Object-Oriented Representation

• Knowledge as structured and organized in terms of what the knowledge is about, the objects of knowledge.

• Objects with parts, constraints

• Frame (Minsky 1975)
Frames

- Individual Frames – to represent single objects
- Generic Frames – to represent categories of objects.
- slots, fillers

(Frame-name
  <slot-name1 filler1>
  <slot-name2 filler2>
  ....)

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Individual Frames: Example

(tripLeg123
  <:INSTANCE-OF TripLeg>
  <:Destination toronto>..)

(toronto
  <:INSTANCE-OF CanadianCity>
  <:Province ontario>
  <:Population 4.5M>..)
(CanadianCity
   <:IS-A City>
   <:Province CanadianProvince>
   <:County canada>..)

(Table
   <:Clearance [IF-NEEDED ComputeClearanceFromLeg...
   ...

(Lecture
   <:DayOfWeek WeekDay>
   <:Date [IF-ADDED ComputeDayOfWeek]>..
   ..)
Inheritance

(Table
  <:Clearance [IF-NEEDED ComputeClearanceFromLegs...])

(CoffeeTable
  <:IS-A Table>...)

(MahoganyCoffeeTable
  <:IS-A CoffeeTable>..)
Inheritance (defaults)

(Elephant
  <:IS-A Mammal>
  <:EarSize large>
  <:Color gray>...)

(raja
  <:INSTANCE-OF Elephant>
  <:EarSize small>..)

(RoyalElephant
  <:IS-A Elephant>
  <:Color white>...)

(clyde
  <:INSTANCE-OF RoyalElephant>
  ..)
Reasoning with Frames

1. a user or external system declares that an object exists, thereby instantiating some generic frame;

2. any slot fillers that are not provided explicitly, but can be inherited, are computed;

3. for each slot with a filler, any **IF-ADDED** procedure that can be inherited is run, possibly causing new slots to be filled, or new frames to be instantiated, and the cycle repeats.
Description Logics

• Objects fall into classes.
• Some classes are more general than others.
• Objects have parts.
• concepts, roles constants
Logical Symbols

1. *punctuation*: “[”, “]”, “(”, “)”;
2. *positive integers*: 1, 2, 3, etc.
3. *concept-forming operators*:
   “ALL”, “EXISTS”, “FILLS”, “AND”;
Non-Logical Symbols

1. *atomic concepts*: written in capitalized mixed case, e.g., *Person*, *WhiteWine*, *FatherOfOnlyDaughters*; and a special atomic concept *Thing*.

2. *roles*: written like atomic concepts, but preceded by “:”, e.g., :Child, :Height, :Employer, :Arm.

3. *constants*: written in uncapitalized mixed case, e.g. *table13*, *maryAnnJones*. 
Syntactic expressions

There are four types of syntactic expressions:

1. *constants*
2. *roles*
3. *concepts*
4. *sentences*
The set of concepts of $\mathcal{DL}$ is the least set satisfying:

- every atomic concept is a concept;
- if $r$ is a role and $d$ is a concept, then $[\text{ALL } r \ d]$ is a concept;
- if $r$ is a role and $n$ is a positive integer, then $[\text{EXISTS } n \ r]$ is a concept;
- if $r$ is a role and $c$ is a constant then, $[\text{FILLS } r \ c]$ is a concept;
- if $d_1 \ldots d_n$ are concepts, then $[\text{AND } d_1 \ldots d_n]$ is a concept;
Sentences

• if $d_1$ and $d_2$ are concepts, then $[d_1 \sqsubseteq d_2]$ is a sentence;

• if $d_1$ and $d_2$ are concepts, then $[d_1 \equiv d_2]$ is a sentence;

• if $c$ is a constant and $d$ a concept, then $[c \to d]$ is a sentence.
Examples: Concepts

[EXISTS n r]

[EXISTS 1 : Child]

[FILLS r c]

[EXISTS : Cousin vinny]

[ALL r d]

[ALL : Employee UnionMember]
Examples (cont)

\[
\text{[ANDWine} \\
\text{[FILLS :Color red]} \\
\text{[EXISTS 2 :GrapeType]}\]
\]
Examples: Sentences

\[(d_1 \sqsubseteq d_2)\]

(Surgeon \sqsubseteq Doctor)

\[(d_1 \models d_2)\]

\[(d_1 \rightarrow d_2)\]

(ProgressiveCompany \models

\[\text{AND} \text{Company}
\[\text{EXISTS} \ 7 : \text{Director}\]
\[\text{ALL} \ 7 : \text{Manager}[\text{AND} \ \text{Woman}
\[\text{FILLS} : \text{Degree phD}]]
\[\text{FILLS} : \text{MinSalary} \$24.00/hour]]\]
An interpretation $\mathcal{I}$ for DL is a pair

$$\langle D, I \rangle$$

where $D$ is any set of objects called the domain of the interpretation

and

$I$ is a mapping called the interpretation mapping from the non-logical symbols of DL to elements and relations over $D$. 
where

1. for every constant symbol $c$, $\mathcal{I}[c] \in \mathcal{D}$;
2. for every atomic concept $a$, $\mathcal{I}[a] \subseteq \mathcal{D}$;
3. for every role symbol $r$, $\mathcal{I}[c] \subseteq \mathcal{D} \times \mathcal{D}$;
Extending I

- $\mathcal{I}[$thing$]$

- $\mathcal{I}[$ALL $r$ $d$]$]

- $\mathcal{I}[$EXISTS $n$ $r$]$]

- $\mathcal{I}[$FILLS $r$ $c$]$]

- $\mathcal{I}[$AND$d_1\ldots d_n$]$]
Truth in an Interpretation

Given an interpretation $\mathcal{I}$, we say that $\alpha$ is true in $\mathcal{I}$, or $\mathcal{I} \models \alpha$ according to the following rules.

1. $\mathcal{I} \models (c \rightarrow d)$ iff $\mathcal{I}[c] \in \mathcal{I}[d]$
2. $\mathcal{I} \models (d \subseteq d')$ iff $\mathcal{I}[d] \subseteq \mathcal{I}[d']$
3. $\mathcal{I} \models (d \equiv d')$ iff $\mathcal{I}[d] = \mathcal{I}[d']$

Assuming that $d$ and $d'$ are concepts, and $c$ is a constant.