A Unifying Formal Basis for the Sensoria Languages

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Information Society Technologies

Content

- Introduction
- Modeling service oriented architectures
- Modeling service oriented calculi
- A general view

- SENSORIA Architecture level
  - High-level specification languages and frameworks
    - UML4SOA
    - SRML
    - Service Modes
  - Guaranteed reconfigurations
- SENSORIA Service-Oriented Calculi level
  - Process algebras & Process calculi approaches
    - SAGAS
    - CaSPiS
  - Sound and Complete graphical encoding

Graphs Are Everywhere

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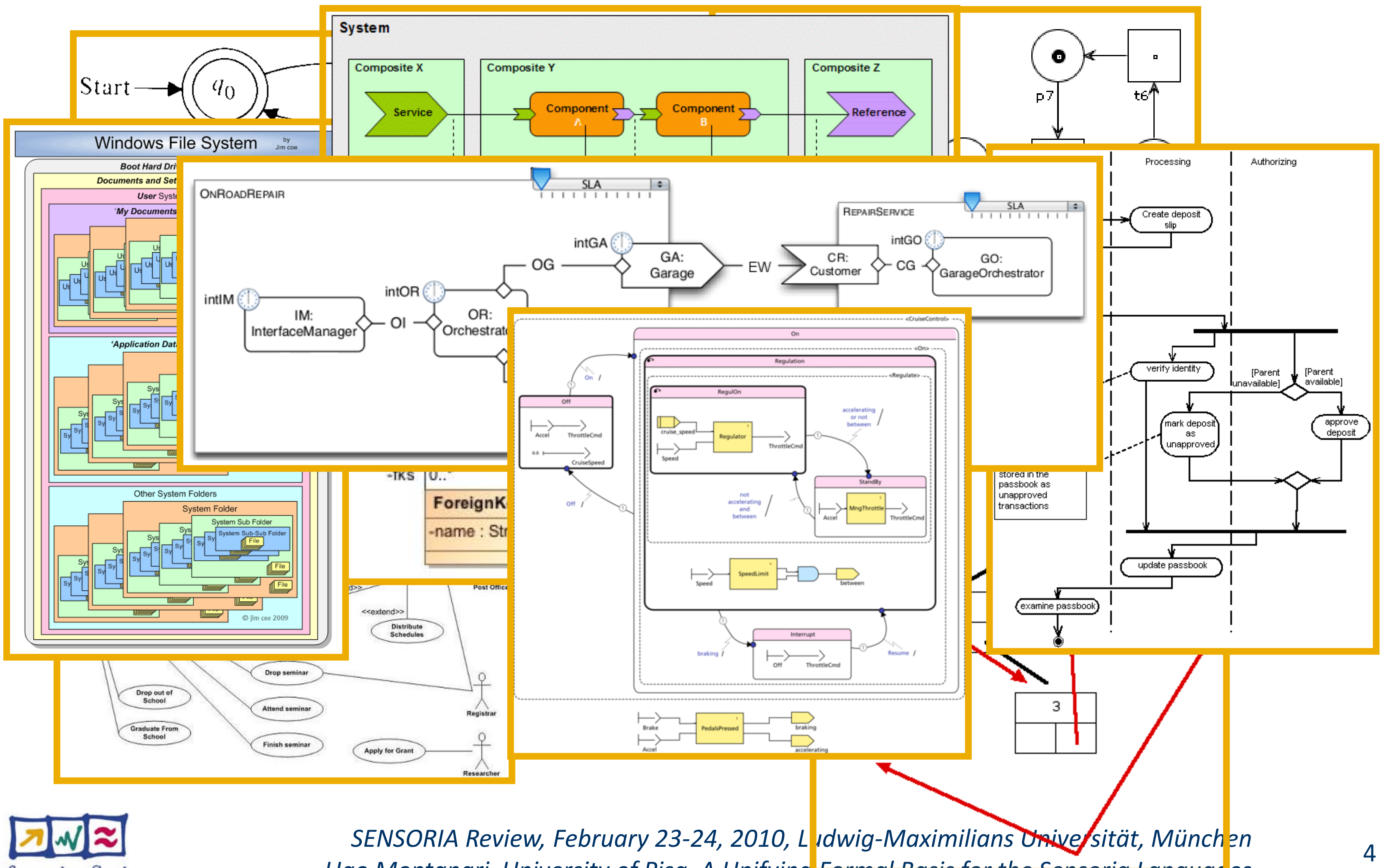
- Use of diagrams / graphs is pervasive to Computer Science



