# Ideas for Efficient Hardware-Assisted Data Breakpoints

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# Watching Variables

- Typical instrumentation is contol-oriented, but watching data is often useful and interesting
- E.g., Tcl “trace variable” command
- Historically, debuggers have been very poor at watching data
  - general locality problem is hard
  - so just break after “every” instruction
  - e.g., 10,400 slowdown on a simple program

# Specialized CPU Hardware

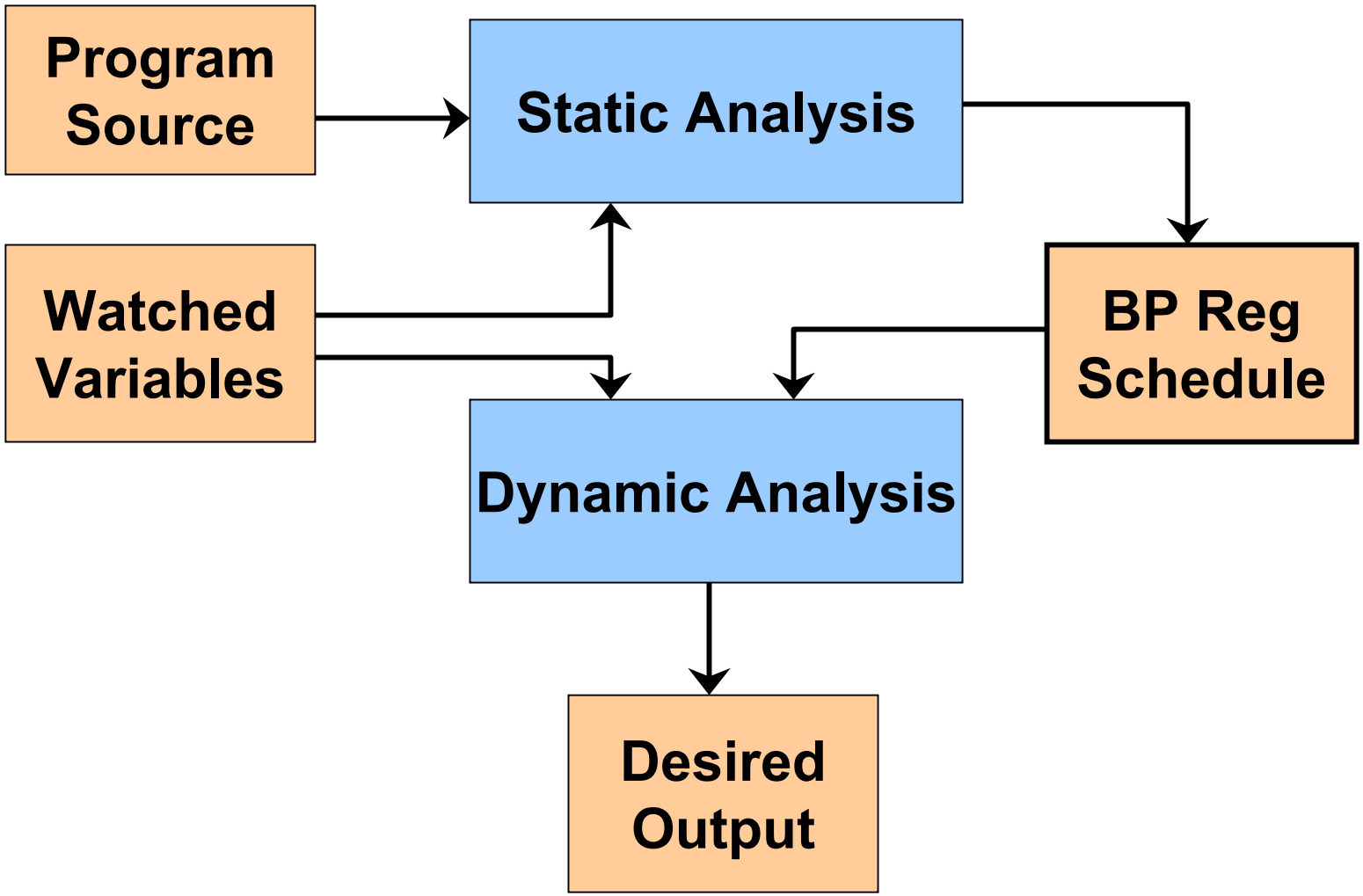
- i386+ has four breakpoint registers (other popular CPUs have one)
- Each will watch one word of memory at CPU speeds
- Enables limited data breakpoints with no slowdown -- unless breakpoint occurs
- Used only naively so far, by debuggers

# Using BP Registers for DA/RM

- Why not use these four registers for many other dynamic analysis/runtime monitoring purposes?
- To consider this, we must not be limited by the number of registers

- How to watch 100 variables with just four registers?

# Overall Process



# Scheduling BP Registers

- Given: program, set of variables to watch
- Produce: schedule of BP register usage
- Simple variables only – easy
- Arrays, pointers make everything hard
- When to change schedule?

# Ideas

- Static analysis informs/creates schedule
- Hierarchy of points at which to change schedule
  - BP triggers themselves (def-def chains?)
  - function call/returns (scoping)
  - basic block entry/exit (scoping)
- Points to analysis to handle pointers
- Backpedal to high coverage but < 100%

# Why this will succeed

- Data watching is useful, and has been hard to support
- It's a shame not to use hardware support if it is available
- Points-to analyses show few offending pointers
- May enable other interesting ideas
  - data-based joinpoints for AOP?
  - security-oriented monitoring

# Why this will fail

- Context switching!
  - BP registers trigger kernel-level trap
  - programming support only allows parent process to catch the trap
- Previous work (Wahbe et al., 1993 PLDI) set a high bar using direct instrumentation
- Maybe not as high a need for data watching as we think?