Let’s Discuss the Situation

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V1.0

Contents

Abstract

Information may be stored or shared in one of many natural languages or one of millions of "structured" forms that are typically defined in data or message "schema" – schema describe the structure of information. Natural languages are, by their nature, imprecise and dependent on deep shared context to understand meaning. Structured forms trade flexibility for a predictable structure that can be automated and precise ***if the meaning is clear****. Yet that meaning typically falls back on natural language definitions that depend on programmers correctly interpreting the meaning encoded in the structure – an expensive and risk prone process.*

Data schema are, by their nature, tuned to the applications and use cases for which they are designed. They frequently combine or "conflate" diverse concepts into an efficient data storage or message structures, that works for their design purpose which incorporates specific assumptions, but becomes confusing or misleading when that same information is needed for other purposes, or other stakeholders, in other formats. The assumptions inherent in a schema design are often unstated or even inconsistent.

Ontologies are increasingly being used to establish a consistent and formal basis for meaning such that the same "facts" can be interpreted correctly regardless of the structure, terminology, technology or schema that encodes them. For this vision to be realized the various schema need to be mapped to a common conceptual model expressed in an ontology.

What has proved challenging in this approach is establishing common concepts that are both sufficiently broad and sufficiently precise to federate these different data structures. Sometimes the same conflation of concepts that "polluted" data schema creep into supporting ontologies – either for the sake of efficiency, limits imposed by the ontology language, or the influence of legacy. For this reason, the search or appropriate "linking concepts" is central to a broad-based information federation, sharing or analytics requirement.

We will discuss two such concepts which have proved valuable as essential linking concepts, what we call "situations" and "statements". These concepts provide a separation of concerns between the world as we conceive it and "statements" about that conceived world. Statements include all forms of communications and recorded information – anything that is "said about" the world. Situations are conditions of the world it's self; sets of relationships and properties that, together, comprise a meaningful topic for statements. In more formal language, statements are epistemological (about what we know or communicate) where as situations are ontological (about the world).

This approach draws on a rich tradition of situation semantics initially developed by Barwise & Perry in the "situation underground" (Barwise J. a., 1980) *paper, and further advanced by Keith Devlin in Situation Theory and Situation Semantics* (Devlin).

We argue that this separation of concerns makes ontologies used as schema concept references more precise and more flexible by not conflating what is said with who is saying it. The result is an improved foundation for information sharing, analytics and machine learning.

Situations: an intuitive understanding

Situations arise when there are things conceived of as connected in a common context over a period of time.

In their 1980 paper "The Situation Underground" (Barwise J. a., 1980), the first published work on situation semantics, Barwise, and Perry wrote of situations:

> *"The world consists not just of objects, or of objects, properties and relations, but of objects having properties and standing in relations to one another. And there are parts of the world, clearly recognized (although not precisely individuated) in common sense and human language. These parts of the world are called situations. Events and episodes are situations in time, scenes are visually perceived situations, changes are sequences of situations, and facts are situations enriched (or polluted) by language."*

Consider these three essential distinguishing features of situations:

- That there is more than one discreet thing
- That there is a set of relationships (or properties) connecting these things
- That these relationships (or properties) hold for a time period
- That the situation provides an identifiable unifying context for the set of related things

We also relate situations to statements, initially just consider one person saying something to another. If I were to say "that cup" (pointing to a coffee cup), there is no information – it is not a complete sentence – "that cup" is not a situation and not a proper subject of a statement; it is just one discreet thing, there are no relationships, there is no timeframe.

Consider "that cup is on my table". Now we have two things – cup and table, we have a relationship between them "on" (or on-ness) and we now the time "is" (or now). "cup on table now" meets all of the requirements of a situation. *Statements are about situations*.

Consider other example situations and non-situations

Situation	Not a situation
A cup falling off of a table	A cup
The Novel Corona Pandemic	Covid-19
The lifetime of George Washington	George Washington
The height of a person (or any other physical characteristic) at a particular time.	6 feet
The change of a person's temperature over a timeframe (or any other change)	2 Degrees per hour
Sue's obligation for a person to pay for a medical service	The general concept of a medical service
John's healthcare appointment at 2PM	John

Parts of the world and context

Any “real world” complex/composite situation involves multiple objects, participants and relations. Each of those may be connected to many other things. Where does a situation “end”. For example; Fred goes for a medical checkup with Dr. Sue. Certainly Fred & Dr. Sue are part of (essential participants in) the checkup situation. Is the medical degree of Dr. Sue a part of the checkup situation?

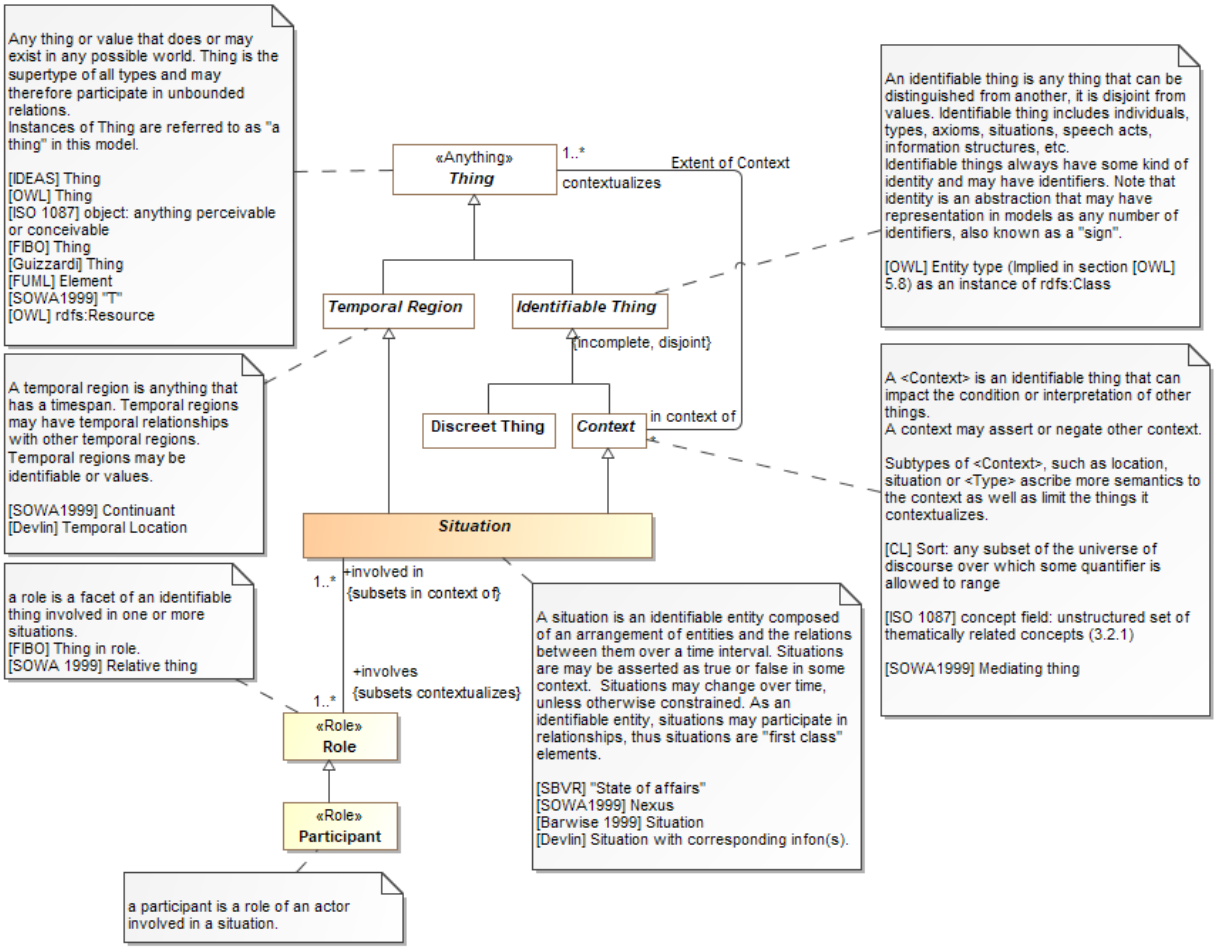
Situations carve-out a “part of the world” we wish to identify as a unique situation, defined by a situation type. What is “in” the situation is guided by stakeholder requirements or evident real-world boundaries. Whatever the “edge” of the situation is, each situation is a slice of the real-world carved out and identified as a situation.

> *Situations are parts of the world and the information an agent has about a given situation at any moment will be just a part of all the information that is theoretically available. (Devlin)*

While there may be boundaries to a situation, situations frequently are impacted by things outside it - the context of the situation. Situations may be affected by, or contextualized by, other contexts (including other situations). Situations are also a context for the things they relate and their parts. Context provides a link between situations that may impact each other without being a proper part of each other. Time, location, jurisdiction, intent, and type are other dimensions of context.

Situation Model (Top Level)

What has been expressed above may be formalized in a model as follows.



