Behavioural, Functional, and Non-Functional Contracts for Dynamic Selection of Services

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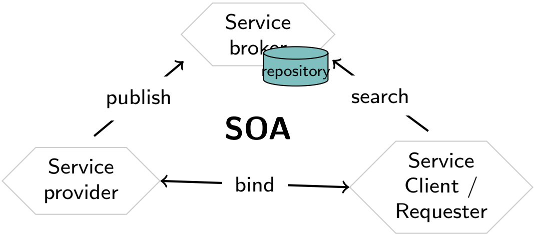
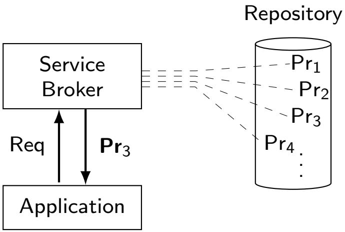
In the next few minutes...

We'll talk about dynamic discovery&binding of service





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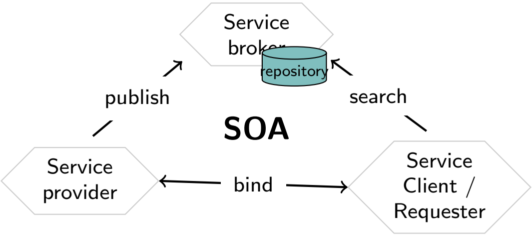

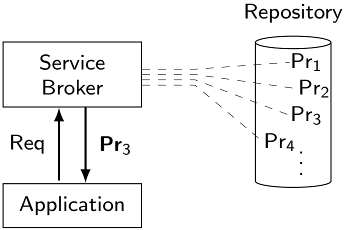

Prologue . . . . A bird-eye view

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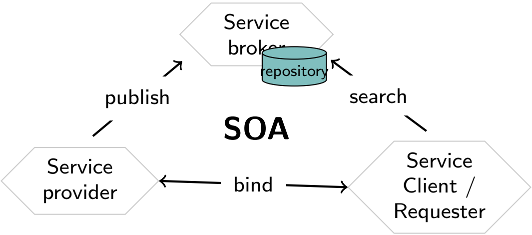

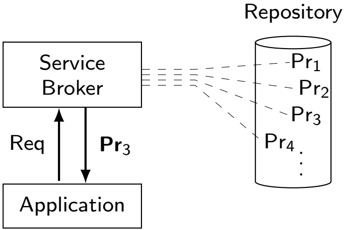

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Act I . . . . A proposal

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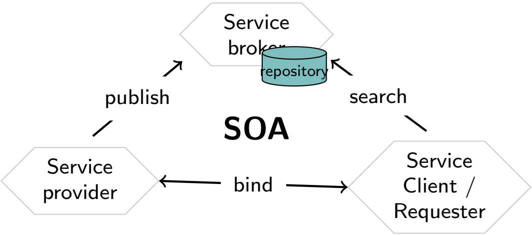

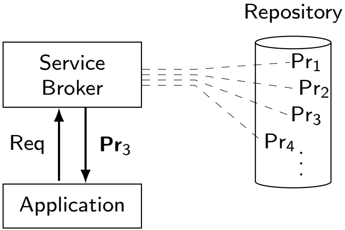

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Act III . . . . Some conclusions

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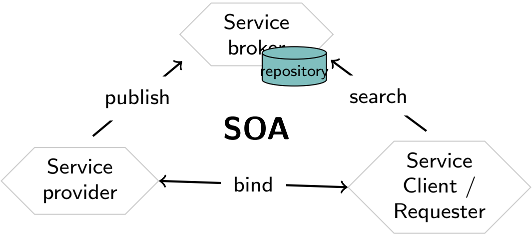

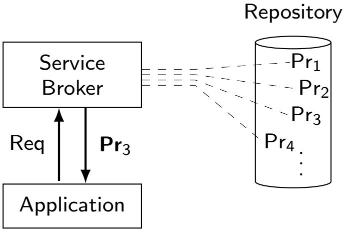

– Prologue –

[Contracts & SOAs]

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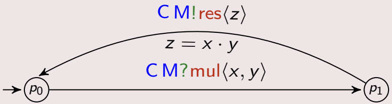
The problem



