# A bestiary of performance diagnosis methodologies

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**CIS-TR-93-24**
November 1993

## Abstract

The goal of this research is to formalize and automatically support parallel *performance diagnosis*. Performance diagnosis is the task of identifying the principal flaws in a parallel program that hinder good performance.

An initial step toward this goal is to identify the performance diagnosis *methodologies* that are supporteed by current performance evaluation tools. This talk presents preliminary results from a survey of ten such tools.

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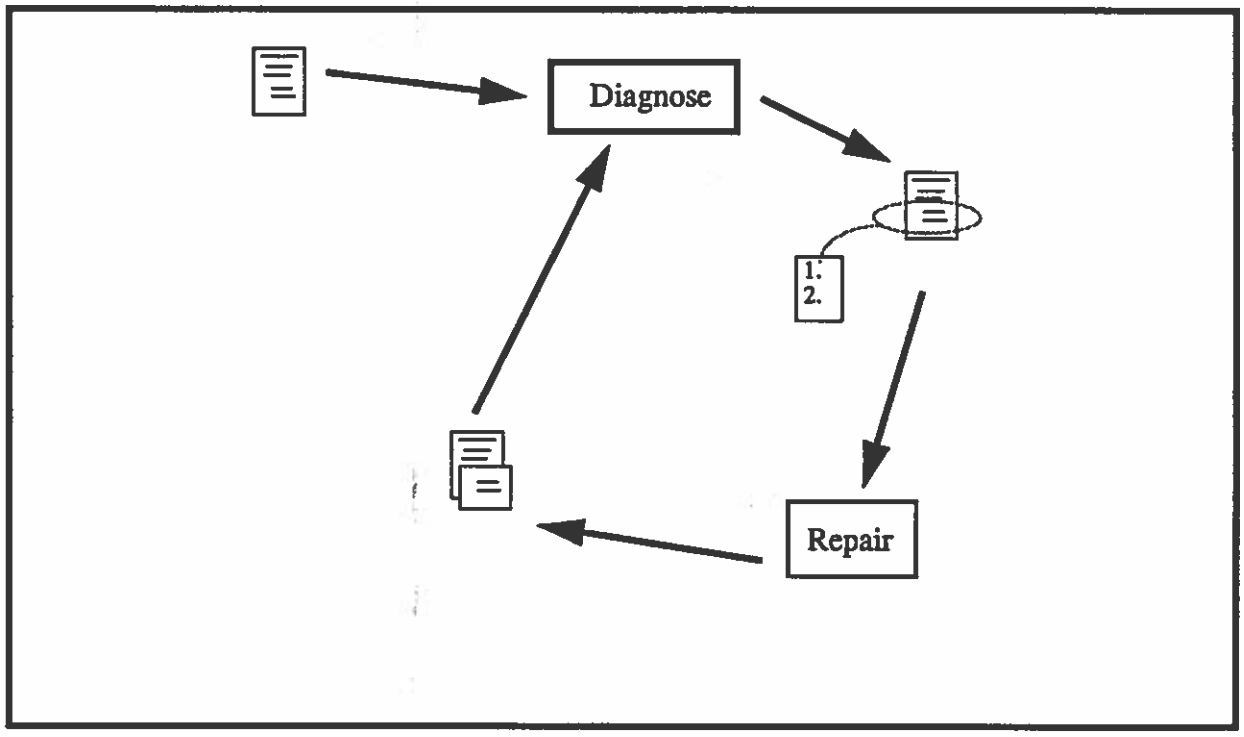
# What is performance diagnosis

Performance diagnosis is identifying the principal performance problems in a program and their causes.

This information is used to guide repair of the program.

Supports a hillclimbing tuning strategy



# How is performance diagnosed?

Numerous papers give hypothetical performance diagnosis scenarios.
Scenarios were intended to highlight an analysis tool.
Most (not all) written by researchers rather than programmers.

**Scenario summary**

| Tool | Targets | Programs | Papers |
|---|---|---|---|
| Predicates | Shared memory. | Parallel search | [1] |
| (PTOPP) | Clustered shared memory. | (6) Perfect Benchmarks | [2],[3] |
| $W^3$ | Shared memory. | (2) Splash Benchmarks | [4] |
| IPS-2 | Shared and dist. memory. | Simplex | [5] |
| Chitra | Shared and dist (?) mem. | Parallel DEVS | [6] |
| MTOOL | Shared memory. | Econometric model | [7] |
| (SPT) | Shared, dist. memory. | Quicksort | [8],[9] |
| PIE | Shared memory | OS thread scheduler | [10] |
| ChaosMon | Shared and dist. memory | Quicksort | [11] |
| PEPP | Shared and dist. memory | Navier-Stokes solver | [12] |

# Supporting Performance Diagnosis

Based on scenarios, the performance diagnosis process:

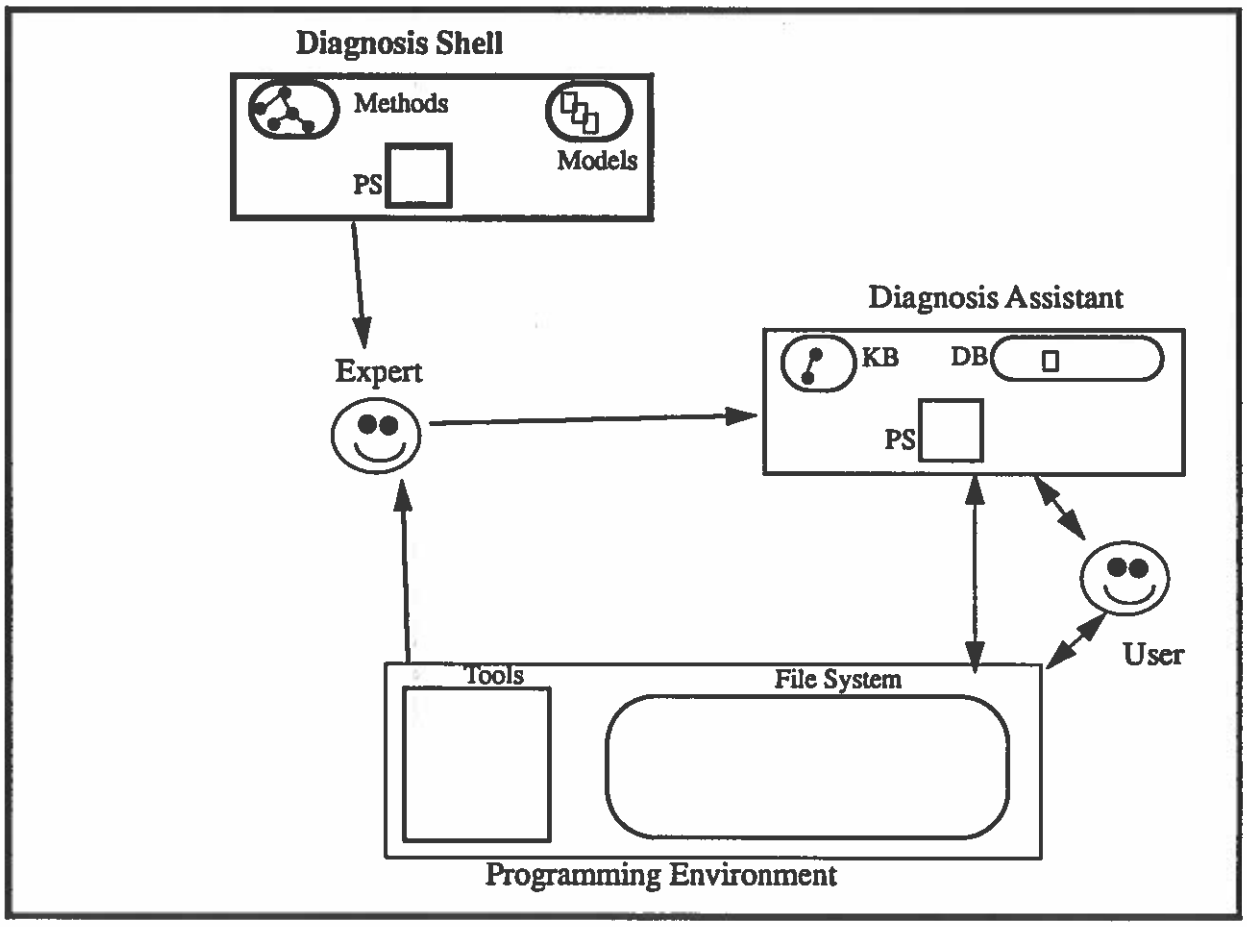
1. Is hypothesis- and data-directed.
2. Generates many program versions and associated data.

# Supporting Performance Diagnosis

Thesis: A machine- and program-independent diagnosis shell that integrates:

1. An reactive, blackboard-like problem-solver.
2. A library of problem-solving goals, methods, and models.
3. An experiment and results management system.

can automate significant aspects of current performance diagnosis methods.