Architectural Design Rewriting (ADR)

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- ADR formulas:
  - ADR = Designs + Term Rewriting
  - Designs = Typed Hierarchical Graphs (with Interfaces)
- ADR ingredients:
  - Sorts: Vocabulary, Types (edge and node labels)
  - Values: Designs (hierarchical graphs with interfaces)
  - Operations: Graph-grammar-like rules
  - Terms: proofs of construction
  - Terms (with variables): partial Designs, partial proofs
  - Axioms: properties of operations
  - Membership predicates: additional style rules
  - Rewrite rules: behaviour, reconfigurations
  - Rewrite strategies: style conformance, style analysis, etc.

Hierarchical Graph Models

- Why graph models?
  - More natural for distributed systems
  - Built-in structural axioms (e.g. name handling, AC axioms)
  - Uniform treatment of most ordinary process algebras (e.g. via the SHR approach)
- Why hierarchical?
  - Nested structures: ambients, block structure, sessions, transactions, etc.
  - Interaction between siblings, without referring to the closest common ancestor
- Yet another graph model?
  - Bigraphs by Robin Milner (2003)
    - place graph for localities and link graph for connectivity
    - Semantics via reduction rules and minimal contexts
  - Gs-monoidal graphs (gs-graphs) by Ferrari and Montanari (1997)
    - Based on gs-monoidal categories by Corradini and Gadducci
  - Top view & side view
- ADR metamodel and Design Algebra:
  - algebras of hierarchical graphs with graphical representations
- Applications to Sensoria
  - ADR modeling of UML4SOA, SRML, Modes
  - DA modeling of process calculi: transaction workflows (Sagas), service sessions (CaSPiS)
  - Reconcile Top view & Side view

