# A **Meaningful** Road to **Explanation**

CAiSE 2023
Zaragoza, Spain

Giancarlo Guizzardi
**Semantics**,
Cybersecurity
& Services

UNIVERSITEIT
TWENTE.

# meaning 1 of 2 noun

mean·ing ˈmē-niŋ

Synonyms of *meaning* ›

**1** **a** : the thing one intends to convey especially by language

> Do not mistake my *meaning*.

**b** : the thing that is conveyed especially by language

> Many words have more than one *meaning*.

**2** : significant quality

*especially* : implication of a hidden or special significance

> a glance full of *meaning*

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Semantics

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Goal-Based

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# Conceptual Modelling I

# Enterprise Modelling II

## Goal-Driven Analysis of Process Model Validity

PDF

Pnina Soffer, Yair Wand
Pages 521-535

## Data Warehouse Methodology: A Process Driven Approach

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Claus Kaldeich, Jorge Oliveira e Sá
Pages 536-549

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John Krogstie, Håvard D. Jørgensen
Pages 550-563


# **Semantics,** $\binom{o}{o}$**ntology** and **Explanation**

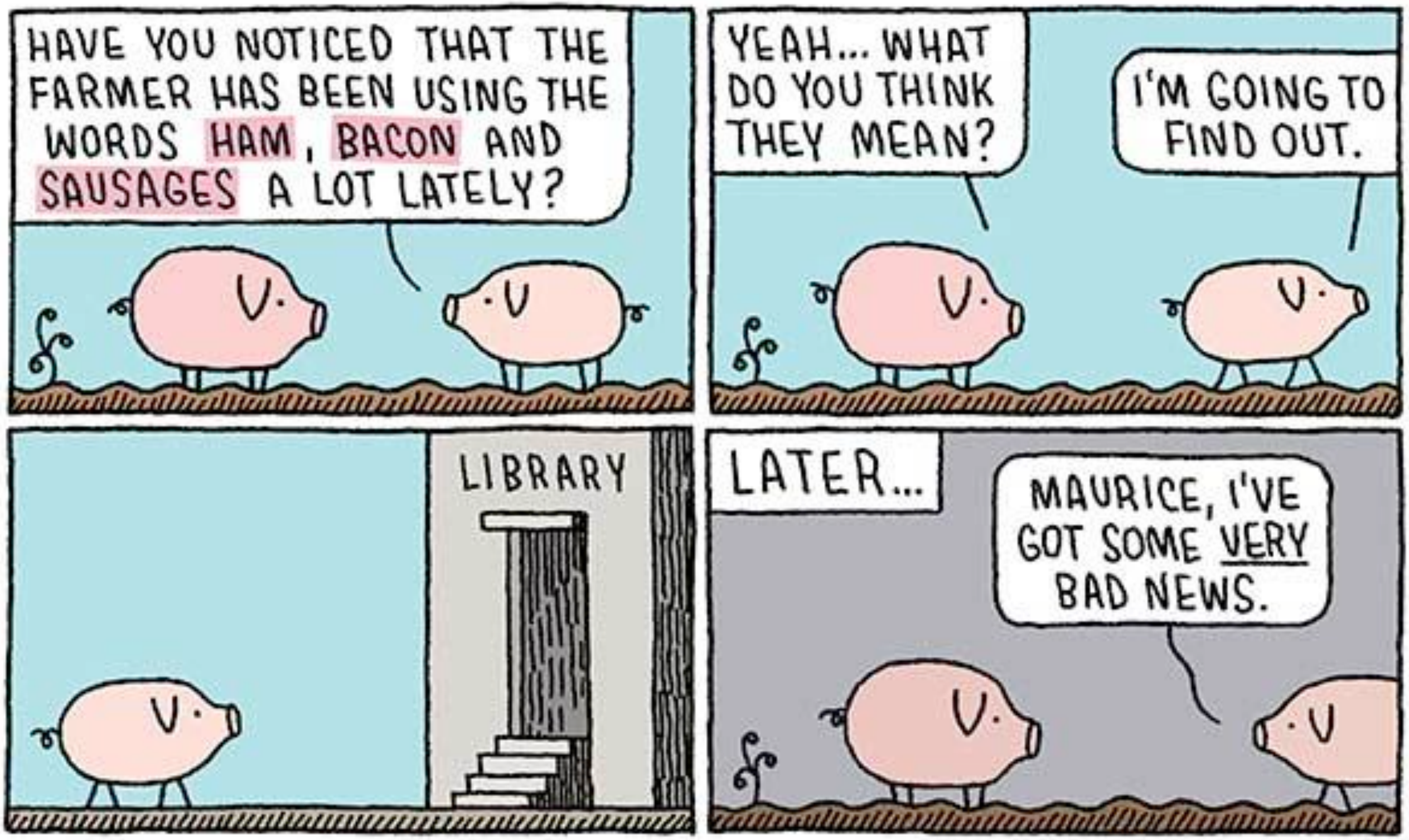
Computer Science > Artificial Intelligence

[Submitted on 21 Apr 2023]

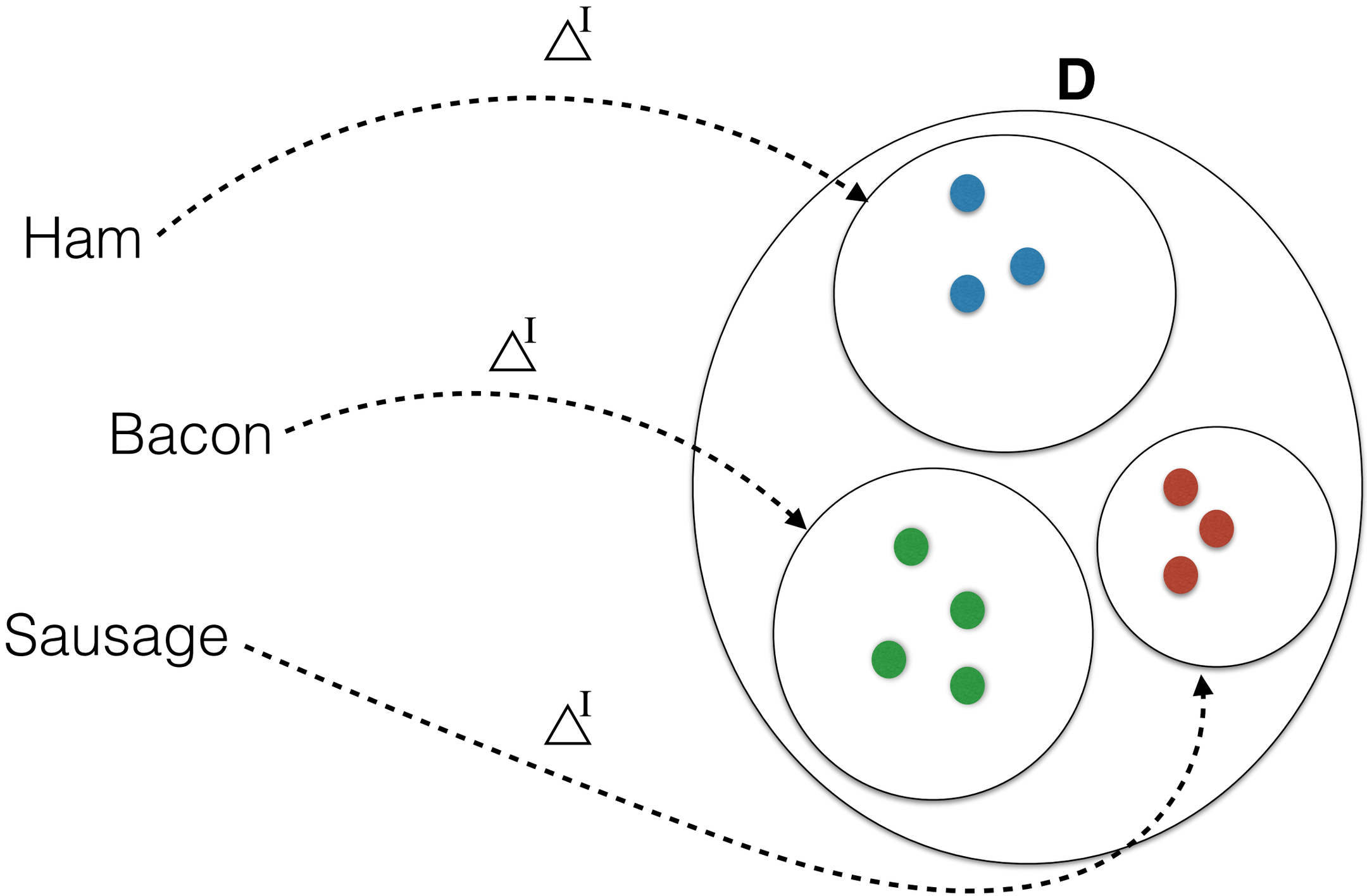
# Semantics, Ontology and Explanation

Giancarlo Guizzardi, Nicola Guarino

The terms 'semantics' and 'ontology' are increasingly appearing together with 'explanation', not only in the scientific literature, but also in o
However, all of these terms are also being significantly overloaded. In this paper, we discuss their strong relation under particular interpreta
a notion of explanation termed ontological unpacking, which aims at explaining symbolic domain descriptions (conceptual models, knowled
specifications) by revealing their ontological commitment in terms of their assumed truthmakers, i.e., the entities in one's ontology that ma
descriptions true. To illustrate this idea, we employ an ontological theory of relations to explain (by revealing the hidden semantics of) a ve
encoded in the standard modeling language UML. We also discuss the essential role played by ontology-driven conceptual models (resulting
processes) in properly supporting semantic interoperability tasks. Finally, we discuss the relation between ontological unpacking and other
philosophy and science, as well as in the area of Artificial Intelligence.


HAVE YOU NOTICED THAT THE FARMER HAS BEEN USING THE WORDS HAM, BACON AND SAUSAGES A LOT LATELY?
YEAH... WHAT DO YOU THINK THEY MEAN?
I'M GOING TO FIND OUT.
LIBRARY
LATER...
MAURICE, I'VE GOT SOME VERY BAD NEWS.

by Tom Gauld


Ham
Bacon
Sausage
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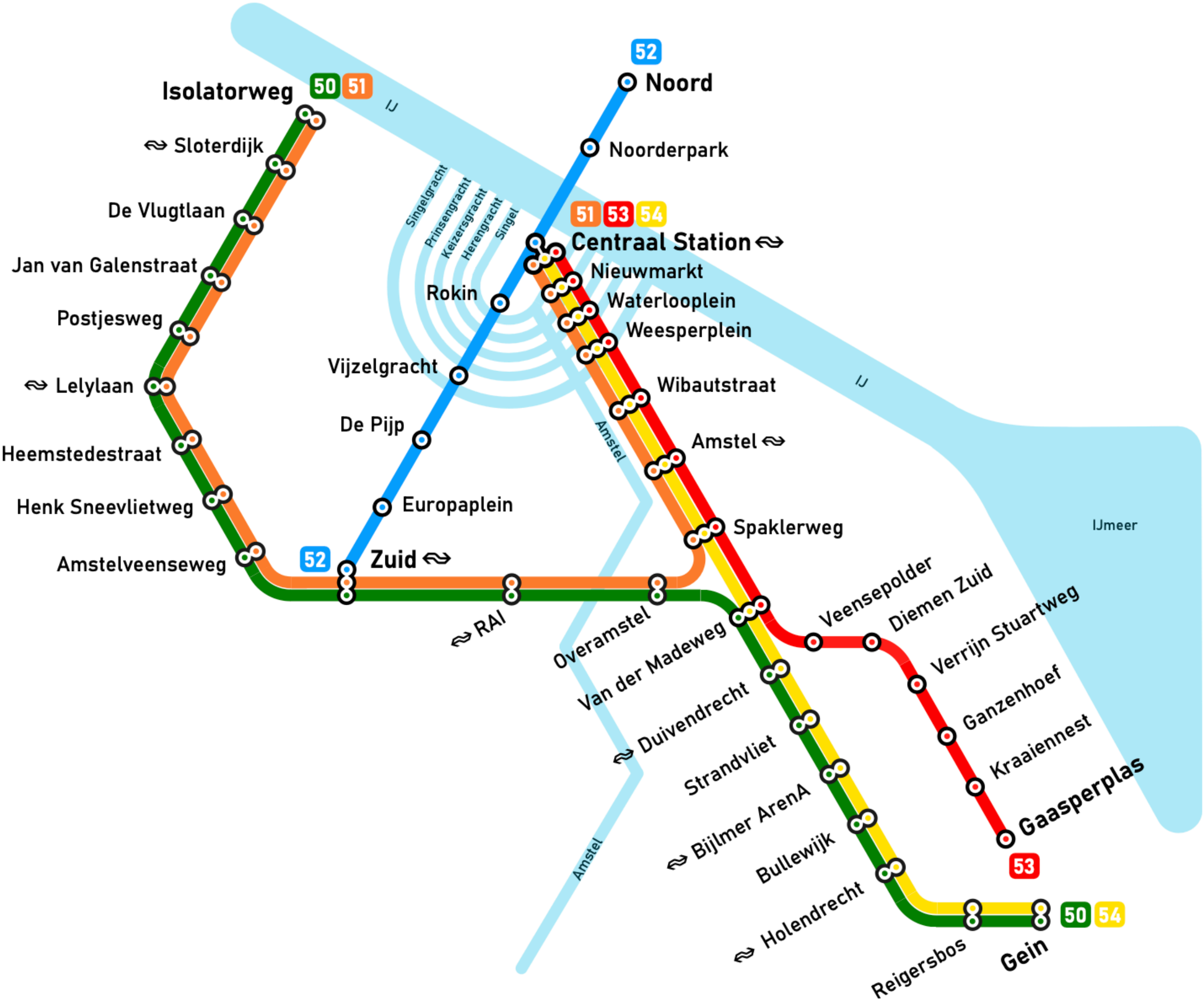
**Formal** Semantics

X

**Real-World**

(or **Ontological**)

Semantics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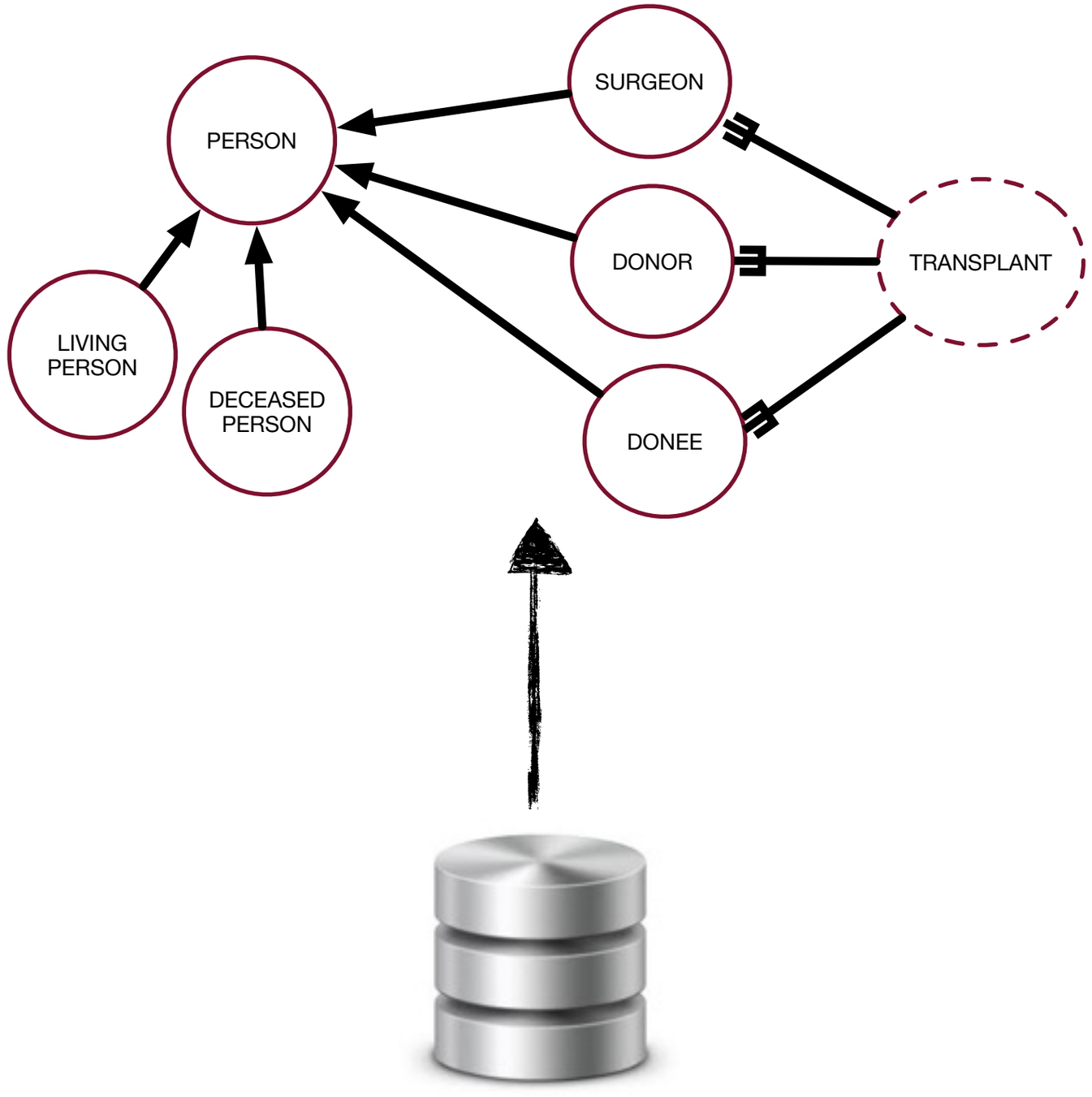
PERSON
SURGEON
DONOR
TRANSPLANT
LIVING PERSON
DECEASED PERSON
DONEE

# Another look at data

*by* GEORGE H. MEALY
*Computer Consultant*
Scituate, Massachusetts

## INTRODUCTION

particular ontology, we can avoid a quarrel by adopt-

*"data are fragments of a **theory of the real world**, and data processing juggles **representations** of these fragments of theory..."*

them in a somewhat new form may prove to be at least suggestive.

To begin on a philosophical plane, let us note that we usually behave as if there were three realms of interest in data processing: the real world itself, ideas about it existing in the minds of men, and symbols on paper or some other storage medium. The lat-

*Toward a theory of data*

### Relations

To fix our ideas, consider the following example of genealogical data, taken from Reference 2:

# Another look at data

*by* GEORGE H. MEALY
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## INTRODUCTION

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*"data are fragments of a theory of the real world, and data processing juggles representations of these fragments of theory...**The issue is ontology, or the question of what exists.**"*

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### Relations

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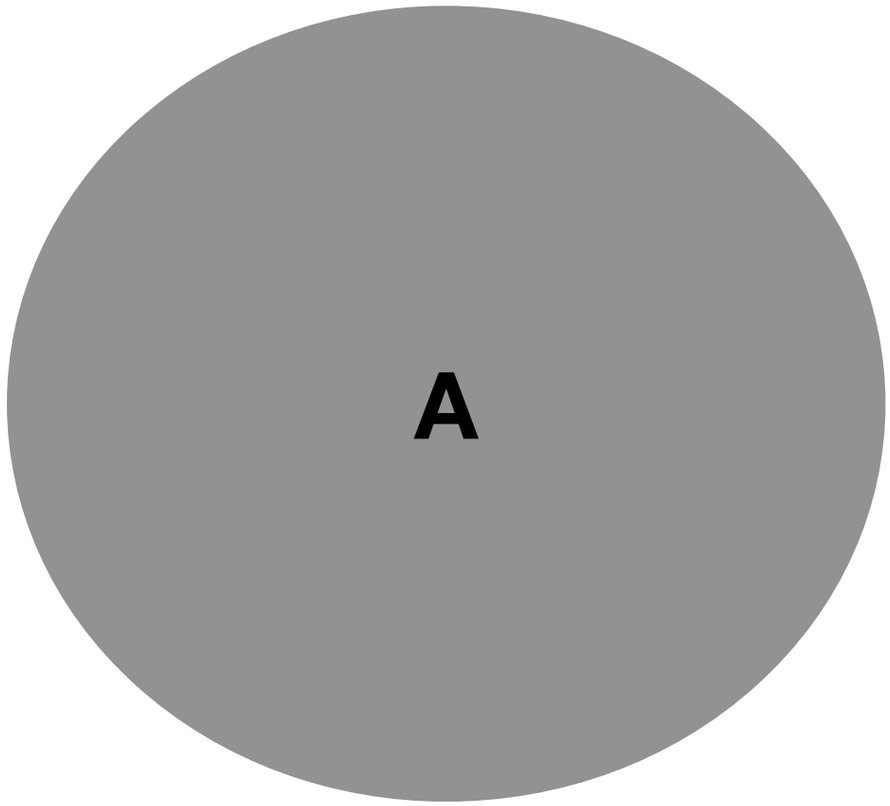
# ontology ≈

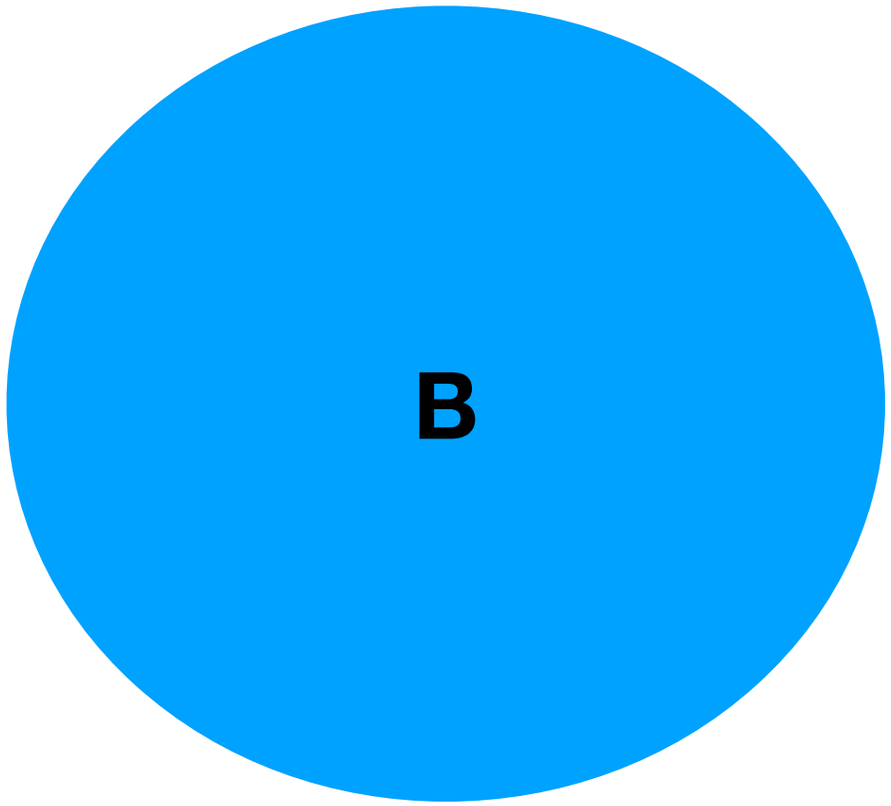
A theory about the kinds of entities and their ties that are assumed to exist by a given description of reality

**ontology ≈**

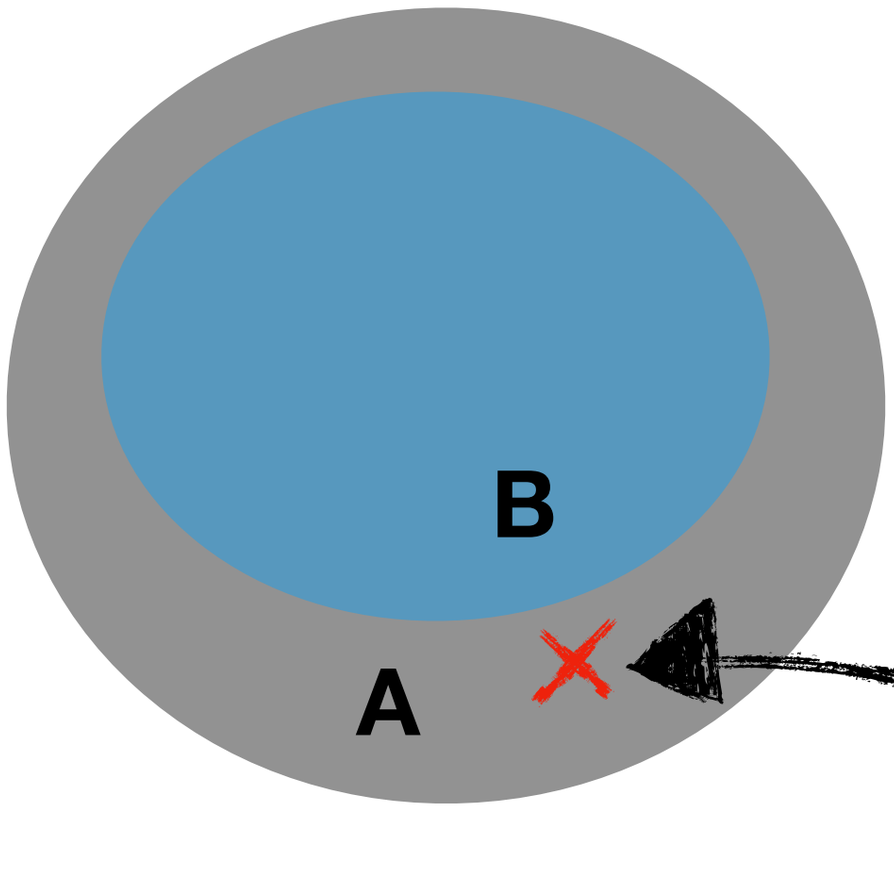
~~A theory about the kinds of entities and their ties that are assumed to exist by~~ a given description of reality



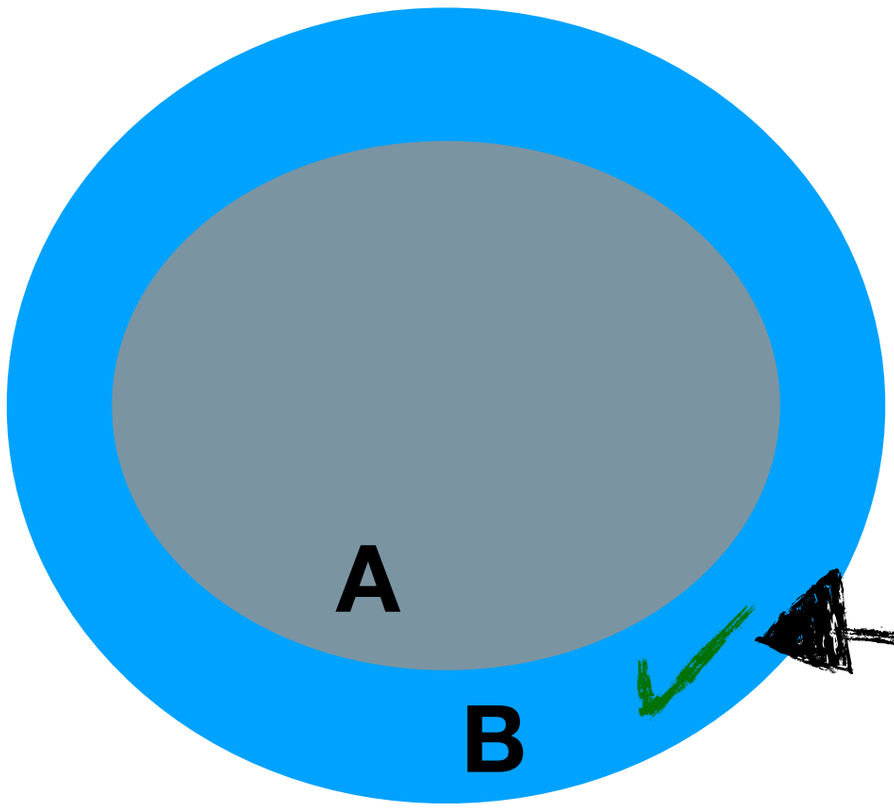

**Possible Interpretations of a Model**



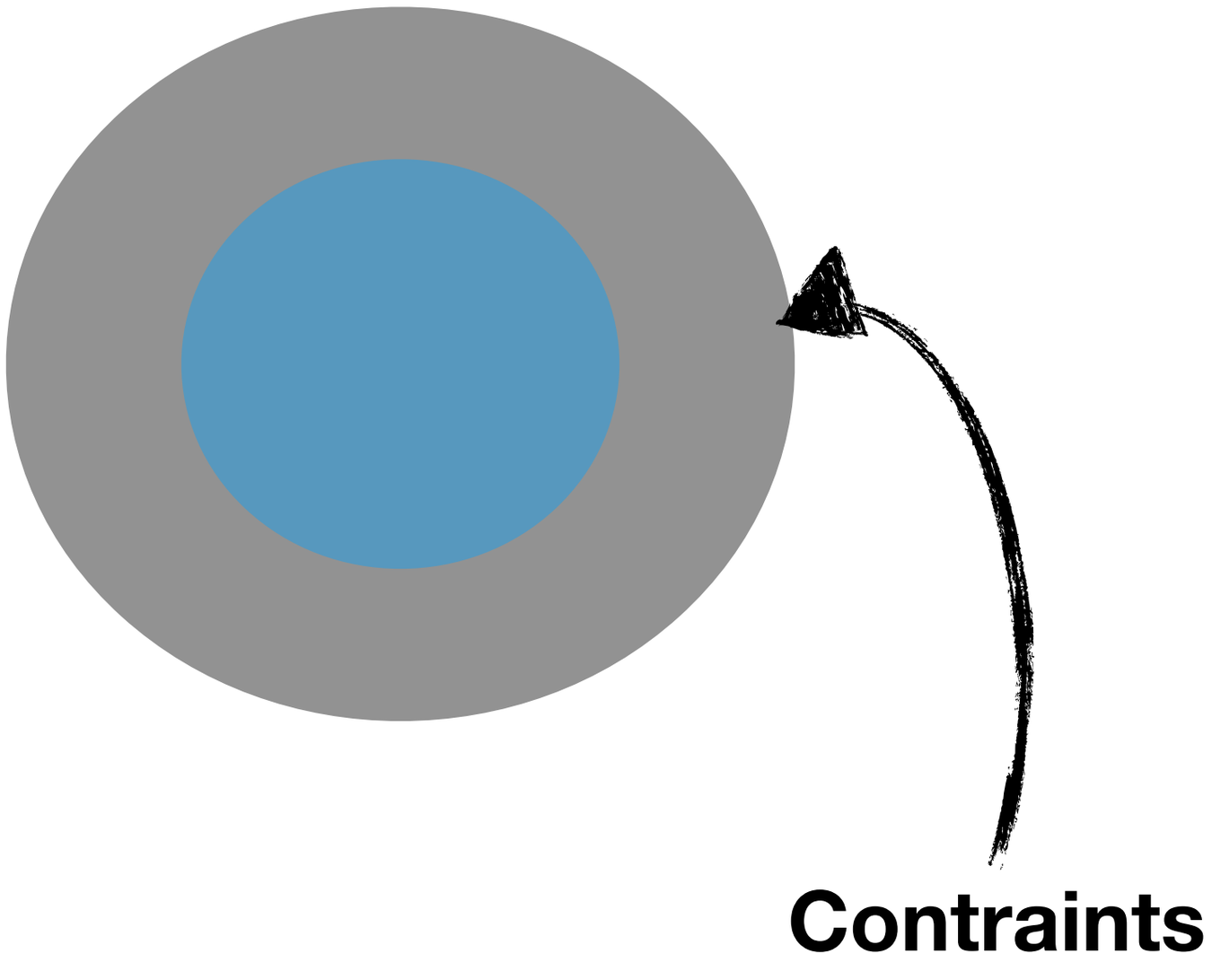

**Intended Interpretations of that Model**



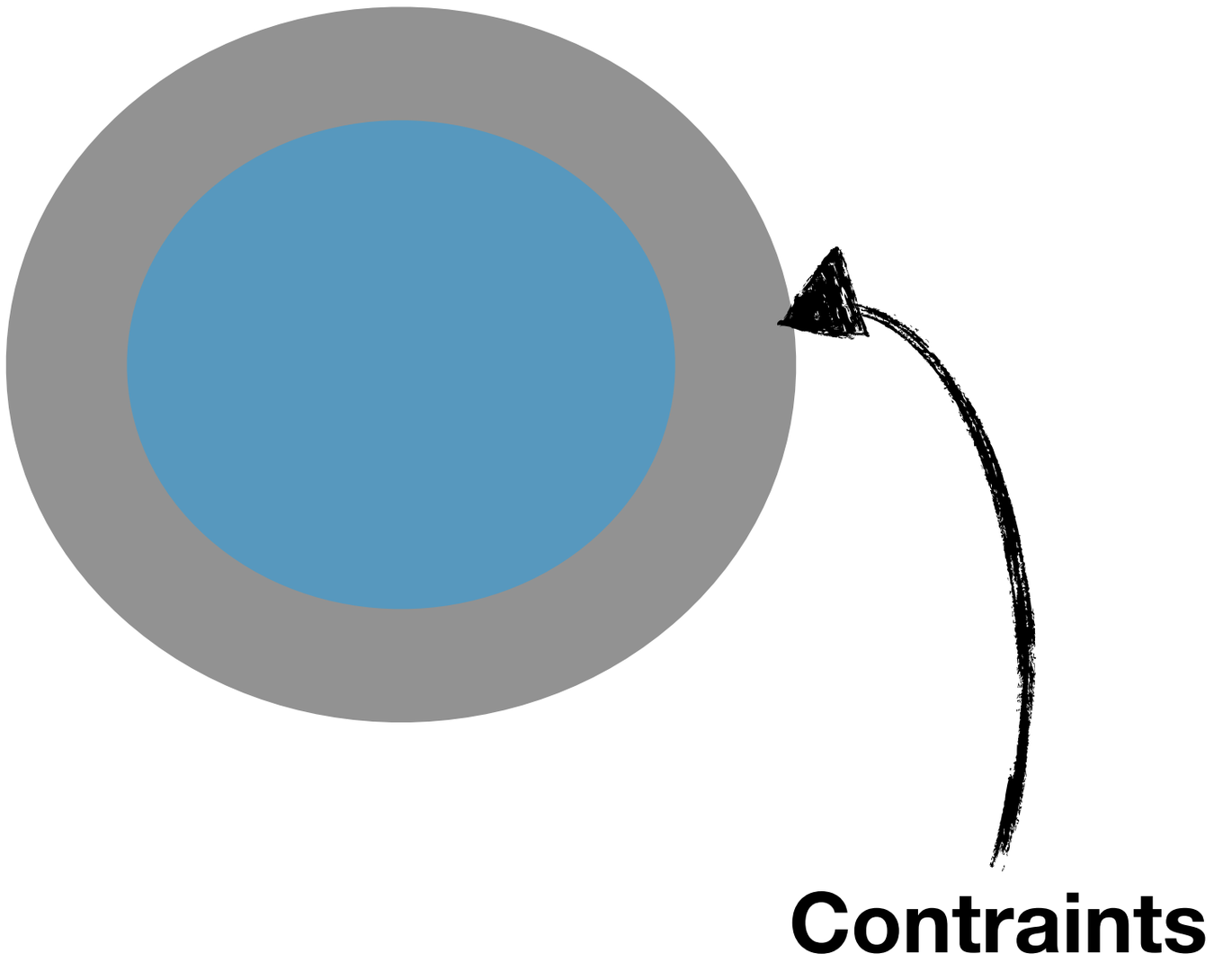

**Under-constrained Model**




**Over-constrained Model**



Contraints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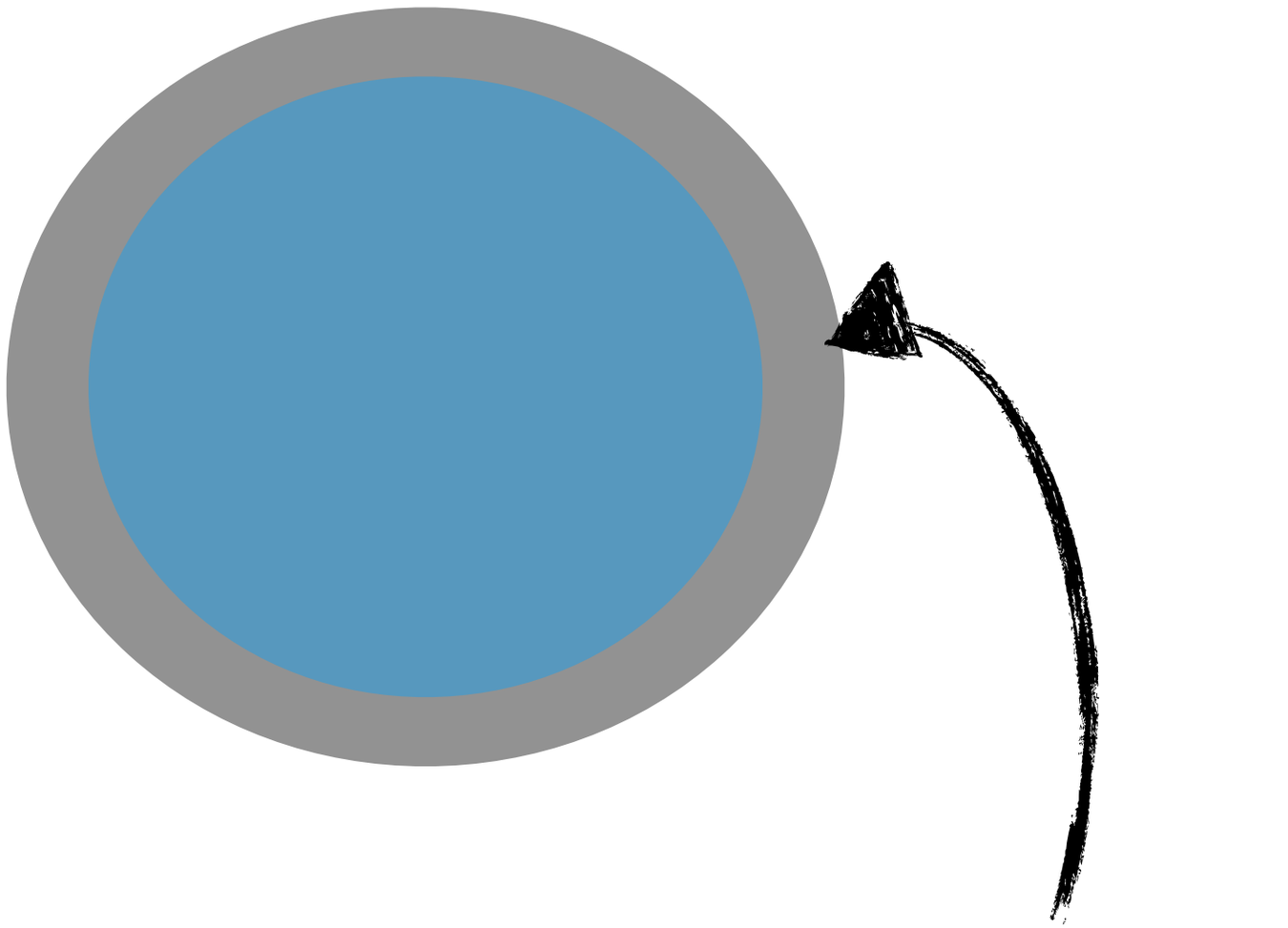

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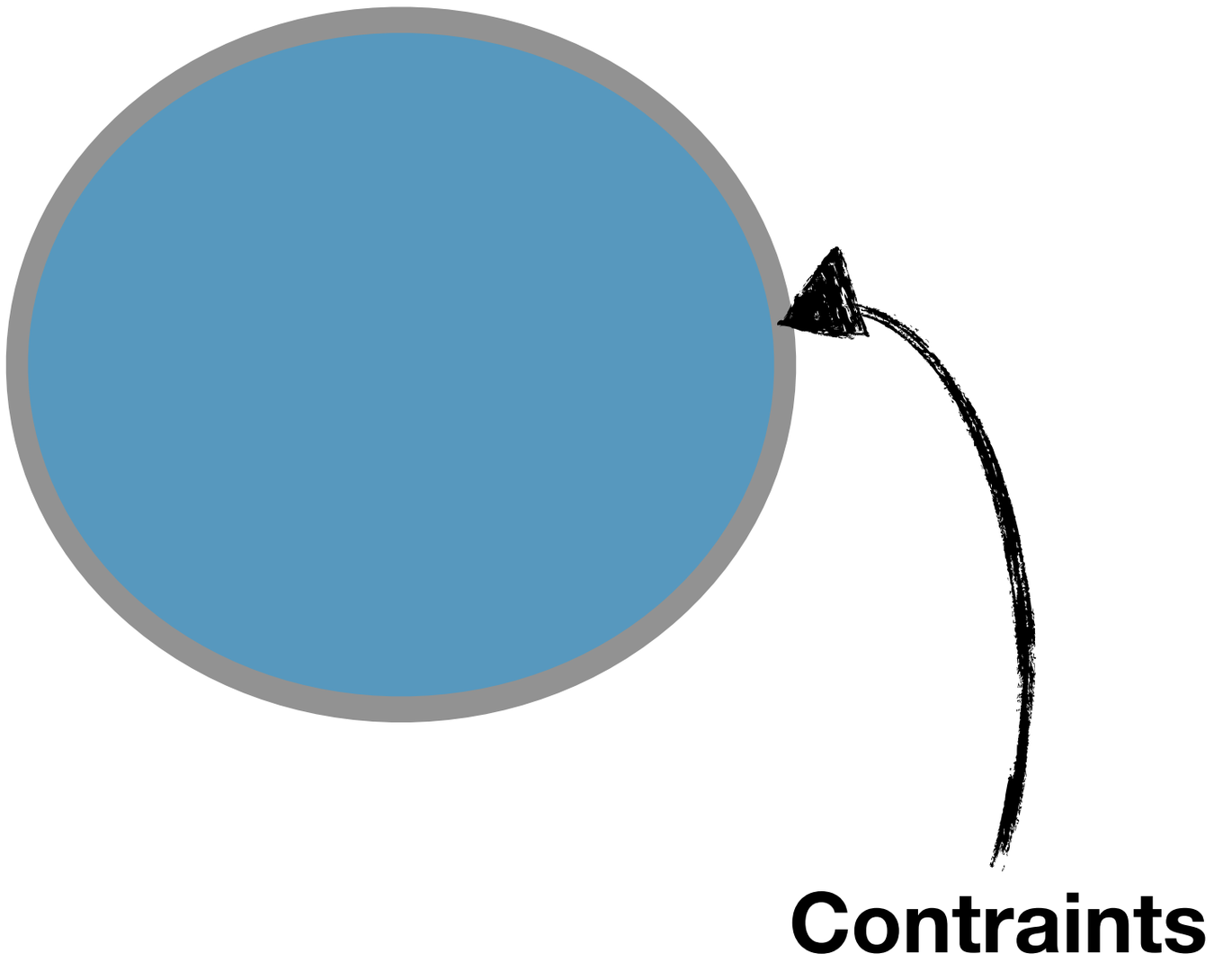