NOTE ON MODEL SEMANTICS AND NOTATION: THE CONCEPT MODELING PROFILE (SMIF/CCM) OF UML IS USED TO DEFINE SITUATIONS. AS A REFERENCE CONCEPT MODEL IT MAY BE DIFFERENT THAN UML BEING USED FOR SOFTWARE MODELING. IN PARTICULAR, SOMETHING MAY BE CLASSIFIED BY ANY NUMBER OF TYPES (UML CLASSES, SHOWN AS BOXES) UNLESS DISALLOWED BY A "DISJOINT" CONSTRAINT. MOST PROGRAMMING LANGUAGES DO NOT ALLOW MULTIPLE CLASSIFICATION OR MULTIPLE INHERITANCE – BUT BOTH MAKE SENSE IN UNDERSTANDING HOW WE CONCEIVE THE WORLD. IN ADDITION, MODELING CONCEPTS SUCH AS "ROLES", VALUES AND RESTRICTIONS ARE UTILIZED. IT SHOULD ALSO BE RECOGNIZED THAT CONCEPTS IN A REFERENCE CONCEPT MODEL DO NOT IMPLY ANY REQUIREMENT TO KNOW, RECORD OR COMMUNICATE THOSE CONCEPTS FOR A PARTICULAR PURPOSE – THOSE CHOICES ARE MADE IN DATA, PROCESS, AND SERVICES MODELS USING THE REFERENCE MODEL.

SMIF ALSO PROVIDES FOR AN OWL REPRESENTATION OF THE SAME CONCEPTS. PLEASE REFER TO (SMIF) FOR DETAILS.

Situation Partitions

Partitions identify distinct aspects of a situation according to some criteria. Each partition set defines options for classifying situations. For each partition set there is a set of mutually exclusive options (aspects). Any particular situation is defined by exactly one choice from each partition set. For each partition set there may be multiple subtypes and subtypes may combine choices from different partition sets.

Partition: Atomic Vs. Composite

Atomic situations (relationships and characteristics)

Considering the distinguishing features of situations what is the most minimal, most atomic situation? Fundamental relationships between things, frequently just two things over a timeframe, meet the criteria for a situation. “cup on table now” is such an atomic situation, which we call a relationship – more formally a “material relationship”. E.g. a relationship is an atomic situation. Take away any element and there is no longer a situation, and no relationship. Atomic situations include relationships between discreet things, between other relationships.

Atomic situations also include characteristics (properties) of things using “values” such as “John weighs 150lbs today” – the value or quantity counts as one of the “discreet things”, so in this case there are two discreet things – john and 150lbs, as well as the timeframe “today”. The semantic of weight is captured as the meaning of the relationship.

Atomic situations are a context for the related things.

Composite Situations

At the other end of the scale, situations can be as “big” as needed from “the lifetime of the universe” to an office visit to the course of a disease and its treatment. Composite situations compose (have parts) – and are a composition of a set of other situations (which may be composite or atomic). Composite situations may also be thought of as “collaborations” (Reenskaug, 1995) between objects.

Partition: Static Vs. Dynamic

Static Situations

Some situations, or states, compose a set of things that are static, not changing, over the lifetime of the situation. “cup on desk” is such a situation – it is “true” as long as the cup is there. Static situations can also be complex (if you could see my desk you would know!). A static situation could be the arrangement of seats in a movie theater, or a person’s temperature (or other characteristic) at a given time.

Other terms include “State”, or “State of affairs”. We will use “State” as our preferred term.

Dynamic situations

Dynamic situations represent things “happening”, some change over time – the cup falling off the desk, the patient’s temperature changing, the progression of COVID-19. Other terms include “events”, “Occurrences”, “activities” and more formally “perdurants”. We will use “Occurrence” as our preferred term.

By unifying static and dynamic concepts under situations we have a common concept that provides a foundation for temporality, causation, dependency and (as we will see below), statements.

Partition: Ontic Vs. Epistemic

A core precept of this approach is a separation of concerns between models of the "real world" and statements, information or opinions about the world. By "real world" we include everything that actually exists, has existed or may exist in the future – these are called "Ontic" (or Ontological) situations.

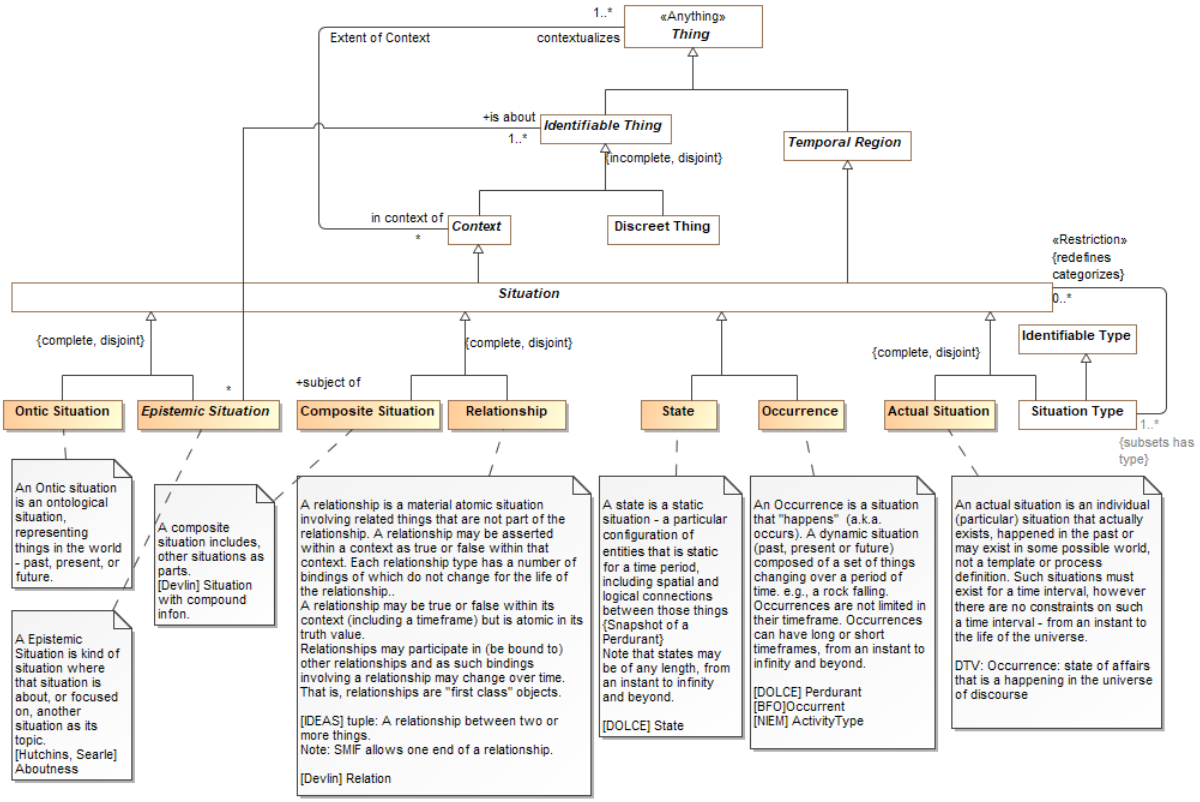
Contrasting Ontic situations are statements, information or opinions – these are all "about" some real-world thing. Situations about other situations are called "Epistemic Situations".

Partition: Actual Situations Vs. Situation Types

What we may observe in the world is specific, actual situations that are or have been current such as Fred's having an insulin shot at 10:30am January 2, 2019. What is also interesting is patterns of such situations, either as history, expectations, or instructions. Fred's shot may be part of a pattern of such shots that happen every Monday, and have since 2009. This situation is a repeating pattern.

Situation types represents a series of like situations with some variable(s) - such as time or participants. A situation pattern defines a "type" for each instantiation of the pattern as an actual situation. Situation types will be discussed in more detail, below.

Model of situation partitions



Note that each partition is grouped with a {complete, disjoint} constraint – meaning there are no others in the partition and they do not overlap.

