Function-Oriented Software Design (continued)

Guidelines For Constructing DFDs

- Context diagram should represent the system as a single bubble:
  - Many beginners commit the mistake of drawing more than one bubble in the context diagram.

Guidelines For Constructing DFDs

- All external entities should be represented in the context diagram:
  - External entities should not appear at any other level of DFD.
- Only 3 to 7 bubbles per diagram should be allowed:
  - Each bubble should be decomposed to between 3 and 7 bubbles.

Guidelines For Constructing DFDs

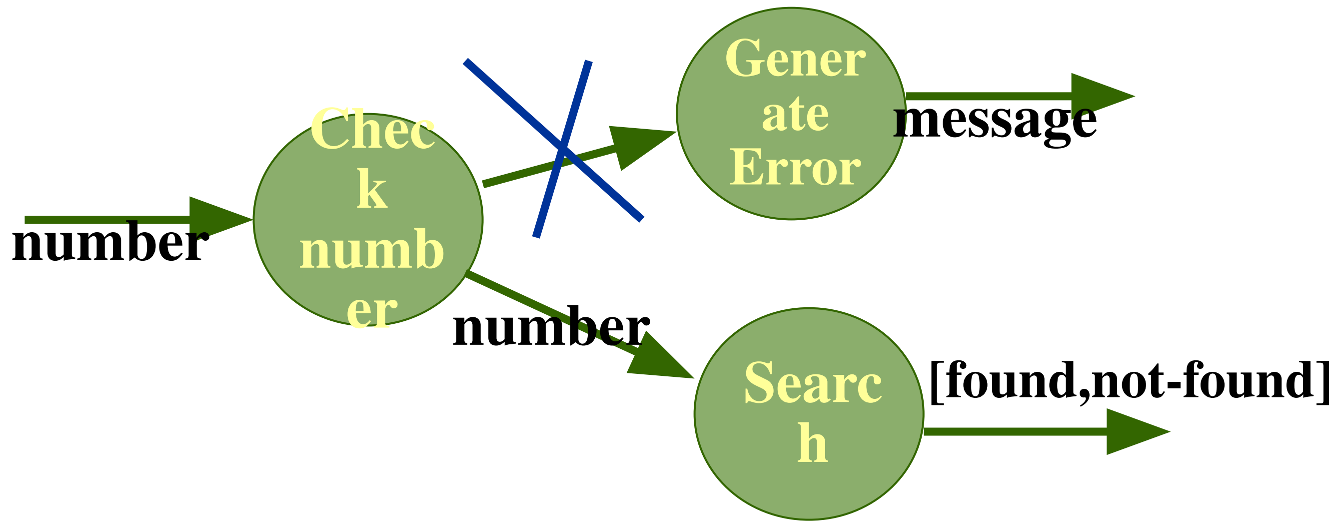
- A common mistake committed by many beginners:
  - Attempting to represent control information in a DFD.
  - e.g. trying to represent the order in which different functions are executed.

Guidelines For Constructing DFDs

- A DFD does not represent control information:
  - When or in what order different functions (processes) are invoked
  - The conditions under which different functions are invoked are not represented.
  - For example, a function might invoke one function or another depending on some condition.
  - Many beginners try to represent this aspect by drawing an arrow between the corresponding bubbles.

Example-1

- Check the input value:
  - If the input value is less than -1000 or greater than +1000 generate an error message
  - otherwise search for the number

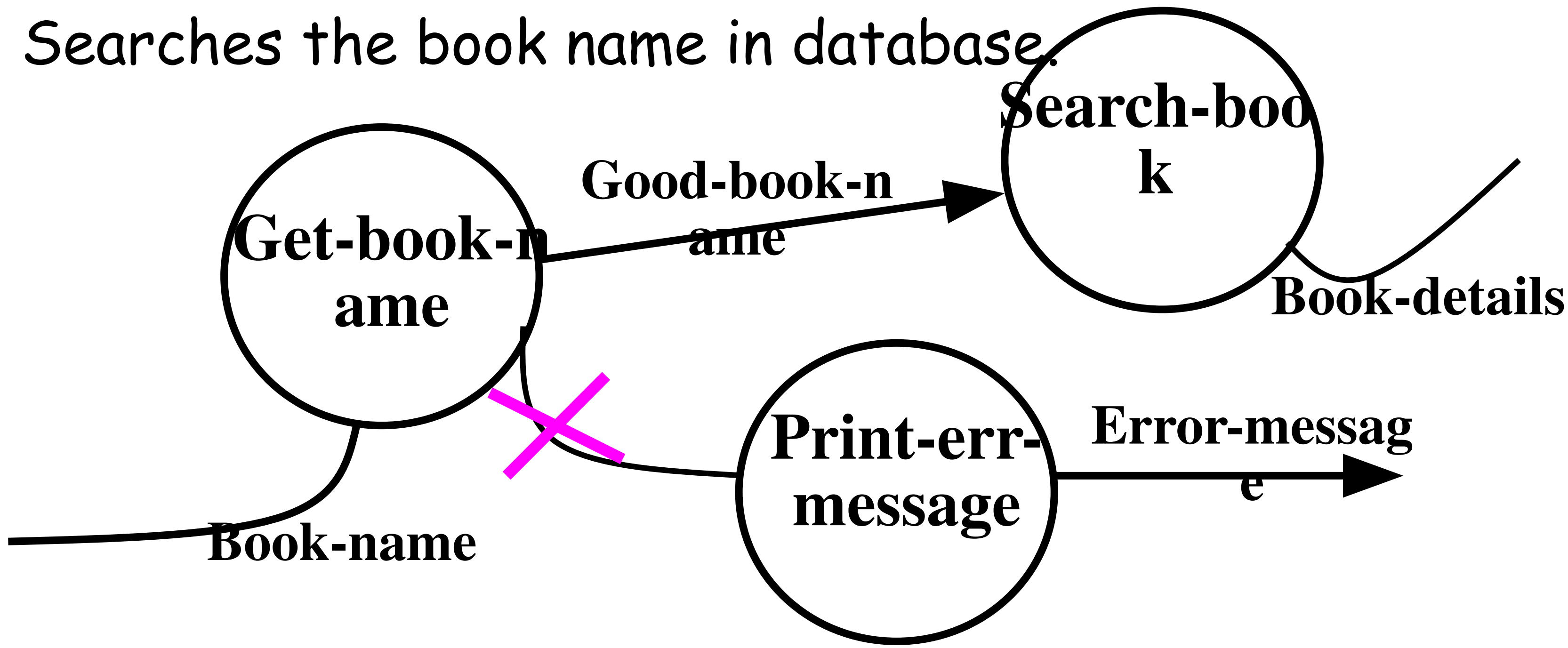


Guidelines For Constructing DFDs

- If a bubble A invokes either bubble B or bubble C depending on some conditions:
  - represent the data that flows from bubble A to bubble B and bubbles A to C
  - not the conditions depending on which a process is invoked.

Example-2

- A function accepts the book name to be searched from the user
- If the entered book name is not a valid book name
  - Generates an error message,
- If the book name is valid,
  - Searches the book name in database.



Guidelines For Constructing DFDs

- All functions of the system must be captured in the DFD model:
  - No function specified in the SRS document should be overlooked.
- Only those functions specified in the SRS document should be represented:
  - Do not assume extra functionality of the system not specified by the SRS document.

