



Laboratory for Applied Ontology

Institute of Cognitive Science and Technology
Italian National Research Council

Professional master on technologies for e-government

Conceptual modelling, ontology design, and semantic interoperability

Lecture 6

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Summary

- Formal ontology
- OntoClean

Formal Ontology

- Theory of *formal distinctions and connections* within:
 - entities of the world, as we perceive it (*particulars*)
 - categories we use to talk about such entities (*universals*)
- Why *formal*?
 - Two meanings: *rigorous* and *general*
 - Formal logic: connections between truths - neutral wrt *truth*
 - Formal ontology: connections between things - neutral wrt *reality*

Essential properties

- For an individual
 - John must have a brain
 - John must be a human
 - John must be alive
- For a type
 - All human beings must have a brain
 - All human beings must be “a whole” (all of a piece)

Essential properties and rigidity

- Certain entities **must** have some properties in order to *exist*
 - John must have a brain
 - John must be a person.
- Certain properties are essential to **all** their instances (***being a person*** vs. ***being hard***).
- These properties are **rigid** - Their extension is the same in all possible worlds. If an entity is ever an instance of a rigid property, it must necessarily be such.
- By the way, what's the meaning of *exist*?
 - Being an element of the domain of discourse
 - Being present *at a certain time* (or in a certain world...)

Carrying essential properties

- A property P *carries* an *informative* essential property Q (different from P) iff Q is essential to all instances of P, **and yet Q is not rigid**:
 - Every person must have a brain.
- Compare with:
 - Every person must be a mammal.

Carrying an informative essential property implies
carrying a (minimal) *identity criterion*

Identity criteria

- *Classic formulation:*

$$\phi(x) \wedge \phi(y) \rightarrow (\rho(x,y) \leftrightarrow x = y)$$

(ϕ carries the identity criterion ρ)

- *Generalization:*

$$\phi(x,t) \wedge \phi(y,t') \rightarrow (\Gamma(x,y,t,t') \leftrightarrow x = y)$$

(synchronic: $t = t'$; diachronic: $t \neq t'$)

- In most cases, Γ is based on the ***sameness*** of certain ***characteristic features***:

$$\Gamma(x,y,t,t') = \forall z (\chi(x,z,t) \wedge \chi(y,z,t'))$$

- **Non-triviality condition:**

- $\Gamma(x,y,t,t')$ must not contain an identity statement between x and y !

Heuristics for Identity

- Finding necessary *and* sufficient ICs for a given property may be ***very hard***.
- Heuristic 1: ***at least a sufficient IC***.
- Heuristic 2: ***some essential parts or qualities***
- Heuristic 3: ***some essential (non-rigid) properties***

Carrying vs. Supplying Identity

- **Supplying** (global) identity (+O)
 - Carrying an IC (or relevant essential property) that doesn't hold for *all* directly subsuming properties
- **Carrying** identity (+I)
 - Not supplying identity, while being subsumed by a property that does.
- **Common sortal principle**: $x=y \rightarrow$ there is a common sortal supplying their identity
- Theorem: only rigid properties supply identity

Sortals and other properties

- **Sortals** (*horse, triangle, amount of matter, person, student...*)
 - Carry (non-trivial) identity conditions
 - Usually correspond to **nouns**
 - High organizational utility
- **Non-sortals** (*red, big, old, decomposable, dependent...*)
 - No identity
 - Usually correspond to **adjectives**
 - Span across different sortals
 - Limited organizational utility (but high semantic value)

Identity Disjointness Constraint

ICs impose *constraints* on sortals, making their ontological nature explicit:

Properties with incompatible ICs are *disjoint*

Examples:

- countries vs. geographical regions
- passengers vs. persons
- assemblies vs. amounts of matter
- sets vs. ordered sets

What about our rocks?

- *Igneous rock, metamorphic rock, sedimentary rock* do supply informative essential properties.
- *Large rock, grey rock, pet rock*
DO NOT!
- Not all properties are the same...

Sortal specialization

- **Type** specialization (e.g. Living being → Person)
 - New features (especially essential properties) **affect identity**
 - ICs are added while specializing types
 - Polygon: same edges, same angles
 - Triangle: two edges, one angle
 - Living being: same DNA, etc...?
 - Zebra: same stripes?
- **Role** specialization (e.g. Person → Student)
 - New features **don't affect identity**

Roles are ‘dynamic’ and ‘antirigid’

Basic Idea (Steimann 2000): Roles have temporal/modal relations with their players

- 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 (*antirigidity*)
 - *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.*

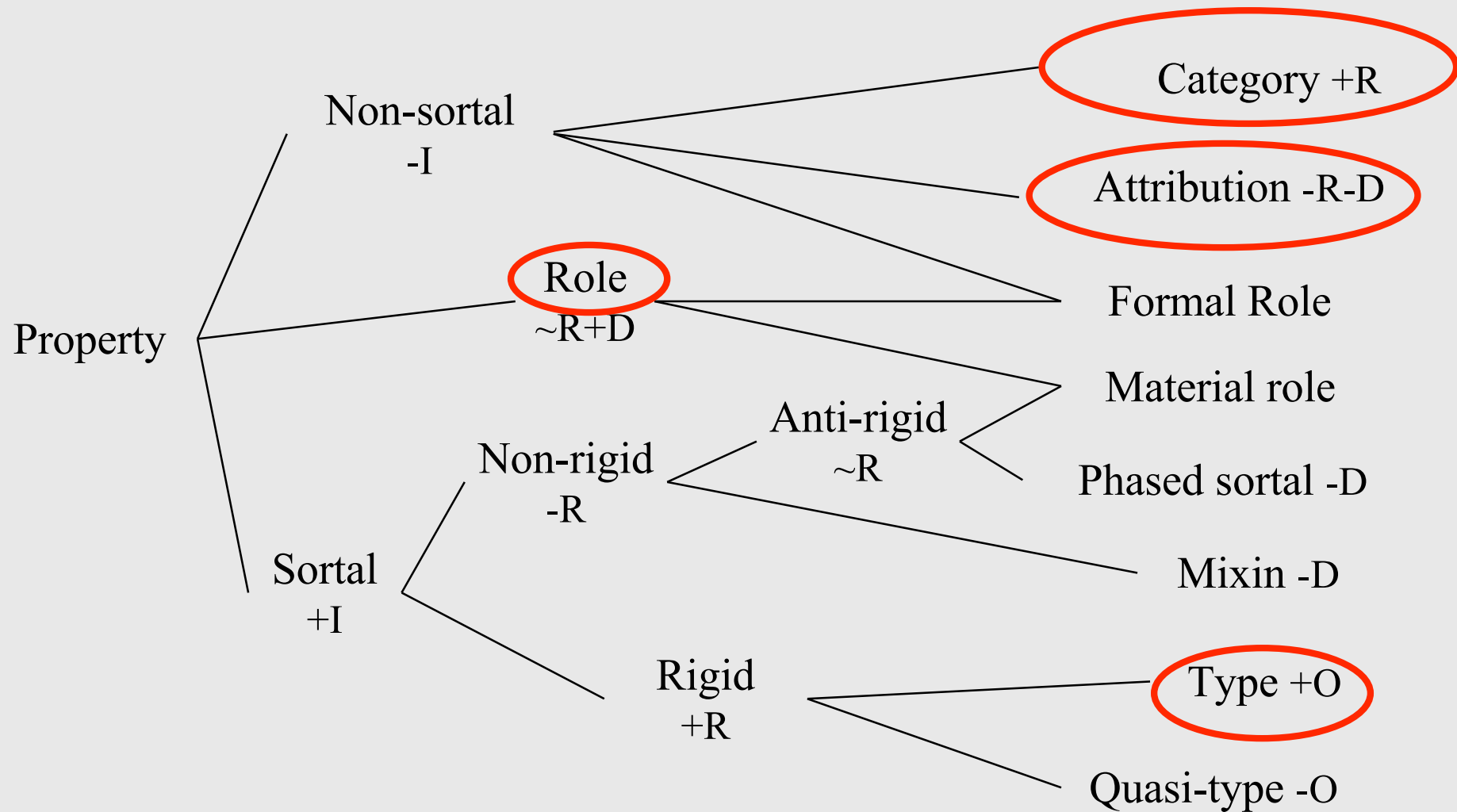
Roles have a relational nature

- Basic Idea (Sowa)
Roles imply *patterns of relationships* (contexts), i.e., they **depend**—via these patterns—on additional ‘external’ properties

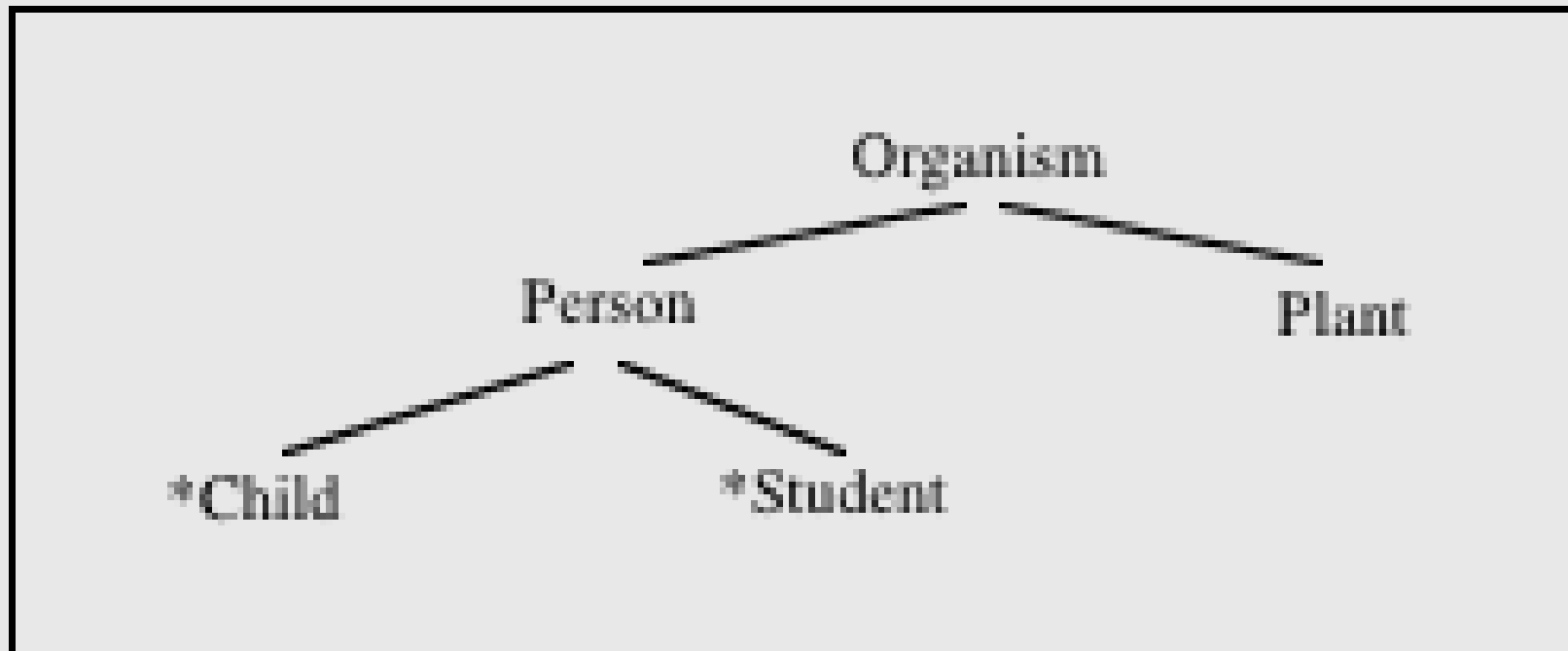
Dependence

- Between particulars
 - **Existential dependence** (specific/generic) (*also constant dependence*)
 - Hole/host, person/brain, person/heart
 - 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 .
 - Metaproperties: +D/-D

A formal ontology of properties

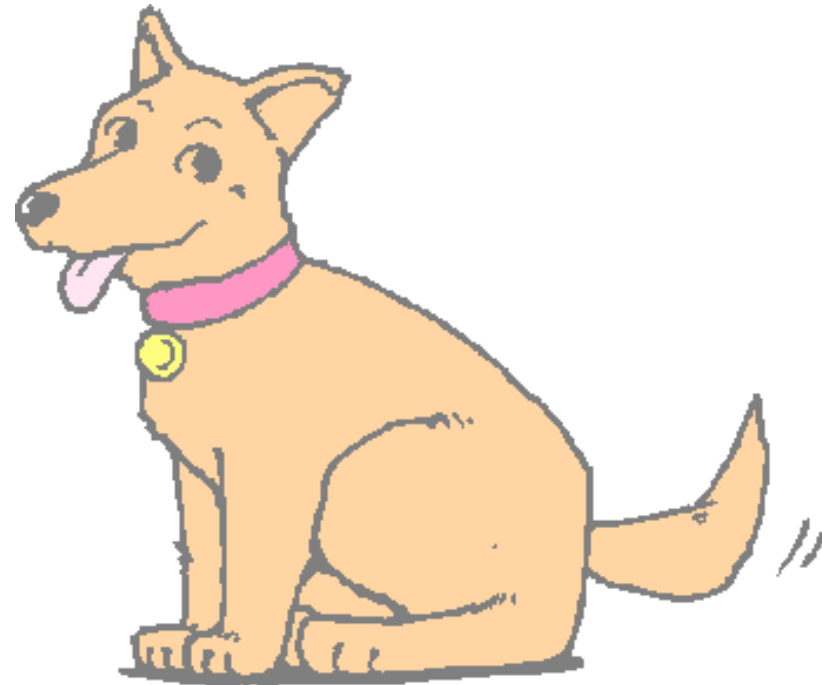


Types, Roles, and disjointness



Unity, Identity, and Essence

- **Unity**: is the collar part of my dog?
 - *Being a whole* (of a certain kind) is also a (relevant) essential property
- **Identity**: is this my dog?
 - Essential properties of *dogs*
 - Essential properties of *my dog*



