Contexts for Integration and Interoperability
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Contexts in Context

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Context Aware Ontologies

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*** as 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***.
    - *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 to support 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 1st, 2017
    - Barack Obama was president of the United Stated 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 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
- Some relationships (including properties) define contextualization
  - (<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 4th, 1789 to Unknown
  - (Workers in the U.S.A. ***must pay*** Income Tax) ***exists for*** Feb. 3rd, 1913 to Unknown
- Implies
  - Since March 30, 1867 Citizens of Alaska have rights and as of Feb. 3rd, 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!

Context to bridge 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 15th, 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

?

How are multiple sources reconciled?

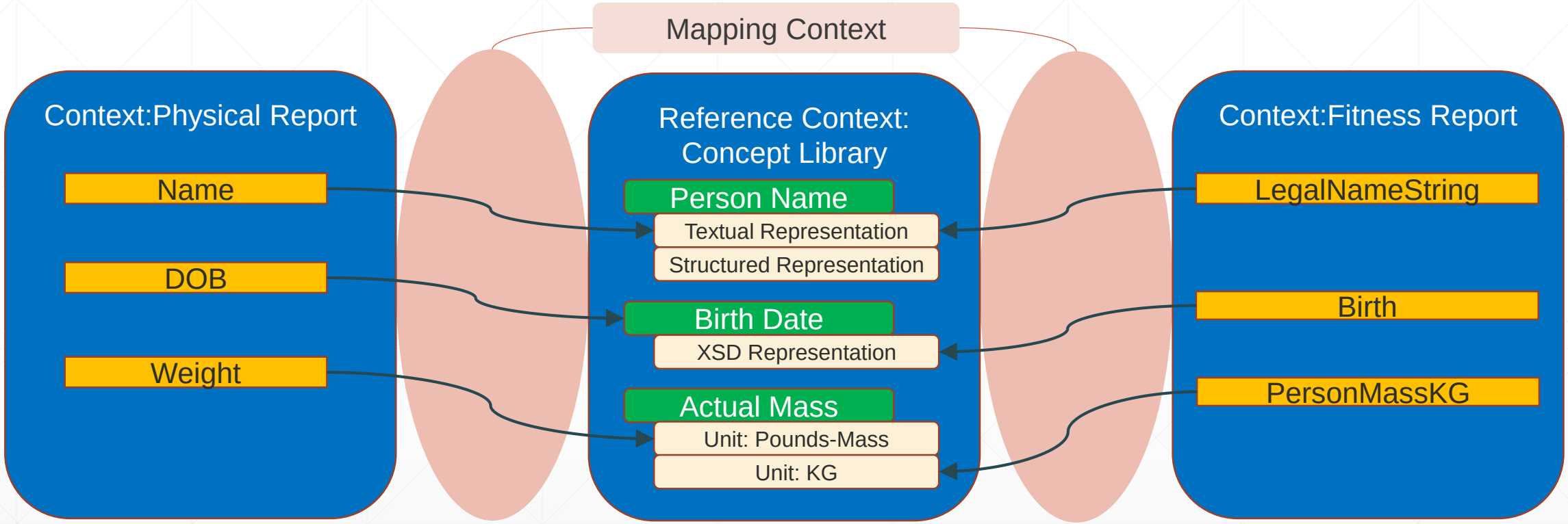
Army Reserve Fitness Report

Sue's Fitness Report
LegalNameString: Sue Plankton
Birth: January 15th, 1968
PersonMassKG: **Unknown**
PersonBloodPressue: **Unknown**
Report Date: **Jan 10th, 2018**

Job Application for Fun Fitness Centers

Sue's Job Application
PNAME: Sue Plankton
PBD: January 15th, 1968
Social: 390-55-8967
CWeight: **134 lbs**
AppDT: **Jan 10th, 2018**

Context determines terms & representation (of data) for concepts



An ontological “concept library” can provide reference concepts, a pivot-point between different data representations, or different ontologies. This can power automation of interoperability and federation.

Context of time and data determine data interoperability

- Weight measurement is in the context of the physical's date
- Potential 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
- 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!

