Function-Oriented Software Design

Introduction

- During the design process high-level functions are successively decomposed into more detailed functions.
- Finally the detailed functions are mapped to a module structure.

Introduction

- Successive decomposition of high-level functions into more detailed functions.
- Technically known as top-down decomposition.

Introduction

SA/SD methodology has essential features of several important function-oriented design methodologies-if you need to use any specific design methodology later on, you can do so easily with small additional effort.

Overview of SA/SD Methodology

- SA/SD methodology consists of two distinct activities:
  - –Structured Analysis (SA)
  - –Structured Design (SD)
- During structured analysis:
  - –functional decomposition takes place.
- During structured design:
  - –module structure is formalized.

Functional decomposition

- Each function is analysed hierarchically decomposed into more detailed functions.
- Simultaneous decomposition of high-level data into more detailed data.

Structured analysis

- Transforms a textual problem description into a graphic model. It is done using data flow diagrams (DFDs).
- DFDs graphically represent the results of structured analysis.

Structured design

- All the functions represented in the DFD: mapped to a module structure.
- The module structure: also called as the <u>software architecture:</u>

Detailed Design

- Software architecture is refined through detailed design.
- Detailed design can be directly implemented using a conventional programming language.

Structured Analysis vs. Structured Design

- Purpose of structured analysis: capture the detailed structure of the system as the user views it.
- Purpose of structured design: arrive at a form that is suitable for implementation in some programming language.

Structured Analysis

- Based on principles of
- Top-down decomposition approach.
- Divide and conquer principle: Each function is considered individually (i.e. isolated from other functions).
- Decompose functions totally disregarding what happens in other functions.
- Graphical representation of results using data flow diagrams (or bubble charts).

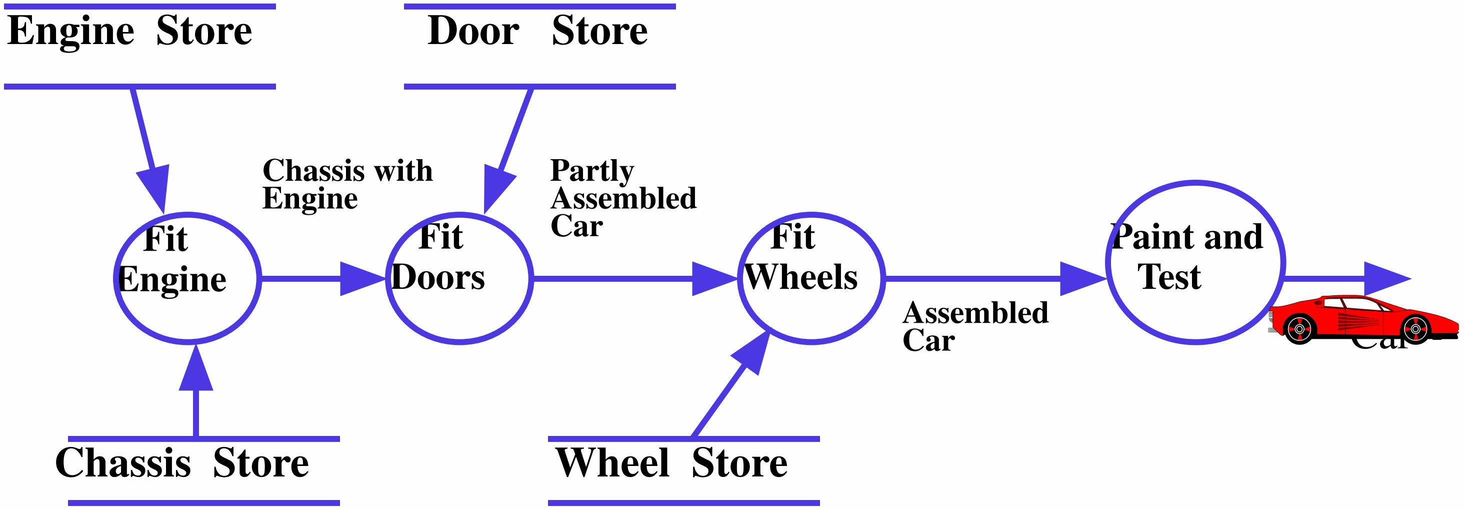
Data flow diagram

- DFD is a hierarchical graphical model:
  - shows the different functions (or processes) of the system and
  - data interchange among the processes.

DFD Concepts

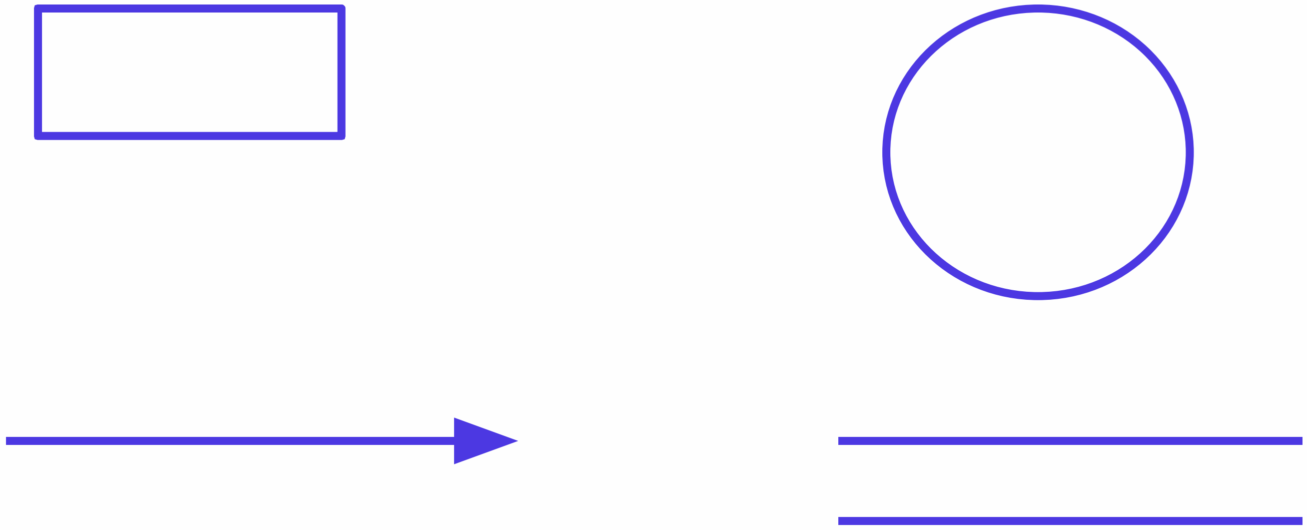
- **It is useful to consider each function as a processing station:**
  - **each function consumes some input data and**
  - **produces some output data.**

