

# POWER Overview

IBM RISC System/6000  
— Architecture and Performance —

Richard Oehler

IBM T. J. Watson Research Center  
Yorktown Heights, New York

IBM 966 X6695

## 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

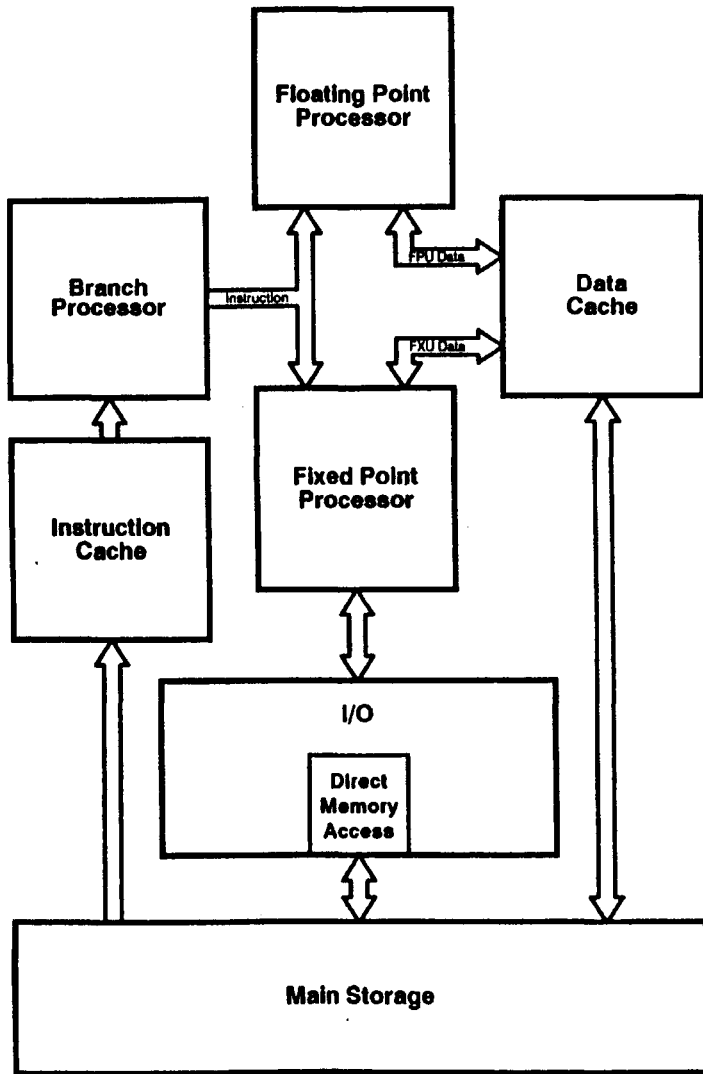
### registers separated by function (GPRs, FPRs, CR, . . .)

### I/O

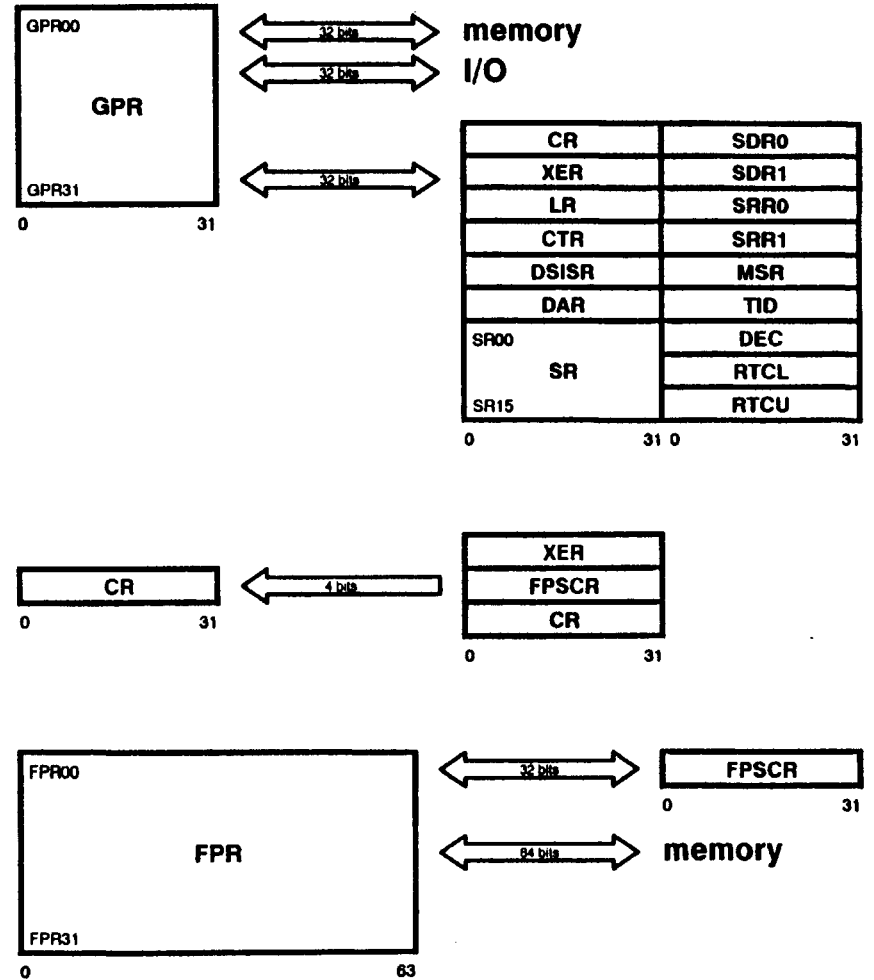
memory mapped  
programmable priority of I/O interrupts