Kinds of Whole

- Depending on the **nature of the *unifying relation***, we can distinguish:
 - ***Topological wholes*** (a piece of coal, a heap of coal)
 - ***Morphological wholes*** (a constellation)
 - ***Functional wholes*** (a hammer, a bikini)
 - ***Social wholes*** (a population)
- * a whole can have ***parts that are themselves wholes*** (with a different unifying relation)

Unity and Plurality

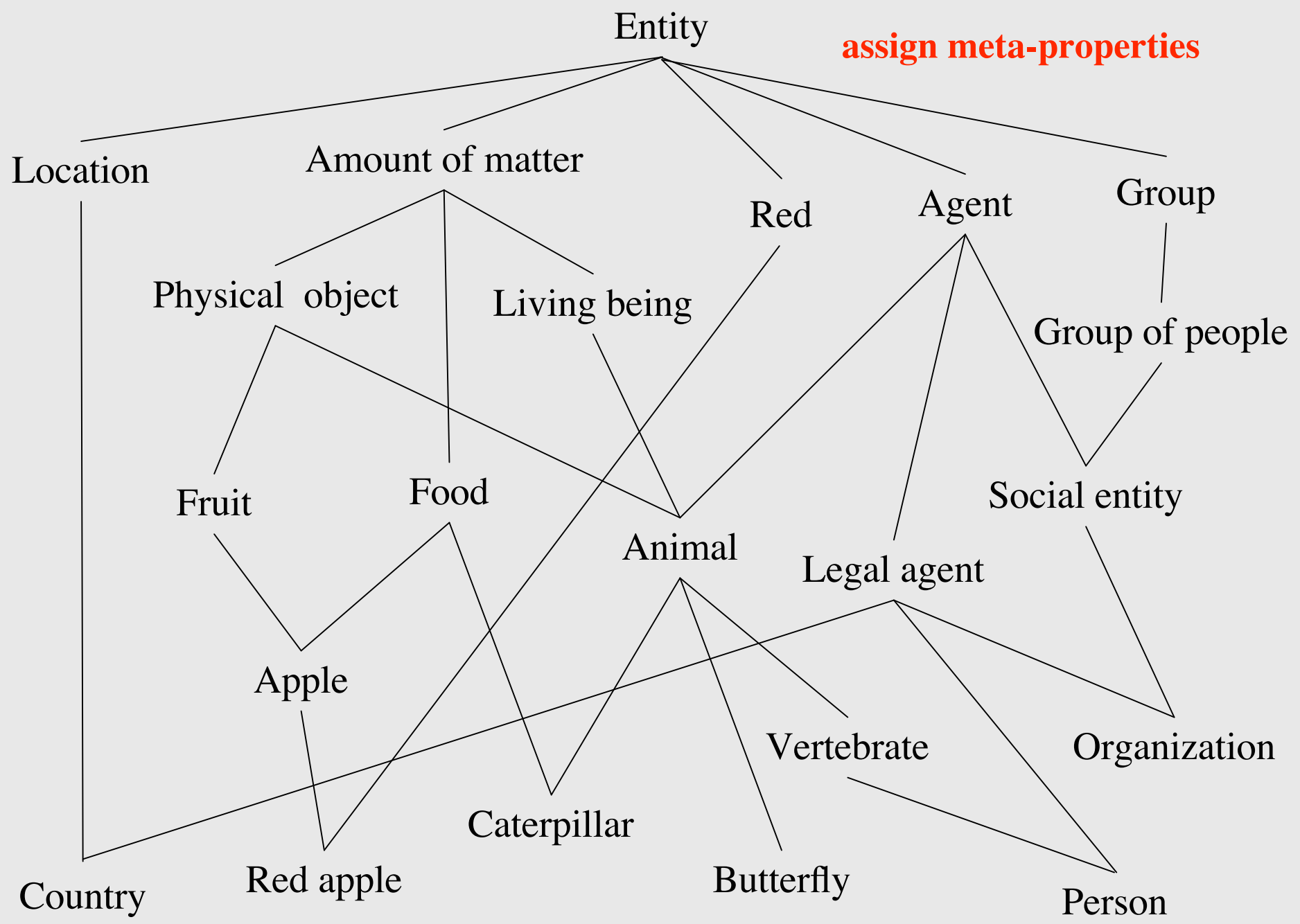
- *Ordinary objects: **wholes or sums of wholes***
 - *Singular: **no wholes as proper parts***
 - *Plural: **sums of wholes***
 - *Plural wholes (the sum is **also a whole**)*
 - *Collections (the sum is not a whole)*

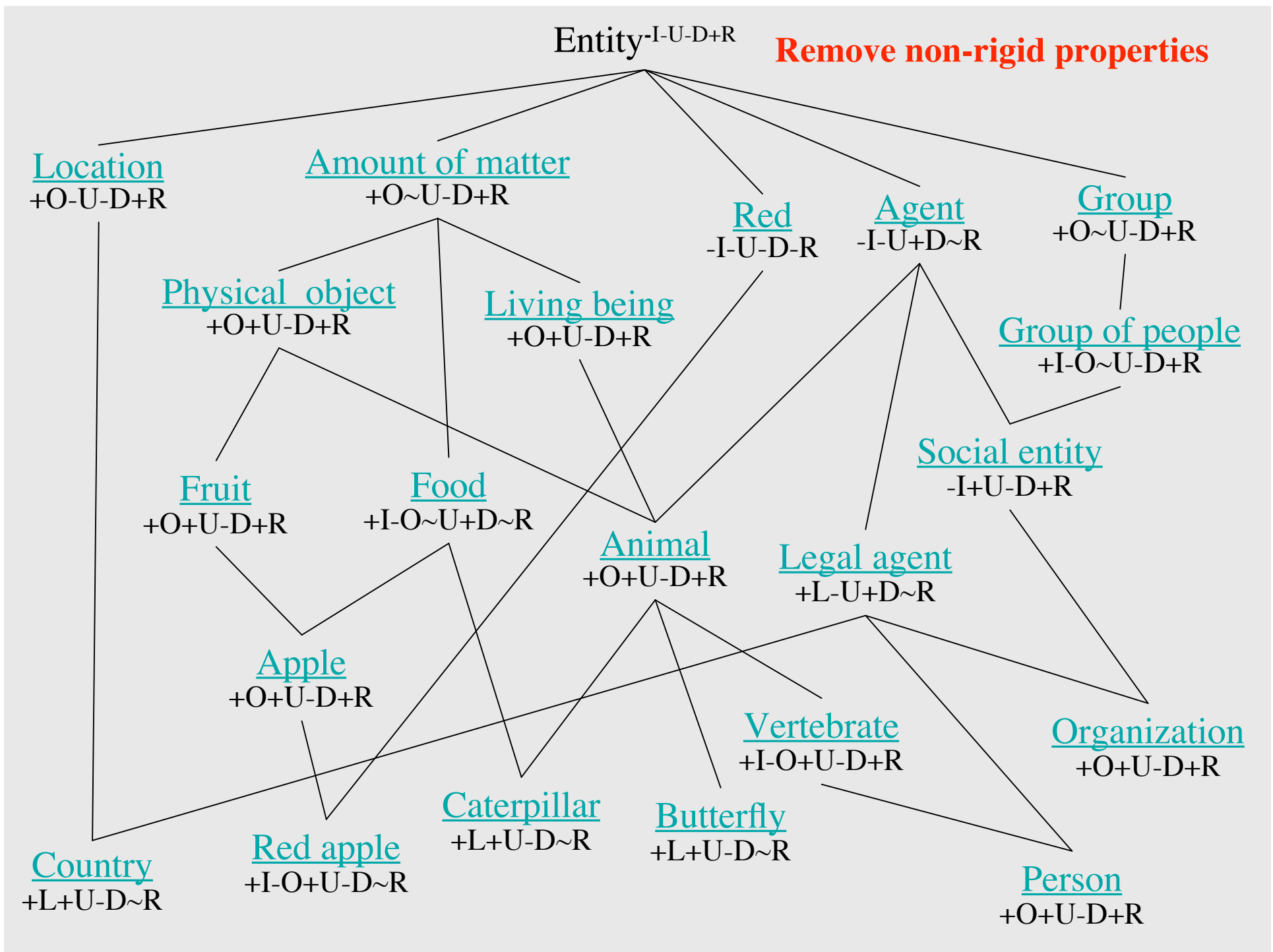
A taxonomy cleaning example

Taxonomic Constraints

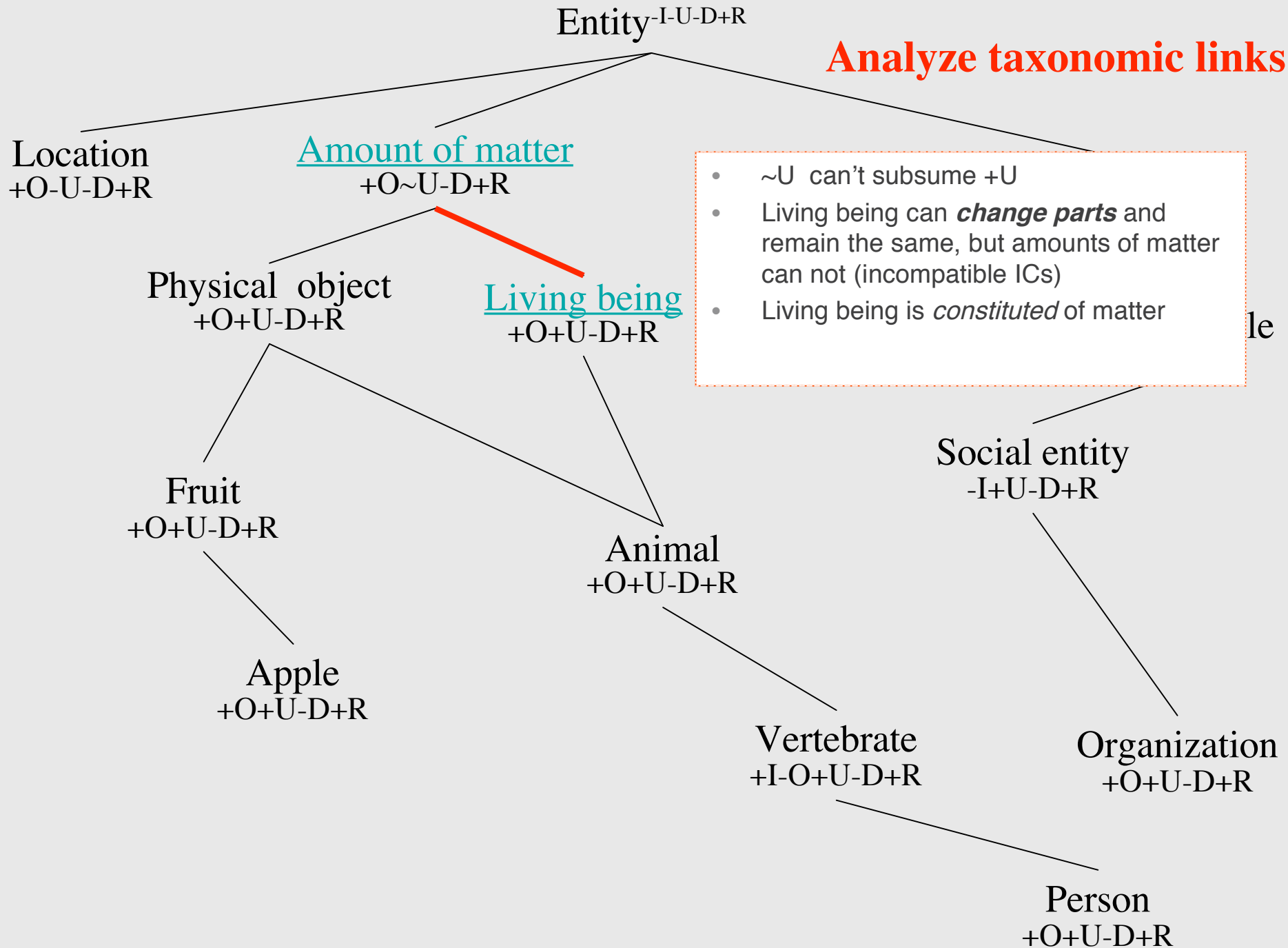
- $+R \not\subset \sim R$
- $-I \not\subset +I$
- $-U \not\subset +U$
- $+U \not\subset \sim U$
- $-D \not\subset +D$
- Incompatible IC's are disjoint
- Incompatible UC's are disjoint