Data Flow Model of a Car Assembly Unit



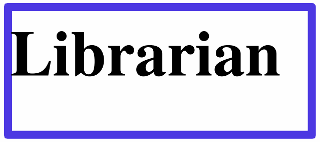
Data Flow Diagrams (DFDs)

- **Primitive Symbols Used for Constructing DFDs:**



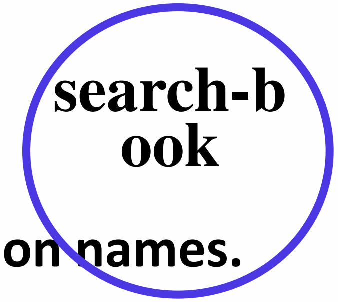
External Entity Symbol

- **Represented by a rectangle**
- **External entities are real physical entities:**
  - **input data to the system or**
  - **consume data produced by the system.**
  - **Sometimes external entities are called terminator, source, or sink.**



Function Symbol

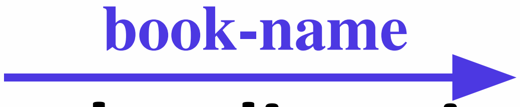
- A function such as “search-book” is represented using a circle:
  - This symbol is called a process or bubble or transform.


search-book

  - Bubbles are annotated with corresponding function names.
  - Functions represent some activity:
    - function names should be verbs.

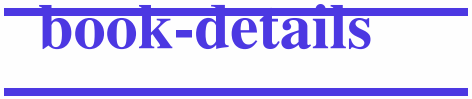
Data Flow Symbol

- A directed arc or line.
  - –represents data flow in the direction of the arrow.
  - –Data flow symbols are annotated with names of data they carry.



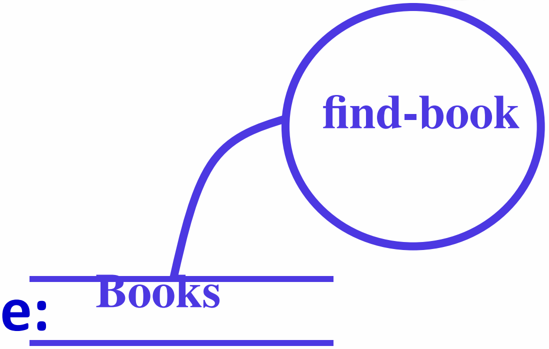
Data Store Symbol

- **Represents a logical file:**
  - –**A logical file can be:**
    - **a data structure**
    - **a physical file on disk.**
  - –**Each data store is connected to a process:**
    - **by means of a data flow symbol.**



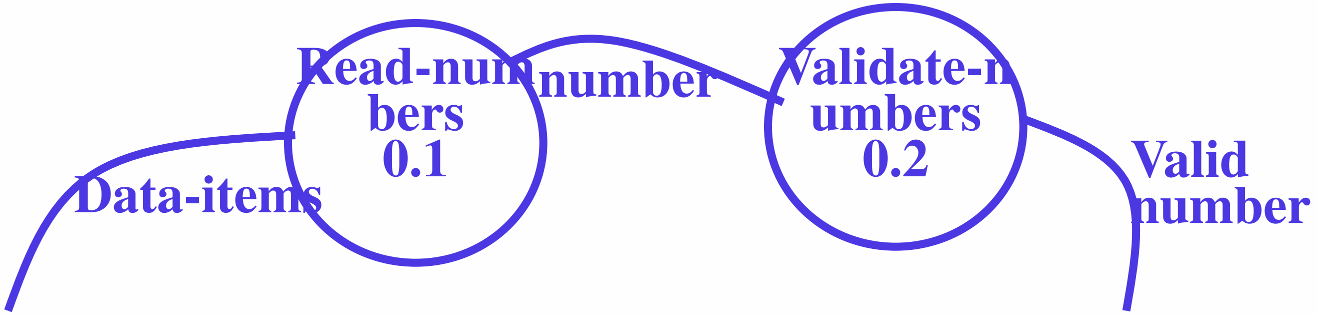
Data Store Symbol

- **Direction of data flow arrow:**
  - **shows whether data is being read from or written into it.**
- **An arrow into or out of a data store:**
  - **implicitly represents the entire data of the data store**
  - **arrows connecting to a data store need not be annotated with any data name.**



