50) Transconsistent Composition and Active Documents for Component-Based Document Engineering (CBDE)

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Literature

- U. Aßmann. Architectural Styles for Active Documents. http://dx.doi.org/10.1016/j.scico.2004.11.006

Overview

- Some problems in document processing
  - And why they require document architecture
- Invasive composition of active documents
- Export declarations as a basis for architecture of active documents
- Features of acyclic, interactive architectures
  - Transconsistency, a novel evaluation concept for active documents
  - Transconsistent architectural styles for active documents
- Conclusions for web engineering

Architecture and Composition

- One of the central insights of the software engineering in the 1990s is:

Separate architecture (composition)
from
the base components

- Purpose: Get a second level of variability
  - Architecture and components can be varied independently of each other
  - Scale better by different binding times of composition programs
  - Be *uniform* for many products of a product family

- However, how to be uniform also for documents?

50.1) Problems in Document Construction

Some Problems 1 – \cite in LaTeX

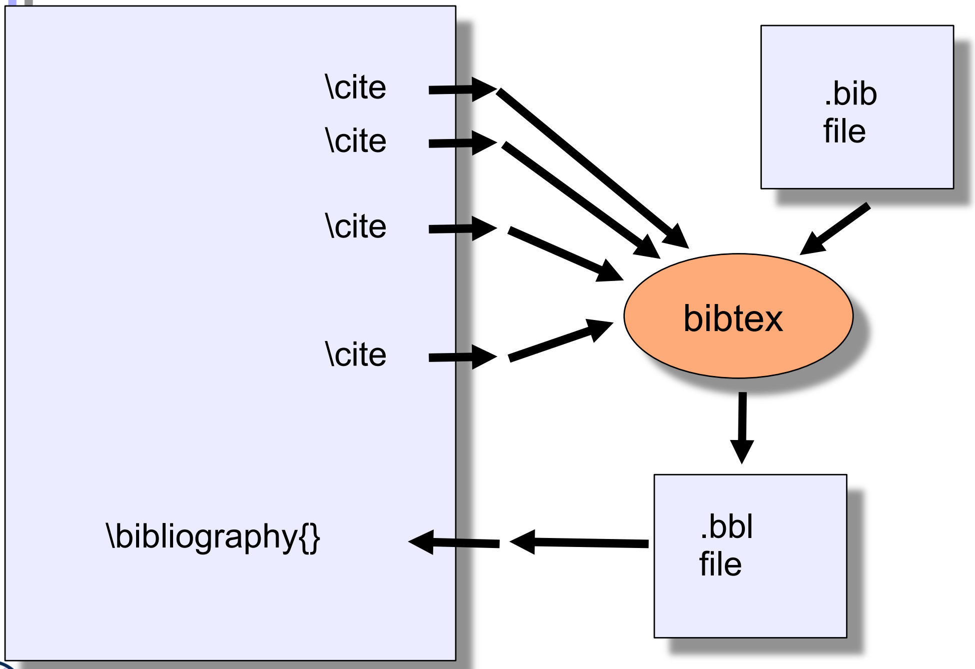
- As already McIlroy.68 has shown, we need components for a ripe industry

```
@InProceedings{ mcilroy.68b,
  author      = "M. Douglas McIlroy",
  title       = "Mass-Produced Software Components",
  booktitl    = "Software Engineering Concepts and Techniques (1968 {NATO}
                 Conference of {S}oftware Engineering)",
  editor      = "J. M. Buxton and Peter Naur and Brian Randell",
  publisher   = {NATO Science Committee},
  pages       = "88--98",
  month       = oct,
  year        = "1968"
}
```

Usual Solution

- Problem: Document is *active*, i.e., contains generated components
- Prodedure:
  - Latex writes citation to .aux-file
  - bibtex greps them and produces a .bbl file
  - .bbl file is included into document
- How does the architecture of a latex document look like that regenerates all generated components?

Maybe Like This...

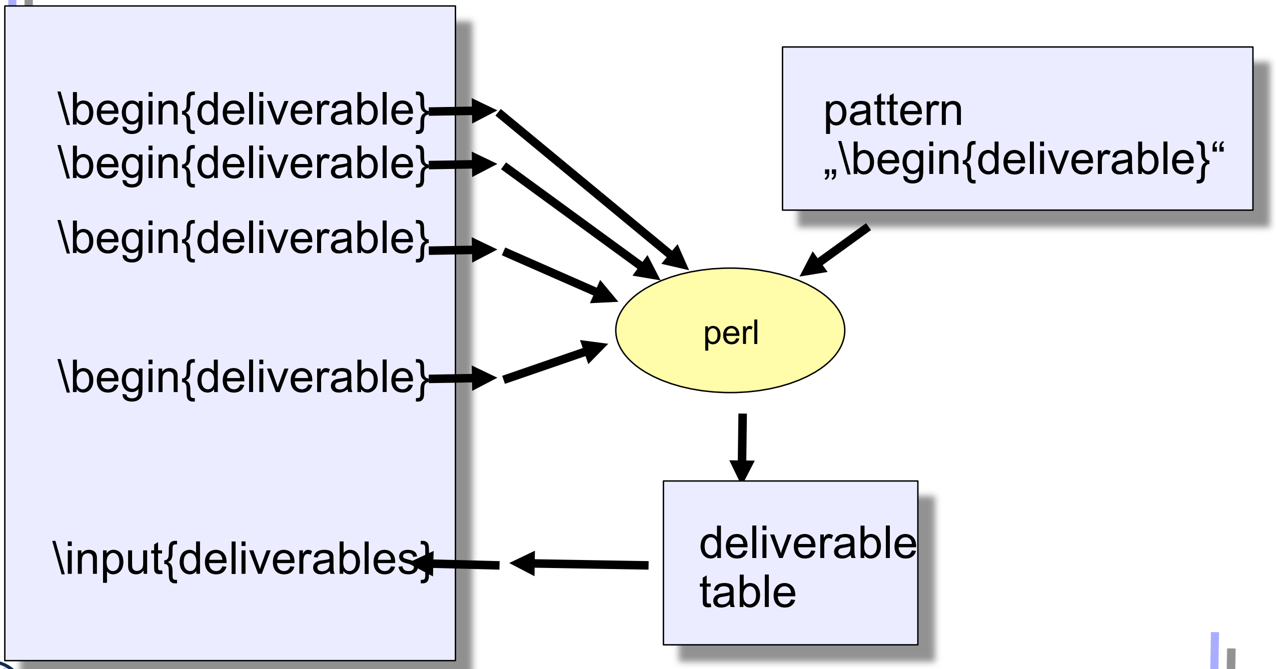


Problem 2 – Deliverable Definitions in LaTeX Project Plan

```
\begin{deliverables}
EASYCOMP workshop I             &\DIS.1.1 &  \UKA & 12 & W & PU & 18 \\
EASYCOMP workshop II            &\DIS.1.2 &  \UKA & 12 & W & PU & 30 \\
Web-based Composition Centre    &\DIS.2 &  \UKA & 3 & H & PU & 36 \\
Composition Handbook            &\DIS.3 & \UKA & 14 & R & PU & 24 \\
Final Report                    &\DIS.4 & \UKA & 6.5 & R & CO/PU & 36 \\
\end{deliverables}
```

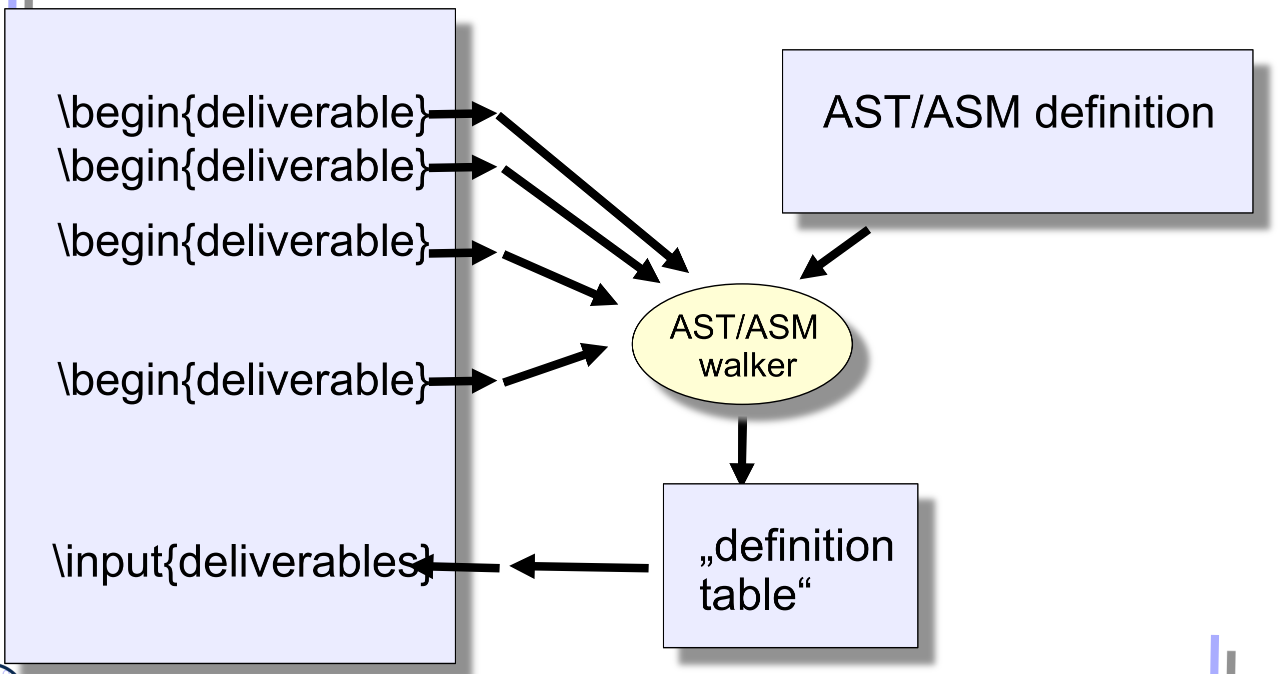
- Procedure:
  - extract deliverables by perl script
  - concat to latex table
  - include table
- How does the architecture of that document look like?

Like This...



