Processes and Operands

Lecture 08, v01

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BSEE

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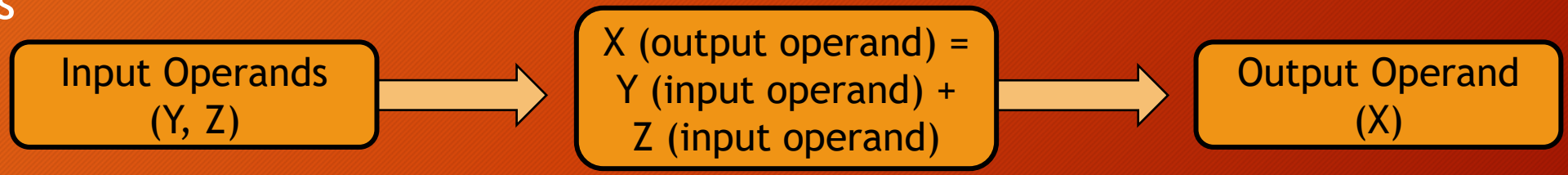
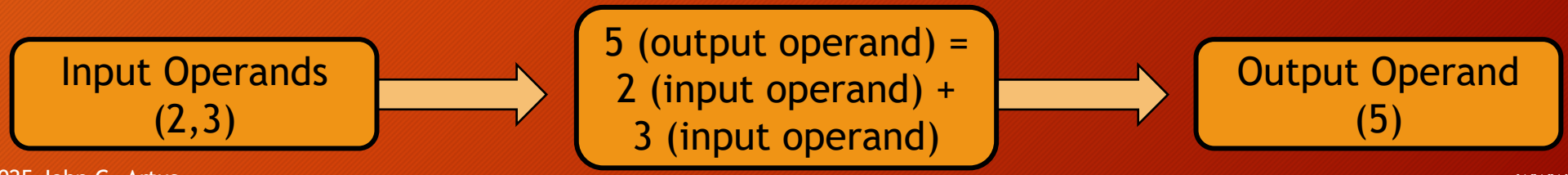
Process/Operand Overview

- This graphic provides a concise overview of the relation between processes and operands

- In the above graphic, a process (that performs some kind of function) takes in one or more input operands which in some way provide inputs to the function that are either consumed or modified to create new operands or modify the input operands into something new on the output side
- In the following example, the Process (a function) consumes two input operands by adding them together to produce a new output operand which is the sum of the two input operands

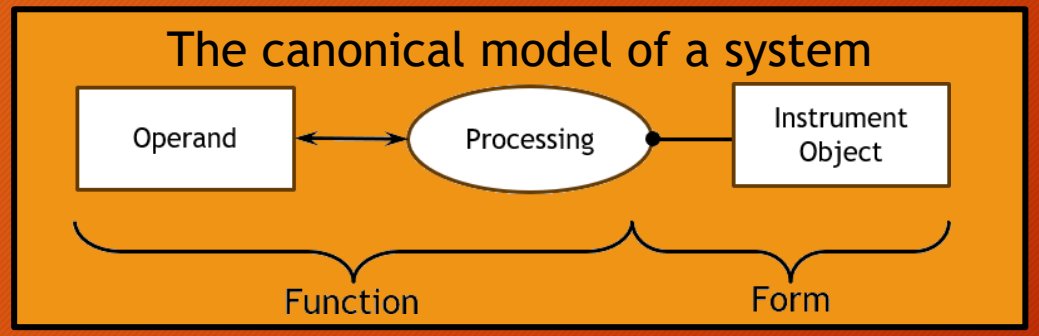


- In the more specific example below, specific input operands are supplied to the process that produces a specific output operand

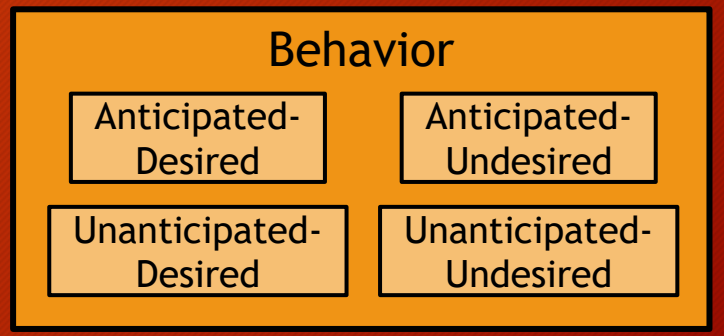


Process versus Function versus Behavior

- Process
  - Describes a task to be performed
  - It is not the implementation of the task, since inputs are also required for the process to work on
- Function
  - Function is what a system does
  - It is the implementation of a task whereby inputs are consumed and outputs are produced
  - Functions can do nothing without the needed inputs
  - Functions also need an element of form to support the implementation of the function
- Behavior
  - Is the observed effect of the system, no matter the functional intent of the design
  - Is closely associated with “emergence” where unexpected or unplanned functionality could emerge from the combination of individually designed functions
  - Some behavior can actually be unanticipated and/or undesired



