Multi-level Contracts for Trusted Components

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Outline

1. Introduction
2. Multi-level Contracts in Component Model
3. Design and Verification Process using Multi-level Contracts
4. Experimentations with Kmelia/COSTO
5. Conclusion and Future Work

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1 Introduction

2 Multi-level Contracts in Component Model

3 Design and Verification Process using Multi-level Contracts

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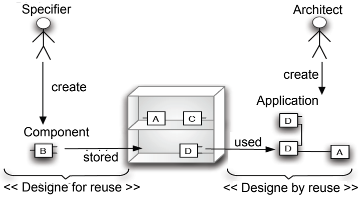
Introduction / context

Context: Trusted Component-Based Software Development

- *Commercial off-the-shelf* concept
- Trusted components and assemblies
- Various aspects (structure, behaviour, interaction...)



Goals:

- Models and techniques to specify and verify component-based systems
  - early in development phases, prior to implementation and deployment

Focus:

- Making explicit contracts at different level in component model for building trusted components and assemblies
  - Using assembly contracts to guarantee interoperability

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Using Multi-level Contracts in Component Model

What are contracts?

- In every day life:
  - Agreement between two or more parties
  - Establishing obligations or benefit of each of these parties
- A part of component definition

Definition (Component)

an unit of composition with **contractually** specified interfaces and explicit context dependencies only [Szyperski, 2002].

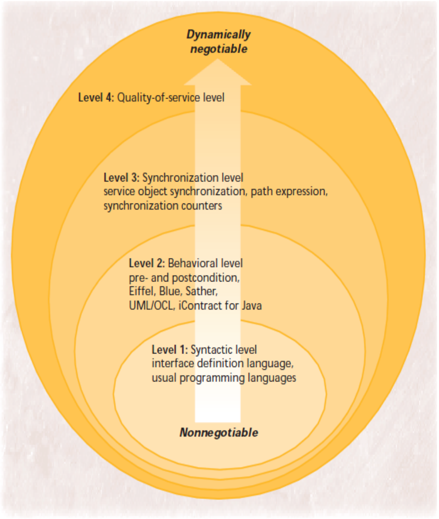
- Why are contracts useful?
  - Precision in specification & design
  - Making responsibilities explicit
  - Checking/Testing
  - Documentation

Using Multi-levels Contract in Component Model

Contract classification [Beugnard et al., 1999]

