



Laboratory for Applied Ontology

Institute of Cognitive Science and Technology  
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# On the Semantics of Functional Roles

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# Summary

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- Kinds of attributes: parts, qualities, roles
- Our previous accounts of roles:
  - Roles as (anti-rigid, dependent) properties (OntoClean)
  - Roles as reified concepts
- Problem 1: what's the nature of the *role playing* relationship?
  - does a *pedestrian* or an *ocular witness* really *play* a role?
  - What's the difference between *driving/teaching* and *driver/teacher*?
- Problem 2: What do we refer to, when we use role terms?
  - *There were 80 passengers on the Lufthansa flight LH828 yesterday*
  - *Lufthansa transported 100,000 passengers to Tbilisi in one year*
  - *Lufthansa replaced the pilot of flight LH828 two times last year*
- Kinds of attributes (again)

# Concepts and their attributes

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- Woods' "What's in a link?" (1975):

JOHN

HEIGHT: 6 FEET

KISSED: MARY

- "no longer do the link names stand for attributes of a node, but rather arbitrary relations between the node and other nodes"; different notations should be used



# Kinds of attributes

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JOHN

HEIGHT: 6 FEET

RIGHT-LEG: LEG#1

MOTHER: JANE

KISSED: MARY

**intrinsic quality**

**part**

**role**

**external relation**

We need different primitives to express *different structuring relationships* among concepts

We need to represent *non-structuring relationships* separately

Current description logics tend to collapse **EVERYTHING!**



## Understanding roles: the OntoClean approach

# Roles are properties

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- **Basic Idea** (Sowa 2000)  
Roles can be 'predicated' of different entities, i.e., different entities can play the same role
- **Standard representation**  
Roles are represented, in FOL, as unary predicates whose instances are their players:
  - Student(john) -> John plays the Student role

## Roles are *anti-rigid*

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- Basic Idea (Steimann 2000): Roles have *dynamic* (temporal/modal) relations with their players
- $\phi$  is rigid (+R):  $\forall x (\Diamond\phi(x) \rightarrow \Box\phi(x))$ 
  - e.g. Person, Apple
- $\phi$  is non-rigid (-R):  $\exists x (\Diamond\phi(x) \wedge \neg \Box\phi(x))$ 
  - e.g. Red, Male
- $\phi$  is anti-rigid ( $\sim$ R):  $\forall x (\Diamond\phi(x) \rightarrow \neg \Box\phi(x))$  e.g. Student, Agent

## Examples of dynamicity for roles

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- An entity can play different roles simultaneously
  - *In 2003, B. was the Italian Prime Minister, the President of the European Union, the president of the Forza Italia party, the owner of the Mediaset company, an Italian citizen, a defendant at a legal trial.*
- An entity can cease playing a role
  - *In 1960, B. was a piano bar singer, now he is the IPM.*
- An entity can play the same role several times, simultaneously
  - *In 2003, B. had two presidencies / was president twice.*
- A role can be played by different entities, simultaneously or at different times
  - *Today, there are 4319 Italian National Research Council researchers.*
  - *In 2000, the Italian Prime Minister was D., now it is B.*



# Roles have a relational nature

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- Basic Idea (Sowa, Guarino&Welty)  
Roles imply patterns of relationships, i.e., they **depend**—via these patterns—on additional ‘external’ properties
- Which kind of dependence?



