundant steps
- Creation of repeatable pattern to align projects, portfolios and programs with different stakeholders.
- Better traceability and transparency.
- Improvement in execution and joint delivery

2.6 BPM Maturity Model

Organizations strive to perform better and bring more value from the products and services that they provide. To accomplish this, the organizations need to know the maturity level of functions and processes that are executed. Maturity models are a structured collection of elements that guide organizations to determine their present capabilities to implement improvement and changes. As stated in [70], there are five BPM maturity levels, which are explained below:

- At level one, the organizational functions and processes are not characterized, and they are disorganized, ad hoc, and uncertain with no clear definition of the processes.

- At level two, the primary process standardization is established to track schedule, functionality and cost.
- At level three, the processes are documented, integrated and standardized within an organization.
- At level four, the performance of the processes within an organization is tracked.
- At level five, the organization has a solid performance management. The organization is widely integrated, and continuous process improvement becomes culturally embedded in the organization.

For example, a *hiring business process* can be tagged from level one to level five maturity in an organization. The business process maturity level one can be tagged to the *hiring* process when the process is in initial stage. Every time a new employee is hired, the process is different. It becomes level two, when the concept of the *hiring* process is understood and repeated each time in some areas of an organization but not all. Level three can be tagged when the *hiring* process has been well documented and is standardized across the organization. The entire organization uses the same process when they want to recruit new employees. The *hiring* process can be tagged to level four, only if the process is measured and controlled. Finally, it can be in level five, when it is optimized and continuous business improvement is happening via feedbacks and collaborations.

Tagging maturity level to a process assists the organization to know the state of each process. If maturity level tagging is in place, the managers can easily specify the processes with lower maturity level and improve them. The managers, process analysts and other responsible persons in the organization should know exactly which processes of the organization they should focus on. They should understand the processes with higher priority

so they could create, redesign, monitor and maintain the processes better. The process priority or strategic imperative may also change because of the change in law and regulation or customer needs. Therefore, the organization should be able to adjust in response to such changes and tagging maturity levels helps to achieve this.

2.7 Tools

Several tools are available which allow process architects to construct business process models. In this section, we provide an overview of these tools.

2.7.1 iGrafx® Flowcharter:

iGrafx is a business process modeling and analysis tool that allows the users to create BPMN diagrams, process maps, value stream diagrams, and cause effect diagrams, create customized template, etc. It also has other features such as intelligent diagramming, lean value streaming mapping, Visio import, model publication, etc. [22]. It has a feature to layout diagrams and also allows the users to export the diagram to PDF, Microsoft PowerPoint, Microsoft Word and Web Page. It does not allow the users to import files in XPDL format. iGrafx® is a proprietary tool but has attractive academic licensing arrangement.

2.7.2 IBM WebSphere

IBM WebSphere allows the users to build business process models. It is designed to support mobile devices, which provides access to models quickly with backwards compatibility to the latest version of IBM WebSphere Integration Developer, IBM WebSphere Process Server and IBM WebSphere® Lombardi Edition. It has a single user interface that

assists the users to better document, understand and display business processes [26]. Import/export of files into XPDL file format is allowed, and license is needed to use this software.

2.7.3 Bonita

Bonita is an open source software with community support. It allows users to assign actors to processes and uses a shared repository that stores business process models. By using Bonita, the user can transfer the processes to personalized business applications [28]. The integration with other Java APIs software can be done very easily. It allows to import BPMN2.0, XPDL 1.0, JBPM 3.2, Bonita 6/7 and Bonira BAR 4.5/5.10 files formats and export as BPMN2.0, image (PNG, GIF, BMP, JPEG, SVG, JPG) and PDF. Currently, it supports XPDL version 1.0 only, and does not have support for the latest version of XPDL 2.2.

2.7.4 HEFLO

HEFLO is a free online application that allows users to create BPMN models. It provides automatic backup functionality which stores the model while user is building it. The already built process can be published to receive feedback from users. All the published processes are stored in the cloud. It only supports XPDL 2.2 but not the other versions. The users can export files into BPMN, PDF, Microsoft Word, Microsoft Excel and HTML but not export files to an XPDL file format [71].

2.7.5 myInvenio

myInvenio is an online application that allows the users to create business process models and provides version control capabilities without losing any history of changes made to the models. It also has visual comparison functionality that allows the users to compare different version of the models. It is compatible with BPMN2.0 and allows the users to import/export XPDL 2.1 version [72] only but not to the latest version of XPDL 2.2.

2.7.6 Bizagi BPM Modeler

Bizagi is an open source tool used to design and develop business process models with the capability to import and export files as Visio, XPDL, and BPMN file format. [25]. It allows the users to publish process models in SharePoint, Wiki, web pages, PDF and Microsoft Word and provides a collaboration platform for users to communicate with each other.

Table 2 provides a comparison of features of tools listed in this section. The common features of these tools include: BPMN compliance, drag and drop functionality, and visual process diagramming tool. Other features which some of these tools have include: role-based access control, powerful administrator features, Single Sign-On (SSO), real-time monitoring and KPI measurement. Here we compare all the features available on existing tools while in Chapter Four we only compare the features that are related to business process models with our proposed framework.

	iGrafx® Flowcharter	IBM WebSphere	Bonita	HEFLO	myInvenio	Bizagi Modeler
Export / import XPDL file format	X	X	Exports XPDL 1.0 only	X	Exports XPDL 2.1 only	✓
Mobile support	X	✓	X	✓	✓	✓
Reports & Analytics	X	✓	✓	X	✓	✓
Provide self-service training courses	Yes but not free	X	Only for developers	X	✓	✓
Case management capabilities	✓	✓	X	X	X	✓
Social collaboration features	X	✓	X	X	X	X
Cloud Deployment	X	✓	✓	✓	✓	✓
Licencing	Required	Required	Not required	Not required	Not required	Not required
Open Source	No	No	Yes	No	No	No

Table 2: Comparison grid of tools with key features

Bizagi Modeler [25] was chosen for our framework because it supports Business Process Modeling and Notation (BPMN), is free to use and facilitates importing and exporting to XPDL 2.2 [36] format. As mentioned before, XPDL is a widely accepted process definition language.

2.8 Summary

In this chapter, we reviewed several techniques and methods that have been proposed in the area of BPM and especially business process models. These techniques and methods have been categorized as: generation, extraction of information, and improvement of business process models.

A common shortcoming of these approaches and methods is that the domain experts have limited involvement in the process of creating business process models. Also, the processes are not aligned with the strategic business objectives of the organization. The authors have also made some unrealistic assumptions and the steps of creating business process models include some manual work. These problems lead to need for a new approach that addresses these concerns. Therefore, we propose a framework which not only creates business process models more efficiently and effectively but also aligns those with strategic business objectives of the organization. We present our proposed framework in Chapter 3.

Chapter 3

3. Architecture Design & Implementation

This chapter provides an overview of architecture design and implementation details of our proposed framework. The design includes front-end and back-end components. The prototype and its implementation is then illustrated with examples. At the end, a brief summary of the chapter is provided.

3.1 Architecture Overview

As concluded from Chapter Two, there are several shortcomings in the approaches and methods proposed in literature. We propose a framework to create business process models more efficiently and effectively and align the processes with strategic business objectives of the organization. The high level architecture design consists of two components: Business Process Model Generation and Strategic Alignment shown in Figure 11 and described below.

In the first component, users provide process requirements through structured forms. These requirements are then transformed into XPDL files which are imported into Bizagi Modeler [25] to display the actual business process model. The users have the ability to edit process requirements and regenerate the model as necessary. We demonstrate the functionality of our framework with the models from OMG and textbooks.

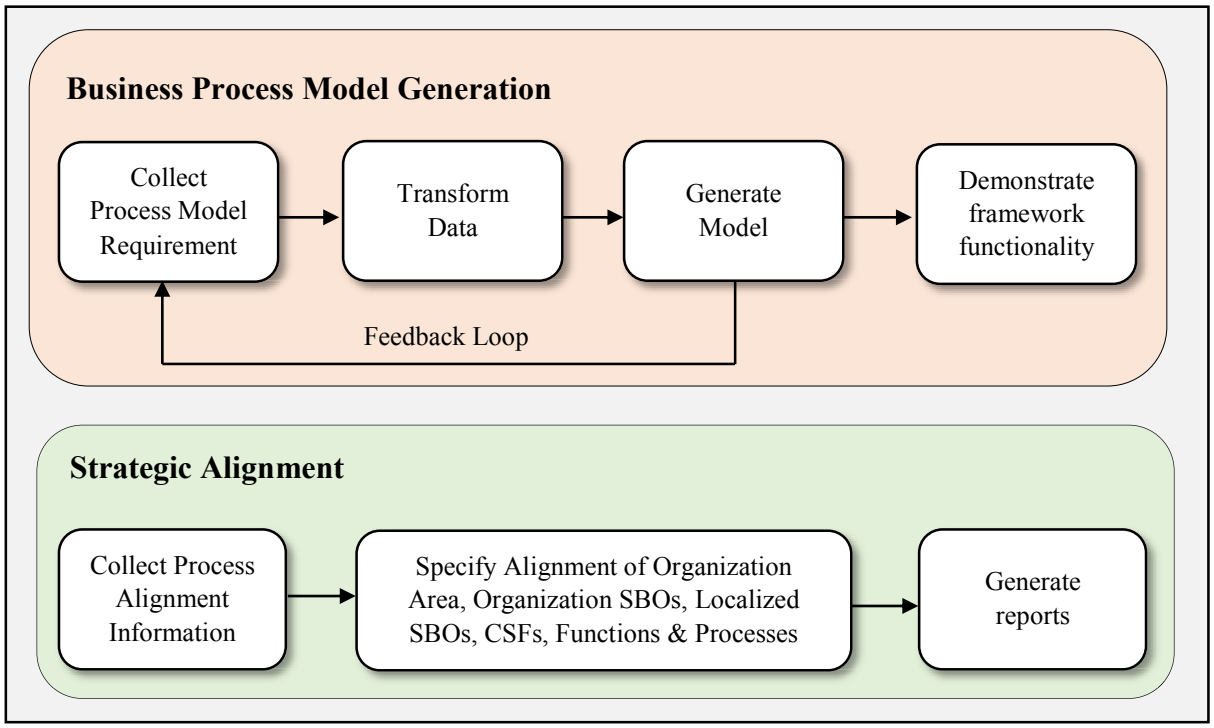


Figure 11: High-level architecture design

In the second component, users provide process alignment information through structured forms. The users are given the ability to specify alignment between organizational SBOs, localized SBOs, Critical Success Factors, functions and processes. Comprehensive reports are generated from the collected information, which contains aggregated information with drill through and drill down capabilities. In next section, we present the framework prototype in detail.

3.2 Framework Prototype

The components of our proposed framework are shown in Figure 12. These include both the front-end and back-end. In the following sections, we describe the implementation details of our proposed framework. The tools and technologies that are used to build the prototype are discussed as well.

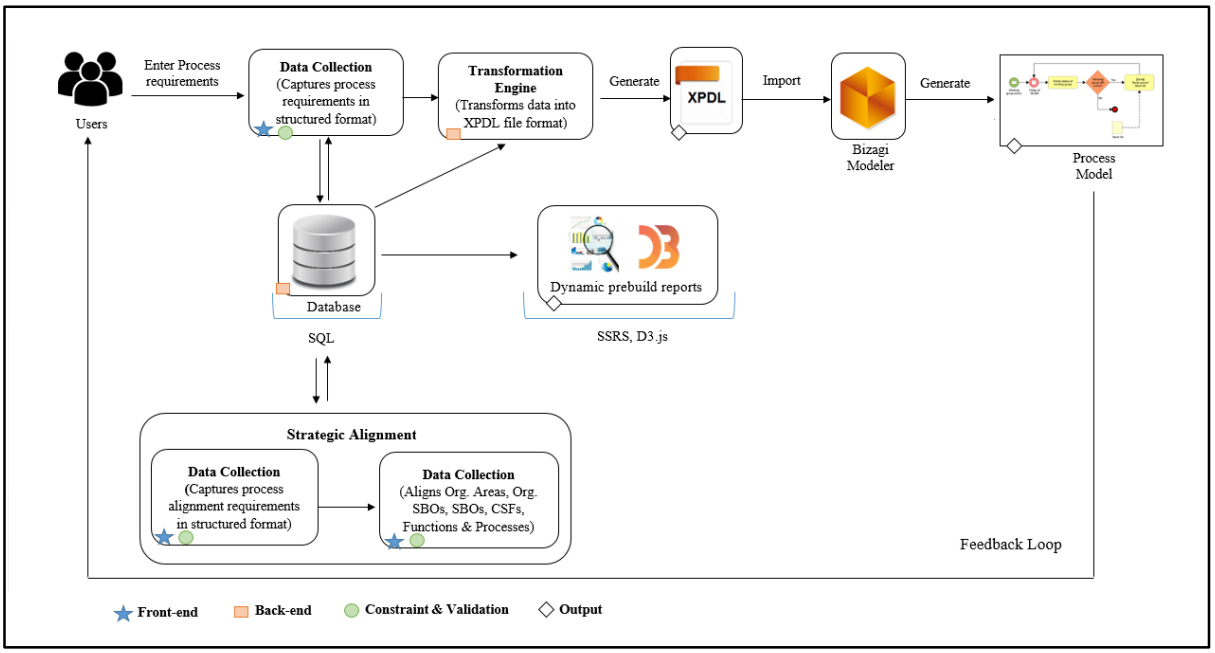


Figure 12: Framework Prototype

3.2.1 Front-end

The main goal of front-end component is to provide an intuitive/user-friendly interface for submitting process requirements. The main components of this interface are data collection, strategic alignments, and dynamic prebuilt reports, which allow the users to easily interact with the framework. It also includes constraints to ensure data integrity.