Commonly Made Errors

- Unbalanced DFDs
- Forgetting to mention the names of the data flows
- Unrepresented functions or data
- External entities appearing at higher level DFDs
- Trying to represent control aspects
- Context diagram having more than one bubble
- A bubble decomposed into too many bubbles in the next level
- Terminating decomposition too early
- Nouns used in naming bubbles

Shortcomings of the DFD Model

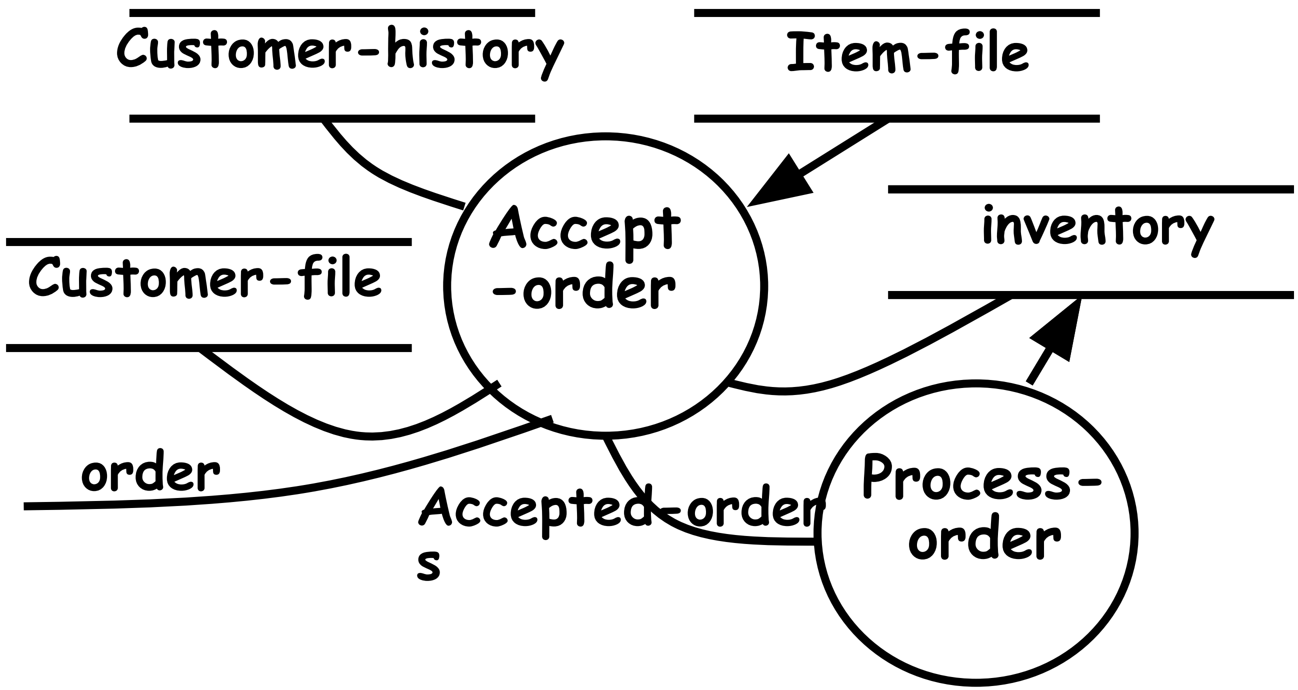
- DFD models suffer from several shortcomings:
- DFDs leave ample scope to be imprecise.
  - In a DFD model, we infer about the function performed by a bubble from its label.
  - A label may not capture all the functionality of a bubble.

Shortcomings of the DFD Model

- For example, a bubble named find-book-position has only intuitive meaning:
  - Does not specify several things:
    - What happens when some input information is missing or is incorrect.
    - Does not convey anything regarding what happens when book is not found
    - or what happens if there are books by different authors with the same book title.

Shortcomings of the DFD Model

- Control information is not represented:
  - For instance, order in which inputs are consumed and outputs are produced is not specified.



Shortcomings of the DFD Model

- A DFD does not specify synchronization aspects:
  - For instance, the DFD in TAS example does not specify:
    - Whether process-order may wait until the accept-order produces data
    - Whether accept-order and handle-order may proceed simultaneously with some buffering mechanism between them.

Shortcomings of the DFD Model

- The way decomposition is carried out to arrive at the successive levels of a DFD is subjective.
- The ultimate level to which decomposition is carried out is subjective:
  - Depends on the choice and judgement of the analyst.
- Even for the same problem,
  - Several alternative DFD representations are possible:
  - Many times it is not possible to say which DFD representation is superior or preferable.

Shortcomings of the DFD Model

- DFD technique does not provide:
  - Any clear guidance as to how exactly one should go about decomposing a function:
  - One has to use subjective judgement to carry out decomposition.
- Structured analysis techniques do not specify when to stop a decomposition process:
  - To what length decomposition needs to be carried out.

Extending DFD Technique to Real-Time Systems

- For real-time systems (systems having time bounds on their actions),
  - Essential to model control flow and events.
  - Widely accepted technique: Ward and Mellor technique.
    - *A* type of process (bubbles) that handles only control flows is introduced.
    - These processes are represented using dashed circles.

Structured Design

- The aim of structured design
  - Transform the results of structured analysis (i.e., a DFD representation) into a structure chart.
- A structure chart represents the software architecture:
  - Various modules making up the system,
  - Module dependency (i.e. which module calls which other modules),
  - Parameters passed among different modules.

Structure Chart

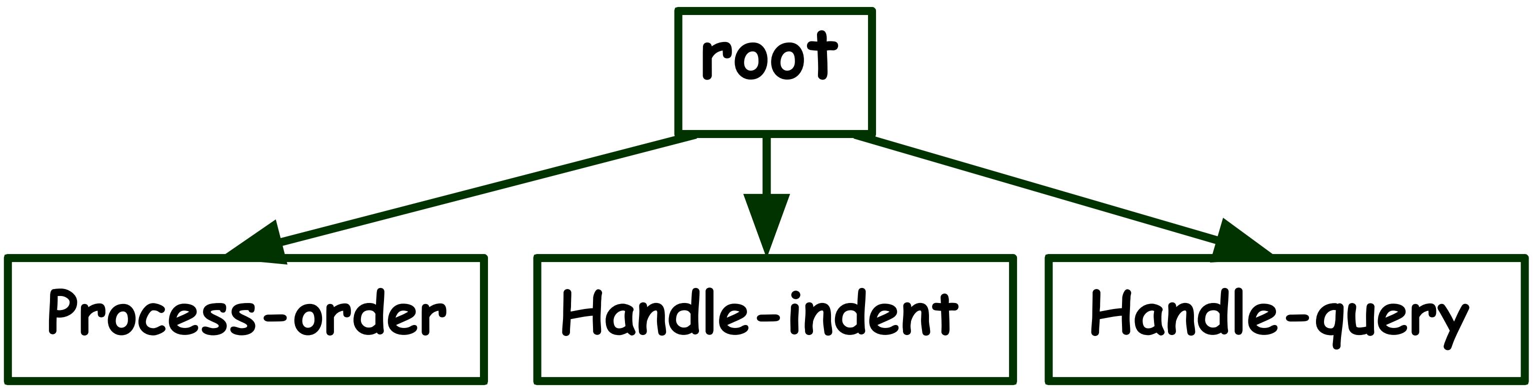
- Structure chart representation
  - Easily implementable using programming languages.
- Main focus of a structure chart:
  - Define the module structure of a software,
  - Interaction among different modules,
  - Procedural aspects (e.g, how a particular functionality is achieved) are not represented.

Basic Building Blocks of Structure Chart

- Rectangular box:
  - A rectangular box represents a module.
  - Annotated with the name of the module it represents.

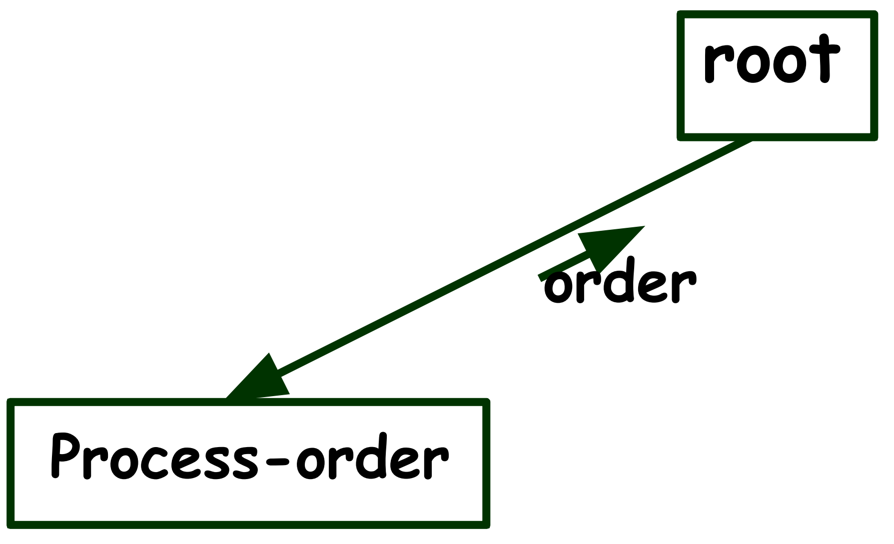
Arrows

- An arrow between two modules implies:
  - During execution control is passed from one module to the other in the direction of the arrow.



