1.1 PRODUCT INFORMATION MANAGEMENT (PIM)

Product Information Management (PIM) encompasses the integration and management of process, applications, and information that defines products across distributed systems and various media in a company. PIM incorporates all product related information, including hard-copy documents, electronic documents, digital files, and database records. The profitability of product development in an organization is dependent on orderly and efficient design, fabrication, and distribution. PIM systems help achieve these goals.

PIM is a tool that helps the enterprise, engineers, and others manage both data and the product development process. PIM systems keep track of the masses of data and information required to design, manufacture, or build and afterwards support and maintain products. PIM is a general extension of techniques commonly known as Engineering Data Management (EDM), Document Management (DM), Product Data Management (PDM), Technical Data Management (TDM), Image Management (IM), and various other names. The term PIM provides an umbrella over all systems that are used to manage product information.

PIM is intended to speed up the product development process, the manufacturing process, and the time to market by making data and drawings more accessible to the people that need them. Additionally, a PIM system can guide users through their part of the product lifecycle and initiate the use of appropriate tools at each step of that lifecycle. This allows users to work across systems and applications without learning or relearning a new environment.

To address the issue of efficient and effective PIM, systems must be structured and implemented in a manner that encompasses all data associated with products (not only engineering drawings), and the products must be accessible to all users in product development chain (not just technical persons).

Product Information Management is intended to give the bigger picture, linking people, processes, and products.

Additionally, PIM systems are if most value when they support all the processes in the cycle – from conceptual design and modeling through tool path generation, manufacturing, and change management to product obsolescence and replacement. In amore complete sense, PIM is intended to give the bigger picture, linking people, processes, involved in creating and supporting a product, going beyond product data alone. PIM provides for defining the responsibilities and data access of each person in an organization. People can also be grouped by function or project team to define authorities, approval requirements, or tasks that need to be complete. PIM systems link groups and individuals to the appropriate process steps that make up the overall lifecycle of a product. Workflows are then linked together to create the complex process steps that define the development and implementation cycle of a product.

Product structures are built within PIM systems by describing the relationships of parts and linking them together based on relationship rules. These links connect

components to their use in multiple products; people to the products they design, approve, and release; and products to the processes used to create, release; and products to the processes used to create, release, and manufacture them.

Motivation for implementing a PIM system may come from the front line of an organization in situations where finding, controlling electronic data is critical. Motivation for organizational changes and process improvement through PIM generally comes from middle and upper management. In either case, a strong commitment from upper management is essential to the success of PIM implementation.

PIM originated in engineering to create a "vault" in which files could be securely stored, to track work in process, and to expedite reviews and approvals of engineering changes.

1.2 PRODUCT

To understand the motivations of PIM, it is paramount for us to know Product Life Cycle (PLC) and Product Development Process (PDP).

PRODUCT LIFE CYCLE (PLC)

Figure 1 indicated a typical model of product life in term of cash flow. In real life, the cycle may be longer or shorter depending on the type of product, and it is always easier to analyze past products than to predict the future.

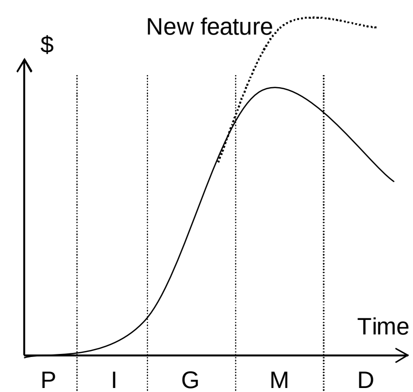


Figure 1 Product Life Cycle

A product life cycle describes the evolution of the product as measured by sales over time. The five stages of a product life cycle are Planning, Introduction, Growth, Maturity, and Decline.

Planning is the development stage, in which both product design and production process are determined. There are no sales during this stage.

Introduction represents a period of low-volume sales. The product is refined, and marketing efforts are beginning.

The ***growth*** stage has rapid product growth and a fast increase in sales. This period is difficult for the manufacturing organization, which has to keep up with the increasing sales volume.

At ***maturity***, we see a tapering off in the growth rate as the market becomes saturated. Demand is stable and may decline slowly.

A drop in product demand is seen in the ***decline*** phase. The product is going to be replaced by new products. Sales and profits decrease, and at some point, production is halted.

PLC is subject to variation, and to influence: the introduction of a new refinement or colour variation, a new application, or a new model added to the product line at the Maturity or Saturation stages, or even at the Decline stage, may lead to an increased length of life for the product or line. All these enhancements required design adaptation, modification, or change.

PIM is a tool to manage information for design changes during the complete PLC.

PRODUCT DEVELOPMENT PROCESS (PDP)

A process is a sequence of steps that transforms a set of inputs into a set of outputs. Most people are familiar with the idea of physical processes, such as those used to bake a cake or to assemble an automobile. A Product Development Process (PDP) is the sequence of steps or activities that an enterprise employs to conceive, design, and commercialize a product. Many of these steps and activities are intellectual and organizational rather than physical. Some organizations define and follow a precise and detailed development process, while others may not even be able to describe their processes. Furthermore, every organization employs a process at least slightly different from that of every other organization. In fact, the same enterprise may follow different processes for each of several different types of development projects.

A well-defined development process is useful for the following reasons:

Quality assurance: A development process specifies the phases a development project will pass through and the checkpoints along the way. Assuming that these phases and checkpoints are chosen wisely, following the development process is one way of assuring the quantity of the resulting product.

Coordination: A clearly articulated development process acts as a master plan defines the roles of each of the team members on the development team. This plan informs the members of the team when their contributions will be needed and with whom they will need to exchange information and materials.

Planning: A development process contains natural milestones corresponding to the completion of each phase. The timing of these milestones anchors the schedule of the overall development project.

Management: A development process is a benchmark for assessing the performance of an ongoing development effort. By comparing the actual events to the established process, a manager can identify possible problem areas.

Improvement: The careful documentation of an organization's development process often helps to identify opportunities for improvement.

Various kinds of information with different versions will be generated during PLC. PIM is used to establish a well-defined PDP.

