# Combinatorial Decision Making and Optimization

# Project Report

VLSI Design

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# 1 CP (Normal)

The normal CP model is one where rotation of the circuits is not allowed. The model has been designed to use as many global constraints as possible. Symmetry breaking has also been applied where applicable to improve the final performance.

## 1.1 Considerations on the Height

By assuming that no gaps are allowed between the circuits, the min height is obtained by taking the sum of the circuits' area and dividing it by the given max width.

If gaps are allowed between the circuits, the board's height can be minimised by the solver to find the minimum height of the board.

## 1.2 Constraints

- 2 `cumulative` constraints are used to find the circuits' x and y coordinates respectively.

```
constraint cumulative(
    start_x, CIRCUIT_WIDTHS,
    CIRCUIT_HEIGHTS, MIN_HEIGHT
);

constraint cumulative(
    start_y, CIRCUIT_HEIGHTS,
    CIRCUIT_WIDTHS, MAX_WIDTH
);
```

- 2 `forall` constraints are used to ensure that the circuits' x and y coordinates along with their corresponding widths and heights do not exceed the board's max width and height.

```
constraint forall(c in CIRCUITS)(
    start_x[c] + CIRCUIT_WIDTHS[c] <= MAX_WIDTH
);

constraint forall(c in CIRCUITS)(
    start_y[c] + CIRCUIT_HEIGHTS[c] <= MIN_HEIGHT
);
```

- A `diffn` constraint is used to remove overlaps between the circuits. This prevents the solver from searching for solutions whereby the circuits are placed on top of each other.

```
constraint diffn(
    start_x, start_y,
    CIRCUIT_WIDTHS, CIRCUIT_HEIGHTS
);
```

- A `lex_lesseq` constraint is used to remove the vertical symmetry of the board. This reduces the total number of solutions by half for each instance.

```
constraint lex_lesseq(
    start_y, reverse(start_y)
);
```

- A search strategy using `most_constrained` and `indomain_min` is applied to the circuits' x and y coordinates.

### 1.3 Final Considerations

The final model is able to solve 32/40 instances with a time constraint of 300 seconds.

A lexicographical constraint was also tested to remove horizontal symmetry from the board. However, although the number of total solutions was reduced, the number of total instances solved did not increase.

In fact, the number of total instances solved worsened and hence, the constraint was not included in the final model.