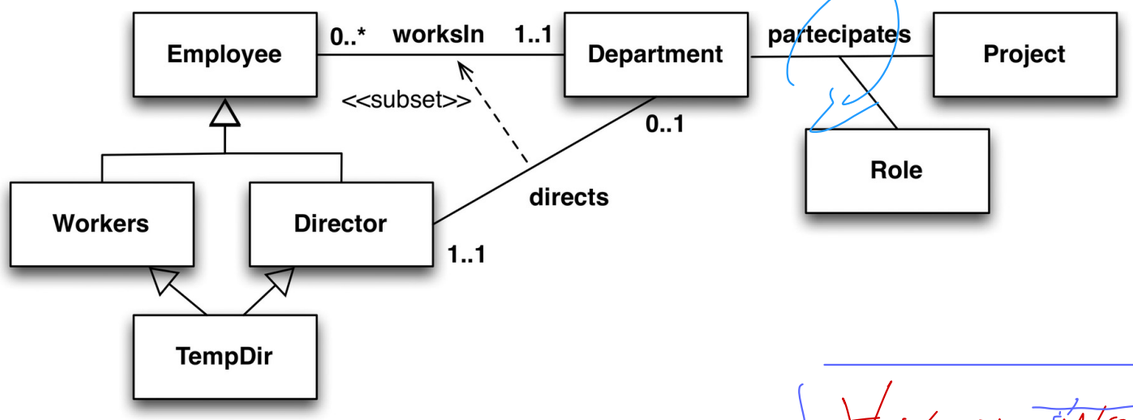


Alphabet

$E(x)$, $D(x)$, $P(x)$, $R(x)$,

$W(x)$, $Dir(x)$, $TDir(x)$

$worksin(x,y)$, $directs(x,y)$

$participates(x,y,z)$

$\forall x,y \; worksin(x,y) \supset E(x) \wedge D(y)$

$\forall x . E(x) \supset 1 \leq \#\{y \mid worksin(x,y)\} \leq 1$

i.e. $\forall x \; E(x) \supset (\exists y . worksin(x,y) \wedge \forall y'. worksin(x,y') \supset y = y')$

$\forall x . W(x) \supset E(x)$

$\forall x . Dir(x) \supset E(x)$

$\forall x . TDir(x) \supset W(x)$

$\forall x \; TDir(x) \supset Dir(x)$

$\forall x,y . directs(x,y) \supset Dir(x) \wedge D(y)$

$\forall x . Dir(x) \supset \#\{y \mid directs(x,y)\} \leq 1$

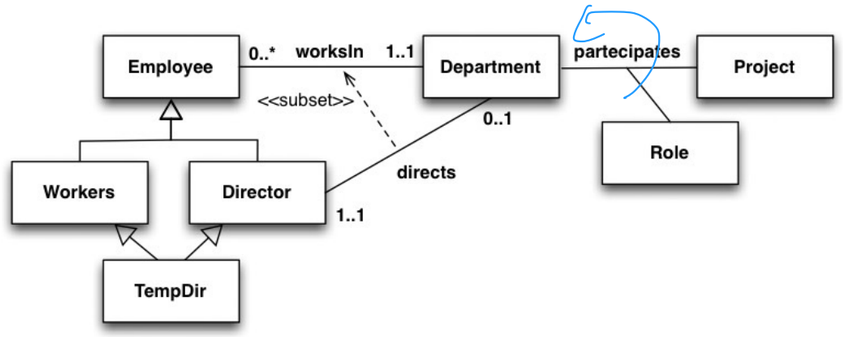
$\forall x . D(x) \supset 1 \leq \#\{y \mid directs(y,x)\} \leq 1$

subset

$\forall x,y . directs(x,y) \supset worksin(x,y)$

$\forall x,y,z . participate(x,y,z) \supset D(x) \wedge P(y) \wedge R(z)$

Exercise 1. Express the following UML class diagram in *FOL*.



Exercise 2. Consider the above UML class diagram and the following (partial) instantiation.

Workers

John
Mary
Joe

Director

Jim
Rick

TempDir

Ann

Department

ICT
HR
Management

Project

EU123
IT456

Role

projectManager
principalInvestigator
partner

worksIn

John	ICT
Mary	ICT
Joe	HR

directs

Ann	ICT
Jim	HR
Rick	Management

partecipates

EU123	ICT	projectManager
EU123	ICT	principalInvestigator
IT456	ICT	partner
IT456	Management	projectManager

1. Check whether the above instantiation, once completed, is correct, and explain why it is or it is not.
2. Express in FOL the following queries and evaluate them over the completed instantiation:
   (a) Return the projects where the same department participates in different roles.
   (b) Return the projects in which each participating department participates with exactly one role.

