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# An Experimental Evaluation of some Design Knowledge Compilation Mechanisms

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# OUTLINE

DSPL - routine design.

BPEN - the domain.

COMPILATION

- Inheritance.
- Absorption.
- Relaxation.
- Combined System.

EXPERIMENT

- Design.
- Results.

# ROUTINE DESIGN & DSPL

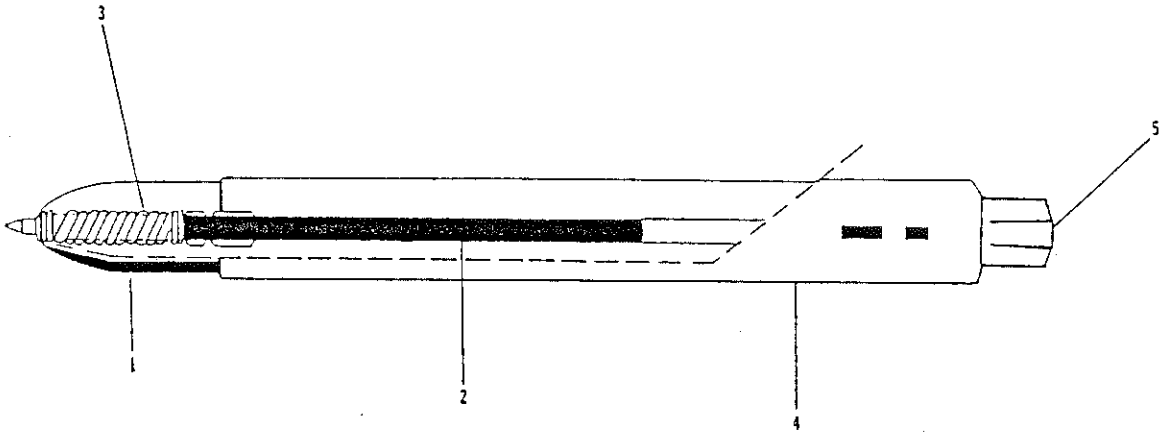
## Routine Design

- ▲ Done many, many times before
- ▲ No innovation
- ▲ Designer knows how to solve the problem
- ▲ Knowledge is in the form of plans
- ▲ May have several alternate plans for solving the same subproblem
- ▲ Design attributes are known

## DSPL

- ▲ Design Specialists and Plans Language
- ▲ Reflects the Designer's decomposition of the problem
- ▲ Hierarchical structure of design agents
- ▲ Specialists, Plans, Tasks, Steps, Constraints

# BPEN




1 - Head

2 - Refill

3 - Spring

4 - Body

5 - Pushing Component

# BPEN DSPL CONSTRAINT

```
(CONSTRAINT
    (NAME TwiceMinThick<LgNotchHt)
    (USED-BY PushCompLgNotchHt)
    (SOFT-CONSTRAINT T)
    (CURRENT-PREFERENCE .0022)
    (RELAXATION-LIMIT (BodySizeOD -- BodySizeId))
    (COMMENT "Example of Soft Constraint")
    (FAILURE-MESSAGE "Large Notch Ht is too small")
    (FAILURE-SUGGESTION
        (SUGGEST (RELAX PushCompLgNotchHt by
                        FAILURE-AMOUNT))
    )
    (BODY
        (KNOWN
            Factor  2
            BodySizeOD
                (KB-FETCH 'PBody 'BodySizeOD)
            BodySizeID
                (KB-FETCH 'PBody 'BodySizeID))

        (TEST
            ((Factor  *  (BodySizeOD -  BodySizeID))
                =  LgNotchHt))))
```

# BPEN REQS ~ EXAMPLE

| | |
|---|---|
| Ridgedisttol | 1 |
| Lgnotchgaptol | 1 |
| Headotolerance | 1 |
| Refillridgelen | 1.25 |
| Refilltipod | 0.002 |
| Refillod | 0.012 |
| Refillbodylen | 3.1 |
| Headoshaftlen | 2 |
| Headtipid | 0.22 |
| Refillbodymaterial | Flexibleplastic |
| Refilltipmaterial | Steel26 |
| Pushcompmaterial | Rigidplastic |
| Bodymaterial | Rigidplastic |
| Headmaterial | Rigidplastic |
| Pushcompendlen | 0.2 |

⋮

# KNOWLEDGE COMPILATION

Deep Knowledge.
Surface Knowledge.

Process of improving the surface knowledge through experience in order to increase the *efficiency* of the problem-solving.

Deep to Surface -- Formation.
Surface to Surface -- Adjustment.

