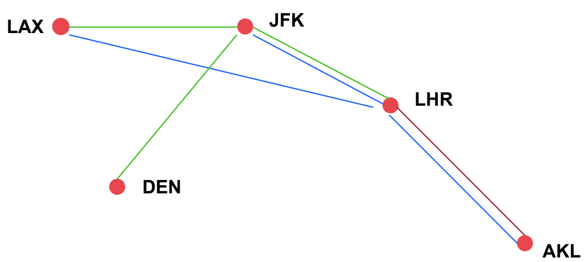
Airline DB



airports & flight connections

```
-- airlines as abstract entities
data Airline = BA | UA  |  NZ  deriving ( Eq, Show)
allAirlines  ::  [Airline]
allAirlines = [BA, UA, NZ]
```

```
type AirlineName  =  String
airlineName  ::  Airline -> AirlineName
airlineName  BA  =  “British Airways”
airlineName  UA  =  “United Airlines”
airlineName  NZ  =   “Air New Zealand”
```



```
-- airports as abstract entities

data  Aiport  = LHR | JFK  | DEN  | LAX |  AKL
                         deriving ( Eq, Show)
allAirports  :: [Airport]
allAirports = [LHR,  JFK,   DEN,   LAX,   AKL]
```

```
type AirportName  =  String
type Country  =  String
type AirportInfo  =  ( AirportName, Country )
```

```
airportInfo  ::  Airport -> AirportInfo
airportInfo  LHR  =  (“London Heathrow”, “England”)
airportInfo  JFK  =  (“J F Kennedy”, “United States”)
airportInfo  DEN  =  (“Denver”, “United States”)
airportInfo  LAX  =  (“Los Angeles Int”, “United States”)
airportInfo  AKL  =  (“Auckland”, “New Zealand”)
```

```
airportName  ::  Airport -> AirportName
airportName   x  =  firstOf2 (airportInfo  x)

airportCountry  ::  Airport -> Country
airportCountry  x  = secondOf2  (airportInfo  x)
```

```
-- flights as abstract entities (airline, source, destination)

data  Flight  = BA1 | UA1 | UA123 | UA987 | UA234 | UA842 | NZ2
                deriving ( Eq, Show)
allFlights  :: [ Flight ]
allFlights = [BA1,  UA1,  UA123,  UA987,  UA234,  UA842,  NZ2 ]
```

```
flightInfo  ::  Flight -> (Airline, Airport, Airport)
flightInfo   BA1      =  (BA, LHR, JFK)
flightInfo   UA1      =  (UA, LHR, JFK)
flightInfo   UA123  =  (UA, JFK, DEN)
flightInfo   UA987  =  (UA, LHR, LAX)
flightInfo   UA234  =  (UA, DEN , LAX)
flightInfo   UA842  =  (UA, LAX, AKL)
flightInfo   NZ2      =  (NZ, LAX, AKL)
```

```
flightAirline   ::  Flight  -> Airline
flightAirline  f  =  firstOf3 (flightInfo  f)
```

```
flightSource   ::  Flight  -> Airport
flightSource  f  =  secondOf3 (flightInfo  f)
```

```
flightDest   ::  Flight  -> Airport
flightDest  f  =  thirdOf3 (flightInfo  f)
```



```
-- codes of the airports located in the United States
```

```
allAirports = [LHR,  JFK,   DEN,   LAX,   AKL]
```

```
airportInfo  LHR  =  (“London Heathrow”, “England”)
airportInfo  JFK  =  (“J F Kennedy”, “United States”)
airportInfo  DEN  =  (“Denver”, “United States”)
airportInfo  LAX  =  (“Los Angeles Int”, “United States”)
airportInfo  AKL  =  (“Auckland”, “New Zealand”)
```

