King Saud University

College of Engineering

IE – 462: "Industrial Information Systems"

Spring – 2025 (2nd Sem. 1446H)

Chapter 4:

Structured Analysis and Functional Architecture Design – p1 – IDEF0 – i - Fundamentals

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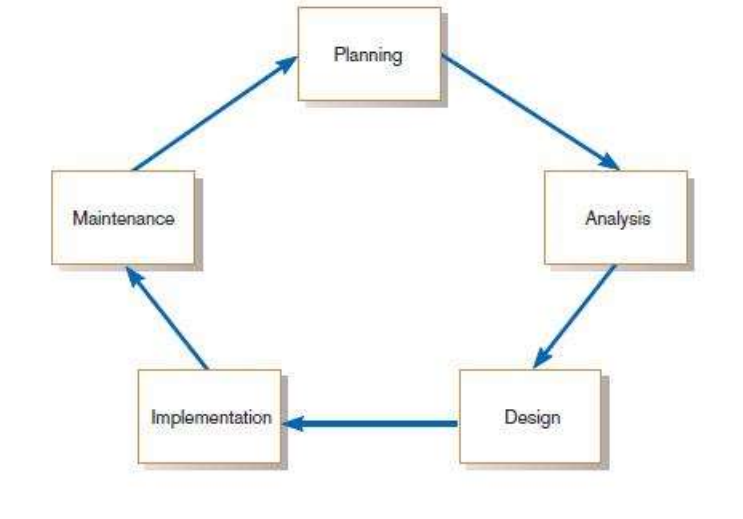
Lesson Overview

- Modeling IIS – (p1)
- Integrated Computer-Aided Manufacturing Definition 0 (IDEF0) – (p1)
- Data Flow Diagram (DFD) – (p2)

Modeling Industrial Information Systems

Modeling IIS

- *REMEMBER*: **Design** – a description of the recommended solution is converted into *logical* and then *physical* system specifications
  - **Logical design**: all *functional features* of the system chosen for development in analysis are described *independently* of any computer platform
  - **Physical design**: transforming the logical specifications of the system into *technology-specific details*

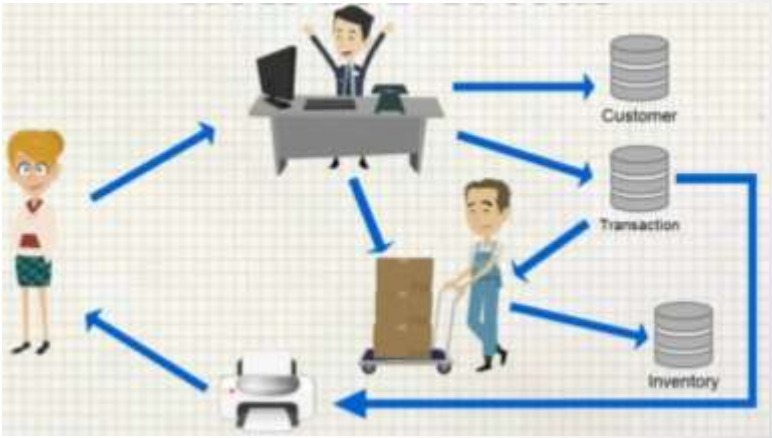


Modeling IIS – cont.

- This is *first step* in design of IIS for an industrial enterprise

- The design proceeds from a **definition of a business model** of the enterprise

- This business model (**IS model**) is a description of the:
  - **functions of the business** (or manufacturing operations)
  - **data requirements**, and
  - **interactions** between the functions and data requirements

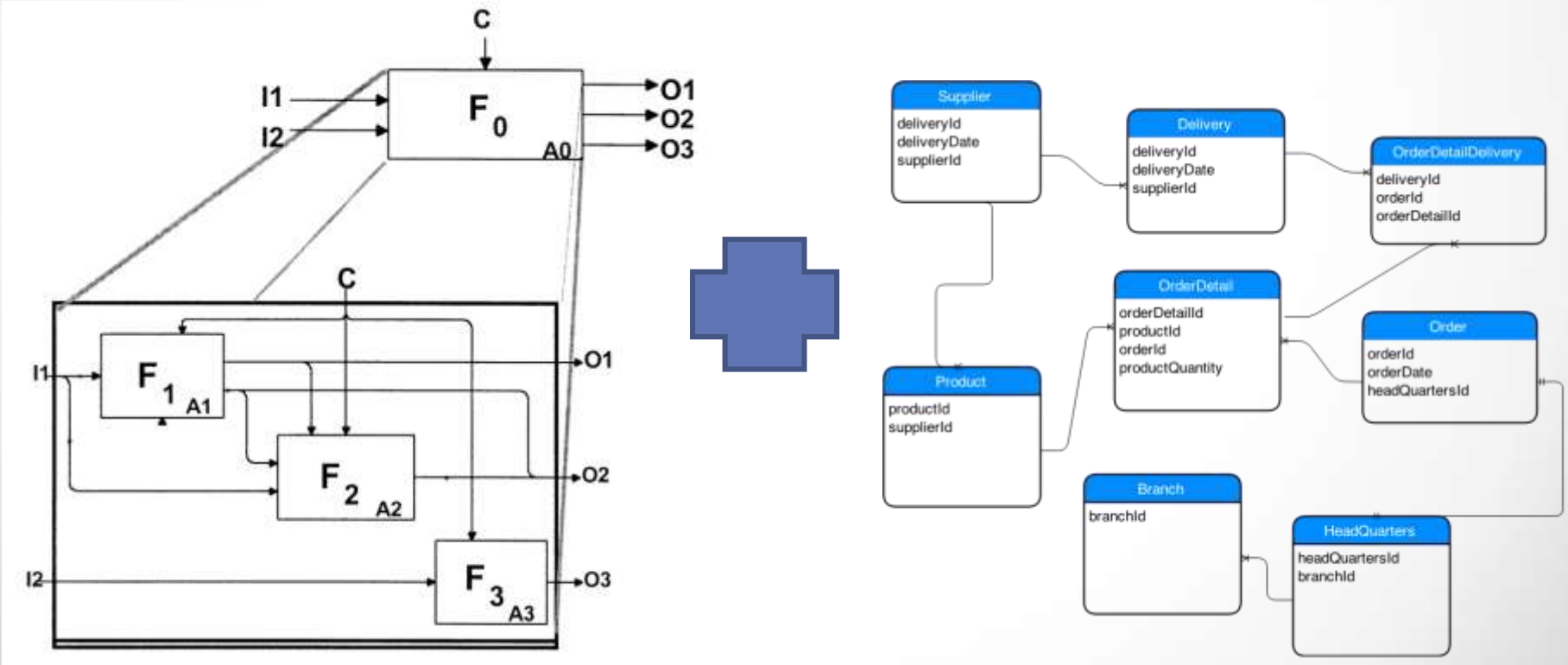


Modeling IIS – cont.

- **Functional or Activity architecture** describes:
  - a conceptual model of the activities that operate the business (or manufacturing operations) *and*
  - the relationships between those activities
- The word **architecture** denotes the fact that the model has a *layered structure*
- A related conceptual model of the firm is the **Informational or Data architecture:**
  - this is a model of the *information requirements* needed to perform the functions of the business

Modeling IIS – cont.

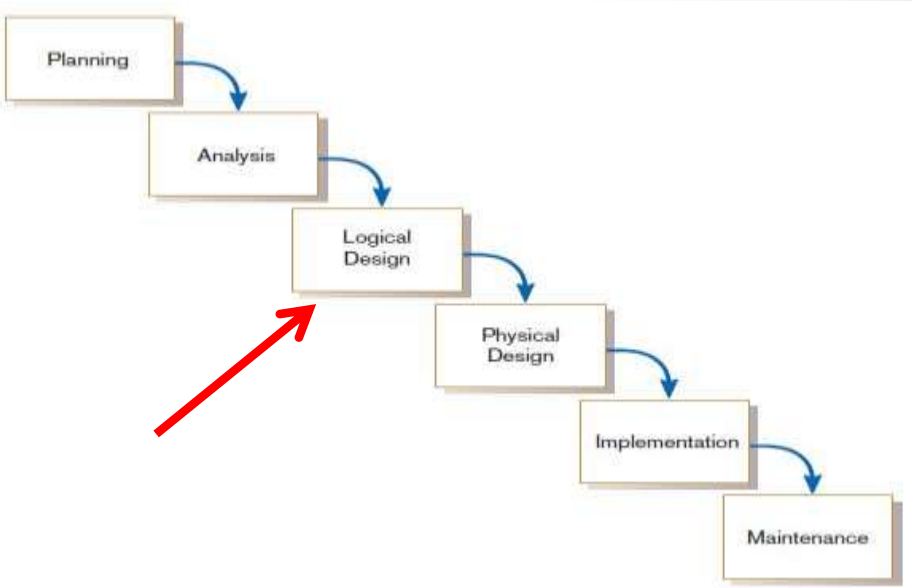
- Functional and informational architectures, when taken together:
  - form a *high-level blueprint* for the implementation of computer integration in the enterprise



