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**Introduction to the
DTS 3.5 Object Model**

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Agenda

- Terminology Overview

- DTS Overview

- DTS Data Model

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Overview

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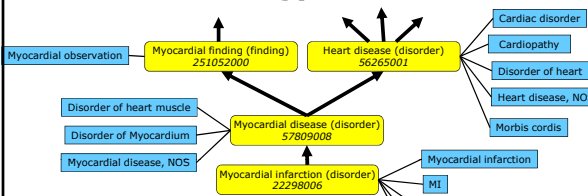## What is a Structured Terminology?

- A <u>structured</u> terminology is composed of *concepts* along with *synonymous terms*, *properties* and various relationships
- *Relationships*
  - Taxonomy (is-a)
  - Partonomy (part-of)
  - Etiology (caused-by)
  - Therapy (treated-by)
  - ...

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Terminology Elements

- *Concepts* <u>represent</u> unique ideas
- *Codes* uniquely <u>identify</u> concepts
- *Terms* <u>refer</u> to concepts
- Typically
  - Humans <u>communicate</u> concepts using terms
  - Computers <u>communicate</u> concepts using codes
- Concepts are language independent; terms are dependent
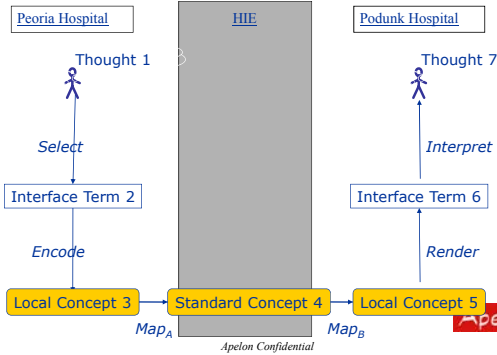
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Interplay among Terminology Elements

- Humans and computers
  - select, apply and transform
    - concepts, codes and terms
  - Across human languages
  - Across contexts (geographic, medical specialty, etc.)
  - Across applications
- Example scenario
  1. English *term* <u>entered</u> by clinician
  2. *Term* is <u>encoded</u> in SNOMED
  3. *Code* is <u>recorded</u> in Electronic Health *Record*
  4. *Record* is <u>retrieved</u>
  5. *Record* is <u>transmitted</u> to another application (perhaps in another institution)
  6. *Code* is <u>extracted</u>
  7. *Term* is <u>requested</u> by a nurse, e.g.,
    - Spanish term
    - Consumer term
    - Spanish consumer term
  8. *Term* is <u>displayed</u>

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Common Understanding

Peoria Hospital	HIE	Podunk Hospital

Thought 1 — Thought 7

Select — *Interpret*

Interface Term 2 — Interface Term 6

Encode — *Render*

Local Concept 3 → Standard Concept 4 → Local Concept 5

Map_A — Map_B

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Why Standard Terminology?

- Provide *consistent meaning*
- Promote *shared understanding*
- Facilitate *communication* with humans
- Enable *comparison* and *integration* of data
- Essential for *interoperation* among systems, applications and institutions
- Crucial for Electronic Health Record (EHR) *sharing* and *portability*
  - Health Information Exchange (HIE)
  - National Health Information Network (NHIN)

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Significant Applications

- Structured terminologies are needed in healthcare for
  - Reimbursement
  - Data integration
  - Decision support
  - Clinical guidelines
  - Medical error reduction
  - Clinical trials
  - Public health surveillance

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Standard Terminologies

- Clinical (SNOMED CT)
- Reimbursement (ICD, CPT, HCPCS)
- Pharmaceuticals (RxNorm, NDF-RT …)
- Labs (LOINC)
- Nursing (ICNP, NIC, NOC, NANDA)
- Adverse events (MedDRA, COSTART, WHOART)
- Genetics (GO)
- …

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What is DTS?

- An enterprise vocabulary server used to :
  - Acquire & maintain standards
  - Integrate and manage local code sets
  - Map/interrelate terminologies
  - Deploy in applications
- Originally developed as an Apelon commercial product, but now open source

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What Is a Terminology Server?

- A Terminology Server is:
  - a networked, software component
  - that centralizes terminology knowledge (e.g. national and international standards)
  - and provides *terminology services* to other network applications.

