Introduction

- Phase ordering problem
  - Traditional compilers have a fixed order in which optimization phases are applied.
  - This problem can be more severe when generating code for embedded applications.
  - VISTA allows the user to finely control both the order and scope of applying optimizations.

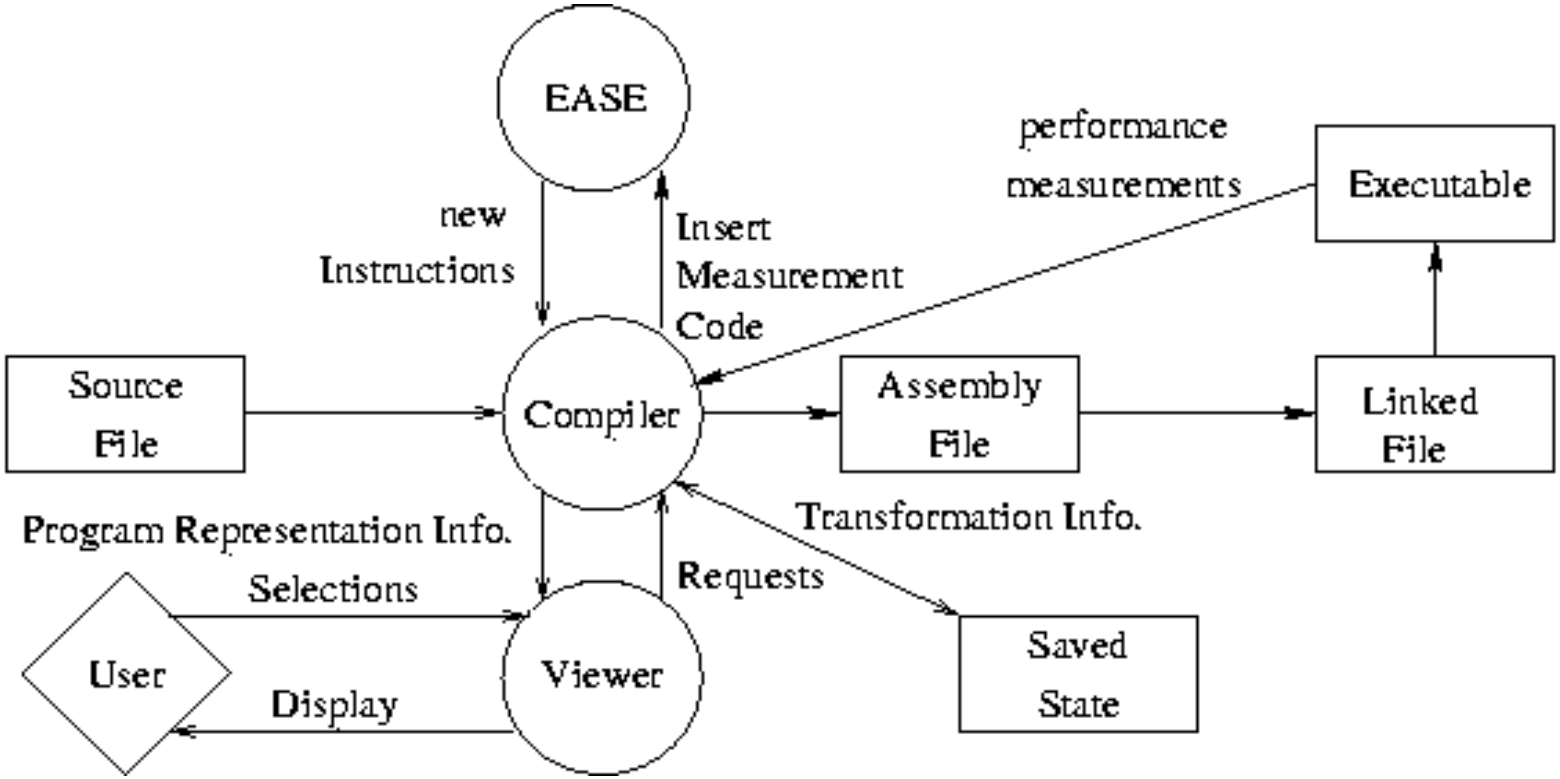
Introduction (cont...)