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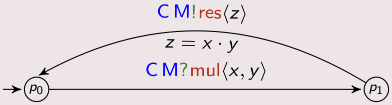

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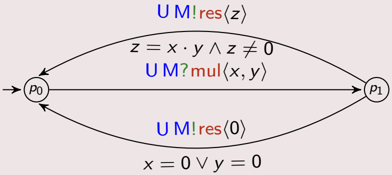
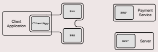


Our proposal: [1, 5] + [2] + [3, 4]



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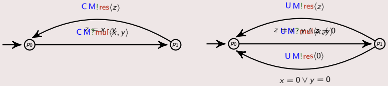


+ QoS-CFSMs

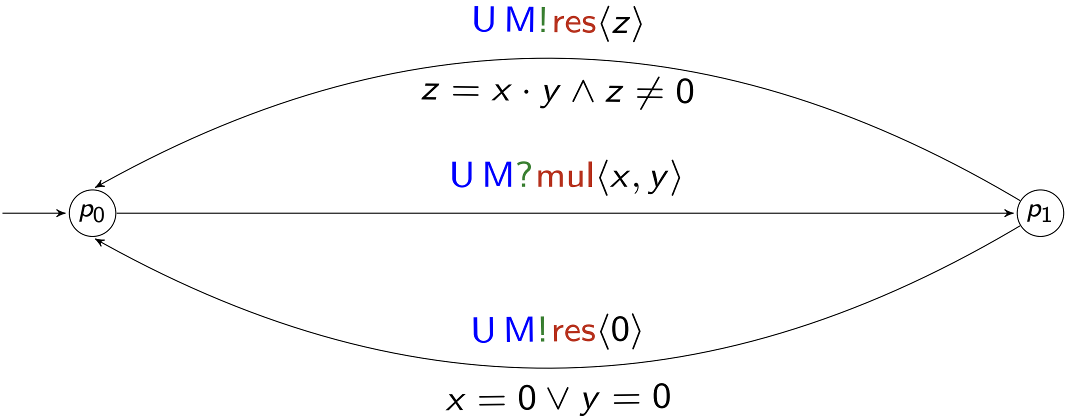
which yields

- A uniform model for discovery based on behavioural and (non-)functional contracts
- Bisimulation-based compliance
- A bisimulation algorithm of service compliance modulo name matching

Preliminaries

Our behavioural and functional contracts

We essentially borrow (with some adaptation) asserted CFSM from [2]



Our non-functional contracts

A variant of CFSMs yields our behavioural contracts; our non-functional contracts are

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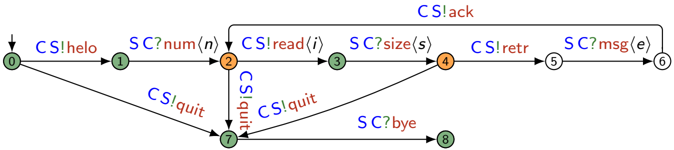

$$\Gamma_{\text{Low}} = \{\mathsf{t} \leq 0.01,\ \mathsf{c} \leq 0.01,\ \mathsf{m} \leq 0.01\}$$

$$\Gamma_{\text{DB}} = \{\mathsf{t} \leq 3 \implies (\exists x)(0.5 \leq x \leq 1 \wedge \mathsf{c} = \mathsf{t} \cdot x),\ \mathsf{t} > 3 \implies \mathsf{c} = 10,\ \mathsf{m} \leq 5\}$$

$\dots$

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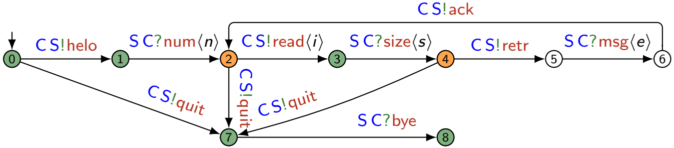

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RCFs allow us to formalise QoS aggregation operators [3, 4]

– Act I –

[A proposal]