Temporality

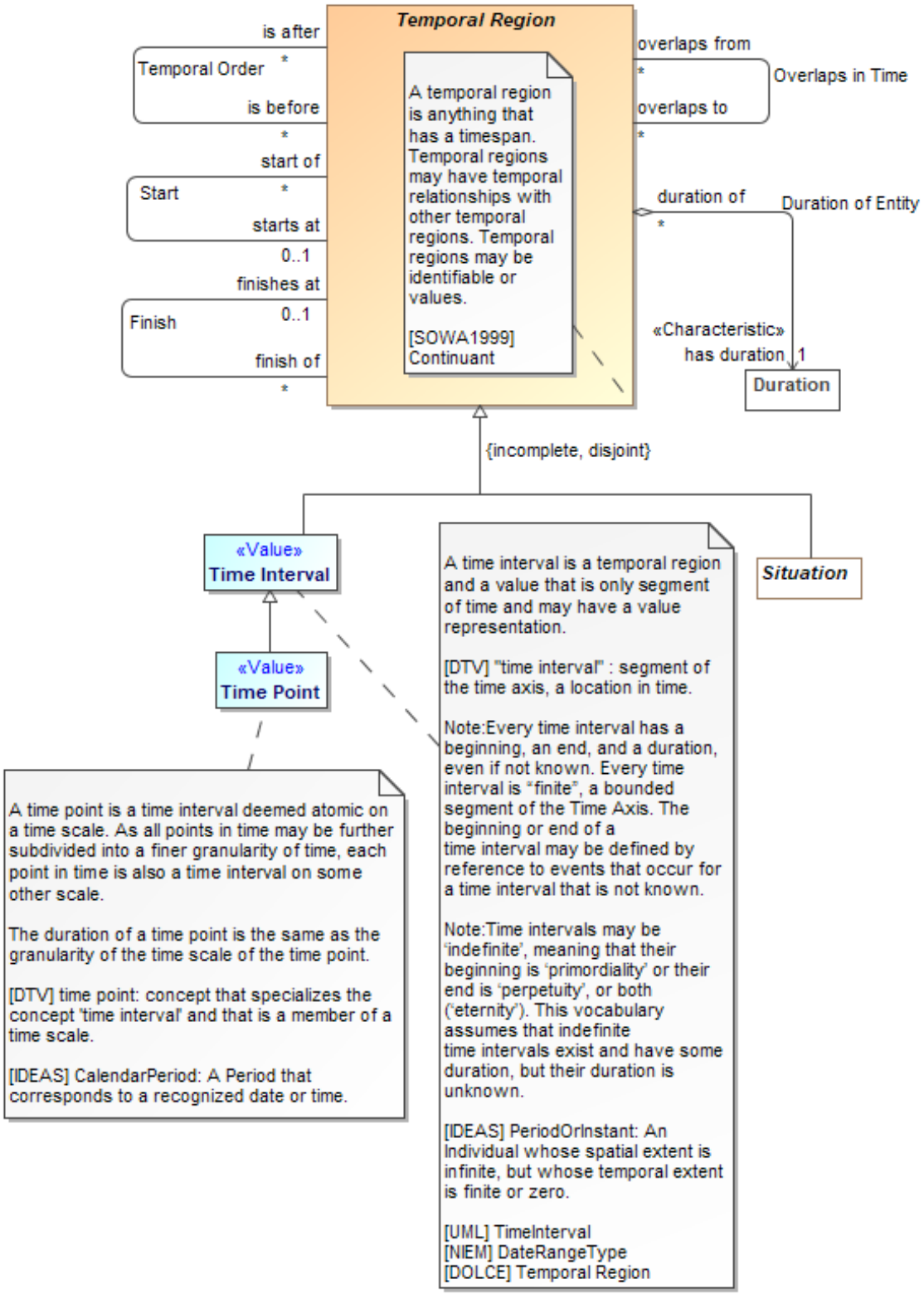
"Existing over a time period" has been asserted as a necessary component of situations. That time period could be instantaneous or extended, it may be known or unknown – but it exists. Even the existence of the earth has a time period – nothing lasts forever. More formally, we say that a situation is a "temporal region" – it is bounded by a start and an end, now, in the past, or in the future.

In the ontology world there is a challenge to understand time and change over time in a way that is both precise and understandable. By attaching time to situations, and to atomic situations, we can understand how the same things may have different characteristics and relationships at different times – yet remain the same thing. Things change because the situations they are involved in become "true" at different times. My weight in January 2001 and my weight in February 2020 are both valid representations of my weight, true at different times.

Another aspect of temporality is the temporal relationships between situations – before, after, during, etc. Anything that exists in time can be related to the timeframe of other situations.

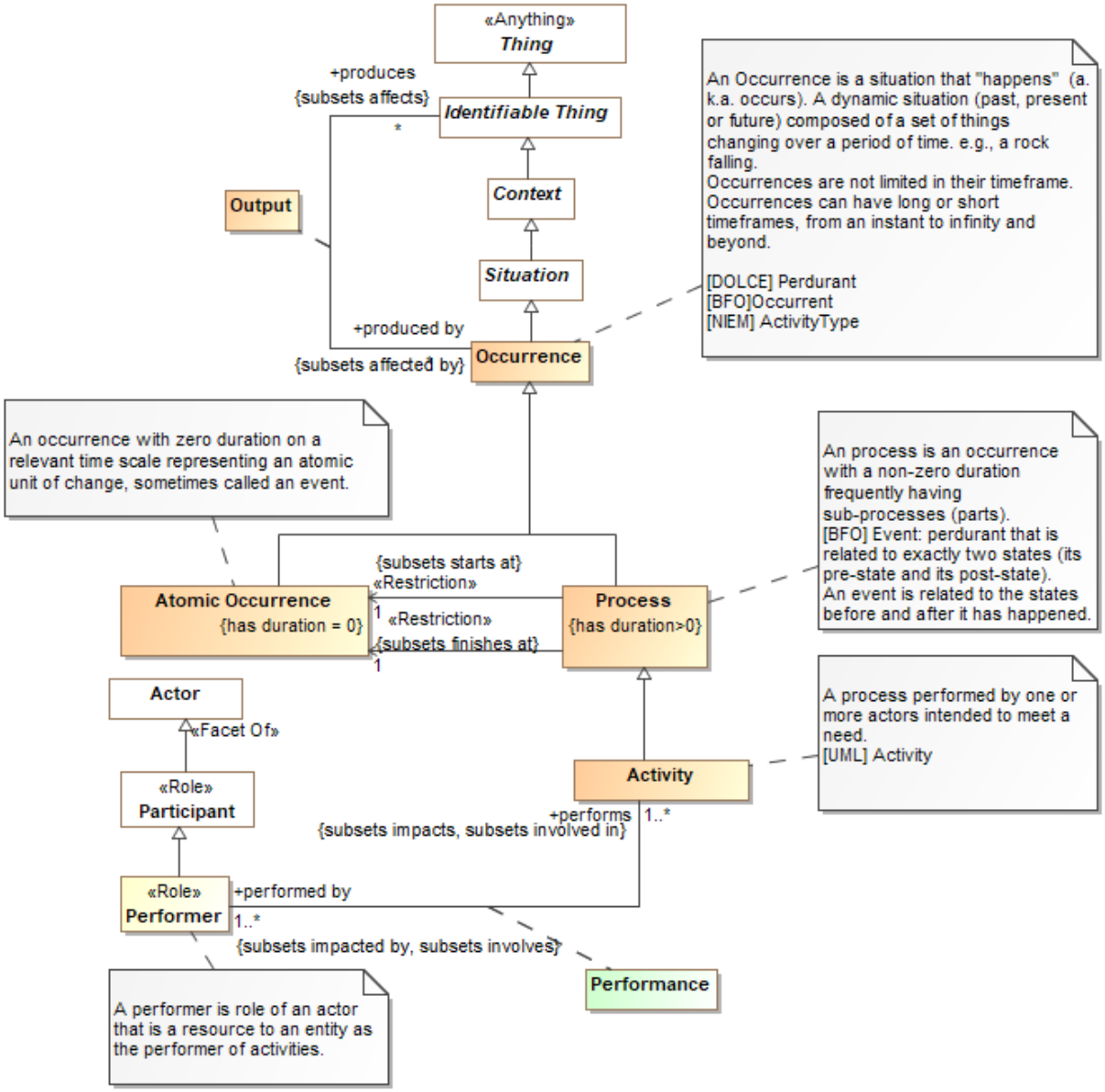
Temporal regions can also be used to identify specific periods of time – time intervals and time points. Time intervals represent "just time", e.g. the year 2020. As such time intervals are considered values that may have a "data type" representation.

As both situations and time intervals are temporal regions, the "Allen relations" (e.g. before, after, etc.) may be stated between situations, between situations and time intervals, or between time intervals.



Occurrences

Occurrences; situations involving change over time, may be instantaneous (sometimes called an event) or a process of any duration. A process may also be considered to have an instantaneous start and end. Activities are processes performed by one or more performers for some purpose. When someone or something is “doing” the process we consider it an activity.



Epistemic Situations & Statements

Above we discussed the separation of concerns between situations and statements. *Statements* are information ***about*** situations. Statements include "speech acts" (any communication), records, documents, information, data, messages, etc. Any time information that is communicated or "written down" (physically or virtually), it is a statement ***about*** one or more situations as ***stated or recorded by some author*** (real or virtual). Statements are our link to the world of information, information about situations.

Prepare for a bit of a mind-loop; *statements* are also "things in the world", they happen at a particular time, they involve multiple things (at least a situation and the author). So, *statements are situations* themselves, but a particular kind of situation that is "about" another – an "epistemic situation". However, the situation that is the statement may have a different time, context, source, trust or other factors that differ from similar factors in the situation it is about. For example, At 3pm Nurse Jane told Dr. Sue that John's temperature was 112 degrees at 1pm based on an observation by Frank, using an electronic thermometer. That temperature was recoded by Sam at 3:10pm in the EHR. Based on this evidence, Dr. Sue concluded that John needed an intervention and ordered an ice bath at 3:15 pm which was subsequently performed from 3:30 to 4:30 on the same day.

