

**Contexts for Integration and Interoperability**  
Ontolog Ontology Summit 2018  
Contexts in Context

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# Context Aware Ontologies

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Context aware ontologies for information and system integration

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# Problem Statement

- Focus: Integration, Interoperability and Federation Leveraging Reference Ontologies\*
  - Every major enterprise needs to integrate and federate information and systems, internally and externally
  - Current manual methods are costly, time consuming and error prone. They tend to tie the enterprise system of systems into a complex, anti-agile Gordian knot
  - These many systems are independently conceived, each containing multiple separate definitions of the same or overlapping concepts. These definitions are technology, organization and application specific
  - **Semantic mediation** has been a primary value proposition for Ontologies, but has proved difficult, particularly for systems without a formal underpinning – which is 99.9% of the systems
  - Our proposition is that successful semantic mediation requires **context**. Ontologies to solve these problems must be **context aware**.
    - Being *Context aware* requires a level of granularity beyond contextualizing ontologies

\* **Reference Ontology**: A set of concepts intended to be referenced by multiple designs, ontologies and schema in support of integration and interoperability among them.

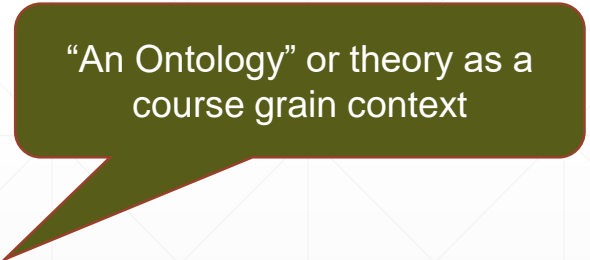
Different from: **Application Ontology**, intended to support reasoning in support of a particular application.

# What is context?

- A **context** is anything that impacts the interpretation or truth value of something else
- There are different kinds of context, **contextual dimensions**. Kinds of context include
  - **Time** – fundamental to our understanding of the world is that things change. Most relationships and other assertions are only meaningful in the context of a timeframe
    - Sue's weight was 50kg on July 1<sup>st</sup>, 2017
    - Barack Obama was president of the United States 2/20/2009 until 1/20/2017
  - **Occurrences** (perdurants) – things that are only true while something is happening
    - The radar's range will be reduced while it is raining
  - **States** - things that are only true when something is in a particular condition
    - Food services will be reduced when the power is off
    - The computer is vulnerable when it is connected to the internet
  - **Authority** - things that are only true within the jurisdiction of some authority (including geopolitical)
    - Radar detectors may not be used within Virginia
    - "Fairfax" is the name of a City in Virginia
  - **Interaction** - things that are only true when communicating for a purpose
    - Mortgage loan applications must include name, address, SSN and current income

# More Contextual Dimensions

- **Social Group** – things that are true for a set of people
  - In French, Germany is called “Allemagne”
- **Location** – things that are true in a particular place
  - The acceleration of gravity is  $9.8 \text{ m/s}^2$  on the surface of the earth
- **Type** – things that are true for kinds of things
  - Mammals have hair
- **System** – things that are true within a specific system
  - Reactor 5, pump A6 is failing
- **Design** – things that are true for a design
  - The victim database contains the victim’s current address and phone number
- **Source (Provenance)** – things that are true within a text, speech act or ontology
  - John’s report said “Reactor 5, pump A6 is failing”
- Others – there are many contextual dimensions
- Things may be in multiple context at the same time



“An Ontology” or theory as a course grain context

# A theory of contextualization

- Contextual dimensions are types of context
  - E.g. U.S.A. is a kind of Geopolitical Organization
  - Geopolitical Organization is a kind of context
- Contexts **contextualize** things that have that context
  - <Thing> **has context** <Context>, or <Context> **contextualizes** <Thing>
  - E.g. U.S.A. **contextualizes** Alaska
  - But, that isn't specific enough
- Relationships define contextualization for a contextual dimension
  - (<Geopolitical Entity> **governs** <Region>) **specializes** (<Context> **contextualizes** <Thing>)
  - E.g. (U.S.A. **governs** Alaska) **implies** (U.S.A. **contextualizes** Alaska)

# Higher Order Context

- Context, such as time, can apply to other statements
  - <Actual Situation> **exists for** <Time Interval>
  - (U.S.A. **governs** Alaska) **exists for** March 30, 1867 to Unknown
  - (U.S.A. **governs** Massachusetts) **exists for** March 4th, 1789 to Unknown
- Rights and Obligations are frequently contextual
  - *Citizens of the U.S.A. have right* Protections from Unreasonable Searches and Seizures
    - **exists for** March 4<sup>th</sup>, 1789 to Unknown
  - (Workers in the U.S.A. **must pay** Income Tax) **exists for** Feb. 3<sup>rd</sup>, 1913 to Unknown
- Implies
  - Since March 30, 1867 Citizens of Alaska have rights and as of Feb. 3<sup>rd</sup>, 1913 must pay taxes

# Ignoring of context is *dangerous!*

- Issues with ignoring context when integrating or federating information or processes
  - Improper integration of information from different timeframes
    - That prescription was for last year!
  - Failure of trust – what information is to be trusted and why
    - We listen to their feed, but it is all lies
  - Violation of compliance, rules are contextual
    - You stored that information in the EU?
  - Consider: “Launch Missile” Vs. Test: “Launch Missile”
    - Sorry Korea!

