CHANGE AND DELAY CONTRACTS FOR HYBRID SYSTEM COMPONENT VERIFICATION

Andreas Müller – andreas.mueller@jku.at
Werner Retschitzegger – werner.retschitzegger@jku.at
Wieland Schwinger – wieland.schwinger@jku.at

Johannes Kepler University, Linz
Department of Cooperative Information Systems
http://cis.jku.at/

Stefan Mitsch – smitsch@cs.cmu.edu
André Platzer - aplatzer@cs.cmu.edu

Carnegie Mellon University, Pittsburgh
Computer Science Department
http://www.ls.cs.cmu.edu

OVERVIEW

- Background
  - Cyber-Physical Systems
  - Component-based Verification

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  - Components
  - Contracts
  - Composition

- Evaluation
  - Implementation
  - Experiments

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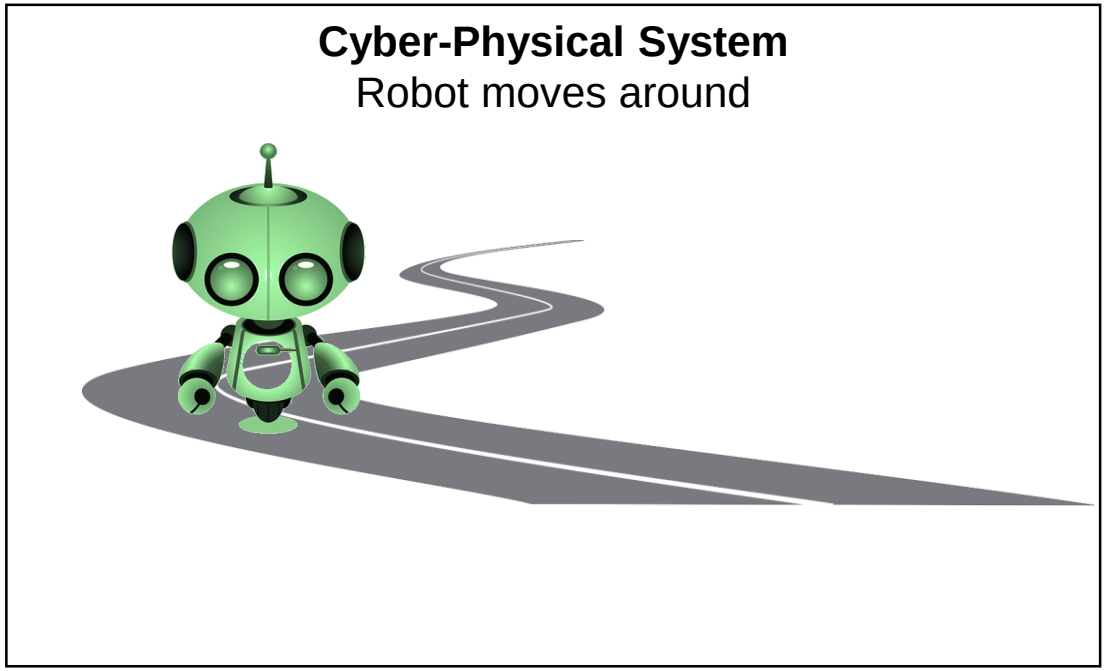

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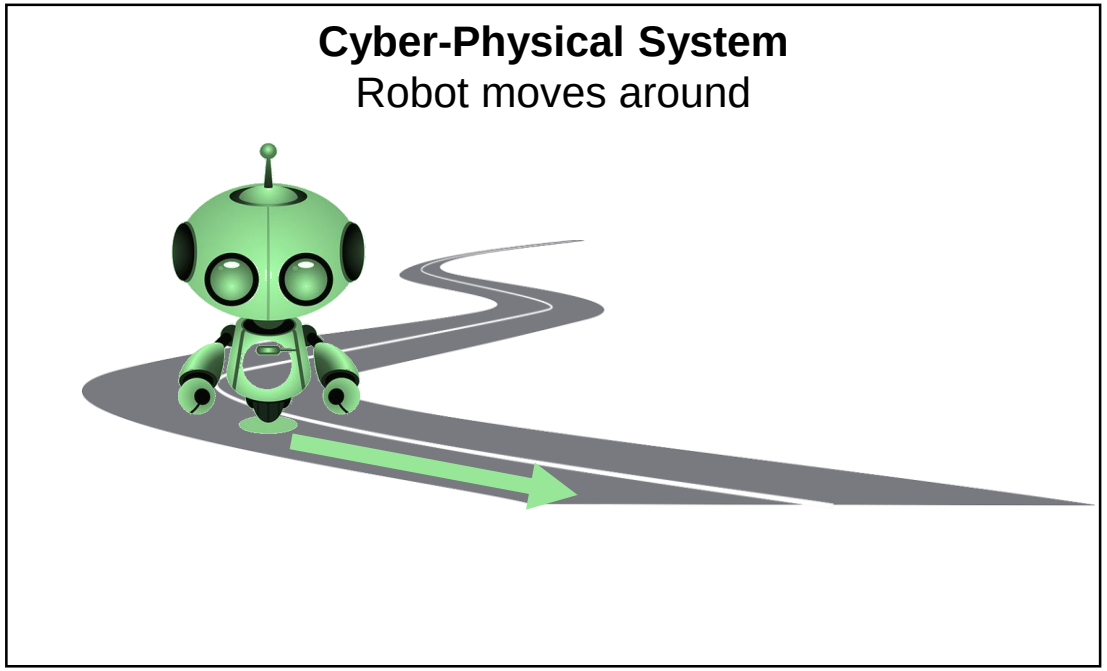

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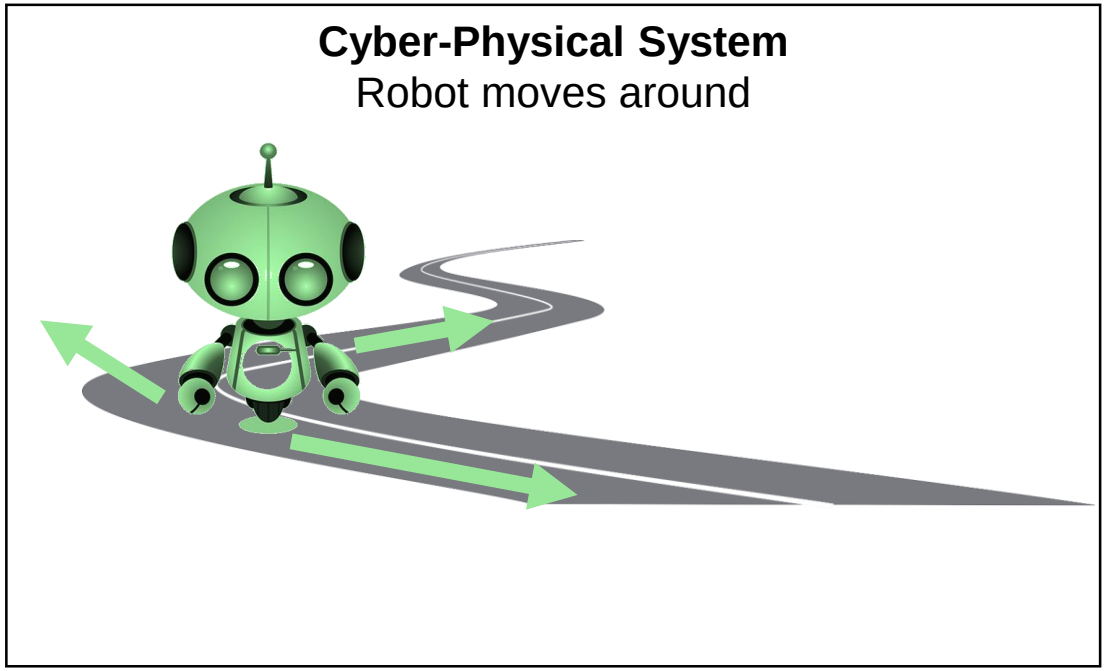

