CPTEST: A framework for the automatic fault detection, localization and correction of constraint programs

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CPTEST tool

• A testing framework for OPL constraint programs (detection, localization and correction):
  – A complete OPL parser,
  – detection, localization and correction algorithms implementation
  – Based-on IBM ILOG CP Optimizer 2.1 solver
  – Java implementation – 25K LOC

• CPTEST available on  www.irisa.fr/celtique/lazaar/CPTEST
Background

\[ M \equiv C_1 \land C_2 \ldots \land C_n \]
\[ \text{sol}(M) : \text{set of solution of } M \]

\[ P \equiv C'_1 \land C'_2 \ldots \land C'_m \]
\[ \text{sol}(P) : \text{set of solution of } P \]

Conformity relations:
\[ P \text{ conf}_{\text{one }} M \iff \text{sol}(P) \neq \emptyset \land \text{sol}(P) \subseteq \text{sol}(M) \]
\[ P \text{ conf}_{\text{all }} M \iff \text{sol}(P) = \text{sol}(M) \]
\[ P \text{ conf}_{\text{best }} M \iff \text{bounds}_{l_w,u_p}(P) \neq \emptyset \land \text{bounds}_{l_w,u_p}(P) \subseteq \text{bounds}_{l_w,u_p}(M) \]
Background: Constraint Negation

- Elementary constraints (e.g. == turns out in !=, …)
- “forall” aggregator

```plaintext
forall(i in 1..3, j in i..3, k in i..i+j: k%10<4)
  (x[i+1] == x[i]+k => x[j+1] != x[j]+k);
```

Rolled

```plaintext
or(i in 1..3, j in i..3, k in i..i+j: k%10<4)
  (x[i+1] == x[i]+k && x[j+1] == x[j]+k);
```

Unrolled

```plaintext
for j in 1..3
  x[j] == x[j-1] + k => x[j+1] != x[j] + k;
for k in 1..3
```

...
Background: Constraint Negation

- Elementary constraints (e.g. == turns out in !=, …)
- “forall” aggregator
- Global constraints

```
inverse(all[R](i in R) g[i],
all[S](j in S) f[j]);
```

```
allMinDistance,
allDifferent,
forbiddenAssignments,
allowedAssignments,
...```

```
forall(i in S) g[f[i]]==i;
forall(j in R) f[g[j]]==j;
or(i in S) g[f[i]]!=i;
or(j in R) f[g[j]]!=j;
```
Golomb Rulers Problem

- A Golomb ruler is a set of \( m \) marks at integer positions along an imaginary ruler such that no two pairs of marks are the same distance apart,
- and the largest distance between two of its marks is its \textbf{length}.
- The goal is to find an optimal Golomb ruler where no shorter Golomb ruler of the same order exists.

\( m = 4 \) \hspace{2cm} \{0,1,4,6\}
N-queens Problem

• The N-queens problem requires to place N queens on an N x N chessboard where all queens are placed on distinct column and two queens cannot be placed on the same upper or lower-diagonal.
Car Sequencing Problem

- Car sequencing is a real-world CP problem that amounts to find an assignment of cars to the slots of a car-production company, where cars are grouped by classes.
- Each class represents cars with some specific options.
- The assembly line must satisfy some option capacity constraints.
References

• Testing Process:

• Localization Process:

• Correction Process:

• CPTEST documentation:
http://www.irisa.fr/celtique/lazaar/CPTEST/