Test Scenario : Control Systems

 Launch  
Missile





# Context to bridge Reference Concepts and Data

Humans share  
a concept of  
“mass/weight”  
– all physical  
things have a  
mass



## Mass/weight in data elements

- May have different labels
- Use different units
- May be required, optional or excluded
- May be past, current, expected, recommended or allowed
- May be represented using various data types (int, real, string, etc)

**But it's the same mass of the same individual!**



# Why would two mappings of the same data on the same day be different? Why would the fields not be the same?

## Bethesda Hospital Records

### Sue's Physical Report

Name: Sue Plankton  
DOB: January 15<sup>th</sup>, 1968  
SSN: 390-55-8967  
Weight: **134 lbs**  
BP: **122/78**  
Physical Date: **June 3, 2017**

### Sue's Home Scale

Weight: **131 lbs**  
Taken: **Dec 3, 2017**

Automated  
Information  
Translations

## Army Reserve Fitness Report

### Sue's Fitness Report

LegalNameString: Sue Plankton  
Birth: January 15<sup>th</sup>, 1968  
PersonMassKG: **Unknown**  
PersonBloodPressue: **Unknown**  
Report Date: **Jan 10<sup>th</sup>, 2018**

## Job Application for Fun Fitness Centers

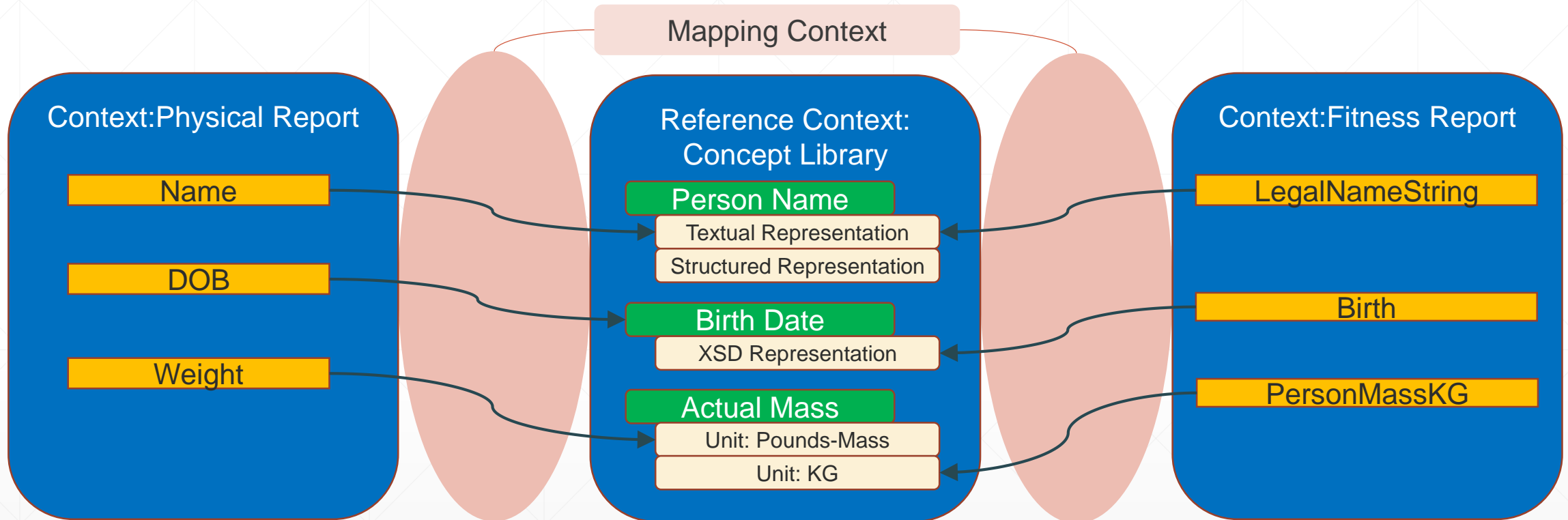
### Sue's Job Application

PNAME: Sue Plankton  
PBD: January 15<sup>th</sup>, 1968  
Social: 390-55-8967  
CWeight: **134 lbs**  
AppDT: **Jan 10<sup>th</sup>, 2018**

?

How are  
multiple  
sources  
reconciled?

# Context determines terms & representation (of data) for concepts



Ontological reference concepts, can serve as a pivot-point between different data representations, or different ontologies. This can power automation of interoperability, integration and federation.

