Chapter 6.

Process Modeling

Introduction

- **The chapter will address the following questions:**
  - What is systems modeling and what is the difference between logical and physical system models?
  - What is process modeling and what are its benefits?
  - What are the basic concepts and constructs of a process model.
  - How do you read and interpret a data flow diagram.
  - When in a project are process models constructed and where are they stored?
  - How do you construct a context diagram to illustrate a system's interfaces with its environment?
  - How do you identify external and temporal business events for a system?

Chapter 6.

Process Modeling

Introduction

- **The chapter will address the following questions:**
  - How do you perform event partitioning and organize events in a functional decomposition diagram?
  - How do you draw event diagrams and then merge those event diagrams into a system diagram?
  - How do you draw primitive data flow diagrams, and describe the elementary data flows and processes in terms of data structures and procedural logic (Structured English and decision tables), respectively?

Process Modeling

An Introduction to System Modeling

- **System Models**
  - System models play an important role in systems development.
  - Systems analysts or users constantly deal with unstructured problems.
  - One way to structure such problems is to draw models.
    - A **model** is a representation of reality.Most system models are pictorial representations of reality.

Process Modeling

An Introduction to System Modeling

- **System Models**
  - Models can be built for existing systems as a way to better understand those systems, or for proposed systems as a way to document business requirements or technical designs.
    - **Logical models** show what a system 'is' or 'does'. They are implementation-independent; that is, they depict the system independent of any technical implementation. As such, logical models illustrate the *essence* of the system. Popular synonyms include **essential model,** *conceptual model*, and *business model*.
    - **Physical models** show not only *what* a system 'is' or 'does', but also how the system is physically and technically implemented. They are implementation-dependent because they reflect technology choices, and the limitations of those technology choices. Synonyms include *implementation model* and *technical model*

Process Modeling

An Introduction to System Modeling

- **System Models**
  - Systems analysts have long recognized the value of separating business and technical concerns.
    - They use logical system models to depict business requirements.
    - They use physical system models to depict technical designs.

- **System Models**
  - Systems analysis activities tend to focus on the logical system models for the following reasons:
    - Logical models remove biases that are the result of the way the current system is implemented or the way that any one person thinks the system might be implemented.
    - Logical models reduce the risk of missing business requirements because we are too preoccupied with technical details.
    - Logical models allow us to communicate with end-users in non-technical or less technical languages.

Chapter 6.

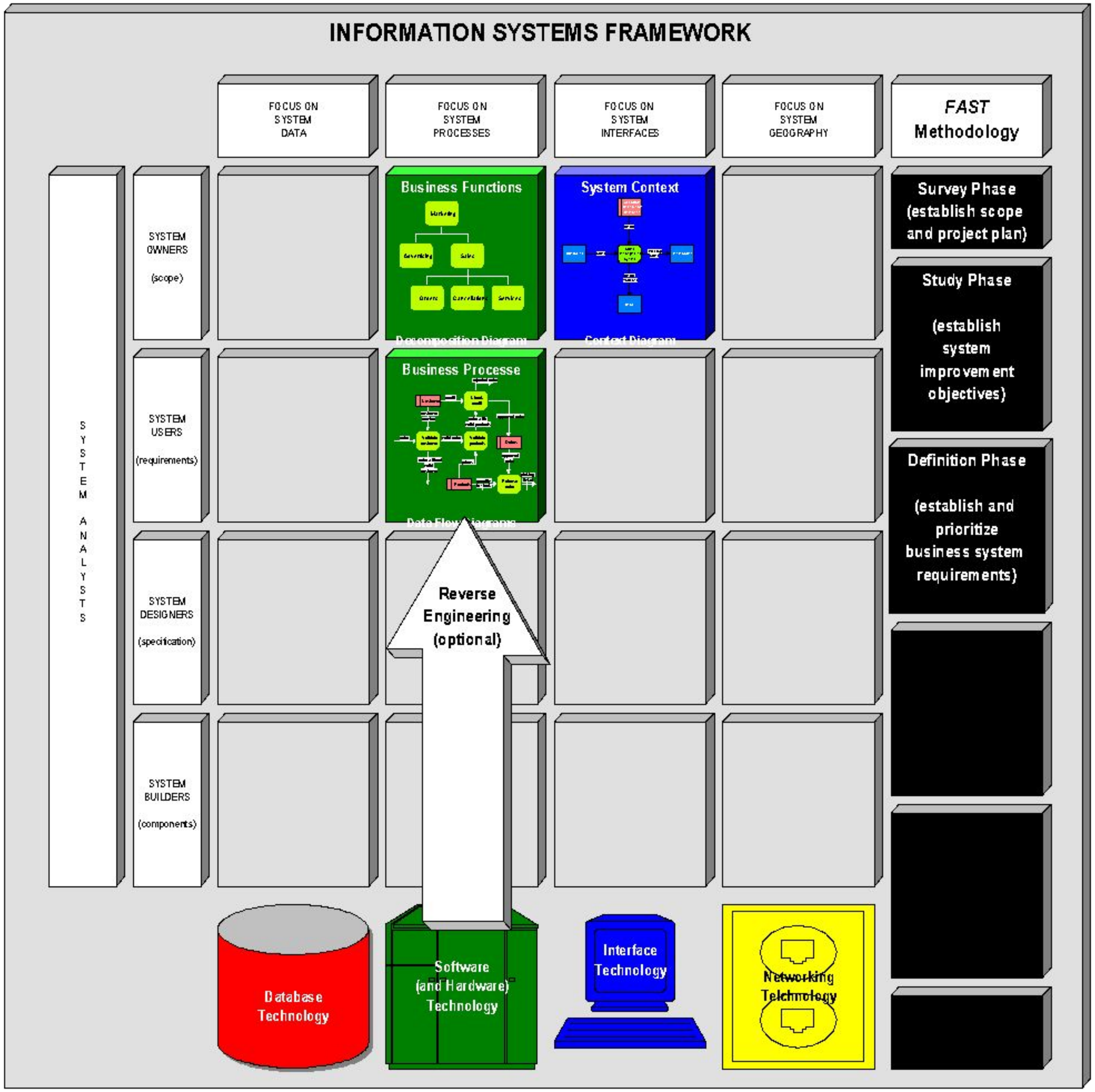
Process Modeling

An Introduction to System Modeling

- **System Models**
  - What is *Process Modeling*?
    - **Process modeling** is a technique for organizing and documenting the structure and flow of data through a system's PROCESSES and/or the logic, policies, and procedures to be implemented by a system's PROCESSES.
    - Process modeling originated in classical software engineering methods.
    - A systems analysis process model consists of *data flow diagrams* (DFDs).
      - A **data flow diagram (DFD)** is a tool that depicts the flow of data through a system and the work or processing performed by that system. Synonyms include bubble chart, transformation graph, and **process model**.

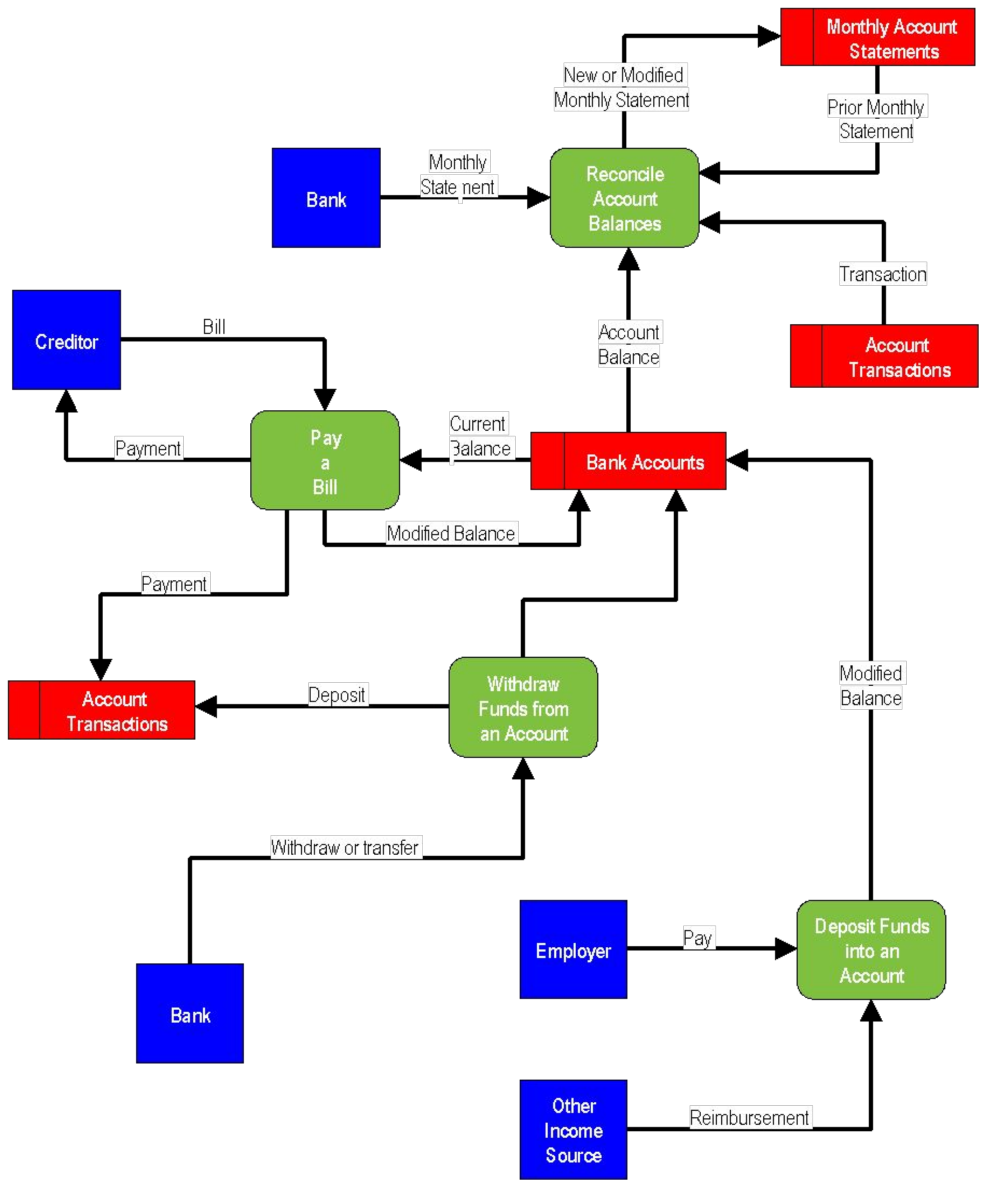
Chapter 6.

Process Modeling



Logical Process Models in The Information System Framework

Process Modeling



A Simple Data Flow Diagram

Prepared by Kevin C. Dittman for
Systems Analysis & Design Methods 4ed
by J. L. Whitten & L. D. Bentley

Process Modeling

An Introduction to System Modeling

- **System Models**
  - Data Flow Diagram
    - There are only three symbols and one connection:
      - The rounded rectangles represent *processes* or work to be done.
      - The squares represent external agents – the *boundary* of the system.
      - The open-ended boxes represent *data stores*, sometimes called files or databases, and correspond to all instances of a single entity in a data model.
      - The arrows represent *data flows,* or inputs and outputs, to and from the processes.

Chapter 6.

Process Modeling

An Introduction to System Modeling

- **System Models**
  - Data Flow Diagrams Versus Flowcharts
    - Processes on a data flow diagram can operate in parallel. Processes on flowcharts can only execute one at a time.
    - Data flow diagrams show the flow of data through the system.
      - Their arrows represent paths down which data can flow. Looping and branching are not typically shown.
    - Flowcharts show the sequence of processes or operations in an algorithm or program.
      - Their arrows represent pointers to the next process or operation. This may include looping and branching.
    - Data flow diagrams can show processes that have dramatically different timing and flowcharts don't.

Process Modeling

System Concepts for Process Modeling

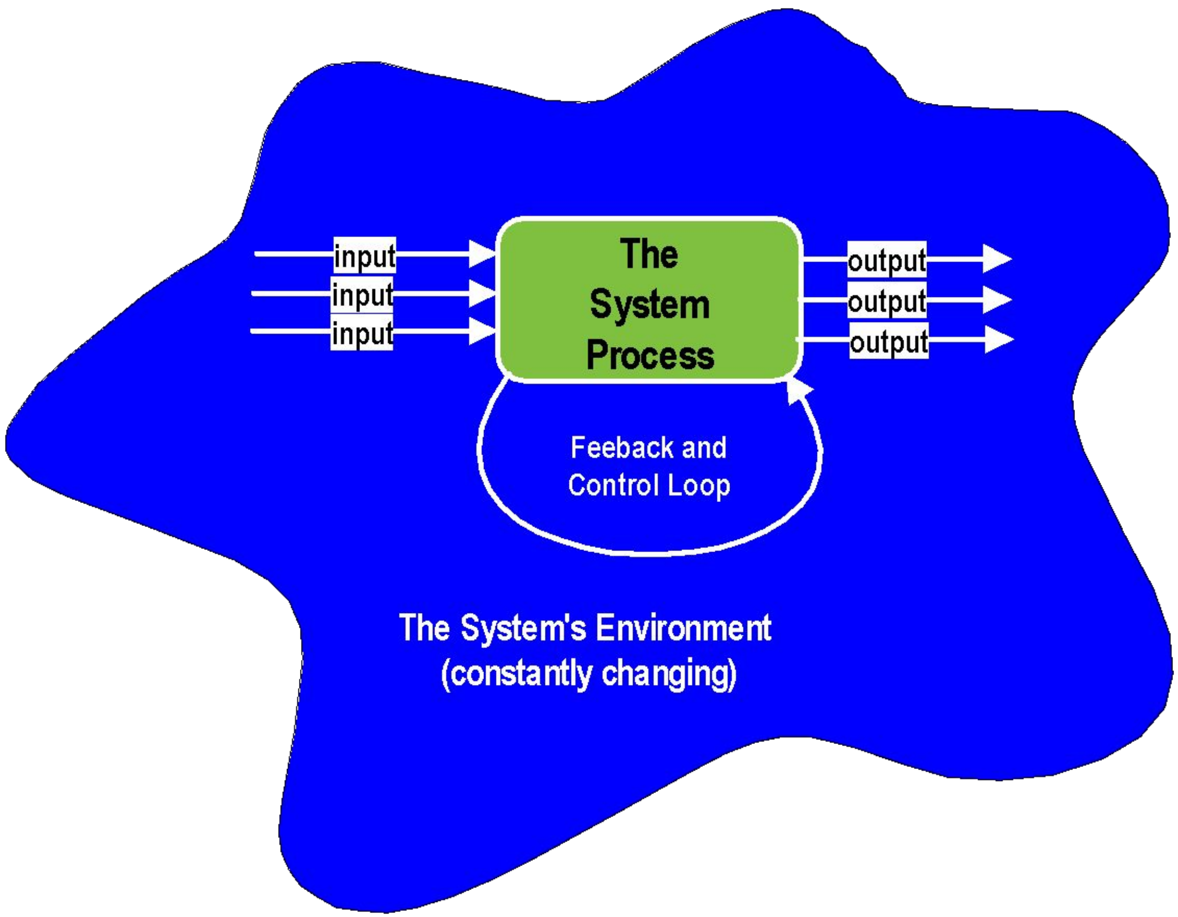
- **What is Systems Thinking?**
  - **Systems thinking** is the application of formal systems theory and concepts to systems problem solving.
  - Systems theory and concepts help us understand the way systems are organized, and how they work.
  - Techniques teach us how to apply the theory and concepts to build useful real-world systems.

