Process equivalences for Multiparty interactions

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based on (an ongoing) joint work with Marzia Buscemi and Rocco de Nicola

Theory of contracts

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$$p ::= \mathbf{0} \mid \mu.p \mid \sum_{i \in I} p_i \mid \bigoplus_{i \in I} p_i \mid A$$

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Happiness means graceful termination

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In what follows we will consider happy clients

Subcontract

- Compliance induces a **subcontract** relation $(<)$:
  - if $p < p'$. *A* client happy with p is equally happy with p'.

Subcontract

- Compliance induces a **subcontract** relation (<):
  - if $p < p'$. A client happy with p is equally happy with p'.
- < Ensures safe replacement
- It can be used for service discovery

Compliance & Subcontract

- Focus on two-party interaction

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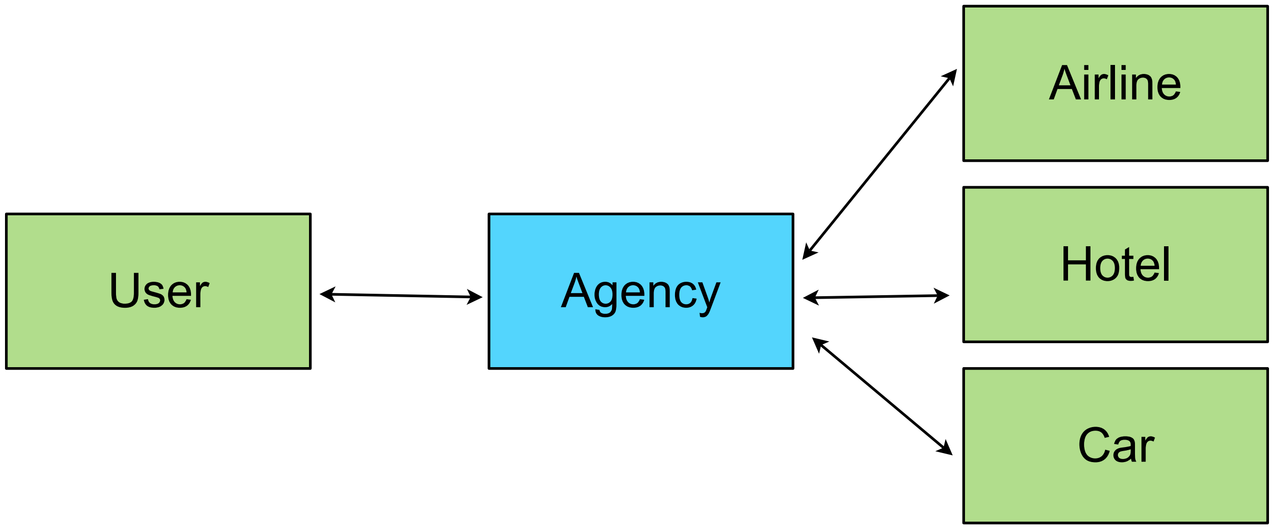
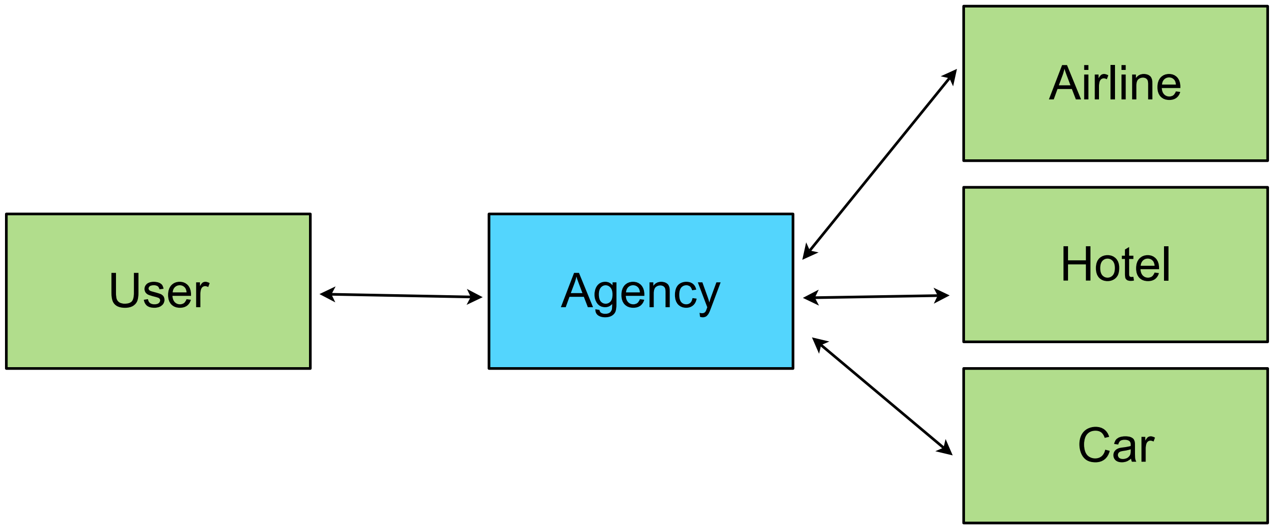