assign meta-properties

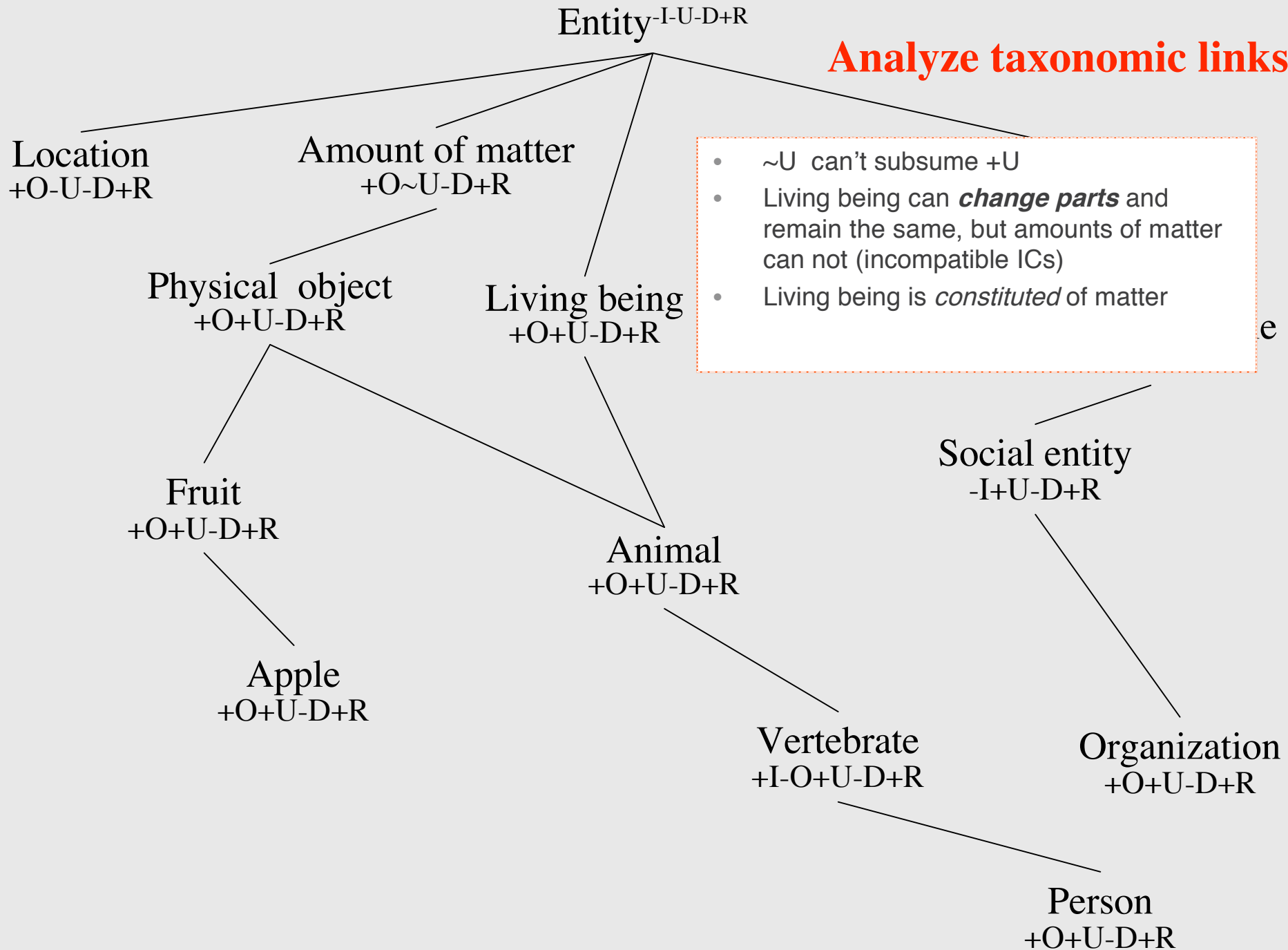




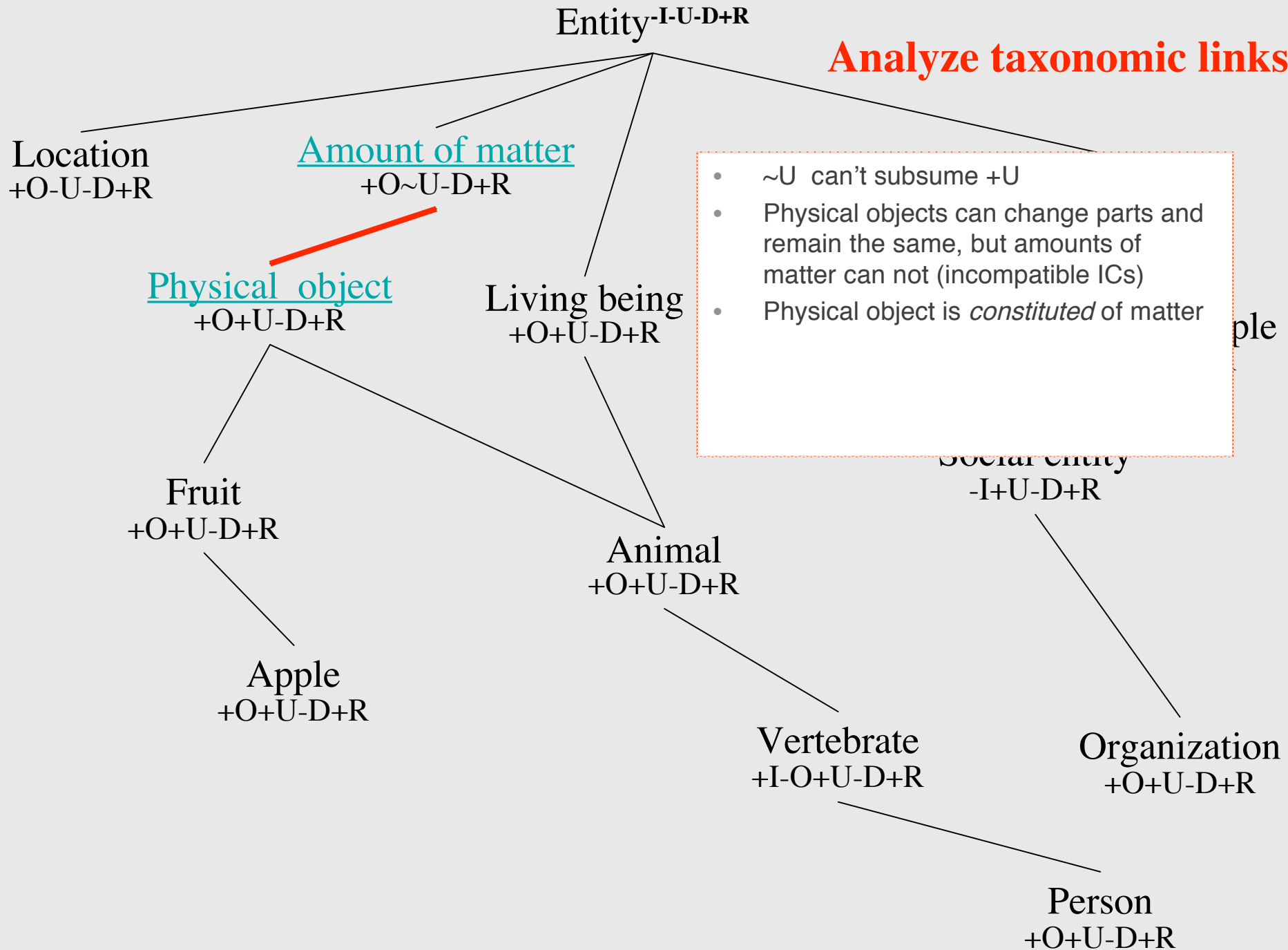
Analyze taxonomic links



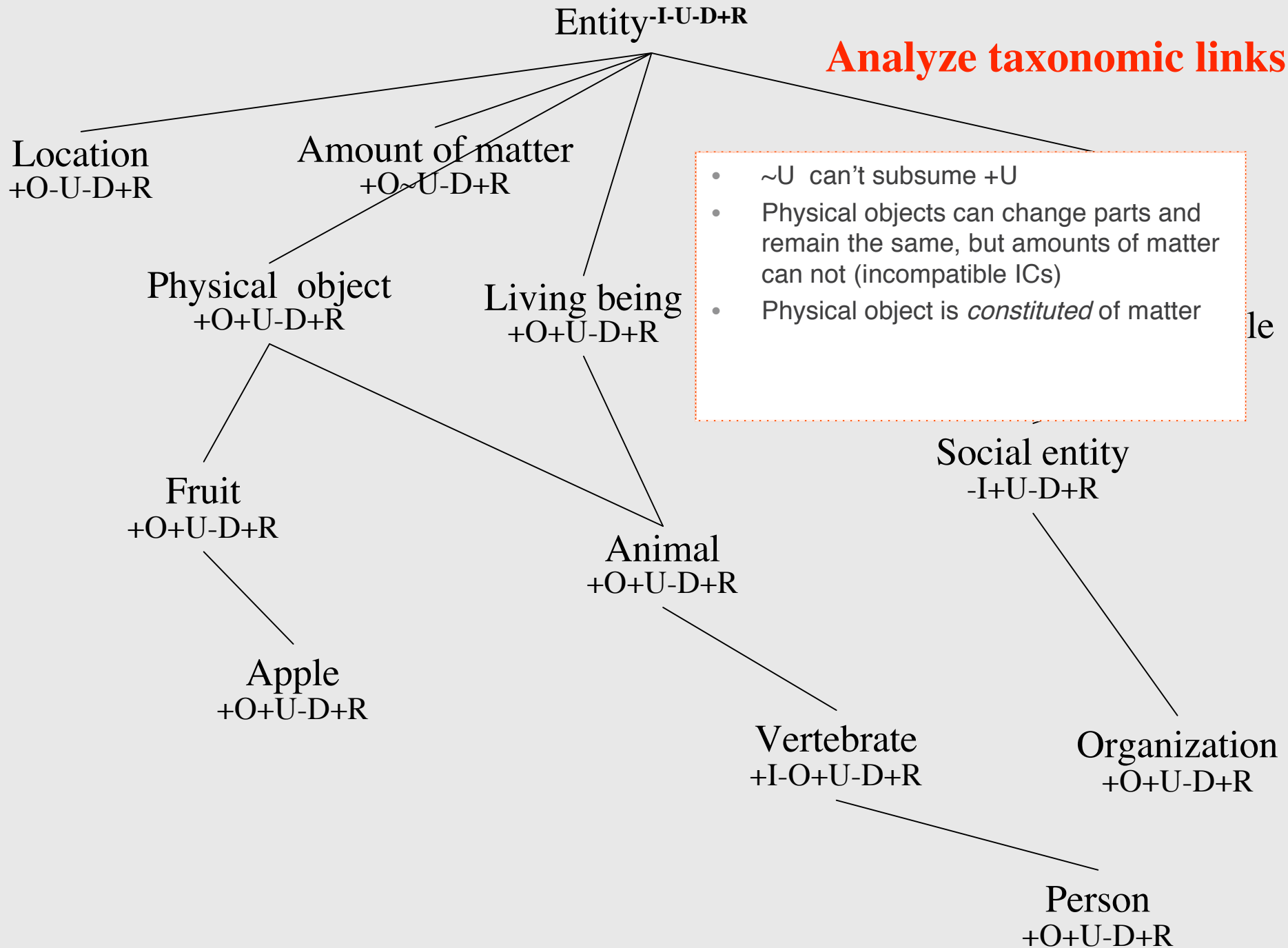
Analyze taxonomic links



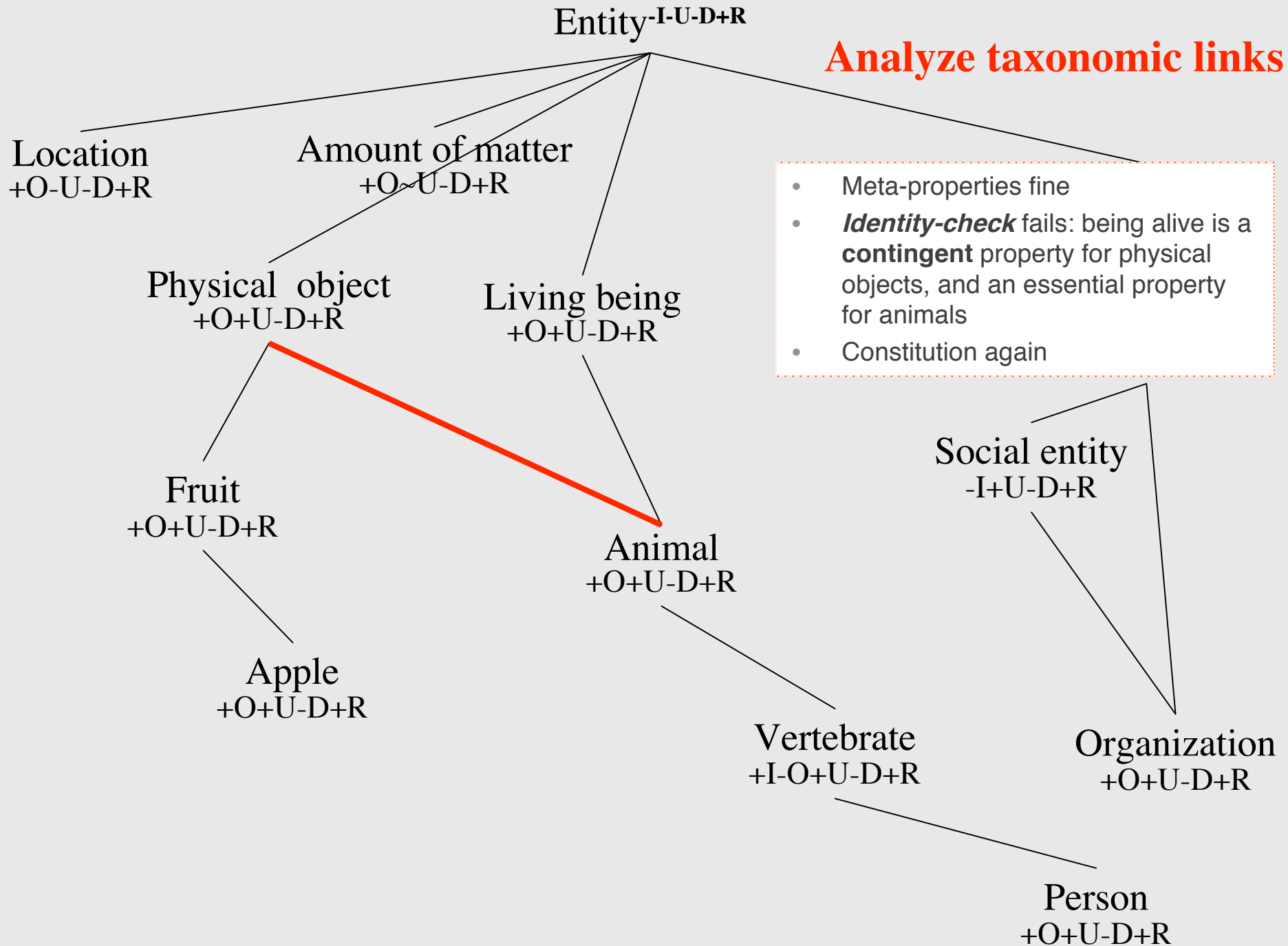
Analyze taxonomic links



