Requirements Engineering

Semi-Formal Specification:

Structural Functional Requirements – Structured Analysis

- Data Flow Diagrams
- SADT
- IDEF0

Types of Requirements along different views

- Functional Requirements (FRs)
  - Structural Functional Requirements
    - Functional, i.e., Function-oriented
    - Informational. i.e., Information-oriented
  - Behavioral Functional Requirements
- Non-Functional Requirements (NFRs)

Function Oriented Problem Analysis

- Creates a hierarchy of functions
  - Also called (process, activity, work-step, transactions, transforms, bubbles)
- Root is most abstract
- Leaf nodes the most detailed
- Most methods use data flow diagrams and dictionaries
- Examples
  - SRD structured requirements definition
  - SADT
  - Information Engineering
  - Modern structured Analysis
  - Problem statement Language

Process Modeling

A data flow diagram (DFD) is a tool (and type of process model) that depicts the flow of data through a system and the work or processing performed by that system.

DFDs have become a popular tool for business process redesign.

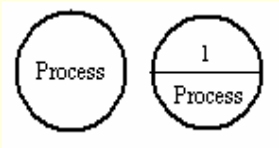
Data Flow Diagrams

- Existed long before computers
- Show the flow of data through a system
- System
  - Organization
  - Company
  - A computer hardware system
  - A software system
- Icons
  - Data on the move – named arrows
  - Transformations of data – named bubbles
  - Sources and destinations of data – named rectangles (terminators)
  - Data in static storage – two parallel lines

Data Flow Diagram Notations

Process
A process transforms incoming data flow into outgoing data flow.

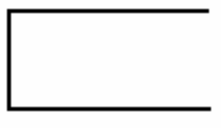
Yourdon and Coad Process Notations



Gane and Sarson Process Notation

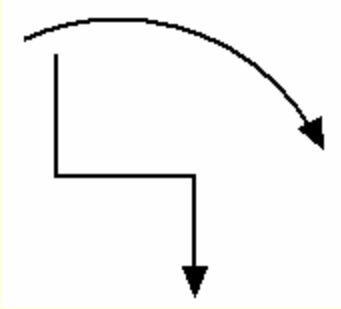
Data Store
Data stores are repositories of data in the system. They are sometimes also referred to as files.

Yourdon and Coad Datastore Notation

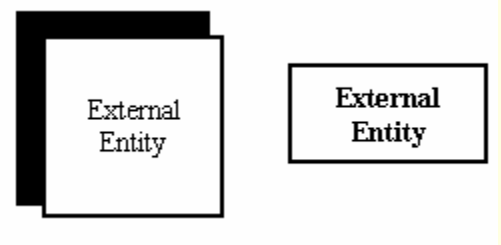


Gane and Sarson Datastore Notations

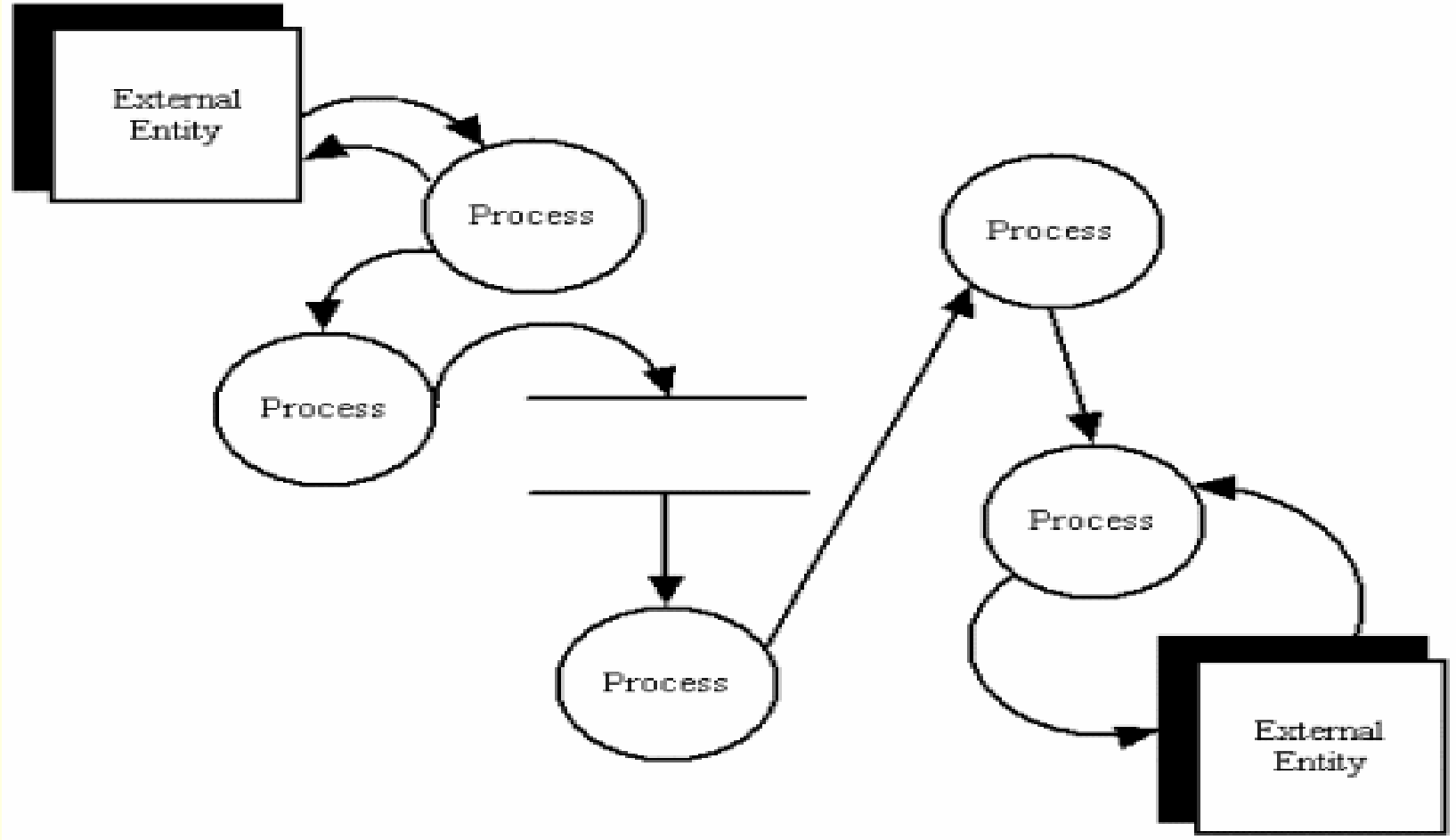
Dataflow
Dataflows are pipelines through which packets of information flow. Label the arrows with the name of the data that moves through it.



External Entity
External entities are objects outside the system, with which the system communicates. External entities are sources and destinations of the system's inputs and outputs.

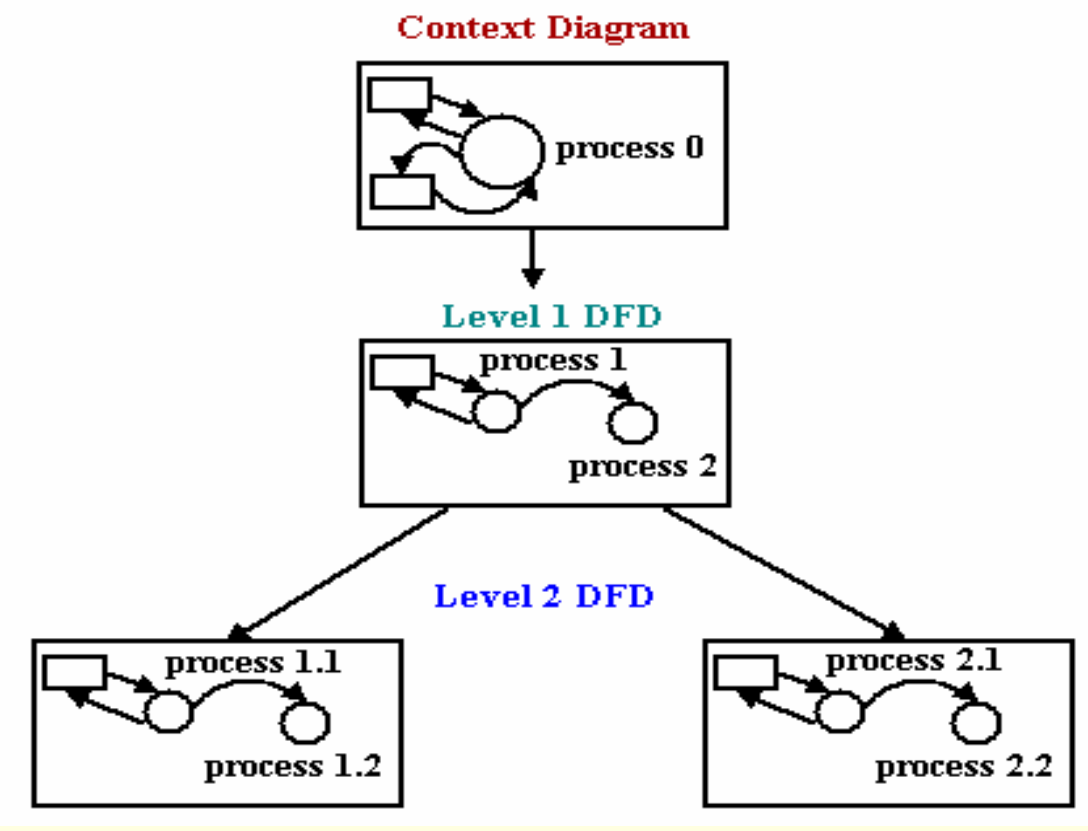


DataFlow Diagrams



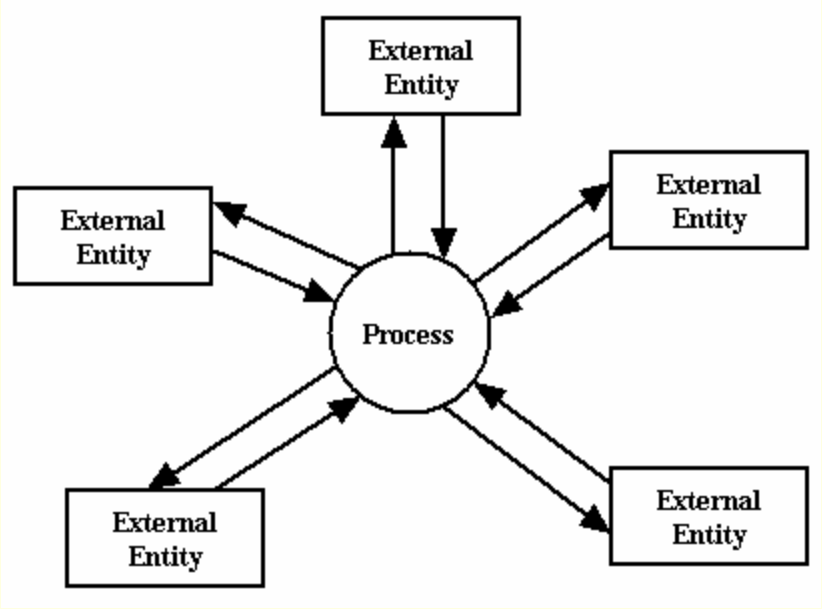
Data Flow Diagram Layers

- Data flow diagrams are drawn in several nested layers
- A single process node on a high level diagram can be expanded to show a more detailed data flow diagram.
- Draw the context diagram first, followed by various layers of data flow diagrams.



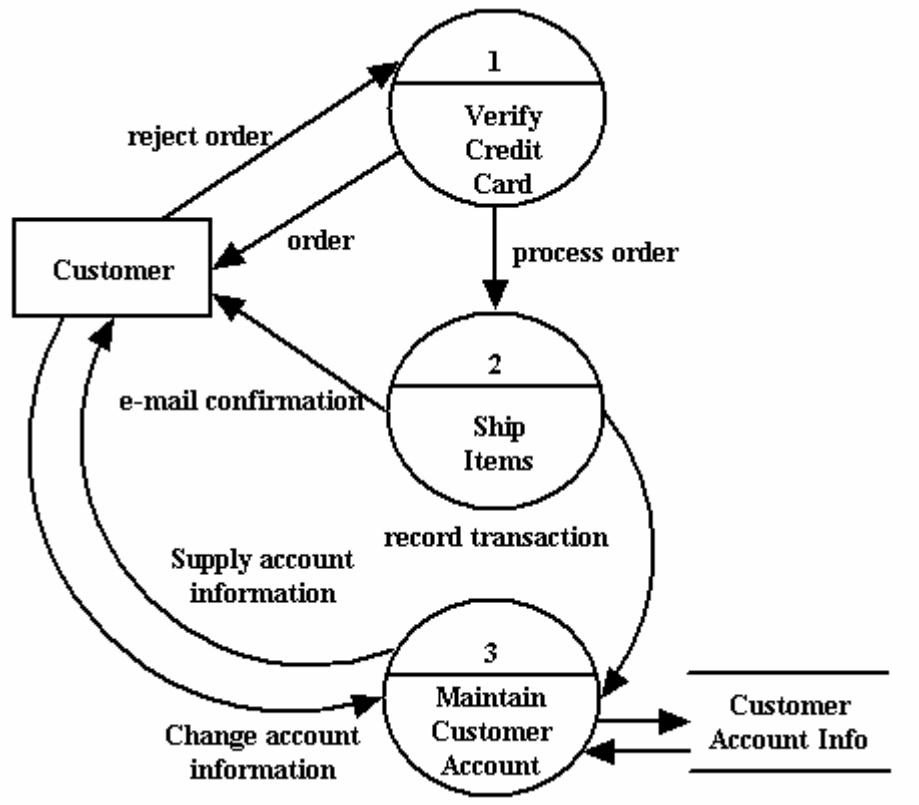
Context Diagrams

- A context diagram is a top level (also known as Level 0) data flow diagram. It only contains one process node (process 0) that generalizes the function of the entire system in relationship to external entities.