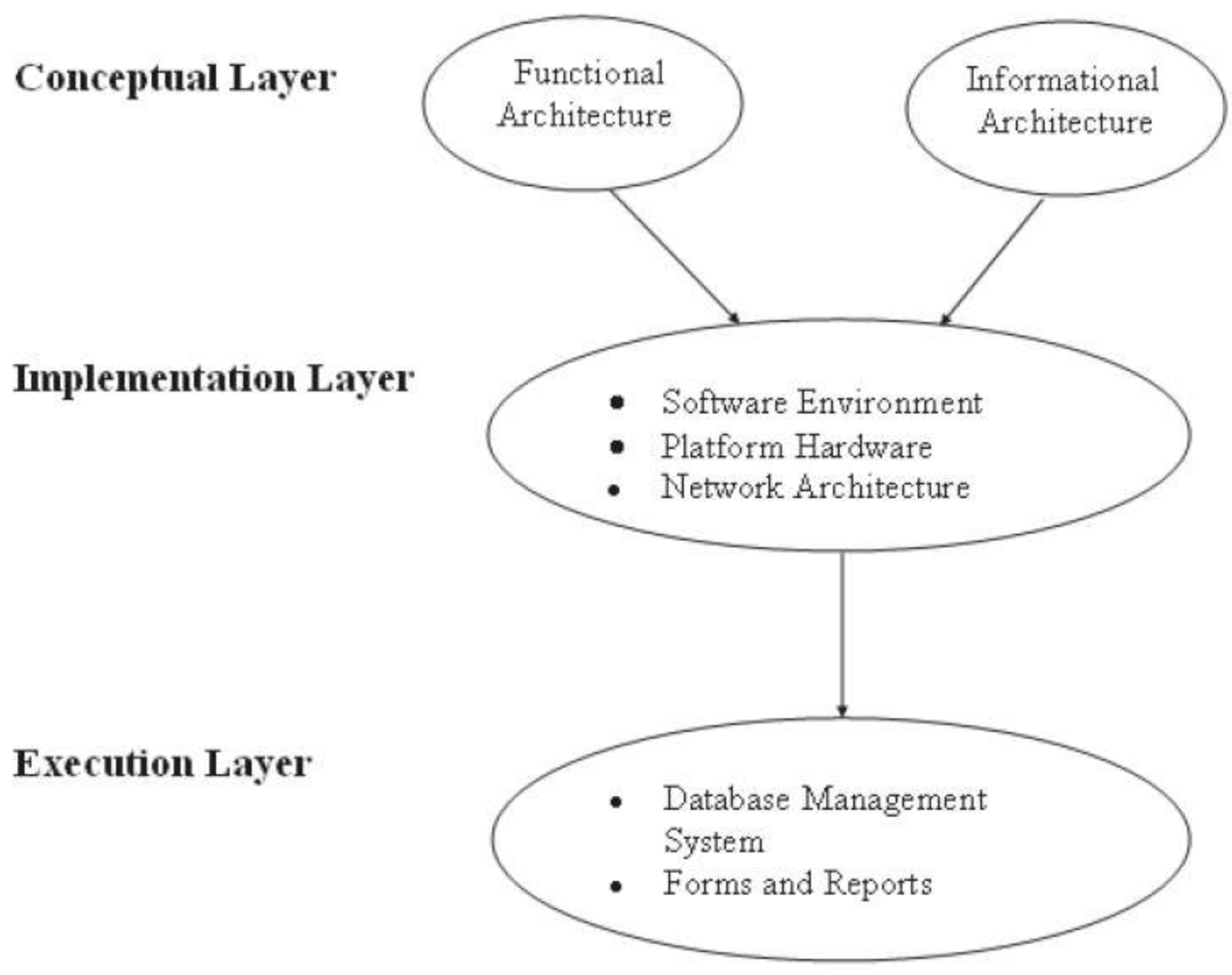
Modeling IIS – cont.

- There are **three layers** of system design to consider in an information system project:
  - Conceptual
  - Implementation and
  - Execution

- Conceptual layer consists of **logical** design of functional and data requirements



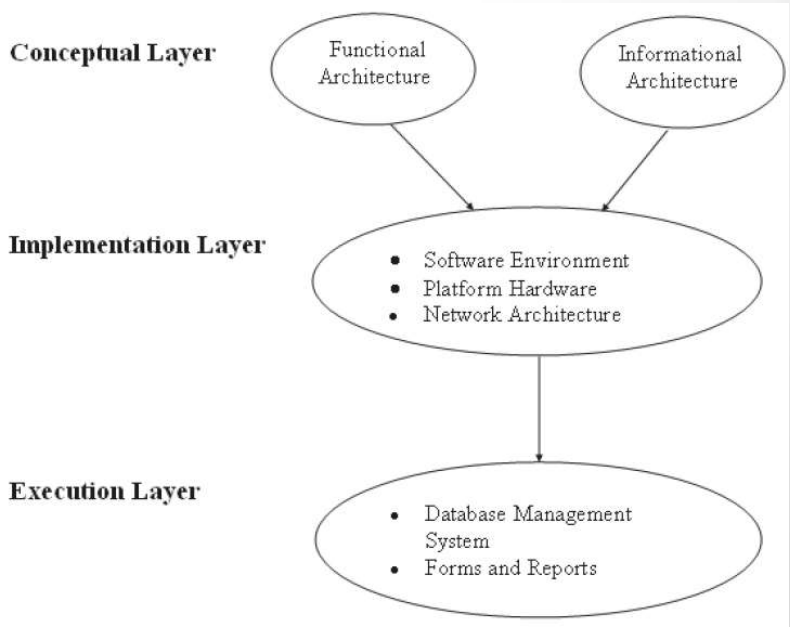
Layers of IS Design Process



Modeling IIS – cont.

- When a conceptual design is complete, the next step is to **implement** the blueprint as hardware and software

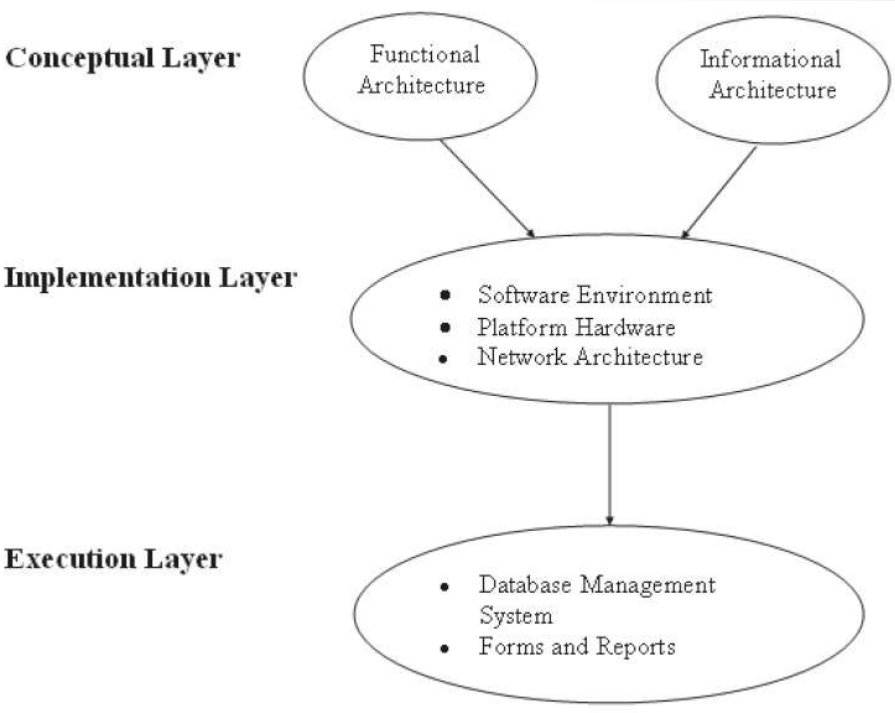
- This is the *implementation layer* that requires the selection of:
  - database management system (DBMS)
  - hardware platforms, and
  - communication medium



Modeling IIS – cont.

- At the **execution** layer, the conceptual model and implementation techniques are coded in **software** in terms of forms and reports

- *Forms* and *reports* are used to interface with the individuals performing the functions defined in the functional architecture



Modeling IIS – cont.