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Terminology Servers

- Terminology Servers are used:
  - By *informaticians* to create, extend, localize, and map terminologies
  - By *interface applications* to translate data elements between applications
  - By *clinical applications* to select and standardize data input

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Examples of Terminology Services

- Term/name normalization:
  What is SNOMED CT name for "heart attack"?   ***Myocardial Infarction***
- Code translation
  What is the ICD-9 code for *Myocardial Infarction?*   **410.9**
- Grouping and aggregation
  Is *Myocardial Infarction* a *Cardiac Disease*?   **Yes**
- Clinical knowledge
  What drug treats *Myocardial Infraction*?   **Streptokinase**
- Local information
  Add L227 as the local code for *Serum Calcium*.   **Okay**
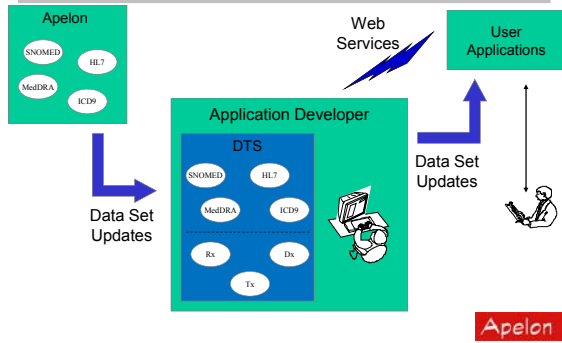
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DTS Components

- Knowledge Base (Content)
- Server
- Client API
- GUI applications
- Utilities and samples
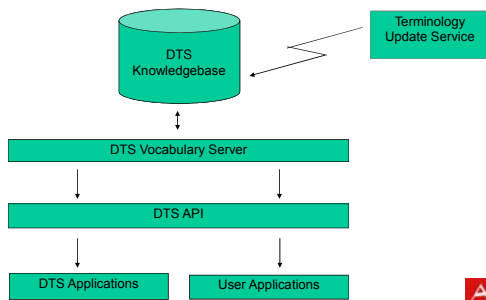- Subscription content service
- Professional support

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Apelon Terminology Model
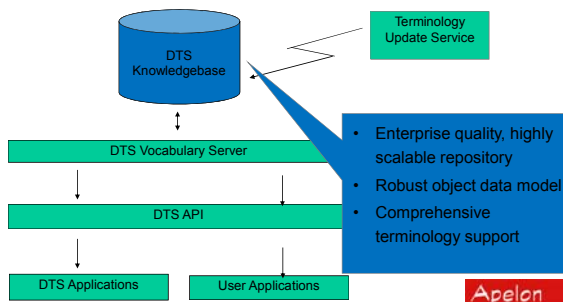

DTS Components

DTS Components

- Enterprise quality, highly scalable repository
- Robust object data model
- Comprehensive terminology support

DTS Knowledgebase

– Clinical framework (SNOMED CT)

– Reimbursement code sets w/mappings: ICD, CPT, HCPCS

– Multum and NDF-RT drug terminology and classification systems

– Nursing sets: NIC, NOC, and NANDA

– Adverse event terminologies MedDRA, COSTART, WHOART

– Mappings to MeSH and UMLS CUIs

– Apelon's Consumer Health Vocabulary (mappings to SCT)
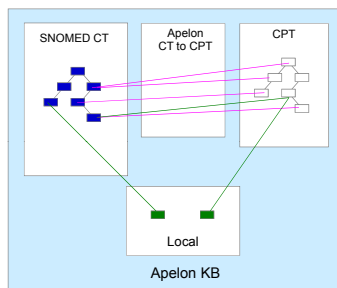
– Extensible with local additions

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Apelon KB Architecture

Subscription Namespaces
• Derived from industry sources
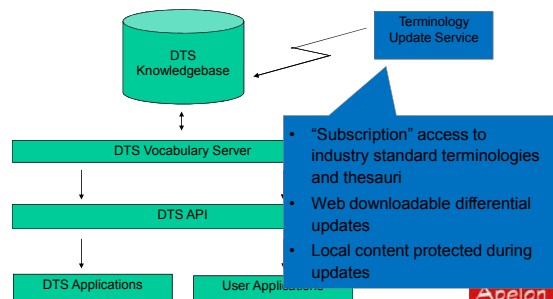• Provided by Apelon
• "Read only" in DTS

Local Namespaces
• Customer-specific data
  • Concepts
  • Properties
  • Associations (mappings)
  • Code and Value sets
• Protected during updates

SNOMED CT   Apelon CT to CPT   CPT

Local

Apelon KB

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DTS Components

DTS Knowledgebase

Terminology Update Service

DTS Vocabulary Server

DTS API

DTS Applications   User Applications

• "Subscription" access to industry standard terminologies and thesauri
• Web downloadable differential updates
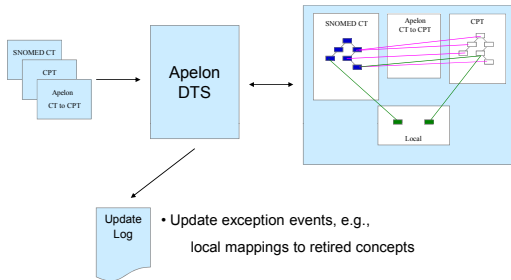• Local content protected during updates