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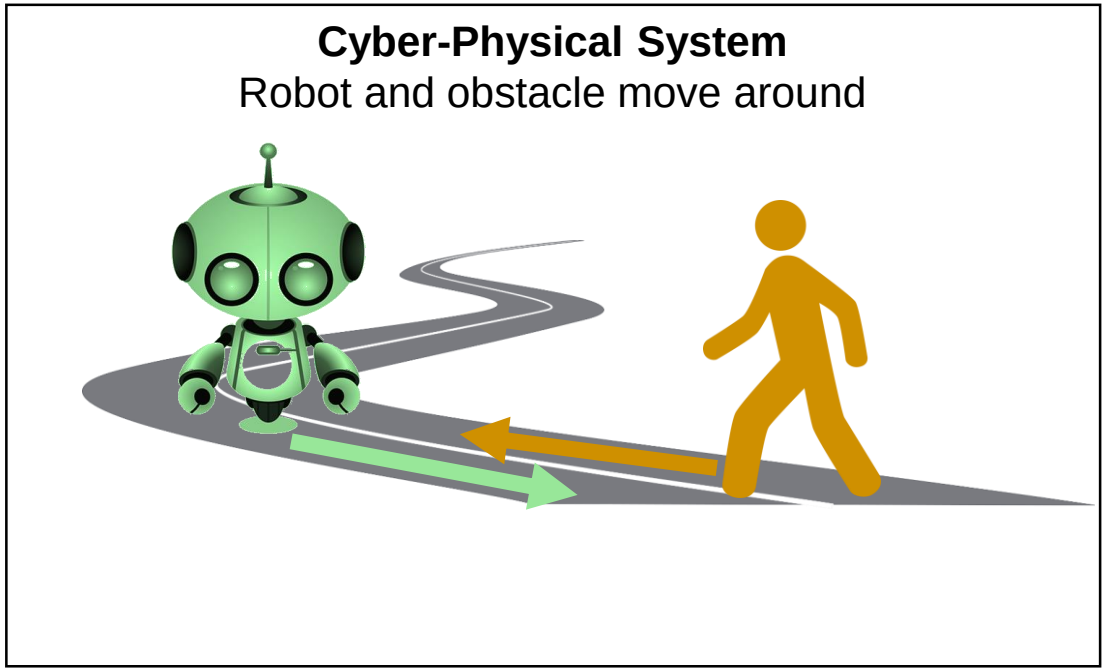

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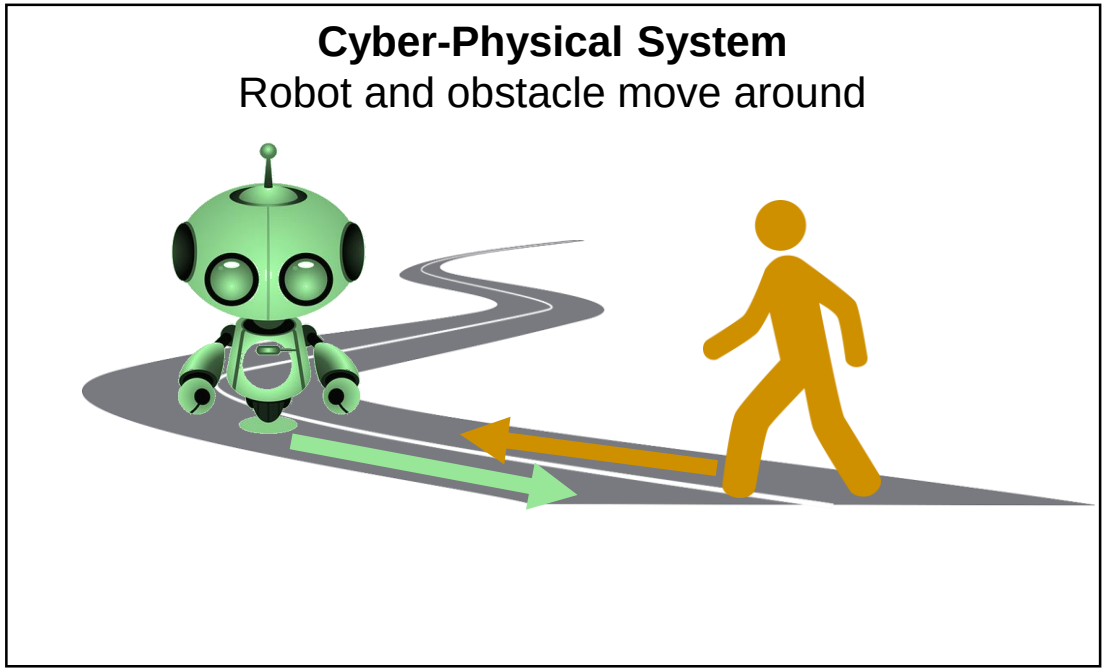

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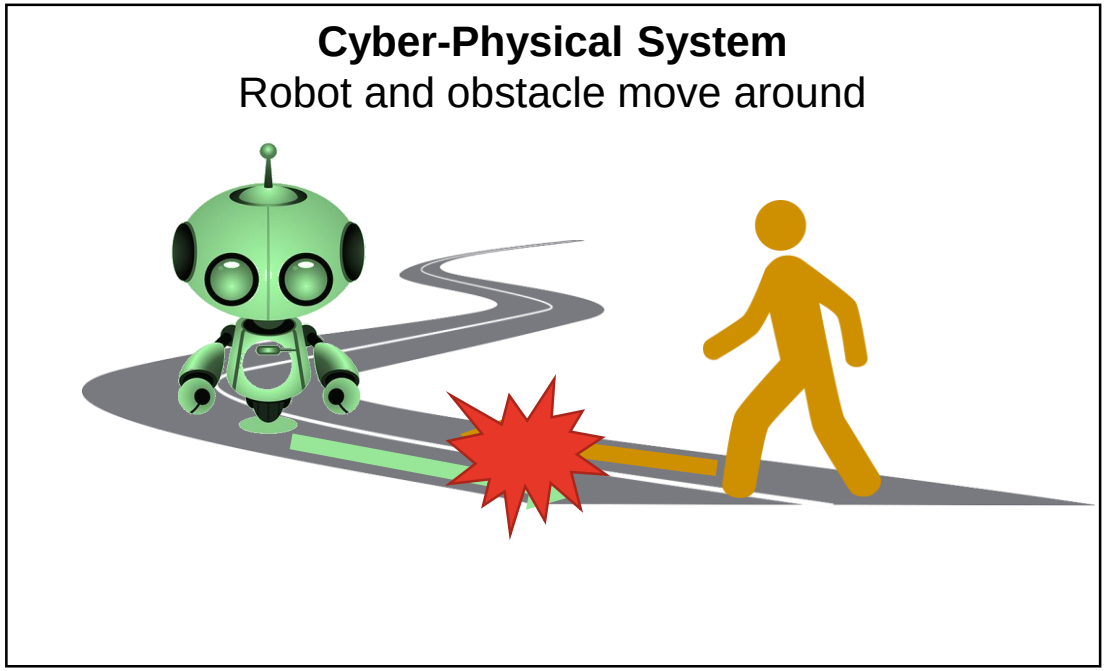