- Two methodologies for designing a functional architecture, known as "structured analysis" techniques:
  - ***data flow diagrams*** (1979), widely used by information system professionals in all industries
  - ***structured analysis and design technique*** (SADT) (1988), adapted for manufacturing enterprises under the name ***integrated computer-aided manufacturing definition 0*** (IDEF0)
  - Both methodologies are based on *graphical notations* used to describe information flows among processes of the enterprise being documented (described next)

Functional Modeling

Integrated Computer-Aided Manufacturing Definition 0 (IDEF0)

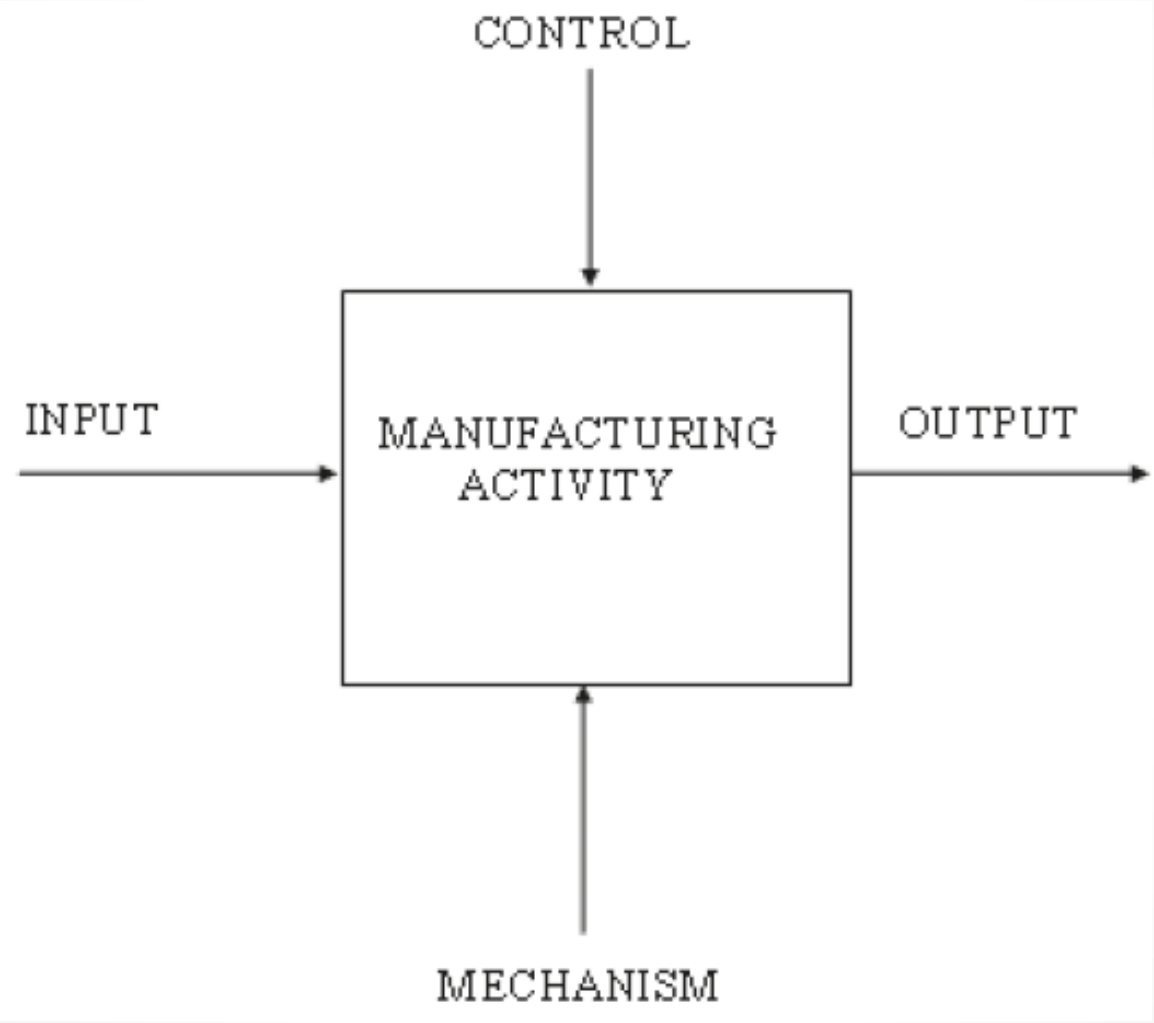
IDEF Family

- **IDEF Family of Methods:**
  - IDEF0: Function Modeling (purpose: description)
  - IDEF1: Information Modeling (purpose: description)
  - IDEF1x: Data Modeling (purpose: design)
  - IDEF2, IDEF3: Process Modeling (purpose: description)
  - IDEF4: for Object-Oriented Programming (purpose: design)
  - Other: IDEF5, IDEF6, IDEF8, IDEF9, IDEF14

IDEF0 Methodology - Modeling Primitives

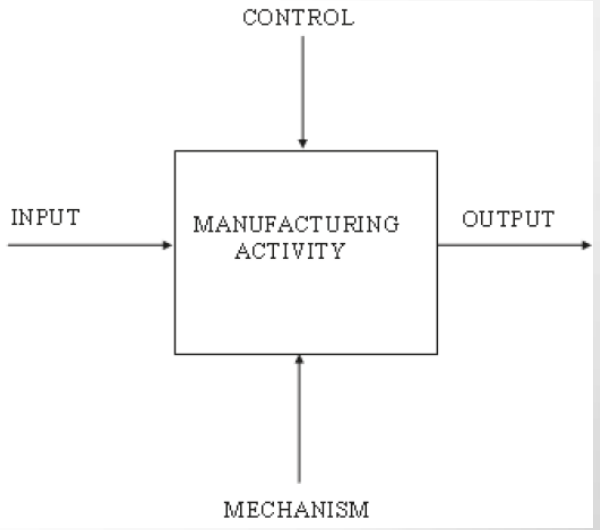
- **IDEF0 (integrated computer-aided manufacturing definition 0):**
  - modeling methodology
  - used for designing and documenting **hierarchic**, **layered**, **modular systems**
- The **activity box**:
  - used to describe a *function being performed* in the enterprise
- Function can be either a:
  - *material conversion* function (e.g. machining a part), *or*
  - *information conversion* function (e.g. processing a requisition for ordering materials)

IDEF0 Activity Box and Connecting Arrows



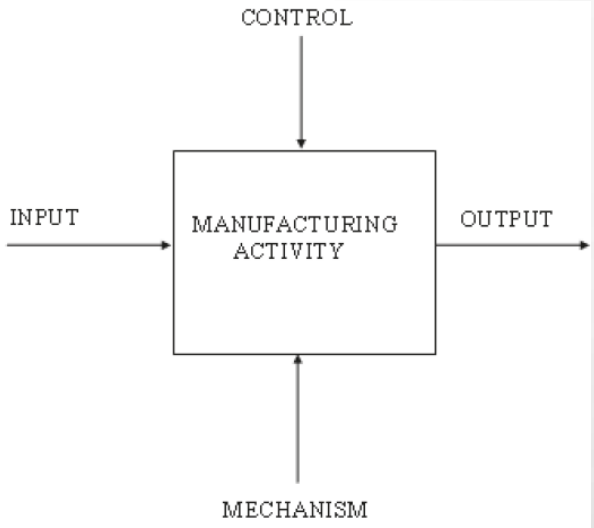
IDEF0 Activity

- **Inputs**: items that are transformed by the function
  - a workpiece to be machined, or
  - requisition information to be transformed into a purchase order
- **Outputs**: result of the transformation process provided by the activity
  - finished component after machining, or
  - a purchase order



IDEF0 Activity – cont.

- **Mechanisms**: means by which a function is realized
- Mechanism in material conversion of a workpiece to a finished component might require (as mechanisms):
  - a *lathe* and
  - lathe *operator*
- Information conversion to process a requisition into a purchase order:
  - Could involve a *purchasing agent* as the mechanism

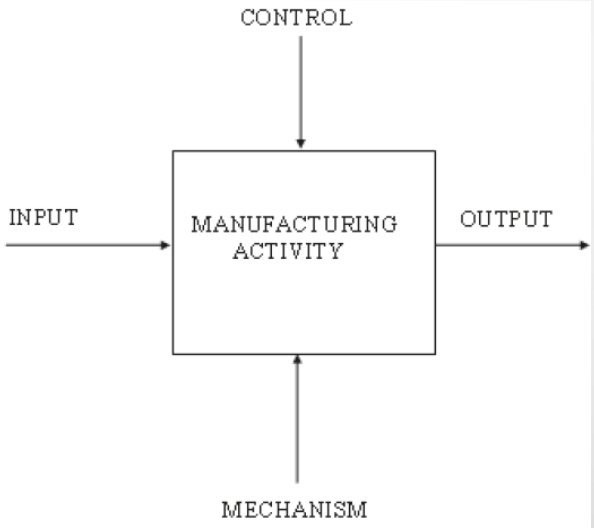


IDEF0 Activity – cont.

- A **control** is a condition or set of conditions that *guide* or *constrain* the performance of the activity

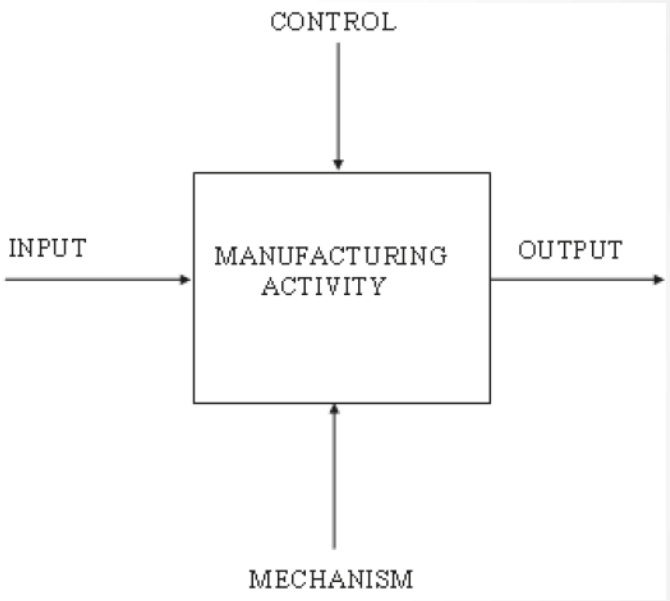
- *Machining activity* example:
  - parts may require a *numerical control parts program*

- *Information conversion* example:
  - requisition processing function may require adherence to *set of company rules or purchasing policy*
  - e.g. purchasing only from approved vendors



IDEF0 Activity – cont.