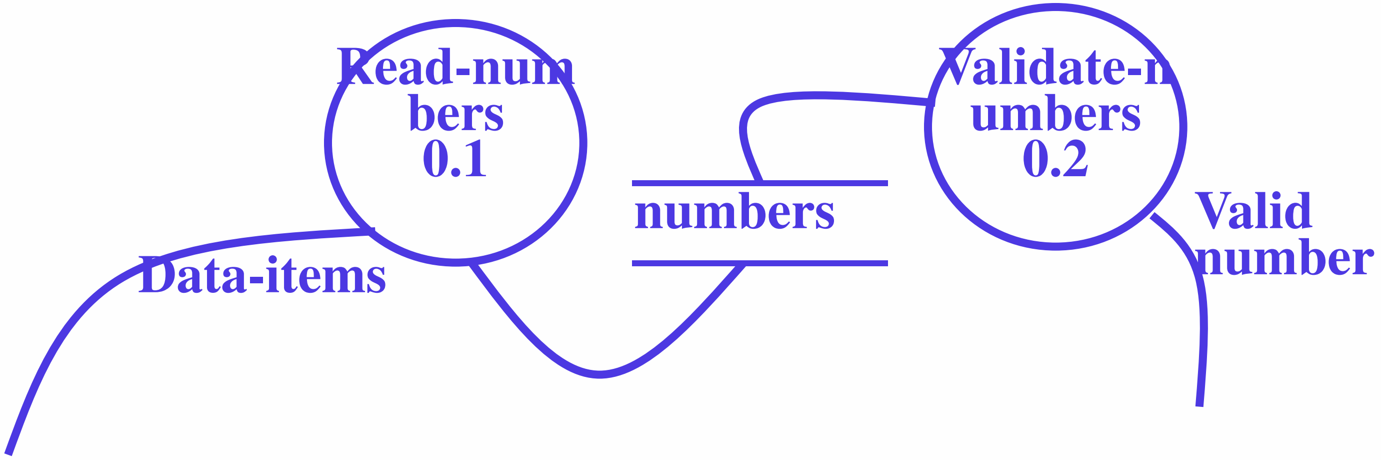
Synchronous operation

- **If two bubbles are directly connected by a data flow arrow:**
  - **they are synchronous**



Asynchronous operation

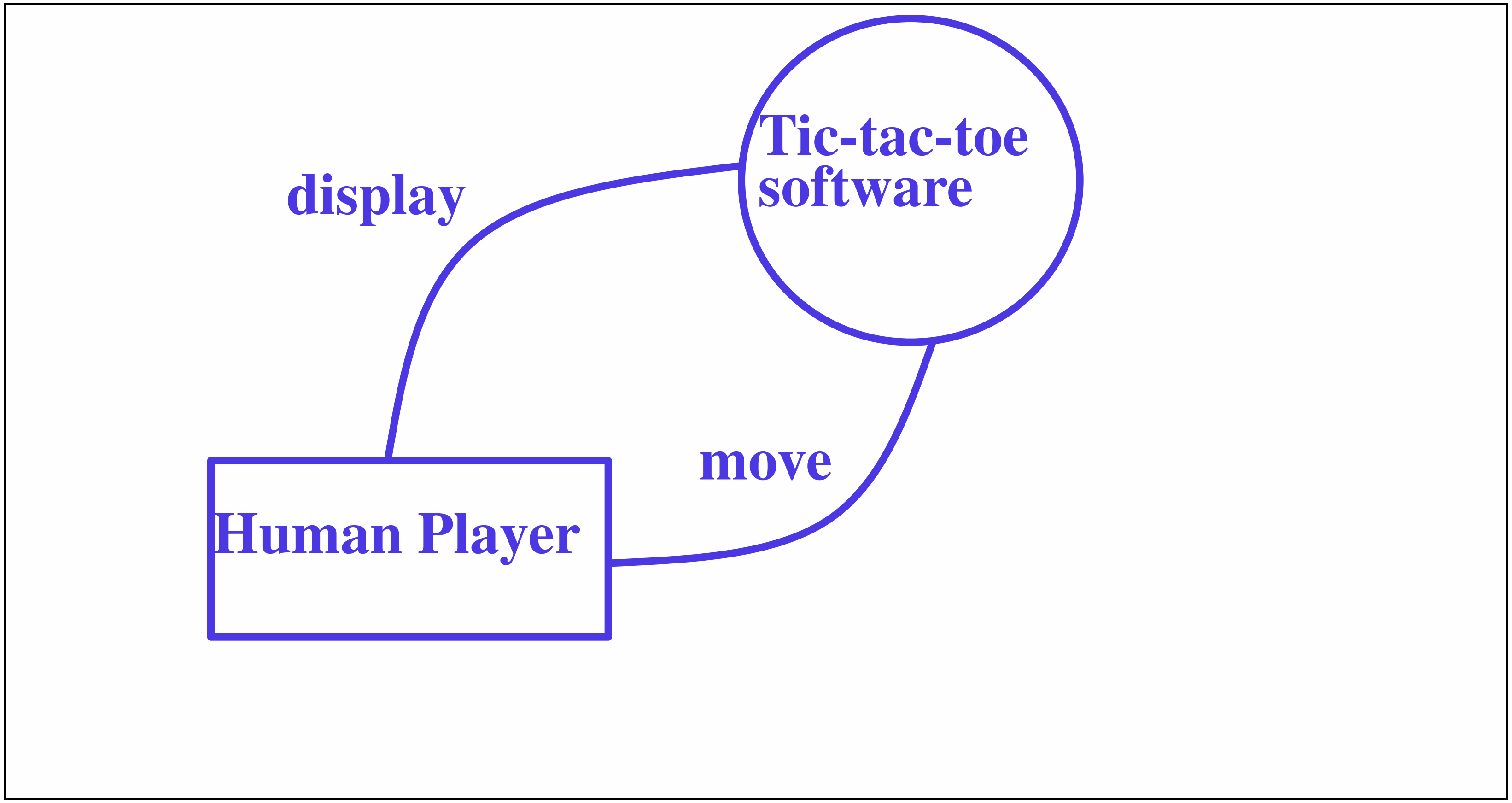
- **If two bubbles are connected via a data store:**
  - **they are not synchronous.**



How is Structured Analysis Performed?