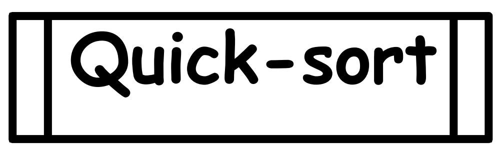
Data Flow Arrows

- Data flow arrows represent:
  - Data passing from one module to another in the direction of the arrow.



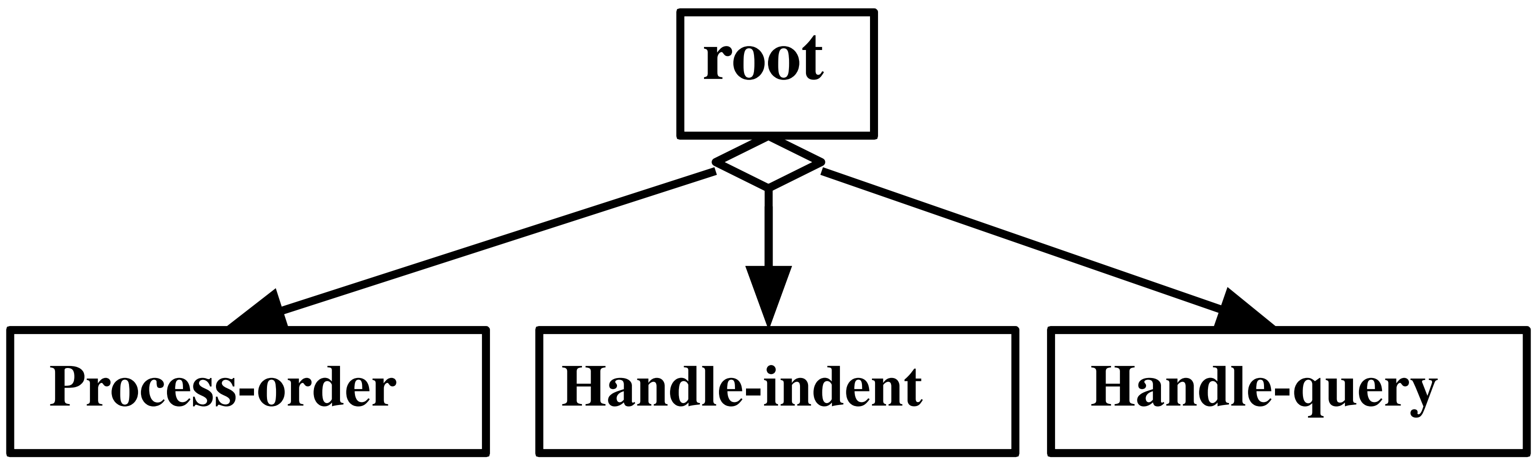
Library Modules

- Library modules represent frequently called modules:
  - A rectangle with double side edges.
  - Simplifies drawing when a module is called by several modules.



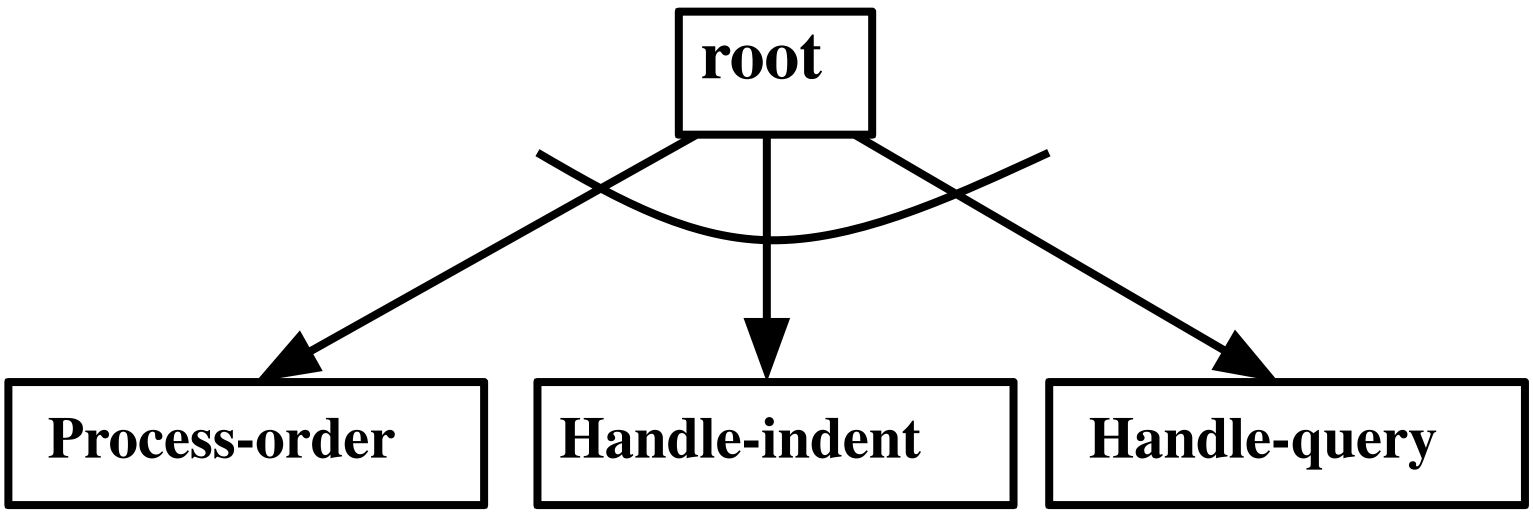
Selection

- The diamond symbol represents:
  - One module of several modules connected to the diamond symbol is invoked depending on some condition.



Repetition

- A loop around control flow arrows denotes that the concerned modules are invoked repeatedly.



