1 O8aK

%^%k%A%W%m%;%C%59=@.$N%7%9%F%`$K$*$$$F!$%f!<%6$,MF
0W$K%7%9%F%`$N@-G=$r:GBg8B$K0z$-=P$9$?$a$K$O!$C`<!E*
$K5-=R$5l?%W%m%0%i%`$+$iJBNs@-$rCj=P$7!$3F%W%m%;%C
%5$K%?%9%/$r<+F0E*$K%9%1%8%e!<%j%s%0$9$kJBNs2=%3%s%Q
%$%i$,I,MWG"$k!%$3l^Gb!$$3li%3%s%Q%$%i!$%9%1
%8%e!<%i$N8&5f$,9TolF-$?$,!$$$$:lb4{B8$N%^%k%A
%W%m%;%C%5%7%9%F%`$K9g$o$;$?%9%1%8%e!<%j%s%0$r9T$
$a!$@-G=$N8~>e$K$O8B3&$,$"$C$?!%$=3G!$2f!9$OH/A
5UE>$7!$%3%s%Q%$%i$d%9%?%F%#%C%/%9%1%8%e!<%j%s%0$K9
$;$F%^%k%A%W%m%C%5$N9=@.$r4pK\$+$i@_7W$9k3Hr9
$?!%$3Nh$&$J%=%U%H%&%'%"<gF3$N%"!<%-%F%/%A%c$H$7
%^%k%A%W%m%;%C%5%7%9%F%` ASCA (Advanced Scheduling
oriented Computer Architecture) $,4{$KDs0F5l$F$$$k
[1]!%3N%^%k%A%W%m%;%C%5%7%9%F%`$O!$8=:_$N<+F0JBNs
%3%s%Q%$%i$,<g$K9T$C$F$$$kJBNs<jK!G"$k%k!<%W%l%
$NJBNs2=$@1GJ/!$AFN3EY!$6a:YN3EYJBNs=hM}$H8F$P$l
$kJBNs=hM}<jK!$rAH$_9g$o$;$?%^%k%A%0%l%$%sJBNs=hM} [2]
$r8z2LE*$K9T$&$3HNG-$k%"!<%-%F%/%A%c9=@.$r<h$k!%
3N%^%k%A%0%l%$%sJBNs=hM}<jK!$Khj!$C`<!%W%m%0%i%`
N"if$kJBNs@-$rCj=P9k3H$,2DG=$HJk!%

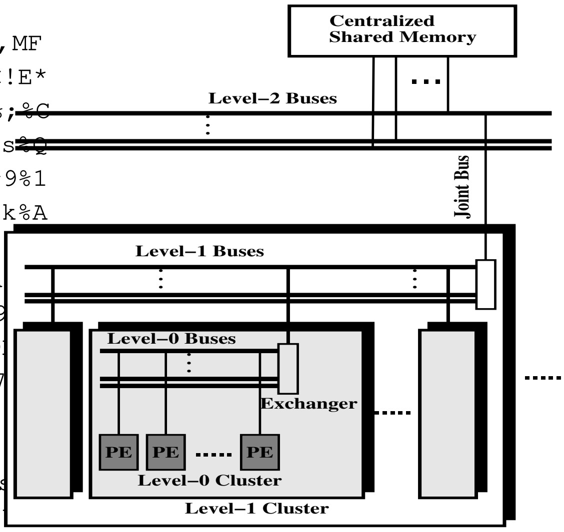
ASCA $,8zN(NI$/%^%k%A%0%l%$%sJBNs=hM}$r9T$&$?$a
$O!$%3%s%Q%$%i$k;~$K%G!<%?$NE>Aw;~4V$dL?Na$N<B9T
=PMh$k8B$jM=B,2DG=G"$k;v$,K>$^$7$$!%99$K6a:Y
Ns=hM}$rL5F14|$G9To;k?aK$O!$$3li$N;~4V
%Q%$%i$k;~$K40A4$KM=B,2DG=GJ1lPJiJ$$!%$7
:_$N>&MQ%W%m%;%C%5$O$=$N9bB.2=$N<jK!$H7F%9!<
%+%i$dF0E*J,4tM=B,Ey$N5;=Q$rMQ$$$F$*$j!$$=li
%Q%$%i$N@EE*M=B,$r:$FqK5$;$k!%B($A>&MQ%W%m%;%C
ASCA %7%9%F%`$N9=@.MWAG%W%m%;%C%5$H7F$OITE,3
$j!$%W%m%;%C%5$rFH<+$K@_7W9kI,MW$,@8$8$k!%99
IbF0>.?tE@1i;;AuCV$O%a%$%s%W%m%;%C%5FbItKAH_9
$k%?%$%WNbN,0lHLE*HJ$j!$$=$NG=NO$bHtLvE*
7F$$$k!%$=$3$G ASCA $NIbF0>.?tE@%f%K%C%H$O!$
%;%C%5KAH_9~$`$N$OL^O@!$%3%s%Q%$%i$N%9%?%F%#
%1%8%e!<%j%s%0$rK832$9k3HJ$/!$$^$?$=$N@-G=$r
$9$3HN$J$$$h$&$K@_7W$r9T$oJ1lPJi$J$$!%