- For interoperability, business and data context impacts 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:
1KG= 2.204+-0.015 lbs

Holds within

Context: Surface of the Earth

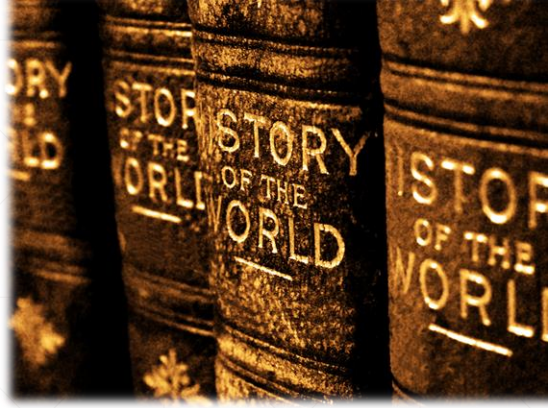
Sue's Home Scale
Weight: **134 lbs (Integer)**

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

Real data is messy

- Context can prioritize rules for conflict between information sources
  - Which information source is more reliable?
  - How important is time?
  - Should all potential values for a property be mapped (with source), or only one?
  - How is provenance of each element handled?
- Sometimes lies are valuable information!
  - Well, if you are the CIA!

History Happened



- While many DBMS (and some 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.
  - Sue weighted 134 lbs on June 3th 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

Concept of Context

Reminder

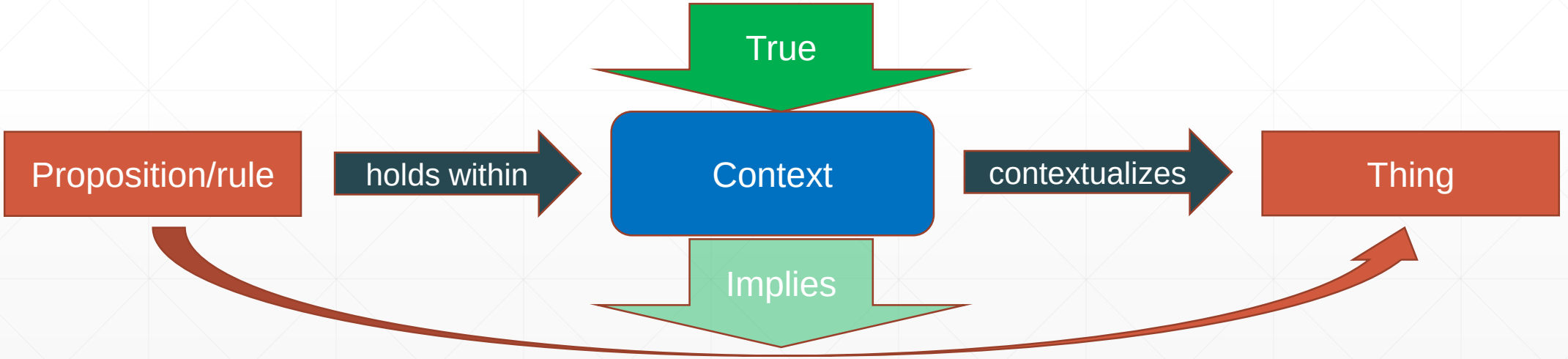
A ***context*** is anything that impacts the interpretation or truth value of something else

