Chapter 9

Process Modeling

Objectives

- Draw event diagrams and merge them into a system diagram.
- Draw primitive data flow diagrams and describe the elementary data flows in terms of data structures and procedural logic.
- Synchronize(同步) data and process models using a CRUD matrix.

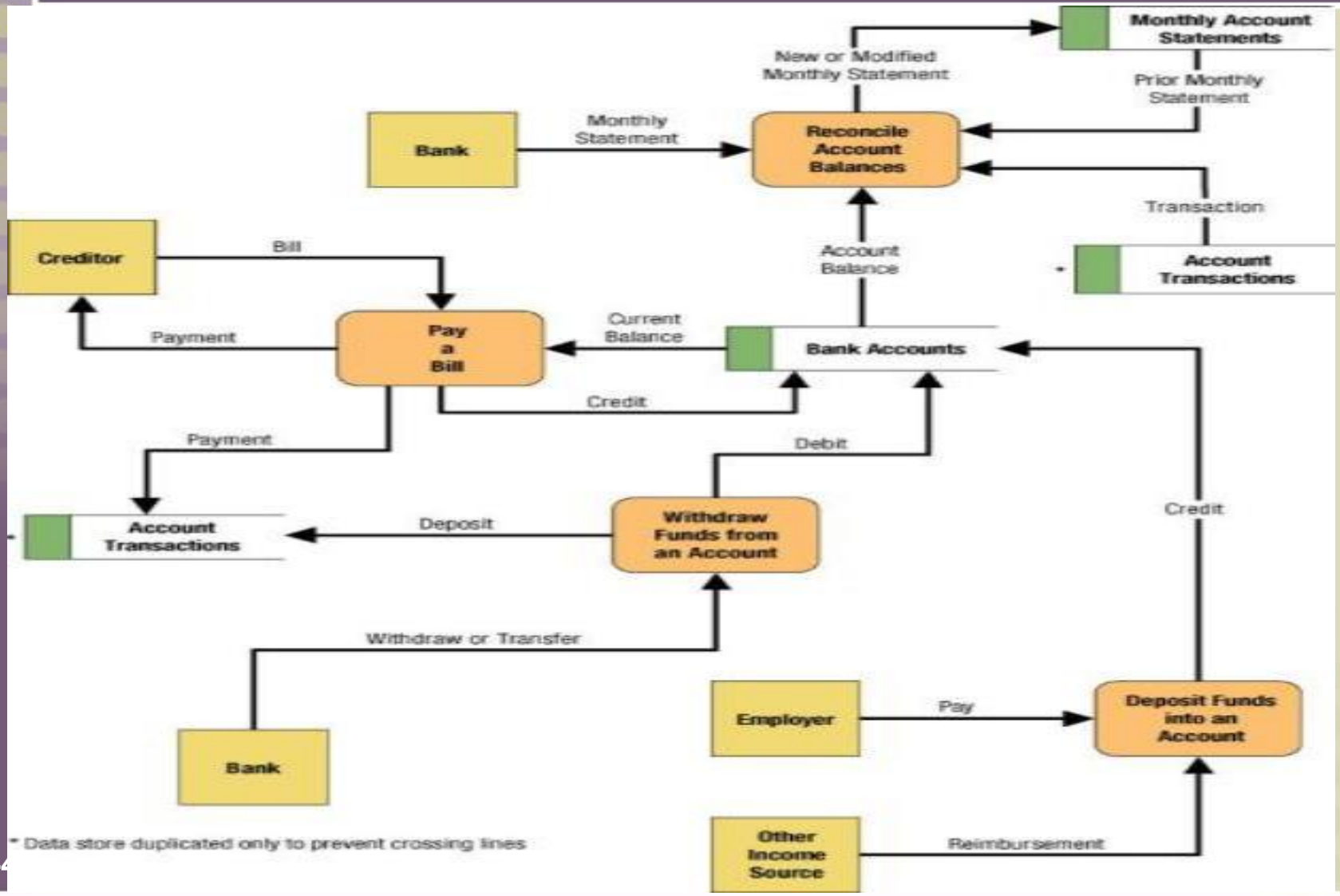
9.1Process Modeling and DFDs

Process modeling – a technique used to organize and document the structure and flow of data through a system's processes.

Data flow diagram (DFD) – a process model used to depict the flow of data through a system and the work or processing performed by the system. Synonyms are bubble chart, transformation graph, and process model.

- The DFD has also become a popular tool for business process redesign.

Simple Data Flow Diagram



9.2 External Agents

External agent – an outside person, unit, system, or organization that interacts with a system. Also called an *external entity*.

- External agents define the "boundary" or scope of a system being modeled.
- As scope changes, external agents can become processes, and vice versa.
- Almost always one of the following:
  - Office, department, division.
  - An external organization or agency.
  - Another business or another information system.
  - One of system's end-users or managers
- Named with descriptive, singular noun

Gane and Sarson shape

DeMarco/Yourdon shape

Data Stores

Data store – stored data intended for later use. Synonyms are *file* and *database*.

- Frequently implemented as a file or database.
- A data store is "data at rest" compared to a data flow that is "data in motion."
- Almost always one of the following:
  - Persons (or groups of persons)
  - Places
  - Objects
  - Events (about which data is captured)
  - Concepts (about which data is important)
- Data stores depicted on a DFD store all instances of data entities (depicted on an ERD)
- Named with plural noun

Gane and Sarson shape

DeMarco/Yourdon shape

Process Concepts

Process – work performed by a system in response to incoming data flows or conditions. A synonym is *transform(转换)* .

- All information systems include processes - usually many of them
- Processes respond to business events and conditions and transform data into useful information

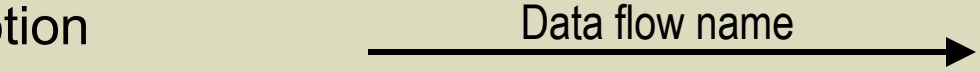
Gane and Sarson shape

- Modeling processes helps us to understand the interactions with the system's environment, other systems, and other processes.
- Named with a strong action verb followed by object clause describing what the work is performed on/for .

Data Flows & Control Flows

Data flow – data that is input to or output from a process.

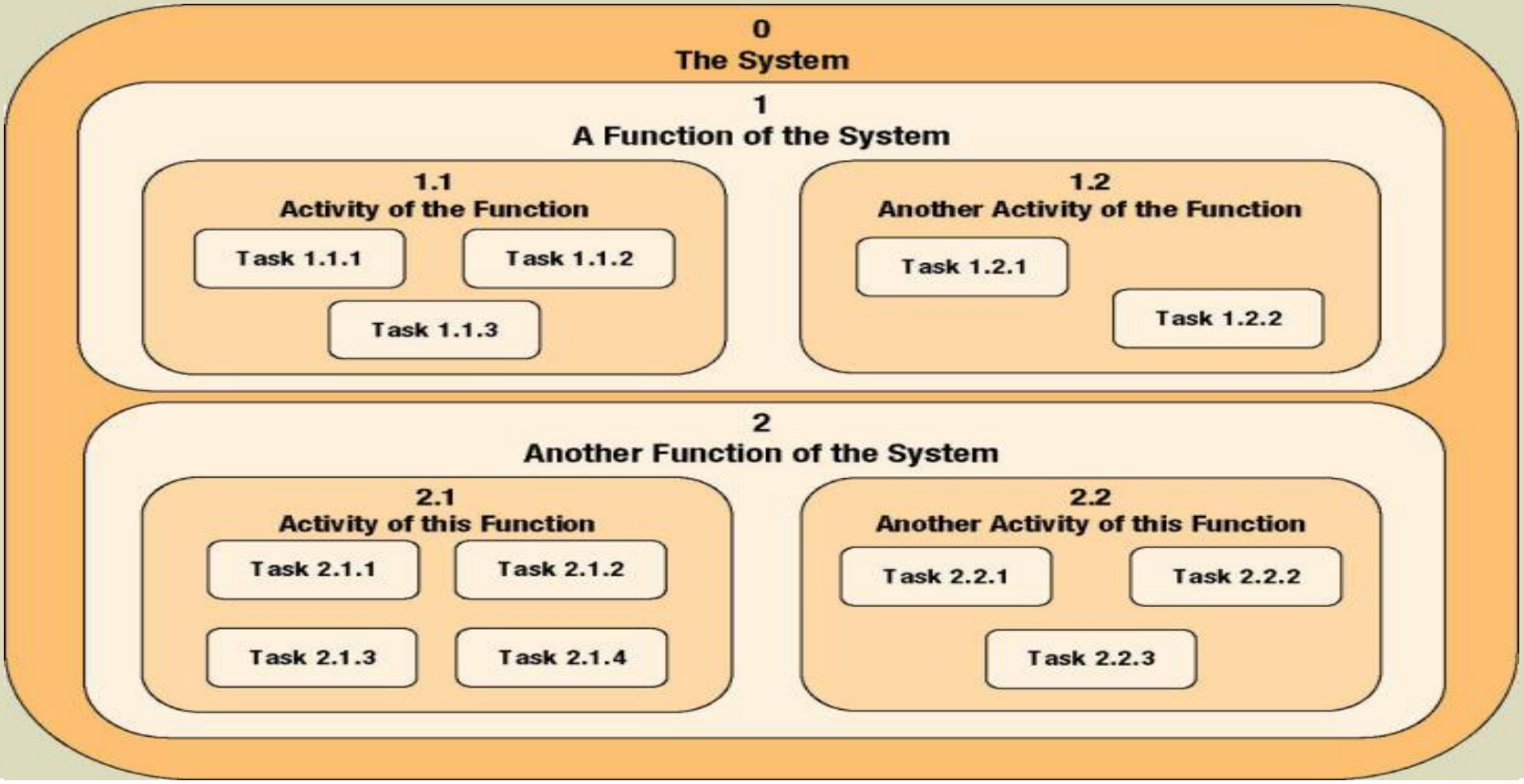
- A data flow is data in motion
- A data flow may also be used to represent the creation, reading, deletion, or updating of data in a file or database (called a data store).



Composite data flow – a data flow that consists of other data flows.