The five phases of PDP are:

Concept Development: In the concept development phase, the needs of the target market are identifies, alternative product concepts are generated and evaluated, and a single concept is selected for further development. A concept is a description of the form, function, and features of a product and is usually accompanied by a set of specifications, an analysis of competitive products, and an economic justification of the project.

System-level Design: The system-level design phase includes the definition of the product architecture and the division of the product into subsystems and components. The final assembly scheme for the production system is usually defined during this phase as well. The output of this phase is usually a geometric "layout" of the product, a functional specification of each of the product's subsystems, and a preliminary process flow diagram for the final assembly process.

Detailed Design: The detail design phase includes the complete specification of the geometry materials, and tolerances of all of the standard parts to be purchased from suppliers. A process plan is established and tooling is designed for each part to be fabricated within the production system. The output of this phase is the control documentation for the product – the drawings or computer files describing the geometry of each part and its production tooling, the specifications of the purchased parts, and the process plans for the fabrication and assembly of the product.

Testing and Refinement: The testing and refinement phase involves the construction and evaluation of multiple preproduction versions of the product. Early (alpha) prototypes are usually built with production-intent parts-parts with the same geometry and material properties as intended for the production version of the product but not necessarily fabricated with the actual processes to be used in production. Alpha prototypes are tested to determine whether or not the product will work as designed and whether or not the product satisfies the key customer needs. Later (beta) prototypes are usually built with parts supplied by the intended production processes but may not be assembled using the intended final assembly process. Beta prototypes are extensively evaluated internally and are also typically tested by customers in their own use environment. The goal for the beta prototypes is usually to answer questions about performance and reliability in order to identify necessary changes for the final product.

Production Ramp-up: In the production ramp-up phase the product is made using the intended production system. The purpose of the ramp-up is to train the work force and to work out any remaining problems in the production processes. The artifacts produced during production ramp-up are sometimes supplied to preferred customers and are carefully evaluated to identify any remaining flaws. The transition from production ramp-up to ongoing production is usually gradual and continuous. At some point in this transition, the product is launched and becomes available for widespread distribution.

1.3 INFORMATION

BASIC CONCEPTS & DEFINITIONS

Database is an organized collection of logically related data. It may be of any size and complexity. For example, a salesperson may maintain a small database of customer contacts on her laptop computer that consists of a few megabytes of data. A large corporation may build a very large database consisting of several terabytes of data (a terabyte is a trillion bytes) on a large mainframe computer that is used for decision support applications.

Database: An organized collection of logically related data.

DATA

Historically, the term data referred to known facts that could be recorded and stored on computer media. For example in a salesperson's database, the data would include facts such as customer name, address, and telephone number. This definition now needs to be expanded to reflect a new reality. Databases today are used to store objects such as documents, photographic images, sound, and even video segments, in addition to conventional textual and numeric data. For example, the salesperson's database might include a photo image of the customer contact. It might also include a sound recording or video clip of the most recent conversation with the customer. To reflect this reality, we use a broadened definition: Data consist of facts, text, graphics, images, sound, and video segments that have meaning in the users' environment.

Data: Facts, text, graphics, images, sound, and video segments that have meaning in the uses' environment.

Database is defined as an organized collection of related data. By organized it meant that the data are structured so as to be easily stored, manipulated, and retrieved by users. By related it meant that the data describe a domain of interest to a group of users and that the users can use the data to answer questions concerning that domain. For example a database for an automobile repair shop contains data identifying customers (the data items it lists include each customer's name, address, work phone number, home phone number, and preferred credit card number), automobiles belonging to those customers (the data items include make, model, and year), and repair histories for each of those automobiles.

DATA VERSUS INFORMATION

The terms data and information are closely related, and in fact are often used interchangeably. However, it is often useful to distinguish between data and information. Information is defined as data that has been processed in such a way that it can increase the knowledge of the person who uses it. For example, consider the following list of facts:

CHAN, Tai Man	E456743(1)
LEUNG, Wing Hon	D235476(A)
CHOW, Siu Ming	B667854(3)
WONG, Kin Hong	D674312(7)

Table 1 Data

These facts satisfy our definition of data, but most persons would agree that the data are useless in their present form. Even if we guess that this is a list of persons' names together with their HKID card numbers, the data remain useless since there is no indication on what the entries mean. Notice what happens when the same data is placed in a context, as shown in Figure 2.

Surname	Name	HKID No.
CHAN	Tai Man	E456743(1)
LEUNG	Wing Hon	D235476(A)
CHOW	Siu Ming	B667854(3)
WONG	Kin Hong	D674312(7)

Table 2 Information

Another way to convert data into information is to summarize it or otherwise process and present it for interpretation shows summarized student enrollment data presented as graphical information.

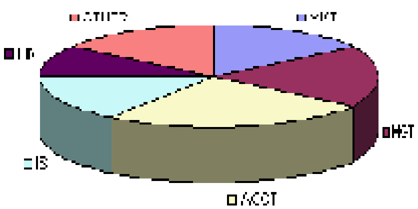


Figure 2 Summarized Data

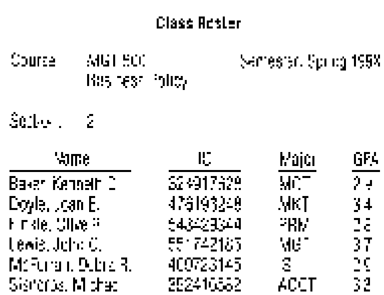
This information could be used as a basis for deciding whether to add new courses or to hire new faculty members.

In practice, databases today may contain either data or information (or both), according to our definitions. For example, a personnel database may contain employee photo images. Also, data are often preprocessed and stored in summarized form in databases that are used for decision support. Throughout this text we use the term database without distinguishing its contents as data or information.

Information: Data that have been processed in such a way as to increase the knowledge of the person who uses the data.

METADATA

As discussed in last section, data only become useful when placed in some context. The primary mechanism for providing context for data is metadata. Metadata are data that describe the properties or characteristics of other data. Some of these properties include data definitions, data structures, and rules or constraints.



