Service selection by choreography-driven matching

Emerging Web Service Technology

Christoph Thiele
Agenda

- From reuse & selection
- Aspirin
- Math preparation
- Goal-preserving match
  - What doesn’t work
  - What works
- Conclusion
From reuse & selection

- Service reuse
  - Retrieve service according to needs
  - No exact match and flexibility (relaxed match)
  - Reuse outside original context
- Semantic annotation & IOPE
- Hierarchy
  - Single operations
  - Sequence → global point of view
  - Choreography
- Web service selection
  - Conformance to a specification
  - Use of service allows achievement of a goal
Aspirin

- painkiller
- blood-thinner
- conformance
- global goal
- patient in pain
- patient in pain
- with a clotting problem
Math prep.

- Fluent: properties whose truth value can change over time due to the application of actions
- State: set of fluents

One could not assume that the value of a fluent is known.
- $\mathcal{B}$: Beliefs of an entity about the world
  - $\mathcal{B}f$ – $f$ is known to be true
  - $\mathcal{B}-f$ – $f$ is known to be false
  - $\neg\mathcal{B}f \wedge \neg\mathcal{B}-f$ – $f$ is undefined
  - A fluent could be: true, false or unknown
Math prep. – service representation

Flight reservation

:Buyer

searchFlight(Date, Start, Dest)

not_available()

offer(flight)

ALT

:Seller

checkAvailability

evaluateOffer

ALT

ack()

n_ack()
Math prep. – service representation

- Service description: \( \langle \mathcal{O}, \mathcal{G}, \mathcal{P} \rangle \)
  - \( \mathcal{O} \) – set of operations
  - \( \mathcal{G} \) – set of actions that allow to receive messages
  - \( \mathcal{P} \) – description of interactive behavior

- \( \mathcal{O} \) – set of operations (atomic action)
  - Description in terms of:
    - Preconditions
    - Effects
    - Both sets of fluents
    - Trigger revision process on beliefs
Math prep. – service representation

- Service
  - Initiator – *operation*»
  - Servant – *operation*«

- *operation*^d*(interlocutor, content)* possible if \{P_1 \ldots P_t\}
- *operation*^d*(interlocutor, content)* causes \{E_1 \ldots E_n\}

- Example:

  \(\text{searchflight}»(\text{seller, Date, Start, Dest})\)
  possible if \{BDate, BStart, BDest\}
  \(\text{searchflight}»(\text{seller, Date, Start, Dest})\)
  causes \{Bwill_get_offer\}
Math prep. – service representation

- $G$ – get_answer actions
  - $receive_act(interlocutor, content)$ receives $I$
  - Finite set of possibilities
  - Example:

  $get_answer(Seller)$ receives $[not\_available \ll (Seller) \ or \ offer \ll (Seller)]$

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- $\mathcal{P}$ – encodes the behavior of a service
  - Collection of kind:
    - $p_0$ is $p_1 \ldots p_n$
    - $p_0$ – procedure
    - $p_1$ – atomic operation, get\_answer action, testing action, procedure call
  - Example:
    
    $$booking(Seller, Date, Start, Dest) \text{ is }$$
    $$\text{search\_flight}\quad (Seller, Date, Start, Dest),$$
    $$\text{get\_answer}(Seller), \text{Boffer}(\text{not\_avail})?$$
    
    $$booking(Seller, Date, Start, Dest) \text{ is }$$
    $$\text{search\_flight}\quad (Seller, Date, Start, Dest),$$
    $$\text{get\_answer}(Seller), \text{Boffer}(\text{flight})?,$$
    $$\text{eval\_offer}, \text{finalize}(Seller)$$

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Choreography

- set of interacting roles
- $\mathcal{O}$ divided in
  - Bound operations
  - Unbound operations

Binding by substitution $\theta$

$$\theta = \left[ \mathcal{O}_S / \mathcal{O}_U \right]$$

$$S_d \theta = \langle \mathcal{O}_\theta, \mathcal{G}_\theta, \mathcal{P}_\theta \rangle$$
Math prep. – substitution

\[ \theta = \left[ \mathcal{O}_{\text{Aspirin}} / \mathcal{O}_u \right] \]

\[ S_d \theta = \langle \mathcal{O} \theta, \mathcal{G} \theta, \mathcal{P} \theta \rangle \]

**releve_pain**\(^\text{(Pharmaceutical)}\) **possible if** \{Bin\_pain\}

**releve_pain**\(^\text{(Pharmaceutical)}\) **causes** \{B\text{\textemdash}in\_pain\}

\[ \in \mathcal{O}, \mathcal{O}_u \]

**releve_pain**\(^\text{(Pharmaceutical)}\) **possible if** \{Bin\_pain\}

**releve_pain**\(^\text{(Pharmaceutical)}\) **causes** \{B\text{\textemdash}in\_pain, Bthin\_blood\}

\[ \in \mathcal{O}_{\text{Aspirin}}, \mathcal{O} \theta \]
"Is it possible to execute p in such a way, that the condition Fs is true in the final state?"

