Towards Trustworthy Multiparty Sessions

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Outline

A Shared Vision (Hopefully!)

1st Fact

Trustworthy Service Oriented Computing is hard: services are autonomous, heterogeeneous, separately designed computational entities to be dynamically assembled.

2nd Fact

Process Calculi can help: they allow to focus on salient features at a convenient level of abstraction.

3rd Fact

Behavioural types can help: syntactic descriptions of services are not expressive enough to guarantee their trustworthy assembly.

4th Fact (or mere conjecture?)

Existing techniques must be adapted: SOC has specific features like endpoints, sessions, dynamicity.

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Our Proposal

μse (after MUltiparty SEssions)

μse is a process calculus for expressing computations where endpoints dynamically join existing multiparty sessions (as seen on Emilio's talk @ COORDINATION 2008)

Types for

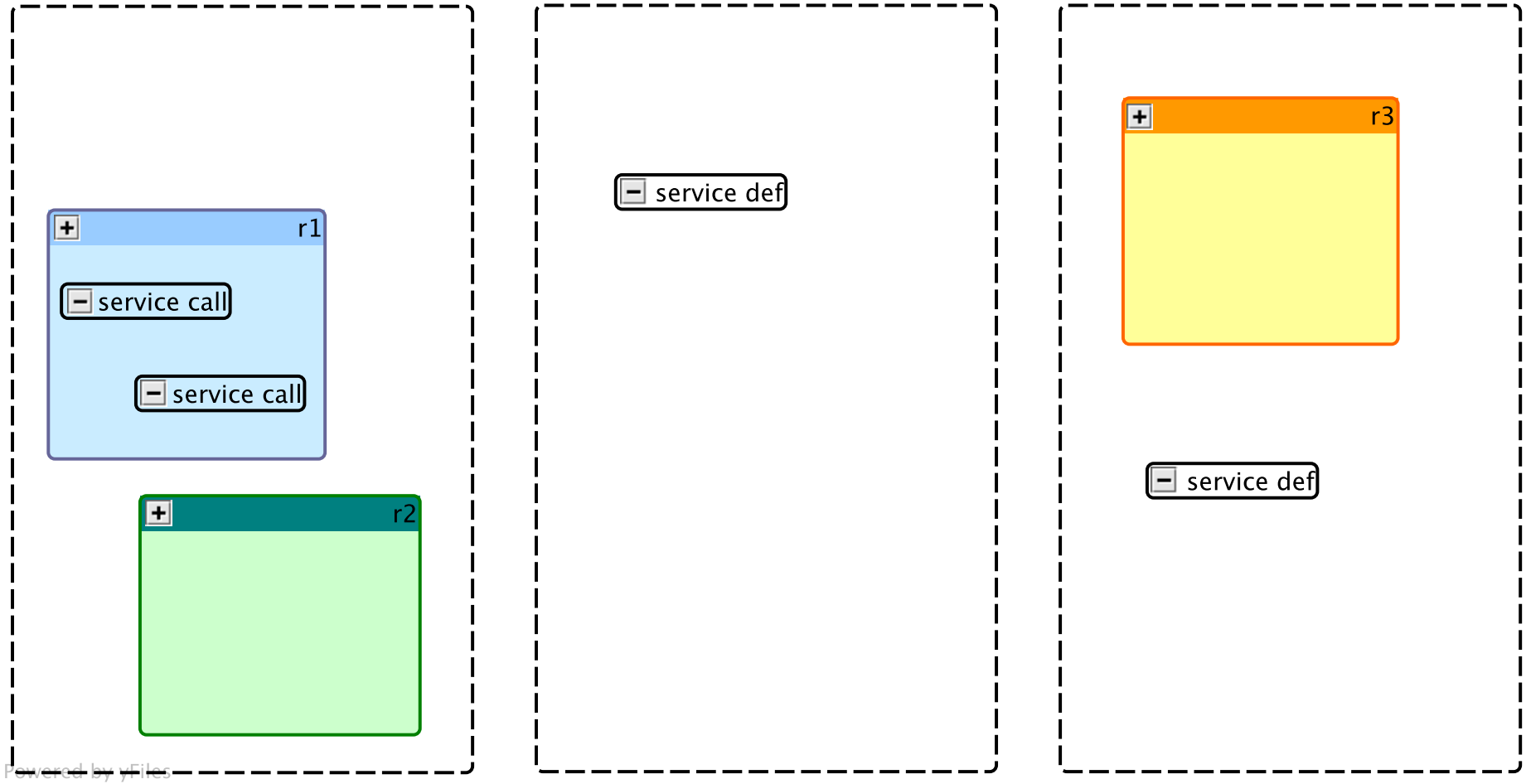
- Semantic description of services (for discovery)
- Compatibility check (for dynamic assembly)
- Early detection of possible sources of problems (trustworthiness)