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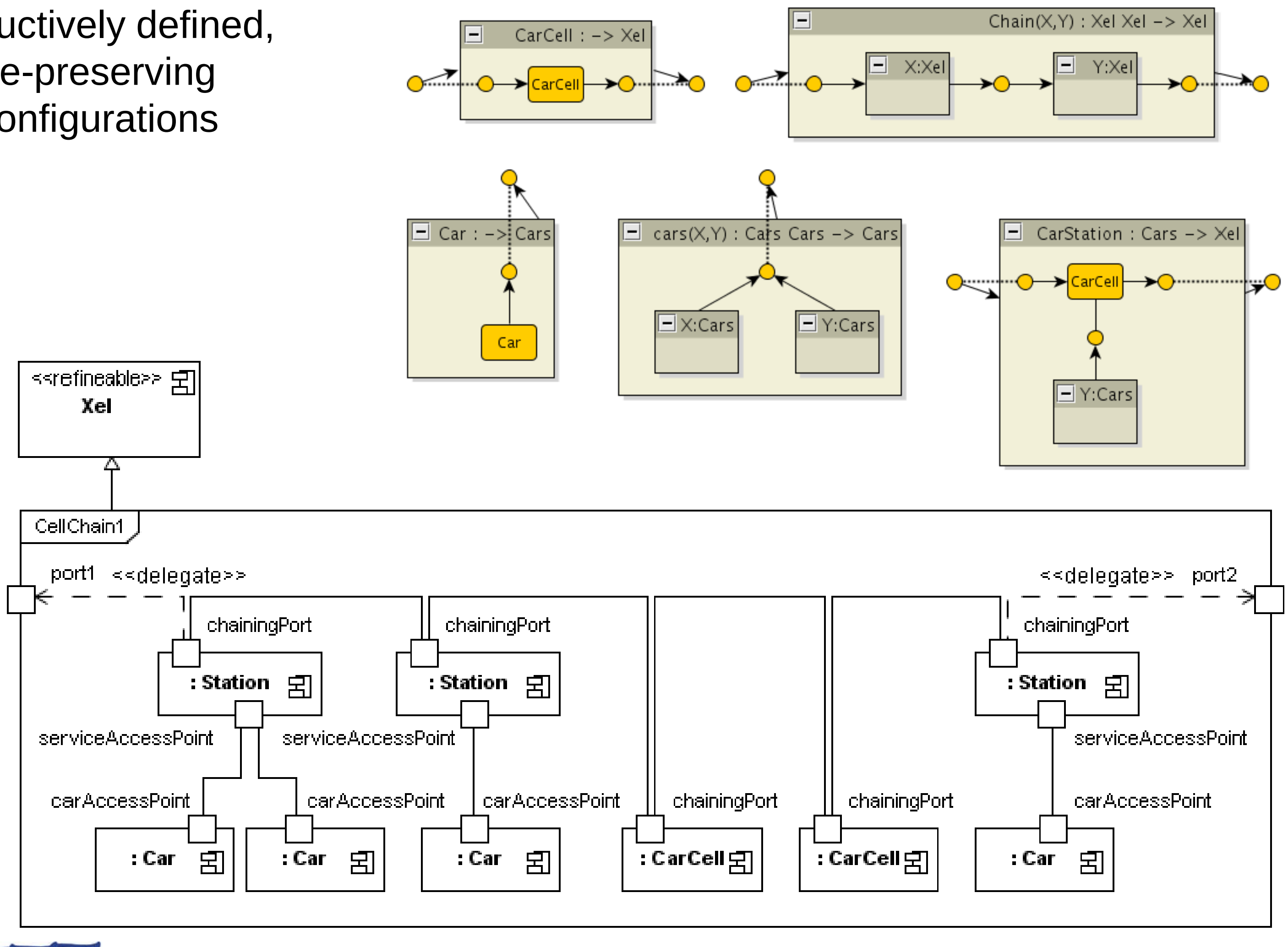
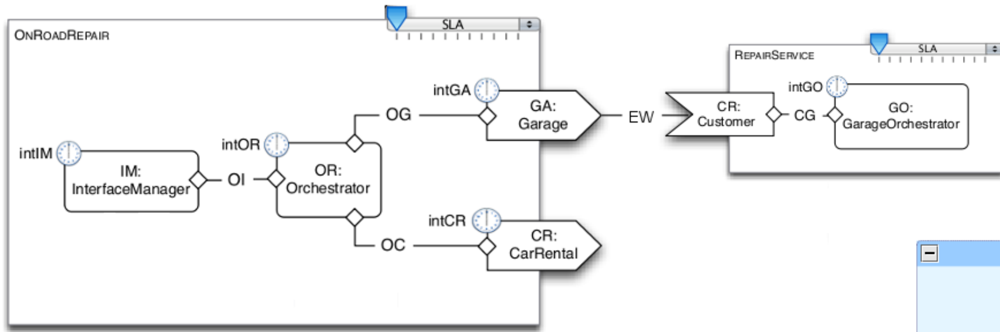
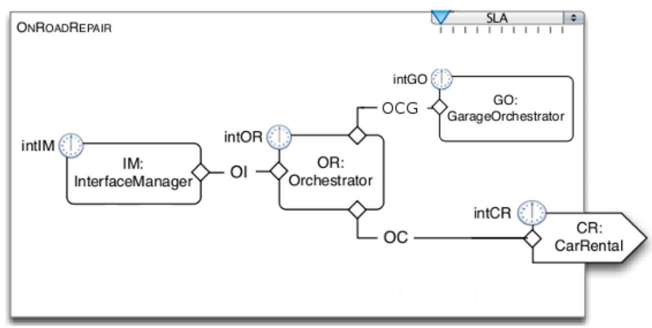
Inductively defined, style-preserving reconfigurations