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Terminology Update Service

- Subscription-based access to standard terminologies
- Simplifies terminology acquisition and management
  - Multiple data sources
  - Multiple (changing) data formats
  - Varying update frequencies
- Saves management time and development resources
- Maintains integrity of customer content and mappings
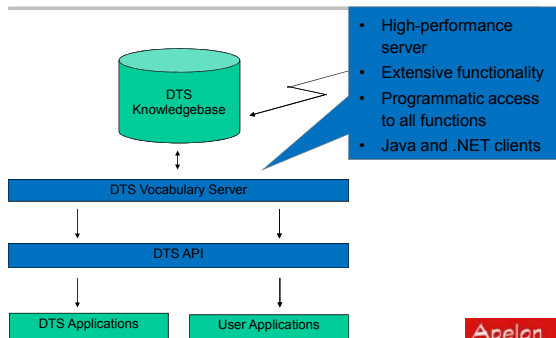- Easy updating with exception reporting

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Subscription Update Process

- Update exception events, e.g., local mappings to retired concepts

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DTS Components

- High-performance server
- Extensive functionality
- Programmatic access to all functions
- Java and .NET clients

DTS Knowledgebase

DTS Vocabulary Server

DTS API

DTS Applications

User Applications

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DTS Server

- Programmatic interface to terminology data

- Scalable, high-performance architecture

- Built on industry standard platforms:
  - Windows, J2EE, Oracle, .NET, SQL Server

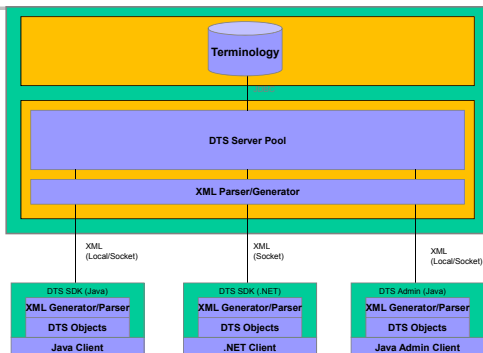- API (Java/.NET) provides access to all terminology

  functions

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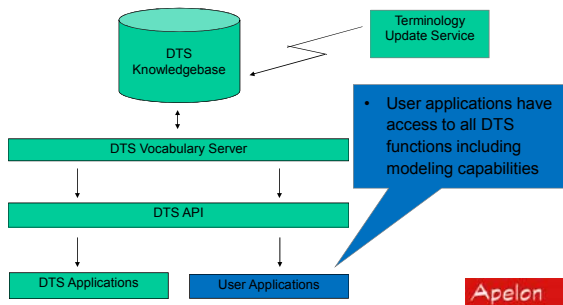

DTS Functionality

- API Services:
  - Search (w/spelling correction, stemming, contexts, etc.)
  - Navigation and code translation
  - Subsetting
  - Class/subsumption query
  - Localization

- Performance features:
  - Connection pooling
  - Concept caching
  - Multi-concept (batch) requests

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DTS Server Architecture

Terminology

DTS Server Pool

XML Parser/Generator

XML
(Local/Socket)

XML
(Socket)

XML
(Local/Socket)

DTS SDK (Java)	DTS SDK (.NET)	DTS Admin (Java)
XML Generator/Parser	XML Generator/Parser	XML Generator/Parser
DTS Objects	DTS Objects	DTS Objects
Java Client	.NET Client	Java Admin Client

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DTS Components

- User applications have access to all DTS functions including modeling capabilities

DTS Knowledgebase

Terminology Update Service

DTS Vocabulary Server

DTS API

DTS Applications

User Applications

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DTS Components

- DTS Browser
- DTS Editor
- TermWorks Web Services

DTS Knowledgebase

Terminology Update Service

DTS Vocabulary Server

DTS API

DTS Applications

User Applications
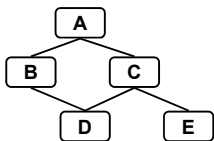
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Data Model

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Objective

Understand the basic Data Model used to represent terminology information in the Apelon Knowledge Base.

This understanding is a prerequisite for both content browsers, modelers and programmers using DTS.

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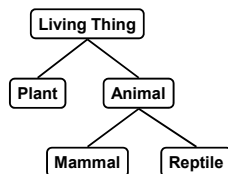
Background: *Hierarchy*

- **A** is the *parent* of B and C
- **D** is a *child* of B and C
- **A** is an *ancestor* of all the other concepts
- **E** is a *descendant* of **A** and **C**
- **A** is the *root*
- **D** and **E** are *leaves*
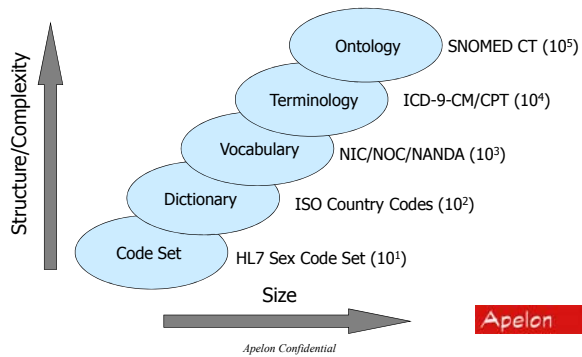
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Background: *Taxonomy*