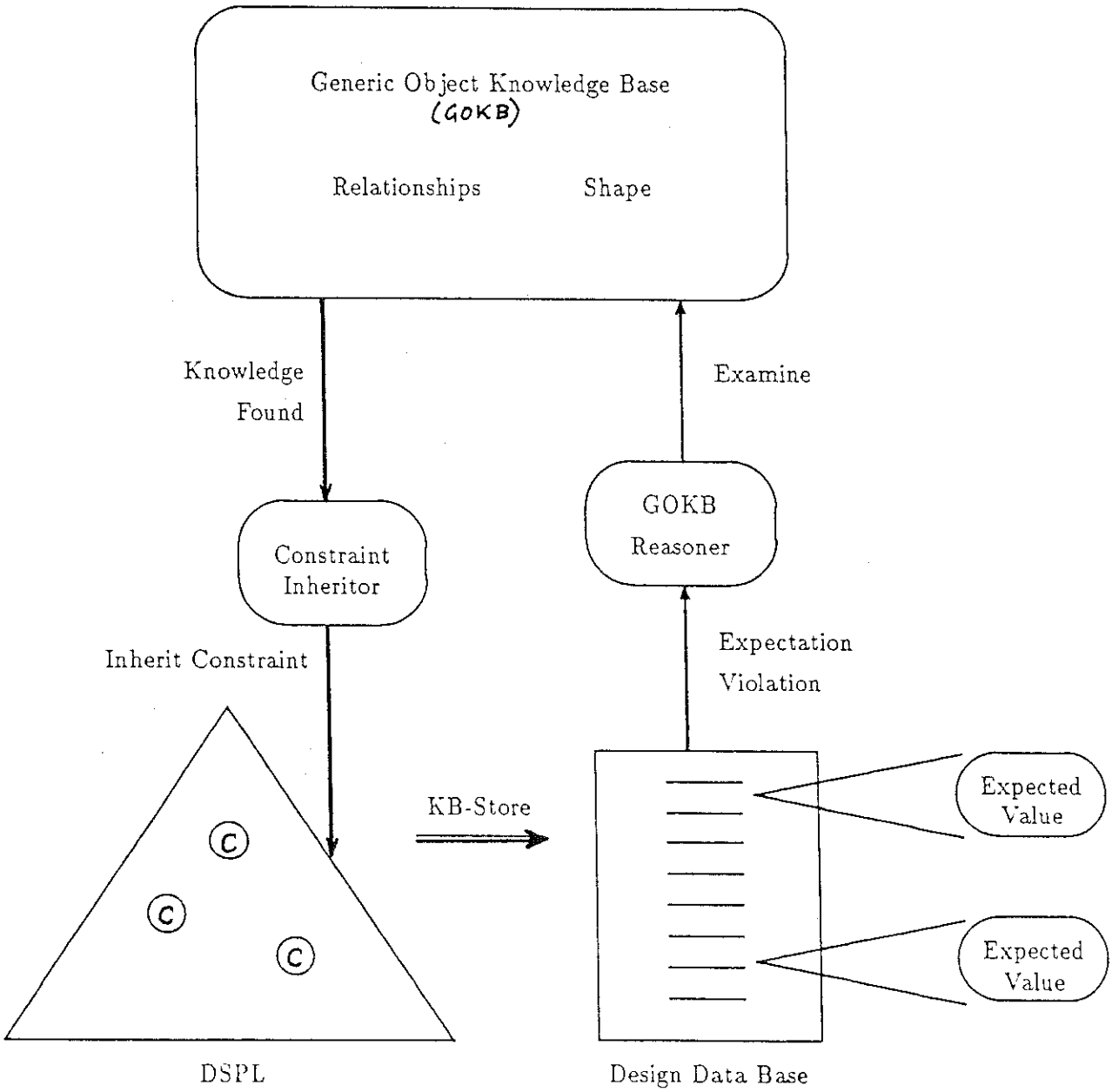
**Absorption (& Relaxation) System:**

Constraints disappear (or relax).

**Inheritance System:**

Constraints appear.

# CONSTRAINT INHERITANCE



# CONSTRAINT ABSORPTION

Detection of redundant constraining knowledge and its removal.

After absorption, the constraint need not be tested again.

Condition:

- always true.
- subsumed by prior knowledge.

Success-driven Knowledge Refinement.

Uses History to notice candidates.

# CONSTRAINT RELAXATION

## Hard Constraints:

- Normal DSPL.
- Must be true for success of design.

## Soft Constraints:

- Allows range of valid values.
- Temporary relaxation when constraint fails and there is suggestion to try relaxing.