1. Syntactic contracts
2. Behavioural contracts
3. Synchronisation contracts
4. Quality of services contracts

	COM	SOFA	FRACTAL	Wright	CQM
Level 1	✓	✓	✓	✓	✓
Level 2	×	×	✓	×	×
Level 3	×	✓	×	✓	×
Level 4	×	×	×	×	✓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Level 4: Quality-of-service level
Level 3: Synchronization level
service object synchronization, path expression, synchronization counters
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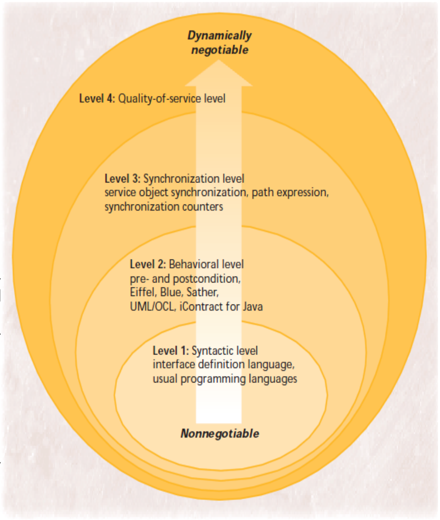
Level 4	×	×	×	×	√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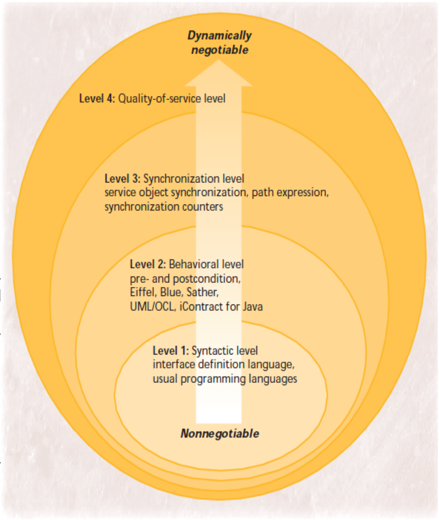
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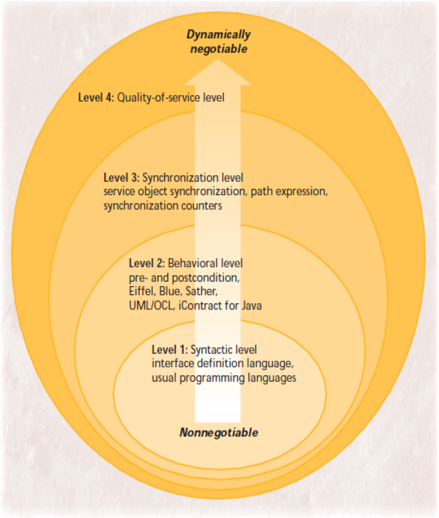
[a] Using CCL-J in ConFract extention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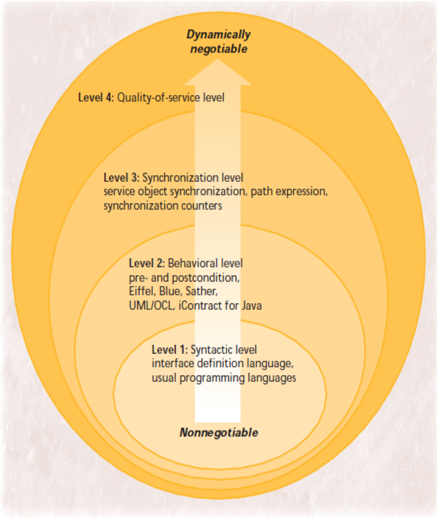
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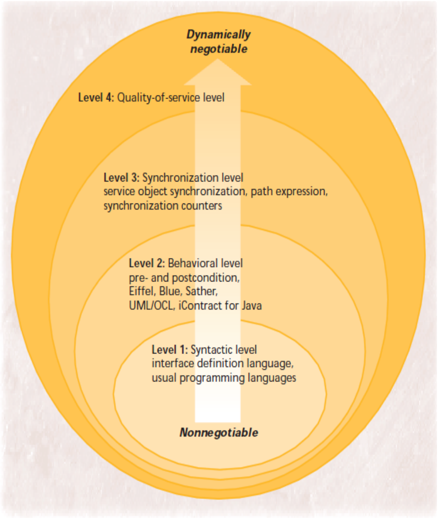

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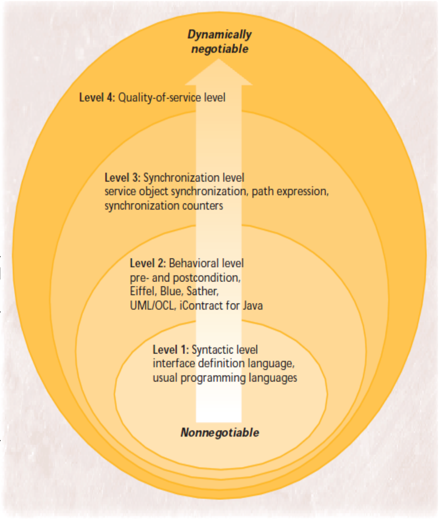

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No one covers more than two levels

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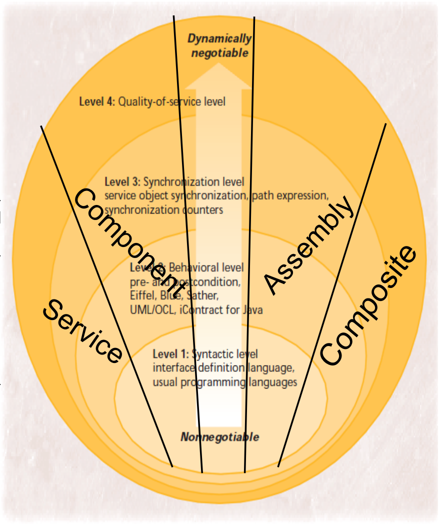
Different contexts for making contracts



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Component
Service
Assembly
Composite

Using Multi-levels Contract in Component Model

Crossing contexts and contracts = Multilevel Contracts

	Component model level			
Contract levels	Service	Component	Assembly	Composite
Syntactic	type checking	interface, type checking	signature matching, service dependencies	promotion, observability
Behaviour	functional correctness	invariant preservation	pre/post compliance	pre/post compliance
Synchronisation	deadlock freedom	protocol	behavioural compatibility	
QoS	-	-	-	-
Properties	Correctness	Consistency	Interoperability	Encapsulation

