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The Date-Time Vocabulary, and Mapping SBVR to OWL

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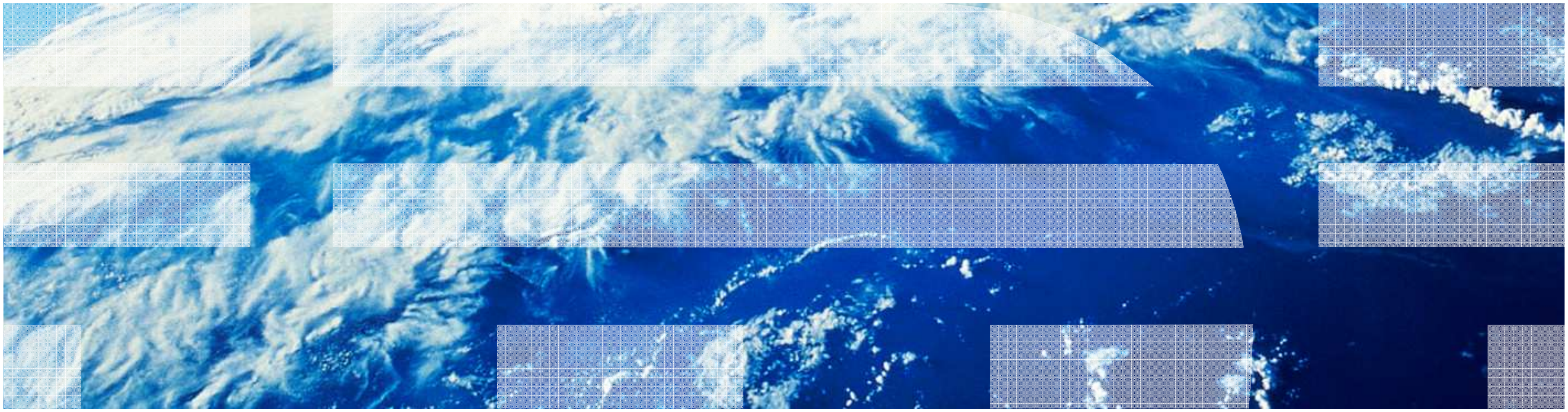

Agenda

The Date-Time Vocabulary

- What is the Date-Time Vocabulary?
- Previous Work
- What is SBVR?
- Foundations – sequences, quantities, mereology vocabularies
- Continuous Time Model
- Discrete Time Model
- Calendars
- Situations and Time
- Language Tense & Aspect
- Schedules

Mapping SBVR to OWL

- Why?
  – 2-way information preserving
- Direct mapping where applicable
- Namespace management
- Annotations for what doesn't map
  – Capturing the SBVR concept type
- Status

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What is the Date-Time Vocabulary?

- A business-oriented vocabulary (ontology) for dates & times
  – Example use case: Financial Industry Banking Ontology (FIBO)
  – Potential use case: ISO 24617 (TimeML)
- Available from the OMG as a "beta specification" - www.omg.org/spec/DTV
  – Specification document
  – SBVR machine-readable vocabulary
  – Complete UML model, with OCL
  – Partial CLIF axiomatization
  – Partial OWL ontology
- OMG "Finalization Task Force"
  – Final version due November 12, 2012
  – Acceptance expected December, 2012
  – Adoption expected in early 2013

Date: January 2012

Date-Time Vocabulary (DTV)

FTF - Beta 1

OMG Document Number: dtc/2012-01-02
Standard document URL: http://www.omg.org/spec/DTV/1.0/PDF
Associated Schema Files: http://www.omg.org/spec/DTV/20111209
http://www.omg.org/spec/DTV/20111209/dtv-sbvr.xml
http://www.omg.org/spec/DTV/20111209/dtv-uml.xml
http://www.omg.org/spec/DTV/20111209/dtv.ocl
http://www.omg.org/spec/DTV/20111209/dtv.clif
http://www.omg.org/spec/DTV/20111209/sbvr.owl
http://www.omg.org/spec/DTV/20111209/sequences.owl

This OMG document replaces the submission document (bmi/2011-08-01, alpha). It is an OMG Adopted Beta specification and is currently in the finalization phase. Comments on the content of this document are welcome, and should be directed to issues@omg.org by June 4, 2012.

You may view the pending issues for this specification from the OMG revision issues web page http://www.omg.org/issues/.

