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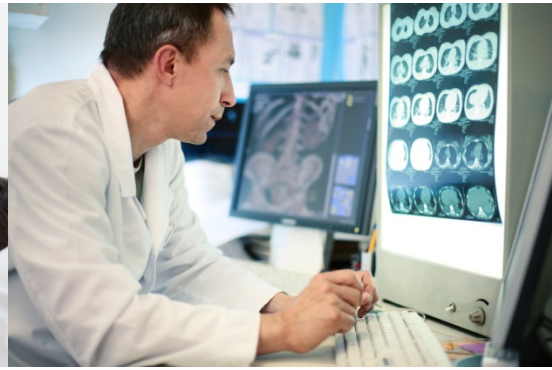
Leading healthcare terminology, worldwide

Terminology Binding and Expression Constraints



Delivering SNOMED CT

The global language of healthcare

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Implementation Specialist

Audience and Objectives

Audience

- Designers and developers of EHR systems, health standards, information models and related tooling.

Objectives

To understand:

- Why, where and how SNOMED CT can be bound to information models
- How SNOMED CT expression constraints can be used
- The types of terminology binding approaches

Agenda

- What is terminology binding?
- Why is it important?
- When should it be done?
- Where should it be stored/bound?
- How should it be represented?
- Types of binding and approaches
- Metadata
- Examples
- Questions

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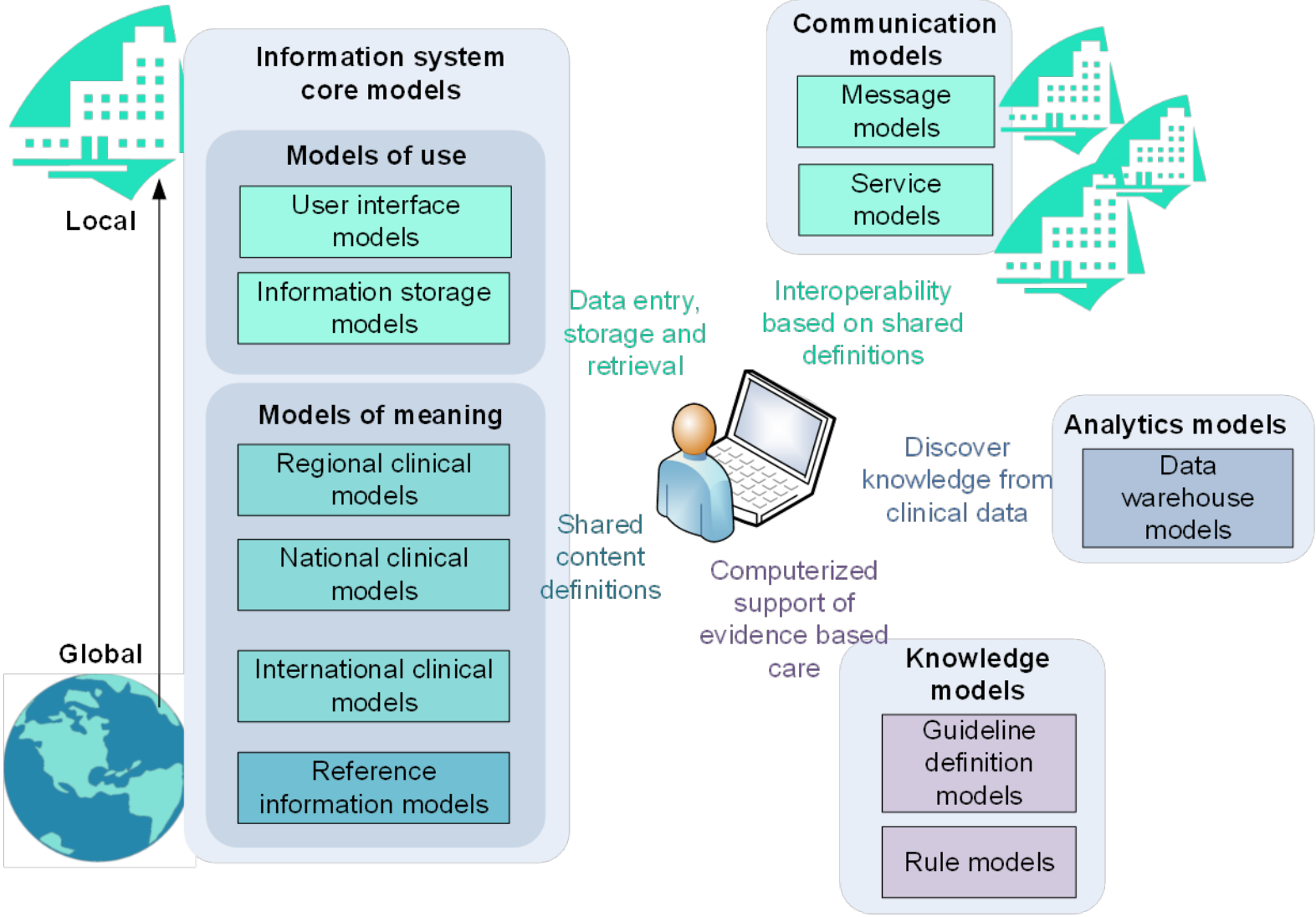
What is Terminology Binding?

A link between an *information model* artefact and a *terminology artefact*

- Information model artefacts
  - Data model
  - Data groups
  - Data elements
  - Data type attributes
  - Data values
- Terminology artefacts
  - Codes
  - Sets of codes
  - Expressions
  - Sets of expressions

Types of Information Models



Types of Terminologies

Interface terminologies

- Local code systems
- MEDCIN
- Categorical Health Information Structured Lexicon
- SNOMED CT

Statistical Classifications

- ICD 9, 10, 11
- ICPC
- ICF

Data entry and retrieval display

Statistics and reimbursement

Consistent representation of clinical meaning

Other terminological resorces

- UMLS
- MeSH

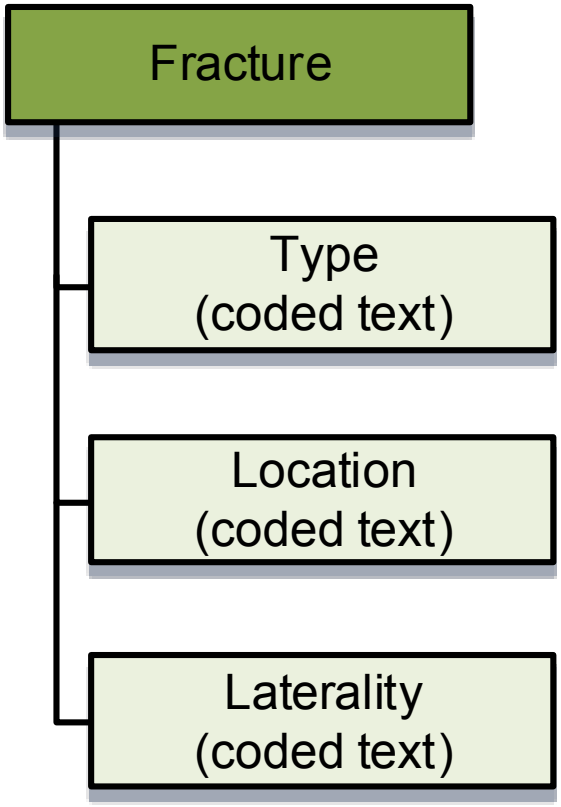
Reference terminology

- SNOMED CT
- LOINC

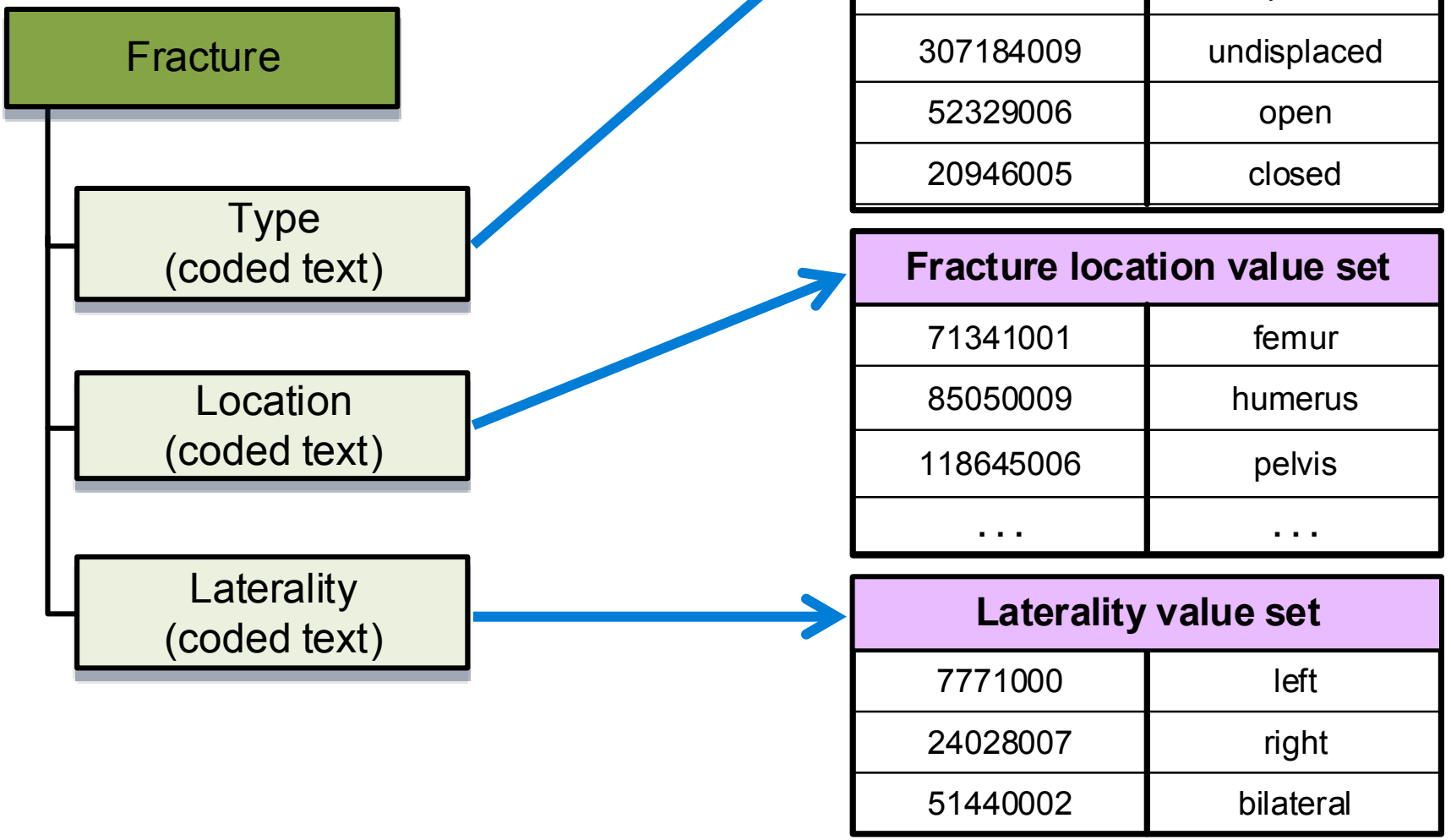
Types of Terminology Binding

- Value set binding
  - To record the set of possible values which can populate a given coded data element or attribute in the information model
- Model meaning binding
  - To define the meaning of an information model artefact using a concept or expression from the terminology

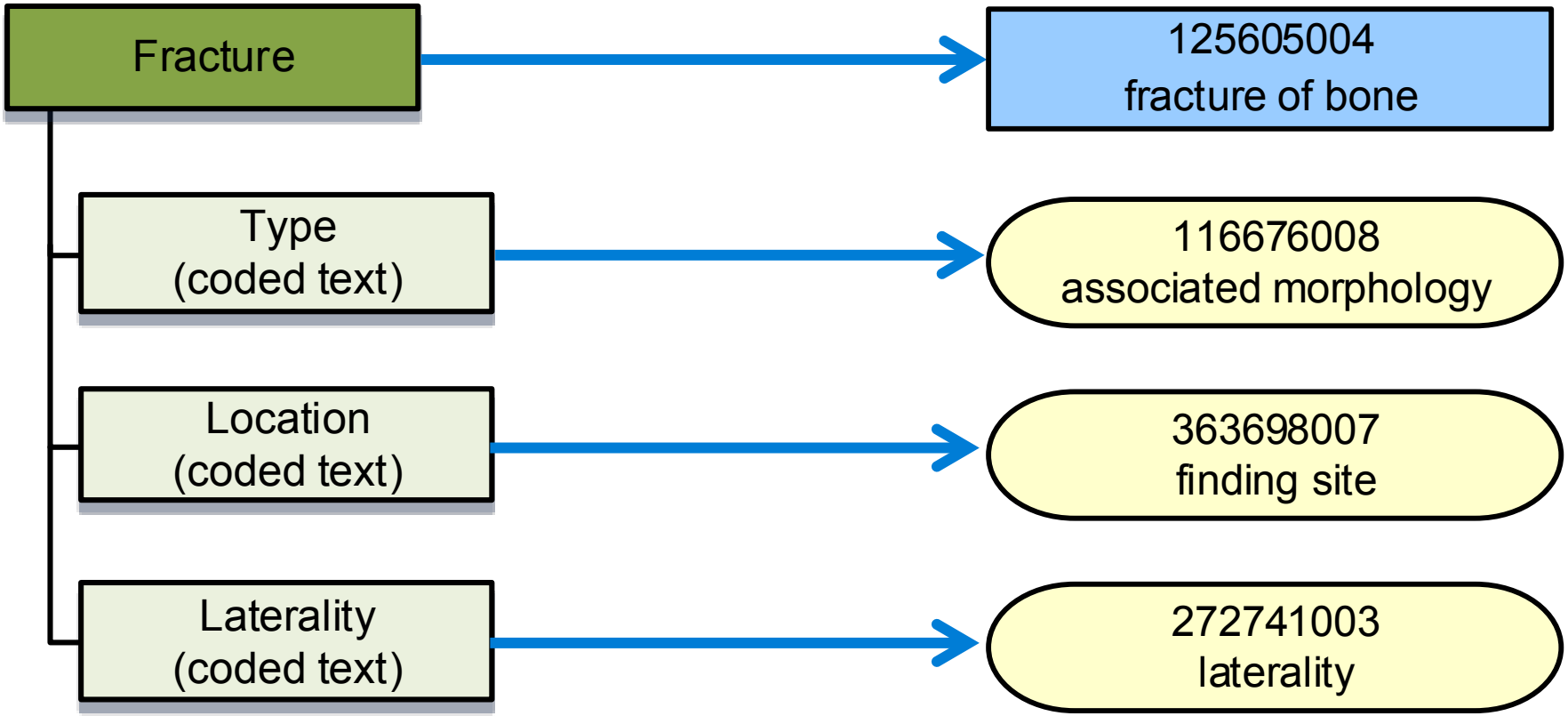
Example


Fracture
Type
(coded text)
Location
(coded text)
Laterality
(coded text)

Example – Value Set Binding



Example – Model Meaning Binding



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Why?

1. Why terminology binding matters?
2. Why terminology binding is useful?
3. Why is understanding SNOMED CT important?

Why Terminology Binding Matters

- To support information retrieval & decision support, EHR information must be computable in a meaningful way
- Reliable interpretation of meaning depends on
  - The way information is structured
  - The way clinical concepts are represented
  - The way the terminology is used within the structure
- A consistent approach to the interface between structural and terminological representations of information is required

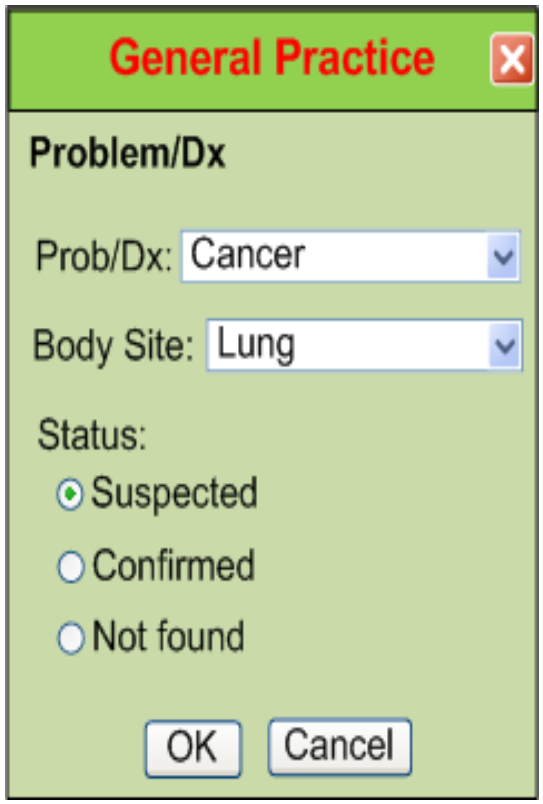
Alternative representations

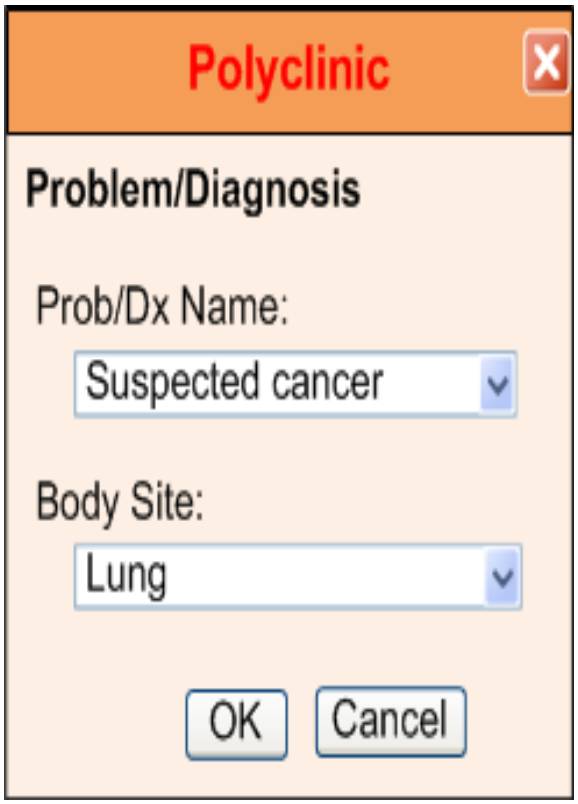
The same idea can be expressed in different ways

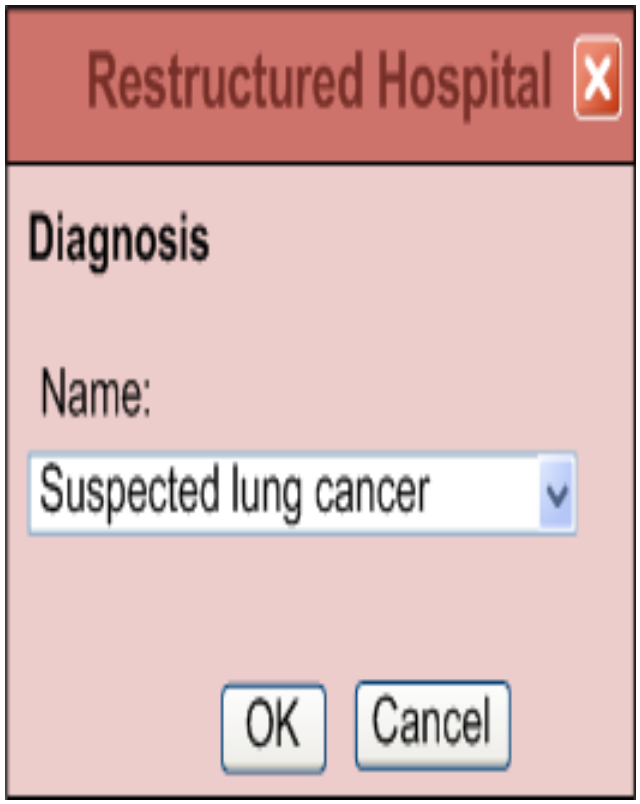
- Information structures to match different user-interfaces
  a) A SNOMED CT coded check-lists (‘yes’ ‘no’ ‘unknown’)
  b) A SNOMED CT value list (e.g. ‘asthma’, ‘diabetes’)
- Combining different information model structures with different terminology components
  a) Entering a disorder into a ‘Past history’ section
  b) Using a concept with a “Past” temporal context attribute
- Populating the same information model structure with different amounts of precoordination

Semantically Equivalent Models

e.g. “Suspected Lung Cancer”

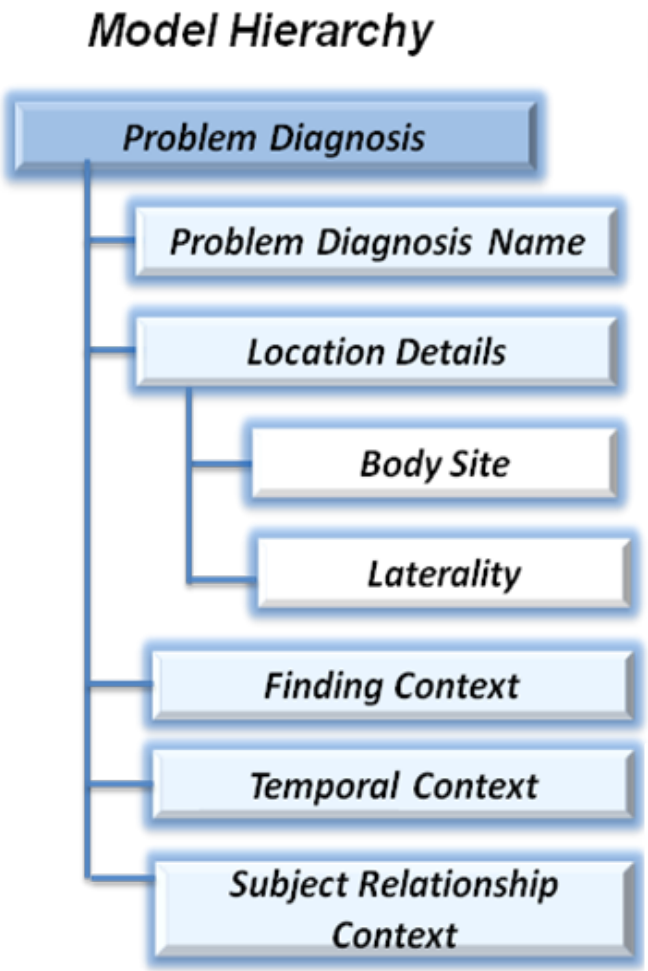






Semantically Equivalent Instances

e.g. “Suspected Lung Cancer”



General Practice	Polyclinic	Hospital
cancer	suspected cancer	suspected lung cancer
lung	lung	
suspected		

Alternative Representations

Different structure/terminology combinations may lead to similar information being missed when retrieving.