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - A System is a Process
    - The simplest process model of a system is based on inputs, outputs, and the system itself – viewed a process.
    - The process symbol defines the boundary of the system.
    - The system is inside the boundary; the environment is outside that boundary.
    - The system exchanges inputs and outputs with its environment.

Process Modeling



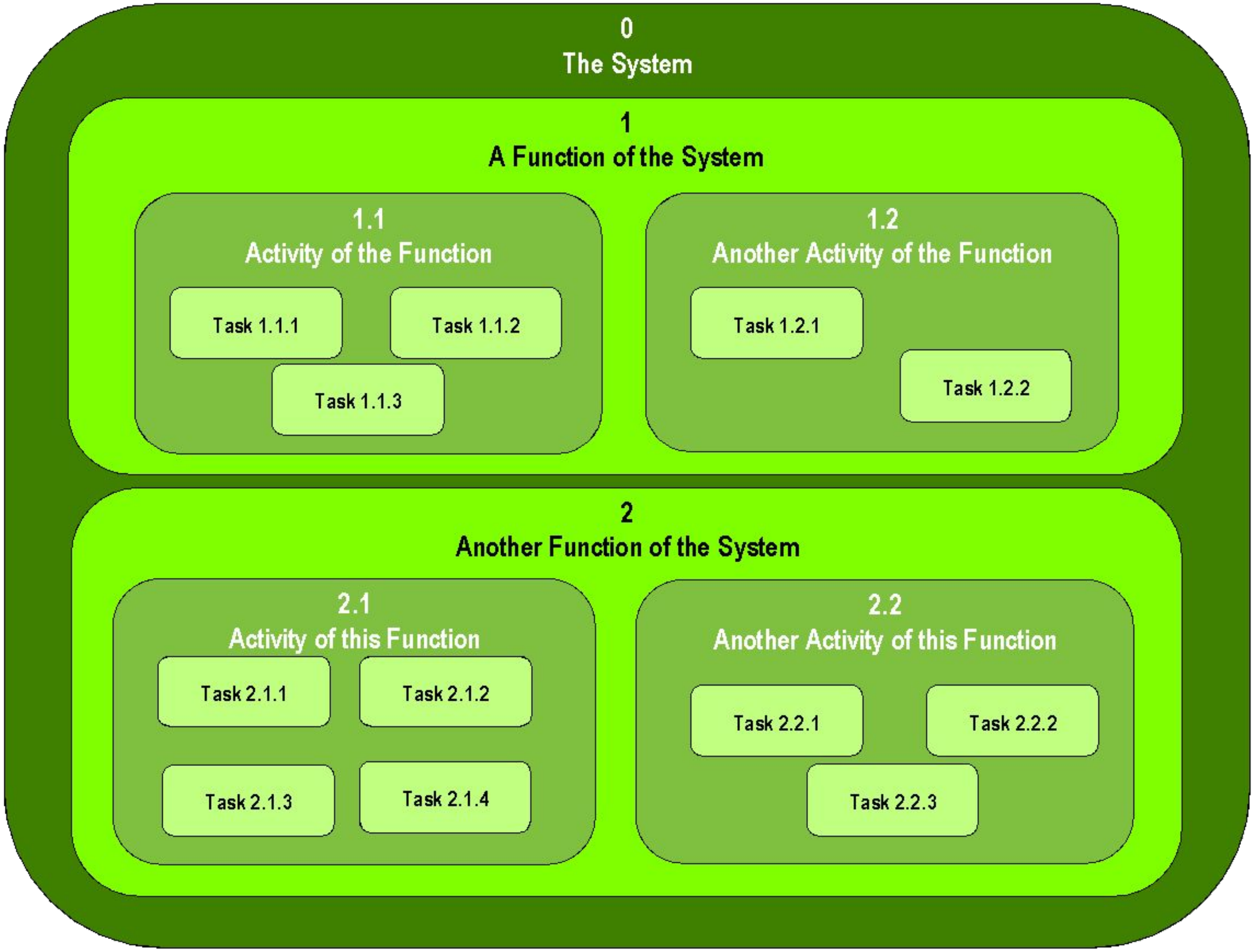
The Classical Process Model of a System

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Process Decomposition
    - What do you do when a complex system is too difficult to fully understand when viewed as a whole (meaning, *as a single process*)?
      - In systems analysis we separate a system into its component subsystems, which in turn are decomposed into smaller subsystems, until such a time as we have identified manageable subsets of the overall system.
      - This technique is called *decomposition*.
        - **Decomposition** is the act of breaking a system into its component subsystems, processes, and subprocesses. Each ‘level’ of *abstraction* reveals more or less detail (as desired) about the overall system or a subset of that system.

Process Modeling



A System Consists of Many Subsystems & Processes

Process Modeling

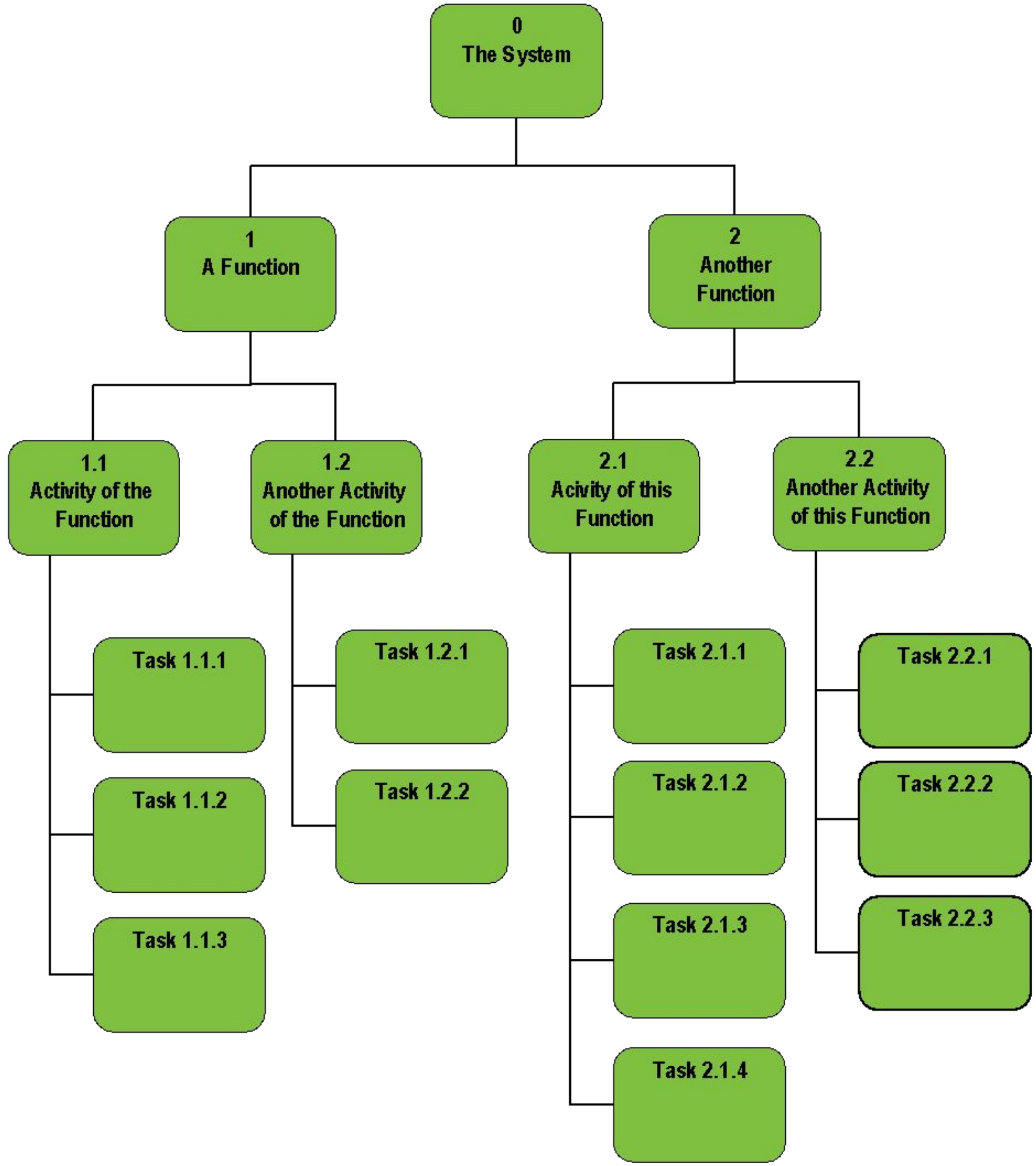
System Concepts for Process Modeling

- **Process Concepts**
  - Process Decomposition (continued)
    - A *decomposition diagram* is a popular tool to illustrate system decomposition.
      - A **decomposition diagram**, also called a *hierarchy chart*, shows the top down functional decomposition and structure of a system.
    - A decomposition diagram is essentially a planning tool for more detailed processes models, namely, data flow diagrams.

System Concepts for Process Modeling

- **Process Concepts**
  - Process Decomposition (continued)
    - The decomposition diagram rules:
      - Each process in a decomposition diagram is either a *parent process,* a *child process* (of a parent), or both.
      - A parent *must* have two or more children – a single child does not make sense since that would not reveal any additional detail about the system.
      - In most decomposition diagramming standards, a child may have only one parent.
      - A child of one parent may, of course, be the parent of its own children.

Process Modeling



A Decomposition Diagram

System Concepts for Process Modeling

- **Process Concepts**
  - Logical Processes and Conventions
    - Logical processes are work or actions that must be performed no matter how you implement the system.
    - Each logical process is (or will be) implemented as one or more physical processes that may include:
      - work performed by people
      - work performed by robots or machines
      - work performed by computer software
    - Naming conventions for logical processes depend on where the process is in the decomposition diagram/data flow diagram and type of process depicted.

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Logical Processes and Conventions (continued)
    - There are three types of logical processes: *functions*, events, and elementary processes.
      - A **function** is a set of related and on-going activities of the business. A function has no start or end – it just continuously performs its work as needed.
        - Each of these functions may consist of dozens, or hundreds of more discrete processes to do support specific activities and tasks.
        - Functions serve to group the logically related activities and tasks.
        - Functions are named with nouns that reflect the entire function.

Chapter 6.

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Logical Processes and Conventions (continued)
    - There are three types of logical processes: functions, *events*, and elementary processes.
      - An **event** is a logical unit of work that must be completed as a whole. An event is triggered by a discrete input, and is completed when the process has responded with appropriate outputs. Events are sometimes called *transactions*.
        - Functions consist of processes that respond to events.
        - Each of these events has a trigger and response that can be defined by its inputs and outputs.
        - System functions are ultimately decomposed into business events.
        - Each business event is represented by a single process that will respond to that event.

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Logical Processes and Conventions (continued)
    - There are three types of logical processes: functions, events, and *elementary processes*.
      - A event process can be further decomposed into elementary processes that illustrate in detail how the system must respond to an event.
        - **Elementary processes** are discrete, detailed activities or tasks required to complete the response to an event. In other words, they are the lowest level of detail depicted in a process model. A common synonym is **primitive process**.
        - Elementary processes should be named with a strong action verb followed by an object clause that describes what the work is performed on (or for).