- Generalization ("is-a") hierarchy
- Composed of concepts (ideas)
- Parents are more general than children
- Thus, ancestors are more general than descendants
- Root(s) are the most general concept(s)

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Nomenclatures

Structure/Complexity →

- Ontology — SNOMED CT (10^5)
- Terminology — ICD-9-CM/CPT (10^4)
- Vocabulary — NIC/NOC/NANDA (10^3)
- Dictionary — ISO Country Codes (10^2)
- Code Set — HL7 Sex Code Set (10^1)

Size →

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Data Model

- Crucial for understanding how to use DTS
- Today
  - Quick graphical overview
  - Outline of further details
- Caveats
  - Simplified view
  - Reflects Browser and Editor
  - API is more involved

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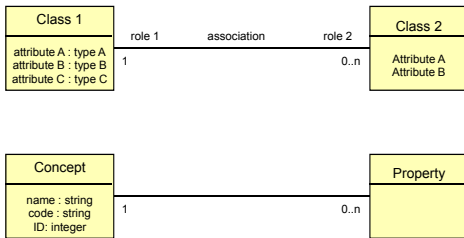## Background: UML Class Diagrams

- Classes
  - Name
  - Attributes
  - …
- Associations *
  - Name
  - Roles *
  - Cardinality
  - …
- …

* UML *roles* and *associations* are different from DTS *roles* and *associations* (the data modeling and knowledge representation community have historically used the names differently)
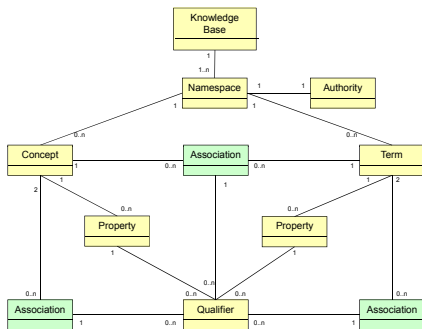
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Background: Generic and Specific Class Diagrams

Simplified DTS Data Model

DTS KB Objects

- The DTS KB consists of instances of basic DTS Objects:

Namespaces	Properties
Concepts	Roles
Terms	Associations
Synonyms	Qualifiers

- Every KB Object has:
  - A string Name - Preferably meaningful, e.g., "Myocardial Infarction"
  - A string Code – Preferably meaningless, e.g., "C98765"
  - An integer Id - Preferably meaningless, e.g., 98765
- The Name, Code, and Id must be unique within their associated Namespace

Simplified DTS Data Model
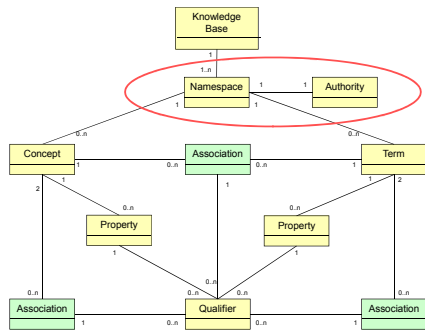
DTS KB Architecture

- Basic management unit is the *Namespace*
- A Namespace is a <u>logical</u> subdivision of the KB
- Defined as an authoritative point of view or content area (an Authority is the identifier for the supplier)
- Generally a single terminology
- Basic element of updates
- Basic element of security
  - Individual access privileges at Namespace level

DTS Namespace Types

|	Thesaurus	Ontylog	Extension
Modeling Tool for Content	DTS	TDE	DTS
Supports Apelon Supplied Content (Subscriptions)	Yes	Yes	No
Access Control	Read / Write Read Only (Subscription)	Read Only	Read / Write
Supports Local Content Modeling	Yes	No	Yes

DTS KB Architecture

Subscription Namespaces
- Ontylog or Thesaurus
- Derived from industry sources
- Provided by Apelon
- "Read only" in DTS

Local Namespaces
- Thesaurus & Extension
- Customer-specific data
  - Concepts
  - Properties
  - Associations (mappings)
- Protected during updates

SNOMED CT

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CT to CPT

CPT

Local

DTS KB
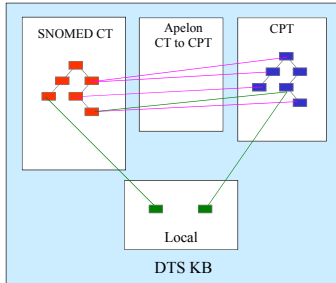
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Subscription Update Process