Disclaim

- We restrict to consider a "bare bones" fragment of μse
- We present a parametric type system w.r.t. 3 notions (task separation, dual type compatibility, session completion)
- We conjecture subject reduction + all non-typeable processes can deadlock
- We look for stronger guarantees

Outline

Sites, Service Invocation and Sessions



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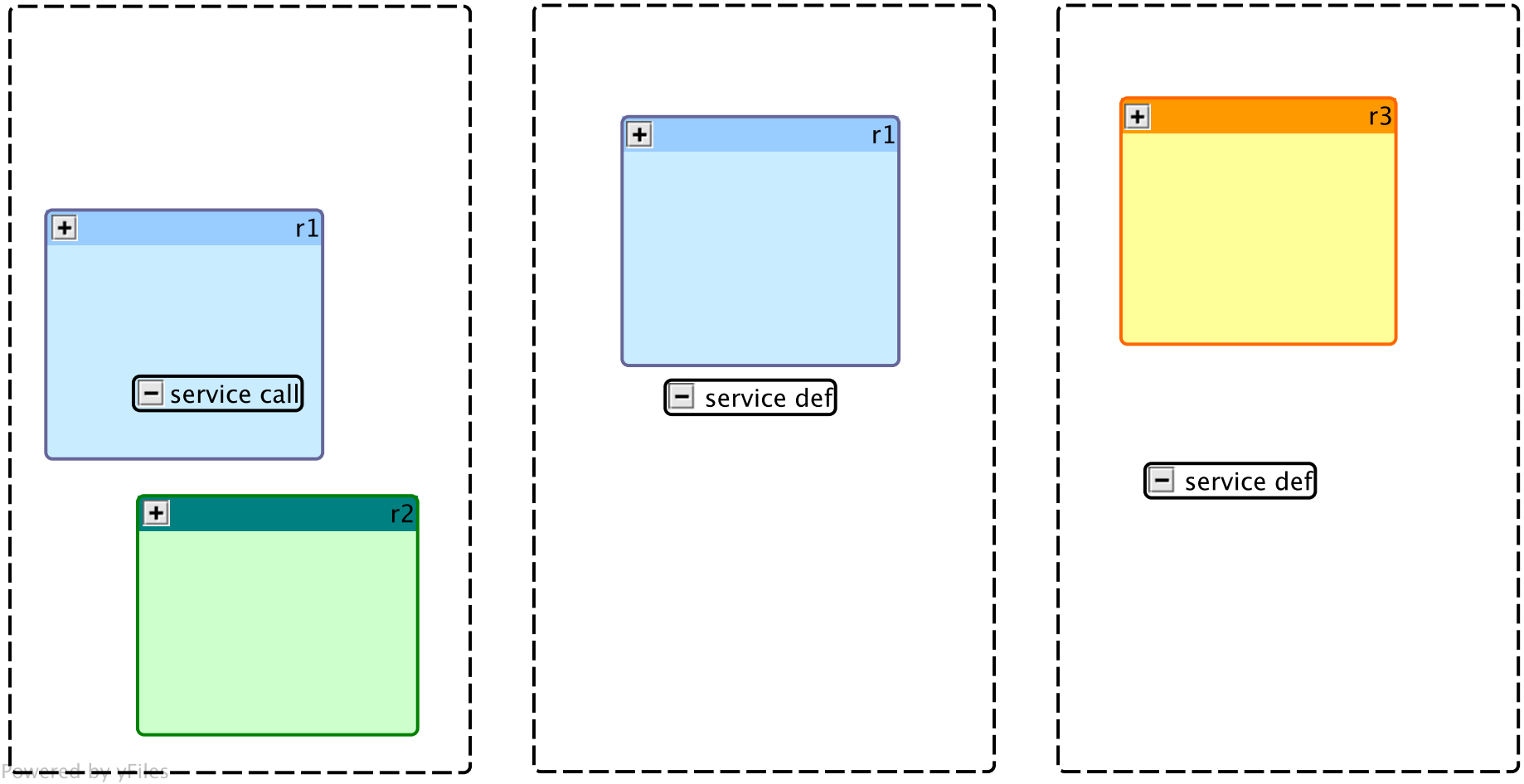