Illustration with Kmelia component model

Architecture levels in Kmelia [André et al., 2009]

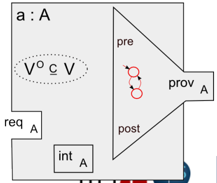
Service component "functionality"
- Interface = sub-services
- *Assertions = pre-/postconditions*
- Dynamic behaviour = eLTS

Component abstract and non executable
- State space with an *Invariant*
- Interface = required + provided services

Assembly Links between provided/required services

Composition encapsulation and promotion

```
Provided service1 ()
    Interface   <Interface descr>
    Pre         <Predicate>
    Post        <Predicate>
    Behaviour
        init    q_0
        final   q_f
        { ...,
        q_i - - label - - > q_j,
        ... }
end
Required service2 () ...
```



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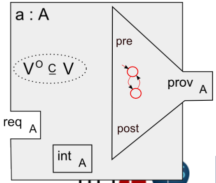

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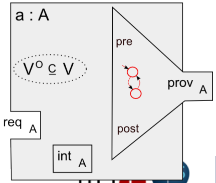

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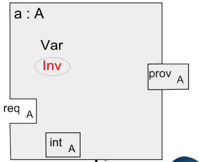
```
Component compo_name
    Interface       <Interface descr.>
    Types           < Type Defs >
    Variables       <Var list>
    Invariant       <Predicate>
    Initialisation
        ...         // var. assignments
    Services
        ...
end
```



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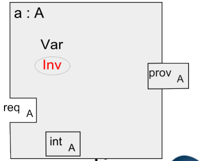

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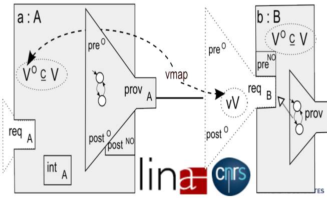
```
ASSEMBLY assembly_name
    Components
                <Compos>
    Links
                < Links>
        context mapping
                <Predicats>
        ...
End_links
END
```



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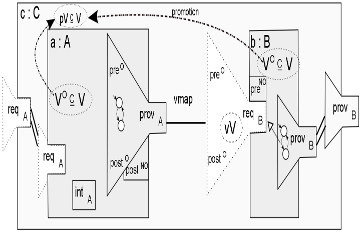
```
COMPOSITION composite_name
    ASSEMBLY assembly_name
        <...>
    End
        PROMOTION
        Links
                <...>
        Variables
                <...>
END
```



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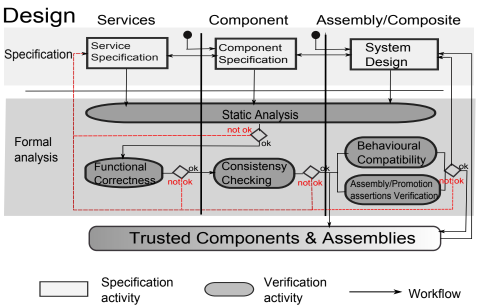
Making explicit contracts in component-based development process

1. Service
2. Component
3. Assembly



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   -
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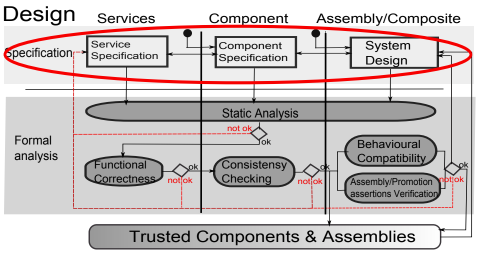
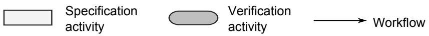
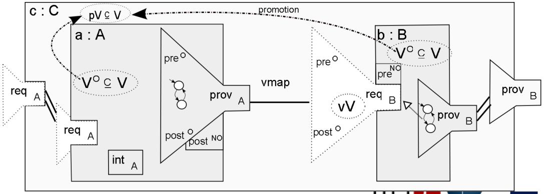