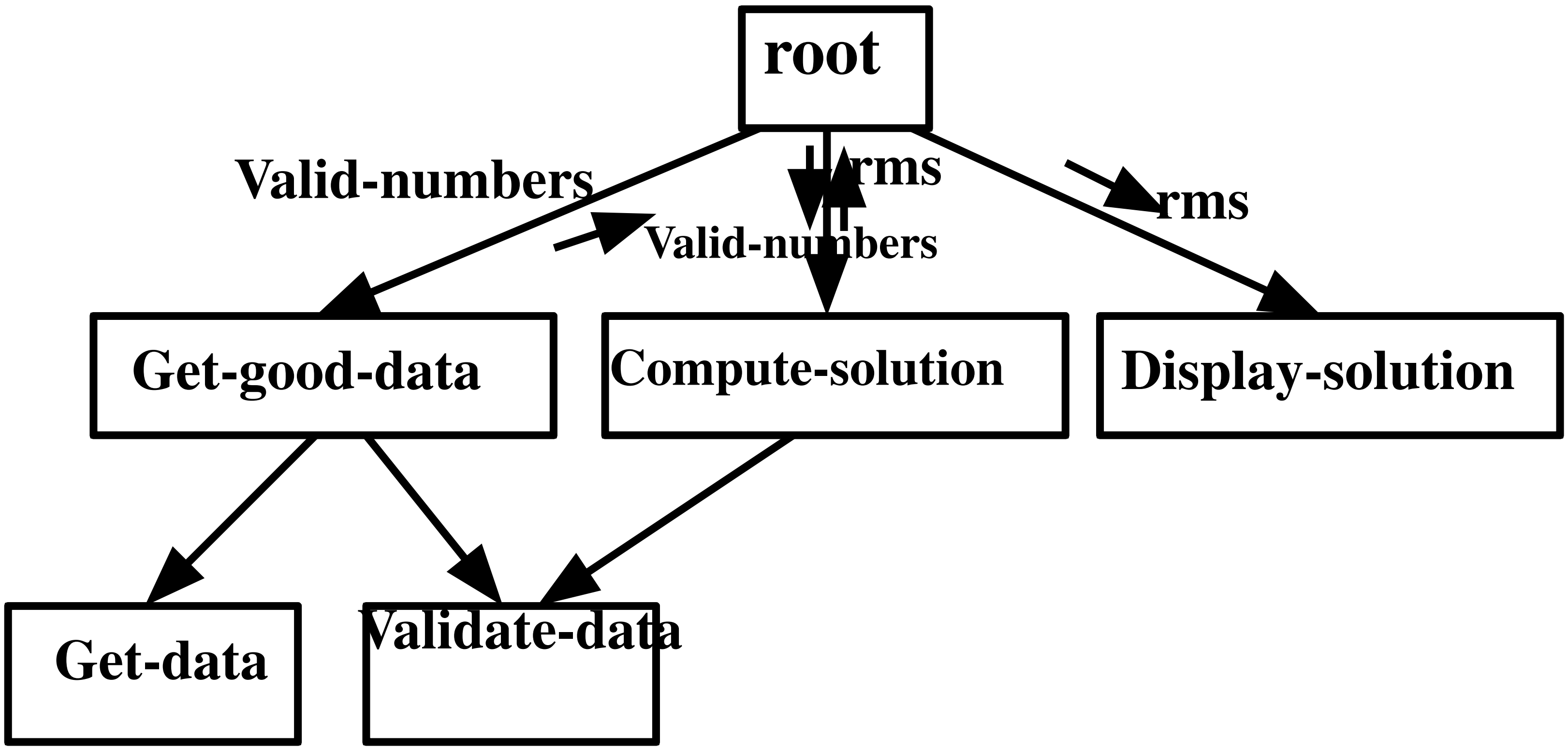
Structure Chart

- There is only one module at the top:
  - the root module.
- There is at most one control relationship between any two modules:
  - if module A invokes module B,
  - Module B cannot invoke module A.
- The main reason behind this restriction:
  - consider modules in a structure chart to be arranged in layers or levels.

Structure Chart

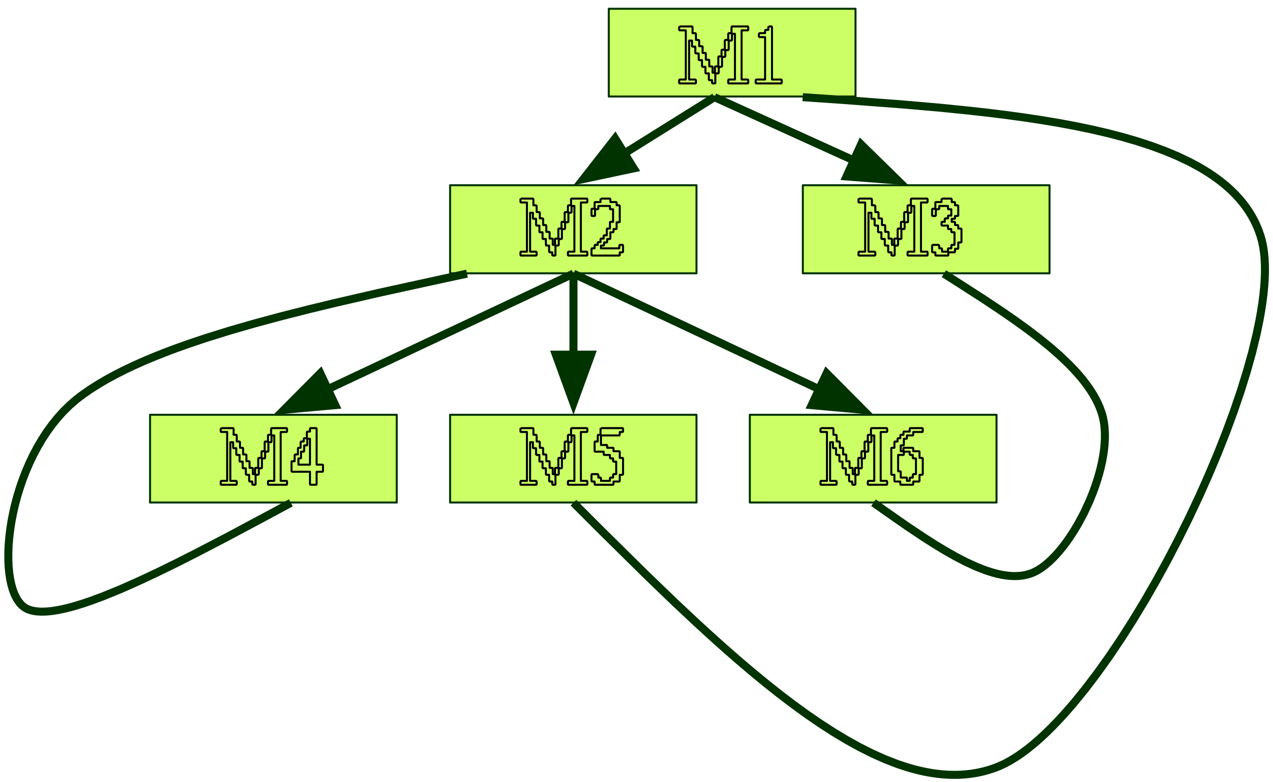
- The principle of abstraction:
  - does not allow lower-level modules to invoke higher-level modules:
  - But, two higher-level modules can invoke the same lower-level module.

Example



root
Valid-numbers
Valid-numbers
rms
rms
Get-good-data
Compute-solution
Display-solution
Get-data
Validate-data

Bad Design

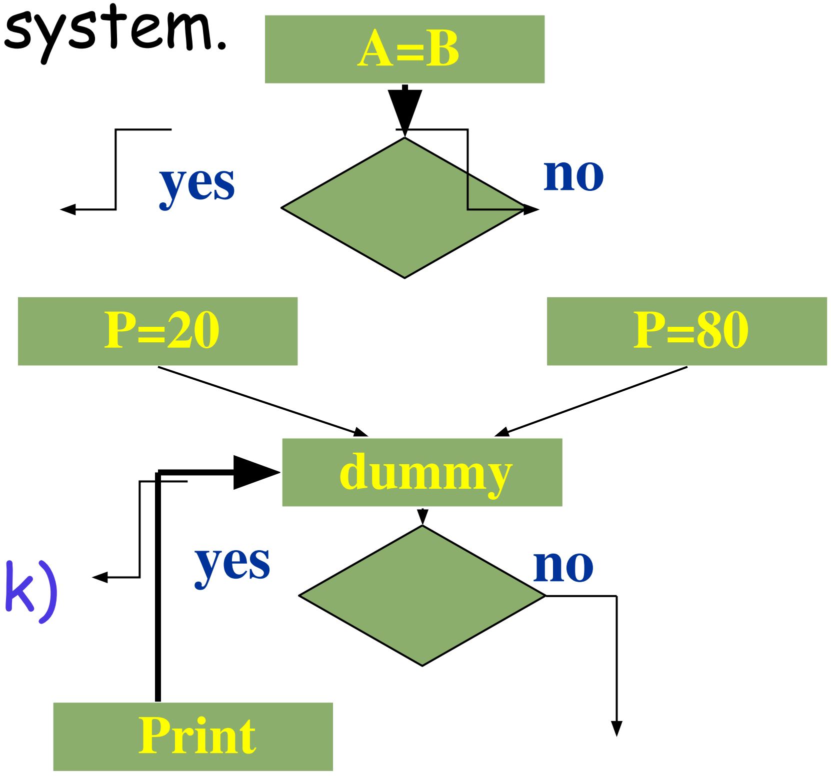


Shortcomings of Structure Chart

- By looking at a structure chart:
  - we can not say whether a module calls another module just once or many times.
- Also, by looking at a structure chart:
  - we can not tell the order in which the different modules are invoked.

Flow Chart (Aside)

- We are all familiar with the flow chart representations:
  - Flow chart is a convenient technique to represent the flow of control in a system.
- A=B
- if(c == 100)
-     P=20
- else p= 80
- while(p>20)
-     print(student mark)



Flow Chart versus Structure Chart

- A structure chart differs from a flow chart in three principal ways:
  - It is difficult to identify modules of a software from its flow chart representation.
  - Data interchange among the modules is not represented in a flow chart.
  - Sequential ordering of tasks inherent in a flow chart is suppressed in a structure chart.

Transformation of a DFD Model into Structure Chart

- Two strategies exist to guide transformation of a DFD into a structure chart:
  - Transform Analysis
  - Transaction Analysis

Transform Analysis

- The first step in transform analysis:
  - Divide the DFD into 3 parts:
    - input,
    - logical processing,
    - output.

Transform Analysis

- Input portion in the DFD:
  - processes which convert input data from physical to logical form.
  - e.g. read characters from the terminal and store in internal tables or lists.
- Each input portion:
  - called an afferent branch.
  - Possible to have more than one afferent branch in a DFD.