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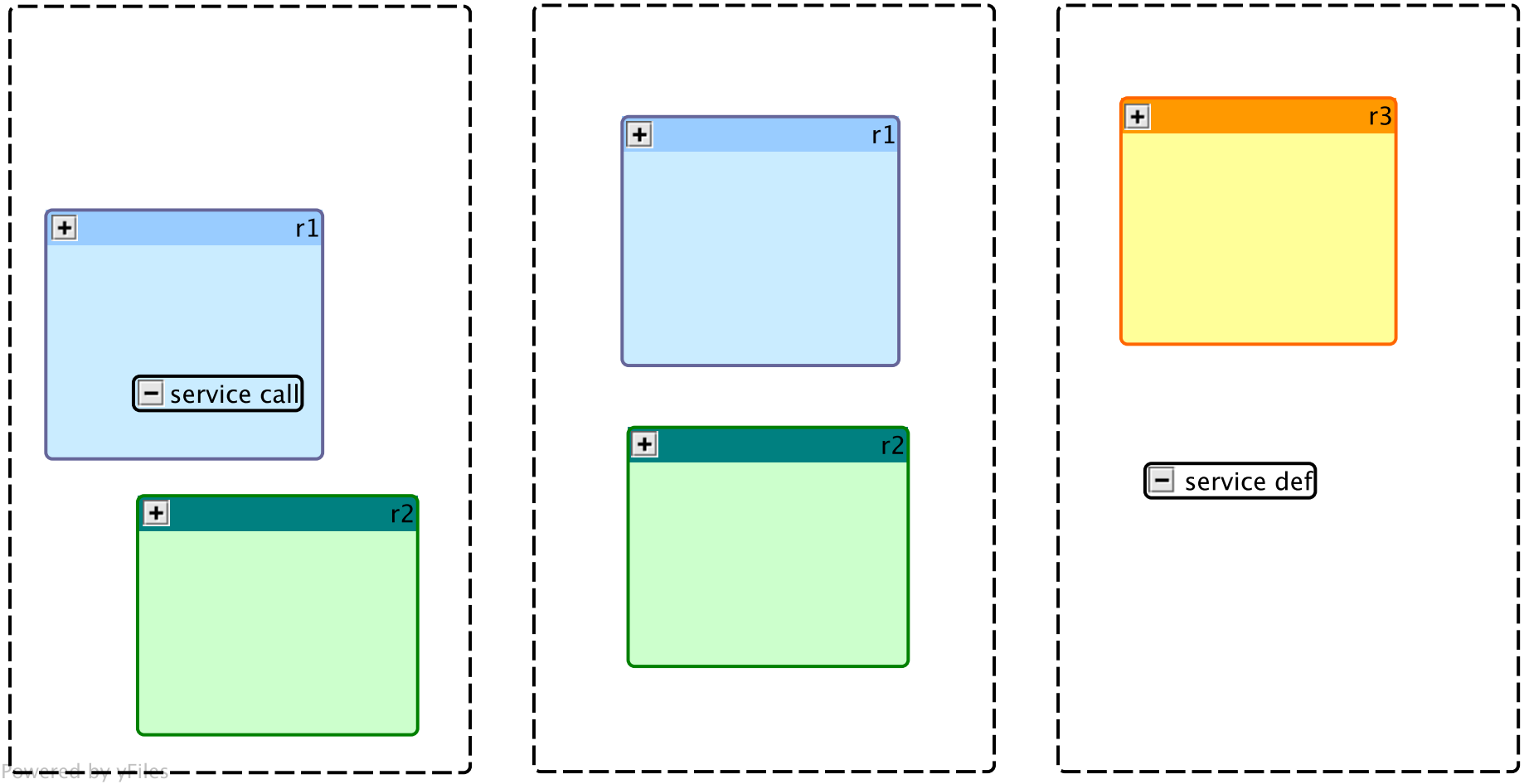

