Implementing SNOMED CT Expressions
Expo 2016 Tutorial

David Markwell, Head of Education
Linda Bird, Senior Implementation Specialist

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SNOMED CT
The global language of healthcare

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Leading healthcare terminology, worldwide
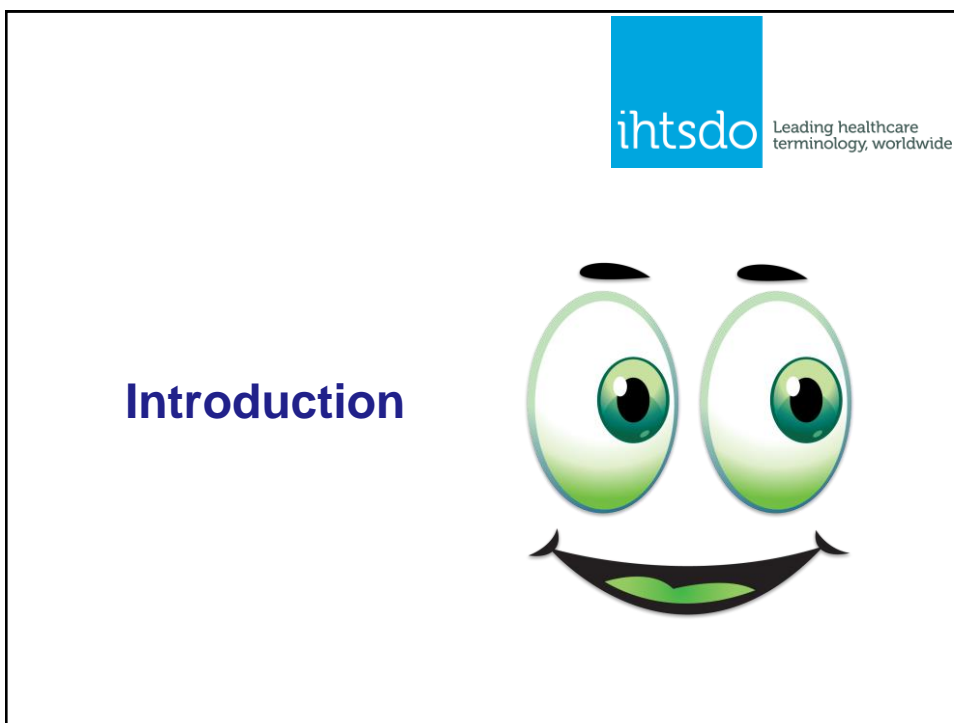

Presentation Overview

- Introduction
- Compositional Grammar
- Data entry and display
- Storage and retrieval
- Exchange
- Query
- Summary
- Discussion

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Introduction

SNOMED CT Concepts

A clinical idea with a unique SNOMED CT identifier

- Distributed as part of SNOMED CT

- Linked by descriptions to terms that provide a human-readable representation of the meaning of the concept

- Related to one another by defining relationships that provide a machine-processable representation of that meaning

22298006

Example of a SNOMED CT Concept

≡   Fracture of tibia (disorder)

SCTID: 31978002 Fully defined , Active

Term	Acceptability(US)	
F ☆ Fracture of tibia (disorder)	Preferred	
S ★ Fracture of tibia	Preferred	

Type	Destination	Group	CharType
Is a (attribute)	≡ Injury of tibia (disorder)	0	Inferred
Is a (attribute)	≡ Fracture of lower leg (disorder)	0	Inferred
Finding site (attribute)	Bone structure of tibia (body structure)	1	Inferred
Associated morphology (attribute)	Fracture (morphologic abnormality)	1	Inferred

SNOMED CT Concept Identifiers

- Concept identifiers can be used to record a clinical idea, or link instances of information about a clinical idea

Example

The concept identifier 31978002 can be used as a code in …

- A patient record to indicate the patient has a fractured tibia
- Clinical knowledge resources to provide links to advice about assessment and treatment of fractures of the tibia
- Data retrieval queries to select patients who have had a fractured tibia
- A data analysis report to identify the incidence of fractures of the tibia

SNOMED CT Expression

A structured combination of one or more concept identifiers used to represent a clinical meaning.

Example - *Right hip*

182201002 |Hip joint| : 272741003 |Laterality| = 24028007 |Right|

Use Cases

1. Expressions in health records
2. Expressions in messages
3. Precoordinated concept definitions
4. Expression associations with LOINC

SNOMED CT Precoordinated Expression

An expression containing a single concept identifier

The meaning is represented by the predefined meaning of a single concept

Example

- Can be just an identifier
  - 31978002
- Can optionally include an associated term
  - 31978002 |Fracture of tibia|

SNOMED CT Postcoordinated Expression

An expression containing two or more concept identifiers

The meaning is represented by the combination of the meanings of the included concepts

Example

- "Fracture of left tibia" can be represented as
  - 31978002 |Fracture of tibia| :
    272741003 |Laterality| = 7771000 |Left|
- Terms can be omitted to shorten expression
  - 31978002 : 272741003 = 7771000

SNOMED CT Postcoordinated Expressions

May refine the meaning of a concept by applying a more specific value to one or more defining relationships

Example

- The concept 31978002 |Fracture of tibia| has relationship
  - 116676008 |Associated morphology| = 72704001 |Fracture|
- 'Open fracture of tibia' can therefore be represented as
  - 31978002 |Fracture of tibia| :
    116676008 |Associated morphology| =
    52329006 |Fracture, open|
- Terms can be omitted to shorten expression
  - 31978002 : 116676008 = 52329006

SNOMED CT Postcoordinated Expressions

May refine the meaning of a concept by applying values to other attributes permitted by the SNOMED CT concept model

Example

- 31978002 |Fracture of tibia| is a subtype of 404684003 |Clinical finding|
- Concept model permits subtypes of 404684003 |Clinical finding| to have a 42752001 |Due to| attribute
- 'Fracture of tibia due to fall on ice' can therefore be represented as
  - 31978002 |Fracture of tibia| : 42752001 |Due to| = 75354000 |Fall on ice|
- Terms can be omitted to shorten
  - 31978002 : 42752001 = 75354000

