Towards Trustworthy Multiparty Sessions

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Outline

1. Introduction & Motivation

2. A Glimpse of \( \mu \text{se} \), graphically

3. Something About Types

4. Concluding Remarks
A Shared Vision (Hopefully!)

1st Fact

*Trustworthy Service Oriented Computing is hard:* services are autonomous, heterogeneous, 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

\( \mu \text{se} \) (after MUltiparty SEssions)

\( \mu \text{se} \) 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 \( \mu \text{se} \)
- 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
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Bruni et al. (PI, BO, UBA, IMT, UL)

Typing μse

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Merging Sessions

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Types for Dynamic Multiparty Sessions

Type judgments

\[ \Gamma; \Delta \vdash P : \{ \sigma \rightarrow \rho \} \]

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

Self typeable systems

\[ \Gamma; \Delta \vdash S : \{ 0 \rightarrow 0 \} \]
Task separation

Task separation $c \ast \sigma$ 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 $c \ast \sigma = c|\sigma$.

Used in

\[
\frac{(\text{T} \text{a} \text{c} \text{i} \text{o} \text{n})}{\Gamma; \Delta \vdash P : \{\sigma \rightarrow \rho\}} \quad \frac{\Gamma; \Delta \vdash c \cdot P : \{c \ast \sigma \rightarrow \rho\}}{
\Gamma; \Delta \vdash c \cdot P : \{c \ast \sigma \rightarrow \rho\}}
\]
Type compatibility

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

Our choice

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

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

Used in

$\Gamma$ is well-formed if:

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

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

Our choice

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

- for each $c \in I(\sigma)$ such that $\overline{c} \not\in I(\sigma)$ and for each $\sigma \xrightarrow{T} \sigma'$ there exists $\sigma''$ such that $\overline{c} \in I(\sigma'')$ and $\sigma' \xrightarrow{T}^* \sigma''$,

- if $\sigma \xrightarrow{T} \sigma'$ then $\sigma' \in \Downarrow_0$.

Used in

We say that $\Delta$ is fully-formed if whenever $\Delta(r) = \sigma$, then $\sigma \in \Downarrow_0$. 
Example: Two Buyers
\((\nu r_1, r_2)(l_s :: Sell \mid l_1 :: Buy_1 \mid l_2 :: Buy_2)\)

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

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 \(offer\).

\[ Offer = offer \Rightarrow \text{merge}^+ e.(title.(quote.Q_3|quote.Q_4)) \]

\(offer\) provides the book’s \(title\) so that quotes are communicated to both buyers after the sessions are merged.

\[ Buy_1 = r_1 \triangleright \text{invoke sell}.title.\text{quote}.\text{bid}.Q_1 \]
\[ Buy_2 = r_2 \triangleright \text{invoke offer}.title.\text{quote}.\text{bid}.Q_2 \]

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

\[ \Gamma = \{ \begin{align*}
\text{sell}^+ : (0 \not\vdash b \mid t \mid \overline{q} \mid Q_3), \\
\text{offer}^+ : (0 \not\vdash \overline{b} \mid \overline{t} \mid \overline{q} \mid Q_4), \\
\text{sell}^- : (0 \not\vdash \overline{b} \mid \overline{t} \cdot q \mid Q_1), \\
\text{offer}^- : (0 \not\vdash b \mid t \cdot q \mid Q_2), \\
e^- : (\overline{b} \not\vdash 0), \\
e^+ : (\overline{q} \mid b \mid Q_3 \not\vdash 0) \} \]

(T\text{INSTALL})
\[ \Gamma; \Delta \vdash P : \{\sigma_1 | \sigma_2 \not\vdash \rho\} \quad \frac{\Gamma(a^+) = \sigma_1 \not\vdash \sigma_2 \quad \Gamma(a^-) = 0 \not\vdash \rho'}{\Gamma; \Delta \vdash \text{install}[a \Rightarrow P].Q : \{\Phi\}} \]

(T\text{MERGE})
\[ \Gamma; \Delta \vdash P : \{\sigma_1 | \sigma_2 | \sigma_3 \not\vdash \rho\} \quad \frac{\Gamma(e^p) = \sigma | \sigma_2 \not\vdash \sigma_3 \quad \Gamma(\overline{e^p}) = \sigma' | \sigma'' \not\vdash \rho'}{\Gamma; \Delta \vdash \text{merge}^p e.P : \{\sigma' | \sigma_1 | \sigma'' \not\vdash \sigma_2 | \sigma_3 | \rho\}} \]
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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 $c \ast \sigma$, $\approx$ and $\Downarrow_0$ if needed

Your feedback would be welcome!!
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Your feedback would be welcome!!