

Experiments with Tomasulo's Algorithm Simulator

Based on a total budget of 10 reservation stations, either all part of one unified RS or split amongst the three RS types (add, divide, memory), the highest-performing configuration with respect to the files in the traces directory:

Summary:

For the gen-lin-recc.trc file, the best performing configuration of reservation stations was a 10 entry unified, yielding an IPC of **0.485369**. Coming in second place, is a non-unified reservation station with 3 entries for ADD, 1 access for DIV, and 6 for MEM, which yielded an IPC of **0.353502**. My experiment method for the non-unified reservation stations was to analyze the amount of add, div, and mem operations ratio. For the gen-lin-recc.trc file, the ratio was balanced so I tested a balanced split amongst all stations. I then tested increasing the number of stations for the memory operation because the memory operations have the greatest latency.

For the iccg.trc file, the best-performing configuration of reservation stations was a 10 entry unified, yielding an IPC of **0.602194**. Coming in second place, is a non-unified reservation station with 4 entries for ADD, 4 access for DIV, and 3 for MEM, which yielded an IPC of **0.443498**. My experiment method was very similar to that of the gen-lin-recc.trc file. I began with a balanced number of entries for each functional unit. I then adjusted the number of entries based on the fact that ADD and MEM instructions occurred multiple times in sequence and the DIV instructions occurred in segmented singles or pairs.

For the inner-product.trc file, the best-performing configuration of reservation stations was a 10 entry unified, yielding an IPC of **0.797820**. Coming in second place, is a non-unified reservation station with 4 entries for ADD, 2 access for DIV, and 4 for MEM, which yielded an IPC of **0.609239**. My experiment method for this trace file was based on the fact that there was an abundance of ADD instructions and twice the MEM instructions than DIV instructions. I consequently prioritized giving ADD and MEM more entries. I ended up with a balanced amount between ADD and MEM reservation stations due to the latency of MEM instructions earning prevalence despite the higher number of ADD instructions.

For the unified reservation station, 10 entries always provided the greatest instructions per cycle. This was not a surprise: If the functional units are going to share reservation stations,

then the greatest number of entries available is optimal for performance. The 10 entry unified reservation stations had greater IPC values than the per-functional units across all three trace files. This was to be expected as unified reservation stations offer better performance than non-unified ones.

Experiments Results:

- **Gen-Lin-Recc.trc**

UNIFIED

Experiment 1:

Scheduler Settings

Scheduler Type: U

Registers: 32

Reservation Station: 10 entries

Scheduler Statistics

Insts: 722420

Cycles: 1488394

IPC: 0.485369 ←

Issue Stall: 765950

Max Insts Fired: 3

Max Insts Completed: 3

ADD FU Max Active: 2

DIV FU Max Active: 3

MEM FU Max Active: 8

Experiment 2:

Scheduler Settings

Scheduler Type: U

Registers: 32

Reservation Station: 8 entries

Scheduler Statistics

Insts: 722420

Cycles: 1916868

IPC: 0.376875
Issue Stall: 1194399
Max Insts Fired: 3
Max Insts Completed: 3
ADD FU Max Active: 2
DIV FU Max Active: 2
MEM FU Max Active: 7

Experiment 3:

Scheduler Settings
Scheduler Type: U
Registers: 32
Reservation Station: 5 entries

Scheduler Statistics
Insts: 722420
Cycles: 3045520
IPC: 0.237207
Issue Stall: 2323086
Max Insts Fired: 2
Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 3
MEM FU Max Active: 5

PER FUNCTIONAL UNIT

Experiment 1:

Scheduler Settings
Scheduler Type: F
Registers: 32
Reservation Station ADD: 5 entries
Reservation Station DIV: 1 entries
Reservation Station MEM: 4 entries

Scheduler Statistics
Insts: 722420
Cycles: 2211512
IPC: 0.326663
Issue Stall: 1489058

Max Insts Fired: 2
Max Insts Completed: 3
ADD FU Max Active: 2
DIV FU Max Active: 1
MEM FU Max Active: 4

Experiment 2:

Scheduler Settings
Scheduler Type: F
Registers: 32
Reservation Station ADD: 3 entries
Reservation Station DIV: 4 entries
Reservation Station MEM: 3 entries

Scheduler Statistics
Insts: 722420
Cycles: 2398390
IPC: 0.301210
Issue Stall: 1675947
Max Insts Fired: 2
Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 2
MEM FU Max Active: 3

