Papers

- S. S. Mukherjee, M. Kontz, S. K. Reinhardt, "Detailed Design and Evaluation of Redundant Multithreading Alternatives", in ISCA, 2002

Fault Detection with Lockstepping
Lockstepping Sucks

Why?
- Twice as slow
- Enormous communication costs
- Second processor does all the same work
  - Branch mispredictions
  - Cache misses
The Alternative

- S. S. Mukherjee, M. Kontz, S. K. Reinhardt, "Detailed Design and Evaluation of Redundant Multithreading Alternatives", in ISCA, 2002

- Allow one thread to run behind the other

- Benefits?
  - Makes performance reasonable (30% cost)
  - Lets trailing thread…
    - avoid all branch mispredictions
    - avoid all cache misses
  - When done on multiple processors….
    - allows other processors to do other work as well
SRT vs. CRT

- **SRT: 1 Processor, 2 Threads**
  - One processor redundancy
  - Pay 30% cost for the benefit of safety checks
  - Savings of 11% over running 2 full threads

- **CRT: 2 Processors, 2 Threads**
  - Two-processor redundancy
    - Detection of permanent faults
  - Loose synchronization (better resource usage)
    - Outperforms lockstepping by 13% average
  - Big benefits when running multiple threads
Cross-Coupling Multiple Threads

**Figure 5.** CRT processor configuration. The arrows represent threads in the processors. A and B are logically distinct programs. Each program runs a redundant copy: a leading copy and a trailing copy in the physically distinct processor pipelines. Note that the leading thread of A is coupled with the trailing thread of B and vice versa in the two processors.
Global Checkpoints


- Allows for...
  - global recovery...
  - without the run-time cost of redundancy

- No software changes necessary

- Logging is fast...
  - Recovery is slow

- Independent of detection method
Conceptual View

Figure 1. SafetyNet Abstraction. In SafetyNet, 1 processors operate on the current state of the system, 2 the system recovers to the recovery point if a fault is detected, and 3 some number of non-current checkpoints can be pending validation.
Which is better?

For performance during normal operation
- Checkpoints

For detection of faults
- CRT

For quick recovery
- CRT

Importance of recovery time depends on how often faults are detected
Who cares?

![Graph showing interest levels across pages read]

- **Jordan**
- **Kevin**
- **The Class**

**Pages Read**

**Reader Interest**