# Context of time and data determine data interoperability



- Weight measurement is in the context of the physical's date
- Example data rules (data context)
  - Army Reserve Fitness Report must include Name, DOB, May include Weight and BP if known.
  - Job Application for Fun Fitness Centers must include name, DOB, SSN & Weight
- Example business rules (mapping context)
  - Army Reserve: Recording of a solders weight must be based on a measurement within the last 60 days.
  - Fun Fitness Centers: Recording of weight must be reported from last physical

Why the same data on the same day be different in different context

Ontologically, all living humans have a weight. The concept of weight may be used to ground data in multiple repositories – great!

- Rules for business and data context impact data mappings and therefor interoperability.
- Understanding context and their implications is crucial.

# Location Context

- On the surface of the earth, weight and mass are convertible
- The surface of the earth provides a location context for the rule:
  - One Kilogram is equal to approx. 2.20 Pounds

Rule:  
 $1\text{KG} = 2.204 \pm 0.015 \text{ lbs}$

Holds  
within

Context: Surface of the Earth

Sue's Home Scale  
Weight: **134 lbs (Integer)**



Sue's Fitness Report  
PersonMassKG: **60.78 (Real)**

# Concept of Context

## Reminder

A **context** is anything that impacts the interpretation or truth value of something else

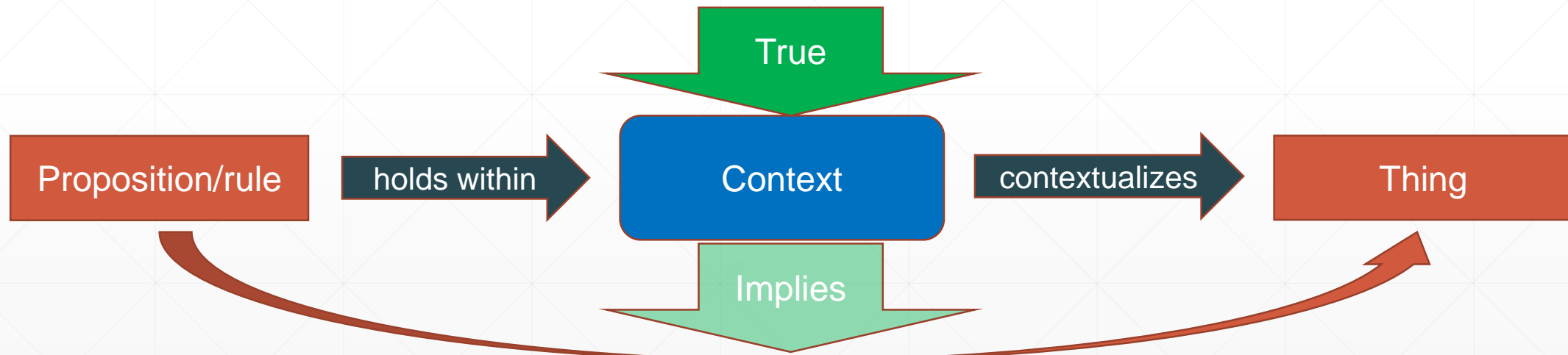
“Propositions” are the interpretations/truth values. “Things” are the something else.



Propositions that hold within a context hold for all things the context contextualizes