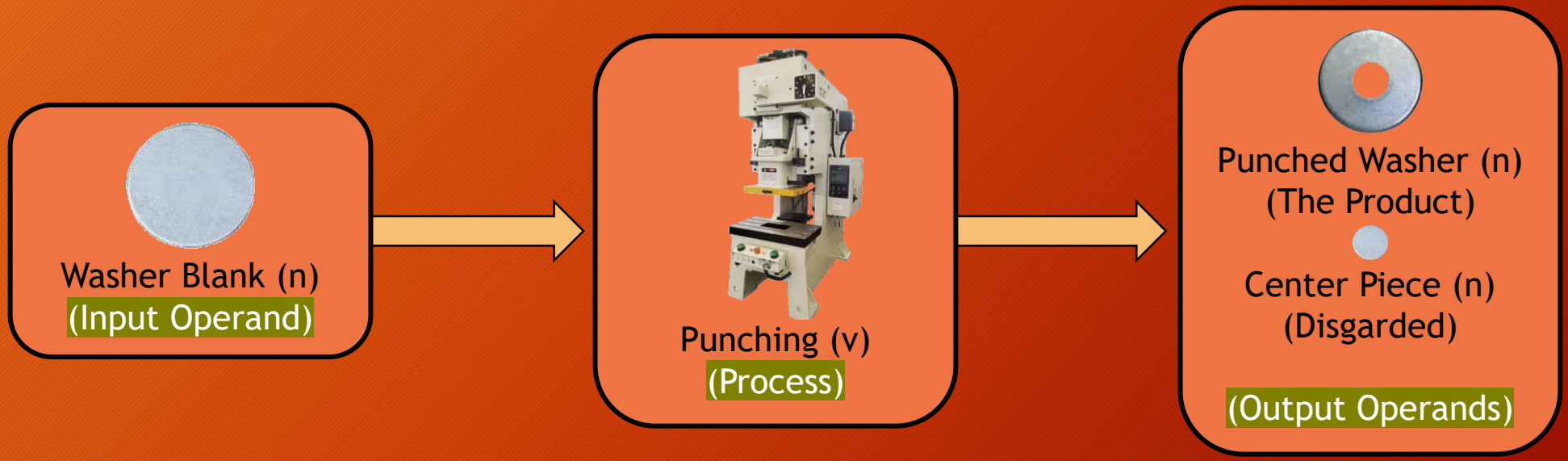
During Design



During Operational Use

Simple System Process Example

- Processes transform operands in some way
  - If operands are not transformed, nothing interesting happens
  - Interesting things only happen when operands are transformed
- Simple example of transformation of operands by a process
  - Machine Shop Process: Punching of blanks to produce washers



The input operand is consumed and two output operands are produced

In some ways, this process can also be viewed as modifying the input operand to produce the two output operands

Process

Processes generally involve the consumption of, or modification of operands on the input side of the process

And the creation of output operands on the output side or the passing on of a modified input operand to the output side

As a result, an operand object typically undergoes some kind of transformation

- A process is a pattern of transformation applied to one or more operand objects
  - One example of such a pattern is simple addition: X = Y + Z
  - This is a pattern of transformation that can be applied to several different types of operands, such as integer numbers
- Processes are transient and dynamic and take place along a timeline
- The gerund form of a verb (-ing) is used to describe processes

