2009 Spring

Software Modeling & Analysis

- Introduction to SASD
- Structured Analysis
- Structured Design

Lecturer: JUNBEOM YOO
jbyoo@konkuk.ac.kr

References

- Modern Structured Analysis, Edward Yourdon, 1989.
- Introduction to System Analysis and Design: a Structured Approach, Penny A. Kendall, 1996.

- Zhou Qun, Kendra Hamilton, and Ibrahim Jadalowen (2002). Structured Analysis and Structured Design (SASD) - Class Presentaion http://pages.cpsc.ucalgary.ca/~jadalow/seng613/Group/

Structured Analysis

- Structured analysis is [Kendall 1996]
  - a set of techniques and graphical tools
  - that allow the analysts to develop a new kind of system specification
  - that are easily understandable to the users.
  - Analysts work primarily with their wits, pencil and paper.

- SASD
  - Structured Analysis and Structured Design

History of SASD

- Developed in the late 1970s by DeMarco, Yourdon and Constantine after the emergence of structured programming.
- IBM incorporated SASD into their development cycle in the late 1970s and early 1980s.
- Yourdon published the book “Modern Structured Analysis” in 1989.
- The availability of CASE tools in 1990s enabled analysts to develop and modify the graphical SASD models.

Philosophy of SASD

- Analysts attempt to divide large, complex problems into smaller, more easily handled ones.
  → "Divide and Conquer"

- Top-Down approach

- Functional view of the problem

- Analysts use graphics to illustrate their ideas whenever possible.

- Analysts must keep a written record.

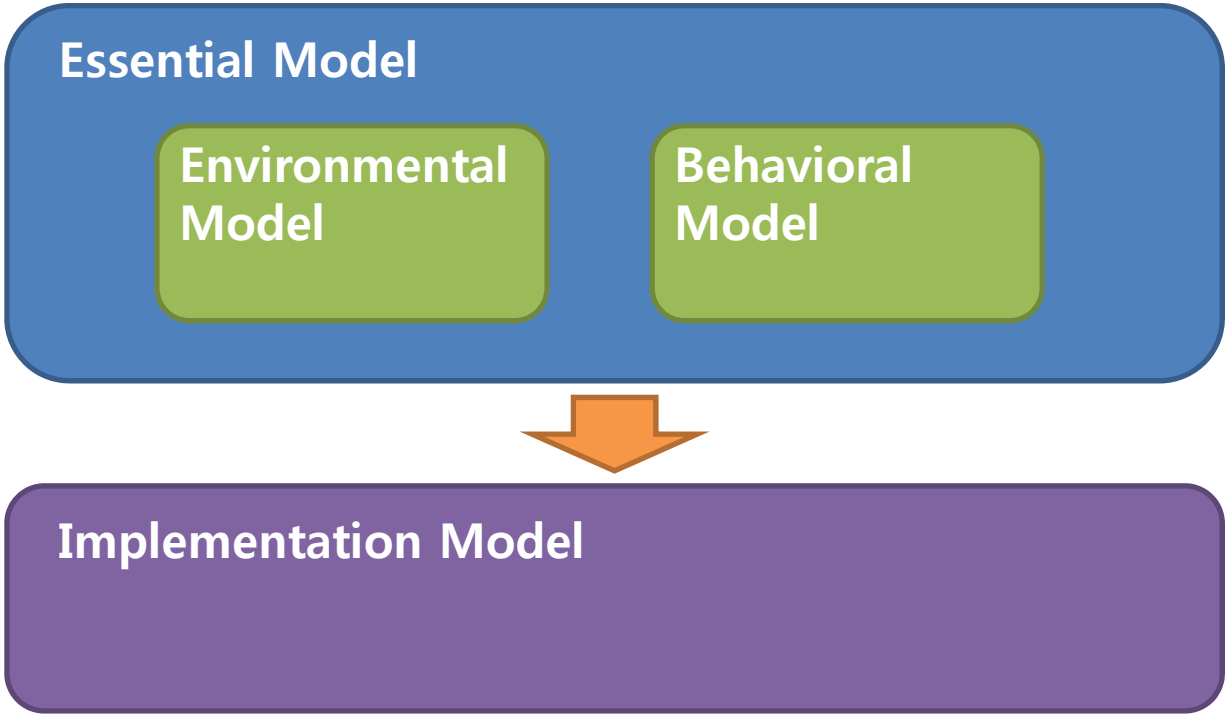
Philosophy of SASD

- " The purpose of SASD is to develop a useful, high quality information system that will meet the needs of the end user. [Yourdon 1989] "

Goals of SASD

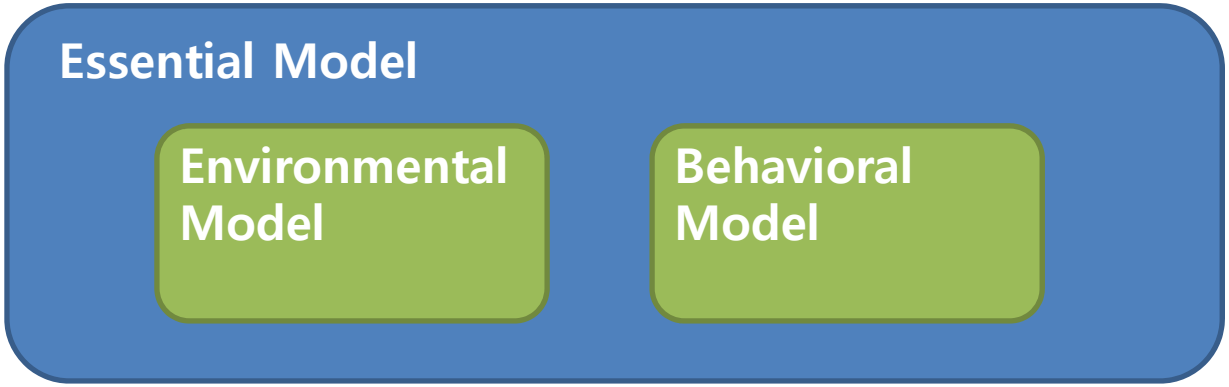
- Improve quality and reduce the risk of system failure.
- Establish concrete requirements specifications and complete requirements documentations.
- Focus on reliability, flexibility and maintainability of system.

Elements of SASD



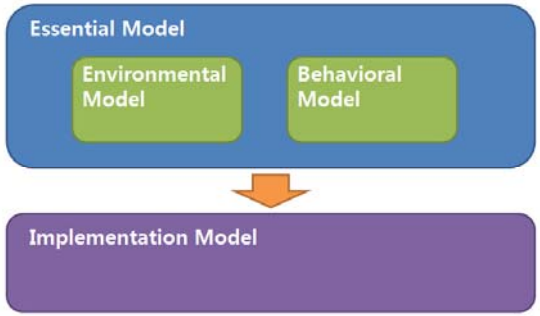
Essential Model

- Model of **what** the system must do
- Not define how the system will accomplish its purpose.
- A combination of environmental and behavioral models



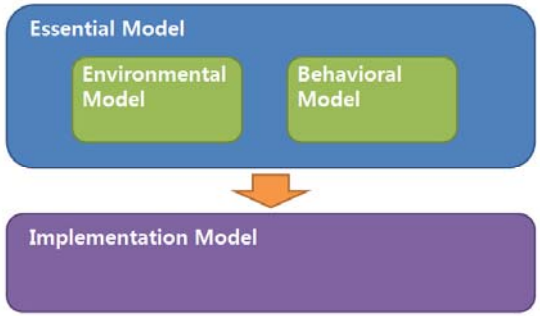
Environmental Model

- Defines the **scope** of the proposed system.
- Defines the **boundary** and **interaction** between the system and the outside world.
- Composed of
  - Statement of purpose
  - System Context diagram
  - Event list



Behavioral Model

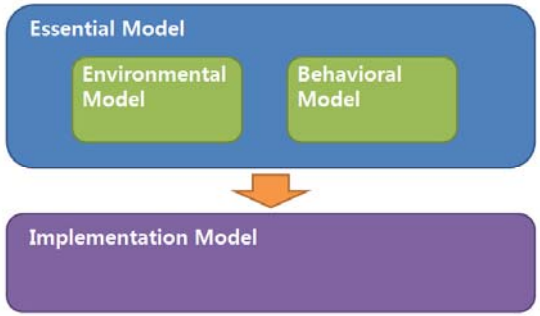
- Model of the **internal behavior** and **data entities** of the system
- Models **functional requirements**.
- Composed of
  - Data Dictionary
  - Data Flow Diagram (DFD)
  - Entity Relationship Diagram (ERD)
  - Process Specification
  - State Transition Diagram



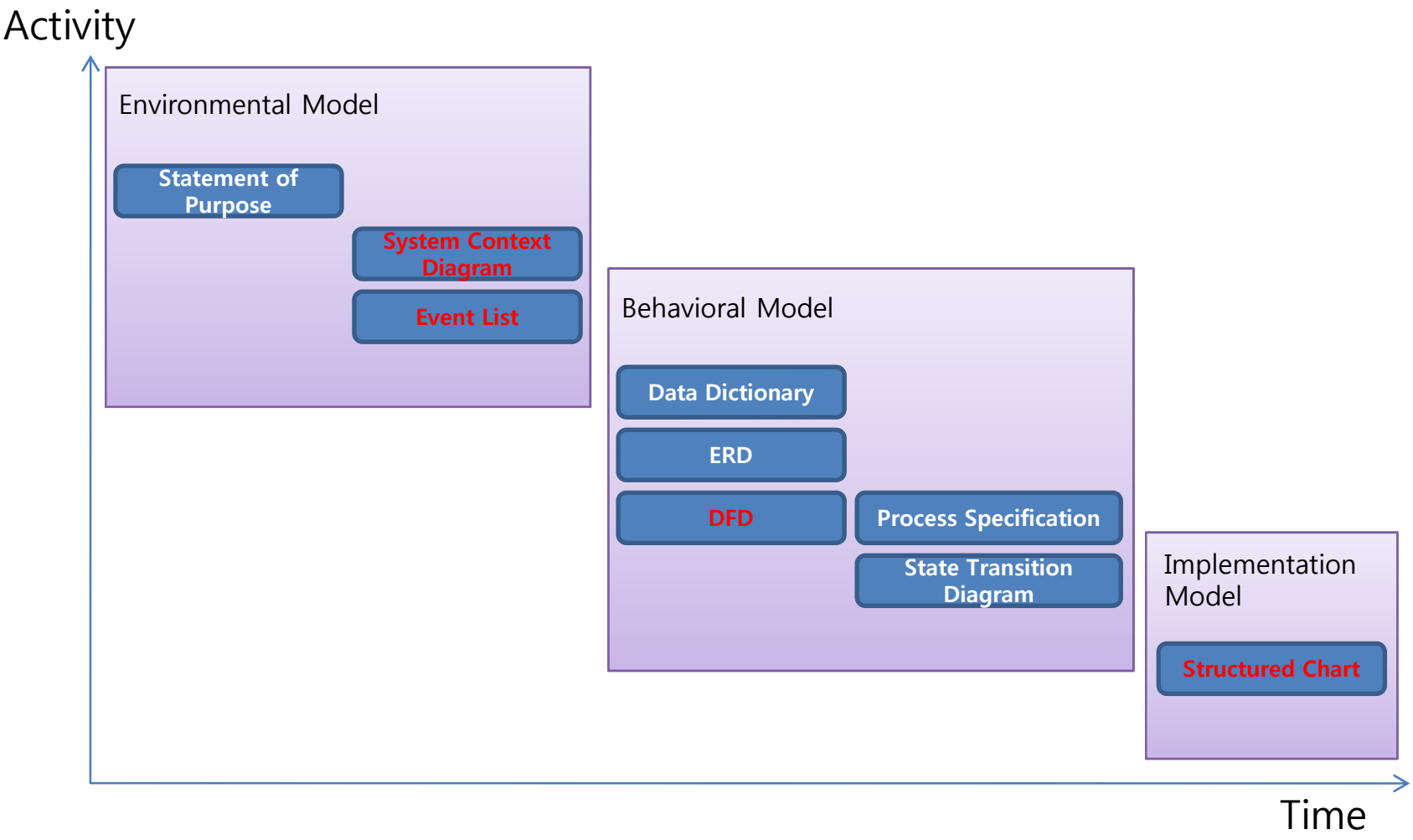
Implementation Model

- Maps the functional requirements to hardware and software.
- Minimizes the cost of the development and maintenance.
- Determines which functions should be manual vs. automated.
- Can be used to discuss the cost-benefits of functionality with user/stakeholders.
- Defines the Human-Computer interface.
- Defines non-functional requirements.