The FTF Recommendation and Report for this specification will be published on September 21, 2012. If you are reading this after that date, please download the available specification from the OMG Specifications Catalog.

Previous Work

- Numerous standards (the most significant listed here):
  - ISO 8601: *Data Elements and Exchange Formats – Information Interchange – Representation of Dates and Times*
  - ISO 80000-3: *Quantities and Units – Part 3: Space and Time*
  - SI: *The International System of Units*
  - VIM: *International Vocabulary for Metrology*
  - ISO 18026: *Information Technology – Spatial Reference Model*
- Lots of academic work (only some listed here):
  - Knowledge Representations of Time:
    - OWL-Time & Pan *Representing Complex Temporal Phenomena for the Semantic Web and Natural Language*, Thesis, 2007
    - DOLCE, SUMO
    - Allen: Maintaining Knowledge about Temporal Intervals, 1983
    - Hayes: *A Catalog of Temporal Theories*, 1995-1996
    - Sowa: *Laws, Facts, and Contexts*, 2003
  - Linguistics & Philosophy
    - Davidson: *The Logical Form of Action Sentences*, 1967
    - Lowe: *The Four-category Ontology: A Metaphysical Foundation for Natural Science*, 2006
    - Menzel: *Actualism*, 2011
    - Parsons: *Events in the Semantics of English*, 1990
    - Zalta: *Abstract and Non-Existent Objects*, 2003; *Twenty-Five Basic Theorems in Situation and World Theory*, 1993

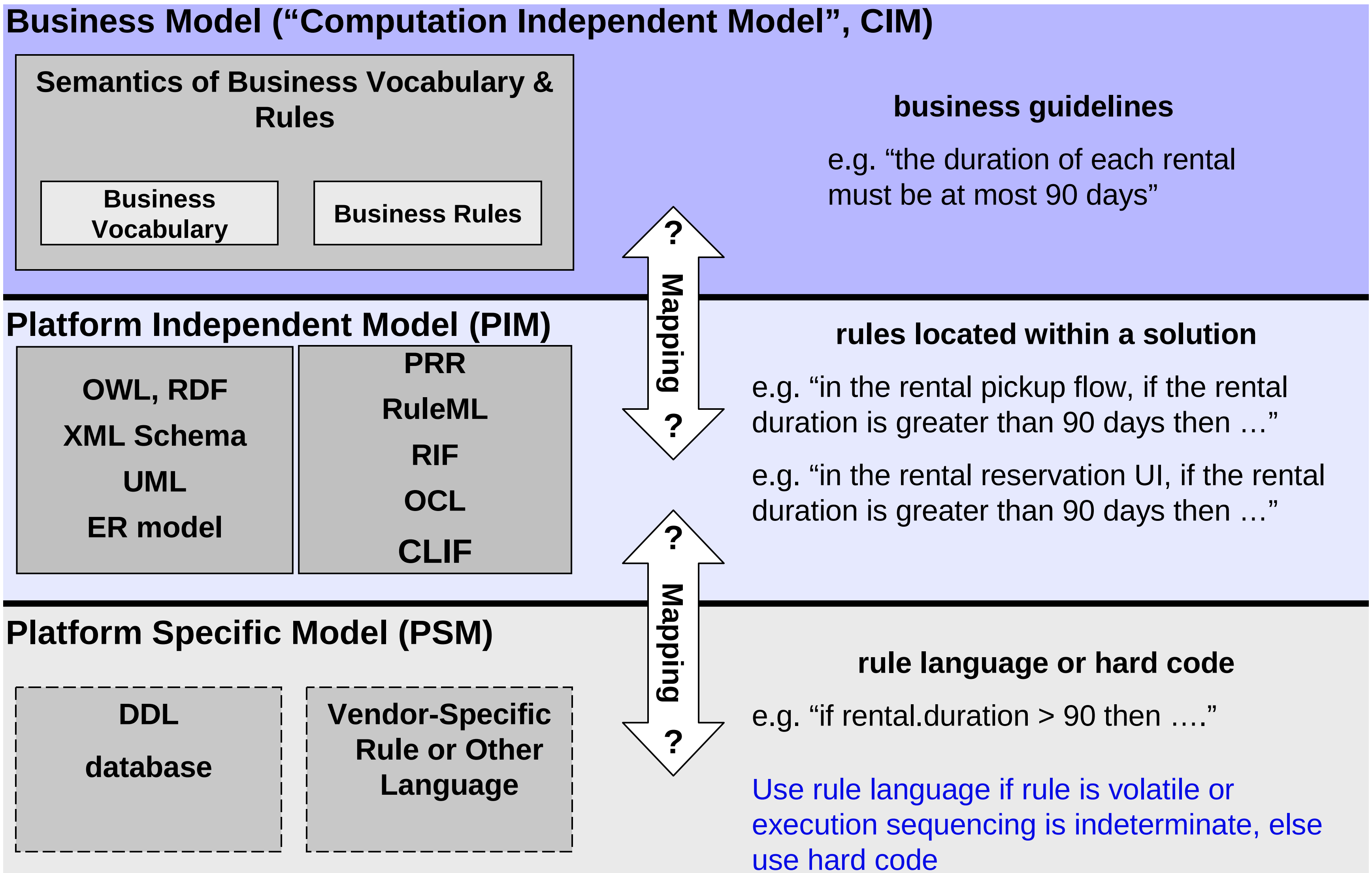
What is SBVR?

