

# Terry Payne & Valentina Tamma

# Dialogue-Based Meaning Negotiation

**Gabrielle Santos, Valentina Tamma, Terry Payne & Floriana Grasso**

# Using Dialogues to find Alignments



- Different Systems (sensors, devices, services) can assume different ontological models
  - Many approaches exist, producing different alignments
  - But what if fragments of the ontological space are confidential, or commercially sensitive?
- Agents can exchange knowledge about mappings to find a mutually acceptable alignment.
  - Agents disclose **preferences** on correspondences, terms, axioms
  - Allows agents to **reason** with different types of information



I know nothing!

# Discovering novel mappings

- Offer limited ontological knowledge of seed entities
  - Agents selectively share conceptual knowledge to identify localised structural similarity
- Bootstraps the process of aligning different data systems

# Dialogues for finding Correspondences between partially disclosed Ontologies

**Terry Payne & Valentina Tamma**

(in collaboration with Ernesto Jimenez-Ruez & Alessandro Solimando)



Jimenez-Ruiz E., Payne T.R., Solimando A. and Tamma, V. (2016) **Limiting Logical Violations in Ontology Alignment Through Negotiation**. In: *15th International Conference on Principles of Knowledge Representation and Reasoning. (KR'16), Cape Town*.

Payne T.R., and Tamma, V. (2014) **A Dialectical Approach to Selectively Reusing Ontological Correspondences**. In: *19th International Conference on Knowledge Engineering and Knowledge Management (EKAW2014), Linköping, Sweden*

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- *Pre-conditions*

1.  $x \neq \rho$
2.  $\text{movetype}(m_{s-1}) \in \{\text{join}, \text{endassert}, \text{close}\}$
3.  $\exists \phi \in \Delta^x, s.t.$ 
  - (a)  $\phi \notin JB^x$
  - (b)  $\forall \phi' \in \Delta^x, \text{ if } \phi' \notin JB^x, \text{degree}(\phi') \leq \text{degree}(\phi)$
  - (c)  $\text{grounded}(\phi, \mathcal{W}^x)$
  - (d)  $\text{joint}_{est}(\text{corr}(\phi)) \geq \epsilon$

- *Post-conditions*
  1.  $JB^{x'} = \{\phi\} \cup JB^x$ ;  $JB^{\hat{x}'} = \{\phi\} \cup JB^{\hat{x}}$
  2.  $\kappa_{upper}^{\hat{x}} = \text{degree}(\phi)$
  3.  $Ag' = Ag \cup \{\langle \text{corr}(\phi), \text{joint}_{est}(\phi) \rangle\}$
  4.  $\rho = x$

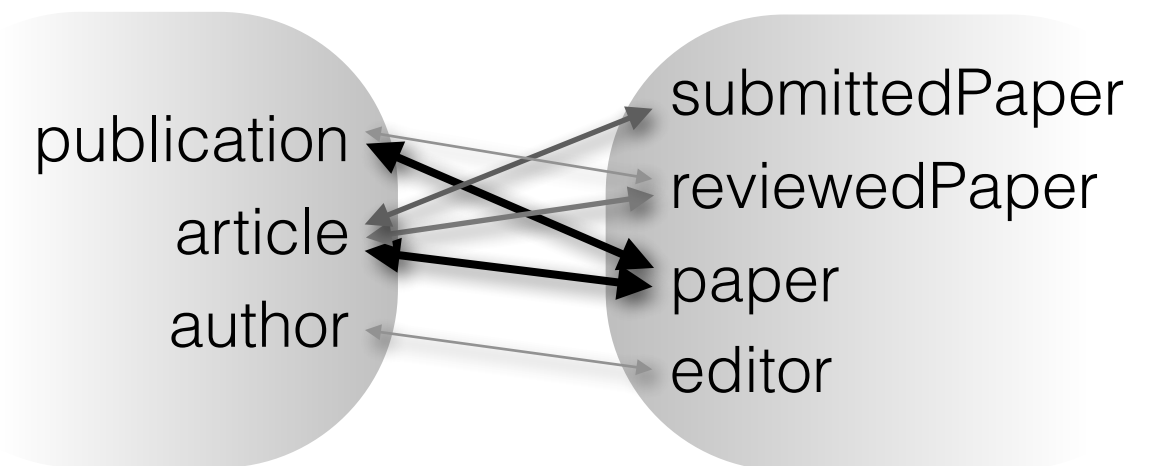


# Selecting a subset of possible mappings



- Alignments typically consist of one-to-one mappings
  - Combining mappings from different alignment fragments can result in one-to-many mappings; i.e. **ambiguity**

Correspondences $c$	$\kappa_c^{Alice}$	$\kappa_c^{Bob}$	joint( $c$ )
$\langle \text{publication, paper, } = \rangle$	0.8	0.6	<b>0.7</b>
$\langle \text{article, paper, } = \rangle$	0.5	0.8	<b>0.65</b>
$\langle \text{article, submittedPaper, } = \rangle$	0.6	0.4	<b>0.5</b>
$\langle \text{article, reviewedPaper, } = \rangle$	0.9	—	<b>0.45</b>
$\langle \text{author, editor, } = \rangle$	—	0.2	<b>0.1</b>
$\langle \text{publication, reviewedPaper, } = \rangle$	0.1	—	<b>0.05</b>



- Which of these should be selected?
  - Could it be resolved through **objections** within the dialogue?
  - What if the inclusion of a candidate causes a **violation**?