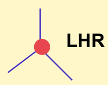
```
airportCountry  x  = secondOf2  (airportInfo  x)
```

```
[ p | p <- allAirports, airportCountry p = “United States”]
```

```
-- all airports flown to/from by a given airline

allFlights = [BA1,  UA1,  UA123,  UA987,  UA234,  UA842,  NZ2]

flightInfo  ::  Flight -> (Airline, Airport, Airport)
flightInfo   BA1      =  (BA, LHR, JFK)
flightInfo   UA1      =  (UA, LHR, JFK)
flightInfo   UA123   =  (UA, JFK, DEN)
flightInfo   UA987   =  (UA, LHR, LAX)
flightInfo   UA234   =  (UA, DEN , LAX)
flightInfo   UA842   =  (UA, LAX, AKL)
flightInfo   NZ2      =  (NZ, LAX, AKL)

flightSource  f  =  secondOf3 (flightInfo  f)

flightDest  f  =  thirdOf3 (flightInfo  f)

serves  :: Airline  ->  [ Airport ]
serves   x =
            [flightSource  f  |  f <- allFlights, flightAirline  f == x]  ++
            [flightDest  f  |  f <- allFlights, flightAirline  f == x]
```

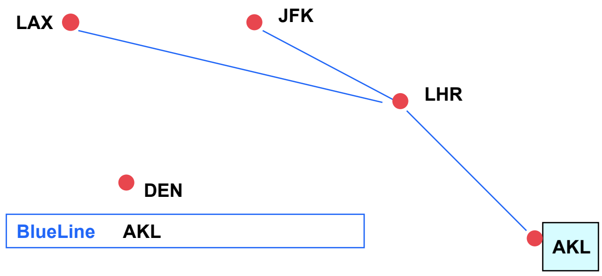


```
-- all airports from where an airline flies to more than one destination
```




```
hubs  :: Airline  ->  [ Airport ]
hubs   x =
          [p  | p <-  allAirports,
           f1 <- allFlights, flightAirline  f1 == x, flightSource f1 == p,
           f2 <- allFlights, flightAirline  f2 == x,  flightSource  f2 == p,
           flightDest  f1 /= flightDest  f2]
```

-- all airports reachable from a given airport on a given airline




```
getthere :: Airline -> Airport -> [Airport]
getthere x y =
        dests ++ [y' | d <- dests, y' <- getthere x d]
        where dests = [ flightDest f | f <- allFlights,
                      flightAirline f == x, flightSource f == y]
```


Relational Airline DB

LINE

ID	NAME
BA	British Airways

PORT

CODE	NAME	COUNTRY
LHR	Heathrow	England

CONNECT

No	L-ID	ORIG	DEST
704	BA	LHR	VIE

-- airports located in the United States

```
[ p | p <- allAirports,
      airportCountry p = "United States"]
```

Π (σ PORT (COUNTRY =' United States")) ID

```
select ID from PORT
where COUNTRY = "United States"
```


-- airports served by a given airline

```
serves   x =
   [flightSource  f  |  f <- allFlights, flightAirline  f == x]
   ++ [flightDest  f  |  f <- allFlights, flightAirline  f == x]
```

Π (σ ((LINE ▸◂ PORT) ▸◂ CONNECT)
(CODE = ORIG or CODE = DEST))
NAME

```
select distinct  PORT.NAME
from    LINE, PORT, CONNECT
where  ID = L-ID
and     (CODE = ORIG  or CODE = DEST)
and     LINE.NAME = x
```

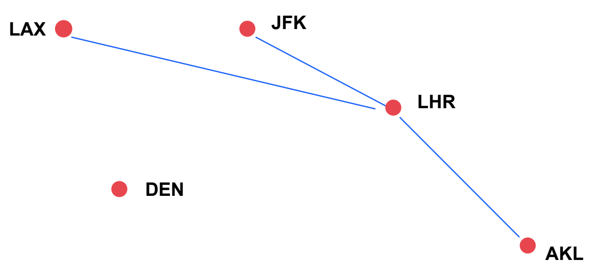
-- airports from where an airline flies to more than one destination

```
hubs  :: Airline  ->  [ Airport ]
hubs   x =[p  | p <-  allAirports,
    f1 <- allFlights, flightAirline  f1 == x, flightSource f1 == p,
    f2 <- allFlights, flightAirline  f2 == x, flightSource  f2 == p,
    flightDest  f1 /= flightDest  f2]
```

A ::= Π (σ (CONNECT (L-ID = x))) (ORIG, DEST)
returns all connection pairs for x - but R/Algebra does not provide tools for grouping or counting

```
select ORIG from CONNECT
where L-ID = x
group by ORIG having count (*) > 1
```