- \( Fs \) after \( p \)
- If true \( \Rightarrow \) sequence of actions \( \sigma \)
- \((\emptyset, G, P), S_0) \vdash G \) w. a. \( \sigma \)

Example:

\[ S_0 = \{Bdate, Bstart, Bdest, Bsmoking\_flight\} \]

\[ G = \{Bbooked(flight), Bsmoking\_flight\} \]

\textbf{after} booking(...)

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Definition 1 (Conservative substitution). Let us consider a service $S_i = \langle \mathcal{O}, \mathcal{G}, \mathcal{P} \rangle$ which plays a role $R_i$ in a given choreography, and a query $G$ such that, given an initial state $S_0$,

$$\langle \langle \mathcal{O}, \mathcal{G}, \mathcal{P} \rangle, S_0 \rangle \vdash G \text{ w.a. } \sigma$$

Consider a substitution $\theta = [\mathcal{O}_{S_j} / \mathcal{O}_{\omega(R_j)}^{\sigma}]$, where $\mathcal{O}_{\omega(R_j)}^{\sigma} = \{ o \in \mathcal{O} \mid o \text{ occurs in } \sigma \}$ is the set of all unbound operations that refer to another role $R_j$, $j \neq i$, of the same choreography, that are used in the execution trace $\sigma$. $\theta$ is conservative when the following holds:

$$\langle \langle \mathcal{O}\theta, \mathcal{G}\theta, \mathcal{P}\theta \rangle, S_0 \rangle \vdash G \text{ w.a. } \sigma\theta$$
Matching – what doesn’t work

- **EM – Exact Pre/Post Match**
  - $\text{Precs}(r) = \text{Precs}(s) \land \text{Effs}(r) = \text{Effs}(s)$

- **PIM – Plugin Match**
  - Strongest of the flexible
    - $\text{Precs}(r) \supseteq \text{Precs}(s) \land \text{Effs}(s) \supseteq \text{Effs}(r)$
  - Allow at least all old conditions
  - Provide a guarantee at least as strong
What doesn't work

Example using PIM:

\[ S_0 = \{Bbp, Bin\_pain, B\_thin\_blood\} \]
\[ G = \{ B\_in\_pain, B\_thin\_blood\} \text{ after medication(...) } \]
\[ (\langle O, G, P \rangle, S_0) \vdash G \text{ w. a. } \sigma \]

\textit{release_pain} (Pharm) possible if \{Bin\_pain\}
\textit{release_pain} (Pharm) causes \{B\_in\_pain\}

\textit{release_pain} (Pharm) possible if \{Bin\_pain\}
\textit{release_pain} (Pharm) causes \{B\_in\_pain, B\_thin\_blood\}
Goal-preserving match – what works

- **Dependency**
  - $\sigma = a_1; a_2; \ldots; a_n$
  - 2 fictitious actions
    - $a_0 \rightarrow \text{Effs}(a_0) = S_0$
    - $a_{n+1} \rightarrow \text{Precs}(a_{n+1}) = F_s$
  - $\bar{\sigma} = a_0; a_1; a_2; \ldots; a_n; a_{n+1}$
  - Indexes $i,j = 0, \ldots, n + 1$ with $j < i$
    - $a_i$ depends on $a_j$ for the fluent $Bl$ in $\sigma$: $a_j \xrightarrow{(Bl, \bar{\sigma})} a_i$
    - if $\exists k (j < k < i, Bl \in \text{Effs}(a_k))$

- **Dependency set:** $\text{Dep}(Bl, \sigma) = \{(j, i) | a_j \xrightarrow{(Bl, \bar{\sigma})} a_i\}$

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Goal-preserving match – what works

- Uninfluential fluent
  
  - \([s/o_u] \in \theta_{PIM}\)
  - \(B \backslash l \in Effs(s) - Effs(o_u)\) is uninfluential Fluent iff all pairs \((j, i) \in Deps(Bl, \sigma)\) with \(k\) identifying the position of \(o_u\) in \(\sigma\) and \(k < j\) or \(i \leq k\)
A substitution $\theta_{PIM}$ is called **uninfluential** iff for any substitution $[s/o_u]$ in $\theta_{PIM}$, all beliefs in $Effs(s) - Effs(o_u)$ are uninfluential fluents w.r.t. $\sigma$. 
Theorem 2. Let us consider a service $S_i = \langle O, G, P \rangle$ which plays a role $R_i$ in a given choreography, and a query $G$ such that, given an initial state $S_0$,

$$(\langle O, G, P \rangle, S_0) \vdash G \text{ w.a. } \sigma$$

Consider an uninfluential substitution $\theta_{PIM} = [O_{S_j}/O_{u(R_j)}^\sigma]$, where $O_{u(R_j)}^\sigma = \{o_u \in O \mid o \text{ occurs in } \sigma\}$ is the set of all unbound operations that refer to another role $R_j, j \neq i$, of the same choreography, that are used in the execution trace $\sigma$. Then, the following holds:

$$(\langle O\theta_{PIM}, G\theta_{PIM}, P\theta_{PIM} \rangle, S_0) \vdash G \text{ w.a. } \sigma\theta_{PIM}$$
Conclusion

- Achieved
  - Formal representation of a service
  - Uninfluential Plugin Match
  - Definition of a goal-preserving match

- Semantical annotation
- Definition of unbound operations
- Feasibility