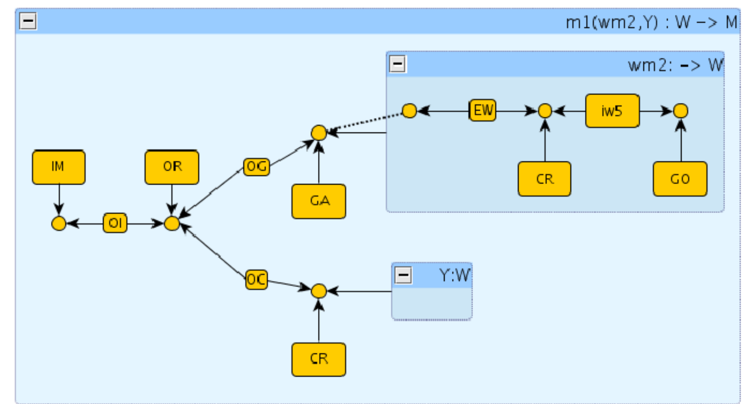


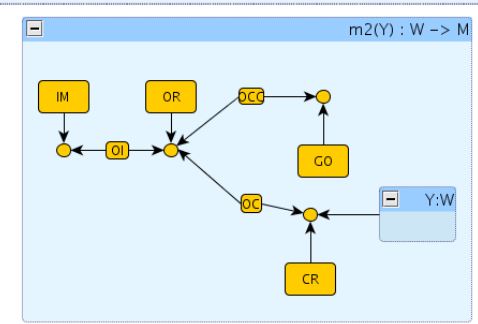
ADR for SRML





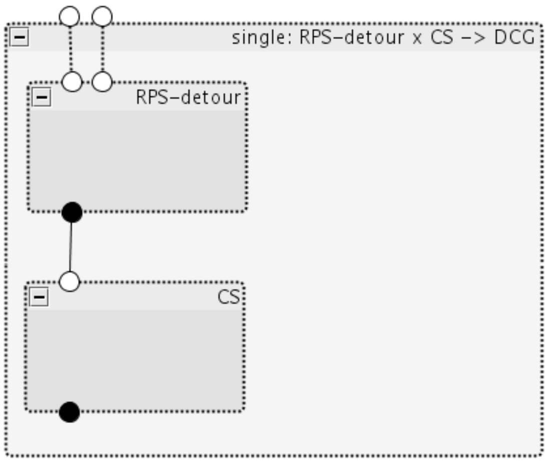
Inductively defined,
well-formed,
static & dynamic binding

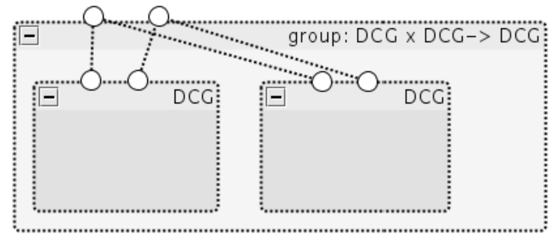




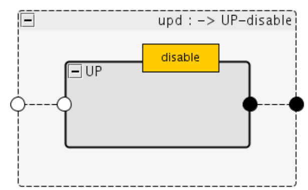
Formal perational semantics via SHR rules
(Synchronized Hyperedge Replacement)

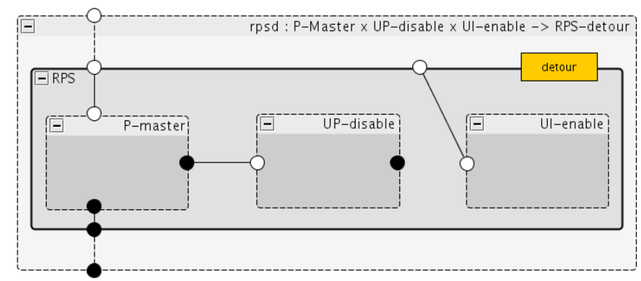
ADR for Modes

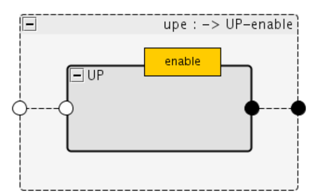


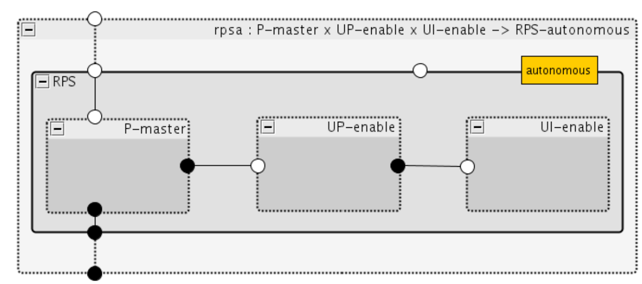


Inductively defined, mode-driven, style-preserving reconfigurations









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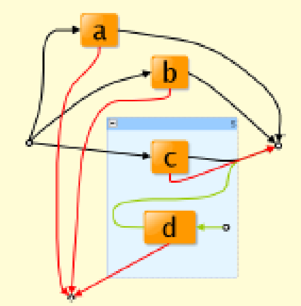
The Goal: Sound and Complete Encoding Also for Hierarchical Graphs

flow1

```
a
| b
| [ c % d]
```

graph1



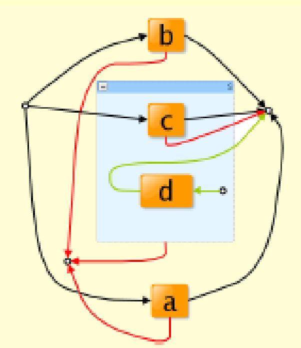
congruent

isomorphic

flow2

```
b
| [ c % d ]
| a
```

graph2



Design Algebra

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$$\mathbb{D} ::= L_{\overline{x}}[\mathbb{G}]$$
$$\mathbb{G} ::= \mathbf{0} \mid x \mid l\langle\overline{x}\rangle \mid \mathbb{G} \mid \mathbb{G} \mid (\nu x)\mathbb{G} \mid \mathbb{D}\langle\overline{x}\rangle$$