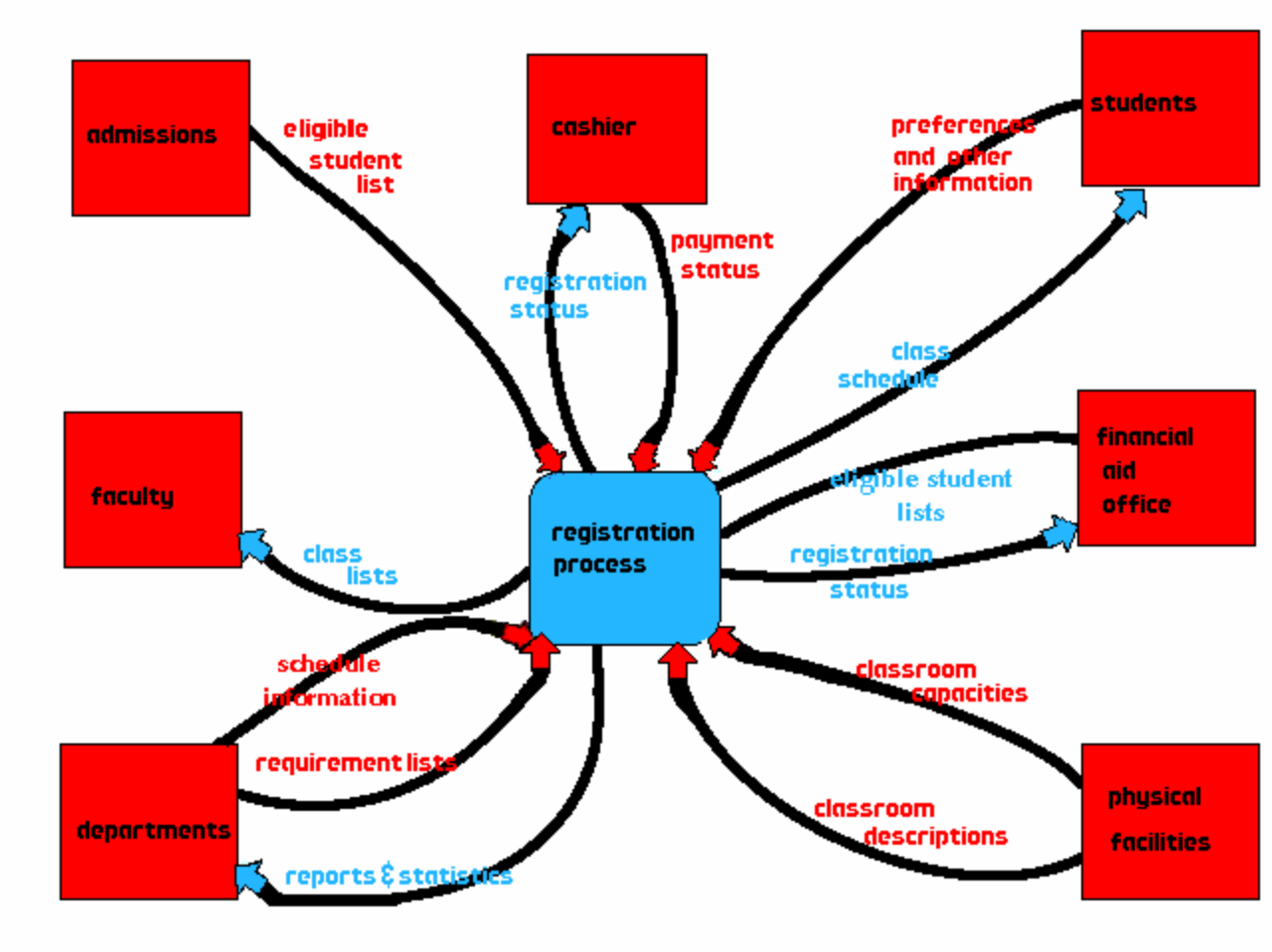


DFD levels

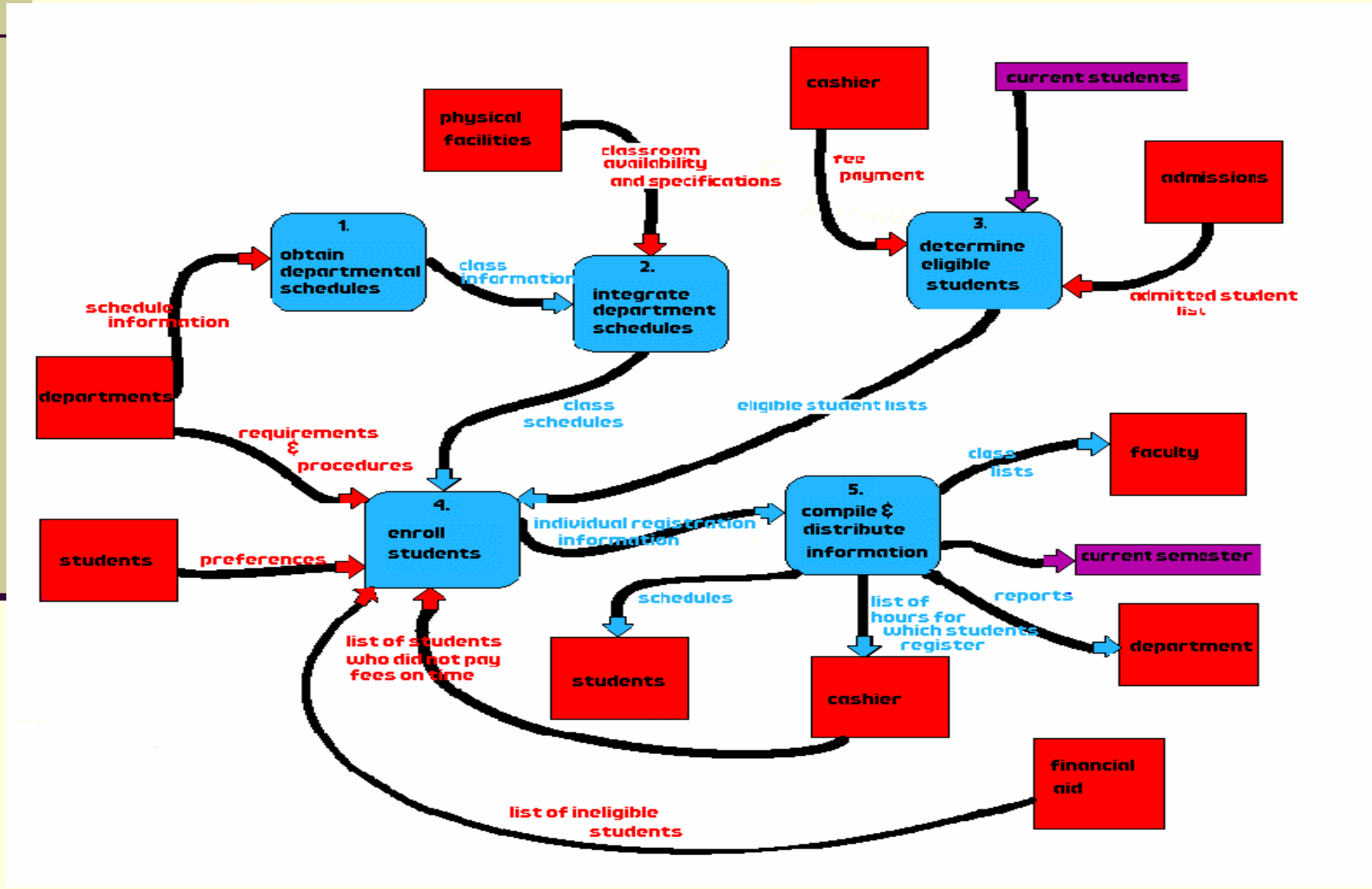
The first level DFD shows the main processes within the system. Each of these processes can be broken into further processes until you reach pseudocode.



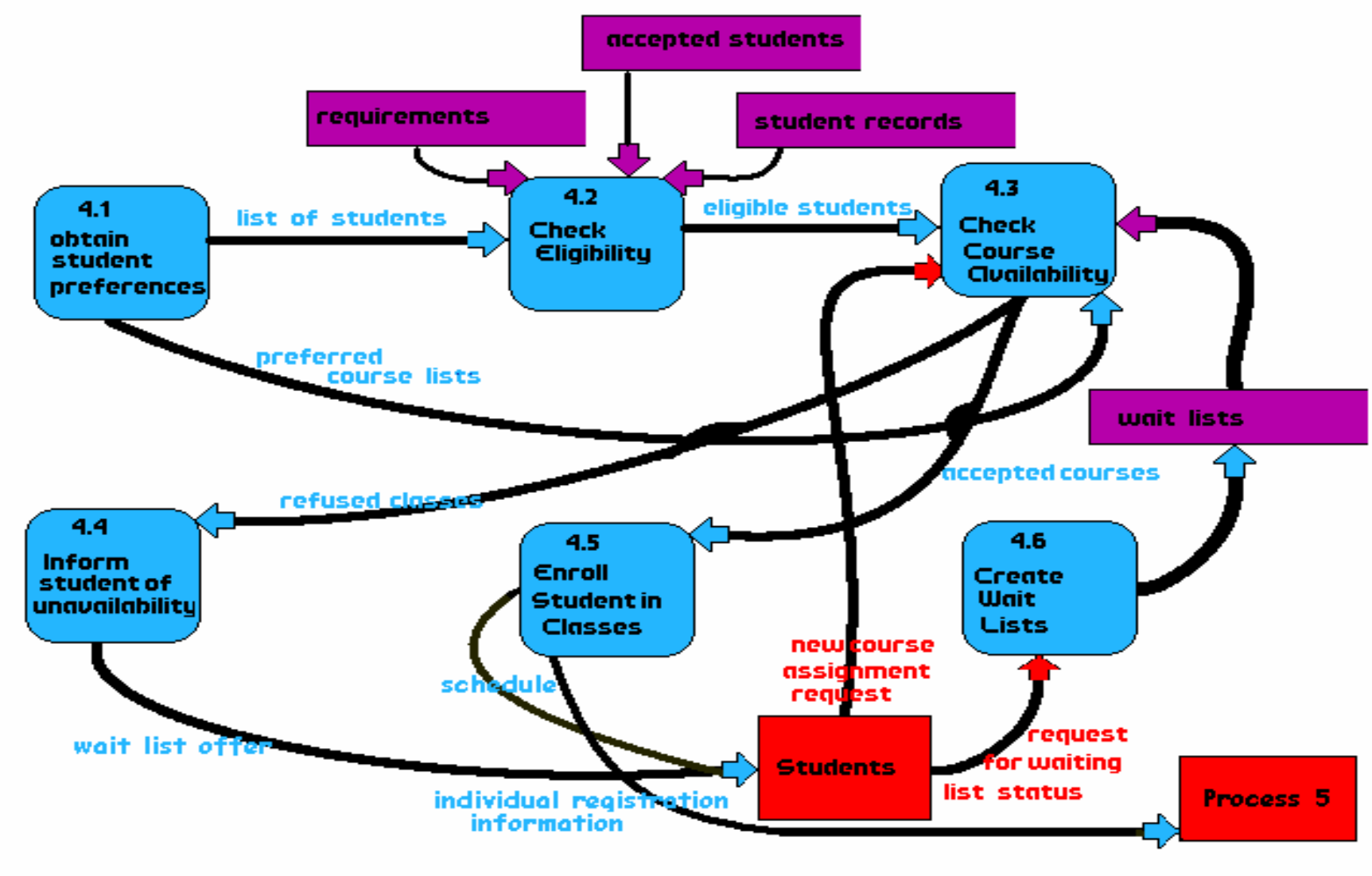
Context Diagram- Registration



Level 0 Data Flow Diagram

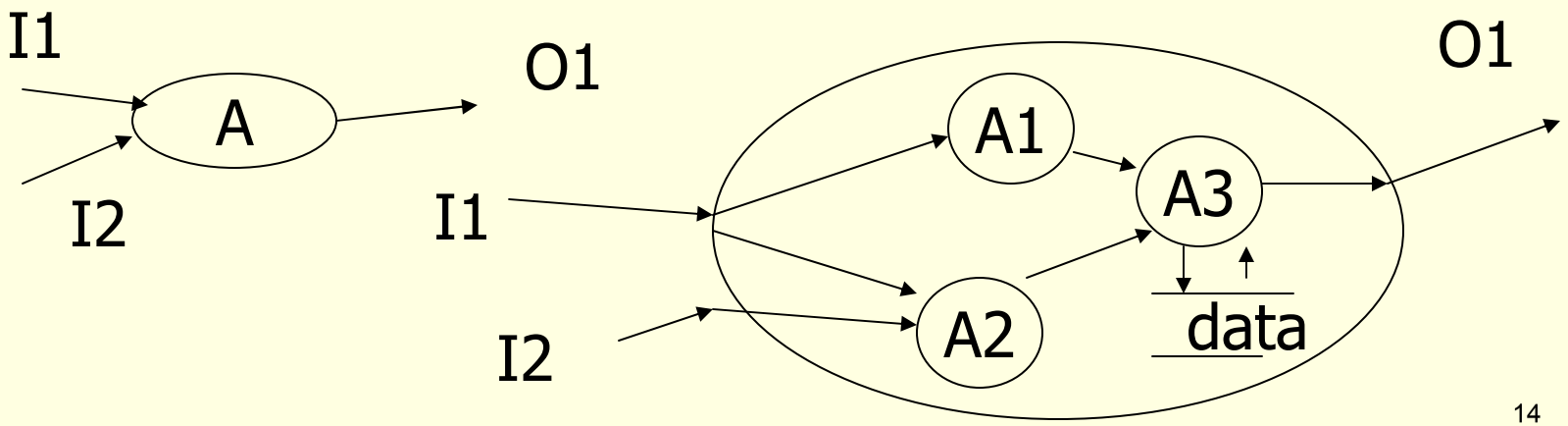


Explosion of Process 4



Data Flow Diagrams

- Rules
  - All names must be unique
  - Not a flow chart – no order implied
  - No logical decisions
  - Don't get bogged down in detail
- Leveling
  - Preserve the number of inputs and outputs between the levels



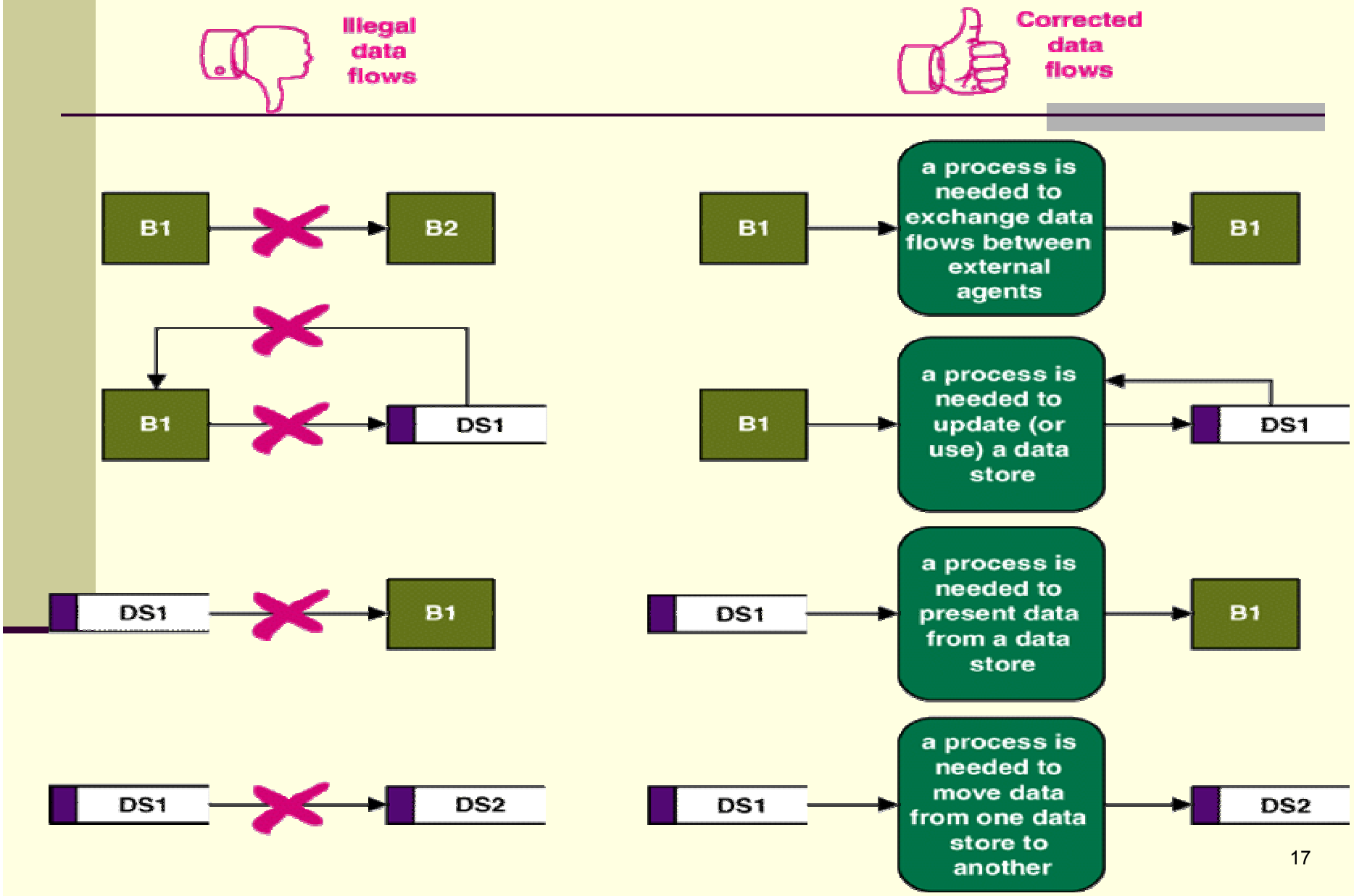
Difference between DFD and Flowcharts

- Processes on DFDs can operate in parallel (at-the-same-time)
  - Processes on flowcharts execute one at a time
- DFDs show the flow of data through a system
  - Flowcharts show the flow of control (sequence and transfer of control)
- Processes on one DFD can have dramatically different timing
  - Processes on flowcharts are part of a single program with consistent timing

Homework -

- Draw a DFD for an ATM

Illegal Data Flows



Structured English context

Construct	Sample Template
Sequence of steps – unconditionally perform a sequence of steps.	[Step 1] [Step 2] … [Step n]
Simple condition steps – if the specified condition is true, then perform the first set of steps. Otherwise, perform the second set of steps. 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 steps or other conditional steps] **else** [sequence of steps or other conditional steps] ~~End If~~
Complex condition steps – test the value of the condition and perform the appropriate set of steps. 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 steps or other conditional steps] **Case 2: If** [condition] = [value] then [sequence of steps or other conditional steps] … **Case n: If** [condition] = [value] then [sequence of steps or other conditional steps] ~~End Case~~

Structured English Rules

Condition stubs

Multiple conditions – test the value of multiple conditions to determine the correct set of steps.