Family history of asthma

- Family history *check-list* with ‘asthma’ marked ‘yes’
- Family history *section* referring to the concept ‘asthma’
- R*ecord entry* referring to the concept ‘family history of asthma’
- R*ecord entry* containing an expression such as

  ‘family history : associated finding = asthma’
- R*ecord entry* containing the concept ‘asthma’ with an associated field to record the ‘family member’

To avoid false negatives different representations must be transformed to a common model

Alternative Representations

Risk of ambiguity from alternative interpretations

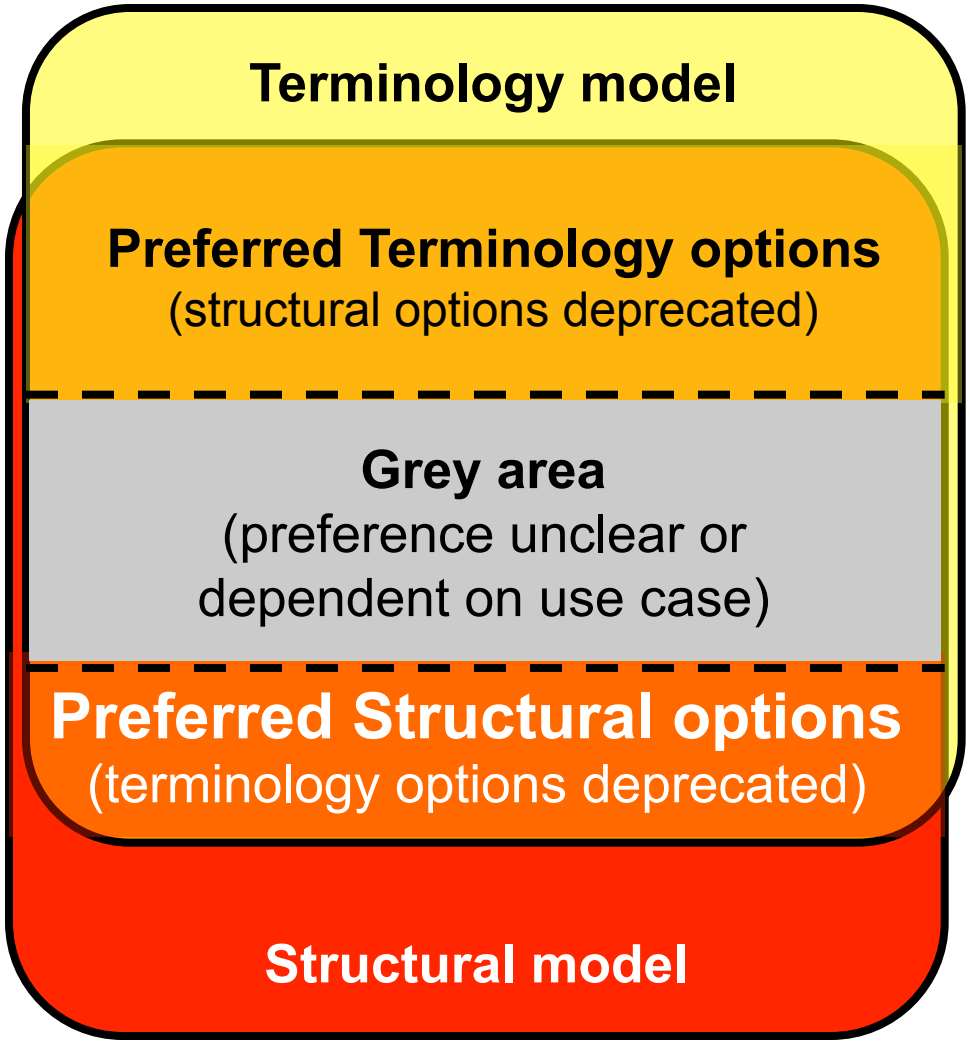
Absent Finding

- Information model attributes may indicate 'absence' or 'negation'
- SNOMED CT finding context can represent 'known absent'
- Does the combination of two representations of absence mean …
  - *double-negative*
  - *redundant restatement of the negative*
  - *additional emphasis of the negative*
- Logical interpretation (*double-negative*) may not be what was intended
- It many not be clear which concepts are 'negative'

E.g. 'conscious' '**not** conscious'
'unconscious' '**no loss of** consciousness'

To avoid misinterpretation there need to be clear rules about the way information model and terminology semantics combine

Balancing Structure and Terminology



Spectrum of Strengths of Terminology and Structural Models

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Terminology Model	What, how and why
+++	Disease, Symptom, Sign, Procedure, Body structure, Morphology, Substance, Drug, Device, Organism
++	Semantic constraints Refinement of concepts (e.g. laterality)
+ +	Clinical situations (context), Present/Absent/Uncertain, Family history, Past history, Requested/Planned/Done
++	Relationships between record entries Structural constraints on classes or attributes
+++	Dates, Times, Durations, Quantities, Text & markup, Instances of People, Organizations and Places
Structural Model	**Who, when and where**

Why is Terminology Binding Useful?

Terminology binding is important whenever the link between information model and terminology is significant in achieving specific business or clinical objectives.

- Data capture
- Retrieval and querying
- Information model library management
- Semantic interoperability

Data Capture

Data entry using value sets

Data entry guided by decision support

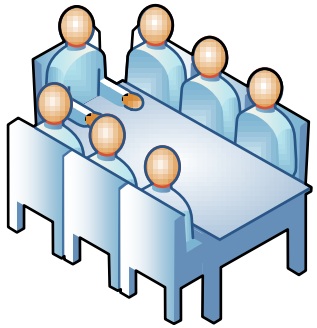
Data entry with exception handling

Consistency of data entry

Retrieval and Querying

Analytics over valid values

Analytics over model meaning

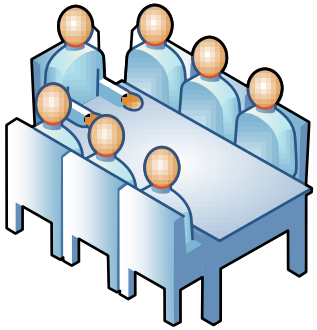


Analytics over context-specific data

Analytics over data with different amounts of precoordination

Information Model Library Management

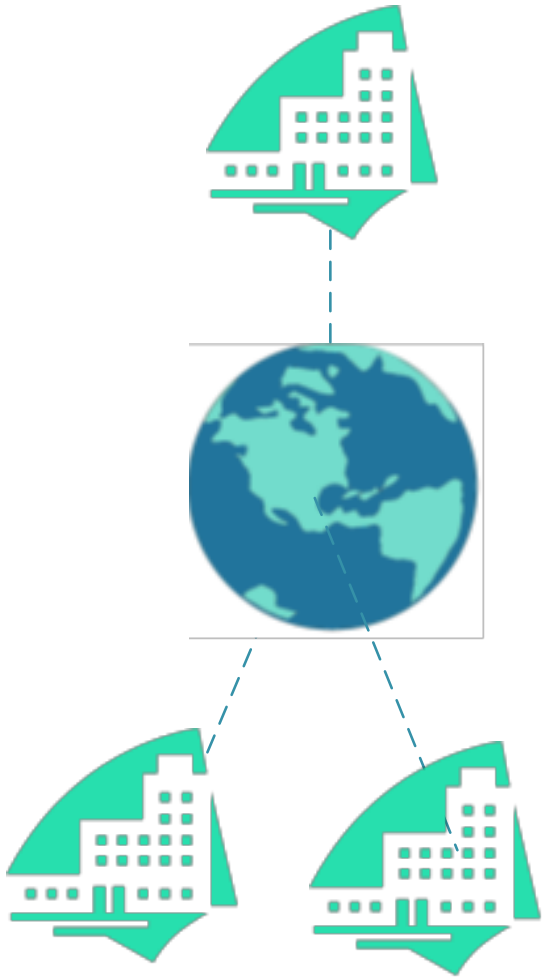
Search information models based on meaning



Identify semantic overlap between models

Validation between model dependencies

Semantic Interoperability



Message conformance testing

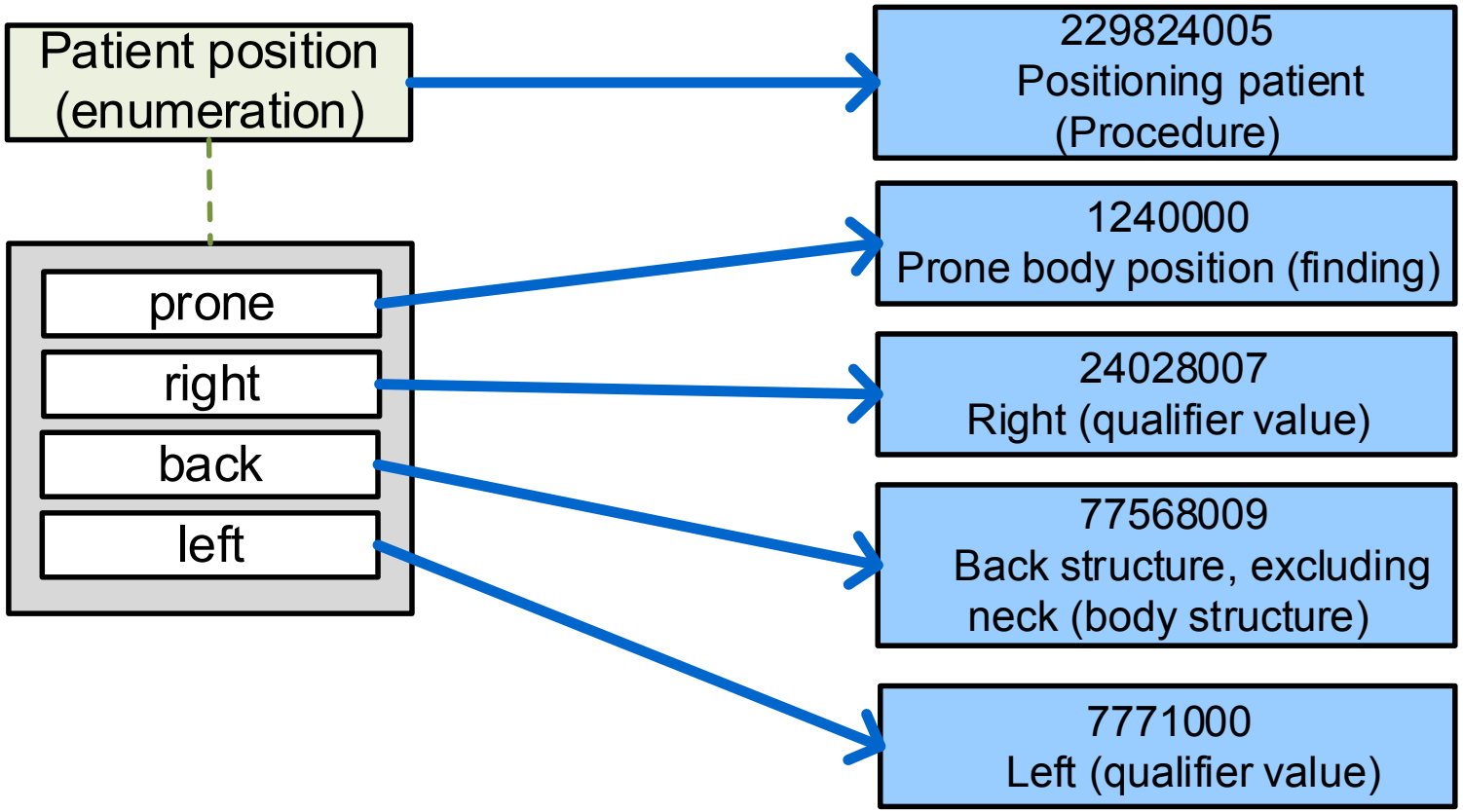
Sharing data with similar models and value sets

Sharing data with different models or value sets

Why is Understanding SNOMED Important?

- Understanding SNOMED CT's content, structure and principles is required to create consistent terminology bindings
- Consistent concept selection is a prerequisite for meaningful entry, querying and communication of patient information.

Inconsistent Terminology Binding



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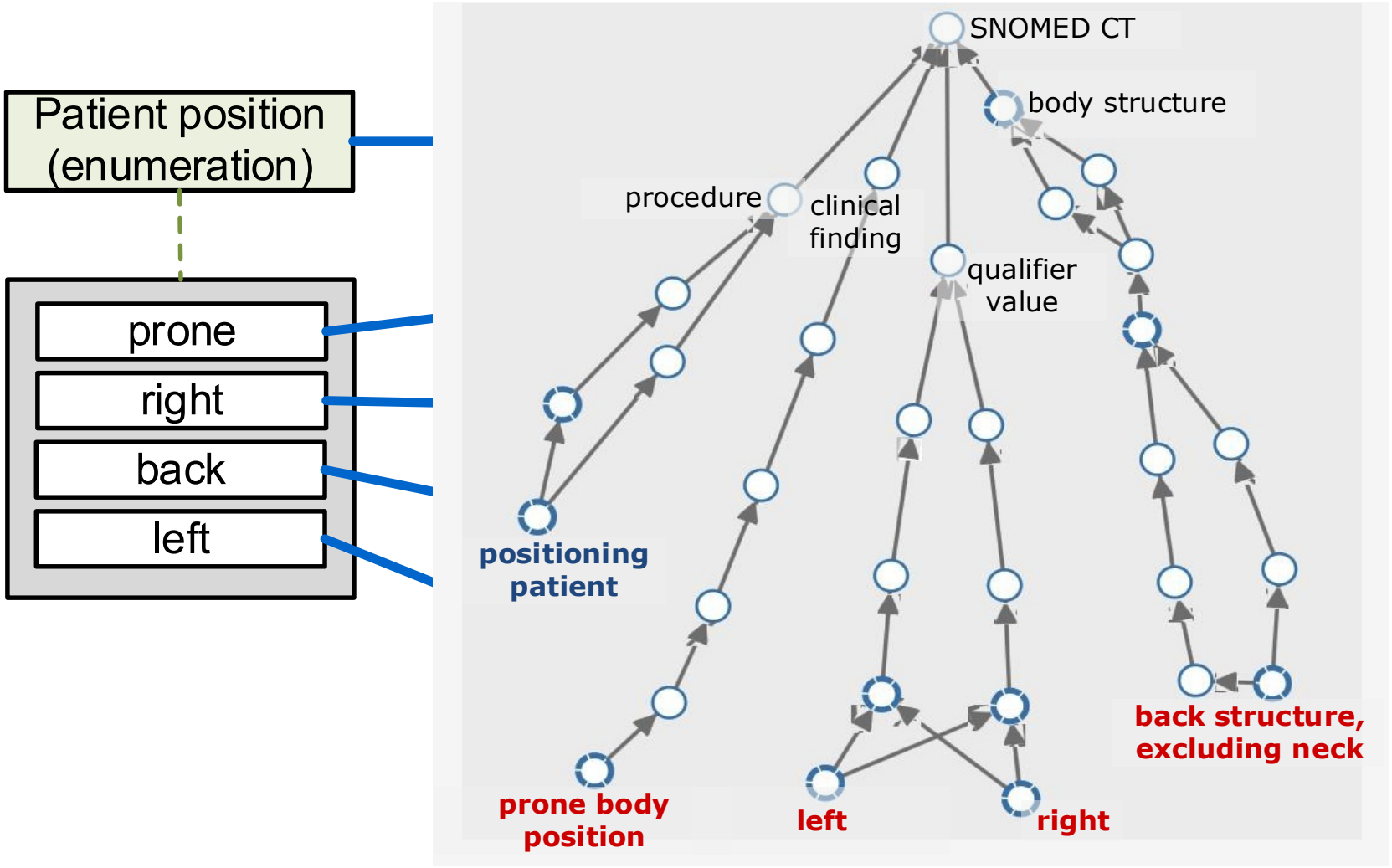
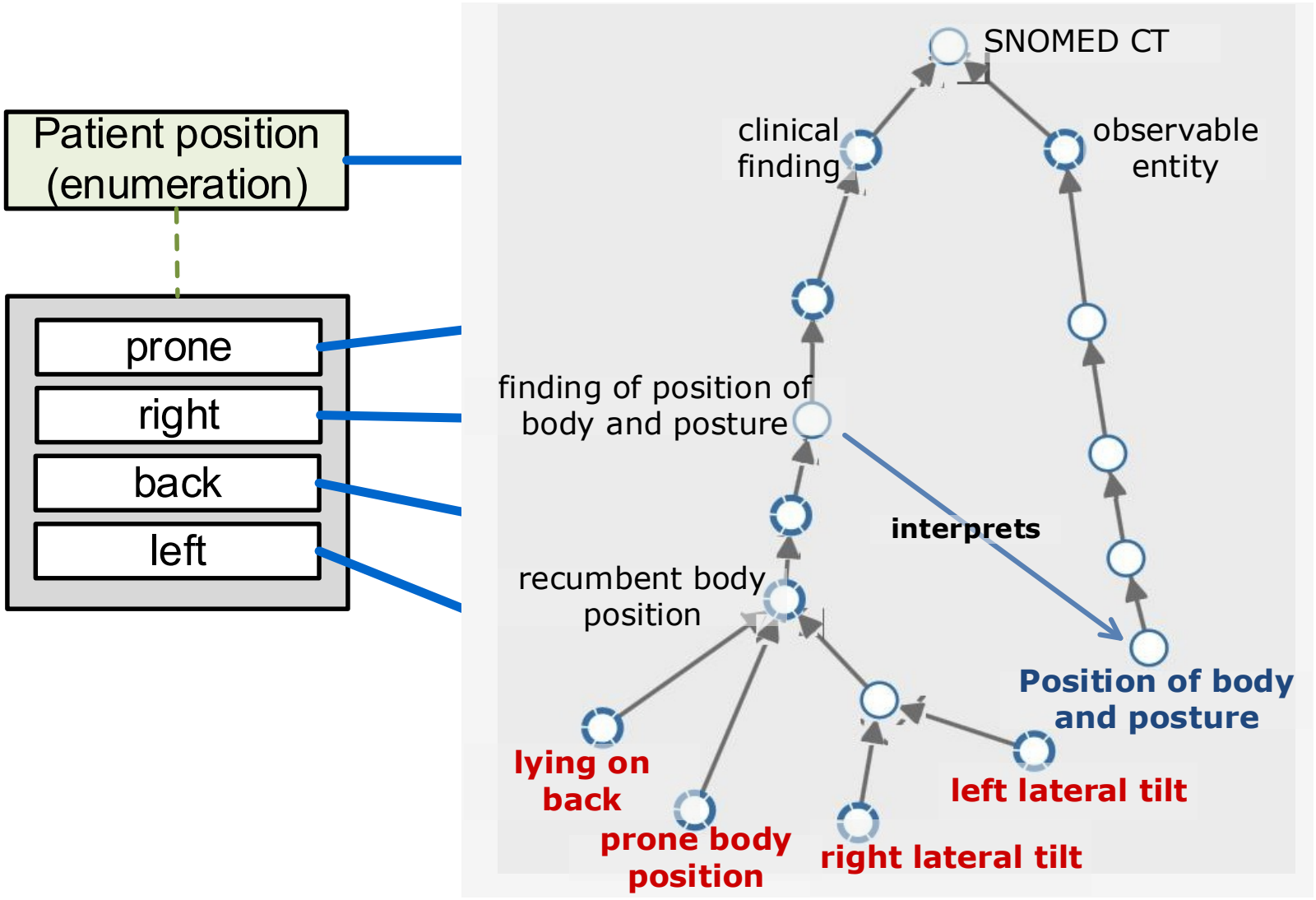


Consistent Terminology Binding



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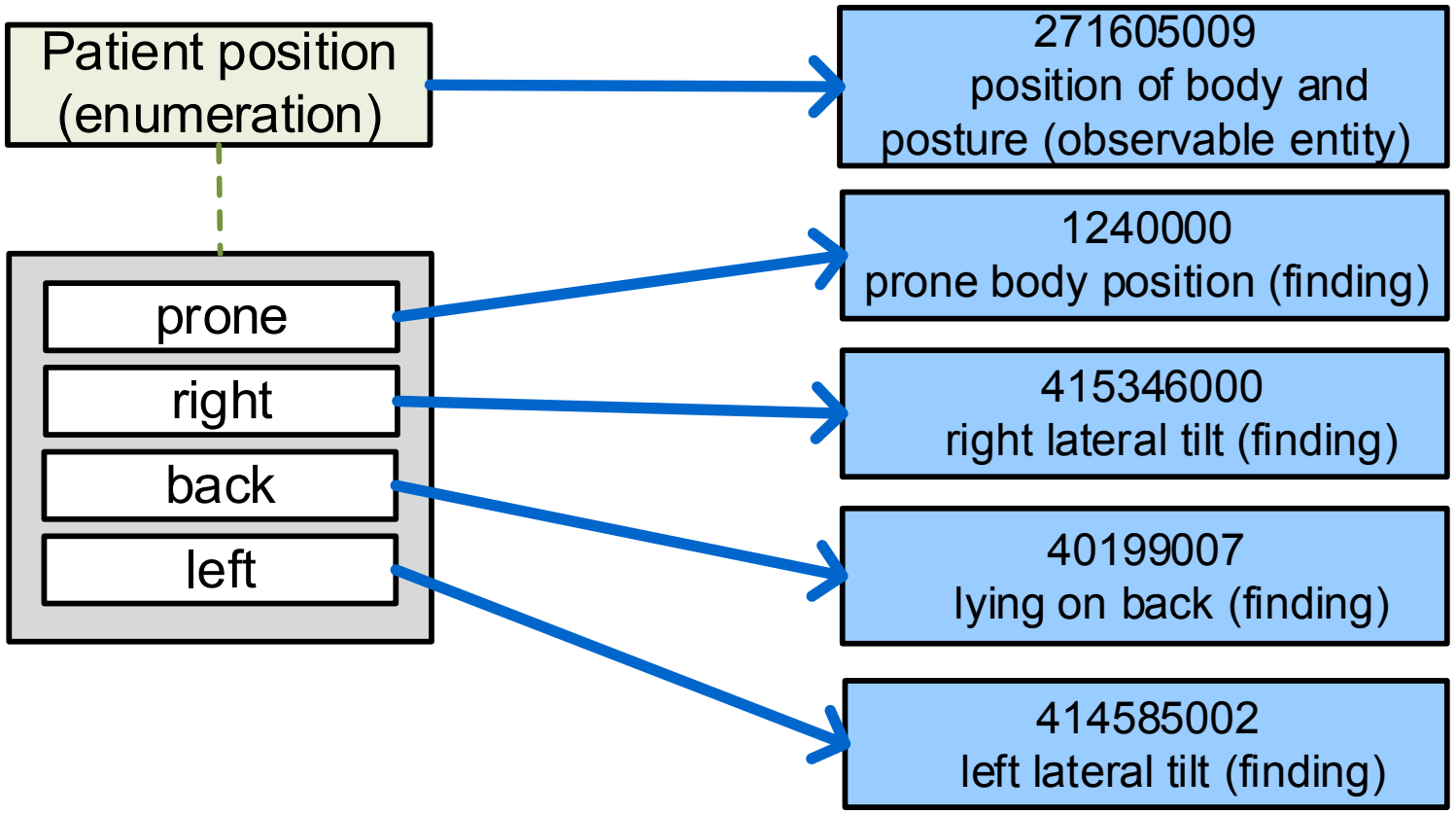