- Through the dialogue each agent extends their ontology by including correspondences
  - however the integrated ontology  $\mathcal{O}^x \cup \mathcal{A} \cup \mathcal{O}^{\hat{x}}$  should not introduce any change at least in the hierarchy of  $\mathcal{O}^x$
  - Incomplete knowledge about the other agent means the agents only assess the changes introduced by  $\mathcal{O}^x \cup \mathcal{A}$
- Modify the repair mechanism by Solimando et al. to incrementally check for violations as new correspondences are proposed

# Example Dialogue



## Private Knowledge

### Ontology

$$b \sqsubseteq a$$

$$c \sqsubseteq a$$

### Correspondence Store $\Delta$

$$\langle a, w, \equiv \rangle \quad \kappa_c^{Alice} = 0.25$$

$$\langle a, x, \equiv \rangle \quad \kappa_c^{Alice} = 0.9$$

$$\langle b, x, \equiv \rangle \quad \kappa_c^{Alice} = 0.55$$

$$\langle b, y, \equiv \rangle \quad \kappa_c^{Alice} = 0.4$$

$$\langle b, z, \equiv \rangle \quad \kappa_c^{Alice} = 0.6$$

## Public Knowledge

As Bob has the axiom  $z \sqsubseteq y$ , the inclusion of  $b \equiv y$  and  $b \equiv z$  would infer:  $y \sqsubseteq z$  (similarly for  $x \sqsubseteq z$ )

$\langle \text{Alice}, \text{assert}, \langle b, z, \equiv \rangle, 0.6, \emptyset \rangle$

Bob discovers a conservatively violation!!!

## Private Knowledge

### Ontology

$$x \equiv y$$

$$z \sqsubseteq y$$

$$w$$

### Correspondence Store $\Delta$

$$\langle a, w, \equiv \rangle \quad \kappa_c^{Bob} = 0.3$$

$$\langle a, x, \equiv \rangle \quad \kappa_c^{Bob} = 0.85$$

$$\langle b, x, \equiv \rangle \quad \kappa_c^{Bob} = 0.5$$

$$\langle b, y, \equiv \rangle \quad \kappa_c^{Bob} = 0.55$$

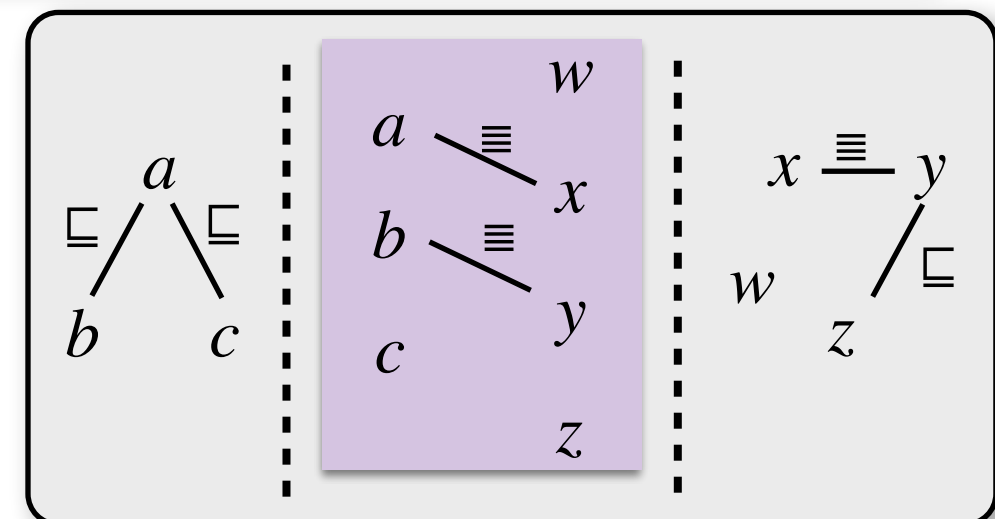
$$\langle b, z, \equiv \rangle \quad \kappa_c^{Bob} = 0.575$$

## Public Knowledge

### Commitment Store CS

$$\kappa_{\langle a, x, \equiv \rangle}^{Alice} = 0.9 \quad \kappa_{\langle a, x, \equiv \rangle}^{joint} = 0.85$$

$$\kappa_{\langle b, y, \equiv \rangle}^{Bob} = 0.7 \quad \kappa_{\langle b, y, \equiv \rangle}^{joint} = 0.55$$





A word cloud visualization representing research trends in intelligent systems. The most prominent words are "research", "ontology", "services", "knowledge", "dialogue", "discovery", "data", "agents", "service use", "distributed", "conservativity", "recently", "image", "included", "reverting", "dynamic", "semantic", "provision", "cognitive", "public", "explored", "open", "systems", "modularisation", "include", "semantics", "just-in-time", "validation", "market", "social", "described", "residual", "support", "violation", "illustrated", "capabilities", "self-organization", "pervasive", "based", "engineering", "internet-of-things", "alignment", "correspondence", "taking", "interests", "description", "transient", "encompasses", "facilitate", "interlocutor", "coalition", "also", "issues", "system", "devices", "works", "environments", "biometrics", "signature", "community", "epidemiological", "approach", "environment", "argumentation", "agent", "trust", "multicenter", "hamiltonian", "gully", "correct".

$$c \sqsubseteq a$$

## Correspondence Store $\Delta$

$$\langle a, w, \equiv \rangle \quad \kappa_c^{Alice} = 0.25$$
$$\langle a, x, \equiv \rangle \quad \kappa_c^{Alice} = 0.9$$
$$\langle b, x, \equiv \rangle \quad \kappa_c^{Alice} = 0.55$$
$$\langle b, y, \equiv \rangle \quad \kappa_c^{Alice} = 0.4$$
$$\langle b, z, \equiv \rangle \quad \kappa_c^{Alice} = 0.6$$