Advantages of Postcoordination

- Scope coverage and terminology size
  - Coverage to an adequate level of specificity does not require every possible concept to exist
  - Reduces the need for "combinatorial explosion" in concept numbers
- Terminology maintenance
  - The maintenance burden is related to terminology size
- Structured data entry
  - Ability to represent refined content is not dependent on specific concepts existing
  - Expressions can be constructed in a consistent manner rather than searching hundreds of similar terms for precisely the correct one
- Consistent retrieval
  - Less dependency on modelling of individual concepts
    - 416098002 |Drug allergy| :
    - 246075003 |Causative agent| = 372725003 |Penicillin V|

Disadvantages of Postcoordination

- Human readability
  - Extreme postcoordination can lead to loss of natural terms
  - Example - '*Procedure with method of excision and procedure site of appendix*' may be better expressed as '*Appendectomy*'
- Data entry
  - Users may need to construct expression by selecting multiple options rather than simply typing or choosing the term they want
- Storage and Exchange
  - Expressions that have an unspecified number of refinements are less easy to store, manipulate and exchange than simple codes
- Retrieval
  - Several postcoordinated expressions may mean the same
  - Queries need to process expressions rather than simple codes

Conclusions about Pre and Post Coordination

- Both pre and postcoordination have benefits
- A successful terminology should
  - Enable postcoordination to add flexibility
  - Include precoordinated concepts for commonly used meanings
  - Avoid attempting to identify an absolute boundary of what may or may not be precoordinated
  - Deal with the issues raised by alternative representations
    - The key issue is detection of equivalence[1] and subsumption[2] of alternative expressions

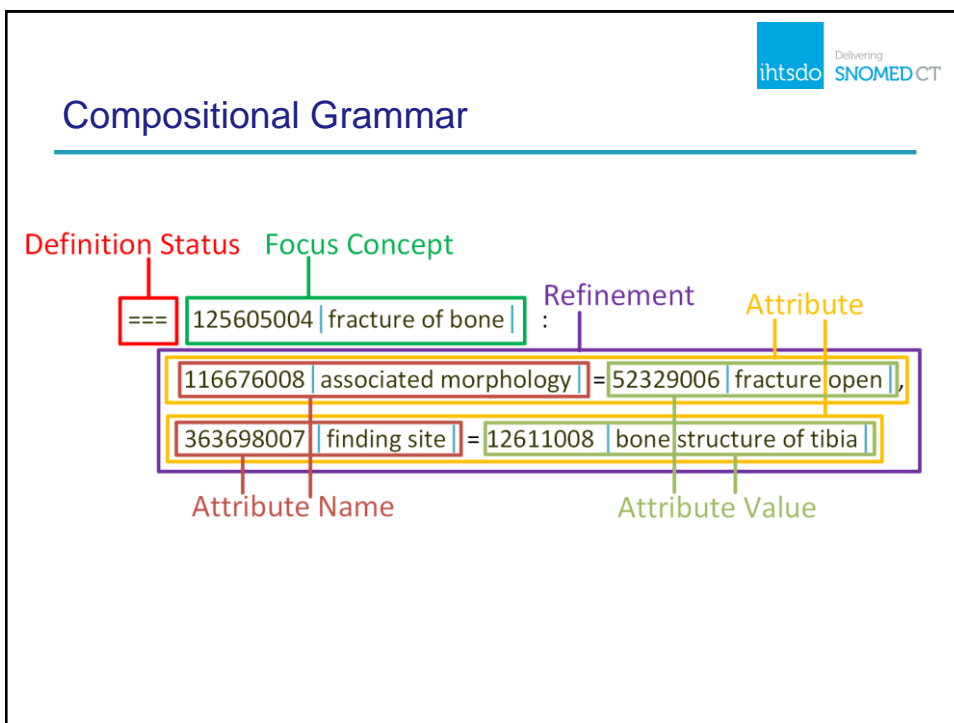1: Equivalence is when two expressions have the same meaning
2: Subsumption is when the meaning of one expression is a subtype of the meaning of the other

Pre and Post Coordination with SNOMED CT

- SNOMED CT supports both pre and postcoordination
  - No absolute boundaries between them
- SNOMED CT enables computation of equivalence and subsumption between alternative representations
  - For example, the postcoordinated expression
    22253000 |Pain| : 363698007 |Finding site| = 56459004 |Foot|
  - is a subtype of the precoordinated concept
    - 10601006 |Pain in lower limb|
  - because this precoordinated concept is defined as
    22253000 |Pain| :
        363698007 |Finding site| = 61685007 |Lower limb structure|
  - and
    - 56459004 |Foot| is a subtype of 61685007 |Lower limb structure|

SNOMED CT Compositional Grammar

SNOMED CT
Compositional
Grammar

Compositional Grammar

Definition Status   Focus Concept

Refinement   Attribute

=== | 125605004 | fracture of bone | :

116676008 | associated morphology | = 52329006 | fracture open |,

363698007 | finding site | = 12611008 | bone structure of tibia |

Attribute Name   Attribute Value

Compositional Grammar – ABNF Syntax

expression = ws [definitionStatus ws] subExpression ws
definitionStatus = equivalentTo / subtypeOf
equivalentTo = "==="
subtypeOf = "<<<"
subExpression = focusConcept [ws ":" ws refinement]
focusConcept = conceptReference *(ws "+" ws conceptReference)
conceptReference = conceptId [ws "|" ws term ws "|"]
conceptId = sctId
term = nonwsNonPipe *(*SP nonwsNonPipe)
refinement = (attributeSet / attributeGroup) *(ws ["," ws] attributeGroup)
attributeGroup = "{" ws attributeSet ws "}"
attributeSet = attribute *(ws "," ws attribute)
attribute = attributeName ws "=" ws attributeValue
attributeName = conceptReference
attributeValue = expressionValue / QM stringValue QM / "#" numericValue
. . . . . .