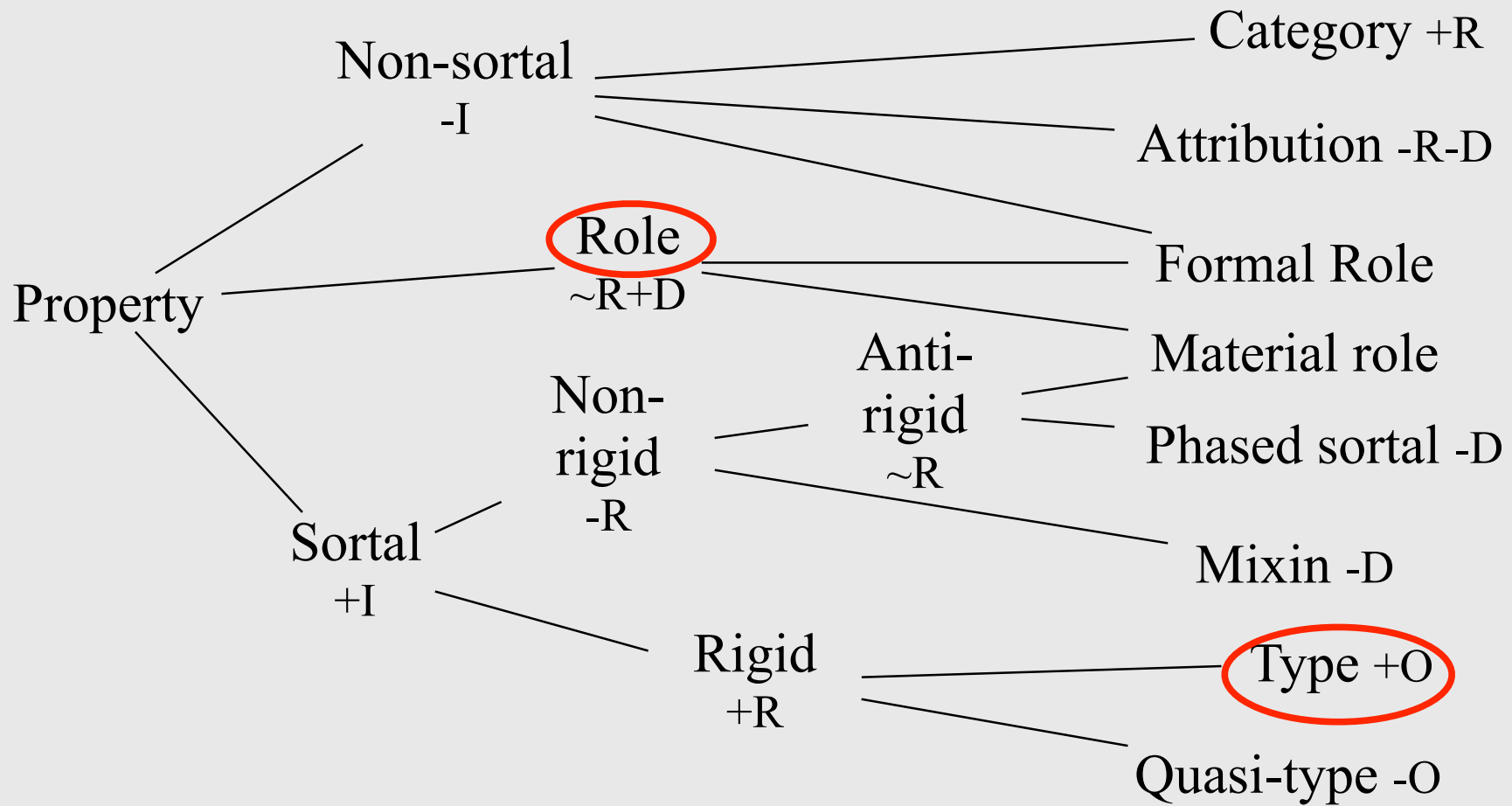
# Dependence

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- Between particulars
  - **Existential dependence** (specific/generic) (also *constant dependence*)
    - Hole/host, person/brain, person/heart
  - Internal vs. external dependence
    - Region/boundary....
  - Historical dependence
    - Person/parent
  - Causal dependence
    - Heat/fire
- Between universals
  - **Definitional dependence**
    - $P$  depends on  $Q$  iff  $Q$  is involved in the **definition** of  $P$  [Fine 1995].
    - *External* definitional dependence [Masolo et al. 2004]: +D/-D