Query Should Use the AST/ASM

- Regular expressions are too weak

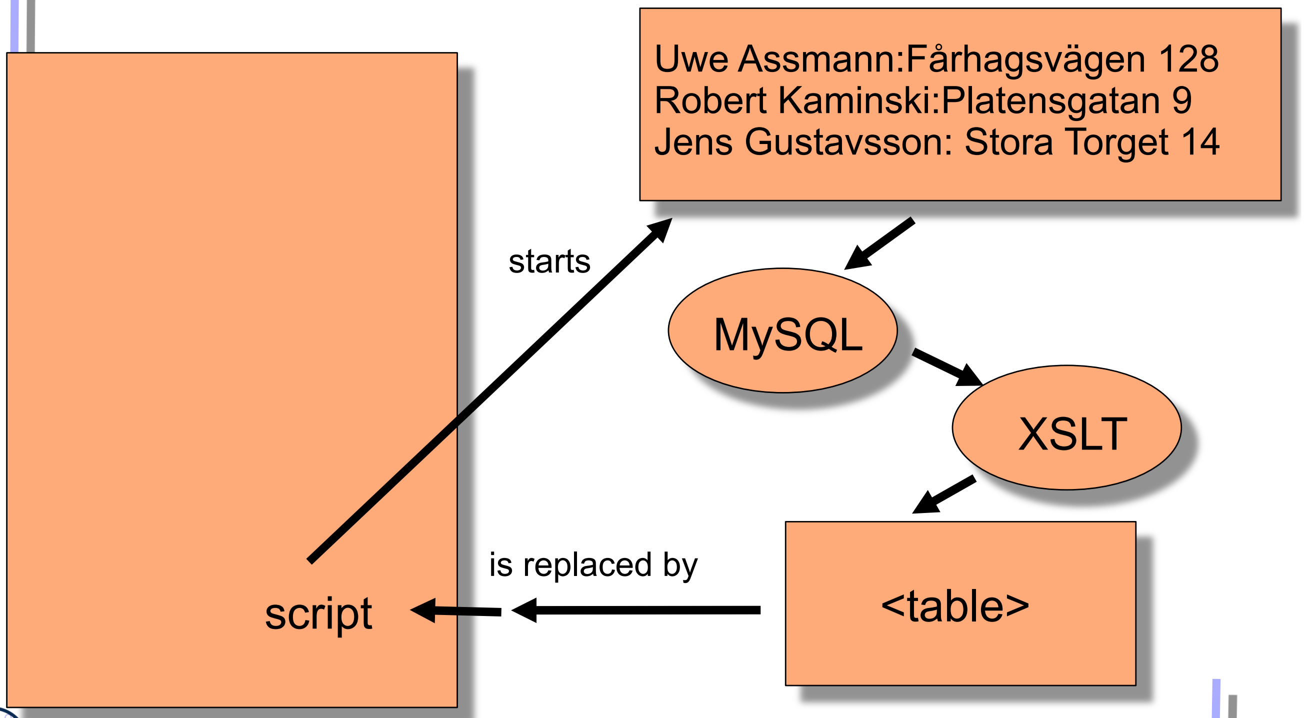


Problem 3 – A Simple Web Page, Generated By a Database

```
<html>
..
<table>
  <tr> <td> Employee </td> <td> Address </td> </tr>
  <tr> <td> Uwe Assmann </td> <td> Farhagsvägen 128 </td> </tr>
  <tr> <td> Robert Kaminski </td> <td> Platensgatan 9 </td> </tr>
  <tr> <td> Jens Gustavsson </td> <td> Stora Torget 14 </td> </tr>
</table>
..
</html>
```

- Procedure:
  - Run the embedded script of an HTML template
  - Start SQL query in MySQL
  - Transform (with XSLT) the plain text to HTML
  - Include table and replace the embedded script
- How does the architecture of that document look like?

Like This...


Uwe Assmann:Fårhagsvägen 128
Robert Kaminski:Platensgatan 9
Jens Gustavsson: Stora Torget 14
starts
MySQL
XSLT
is replaced by
script
<table>

Problem 4: Electra Spreadsheet

- Used for contract negotiations about project budges with the EC
- About 10 summary pages, generated from participant figures
- 4 pages per participant

- No architecture available....

Conclusion

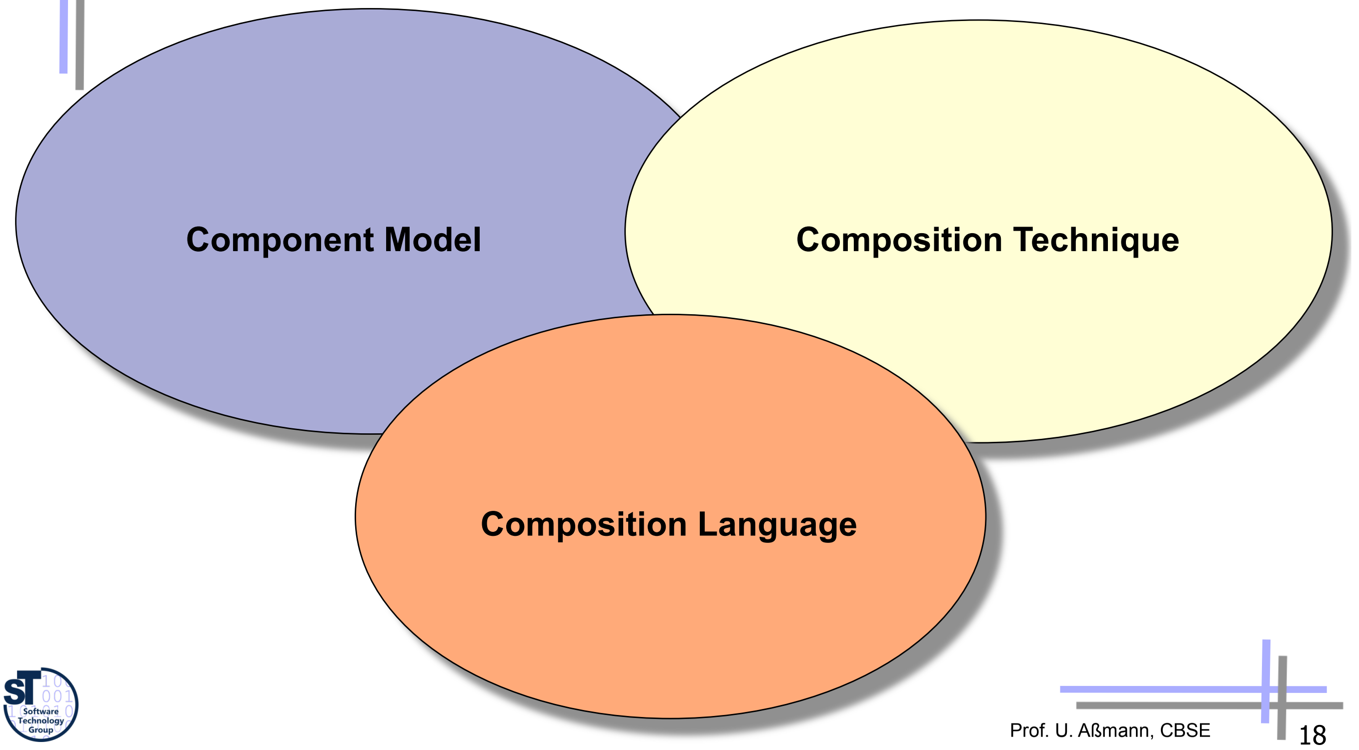
- Why don't we define document architectures?
  - That allows for extracting the architecture and separating it from „components“
- Software architecture and composition have been successful for
  - Developing in the large
  - Software reuse
- Why don't we define a *document architecture language*?
  - That allows for expressing the coarse grain structure of documents?
  - And unify it with software architecture / software composition?

But An Architectural Language For Documents is Difficult..

- Well, connectors as binding elements between components don't suffice
  - It must be composition operations or other mechanisms (such as AG) that glue the components together
  - We need composition languages for uniform composition
- There are some other problems...
  - Invasiveness
  - Transconsistency

50.2) Invasive Composition of Active Documents

The Elements of Composition



Uniform Composition Systems		Universal ISC
Software Composition Systems	Composition Language	Invasive Composition λN-calculus
Systems with Composition Operators	Composition Operators	Composition Filters Hyperslices
Aspect Systems	Aspect Separation	Aspect/J
Architecture Systems	Architecture as Aspect	Aesop
Classical Component Systems	Standard Components	DCOM CORBA Beans/EJB
Object-Oriented Systems	Objects as Run-Time Components	C++ Java Sather
Modular Systems	Modules as Compile-Time Components	Modula Ada-85 C..

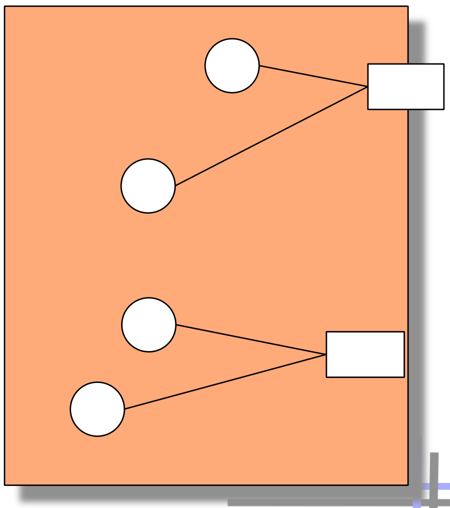
For Active Documents, We Need Invasiveness

- Active documents require invasive patching
- If some parts are changed, others need to be updated
- Question: are there invasive component models?
- Answer: yes

A Greybox Component Model For Uniform Compo

Invasive document composition adapts and extends Document fragment components at hooks by transformation

- A **fragment component** is a fragment group of a document language
  - OpenOffice XML, Word XML, AbiWord, many others
- Uniform representation for
  - Text
  - Pictures
  - Sheets