- Enhancing VISTA to make it more proficient at finding effective optimization sequences
  - Getting program performance measures anytime
  - Performance driven *interactive* code tuning
  - High level language like constructs to specify optimization phase orders
  - Performance driven *automatic* code tuning

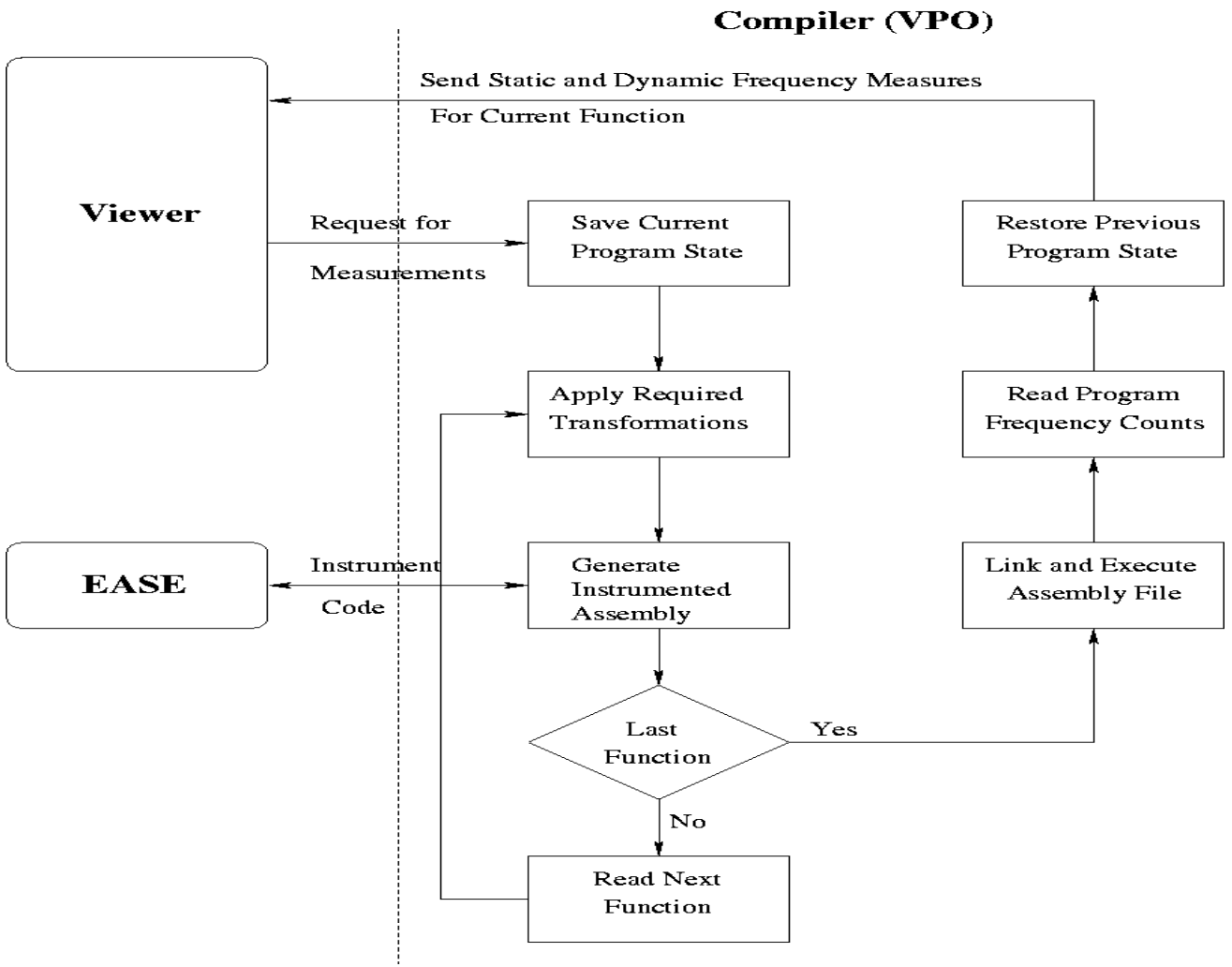
Outline of the Talk

- Overview of VISTA
- Getting performance measures in VISTA
- Support for interactive code tuning
- Support for automatic code tuning
- Experimental results
- Future work
- Conclusions