- **Initially represent the software at the most abstract level:**
  - **called the context diagram.**
  - **the entire system is represented as a single bubble,**
  - **this bubble is labelled according to the main function of the system.**

Tic-tac-toe: Context Diagram



Context Diagram

- **A context diagram shows:**
  - **data input to the system,**
  - **output data generated by the system,**
  - **external entities.**

Context Diagram

- **Context diagram captures:**
  - **various entities external to the system and interacting with it.**
  - **data flow occurring between the system and the external entities.**
- **The context diagram is also called as the level 0 DFD.**

Level 1 DFD

- **Examine the SRS document:**
  - **Represent each high-level function as a bubble.**
  - **Represent data input to every high-level function.**
  - **Represent data output from every high-level function.**

Higher level DFDs

- **Each high-level function is separately decomposed into subfunctions:**
  - **identify the subfunctions of the function**
  - **identify the data input to each subfunction**
  - **identify the data output from each subfunction**
- **These are represented as DFDs.**

Decomposition

- **Decomposition of a bubble:**
  - **also called factoring or exploding.**
- **Each bubble is decomposed to**
  - **between 3 to 7 bubbles.**

Decomposition

- **Too few bubbles make decomposition superfluous:**
  - **if a bubble is decomposed to just one or two bubbles:**
    - **then this decomposition is redundant.**

Decomposition

- **Too many bubbles:**
  - –**more than 7 bubbles at any level of a DFD**
  - –**make the DFD model hard to understand.**

Decompose how long?

- **Decomposition of a bubble should be carried on until:**
  - **a level at which the function of the bubble can be described using a simple algorithm.**

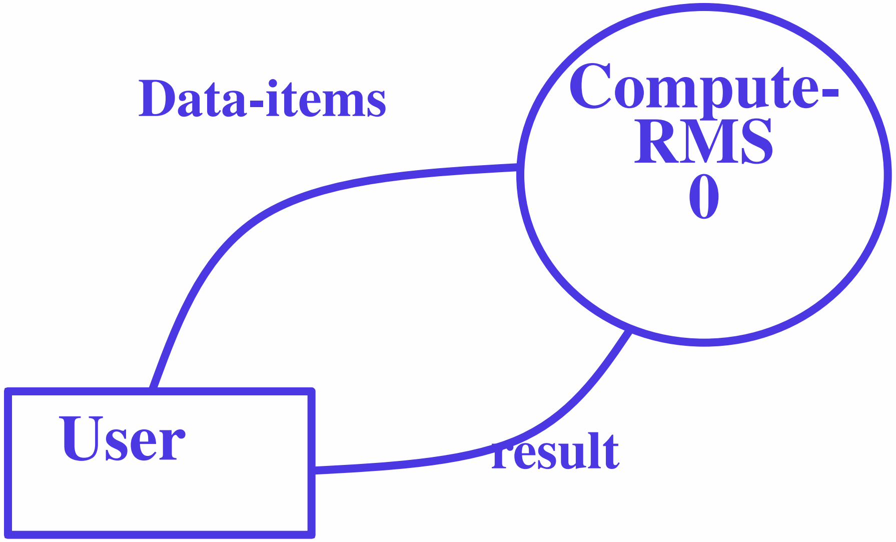
Example 1: RMS Calculating Software

- **Consider a software called RMS calculating software:**
  - **reads three integers in the range of -1000 and +1000**
  - **finds out the root mean square (rms) of the three input numbers**
  - **displays the result.**

Example 1: RMS Calculating Software

- **The context diagram is simple to develop:**
  - **The system accepts 3 integers from the user**
  - **returns the result to him.**

Example 1: RMS Calculating Software



Context Diagram

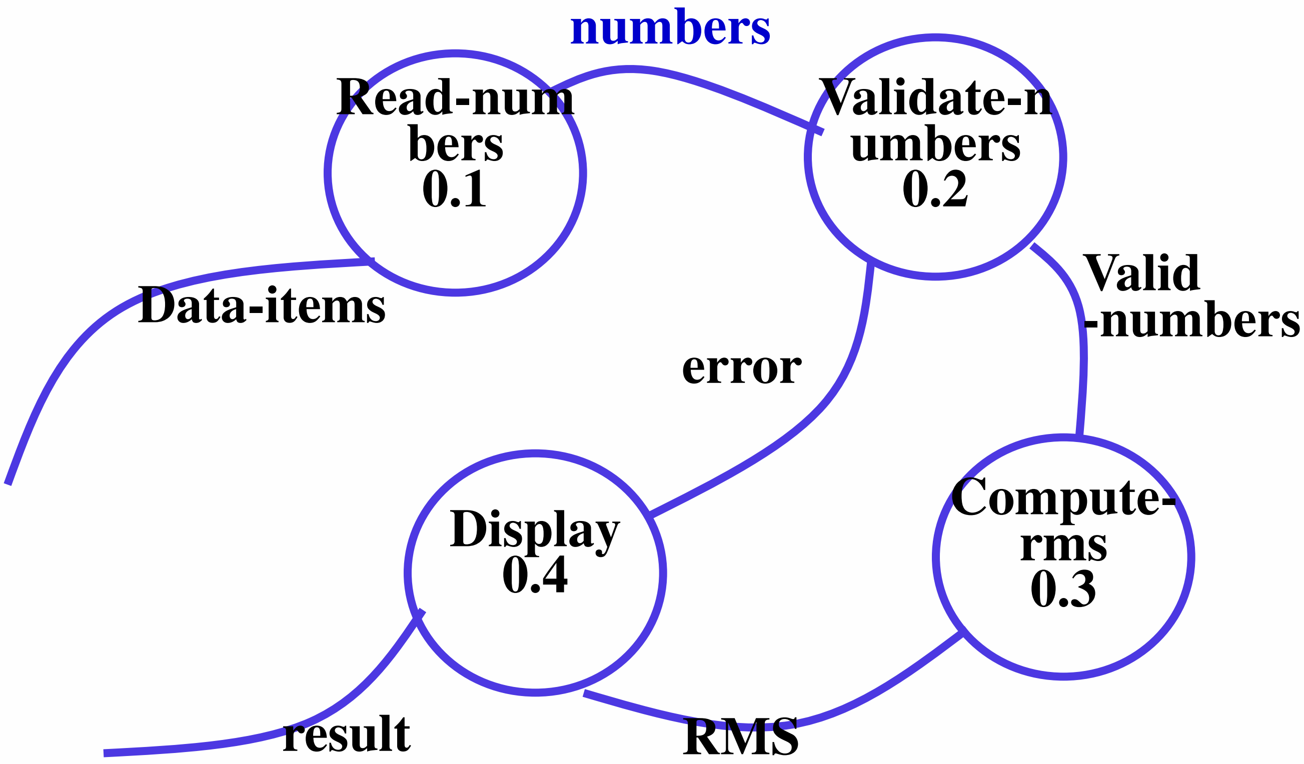
Example 1: RMS Calculating Software

- **From a cursory analysis of the problem description:**
  - **we can see that the system needs to perform several things.**