- Composed of
  - Structure Charts



SASD Process



Statement of Purpose

- A clear and concise textual description of the purpose for the system to develop
- It should be deliberately vague.
- It is intended for top level management, user management and others who are not directly involved in the system.

Statement of Purpose – RVC Example

Robot Vacuum Cleaner (RVC)

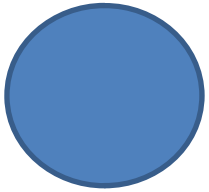
- An RVC automatically cleans and mops household surface.
- It goes straight forward while cleaning.
- If its sensors found an obstacle, it stops cleaning, turns aside, and goes forward with cleaning.
- If it detects dust, power up the cleaning for a while
- We do not consider the detail design and implementation on HW controls.
- We only focus on the automatic cleaning function.

System Context Diagram

- Highlights the boundary between the system and outside world.
- Highlights the people, organizations and outside systems that interact with the system under development.

- A special case of DFD

System Context Diagram - Notation

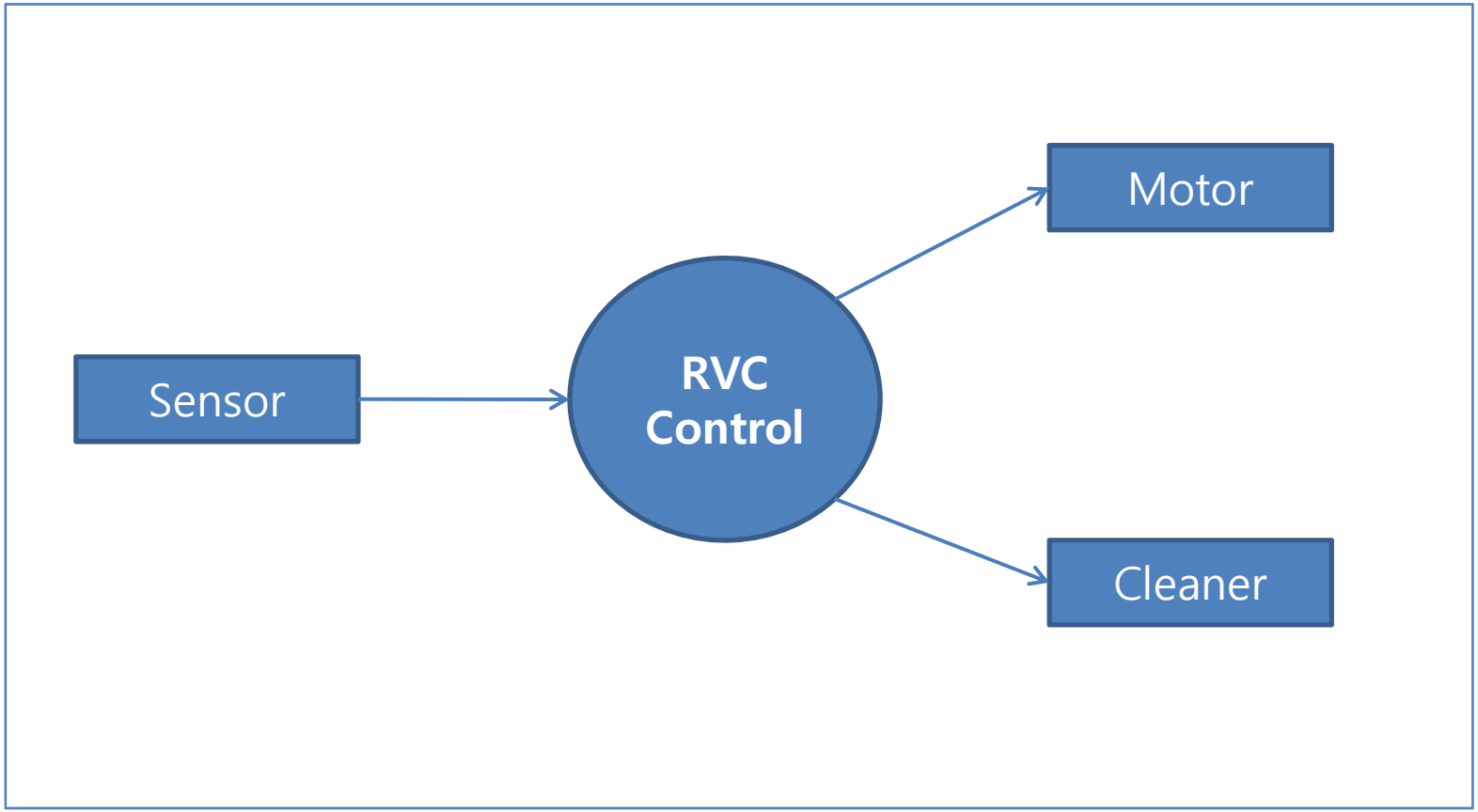


Process : represents the proposed system

Terminator : represents the external entities

Flow : represents the in/out data flows

System Context Diagram – RVC Example



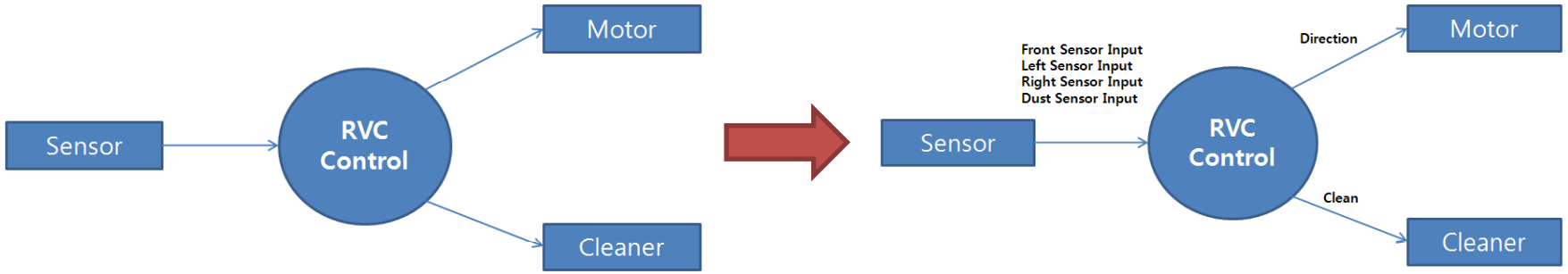
Event List

- A list of the event/stimuli outside of the system to which it must respond.
- Used to describe the context diagram in details.

- Types of events
  - Flow-oriented event : triggered by incoming data
  - Temporal event : triggered by internal clock
  - Control event : triggered by an external unpredictable event

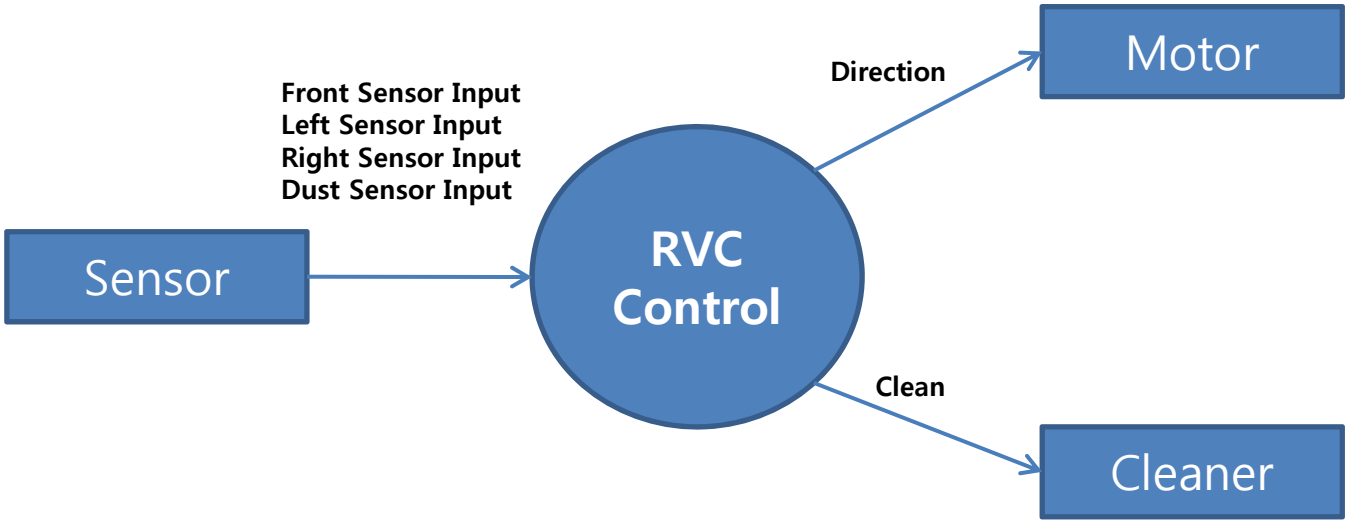
Event List – RVC Example

Input/ Output Event	Description
Front Sensor Input	Detects obstacles in front of the RVC
Left Sensor Input	Detects obstacles in the left side of the RVC periodically
Right Sensor Input	Detects obstacles in the right side of the RVC periodically
Dust Sensor Input	Detects dust on the floor periodically
Direction	Direction commands to the motor (go forward / turn left with an angle / turn right with an angle)
Clean	Turn off / Turn on / Power-Up



