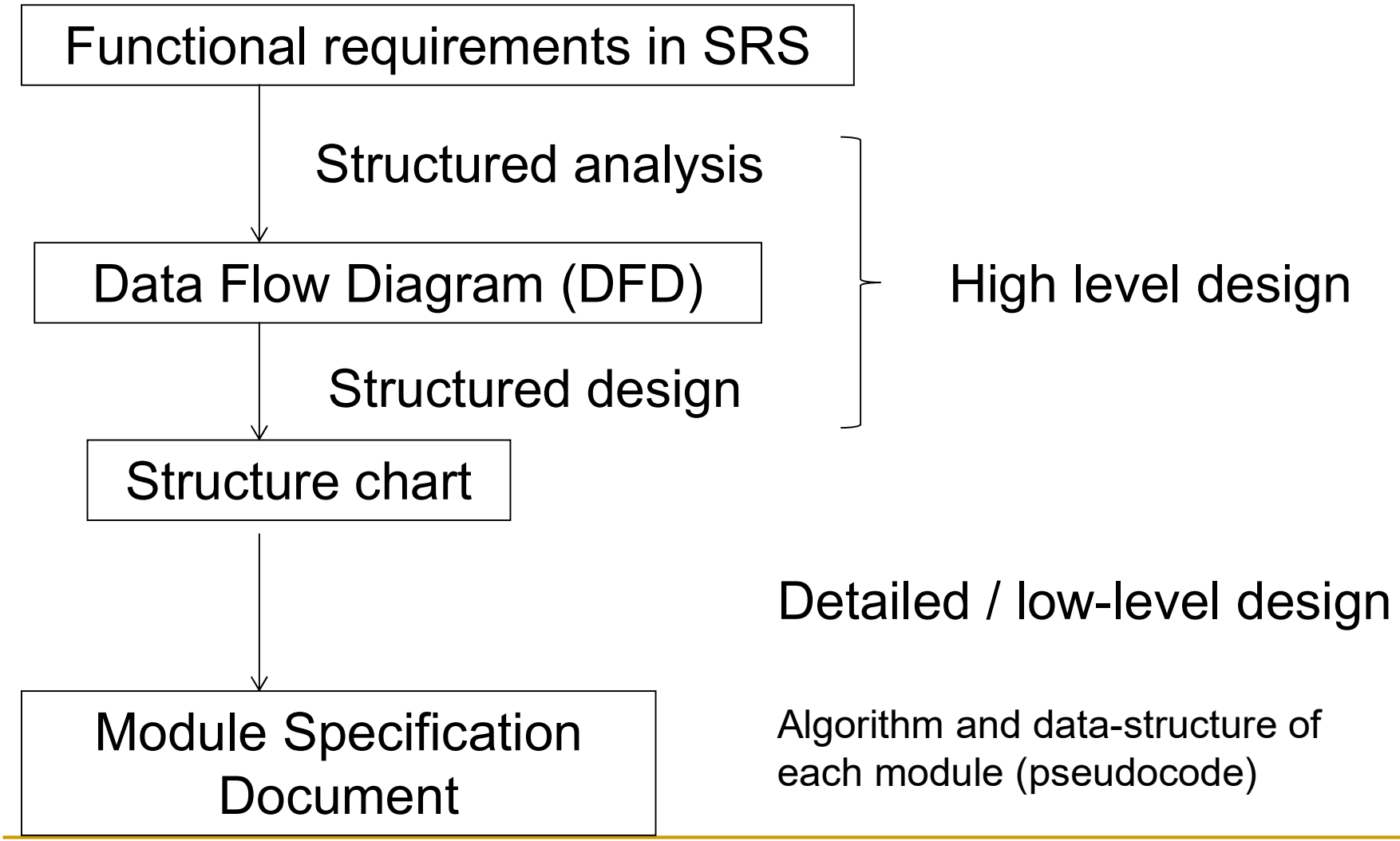
Software Design

Function Oriented Design

Function-oriented design: summary



SA/SD methodology

- One of several function-oriented design methodologies, used for high-level design
- **Structured analysis (SA)**
  - Top-down decomposition of high-level functions into detailed functions
  - Simultaneous decomposition of high-level data
  - Transform textual problem description into a graphic model (DFD)
- **Structured design (SD)**
  - Map detailed functions represented in DFD to modules
  - Module structure is formalized (software architecture)

SA vs SD

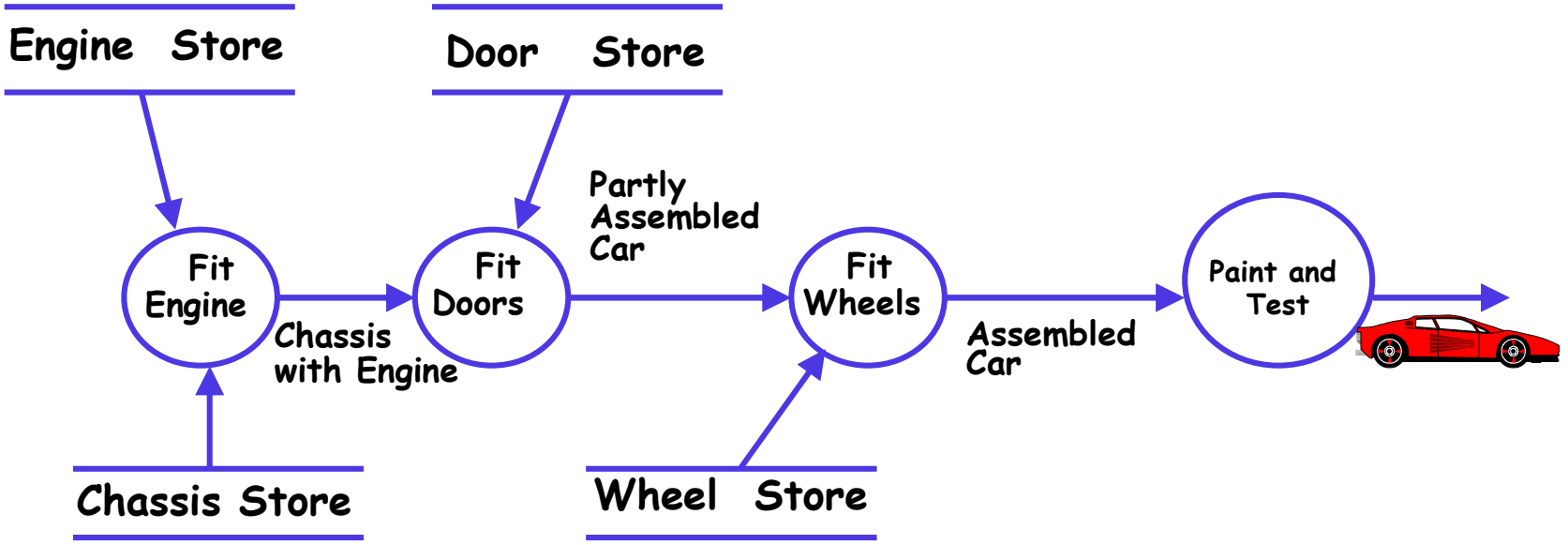
- Purpose of structured analysis
  - Capture the detailed structure of the system as the user / customer views it
  - Use customer terminology for functions & data
  - Can be reviewed by customer, knowledge of computer not required to understand DFD

- Purpose of structured design
  - Arrive at a form that is suitable for implementation in some programming language
  - To be used in subsequent implementation phase

Structured Design

Data Flow Diagram (DFD)

- Graphical representation of data flow in a system
  - Hierarchical model
  - Also called bubble chart
  - Each function considered as a processing station which consumes some input, produces some output

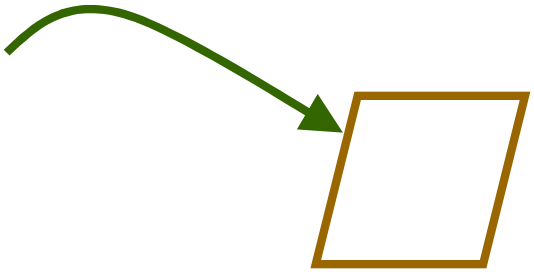


DFD symbols

- External entity (also called source / sink)
  - Real physical entities who input data to the system or consume data produced by system

- Function
  - Symbol also called process / bubble / transform
  - Bubbles annotated with name of function
  - Name should be a verb

- Output produced by the system



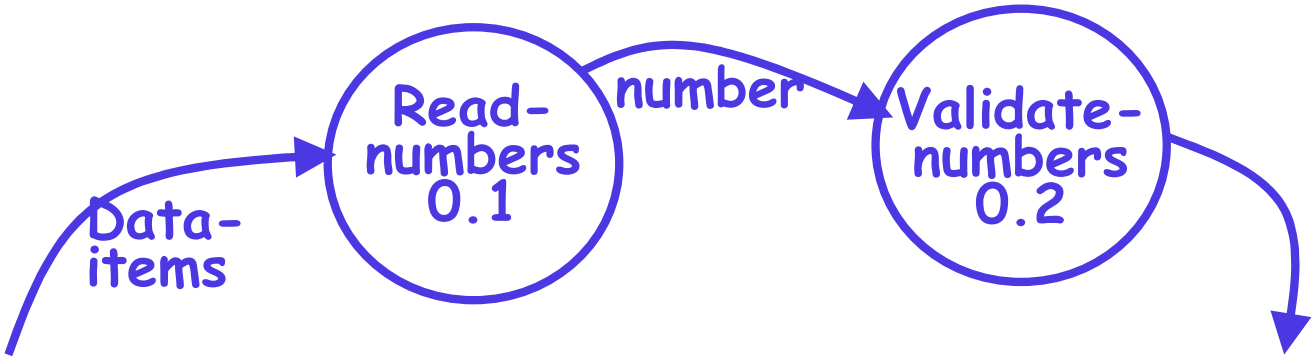
DFD symbols

- Data flow symbol
  - Data flow in the direction of the arrow
  - Annotated with names of data they carry