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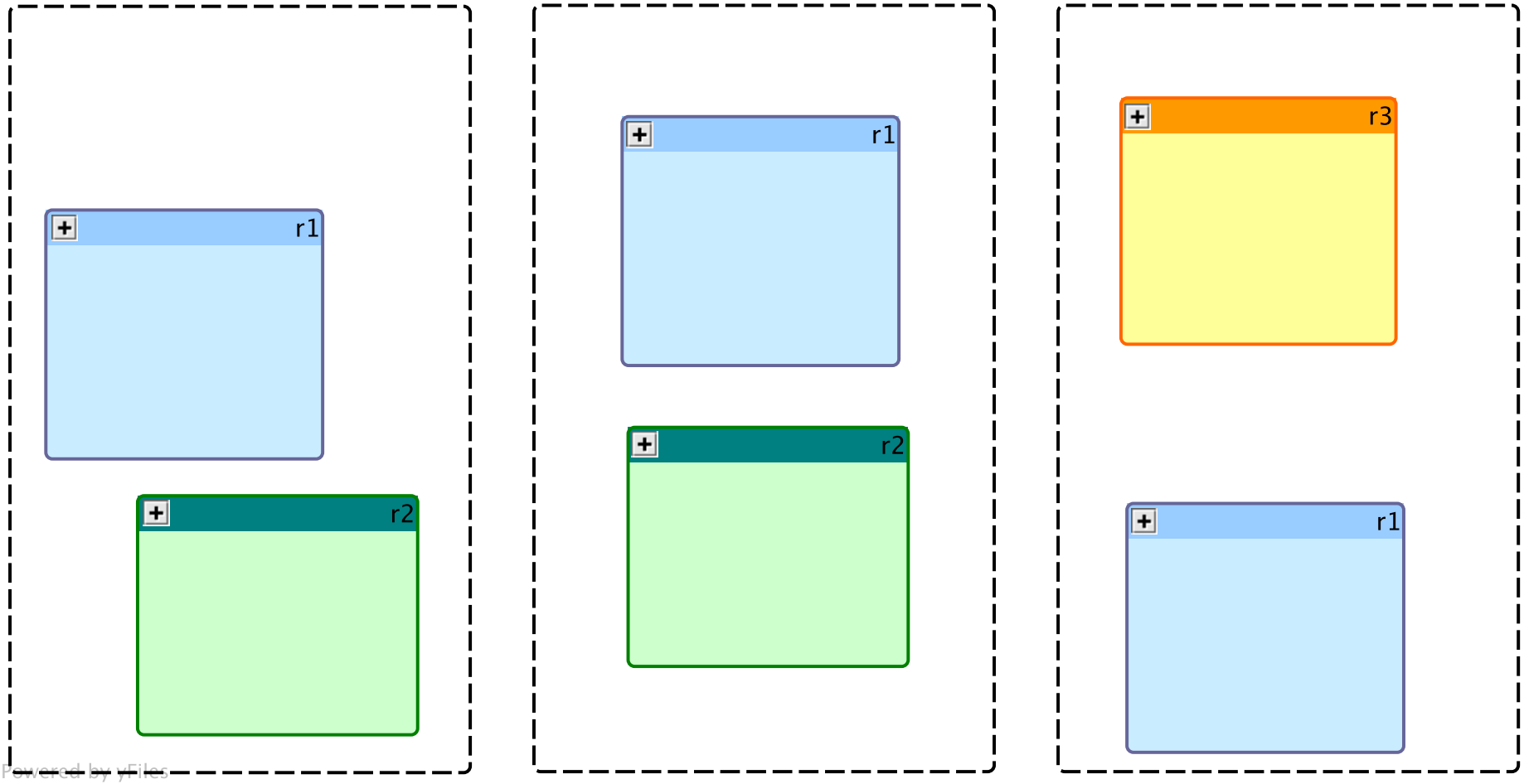
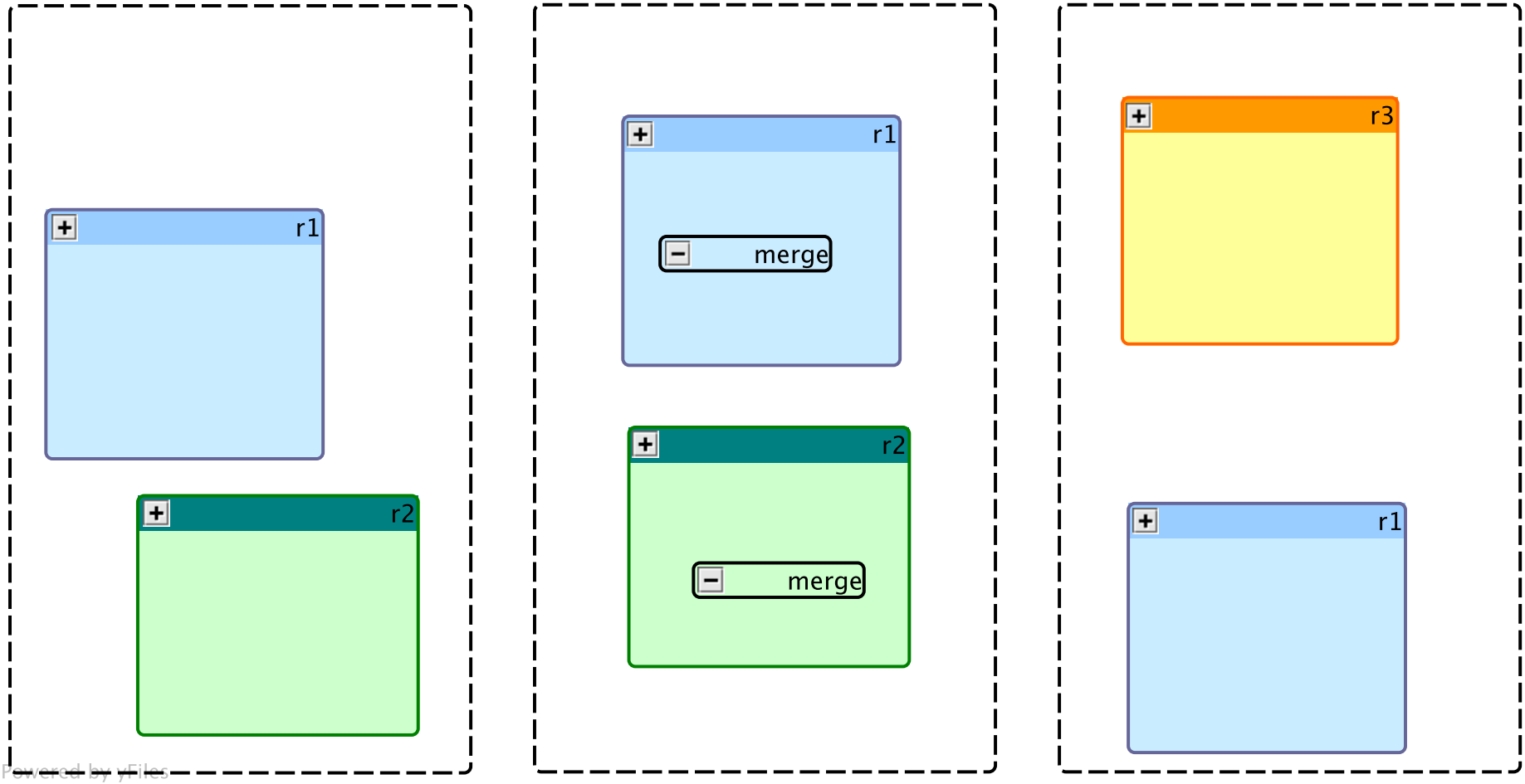


