Integrated Process Modeling : From BPR to System Development*

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ABSTRACT

Enhancement of organizational effectiveness has been approached from the process perspective since the emergence of Business Process Redesign(BPR). While process modeling, as the main element of BPR method, is required to understand, represent, and redesign the target processes, there has been lack of agreement on the definition of the term "process". In this research, we classify previously suggested process definitions in terms of viewpoint and process structure. Based on the classification, we define two process subtypes -- Business Process and Functional Process -- and compare them over eight criteria. Based on the two process types, we suggest an integrated process modeling method which extends the BPR projects to the systems development phase. We demonstrate its effectiveness by applying it to a real-world case.

I. INTRODUCTION

Business organizations in the 1990s are facing the ever-increasing uncertainty and unprecedented volatility of the external environment, often characterized by the rapid technological advance and rising customer power. Under increased competition, many organizations attempt to improve their business processes from the customer's perspective utilizing information technology in Business Process Redesign (BPR) initiative [Davenport 90], also called Business Reengineering (BR) [Hammer 90]. BPR focuses on "fundamental rethinking and radical redesign of their age-old business processes [Hammer 90]." Process modeling, as a main element of BPR, is "a technique for understanding, representing, and when necessary, redesigning the fundamental business processes" [Kim 95]. Lack of a disciplined method to model business processes, however, was a problem in many BPR efforts [Caron 94; Grover 95]. Also, despite that the business process being the object of BPR, there has been lack of agreement on the definition of the term "process". In addition, the definition and its modeling concern is different between the BPR stage and the subsequent system development stage. These issues induce the transition gap between process redesign (conceptual level) and system development (implementation level).

In this paper, we try to reduce such difficulty through classifying previous process definitions, proposing two process types, and suggesting an integrated process modeling method. First, we review and classify process definitions in terms of viewpoint and process structure because the process model in BPR has two main characteristics -- customer-oriented [Hammer 90] and cross-functional process flow [Davenport 90]. Process definitions for BPR as well as for system analysis and design will be considered. Second, we propose two process types -- Business Process and Functional Process -- from the classification. We define the two types and compare them over eight criteria. From

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this comparison, we can identify the usage and characteristics of each process modeling type. Finally, based on those process types, an integrated process modeling method called IPM (Integrated Process Modeling) is introduced. IPM supports both BPR and systems development activities. And it is validated through its application to the real world hospital case.

The rest of the paper proceeds as follows. Section 2 describes various process definitions and classification of them. In section 3, we propose and compare two process types based on the classification. In section 4, we suggest the IPM method. Section 5 illustrates the application of the IPM method to a real-world case. In section 6, we draw the conclusion of the paper and suggest future research directions to extend the current study.

II. PROCESS CLASSIFICATION

The term, "process", has been an important element in the information systems (IS) field. Throughout the 1970s and 1980s, it meant the transformation of input data into output data as supported by the various structured analysis and design methods [DeMarco 79; Jackson 83; Yourdon 89; Martin 89; Senn 89]. As BPR emerged in 1990s, however, process has been defined and used differently. We have summarized various process definitions over the years in Appendix 1.

We can classify the above definitions from the viewpoint and process structure as in Figure 1. Viewpoint is divided into customer and organization. Customer viewpoint means that the relationship between customer and server organization is reflected in the definition. This viewpoint is adopted mostly by process modeling in BPR, which aims for enhancement of customer satisfaction. In the organization viewpoint, the process is considered solely from the organization's perspective. There is no mention of customer in the definition. This viewpoint has been taken mainly by the information system development projects.

Process structure, the process elements' arrangement style, is divided into horizontal sequence and vertical set. Horizontal sequence means that the process is defined an ordered sequence of activities. Its main concern is the cross-functional process flow modeling. This horizontal type is required for process modeling and redesigning for BPR. The vertical set means that the process and its subactivities are hierarchically structured without any sequence between them. Its modeling concern is not the process flow, but data flow and transformation. This vertical type is required for function analysis and design in information system development.

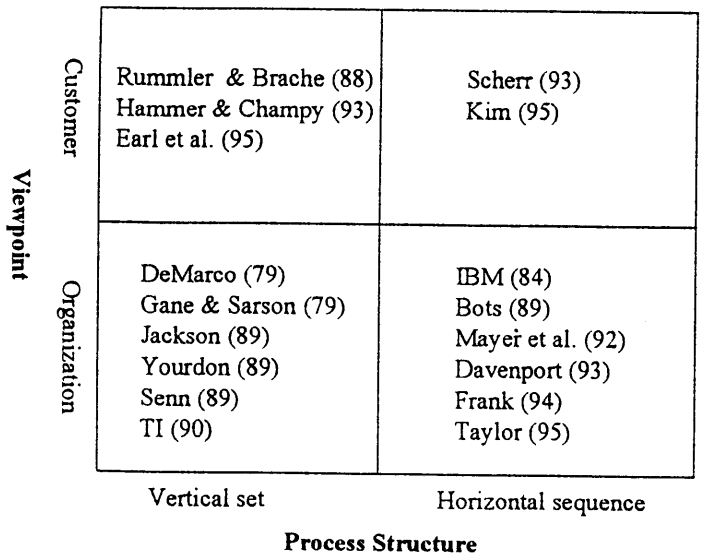

Figure 1. Classification of Process Definitions

In Figure 1, there are four process definition types. The first type is in the lower-left section with organizational viewpoint and vertical set type. Definitions in this section have been proposed for information system analysis and design. Based on this definition type, structured methodologies