-- all airports reachable from a given airport on a given airline

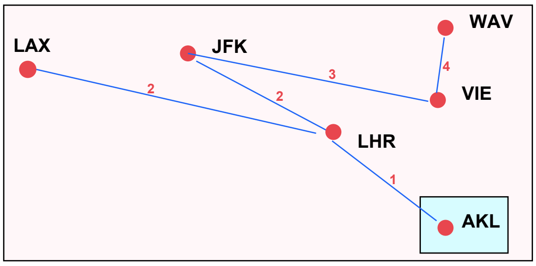



```
select DEST from CONNECT
where L-ID = x
and ORIG = y
```

→ (Blue AKL) -> LHR

```
SQL> select * from GRAPH;

ORIG     DEST
-------  ------
AKL      LHR
LHR      JFK
LHR      LAX
JFK      VIE
VIE      WAW

SQL> select level, dest
  2  from graph
  3  connect by prior dest = orig
  4* start with orig = 'AKL';

LEVEL         DEST
------        ----
1             LHR
  2           JFK
    3         VIE
      4       WAW
  2           LAX
```

```
getthere  x  y =
    dests  ++  [y'  | d <-  dests,  y' <- getthere  x  d]
    where dests = [ flightDest  f | f <- allFlights,
                          flightAirline  f == x,  flightSource  f == y]
```



3 examples
mastered by your predecessors

Employees, managers, projects


```
-- employees
data Employee = E1 | E2 | E3 | E4 deriving (Eq, Show)
allEmployees :: [Employee]
allEmployees = [E1, E2, E3, E4]
```

```
type EmployeeName = String
type EmployeeSalary = Int
type EmployeeInfo = (EmployeeName, EmployeeSalary)
```

```
employeeInfo E1 = ("Karin", 30000)
employeeInfo E2 = (”John", 25000)
employeeInfo E3 = ("Mary", 22000)
employeeInfo E4 = ("Peter", 20000)
```

```
-- employees report to their supervisors
reportsto :: Employee -> [Employee]
reportsto E1 = []
reportsto E2 = [E1]
reportsto E3 = [E2]
reportsto E4 = [E1]
```

```
-- employees work on projects
data Project = Red | Blue deriving (Eq, Show)
allProjects :: [Project]
allProjects = [Red, Blue]
```

```
-- an employee may work on one or more project
workson :: Employee -> [Project]
workson E1 = [Red, Blue]
workson E2 = [Red]
workson E3 = [Red]
workson E4 = [Blue]
```



```
-- find all managers
-- (i.e. employees reported to = the whole tree except leaves)

managers :: [Employee]
managers = [x | emp <- allEmployees, x <- reportsto emp]
```

```
-- for a given employee find his manager, his manager's manager, and so on

manages :: Employee -> [Employee]
manages x = reportsto x ++ [man|m <- reportsto x, man <- manages m]
```

-- find all the employees who work on a given project

```
team :: Project -> [Employee]
team x = [emp | emp <- allEmployees, project <- workson emp, project == x]
```

-- find the names of all the managers whose employees work on a given project

```
names :: Project -> [EmployeeName]
names x = [getFirst (employeeInfo manager) | manager <- managers,
teammember <- team x, manager == teammember]
where getFirst (x, _) = x
```