$I_0 = \emptyset$, I_1 = the one given below

I_2 = as I_1 but

$W^{I_2} = W^{I_1} \cup \{ann\}$

$D^{I_2} = D^{I_1} \cup \{ann\}$

$works_{I_2} = works_{I_1} \cup \{(ann, ICT), (jim, HR), (rick, Management)\}$

$E^{I_2} = \{john, mary, joe\} \cup \{jim, rick\}$ $\cup E^{I_1}$

all the rest as in I_1

I_3 = as I_2 but

$E^{I_3} = E^{I_2} \cup \{ann\}$

all the rest as in I_2

$I_4 = I_3$ complete extension reached

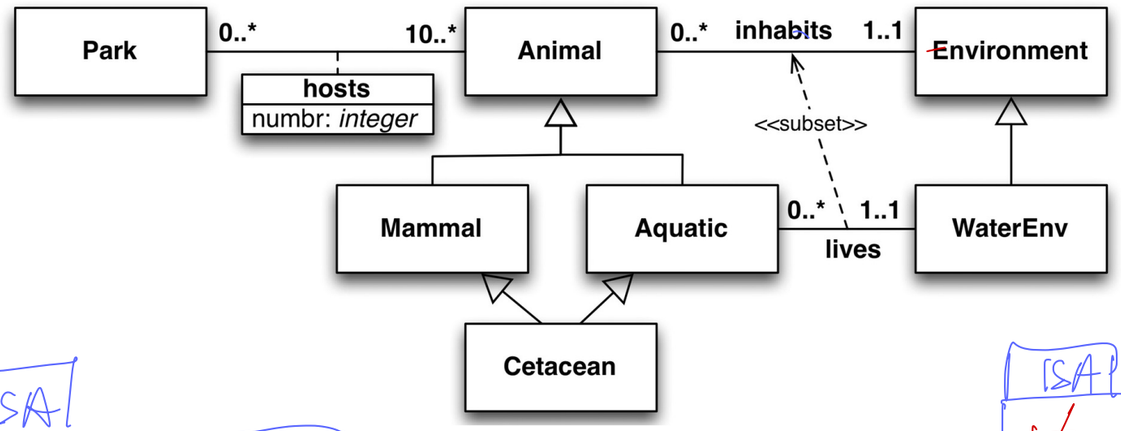
a) $\exists x, z, z' . p(x, y, z) \wedge p(x, y, z') \wedge z \neq z'$

$\Rightarrow y = EU123$

b) $\forall y . \exists z . p(y, x, z)$

$\Rightarrow (\forall z . z' . p(y, x, z) \wedge p(y, x, z') \Rightarrow z = z')$