Context Diagram for RVC

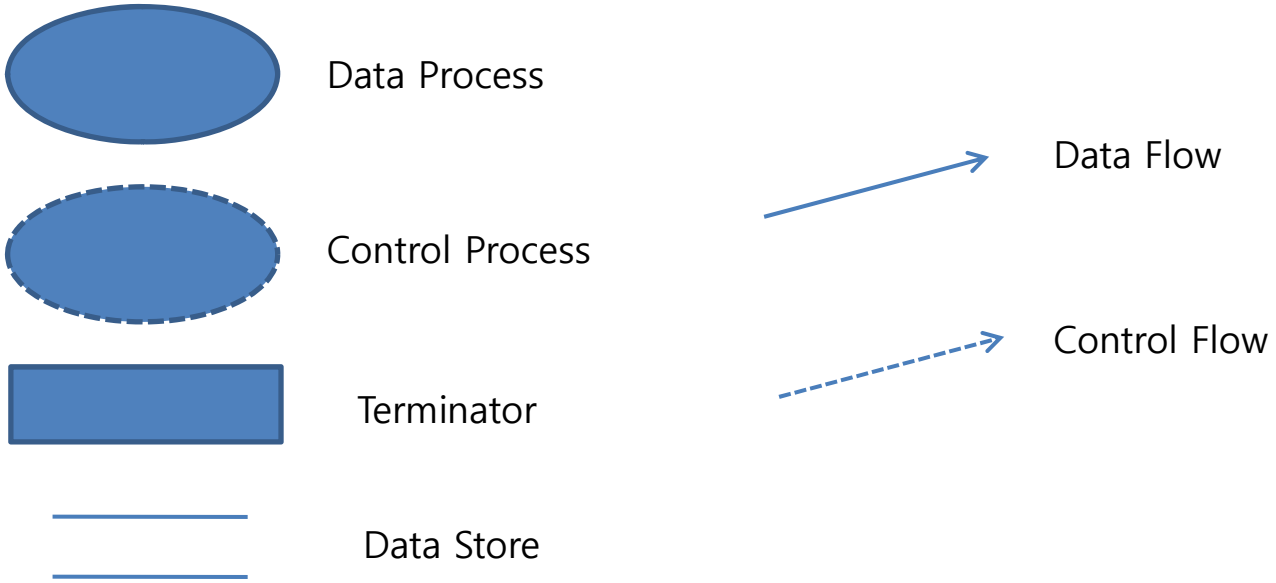
System Context Diagram – RVC Example



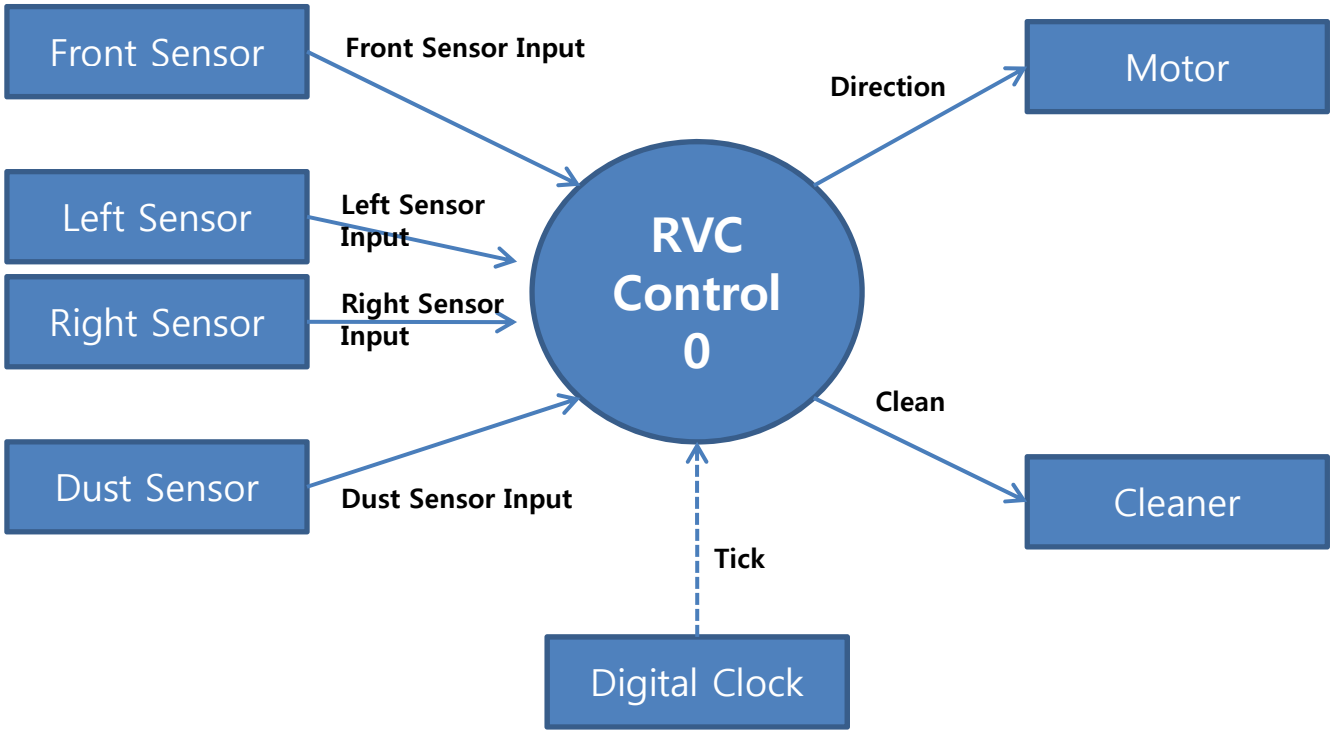
Data Flow Diagram (DFD)

- Provides a means for functional decomposition.
- Composed of hierarchies(levels) of DFDs.

- Notation (A kind of CDFD)