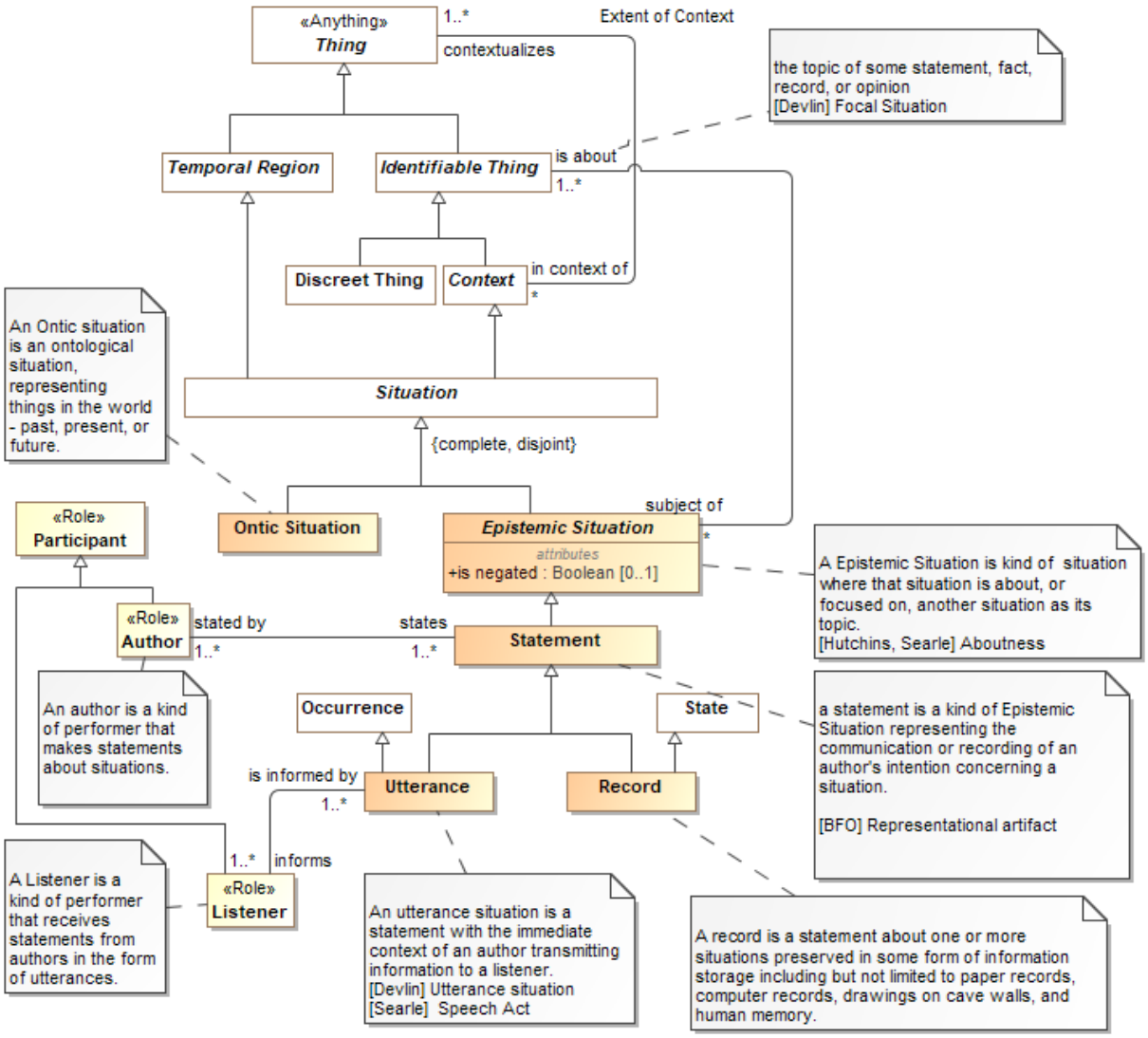
Count the situations! By understanding that each situation has its own timeframe, participants, and characteristics we can accurately record and decompose exactly what happened and connect related "chains of events". We have a basis for recording dependencies, for provenance, for trust (e.g. what if the thermometer was later found to be faulty). When these different situations are "mixed together" in a data record, important basis for decision making can be lost or misconstrued.

The essential take-away is that the statement and the situation it is about it is about are different but related things.

In formalizing statement we separate the concept of *aboutness* as a "epistemic situation" where aboutness captures any kind of situation that is about another. Statements are but one kind of epistemic situation. We differentiate epistemic situation from "Ontic Situations"; ontic situations represent things in the "actual world", not something about it. So John's temperature at 3:10 PM is real – Ontic, where as the record of that temperature is "about" – epistemic.

Refining further: Statements may be *utterances,* communications between an author and a listener. Statements may also be *records*, stored or remembered authored information.

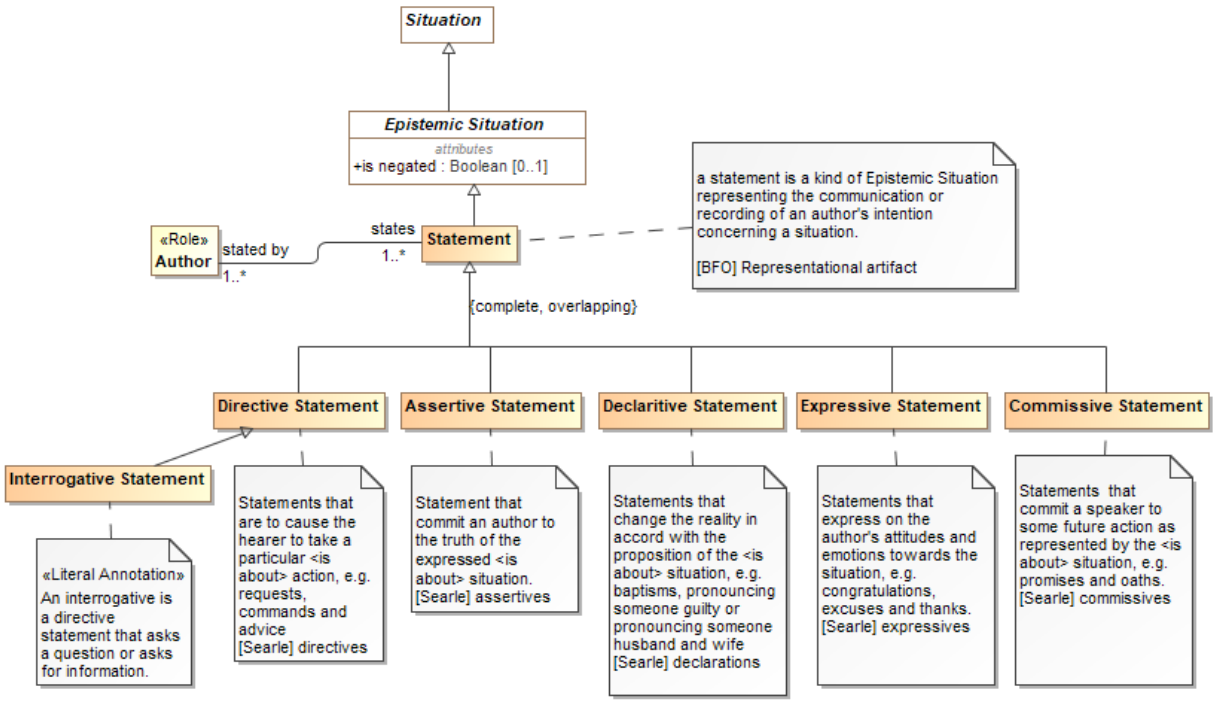
Diagram of aboutness and statements



Classification of statements

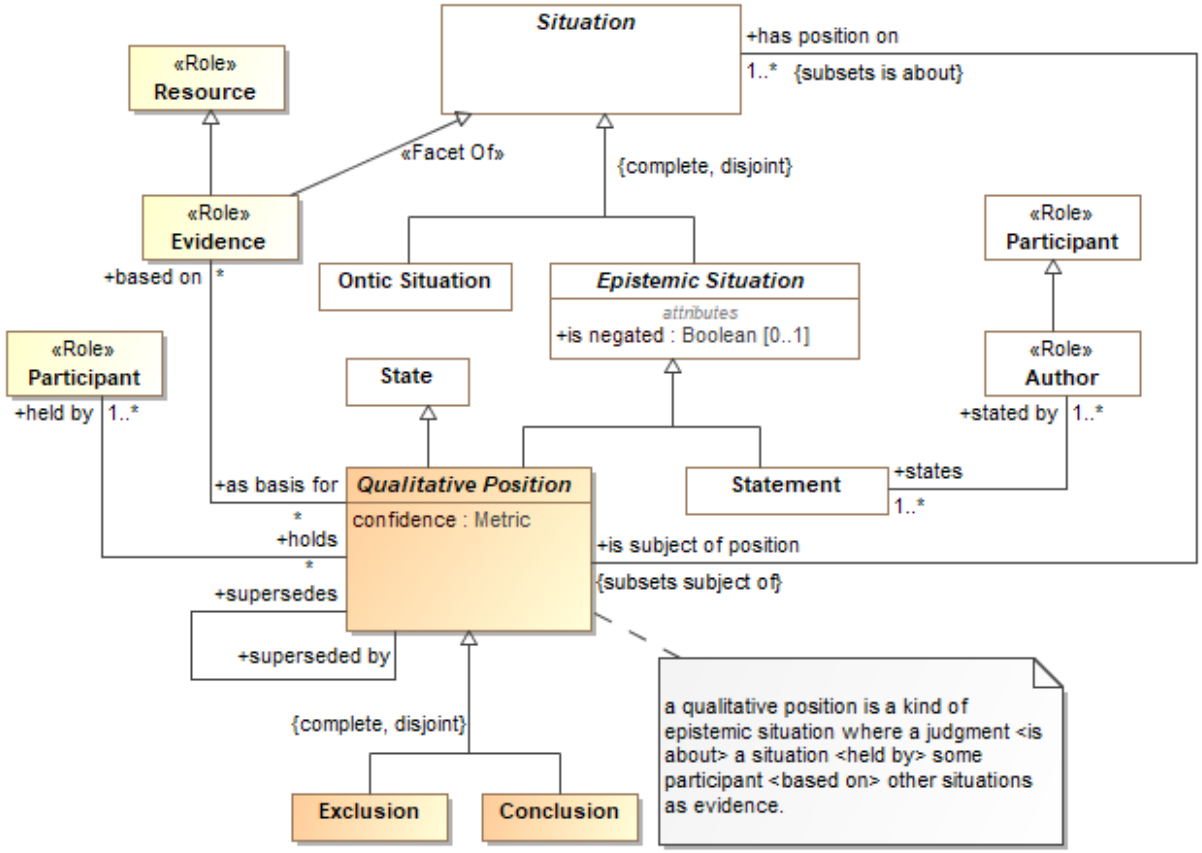
There are different kinds of statements, the most simple being some assertion – an assertive statement. John Searle (Searle, 1975) identified five classifications of “speech acts” which correspond to kinds of statements, as defined below. We apply these classifications to all statements (records as well as speech acts). Note that a statement may combine more than one speech act classification.

