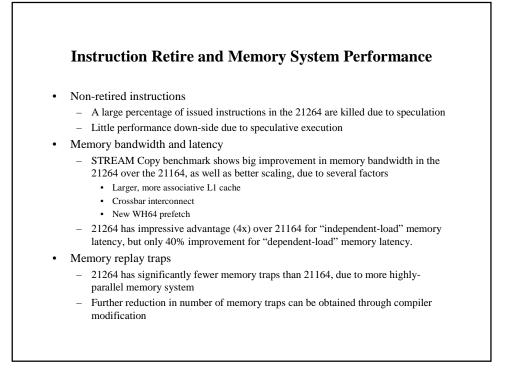
## Performance Analysis of the Compaq ES40--An Overview

- Paper evaluates Compaq's ES40 system, based on the Alpha 21264
- Only concern is performance: no power or cost issues
- Compares the ES40 and systems from other vendors in terms of speed, throughput, and sustained memory bandwidth
- Primary focus of paper is on comparison of ES40 against previous-generation AlphaServer 4100 to explore the improvements in the new system
  - Larger L1 cache
  - Tournament branch predictor
  - Out-of-order execution
  - Larger number of execution pipelines
  - More advanced memory system

## Methodology On-line transaction processing and technical/scientific workloads • - TPC-C: transaction processing benchmark • Measures throughput (transactions per minute) · Exercises processor power, memory interface, and I/O - SPEC95 benchmark suite SPECint95/SPECfp95 measure speed; SPECint\_rate95/SPECfp\_rate95 measure throughput Exercises processor, memory hierarchy, and compiler performance (to be included in the • suite, can not stress I/O or include networking or graphics) Measures geometric mean of normalized execution times, which can present a skewed perspective - Linpack: solves linear equations and least-squares problems Paper uses benchmark once to get a MFLOPS rating STREAM: synthetic benchmark program that includes four vector kernels • Measures sustainable memory bandwidth (in MB/s) ProfileMe and DCPI tools used to profile data Paper does not specify compiler used

## **I-Cache, Branch Prediction, and IPC Performance**

- Instruction cache performance
  - 21164 has 8 KB direct-mapped L1 cache, while 21264 has 64 KB two-way associative L1 cache
  - Most cache misses in 21264 appear to be compulsory misses for the given benchmarks; difficult to tell how the cache would handle larger programs
- Branch prediction performance
  - 21164 uses a simple two-bit branch predictor; 21264 uses a tournament branch predictor that tracks local and global history
  - 21264 typically has improved branch prediction over the 21164, but it does not do
    as well with transaction processing branch prediction
- Comparison of Instructions Per Cycle
  - Out-of-order execution, up to 80 in-flight instructions, additional functional units, and other advances lead to IPC improvements in the 21264 over the 21164
  - IPC comparison could be skewed: IPC in 21264 measures number of retired instructions, which favors the 21164, but the ES40 results were obtained with code that targeted 21264, which favors that system



## Conclusions

- The 21264-based Compaq ES40 has many architectural features that improve performance over the 21164-based AlphaServer 4100
- Authors claim that the ES40 has performance advantage over other vendor machines based on results of SPEC95 and STREAM benchmarks
- It is acknowledged in the paper that further study is required using a greater variety of applications--SPEC95 results are generally impressive, but TPC results show that there is room for improvement
- Paper does a good job of examining the architectural features of the ES40 and their effect on performance
- Other areas of interest--power consumption, area, cost