TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Informatik, Institut für Software- und Multimediatechnik, Lehrstuhl für Softwaretechnologie

25) Functional, Action-, Data-Flow, ECA-Based Design Illustrated by Example

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1. The KWIC Case Study

Obligatory Readings

- Ghezzi Chapter 3, Chapter 4, esp. 4.2
- Pfleeger Chapter 5, esp. 5.7
- David Garlan and Mary Shaw. An Introduction to Software Architecture. In: Advances in Software Engineering and Knowledge Engineering, Volume I, edited by V.Ambriola and G.Tortora, World Scientific Publishing Company, New Jersey, 1993.
  - Also appears as CMU Software Engineering Institute Technical Report CMU/SEI-94-TR-21, ESC-TR-94-21.
  - http://www-2.cs.cmu.edu/afs/cs/project/able/ftp/intro_softarch/intro_softarch.pdf
  - http://www.stormingmedia.us/65/6538/A653882.html
- [Parnas] David Parnas. On the Criteria To Be Used in Decomposing Systems into Modules. Communications of the ACM Dec. 1972 (15) 12.

Literature

- [Shaw/Garlan96] Software Architecture. 1996. Prentice-Hall.

Pfleeger 5.7, Shaw/Garlan 1996

25. THE KWIC EXAMPLE PROBLEM

The KWIC Problem

- "Keyword in Context" problem (KWIC) is one of the 10 model problems of architecture systems [Shaw-ModelProblems, www.cmu.edu] [Shaw/Garlan96, Pfleeger 5.7]
- Originally proposed by Parnas to illustrate advantages of different designs [Parnas72]
- For a text, a KWIC algorithm produces a permuted index
  - Every sentence is replicated and permuted in its words, i.e., the words are shifted from left to right.
  - Every first word of a permutation is entered into an alphabetical index, the permuted index.

KWIC

- The KWIC index system accepts an ordered set of lines
  - Each line is an ordered set of words,
  - and each word is an ordered set of characters.
- Any line may be "circularly shifted" by repeatedly removing the first word and appending it at the end of the line.
- The output of the KWIC index system is a listing of all circular shifts of all lines in alphabetical order

[Parnas]

A KWIC Index

every sentence is replicated ..	**and**	permuted
..	**every**	sentence is replicated and permuted
.. every sentence	**is**	replicated and permuted
.. every sentence is replicated and	**permuted**	
.. every sentence is	**replicated**	and permuted
.. every	**sentence**	is replicated and permuted

Modules in The KWIC Problem and Some of Their Secrets

- **Input:** reads the sentences
  - Input formats
  - Are all lines stored in memory? (bad for large texts)
  - Packed or unpacked character storage
  - Store the index?
  - Distributed or non-distributed memory?
- **Output:** outputs the KWIC index
  - Highlighting of keywords?
  - Text or PS, or PDF-output
- **Circular Shifter:** permutes the generated sentences
- **Sorter:** sorts the shifted sentences so that they form a keyword-in-context index
  - Sort all the index or look entries up?
  - Complete or partial sorting
- **Caps**: replicates the sentences as necessary
  - Lazy or eager replication

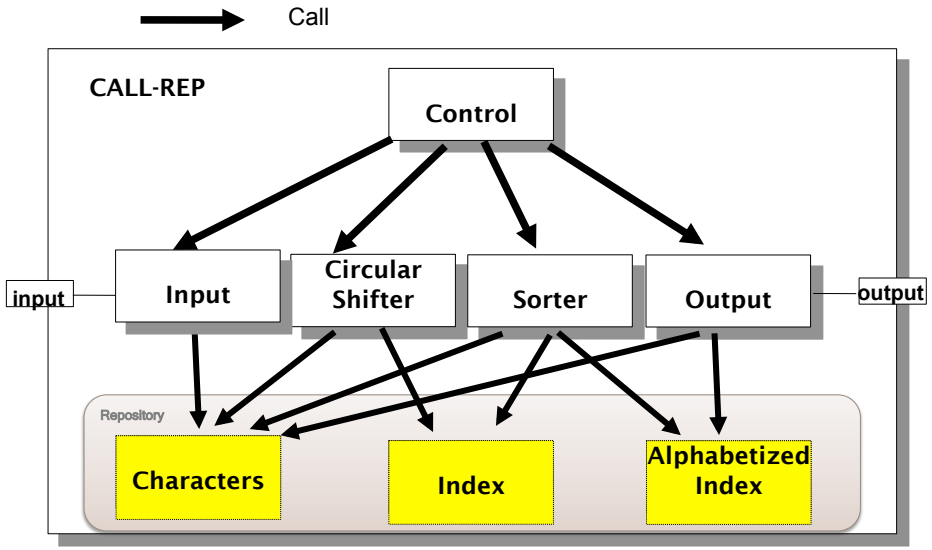
Problem?