# The OntoClean ontology of properties



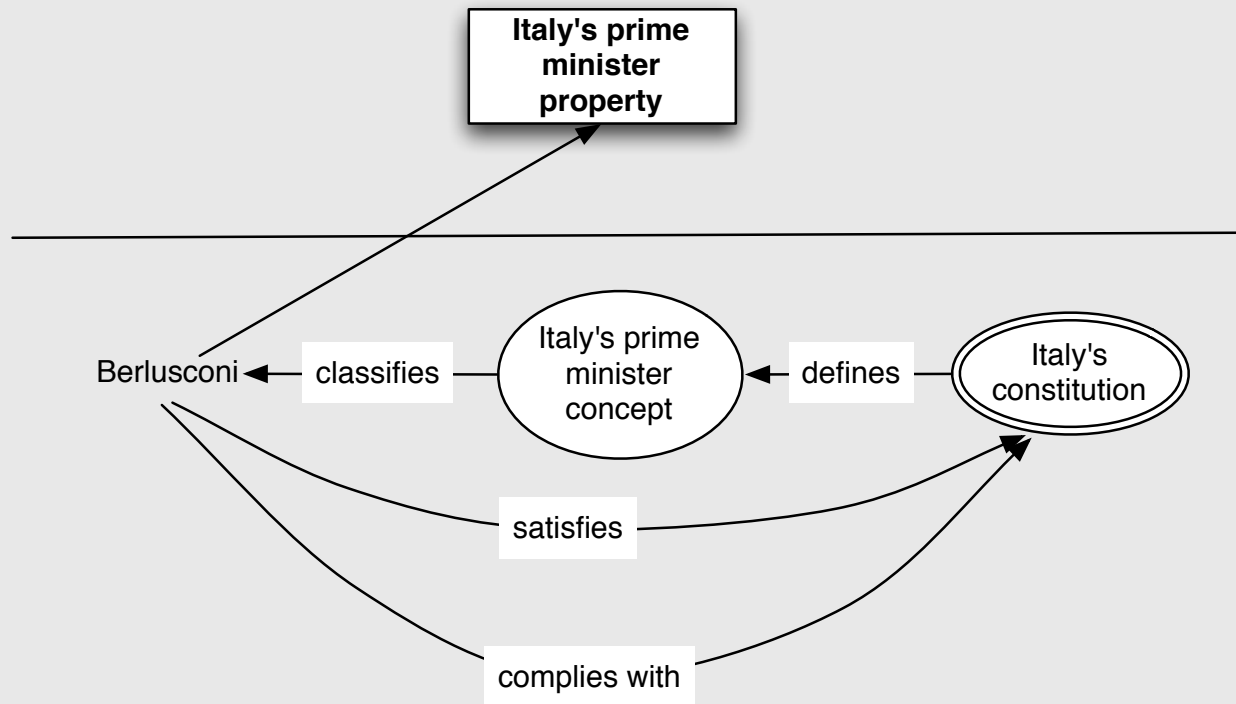
## The dual nature of roles [Masolo et al 2004]

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- Social (and dynamic) aspects of roles not accounted for by the property view
  - Roles are created and disappear; are defined by conventions; are adopted and accepted by communities of agents
- Roles need to be considered **both** as properties (also called *role sortals*) and “first-class citizens” (simply called *roles*, typically focusing on *socially-constructed* roles).