Process Modeling

System Concepts for Process Modeling

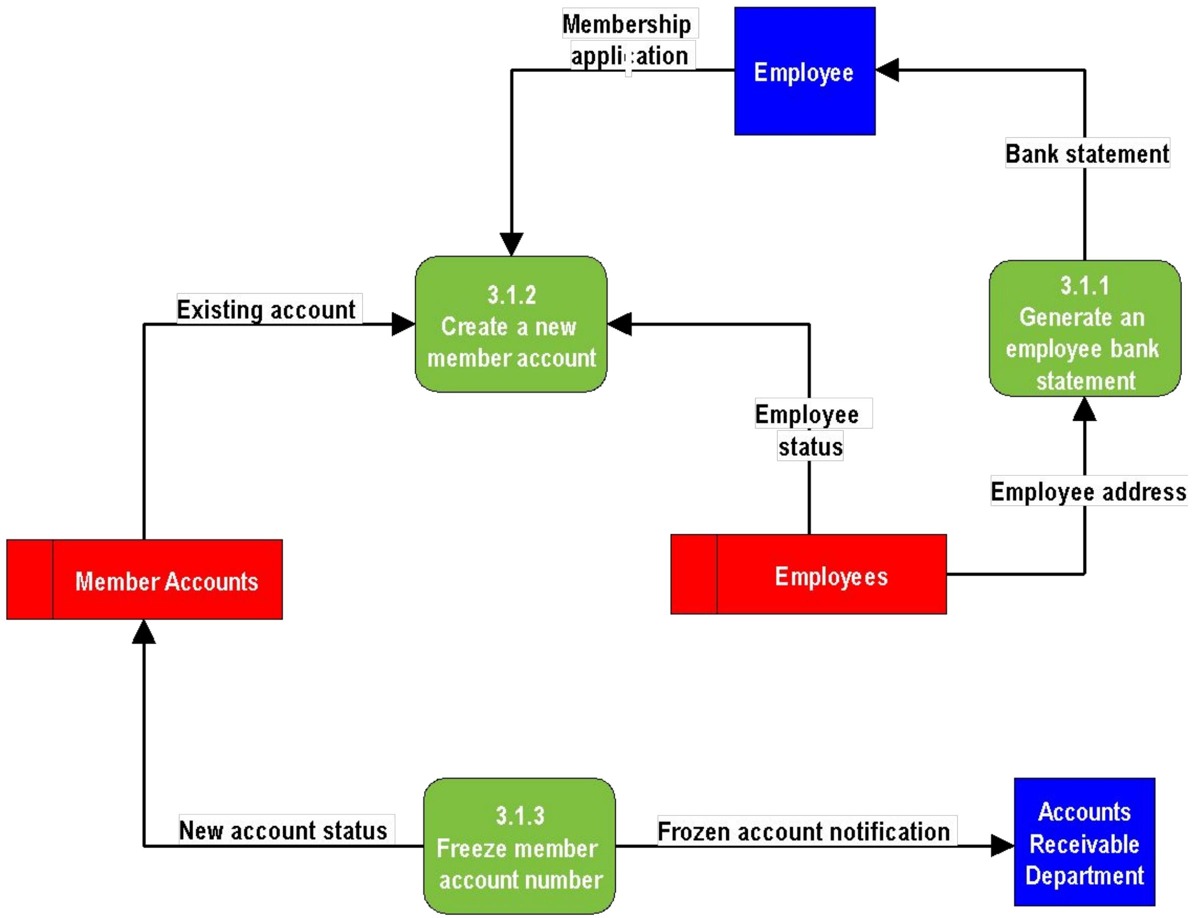
- **Process Concepts**
  - Logical Processes and Conventions (continued)
    - *Logical* process models omit any processes that do nothing more than move or route data, thus leaving the data unchanged.
    - You should be left only with logical processes that:
      - *Perform computations* (e.g., calculate grade point average)
      - *Make decisions* (determine availability of ordered products)
      - *Sort, filter or otherwise summarize data* (identify overdue invoices)
      - *Organize data into useful information* (e.g., generate a report or answer a question)
      - *Trigger other processes* (e.g., turn on the furnace or instruct a robot)
      - *Use stored data* (create, read, update or delete a record)

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Logical Processes and Conventions (continued)
    - Be careful to avoid three common mechanical errors with processes (as illustrated in the following slide):
      - A **black hole** is when a process has inputs but no outputs. Data enters the process and then disappears.
      - A **miracle** is when a process has outputs but no input.
      - A **gray hole** is when the inputs of a process are insufficient to produce the output. (most common)

Process Modeling



Common Errors on Data Flow Diagrams

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Process Logic
    - Decomposition diagrams and data flow diagrams will prove very effective tools for identifying processes, but they are not good at showing the logic inside those processes.
    - We need to specify detailed *instructions* for the elementary processes on a data flow diagram.
    - To address this problem, we require a tool that marries some of the advantages of natural English with the rigor of programming logic tools.
      - **Structured English** is a language and syntax, based upon the relative strengths of structured programming and natural English, for specifying the underlying logic of elementary processes on process models (such as *data flow diagrams*).

Process Modeling

* Many of us do not write well, and we also tend not to question our writing abilities.
* Many of us are too educated! It's often difficult for a highly educated person to communicate with an audience that may not have had the same educational opportunities. For example, the average college graduate (including most analysts) has a working vocabulary of 10,000 to 20,000 words; on the other hand, the average non-college graduate has a working vocabulary of around 5,000 words.
* Some of us write everything like it was a program. If business procedures required such precision, we'd write everything in a programming language.
* Too often, we allow the jargon and acronyms of computing to dominate our language.
* English statements frequently have an excessive or confusing scope. How would you carry out this procedure: "If customers walk in the door and they do not want to withdraw money from their account or deposit money to their account or make a loan payment, send them to the trust department." Does this mean that the only time you should not send the customer to the trust department is when he or she wishes to do all three of the transactions? Or does it mean that if a customer does not wish to perform at least one of the three transactions, that customer should not be sent to the trust department?
* We overuse compound sentences Consider the following procedure: "Remove the screws that hold the outlet cover to the wall. Remove the outlet cover. Disconnect each wire from the plug, but first make sure the power to the outlet has been turned off." An unwary person might try to disconnect the wires prior to turning off the power!
* Too many words have multiple definitions.
* Too many statements use imprecise adjectives. For example, an loan officer asks a teacher to certify that a student is in good academic standing. What is good?
* Conditional instructions can be imprecise. For example, if we state that "all applicants under the age of 19 must secure parental permission," do we mean less than 19, or less than or equal to 19?
* Compound conditions tend to show up in natural English. For example, if credit approval is a function of several conditions: credit rating, credit ceiling, annual dollar sales for the customer in question, then different combinations of these factors can result in different decisions. As the number of conditions and possible combinations increases, the procedure becomes more and more tedious and difficult to write.

Problems with Natural English as a Procedure Specification Language

Process Modeling

Using Structured English to Document an Elementary Process

1. For each CUSTOMER NUMBER in the data store CUSTOMERS:
   a. For each LOAN in the data store LOANS that matches the above CUSTOMER NUMBER:
      1) Keep a running total of NUMBER OF LOANS for the CUSTOMER NUMBER.
      2) Keep a running total of ORIGINAL LOAN PRINCIPLE for the CUSTOMER NUMBER.
      3) Keep a running total of CURRENT LOAN BALANCE for the CUSTOMER NUMBER.
      4) Keep a running total of AMOUNTS PAST DUE for the CUSTOMER NUMBER.
   b. If the TOTAL AMOUNTS PAST DUE for the customer number is greater than 100.00 then
         1) Write the customer number and data in the data flow LOANS AT RISK.
      Else
         1) Exclude the customer number and data from the data flow LOANS AT RISK.

Process Modeling

System Concepts for Process Modeling

Process Concepts

- Process Logic (continued)
  - The overall structure of a Structured English specification is built using the fundamental constructs that have governed structured programming for nearly three decades.
  - These constructs are:
    - A *sequence* of simple, declarative sentences – one after another.
    - A *conditional* or *decision structure* indicate that a process must perform different actions under well specified conditions.
    - A *iteration* or *repetition* structure specifies that a set of actions should be repeated based on some stated condition. There are two variations on this construct.

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Process Logic (continued)
    - The *sequence* construct:
      - Compound sentences are discouraged because they frequently create ambiguity.
      - Each sentence uses strong, action verbs such as GET, FIND, RECORD, CREATE, READ, UPDATE, DELETE, CALCULATE, WRITE, SORT, MERGE, or anything else recognizable or understandable to the users.
      - A formula may be included as part of a sentence (e.g., CALCULATE GROSS PAY = HOURS WORKED X HOURLY WAGE.)

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Process Logic (continued)
    - The *conditional* or *decision structure* construct:
      - There are two variations (and a departure) on this construct.
        - The IF-THEN-ELSE construct specifies that one set of actions should be taken if a specified condition is 'true', but a different set of actions should be specified if the specified condition is false.
        - The CASE construct is used when there are more than two sets of actions to choose from.
        - For logic that based on multiple conditions and combinations of conditions, *decision tables* are a far more elegant logic modeling tool.

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Process Logic (continued)
    - The *iteration* or *repetition* construct:
      - There are two variations on this construct.
        - The DO-WHILE construct indicates that certain actions (usually expressed as one or more *sequential* and/or *conditional* statements) are repeated zero, one, or more times based on the value of the stated condition.
        - The REPEAT-UNTIL constructs indicates that certain actions (again, usually expressed as one or more *sequential* and/or *conditional* statements) are repeated one or more times based on the value of the stated condition.

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Process Logic (continued)
    - Structured English places the following restrictions on process logic:
      - Only strong, imperative verbs may be used.
      - Only names that have been defined in the project repository may be used.
      - State formulas clearly using appropriate mathematical notations.
      - Undefined adjectives and adverbs are not permitted unless clearly defined in the project repository as legal values for data attributes.
      - Blocking and indentation are used to set off the beginning and ending of constructs and to enhance readability.
      - When in doubt, user readability should always take precedence over programmer preferences.

Process Modeling

Construct	Sample Template
Sequence of actions – unconditionally perform a sequence of actions.	[Action 1] [Action 2] ... [Action n]

Simple condition actions – if the specified condition is true, then perform the first set of actions. Otherwise, perform the second set of actions.
 	
Use this construct if the condition has only two possible values.
 	
(Note: The second set of conditions is optional.)
	If [truth condition]
	then
	[sequence of actions or other conditional actions]
	else
	[sequence of actions or other conditional actions]
	End If

Complex condition actions – test the value of the condition and perform the appropriate set of actions. Use this construct if the condition has more than two values.	**Do the following based on** [condition]: **Case 1: If** [condition] = [value] then [sequence of actions or other conditional actions] **Case 2: If** [condition] = [value] then [sequence of actions or other conditional actions] ... **Case n: If** [condition] = [value] then [sequence of actions or other conditional actions] End Case
Multiple conditions – test the value of multiple conditions to determine the correct set of actions. Use a **decision table** instead of nested if-then-else Structured English constructs to simplify the presentation of complex logic that involves *A* **decision table** is a *tabular presentation of complex*	

Structured English Constructs

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Process Logic (continued)
    - Many processes are governed by complex combinations of conditions that are not easily expressed with Structured English.
    - This is most commonly encountered in business policies.
      - A **policy** is a set of rules that govern some process in the business.
    - In most firms, policies are the basis for decision making.
    - Policies consist of *rules* that can often be translated into computer programs if the users and systems analysts can accurately convey those rules to the computer programmer.

Process Modeling

System Concepts for Process Modeling

- **Process Concepts**
  - Process Logic (continued)
    - One way to formalize the specification of policies and other complex combinations of conditions is by using a *decision table*.
      - A **decision table** is a tabular form of presentation that specifies a set of conditions and their corresponding actions.
    - A decision table consists of three components:
      - Condition stubs (the upper rows) describe the conditions or factors that will affect the decision or policy.
      - Action stubs (the lower rows) describe, in the form of statements, the possible policy actions or decisions.
      - Rules (the columns) describe which actions are to be taken under a specific combination of conditions.

A Sample Decision Table

A SIMPLE POLICY STATEMENT

CHECK CASHING IDENTIFICATION CARD

A customer with check cashing privileges is entitled to cash personal checks of up to $75.00 and payroll checks of from companies pre-approved by *LMART*. This card is issued in accordance with the terms and conditions of the application and is subject to change without notice. This card is the property of *LMART* and shall be forfeited upon request of *LMART*.

SIGNATURE Charles C Parker, Jr.

EXPIRES **May 31, 1998**

THE EQUIVALENT POLICY DECISION TABLE

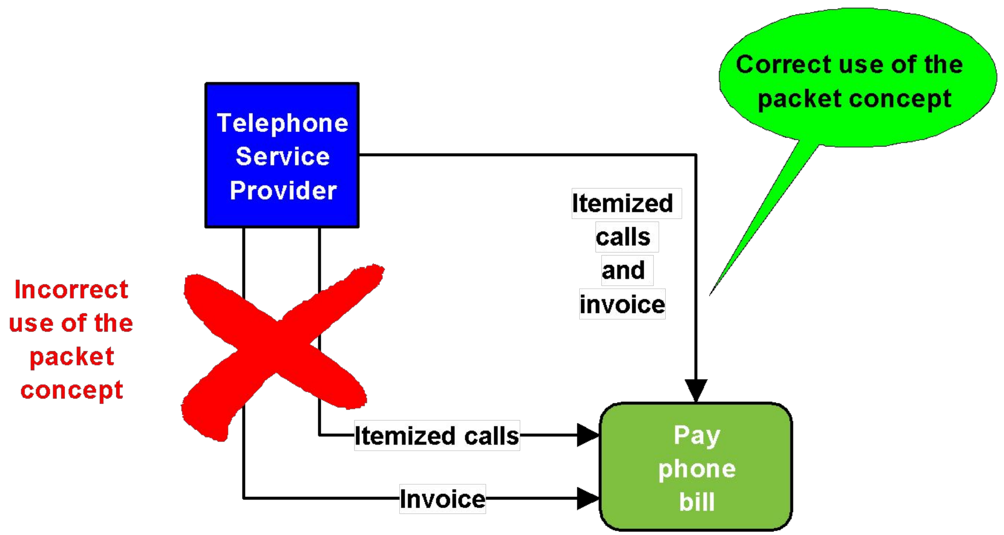
Conditions and Actions	Rule 1	Rule 2	Rule 3	Rule 5
C1: Type of check	personal	payroll	personal	payroll
C2: Check amount less than or equal to $75.00	yes	doesn't matter	no	doesn't matter
C3: Company accredited by *LMART*	doesn't matter	yes	doesn't matter	no
A1: Cash the check	X	X		
A2: Don't cash the check			X	X

Process Modeling

System Concepts for Process Modeling

- **Data Flows**
  - Data in Motion
    - A data flow is *data in motion*.
    - The flow of data between a system and its environment, or between two processes inside a system an relationship between a system and its environment, or between two processes is *communication*.
      - A **data flow** represents an input of data to a process, or the output of data (or information) from a process. A data flow is also used to represent the creation, deletion, or update of data in a file or database (called a *data store* on the DFD).
      - A data flow is depicted as a solid-line with arrow.