Transform Analysis

- Output portion of a DFD:
  - transforms output data from logical form to physical form.
    - e.g., from list or array into output characters.
  - Each output portion:
    - called an efferent branch.
- The remaining portions of a DFD
  - called central transform

Transform Analysis

- Derive structure chart by drawing one functional component for:
  - the central transform,
  - each afferent branch,
  - each efferent branch.

Transform Analysis

- Identifying the highest level input and output transforms:
  - requires experience and skill.
- Some guidelines:
  - Trace the inputs until a bubble is found whose output cannot be deduced from the inputs alone.
  - Processes which validate input are not central transforms.
  - Processes which sort input or filter data from it are.

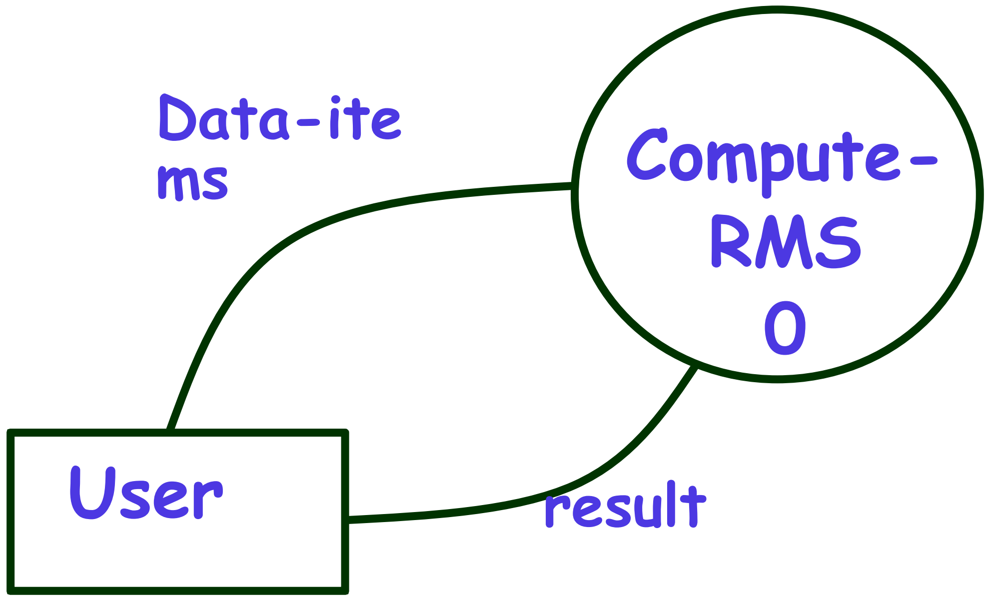
Transform Analysis

- First level of structure chart:
  - Draw a box for each input and output units
  - A box for the central transform.
- Next, refine the structure chart:
  - Add subfunctions required by each high-level module.
  - Many levels of modules may required to be added.

Factoring

- The process of breaking functional components into subcomponents.
- Factoring includes adding:
  - Read and write modules,
  - Error-handling modules,
  - Initialization and termination modules, etc.
- Finally check:
  - Whether all bubbles have been mapped to modules.

Example 1: RMS Calculating Software

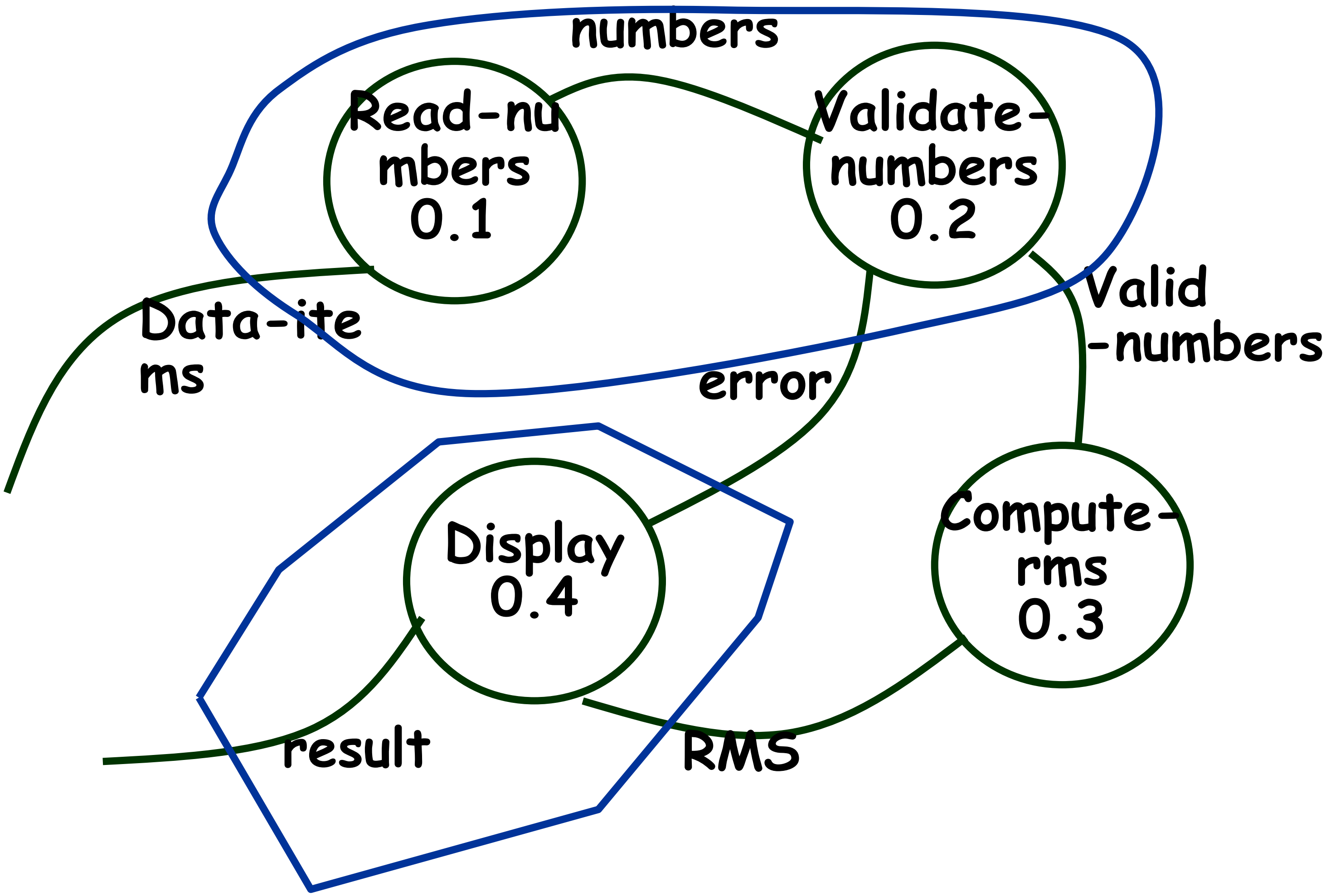


Context Diagram

Example 1: RMS Calculating Software

- From a cursory analysis of the problem description,
  - easy to see that the system needs to perform:
    - accept the input numbers from the user,
    - validate the numbers,
    - calculate the root mean square of the input numbers,
    - display the result.