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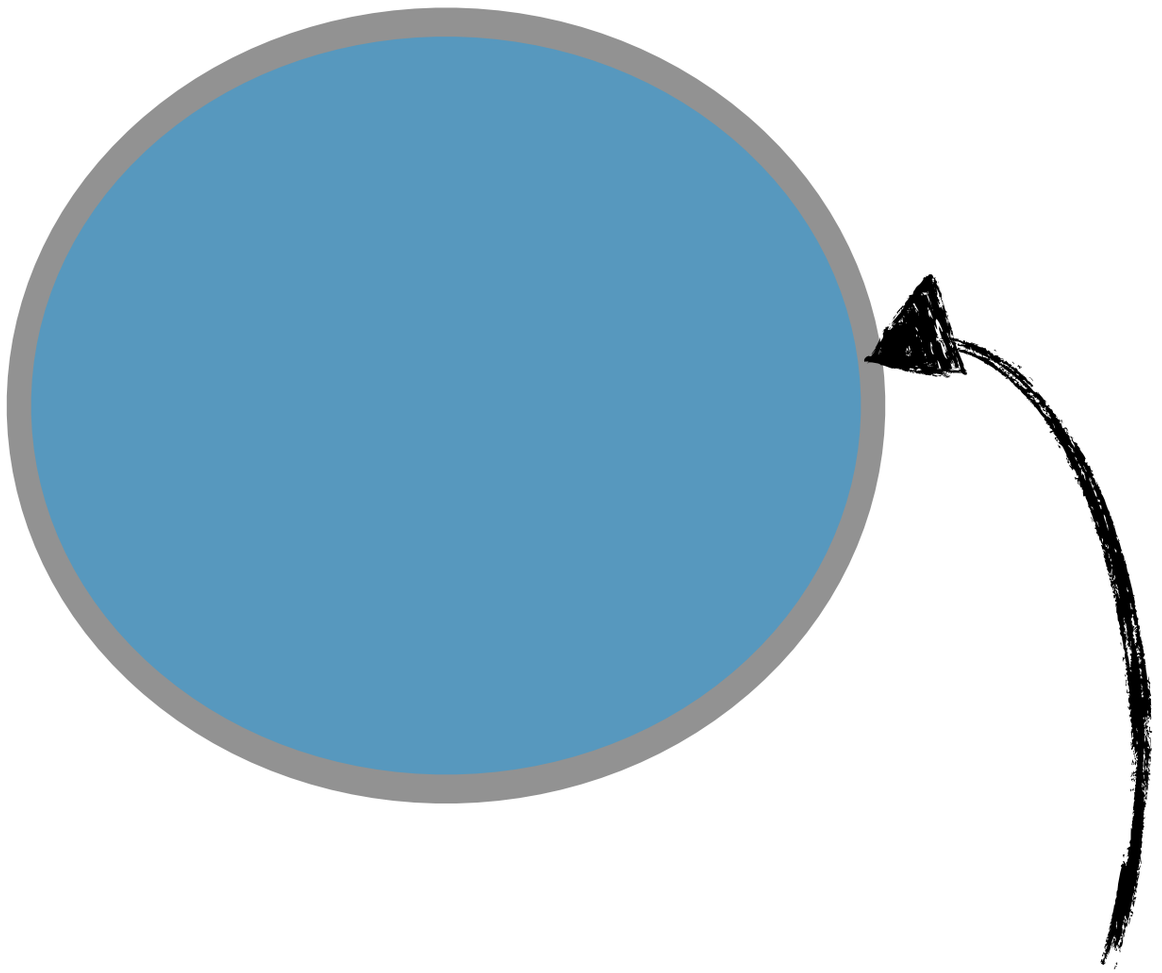
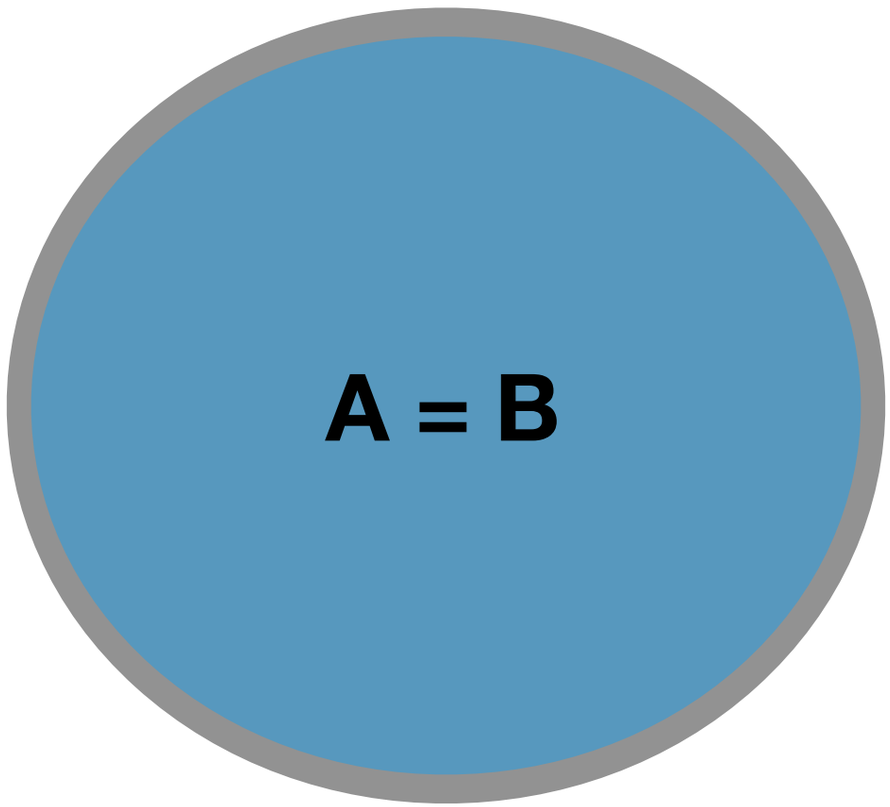


**Ontological Commitment**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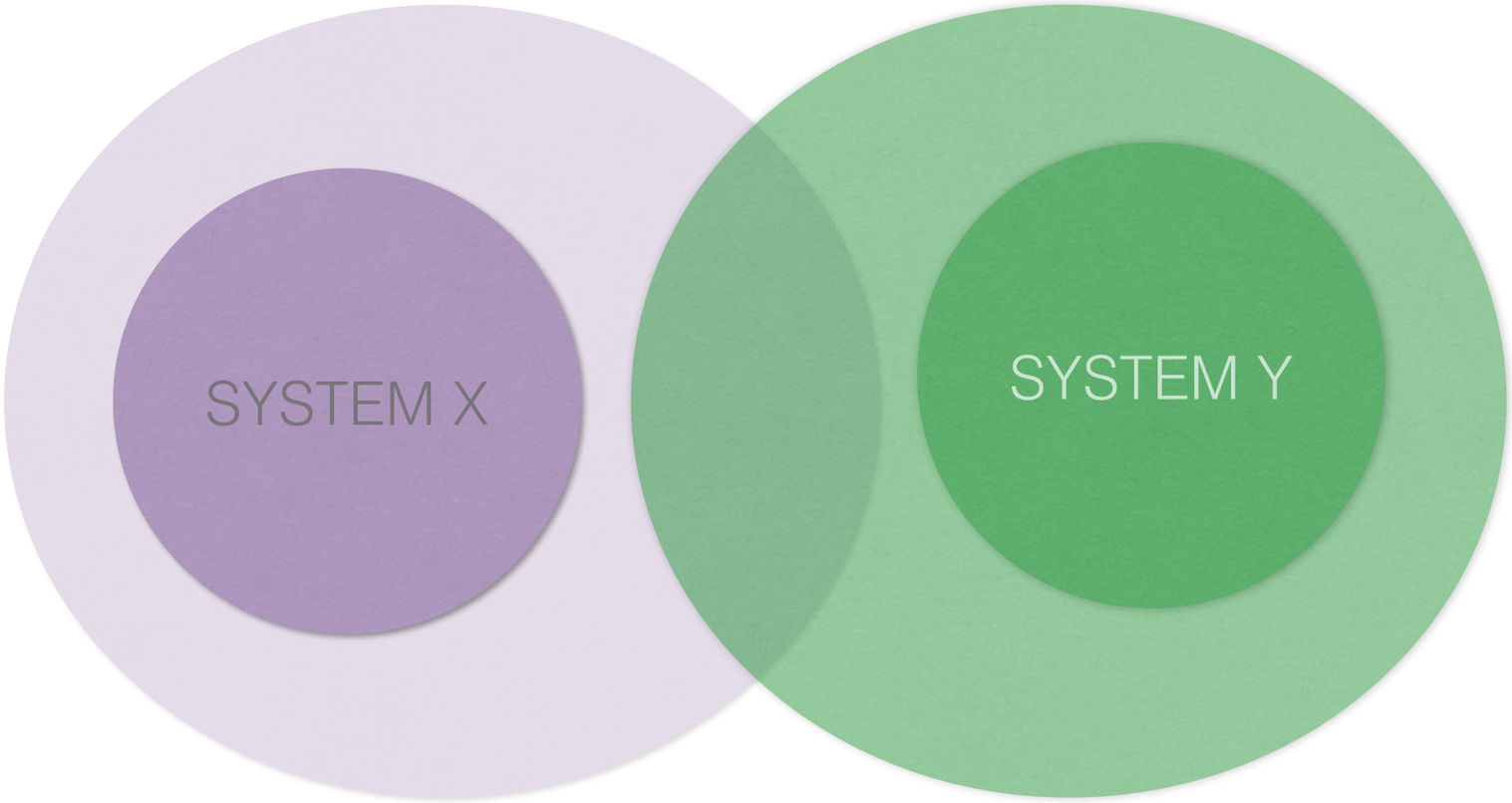
SYSTEM X
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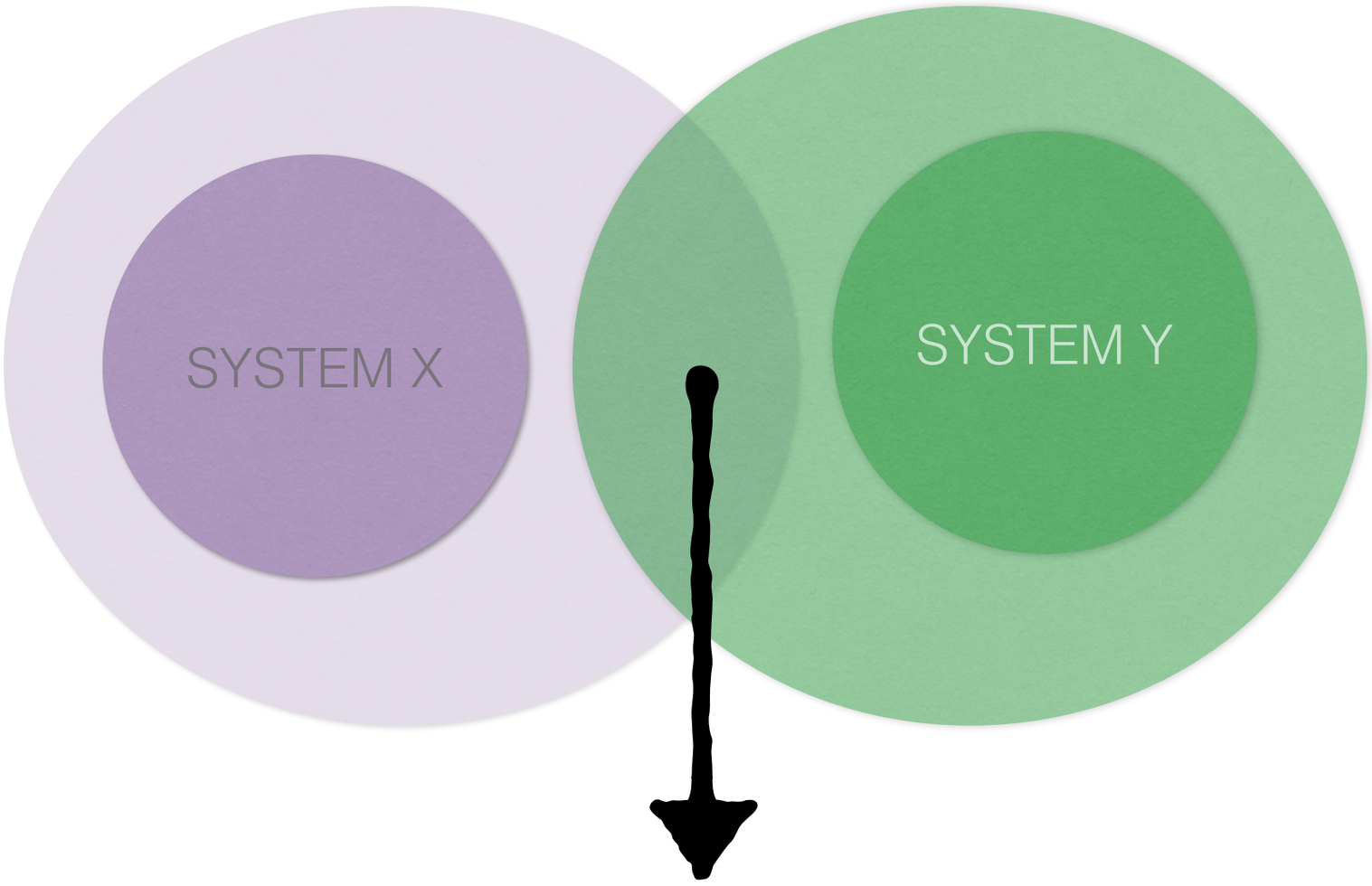
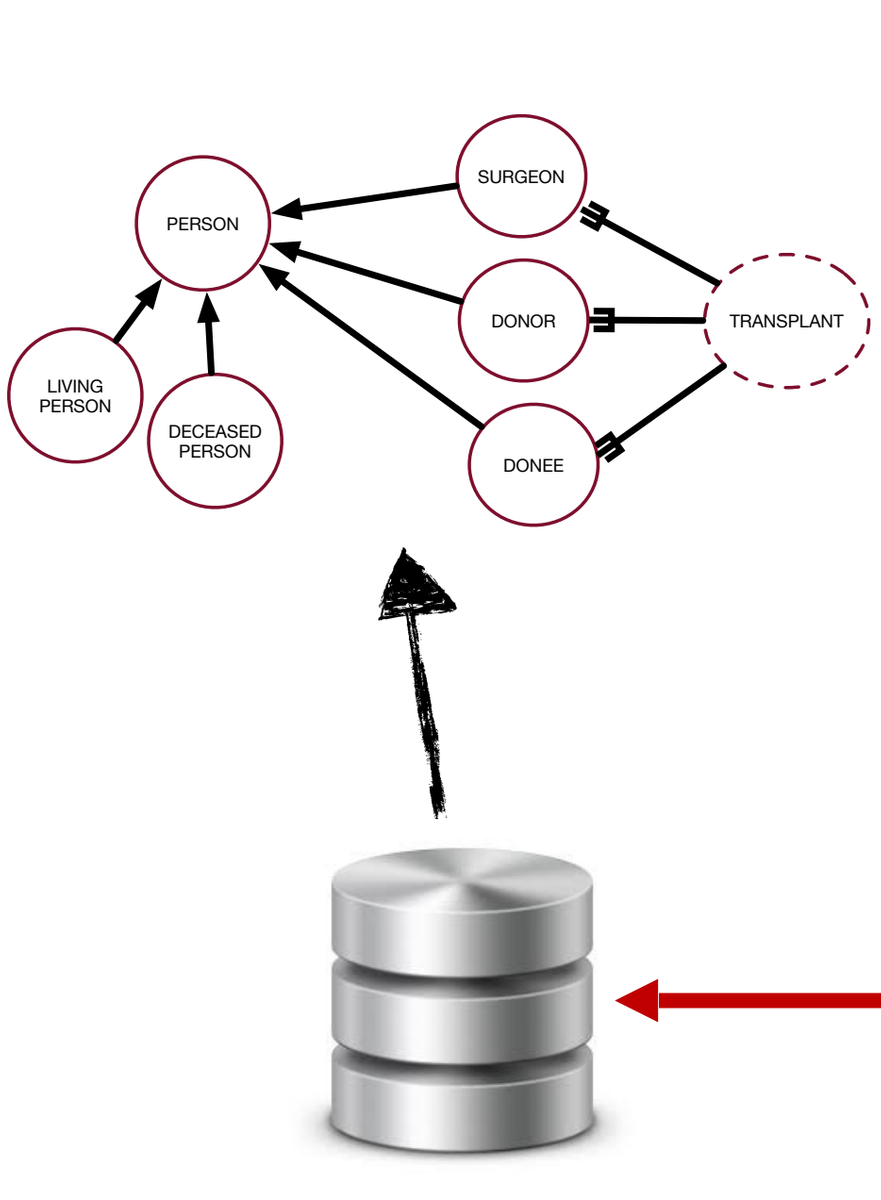



**FALSE AGREEMENT**

# Semantic Interoperability

=

relating different
**worldviews**, i.e., different
**ontologies**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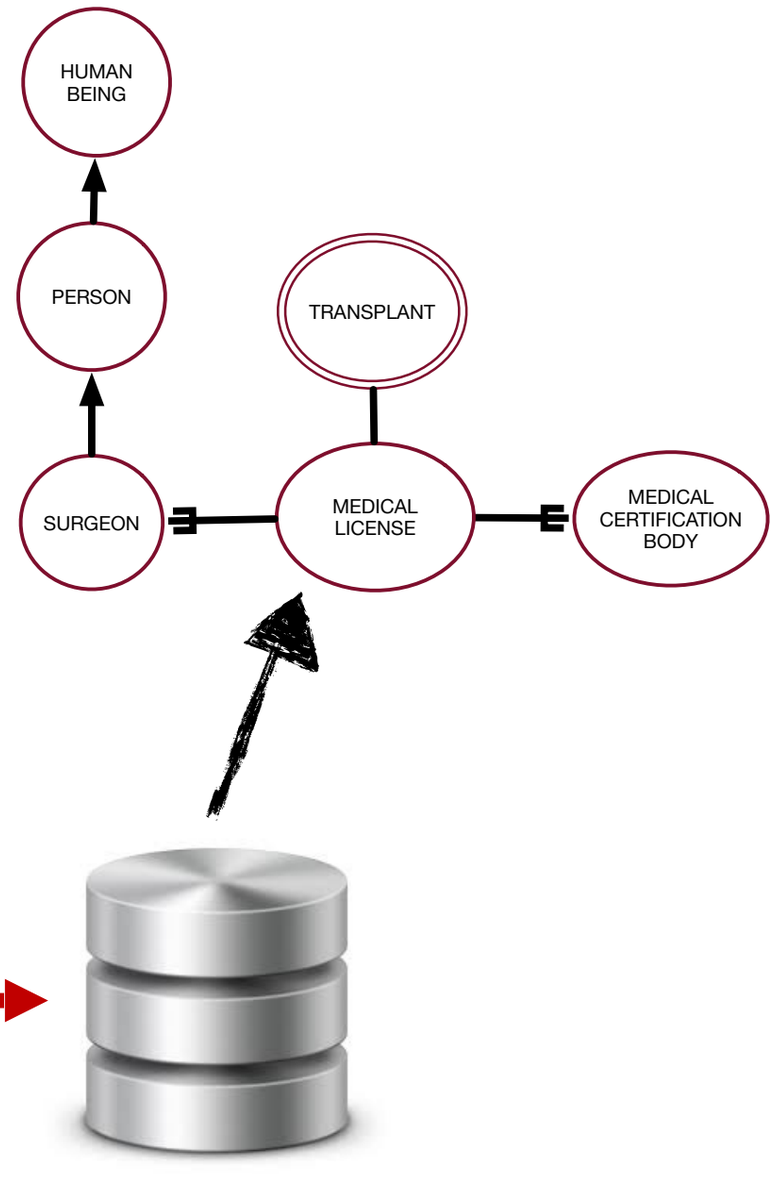
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MEDICAL LICENSE
MEDICAL CERTIFICATION BODY

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DONOR

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TRANSPLANT

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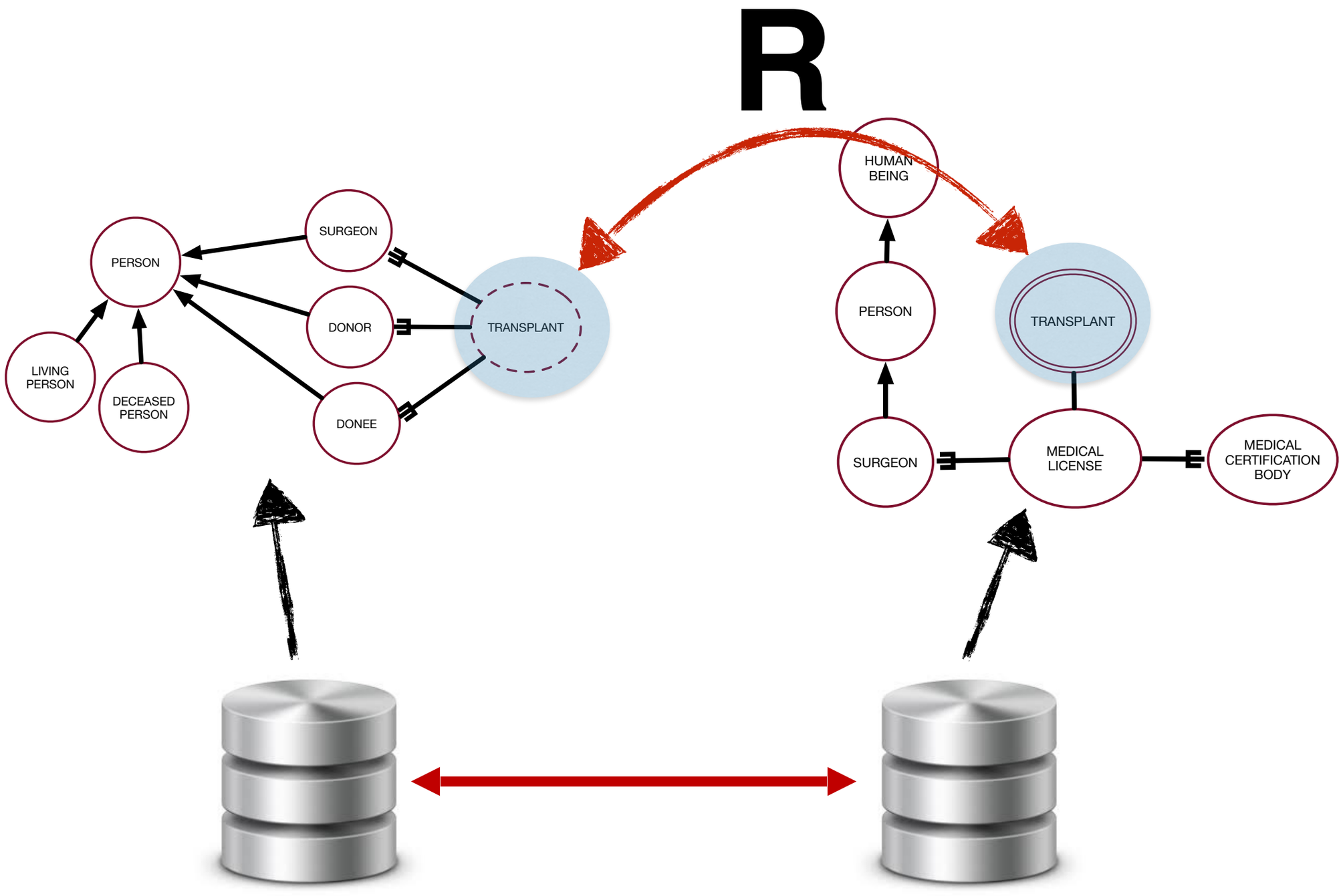
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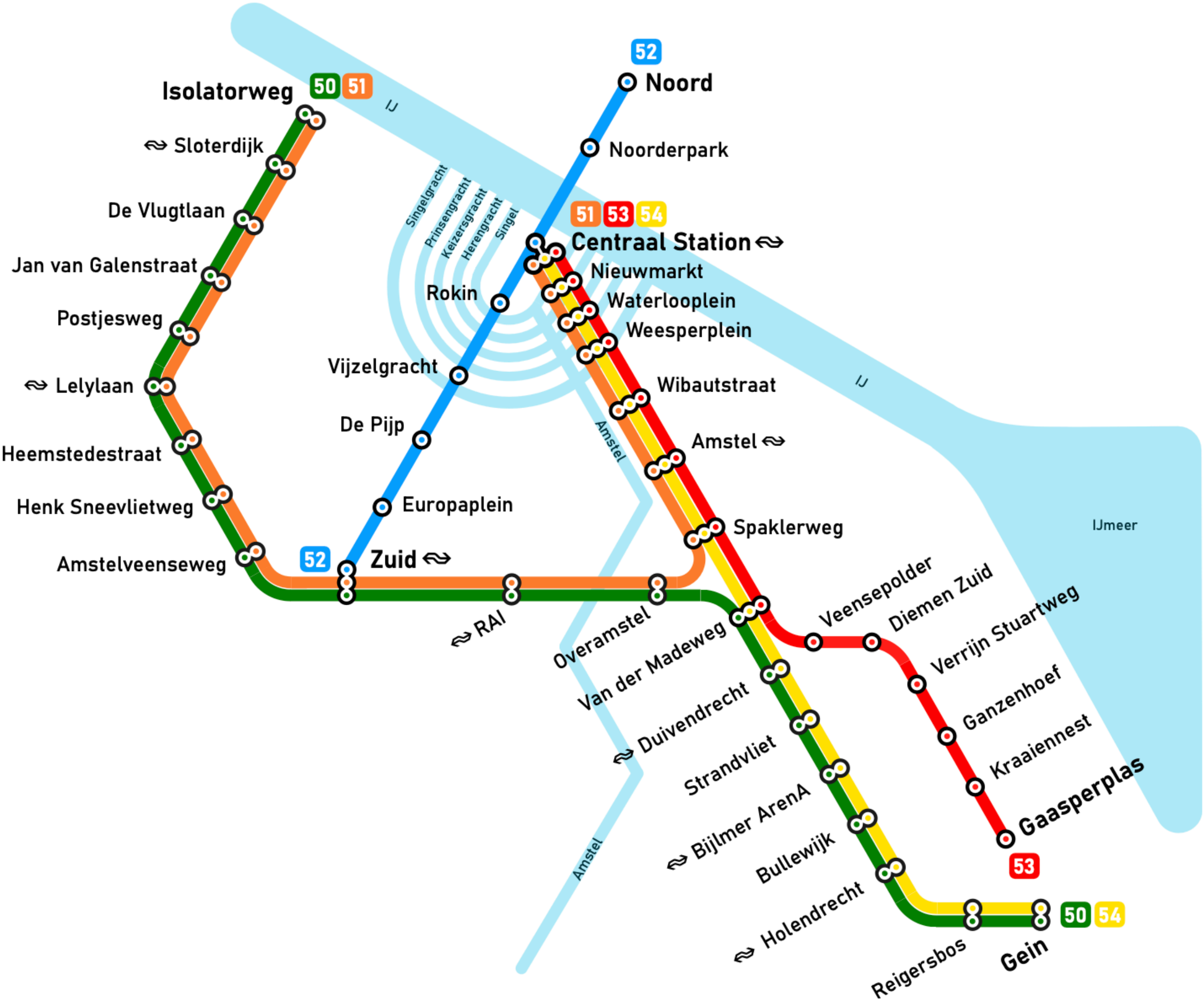
# Ontology ≈

An area devoted to developing these domain-independent “toolboxes” with “tools”for supporting ontological analysis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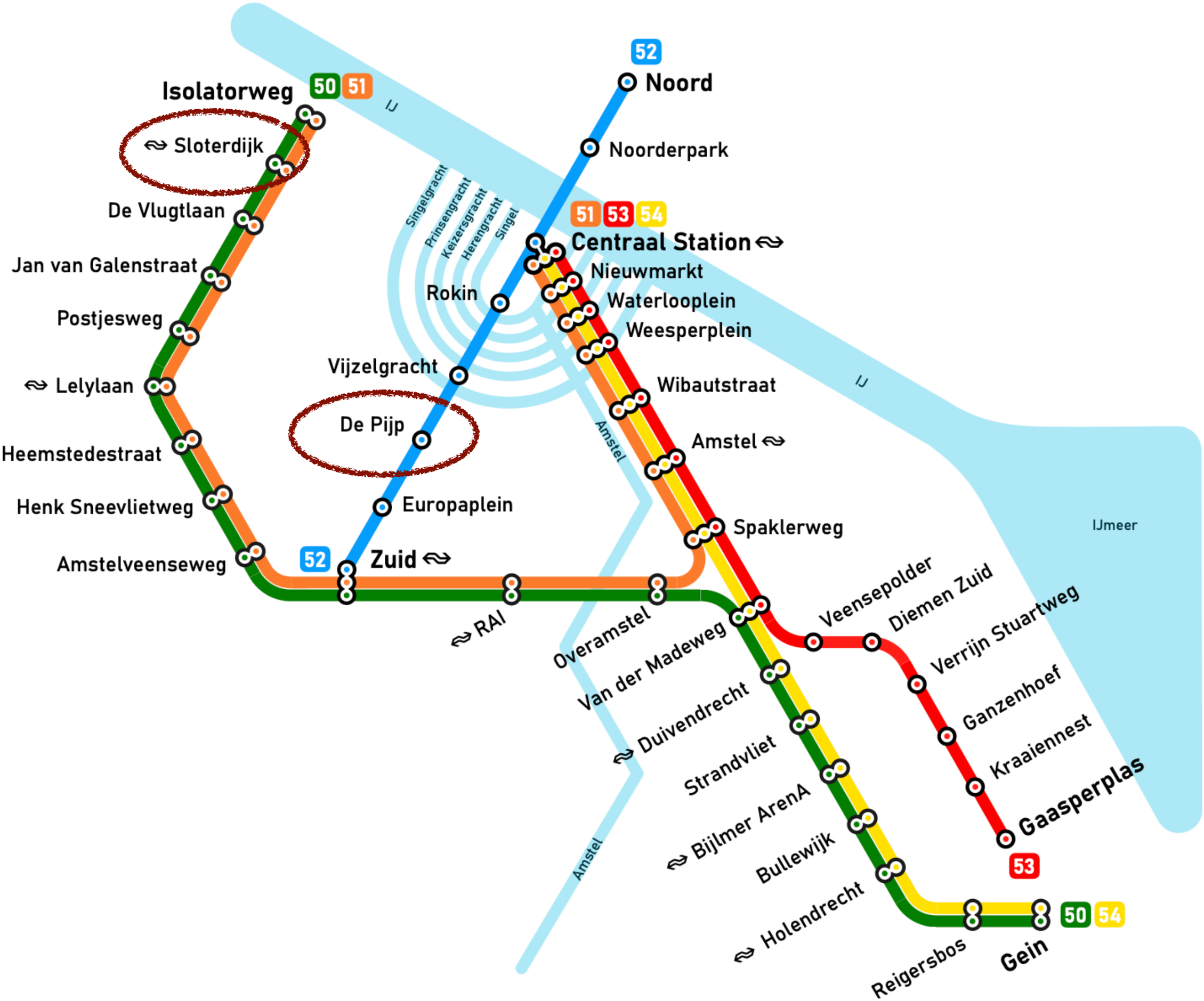
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Reigersbos
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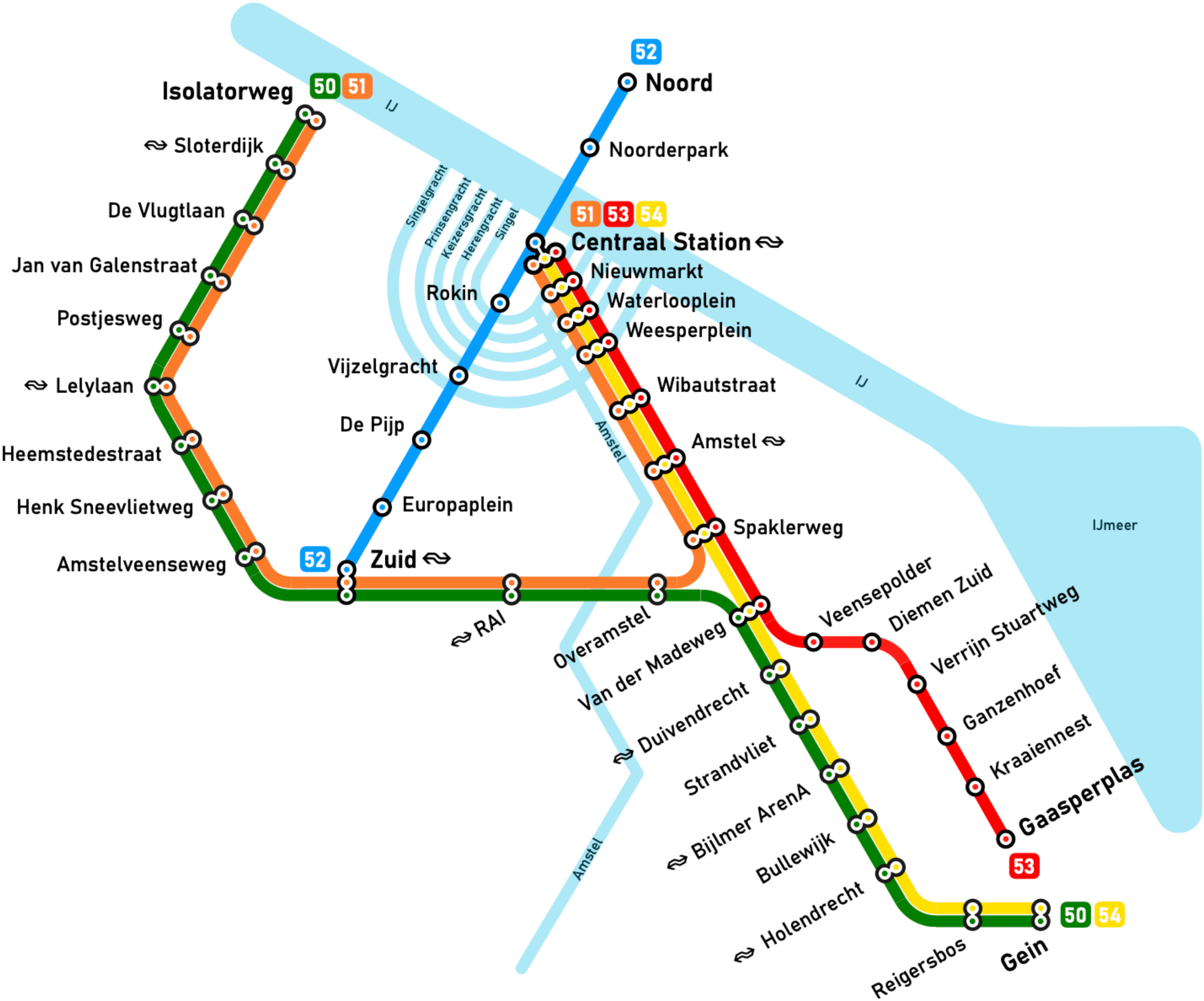
“The **ontological** approach to **explanation**” by

T.Y. Cao(2004). Ontology and scientific explanation. Oxford University Press

**“whenever we have something important but difficult to understand, we should focus our attention on finding what the primary entities are in the domain under investigation are…”**

**“…Discovering these entities and their intrinsic and structural properties, rather than manipulating uninterpreted or ill-interpreted mathematical symbols, or speculating on free-floating universal laws and principles, is the real work of science…”**

“Mathematical formalisms and universal laws and principles are relevant and important only when they have a firm ontological basis.”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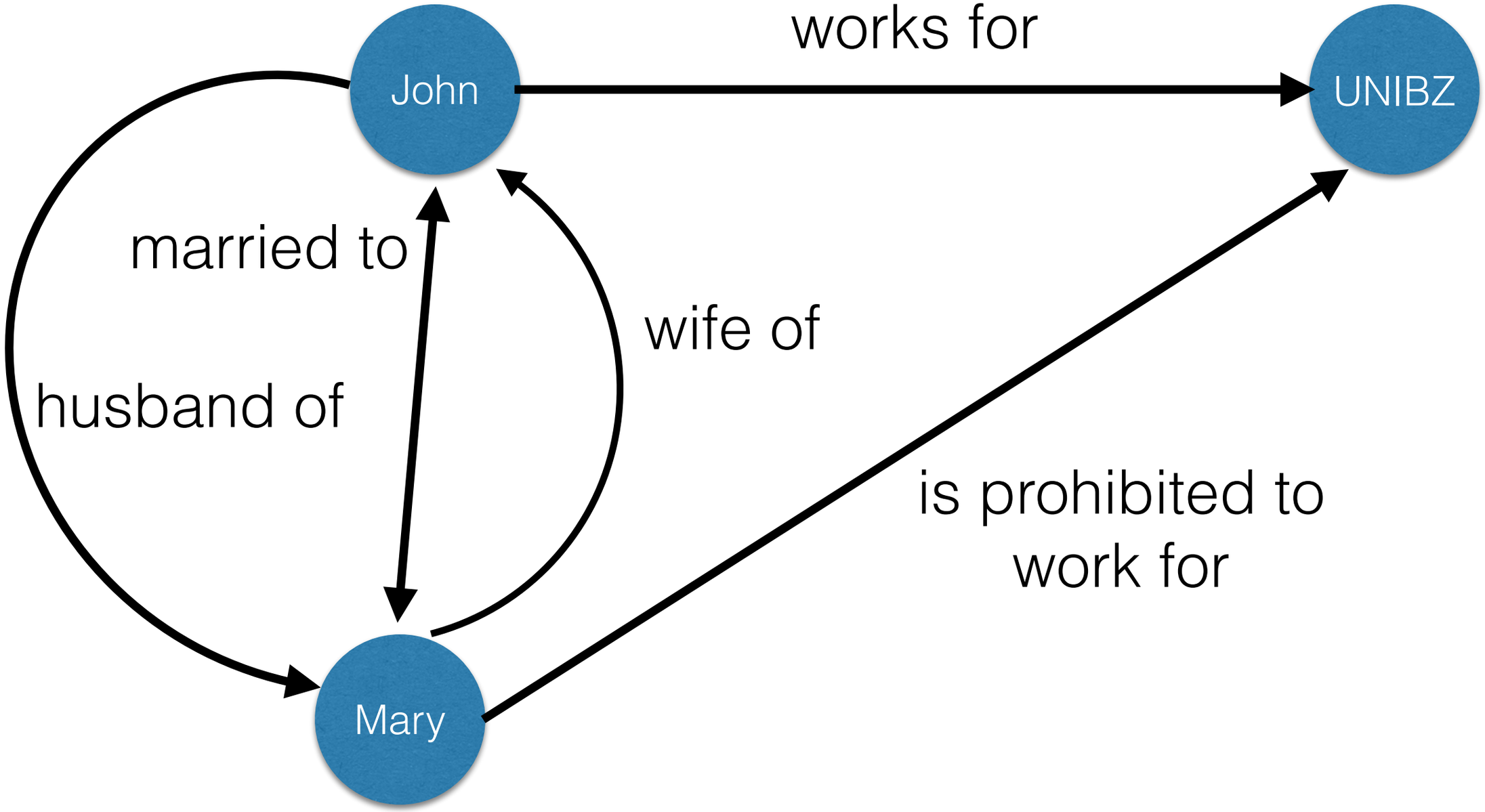
# Truth-bearers

