POWER Overview

RISC

concurrent execution
branch unit
fixed point unit
floating point unit
multi-instructions / cycle
branch & count w/ CC 1
CR AND 1
load with update 1
fp multiply-add 2
total 5 x 25 MHz = 125 MOPS (peak)

separate instruction and data caches
caches optimized for function

uniform Instructions
4 bytes
up to 4 operands

extended storage model
real address space 4 GigaBytes (32 bit real address)
virtual address space 4 PetaBytes (52 bit virtual address)
page size 4 KiloBytes (12 bit page offset)
automatic lock grants (avoids DSI)
cache / TLB control

registers separated by function (GPRs, FPRs, CR, . . . )

I/O
memory mapped
programmable priority of I/O interrupts

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Logical View of POWER

POWERS Programming Model
POWER Branch Unit

Instruction prefetch
branch preprocessing
Instruction dispatch

functional registers
Condition Register (CR)
Machine State Register (MSR)
Save/Restore Registers (SRR0/SRR1)
Link Register (LR)
Count Register (CTR)

POWER Fixed Point

32 bit dataflow
GPRs
arithmetic unit
logical unit
barrel shifter / rotator
single cycle execution
POWER Floating Point

- 64 bit floating point dataflow
- FPRs
- combinatorial multiplier
- multiply-add / cycle
- 2 stage pipeline
- register renaming

POWER Storage Control

- TLBs
- cache directory
- ECC
- memory control
- 32 bit real addressing
Wide data buses provide the bandwidth required for high performance

Adaptive FIR example

4 | SUBROUTINE AFIR(HR,HI,XR,XI,YR,YI, ...,N)
5 | REAL*8 HR(1024),BETAR,XR(1024),YR
6 | REAL*8 HI(1024),BETAI,XI(1024),YI
7 | YR = 0.0
8 | YI = 0.0
9 | DO 100 I = 0,N-1
10 | YR = YR + HR(I)*XI((N-1)-I)
11 | YI = YI + HI(I)*XR((N-1)-I)
12 | YR = YR - HI(I)*XI((N-1)-I)
13 | YI = YI + HR(I)*XI((N-1)-I)
14 | 100 CONTINUE
15 | ...
Adaptive FIR example

CL.0:  LFDU  fp6,r31 = hr(r31,8)
LFDU  fp5,r29 = xr(r29,-8)
FMA  fp4 = fp4,fp6,fp5
LFDU  fp3,r12 = hi(r12,8)
FMA  fp2 = fp2,fp5,fp3
LFDU  fp1,r30 = xi(r30,-8)
FNMS  fp4 = fp4,fp3,fp1
FMA  fp2 = fp2,fp6,fp1
BCTF  CL.0,cr1,0x2/gt

9 compound instructions in 4 cycles
### Instruction Frequencies

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branch</td>
<td>6.1%</td>
</tr>
<tr>
<td>Load</td>
<td>33.1%</td>
</tr>
<tr>
<td>Store</td>
<td>9.6%</td>
</tr>
<tr>
<td>Compare</td>
<td>1.7%</td>
</tr>
<tr>
<td>Add/Sub (FLT)</td>
<td>15.0%</td>
</tr>
<tr>
<td>Multiply (FLT)</td>
<td>10.7%</td>
</tr>
<tr>
<td>Mlt/Add (FLT)</td>
<td>10.4%</td>
</tr>
<tr>
<td>Divide</td>
<td>6%</td>
</tr>
</tbody>
</table>

### No use of CTR Register

- **Unconditional Branches**: 38.3% of Total
- **Conditional Branches**: 61.7% of Total

<table>
<thead>
<tr>
<th>Condition to Branch Distance</th>
<th>COUNT</th>
<th>TAKEN</th>
<th>NotTAKEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>60.6%</td>
<td>41.0%</td>
<td>59.0%</td>
</tr>
<tr>
<td>1</td>
<td>20.8%</td>
<td>32.7%</td>
<td>67.3%</td>
</tr>
<tr>
<td>2</td>
<td>10.0%</td>
<td>17.1%</td>
<td>82.9%</td>
</tr>
<tr>
<td>3</td>
<td>9.4%</td>
<td>9.3%</td>
<td>90.5%</td>
</tr>
<tr>
<td>4+</td>
<td>1.5%</td>
<td>22.7%</td>
<td>77.3%</td>
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</tbody>
</table>

*Basic Block Average Length 4.4*

#### Instruction Frequencies

- **Unconditional Branches**: 0.3% of Total
- **Conditional Branches**: 99.7% of Total

<table>
<thead>
<tr>
<th>Condition to Branch Distance</th>
<th>COUNT</th>
<th>TAKEN</th>
<th>NotTAKEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14.1%</td>
<td>98.7%</td>
<td>1.3%</td>
</tr>
<tr>
<td>2</td>
<td>1 %</td>
<td>2.3%</td>
<td>97.7%</td>
</tr>
<tr>
<td>30+</td>
<td>85.8%</td>
<td>99.9%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Block</td>
<td>Average Length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>14.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>.1%</td>
<td></td>
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</tr>
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<td>5</td>
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<td></td>
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<tr>
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<td>14.0%</td>
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<tr>
<td>8</td>
<td>.1%</td>
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<tr>
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<td>13.9%</td>
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<tr>
<td>10</td>
<td>.1%</td>
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</tr>
<tr>
<td>12</td>
<td>1.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>13.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>13.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18+</td>
<td>14.6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

-3- 9/90 (Richard Oehler)