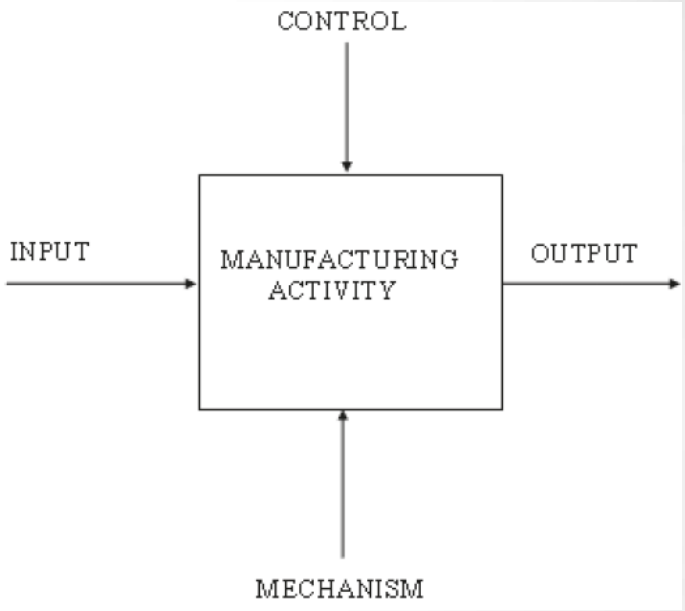
- **Activity box** and 4 **arcs** provide a concise expression:
  - an **input** is transformed …
  - into an **output** …
  - by an **activity** (**function**) …
  - performed by a **mechanism** …
  - and governed by a **control**



- The specific activity, inputs, outputs, mechanisms, and controls are defined by the *situation* being modeled

IDEF0 Activity – cont.

- **Grammatical convention** used in naming activities and arcs:
  - **Activities** represent *actions* being performed and are labeled with *verb phrases*
  - **Inputs**, **outputs**, **mechanisms**, and **controls** represent things and are labeled with *noun phrases*

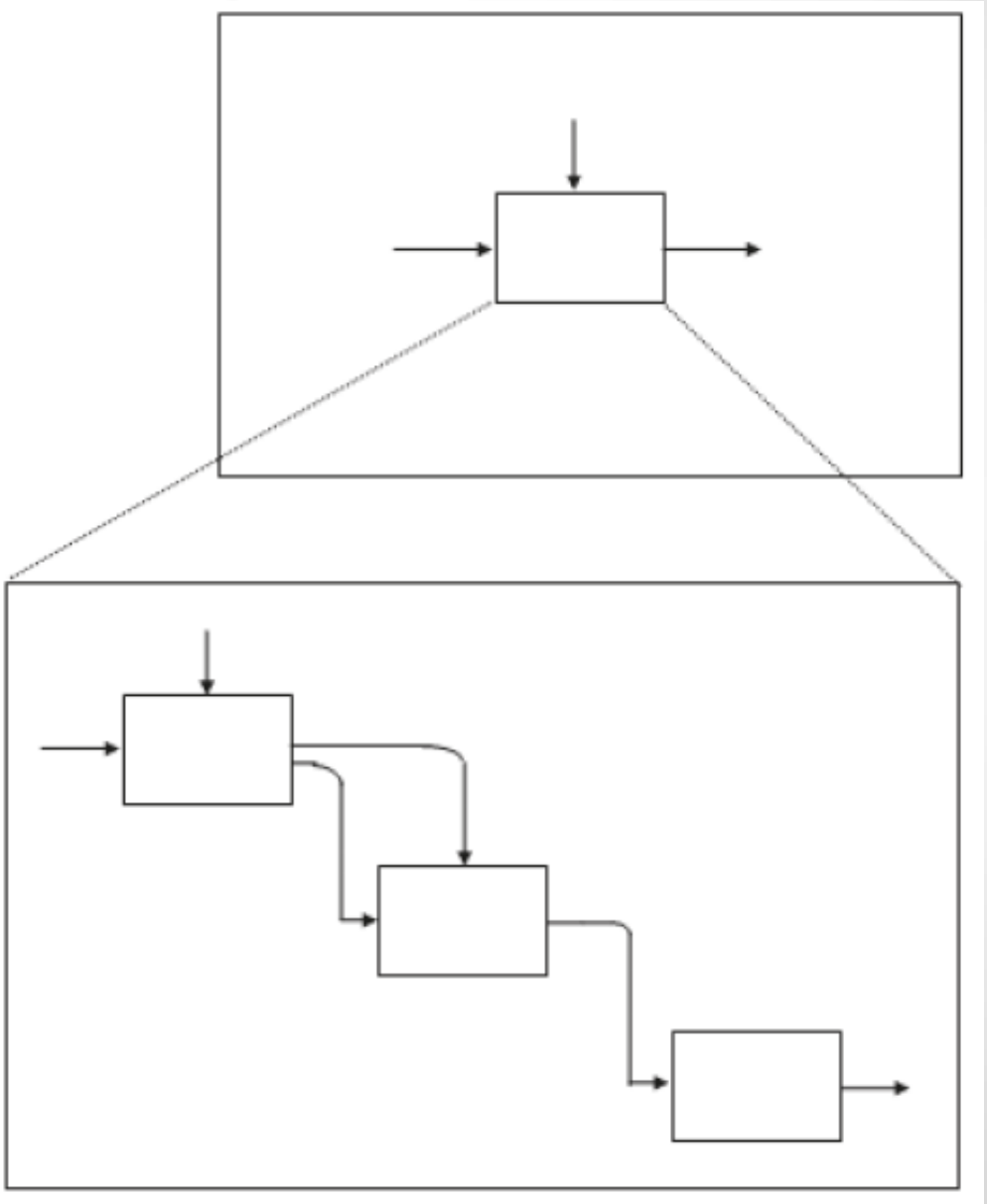


IDEF0 Hierarchic decomposition

- IDEF0 is a top-down modeling approach
- *First layer*:
  - a **single activity box**
  - describes the *overall function* of the enterprise, organization, or process within the enterprise (i.e. the subject of the model)
- This overall activity is then decomposed into its *major sub-activities* at the *second layer*
- Functions are related to each other by their **material flows** and **information flows**
  - e.g. the *output* material or information of one activity may provide the *input* to another activity

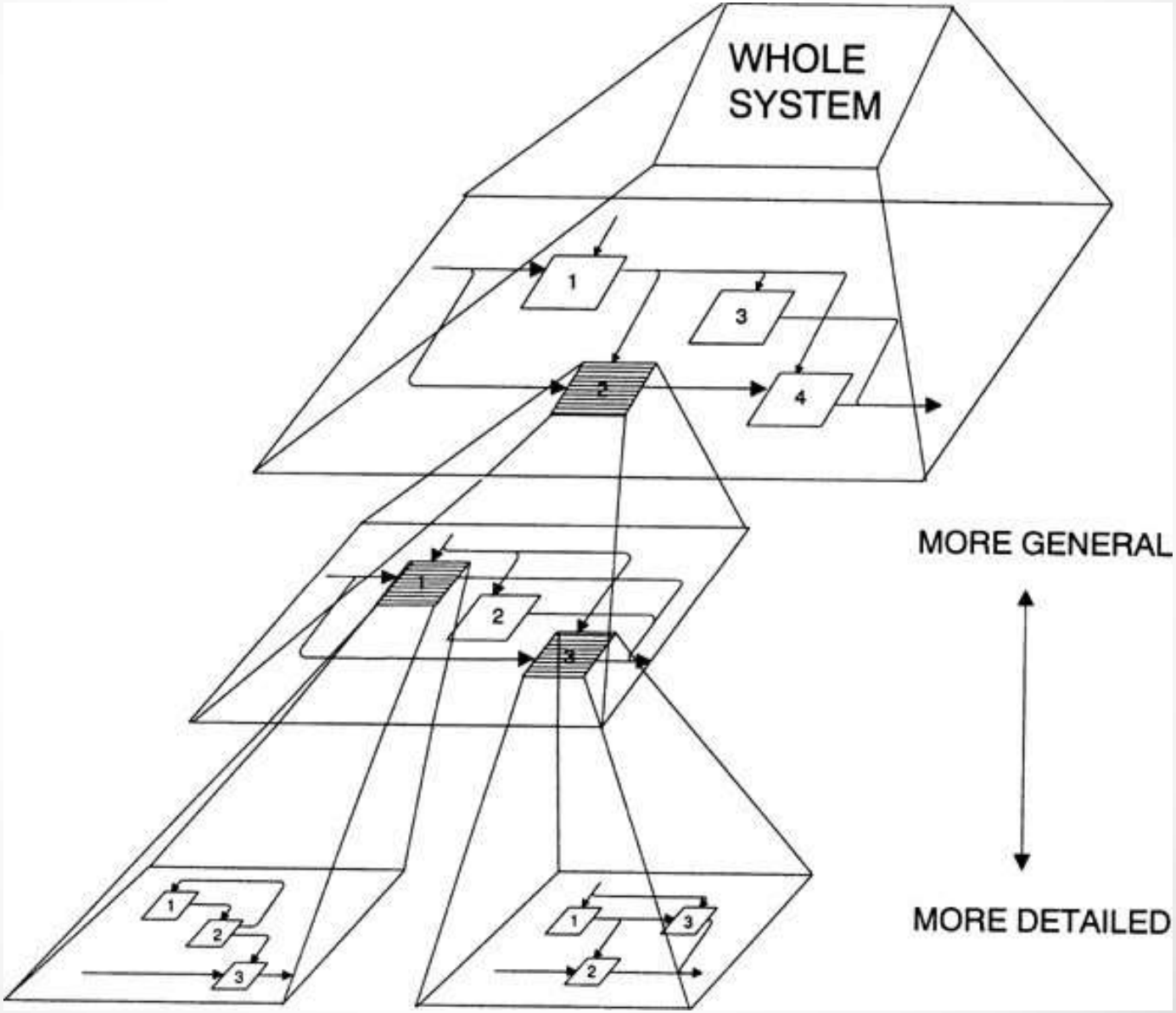
IDEF0 Activity – cont.