9
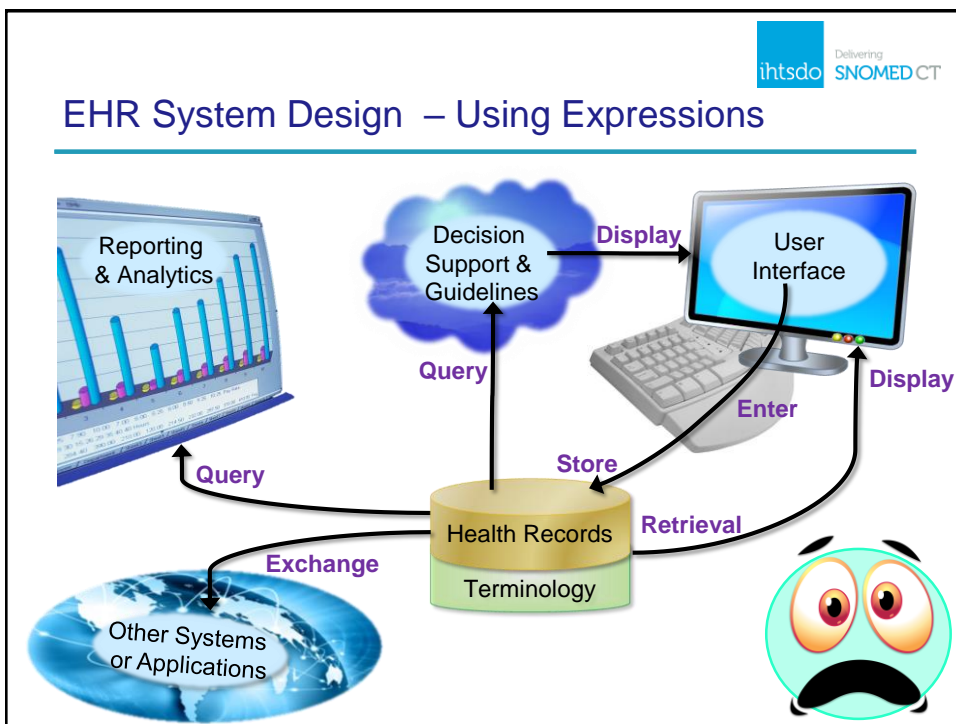
Compositional Grammar – Examples (1)

- *Fracture of tibia*
    - 31978002 |Fracture of tibia|
- *Spray suspension*
    - 421720008 |Spray dose form| + 7946007 |Drug suspension|
- *Right hip*
    - 182201002 |Hip joint| : 272741003 |Laterality| = 24028007 |Right|
- *Replacement of the right hip*
    - 397956004 |Prosthetic arthroplasty of the hip| :
        - 363704007 |Procedure site| = (182201002 |Hip joint| :
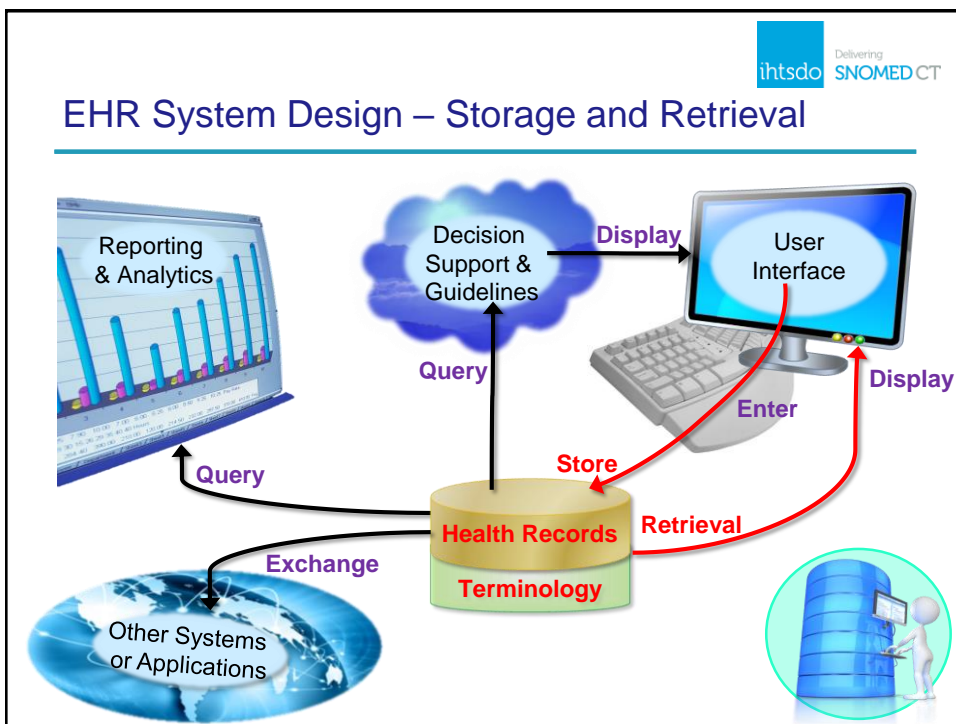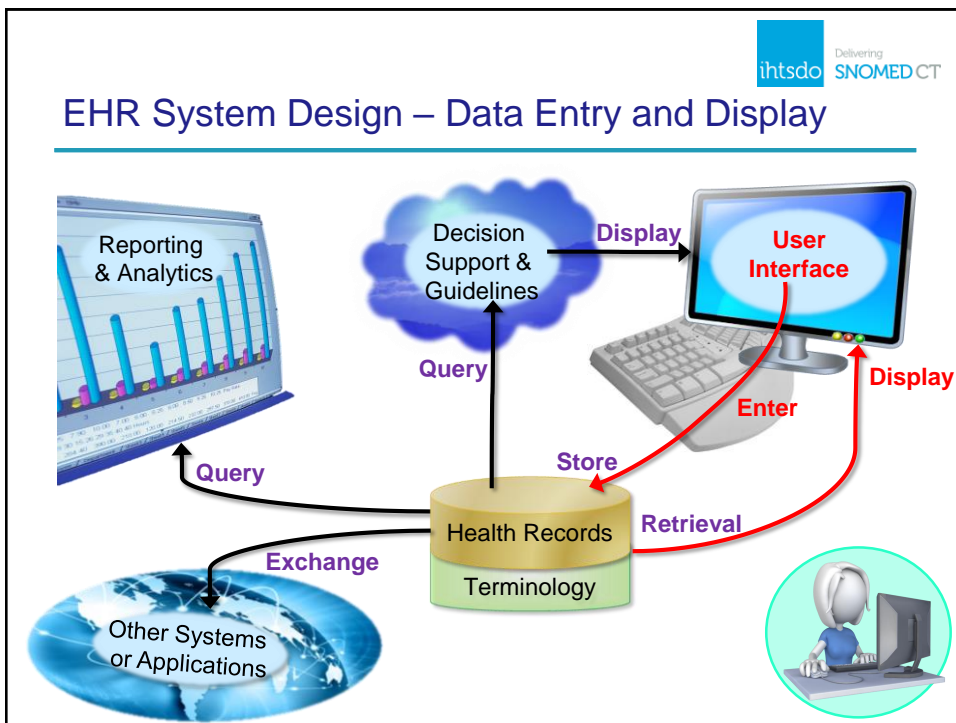   - 272741003 |Laterality| = 24028007 |Right|)