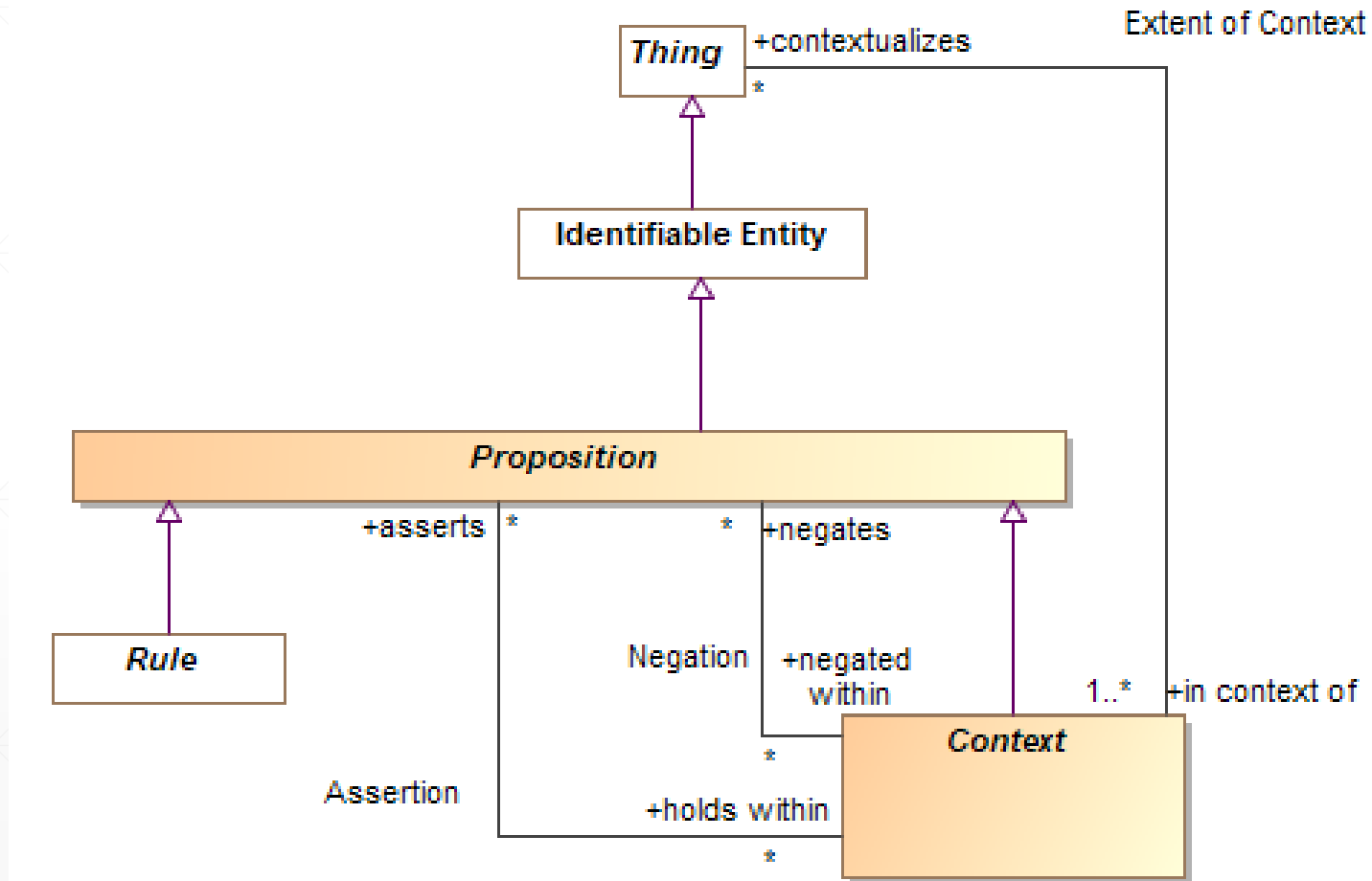
# Context as predicates

- A context be false
  - E.g. It is not 2017 or we are not on the surface of the earth.
- If a context is false, propositions do not hold for what the context contextualizes



Context(x) ***implies*** propositions that hold within x hold for all things x contextualizes