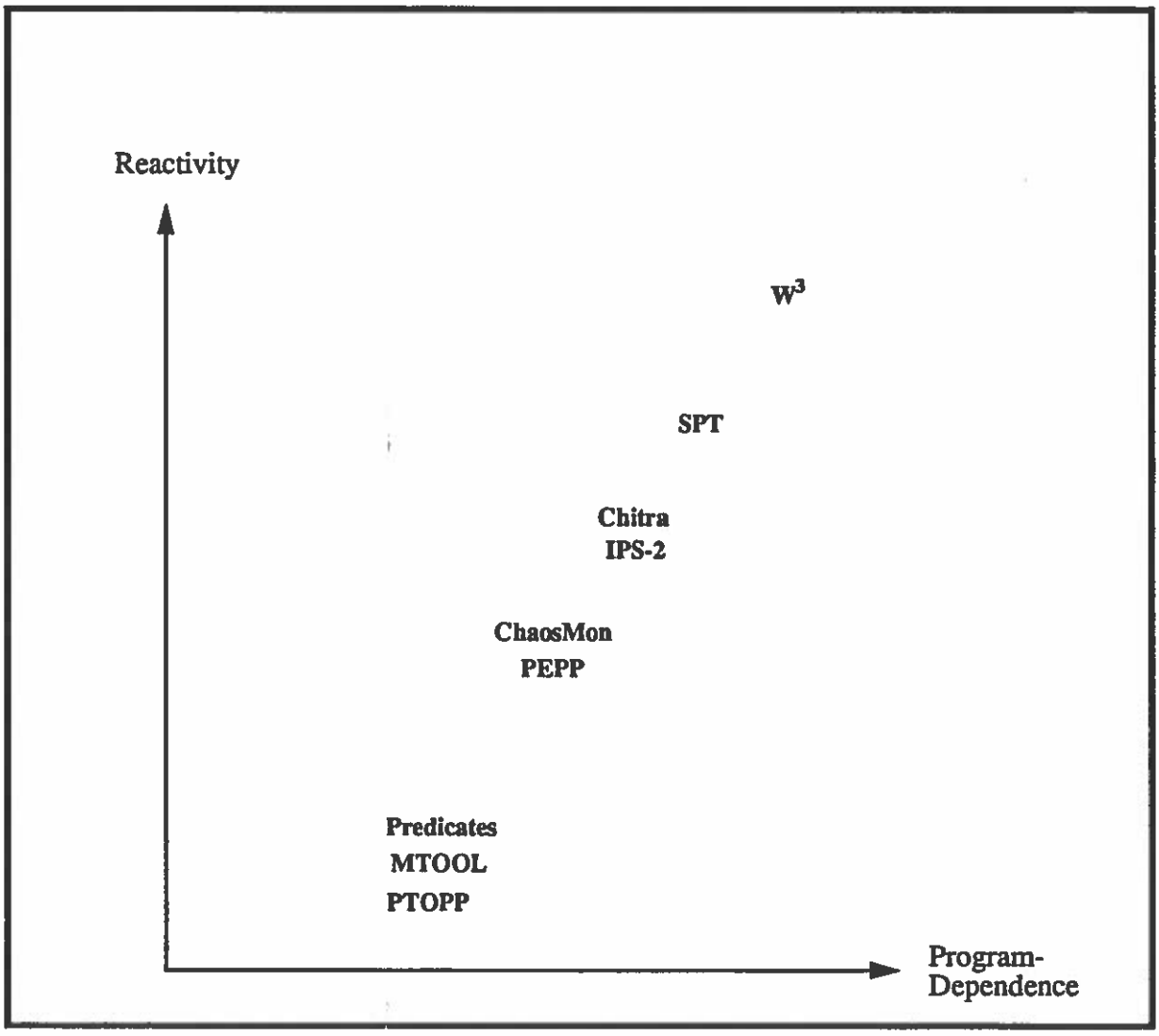


# A Problem-Solving Model for Diagnosis

Claim 1: Performance diagnosis is best characterized as refinement of a set of hypotheses that explain negative aspects of performance.

Refinement strategies range from planned to reactive.

Differing amounts of program- and architecture-specific knowledge are used to generate and order hypotheses.

