

# What's in a Service?: An Ontological Perspective

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# Acknowledgement

- Work done with: *João Paulo Almeida, Julio Nardi, Ricardo Falbo, Nicola Guarino, Marten van Sinderen and Luís Ferreira Pires, Monalessa Barcellos, Glaice Quirino, Claudenir Fonseca, Antonella Longo, Mario Bochicchio, Marco Zappatore and Barbara Livieri*

# Why Ontology?

NEW YORK TIMES BESTSELLER

"*Sapiens* tackles the biggest questions of history and of the modern world, and it is written in unforgettably vivid language."

—JARED DIAMOND, Pulitzer Prize-winning  
author of *Guns, Germs, and Steel*

Yuval Noah Harari



# Sapiens

A Brief  
History of  
Humankind

# Think about your participation to EEWC...

- Bought a **Ticket** and a **Travel Insurance**
- Both paid with **Money**
- Made a Hotel **Reservation**
- Made a **Conference Registration**
- Showed your **passport** as proof of your **Citizenship** to a given **Country**
- Sent **Paper** that was granted an **Acceptance** and might receive an **Award**

# This is all made up!

- Our lives are governed by **Fiat Objects**, which are ontologically subjective but epistemologically objective
- So we better understand and define well the very **nature** of these creatures

# Why Ontology?

- Analyzing and systematically characterizing the shared conceptualization of certain phenomena in reality is the very business of Ontology
- We can benefit from 2400 years of accumulated knowledge
- Ontology is fundamental for understanding the nature of these fiat objects and their ties, i.e., for affording interoperability between social entities. Semantic Interoperability between computer systems is secondary to that
- Because we don't have a choice! **The opposite of Ontology is not Non-Ontology but Bad Ontology**



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World Trade Centre insurance

# Bad forms

**After a rancorous trial, relief for many insurers of the twin towers**

May 6th 2004 | From the print edition



IT WAS a \$3.5 billion question: was the crashing of two aeroplanes into New York's twin towers in September 2001 one event or two? One, many insurers are relieved to know. On May 3rd a jury ruled that Swiss Re, the world's second-largest reinsurer, which wrote about a quarter of the coverage for the World Trade Centre, was bound by a form that classed such attacks as a single occurrence. Last week the same jury had reached a similar verdict for several Lloyd's of London syndicates and seven other insurers. The loser was Larry Silverstein, the centre's leaseholder. He had argued that another form was valid, in the hope of claiming around \$7 billion for two events. Now he may get only half that.

In most disaster insurance, "occurrence" is carefully defined. Earthquake coverage typically treats all shaking

AP



Silverstein's the loser

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World Trade Centre insurance

## Bad forms

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“In most disaster insurance, “**occurrence**” is carefully defined...”

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World Trade Centre insurance

# One into two

**Having lost one legal case to insurers, the towers' leaseholder wins a second**

Dec 9th 2004 | NEW YORK | From the print edition



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SEVEN months ago, a jury in lower Manhattan ruled that under the forms covering insurance of the World Trade Centre, the striking of the twin towers by two aeroplanes constituted only one "occurrence". Consequently, Larry Silverstein, who had recently leased the Trade Centre complex, was entitled to one payment, not two—a difference of \$3.5 billion. On December 6th, in the same courtroom with the same judge presiding, another jury decided that under the documents used by nine other insurers the attacks were two events, thus qualifying for two payments. The verdict will provide Mr Silverstein with as much as \$1.1 billion extra for rebuilding the Trade Centre. It will also ensure that he remains in control of the project.

Why, after two weeks of deliberation, did the second jury come to a different conclusion from the first? The main reason lay in the preliminary paperwork signed by the underwriters. Because the Trade Centre had been leased to Mr Silverstein only weeks before the attack, the final insurance contracts had yet to be signed. The insurers in the first trial had signed a form with a much tighter definition of an "occurrence" than in the form signed by the nine insurers in the second trial. In addition, the insurance companies' claim that they always defined "occurrence" precisely may have been undermined by testimony that they had been flexible in other cases—for example, involving sequences of



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“The insurers in the first trial had signed a form with a **much tighter definition of “occurrence”**...the insurance companies' claim that they always defined **“occurrence” precisely**”

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# (Ambitious) Goals of this Talk

1. Exemplify the Approach
2. ...by employing it in an actual complex domain that is itself of great value, namely,  
**Services**

# UFO

## (Unified Foundational Ontology)

- Over the years, we have built a Philosophically and Cognitively well-founded Ontology to contribute to the general goal of serving as a Foundation for Conceptual Modeling
- This Ontology has been used to as a theory for addressing many classical conceptual modeling constructs such as Object Types and Taxonomic Structures (CAISE 2004, CAISE 2007, CAISE 2012), Part-Whole Relations (CAISE 2007, CAISE 2009, CAISE 2011), Intrinsic and Relational Properties (ER 2006, ER 2008, ER 2011, CAISE 2015), Weak Entities, Attributes and Datatypes (ER 2006), Events (ER 2013), Services (EDOC 2013, IS 2015), Capabilities (EDOC 2013, IS 2015), Goals, Communities, Multi-Level Modeling, etc...

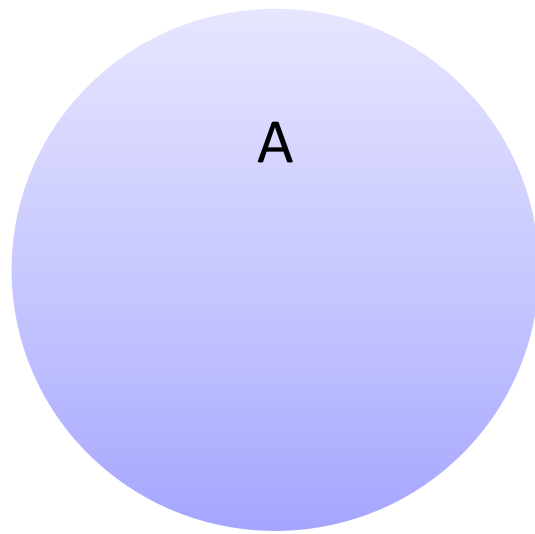
# The Approach

- A **Foundational Ontology** (UFO) has been applied in the design of general purpose conceptual modeling language (OntoUML)
- OntoUML is then used to build **Core Ontologies**
- Core Ontologies become the source of Domain-Related Patterns forming a **Pattern-Language** that can be used for the Construction of **Domain-Specific Models**

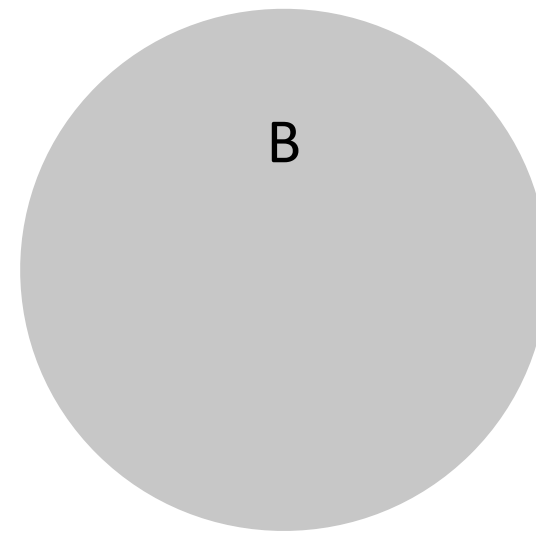




- A redesigned version of UML such that:
  - the modeling of primitives of the language reflect the ontological distinctions in UFO
  - The grammatically valid models of the language conform to the axiomatization of UFO
- It is more than a language including also a methodology, a set of ontology design patterns and anti-patterns as well as formal approaches for model transformation, verification and **validation**

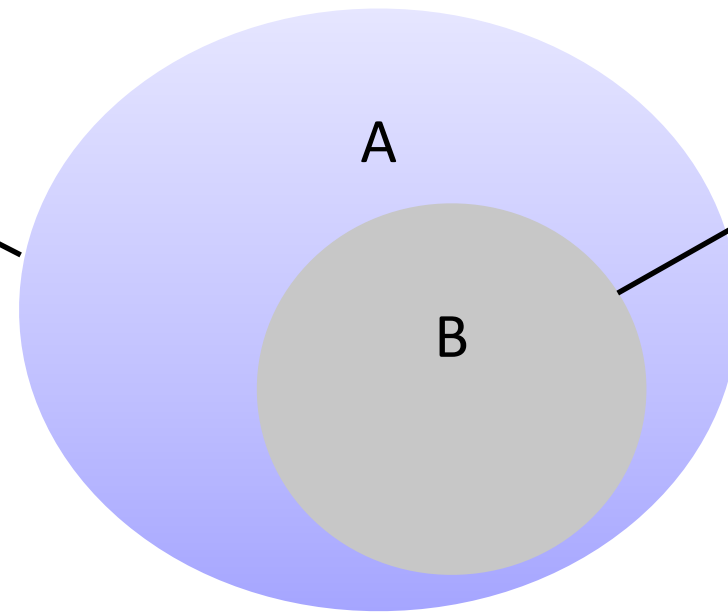


Valid state of affairs  
according to the representation



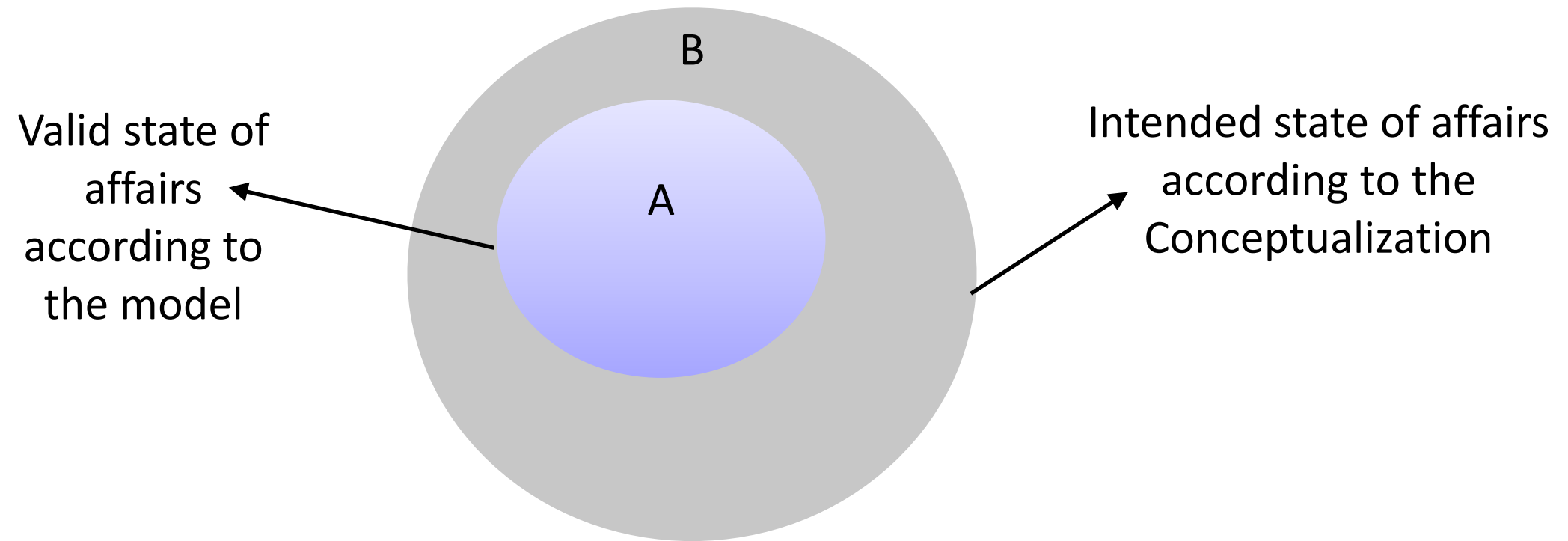
Intended state of affairs  
according to the Conceptualization