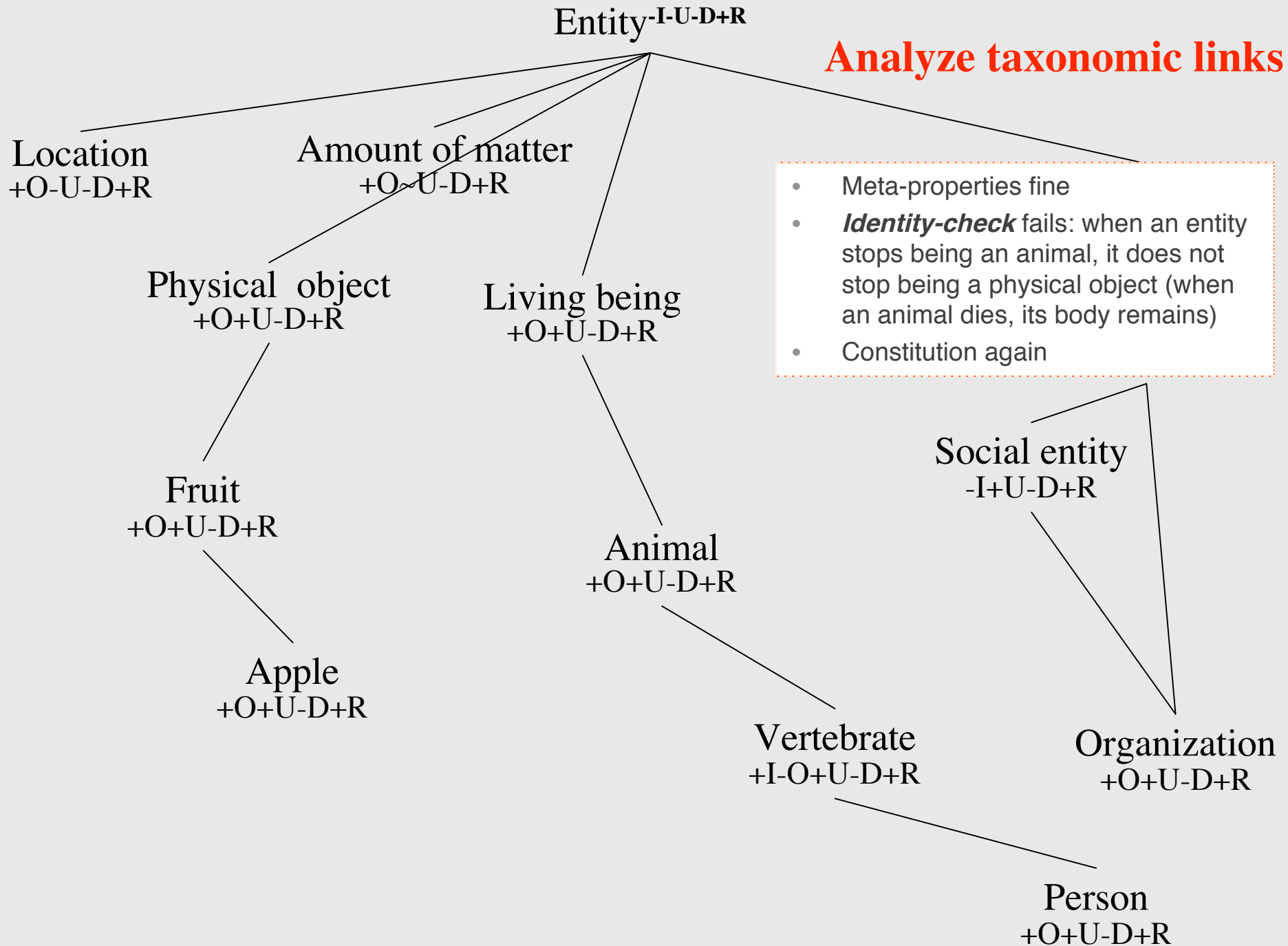
Analyze taxonomic links



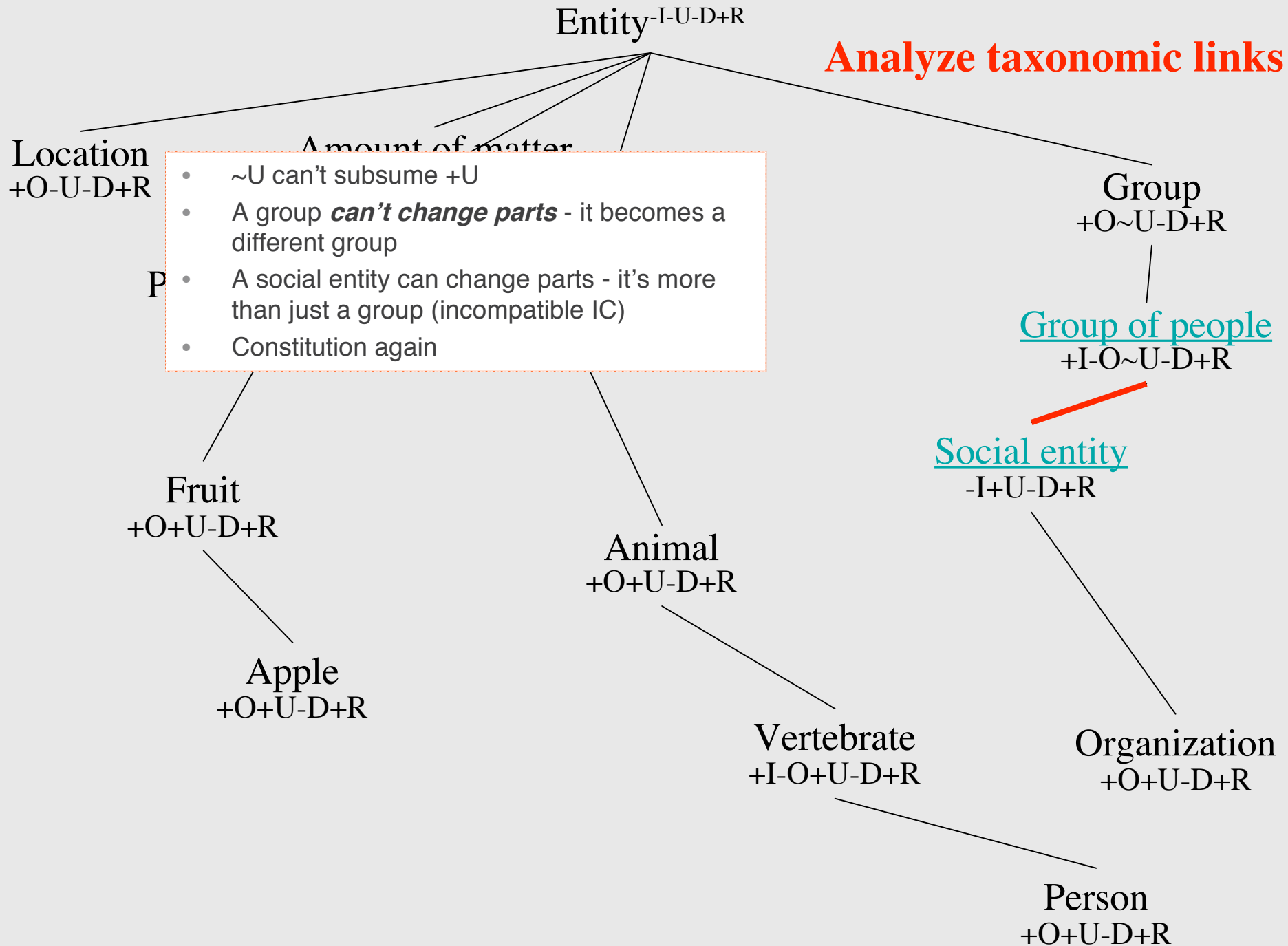
Analyze taxonomic links

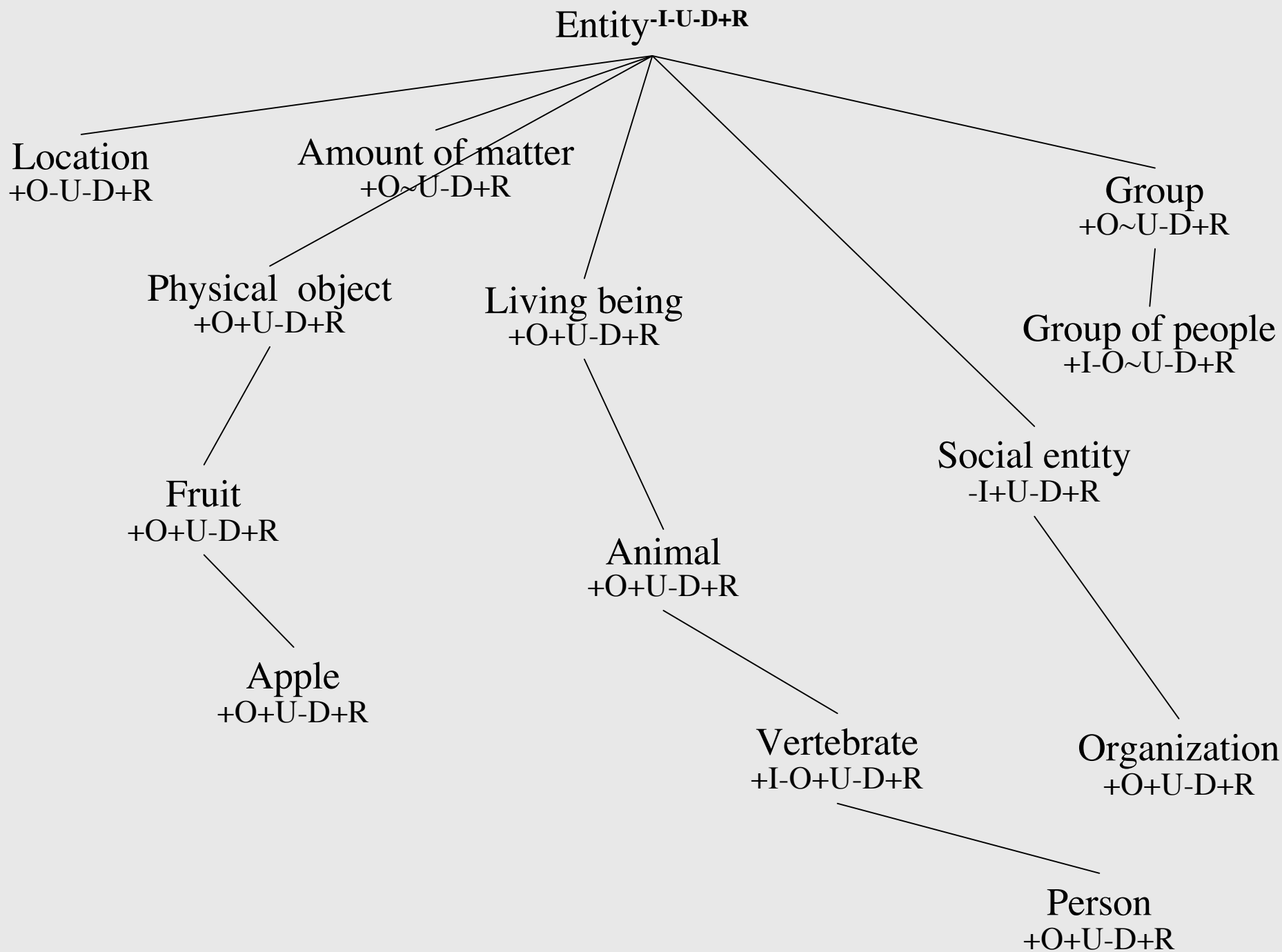


Analyze taxonomic links

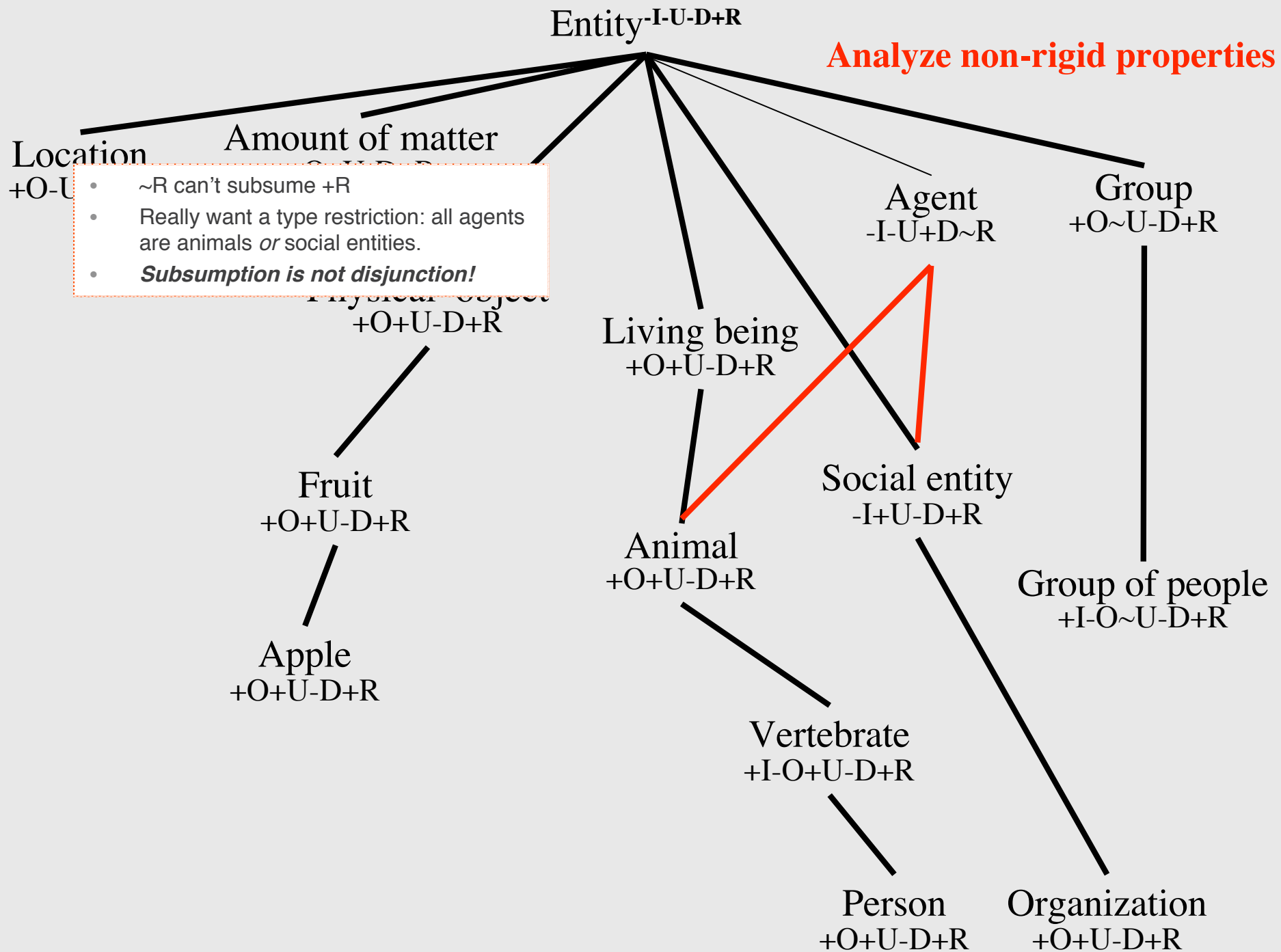