- Relationship among levels in IDEF0 methodology e.g. 1



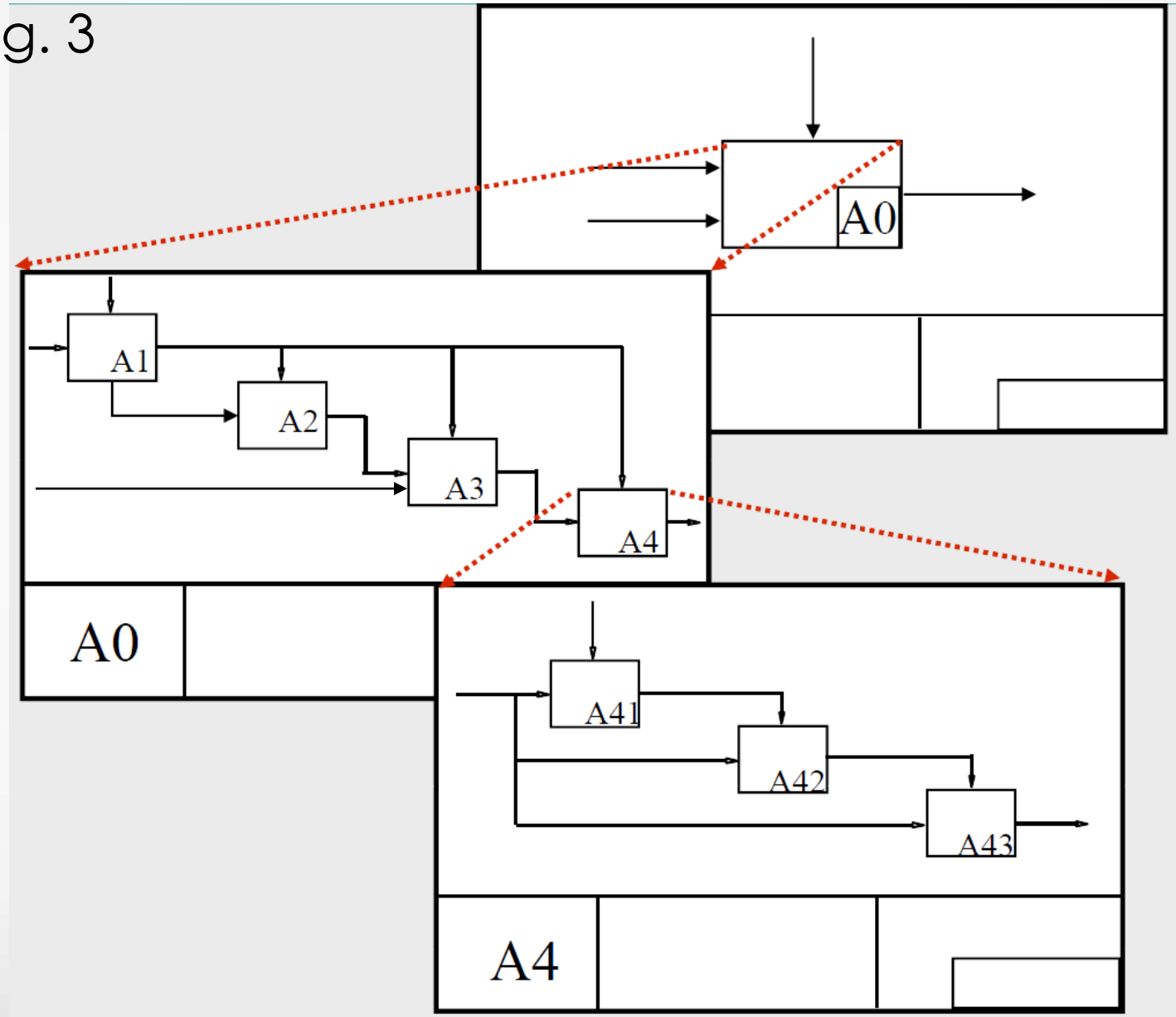
IDEF0 Activity – cont.

- e.g. 2



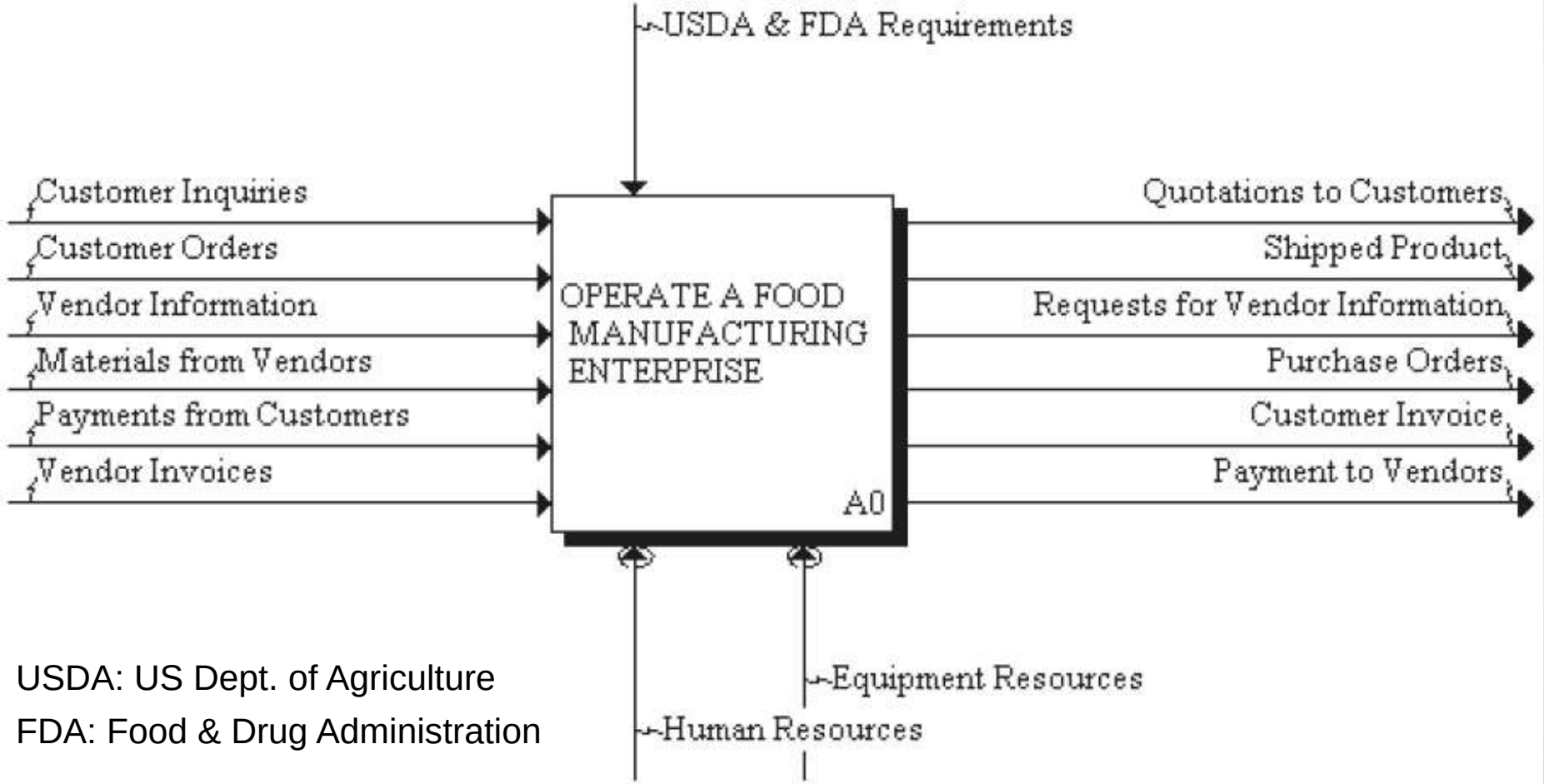
IDEF0 Activity – cont.