Have to investigate: Searle does not include interrogatives?



Qualitative Positions

The other kind of “epistemic situation”, something about something else, are qualitative positions. Qualitative positions represent the opinion or mode of some authority with respect to something else. This can include but is not limited to opinions, diagnoses, and evaluations.



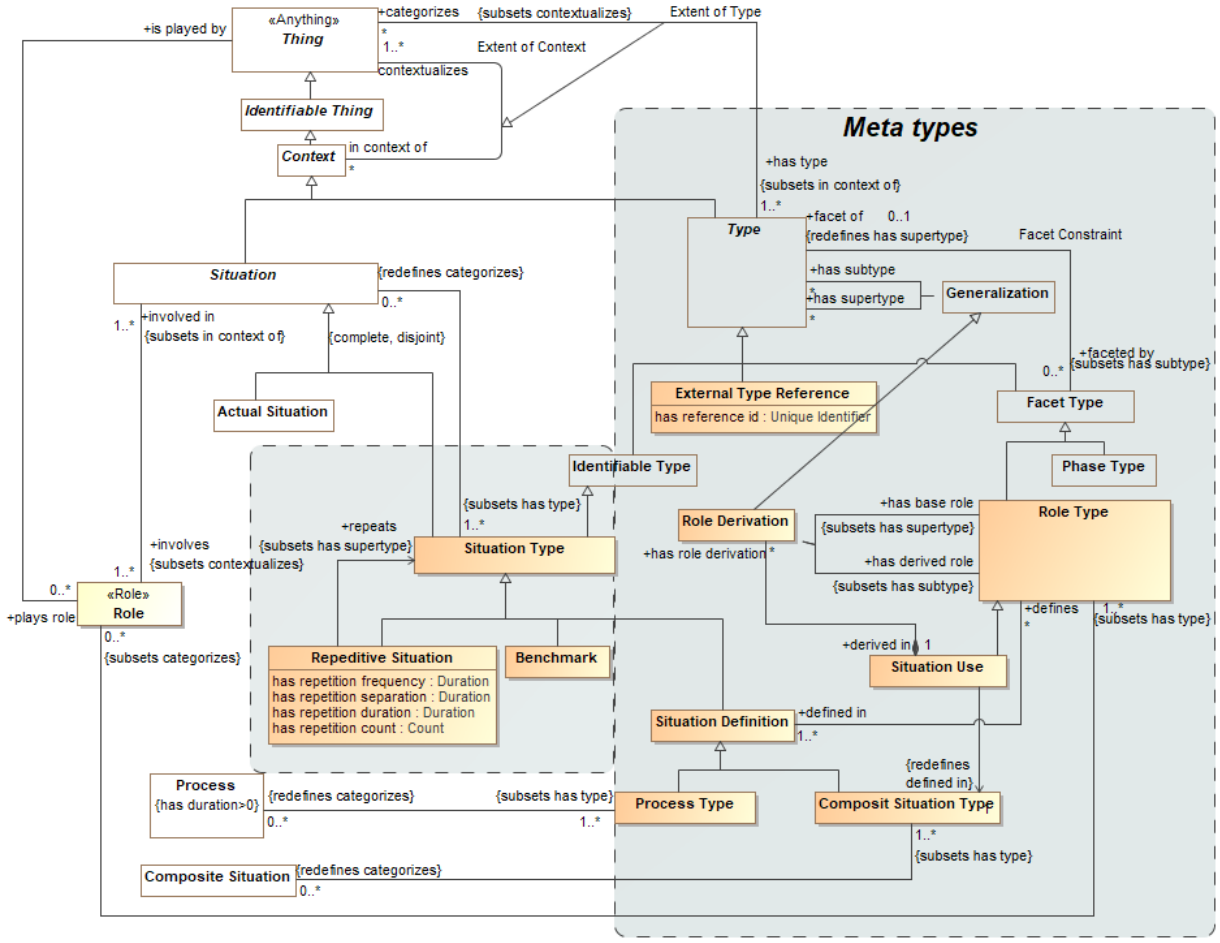
Situation Types and Definitions

The situation examples thus far have been what we call “actual situations” – a single thing “happening” over a specific timeframe. It is also important to be able to understand patterns of situations – be they the same kind of situation over and over (a shot administered daily for one year) or a pattern of different kinds of related situations, a situation definition.

Situation types differ from actual situations in that situation types have one or more “variables” in their composition, each such variable is a “Role Type” – something that can change when the type is realized in an actual situation. Actual situations have real individuals attached to each role. In that a situation types describes a set of actual situations, it can be considered a situation “type” where a <Type> is a categorization of a thing based on specific criteria {reference to type theory}. The criteria in this case is that the actual situation “fits the pattern” of the situation type by the assignment of actual things to the variables.

Two basic kinds of situation types are defined – repetitive situations and situation definitions. Repetitive situations are the same except for the time each actual situation is realized. Situation definitions define new "patterns" of roles, relationships and constraints.

The semantics of situation definitions draw strongly on "collaborations" as defined in (Reenskaug, 1995) and utilized in UML-2. A situation definition is a collaboration of objects behaving in specific ways, filling specific roles. Collaboration synthesis defines how composite situations can be built up, synthesized from, other atomic (relations) and composite situation types.