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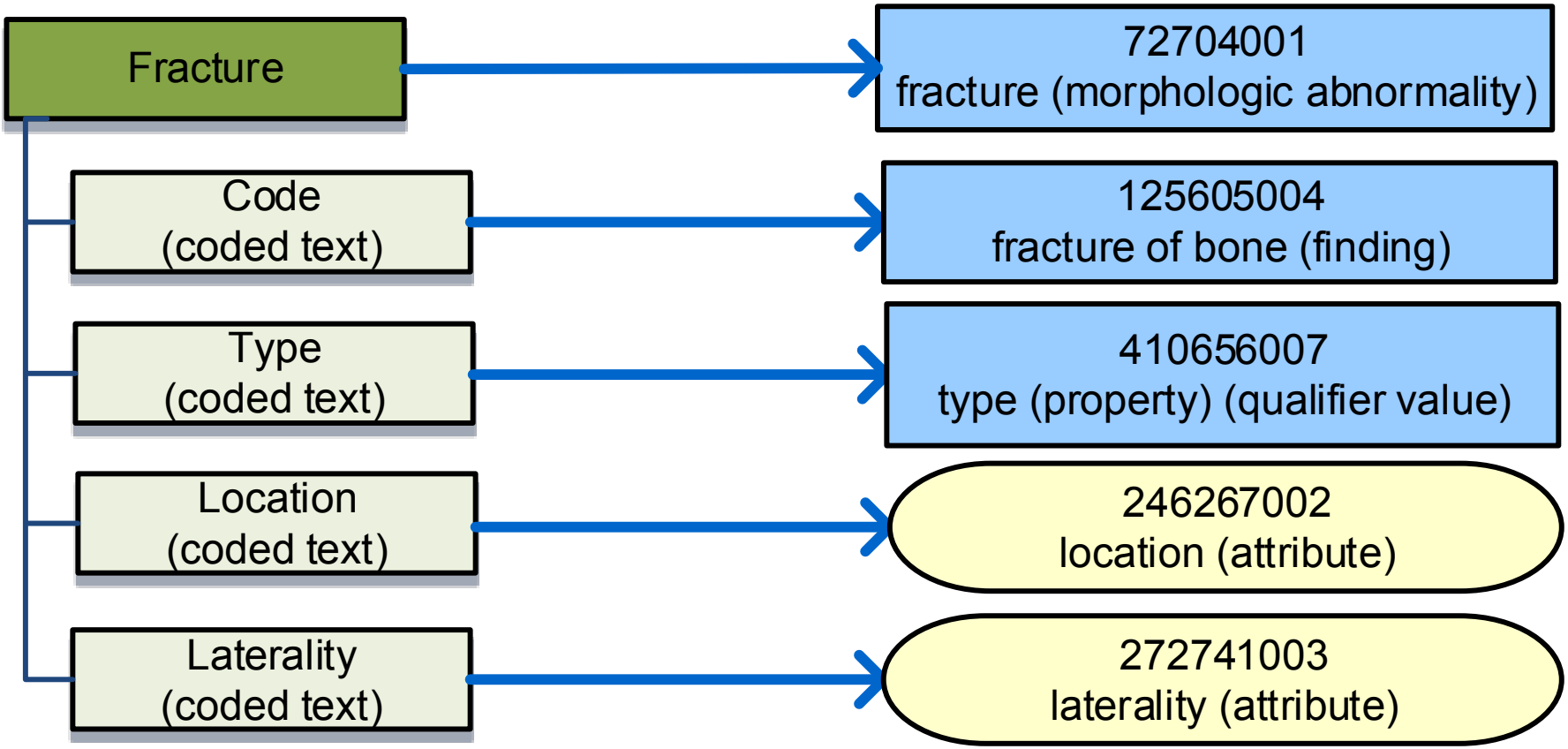

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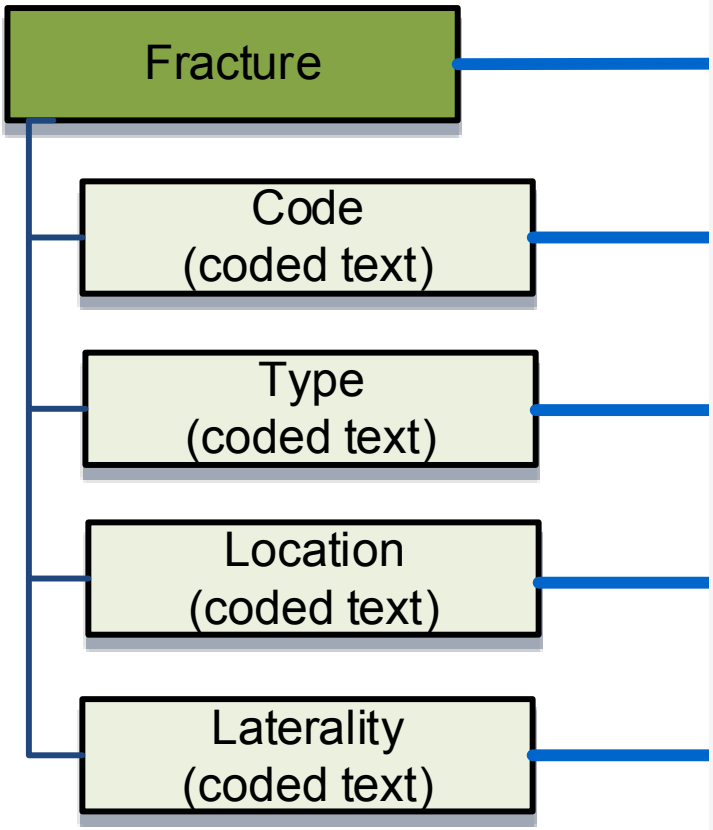

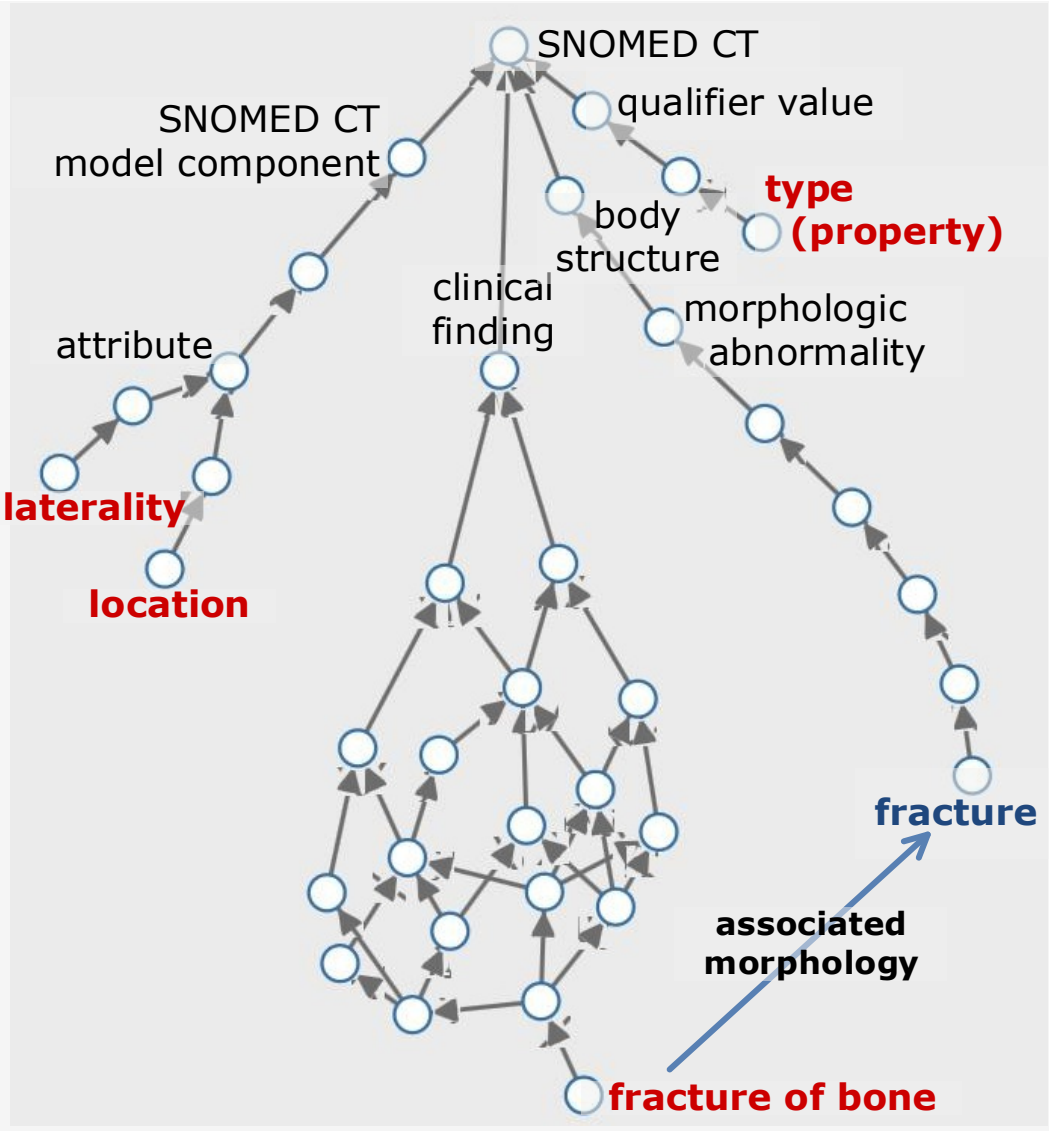

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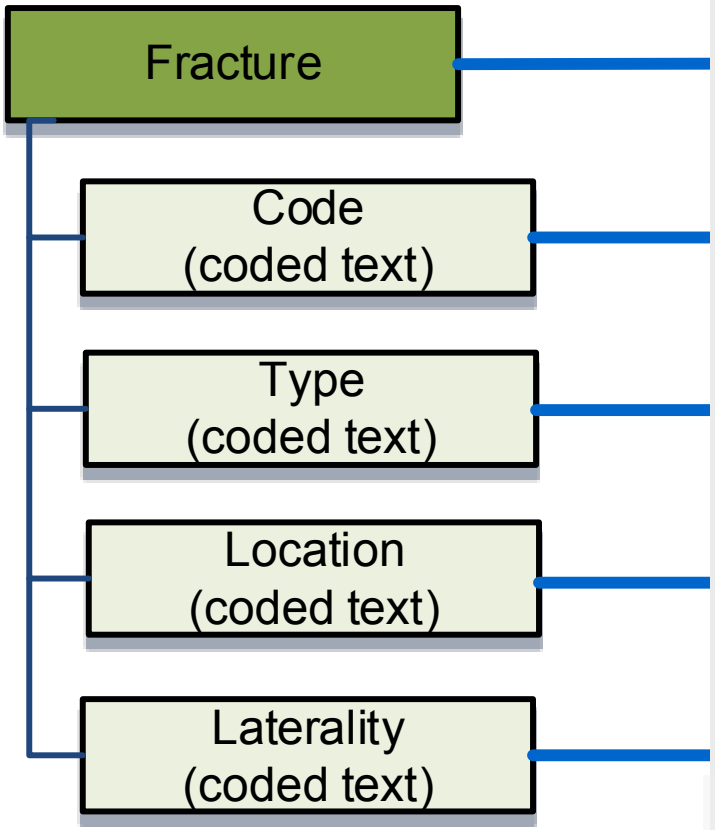

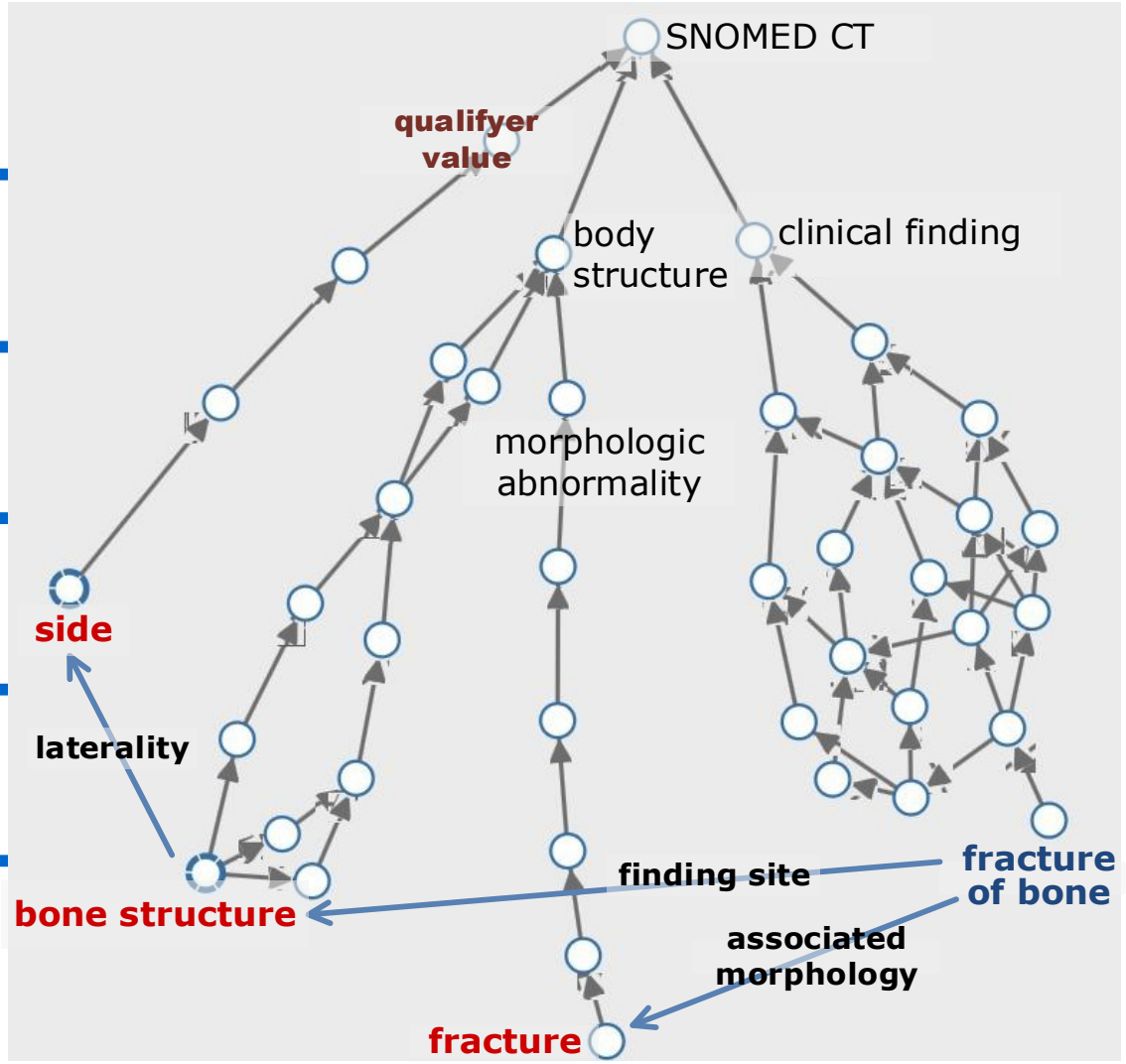

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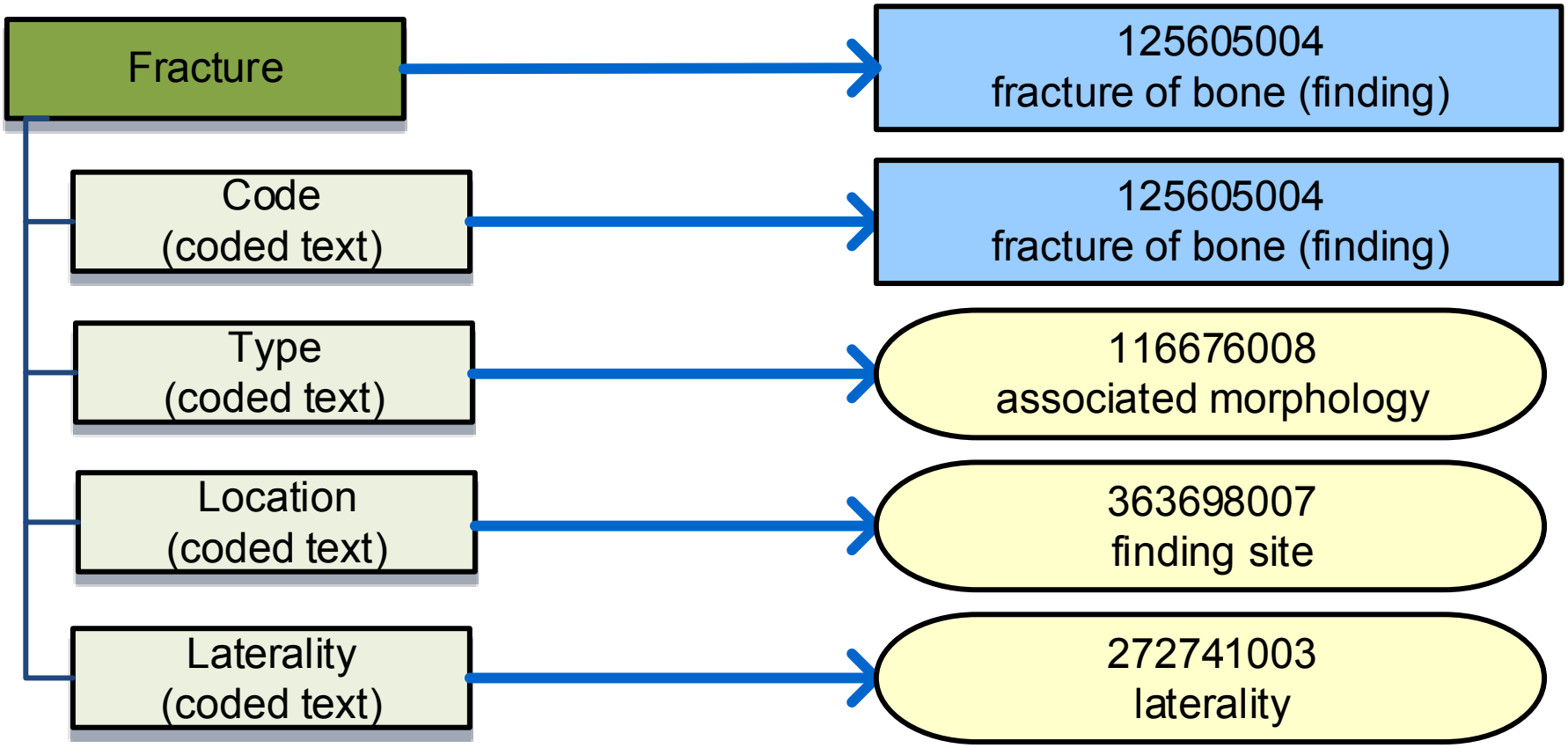