Valid state of  
affairs  
according to  
the model

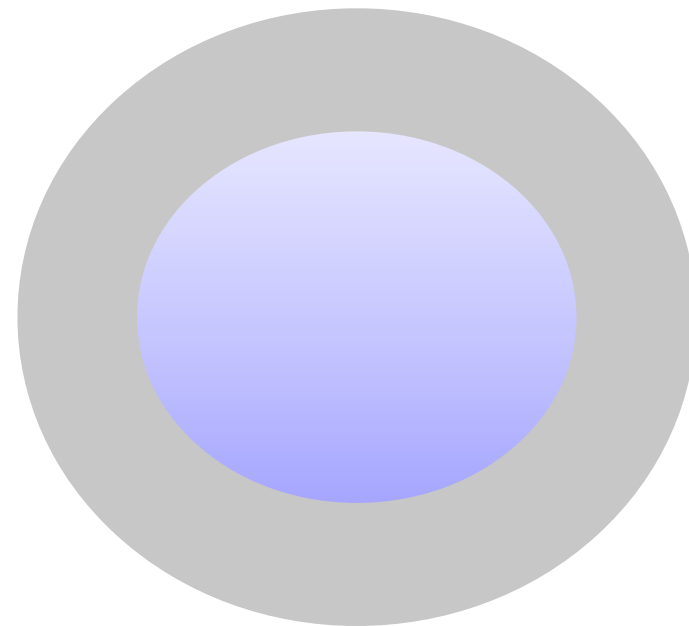


Intended state of affairs  
according to the  
Conceptualization

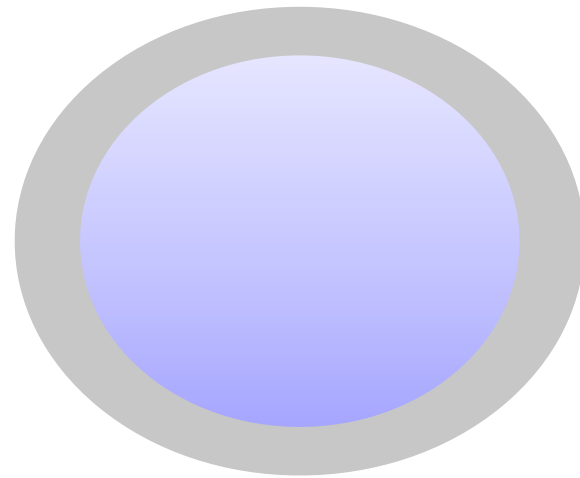
Under-constraining



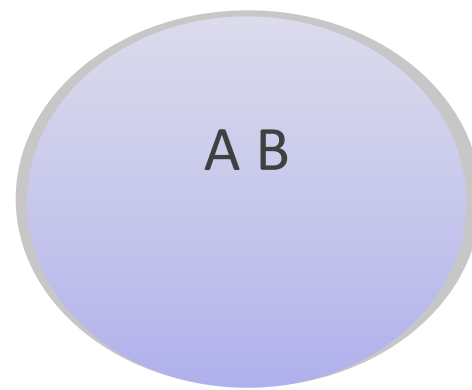
Over-constraining



Constraints

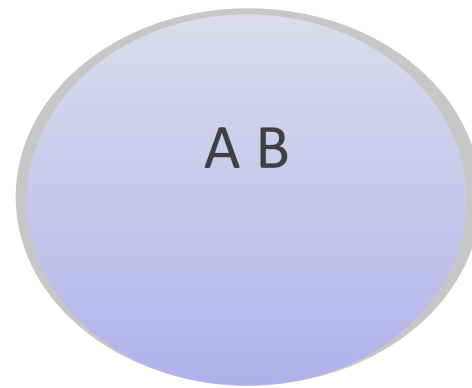


Constraints

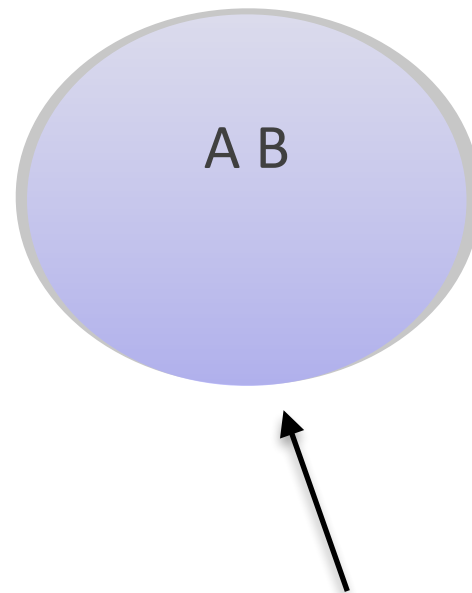


Constraints

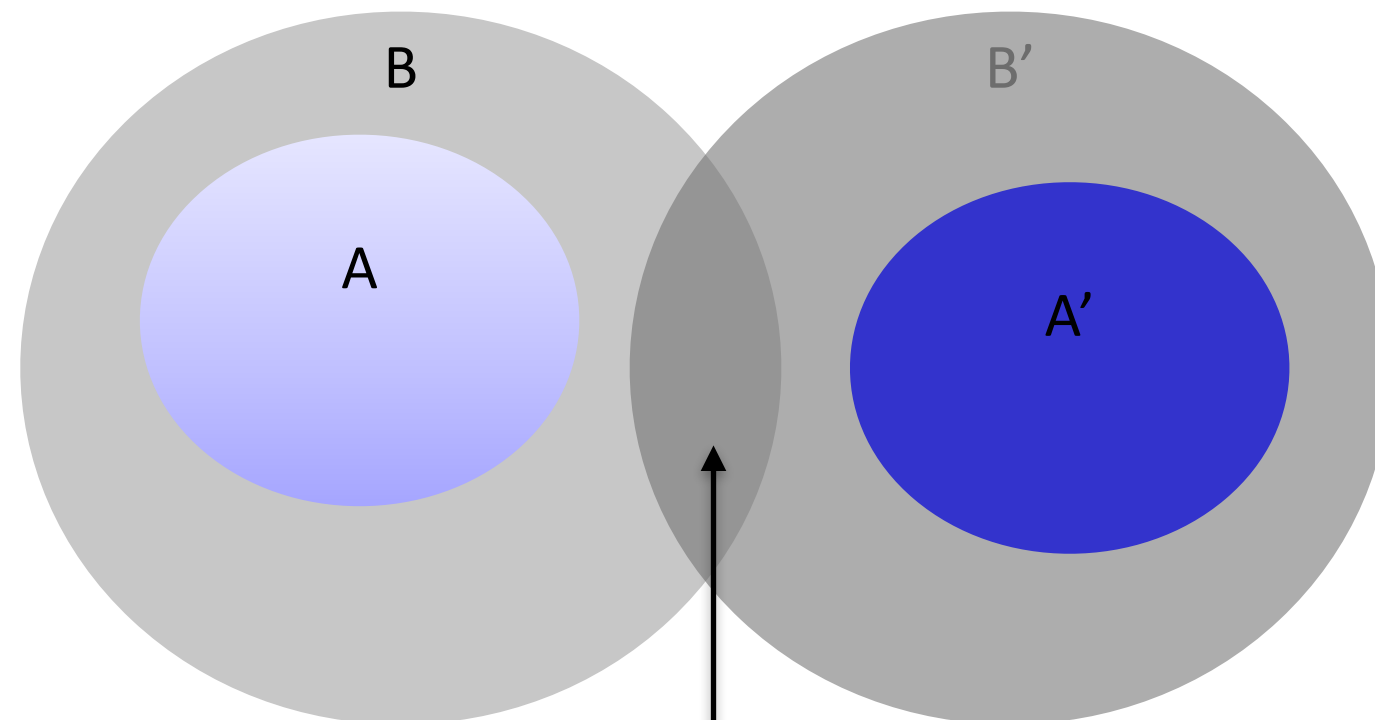




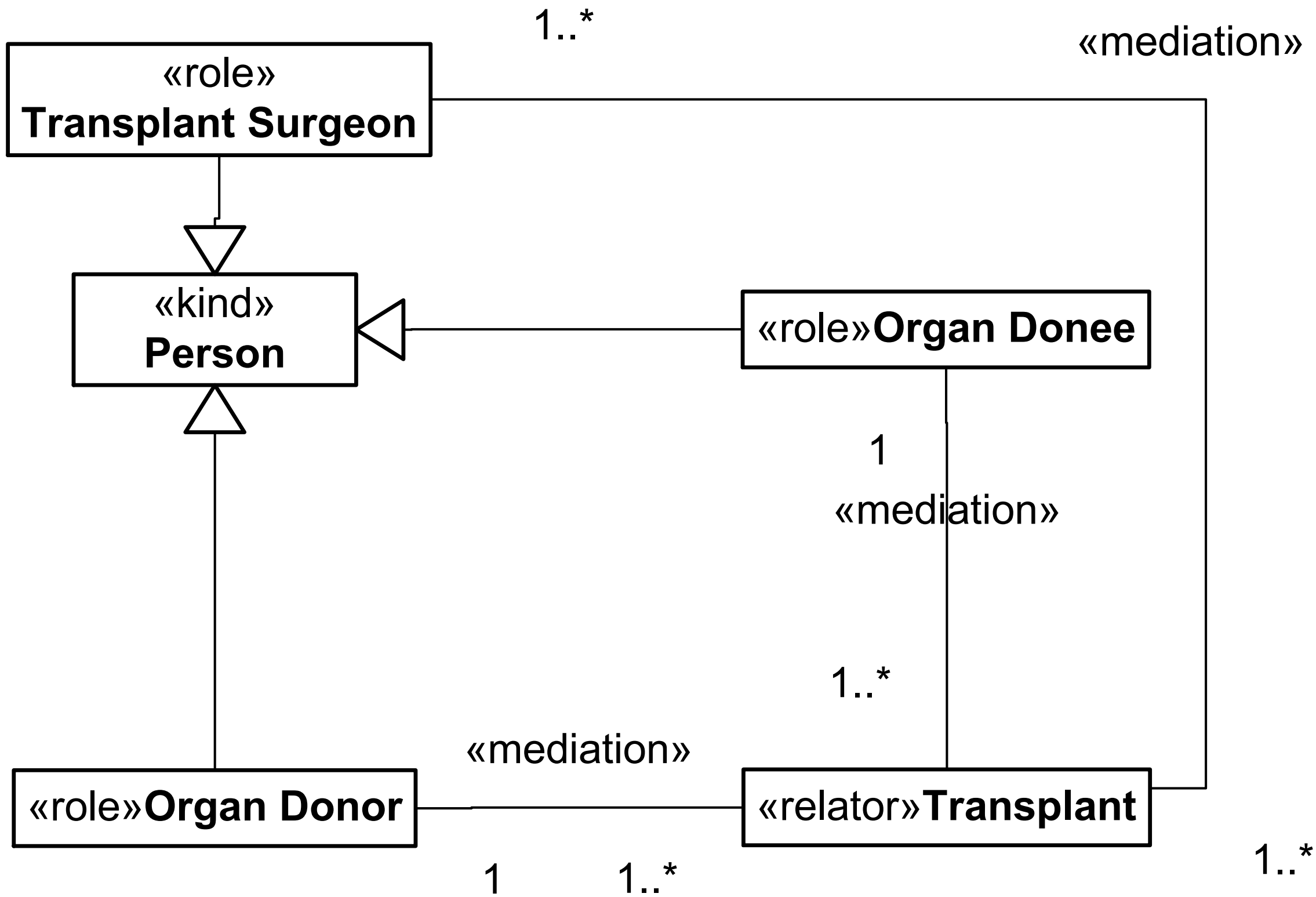
Conceptual Model = Structure + Axiomatization