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

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

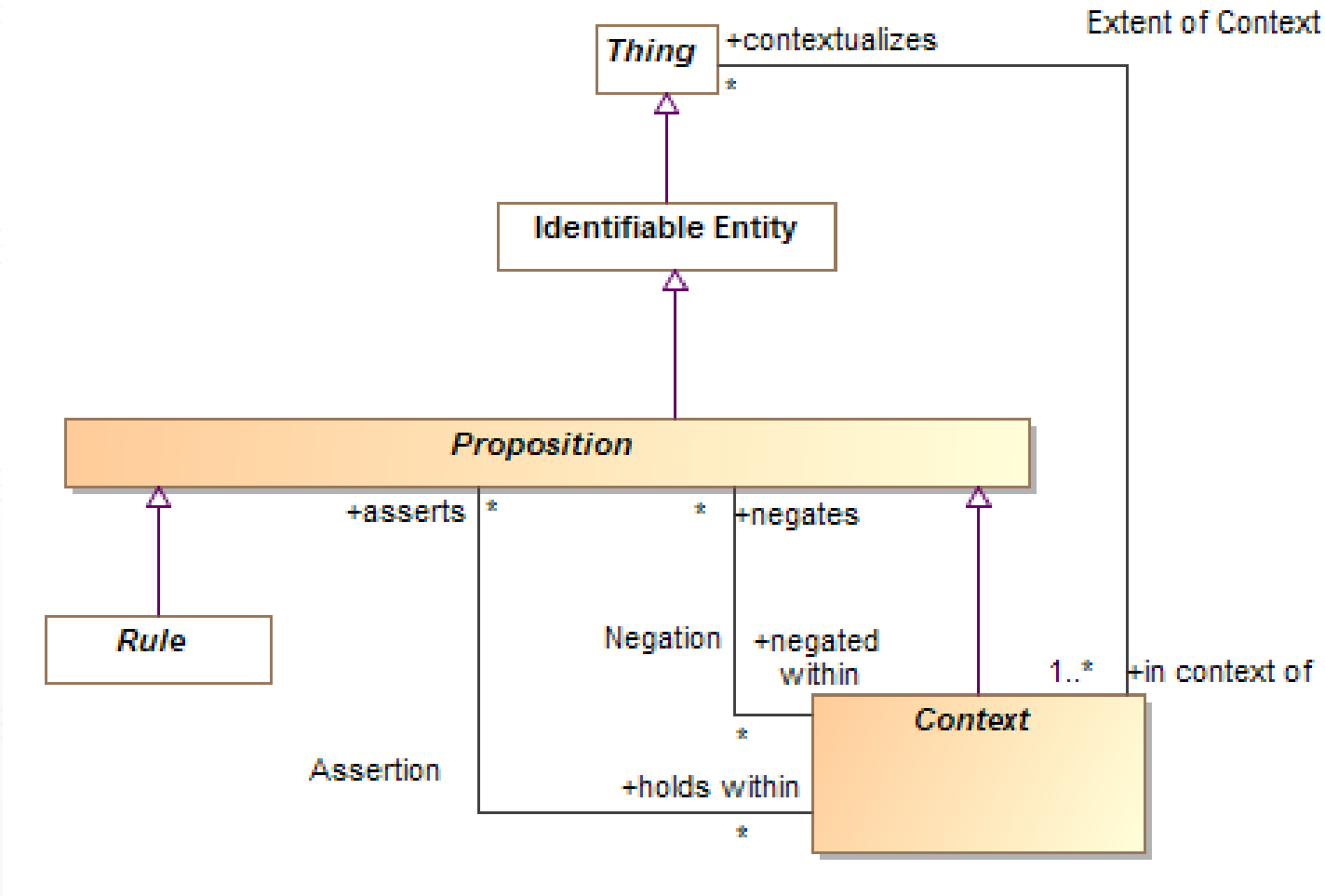
Context as predicates

- Can 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



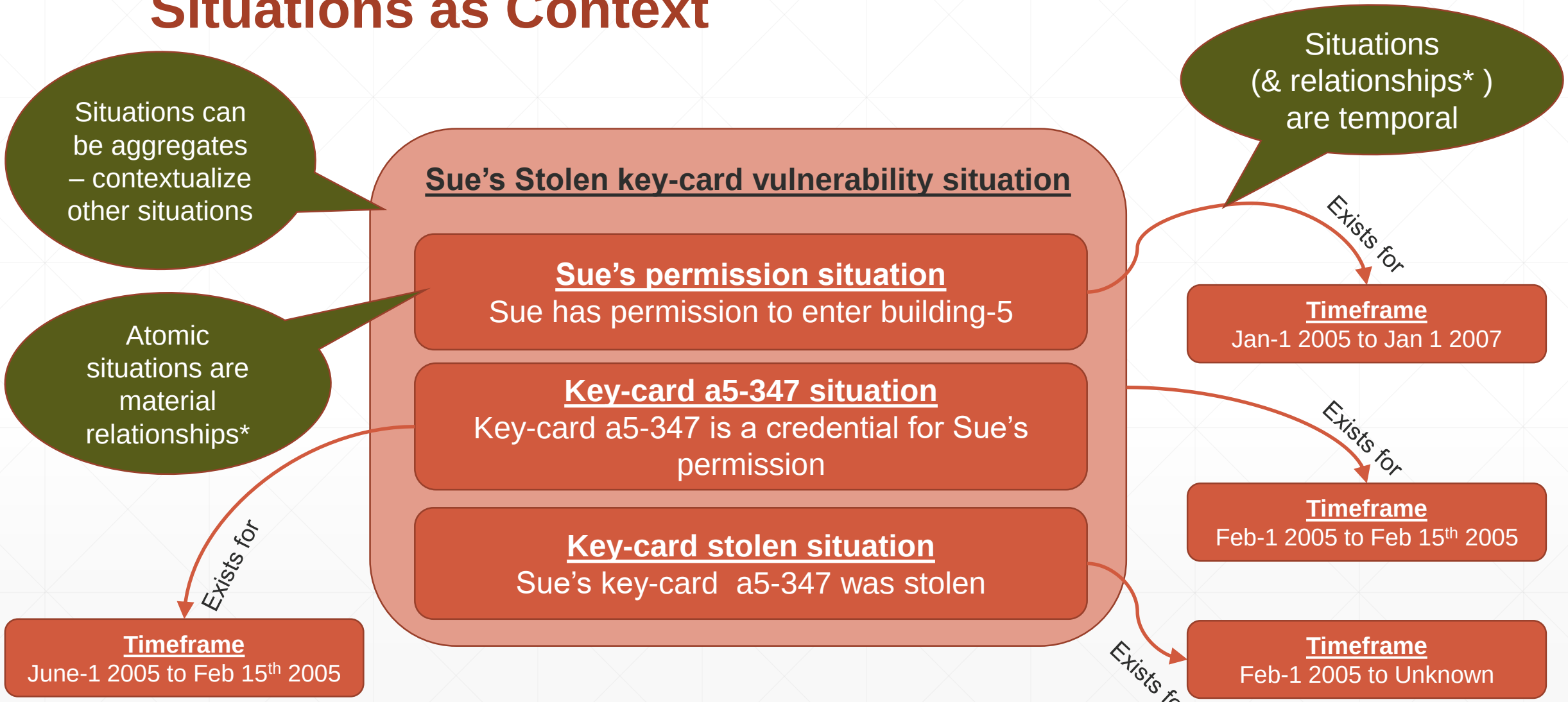
Context(x) ***implies*** propositions that hold within x hold for all things x contextualizes

Candidate Context Model*



- Semantic Modeling for Information Federation (SMIF) conceptual model

Situations as Context

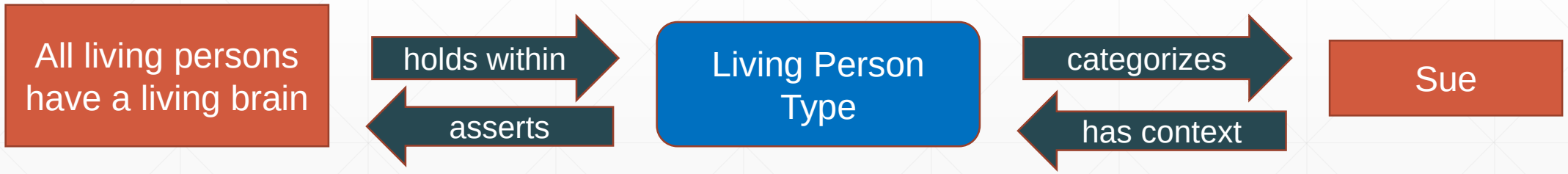


Situations involve (contextualize) other, related things.

