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23 Action-Oriented Design Methods

1. Use Cases
2. Structured Analysis/Design (SA/SD)
3. Structured Analysis and Design Technique (SADT)

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Obligatory Reading

- Balzert, Kap. 14
- Ghezzi Ch. 3.3, 4.1-4, 5.5
- Pfleeger Ch. 4.1-4.4, 5

Secondary Literature

- Usually, action-oriented design is *structured*, i.e., based on hierarchical stepwise refinement.
- Resulting systems are
  - *reducible*, i.e., all results of the graph-reducibility techniques apply.
  - Often *parallel*, because processes talk with streams
- SA and SADT are important for *embedded systems* because resulting systems are parallel and hierarchic

23.1 ACTION-ORIENTED DESIGN

- Action-oriented design is similar to function-oriented design, but admits that the system has states.
  - It asks for the internals of the system
  - Actions require state on which they are performed (imperative, state-oriented style)
- Divide: finding subactions
- Conquer: grouping to modules and processes
- Example: all function-oriented design methods can be made to action-oriented ones, if state is added

What are the actions the system should perform?

Data-flow connects processes (parallel actions)

23.2 ACTION-ORIENTED DESIGN WITH SA/SD

Structured Analysis and Design (SA/SD)

- [DeMarco, T. Structured Analysis and System Specification, Englewood Cliffs: Yourdon Press, 1978]
- Representation
  - Function trees (action trees, process trees): decomposition of system functions
  - Data flow diagrams (DFD), in which the actions are called *processes*
  - Data dictionary (context-free grammar) describes the structure of the data that flow through a DFD
  - Pseudocode (minispecs) describes central algorithms
  - Decision Table and Trees describes conditions (see later)

Structured Analysis and Design (SA/SD) – The Process

- On the highest abstraction level:
  - Elaboration: Define interfaces of entire system by a top-level function tree
  - Elaboration: Identify the input-output streams most up in the function hierarchy
  - Elaboration: Identify the highest level processes
  - Elaboration: Identify stores
- Refinement: Decompose function tree hierarchically
- Change Representation: transform function tree into process diagram (action/data flow)
- Elaboration: Define the structure of the flowing data in the Data Dictionary
- Check consistency of the diagrams
- Elaboration: Minispecs (pseudocode)

DFD- Modellierung

- **Graphische Mittel:** ***Datenflußdiagramme - DFD***

Kontextdiagramm (mit Terminatoren)
Parent-Diagramme
Child-Diagramme

hierarchisch gegliedert mit übereinstimmender Prozeß-/Diagramm-numerierung

Symbole:

Prozeß(Aktion) — name nr.

Datenfluß (auch bidirektional) — (name)

Terminator — name

Speicher — name

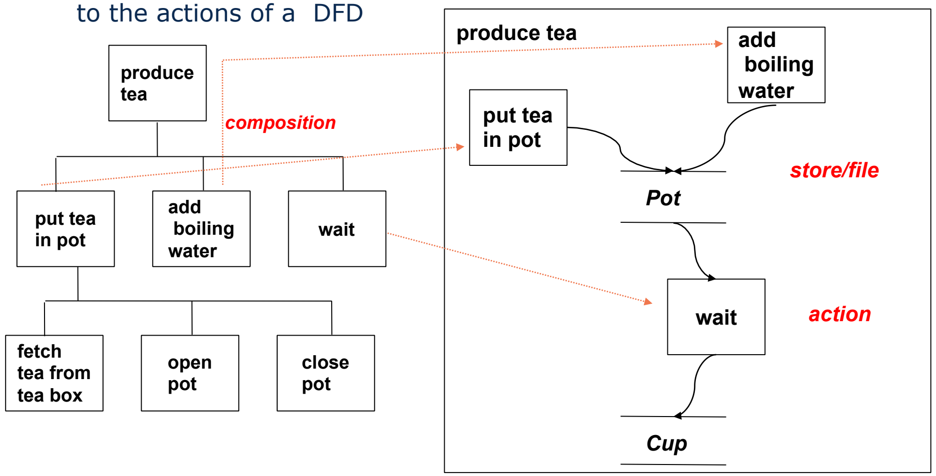
- **Textliche Mittel:**

Data Dictionary: Im Datenkatalog ist jeder Speicher und jeder Datenfluß in seiner Zusammensetzung zu beschreiben. Es ist identisch mit dem der IM-Modellierung.

Mini-Spezifikationen: Dienen der näheren Beschreibung der in Elementarprozessen durchzuführenden (Daten-)Transformationen.