Modules, prerequisites, teachers

```
data Prof = WS | HL | SP | AT deriving (Eq, Show)
allProfs :: [Prof]
allProfs = [WS, HL, SP, AT]
```

```
type ProfName      = String
type ProfRoom      = String
type ProfInfo      = (ProfName, ProfRoom)
```

```
profInfo :: Prof -> ProfInfo
profInfo WS = ("Wayne Smith", "WHE110")
profInfo HL  = ("Henry Long", "WHE115")
profInfo SP  = ("Steve Pirx", "WHE 101")
profInfo AT  = ("Andy Thue", "WHE 300")
```

```
profName :: Prof -> ProfName
profName a = firstOf2 (profInfo a)
```

```
profRoom :: Prof -> ProfRoom
profRoom a = secondOf2 (profInfo a)
```



```
data Subject = ADT | DM | EBUS | FP | IM deriving (Eq, Show)
allSubjects :: [Subject]
allSubjects = [ADT, DM, EBUS, FP, IM]
```

```
type ID = String
type Title = String
```

```
subjectInfo :: Subject -> (ID, Title, ProfName)
subjectInfo ADT    = ("103020", "Abstract Data Types", "Wayne Smith")
subjectInfo DM     = ("345730", "Data Management", "Wayne Smith")
subjectInfo EBUS  = ("195640", "eBusiness", "Henry Long")
subjectInfo FP      = ("338313", "Functional Programming", "Steve Pirx")
subjectInfo IM      = ("672943", "Information Management", "Andy Thue")
```

```
idNr :: Subject -> ID
idNr b = firstOf3 (subjectInfo b)

title :: Subject -> Title
title b = secondOf3 (subjectInfo b)

subProf :: Subject -> ProfName
subProf b = thirdOf3 (subjectInfo b)
```

```
data PreSubject = ADT1 | FP1 | DM1 | FP2 | IM1 deriving (Eq, Show)
allPreSubjects :: [PreSubject]
allPreSubjects = [ADT1, DM1, FP1, FP2, IM1]
```

```
preInfo :: PreSubject -> (ID, ID)
preInfo ADT1 = ("103020", "672943")
preInfo FP1 = ("338313", "345730")
preInfo FP2 = ("338313", "103020")
preInfo DM1 = ("345730", "672943")
preInfo IM1 = ("672943", "195640")
```

```
subId :: PreSubject -> ID
subId c = firstOf2 (preInfo c)

reqSubId :: PreSubject -> ID
reqSubId c = secondOf2 (preInfo c)
```

```
firstOf2, secondOf2 :: (String, String) -> String
firstOf2 (x, y)      = x
secondOf2 (x, y)     = y

firstOf3, secondOf3, thirdOf3 :: (String, String, String) -> String
firstOf3 (x, y, z)   = x
secondOf3 (x, y, z) = y
thirdOf3 (x, y, z)   = z
```



```
--all subjects taught by a given professor

allSubProf :: Prof -> [Title]
allSubProf p = [title b | b <- allSubjects, subProf b == profName p]
```

```
--prerequisite for a subject

reqSub :: ID -> [ID]
reqSub p = [reqSubId c | c <- allPreSubjects, subId c == p]
```

```
--subjects with no pre-requisites

noReqSub :: [ID]
noReqSub = [idNr b | b <- allSubjects, reqSub (idNr b) == []]
```

--subjects that have more than one pre-requisite

```
moreOne :: [ID]
moreOne = [idNr b | b <- allSubjects,
            c1 <- allPreSubjects, idNr b == subId c1,
            c2 <- allPreSubjects, idNr b == subId c2,
            reqSubId c1 /= reqSubId c2]
```


Parents, Education & Employment

PERS-ID	COMPANY	FROM	TO	POSITION	SALARY
210578123	ABC Software	2001	2002	Analyst	45K
……………	……………….	……	…….	……….	…..

ID	SURNAME	BIRTH-PLACE	SEX	FATHER-ID	MOTHER-ID
210578123	Schmidt	Linz	Female	1112583456	0203605678
……………	……….	……	……….	…………….	…………….