DFD Level 0 – RVC Example

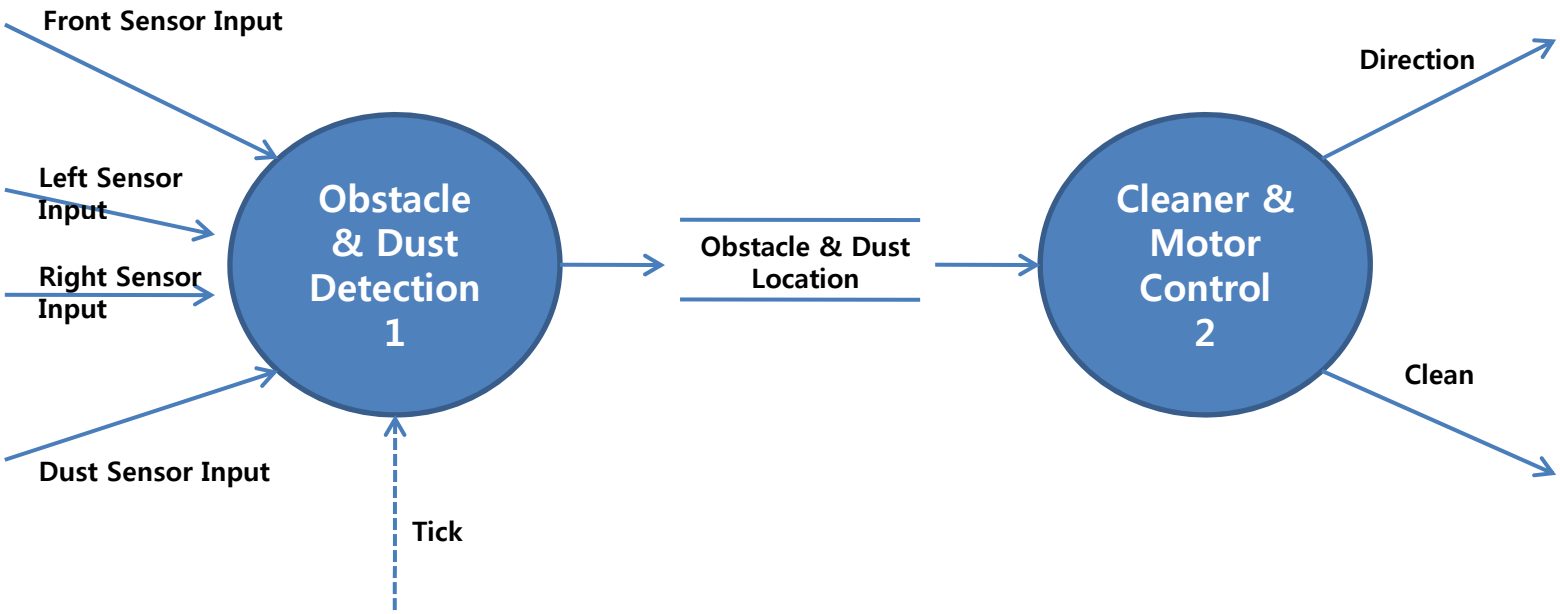


DFD Level 0 – RVC Example

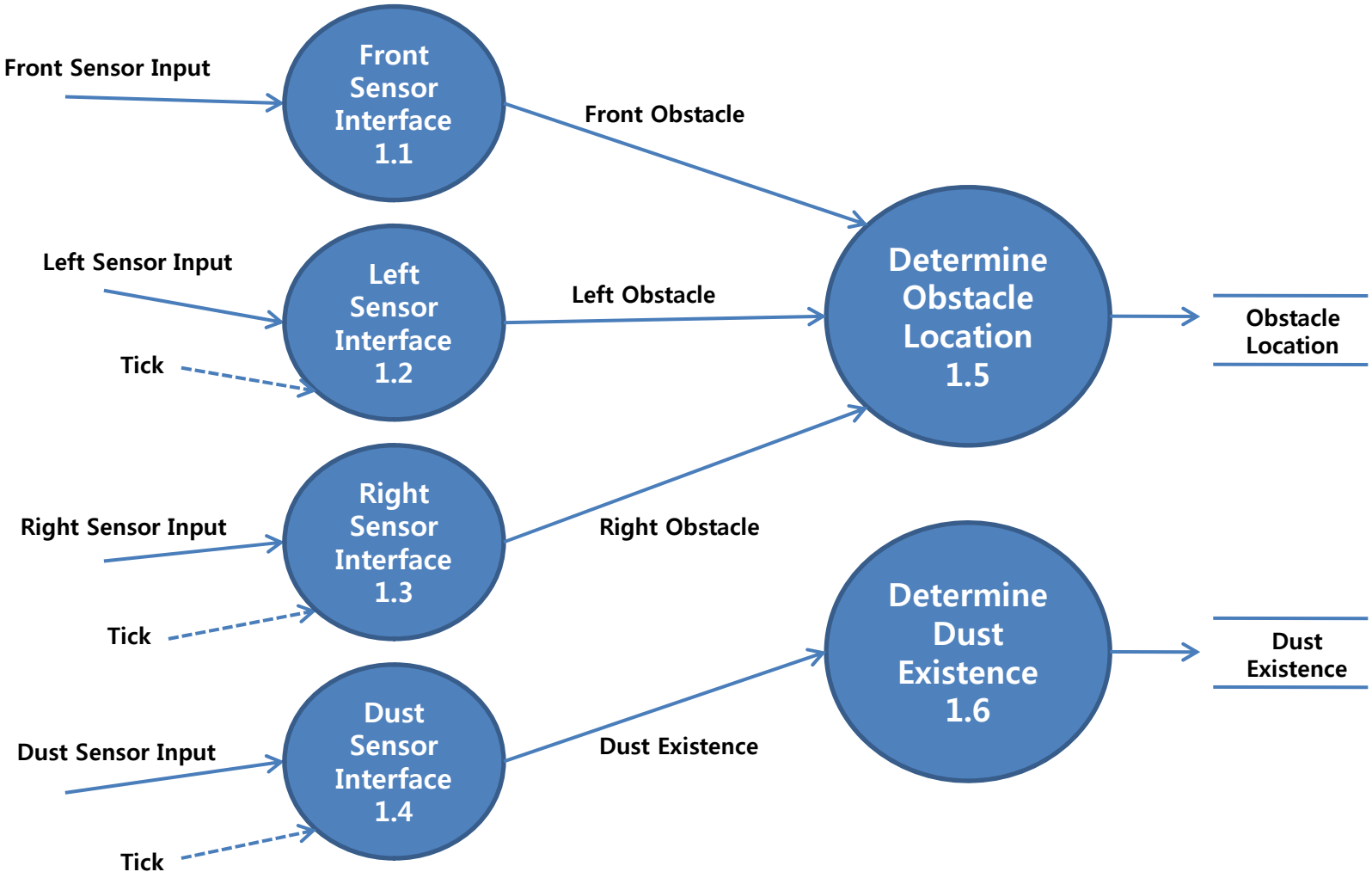
(A kind of) Data Dictionary

Input/ Output Event	Description	Format / Type
Front Sensor Input	Detects obstacles in front of the RVC	True / False , Interrupt
Left Sensor Input	Detects obstacles in the left side of the RVC periodically	True / False , Periodic
Right Sensor Input	Detects obstacles in the right side of the RVC periodically	True / False , Periodic
Dust Sensor Input	Detects dust on the floor periodically	True / False , Periodic
Direction	Direction commands to the motor (go forward / turn left with an angle / turn right with an angle)	Forward / Left / Right / Stop
Clean	Turn off / Turn on / Power-Up	On / Off / Up