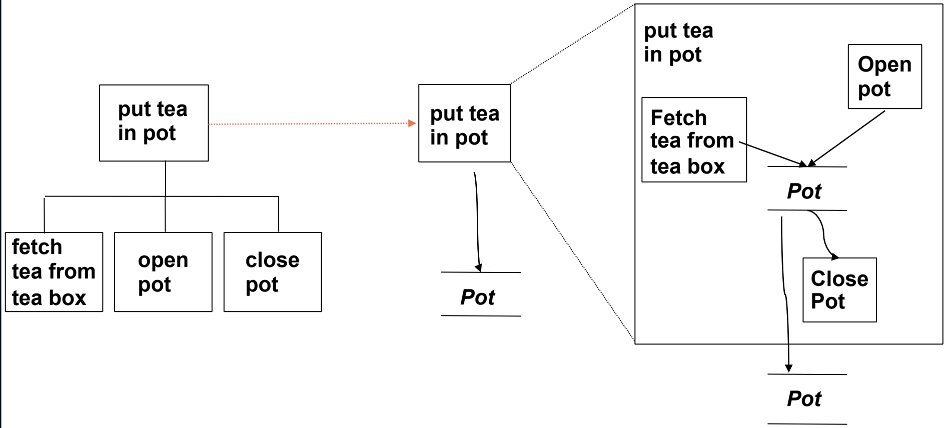
Function Trees (Action Trees) and DFDs

- Function trees are homomorphic to DFD
- RepresentationChange: Construct a function tree and transform it to the actions of a DFD



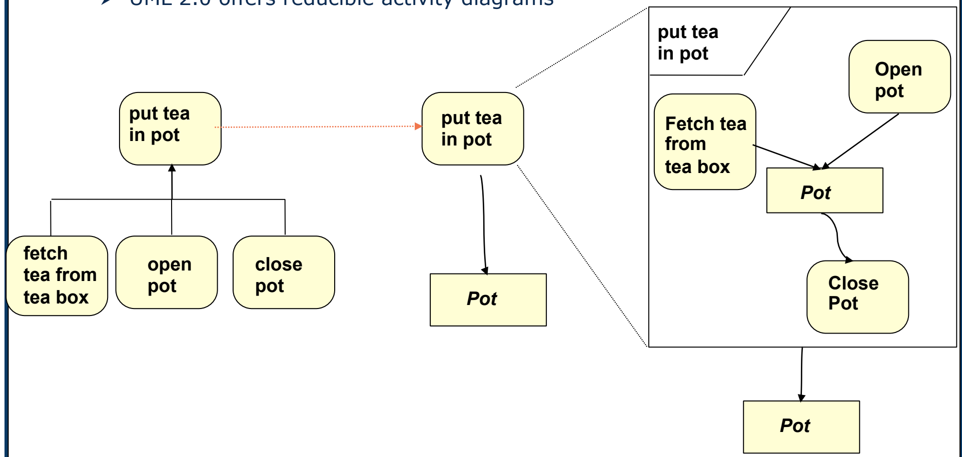
Decomposition of DFDs and Actions

- Subtrees in the function tree lead to reducible subgraphs in the DFD



Data Flow in UML

- UML function trees can be formed from actions, and aggregation
- Activity diagrams can specify dataflow
  - UML 2.0 offers reducible activity diagrams



Regeln der DFD-Erstellung

(möglichst werkzeugunterstützt prüfen)

- **Semantische Regeln** zur Namensgebung:
  - **Prozeßnamen:** *Verb_Substantiv* zur aussagekräftigen Beschreibung einer Aktion (z.B. *berechne_Schnittpunkt*)
  - **Datenflußnamen:** *[<Modifier>]Substantiv* beschreibt momentanen Zustand des Datenflusses (z.B. *<neue>Anschrift*)
  - **Speichernamen:** *Substantiv*, das den Inhalt des Speichers (identisch Entity im DD) beschreibt (z.B. *Adressen*)
- **Syntaktische Regeln** zur graphischen DFD-Darstellung:
  - Jeder Datenfluß muß mit mindestens einem Prozeß verbunden sein.
  - **Datenflüsse** zwischen Terminatoren und direkt zwischen Speichern sind nicht erlaubt.
  - **Datenspeicher**, die nur einseitig beschrieben (ohne zu lesen) und nur einseitig gelesen (ohne zu beschreiben) werden, sind nicht erlaubt.
  - **Prozesse**, die Daten ausgeben, ohne sie erhalten zu haben oder umge- kehrt, die Daten erhalten, ohne sie auszugeben oder zu verarbeiten, sind nicht erlaubt.
  - Im **Kontext** darf es keine Speicher geben , in **Verfeinerungen** keine Terminatoren

Jeder Prozeß, Speicher und Datenfluß muß einen Namen haben. Nur in dem Fall, wo der Datenfluß alle Attribute des Speichers beinhaltet, kann der Datenflußname entfallen.