The structured forms to collect process requirements are built with ASP.NET, C#, Hyper Text Markup Language (HTML), JavaScript, Cascading Style Sheets (CSS), and Server Scripting. All the information is stored in Microsoft SQL Server database by using SQL (Structured Query Language).

In this section, we provided an overview of the front-end and its main components which are: information collection, strategic alignments and dynamic prebuilt reports.

3.2.1.1 Information Collection & Model Generation

Prior to requirement collection, the users need to follow specified prerequisite instructions to ensure that the required information to build business process model is adequately captured. The users can then submit process requirements in a structured format using standardized forms. These requirements include information about the process, roles, activities, decisions, and events.

The users are able to create a new process model or add information to an existing one. The information required to add new process model includes; area of the organization, process name, type, tier, maturity level, desired maturity level and comments about the process as shown in Figure 13.

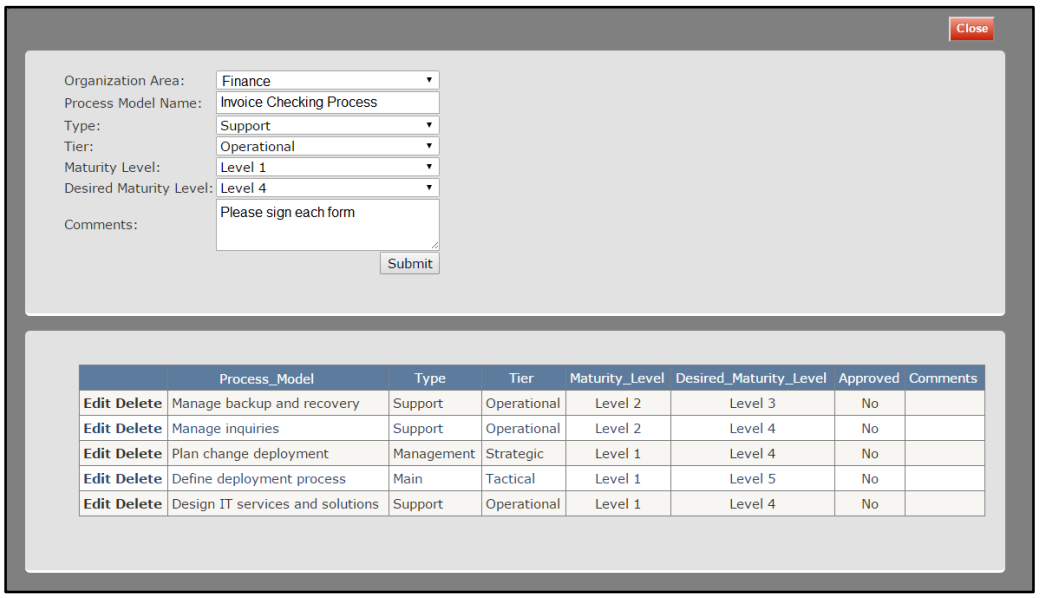


Figure 13: Model Meta Data process information

The users can submit additional process requirements such as roles and department which are involved in the process (Figure 14). The users are also allowed to choose from the

list of department and role that is stored in the database. There is also a functionality to add/edit/delete the departments and roles, but this functionality is restricted to admin-users.

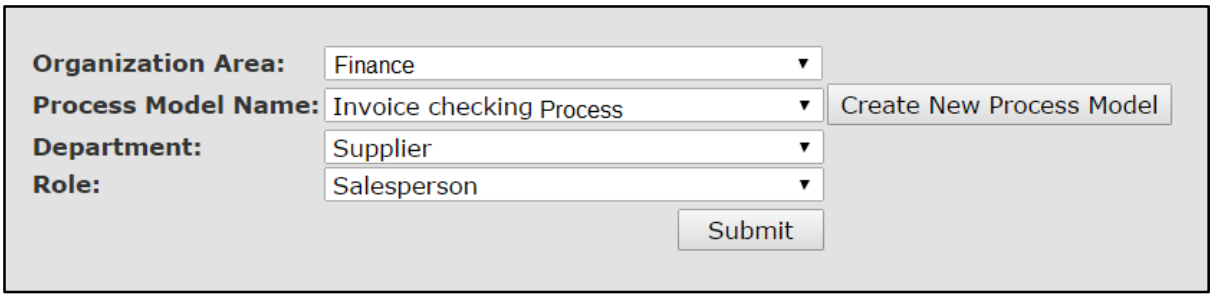


Figure 14: Model Meta Data department and role

The users can add events, tasks, decisions, type of decisions, comments, files and precedent objects as shown in Figure 16. For decisions, two pathways are compulsory, and the user can add or remove more pathways. The precedent objects are selected automatically if the users enter the information in sequential order. An option to change precedent objects and the decision type is available. The object types are discussed in more detail in the next section. After successfully submitting all the process requirements, the users can generate and download the XPDL file for the selected process (Figure 15).

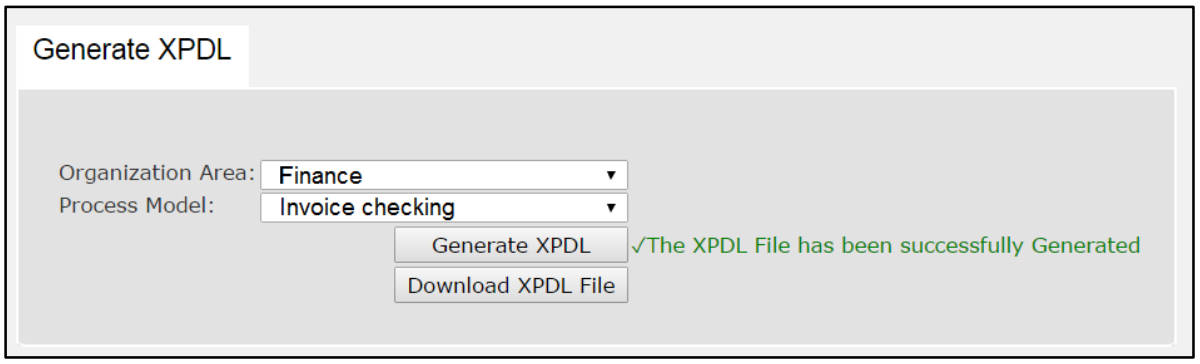


Figure 15: Download XPDL file

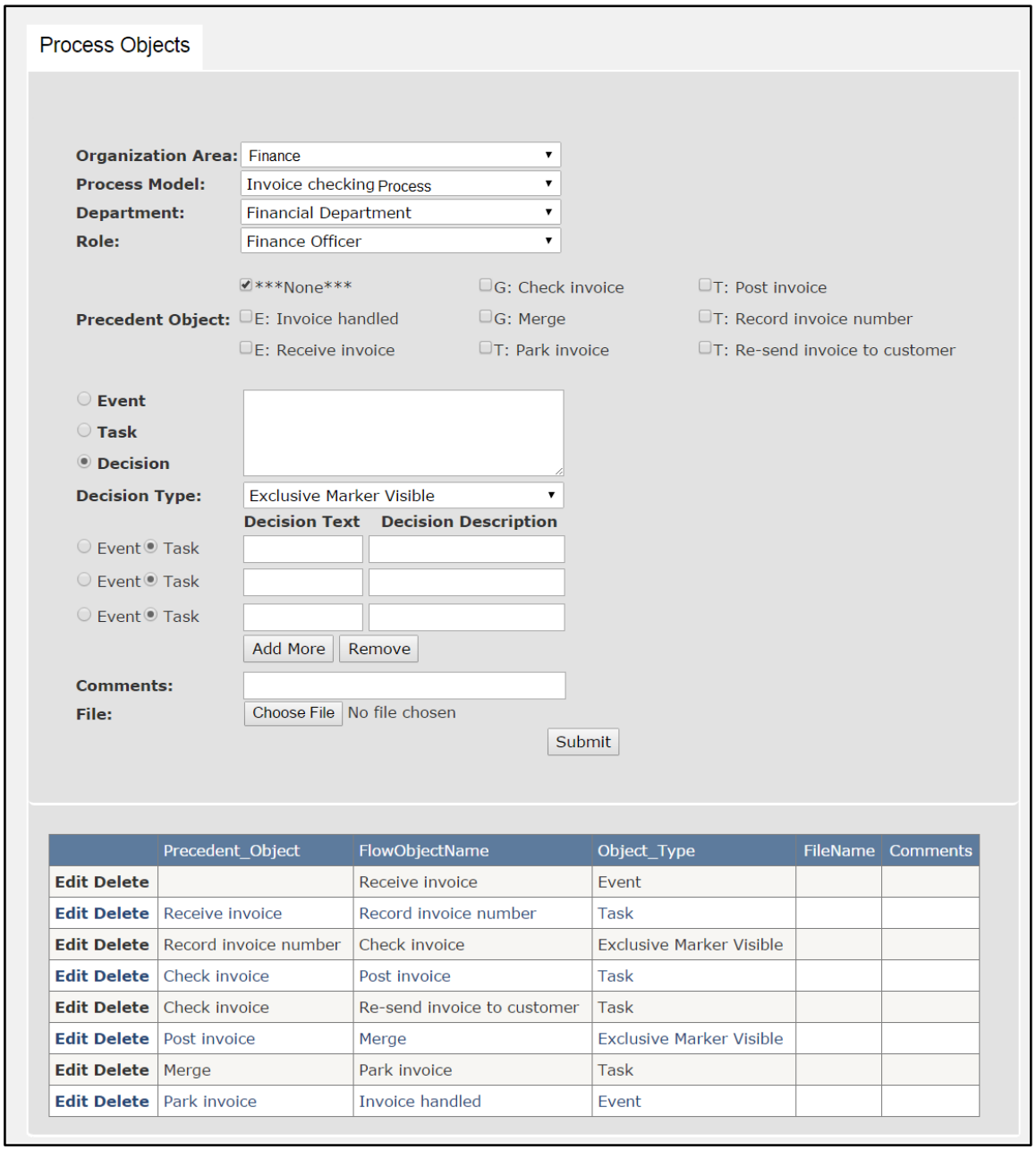


Figure 16: Process objects form

The XPDL file is imported into Bizagi Modeler [25] to view the business process model as shown in Figure 17.

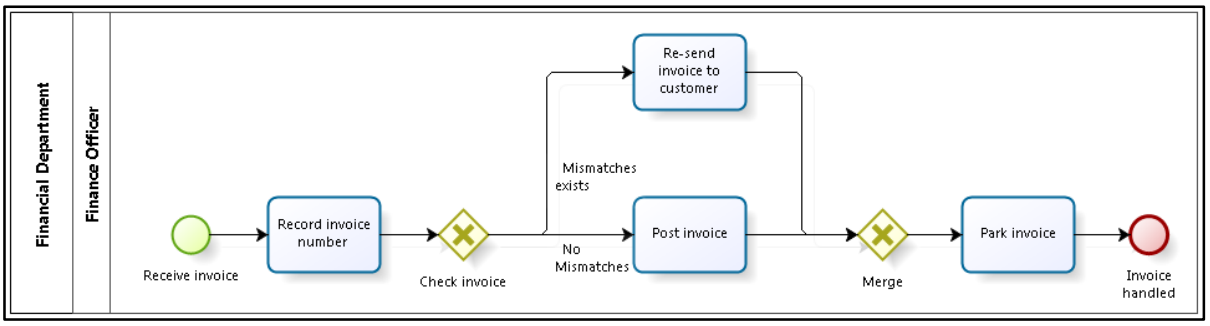


Figure 17: Invoice checking process

In this section, the functionality of information collection and business process model generation component was reviewed. In the following sections, the strategic alignments component is described.

3.2.1.2 Strategic Alignment

The strategic alignment component is designed to allow users to specify relationships between strategic business objectives of the organization and business process (Figure 18). It is implemented using C#, ASP.Net and JavaScript. All information about the relationships are stored in the database. The data constraint is applied in strategic alignment component to ensure the consistency of data entered by the users. The user can add organization SBOs, organization areas and localized SBOs. The framework also allows to add/edit/delete relationships.

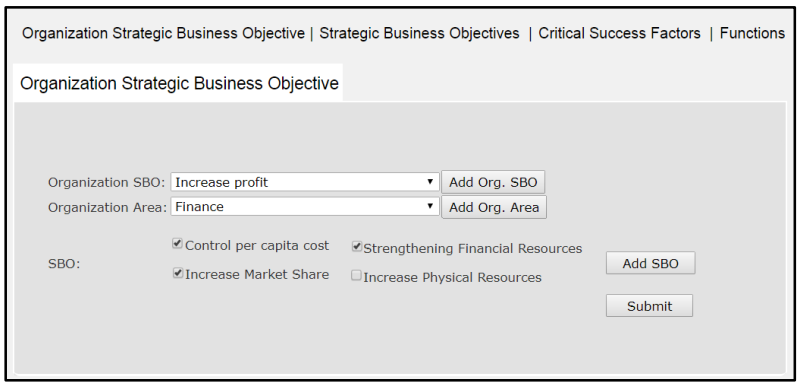


Figure 18: Specify relationship between organization SBO and localized SBO

This section talked about strategic alignment, and in the next section, the dynamic prebuilt reports generated from the information collected from users is discussed.

3.2.1.3 Dynamic Prebuilt Reports

Reports are generated by the information collected from the users. The top level dashboard (Figure 19) consists of various charts with drill-through and drill-down reports, and provides real time information about the business process models together with their relationships. The reports are created using SSRS (SQL Server Reporting Services), D3.js (a JavaScript library), Hypertext Markup Language (HTML5), and Cascading Style Sheets (CSS). The data is converted into JavaScript Object Notation (JSON) file format for reports that are built in D3.js. Some of the key reports are explained below.