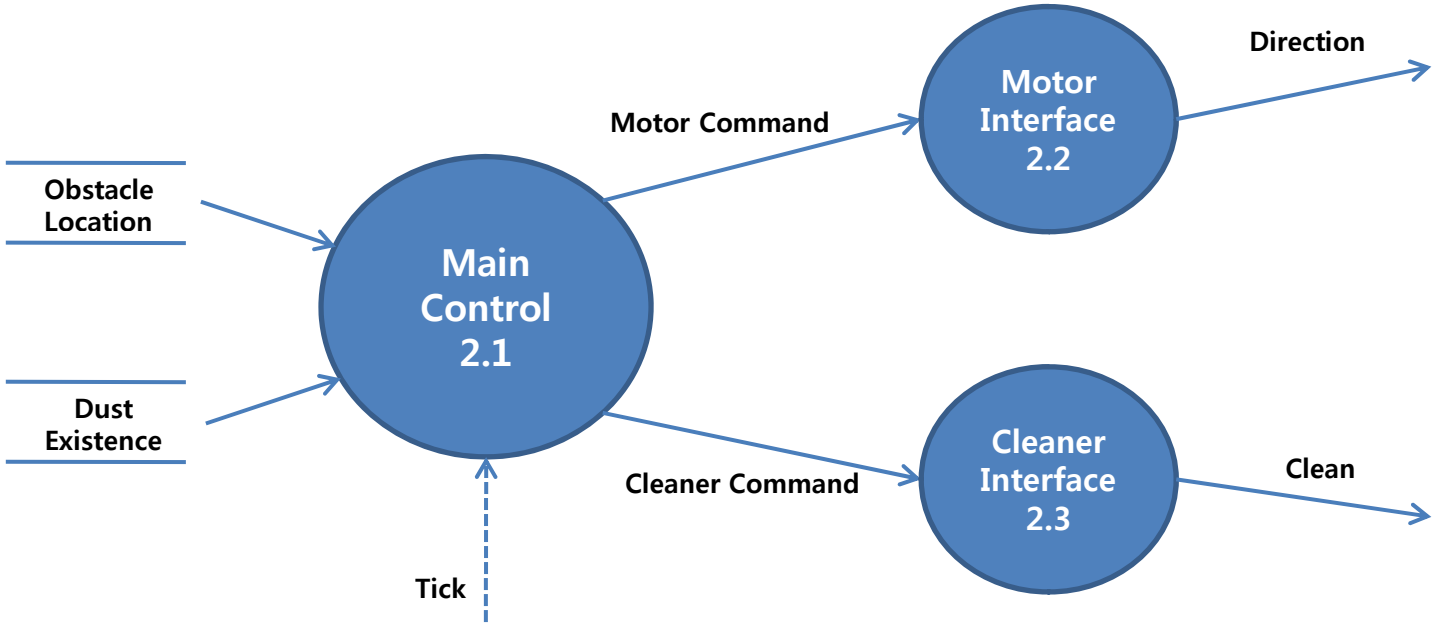
DFD Level 1 – RVC Example



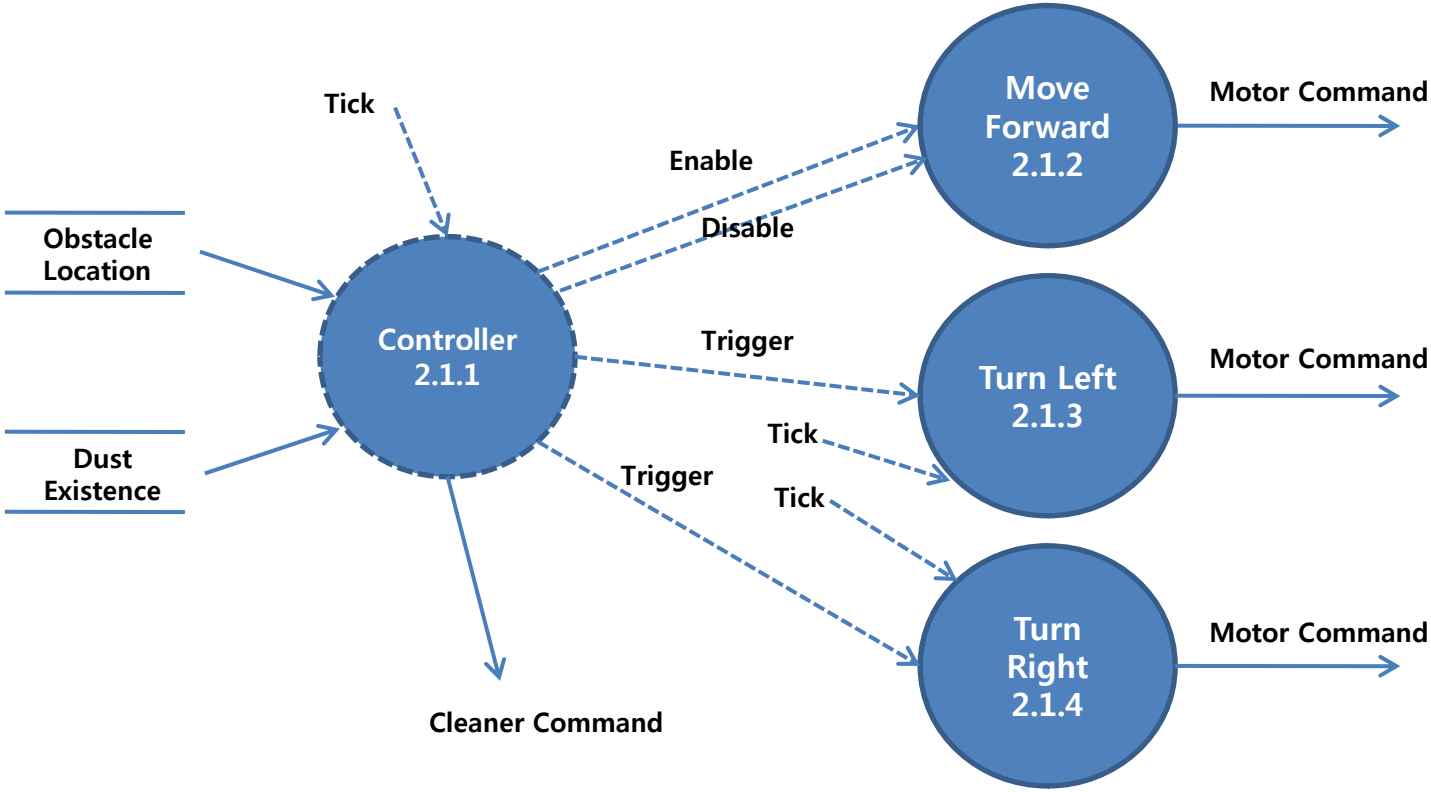
DFD Level 2 – RVC Example



DFD Level 2 – RVC Example

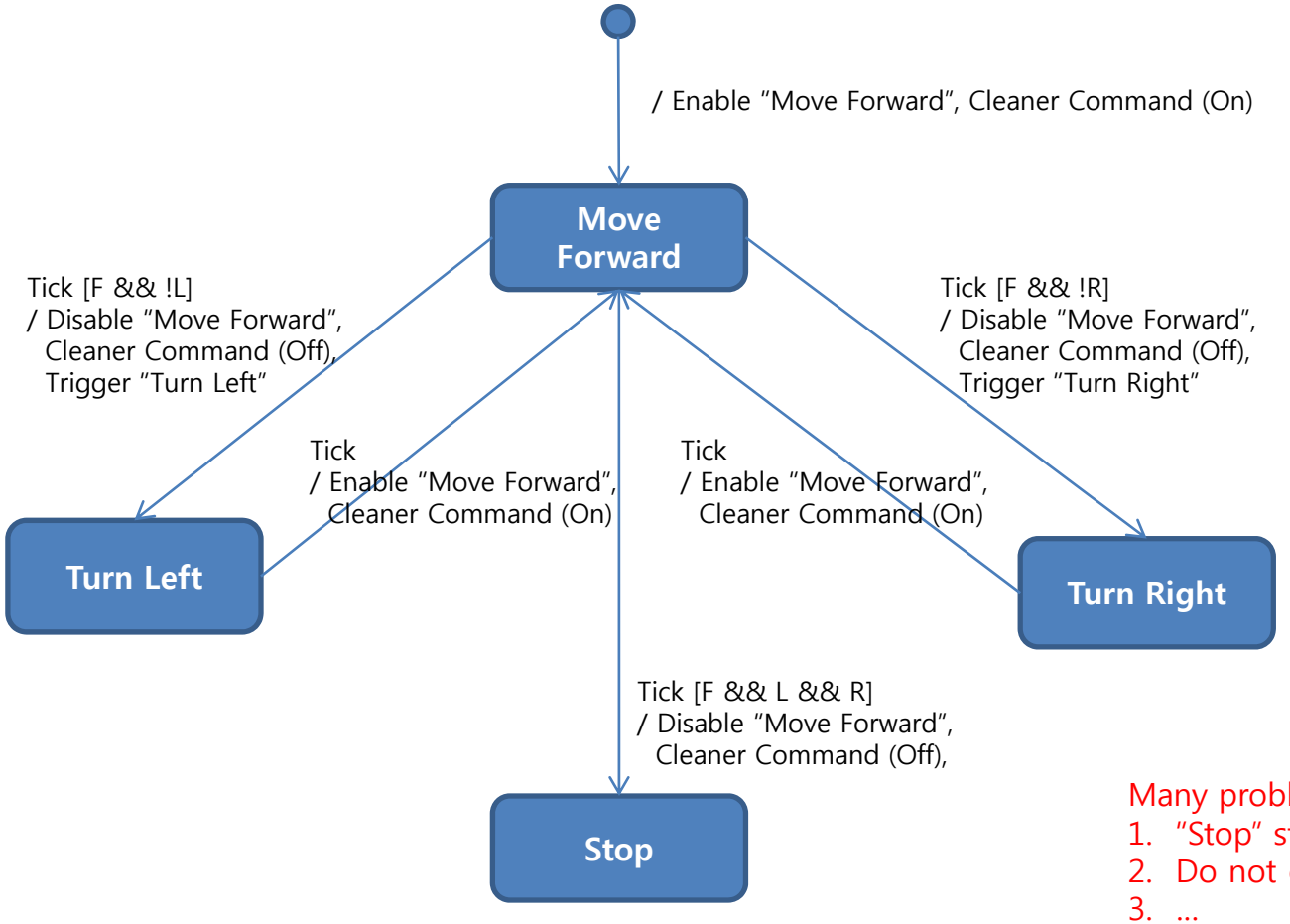


DFD Level 3 – RVC Example



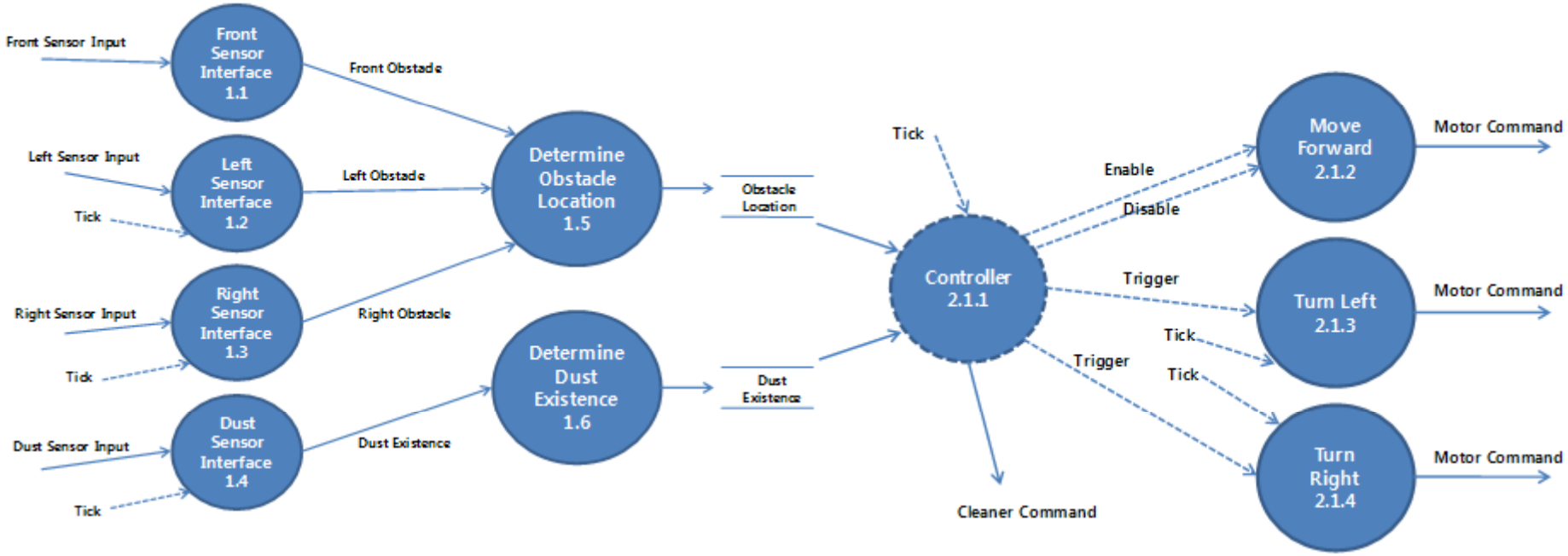
DFD Level 4 – RVC Example

State Transition Diagram for Controller 2.1.1



Many problems in this model:
1. "Stop" state
2. Do not consider "Dust"
3. …

DFD – RVC Example



Process Specification

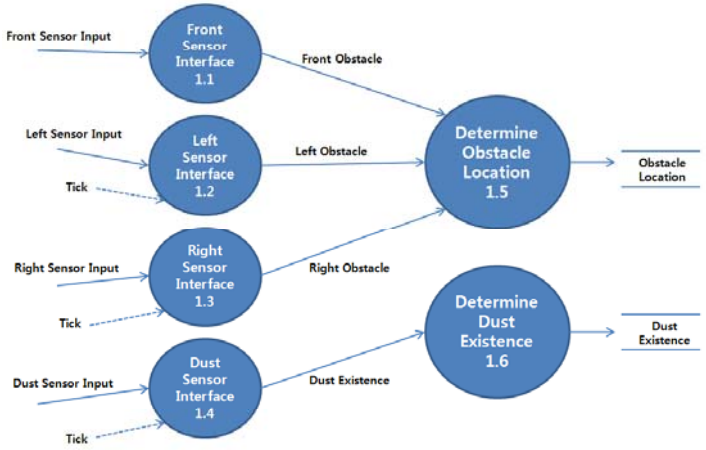
- Shows process details which are implied but not shown in a DFD.
- Specifies the input, output, and algorithm of a module in a DFD.
- Normally written in pseudo-code or table format.

- Example – "Apply Payment"

```
For all payments
  If payment is to be applied today or earlier and has not yet been applied
    Read account
    Read amount
    Add amount to account's open to buy
    Add amount to account's balance
    Update payment as applied
```

Zhou Qun, Kendra Hamilton, and Ibrahim Jadalowen (2002)

Process Specification – RVC Example



Reference No.	1.2
Name	Left Sensor Interface
Input	Left Sensor Input (+Data structure if possible) , Tick
Output	Left Obstacle (+Data structure)
Process Description	"Left Sensor Input" process reads a analog value of the left sensor periodically, converts it into a digital value such as True/False, and assigns it into output variable "Left Obstacle."

Data Dictionary