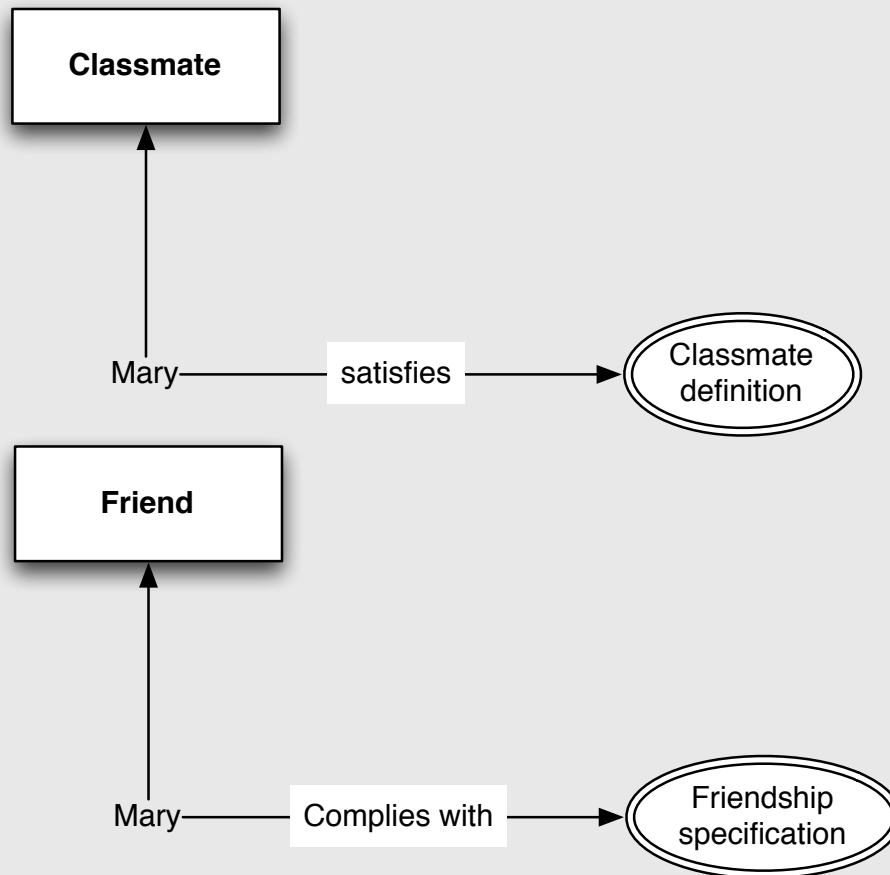


## (Weak) social roles and their descriptions in the domain of discourse (Masolo et al 2004)



How strict should role players comply with their  
role descriptions?

## Relational roles vs. (strong) social roles



Note: satisfaction implies compliance, but not viceversa!

## Linguistic differences marking *expected behavior* for social roles

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- Verbs vs. nouns:
  - *driving vs. driver*
- Comparatives:
  - *John has a good friend vs. John has a good classmate*
  - *He is a good driver vs. he is a good pedestrian/passenger*
  - *He is a good president vs. he is a good ocular witness*

# Functional roles and functional parts in artefacts

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1. The right headlamp of my car was not working
2. The right headlamp of my car is *uninstalled/missing*
3. This cable connects the battery to the right headlamp
4. The right headlamp of my car has been replaced 2 times

What are the referents of role terms?





# Functional roles in organizations

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- *President vs. presidency*
- *The presidency is vacant*
- *The presidency never acted against the parliament*
- *People can send letters to the presidency (even while the presidency is vacant)*