X

# Truth-makers


works for
John
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married to
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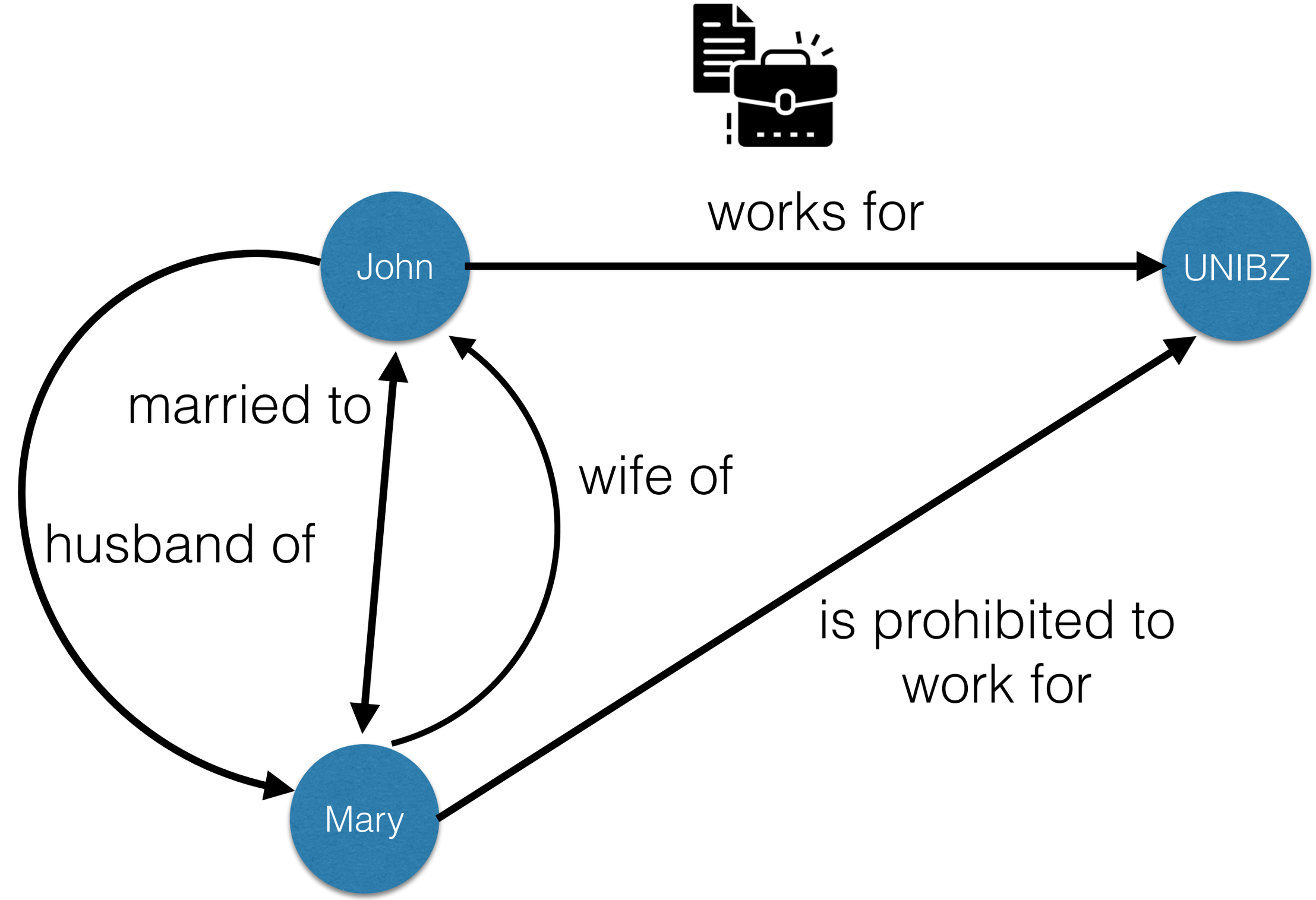
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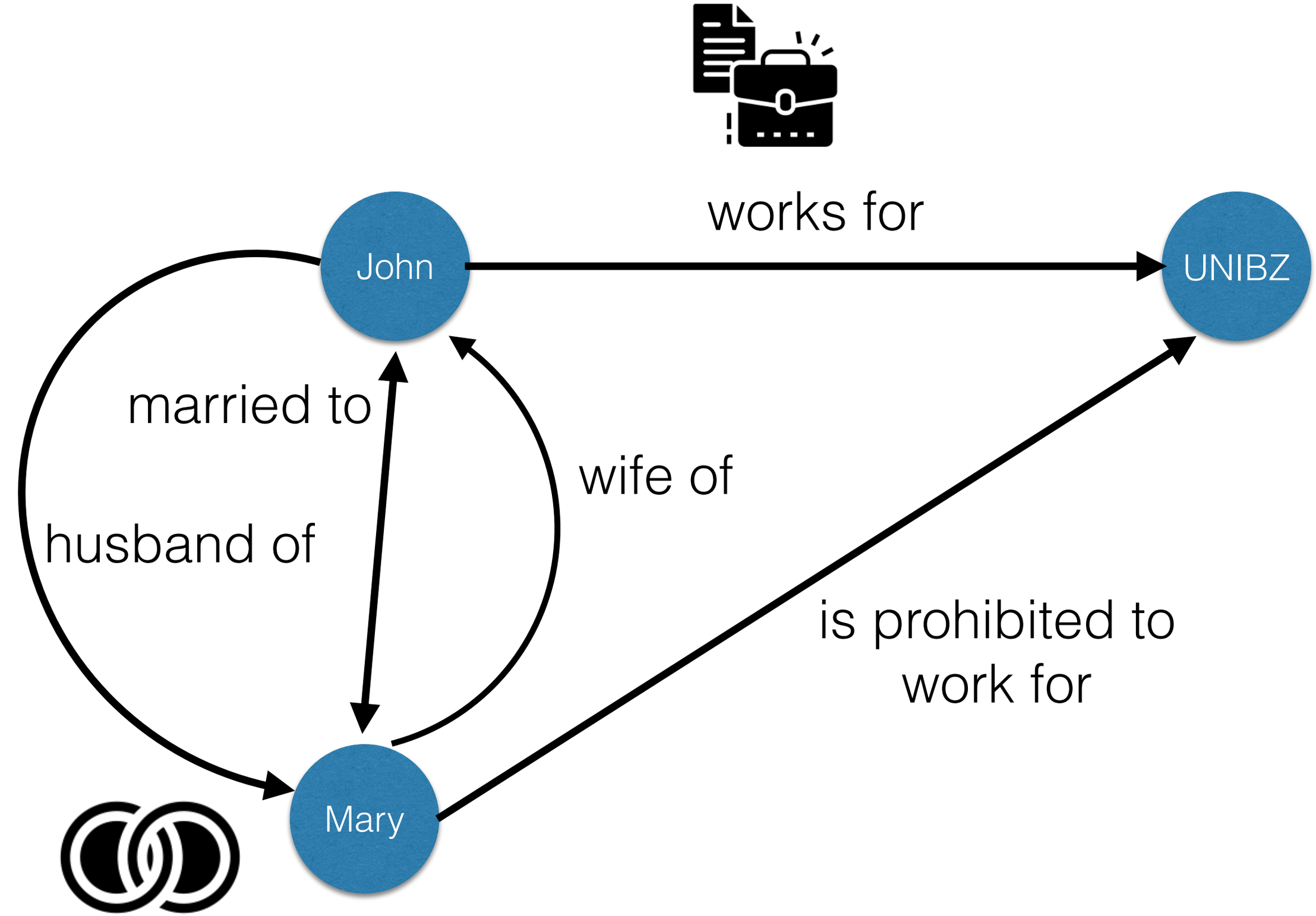
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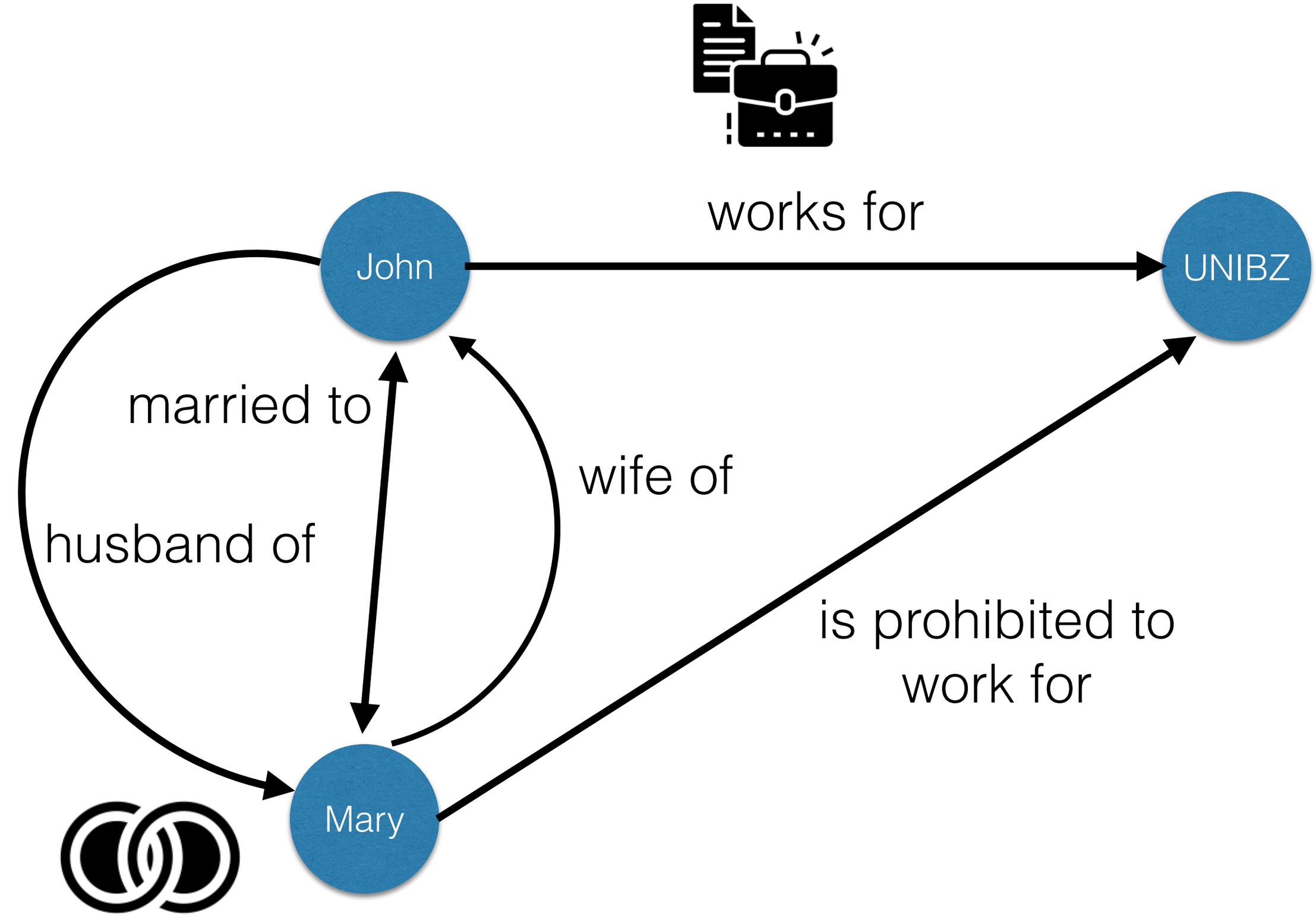
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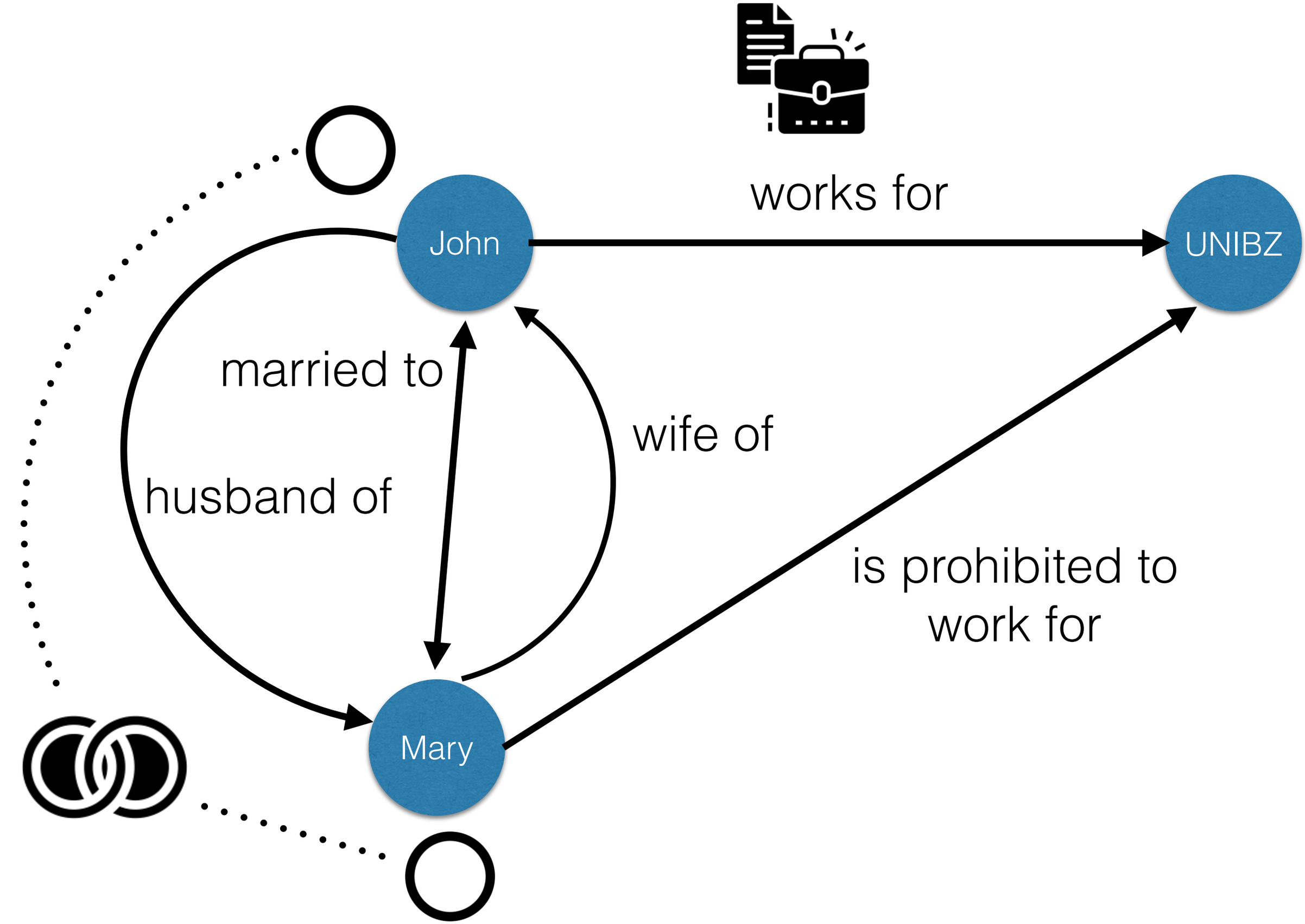
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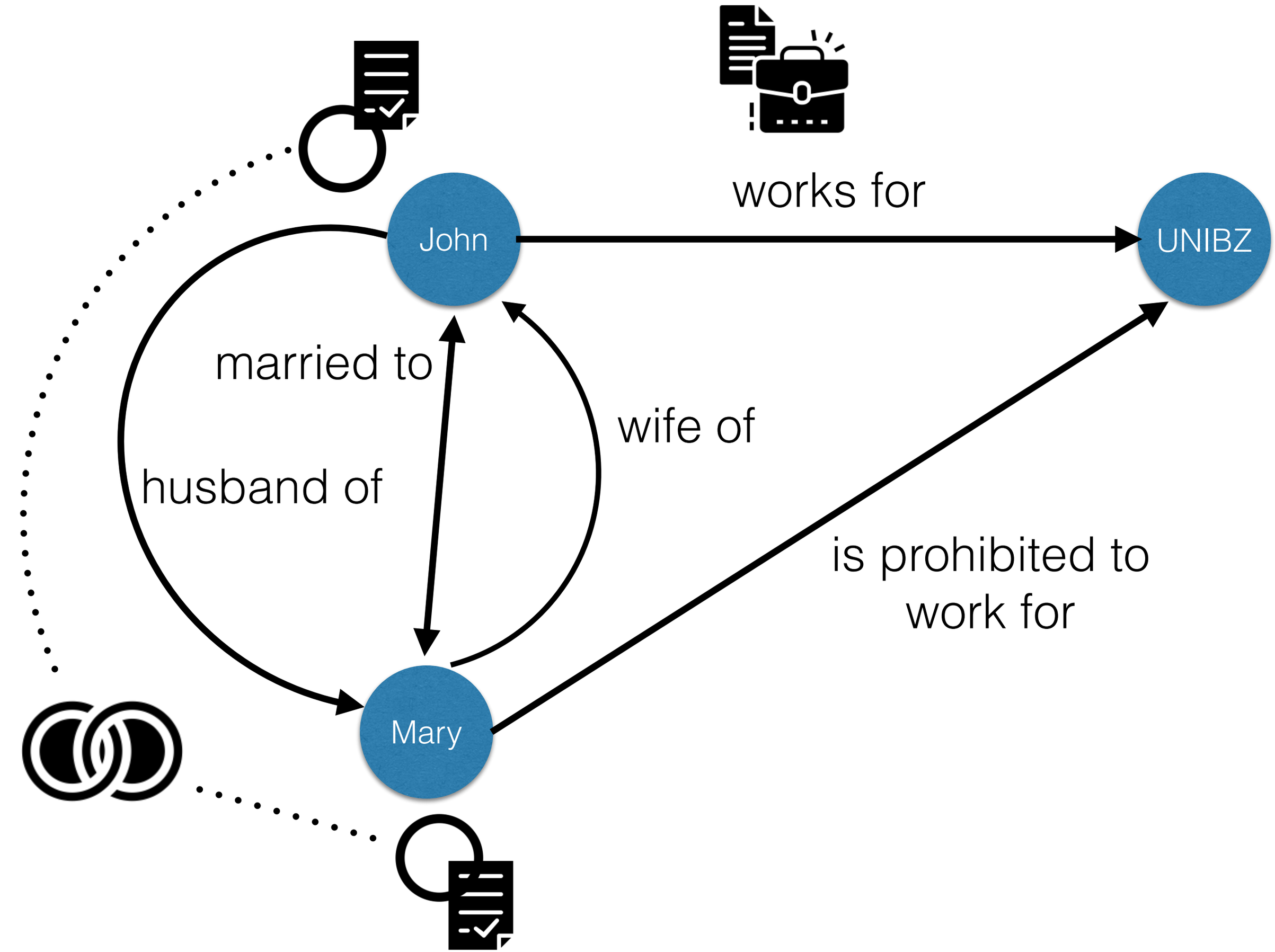
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**Structuring Function**
(of a Conceptual Model)
X
**Ontological Function**
(of a Conceptual Model)

**Truth-bearers**
**(Descriptive)**

X

**Truth-makers**
**(Explanatory)**

RESEARCH ARTICLE

# Semantic Interoperability: Ontological Unpacking of a Viral Conceptual Model

Anna Bernasconi[1,4*], Giancarlo Guizzardi[2,3], Oscar Pastor[4] and Veda C. Storey[5]

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[1]Department of Electronics, Information and Bioengineering, Politecnico di Milano, Milan, Italy
[4]PROS Research Center & VRAIN Research Institute, Universidad Politècnica de València, Valencia, Spain
Full list of author information is available at the end of the article

**Abstract**

**Background:** Genomics and virology are unquestionably important, but complex, domains being investigated by a large number of scientists. The need to facilitate and support work within these domains requires sharing of databases, although it is often difficult to do so because of the different ways in which data is represented across the databases. To foster semantic interoperability, models are needed that provide a deep understanding and interpretation of the concepts in a domain, so that the data can be consistently interpreted among researchers.

**Results:** In this research, we propose the use of conceptual models to support semantic interoperability among databases and assess their ontological clarity to support their effective use. This modeling effort is illustrated by its application to the Viral Conceptual Model (VCM) that captures and represents the sequencing of viruses, inspired by the need to understand the genomic aspects of the virus responsible for COVID-19. For achieving semantic clarity on the VCM, we leverage the "ontological unpacking" method, a process of ontological analysis that reveals the ontological foundation of the information that is represented in a conceptual model. This is accomplished by applying the stereotypes of the OntoUML ontology-driven conceptual modeling language. As a result, we propose a new OntoVCM, an ontologically grounded model, based on the initial VCM, but with guaranteed interoperability among the data sources that employ it.

# An Ontology-Based Approach to Engineering Ethicality Requirements

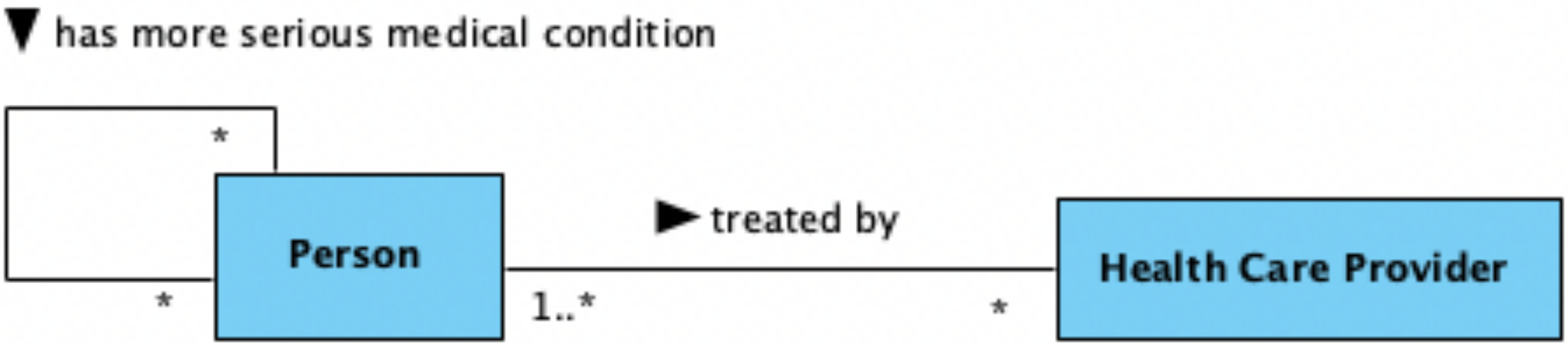
Renata Guizzardi[1], Glenda Amaral[1], Giancarlo Guizzardi[1], and John Mylopoulos[2]

[1] University of Twente, Enschede, The Netherlands
{r.guizzardi,g.c.mouraamaral,g.guizzardi}@utwente.nl
[2] University of Toronto, Toronto, Canada
jm@cs.toronto.edu

**Abstract.** In a world where Artificial Intelligence (AI) is pervasive, humans may feel threatened or at risk by giving up control to machines. In this context, ethicality becomes a major concern to prevent AI systems from being biased, making mistakes, or going rogue. Requirements Engineering (RE) is the research area that can exert a great impact in the development of ethical systems by design. However, proposing concepts, tools and techniques that support the incorporation of ethicality into the software development processes as explicit requirements remains a great challenge in the RE field. In this paper, we rely on Ontology-based Requirements Engineering (ObRE) as a method to elicit and analyze ethicality requirements[3]. ObRE applies ontological analysis to ontologically unpack terms and notions that are referred to in requirements elicitation. Moreover, this method instantiates the adopted ontology and uses it to guide the requirements analysis

2

# **Ontological** Unpacking as **Explanation**


has more serious medical condition
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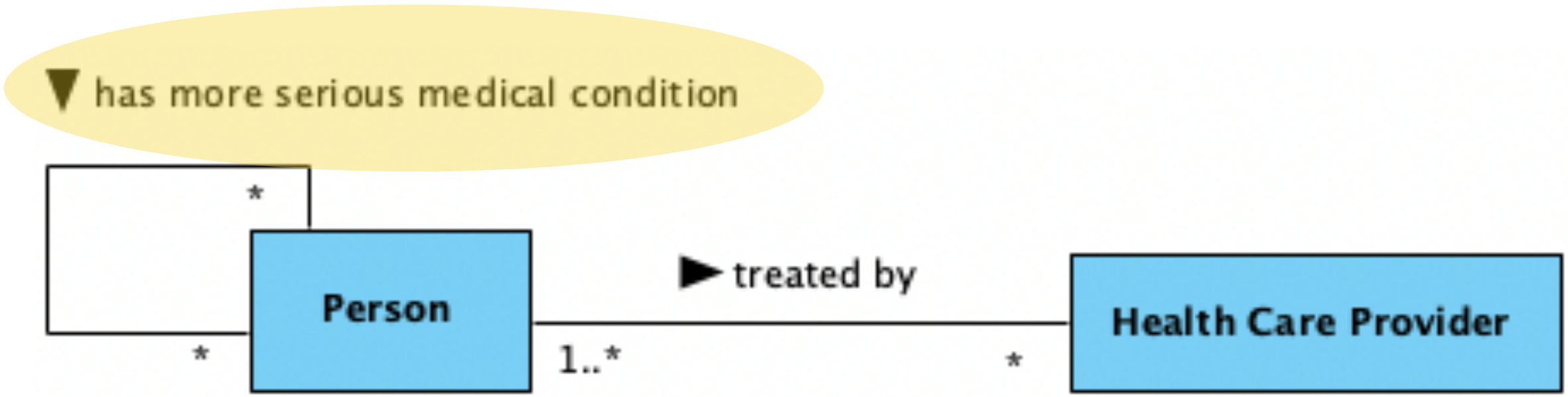
*
Health Care Provider


has more serious medical condition
*
Person
*
treated by
1..*
*
Health Care Provider

John


Bob


**has-more-serious-medical-condition(**Bob,John**)**
**iff** both x and y have medical conditions
and x has at least one medical condition
that is more severe than all the medical conditions of y

# **has-more-serious-medical-condition(**Bob,John**)**

John

S1

S2

S3

Bob

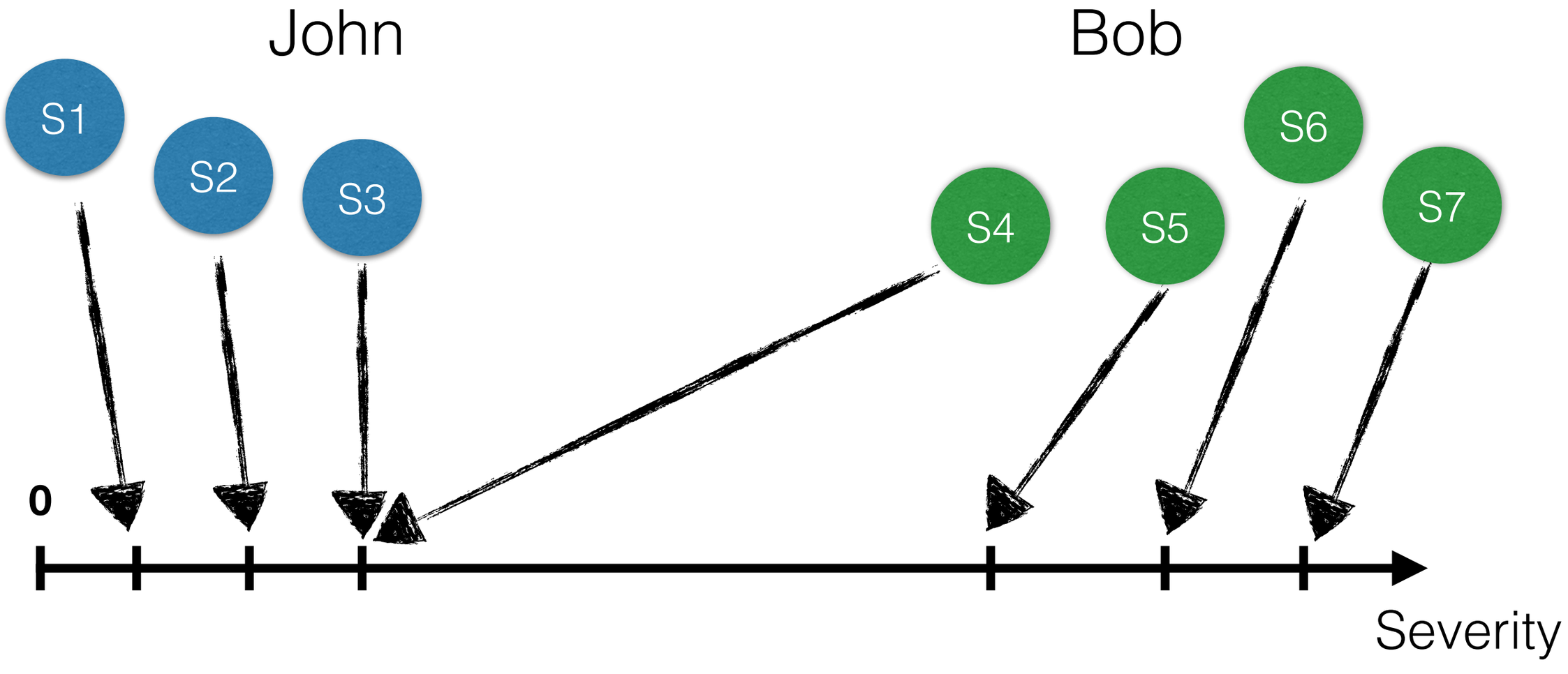
S4

S5

S6

S7

# **has-more-serious-medical-condition(**Bob,John**)**

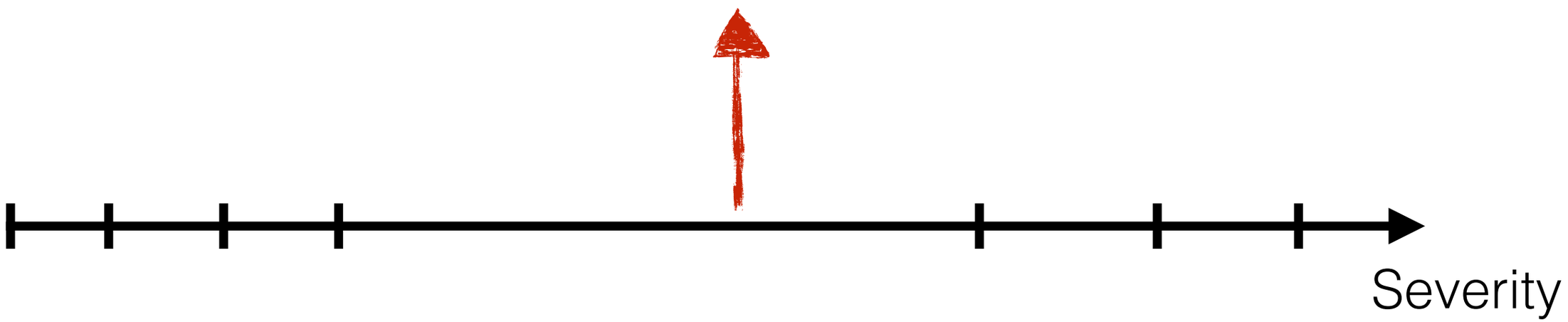


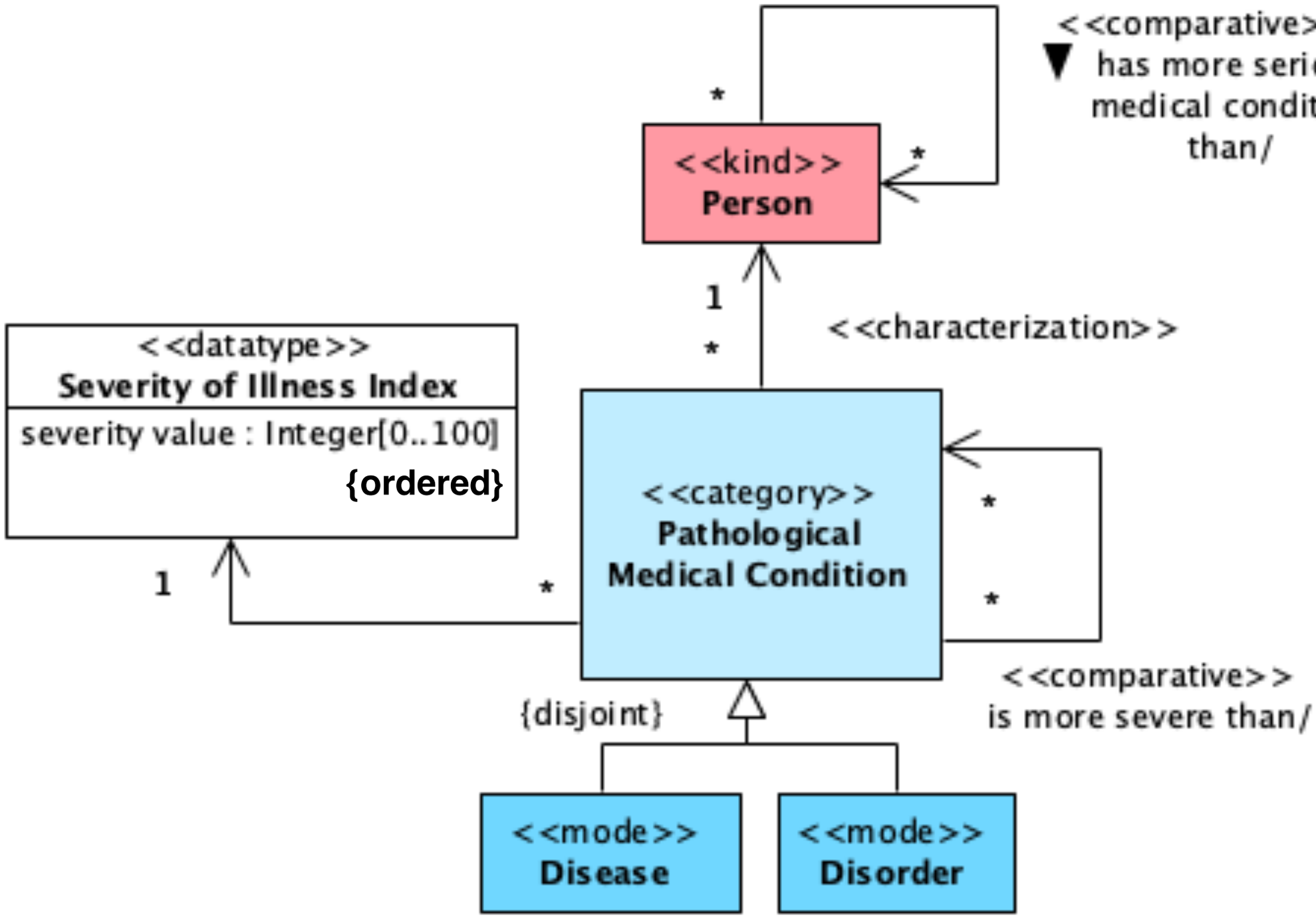
# **has-more-serious-medical-condition(**Bob,John**)**

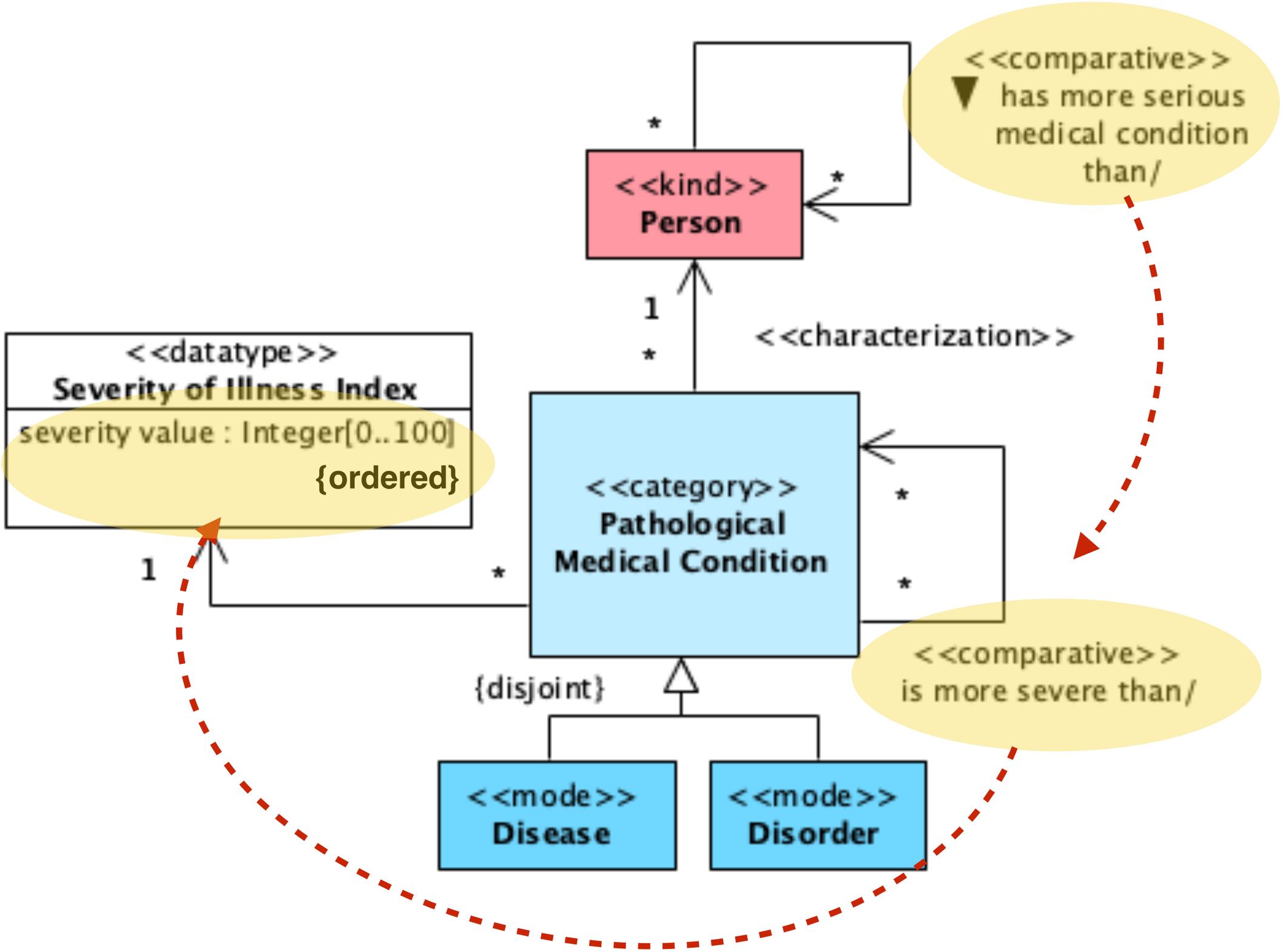
**Totally Ordered**
(Non-reflexive
Asymmetric
Transitive
Total)

# **has-more-serious-medical-condition(**Bob,John**)**


**Totally Ordered**
(Non-reflexive
Asymmetric
Transitive
Total)




<<comparative>>
has more serious
medical condition
than/
*
*
<<kind>>
Person
1
*
<<characterization>>
<<datatype>>
Severity of Illness Index
severity value : Integer[0..100]
{ordered}
1
*
<<category>>
Pathological
Medical Condition
*
*
<<comparative>>
is more severe than/
{disjoint}
<<mode>>
Disease
<<mode>>
Disorder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has more serious
medical condition
than/
*
*
<<kind>>
Person
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Severity of Illness Index
severity value : Integer[0..100]
{ordered}
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Pathological
Medical Condition
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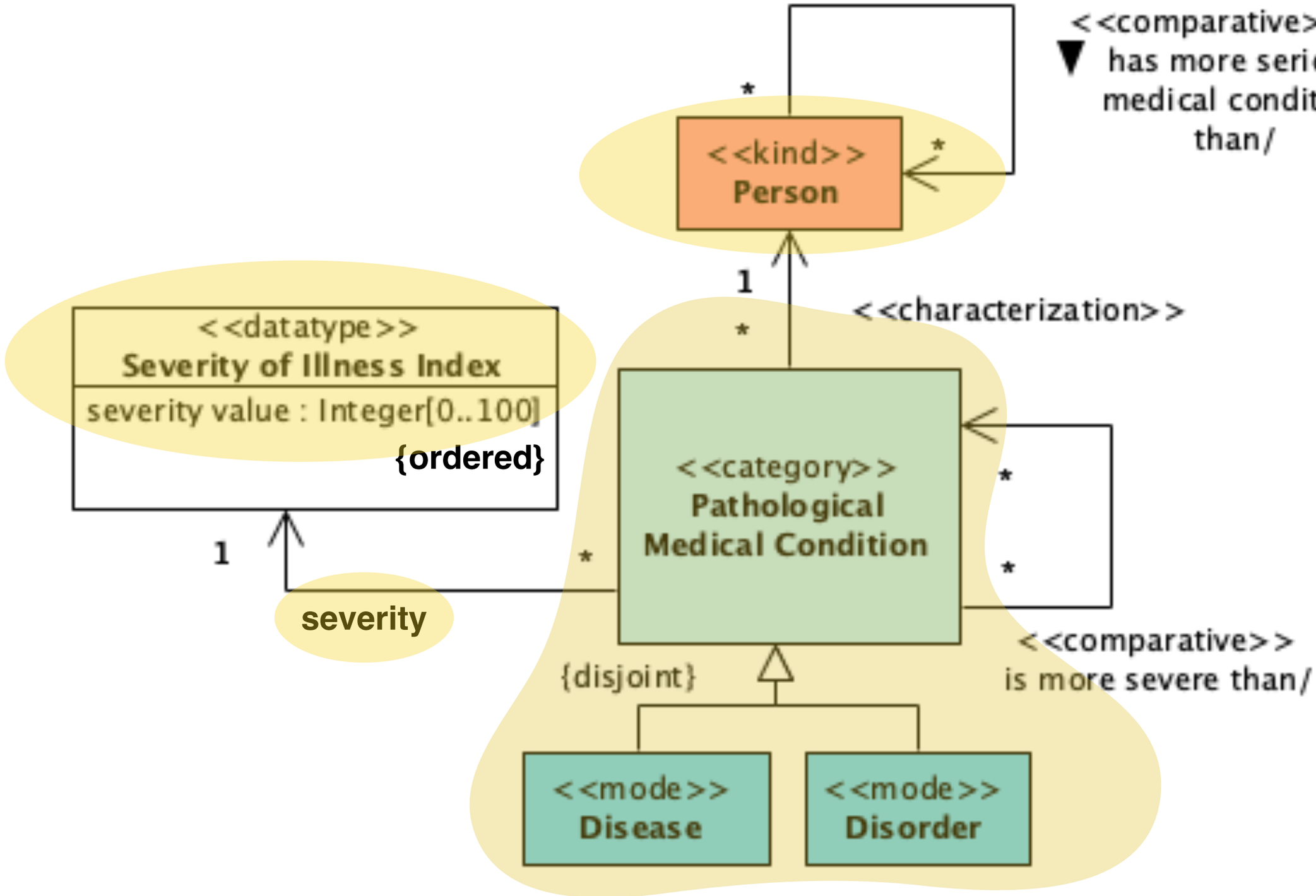
is more severe than/
{disjoint}
<<mode>>
Disease
<<mode>>
Disorder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medical condition
than/
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Person
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<<characterization>>
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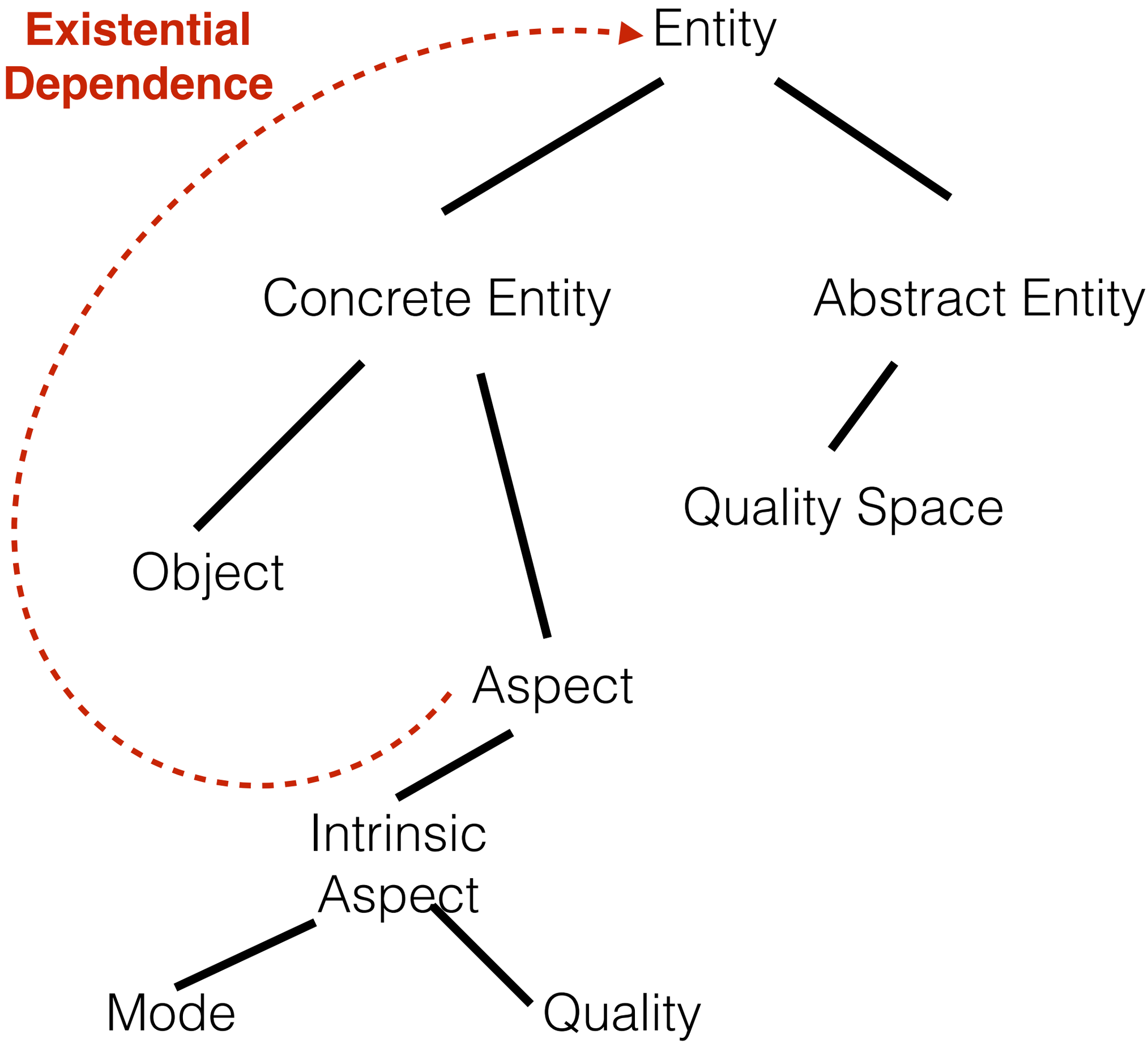
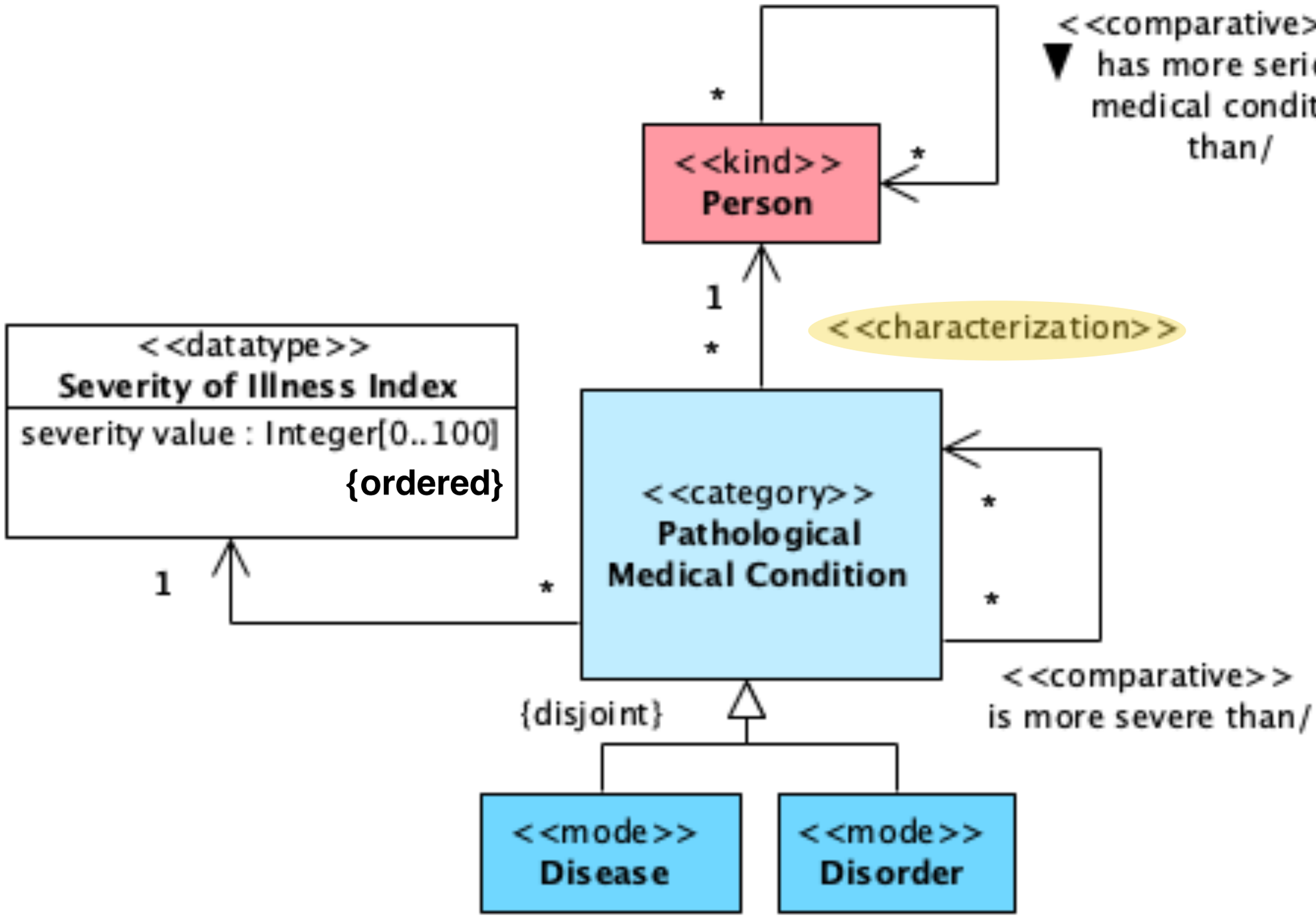
Severity of Illness Index
severity value : Integer[0..100]
{ordered}
<<category>>
Pathological
Medical Condition
*
*
1
*
severity
<<comparative>>
is more severe than/
{disjoint}
<<mode>>
Disease
<<mode>>
Disorder