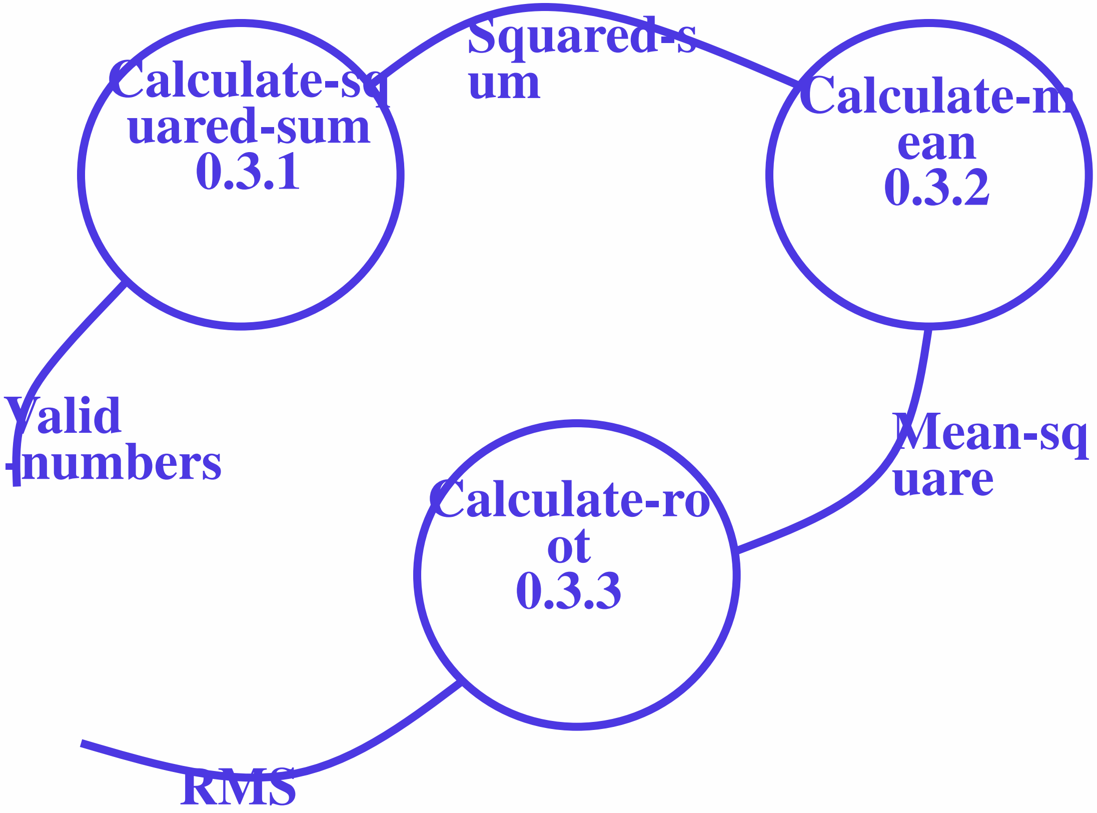
Example 1: RMS Calculating Software

- **Accept input numbers from the user:**
  - **validate the numbers,**
  - **calculate the root mean square of the input numbers**
  - **display the result.**

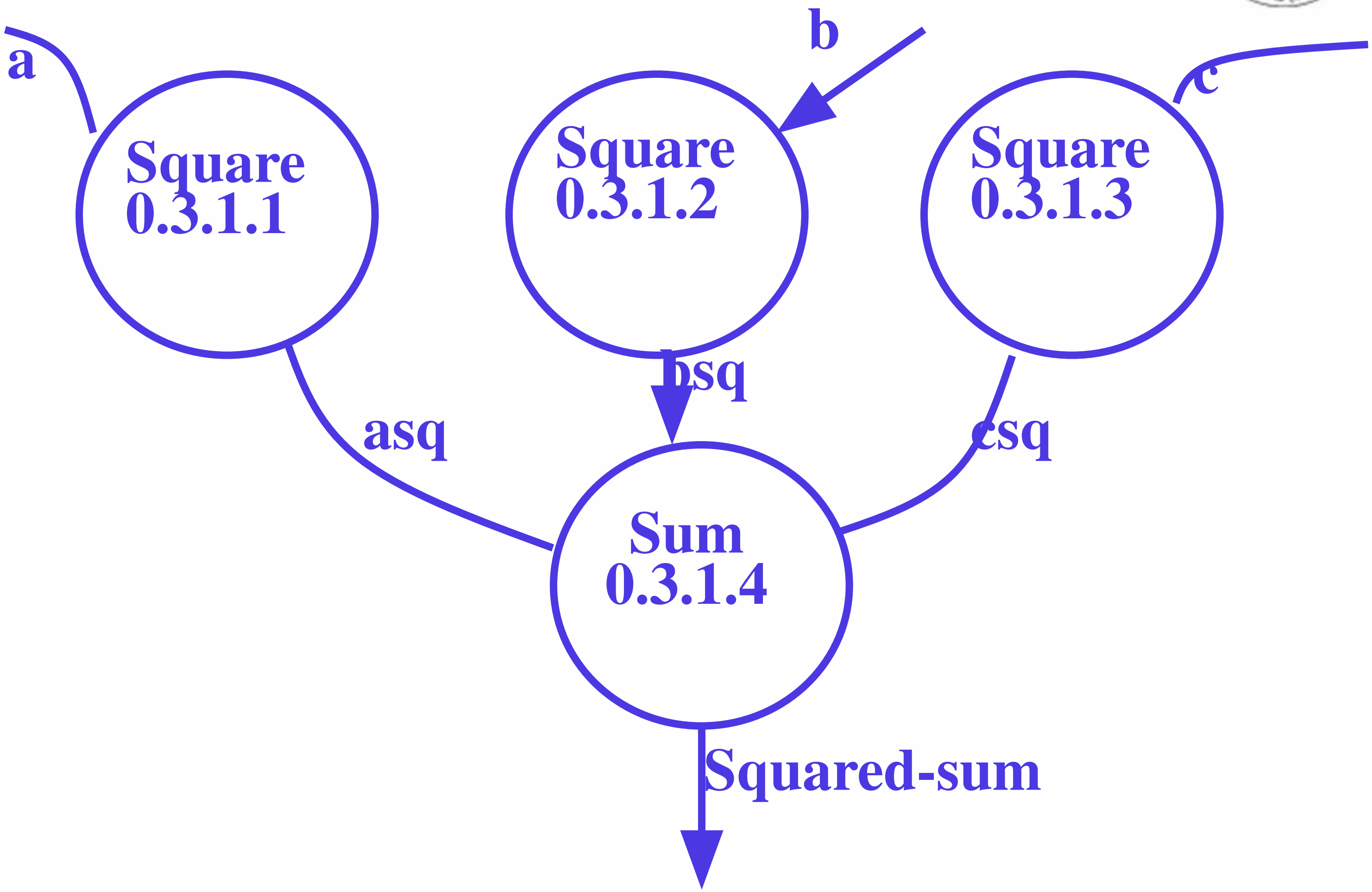
Example 1: RMS Calculating Software(Level-1)