Process Modeling



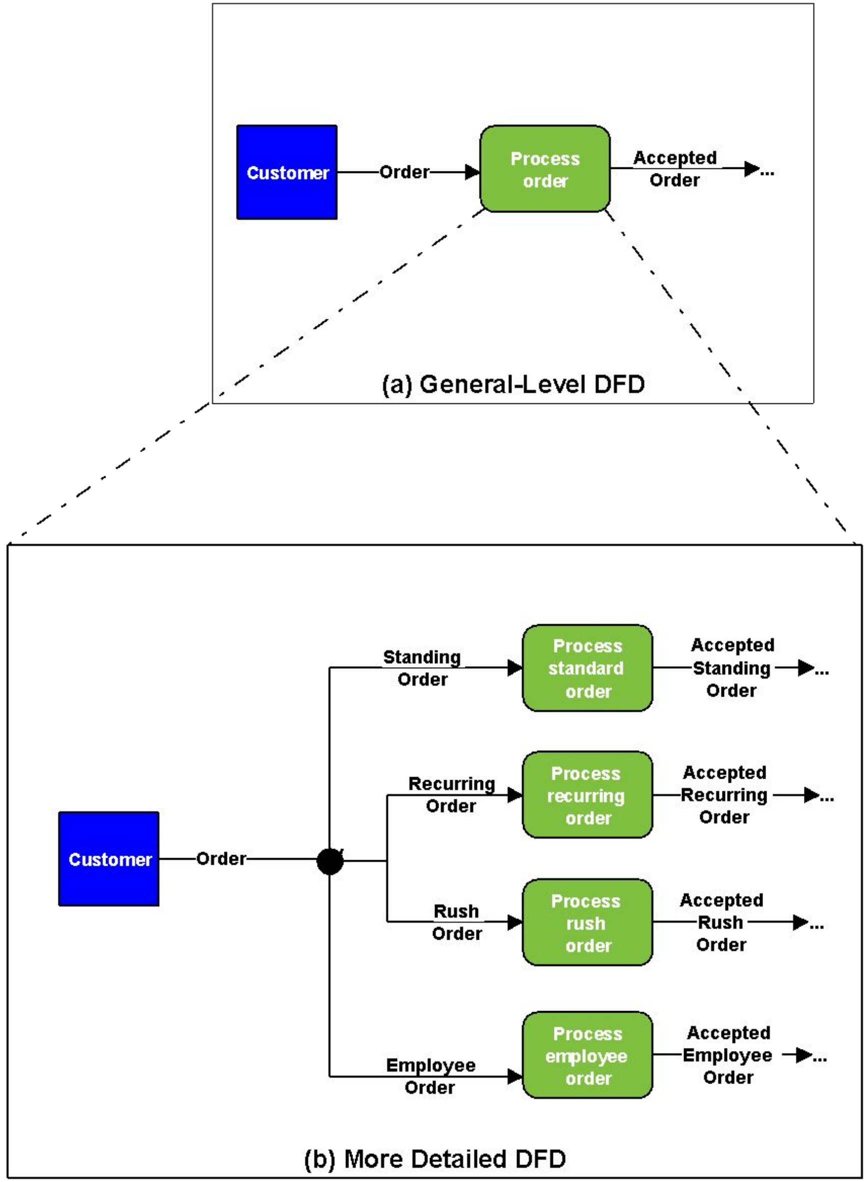
The Data Flow Packet Concept

Process Modeling

System Concepts for Process Modeling

- **Data Flows**
  - Data in Motion (continued)
    - A data flow is composed of either actual data attributes (also called *data structures*), or other data flows.
      - A **composite data flow** is a data flow that consists of other data flows. They are used to combine similar data flows on general-level data flow diagrams to make those diagrams easier to read.

Process Modeling



Composite & Elementary Data Flows

System Concepts for Process Modeling

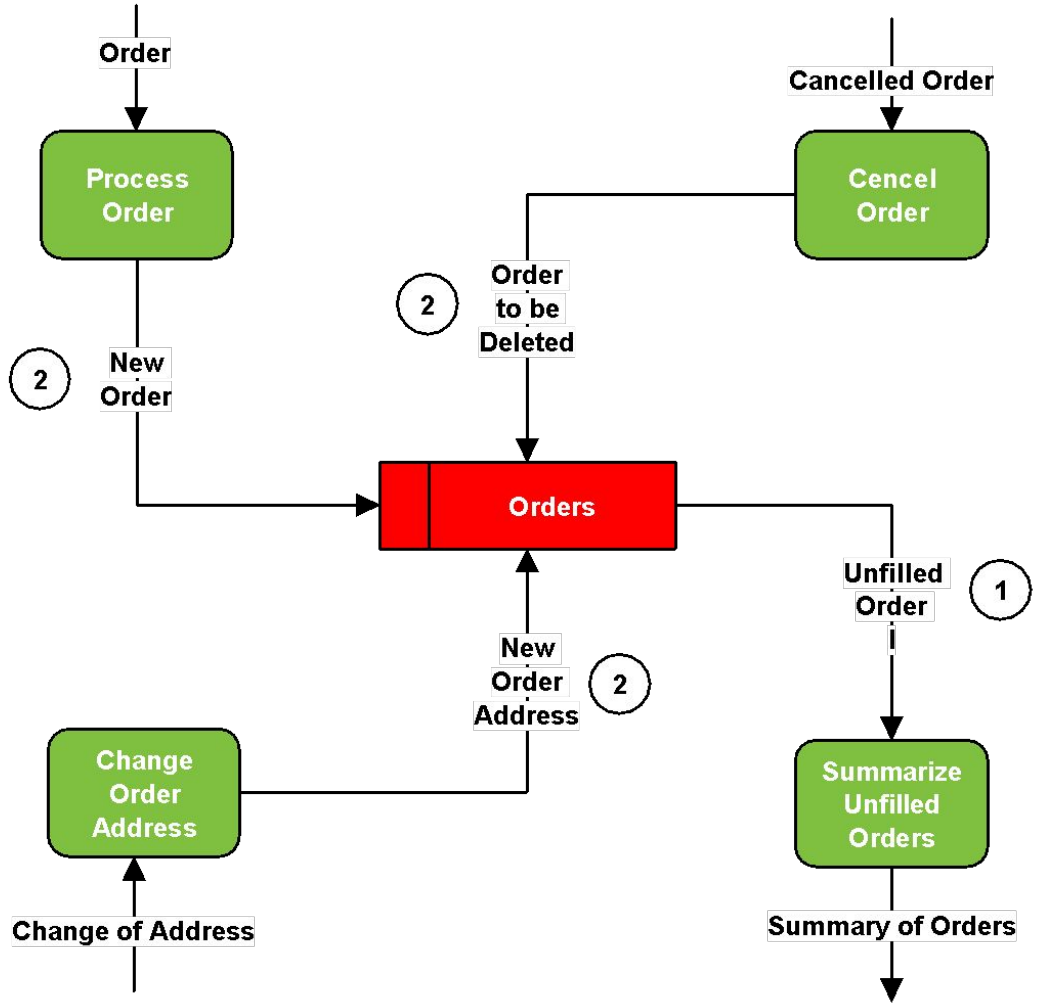
- **Data Flows**
  - Data in Motion (continued)
    - Some data flow diagramming methods also recognize *non-data* flows called control flows.
      - A **control flow** represents a condition or non-data event that triggers a process. Think of it as a condition to be monitored while the system works. When the system realizes that the condition meets some predetermined state, the process to which it is input is started.
      - The control flow is depicted as a dashed-line with arrow.

Process Modeling

System Concepts for Process Modeling

- **Data Flows**
  - Logical Data Flows and Conventions
    - In the Analysis phase, we are only interested in *logical* data flows, that the flow is needed (not how we will implement that flow).
    - Data Flow Names:
      - Should discourage premature commitment to any possible implementation.
      - Should be descriptive nouns and noun phrases that are singular, as opposed to plural.
      - Should be unique.
        - Use adjectives and adverbs to help to describe how processing has changed a data flow.

Process Modeling



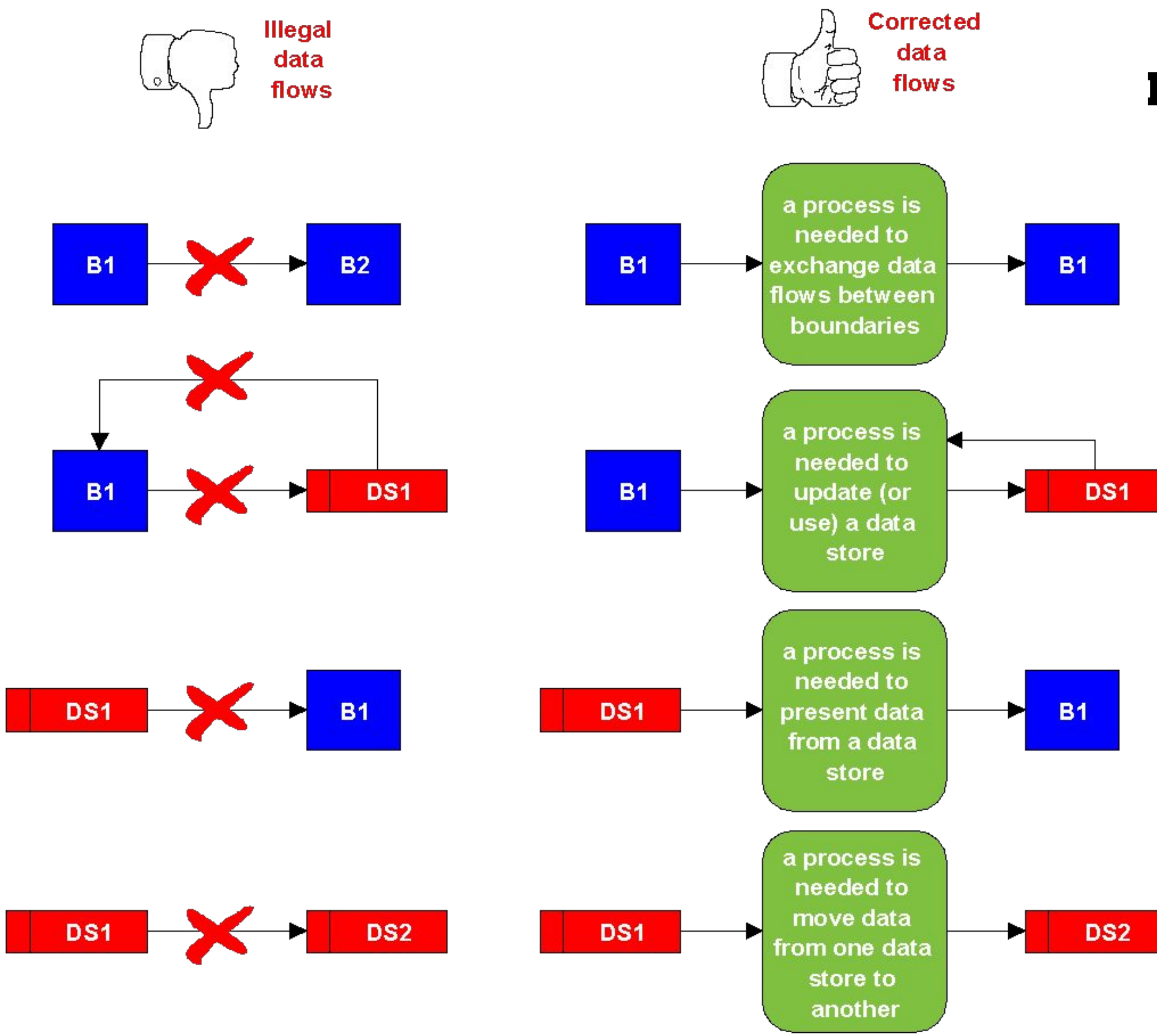
Data Flows to and from Data Stores

Process Modeling

System Concepts for Process Modeling

- **Data Flows**
  - Logical Data Flows and Conventions (continued)
    - No data flow should ever go completely unnamed.
    - Data flow names should describe the data flow without describing how the flow is or could be implemented.
    - All data flows must begin or end at a process, because data flows are the inputs and outputs of a process.

Illegal Data Flows



Process Modeling

System Concepts for Process Modeling

- **Data Flows**
  - Data Flow Conservation
    - **Data conservation**, sometimes called “starving the processes”, requires that a data flow only contain that data which is truly needed by the receiving process.
    - By ensuring that processes only receive as much data as they really need, we simplify the interface between those processes.
    - In order to practice data conservation, we must precisely define the data composition of each (non-composite) data flow.
      - Data composition is expressed in the form of *data structures*.

Chapter 6. Process Modeling

System Concepts for Process Modeling

- **Data Flows**
  - Data Structures
    - A data flow contains data items called attributes.
      - A **data attribute** is the smallest piece of data that has meaning to the end users and the business.
      - The data attributes that comprise a data flow are organized into data structures.
        - **Data structures** are specific arrangements of data attributes that define the organization of a single instance of a data flow.
    - Data flows can be described in terms of the following types of data structures:
      - A *sequence* or group of data attributes that occur one after another.
      - The *selection* of one or more attributes from a set of attributes.
      - The *repetition* of one or more attributes.

