Knowledge Representation and Engineering

LIST OF EXERCISES

INTRODUCTION

1. What is data? What is Information? What is knowledge?
2. Identify the underlined sentences of the following paragraphs as data, information or knowledge:

   a) "This course of Knowledge Representation and Engineering is composed of three chapters: Introduction and Concepts, Knowledge Representation, and Knowledge Engineering. It's a six-credit course with two week hours for theory and two week hours for problems and practice. Like all the other subjects in the master, half of the practical hours will be off class. As the rest of subjects, KRE will be continuously evaluated. Continuous evaluation in KRE will consist of two theoretical-practical tests, and two practical work deliveries. The final mark will be calculated as 30% of the results of each one of the theoretical tests and 20% of each practical work. For second evaluation, there will be a single exam."

   b) "Computer hardware equals the collection of physical elements that comprise a computer system. Computer hardware refers to the physical parts or components of a computer such as monitor, keyboard, hard drive disk, mouse, printers, graphic cards, sound cards, memory, motherboard and chips, etc. all of which are physical objects that you can actually touch. In contrast, software is untouchable. Software exists as ideas, application, concepts, and symbols, but it has no substance. A combination of hardware and software forms a usable computing system."

   c) "Primary care is the health care given by a health care provider. Typically this provider acts as the principal point of consultation for patients within a health care system and coordinates other specialists that the patient may need. Such a professional can be a primary care physician, such as a general practitioner or family physician, or depending on the locality, health system organization, and patient's discretion, they may see a pharmacist, a physician assistant, a nurse practitioner, a nurse (such as in the United Kingdom), a clinical officer (such as in parts of Africa), or an Ayurvedic or other traditional medicine professional (such as in parts of Asia).

   A patient-centered primary care stores all the information about one patient in the different episodes of care (eoc). A patient has a name, sex (M/W), race, and a date of birth. An eoc contains the date when the episode was created, and a sequence of encounters between the health care professional and the patient. Each encounter has a date a reference to the health care provider and a set of treatments. A treatment is composed of a set of findings which are textual descriptions of the patient signs and symptoms (for example, fever, high blood pressure, breast pain, …). A treatment can have attached a disease or set of diseases that the patient is treated of, and a set of medical actions that can be of the sort: pharmacological, test order, visit (to provider such as a specialist), or recommendation."

   d) "A chair is a raised surface used to sit on, commonly for use by one person. Chairs are most often supported by four legs and have a back; however, a chair can have three legs or could have a different shape.

   A chair without a back or arm rests is a stool, or when raised up, a bar stool. A chair with arms is an armchair and with folding action and inclining footrest, a recliner. A permanently fixed chair in a train or theater is a seat or, in an airplane, airline seat; when riding, it is a saddle and bicycle saddle, and for an automobile, a car seat or infant car seat. With wheels it is a wheelchair and when hung from above, a swing."

   e) "The Nobel Prizes are annual international awards bestowed by Scandinavian committees in recognition of cultural and scientific advances. The will of the Swedish chemist Alfred Nobel, the inventor of dynamite, established the prizes in 1895. The

prizes in Physics, Chemistry, Physiology or Medicine, Literature, and Peace were first awarded in 1901.

The Peace Prize is awarded in Oslo, Norway, while the other prizes are awarded in Stockholm, Sweden. Each Nobel Prize is regarded as the most prestigious award in its field.

In 1968, Sveriges Riksbank instituted an award that is often associated with the Nobel prizes, the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel. The first such prize was awarded in 1969. Although it is not an official Nobel Prize, its announcements and presentations are made along with the other prizes.

The Royal Swedish Academy of Sciences awards the Nobel Prize in Physics, the Nobel Prize in Chemistry, and the Nobel Memorial Prize in Economic Sciences. The Nobel Assembly at Karolinska Institutet awards the Nobel Prize in Physiology or Medicine. The Swedish Academy grants the Nobel Prize in Literature. The Nobel Peace Prize is not awarded by a Swedish organization but by the Norwegian Nobel Committee.

Each recipient, or laureate, receives a gold medal, a diploma, and a sum of money which depends on the Nobel Foundation's income that year. In 2011, each prize was worth €1.15 million."

f) "A stock market is a public market for the trading of company stock (shares) and derivatives at an agreed price. A share is a unit of account for various financial instruments including stocks, and investments. On the other hand, a derivative is a financial instrument that has a value, based on the expected future price movements of the asset to which it is linked."

g) "Engines can be classified into internal and external combustion engines. Internal combustion engines (ICE) are engines in which the combustion of a fuel (substance) occurs with an oxidizer (substance) in a combustion chamber. On the contrary, in external combustion engines (ECE), such as steam engines or Stirling engines, the energy is delivered to a working fluid (substance) different of a combustion product. Working fluids can be air, hot water, or pressurized water."

h) "Chronic disease treatment divides each disease in stages. Patients that have one chronic disease are classified in one of these stages. General practitioners base their decisions in the current stage of the patient and the time this patient has been in that stage. In general, a patient that is in a mild-moderate dangerous stage (MDS) is asked to modify his/her lifestyle (diet, salt intake reduction, moderate exercise), if the patient has been in a MDS for a significant period, he/she is prescribed with one drug to minimal dosage, while the patient is not improving the dosage is increased with fix increments. If a maximal dosage is reached, then a second drug to minimal dosage is prescribed. Patients can reach treatments with 4 drugs. Patients that arrive in highly dangerous stage (HDS) are directly prescribed with one drug and recommended lifestyle changes."

3. Find out *know-what* and *know-how* knowledge in the paragraphs of the exercise 2.

FIRST ORDER LOGIC

4. Provide expressions to represent the following facts in FOL:
   a) Men are not women.
   b) Surgeons are doctors.
   c) Adults can only be Men and Women.
   d) If a person marries another person, this one is also married to the first one.
   e) Parents have children.
   f) Adults are defined as Men and Women who are older than 18.
   g) Marriage is only allowed between two Adults.

h) A person cannot be married to two or more different persons.

i) Two persons can only get divorced if they are *previously* married.

j) People can only be given birth by a Man and a Woman.

5. Formalize the following sentences as FOL expressions, after identifying function symbols and predicate symbols:

   a) Mike is younger than the boy in the green T-shirt.

   b) The five-year boy wore a T-shirt with a square symbol.

   c) Mike's T-shirt is yellow.

   d) Mary's T-shirt does not bear a square symbol.

   e) Square symbols cannot appear in white T-shirts.

   f) The youngest person cannot wear a T-shirt.

   g) There are three T-shirt symbols: squares, pictures, and circles.

   h) There is not a person wearing a T-shirt with a circle if there's another person older than the first one wearing a square.

   i) Everybody wearing a T-shirt is older than any other not wearing a T-shirt.

   j) The number of people wearing a T-shirt yellow, are bigger than the ones not wearing a T-shirt with a square.

6. Given the following description:

   "Tony, Mike, and John belong to the Alpine Club. Every member of the Alpine Club who is not a skier is a mountain climber. Mountain climbers do not like rain, and anyone who does no like snow is not a skier. Mike dislikes whatever Tony likes, and likes whatever Tony dislikes."

   a) Formalize this knowledge as FOL expressions.

   b) Find out whether Tony is a mountain climber or not. Is it possible?

   c) What do you know about John?

   d) Prove that there is a member of the Alpine Club who is a mountain climber but not a skier.

   e) Suppose that Mary, a new member of the Alpine Club, likes what Mike and John likes. What can you say about Mary?

7. Given the relationship `Parent(x,y)` representing the fact "x is parent of y", and `Male(x)` representing "x is male", define in FOL the following family relationships:

   a) Son, Daughter, Brother, Sister, Sibling, Ancestor, Father, Mother, Grandfather, Grandmother, Uncle, Aunt, Cousin, and Nephew.

   b) John has not children. Jon has not siblings.

   c) John's parents are Mary (female) and Paul (male).

   d) John's sister has some children.

   e) The mother of Mary is the aunt of Michael.

8. Given the simplified set theory in which all the variables are considered sets, and using the predicates Sub(x,y)="x is a subset of y", E(e,x)="e is an element of the set x", and the functions u(x,y)="the union of x and y", i(x,y)="the intersection of x and y"; provide FOL expressions to represent the following knowledge:

a) No set is an element of itself.

b) A set x is a subset of a set y iff every element of x is an element of y.

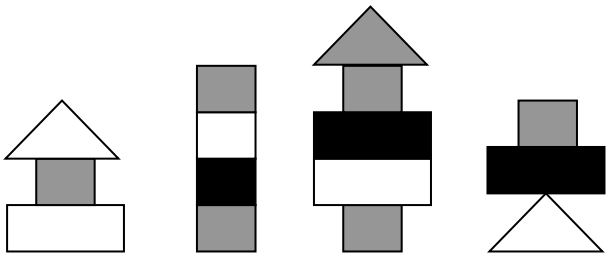
c) Something is an element of the union of two sets x and y iff it is an element of x or an element of y.

d) Something is an element of the intersection of two sets x and y iff it is an element of x and an element of y.