## Private Knowledge

## Ontology

$$x \equiv y$$
$$z \sqsubseteq y$$
 $\mathcal{W}$ Correspondence Store  $\Delta$ 
$$\langle a, w, \equiv \rangle \quad \kappa_c^{Bob} = 0.3$$
$$\langle a, x, \equiv \rangle \quad \kappa_c^{Bob} = 0.85$$
$$\langle b, x, \equiv \rangle \quad \kappa_c^{Bob} = 0.5$$
$$\langle b, y, \equiv \rangle \quad \kappa_c^{Bob} = 0.55$$
$$\langle b, z, \equiv \rangle \quad \kappa_c^{Bob} = 0.575$$

## Public Knowledge

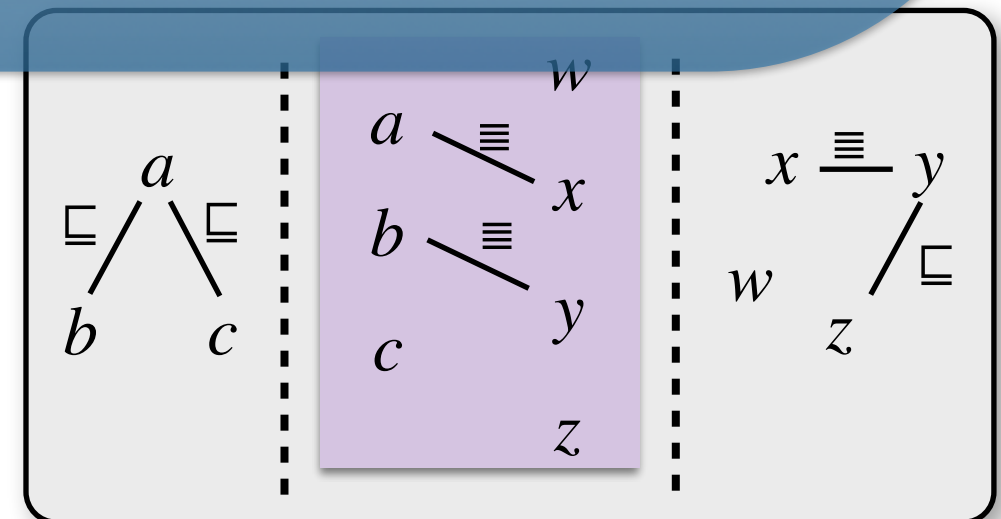
*Commitment Store CS*

$$\kappa_{\langle a, x, \equiv \rangle}^{Alice} = 0.9 \quad \kappa_{\langle a, x, \equiv \rangle}^{joint} = 0.85$$
$$\kappa_{\langle b, y, \equiv \rangle}^{Bob} = 0.7 \quad \kappa_{\langle b, y, \equiv \rangle}^{joint} = 0.55$$

Either  $b \equiv y$  or  $b \equiv z$  should be weakened!  
 As  $\kappa_{\langle b, y, \equiv \rangle}^{joint} < \kappa_{\langle b, z, \equiv \rangle}^{joint}$ , Bob suggests a repair  
 that weakens  $b \equiv y$  by removing  $b \sqsupseteq y$ ,  
 leaving the correspondence  $b \sqsubseteq y$

$$\langle \text{Bob}, \text{repair}, \langle b, z, \equiv \rangle, 0.575, \{ \langle b, y, \sqsupseteq \rangle \} \rangle$$

*Bob suggests a repair by weakening the alignment between  $b$  and  $y$*



# Dialogue-Based Meaning Negotiation

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Santos G., Tamma, V., Payne T.R., and Grasso, F. (2016) **A Dialogue Protocol to Support Meaning Negotiation**. In: *15th International Conference on Autonomous Agents and MultiAgent Systems. (AAMAS'16)*, Singapore.

Santos G., Tamma, V., Payne T.R., and Grasso, F. (2015) **Dialogue Based Meaning Negotiation**. In: *15th Workshop on Computational Models of Natural Argument (CMNA 2015)*, Bertinoro, Italy