K\O@J8GO!$$3$N%^%k%A%W%m%;%C%5%7%9%F%` ASCA
$N4pK\9=@.MWAG$HJk%+%9%?%`%^%$%/%m%W%m%;%C%5
MAPLE(Multiprocessor system ASCA Processing eLE-
ment) $N%"!<%-%F%/%A%c$K$D$$$F=RYk!%$^$:!$2 >O$G$O
ASCA %7%9%F%`$NA4BN9=@.$r!$<g$K MAPLE 0J30$NItJ,
KD$$$F=RYk!%3 >OGO MAPLE $NFCD'$K$D$$$F@bL@$7!%
0z$-B3$-4 >O$G MAPLE $N%A%C%WC1BN$K$D$$$F%7%_%e%l!<
%7%g%s$r9T$$!$%O!<%I%&%'%"NL$H=hM}G=NO$N2E@$rI>2A$7!$
B>$N%W%m%;%C%5$HHf3S9k!%

2 %^%k%A%W%m%;%C%5%7%9%F%` ASCA

2.1 ASCA $NA4BN9=@.

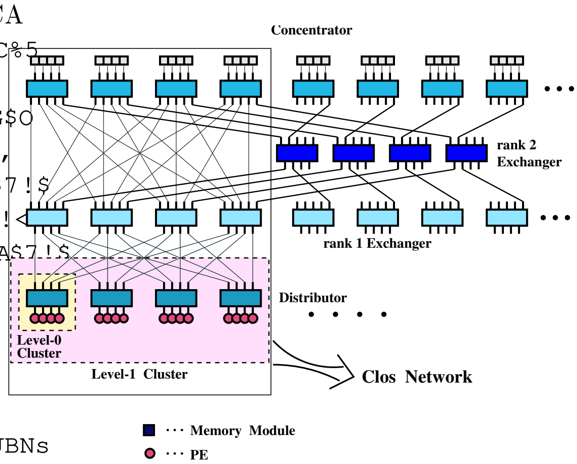
%^%k%A%0%l%$%sJBNs=hM}$r8z2LE*$K<B8=$9k?aNJBNs
7W;;5!G"$k ASCA $NA4BN9=@.$O!$?^ 1$Nh&KJCF$$
$k!%ASCA $O!$4 $^$?$O 8 8D$N%W%m%;%C%7%s%0(%l%a%s%H
(PE) $+$i9=@.5l$k%W%m%;%C%7%s%0%/%i%9%? (PC) $H6&M-
JQ?t$N3JG<$K;HMQ9k=8Cf6&M-%a%b%j (CSM:Centralized
Shared Memory) $r2>A[E*$J3,AXE*B?=E%P%9$G7k9g$7$?3
%k%A%W%m%;%C%5%7%9%F%`G"$k!%



?^ 1: ASCA $N9=@.

2.2 ASCA $N7k9gLV

6&M-%P%9$O:G$b4JC1$J7k9gJ}<0$G$"$j!$$I$N%W%m%;%C
~4V9N=jM-8"$rF@$k$+$N$_$r9MN8$9$l$P%P%9$N:.;($rK
N3EYJB3H$,$G$-$k$?$a!$%9%1%8%e!<%i$+iN@)8f$,:G
M;0DG"$k!%$^$?!$Aa0pEDBg3X$G3+H/$5l? OSCAR[3] $O
Kh$k6&M-%P%9$r;}$A!$$3li$N%P%9>e$G$NE>Aw=g=x$N%
$Q!<%9!<%j%s%0$r/%m%C%/%l%Y%k$G9T$$!$%G!<%?$NE>Aw$r
$O4pK\%V%m%C%/Fb$NF14|%3!<%I$rA4F=|5n$7Fb@5$7$$7
%7%LO$NF@$ilkL5F14|6a:YN3EYJBNs=hM}$r9T$&3H$,
Gk3H$,3NG'$5lF$$$k [4]!%7+$7!$<B:]$N6&M-%P%9$O
KaCN PE $r7k9g$9$kJ}K!$H7F$O<BAu>e$NLdBj$,$"$
!$$$!%$=$3$G!$ASCA GO!$%3%s%Q%$%i/%9%1%8%e!<
K+$i8+$?7k9gbGkH<B:]$N7k9gLV$rJ,N%9k!%%3%s
%W%m%9%1%8%e!<%i8~$-$NbGkH7F$O!$3,AX7?B?=E%P
$6&M-%P%9$r:NMQ9k!%$=$7$F<B:]$N ASCA $N7k9gLV$K$O3,AX
$rB?=E%P%9$r($_%e%l!<%H2DG=$JB?CJ7k9gLV R-Clos LV [5]
$rMQ$$$F$$$k (?^ 2)!%



?^ 2: R-Clos LV

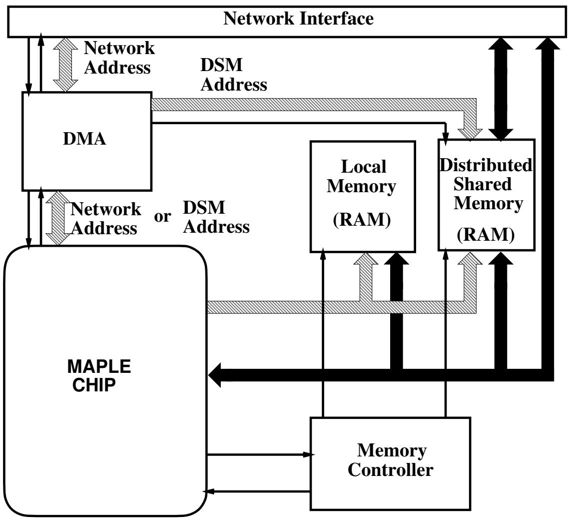
$"$j!$6a:YN3EYJBNs=hM}$K$*$1$k%W%m%;%C%54V$NF14|$
9=@.$K9T$&$?$a!$3,AX%P%9$HOJLKF14|@lMQ%P%9$r@_1$
$$$k!%