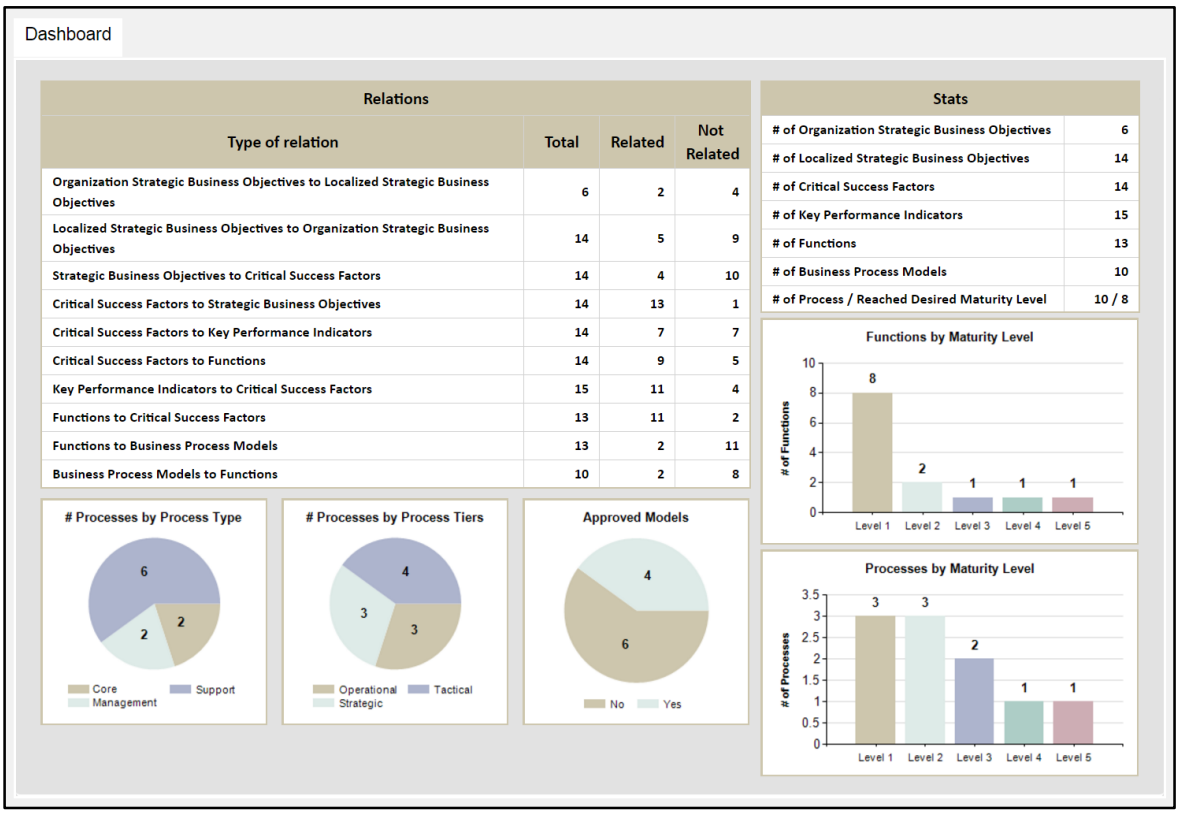


Figure 19: Dashboard

Stats Report: This report includes key stats including:

- Organization Strategic Business Objectives: These are long term (~5 years) objectives of an organization. It keeps all the department of the organization focused on the main objectives that gives an advantage in increasing productivity. A drill-down report is generated for more information (Figure 20)
- Localized Strategic Business Objectives: These are medium term (~3 years) objectives within a specific area of the organization (e.g. Human Resource, Finance etc.) as opposed to the entire organization.
- Critical Success Factors: CSFs are necessary for an organization to achieve its goals or objectives and have a direct impact on efficiency and effectiveness of an organization.
- Key Performance Indicators: KPIs are measurable values which show how an organization is achieving its key objectives.
- Functions: These are activities which are carried out to assist in the production of services or goods in an organization.
- Business Process Models: They represent the processes of an organization, which can then be analyzed and improved.

All stats generate drill down reports which show more information (for example, Figure 20).

Org Area	Strategic Business Objectives (SBOs)
Finance	Decrease expenses by 5%
	Exceed $10 million in the next 10 years
	Increase net profit by 10% annually
	Increase revenue by 10% annually

Figure 20: Stats - drill down report

Functions & Processes by Maturity Level Report: The organization's processes and functions normally exist at different maturity levels. The two bar charts on the dashboard (Figure 19) display the breakdown from level 1 to level 5. This provides an opportunity to improve the process and function with lower maturity level by reallocating or assigning more resources.

Process Tiers & Types: The two pie charts on the dashboard show the classification of processes based on process type and process tiers. Such classification helps to reduce the complexity of work as it creates patterns which provide a clear picture of the area of interest and also leads to better understanding of the relationships between processes.

Approved Models Report: This report shows the number of business process models that were approved or not approved. Thus, it helps the managers to work and improve the business process models that are not approved yet.

SBO Alignment Report: This report (Figure 21) demonstrates the relationship between SBOs and business process models. It allows the users to filter the report by organization area and SBO together with print functionality. This report helps to integrate and standardize processes as it shows all the processes across the organization. The report is built in D3.js for better visualization. The data entered by users is converted into JSON file format so it could be read

by D3.js. The area of organization and SBO can be selected from a dropdown menu to highlight its alignment to CSFs, *Functions* and processes. For example, Figure 21 shows that SBO (decrease expenses by 5%) is linked with four different CSFs (communicating brand, utilizing technologies, etc.) and *communicating brand* is in turn related to three functions (audit and communication, budget and client services and payment and expense). One of these functions (*audit and communication)* is then related to the *perform audits* process. Thus, it shows the alignment of this process to an SBO through *audit and communication* function which assists to accomplish the *communicating brand* and finally *decrease expenses by 5%*. A process can also be related to more than one function.

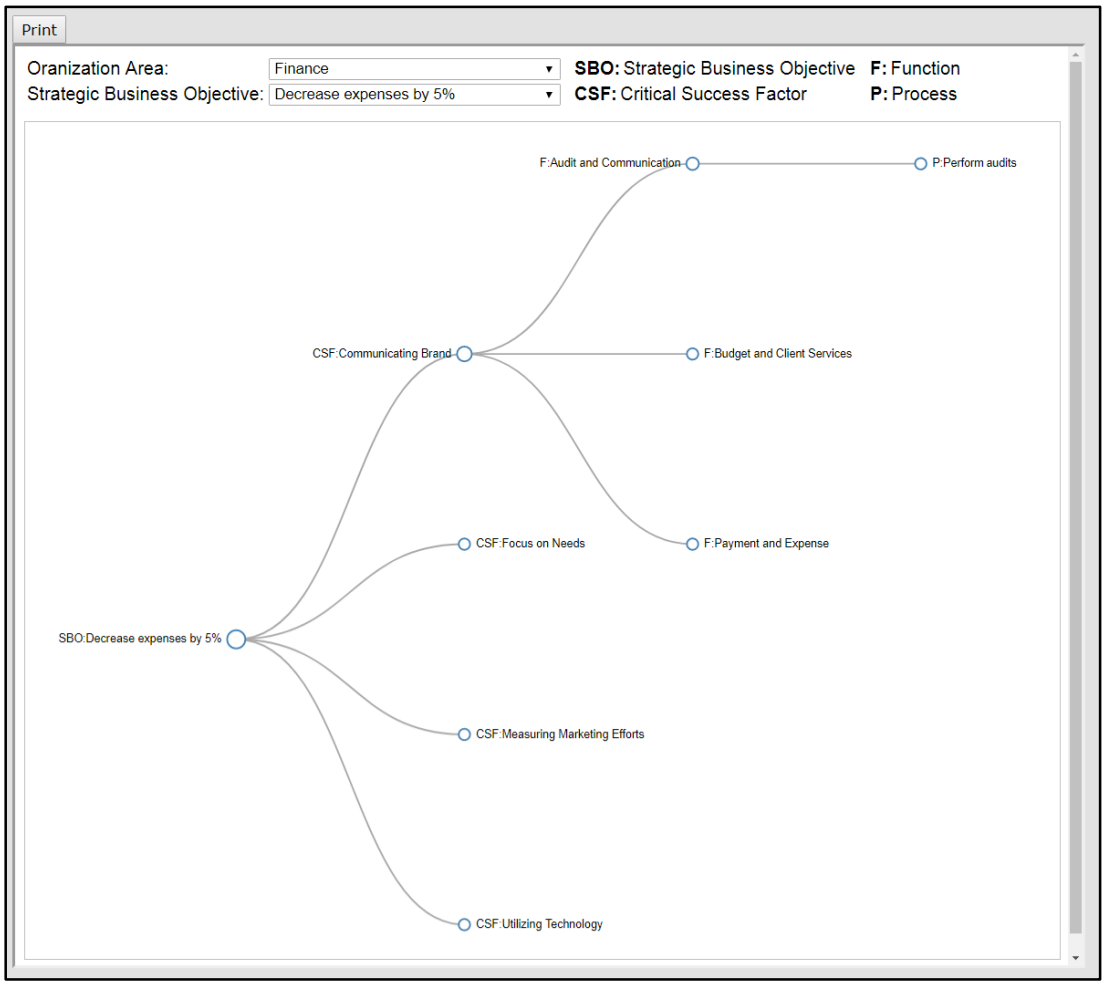
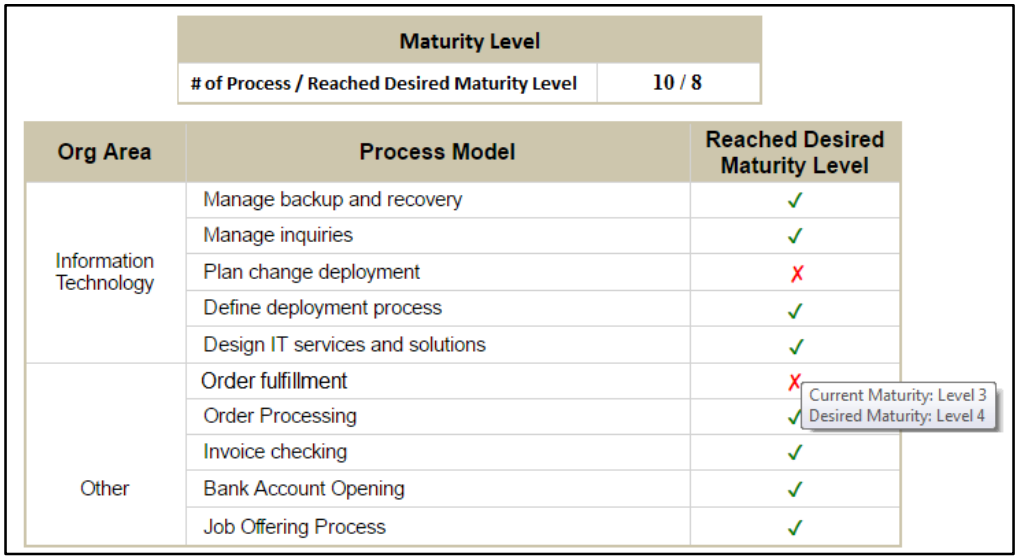


Figure 21: Alignment to SBOs

Drill Down Reports: A number of reports on the dashboard can be drilled down to see information at finer granularity. For example, stat report in dashboard (Figure 19) can be drilled down (Figure 22) to get information about area of process, maturity level, and desired maturity level.



Maturity Level	
# of Process / Reached Desired Maturity Level	10 / 8

Org Area	Process Model	Reached Desired Maturity Level
Information Technology	Manage backup and recovery	✓
	Manage inquiries	✓
	Plan change deployment	✗
	Define deployment process	✓
	Design IT services and solutions	✓
Other	Order fulfillment	✗
	Order Processing	✓
	Invoice checking	✓
	Bank Account Opening	✓
	Job Offering Process	✓

Figure 22: Report maturity level

3.2.2 Back-end

The back-end components are hidden from the users and are built using C#. The information provided by users is stored in SQL Server Database. The data is subsequently converted into XPDL file format which is then transformed into the business process models. The back-end components include data storage, transformation engine to transform data into XPDL file format, validation component to validate the accuracy of data for redundancy, and user authentication.

3.2.2.1 Transformation Engine

The transformation engine is one of the most important components of the proposed framework. The collected data from users runs through business model generation steps to transform into XPDL file format and thereafter into the business process models.

The activities, events and decisions that occur within a process are automatically arranged in a sequential order. Once this information is stored in the database, the transformation engine transforms the data into XPDL file format. The XPDL file is then imported into the Bizagi Modeler [25] in order to create the business process model. Once the model is constructed, the users add feedback for the generated model(s) or submit change(s) for the processes if needed. More details about the transformation engine are discussed in the following sections.

3.2.2.2 Transformation Engine Components

In this section, we explain how the collected information from the users is transformed into XPDL file format and then translated into the business process models. The steps shown in Figure 23 are followed in order to create an XPDL file format for each process that is stored in the database.

