Constraint-based Recognition of Program Plans in Legacy Code

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Presentation Outline

1. Introduction to Legacy Understanding Problem
2. Overview of Constraint Satisfaction Paradigm
3. Understanding as Constraint Satisfaction
4. Previous Work and Shortcomings
5. Ongoing Work

The Problem with Legacy Code

- *Large* legacy code source presents many challenges :
  - Difficult to maintain, extend, debug
  - Old, embedded unused code
  - Outdated or non-existent documentation
  - **Redundant code functionality**
  - **Dispersed, local, or non-existent knowledge of code function,libraries**
  - ... many other problems

Dealing with Legacy Code

- Maintainers attempt to alleviate these problems by :

  $\longrightarrow$ Rewriting all or some systems if practical

  $\longrightarrow$ Consolidating code functionality where possible

  $\longrightarrow$ Simplifying code via shared or commerical libraries if available

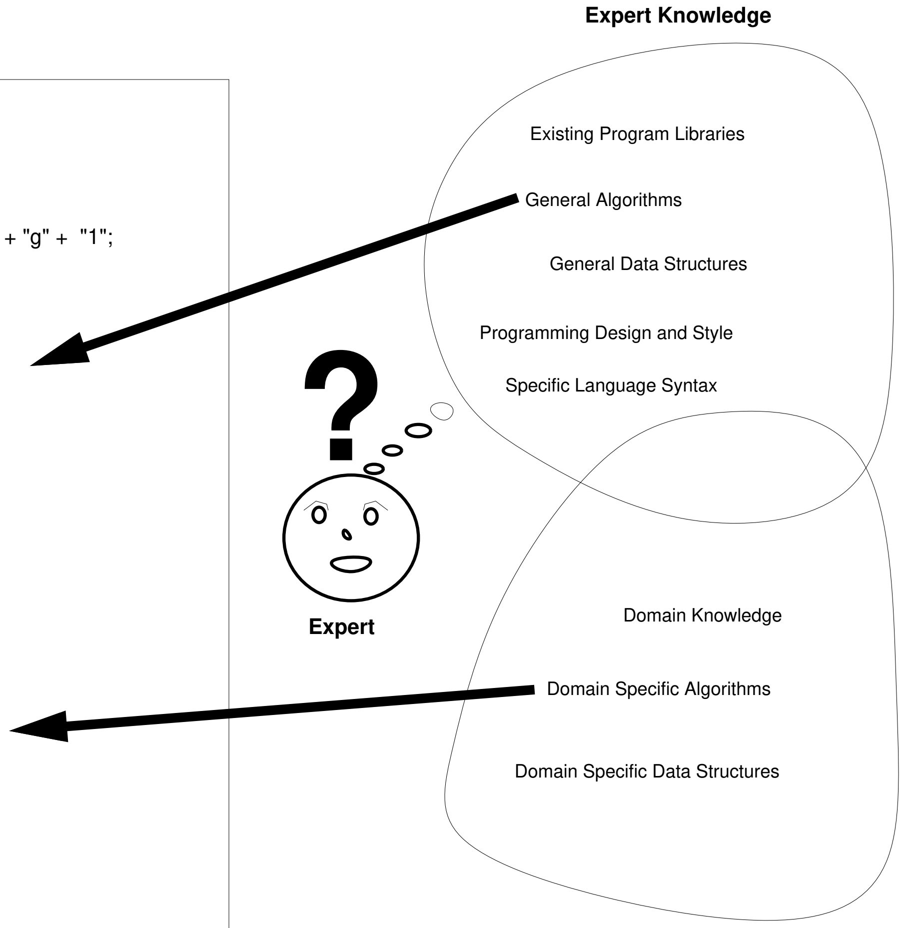
- Maintainers, knowledgeable about the domain, must somehow *Understand* a given legacy source

But what do we mean by "*Understand* legacy code" ?

Understanding Legacy Code : Conceptualization

Legacy Source Code

```
main()
{
  char* A, B, C;
  ...

  A = "s" + "t" + "r" + "i" + "n" + "g" +  "1";
   ...

  B = "string 2";
  ...
  sz = 7;
  for (int j = sz; j > 0; j––) {
       ....
       C[sz – j] = B[sz – j];
       ... }
  ...
  C[sz] = 3;

  ...

  for (int i=0; B[i]; i++)
        ...
     print(B[i])
        ....
  ...

  for (int j=0; C[j];j++) {
        ....
        printf("%s",C[i]);
        ... }
  ...
  for (int k=0;A[k]; k++) {
        ...
        outchar(A[k]);
        ... }
  ...
  ...
 }
```

