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Christmas model in Picat

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OVERVIEW

The DMCommunity Challenge Jan-2023 (https://dmcommunity.org/challenge-jan-2023/) is a modeling challenge to optimize Christmas Gifts to some people with a limited budget. Here is the data:

```
PEOPLE:  "Alice", "Bob", "Carol", "Dave", "Eve"

GIFTS: "Book", "Toy", "Chocolate", "Wine", "Flowers"

GIFT COSTS: 10, 20, 5, 15, 7

HAPPINESS:

    "Book": [3, 2, 5, 1, 4]

    "Toy": [5, 2, 4, 3, 1]

    "Chocolate": [1, 3, 4, 5, 2]

    "Wine": [2, 5, 3, 4, 1]

    "Flowers": [4, 3, 1, 2, 5]

BUDGET: 50
```

Picat model

I modeled this problem in Picat (http://picat-lang.org/). Picat is a logic-based multi-paradigm programming language with a CP solver, SAT solver as well as support for SMT solvers (z3 and cvc4) and MIP (z3 and GLPK). Here we use the CP solver.

The model is a little more elaborate than necessary since I wanted to check for all optimal solutions, and it also tests different budgets (which shows more than one optimal solution). The Picat model is also available at http://hakank.org/picat/christmas_model.pi .

It is run as

$ picat christmas_model.pi

The original problem (budget 50) has the following unique solution:

```
total_happiness = 24

total_cost = 44

Alice will get Flowers with happiness 4

Bob will get Wine with happiness 5

Carol will get Book with happiness 5

Dave will get Chocolate with happiness 5

Eve will get Flowers with happiness 5
```

With a little larger budget (52) there are 2 optimal solutions (with different total costs: 52 and 44). The second solution is the same as for budget 50 above.

```
total_happiness = 24

total_cost = 52

Alice will get Toy with happiness 5

Bob will get Wine with happiness 5

Carol will get Chocolate with happiness 4

Dave will get Chocolate with happiness 5
```

```
Eve will get Flowers with happiness 5


total_happiness = 24

total_cost = 44

Alice will get Flowers with happiness 4

Bob will get Wine with happiness 5

Carol will get Book with happiness 5

Dave will get Chocolate with happiness 5

Eve will get Flowers with happiness 5
```

The model also tests a budget of 27 which have 2 optimal solutions with happiness 18 (total cost are both 27).

Here is the Picat model.

```
import cp.

main => go.

go ?=>

  people(People),

  gifts(Gifts,Costs),

  happiness(Happiness),

  budget(Budget),

  println(budget=Budget),

  christmas(People,Gifts,Costs,Happiness,Budget, _X,_TotalCost,TotalHappiness),

  printf("All optimal solutions with total happiness %d:\n", TotalHappiness),


  % Get all optimal solutions

  christmas(People,Gifts,Costs,Happiness,Budget, X,TotalCost,TotalHappiness),

  println_gifts(People,Gifts,Costs,Happiness,Budget, X,TotalCost,TotalHappiness),
```

```
  nl,
  fail,
  nl.
% Print the solution
println_gifts(People,Gifts,Costs,Happiness,Budget, X,TotalCost,TotalHappiness) =>
  println(total_happiness=TotalHappiness),
  println(total_cost=TotalCost),
  foreach(I in 1..People.len)
        printf("%w will get %w with happiness %d\n", People[I], Gifts[X[I]], Happiness[X[I],I]
)
  end,
  nl.
% Solve the Christmas gift problem
christmas(People,Gifts,Costs,Happiness,Budget, X,TotalCost,TotalHappiness) =>
  NumPeople = People.len,
  NumGifts = Gifts.len,
  % What gift should Person X[I] get?
  X = new_list(NumPeople),
  X :: 1..NumGifts,
  TotalCost #= sum([C : I in 1..NumPeople, element(X[I],Costs,C)]),
  TotalCost #<= Budget,

  % Note: Happiness is Gift (rows) / People (columns)
  TotalHappiness #= sum([H : P in 1..NumPeople, matrix_element(Happiness,X[P],P,H)]),
  Vars = X ++ [TotalCost],
  if var(TotalHappiness) then
        % Find maximum total happiness
        solve($[max(TotalHappiness)],Vars)
  else
        % Show solution with the given TotalHappiness
```

```
        solve($[],Vars)
  end.


%
% Data
%
people(["Alice", "Bob", "Carol", "Dave", "Eve"]).
gifts(["Book", "Toy", "Chocolate", "Wine", "Flowers"],
        [10,    20,     5,             15,     7]).


%
% Happiness for Gift (rows) / People (columns)
%              A  B  C  D  E
happiness([[3, 2, 5, 1, 4], % Book
         [5, 2, 4, 3, 1], % Toy
        [1, 3, 4, 5, 2], % Chocolate
        [2, 5, 3, 4, 1], % Wine
        [4, 3, 1, 2, 5]  % Flowers
        ]).


budget(50).
% Some other budgets to test
budget(52). % 2 optimal solutions with total happiness 24
budget(27). % 2 optimal solutions with total happiness 18
```