Weiterführende Literatur: [2, S.437]

Typing Edges with Types from the Data Dictionary

- In an SA model, the *data dictionary* describes the context free structure of the data flowing over the edges
  - For every edge in the DFDs, it contains a context-free grammar that describes the flowing data items
- Notation is also called Extended Backus-Naur Form (EBNF)

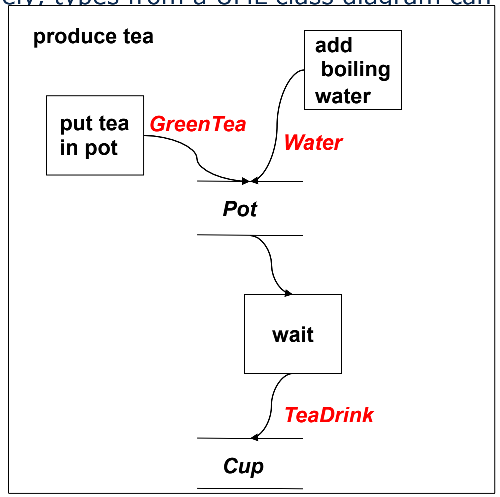
	Notation	Meaning	Example
	::= or =	Consists of	A ::= B.
Sequence	+	Concatenation	A ::= B+C.
Sequence	<blank>	Concatenation	A ::= B C.
Selection	[|]	Alternative	A ::= [B | C].
Repetition	{ }^n		A ::= { B }^n.
Limited repetition m	{ } n	Repetition from m to n	A ::= 1{ B }10.
Option	( )	Optional part	A ::= B (C).

Example Data Dictionary

```
DataInPot ::= TeaPortion WaterPortion.
TeaAutomatonData ::= Tea | Water | TeaDrink.
Tea ::= BlackTea | FruitTea | GreenTea.
TeaPortion ::= { SpoonOfTea }.
SpoonOfTea ::= Tea.
WaterPortion ::= { Water }.
```


Adding Types to DFDs

- Nonterminals from the data dictionary become types on flow edges
- (Alternatively, types from a UML class diagram can be annotated)



Minispecs in Pseudo Code

- Minispecs describes the processes in the nodes of the DFD in pseudo code. They describe the data transformation of every process
- Here: specification of the minispec attachment process:

```
procedure: AddMinispecsToDFDNodes
   target.bubble := select DFD node;
   do while target-bubble needs refinement
          if target.bubble is multi-functional
                 then decompose as required;
                         select new target.bubble;
                        add pseudocode to
target.bubble;
                 else no further refinement needed
          endif
   enddo
end
```


Good Languages for Pseudocode

- SETL (Schwartz, New York University)
  - Dynamic sets, mappings
  - Iterators
- PIKE (pike.ida.liu.se)
  - Dynamic arrays, sets, relations, mappings
  - Iterators
- ELAN (Koster, GMD)
  - Natural language as identifiers of procedures
- Smalltalk (Goldberg et.al, Parc)
- Attempto Controlled English (ACE, Prof. Fuchs, Zurich)
  - A restricted form of English, easy to parse

Structured Analysis and Design (SA/SD) - Heuristics

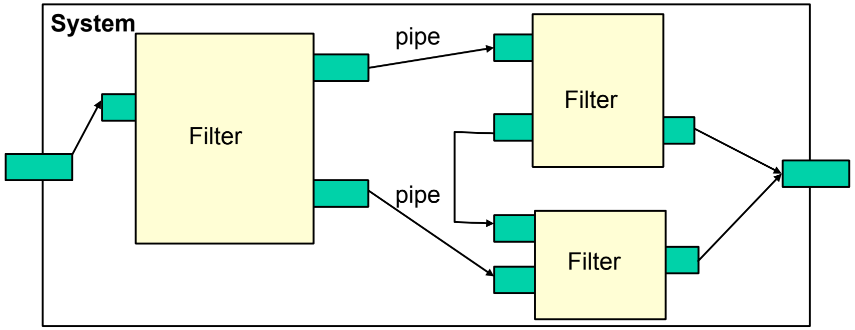
- Consistency checks
  - Several consistency rules between diagrams (e.g., between function trees and DFD)
  - Corrections necessary in case of structure clash between input and output formats
- Advantage of SA
  - Hierarchical refinement: The actions in the DFD can be refined, I.e., the DFD is a reducible graph
  - SA leads to a hierarchical design (a component-based system)