Use a **decision table** instead of nested if-then-else Structured English constructs to simplify the presentation of complex logic that involves combinations of conditions.

A **decision table** is a *tabular presentation of complex logic in which rows represent conditions and possible steps, and columns indicate which combinations of conditions result in specific steps.*

DECISION TABLE	Rule	Rule	Rule	Rule
[Condition]	value	value	value	value
[Condition]	value	value	value	value
[Condition]	value	value	value	value
[Sequence of actions or conditional actions]	X			
[Sequence of actions or conditional actions]		X	X	
[Sequence of actions or conditional actions]				X

Although it isn't a Structured English construct, a decision table can be named, and referenced within a Structured English procedure.

Action Stubs

Decision Table Example

	Condition Stub	***Condition Entry***					
If	Customer is bookstore	Y	Y	N	N	N	N
	Order size > 6 copies	Y	N	N	N	N	N
	Customer is librarian/individual			Y	Y	Y	Y
	Order size 50 copies or more			Y	N	N	N
	Order size 20 to 49 copies				Y	N	N
	Order size 6 – 19 copies					Y	N
Then	Allow a 25% discount	X					
	Allow a 15% discount			X			
	Allow 10% discount				X		
	Allow a 5 % discount					X	
	Allow 0% discount		X				X
	Action Stub	***Action Entries***					

Structured English constructs

One-to-many iteration – Repeat the set of steps until the condition is false. Use this construct if the set of steps must be performed at least once, regardless of the condition's initial value.	**Repeat the following until** [truth condition]: [sequence of steps or conditional steps] ~~**End Repeat**~~
Zero-to-many iteration – Repeat the set of steps until the condition is false. Use this construct if the set of steps are conditional based on the condition's initial value.	**Do While** [truth condition]: [sequence of steps or conditional steps] ~~**End Do**~~ **- OR -** **For** [truth condition]: [sequence of steps or conditional steps] ~~**End For**~~

Structured English

Structured English is a language and syntax, based on the relative strengths of structured programming and natural English, for specifying the underlying logic of elementary processes on DFDs.

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 the ORIGINAL LOAN PRINCIPAL 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 all their data attributes as described in the data flow LOANS AT RISK.

   Else
      1) Exclude the CUSTOMER NUMBER and data from the data flow LOANS AT RISK.

Data Dictionaries

- Used to augment the Data Flow Diagrams
- Repository
- Layout
  - Name of the item
  - Alias
  - Description/Purpose
  - Related data items
  - Range of values
  - Data flows
  - Data structure definition/form

Data Structures

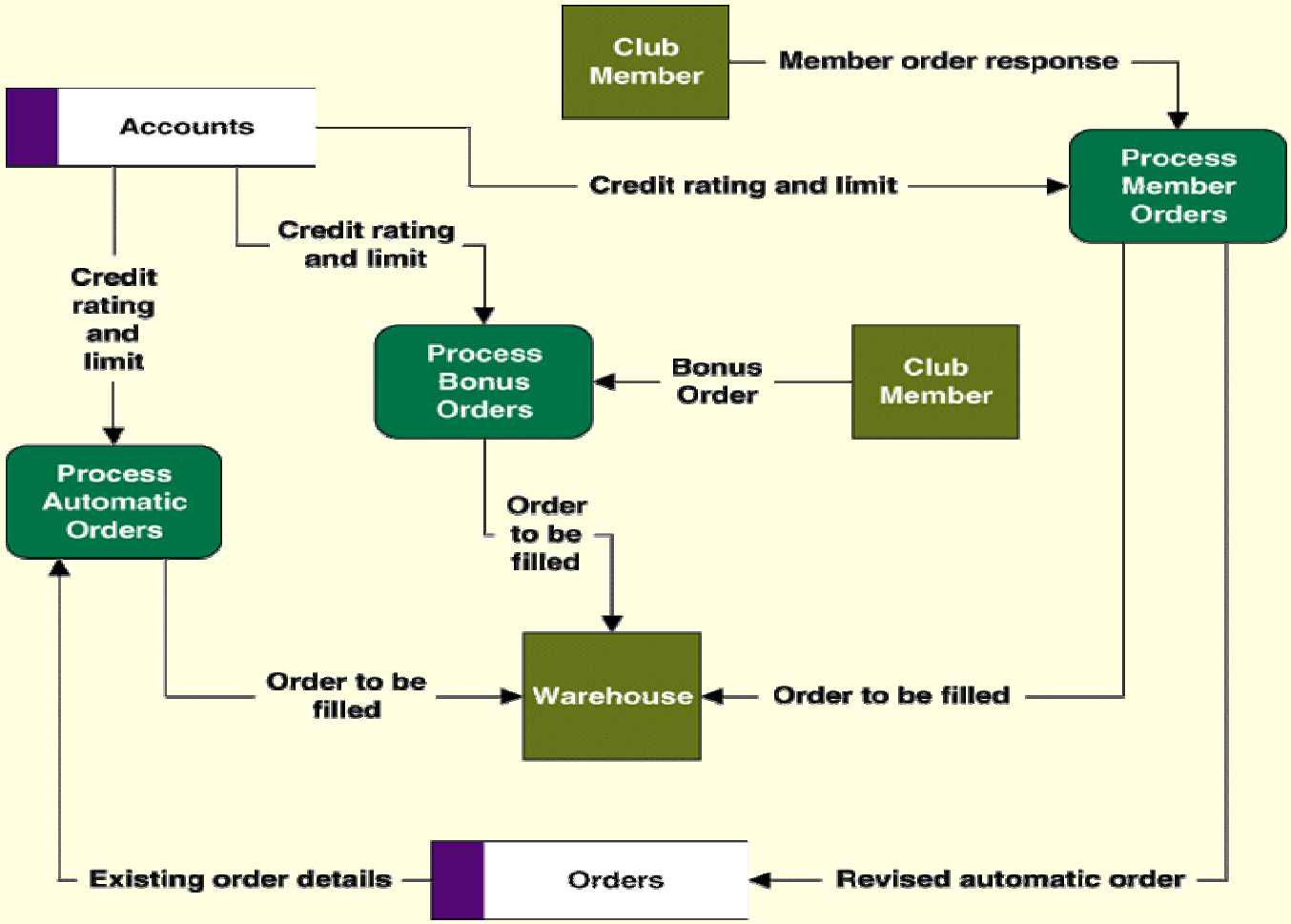
- Are specific arrangements of data attributes that define a single instance of a data flow
  - A sequence that occur one after another
  - A selection of one or more attributes from a set
  - A repetition of one or more attributes
- Most common data structure notation is Boolean algebraic notation

=	"Consists of" or "is composed of"
+	Means and and designates sequence
[. . .]	Only one of the attributes may be present – ***selection*** - Attributes separated by commas Either/or
{. . .}	Attributes may occur many times – ***repetition*** - Attributes separated by commas
(. . .)	Attributes in side are optional no value for some of the data flows

Example Data Structure

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) 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 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 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

A Simple Process Model



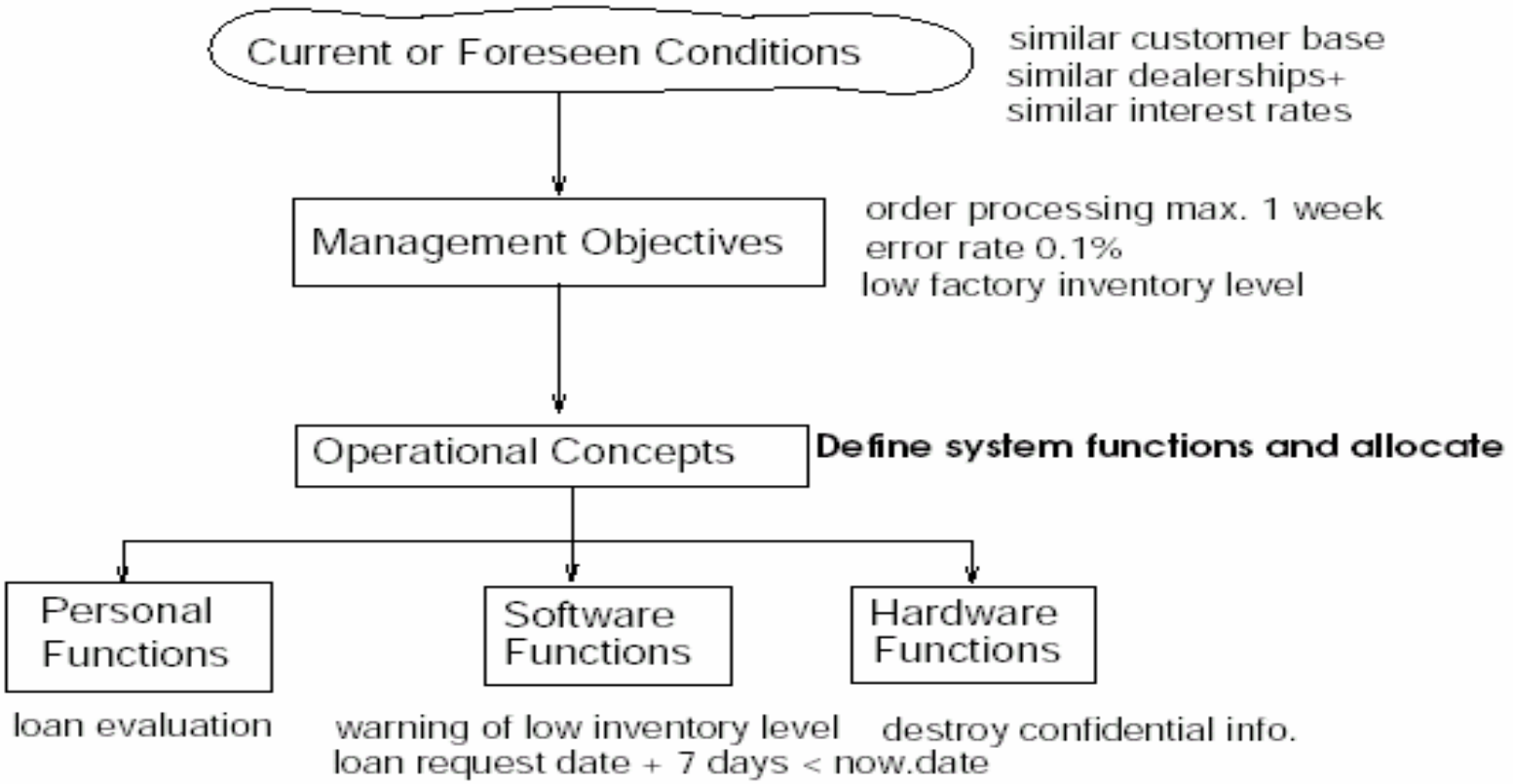
Traditional Approaches to Enterprise Modeling
SADT (Structured Analysis and Design Technique)

- **Background**
  - in use since the mid-seventies
  - inspiration for many commercial tools
  - (DFD?)trademark of Softech, Inc.
- **View**
  - "System" refers to any enterprise/organization, physical, manufacturing,and SW system
- **Context Analysis should involve**
  - technical assessment: feasibility of system architecture
    - *Are the components and inter-relationships technically realizable?*
  - operational assessment: system performance in a working environment
    - *Can the system perform task X in less than a week of time?*
  - economic assessment: costs & impacts of system implementation & use
    - *Can the system be built with $20M, 1000 SE's, in 2 yrs?*

SADT (Structured Analysis and Design Technique)

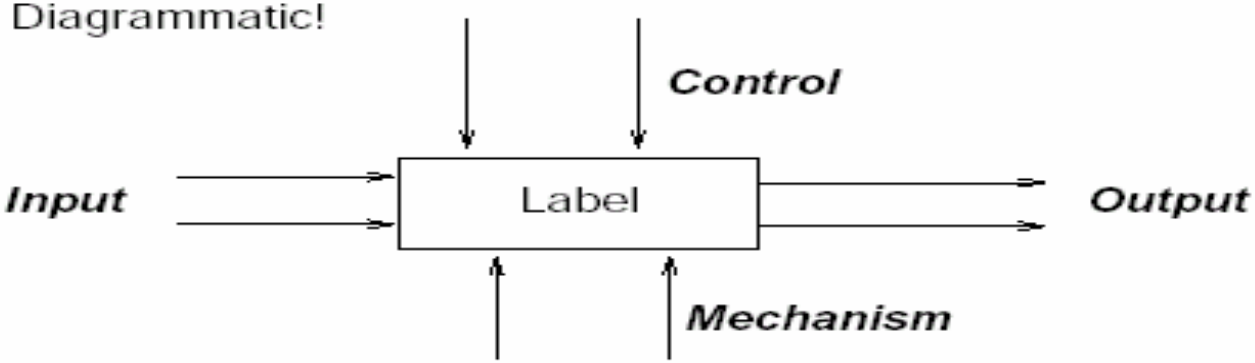
Requirements definition

encompasses all aspects of system development prior to actual system design



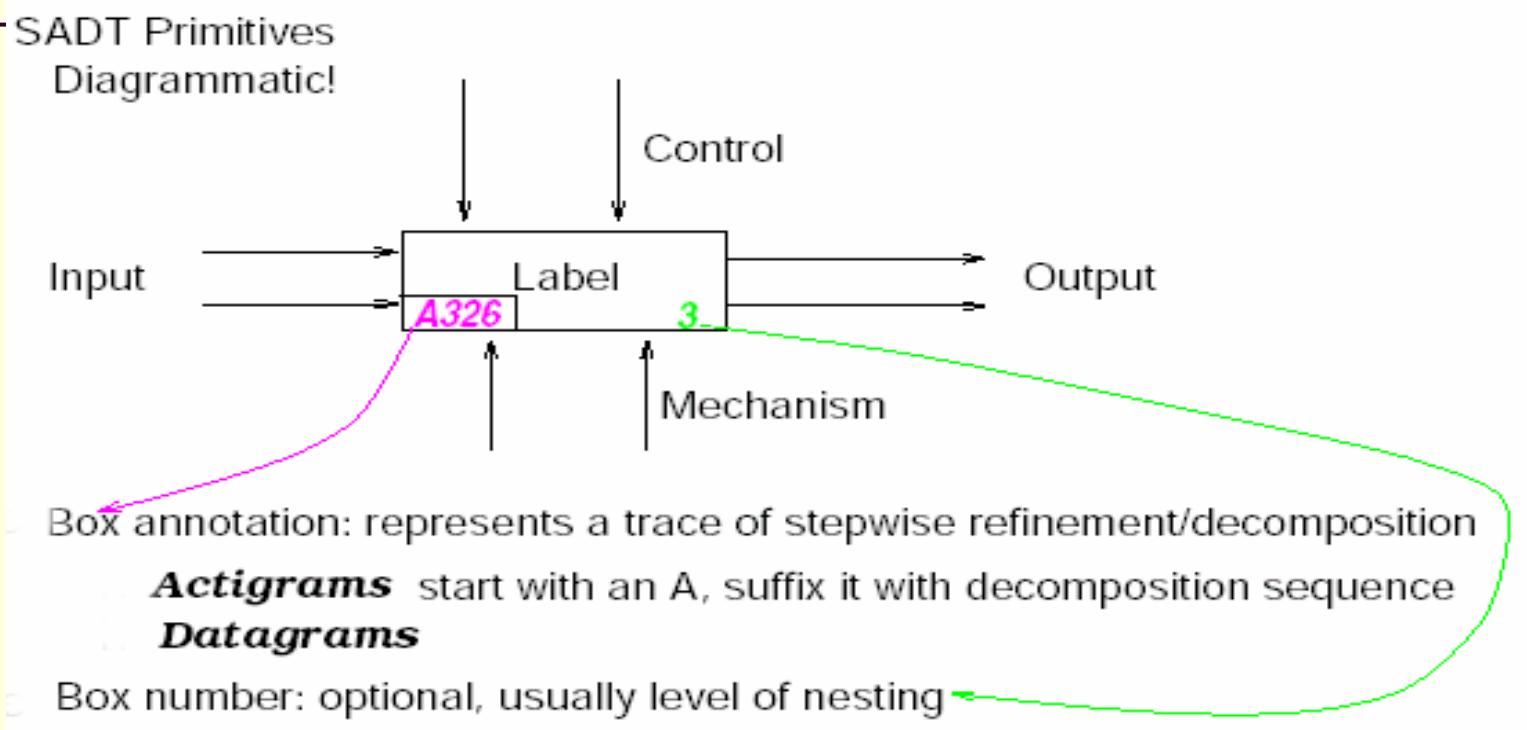
SADT (Structured Analysis and Design Technique

SADT Primitives
Diagrammatic!



