Example: Normalization

\[
\text{WellRoundedCo} \equiv \\
[\text{AND } \text{Company } [\text{ALL } : \text{Manager} \\
[\text{AND } \text{B-SchoolGrad} \\
[\text{Exists 1 } : \text{TechnicalDegree}]]]
\]

\[
\text{HighTechCo} \equiv \\
[\text{AND } \text{Company } [\text{FILLS } : \text{Exchange nasdaq} \\
[\text{ALL } : \text{ManagerTechie}]]
\]

\[
\text{Techie} \equiv \\
[\text{EXISTS 2 TechnicalDegree}]
\]

\[
[\text{AND WellRoundedCo HighTechCo}]
\]
Example: Subsumption

\[\text{AND Company} \]
\[\text{ALL :Manager} \]
\[\text{AND B-SchoolGrad} \]
\[\text{EXISTS 2 TechnicalDegree} ]\]
\[\text{FILLS :Exchange nasdaq} ]\]

\[\text{AND LegalEntity} \]
\[\text{ALL :Manager B-SchoolGrad} ]\]

(Company \sqsubseteq \text{LegalEntity})
Structure Mapping

\[ KB \models (d \sqsubseteq e) \]

**IDEA:** For \( d \) to be subsumed by \( e \), the normalized \( d \) must account for each component of the normalized \( e \) in some way.
**Structure Mapping Procedure**

**Input:** Two normalized concepts $d$ and $e$ where $d$ is of the form $[\text{AND} \, d_1 \ldots d_m]$ and $e$ is of the form $[\text{AND} \, d_1 \ldots d_m]$

**Output** yes or no, according to whether $KB \models (d \sqsubseteq e)$

Return yes iff for each component $e_j$, there exists a component $d_i$ such that $d_i$ matches $e_j$ as follows:

1. if $e_j$ is an atomic concept, then either $d_i$ is identical to $e_j$, or there is a sentence of the form $(d_i \sqsubseteq d')$ in the KB, where recursively some component of $d'$ matches $e_j$;

2. if $e_j$ is of the form $[\text{FILLS} \, r \, c]$, then $d_i$ must be identical to it;

3. if $e_j$ is of the form $[\text{EXISTS} \, n \, r]$, then the corresponding $d_i$ must be of the form $[\text{EXISTS} \, n' \, r]$, for some $n' \geq n$; if $n = 1$, then $d_i$ may be of the form $[\text{FILLS} \, r \, c]$;

4. if $e_j$ is of the form $[\text{ALL} \, r \, e']$, then $d_i$ must be of the form $[\text{ALL} \, r \, d']$, where recursively $d'$ is subsumed by $e'$. 
Taxonomies and Classification

• Given some query concept \( q \), find all \( c \) in KB such that

\[
KB \models (c \rightarrow q)
\]

• Given some constant \( c \), find all atomic concepts \( a \) such that

\[
KB \models (c \rightarrow a)
\]
Consider adding a sentence \((a \equiv d)\) to a taxonomy.

1. First calculate \(S\), the most specific subsumers of \(d\)

   The atomic concepts \(a\) such that
   \(KB \models (d \sqsubseteq a)\) but there is no \(a'\) distinct from \(a\) such that
   \(KB \models (d \sqsubseteq a')\) and \(KB \models (a' \sqsubseteq a)\)

2. Next calculate \(G\), the most general subsumees of \(d\).

   The atomic concepts \(a\) such that
   \(KB \models (a \sqsubseteq d)\) but there is no \(a'\) distinct from \(a\) such that
   \(KB \models (a' \sqsubseteq d)\) and \(KB \models (a \sqsubseteq a')\)
3. If there is a concept $a'$ in $S \cap G$, then the concept is already present.

4. Otherwise, insert $a$.

5. Handle Constants
Computing (cont)

1. Computing most specific subsumers.

2. Computing the most general subsumees.
Example: Classification

Surgeon =

[AND Doctor

[FILLS :Specialty surgery]]
Extensions

- [AT-MOST $n$ $r$]
- [ONE-OF $c_1 \ldots c_n$]
- [SAME-AS $r_1$ $r_2$]
- Qualified Number Restriction
  
  [EXISTS $n$ $r$ $d$]
Classification (cont)

1. Answering Questions
2. Taxonomies and Frame Hierarchies
3. Inheritance