Multiparty GV

Functional Multiparty Session Types With Certified Deadlock Freedom

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Usual message passing:

- Stream of messages of fixed type
- e.g., Go, Rust: `Receiver<T>, Sender<T>`

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Session types:

- Flexible message passing protocols
- Type of message can depend on the state of the protocol
- Linear types

Binary session types: Honda et al. '93, '98

$$c \; : \; \mathbf{!}\mathit{Nat}.\,\mathbf{?}\mathit{Bool}.\,\mathbf{!}\mathit{Nat}.\,\mathsf{End}$$

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$$c \; : \; !Nat.?Bool.!Nat.\mathrm{End}$$

$$\Updownarrow \text{dual}$$

$$c' : \; ?Nat.!Bool.?Nat.\mathrm{End}$$

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Multiparty session types: Honda et al. '08

$$\left.\begin{array}{ll} c_0 : & !^1 Nat.\,?^2 Nat.\,\mathsf{End} \\ c_1 : & ?^0 Nat.\,!^2 Bool.\,\mathsf{End} \\ c_2 : & ?^1 Bool.\,!^0 Nat.\,\mathsf{End} \end{array}\right\}\ \text{consistent}$$

Two worlds of session types

GV family languages
Gay, Vasconcelos '10, Wadler '12

- Binary session types

MPST family languages
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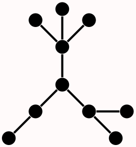

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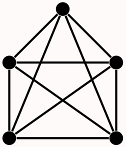

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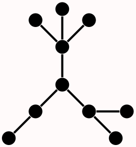

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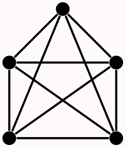

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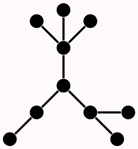

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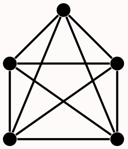

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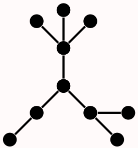

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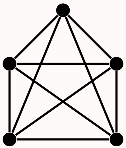

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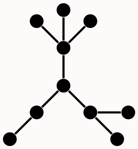

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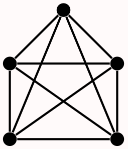

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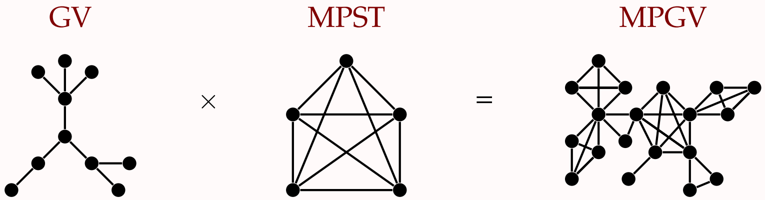
GV $\times$ MPST = MPGV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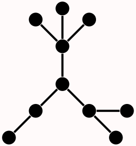

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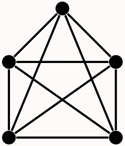

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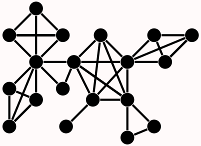
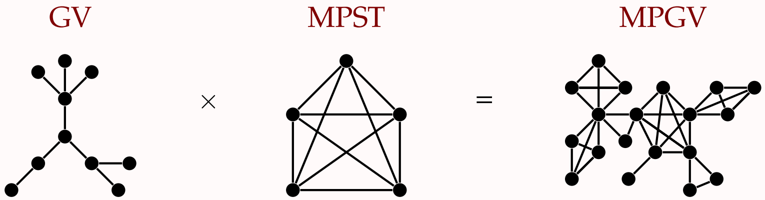


Contributions

1. **Design of MPGV:** concurrent λ-calculus with multiparty message-passing channels as first-class values (+ channel/thread spawning + rectypes + choice)