Class Roster

Course: MGT 500 Business Policy Semester: Spring 199X

Section: 2

Name	ID	Major	GPA
Baker, Kenneth D.	[illegible]	MGT	[illegible]
Doyle, Joan E.	[illegible]	MKT	3.4
[illegible]	[illegible]	PRM	[illegible]
Lewis, John C.	[illegible]	MGT	3.7
McFerran, Debra R.	409723145	IS	[illegible]
[illegible]	[illegible]	ACCT	3.2

Figure 3 Converting Data into information

Some sample metadata for the Class Roster (Figure 3) are listed in Table 3. For each data item that appears in the Class Roster, the metadata show the data item name, the data type, length, minimum and maximum allowable values (where

appropriate), and a brief description of each data item. Notice the distinction between data and metadata: Metadata are once removed from data. That is, metadata describe the properties of data but do not include that data. Thus, the metadata shown in Table 3 do not include any sample data from the Class Roster of

Metadata allow database designers and users to understand what data exist, what the data mean, and what the fine distinctions are between seemingly similar data items. The management of metadata is at least as crucial as managing the associated data since data without clear meaning can be confusing, misinterpreted, or erroneous.

Data Item			Value	
Name	Type	Length	Min	Max
Course	Alphanumeric	30		
Section	Integer	1	1	9
Semester	Alphanumeric	10		
Name	Alphanumeric	30		
ID	Integer	9		
Major	Alphanumeric	4		
GPA	Decimal	3	0.0	4.0

Name	Description
Course	Course ID and name
Section	Section number
Semester	Semester and year
Name	Student name
ID	Student ID (SSN)
Major	Student major
GPA	Student grade point average

Table 3 Example of Metadata for class roster

Metadata: Data that describe the properties or characteristics of other data.

TRADITIONAL FILE PROCESSING SYSTEMS

In the beginning of computer-based data processing, there were no databases. Computers that were considerably less powerful than today's personal computer filled large rooms and were used almost exclusively for scientific and engineering calculations. Gradually computers were introduced into the business world. To be useful for business applications, computers must be able to store, manipulate, and retrieve large files of data. Computer file processing systems were developed for this purpose. Although these systems have evolved over time, their basic structure and purpose have changed little over several decades.
As business applications became more complex, it became evident that traditional file processing systems had a number of shortcomings and limitations (described below). As a result, these systems have been replaced by database processing systems in most critical business applications today. Nevertheless, you should have at least some familiarity with file processing systems for the following reasons:

1. File processing systems are still widely used today, especially for backing up database systems.

2. Understanding the problems and limitations inherent in file processing systems can help us avoid these same problems when designing database systems.

EVOLUTION OF DATABASE SYSTEMS

Database management systems were first introduced during the 1960s and have continued to evolve during subsequent decades.

Database management systems were developed to overcome the limitations of file processing systems. They are:

- Program-data dependence
- Duplication of data
- Limited data sharing
- Lengthy development times
- Excessive program maintenance

Database is targeted to overcome these shortcomings. In short, some combination of the following three objectives always drove the development and evolution of database technology:

- The need to provide greater independence between programs and data, thereby reducing maintenance costs
- The desire to manage increasingly complex data types and structures
- The desire to provide easier and faster access to data for users who have neither a background in programming languages nor a detailed understanding of how data are stored in databases

1960's

File processing systems were still dominant during this period. However, the first database management systems were introduced during that decade and were used primarily for large and complex ventures such as the Apollo moon-landing project. It can be regarded as an experimental "proof of concept" period in which the feasibility of managing vast amounts of data with a DBMS was demonstrated. Also, the first efforts at standardization were taken with the formation of the Data Base Task Group in the late 1960's.

Database Management System DBMS: A software application that is used to create, maintain and provide controlled across to user databases.

1970's

During this decade the use of database management systems became a commercial reality. The hierarchical and network database management systems were developed largely to cope with increasingly complex data structures such as manufacturing bills of materials that were extremely difficult to manage with conventional file processing methods. The hierarchical and network models are generally regarded as first generation DBMS. Both approaches were widely used, and in fact many of these systems continue to be used today.

- It is Difficult to access data based on navigational record at a time procedures. As a result, complex programs have to be written to answer even simple queries.
- Very limited data independence, so that programs are not insulated from changes to data formats
- No widely accepted theoretical foundation for either model, unlike the relational data model

More detailed discussion will be presented in later Chapter 3 and 4.

1980's

To overcome these limitations, E. F. Codd and others developed the relational data model during the 1970's. This model, considered second generation DBMS received widespread commercial acceptance and diffusion during the 19805. With the relational model, all data are represented in the form of tables. A relatively simple fourth generation language called SQL (for Structured Query Language) is used for data retrieval. Thus the relational model provides ease of access for nonprogrammers, overcoming one of the major objections to first generation systems.

1990's

The decade of the 1990s ushered in a new era of computing, first with client/server computing then Internet applications becoming increasingly important. Whereas the data managed by a DBMS during the 1980s was largely structured (such as accounting data), multimedia data (including graphics, sound, images, and video) became increasingly common during the 1990s. To cope with these increasingly complex data, object oriented databases (considered third generation) were introduced during the late 1980s. These databases are becoming increasingly important during the 1990s (David, 1997). Since organizations must manage a vast amount of both structured and unstructured data, both relational and object oriented databases are of great importance today. In fact, some vendors are developing combined object relational DBMS that can manage both types of data, such as ORACLE and DB2

Database Technology becomes a necessary tool in every aspect.

2000 and Beyond

B2B, B2C, e-Commerce, e-Business are trendy mode of businesses in the beginning of 2000. Several well established trends on database development on these areas are expected.

The ability to manage database with increasingly complex data types. These types include multidimensional data, which have already assumed considerable importance in data warehouse applications.

The continued development of "universal servers". Based on object relational DBMS, these are database servers that can manage a wide range of data types transparently to users. They will become especially important to Internet applications.

Fully distributed databases will become a reality. Thus an organization will be able to physically distribute its databases to multiple locations and update them automatically, transparent to the user community.