[Yourdon 89; Senn 89; Martin 89] have been developed. The second type is in the lower-right section with organizational viewpoint and horizontal sequence type. Definitions in this section have been proposed mainly for BPR, except for IBM (1984) which aims for business systems planning. Those processes, however, do not consider customer perspective even though they deal with cross-functional process flow. The third type is in the upper-left section with the customer's viewpoint and vertical set type. Definitions in this section have been proposed for BPR, too. However, they do not consider process flow while they reflect the customer's perspective in the definition. The fourth type is in the upper-right section with the customer's viewpoint and horizontal sequence type. Definitions in this section have been proposed to accommodate BPR's two core characteristics -- customer viewpoint and cross-functional process flow.

We can label the four classification types of process definitions in Figure 1 according to their purpose. The first type in the lower-left section is labeled as the functional process, which is useful mainly for systems analysis and design purpose. We define functional process as "the transformation of input data into output data to satisfy a specific functional requirement." The other types in the upper-right section is labeled as the business process, which is appropriate for the BPR purpose. We define business process as "an ordered set of activities performed by the customer or between customer and server organization to satisfy a specific customer requirement". Here, customer can be any person or organization, internal or external, which has a need that the server organization attempts to satisfy. We will compare those characteristics of the functional and business processes in the next section.

III. COMPARISON OF PROCESS TYPES

In the previous section, we classified processes into functional process and business process. Since each process has a different objective and usage, there exist many differences between the two process types. We summarize and compare the characteristics of each process type in Table 1. Functional process, as previously stated, deals with data transformation and aims for the development of an information system, using diagrams like Data-Flow Diagram (DFD). It also contributes to converting such diagrams into module structure (structure chart) or pseudocodes. Its main role is to support the development of IS applications for functional areas or specific groups of users. Naturally, its modeling orientation is toward system perspective and often its goal is to improve process productivity by automating routine tasks. Also, the functional process is mainly represented as data-process coupling such as DFD.

Table 1. Comparison of two process types

	Functional process	**Business process**
Focus	Data transformation	Process coordination
Purpose	System development	Business process redesign
Level of abstraction	Medium-Low	High
Modeling scope	Functional area	Enterprise-wide
Modeling orientation	Employee	Customer
Processing target	Data and documents	Objects of all types
Stage	System analysis and design	Process analysis and redesign
Representation	Data-process coupling	Process flow with time and place
Tools/technique	DFD, Structure chart	EPC, Process Map

Business process deals with the coordination of interrelated process elements and is used for BPR. Instead of focusing on developing IS applications, this type focuses on modeling, using diagrams like Event-Process Chain (EPC) [Kim 95] or Process Map [Andersen 93], the interrelated process elements across functional boundaries, encompassing the entire organization. Frequently, these processes are initiated by customers and the modeling orientation reflects the strong customer perspective. The goal of such process modeling is to support the "understanding and radical redesign of critical business processes to better serve its customer -- BPR." [Kim 95] In addition, business process targets not only data and documents as in DFD, but also any object of interest including

customers or physical things. Such objects are represented as the process flow across time and place dimension.

We can also compare the two process types from the representation perspectives [Curtis et al. 92] as in Table 2. There are four representation perspectives -- Functional, Behavioral, Organizational, and Informational. Functional perspective represents what activities are being performed and what data flows connect them. Behavioral perspective represents when and how activities are performed, with sequencing, feedback loops, iteration, decision making, triggering conditions, etc. Organizational perspective represents where and by whom activities are performed. Information perspective represents the data entities involved in a process, including their structure and interrelationships. It is possible to develop a single process modeling formalism which covers all of these four representation perspectives. However, it is difficult to cover all four perspectives in a single modeling formalism without incurring too much complexity. More effective approach will be to use several modeling techniques to cover all these perspectives in an integrated way [Huckvale 95].

We consider DFD as an example of the functional process model and EPC as an example of the business process model. By matching the representation perspectives with process types, we find that the key perspectives for the functional process are the functional and informational. That is, DFD represents data-process coupling and data flow, not the process flow. Also, the data dictionary in DFD deals with information entities and their structure and relationships using a data model such as Entity-Relationship Diagram (ERD). On the other hand, the key perspectives for the business process are the behavioral and organizational. As previously stated, business process is represented as process flow across time and place. For BPR purpose, it deals with when, by whom, and how those processes are performed, as well as its location.