Difference to Functional and Modular Design

- SA focusses on actions (activities, processes), not functions
  - Describe the *data-flow* through a system
  - Describe stream-based systems with pipe-and-filter architectures
- Actions are processes
  - SA and SADT can easily describe parallel systems
- Function trees are interpreted as *action trees (process trees)* that treat streams of data

Result: Data-Flow-Based Architectural Style

- SA/SD design leads to dataflow-based architectural style
- Processes exchanging streams of data
- Data flow forward through the system
- Components are called *filter*, connections are pipes



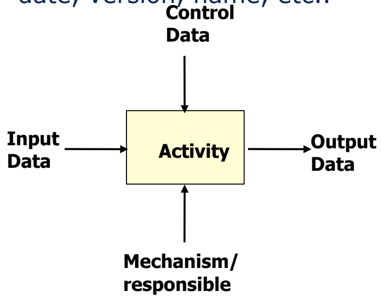
Examples

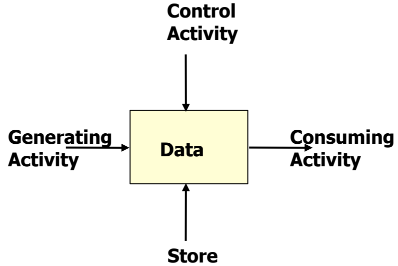
- Shell pipes-and-filters
- Image processing systems
- Signal processing systems (DSP-based embedded systems)
  - The satellite radio
  - Video processing systems
  - Car control
  - Process systems (powerplants, production control, …)
- Content management systems (CMS)

23.3 SADT

Structured Analysis and Design Technique (SADT)

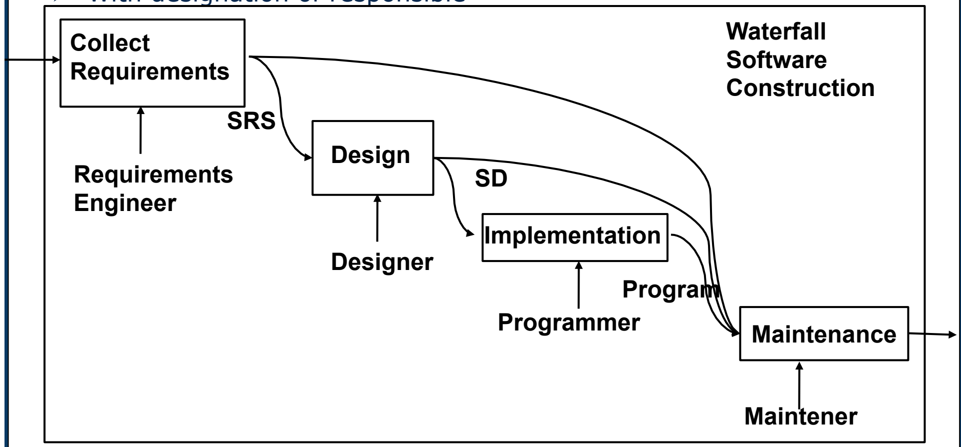
- SADT is a action- and data-flow-oriented method
- Reducible graphs with 2 main forms of diagrams:
  - Activity diagrams: Nodes are activities, edges are data flow (like DFD)
    - Data flow architectures result
  - Data diagrams: Nodes are data (stores) and edges are activities
  - Layout constraint: edges go always from left to right, top to bottom
- Companies used to have standardized forms, marked with author, date, version, name, etc..