Example 1: RMS Calculating Software(Level-2)



Example: RMS Calculating Software(Level-3)



Example: RMS Calculating Software

- Decomposition is never carried on up to basic instruction level:
  - a bubble is not decomposed any further:
    - if it can be represented by a simple set of instructions.

Data Dictionary

- A DFD is always accompanied by a data dictionary.
- A data dictionary lists all data items appearing in a DFD:
  - definition of all composite data items in terms of their component data items.
  - all data names along with the purpose of data items.
- For example, a data dictionary entry may be:
  - grossPay = regularPay+overtimePay

Importance of Data Dictionary

- Provides all engineers in a project with standard terminology for all data:
  - A consistent vocabulary for data is very important
  - different engineers tend to use different terms to refer to the same data,
    - causes unnecessary confusion.

Importance of Data Dictionary

- Data dictionary provides the definition of different data:
  - in terms of their component elements.
- For large systems,
  - the data dictionary grows rapidly in size and complexity.
  - Typical projects can have thousands of data dictionary entries.
  - It is extremely difficult to maintain such a dictionary manually.

Data Dictionary

- CASE (Computer Aided Software Engineering) tools come handy:
  - CASE tools capture the data items appearing in a DFD automatically to generate the data dictionary.

Data Dictionary

- CASE tools support queries:
  - about definition and usage of data items.
- For example, queries may be made to find:
  - which data item affects which processes,
  - a process affects which data items,
  - the definition and usage of specific data items, etc.
- Query handling is facilitated:
  - if data dictionary is stored in a relational database management system (RDBMS).

Data Definition

- Composite data are defined in terms of primitive data items using following operators:
- +: denotes composition of data items, e.g
  - a+b represents data a and b.
- [,,,]: represents selection,
  - i.e. any one of the data items listed inside the square bracket can occur.
  - For example, [a,b] represents either a occurs or b occurs.

Data Definition

- ( ): contents inside the bracket represent optional data
  - which may or may not appear.
  - a+(b) represents either a or a+b occurs.
- {}: represents iterative data definition,
  - e.g. {name}5 represents five name data.

Data Definition

- {name}* represents
  - zero or more instances of name data.
- = represents equivalence,
  - e.g. a=b+c means that a represents b and c.
- *   *: Anything appearing within *   * is considered as comment.