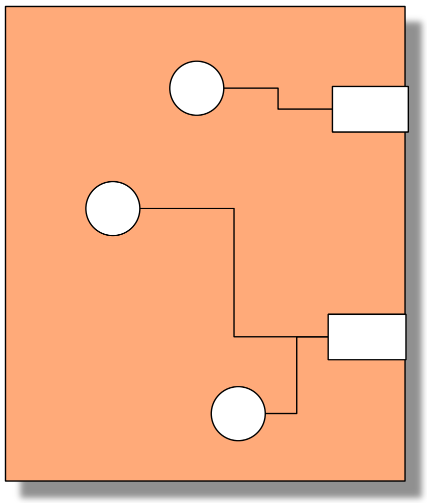


Document Components have Hooks

Hooks are change points of a box: fragments which are subject to change

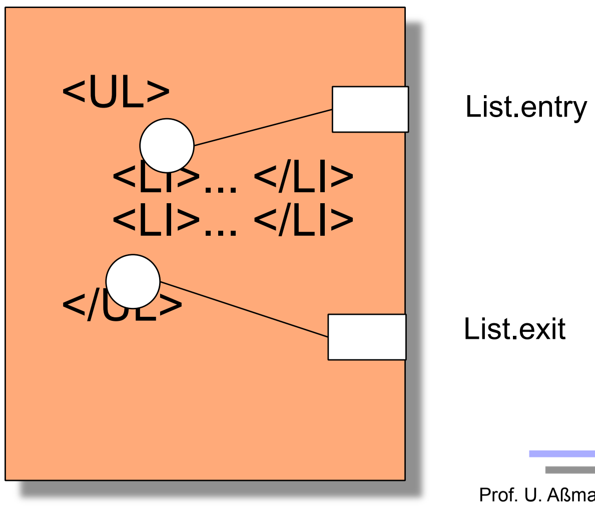
- XML Variation Points
  - beginning/end of tag lists
  - anchors
- Software Variation Points
  - method entries/exits
  - generic parameters

```
<UL>
        <LI>... </LI>
        <LI>... </LI>
</UL>
```



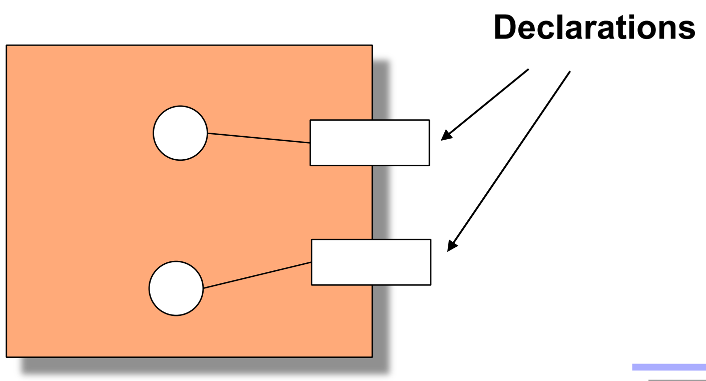
Implicit Hooks For XML

- A **hook (extension point)** is given by the document language
  - In XML given by the DTD or Xschema
- Hooks can be *implicit* or *explicit (declared)*
  - We draw implicit hooks *inside* the component, at the border
- Example List Entry/Exit



Slots (Declared Hooks)

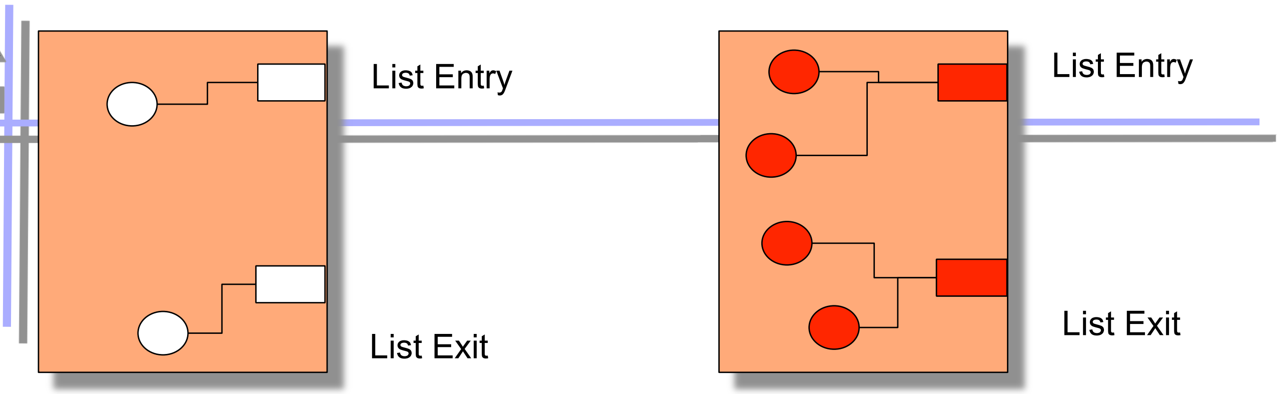
- A **slot** is a variation point (a code parameter)
- Slots are always *declared,* i.e., declared or explicit hooks
  - They are never implicit, i.e., must be declared by the component writer
  - We draw slots as crossing the border of the component



The Composition Technique of Invasive Composition

- A composer is a tag transformer from unbound to bound hooks
  composer: box with hooks --> box with tags

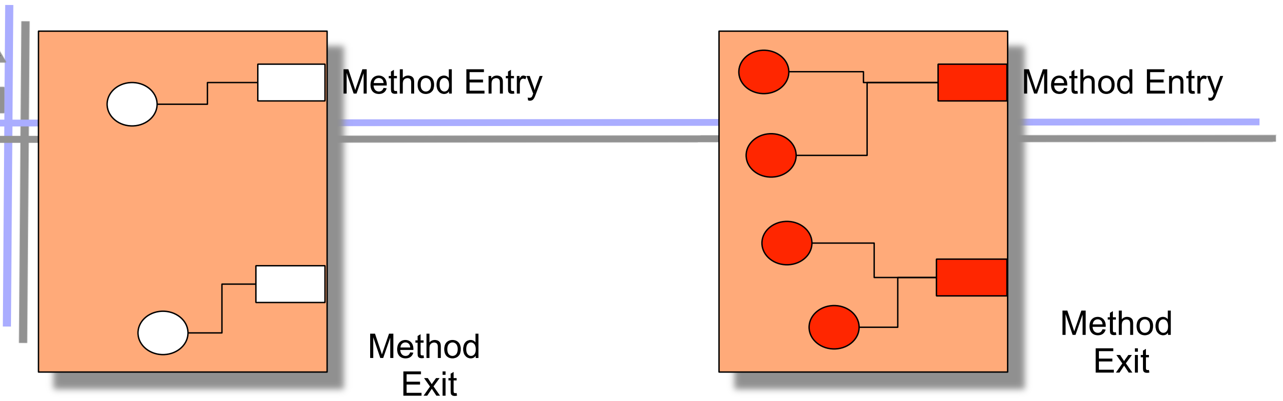
Invasive Document Composition
parameterizes and extends
document components
at hooks
by transformation



```
<UL>

    <LI>... </LI>
    <LI>... </LI>

</UL>
```

```
<UL>
    <LI>... </LI>
    <LI>... </LI>
    <LI>... </LI>
    <LI>... </LI>
</UL>
```

```
box.findHook(„ListEntry“).extend(„<LI>... </LI>”);

box.findHook(„ListExit“).extend(“<LI>... </LI>”);
```

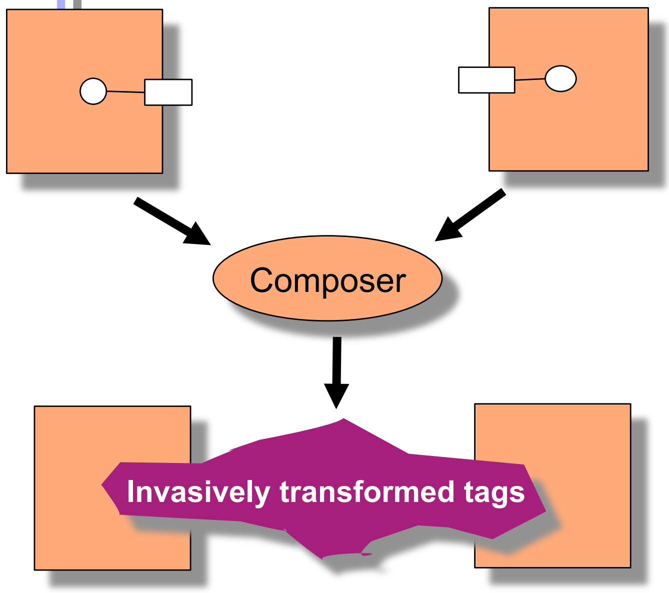


```
m (){

    abc..
    cde..

}
```

```
m (){
    print(“enter m”);
    abc..
    cde..
    print(“exit m”);
}
```

```
box.findHook(„MethodEntry“).extend(“print(\”enter m\”);”);

box.findHook(„MethodExit“).extend(“print(\”enter m\”);”);
```

Invasive Composition



- Invasive Composition works uniformly over code and data
- Allows to compose XML documents uniformly
- Extend operation implements what we need for document architectures

Basic Operations on Hooks

- bind (parameterize)
- extend
- rename
- copy

50.3 Explicit Invasive Architectures for Active Documents

Documents Must be Decomposed

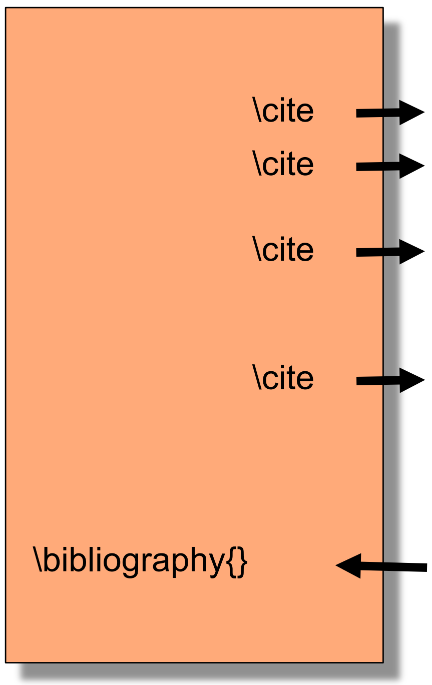
- For architecture of active documents, we need fragment *composition* and *decomposition*
- For fragment-based composition of documents, other documents need to be decomposed
  - Fragment extraction
  - Fragment selection or query
  - Fragment component search
  - A *fragment query language* is needed
- In the simplest case, components export all fragments (white-box)
  - Visibility can be controlled by *fragment export languages* forming export interfaces

Fragment Query Languages

- A *exported fragment* (provided fragment) is defined by a component of an active document and exposes to the external world
- The programmer declares the exported item in
  - a *fragment export language*
    - a markup language (explicit definition, embedded)
    - Often the explicit specification of exports of fragments is too cumbersome
  - a *fragment query language*
    - a match language (implicit definition, exbedded), to select fragments from a component
    - a query language (implicit definition, exbedded)
    - a position addressing language (implicit, exbedded)
- In whitebox reuse, fragment export and query language coincide