Overview of VISTA



Getting Performance Measures



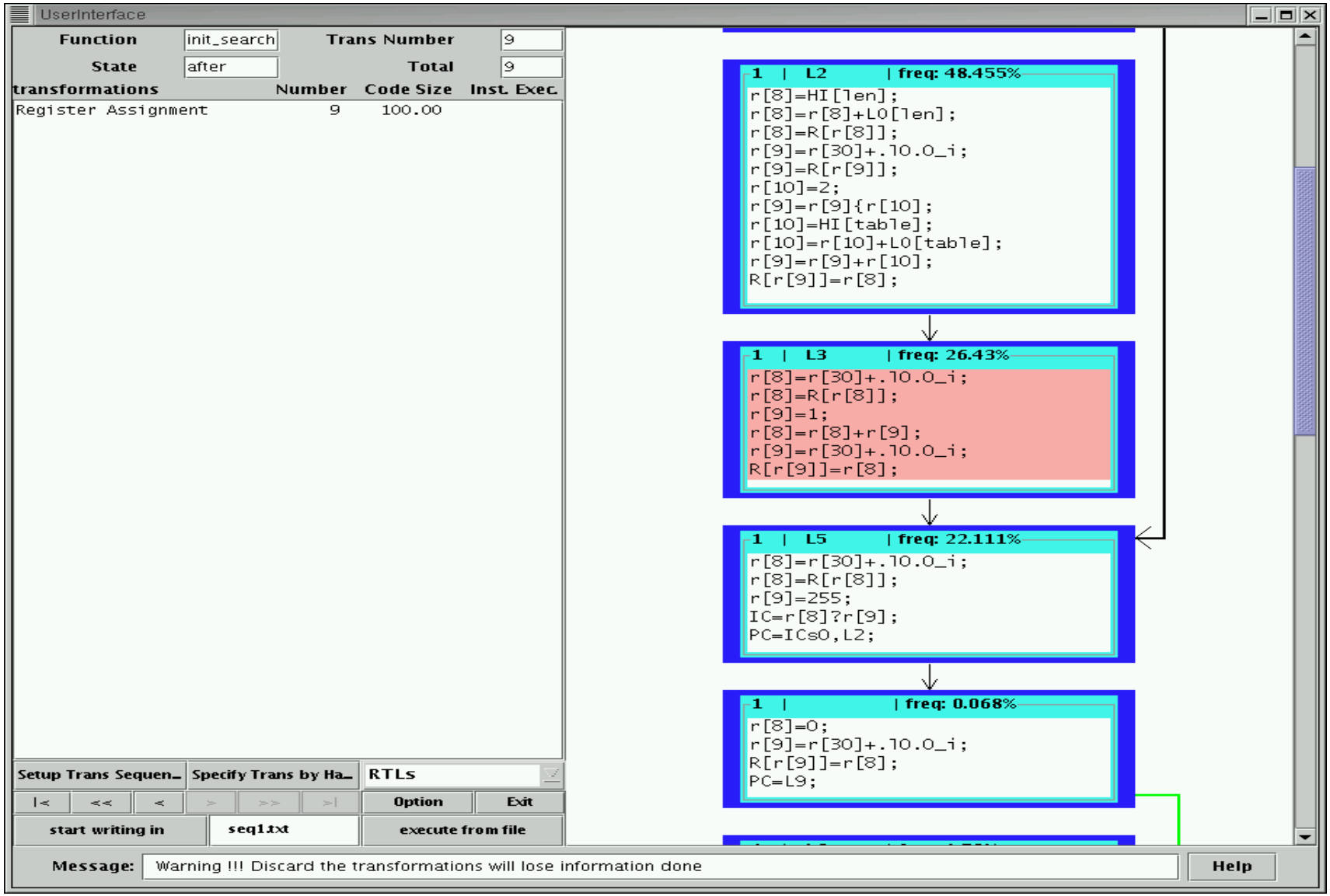
Interactive Code Tuning

- VISTA provides the user with performance measures during interactive compilation.
- VISTA currently provides two types of performance counts:
  - *Static counts* – a count of the number of static instructions in that function
  - *Dynamic counts* – a count of the number of instructions executed during a particular run of the program
- VISTA also displays the execution frequency of each basic block.