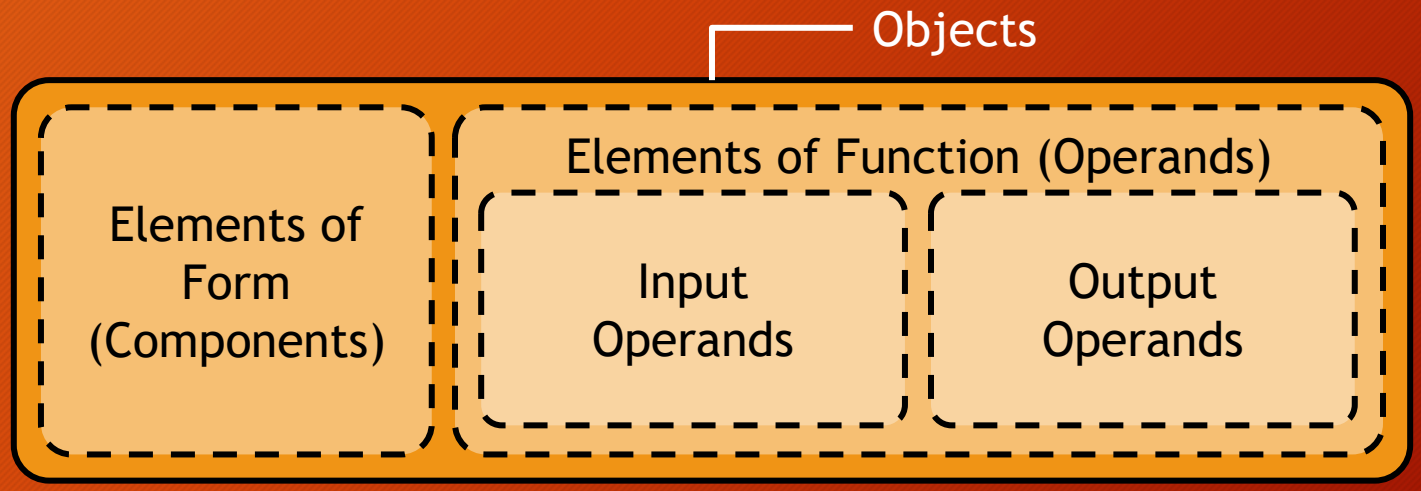
Operands

- Operands are the objects being operated on by processes
  - Input Operands
  - Output Operands
- They are the objects on which the system operates to
  - Consume (the input operands, aka “destroy”)
  - Modify (change the input operands in some way)
  - Copy (reproduce the input operands)
  - Produce (create new output operands from the input operands, aka “create”)
- In this lecture, we will be using generic terms to describe the general usage of operands
  - *Consume* input operands (instead of “destroy”)
  - *Produce* output operands (instead of “modify”, “copy”, or “create”)

Note: The textbook “Systems Architecture” uses the terms “destroy” to represent the effect on input operands and “create” to represent the effect on output operands
In this lecture, we instead use the terms “consume” and “produce”

Objects versus Operands

- *Objects*
  - Some objects in a system are elements of form (system components)
  - Others are elements of function
    - Objects consumed by functions (inputs)
    - Objects produced by functions (outputs)
- Elements of function are called *operands*
  - Operands are the parts of function that represent what is changed by the function
  - Operands need not exist prior to the execution of function and are in some way acted upon by the function
  - Operands may be consumed, modified, or produced by a function
  - Operands are usually not supplied by the architect or builder of the system
  - They often appear at the time of operation, usually from other sources



Euler Diagram Defining Subsets of Objects

Processes and Operands at the System Level

General Case

External Input Operands → Overall System Process → External Output Operands

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Specific Case
(ATM Machine)

Here, we are considering the ATM as a whole system, and examining only the external inputs and external outputs as operands

Bank Card (Supplied by User) → ATM Function (Withdraw Cash) → Cash (Delivered to User)

Considering the Internal Workings of the System

- By considering the ATM as a whole system, we are examining only the external inputs and external outputs as operands
- Quite often, we are more interested in looking internal to the system at detailed functionality occurring within the system
- In these cases, more often than not, the operands are internal, and have nothing to do with the user
- It is often difficult to look carefully and deeply at these internal processes to identify the actual internal input and output operands at play
- Many of these cases require a bit of engineering experience with systems of the type under study in order to be able to identify the correct operands for the functionality being examined

A More Subtle Process Example

- This example illustrates a subtle, and difficult to conceptualize process
- Subtle (difficult to see) example of transformation of operands by a process
  - Electronic Process: Reading User Information off of Magnetic Strip, such as on an ATM Debit Card

The ATM User is not the input operand

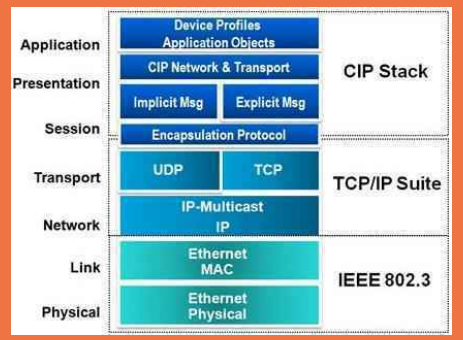
The Debit Card is not the input operand

Card Data (n)
(Input Operand)