Existential Dependence
Entity
Concrete Entity
Abstract Entity
Quality Space
Object
Aspect
Intrinsic Aspect
Mode
Quality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has more serious
medical condition
than/
*
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<<kind>>
Person
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<<characterization>>
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Severity of Illness Index
severity value : Integer[0..100]
{ordered}
<<category>>
Pathological
Medical Condition
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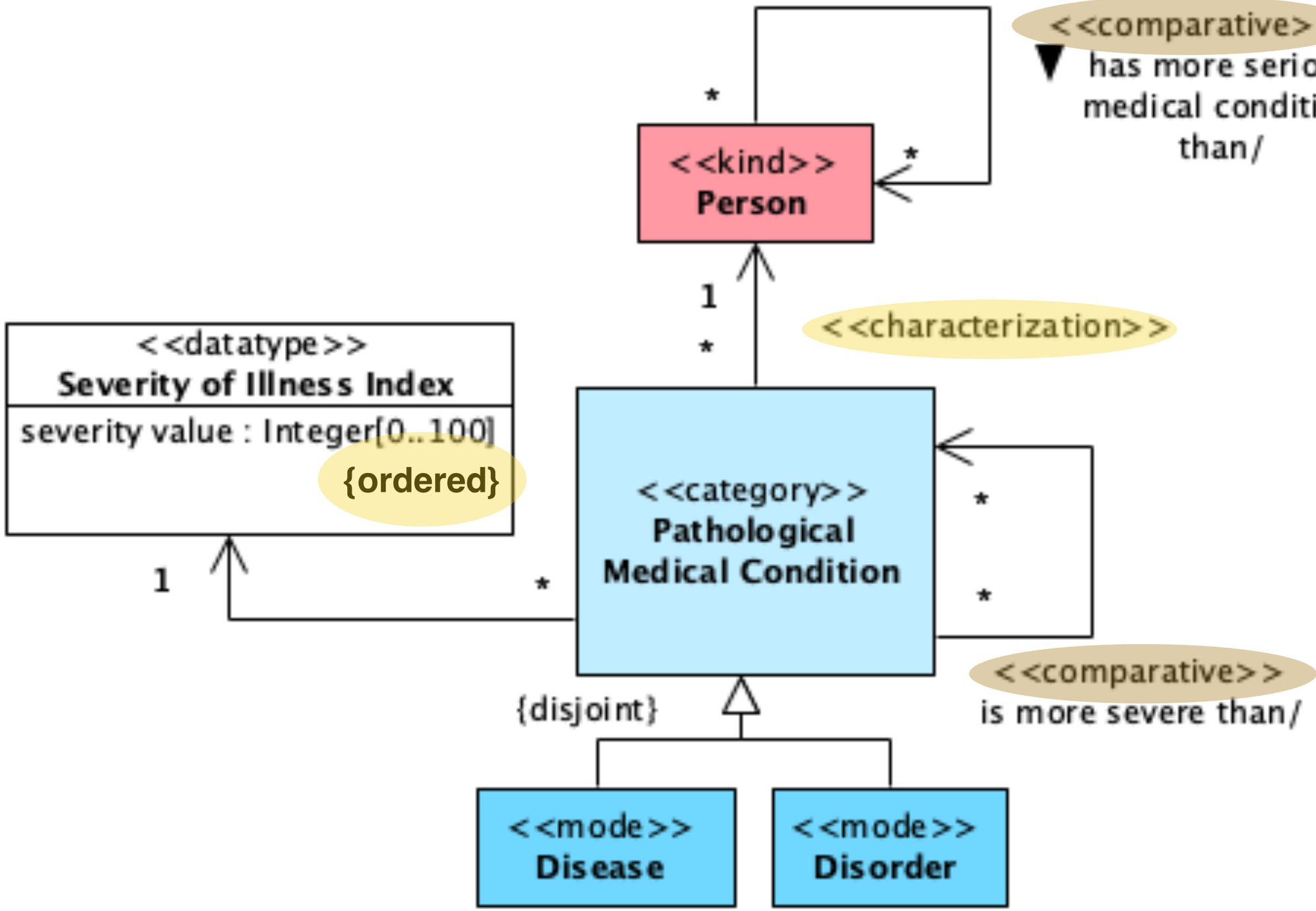
is more severe than/
{disjoint}
<<mode>>
Disease
<<mode>>
Disorder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Person
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Severity of Illness Index
severity value : Integer[0..100]
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Pathological Medical Condition
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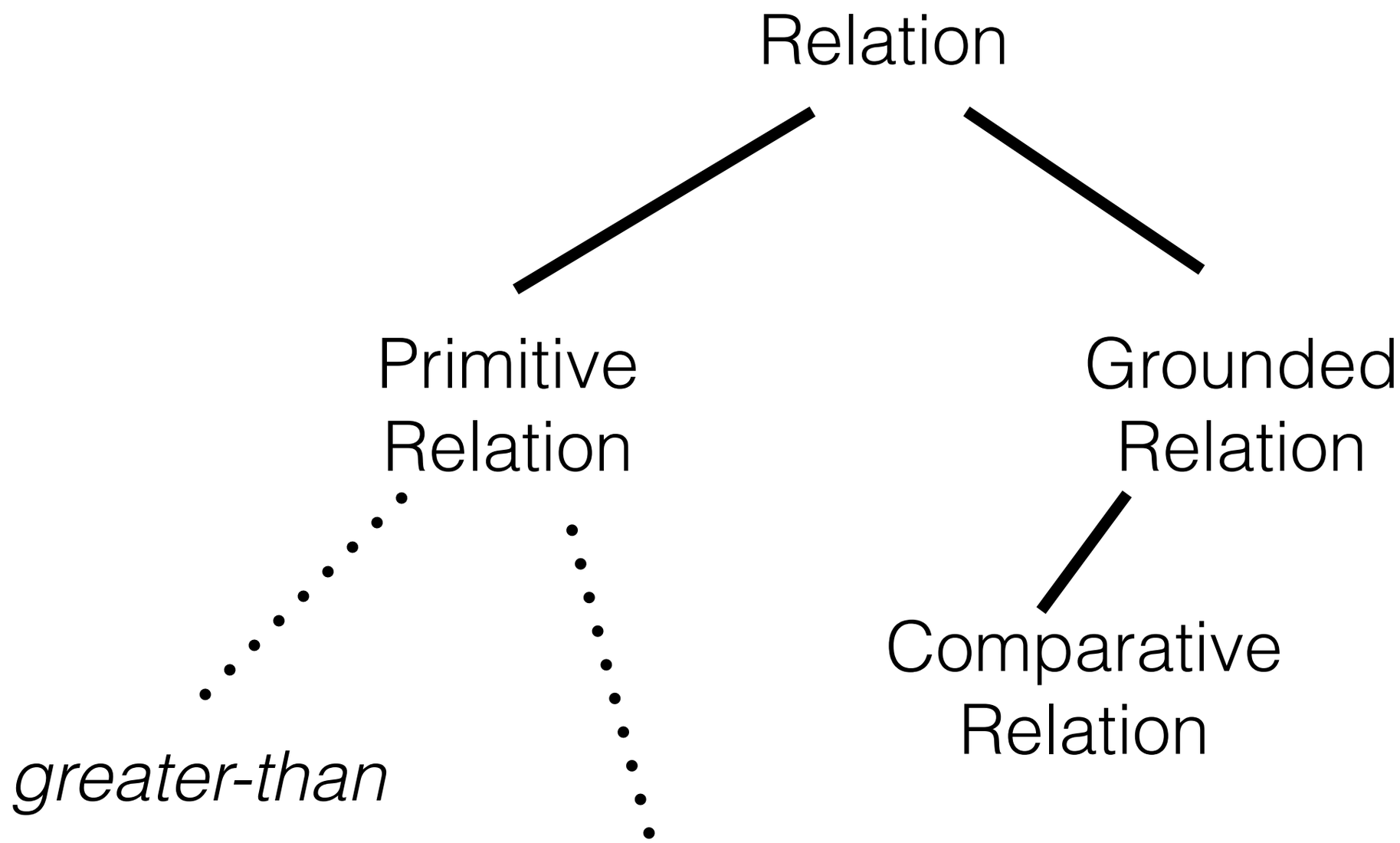
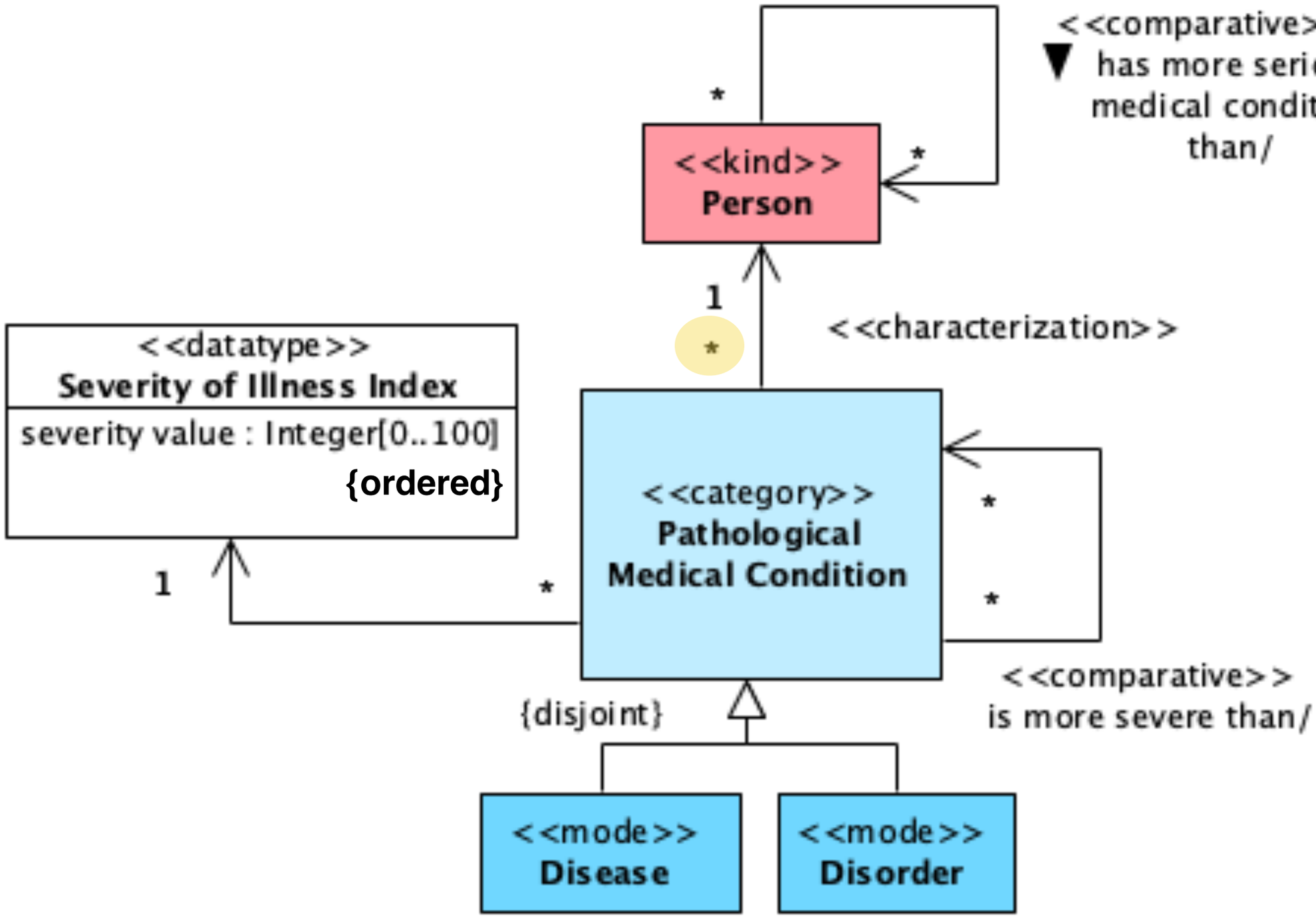
*
1
*
<<comparative>>
is more severe than/
{disjoint}
<<mode>>
Disease
<<mode>>
Disorder


Relation
Primitive Relation
Grounded Relation
Comparative Relation
greater-than
characterization
(Existential Dependence)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has more serious
medical condition
than/
*
*
<<kind>>
Person
1
*
<<characterization>>
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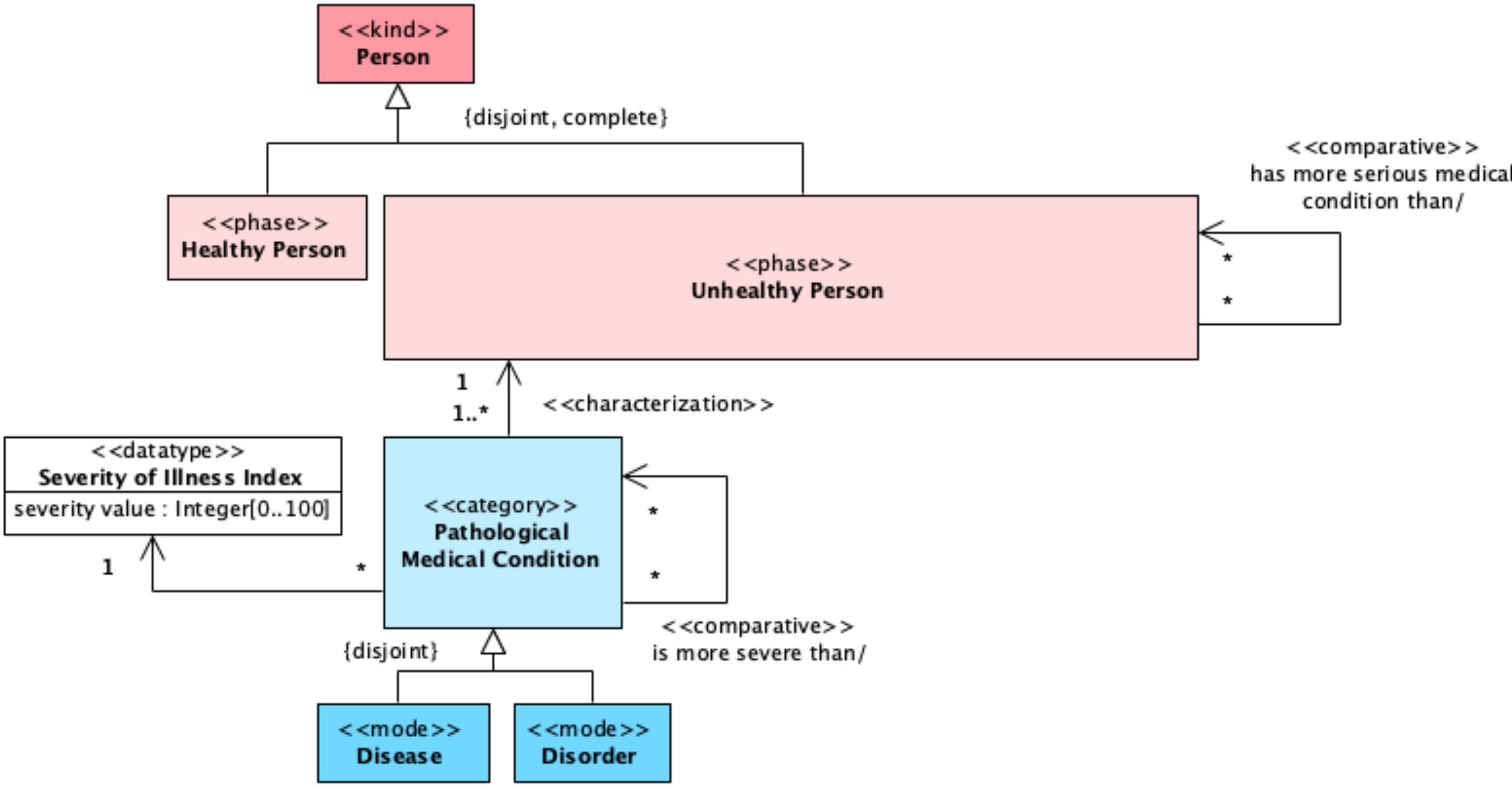
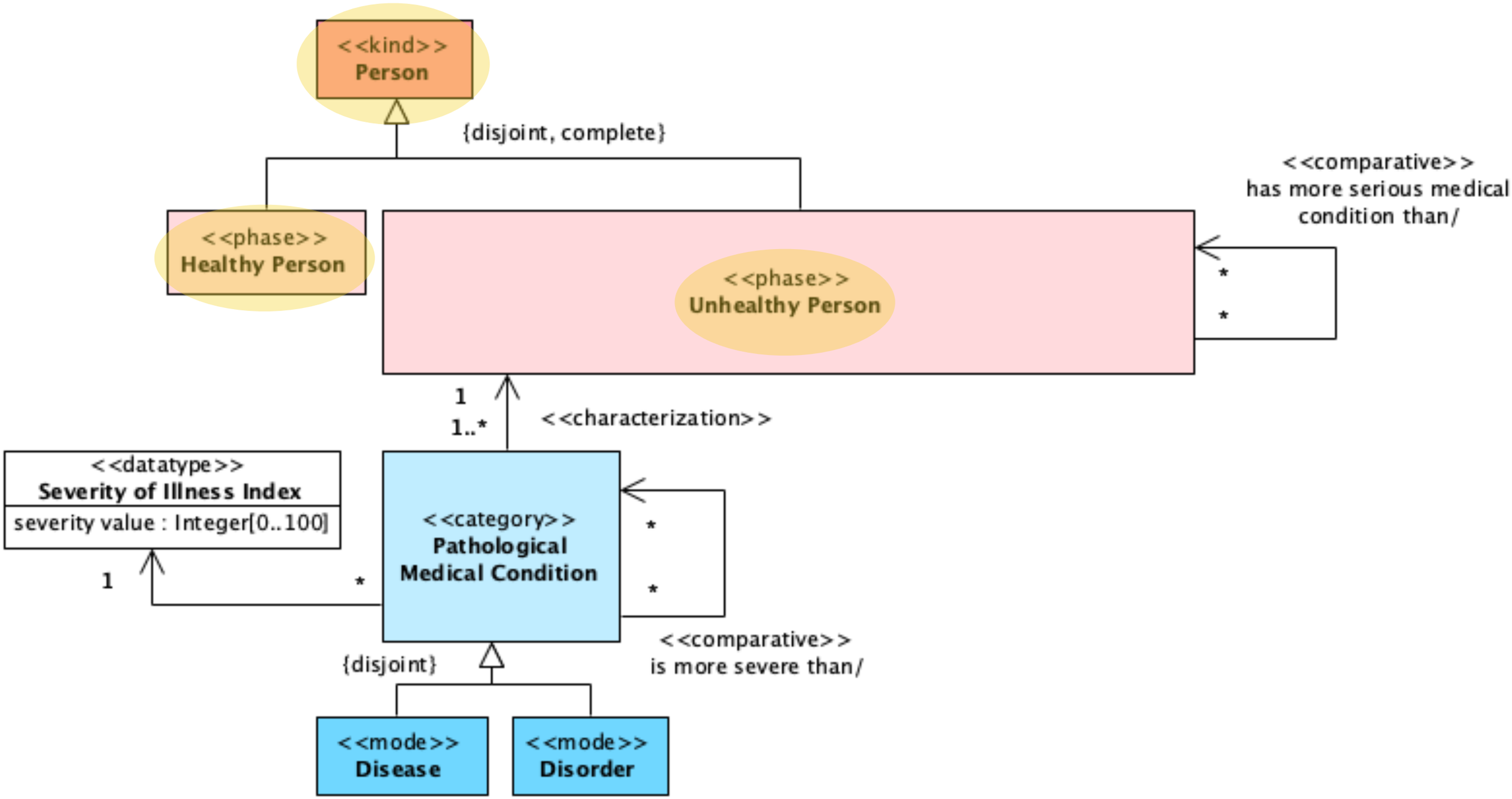
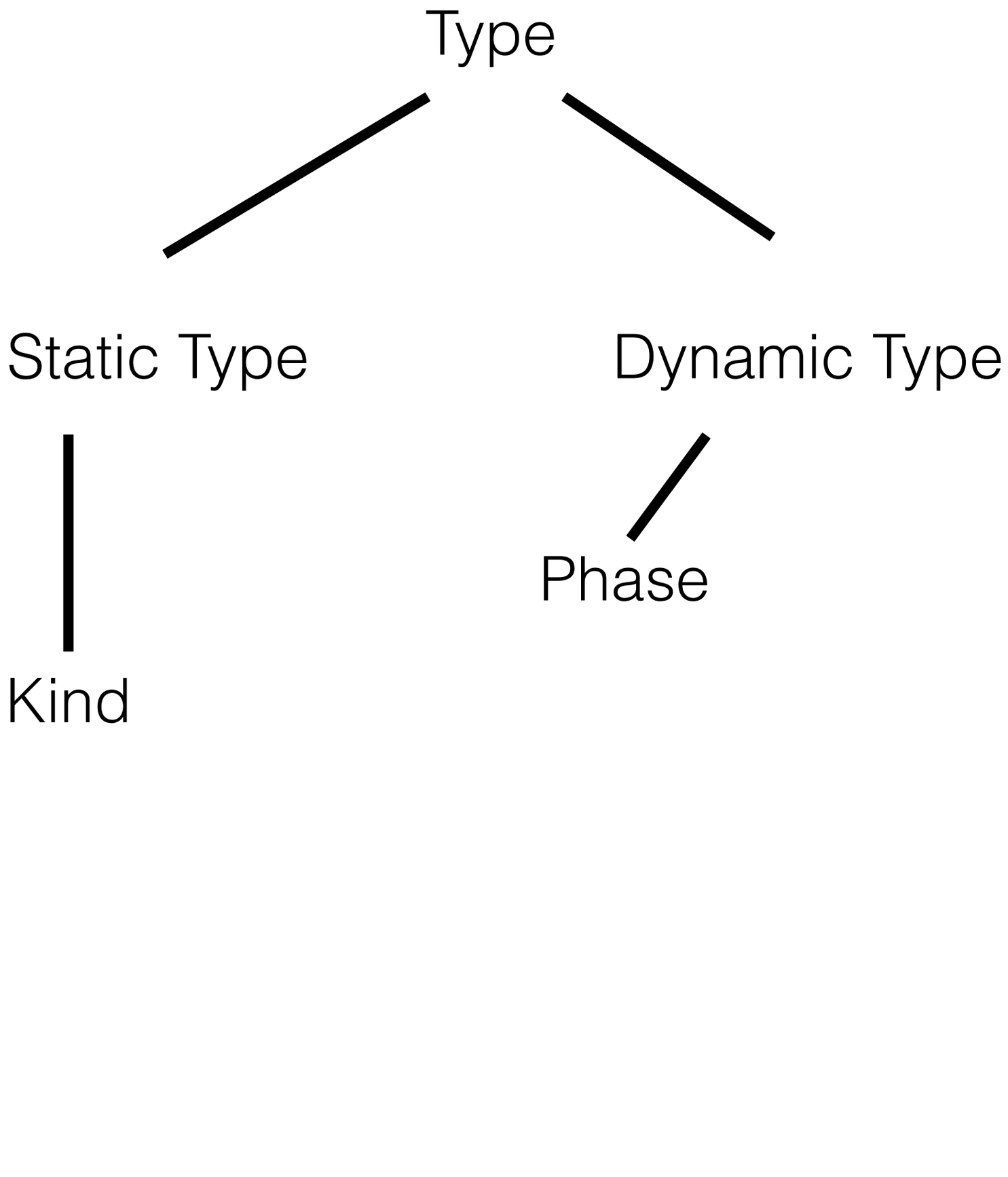
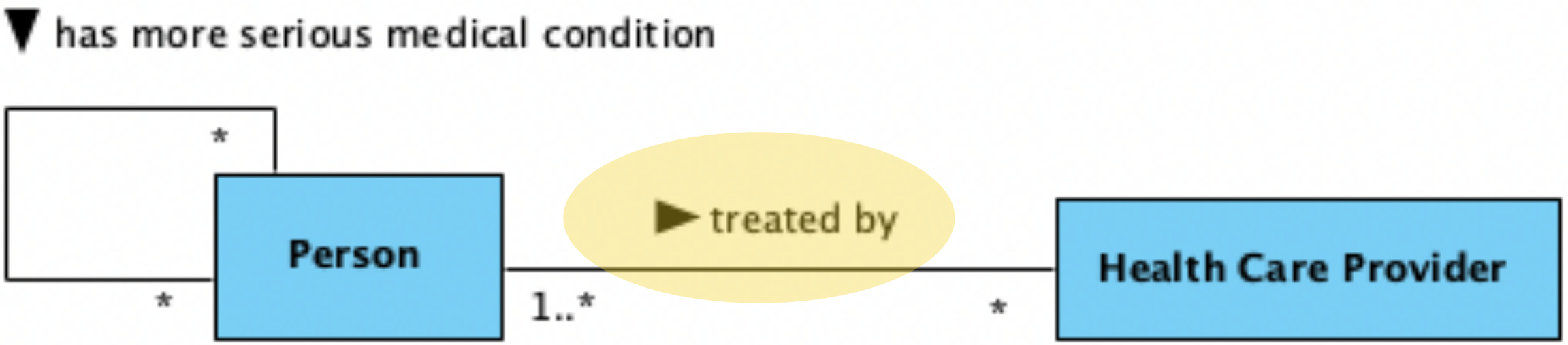
Severity of Illness Index
severity value : Integer[0..100]
{ordered}
1
*
<<category>>
Pathological
Medical Condition
*
*
<<comparative>>
is more severe than/
{disjoint}
<<mode>>
Disease
<<mode>>
Disorder


<<kind>>
Person
{disjoint, complete}
<<phase>>
Healthy Person
<<phase>>
Unhealthy Person
<<comparative>>
has more serious medical condition than/
*
*
1
1..*
<<characterization>>
<<datatype>>
Severity of Illness Index
severity value : Integer[0..100]
1
*
<<category>>
Pathological Medical Condition
*
*
<<comparative>>
is more severe than/
{disjoint}
<<mode>>
Disease
<<mode>>
Disorder


<<kind>>
Person
{disjoint, complete}
<<phase>>
Healthy Person
<<phase>>
Unhealthy Person
<<comparative>>
has more serious medical
condition than/
*
*
1
1..*
<<characterization>>
<<datatype>>
Severity of Illness Index
severity value : Integer[0..100]
1
*
<<category>>
Pathological
Medical Condition
*
*
<<comparative>>
is more severe than/
{disjoint}
<<mode>>
Disease
<<mode>>
Disorder


Type
Static Type
Dynamic Type
Kind
Phase


has more serious medical condition
*
*
Person
1..*
treated by
*
Health Care Provider

Relation

Primitive Relation

*greater-than*

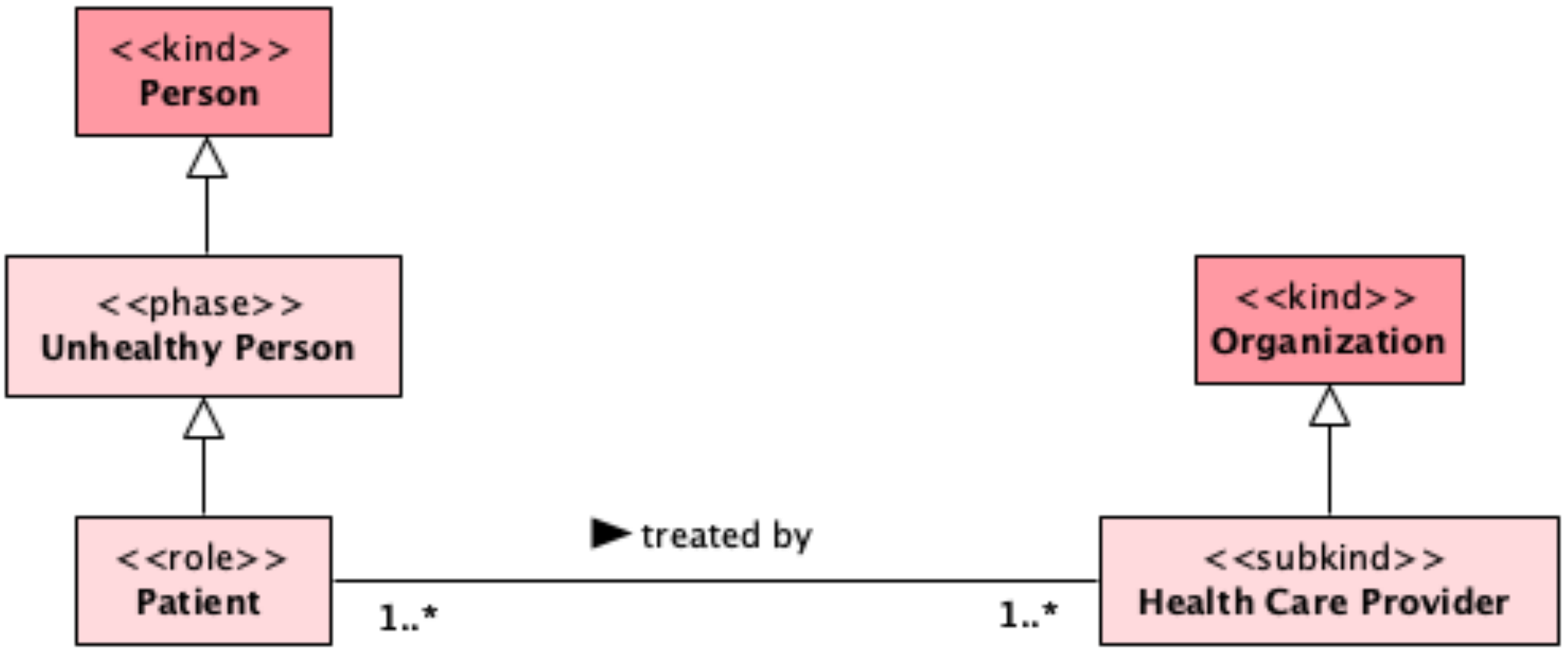
Grounded Relation

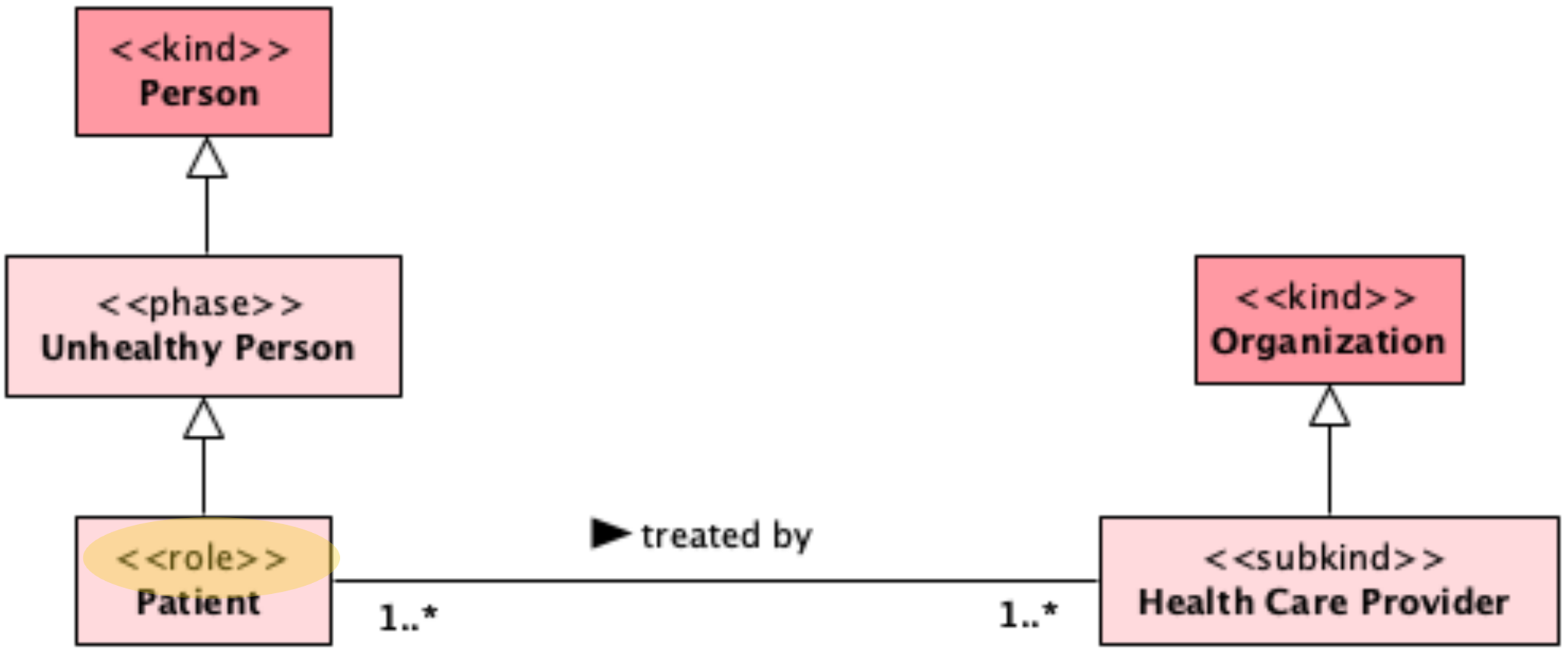
Comparative Relation

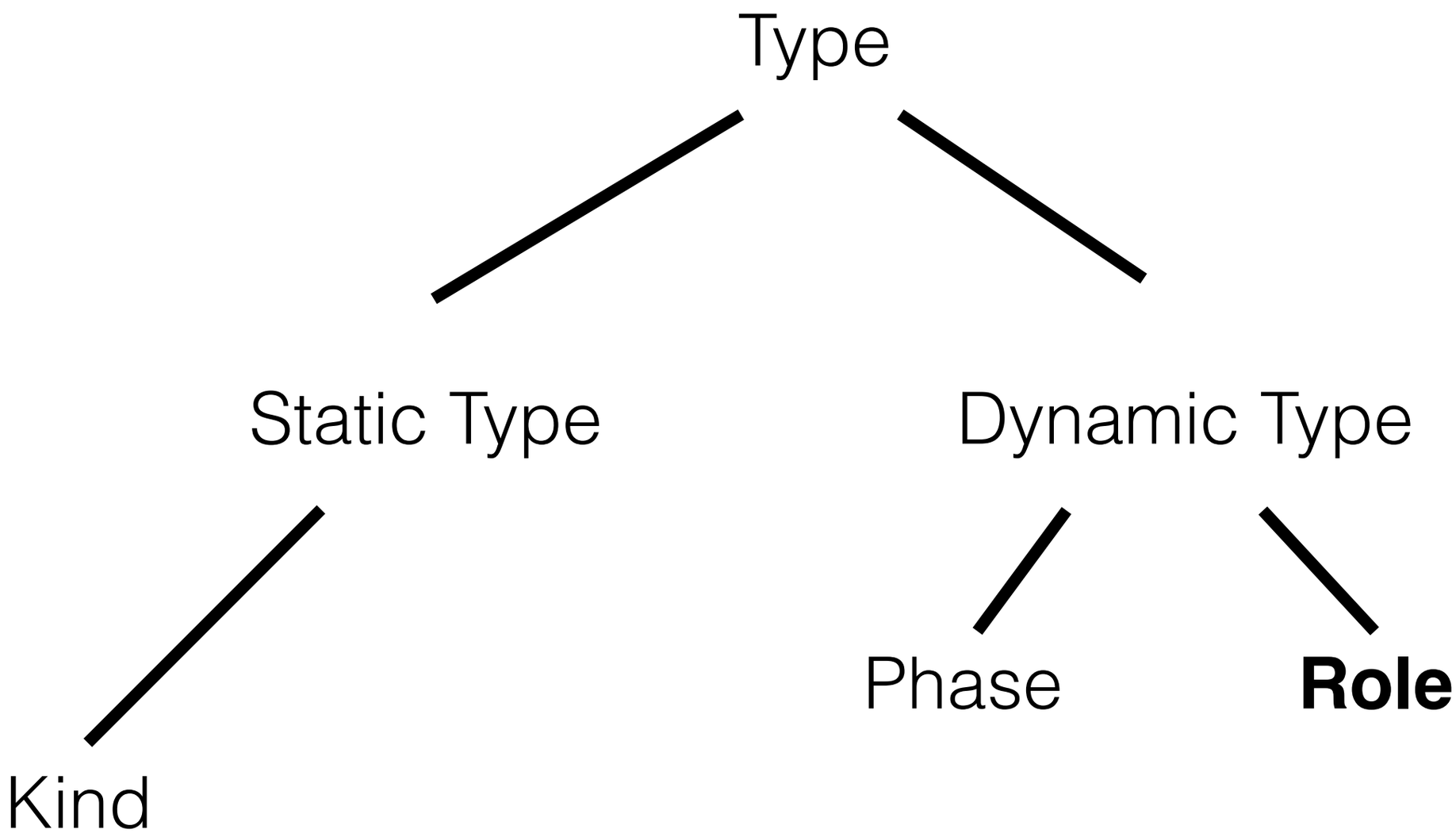
**Material Relation**

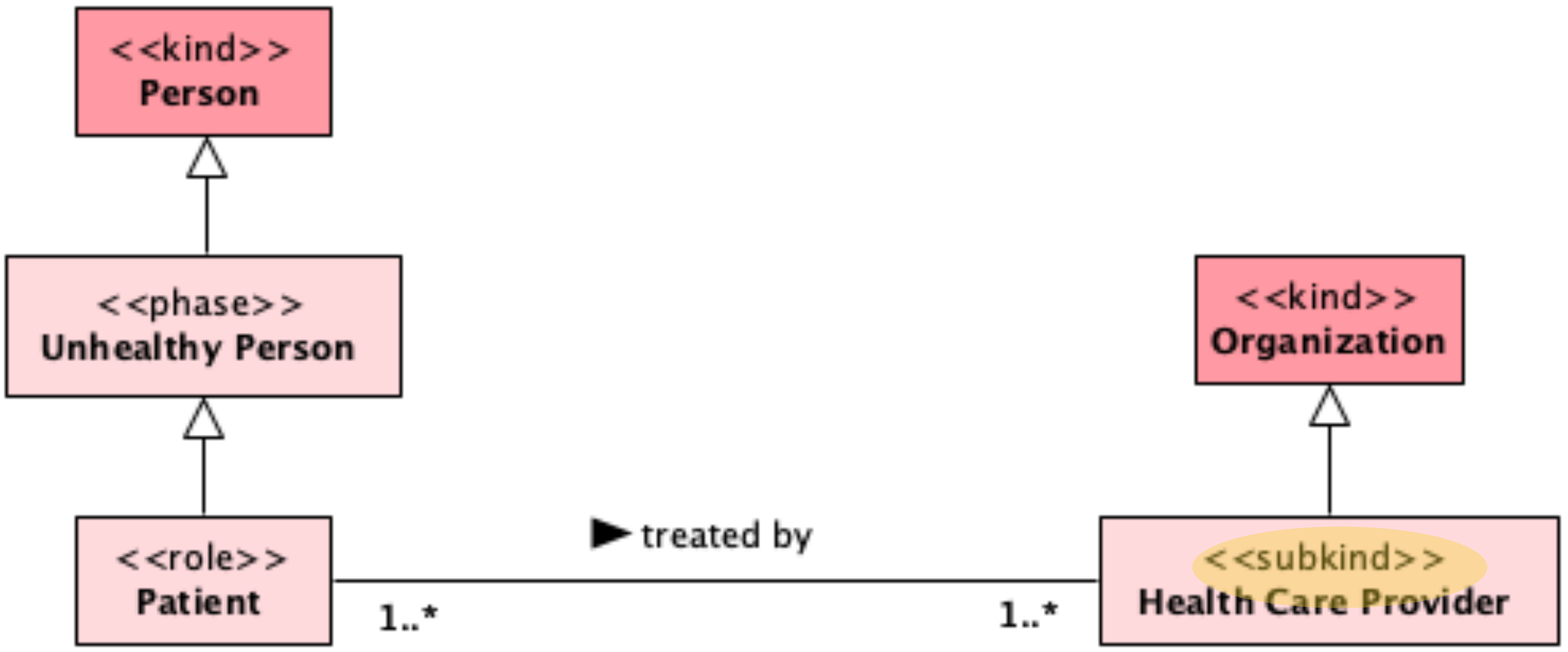
*characterization*
(Existential Dependence)


has more serious medical condition
*
*
Person
treated by
1..*
*
Health Care Provider