- Defines data elements to avoid different interpretations.
- Not used widely in recent years.

- Example [Yourdon 1989]

  A: What's a name?

  B: Well, you know, it's just a name. It's what we call each other.

  A: Does that mean you can call them something different when you are angry or happy?

  B: No, of course not. A name is the same all the time.

  A: Now I understand. My name is 3.141592653.

  B: Oh your name is PI…But that's a number, not a name. But what about your first and last name. Or, is your first name 3 and your last name 141592653?

Data Dictionary

- Notation
  - = : is composed of
  - + : and
  - ( ) : optional element
  - { } : iteration
  - [ ] : selects one of the elements list
  - | : separation of elements choice
  - ** : comments
  - @ : identifier for a store (unique ID)

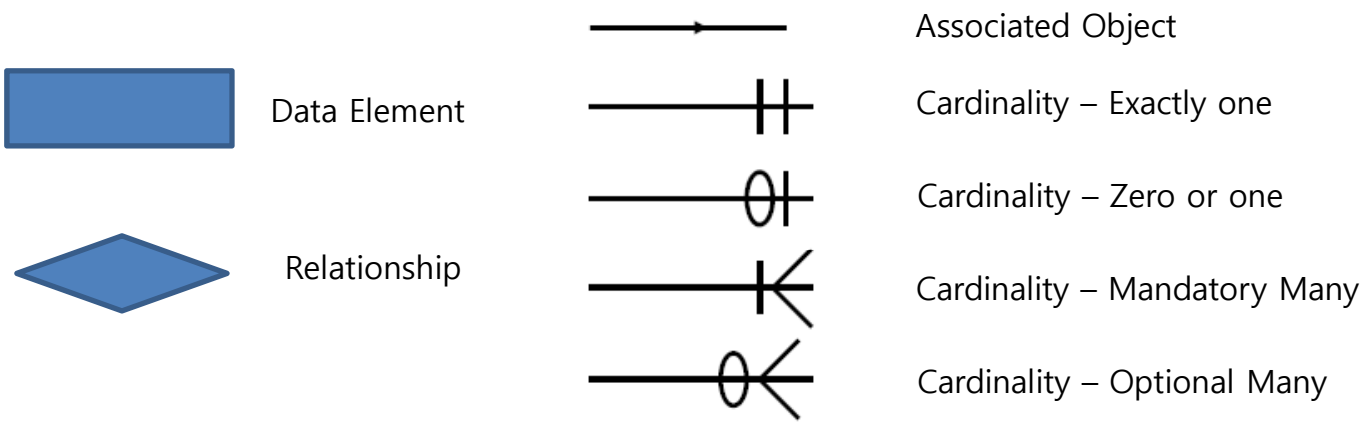
Data Dictionary

- Example
  - Element Name = Card Number
  - Definition = *Uniquely identifies a card*
  - Alias = None
  - Format = LD+LD+LD+LD+SP+LD+LD+LD+LD+SP+ LD+LD+LD+LD+SP+LD+LD+LD+LD
  - SP = " " *Space*
  - LD = {0-9} *Legal Digits*
  - Range = 5191 0000 0000 0000 ~ 5191 9999 9999 9999

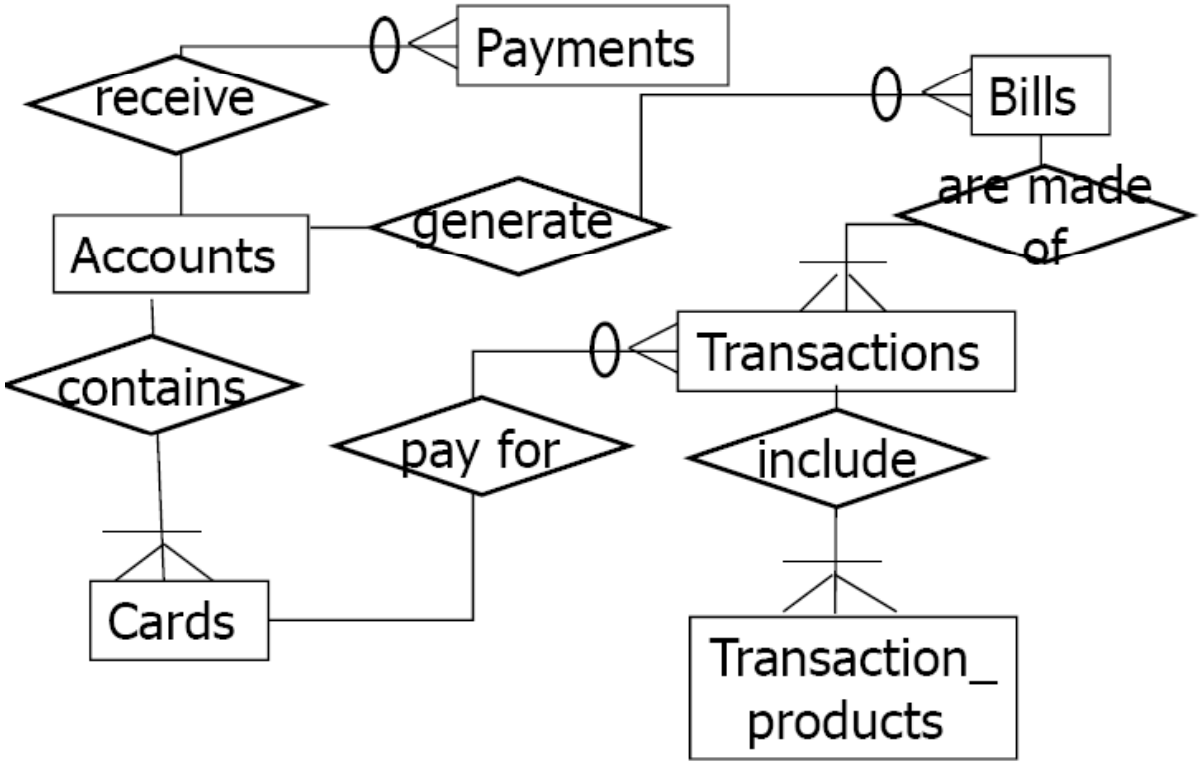
Entity Relationship Diagram (ERD)

- A graphical representation of the data layout of a system at a high level of abstraction
- Defines data elements and their inter-relationships in the system.
- Similar with the class diagram in UML.

