Hybrid Approach for Dataflow Analysis of MPI Programs
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Objective

• To improve precision of dataflow analysis on MPI programs
• Detect communication pattern statically

Dataflow Analysis

• Static compiler analysis technique to discover program properties
• Maintains an abstract program state for each control-flow graph node
• Abstract states are modified based on the semantics of the statement
• Program execution by the analysis is a sequence of abstract states

Dataflow Analysis for MPI

• Dataflow analyses to improve performance or debugging of MPI applications require precise communication information
• Existing techniques over-approximates communication behavior or employ complex matching algorithm to determine communication statically

Our Approach

• Key insight: Communication is determined by values of rank and size of the MPI communicator
• Treat these variables concrete to determine values of target expressions in MPI function calls
• To solve message matching, replicate CFGs and connect send and receive operation in CFGs by concretely executing them

Details

• Each analysis instance is a composition of multiple analyses
• Each analysis instance is also a MPI process
• Slicing reduces the program to contain only statements that affect communication
• Constant propagation determines concrete values for target expressions in MPI communication calls
• Dead path elimination prunes out unreachable paths
• Communication invariance determines that communication is not input or message dependent
• Dynamic send receive matching concretely executes the operations exchanging CFG information to establish the communication edges

Fuse

• Our analysis composition is based on Fuse framework implemented in ROSE compiler
• Fuse allows transparent composition of multiple analyses requiring no knowledge of API or abstractions implemented by other analyses to exchange information

References

• Compositional Dataflow via Abstract Transition Systems (Fuse), Bronevetsky et al, LLNL TR
• Dataflow Analysis for MPI Programs, Strout et al, ICPP’06
• Communication sensitive static dataflow for MPI – Bronevetsky, CGO’09