## Roles as ways to participate to *contexts*

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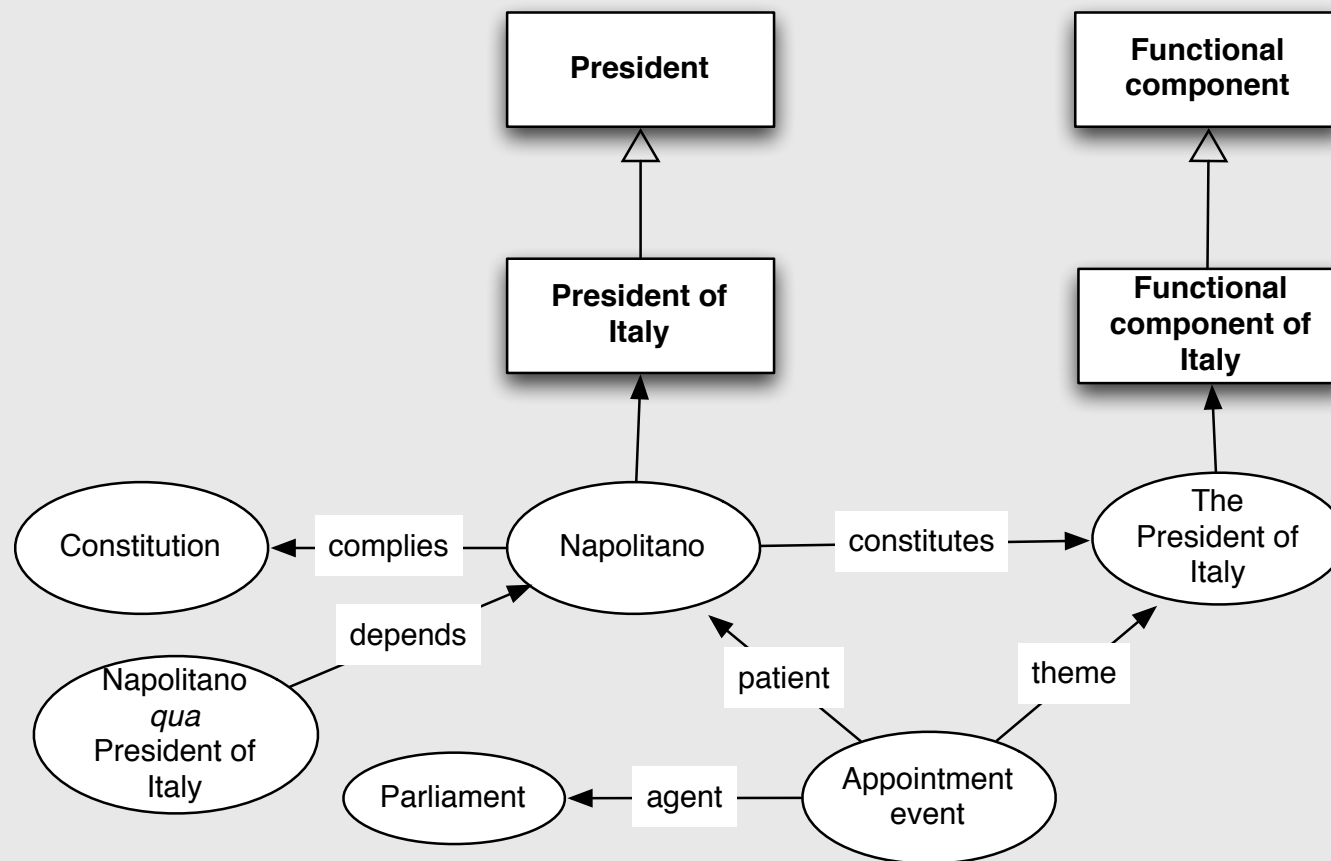
- Possible contexts for roles:
  - Abstract relational context
  - Eventual context
  - Objectual context
  - Extended context (including everything that participates to an object's *life*)
- Example: the context of *teaching* is the relationship with the student, the context of *teacher* can be the school, or a particular kid.
- We can distinguish roles according to their context's kind:
  - Abstract roles (*parameter*)
  - Eventual roles (*agent*)
  - Objectual role (*part, color*)
  - Contextual role (*friend, teacher*)

## Within their context, functional roles are *replaceable*

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- *classmate vs. teacher*
  - *employee vs. customer*
  - ...
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- Replaceability presupposes a *new entity* in people's mind ontology, a kind of *virtual, idealized role player*