- Notation (Original)



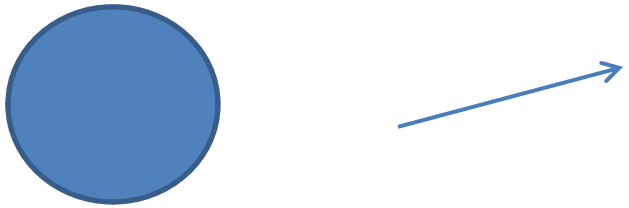
Entity Relationship Diagram - Example



State Transition Diagram

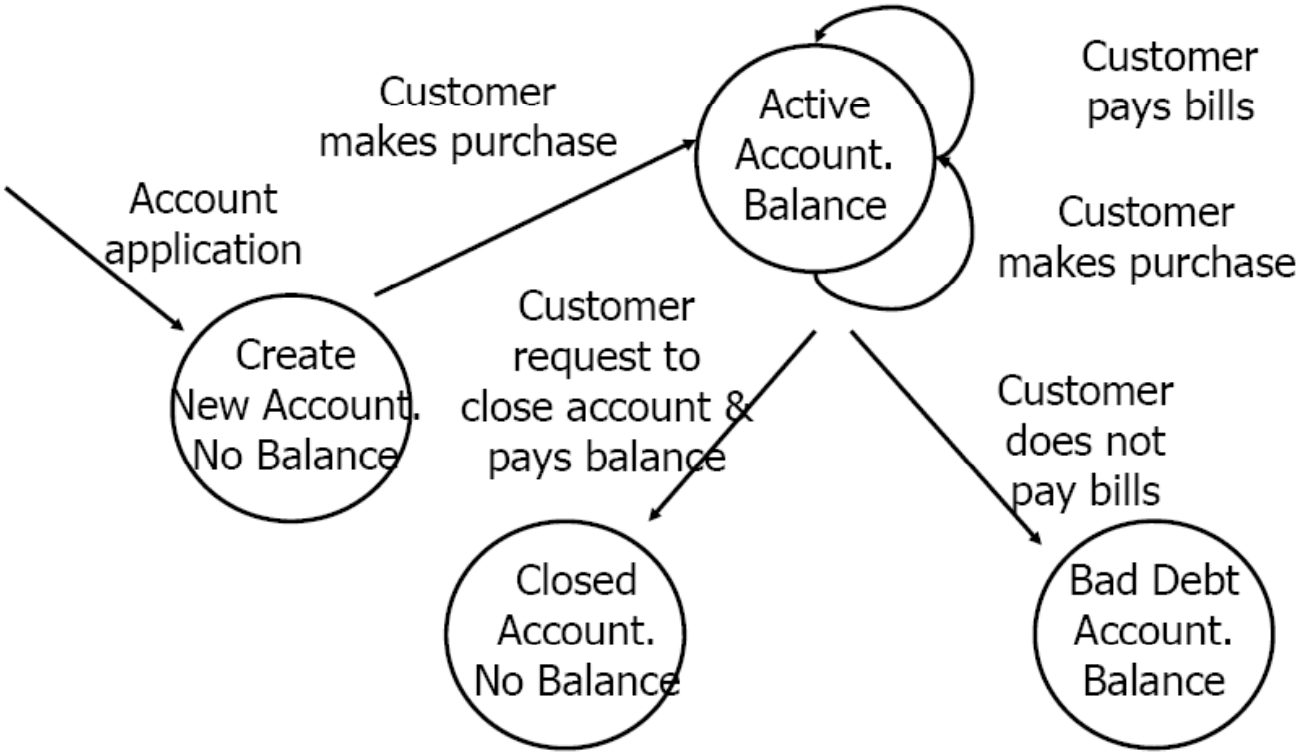
- Shows the time ordering between processes.
- More primitive than the Statechart diagram in UML.
- Different from the State transition diagram used in DFD.
- Not widely used.

- Notation



Objects Transitions

State Transition Diagram - Example



Practice

- Complete the RVC analysis in more details.
  - Consider the "Dust".
  - You may have several controller.

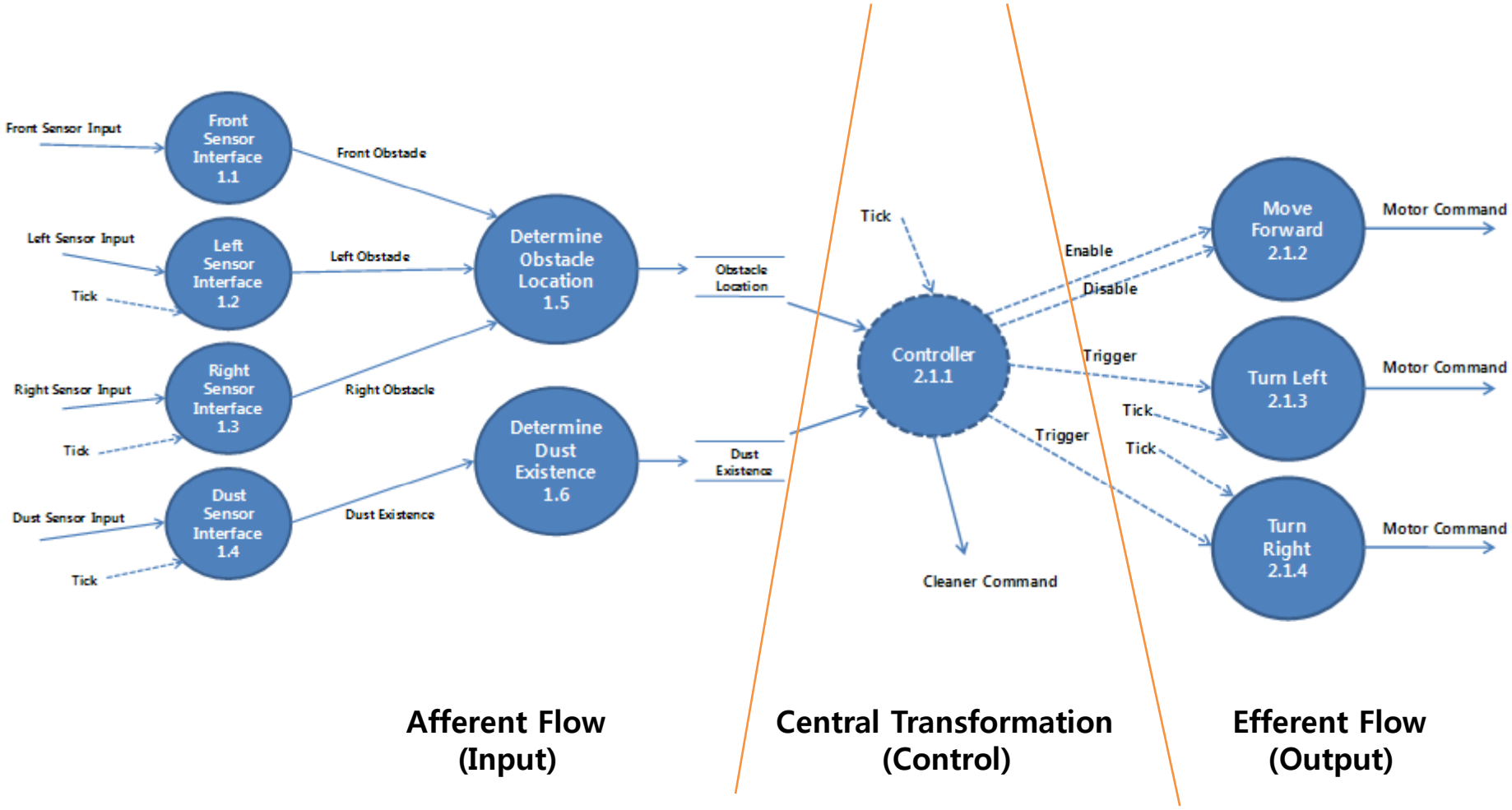
Structure Charts

- Structured Design (SD)

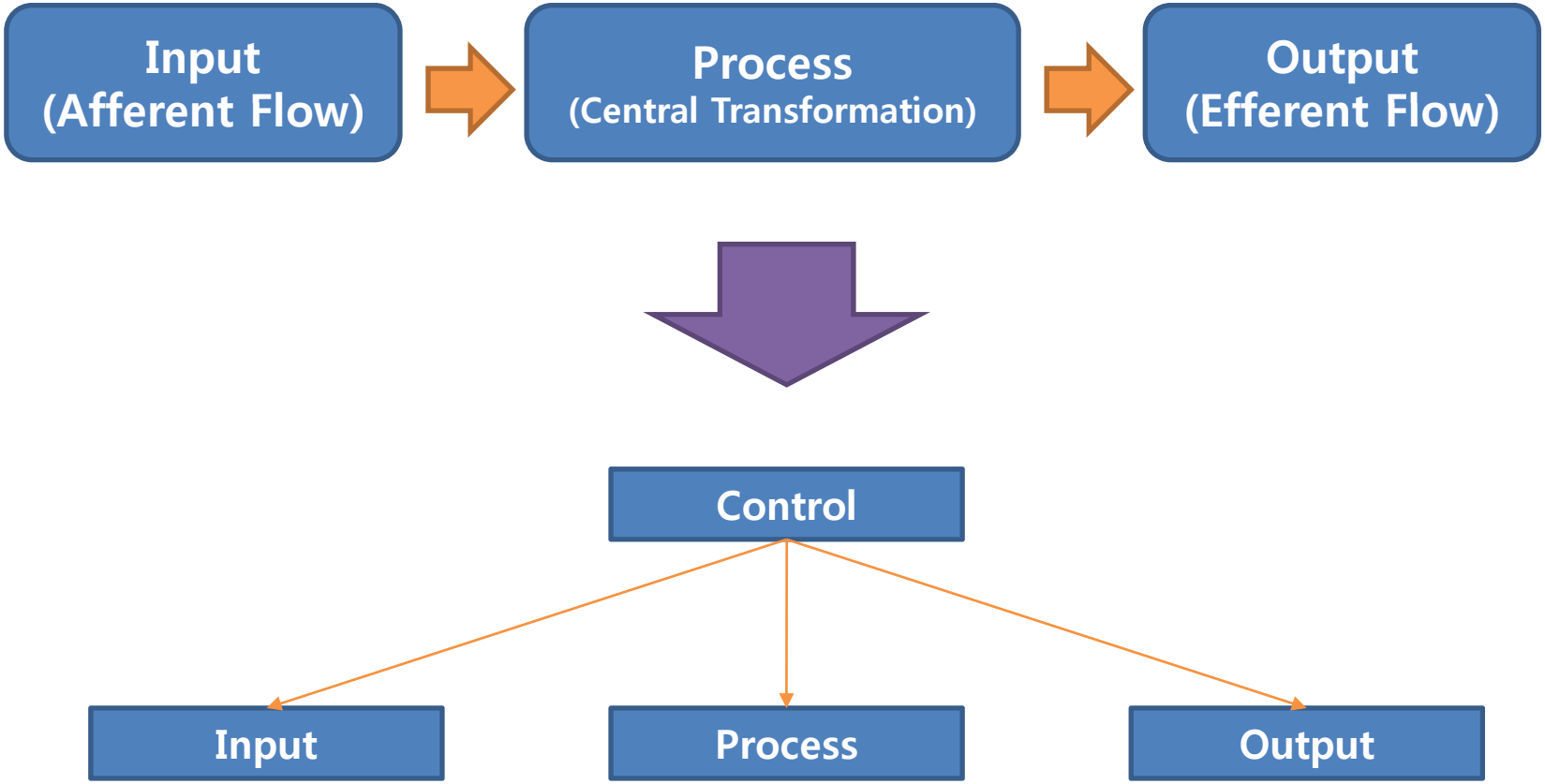
- Functional decomposition (Divide and Conquer)
  - Information hiding
  - Modularity
  - Low coupling
  - High internal cohesion