- Boxes "composed" into a diagram and interconnected through arrows
- Each diagram is decomposed into up to "six" other diagrams
- Informal documentation (as with DFDs)
- Two types of diagrams
  - ***Actigrams***
    - boxes: happenings - activities, operations, processing, events
    - box label: start with a verb
  - ***Datagrams***
    - boxes: things - entities, objects, data, information, substances
    - box label: noun

SADT (Structured Analysis and Design Technique

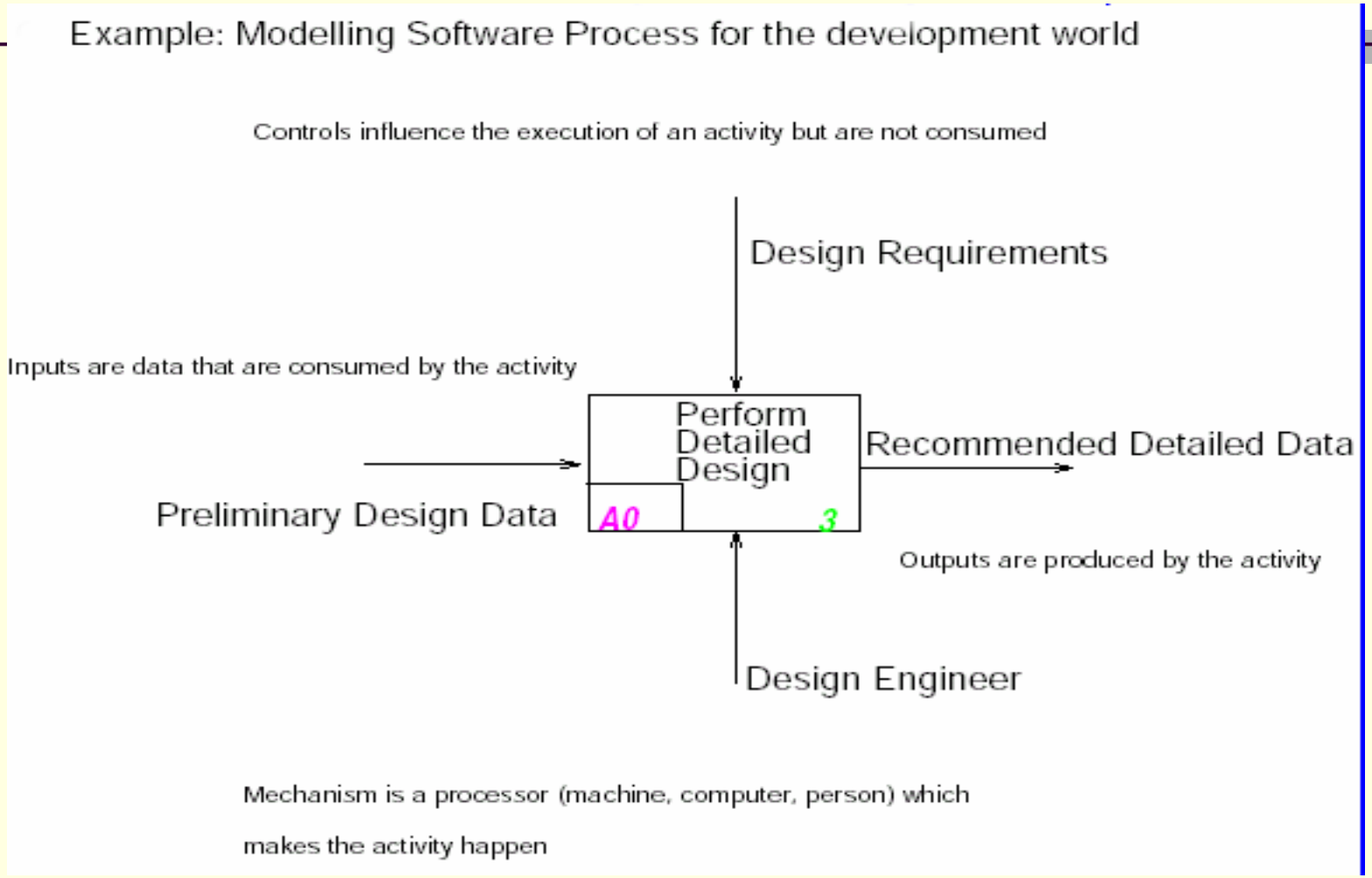


Semantics of Arrows

In an actigram

- **Inputs are data that are consumed by the activity**
- **Outputs are produced by the activity**
- **Controls influence the execution of an activity but are not consumed**
- **Mechanism is a processor (machine, computer, person) which makes the activity happen**

SADT (Structured Analysis and Design Technique



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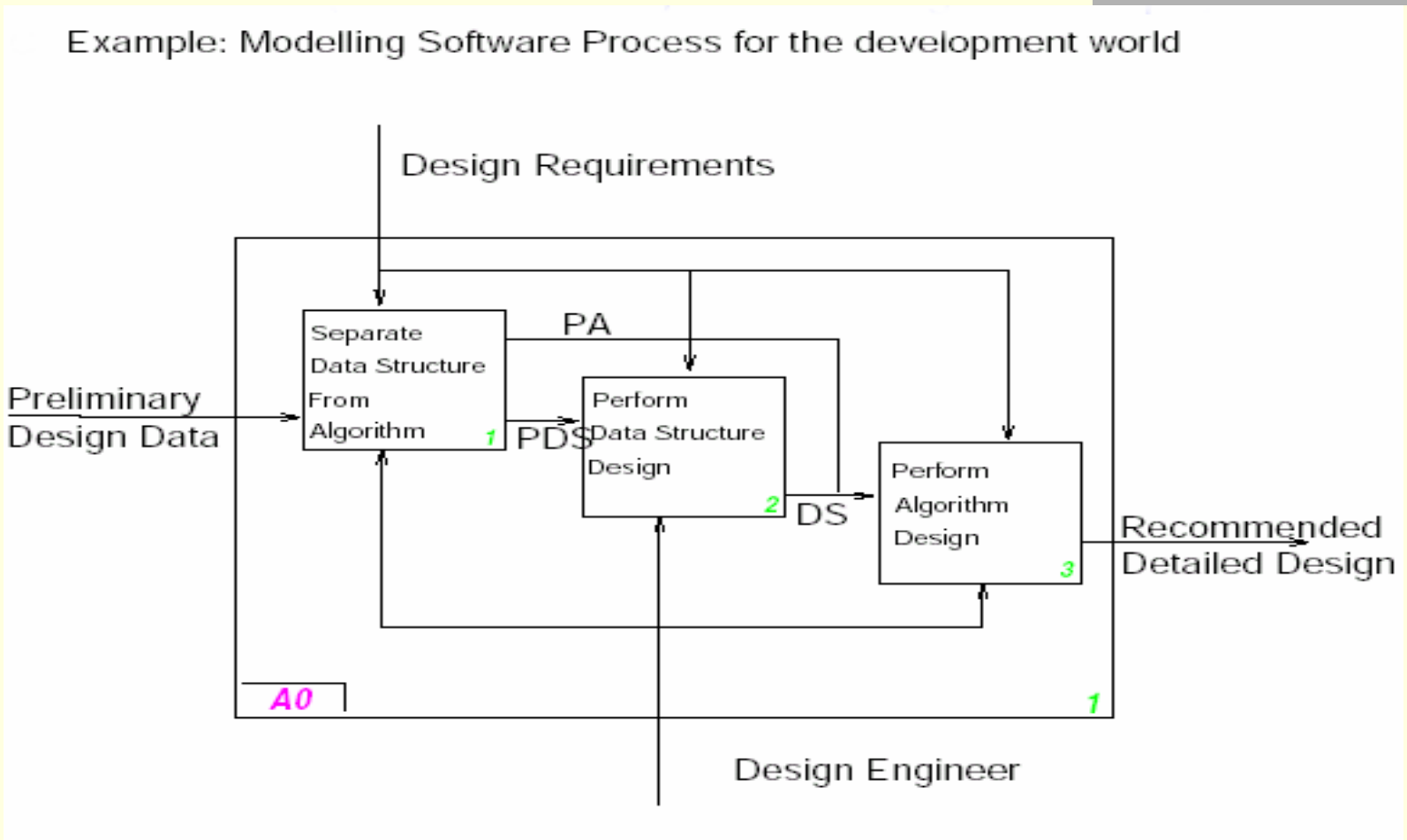

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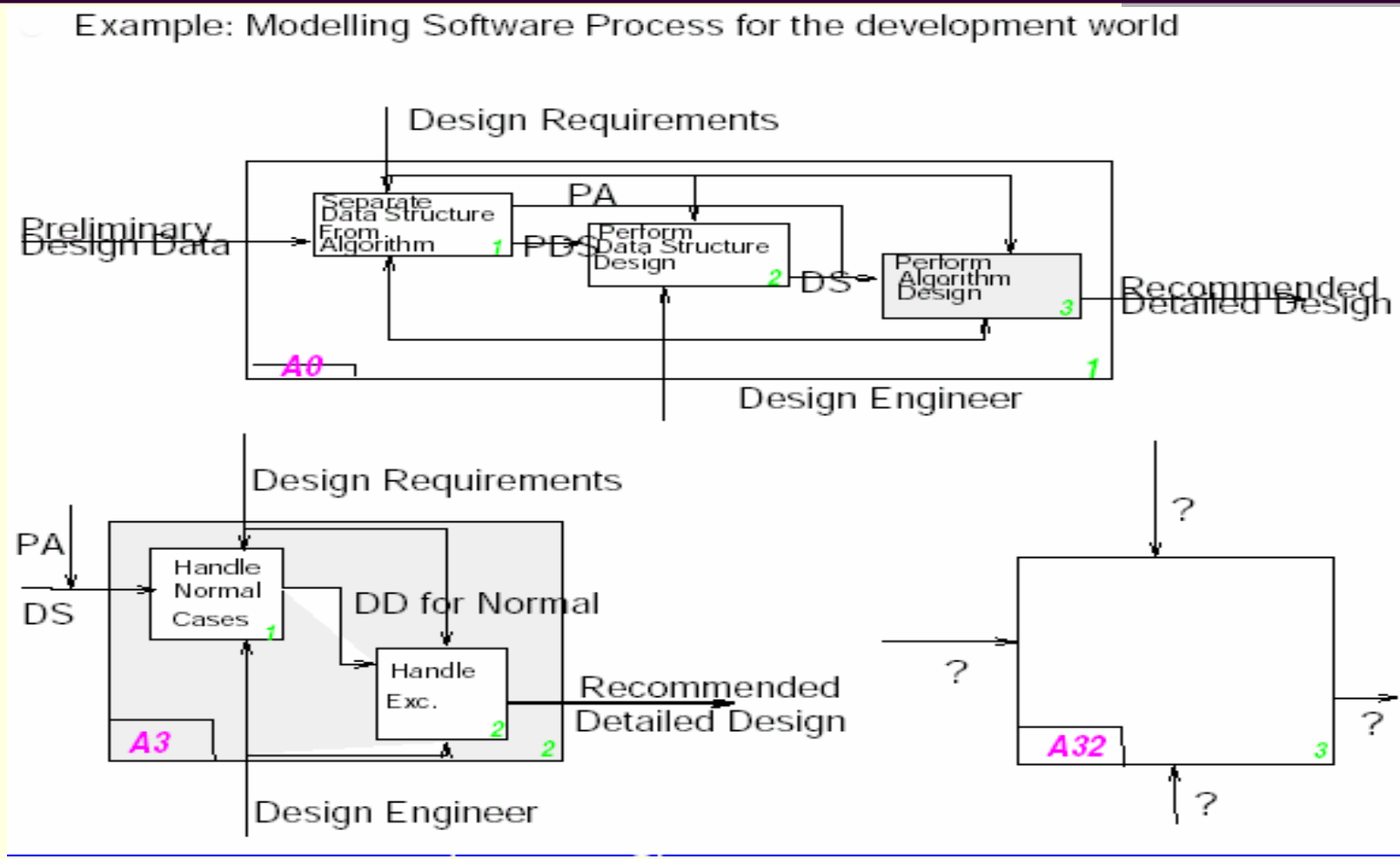

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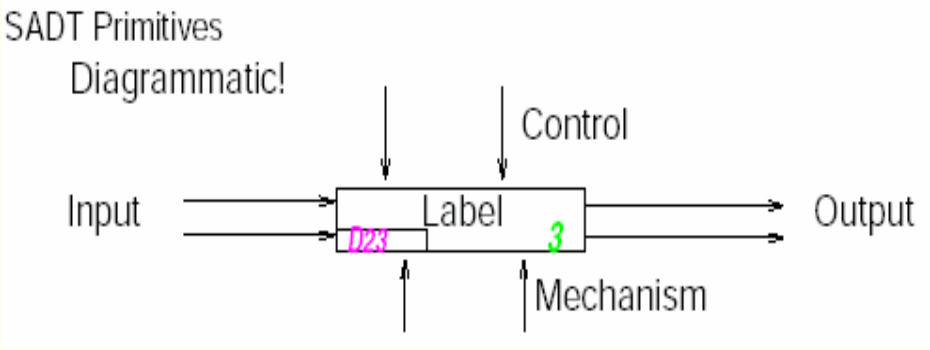

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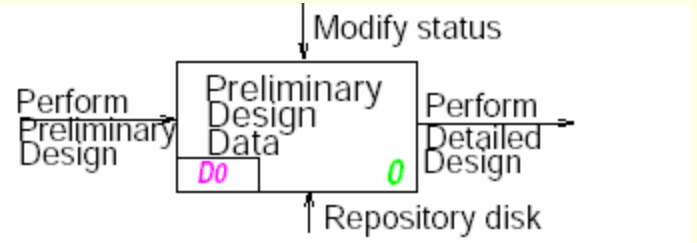
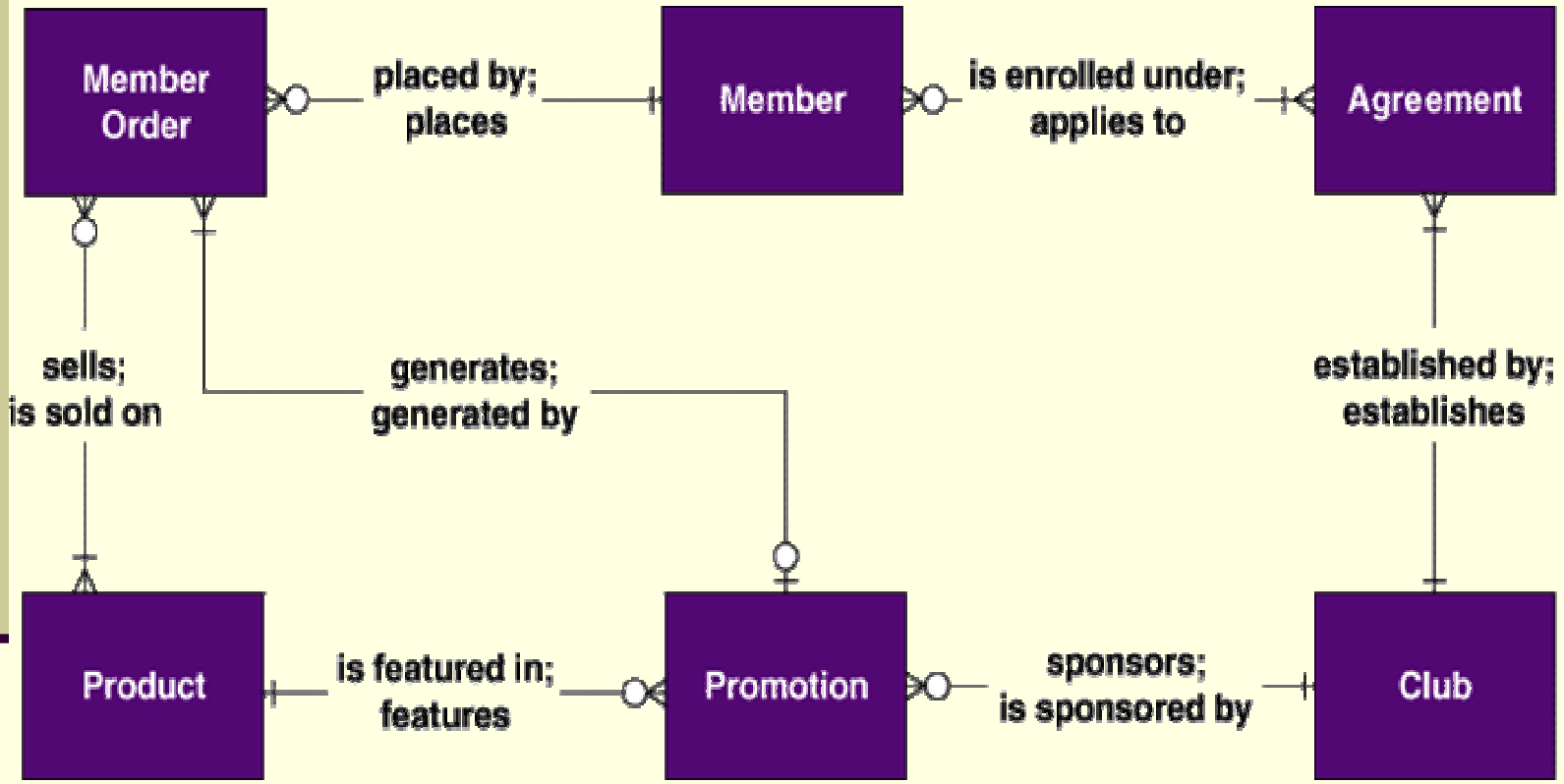
- **Mechanism is a processor (machine, computer, person) which makes the activity happen**

- *in a datagram*
  - Inputs are activities that produce the data
  - Outputs consume the data
  - Controls influence the internal state of the data
  - Mechanism is a device for storage, representation, impl., etc.