Compliance & Subcontract

- Focus on two-party interaction



Two-party compliance induces a subcontract notion that may be to fine-grained in some multiparty context

Controllability in OWNs

- A service is controllable if it has a compatible client

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  - Centralized
  - Decentralized
  - Local

Characterizes the degree of coordination in the clients

Decentralized client

- A set of partners that
  - communicate with the server
  - but do not communicate with each other

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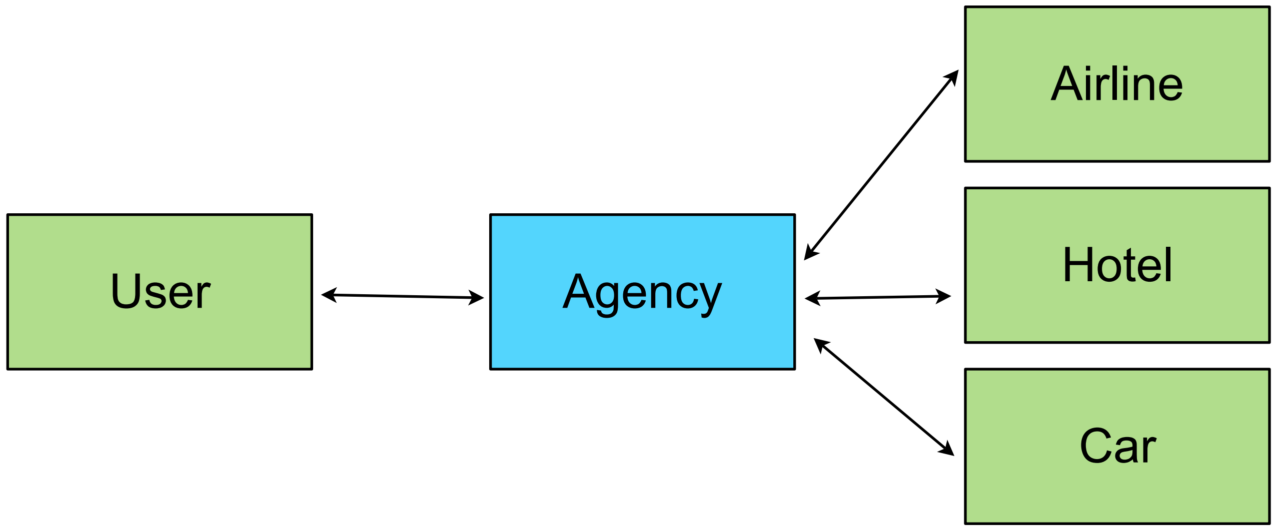