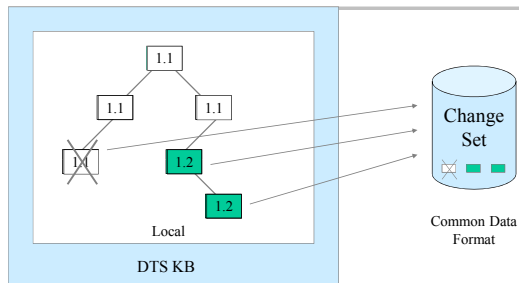- Updates to standard (external) terminologies are provided by Apelon
- Updates are downloadable Change Sets
  - Differential/incremental updates
  - Apelon Common Data Format (CDF)
- Update and Change Set utilities available to licensees
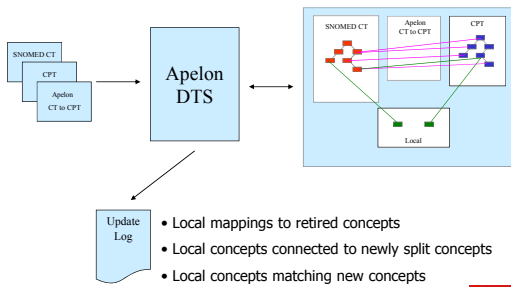
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Change Set Creation

1.1

1.1

1.1

1.1

1.2

1.2

Local

DTS KB

Change
Set

Common Data
Format

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Subscription Update Process

- Local mappings to retired concepts
- Local concepts connected to newly split concepts
- Local concepts matching new concepts

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Simplified DTS Data Model
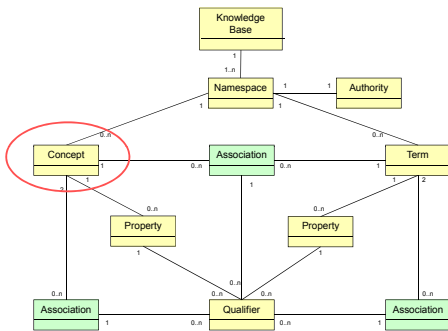
Concepts

- The foundational KB object is the *Concept*
- A *Concept* represents a unit of thought or meaning
- A *Concept* is "owned" by a specific *Namespace*
- *A Concept* should be unique within a *Namespace*
- Associated with a *Concept* are its *Attributes:*
  - *Properties*
  - *Synonyms*
  - *Roles*
  - *Associations*

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Concepts

Concept

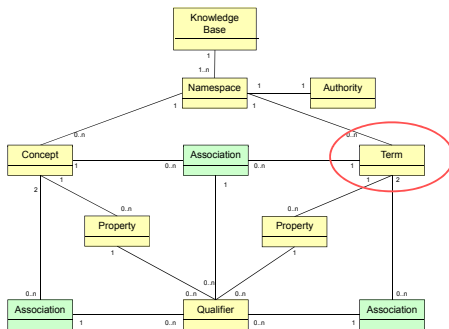Concept Name (String)   Myocardial infarction (disorder)
Concept Code (String)   D3-15000
Concept ID (int)   22298006
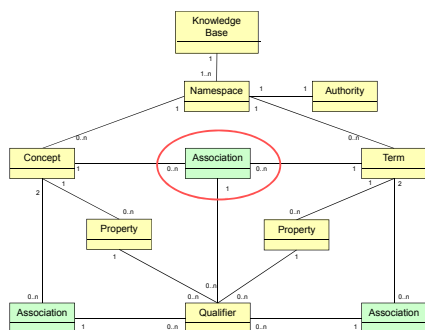Namespace   SNOMED CT

Simplified DTS Data Model

Terms

- Terms are words or phrases (commonly used to refer to concepts)
- A Term is "owned" by a specific *Namespace*
- Terms can also have their own *Attributes*
  - *Properties*
  - *Associations*

Simplified DTS Data Model

Synonyms

- A *Synonym* is a named relationship object between a *Concept* object and a *Term* object (a name)
- The relationship is an instance of an *Association Type*.
- *Synonym* triple: (*Synonym*) *Association Type, Term, Concept*
- The *Synonym Type, Term* and *Concept* can be from different Namespaces, aka "local Synonym"
- One (and only one) Synonym can be designated as the "Preferred Synonym"

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Synonyms (cont.)

Association Type = Local Synonym

Concept → Term

Name = Myocardial infarction   Name = Hurt heart
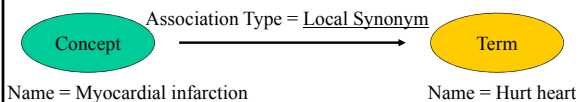
- A *Term* can be associated with multiple *Concepts*.