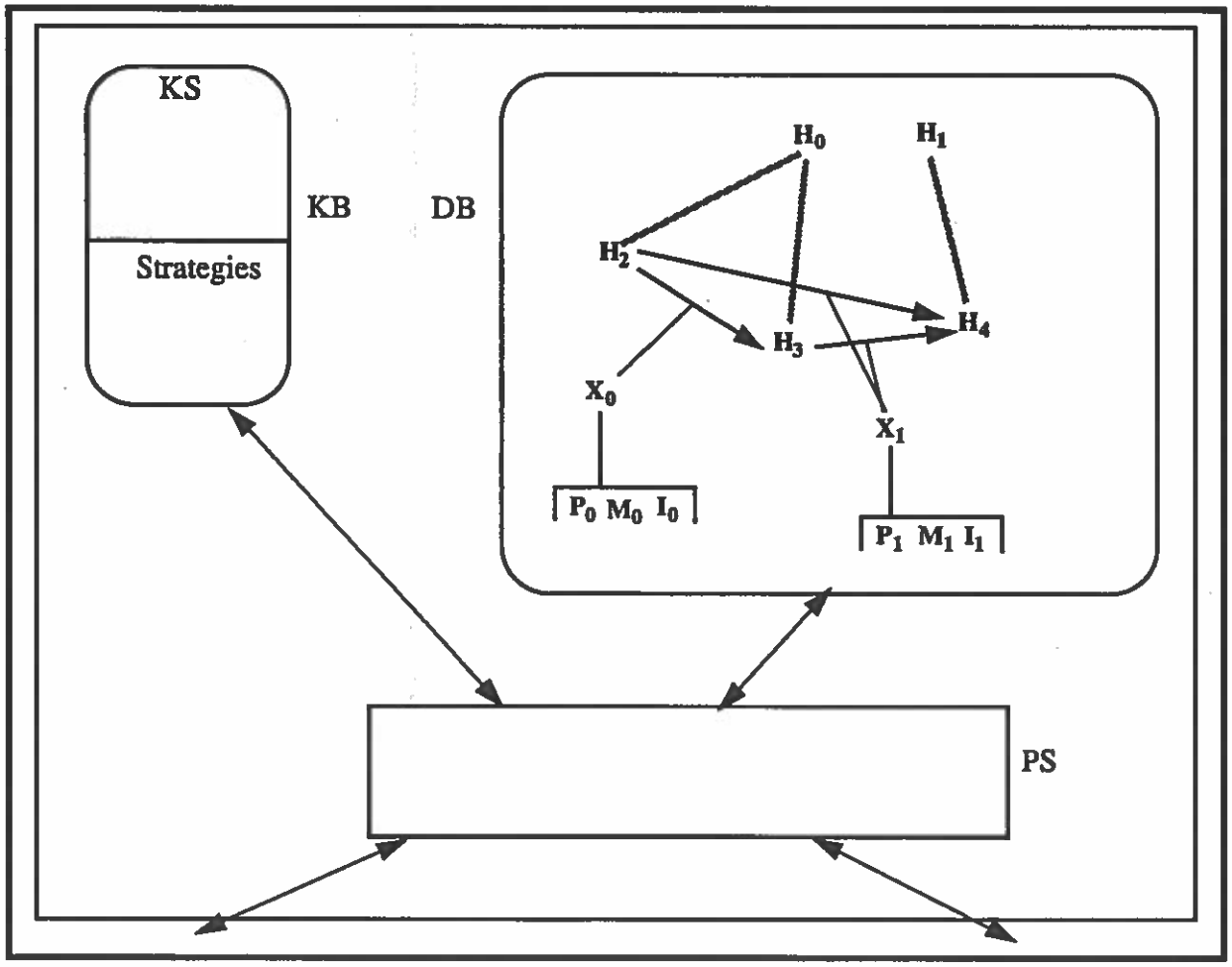


# Problem-Solving Model: Automated Support

Support the model with an expert system shell providing extensible facilities for representing:

- Diagnosis state (hypotheses, experiments, and results).
- Diagnosis actions (rules for experimentation and updating hypotheses).
- Diagnosis strategies.

Blackboard framework will serve as a basis.



# Experiment Management for Performance Diagnosis

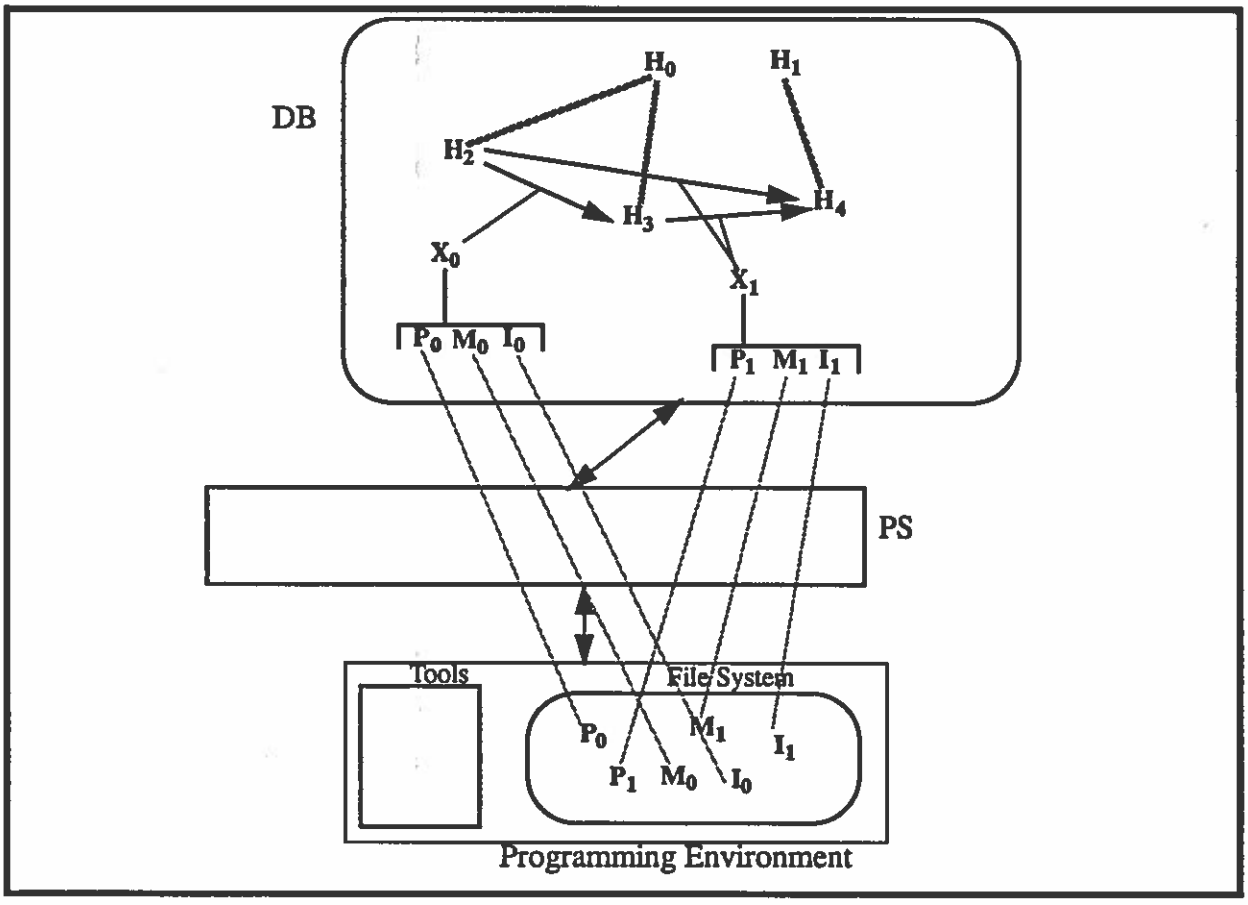
Claim 2: Tracking source/object code and input/output data is a significant, difficult subtask of performance diagnosis.

- Construction of correct *experiments* out of consistent program versions, machine configurations, and input data sets is difficult.
- Experiments and experimental results should be reused within and across sessions where possible.