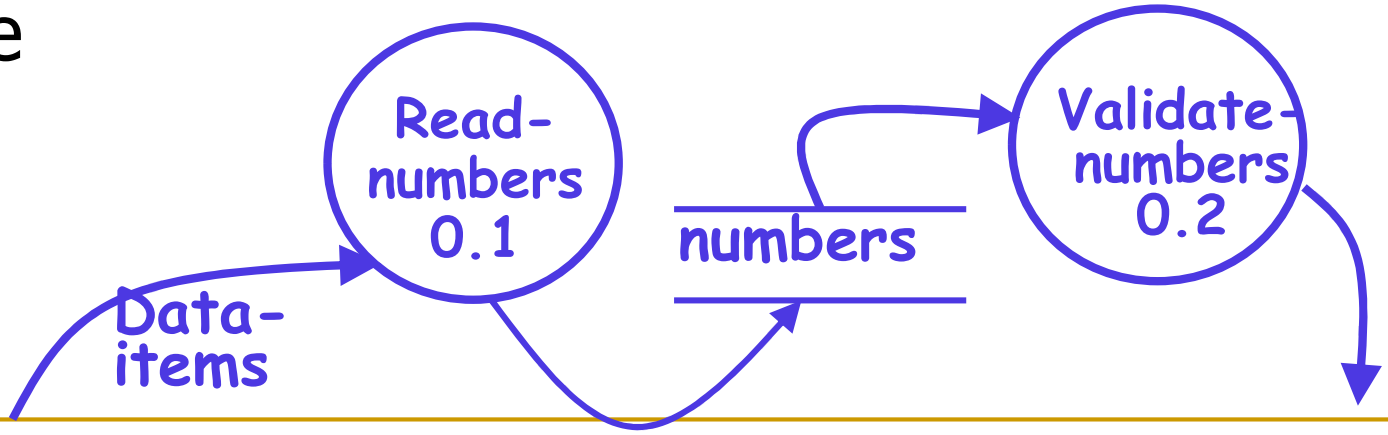
- Data store
  - Represents a logical file (data structure in memory, or physical file in disk or database)
  - An arrow into or out of a data store
    - Direction shows whether data is read from / written to data store
    - Implicitly represents the entire data of the data store, need not be annotated with any data name

Synchronous vs asynchronous

- Synchronous: two bubbles directly connected by data flow arrow

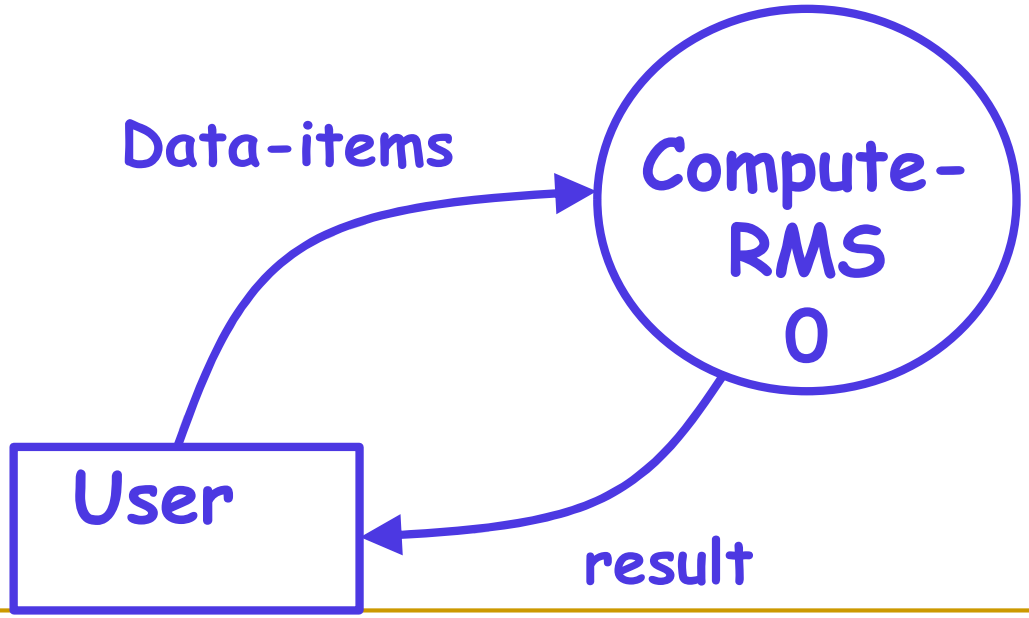


- Asynchronous: two bubbles connected via a data store



Performing structured analysis

- Initially represent system at the most abstract level
  - Called the context diagram or Level 0 DFD
  - Entire system represented as a single bubble (labeled)
  - Show data input to system, output data generated by system, external entities



Performing structured analysis

- Level 1 DFD
  - For each high-level function in the SRS …
  - Represent each function as a bubble
  - Represent data input to / output from each function

- Higher level DFDs
  - Each high-level function separately decomposed into sub-functions
  - DFDs represent the sub-functions, data input to / output from each sub-function

Decomposition of a bubble

- Also called factoring or exploding a bubble
- Each bubble usually decomposed into 3 to 7 bubbles
- Decomposition of a bubble should be carried on until a level at which each function can be described by a simple algorithm

- Numbering of bubbles
  - Single bubble in context diagram numbered 0
  - When bubble numbered x is decomposed, its children bubbles are numbered x.1, x.2, x.3, ...

Data Dictionary

- A DFD is always accompanied by a data dictionary
- Data dictionary lists all data items appearing in DFD
  - Definition of all composite data items in terms of their component data items
  - All data names along with the purpose of the data items
  - Example of a data dictionary entry:

grossPay = regularPay + overtimePay

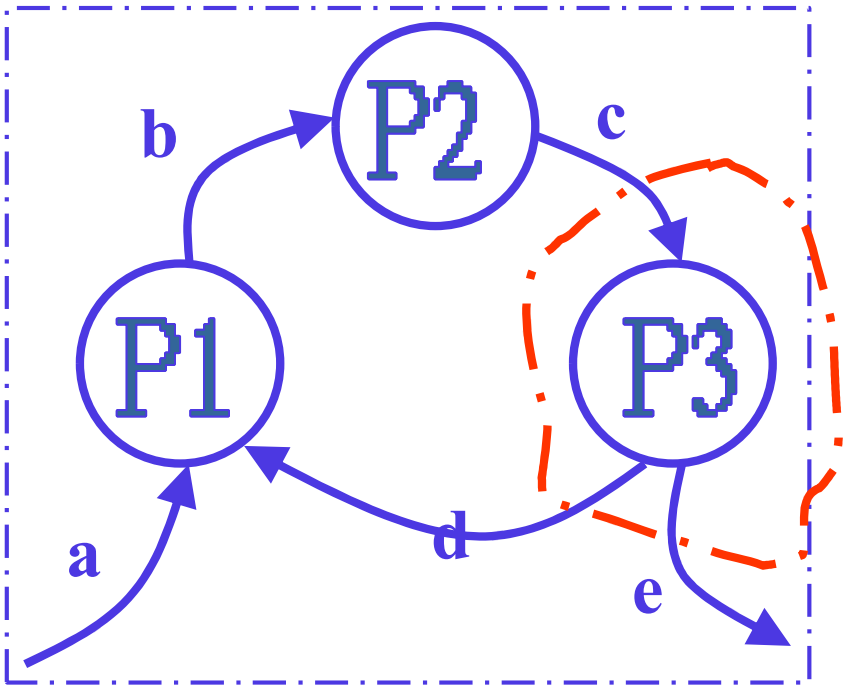
- Importance of Data Dictionary
  - Provides everyone involved in project with standard terminology for all data (consistent vocabulary)

Data definition in data dictionary

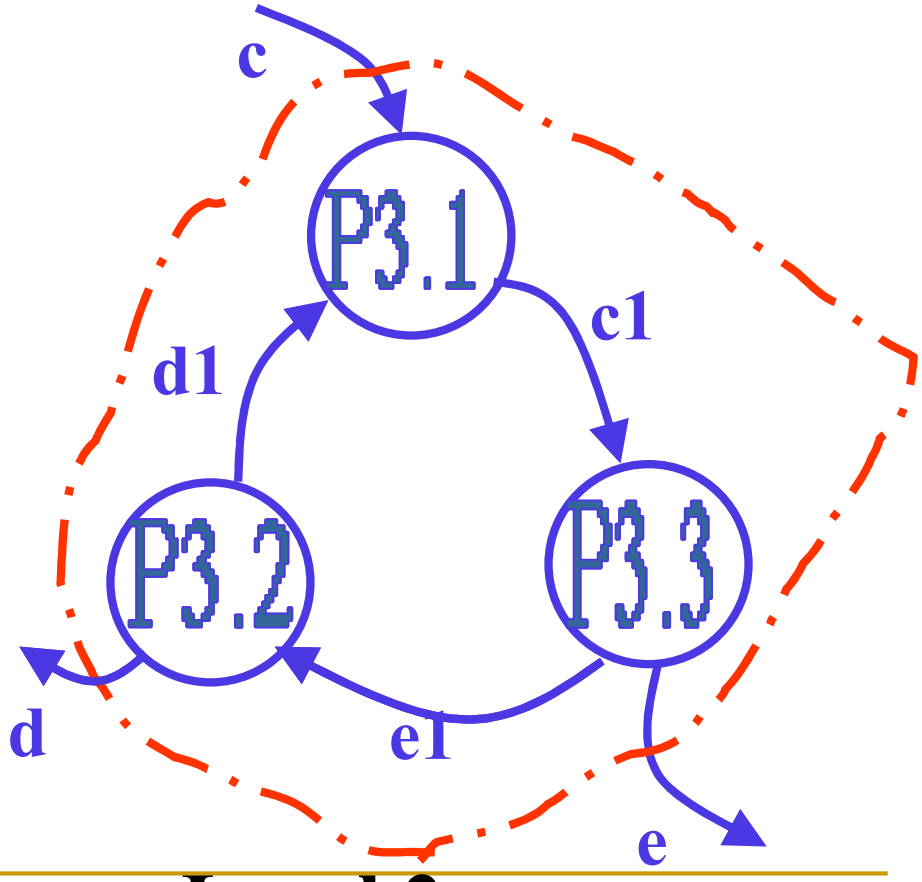
- Composite data are defined in terms of primitive data items using following operators
  - + denotes composition of data items
  - [, , ,] represents selection, i.e. any one of the data items listed inside the square bracket can occur
  - Contents inside the brackets ( ) represent optional data e.g. a+(b) represents either a or a+b occurs
  - {} represents iterative data definition, e.g. {name}5
  - {name}* represents zero or more instances of name data
  - = represents equivalence
- Anything between * ... * is a comment

Balancing a DFD

- Data flow into or out of a bubble at level j DFD must match the data flows at level j+1 DFD