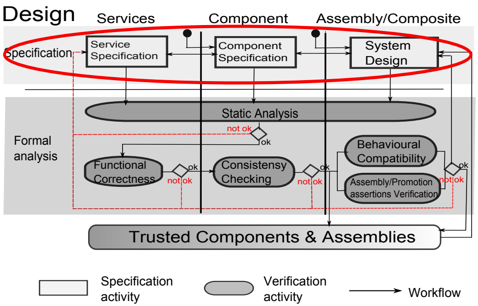


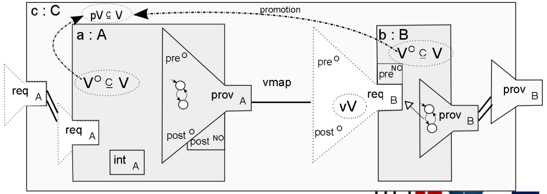


Multi-levels Contracts Design and Verification Process

Making explicit contracts in component-based development process

1. Service contract
2. Component contract
3. Assembly contract

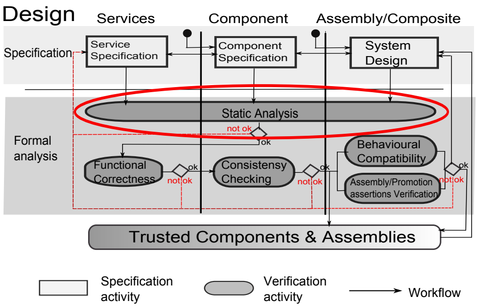


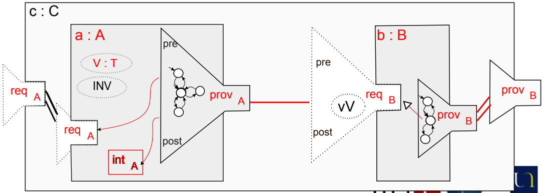


Multi-levels Contracts Design and Verification Process

Making explicit contracts in component-based development process

1. Service contract
   - Service dependency
   -
   -
2. Component contract
   - Service accessibility
   -
   -
3. Assembly contract
   - Static interoperability
   -
   -





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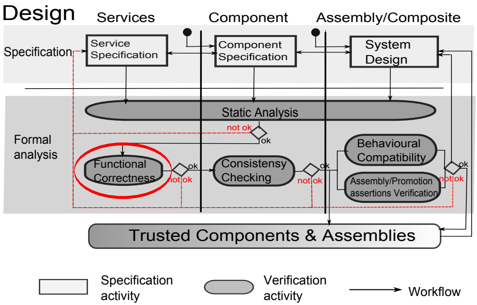

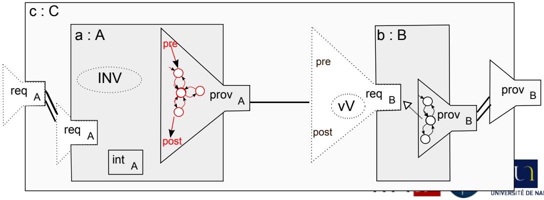

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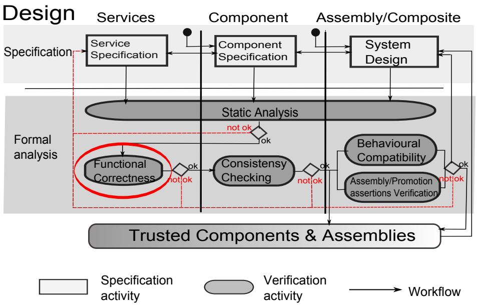

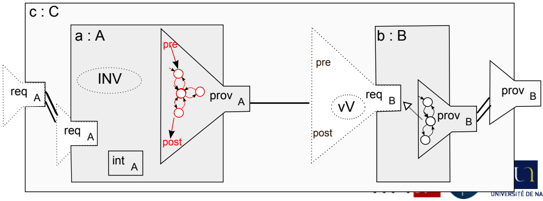

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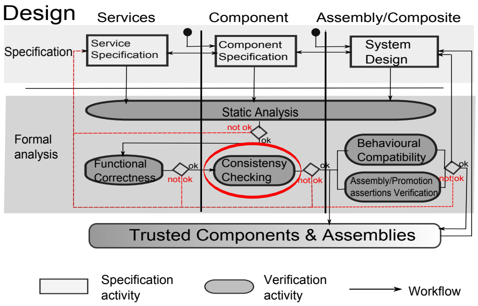