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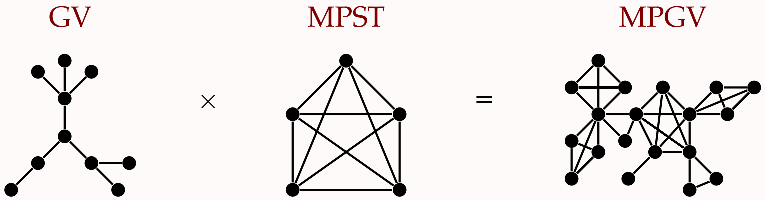

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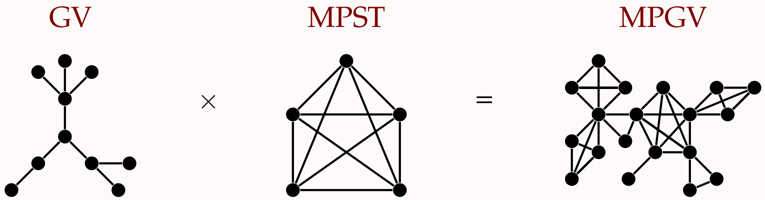

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4. **Meta theory:** fully mechanized in Coq

Tour of MPGV: n-ary fork

Inspired by multi-cut of Carbone et al. CONCUR'16:

$$
\begin{aligned}
&\textbf{let } c_0 = \textbf{fork}(\lambda c_1.\, e_1,\\
&\qquad\qquad\qquad\;\; \lambda c_2.\, e_2,\\
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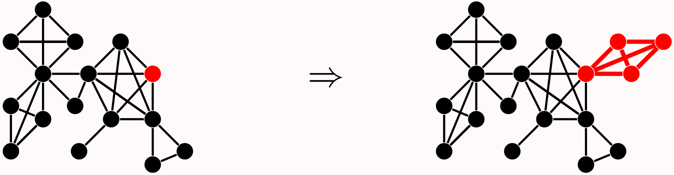

Tour of MPGV: send and receive

$$\textbf{send}^{p} : (!^{p}\tau.\, s) \times \tau \to s$$

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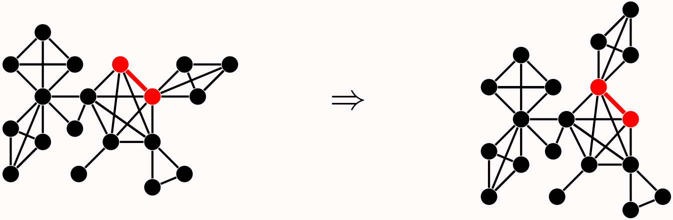

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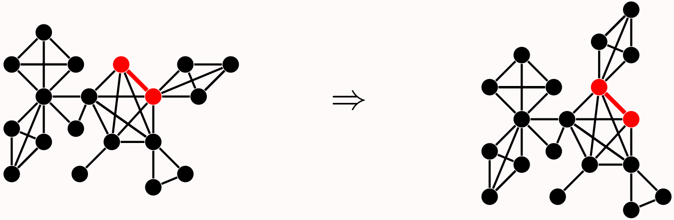


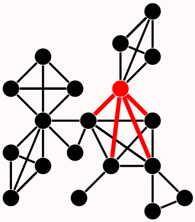
- In the paper: asynchronous semantics (messages go via buffers)

Close

$$\textbf{close} : \mathsf{End} \to (\,)$$

Close

$$\textbf{close} : \mathsf{End} \rightarrow (\,)$$



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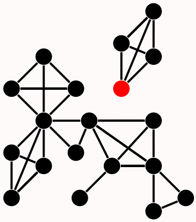

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- Used in translation from GV to MPGV
- In the paper: useful for modularity

Mechanized meta theory

> Unfortunately, the more complicated the behaviour is, the more *error-prone* the theory becomes. The literature reveals broken proofs of subject reduction for several MPST systems [42], and a flaw of the decidability of subtyping [6] for asynchronous MPST. All of which are caused by an incorrect understanding of the (asynchronous) behaviour of types.

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- **Leak freedom:** no messages left behind

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- 1 LOC, no auxiliary definitions
- Sanity check on deadlock freedom statement

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