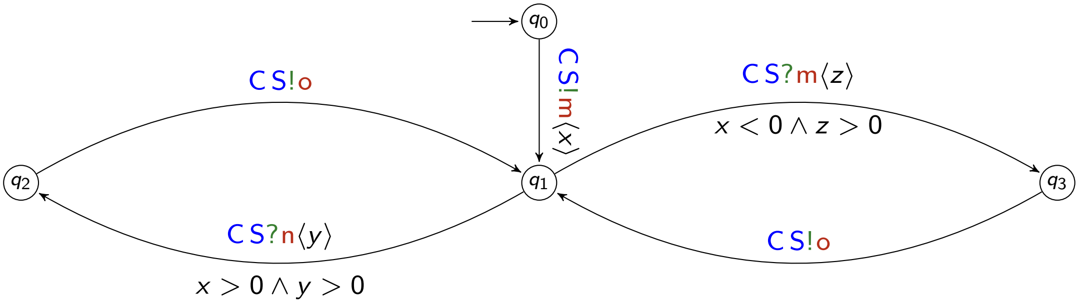
Extended CFSMs

An extended CFSM (e-CFSM for short) is a tuple $\langle M, F, \text{qos}, \text{asrt}\rangle$ where:

- $M = \langle Q, q_0, \rightarrow\rangle$ is a CFSM with $F \subseteq Q$ the set of final states ,
- asrt maps transitions of M to first-order formulae in $\mathcal{F}(\Sigma)$, and
- $\text{qos} : Q \rightarrow \mathcal{C}$ maps states of M to QoS specifications.

An extended communicating system is a map $(M_{\mathsf{A}})_{\mathsf{A}\in\mathcal{P}}$ assigning an A-local e-CFSM M_{A} to each $\mathsf{A} \in \mathcal{P}$.

Oddities



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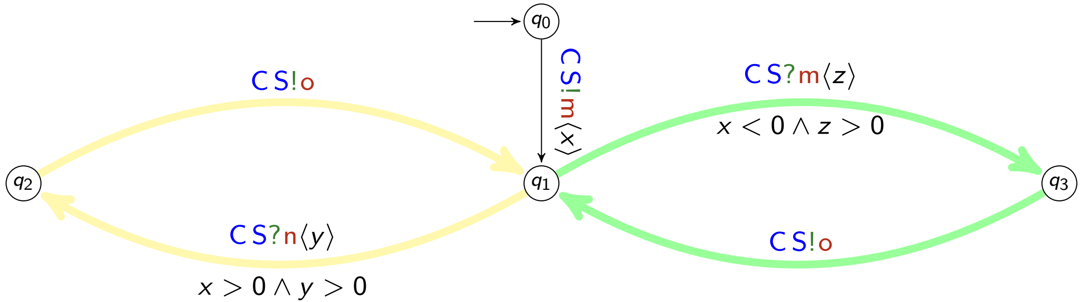
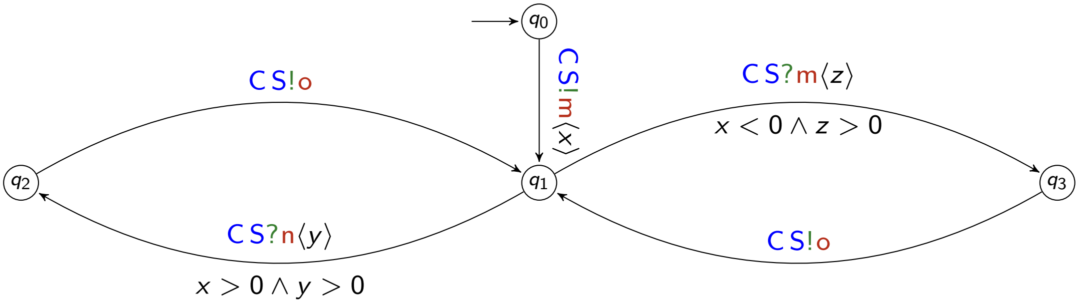


q_0
$C\,S!m\langle x\rangle$
$C\,S!o$
$C\,S?m\langle z\rangle$
$x < 0 \wedge z > 0$
q_2
q_1
q_3
$C\,S?n\langle y\rangle$
$C\,S!o$
$x > 0 \wedge y > 0$

Oddities


q_0
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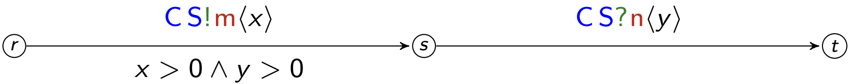
r
s
t
C S!m$\langle x \rangle$
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Knowledge