* "Material relations & relators", see: https://inf.ufes.br/~gguizzardi/AI_IA2016.pdf

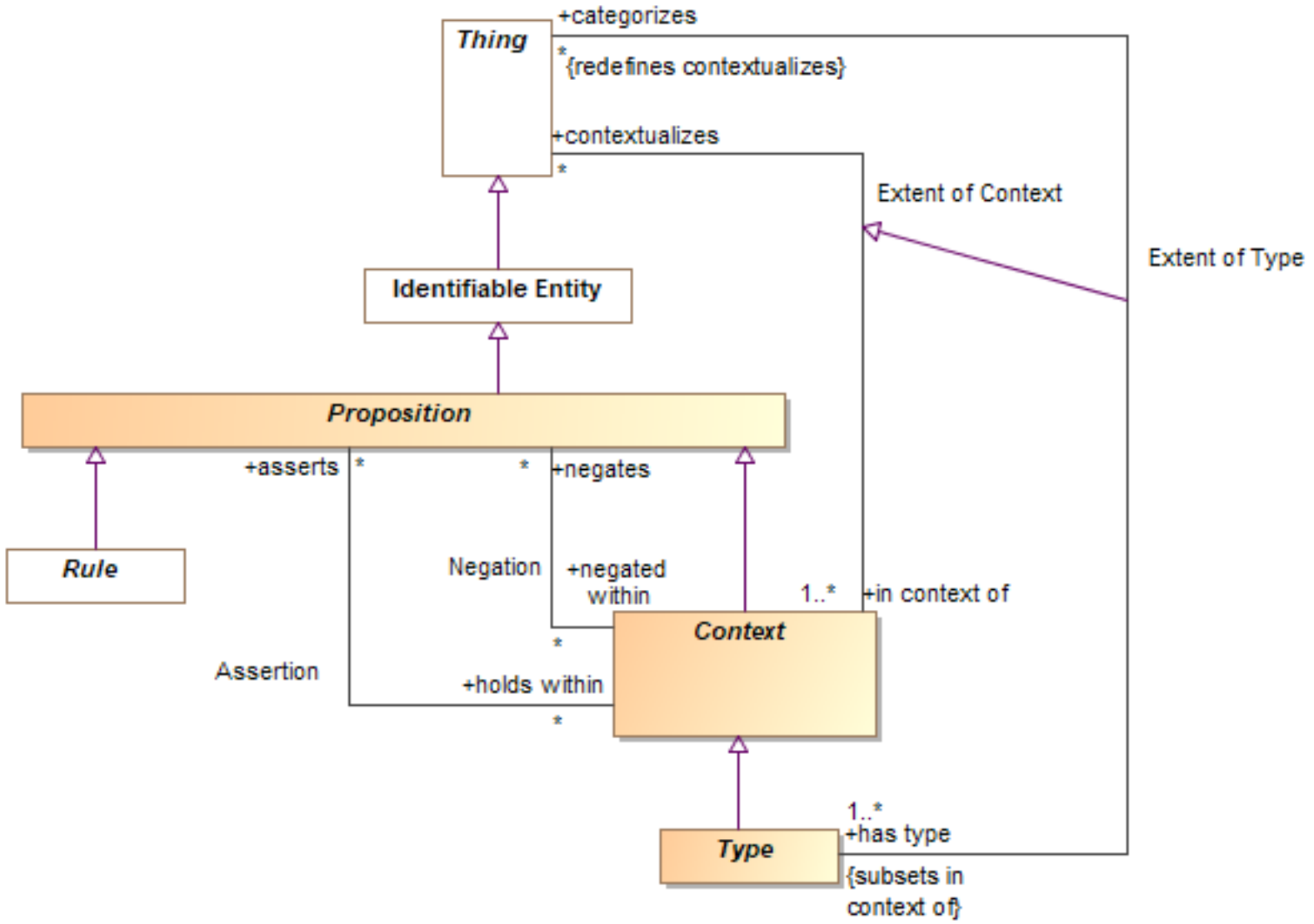
Type as Context

- 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”