$\mathbb{G} \mid \mathbb{H}$	$\equiv$	$\mathbb{H} \mid \mathbb{G}$		(DA1)
$\mathbb{G} \mid (\mathbb{H} \mid \mathbb{I})$	$\equiv$	$(\mathbb{G} \mid \mathbb{H}) \mid \mathbb{I}$		(DA2)
$\mathbb{G} \mid \mathbf{0}$	$\equiv$	$\mathbb{G}$		(DA3)
$(\nu x)(\nu y)\mathbb{G}$	$\equiv$	$(\nu y)(\nu x)\mathbb{G}$		(DA4)
$(\nu x)\mathbf{0}$	$\equiv$	$\mathbf{0}$		(DA5)
$\mathbb{G} \mid (\nu x)\mathbb{H}$	$\equiv$	$(\nu x)(\mathbb{G} \mid \mathbb{H})$	if $x \notin fn(\mathbb{G})$	(DA6)
$L_{\overline{x}}[\mathbb{G}]$	$\equiv$	$L_{\overline{y}}[\mathbb{G}\{^{\overline{y}}/_{\overline{x}}\}]$	if $\lfloor\overline{y}\rfloor \cap fn(\mathbb{G}) = \emptyset$	(DA7)
$(\nu x)\mathbb{G}$	$\equiv$	$(\nu y)\mathbb{G}\{^{y}/_{x}\}$	if $y \notin fn(\mathbb{G})$	(DA8)
$x \mid \mathbb{G}$	$\equiv$	$\mathbb{G}$	if $x \in fn(\mathbb{G})$	(DA9)
$L_{\overline{x}}[z \mid \mathbb{G}]\langle\overline{y}\rangle$	$\equiv$	$z \mid L_{\overline{x}}[\mathbb{G}]\langle\overline{y}\rangle$	if $z \notin \lfloor\overline{x}\rfloor$	(DA10)

$$fn(\mathbf{0}) = \emptyset$$
$$fn(l\langle\overline{x}\rangle) = \lfloor\overline{x}\rfloor$$
$$fn((\nu x)\mathbb{G}) = fn(\mathbb{G}) \setminus \{x\}$$
$$fn(L_{\overline{x}}[\mathbb{G}]) = fn(\mathbb{G}) \setminus \lfloor\overline{x}\rfloor$$
$$fn(x) = x$$
$$fn(\mathbb{G} \mid \mathbb{H}) = fn(\mathbb{G}) \cup fn(\mathbb{H})$$
$$fn(\mathbb{D}\langle\overline{x}\rangle) = fn(\mathbb{D}) \cup \lfloor\overline{x}\rfloor$$

Theorem: Sound and Complete axioms for hierarchical graphs
(also surjective map from terms to hierarchical graphs)

Theorem: Sound and Complete axioms for gs-graphs

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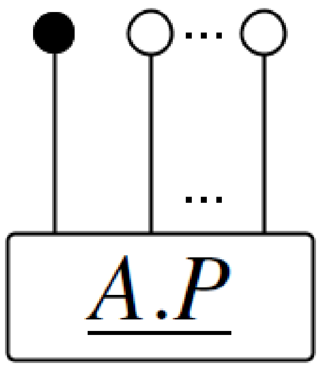
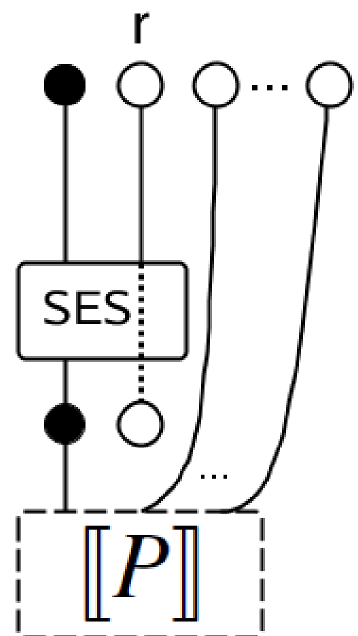
CaSPiS encoding over the Design Algebra, I