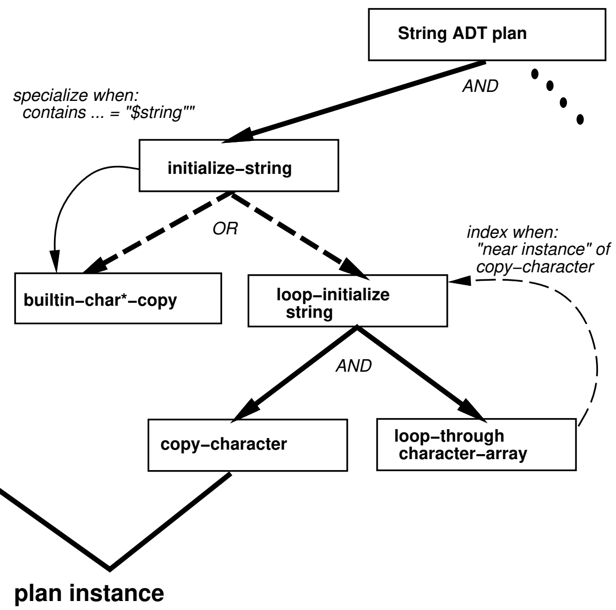


Understanding Legacy Code : Knowledge Mapping

Legacy Source Code

```
main()
{
  char* A, B, C;
  ...

  A = "s" + "t" + "r" + "i" + "n" + "g" +  "1";
   ...

  B = "string 2";
  ...
  sz = 7;
  for (int j = sz; j > 0; j--) {
     ....
     C[sz - j] = B[sz - j];
     ... }
  ...
  C[sz] = 3;
  ...

  for (int i=0; B[i]; i++)
       ...
     print(B[i])
       ....
  ...

  for (int j=0; C[j];j++) {
       ....
       printf("%s",C[i]);
       ... }
  ...
  for (int k=0;A[k]; k++) {
       ...
       outchar(A[k]);
       ... }
  ...}
```

Program Plan Library (excerpt)



→ How may we automate some of this mapping process ?

Approach : Constraint Satisfaction Paradigm

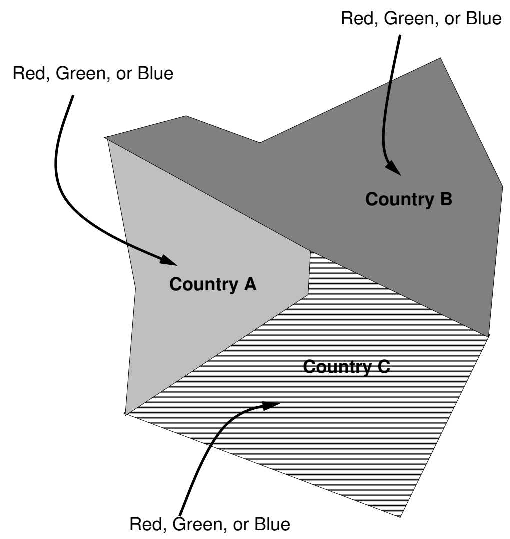


Figure 1: Map Color Example.

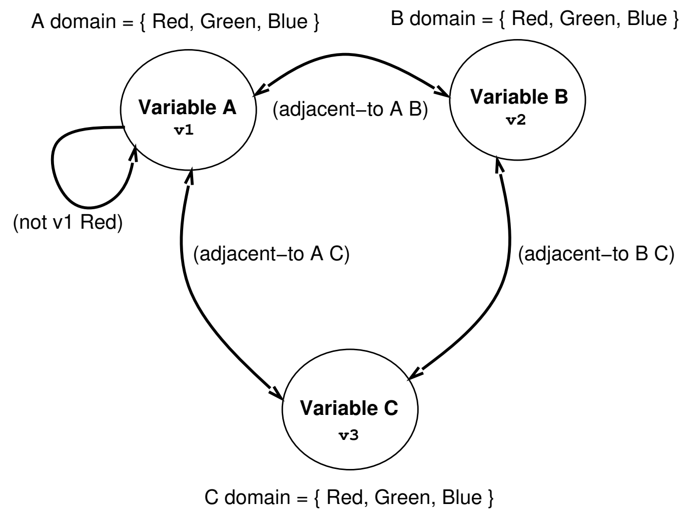


Figure 2: Map Color CSP.

- Known solution approaches (Search, Propagation, Hybrid)
- Well constrained problems → reasonable performance
- Domain knowledge (i.e. plan library) → tight constraints

