Plan for Today's Lecture(s)

- Introduction to Relationships and Structures
- Semantic Perspective
- Lexical Perspective

UNIVERSITY OF CALIFORNIA, BERKELEY
SCHOOL OF INFORMATION

INFO 202
"Information Organization & Retrieval"
Fall 2013

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3 October 2013
Lecture 11.1 – Introduction to Relationships and Structures

Defining "Relationship"

- “An association among several things, with that association having a particular significance”
- “Relationships are the stuff out of which information is made”
- The reason is an important part of the relationship
- Multiple relationships can exist among the same objects, so the order of the objects matters

Relationship != Relation

- In mathematics and computer science a “relation” is a set of ordered elements (“tuples”) of equal degree
- A binary relation is a set of element pairs, a ternary relation is a set of 3-tuples, and so on.
- The elements in each tuple are “related” but they do not need to have any “significant association” or “relationship” among them

Five Perspectives on Relationships (1)

- SEMANTIC: the meaning of the association
- LEXICAL: how the conceptual description of a relationship is expressed using words in a specific language
- STRUCTURAL: analyzes the patterns of association, arrangement, proximity, or connection between resources

Five Perspectives on Relationships (1)

- ARCHITECTURAL: emphasizes the number and abstraction level of the components of a relationship, which together characterize its complexity
- IMPLEMENTATION: how the relationship is implemented in a particular notation and syntax and the manner in which relationships are arranged and stored in some technology environment.

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Lecture 11.2 – The Semantic Perspective on Relationships

The Semantic Perspective on Relationships

- The essence of relationships; why the resources are related
- Relies on or expresses information that is not directly available from perception
- “Homer is married to Marge" is a semantic assertion; "Homer is standing next to Marge" is not
- It is difficult to define what a relationship means in a non-circular way that doesn't rely on lots of undefined relationships...

Making Sense (1)

I saw :	with :
a Man	a Telescope
a Star	a Microscope
a Molecule	Binoculars

How many of these 9 combinations make sense?

Making Sense (2)

- Draw a diagram that represents these assertions:
  - "Mary and Sue are sisters“
  - "Sally and Martha are mothers”
- Now try:
  - “Bob saw the plane flying over Denver”
  - “Bob saw the mountains flying over Denver”

Language and Meaning

- Words and sentence structure only hint at meaning
- Meaning is constructed not just from the literal language used, but from all the clues or cues in the context of use -- common knowledge, assumptions, previous discourse, the present situation, and inferences from all of these

Specifying Semantic Relationships

- "A sequence of categories, that includes one thing from each category“ (Kent)
- Predicate/Argument Syntax:

  is-married-to (Homer Simpson, Marge Simpson)