# Experiment Management: Automated Support

Support experiment management by integrating the diagnosis shell with facilities for:

- Linking program versions, data sets, and machine configurations into experiments.
- Running experiments and incorporating results into the diagnosis database.
- Retrieving past experiments and results guided by the current problem-solving state



# Related Work

Performance analysis.

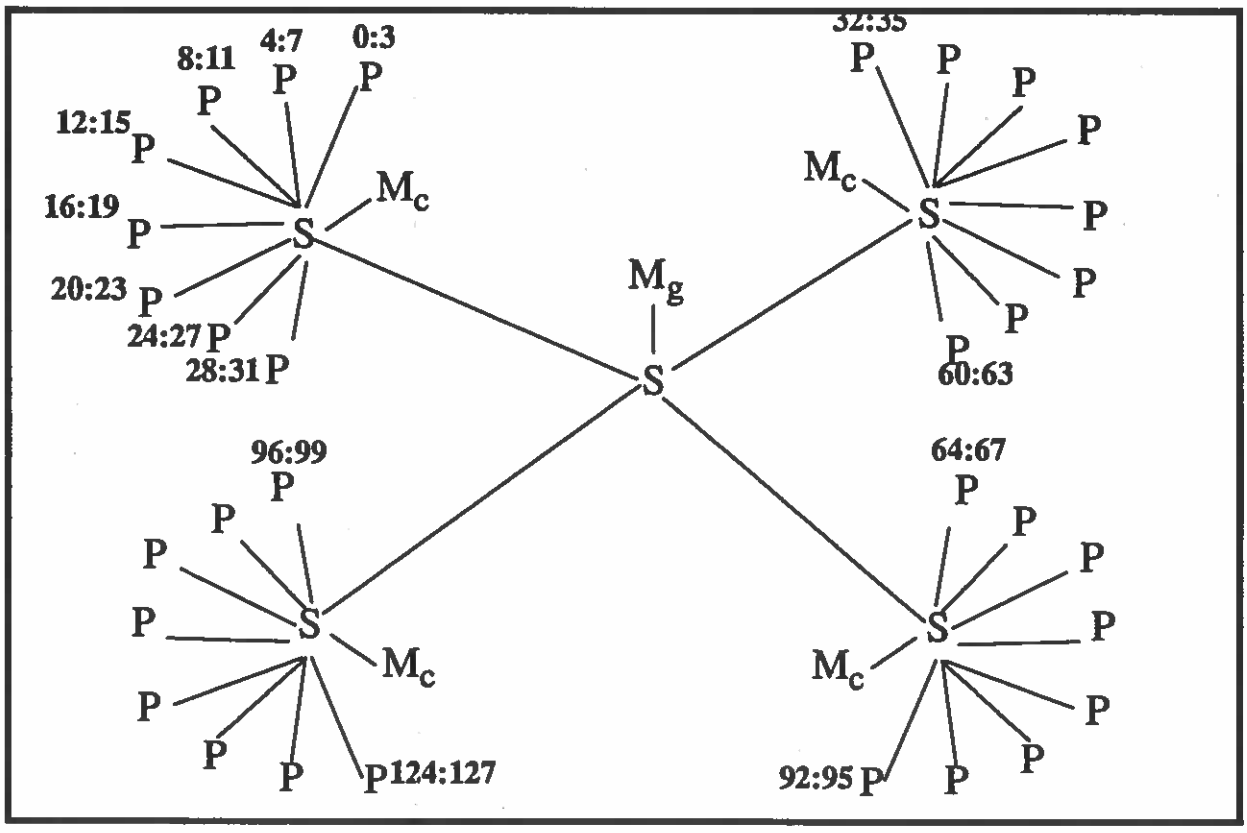
Diagnostic expert system shells.

Rule-based process programming environments.
- Marvel.
- Law-governed systems.

# PTOPP Methodology

The hypothesis space, knowledge sources, and strategy are based on:

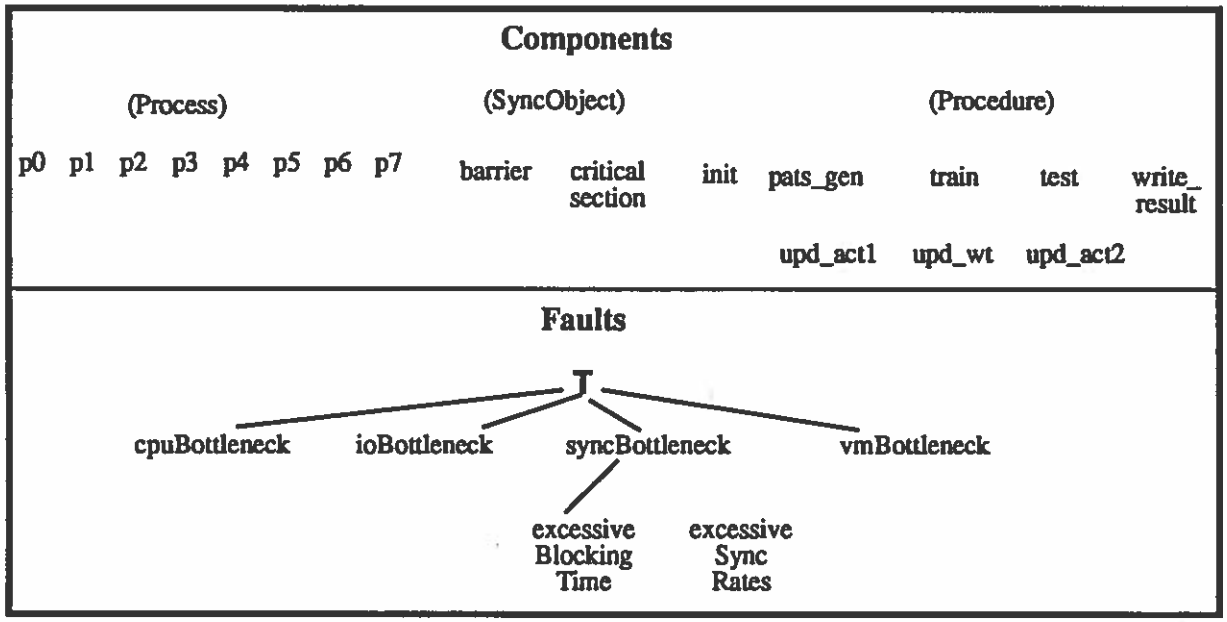
- The Cedar architecture and machine.
- The type of parallelism supported (DO-loop spreading).
- The programs being diagnosed (Perfect benchmarks).