The residual of an assertion ϕ after l, written $\phi \mathbin{\overline{\wedge}} l$, is $\bot$ unless

$$
\begin{aligned}
p(x_1, \ldots, x_n) \mathbin{\overline{\wedge}} l &= p(x_1, \ldots, x_n) && \text{if } var(l) \cap \{x_1, \ldots, x_n\} = \emptyset \\
(\neg\phi) \mathbin{\overline{\wedge}} l &= \neg(\phi \mathbin{\overline{\wedge}} l) && \text{if } \phi \mathbin{\overline{\wedge}} l \neq \bot \\
(\phi_1 \vee \phi_2) \mathbin{\overline{\wedge}} l &= (\phi_1 \mathbin{\overline{\wedge}} l) \vee (\phi_2 \mathbin{\overline{\wedge}} l) && \text{if } \phi_1 \mathbin{\overline{\wedge}} l \neq \bot \text{ and } \phi_2 \mathbin{\overline{\wedge}} l \neq \bot \\
((\exists x)\phi) \mathbin{\overline{\wedge}} l &= (\exists x)(\phi \mathbin{\overline{\wedge}} l) && \text{if } x \notin var(l) \text{ and } \phi \mathbin{\overline{\wedge}} l \neq \bot \\
((\exists x)\phi) \mathbin{\overline{\wedge}} l &= ((\exists x)\phi) \mathbin{\overline{\wedge}} l((\exists y)(\phi[y/x])) \mathbin{\overline{\wedge}} l && \text{if } x \in var(l),\ y \text{ fresh, and } \phi \mathbin{\overline{\wedge}} l \neq \bot
\end{aligned}
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Knowledge

The residual of an assertion ϕ after l, written $\phi \bar{\wedge} l$, is $\bot$ unless

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The knowledge $\mathcal{K}(\pi)$ on π is $K(\pi, \{True\})$ where

$$
K(\pi, X) = \begin{cases} \bigwedge_{\psi \in X} \psi, & \pi \text{ is the empty path} \\ K(\pi', \{\psi \mid \psi \in X \text{ and } \psi \bar{\wedge} l \neq \bot\} \cup \{\phi\}), & \pi = q \xrightarrow[\phi]{l} \pi' \end{cases}
$$

Bisimulating e-CFSMs

Let M_1 and M_2 be two e-CFSMs respectively with states Q_1 and Q_2 and initial states $p_0 \in Q_1$ and $q_0 \in Q_2$.

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A relation $\mathcal{R} \subseteq (Q_1 \times \mathrm{FOL}_=) \times (Q_2 \times \mathrm{FOL}_=)$ is a simulation if $\big(p, K\big)\mathcal{R}\big(q, K'\big)$ and $p \xrightarrow[\phi]{l} p'$ in M_1 imply that there is $T = \{q \xrightarrow[\psi_1]{l} q_1, \ldots, q \xrightarrow[\psi_k]{l} q_k\} \neq \emptyset$ in M_2 and

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2. for all $q \xrightarrow[\psi]{l} q' \in T$, $(p', \overline{(K \,\overline{\wedge}\, l) \wedge \phi \wedge \psi})\mathcal{R}(q', \overline{(K' \,\overline{\wedge}\, l) \wedge \psi})$

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3. if $p \in F_1$, then $q \in F_2$ and $\mathrm{qos}(p) = \langle \Sigma, \Gamma_1 \rangle$ and $\mathrm{qos}(q) = \langle \Sigma, \Gamma_2 \rangle$ then $\neg\big(\bigwedge_{\phi \in \Gamma_1} \phi \implies \bigwedge_{\phi \in \Gamma_2} \phi\big)$ unsat

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M_2 simulates M_1 if there is a simulation $\mathcal{R}$ such that $\big(p_0, \mathit{True}\big)\mathcal{R}\big(q_0, \mathit{True}\big)$.

– Act II –

[Some conclusions]

In the paper

- an example on the POP protocol
- Bisimulation checking algorithm module name matching

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We are planning to

- extend **SEArch** to support
- generalise to name embeddings

In the paper

an example on the POP protocol

Bisimulation checking algorithm module name matching

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Some doubts...

is the approach feasible? (From one reviewer)

isn't bisimulation to strong a notion for compliance?

Thank you

References I

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