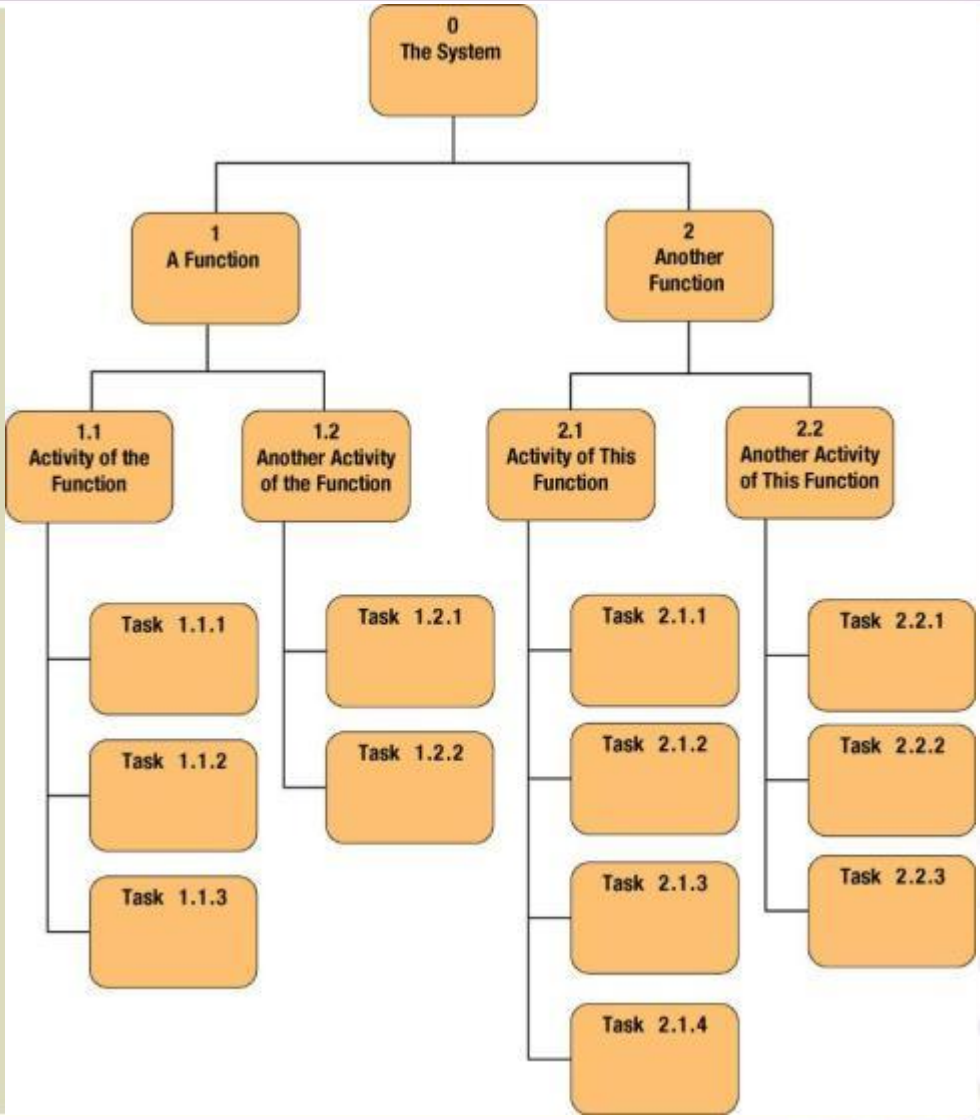
Process Decomposition

Decomposition – the act of breaking a system into sub-components. Each level of abstraction reveals more or less detail.



Decomposition Diagrams

Decomposition diagram – a tool used to depict the decomposition of a system. Also called hierarchy chart.



Types of Logical Processes

Function – a set of related and ongoing activities of a business.

- A function has no start or end. Eg. Order management

Event – a logical unit of work that must be completed as a whole. Sometimes called a *transaction*.

- Triggered by a discrete input and is completed when process has responded with appropriate outputs.
- Functions consist of processes that respond to events.

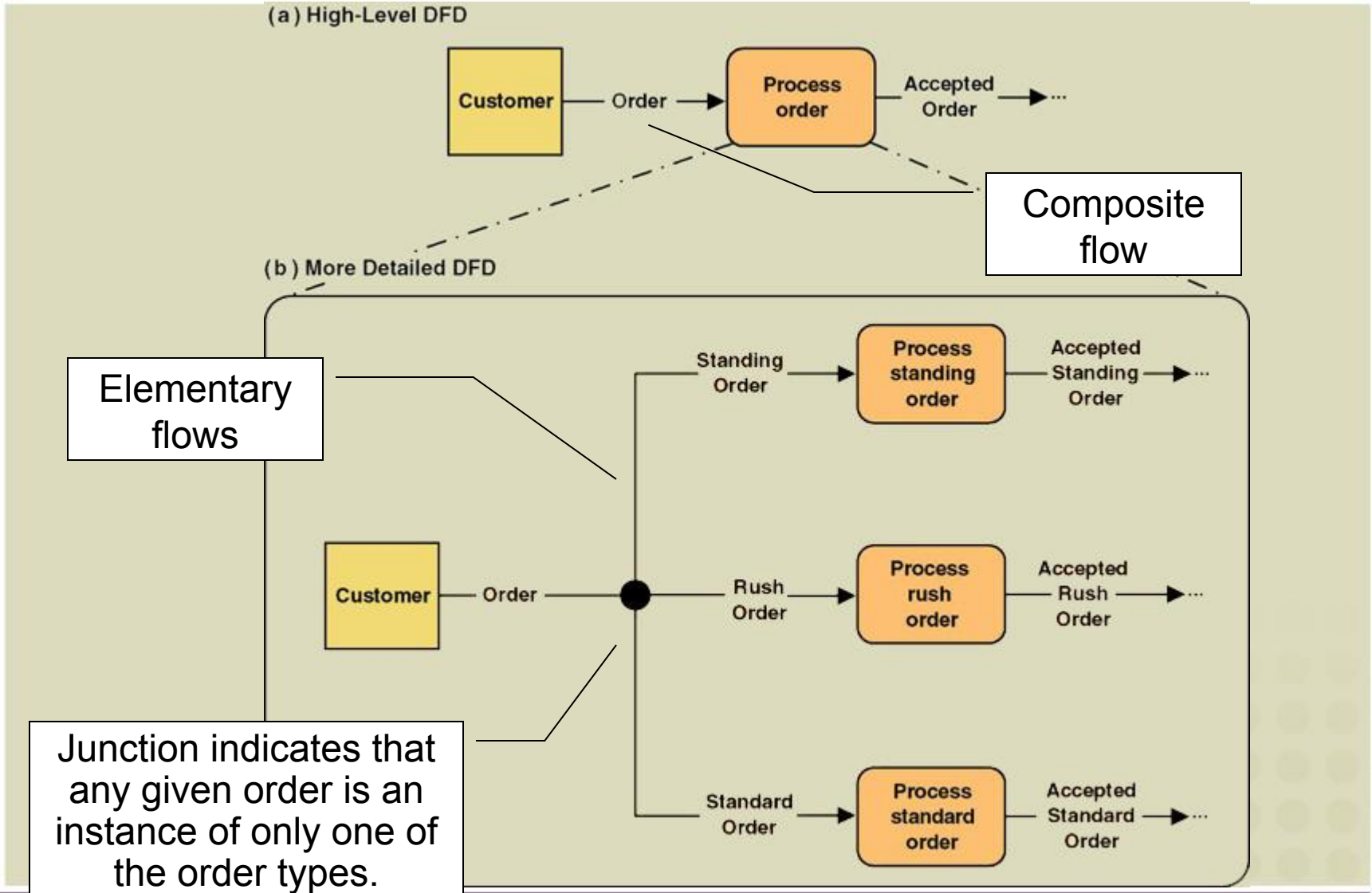
eg. process order

Elementary process – a discrete, detailed activity or task required to complete the response to an event. Also called a *primitive process*.

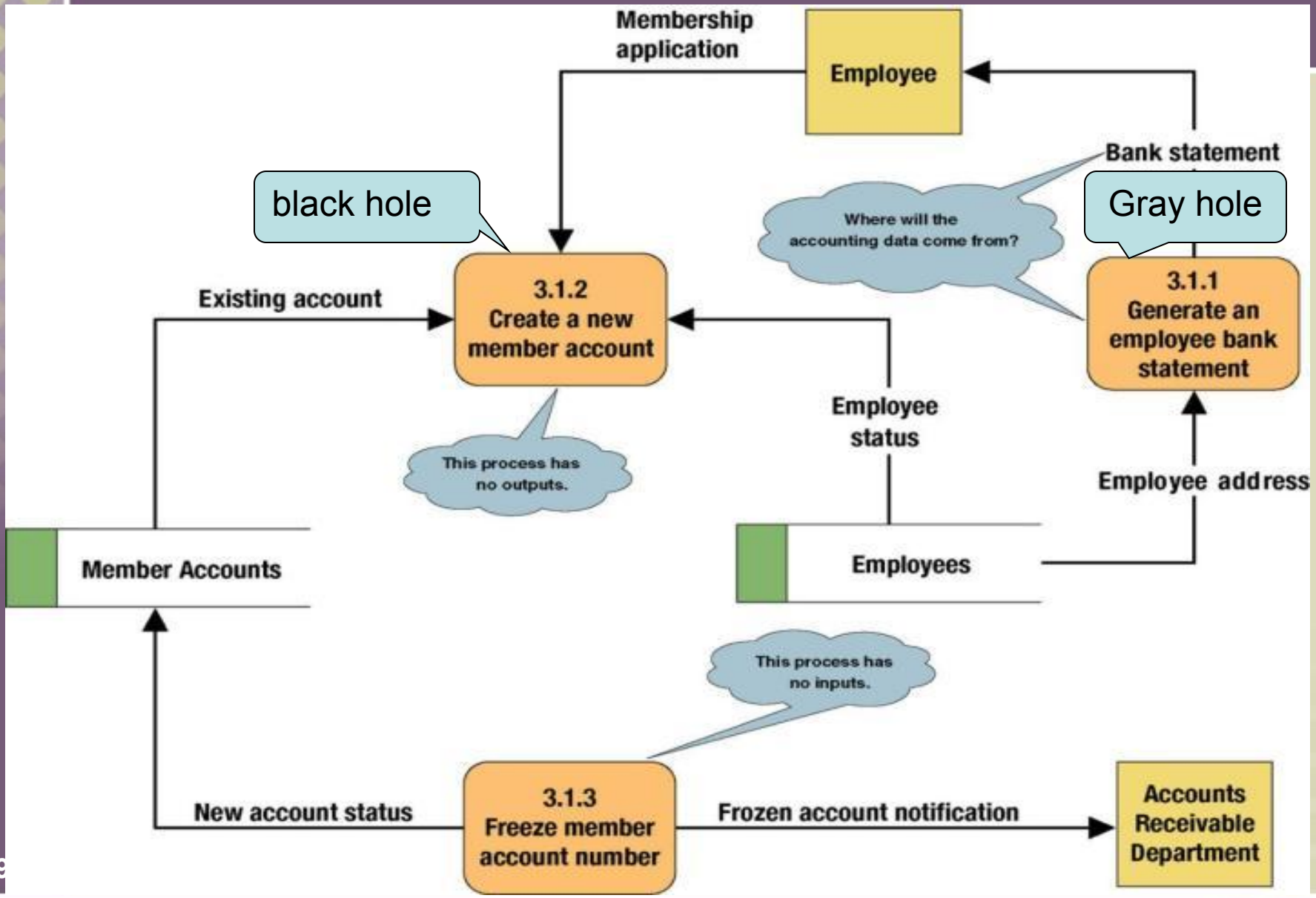
- The lowest level of detail depicted in a process model.