Process Modeling

DATA STRUCTURE	ENGLISH INTERPRETATION
ORDER = ORDER NUMBER + ORDER DATE + [PERSONAL CUSTOMER NUMBER, CORPORATE ACCOUNT NUMBER]+ SHIPPING ADDRESS = ADDRESS + (BILLING ADDRESS = ADDRESS) + 1 { PRODUCT NUMBER + PRODUCT DESCRIPTION + QUANTITY ORDERED + PRODUCT PRICE + PRODUCT PRICE SOURCE + EXTENDED PRICE } N + SUM OF EXTENDED PRICES + PREPAID AMOUNT + (CREDIT CARD NUMBER + EXPIRATION DATE) (QUOTE NUMBER) ADDRESS = (POST OFFICE BOX NUMBER) + STREET ADDRESS + CITY + [STATE, MUNICIPALITY] + (COUNTRY) + POSTAL CODE	An instance of ORDER consists of: ORDER NUMBER and ORDER DATE and Either PERSONAL CUSTOMER NUMBER or CORPORATE ACCOUNT NUMBER and SHIPPING ADDRESS (which is equivalent to ADDRESS) and optionally: BILLING ADDRESS (which is eqivalent to ADDRESS) and one or more instances of: PRODUCT NUMBER and PRODUCT DESCRIPTION and QUANTITY ORDERED and PRODUCT PRICE and PRODUCT PRICE SOURCE and EXTENDED PRICE and SUM OF EXTENDED PRICES and PREPAID AMOUNT and optionally: both CREDIT CARD NUMBER and EXPIRATION DATE and optionally: QUOTE NUMBER An instance of ADDRESS consists of: optionally: POST OFFICE BOX NUMBER and STREET ADDRESS and CITY and Either STATE or MUNICIPALITY and optionally: COUNTRY and POSTAL CODE

Figure 6.15

A Data Structure for a Data Flow

Process Modeling

Data Structure	Format by Example (relevant portion is **boldfaced**)	English Interpretation (relevant portion is **boldfaced**)
Sequence of Attributes - The sequence data structure indicates one or more attributes that may (or must) be included in a data flow.	WAGE AND TAX STATEMENT = **TAXPAYER IDENTIFICATION NUMBER +** **TAXPAPYER NAME +** **TAXPAPYER ADDRESS +** **WAGES, TIPS, AND COMPENSATION +** **FEDERAL TAX WITHHELD + ...**	An instance of WAGE AND TAX STATEMENT consists of **TAXPAYER IDENTIFICATION NUMBER and** **TAXPAYER NAME and** **TAXPAYER ADDRESS and** **WAGES, TIPS, AND COMPENSATION and** **FEDERAL TAX WITHHELD and ...**
Selection of Attributes - The selection data structure allows you to show situations where different sets of attributes describe different instances of the data flow.	ORDER = **(PERSONAL CUSTOMER NUMBER,** **CORPORATE ACCOUNT NUMBER) +** ORDER DATE + ...	An instance of ORDER consists of **Either PERSONAL CUSTOMER NUMBER or** **CORPORATE ACCOUNT NUMBER**; and ORDER DATE and ...
Repetition of Attributes - The repetition data structure is used to set off a data attribute or group of data attributes that may (or must) repeat themselves a specified number of times for a single instance of the data flow. The minimum number of repetitions is usually *zero* or *one*. The maximum number of repetitions may be specified as "n" meaning "many" where the actual number of instances varies for each instance of the data flow.	CLAIM = POLICY NUMBER + POLICYHOLDER NAME + POLICYHOLDER ADDRESS + **0 { DEPENDENT NAME +** **DEPENDENT'S RELATIONSHIP } N +** **1 { EXPENSE DESCRIPTION +** **SERVICE PROVIDER +** **EXPENSE AMOUNT } N**	An instance of CLAIM consists of: POLICY NUMBER and POLICYHOLDER NAME and POLICYHOLDER ADDRESS and **zero or more instances of:** **DEPENDENT NAME and** **DEPENDENT'S RELATIONSHIP** and **one or more instances of:** **EXPENSE DESCRIPTION and** **SERVICE PROVIDER and** **EXPENSE ACCOUNT**
Optional Attributes – The optional notation indicates that an attribute, or group of attributes <u>in a</u> sequence or selection data structure may not be included all all instances of a data flow. *Note: For the repetition data structure, a minimum of 'zero' is the same as making the entire repeating group 'optional'.*	CLAIM = POLICY NUMBER + POLICYHOLDER NAME + POLICYHOLDER ADDRESS + **(SPOUSE NAME +** **DATE OF BIRTH) +** ...	An instance of CLAIM consists of: POLICY NUMBER and POLICYHOLDER NAME and POLICYHOLDER ADDRESS and **optionally, SPOUSE NAME and** **DATE OF BIRTH** and ...
Reusable Attributes – For groups of attributes that are contained in many data flows, it is desirable to create a separate data structure that can be resued in other data structures.	DATE = MONTH + DAY + YEAR	Then, the resuable structures can be included in other data flow structures as follows: ORDER = ORDER NUMBER ... + DATE INVOICE = INVOICE NUMBER ... + DATE PAYMENT = CUSTOMER NUMBER ... + DATE

Data Structure Constructs

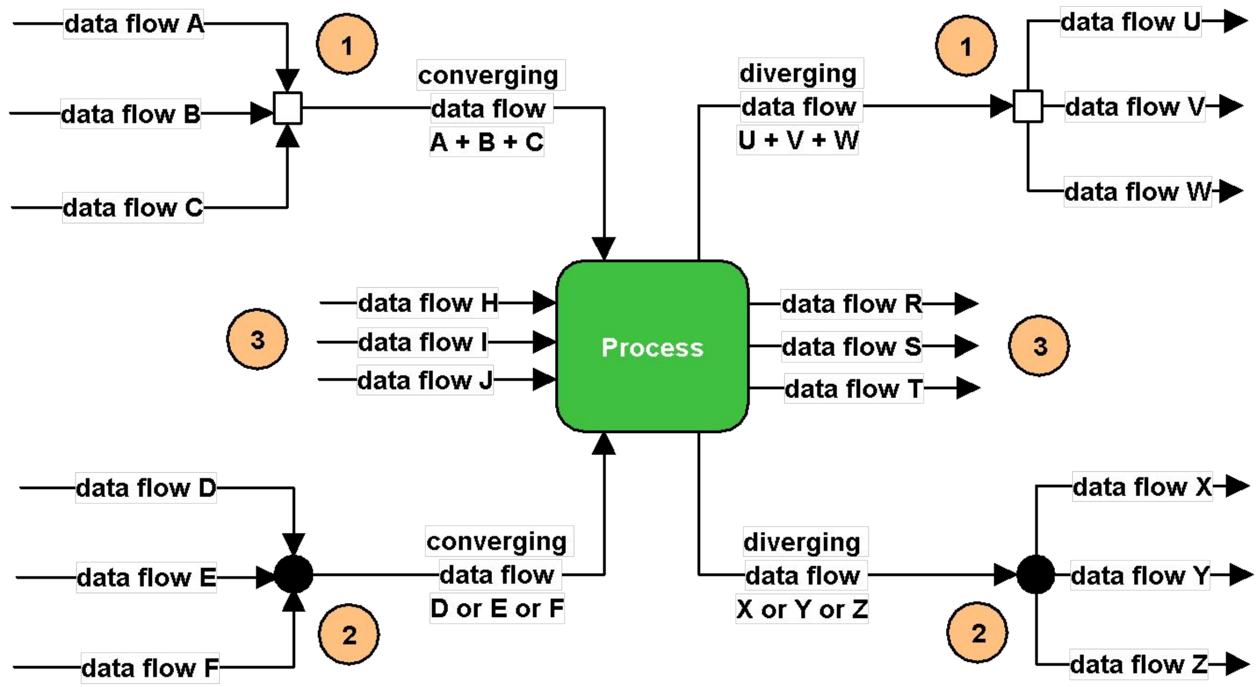
- **Data Flows**
  - Domains
    - An attribute is a piece of data.
    - The values for each attribute are defined in terms of two properties: data type and domain.
      - The **data type** for an attribute defines what class of data can be stored in that attribute.
      - The **domain** of an attribute defines what values an attribute can legitimately take on.

Process Modeling

System Concepts for Process Modeling

- **Data Flows**
  - Divergent and Convergent Flows
    - A **diverging data flow** is one which ‘splits’ into multiple data flows.
      - Diverging data flows indicate that all or parts of a single data flow are routed to different destinations.
    - A **converging data flow** is the ‘merger’ of multiple data flows into a single data flow.
      - Converging data flows indicate that data flows from different sources can (must) come together as a single packet for subsequent processing.

Process Modeling



Diverging & Converging Data Flows

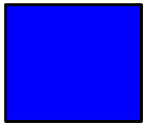
Process Modeling

System Concepts for Process Modeling

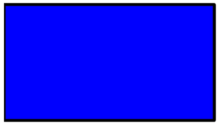
- **External Agents**
  - All information systems respond to events and conditions in the environment.
  - The environment of an information system includes *external agents* that form the boundary of the system, and define places where the system interfaces with its environment.
    - A **external agent** defines an a person, organization unit, other system, or other organization that lies outside of the scope of the project, but which interacts with the system being studied. External agents provide the net inputs into a system, and receive net outputs from a system. Common synonyms include **external entity.**

System Concepts for Process Modeling

- **External Agents**
  - The term external means “external to the system being analyzed or designed.”
  - An external agent is represented by a square on the data flow diagram.
  - The Yourdon/Demarco equivalent is a rectangle
  - External agents on a logical data flow diagram may include people, business units, other internal systems with which your system must interact, and external organizations.



Gane & Sarson External Agent Shape



DeMarco/Yourdon External Agent Shape

Process Modeling

System Concepts for Process Modeling

- **External Agents**
  - External agents should be named with descriptive, singular nouns.
  - External agents represent fixed, *physical* systems; therefore, they can have very physical names or acronyms.
  - To avoid crossing data flow lines on a DFD, it is permissible to duplicate external agents on DFDs.
  - As a general rule, external agents should be located on the perimeters of the page, consistent with their definition as a system boundary.

Process Modeling

System Concepts for Process Modeling

- **Data Stores**
  - Most information systems capture data for later use.
  - The data is kept in a *data store*.
    - A **data store** is an ``inventory'' of data. Synonyms include file and database (although those terms are too implementation-oriented for essential process modeling).
  - A data store is represented by the open-end box.
  - If data flows are *data in motion*, think of data stores as *data at rest*.
  - Data stores should describe ``things'' about which the business wants to store data.

Gane & Sarson
Data Store Shape

Process Modeling

System Concepts for Process Modeling

- **Data Stores**
  - There should be one data store for each data entity on your entity relationship diagram.
  - Data stores should be named as the plural of the corresponding data model entity
    - Avoid physical terms such as *file, database, file cabinet, file folder*, and the like.
  - It is permissible to duplicate data stores on a DFD to avoid crossing data flow lines.

Process Modeling

The Process of Logical Process Modeling

- **Strategic Systems Planning**
  - Many organizations select application development projects based on strategic information system plans.
  - Strategic planning produces an information systems strategy plan.
  - The information systems strategy plan defines an architecture for information systems and this architecture frequently includes an **enterprise process model**.
    - An enterprise process model identifies only business areas and functions.
    - An enterprise process model usually takes the form of a decomposition diagram and/or very high-level data flow diagram.
    - A enterprise process model is stored in a corporate repository.

Process Modeling

The Process of Logical Process Modeling

- **Process Modeling for Business Process Redesign**
  - BPR projects analyze business processes and then redesign them to eliminate inefficiencies and bureaucracies prior to any (re)application of information technology.
  - In order to redesign business processes, the existing processes must first be studied and documented using process models.

Chapter 6.

Process Modeling

The Process of Logical Process Modeling

- **Process Modeling during Systems Analysis**
  - In systems analysis, the logical process model for a system or application is an **application process model**.
  - In the heyday of the original structured analysis methodologies, process modeling was also performed in the study phase of systems analysis.
    - Analysts would build a *physical process model of the current system*, a *logical model of the current system*, and a *logical model of the target system*.
    - While conceptually sound, this approach led to "analysis paralysis" - modeling overkill.

Process Modeling

The Process of Logical Process Modeling

- **Process Modeling during Systems Analysis**
  - Today, most modern structured analysis strategies focus exclusively on the *logical model of the target system* being developed.
  - They are organized according to a strategy called *event partitioning*.
    - **Event partitioning** factors a system into subsystems based on business events and responses to those events.

Process Modeling

The Process of Logical Process Modeling

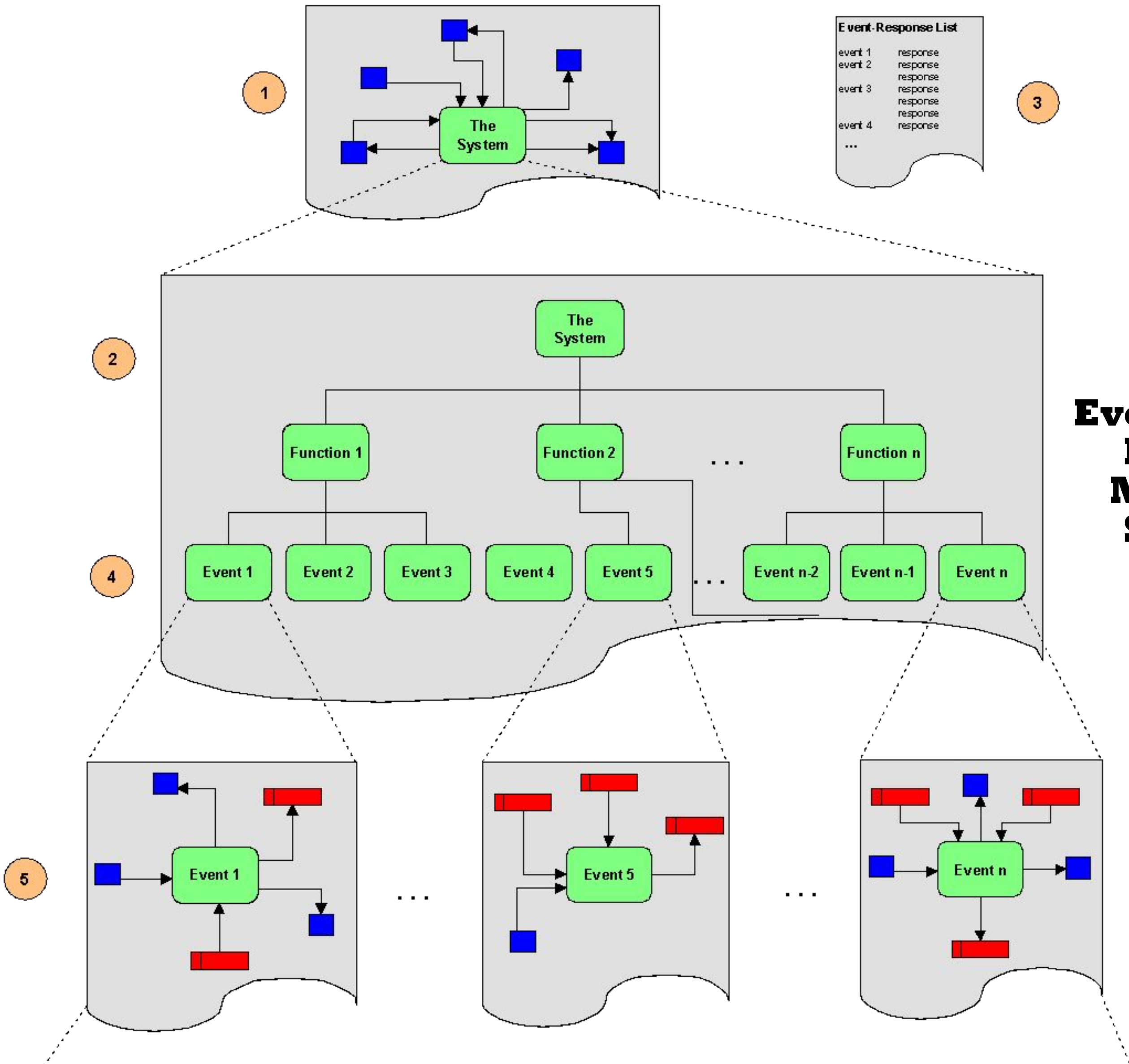
- **Process Modeling during Systems Analysis**
  - The strategy for event-driven process modeling is as follows:
    - **Step 1**: A system **context diagram** is constructed to establish <u>initial</u> project scope.
    - **Step 2**: A **functional decomposition diagram** is drawn to partition the system into logical subsystems and/or functions.
    - **Step 3**: An **event-response list** is compiled to identify and confirm the business events to which the system must provide a response.
    - **Step 4**: One process, called an **event handler** is added to the decomposition diagram for each event.
    - **Step 5**: An **event diagram** is constructed and validated for each event.