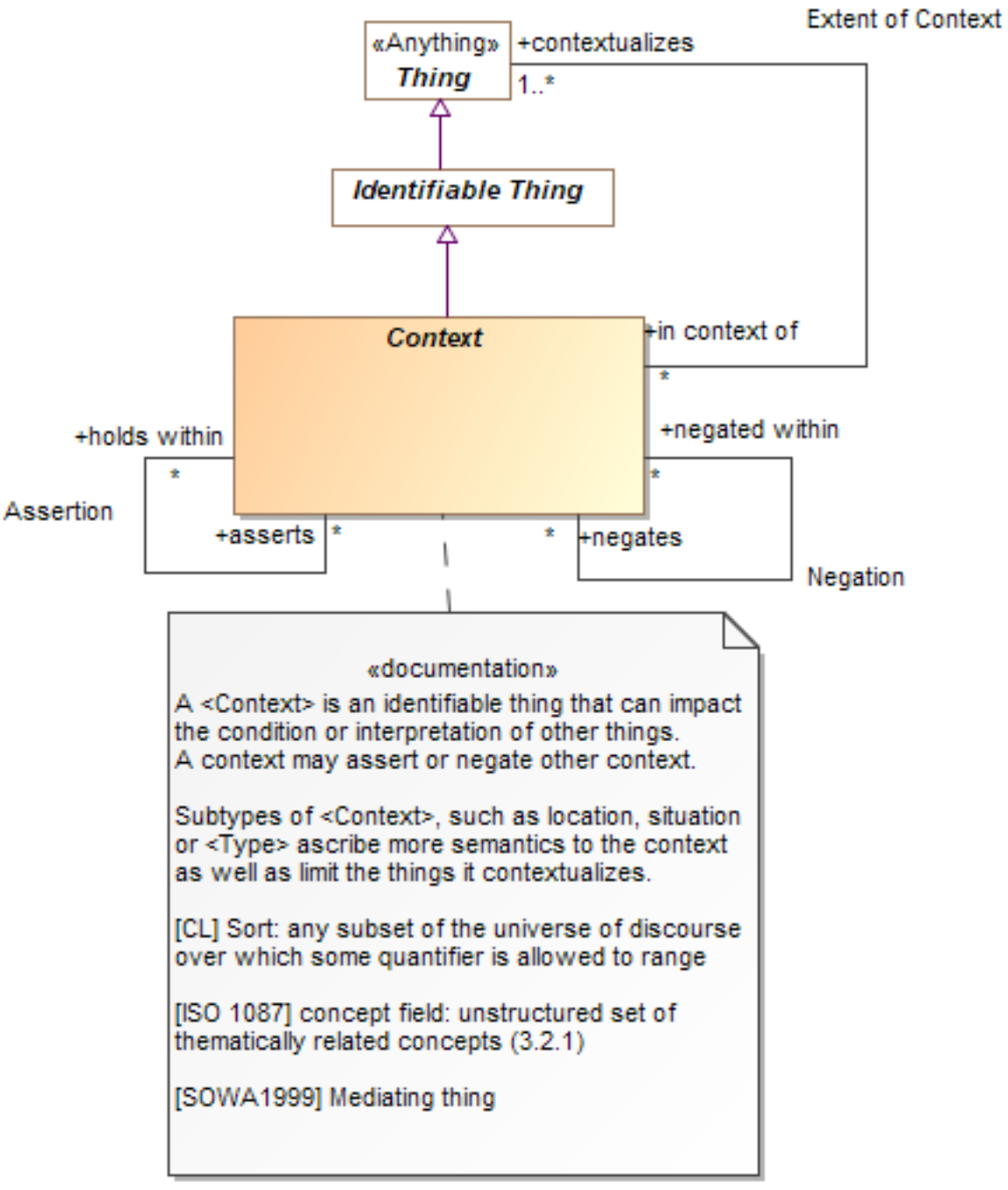


#	△ Term	Description	Owner
1	Benchmark	A benchmark is a situation type for comparison against expected patterns or values.	Situation Types
2	Composit Situation Type	A composite situation type is a Situation Definition that uses (synthesizes) other situation definitions as its parts. [Reenskaug 1995] Collaboration	Situation Types
3	defined in	definition is which the role is defined	Role Type
4	defines		Situation Definition
5	derived in	roles defined as meaningful within the situation type	Role Derivation[has base role:Rol...
6	has base role	role that will supertype of derived role and synthesized into the composite pattern.	Role Type
7	has derived role	role that is defined as being a subtype of a base role	Role Type
8	has repetition count	number of times the situation should repeat	Repeditive Situation
9	has repetition duration	how long each repetition should last	Repeditive Situation
10	has repetition frequency	how often each actual repetition should happen	Repeditive Situation
11	has repetition separation	time between actual situations	Repeditive Situation
12	has role derivation	a role derived from a situation that is used by a composite situation.	Situation Use
13	repeats	situation type that is repeated (if any)	Repeditive Situation
14	Repeditive Situation	a situation that repeats. Repetitive is a "mixin" class, any situation may be repetitive unless otherwise restricted.	Situation Types
15	Role Derivation	A role derivation "synthesizes" a base role into a role within the context of a situation use based on the synthesis pattern described in [Reenskaug 1995] Derived Role Constraint. [UML] Role binding	Situation Types
16	Role Type	A role type is a facet type that defines a specific purpose or behavior of a class of things. E.g. teacher, policeman, or employer. [Reenskaug 1995] Role [FIBO] Role. Note that partyInRole or thingInRole are implied by classification of a thing.	Situation Types
17	Situation Definition	A Situation Definition is a kind of Situation Type that defines roles and constraints describing situations. A situation definition is also a situation in that it has a lifetime and may involve Roles to bind individuals playing roles to situation definitions.	Situation Types
18	Situation Type	A situation type defines a kind of identifiable arrangement of individuals, assertions and the relations between them over a timespan. [DTV] situation kind: state of affairs that may or may not happen in some possible world [Barrwise 1999] Situation Type	Situation Types
19	Situation Use	Situation use is a kind of role type that uses another situation type within a defining composite situation type based on the synthesis pattern described in [Reenskaug 1995] (Synthesis).	Situation Types

Supporting concepts

The following are concepts supporting and refining situation concepts.

Context

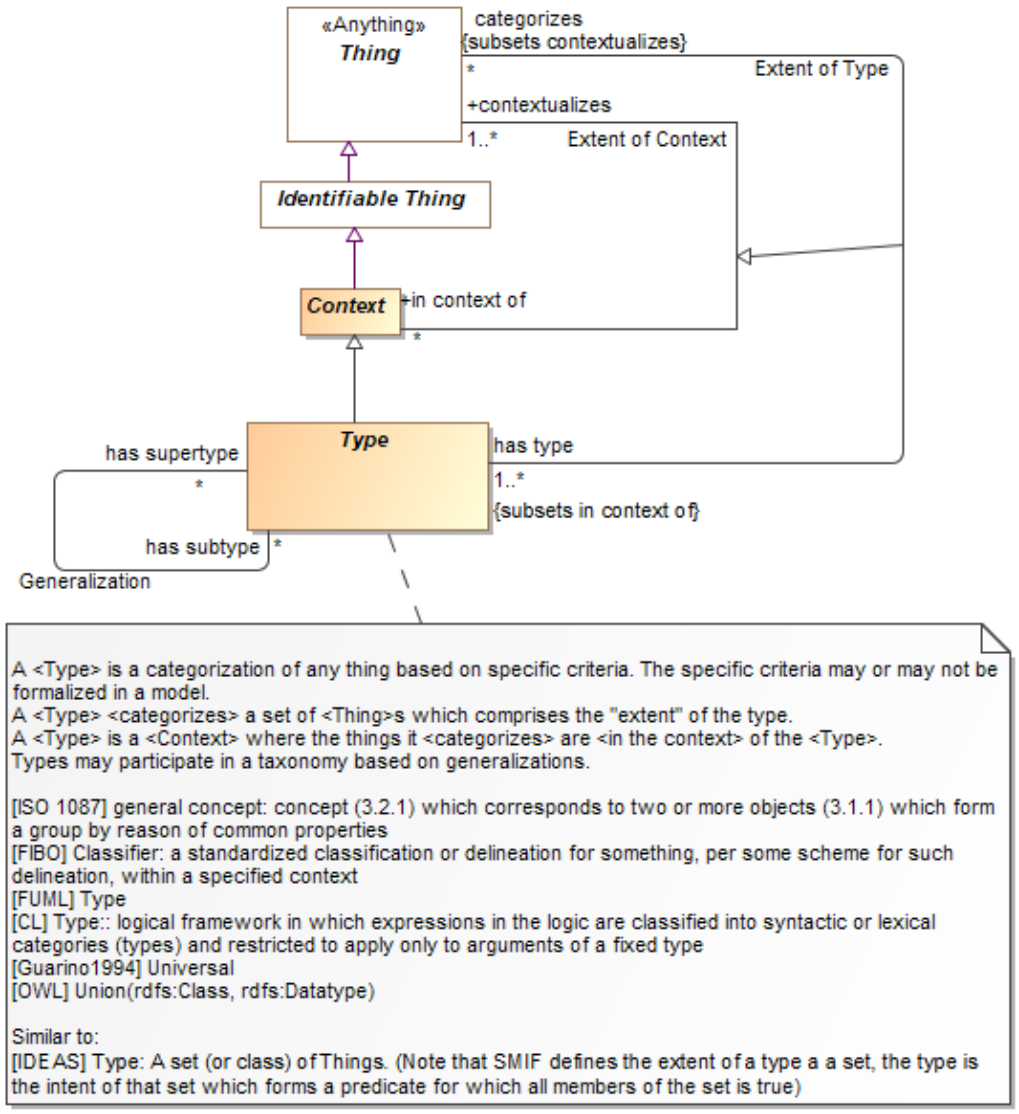


Example: Radar detectors are illegal in the context of Virginia

Types

Types and the type-categorizes (instance) relationship is a foundational concept. Types discriminate one kind of thing from another. Types in domain models are used for any form of classification or "pre-coordination" of concepts – such as kinds of processes, information, diseases, or treatments.

Example: Fido (Thing) has type Dog (Type)