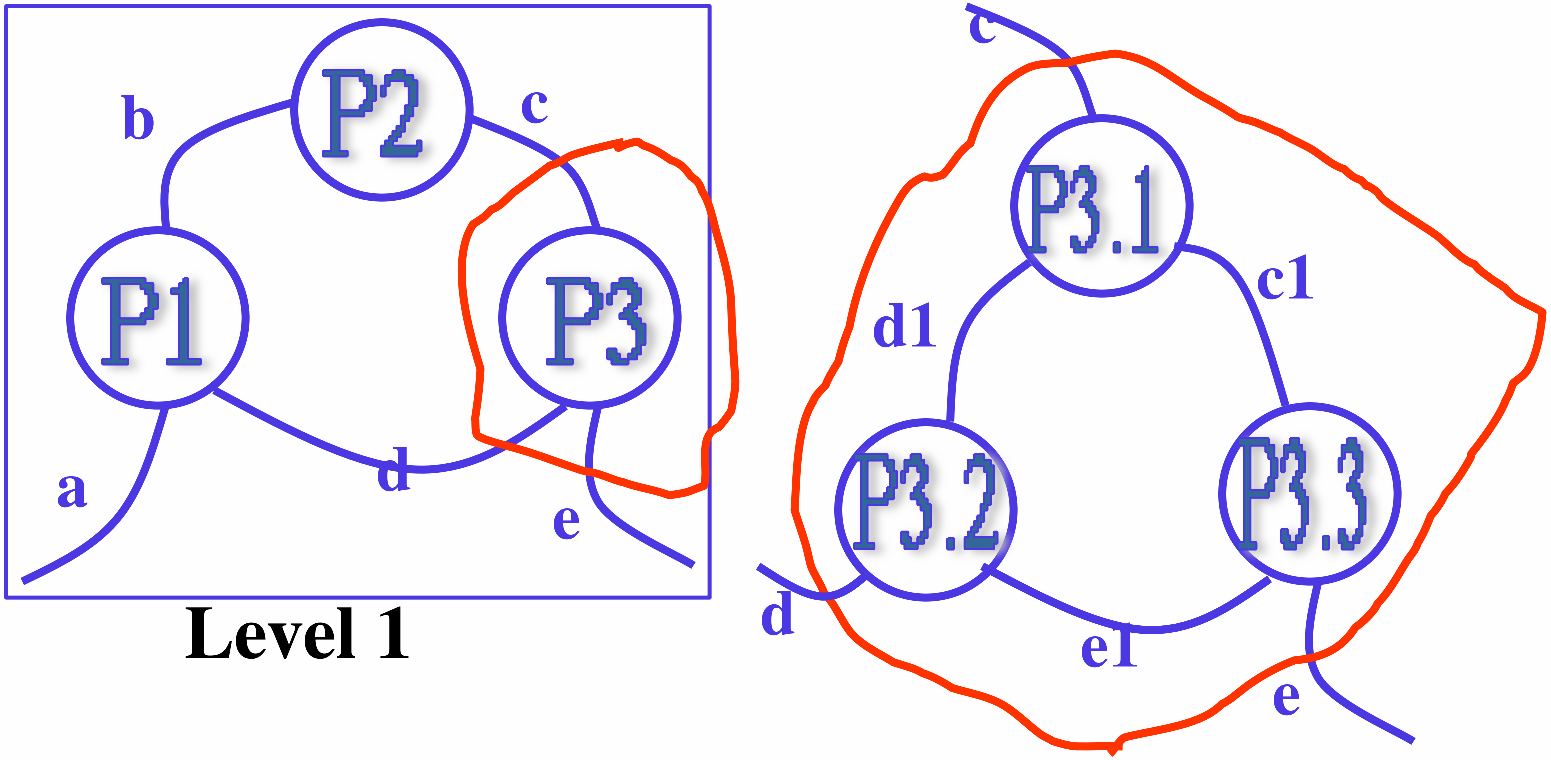
Data dictionary for RMS Software

- numbers=valid-numbers=a+b+c
- a:integer * input number *
- b:integer * input number *
- c:integer * input number *
- asq:integer
- bsq:integer
- csq:integer
- squared-sum: integer
- Result=[RMS,error]
- RMS: integer * root mean square value*
- error:string * error message*

Balancing a DFD

- Data flowing into or out of a bubble:
  - must match the data flows at the next level of DFD.
  - This is known as balancing a DFD
- In the level 1 of the DFD,
  - data item c flows into the bubble P3 and the data item d and e flow out.
- In the next level, bubble P3 is decomposed.
  - The decomposition is balanced as data item c flows into the level 2 diagram and d and e flow out.

Balancing a DFD



Level 1

Level 2

Numbering of Bubbles:

- Number the bubbles in a DFD:
  - numbers help in uniquely identifying any bubble from its bubble number.
- The bubble at context level:
  - assigned number 0.
- Bubbles at level 1:
  - numbered 0.1, 0.2, 0.3, etc
- When a bubble numbered x is decomposed,
  - its children bubble are numbered x.1, x.2, x.3, etc.