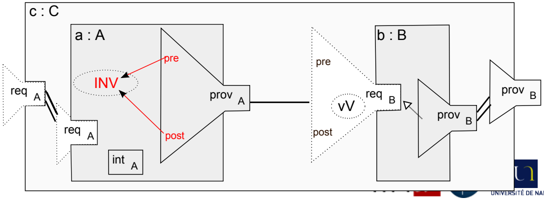

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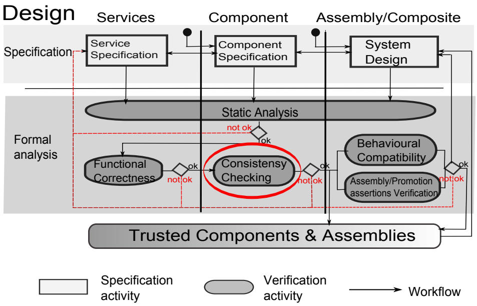

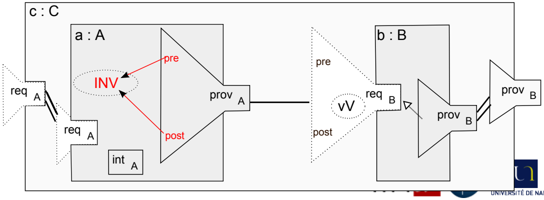

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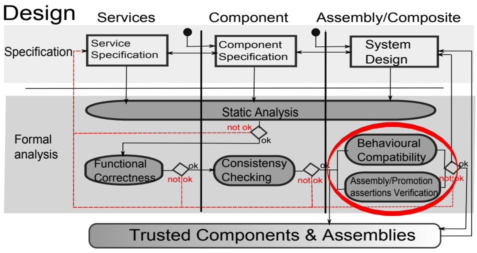
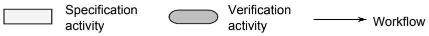
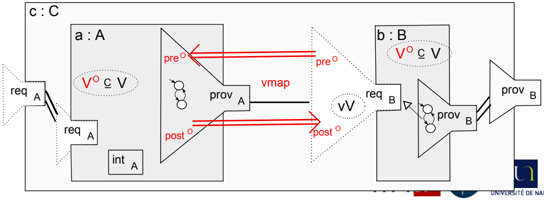
3. Assembly contract
   - Static interoperability
   - *Service assertions compliance* on an assembly link.
   -



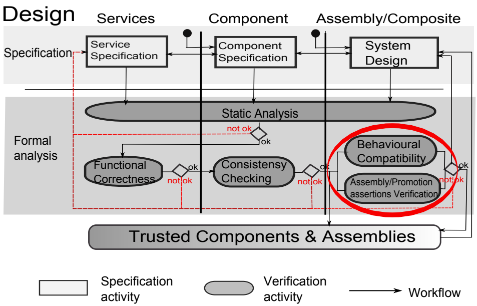


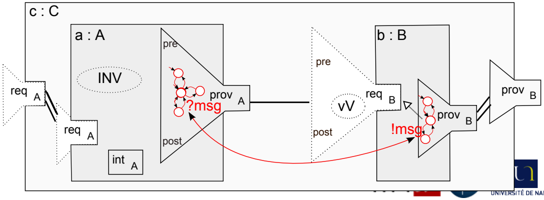


Multi-levels Contracts Design and Verification Process

Making explicit contracts in component-based development process

1. Service contract
   - Service dependency
   - *Functional correctness*
   - *Behavioural consistency*
2. Component contract
   - Service accessibility
   - *Component consistency*
   - *Protocol correctness*
3. Assembly contract
   - Static interoperability
   - *Service assertions compliance* on an assembly link.
   - *Behavioural compatibility* between the linked services in an assembly.





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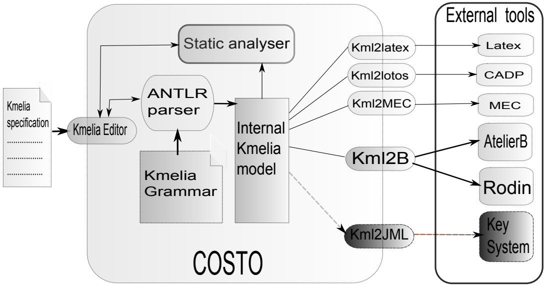
4 Experimentations with Kmelia/COSTO

5 Conclusion and Future Work

COSTO Framework Overview



- COSTO is a Toolbox made of Eclipe-based plugins, dedicated to the specification and formal analysis of Kmelia Components.
- COSTO manages the Kmelia specifications and handles the verification of the primary properties (syntax, types, observability, signature matching, services dependency).
- Verifications of complex properties such as deadlock freeness, component or assembly consistency are delegated to other more appropriate tools.