Part 1 : Program Understanding as CSP

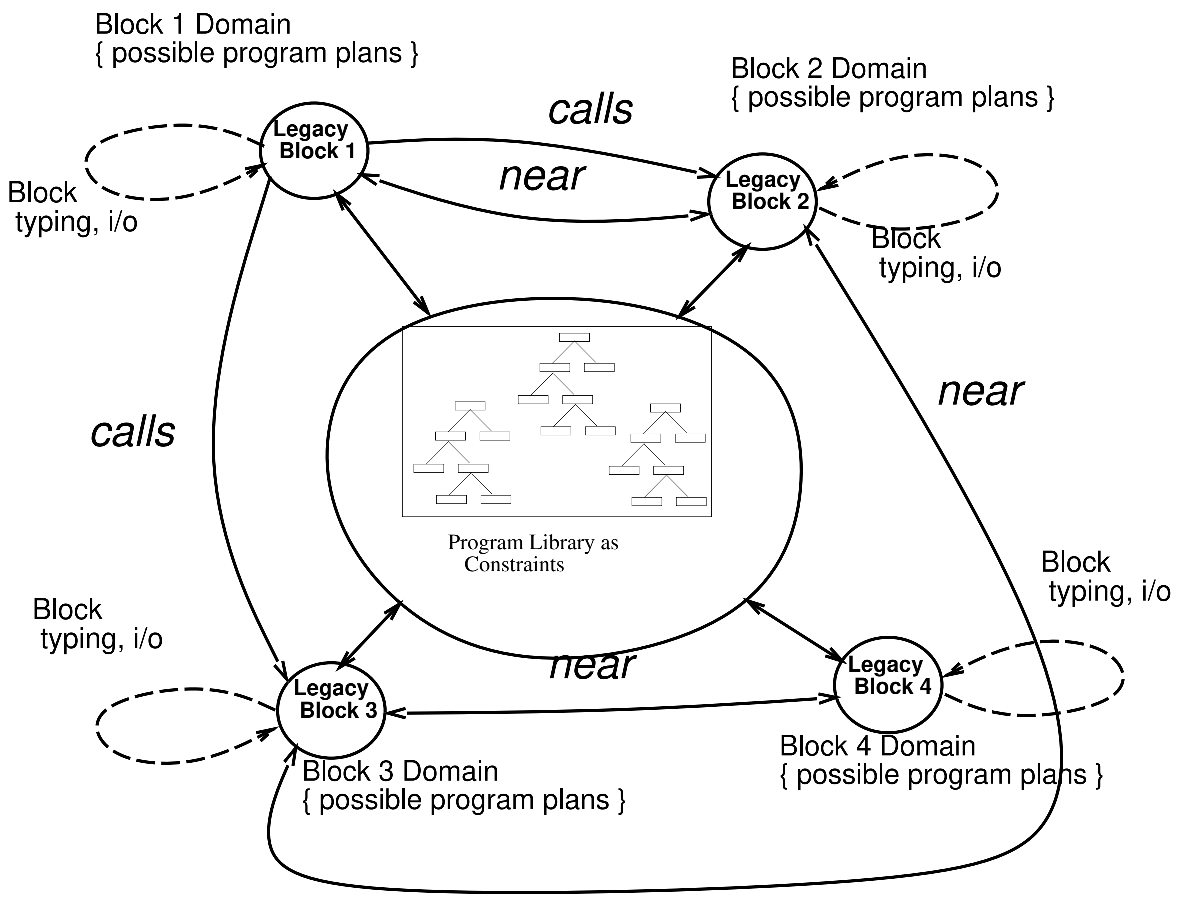


Figure 3: Mapping *Sliced* Legacy Code to program plans.