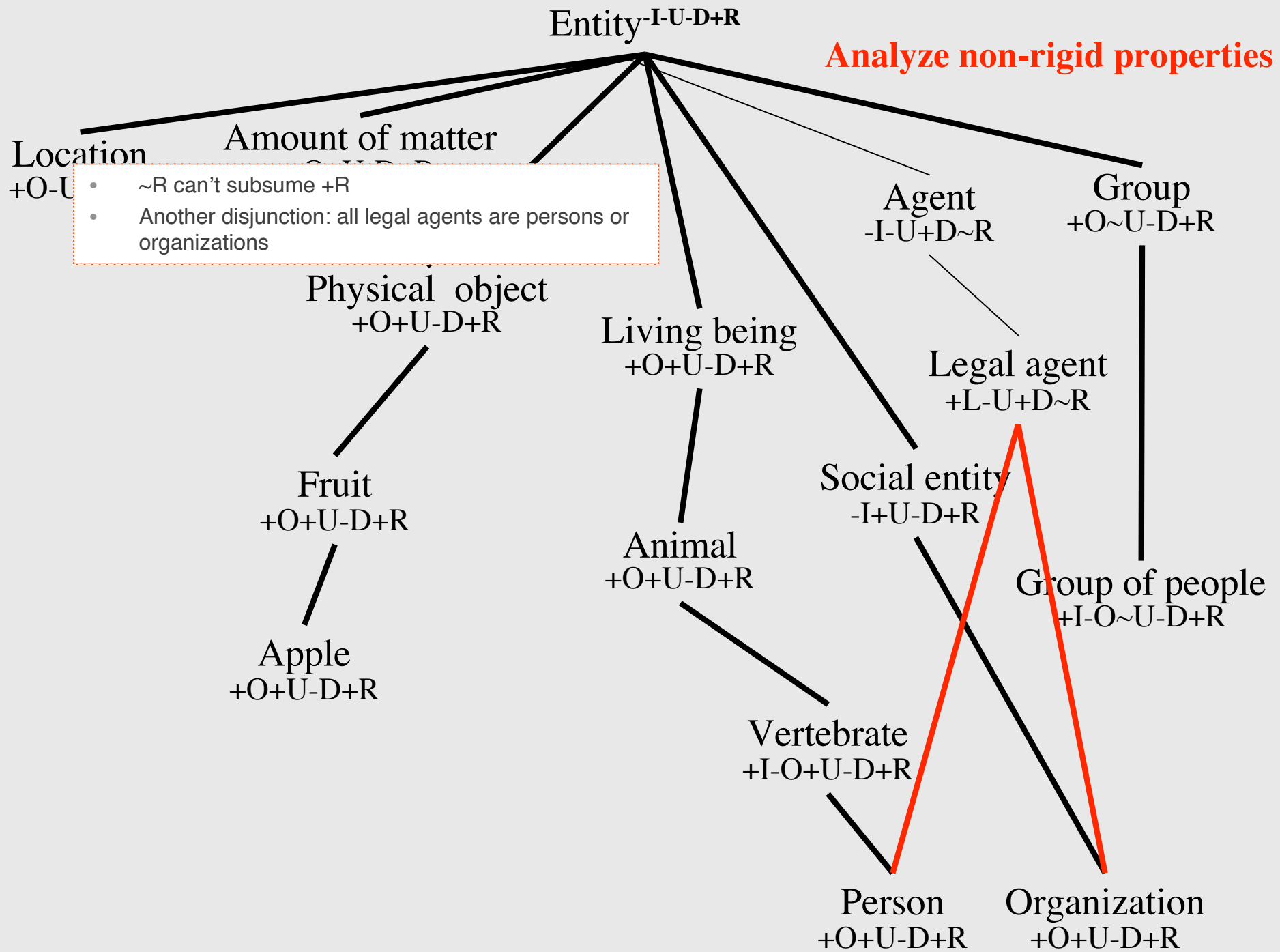
Analyze taxonomic links

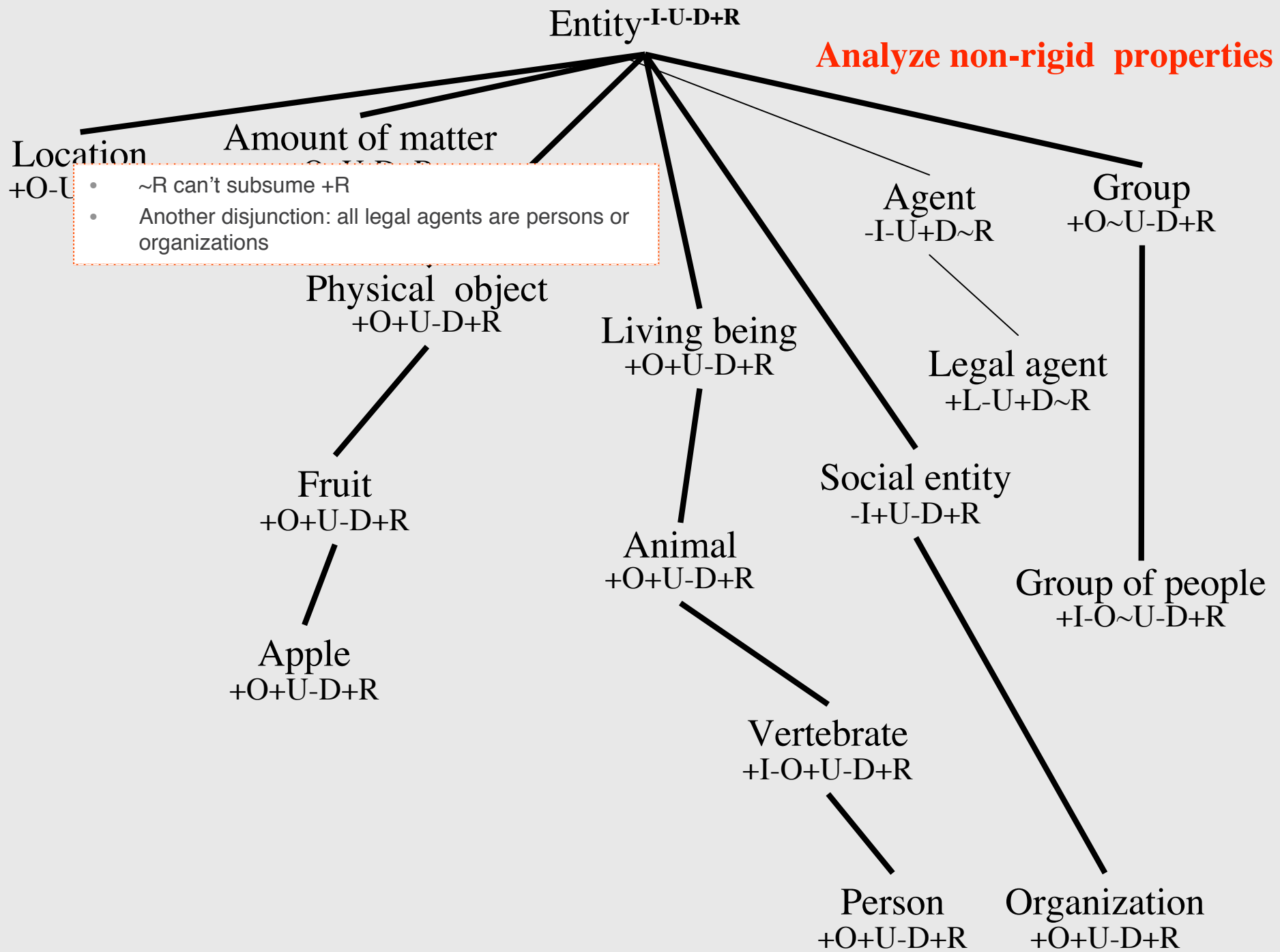




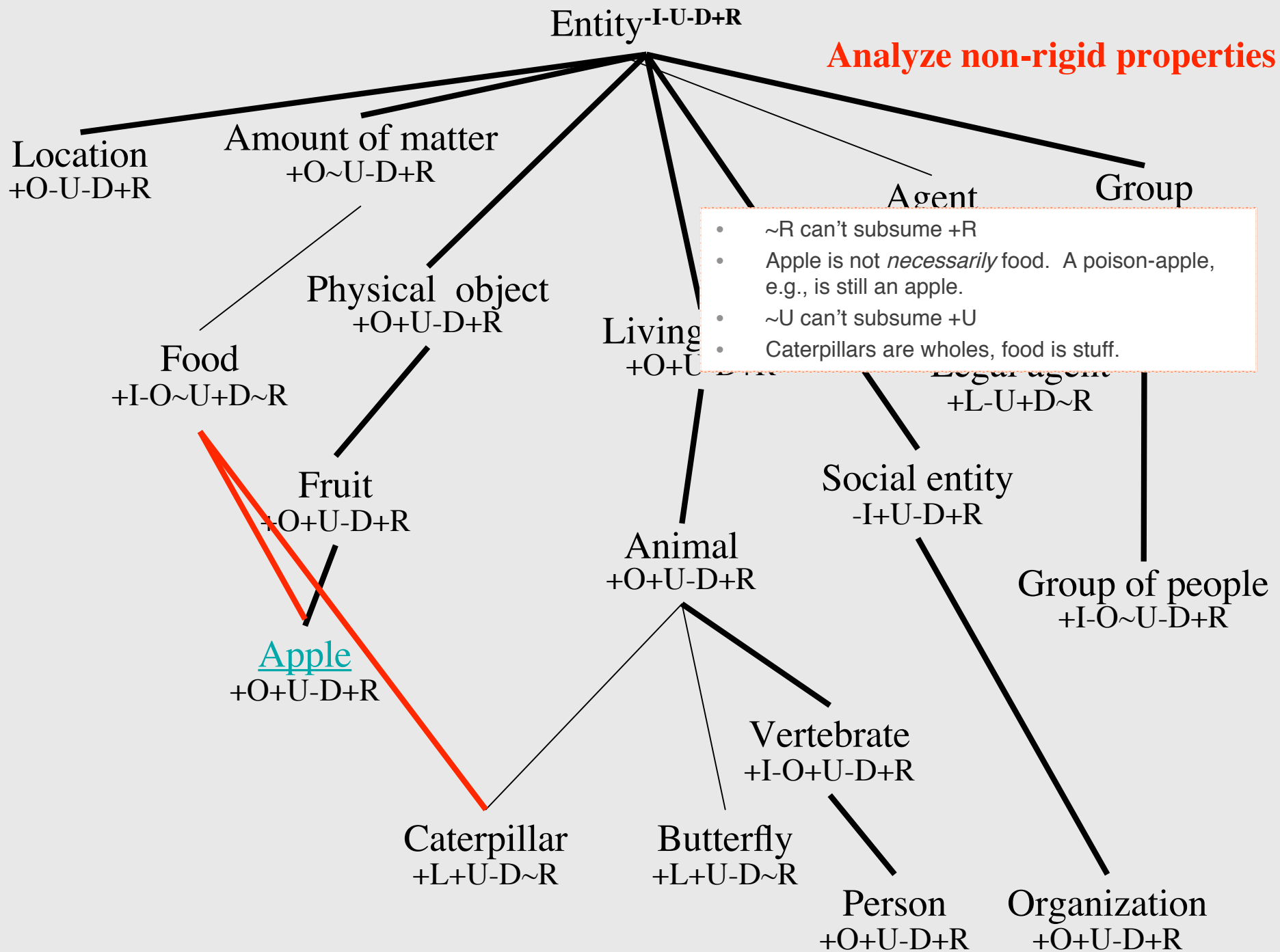
Analyze non-rigid properties



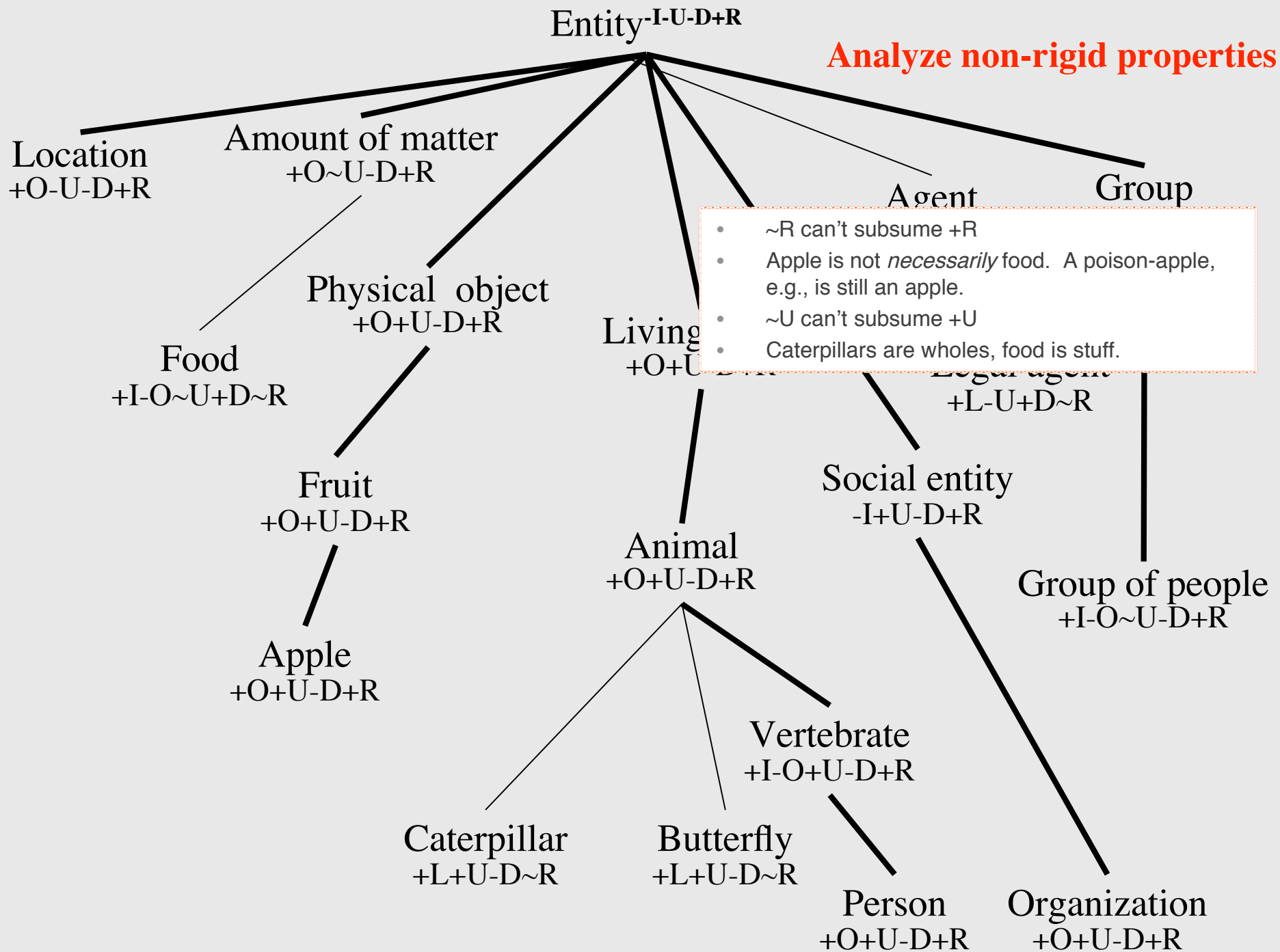


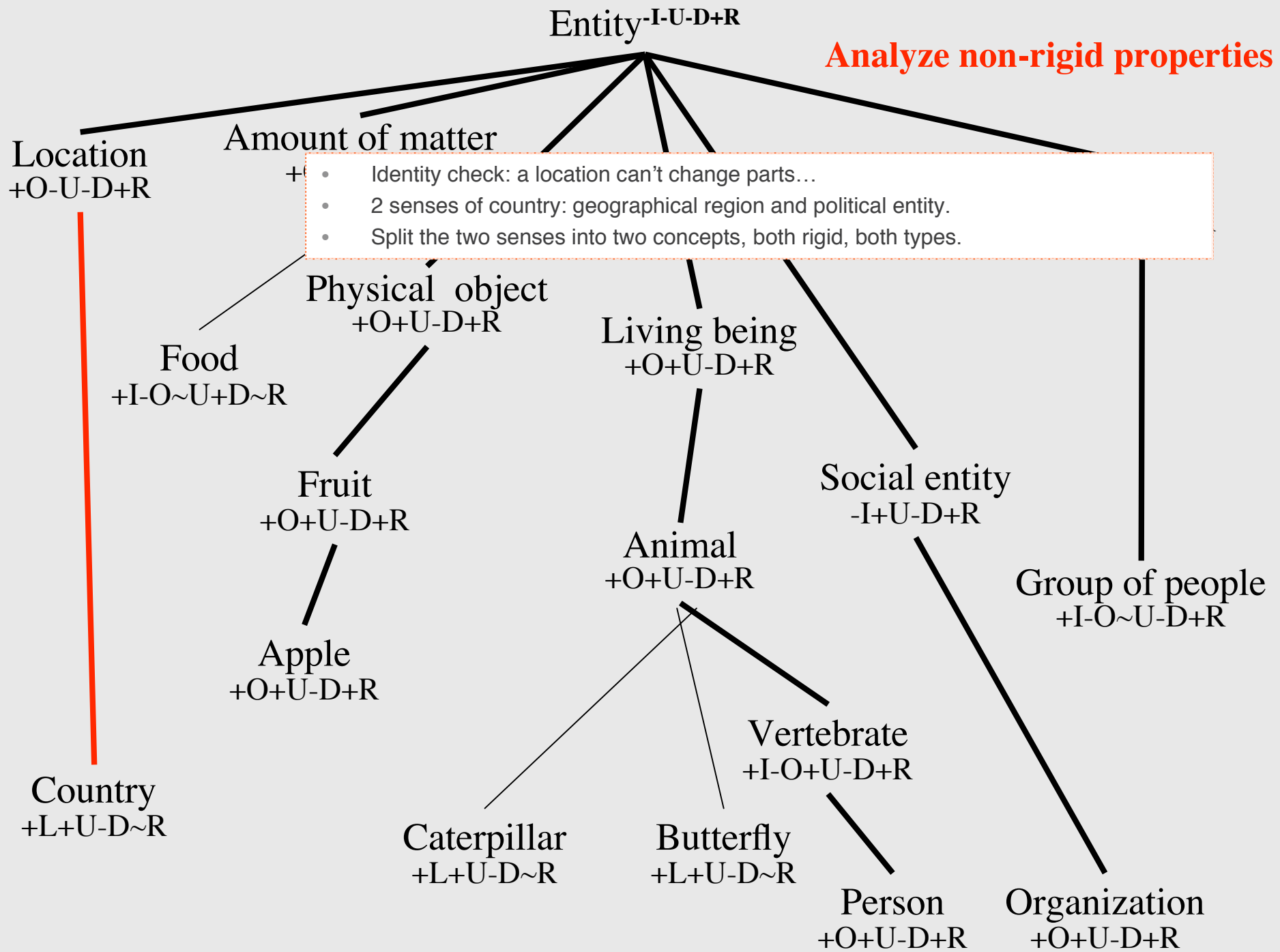


Analyze non-rigid properties



Analyze non-rigid properties





Analyze non-rigid properties

Entity -I-U-D+R

Location
+O-U-D+R

Amount of matter
+O~U-D+R

Agent
-I-U+D~R

Group
+O~U-D+R

There is a relationship between the two,
but not subsumption.