PERS-ID	DEGREE	DISCIPLINE	UNIVERSITY	AWARD-YEAR
210578123	MSc	Mathematics	JKU	1998
210578123	PhD	Computing	JKU	2001
210578123	MBA	Business	Harvard	2003
………….	…….	…………….	……….	……


```
data Person =A|B|C|D|E|F|G deriving (Eq,Ord,Enum,Show)
allPersons::[Person]
allPersons=[A,B,C,D,E,F,G]

type ID = Int
type SURNAME = String
type BIRTHPLACE = String
type SEX = String
type FATHERID = ID
type MOTHERID = ID

type PersonInfo = (ID,SURNAME,BIRTHPLACE,SEX,FATHERID,MOTHERID)
```

```
personInfo :: Person->PersonInfo
personInfo A = (1,"Schmidt","Linz","Female",2,3)
personInfo B = (2,"Huber","Linz","Male",4,5)
personInfo C = (3,"Huber","Wien","Female",6,7)
personInfo D = (4,"Grossvater vaeterlichseits","Traun","Male",0,0)
……………………………………………………………………………………………

id :: Person->ID
id x = firstOf6(personInfo x)

surname :: Person->SURNAME
surname x = secondOf6(personInfo x)

birthplace :: Person->BIRTHPLACE
birthplace x = thirdOf6(personInfo x)

sex :: Person->SEX
sex x = fourthOf6(personInfo x)

fatherid :: Person->FATHERID
fatherid x = fifthOf6(personInfo x)

motherid :: Person->MOTHERID
motherid x = sixthOf6(personInfo x)
```



```
data Education = Ed1|Ed2|Ed3|Ed4|Ed5 deriving (Eq,Ord,Enum,Show)
allEducations::[Education]
allEducations=[Ed1,Ed2,Ed3,Ed4,Ed5]

type DEGREE = String
type DISCIPLINE = String
type UNIVERSITY = String
type AWARDYEAR = Int

type EducationInfo = (Person,DEGREE,DISCIPLINE,UNIVERSITY,AWARDYEAR)
```

```
educationInfo :: Education->EducationInfo
educationInfo Ed1 = (A,"Msc","Mathematics","JKU",1998)
educationInfo Ed2 = (A,"PhD","Computing","JKU",2001)
educationInfo Ed3 = (A,"MBA","Business","Harvard",2003)
educationInfo Ed4 = (B,"DI","Informatics","TU Wien",1980)
educationInfo Ed5 = (C,"BSc","Informatics","TU Wien",1982)
……………………………………………………………………

personeducation :: Education->Person
personeducation x = firstOf5(educationInfo x)

degree :: Education->DEGREE
degree x = secondOf5(educationInfo x)

discipline :: Education->DISCIPLINE
discipline x = thirdOf5(educationInfo x)

university :: Education->UNIVERSITY
university x = fourthOf5(educationInfo x)

awardyear :: Education->AWARDYEAR
awardyear x = fifthOf5(educationInfo x)
```



```
data Employment = Em1|Em2|Em3|Em4|Em5|Em6 deriving (Eq,Ord,Enum,Show)
allEmployments::[Employment]
allEmployments=[Em1,Em2,Em3,Em4,Em5,Em6]

type COMPANY = String
type FROM = Int
type TO = Int
type POSITION = String
type SALARY = Int

type EmploymentInfo = (Person,COMPANY,FROM,TO,POSITION,SALARY)

employmentInfo :: Employment->EmploymentInfo
employmentInfo Em1 = (A,"ABCSoftware",2001,2002,"Analyst",45000)
employmentInfo Em2 = (A,"Harvard",2002,2003,"Assistant",30000)
employmentInfo Em3 = (B,"ABCSoftware",1990,1995,"Administrator",20000)
employmentInfo Em4 = (B,"Siemens",1995,2006,"Developer",60000)
………………………………………………………………………………
```

```
personemployment :: Employment->Person
personemployment x = firstOf6(employmentInfo x)

company :: Employment->COMPANY
company x = secondOf6(employmentInfo x)

from :: Employment->FROM
from x = thirdOf6(employmentInfo x)

to :: Employment->TO
to x = fourthOf6(employmentInfo x)

position :: Employment->POSITION
position x = fifthOf6(employmentInfo x)

salary :: Employment->SALARY
salary x = sixthOf6(employmentInfo x)
```



```
ins::Person->[Person]->[Person]
ins x[]=[x]
ins x(y:ys)
  |x<=y = x:y:ys
  |otherwise = y:ins x ys

member::[Person]->Person->Bool
member[] y = False
member(x:xs)y=(x==y)||member xs y

distinct::[Person]->[Person]
distinct[]=[]
distinct(x:xs)
  |member (distinct xs)x = (distinct xs)
  |otherwise = ins x(distinct xs)

namesOf::[Person]->[SURNAME]
namesOf [] = []
namesOf (x:xs) = surname x : namesOf xs
```

```
firstOf5 (a,b,c,d,e) = a
secondOf5 (a,b,c,d,e) = b
thirdOf5 (a,b,c,d,e) = c
fourthOf5 (a,b,c,d,e) = d
fifthOf5 (a,b,c,d,e) = e

firstOf6 (a,b,c,d,e,f) = a
secondOf6 (a,b,c,d,e,f) = b
thirdOf6 (a,b,c,d,e,f) = c
fourthOf6 (a,b,c,d,e,f) = d
fifthOf6 (a,b,c,d,e,f) = e
sixthOf6 (a,b,c,d,e,f) = f
```

```
-- Persons at a specific University after a specific AwardYear

personsAtUniversityWithAwardYearAfter::UNIVERSITY->AWARDYEAR->[Person]
personsAtUniversityWithAwardYearAfter u a = distinct[personeducation
ed|ed<-allEducations, university ed == u, awardyear ed >= a]
```

```
-- Grandparents of a specific person

personWithID::Database.ID->Person
personWithID i = head[p|p<-allPersons, i == Database.id p]

parentsOf::Person->[Person]
parentsOf p = [personWithID(fatherid p), personWithID(motherid p)]

grandParentsOf::Person->[Person]
grandParentsOf p = parentsOf(head[q|q<-allPersons, Database.id q ==
fatherid p]) ++ parentsOf(head[r|r<-allPersons, Database.id r == motherid p])
```



```
-- Colleagues of a specific person

employmentsOfPerson::Person->[Employment]
employmentsOfPerson p = [em|em<-allEmployments, personemployment em == p]

employmentsWithOfCompanyWithinTime::COMPANY->FROM->TO->[Employment]
employmentsWithOfCompanyWithinTime c f t = [em|em<-allEmployments, company
em == c, (((f<=from em)&&(from em<=t))||((f<=to em)&&(to em <=t)))]

colleaguesOfPersonEmployment::[Employment]->[Person]
colleaguesOfPersonEmployment[] = []
colleaguesOfPersonEmployment(x:xs)=[personemployment em|em<-
employmentsWithOfCompanyWithinTime (company(x)) (from(x)) (to(x)),
personemployment em /= personemployment x] ++ colleaguesOfPersonEmployment xs

colleaguesOfPerson::Person->[Person]
colleaguesOfPerson p = colleaguesOfPersonEmployment(employmentsOfPerson p)
```