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Concepts

Concept

—	Concept Name (String)	Myocardial infarction (disorder)
—	Concept Code (String)	D3-15000
—	Concept ID (int)	22298006
—	Namespace	SNOMED CT
—	Synonyms	Synonym: Heart attack(Preferred
		Synonym: Infarction of the heart

Simplified DTS Data Model
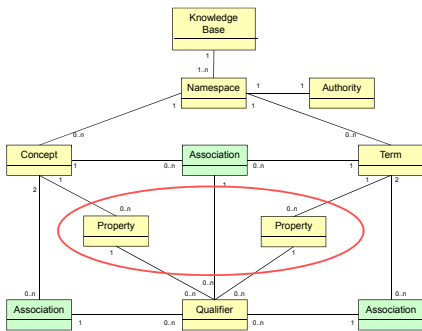
Properties

- A *Property* is an object (triple) that has a name/value pair associated with a *Concept*
  - Name is a *DTS Property Type* (another KB object)
  - Value is a string value
    - *Myocardial Infarction* → UMLS CUI: C0155626
- *Property Types* and *Properties* are "owned" by Namespaces that can be different from that of the Concept
    - Local Property Type = Local Code
- *Properties* are often used to encode operational data:
    - *Myocardial Infarction* → Specialty: Cardiology

Concepts

Concept

Concept Name (String)	Myocardial infarction (disorder)
Concept Code (String)	D3-15000
Concept ID (int)	22298006
Namespace	SNOMED CT
Synonyms	Synonym: Heart attack
	Synonym: Infarction of the heart
Properties	Concept Status - Current
	UMLS CUI – C0155626
	Local Code – Z76523

- Myocardial infarction (disorder)
  - Code: D3-15000
  - ID: 22298006
  - Namespace: SNOMED CT (Ontylog, Subscription, Read-Only)
  - Synonyms
    - ✱ Cardiac infarction
    - ✱ Cardiac infarction, NOS
    - ✱ Heart attack
    - ✱ Heart attack, NOS
    - ✱ *Hurt heart*
    - ✱ Infarction of heart
    - ✱ Infarction of heart, NOS
    - ✱ Myocardial infarction (Preferred)
    - ✱ Myocardial infarction (disorder)
    - ✱ Myocardial infarction, NOS
  - Properties
    - ▲ Concept Status: Current
  - Superconcepts
  - Subconcepts
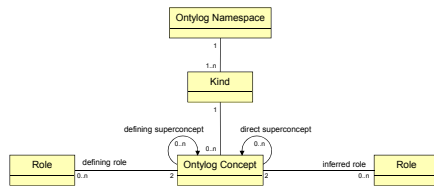 - Roles
  - Inverse Roles
  - Associations

Ontylog Namespaces

- Ontylog Namespaces (SNOMED CT) are based on Description Logic (DL) Formalisms
- DL enables provably consistent hierarchical structures (among other features)
- This results in additions to the basic Object Model:
  - SuperConcepts (Parents)
  - Subconcepts (Children)
  - Roles
  - Kind

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DL Aspects of DTS Data Model

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Parents and Children

- *Concepts* in Ontylog and Thesaurus *Namespaces* have hierarchical relationships
- More general *Concepts* are known as *Parents* or *Superconcepts*
- More specific *Concepts* are known as *Children* or *Subconcepts*
- *Ontylog Namespaces* use the *Superconcept* and *Subconcept* attributes
- *Thesaurus Namespaces* (usually) use a *Parent Of Concept Association*

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Hierarchies

Concept
Name = Myocardial disease

Concept
Name = Structural disorder …

Parents

Concept
Name = Myocardial infarction

Children

Concept
Name = Acute Myocardial infarction

Concept
Name = Microinfarct of heart

```
☐─● Myocardial infarction (disorder)
   ├─▣ Code:  D3-15000
   ├─▣ ID:  22298006
   ├─▣ Namespace:  SNOMED CT ( Ontylog, Subscription, Read-Only )
   ├─⊞ 📁 Synonyms
   ├─⊞ 📁 Properties
   ├─☐ 📁 Superconcepts
   │     ├─🔍 Myocardial disease (disorder)
   │     └─🔍 Structural disorder of heart (disorder)
   ├─☐ 📁 Subconcepts
   │     ├─● Acute myocardial infarction (disorder)
   │     ├─● First myocardial infarction (disorder)
   │     ├─● Microinfarct of heart (disorder)
   │     ├─● Myocardial infarction with complication (disorder)
   │     ├─● Old myocardial infarction (disorder)
   │     ├─● Other specified anterior myocardial infarction (disorder)
   │     ├─● Postoperative myocardial infarction (disorder)
   │     ├─● Silent myocardial infarction (disorder)
   │     ├─● Subsequent myocardial infarction (disorder)
   │     └─● True posterior wall infarction (disorder)
   ├─⊞ 📁 Roles
   ├─⊞ 📁 Inverse Roles
   └─⊞ 📁 Associations
```
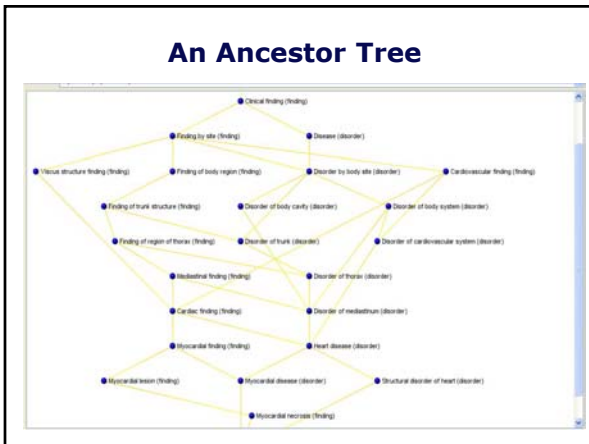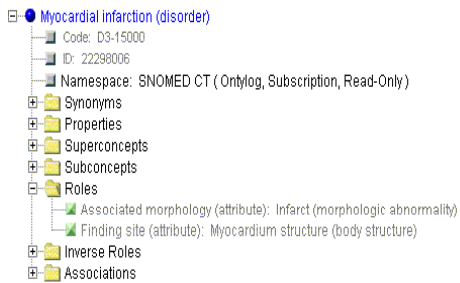
An Ancestor Tree