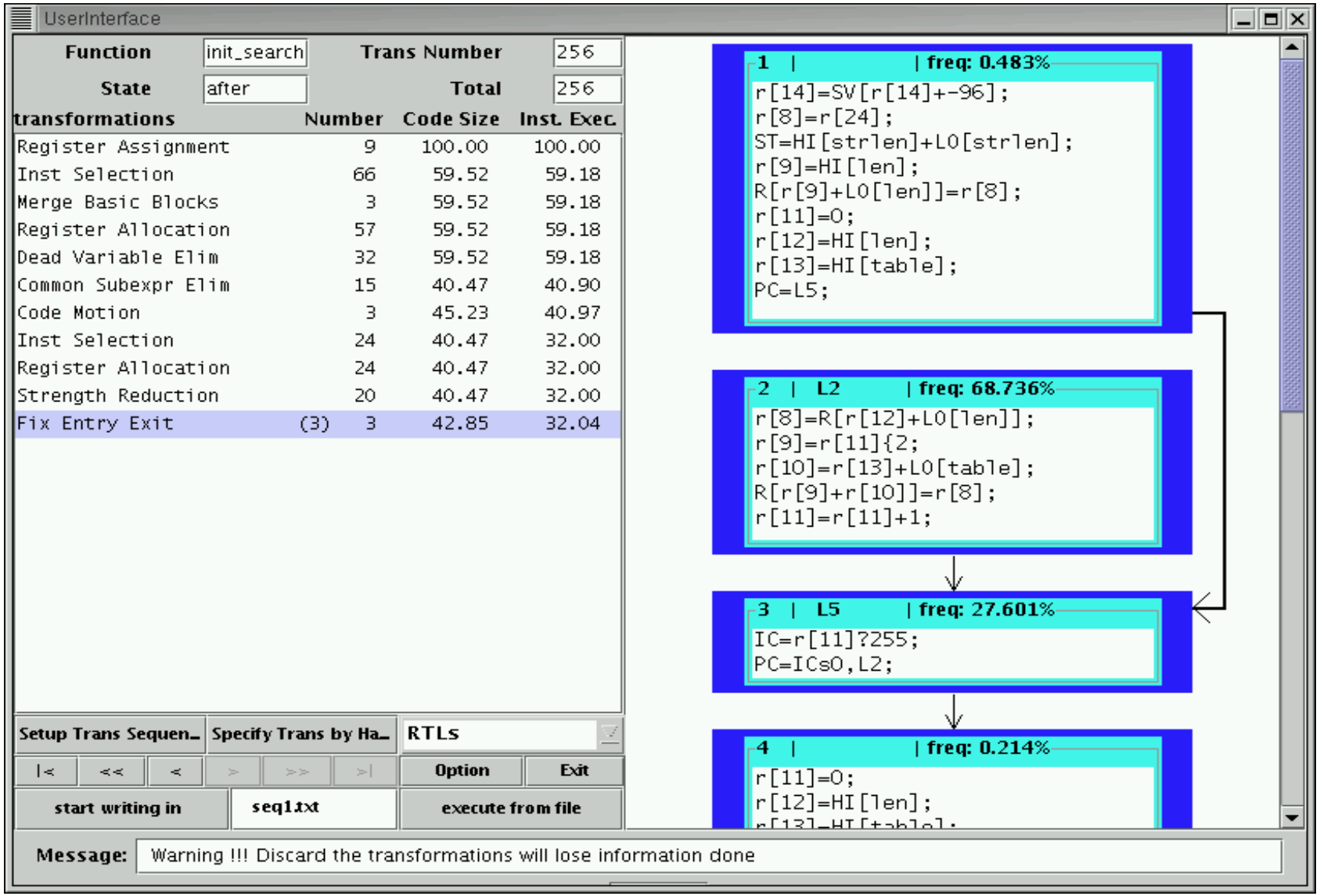
Interactive Code Tuning (cont...)

- VISTA provides two options for getting measures interactively.
  - Get frequency measures
  - Start / Stop measurements

Get Frequency Measures



Start / Stop Measurements



Interactive Code Tuning (cont...)

- Control Statements in VISTA
  - High-level programming language like constructs are used in VISTA to conditionally invoke an optimization phase.
    - if-changes-else
    - if-changes-then-else
    - do-while-changes
    - while-changes-do

Automatic Code Tuning

- The previous approach requires user knowledge, intuition and effort to guide the code improvement process.
- We provided two new constructs in VISTA to support automatic code tuning
  - select best sequence
  - select best combination

Select Best Sequence

- The user selects two or more different optimization sequences.
- Each sequence is evaluated by the compiler for its performance.
- The user can specify weights for static and dynamic counts to determine the overall improvement.
- The best performing sequence is found and re-applied by the compiler.

Select Best Combination

- The user specifies a set of optimization phases.
- The compiler tries to determine the best ordering of this sequence of phases.
- The compiler forms different combinations of phases.
- Each is evaluated for performance, depending on weights specified by the user.
- Only the best performing sequence is re-applied.

Select Best Combination (cont...)