Eg. Calculate order cost

Composite and Elementary Data Flows

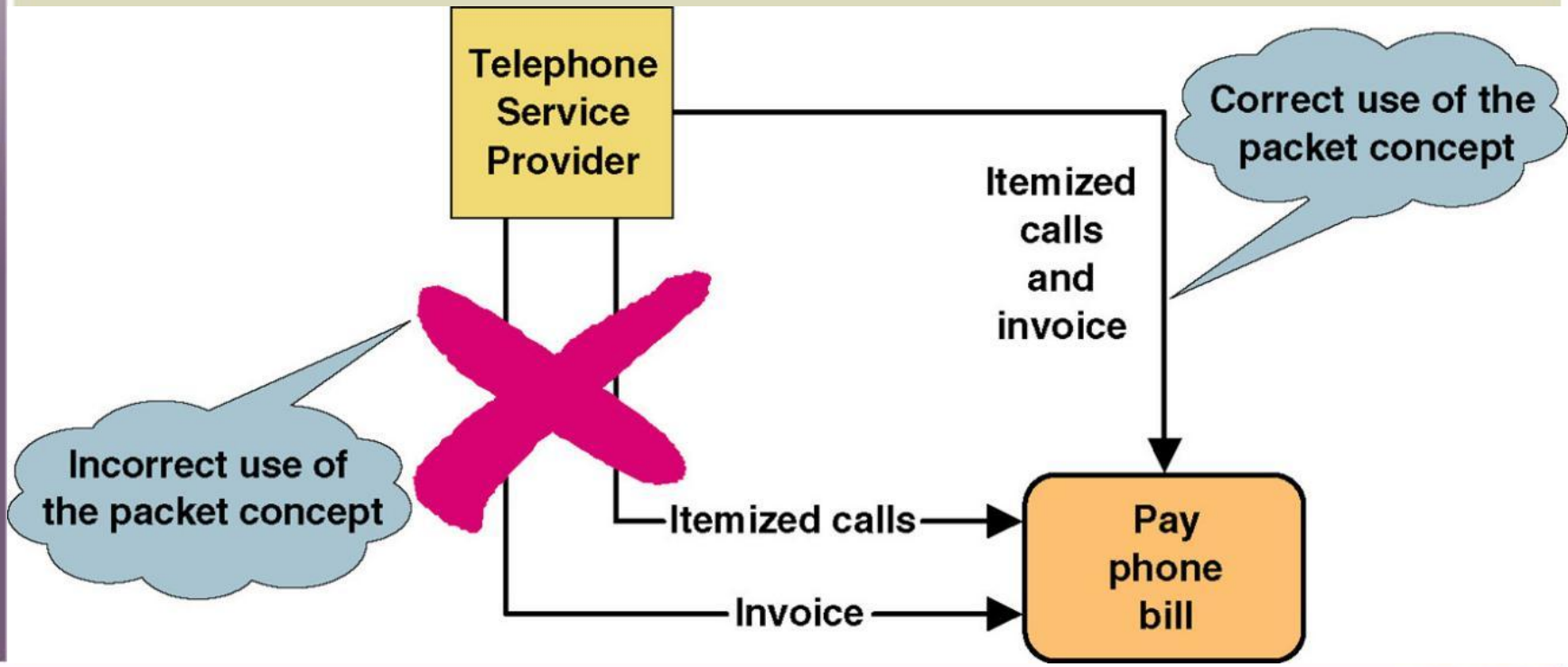


Common Process Errors on DFDs

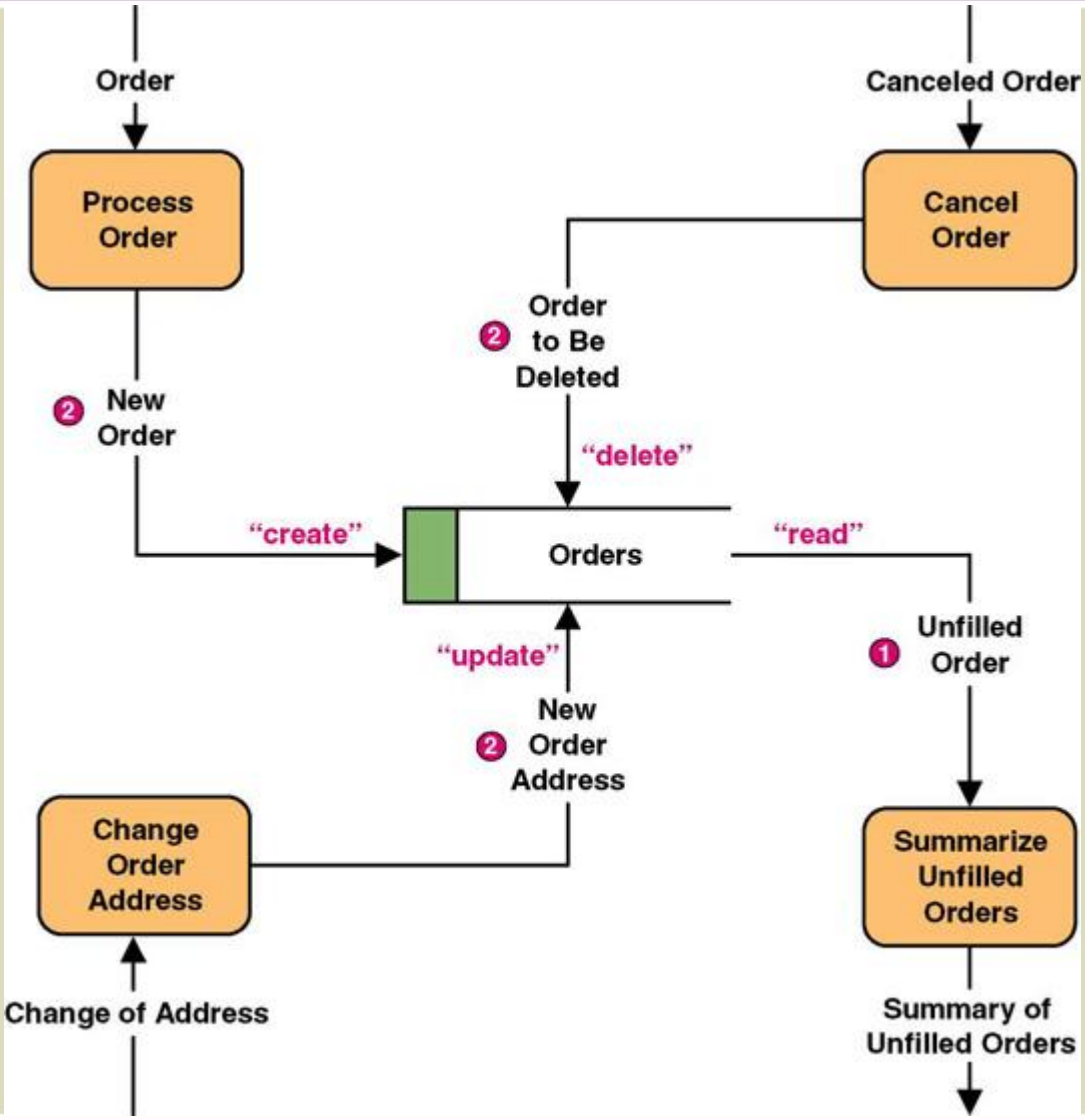


Data Flow Packet Concept(报文)

- Data that should travel together should be shown as a single data flow, no matter how many physical documents might be included.