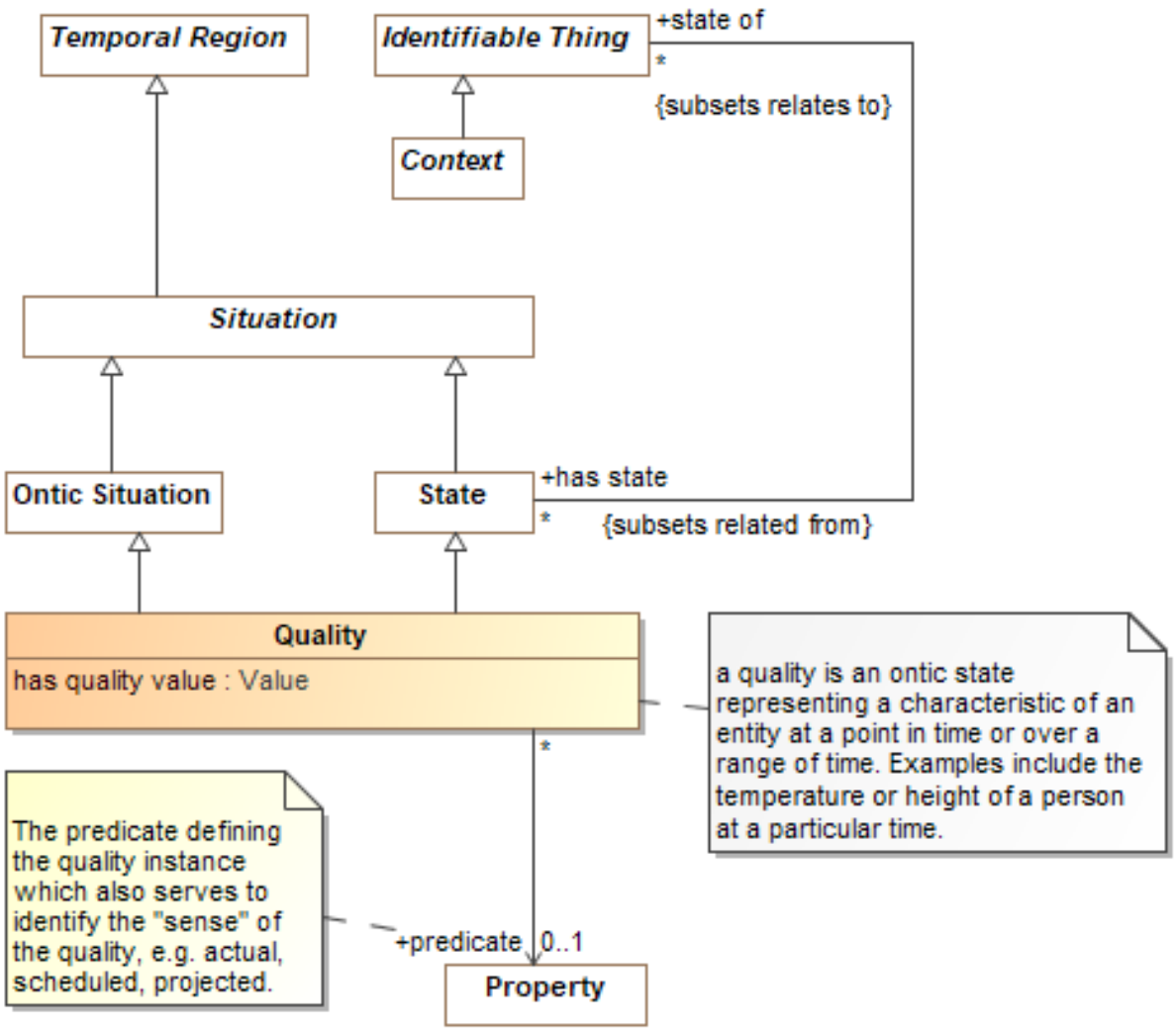


Qualities

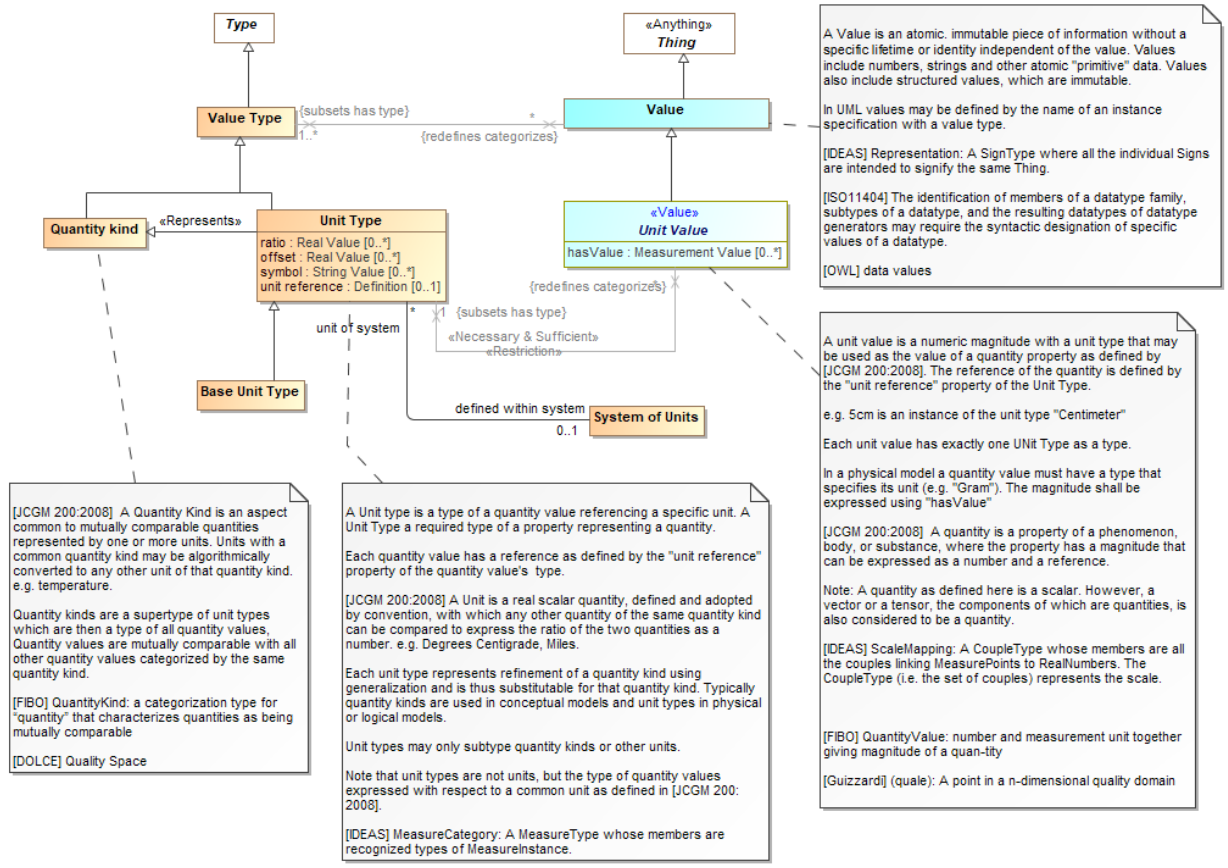
Qualities define some characteristic of something within a timeframe. Qualitied “reify” a predicate (property) such that it may have a timeframe, other context and relationships.

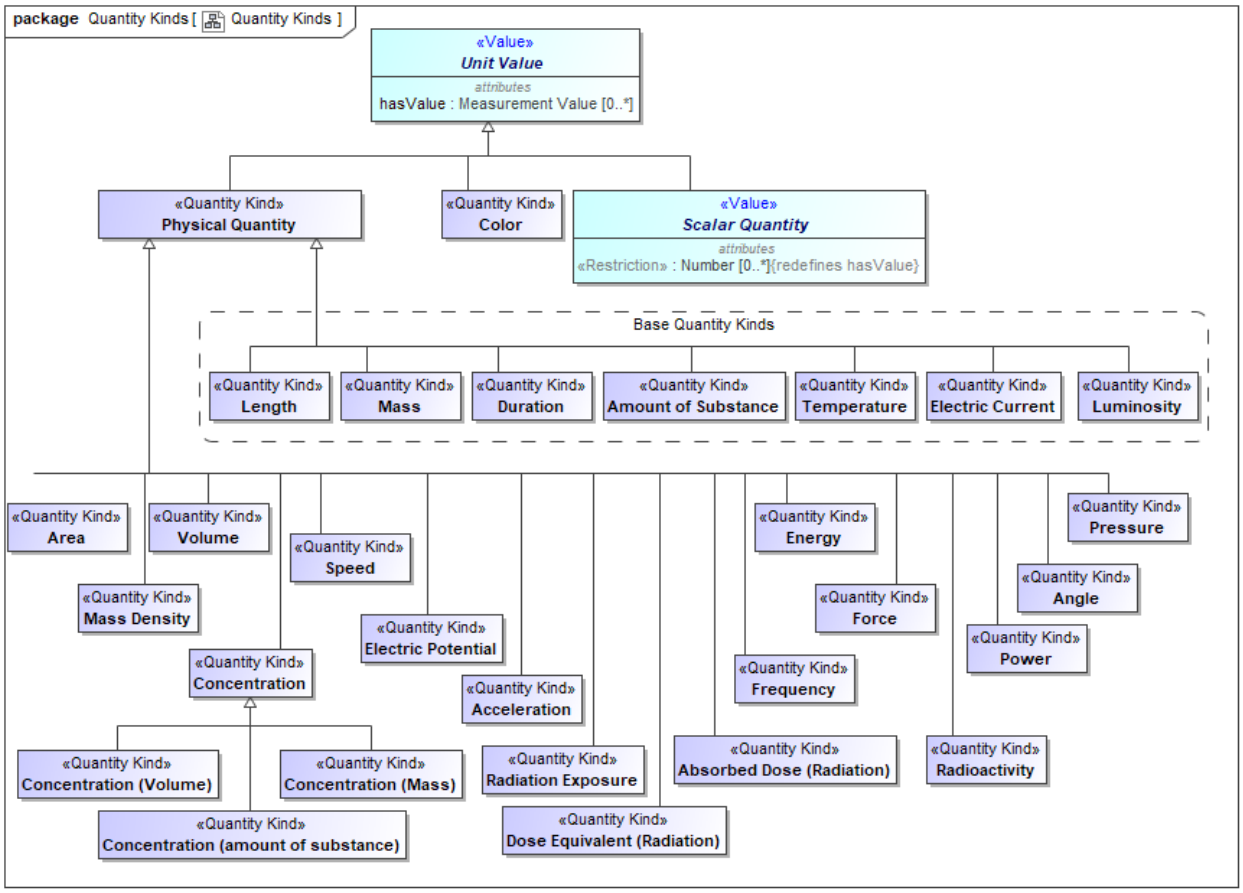
As something that may be “true” within a timeframe qualities are situations and more specifically a “State” of something and an Ontic Situation.