Food
+I-O~U+D~R

being
+O+U-D+R

Legal agent
+L-U+D~R

Fruit
+O+U-D+R

Social entity
-I+U-D+R

Animal
+O+U-D+R

Group of people
+I-O~U-D+R

Apple
+O+U-D+R

Geographical
Region
+O-U-D+R

Vertebrate
+I-O+U-D+R

Country
+O+U-D+R

Caterpillar
+L+U-D~R

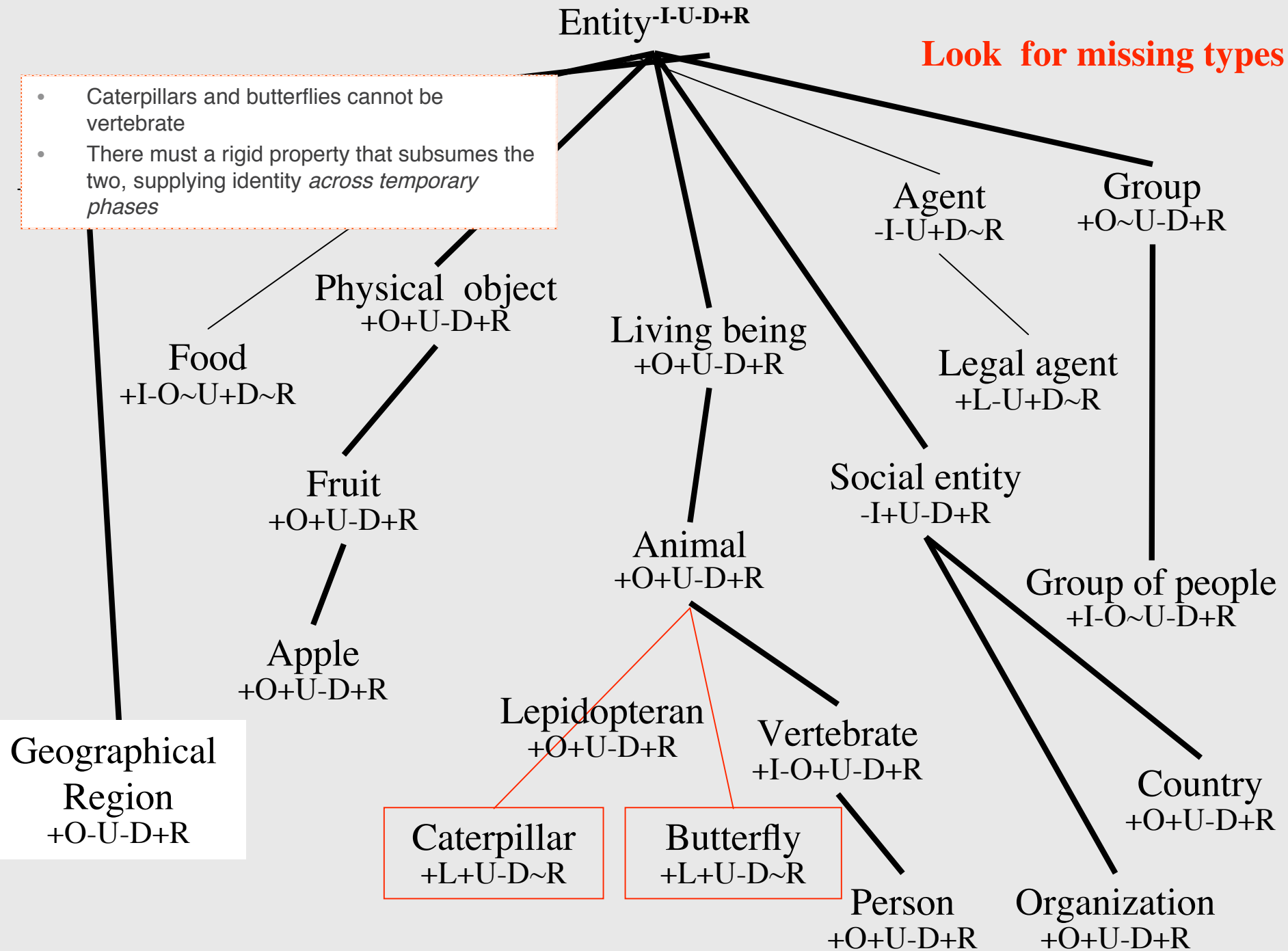
Butterfly
+L+U-D~R

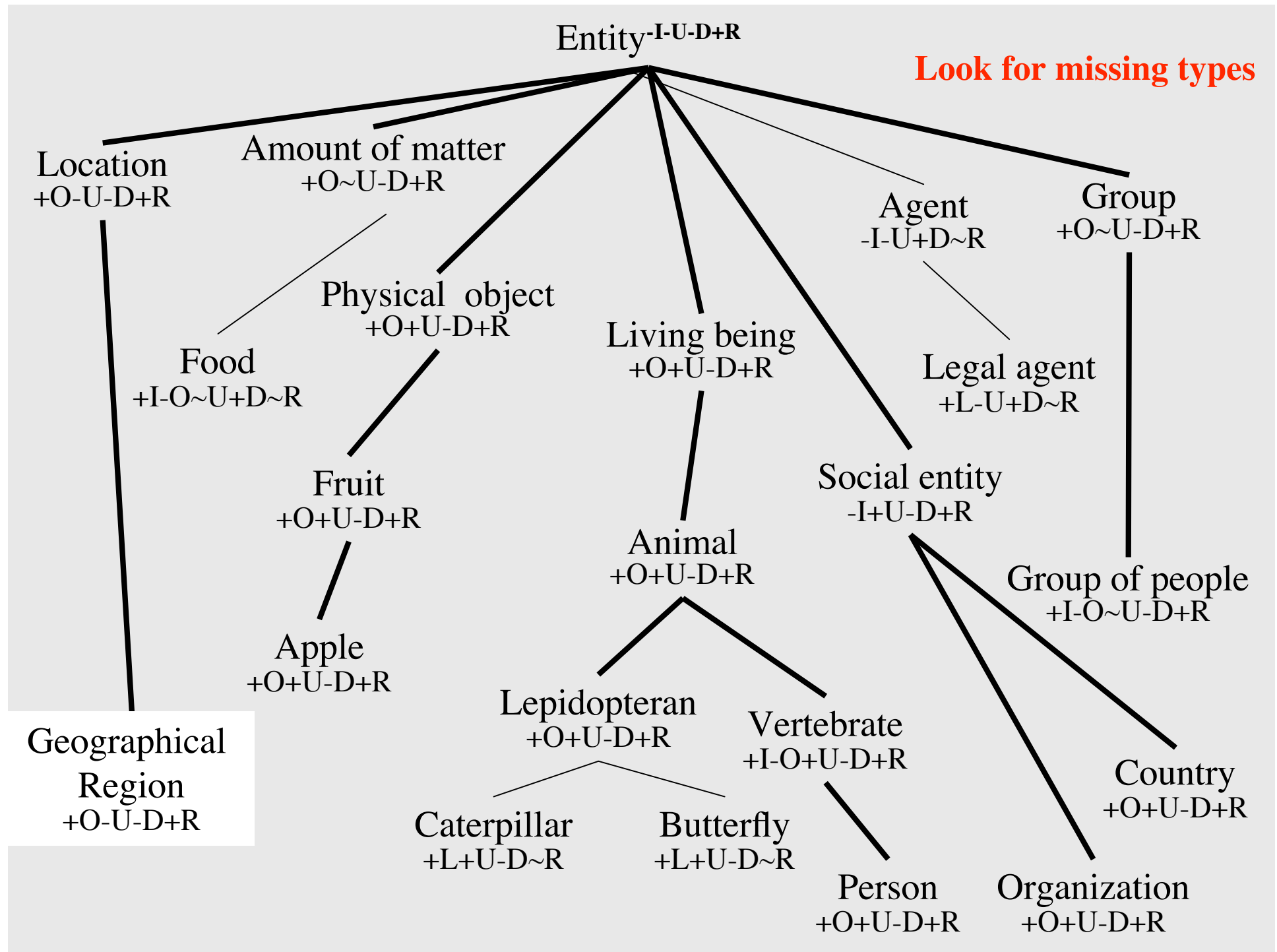
Person
+O+U-D+R

Organization
+O+U-D+R

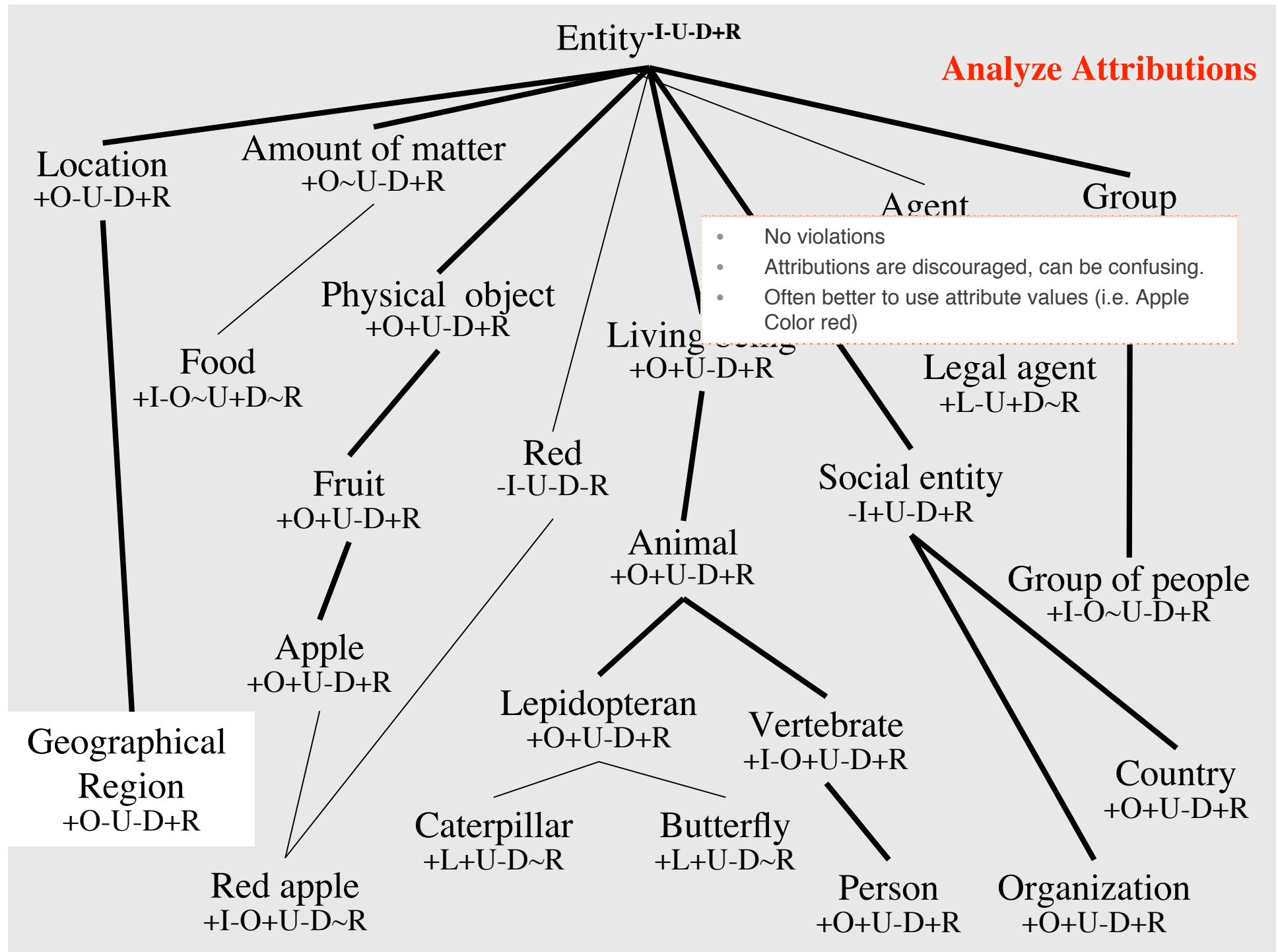
Look for missing types

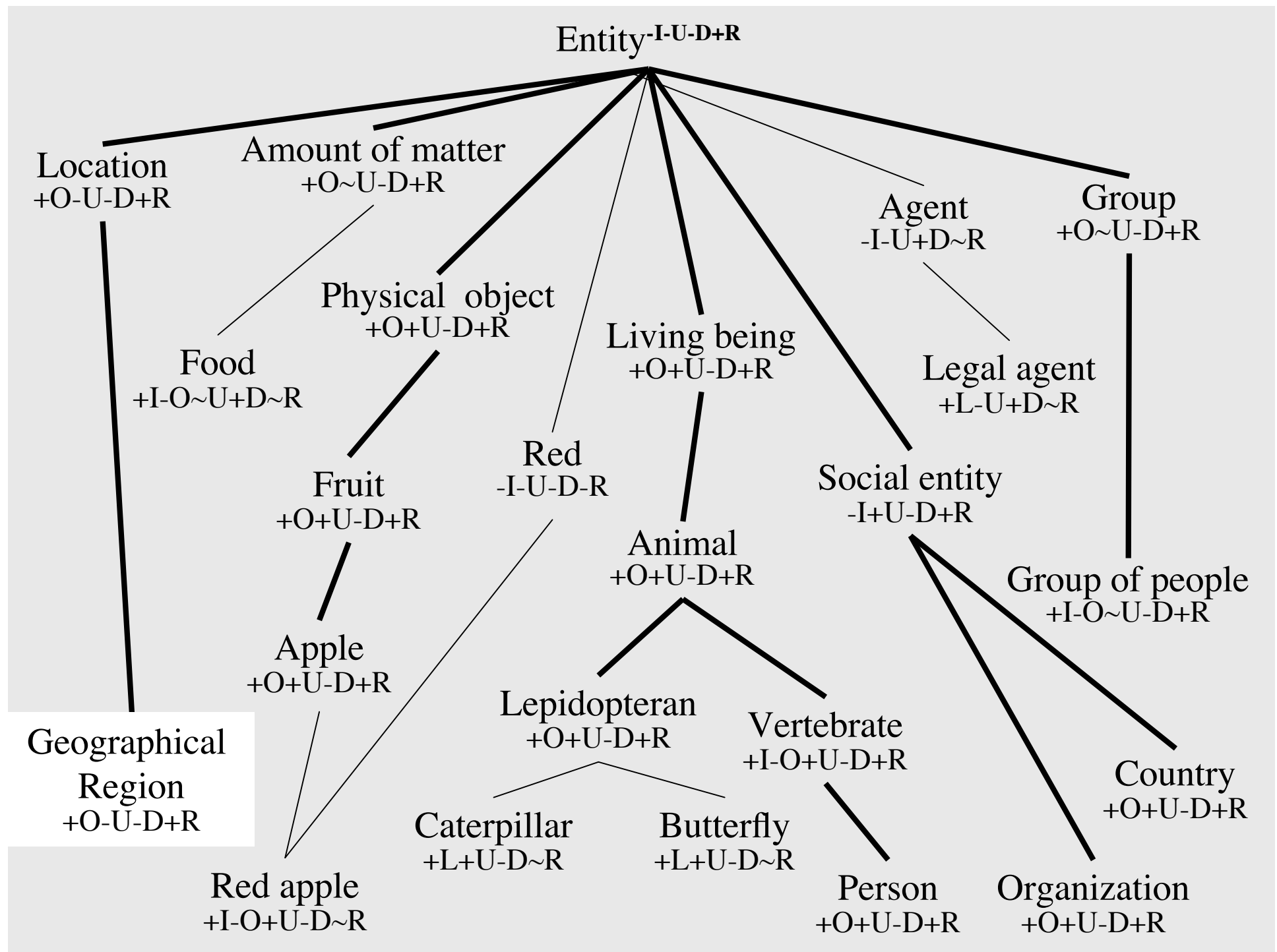
- Caterpillars and butterflies cannot be vertebrate
- There must a rigid property that subsumes the two, supplying identity *across temporary phases*