Part 2 : Plan Template/Cliché Matching as CSP

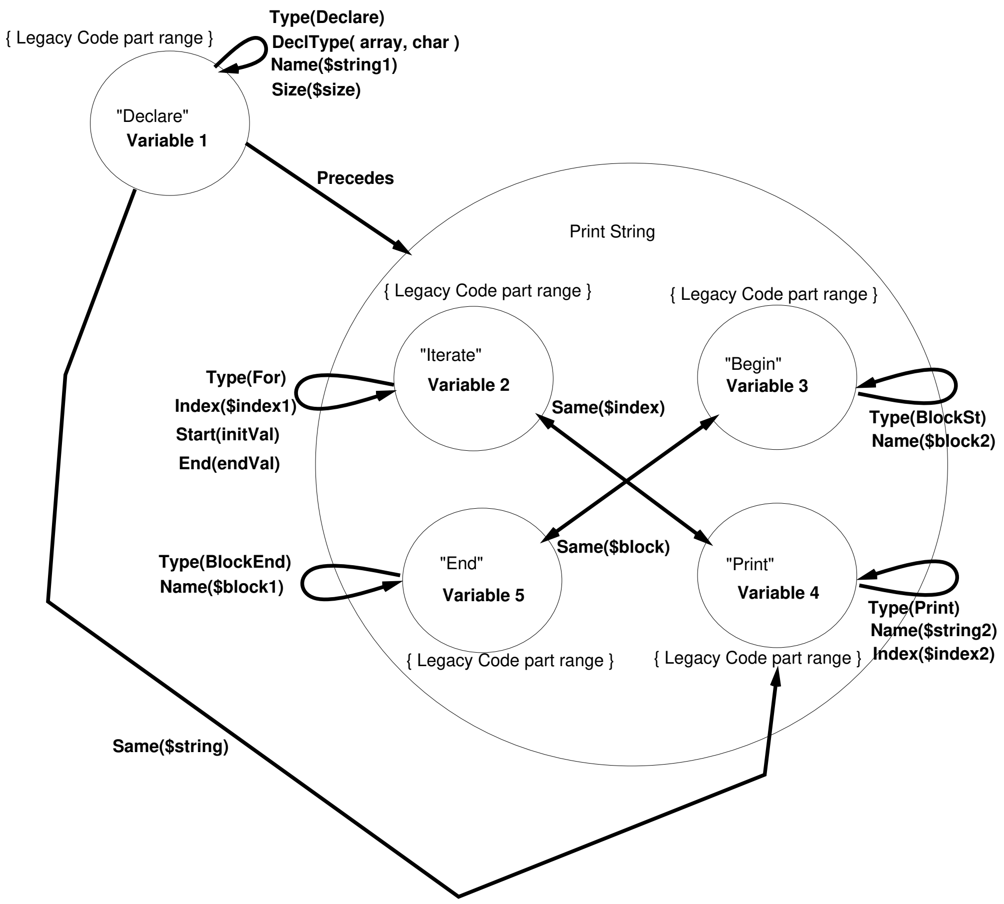


Figure 4: Partial String ADT CSP (From SLIDE 6).

Related Efforts

- Quilici (1994) Memory-based recognition

  → No unified model, heuristic tricks only

  → No empirical results

- Kozaczynski & Ning (1994) Concept recognition

  → No unified model, primarily controlled top-down

  → No empirical results

- Wills (1992) Cliché concept recognition

  → Awkward representation of clichés (grammars)

  → Does not constrain search with knowledge

Empirical Results : Standard Backtracking

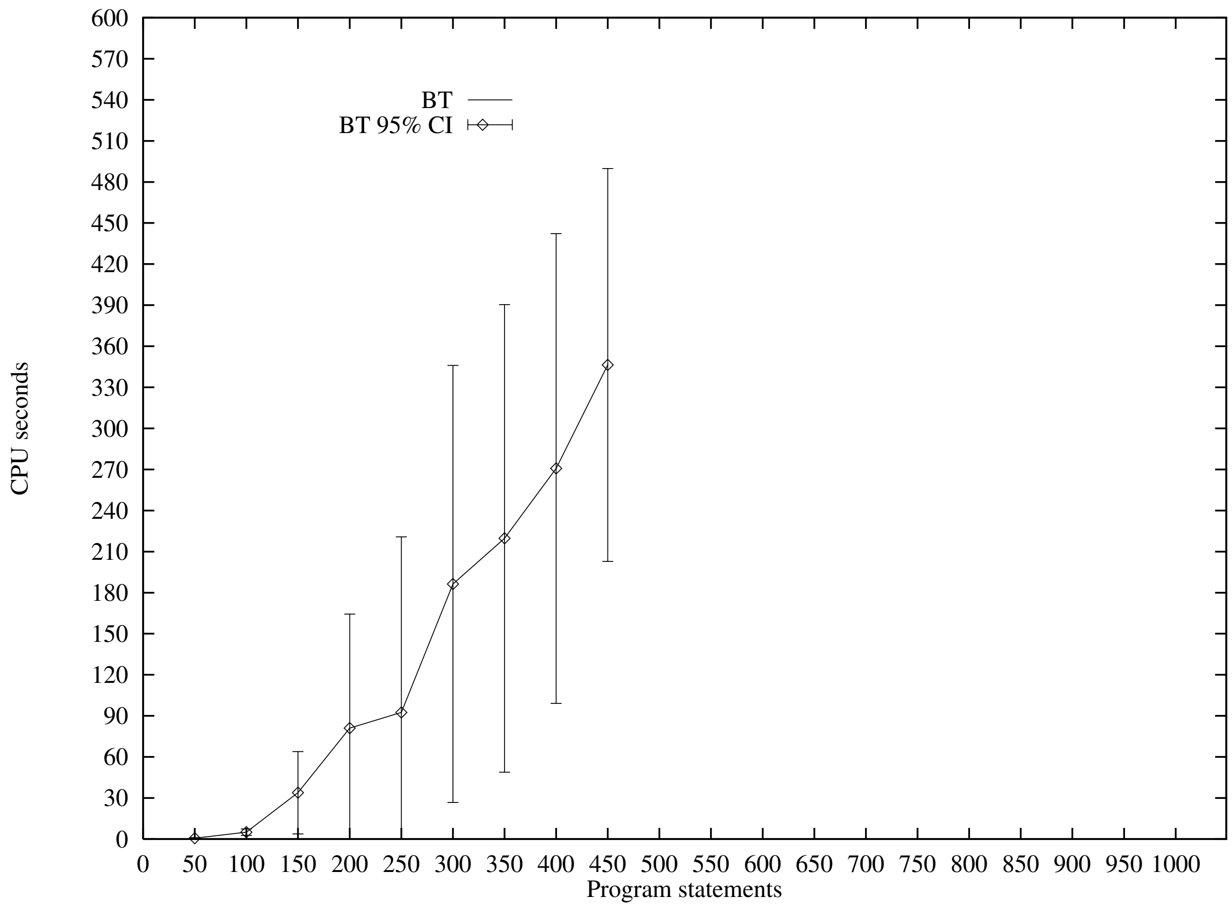


Figure 5: Standard Backtracking (cpu seconds).

