Contact during exam:
Tore Amble (94451)

ENGLISH

EXAM IN COURSE

TDT4136 Logic and Reasoning Systems

Friday December 19. 2008
Time: 09.00 – 13.00

Allowed aids D:
No printed or hand written aids are allowed.
Specific simple calculator is allowed.

The grading is expected in week 3, 2009 .

A translation from English to Norwegian is enclosed.
You are free to answer in any of these languages.

TASK 1 (25 %)

Consider the following sentence:

“ Every restaurant has a menu “

This sentence has two interpretations:

- (A) for each restaurant there exists a menu so that the restaurant has this menu.
- (B) there exists a menu such that every restaurant has this menu.

a) The two sentences are so that one of them implies the other. Show informally that (B) implies (A).

b) Formulate each of these interpretations in first order logic using the predicates

- R(x) x is a restaurant
- M(y) y is a menu
- H(x,y) x has y

Call these formulations FA and FB

c) Explain how we can use resolution to prove that FB implies FA .

d) Perform the necessary steps to convert the relevant formulas into clausal form.

e) Prove that FB implies FA by means of a resolution proof.

TASK 2 (20 %)

At a conference, a list of conference assistants shall be allocated to a set of tasks.

The conference is 4 days, and conference working hours are slots of 2 hours from morning 8 to 12 and afternoon 14 to 18 every day.

There is a lecture hall, an exhibition area and a lobby.

The conference staff will have the following 5 activities

```
A1      Registration
A2      Information desk in lobby
A3      Lecture
A4      Exhibition
A5      Computer service, including  update of web-pages
```

There are several types of staff, defined by which subset of tasks A1-A5 they can do.

The following constraints apply:

Registration is only open the first morning and needs 3 people.

The information desk has to be manned at all times.

Each lecture needs an assistant in the lecture hall.

Computer service must be done both once in the morning and once in the afternoon each day.

The exhibition needs an assistant when open.

No assistant shall work more than 1 time slot in a row with the same task.

One person can only do one activity at a time

The manning plan can be set up in a matrix, as sketched in the example below.

```
               Day 1                     Day 2

Hour           08-10 10-12 14-16 16-18   08-10 10-12 14-16 16-18

Person
        P1     A1

        P2     A1    A2   A2

        P3     A1

        P4     A1

        P5     A2

        P6
```

a) Formulate in general terms what is meant by a constraint satisfaction problem (CSP)

b) Formulate the problem above as a CSP using a constraint graph.

c) Formalize the constraints of the problem as the constraints on the constraint graph, and show some examples.

d) Discuss very briefly the main methods for solving CSP problems including

- Backtracking search for CSP
- Local search for CSP

TASK 3 (25 %)

Consider the two-agent game as described below:

The state of the game is represented as a positive integer number (N) starting with a start value.

After turn, the players A and B will perform moves which can consist of

- divide by a prime number (2,3,5,7,11,13,17,19,...) if it divides N
- reduce N by 1 if N >1

The player who cannot move (i.e. with N=1) has lost.

a) Explain the principles for analyzing game trees by means of the Minimax analysis.

b) Use the following static evaluation function for A to move

```
f(S) =       -99    if S=1
f(S) =       +99    if S is a prime
f(S) =       number of different prime numbers that divides S
```

What would be the static evaluation function when B is in the move ?

What can be the motivation for this evaluation function ? Safely assume that its value < 99.

c) Suppose the the game starts with N=20, where A is to begin.

Draw a game tree down 2 double moves. Draw every terminal state as a picture of the situation with the mover, state number and evaluation.

```
       --
A  |1  |  -99
       --
```

d) Explain what is meant by Alpha-Beta pruning of game trees.

What are the benefits compared to Mininax analysis. In particular, what are the theoretical optimum gain, and what is the theoretical avarage gain during various conditions ?

e) Make a new game tree of the game above, but utilize the Alpha-Beta cutoff to avoid expanding nodes unnecessarily.

Explain carefully exactly where the cutoff were done, and why.

TASK 4 (20 %)

In this task, we will consider the problem of planning a route to travel from one location to another by foot or by bus.

A location may be the origin or destination of the travel or a station (bus stop). The buses come and go at prescheduled hours without delay.

A bus (BusId) is actually a bus departure identifier, with a scheduled starting place, starting time and a specified trace with passing times (Time). The bus times are vailable in a KB as the preicate

```
Passes(BusId,Location,Time)
```

Walking time between locations are availale in a KB

```
WalkingTime(Location1,Location2,WalkingTime)
```

The basic actions for the passengers are

```
Walk(Location,Location,StartTime)
Enter(BusId,Location,Time)
Leave(BusId,Location,Time)
```

The following predicates define the states of a passenger

```
AtLocation(Location,Time)
InBus(BusId)
```

a) Formulate this scenario as a planning problem using the Situation Calculus.

The plan shall in addition to the proposed route also provide the timing information. You need not consider optimal routes in this planning. You need not either think of pretty presentation of the solution, as in the example below.

An example of a goal and a plan may look like this:

Goal:

```
From  NTH  to  Solsiden before 1630.
```

Plan:

```
Walk from NTH  before  1608  to Gløshaugen Syd   before 1609
Take Bus 5 from Gløshaugen Syd at 1609  to Dronningens gate D2 at 1618.
Walk from  Dronningens gate D2 after 1618 to  Munkegata  M5 before 1623
Take  bus 9 goes from Munkegata  M5 at 1623  to Dokkparken at 1627  .
Walk from  Dokkparken after 1627 to Solsiden before  1630
```

b) In this task, we shall find optimal solutions using the methods of state space search.

Formulate the scenario above as a problem that is to be solved as a heuristic search problem.

The task is to find a plan for coming from A to B where the arrival time is specified. The optimality criteria are as follows:

ii) Find a plan that arrives as late as possible before the specified arrival time

ii) Among equal arrival times, select the route with the latest departure time.

Discuss ways to organize the search, and which heuristics that are useful.

TASK 5 (10 %)

Consider the sentence:

"Someone walked slowly to the supermarket"

and the following lexicon:

```
Pronoun --> someone
Adv     --> slowly
Det     --> the
V       --> walked
Prep    --> to
Noun    --> supermarket
```

a) Show that the following grammar in connection with the lexicon generates the given sentence, and show the parse tree.

```
S --> NP VP
NP --> Pronoun
NP --> Noun
NP ->  Article Noun
VP --> Verb Vmod
Vmod --> Adv Vmod
Vmod --> Adv
Vmod --> PP
PP --> Prep NP
```

b) Extend the lexicon and grammar to include the sentence

" A restaurant has a menu "