KNOWLEDGE ::=

ELEMENTARY FACTS

- John Doe was born in London on 19 Nov 1962
- The car with a number plate B1 BYE is a Ferrari

SIMPLE RULES

- Every man has necessarily two parents of whom he is the child
- A person has sometimes a spouse and if X is the spouse of Y then Y is the spouse of X
- A car has (if any) only one owner. Conversely, an owner may have zero, one or several cars

COMPLEX RULES

- The sex of a person is not subject to any change
- A single person who marries may not be single again in the future
- A person may not be, at a given time, in two different places

DEDUCTIVE RULES

- if x > y then BIG:= x else BIG:= y
- square() = twice (twice ())

WHEN THE MODEL DOES NOT KNOW A FACT OR A LAW ABOUT REALITY
THIS DOES NOT MEAN THAT THIS FACT OR LAW DOES NOT EXISTS,

CONSEQUENCE:

IF

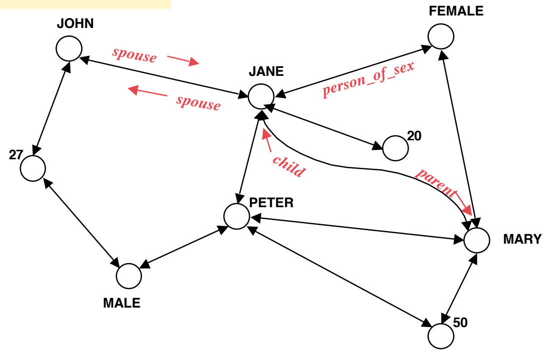
THE MODEL HAS EXACTLY THE SAME KNOWLEDGE OF TWO OBJECTS
IT DOES NOT FOLLOW THEY ARE ONE AND THE SAME OBJECT.