Relationships

- Relationship *Attributes* have a relationship *Type* and connect one *Concept* to another *Concept*
- The *Concepts* can be in the same or different *Namespaces*
- Types of Relationships include:
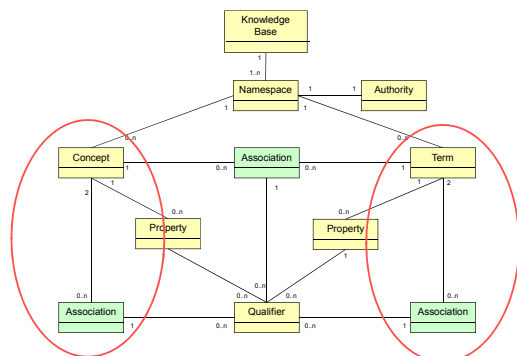 - *Roles Types*
  - *Associations Types*

Roles

- *Roles* are relationships created by Apelon (or our customers) in Ontylog and Extension *Namespaces*
- *Roles* are used by Apelon's Description Logic classifier to build hierarchies
- *Roles* make explicit key relationships between *Concepts* in one *Namespace*:

  Myocardial Infarction has finding site *Myocardium*

- An instance of a *Role* has a *Role Type* (finding site) and a *from* and *to Concept*
- New *Role Types as well as Role* instances can be created in Extension *Namespaces (as of 3.5)*

□ ● Myocardial infarction (disorder)
   — Code: D3-15000
   — ID: 22298006
   — Namespace: SNOMED CT (Ontylog, Subscription, Read-Only)
  ⊞ Synonyms
  ⊞ Properties
  ⊞ Superconcepts
  ⊞ Subconcepts
  ⊟ Roles
    — Associated morphology (attribute): Infarct (morphologic abnormality)
    — Finding site (attribute): Myocardium structure (body structure)
  ⊞ Inverse Roles
  ⊞ Associations

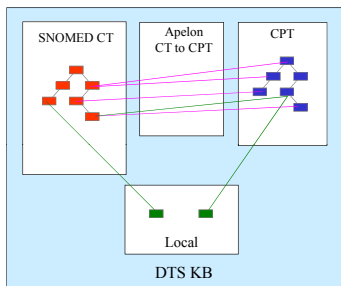
Simplified DTS Data Model

Associations

- *Associations* are general relationships between *Concepts (or Terms)*
- *Concepts* can be in the same or different *Namespaces*

  Myocardial infarction has onset *Gradual onset*
- An *Association* triple has an *Association Type* (has onset) and a *from* and *to Concept*
- *Associations* are commonly used for "mappings" (*Associations* connecting *Concepts* in two different *Namespaces* used to designate equivalence)
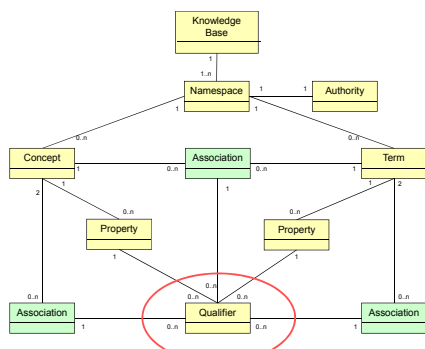
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Associations

