TECHNISCHE UNIVERSITÄT DRESDEN

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

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

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- Version 10-03. 20.12.2010

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

14 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

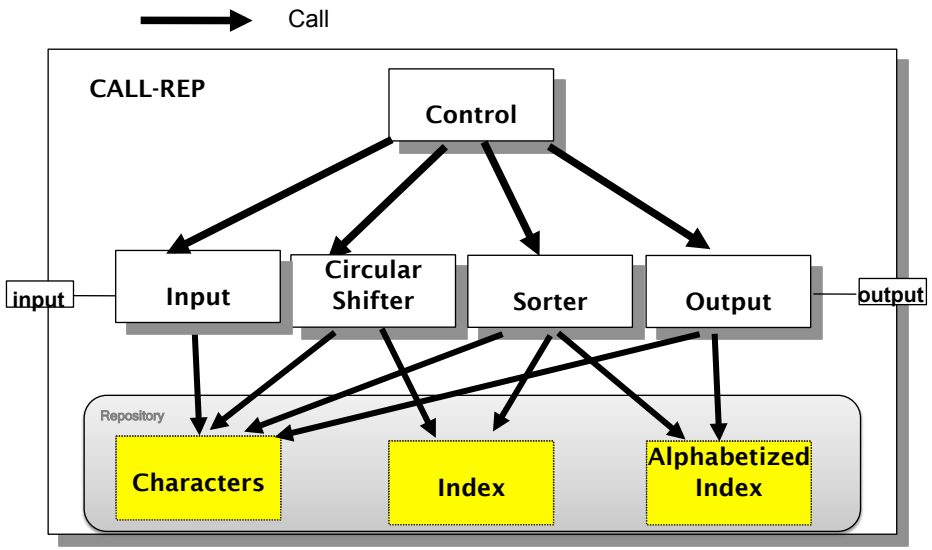
Problem?

- 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

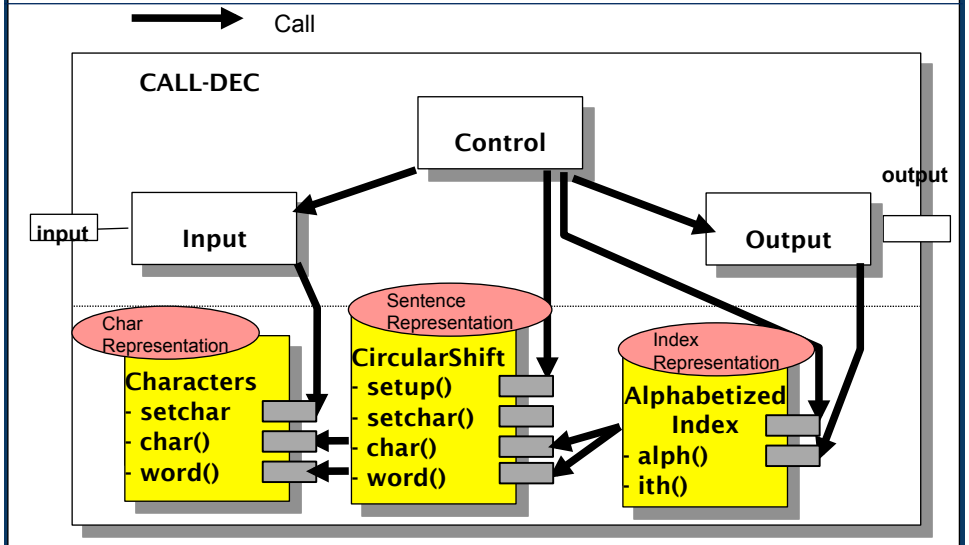
The KWIC Problem in Action-Based Design: Call-Based Style with Shared Repository



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.

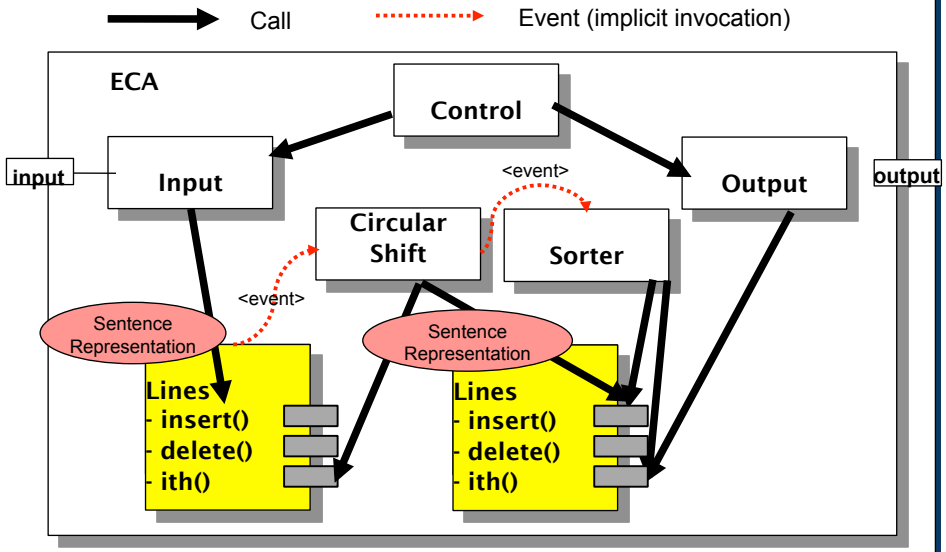
The KWIC Problem in Function-Based Design: (Abstract Data Types with Private Decentralized Memory)



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

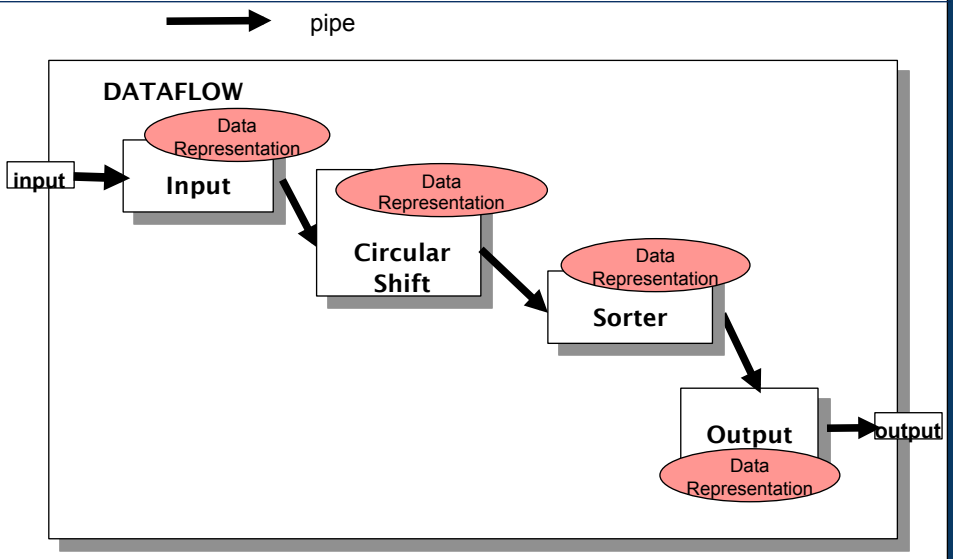
The KWIC Problem in Event-Condition-Action Design (Implicit Invocation Style)



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)