# Candidate Context Model\*

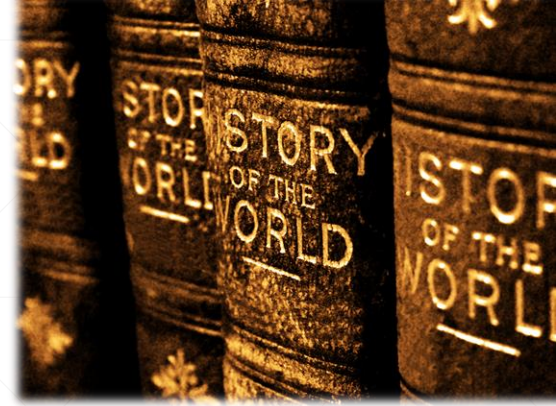


- Semantic Modeling for Information Federation (SMIF) conceptual model

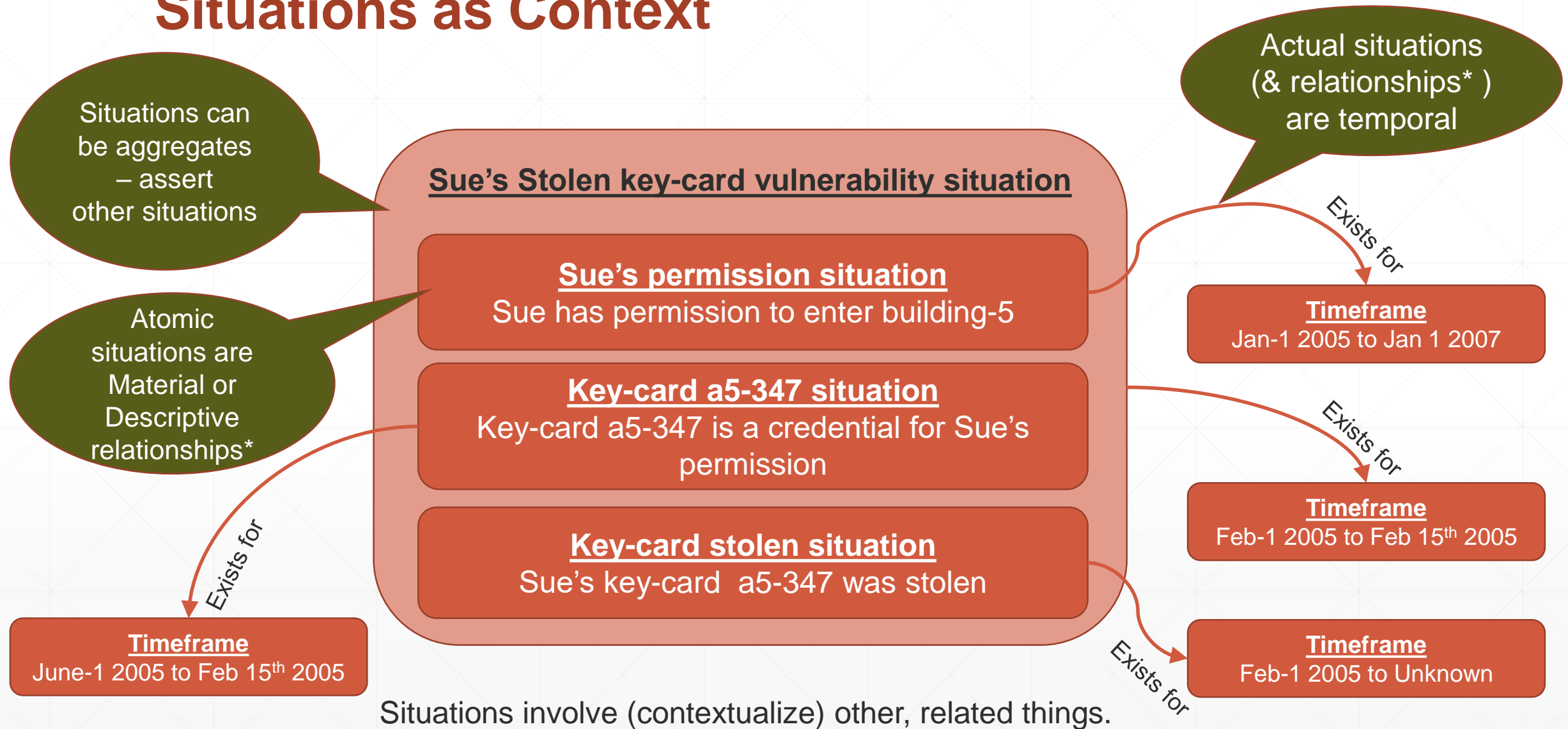


# History Happened

- Many DBMS (and many ontologies!) only consider the “current state”
  - the past is just as important
- It will always be true that:
  - Barack Obama was president of the united states Jan 20 2009-Jan 20, 2013.
  - Donald Trump is/was president of the united states Jan 20 2013-Unknown.
  - Sue weighed 134 lbs on June 3<sup>th</sup> 2017
- Historical statements can be just as important as current statements
- Time is a context for when any assertion is made and the timeframe for which it is applicable
- Different data context will have different assumptions about time and history
- Multiplicity and time
  - Consider the impact on multiplicity: A person only has one weight (at a time) but will have many weights that include time context.
  - But, a person only has one brain, for all time
  - Multiplicity constraints should differentiate: at a time Vs. for all time

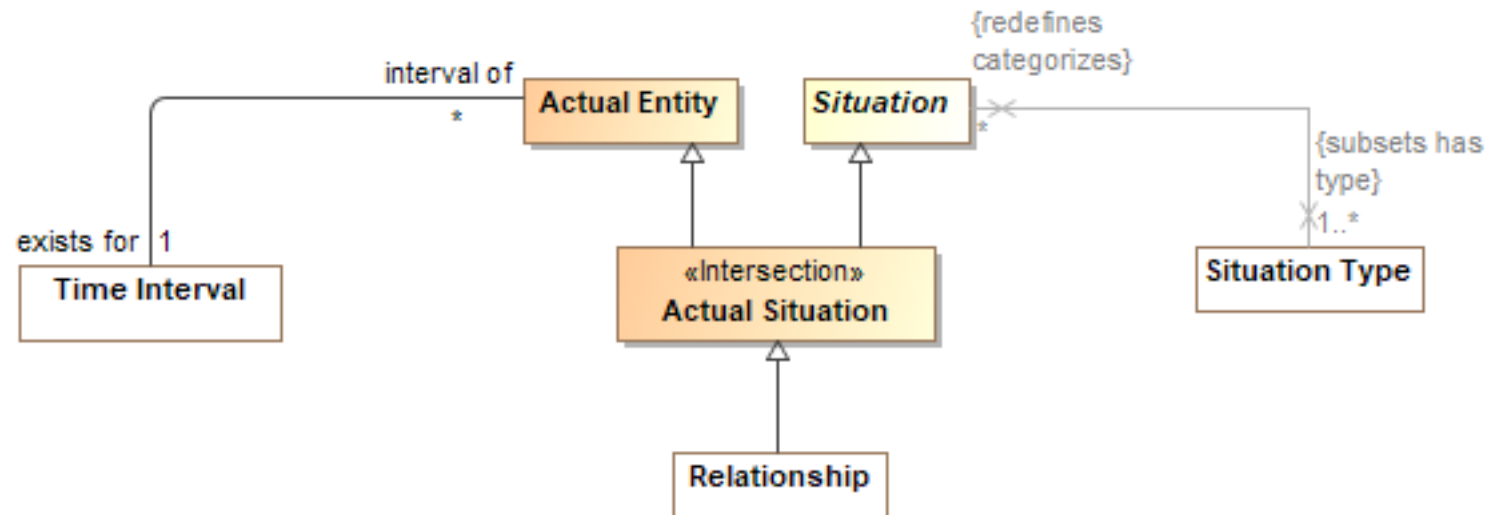


# Situations as Context



\* "Material relations & relators", see: [https://inf.ufes.br/~gguizzardi/AI\\_IA2016.pdf](https://inf.ufes.br/~gguizzardi/AI_IA2016.pdf)