$\Rightarrow x = IT456$



ISA

$\forall x \; M(x) \supset A(x)$

$\forall x \; Aq(x) \supset A(x)$

$\forall x \; C(x) \supset M(x) \wedge Aq(x)$

i.e. $\forall x . C(x) \supset M(x)$

$\forall x . C(x) \supset Aq(x)$

ISA

$\forall x \; WE(x) \supset E(x)$

$\forall x,y . \; inh(x,y) \supset A(x) \wedge E(y)$

$\forall x \; A(x) \supset 1 \leq \#\{y \mid inh(x,y)\} \leq 1$

$\forall x,y . \; hosts(x,y) \supset P(x) \wedge A(y)$

$\forall x . \; P(x) \supset 10 \leq \#\{y \mid hosts(x,y)\}$

$\forall x,y . \; lives(x,y) \supset Aq(x) \wedge WE(y)$

$\forall x . Aq(x) \supset 1 \leq \#\{y \mid lives(x,y)\}$

SUBSET

$\forall x,y \; lives(x,y) \supset inh(x,y)$

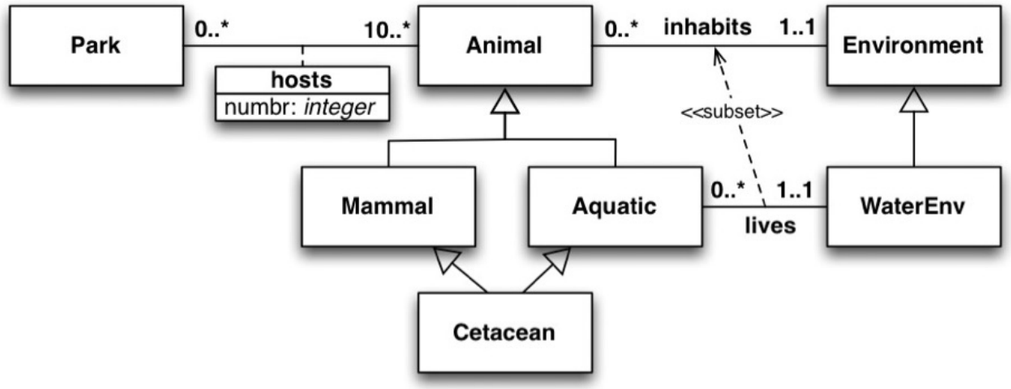
attribute of association

$\forall xyz \; number(x,y,z) \supset \frac{hosts(x,y) \; 1}{Int(z)}$

$\forall x,y \; hosts(x,y) \supset$

$1 \leq \#\{z \mid number(x,y,z)\} \leq 1$

Exercise 1. Express the following UML class diagram in FOL.



Exercise 2. Consider the above UML class diagram and the following (partial) instantiation.

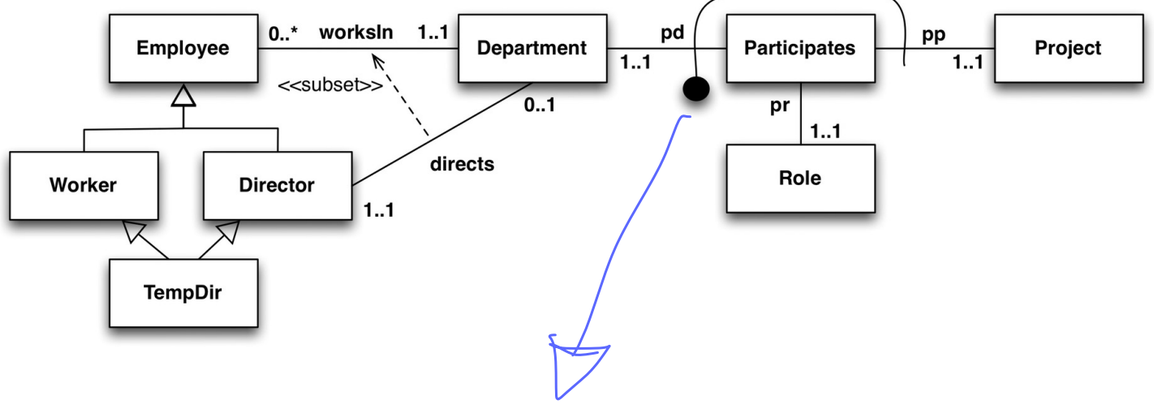
$Aquatic$
sawshark

$Cetacean$
dolphin
bluewhale

$WaterEnv$
ocean

$lives$	
dolphin	ocean
bluewhale	ocean
sawshark	ocean

1. Check whether the instantiation (once completed) is correct (and explain why it is or it is not).
2. Express in FOL and evaluate the following queries:
   (a) Return the all animals and the environment they inhabit.
   (b) Return the mammals that inhabit all environments.



$\forall x,y.\ pol(x,y) \supset P(x) \wedge D(y)$

$\forall x\ P(x) \supset 1 \leq \#\{y \mid pd(x,y)\} \leq 1$

$\forall x,y.\ pp(x,y) \supset P(x) \wedge Pr(y)$

$\forall x.\ P(x) \supset 1 \leq \#\{y \mid pp(x,y)\} \leq 1$

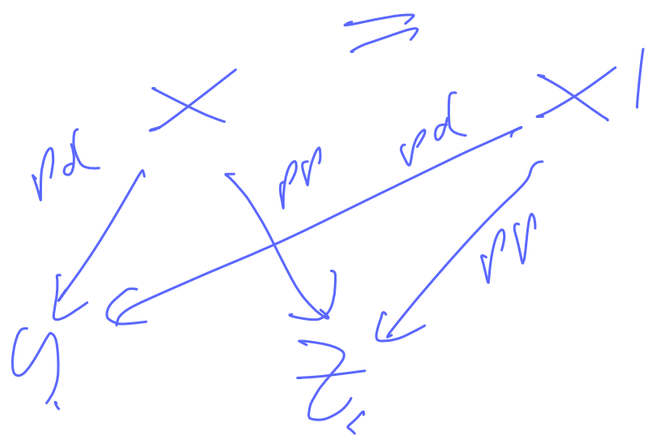
$\forall x,y.\ pr(x,y) \supset P(x) \wedge R(y)$