# Functional roles: the whole picture



## Functional roles are assigned roles

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- Pre-defined *intended properties* are assigned to the instances (players) of such roles:
  - Intrinsic properties
  - Relational properties
  - Behavior
- *Being the right headlamp of Toyota Yaris Verso 2002* is a functional role
- *Being smashed in an accident* is an ordinary role



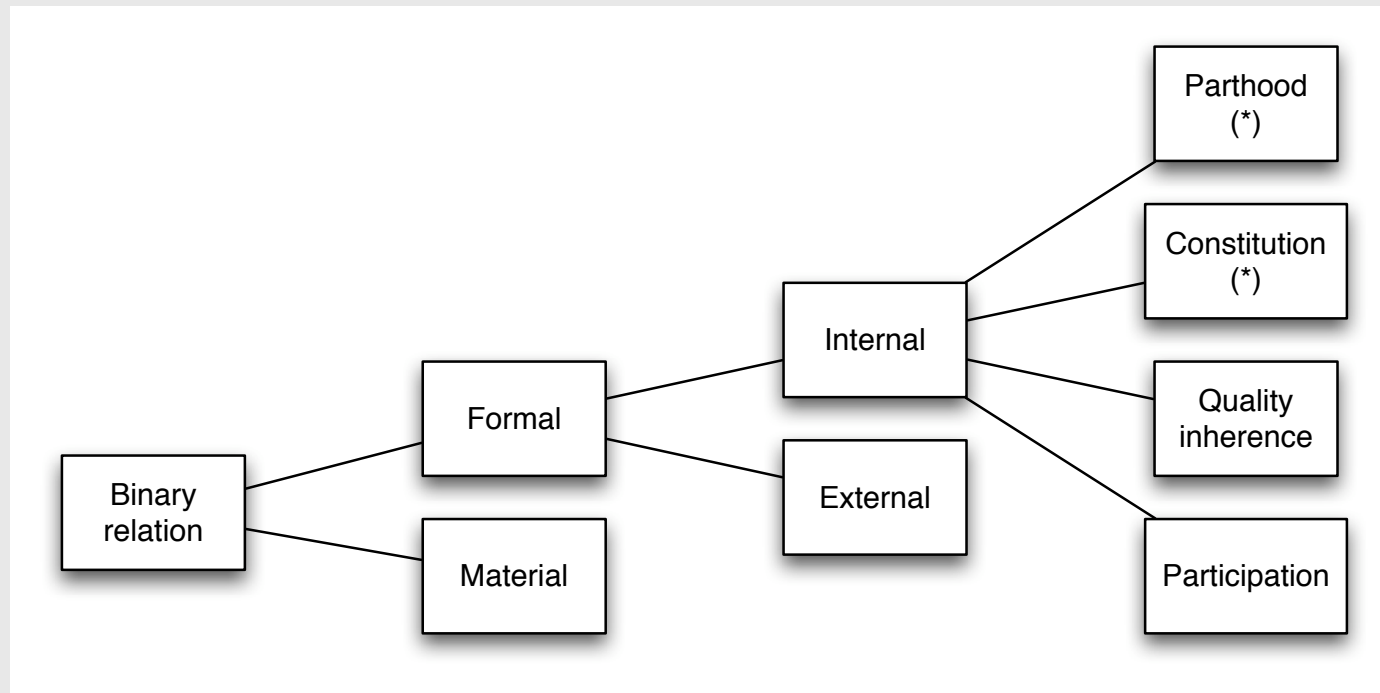
## Virtual players and nominal players

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- Virtual players: located within the artifact, can be “materialized” or not, but they are physical, so to speak
- Nominal players: abstract prototypical particulars, *which however can have physical qualities*



# Binary relations: a general classification



**Conjecture: attributes are always internal  
...within a context**



# Conclusions

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1. There is a formal difference between *being in a role* and *playing a role*
2. There is a formal difference between  
  
*school mate, school friend and school teacher*
3. Attributes are *internal relations* (within a possibly extended context)





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