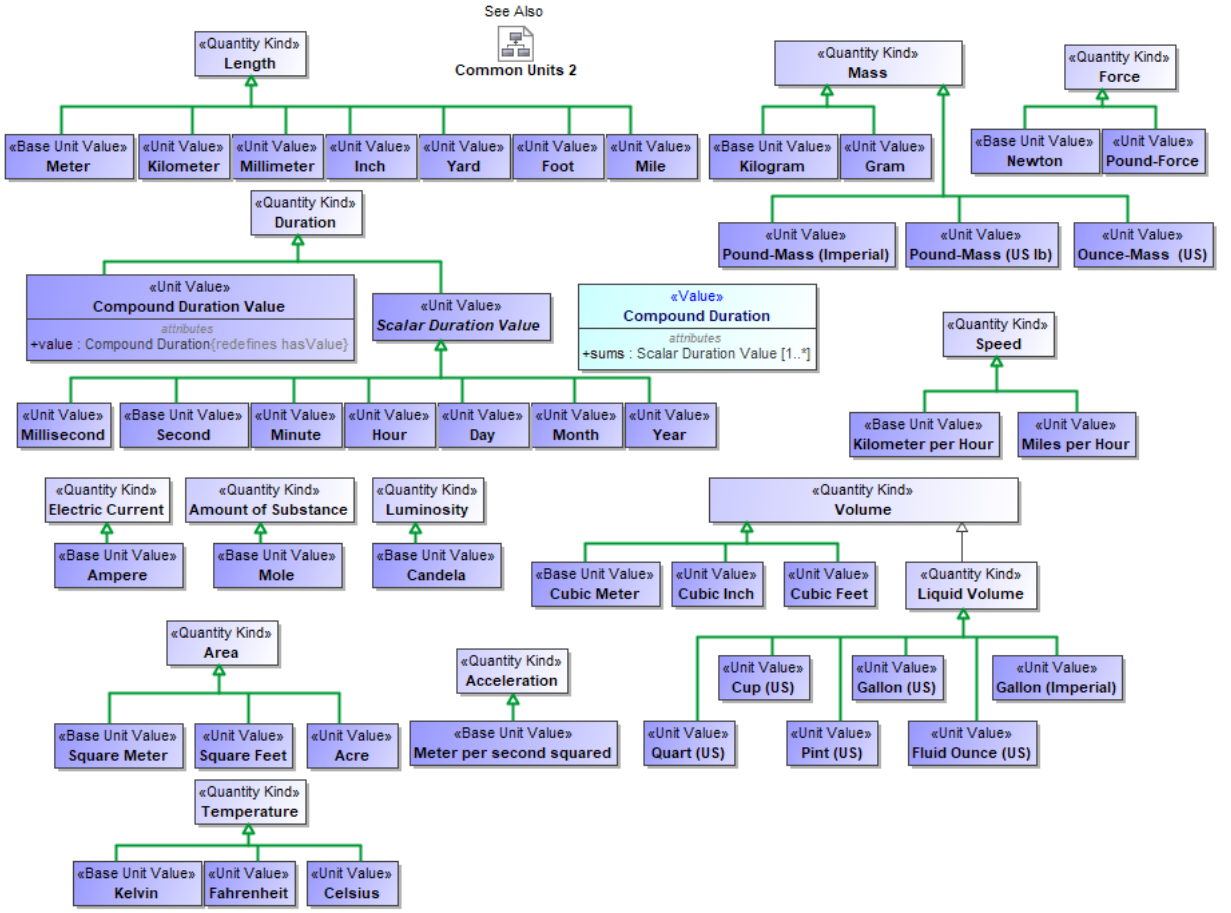
Qualities “as quality value” some Value, which may be a primitive value or a complex value. Qualities are immutable except for the possible addition of an end date where the end date may be unknown at instantiation.

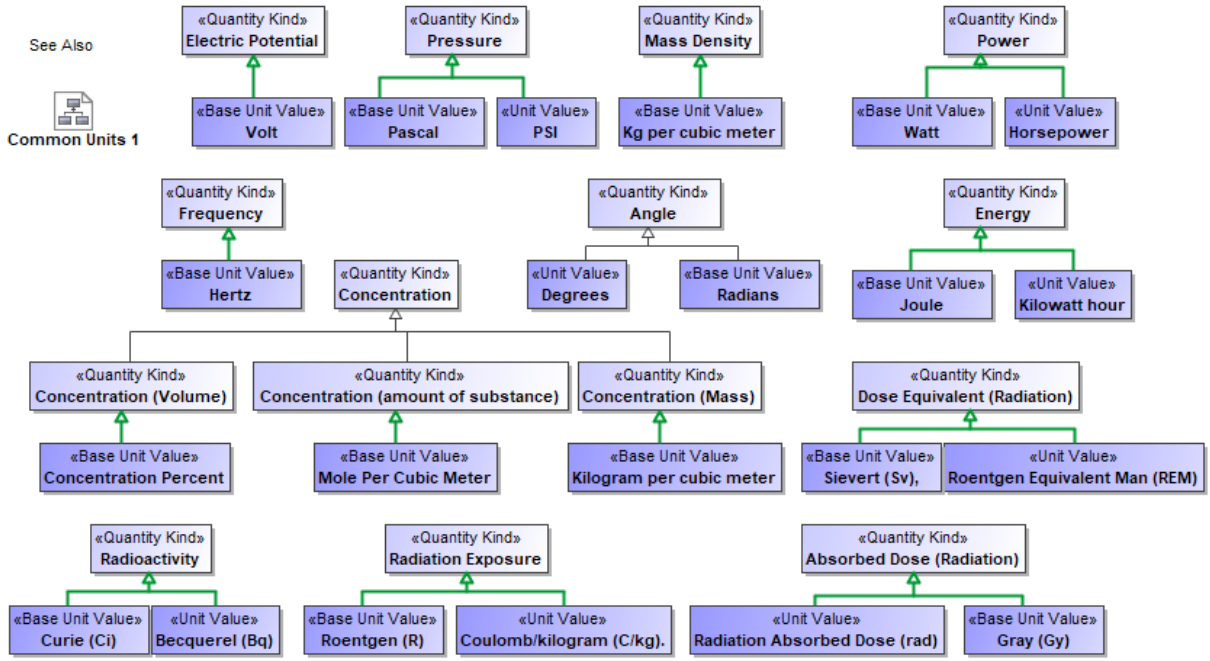


Values and units









References

Barwise, J. a. (1980). The Situation Underground. *Stanford Working*(Vol. 1), 1–55.

Barwise, J. a. (1999). *Situations and Attitudes (Republished).* CSLI Publications.

Devlin, K. (n.d.). *Situation Theory and Situation Semantics.* Retrieved from Stanford.edu: https://web.stanford.edu/~kdevlin/Papers/HHL_SituationTheory.pdf

Reenskaug, T. (1995). *Working with objects, The OOram Software Engineering Method.* Oslo, Norway: Taskon. Retrieved from http://heim.ifi.uio.no/~trygver/1996/book/WorkingWithObjects.pdf

Searle, J. (1975). *Experience and Meaning. Studies in the Theory of Speech Acts.* Cambridge: Cambridge University Press.

SMIF. (n.d.). *Semantic Modeling for Information Federation Specification.* Retrieved from SMIF: https://github.com/ModelDriven/SIMF/blob/master/DraftSMIFSpecification/SMIFSubmissionMasterDocument.pdf

[UML]	**OMG Unified Modeling Language (UML) v2.5** **http://www.omg.org/spec/UML/2.5/**
[OWL-2]	W3C/TR REC-owl2-syntax:2009 OWL 2 Web Ontology Language: Structural Speciation and Functional-Style Syntax. W3C Recommendation, 27 October 2009. http://www.w3.org/TR/2009/REC-owl2-syntax-20091027/
[NIEM]	http://reference.niem.gov/
[WGS-84]	http://earth-info.nga.mil/GandG/wgs84/
[NIST-SI]	http://physics.nist.gov/cuu/pdf/sp811.pdf
[NIST-800]	http://csrc.nist.gov/publications/PubsSPs.html
[BFO]	http://ifomis.uni-saarland.de/bfo/
[MathWorld]	From *MathWorld*--A Wolfram Web Resource. http://mathworld.wolfram.com

[CL]	ISO Common Logic, ISO/IEC 24707:2007(E)
[ISO1087]	Terminology work — Vocabulary, 2000, ISO 1087-1
[SOWA1999]	John F. Sowa, *Knowledge Representation: Logical, Philosophical, and Computational Foundations*, 1999, ISBN 0-534-94965-7
[ERGO 2018]	http://coherentknowledge.com/wp-content/uploads/2017/05/ergo-manual.pdf

