A Decentralized Analysis of Multiparty Protocols[*]

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  - Verify *correctness, safety, and deadlock-freedom* of implementations, by means of a *binary session type system*.
  - Support expressive classes of protocols (delegation, interleaving).
  - New approach: process networks should be *decentralized*.

Multiparty Session Types

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- An example protocol: global type G_{auth}, server authentication with three participants *server* (s), *client* (c), and *authorization service* (a).

$$\mu X \,.\, s \twoheadrightarrow c \left\{\begin{array}{l} \mathsf{login} \,.\, c \twoheadrightarrow a : \mathsf{passwd}\langle \mathsf{str} \rangle \,.\, a \twoheadrightarrow s : \mathsf{result}\langle \mathsf{bool} \rangle \,.\, X, \\ \mathsf{quit} \,.\, c \twoheadrightarrow a : \mathsf{quit} \,.\, \mathsf{end} \end{array}\right\}$$

Global Type Type Checking Workflow

G_{auth} global type

Global Type Type Checking Workflow

$$\begin{tikzcd}
 & G_{\mathsf{auth}} \arrow[dl] \arrow[d] \arrow[dr] & \\
L_s & L_c & L_a
\end{tikzcd}$$

global type

local projection

local types

Global Type Type Checking Workflow

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& & & \text{local projection} \\
L_s & L_c & L_a & \text{local types} \\
& & & \\
P_s & P_c & P_a & \text{implementations}
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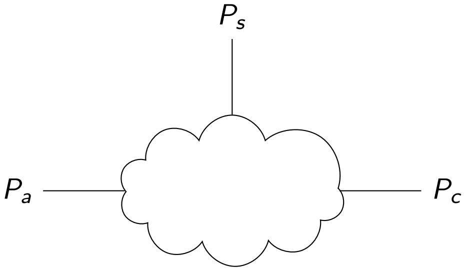
\end{tikzcd}$$

Type Checking Implementations

P_s

P_a P_c

Type Checking Implementations



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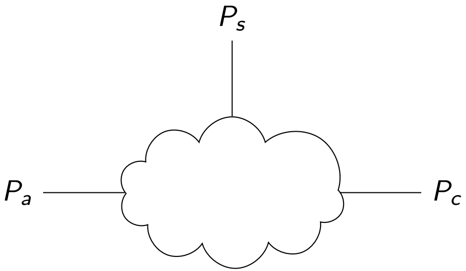

- Open problem: guarantee deadlock-freedom while supporting *delegation* and *interleaving*.

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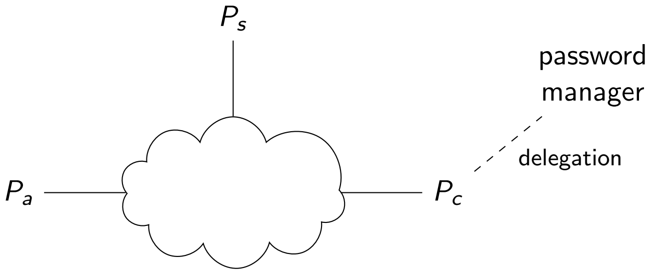

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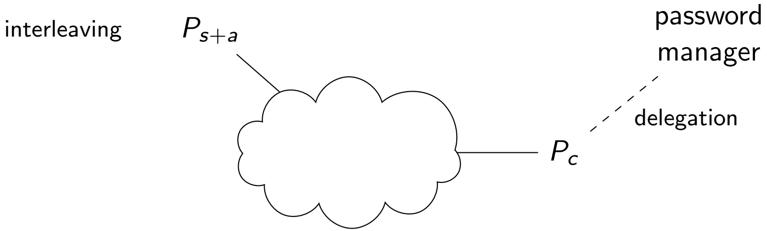