Table 2. Process modeling types with representation perspectives

Representation	Perspectives [Curtis et al. 92]	Functional Process	Business Process
Functional	What processes are performed?	o	o
	What flows of informational entities?	o	x
Behavioral	When process is performed?	x	o
	How it is performed?	o	o
Organizational	Where the process is performed?	x	o
	By whom the process is performed?	x	o
Informational	Information entities related with the process	o	x
	Structure and Relationships	o	x

From Table 2, we find that, when combined, those two process types can handle all four representation perspectives. By integrating the process modeling techniques to support the two process types, we coordinate the seamless implementation of the BPR and the subsequent information system development.

IV. INTEGRATED PROCESS MODELING METHOD

Effective process modeling is crucial for both BPR and information system development. However, each stage dictated its own process modeling method. This fact results in the transition gap between these stages, explaining why it has been difficult to transform the redesigned process into a successful functional information system. Therefore, we need to minimize the transition gap between process modeling formalism. Instead of developing a single process modeling formalism, we decided to use and integrate the previously suggested process types -- business process and functional process.

Before integrating the two types, we need to consider the differences in modeling orientation and scope. Business process modeling is frequently initiated by customers. In this stage, a series of activities performed by customers or between customer and server-organization are modeled. Activities solely performed by the server-organization are not represented as a process but as the customer's wait for service at this representation level. The internal activities of the server organization without direct customer interaction, represented as wait in the upper level, are

represented as a process at the next level from the server organization's perspective. Also, activities performed between customers and the server organization can be modeled from the server organization's perspective if it needs to be computerized. For the computerization, the selected part of the business process should be analyzed -- transformation into a functional process. In this stage, the functional process is modeled from the function perspective, adopting either a structured or object-oriented method. Then the information system is designed based on the previous analysis from the system perspective. These differences are summarized in Figure 2.

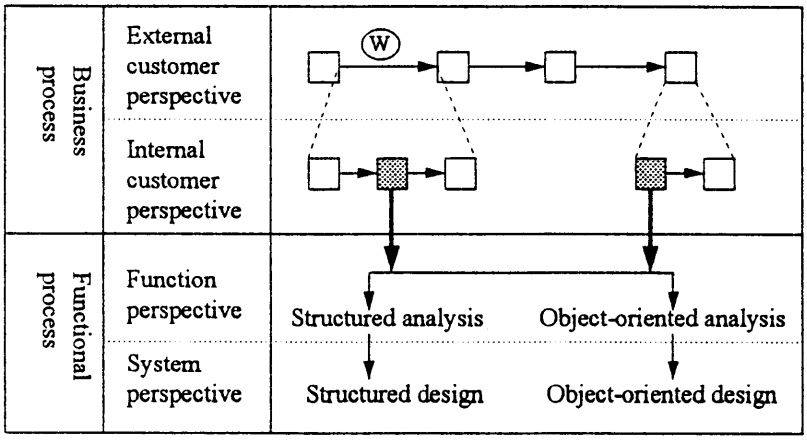

Figure 2. Changes in modeling orientation and scope between process types

Based on the perceived changes in the modeling orientation and scope of the process types, we developed an integrated process modeling(IPM) method. IPM is composed of four steps as in Figure 3. As a first step, business process modeling is performed concerning the current situation [Kim 95], in which both external and internal customer perspectives are reflected as in Figure 2. After analyzing the current situation (step 1), as a second step, we need to diagnose and redesign the business process. In this stage, we can use a simulation technique [Kim and Kim 96] for performance evaluation. After redesigning business processes [Kim and Kim 96], we need to develop IS applications that facilitate the redesigned process. For system development, we can adopt either the structured or object-oriented method. In step 3, functional process -- the selected part of the business process for computerization -- is analyzed. For the analysis, we can use a Data-Flow Diagram(DFD) and Entity-Relationship Diagram(ERD) as a structured method or object-oriented analysis model as an object-oriented method. Based on the system analysis, functional process is designed for system development in step 4. In this step, we can use the Structure Chart and database schema as a structured method and object-oriented design model as an object-oriented method.