Content addressable storage will become more popular. With this approach, users can retrieve data by specifying what data they desire, rather than how to retrieve them. For example, a user can scan a photograph and have the computer search for the closest match to that photo.

Database and other technologies, such as artificial intelligence and television like information services will make database access much easier for untrained users. For example, users will be able to request data in a more natural language, and database technology will anticipate users' data needs based on past queries and relevant database changes.

Database becomes asset and goodwill of companies.

1.4 MANAGEMENT

Most people associate business processes with the typical operations in a bank or an insurance company: the loan process in a bank or claims processing in an insurance company. Such operations have led us to understand business processes as a sequence of activities performed by various persons, the visible result being various pieces of paper.

These activities are typically repeated over and over, following the same well-defined pattern, the process model. This is the type of processing well established in manufacturing: assembly line production of cars in the automobile industry, or customer specific assembly of a personal computer in the factories of PC makers are well known examples. This similarity in processes has led to the metaphor of insurance companies and banks being nothing but paper factories, with paper as the final product.

What about the area of software development? It also is guided by a set of rules that determine the sequence of steps to be followed. In the waterfall model, the steps are Architecture, High Level Design, Low Level Design, Coding, Unit Test, and System Test. Or, let's look at the work of a database administrator. A database administrator performs a set of precisely prescribed processes consisting of a number of steps that may be executed sequentially or in parallel. User interaction in this type of process is minimal, and this user interaction is limited to one person, the database administrator.

This type of a business process allows us to conclude that all batch jobs being run can also be considered some kind of business process. The only difference from the database administrator example is that there is no user interaction. The steps in these batch jobs are described by some kind of scripting language that provides the flexibility to take appropriate actions if one of the steps in the batch job fails to complete correctly. The job control language (JCL) of the OS/390 operating system, one of the most successful operating systems for mainframes, supports such batch jobs, which in turn implement a business process. Code Example 1 shows a sample specification of a business process, using OS/390 JCL.

```
//OVERDUE JOB
//*-----------------------------------------------------------
//* STEP 1 - DETERMINE CUSTOMERS WITH OPEN BILL
//*-----------------------------------------------------------
//EXTRACT  EXEC PGM=OVERDUE
//ICUSERS  DD   DSN=CUSTOMER.DATA,DISP=OLD
//OCUSERS  DD   DSN=OVERDUE.USERS,DISP=(NEW,PASS)
//*-----------------------------------------------------------
//* STEP 2 - WRITE LETTER TO CUSTOMER
//*-----------------------------------------------------------
//WRITE    EXEC PGM=PRINT,COND=(4,LT,EXTRACT)
//OCUSERS  DD   DSN=OVERDUE.USERS,DISP=OLD
//*-----------------------------------------------------------
//* STEP 3 - DELETE FILE
//*-----------------------------------------------------------
//DELETE   EXEC PGM=DELETE,COND=EVEN
//OCUSERS  DD   DSN=(OLD,DELETE)
//
```

Code Example 1 Using the Operating system Job Control Language

The process is used for a credit card company to write a letter to all of the customers that have not paid their open bill. In the first step, all customers that have not paid their bill are selected. This information is saved in a file, identified by OUSER. The second step uses the data obtained in the first step and writes a letter to each customer. If all customers have paid their bill on time, the second step is skipped (COND=(4,LT,EXTRACT)). In the third step, the file is deleted, regardless of whether the second step has been carried out (COND=EVEN). This process shows all of the characteristics of a process. It consists of a set of activities (we called them steps) that are carried out in a particular sequence. Some of the activities may be skipped as the result of a previous activity indicating so. Data is passed from activity to activity. We later call these characteristics control flow and data flow.

The examples above illustrate that the notion of business processes covers a wide spectrum; there is no such thing as a typical business process. The business of a user determines what a business process is: for the database administrator, it is the reorganization of a database; for the controller, it is the creation of the monthly balance sheet; for the CEO of a bank, it is the granting of a loan.

It is this variety of business processes that needs to be addressed by a production workflow management system and that we cover in the book.

Business Processes as Enterprise Resource

Enterprises are considering information more and more as an important resource. They consider it now to be a major asset that is as important as the more traditional ones such as land, labor, and capital. The information includes all data about all resources that are needed to achieve the goals of the enterprise. It is generally agreed that this information should be structured and presented as formally as possible. The set of actions needed to come up with this formal specification is called "enterprise modeling."

The conceptual base for enterprise modeling is sometimes called a **hyper-semantic** data model. The result of modeling a particular enterprise is an enterprise model. An enterprise model consists of two parts: the data model and the knowledge model.

The data model describes the structure of all resources of the enterprise. It is thus somewhat like the syntactical component of the enterprise model, that is, it specifies the static aspects of an enterprise. In this sense, the data model describes what is available in the enterprise to reach the specified goals. Most enterprises build their data model via semantic data models. Some of the more prominent semantic data models are the entity/relationship model, **EXPRESS**, **STEP** and the unified modeling language (**UML**).

The knowledge model describes the use of the resources and their connections. It is thus the semantic component of the enterprise model; it specifies the dynamic aspects of an enterprise. In this sense, the knowledge model describes how the enterprise uses its resource to achieve its goals. The knowledge model contains constraints, heuristics, and procedures. Constraints define the local and global consistency of resources; for data resources stored in databases, constraints define the valid states in the database. Heuristics describe how to derive data. Procedures define events and correlated actions, set sequences of actions, and describe business processes.

Virtual Enterprise

Traditionally, business processes are carried out completely within the boundaries of a company. The processes start within the company and finish within the company. External requests come in as phone calls, faxes, postal mail, or, to a limited extend as electronic messages, for example, in electronic data interchange (**EDI**) or extended markup language (**XML**) format. A sample coding of reference booklist is given in Code Sample 2. The requests handled by appropriate personnel by starting the appropriate business process for each request. As these business processes move to completion, actions, such as shipping goods to the originator, take place. Once the process is complete, the appropriate results are returned to the originator again in the form of phone calls, faxes, postal mail, or electronic messages.