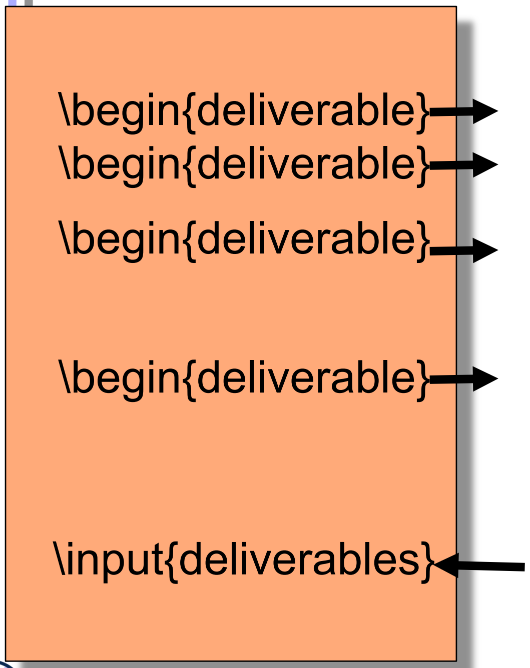
Export (and Query) Language 1

- Basic Operation to Extract Fragments:
- `Match: ExprInQueryLanguage → ExportedDefinitions`



Example 1:
Query language
Regular expressions like
\cite{.+}

Export (and Query) Language 2



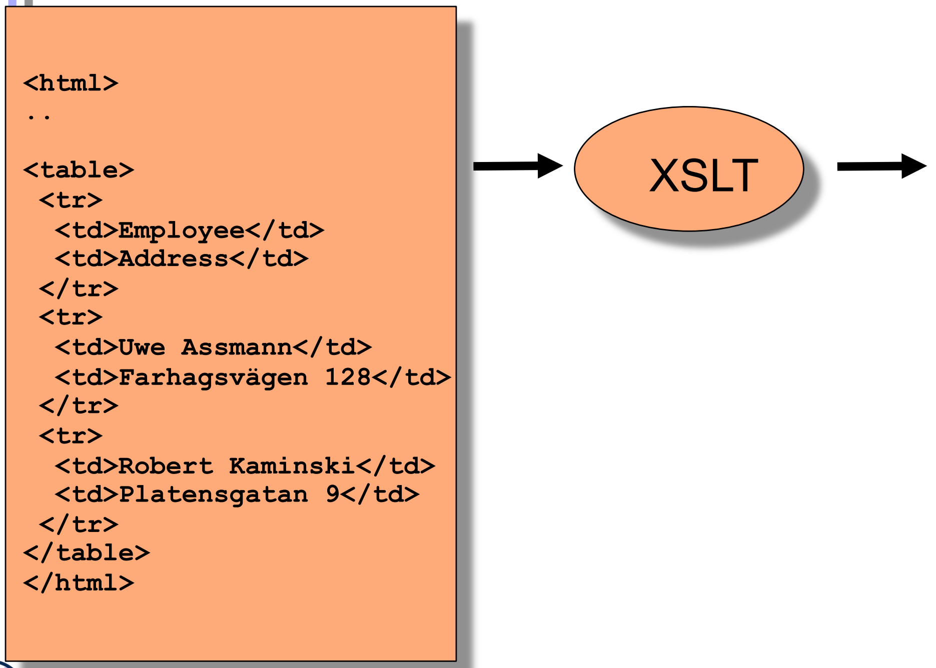
Query language based on AST/ASG, together with regular expressions

Query Language 3

Uwe Assmann:Fårhagsvägen 128
Robert Kaminski:Platensgatan 9
Jens Gustavsson: Stora Torget 14

Query language:
Relational algebra,
started by script

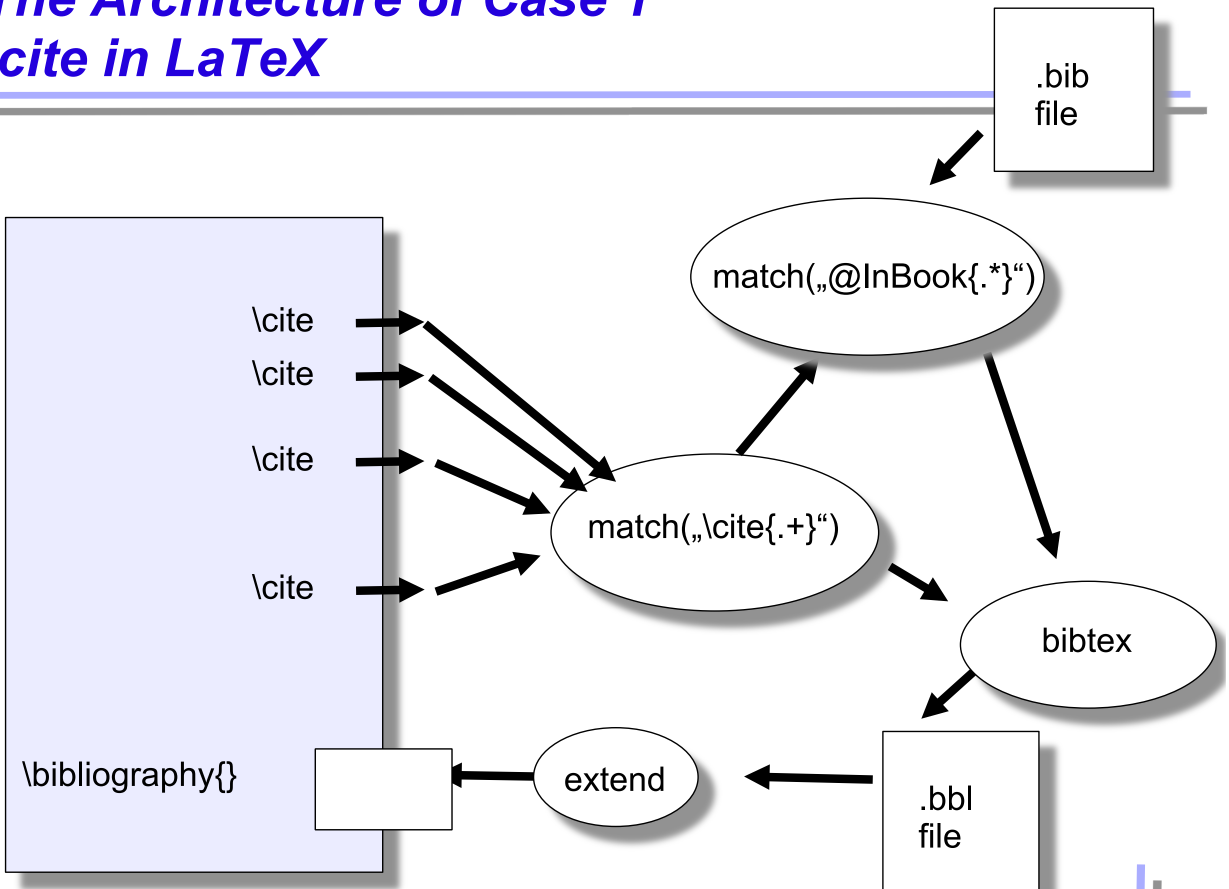
Another query Language is XSLT


```
<html>
..

<table>
 <tr>
  <td>Employee</td>
  <td>Address</td>
 </tr>
 <tr>
  <td>Uwe Assmann</td>
  <td>Farhagsvägen 128</td>
 </tr>
 <tr>
  <td>Robert Kaminski</td>
  <td>Platensgatan 9</td>
 </tr>
</table>
</html>
```

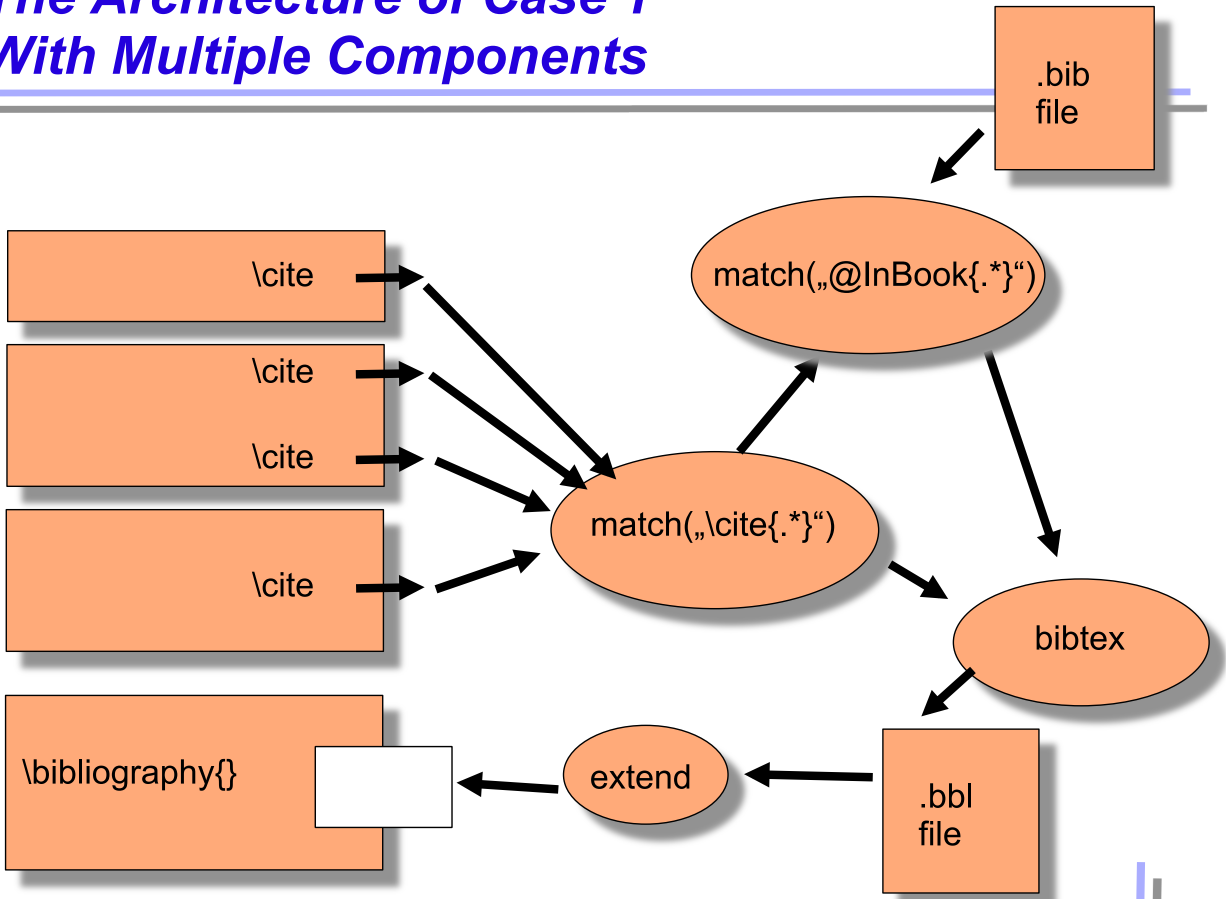
Basic Operations on Hooks of Active Documents