9. Let C(x) be the statement "x has a cat", let D(x) be the statement "x has a dog", and let F(x) be the statement "x has a ferret". Express each of these statements in first-order logic using these relations. Let the domain be your classmates.

   1. A classmate has a cat, a dog, and a ferret.
   2. All your classmates have a cat, a dog, or a ferret.
   3. At least one of your classmates has a cat and a ferret, but not a dog.
   4. None of your classmates has a cat, a dog, and a ferret.
   5. For each of the three animals, there is a classmate of yours that has one.

10. In the world of blocks we have three shapes: Triangle, Square and Rectangle; three colors: White, Black, and Grey; and the possibility of having one block on top of another: On(x,y). Provide a description of the following worlds in FOL:



11. In the world of blocks defined in exercise 10 provide FOL expressions for the following facts:

    a) Triangles cannot have other blocks on top

    b) All composition must have a Triangle at the very best top

    c) All Intermediate blocks must be Grey

    d) Some intermediate block is Black

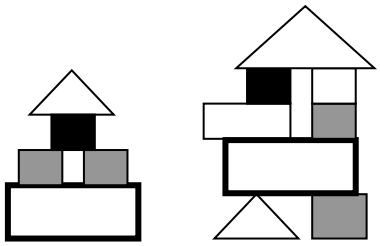
    e) Only White blocks are permitted

    f) There are not Black blocks immediately on top of White blocks

12. Extend the world of blocks of exercise 10 with two possible shapes for blocks: Large and Normal. Consider that large blocks can have one or two small blocks on top or another big block, and that two small blocks can have one single large block on top.

    a) How can you formalize these facts in FOL?

    b) Use this extended representation to describe the following worlds:



a) b)

13. What is the meaning of the following FOL expressions:
    a) $\forall x \forall y$ Loves(x,y)
    b) $\forall x \exists y$ Loves(x,y)
    c) $\exists x \forall y$ Loves(x,y)
    d) $\exists x \exists y$ Loves(x,y)
    e) $\forall x \forall y$ Loves(x,y) $\supseteq \forall z$ Loves(x,z)
    f) $\forall x \forall y$ Loves(x,y) $\supseteq \exists z$ Loves(x,z)
    g) $\forall x \exists y$ Loves(x,y) $\supseteq \forall z$ Loves(x,z)
    h) $\forall x \exists y$ Loves(x,y) $\supseteq \exists z$ Loves(x,z)

14. Provide FOL expressions representing the knowledge involved in each one of the domains described in exercise 2.

15. The Tower of Hanoi is a mathematical game or puzzle. It consists of three rods, and a number of disks of different sizes which can slide onto any rod. The puzzle starts with the disks in a neat stack in ascending order of size on one rod, the smallest at the top, thus making a conical shape.

    The objective of the puzzle is to move the entire stack to another rod, obeying the following rules:

    - Only one disk must be moved at a time.
    - Each move consists of taking the upper disk from one of the rods and sliding it onto another rod, on top of the other disks that may already be present on that rod.
    - No disk may be placed on top of a smaller disk.

    In order to formalize a three-disk Tower of Hanoi in FOL:

    a) Identify the individuals in the exercise
    b) Identify the types in the exercise: rods, disks, etc.
    c) Identify the attribute(s) in the exercise: size, etc.
    d) Formalize the initial configuration
    e) Formalize the concept “disk d can be moved to rod r” according to the second rule above (constraint)
    f) Formalize the movement move(d,r) or “the disk d is moved to rod r” according to the second rule above (know-how knowledge)
    g) Formalize the third rule above (constraint)

16. For the sentence $\forall x:(\forall y:(A(x) \wedge B(x,y) \Rightarrow A(y)))$ state whether it is true or false, relative to the following interpretations. If false, give values for x and y witnessing that.

a) The domain of the natural numbers, where A is interpreted as “even?”, and B is interpreted as “equals”

b) The domain of the natural numbers, where A is interpreted as “even?”, and B is interpreted as “is an integer divisor of”

c) The domain of the natural numbers, where A is interpreted as “even?”, and B is interpreted as “is an integer multiple of”

d) The domain of the Booleans, {true,false}, where A is interpreted as “false?”, and B is interpreted as “equals”

17. The puzzle game of Sudoku is played on a 9×9 grid, where each square holds a number between 1 and 9. The positions of the numbers must obey constraints. Each row and each column has each of the 9 numbers. Each of the 9 non-overlapping 3×3 square sub-grids has each of the 9 numbers.

    Throughout the game, some of the values have not been discovered, although they are determined. You start with some numbers revealed, enough to guarantee that the rest of the board is uniquely determined by the constraints. Thus, when deducing the value of another location, what has been revealed so far would serve as premises in a proof.

    Fortunately, there are the same number of rows, columns, subgrids, and values. So, our domain is {1,2,3,4,5,6,7,8,9}.

    To model the game, we will use the following relations: value(r,c,v) indicates that at row r, column c is the value v. v=w is the standard equality relation. subgrid(g,r,c) indicates that subgrid g includes the location at row r, column c.

    Provide domain axioms for Sudoku, and briefly explain them. These will model the row, column, and subgrid constraints. In addition, you should include constraints on our above relations, such as that each location holds one value.

18. Check for free and bound variables in the following expressions:

- $\forall x(\exists y P(x, y) \Rightarrow \exists z(Q(y, z) \Rightarrow R(x, y) \wedge P(x, y)))$
- $(\forall x(\exists y P(x, y) \Rightarrow \exists z(Q(y, z)))) \Rightarrow R(x, y) \wedge P(x, y)$
- $(\forall x(\exists y P(x, y) \Rightarrow \exists z(Q(y, z)) \Rightarrow R(x, y) \wedge P(x, y)))$
- $(\forall x(\exists y P(x, y))) \Rightarrow (\exists z(Q(y, z) \Rightarrow R(x, y) \wedge P(x, y)))$

19. Represent in FOL:

    i) Maria is mother of a son and a daughter.

    ii) Maria is mother of only one son and only one daughter.

    iii) Maria is mother of a son or a daughter.

    iv) All women are beautiful and some men are beautiful

RULES AND PRODUCTION SYSTEMS

20. Propose a rule for the knowledge represented in the following sentences:

    a) Grandmothers tell nice stories

    b) I hate all people that owns cats

    c) Summer days are hotter than winter days

    d) People that have both life and health insurances are full covered

e) All the subjects in the master have at least two different exams

f) The friends of the friends are friends

g) The friends of the enemies are enemies

h) There are six eye colors: amber, blue, brown, grey, green, and hazel.

i) People with green eye color are more attractive than the rest

j) Drivers take more than three months to get their diving license.

k) When red color is combined with yellow color, we obtain orange color.

l) Students have to pass, at least, three subjects in order to continue studying.

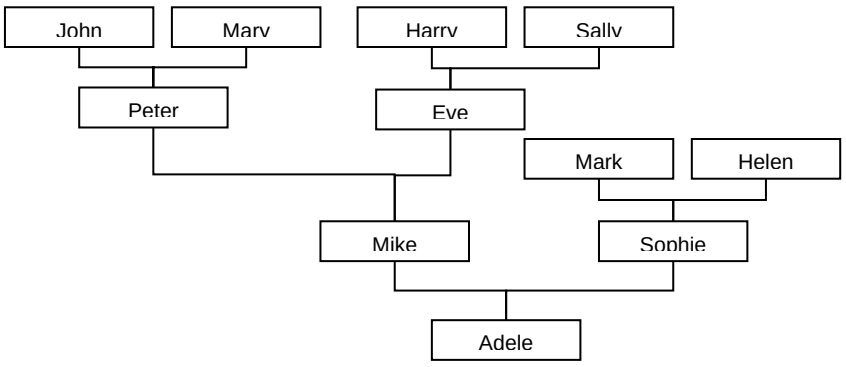
m) There are five groups of live beings: animals, plants, fungi, seaweeds, and bacteria. Animals can move and eat other live beings. People are Animals. Plants cannot move and they build their own food. Trees, bushes, and herbs are plants. Fungi cannot move but they cannot make their own food. Mushrooms and molds are fungi. Seaweeds are simpler than plants. Bacteria are tiny, they only can be observed with a microscopy and they're also called micro-organisms.

n) If something looks like a dog, moves like a dog, and barks like a dog, it is a dog.

o) I hate John, if he registers to a subject I don't.

p) Some people in love get married. All just married people are in love. Some people stop loving their couple some time after marriage. All married people that are not in love, get divorced (express divorce as the absence of marriage).