IBM 966 X6695

# Logical View of POWER



# POWER 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**

IBM 966 X6695

IBM 966 X6695

## **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**

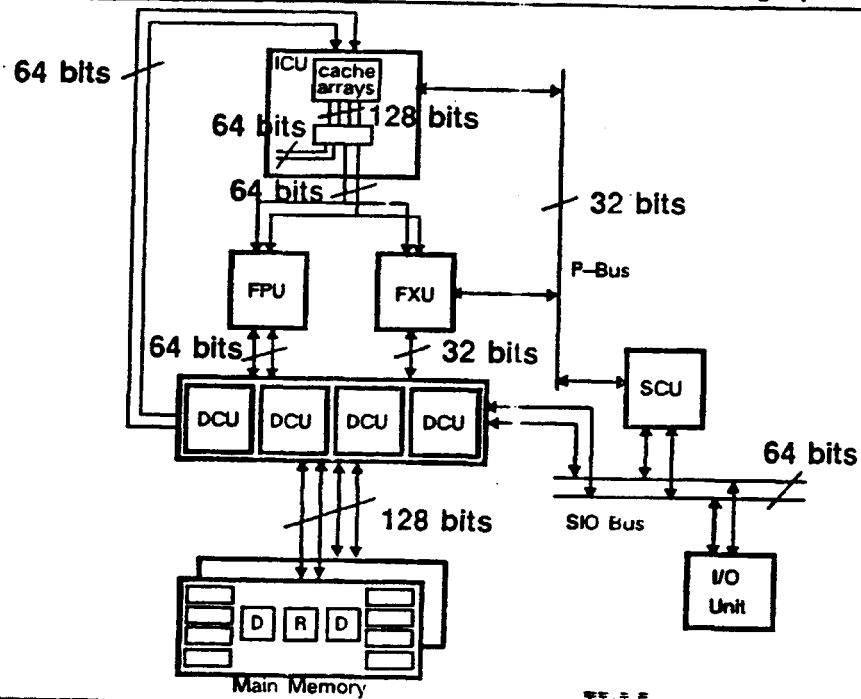
**memory control**

**32 bit real addressing**

IBM 966 X6695

IBM 966 X6695

## Wide data buses provide the bandwidth required for high performance



IBM Advanced Workstation Division

9

## 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)*XIR((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| ...

```

IBM Advanced Workstation Division

# 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

IBM Advanced Workstation Division

IBM 966 2546

## LI STATISTICS

Instruction Frequencies	
o Branch	22.8%
o Load	25.4%
o Store	15.5%
o Compare	13.2%
o Add/Sub	7.1%
o Logical	6.2%
o Rotate/Shift	1.5%
o Move	4.7%
o Floating	-.%
Load to Use Distance	
o 0	53.1%
o 1	19.7%
o 2	5.0%
o 3	2.8%
o 4+	19.4%
Link Register to Branch Distance	
o 0	6.1%
o 1	34.6%
o 2	50.1%
o 3	5.3%
o 4+	3.0%

No use of CTR Register  
 Unconditional Branches 38.3% of Total  
 Conditional Branches 61.7% of Total  
 o Taken 34.8%  
 o Not Taken 65.2%

Condition to Branch Distance

o NO.	COUNT	TAKEN	NotTAKEN
o 0	60.6%	41.0%	59.0%
o 1	20.8%	32.7%	67.3%
o 2	10.0%	17.1%	82.9%
o 3	3.4%	9.5%	90.5%
o 4+	1.5%	22.7%	77.3%

Basic Block Average Length 4.4

o 1	14.2%
o 2	9.8%
o 3	24.6%
o 4	16.2%
o 5	9.1%
o 6	9.1%
o 7+	17.0%

Instruction Frequencies

o Branch	6.1%
o Load	33.1%
o Store	9.6%
o Compare	1.7%
o Add/Sub (FLT)	15.0%
o Multiply (FLT)	10.7%
o Mult/Add (FLT)	18.4%
o Divide	.8%

No use of CTR Register

Unconditional Branches 0.3% of Total  
 Conditional Branches 99.7% of Total  
 o Taken 99.3%  
 o Not Taken 0.7%

Condition to Branch Distance

o NO.	COUNT	TAKEN	NotTAKEN
o 0	14.1%	98.7%	1.3%
o 2	.1%	2.3%	97.7%
o 30+	85.8%	99.9%	0.1%

IBM 966 X6695 IBM 966 X6695

IBM 966 X6695

Basic Block Average Length 16.5

o 1	14.0%
o 2	.1%
o 3	.2%
o 4	.1%
o 5	14.1%
o 6	14.0%
o 8	.1%
o 9	13.9%
o 10	.1%
o 12	1.1%
o 13	13.8%
o 14	.1%
o 17	13.8%
o 18+	14.6%