# W3 - Neural Net Hypothesis Space

The hypothesis space is the cross-product of:

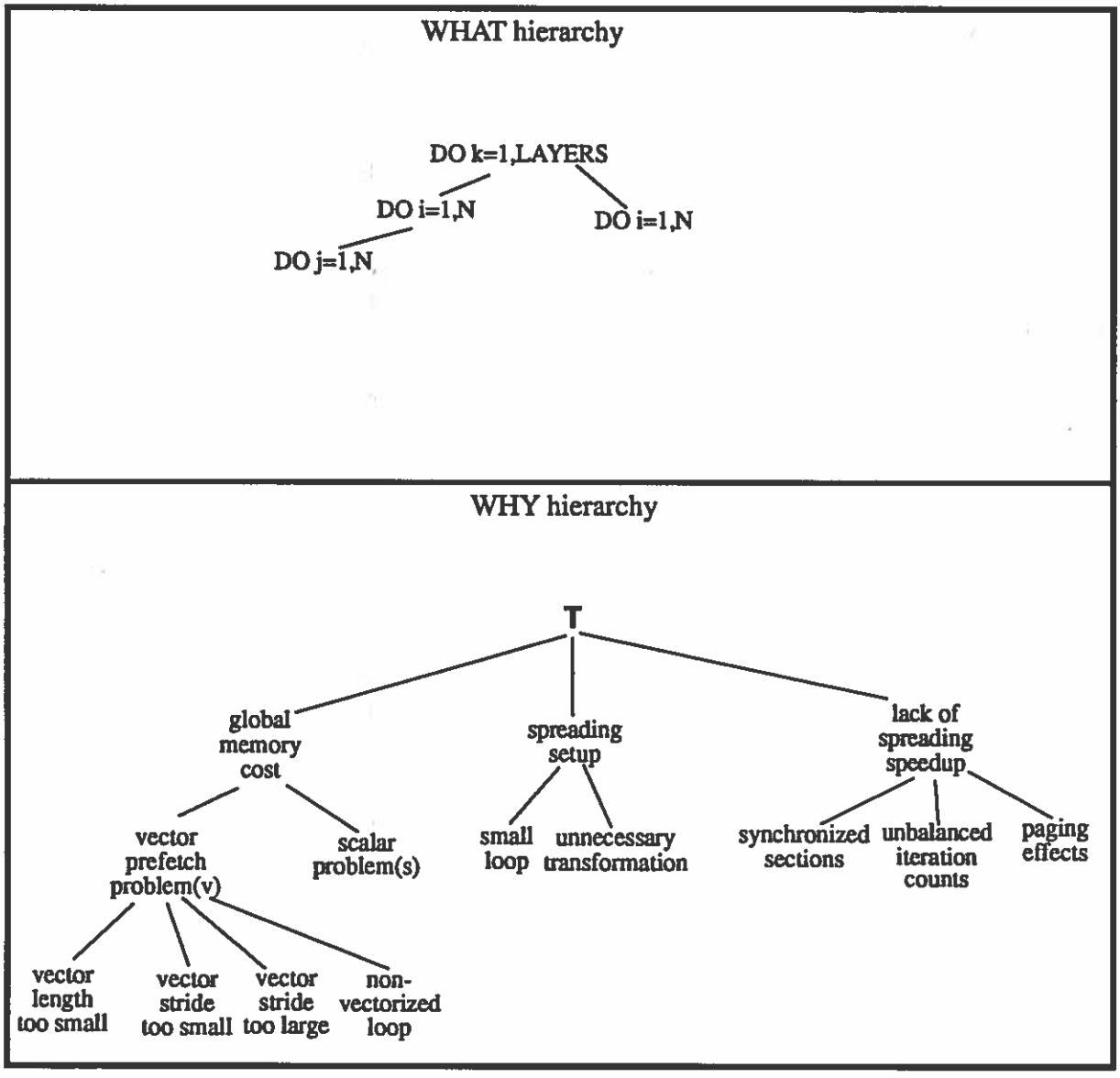
- Where (component)
- Why (fault).



# PTOPP Hypothesis Space

The hypothesis space is the cross-product of:

- Where (which loops have problems)
- Why (what problem each loop has).