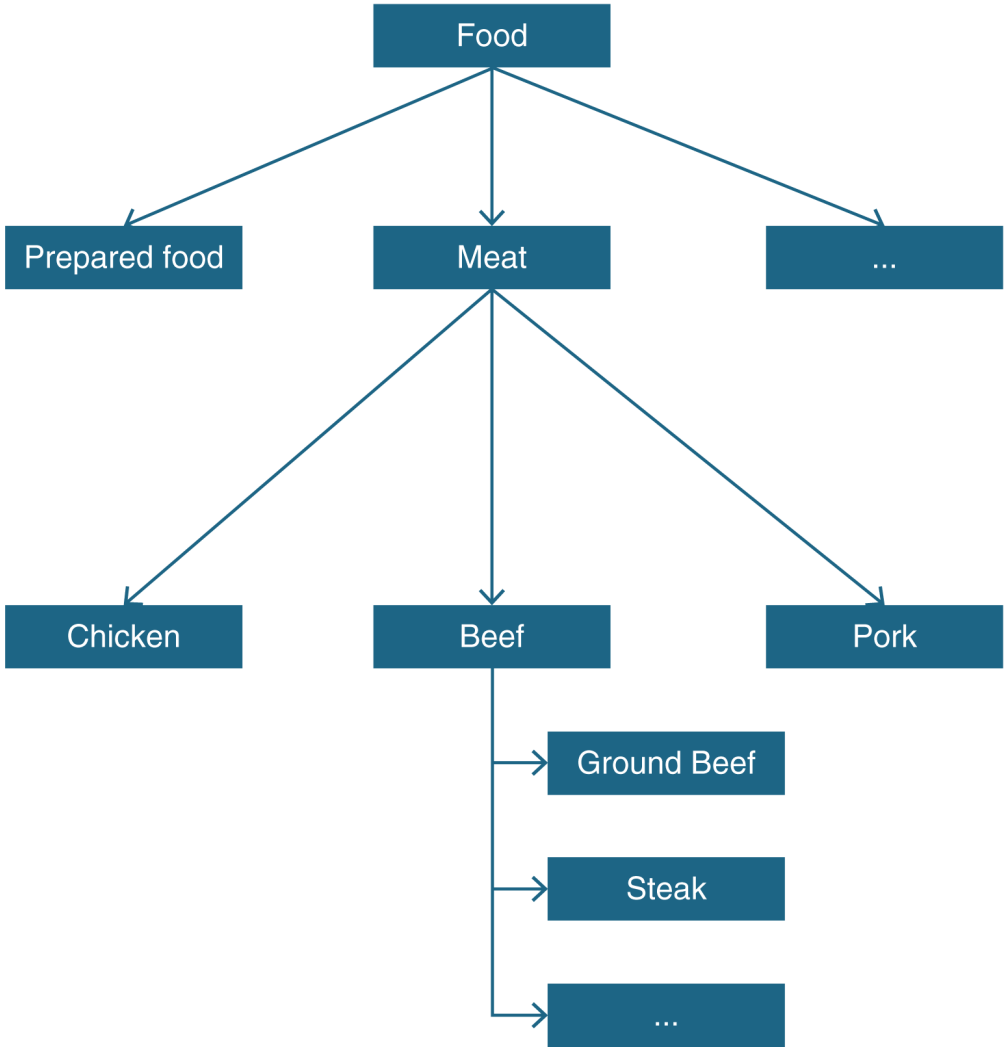
- Subject / Predicate / Argument Syntax:

  Homer Simpson => is-married-to => Marge Simpson

The Semantics of "Inclusion"

- One class or type of resources logically contains another; predicate is usually *is-a* or "*is-a-type-of*"
- A set of interconnected class inclusion relationships defines a HIERARCHY or TAXONOMY
- An inclusion relationship between an instance and a class -- assigning an instance to a class - is CLASSIFICATION