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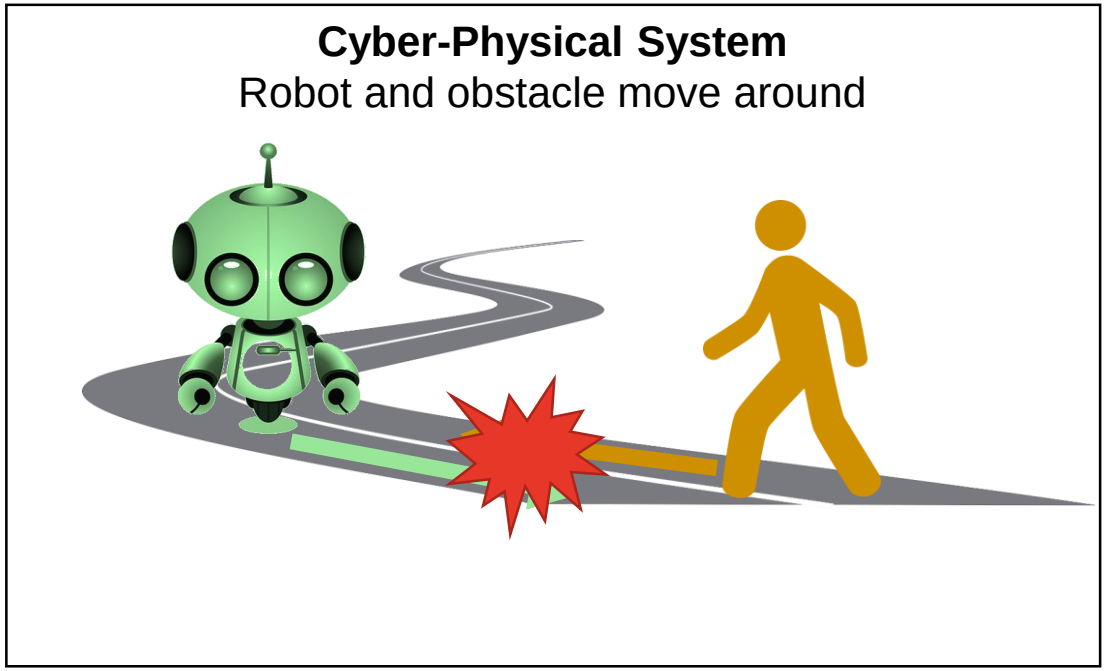

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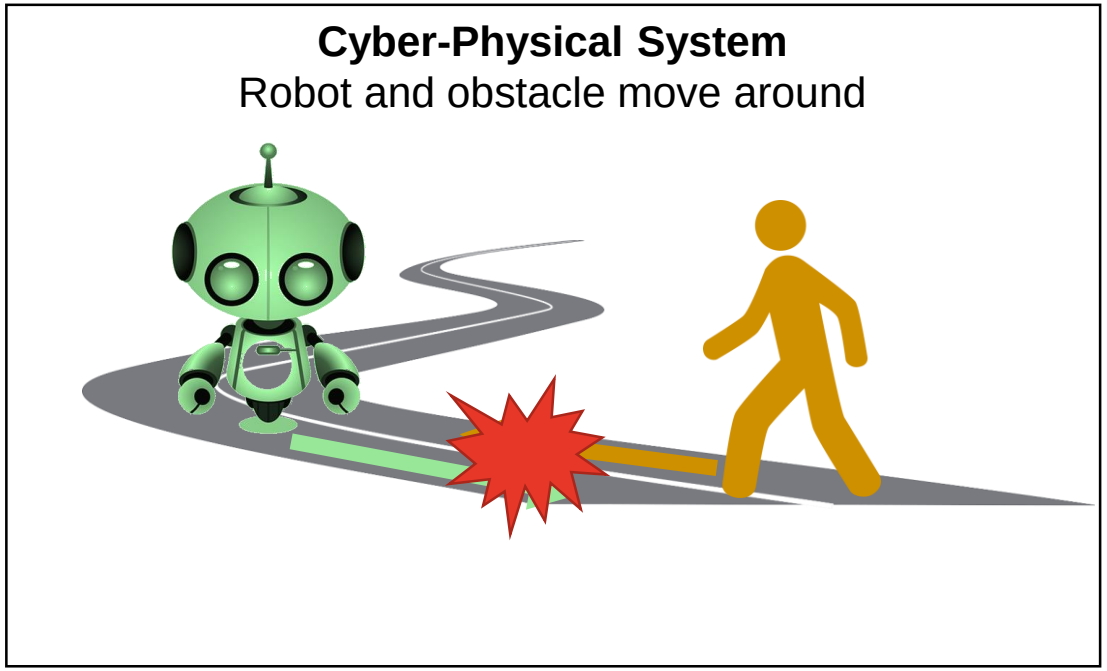

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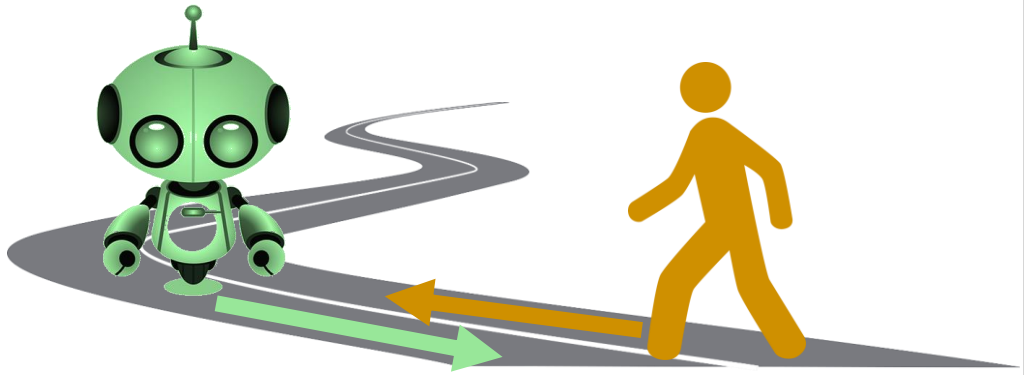
Cyber-Physical System
Robot moves, avoiding collisions with moving obstacle



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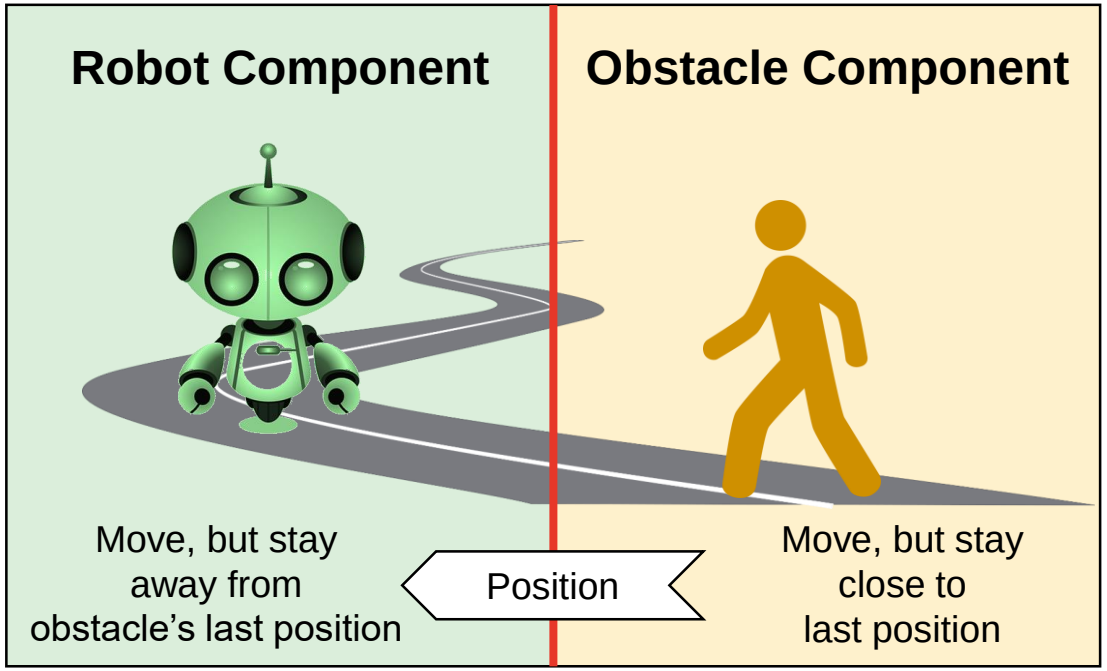

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BACKGROUND – COMPONENT-BASED VERIFICATION

Monolithic

Internal Behavior

System
(Component A ‖ Component B)