Compositional Grammar – Examples (2)
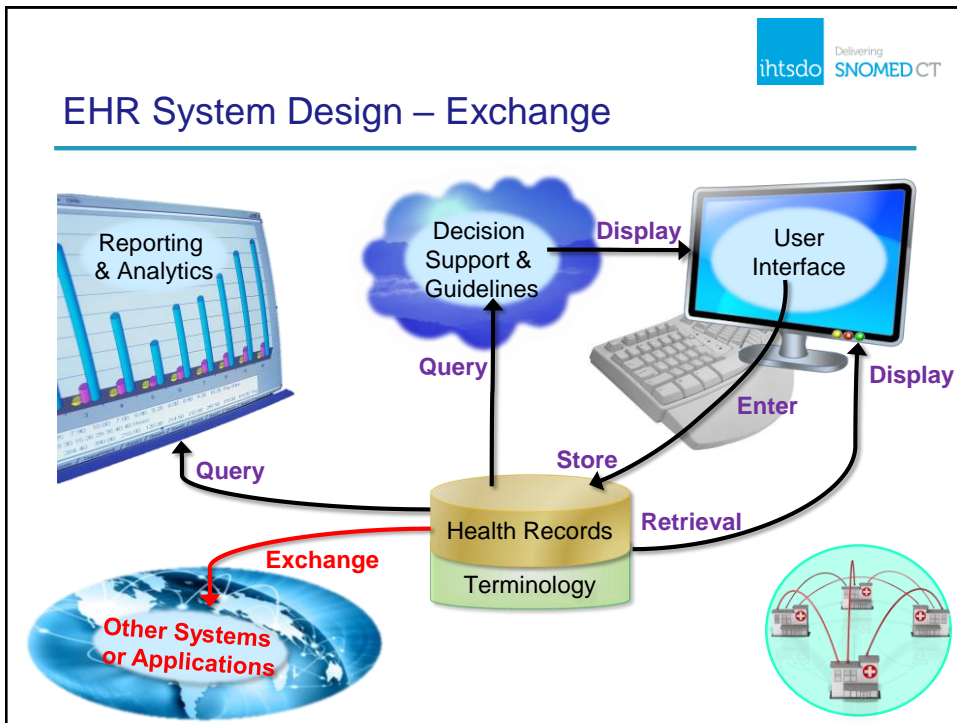
- *Excision of gallbladder and exploration of bile duct*
    - 7138802 |Procedure| :
    - {260686004 |Method| = 129304002 |Excision|,
    - 405813007 |Procedure site - Direct| = 28231008 |Gallbladder structure|},
    - {260686004 |Method| = 281615006 |Exploration|,
    - 405813007 |Procedure site - direct| = 2873000 |Bile duct structure|}
- *Amoxicillin 500 mg capsule*
    - 27658006 |Amoxicillin| :
        - 411116001 |Has dose form| = 385049006 |Capsule|,
        - {127489000 |Has active ingredient| = 372687004 |Amoxicillin|,
            - 111115 |Has basis of strength| = (111115 |Amoxicillin only| :
                - 111115 |Strength magnitude| = #500,
                - 111115 |Strength unit| = 258684004 |mg|)}

Expressions in EHRs

EHR System Design – Using Expressions

Reporting & Analytics

Decision Support & Guidelines

User Interface

Display

Query

Enter

Display

Store

Query

Retrieval

Exchange

Health Records

Terminology

Other Systems or Applications

EHR System Design – Data Entry and Display

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Retrieval

Terminology

Exchange

Other Systems or Applications

EHR System Design – Exchange

EHR System Design – Query

Data Entry and Display

Data Entry and Display – Precoordinated

- Free text
- Semi-structured
- Structured
  - Radio buttons
  - Check boxes
  - Value lists
  - Spatial diagrams

Normal blood glucose

Decreased blood glucose

Increased blood glucose

Symptoms:

☑ High blood pressure

☑ Fever

☐ Head ache

Select from List ⌄
- X-ray
- Abdominal X-ray
- X-ray of chest wall
- MRI
- MRI of abdomen

Location:

Left upper arm

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Data Entry and Display – Postcoordinated

- Free text and semi-structured
    - With Natural Language Processing (NLP)
- Structured
    - Predefined library of clinical phrases
        - Mapped to SNOMED CT expressions
    - Information model with expression templates
        - Radio buttons, check boxes, value lists, spatial diagrams
    - Expression builder
        - Form or grammar

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Data Entry and Display – Postcoordinated

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Data Entry and Display – Free Text with NLP

- Allows clinicians to write free text notes in their preferred style
- May include complex sentences, abbrevs, spilling erorrs
- Postcoordination allows capture of more complete meaning
  - Allows context to be captured to avoid incorrect query results
    - e.g. certainty, temporality and subject relationship
  - Allows qualifying attributes to provide more specificity
    - e.g. severity, laterality, finding site
- MRCM can be used to find postcoordination opportunities

Data Entry and Display – CNLP with Clinithink

clinithink   **CLiX NOTES**

Unstructured Text Input   ▾ Structured Output

| Update | Terms | Acronyms | Spellings |

Patient has FH of gallbladder cancer in maternal grandfather.

Standard View   Filtered View   Advanced View

Data Entry and Display – CNLP with Clinithink

Data Entry and Display – CNLP with Clinithink

Machine Readable Concept Model – MRCM

Represents the SNOMED CT Concept Model in a form that can be read and processed by a computer.

Use Cases:

1. Precoordinated terminology development
2. Expression, constraints, queries and template development
3. **Natural Language Processing**
4. Terminology binding

Reference sets:

1. MRCM domain – lists domains to which attributes may be applied
2. MRCM attribute domain – associates attributes with domains
3. MRCM attribute range – associates attributes with ranges
4. MRCM module scope – specifies set of MRCM refsets that apply

MRCM Example

MRCM domain
<< 404684003 |Clinical finding (finding)|

The patient has **cancer** of the **gallbladder**.