A PARTIAL TAXONOMY OF FOOD

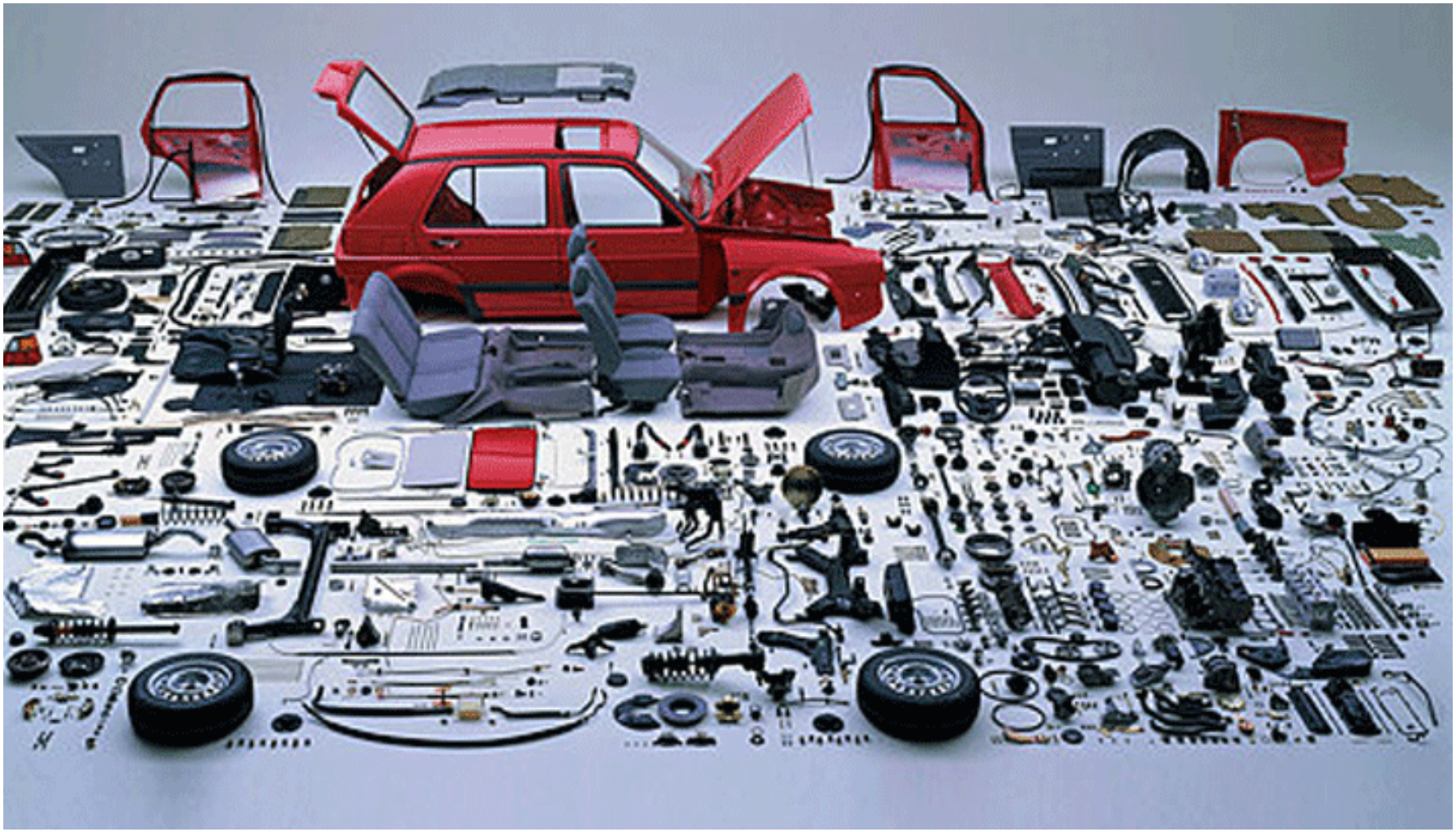


TDO
Figure 5.1

Part-Whole or Meronymic Inclusion

- A resource class or instance physically, topologically, or temporally contains another
  - The engine is part of the car
  - The Napa Valley is part of Northern California
  - Extra time is part of a football match
- expressed using “is-part-of,” “is-partly,” or with other similar predicate expressions

Part-Whole Relationship (Component-Object)



The Semantics of "Attribution"

- In contrast to inclusion expressions that state relationships between resources, attribution relationships assert or assign values to properties for a particular resource
- Attribution can be thought of as a binary relationship whose predicate has a single argument:

  Martin the Gecko => is-small

  "Title" : "Moby Dick"
- Or with two arguments:

  Martin => has-size => small

Properties of Semantic Relationships: Symmetry (1)

- SYMMETRY: the order in which the arguments of a binary relationship doesn't matter

  Homer Simpson => is-married-to => Marge Simpson

  Marge Simpson => is-married-to => Homer Simpson

Properties of Semantic Relationships: Symmetry (2)

- Relationships that are symmetric are also called BI-DIRECTIONAL
- ASYMMETRIC relationships are those where the order of the arguments matters

Homer Simpson => is-parent-of => Bart Simpson

Properties of Semantic Relationships: Transitivity (1)

- TRANSITIVITY: if X and Y have a relationship, and Y and Z have the same relationship, then X also has the relationship with Z

Homer Simpson => is-taller-than => Bart Simpson

Bart Simpson => is-taller-than => Maggie Simpson

IMPLIES THAT

Homer Simpson => is-taller-than => Maggie Simpson

Properties of Semantic Relationships: Transitivity (2)

- Any relationship based on inclusion or ordering is transitive
- Ordering includes numerical, alphabetic, and chronological relationships as well as those that imply qualitative or quantitative measurement