Merging Sessions



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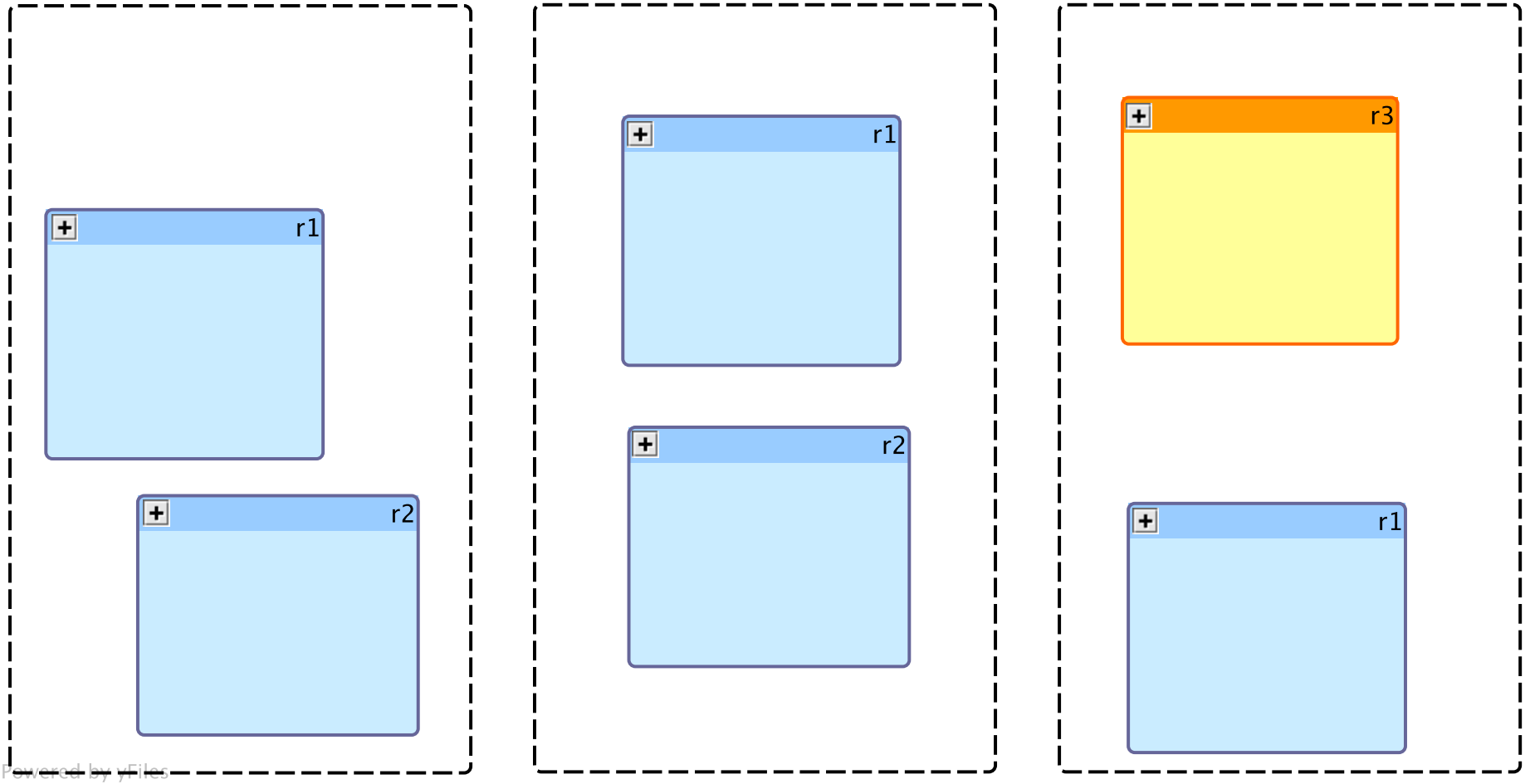

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Types for Dynamic Multiparty Sessions

Type judgments

$\Gamma; \Delta \vdash P : \{\sigma \nearrow \rho\}$

- we call σ the *current* type, and ρ the *delegated* type
- P provides communication activities in σ and ρ
- activities σ concern the current participants of its session,
- activities ρ concern other endpoints that P itself will allow to join its session (via service invocation or merge)
- Γ is a finite partial mapping from variables X and polarized service / entry-point names n^p (with $p \in \{+, -\}$) to type pairs $\sigma \nearrow \rho$, with the understanding that actions in ρ are delegated to $n^{\overline{p}}$.
- Δ is a finite partial mapping from session names r to types σ, such that $\Delta(r)$ is the parallel composition of the current types of all endpoints of r

Self typeable systems

$\Gamma; \Delta \vdash S : \{0 \nearrow 0\}$

Parametric on Task Separation

Task separation

Task separation $c * \sigma$ is used to project the activities of P in separate threads for later delegation.