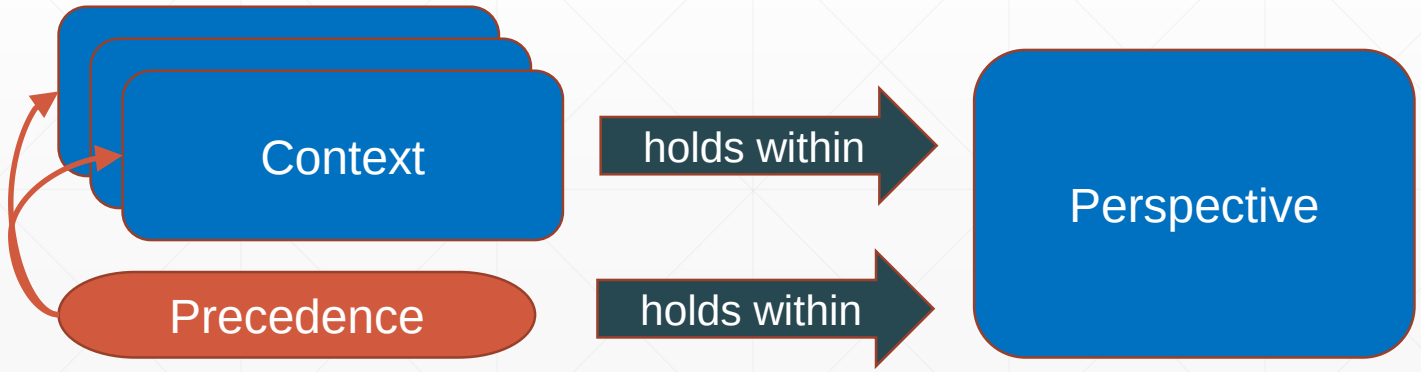
Note: Not all rules about living persons are in the context of the type, consider hospital rules.