Empirical Results : Heuristic Strategy

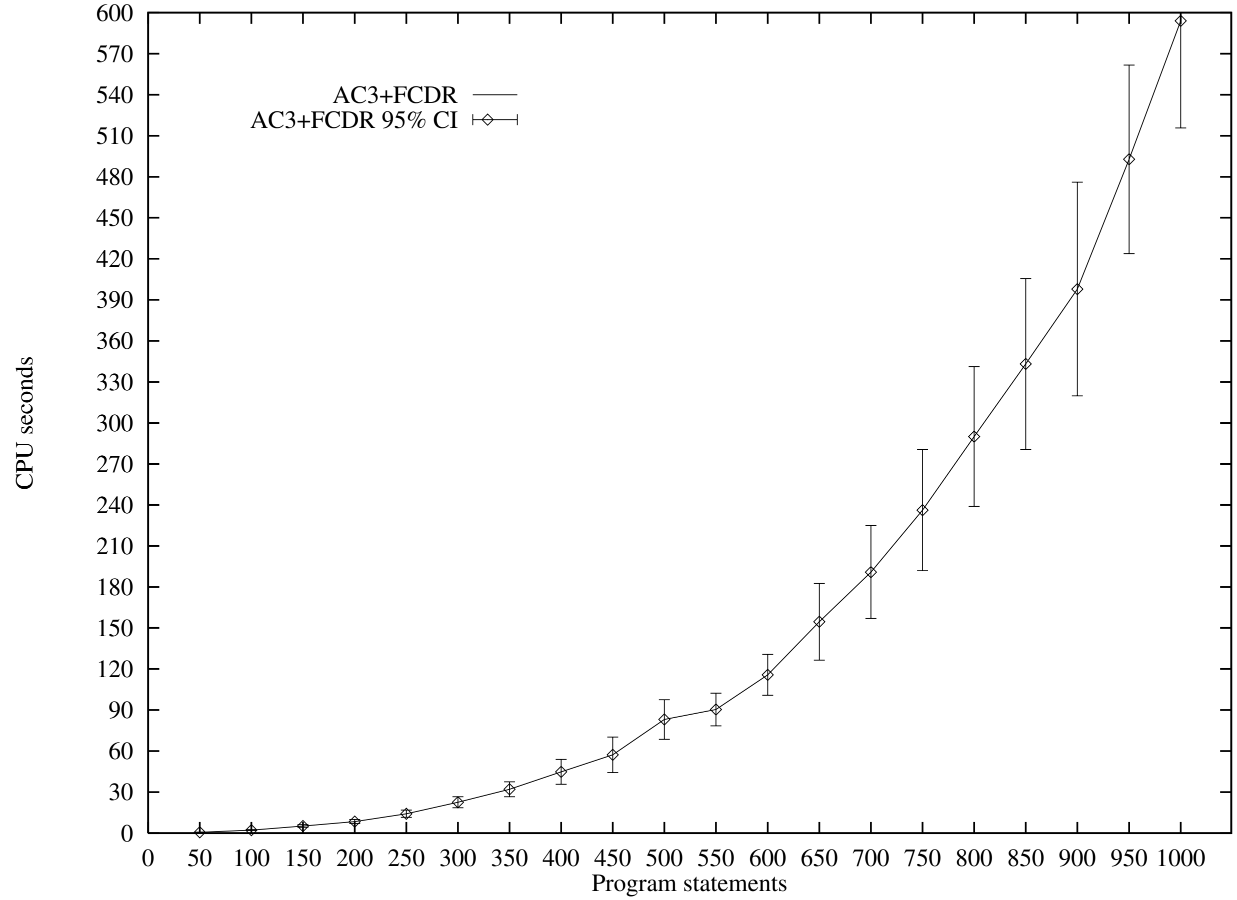


Figure 6: AC-3 with FC, DR (cpu seconds).