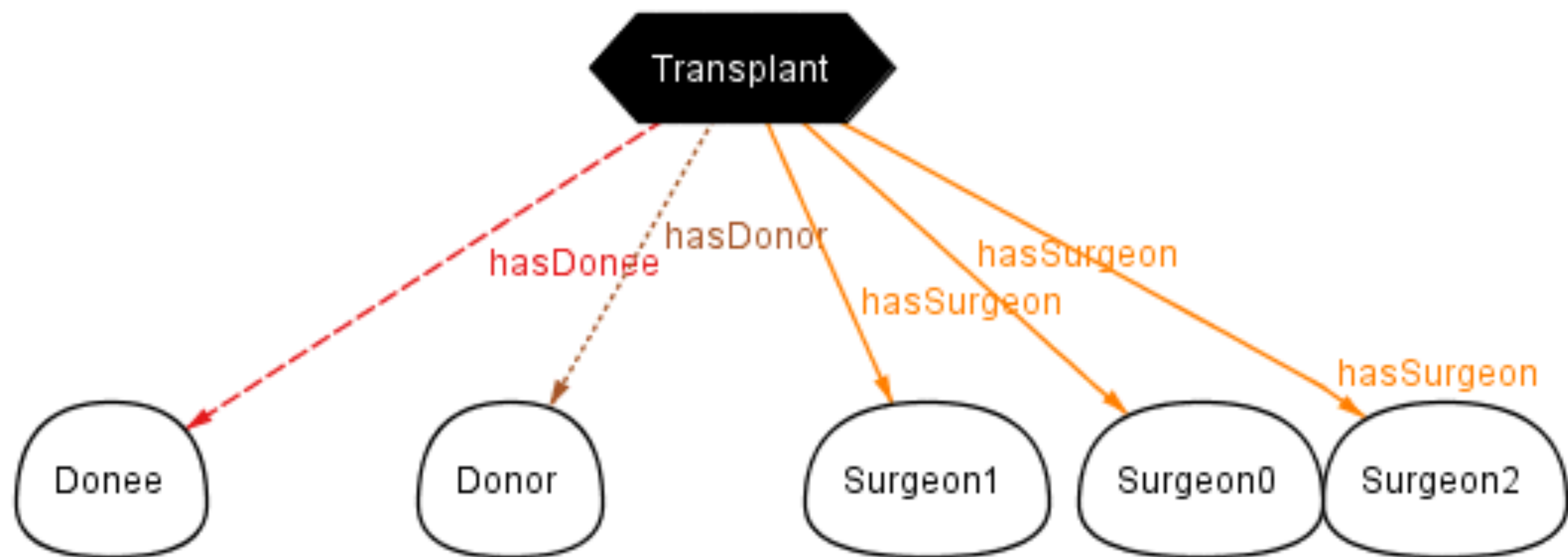


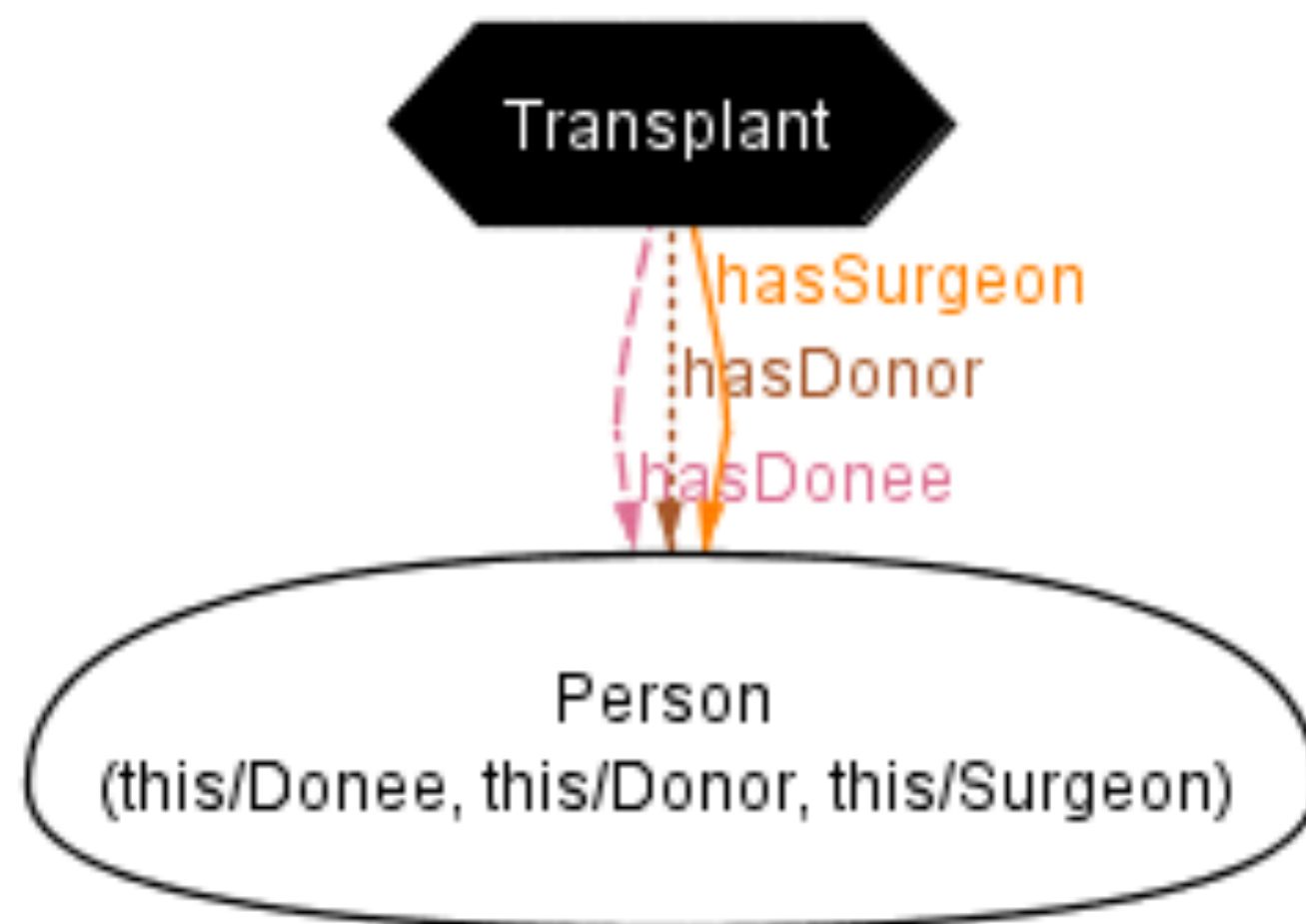
Conceptual Model = Structure + Axiomatization  
**(Ontological Commitment)**

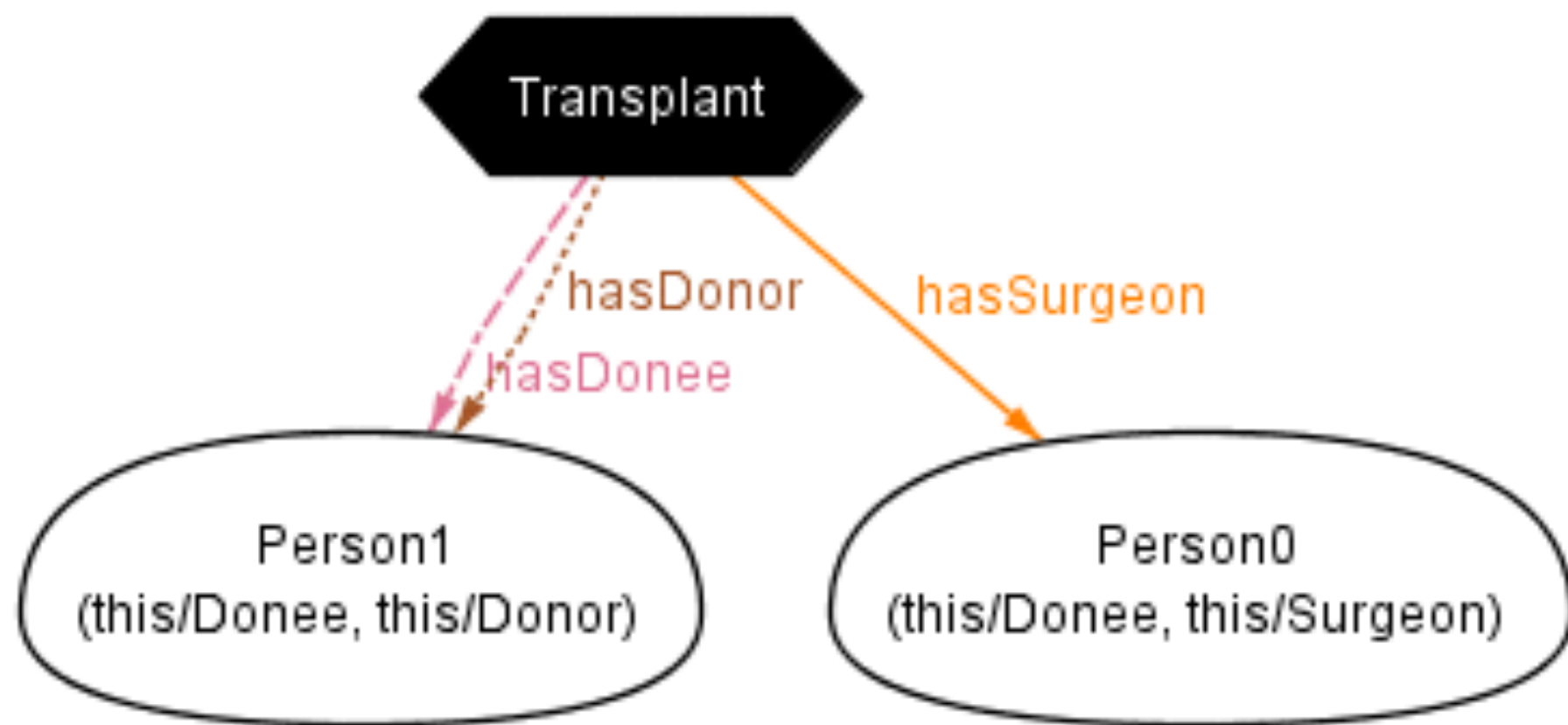
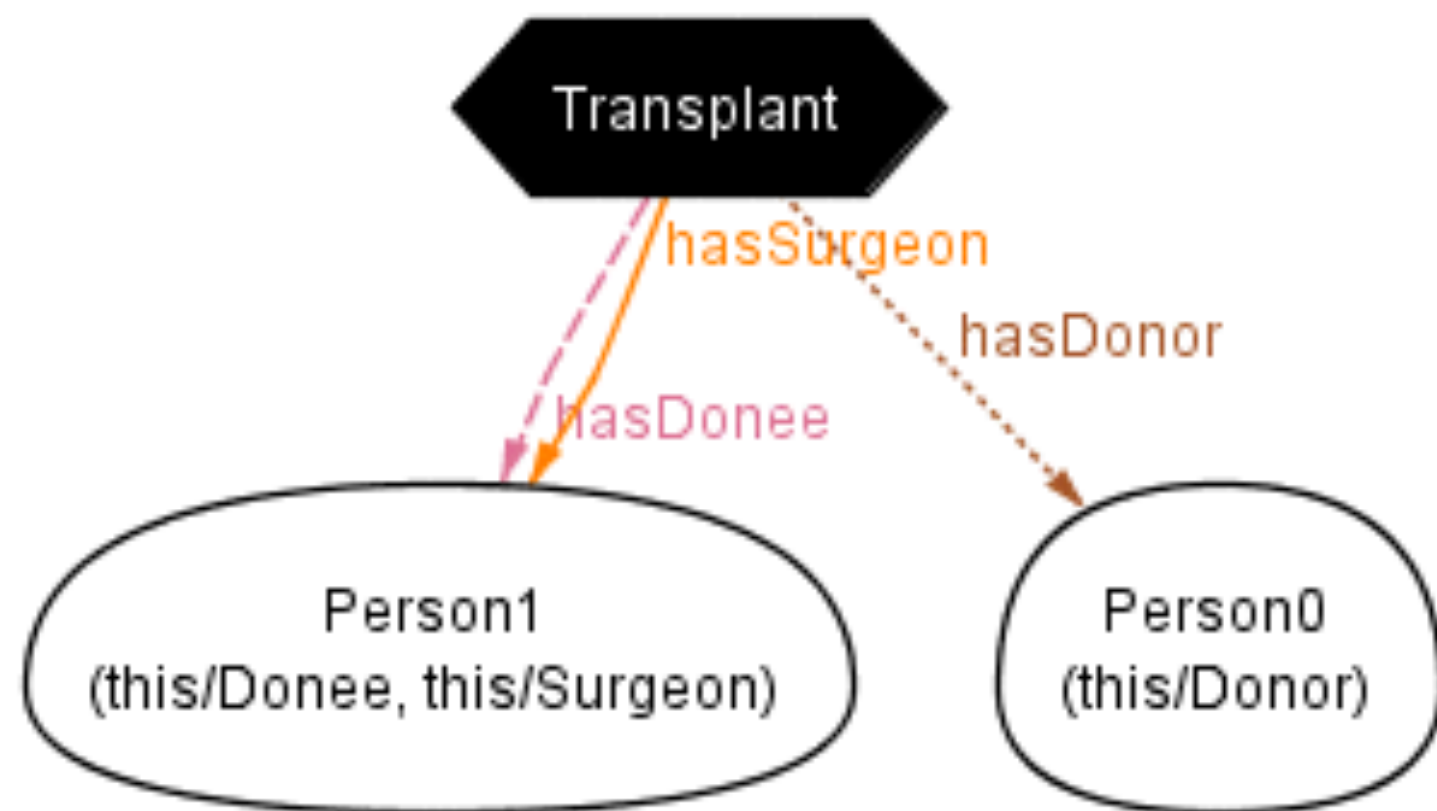