# PREDICTED EFFECTS

## Constraint Inheritance:

- Causes failures to be found earlier.
- Causes different paths to be used.
- Prevents incorrect designs

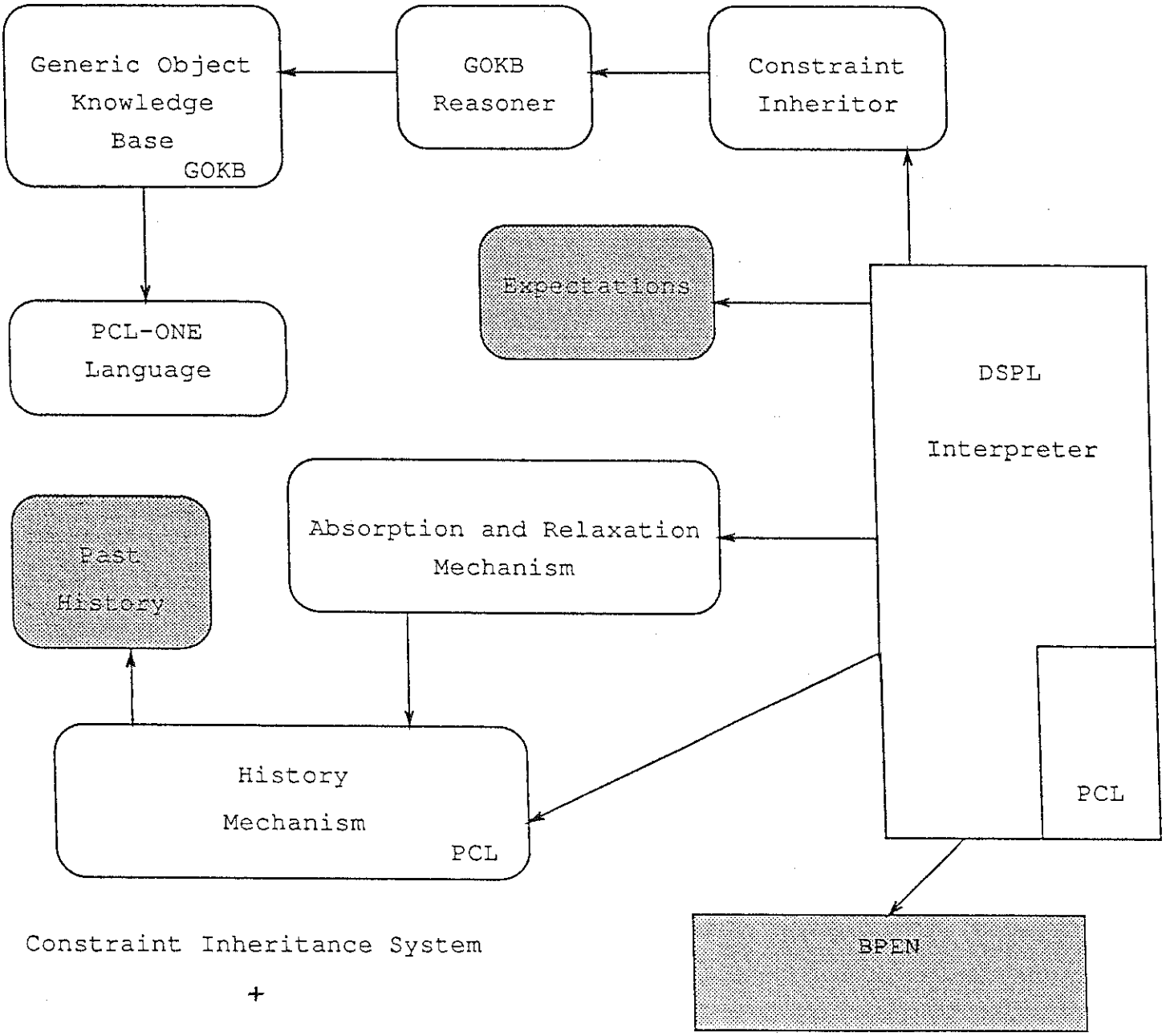
## Constraint Absorption:

- Creates shorter paths.
- Execution time is reduced.

## Constraint Relaxation:

- Removes barriers to completion.
- Reduces failures & backtracking.
- Execution time is reduced.