- e.g. 3



An Integrated IDEF0 Model of an Entire Manufacturing Enterprise

- Top-level view of the enterprise: Node A0



USDA: US Dept. of Agriculture

FDA: Food & Drug Administration

Elements of the A0 Activity

- **A0**: high-level view of the enterprise and its interactions with the outside world

- Related Inputs (I) and Outputs (O):
  - Customer inquiries (I) ⇒ Quotations to customers (O)
  - Customer orders (I) ⇒ Shipped product (O)
  - Customer invoice (O) ⇒ Payments from customers (I)
  - Request for vendor information (O) ⇒ Vendor information (I)
  - Purchase orders (O) ⇒ Materials from vendors (I)
  - Vendor invoice (I) ⇒ Payments to vendors (O)

Elements of the A0 Activity – cont.

- In summary: operation of a manufacturing enterprise can be viewed as *3 interrelated processes*:

  1. **Physical flow of materials**; e.g. input materials from vendors is transformed (i.e. the manufacturing process) into the output shipped product

  2. **Information flow**; e.g. vendor information and quotation to customers

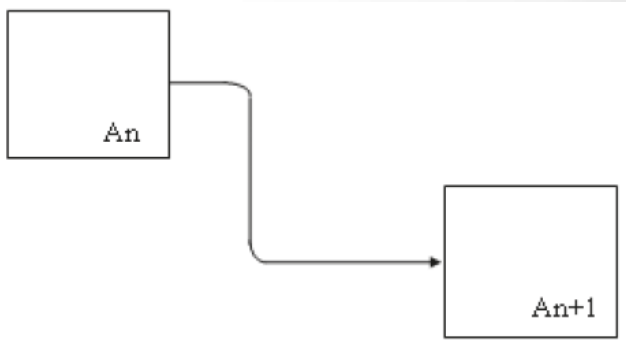
  3. **Financial flow**; e.g. payments from customers and payments to vendors

- Outside **controls**: USDA, FDA (important class of standards)

- **Mechanisms**: human resources and equipment resources; these *convert* inputs to outputs

Decomposition of Node A0

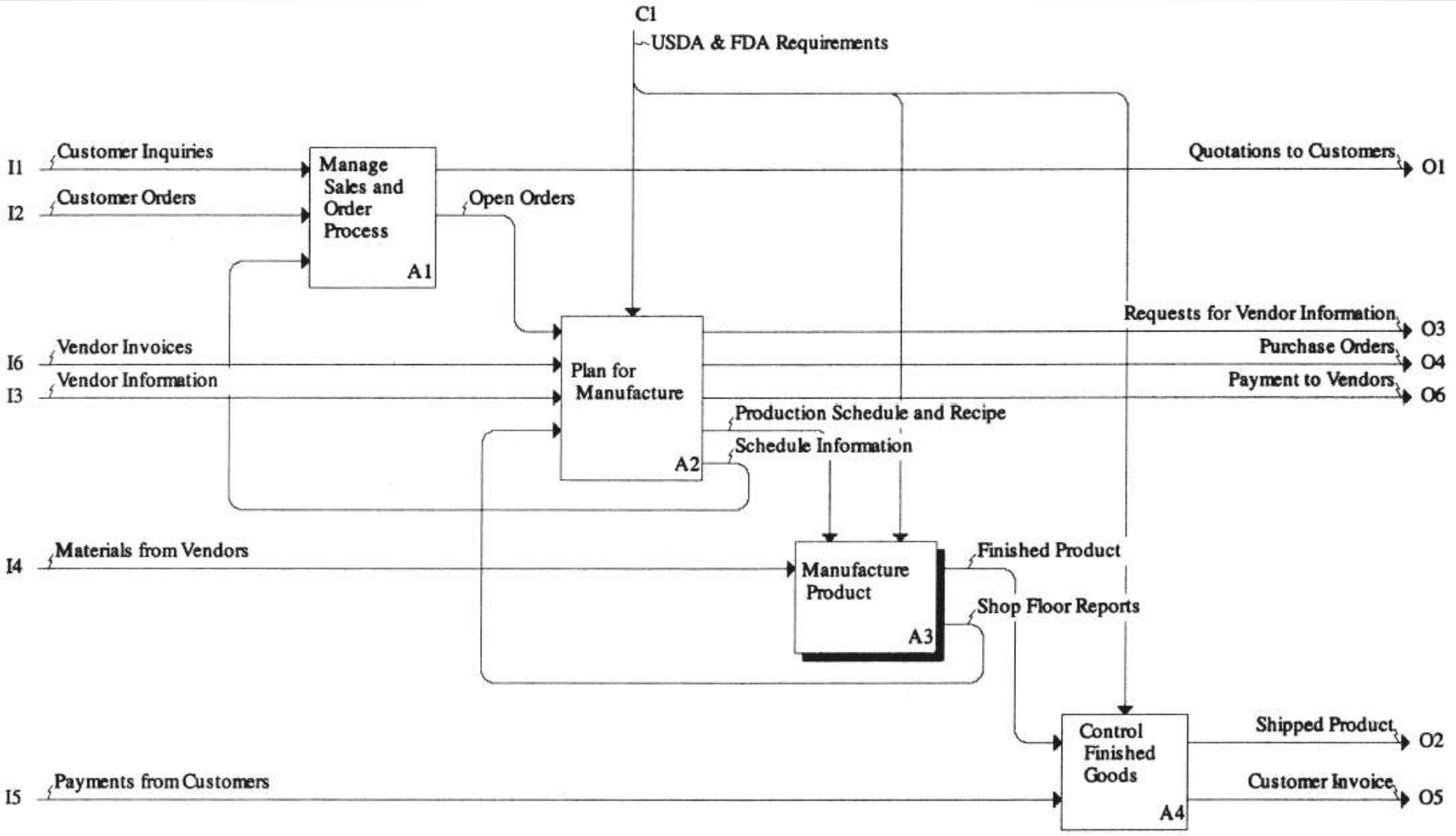
- Decomposing node A0 identifies four major activities at the next level (next slide):
  - A1: Manage Sales and Orders Process,
  - A2: Plan for Manufacture,
  - A3: Manufacture Product, and
  - A4: Control Finished Goods



Simple output/input relationship

- Inputs and outputs of the *parent* activity are **inherited** by the *child*
  - e.g. *customer inquiries* and *customer orders* are handled by the sales organization and are inputs to node A1
  - e.g. *finished product* leaves the enterprise from finished goods inventory (shown as an output of activity A4)

Decomposition of Node A0 – cont.



Decomposition of Node A0 – cont.

- Note the *activity flow relationship:*
  - When several activity boxes are drawn at the *same level* of decomposition, they are ordered by *sequential order/dominance*
    - e.g. "Manage Sales and Order Processes" activity precedes "Plan for Manufacture" activity, etc.
  - For ease of diagramming, IDEF0 methodology recommends using a *staircase pattern* whenever possible
  - Also recommended: at each level of decomposition, from *three to six child* activities be created from each *parent*

Decomposition of Node A0 – cont.

- Decomposition of a parent activity is determined by the analyst in conjunction with enterprise personnel
- The *breakdown structure* of an activity into its main child activities is usually written in an *indented list*
- The following indented list applies at this point:

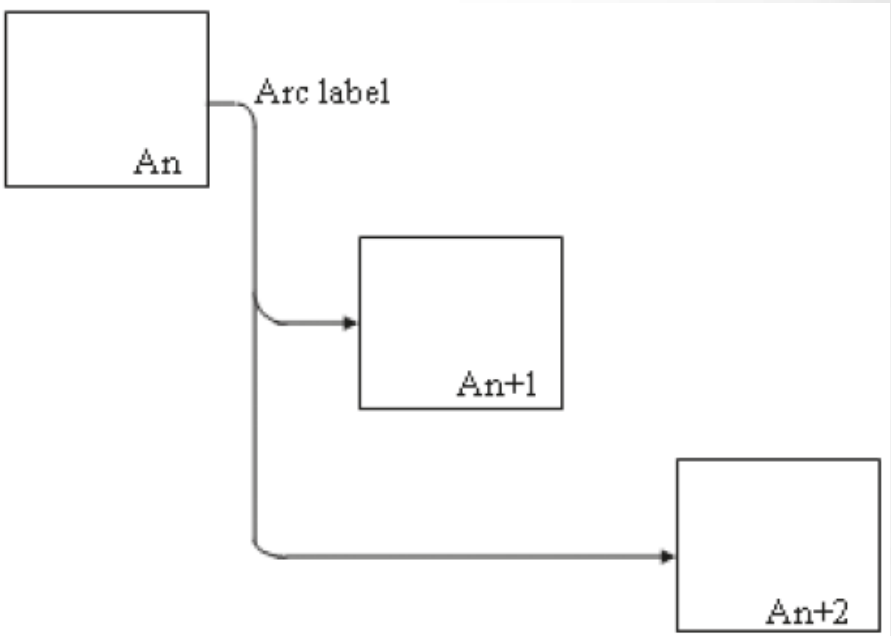
A0 — Operate a Food Manufacturing Enterprise