Properties of Semantic Relationships: Equivalence

- Any relationship that is both symmetric and transitive is an EQUIVALENCE relationship
- We often need to assert that a particular class or property has the same meaning as another class or property or that it is generally substitutable for it

Properties of Semantic Relationships: Inverse

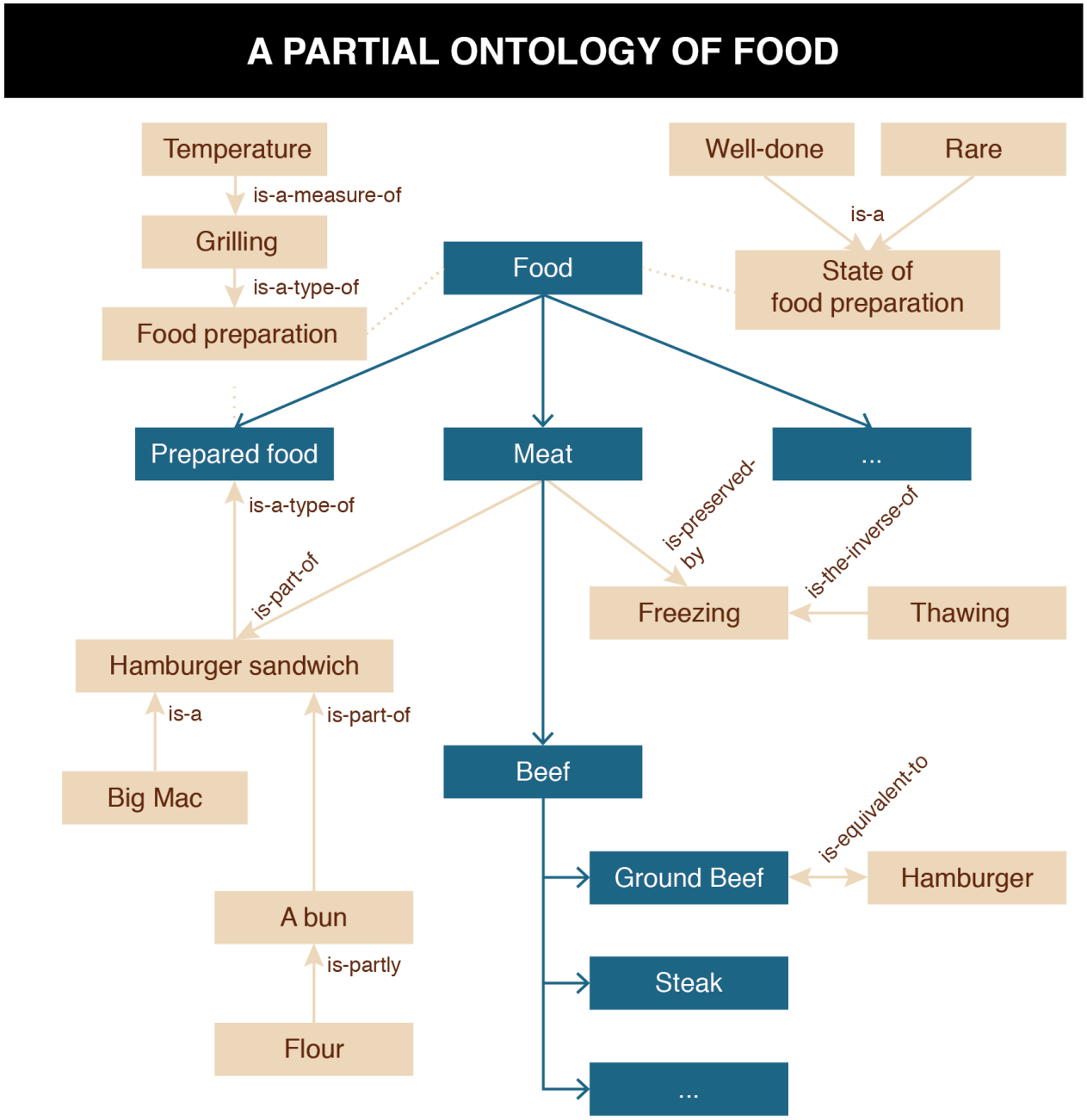
- For asymmetric relationships, it is often useful to be explicit about the meaning of the relationship when the order of the arguments in the relationship is reversed
- The resulting relationship is called the INVERSE or the converse of the first relationship