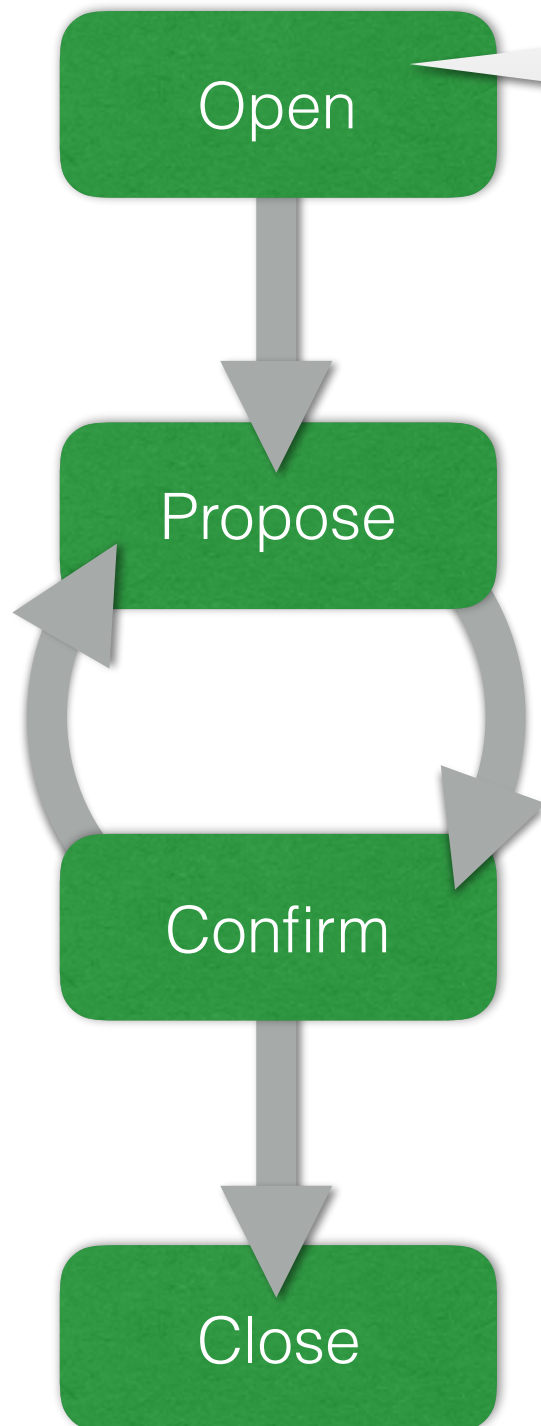
# Meaning-based Dialogue



- Explores a cognitive approach to reaching consensus over possible correspondences...
- Agents identify possible concepts that may be **ontologically equivalent** in their respective ontologies
  - Each then seeks further evidence over the **locality** of each concept to verify if these are structurally similar.
  - Both agents have the opportunity to **ask questions**
  - Correspondences only accepted if both agents **accept the same underlying support**



# Cognitive Approach

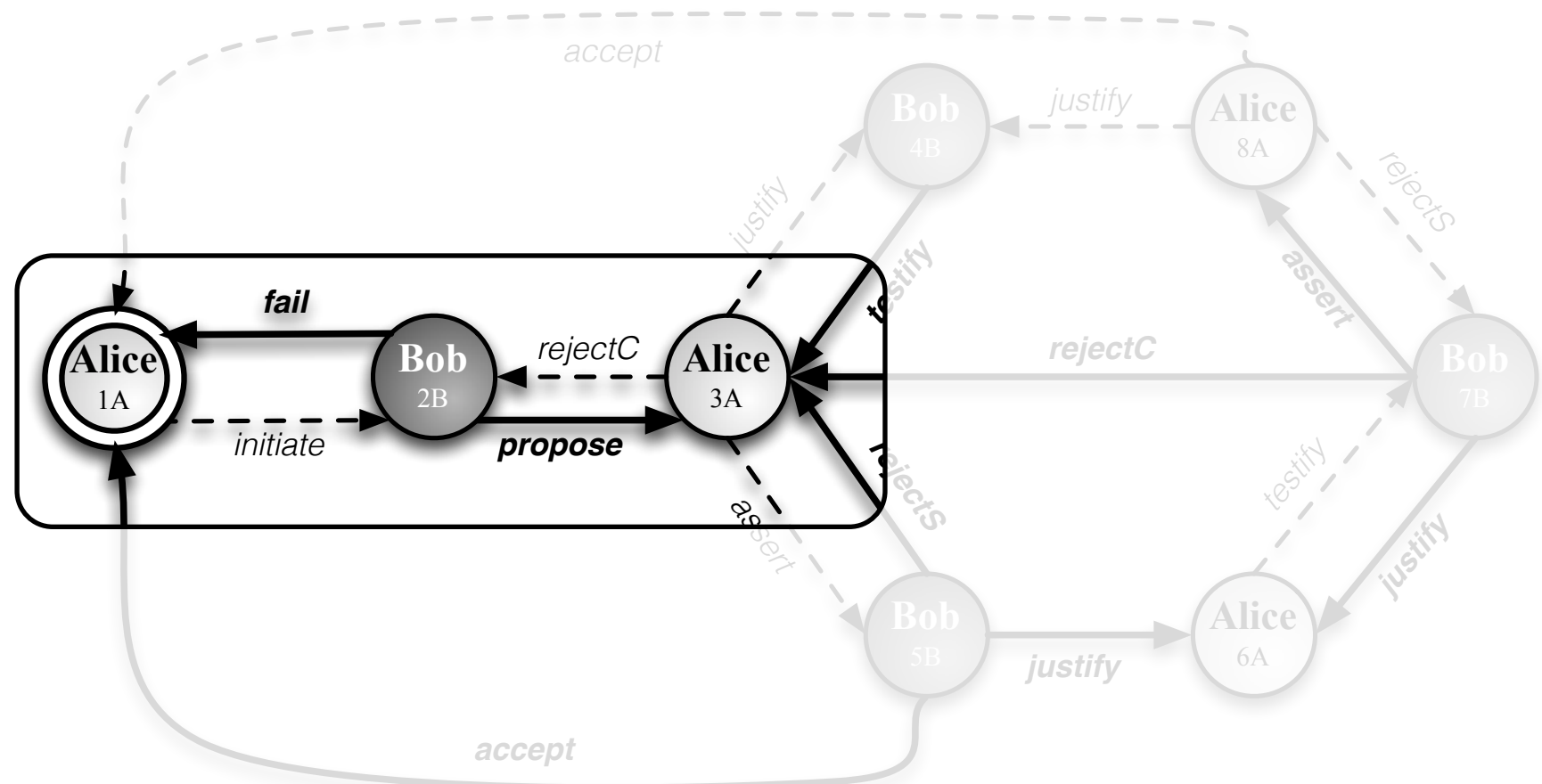


*Agent initiates the dialogue*

- Identify the **name** of the entity to be aligned.
- Opponent can chose to **offer a candidate corresponding entity**, or reject the dialogue

