Alpha 21264 Supplement
CS 740
Oct. 14, 1998

Extracted from
“Digital 21264 Sets New Standard”
Microprocessor Report, Oct. 28, 1996
Branch/Jump Target Prediction

Integrated into instruction cache
- 64KB, consisting of 4K lines, each 16B (4 instructions)
- Each cache line carries 12b “next line” + 1b “next set” predictor
  - 6.5KB total
  - Set to predicted target if line contains predicted-taken branch
  - Set to next sequential line otherwise

Predicting Procedure Return Target
- Maintain stack of return points for 32 most recent calls
- 100% accuracy as long as no non-standard returns

Alignment issues
- Taken branch best if instruction address of form $4i + 3$
  - Will use other 3 instructions in line
- Branch target should have address of form $4i$
  - First instruction in line
Branch Prediction Logic

- **Purpose:** Predict whether or not branch taken
- **35Kb of prediction information**
- **2% of total die size**
- **Claim 0.7–1.0% of all instructions are mispredicted branches**
  - But only 1/6 instructions are branches in the first place
  - $4.2–6.0\%$ mispredication rate
Block Diagram

4 Integer ALUs
- Each can perform simple instructions
- 2 handle address calculations

Register Files
- 32 arch / 80 physical Int
- 32 arch / 72 physical FP
- Int registers duplicated
  - Extra cycle delay from write in one to read in other
  - Each has 6 read ports, 4 write ports
  - Attempt to issue consumer to producer side
Pipeline Behavior

- Misprediction adds 0.1 to SpecInt95 CPI
  - Yielding 0.5
Interesting Facts

Very Complex Chip
- 15.2 M transistors total
- 6 M for CPU core
  - Vs. 4.2M for Intel PentiumPro

Interesting Memory Subsystem
- Have found in past that memory bandwidth is major bottleneck
  - CPU often “starved” waiting for loads & stores
  - Not reflected in SPEC benchmarks
    » Tend to fit entirely in cache
Measured Performance

Machines

- **Alpha 21264 @ 575 MHz**
  - (64+64) KB L1, 4MB L2, 512 MB main memory
- **Intel Pentium II @450 MHz**
  - (16+16) KB L1, 512KB L2, 64 MB main memory

SPEC Results

- **Alpha**
  - June ‘98
  - SpecInt95: 30.3
  - SpecFP95: 47.7
- **Intel**
  - August ‘98
  - SpecInt95: 17.2
  - SpecFP95: 12.7