Testing preorder

- Contracts [BH13]

$$p ::= \mathbf{1} \mid \mu.p \mid \sum_{i \in I} p_i \mid A$$

$$\mu \in \mathsf{Act} \cup \{\tau\}$$

Testing preorder

- Contracts [BH13]

$$p ::= \mathbf{1} \mid \mu.p \mid \textstyle\sum_{i \in I} p_i \mid A$$

$$\mu \in \mathsf{Act} \cup \{\tau\}$$

$$\mathbf{1} \xrightarrow{\checkmark} \mathbf{0} \qquad \mu.p \xrightarrow{\mu} p$$

$$\frac{p \xrightarrow{\mu} p'}{p + q \xrightarrow{\mu} p'} \qquad \frac{q \xrightarrow{\mu} q'}{p + q \xrightarrow{\mu} q'} \qquad \frac{p \xrightarrow{\mu} p'}{A \xrightarrow{\mu} p'}\ A \stackrel{def}{=} p$$

Testing preorder

- Service composition

$$\frac{c \xrightarrow{\mu} c'}{c \parallel d \xrightarrow{\mu} c \parallel d} \qquad \frac{c \xrightarrow{\mu} c'}{c \parallel d \xrightarrow{\mu} c \parallel d'}$$

$$\frac{c \xrightarrow{\alpha} c' \quad d \xrightarrow{\overline{\alpha}} d'}{c \parallel d \xrightarrow{\tau} c' \parallel d'} \qquad \frac{c \xrightarrow{\checkmark} c' \quad d \xrightarrow{\checkmark} d'}{c \parallel d \xrightarrow{\checkmark} c' \parallel d'}$$

Testing preorder

- Maximal computation

$$p_0 \parallel c_0 \xrightarrow{\tau} \ldots \xrightarrow{\tau} p_k \parallel c_k \xrightarrow{\tau} \ldots$$

- p $\mathbf{must}$ c iff for any maximal computation of $p \parallel c$, $\exists k.\ c_k \xrightarrow{\checkmark}$

Testing preorder

- Maximal computation

$$p_0 \parallel c_0 \xrightarrow{\tau} \ldots \xrightarrow{\tau} p_k \parallel c_k \xrightarrow{\tau} \ldots$$

- $p \ \mathbf{must}\ c$ iff for any maximal computation of $p \parallel c$, $\exists k.\ c_k \xrightarrow{\checkmark}$
- $p \sqsubseteq_{\mathbf{must}} q$ iff $p \ \mathbf{must}\ c$ implies $q \ \mathbf{must}\ c$

Decentralized testing

- Let $\mathbb{I} = \{I_i\}_{i \in 0 \ldots n}$ be a partition of names
- $c = p_0 \parallel \ldots \parallel p_n$ is a decentralized test over $\mathbb{I}$ when $n(p_i) \subseteq I_i$

Decentralized testing

- Let $\mathbb{I} = \{I_i\}_{i \in 0 \ldots n}$ be a partition of names
- $c = p_0 \parallel \ldots \parallel p_n$ is a decentralized test over $\mathbb{I}$ when $n(p_i) \subseteq I_i$
- $p \sqsubseteq_{\mathbf{dmust}_{\mathbb{I}}} q$ when considering only decentralized tests over $\mathbb{I}$

Decentralized testing

- $a.b + a + b \sqsubseteq_{\mathbf{dmust}_{\{\{a\},\{b\}\}}} b.a + a + b$

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  take the decentralized test

$$\overline{a}.\mathbf{1} \parallel \mathbf{1}$$

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  take the decentralized test

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Priori knowledge of partners (design-time coordination)

Local testing

- $a.\overline{c} + b.\overline{d} \not\approx_{\mathbf{dmust}_{\{\{a,b\},\{c,d\}\}}} a.\overline{d} + b.\overline{c}$

$$c_1 = \overline{a}.\mathbf{1} \parallel c.\mathbf{1}$$
$$c_2 = \overline{a}.\mathbf{1} \parallel d.\mathbf{1}$$