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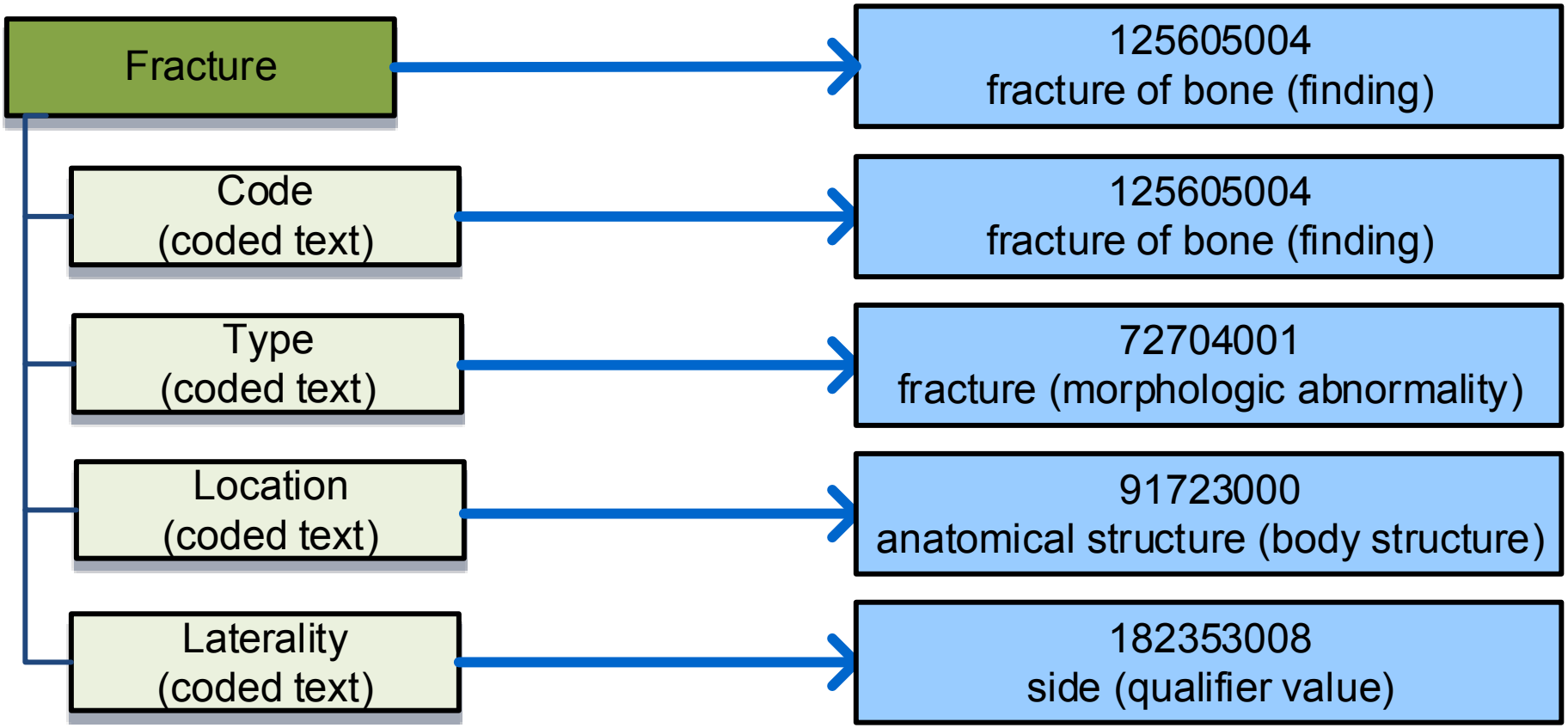

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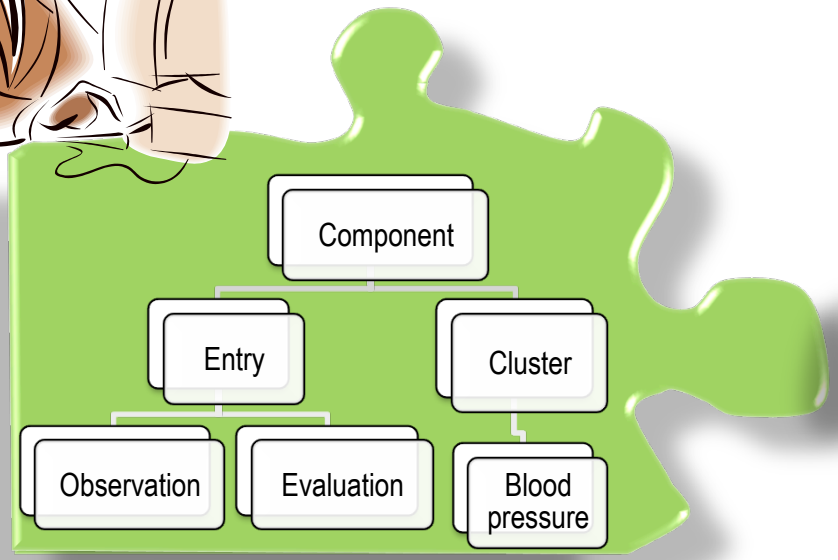
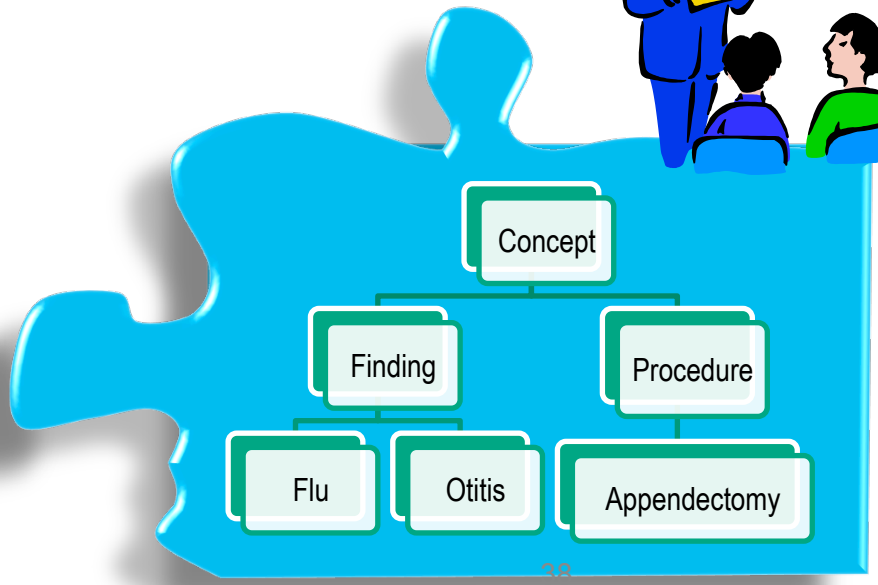
Historical misconceptions

Our EHR information model is terminology independent

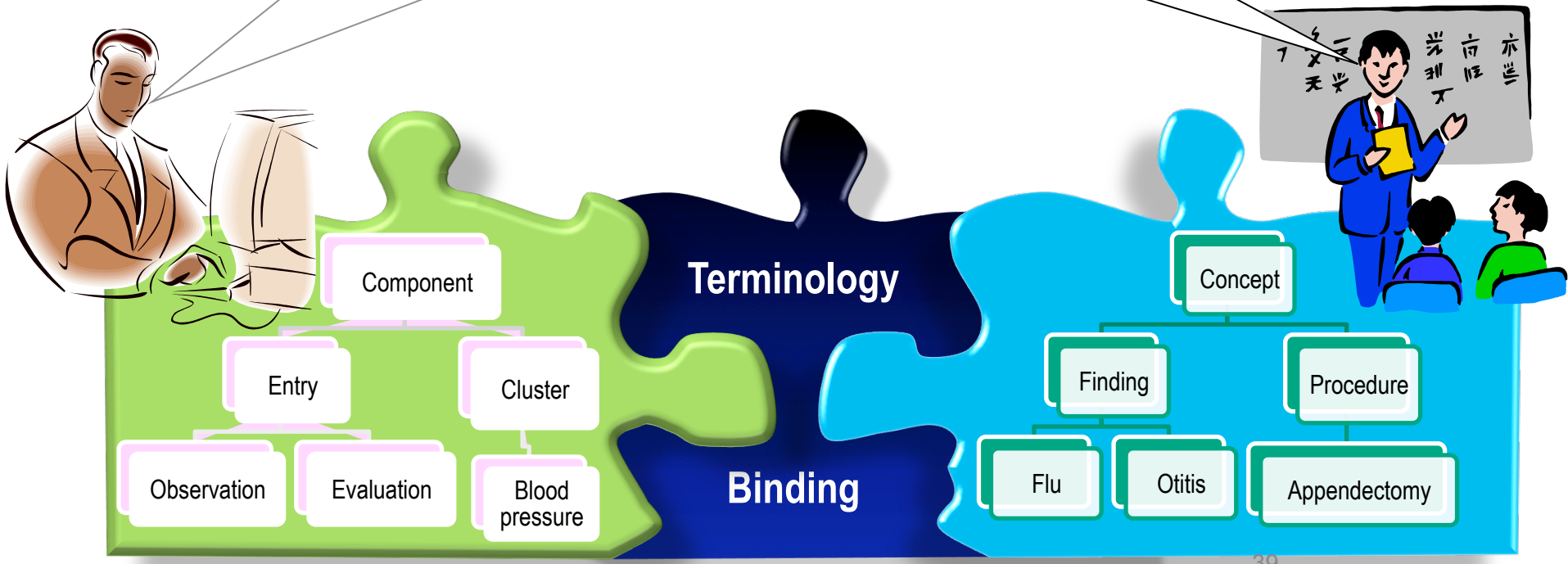
Our clinical terminology can be used in any health record information model





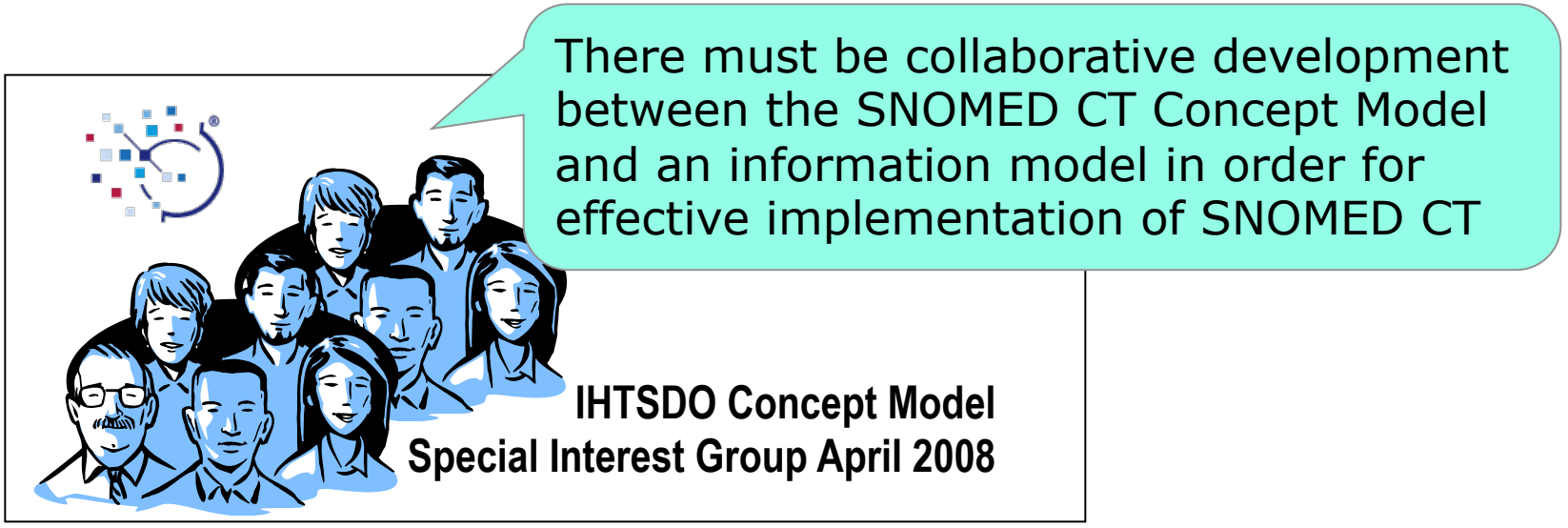
Binding SNOMED CT to an EHR

A meaningful Electronic Heath Record requires the SNOMED CT terminology model to be appropriately bound to a consistently designed structural information model

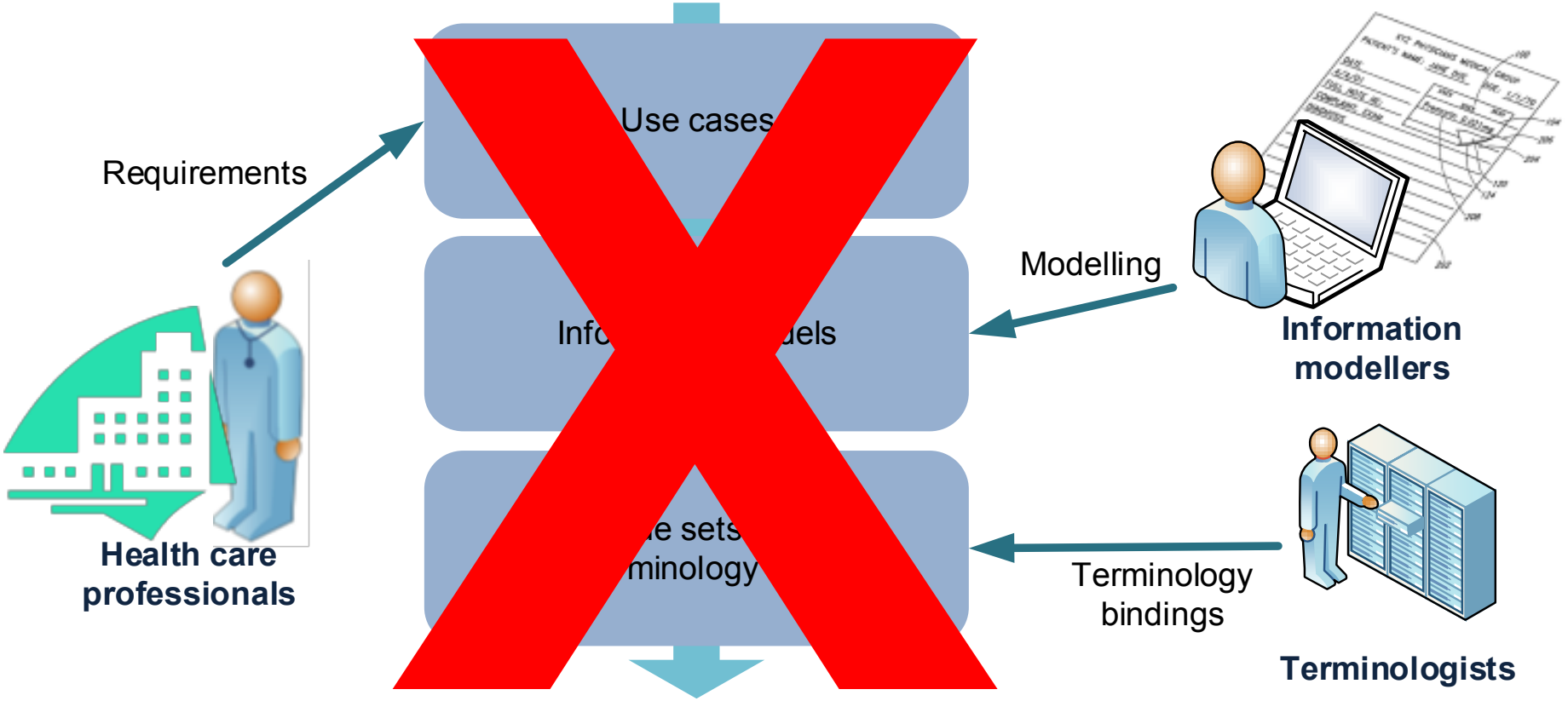


Recognising interdependencies

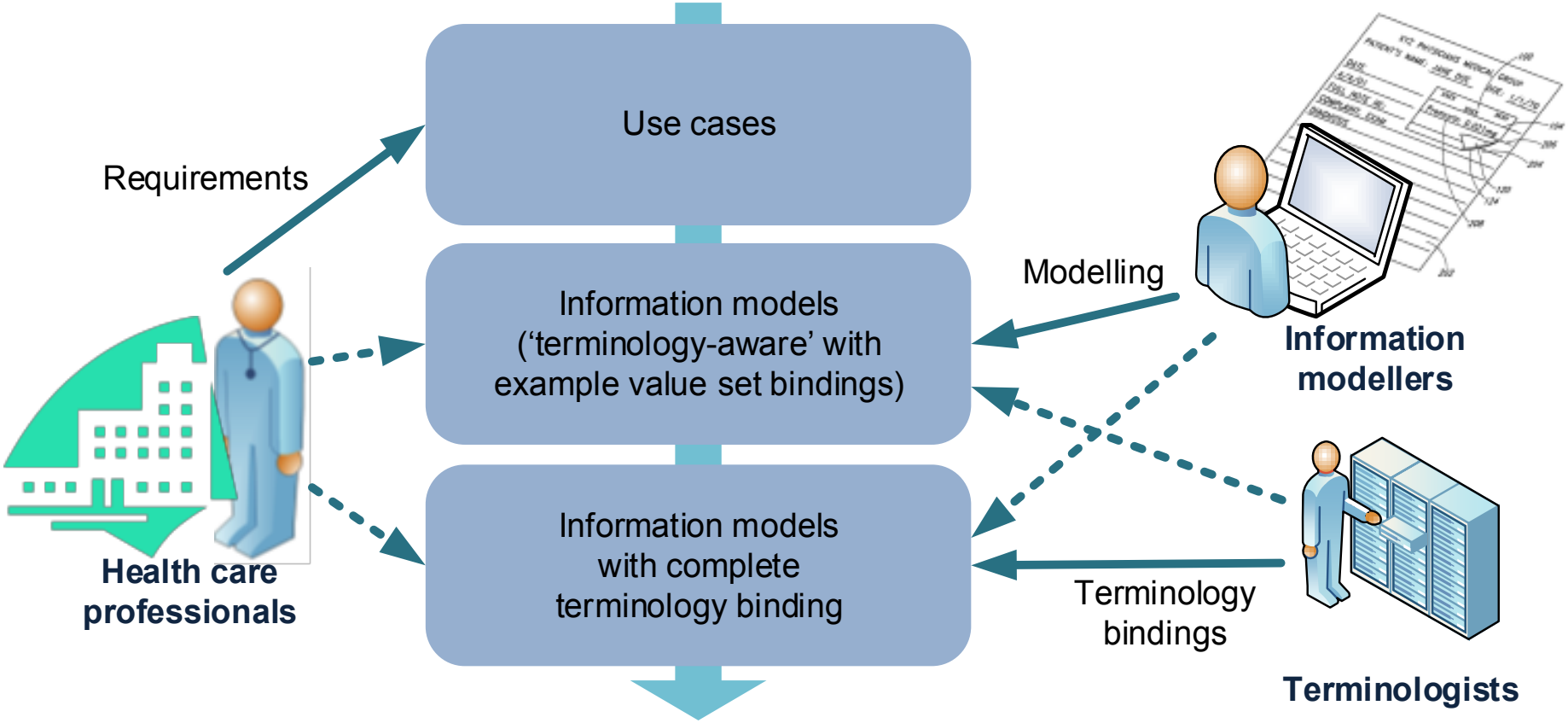
- Practical consequences of interdependency between terminology and structural information models are often underestimated
  - Information models cannot be terminology neutral
  - Implementing SNOMED CT depends on a tight integration with standard information models
- Developers of clinical terminologies and clinical information models should adopt policies that facilitate ‘dependency aware evolution’



Siloed Design Process



Collaborative Design Process



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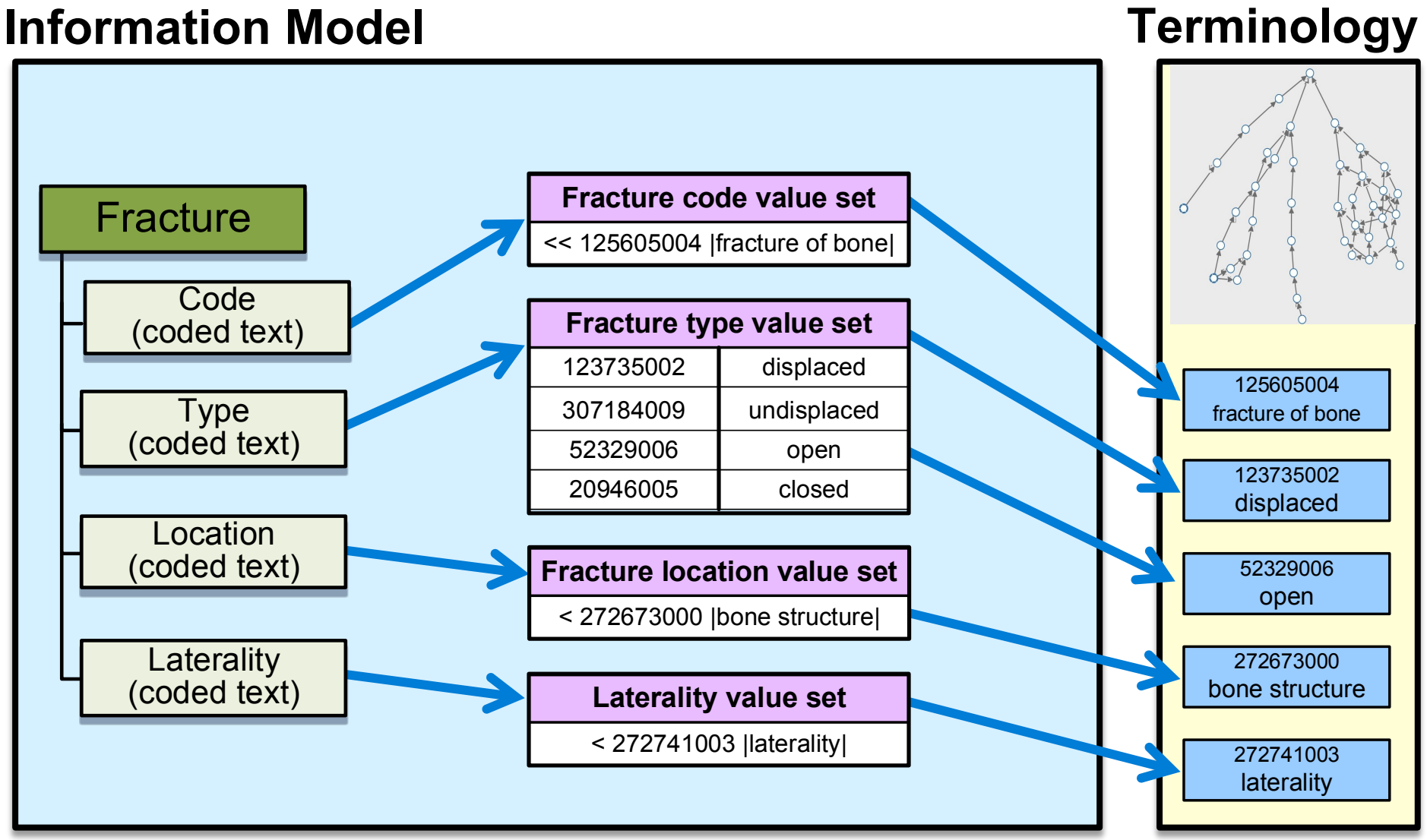
Where

- Where should bindings be stored?
- Where in a model do bindings go?

Where Should Bindings be Stored?