- KWIC are very important for technical documents
- Examples
  - "Beitrag zur Populationsgenetik der sauren Erythrocytenphosphatase-acP-EC3.1.3.2 unter besonderer Berücksichtigung des reinerbigen Typus C" (1980)
  - "Lepton-Hadron-Korrelationen in (2+1)-Jet-Produktion in tief-inelastischer Elektron-Proton-Streuung zur O(alpha2 s)"(1992)
  - "Die molekulare Wirkung von 2,4,5-und 2,4,6-Trichlorphenol auf Eukaryontenzellen" (1990)
  - "Aufklärung, Vernunft, Religion – Kant und Feuerbach" (2005)

KWIC Flexibility Requirements

1. **Variability**: Changes of implementations of components
   1. When does the circular shifter work?
   2. When does the sorting work?
2. **Variability**: Changes of data representations
   1. Representation of sentences, words, lines
   2. Use of indices?
   3. How to avoid reduncancy?
3. **Extension** with new functionality
   1. E.g., insertion of fill words
4. **Speed**
5. **Reusability** of components

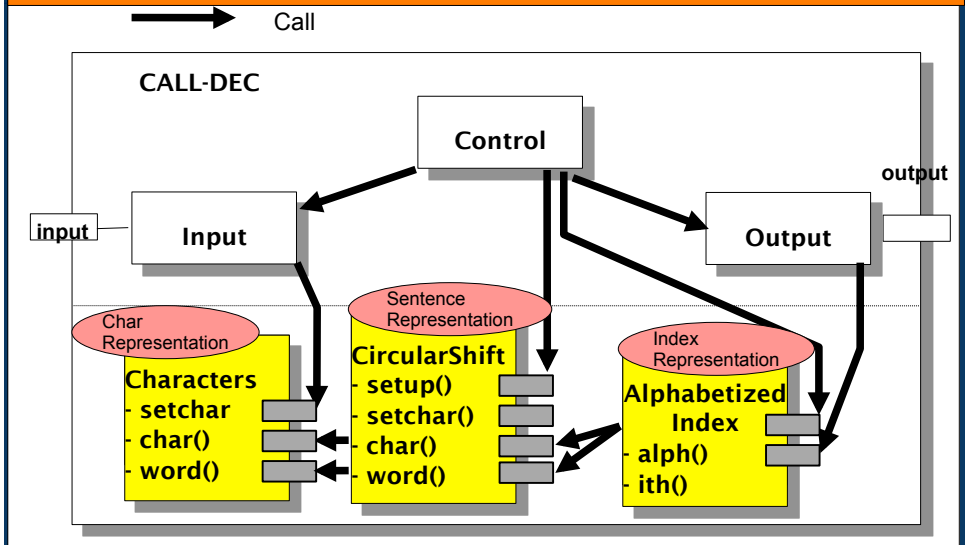
The KWIC Problem in Action-Based Design: Call-Based Style with Shared Repository



The KWIC Problem in Call-Based Repository Style

- Bad:
  - State of the repository visible to several callers
  - A change in the data affects all modules
  - High costs if algorithm have to be changed
  - The modules are not reusable
  - **Bad encapsulation of module secrets!**
- Good:
  - Fast, due to shared memory access
  - Easy to code
- Shared memory is a fast concept, but provides few information hiding.

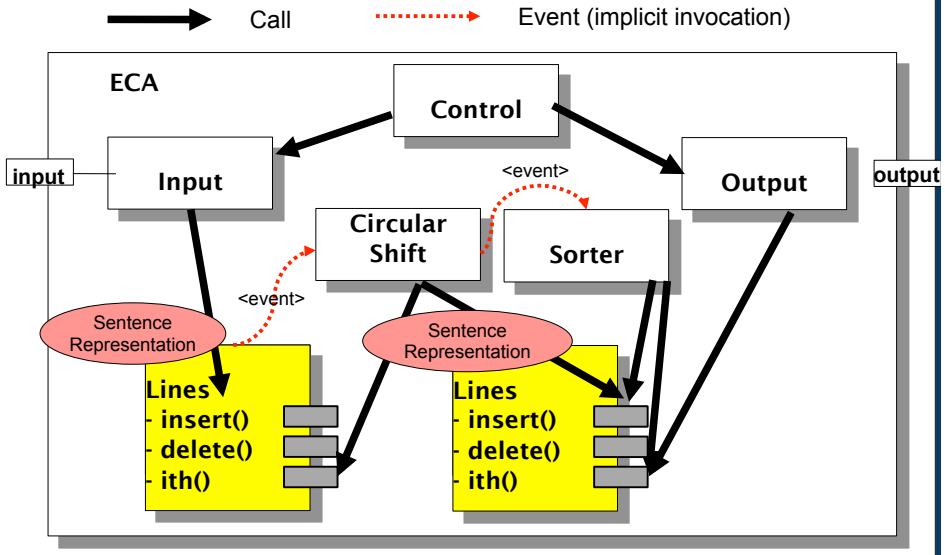
The KWIC Problem in Function-Based Design: (Abstract Data Types with Private Decentralized Memory)