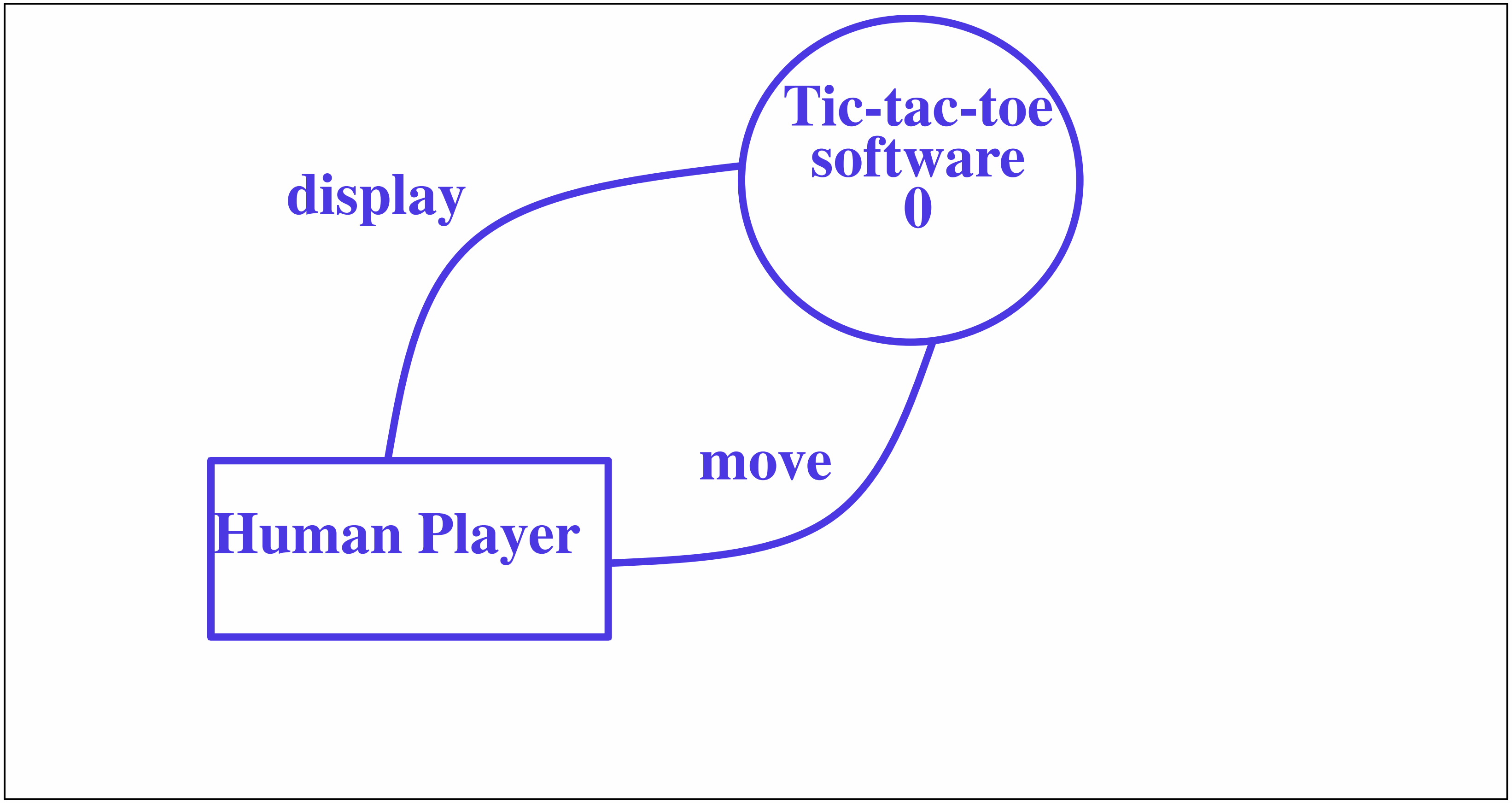
Example 2: Tic-Tac-Toe Computer Game

- A human player and the computer make alternate moves on a 3 3 square.
- A move consists of marking a previously unmarked square.
- The user inputs a number between 1 and 9 to mark a square
- Whoever is first to place three consecutive marks along a straight line (i.e., along a row, column, or diagonal) on the square wins.

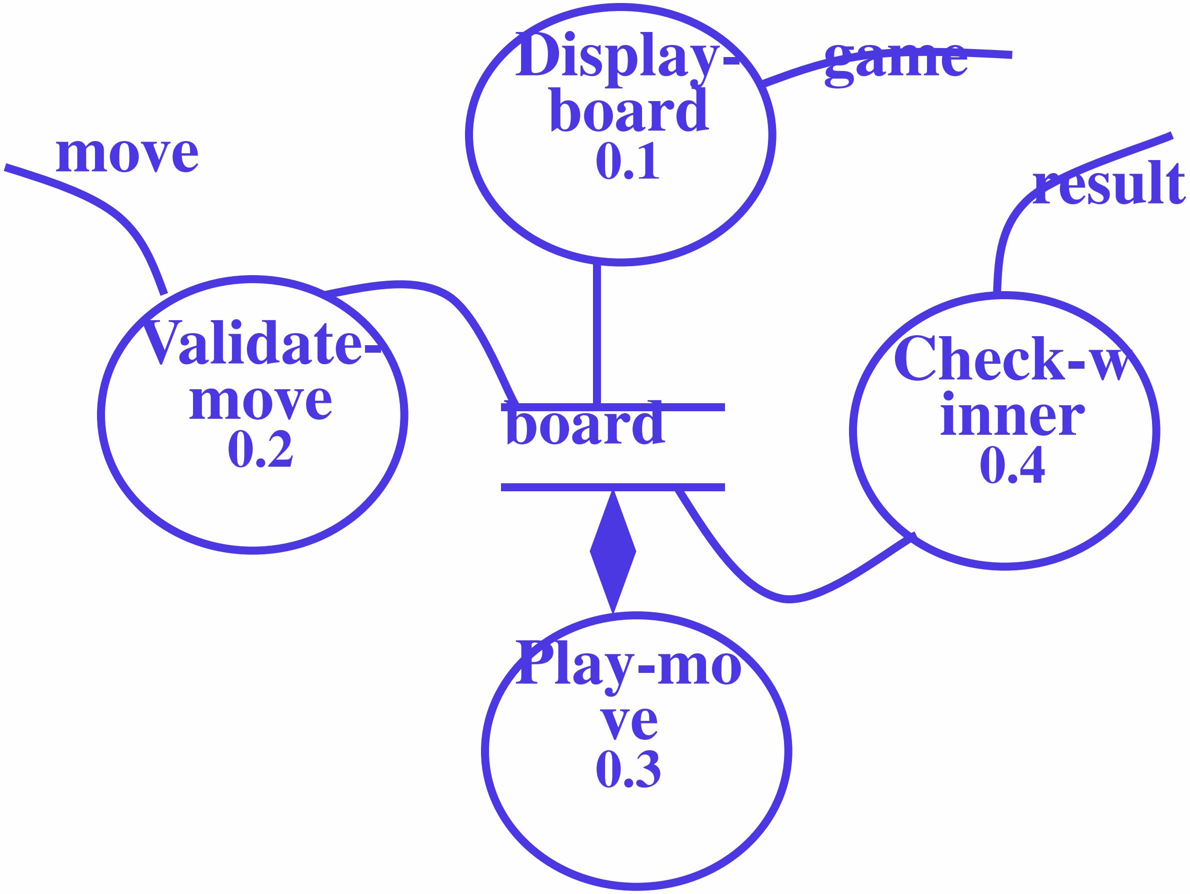
Example: Tic-Tac-Toe Computer Game

- As soon as either of the human player or the computer wins,
  - a message announcing the winner should be displayed.
- If neither player manages to get three consecutive marks along a straight line,
  - and all the squares on the board are filled up,
  - then the game is drawn.
- The computer always tries to win a game.

Context Diagram for Example



Level 1 DFD


Display-board
0.1
game
move
result
Validate-move
0.2
board
Check-winner
0.4
Play-move
0.3

Data dictionary

- Display=game + result
- move = integer
- board = {integer}9
- game = {integer}9
- result=string

Key Points :

- During structured design,
  - the DFD representation is transformed to a structure chart representation.
- DFDs are very popular:
  - because it is a very simple technique.

Key Points :

- **A DFD model:**
  - **–difficult to implement using a programming language:**
  - **–structure chart representation can be easily implemented using a programming language.**