False Agreement

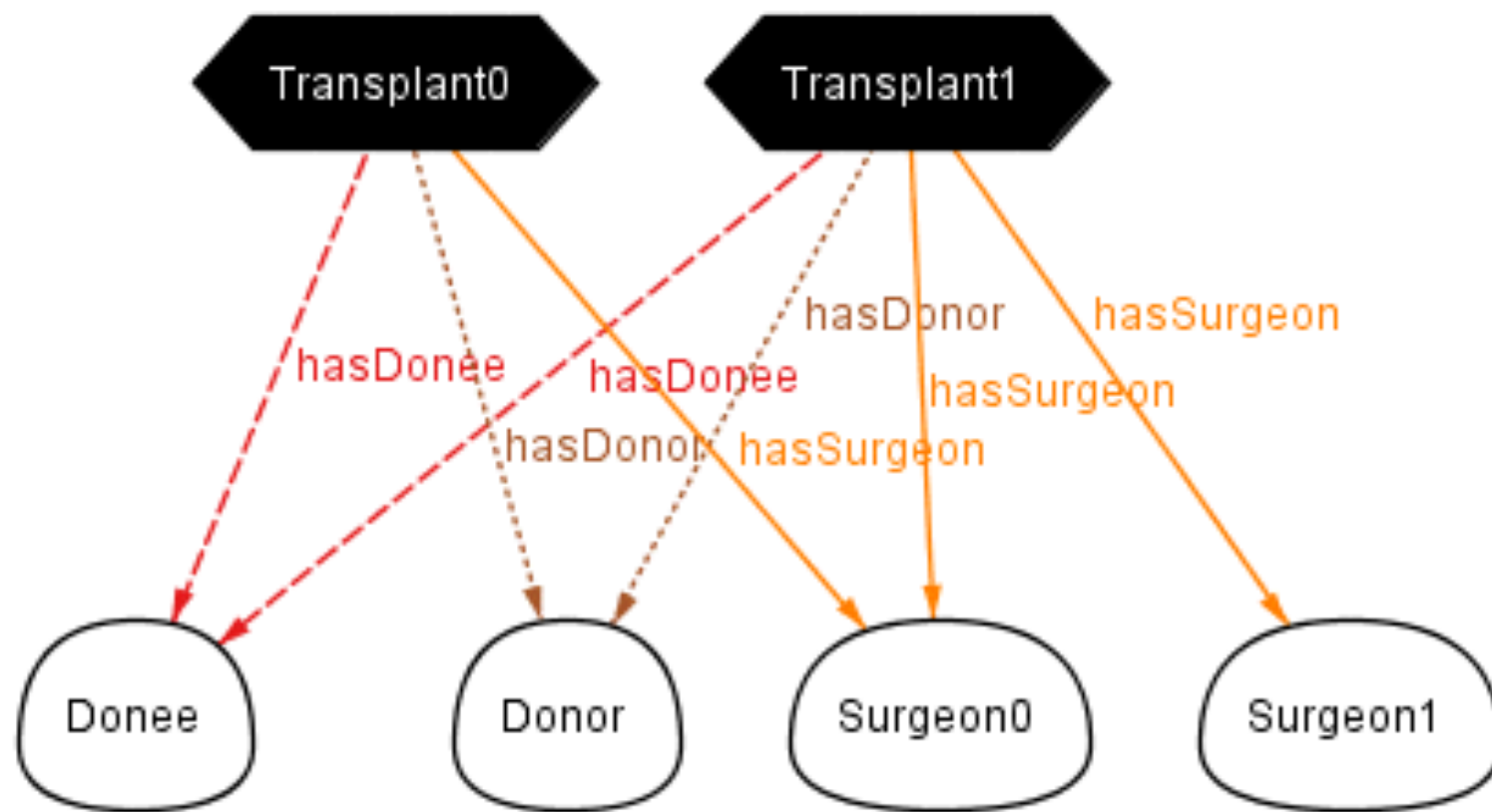




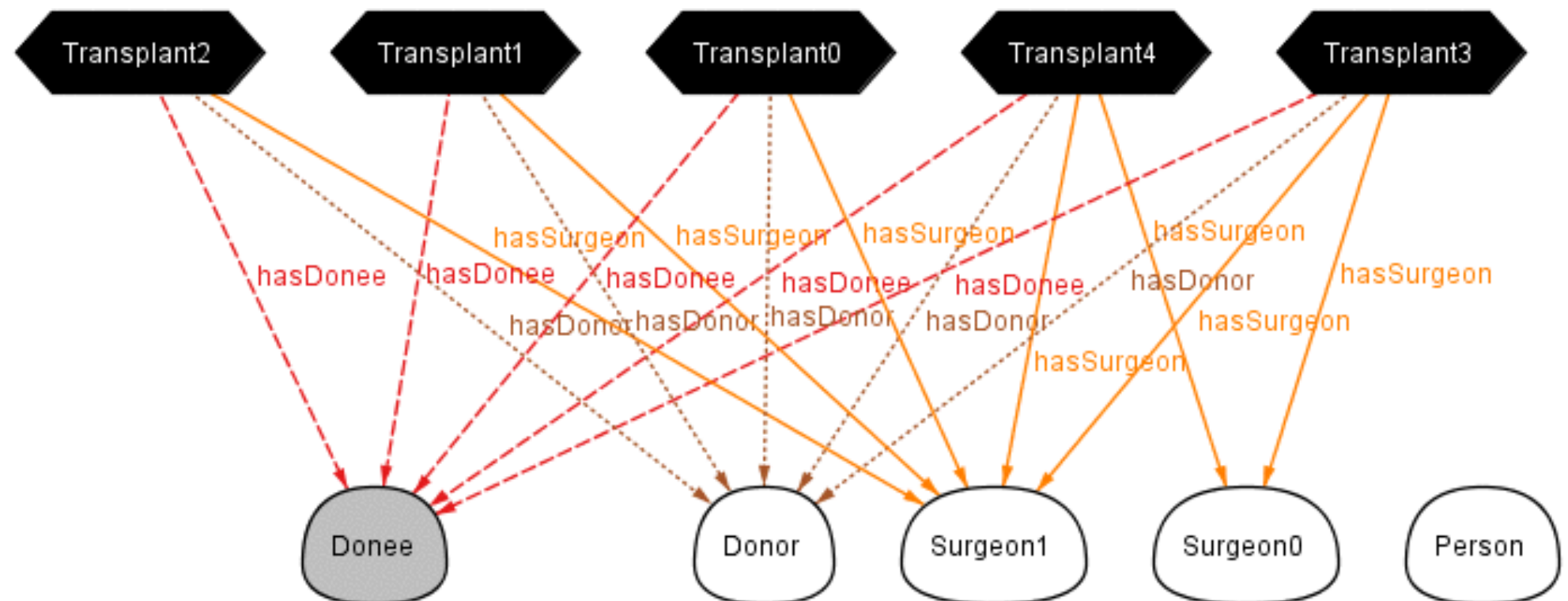








## Real-Word Semantics



# Why Services?

# Why Services?

- Ubiquitous notion in enterprise architecture & computing
- Evolution from different disciplines
  - Service-oriented architecture/service-oriented computing/  
Data Communication Protocols
  - Services in Marketing
  - “Service(s) Science”, a multi-disciplinary effort
- Lack of standardized terminology...
- but even worse... lack of **(shared) conceptualization**

# What is a Service?

- “A **software system** designed to support machine-machine interactions” (W3C, Web Services Glossary)
- “An **abstract resource that represents a capability of performing tasks**...to be used, a service must be realized by a concrete provider agent” (W3C, Web Services Glossary)
- “A service is **a change in the condition of a person, or a good** belonging to the economic activity, brought about as the result of the activity of some other economic entity” (Ted Hill, On goods and Services and NAPCS)

# What is a Service?

- **Quartel et al.:** a service can be regarded “as *multiple related interactions* between a service user and provider”
- **Service-Dominant Logic:** Services as the fundamental basis of *value creation through exchange*
- **Unified Service Theory:** a *production process* for which the customers provides significant inputs. Thus, service processes are distinguished from non-service process (manufacturing or extractive processes) only by the presence of customer inputs

# What is a Service?

- **Visser et al:** Service is an **externally observable behavior**
- **Archimate:** Service as a “*unit of functionality*”. Both business services and computational (application and infrastructural) services are characterized as behavioral elements
- **Terlouw and Albani:** services are characterized in terms of **transactions** constituted by coordination acts and production acts

# What's in a Service?

- Attempt to reduce service into or explain in terms of:
  - Technical Perspective
    - Service as a Process
    - External Behavior/Interaction (ArchiMate, ISO RM-ODP, ISDL, ...)
    - Computational Services
  - Service Science literature
    - Capability
  - Service Marketing literature
    - Value-producing activities
- Service is all this **AND MORE!**

# Why is this a problem?

- We can only judge the adequacy of a representation mechanism to model a certain set of phenomena, if we understand the characteristics of the phenomena being modeled



# UFO-S

- A rich **Core Ontology of Services**
  - Not a lightweight semantic web ontology
  - Aims at Consensus Building and Meaning Negotiation, not automatic inferencing
  - Grounded on a Foundational Ontology (UFO)

# UFO-S

- Accounts for Service Phenomena, involving:
  - Capability
  - Process (Behavior/Interaction)
  - Value Co-Creation
  - Computational Services
  - **Commitments**

# Commitments

- Some services cannot be explained properly without the notion of commitment
- Example of a service that is meaningless without it:
  - Insurance service
  - There may be no behavior execution (if no unwanted event occurs)
  - What matters is the **guarantee** of compensation
- So, services are not reducible to behavior

# Commitments

- Services are also not reducible to capability:
  - I can be capable of making coffee, but I do not offer a coffee making service
  - Not committed to employ this capability in the scope of social relations

**UFO-C (SOCIAL ASPECTS)**

(Agents, Intentional States, Goals, Actions,  
Norms, Normative Descriptions, Social Roles, Social Commitments/Claims,  
Social Dependency Relations, Capabilities,...)

**UFO-A (STRUCTURAL ASPECTS)**

(Objects, their types, their parts/wholes,  
the roles they play,  
their intrinsic and relational properties  
Property value spaces...)

**UFO-B (DYNAMIC ASPECTS)**

(Events and their parts,  
Relations between events,  
Object participation in events,  
Temporal properties of entities,  
Dispositions, Time...)

**UFO-S (SERVICES)**

(Service Offering, Service Negotiation, Service Delivery,  
Service Provider, Target Community, Target Customer, Service  
Agreement, Service Agreement Description,...)

**UFO-C (SOCIAL ASPECTS)**

(Agents, Intentional States, Goals, Actions,  
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**UFO-B (DYNAMIC ASPECTS)**

(Events and their parts,  
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# Ontological Background

1. We distinguish between Endurants (**Objects**, **Qualities**, **Situations**) and **Events** so that:
  - Qualities inhere in Objects
  - Objects and Qualities constitute Situations
  - Objects participate in Events
  - Events change the world by bringing about Situations
2. **Dispositions** are particular types of Qualities
  - Dispositions are activated in certain Situations and are manifested via the occurrence of Events of a certain type
  - Objects bear dispositions (capacities, tendencies, powers, propensities, tendencies) even if these are never manifest

# Ontological Background

3. **Agents** are types of Objects which have intentionality, i.e., that can bear **mental dispositions** (**beliefs, desires, intentions**) which have a **propositional content**
  - **Capabilities** are types of Dispositions
  - **Commitments** are types of Dispositions
  - Intention is a type of commitment (self-commitment)
  - A **Goal** is the propositional content of an intention
4. From Self-Commitment to Social Commitment
  - **Social Dependence** emerges due to the mismatch between one's goals and capabilities
  - Cooperation (shared goals and collective capabilities) and Social Transfer (mutual dependence) emerges because of Social Dependence



# Ontological Background

## 5. Social Commitment, Social Delegation and Social Capability

- Language emerges as a mechanism for coordination (in particular for persuasion, i.e., goal adoption)
- Commitments (intentions and social commitments) can be **Closed Commitments** (commitments to achieve goals by causing the occurrence of events – **Actions** - of a certain type)
- **Social Delegation** requires a Social Commitment
- Social Delegation increases our **Social Capability** (socially-can) and, hence, our capacity to socially commit