1. In the information model
2. In the terminology
3. Independent of both
4. Split between information model & terminology

Bindings in the Information Model



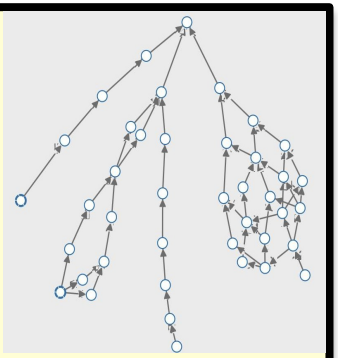
Bindings in the Terminology

Information Model

- Fracture
  - Code (coded text)
  - Type (coded text)
  - Location (coded text)
  - Laterality (coded text)

Terminology

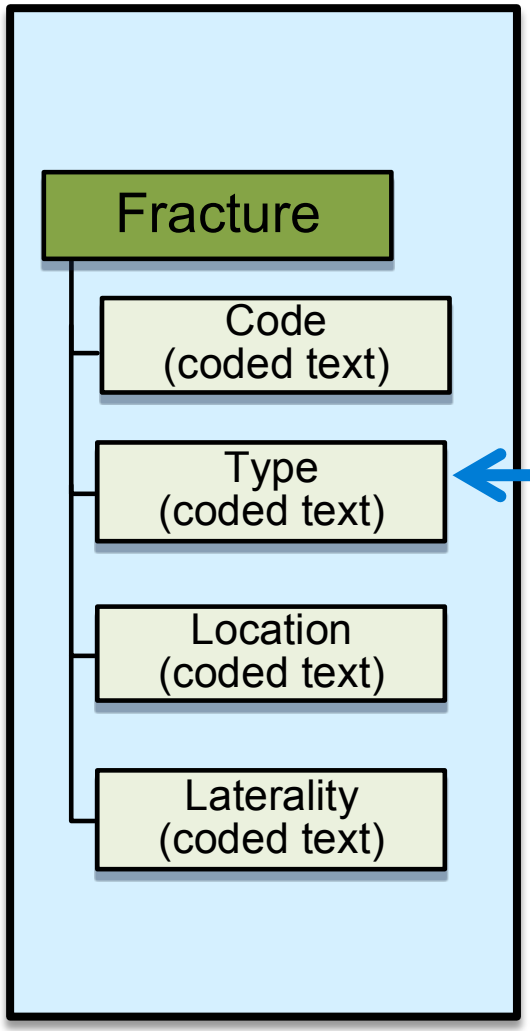
Binding Reference Set	
Id	<uuid>
effectiveTime	20141031
active	1
moduleId	449080006
refsetId	2567891004
referenced Component	10013000
Model	ihtsdo.fracture.v1
Model Component	id3 |type|



Fracture type reference set	
123735002	displaced
307184009	undisplaced
52329006	open
20946005	closed

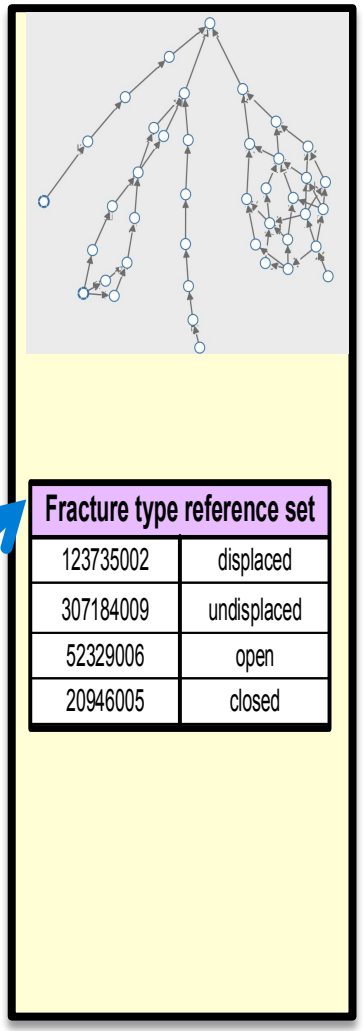
Bindings Stored Independently

Information Model



Information Model Binding	
Id	1
Model	ihtsdo.fracture.v1
Model Component	id3 |type|
Code System	http://snomed.info/sct
Binding Expression	^ 10013000
Binding Type	value set

Terminology



Split Between Information Model and Terminology

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Information Model

Fracture

- Code (coded text) → Fracture code value set
- Type (coded text) → Fracture type value set
- Location (coded text) → Fracture location value set
- Laterality (coded text) → Laterality value set

Terminology

Fracture code value set

<< 125605004 |fracture of bone|

Fracture type value set

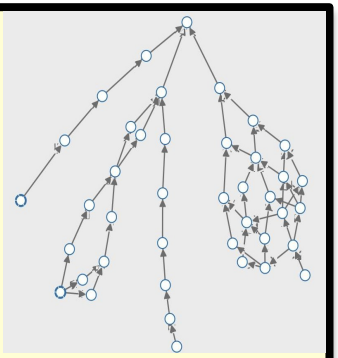
123735002	displaced
307184009	undisplaced
52329006	open
20946005	closed

Fracture location value set

< 272673000 |bone structure|

Laterality value set

< 272741003 |laterality|



125605004 fracture of bone

123735002 displaced

52329006 open

272673000 bone structure

272741003 laterality

Where in a Model do Bindings go?

1. Model Meaning Bindings
   - Model, data group or data element
2. Value Set Bindings
   - Only coded text elements or data type attributes

Coded Text Attribute	Example Values
code	78564009
term	“Pulse rate”
uri	http://snomed.info/id/78564009
terminology (codeSystem)	FHIR/CIMI: http://snomed.info/sct HL7 v3: 2.16.840.1.113883.6.96
terminologyVersion (codeSystemVersion)	http://snomed.info/sct/900000000000207008/version/20140731

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SNOMED CT Languages

- Compositional Grammar
  - To define a SNOMED CT expression
- Expression Constraint Language
  - To constrain the set of possible concepts or expressions
- Query Language
  - To query over SNOMED CT content
- Template Language
  - To incorporate ‘slots’ to be filled at a later time

SNOMED CT Languages

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Expression Constraint Language*

To constrain the set of possible concepts or expressions

- Expression Constraint: A computable rule that can be used to define a set of concepts or expressions
- Use cases:
  - Constrain content of a particular data element in an EHR
  - Create a machine processable query over SNOMED CT concepts
  - Define an intensional reference set
  - Define a range constraint in the SNOMED CT concept model

* Draft language available for comment early 2015

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Expression Constraint Language

Text	Symbol	Definition
memberOf	^	Member of ref set
and	and	Intersection
or	or	Union
and not	and !	Exclusion
descendantOf	<	Descendants
descendantOrSelfOf	<<	Descendants or self
ancestorOf	>	Ancestors
ancestorOrSelfOf	>>	Ancestors or self
[X .. Y], [X .. Many]	[X .. Y], [X .. *]	Cardinality (e.g. [0..*]
reverseOf	R	Reverse relationship
“..”	“..”	Text string
#..	#..	Number

Expression Constraint Language

- Examples:
  - ^ 700043003 |problem list reference set|
  - << 71388002 |procedure|:
    363698007 |finding site| = << 80891009 |heart structure|
  - <19829001|disorder of lung| AND !
    ^ 15272585100015410 6 |cardiology reference set|
  - << 404684003|clinical finding| :
    116676008|associated morphology| = << 55641003|infarct| OR
    42752001 |due to| = << 22298006|myocardial infarction|
  - < 373873005 |pharmaceutical / biologic product|:
    [3..*] 127489000 |has active ingredient| = < 105590001 |substance|
  - < 105590001 |substance|: R (127489000 |has active ingredient| =
    111115 |TRIPHASIL tablet|)

Template Language*

To incorporate slots to be filled at a later time

- Use cases:
  - Defining reusable patterns for pre- or post-coordination
  - Defining information model constraints
  - Transforming between equivalent information models
- Expression Template Examples:
  - [[$diagnosis]]: 363698007 |finding site| = [[$bodySite]]
  - [[<< 64572001 |disease|]]:
    363698007 |finding site| = [[< 91723000 |anatomical structure |]]
- Expression Constraint Template Example:
  - << [[$procedure]]

* Draft language available for comment 2015

Agenda

- What is terminology binding?
- Why is it important?
- When should it be done?
- Where should it be stored/bound?
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- Types of binding and approaches
- Metadata
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- Questions

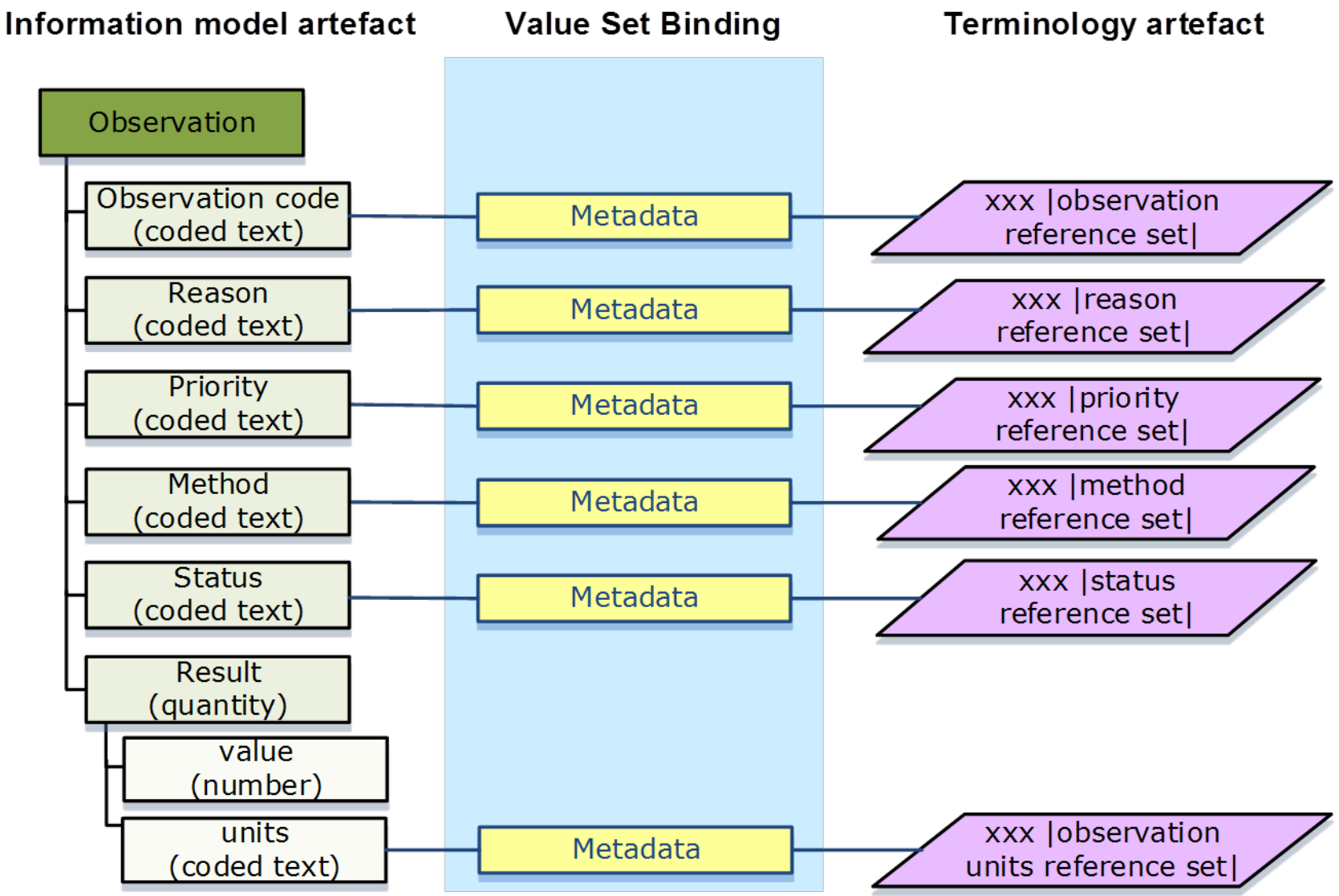
Types of Terminology Binding

- Value set binding
  - To record the set of possible values which can populate a given coded data element or attribute in the information model
- Model meaning binding
  - To define the meaning of an information model artefact using a concept or expression from the terminology

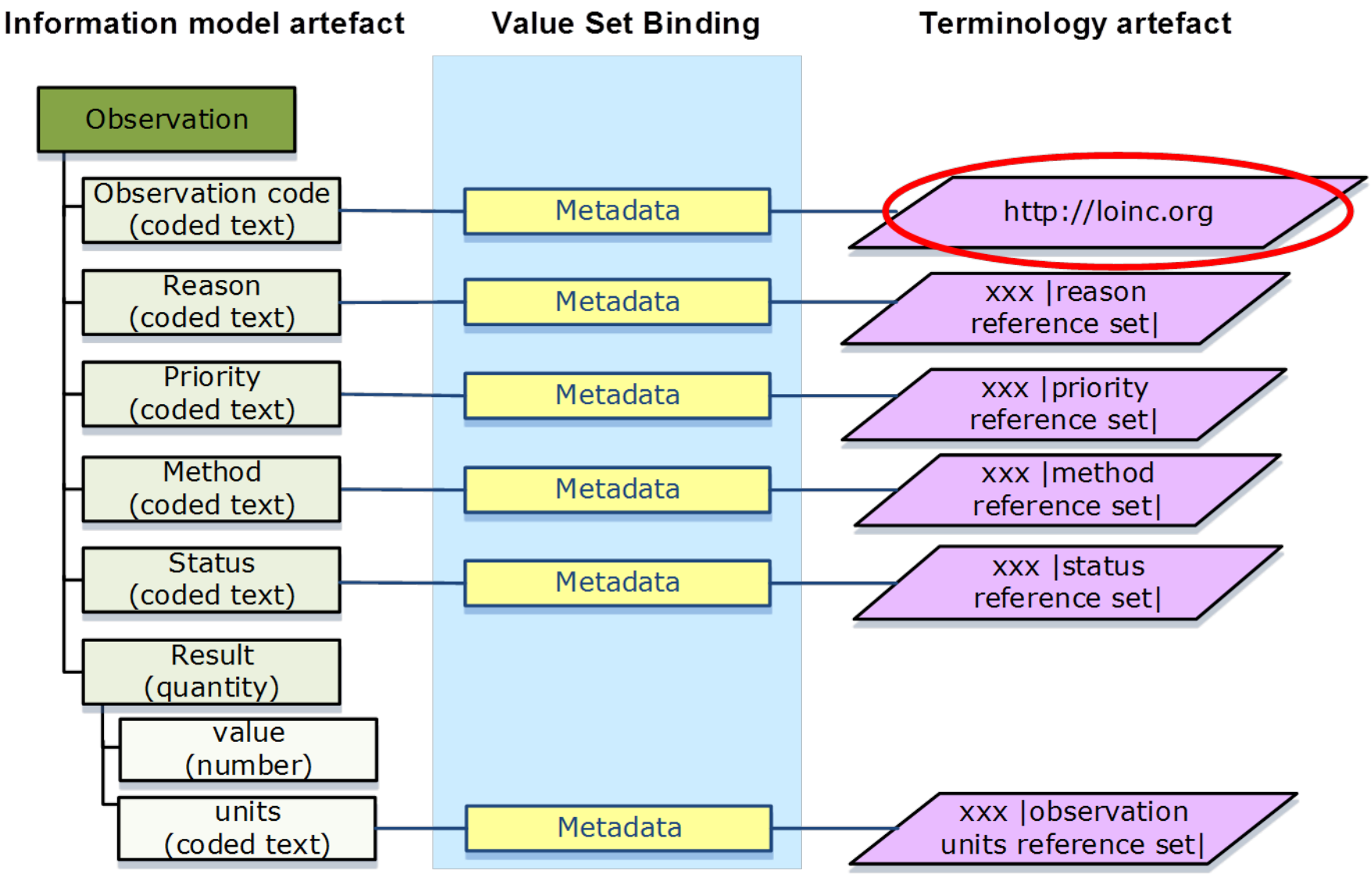
Types of value set binding

- Simple
  - The data element has a single value set
  - Extensional or intensional
- Conditional
  - Which value set is used depends on a condition
- Dependency
  - The value of a data element depends on another value
- Compositional
  - The value of a data element is composed from other values