# Candidate Situation Model\*



- Semantic Modeling for Information Federation (SMIF) conceptual model

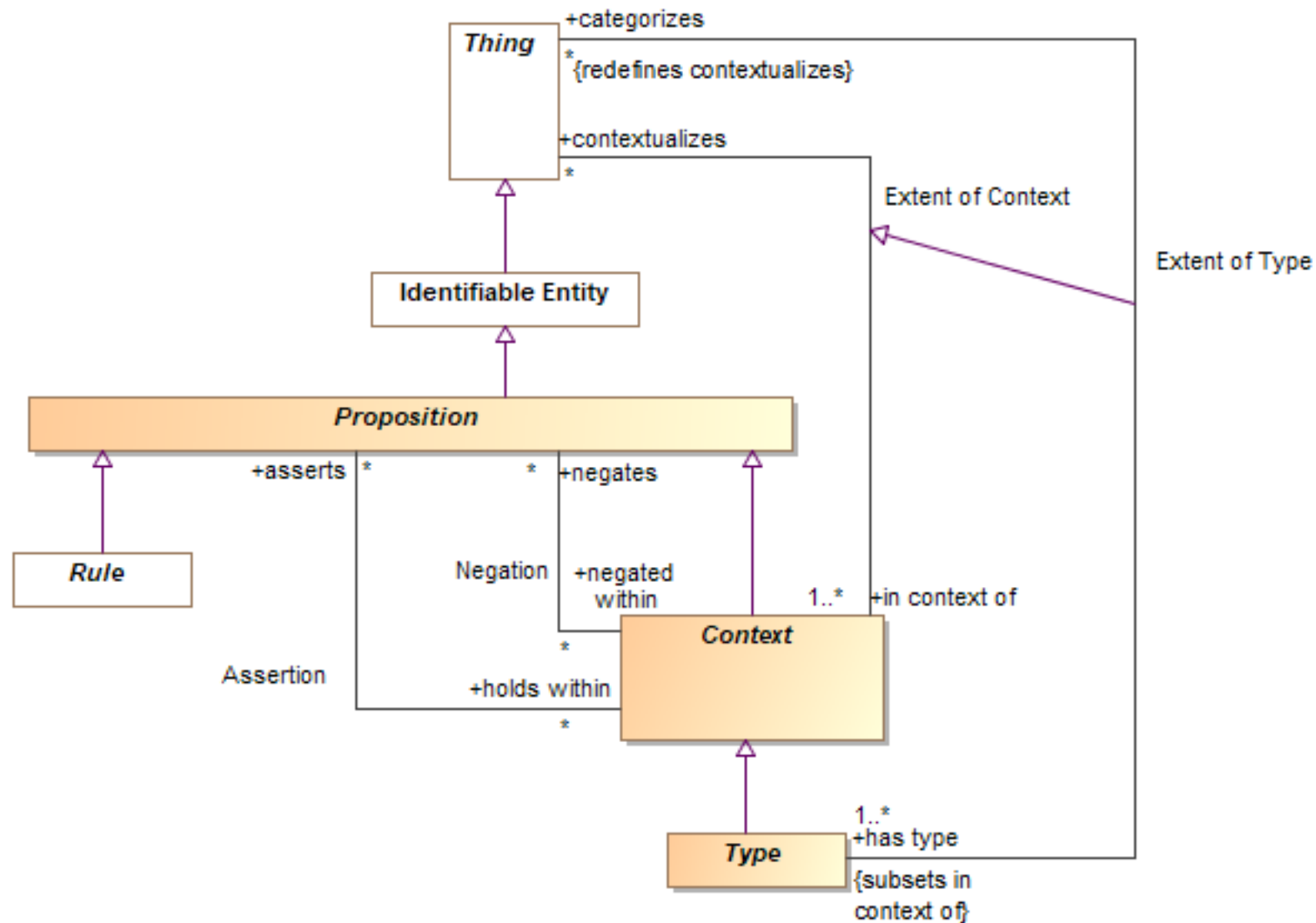
# Type as Context

- Types categorize things of that type
  - Categorizes is a sub-property of contextualizes
- A set of propositions hold for a type
- This set of propositions hold for all things categorized by a type
- “Type” can be modeled as a subtype of “Context”