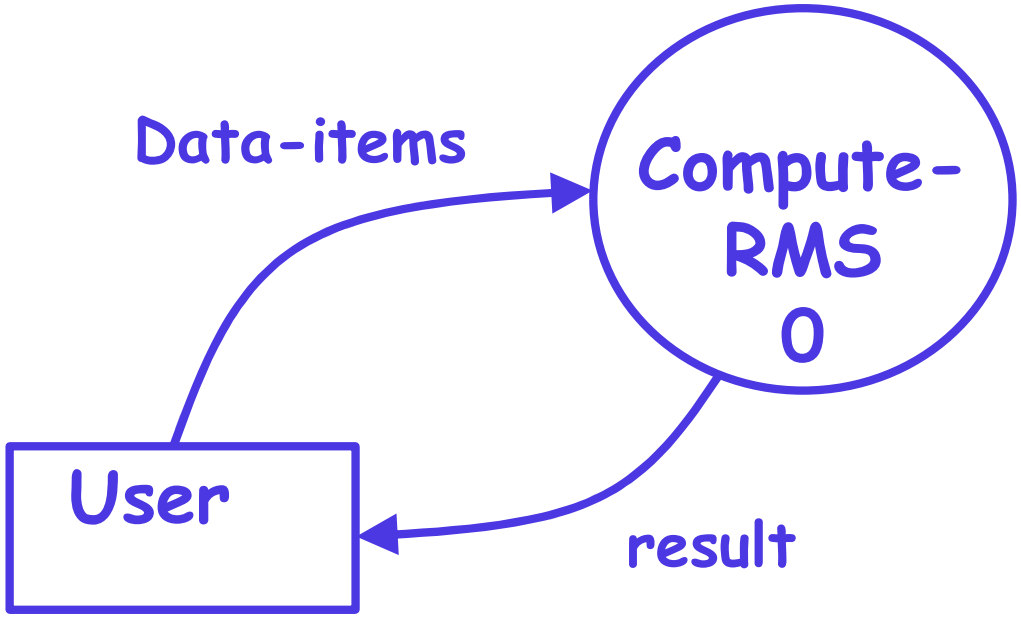
Level 1



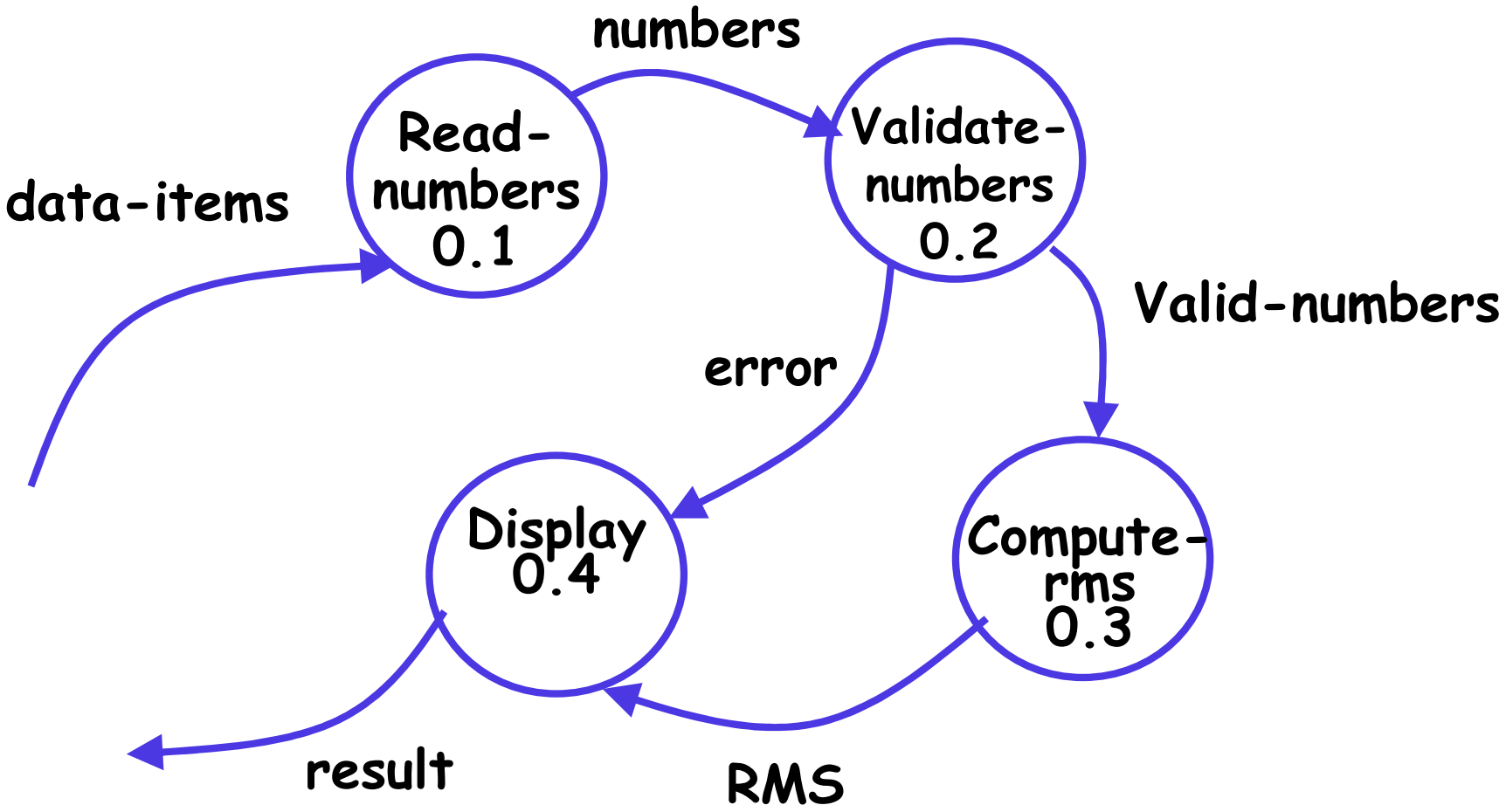
Level 2

Example: RMS calculating software

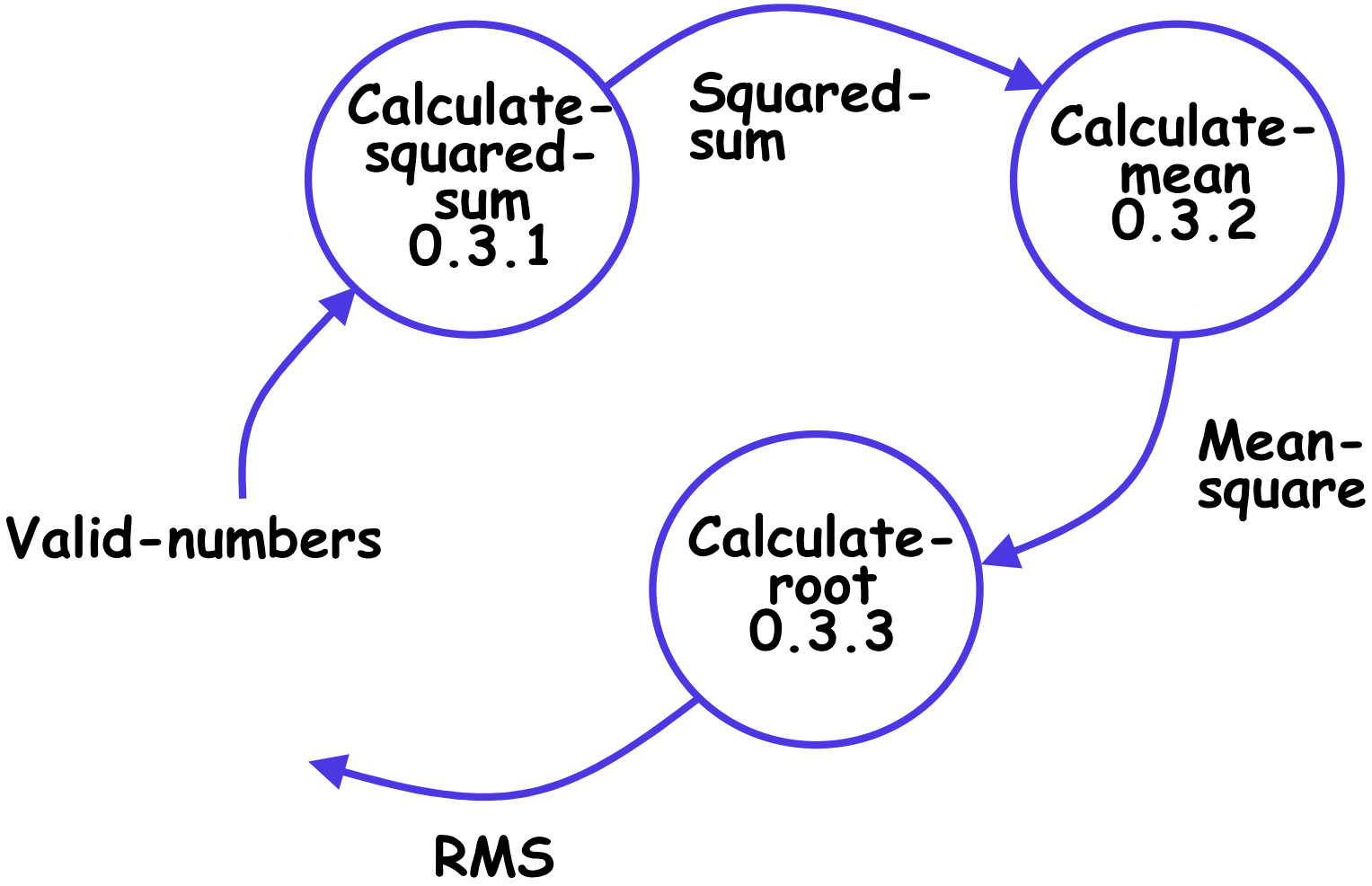
- RMS calculating software
  - Reads three integers in the range of -1000 and +1000
  - Finds out the root mean square (rms) of input numbers
  - Display the result