# Ontological Background

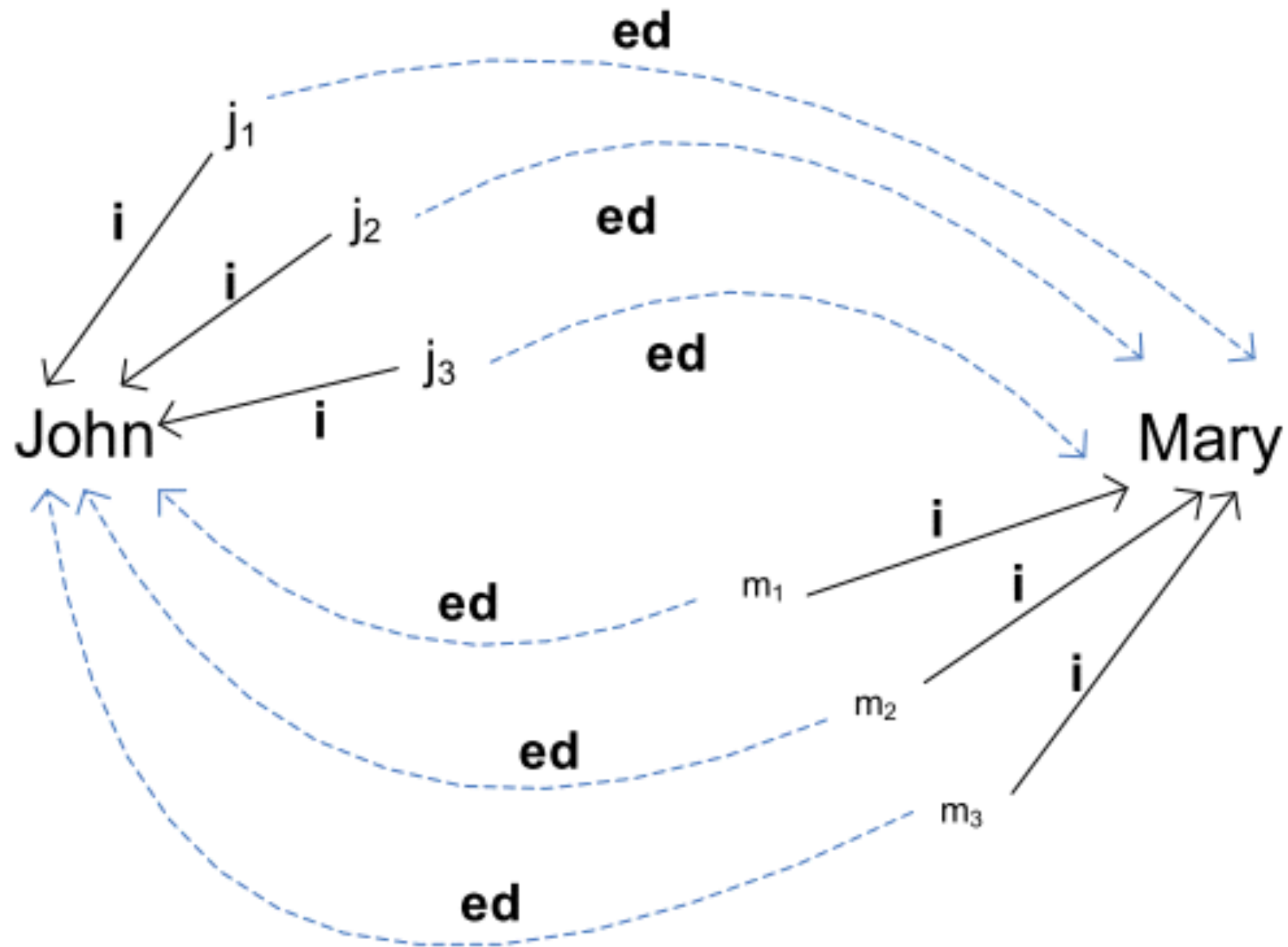
## 6. Meta-Commitments and Social Roles

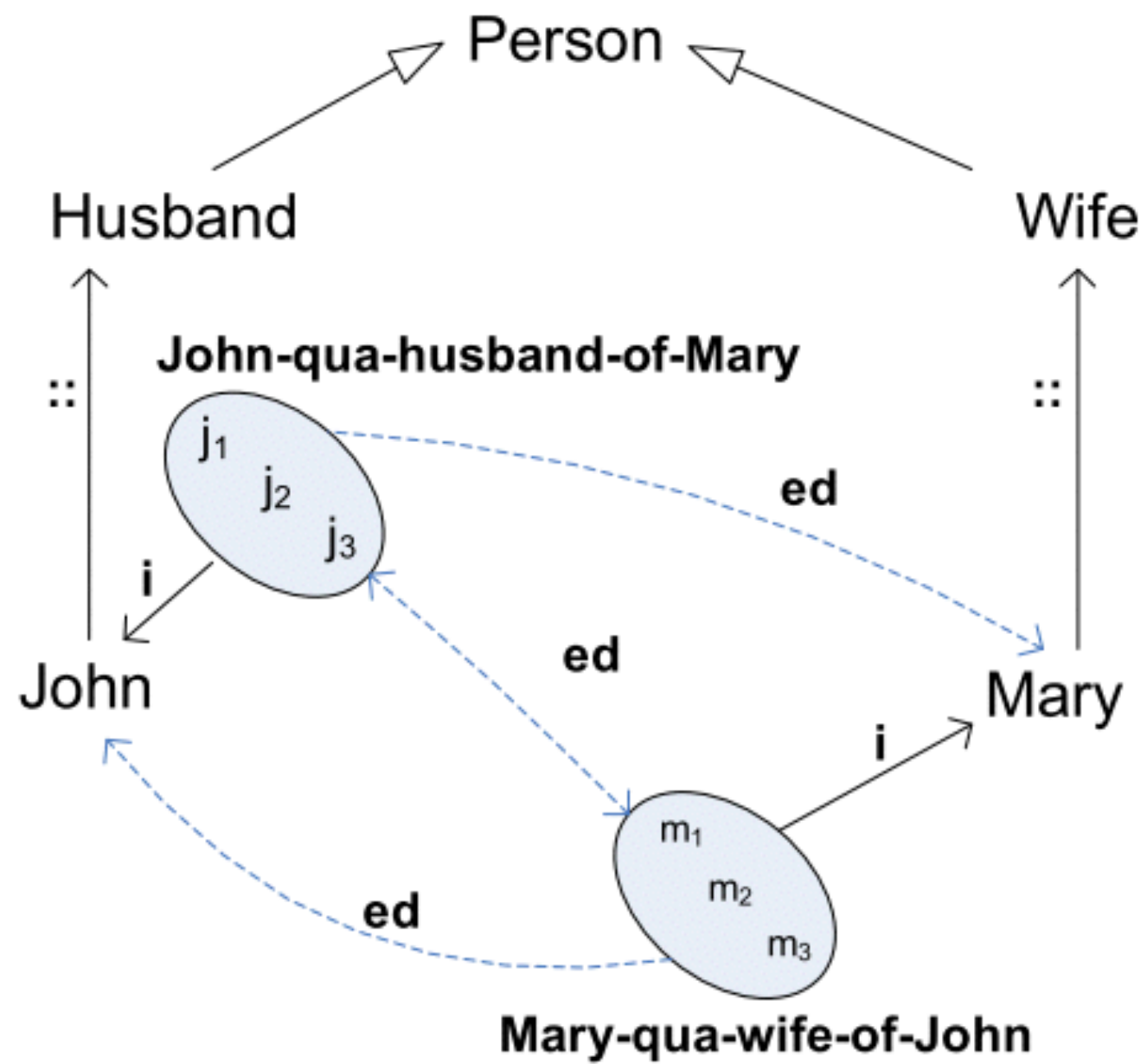
- **Meta-Commitments** are Commitments to accept commitments of a certain kind under certain types of situations
- A **Social Role** is a set of meta-commitments defined by **Social norms** accepted by a **Collective Agent**
- Social Systems are designed in terms of Social Roles, **Normative Descriptions** and Predictable Delegation Relations so that they can increase their Social Capability

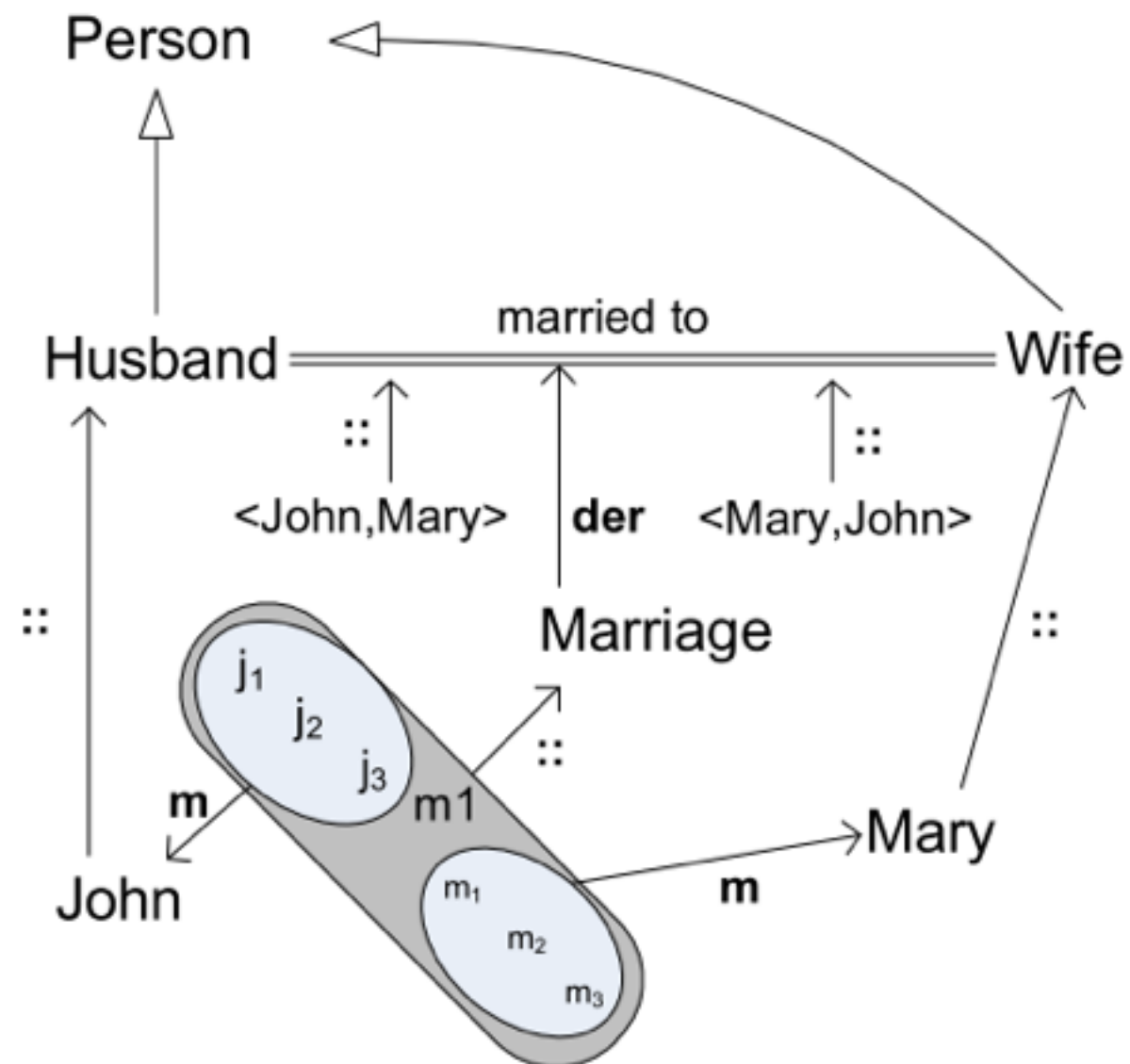
# Ontological Background

7. (Social) Roles are anti-rigid (i.e., they contingently classify their instances) and relationally dependent. The properties (e.g., meta-commitments) that characterize a (Social) Role are **Relational qualities** that constitute a relational complex called a **Relator**