Process Modeling

The Process of Logical Process Modeling

- **Process Modeling during Systems Analysis**
  - The strategy for event-driven process modeling is as follows: (continued)
    - **Step 6**: A **system diagram(s)** is constructed by merging the event diagrams.
    - **Step 7**: A **primitive diagram** is constructed for each event process.
      - These data flow diagrams show all of the elementary processes, data stores, and data flows for single events.

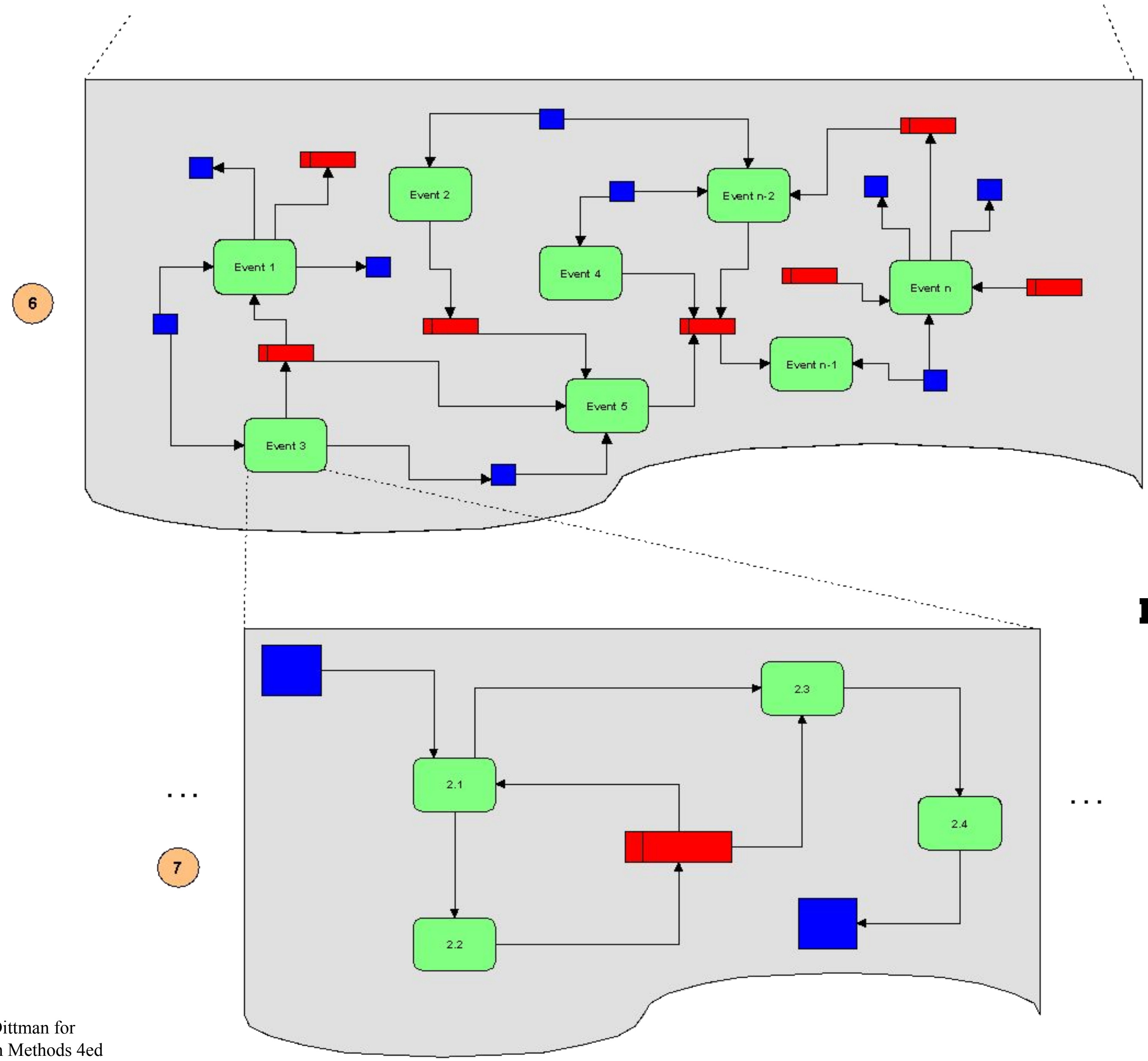
Process Modeling



Event-Driven Process Modeling Strategy

Prepared by Kevin C. Dittman for
Systems Analysis & Design Methods 4ed
by J. L. Whitten & L. D. Bentley

Process Modeling



Event-Driven Process Modeling Strategy (slide 2)

Prepared by Kevin C. Dittman for
Systems Analysis & Design Methods 4ed
by J. L. Whitten & L. D. Bentley

Process Modeling

The Process of Logical Process Modeling

- **Looking Ahead to Systems Configuration and Design**
  - The logical process model from systems analysis describes business processing requirements of the system, not technical solutions.
  - The purpose of the configuration phase is to determine the best way to implement those requirements with technology.
  - During system design, the logical process model will be transformed into a physical process model (called an *application schema*) for the chosen technical architecture.
    - This model will reflect the technical capabilities and limitations of the chosen technology.

Chapter 6.

Process Modeling

The Process of Logical Process Modeling

- **Fact Finding and Information Gathering for Process Modeling**
  - Process models cannot be constructed without appropriate facts and information as supplied by the user community.
    - These facts can be collected by:
      - sampling of existing forms and files
      - research of similar systems
      - surveys of users and management
      - interviews of users and management
      - JAD

Process Modeling

The Process of Logical Process Modeling

- **Computer-Aided Systems Engineering (CASE) for Process Modeling**
  - Process models are stored in the repository.
  - CASE technology provides the repository for storing the process model and its detailed descriptions.

Process Modeling

How to Construct Process Models

- **The Context Diagram**
  - Before we construct the actual process model, we need to establish initial project scope.
    - A project's scope defines what aspect of the business a system or application is supposed to support.
    - A project's scope also defines how the system or application being modeled must interact with other systems and the business as a whole.
    - A project's scope is documented with a *context diagram*.
      - A **context diagram** defines the scope and boundary for the system and project. Because the scope of any project is always subject to change; the context diagram is also subject to constant change. A synonym is *environmental model.*

Process Modeling

How to Construct Process Models

- **The Context Diagram**
  - A strategy follows for determining the system's boundary and scope:
    - **Step 1**: Think of the system as a 'container' in order to distinguish the inside from the outside.
      - Ignore the inner workings of the container .
    - **Step 2**: Ask your end-users what business events or transactions a system must respond to.
      - These are the *net inputs* to the system.
      - For each net input, determine its source.
      - Sources will become *external agents* on the context diagram.

Process Modeling

How to Construct Process Models

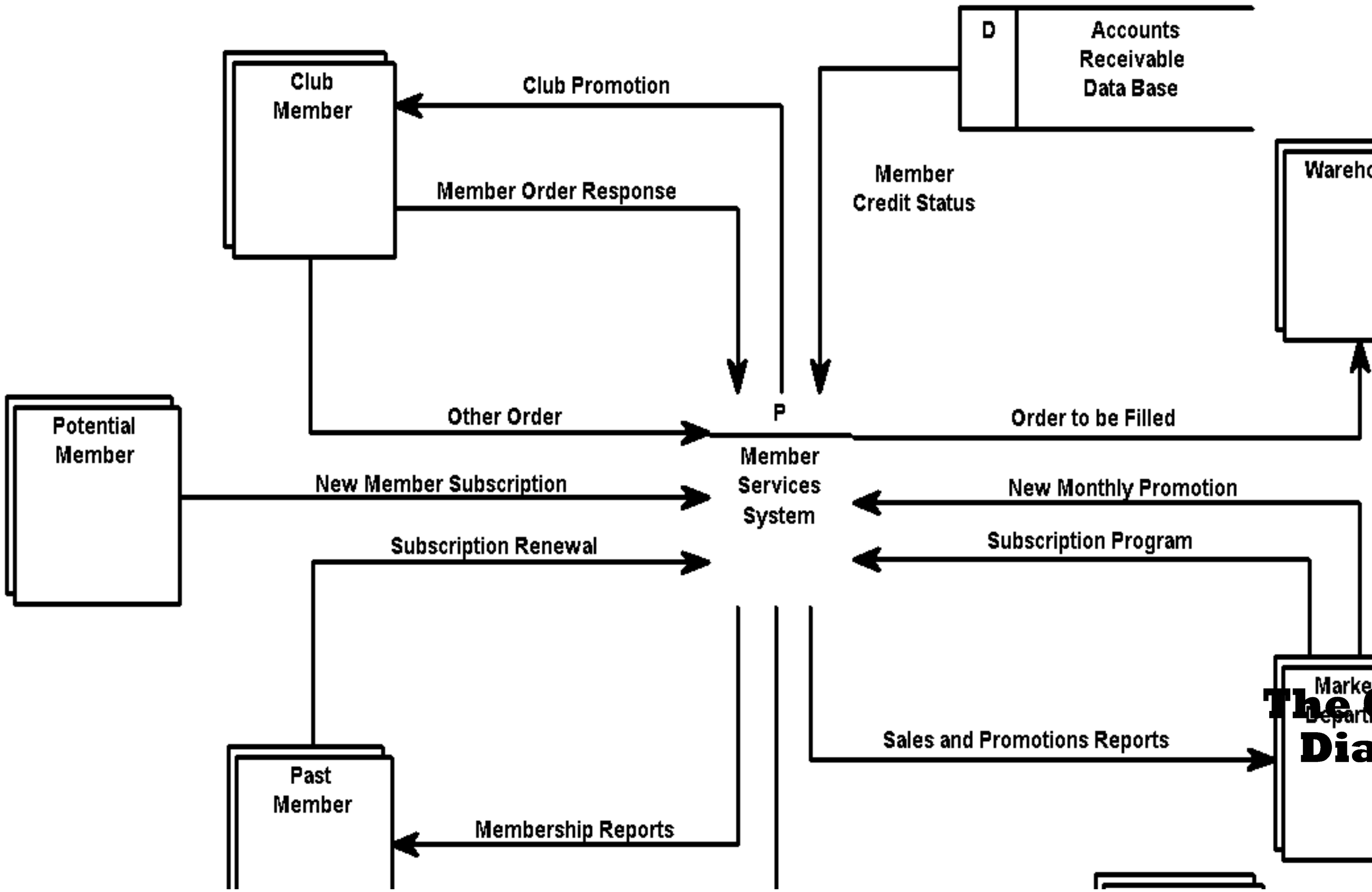
- **The Context Diagram**
  - A strategy follows for determining the system's boundary and scope: (continued)
    - **Step 3**: Ask your end-users what responses must be produced by the system.
      - These are the net outputs to the system.
      - For each net output, determine its destination.
      - Destinations may be *external agents*.
    - **Step 4**: Identify any *external* data stores.
      - Many systems require access to the files or databases of other systems.
    - **Step 5**: Draw your context diagram from all of the preceding information.

Process Modeling

How to Construct Process Models

- **The Context Diagram**
  - The context diagram contains one and only one process.
  - External agents are drawn around the perimeter.
  - External data stores are drawn around the perimeter.
  - Data flows define the interactions of your system with the boundaries and with the external data stores.

