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| ARTIFICIAL INTELLIGENCE AND KNOWLEDGE ENGINEERING |
| CSP Project “Time Equation” |
| Second assignment |
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Problem Formulation and Design

1. Define the problem as a Constraint Satisfaction Problem (CSP)

### Variables

In this CSP the variables are the digits of the equation. It can be defined as

* Ten minute digit (A)
* Unit minute digit (B)
* Ten second digit (C)
* Unit second digit (D)
* Multiplier (M)
* Result ten minute digit (E)
* Result unit minute digit (F)
* Result ten second digit (G)
* Result unit second digit (H)

But also there are 3 auxiliary variables used for add the carry generated by the multiplier: X1, X2, X3

### Value Domains

For this CSP there is just one domain for all the variables:

D = {0, 1 ,2, 3, 4, 5, 6, 7, 8 ,9}

Another option that may be interesting to take in to account is to specify a domain D1 = {0,1,2,3,4,5} for the ten seconds digit, but this domain is a subset of our main domain so this particularity is going to be controlled by the specification of the constraints

### Constraints

Unary constraints

* C<6
* G<6
* H = Constant
* M = Multiplier

Binary constraints

* FE <= Max Minutes
* AB <= Max Minutes (it could be optimized to AB <= Max Minutes / Multiplier + X2 )

Global constraints

* No variable can take the same value as the Multiplier. (they will be converted into unary constraints)
* No variable can take the same value as the Constant. (they will be converted into unary constraints)
* C x Multiplier = G + X1 + 10 x X2
* B x Multiplier = F + X2 + 10 x X3
* D x Multiplier = Constant + 10 x X1
* A x Multiplier = E + X3

## Type of CSP and state formulation

The type of CSP chosen in this task is the incremental state. It has been selected in this way due to there is a digit which has a value assigned already, so it could be considered as if the search of the algorithm is partially solved based in an incremental state problem.

**Initial state:** The time equation has assigned the unit second digit of the result and the multiplier.

**Goal test: is the current assignment complete?**

**State: Any possible state in which there are assigned values to the variables.**

**Actions: Assign a value to an unassigned variable having checked that every constraint with already assigned variables is satisfied.**

**Transition model: A variable has a value assigned**

## The most suitable search algorithm for this CSP

* Simple Backtracking.
* Simple Backtracking with heuristics, which heuristics and why.
* MinimumConflicts

In order to use Minimun Conflicts the problem state formulation must be a complete state problem. This algorithm is not applicable because we are facing an incremental state problem.

## UML Class Diagram