2.3 %a%b%j3,AX

ASCA $N%a%b%j3,AX$O!$3F PE $,BPEy$K%"%/%;%9G-$k=8Cf6&M-%a%b%j (CSM: Centralized Shared Memory)!$3F PE Fb$KG[CV5l$?J,;66&M-%a%b%j (DSM: Distributed Shared Memory)!$%m!<%+%k%a%b%j (LM: Local Memory)!$5Z$S MAPLE $KFbB"$5l?%*%s%A%C%W%-%c%C%7%e$+$i9=@.5l$k!%3F3,AX$O%^%k%A0l%$%sJBNs=hM}$r9T$&$K$"$?CF!$MxMQL\E*$,L@3N$KJ,$+lk!%=8Cf6&M-%a%b%j$O<g$KAF N3EY (%^%/%m%?%9%/) JBNs=hM}K*1k6&M-JQ?t$N<uEO$7$K;HMQ$5lk!%J,;66&M-%a%b%j$O!$%9%F!<%H%a%s%H%l%Y%k$N JBNs@-$rCj=P9k6a:YN3EYJBNs=hM}$d%k!<%WJBNs@-$r0z$-=P$9CfN3EYJBNs=hM}K*$$$F!$B>$N PE HN%G!<%?$d%U%1%0$N<uEO7N:]$K;HMQ$9$k!%%m!<%+%k%a%b%j$OFbItJQ?tEy$r<}G<$9$k!%3F!9$N%5%$%:$K$D$$$F$O!$8=:_8!FCfG$"$j!$%7%_%e%l!<%7%g%sEy$KhC$F!$E,@ZJBg-5r7hDj9kI,MW$,$"$k!%

2.4 %W%m%;%C%7%s%0%(%l%a%s%H (PE)

%W%m%;%C%7%s%0%(%l%a%s%H$O!$?^ 3Nh$&$K%M%C%H%o!<%/%$%s%?%U%'!<%9!$J,;66&M-%a%b%j!$%m!<%+%k%a%b%j$*hS3liN%a%b%j$r@)8f$9$k%a%b%j%3%s%H%m!<%i!$PE 30 ItHN%G!<%?DL?.$r9T$J$& DMA!$$=7F MAPLE $+$i9=@.5l$k!%



?^ 3: %W%m%;%C%7%s%0%(%l%a%s%H$N9=@.

3 ASCA MQ%W%m%;%C%5 MAPLE

3.1 8=9T$N%W%m%;%C%5$NLdBjE@

ASCA %7%9%F%`$KE,$7$?%W%m%;%C%5$r8!F$$9kK$"$?CF!$8=9T$N>&MQ%W%m%;%C%5KO0J2<Nh$&$JLdBjE@$,$"$k!%

- 7W;;%5%$%/%k?t$,%*%Z%i%s%INCMK0MB8$7$F$$$k Sun Mirosystems $N UltraSPARC $d HP PA-8000 $N h&$K!$1i;;%l%$%F%s%7$,%*%Z%i%s%INCMK0MB8$9$k>l9g!$%3%s%Q%$%k;~$NF0:nM=B,$,IT2DG=KJ$k!%$3lO ASCA MQ%W%m%;%C%5$O!$$3$NLdBj$r2r7h9k$?$a!$A4$F$N1i;;%5%$%/%k?t$r8GDj$K9k!%
- %W%m%;%C%5FbIt$GF0E*$J=hM}$r9T$C$F$$$k%9!<%Q%9%+%i%W%m%;%C%5$O!$@-G=8~>eN?aK%W%m%;%C%5$N%Q%$%W%i%$%s$N=hM}I} (%Q%$%W%i%$%s?t) $r%$$k$@$1GJ$/!$$3$NJ#?t$N%Q%$%W%i%$%s$r8z2LE*$K;
MQ$7L?Na$NF1;~<B9T$N8zN($r>e2k$?$a$K!$%W%m%;%
%5$K%l%8%9%?%j%M!<%_%s%0$d out-of-order <B9T!$F0E*
J,4tM=B,Ey$N?t!9$N5;=Q$rF3F~$7$F$$$k!%7+$7%W%m
%;%C%5FbIt$G=hM}$5lk3liN5;K!$O%3%s%Q%$%k;
$KM=B,$9$k;v$,Fq$7$$!%
- %=%c%C%7%e%_%9$,F0E*$KH/@8$9$k
0lHL$N>&MQ$N%W%m%;%C%5GO!$%*%s%A%C%W%-%c%C%7%
$N@)8f$r%W%m%;%C%5$,9T$&!%$=$7$F%-%c%C%7%e%_%9$r
5/$3$7$?>l9g!$FbIt$G%@%$%J%_%C%/$K%$%s%?%m%C%/$,
H/@8$9$k$?$a!$$3$N%$%s%?%m%C%/$r%3%s%Q%$%k;~$KM=
B,9k;v$O:$FqG"$k!%ASCA MQ%W%m%;%C%5$G$O!$2?
i+$NJ}K!$G3l$r2sHr$9kI,MW,$"$k!%

3.2 ASCA $KE,$7$?%W%m%;%C%5

>e5-$NLdBjE@$r4p$K!$$3$3$G$O%3%s%Q%$%k;~$NF0:nM=B
$rMF0W$K$7!$<B9T;~IT3NDj@-rG$-$k8B$jGS=|$9$k;v$rL
E*H7$? ASCA @1MQ%W%m%;%C%5$N6qBNE*$J@_7W$K$D$$$F
=RYk!%ASCA $O%^%k%A%W%m%;%C%5%7%9%F%`G"k?$a!
:#$^$G=RYF$-$?LdBjE@$r2r7h$9kHF1;~$K!$%^%k%A%W%
%;%C%5FCM-$NF14|A`:n$dB>$N%W%m%;%C%5$H$N9bB.%G!<%?E
Aw$r;Y1g$9$k5!G=$bIU2C9kI,MW$,$"$k!%$3N?$a<BAu$
$k%W%m%;%C%5$K$O!$<!Nh$&$J;v9`$,MW5a$5lk!%