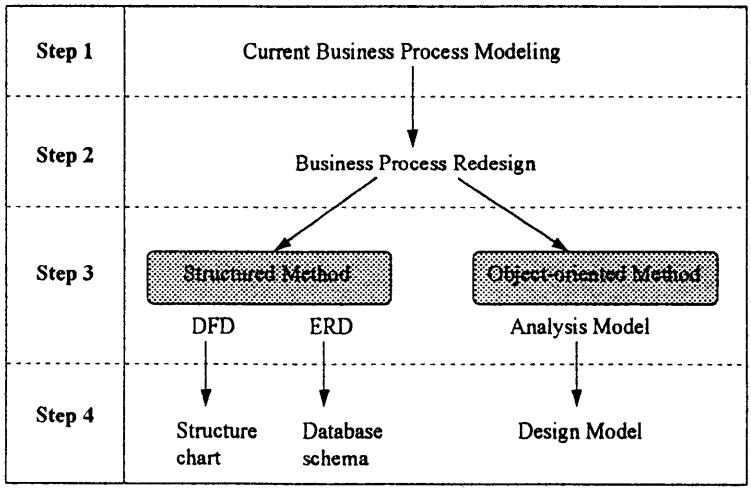

Figure 3. Integrated Processing Modeling Overview

From the above IPM overview, we summarized the IPM method in Table 3. Step 1 -- Current Business Process Modeling -- intends to analyze and model the current situation about the enterprise from the business process perspective. Also, as previously stated, the business process is modeled from the external customer perspective. The key representation perspectives are behavioral and organizational [Curtis et al. 92], which represent when activities are performed and where and by whom activities are performed. Furthermore, this step deals with the cross-functional process flow (Business Process) with Event-Process Chain (EPC) [Kim 95], Process Flow Diagram [Wang 92], Process Map [Andersen 93], Business Design Facility [TI 93], et al.

Step 2 -- Business Process Redesign -- intends to redesign the analyzed cross-functional business process. In this step, we can use the EPC and simulation techniques for performance evaluation about current business process and redesign alternatives [Kim and Kim 96]. When new IS applications may be required to facilitate the redesigned business process, we need to analyze and design an information system, which will be dealt with in step 3.

Table 3. Integrated Process Modeling Methodology

Step 1.	**Current Business Process Modeling**
• Goal	Analyze current business process
• Viewpoint	Customer
• Target	Enterprise (cross-functional area)
• Output	Current cross-functional process flow
• Representation	Behavioral, Organizational perspectives
• Tool/technique	Event-Process Chain, Process Map, BDF
Step 2.	**Business Process Redesign**
• Goal	Redesign the business process
• Viewpoint	Customer
• Target	Current cross-functional process flow
• Output	Redesigned cross-functional process flow
• Representation	Behavioral, Organizational perspectives
• Tool/technique	Simulation, Event-Process Chain, Process Map, BDF
Step 3	**Functional Process Modeling**
• Goal	Analyze functional perspective of part of business process
• Viewpoint	Function
• Target	Part of redesigned business process(functional area)
• Output	Functional process model with data-process coupling
• Representation	Functional, Informational perspectives
• Tool/technique	Data-Flow Diagram, ER Diagram, O-O analysis model
Step 4.	**System Design**
• Goal	Design information system for the functional process
• Viewpoint	System
• Target	Functional process model
• Output	System design specification
• Representation	Functional, Information perspectives
• Tool/technique	Structure chart, DB Schema, O-O design model

Step 3 -- Functional process modeling -- intends to analyze the functional perspective of some part of the entire business process flow, which will be computerized. While the business process is modeled from the customer and server-organization perspective, the functional process is modeled from the function perspective. The key representation perspectives are the functional and informational [Curtis et al. 92] ones, which represent what activities are being performed and what data flows connect them. As an output of this step, the set of functional processes coupled with data is modeled in the functional area with Data-Flow Diagram (DFD) and Entity-Relationship Diagram (ERD) as a structured method or object-oriented analysis model as an object-oriented method.

Step 4 -- System design -- intends to prepare the information system design specification about the analyzed functional process model. In this step, we can use the Structure Chart and database schema (DB table) as a structured method or the object-oriented design model as an object-oriented method.

V. APPLICATION CASE

IPM method was applied to Seoul Adventist Hospital. For this application, we picked the out-patient's visiting process through the internal medicine department, examination room, and pharmacy because it is representative of the most critical and time consuming process of the hospital [Kim 95]. The four steps in the IPM will be discussed through the hospital's case from BPR to system development stages.

As a first step of IPM, the top level of the hospital's outpatient visit process is modeled with EPC as in Figure 3, which is represented from the patient perspective -- **current business process modeling from the customer perspective**. The outpatient's visiting process is initiated by a patient's arrival. Arrived patients register and pay in advance the doctor's fee at the reception desk. Arriving at the internal medicine department's waiting room, the patient waits for his turn. The amount of time the customer has to wait for his turn is represented as wait (W1). During this wait, the patient chart will be delivered from the chart room to the department. This wait can be exploded into a lower level process model where the customer's registration invokes the retrieval and delivery of the patient chart. At this exploded lower level, the situation is modeled from the hospital perspective not from the patient perspective -- **Business process modeling from the internal customer perspective**. Arriving and waiting for some time at the internal medicine department's waiting room, each patient will be consulted by one of the four doctors. After the consultation, those who need additional step(s) -- medicine or examination -- have to pay in advance again. Arriving at the pharmacy desk, the patient submits his paid prescription slip to the pharmacy reception desk. The amount of time the customer has to wait for his medicine is represented as wait (W2). This wait can be exploded into lower level and modeled from the pharmacy perspective [Kim 95]. After receiving the medicine and being examined, the patient leaves the hospital