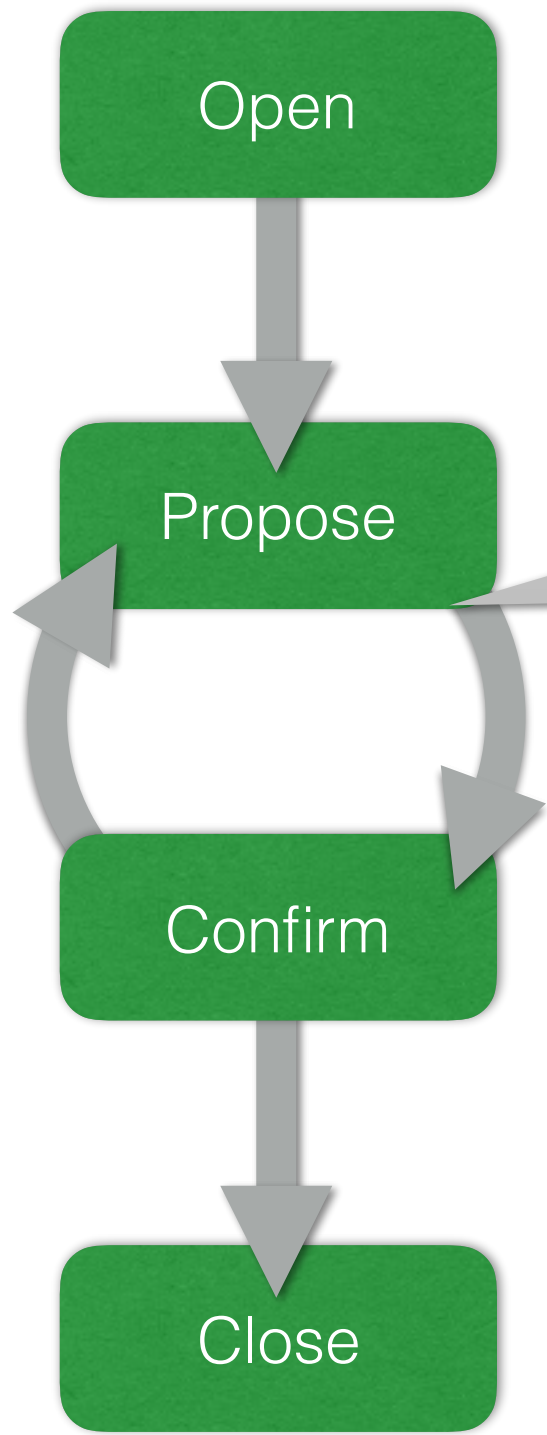
```

1  <Alice, initiate, "d" nil, >
2  <Bob, propose, "d", "w">
3  <Alice, justify, "d", "w">
  
```





# Propose



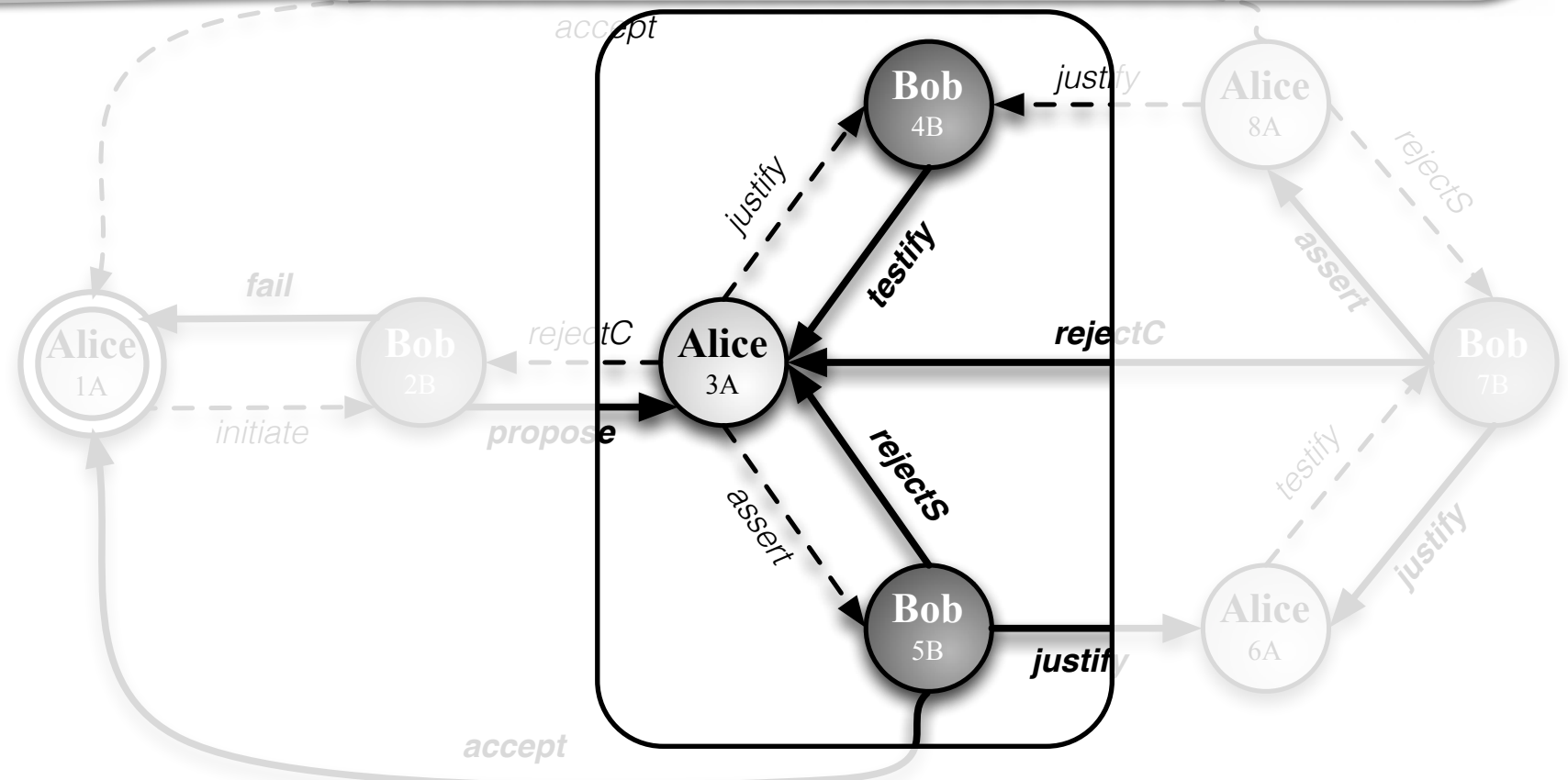
Allows agent to **gather supporting evidence** in favour of a correspondence