1. %3%s%Q%$%i$,@EE*M=B,7d$9$$9=@.
2. 9bB.$+$D=@Fp$JF14|5!9=
3. 9bB.$J%G!<%?E>Aw$N%5%]!<%H
4. 9bB.$JIbF0>.?tE@1i;;

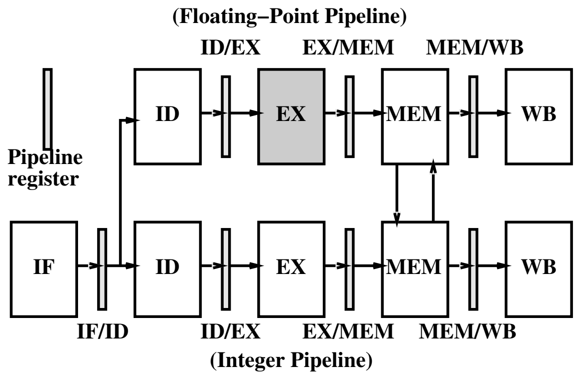
0J>e$NMW5a$KBP$7!$$=$NMW5a$rK~$?$9%W%m%;%C%5%"!<%-%
%/%A%cKD$$$F=g$K@bL@$r9T$&!%

3.3 %3%s%Q%$%i$,@EE*M=B,7d$9$$9=@.

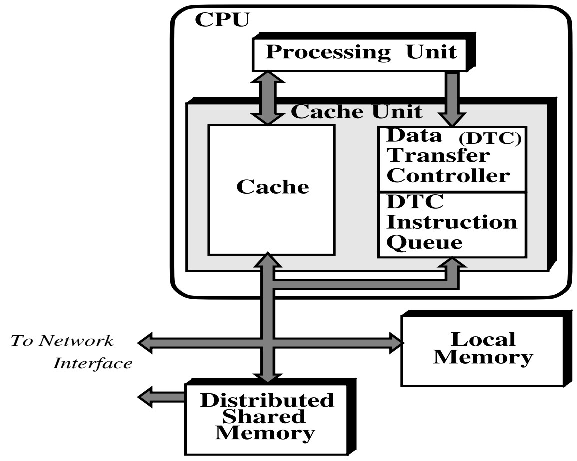
3.3.1 %Q%$%W%i%$%sJ}<0

(3.1) $G=R$Y$?DL$j!$MAPLE $N%Q%$%W%i%$%sJ}<0$K%9!<
%Q%9%+%i$r:NMQ$9k3HOK>$^$7$/$J$$!%$^$?!"%9!<%Q!
%9%+%iKBeo$k5;=Q$H7F!"6aG/5S8wrMaSDD$"$kb
H7$F VLIW(Very-Long-Instruction-Word) $r5s$2k3$H
$,$G$-$k!#7+$7!$%W%m%;%C%5 1 D,B??t$N%Q%$%W%i%$%
$r;}$D VLIW $r%^%k%A%W%m%;%C%5%7%9%F%`K7$?>l9g!$%/
%i%9%?Fb$G=hM}$G$-$kJBNsEY$K=@Fp@-$,L5$/!$7W;;;q8;$
L5BLKJ$k>l9g$,$"$k!% H?BP$K!$@_7W9k%W%m%;%C%5H
FOFbIt$K>/$J$$?t$N%Q%$%W%i%$%s$r;}$?$;!$%/%i%9%?E
$3$$i$N%Q%$%W%i%$%s?t$K<+M3EY$rM?$($kJ}$,$h$$$H9M$($
$=$7$F%9!<%Q%9%+%i$d VLIW $G9T$C$F$$$kh&$JL?Na%l%Y
%kGNJBNs@-(:YN3EYJBNs=hM})$r9T$o$J$$Beoj$K ASCA
GO!$%^%k%A0l%$%sJBNs=hM}N&AN 1 DG$"$k6a:YN
EYJBNs=hM}Kh$k%9%F!<%H%a%s%H%l%Y%kJBNs@-$rMxMQ$9$
3H$G%W%m0%i%`$N8z2LE*$J<B9T$rL\;X7F$$$k!%7k6I
%3%s%Q%$%k;~$NM=B,$rMF0W$K9k$?$aKOJ#;($J=hM}$r9
%o$J!$%7%s%W%k$J%U%)%o!<%G%#%s%05!G=$r;}C? 5 CJ$N%
%$%W%i%$%s$r:NMQ$9$k!%

0J>eNh$&$J9M$($K4p$E$$$F MAPLE $N%Q%$%W%i%$%s$C 4$,<($9h&$K@0?t%Q%$%W%i%$%s$HIbF0>.?tE@%Q%$
%W%i%$%s$N 2 K\$KJ,$+$l$F$$$k!%