- bind (parameterize)
- extend
- rename
- copy
- match

The Architecture of Case 1
\cite in LaTeX



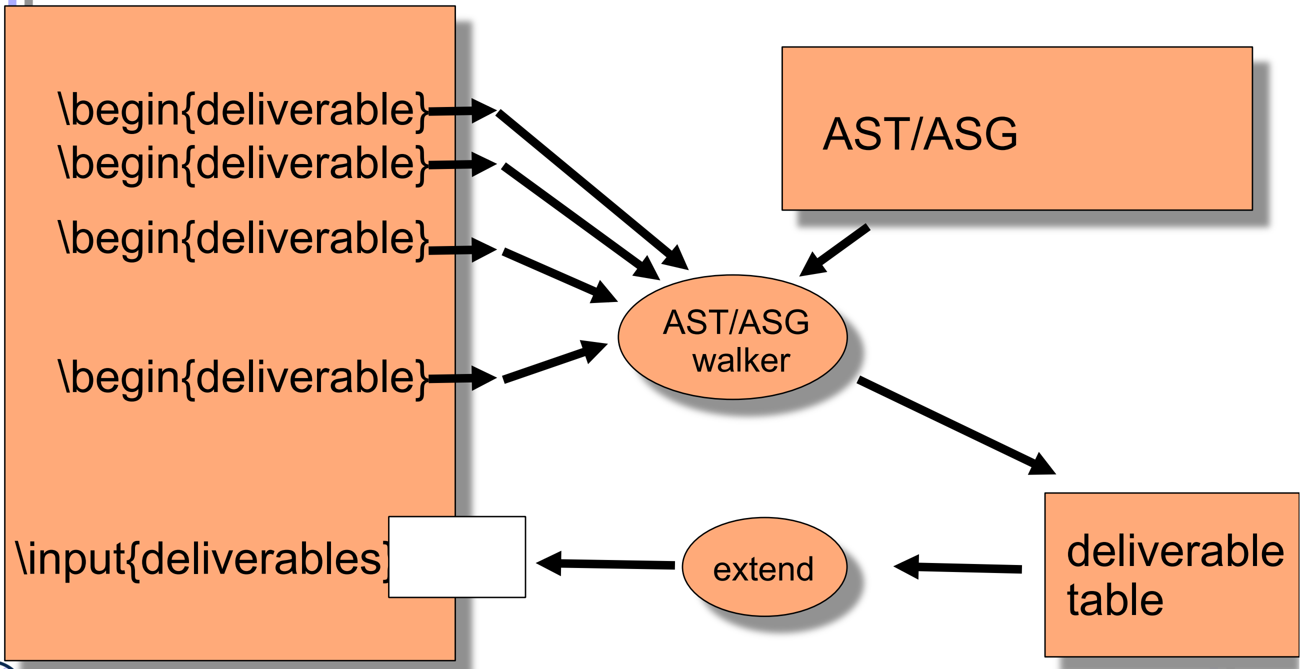
The Architecture of Case 1
With Multiple Components



Advantages of Export Declarations For Example 1

- We have extracted the document's architecture
- LaTeX becomes simpler
  - query is separated into the composition level
- Standard language to write the compositions
  - no architectural language required
- Documents are real components, with a composition interface

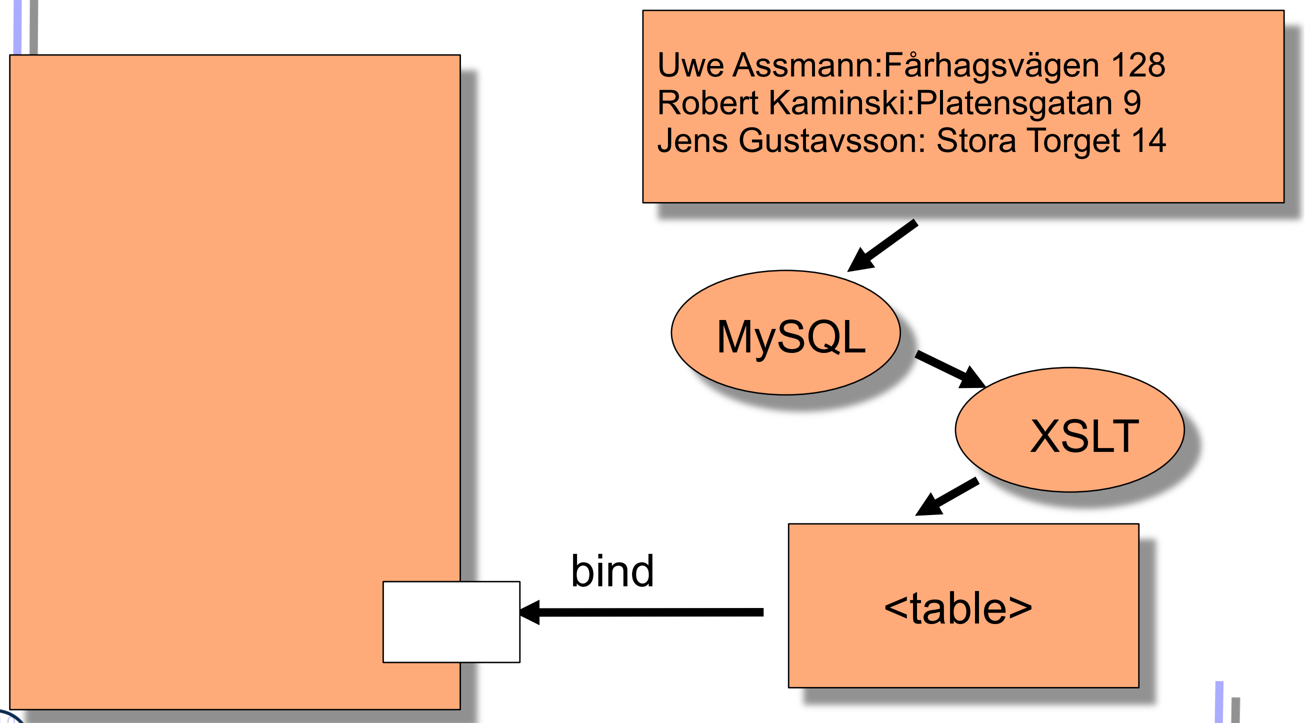
The Architecture of Case 2 Deliverables



Advantages for Example 2

- LaTeX cannot interprete the AST
  - and cannot treat relational algebra either
- We can employ many different definition (query, markup) languages
- We can employ many different connection and composition languages
  - and write connectors with them
- Flexible composition approach

The Architecture of Case 3 Database-driven Web Document


Uwe Assmann:Fårhagsvägen 128
Robert Kaminski:Platensgatan 9
Jens Gustavsson: Stora Torget 14
MySQL
XSLT
<table>
bind

Advantages of Architectures for Active Documents

- Better reuse
  - Scripts are removed from HTML pages
  - The template can be reused in other contexts where the table expansion is not required
- A lot of embedded scripts in HTML is composition code
  - let's move it out!
- Simplifying web engineering

Afterthought: What Flows Through an Active Document

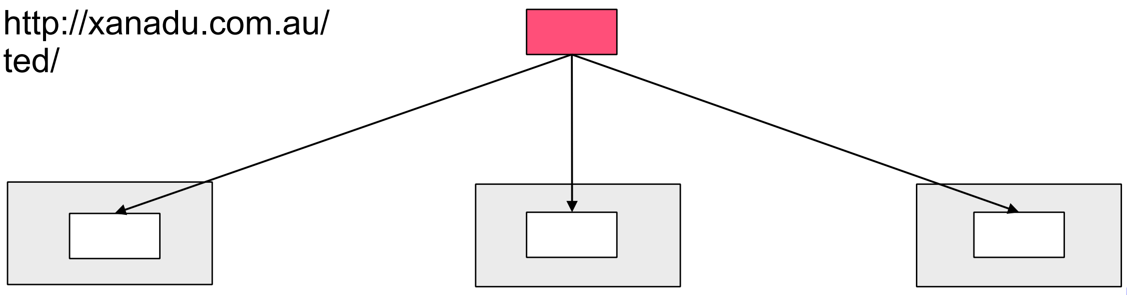
- In contrast to a software architecture, in active documents document fragments flow
  - Like in a spreadsheet, the dataflow graph is acyclic (spreadsheet-documents)
  - Generation and modification of values are modeled with export declaration languages (script languages)
- In contrast to a software architecture, the values only change when the user changes a component
  - Pushed once through that graph, the document is updated
  - Transclusion works for dataflow graphs!
- **Requirements for Active Document Architectures**
  - *Fragment queries* or export definitions
  - *Invasive embedding* of results
  - *Hot update* of all computations (aka transconsistency)

50.4) Transconsistency – A New Architectural Principle for Hot Update in Composed Active Documents