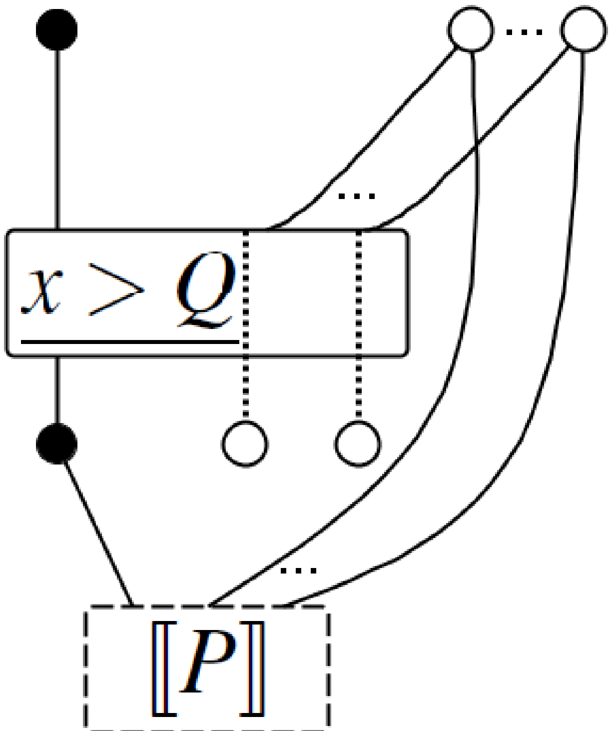




$$[\![\bar{A}.\bar{P}]\!] \stackrel{\text{def}}{=} \underline{A.P}\langle \lceil fn(A.P) \rceil \rangle$$

$$[\![r \triangleright P]\!] \stackrel{\text{def}}{=} SES[\, [\![P]\!] \,]\langle r \rangle$$

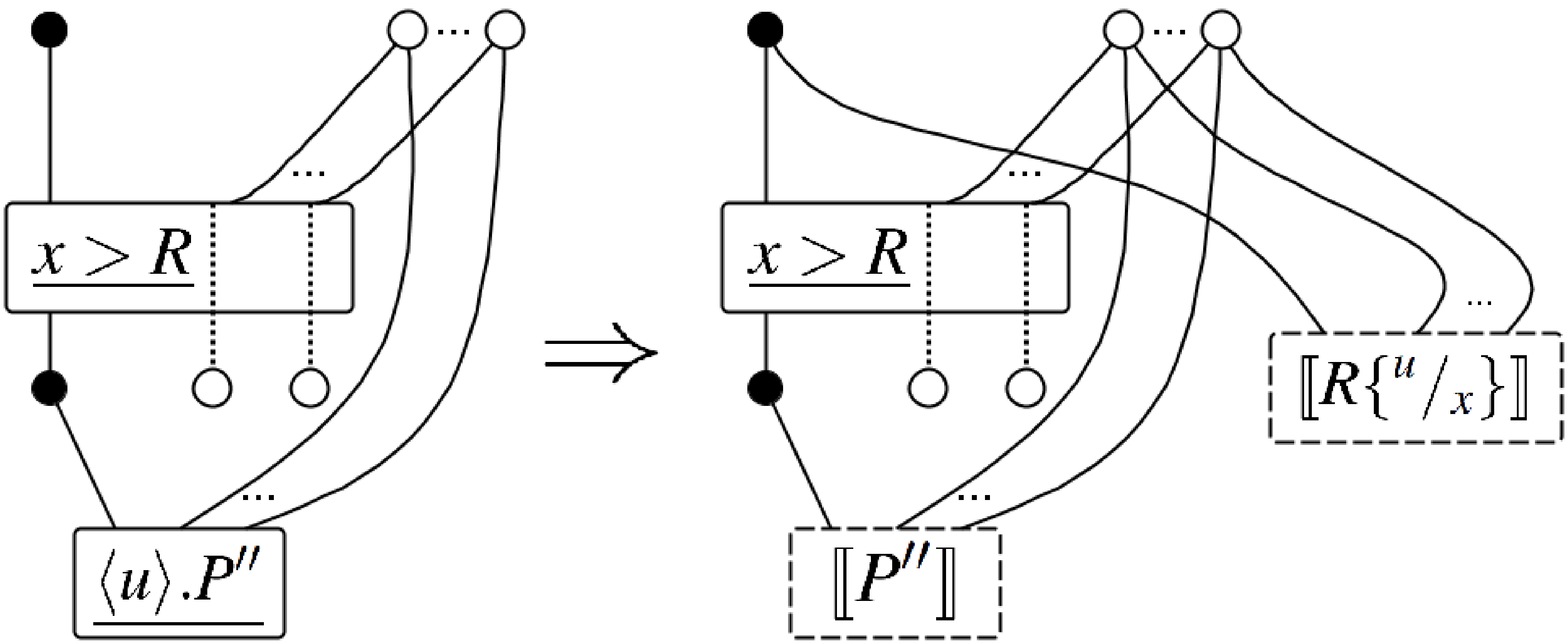
CaSPiS encoding over the Design Algebra, II