Ontology

- An ontology defines the concepts and terms used to describe and represent some domain or area of knowledge
- To fully understand a domain you need to know class and part-whole inclusion, attribution, equivalence, and many other relationships about and between the resources it contains
- Class inclusion relationships can form a kind of backbone or framework to which other kinds of relationships attach, creating a network of relationships

Analyzing the Definition of Ontology

- The word ontology has been used to describe artifacts with different degrees of structure that differ:
  - ... according to how precisely the terms are defined
  - ... according to how precisely the relationships among them are expressed
- So the simplest ontology is a dictionary
- A thesaurus is a somewhat more complex ontology
- More complete ontologies are expressed using formal logic-based language



TDO Figure 5.2

Ontological Assertions That Annotate the Food Taxonomy

Hamburger → is-equivalent-to → Ground Beef
Hamburger → is-prepared-by → Grilling
Grilling → is-a-type-of → Food Preparation
Hamburger Sandwich → is-a-type-of → Prepared Food
BigMac → is-a → Hamburger Sandwich
A bun → is-part-of → Hamburger Sandwich
A bun → is-partly → flour
Temperature → is-a-measure-of → Grilling
Rare → is-a → State of Food Preparation
Well-done → is-a → State of Food Preparation
Meat → is-preserved-by → Freezing
Thawing → is-the-inverse-of → Freezing

Ontologies and the "Vocabulary Problem"

- The Artificial Intelligence solution (for computers) to the vocabulary problem is to give an information system all the knowledge -- including "commonsense" -- that is needed to interpret every user's expressions in every context
- A great deal of work in AI has been dedicated to building knowledge bases to support language understanding, reasoning, problem solving applications
- The most famous / infamous effort is the Cyc project (http://www.cyc.com)

Cyc – Formalized Commonsense Knowledge

- Cyc knows a few hundred thousand basic concepts and a few million human-entered assertions about the world -- "facts, rules of thumb, and heuristics for reasoning about the objects and events of everyday life“
- The Cyc knowledge base consists of terms and assertions that relate those terms
- This kind of common sense is a pre-requisite for computers to achieve anything approaching human competence on natural language processing tasks (once you get outside of narrow, constrained domains)
- How will Cyc change the world in the next 10 years?

SNOMED

- Systematized Nomenclature of Medical-Clinical Terms, http://www.ihtsdo.org/snomed-ct/
- Important aid in accurately recording "healthcare encounters" to improve communication and interoperability among information systems, especially electronic health records
- Contains over 300,000 concepts and formal definitions, organized in several different hierarchies to enable terms to be located and interrelated from different perspectives

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Lecture 11.3 – Lexical Perspective on Relationships

The Lexical Perspective on Relationships

- A prototypical word is the minimal "meaning bearing" element of language
- Words express concepts and relationships, but not all concepts and relationships have words for them (are "lexicalized")
- These "lexical gaps" differ from language to language
- Whereas "conceptual gaps" -- the things we can't think of -- may be innate and universal

Linguistic Relativity in Iceland

Relationships Among Words / Relationships Among Concepts

- Representing the relationships among words is a task for linguistics and cognitive science
- In contrast, representing the relationships among concepts is a task for computer science (e.g., ontologies like Cyc)
- Understanding both kinds of relationships is essential for designers of organizing systems

Relations Among Words

- Hyponymy/Hyperonymy
- Metonymy
- Synonymy
- Polysemy
- Antonymy

Hyponymy/Hyperonymy

- When words encode IS-A or inclusion relationships, the word for the more specific class is the HYPONYM and the other is the HYPERNYM
- So there can be a "lexical hierarchy" that represents the "semantic hierarchy"
- Often used to situate "basic categories" with respect to superordinate and subordinate categories

Hyponymy/Hyperonymy

- A is a hyponym of B if A is a type of B
- A robin is a hyponym of bird
- A is a hypernym of B if B is a type of A
- An animal is a hypernym of bird