- A1 — Manage Sales and Orders Process
- A2 — Plan for Manufacture
- A3 — Manufacture Product
- A4 — Control Finished Goods

Connecting flows between activities

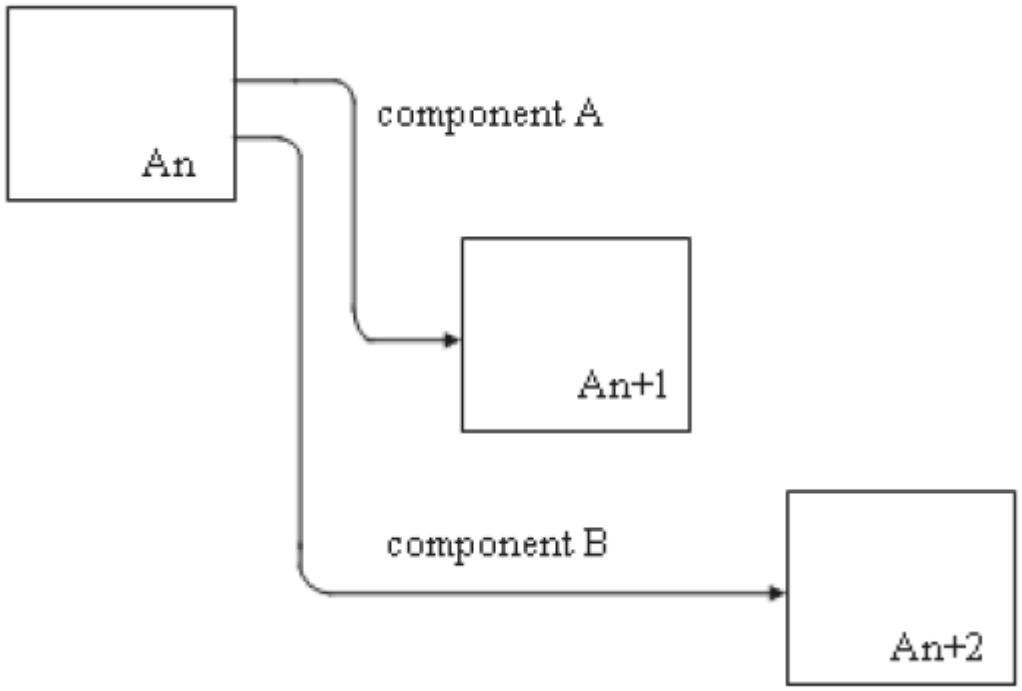
- **Parallelism**: simultaneous flow to more than one activity

- This is more common with a *flow of information* than with a *flow of physical entities*



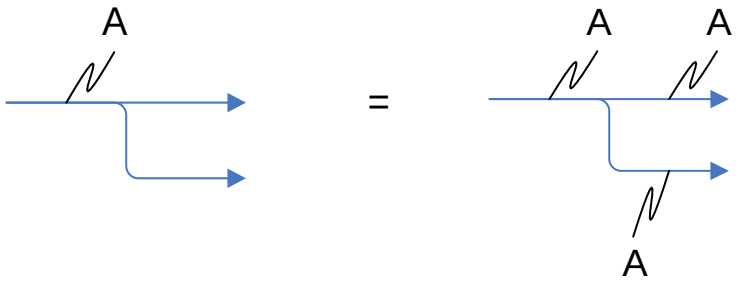
Connecting flows between activities – cont.

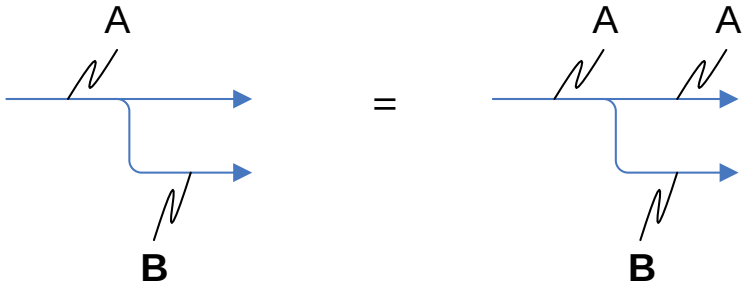
- **Distribution of flows** to more than one activity



Connecting flows between activities – cont.

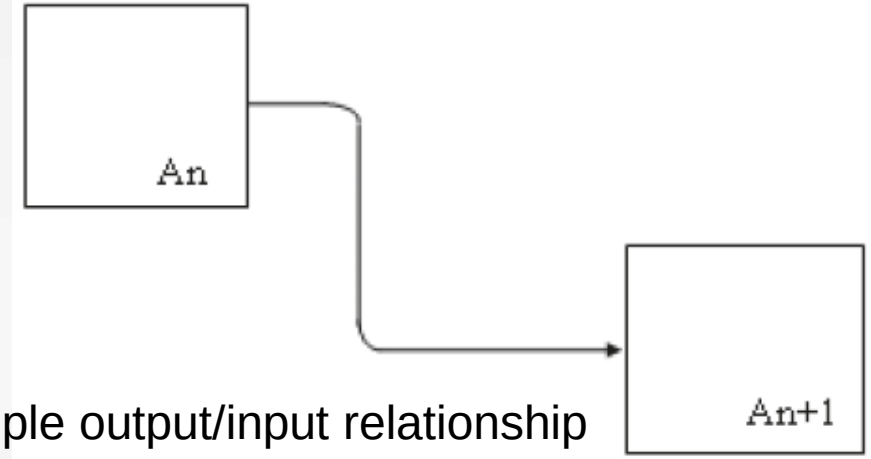
- Examples:



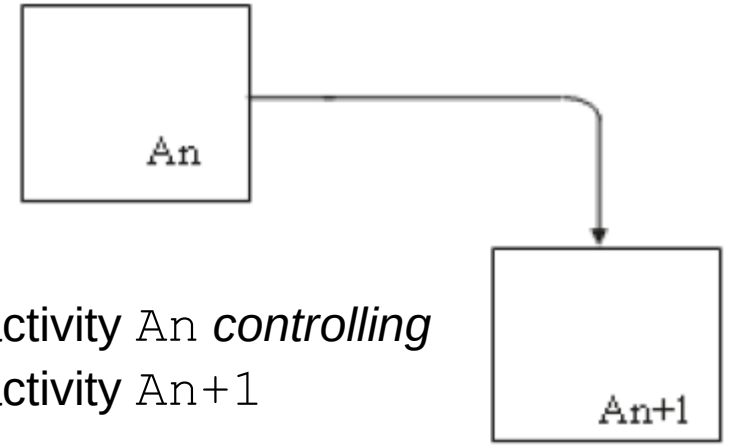


Connecting flows between activities – cont.