21. Given the following knowledge-base on parent relationships representing that John and Mary are parents of Peter, etc.



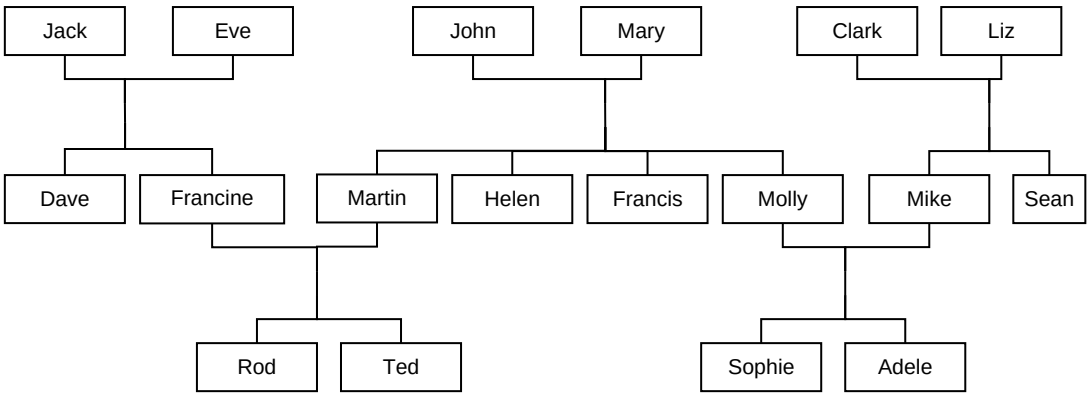
Calculate the number of questions in order to know whether `Ancestor(John,Adele)` is true or not for each one of the following three sets of rules:

a) $\texttt{Ancestor(x,y)} \Leftarrow \texttt{Parent(x,y).}$
$\texttt{Ancestor(x,y)} \Leftarrow \texttt{Parent(x,z)} \wedge \texttt{Ancestor(z,y).}$

b) $\texttt{Ancestor x,y)} \Leftarrow \texttt{Parent(x,y).}$
$\texttt{Ancestor(x,y)} \Leftarrow \texttt{Parent(z,y)} \wedge \texttt{Ancestor(x,z).}$

c) $\texttt{Ancestor(x,y)} \Leftarrow \texttt{Parent(x,y).}$
$\texttt{Ancestor(x,y)} \Leftarrow \texttt{Ancestor(x,z)} \wedge \texttt{Ancestor(z,y).}$

22. Calculate the same as in exercise 21 for the following parental KB:



23. Given the following set of rules

```
Lectures(adele,knowledgeRepresentation).
Lectures(barry,knowledgeRepresentation).
Lectures(charles,knowledgeEngineering).
Enrolled(donnald,knowledgeRepresentation).
Knows(x,y) ⇐ Enrolled(x,s1) ∧ Enrolled(y,s2) ∧ (s1=s2).
Knows(x,y) ⇐ Enrolled(x,z) ∧ Lectures(y,z).
```

1. Perform forward-chaining when “Enrolled(eve,knowledgeRepresentation)” is asserted.
2. Perform forward-chaining when “Enrolled(frank,knowledgeEngineering)” is asserted.
3. Perform backward-chaining when “Knows(donnald,adele)” is asked.
4. Perform forward-chaining when “Knows(donnald,barry)” is asserted.
5. Perform backward-chaining when “Enrolled(frank,knowledgeEngineering)” is asked.
6. Perform backward-chaining when asserted “¬Knows(donnald,charles)”.

24. Given the following working memory apply each one of the respective production rules:

Working Memory:

```
(book name:Don-Quixote author:Miguel-Cervantes year:1605 type:chivalry)
(book name:Hamlet author:William-Shakesperare)
(book name:The-three-Musketeers author:Alexandre-Dumas year:1844)
(book  name:The-Adventures-of-Huckleberry-Finn  year:1884  author:Mark-
Twain)
(writer name:Miguel-Cervantes bithyear:1547 deathyear:1616)
(writer name:William-Shakespeare birthdate:1564 deathyear:1616)
(cites book:The-three-Musketeers to:Don-Quixote)
(cites book:The-Adventures-of-Huckleberry-Finn to:Don-Quixote)
```

Production rules:

a) IF (writer name:x birthyear:y) (writer name:z birthyear:{> y}) THEN ADD (older who:x to:z)

b) IF (writer name:x deathyear:y) (book author:z year:{> y}) THEN ADD (older who:x to:z)

c) IF -(writer name:x) (book author:x) THEN REMOVE 2

d) IF (cites book:x to:y) –(book name:x) THEN REMOVE 1

e) IF (cites book:x to:y) (book name:x) (book name:y type:z) THEN MODIFY 2 (type z)

25. Give the working memory elements in exercise 24 provide production rules to implement each one of the following knowledge (extend the working memory with new elements if required):

    a) books written between 1600 and 1800 are of style baroque

    b) books whose author name is not known are anonymous

    c) writers with more than 10 books written are prolific

    d) writers with birthyear after deathyear must be deleted

    e) books that are cited by more than 5 other books are master-pieces

    f) Authors who wrote a master-piece are classics

26. For the following production system, trace the results, assuming that the conflict resolution strategy is: an instance of most important applicable rule is selected. If there are more than one such instances, the instance is selected randomly. The order of rule importance is: R3 more important than R1, R1 is more important than R2.

F1 animal(tiger)	R1 dangerous(x) $\Leftarrow$ animal(x) ^ large(x) ^ eatsMeat(x)
F2 animal(cat)	R2 breathesOxygen(x)) $\Leftarrow$ animal(x)
F3 large(tiger)	R3 runAwayNow $\Leftarrow$ dangerous(x)
F4 eatsMeat(tiger)	
F5 eatsMeat(cat)	

27. In the world of blocks we have the WME formats (block name:id color:c shape:s) asserting that there's a block with unique name id, (on up:blockid down:blockid) representing that up block is immediately on top of block down.

    a) Represent the knowledge "There are not consecutive blocks of the same color".

    b) Make a constructor saying that a block composition can be combined to make a new block.

    c) If all the blocks within a composite block have the same color and shape, the composite block is said to be homogeneous, otherwise it is heterogeneous.

    d) A structure of blocks is said to be legal if the number of stacked blocks are below one hundred.

    e) Height is the property of a block structure that stores the number of staked blocks of that structure.

    f) Constructing a structure consists on identifying two free blocks, use a crane to pick the free block with a lower height and staking it on top of the other block. Implement the production rules to implement this procedure.

28. In the world of blocks there's a group of blocks on a table, and we want to make a heap with all these blocks and with bigger blocks below smaller blocks. We count with a robot arm. Provide production systems for the following implementations:

    a) We are only allowed to have the type of WME (block id:int size:int position:{table, robot-hand, heap})

    b) We are only allowed to have the type of WME (block id:int size:int position: {table, robot-hand, #position in the heap}.

    c) We are allowed to have the following WME types: (block id:int size:int), (robot-hand block: int), (on block1: int, block2: int). Note: you should convert the blocks that the robot takes into used-blocks to avoid the robot to take them more than once.

    Implement all the solutions in CLIPS.

29. Domino is the game made of rectangular tiles with a line dividing its face into two square ends, each one containing numbers in the range 0-6. There are not repeated tiles. A simplified version of the game for two players consists on an initial selection of seven free tiles for each player. Starting with payer one, he releases one of his tiles (first movement) starting a line of game. Then alternatively, each player can release one of his tiles with one end that fits one of the extremes of the line of game. If a player cannot release one of his tiles, he takes a free tile. The turn passes. A player is said to lose the game when it is his turn to release a tile, he has tiles but he can release none of them, and there are not free tiles available to take.

    a) Provide a working memory element format to represent free tiles.

    b) Provide a working memory element format to indicate the tiles of one player.

    c) Provide a working memory element format to represent the line of game.

    d) Assuming a random conflict strategy, construct a production rule for a player to select one tile at random among the ones that are free.

    e) Construct a production rule for a player to select seven free tiles (beginning of game).

    f) Construct a production rule to represent the first movement of the first player.

    g) Construct a production rule to represent the next tile release of any player in the line of game.

    h) Construct a production rule to represent that a player has lost (he can release none of his tiles and there are no free tiles to take).

30. The *Towers of Hanoi* problem (see exercise 15) has an elegant recursive solution, but it also has a less well known iterative solution as follows. First, we arrange the pegs in a circle, so that clockwise we have rods A, B, C, and then A again. Disks are given the respective names 1, 2, and 3. Following this, assuming we never move the same disk twice, there will always only be one disk that can be legally moved, and we transfer it to the first rod it can occupy, moving it in a clockwise direction, if it is even, and counter-clockwise, if it is odd.