- Asks for **triples** representing the entities **locality**
- Attempts to match this to its own triples

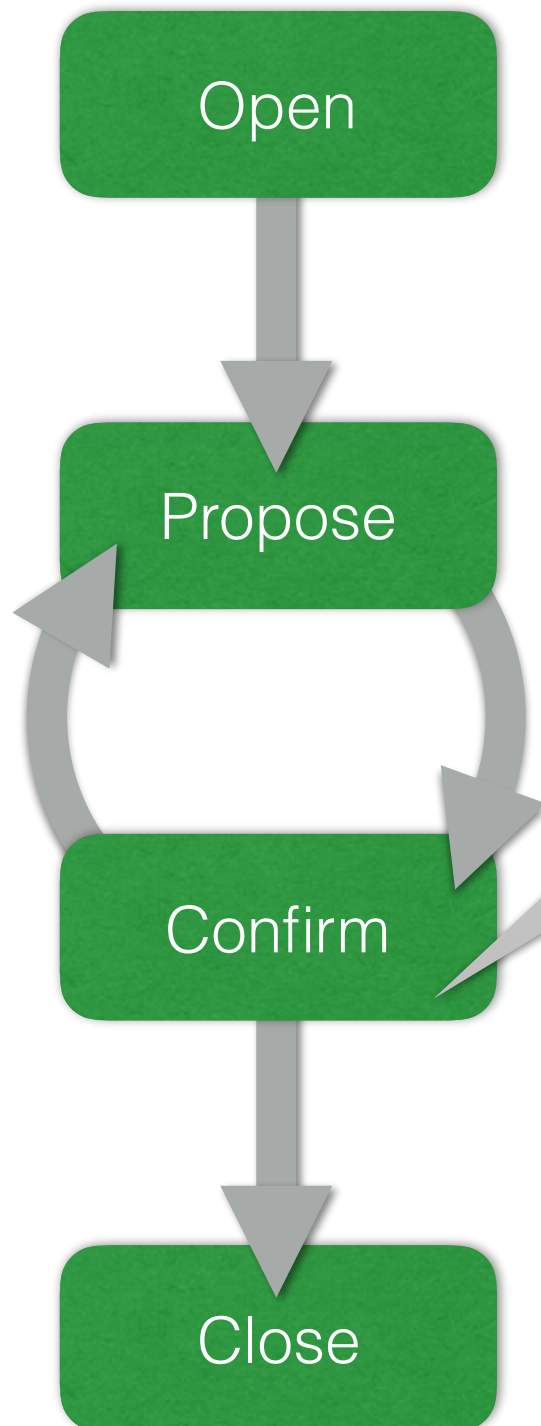
If sufficient support found, then it can **assert a correspondence**

```

5  <Alice, justify, "d", "w">
6  <Bob, testify, "d", "w", <w, r, z>>
7  <Alice, assert, "d", "w", ({<d, l, g>, <w, t, y>},
8  <{<d, k, e>, <w, r, z>}>, <d, w, ≡>)>
9  /Bob, justify, "d", "w"/
    
```