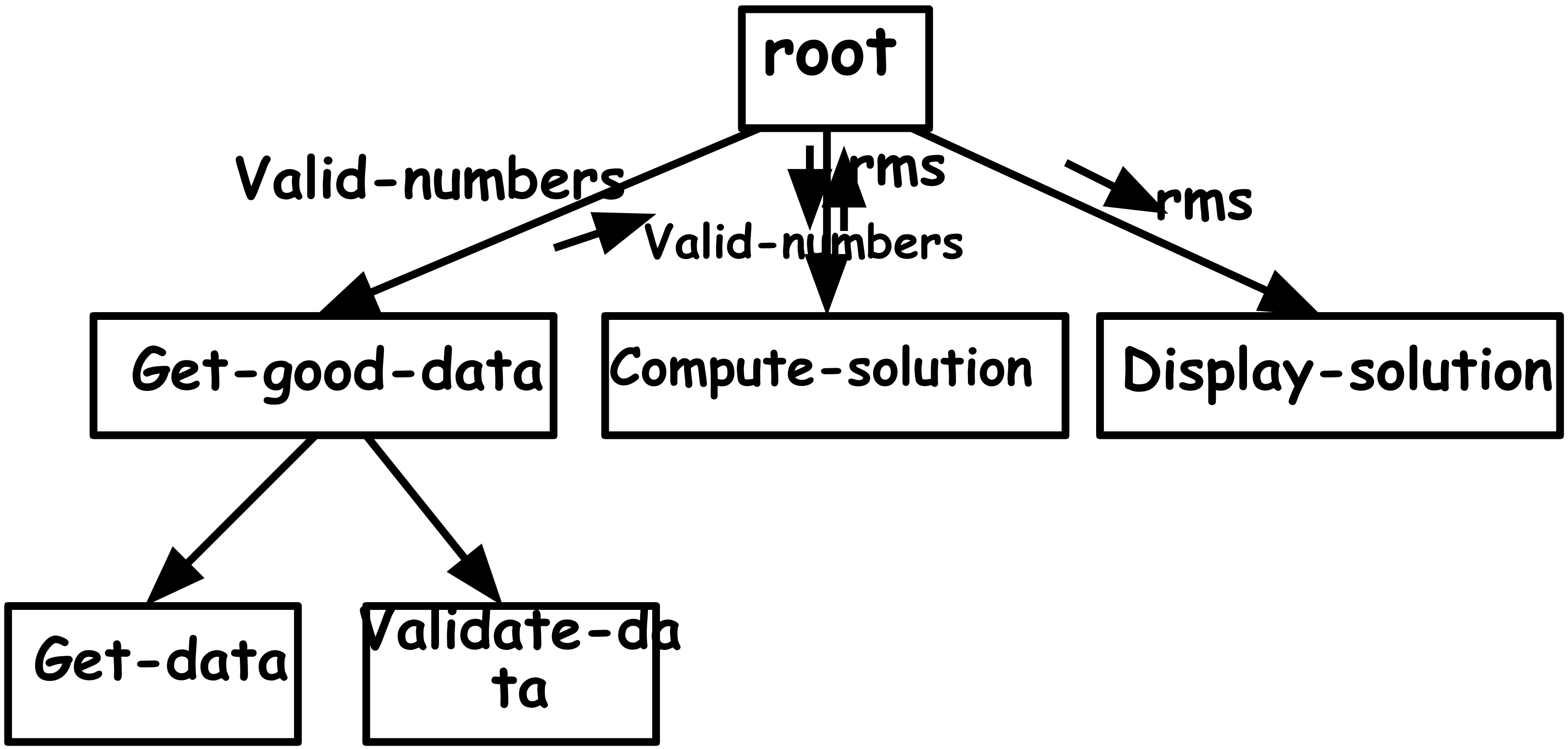
Example 1: RMS Calculating Software



Example 1: RMS Calculating Software

- By observing the level 1 DFD:
  - Identify read-number and validate-number bubbles as the afferent branch
  - Display as the efferent branch.

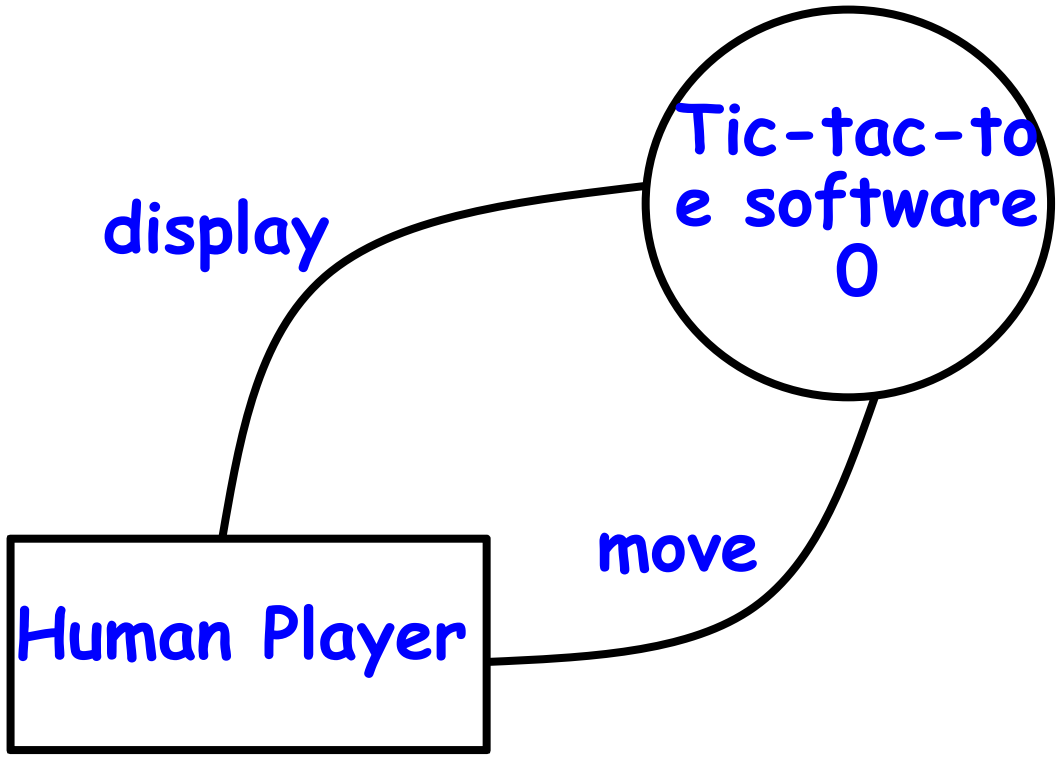
Example 1: RMS Calculating Software



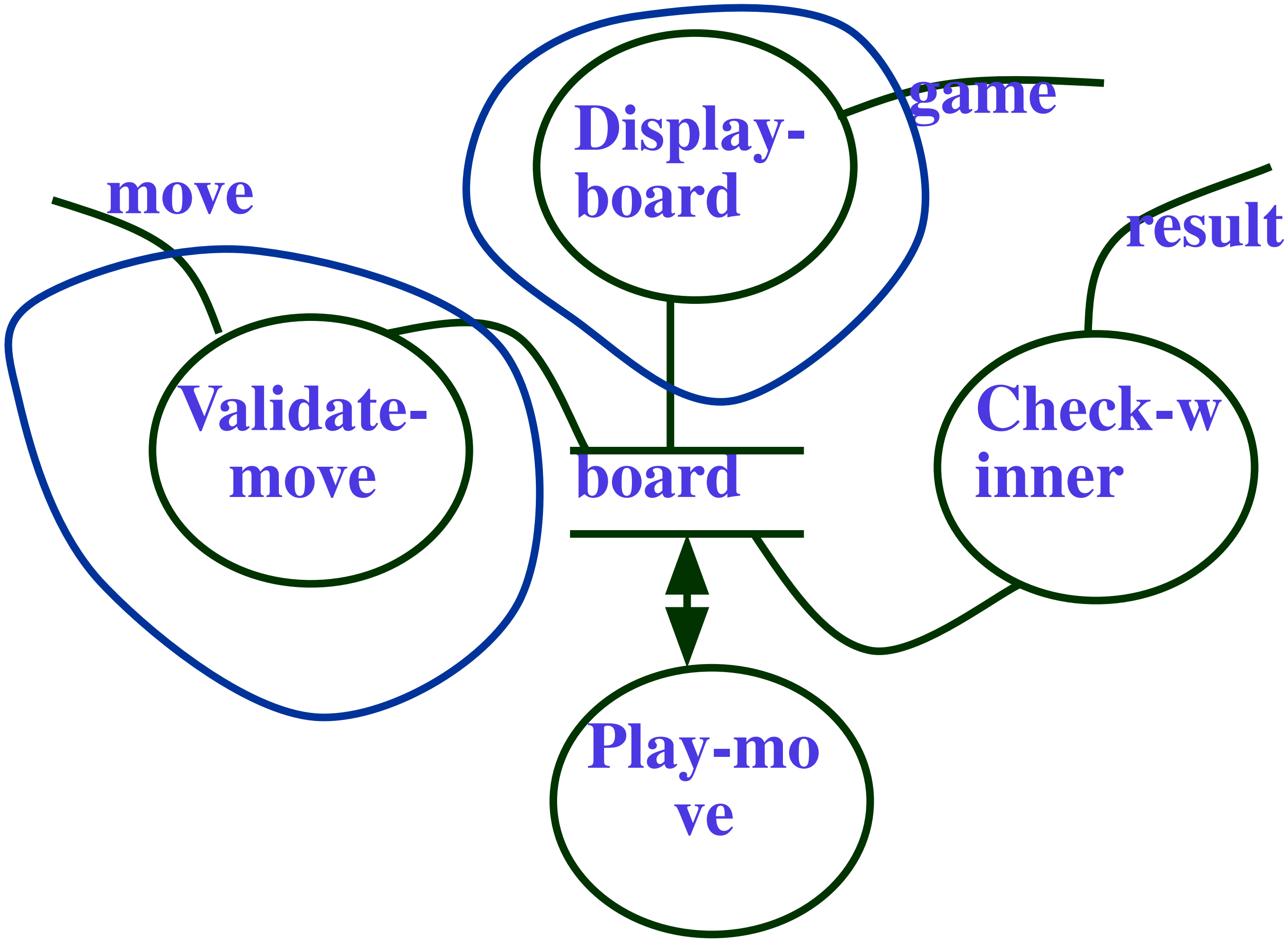
Example 2: Tic-Tac-Toe Computer Game

- As soon as either of the human player or the computer wins,
  - A message congratulating 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 2