    Write a collection of production rules that implement this procedure. Initially, the working memory will have elements (on rod: A disk:i) for each disk and an element (solve). When your rules stop firing, you should have (on rod:C disk:i) for each disk and (done) in the working memory.

31. A circular railway is composed of four train stations S1, S2, S3, and S4. A train T circulates from S1 to S2, from S2 to S3, from S3 to S4, and from S4 to S1, starting the cycle again. The train has a capacity for 30 passengers sited and 20 passengers standing. Passengers arrive to and leave from stations. Some passengers want to be seated, some others don't care. Passengers have a destination station where they want to arrive to. All the passengers arrive to a station, get into the next train with a vacancy of the sort wished (seated or don't care) and waits till the train arrives to the passenger's destination station.

    a) Propose the structure of *the working memory elements* to implement this system.
    b) Propose a rule (or set of rules) describing the *patients arriving and leaving* a station.
    c) Propose a rule (or set of rules) describing the *train moving* between stations (consider that a train does not leave a station till all the passengers with destination this station have stepped off).

    Propose a rule (or set of rules) describing the passengers of a station to *step in the train* when the train arrives to the station, and the passengers to *step off the train* when they arrive to their destination station.

32. In some academies, students are able to enroll in subjects that they want to attend and whose pre-requirement they have all been passed. Pre-requirement of a subject are a set of other subjects that need to be passed before registering to the first one. Represent this behavior with a production system.

Other academies also consider co-requirements, these meaning that one subject can be enrolled if all its co-requirement subjects are also enrolled. Represent these restrictions with a production system.

OBJECT-ORIENTED REPRESENTATION

33. Provide a system of Frames to represent all the following assertions:
    a) A library is a place where there are books, magazines, CDs, and DVDs.
    b) All books are written by one or several authors that are men or women.
    c) There are some books that are anonymous.
    d) Library books, magazines, CDs, and DVDs can be borrowed by library members, which are men or women.
    e) The books with arrival date the current year cannot be borrowed.

34. Provide a system of Frames to represent all the following assertions:
    a) Planes land and take off in airports.
    b) All planes belong to a Flight Company.
    c) Flight Companies may organize into Alliances.
    d) Star Alliance is an alliance that contains the Flight Companies Air Canada, Spanair, Air China, Thai, and others.
    e) Planes flight from one airport to another following a timetable.
    f) There are two sorts of flight tickets: tourist, and business.

35. Represent with OO knowledge representation (frames and COOL) the following knowledge base:
    a) Vehicles are means of transportation with wheels with many possible colors and there are companies building different models of vehicles.
    b) There are vehicles that are classic-cars. These cars are made by a company.
    c) All classic-cars must have a company (i.e., company slot of CLASSIC-CAR is not optional).
    d) Classic-cars have a model. If the company making the car doesn't have this model in its list of models, it is inserted.
    e) Classic-cars have a factory price (the cost of producing the car) and a retail price (the cost to final client). Retail price is always 30% more than the factory-price, and the factory-price can change the production costs.
    f) Classic-cars have a horsepower value that must be always in the range [50, 200].
    g) Classic-cars have one single color that can be red, white, black, yellow, dark, or other. The information is stored codified, and recovered decodified.
    h) Persons can buy and sell classic-cars with the corresponding exchange of money.

36. For the following domains:

    Classroom scheduler: Build a program that helps schedule rooms for classes of various sizes at a university, using the sort of frame technology (frames, slots, and facets). Slots of frames might be used to record when and where a class is to be held, the capacity of a room,

etc., and IF-ADDED and other facets might be used to encode constraints as well as to fill in implied values when the KB is updated.

In this exercise, we want to consider updating the KB in several ways: (1) asserting that a class of a given size is to be held in a given room at a given time; the system would either go ahead and add this to its schedule, or alert the user that it was not possible to do so; (2) asserting that a class of a given size is to be held at a given time, with the system providing a suitable room (if one is available) when queried; (3) asserting that a class of a given size is desired, with the system providing a time and place when queried.

Olympic Assistant: We want to help the International Olympic Committee in the smooth running of the next Olympic Games. In particular, we want to select an event and write a program to deal with that event including facilities for handling the preliminary rounds/heats and finals. Slots of frames might be used to record athletes in a heat/final, the location and time of that heat/final, etc. and IF-ADDED/IF-NEEDED and other procedures might be used to encode constraints as well as fill in implied values when the knowledge base is updated.

We particularly wish to consider several ways of updating the knowledge base: (1) asserting that a heat will take place with certain athletes. The system should add this and determine what time and the location of the venue the athletes need to be at for their heat, etc; (2) asserting that a particular semi-final/final should take place, the system should determine the participating athletes; and, (3) asserting that the medal ceremony should take place at a particular time and location, the system should add this and provide the medalists plus appropriate national anthem when queried. To simplify matters, we assume that an athlete takes part in only the event we have chosen.

a) Design a set of frames and slots to represent the schedule and any ancillary information needed by the assistant.

b) For all slots of all frames, write in pseudo-code the IF-ADDED or IF-NEEDED procedures that would appear there. Annotate these procedures with comments explaining why they are there (e.g., what constraints they are enforcing).

c) Briefly explain how your system would work (what procedures would fire and what they would do) on concrete examples of your choosing illustrating each of the three situations (1, 2, and 3) mentioned in the application.

37. Provide a frame system for exercise a).

38. Provide a frame system for exercise e).

39. Provide a Script to represent the process of borrowing a book in a Library that could cover the following steps: enter into the library, look for a book in the shelves, in the computer, or directly with the librarian, make the reservation, go home with the book (if it was found), and return the book after some time.

40. Provide a Script to represent the process of flying (direct flights) between two airports: find all the companies that connect these airports, then ask for the time tables, select one sort of ticket, and purchase the ticket.

41. In a company there are three departments: Production, Sells, and Marketing. All the departments have one head which is a person with university studies, and other employees that are the workers. All workers of the Production department have a work turn of morning, afternoon, or over-night, and the turn of one person cannot be changed if the number of workers in the leaving turn goes below 10. The company produces two sorts of products: intermediate and final. Intermediate products remain in the Production department as components to produce other more complex products. Final products are those that are ready to be commercialized. All sorts of products have a production rate in units per hour. Once the final products are produced they are added to the catalog of available products. Clients made requests of the sort (n, p) where n is the number of units requested of product p. The workers of the Sell department solve the requests with products in the catalog of available products. Workers in the Marketing department analyze the catalog of available products to detect whether there many products of each sort (each product has an indicator of overstocked) and start a commercial campaign to sell these products to the company clients. The amount of work between workers of the same department are tried to keep balanced: all production workers are assigned one turn, the accumulated number of

requests attended for the sellers is +/-1 the same, and number of campaigns triggered by each marketing worker is +/-1 the same.

a) Provide a frame system to represent this domain.

b) Provide a script system to describe the production-marketing-selling procedure.

42. Represent with Frames the following knowledge: “An agenda is a list of meeting activities in the order in which they are to be taken up. Meeting activities can be professional and personal, and all of them have a priority. They have a date, duration in hours, and place. Optionally they may also have a person to which the meeting is been held with. When a meeting activity is introduced in the agenda it may create a conflict with a previous meeting and if the new meeting is more priority, the previous one is shifted to a list of to-be-assigned activities of the agenda.

    We consider that all the meeting activities are held, except those in the to-be-assigned list. The agenda also has an activity ratio which indicates the proportion of hours that the owner of the agenda has been met with respect to all the activities registered in the agenda (including the ones in the to-be-assigned list).”

43. Represent with Frames the following knowledge: “Backyards in houses are leisure surfaces with an extension measured in m2 containing elements such as vegetal, sport elements and constructions. Vegetal elements can be of the sort trees, bushes, and grass. Each one having a Latin and an ordinary name, a need of water measured in litters per day, a cost (which is unitary for trees and brushes, but which is per m2 for grass). Moreover, they occupy a surface in m2. Sport elements are swimming pools, and tennis courts. Both have extensions in m2, but swimming pools require refilling of water in terms of litters per day. Both elements have a construction cost. Finally, backyard constructions can be huts and greenhouses. Both of them occupy a surface in m2, and have a construction cost. Greenhouses require a supply of water in litters per day. The surface of the grass in a backyard is usually computed as the difference between the whole backyard and the rest of elements in the backyard. The need of water (and the cost) of the backyard is computed as the addition of the needs of water (and costs) of all the elements contained.”