MRCM attribute domain
363698007 |Finding site|
363346000 |Cancer|

- Domain: 404684003 |Clinical finding (finding)|
- Grouped: 1
- Attribute cardinality: 0..*
- Attribute in group cardinality:

363346000 |Cancer| :
{ 363698007 |Finding site| =
28231008 |Gallbladder structure|, …}
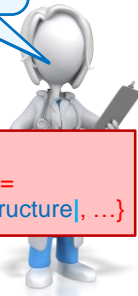
MRCM attribute range
363698007 |Finding site|
- Range: << 442083009 |Anatomical or acquired body structure|

Expression Constraint

A computable rule that can be used to define a bounded set of clinical meanings.

Use Cases

1. Terminology binding
2. Intensional reference set definitions
3. SNOMED CT content queries
4. **SNOMED CT MRCM**

Example

Lung disorders with morphology a type of edema

< 19829001 |Disorder of lung| :
     116676008 |Associated morphology| = << 79654002 |Edema|

Data Entry and Display – Postcoordinated

- Free text and semi-structured
  - With Natural Language Processing (NLP)
- Structured
  - Predefined library of clinical phrases
    - Mapped to SNOMED CT expressions
  - Information model with expression templates
    - Radio buttons, check boxes, value lists, spatial diagrams
  - Expression builder
    - Form or grammar

Data Entry and Display – Library of Clinical Phrases

Clinical Phrase	SNOMED CT Expression
FH of gastric bleeding	416471007 |FH: clinical finding|: 246090004 |Associated finding| = 61401005 |Gastric hemorrhage|
Pain in left elbow	74323005 |Pain in elbow|: 272741003 |Laterality| = 7771000 |Left|
Severe abdominal pain	21522001 |Abdominal pain|: 246112005 |Severity| = 24484000 |Severe|
Suspected gastric ulcer	444433005 |Suspected clinical finding|: 246090004 |Associated finding| = 397825006 |Gastric ulcer|
Suspected gastric bleeding	444433005 |Suspected clinical finding|: 246090004 |Associated finding| = 61401005 |Gastric hemorrhage|

Data Entry and Display – Library of Clinical Phrases

Select from List ∨

FH of gastric bleeding

Pain in left elbow

Severe abdominal pain

Suspected gastric ulcer

Suspected gastric bleeding

- Can be displayed using precoordinated techniques
  - Radio buttons
  - Check boxes
  - Value lists
  - Spatial diagrams
- New phrases can be added without waiting for a new SNOMED CT release
- Value lists may get long
- Phrases are predefined
  - Less flexible

Data Entry and Display – Postcoordinated

- Free text and semi-structured
  - With Natural Language Processing (NLP)
- Structured
  - Predefined library of clinical phrases
    - Mapped to SNOMED CT expressions
  - Information model with expression templates
    - Radio buttons, check boxes, value lists, spatial diagrams
  - Expression builder
    - Form or grammar

Data Entry and Display – Model with Template

65363002 |Otitis media| :
   246112005 |Severity| = 6736007 |Moderate|,
   246456000 |Episodicity| = 255217005 |First episode|

Disorder:

Select…

Labyrinthitis

Otitis externa

Otitis media

Severity:
- Mild
- Moderate
- Severe

Episodicity:
- First episode
- Old episode
- New episode

Data Entry and Display – Model with Template

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413350009 |Finding with explicit context|:
{ 246090004 |Associated finding| = 74400008 |Appendicitis|,
  408732007 |Subject relationship context| = 410604004 |Subject of record|,
  408729009 |Finding context| = 410515003 |Known present|,
  408731000 |Temporal context| = 410513005 |Past| }

Disorder:

Select… ▼

Appendicitis
Arthritis
Asthma

Temporal context
- ● Current
- ◉ In the past

Finding context
- ◉ Known present
- ● Known absent

Expression Template

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An incomplete expression containing 'slots' to be filled later.

Use Cases:
1. SNOMED CT concept authoring
2. **SNOMED CT expression authoring**
3. Terminology binding

Template Slots:
- Some slots are removed [[…]]
- Some slot are replaced [[+ …]]
- Slots may contain
  - Slot name: @name
  - Reference to value: $codedField
  - Cardinality: 0..*
  - Value constraint: + (< 404684003 |Clinical finding|)

Expression Template – Examples

Example 1: *CT of X*
    71388002 |Procedure| : [[1..1]]
    { 260686004 |Method| =
        312251004 |Computed tomography imaging action|,
      405813007 |Procedure site - Direct| =
        [[+(<<442083009 |Anatomical or acquired body structure|)]] }

Example 2: *Family history of disease X in family member Y*
    413350009 |Finding with explicit context| : [[1..1]]
    { 246090004 |Associated finding| =
        [[+(< 404684003 |Clinical finding)]],
      408732007 |Subject relationship context| =
        [[+(<< 125676002 |Person (person)|)]],
      408729009 |Finding context| = 410515003 |Known present|,
      408731000 |Temporal context| = 410511007 |Current or past (actual)| }

Data Entry and Display – Postcoordinated

- Free text and semi-structured
  - With Natural Language Processing (NLP)
- Structured
  - Predefined library of clinical phrases
    - Mapped to SNOMED CT expressions
  - Information model with expression templates
    - Radio buttons, check boxes, value lists, spatial diagrams
  - Expression builder
    - Form or grammar

Data Entry and Display – Expression Builder

- Form-based expression builder
  - With expression template
    - Form may be automatically generated from template

413350009 |Finding with explicit context|:
  {246090004 |Associated finding| = [[+$Finding]],
   408732007 |Subject relationship context| = [[+$Relationship]],
   408729009 |Finding context| = 410515003 |Known present|
   408731000 |Temporal context| = 410511007 |Current or past (actual)|}

Family History Expression Builder

Finding Cancer
  Asthma
  Cancer
  Diabetes

Relationship Father

413350009 |Finding with explicit context|:
  {246090004 |Associated finding| =
    363346000 |Cancer|,
   408732007 |Subject relationship context| =
    444295003 |Father of subject|,
   408729009 |Finding context| =
    410515003 |Known present|,
   408731000 |Temporal context| =
    410511007 |Current or past (actual)|}

Data Entry and Display – Expression Builder

- Form-based expression builder
  - With expression template
  - Without expression template
    - MRCM can be used to determine valid attributes (and their ranges) to apply to the selected focus concepts