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External Behavior

System Contract
(Contract A ∧ Contract B)

Internal Behavior

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(Component A ‖ Component B)

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Formal Verification

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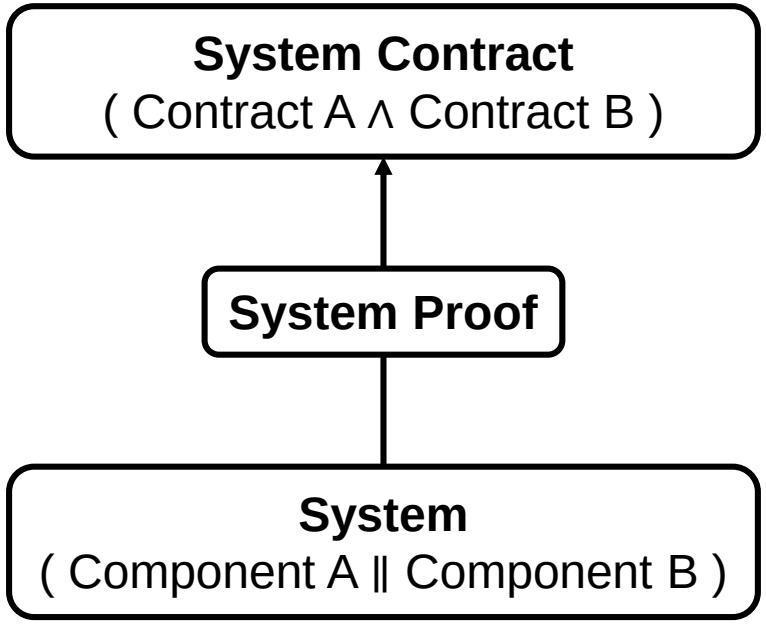

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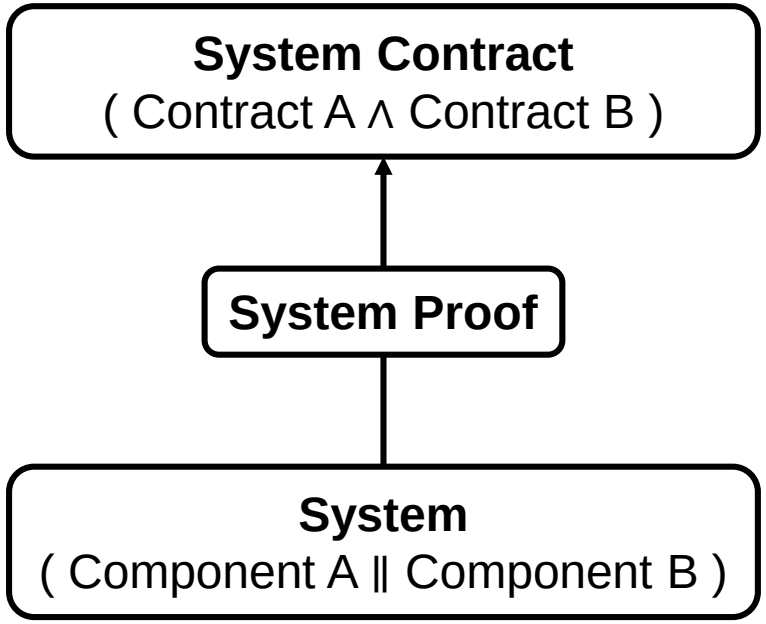

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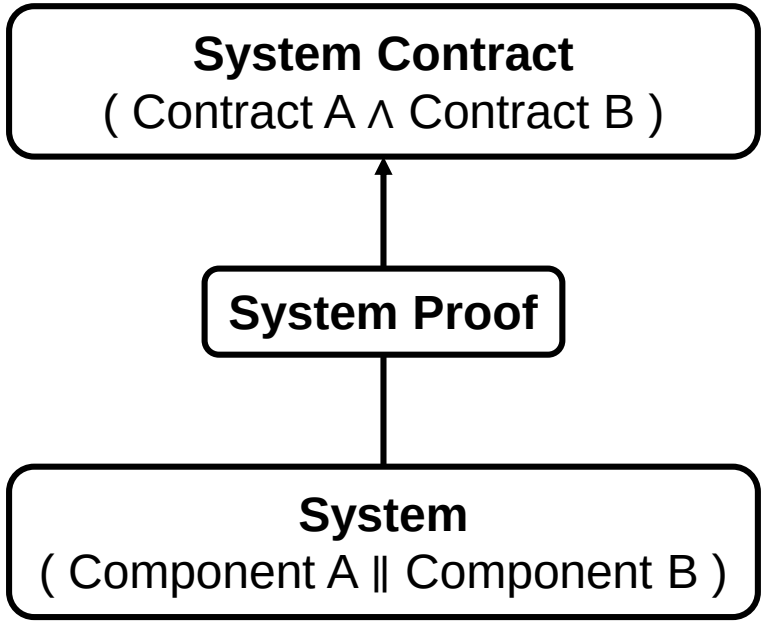

Component A

Component B

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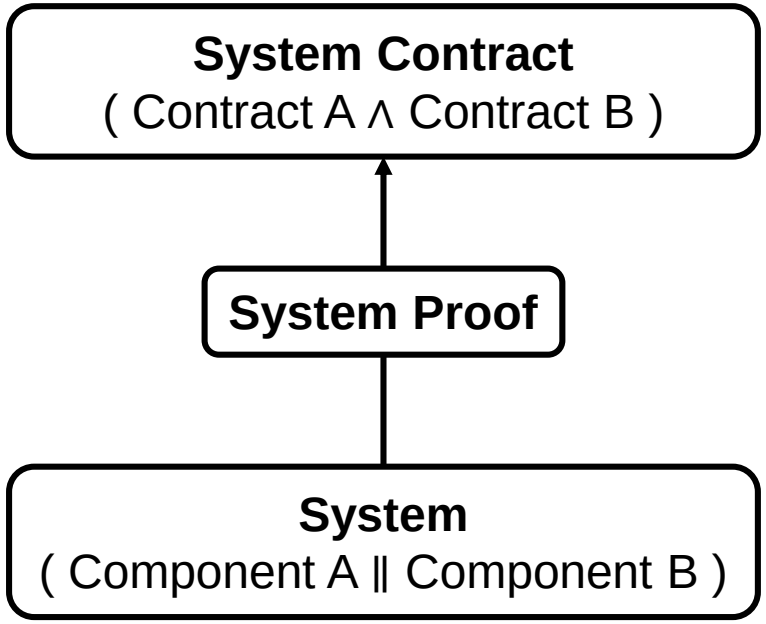

Contract A

Contract B

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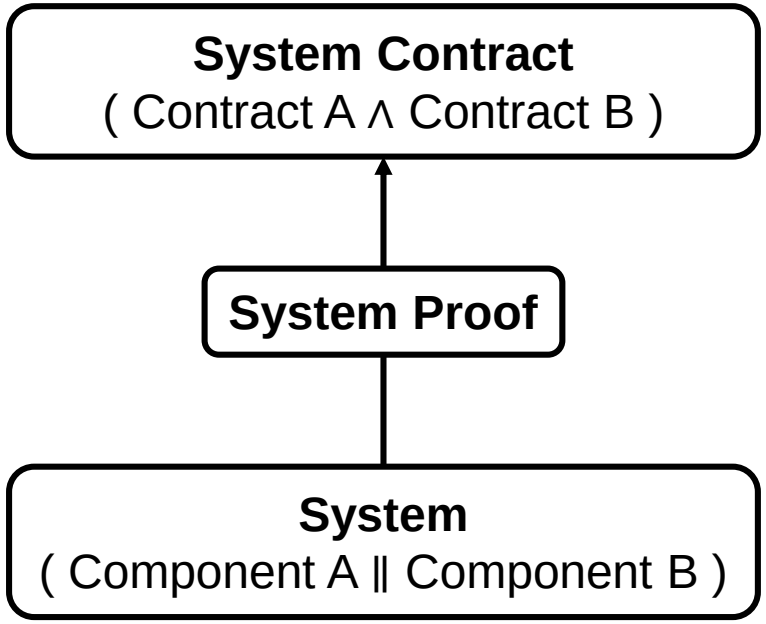