A Simple Data Model



FUNCTION MODELING USING IDEF-0

A Function Model is a Representation of the Activities and Relationships Between Activities in an Existing or Planned System.

IDEF0 (Integration Definition for Function Modeling)

Background

- released in Dec., 1993
- the "reference model" for system/enterprise function modeling
- also in use for software process modeling
- Federal Information Processing Standard maintained by Dept. of Commerce,NIST (National Institute of Standards and Technology) & Computer Systems Laboratory
- based on ICAM (Integrated Computer-Aided Manufacturing) from the US Air Force Wright Aeronautical Laboratories
- Information Modeling (IDEF1X) uses ERD + generalization/specialization
- closely resembles "actigrams" of SADT

Stringent Rules

E.g., Boxes shall be sufficient to insert box names

rectangular in shape with square corners

drawn with solid lines

Arrows that bend shall be curved using only 90 degree arcs

shall be drawn in solid line segments

vertically or horizontally, not diagonally

Traditional Approaches to Enterprise Modelling

IDEF0 (Integration Definition for Function Modelling)

- Diagram syntax rules

E.g.,

- ***control feedbacks shall be shown as "up and over"***

- ***input feedbacks shall be shown as "down and under"***

- ***mechanism feedbacks shall be shown as "down and under"***

Terminology of IDEFØ

- Functions and activities
- Diagrams, Boxes, and Arrows
- ICOMs: Inputs, Controls, Outputs, and Mechanisms
- Arrows, links, relationships, and concepts
- Splits, Joins, Unbundling, Bundling, and Branching
- Decompositions
- Viewpoint, Purpose, and Context
- NIST (FIPS) standard

What is IDEFØ?

- An IDEF method for modeling functions
  - Graphics (diagrams)
  - Text (glossary & narrative)
- Provides both a process and a language for constructing a model of the decisions, actions, and activities in an organization

What is an IDEFØ Model?

- A definition of activities and information
  - Within a particular *Context*
  - Having a consistent *Viewpoint*
  - For a particular *Purpose*
- Series of diagrams (that decompose a subject into manageable chunks)
- A foundation for requirements specification, design, and programming
- A useful record throughout the life-cycle of an enterprise

Example IDEFØ Diagram

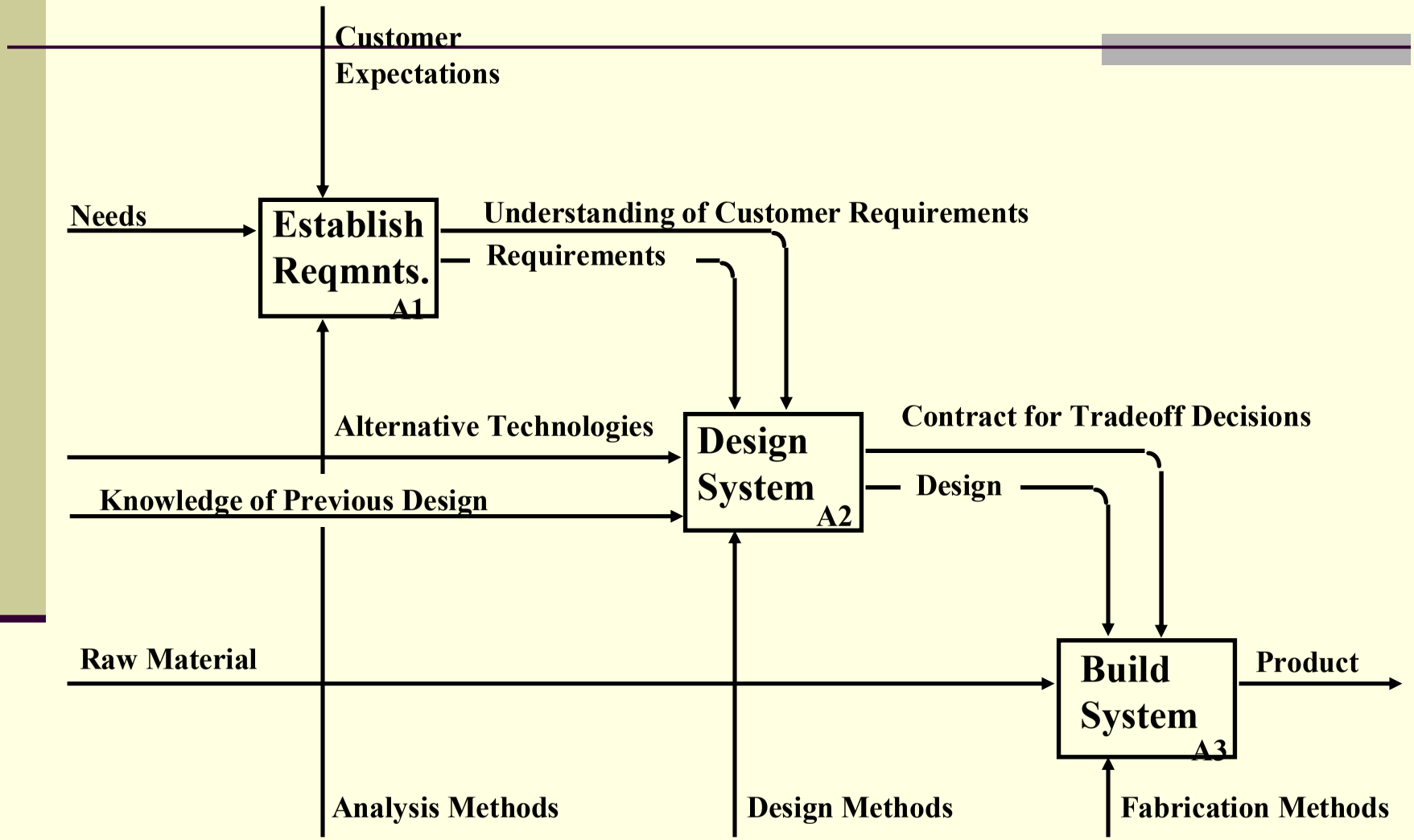


Diagram Construction (1)

- Boxes represent functions

- Arrows represent real objects or data

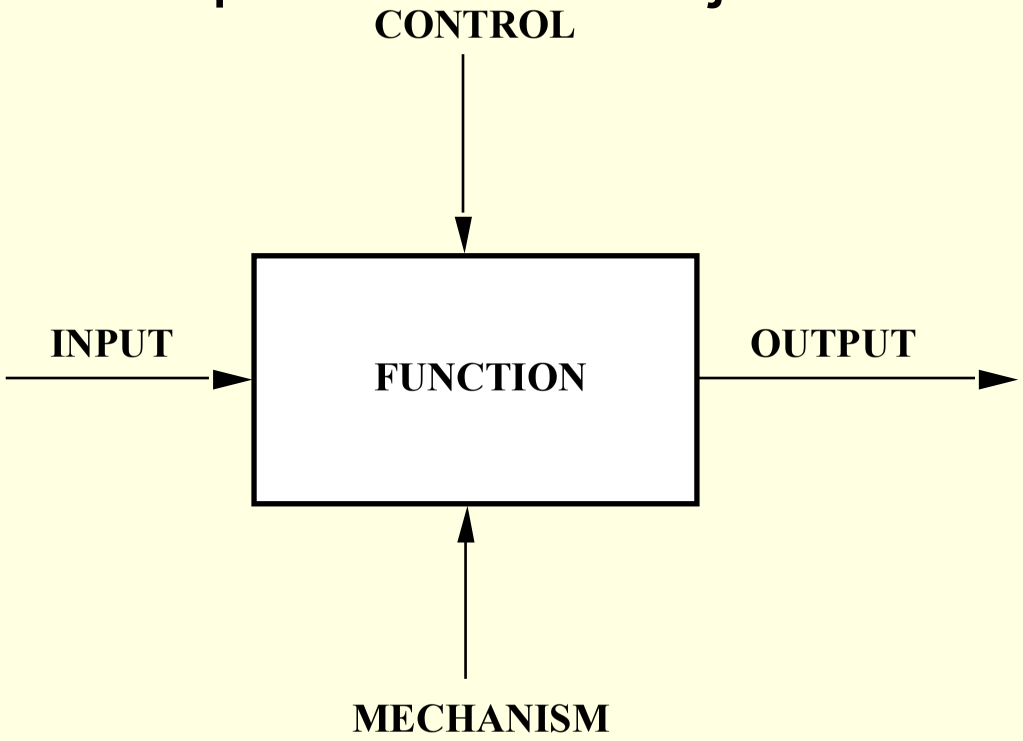
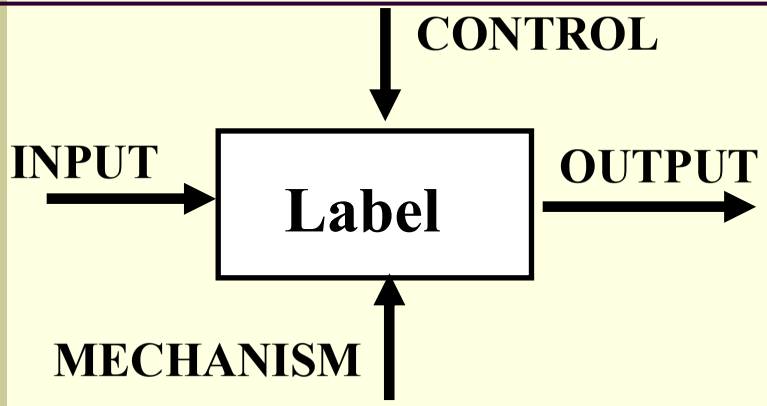


Diagram Construction (2)



- Labels are words that name functions and data/real objects
- Function labels are verbs or verb phrases and are put in the center of the function box
- Data labels are nouns or noun phrases
- Data labels name the input, control, output, and mechanism arrows

IDEFØ Function

- An Activity, Action, Process, or Operation
- A Description of “What Happens” in a Particular Environment
- Accomplished by People, Machines, Computers
- Labeled with an Active Verb or Verb Phrase

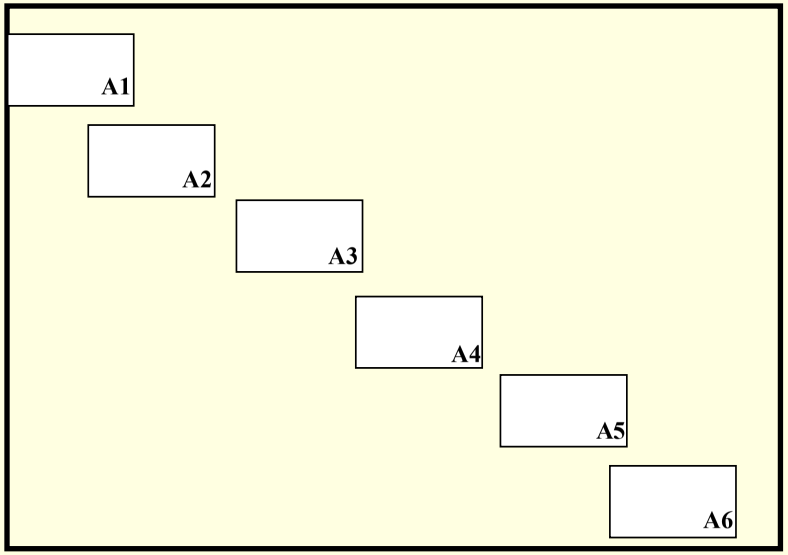
Function Label

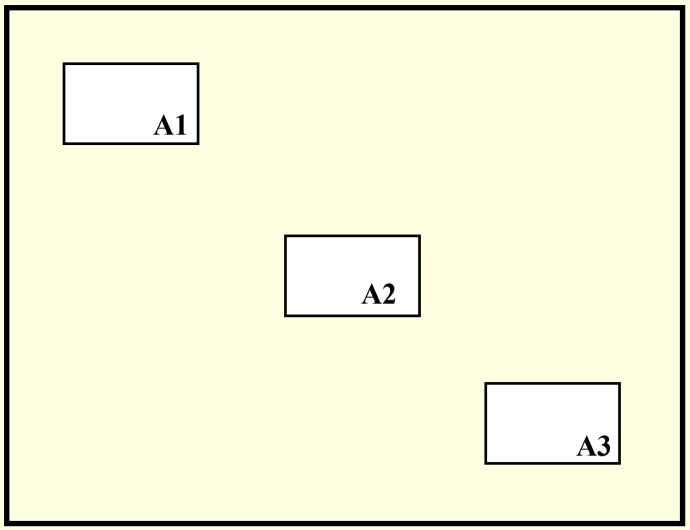
IDEFØ Functions (Activities)

Represented as a box in an IDEF0 Model.