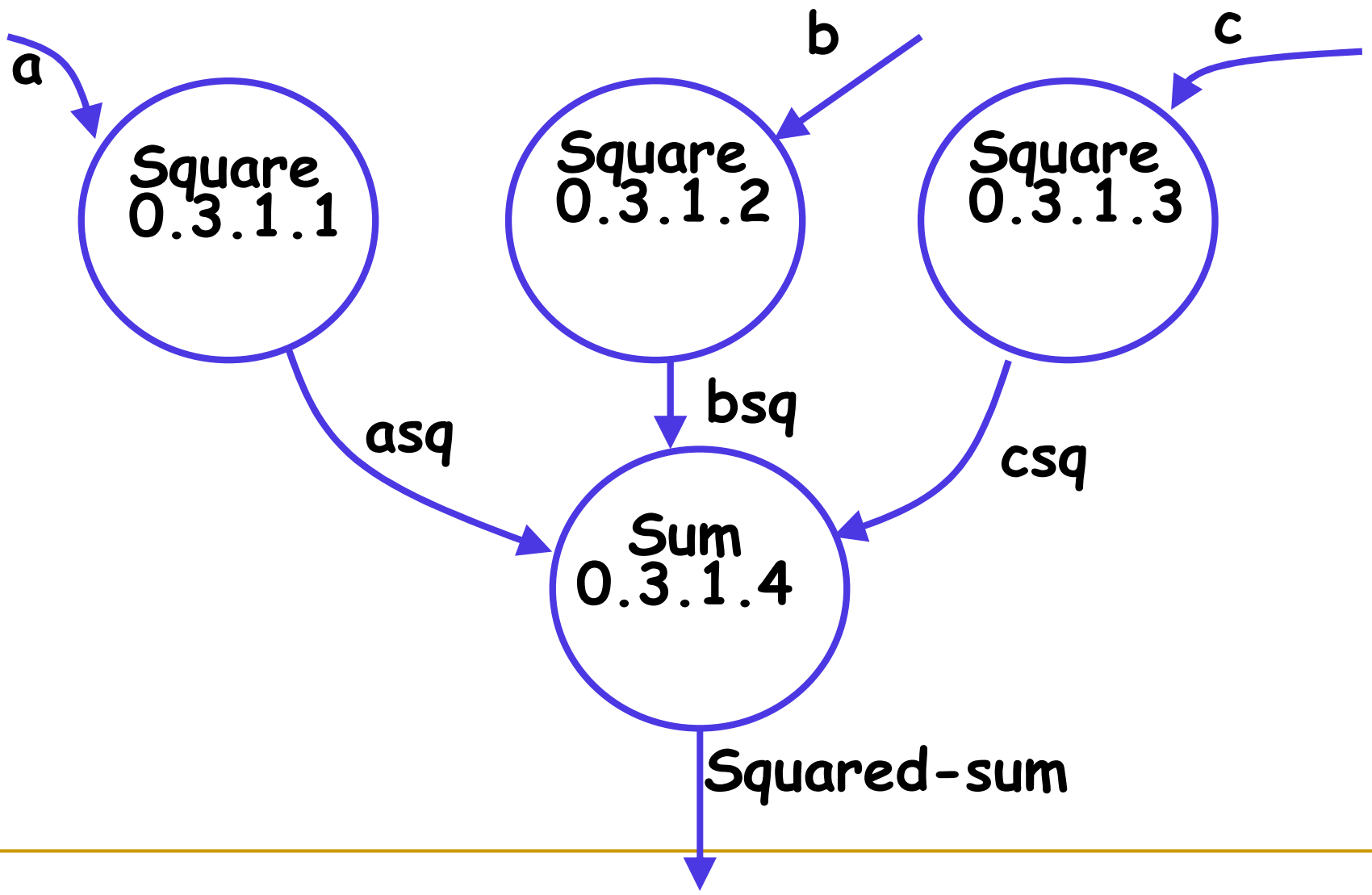
RMS software: Level 1 DFD



RMS software: Level 2 DFD



RMS software: Level 3 DFD



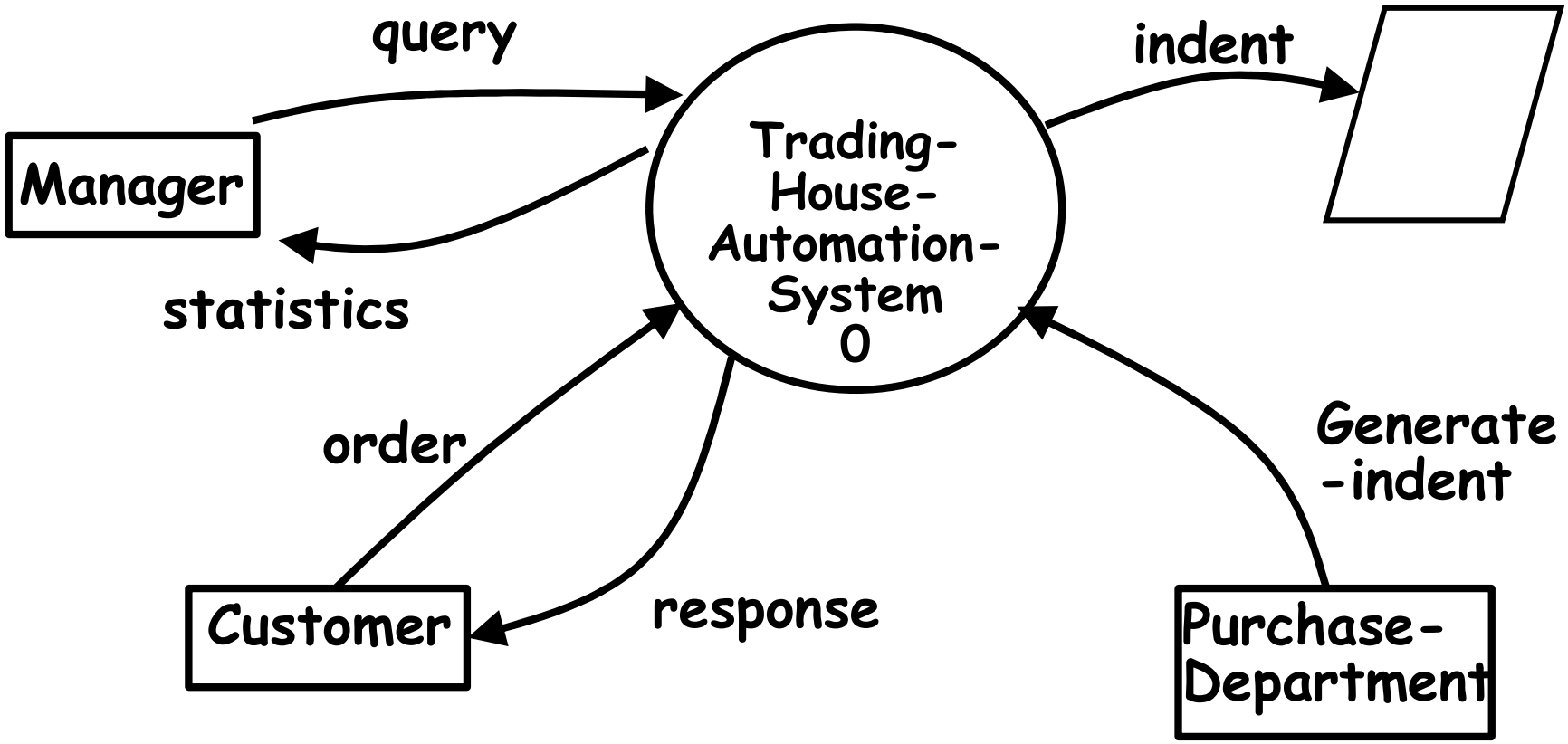
RMS software: Data Dictionary

- data-items = {integer}3
- numbers = data-items
- valid-numbers = numbers
- a: integer * input number *
- b: integer * input number *
- c: integer * input number *
- asq: integer
- bsq: integer
- csq: integer
- squared-sum: integer
- RMS: float * root mean square value*
- error: string * error message*
- Result = [RMS,error]

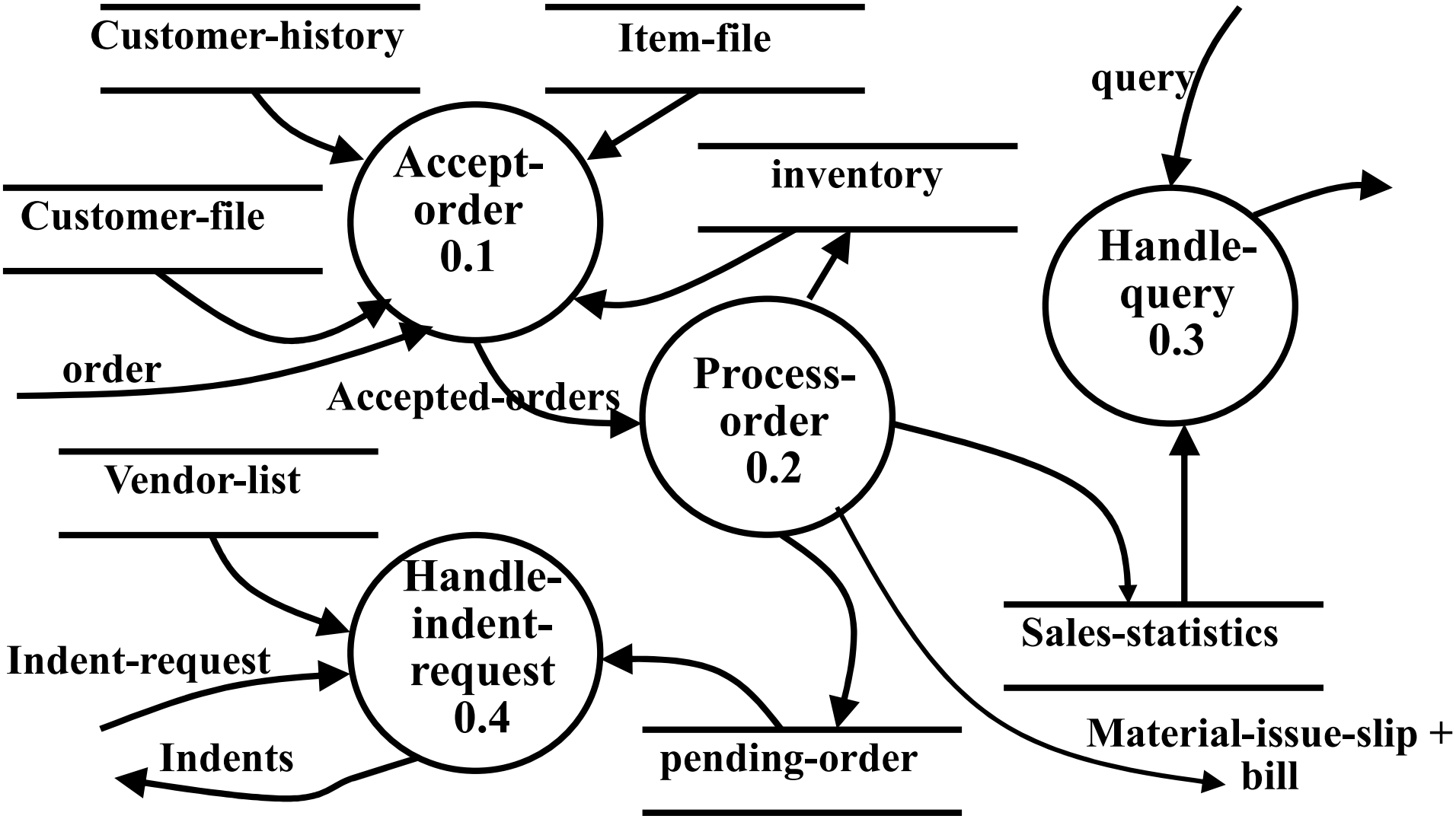
Example: Trading house automation software