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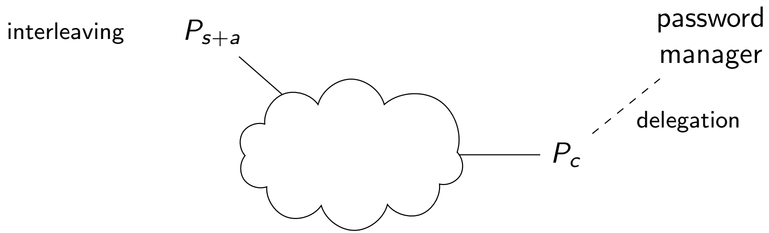
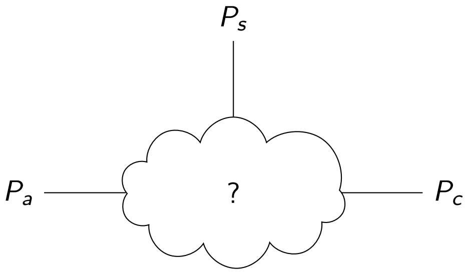


- Open problem: guarantee deadlock-freedom while supporting *delegation* and *interleaving*.
- Our approach: reduce the problem to *binary* session types, where deadlock-freedom follows from typing and delegation and interleaving are naturally supported.

Routers



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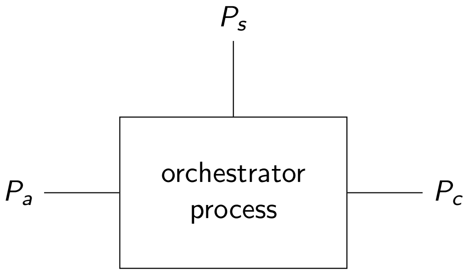

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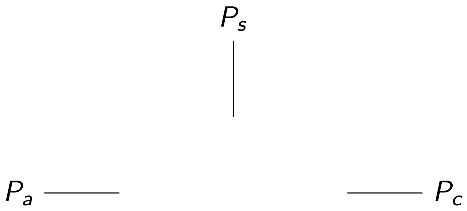

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P_a \arrow[r, dash] & \mathcal{R}_a \quad\quad\quad\quad \mathcal{R}_c \arrow[r, dash] & P_c
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- Routers are local to their participant implementation,
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- Result: decentralized network of routed implementations.

Type Checking Networks of Routed Implementations

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- Type system *APCP*, with deadlock-freedom guarantee for cyclic process networks *without cyclic dependencies*.

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- Type system *APCP*, with deadlock-freedom guarantee for cyclic process networks *without cyclic dependencies*.
- Channels between implementations and routers: use local projections.
- Channels between routers: we introduce *relative projection*.

$$R_{s,a} = G_{\mathsf{auth}} \downharpoonright (s, a) \quad R_{a,c} = G_{\mathsf{auth}} \downharpoonright (a, c) \quad R_{c,s} = G_{\mathsf{auth}} \downharpoonright (c, s)$$

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- Relative projection onto (c, s) is straightforward:

$$G_{\text{auth}} \downharpoonleft (c, s) = \mu X \mathrel{.} s\{\text{login} \mathrel{.} X, \quad \text{quit} \mathrel{.} \text{end}\}$$

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- Solution: non-local choices as explicit *dependency* messages.

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- We can derive from G a well-formed global type:

$$G' = b \twoheadrightarrow a \begin{Bmatrix} \mathsf{ok} \,.\, b \twoheadrightarrow s : \mathsf{ok} \,.\, s \twoheadrightarrow m \{ \mathsf{deliver}\langle \mathsf{str} \rangle \,.\, \mathsf{end},\ \mathsf{quit} \,.\, \mathsf{end} \}, \\ \mathsf{quit} \,.\, b \twoheadrightarrow s : \mathsf{quit} \,.\, s \twoheadrightarrow m \{ \mathsf{deliver}\langle \mathsf{str} \rangle \,.\, \mathsf{end},\ \mathsf{quit} \,.\, \mathsf{end} \} \end{Bmatrix}$$

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- Key innovations: routers and relative projection.
- New class of well-formed global types.
- Work currently under submission, draft available at `https://basvdheuvel.github.io`.