# Confirm

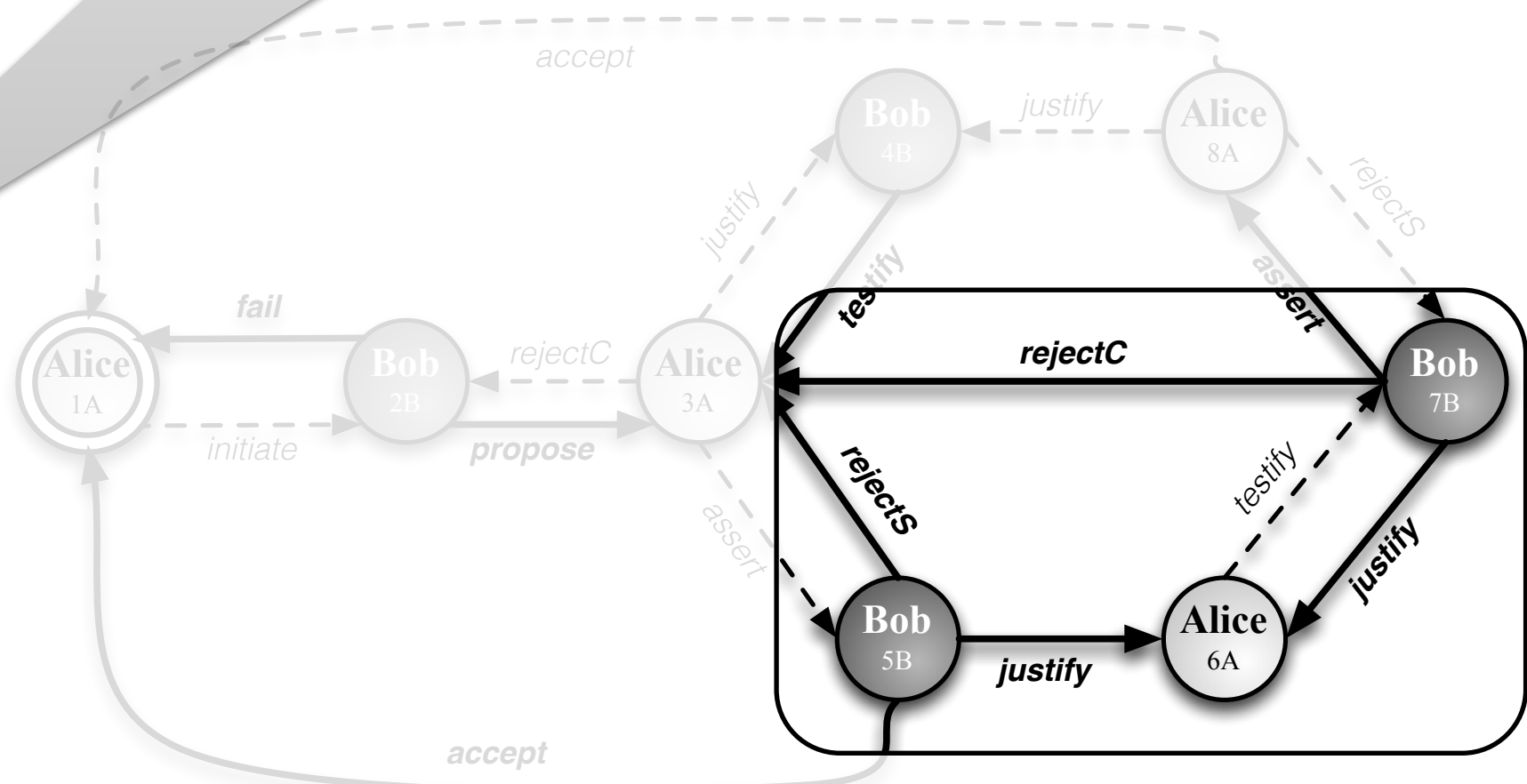


*Opponent verifies the support for the correspondence*

- Can **accept** the correspondence
- May **ascertain its own evidence** to augment the support (i.e returning to the propose phase)

```

8   <Bob, justify, "d", "w">
9   <Alice, testify, "d", "w", {d, m, f}>
10  <Bob, assert, "d", "w", ({({w, t, y}, {d, l, g}),
    ({w, r, z}, {d, k, e}), ({w, s, x}, {d, m, f})},
    {d, w, ≡})>
11  / Alice accept "d", "w" / (1, 1, 1)
  