Process Modeling



The Context Diagram

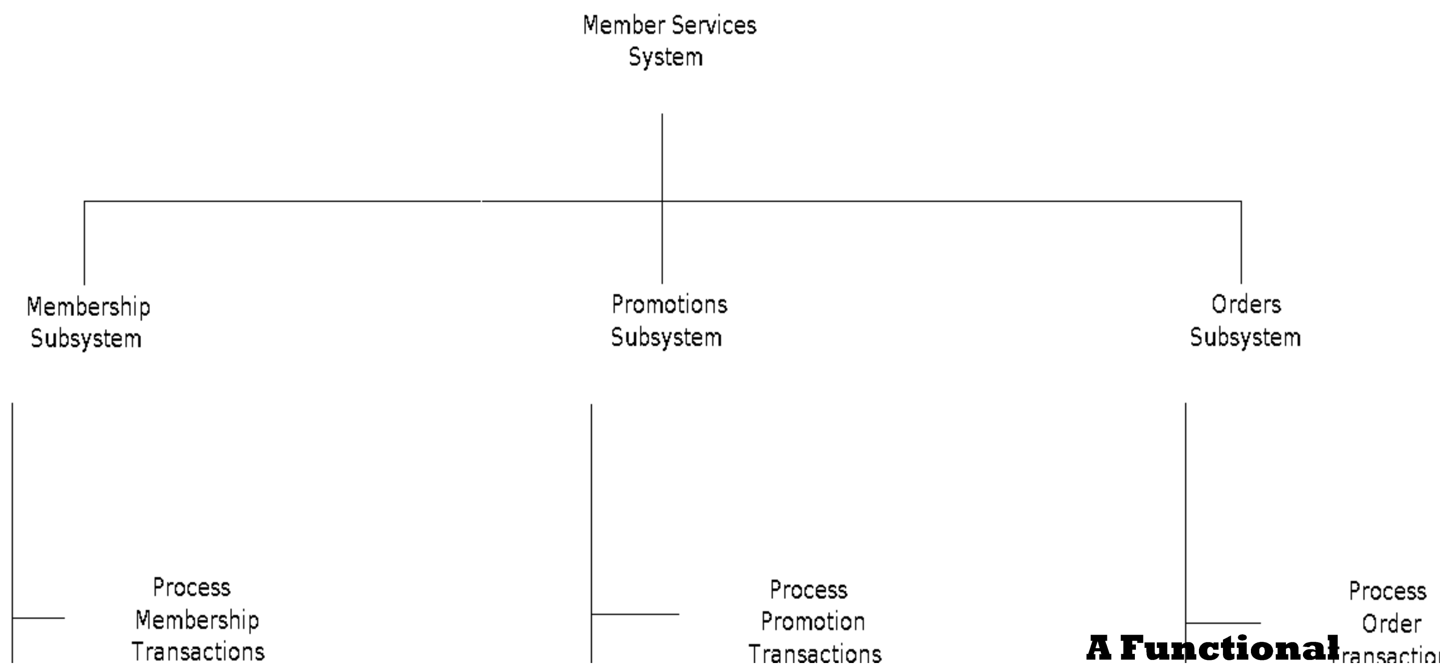
Process Modeling

How to Construct Process Models

- **The Functional Decomposition Diagram**
  - A decomposition diagram shows the top-down functional decomposition or structure of a system.
  - A decomposition diagram provides the beginnings of an outline for drawing data flow diagrams.
  - The following is an item-by-item discussion of the decomposition diagram.
    - **Item 1**: The root process corresponds to the entire system.
    - **Item 2**: The system is initially factored into subsystems and/or functions.
    - **Item 3**: Factor the subsystems into the operational and reporting aspects.

Chapter 6.

Process Modeling



A Functional Decomposition Diagram

Process Modeling

How to Construct Process Models

- **The Event-Response List**
  - The purpose of this step is to determine what business events the system must respond to, and what responses are appropriate.
  - Some of the inputs on the context diagram are associated with events.

Process Modeling

How to Construct Process Models

- **The Event-Response List**
  - There are three types of events.
    - **External events** are so named because they are initiated by external agents.
      - External events are illustrated as input data flows.
    - **Temporal events** trigger processes on the basis of time, or something that merely happens.
      - Temporal events are illustrated as input *control flows*.
    - **State events** trigger processes based on a system's change from one state or condition to another.
      - State events are illustrated as an input *control flows*.

Process Modeling

How to Construct Process Models

- **The Event-Response List**
  - Each event should be named.
  - The name should reveal the system nature of the event – that is, provide some insight as to at least one appropriate response.
  - The following guidelines for external and temporal events:
    - **External event** - External agent name + reason for the data flow.
      - Example: CUSTOMER REQUESTS ACCOUNT BALANCE.
    - **Temporal event** - Time to + action that must be taken.
      - Example: TIME TO BILL CUSTOMER ACCOUNTS.

Process Modeling

EVENT LIST

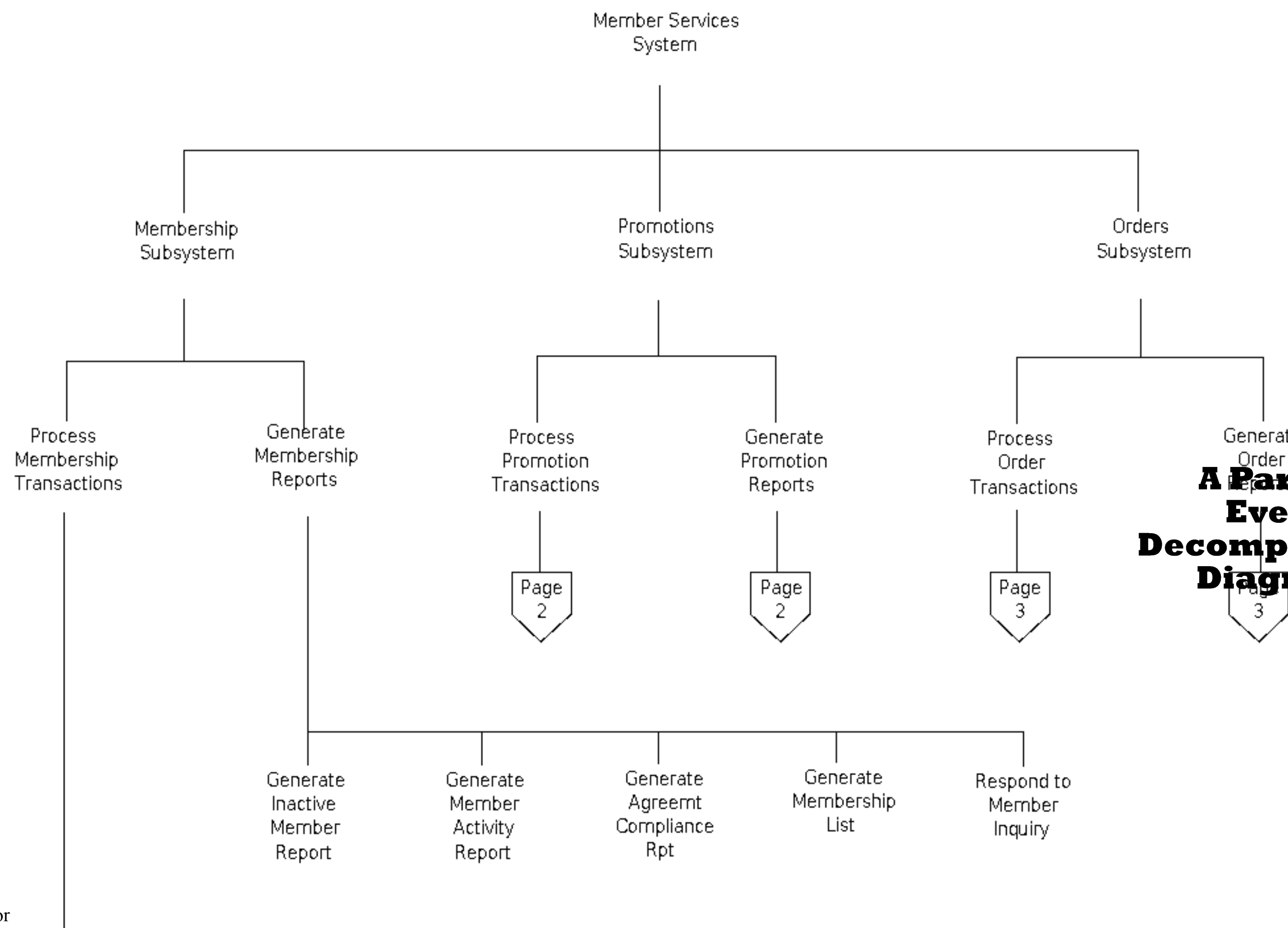
Event Description	Trigger (Inputs)	Responses (Outputs)
Marketing department establishes a new membership plan and offer.	SUBSCRIPTION PROGRAM	SUBSCRIPTION PLAN CONFIRMATION CREATE AGREEMENT
Marketing department terminates a membership offer.	SUBSCRIPTION PROGRAM TERMINATION	SUBSCRIPTION PLAN TERMINATION NOTICE DELETE AGREEMENT UPDATE MEMBERS
Potential member responds to a subscription offer.	NEW MEMBER SUBSCRIPTION	SUBSCRIPTION CONFIRMATION SUBSCRIPTION REJECTION CREATE MEMBER
Potential member is referred to membership by a current member.	REFERAL SUBSCRIPTION REFERAL BONUS ORDER	SUBSCRIPTION CONFIRMATION SUBSCRIPTION REJECTION CREATE MEMBER
Potential member exercises 10 day cancellation option.	SUBSCRIPTION CANCELLATION	SUBSCRIPTION CANCELLATION NOTICE DELETE MEMBER
Club member changes name or address.	MEMBER CHANGE OF NAME OR ADDRESS	UPDATE MEMBER
Time to cancel those inactive members.	INACTIVITY CHECK	CANCELLED MEMBERS REPORT UPDATE MEMBER
Marketing department establishes a new monthly or seasonal promotion.	MONTHLY PROMOTION SEASONAL PROMOTION	DATED ORDER CREATE ORDER
Member responds to dated promotional order.	MEMBER ORDER RESPONSE	ORDER TO BE FILLED CREDIT PROBLEM NOTIFICATION UPDATE MEMBER UPDATE ORDER UPDATE PRODUCT
Time to automatically fill order for which member has not replied to dated promotion.	DATED ORDER DEADLINE	ORDER TO BE FILLED DELETE ORDER CREATE ORDER UPDATE ORDER UPDATE MEMBER UPDATE PRODUCT
Time to produce promotion analyses	END OF PROMOTION	PROMOTION ANALYSIS REPORT
Time to analyze sales.	END OF MONTH END OF QUARTER END OF FISCAL YEAR	SALES ANALYSIS REPORT

A Partial Event-Response List

- **The Event-Decomposition Diagram**
  - The purpose of this step is to further partition our functions in the decomposition diagram.
  - Simply add event handling processes (one per event) to the decomposition.
  - If the entire decomposition diagram will not fit on a single page, add separate pages for subsystems or functions.
  - The root process on a subsequent page should be duplicated from an earlier page to provide a cross reference.

Chapter 6.

Process Modeling



A Partial Event Decomposition Diagram

Process Modeling

How to Construct Process Models

- **The Event Diagram**
  - Using the decomposition diagram as an outline, one event diagram can be constructed for each event process.
    - An **event diagram** is a context diagram for a single event. It shows the inputs, outputs, and data store interactions for the event.
  - Most event diagrams contain a single process – the same process that was named to handle the event on the decomposition diagram.

Process Modeling

How to Construct Process Models

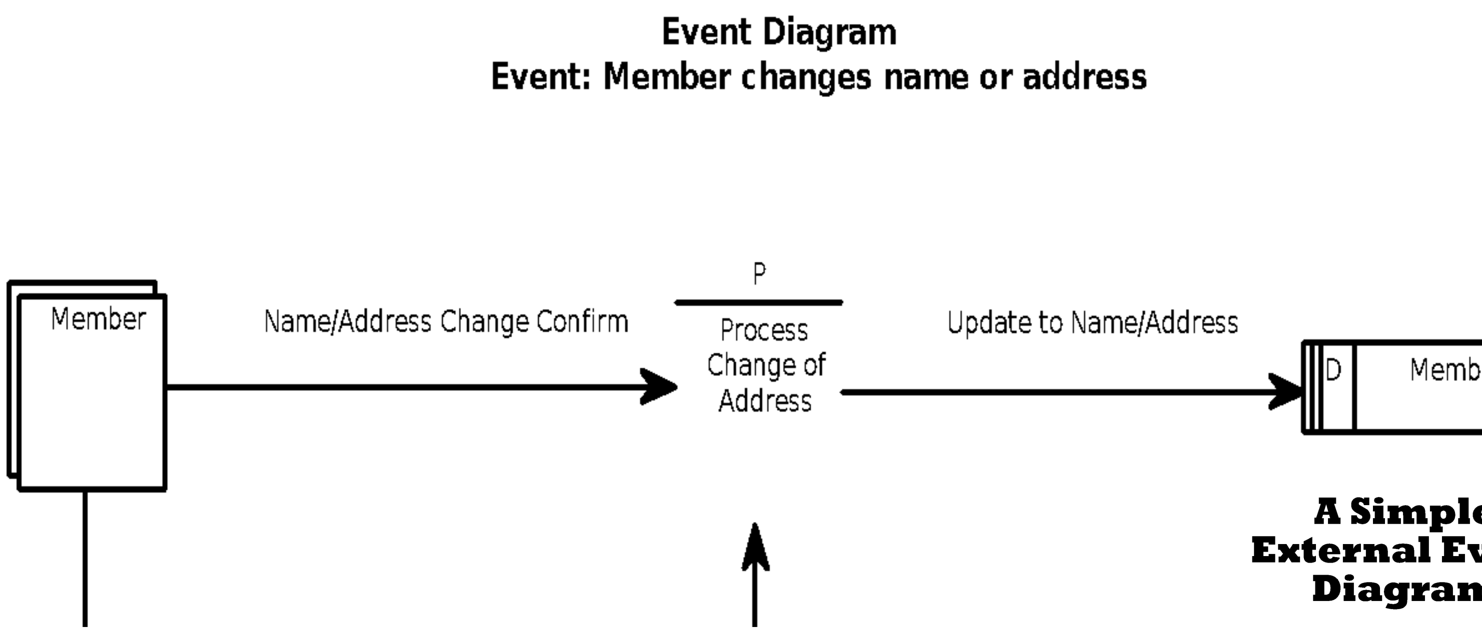
- **The Event Diagram**
  - For each event, illustrate the following:
    - The input(s) and its source(s).
      - Sources are depicted as external agents.
      - The data structure for the input should be recorded in the repository.
    - The outputs and their destinations.
      - Destinations are depicted as external agents.
      - The data structure for the output should be recorded in the repository.