A Formula for Definitions

hyponym = {adjective+} hypernym {distinguishing clause+}

- Robin = Migratory BIRD with clear melodious song, a reddish breast, gray or black upper plumage
- Doesn't mention every characteristic of hyponym, only those needed to distinguish from other hyponyms

Metonymy

- The lexical representation of or analogy to part-whole or meronymic relationships
- Using one aspect of something to stand for the whole
  - "Bank" as building stands for the institution of the "bank"
  - "The White House released new budget figures today"

Synonymy

- Synonyms are different word forms that can express the same concept
  - cat, feline, Siamese cat
- Absolute synonyms that can always substitute for each other probably don't exist
- Propositional synonyms are those where substituting one for another isn’t likely to change the truth value of the statement

Polysemy

- Many "word forms" (particular spelling patterns) are polysemous with multiple senses established in the language -- they are semantically ambiguous

  - That dog has floppy ears
  - She has a good ear for jazz.

- "bank" (financial) has related senses:

  - a building (the bank on Shattuck)
  - specific financial firm (Wells Fargo)
  - where money is kept (abstract notion)
  - where anything of value is kept (more abstract)

Polysemy vs Homonymy

- A HOMOGRAPH is a word with multiple senses that are not conceptually related

  - bank (financial sense)
  - bank (river sense)

- But what looks like homography may be polysemy from a historical perspective

  - mole (an animal that digs holes; an infiltrating spy)

- HOMOPHONES are words with the same pronunciation but different spellings and meanings

  - to, two, too; might, mite; clawed, claude

Antonymy

- Antonyms are lexical opposites
- Some are inherently binary “true antonyms”
  - dead / alive, true / false, on / off
- Others are "graded"
  - long / short, hot / cold
- Markedness: if one member of a pair is more restricted in its contexts it can stand out psychologically
  - long is unmarked, short is marked

Thesauri

- A THESAURUS is a tool for finding the "right" or "good" terms of a controlled vocabulary
- It is a collection of vocabulary terms annotated with lexical relationships to indicate terms that are:
  - Preferred (UF "used for")
  - Broader (BT "broader term")
  - Narrower (NT "narrower term")
  - Related (RT "related term" or "see also")
  - USE in a thesaurus refers the reader from a variant term to a preferred term; the inverse of UF

Examples from Food Domain (TDO 5.4.2)

Food BT Meat
Beef NT Meat
Food UF Sustenance, Nourishment
Food RT Cooking, Dining, Cuisine

Victuals USE Food

WordNet

- Another "ontological resource" -- a "semantic dictionary" - started in 1985 by George Miller and others at Princeton's Cognitive Science program
  - over 100,000 nouns in 80,000 “synonym sets”
  - 11000 verbs in 13000 synsets
- Instead of using spelling as the primary organizing principle for words, it uses their semantic properties and relationships
- Designed as a network to capture the idea that words and concepts are an interrelated system

Using WordNet

- The WordNet database is freely downloadable from http://wordnet.princeton.edu/
- http://www.synonym.com/ is easier to work with
- The Visual Thesaurus is a commercial product that uses WordNet (http://www.visualthesaurus.com)
- WordNet is very commonly used in natural language processing research and applications
- Most important automated use of WordNet is in sense disambiguation, identifying a sense based on contexts in which it occurs

Implications for Vocabulary Design

- Choosing vocabulary terms, and precisely defining their semantics, is essential but impossible to do perfectly
- Your vocabulary must express what YOU intend, so you "look inward" -- analyze how you think about a domain
- You want others to understand what you mean, so you need to "look outward" -- analyze the terms used by your users, competitors, or subject matter experts
- You should reuse other vocabularies or thesauri if they exist, especially for any "horizontal" components, to improve transformability and interoperability
- But these three approaches may suggest different terms

Readings for Next Lecture

- rest of TDO 5
- TDO 8 through 8.2.1.5
- Glushko, Robert J. – "Modeling Methods and Artifacts for Crossing the Data/Document Divide", people.ischool.berkeley.edu/~glushko/glushko_files/GlushkoXML2005.pdf
- www.oasis-open.org/org
- Getting started with schema.org schema.org/docs/gs.html