Expression Builder

Focus Concept(s)
  Disease
  Clinical finding
  Disease
  Procedure

Refinements

Name   **Value**
Finding site   Endocrine system

64572001 |Disease|:
  363698007 |Finding site| =
    113331007 |Endocrine system|

Data Entry and Display – Compositional Grammar

- Form-based expression builder
  - With expression template
  - Without expression template
- Compositional Grammar expression editor
  - Authoring support may include
    - Syntax validation, MRCM conformance checking, auto-populating terms, concept searching (filtered based on MRCM rules), auto-suggestions for operators or characters

```
57177007 |Family history with explicit context| :
{246090004 |Associated finding| = 73211009 |Diabetes mellitus|,
 408732007 |Subject relationship context| = 444301002 |Mother of subject|,
 408731000 |Temporal context| = 410511007 |Current or past (actual)|,
 408729009 |Finding context| = 410515003 |Known present|}
```

Data Entry and Display – Display Options

1. Display using originally authored and stored form
2. Add in terms that have been omitted
3. Replace existing terms with local-dialect PTs or FSNs
4. Use different font colors and whitespace
5. Display term shown to the user when entering expression
6. Use form to display focus concept and attribute values

```
413350009|Te kimi me te           246090004|Kitenga e pā ana|=
413350009:{246090004=7321         301002,408731000=410511007,
4087
```

Expression

Finding with explicit context

```
Family history of diabetes mellitus in mother of subject
```

Subject relationship context
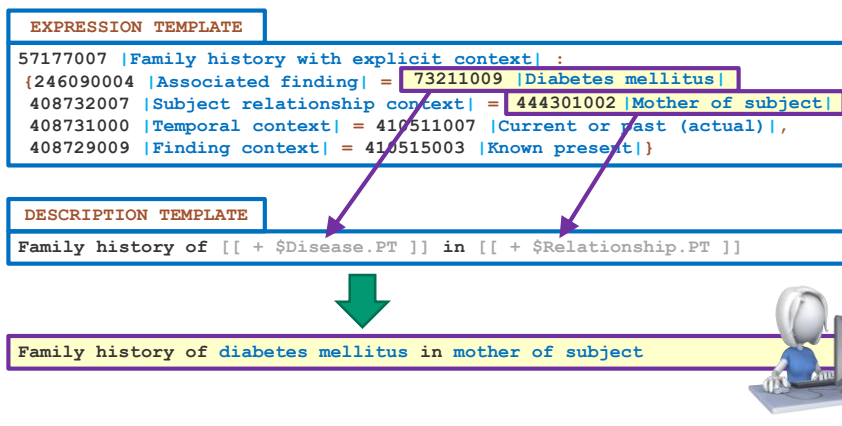Mother of subject

Temporal context
Current or past (actual)

Finding context
Known present

Data Entry and Display – Description Generation

▪ Automatic term generation
  ▪ Can be used to provide a more clinician friendly term
  ▪ Simple approach is to use a description template

EXPRESSION TEMPLATE

```
57177007 |Family history with explicit context| :
{246090004 |Associated finding| = 73211009 |Diabetes mellitus|
 408732007 |Subject relationship context| = 444301002 |Mother of subject|
 408731000 |Temporal context| = 410511007 |Current or past (actual)|,
 408729009 |Finding context| = 410515003 |Known present|}
```

DESCRIPTION TEMPLATE

```
Family history of [[ + $Disease.PT ]] in [[ + $Relationship.PT ]]
```

```
Family history of diabetes mellitus in mother of subject
```

Storage and Retrieval

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Storage and Retrieval – Precoordinated

- Always store the SNOMED CT *concept id*
  - Provides machine readable interoperability
  - Code field must support up to 18 characters
    - Max length of SNOMED CT extension ids
- Preferably store *term* selected or displayed
  - Provides human readable clinical interoperability
- Never rely on the *description id* for interoperability

Storage and Retrieval – Postcoordinated

Options

1. Use a separate field for focus concept and each attribute value
   - Use if a fixed expression template can be defined
2. Store the expression string as the code in patient record
   - Flexible - allows a variety of expressions to be stored
   - Code must support long expression strings (>56 chars)
   - May be stored without terms or spaces to reduce length
     - 31978002 |Fracture of tibia| : 272741003 |Laterality| = 7771000 |Left|
     - ➡ 31978002:272741003=7771000
   - Should also store human readable display term
3. Store an expression id as the code in patient record, expression repository stores expressions for each id
   - Shorter identifiers in patient record
   - Index expressions to improve retrieval time
   - Can be local or shared across organizations
   - Can precompute subsumption hierarchy

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Storage and Retrieval – Expression Repositories

- Example expression repository design
  - Expression
    - id: SCTID
    - effectiveTime: Time
    - active: Boolean
    - moduleId: SCTID
    - expression: String
  - Expression Link
    - id: SCTID
    - effectiveTime: Time
    - active: Boolean
    - moduleId: SCTID
    - sourceId: SCTID
    - destinationId: SCTID
    - typeId: SCTID

> A generated clinical term could be added OR an Expression Description table could be used to support multiple synonyms.

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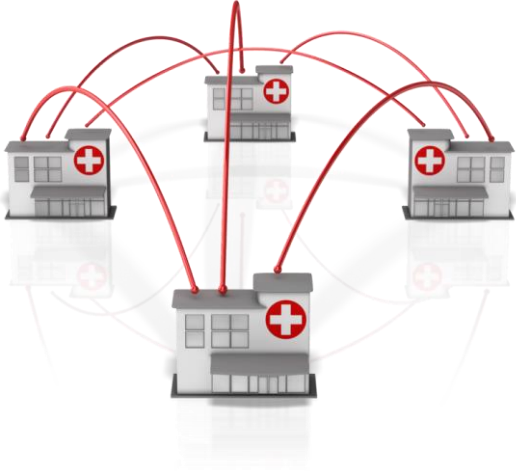## Storage and Retrieval – Expression Repositories

- Example expression repository functions
  - Retrieve an id for a given expression
  - Retrieve an expression for a given id
  - Compute subsumption hierarchy
  - Test two expressions for subsumption
  - Return attribute value in an expression
  - Prepopulate repository with a set of expressions matching a given expression template
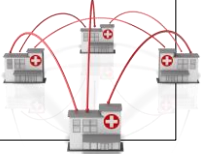 - Generate a term for a given expression