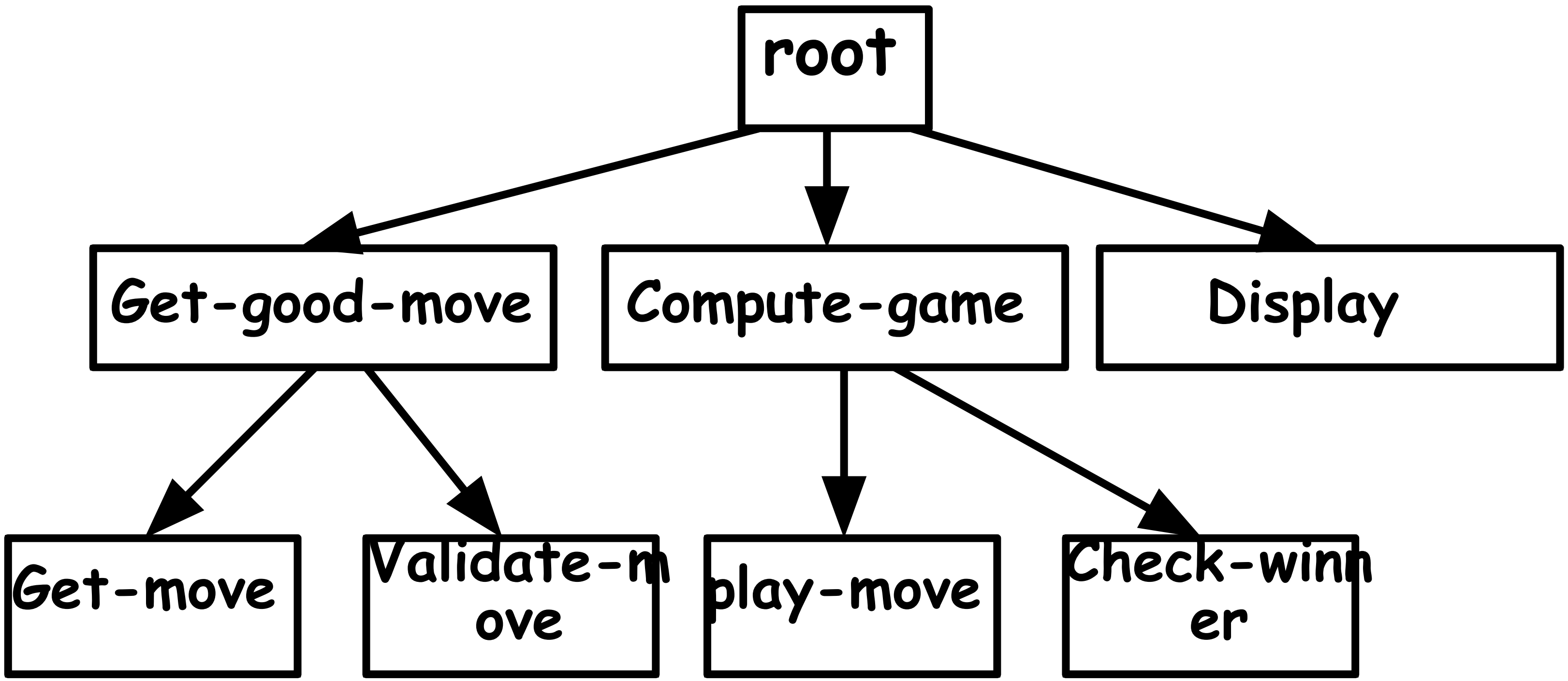


Level 1 DFD



move
Display-
board
game
result
Validate-
move
board
Check-w
inner
Play-mo
ve

Structure Chart



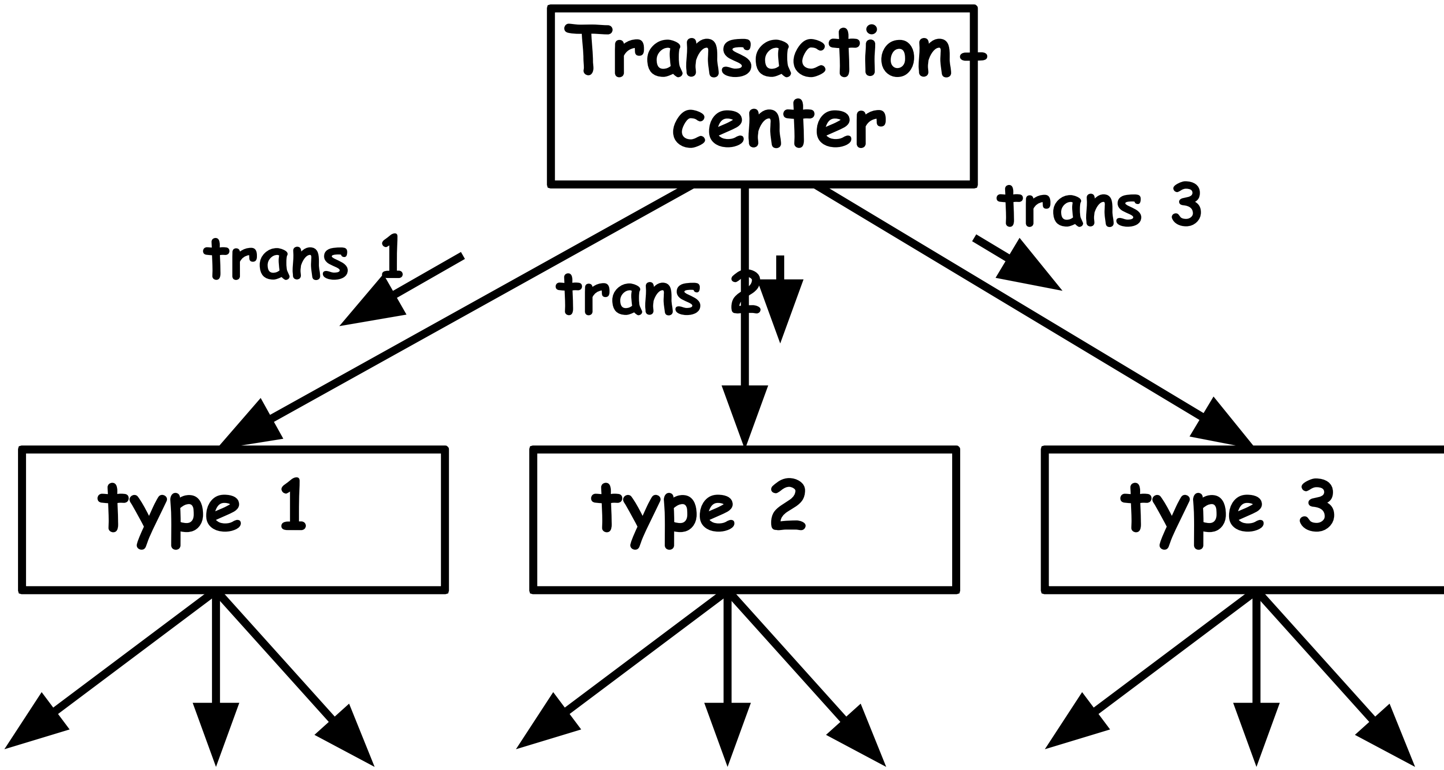
Transaction Analysis

- Useful for designing transaction processing programs.
  - Transform-centered systems:
    - Characterized by <u>similar processing steps for every data item</u> processed by input, process, and output bubbles.
  - Transaction-driven systems,
    - <u>One of several possible paths</u> through the DFD is traversed depending upon the input data value.