# PTOPP Strategy

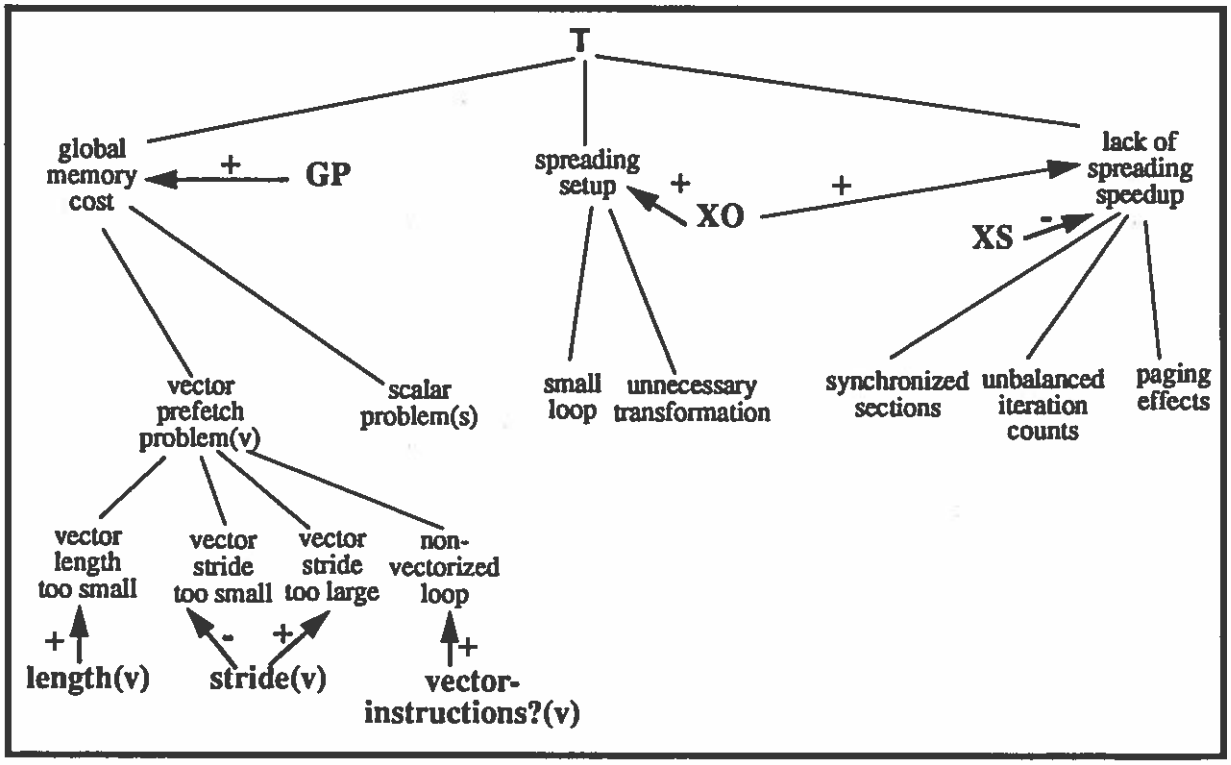
1. Order loops by significance.
   - Profile serial execution time, broken down by loops.
   - Order hypothesis space along "where" dimension based on results.
2. Compute basic metrics for program.
3. Refine lead hypothesis.
   - Generate hypotheses for longest loop.
   - Order and prune using rules and metric results.
4. -> Repair based on diagnoses.
5. Go to 1.

# PTOPP Hypothesis refinement

Order and/or prune possible performance problems using metrics:

- GP (O1g/O1 - 1) indicates memory problems.
- XO (C1/O1g - 1) indicates cluster spreading overhead.
- XS (C1/C4) indicates effectiveness of cluster spreading.

Final refinements selected principally by static analysis of parallel code.



# PTOPP File Tracking

Source files:

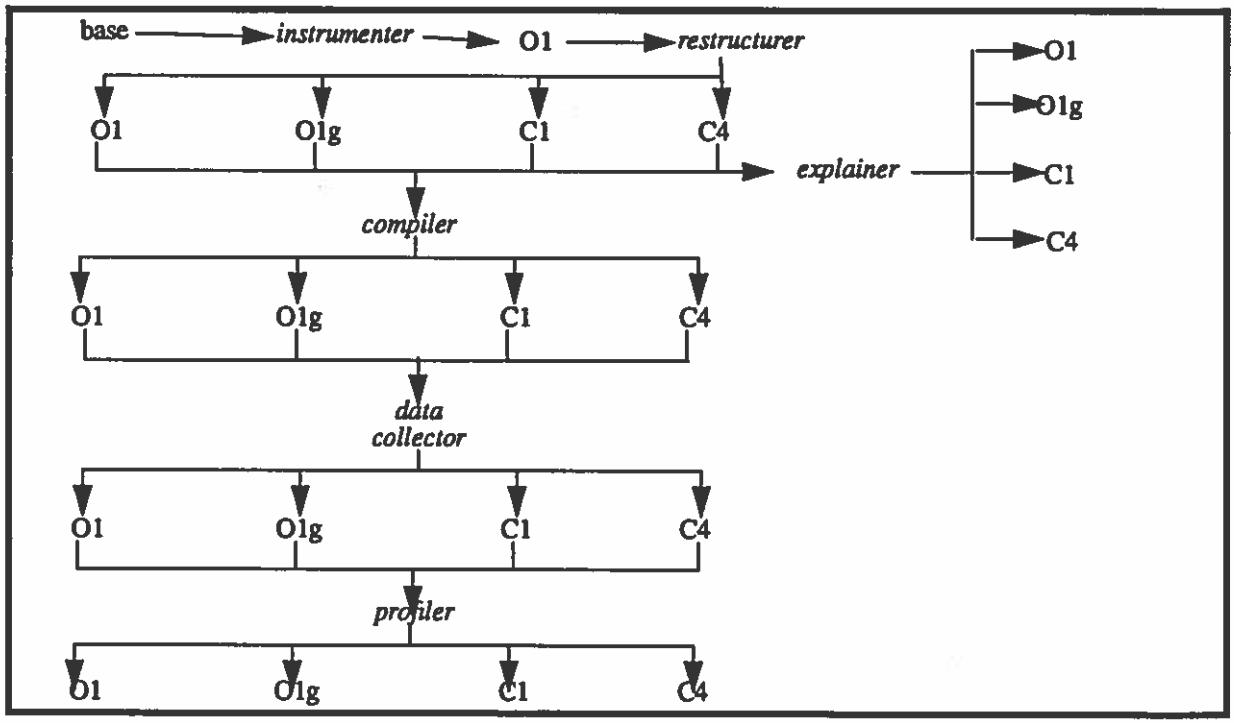
- Sequential base version
- Sequential version instrumented for loop-level profiling (O1).