?^ 4: MAPLE $N%Q%$%W%i%$%s



?^ 5: %=%U%H%&%'%"@)8f%-%c%C%7%e35G0?^

IbF0>.?tE@%Q%$%W%i%$%s$OIbF0>.?tE@$K4X9kL?Na$@$1 GOJ/!$<B9T%9%F!<%8$, 2 %5%$%/%k0J>e$+$+$k@0?tL?Na (>h=|;;L?Na) $bC4Ev$7!$@0?t%Q%$%W%i%$%s$N<B9T%9%F!<%8 $O 1 %5%$%/%k$G=*N;$5$;$k3HNG$-$k;DjN@0?tL?Na$N %5%]!<%H$9$k!%$3Nh$&$J%]%j%7!<$G%Q%$%W%i%$%s$r2~3(9k3H$G!$@0?t%Q%$%W%i%$%s$,C4Ev$9$kA4$F$NL?Na$O!$ <B9T%9%F!<%8$r 1 %5%$%/%k$G=*N;$9k?$a!$$=$N@_7W$,ME 0WHJ$k!% $^$?!$%Q%$%W%i%$%s$G<B9T5l$k1i;;L?Na$O!$ %3%s%Q%$%k;~$NF0:nM=B,$r2DG=$K9k$?$a$KA4$F$N1i;;$9$ %$%/%k$r8GDjK7$F$$$k!%=hM}$N4JC12=$Khj9bB.$J?.9f $*$h$S%3%s%Q%$%k;~$N@EE*2r@O$rMF0WK7!$%=%U%H%&%' Kh$kJBNs@-Cj=PEY$r9bak3H$, MAPLE $N@_7W$NA@$ G"$k!%

3.3.2 L?Na%;%C%H%"!<%-%F%/%A%c(ISA)

:G6a$N%W%m%;%C%5$O!$%0%i%U%#%C%/%"%W%j%1!<%7%g%s$d %k%A%a%G%#%"%"%W%j%1!<%7%g%s$rG0F,$K$*$$$F@_7W5l$F $$$k$?$a!$ISA KODL>o$NL?Na$NB>K3li$N%"%W%j%1!< %7%g%s$r9bB.$K<B9T$9k?aKFC<lL?Na$,<BAu$5lF$$$k!% ASCA %W%m%8%'%/%HGO!$2J3X5;=Q7W;;$N<B9T@-G=$r9b$a k3Hr<g$JL\E*$H7F$$$k$?$a!$:G6a$N%W%m%;%C%5GN MQ5l$F$$$kFC<l$J ISA $r<BAu$9kI,MWO$J$$!%$^$?!$$3 $?$KFH<+$N ISA $r@_7W$9k3HO!$@_7W$NJ#;(EY$,A}$9 $@$1$G!$$=$N%a%j%C%H$O>.$5$$$H9M$($ilk!%$=$N$?$a!$ MAPLE $N4pK\E*$J ISA $O!$%7%s%W%k$G@vN}$5lF$$$k65 0iMQ RISC %A%C%W$N DLX[6][7] $r:NMQ$7!$$3lK%^%k%A%W%m %;%C%59=@.$r%5%]!<%H$7!$9bB.$J%G!<%?E>Aw$r9T$& ASCA FCM-$NL?Na$r2C$($F$$$k!%

3.3.3 %-%c%C%7%e@)8f

%O!<%I%&%'%"$G 1 <!%-%c%C%7%e$r@)8f9k>l9g!$$JCCC?>l9g!$MAPLE %3%"$*hS%-%c%C%7%e%7%9%F%`%7%e%_%9$r5/$3$9$H!$%W%m%;%C%5$O%a%b%j$+$i%-%c%C%7%e $X%G!<%?E>Aw$r9T$&$?$a%Q%$%W%i%$%s$r%$%s%?%m%C%/$7 7^$&!%$3$N%$%s%?%m%C%/$O!$%O!<%I%&%'%"Kh$j%Q%$%W %_%C%/$K9T$olk$?$a%3%s%Q%$%k;~$KM=B,9k3HOG$-$J G=G"$k!%$=N?$a!$ASCA KO%=%U%H%&%'%"@)8f%-%c%C %7%e[8] $rF3F~$7!$%W%m%;%C%5$KO3lr;Y1g9k5!G=$r 1k!% ?^ 5$K%=%U%H%&%'%"@)8f%-%c%C%7%e$N35G0?^$r<($9!%

%=%U%H%&%'%"@)8f%-%c%C%7%e$O!$%3%s%Q%$%i$N%W%j%U%'%C %A$K4p$E$/$bNG$"$k!%7+$7!$IaDL$N%W%j%U%'%C%A$O %3%s%Q%$%k;~$K%-%c%C%7%e%a%b%jXN%G!<%?E>Aw$r%A4

L?Na$r%e!<%j%s%0$7F7$^$&E@$,M%$l$F$$$k!%3N%=%U %H%&%'%"@)8f%-%c%C%7%e$O MAPLE $KFbB"$5l?!$Data Transfer Controller(DTC) KhCF@)8f5l$k!%DTC $O!$DTC L? Na$r%e!<$K$"$kE>AwL?Na$r=gHV$K<B9T$7!$%a%b%j>e$N%G! %?$r%-%c%C%7%eNN0h$XE>Aw$9$k!%$3$NE>Aw$O MAPLE %3%"$N <B9T$9kNGOJ/!$DTC $,%P%C%/%0%i%&%s%I$G<B9T$9 $k!%$MAPLE %3%"$N%*!<%P!<%X%C%I$HOJiJ$$!% %=%U%H%&%'%"@)8f%-%c%C%7%e$,4|BTDL$j$NF0:n$r7F$$$l$ <B9TKI,MWJ%G!<%?$OI,$:%-%c%C%7%eK"kN$G!$M O@E*KO%W%m%0%i%`%+%&%s%?$d%a%b%j%G!<%?%"%I%l%9%l %9%?$O%-%c%C%7%e$N%"%I%l%9$r<($9$@$1$G!$A4%a%b%j6u4 $r%"%/%;%9$9k3H,2DG=HJ$k!%