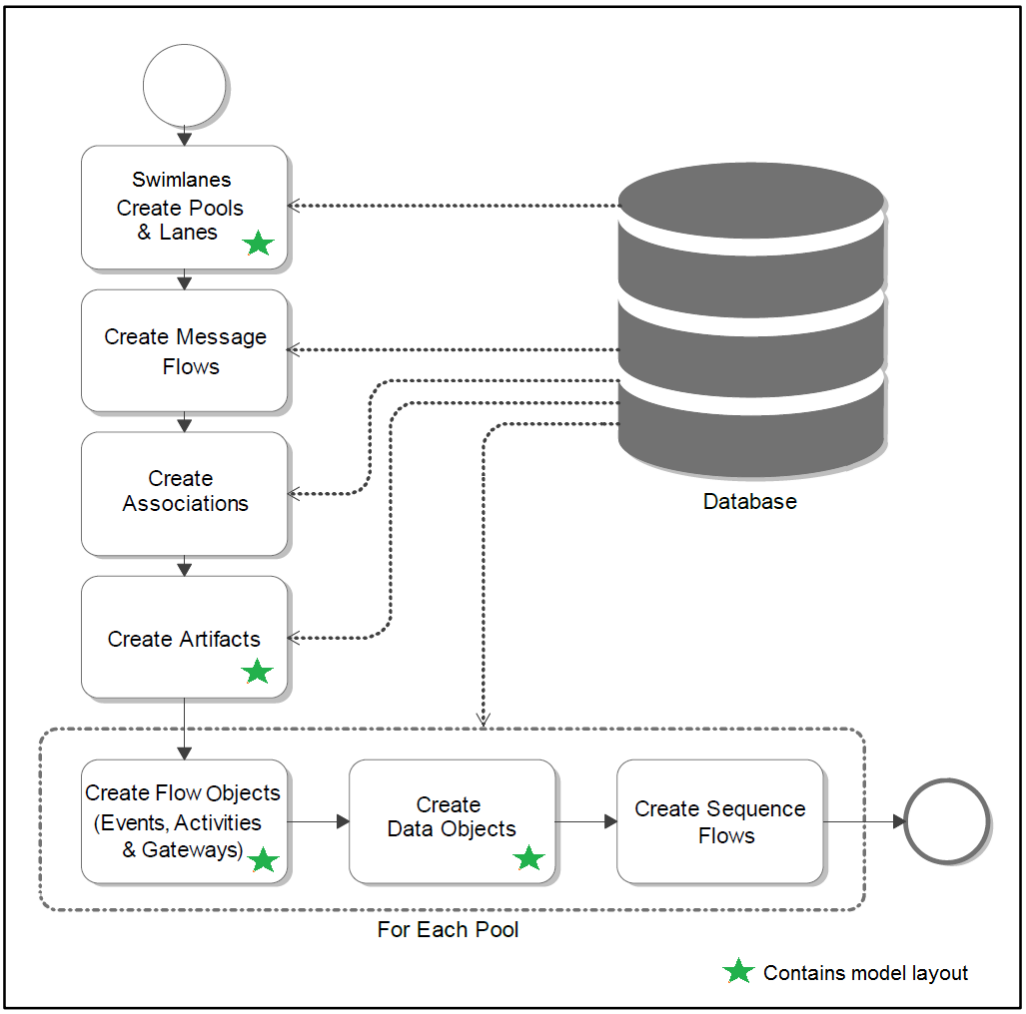


Figure 23: Steps for data transformation

Swimlanes (Pool & Lane)

The first step of the model generation is to create swimlanes. First, the number of pools and lanes are obtained from the business process model. The number of the lanes inside each pool determines the height of each pool. The height of the lane increases if there is a comment (text annotation) or a data object (file attached to activity). The height also increases by the number of antecedent flow objects within that lane. After determining the height of pool and lane, the lanes are created within their respective pools. The extra space is added between each

pool in order to distinguish from each other. Figure 24 shows pool (Human Resource) and lane (Recruitment Officer) created by our proposed framework.

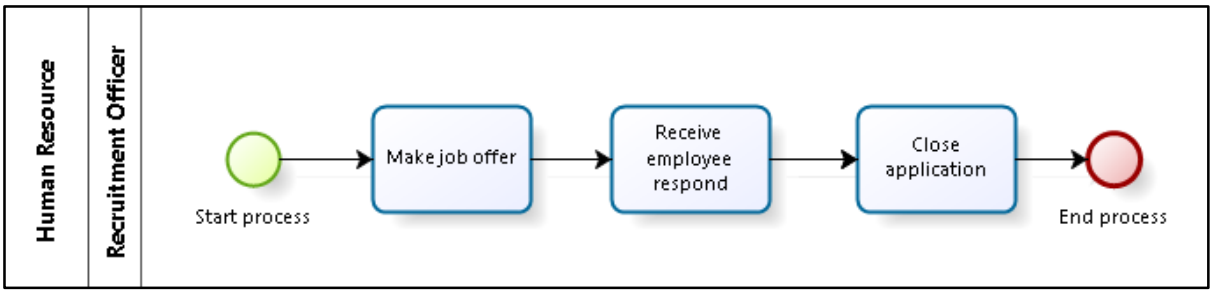


Figure 24: Hiring process

Message Flow

The message flow is created between flow objects (activities, events and gateways) that are located in different pools. It is determined by checking antecedent and precedent flow objects and is shown with an arrow in dotted line. Figure 25 shows the message flow created by our proposed framework. In this example the communication is happening between recruitment officer and employee who are in different pools. The model shows the job offer is sent by recruitment officer and the response from employee through message flow (Figure 25).

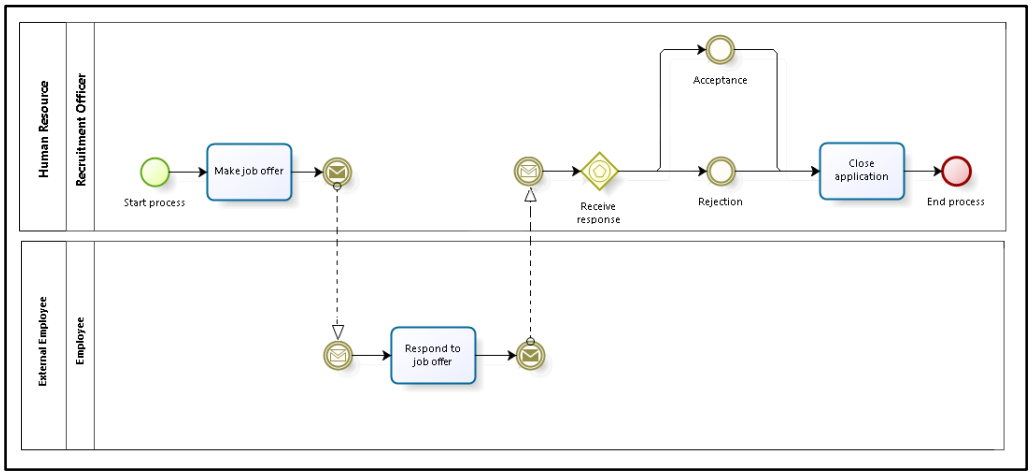


Figure 25: Message flow

Association

An association is developed in order to illustrate the relationship between artifacts (Data Objects and Text Annotation) and the flow objects (activities, events and gateways). It is generated after all of the flow objects and artifacts have been determined. For example, in *order fulfillment* process the user wants to attach form and comment to *take order* activity. In this process the relation between *take order*, *order form* and *store all orders in order form* is shown by using association (Figure 26). Association can be shown as dotted line or dotted line with an arrow.

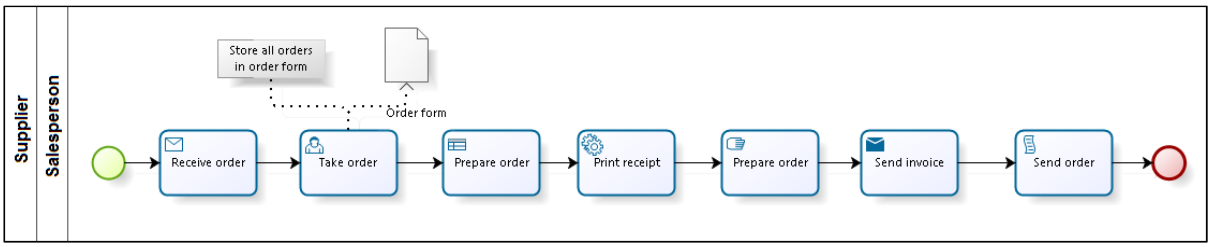


Figure 26: Order fulfillment

Artifacts

An artifact is developed to show the usage of documents and data in a business process model. In order to create an artifact, first the flow object connected to that particular artifact is determined. Then the lane and pool related to the artifact are identified. The artifact position is specified based on the position of the flow objects. Thus increasing the height of the pool. For example, in *invoice checking* process the user wants to attach *invoice form* and comment that relates to *record invoice number* activity. The comment (Invoice number should be unique) and form (Invoice form) that is attached to *record invoice number* activity are artifacts (Figure 27).

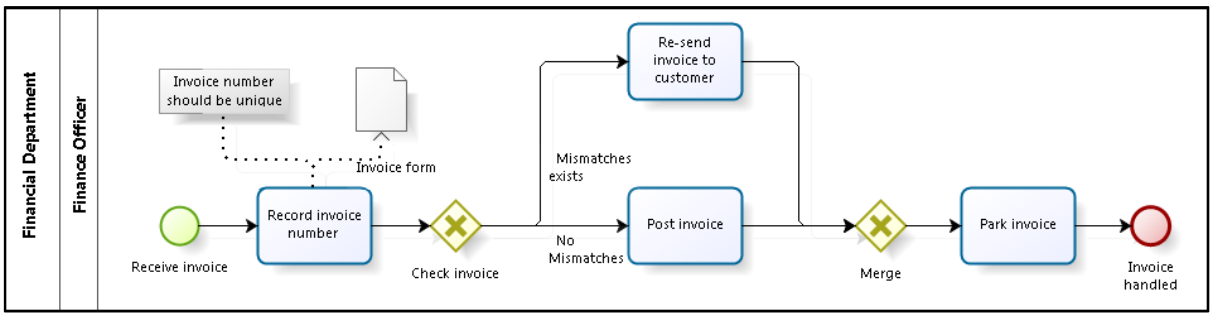


Figure 27: Invoice checking process

Flow Objects

Three types of flow objects (activity, event or gateway) are created by proposed framework. Each flow object is explained in more detail in this section.

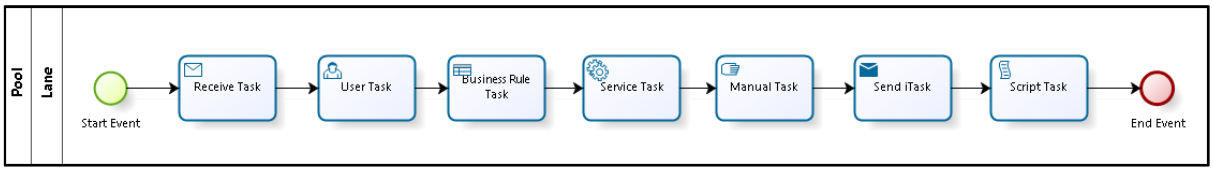


Figure 28: Start, end event and task types

a. **Activities:** While generating an activity, its type (if it is a user task, service task, receive task, send task, script task, manual task or business rule task) is identified. The tasks generated by our framework are shown in Figure 28.

b. **Events:** If an event does not have any precedent object then it is a start event; if it does not have any antecedent object then it is an end event. Otherwise, it is considered as an intermediate event. Table 3 lists the supported events, which were explained in Chapter One.

Start event	Intermediate event	End event
Timer	Message	Terminate
Message	Signal	Message
Signal	Link	Signal
Conditional	Compensate	Compensation
Parallel Multiple	Escalation	Escalation
Multiple	Conditional	Error
	Parallel Multiple	Cancel
	Multiple	Multiple

Table 3: Type of events

c. **Gateways:** While creating gateways the type, number of pathways and text description are checked. The constraints and validation are applied while collecting decision information in order to ensure that BPMN compliant models are generated. These constraints are described in Section 3.2.4. The users can add decision types and explanation for each chosen decision. Four type of gateways can be generated.

   1. **Exclusive gateway:** In our framework, decisions are considered as an exclusive gateway by default. In exclusive gateways, the users are required to enter two decision pathways together with their description. One of these paths is then chosen. For example, in Figure 29, Financial Officer receives an invoice and records the invoice number. If a mismatch is discovered, the invoice is sent back to customer, otherwise it is posted. At the end the invoice is archived. This illustrates that exclusive gateways allow only one of the path to be chosen.

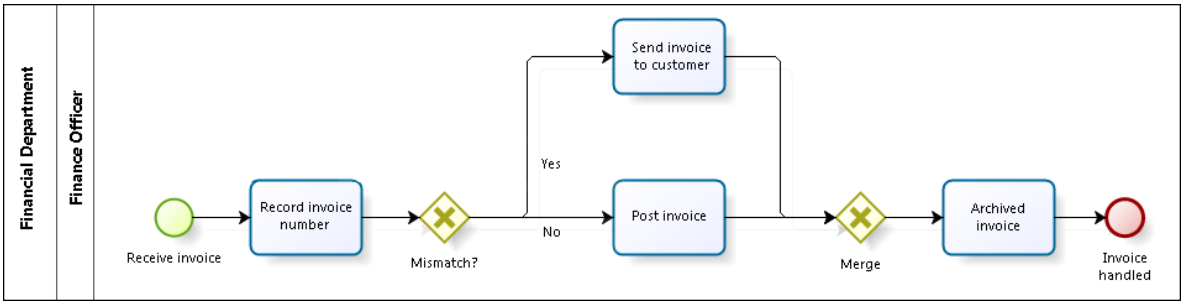


Figure 29: Exclusive gateway demonstration

2. **Parallel gateway:** The parallel gateway is an option available to the users when entering process requirements. In parallel gateways, the users are required to enter at least two pathways. The activities followed by the parallel gateway can happen at the same time. For example, to open an account for a customer, the financial service representative prepares the documents (Figure 30). Then he/she schedules to review the status of account and records customer information at the same time. Upon completion of these activities, the bank account is opened.