- To automate book keeping activities associated with the business of a trading house
  - Customers place orders for various items
  - Before accept order, check if customer is credit-worthy
  - If order accept, customer issued a bill & material issue (to be produced at storehouse to get the items)
  - If ordered items not available, store details in a pending-orders file
  - Purchase department periodically generates an indent to know what needs to be bought (pending orders)
  - TAS software should also answer managerial queries

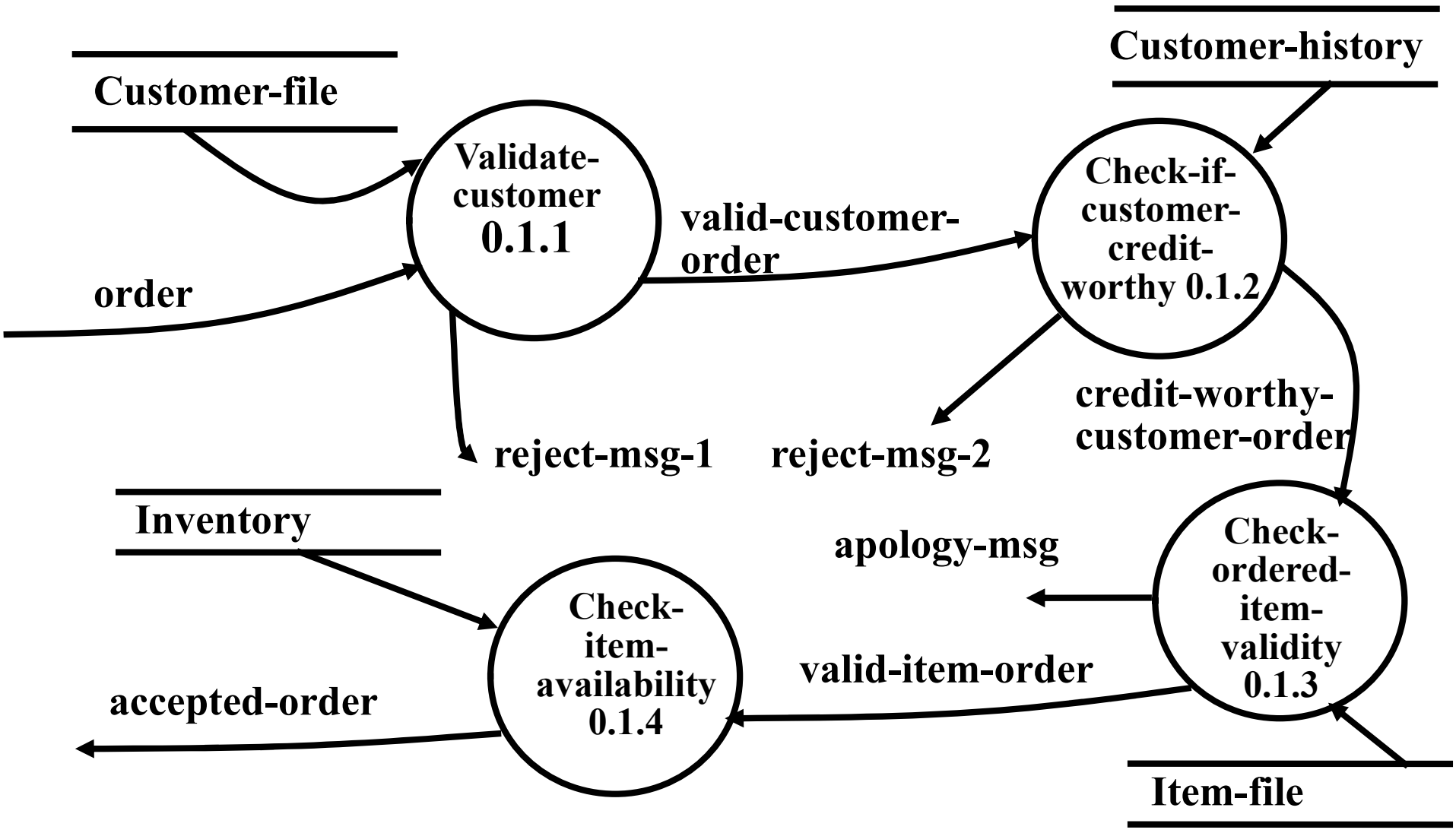
TAS software: Context Diagram



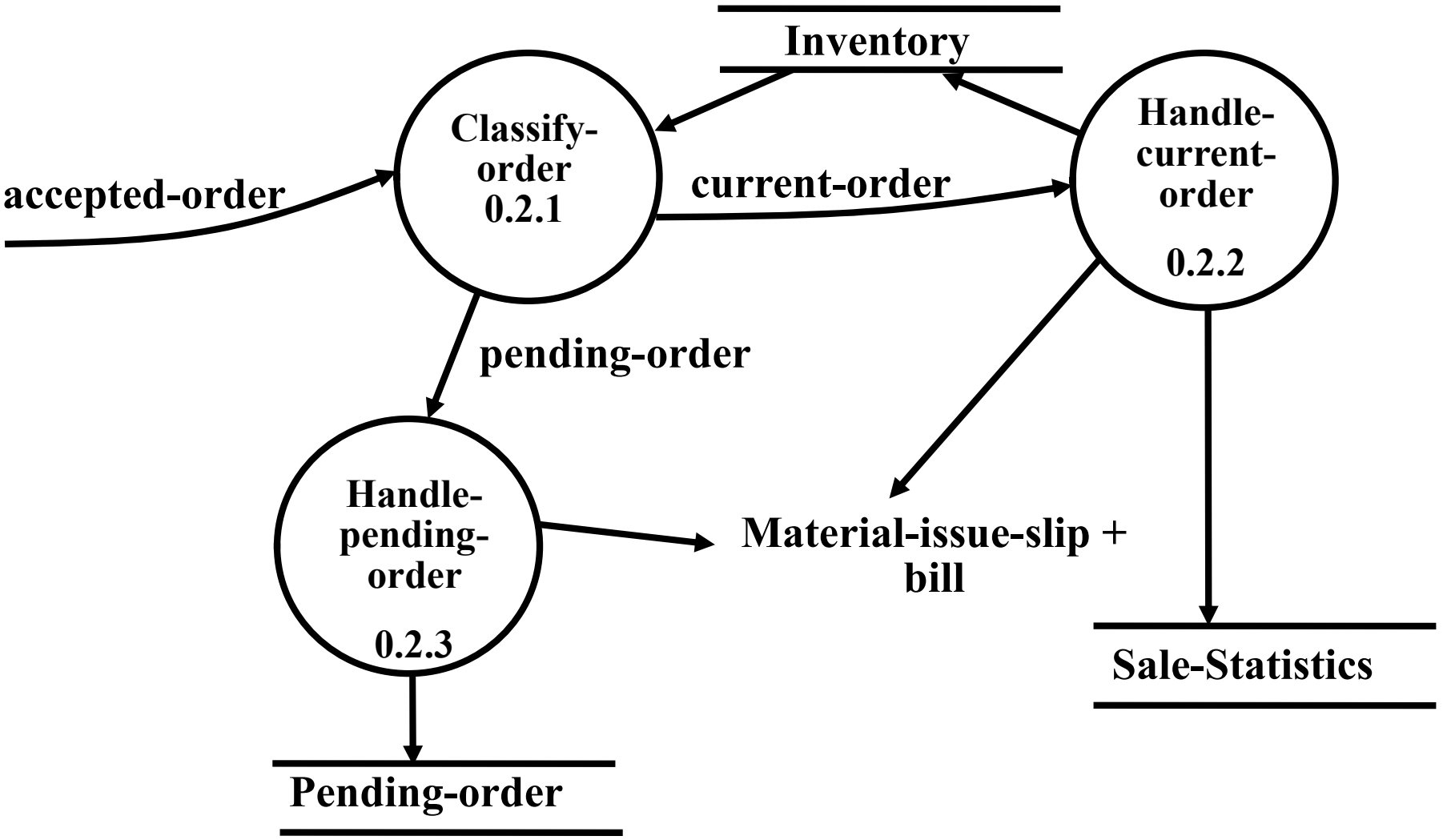
TAS software: Level 1 DFD



TAS : Level 2 DFD : Accept Order



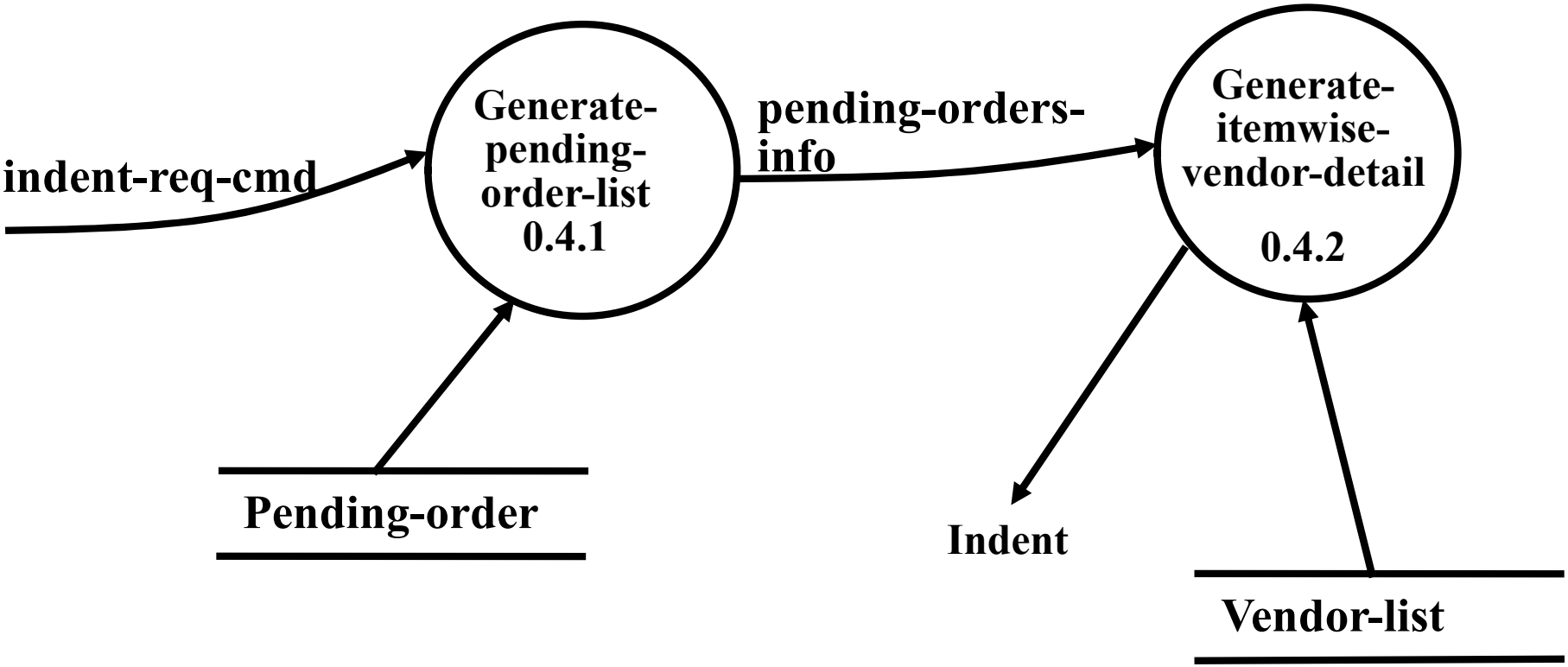
TAS : Level 2 DFD : Process Order



TAS : Level 2 DFD : Handle Query

- Skipping level 2 DFD for Handle Query

TAS : Level 2 DFD : Indent Request



More about DFD

- DFDs help create
  - **Function model** – analyst is performing an implicit functional decomposition
  - **Data model** – deciding what data items need to be exchanged, refinements of data, etc