Empirical Results : Backtrack vs Heuristic

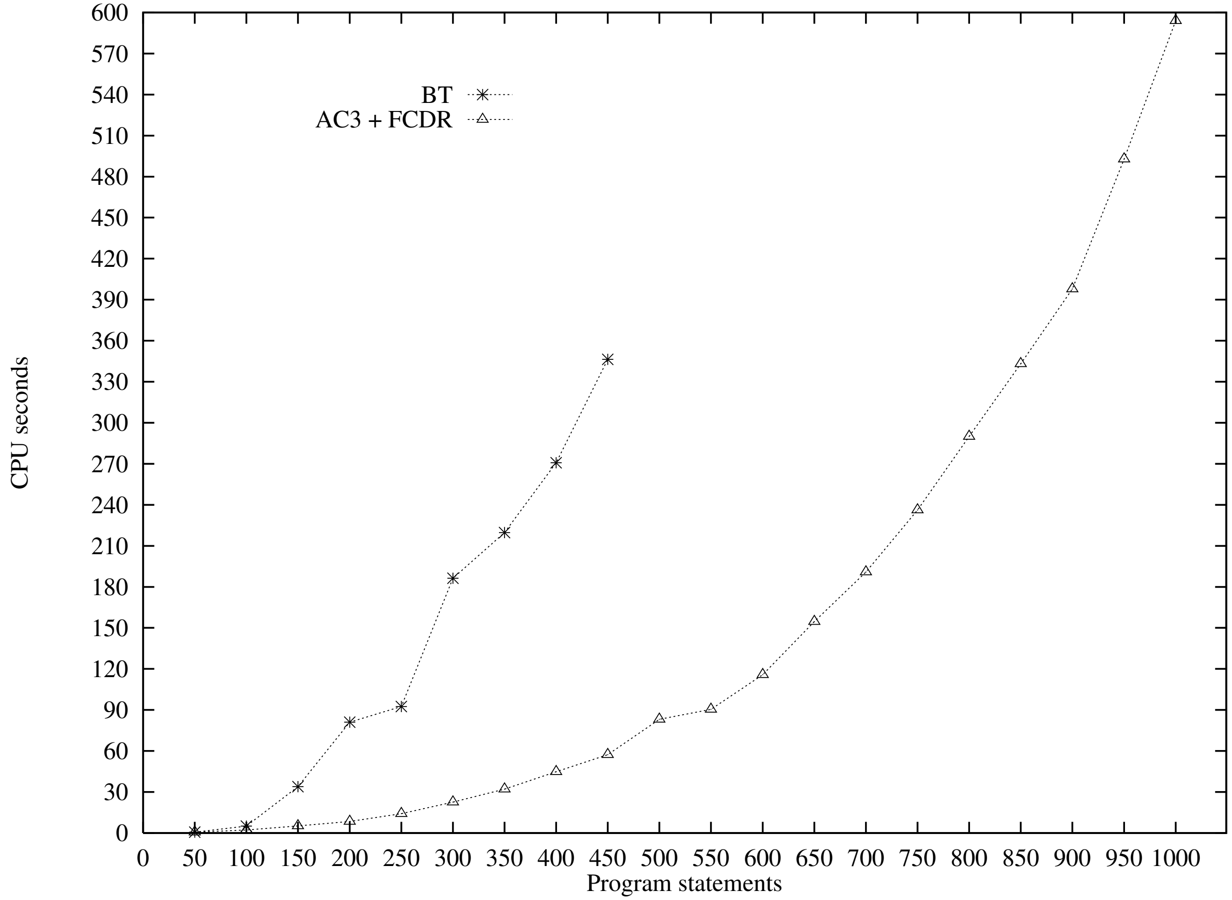


Figure 7: Standard BT vs AC-3 with FC, DR (cpu seconds).