NETWORK REPRESENTATION

44. Provide a definitional semantic network representing the knowledge in the following paragraph: “Mammals (class Mammalia) are a class of vertebrate animals characterized by the presence of sweat glands, including sweat glands modified for milk production, hair, three middle ear bones used in hearing, and a neocortex region in the brain. All mammals (except for the five species of monotremes) give birth to live young instead of laying eggs. Most mammals also possess specialized teeth, and the largest group of mammals, the placentals, uses a placenta during gestation”.

45. Provide a definitional semantic network representing the knowledge in the following paragraph: “A rocket or rocket vehicle is a missile, aircraft or other vehicle which obtains thrust by the reaction of the rocket to the ejection of fast moving fluid from a rocket engine. Chemical rockets work by the action of hot gas produced by the combustion of the propellant against the inside of combustion chambers and expansion nozzles. This generates forces that accelerate the gas to extremely high speed and exert a large thrust on the rocket”.

46. Provide an assertional semantic network to represent the following knowledge: “People are mammals. Rockets can be crewed or not. All the crewed rockets are crowed by people. All the rockets lift-off, but not all of them land. Outspace rockets are crewed by astronauts. If an outspace rocket lands, the astronaut becomes a hero. Neil Armstrong and Yuri Gagarin were astronauts of Gemini 8 and Vostok 1 rockets, respectively”.

47. Make a Petri Net to pipeline the following process of making bread: “Get the ingredients: yeast (2 Tbsp.), hot-ish water (2 cups), bread flour (5 cups total, 2 for the sponge and 3 for later.), sugar (2 Tbsp.), salt (2 tsp.), and oil (2 Tbsp.). Make the sponge: start by mixing 2 cups of hot-ish water and the flour, then add 2 Tbsp. sugar, 2 Tbsp. oil, 2 Tbsp. yeast, and 2 tsp. salt. Add some flour and knead it: add "about" 3 more cups of flour. Let it rise in a warm

place for about 45 minutes to an hour, it should be about doubled in size by the time it's finished. Put it in the loaf pans: punch the dough down and divide it into 3 parts. Spray the pans and put the dough in. Let it rise again in the pans. Bake it: preheat your oven to 350 degrees and put the loaves in. Bake them for about 25 minutes. Your quick read thermometer should read between 180 and 190 degrees. Pull the loaf".

48. Construct a definitional semantic network to represent the world of airlines: "Airlines have planes and hire pilots and hostesses that are assigned to planes; planes are assigned to flights; flights are between two cities (from and to), they have two dates and hours assigned (departure and arrival); flights define travels, though travels can have several flights connected; passengers are assigned to travels; cities have an intended influence population that can be high, medium or low; flights between two high populated cities require big planes; flights between two low populated cities require small planes; the rest of flights require medium planes."

49. Construct a definitional semantic network to represent the world of chairs: "A chair is a piece of furniture with a raised surface used to sit on, commonly for use by one person. Chairs are most often supported by four legs and have a back; however, a chair can have three legs or could have a different shape.

    A chair without a back or arm rests is a stool, or when raised up, a bar stool. A chair with arms is an armchair and with folding action and reclining footrest, a recliner. A permanently fixed chair in a train or theater is a seat or, in an airplane, airline seat; when riding, it is a saddle and bicycle saddle, and for an automobile, a car seat or infant car seat. With wheels it is a wheelchair and when hung from above, a swing." (Extracted from Wikipedia)

ONTOLOGIES

50. What is an ontology?
51. Represent the knowledge in all the section of the exercise 2 as ontologies.
52. Represent the PIZZA ontology with the following assertions.
    a) All pizzas have a base and some toppings.
    b) There are two sorts of pizzas: red pizzas and white pizzas.
    c) Red pizzas must have tomato as topping.
    d) White pizzas cannot have tomato.
    e) Toppings can be spicy or soft.
    f) Chilly is a spicy topping.
    g) A pizza with a thin base is a crispy pizza.
    h) Pizzas with more than two spicy toppings are hot pizzas.
    i) Vegetarian pizzas cannot contain meat toppings.
    j) Pizzas can only have one base (functional property).

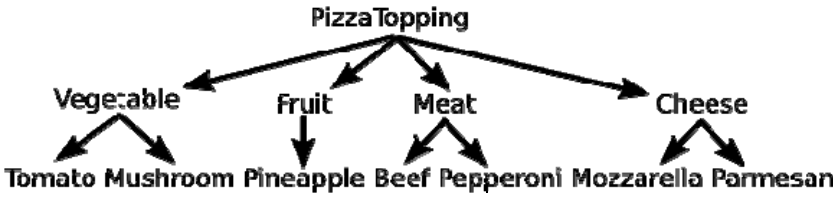
53. Represent the BANK ontology that contains the following knowledge:
    a) A bank has customers.
    b) Customers can be persons (retail customers) or companies (business customers).
    c) A retail customer cannot be a business customer; a business customer can never be a retail customer.
    d) Nicolas Claus is a retail customer; Santa Inc. is a business customer.
    e) A customer can have a bank account; a bank account belongs to a specific bank.
    f) A customer has to have at least one bank account.

g) Only trusted customers can get a credit.

h) A retail customer is a trusted customer if he has a trusted account; a business customer is always a trusted customer.

54. Use the Protégé tool to represent the knowledge contained in the exercise 52.

55. In the world of pizza toppings, we have the following hierarchy of classes:



Each word in the figure is a class and the arrows represent subclasses (e.g. Tomato is a subclass of Vegetable). Note that some of the class names in this ontology are purposefully misleading for the purposes of this exercise. Without making assumptions about information not present in the figure, answer the following questions about OWL:

According to this ontology,

a) Can something be meat but not a pizza topping?

b) Can something be both meat and a vegetable?

c) Is beef a pizza topping?

d) In OWL, can we prevent something from being both a fruit and a vegetable? If so, how? If not, why not?

e) How are the class names in this ontology misleading? How would you rename the classes to make them less misleading?

56. Following with the pizza topping world, Consider the following segment of OWL code:

```
class(VegetarianPizza,
Pizza,
complementOf(restriction(hasTopping someValuesFrom Meat)))

class(TomatoPizza
Pizza
restriction(hasTopping someValuesFrom Tomato))
```

Using information from both the pizza topping hierarchy and the OWL code segment, answer the following questions:

a) Can a TomatoPizza contain meat?

b) Can a pizza be both a VegetarianPizza and a TomatoPizza?

c) Are all TomatoPizzas VegetarianPizzas?

57. Define a new pizza called "BeefPizza" using a similar syntax style as used on the OWL code segment above. A BeefPizza has some Tomato toppings, some Beef toppings, but no other toppings.

58. Engineer a comprehensive ontology describing domain of university education in accordance to the statement provided below. Select the methodology described through lecturing material. Express the ontology in OWL.

"*A set of faculties and institutes comprise a university. A university is responsible for organizing teaching process formalized through curricula. Faculties and institutes are contributing to a curriculum through lectures and tutorials, conducted by university personnel (professors and assistants). Students must subscribe themselves to a specific curriculum and must pass lecture exams and successfully conclude tutorial exercises. A*

student may take an exam up to three times for a specific lecture. Upon successful exam a grade is recorded in the student transcript."

59. To represent OWL ontologies we can use the TURTLE notation which is explained with the following examples:

To indicate A is a class: A is Class; (ex: *Person is Class*;).
To indicate A is a subclass of B: A is B; (ex: *Man is Person*;).
To indicate p is a property: p is Property; (ex: *marriedTo is Property*;).
To indicate I is an instance of class A: I instanceOf A; (ex: *John instanceOf Man*;).
To indicate p is a property of classes A, B, …: p hasDomain A, B, …; (ex. *marriedTo hasDomain Man, Woman*;).
To indicate p is a property with range R: p hasRange R; (ex. *marriedTo hasRange Person*;).

Recall that the range R of a propert can be a complex experssion reflecting:

- A class with a name (ex: *Woman* representing all the instances of the class Woman)
- An intersection (ej: *Person* $\cap$ *Adult* representing all the adult persons).
- A union (ex: *Woman* $\cup$ *Girl* representing women and girls).
- A complement (ex. $\neg$*Woman* representing all instances not of the class Woman).
- A minimal limitation of the number of instances in a class (ex: $\leq$*3marriedTo* represents all the instances that are married to 3 or less persons).
- A maximal limitation of the number of instances in a class (ex: $\geq$*2marriedTo* represents all the instances that are married to 2 or more people).
- A universal quantifier (ex: $\forall$*marriedTo.Man* indicates all the instances that are only married to men, one or more times).
- An existential quantifier (ex: $\exists$ *marriedTo.Person* indicates the entire instances that are married to one person, at least).