<<kind>>
Person
<<phase>>
Unhealthy Person
<<role>>
Patient
treated by
1..*
1..*
<<kind>>
Organization
<<subkind>>
Health Care Provider


<<kind>>
Person
<<phase>>
Unhealthy Person
<<role>>
Patient
treated by
1..*
1..*
<<kind>>
Organization
<<subkind>>
Health Care Provider


Type
Static Type
Dynamic Type
Kind
Phase
Role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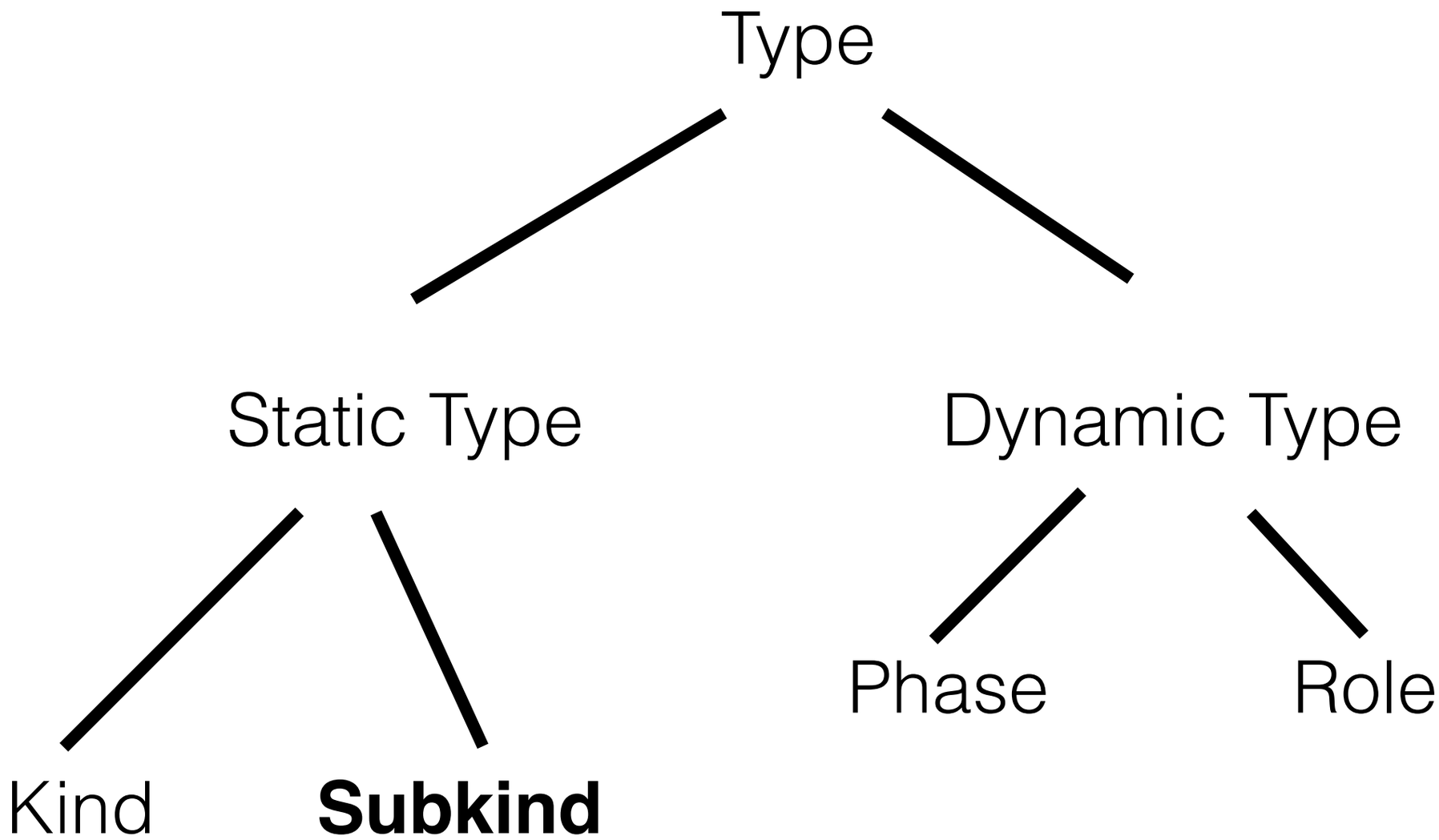
Person
<<phase>>
Unhealthy Person
<<role>>
Patient
treated by
1..*
1..*
<<kind>>
Organization
<<subkind>>
Health Care Provider


Type
Static Type
Dynamic Type
Kind
Subkind
Phase
Role


<<kind>>
Person
<<phase>>
Unhealthy Person
<<role>>
Patient
treated by
1..*
1..*
<<kind>>
Organization
<<subkind>>
Health Care Provider

# How to interpret 1..* ?

- Given a treatment, there is **exactly one patient**, **exactly one healthcare provider** but **both** patient and healthcare provider **can participate in many treatments**

# How to interpret 1..* ?

- Given a treatment, there is **exactly one patient**, **exactly one healthcare provider** but **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there are **possibly many patients**, **exactly one healthcare provider** but **both** patient and healthcare provider **can participate in many treatments**

# How to interpret 1..* ?

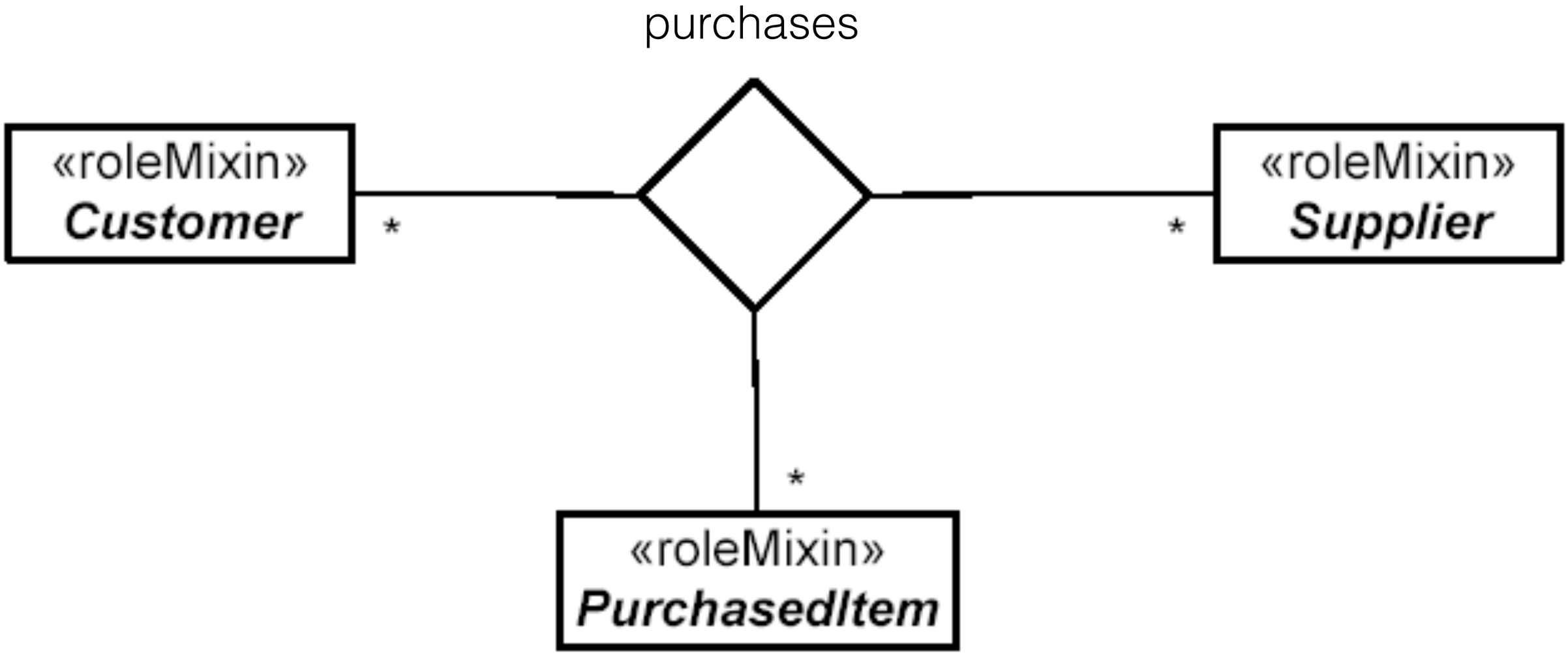
- Given a treatment, there is **exactly one patient**, **exactly one healthcare provider** but **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there are **possibly many patients**, **exactly one healthcare provider** but **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there is **exactly one patient, possibly many healthcare providers** but **both** patient and healthcare provider **can participate in many treatments**

# How to interpret 1..* ?

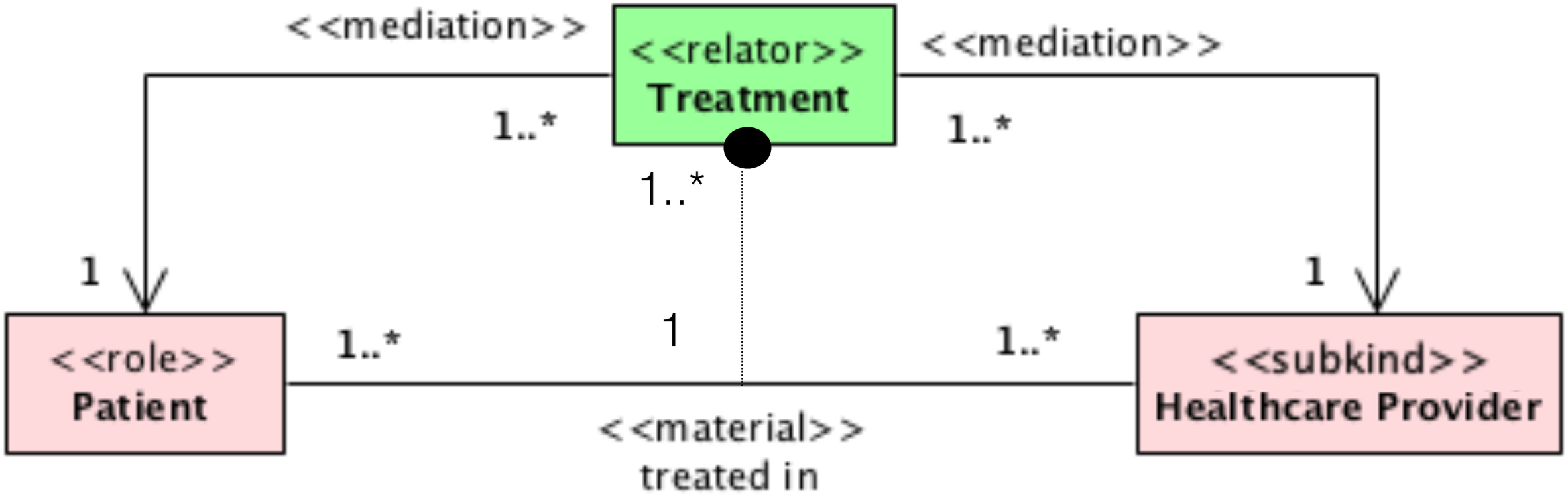
- Given a treatment, there is **exactly one patient**, **exactly one healthcare provider** but **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there are **possibly many patients**, **exactly one healthcare provider** but **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there is **exactly one patient, possibly many healthcare providers** but **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there are **possibly many patients**, **possibly many healthcare providers** and **both** patient and healthcare provider **can participate in many treatments**

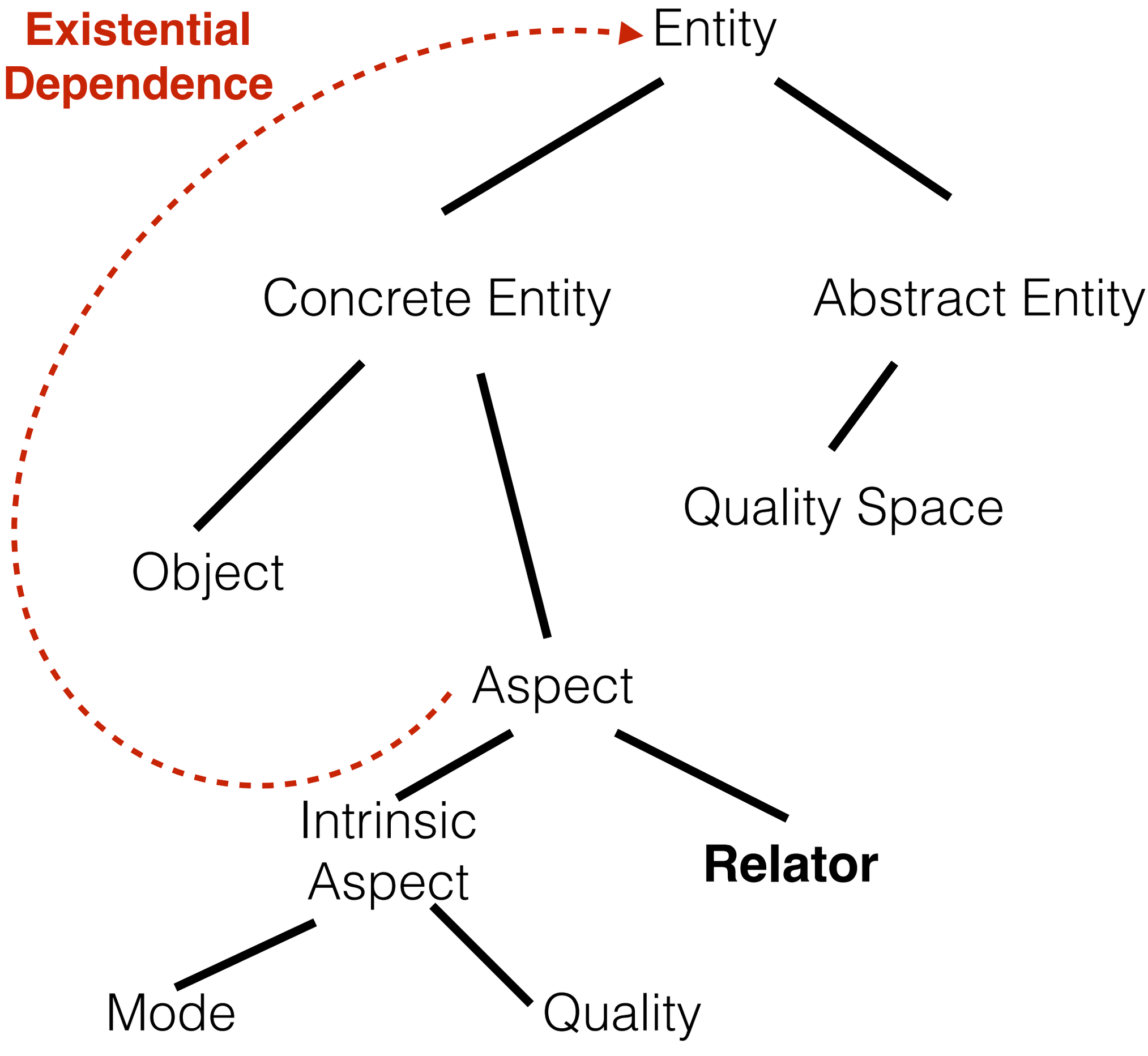
# How to interpret 1..* ?

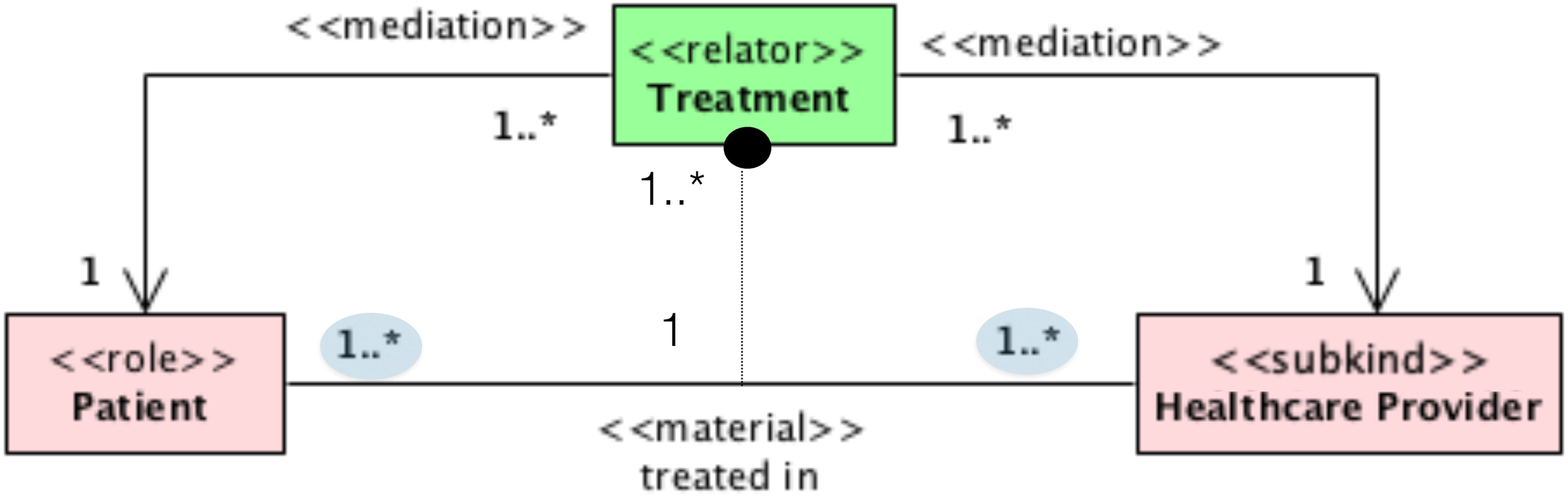
- Given a treatment, there is **exactly one patient**, **exactly one healthcare provider** but **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there are **possibly many patients**, **exactly one healthcare provider** but **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there is **exactly one patient, possibly many healthcare providers** but **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there are **possibly many patients**, **possibly many healthcare providers** and **both** patient and healthcare provider **can participate in many treatments**
- Given a treatment, there are **possibly many patients**, **possibly many healthcare providers** and **both** patient and healthcare provider **can participate in exactly one treatment**
- …

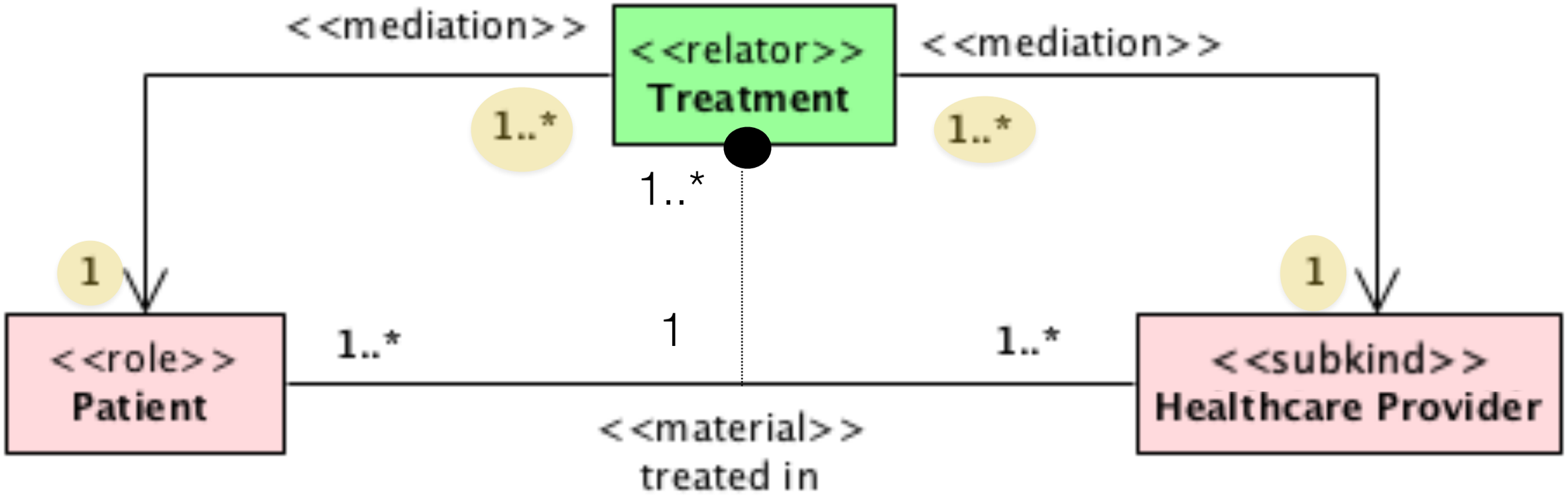

purchases
«roleMixin»
Customer
*
*
«roleMixin»
Supplier
*
«roleMixin»
PurchasedItem

1. In a given purchase, a Customer participates by buying many items from many Suppliers and a customer can participate in several purchases;
2. In a given purchase, many Customers participate by buying many items from many Suppliers, and a customer can participate in only one purchase;
3. In given purchase, a Customer participates by buying many items from a Supplier, and a customer can participate in several purchases;
4. In given purchase, many Customers participate by buying many items from a Supplier, and a customer can participate in several purchases
5. …


<<mediation>>
<<relator>>
Treatment
<<mediation>>
1..*
1..*
1..*
1
1
1..*
<<role>>
Patient
<<material>>
treated in
<<subkind>>
Healthcare Provider


Existential Dependence
Entity
Concrete Entity
Abstract Entity
Quality Space
Object
Aspect
Intrinsic Aspect
Relator
Mode
Quality


<<mediation>>
<<relator>>
Treatment
<<mediation>>
1..*
1..*
1..*
1
1
1..*
1..*
<<role>>
Patient
<<subkind>>
Healthcare Provider
<<material>>
treated in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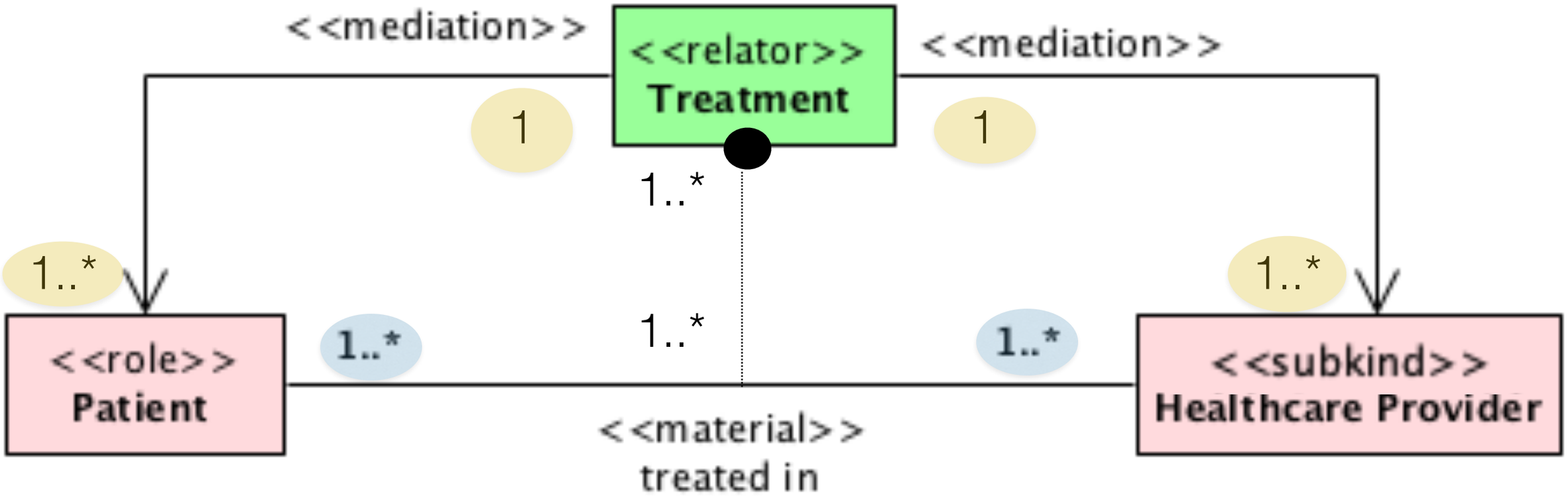
<<relator>>
Treatment
<<mediation>>
1..*
1..*
1..*
1
1
1..*
<<role>>
Patient
<<subkind>>
Healthcare Provider
<<material>>
treated in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Treatment
<<mediation>>
1
1
1..*
1..*
1..*
1..*
<<role>>
Patient
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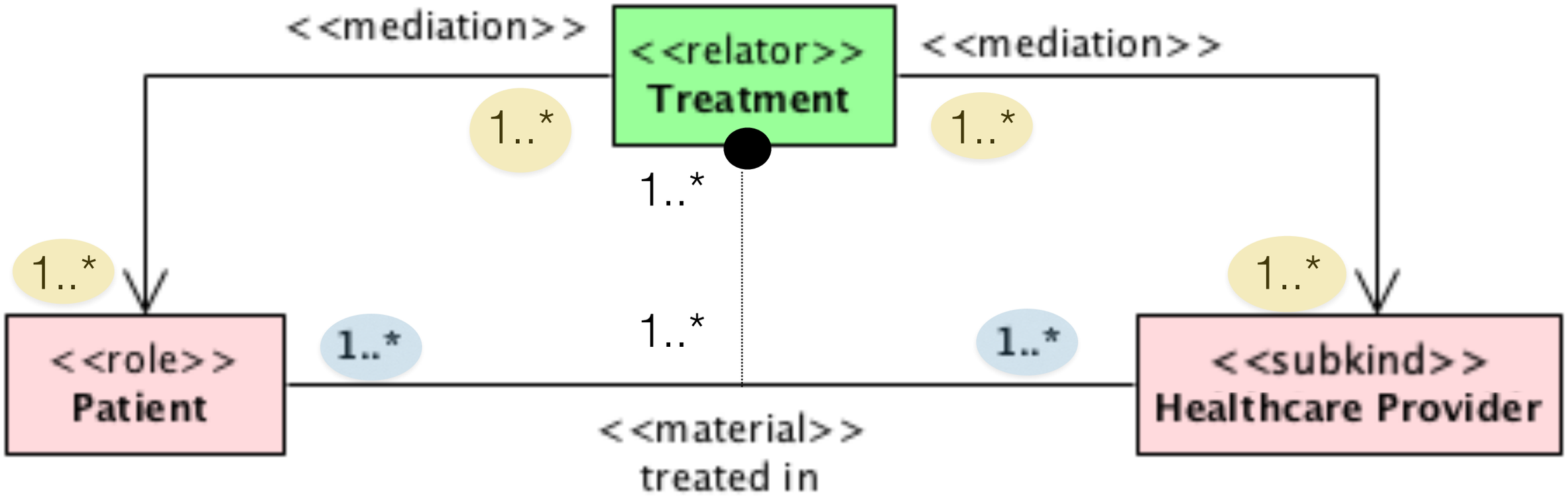
Healthcare Provider
<<material>>
treated in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Treatment
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1..*
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1..*
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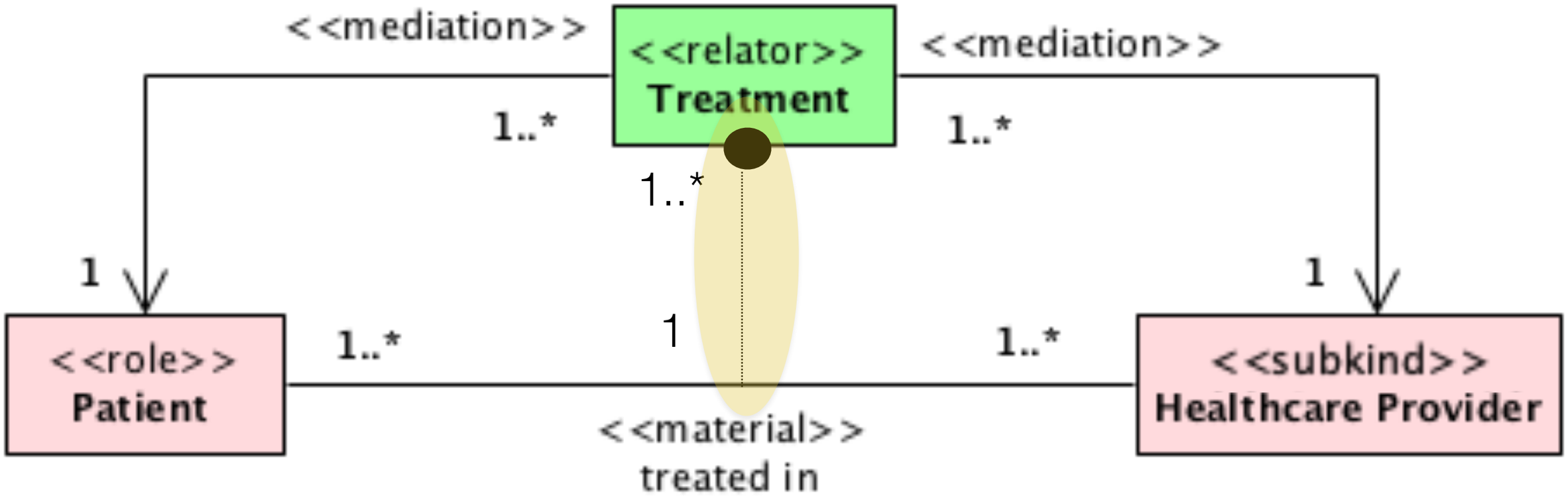
Patient
1..*
1..*
1..*
<<subkind>>
Healthcare Provider
<<material>>
treated in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Treatment
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1..*
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1
1..*
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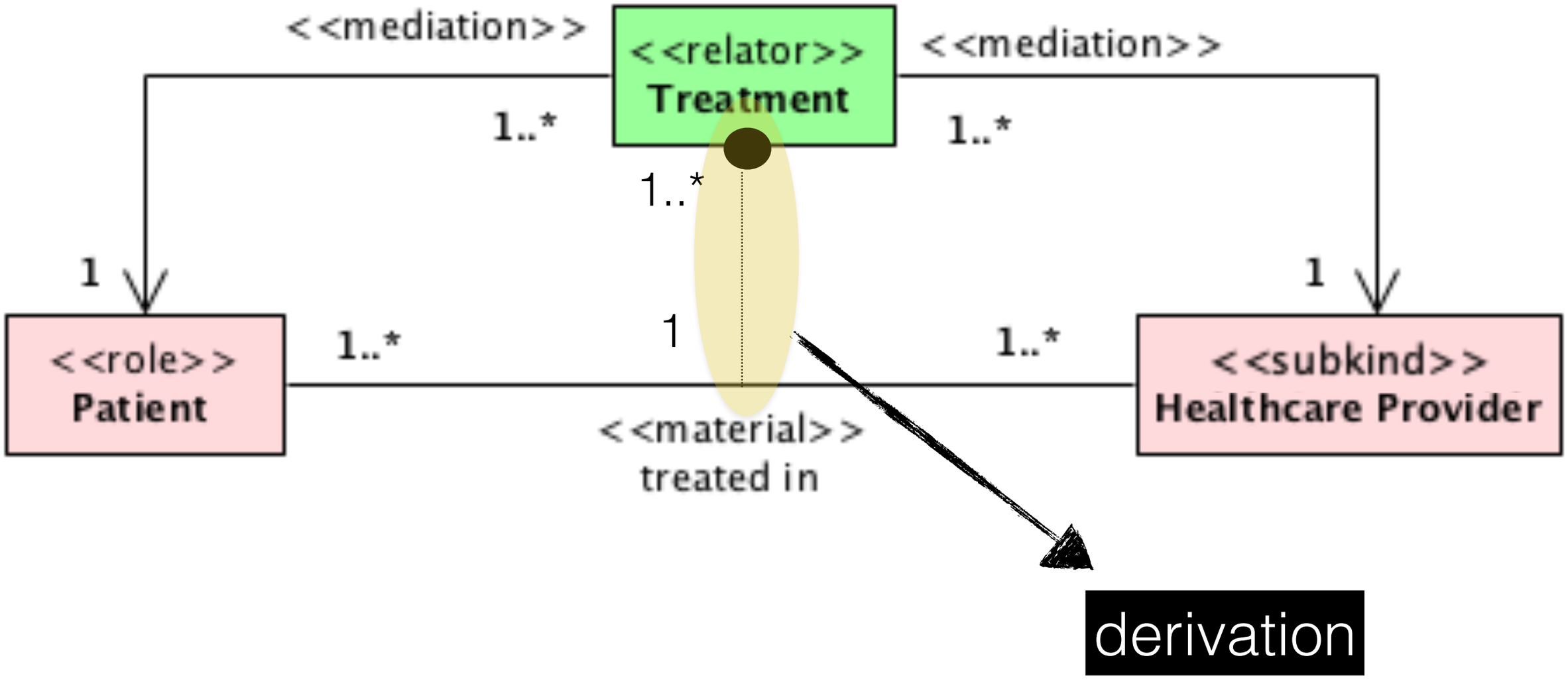
Patient
<<material>>
treated in
<<subkind>>
Healthcare Provider