- **SBVR: *Semantics of Business Vocabulary and Rules* – a specification from the Object Modeling Group (OMG)**
- **SBVR captures the business sense of business terminology, policies, regulations, contracts, SLA's with:**
  – Formal semantic model
  – Human readable presentation
  – Not a rule engine

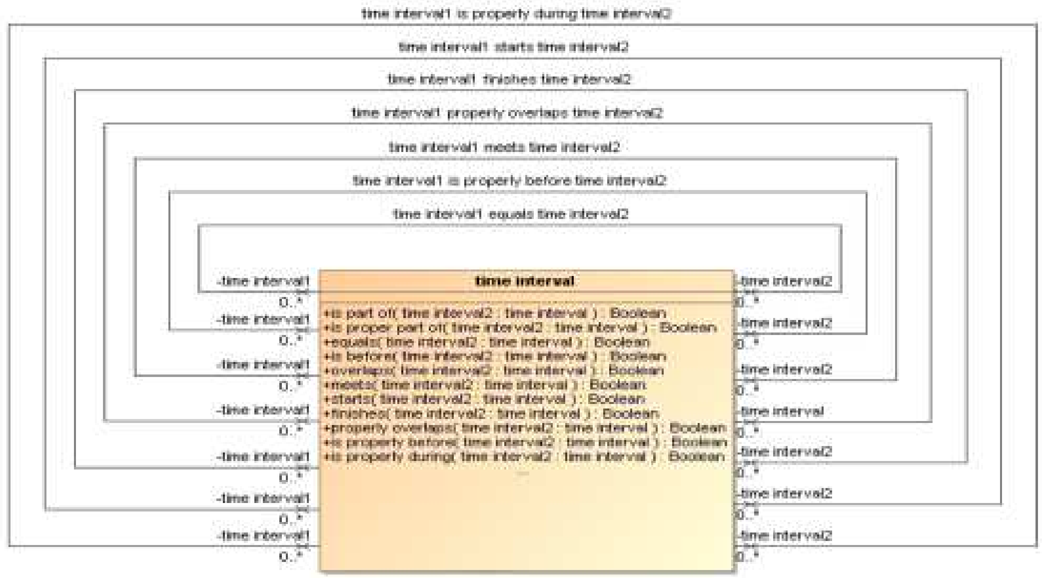
	Understood and used by human	**Automatically processed by computer**
Existing methods of capturing business knowledge		
Natural Language	**Easy**	**Hard**
Formal Logic (e.g. OWL, first order logic)	**Hard**	**Easy**
SBVR = formal logic + structured natural language presentation		
SBVR Meaning		**Easy**
SBVR Presentation	**Easy**	

- **Benefits**:
  – Enable business analysts to capture business knowledge
  – Facilitate the review and validation of formalized knowledge by business users
  – Improve communication among business people & between business & IT users
  – Reduce the cost of knowledge engineering (e.g. OWL, rule languages)
  – Simplify querying in knowledge-based analytics solution
  – Potential automated transformations to executable software

SBVR and Model-Driven Architecture



Example – Allen Relations



UML diagram, showing 7 relationships among any two time intervals, and 10 methods that are used as predicates by the OCL

Figure 8.4 - UML Diagram of Allen Relations

time interval$_1$ ***is properly before*** time interval$_2$

Synonymous Form: time interval$_2$ *is properly after* time interval$_1$

Definition: the time interval$_1$ *is before* the time interval$_2$ and the time interval$_1$ *is before* a time interval$_3$ and the time interval$_3$ *is before* the time interval$_2$