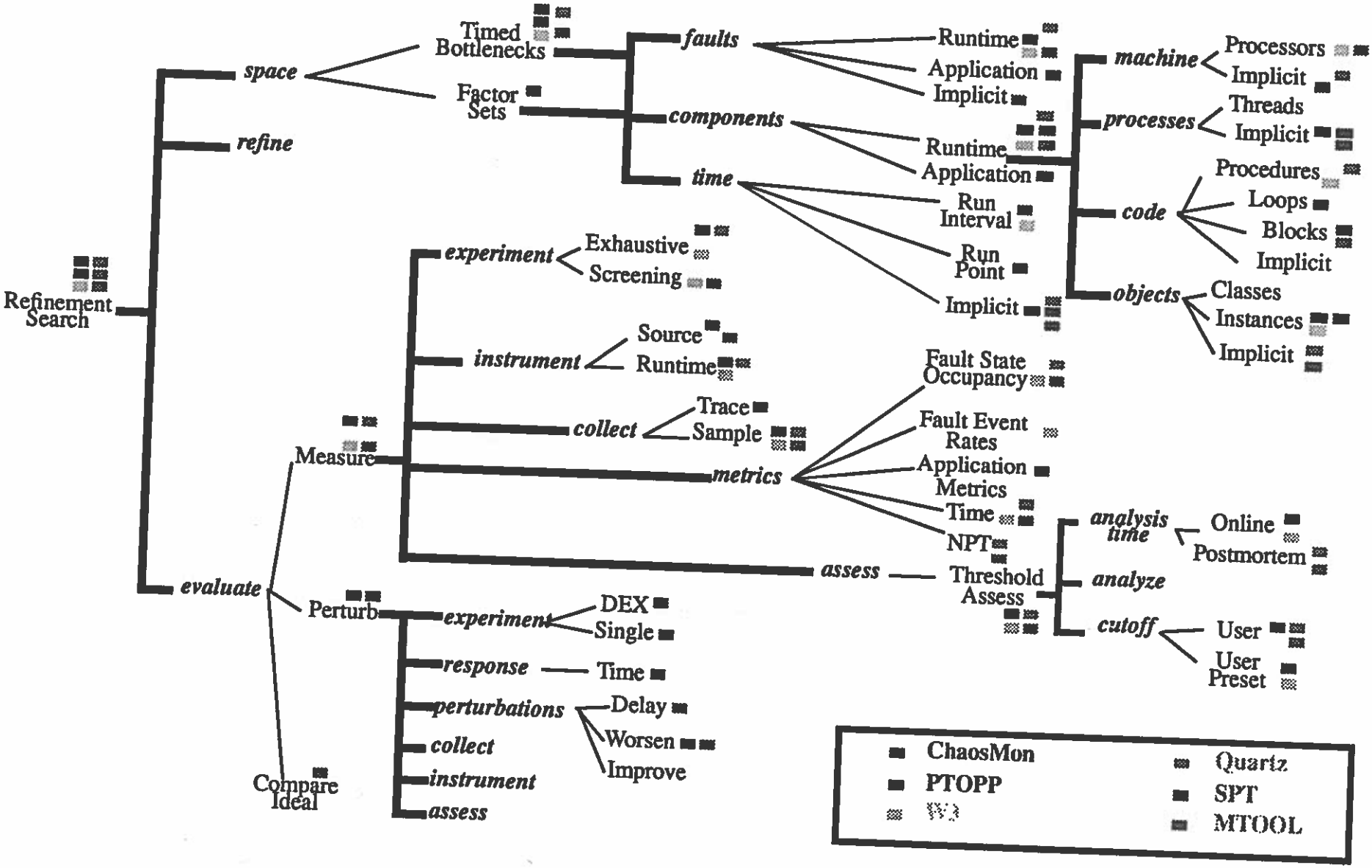
Compiler outputs:

- Restructured source code for O1, O1g, C1, C4.
- Restructurer static analysis report.
- Object codes.

Experiment results

- O1, O1g, C1, C4 loop-level profiles.

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