<<mediation>>
<<relator>>
Treatment
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1..*
1..*
1..*
1
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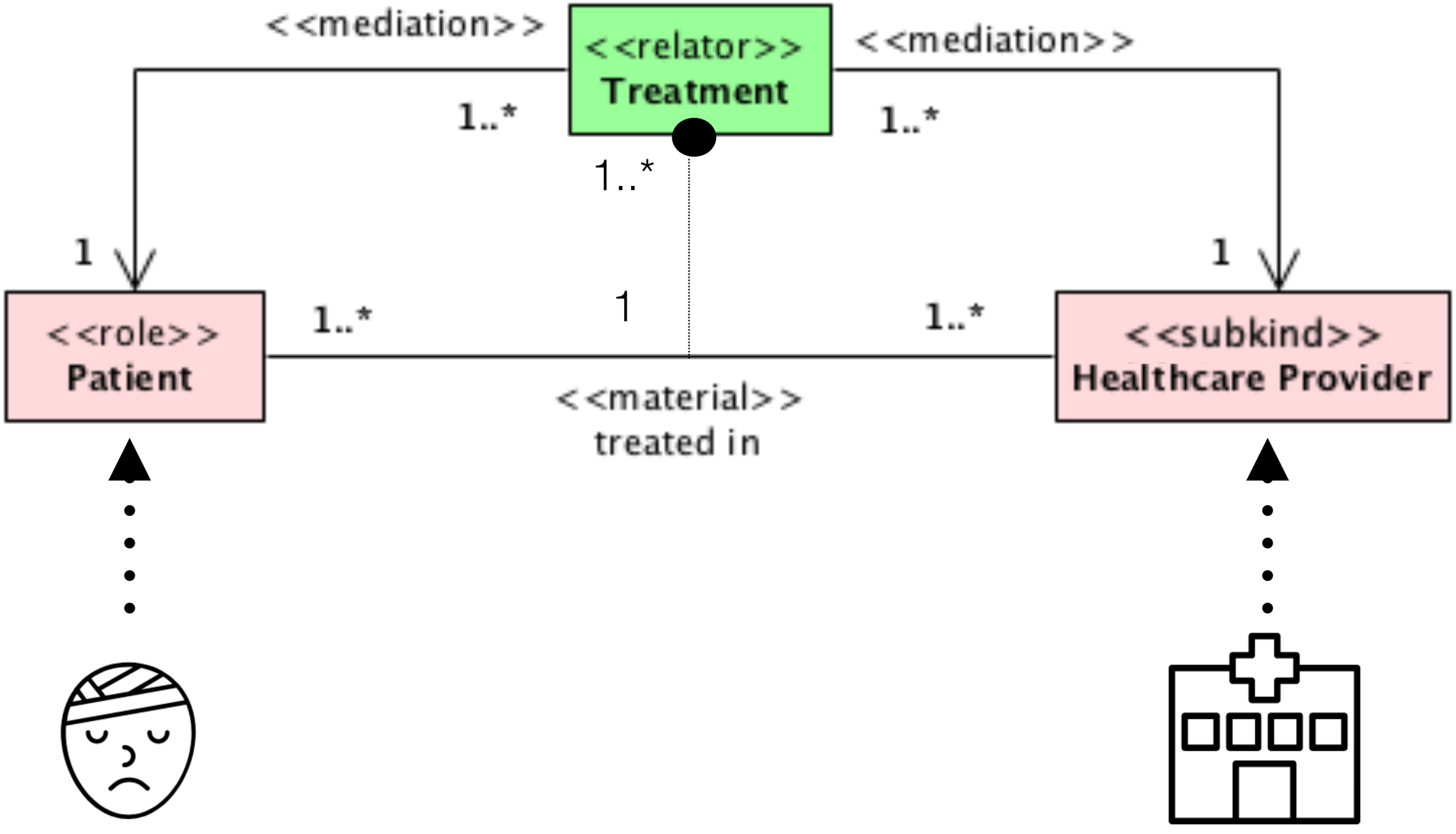
1..*
<<role>>
Patient
1..*
<<subkind>>
Healthcare Provider
<<material>>
treated in
derivation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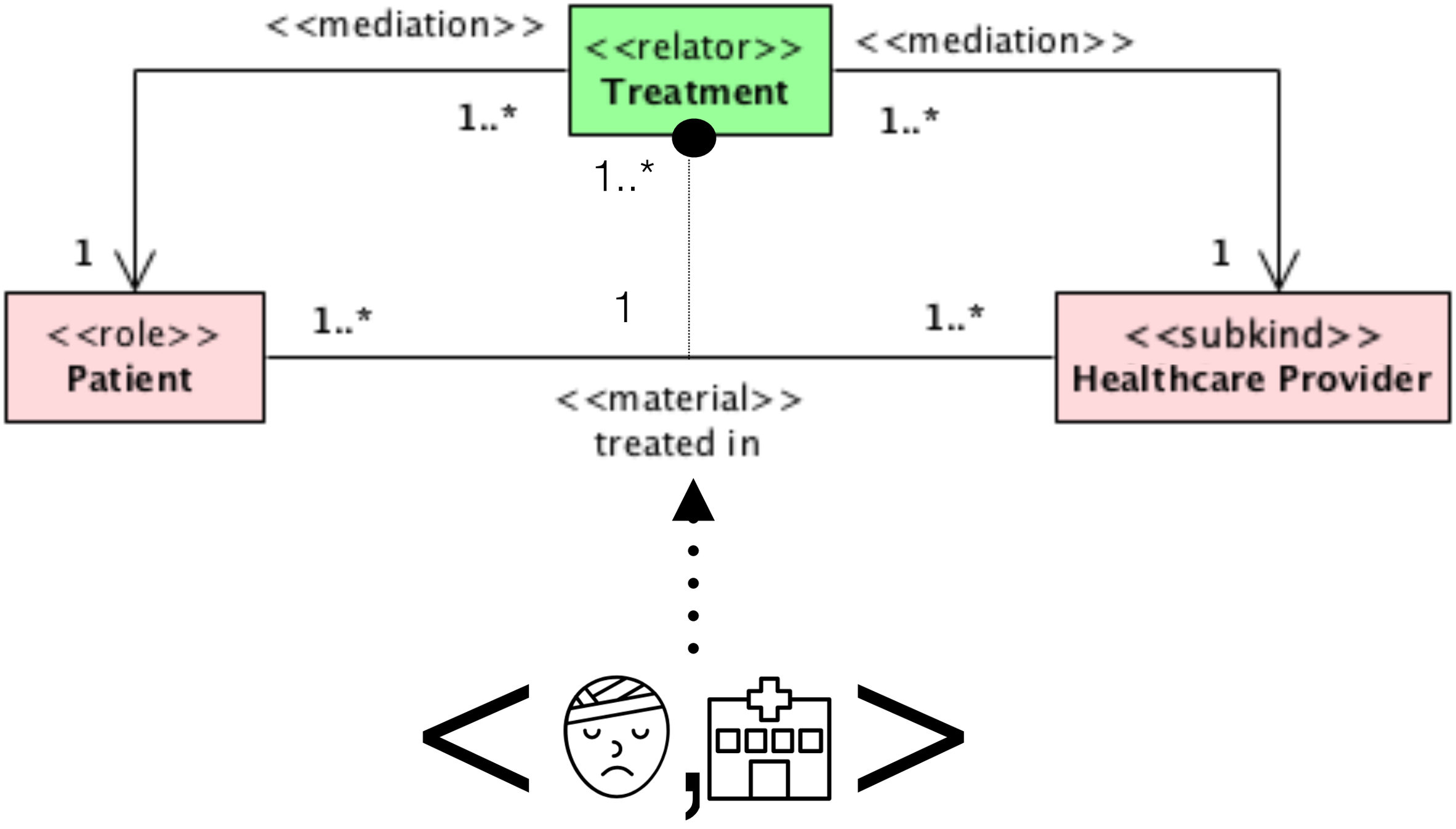
<<relator>>
Treatment
<<mediation>>
1..*
1..*
1..*
1
1
1..*
<<role>>
Patient
<<material>>
treated in
<<subkind>>
Healthcare Provider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Treatment
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1..*
1..*
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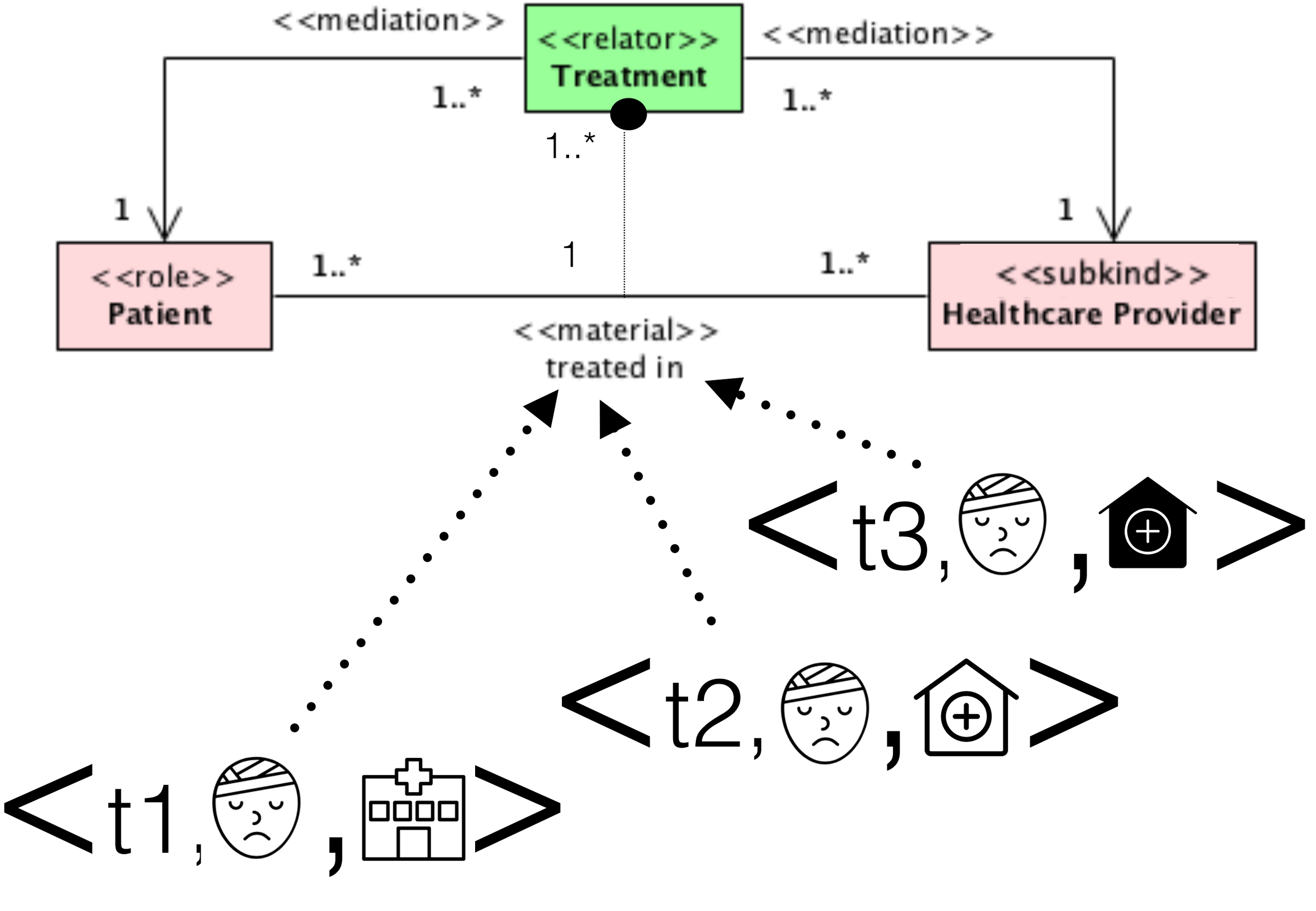
1
1..*
<<role>>
Patient
<<subkind>>
Healthcare Provider
<<material>>
treated in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Treatment
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1..*
1..*
1
1
<<role>>
Patient
1..*
1
1..*
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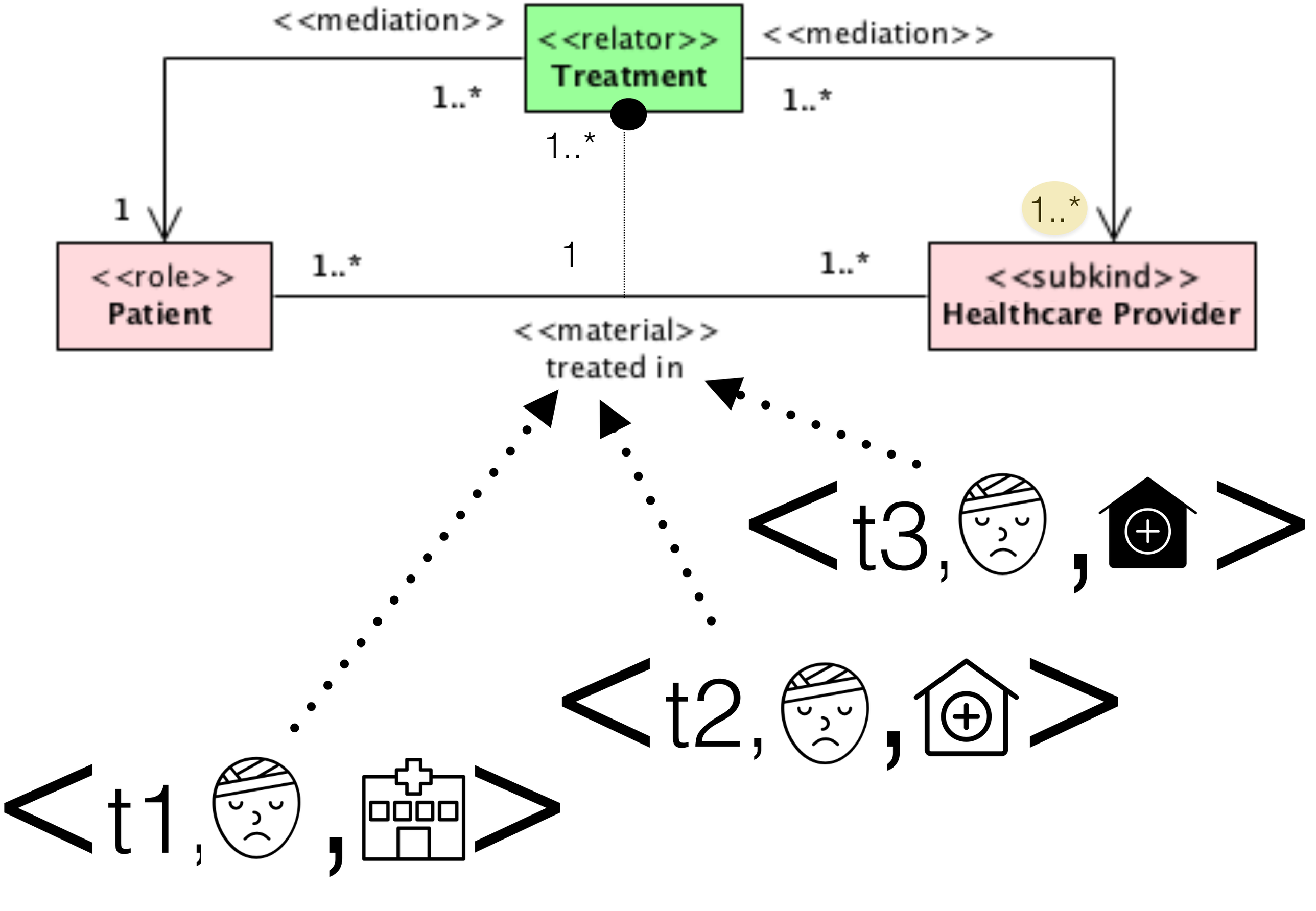
Healthcare Provider
<<material>>
treated in
<t3, , >
<t2, , >
<t1, , >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<<relator>>
Treatment
<<mediation>>
1..*
1..*
1..*
1
1..*
1
1..*
1..*
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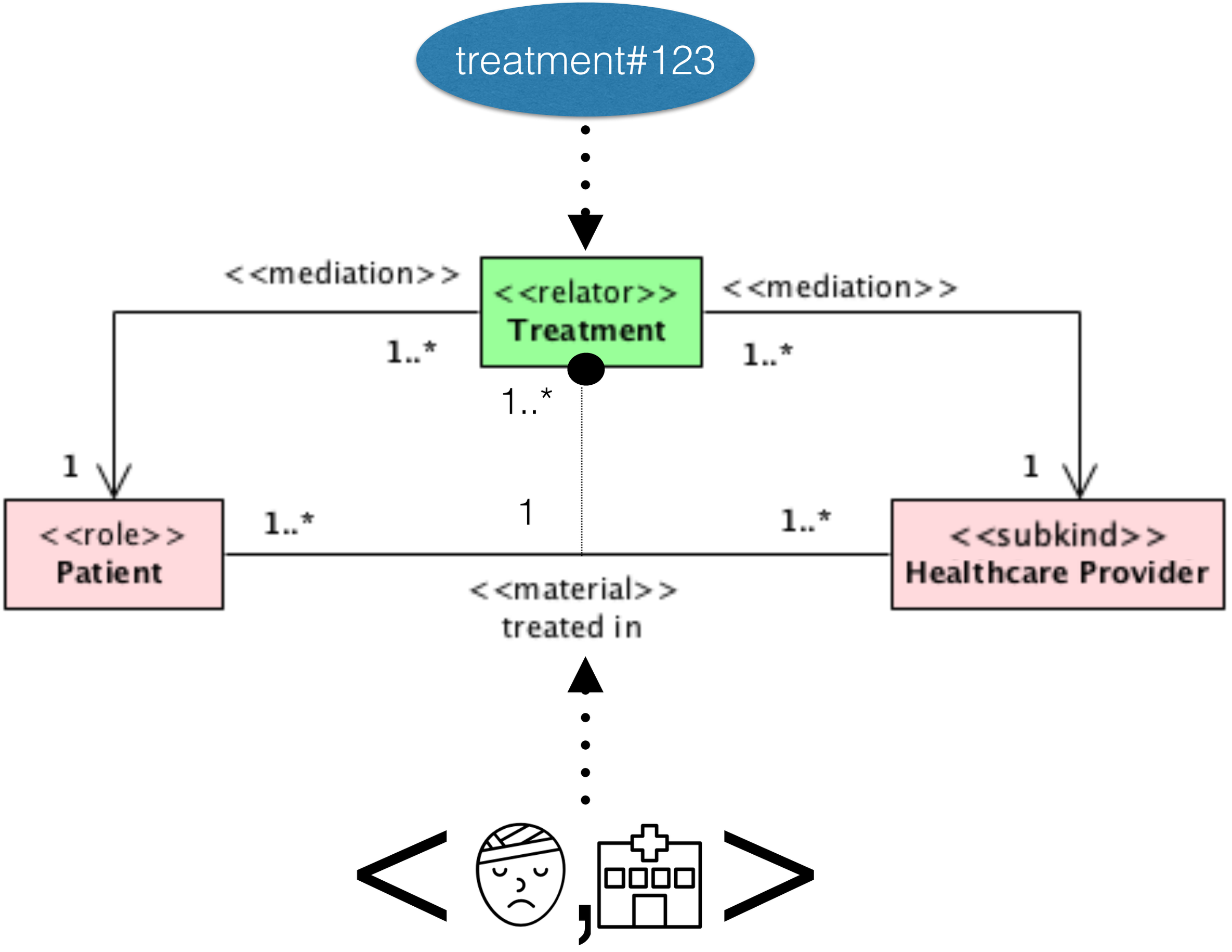
Patient
<<subkind>>
Healthcare Provider
<<material>>
treated in
<t3, , >
<t2, , >
<t1, , >


treatment#123
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<<relator>>
Treatment
<<mediation>>
1..*
1..*
1..*
1
1
1..*
1..*
<<role>>
Patient
<<subkind>>
Healthcare Provider
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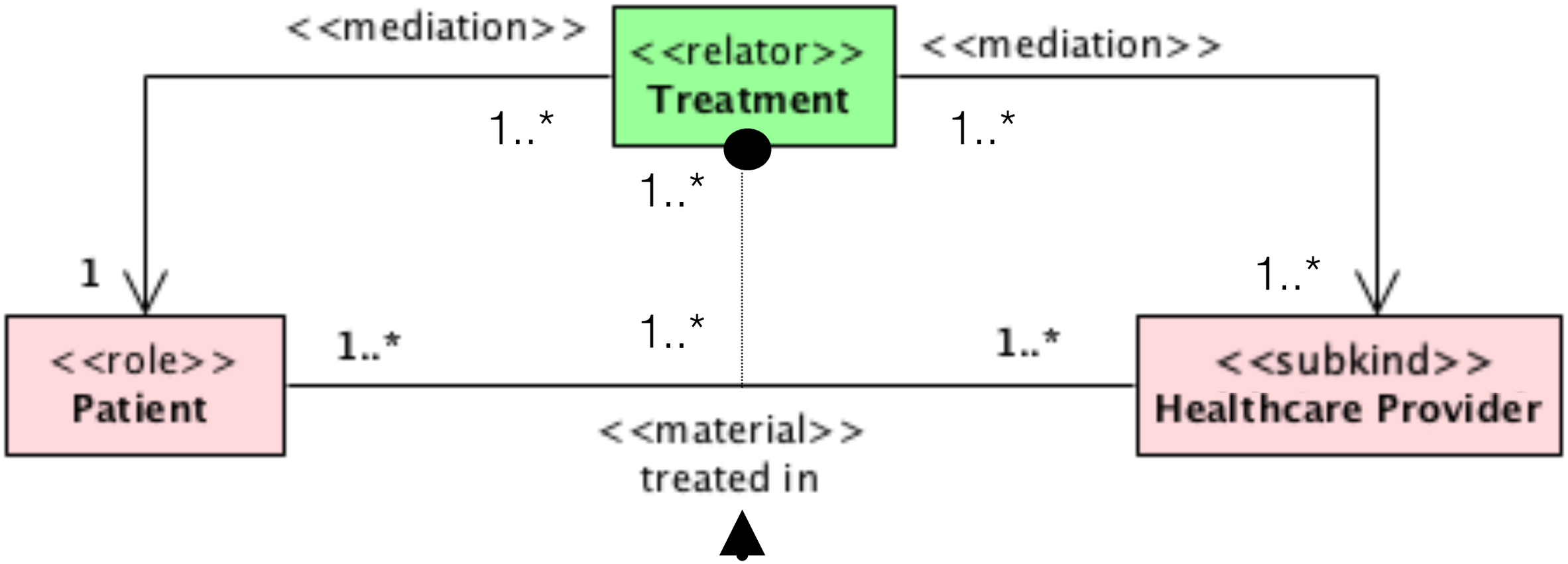
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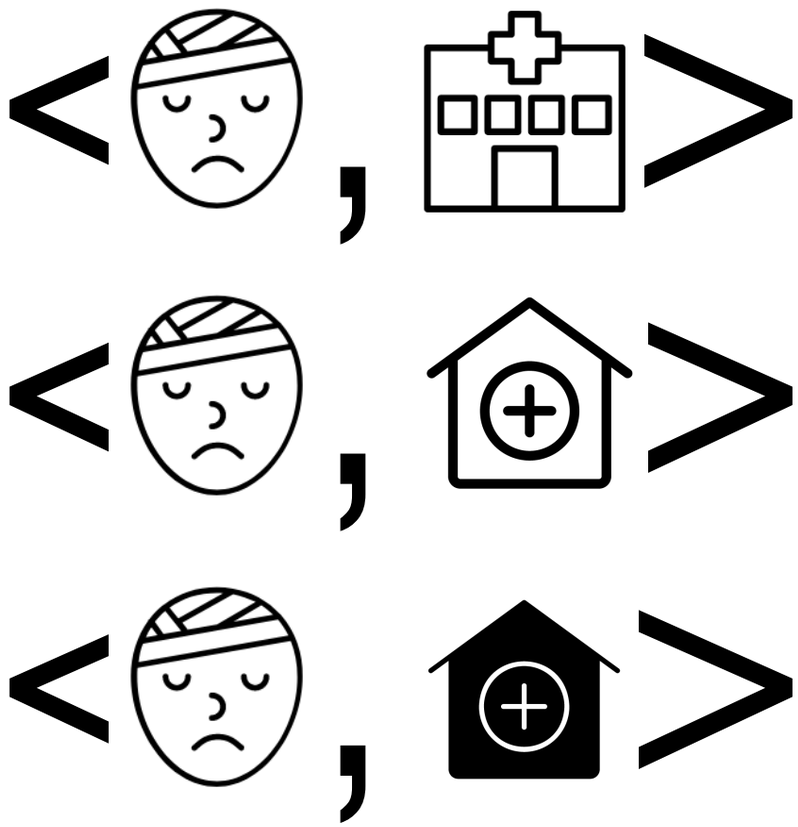

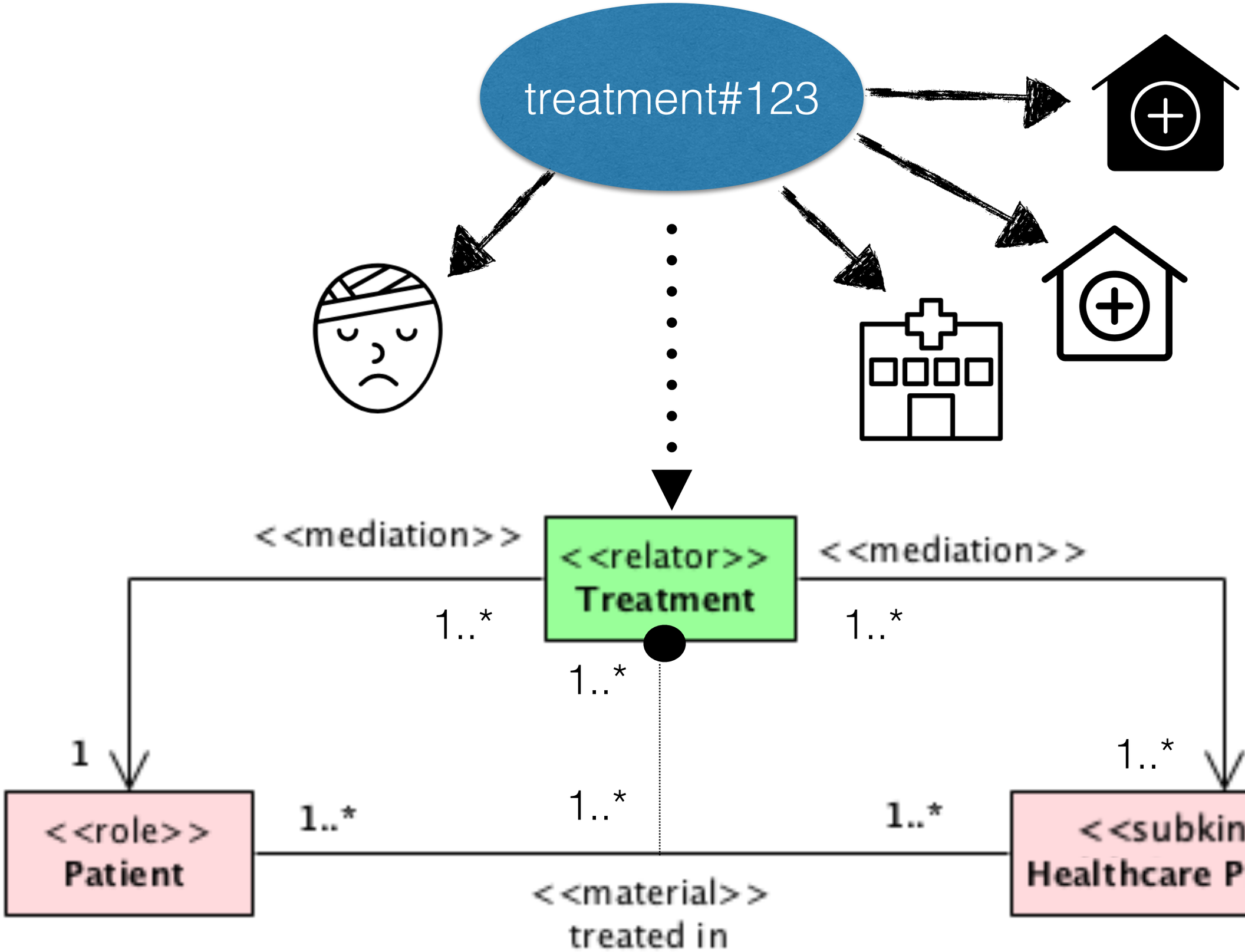
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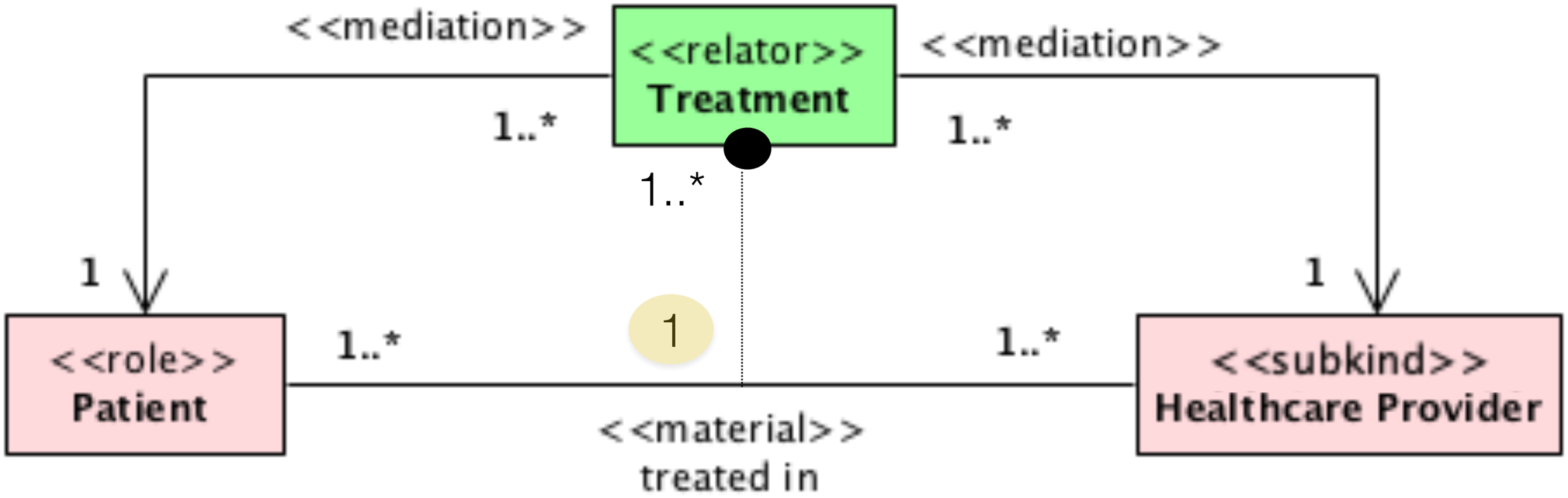
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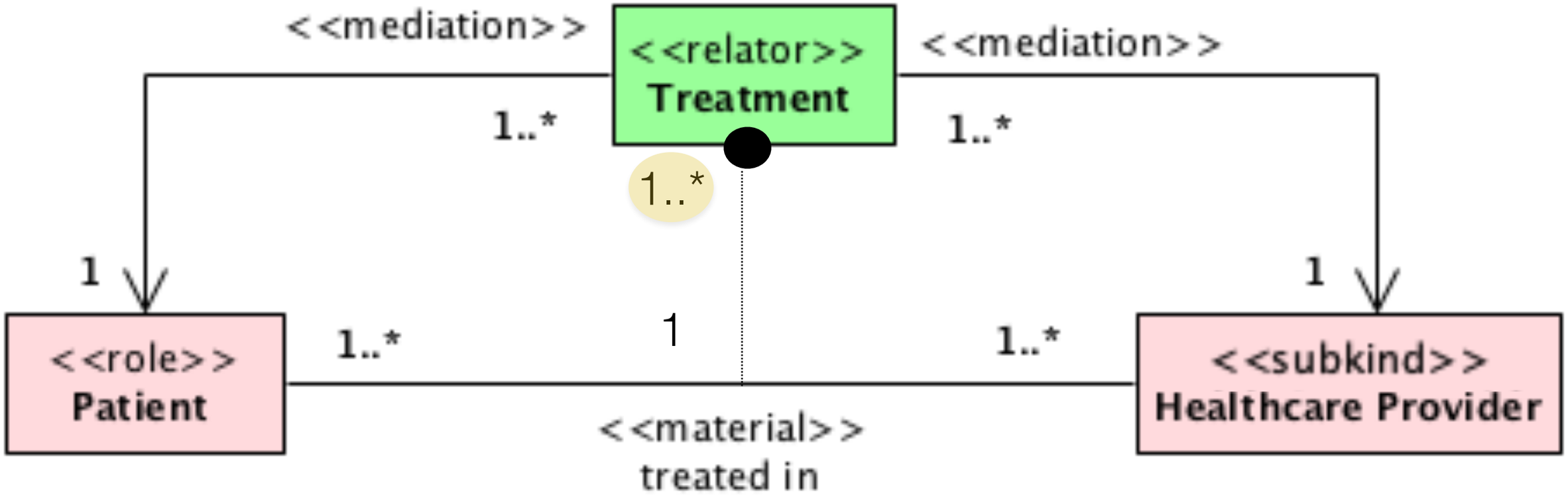
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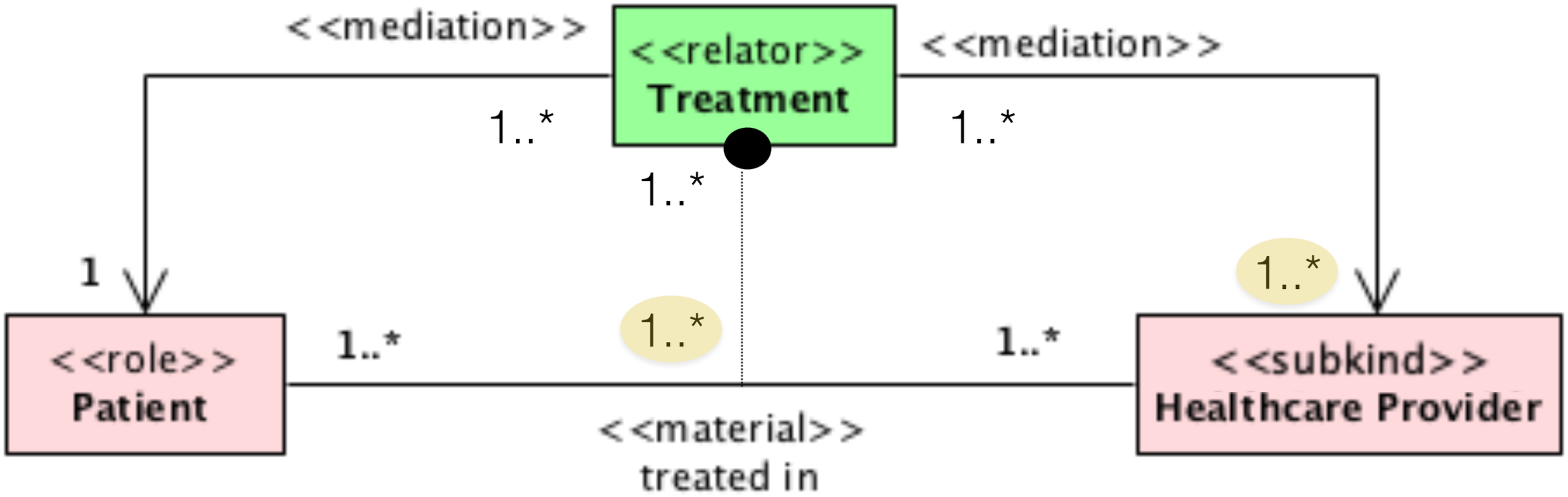
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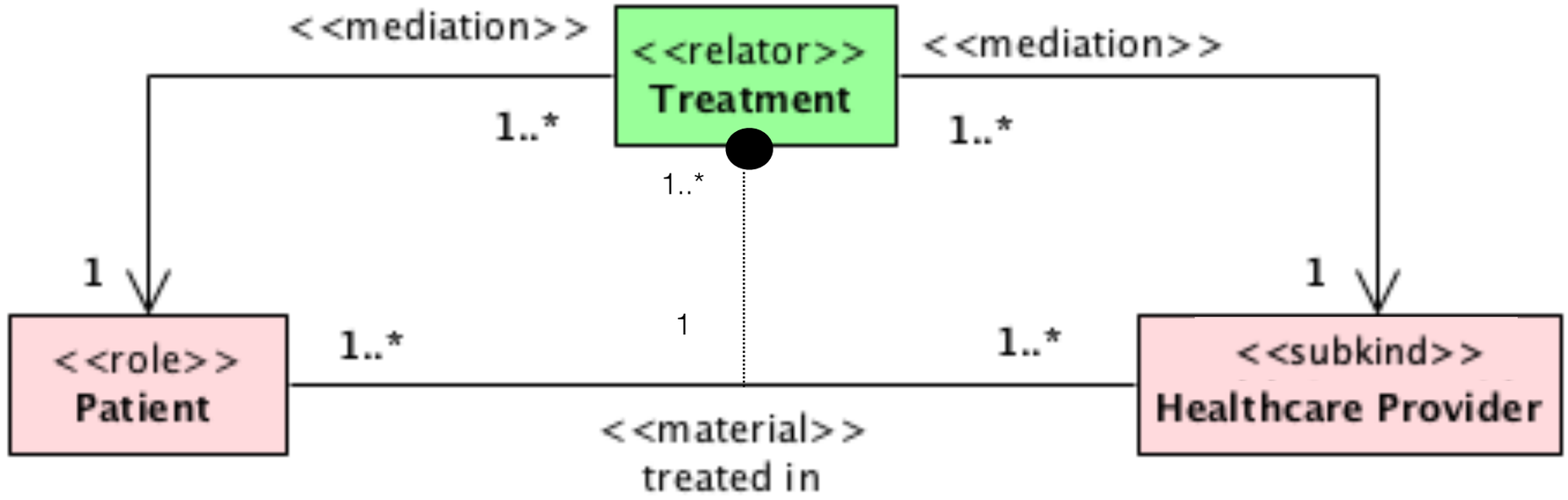
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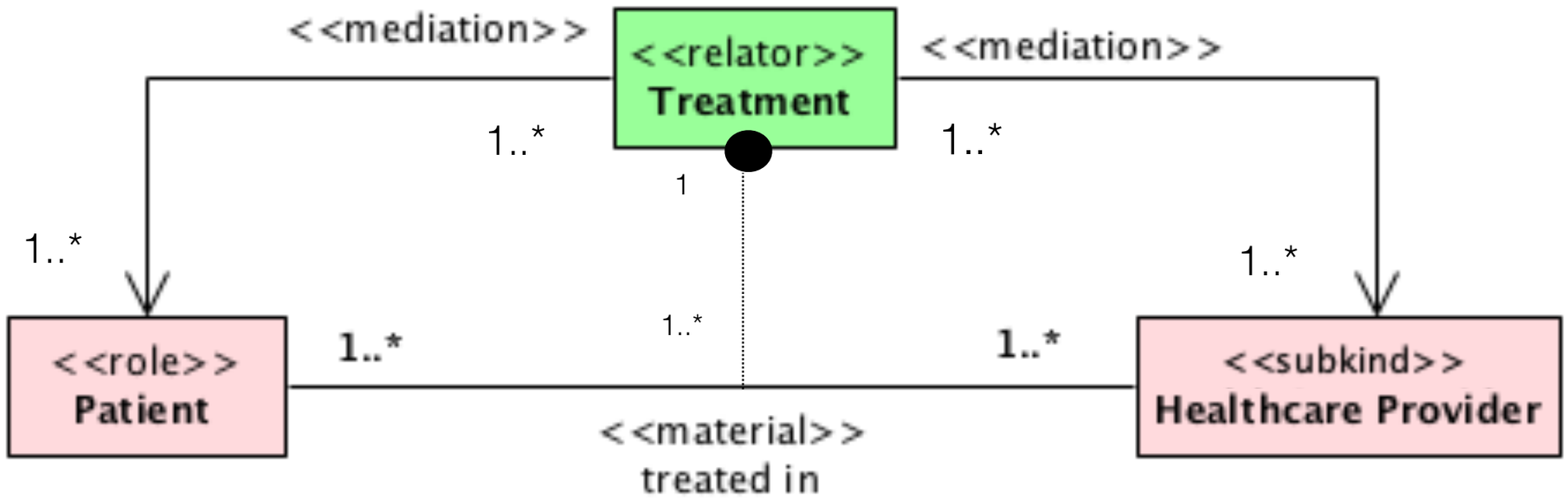
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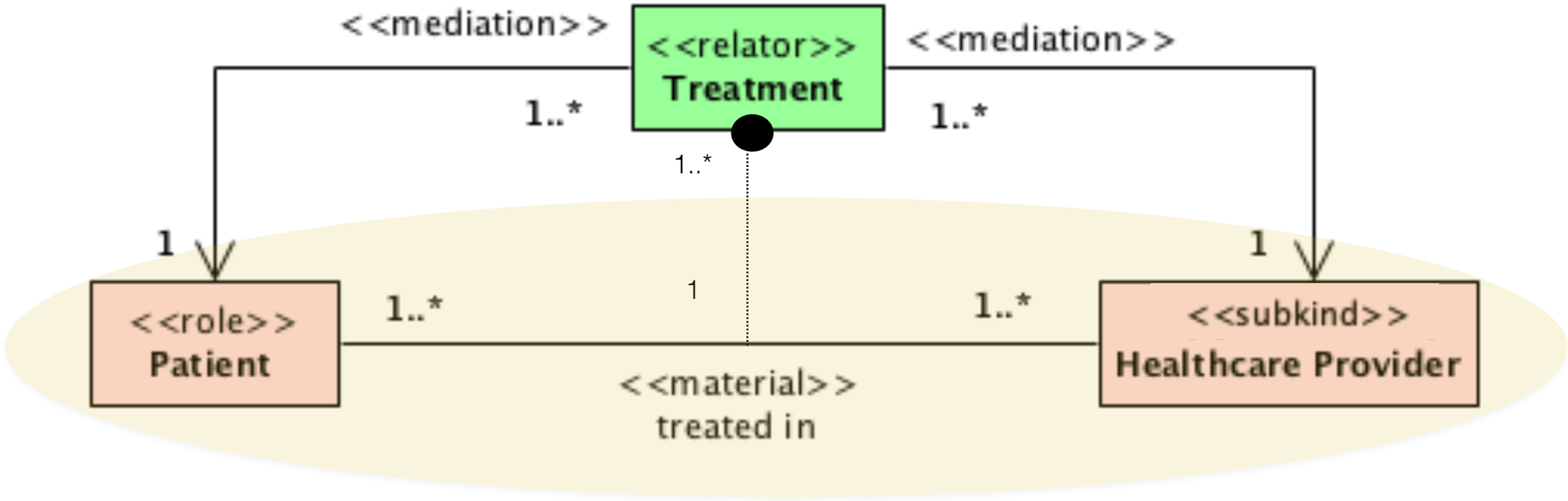
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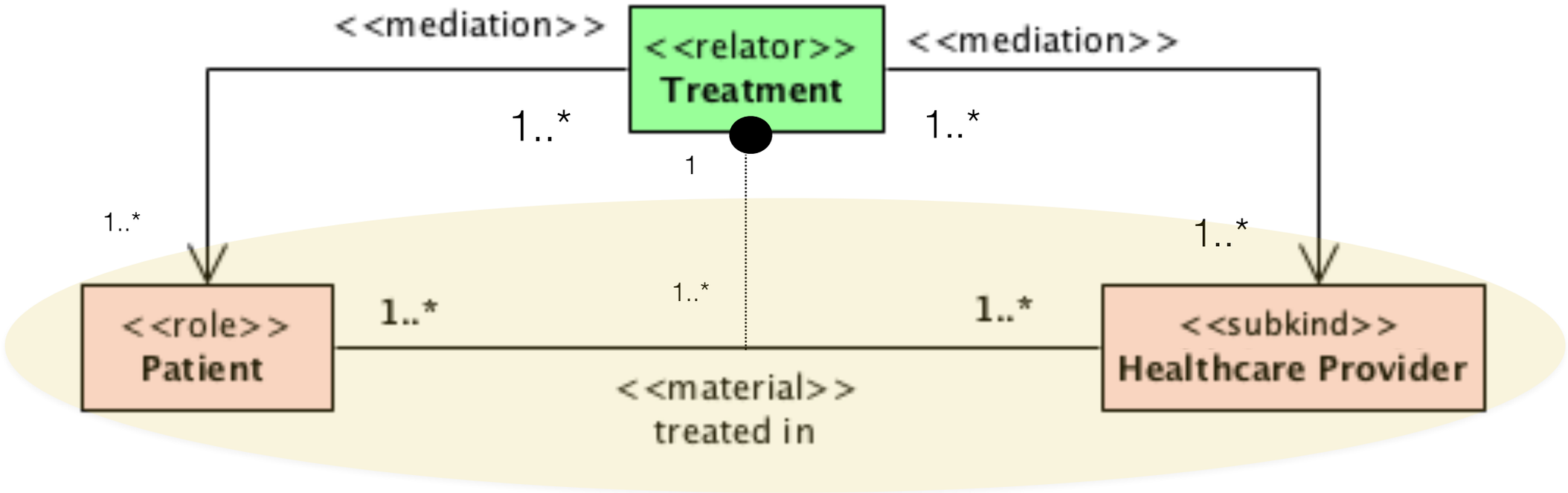
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Healthcare Provider
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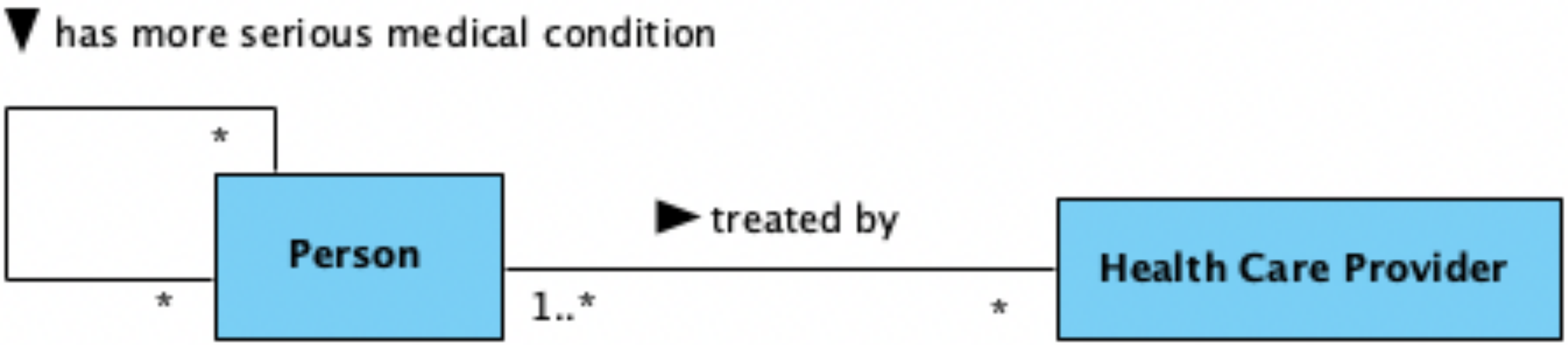
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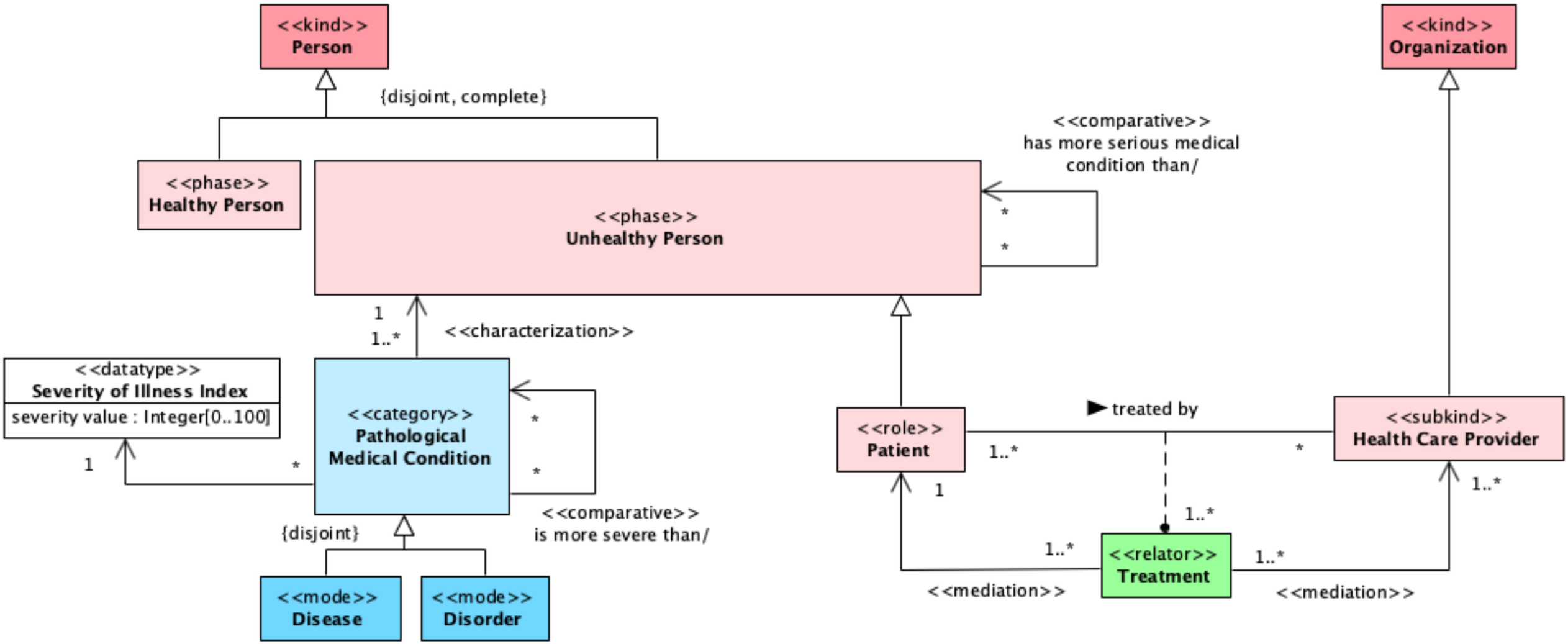
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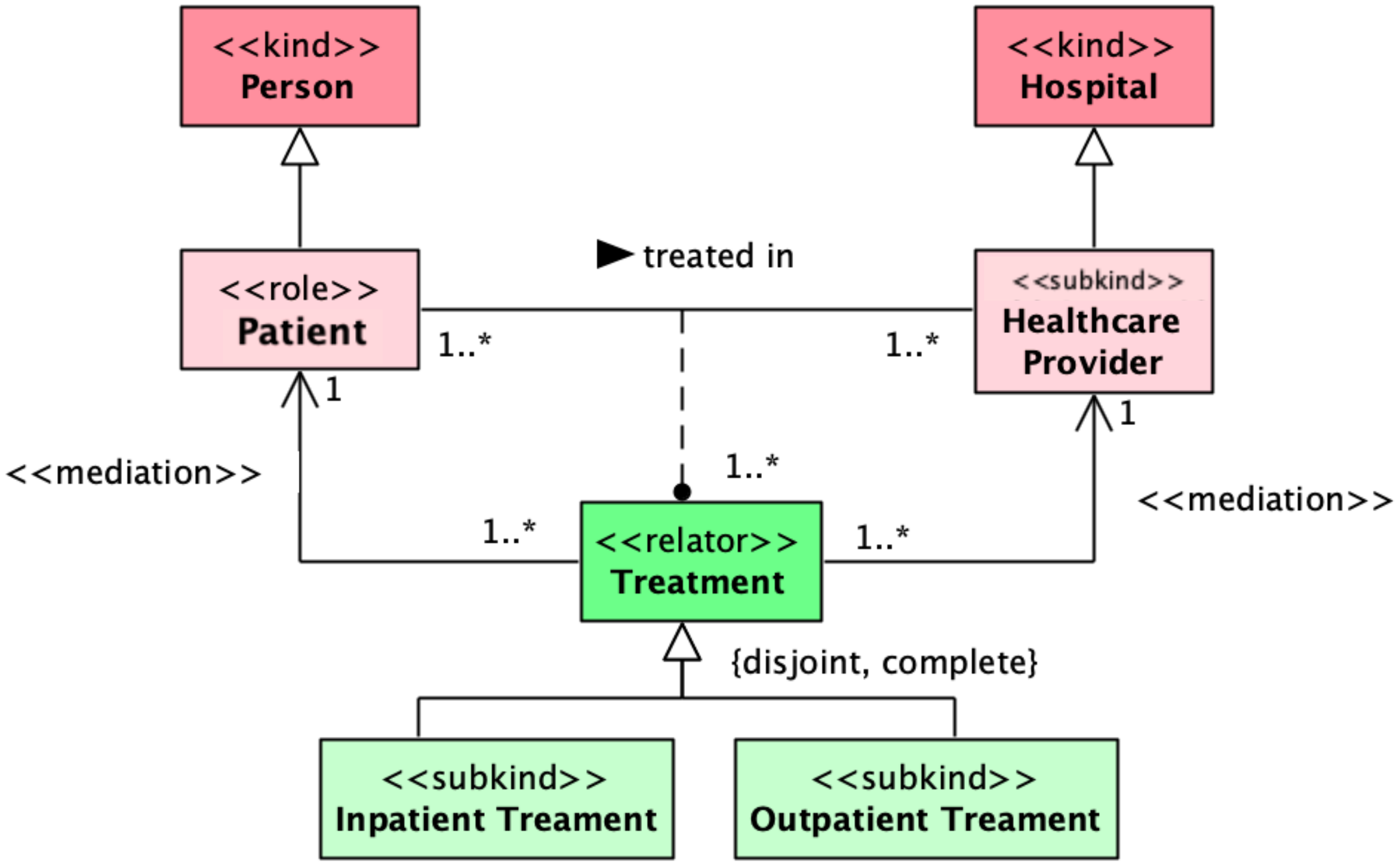
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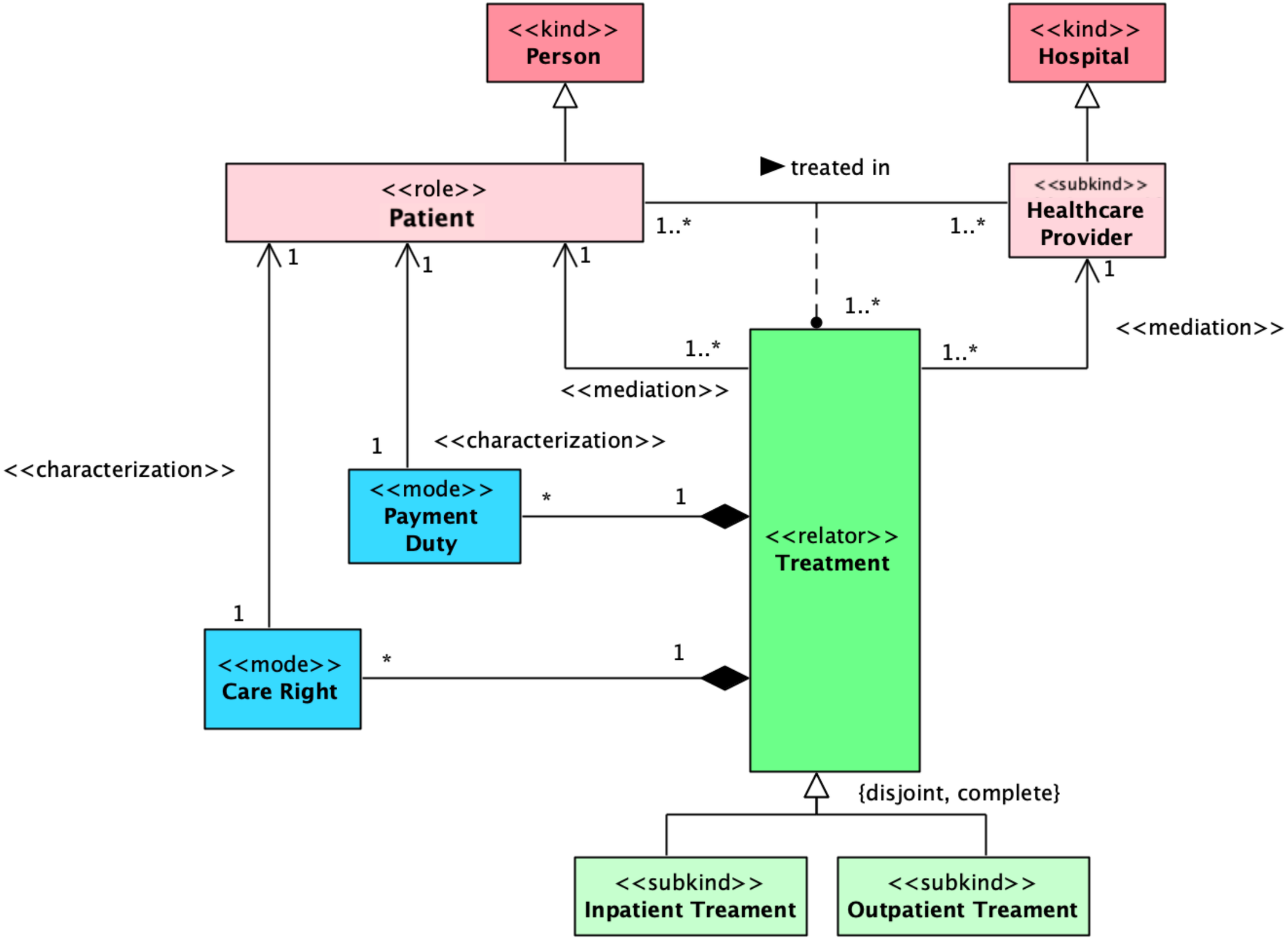
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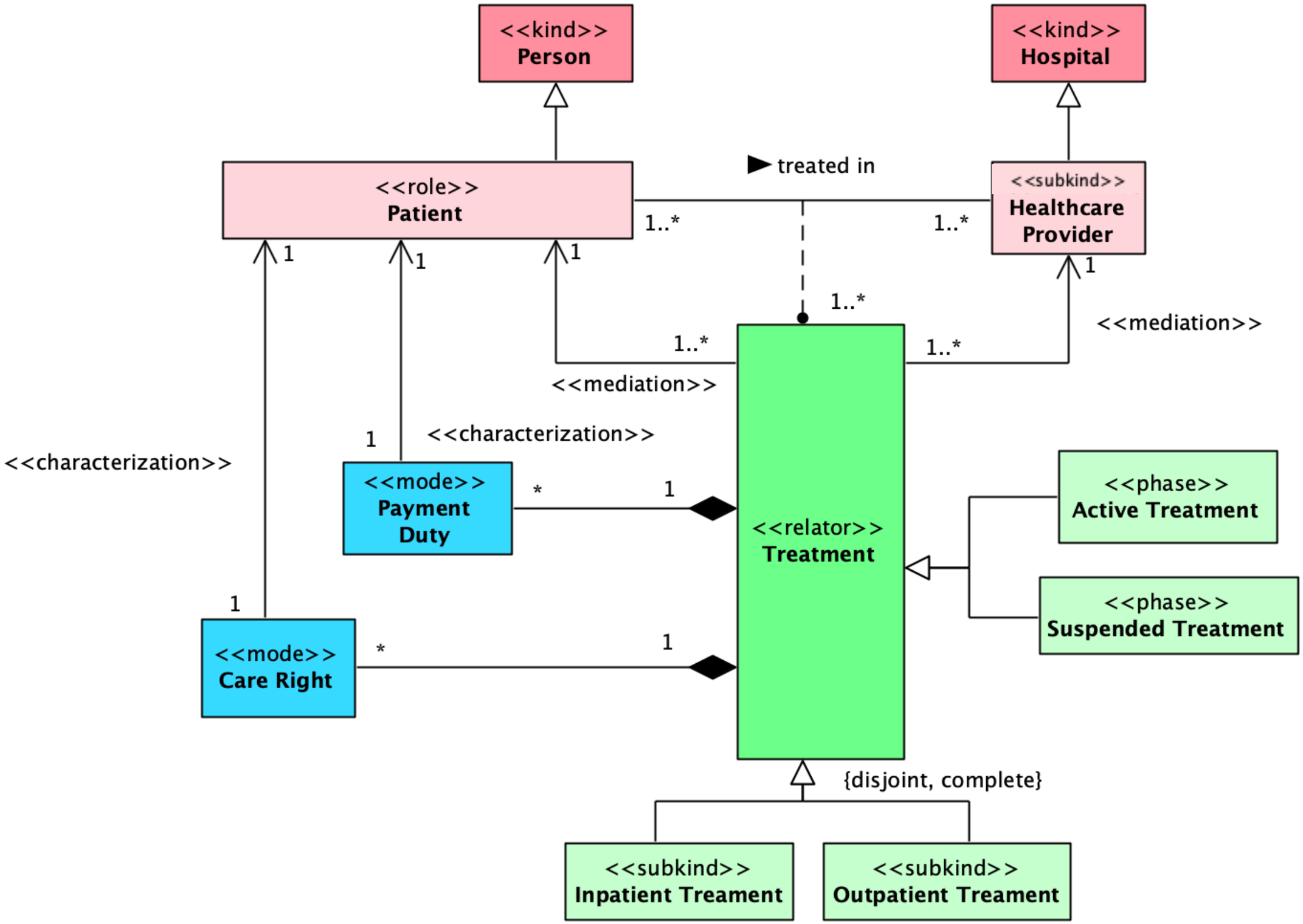
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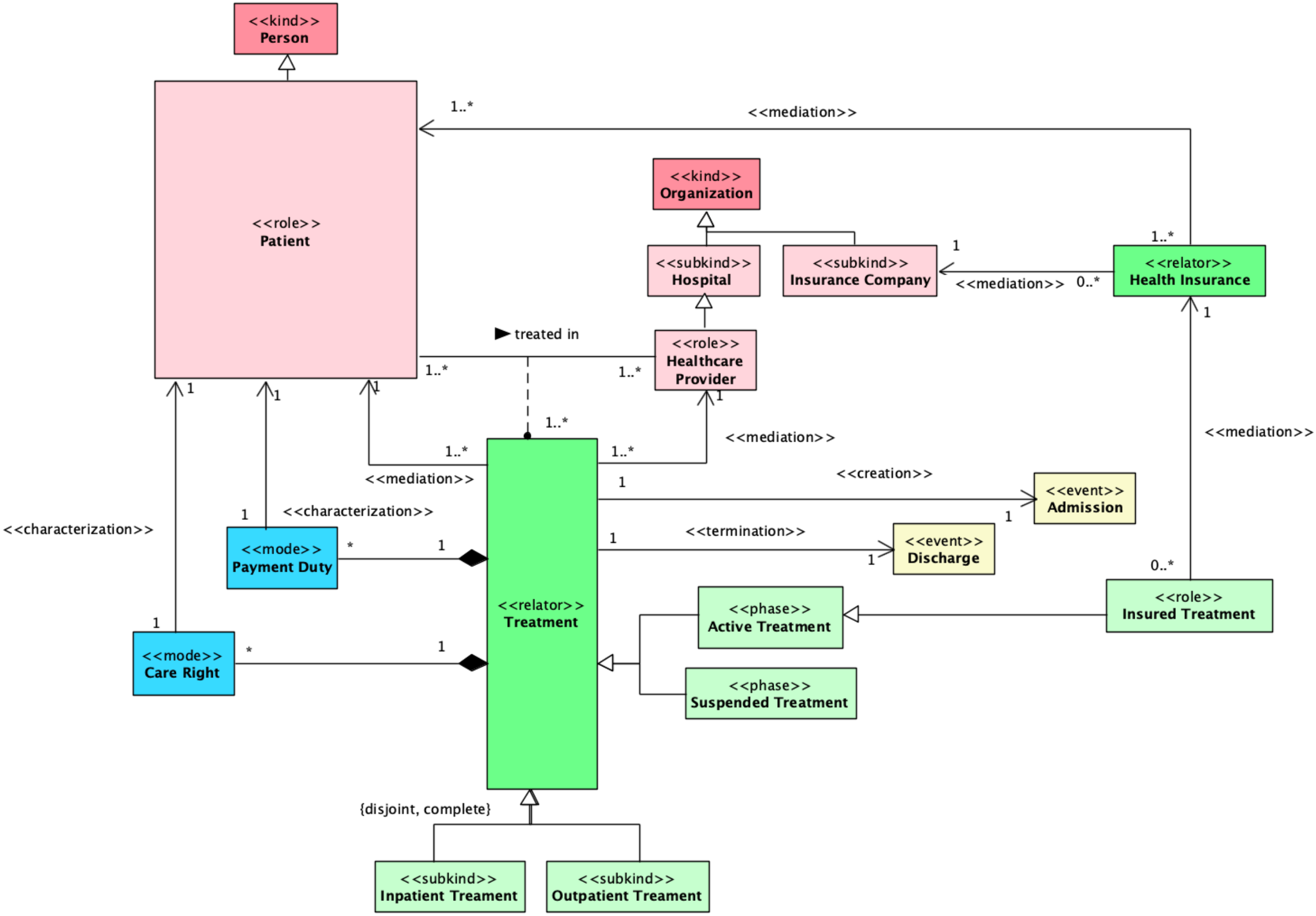
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Outpatient Treament