Given the former language to represent OWL ontologies, represent the following knowledge units:

a) "… Owners are classified into companies, individuals, families, and groups …".
b) "… Individual are adult persons living alone …".
c) "… Families can be young families (they have, at least, an adult, but also one or more young people or children), adult families (when all the members are adults, but not elder) and elder families (whne all the members are elder) …".
d) "… Alejandro has Passport No 46001122 and he's owner of a flat of 100 m^2 …".

KNOWLEDGE LIFECYCLE

60. What's the meaning of the concept of "Knowledge Lifecycle"? What is it representing?.
61. Describe the primary knowledge processes of a Knowledge Lifecycle.

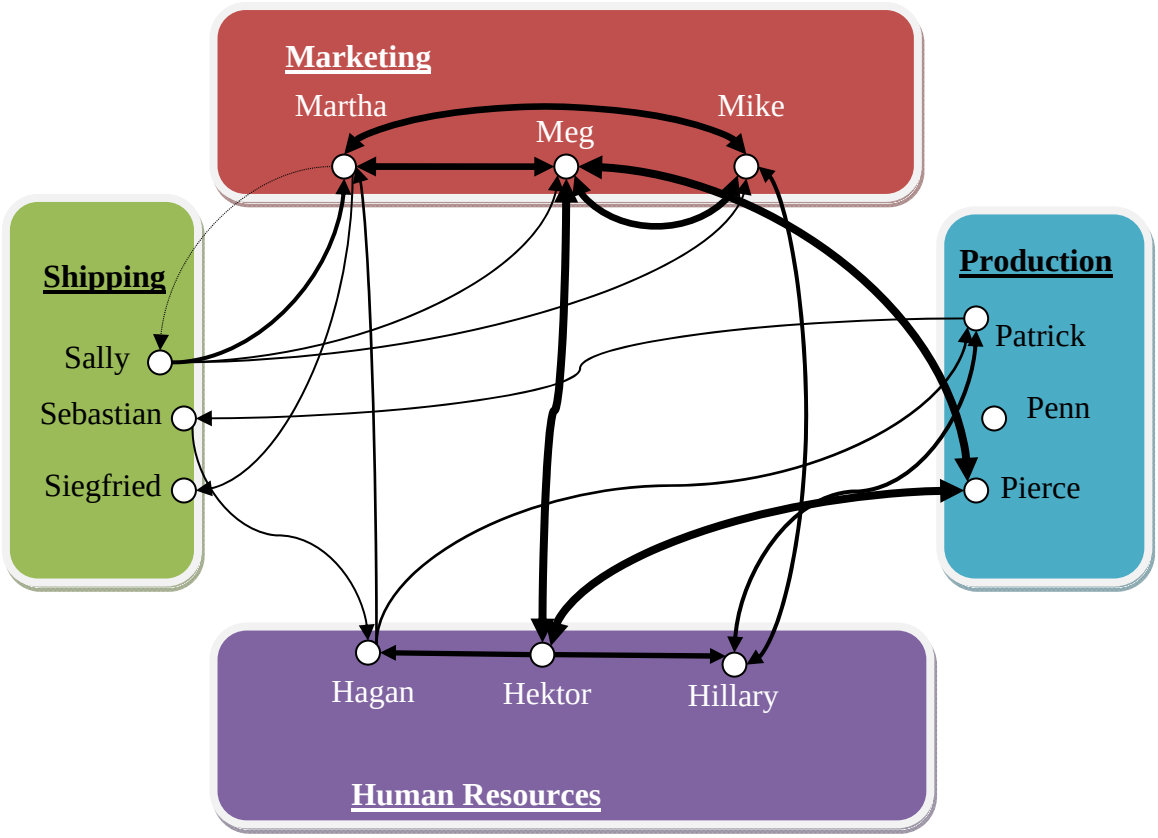
KNOWLEDGE AUDITING AND DEPLOYMENT

62. What is a knowledge Audit? What are its general steps?
63. What sections a knowledge audit document should contain? Explain.

64. If you have a chance, find a friend or familiar running a business and work with him/her for no more than an hour following the knowledge audit algorithm presented in class. After this experience, what are your conclusions? Was this beneficial to your friend/familiar? How?

65. After exercise 64, write an audit document with the basic results after the experience.

66. Given the following knowledge map on the interactions of the members in a company, ¿what can you deduce for the departments with regard to the way they work inside and with other departments? ¿what can you deduce from the people in the company? Provide an example of business process that is not possible in this company (for example: "Martha detects a market need and discusses it with Mike, who decides to contact Hillary to analyze the possibilities to ask Patrick's help to start producing a new product, and Sally for future shipping of this product". Clearly this situation is not possible since there is not a communication from Mike to Sally. Notice that the rest of communications in the scenario depicted are possible).

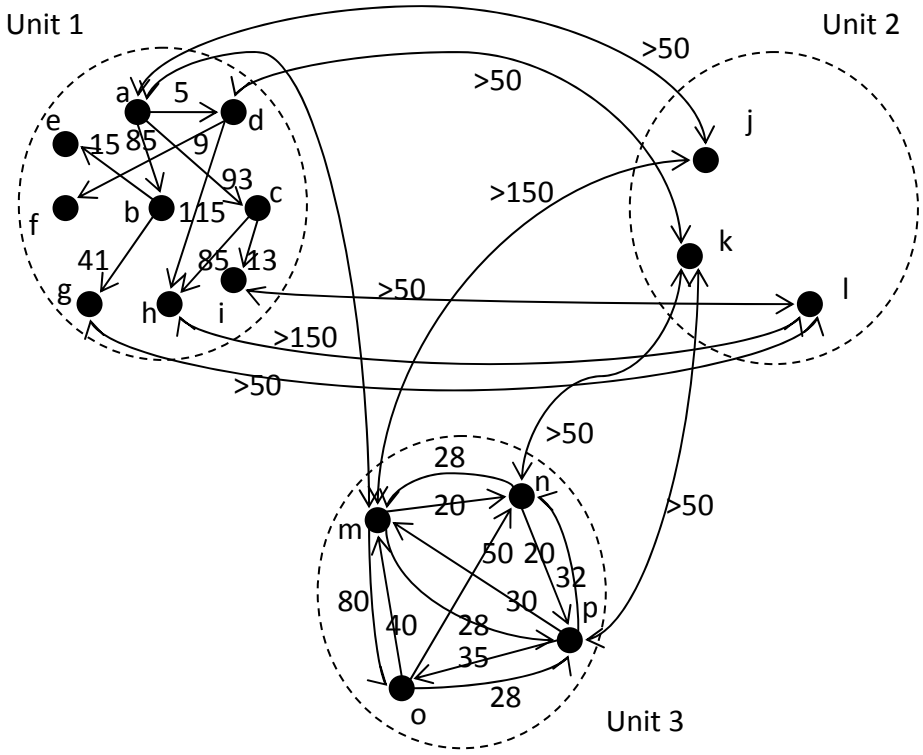


67. Collaboration between workers in a company are represented in the knowledge map attached; where workers are identified with letters a, b, …, p; and collaborations with arrows with a number representing the number of communications in the collaboration.

    a) ¿what can you say about the work structure inside the units?

    b) ¿what can you say of the collaboration between each pair of units?

    c) ¿What other things can you deduce from the knowledge map?



68. Make a knowledge semantic map to represent the knowledge contained in each one of the paragraphs in exercise 2.

KNOWLEDGE ACQUISITION

69. What is knowledge acquisition? What is it for? Is it necessary? Why?
70. What are the elements that domain experts and knowledge engineers exchange along a knowledge acquisition process?
71. If you have a chance, find a friend or familiar with a hobby on which he/she knows quite a lot, and practice the knowledge acquisition task. Represent the knowledge captures as a:
    a) Semantic Network.
    b) Ontology.
    c) Knowledge semantic map.

    Which representation formalism was easier to apply? Why?
72. Use Wikipedia as a domain expert and surf it in a knowledge acquisition process with regard to the following domain areas:
    a) Butterflies
    b) Knowledge engineering
    c) Knowledge acquisition
    d) Choose your own topic of interest

    Represent the knowledge captured as a semantic network.