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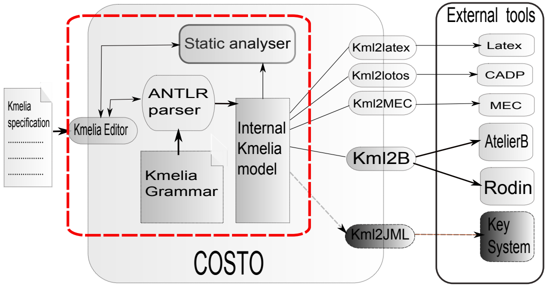

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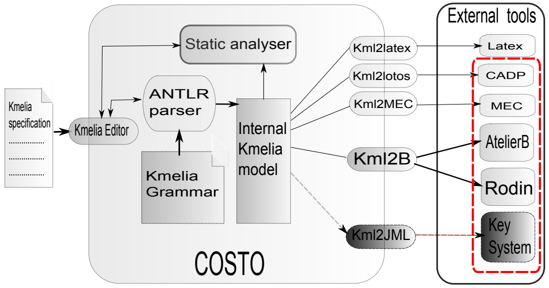

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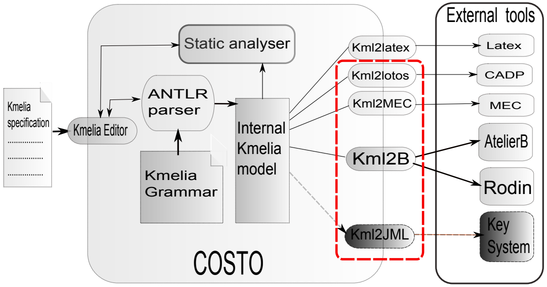

- The parts of the Kmelia specifications involved in the target property are extracted and translated into the input formalism of the target tool.
- The property is checked under the external tool. Currently:
  - Behavioural compatibility experimented with LOTOS/CADP and MEC
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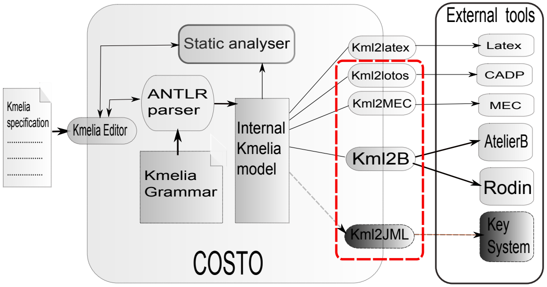

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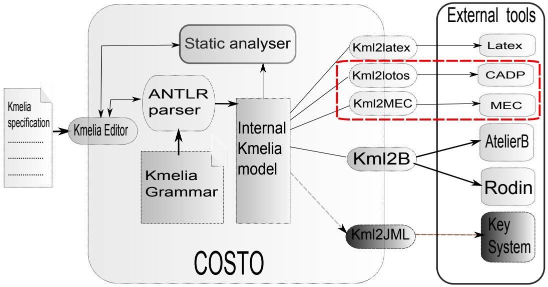

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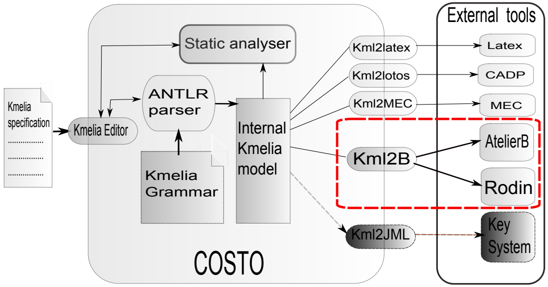

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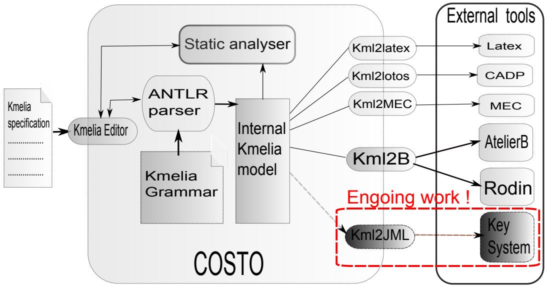

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- A process development based on contract checking
- A mechanisation of this process based on integrating existing tools such as theorem-provers or model-checkers

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Perspectives

Short term (actually ongoing work)

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Medium term

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Long term

- Apply these ideas and techniques to heterogeneous component and service models

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Thanks for your attention!

References I

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