- One activity can provide inputs, controls, or both to other activities



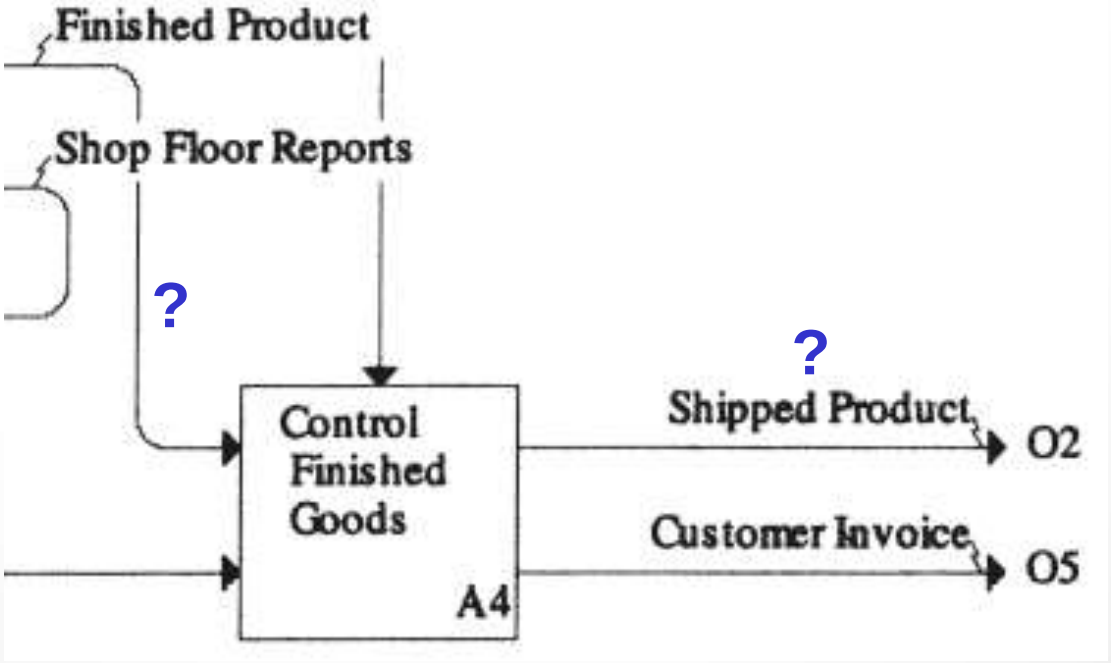
Simple output/input relationship



activity `An` *controlling*
activity `An+1`

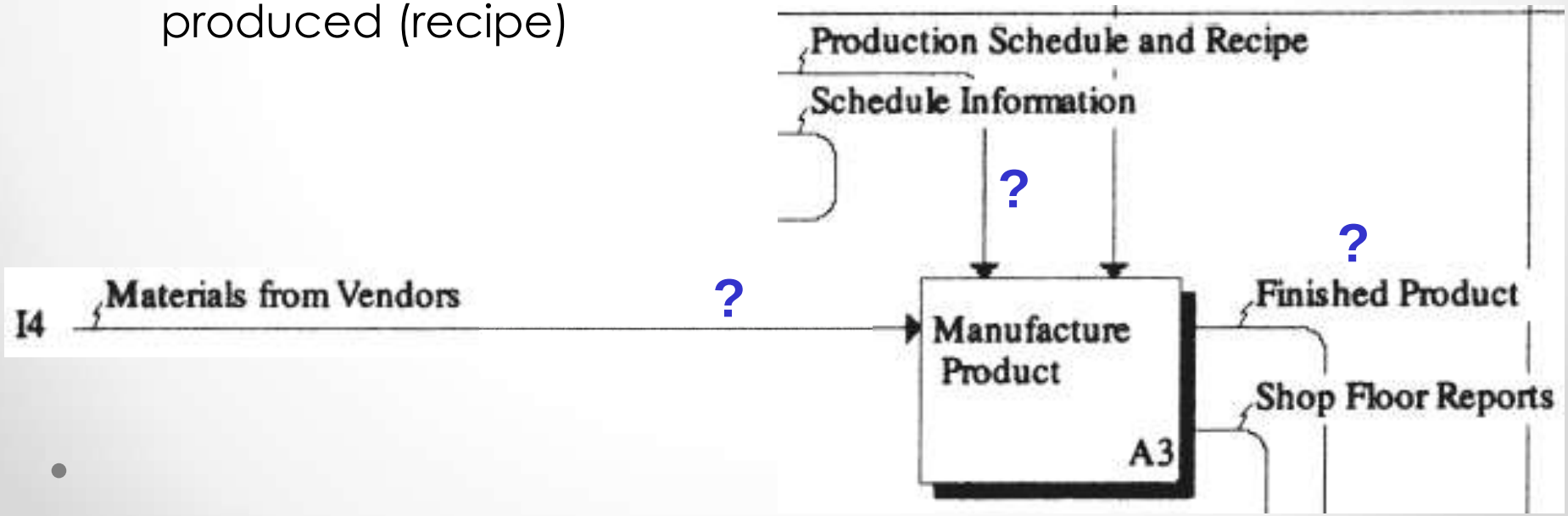
Connecting flows between activities – cont.

- Q: how to avoid confusion in deciding whether an arc is either an *input* to an activity or a *control*?
  - If entity represented by arc is ***converted*** into some other form by the activity, it is clearly an ***input***
  - e.g. activity A4 converts *finished product* into *shipped product*



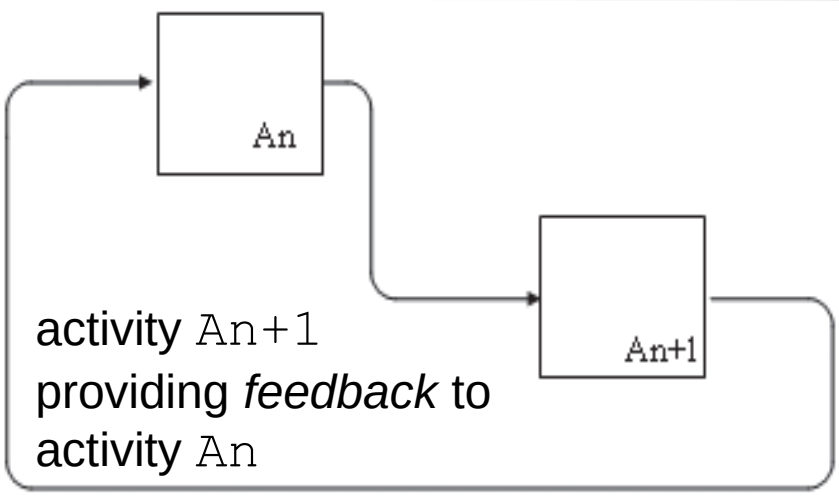
Connecting flows between activities – cont.

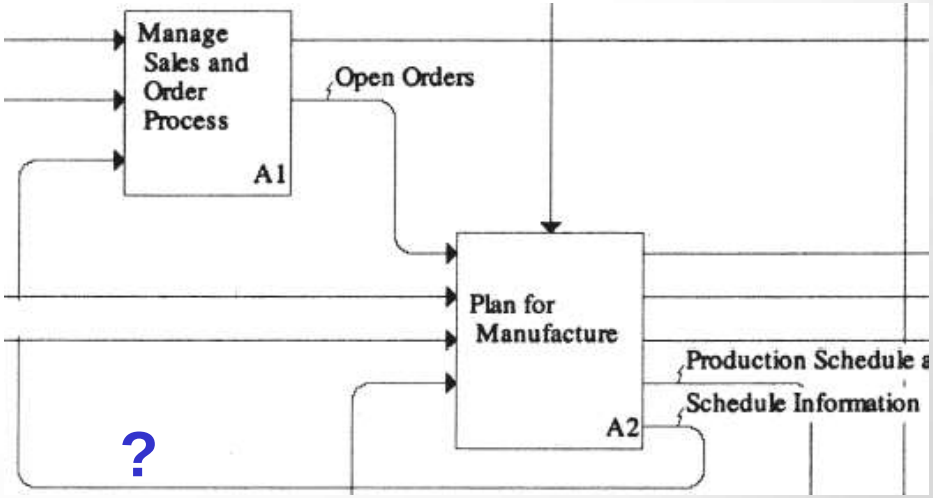
- Q: how to avoid confusion in deciding whether an arc is either an *input* to an activity or a *control*? (cont.)
  - If entity represented by arc ***directs*** the activity as to *how* it will perform its function, it is clearly a ***control***
  - e.g. "*production schedule and recipe*" is information that *tells* activity A3 *what* products will be produced on a specific day (production schedule) *and* how these products will be produced (recipe)



Connecting flows between activities – cont.

- **Feedback**: occurs when information generated in a subsequent activity is used by a prior activity in the activity diagram
  - e.g. relationship between *A1: Manage Sales and Order Process* and *A2: Plan for Manufacture* (i.e. to know delivery dates for customer quotation, you must know planned mfg. schedule)*

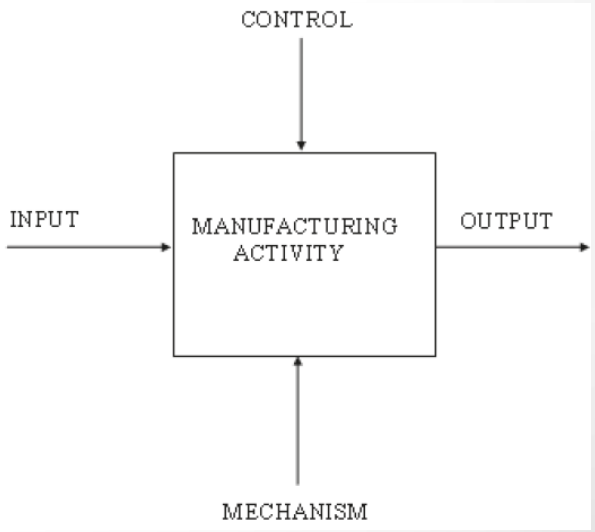




Connecting flows between activities – cont.

- Note, we have not shown *mechanisms* in the decomposition of node A0

- Mechanisms are only required at the **elemental level** of the modeling process (i.e. when a specific activity is identified at the *lowest level* of the hierarchy)



Sources

- Design of Industrial Information Systems. Thomas Boucher, and Ali Yalcin. Academic Press. First Ed. 2006. Chapter 4.

- Some useful videos:
  - Function modelling using IDEF0: The basics of functions, inputs, outputs, mechanisms and controls (https://youtu.be/xyO5n6Ay-1I)
  - AI0Win Tutorial – "Manage a Coffee Shop" (https://youtu.be/kHDNlFclsiY)