7+7J$,$i!$>o$K3N%=%U%H%&%'%"@)8f%-%c%C%7%e$ 5l$F$$$&J]>ZOJ$$!%J<Ji$P!$<B9T9k%"%W%j%1! %7%g%s$N%^%/%m%?%9%/ (MT) $N%5%$%:$,%-%c%C%7%e$N%5%$ $r1[$($F$$$k>l9g!$$3sF$$$k!%3Nh&$J>l9g!$%3%s%Q%$%k;~$KI,MW $$%e!<%j%s%0$7$F$b!$MAPLE %3%"$,I,MW$J;~KI,MWJ %G!<%?$r%-%c%C%7%e>e$KG[CVG-$J$$!%

$=$3G3$NLdBj$r2r7h9k$?$a$K MAPLE GO!$%-%c%C %7%e$N@)8fKD$$$F!$%=%U%H%&%'%"@)8f%-%c%C%7%e$b!<%I $H%O!<%I%&%'%"@)8f%-%c%C%7%e$b!<%I$H$$$& 2 DN%b!<%I $r;}$?$;$F$$$k!%ASCA $ODL>o!$%=%U%H%&%'%"@)8f%-%c%C %7%e$b!<%I$N>uBVK"$j!$$3$N%b!<%I$K$*$$$F$O40A4$K% %s%Q%$%i$,%-%c%C%7%e$N%G!<%?2r@O$r7F$$$k$?$a!$%3!< %I>e$K8=ol$kF14|L?Na$rHtP7!$6a:YN3EYJBNs=hM}$K$ 1kL5F14|<B9T [4] $r9T$&!%7+$7!$%-%c%C%7%e$N%G!<% 2r@O$,G-J/JC$?Ey$NM}M3$G%G!<%?E>Aw$NJ]>Z$,$G$ J/JC$?>l9g!$%3%s%Q%$%i$O%O!<%I%&%'%"@)8f%-%c%C %7%e$b!<%I$KJQ99$9$k!%%O!<%I%&%'%"@)8f%-%c%C%7%e$b! IG$OIaDL$N%-%c%C%7%e$HF1$8bN$G!$FbIt$G%$%s%?%m% %/$r5/$3$9$3H,$"$k!% 3N;~$O!$%3%s%Q%$%k;~$NM=B, $KMQ$$$?lk$?$a!$%3!<%ICf$NF14|L?Na$r<B9T$9k3$H %G!<%?E>Aw$NJ]>Z$r9T$&!%%b!<%I$N@Z$jBX$($O!$%O!<%I %&%'%"@)8f%-%c%C%7%e>eKI,MWJ%G!<%?$,FO$$$F$$$J$$$3$ $r8!=P$7$F%@%$%J%_%C%/$K@Z$jBX$($ilk!% $^$?!$%3%s%Q %$%iKb!<%I@ZjBX(L?NarKda9~$_!$$=$NL?Na$r<B9T$9 k3HG%=%U%H%&%'%"@)8f%-%c%C%7%e$b!<%I$KJQ99$9$k3H $b2DG=$G$"$k!%$^$?!$MT $N=i4|%b!<%I$O<3s%Q%$%i$,7h Dj9k!%

M3$K@_Dj$G$-$k3H$,K>$^$7$$!%IAiN%b!<%I$N>l9g$G
$b%-%c%C%7%e%a%b%j$OF10lNbNr;HMQ9k!%

3.4 9bB.$+$D=@Fp$JF14|5!9=

%^%k%A%W%m%;%C%5%7%9%F%`$G%\%H%k%M%C%/$H$J$kF14|A`
:n$r9bB.$K9T$&$?aKF14|L?NarAH_9~$_!$%/%m%C%/%l%Y
%k$NF14|$r<B8=9k!%5i$K!$F14|$K=@Fp@-$r;}$?$;k?
$a!$%0%k!<%W%P%j%"%f%K%C%H$r MAPLE %A%C%WFb$K<BAu
9k!%

3.5 9bB.$J%G!<%?E>Aw$N%5%]!<%H

%^%k%A%0%l%$%sJBNs=hM}!$FC$K6a:YN3EYJBNs=hM}$K$*
$$$F%G!<%?E>Aw$r9T$&$?$a$K!$%W%m%;%C%5KBP7$F Send!$
Receive L?Na$H!$Write L?Na$H$$$&2 <oN`$NE>AwL?Na$r<BAu
9k!%Send!$Receive L?Na$O!$%=!<%9%W%m%;%C%5$N%l%8%9
%?$NFbMF$r%G%9%F%#%M!<%7%g%s%W%m%;%C%5$N%l%7!<%V%l%8
%9%?$KD>@\=q$-9~$`;v$,2DG=G"$k!%$=N?$a!$$3$NL?Na
Kh$kE>Aw%m%9$O%M%C%H%o!<%/$NDL2a;~4V$N$_$G$"$k!%$7
$+$7!$$3$NL?Na$O 1 %o!<%I$N=q$-9~$_$7$+%5%]!<%H$7F*
i:!$ 2 %o!<%I0J>e$NE>Aw$K$O!$Write L?Na$r;HMQ$9k3
MW$,$"$k!%

Write L?Na$O!$%=!<%9%W%m%;%C%5$NJ,;66&M-%a%b%j (DSM)
>e$N%G!<%?$r%G%9%F%#%M!<%7%g%s%W%m%;%C%5$N DSM $^$?$O
CSM $K=q$-9~$`!%DSM E>Aw$N>l9g!$%G%9%F%#%M!<%7%g%s%W
%m%;%C%5B&GO%G!<%?$NE>Aw=*N;$r3NG'9k$?$a$K%U%i%0
$N%A%'%C%/$r9T$&I,MW$,$"$k!%%U%i%0$O!$%G%9%F%#%M!<%7%g
%s%W%m%;%C%5$N DSM >e$KCV$+$lk?$a!$%U%i%0%A%'%C%/$K
%*!<%P%X%C%IOBg-$$!%$?$@$76a:YN3EYJBNs=hM}$K$*$1$k
%G!<%?E>Aw$O!$$=$NBgItJ,$, 1 %o!<%I E>Aw (Send!$Receive
L?Na) G"k?$a!$Write L?Na$N%*!<%P!<%X%C%I$,%7%9%F%
A4BN$KM?$($k1F6A$O>/$J$$$H9M$($ilk!%