Our choice

Here we take the most relaxed form of separation, where $c * \sigma = c|\sigma$.

Used in

$$\frac{\Gamma; \Delta \vdash P : \{\sigma \nearrow \rho\}}{\Gamma; \Delta \vdash c.P : \{c * \sigma \nearrow \rho\}} \text{(TACTION)}$$

Parametric on Type Compatibility

Type compatibility

Type compatibility $\sigma \approx \rho$ says that σ and ρ are complementary.

Our choice

Let $I(\sigma) = \{c \mid \exists \sigma' : \sigma \overset{c}{\mapsto} \sigma'\}$ be the set of initial actions of σ.
Here we take the largest relation on types such that whenever $\sigma \approx \rho$:

- either $I(\sigma) = I(\rho) = \emptyset$,
- or $K = I(\sigma) \cap \overline{I(\rho)} \neq \emptyset$ and, for each $x \in K$ and for each σ' and ρ' such that $\sigma \overset{x}{\mapsto} \sigma'$ and $\rho \overset{\overline{x}}{\mapsto} \rho'$, then $\sigma' \approx \rho'$.

Used in

Γ is *well-formed* if:

- whenever $\Gamma(n^p) = \sigma \nearrow \rho$, then $\Gamma(n^{\overline{p}}) = \sigma' \nearrow \rho'$ for some $\rho' \approx \rho$,
- whenever $\Gamma(a^-) = \sigma \nearrow \rho$, then $\sigma = 0$.

Parametric on Session Completion

Session completion

The completion set $\Downarrow_0$ contains those types σ that express admissible interactions of multiple endpoints.

Our choice

Here we define $\Downarrow_0$ as the largest set of types σ such that:

- for each $c \in I(\sigma)$ such that $\overline{c} \notin I(\sigma)$ and for each $\sigma \overset{\tau}{\mapsto} \sigma'$ there exists σ'' such that $\overline{c} \in I(\sigma'')$ and $\sigma' \overset{\tau}{\mapsto}^* \sigma''$,
- if $\sigma \overset{\tau}{\mapsto} \sigma'$ then $\sigma' \in \Downarrow_0$.

Used in

We say that Δ is *fully-formed* if whenever $\Delta(r) = \sigma$, then $\sigma \in \Downarrow_0$.

Example: Two Buyers

$(\nu r_1, r_2)(l_s :: Sell \mid l_1 :: Buy_1 \mid l_2 :: Buy_2)$

$$Sell = sell \Rightarrow title.\mathsf{install}[Offer].\mathsf{merge}^{-}\ e$$

The service *sell* waits for a buyer to require a quote for a book (*title*), installs a new service *offer* for a second buyer and prepares for merging with an instance of *offer*.

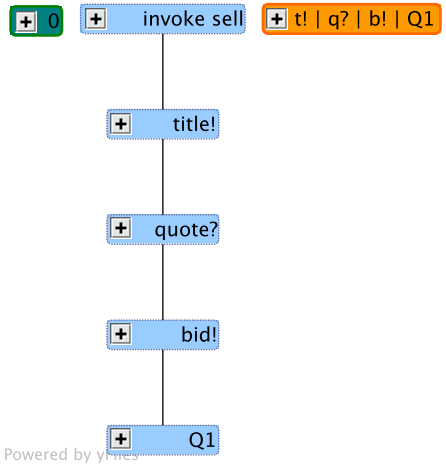
$$Offer = offer \Rightarrow \mathsf{merge}^{+}\ e.(\overline{title}.(\overline{quote}.Q_3 | \overline{quote}.Q_4))$$