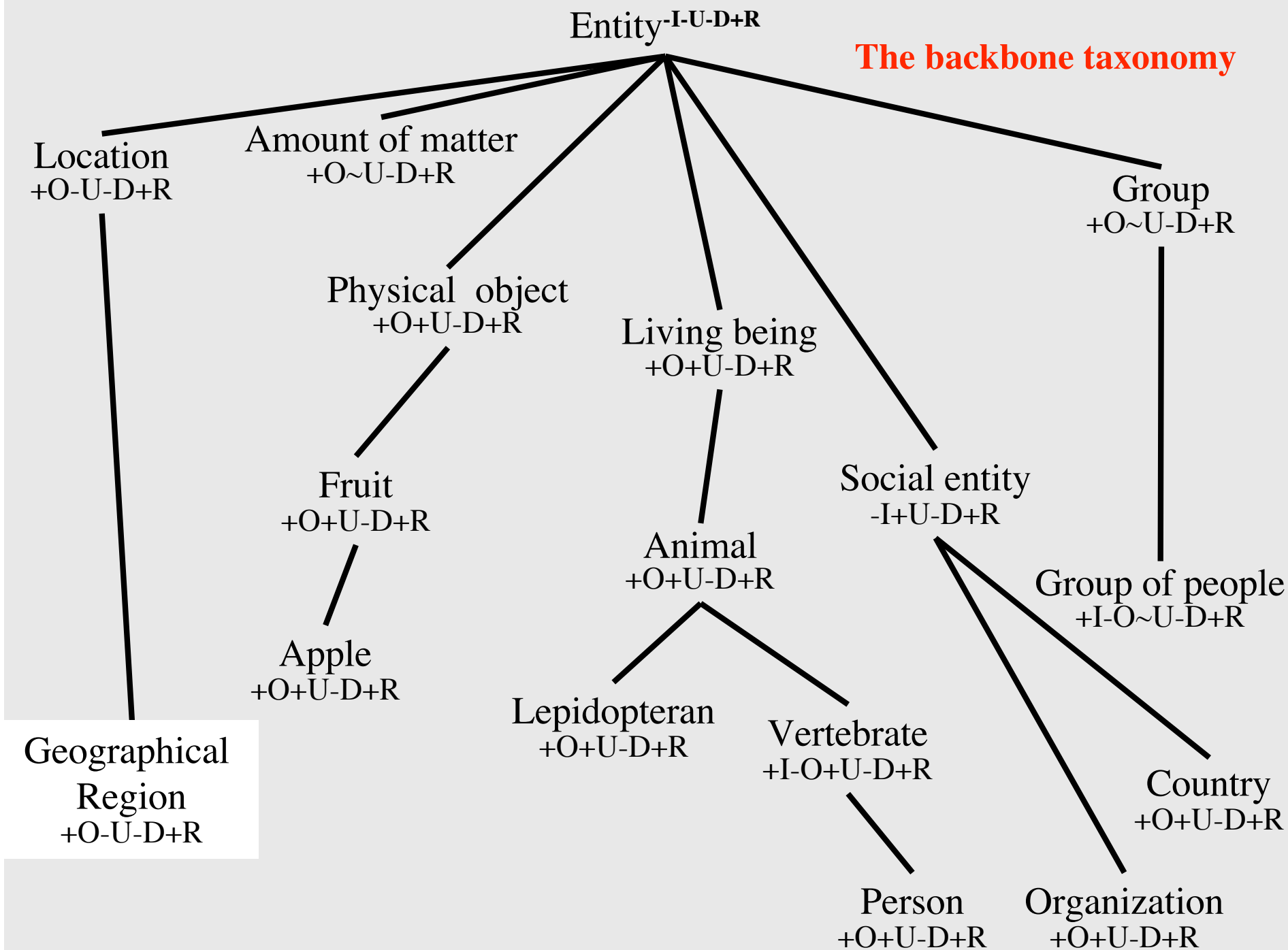


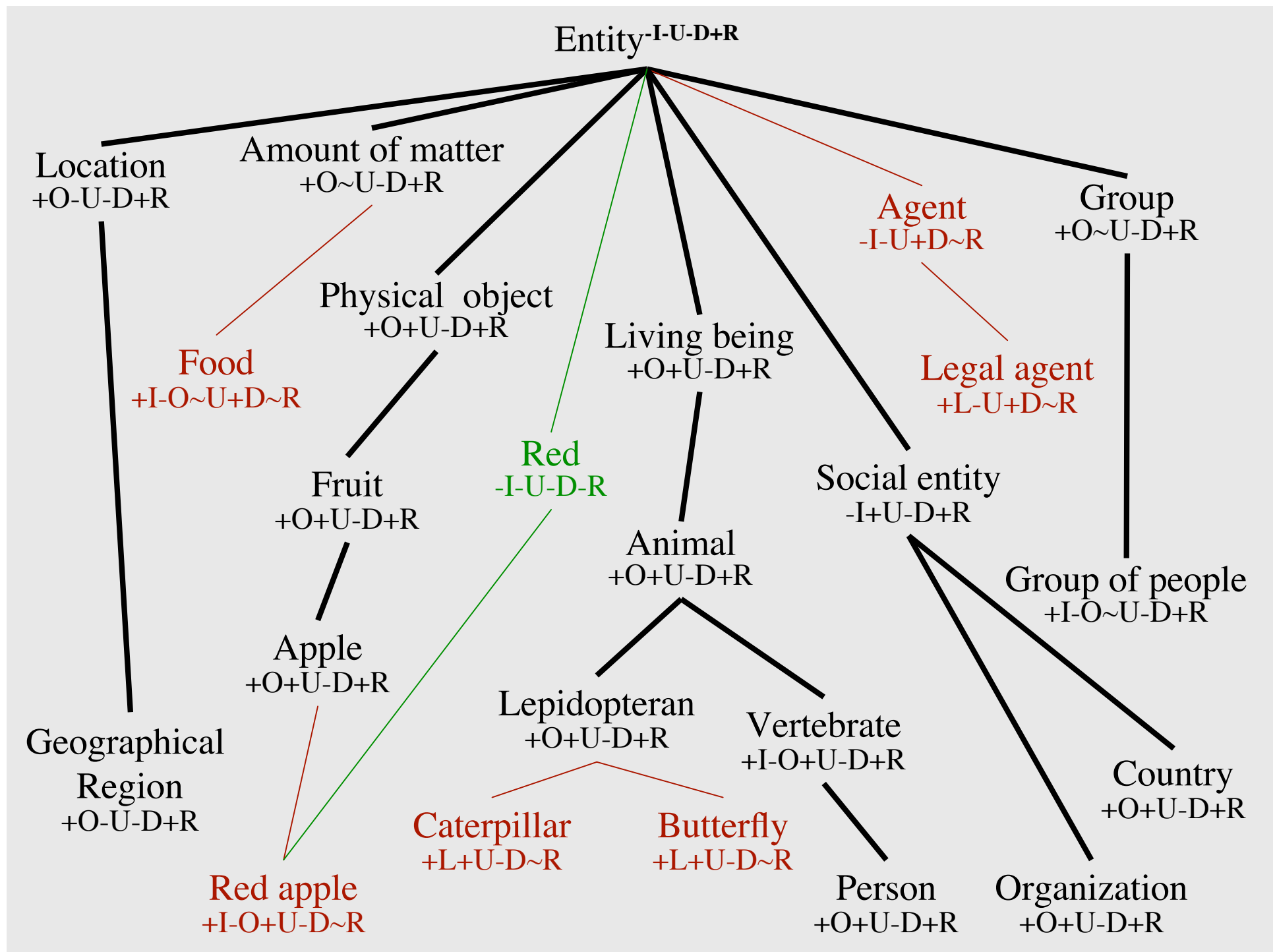
Analyze Attributions



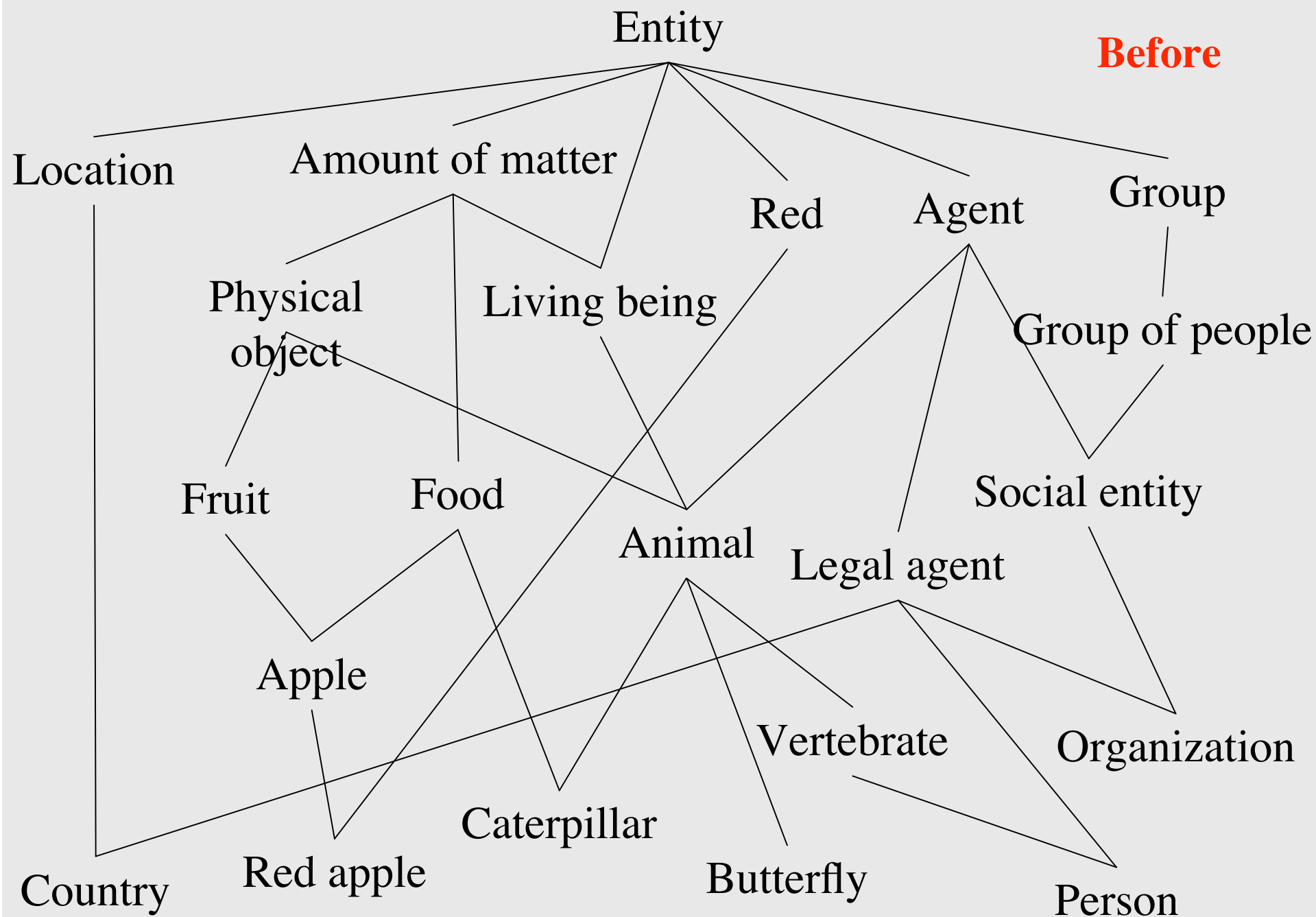


The backbone taxonomy





Before



After