SBVR glossary entry for one relationship, with synonym & definition

CLIF Definition:

```
(forall ((t1 "time interval") (t2 "time interval"))
 (iff ("time interval1 is properly before time interval2" t1 t2)
    (and ("time interval1 is before time interval2" t1 t2)
         (exists ((t3 "time interval"))
          (and ("time interval1 is before time interval2" t1 t3)
              ("time interval1 is before time interval2" t3 t2)
              )))))
```

CLIF version of definition

OCL Definition:

```
context "time interval"
def: "time interval1 is properly before time interval2"
    (t1: "time interval", t2: "time interval")
    : Boolean =
    t1.before(t2) and
    "time interval".allInstances-->exists(t3 |
     t1.before(t3) and t3.before(t2))
```

OCL version of definition

Example: 2009 *is properly before* 2011

Example

Sequences Vocabulary

- A general model of sequences
  - regular, consecutive, or unique
  - finite or indefinite
- Members may be independent or intrinsic to the sequence
- Every element has an index – either a property of each member or assigned by the sequence

Quantities Vocabulary

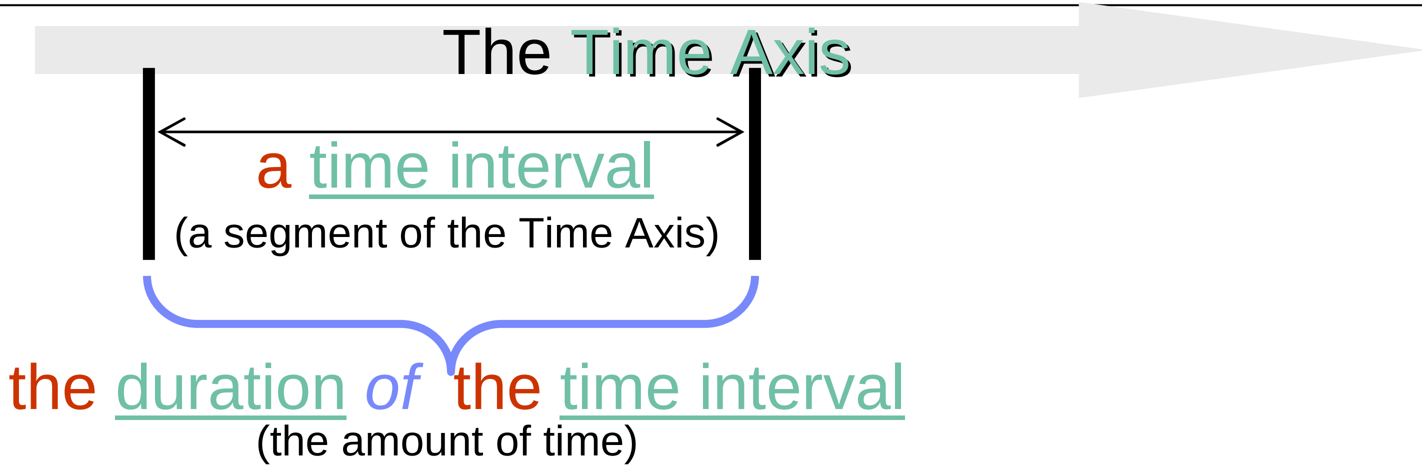
- A minimal model, based on VIM
- Distinguishing:
  - Quantity
  - Quantity Kind
  - Particular Quantity
  - Quantity Values
  - Measurement Unit

Mereology Vocabulary

- A general model of part-whole relationships
  - A “Minimal Model” in the sense of Casati & Varzi
- Includes:
  - *Part of*
  - *Overlaps*
  - *Proper part*
  - Weak supplementation