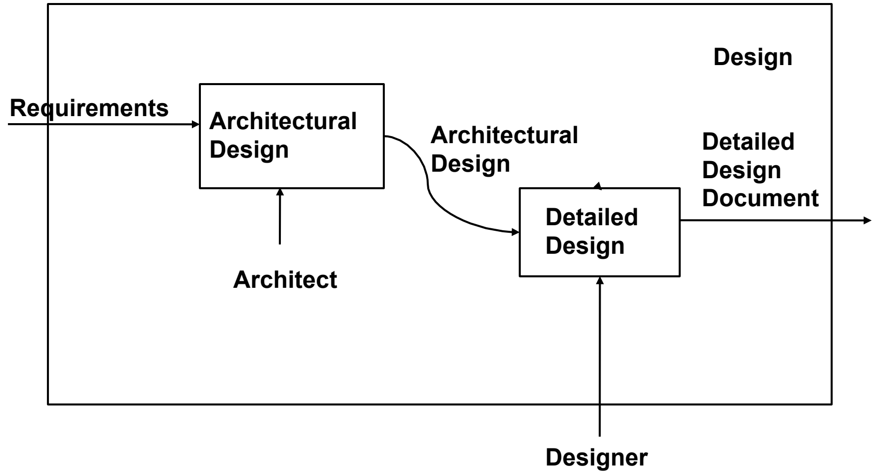


Example: The Waterfall Software Model with Activity Diagram of SADT

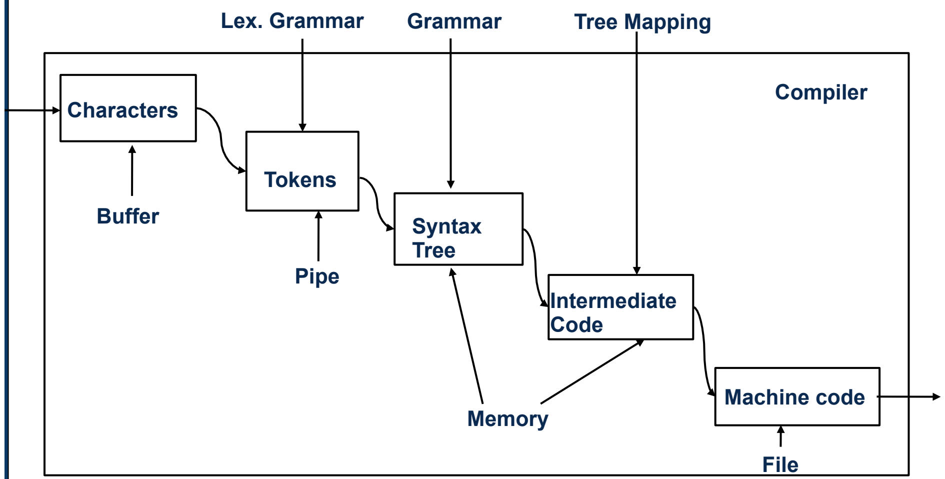
- Activity Diagrams SADT – Similar to DFD
- Read direction left to right, top to bottom
- With designation of responsible

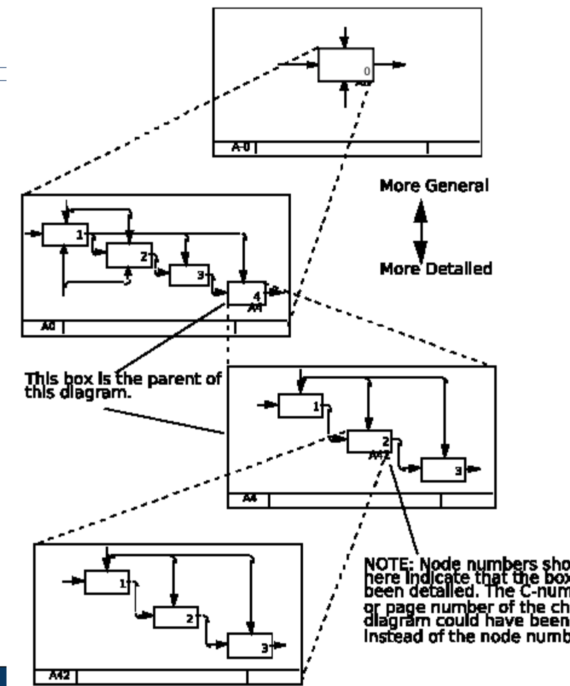


Refinement of Nodes



Data Diagrams SADT





Comparison SADT vs SA/SD

- SADT, SA/SD are system-oriented methods, known in other disciplines
  - *Action-oriented methods*
    - they only distinguish between actions (processes) and data
  - *Stream-oriented,* i.e., model streams of data flowing through the system
  - *System-oriented,* know the concept of a *subsystem*
- SA-DFDs are more flexible as SADT actitity diagrams, since the layout is not constrained
  - Function trees and DDs may be coupled with SADT

Why are SA and SADT Important?

- They lead to component-based systems (hierarchical systems)
  - Component-based systems are ubiquituous for many areas
  - Object-orientation is not needed everywhere
  - Other engineers use SADT also
- SA and SADT can easily describe parallel systems in a structured way
- SA and SADT are stream-based, i.e., for stream-based applications. When your context model has streams in its interfaces, SA and SADT might be applicable
- Use case actions can be refined similarly as SA and SADT actions!

What Have We Learned

- Use case diagrams are an action-oriented diagram notation
  - that can be coupled with several design methods (action trees, communication diagrams)
- Besides object-oriented design, *structured, action-oriented design* is a major design technique
  - It will not vanish, but always exist for certain application areas
  - If the system will be based on stream processing, system-oriented design methods are appropriate
  - System-oriented design methods lead to *reducible systems*
- Don't restrict yourself to object-oriented design

The End