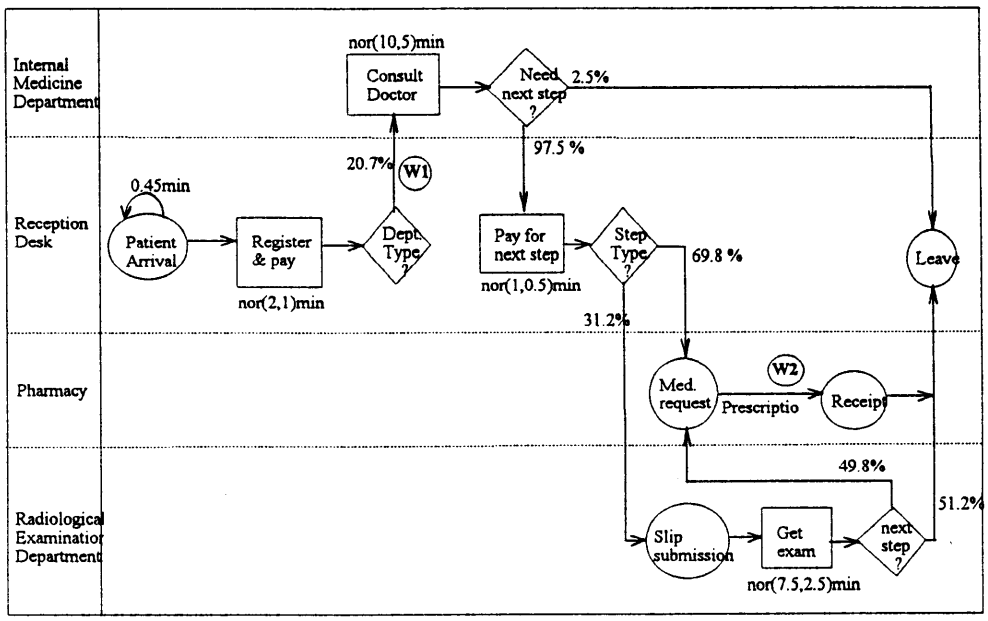

Figure 3. Patient's visit process at the hospital

As a second step of IPM, the visit process is redesigned and modeled as in Figure 4 -- **Business process redesign**. To redesign the business process, we adopted the simulation technique and performance-based change guidelines [Kim and Kim 96]. We considered issuing each patient a

smart card with all the personal health history and bank account information at the reception desk -- automating the manual registration process. When the patient arrives at the doctor's office after checking his card, he is registered and his consultation history data is prepared already. Also, all his expenses that day will be handled through his bank account. In addition, the invoice amount will be calculated based on the treatment as prescribed by the doctor. Based on the performance evaluation with the simulation technique, we adopted this redesign alternative [Kim and Kim 96].