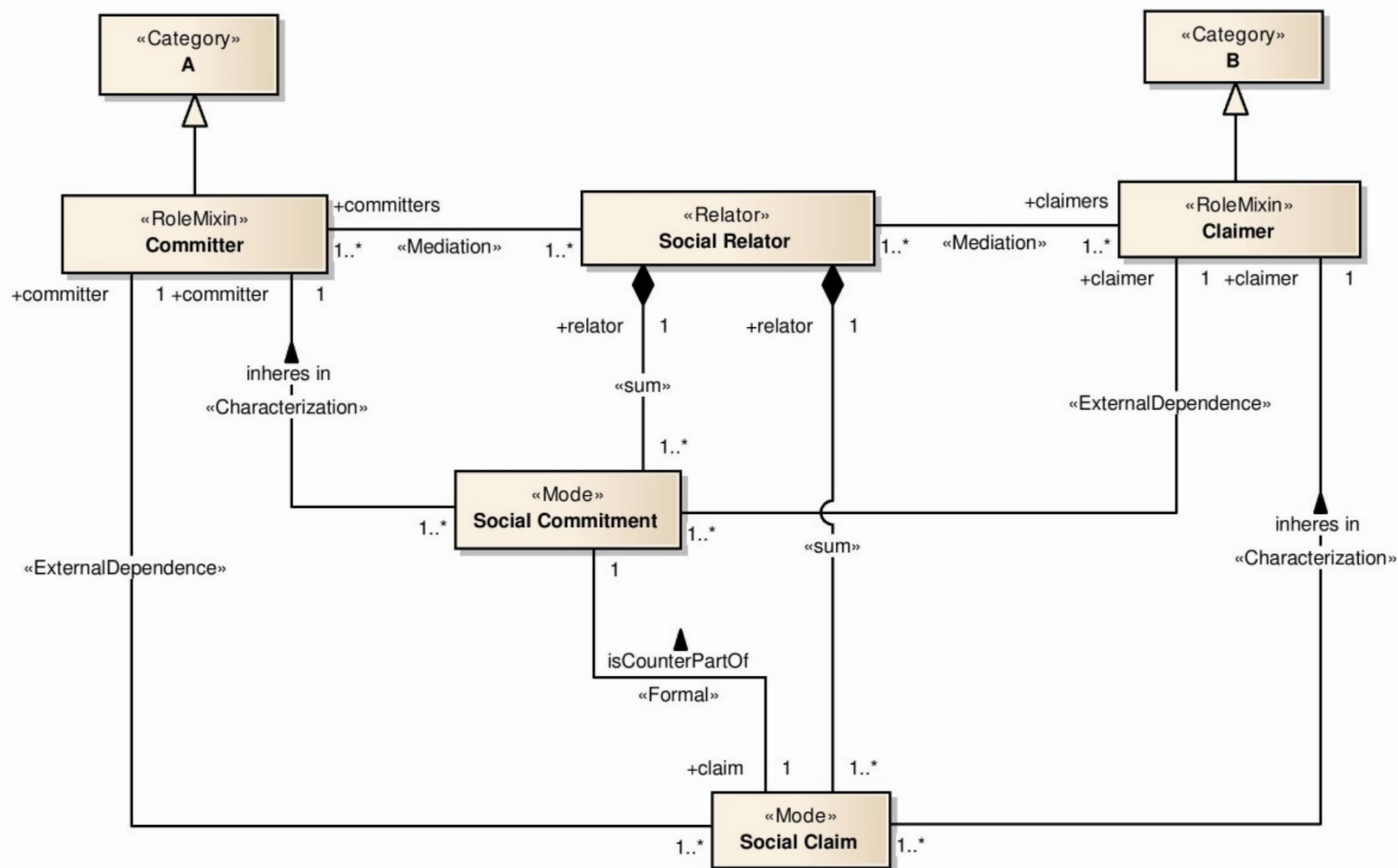
Suppose John marries Mary







# The Social Relator Pattern

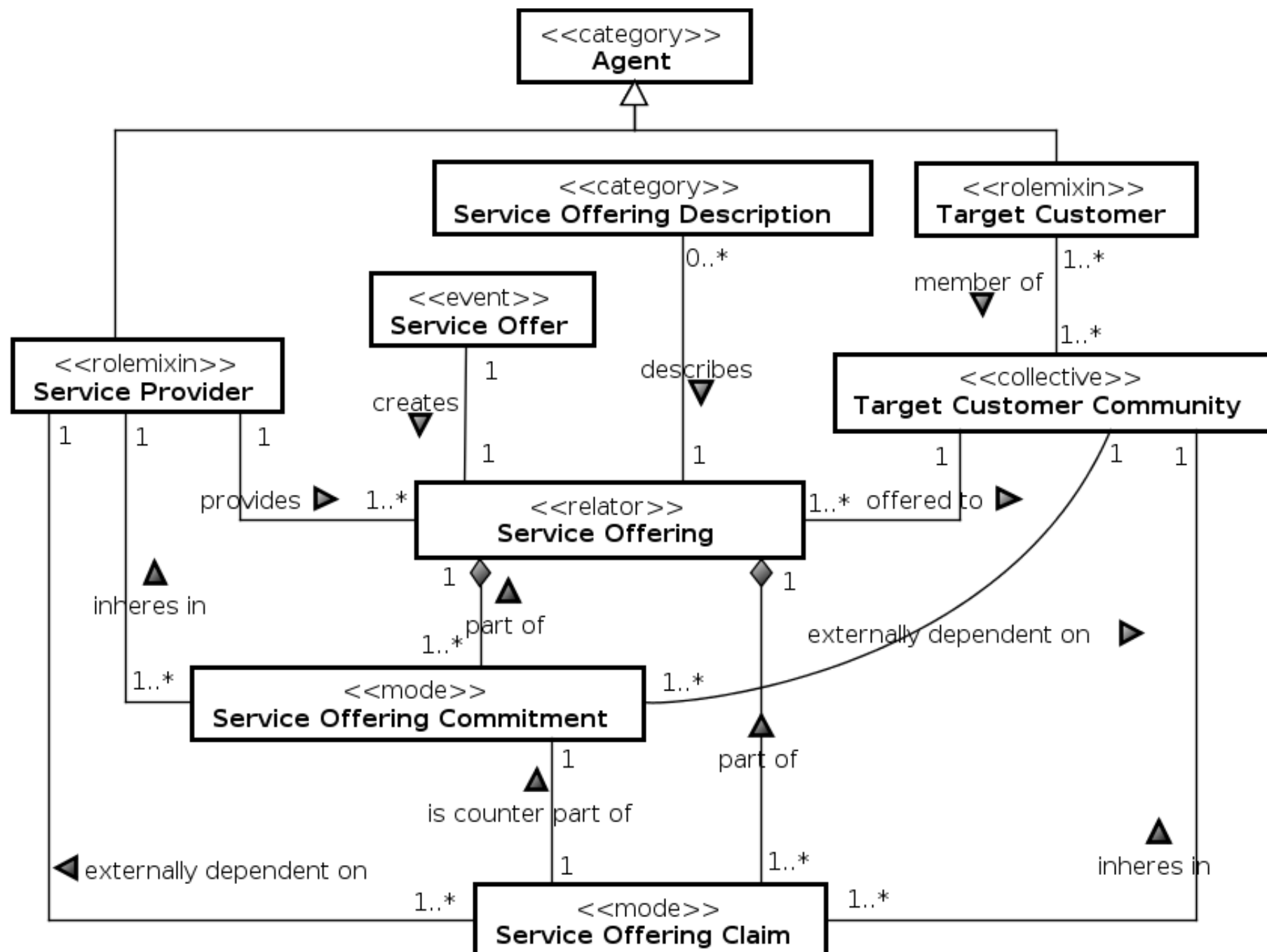


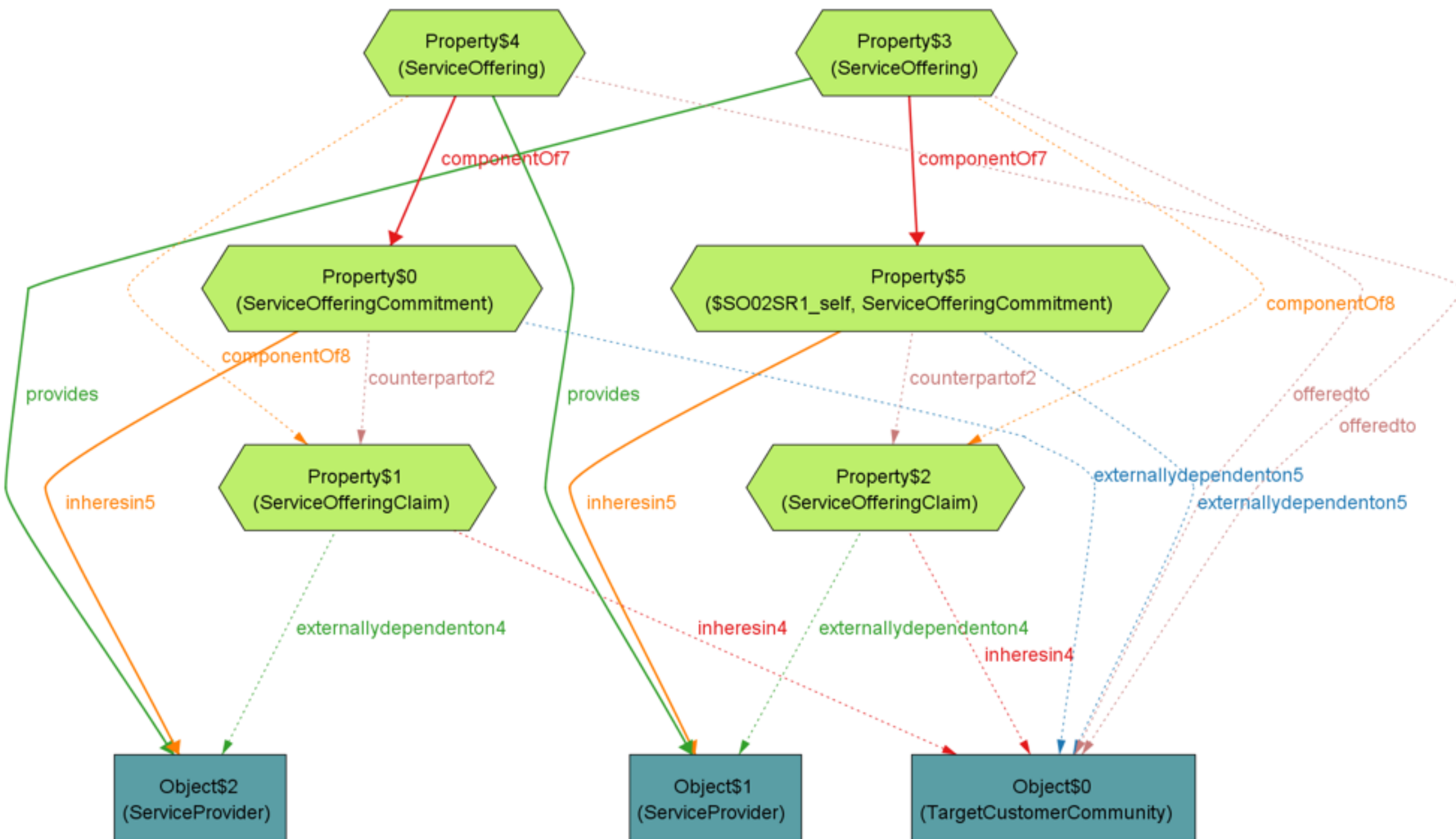
# Social Roles and Services

- Bundles of Meta-Commitments defined by Normative Descriptions
- A particular **Service Request** is a **Social Delegation Relation**
- A **Service Relator** generates mutual (reciprocal) commitments and are generally captured by normative descriptions
- Typically, these are Closed Commitments, i.e, Commitments to Execute Actions of a particular type under certain types of situations
- The involved roles are typically **RoleMixins**