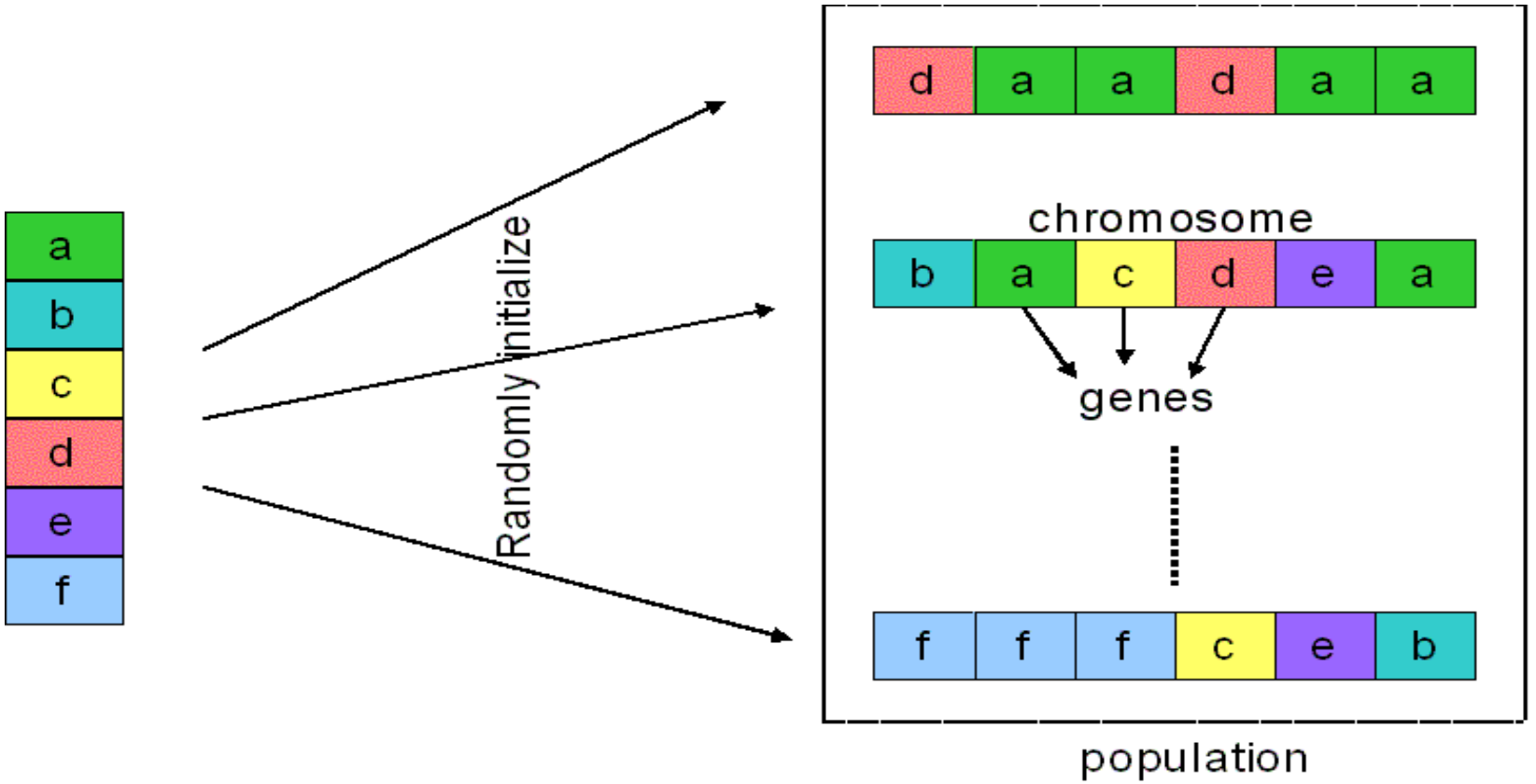
- The compiler finds the next combination to evaluate based on the search option specified by the user.
- Search options
  - Exhaustive search – All possible combinations are attempted by the compiler
  - Biased sampling search – Compiler uses a genetic algorithm to probe the search space for an effective sequence
  - Permutation Search – Compiler attempts to evaluate all permutations of the specified length

Genetic Algorithms

- These are search algorithms designed to mimic the process of natural selection and evolution in nature.
- Some genetic algorithm terms
  - Chromosome – optimization sequence
  - Gene – individual optimization phase in a sequence
  - Population – set of chromosomes
  - Fitness value – performance of that optimization sequence
  - Crossover – combination of sequences to form new sequences
  - Mutation – individual phases in a sequence are replaced
  - Generation – time step for evaluation of sequences in one population and formation of the next population

Genetic Algorithm Used

- Initialization of first population
  - The first population of optimization sequences is randomly generated