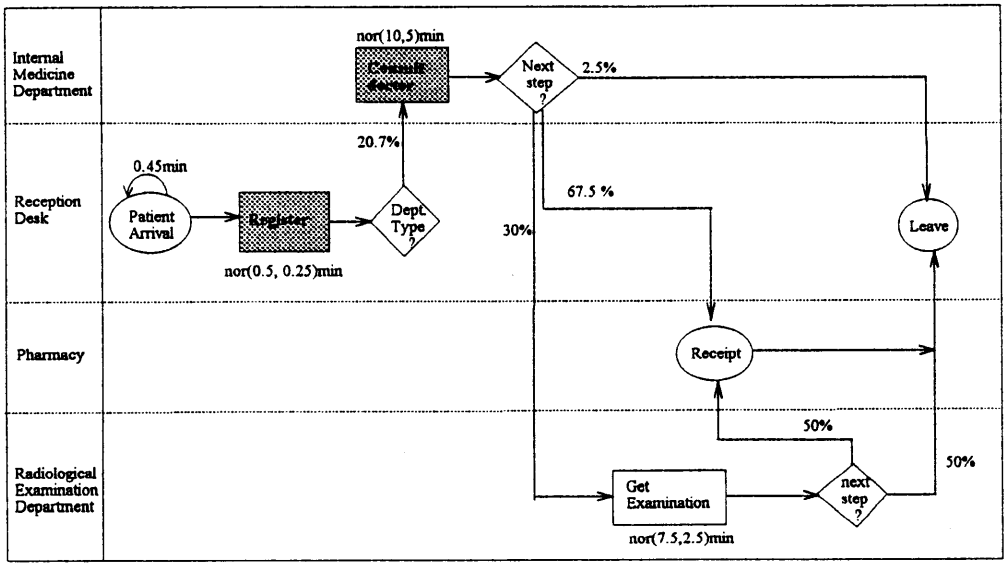

Figure 4. Redesigned visit process

As a third step, we need to do functional process modeling. In the second step of IPM, we considered issuing each patient a smart card with all the personal health history and bank account information. For this purpose, we need to develop a registration and charging system which facilitates those two redesigned processes : Register and Consult Doctor. For the system development, we should analyze the registration and charging-related functional processes beforehand -- **functional process modeling**. For the analysis, we can adopt either the structured method or object-oriented method. As a structured method, DFD and ERD can be used for data-process coupling. While DFD represents functional perspectives of the system as in Figure 5, ERD represents information perspectives as in Figure 6. DFD reveals that invoice is prepared based on the registration and treatment data. Also ERD reveals that there are four major entities -- Patient, Registration, Consultation, and Treatment -- in the system. We can refine each DFD and ERD and their relationship with the joint data and functional analysis method [Batini 92].

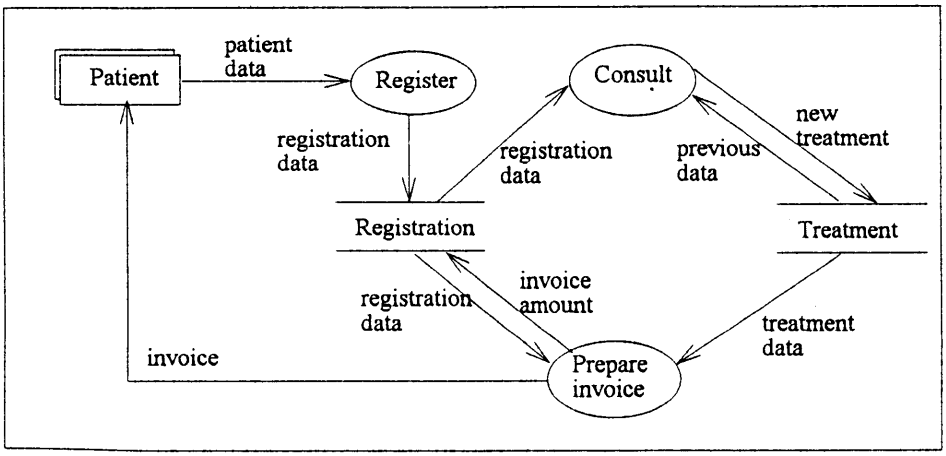

Figure 5. DFD for the registration and charging system

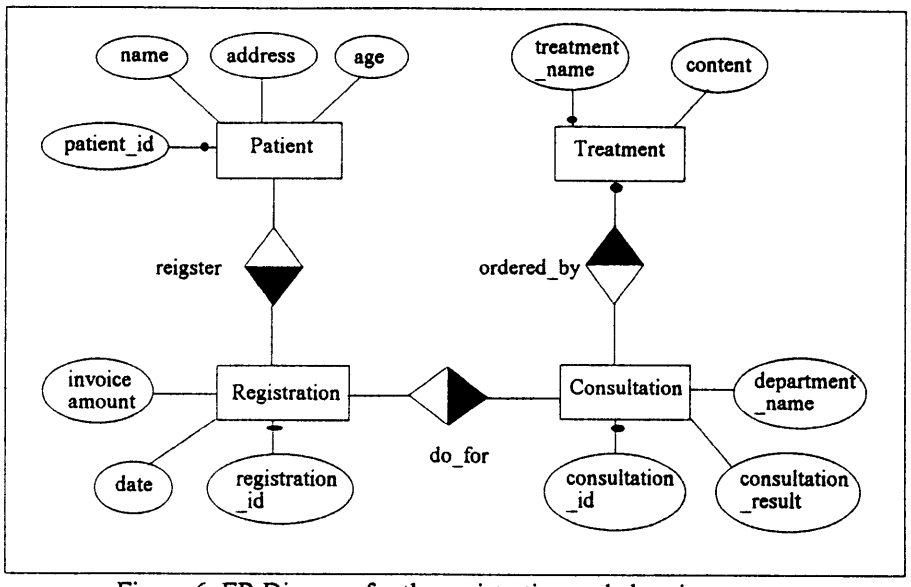

Figure 6. ER Diagram for the registration and charging system

As an object-oriented method in Step 3, we can adopt Jacobson's(1992) approach. The registration and charging process is analyzed and modeled as an object model in Figure 7. Object model is composed of interface objects, entity objects, and control objects. All functionalities that are dependent on the system environment is placed in the interface objects -- Registration window, Consultation window, and Invoice window. Entity object -- patient, registration, invoice, and patient chart -- is used to model the information that the system handles over a longer period of time. The control object -- register, patient chart generator, treatment prescriber, and invoice generator -- is used to model behaviors that affect other objects. From these objects and their interrelationships, we can perceive data-process coupling.