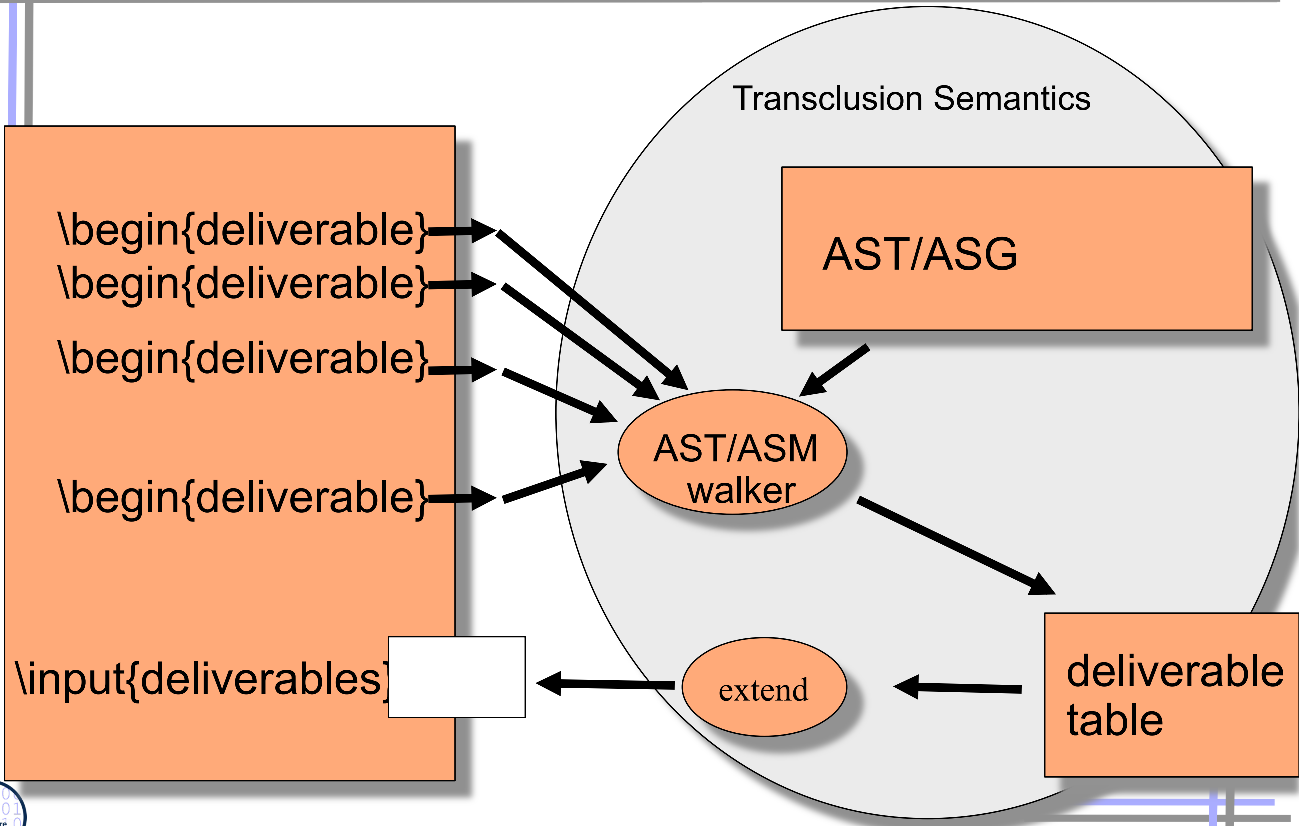
Transclusion

- Transclution is *embedded sharing of document components in distributed edits*
  - Invented by Ted Nelson, the inventor of hypertext
- „hot update“ (incremental update)
  - Every change in a definition is immediately shared by all uses
  - Realized by reference and special edit protocols
  - Semantics is between call by name and call by value
- Nelson says: “That's what the computer is all about”

http://xanadu.com.au/ted/



Hot Update is Necessary in Active Documents



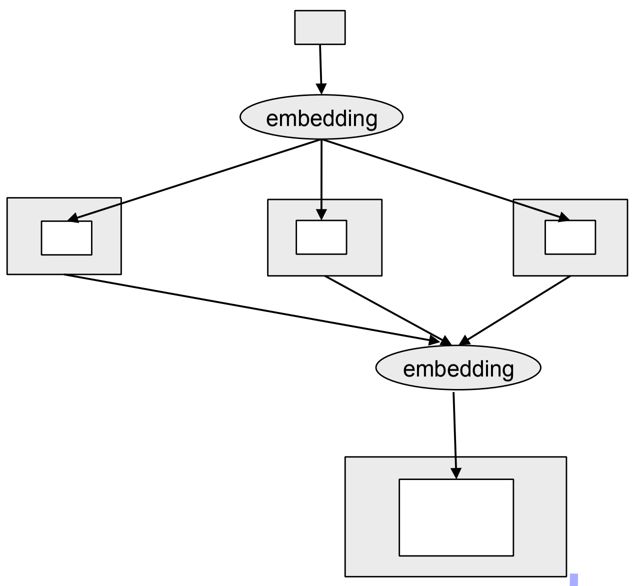
Transconsistency of Active Documents (Immediate Update)

- The architecture of an active document should obey *immediate* (*hot) update (transconsistency)*
  - Transclusion only deals with equality of hooks, but does not treat operations or modifications
  - Dependent components must be updated immediately
- For transconsistency, transclusion is a basis
  - Transconsistency requires a data-flow graph over operations in the document, i.e., a data-flow-based architecture
  - Whenever the input of a slice of the data-flow graph changes, recompute the result by reevaluating the slice
- Transconsistency requires invasive embedding
  - The component model of an active document must be graybox, otherwise embeddings are not possible

50.4.1. A Graph-Theoretic Definition of Transconsistency

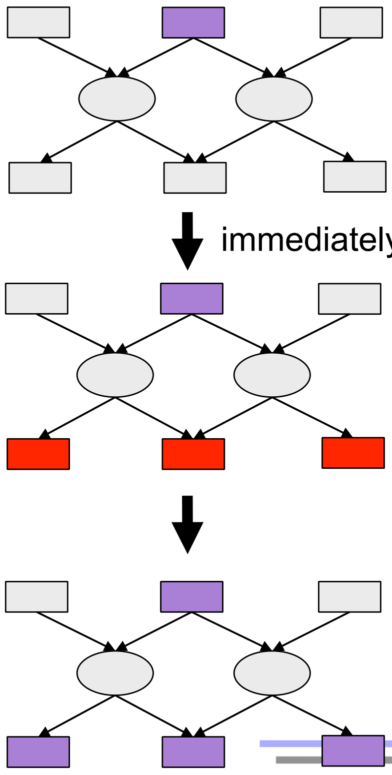
Transclusion in Flow Graphs of Embedding Operations

- Let D be a dataflow graph of *embedding operations*, a bipartite graph of EmbeddingOperations and Values.
- D is called *transclusive,* if:
  - If an input value changes, all dependent values are declared inconsistent immediately, until they are reembedded



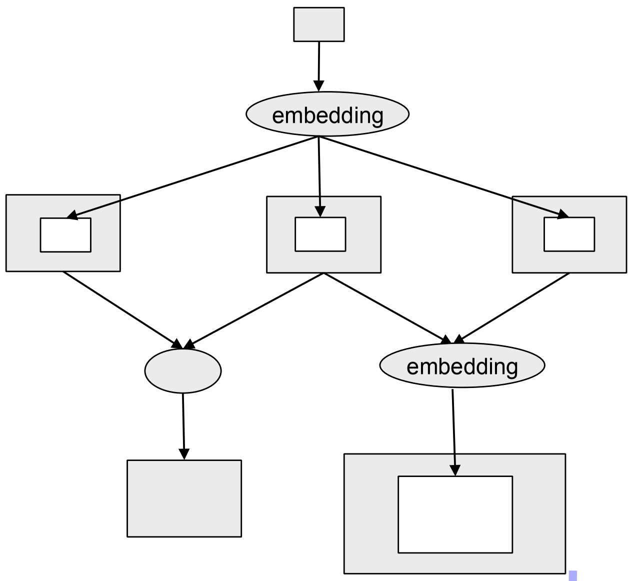
Transconsistency in Data Flow Graphs

- Let D be a dataflow graph, a bipartite graph of Operations and Values.
- D is called *transconsistent,* if the *hot update condition* is true:
  - If an input value changes, all dependent values are declared inconsistent immediately, until they are recomputed



Transconsistency in Active Documents

- Let A be an active document with an underlying dataflow graph D for document parts.
- Then, D is called the *architecture* of A.
- A is called *transconsistent,* if D is transconsistent



Transclusion and Transconsistency

Transclusion
=
Invasive Embedding +
Incrementality (hot update)

Transconsistency
=
Transclusion +
Data flow graph

Transconsistent Architecture
=
Transconsistency + Architecture

Transconsistency Goes Beyond Transclusion

- Transclusion only treats embedding and hot update
- It does not treat
  - Operations beyond embedding
  - Data flow graphs of these operations
  - Components

Examples for Transconsistency

Spreadsheets: A spreadsheet relies on a dataflow graph (pipe-and-filter)

- It is a set of slices, i.e., a set of expressions, or scriptlets
- A scriptlet describes a dataflow graph of operations
- Every slice is independent, i.e., can be recomputed independently

- Spreadsheets are simple active document with transconsistency, i.e., immediate update
- Spreadsheets do not have architecture
  - No component model nor composition interface

Web Documents: Servlet-based documents rely on re-expansion if users change forms or templates

- The servlets span up a data flow graph
  - Templates and form inputs are the inputs
  - Result pages the output
- The regeneration is an implementation of transconsistency