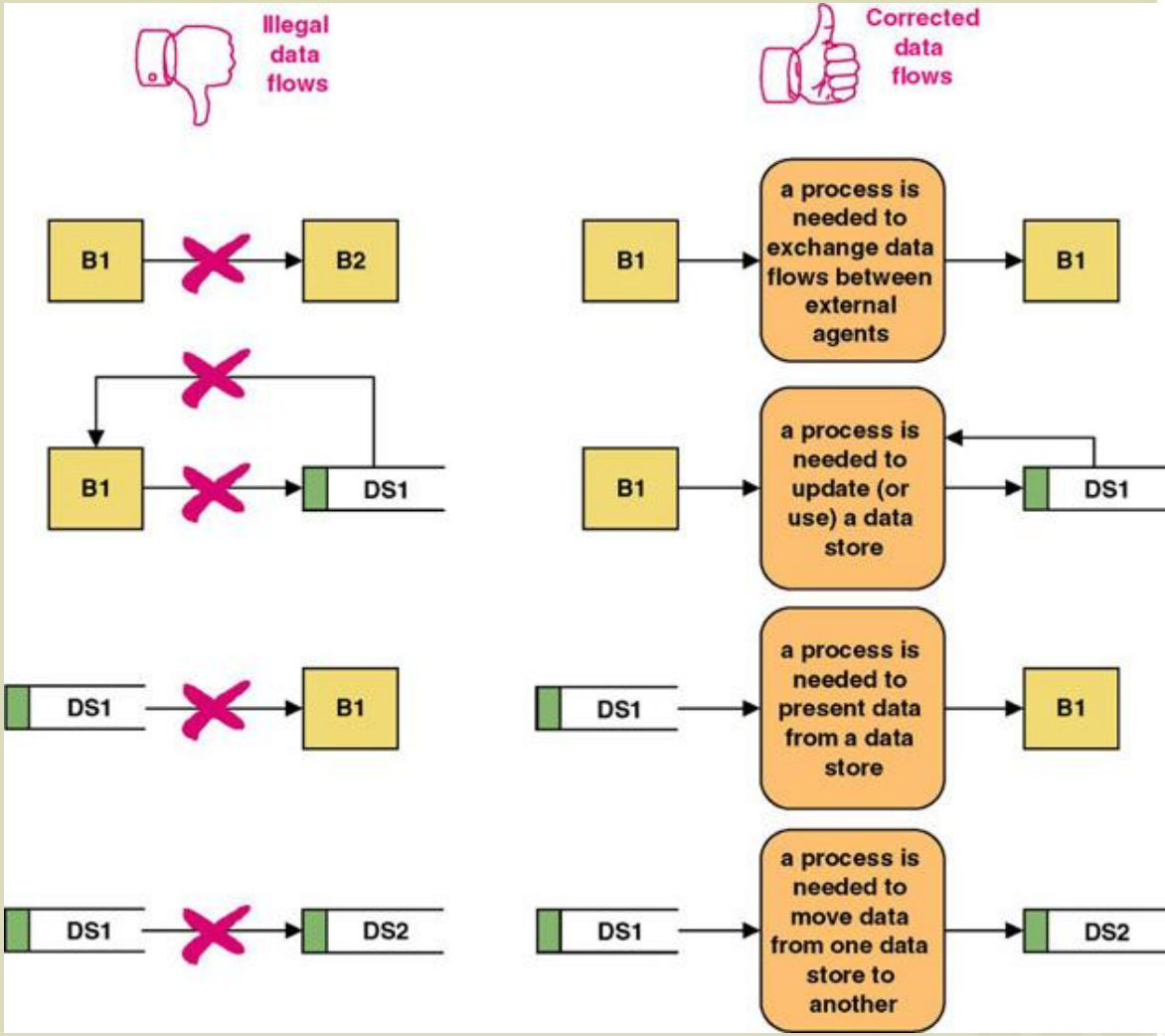


Data Flows to and from Data Stores



Rules for Data Flows

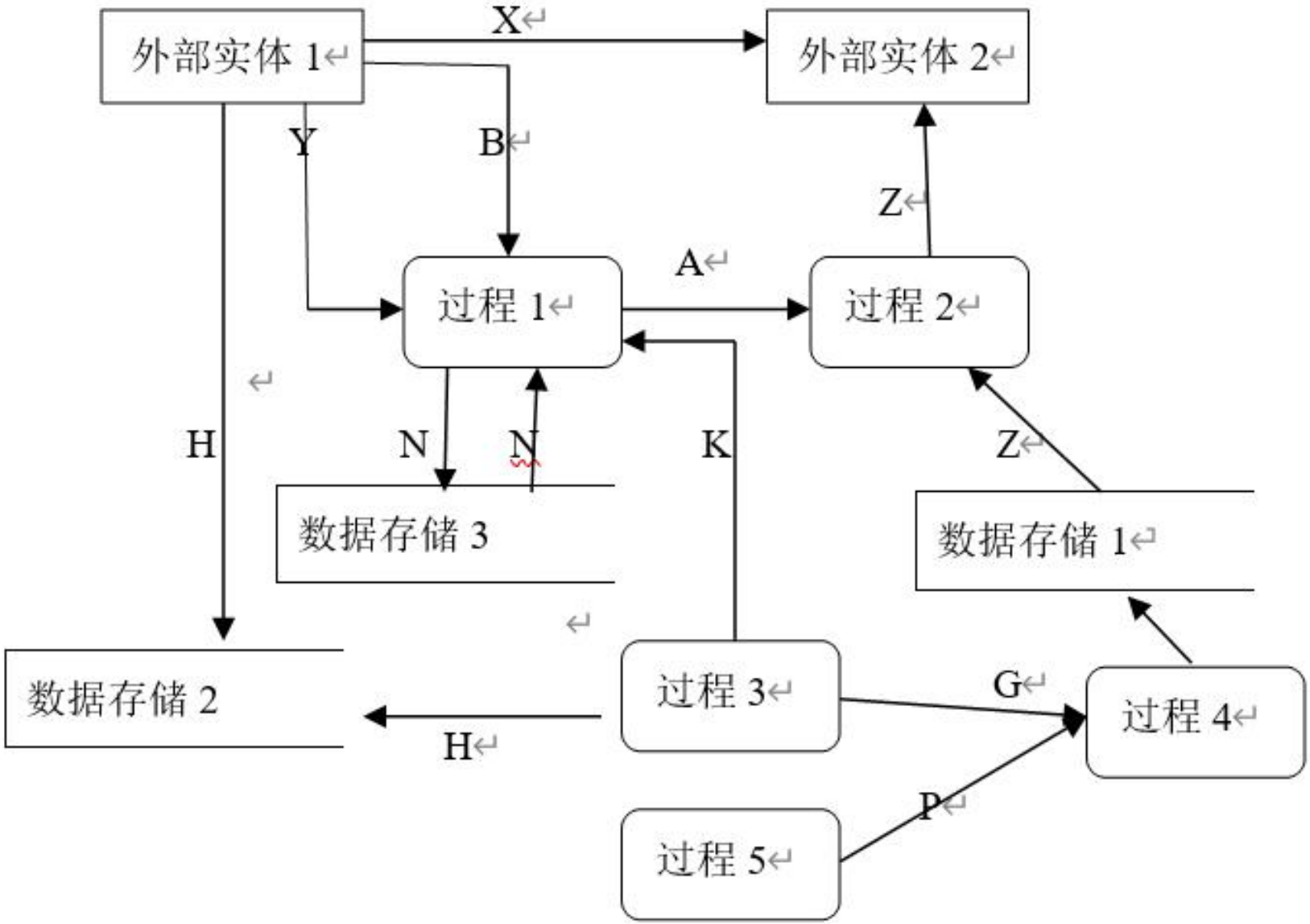
- A data flow should never go unnamed.
- In logical modeling, data flow names should describe the data flow without describing the implementation
- All data flows must begin and/or end at a process.



Data Conservation数据流的守恒

Data conservation – the practice of ensuring that a data flow contains only data needed by the receiving process.

- Sometimes called *starving the processes*.
- Must precisely define the data composition of each data flow, expressed in the form of *data structures*.


外部实体 1
X
外部实体 2
Y
B
Z
过程 1
A
过程 2
H
N
N
K
Z
数据存储 3
数据存储 1
数据存储 2
过程 3
G
过程 4
H
P
过程 5

Data Structures

Data attribute – the smallest piece of data that has meaning to the users and the business.

Data structure – a specific arrangement of data attributes that defines an instance of a data flow.

- The data attributes that comprise a data flow are organized into data structures.
- 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.

Data Structure for a Data Flow

DATA STRUCTURE	ENGLISH ENTERPRETATION
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)	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 equivalent 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
ADDRESS= (POST OFFICE BOX NUMBER)+ STREET ADDRESS+ CITY+ [STATE, MUNICIPALITY]+ (COUNTRY)+ POSTAL CODE	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

Data Structure Constructs

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+** **TAXPAYER NAME+** **TAXPAYER ADDRESS+** **WAGES, TIPS, AND COMPENSATION+** **FEDERAL TAX WITHHELD+…**	An instance of WAGE AND TAX STATEMENTS 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 or ORDER consists of: **Either PERSONAL CUSTOMER NUMBER or CORPORATE ACCOUNT NUMBER;** and ORDER DATE and…

Data Structure Constructs (continued)

Data Structure	Format by Example (relevant portion is **boldfaced**	English Interpretation (relevant portion is **boldfaced**)
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 specific number of time 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.	POLICY NUMBER+ POLICYHOLDER NAME+ POLICY HOLDER 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 instance of:** **DEPENDENT NAME and** **DEPENDENT'S RELATIONSHIP and** **one or more instances of:** **EXPENSE DESCRIPTION and** **SERVICE PROVIDER and** **EXPENSE ACCOUNT**

Data Structure Constructs (concluded)

Data Structure	Format by Example (relevant portion is **boldfaced**	English Interpretation (relevant portion is **boldfaced**)
Optional Attributes - The optional notation indicates that an attribute, or group of attributes in a sequence or selection date structure may not be included in 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 reused in other data structures.	DATE= MONTH+ DAY+ YEAR+	Then, the reusable structures can be included in other data flow structures as follows: ORDER=ORDER NUMBER…+DATE INVOICE=INVOICE NUMBER…+DATE PAYMENT=CUSTOMER NUMBER…+DATE

Data Types and Domains

Data attributes should be defined by data types and domains.

Data type - a class of data that be stored in an attribute.

- Character, integers, real numbers, dates, pictures, etc.

Domain – the legitimate values for an attribute.

Diverging and Converging Data Flows

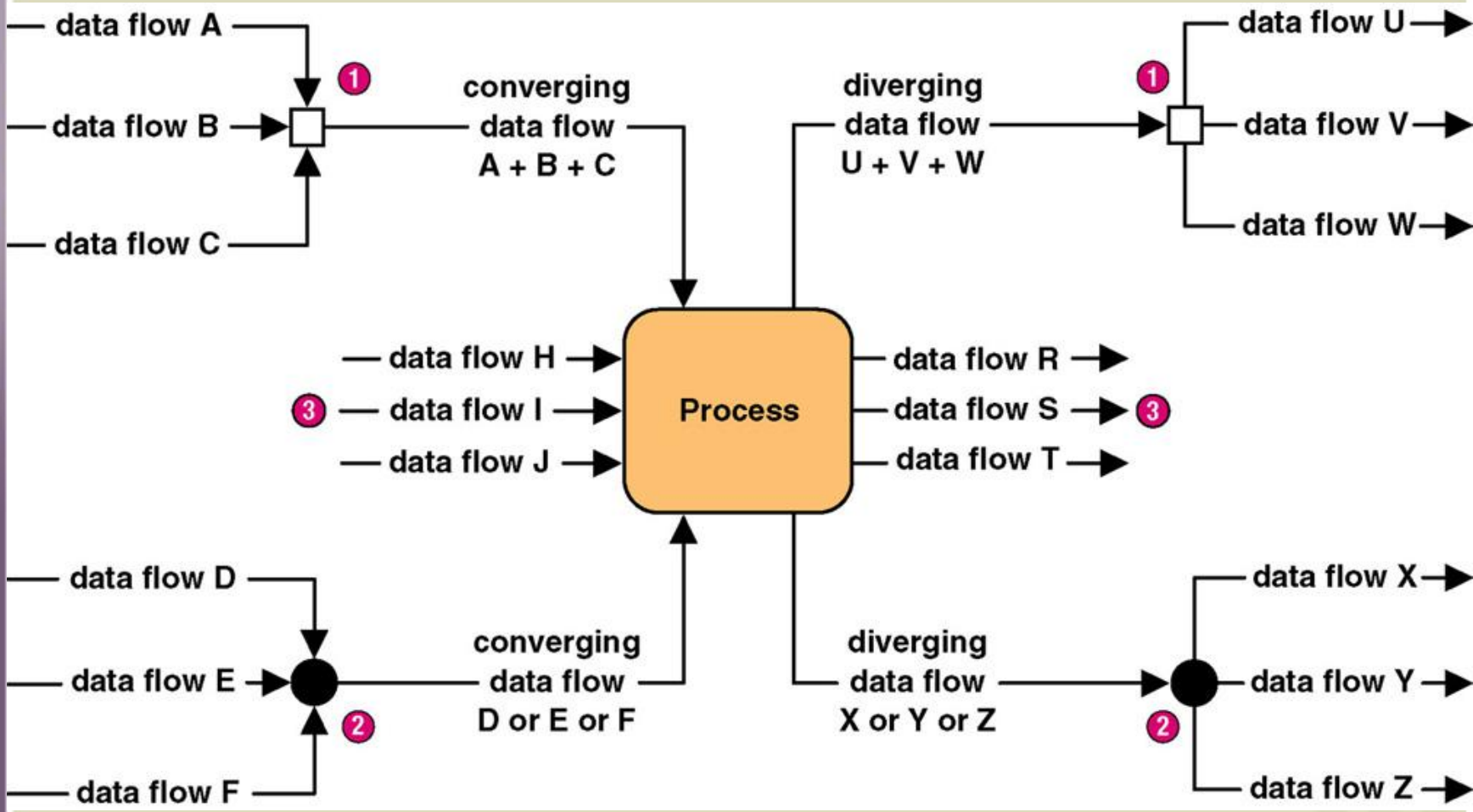
Diverging data flow （分支数据流）– a data flow that splits into multiple data flows.