Experiment 3:

Scheduler Settings
Scheduler Type: F
Registers: 32
Reservation Station ADD: 6 entries
Reservation Station DIV: 1 entries
Reservation Station MEM: 3 entries

Scheduler Statistics
Insts: 722420
Cycles: 2190512
IPC: 0.329795
Issue Stall: 1468075
Max Insts Fired: 2

Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 1
MEM FU Max Active: 3

Experiment 4:

Scheduler Settings
Scheduler Type: F
Registers: 32
Reservation Station ADD: 7 entries
Reservation Station DIV: 1 entries
Reservation Station MEM: 2 entries

Scheduler Statistics
Insts: 722420
Cycles: 3316951
IPC: 0.217796
Issue Stall: 2594512
Max Insts Fired: 2
Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 1
MEM FU Max Active: 2

Experiment 5:

Scheduler Settings
Scheduler Type: F
Registers: 32
Reservation Station ADD: 4 entries
Reservation Station DIV: 1 entries
Reservation Station MEM: 5 entries

Scheduler Statistics
Insts: 722420
Cycles: 2420980
IPC: 0.298400
Issue Stall: 1698523
Max Insts Fired: 3

Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 1
MEM FU Max Active: 5

Experiment 6:

Scheduler Settings

Scheduler Type: F

Registers: 32

Reservation Station ADD: 3 entries

Reservation Station DIV: 1 entries

Reservation Station MEM: 6 entries

Scheduler Statistics

Insts: 722420

Cycles: 2043608

IPC: 0.353502 ←-----

Issue Stall: 1321158

Max Insts Fired: 2

Max Insts Completed: 2

ADD FU Max Active: 2

DIV FU Max Active: 1

MEM FU Max Active: 5

- **ICCG.trc**

UNIFIED

Experiment 1:

Scheduler Settings

Scheduler Type: U

Registers: 32

Reservation Station: 10 entries

Scheduler Statistics

Insts: 125387

Cycles: 208217

IPC: 0.602194 ←—

Issue Stall: 82802

Max Insts Fired: 3
Max Insts Completed: 3
ADD FU Max Active: 2
DIV FU Max Active: 5
MEM FU Max Active: 5

Experiment 2:

Scheduler Settings
Scheduler Type: U
Registers: 32
Reservation Station: 9 entries

Scheduler Statistics
Insts: 125387
Cycles: 232680
IPC: 0.538882
Issue Stall: 107273
Max Insts Fired: 3
Max Insts Completed: 3
ADD FU Max Active: 2
DIV FU Max Active: 4
MEM FU Max Active: 5

Experiment 3:

Scheduler Settings
Scheduler Type: U
Registers: 32
Reservation Station: 5 entries

Scheduler Statistics
Insts: 125387
Cycles: 331553
IPC: 0.378181
Issue Stall: 206150
Max Insts Fired: 2
Max Insts Completed: 2

ADD FU Max Active: 2
DIV FU Max Active: 3
MEM FU Max Active: 5

PER FUNCTIONAL UNIT

Experiment 1:

Scheduler Settings

Scheduler Type: F

Registers: 32

Reservation Station ADD: 3 entries

Reservation Station DIV: 3 entries

Reservation Station MEM: 3 entries

Scheduler Statistics

Insts: 125387

Cycles: 339937

IPC: 0.368854

Issue Stall: 214530

Max Insts Fired: 2

Max Insts Completed: 2

ADD FU Max Active: 2

DIV FU Max Active: 3

MEM FU Max Active: 3

Experiment 2:

Scheduler Settings

Scheduler Type: F

Registers: 32

Reservation Station ADD: 3 entries

Reservation Station DIV: 3 entries

Reservation Station MEM: 4 entries

Scheduler Statistics

Insts: 125387

Cycles: 331506

IPC: 0.378234
Issue Stall: 206096
Max Insts Fired: 2
Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 3
MEM FU Max Active: 4

Experiment 3:

Scheduler Settings
Scheduler Type: F
Registers: 32
Reservation Station ADD: 2 entries
Reservation Station DIV: 3 entries
Reservation Station MEM: 5 entries

Scheduler Statistics
Insts: 125387
Cycles: 390475
IPC: 0.321114
Issue Stall: 265072
Max Insts Fired: 2
Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 3
MEM FU Max Active: 5

Experiment 4:

Scheduler Settings
Scheduler Type: F
Registers: 32
Reservation Station ADD: 1 entries
Reservation Station DIV: 4 entries
Reservation Station MEM: 4 entries