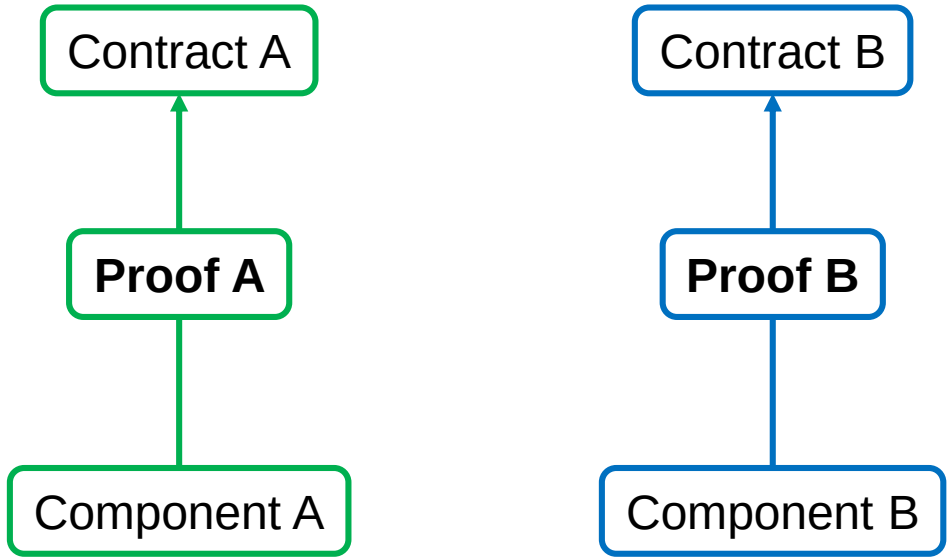

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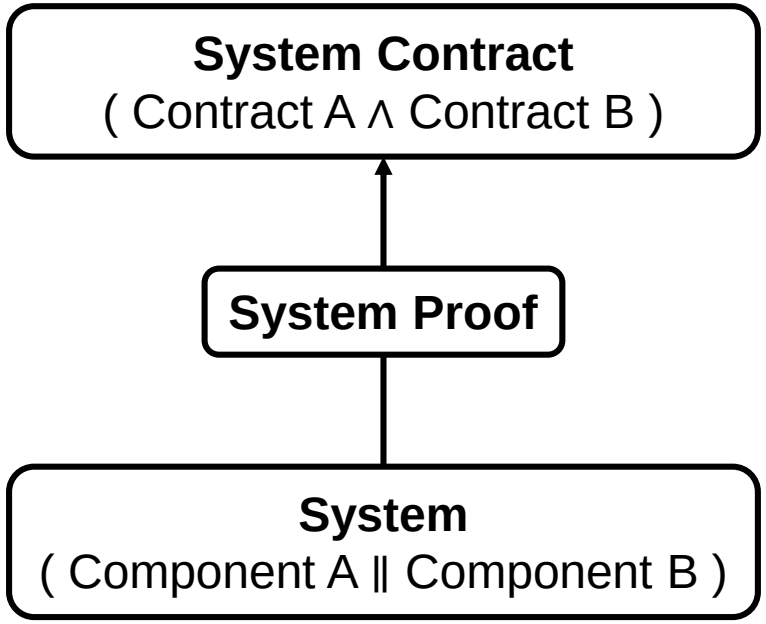

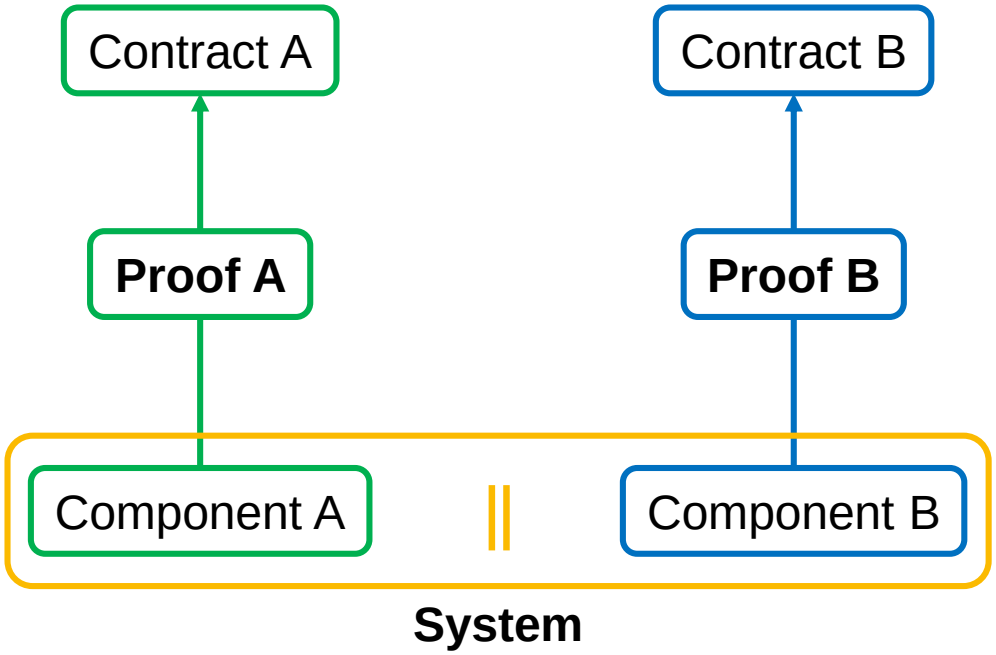

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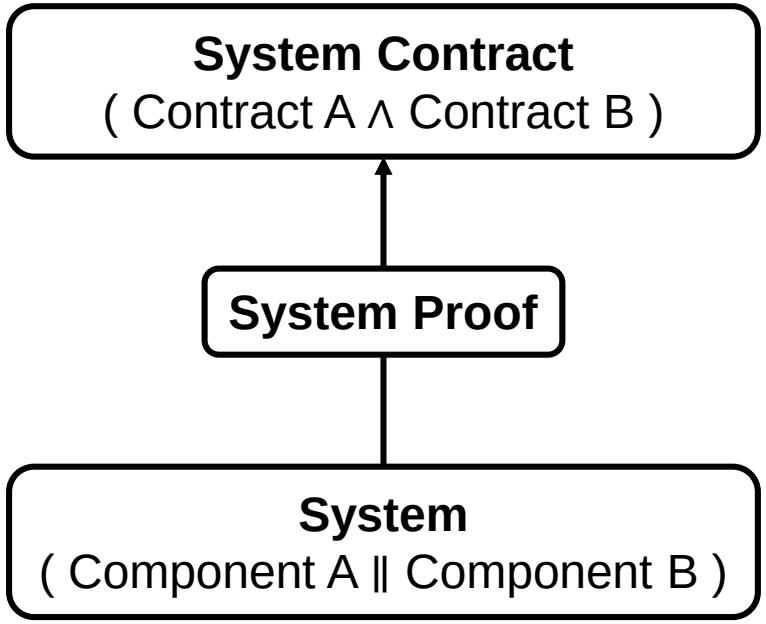