- Needs a transform analysis.

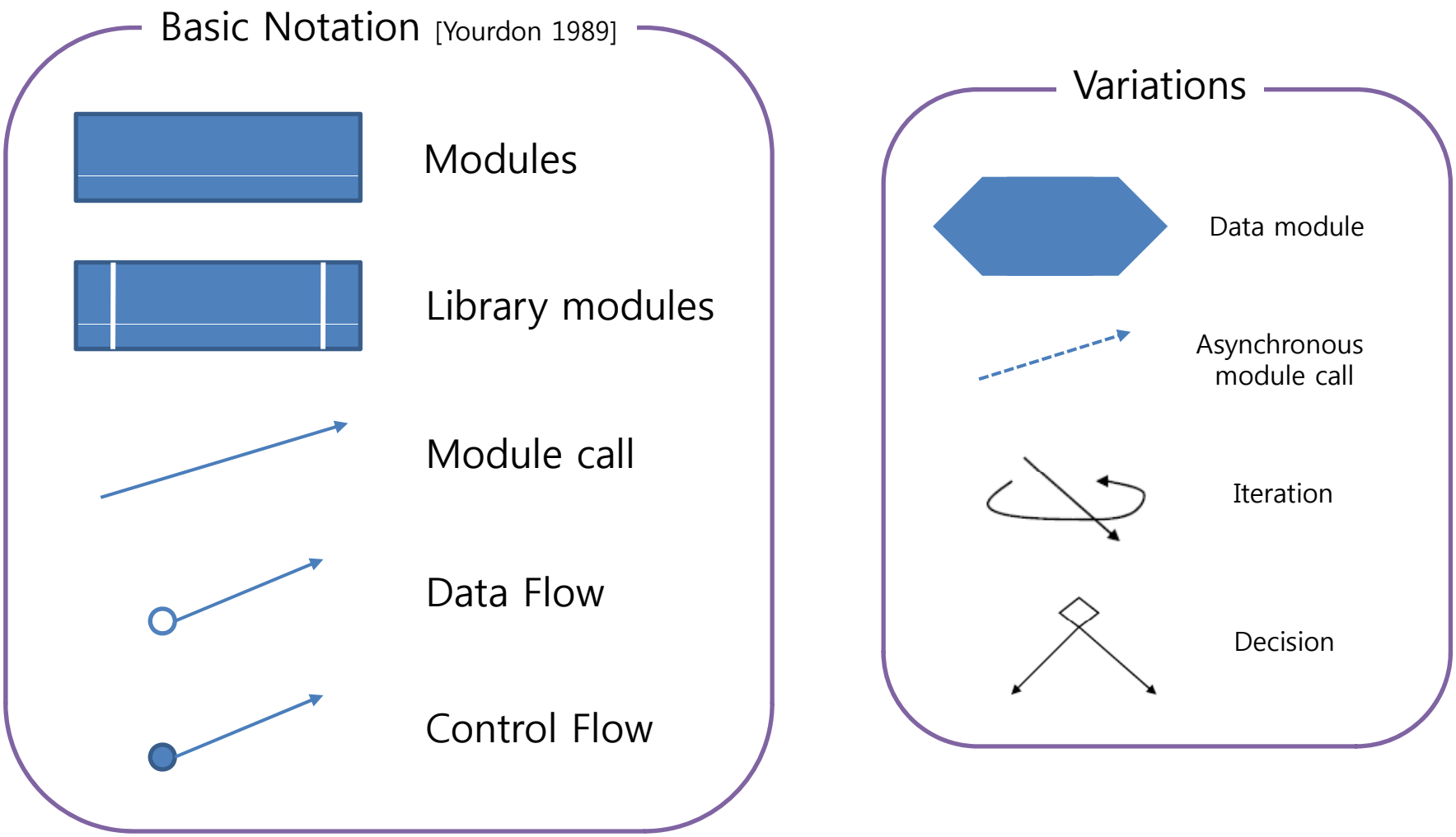
Structured Charts – Transform Analysis



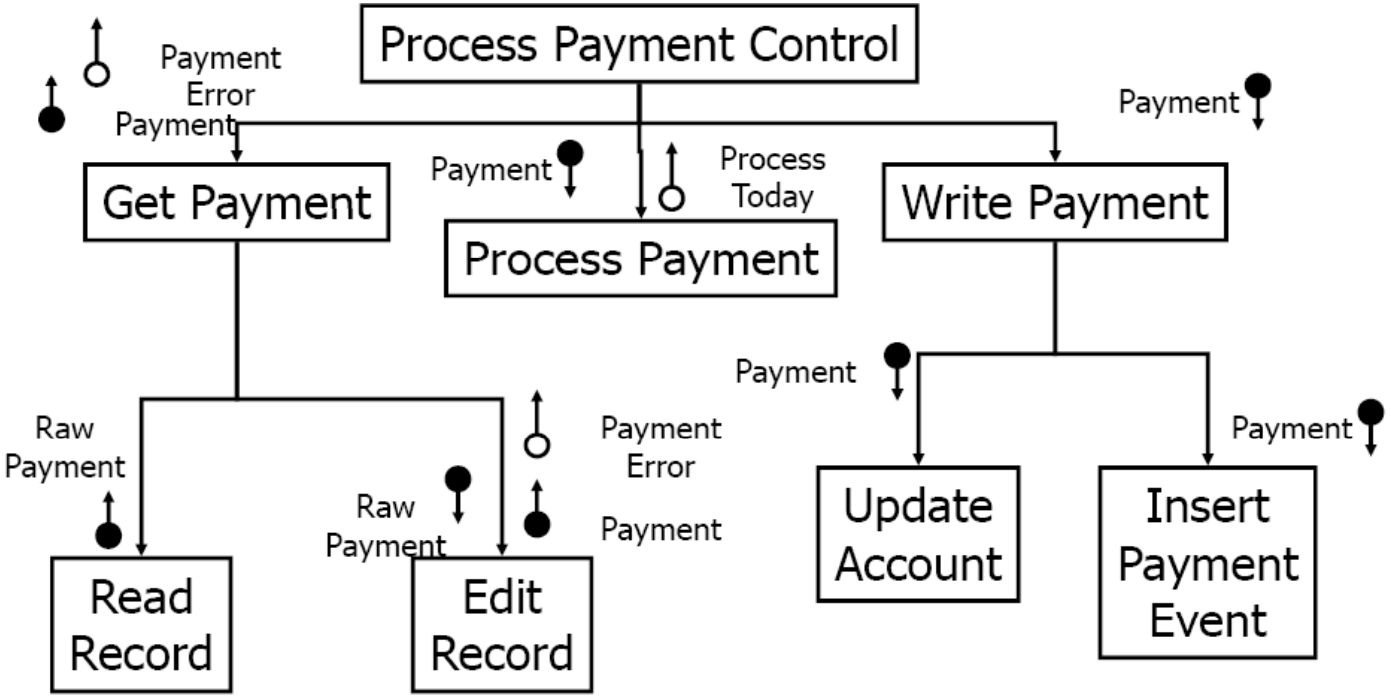
Structured Charts – Transform Analysis



Structured Charts – Notation

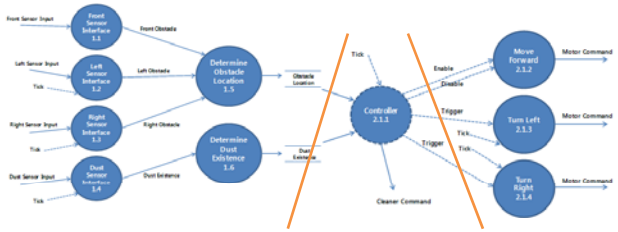


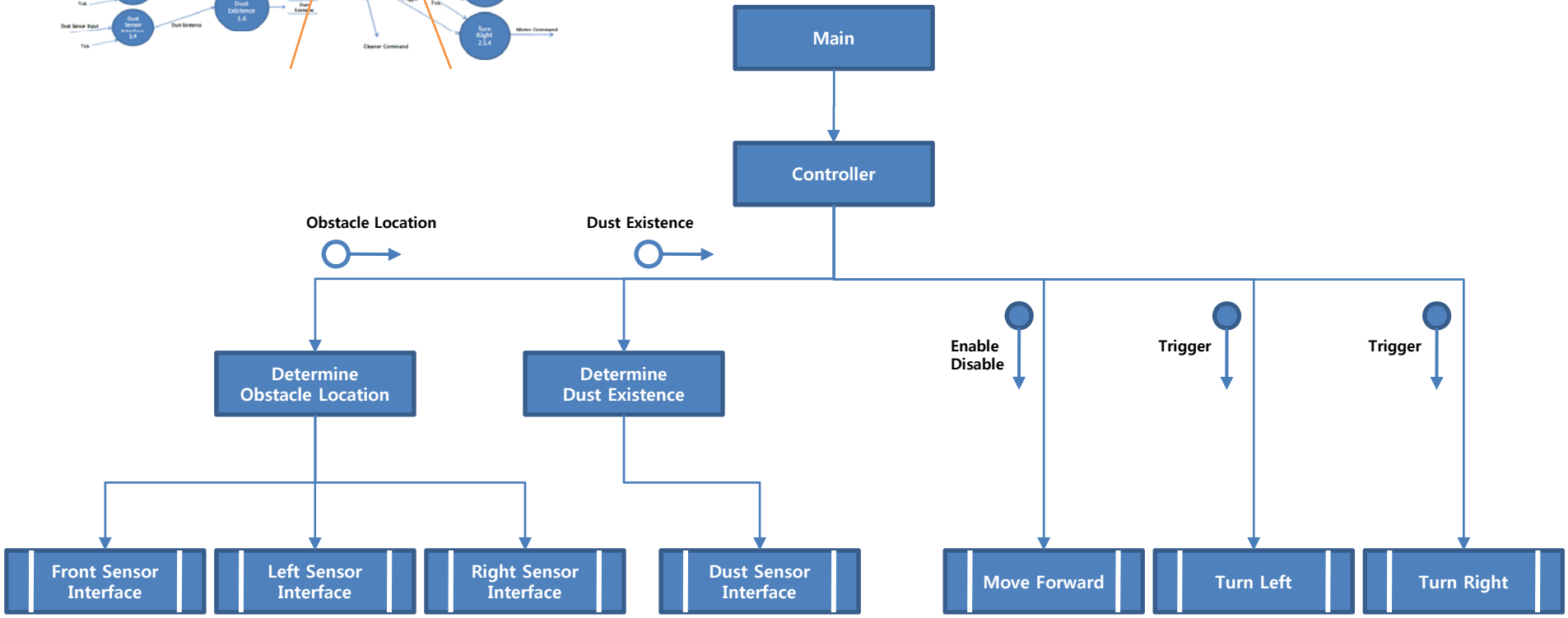
Structured Charts - Example



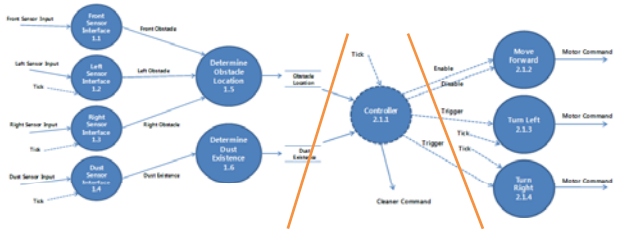
Zhou Qun, Kendra Hamilton, and Ibrahim Jadalowen (2002)

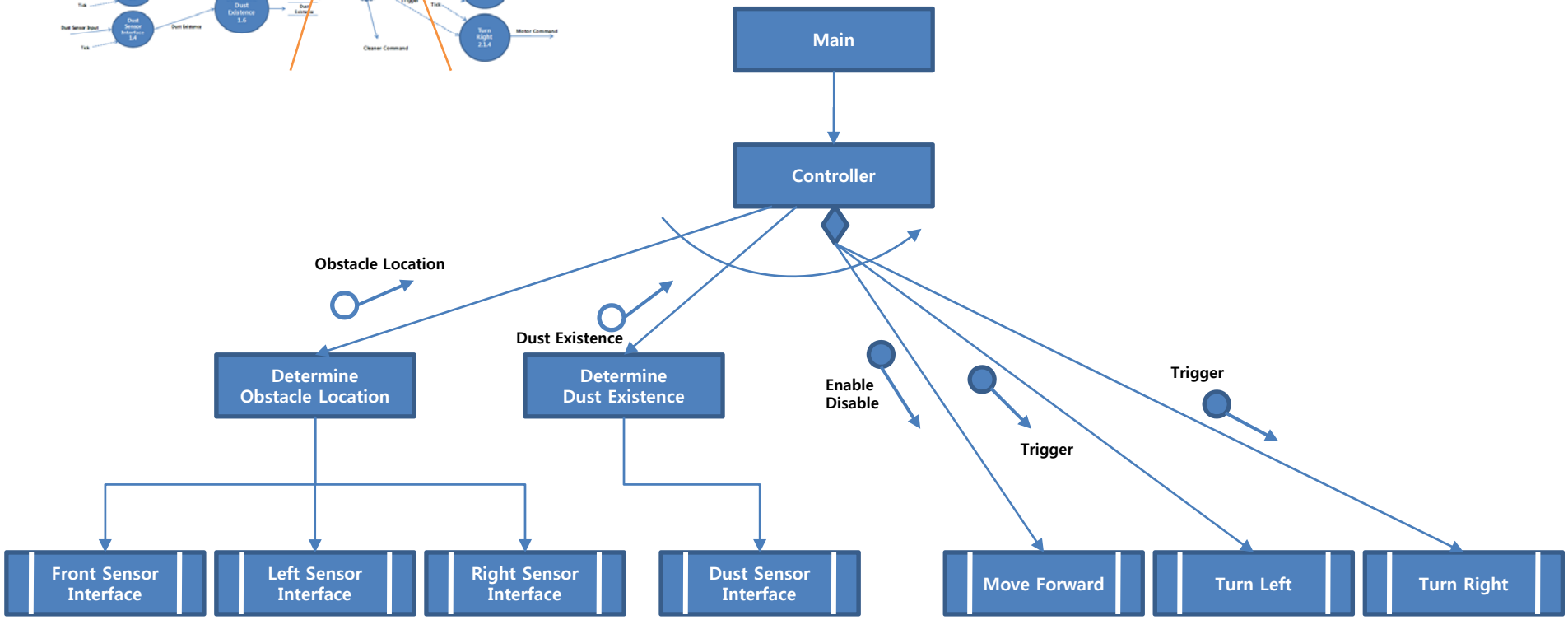
Structured Charts – RVC Example (Basic)





Structured Charts – RVC Example (Advanced)





Pros of SASD

- Has distinct milestones, allowing easier project management tracking.
- Very visual – easier for users/programmers to understand
- Makes good use of graphical tools
- Well known in industry
- A mature technique
- Process-oriented way is a natural way of thinking
- Flexible
- Provides a means of requirements validation
- Relatively simple and easy to read

Pros of SASD

- System Context Diagram
  - Provides a black box overview of the system and the environment
- Event List
  - Provides a guidance for functionality
  - Provides a list of system inputs and outputs
  - A means of requirements summarization
  - Can be used to define test cases (as we will see soon.)
- Data Flow Diagram (DFD)
  - Ability to represent data flows
  - Functional decomposition (divide and conquer)

Pros of SASD

- Data Dictionary
  - Simplifies data requirements
  - Used at high or low level analysis
- Entity Relationship Diagram (ERD)
  - Commonly used and well understood
  - A graphical tool, so easy to read by analysts
  - Data objects and relationships are portrayed independently from the process
  - Can be used to design database architecture
  - Effective tool to communicate with DBAs
- Process Specification
  - Expresses the process specifications in a form that can be verified

Pros of SASD

- State Transition Diagrams
  - Models real-time behavior of the processes in the DFD
- Structure Charts
  - Modularity improves the system maintainability
  - Provides a means for transition from analysis to design
  - Provides a synchronous hierarchy of modules

Cons of SASD

- Ignores non-functional requirements.
- Minimal management involvement
- Non-iterative – waterfall approach
- Not enough use-analysts interaction
- Does not provide a communication process with users.
- Hard to decide when to stop decomposing.
- Does not address stakeholders' needs.
- Does not work well with Object-Oriented programming languages.

Cons of SASD

- System Context Diagram
  - Does not provide a specific means to determine the scope of the system.
- Event List
  - Does not define all functionalities.
  - Does not define specific mechanism for event interactions.
- Data Flow Diagram (DFD)
  - Weak display of input/output details
  - Confused for users to understand.
  - Does not represent time.
  - No implied sequencing
  - Assigns data stores in the early analysis phase without much deliberation.

Cons of SASD

- Data Dictionary
  - No functional details
  - Formal language is confusing to users.
- Entity Relationship Diagram (ERD)
  - May be confused for users due to its formal notation.
  - Become complex in large systems.
- Structure Chart
  - Does not work well for asynchronous processes such as networks.
  - Could be too large to be effectively understood with larger programs.

Cons of SASD

- Process Specification
  - They may be too technical for users to understand.
  - Difficult to stay away from the current "How to implement."
- State Transition Diagram
  - Explains what action causes a state change, but not when or how often.

When to use SASD?

- Well-known problem domains
- Contract projects where SRS should be specified in details
- Real-time systems
- Transaction processing systems
- Not appropriate when time to market is short.

- In recent years,
  SASD is widely used in developing real-time embedded systems.

SASD vs. OOAD

- Similarities
  - The both have started off from programming techniques.
  - The both use graphical design and tools to analyze and model requirements.
  - The both provide a systematic step-by-step process for developers.
  - The both focus on the documentation of requirements.

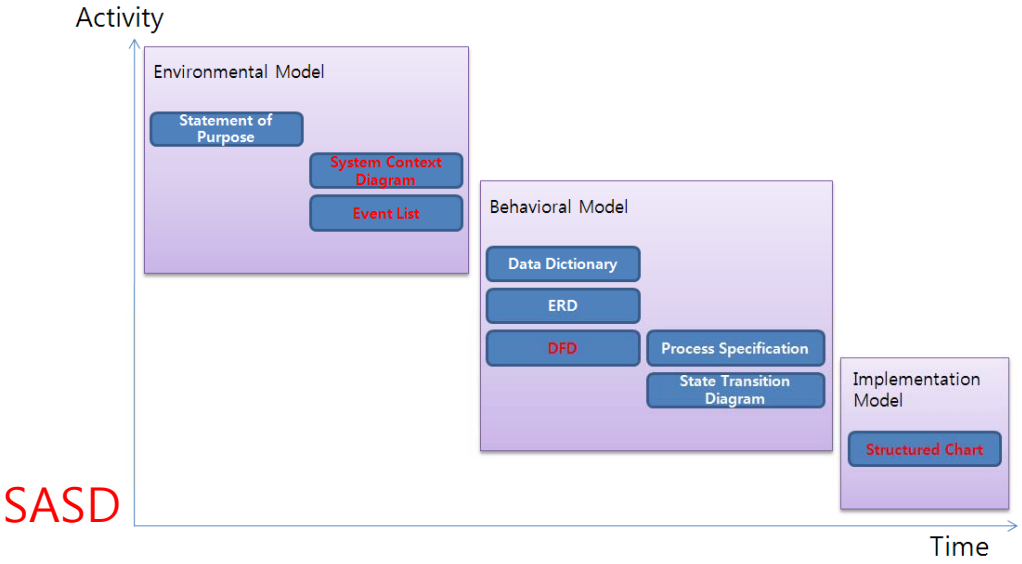
- Differences
  - SASD is process-oriented.
  - OOAD is data(object)-oriented.
  - OOAD encapsulates as much of the system's data and processes into objects,
  - While SASD separates them as possible as it can.

Class Questions

- What is your opinion on ?
  - Does it reduce maintainability costs?
  - Is it useful?
  - Is it efficient?
  - Is it appropriate for E-commerce(business) development?
- What is SASD's target domain?

Summary

- SASD is a process-driven software analysis technique.
- SASD has a long history in the industry and it is very mature.
- It provides a good documentation for requirements.
- In recent years, it is widely used for developing real-time embedded system's software.



Final Presentation (OOAD vs. SASD)

- English presentation
- Compare OOAD with SASD using your elevator controller team project.
  - Pros and Cons of SASD and OOAD for developing elevator controllers respectively
  - Your opinion and suggestion!!!