# COMBINED SYSTEM




Constraint Inheritance System

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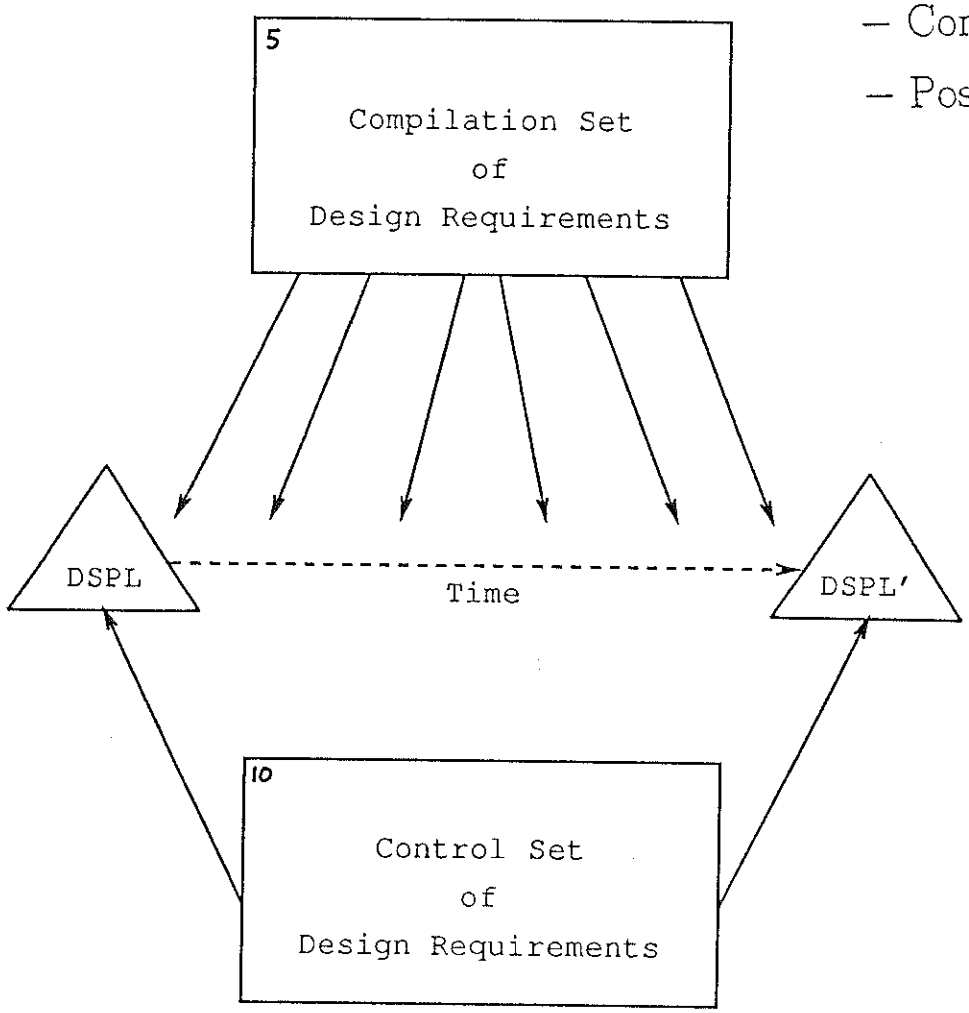
Absorption and Relaxation System

# THE EXPERIMENT

- 3 phases:
  - Pre-compilation
  - Compilation
  - Post-compilation



# EVALUATION CRITERIA

- System:
  - CPU time
  - Number of each agent used
  - Number of each agent failed
  - Total number of agents used
  - Total number of agents in the system
  - Ratio of failed agents to successful agents
- Compilation:
  - Amount of compilation
  - What type and where in the process it occurred
- Design object:
  - Ensured the final design met all constraints

# DURING COMPILATION

Non-Compiled & Compilation Phase Results

| Test Run | Avg. Time Non-Comp. | Avg. Time Compilation | Change in Time | % Change in Time | Change in Design Path |
|---|---|---|---|---|---|
| Inheritance | 510.4 | 710.8 | +200.4 | 39.26% slow down | +35.8 agents |
| Relaxation & Absorption | 510.4 | 786.4 | +276 | 54.07% slow down | +1.4 agents |
| Combined | 510.4 | 1064.6 | +554.2 | **108.58%** slow down | **+36.6** agents |

On average it is ≈ 100% slower during compilation.

# PRE vs POST COMPILATION

Pre & Post-Compilation Phase Results

| Test Run | Avg. Time Pre-Comp. | Avg. Time Post-Comp. | Change in Time | % Change in Time | Change in Design Path |
|---|---|---|---|---|---|
| Inheritance | 554.7 | 501.2 | -53.5 | 9.64% speed up | +3.1 agents |
| Relaxation & Absorption | 554.7 | 471.7 | -83.0 | 14.96% speed up | -2.9 agents |
| Combined | 554.7 | 529.8 | -24.9 | **4.49%** speed up | **-4.5** agents |

$$3.1 - 2.9 \neq -4.5$$

Constraints appear.

constraints disappear.

different paths used.