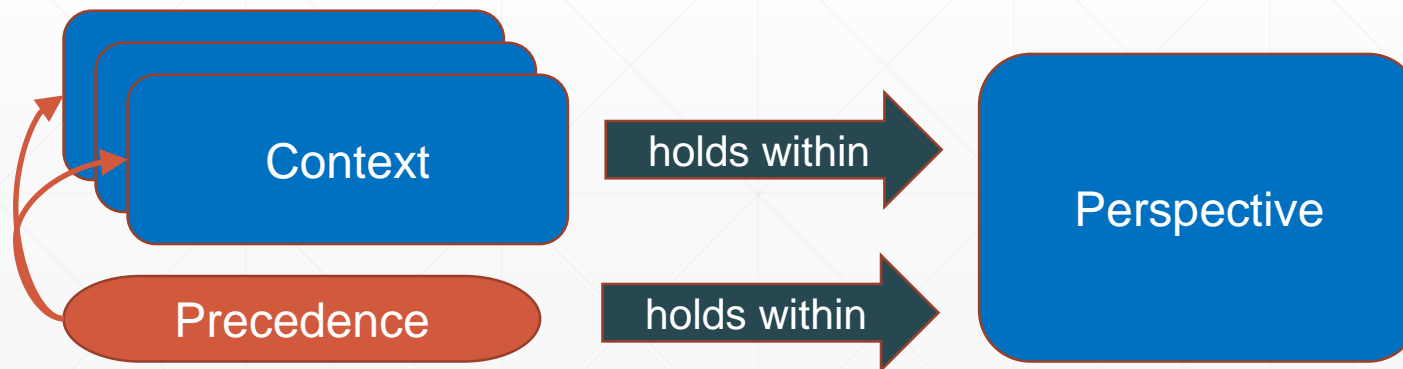
Note: Not all rules about living persons are in the context of the type, consider hospital rules.

# Candidate Type as Context Model

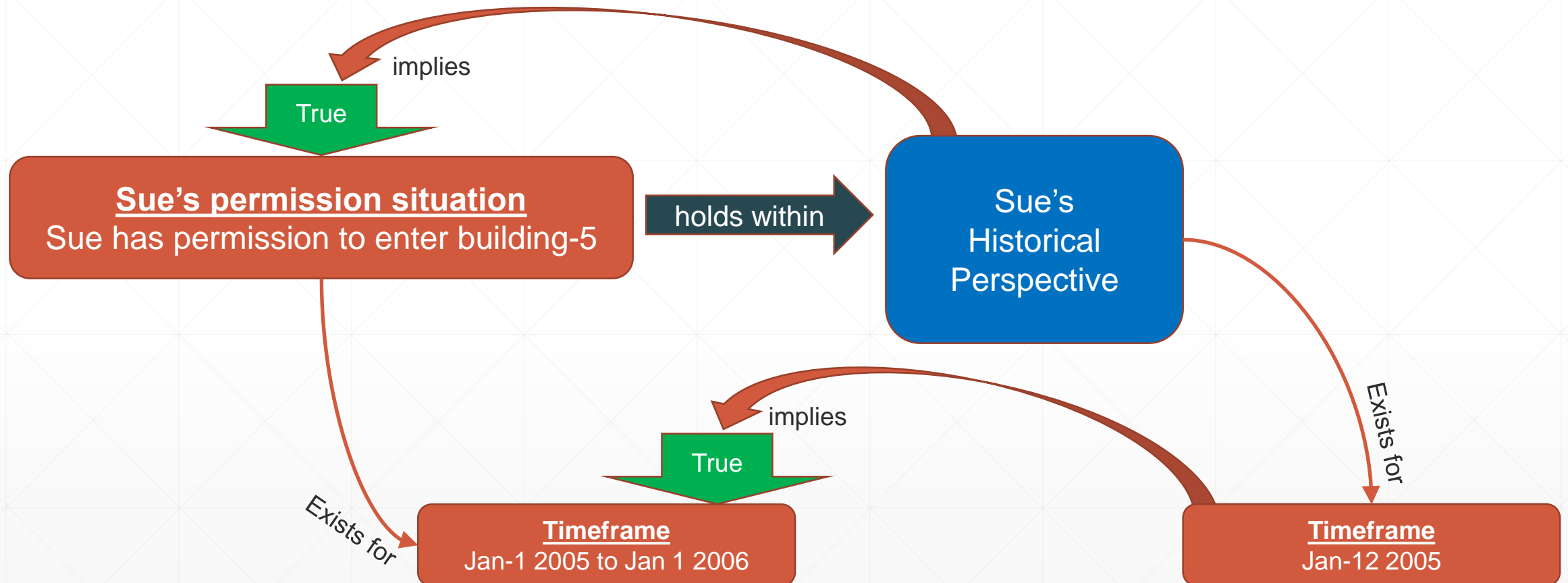


# Perspectives and Context

- A perspective selects which context are true, for that perspective
  - E.g. a perspective can establish timeframe and the set of applicable (asserted) ontologies
- A perspective can order context by precedence, to resolve conflict
  - E.g. a perspective can order ontologies of preferred terms, perhaps French first and English second.
- A perspective is, its self, a context
  - Context hold within a perspective