- Indicates data that starts out naturally as one flow, but is routed to different destinations.
- Also useful to indicate multiple copies of the same output going to different destinations.

Converging data flow （合并数据流）– the merger of multiple data flows into a single packet.

- Indicates data from multiple sources that can (must) come together as a single packet for subsequent processing.

Diverging and Converging Data Flows



Modern Structured Analysis (More Commonly Practiced)

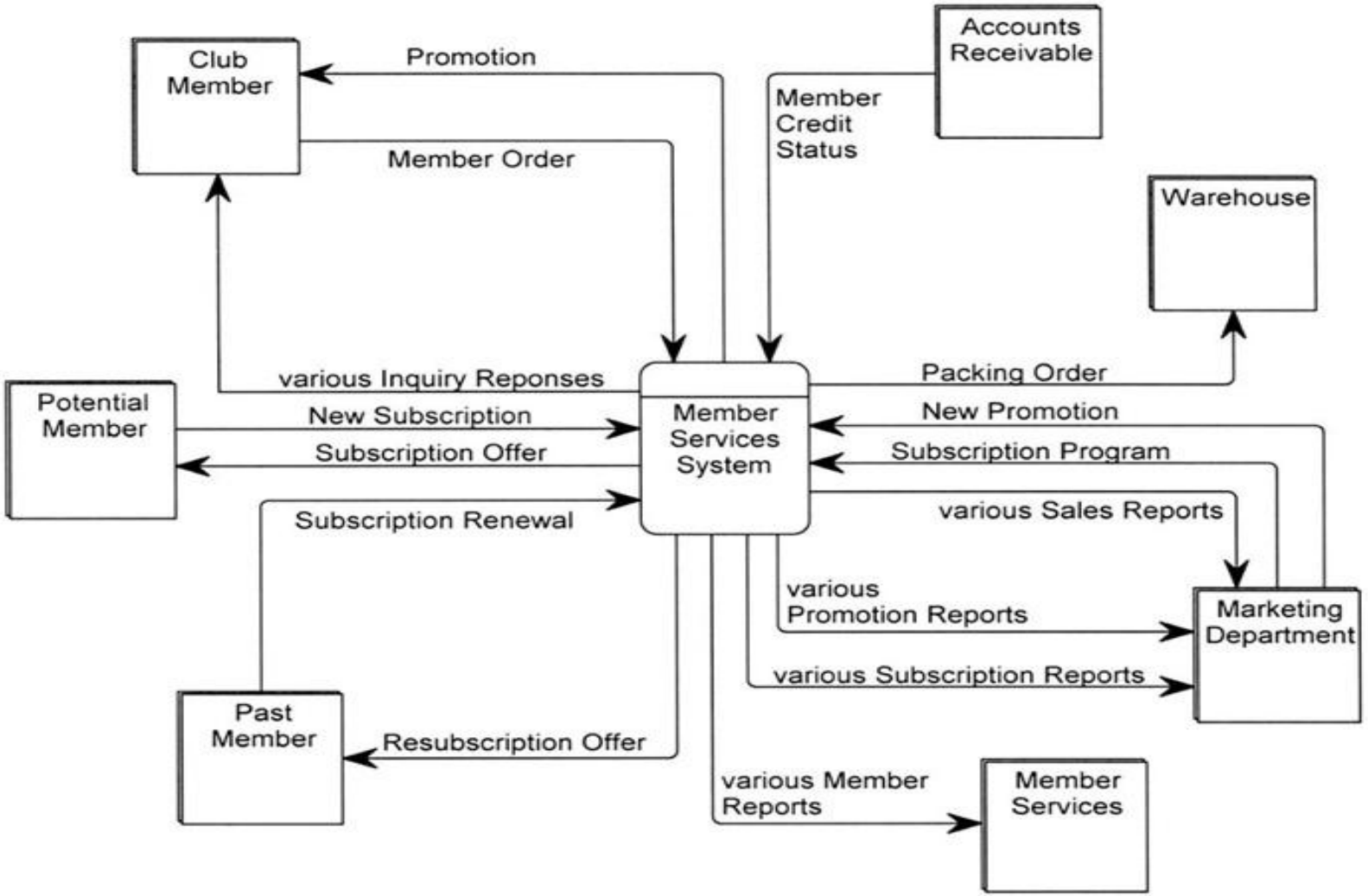
1. Draw context DFD to establish initial project scope.
2. Draw functional decomposition diagram to partition the system into subsystems.
3. Create event-response or use-case list for the system to define events for which the system must have a response.
4. Draw an event DFD for each event.
5. Merge event DFDs into a system diagram (or, for larger systems, subsystem diagrams).
6. Draw detailed, primitive DFDs for the more complex event.
7. Document data flows and processes in data dictionary.

9.4 Context Data Flow Diagram

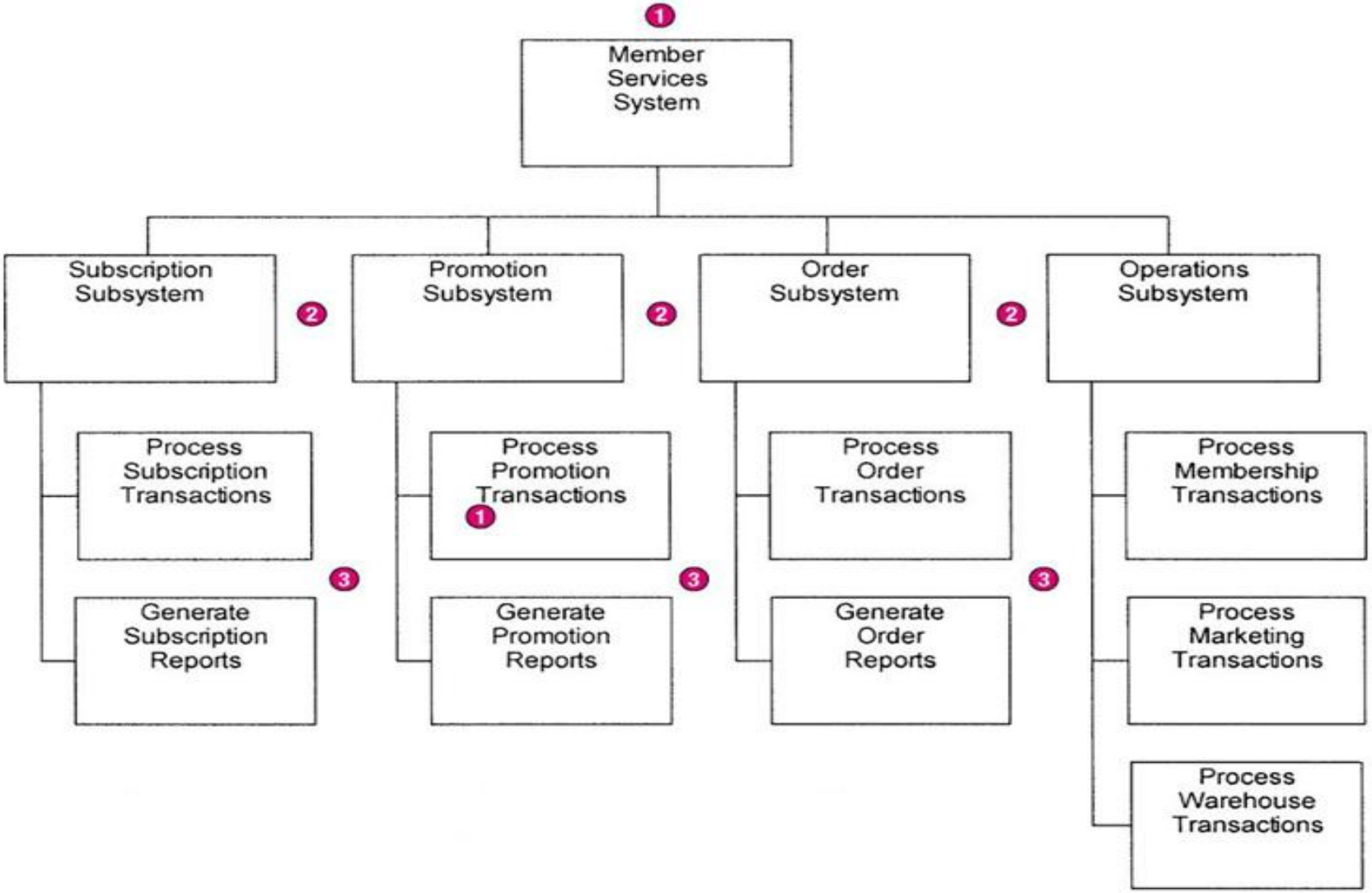
- **Context data flow diagram** - a process model used to document the scope for a system. Also called the environmental model.

1. Think of the system as a "black box."
2. Ask users what business transactions the system must respond to. These are inputs, and the sources are external agents.
3. Ask users what responses must be produced by the system. These are outputs, and the destinations are external agents.
4. Identify any external data stores, if any.
5. Draw a context diagram.