# **Unpacking** Relations

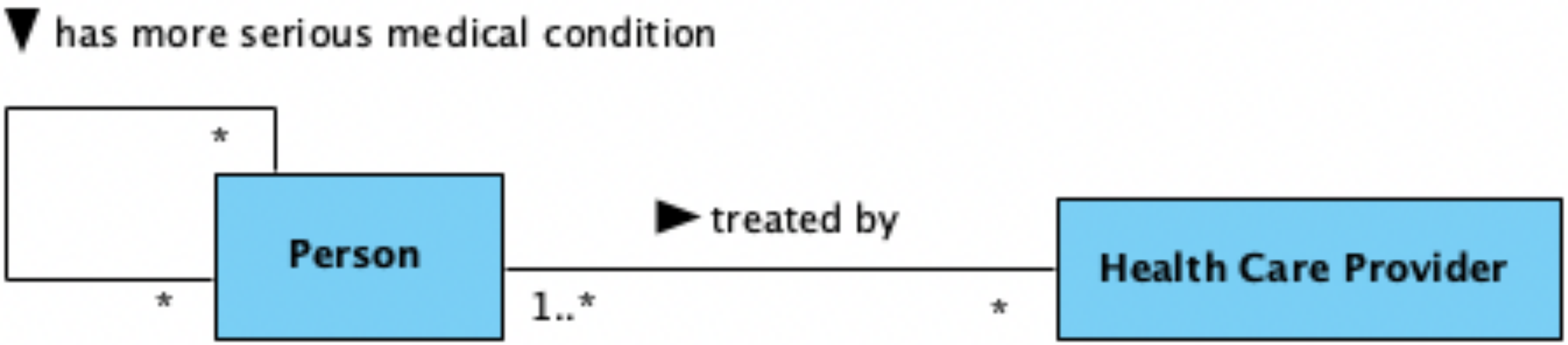
1. Truthmaking
2. Disambiguation (**Semantic Clarity**)
3. Helps to elicit tacit knowledge that would otherwise remain tacit (**Completeness**)
4. Makes justice to the complexity of the relational phenomena (**Precision**)
5. It helps differentiating subsetting, redefinition and specialisation between relations
6. It solves the problem of transitivity of parenthood
7. It disambiguates between relators and events

The difference between these models is not just one of **expressivity** but one of **nature**!
(Descriptive x Explanatory)

"Traditionally, theories are said to bear two sorts of relation to the observable phenomena: **description** and **explanation**. Description can be more or less accurate, more or less informative; as a minimum, the facts must 'be allowed by the theory' (fit some of its models), as a maximum the theory actually implies the facts in question."

“**Explanation is…‘over and above’ description**; for example, Boyle’s law describes the relationship between the pressure, temperature, and volume of a contained gas, but does not explain it - kinetic theory explains it”
(Bas van Fraasen)

To **explain** is to **reveal** one's **ontological commitment** (**real-world semantics**) and that is what is **needed for semantic interoperability**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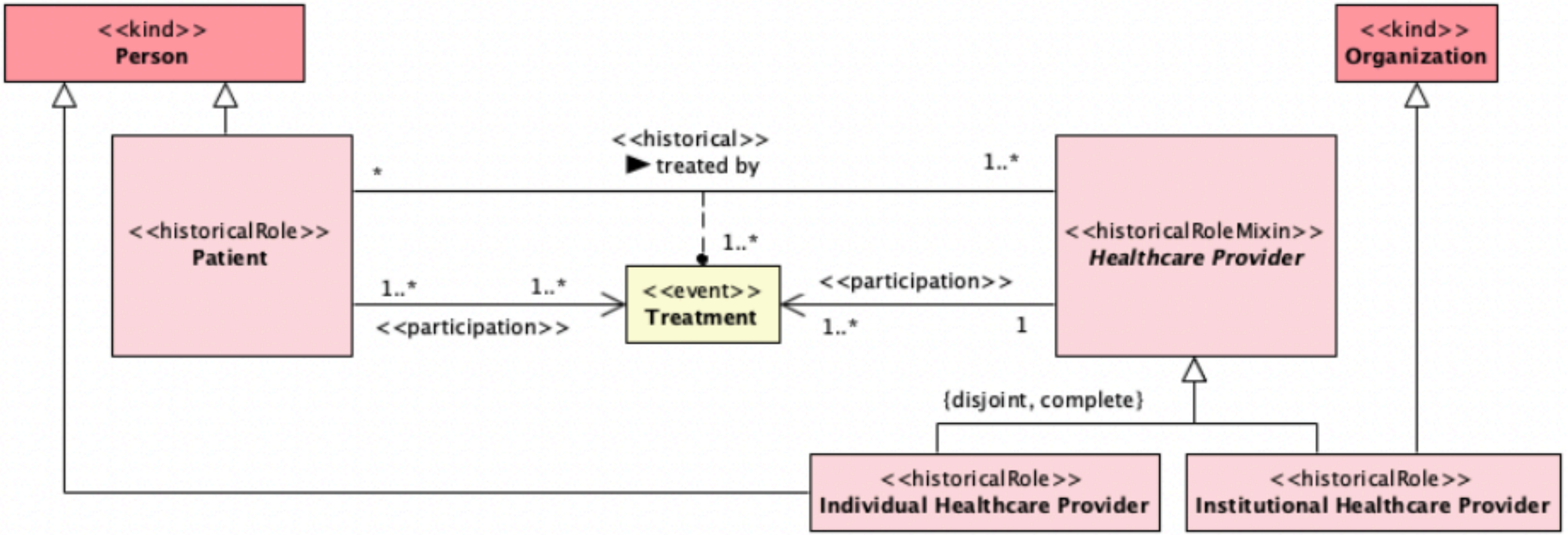
*
Person
treated by
1..*
*
Health Care Provider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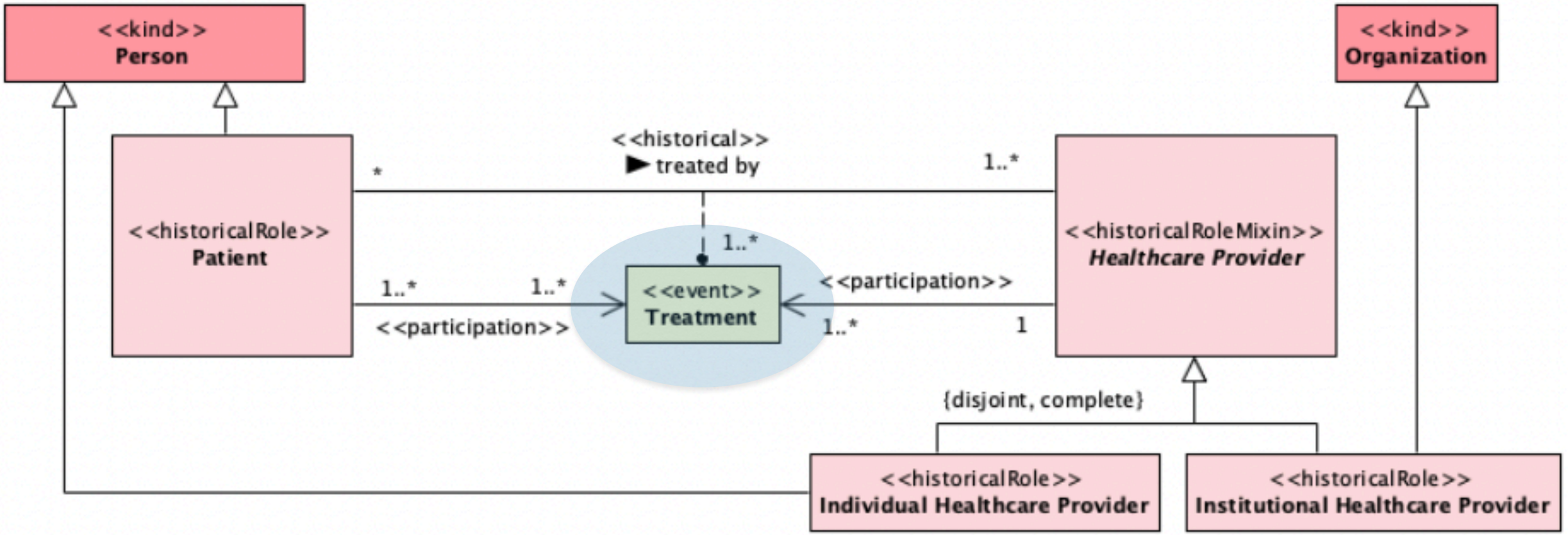
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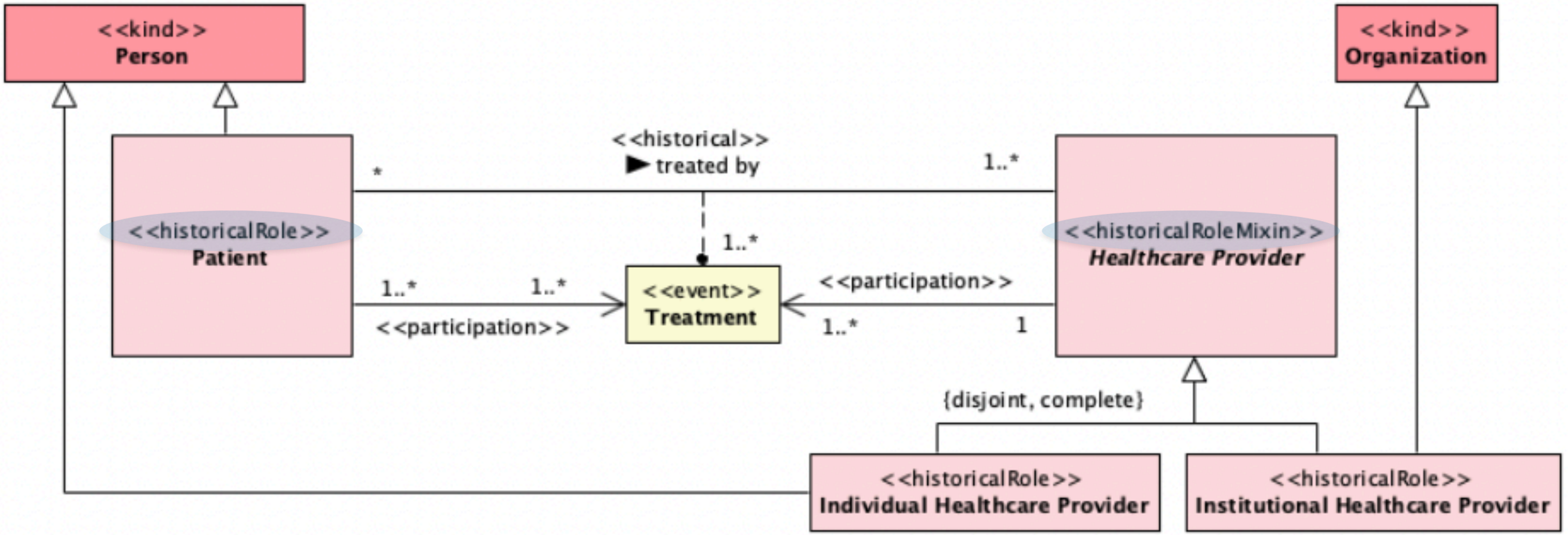
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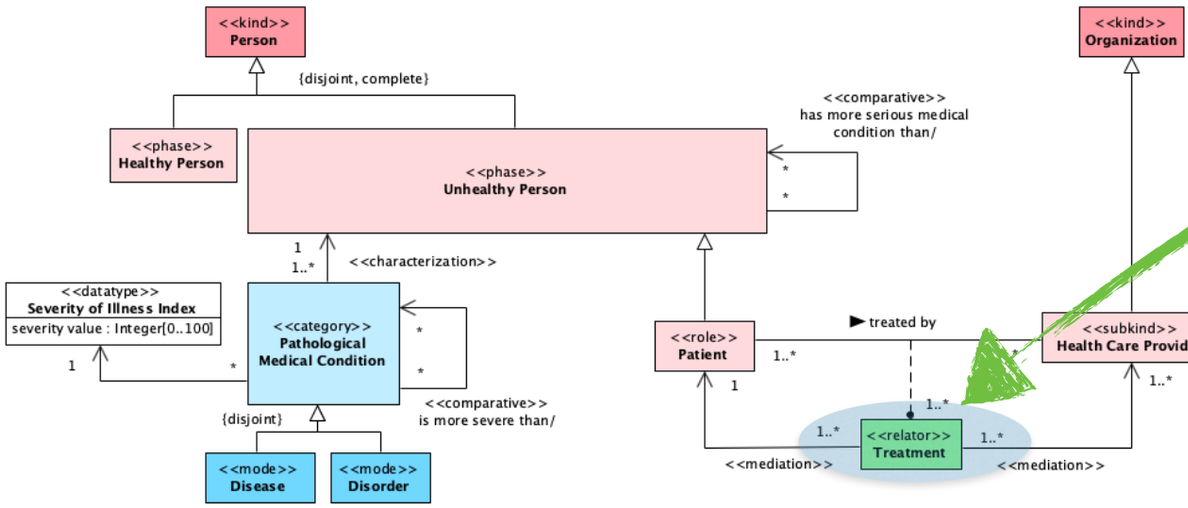
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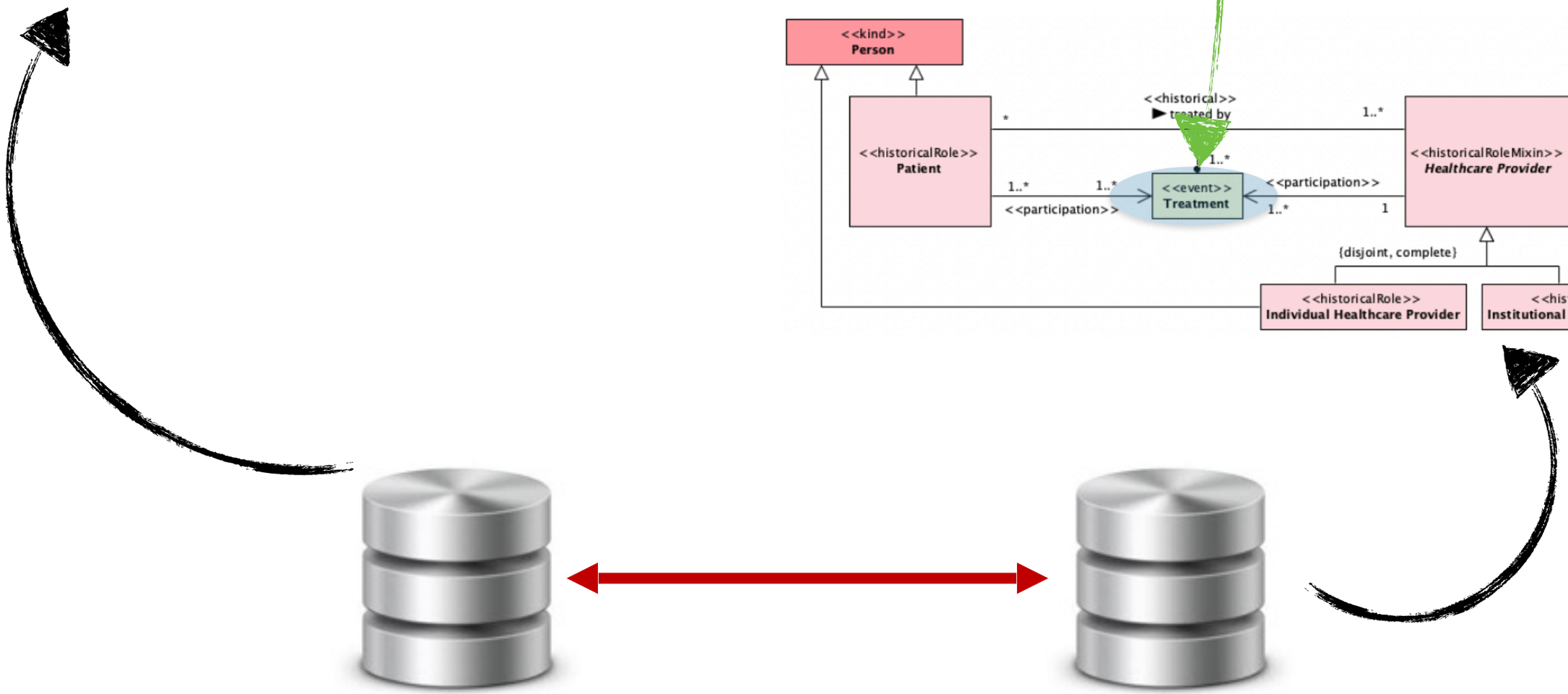
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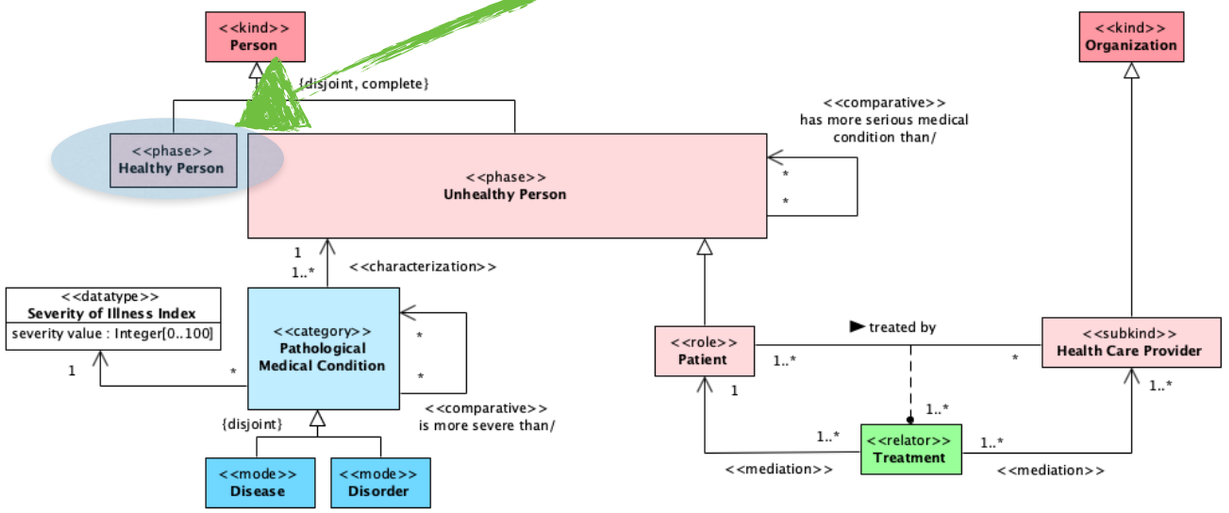
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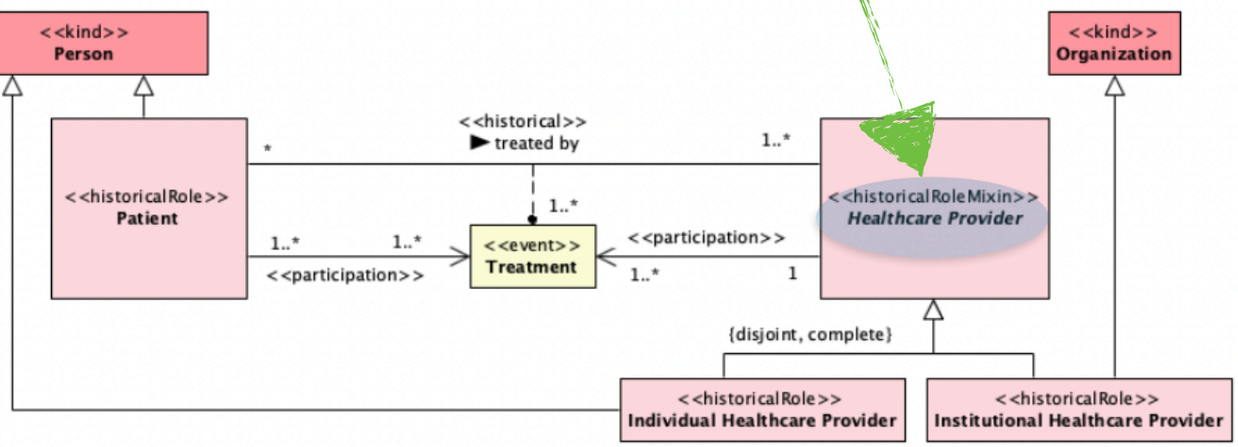
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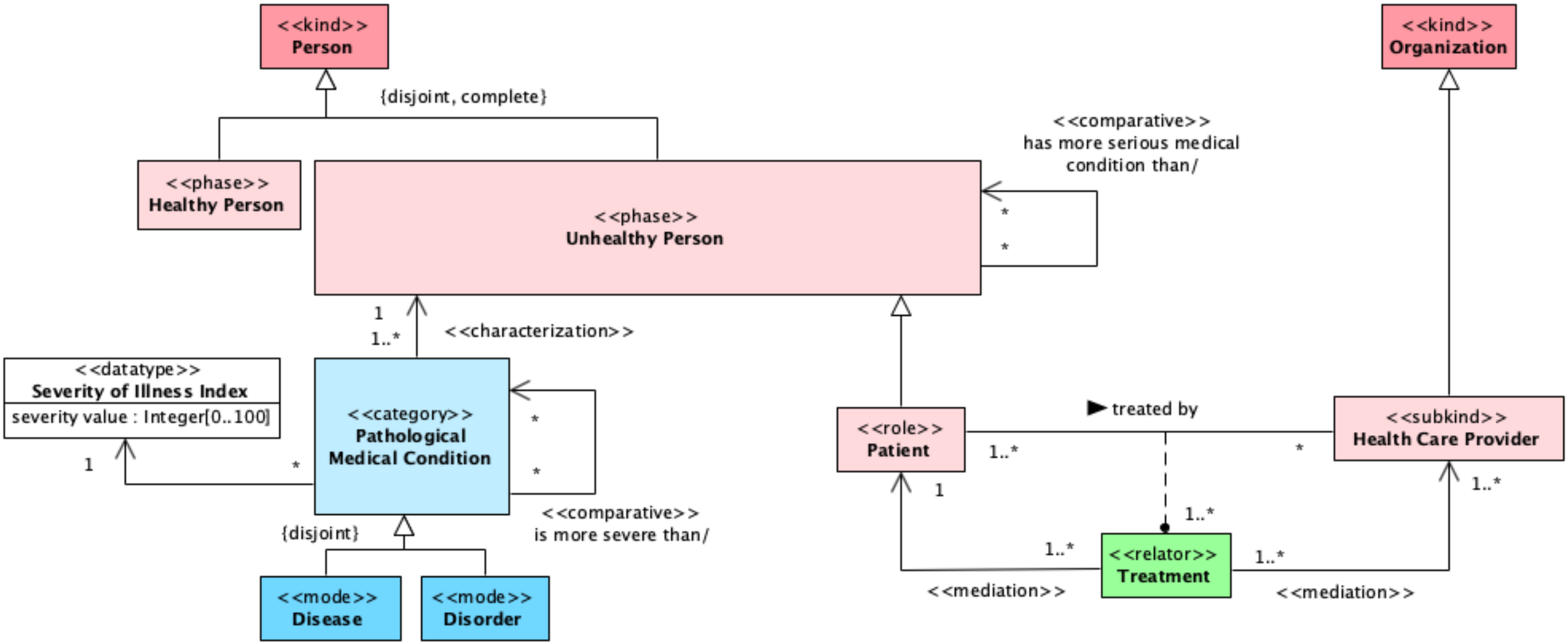
Institutional Healthcare Provider



1. Primitives reflecting ontological distinctions

2. Grammar reflecting ontological axiomatisation

3. Patterns reflecting ontological micro-theories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treated by
*
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1..*
1..*
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Treatment
1..*
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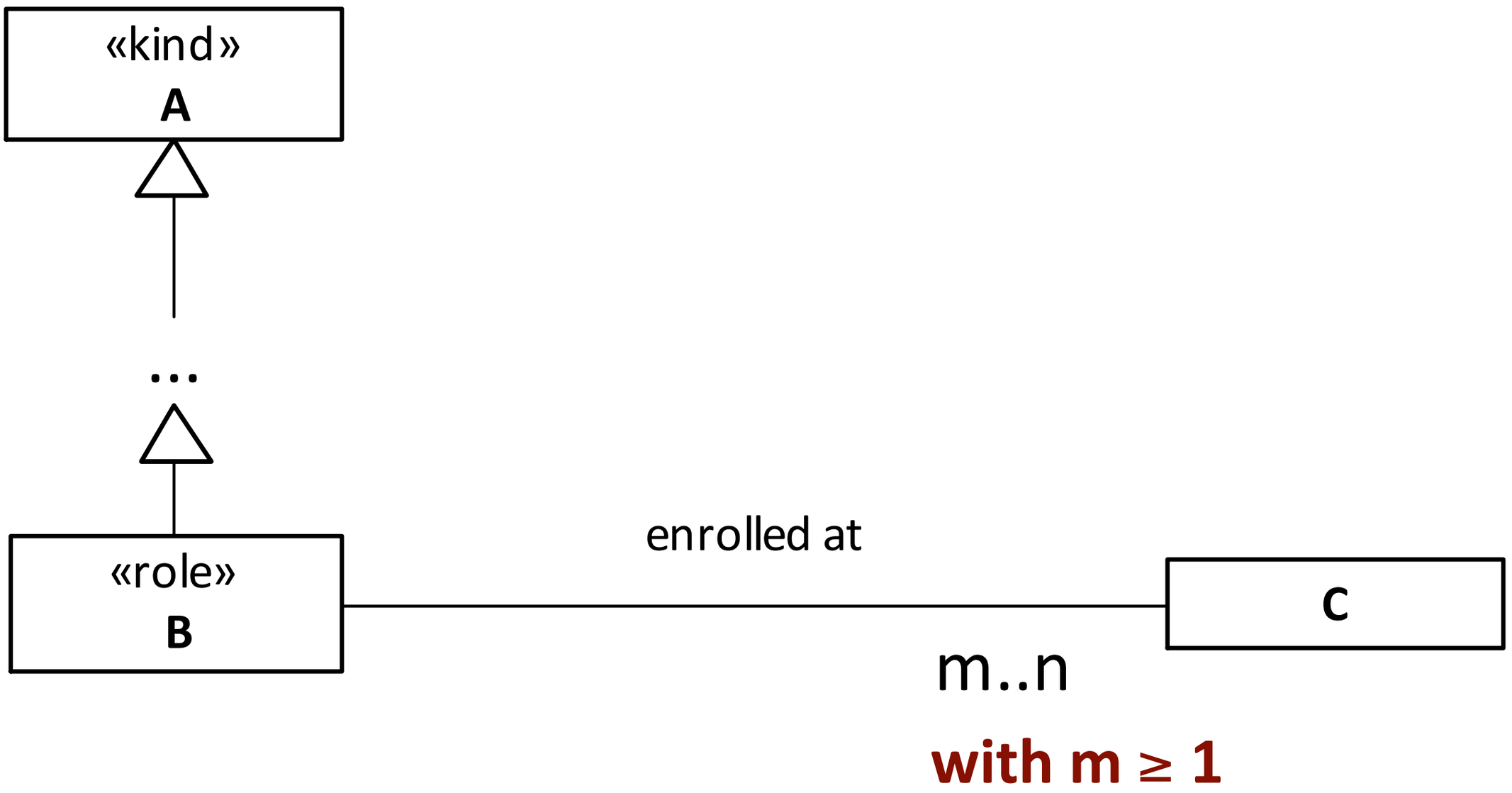
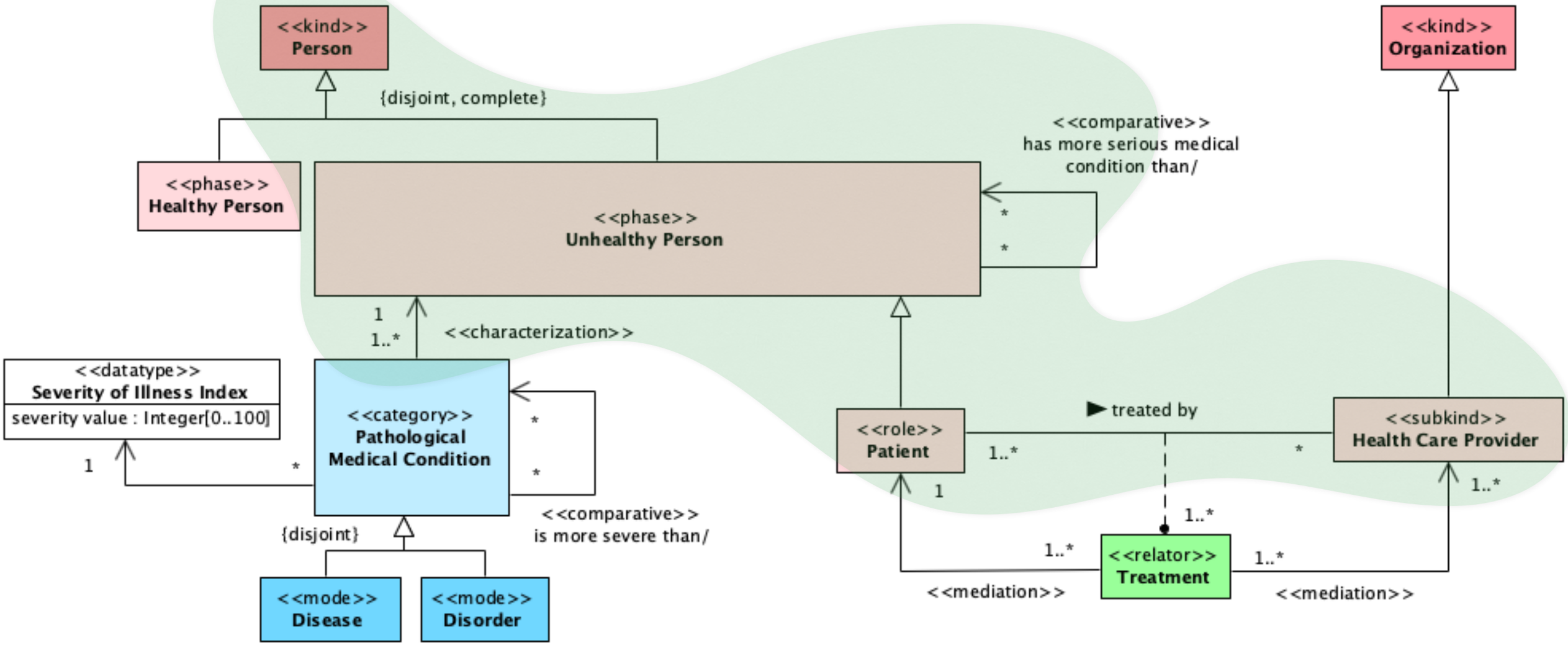
# Role