pipeline construct

$$[\![P > (?x)Q]\!] \stackrel{\text{def}}{=} \underline{x > Q}[\ [\![P]\!]\ ]\langle \lceil fn(Q) \setminus \{x\} \rceil \rangle$$

Transformation Rules for CaSPiS Reduction Semantics, III



$$
\begin{array}{lll}
P & \equiv & C[\ (P' | \langle u \rangle .P'') > (?x).R\ ] \\
Q & \equiv & C[\ R\{^u/_x\} \mid ((P' | P'') > (?x).R)\ ]
\end{array}
\qquad (PipelineSync)
$$

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A General View from a Personal Perspective

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graph modeling
isom. vs. struct.axioms
DPO, SHR
SO hierarchical graphs

algebraic specifications
typing, refinement
(conditional) rewriting
SOS, De Simone

LTS, coalgebras
bisimilarity, final object
adequate modal logic

process calculi
bialgebras
bisimilar. as congruence
process algebras

nominal calculi
coalgebras on presheaves
ext. to resources, constrains

behavioral types
sessions
transactions
Negotiate Commit Execute

quantitative LTS
probabilistic/stochastic LTS
Markov chains, processes
non idempotency
coalgebras on metric spaces

THANKS FOR THE ATTENTION

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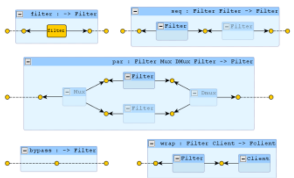

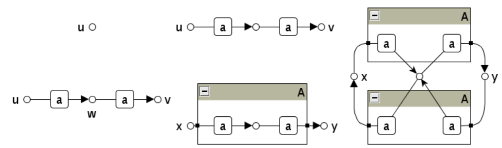

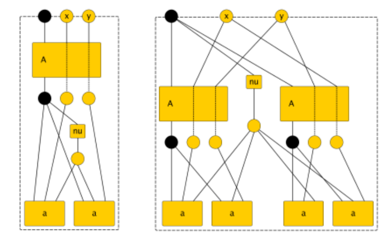

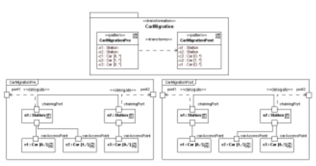

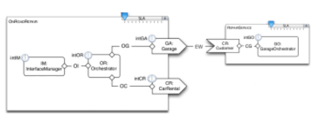

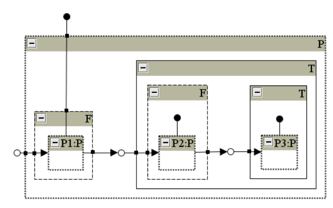

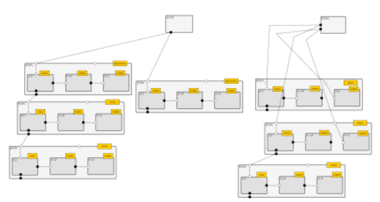

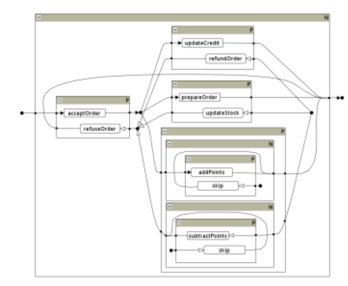

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