THEREFORE

AN OBJECT ENTERING THE 'PERCEPTION FIELD' OF THE MODEL MUST
IDENTIFY ITSELF AS either NEW OBJECT or ALREADY KNOWN OBJECT

THE DESCRIPTION OF AN OBJECT INSIDE THE MODEL IS GIVEN VIA THE
CONNECTIONS (access functions) IT HAS WITH OTHER OBJECTS

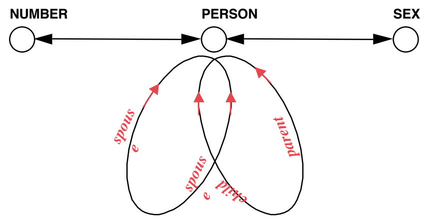
person_of_sex (MALE) = {JOHN, PETER}
person_of_sex (FEMALE) = {JANE, MARY}
age (JOHN) = {27}
person_of_age (50) = {PETER, MARY}
child (PETER) = {JANE}
parent (JANE) = {PETER, MARY}
. . .



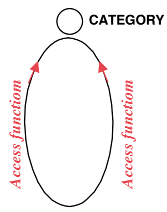
CATEGORIES

JOHN, JANE, PETER, MARY	are	PERSONs
27, 50, 20	are	NUMBERs
MALE, FEMALE	are	SEXes

THUS, THE STRUCTURE OF THE EXAMPLE CAN BE ABSTRACTED INTO



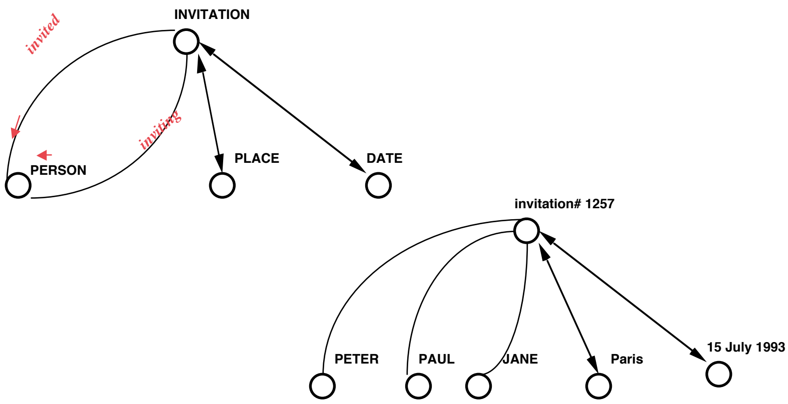
AND FURTHER STILL INTO



CONNECTIONS MAY THEMSELVES REQUIRE SOME INFORMATION

EXAMPLE: PETER was_invited_by (PAUL and JANE) to PARIS on 15Jul1993

THIS CAN BE DESCRIBED BY BUILDING A NEW CATEGORY- INVITATION AND THE FOLLOWING STRUCTURE



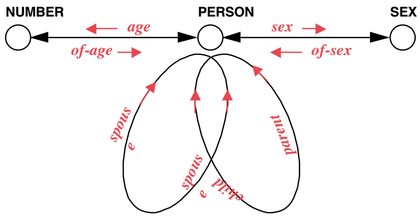
defn CATEGORIES

PERSON = cat there is new category

JOHN = generate PERSON create new object of category

x ← generate PERSON

kill JOHN, kill x



a person has exactly one sex, one age, two parents, zero or one spouse and any number of children

r1 = rel (PERSON, SEX, *sex* = fun(1, 1), *of_sex* = fun (0, ∞))

r2 = rel (PERSON, NUMBER, *age* = fun(1, 1), *of_age* = fun (0, ∞))