Scheduler Statistics

Insts: 125387
Cycles: 469473
IPC: 0.267080
Issue Stall: 344070
Max Insts Fired: 1
Max Insts Completed: 1
ADD FU Max Active: 1
DIV FU Max Active: 2
MEM FU Max Active: 4

Experiment 5:

Scheduler Settings
Scheduler Type: F
Registers: 32
Reservation Station ADD: 4 entries
Reservation Station DIV: 3 entries
Reservation Station MEM: 3 entries

Scheduler Statistics
Insts: 125387
Cycles: 282723
IPC: 0.443498 ←——
Issue Stall: 157311
Max Insts Fired: 2
Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 3
MEM FU Max Active: 3

● **Inner-Product.trc**

UNIFIED

Experiment 1:

Scheduler Settings

Scheduler Type: U

Registers: 32

Reservation Station: 10 entries

Scheduler Statistics

Insts: 65517

Cycles: 82120

IPC: 0.797820 ←

Issue Stall: 16585

Max Insts Fired: 3

Max Insts Completed: 3

ADD FU Max Active: 2

DIV FU Max Active: 3

MEM FU Max Active: 6

Experiment 2:

Scheduler Settings

Scheduler Type: U

Registers: 32

Reservation Station: 5 entries

Scheduler Statistics

Insts: 65517

Cycles: 147814

IPC: 0.443239

Issue Stall: 82281

Max Insts Fired: 3

Max Insts Completed: 2

ADD FU Max Active: 2

DIV FU Max Active: 2

MEM FU Max Active: 5

Experiment 3:

Scheduler Settings

Scheduler Type: U

Registers: 32

Reservation Station: 8 entries

Scheduler Statistics

Insts: 65517
Cycles: 107134
IPC: 0.611543
Issue Stall: 41601
Max Insts Fired: 3
Max Insts Completed: 3
ADD FU Max Active: 2
DIV FU Max Active: 3
MEM FU Max Active: 6

PER FUNCTIONAL UNIT

Experiment 1:

Scheduler Settings

Scheduler Type: F
Registers: 32
Reservation Station ADD: 3 entries
Reservation Station DIV: 3 entries
Reservation Station MEM: 3 entries

Scheduler Statistics

Insts: 65517
Cycles: 127092
IPC: 0.515508
Issue Stall: 61542
Max Insts Fired: 2
Max Insts Completed: 3
ADD FU Max Active: 2
DIV FU Max Active: 2
MEM FU Max Active: 3

Experiment 2:

Scheduler Settings

Scheduler Type: F

Registers: 32
Reservation Station ADD: 6 entries
Reservation Station DIV: 2 entries
Reservation Station MEM: 2 entries

Scheduler Statistics

Insts: 65517
Cycles: 171877
IPC: 0.381185
Issue Stall: 106327
Max Insts Fired: 2
Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 2
MEM FU Max Active: 2

Experiment 3:

Scheduler Settings

Scheduler Type: F
Registers: 32
Reservation Station ADD: 3 entries
Reservation Station DIV: 3 entries
Reservation Station MEM: 4 entries

Scheduler Statistics

Insts: 65517
Cycles: 117712
IPC: 0.556587
Issue Stall: 52162
Max Insts Fired: 3
Max Insts Completed: 2
ADD FU Max Active: 2
DIV FU Max Active: 2
MEM FU Max Active: 4

Experiment 4:

Scheduler Settings

Scheduler Type: F

Registers: 32

Reservation Station ADD: 2 entries

Reservation Station DIV: 4 entries

Reservation Station MEM: 4 entries

Scheduler Statistics

Insts: 65517

Cycles: 168575

IPC: 0.388652

Issue Stall: 103026

Max Insts Fired: 2

Max Insts Completed: 2

ADD FU Max Active: 2

DIV FU Max Active: 2

MEM FU Max Active: 4

Experiment 5:

Scheduler Settings

Scheduler Type: F

Registers: 32

Reservation Station ADD: 4 entries

Reservation Station DIV: 2 entries

Reservation Station MEM: 4 entries

Scheduler Statistics

Insts: 65517

Cycles: 107539

IPC: 0.609239 ←——

Issue Stall: 42006

Max Insts Fired: 2

Max Insts Completed: 2

ADD FU Max Active: 2

DIV FU Max Active: 2

MEM FU Max Active: 4