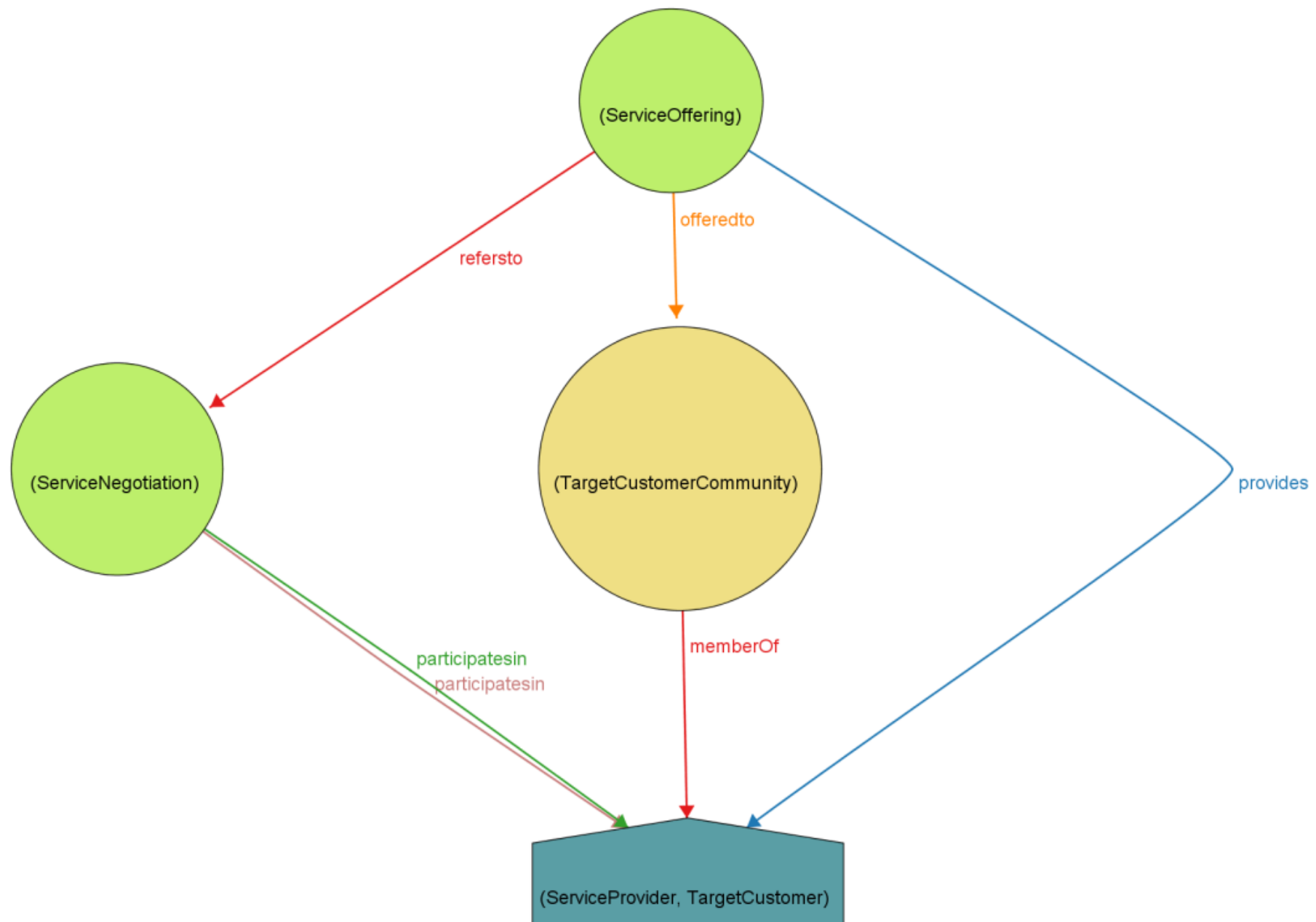
# Service Offering





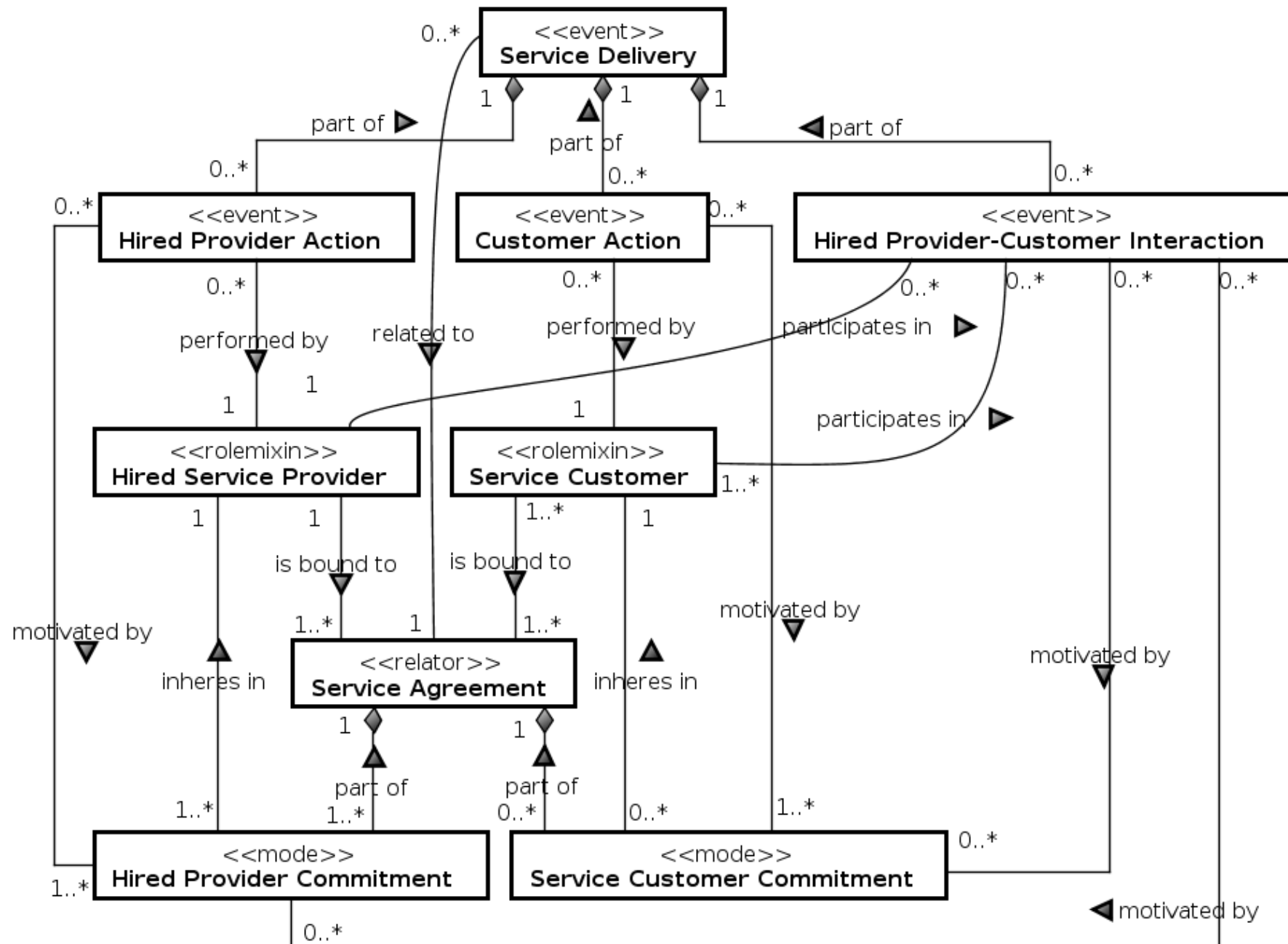
ID	Description
SO01	Service offering commitments and claims, which are counterparts, are part of the same service offering.
	$\forall co, cl ((\text{ServiceOfferingCommitment}(co) \wedge \text{ServiceOfferingClaim}(cl) \wedge \text{isCounterPartOf}(cl, co)) \rightarrow (\exists so (\text{ServiceOffering}(so) \wedge \text{partOf}(cl, so) \wedge \text{partOf}(co, so))))$
SO02	Each service offering commitment that is part of a service offering inheres in the service provider that provides the service offering, and is externally-dependent on the target customer community to which this offering is offered.
	$\forall co, so ((\text{ServiceOfferingCommitment}(co) \wedge \text{ServiceOffering}(so) \wedge \text{partOf}(co, so)) \rightarrow (\exists sp, tcc (\text{ServiceProvider}(sp) \wedge \text{TargetCustomerCommunity}(tcc) \wedge \text{provides}(sp, so) \wedge \text{offeredTo}(so, tcc) \wedge \text{inheresIn}(co, sp) \wedge \text{externallyDependentOn}(co, tcc))))$
SO03	Each service offering claim that is part of a service offering inheres in the target customer community to which the service offering is offered, and is externally-dependent on the service provider that provides the service offering.
	$\forall cl, so ((\text{ServiceOfferingClaim}(cl) \wedge \text{ServiceOffering}(so) \wedge \text{partOf}(cl, so)) \rightarrow (\exists tcc, sp (\text{TargetCustomerCommunity}(tcc) \wedge \text{ServiceProvider}(sp) \wedge \text{offeredTo}(so, tcc) \wedge \text{provides}(sp, so) \wedge \text{inheresIn}(cl, tcc) \wedge \text{externallyDependentOn}(cl, sp))))$

[illegible]



ID	Description
SN01	When a service negotiation results in a service agreement, that agreement must conform to the offering to which the negotiation refers.
	$\forall sn, sa ((ServiceNegotiation(sn) \wedge ServiceAgreement(sa) \wedge resultsIn(sn, sa)) \rightarrow (\exists so (ServiceOffering(so) \wedge conformsTo(sa, so) \wedge refersTo(sn, so))))$
SN02	An agent cannot simultaneously play the roles of service provider and target customer in the same service negotiation.
	$\forall sp, tc, sn ((Agent(sp) \wedge Agent(tc) \wedge ServiceNegotiation(sn) \wedge participatesIn(sp, sn) \wedge participatesIn(tc, sn)) \rightarrow (sp \neq tc))$
SN03	The service provider that participates in a service negotiation provides the service offering to which the negotiation refers.
	$\forall sp, sn ((ServiceProvider(sp) \wedge ServiceNegotiation(sn) \wedge participatesIn(sp, sn)) \rightarrow (\exists so (ServiceOffering(so) \wedge provides(sp, so) \wedge refersTo(sn, so))))$
SN04	Every target customer that participates in a service negotiation is a member of the target customer community to which the service offering is offered.
	$\forall tc, sn ((TargetCustomer(tc) \wedge ServiceNegotiation(sn) \wedge participatesIn(tc, sn)) \rightarrow (\exists tcc, so (TargetCustomerCommunity(tcc) \wedge ServiceOffering(so) \wedge memberOf(tc, tcc) \wedge offeredTo(so, tcc))))$
SN05	The agents that are bound to a service agreement as hired service provider and service customer, have acted, respectively, as service provider and target customer in the service negotiation that resulted in this agreement.

# Service Delivery



# Services as Co-Creation of Value/Capabilities/ Competences

- In **UFO-S**, the service offer is designed and announced such that commitments of the service provider (matching the provider's exploitable capabilities) should match the goals of the members of a target community, and the counterpart claims of these commitments should satisfy this service provider's own goals.
- In pace with Vargo and Lusch, we agree that “*value is always uniquely and phenomenologically determined by the beneficiary*”. Here, value is the result of a judgement of the participants regarding to the degree that a situation brought about by actions motivated by commitments satisfy a certain goal



# Service as Behavior

- In **UFO-S**, a number of action universals are involved in the characterization of services. These include the service offer, the interactions between service provider and potential service customer (target community member) that take place during the service negotiation as well as the (potential) service delivery itself.
- In particular, in order for the service delivery as an (inter)action to occur, a set of commitments of **entities playing both roles** are necessary to motivate the performance of its sub-actions (as manifestation of the corresponding capabilities).
- In fact, action universals can be referred to in service offering and service agreement descriptions, describing how the service delivery will be executed (closed delegation).

# But what **is** a service after all?

- We believe the term to be a case of **systematic polysemy** (Dual-Aspect Nouns, Complex Types, Dot-Types)
  - The concept assume different senses depending on the context but all senses are more or less implicitly present
  - subject to *co-predication*

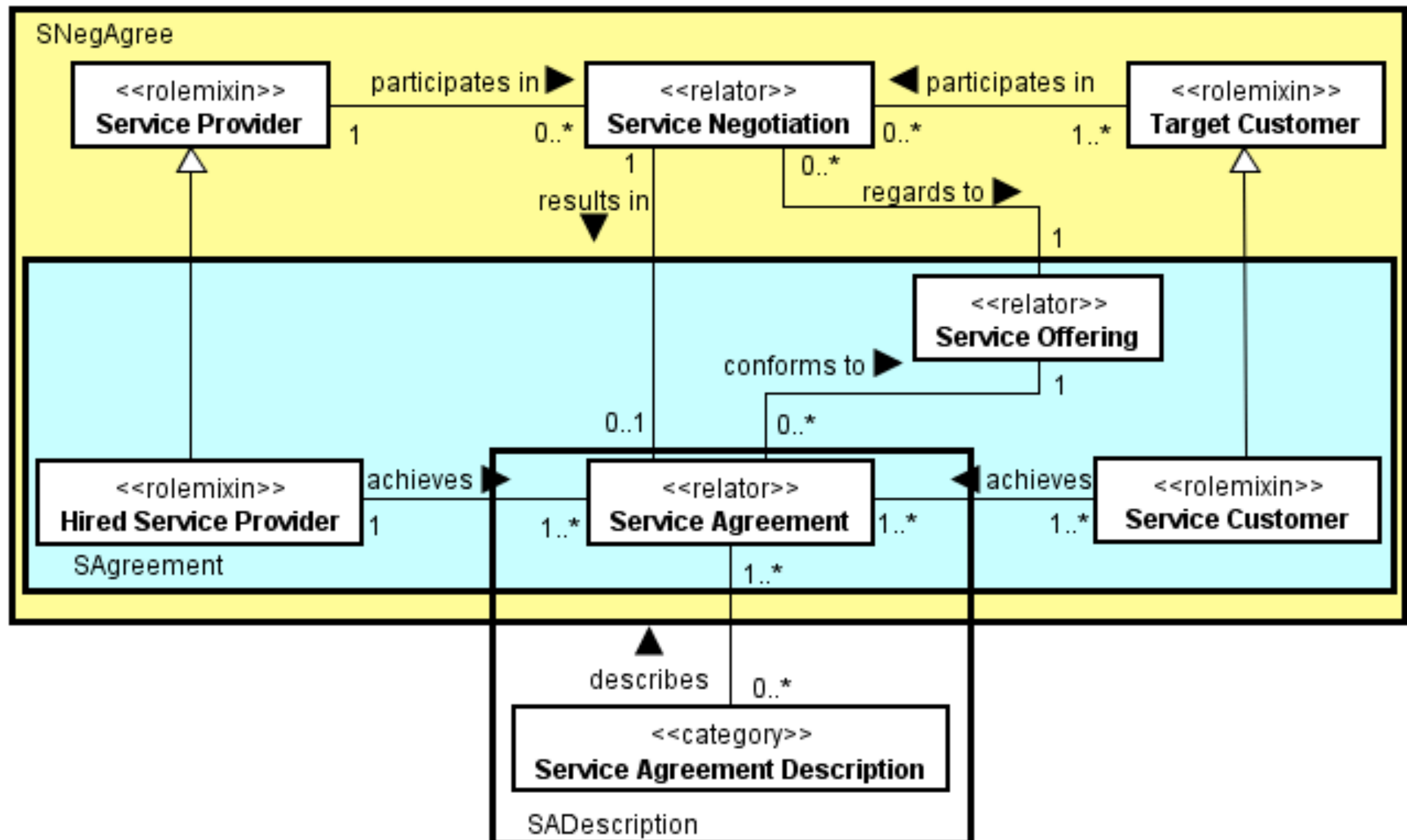
# But what **is** a Service after all?