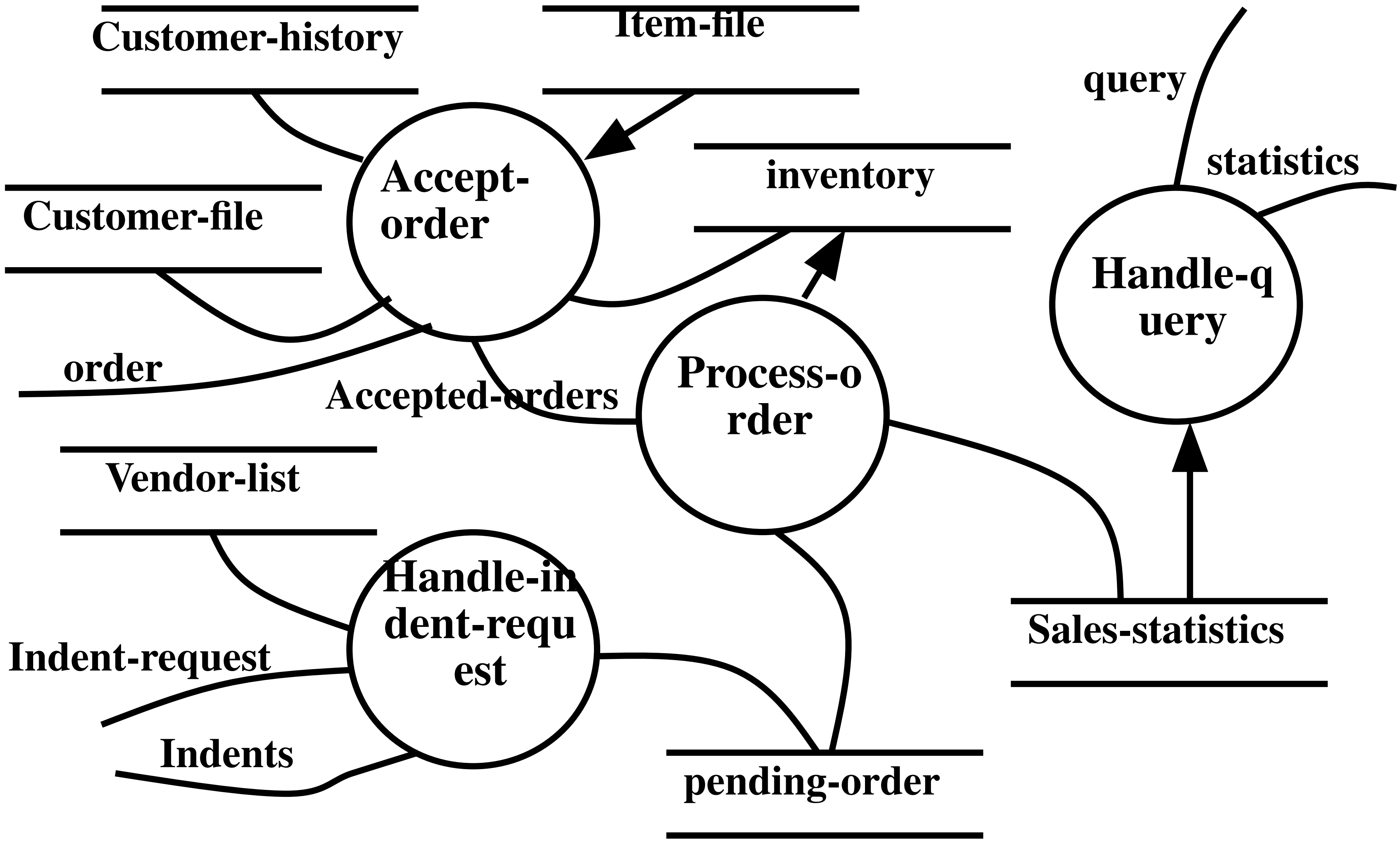
Transaction Analysis

- Transaction:
  - Any input data value that triggers an action:
  - For example, selected menu options might trigger different functions.
  - Represented by a tag identifying its type.
- Transaction analysis uses this tag to divide the system into:
  - Several transaction modules
  - One transaction-center module.

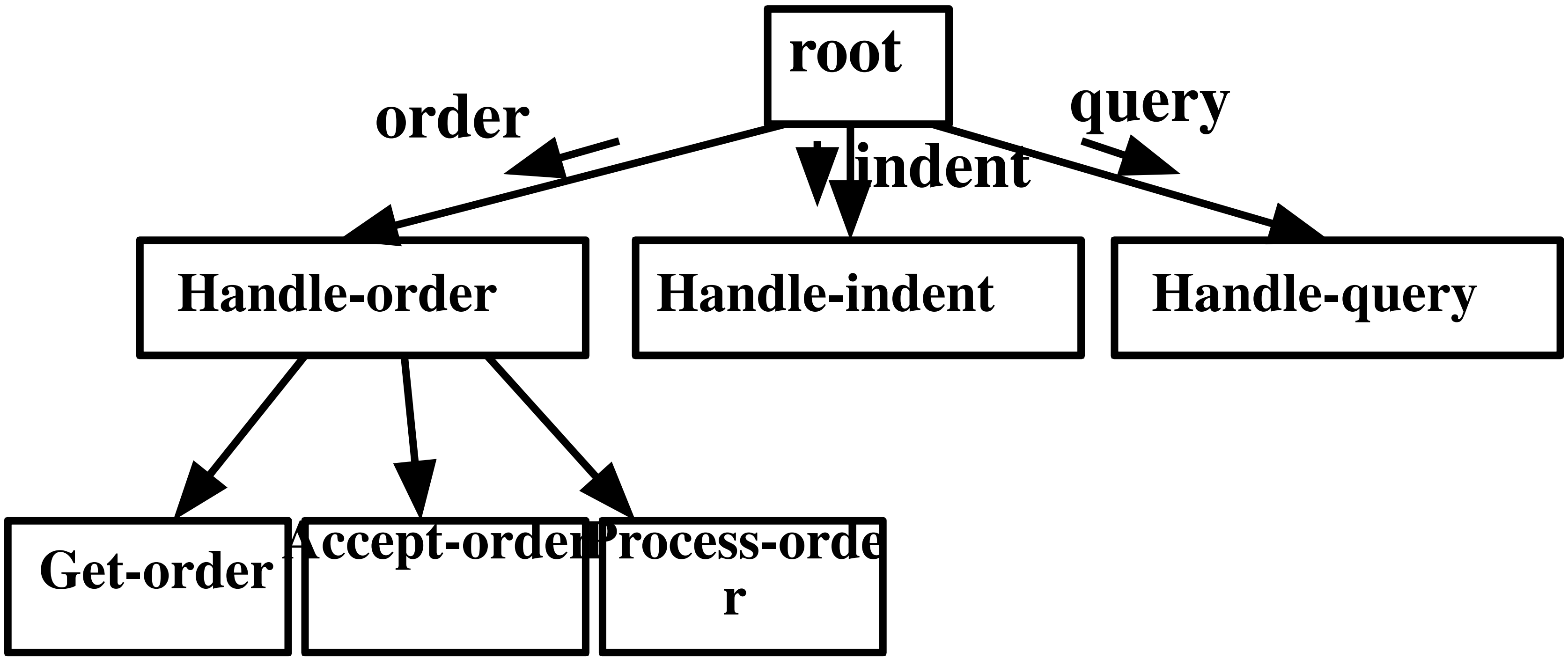
Transaction analysis



Level 1 DFD for TAS



Structure Chart



Summary

- We first discussed structured analysis of a larger problem.
- We defined some general guidelines
  - for constructing a satisfactory DFD model.
- The DFD model though simple and useful
  - does have several short comings.
- We then started discussing structured design.

Summary

- Aim of structured design:
  - Transform a DFD representation into a structure chart.
- Structure chart represents:
  - Module structure
  - Interaction among different modules,
  - Procedural aspects are not represented.

Summary

- Structured design provides two strategies to transform a DFD into a structure chart:
  - Transform Analysis
  - Transaction Analysis

Summary

- We Discussed three examples of structured design.
- It takes a lot of practice to become a good software designer:
  - Please try to solve all the problems listed in your assignment sheet,
  - Not only the ones you are expected to submit.