The KWIC Problem in Decentralized Memory

- Good:
  - Data and algorithm are easier to change (e.g., packing and storing the whole character) since
    - Data representation is hidden in functions
    - Algorithm partly hidden
    - The control flow works "on demand" from the Control through the Output backwards to the Input
  - **More module secrets: char, sentence, and index representation**
  - Layering
- Bad:
  - Adding new functions may be hard, since control flow intertwines the modules tightly

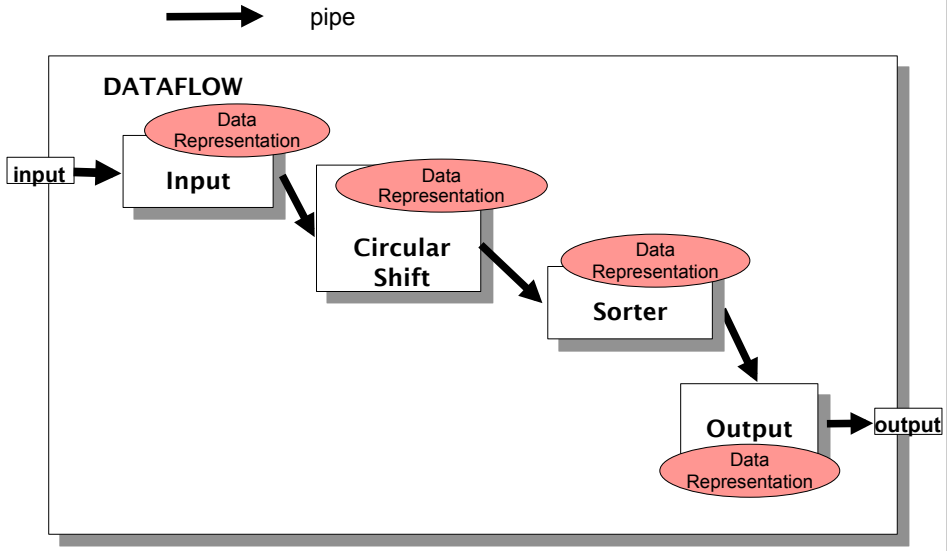
The KWIC Problem in Event-Condition-Action Design (Implicit Invocation Style)



The KWIC Problem in Implicit Invocation Style (ECA Style)

- Good:
  - Data and algorithm are easy to change
    - they are hidden in functions
  - The control flow works forward by "implicit invocation", i.e., sending an event, from the Input/Lines through the Shifter and the Sorter
    - The listeners test conditions and execute an action
  - Layering
  - Event-based style simplifies the addition of new functions, since they may additionally listen to the events; event sources need not be changed (even more module secrets)
- Bad:
  - Flow of control is hard to predict
  - Hard to analyze statically; unusable for safety-critical systems

The KWIC Problem in Action-Based Design (Pipe-and-Filter Data-flow Style, SA)



The KWIC Problem in Pipe-And-Filter Data-Flow Style

- Good:
  - Data and algorithm are easy to change (by filter exchange)
  - Adding new functions is easy (new filters)
  - Flow of control is easy to say
  - **Data representation is completely hidden in the filters**
  - Highly reusable filter modules
- Bad:
  - No evolution to interactive system

Comparison of KWIC Designs

Easy to use	CALL-REP	CALL-DEC	ECA	DATA-FLOW
Algorithm	-	-	+	+
Data representation	-	+	-	+
Function	-	-	+	+
Good performance	+	+	-	-
Easy reuse	-	+	+	+

- [Shaw/Garlan 1996] Comparison can be improved with weighted priorities.

What Have We Learned?

- When designing with functions, use function trees and subfunction decomposition
- When grouping to modules, fix module secrets
- The more module secrets, the better the exchange and the reuseability
  - Change-oriented design means to encapsulate module secrets
- Functional and modular design are still very important in areas with hard requirements (safety, speed, low memory)