First diagram has one Function which bounds the context of the Model. (A - 0 diagram)

Diagram has a maximum of 6 functions & a minimum of 3





IDEFØ Relationships (Between Functions)

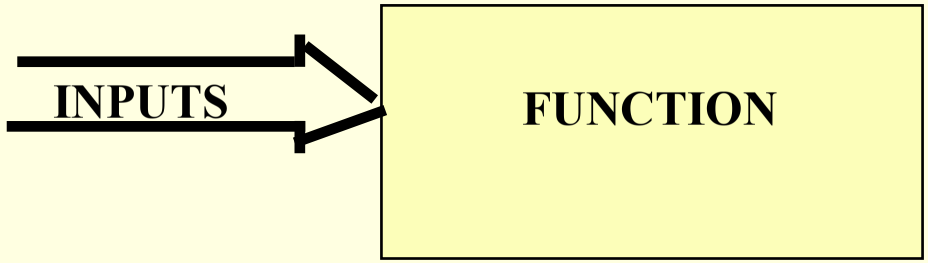
- Represented as arrows
- AKA concepts
- Real objects, data, people, machines, and computers

ICOMs

- Inputs
- Controls
- Outputs
- Mechanisms

Inputs

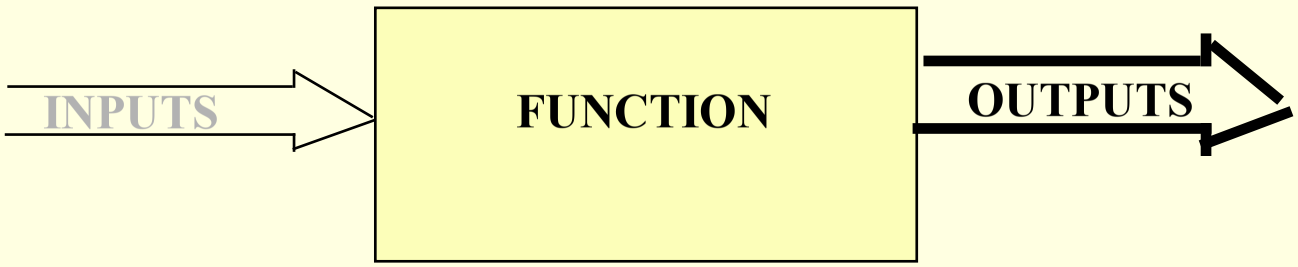
- Real Objects or Data Needed to Perform a Function
- Objects or Data Transformed by a Function
- Labeled with a Noun or Noun Phrase



Output

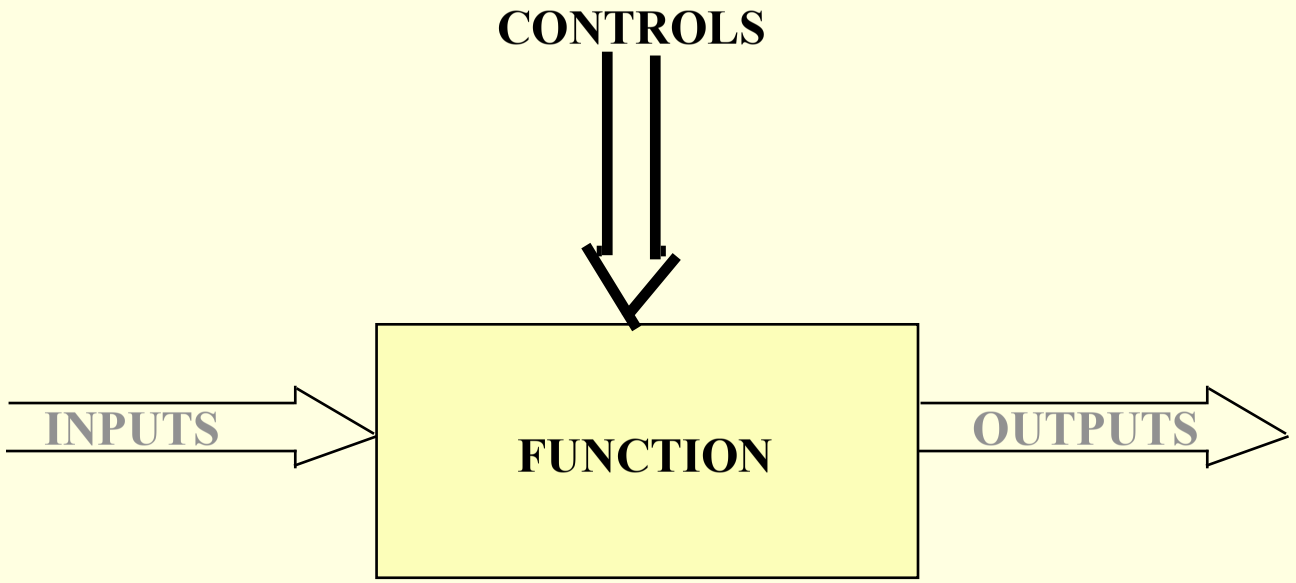
- Objects or Data Produced as a Result of the Function

- Labeled with a Noun or Noun Phrase



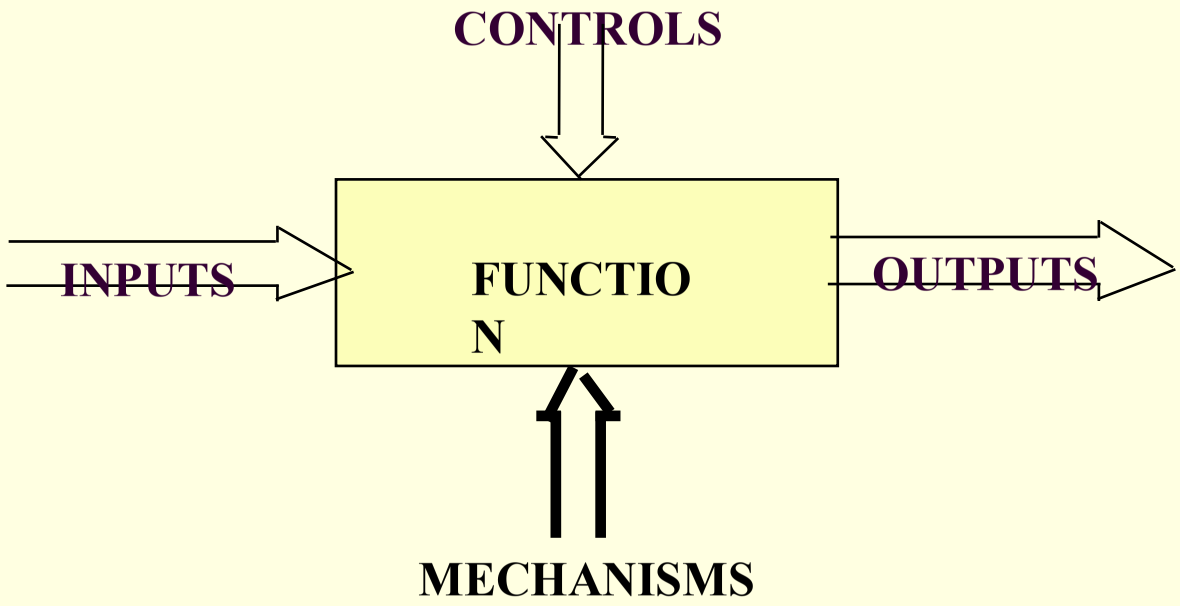
Control

- That which Governs the Accomplishment of the Function
- Things that Influence or Determine the Outputs
- Labeled with a Noun or Noun Phrase

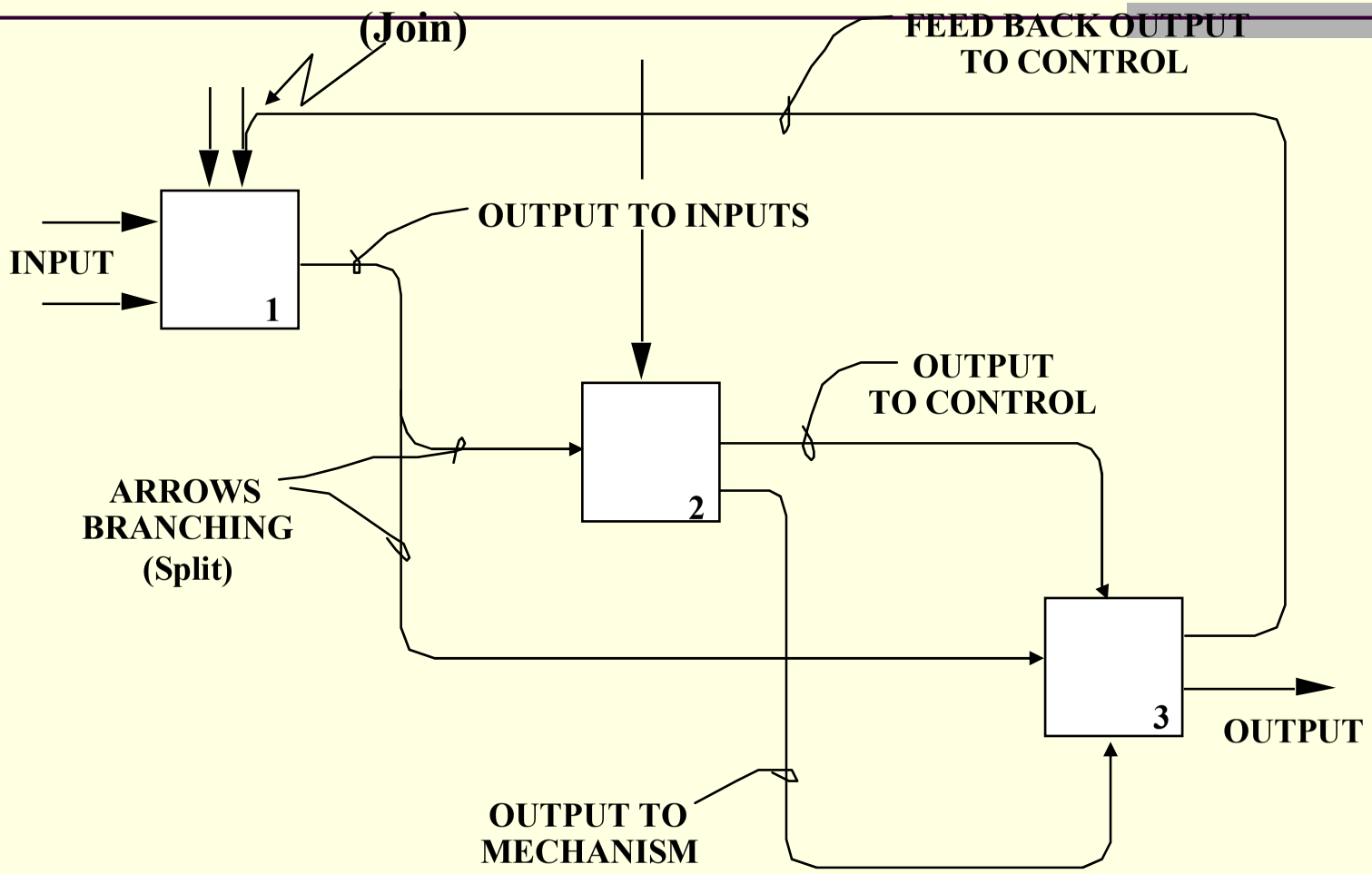


Mechanism

- Person, Device, or Data which Carries out the Function
- The Means by which the Function is Performed
- Labeled with a Noun or Noun Phrase

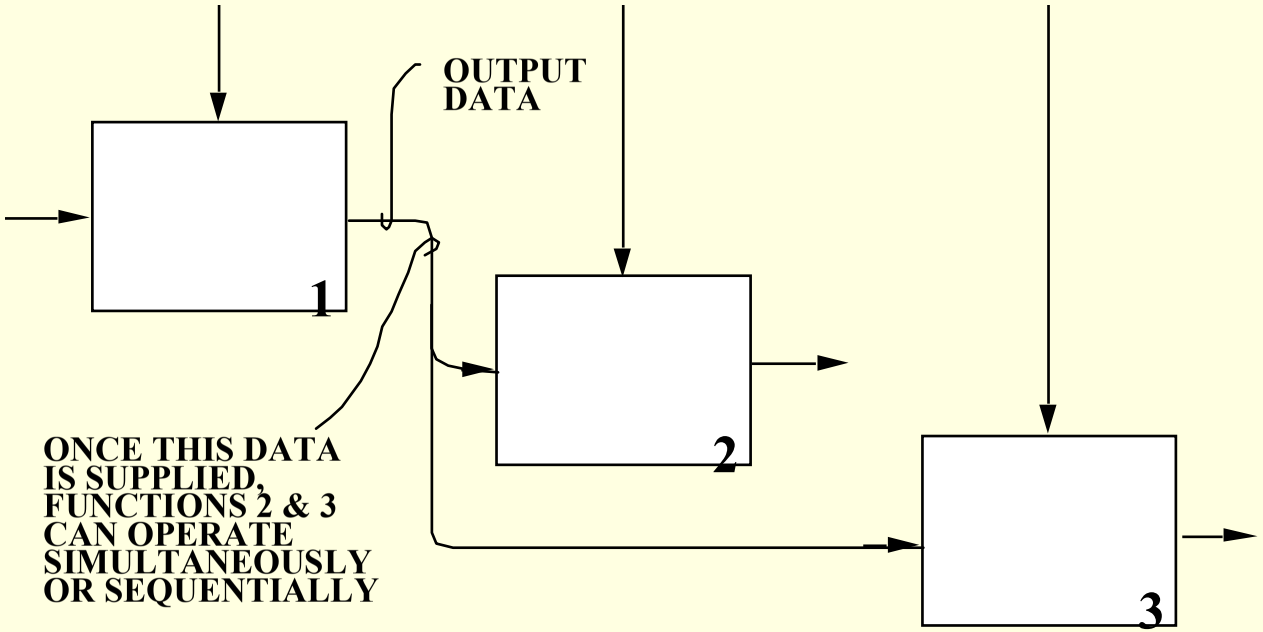


Box and Arrow Relations in a Diagram



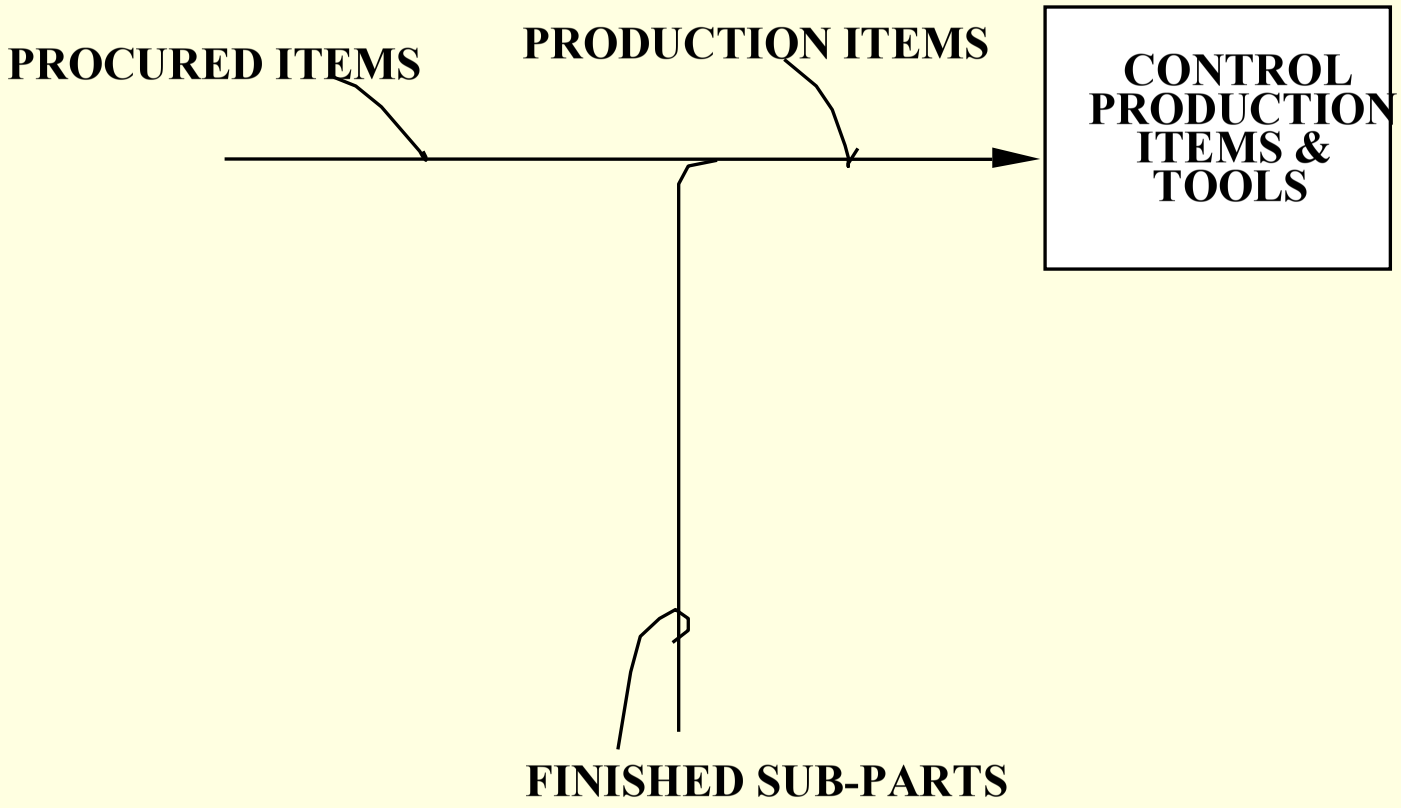
Arrows: "Branching"