Local testing

- $a.\overline{c} + b.\overline{d} \not\approx_{\mathbf{dmust}_{\{\{a,b\},\{c,d\}\}}} a.\overline{d} + b.\overline{c}$

$$c_1 = \overline{a}.\mathbf{1} \parallel c.\mathbf{1}$$
$$c_2 = \overline{a}.\mathbf{1} \parallel d.\mathbf{1}$$

- When having only partial view both look the same

$$a + b \qquad\qquad \overline{c} \oplus \overline{d}$$

Hiding

$$\frac{p \xrightarrow{\alpha} p' \quad \alpha \in V}{p/V \xrightarrow{\alpha} p'/V}$$

$$\frac{p \xrightarrow{\alpha} p' \quad \alpha \notin V}{p/V \xrightarrow{\tau} p'/V}$$

Local testing

- $p \sqsubseteq_{\mathbf{lmust}_{\mathbb{I}}} q$ iff $p/I_i \ \mathbf{must}\ c$ implies $q/I_i \ \mathbf{must}\ c$ (for all $I_i \in \mathbb{I}$ and c)

Local testing

- $p \sqsubseteq_{\mathbf{lmust}_{\mathbb{I}}} q$ iff p/I_i $\mathbf{must}$ c implies q/I_i $\mathbf{must}$ c (for all $I_i \in \mathbb{I}$ and c)

- $a.b \approx_{\mathbf{lmust}_{\{\{a\},\{b\},\}}} b.a$
- $a.c + b.d \approx_{\mathbf{lmust}_{\{\{a,b\},\{c,d\},\}}} a.d + b.c$

Characterization of must

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- $p \sqsubseteq_{\mathbf{must}} q$ iff, for all s, if $p \Downarrow s$ then
  - $q \Downarrow s$
  - $\forall B \in \mathbf{Acc}(q,s), \exists A \in \mathbf{Acc}(p,s) \text{ s.t. } A \subseteq B$
  - if $q \stackrel{s}{\Longrightarrow}$ then $p \stackrel{s}{\Longrightarrow}$

Mazurkiewicz traces

- Least congruence $\equiv_D$ s.t.

$$(a, b) \in I_D \implies ab \equiv_D ba$$

- $[t]_D$ denotes the equivalence class of t

Characterization of dmust

- $p \sqsubseteq_{\mathbf{dmust}_{\mathbb{I}}} q$ iff, for all s, if $p \Downarrow [s]_D$ then
    - $q \Downarrow [s]_D$
    - $\forall B \in \mathbf{Acc}(q, [s]_D), \exists A \in \mathbf{Acc}(p, [s]_D)$ s.t. $A \subseteq B$
    - if $q \stackrel{[s]_D}{\Longrightarrow}$ then $p \stackrel{[s]_D}{\Longrightarrow}$

Noisy traces

- $s \in I_i$, $t \in \mathsf{Act}^*$. Then $s \stackrel{\bullet}{\equiv}_{I_i} t$ when $ss' \equiv_{\{I_i, \mathsf{Act} \setminus I_i\}} t$ for some $s' \in (\mathsf{Act} \setminus I_i)^*$

- $[[s]]_{I_i}$ the set of all noisy traces of s

Characterization of lmust

- $p \sqsubseteq_{\mathbf{lmust}_{\mathbb{I}}} q$ iff, for all $I \in \mathbb{I}, s \in I*$ if $p \Downarrow [[s]]_I$ then
  - $q \Downarrow [[s]]_I$
  - $\forall B \in \mathbf{Acc}(q, [[s]]_I), \exists A \in \mathbf{Acc}(p, [[s]]_I)$ s.t. $A \subseteq B$
  - if $q \stackrel{[[s]]_I}{\Longrightarrow}$ then $p \stackrel{[[s]]_I}{\Longrightarrow}$

Things we would like to explore

- Equational characterizations (Algorithm deduction)
- Coinductive characterizations
- Interplay with client and p2p preorders
- Expressing different kinds of coordination power of the context
  - Can we use choreography descriptions to collect such information?
- Relationship with sub-typing in MST