Exchange

Exchange – Precoordinated

- Coded datatype is populated as defined – e.g.

```xml
<Condition xmlns="http://hl7.org/fhir">
  <id value="example"/>
  <verificationStatus value="generated"/>

  <code>
    <!--  The problem is a bacterial infection   -->
    <coding>
      <system value="http://snomed.info/sct"/>
      <version value="http://snomed.info/sct/900000000000207008/version/20160731"/>
      <code value="87628006"/>
      <display value="Bacterial infectious disease"/>
    </coding>
    <text value="Disease caused by bacteria"/>
  </code>

  <subject>
    <reference value="Patient/pt100"/>
    <display value="value"/>
  </subject>
  <dateRecorded value="2016-07-18"/>
  <asserter>
    <reference value="Practitioner/pr200"/>
  </asserter>
</Condition>
```
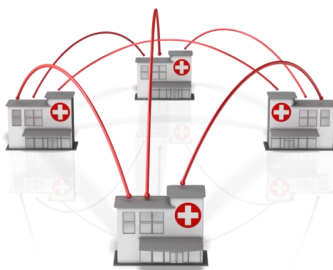
Exchange – Postcoordinated

- Options
    1. Place full expression in 'code' attribute of relevant field
    2. Place a unique expression id in 'code' attribute of relevant field
        - Requires a shared expression repository to be in place
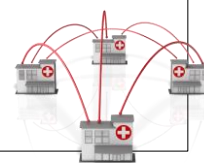   3. Decompose expression into separate codes that can be placed into different fields in message

Exchange – Postcoordinated

- Expression string is populated in the 'code' field – e.g.

```xml
<Condition xmlns="http://hl7.org/fhir">
 <id value="example"/>
 <verificationStatus value="generated"/>

 <code>
   <!--  The problem is a bacterial infection   -->
   <coding>
     <system value="http://snomed.info/sct"/>
     <version value="http://snomed.info/sct/900000000000207008/version/20160731"/>
     <code value="31978002:272741003=7771000"/>
     <display value="Fracture of left tibia"/>
   </coding>
   <text value="Fracture of left tibia"/>
 </code>

 <subject>
   <reference value="Patient/pt100"/>
   <display value="value"/>
 </subject>
 <dateRecorded value="2016-07-18"/>
 <asserter>
   <reference value="Practitioner/pr200"/>
 </asserter>
</Condition>
```

Exchange – Postcoordinated

▪ Expression string is populated in the 'code' field – e.g.
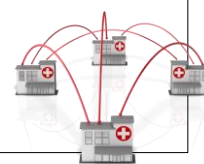
```
<Condition xmlns="http://hl7.org/fhir">
  <id value="example"/>
  <verificationStatus value="generated"/>

  <code>
    <!--  The problem is a bacterial infection
    <coding>
      <system value="http://snomed.info/sct
      <version value="http://snomed.info/
      <code value="157681000003164"/>
      <display value="Fracture of left tibia"/
    </coding>
    <text value="Fracture - left tibia"/>
  </code>

  <subject>
    <reference value="Patient/pt100"/>
    <display value="value"/>
  </subject>
  <dateRecorded value="2016-07-18"/>
  <asserter>
    <reference value="Practitioner/pr200"/>
  </asserter>
</Condition>
```

If using a shared Expression Repository, the precoordinated approach can be used.
The 'code' is then populated with the expression identifier, and resolved by the receiving system.
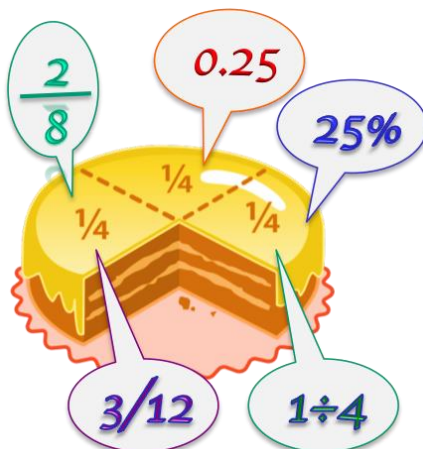

Query

Querying – Precoordinated

- SNOMED CT editions can be classified prior to release
  - Inferred relationships are distributed and available for systems to query and reason over
  - Subsumption can be tested easily using transitive closure
- Query Techniques
  - Subsets
  - Subsumption
  - Defining relationships
  - Description logic reasoning
- Query Languages
  - Expression Constraint Language
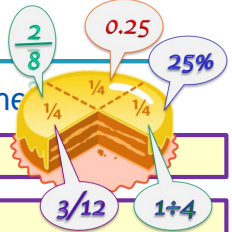 - SQL, OQL, SPARQL

Querying - Postcoordinated

- Supports different ways to express the same meaning

Querying - Postcoordinated

▪ Supports different ways to express the same

28012007 |Closed fracture of shaft of tibia|

125605004 |Fracture of bone| :
  { 363698007 |Finding site| = 52687003 |Bone structure of shaft of tibia|,
  116676008 |Associated morphology| = 20946005 |Fracture, closed| }

64572001 |Disease| :
  { 363698007 |Finding site| = 52687003 |Bone structure of shaft of tibia|,
  116676008 |Associated morphology| = 20946005 |Fracture, closed| }

423125000 |Closed fracture of bone|:
  363698007 |Finding site| = 52687003 |Bone structure of shaft of tibia|

6990005 |Fracture of shaft of tibia|:
  116676008 |Associated morphology| = 20946005 |Fracture, closed|

Querying – Postcoordinated

▪ Approach 1 – Expression template
  ▪ Use an expression template with predictable slots
  ▪ Allow queries over the values that fill each 'slot'
▪ Approach 2 – Expression normalization
  ▪ Use expressions normalization techniques for subsumption testing
    ▪ Replace fully defined concepts with proximal primitive parents and defining relationships
▪ Approach 3 – Description Logic
  ▪ Convert expressions to OWL and use DL reasoner (Fact++, ELK)
    ▪ Transform expression to conform to concept model
    ▪ Group all ungrouped attributes which are 'groupable'
▪ Approach 4 – Preclassified expression repository
  ▪ Use a DL reasoner to preclassify a shared repository
  ▪ Query expressions using precoordinated approaches

Querying – Expression Template

- Expression template
  [[+ (< 404684003 |Clinical finding|) **@finding**]] **:**
      363698007 |Finding site| =
          ([[+ (< 52530000 |Body region structure|) **@site**]] **:**
              272741003 |Laterality| = [[+ (< 182353008 |Side|) **@side**]])
- Diagnosis
  125667009 |Contusion| **:** 363698007 |Finding site| **=**
          (83738005 |Index finger structure| **:**
              272741003 |Laterality| **=** 7771000 |Left| **)**
- Query
  For the given patient, find the **$site** and **$side** of
  all diagnoses where **$finding** = 125667009 |Contusion|

Note: Precoordinated concepts must be decomposed into the template
      for consistent querying.