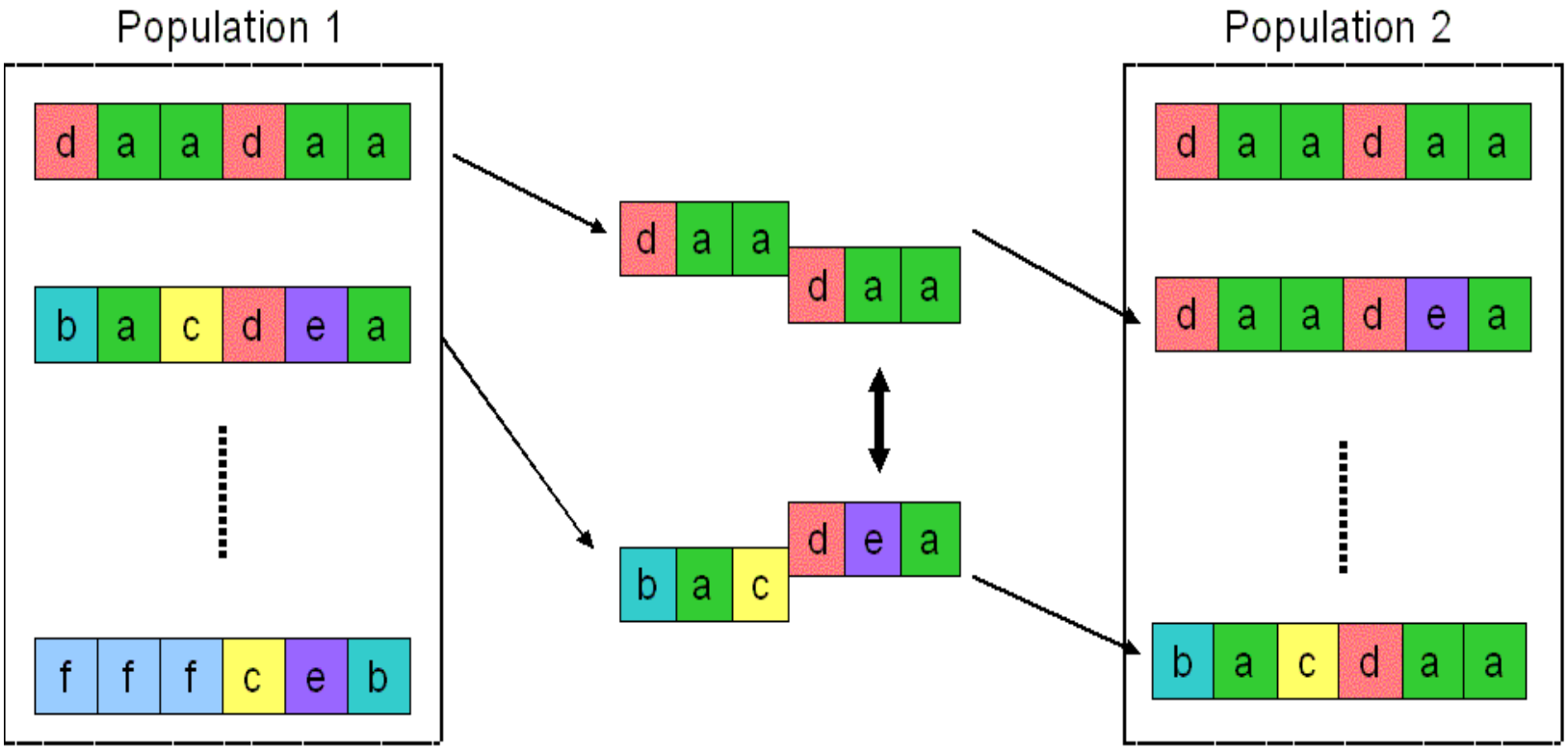


Genetic Algorithm Used (cont...)

- The performance of each sequence in the population is evaluated.
- The chromosomes are sorted based on performance.
- The population is divided into two halves.
- Some chromosomes from the poorly performing half are deleted.
- The vacancies are filled using the crossover and mutation operation.

Genetic Algorithm Used (cont...)

- Crossover operation
  - upper half of the first chromosome is combined with lower half of the second and vice-versa.



Genetic Algorithm Used (cont...)

- The chromosomes are subjected to mutation.
- The best performing chromosome over all the generations is maintained.