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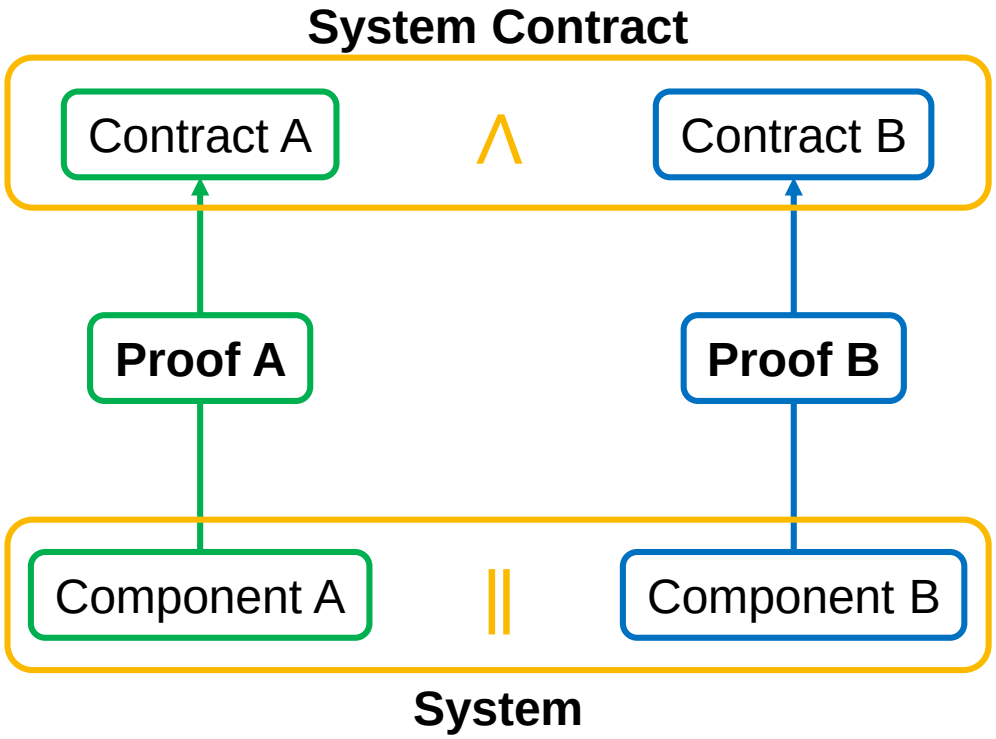

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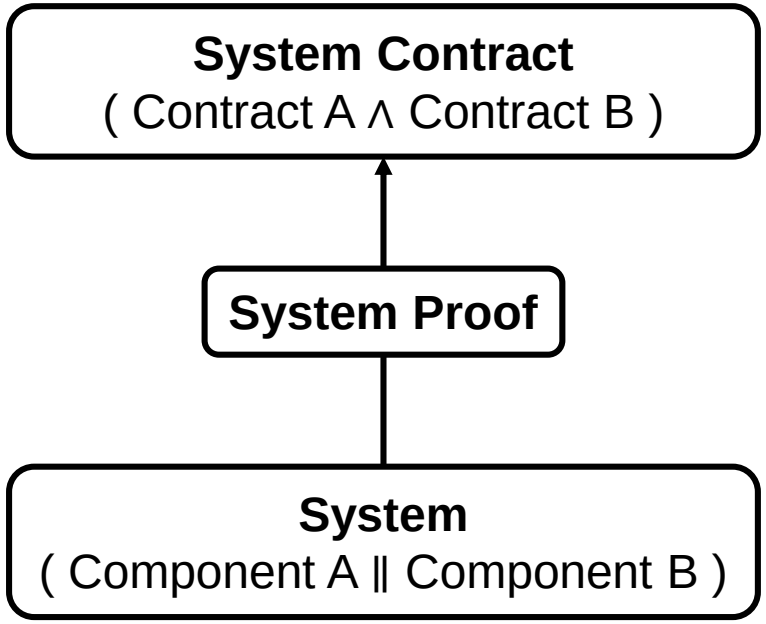

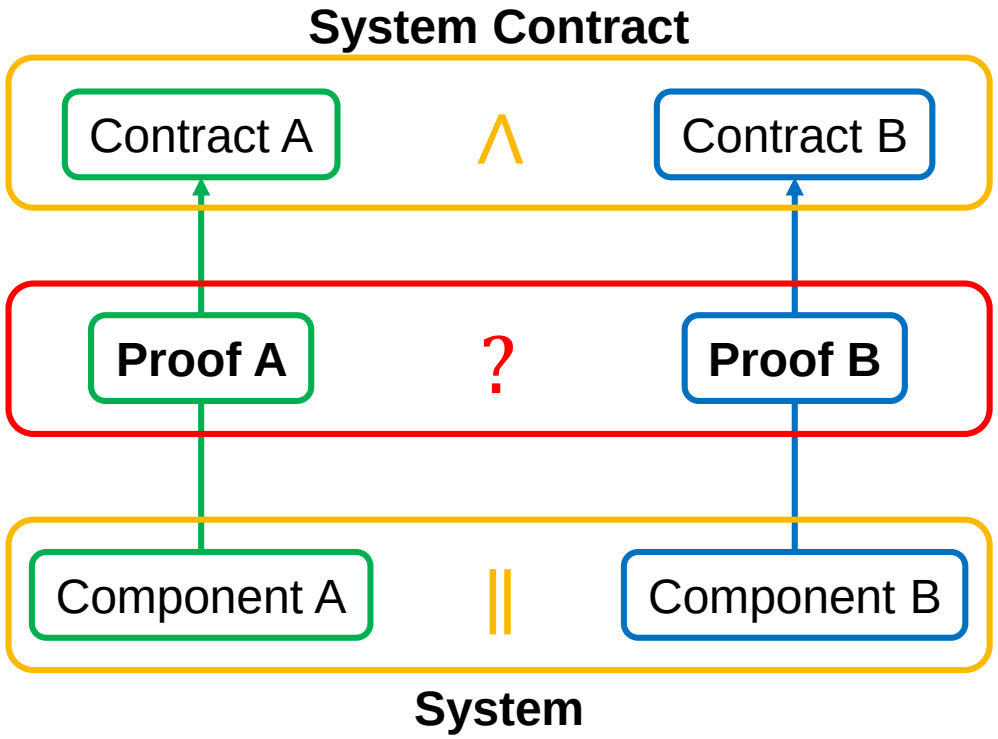

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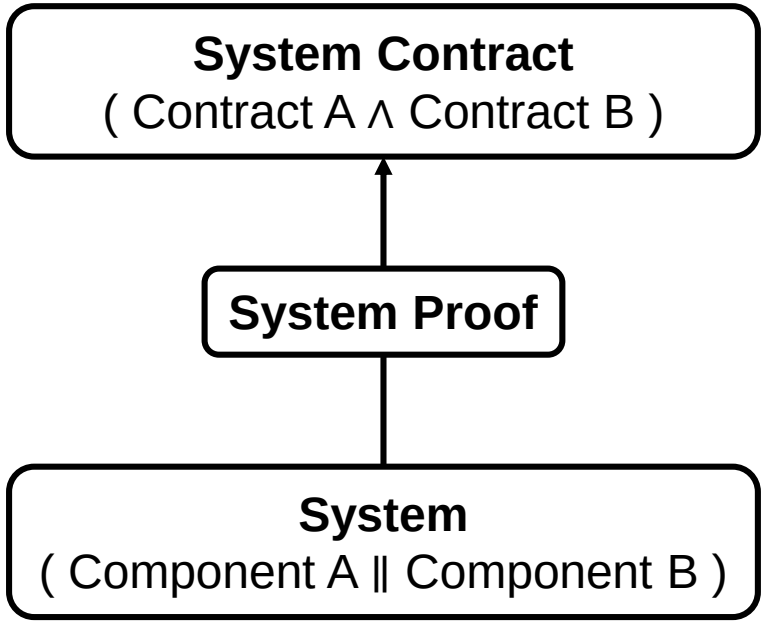