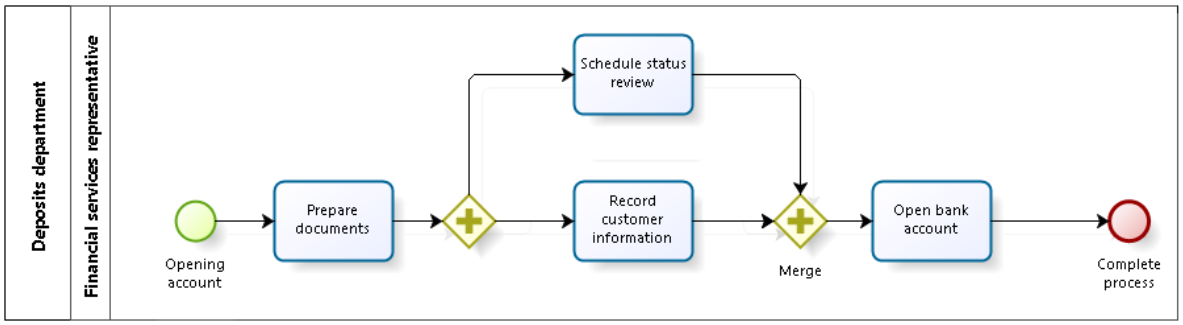


Figure 30: Parallel gateway demonstration

3. **Inclusive gateway:** Likewise, an inclusive gateway is an option available to the users when entering process requirements. In inclusive gateways, the users are required to enter at least two pathways but pathway's description are optional. More than one path can be followed after using inclusive gateway. For example,

in Figure 31, Salesperson identifies the payment method and then he/she can process payment from three types (debit card, credit card and cash) which is available. Half of the payment for a product can be taken by credit card and the other half by cash or debit card. At the end Salesperson prepares the product. This illustrates that inclusive gateway allows more than one pathway to be chosen.

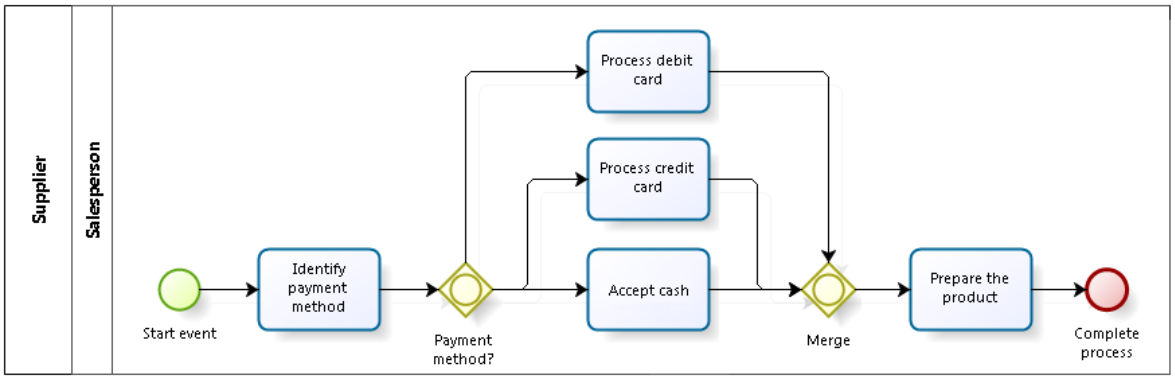


Figure 31: Inclusive gateway demonstration

4. **Exclusive event-based gateway:** The users have an option to choose an exclusive event-based gateway during data collection process. It is different than the other types of gateways. The users are only allowed to choose an event as succedent flow object. For example, in Figure 32, Recruitment Officer makes a job offer to an employee and receives a response. Based on employee response he/she accepts or rejects (both are events) the employee and closes application. This illustrates that only one of the events (acceptance or rejection) is followed when an exclusive event-based gateway is used.

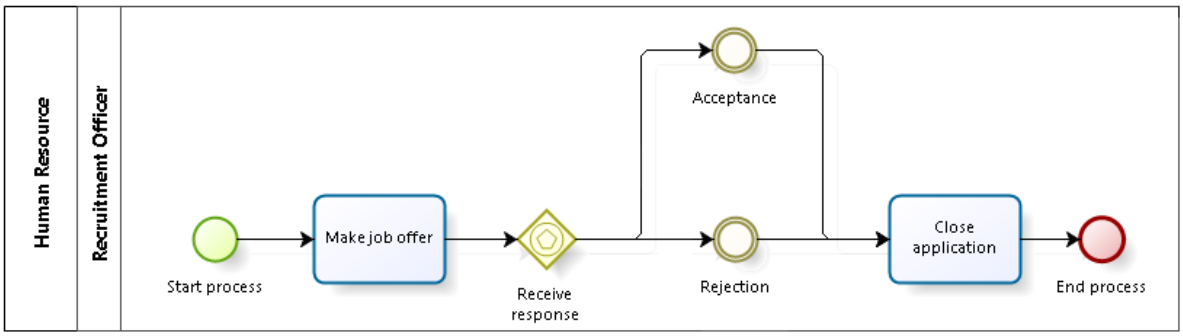


Figure 32: Exclusive event-based demonstration

Data Object

Data objects are used to show the documents or data in a process. First the related flow objects (activity, event or gateway) are determined. Then the lane and pool related to the data objects are identified. The data object position is specified based on the position of the related flow objects (activity, event or gateway). The position of the data object is one of the factors that influences the height of the pool. For example, in bank account opening process the user wants to know which database the information is recorded. Thus, data object (Customer Database) is used to show this information (Figure 33).

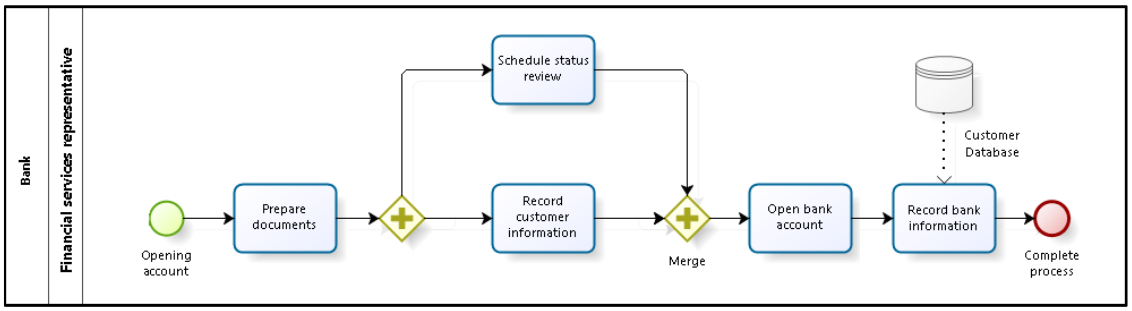


Figure 33: Bank account opening process

Sequence flow

The sequence flow is built between flow objects (activities, events and gateways) that are within the same pool. First, flow objects in the same pool are checked through antecedent and precedent flow objects. Then the sequence flows between them are created after all the

flow objects of the business process model are built. It is shown with solid arrow, and it shows the order that activities are performed. For example, in Figure 33 all the activities are performed by financial services representative within the same pool. The flow starts from opening account to complete the process and it's shown with a solid arrow which is sequence flow.

Model Layout

As each element of the model is generated, it does not contain the information for the position of the elements. Therefore, before creating pool and lane, the height of each lane is calculated based on the comment (text annotation), data object (attached file to activity) and antecedent flow object within that lane. While building the XPDL file for the model, the position (x-coordinate and y-coordinate) of the element is automatically calculated by our proposed framework. The y-coordinate for a flow object is based on the lane that the element belongs to and also the number of elements that follow the specific antecedent element. The position of the flow object changes if it has more than one antecedent flow objects. The x-coordinate, on the other hand is determined by the flow of an element and number of antecedent elements. The model layout which consists of x-coordinates and y-coordinates aligns and arranges each component (pools, lanes, flow objects & gateways) of business process model automatically. For example, Figure 34 shows *recruitment* process before and after applying model layout. If model layout is not applied to the model, its components are not aligned in a sequence that they appear in the process, and also making it difficult to comprehend.

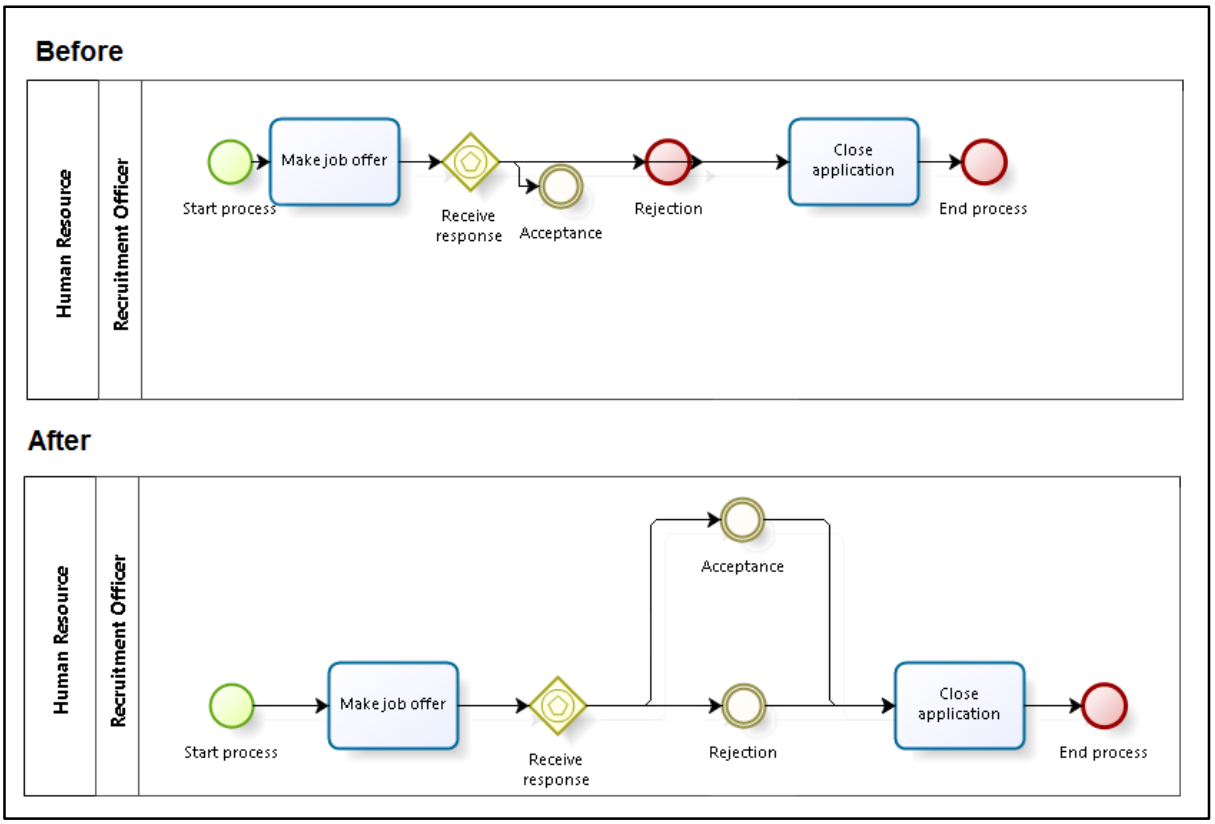


Figure 34: Before & after applying model layout

3.2.3 Feedback Loop

The framework facilitates editing and updating through the feedback loop. This prevents the users from going through the entire process of collecting information when changes occur in business processes. These changes can be accommodated through the web-forms. The delete functionality on each data collection page allows the user to remove information from business process models. The edit and delete functionality of the framework is available across all web-forms as illustrated in Figure 35.

	Process_Model	Type	Tier	Maturity_Level	Desired_Maturity_Level	Approved	Comments
Edit Delete	Manage backup and recovery	Support	Operational	Level 2	Level 3	No	
Edit Delete	Manage inquiries	Support	Operational	Level 2	Level 4	No	
Edit Delete	Plan change deployment	Management	Strategic	Level 1	Level 4	No	
Edit Delete	Define deployment process	Main	Tactical	Level 1	Level 5	No	
Edit Delete	Design IT services and solutions	Support	Operational	Level 1	Level 4	No	

Figure 35: Edit and delete functionality

Figure 36 shows the edit functionality for *manage backup and recovery* process. For example, process type can be changed from *support* to *management,* or similarly *maturity level* can be changed from *level 2* to *level 4*.

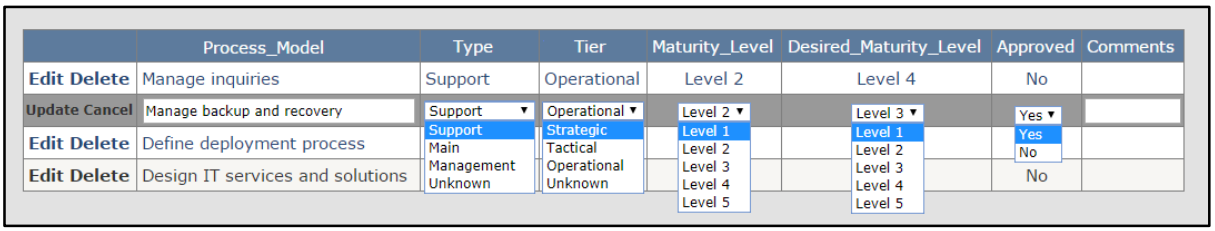


Figure 36: Edit view

3.2.4 Constraints & Validation

The constraints and validation are built in order to remove redundancy in the data and to improve the accuracy of the information captured by the framework. Another reason is to make sure that the information captured in data collection is BPMN compliant. Some of the key constraints and validations are outlined below:

- **Decision constraint:** Once the user chooses a decision, the framework will force the user to add the descendant tasks that follow the decision, in order to make it BPMN compliant. For example, the framework forces the users to enter at least two decision pathways and descriptions.

- **Activity type constraint:** The users are required to identify the type of tasks, for example whether the task is performed manually, automatically, with the help of software, or if a business rule is attached to the task, etc.
- **Required field:** It ensures that the users do not miss any mandatory information. For example, the framework will not allow the users to submit without providing task description because it is a required field. A snippet of required field validator is shown in Figure 37.
- **Prepopulated information:** As roles and departments within an organization are fixed, they are stored in the database. The users are able to choose the prepopulated information from dropdown lists. There is also a web-form to add/edit/delete prepopulated information, but this functionality is restricted to admin users. The department name and roles are thus consistent across all business process models.

```
<asp:RequiredFieldValidator ID="FieldValidatorTextBoxTask" runat="server"
          ControlToValidate="TextBoxTask"
          ErrorMessage="*Object Type" ForeColor="Red"
          ValidationGroup="ValidationProcessObjects" Display="Dynamic">
</asp:RequiredFieldValidator>
```

Figure 37: Required field validator

3.3 Summary

In this chapter, we discussed the implementation of our proposed framework which consists of front-end, back-end. In the front-end section, the process of collecting information from the users and creating reports was explained. In the back-end section, the transformation engine which involves the steps to generate business process model was discussed along with the feedback loop which allows users to submit process changes or correct errors. The back-end also includes data storage and user authentication. In the end, both the constraints and validation process to remove redundancies in data and improve accuracy of the captured information were highlighted.