Empirical Results : BackTrack Quadratic

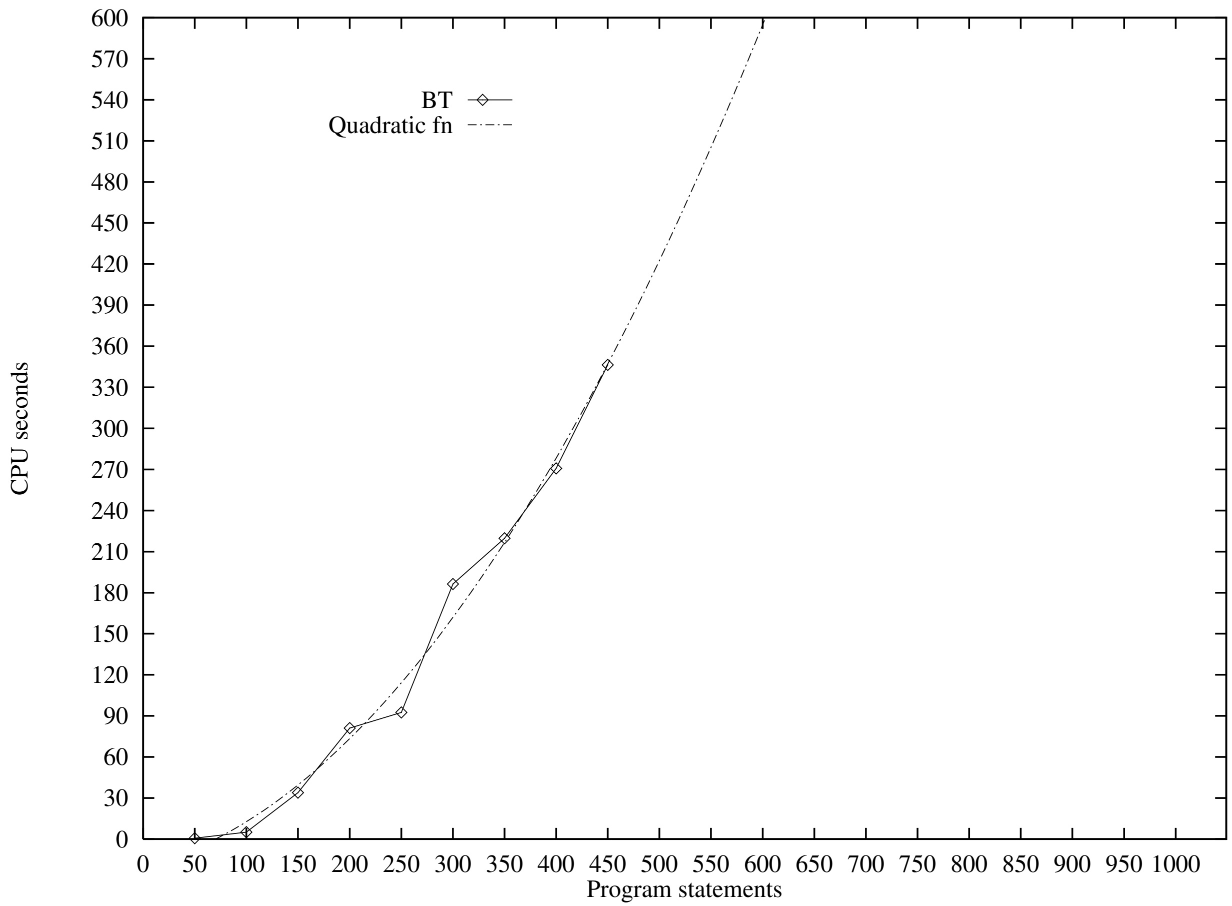


Figure 8: Quadratic fit to Standard BT Data.