- External entities appear only in context diagram, not in higher level DFDs

More about DFDs

- DFD does not represent control information
  - When or in what order different functions are invoked
  - Conditions under which different functions are invoked

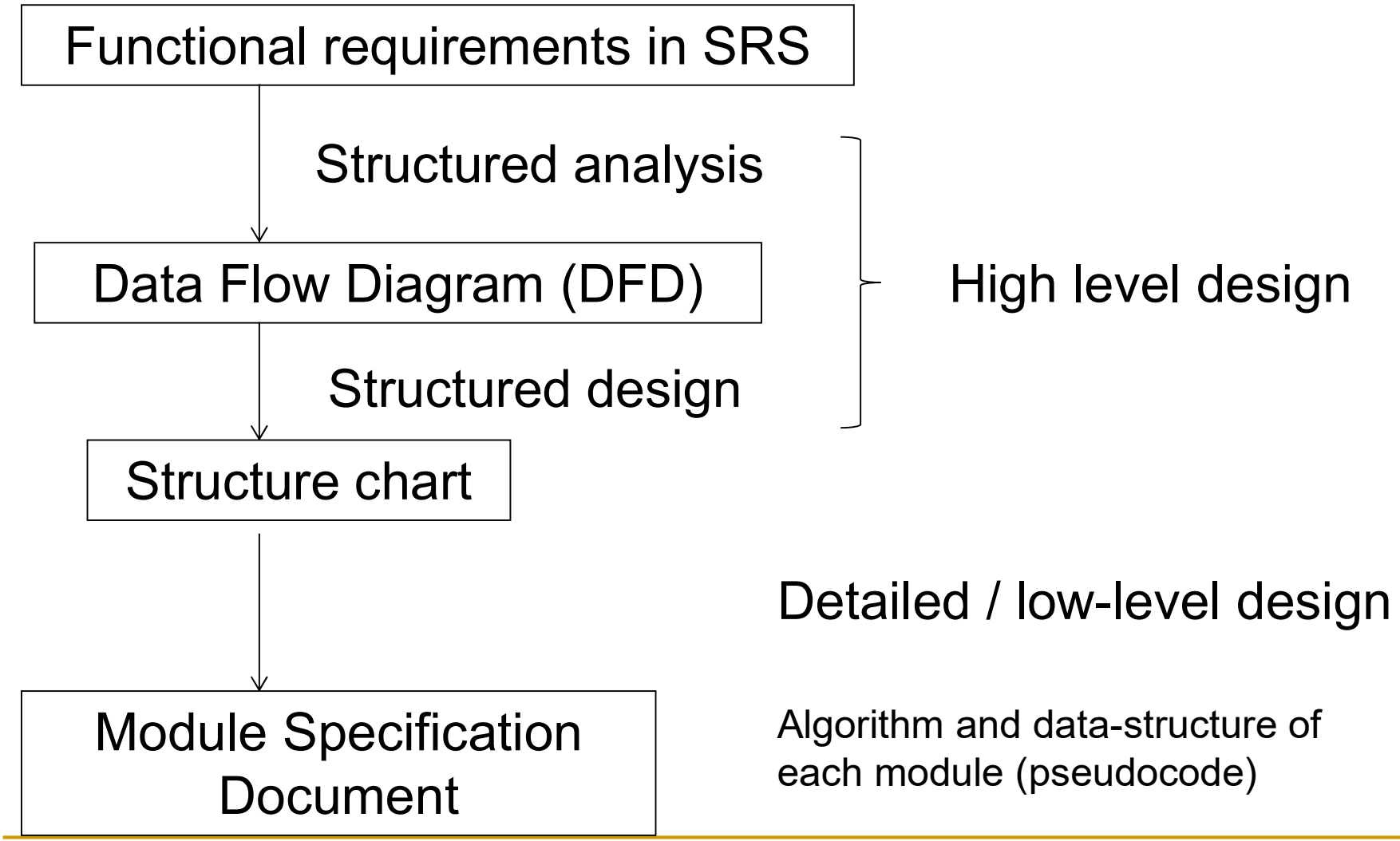
- If bubble A invokes either bubble B or bubble C depending on some conditions
  - Represent the data that flows from bubble A to bubble B and from bubble A to C, ...
  - not the conditions depending on which a process is invoked

Shortcomings of DFD model

- Ample scope to be imprecise
  - May not specify action for wrong / missing input
- Control information not represented
- Synchronization aspects not specified
- Subjective way of decomposing functions
  - Many decompositions possible for same system
  - No objective way of determining which is better
  - Level to which a function needs to be decomposed is subjective

Structured Design

Function-oriented design: summary



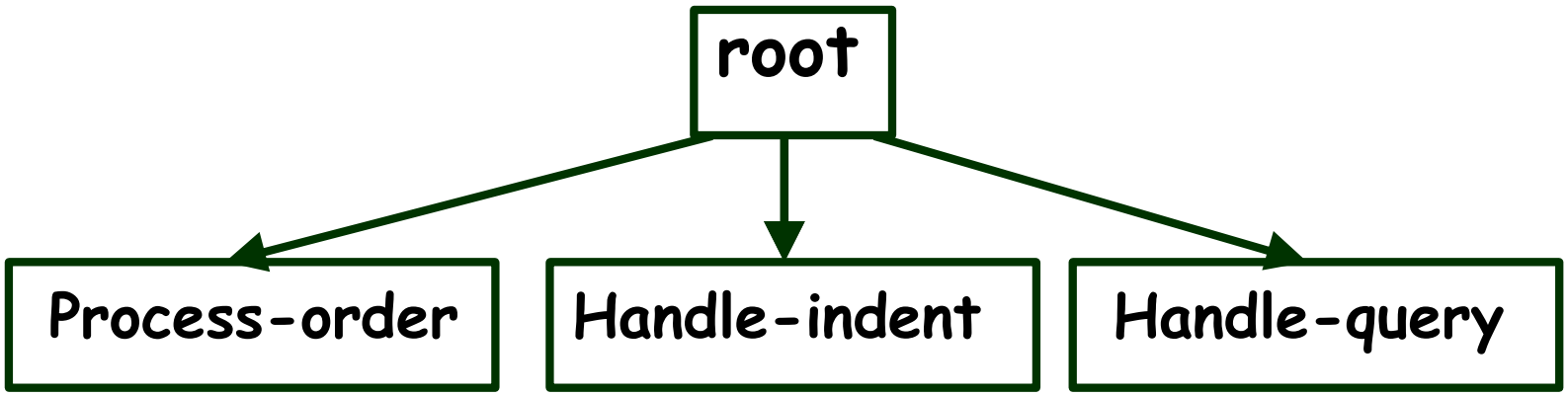
Structured design

- Goal
  - Transform results of SA (e.g. DFD) into software architecture (represented by Structure Chart)

- Structure Chart specifies
  - Various modules making up the system (module structure)
  - Module dependency (i.e. which module calls which other modules)
  - Parameters passed among different modules
  - Procedural aspects (e.g. how a particular functionality is achieved) are not represented

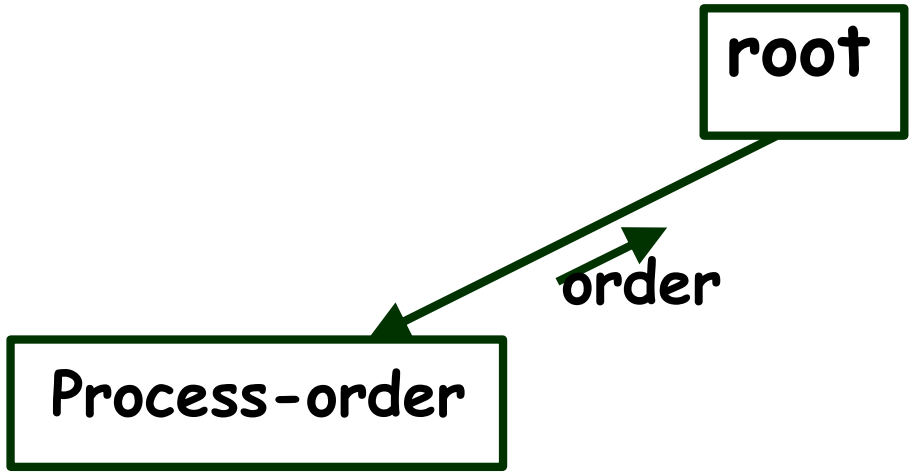
Structure chart symbols

- Module: rectangle, annotated with name of module
- Arrow between two modules
  - During execution, control passed from one module to the other in the direction of the arrow