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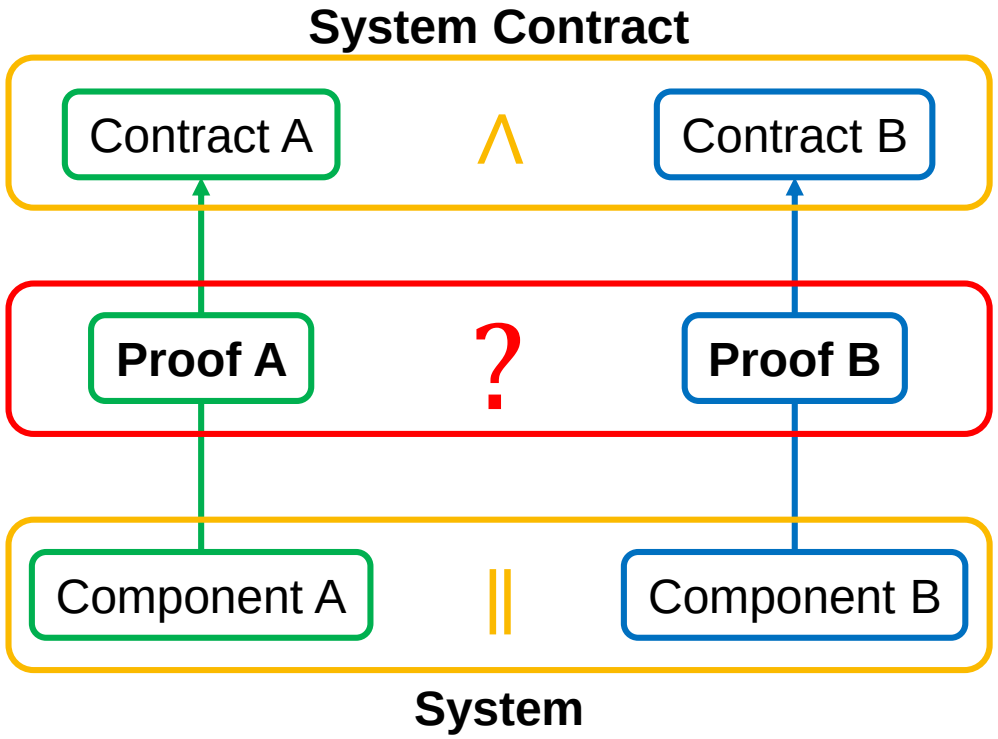

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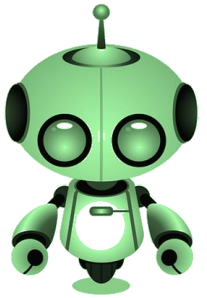

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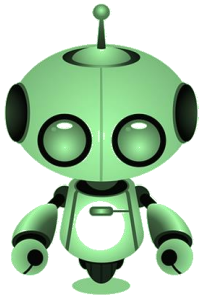

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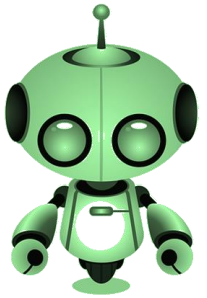

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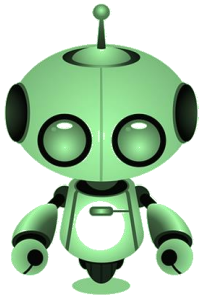

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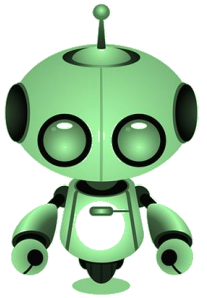

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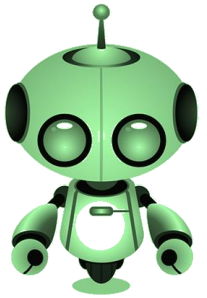

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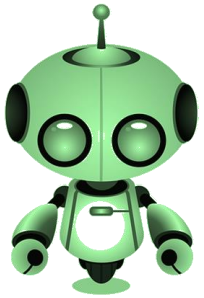

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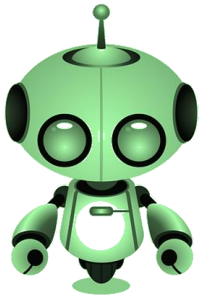

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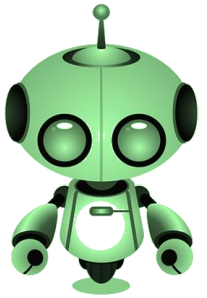

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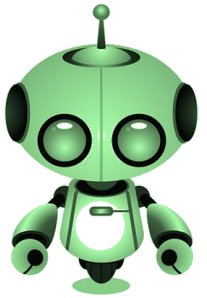

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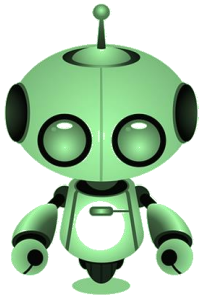

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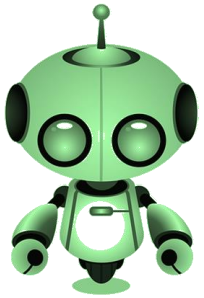

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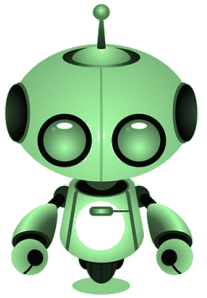

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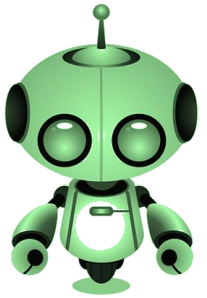
COMPONENT-BASED VERIFICATION – CONTRACTS



- **Initial condition**
  - Choose validity ranges for **global constants**
  - Additional **assumptions** regarding initial state
- **Safety condition**
  - Describes **safety** property and (optional) **guarantees** for values produced on **ports**

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$$\textbf{contract} \approx \boldsymbol{initial} \rightarrow [\ \textbf{program}\ ]\ \boldsymbol{post}$$

COMPONENT-BASED VERIFICATION – COMPOSITION (1)

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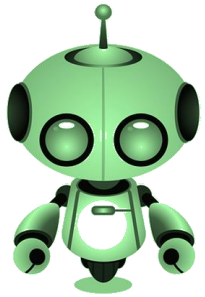

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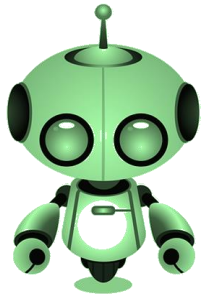

- Parallel Composition
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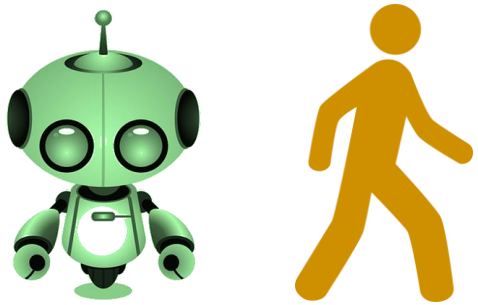

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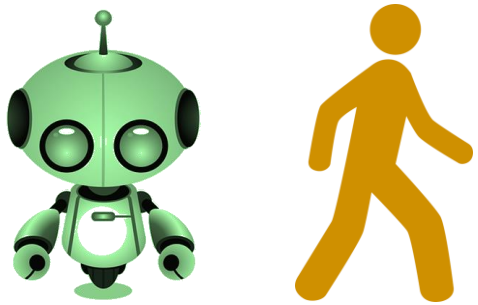

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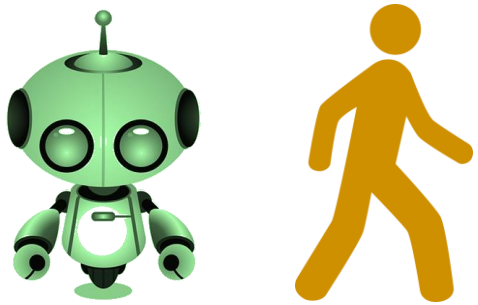