50.4.2 Transconsistent Architectures

Uniform Composition of Active Documents with Staging and Transconsistency

Transconsistent Documents

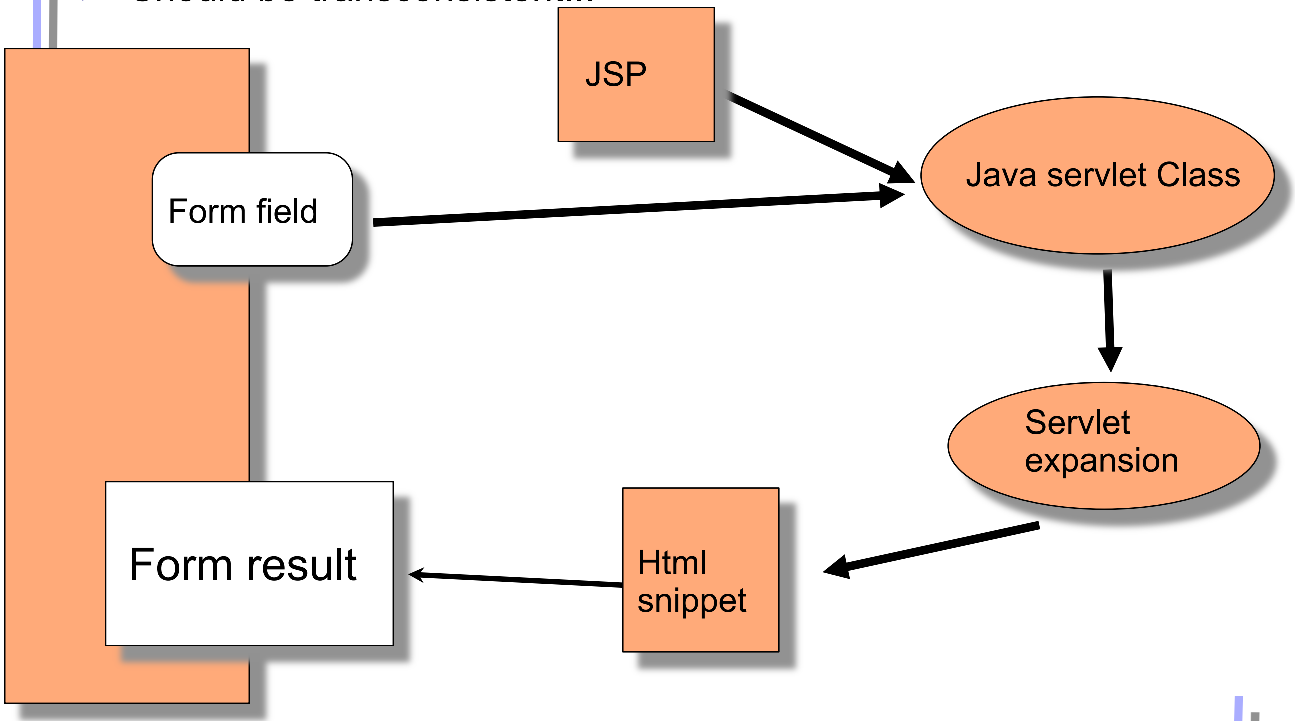
- *Transconsistent documents* are active documents with explicit *transconsistent architecture*
  - Like spreadsheets, but with explicit architecture
  - Based on a
    - Dataflow graph
    - Graybox component model (invasive embedding)
    - Incrementaility (Hot update)
- Purpose of Transconsistent Architectures
  - Transconsistency copes interactive editing
  - This is fundamentally different to the so-far batch-oriented style of software construction, software build, and software execution
  - Transconsistency is needed in software editing, too

50.5 Transconsistent Architectural Styles

Composition of Active Documents with Staging and Transconsistency

Web Form Processing with JSP

- Should be transconsistent...



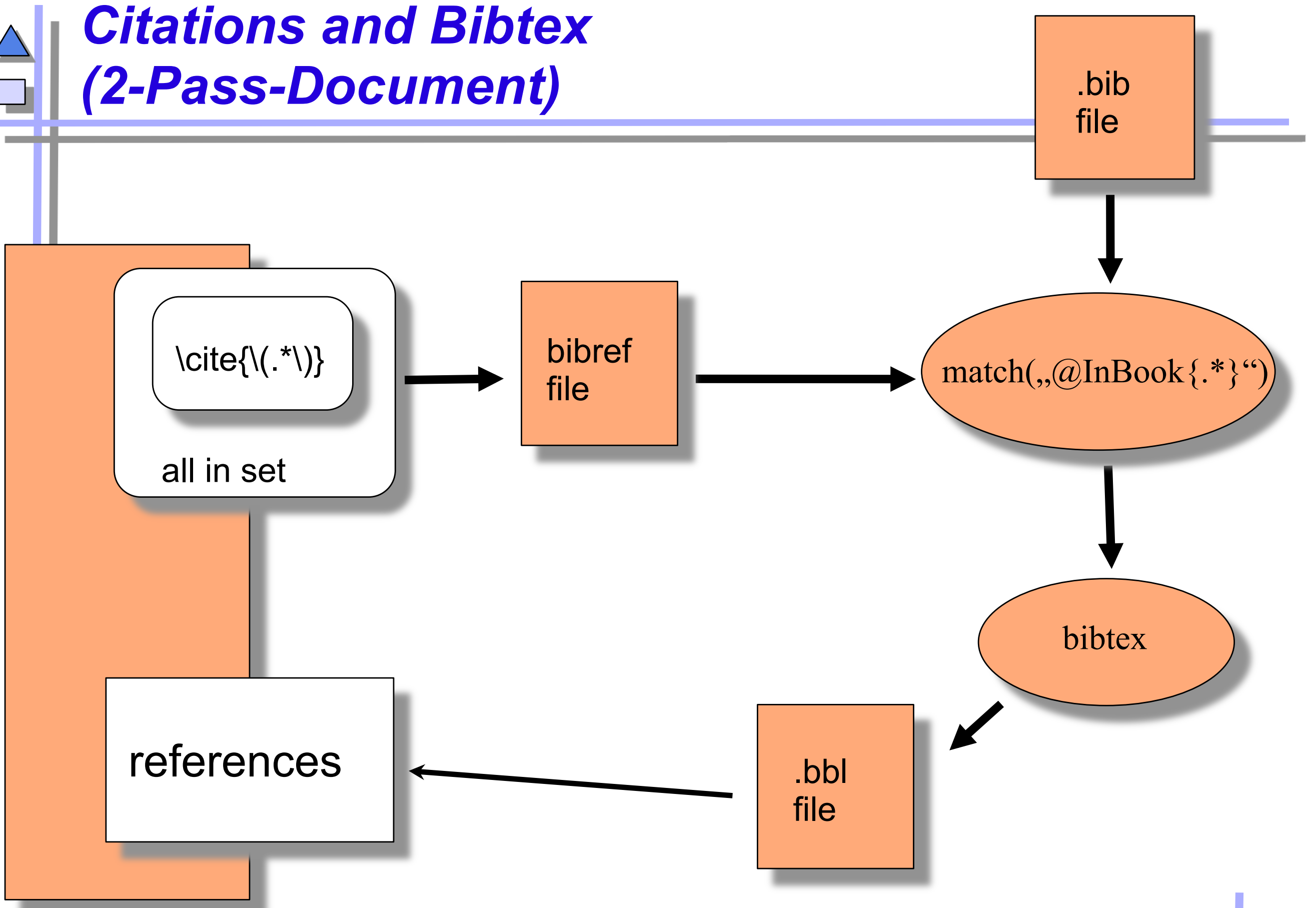
Spreadsheet-documents and Pipe-And-Filter Architectures

- **Spreadsheet-Documents:** A **spreadsheet-document** is a an active document with a pipe-and-filter architecture
  - Resembles spreadsheets
  - The question is how often the filter architecture is evaluated for transconsistency
  - A web form (e.g., JSP) is a *distributed spreadsheet-document*

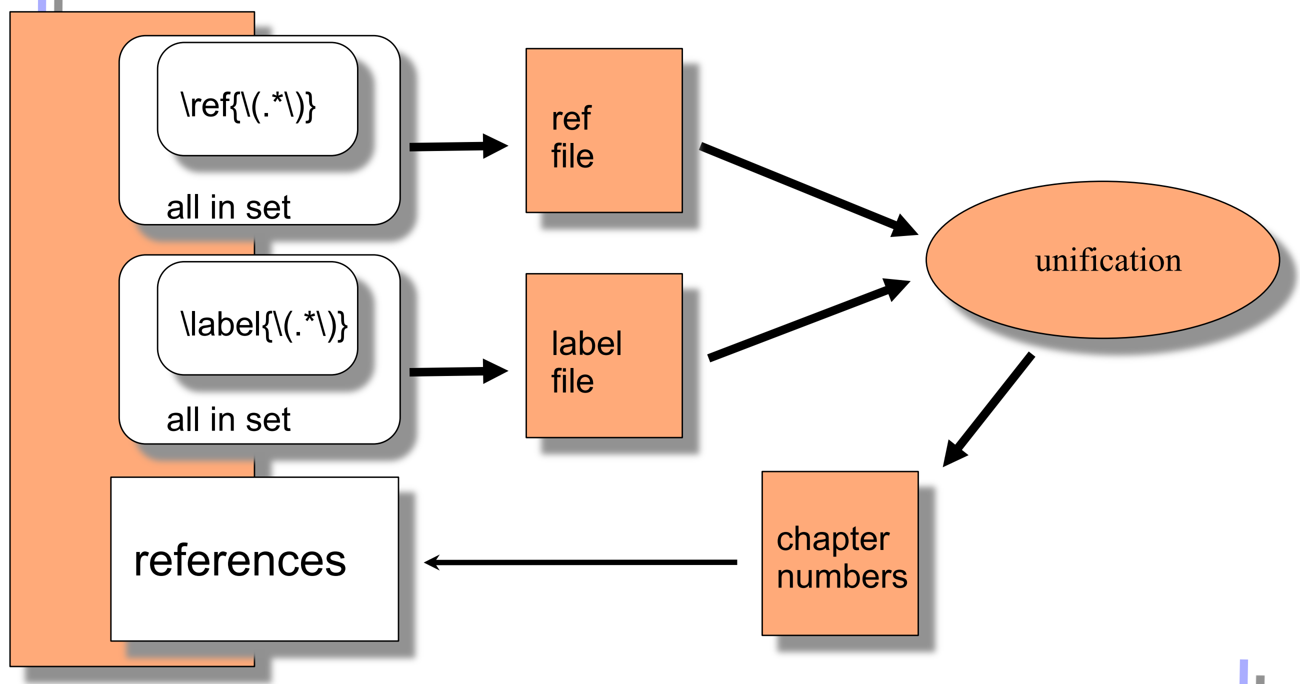
2-Pass Transconsistent Documents

- Transconsistent documents underly a dependency graph for their update
  - This dependency graph must be acyclic
- Evaluation classes for transconsistent documents
  - 1-pass problems along the document (all definitions before uses)
  - 2-pass (backpatch problems) along the document
  - Statically orderable along the dependencies (similar to wavefront or OAG)
  - Form processing