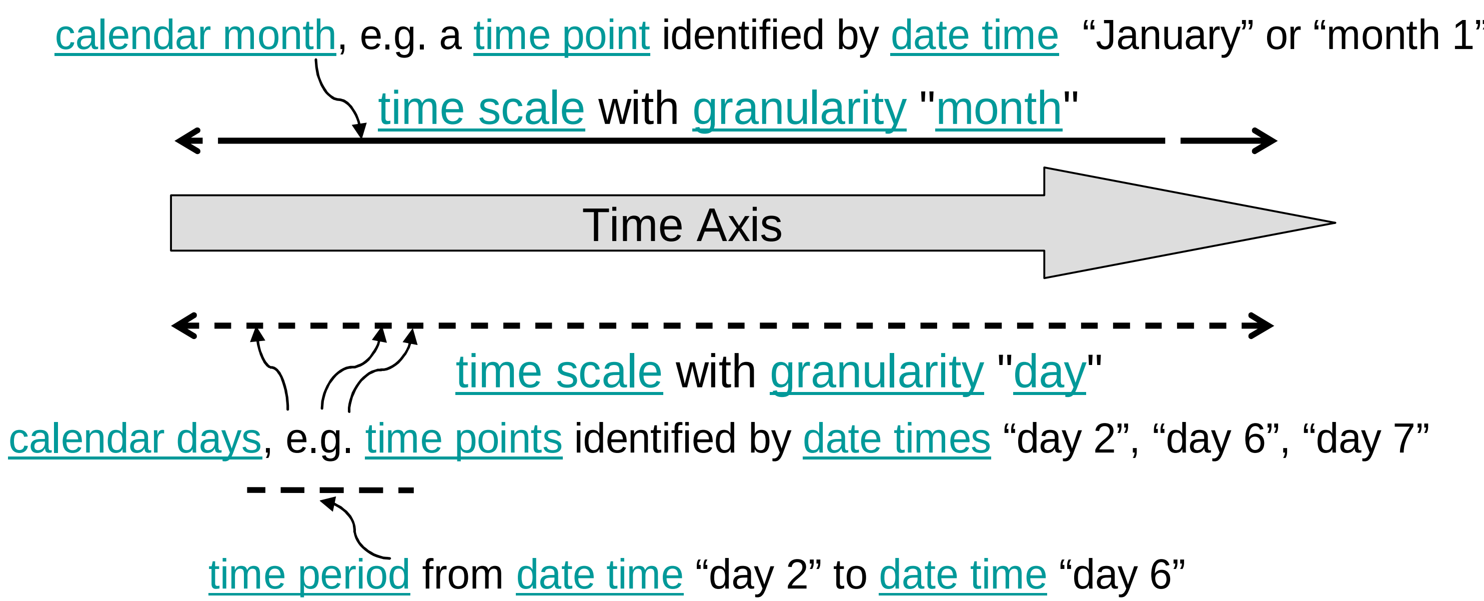
All three of these in SBVR + CLIF + OCL

Continuous Time Model



- Three primitive relationships:
  - – mereological: time interval$_1$ *is part of* time interval$_2$
  - – partial order: time interval$_1$ *is before* time interval$_2$
  - – duration: time interval *has* duration
- No time interval with zero duration: no ‘time instant’
  - – business applications don’t use ‘instants’ of time
  - – every time interval has a proper part
- Extensive set of verb concepts (relationships) among time intervals and durations
  - – the Allen relationships
  - – completely axiomatized in CLIF and OCL, using the primitives above
  - – Example: time interval$_2$ *is* duration *after* time interval$_1$

Discrete Time Model

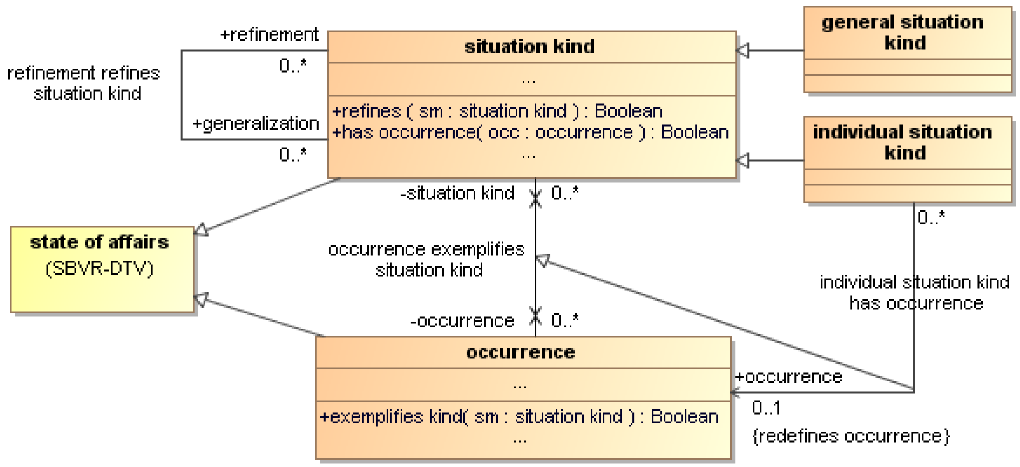


- time point: concept that *specializes* the concept 'time interval' and
  that *is* a member *of* a time scale
  - the instances of a time point are time intervals
- Time coordinates *indicate* time points
  - a time point may *be indicated by* multiple time coordinates: the time coordinates are *equivalent*
  - example: “January 3, 2011” is equivalent to “2011 day 3”