73. Define DTD for each one of the following descriptions and use the web tools discussed in class to validate them:

    a) "Letters have a header a body and a footer. In the header there is a date (month, day, and year) and the information about the destination (optional person name, position, and full address –number, street/avenue, city, ZIP, optional state, country-), the body has an introduction of the sort formal ("Dear"), friendly ("Dear friend", "Hi", "Hello"), or nonexistent, and a free content made of paragraphs. The letter concludes with a footer with a closing sentence that can be formal ("Looking forward to knowing about you", "Sincerely", …), semiformal ("Regard", "Best regards", …), or informal ("Bye", "Best regards", "see you", "ciao", …), concluding with the sender, that can contain, the name, the name and the surname, or the name, surname, and affiliation of the sender."

    b) "The minutes of the meetings in a company are stored as XML files. They contain the following information: date, place, called people, list of participants, person or department calling, conductor of the meeting, whether this meeting is the continuation of a previous one and which, an agenda or list of topics to discuss (always containing an agreement on the previous minute (if there's any) and a report of the calling person, and concluding with the item "close session"). Then the detail of the discussed issues, one by one, started with a title of the agenda item and then all the comments in the meeting preceded by the name of the person exposing the facts. The minutes conclude with a list of decisions, and optionally with a next proposed meeting day. "

    c) "In health care, the minimum basic data set (MBDS) is a data structure that contains important information to know the health care reality in a cohort since in addition to the demographic data about patients (age, gender, residence place), it registers the diagnosis motivating the admission (primary diagnosis), the risk factors, comorbidities and complications of the patient during the treatment (secondary diagnoses), some relevant diagnostic techniques and the therapeutic interventions used to treat the patient (the procedures). Finally, in the MBDS we find the admission and the discharge dates, the admission cause (urgency, scheduled), and the discharge reason (home, death, transfer to other hospital, etc.)".

    d) "The Dublin Core Schema is a small set of vocabulary terms that can be used to describe web resources (video, images, web pages, etc.), as well as physical resources such as books or CDs, and objects like artworks. The original Dublin Core Metadata Element Set consists of 15 metadata elements: Title, Creator, Subject, Description, Publisher, Contributor, Date, Type, Format, Identifier, Source, Language, Relation, Coverage, and Rights. Each Dublin Core element is optional and may be repeated."

74. Define XML schemas for each one of the descriptions in exercise 73 and use the web tools discussed in class to validate them.

75. Construct the XPath queries to recover the following information:

	Source document	Recover
a)	`<document name="getit Übungsaufgaben" />`	The attribute "name".

b)	`<document xmlns:xlink="http://www.w3.org/1999/xlink">`
	`  <linkList name="A">`
	`  <document xlink:href="15024" />`
	`  <document xlink:href="15028" />`
	`  </linkList>`
	`  <linkList name="B">`
	`  <document xlink:href="15030" />`
	`  <document xlink:href="15032" />`
	`  </linkList>`
	`</document>`
		The document elements below the node "linkList".

c)	`<person>`
	`  <lastName>Peter</lastName>`
	`  <firstName>Hans</firstName>`
	`</person>`
		The combination of "lastName", followed by the string ", ", and the "fistName".

d)	`<jobs>` `  <job priority="critical" name="Müll rausbringen" />`	The jobs with a priority

	<job priority="low" name="Möbel säubern" /> <job priority="low" name="Teppich reinigen" /> <job priority="medium" name="Fenster putzen" /> <job priority="high" name="Pflanzen gießen" /> </jobs>	with value equal to "critical" or "high".
e)	<persons> <person firstName="Hans" lastName="Mustermann" age="28" /> <person firstName="Herbert" lastName="Möllemann" age="33" /> <person firstName="Peter" lastName="Meier" age="37" /> <person firstName="Ulrike" lastName="Albrecht" age="45" /> </persons>	All persons with age<35.
f)	<persons> <person firstName="Hans" lastName="Mustermann" age="28" /> <person firstName="Herbert" lastName="Möllemann" age="33" /> <person firstName="Peter" lastName="Meier" age="37" /> <person firstName="Ulrike" lastName="Albrecht" age="45" /> </persons>	The first three person elements.
g)	<persons> <person firstName="Hans" lastName="Mustermann" age="28" /> <person firstName="Herbert" lastName="Möllemann" age="33" /> <person firstName="Peter" lastName="Meier" age="37" /> <person firstName="Ulrike" lastName="Albrecht" age="45" /> </persons>	Persons whose first name begins with H
h)	<persons> <person firstName="Hans" lastName="Mustermann" age="28" /> <person firstName="Herbert" lastName="Möllemann" age="33" /> <person firstName="Peter" lastName="Meier" age="37" /> <person firstName="Ulrike" lastName="Albrecht" age="45" /> <person firstName="Uwe" lastName="Peters" age="34" /> </persons>	Person elements with attribute "firstName" a maximum 5 characters long.
i)	<numbers> <number>33</number> <number>34.4</number> <number>33.8</number> <number>33.43</number> <number>34.46</number> <number>35</number> <number>33.49</number> <number>33.00</number> </numbers>	The sum of all numbers which round off to 34 (Result: 102.66).
j)	<products> <product id="1" name="Teekanne" price="25.00" category="1" /> <product id="2" name="Bleistift" price="0.29" category="2" /> <product id="3" name="Lautsprecher" price="19.00" category="2" /> <product id="4" name="Tasse" price="1.99" category="1" /> <product id="5" name="Apfelsaft" price="1.49" category="1" /> <product id="6" name="CD-Rohling" price="0.89" category="2" /> <category id="1" name="Sortiment 2005" /> <category id="2" name="Sortiment 2006" /> </products>	The product siblings relatively from their current node (Result: products 4, 5, 6).
k)	<products> <product id="1" name="Teekanne" price="25.00" category="1" /> <product id="2" name="Bleistift" price="0.29" category="2" /> <product id="3" name="Lautsprecher" price="19.00" category="2" /> <product id="4" name="Tasse" price="1.99" category="1" /> <product id="5" name="Apfelsaft" price="1.49" category="1" /> <product id="6" name="CD-Rohling" price="0.89" category="2" /> <category id="1" name="Sortiment 2005" /> <category id="2" name="Sortiment 2006" /> </products>	The product siblings containing 1 in category, relatively from their current node (Result: 4, 5).
l)	<collection> <artist> <name>Robbie Williams</name> <cds> <cd>Rudebox</cd> <cd>Swing when you're winning</cd> </cds> </artist> <band> <name>Juli</name> <cds> <cd>Ein neuer Tag</cd> </cds> </band> <band> <name>Silbermond</name> <cds> <cd>Verschwende deine Zeit</cd> </cds> </band> <artist> <name>Michael Jackson</name> <cds> <cd>Bad</cd> <cd>Thriller</cd> </cds> </artist>	How many albums in the collection are by solo artist and how many are by bands (Result: 4 and 2). The name of the artist that goes with the cd Rudebox (Result: Robbie Williams). The name of the first listed cd of the last artist in the collection (Result: Bad).

	`</collection>`	

m)	`<jobs>`
	`  <job priority="critical" name="Müll rausbringen" />`
	`  <job priority="low" name="Möbel säubern" />`
	`  <job priority="low" name="Teppich reinigen" />`
	`  <job priority="medium" name="Fenster putzen" />`
	`  <job priority="high" name="Pflanzen gießen" />`
	`</jobs>`
		Number of jobs with priority "low" (Result: 2)

n)	`<jobs>`
	`  <job name="cut Screens" availableBudget="8">`
	`  <work usedBudget="3">Conception</work>`
	`  <work usedBudget="3">Implementation</work>`
	`  <work usedBudget="2.5">Implementation</work>`
	`  </job>`
	`  <job name="build HTML-demonstration" availableBudget="6">`
	`  <work usedBudget="1.5">Conception</work>`
	`  <work usedBudget="2.5">Implementation</work>`
	`  <work usedBudget="2">Implementation</work>`
	`  </job>`
	`  <job name="CMS implementation" availableBudget="12">`
	`  <work usedBudget="1">Data model</work>`
	`  <work usedBudget="4">Editor-Customizing</work>`
	`  <work usedBudget="4">Transformations</work>`
	`  <work usedBudget="2">QS</work>`
	`  </job>`
	`</jobs>`
		Select all job elements with an exceeded budget. That is to say the "availableBudget" is greater than the addition of all its work expenses (attributes "useBudget") (Result: element "cut Screens").

o)	`<artist name="Robbie Williams">`
	`  <cd name="Rudebox">`
	`  <title>Rudebox</title>`
	`  <title>Viva Life On Mars</title>`
	`  <title>Lovelight (Lewis Taylor Cover)</title>`
	`  <title>King Of The Bongo (Manu Chao Cover)</title>`
	`  <title>Swing when you're winning</title>`
	`  <title>Good Doctor</title>`
	`  </cd>`
	`</artist>`
		Calculate the number of titles using its position (Result: 5).

76. A library contains bookcases and each bookcase is composed of shelves that can contain an undefined number of books and/or magazines. The DTD defining this structure is:

```
<!ELEMENT library (bookcase*)>
<!ELEMENT bookcase (shelf+)>
<!ELEMENT shelf (book* magazine*)>
<!ELEMENT book (author? title)>
<!ATTLIST book code ID #REQUIRED year CDATA #REQUIRED>
<!ELEMENT author (#PCDATA)>
<!ELEMENT title (#PCDATA)>
<!ELEMENT magazine (#PCDATA)>
<!ATTLIST magazine year CDATA #REQUIRED>
```

Provide XPath expressions for the following queries:

a) The first book in the library.
b) The bookcase that contains the book with code 'A323'.
c) The title of all the books of Mark Twain in the library.
d) The books that are published in year 1968 and are in the second shelf of any bookcase.
e) The shelves that contain only magazines
f) Number of books in the library that have no author (anonymous).