It is the Debit Card Data that is the input operand

Reading (v)
(Process)

The process is "Reading" the data off the card strip
The instrument that performs this process is the ATM Card Reader



Network Message (n)
(Output Operand)

The output operand is a network message that contains the card data and goes to some other element of the ATM

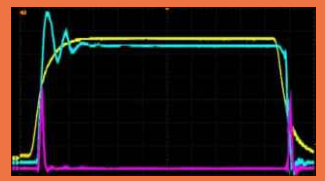
To identify the correct operands and processes requires careful consideration of the detailed transactions occurring within the system

Another Subtle Process Example

- This example illustrates a subtle, and difficult to conceptualize process
- Subtle (difficult to see) example of transformation of operands by a process
  - Electronic Process: User entering PIN on Keypad, such as on an ATM Machine

The ATM User is not the input operand

The ATM Keypad is not the input operand

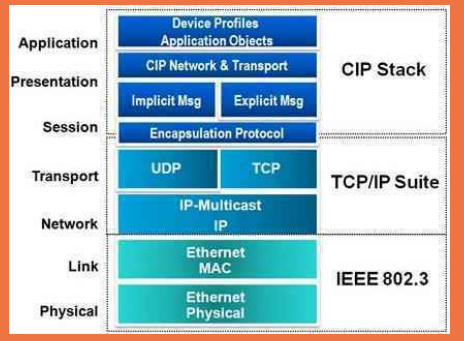


Keypress Signal (n)
(Input Operand)

It is the signal transmitted on the press of a Keypad key that identifies the struck key that is the input operand

Reading (v)
(Process)

The process is "Reading" the key-press signal that describes the struck key
The instrument that performs this process is the Keypad CPU or other processor



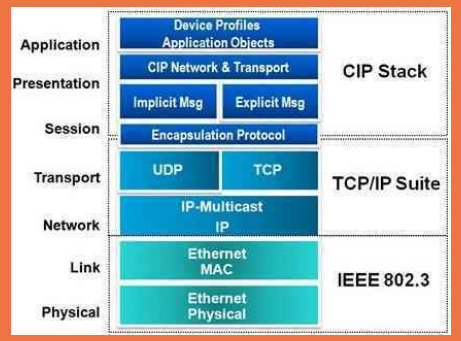
Network Message (n)
(Output Operand)

The output operand is a network message that identifies the pressed key and goes to some other element of the ATM

To identify the correct operands and processes requires careful consideration of the detailed transactions occurring within the system

Another Subtle Process Example

- This example illustrates a subtle, and difficult to conceptualize process
- Subtle (difficult to see) example of transformation of operands by a process
  - Electronic Process: User reading information displayed on a screen, such as on an ATM Machine



Network Message (n)
(Output Operand)

The input operand is a network message that describes the character(s) to display

Displaying (v)
(Process)

The process is "Displaying" the character(s) onto the display
The instrument that performs this process is the Display CPU or other processor

Display Photon (n)
(Output Operand)

It is the set of photons transmitted by the display that is the output operand

The ATM Display is not the output operand

The ATM User is not the output operand

To identify the correct operands and processes requires careful consideration of the detailed transactions occurring within the system

Process-Operand (PO) Array

- A matrix approach can be used to represent internal functionality
  - Create an array that lists the processes on one axis and the operands on the second axis
  - Called the Process-Operand (PO) Array
- This procedure is applied to a centrifugal pump example
  - Two obvious pump functions that can be observed externally are the inflowing and outflowing functions
  - To identify the two principal internal functions of the pump requires some domain knowledge of pump design
  - The pump first invests kinetic energy into the fluid by accelerating it (implemented by the impeller)
  - It then trades kinetic energy for potential energy by diffusing the flow (implemented by the volute chamber), thereby converting high velocity, low pressure fluid flow into low velocity, high pressure fluid flow

Note: The textbook "Systems Architecture" uses the terms "destroy" to represent the effect on input operands and "create" to represent the effect on output operands
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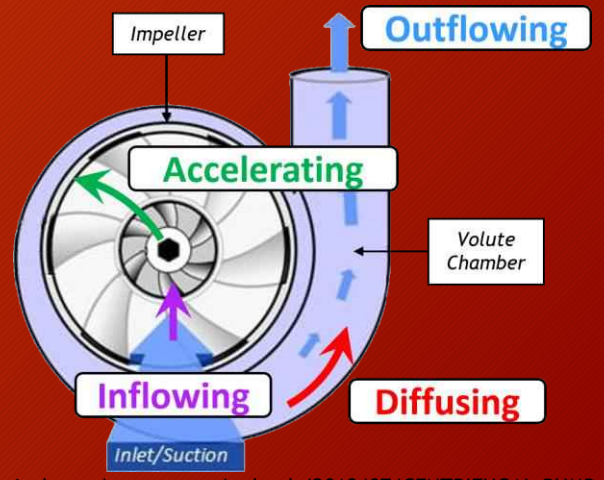
Impeller