Calendars

- We define an infrastructure that permits anyone to define their own calendars
  - examples: religious, cultural, historical calendars
  - examples: business, financial, manufacturing calendars
- calendars consist of:
  - time units, time scales, time points, time periods, and time coordinates
  - relationships among the time units, time scales, and time points
    - example: minute of seconds scale defined as "the finite time scale that *subdivides* 'minute of hour' *into* 60 *of* 'second of minute'"
  - an interchange format to transmit time coordinates among implementations
- We define 4 standard calendars & time scales:
  - the Gregorian Calendar
  - the Week calendar
  - time of day time scales
  - the Internet Time calendar

Situations and Time



- The Date-Time Vocabulary distinguishes situation kinds from occurrences
  - Situation kind: a potential situation. Example: building codes require planning for building fires (situation kinds).
  - Occurrences: an actual situation, a happening. Example: a building fire that burns you.
  - A situation kind may have multiple occurrences.
- Temporal relationships for situation kinds & occurrences enable rules to constrain either
  - Example: Each shipment *of* an order must *be preceded by* a payment *of* the order.
- Propositions correspond to situation kinds
  - A proposition *is true* if it corresponds to a situation kind that has an occurrence that *is current*
- Examples:
  - A contract must *be fulfilled* if and only if the contract *was signed*.
  - Each factory manager must *plan for* electrical power *being cut off*.
  - Each machine breakdown must *be reported to* the repair center.

Language Tense and Aspect

		Aspect			
		Simple	Progressive	Perfect	Progressive & Perfect
Tense	Past	past simple company x *traded with* company y	past progressive company x *was trading with* company y	past perfect, pluperfect company x *had traded with* company y	pluperfect progressive company x *had been trading with* company y
	Present	present simple company x *trades with* company y	present progressive company x *is trading with* company y	present perfect company x *has traded with* company y	present perfect progressive company x *has been trading with* company y
	Future	future simple company x *will trade with* company y	future progressive company x *will be trading with* company y	future perfect company x *will have traded with* company y	future perfect progressive company x *will have been trading with* company y

Schedules

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An Example Schedule Vocabulary	A Schedule Example

Put: option that an owner *sells* an issue *according to* a Put Schedule
 	
owner *sells* issue *according to* Put schedule
 	
Put *redeems at* price: the owner *of* the Put *sells* the issue *of* the Put *at* the price
 	
owner *sells* issue *at* price
 	
Put redemption: general situation kind that a Put *redeems at* a price
 	
Put Schedule: schedule that *is for* 'Put redemption'
	Put 123: owner abc *sells* issue 123 *according to* Put 123 schedule
	
	Put 123 schedule: {
	'Put 123 *redeems at* $100' *occurs for* December 14 2011
	'Put 123 *redeems at* $101' *occurs for* December 15 2011
	'Put 123 *redeems at* $102' *occurs for* December 16 2011
	}

- Situations that repeat according to an ad-hoc or regular time table
- The time intervals of the time table may be identified by definite descriptions or by a repeat interval
- Finance has particularly complex examples