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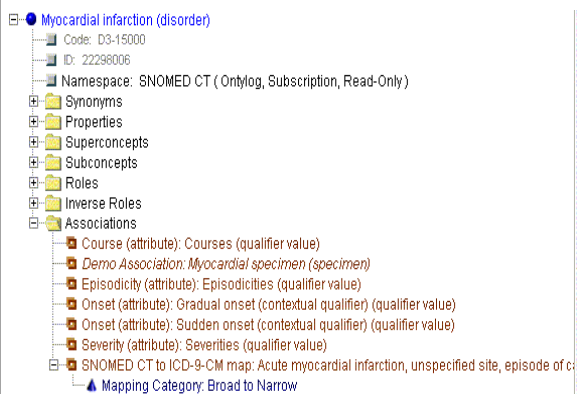

Simplified DTS Data Model

Qualifiers

- *Association* and *Property* instances can have one or more *Qualifiers* associated with them.
- *Qualifiers* are used to provide additional information on the *Attributes*:

  Date of Change: 08/26/2005

  Mapping Category: Broad to Narrow

- An instance of an *Qualifier* has an *Qualifier Type* (Mapping Category) and a string value ("Broad to Narrow")

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```
⊟──● Myocardial infarction (disorder)
    ──▤ Code: D3-15000
    ──▤ ID: 22298006
    ──▤ Namespace: SNOMED CT (Ontylog, Subscription, Read-Only)
   ⊞──📁 Synonyms
   ⊞──📁 Properties
   ⊞──📁 Superconcepts
   ⊞──📁 Subconcepts
   ⊞──📁 Roles
   ⊞──📁 Inverse Roles
   ⊟──📁 Associations
       ──🔲 Course (attribute): Courses (qualifier value)
       ──🔲 Demo Association: Myocardial specimen (specimen)
       ──🔲 Episodicity (attribute): Episodicities (qualifier value)
       ──🔲 Onset (attribute): Gradual onset (contextual qualifier) (qualifier value)
       ──🔲 Onset (attribute): Sudden onset (contextual qualifier) (qualifier value)
       ──🔲 Severity (attribute): Severities (qualifier value)
      ⊟──🔲 SNOMED CT to ICD-9-CM map: Acute myocardial infarction, unspecified site, episode of c
          ──▲ Mapping Category: Broad to Narrow
```
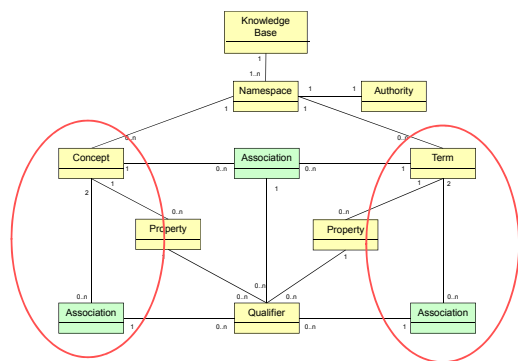
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Simplified DTS Data Model

Inverse Relationships

- *Roles* and *Associations* have a preferred direction
- DTS provides capabilities for search and retrieval by the inverse of these relationships
- The Inverse Relationship can be given a different name or declared to be non-displayed:

  A treats *B* ↔   *B* is-treated-by *A*
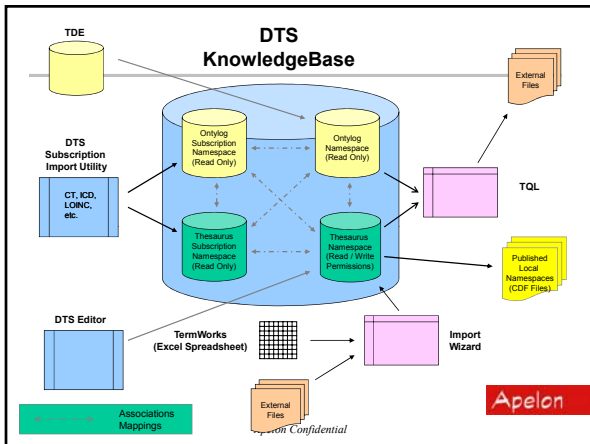
  This assignment is made on the *Association/Role Type*

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Object Model Summary

- Terminology data is structured in *Namespaces*
- A *Namespace* contains *Concepts* and associated *Attributes*
- Every *Concept* has a namespace-unique Name, Code and Id
- Subscription *Concepts* have pre-defined *Parents* and *Children*
- *Properties* are used to associate string data with *Concepts*
- *Roles* and *Associations* are *Concept*-to-*Concept* connections
- *Properties* and *Associations* can have *Qualifiers*

TDE

DTS KnowledgeBase

External Files

Ontylog Subscription Namespace (Read Only)

Ontylog Namespace (Read Only)

DTS Subscription Import Utility

CT, ICD, LOINC, etc.

TQL

Thesaurus Subscription Namespace (Read Only)

Thesaurus Namespace (Read / Write Permissions)

Published Local Namespaces (CDF Files)

DTS Editor

TermWorks (Excel Spreadsheet)

Import Wizard

Associations Mappings

External Files

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Questions?

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Medical terminology in practice