Operands

Processes	Process List	Internal low pressure flow	Internal high velocity flow	Internal high pressure flow	External low pressure flow	External high pressure flow
	Inflowing	p			c (Input)	
	Accelerating	c	p			
	Diffusing		c	p		
	Outflowing			c		p (Output)

Value-related operand

"White-box" View of Pump



https://learnmechanical.com/wp-content/uploads/2018/07/CENTRIFUGAL-PUMP.jpg

Integral Versus Modular Design

- An integral design is one in which all functions are embodied by a single, or very small number of physical elements
- A module design is one in which the physical structures of the system have a one-to-one correspondence with associated functional structures
- Modular products may be defined as machines, assemblies, or components that accomplish an overall function through combination of distinct building blocks or modules
- Modular products have distinct manufacturing advantages
  - If modularity is identified and exploited in the initial conceptual engineering effort, the immediate product design reaps benefits in reduced development time and costs
  - Once a product is designed and developed, components of the product are observed to have other potential uses
  - Effective application of these components as modules can lead to faster development and reduced costs in future product designs

Functional Basis

- A function as a transformation from a set of inputs flows to a set of output flows
- Flows represent energy, material, or data that flow into and out of the physical artifact being represented functionally
- A Functional Basis describes a function as a transformation between a set of inputs flows to a set of outputs
  - Flows represent material, energy, or data that flow into and out of the physical artifact that hosts the subject functionally
  - Electric Motor Example
    - The function can be represented as “converting electrical energy into mechanical torque”
    - The input flow is electrical energy
    - The output flow is mechanical torque
    - The process associated with this function would be named “Converting”
- There are many Functional Bases (organized taxonomy of system functionality) published in the technical literature
  - One such example is provided in the next two slides
  - Such a Functional Basis is dependent on the domain within which the design effort is being performed
  - One domain of product engineering could elaborate one set of functions versus that of some other domain

Operand Types

These are examples and do not constitute a complete set

- Material (Transmitted or Received)

Basis	Sub-Basis	Causal Factor	Operand Analogy Example
Human		Hand, foot, head, etc	Button press, head or eye movement
Non-Human	Gas	Vacuum, pressure	Air flowing into the cowl of a jet engine
	Liquid	Vacuum, pressure	Water flowing into a flood control pump
	Solid	Force	A washer blank flowing into a washer punching machine

Adapted from Stone (1999)

- Data (Transmitted or Received)

Basis	Sub-Basis	Causal Factor	Operand Analogy Example
Human	Auditory	Transmission of sound	Speech, non-speech
	Olfactory	Smelling sense	Toxic fumes
	Tactile	Touching sense	Temperature, pressure, roughness
	Taste	Tasting sense	Sweet, sour, salty, bitter, savory
	Visual	Visual input	Position, displacement
Non-Human	Signal	Transmitted or received	Discrete, continuous
	Stream	Transmitted or received	Digital, analog

Adapted from Stone (1999)

Constructing a Functional Basis for a specific domain or business can help streamline the development effort and promote consistency among a product line, since architects can all refer to the same function descriptions

Operand Types (continued)

- Energy (Transmitted or Received)

These are examples and do not constitute a complete set

Basis	Sub-Basis	Effort Causal Factor Analogy Example	Flow Causal Factor Analogy Example
Human		Application of force or torque	Motion (overcoming friction)
Acoustic		Pressure	Fluid medium particle velocity
Biological		Pressure	Volumetric flow
Chemical		Affinity	Reaction rate
Electrical		Electromotive force	Electrical current
Electromagnetic	Optical	Intensity	Velocity
	Solar	Intensity	Velocity
Hydraulic		Pressure	Volumetric flow
Magnetic		Magnetomotive force	Magnetic flux rate
Mechanical	Rotational	Torque	Angular velocity
	Translational	Force	Linear velocity
	Vibrational	Amplitude	Frequency
Pneumatic		Pressure	Mass flow
Radioactive		Intensity	Decay rate
Thermal		Temperature	Heat flow

Adapted from Stone (1999)

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