Mapping SBVR Vocabularies to OWL2

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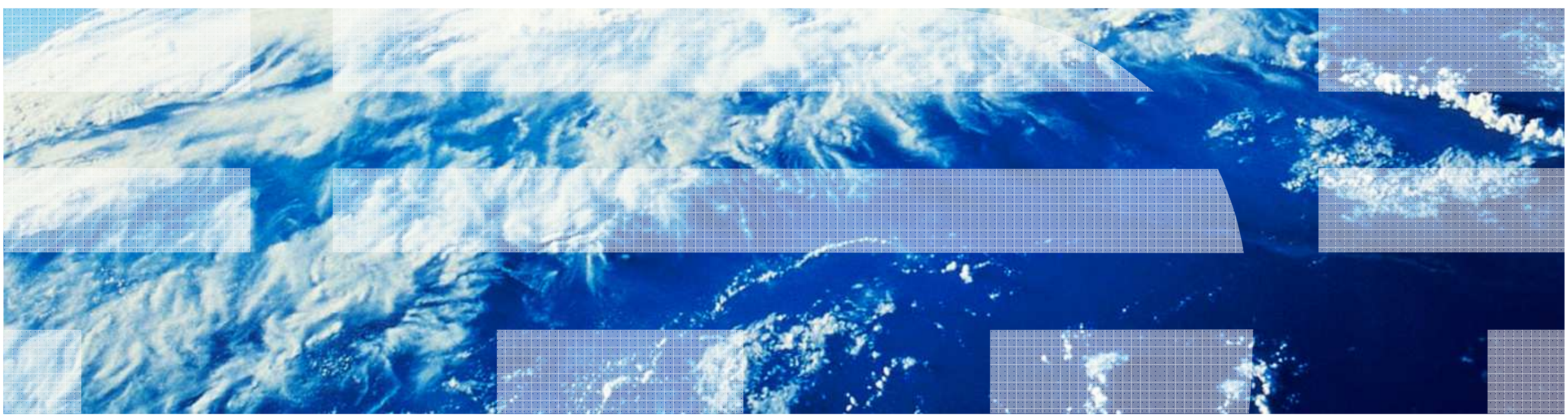
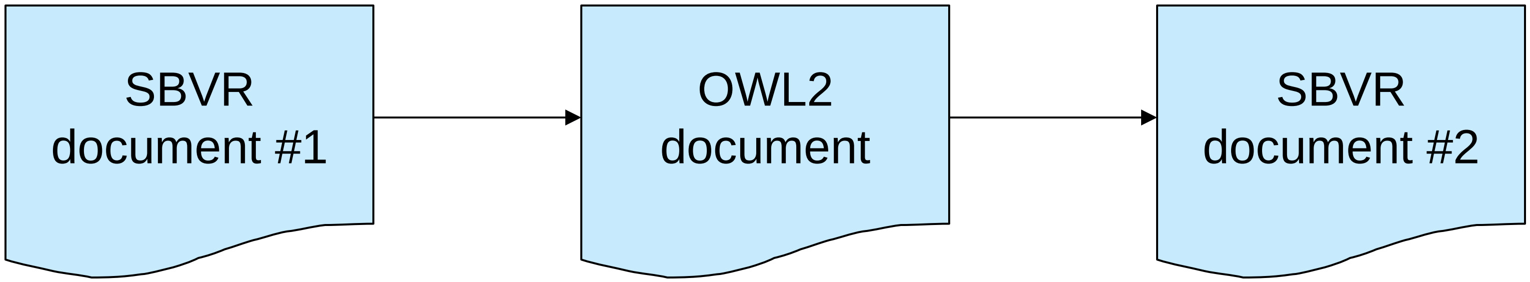


Why?

- The EDMC's Financial Industry Business Ontology (FIBO) -- and other use cases -- need an OWL2 version of the Date-Time Vocabulary
  - We focus on SBVR vocabularies, not behavioral rules – but our approach can be extended to behavioral rules
- The mapping provided in the SBVR spec is:
  - Incomplete
  - Lossy (i.e. not two-way information preserving)

2-Way Information Preserving



- The meaning of SBVR document #2 is equivalent to the meaning of SBVR #1
  - But the representation (syntax, formatting) may differ
- Supporting parts of #1 are recreated in #2
  - Definitions, rules, descriptions, notes, examples, etc.
- Mechanism:
  - Where SBVR and OWL have equivalent concepts, map the SBVR meaning to the OWL meaning & back
  - Where they do not have equivalent concepts, capture the SBVR intent as an OWL annotation
- Implication: OWL2 could be used as a tool interchange format, as an alternative to the XML schema documented in the SBVR spec
- Implication: this identifies what SBVR "adds" to OWL2

Direct Mapping of Some SBVR Concepts

SBVR Concept	OWL2
vocabulary (terminological dictionary)	ontology
noun concept	class
individual concept	individual
characteristic (unary verb concept)	dataProperty of type xsd:Boolean, applied to the single verb concept role
binary verb concept that is not a property	objectProperty + InverseObjectProperty, with the roles as domain and range
property association verb concept	sbvr:objectProperty or sbvr:dataProperty, with the first role as the domain and the second role as the range or type
n-ary verb concept	reify the relationship by creating a new class with *n* properties (one per role), per Pattern 1 in http://www.w3.org/TR/swbp-n-aryRelations/
verb concept role	(see above)
categorization type	class CT + SubClassof(class, class CT)
characteristic type	enumeration
reference scheme	reference keys
concept1 specializes concept2	sub class
concept1 is coextensive with concept2	equivalent class