```

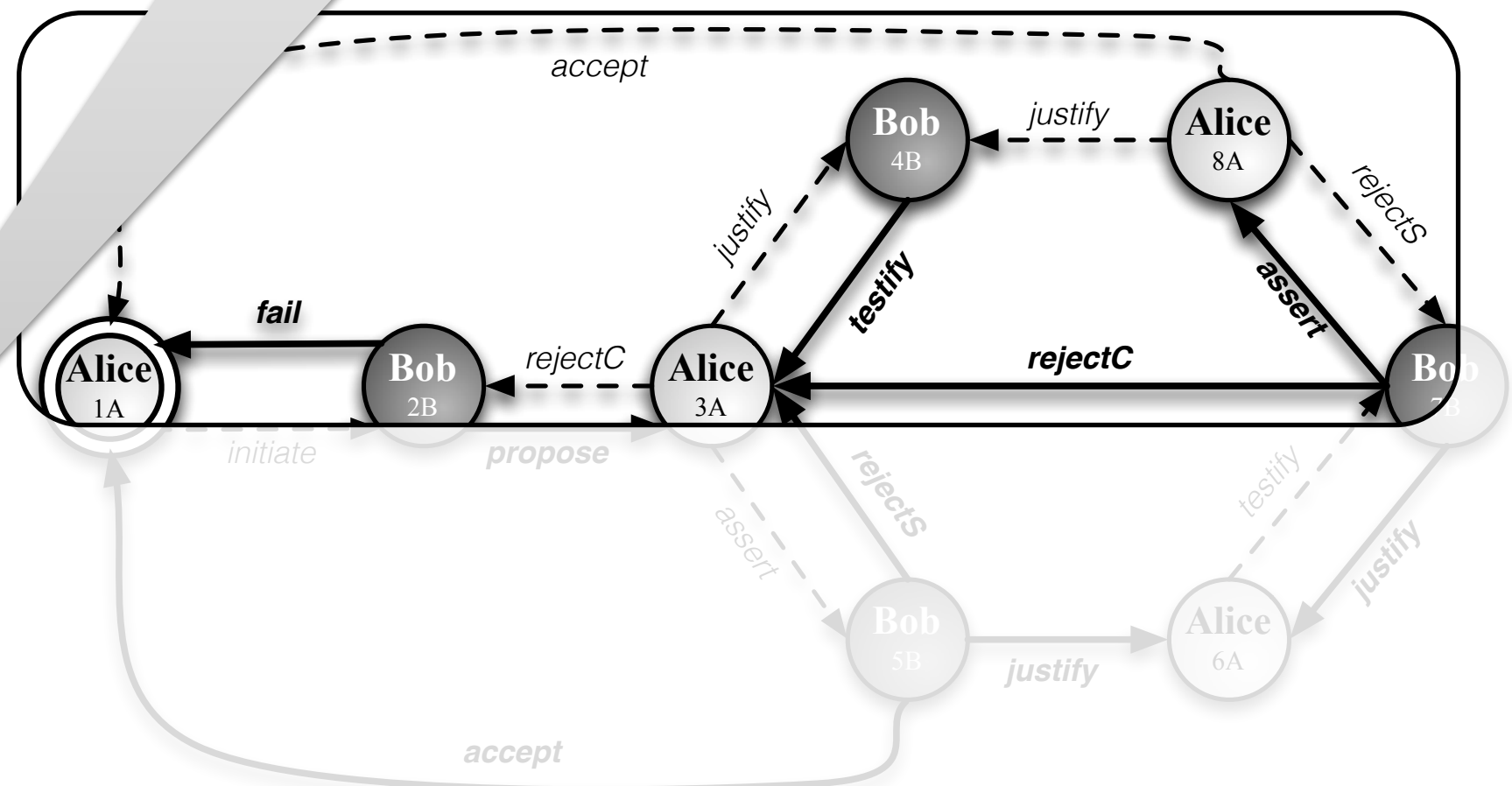
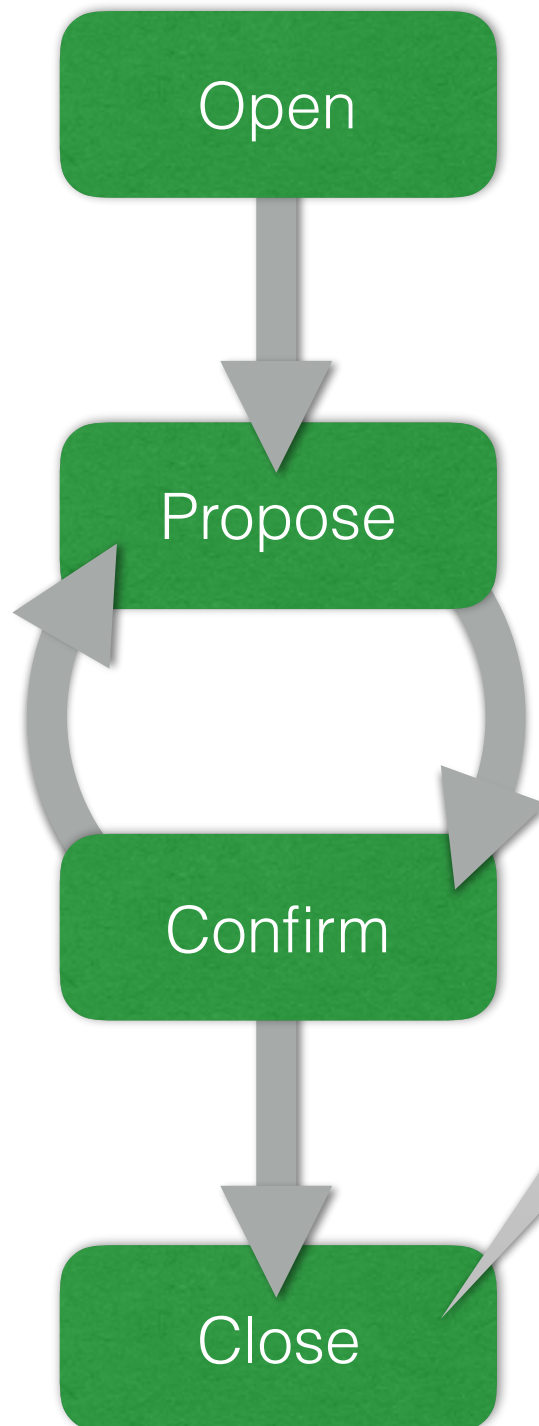


# Close

Dialogue fragment terminates if

- Both agents **accept** the correspondence
- No support can be found that is **acceptable to both** agents

```
10  ⟨Bob, assert, “d”, “w”, ({(⟨w, t, y⟩, ⟨d, l, g⟩),
    (⟨w, r, z⟩, ⟨d, k, e⟩), (⟨w, s, x⟩, ⟨d, m, f⟩)},
    ⟨d, w, ≡⟩)⟩
11  ⟨Alice, accept, “d”, “w”, ⟨d, w, ≡⟩)⟩
```



A word cloud visualization of terms related to the Semantic Web. The most prominent words are 'ontology', 'research', 'services', 'knowledge', 'dialogue', 'discovery', 'data', 'agents', 'service', 'use', 'internet-of-things', 'based', 'capabilities', 'self-organization', 'pervasive', 'distributed', 'conservativity', 'recently', 'image', 'included', 'reverting', 'supporting', 'topic', 'facilitate', 'interlocutor', 'coalition', 'within', 'correspondence', 'alignment', 'stake', 'interests', 'encompasses', 'development', 'information', 'etc', 'standards', 'agency', 'community', 'work', 'events', 'just-in-time', 'modularisation', 'ontological', 'include', 'semantics', 'open', 'cognitive', 'public', 'conferences', 'expansion', 'lot', 'motion', 'described', 'social', 'selection', 'multi', 'agent', 'dynamic', 'provision', 'grid', 'support', 'violation', 'heterogeneity', 'heteromedia', 'gabby', 'current', 'others', 'resilient', 'focus', 'transformation', 'collaboration', 'big', 'issues', 'also', 'system', 'devices', 'also', 'issues', 'also', 'system', 'devices'.

- <http://cgi.csc.liv.ac.uk/~trp/Knowledge-Based-Agents.html>