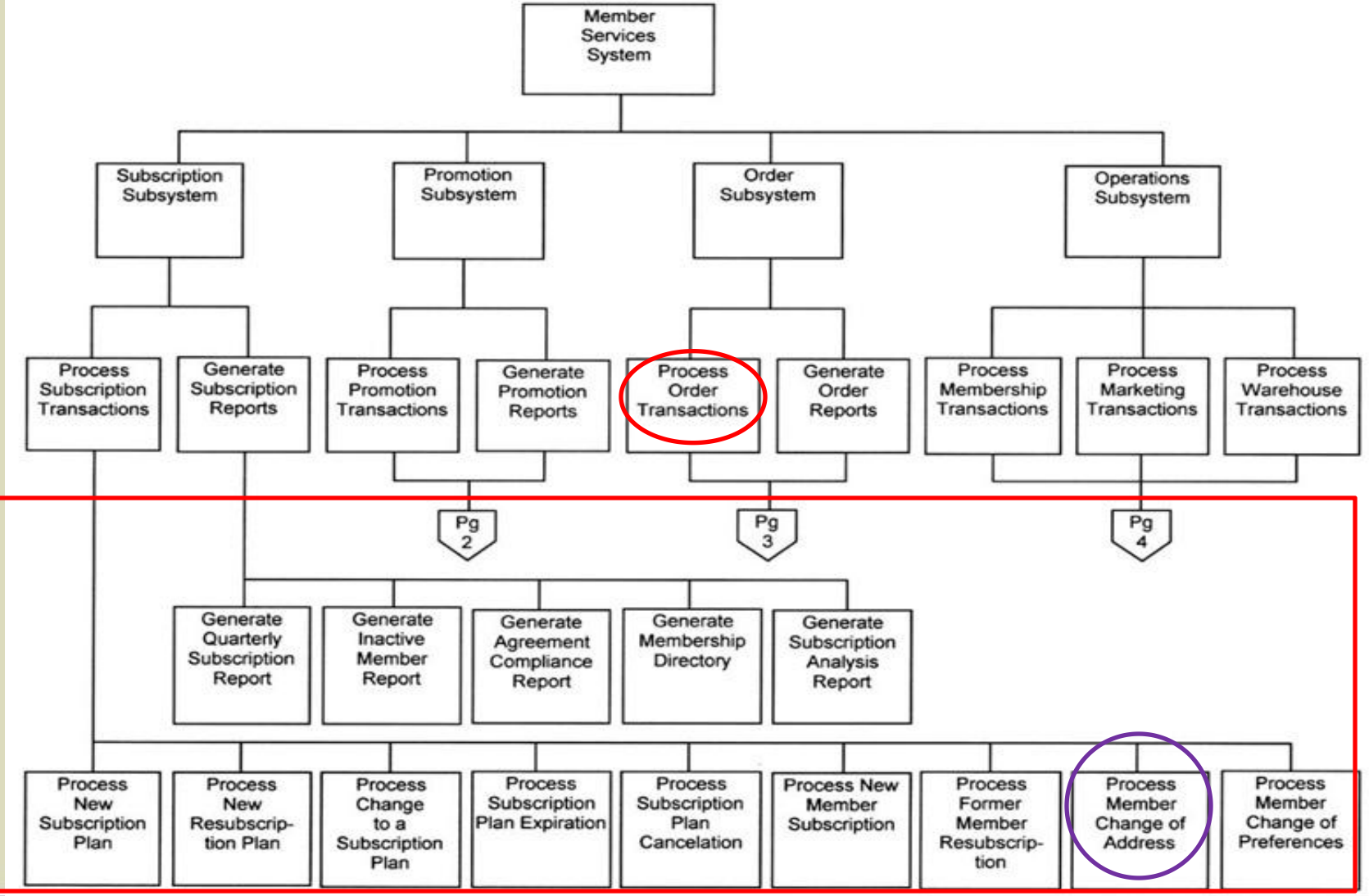
SoundStage Context DFD



SoundStage Functional Decomposition Diagram



SoundStage Partial Event Decomposition Diagram(事件分解图)



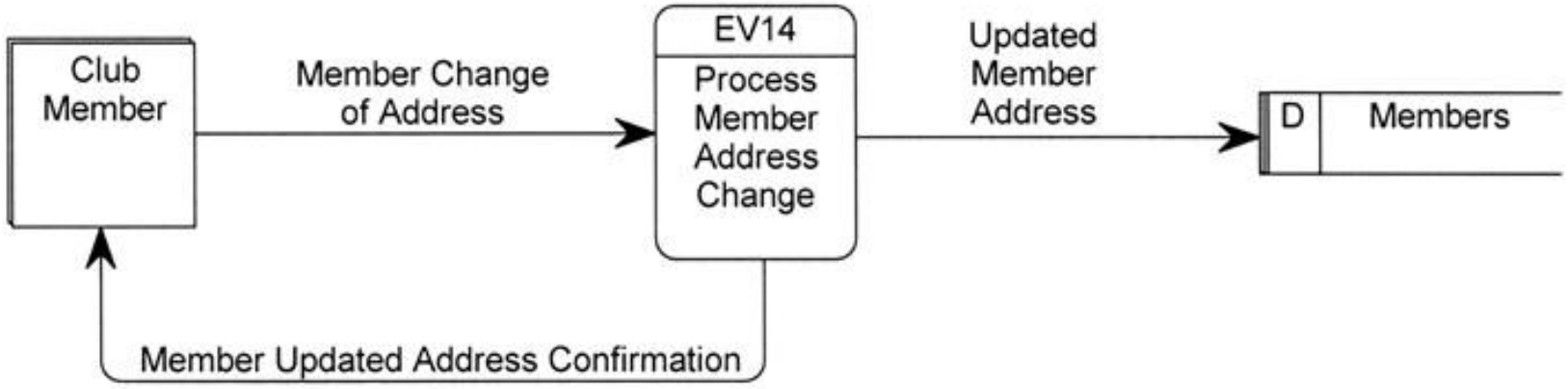
Event Diagrams(事件图)

Event diagram – data flow diagram that depicts the context for a single event.

- One diagram for each event process
- Depicts
  - Inputs from external agents
  - Outputs to external agents
  - Data stores from which records must be "read." Data flows should be added and named to reflect the data that is read.
  - Data stores in which records must be created, deleted, or updated. Data flows should be named to reflect the update.