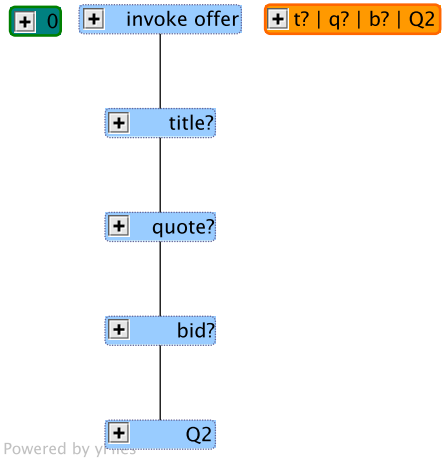
offer provides the book's *title* so that quotes are communicated to both buyers after the sessions are merged.

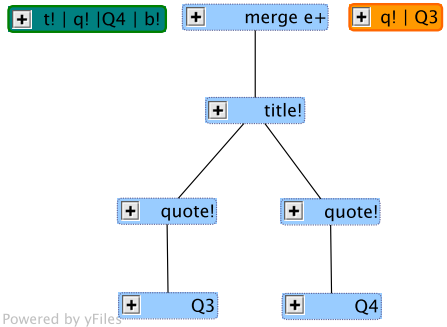
$$\begin{aligned} Buy_1 &= r_1 \triangleright \mathsf{invoke}\ sell.\overline{title}.quote.\overline{bid}.Q_1 \\ Buy_2 &= r_2 \triangleright \mathsf{invoke}\ offer.title.quote.bid.Q_2 \end{aligned}$$

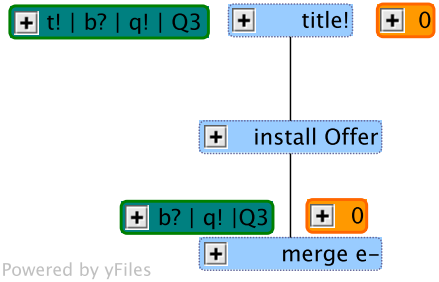
Buyers communicate over *bid* and the negotiation is concluded by the interactions among Q, Q_1 and Q_2 (not modeled here).

Example: Typing the Two Buyers









$$\Gamma = \{ \quad sell^+ : (0 \nearrow b|t|\overline{q}|Q_3), \quad sell^- : (0 \nearrow \overline{b}|\overline{t}.q|Q_1),$$
$$offer^+ : (0 \nearrow \overline{b}|\overline{t}|\overline{q}|Q_4), \quad offer^- : (0 \nearrow b|t|q|Q_2),$$
$$e^- : (\overline{b} \nearrow 0), \quad e^+ : (\overline{q}|b|Q_3 \nearrow 0) \ \}$$

(TINSTALL)

$$\frac{\Gamma;\Delta \vdash P : \{\sigma_1|\sigma_2 \nearrow \rho\} \quad \Gamma(a^+) = \sigma_1 \nearrow \sigma_2 \quad \Gamma(a^-) = 0 \nearrow \rho' \quad \Gamma;\Delta \vdash Q : \{\Phi\}}{\Gamma;\Delta \vdash \mathsf{install}[a \Rightarrow P].Q : \{\Phi\}}$$

(TMERGE)

$$\frac{\Gamma;\Delta \vdash P : \{\sigma_1|\sigma_2|\sigma_3 \nearrow \rho\} \quad \Gamma(e^p) = \sigma|\sigma_2 \nearrow \sigma_3 \quad \Gamma(e^{\overline{p}}) = \sigma'|\sigma'' \nearrow \rho' \quad \sigma \approx \sigma''}{\Gamma;\Delta \vdash \mathsf{merge}^p\ e.P : \{\sigma'|\sigma_1|\sigma'' \nearrow \sigma_2|\sigma_3|\rho\}}$$

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Conclusion

Preliminary study

Some self typeable systems can behave "badly" (no check on availability of services, entry points, etc).

Future work

- Suitable syntactic restrictions to obtain stronger guarantees.
- Change the notions of $c * \sigma$, $\approx$ and $\Downarrow_0$ if needed

Your feedback would be welcome!!

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