Output can branch and be used by two functions simultaneously or sequentially

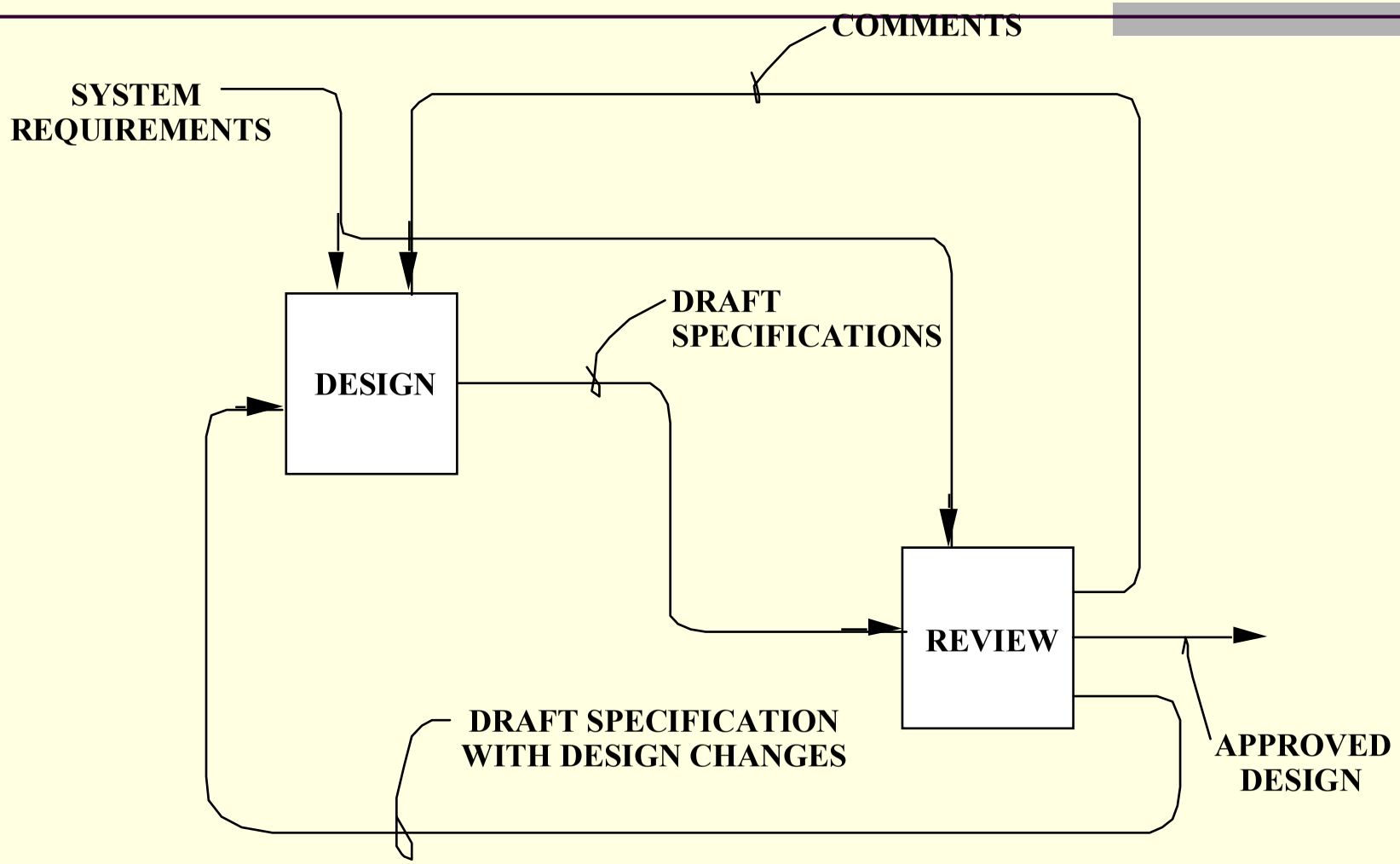


Without labels we cannot tell how the branching occurs

Arrows: "Joining"

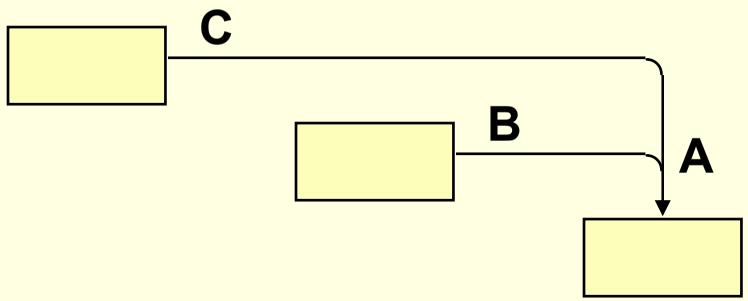


Arrows: "Feedback"

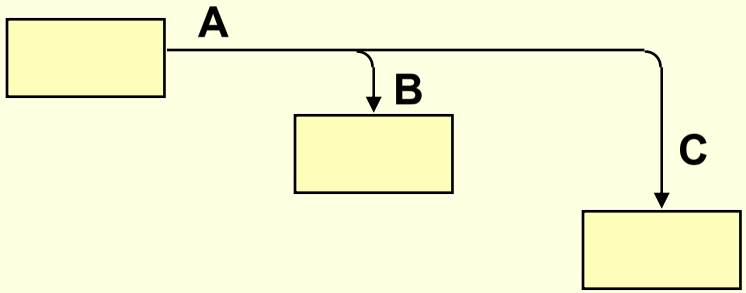


Bundling and Unbundling

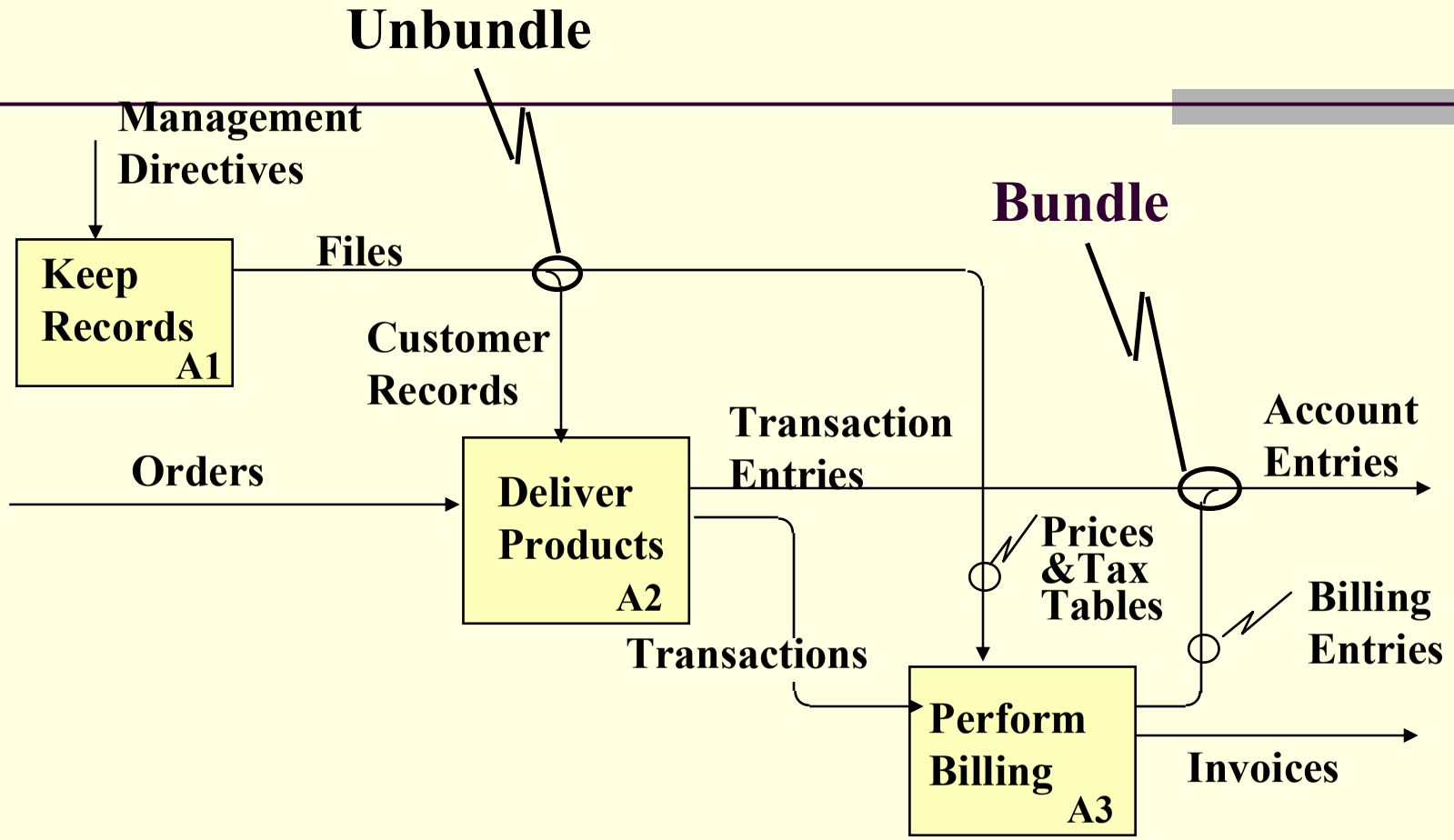
Bundle: Concepts B and C are bundled to form concept A.



Unbundle: Concept A is unbundled into concepts B and C.