Structure chart symbols

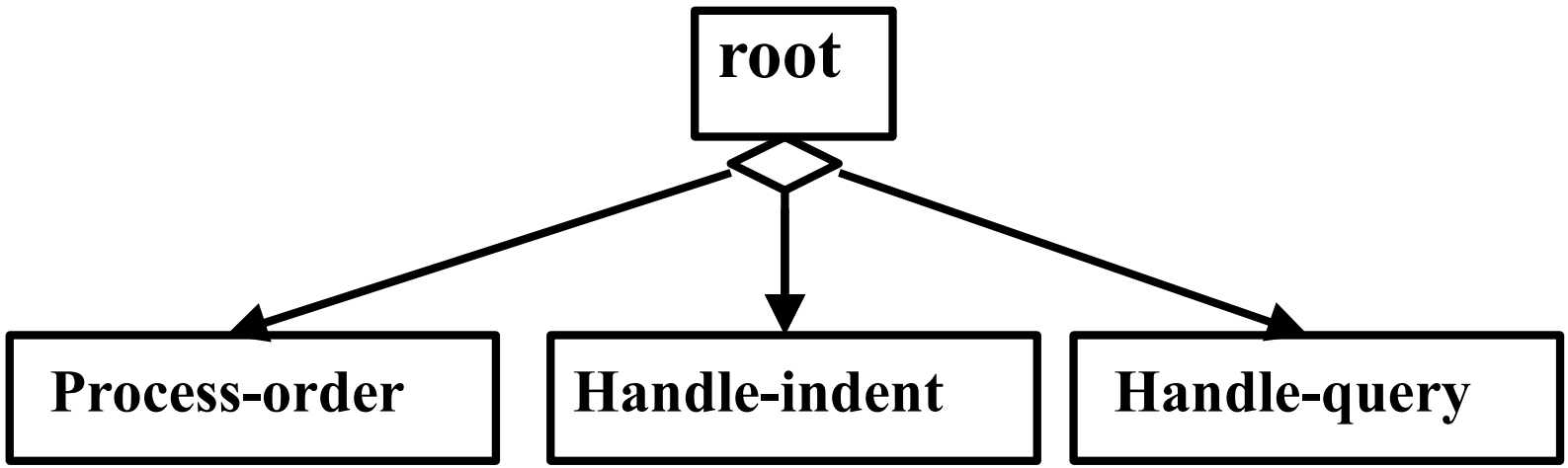
- Data flow arrows
  - Data passing from one module to another in the direction of the arrow



- Library modules
  - Represents frequently used modules (i.e. A module that is called by several modules)

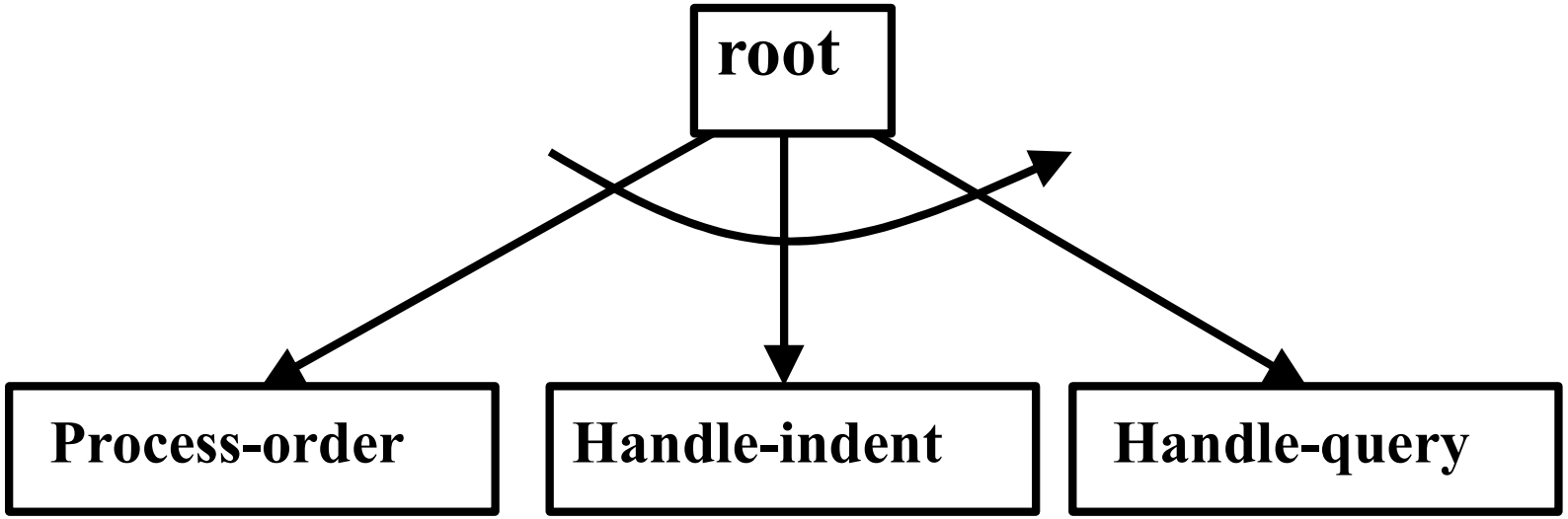
Structure chart symbols

- Selection: diamond symbol
- One of the several modules connected to the diamond symbol is invoked depending on some **condition**



Structure chart symbols

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



Rules for structure chart

- Modules arranged in layers or levels
  - Only one module at the top level – root module
  - At most one control relationship between two modules
  - Principle of abstraction: lower-level modules should not need to call higher-level modules

- Shortcomings of structure chart
  - Flow of control within modules is not represented
  - Does not specify order in which different modules invoked

Transforming DFD to structure chart

- Two strategies to transform DFD to structure chart
  - Transform analysis
  - Transaction analysis

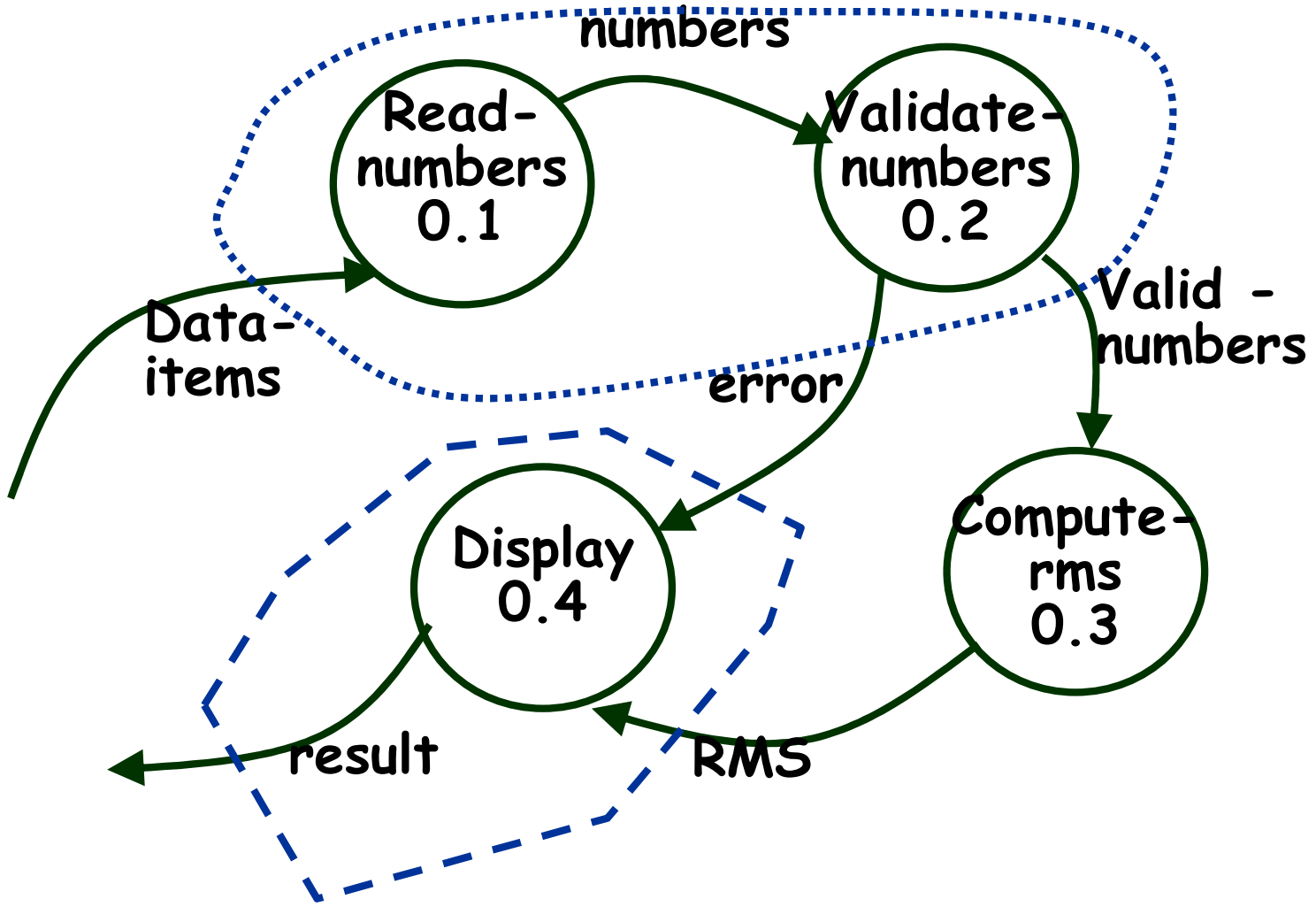
- Transform analysis (for transform-centered system)
  - Similar processing steps for every data item
  - E.g. input, process and output bubbles

- Transaction analysis (for transaction-driven systems)
  - One of several possible paths through the DFD is traversed depending upon the input data value