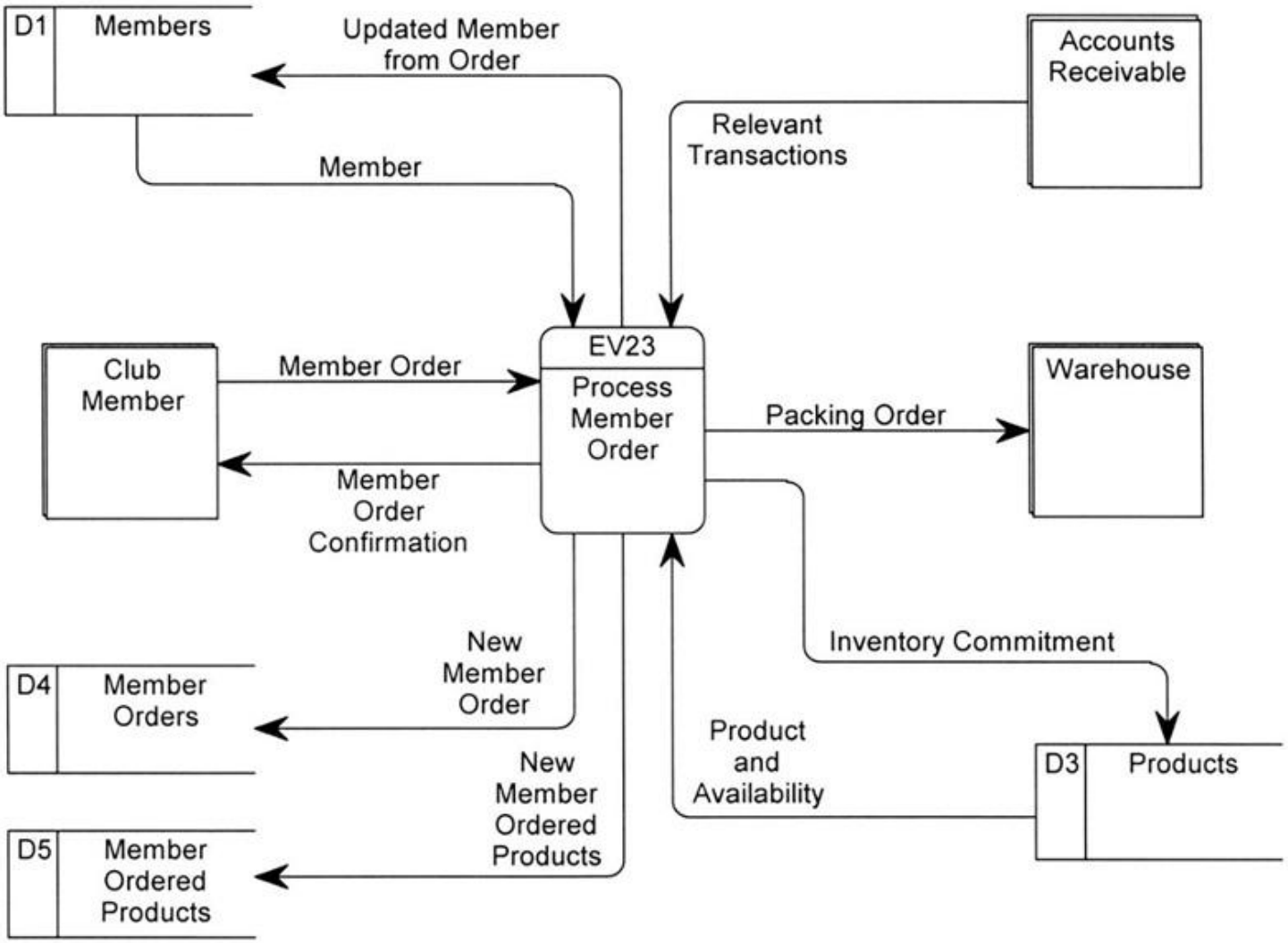
对数据存储的常规维护

Simple Event Diagram

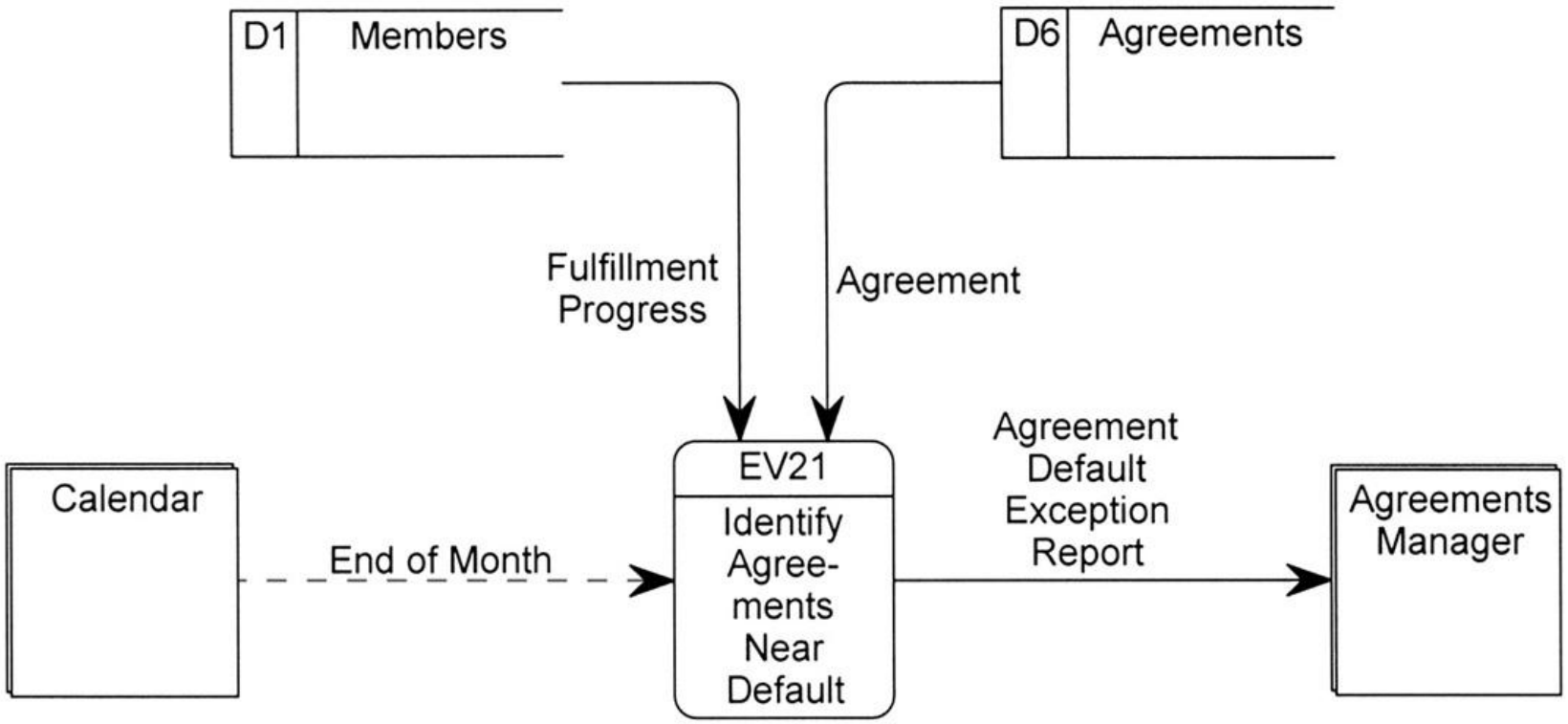


一个事件中可以有多个过程（3个以内），大多数事件过程不直接互相沟通，它们通过共享的数据存储进行沟通。

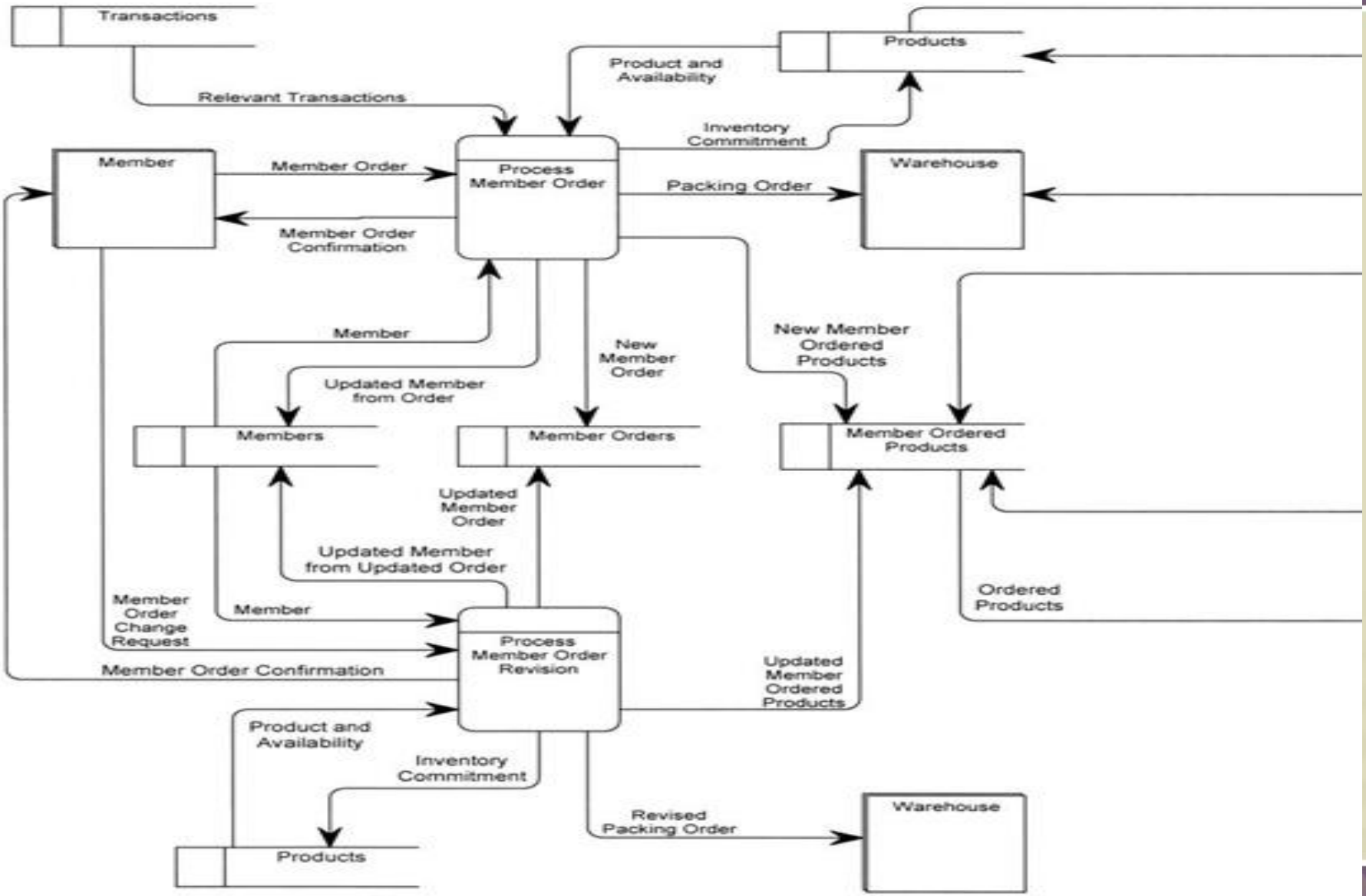
Event Diagram (more complex)



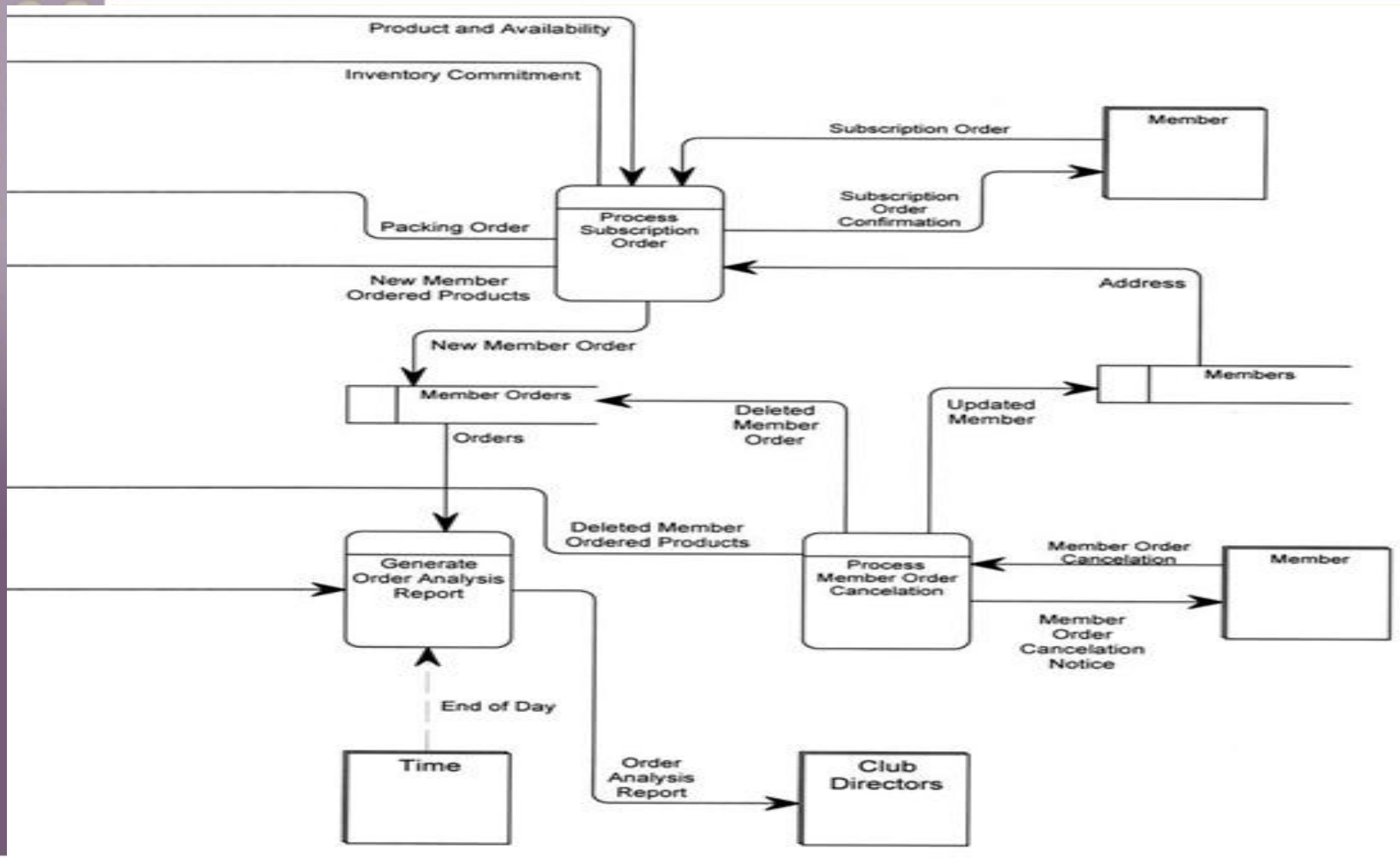
Temporal Event Diagram



System DFD系统图 P244



System DFD (concluded)