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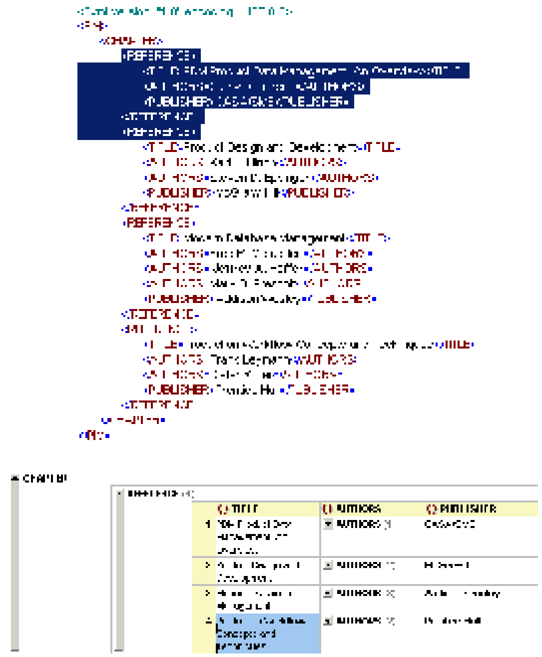
Chapter 1: Introduction of PIM

Inquiries about the status of a business process were usually received as phone calls, with the customer waiting for the result. The call center operator would immediately perform the appropriate query against the proper application system to determine the status and give the corresponding answers to the customer. This dialog would go on for some time until the customer was happy with the answer. As a result of all the involved manual interactions, the service to customers and suppliers was limited to certain operation hours.



Code Sample 2 XML Sample

In a fast paced global market, companies can no longer operate in this traditional way of doing business. Consumers select those companies where they can do business any time they want. To support the cycle time needed by customers and suppliers, the business processes of customers and suppliers must interact with a company's business processes without any human intervention. Figure 4 depicts the interactions between a company and its customers and suppliers, as well as the interactions between the different parts of a company, such as the sales head office and the manufacturing plant. These interactions range from simple inquiries to complex interactions between companies to the situation where organizational units of different companies are tied together by sharing data, business process and operate like an independent enterprise (virtual enterprise).

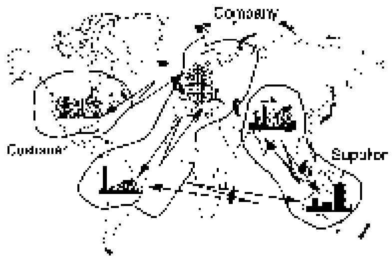


Figure 4 Connected Business Processes

Customers no longer make phone calls or mail order forms when they want to do business with a particular company. They no longer have to deal with an operator at a call center when they want to know the status of the order they had placed a few days ago. They enter the company's URL on their Web browser and are then connected to the company's home page, from which they can select the appropriate application system. The Web browser runs on such diverse devices as a personal computer, a mobile phone with a built in monitor, or even a microwave oven.

B2B, B2C, e-Business, e-Commerce are common trend for nowadays business arena.

Business processes of different companies honor each other's requests without any manual intervention. No interaction is required to have a company's business processes talk to the appropriate business processes of customers, suppliers, distributors, or even government agencies, such as the tax department.

The levels of interaction between the different business processes cover a wide spectrum:

- An activity in a business process invokes another business process. That new business process executes totally independently of the original business process.
- An activity in a business process invokes another business process and waits until that new business process has completed.
- An activity in a business process invokes another business process, and an activity later in the business process waits until that new business process has completed.

Very complex scenarios can be built with these basic structures. We discuss these structures in detail in chapter 7,8,9 and 10. Typical business processes that are made up of these basic structures are the business processes that define the interactions between the manufacturing company and its suppliers. A manufacturer of personal computers may have a business process for the assembly of the personal computers. One of the activities is the ordering of motherboards to be delivered by a supplier when the amount of available motherboards falls below a

certain level. In this case, a request is sent to the supplier; the request starts the appropriate order entry process. When production of the motherboards has completed and they have been shipped, the final activity in the order entry process sends the appropriate billing request back to the manufacturer. The manufacturer receives the billing request and starts the appropriate accounts payable process.

To make sure that business processes are carried out correctly, each business process has a process administrator assigned to it. If an out of line situation occurs, the process administrator is notified so that corrective actions can be taken. A typical out of line situation occurs when a time limit is associated with a process and the process takes longer than the time specified. Tools are available to the process administrator to query the state of the business process, assign a higher priority to the business, or shift work from one person to another.

In the case of inter-enterprise business processes, it is also possible that the problem is associated with a process that is running at another company. In this case, it is desirable that a process administrator can also query the state of that other process so that the process administrators of both companies can jointly work on the appropriate corrective actions.

The level of interaction we have discussed so far reflects interaction between independent companies. Each company runs its business in its own way with its own distinct business processes. Each business process is associated with data that is part of the enterprise data. Ideally when data is requested by process from other company, the data is shipped together with the invocation of other process.

Within an enterprise, the difference between processes and sub-processes is not visible at all. All programs associated with the different business processes access, in general, the same set of enterprise data. Communication between the applications that make up the business process is not visible to the outside.
Virtual enterprises are enterprises in the sense that they operate as any other enterprise. However, they are not organizationally the same as a typical enterprise. They are made up of parts of different companies, where each company contributes parts to the overall enterprise. In the extreme case, one company contributes by manufacturing the product; another company is responsible for distribution; a third one, for marketing; and a fourth one, for billing.

In this case, the different pieces of the virtual enterprise operate as one enterprise. This collaboration is made possible by the use of common business processes and common data. Each activity within a business process can then be performed by one of the participating companies. The data is accessible to all of the companies. The Internet provides the communication backbone for running the processes and accessing the data.
It is interesting to observe that the same methods for carrying out business processes can be observed if parts of a company are outsourced. For example, a new, independent company is formed to perform a certain task. In this case, existing business processes need to continue to be performed even though there are two independent companies.

Each level of interaction we have discussed requires that the different systems work together without any friction independently of the type of implementation that has been chosen by the involved parties. This requirement mandates that the protocols used to communicate are standardized. Without standardization, bilateral agreements would have to be negotiated and then implemented on both ends for every new set of interactions.