Direct Mapping of Some SBVR Definition & Rule Patterns

SBVR Definition/Rule Pattern	OWL2
concept1 Definition: concept2 that ….	sub class
concept1 Definition: concept2 that is a concept3 …	sub class (multiple inheritance)
concept1 Definition: concept2 or concept3 …	union
No concept1 is a concept2	disjoint classes
Necessity: Each concept1 has exactly/at least/at most *n* concept2.	cardinality restriction

Namespace Management

- SBVR namespaces are mapped to IRIs
- Each SBVR vocabulary is an OWL ontology with its own IRI
- Each SBVR property is in the namespace of the concept that 'owns' the property – handled by concatenating the owning property name, '/', and the property name

Example

SBVR	OWL2
Vocabulary **General Concept:** vocabulary **Namespace URI:** <IRI for vocabulary> <u>car</u> *has* <u>door</u> <u>house</u> *has* <u>door</u>	Prefix(vocab = <IRI for vocabulary>) Ontology(<IRI for vocabulary>) Class(vocab:door) ObjectProperty(sbvr:objectProperty vocab:car **vocab:car/door**) ObjectProperty(sbvr:objectProperty vocab:house **vocab:house/door**)

Annotations

- We define a set of annotations for capturing aspects of SBVR that have no OWL equivalent
  - Synonyms
  - Descriptions, examples, notes
  - References
  - Rules
  - Unambiguously identifying the Concept Type of an SBVR glossary entry
- We use SKOS and Dublin Core annotations where they exist and mean what SBVR means

Annotations for Definitions & Rules

- Annotations: sbvr:definition, sbvr:necessity, sbvr:possibility
- Domain: sbvr:concept
- Range: an XML-tagged string literal
  - use XML tags to distinguish the parts of speech: noun concepts, individual concepts, verb concepts, keywords, subscripts

Identifying the SBVR Concept Type

- Each SBVR glossary entry has a Concept Type
  - Implied by the form of the glossary entry text
  - Or explicit
- We capture the SBVR Concept Type with an sbvr:type annotation
  - The domain of this annotation is any OWL:Resource
  - The range of this annotation is an OWL ontology of SBVR meanings
    - This ontology is used only for the sbvr:type annotation

Example (abbreviated)

SBVR

Time Axis

Definition: the indefinite continued progress of existence and events in the past, present, and future, regarded as a continuum

Necessity: There exists exactly one **Time Axis**

OWL

Prefix(vocab=<dtv uri>)

NamedIndividual(vocab:TimeAxis)

AnnotationAssertion(**sbvr:type**
vocab:TimeAxis
sbvr:individualConcept)

AnnotationAssertion(**skos:definition**
vocab:TimeAxis
"the indefinite continued progress of existence and events in the past, present, and future, regarded as a continuum")

AnnotationAssertion(**sbvr:necessity**
vocab:TimeAxis
"**<sbvr:keyword>**There exists exactly one **</sbvr:keyword> <sbvr:individual>** Time Axis**</sbvr:individual>**")

Status

- Partially done
  - – Working document describing the mapping
  - – OWL ontologies for the SBVR annotations and SBVR concept hierarchy
- We have deferred actually mapping the DTV vocabulary until we are satisfied with the SBVR→OWL→SBVR mapping
- Target: year end 2012

Vision

- Create vocabularies and rules in SBVR
  - A way for real business people to understand and give feedback on the rules & vocabulary
    - Because the rules can be displayed in graphical or "Structured English" forms that are accessible to non-technical people
  - Both rules and vocabulary are captured in a single integrated, formal meta-model
    - Vocabularies are business-oriented ontologies
    - Rules are based on predicate + modal logic
- Translate the vocabularies and rules to implementation-level standards & languages, e.g. OWL
  - To reuse implementation-level technology
  - To apply the vocabulary & rules in existing IT systems
  - Extend the "reach" of established standards
- The Date-Time Vocabulary enables this vision

Write rules once and apply in multiple existing technologies

Central, enterprise-level management of vocabulary and rules