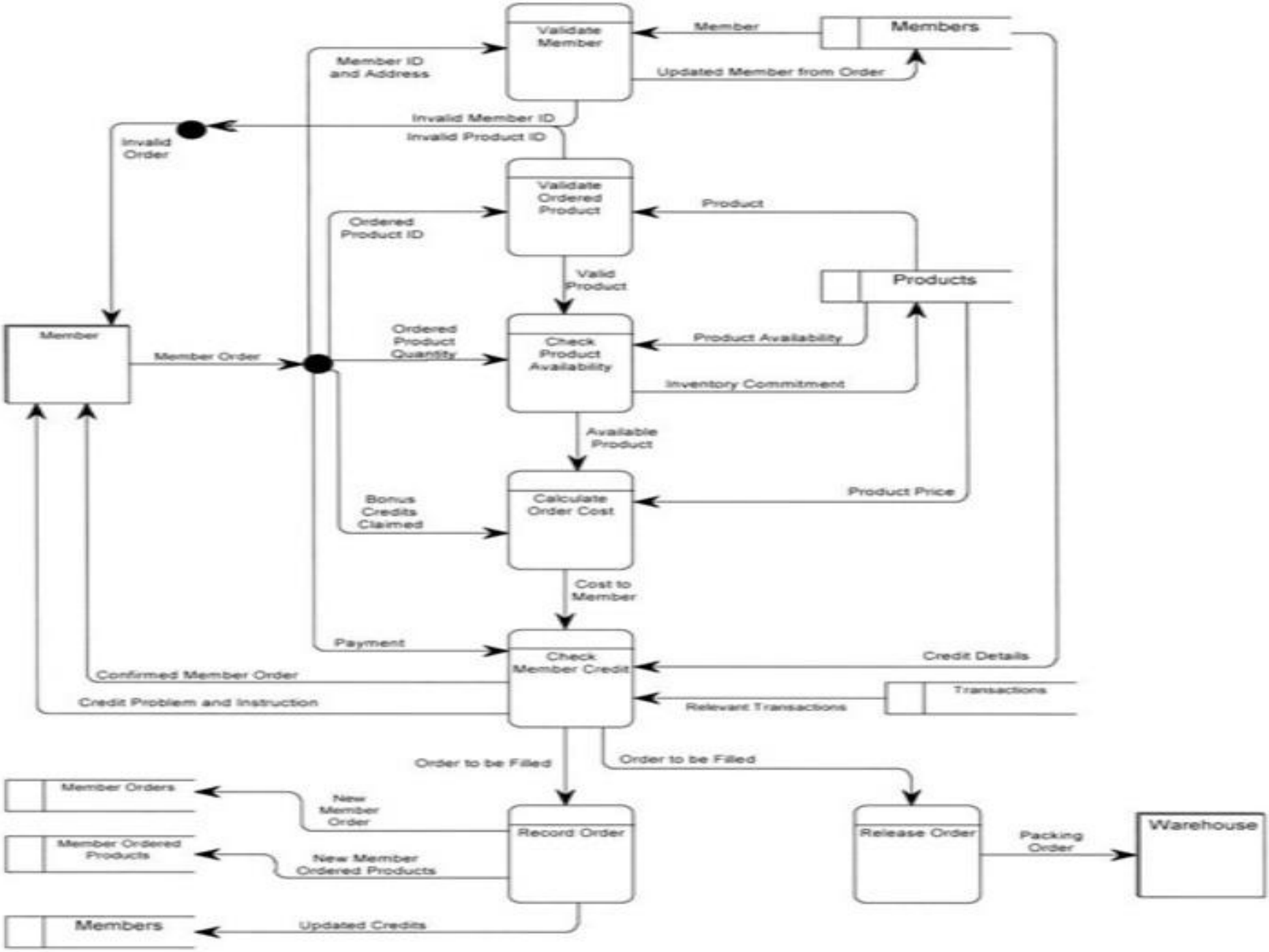
Balancing

Balancing - a concept that requires that data flow diagrams at different levels of detail reflect consistency and completeness

- Quality assurance technique
- Requires that if you explode a process to another DFD to reveal more detail, you must include the same data flows and data stores

Primitive Diagrams(基本图)

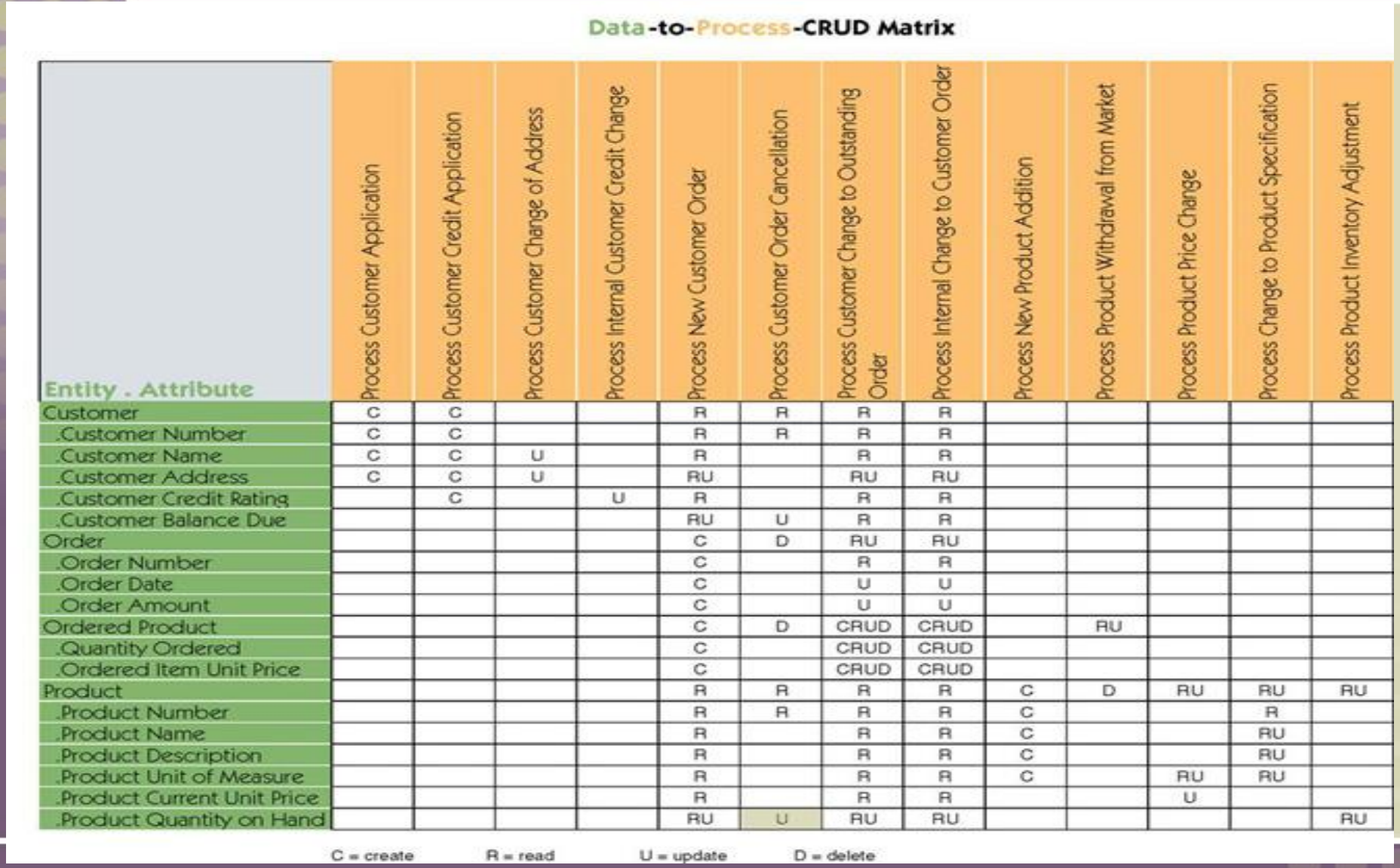
- Some (not necessarily all) event processes may be exploded into primitive diagrams to reveal more detail.
  - Complex business transaction processes
  - Process decomposed into multiple elementary processes
  - Each elementary process is cohesive - it does only one thing
  - Flow similar to computer program structure


Validate Member
Member
Members
Member ID and Address
Updated Member from Order
Invalid Member ID
Invalid Product ID
Invalid Order
Validate Ordered Product
Product
Ordered Product ID
Valid Product
Products
Member
Member Order
Ordered Product Quantity
Check Product Availability
Product Availability
Inventory Commitment
Available Product
Calculate Order Cost
Product Price
Bonus Credits Claimed
Cost to Member
Payment
Check Member Credit
Credit Details
Confirmed Member Order
Credit Problem and Instruction
Transactions
Relevant Transactions
Order to be Filled
Order to be Filled
Member Orders
New Member Order
Record Order
Release Order
Packing Order
Warehouse
Member Ordered Products
New Member Ordered Products
Members
Updated Credits

- Context diagram: 图 9-15
- System diagran： 图922
- Event diagram： 图9-19, 图9-20
- Primitive diagram: 图9-23

Consist of a DFD.

9.5 Data & Process Model Synchronization CRUD Matrix



Data-to-Process-CRUD Matrix

Entity . Attribute	Process Customer Application	Process Customer Credit Application	Process Customer Change of Address	Process Internal Customer Credit Change	Process New Customer Order	Process Customer Order Cancellation	Process Customer Change to Outstanding Order	Process Internal Change to Customer Order	Process New Product Addition	Process Product Withdrawal from Market	Process Product Price Change	Process Change to Product Specification	Process Product Inventory Adjustment
Customer	C	C			R	R	R	R					
.Customer Number	C	C			R	R	R	R					
.Customer Name	C	C	U		R		R	R					
.Customer Address	C	C	U		RU		RU	RU					
.Customer Credit Rating		C		U	R		R	R					
.Customer Balance Due					RU	U	R	R					
Order					C	D	RU	RU					
.Order Number					C		R	R					
.Order Date					C		U	U					
.Order Amount					C		U	U					
Ordered Product					C	D	CRUD	CRUD		RU			
.Quantity Ordered					C		CRUD	CRUD					
.Ordered Item Unit Price					C		CRUD	CRUD					
Product					R	R	R	R	C	D	RU	RU	RU
.Product Number					R	R	R	R	C			R	
.Product Name					R		R	R	C			RU	
.Product Description					R		R	R	C			RU	
.Product Unit of Measure					R		R	R	C		RU	RU	
.Product Current Unit Price					R		R	R			U		
.Product Quantity on Hand					RU	U	RU	RU					RU

C = create R = read U = update D = delete

Process Distribution

Central / local implementation

Process-to-Location-Association Matrix

Process	Customers	Kansas City	. Marketing	. Advertising	. Warehouse	. Sales	. Accounts Receivable	Boston	. Sales	. Warehouse	San Francisco	. Sales	San Diego	. Warehouse
Process Customer Application	X					X			X			X		
Process Customer Credit Application	X						X							
Process Customer Change of Address	X					X			X			X		
Process Internal Customer Credit Change							X							
Process New Customer Order	X					X			X			X		
Process Customer Order Cancellation	X					X			X			X		
Process Customer Change to Outstanding Order	X					X			X			X		
Process Internal Change to Customer Order						X			X			X		
Process New Product Addition			X											
Process Product Withdrawal from Market			X											
Process Product Price Change			X											
Process Change to Product Specification			X	X										
Process Product Inventory Adjustment					X					X				X