Chapter 4

4. Functional Demonstration

In addition to the reporting capability described in the previous chapter, we now present various use case scenarios to demonstrate the functionality of the proposed framework and its advantages over existing tools. The entire end-to-end process of our framework which consists of generating business process model from process description, being able to edit existing models, alignment of models with SBOs and maintenance are explained in detail in this chapter. The benefits of tagging business process to maturity level, process type, and process tier are also described. Finally, a comparison of the functionality of existing tools together with our proposed framework is presented.

4.1 Generating Business Process Model

This section demonstrates how a business process description is transformed into BPMN model by the proposed framework. It also presents how our framework facilitates the users to find the missing information in a process during data collection. First, we present an example of a business process model consisting of a single pool and lane, events and activities. Later on, we create a business process model with multiple pools and lanes, events, activities, and gateways. The *order fulfillment* process used in this use case was taken from [3].

Process description: "The process starts whenever a purchase order is received from a customer. The first activity that is carried out is confirming the order. Next, the shipment address is received followed by emitting the invoice; once the payment is received the order is archived, thus completing the process." [3]

As stated earlier, the first step in our framework is to follow specified prerequisite instructions to gather information required for building the business process model. This information will consist of:

- Events (Purchase order received, and Order fulfilled)
- Activities (confirm order, get shipment address, ship product, receive payment and archive order)

The information about the role (sales person) and department (supplier) is not provided in process description. Therefore, prerequisite steps enforce gathering of the missing information before submitting the process requirements to the proposed framework. Once the information is complete, the users can use *Model Meta Data* web-form to submit the department and role. Events and tasks are added by using *Process Objects* form. After successfully submitting all required information, an XPDL file is generated and imported into Bizagi Modeler [25] to view the business process model as shown in Figure 38. As explained in Chapter 3, this step has been automated via an extensive suite of code components using C# and ASP.Net framework which integrates with a SQL database.

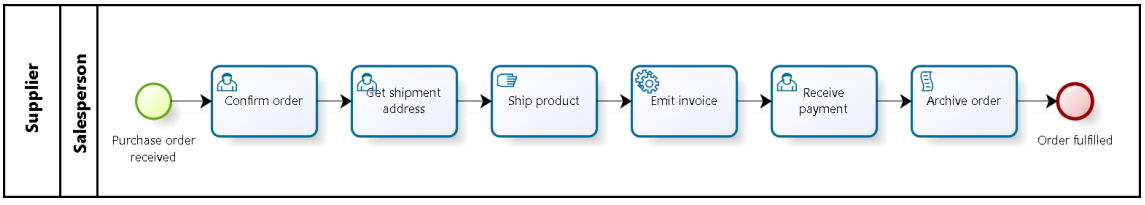


Figure 38: Order fulfilment process – version 1

To demonstrate multiple pools, we extend the same *order fulfillment* process by adding client information to the process model. Once the product is shipped, the customer receives the product. Then Salesperson emits the invoice, and the client pays the invoice. After adding customer pool and extra activities (receive product, pay invoice), we can generate the business process model (Figure 39). It should be noted that there may be an alternative sequence of these activities as well. More detail about the process of adding extra information to the existing model is provided in section 4.2.

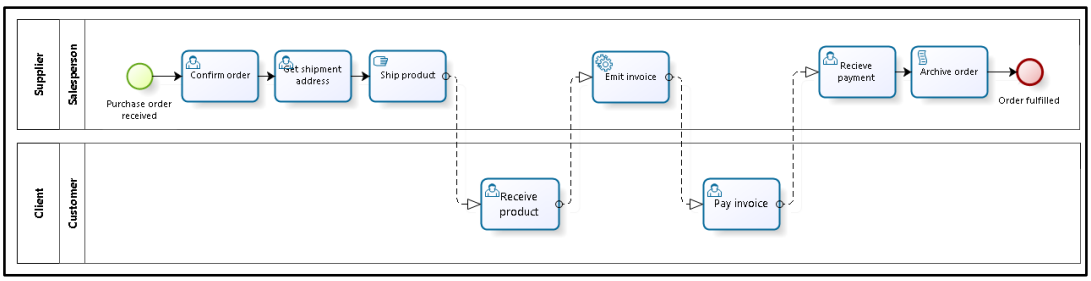


Figure 39: Order fulfilment process – version 2

In this section, we demonstrated how a simple business process model can be generated by the proposed framework. This model is similar to that generated by [3], but carries a number of additional advantages. For example, it enforces collection of additional information (department and role) which allows to build more accurate and correct business process model. It also stores flow objects with their respective departments and roles. Thus a report can be generated to show the number of tasks performed by each role and department within an organization.

To demonstrate usage of gateways in multiple pools, we extend the same *order fulfillment* process by adding client payment methods information to the process model. The client can pay the invoice by debit card, credit card or cash. In addition, the client copies the invoice for his/her records. After adding new information (payment method, pay by credit card,

pay by debit card, pay by cash & copy invoice for record), a revised business process model is generated (Figure 40). This model includes an inclusive (OR) gateway which allows selection of one or more payment methods.

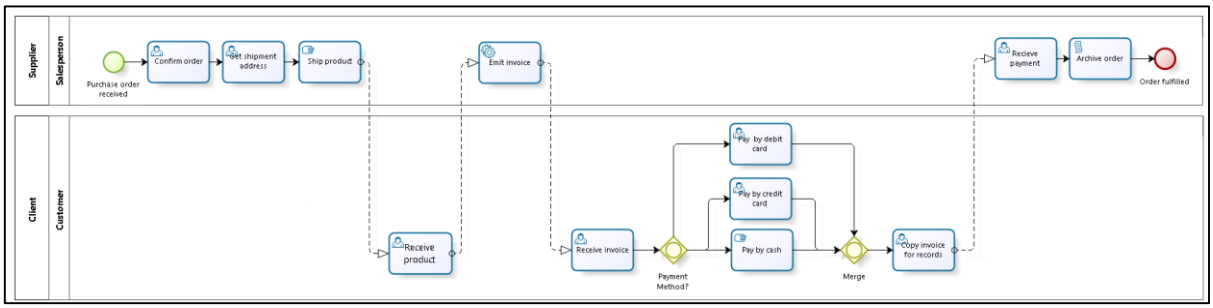


Figure 40: Order fulfilment process – version 3

Constraint and validation are built in order to improve the accuracy of information and remove redundancy in the data captured by framework. For example, the *order fulfillment* process has already been added into the database. If we enter the same process again, it will show a message stating that *data already exists*. This constraint eliminates duplicate information to be entered into the database (Figure 41).

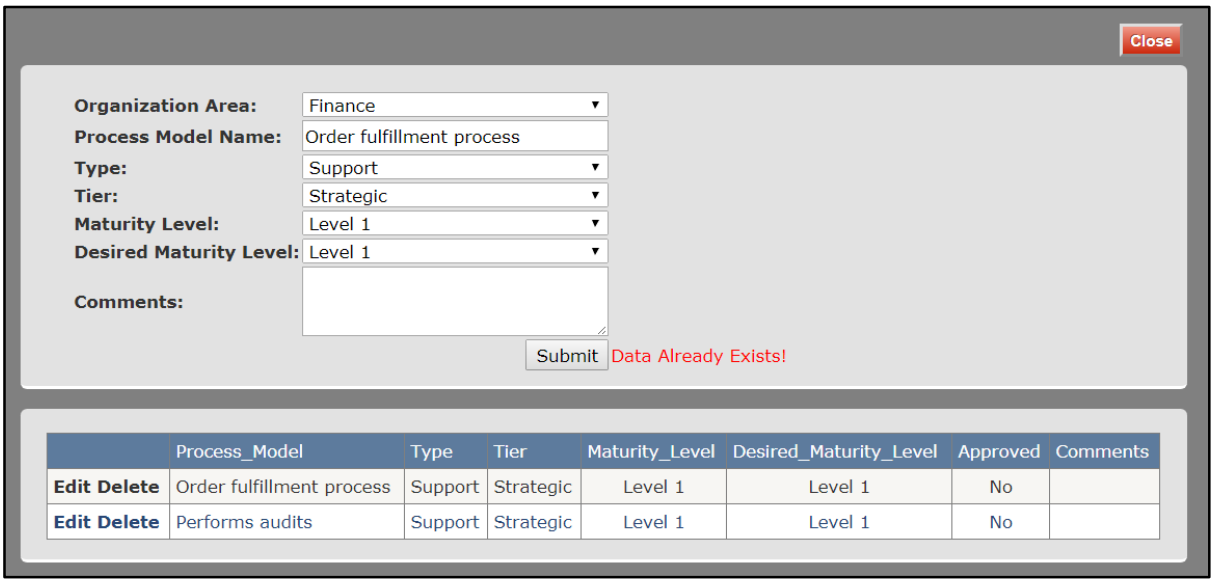


Figure 41: Constraint and validation

Another reason of constraint and validation is to make sure that the information captured is BPMN compliant. For example, once the user chooses *exclusive event-based* decision it will automatically choose events as succeeding flow objects. As required in BPMN, this decision can only be followed by entering events. The decision and its description are required fields (Figure 42).

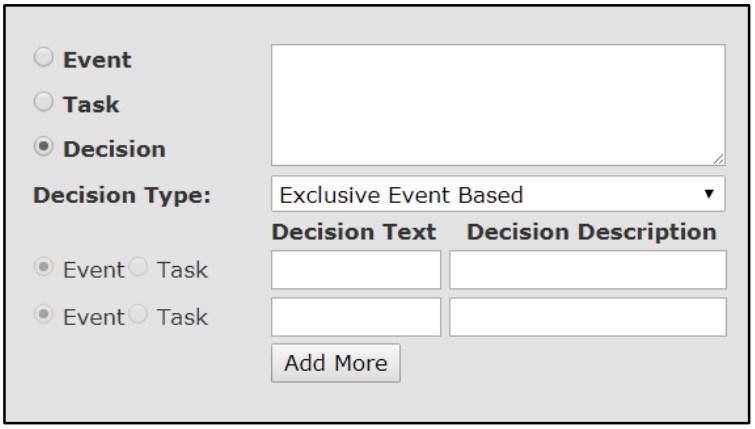


Figure 42: Constraint and validation – required field

4.2 Editing Existing Business Process Model

In this section, we demonstrate how the proposed framework assists when changes are applied to existing business process models. The changes can be either adding new information or editing existing information. To demonstrate the changes we extend the same *order fulfillment* process used in section 4.1.

1st Change description: We extend *order fulfillment* process by adding an activity to check availability of product in warehouse before confirming the order. Also, the activities *confirm shipment address* with customer to send the product to the right address and *emit invoice* is happening in parallel.

As per change description, the new information (check availability of product in warehouse and confirm shipment address with customer) needs to be added to the model. As shown in Figure 43 the new information can be added by using the *process objects* form.

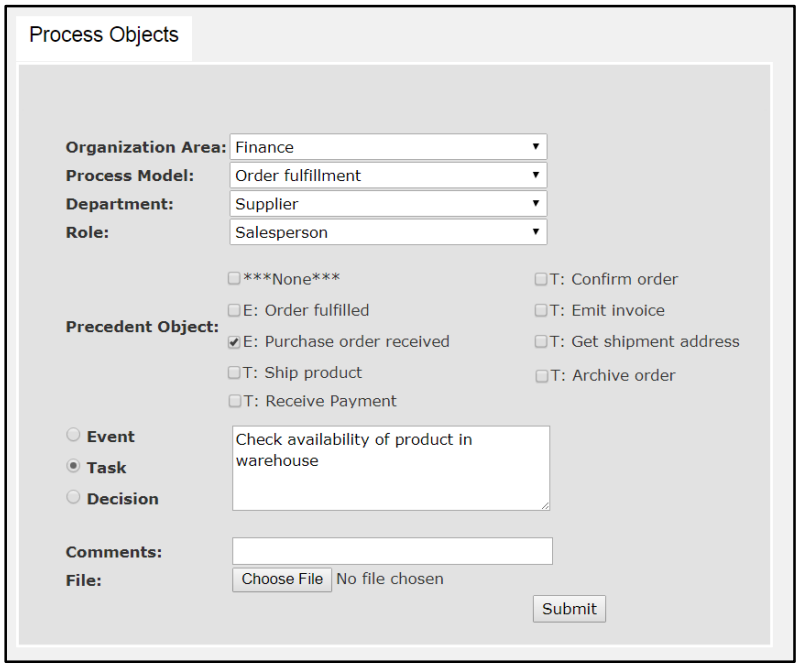


Figure 43: Adding new information to business process model

The change description also includes change to the existing model information (confirm shipment address with customer and emit activities which can happen in parallel). This requires that *ship product*'s precedent object needs to be changed because of newly added activities. The *Edit* button provides (Figure 44) a dropdown list consisting of the all the flow objects of specified process model. The precedent object (Merge) is selected, because per our change description, the *ship product* activity happens after two parallel activities (confirm shipment address with customer and emit invoice) and then update button is clicked to update the information in the database.