$\forall x.\ P(x) \supset 1 \leq \#\{y \mid pr(x,y)\} \leq 1$

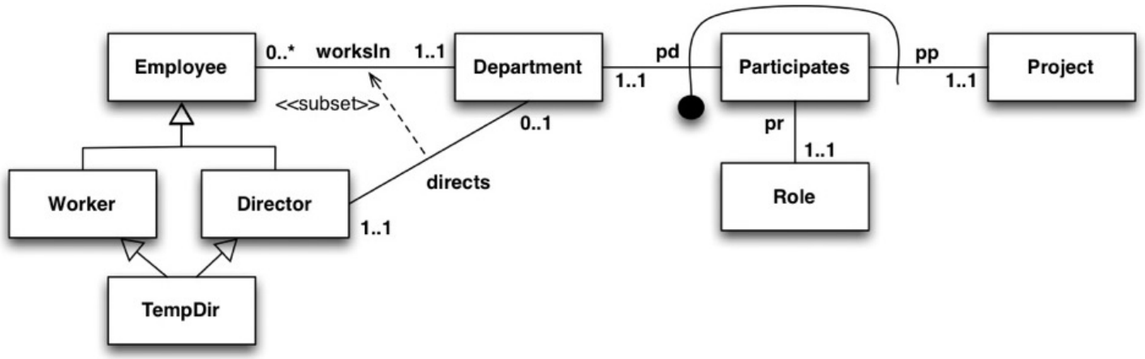
$$\forall x, x', y, z.\ pol(x,y) \wedge pd(x',y) \wedge pr(x,z) \wedge pp(x',z) \supset x = x'$$

Key of class

$\Rightarrow$



Exercise 1. Express the following UML class diagram in FOL.



Exercise 2. Consider the above UML class diagram and the following (partial) instantiation.

$Worker$

John
Mary
Joe

$Director$

Jim
Rick

$TempDir$

Ann

$Department$

ICT
HR
Management

$worksIn$

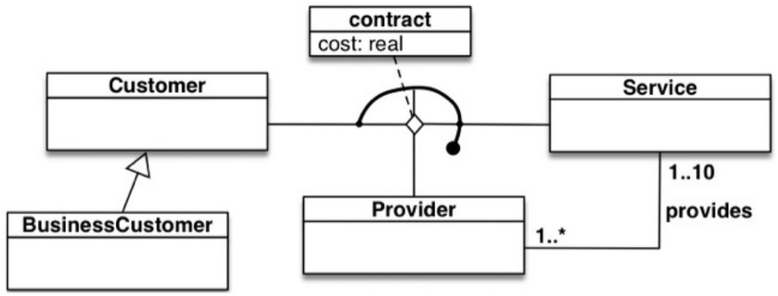
John	ICT
Mary	ICT
Joe	HR

$directs$

Ann	ICT
Jim	HR
Rick	Management

1. Check whether the above instantiation, once completed, is correct, and explain why it is or it is not.
2. Express in FOL the following queries and evaluate them over the completed instantiation:
   (a) Return the directors that direct a department with at least one worker.
   (b) Return the departments whose employees are all directors.

Exercise 1. Express the following UML class diagram in FOL:



Exercise 2. Consider the above UML class diagram and the following (partial) instantiation:

Customer

c1
c2
c3
c4

BCustumers

b1
b2
b3

Services

s1
s2
s3

Provider

p1
p2

provides

p1	s1
p1	s2
p1	s3
p2	s2

contacts/cost

c1	s1	p1	90.0
c1	s2	p1	80.0
c1	s3	p1	50.0
b2	s1	p2	170,0
b2	s2	p2	100,0

1. Check whether the above instantiation, once completed, is correct, and explain why it is or it is not.
2. Express in FOL the following queries and evaluate them over the completed instantiation:
   (a) Check whether there is a customer with contract with two providers for the same service.
   (b) Return those customers that have contracts only for one service.
   (c) Return those customers that have a contracts with the same provider for all their services.