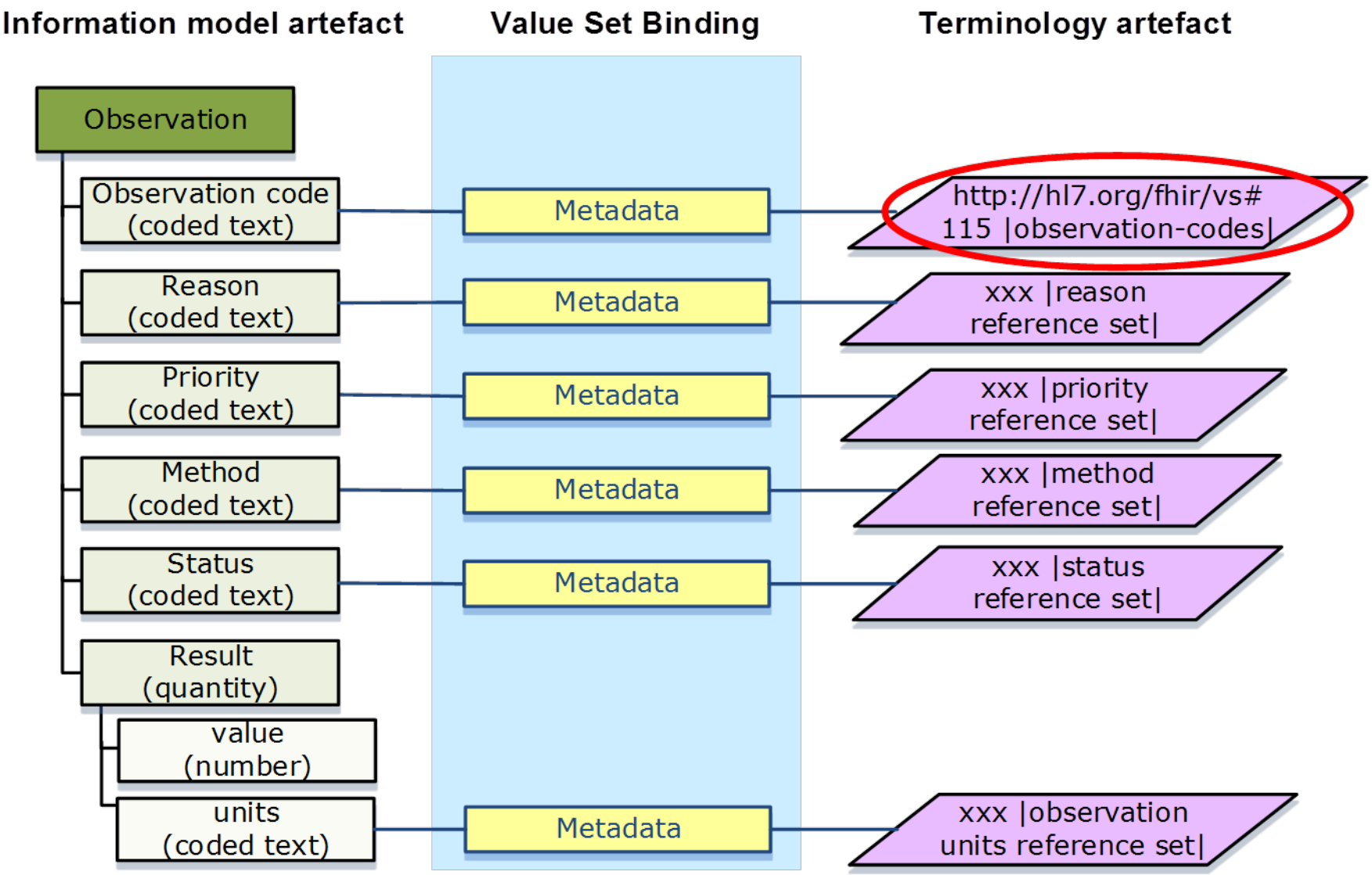
Value Set Binding - Simple



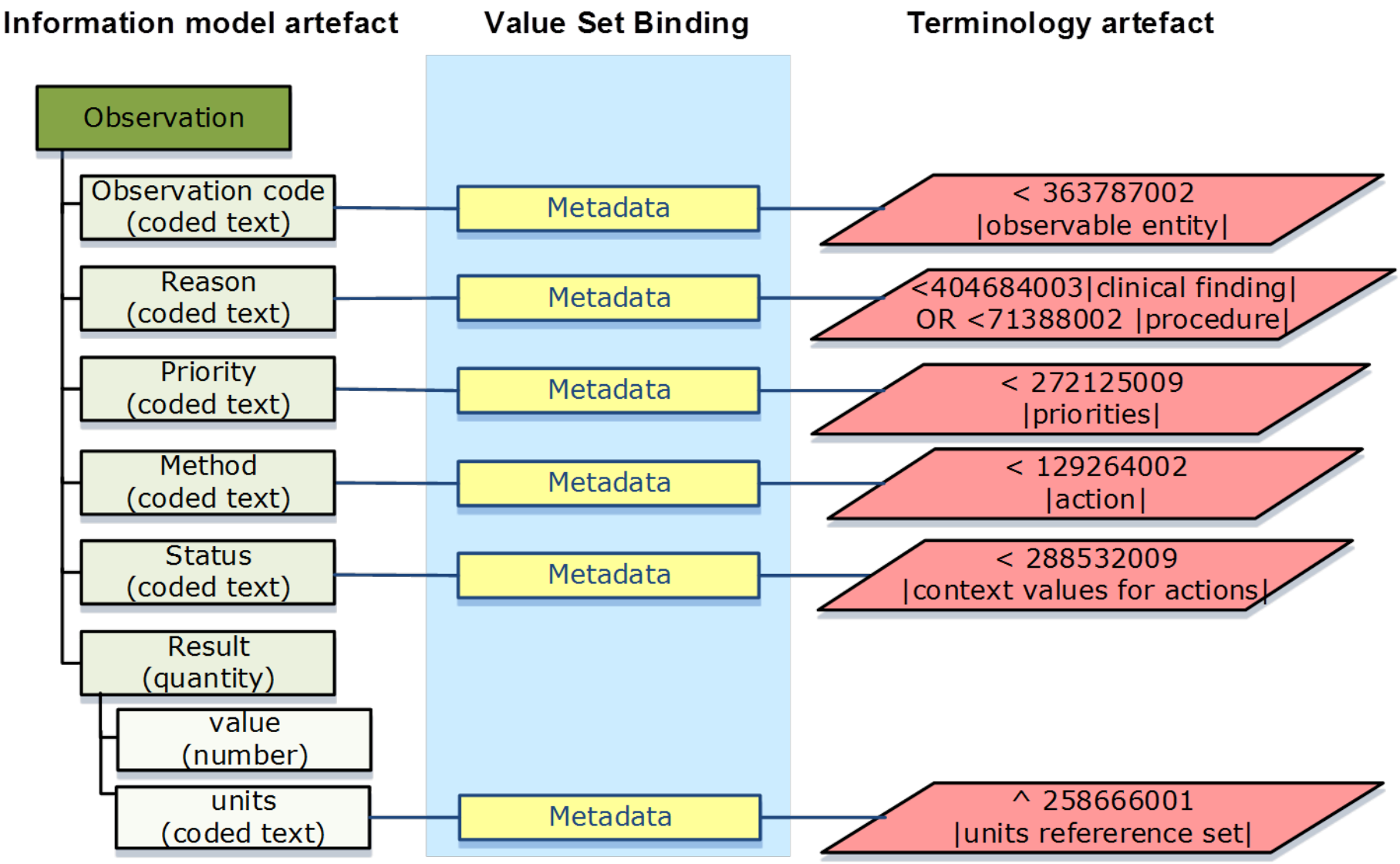
Value Set Binding - Simple



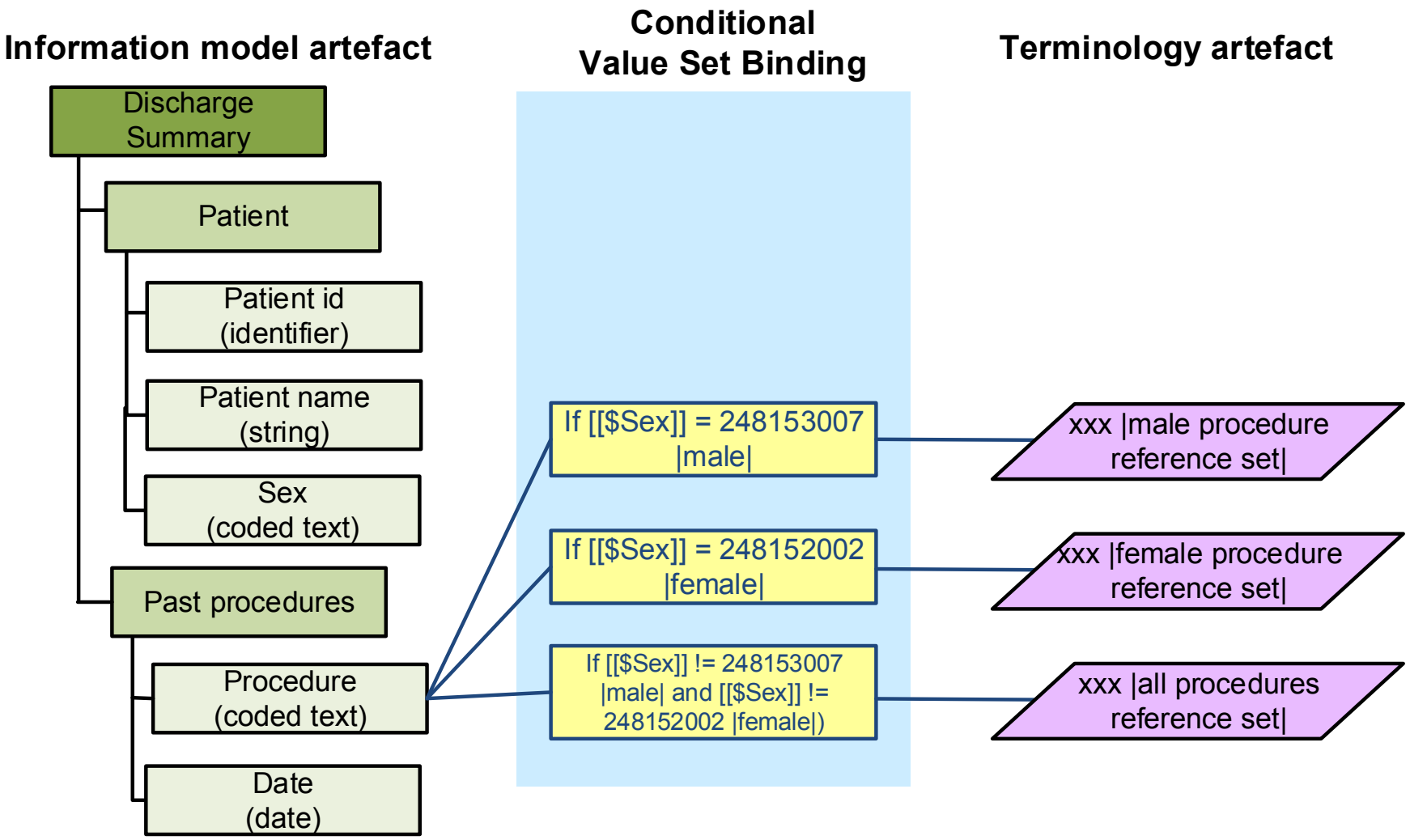
Value Set Binding - Simple



Value Set Binding - Simple

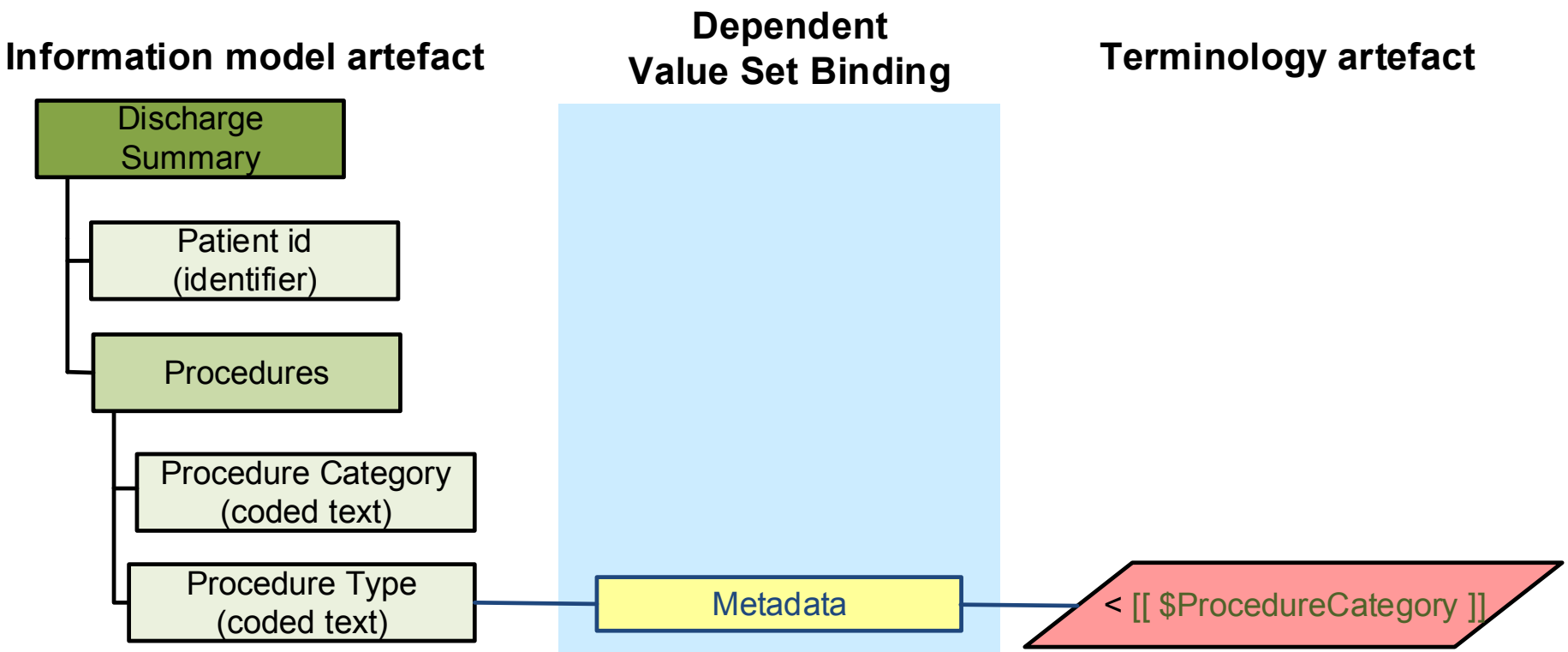


Value Set Binding - Conditional



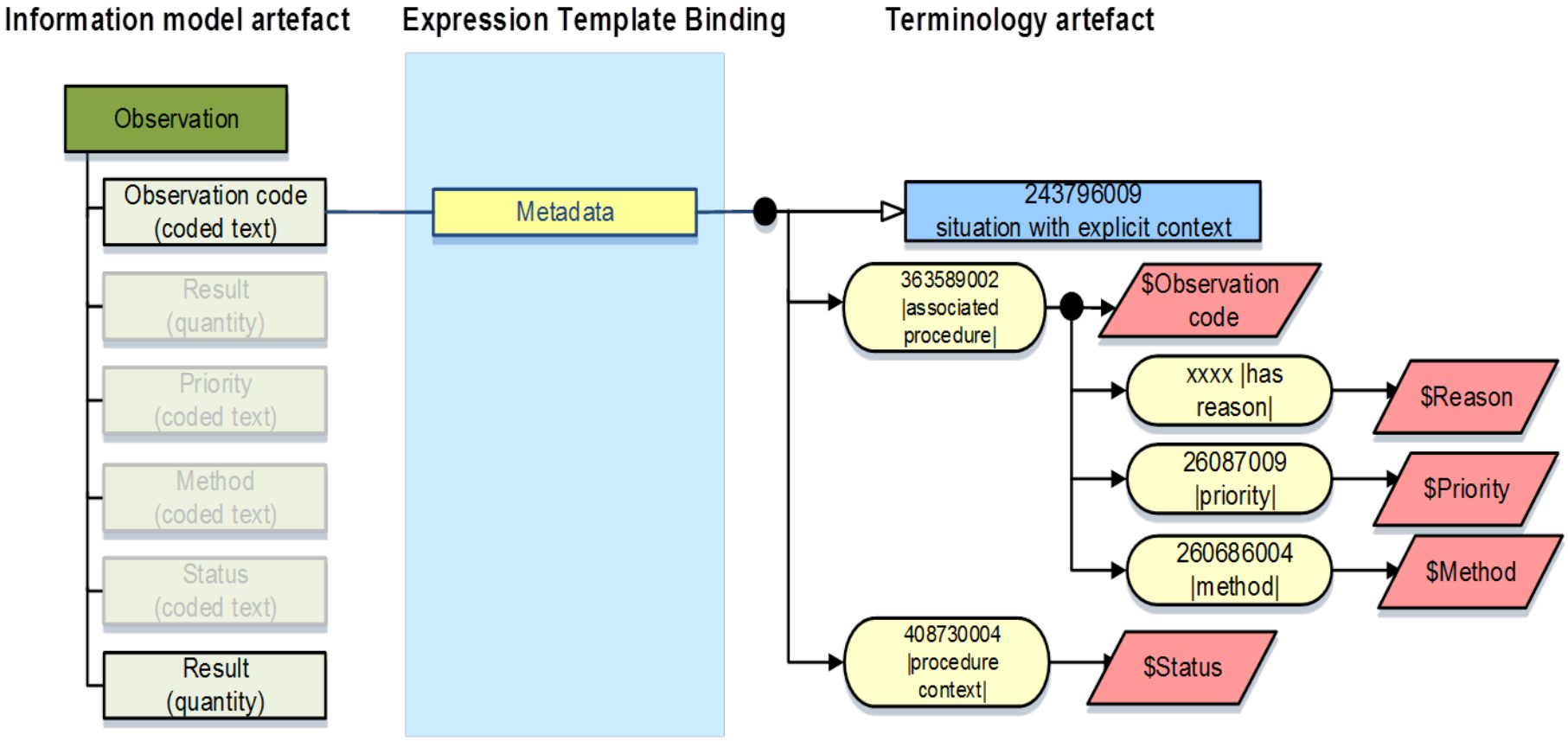
Patient's sex determines which Procedure reference set to use

Value Set Binding - Dependent



Procedure type must be a descendant of Procedure Category

Value Set Binding - Compositional

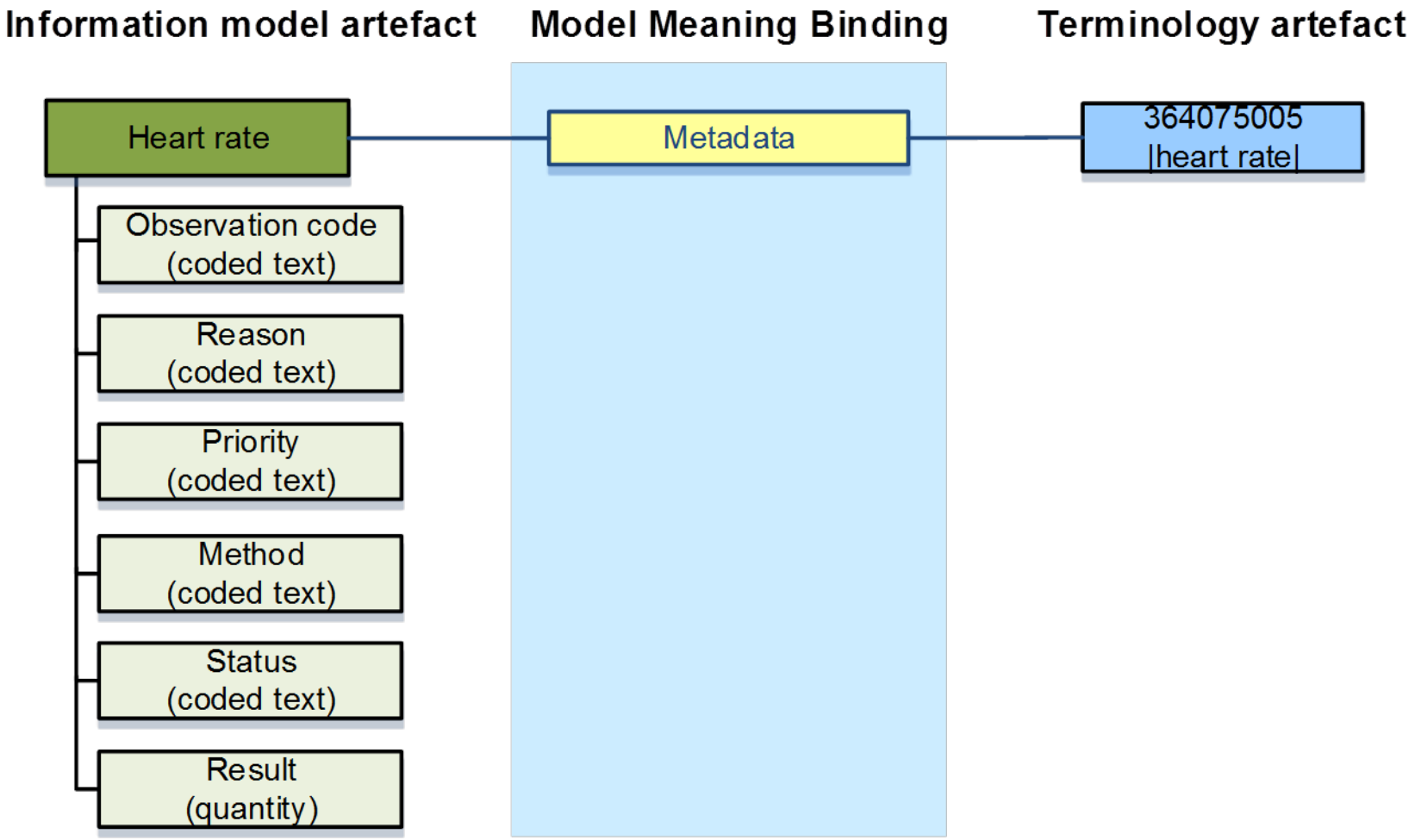


Transforming data from one model to another

Types of model meaning binding

- Simple with context
  - The meaning (and context) of each model
- Concept Domains
  - The SNOMED CT domain from which values are selected
- Attribute and Range
  - The relationship type and (optionally) concept domain
- Expression Template
  - The meaning of each data group instance

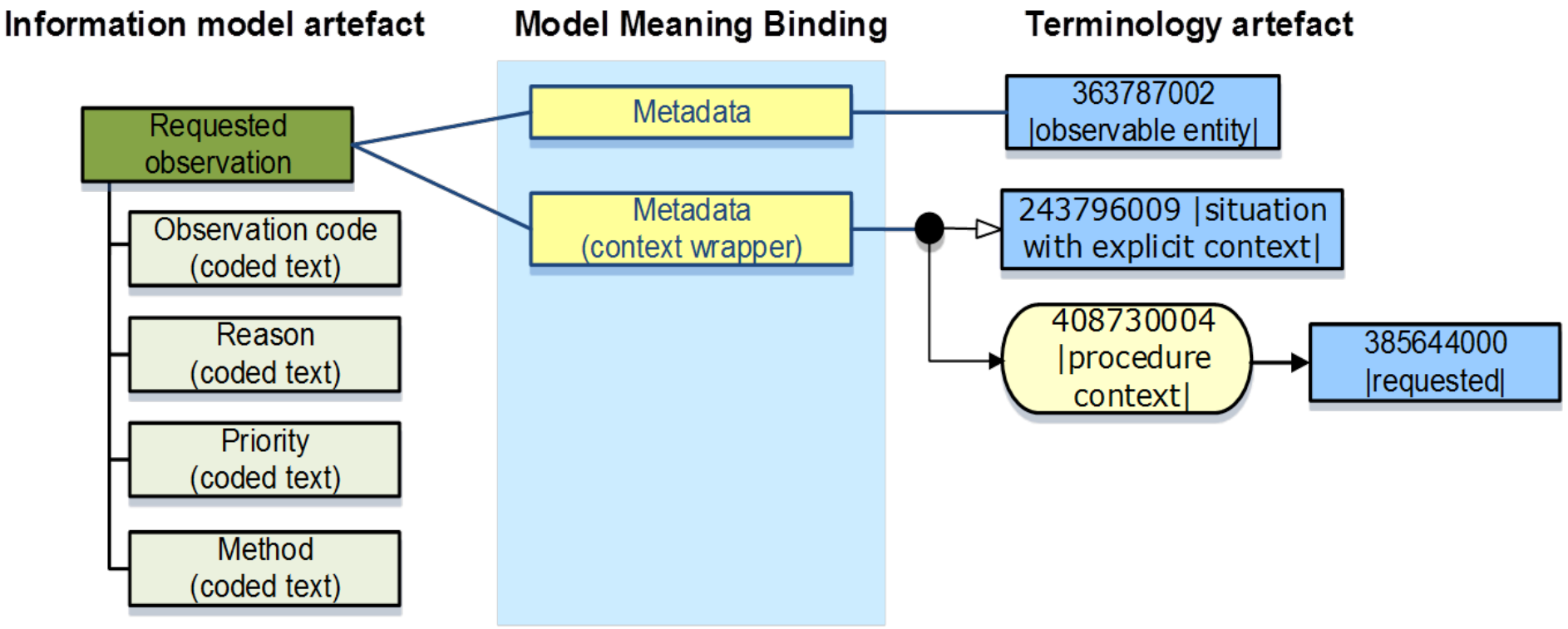
Model Meaning Binding – Simple



Searching information model libraries

- e.g. Find all ‘Cardiovascular observation’ models

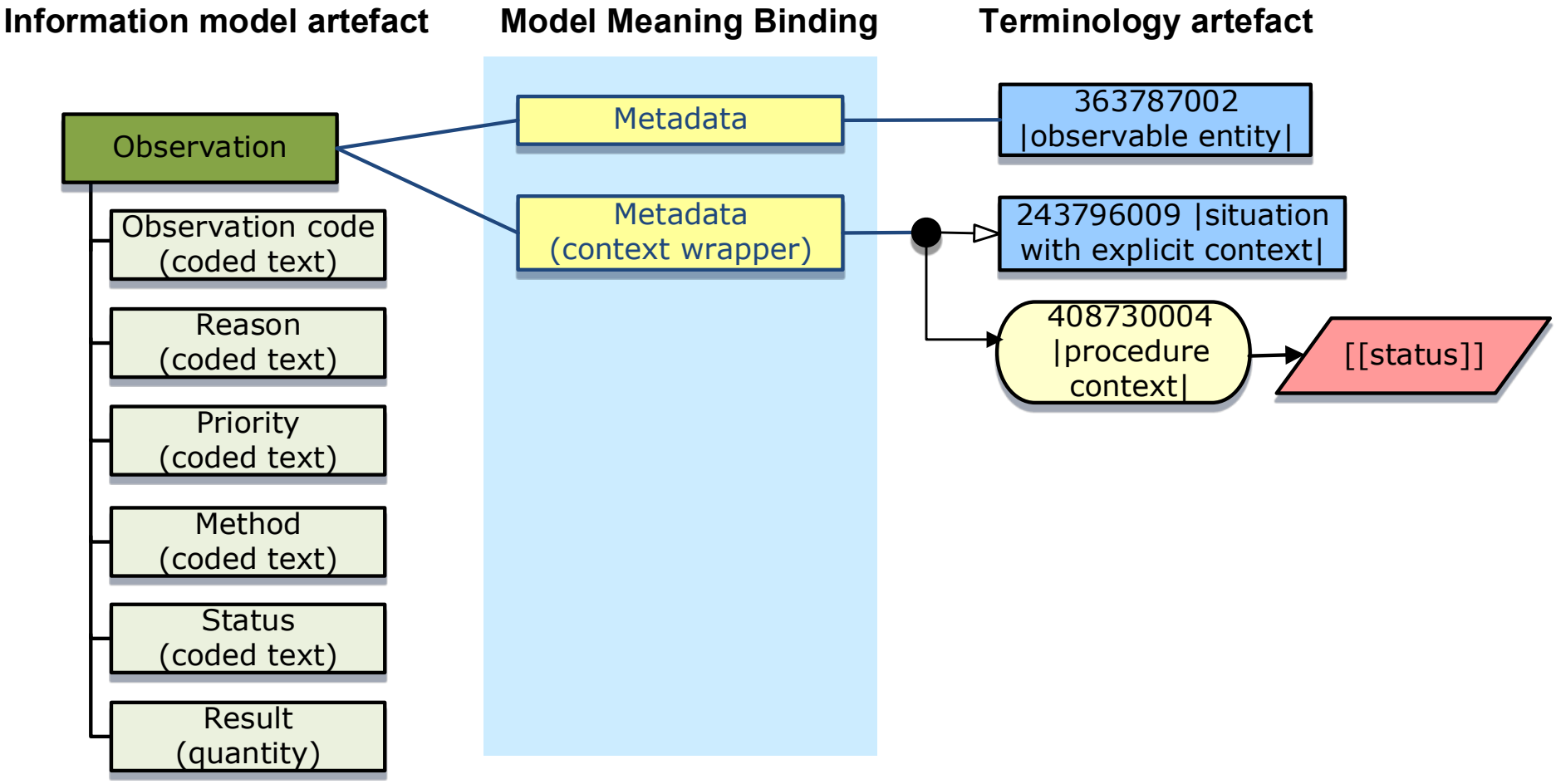
Model Meaning Binding – Context (1)