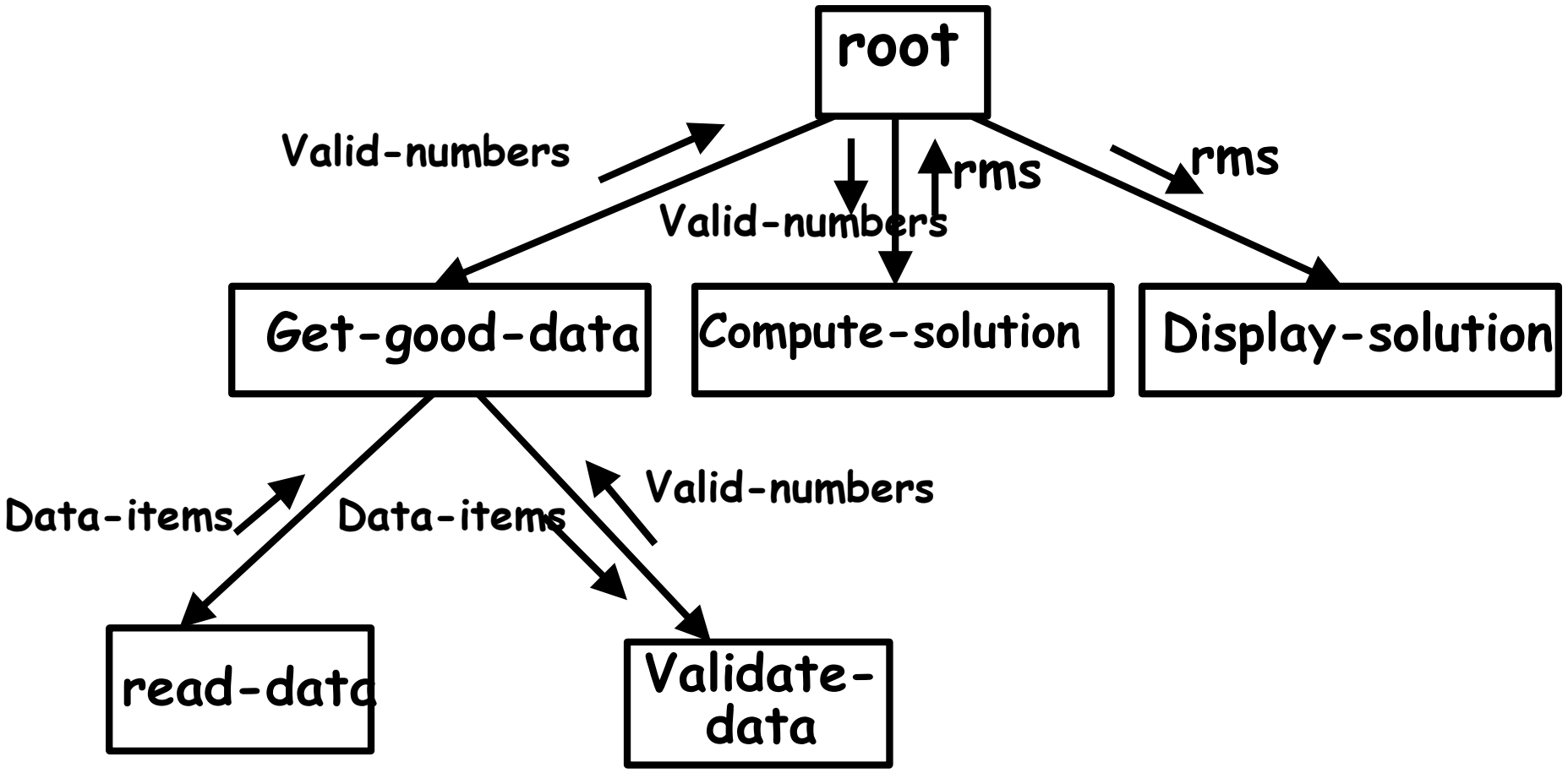
Transform analysis

- Divide DFD into three portions – input, logical processing, output
  - Each input portion called an afferent branch
  - Each output portion called an efferent branch
  - Possible to have more than one afferent / efferent branch in a DFD
- Derive structure chart
  - Draw one functional component for each efferent and afferent branch, one for the central transform
  - Add sub-modules required by each high-level module (also called factoring)

Level 1 DFD for RMS calculator …



… converted to Structure Chart

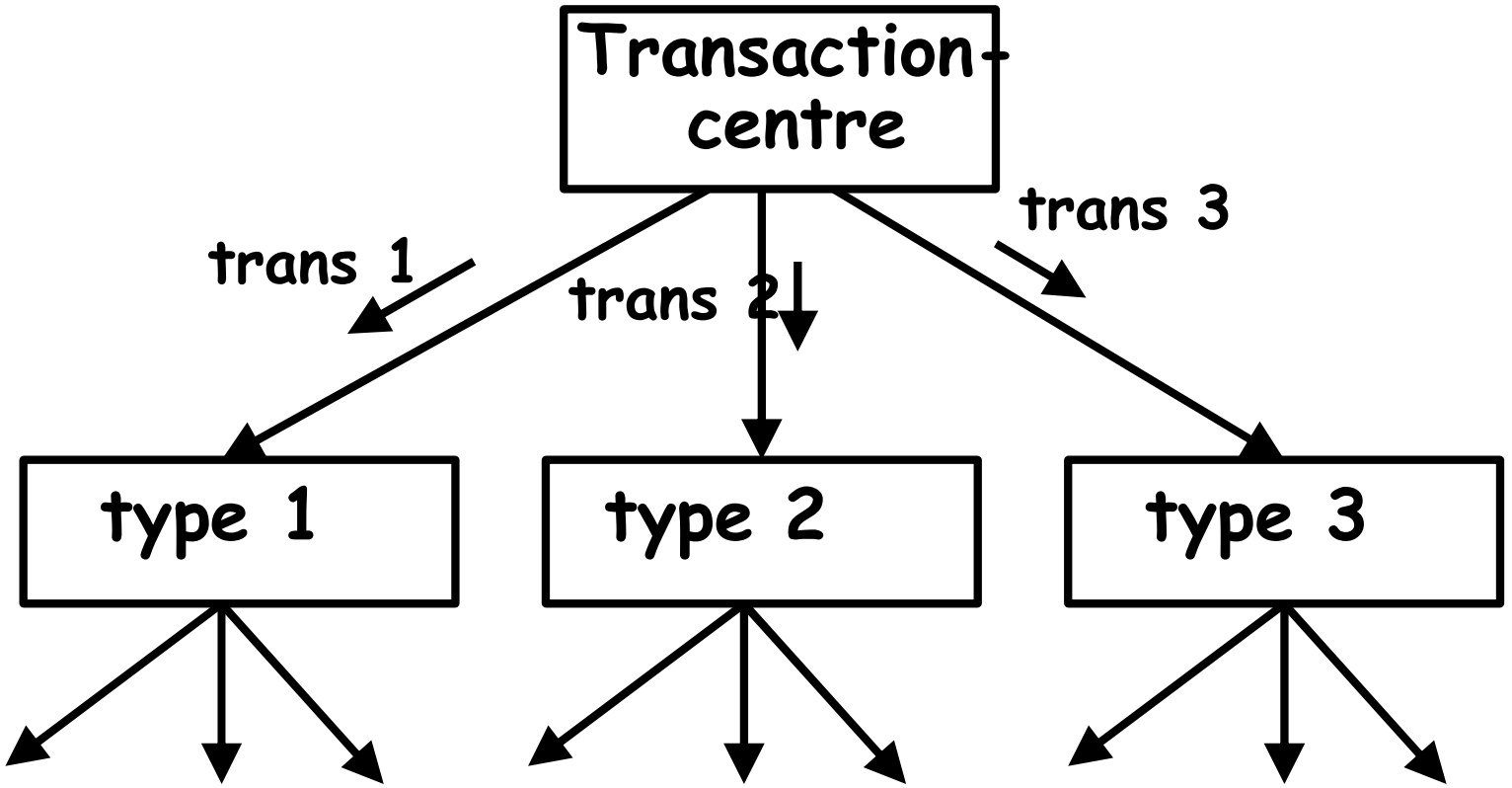


Transaction analysis

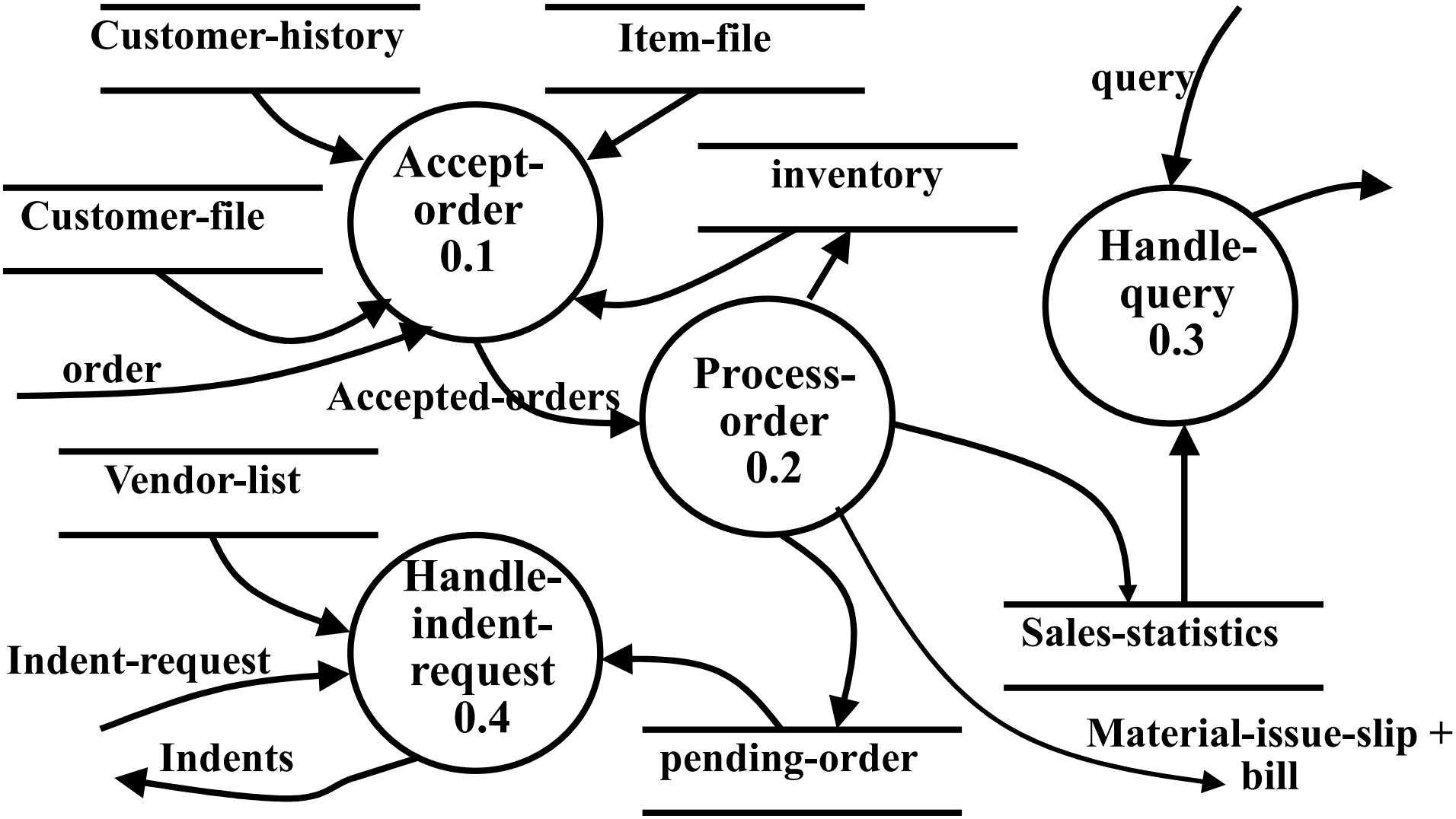
- Transaction-driven system
  - E.g. selected menu options might trigger different functions

- Transaction analysis divides system into
  - Several transaction modules
  - One transaction-centre module

Transaction analysis



TAS software: Level 1 DFD



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