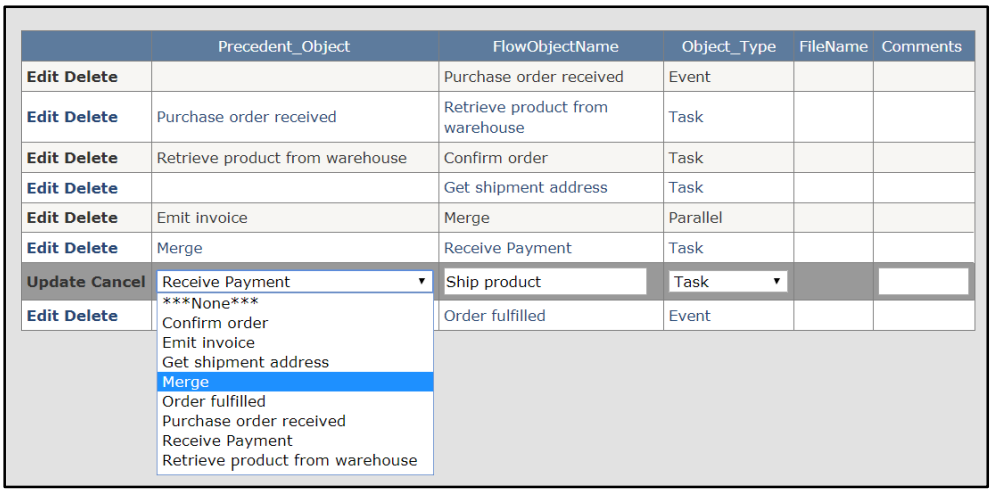


Figure 44: Edit existing information in business process model

After submitting the changes, the new business process model is generated as shown in Figure 45.

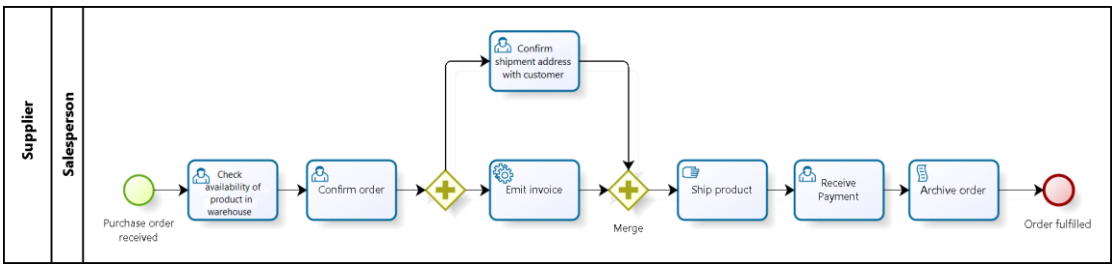


Figure 45: Order fulfillment process – version 4

To demonstrate the communication between multiple pools and lanes we again extend *order fulfillment* process by adding customer along with her/his activities.

2nd Change description: Once the product is shipped, the customer receives the product and pays the invoice generated by Salesperson.

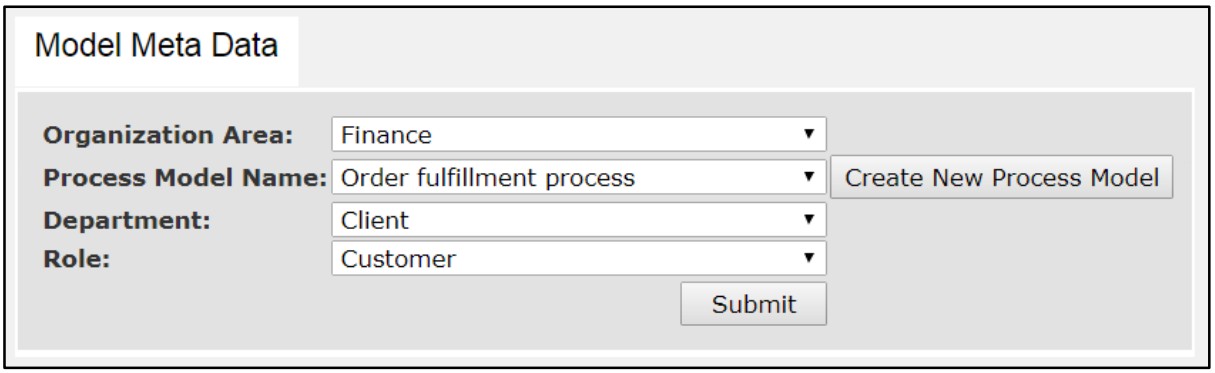


Figure 46: Model Meta Data form

These changes require that, the new information about the customer itself and its activities (receive product, pay invoice) to be entered in database. This is done by using the form shown in Figure 46 whereas, the activity information can be added by using *process objects* form (Figure 43). After submitting the changes, the new business process model is generated (Figure 47).

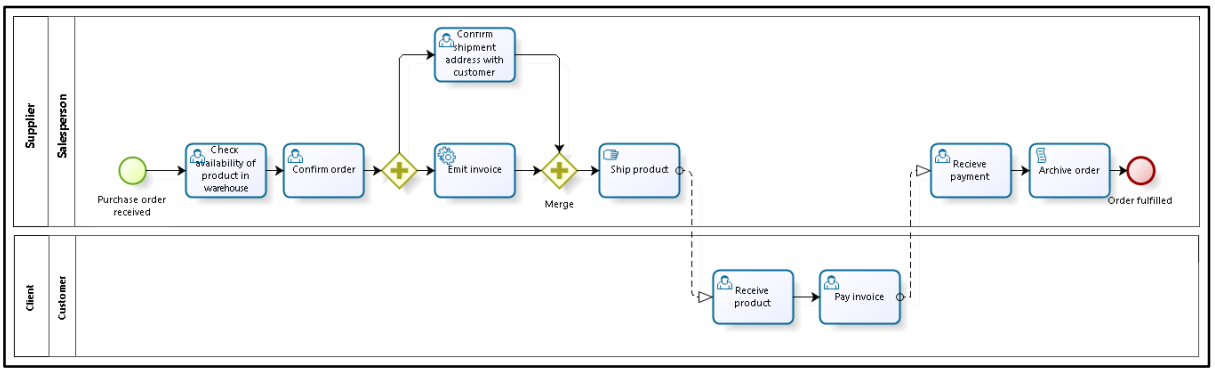


Figure 47: Order fulfillment process – version 5

3rd Change description: If the payment is via credit card/debit card Salesperson confirms the payment, if it is cash then funds are deposited in the bank.

This change requires that the model should allow selection of payment method and include new activities (confirm payment & deposit money in bank). The activity and decision

information can be added by using *process objects* form (Figure 43). The resulting business process model is shown in Figure 48.

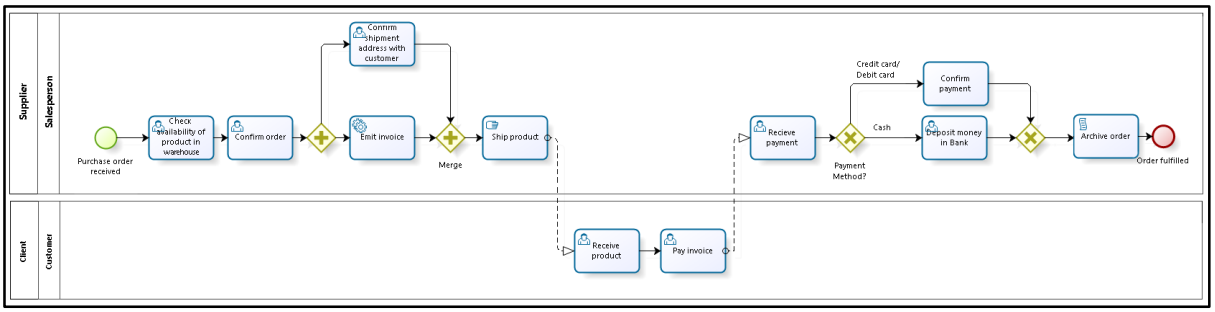


Figure 48: Order fulfillment process – version 6

This section demonstrated how our proposed framework accommodates changes to the existing business process models without building a new model from scratch. The changes can be both adding new information to the model, or modifying existing model's information. Thus, the framework provides the ability to reuse existing models to avoid redundant work by the users.

4.3 Alignment of Business Processes to SBO

In this section, we demonstrate how business process can be aligned with organization's SBOs. The alignment information is specified by the organization and is displayed within our framework. To add the alignment information in the proposed framework first, the SBOs need to be linked with CSFs which are in turn linked with *functions.* At the end, the *functions* need to be linked with business processes. For example, *order fulfillment* process can be aligned to a SBO (Decrease expenses by 5%) by using the forms shown in Figure 49.

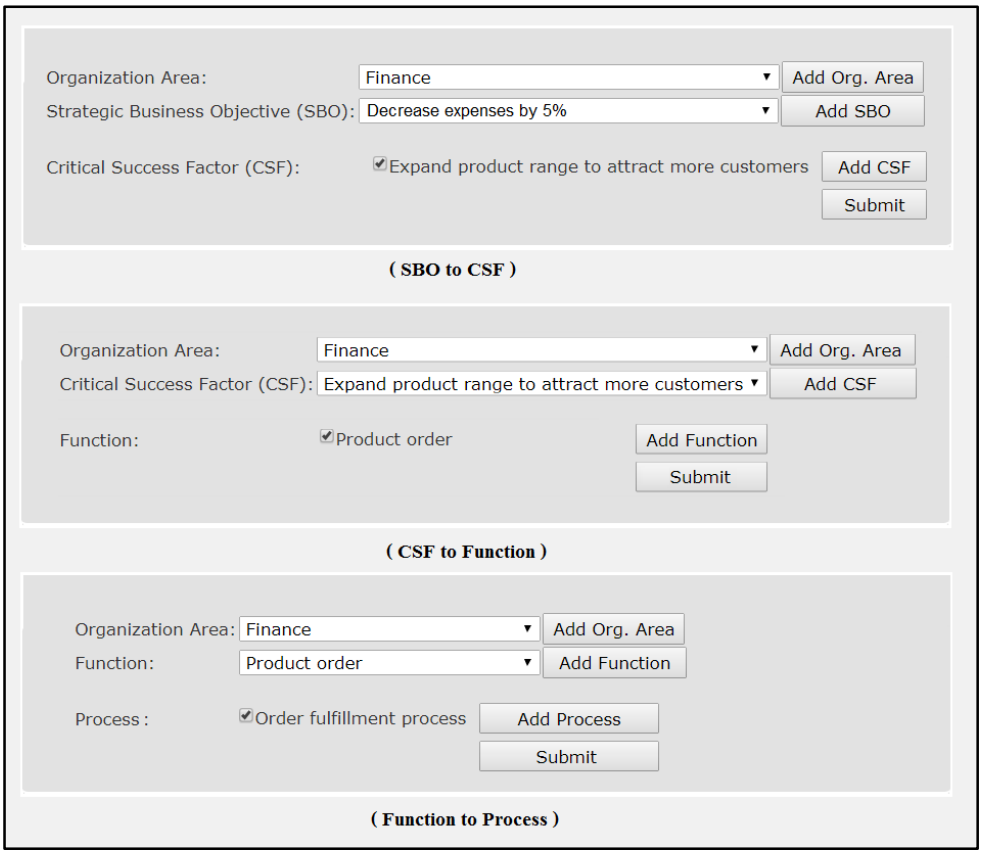


Figure 49: Alignment of SBO to business process model forms

After submitting the alignment information, the linkage between SBO (Decrease expenses by 5%) and business process (order fulfillment process) is displayed in reports (Figure 50). For example, SBO (decrease expenses by 5%) is linked with three different CSFs (expand product range to attract more customers, focus on needs & utilizing technologies) and *expand product range to attract more customers* is in turn related to two functions (product order & payment and expenses). One of these functions (*product order)* is then related to the *order fulfillment* process. Thus it shows the alignment of this process to an SBO through *product order* function which assists to accomplish the *expand product range to attract more customers* and finally *decrease expenses by 5%*. All the reports are dynamic, and any changes to the information is instantly reflected in the reports.

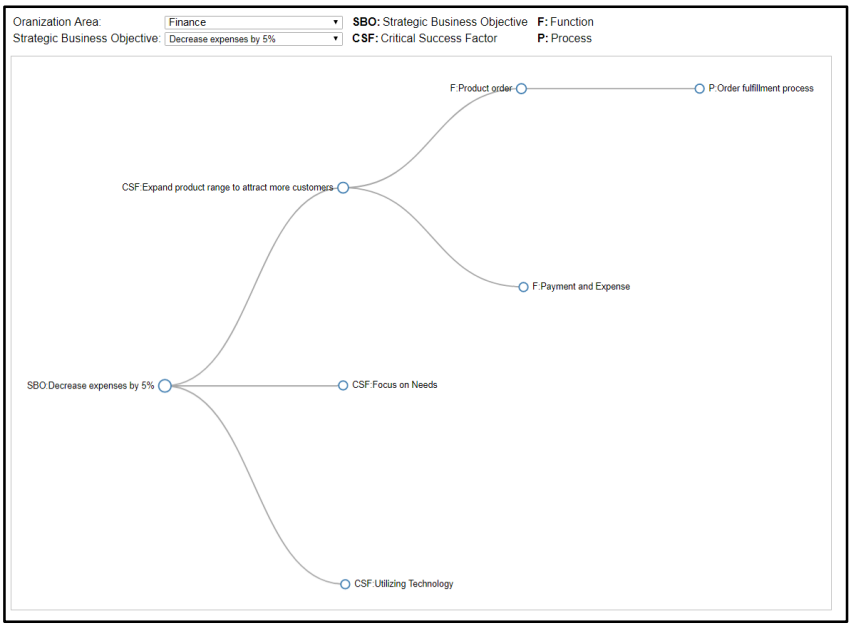


Figure 50: Order fulfillment process alignment to SBO

The dashboard shows the total number of SBOs and the number of SBOs that are aligned with CSFs. It has drill down which displays the complete alignment from SBOs to business processes (Figure 51) and also the ones which are not aligned. For example, in *finance* area of the organization, the two SBOs (increase net profit by 10% annually & increase revenue by 10% annually) are not aligned with CSFs, *functions* and processes. Thus it shows the alignment of this process to an SBO through *product order* function which assists to accomplish the *expand product range to attract more customers* and finally *decrease expenses by 5%*. It provides an opportunity for the decision makers to improve the organizational alignments (Figure 51).