Analytics over meaning of model

- e.g. Find everything that has been requested

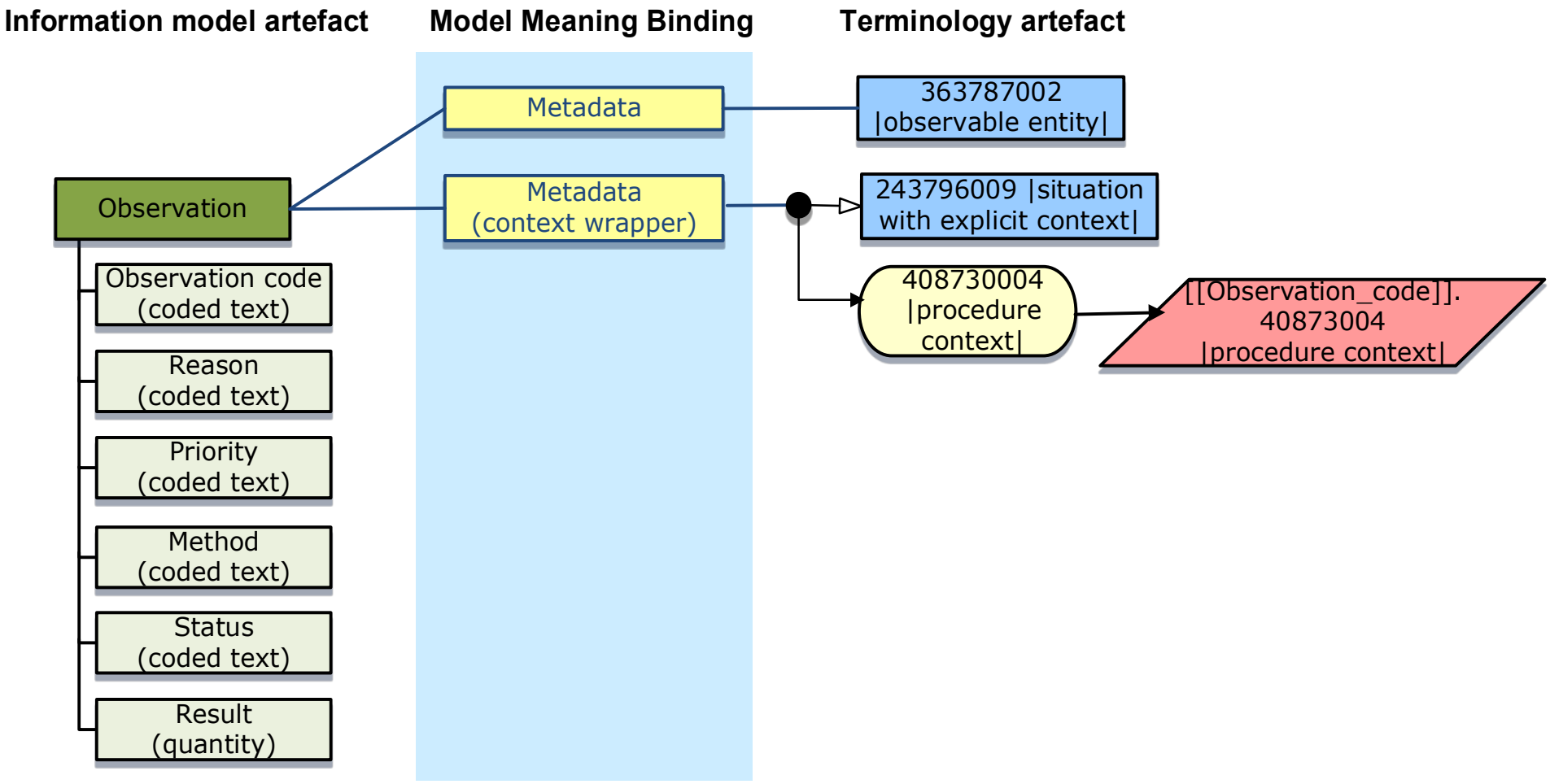
Model Meaning Binding – Context (2)



Analytics over meaning of model

- e.g. Find everything that has been requested

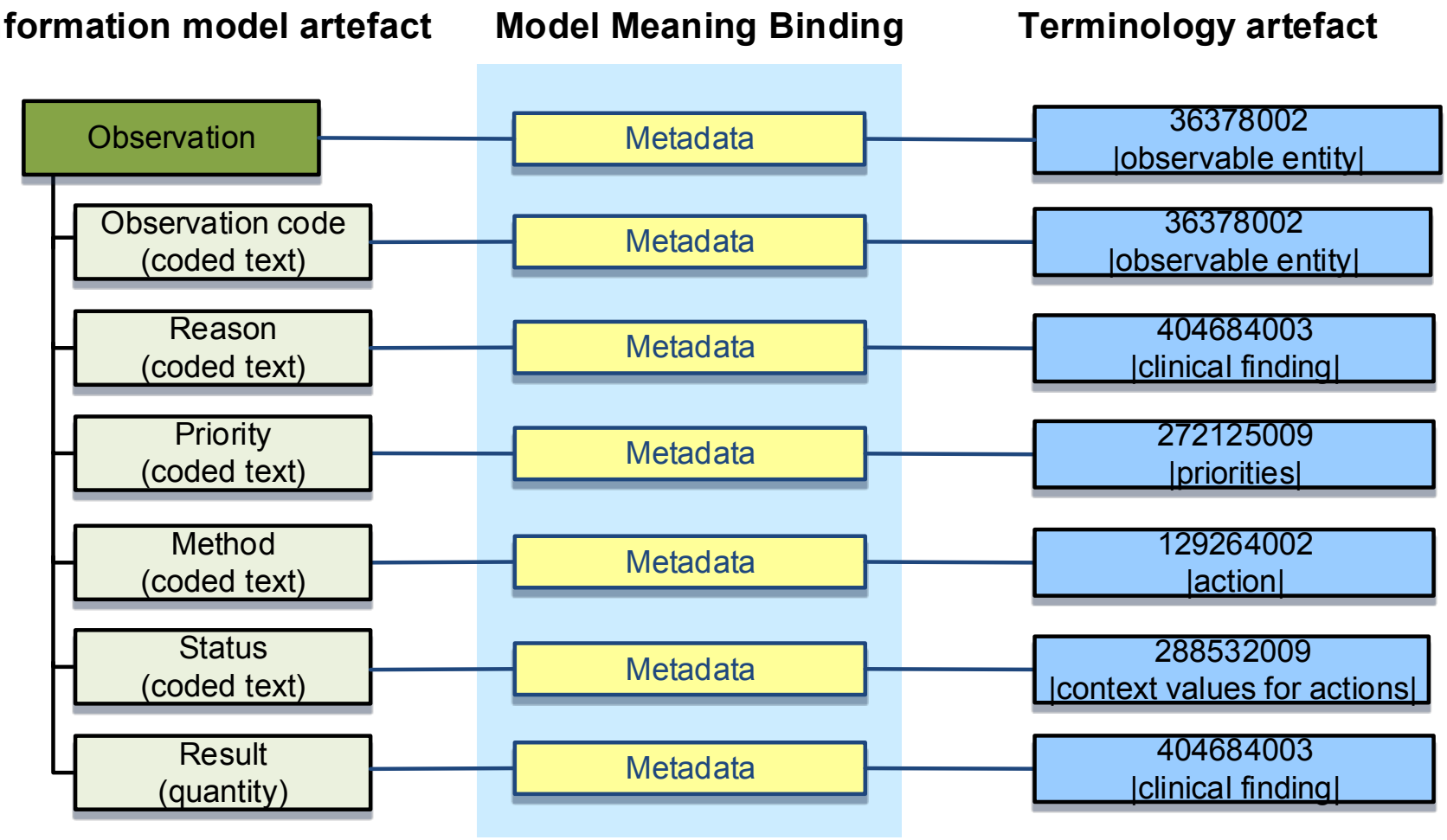
Model Meaning Binding – Context (3)



Analytics over meaning of model

- e.g. Find everything that has been requested

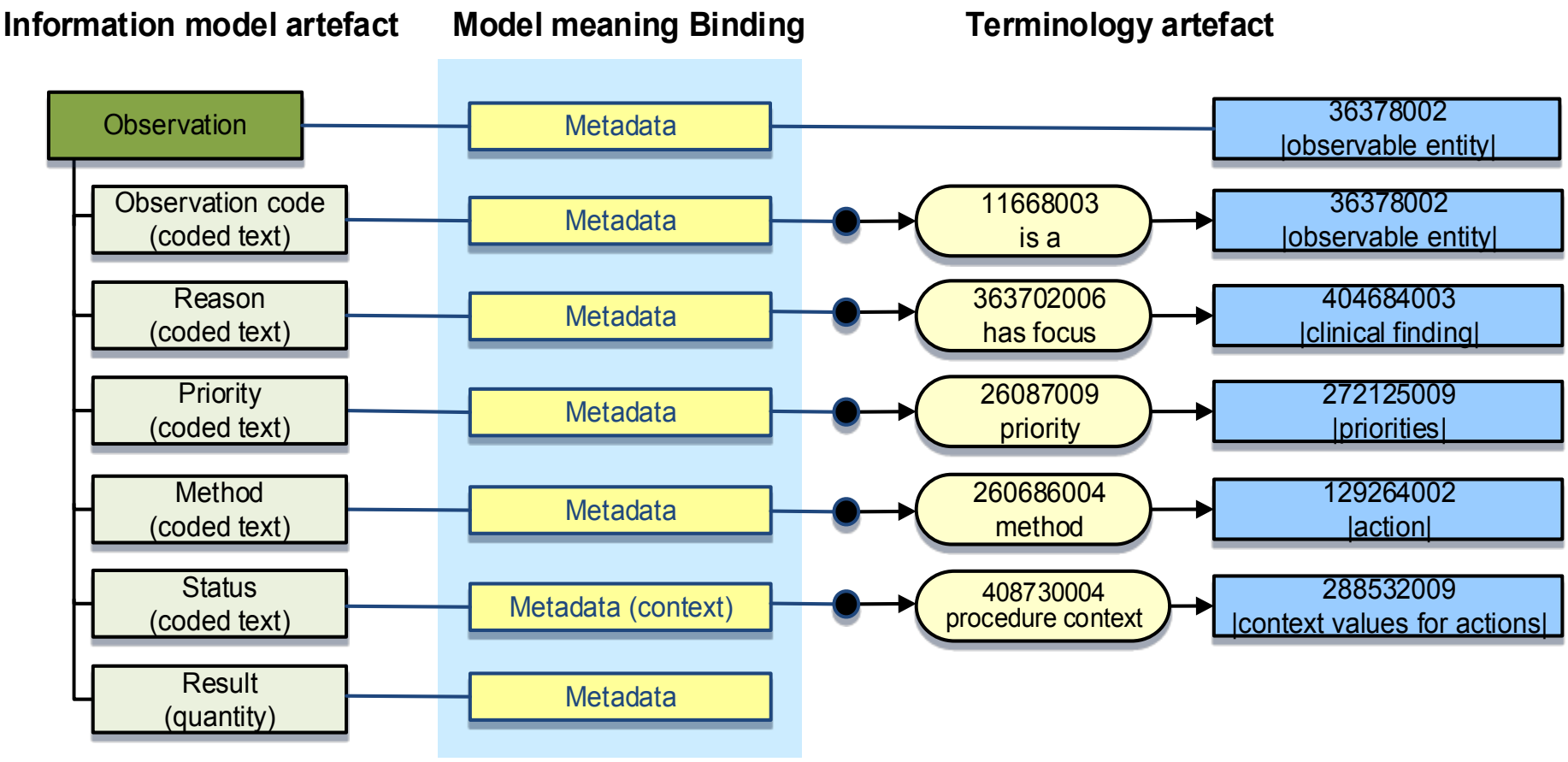
Model Meaning Binding – Concept Domain



Query, semantic overlap and inconsistency between models

Helps to generate and validate value bindings

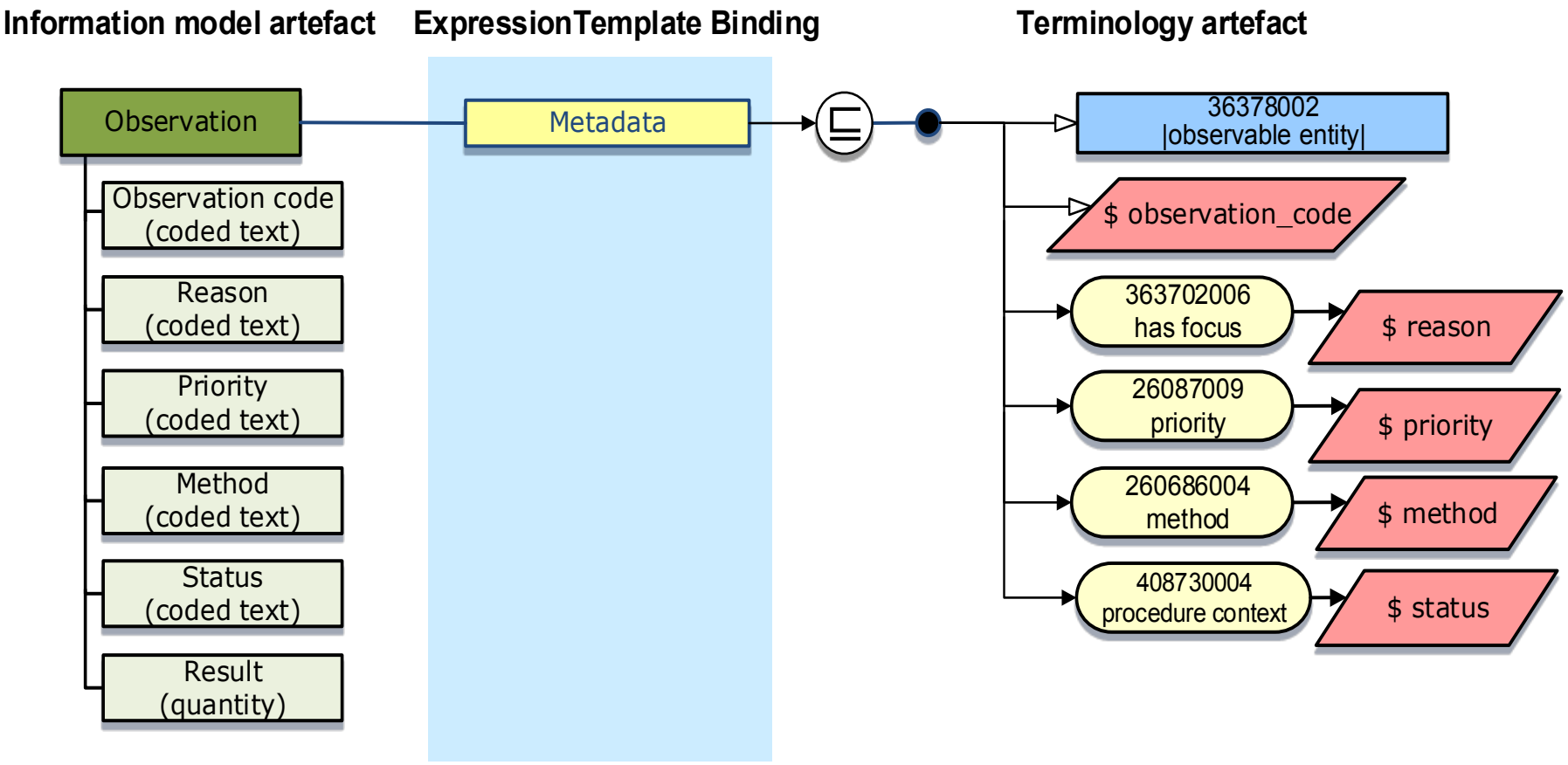
Model Meaning Binding – Attribute Range



Allows precoordinated concepts or expressions to be decomposed into structure

Note: 'Close to user' form may need transformation to be Concept Model valid

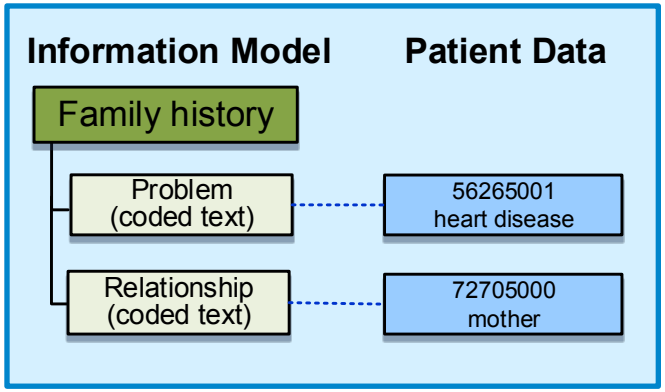
Model Meaning Binding - Template

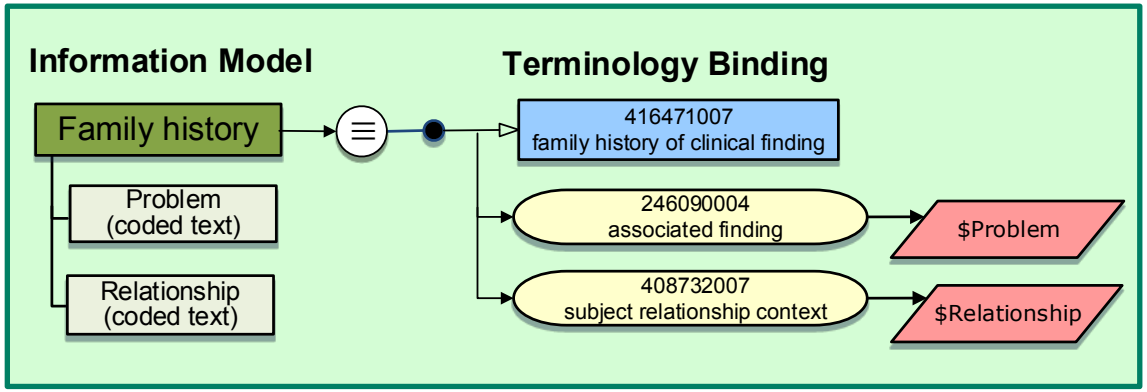


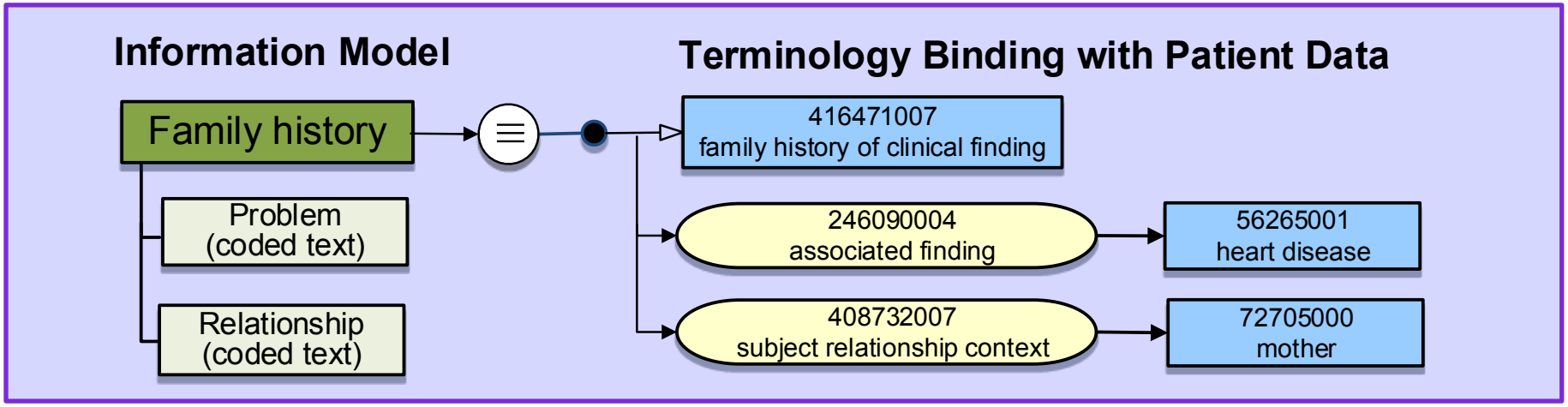
Individual concepts can be combined into a single expression

Note: 'Close to user' form may need transformation to be Concept Model valid

Model Meaning Binding - Template







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Value Set Binding - Metadata

- Regional scope
- Extensibility
  - Extensible by specialisation only
  - Extensible by extension only
  - Not extensible
  - Example only
- Coded Text value pattern
  - Specifies how each attribute in Coded Text datatype is populated
- Versioning
  - Information model, Terminology, Binding
- Substrate of expression constraints
  - Module, edition, extension, version
- Fixed, Default, Assumed value
- Literal or semantic (eg other equivalent codes acceptable)
- Only precoordinated concepts / Postcoordinated expressions allowed

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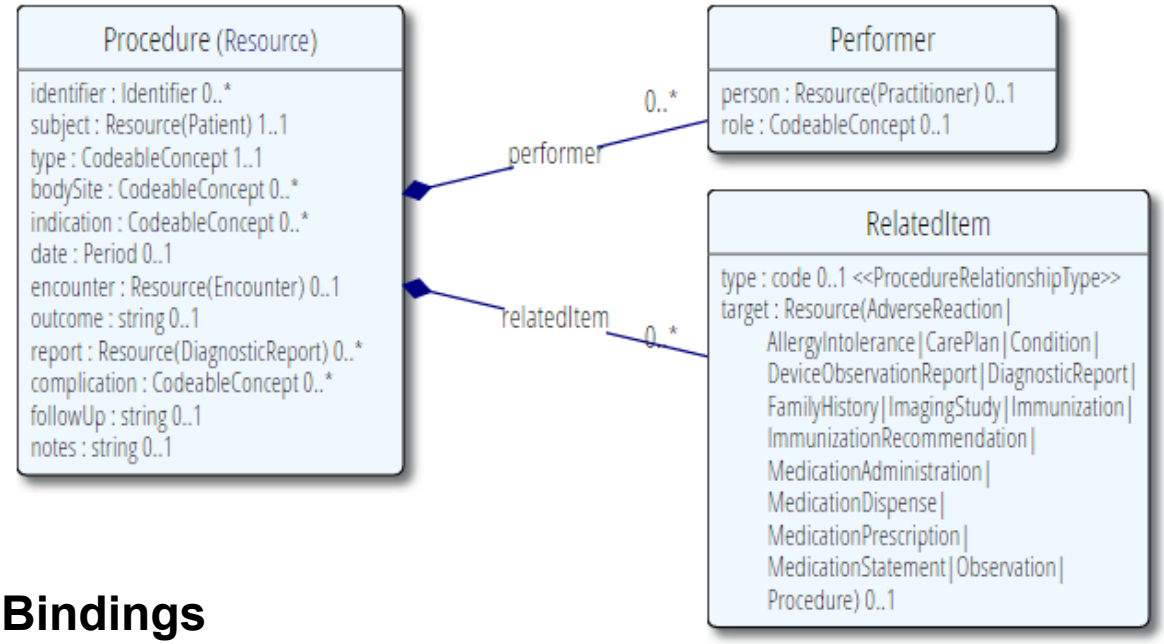
Terminology Binding Examples

1. Health Level 7 (HL7)
   a) FHIR (Fast Healthcare Interoperability Resources)
   b) TermInfo
2. Archetype Definition Language (ADL)
3. Archetype Modelling Language (AML, UML)
4. Binding Terminology to User Interfaces

HL7 - FHIR



Terminology Bindings

Path	Definition	Type	Reference
Procedure.relatedItem.type	The nature of the relationship with this procedure	Fixed	http://hl7.org/fhir/procedure-relationship-type

Value Set: Procedure Relationship Type

Code	Display	Definition
caused-by		This procedure had to be performed because of the related one.
because-of		This procedure caused the related one to be performed.