- “The Bank is around the corner and gives good advice on sub-prime loans” (*Physical Object x Organizational Agent*)
- “The Book is heavy to carry but is easy to understand” (*Physical Object x Abstract Information Content*)
- “These ducks laying eggs in my backyard are common around Europe” (*Physical Object x Kind*)
- **“Dr.Smith’s Dental Service is fast but expensive” (*Service Delivery x Service Offering*)**

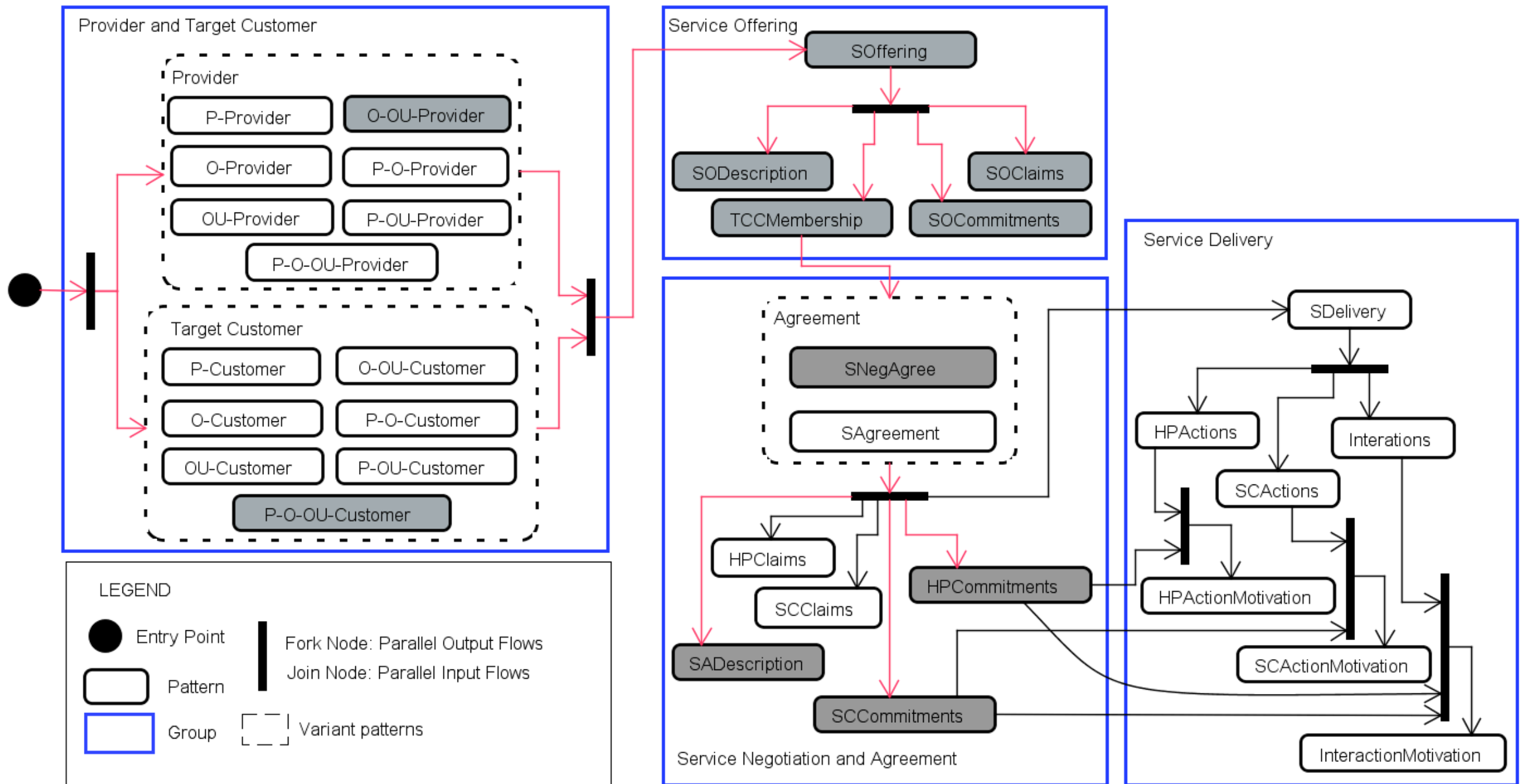
# From Core Ontologies to Ontology-Based Domain-Related Pattern Languages

- We have developed an approach for deriving Ontology-Based Domain-Related Pattern Languages (OPLs) from Core Ontologies
- These languages can then be used in the construction of domain models in the specific domain at hand

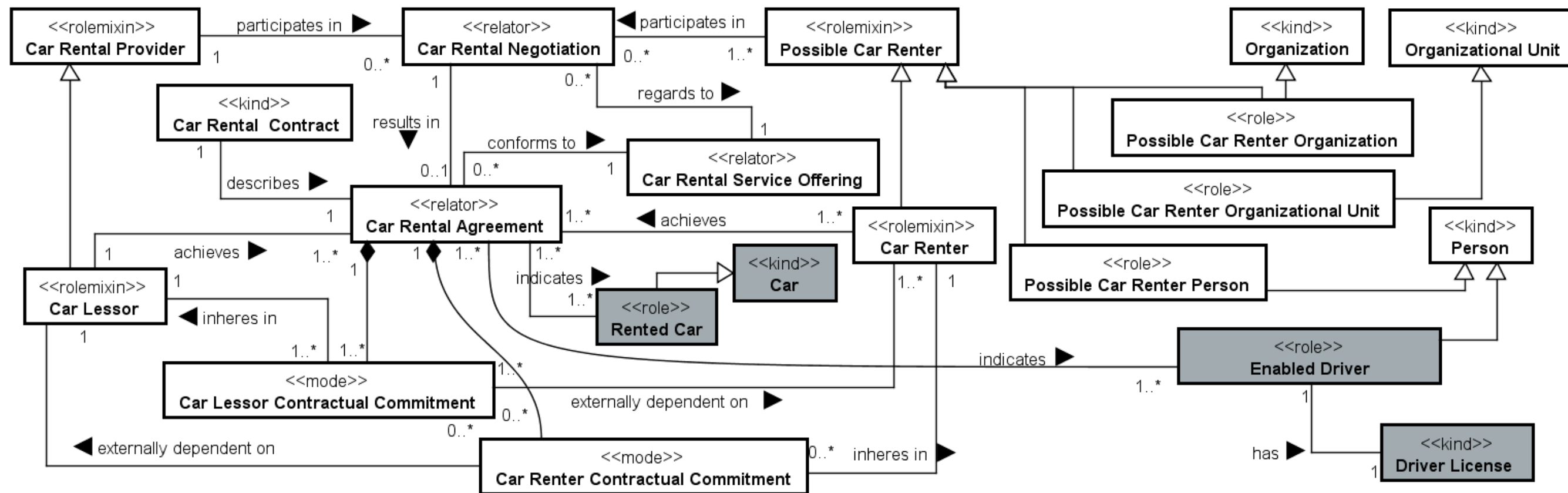
# OPL Patterns (subset)



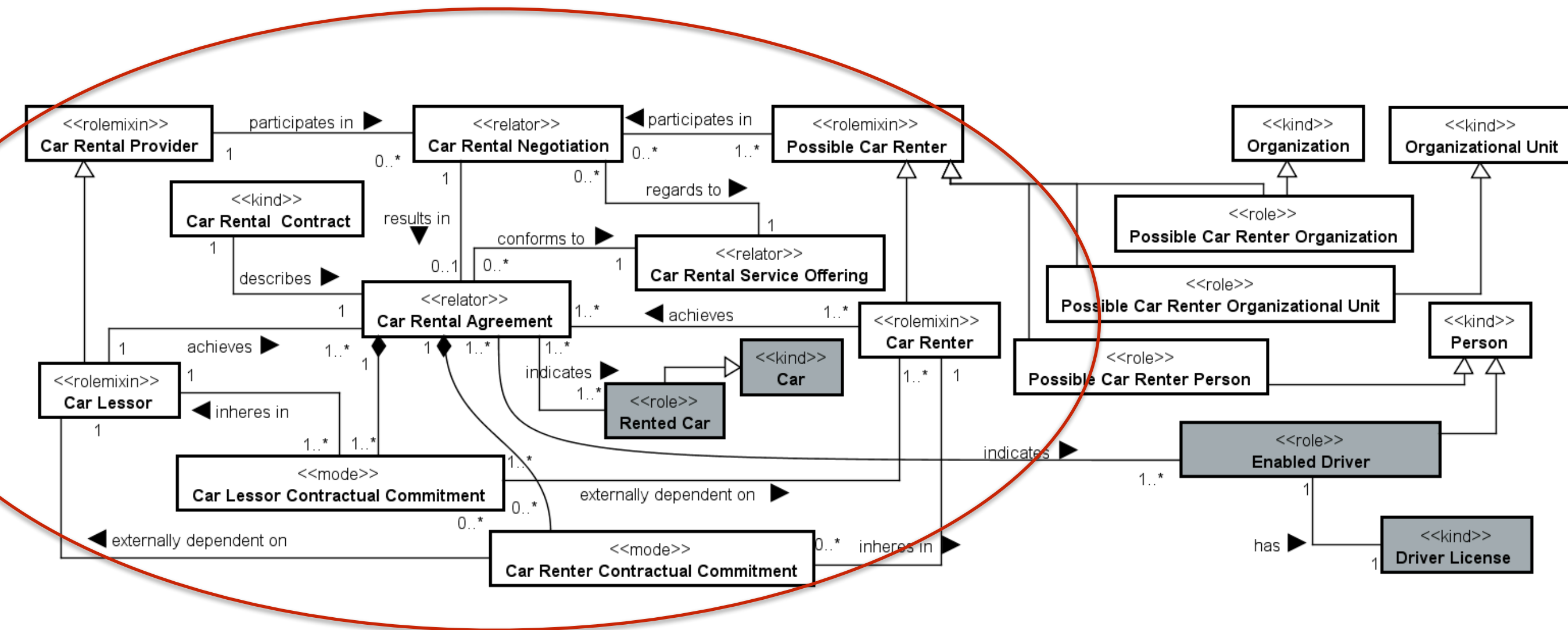
# A Service OPL



# Car Rental Negotiation Model (partial model)



# Car Rental Negotiation Model (partial model)





# Ontological interpretation and analysis of Modeling Languages and Reference Standards

- We have recently provided an in depth evaluation of the **Archimate** standard regarding its notion of service. This analysis is followed by a number of modeling patterns addressing several limitations of Archimate's modeling approach to services
- An initial analysis have shown the same potential for analyzing and addressing limitations in other approaches such as the Open Group Service-Oriented Architecture Ontology, Reference Ontology for Semantic Service Oriented Architectures developed by OASIS, the Healthcare SOA Ontology, etc.

# Many Possibilities...

- Extensions to these ontological foundations
  - Ontology of Value
  - Deontic notions to describe the content of commitments
  - QoS from an ontological perspective (including the notion of vagueness)
  - Software as a Service (in the Ontological Sense)

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