Querying – Expression Normalization

- Diagnosis (predicate expression)
  125667009 |Contusion|**:**
      363698007 |Finding site| **=** **(** 83738005 |Index finger structure|**:**
          272741003 |Laterality| = 7771000 |Left| **)**

  Predicate In Normal Form
  64572001 |Disease|: **{** 116676008 |Associated morphology| **=**
          308492005 |Contusion - lesion|**,**
      363698007 |Finding site| **=** **(** 83738005 |Index finger structure|**:**
          272741003 |Laterality| **=** 7771000 |Left| **)** **}**

- Query (candidate expression)
  416462003 |Wound|

  Candidate In Normal Form
  64572001 |Disease|**:**
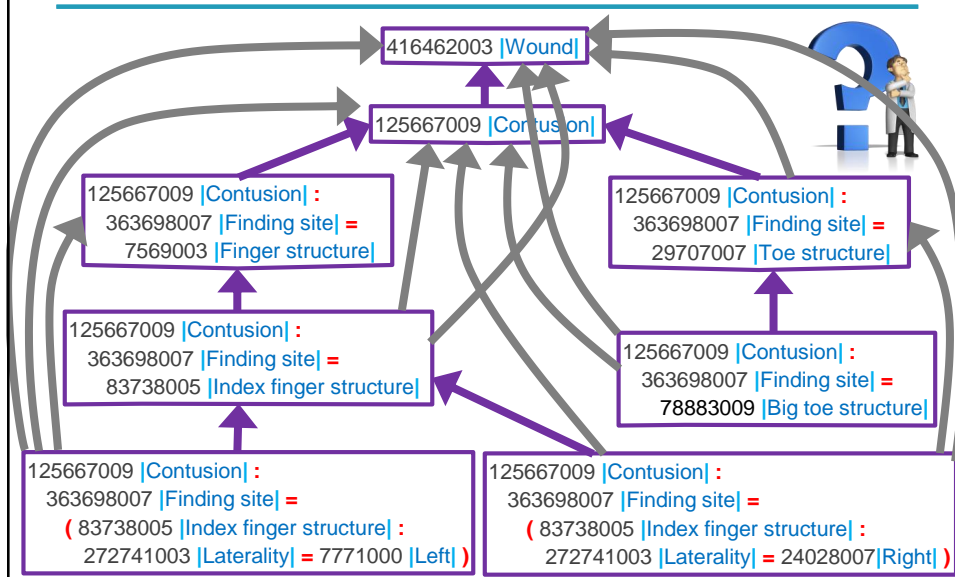 **{** 116676008 |Associated morphology| **=** 13924000 |Wound|**}**

Querying – Description Logic

- **Diagnosis** (in compositional grammar)
  125667009 |Contusion| **:**
    363698007 |Finding site| **= (** 83738005 |Index finger structure| **:**
      272741003 |Laterality| **=** 7771000 |Left| **)**
- **Diagnosis** (in OWL 2 EL)
  'Contusion (disorder)'
  and ('Role group (attribute)' some
    (('Associated morphology (attribute)' some 'Contusion - lesion
        (morphologic abnormality)') and
    ('Finding site (attribute)' some
        ('Index finger structure (body structure)' and
          ('Laterality (attribute)' some 'Left (qualifier value)')))))
- **DL Query / SPARQL**
  Subclasses of 'Wound (disorder)'

Querying – Preclassified Expression Repository

416462003 |Wound|

125667009 |Contusion|

125667009 |Contusion| **:**
  363698007 |Finding site| **=**
  7569003 |Finger structure|

125667009 |Contusion| **:**
  363698007 |Finding site| **=**
  29707007 |Toe structure|

125667009 |Contusion| **:**
  363698007 |Finding site| **=**
  83738005 |Index finger structure|

125667009 |Contusion| **:**
  363698007 |Finding site| **=**
  78883009 |Big toe structure|

125667009 |Contusion| **:**
  363698007 |Finding site| **=**
  (83738005 |Index finger structure| **:**
  272741003 |Laterality| **=** 7771000 |Left| **)**

125667009 |Contusion| **:**
  363698007 |Finding site| **=**
  (83738005 |Index finger structure| **:**
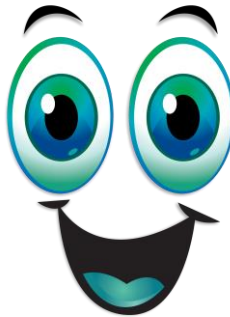 272741003 |Laterality| **=** 24028007|Right| **)**

Summary

Summary – SNOMED CT Expressions

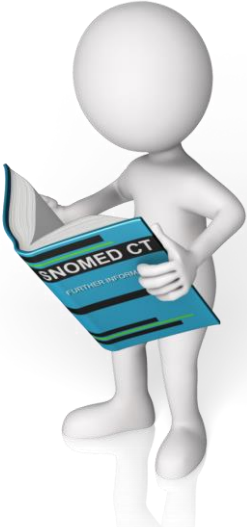*A structured combination of one or more concept identifiers used to represent a clinical meaning*

- Data entry and display
  - Free text with NLP
  - Predefined library of clinical phrases
  - Information model with expression templates
  - Expression builder
- Storage and retrieval
  - Separate fields for each attribute value
  - Expression string in code field
  - Expression ids and expression repository
- Exchange
  - Expression string or id in code field
- Query
  - Expression template, normalization, DL reasoner
  - Preclassified expression repository supports simple subsumption

Links to Further Information

- Technical Implementation Guide
  - http://snomed.org/tig
- Data Search and Entry Guide
  - http://snomed.org/searchguide
- Compositional Grammar
  - http://snomed.org/scg
- Expression Constraint Language
  - http://snomed.org/ecl

Questions and Discussion