Area	Strategic Business Objective	Critical Success Factor	Function	Process
Finance	Decrease expenses by 5%	Communicating Brand	Audit and Communication	Performs audit process
		Focus on Needs	-	-
		Measuring Marketing Efforts	-	-
		Utilizing Technology	-	-
	Exceed $10 million in the next 10 years	Expand product range to attract more customers	Product order	Order fulfillment process
	Increase net profit by 10% annually	-	-	-
	Increase revenue by 10% annually	-	-	-

Figure 51: SBOs alignment to processes

The dashboard also shows the total number of processes with drill down functionality, which displays the complete alignment from business process to SBOs (Figure 52) and also the ones which are not aligned. For example, in *finance* area of the organization, the four processes (collaborate with suppliers, develop sale forecast, manage customer's account & prepare budget) are not aligned with SBOs.

Area	Process	Function	Critical Success Factors	Strategic Business Objectives
Finance	Collaborate with suppliers	-	-	-
	Develop sale forecast	-	-	-
	Manage customer's accounts	-	-	-
	Order fulfillment process	Product order	Expand product range to attract more customers	Exceed $10 million in the next 10 years
	Performs audit process	Audit and Communication	Communicating Brand	Decrease expenses by 5%
	Prepare budget	-	-	-

Figure 52: Processes to SBOs

This section discussed the ability of our proposed framework to align business processes to organization SBOs. The alignment to SBOs helps in integration and standardization of processes across all organizational units. It also provides better transparency and traceability of processes and can be used to identify processes that are not aligned with SBOs, so the decision makers can eliminate redundant processes. These processes can then be reviewed and possibly eliminated by decision makers.

4.4 Maturity Level in Business Processes

This section demonstrates tagging of maturity level with business process which assists the organization in knowing the state of each process. With such tagging, the managers can easily see the processes with lower maturity level and improve them. As explained in Chapter One there are five maturity levels and each level provides opportunity for process improvement.

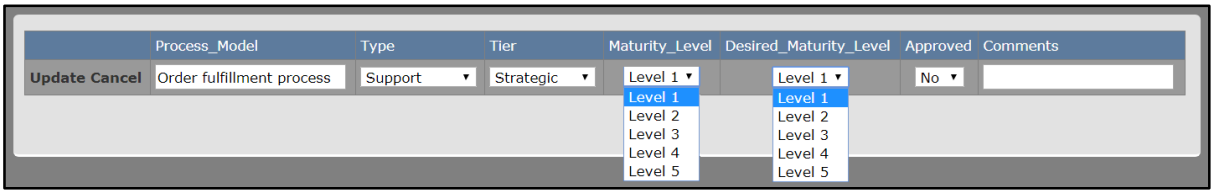


Figure 53: Updating maturity level & desired maturity level

The current and desired maturity level for each process is captured during submission of process requirements. For example, Figure 54 shows that for the order fulfilment process, the current maturity level is three and desired maturity level is four. After successfully improving the process, the maturity level can be updated by using edit functionality in *Meta Model* form (Figure 53), which then automatically updates the reports. For example, Figure 55 shows that *order fulfilment* process has reached its desired maturity level.

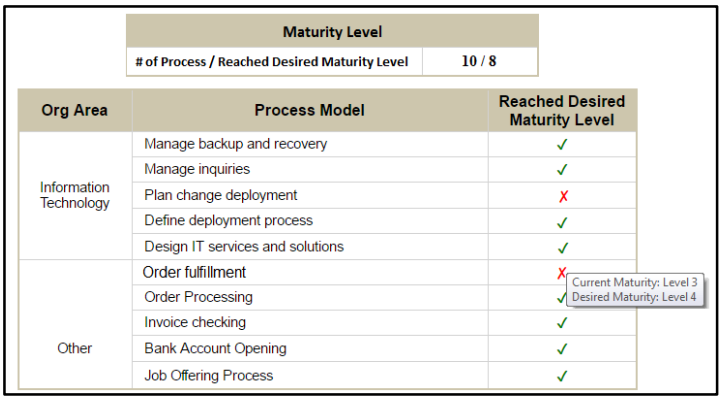
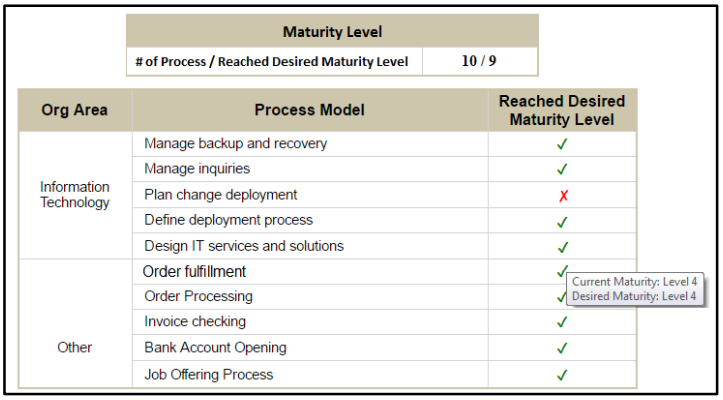


Figure 54: Maturity level before update

Although the highest maturity level is five, a process can have desired maturity level less than five. For instance, it may not be feasible to allocate resources to a process, which adds very little value to the organization. Such a process will then be assigned a lower desired maturity level so that focus can be shifted to processes that bring more value.



Maturity Level	
# of Process / Reached Desired Maturity Level	10 / 9

Org Area	Process Model	Reached Desired Maturity Level
Information Technology	Manage backup and recovery	✓
	Manage inquiries	✓
	Plan change deployment	✗
	Define deployment process	✓
	Design IT services and solutions	✓
Other	Order fulfillment	✓
	Order Processing	✓
	Invoice checking	✓
	Bank Account Opening	✓
	Job Offering Process	✓

Figure 55: Maturity level after update

This section showed how tagging of maturity level to business process can be done in the proposed framework. The reports such as those shown in Figure 54 and Figure 55 assist the organization to know the state of each process, especially the ones which have not reached their desired maturity level. This provides an opportunity for the managers and decision makers to improve those processes if necessary. The tools reviewed in literature do not provide this functionality.

4.5 Tagging Process Type & Process Tiers

This section demonstrates the usage of process tiers and process type. As stated earlier, classification helps to reduce the complexity of work as it creates patterns, which provide a clear picture of the area of interest, and leads to better understanding of the relationships between processes. A process can be classified as of a certain type (core, management and support). Similarly, each process can belong to a specified tier (strategic, tactical and

operational). This classification helps the managers and decision makers in prioritization of the work. For example, if we want to change a process and it is in operational tier then we know the impact will be less compared to the process that is in strategic tier which affects the entire organization.

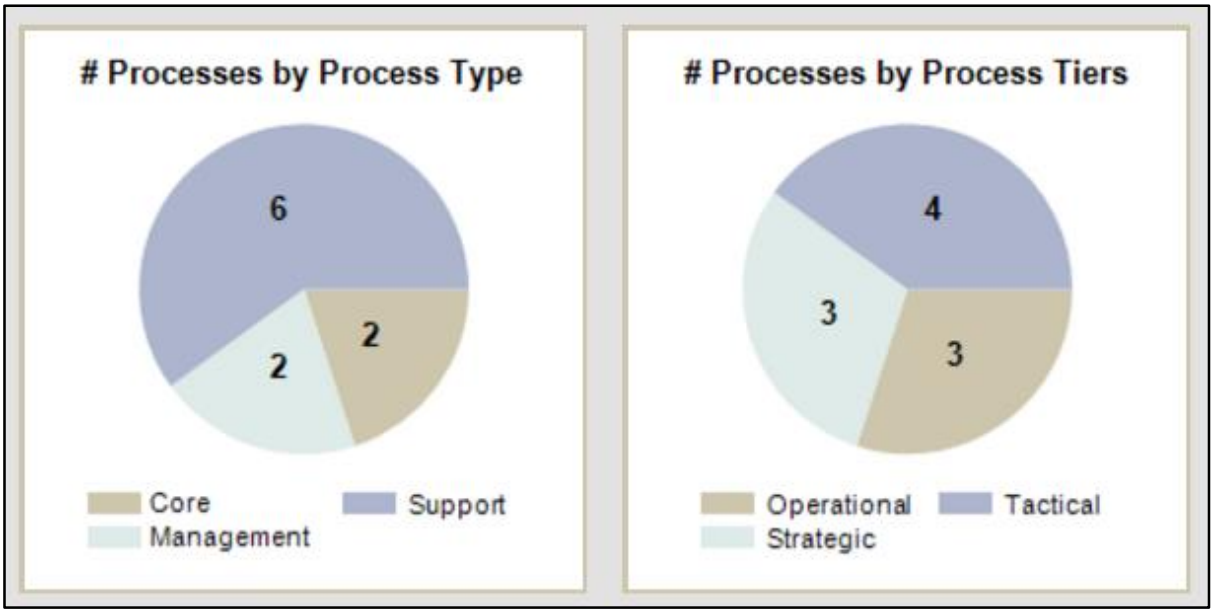


Figure 56: Process tier and process type

The proposed framework provides a functionality to tag the models to process tiers and process types. This information can be captured by using *Model Meta Data* web-form at the time of process requirement submission, or later on added to the process (Figure 53). Reports can then be generated to show process tiers and process types (Figure 56). If the process type/tiers changes in a process it will automatically be updated in these reports. It also relates processes to the right accountability level which helps in the prioritization of work. This is one of the key functionality which is missing in existing tools.

	Proposed Framework	iGrafx flowcharter	Bizagi	Bonita	myInvenio
Specify relationship between strategic business objectives, critical success factors, KPIs, functions and business models	✓	X	X	X	X
Stores flow objects with their respective departments and roles.	✓	X	X	X	X
Constraint to build BPMN compliant business process models	✓	✓	X	X	X
Tag maturity level & desired maturity level to business processes	✓	X	X	X	X
Assign process tier and process type to business process models	✓	X	X	X	X
Real-time dashboard with aggregated reports	✓	X	X	X	X
Generate XPDL file	✓	X	✓	XPDL 1.0 only	XPDL 2.1 only
Easy extension and removal of a component	✓	X	X	X	X
add feedback	✓	✓	✓	✓	✓
Drag & drop functionality for generating business process models	X	✓	✓	✓	✓

Table 4: Functionality comparison of tools

Table 4 shows a comparison of the functionality available in different tools along with proposed framework which are specific to business process models. Recall, that Table 2 (Chapter Two) provided a comparison of these tools at a more abstract level.

4.6 Summary

This chapter presented various use case scenarios to demonstrate the end-to-end functionality of the proposed framework and its advantages compared with existing tools. The end-to-end process of our framework was presented in this chapter. First, the process of generating a business process model was demonstrated, which enforces collection of additional information that allows to build more accurate and BPMN complaint process models. Then the ability of changes to an existing business process model without building a model from scratch was presented. The changes can either be modifying existing model's information or adding new information to the model. The ability to align business processes to organization SBOs was described which helps in integration and standardization of processes across all organization units. The tagging of maturity level to business processes that assists the organization to know the state of each process was discussed. It provides an opportunity for the managers and decision makers to improve underperforming processes. Tagging process tier/type was also explained which relates processes to the right accountability level and helps in the prioritization of work. A comparison of the functionality available in different tools along with proposed framework was also presented.

Chapter 5

5. Conclusion & Future Work

In the past few decades, the usage of BPM (Business Process Management) has enormously increased, and organizations are using BPM technologies to analyze, model, improve and implement business processes. Therefore, the need to create efficient business process models has also increased. Many techniques and methods have been proposed in the area of BPM and especially business process models. A common shortcoming of these approaches and methods is that the domain experts are not fully involved in the process of creating business process models. In addition, the processes are not aligned with the strategic business objectives of the organization. These problems lead to need for a new approach that addresses these concerns.

We have proposed a framework which not only creates business process models more efficiently and effectively but also aligns the processes with strategic business objectives of the organization. To achieve this goal we created structured data entry that verifies and validates the process of submitting business process requirements. We convert the data entered by the users into an XPDL file format and later transformed it into business process model. The framework also allows the users to add strategic business objectives, critical success factors, KPIs, functions, and processes and specify the relationship between them. It also has a

feedback loop functionality allowing the users to submit changes for the business process models. The constraint and validation are built in order to reduce redundancy in the data and to improve the accuracy of the information captured by the framework from users' inputs. It also validates the captured process requirements to build BPMN compliant models.

Comprehensive reports are generated from the collected information, which contains aggregated information with drill through and drill down capabilities. Reports show the maturity level of functions and processes, process type, process tier, information about approved processes and alignment of processes to SBOs. All the reports are real-time if any changes are immediately reflected in the reports. The proposed framework reduces the complexity of the current procedure used for collecting information to create business process models, which generally lead to misunderstanding or ambiguity between model and domain experts. The proposed framework also helps to document the processes within the organization, thus providing for automation and simplified maintenance of the processes.

5.1 Future Work

In our proposed framework, we have used several use case scenarios to demonstrate how to create business process models from users' inputs and align those processes to strategic business objectives of the organization. While the framework is capable of building models using core BPMN artifacts, this work can be extended in various directions in order to enhance the scope. Some of these extensions are listed below:

- In BPM, once the models are (re)designed, they must be implemented. This is normally done in Phase 5 of the BPM lifecycle. The business process models generated by our

framework can be converted into executable models for automation, monitoring and controlling.

- The BPMN standard provides additional elements such as sub-process and activity markers (eg. compensation marker, adhoc marker, loop marker). These advanced elements can be implemented in an enhanced version of the framework.
- Currently, our framework shows business process model when the file generated by the transformation engine is opened in XPDL reader. A very desirable extension could be to visually build model while process requirements are entered.
- While the web forms and dashboard is usable from mobile devices, specific layouts for smaller screens can be a desirable feature.

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