Process Modeling

How to Construct Process Models

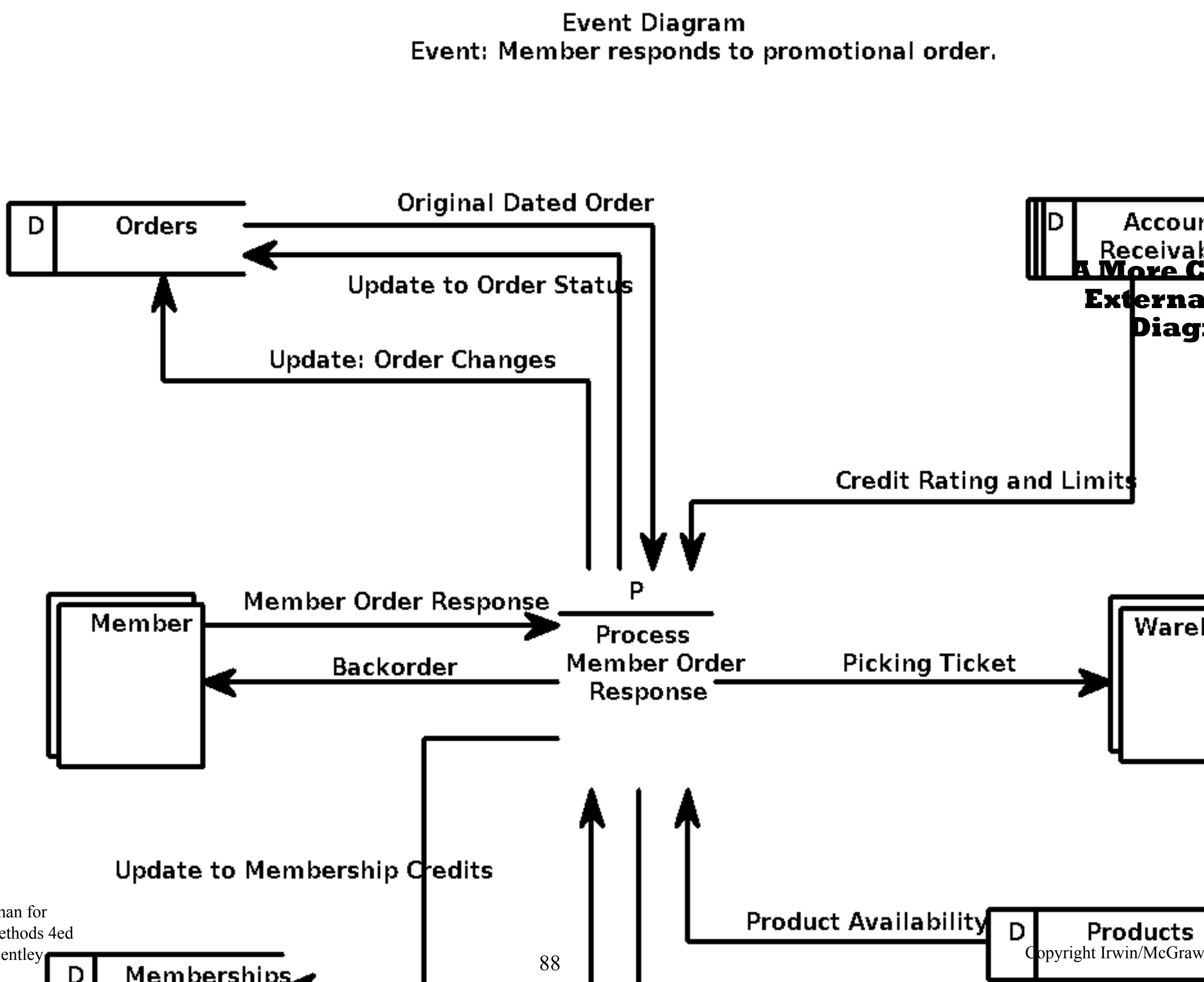
- **The Event Diagram**
  - For each event, illustrate the following: (continued)
    - Any data stores from which records must be ‘read’ should be added to the event diagram.
      - Data flows should be added and named to reflect what data is read by the process.
    - Any data stores in which records must be ‘created’, ‘deleted’, or ‘updated’ should be included in the event diagram.
      - Data flows to the data stores should be named to reflect the nature of the update.

Process Modeling



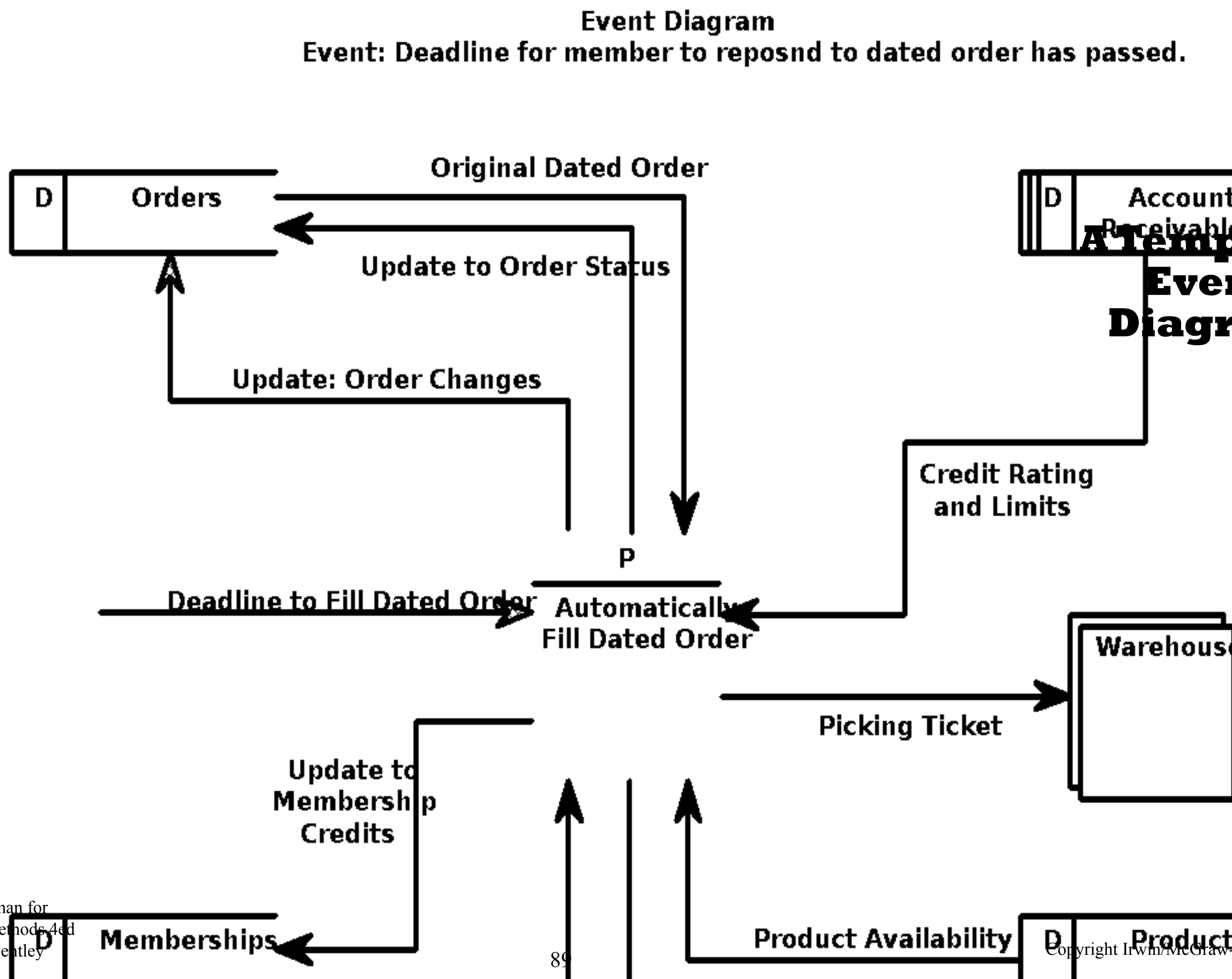
A Simple External Event Diagram

Process Modeling



A More Complex External Event Diagram

Process Modeling



A Temporal Event Diagram

Process Modeling

How to Construct Process Models

- **The Event Diagram**
  - Each event process should be described to the CASE repository with the following properties:
    - Event sentence – for business perspective.
    - Throughput requirements – the volume of inputs per some period of time.
    - Response time requirements – how fast the typical event must be handled.
    - Security, audit, and control requirements.
    - Archival requirements (from a business perspective).
  - All of the above properties can be added to the descriptions associated with the appropriate processes, data flows, and data stores on the model.

Process Modeling

How to Construct Process Models

- **The System Diagram**
  - The system diagram is said to be ‘exploded’ from the single process that was created on the context diagram.
  - The system diagram(s) shows either:
    - all of the events for the system on a single diagram
    - all of the events for a single subsystem on a single diagram
  - Depending on the size of the system, a single diagram may be too large.
  - **Synchronization** is the balancing of data flow diagrams at different levels of detail to preserve consistency and completeness of the models.
    - Synchronization is a quality assurance technique.

Process Modeling

How to Construct Process Models

- **The System Diagram**
  - The event diagram processes are merged into the system diagrams.
  - It is very important that each of the data flows, data stores, and external agents that were illustrated on the event diagrams be represented on the system diagrams.
    - This is called *balancing*.
    - Most CASE tools include facilities to check balancing for errors.

Process Modeling

How to Construct Process Models

- **The System Diagram**
  - When creating a system diagram, do not consolidate data stores – otherwise, you will create balancing errors between the system and event diagrams.
  - You may elect to consolidate some data flows (from event diagrams) into composite data flows on the system diagram.
    - If you do, be sure to use junctions on the event diagrams to demonstrate how the elementary data flows are derived from the composite data flows.

Process Modeling

How to Construct Process Models

Primitive Diagrams

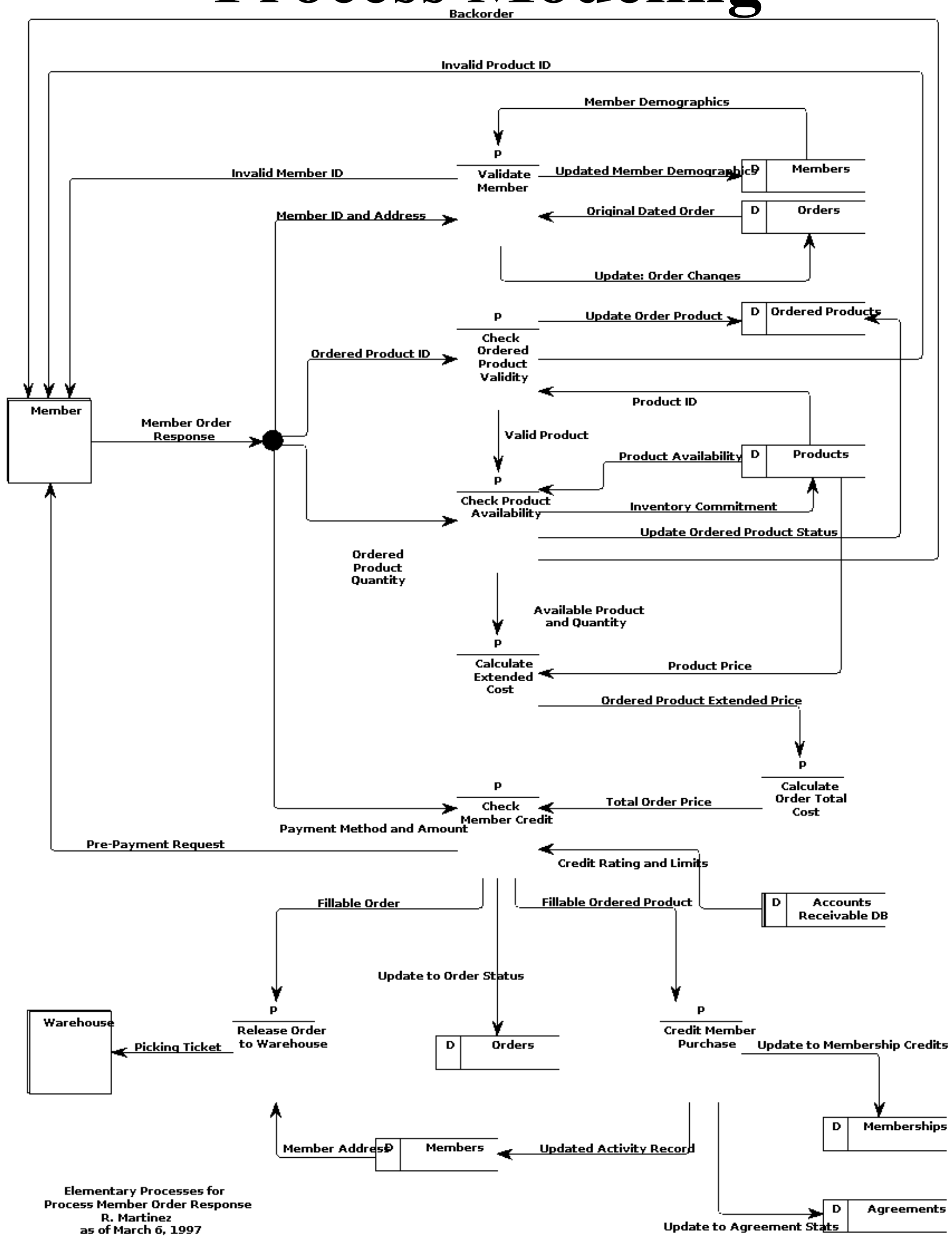
- Each event process on the system diagram(s) must be exploded into either:
  - a procedural description
  - a primitive data flow diagram
- For event processes that are not very complex – in other words, they are both an event and an elementary process, they should be described in one page (usually much less) of Structured English.
- Event processes with more complex event diagrams should be exploded into a more detailed, primitive data flow diagram.

Process Modeling

How to Construct Process Models

- **Primitive Diagrams**
  - A primitive DFD shows detailed processing requirements for the event.
  - A primitive DFD shows several elementary processes *for* the event process.
    - Each elementary process is cohesive – that is, it does only one thing.
    - Each of the elementary processes can now be described with procedural Structured English specifications, and where appropriate, decision tables.

Process Modeling



A Primitive Diagram

Process Modeling

The Next Generation

- **The Next Generation**
  - Process modeling skills remain valuable for two reasons:
    - The current interest of **business process redesign** requires process models.
    - Process models are included in many object modeling strategies such as the *Object Modeling Technique* (OMT).
  - Business process design emphasizes **physical process modeling**.
    - Physical process models include those processes which reflect the current implementation.
      - This may include sequential processes that merely edit, route, copy or approve a data flow.
      - Physical data flow diagrams also include additional details such as who or what performs each process, the cost of each process, and a critical evaluation of the value returned by each process.

Chapter 6.

Process Modeling

Summary

- Introduction
- An Introduction to System Modeling
- System Concepts for Process Modeling
- The Process of Logical Process Modeling
- How to Construct Process Models
- The Next Generation