3.6 9bB.$JIbF0>.?tE@1i;;

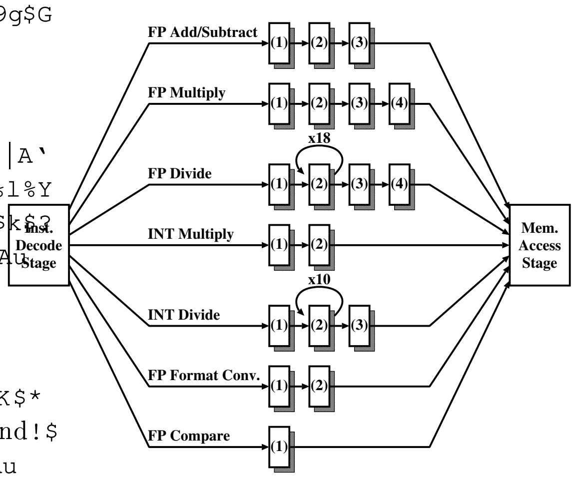
3.6.1 IEEE754 5,3J$N%5%]!<%H

MAPLE $NIbF0>.?tE@1i;;$O!$I8=`5,3J$G$"$k AN-
SI/IEEE 754-1985[9] $K=`5r$7$F$$$k!%$^$?!$:#F|$G$O2J
3X5;=Q7W;;K*1k;v<B>e$NI8=`%U%)!<%^%C%H$G$"$kG\@:
EY$b%5%]!<%H$9$k!%IEEE 754 5,3J$NCf$G!$J#;($J5,Dj$r
9TCF$$$kA2?JE*%"%s%@!<%U%m!<$d!$%*!<%P!<%U%m!<KD
$$$F$OA4$F%O!<%I%&%'%"$G=hM}$7F*$j!$$^$?!$>&MQ5!$K
8+il$k5,3J301i;;%b!<%I (9bB.%b!<%I: A2?JE*%"%s%@!<
%U%m!<$r%5%]!<%H$7$J$$Beoj$K9bB.$K1i;;$r9T$&%b!<%I)
Nh$&$J$*%W%7%g%s$O;}$?$;$J$$!%

3.6.2 FPU $N<B9T%9%F!<%8

$3$3GOIbF0>.?tE@%Q%$%W%i%$%s$N<B9T%9%F!<%8 (?^ 4
NLV+$1It) KD$$$F>\:Y$K@bL@$9$k!%?^ 6$K!$IbF0>.?tE@
%Q%$%W%i%$%s$N<B9T%9%F!<%8$r<($9!%?^$Nh&$K!$IbF0>.
?tE@%Q%$%W%i%$%s$N<B9T%9%F!<%8$O!$40A4$KFHN)7? 7 $D
$N1i;;%Q%$%W%i%$%s$+$i9=@.$5lF$$$F!$IbF0>.?tE@2C8:;;
1i;;!$IbF0>.?tE@%U%)!<%^%C%HJQ49!$IbF0>.?tE@Hf3S1i;;$O
@0?t>h=|;;$r9T$&3H$,$G$-$k!%

$=$7$F!$=|;;1i;;0J30!$<B9T%9%F!<%8$O40A4$K%Q%$%W%i
%$%s2=$5lF$*$j!$1 %5%$%/%kKh$KL?Na$NEjF~$,2DG=$G$"
$k!%=|;;$O@0?t$, 10 %5%$%/%k!$IbF0>.?tE@$O 18 %5%$%/%k
Kh$KEjF~$,2DG=G"$k!%=|;;$r40A4$K%Q%$%W%i%$%s2=$7$J



?^ 6: IbF0>.?tE@%Q%$%W%i%$%s$N<B9T%9%F!<%8

7F$*$N$O%O!<%I%&%'%"$,KDBgJNLKJk3d$K!$=|;;$NI
EY$O>/$J$$$3HH!$%W%m%;%C%5$OA4FN%9%F!<%8$r4F;k$
kI,MW,$"$j!$IbF0>.?tE@=|;;$Nh&$K 21 %9%F!<%8$b$
kH$=$N@)8f$=$NbN$,6K$a$F:$FqKJCF7^$&!$$H$
$&2 E@$N$?$aG"$k!%

3.6.3 1i;;%"%k%4%j%:%`

MAPLE $N FPU $G:NMQ$7$?!$2C8:;;!$>h;;!$5Z$S=|;;
$N%"%k%4%j%:%`$O0J2<NDLjG"$k!%

- (IbF0>.?tE@) 2C8:;;
  IbF0>.?tE@2C8:;;KO!$<B:]$K7W;;$r9T$&A0$NHo2C;
  ?t$N7e9g$o$;$N%7%U%H$H!$6a$$CMF1;N$N8:;;$N:]$K5/
  3k7k2L$N@55,2=%7%U%H$H$$$& 2 DN%7%U%H$,$"$k!
  3liN%7%U%HF0:n$OGSB>E*$KF0:n9k$H$$$&E@$KCe
  L\$7$F9bB.2=$r?^CF$$$k [10]!%
- >h;;
  2bit Booth %(%s%3!<%I K!$H Wallace LZ$Khk05=L2s
  O) [6] $rMQ$$$F$$$k!%3NJ}K!$O%O!<%I%&%'%"NL$OBg
  $/$JkbNN!$$=$NJ,9bB.$JF0:n$,4|BT$G$-$k (>h
  ;2sO) $N%O!<%I%&%'%"NL$O!$FPU <B9T%9%F!<%8A4BN$N
  h= 50%$r@j$a$F$$$k)!%
- =|;;
  >\D9 2 ?J?tI=8=$rMQ$$$? 1bit 3HD% SRT K! [11] $r:NMQ
  7F$*$j!"1 %5%$%/%kEv$?$j 3 %S%C%H$N>&$r5a$ak3
  H,G-$k!%