1. All instances of a given ROLE are of the **same KIND** (e.g., all Students are Person)
2. All instances of a ROLE instantiate that type only **contingently** (e.g., no Student is necessarily a Student)
3. Instances of a KIND instantiate that ROLE when participating in a certain **relational context** (e.g., instances of Person instantiate the Role Student when enrolled in na Educational Institution)
4. A ROLE cannot be a supertype of a KIND

# The Emerging **Role** Pattern

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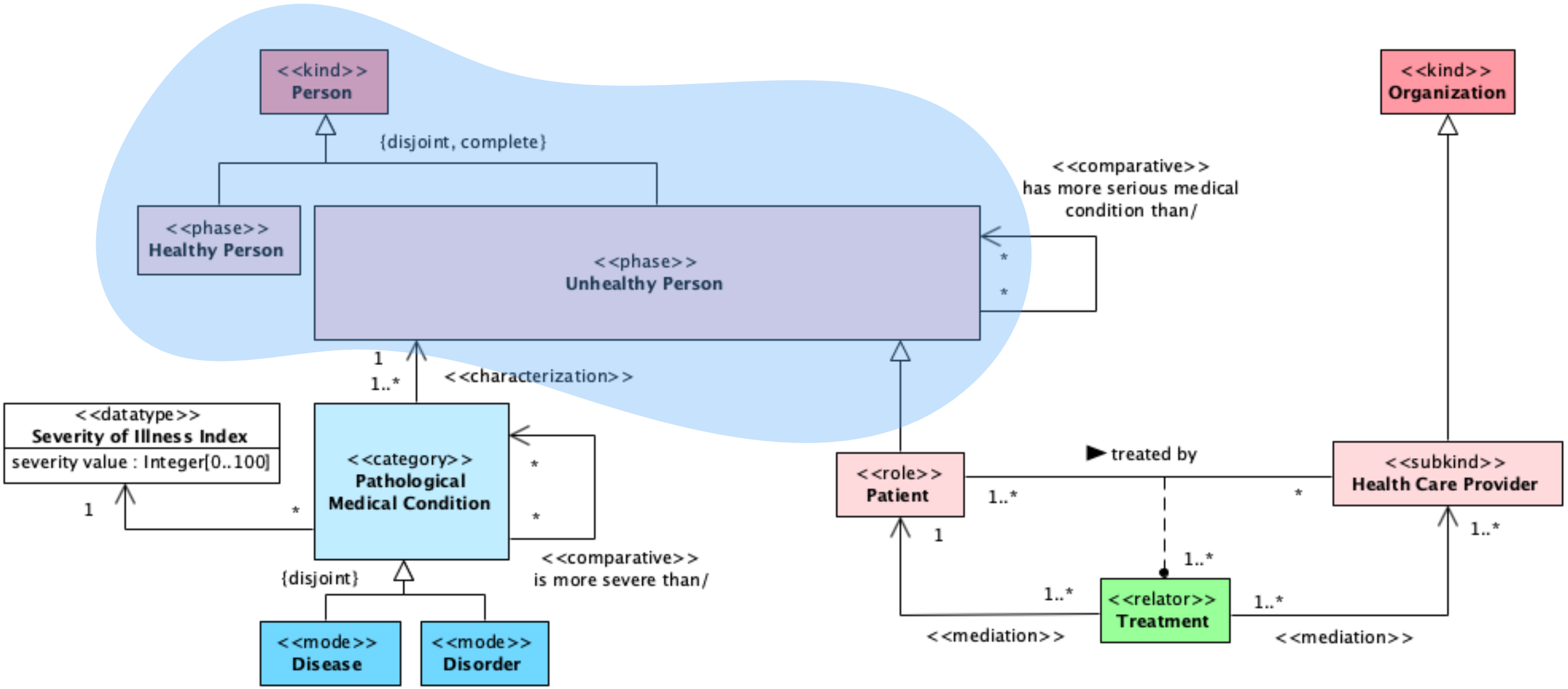
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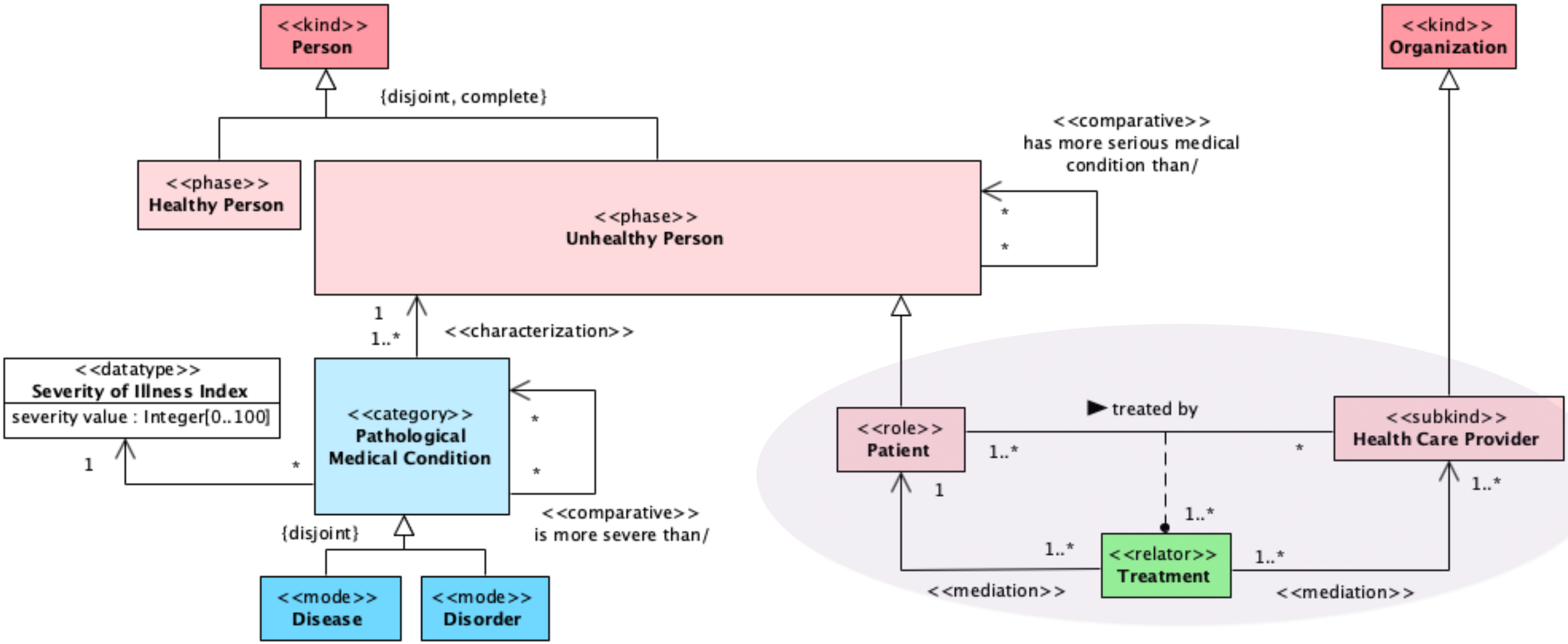
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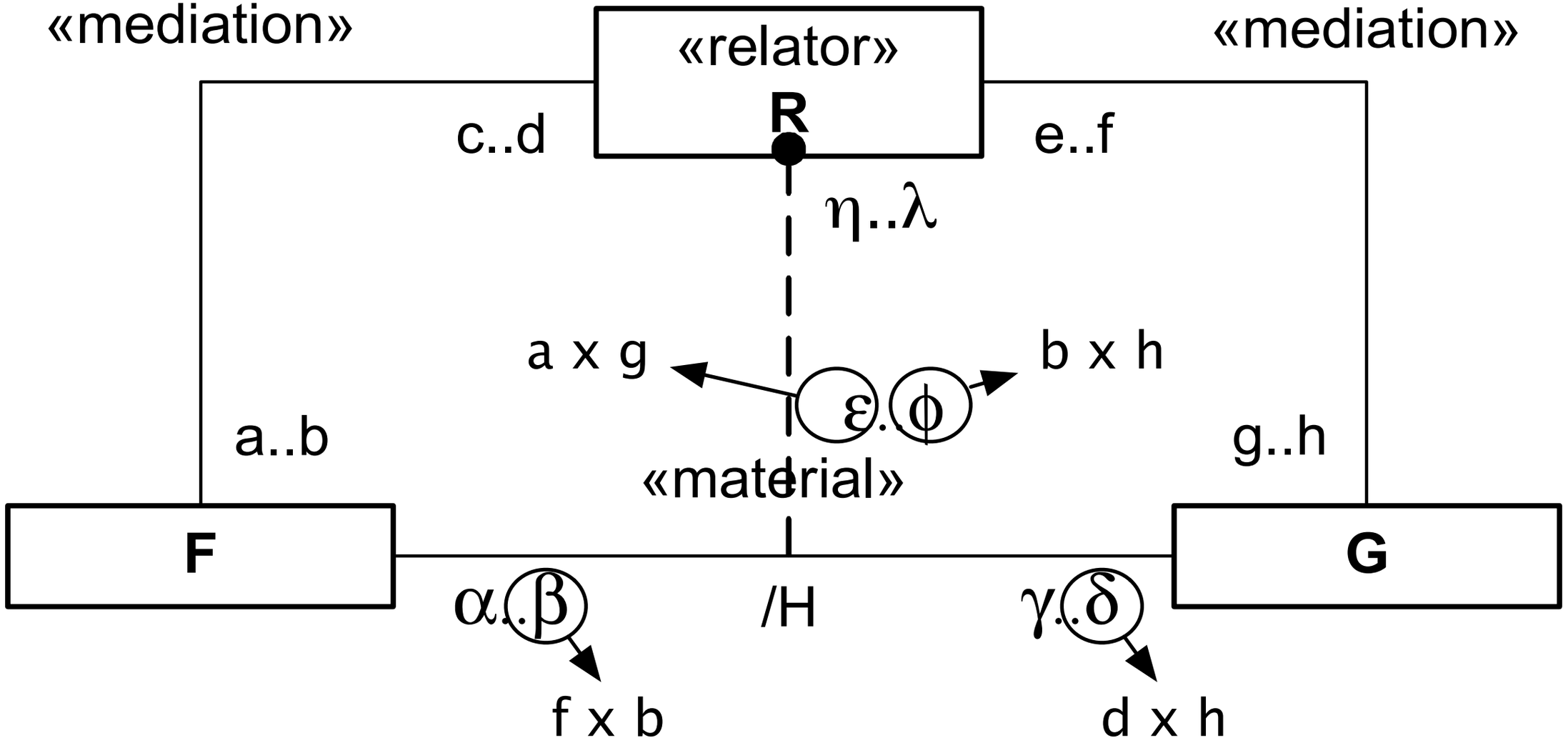
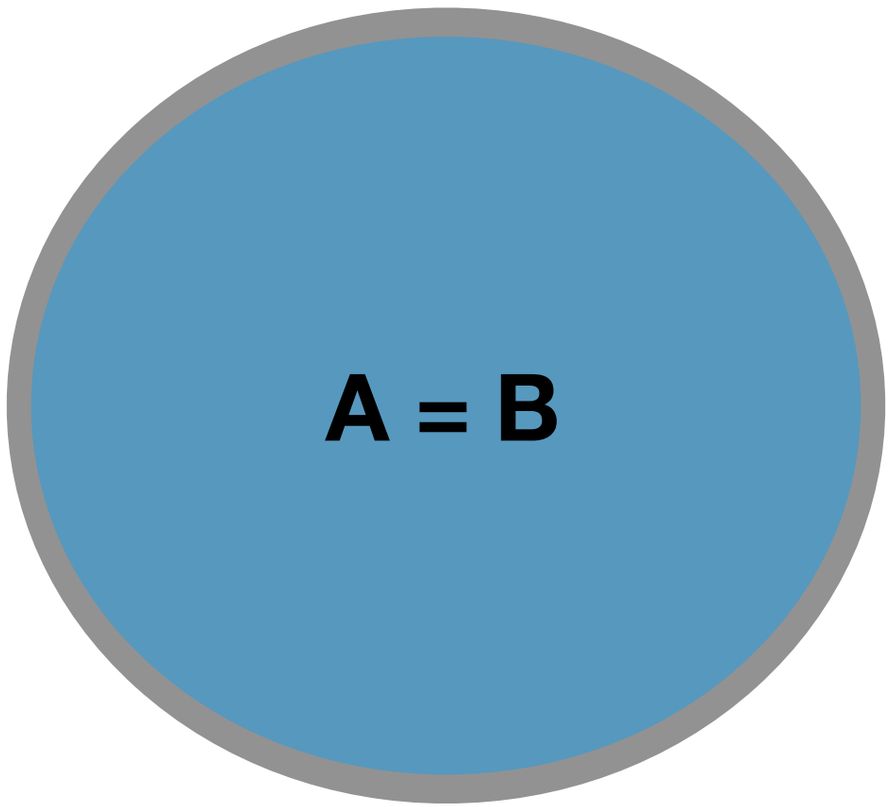
Treatment
1..*
<<mediation>>
<<mediation>>

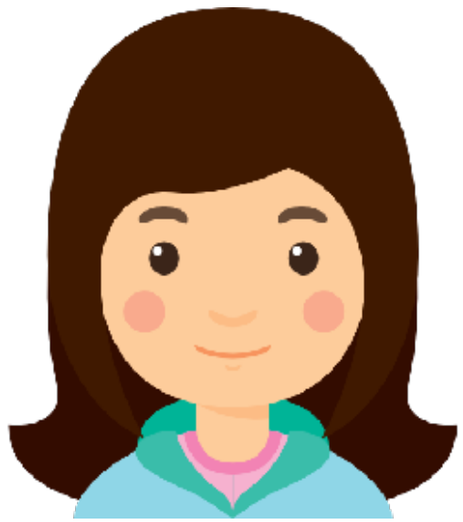


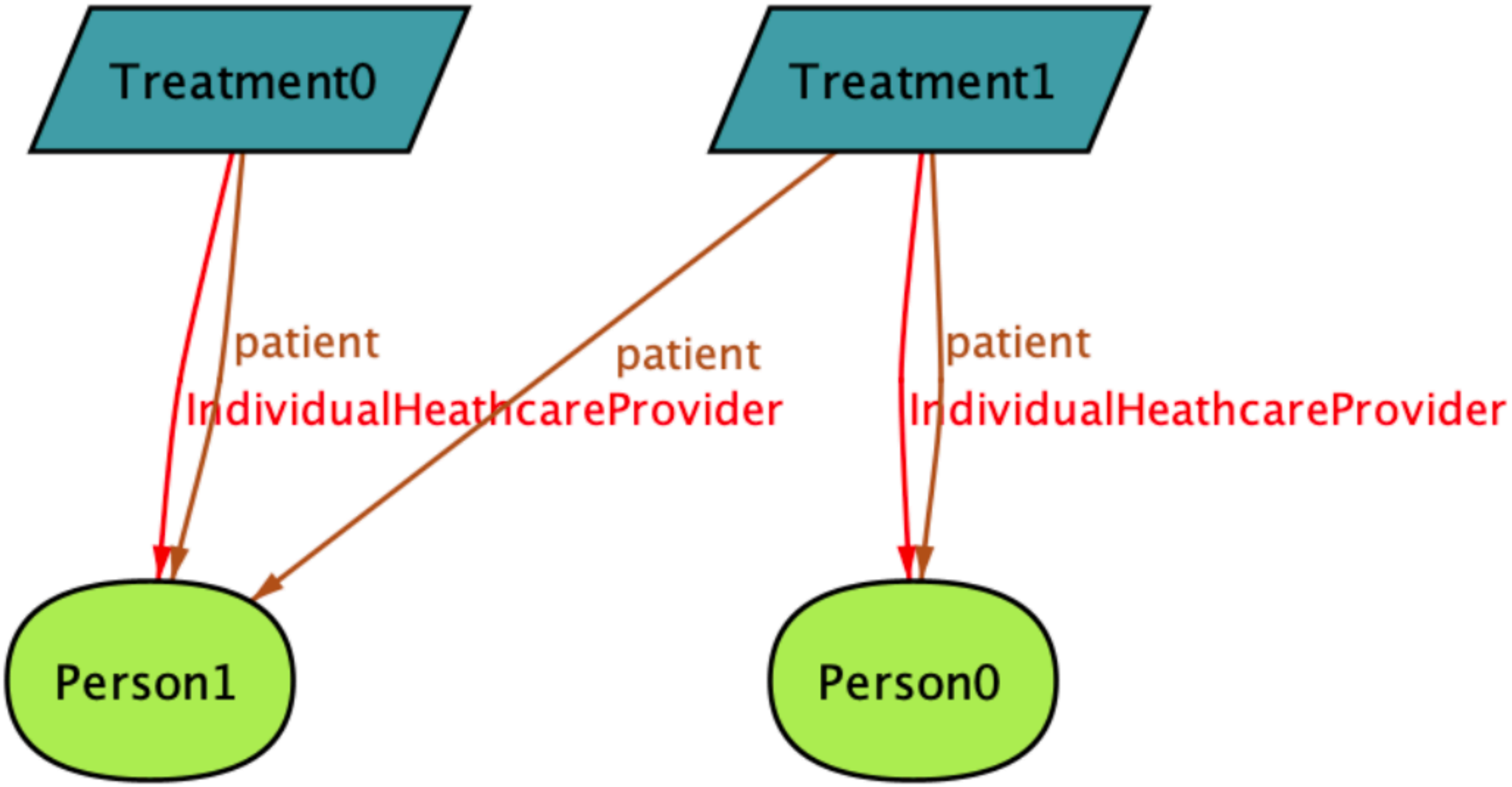

$$\forall x : F, y : G\,(H(x, y) \iff \exists r : R\,(mediation(r, x) \wedge mediation(r, y))$$


A = B

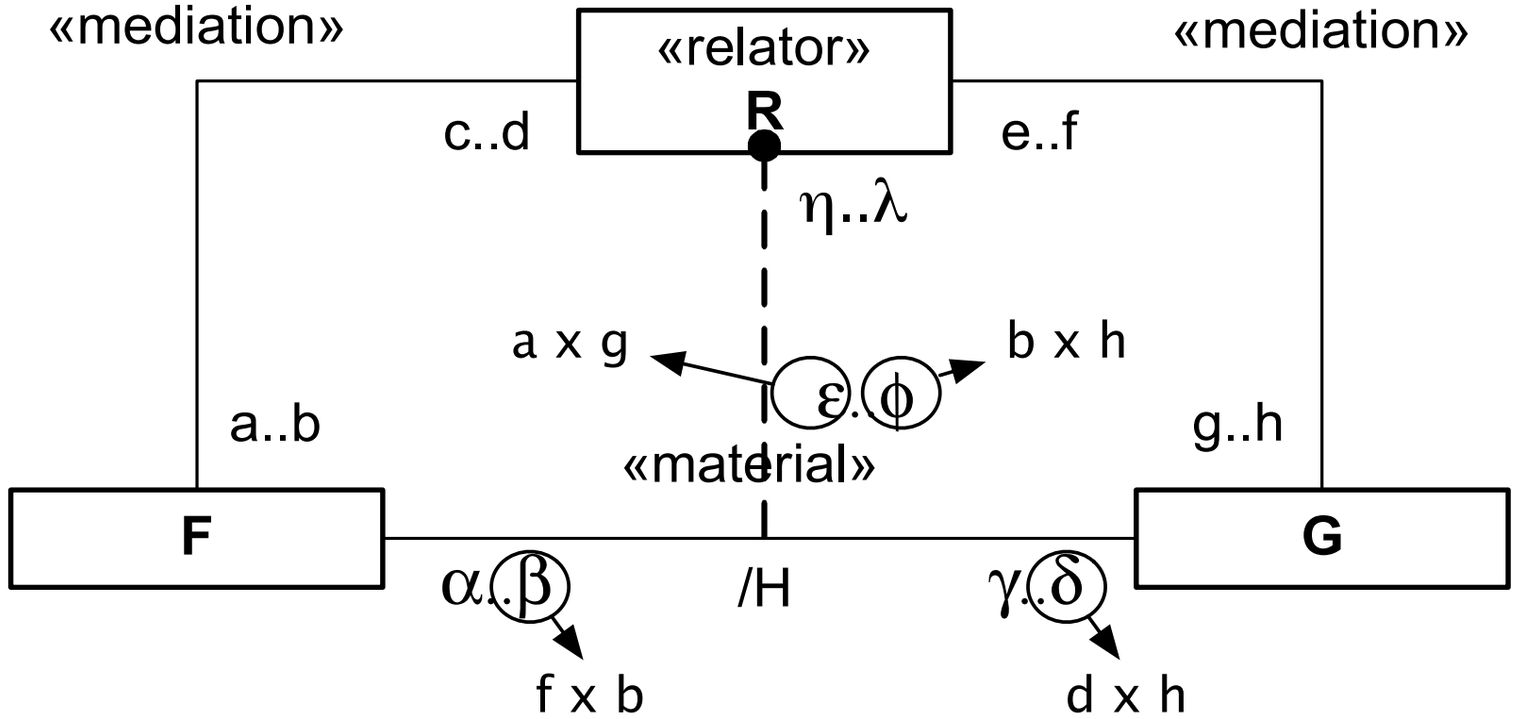
A

B




Treatment0
Treatment1
patient
IndividualHeathcareProvider
patient
patient
IndividualHeathcareProvider
Person1
Person0

# Unificatory Approach




"Science advances our understanding of nature by showing us how to **derive descriptions** of many phenomena, using the same **patterns of derivation** again and again" (P. Kitcher)

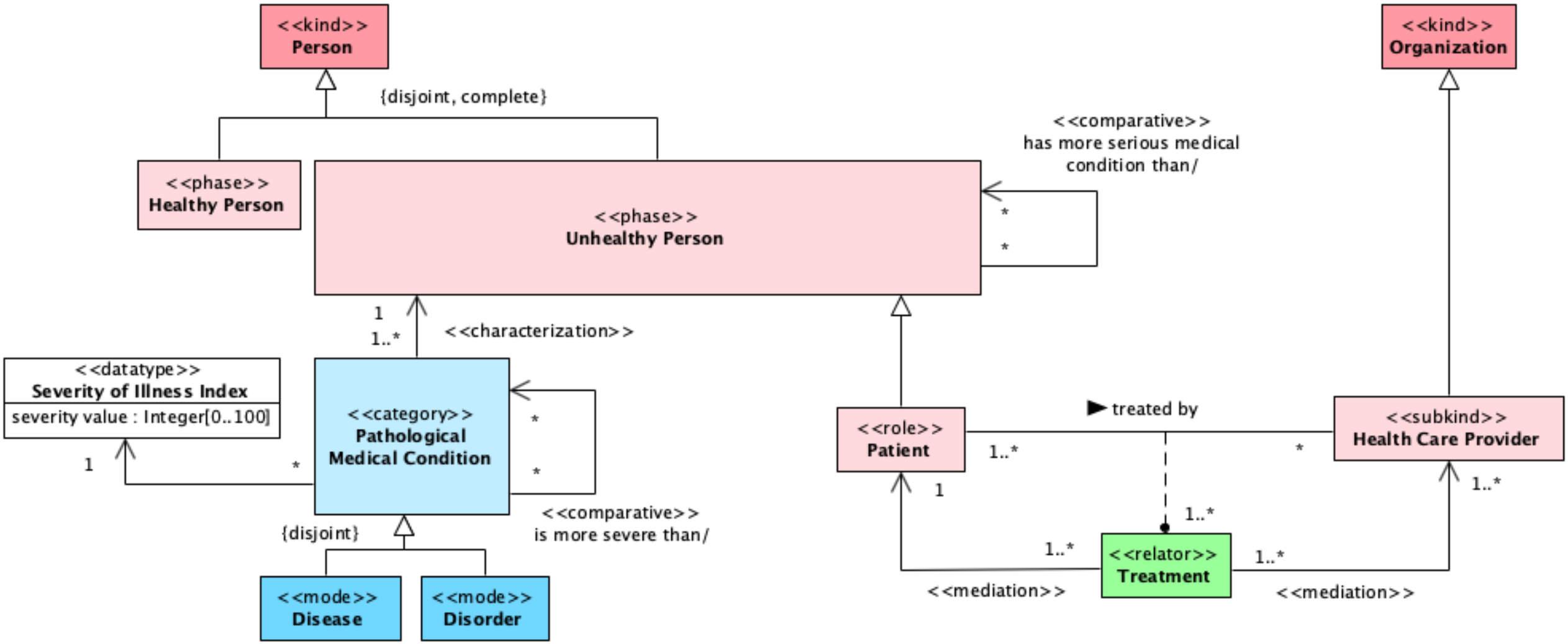
# Pragmatic Explanation

1. **Requests for Explanation**, i.e., to explain is to satisfy information seeking goals of an **explanation seeker**

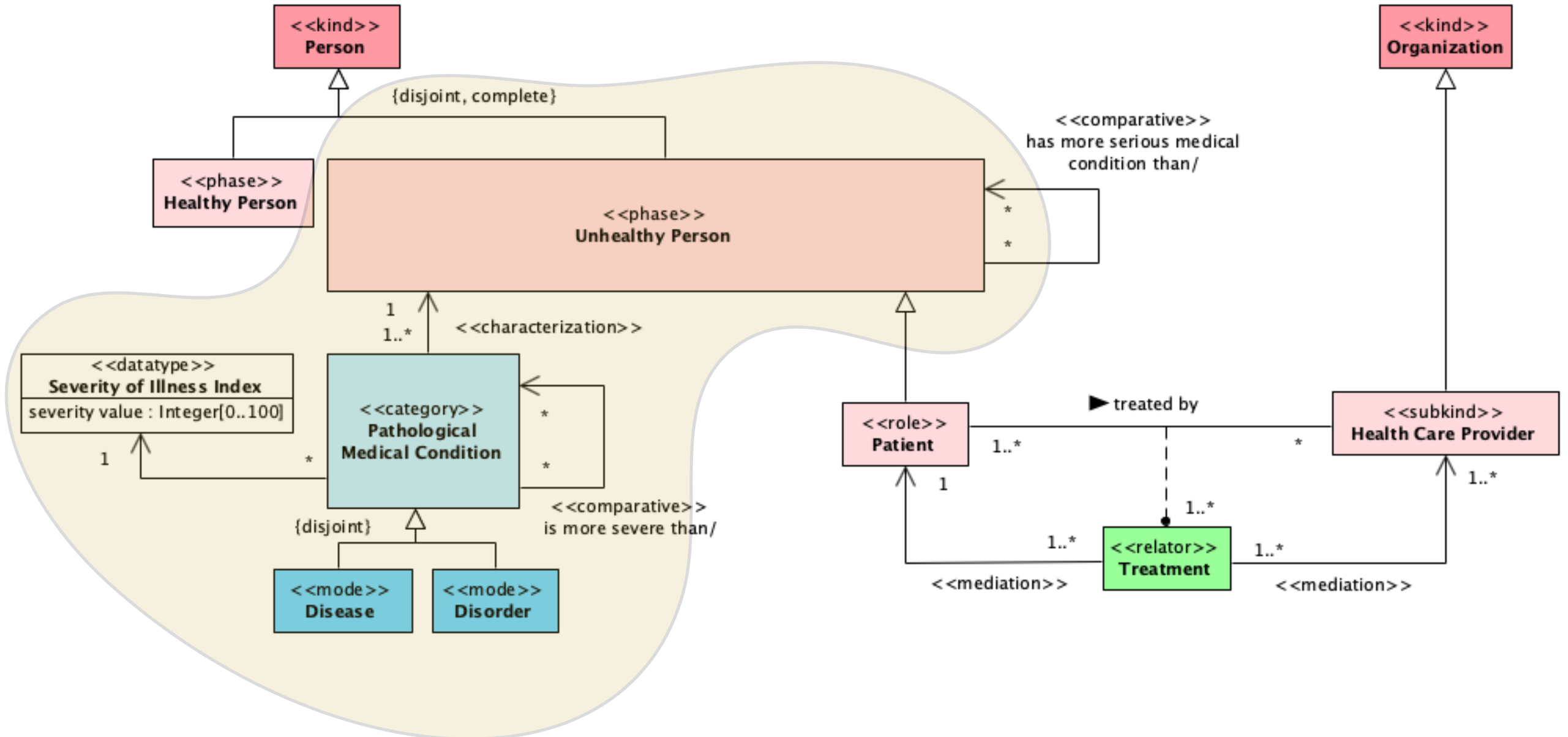
2. **Competence Questions** as Requests for Explanations

3. **Contrastive** Questions

# Why is a person treated by a given healthcare provider?

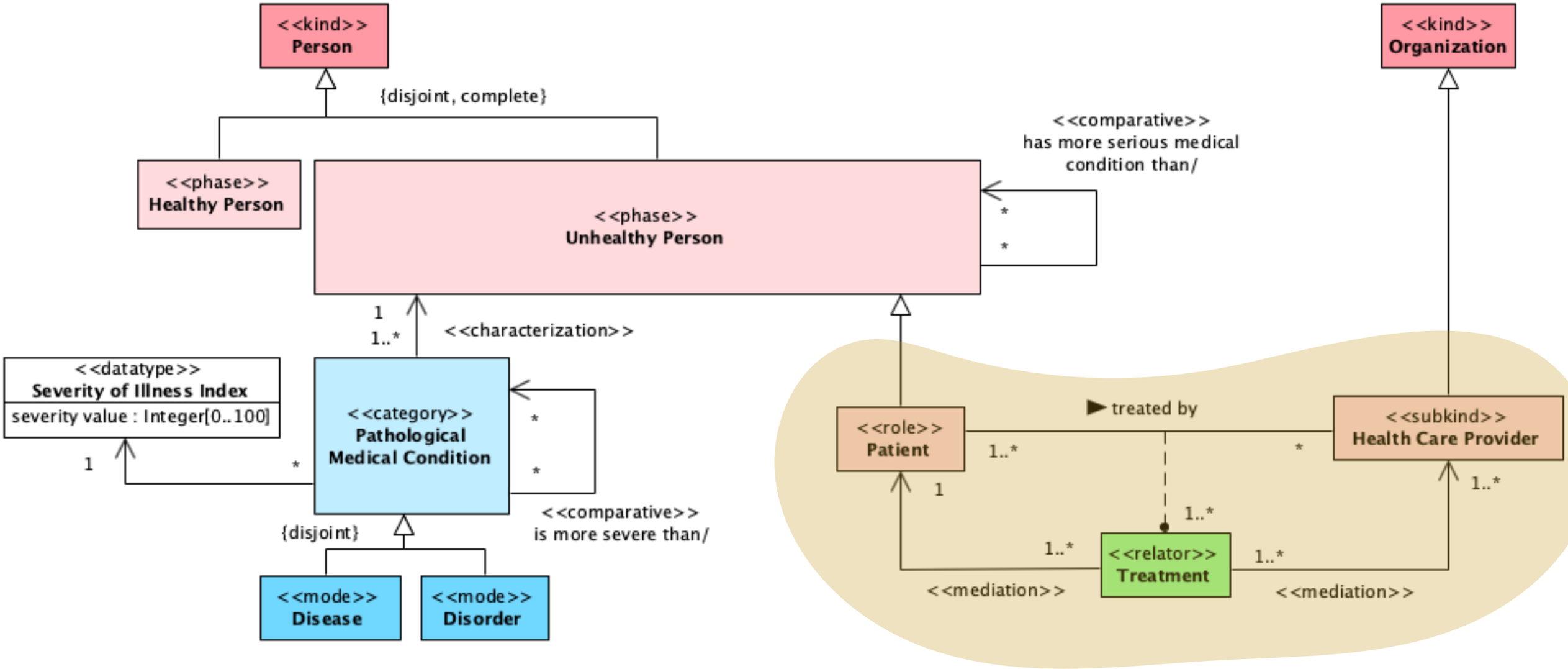


# Why is a person treated by a given healthcare provider?




…**as opposed to** not being treated

# Why is a person treated by a given healthcare provider?




…**as opposed to** being treated by a different healthcare provider

# Pragmatic Explanation

1. **Requests for Explanation**, i.e., to explain is to satisfy information seeking goals of an **explanation seeker**

2. **Competence Questions** as Requests for Explanations

3. **Contrastive** Questions

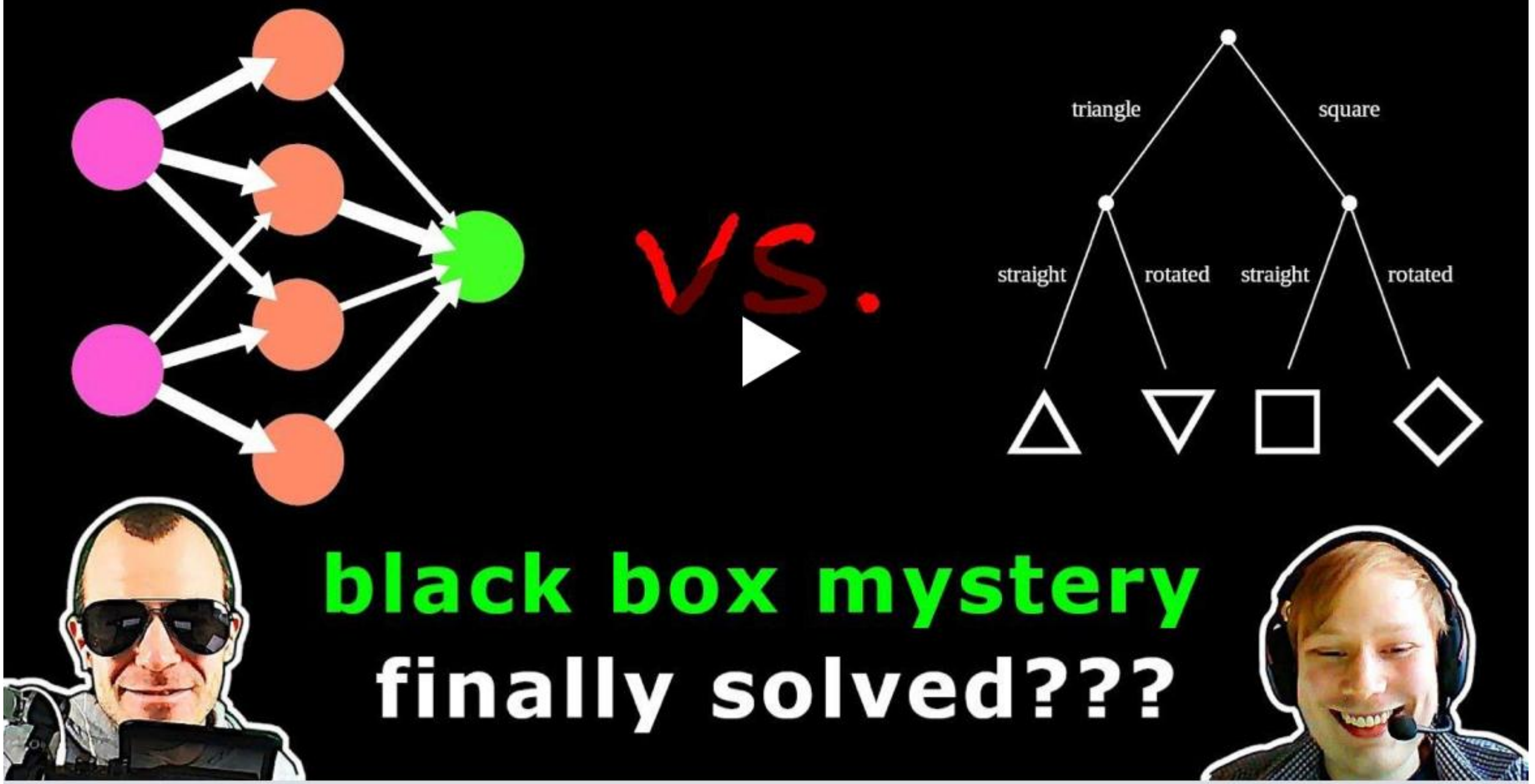
4. So, it is also about complexity management (**abstraction**)

3

# XAI

# Explainable AI

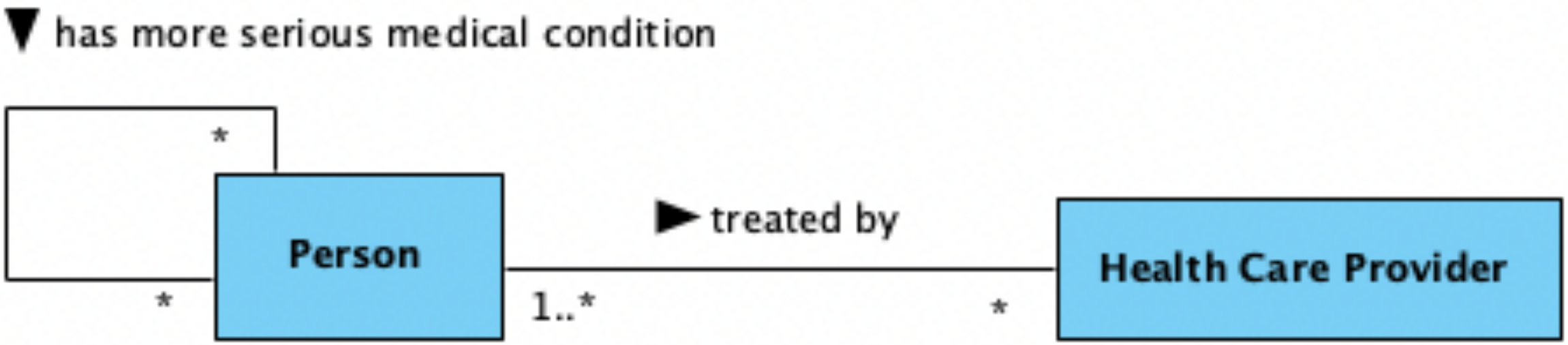
1. Interpretability Framework or Complete Model View (“**Inherently Interpretable Models**”)




# Neural Networks are Decision Trees (w/ Alexander Mattick)

youtube.com

Symbolic Artifacts are **not Self-Explanatory** just in virtual of being symbolic!


has more serious medical condition
*
*
Person
treated by
1..*
*
Health Care Provider

# Explainable AI

1. Interpretability Framework or Complete Model Approach (**“Inherently Interpretable Models”**)
2. Explainability Framework Partial-Model Approach

# Counterfactual Explanations

"You were denied a loan because your annual income was £30,000. If your income had been £45,000, you would have been offered a loan."

# Semantics and explanation: why counterfactual explanations produce adversarial examples in deep neural networks

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"counterfactual explanations consisting only of **semantically dense** and contextually relevant dimensions in the network's feature space…in order to do that, we would need to be able to **reveal the semantics** of hidden network units ('hidden neurons')…**there can be no explanation without semantics**"

“**representations in NNs are not really ‘signs’** that correspond to anything interpretable — but are distributed, correlative and continuous numeric values …a hidden unit cannot on its own represent any object that is **metaphysically meaningful**”
(Walid Saba)

# Counterfactual Explanations

"You were denied a **loan** because your **annual income** was £30,000. If your income had been £45,000, you would have been **offered** a loan."

# “What good is an explanation?” (Peter Lipton)

1. Knowing-that x Knowing-why

2. Why-Regress

3. Self-Evidencing

# Final **Take Away** Messages

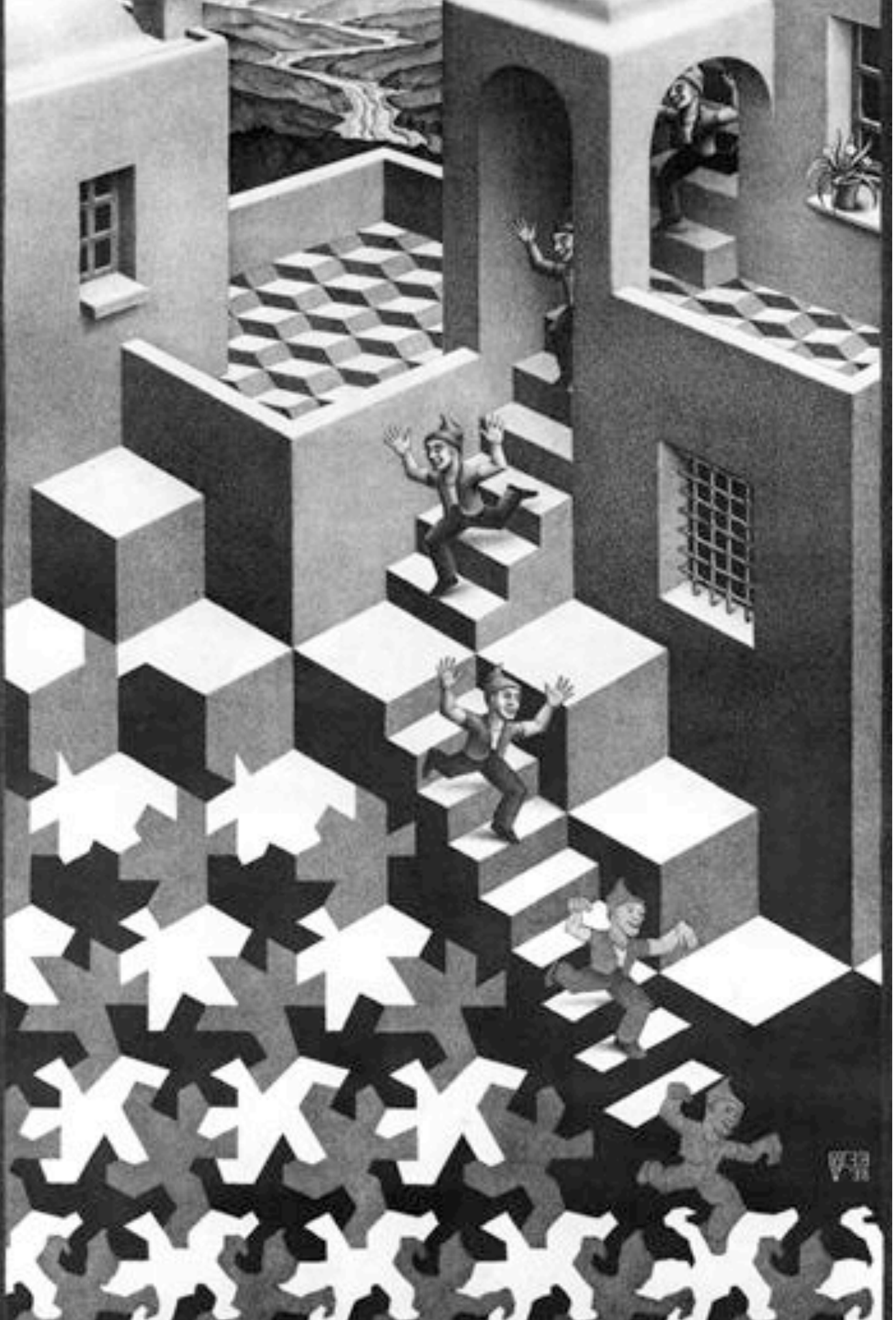
1. “No **Explanation** without **Semantics**”

# Final **Take Away** Messages

1. “No **Explanation** without **Semantics**”
2. No **Semantics** without **ontology**

# Final **Take Away** Messages

1. “No **Explanation** without **Semantics**”
2. No **Semantics** without **ontology**
3. No **ontology** without **Ontology**



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