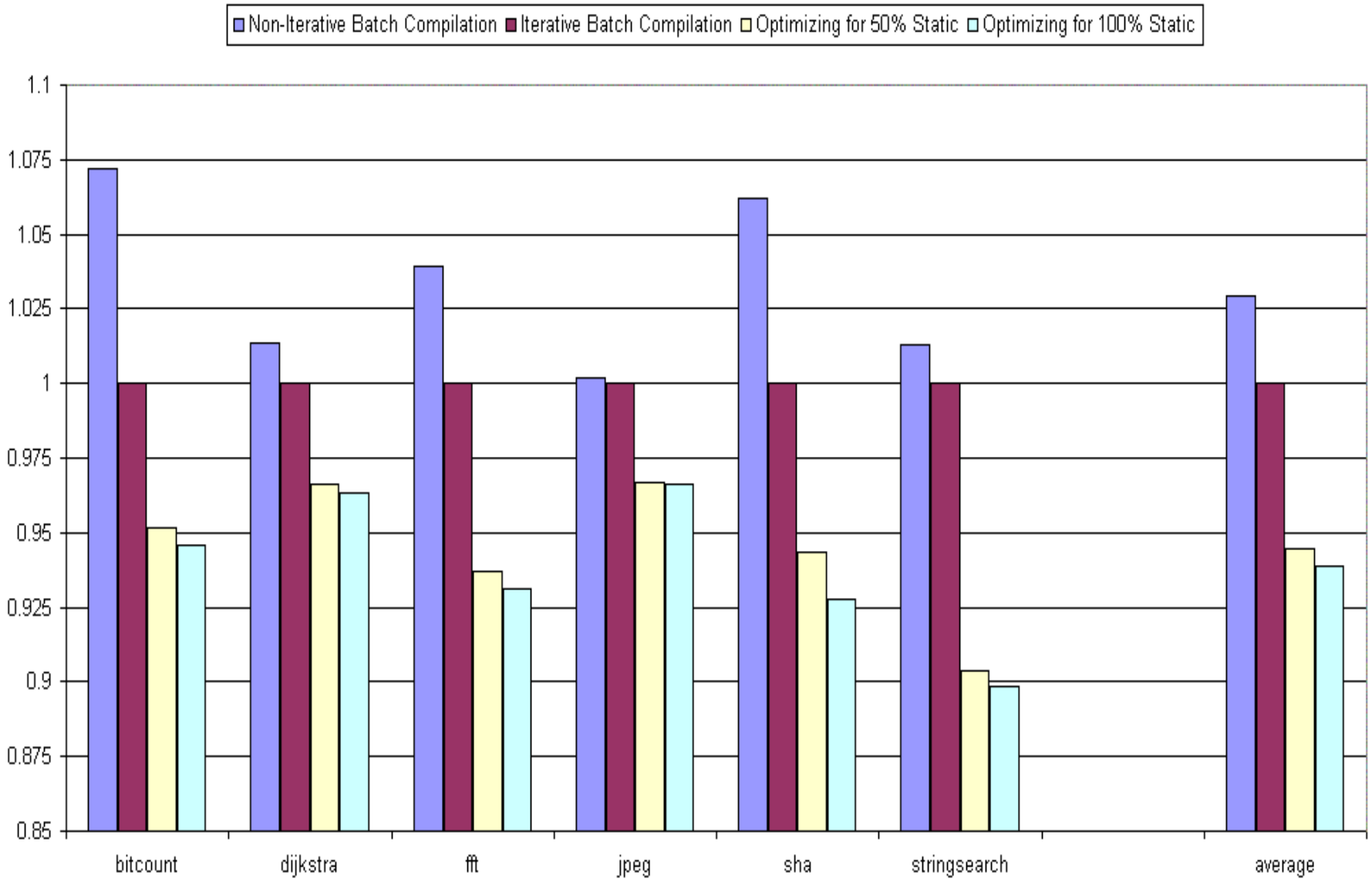
Experimental Results

- A set of experiments were conducted to illustrate the effectiveness of using VISTA's biased sampling search.
- The experiments were conducted on a set of *mibench* programs.
- The target architecture for the experiments was the SPARC.
- The genetic algorithm was used to find the best sequence among 14 phases between *register assignment* and *fix entry exit.*
- The *sequence length* was set to 1.25 times the length of sequence applied during batch compilation.