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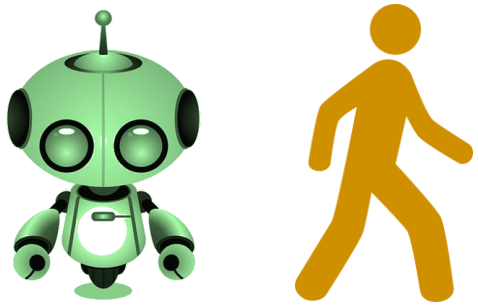

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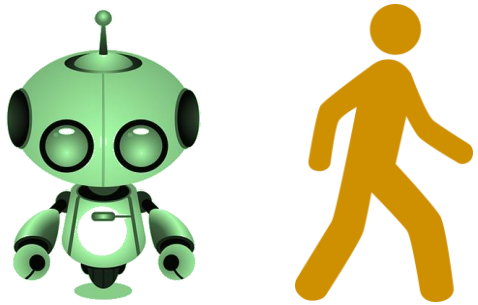

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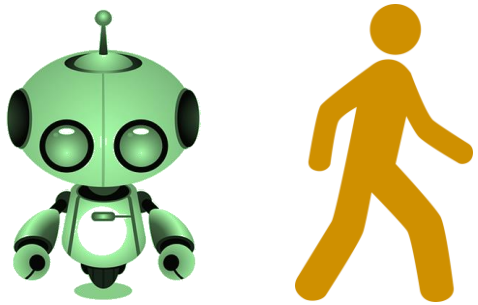

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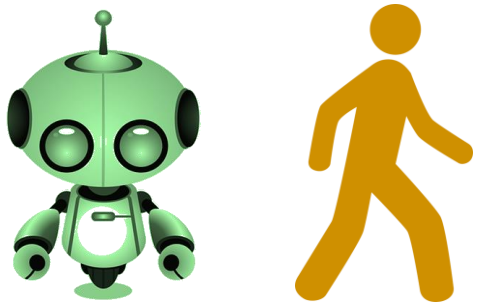

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    - Robot expects position of obstacle close to previous position

COMPONENT-BASED VERIFICATION – COMPOSITION (2)

- Composite program

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- Composite contract

$$cont_3 \approx (\; init_1 \wedge init_2 \;) \; \rightarrow [\; prog_3 \;] \; (\; post_1 \wedge post_2 \;)$$

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  - ☐ User provides **Proof A** and **Proof B**
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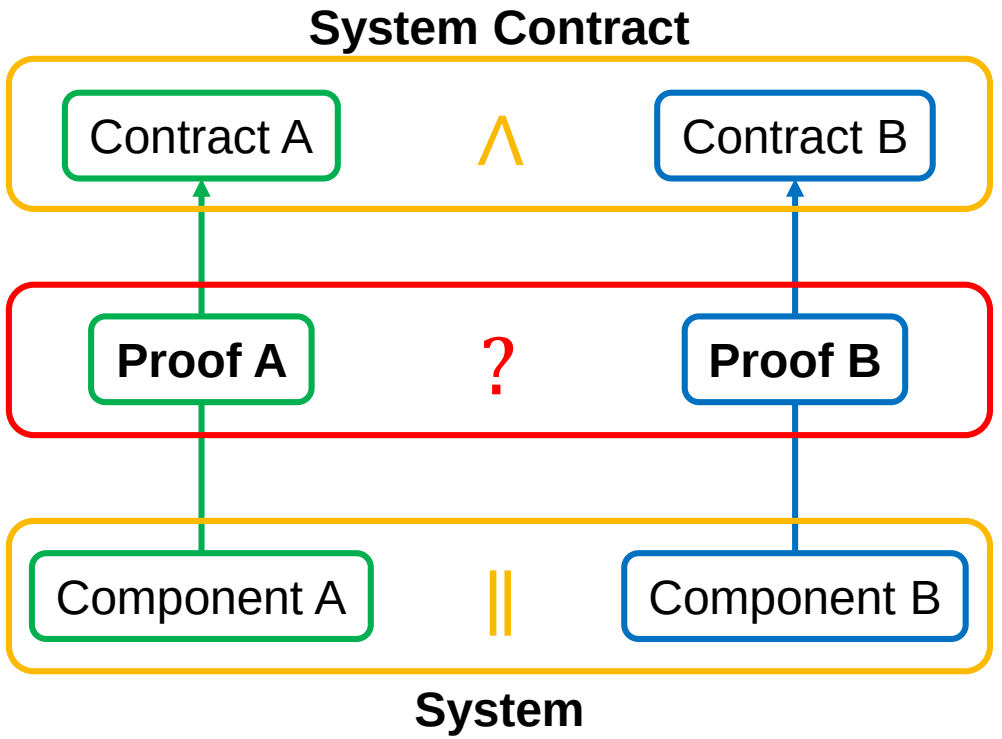

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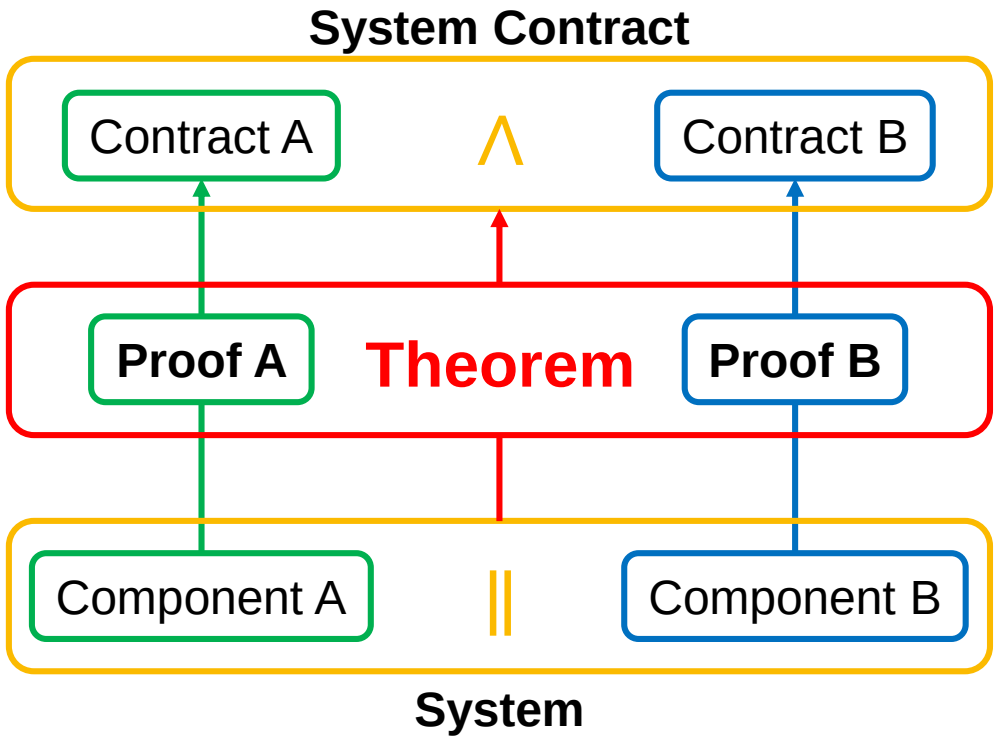

OVERVIEW

- Background
  - Cyber-Physical Systems
  - Component-based Verification

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  - Components
  - Contracts
  - Composition

- Evaluation
  - Implementation
  - Experiments

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- Summary
  - Reduction of verification time (especially for automated proofs)
  - Reduction of proof effort

Safe Component + Safe Component
=
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CHANGE AND DELAY CONTRACTS FOR HYBRID SYSTEM COMPONENT VERIFICATION

Andreas Müller – andreas.mueller@jku.at
Werner Retschitzegger – werner.retschitzegger@jku.at
Wieland Schwinger – wieland.schwinger@jku.at

Johannes Kepler University, Linz
Department of Cooperative Information Systems
http://cis.jku.at/

Stefan Mitsch – smitsch@cs.cmu.edu
André Platzer - aplatzer@cs.cmu.edu

Carnegie Mellon University, Pittsburgh
Computer Science Department
http://www.ls.cs.cmu.edu