HL7 – TermInfo

- Provides guidance for the use of SNOMED CT in:
  - HL7 V3 Clinical Statement Pattern & CDA R2
- How to deal with overlaps between RIM and SNOMED CT
- Set of examples & patterns for common clinical statements
- Constraints on SNOMED CT concepts applicable to relevant attributes in Clinical Statement Pattern

```
<observation classCode="OBS" moodCode="EVN">
  <code code="ASSERTION"
    codeSystem="2.16.840.1.113883.5.4"/>
  <text>Headache</text>
  <value xsi:type="CD" code="25064002"
    codeSystem="2.16.840.1.113883.6.96"
    displayName="Headache"/>
</observation>
```

moodCode	Mood name	Procedure context
EVN	Event	[385658003 | done) OR (*values dependent of Act.statusCode - see note*)]
INT	Intent	[410522006 | pre-starting action status |]
RQO	Request	[385644000 | requested |]
PRP	Proposal	[385643006 | to be done |]
PRMS	Promise	[385645004 | accepted |]
ARQ	Appointment request	[385644000 | requested |]
APT	Appointment	[416151008 | scheduled |]

Archetype Definition Language

- ADL 1.4 published as part of ISO13606 standard
- ADL 2.0 includes enhancements added by openEHR
- Value Set Bindings:

```
terminology
   term_bindings = <
            [“snomedct”] = <
                  [“at2"] = <http://snomed.info/id/78564009>
                  [“ac3"] = <http://snomed.info/id/12394009>>
                  ["id5.0.3"] = <http://snomed.info/id/363702006>>
```

Archetype Definition Language

Classification of diabetic retinopathy during screening

Structure: Cluster
Mandatory (1..1)
Cardinality: Mandatory, repeating, unordered
(1..*)

DR screening
T Coded Text
Optional (0..1)
[SNOMED-CT::134395001] (Diabetic retinopathy screening (procedure))

Identification of presence or absence of diabetic retinopathy during screening. This classification has been grounded considering the characteristics of category 1 regarding the recommendations provided by the ATA.

- **No apparent DR** [ETDRS Levels of DR 10, 14, 15; DR absent] [SNOMED-CT::201141000000103]
- **Diabetic retinopathy apparent** [Level above 20 from the ETRDS classification] [SNOMED-CT::4855003] (Diabetic retinopathy (disorder))
- **DR not assessable** [The test is not assessable due to the low quality of acquisitions or uncertainty of the evaluator]

Comments
T Text
Optional (0..1)

Comments directed to reviewers specialized on DR screening. It may include test details or issues that provoke uncertainty while classifying the disease. It is useful as feedback channel to improve the quality of the DR screening service.

< Previous Next >

Archetype Modelling Language (AML)

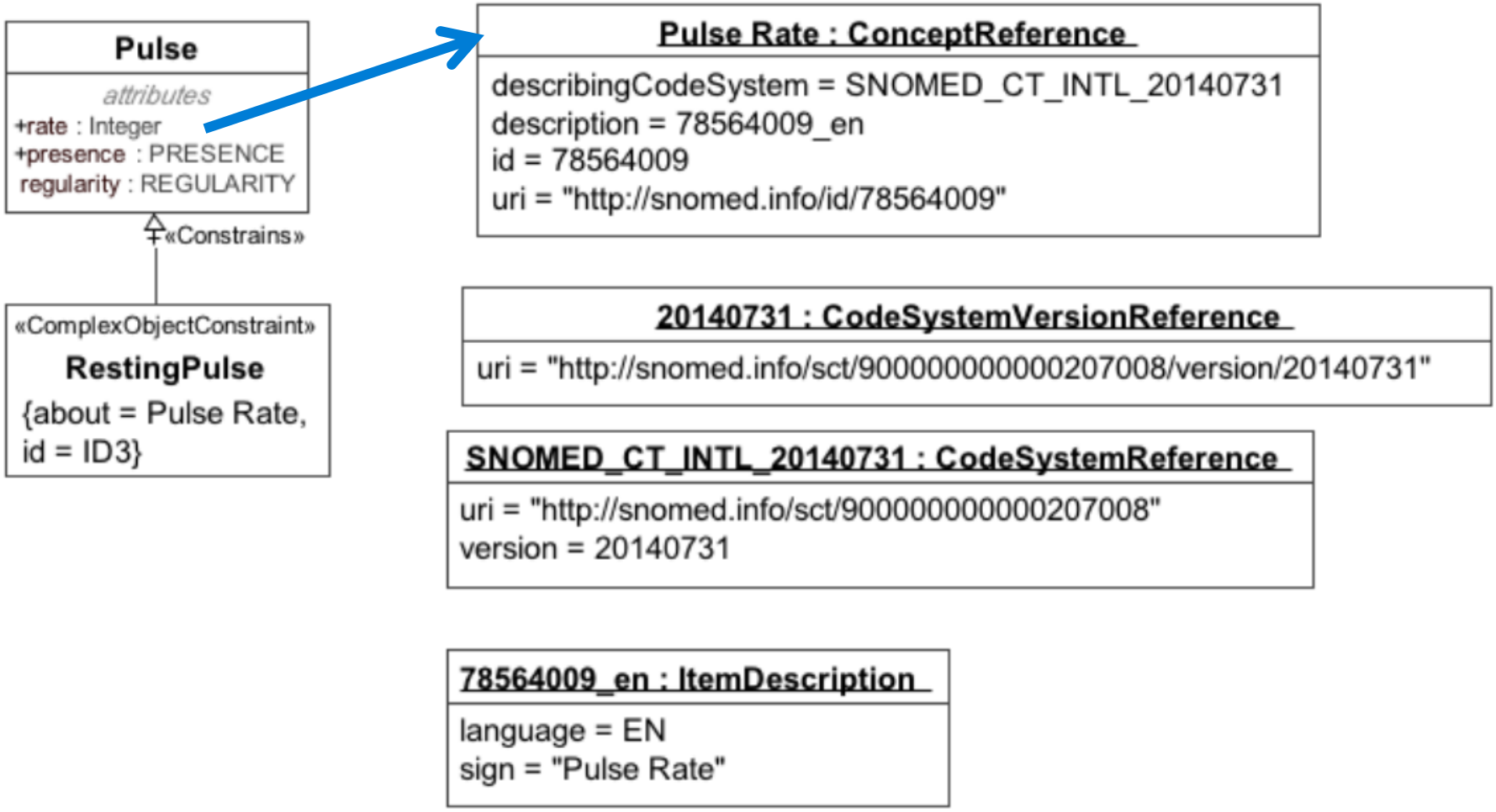
Goal: To create a standard for modelling Archetype Models (AMs) using UML to support the representation of Clinical Information Modelling Initiative (CIMI) artefacts in UML.

Process: Being submitted for standardisation to OMG

Profiles:

- Reference Model Profile (RMP)
- Constraint Model Profile (CMP)
- **Terminology Binding Profile (TMP)**

AML Terminology Binding Profile

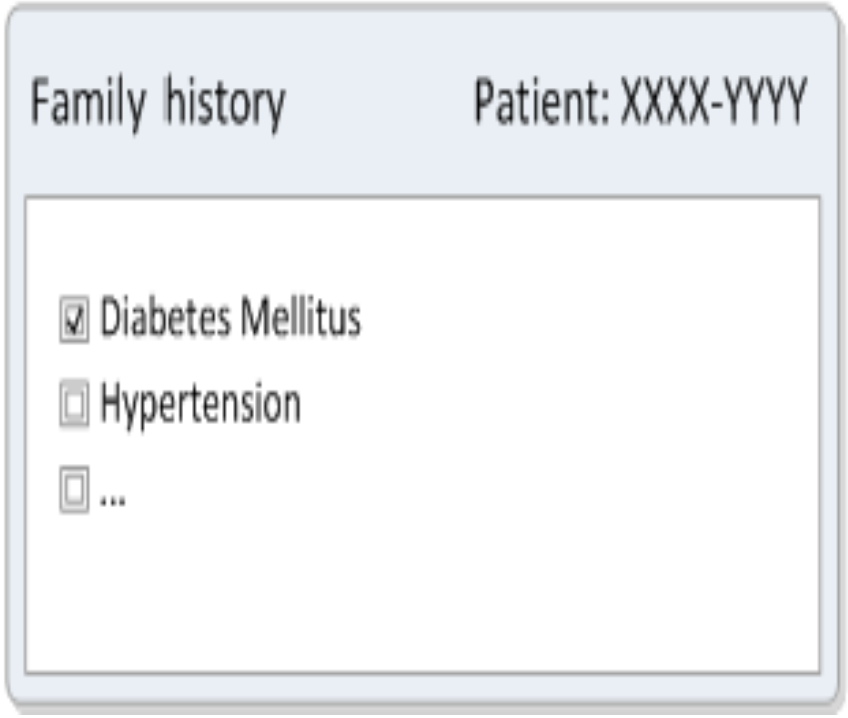


Binding Terminology to User Interfaces

- User interfaces should make it easy to enter data
  - Needs to be tailored to the way different clinicians work and think
- Data storage should enable effective retrieval and reuse
  - Retrieval must have answers that are:
    - Accurate – No false negatives
    - Precise – No false positives
    - Timely – Available when needed
    - Efficient – Without disproportionate time and effort
    - Consistent – Independent of how the data was entered
  - Storage design must represent similar types of information in the same way irrespective of the method of data entry

Binding Terminology to User Interfaces

- Balance interface design and information retrieval
  - How easy is it to answer simple questions?
    - *Does the patient have a family history of diabetes mellitus?*

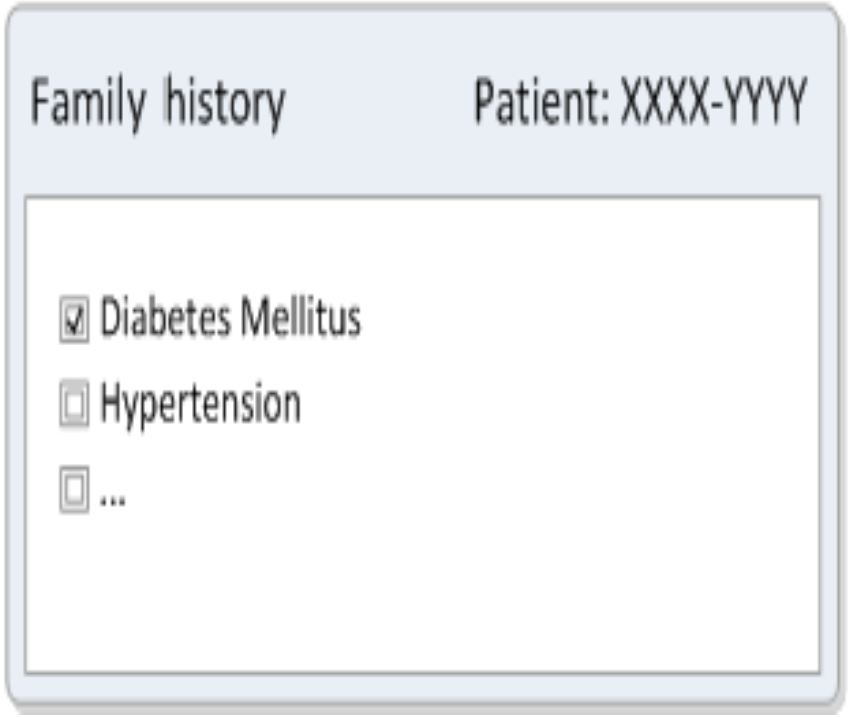


150265008 |family history taken (situation)|

73211009 |diabetes mellitus (disorder)|

Binding Terminology to User Interfaces

- Balance interface design and information retrieval
  - How easy is it to answer simple questions?
    - *Does the patient have a family history of diabetes mellitus?*

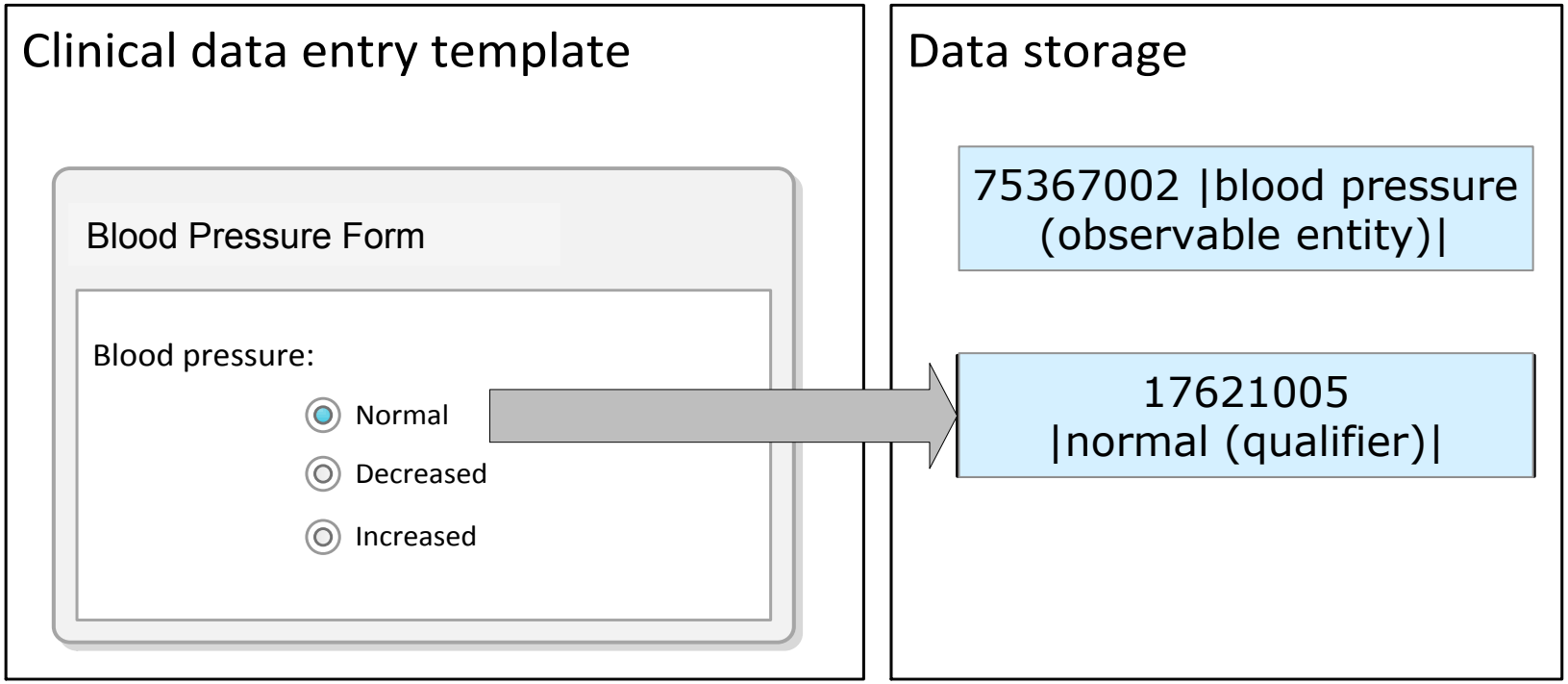


150265008 |family history taken (situation)|

160303001 |family history: diabetes mellitus (situation)}

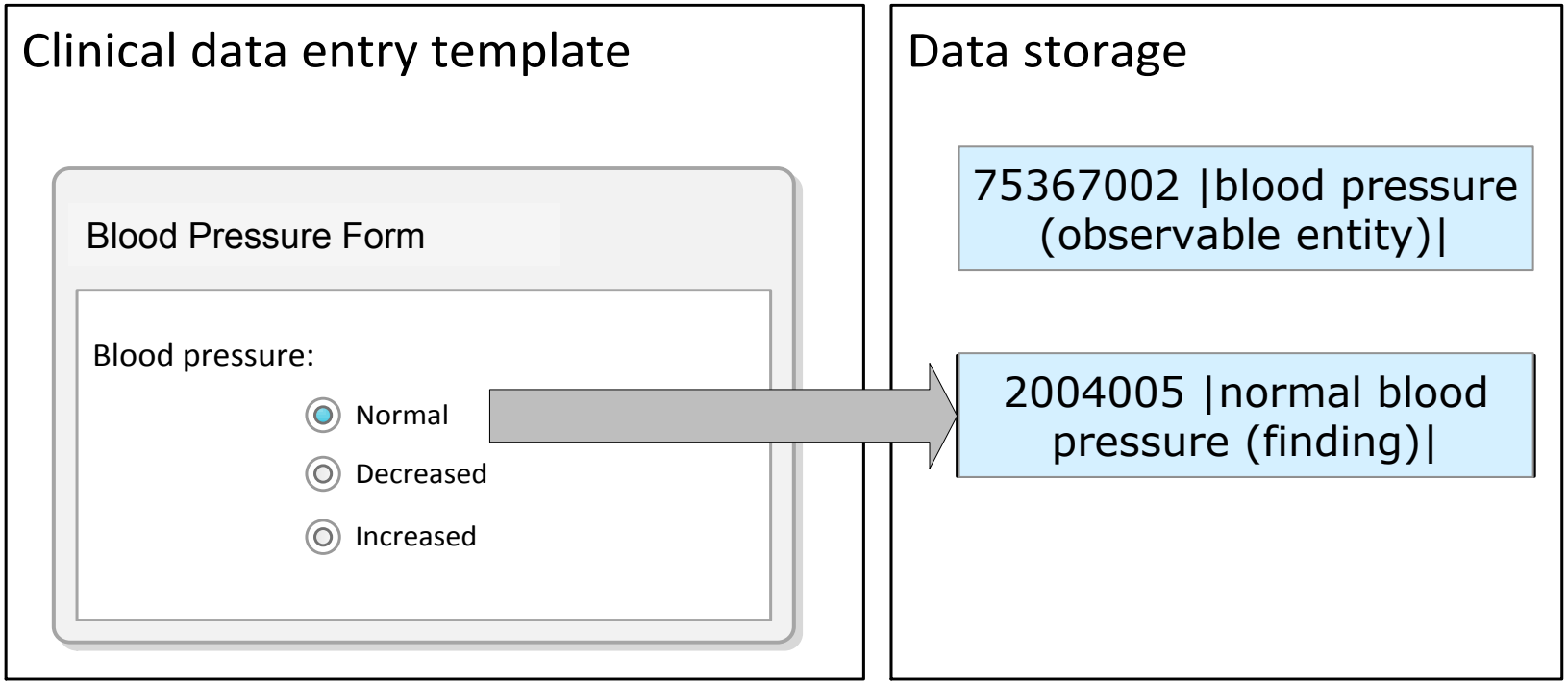
Binding Terminology to User Interfaces

- Balance interface design and information retrieval
  - How easy is it to answer simple questions?
    - *Does the patient have normal blood pressure?*



Binding Terminology to User Interfaces

- Balance interface design and concept selection
  - How easy is it to answer simple questions?
    - *Does the patient have normal blood pressure?*



SNOMED CT Use in Information Models

- For more information please refer to:
  - SNOMED CT Starter Guide: www.snomed.org/sg.pdf
  - Technical Implementation Guide: www.snomed.org/tig.pdf
  - An Introductory Guide to Binding SNOMED CT to Information Models (2014 / early 2015)

ihtsdo Delivering SNOMED CT

Questions and Discussion

Delivering

SNOMED CT

The global language of healthcare