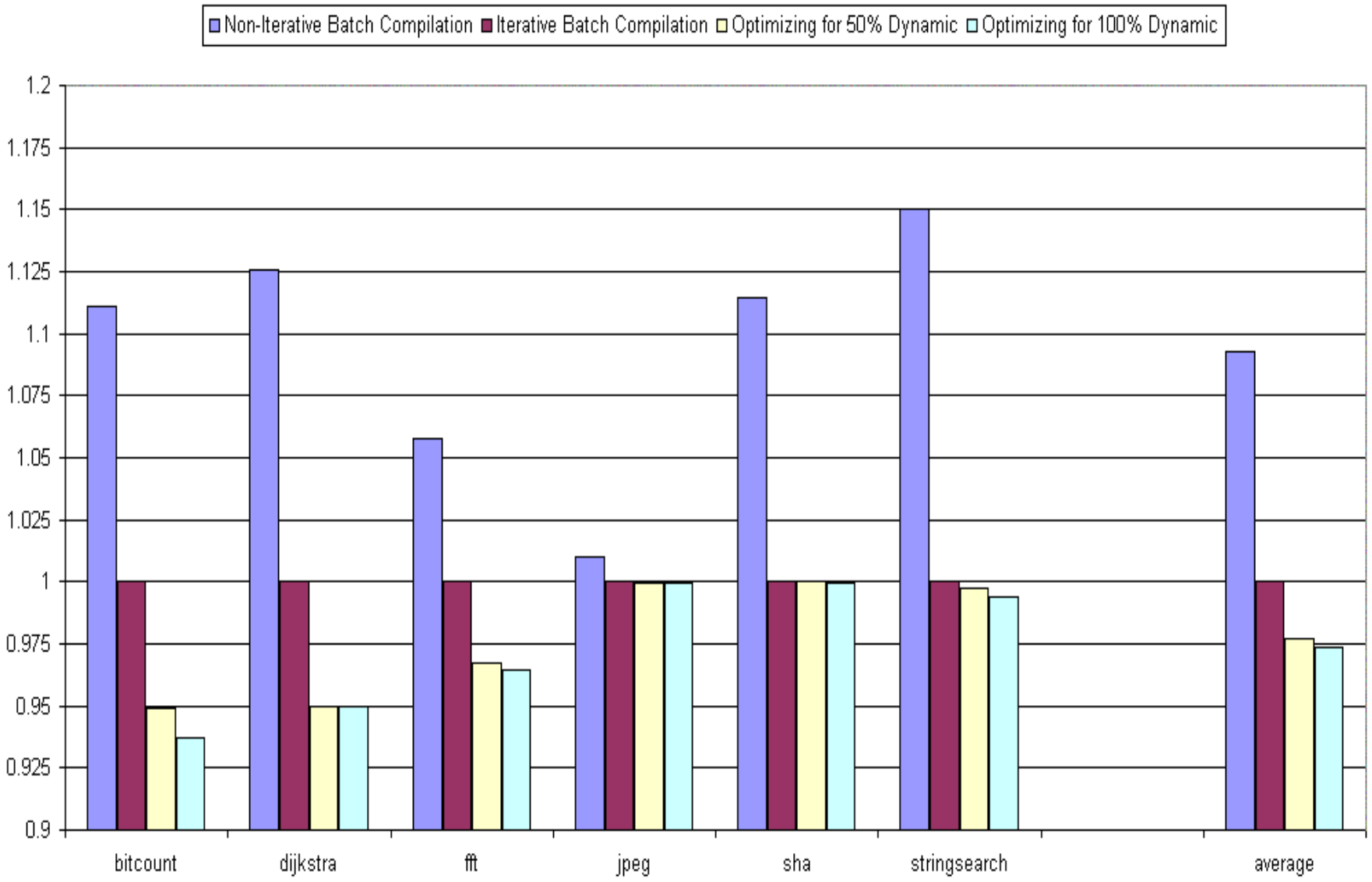
Experimental Results (cont...)

- Interactive compilation measures
  - An attempt was made to find an optimization sequence giving equal or better performance than that given by the batch compiler.
  - Genetic algorithm was used to probe the search space.
  - The population size was fixed at 20.
  - The algorithm was repeated for 100 generations.
  - Results were obtained for 3 different criteria, static count only, dynamic count only and 50% for each factor.

Overall Effect on Static Instruction Count



Overall Effect on Dyanmic Instruction Count



Future Work

- Obtaining measurements on a real embedded systems architecture
- Getting a more accurate measure of the dynamic performance
- Study the effect of varying the parameters in the genetic algorithm
- Study the result of performing genetic algorithm searches on sets of basic blocks in a function

Conclusion

- We have developed an interactive compilation system that automatically provides performance feedback information.
- Structured constructs are provided for specifying optimization sequences interactively.
- Constructs are provided to automatically select optimization phase sequences.
- Experiments were performed to illustrate the effectiveness of using a genetic algorithm to search for effective optimization sequences.