77. Construct XSLT programs to transform all the XML source documents of exercise 75 into HTML documents that show the data in a pretty nice form (colors, styles, tables with headings, etc.)

78. Construct a Family Relations OWL ontology following the next list of steps (you can use the Protégé tool):
    a) State that a person can only have one mother and only one father.
    b) State that a woman can only have female as gender, and a man can only have male as gender.
    c) State that nothing can be both male and female.
    d) Define the gender so that there can only be the genders man and woman.
    e) For all pair of classes in the family ontology, add the correct disjoint axioms.
    f) State that a person is either a man or a woman, but not both.

g) For all the properties that exist in our ontology, add the correct inverse property axioms.
h) For all the properties in the ontology, state those that are transitive and/or symmetric.
i) For all properties in our ontology, state those they are inverse functional.

79. Construct a Business OWL ontology following the next list of steps (you can use the Protégé tool):
    a) There should be three classes: Customer, Shop, and Product.
    b) Customer and Shop should be equipped with properties name (xsd:string) and email (xsd:string).
    c) Each Product should have an order number (xsd:int). An order number can be unambiguously assigned to a Product.
    d) A Shop should have a property sells (range: Product) and a Product should have a property soldBy (range: Shop) respectively.
    e) Instances of class Shop that sell more than 100 products should belong to a new class BigShop.
    f) A Product must not be a Customer.
    g) Instances that are both, Shop and Customer should belong to a class PurchaseAndSale.

80. Given the following OWL DL ontologies, define in plain text what their main class stands for:

	OWL Ontology

a)	`<owl:Class rdf:ID="ntnu_skier">`
	`<rdfs:subClassOf>`
	`<owl:Restriction>`
	`<owl:allValuesFrom>`
	`<owl:Class rdf:ID="skier"/>`
	`</owl:allValuesFrom>`
	`<owl:onProperty>`
	`<owl:ObjectProperty rdf:ID="hasFriend"/>`
	`</owl:onProperty>`
	`</owl:Restriction>`
	`</rdfs:subClassOf>`
	`<rdfs:subClassOf>`
	`<owl:Restriction>`
	`<owl:hasValue>`
	`<university rdf:ID="NTNU"/>`
	`</owl:hasValue>`
	`<owl:onProperty>`
	`<owl:ObjectProperty rdf:ID="studiesAt"/>`
	`</owl:onProperty>`
	`</owl:Restriction>`
	`</rdfs:subClassOf>`
	`<rdfs:subClassOf rdf:resource="#skier"/>`
	`</owl:Class>`

b)	`<owl:Class rdf:ID="Person">`
	`<rdfs:subClassOf rdf:resource="http://www.w3.org/2002/07/owl#Thing"/>`
	`</owl:Class>`
	`<owl:ObjectProperty rdf:ID="hasParent">`
	`<rdfs:subPropertyOf>`
	`<owl:ObjectProperty rdf:ID="hasAncestor"/>`
	`</rdfs:subPropertyOf>`
	`<rdfs:domain rdf:resource="#Person"/>`
	`<rdfs:range rdf:resource="#Person"/>`
	`</owl:ObjectProperty>`
	`<owl:ObjectProperty rdf:about="#hasAncestor">`
	`<rdfs:domain rdf:resource="#Person"/>`
	`<rdfs:range rdf:resource="#Person"/>`
	`<rdf:type rdf:resource="http://www.w3.org/2002/07/owl#TransitiveProperty"/>`
	`</owl:ObjectProperty>`

81. Given the following OWL DL ontology, define the class hierarchy described:

a)	`<owl:Class rdf:ID="Shirts">`
	`<rdfs:subClassOf>`
	`<owl:Class rdf:ID="MensWear"/>`
	`</rdfs:subClassOf>`

```
</owl:Class>
<owl:Class rdf:ID="Henleys">
  <rdfs:subClassOf rdf:resource="#Shirts"/>
</owl:Class>
<owl:Class rdf:about="#MensWear">
  <rdfs:subClassOf rdf:resource="http://www.w3.org/2002/07/owl#Thing"/>
</owl:Class>
<owl:Class rdf:ID="WomensWear">
  <rdfs:subClassOf rdf:resource="http://www.w3.org/2002/07/owl#Thing"/>
</owl:Class>
<owl:Class rdf:ID="Tshirts">
  <rdfs:subClassOf rdf:resource="#Shirts"/>
</owl:Class>
<owl:Class rdf:ID="Blouses">
  <rdfs:subClassOf rdf:resource="#WomensWear"/>
</owl:Class>
<owl:Class rdf:ID="Oxfords">
  <rdfs:subClassOf rdf:resource="#Shirts"/>
</owl:Class>
```

82. Given the following OWL DL ontologies, define the class-relationship networks described:

a)

```
<owl:Class rdf:ID="Play">
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Play</rdfs:label>
</owl:Class>
<owl:Class rdf:ID="Place">
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Place</rdfs:label>
</owl:Class>
<owl:Class rdf:ID="Person">
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Person</rdfs:label>
</owl:Class>
<owl:Class rdf:ID="Author">
  <rdfs:subClassOf rdf:resource="#Person"/>
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >Author</rdfs:label>
</owl:Class>
<owl:ObjectProperty rdf:about="[…]”>
  <rdfs:domain rdf:resource="#Person"/>
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >married</rdfs:label>
  <rdfs:range rdf:resource="#Person"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="setIn">
  <rdfs:range rdf:resource="#Place"/>
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >set in</rdfs:label>
  <rdfs:domain rdf:resource="#Play"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="wrote">
  <rdfs:range rdf:resource="#Play"/>
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >wrote</rdfs:label>
  <rdfs:domain rdf:resource="#Author"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:about="[…]">
  <rdfs:domain rdf:resource="#Person"/>
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >lived in</rdfs:label>
  <rdfs:range rdf:resource="#Place"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:about="[…]">
  <rdfs:domain rdf:resource="#Place"/>
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >part of</rdfs:label>
  <rdfs:range rdf:resource="#Place"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:about="[…]">
  <rdfs:domain rdf:resource="#Place"/>
  <rdfs:label rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
  >is in</rdfs:label>
  <rdfs:range rdf:resource="#Place"/>
```

	`</owl:ObjectProperty>`

b)	`<owl:Class rdf:ID="Company">`
	`  <rdfs:subClassOf rdf:resource="http://www.w3.org/2002/07/owl#Thing"/>`
	`</owl:Class>`
	`<owl:Class rdf:ID="Person">`
	`  <rdfs:subClassOf rdf:resource="http://www.w3.org/2002/07/owl#Thing"/>`
	`</owl:Class>`
	`<owl:ObjectProperty rdf:ID="isEmployedBy">`
	`  <rdfs:domain rdf:resource="#Person"/>`
	`  <rdfs:range rdf:resource="#Company"/>`
	`  <rdfs:subPropertyOf>`
	`  <owl:ObjectProperty rdf:ID="worksFor"/>`
	`  </rdfs:subPropertyOf>`
	`</owl:ObjectProperty>`
	`<owl:ObjectProperty rdf:ID="contractsTo">`
	`  <rdfs:domain rdf:resource="#Person"/>`
	`  <rdfs:range rdf:resource="#Company"/>`
	`  <rdfs:subPropertyOf>`
	`  <owl:ObjectProperty rdf:about="#worksFor"/>`
	`  </rdfs:subPropertyOf>`
	`</owl:ObjectProperty>`
	`<owl:ObjectProperty rdf:ID="indirectlyContractsTo">`
	`  <rdfs:subPropertyOf rdf:resource="#contractsTo"/>`
	`  <rdfs:range rdf:resource="#Company"/>`
	`  <rdfs:domain rdf:resource="#Person"/>`
	`</owl:ObjectProperty>`
	`<owl:ObjectProperty rdf:about="#worksFor">`
	`  <rdfs:domain rdf:resource="#Person"/>`
	`  <rdfs:range rdf:resource="#Company"/>`
	`</owl:ObjectProperty>`
	`<owl:ObjectProperty rdf:ID="freeLancesTo">`
	`  <rdfs:domain rdf:resource="#Person"/>`
	`  <rdfs:range rdf:resource="#Company"/>`
	`  <rdfs:subPropertyOf rdf:resource="#contractsTo"/>`
	`</owl:ObjectProperty>`