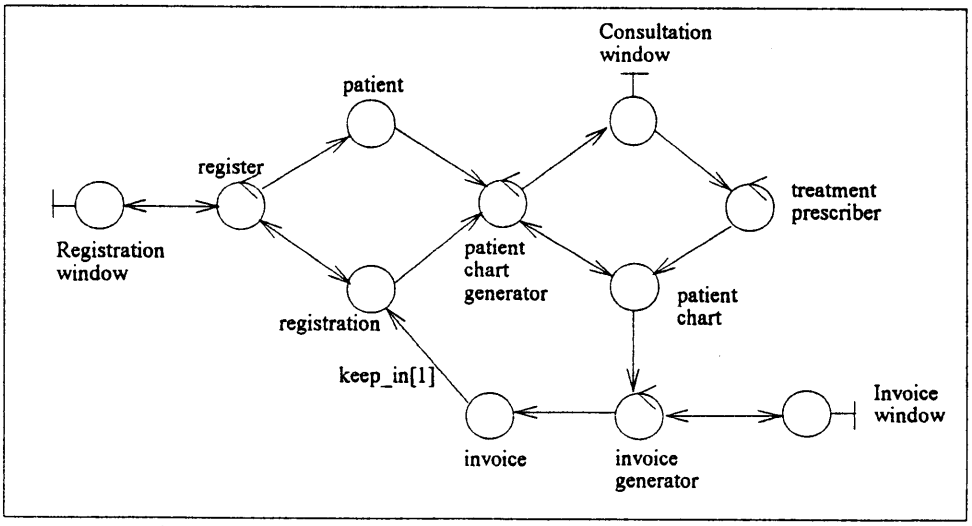

Figure 7. Object model for the registration and charging system

As a fourth application step of IPM, we need to design the registration and charging system -- **System design**. In this step, we can also adopt the structured method or object-oriented method. As a structured method, we can use the structure chart derived from DFD as in Figure 8. The system is composed of three main modules -- Register, Consult, and Prepare invoice. In addition to this structure chart, we need data model derived from ERD -- database schema -- for system development.

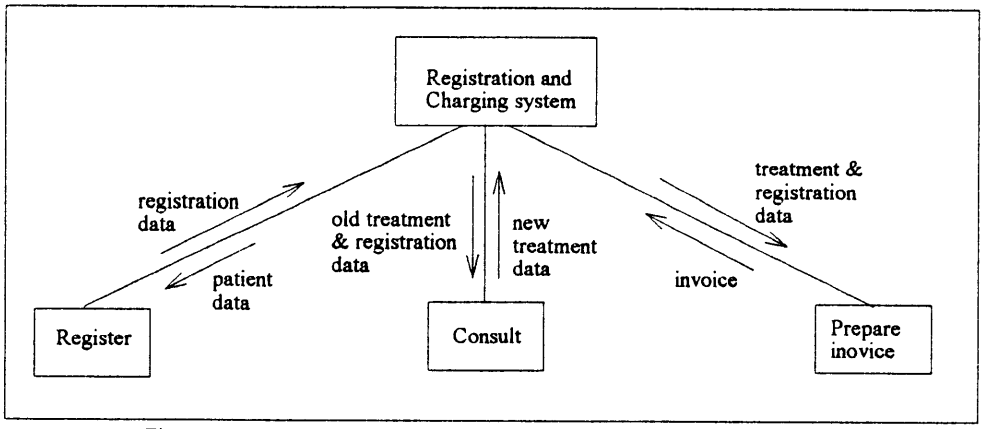

Figure 8. Structure chart for the registration and charging system

Besides the structure method, we can adopt the object-oriented design model [Jacobson 92] as an object-oriented method. As a design model, we can use the interaction diagram derived from the object model as in Figure 9, which is used to model the interrelationships between multiple objects in the system. This interaction diagram reveals the transition sequences and some message passings between objects.