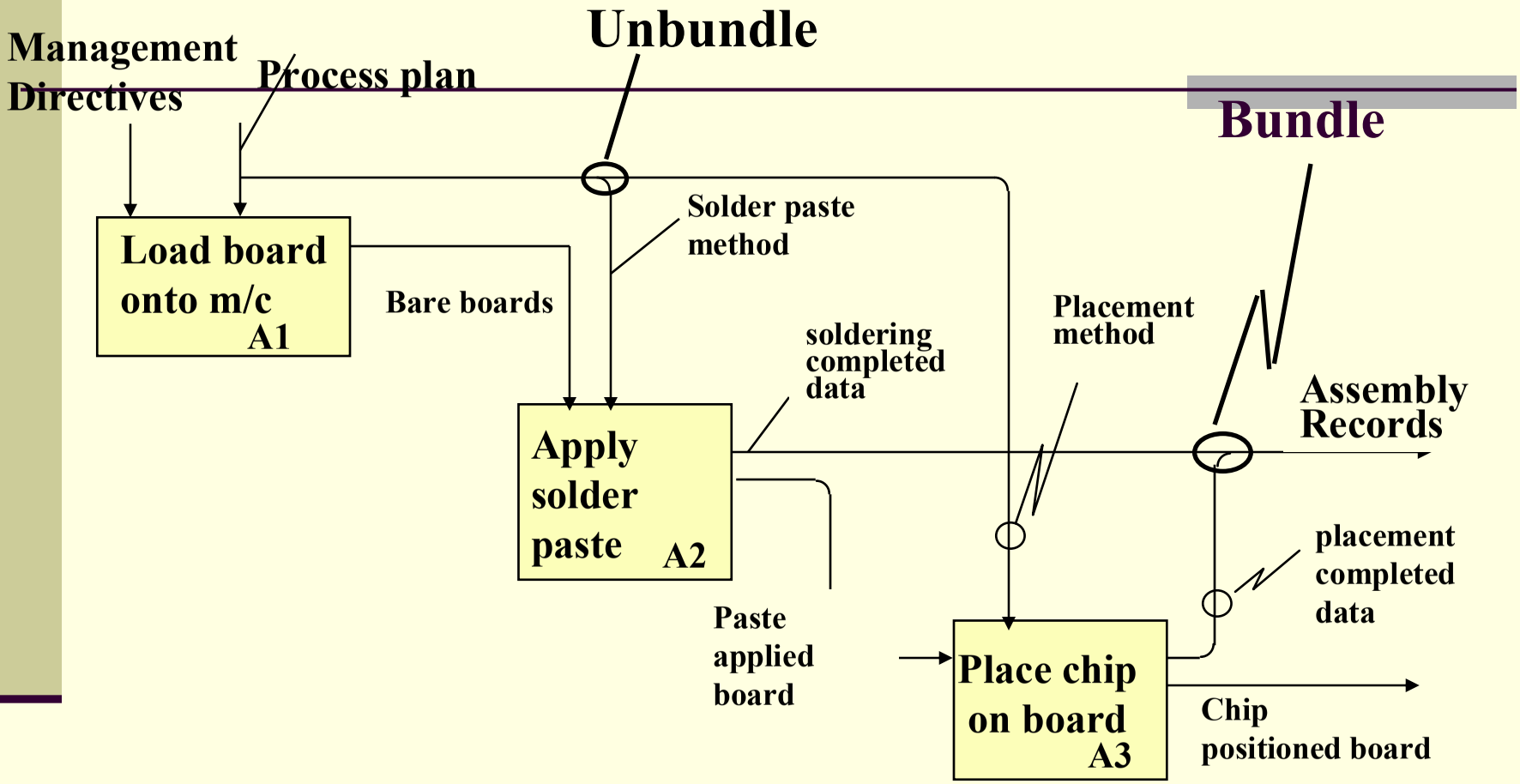
Bundles and Unbundles



Files = Customer Records + Price & Tax Tables

Account Entries = Transaction Entries + Billing Entries

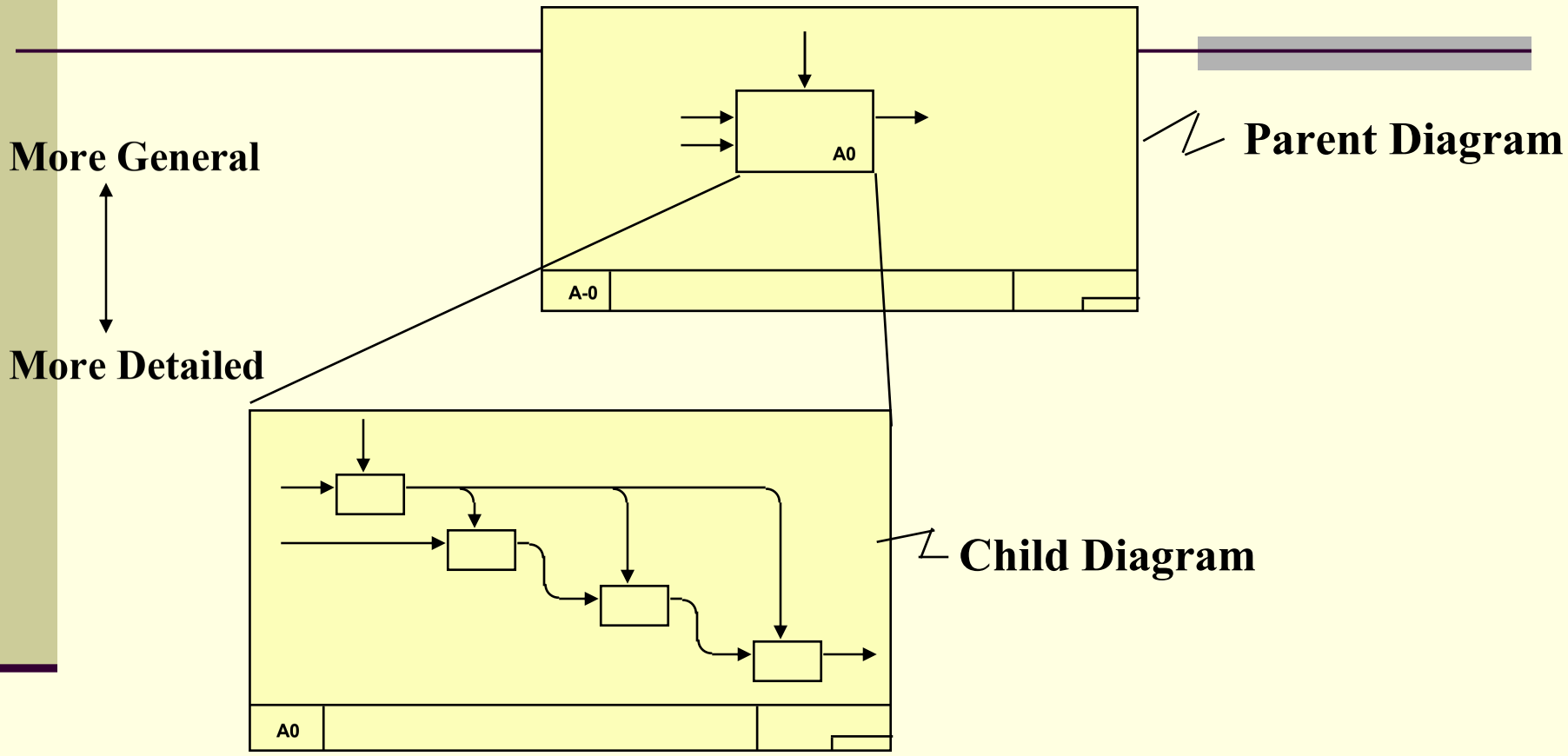
Bundles and Un-bundles: PCB ASSEMBLY



Process Plan = loading details + solder paste details + chip placement method

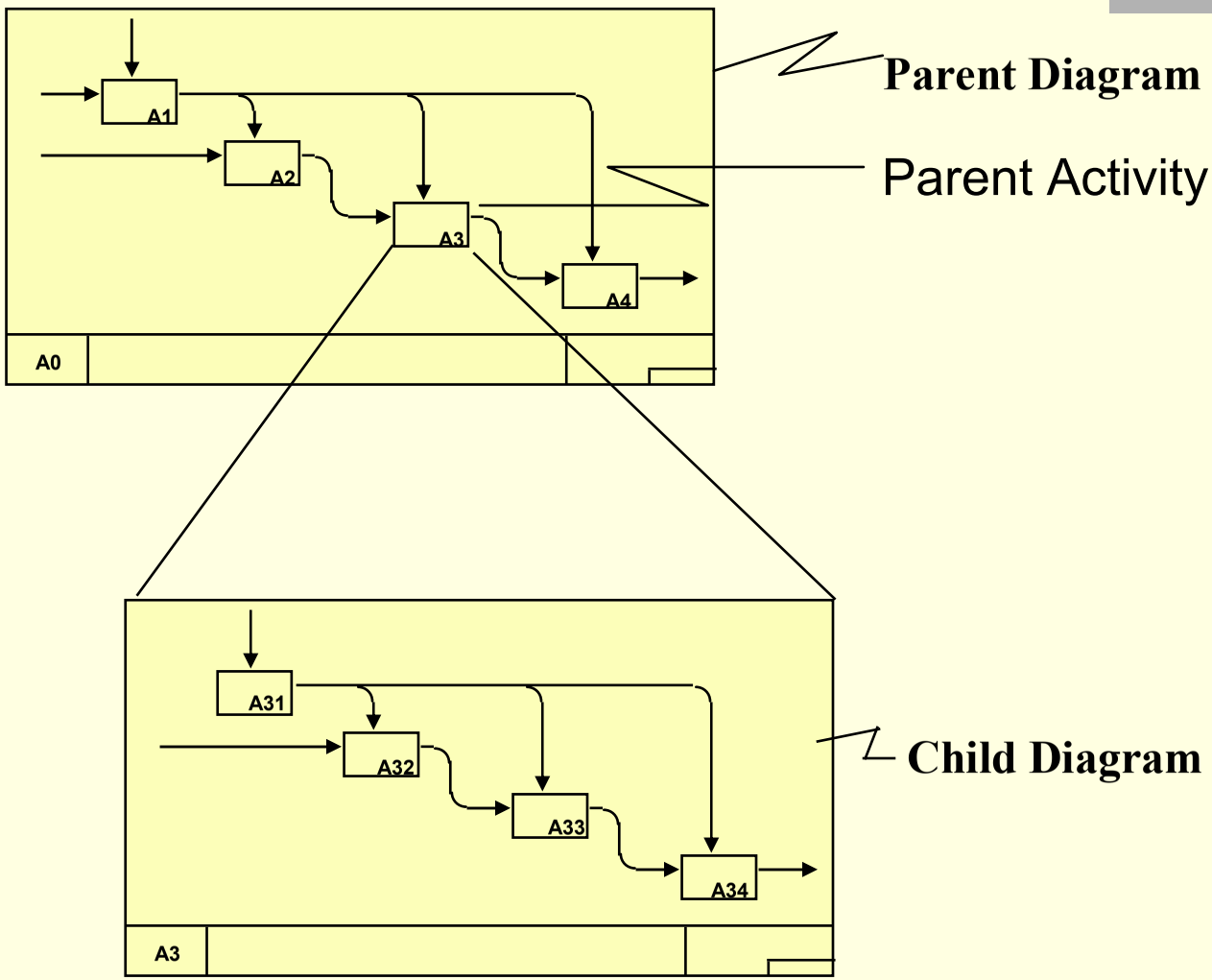
Assembly Records = soldering completed data + placement completed data

Function Decomposition



"Parent" Activities Represent a Higher Level of Abstraction than that of Their "Children"

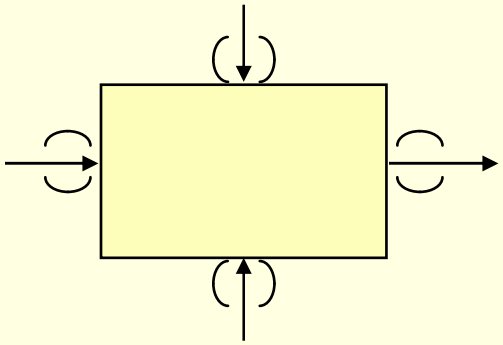
Further Decomposition



Decomposition

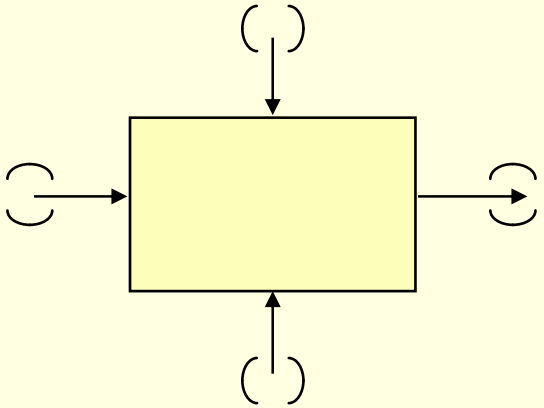
- Establishes model hierarchy
- Functions are comprised of other functions
- Decompositions is a process of breaking down of the functions (level-by-level)
- Data consistency is required throughout the level-by-level decomposition breakdown

Complexity Simplification Technique Tunneled Arrows



Tunneled Arrows at Connected Ends

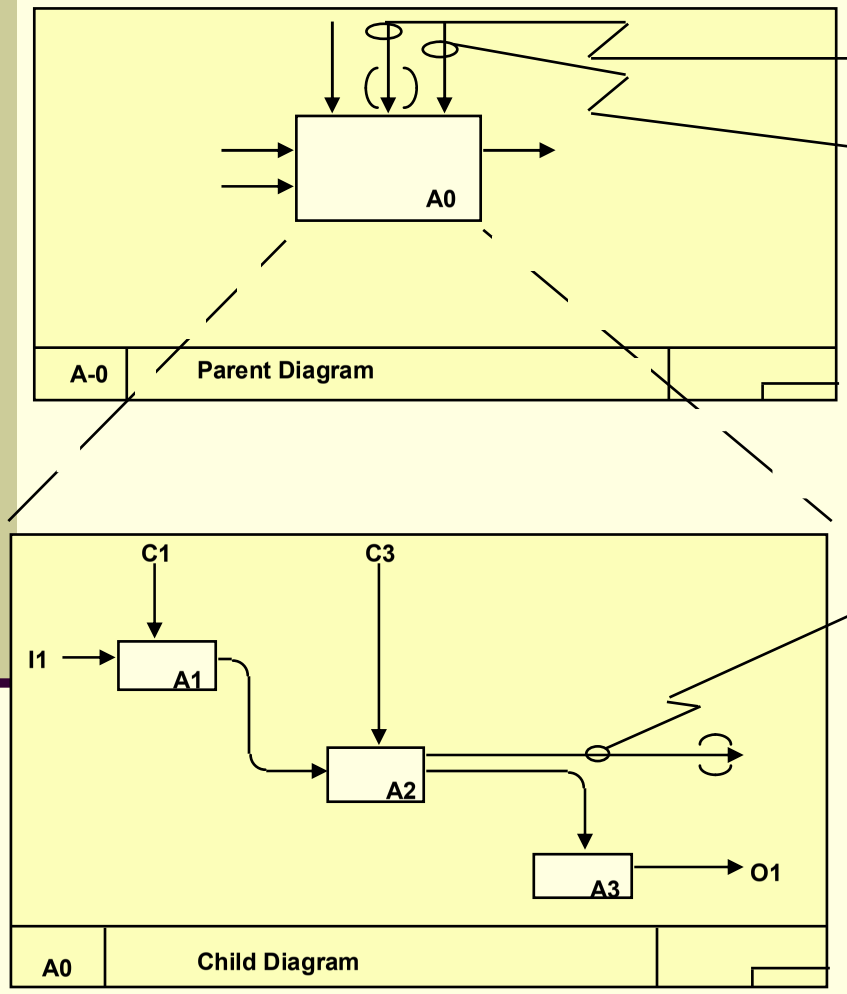
(Concept Does Not Appear on the Next Lower Level.)



Tunneled Arrows at Unconnected Ends

(Concept Does Not Appear on the Next Higher Level.)

Tunneling Example



This control will not appear on child diagram.

This control will still be designated as C3 on child diagram.

This output will not be shown on parent diagram.

Steps in Building a Model

- 1. Define Viewpoint, Purpose, and Context
- 2. Develop the Context Diagram (Putting the situation in context)
- 3. Decompose activities to fit scope of modeling task (complete modeling per rules, etc)
- 4. Develop glossary

Model Orientation!!!!

- Context (Subject)

  The Boundaries of the Subject Matter

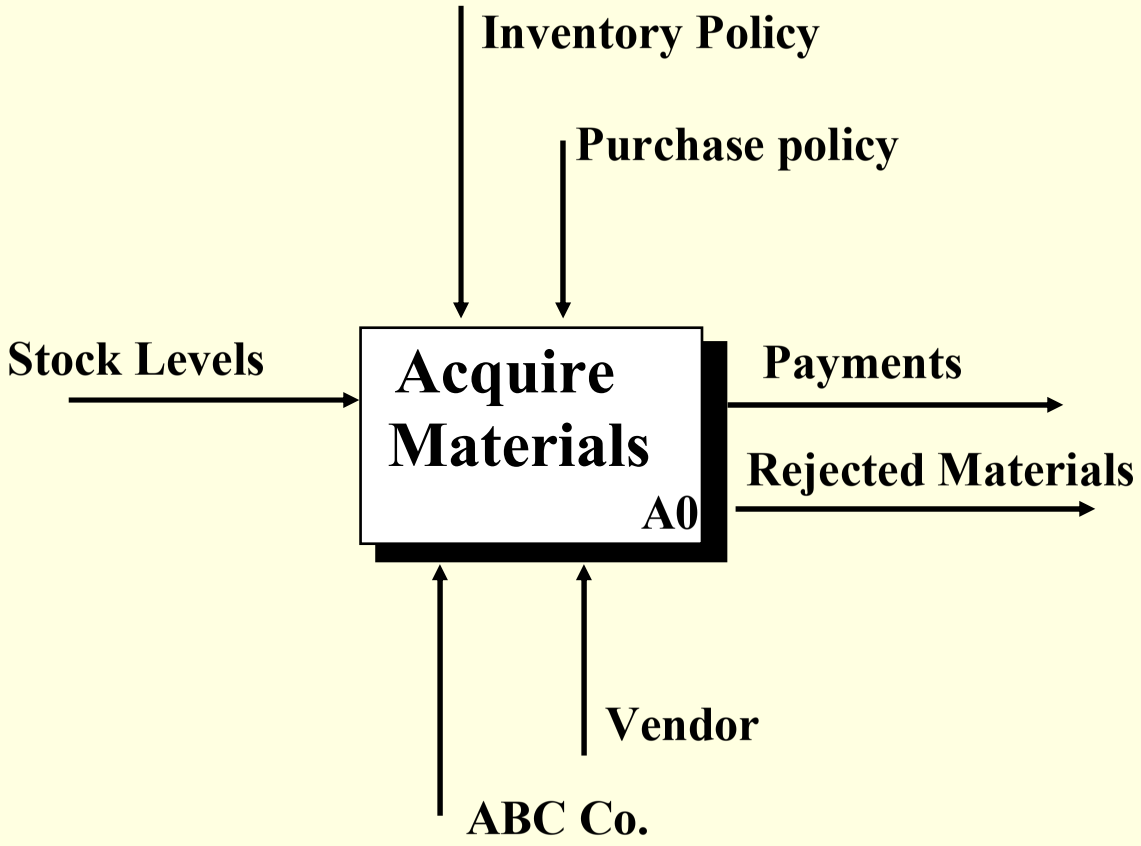
- Viewpoint (Bias)

  The Perspective from which a Subject is Analyzed

- Purpose (Objective)

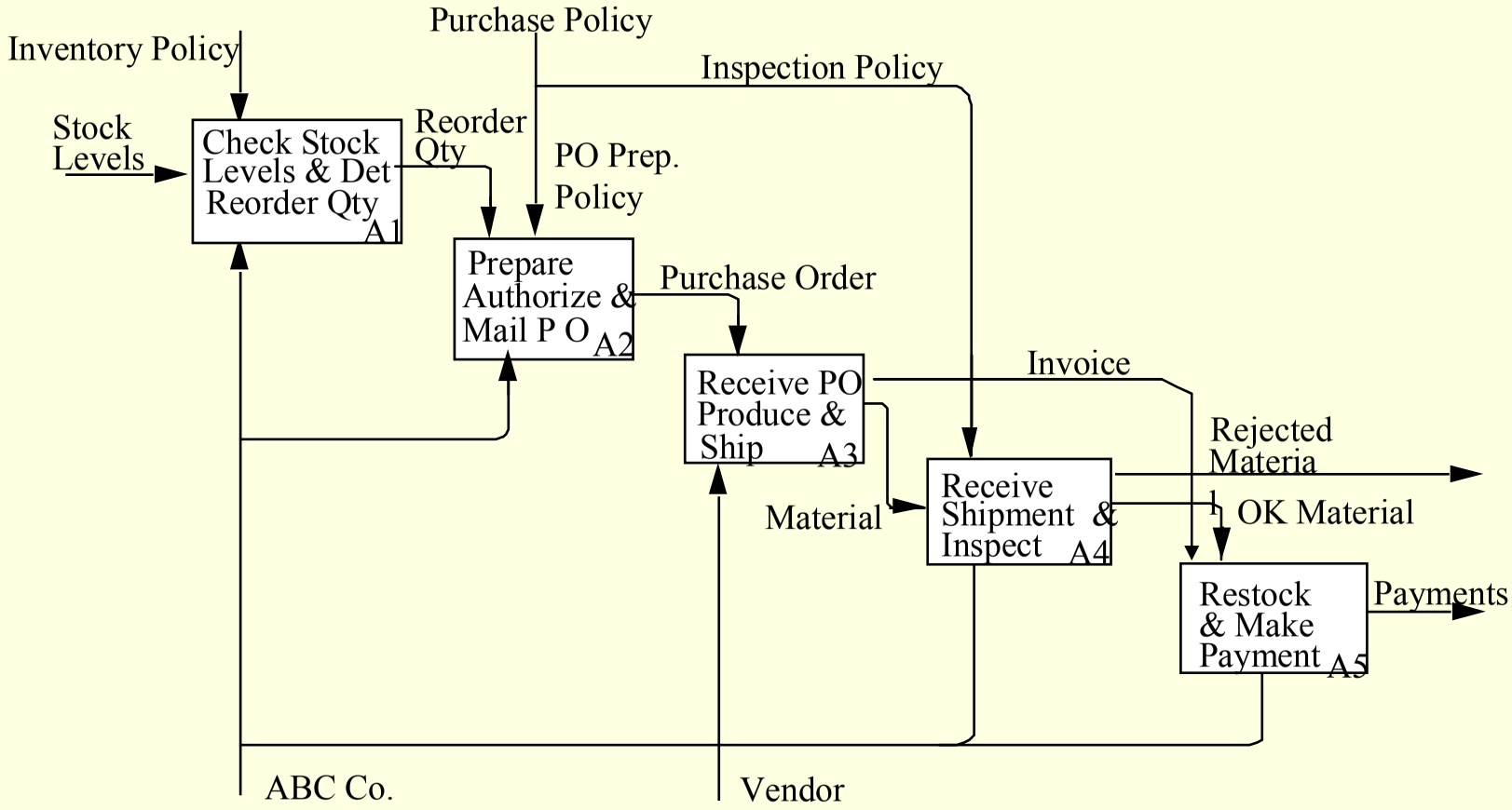
  The Reason(s) a Model is Created

Example - Context Diagram



A-0 Diagram

Example - Decomposition of the Context Diagram



A0 Diagram

Function Model for Planning and Implementing a Feature Extraction module

- Purpose: To obtain a better understanding of the various tasks involved in planning and implementation of a feature extraction module
- Context: We will assume CAD model formats, process planning requirements and resources available (people and computers) are known. The FE module will be built using available existing resources (no new tools or software will be purchased).
- Viewpoint: that of an industrial / mfg engineer who has a background in designing / building software systems