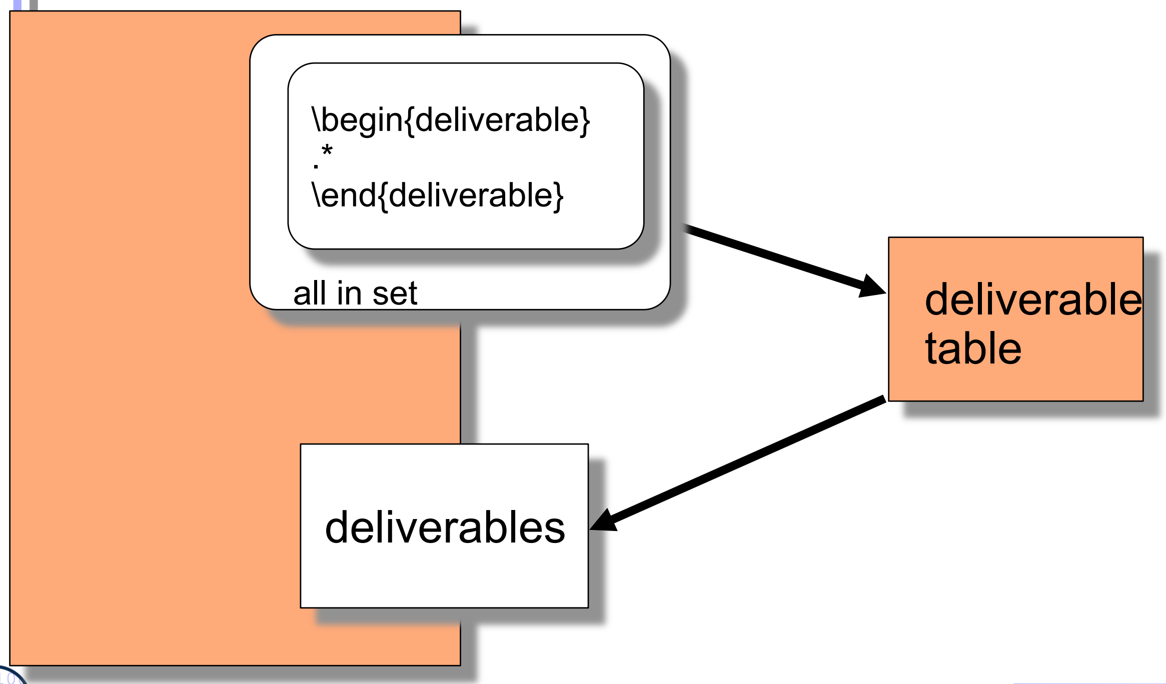
Citations and Bibtex (2-Pass-Document)



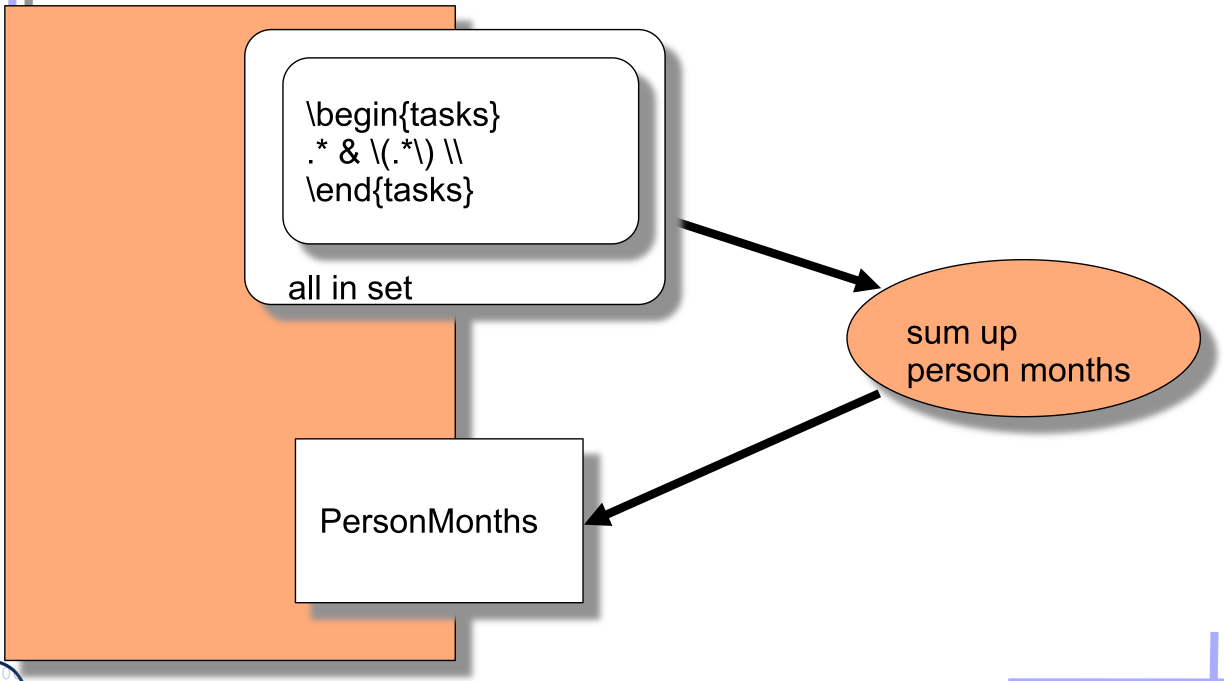
References (2-Pass-Document)



Central Tables (2-Pass-Document)



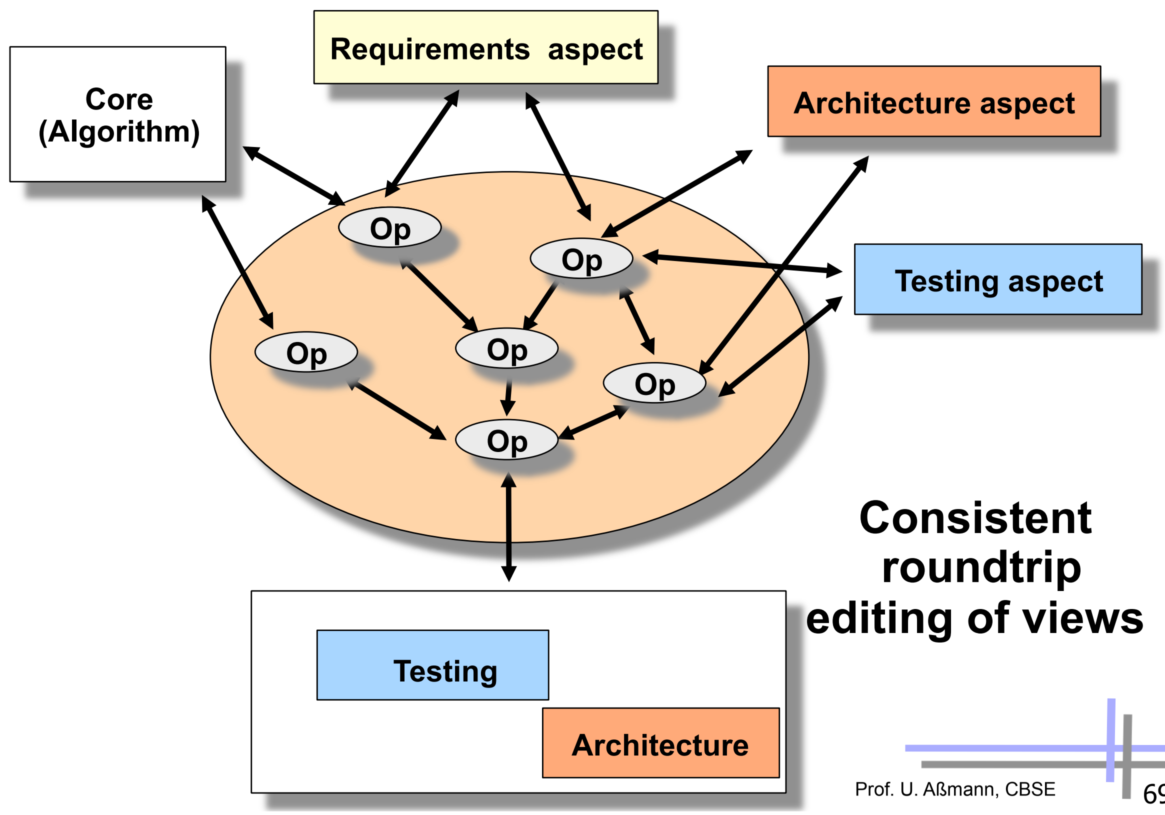
Person Cost Calculation Central Tables (2-Pass-Document)



Stream-Documents (Spreadsheet Documents with Pipe Ports)

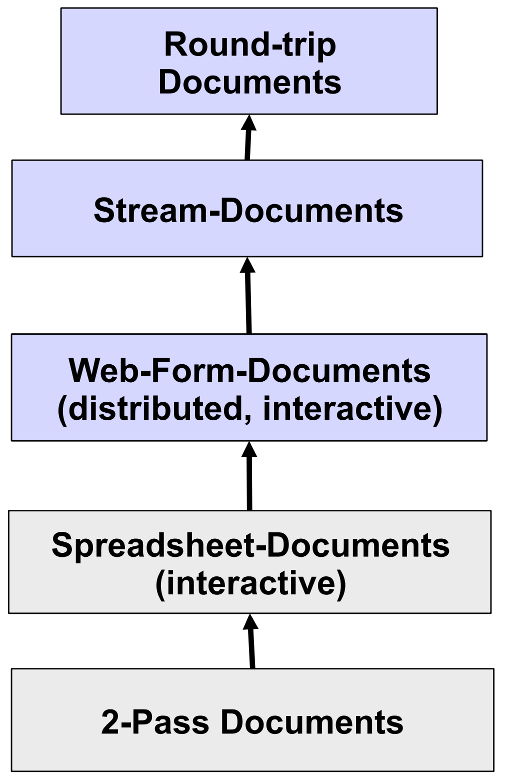
- Instead of being a closed document, spreadsheet-documents can be open in the sense that they take in data streams over stream ports
  - START submission phase
  - START reviewing phase
- Such a change corresponds to a document extension, but works via communication channels/connectors
- User changes and sends via ports are the similar effects
  - User change: change component values
  - Send via ports: change from external world

Transconsistent Documents: Roundtrip Engineering Documents



Consistent roundtrip editing of views

Transconsistent Architectural Styles for Active Documents


Round-trip Documents
Stream-Documents
Web-Form-Documents (distributed, interactive)
Spreadsheet-Documents (interactive)
2-Pass Documents

Benefit of Transconsistent Architectures For Active Documents

Advantages of Transconsistent Active Documents

- Beyond standard document models (such as OLE):
  - Explicit distinction between architecture and content
  - Better reuse
  - Can be combined with staged composition for Web engineering
- Beyond spreadsheets:
  - Full table and sheet extension, not only value transconsistency (table extension hot update)
- Beyond template-based documents:
  - Decentralized definition of databases/relations
- Benefits for Web Engineering
  - Transconsistent active documents provide a first unified model for web- and document engineering
  - Beyond simple approaches such as JSP, ASP
  - Improvement of quality:
    - Documentative due to architecture
    - Gets rid of the spagetti code in web engineering

Summary

- For engineering of active documents, explicit distinction of architectures is important
  - Invasive embedding is required
  - Data flow graphs are required
- Transconsistent architectures are an important architectural styles for active documents
  - Rely on an extended concept of transclusion
  - Cope with streams of interactive input

The End