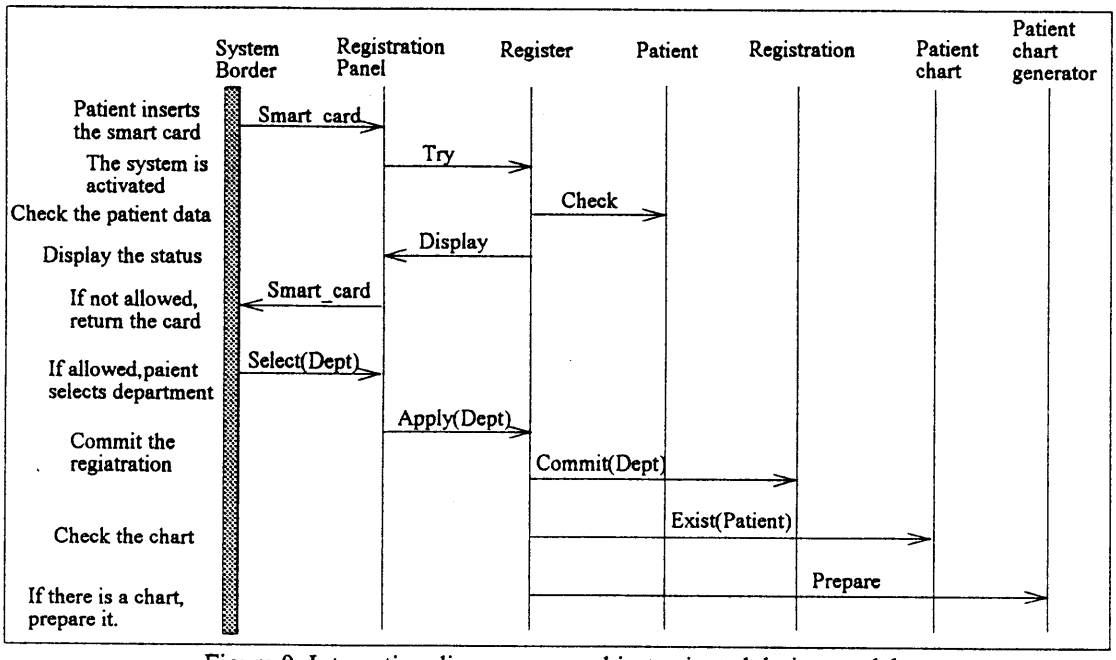

Figure 9. Interaction diagram as an object-oriented design model

VI. CONCLUSION

As business organizations in 1990s face the increasing uncertainty and unprecedented volatility of the external environment, they need to redesign their business process around customers. However, ambiguity around the term, "process", results in confusion and transition gap between BPR and traditional systems development projects. In this research, we reviewed and classified process definitions from the IS literature in terms of viewpoint and process structure. Based on the classification results, we suggested two process types --business process and functional process. While the business process modeling deals with customer/organization-oriented process flows in the cross-functional area for BPR, the functional process modeling deals with a set of system-oriented transformation processes for information system development. Besides the definition and purpose,

each modeling type has its own characteristics. The comparison between the two process types helps us to minimize the confusion of process concept and its usage.

By integrating the two modeling types, we introduced an IPM method which guides process modeling in each stage from BPR to system development. The proposed IPM method fits the customer orientation and cross-functional process modeling requirements of BPR with business process modeling. Also it deals with system analysis and design requirements with functional process modeling, which focuses on data flows and data transformation. We provide behavioral and organizational representation perspectives through business process modeling and functional and information perspectives through functional process modeling for simplicity in modeling and ease of understanding. The integrated modeling characteristics induce a smaller transition gap between the stages. We demonstrated its effectiveness by applying it to the real-world hospital case.

On the basis of this research, we can now think of the related future research directions. First, since IPM is process-oriented, we need to expand IPM to information system architecture which is composed of process, data, technology, and control. As IPM handles conceptual to physical levels of process, other components in the IS architecture should be matched each other at each level. Then, the new IS architecture will become a much clearer blueprint for the system development. Second, we need to develop a supporting tool for IPM. It should support business process modeling, performance evaluation with simulation technique, and system analysis/design. Also the system needs an information repository to keep the process-related information.

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Apendix 1. Process Definition

Source	Definition
DeMarco(79)	A transformation of incoming data flow(s) into outgoing data flow(s)
Gane and Sarson(79)	A set of operations transforming data, logically or physically, according to some process logic
Jackson(83)	An action or set of actions performed by the system and resulting in the production of output(Function)
IBM(84)	Groups of logically related decisions and activities required to manage the resources of the business
Rummler and Brache(88)	Any activity or group of activities that takes an input, adds value to it, and provides an output to an internal or external customer
Yourdon(89)	Transformation of input data flows into output data flows
Senn(89)	Procedures that use or produce (transform) data
Bots(89)	Some activity or combination of activities which is performed on some item in order to achieve a certain goal
TI(90)	A defined business activity whose executions may be identified in terms of the input and output of specific entities or of data about specific entities
Mayer et al.(92)	An ordered sequence of events or activities
Hammer and Champy(93)	A collection of activities that takes one or more kinds of input and creates an output that is of value to the customer
Davenport(93)	A specific ordering of work activities across time and place, with a beginning, and end, and clearly inputs and outputs
Scherr(93)	A series of customer-supplier relationships that produces specific results at specific point in time
Frank(94)	A chain of activities with each activity characterized by the resources it consumes and its outcome
Taylor(95)	Sequence of goal-directed activities that consumes and generate resources
Earl et al.(95)	The structure by which organizations do what is necessary to produce value for customers
Kim(95)	Activity or a series of activities performed by customers or between customer and server organization over time