Processes and Workflows

The process model describes the structure of a business process in the real world. It defines all possible paths through the business process, including the rules that define which paths should be taken and all actions that need to be performed. This model is a template from which each process is instantiated; that is an instance of the process model is created. Some people use the term process instance for the instances that are created from process models. An individual process (process instance) is carried out according to a set of values that determines the actual path through the process. In an insurance company the process model might be called DESIGNTOOLING, and from this model a large number of processes are created, one for CY Wong, one for WC Lee, and so on.

XML is the de-facto standard for Intra-business and Inter-business applications.

Processes need not necessarily be run on a computer. A large number of business processes are performed without a single step being performed by a computer. A typical example is that of a manager circulating a document for each employee to read. Whenever an employee receives the document in her mail basket, she reads it, signs it, determines who has not seen it, and then puts it into the mail basket of somebody who has not yet signed it. The employee who signs the document last puts it back into the mail basket of the manager.

Business processes thus may consist of parts that are carried out by a computer and parts that are not supported through computers. As shown in Figure 5, the parts that are run on a computer are called a workflow model.

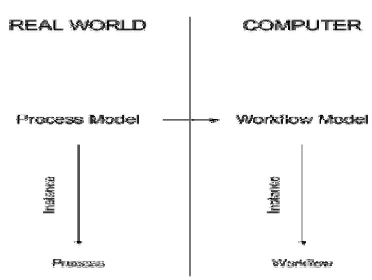


Figure 5 Processes and Workflows

A workflow model may be just a small part of a larger process model, or it may encompass the whole process model. The computer programs that carry out the workflow can be a general purposed workflow management system or specialized applications that implement the process model. The workflow model is a template for creating workflows in the same sense that the process model is a template for creating processes.

In this book, we follow the convention of using the term process when talking about processes and process models, and workflow when talking about workflows and workflow models. In fact, we even follow the conventions of even using the terms process and workflow interchangeably. The context will make it obvious which one we are talking about. In cases, where the meaning could be ambiguous, we use the full term.

Dimensions of Workflow

Business processes, and therefore workflows, have three independent (orthogonal) dimensions. These three dimensions can be graphically depicted as a cube, as shown in Figure 6.

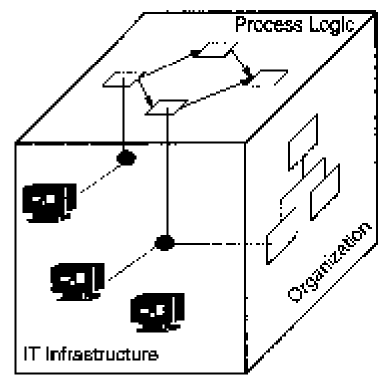


Figure 6 The Three Dimensions of Workflow

The cube's first dimension represents the process logic. It describes what in terms of which activities are to be performed and in which sequence they need to be performed. Each box represents either a program that is invoked or another process that is executed either as a local sub-process or as a remote sub-process within the same company or in another company. The arrows show the flow of control from one activity to the next. The flow can be sequential or parallel. If it is sequential, one activity is performed after the other; if it is parallel, two or more activities are executed at the same time, usually reducing the time required to perform a business process.

The cube's second dimension, orthogonal to the process logic, is the organization dimension. It describes the organizational structure of the company in terms of departments, roles, and people. This information is used to define who should perform each activity. A query can be specified for each activity to identify the set of people in the organization to whom the activity can be assigned. For example, if it has been defined, that an activity can only be performed by someone meeting a particular job function (role), then all persons assigned to the job function are selected and are assigned to perform the activity. If the activity does not interact with a user, the workflow management system carries out the activity on behalf of the selected user.

The individual tasks are typically performed though a graphical user interface (GUI). This user interface could be anything from a Web browser running on a network station, a window on a regular PC, or the tiny monitor of a hand held device.

The cube's third dimension, orthogonal to the process logic and the organization, constitutes the dimension of information technology (IT) infrastructure. It describes which IT resources, such as programs that perform a particular activity, are required.

The execution history of a process is thus a sequence of triplets (activity, user, IT resource), or in other words, a series of points (trajectory) in the three dimensional workflow space W3 (what, who, which).

User Support

Several users are involved in running workflows: end users that perform the individual tasks, system administrators that have overall responsibility for the workflow management system and the actions it performs, operation administrators that are responsible that the workflow management system is up and running, and process administrators that monitor the expected processing of the individual business processes.

End users receive the requests for processing individual activities as workitems. These workitems are typically represented as icons. The representation of the icon shows, at least to a certain extent, the type of work that must be performed. These workitems are made available to the user either upon explicit request or upon being pushed by the workflow management system onto the user's desktop. When a user wants to work on a particular activity, she clicks on the appropriate icon, which then starts the associated program. When the work associated with the activity has been completed, the workitem is automatically removed. The user can organize the individual workitems according to specified criteria into worklists. Criteria can be priority, age, or type of activity, such as confidential or public.

Operation administrators are provided with a graphical view of the status of each of the different workflow management system components. This interface can be provided either by the workflow management system or by a systems management system. The interface typically supports alerts for out of line situations as well as query and change capabilities for all or individual components.

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Chapter 1: Introduction of PIM

The user interface for process administrators is geared toward managing individual process instances and acting as a focal point for all process related events. The events are represented as workitems that can be started to perform appropriate process repair actions. The starting point is a graphical representation of the business process. By pointing to individual activities, the process administrator can dig deeper into the structure of the workflow. Corrective actions that could be performed are restarting the process, transferring workitems from one user to another, or repairing a broken process.

Categories of Workflows

Many schemes have been developed to classify workflows. Figure 7 shows one of the more prominent ones. In this scheme, used by GIGA Information Group, workflows are categorized according to their value to the business and their repetition.

The business value defines the importance of a workflow to the company's business.

A process of high business value is at the core of a company; it's a core competency of the company. The company has been founded to perform those processes; this means the company is defined as running those business processes. Typical examples of high business value processes are the granting of a loan for a bank or the manufacturing of a car by a car manufacturer.