Empirical Results : Heuristic Quadratic

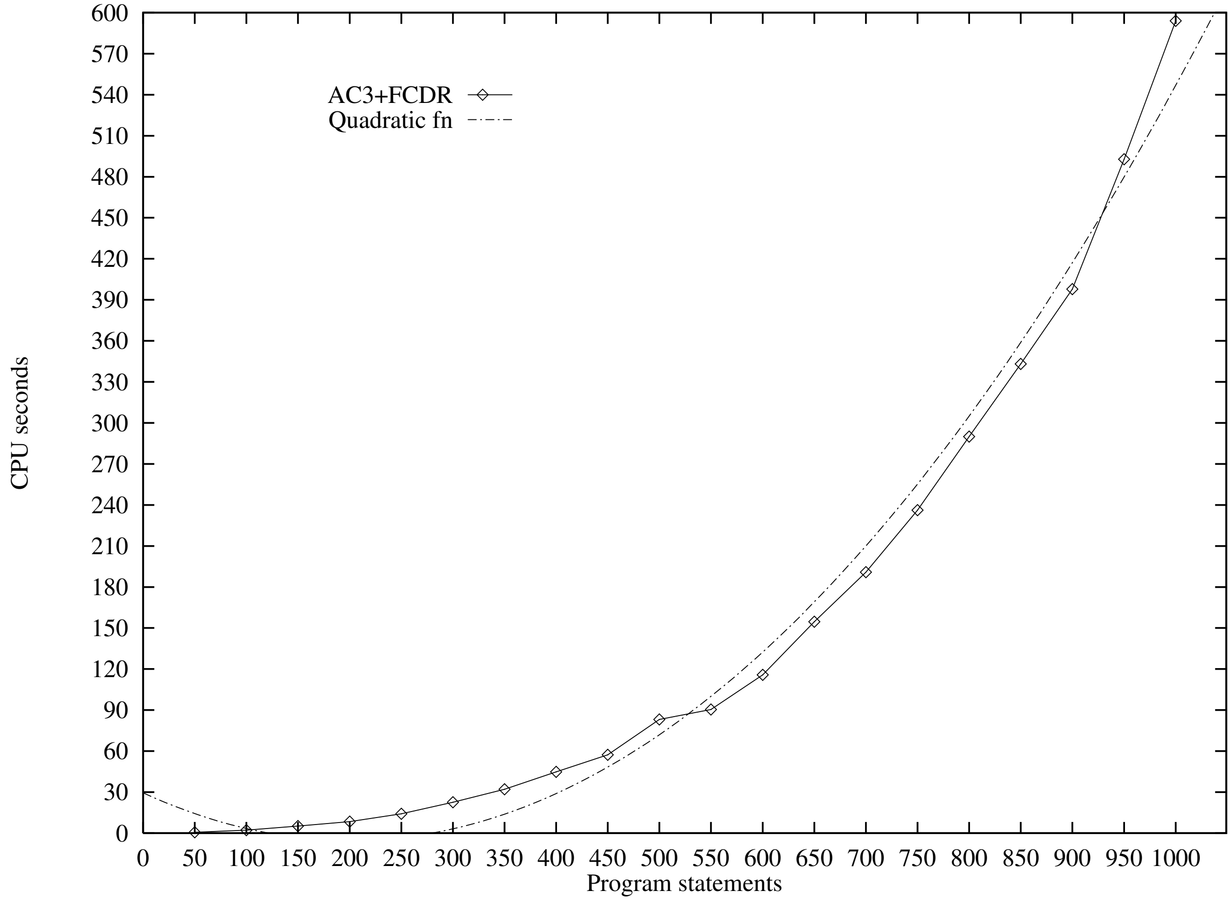
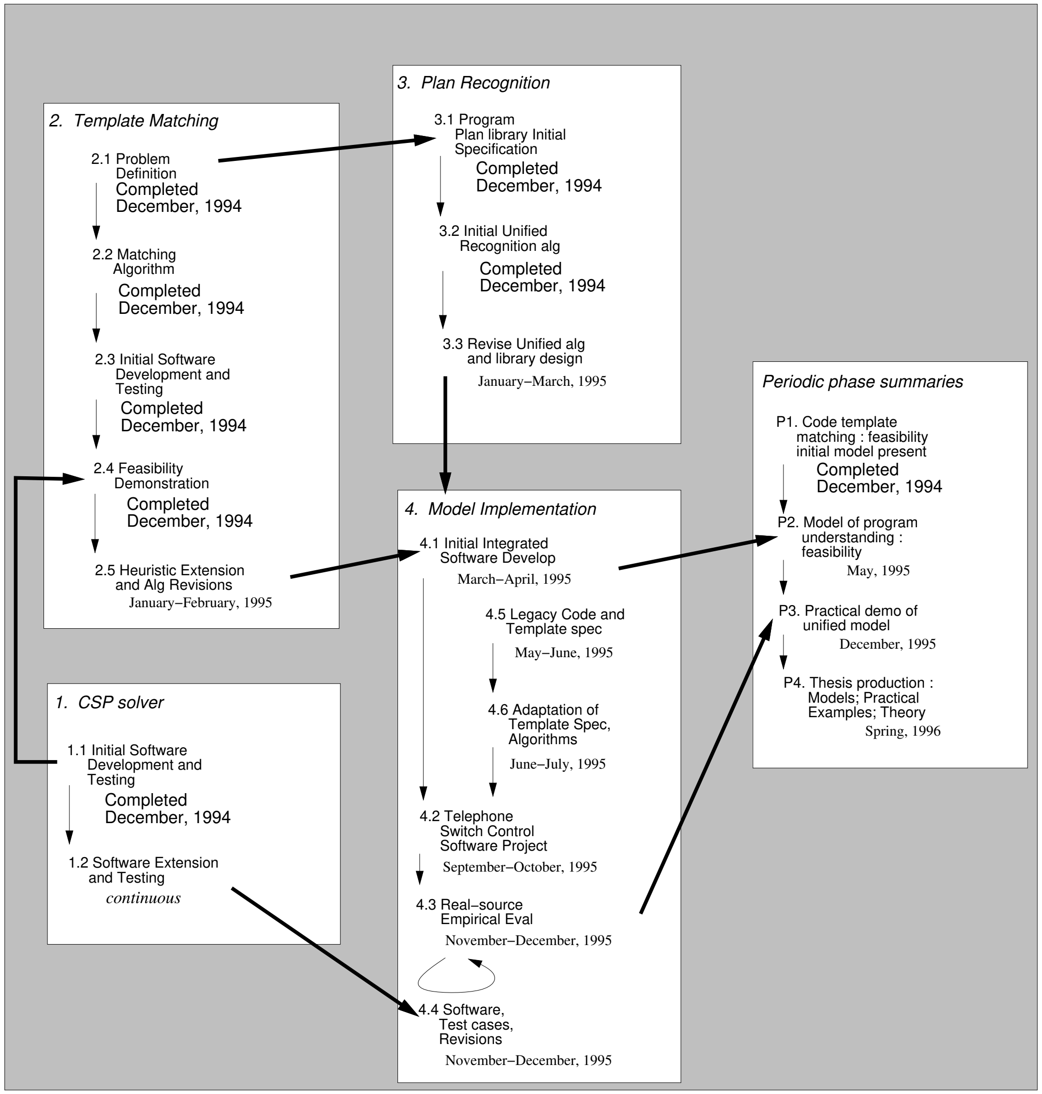


Figure 9: Quadratic fit to AC-3 with FC, DR.

Research Timeline



Major Milestones

- **[May, 95]** Represent program plan *knowledge* & legacy source *structure* as constraints in **Understanding CSP**.
- **[May, 95]** Combine **Matching CSP** and **Understanding CSP** $\longrightarrow$ integrated model of understanding including *Plan Under.* and *Rev. Eng.* heuristics
- **[Oct, 95]** Formulate partial library from industrial abstracted plans (BNR cooperation)
- **[Dec, 95]** Empirically demonstrate (partial) understanding of industrial source using **Understanding CSP**
- **[Dec, 95]** Identify knowledge and constraints req'd to give heuristic adequacy in interactive and batch instances