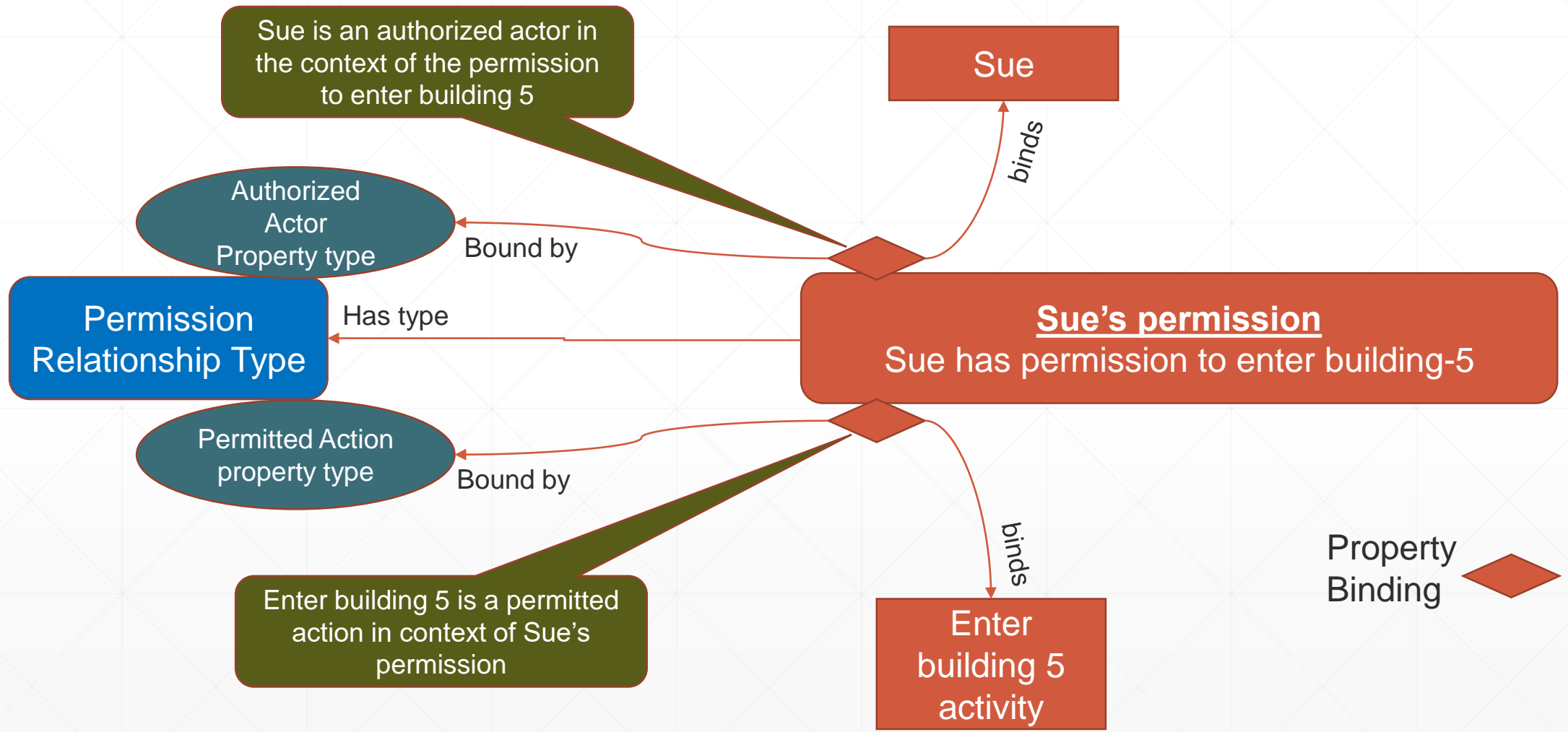


# Perspectives May Include Time





# Relationships as Context



# Context, Perspective & “Higher Order” Logics

- Context and perspectives introduce higher order relations
- Many reasoning systems are FOL only, how can we reason about context?
  - Option 1 Use a rules approach
  - Option 2 Use a higher order logic
  - Option 3 Pre-compute the context
    1. Asset perspective
    2. Derive “true” context, recursively
    3. Export context-free (FOL) ontology
    4. Infer exported ontology using FOL
- Our focus is reference ontologies, application ontologies have different (and usually more complex) reasoning requirements – a rules approach seems most applicable.

We can build a model and implement this program, can we formalize the semantics?

# References

- Relationships and Events: Towards a General Theory of Reification and Truthmaking
  - Nicola Guarino, Giancarlo Guizzardi
  - [https://inf.ufes.br/~gguizzardi/AI\\_IA2016.pdf](https://inf.ufes.br/~gguizzardi/AI_IA2016.pdf)
- Situation Semantics
  - See references in John Sowa's presentation
  - <http://jfsowa.com/ikl/contexts/contexts.pdf>
- Semantic Modeling for Information Federation (SMIF)
  - Needs an update, latest complete document:
  - <https://github.com/ModelDriven/SIMF/blob/master/NextSubmission/SMIFSubmissionMasterDocument.pdf>