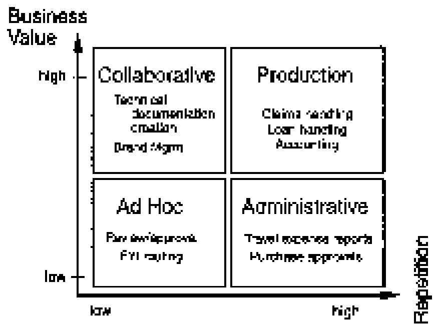

Figure 7 Classifying Workflow According to Business Value and Repetition

The repetition measures how often a particular process is performed in the same manner. It is an indicator of whether the process is worth being modeled. This indicator is important since modeling of a process for the first time is nontrivial and is time consuming, which makes it typically an expensive task. The "for your information routing" business process, for example, is typically performed in large volumes; however the underlying process models are always different.

By using these two characteristics, we can distinguish the four different types of workflows as shown in Figure 7

Collaborative workflows are characterized by a high business value but are executed only a few times. The processes associated with building a ship, creating technical documentation for a software product, or performing brand management for a consumer product fall into this category; all of them are extremely important for the success of the corresponding company. Their underlying process is generally rather complex and is created specifically for the particular task, often by customizing a given project plan. Changes to the underlying plan are fairly common.

Ad hoc workflows show a low business value and low repetition rate. Generally, these workflows either have no predefined structure and the next step in the process is determined by each user involved in the process, or each business process is constructed individually whenever there is a need to perform a series of actions. For your information routing is a typical workflow without a defined structure. A manager, for example, sends a note to all his department members with information deemed to be important for them. The receivers of the note can do whatever they want with it, including routing the note to other people who should know about this particular information. Such a process terminates if nobody routes this note to anyone else.

Administrative workflows also show a low business value; however the repetition factor is high. These workflows are the typically administrative processes such as expense account or purchase order processing. In the case of expense account processing, the employee fills out a form, the employee's manager approves it, and the expense account department verifies the correctness and issues the appropriate bank order.

Production workflows are characterized by having a high business value and a high repetition factor. These are the workflows that implement the core business of the company, such as the loan process in a bank or the claims management process in an insurance company. It is their efficient execution that provides a company with a competitive advantage. Often, production workflows are still implemented without a workflow management system because the corresponding processes have been in place for decades. And because of their importance, the corresponding applications were typically implemented as transaction processing monitor programs. The scalability, availability, and robustness of these environments are consequently a prerequisite for workflow engines that run production workflows; such a workflow management system is called a **production WFMS**.

An additional distinctive dimension to the business value and the repetition factor is the degree of automation of a workflow as shown in Figure 8. This measurement shows the independence of a workflow from human intervention, that is, whether the activities of a workflow are mainly performed by humans or by the system.

A highly automated process is computation intensive and typically integrates heterogeneous and autonomous application systems.

Fully automatic workflows have many similarities with batch procedures known for decades. They can be found in database administration, such as database reorganization, systems management (e.g. reacting to system events), and data warehousing (e.g. merging and cleansing of different data sources).

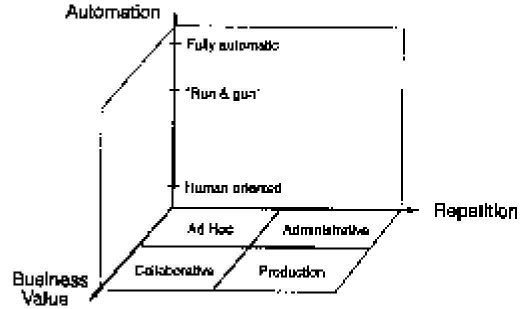

Figure 9 Classifying Workflow According to Business Value, Repetition, and Automation

A process with a high degree of automation does not necessarily mean the process has no interactions with humans. But typically, a highly automated workflow is fragmented into sequences of activities, each of which is performed by a single user, intermixed with automatically performed sequences. The sequences of activities assigned to a particular user are often worked on in a stream environment, meaning the sequence is performed consecutively without any interrupt.

KnowledgeManagement

Data. At first we had too little. We asked for more and we got it. Now we have more than we want. Data led to information, but what we were looking for in the first place was knowledge.

As an increasing number of companies now realize that knowledge is their key asset, they want to turn to managing this asset to deliver business results. Maybe you want to introduce knowledge management (KM) in your own company.

But where and how do you begin? What is behind the buzz? What is KM's value proposition? What types of companies can actually begin knowledge management? Is it a technology problem or a management problem? What happens to the millions that your company has invested in information technology (IT) if it is replaced by yet another hyped "fix-it-all" technology? Can you build upon existing IT investments? What kinds of people, skills, and organizational structures are necessary to pull it off? How can KM be aligned with your business's strategy? Is there an architecture that you can use? How can you deploy KM in your own company? Are there any business metrics for it? How can you maximize payoff if you implement KM? Can your small business without deep pockets afford it? How do you know if your business is even ready for it? These are some of the questions that this book will help you answer.

Knowledge management might be "hot" as of today, but successful managers have always realized its value. Long before terms such as expert systems, core competencies, best practices, learning organizations, and corporate memory were in vogue, these managers knew that their company's key asset was not its buildings, its market share, or its products, but it lay in its people, their knowledge, and skills. After having tried everything else-from the greatest products and the best technology to virtual monopolies-in their respective markets, more businesses have finally come to the realization that the only sustainable source of competitive advantage is their knowledge.

Far from vendor sales pitches, a crying need for knowledge management is evident. The need of KM is a growing reality worldwide.

Why knowledge?

Researcher reports that 98 percent of senior managers in a KPMG survey believe that knowledge management was more than just a passing fad. he need is evident in Singapore, where The Strait Times reported at "organizations lack a strategy to manage knowledge sharing among their staff." Some organizations there, The Strait Times reports, are not even sure what a knowledge management strategy is or how to develop one. Of 75 senior managers interviewed in Singapore, only 3 of whom felt that their companies were even moderately effective at knowledge sharing, unequivocally voice their intent to make knowledge management their number one priority. This sounds very much like the opinion that we've been hearing in the United States. For good reason: forty percent of the U.S. economy is directly attributable to the creation of intellectual capital. As companies fail to solve KM problems by plugging in "fix-it-all" technology solutions, echoes of the cultural complement needed to make these solutions actually work are resounding far beyond regional area.