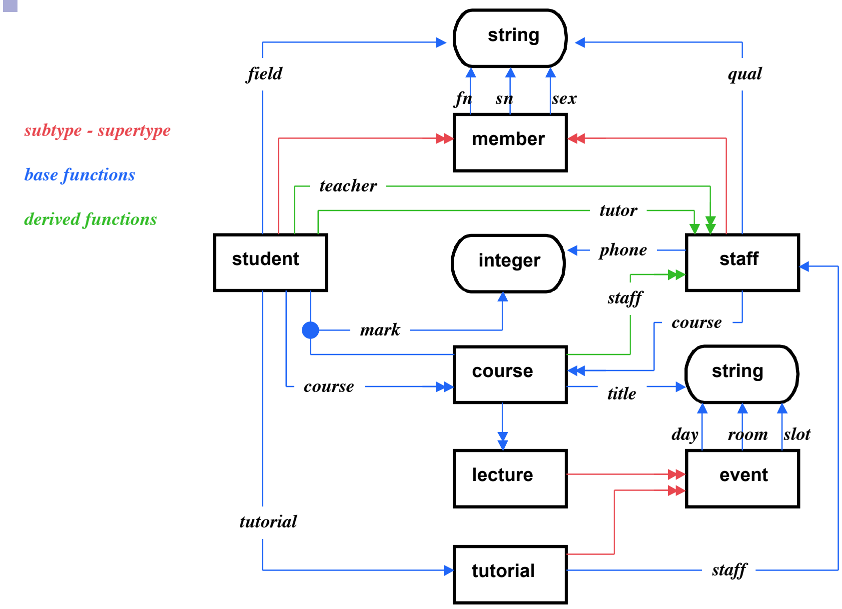
r3 = rel (PERSON, PERSON, *spouse* = fun(0, 1), spouse)

r4 = rel (PERSON, PERSON, *parent* = fun(2, 2), *child* = fun (0, ∞))

min *max*

Extended Functional Model

- structures
  - *single-valued* →
  - function (aruments) results
  - ⇒ *multi-valued*
  - base function stored data
  - derived function algorithm
  - f ( ) defines new entity type
  - f (a_1, a_2, ...) defines attributes & relationships
- entity diagram
- operations
- constraints
- user views
- metadata



base functions

declare
{

member () ⇒ entity
student () ⇒ member
staff() ⇒ member
course() ⇒ entity
event () ⇒ entity
tutorial() ⇒ event
lecture() ⇒ event

fn (member) → string
sn (member) → string
sex (member) → string

course (student) ⇒ course
tutorial (student) → tutorial
mark (student, course) → integer
field (student) → string

title (course) → string
lecture (course) ⇒ lecture

day (event) → string
slot (event) → string
room (event) → string

course (staff) ⇒ course
phone (staff) → integer
qual (staf) → string
staff (tutorial) → staff

}

derived functions

```
define
  {     staff(course) ⇒  staff such that
                           some c in course (staff)
                           has c = course            -- inverse of

        teacher (student)    ⇒   staff (course (student))

        tutor (student)      →   staff (tutorial (student))

  }  -- combinations of inverse, composition, recursion, transitivity
```

derived functions are represented by algorithms accepting arguments to compute results

retrievals

```
-- get the names of all members

for each m in member
get fn(m), sn(m)
```

```
-- get surnames of all female students

for each s in student
such that sex(s) = 'F'
get sn(s)
```

retrievals

```
-- get the names of those students that take a course on FDB

for each s in student
such that
        some c in course (s)
        has title (c) = 'FDB'
get sn(s)
```


retrievals

```
-- get the titles of courses taught by Stefan

for the s in staff
        such that  fn (s) = 'Stefan'
        for each c in course (s) get title(c)

-- error handling procedure is called if more than one Stefan exists
```

updating - insertion

```
a new m in member

-- creates a new member entity,  adds it to the extent of
            member type, associates it with the variable m
```

```
a new s in student

-- creates a new entity, which is included in the extents
                 of both student and member entity types
```


updating - new record

```
for a new s in student
  let fn(s) = 'Mary'
  let sn(s) = 'Jones'
  let sex(s) = 'F'
  let field(s) = 'Comp'
```

updating - change values

```
for the s in student  such that
fn(s) = ‘Mary’ and sn(s) = ‘Jones’
  let tutorial(s) = the t in tutorial such that
  day(t) = ‘Mon’ and slot(t) = ‘09,10’ and room(t) = ‘m101’
```


updating - adding rules

```
for the s in student  such that
fn(s) = ‘Mary’ and sn(s) = ‘Jones’
  include course(s) = {
              the c1 in course such that title(c1) = ‘Haskell’
              the c2 in course such that title(c2) = ‘Prolog’ }

-- similarly exclude
```

constraint unique-id on
fn(member), sn(member) → unique

constraint must-be-supplied on
sex(member) → total -- i.e. not partial

constraint must-differ on
student, staff → disjoint

constraint non-upd-sex on
sex(member) → fixed

constraint ris on
mark (student, course) →
some c in course(student)
has c = course