Candidate Type as Context Model

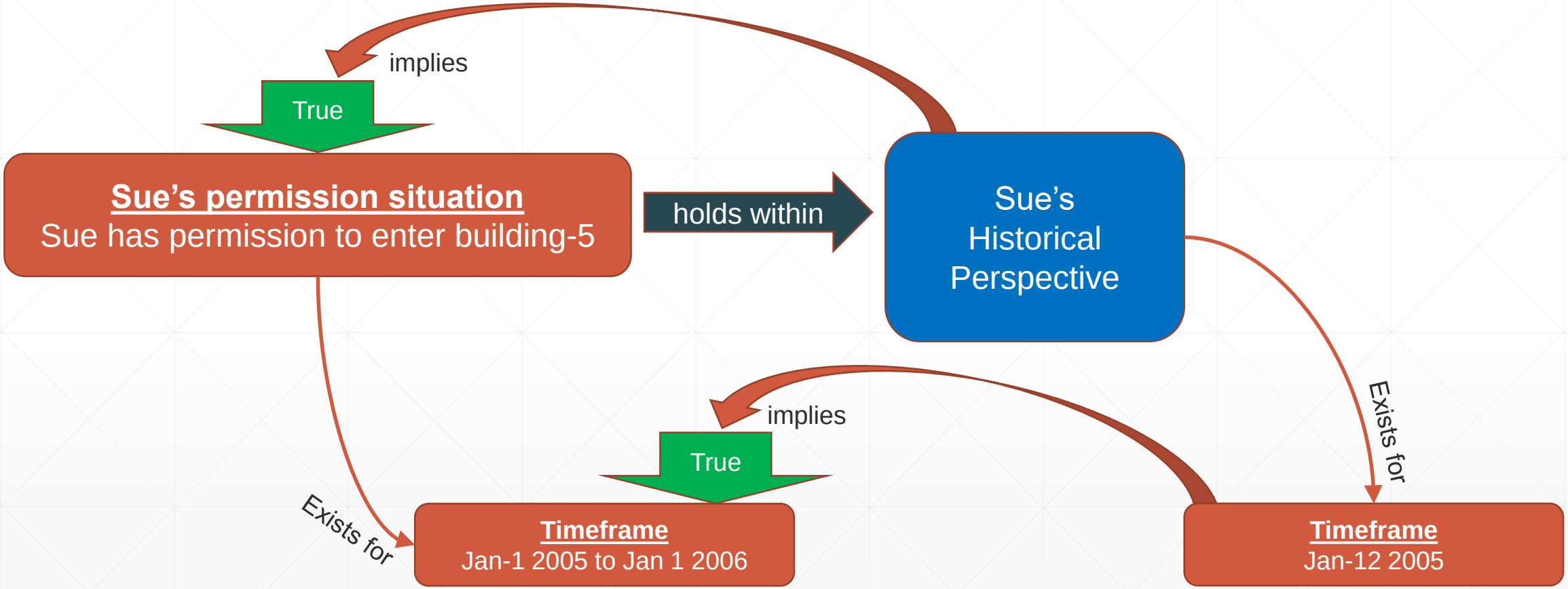


Perspectives and Context

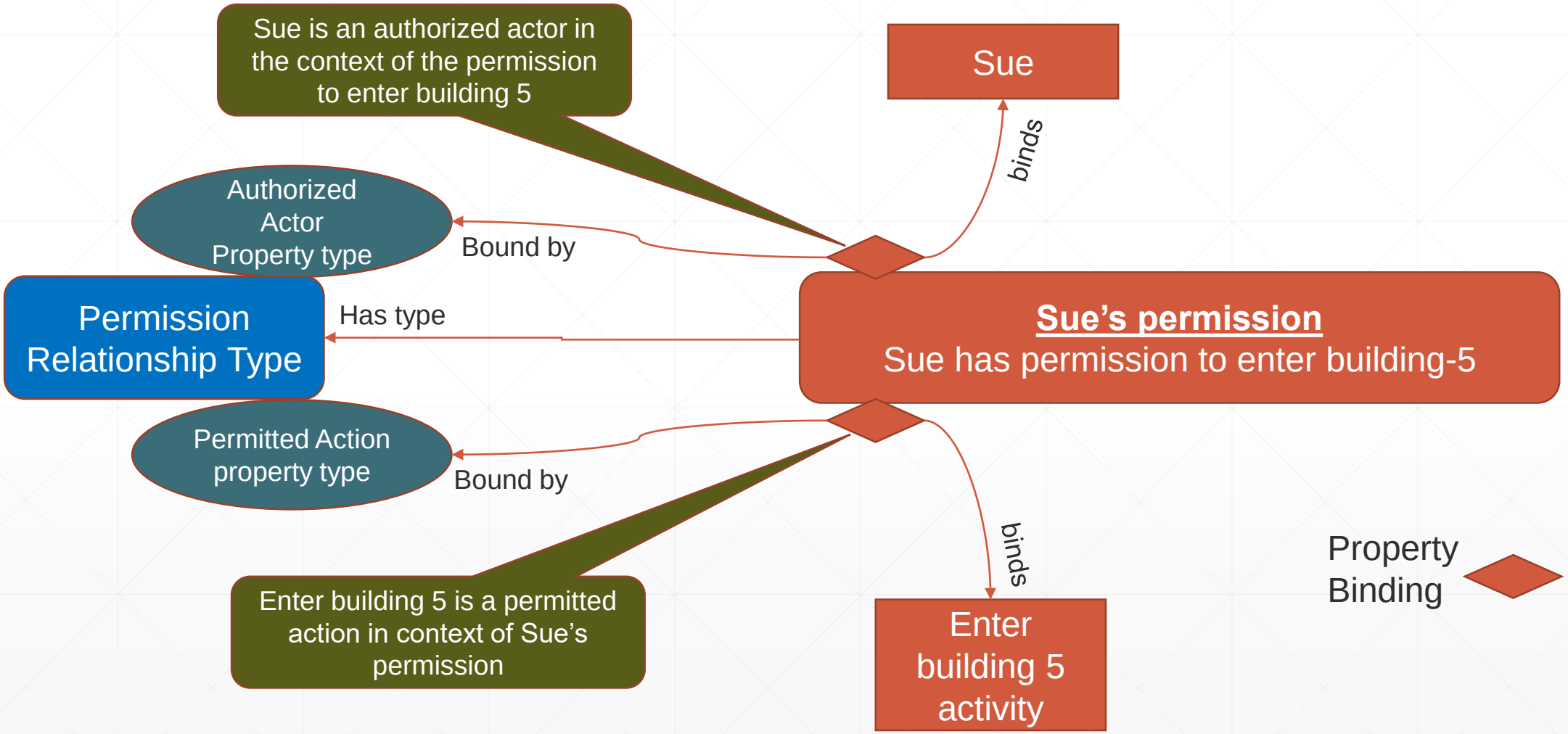
- A perspective selects which context are true, for that perspective
  - E.g. a perspective can establish timeframe and the set of applicable (true) ontologies
- A perspective can order context by precedence, to resolve conflict
  - E.g. a perspective can order ontologies of preferred terms, perhaps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



Perspectives 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

We can write 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
- 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