What's knowledge?

Knowledge and knowledge management are lofty concepts-debated by academics and managers and even doubted by some analysts-one that only a few businesses have mastered. The few big businesses that have are the ones that now top the Fortune 500 list and the few small ones top the Inc. 100 hot companies to watch list. Before we continue, here is a working definition of knowledge suggested by pioneers.

Knowledge is a fluid mix of framed experience, values, contextual information, expert insight and grounded intuition that provides an environment and framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not

only in documents or repositories but also in organizational routines, processes, practices, and norms.

So What's Knowledge Management?

Next, let's try getting a temporary handle on what knowledge management means. In the simplest terms it means exactly that: management of knowledge. In the context of our discussion, it can be extended to "management of organizational knowledge for creating business value and generating a competitive advantage." Knowledge management enables the creation, communication, and application of knowledge of all kinds to achieve business goals.

Knowledge management is the ability to create and retain greater value from core business competencies.

Knowledge management addresses business problems particular to your business-whether it's creating and delivering innovative products or services; managing and enhancing relationships with existing and new customers, partners, and suppliers; or administering and improving work practices and processes.

Knowledge management is the only way to reach and apply this knowledge in time. eBay (market value, $22 billion), eFax ($200 million), CISCO ($190 billion), Pfizer ($150 billion), and Microsoft ($400 billion) are a few of several hundred thousand examples.

KM's value proposition

The ability of companies to exploit their intangible assets has become far more decisive than their ability to invest and manage their physical assets." As markets shift, uncertainty dominates, technologies proliferate, competitors multiply, and products and services become obsolete rapidly, successful companies are characterized by their ability to consistently create new knowledge, quickly disseminate it, and embody it in their new products and services. In the postindustrial era, the success of a corporation lies deeply embedded in its intellectual systems, as knowledge-based activities of developing new products, services, and processes become the primary internal function of firms attempting to create the greatest promise for a long-term competitive advantage. Expert suggests that companies can reap an immense payoff when a knowledge management solution makes it easier for practitioners to reach out to other practitioners who share common problems or have experience to share. Why all this noise about knowledge management and why now?

Companies are becoming knowledge intensive, not capital intensive. Knowledge is rapidly displacing capital, monetary prowess, natural resources, and labor as the quintessential economic resource. Knowledge is the only input that can help your company cope with radical change and ask the right questions before you attempt to find the answers, for without this knowledge you might never even realize how your industry's competitive environment is changing until it's a little too late. It is this knowledge that brings quality into any company's product and service offerings. Further, product life cycles and service time-to-market can be accelerated in unprecedented ways through knowledge.

KM lets you lead change so change does not lead you. KM is no longer popular by service-based businesses only. Even conventional retailers like Wal-Mart consider their competence in logistics management-a knowledge-intensive activity-to be their primary driver of business success.

Only the knowledgeable survive. "The survival of the Fittest firm" is an outmoded thought in the knowledge-based economy. The ability to survive and thrive comes only from a firm's ability to create, acquire, process, maintain, and retain old and new knowledge in the face of complexity, uncertainty, and rapid change. It becomes deterministic in the firm's long-term survival.

Cross-industry amalgamation is breeding complexity. Knowledge management has allowed many companies such as Bay Networks to turn this complexity to their advantages.

Knowledge can drive decision support like no other: Providing effective decision support by making knowledge about past projects, initiatives, failures, successes, and efforts readily available and accessible can make a significant contribution toward convalescing this process.

Knowledge requires sharing; IT barely supports sharing. KM requires a strong culture of sharing that information systems do not inherently support.

Tacit knowledge is mobile. Too often when someone leaves your firm, his or her experience leaves too. This knowledge, skills, competencies, understanding, and insight then often go to work for a competitor. Knowledge management can save your company from losing critical capabilities when that happens.

Your competitors are no longer just nearby. We are becoming increasingly global, keeping up with developments and ensuing threats or opportunities in other countries is a tedious, time-consuming, and difficult process.

Relation to Other Technologies

So far, we have sketched how workflow management is related to Product Development Process and Information Technology. There are many additional technologies that are more or less closely related to workflow. Figure 10 lists some of the more prominent ones. We start our discussion with Product Technology and then continue around the tree.

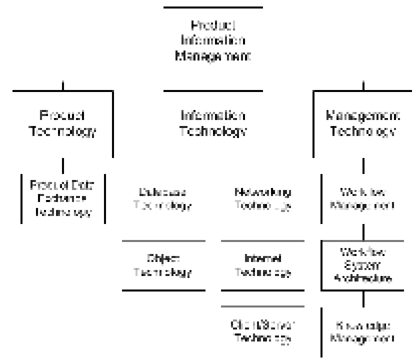

Figure 10 Relations to Technologies

Product Technology is a collection of activities and technology help to define the final design of the product, from 2D CAD Drawing to 3D Solid Analysis. In this chapter, various type of data generated during the product development process will be addressed and then we will discuss the de facto standard STEP for product data exchange in Chapter 2.

Information Technology provides the infrastructure for running the Workflow applications. Database technology with object oriented analysis and design (OOA/D) will be introduced. With OOA/D Technology we can derive the workflow specifications and database structures. Besides database technology, networking technology, Internet technology and Client/Server Technology will also be discussed in Chapter 3 to 7.

In the scope of PIM, Management Technology refers Workflow Management. It is a relatively new technology for managing information flow process. Beside Workflow, Workflow System Architecture and Knowledge Management will be covered in Chapter 7, 8 and 9.

Development of applications is typically performed with the aid of an application development methodology particularly suited for the type of application that needs to be implemented. We devoted Chapter 8- 10 to a fundamental discussion of a development methodology for workflow-based applications with possible implementation of knowledge management in Chapter 9.