IbF0>.?tE@%Q%$%W%i%$%s$N<B9T%9%F!<%8$N=hM}G=NO$O!$I
1NDLjG"$k!%

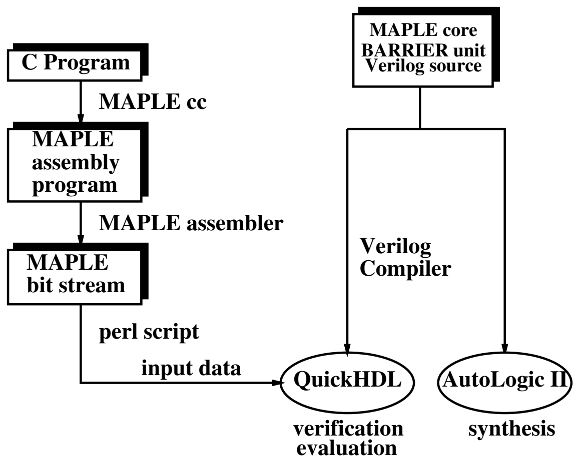
I= 1: FPU $N<B9T%9%F!<%8$KMW9k%5%$%/%k?t

%b%8%e!<%k	%Q%$%W%i%$%s%9%F!<%8?t	<B9T40N; [cycle]	EjF~4V3V [cycle]
IbF0>.?tE@2C8:;;	3	3	1
IbF0>.?tE@>h;;	4	4	1
IbF0>.?tE@=|;;	4	21	18
%U%)!<%^%C%HJQ49	2	2	1
IbF0>.?tE@Hf3S	1	1	1
@0?t>h;;	2	2	1
@0?t=|;;	3	12	10

4 MAPLE $NI>2A

4.1 I>2AJ}K!

I>2A$N35MW$O?^ 7Nh$&$KJCF*$j!$6qBNE*KO0J2< $N<j=g$G9TC?!%



?^ 7: I>2AK!$N35N,?^

1. MAPLE %3%"$N Verilog %=!<%9$r!$Mentor Graphics <R$N Verilog %3%s%Q%$%i qvlcom $G%3%s%Q%$%k$r9T$C $?8e!$QuickHDL $G%7%_%e%l!<%H$7O@M}8!>Z$r9T$C$?!% $^$?!$O@M}9g@.$O Verilog %=!<%9$r Mentor Graphics <R$N9g@.%D!<%k AutoLogic II $rMQ$$$F9T$$!$%O!<%I %&%'%"NL (%2!<%H?t) $*$h$SF0:n<~GH?t (%/%j%F%#%+%k %Q%9) $r5a$a$?!%

2. C 8@8l$G%W%m%0%i%`$rMQ0U$7$F!$3F<o%3%s%Q%$%i$G MAPLE MQ$N%S%C%H%9%H%j!<%`$KJQ49$9$k!%C 8@8l$N %s%Q%$%i$O!$gcc 1.37.1 $K University of California at Bekeley $,:n@.$7$? DLX MQ$N%Q%C%A [12] $r MAPLE MQ$KJQ99$7$? C %3%s%Q%$%i (MAPLE cc) $r;HMQ$7 $F$$$k!%%"%;%s%V%i$O!$University of Cincinnati $, :n@.$7$? DLX MQ$N%"%;%s%V%i [12] $r MAPLE MQ$K JQ99$7$?bN (MAPLE assembler) $r;HMQ$7$F$$$k!% MAPLE assembler $,@8@.$7$?%S%C%HNs$r perl script Kh$j!$Mentor Graphics <R Verilog %7%_%e%l!<%?$G $"$k QuickHDL $NF~NO$U%)!<%^%C%H$KJQ49$7!$<B9T$, 4V$r85$K=hM}B.EY$K4X$9$kI>2A$r9T$&!%

4.2 %O!<%I%&%'%"NL$H:GBgF0:n<~GH?t

<BAu:Q$N%b%8%e!<%k$rEl<G ASIC(0.4μm CMOS)TC203G %i%$%V%i%j$r;HMQ$7!$Mentor Graphics <R$N AutoLogic II Optimizer v8.5_3.1 GENIE version 10.1 $G9g@.$7$?7k2L$, I= 2G"$k!%9g@.$N:]$N AutoLogic II $N%(%j%"!$%?%$%_%s %0$K4X9k:GE,2=%*%W%7%g%s$O!$$IAi$b low $rA*Br$7!$G CY1d%b%G%k$O typical $rA*Br$7$?!%I= 2$KO@M}9g@.$N7k2L$r<($9!%

I= 2: MAPLE $NO@M}9g@.7k2L

%b%8%e!<%kL>	%2!<%H?t
%W%m%0%i%`%+%&%s%?	392
IF %9%F!<%8	1,149
ID %9%F!<%8	3,575
EX %9%F!<%8	3,862
MEM %9%F!<%8	1,652
WB %9%F!<%8	8
%Q%$%W%i%$%s@)8f	61
%U%)%o!<%G%#%s%08!=P	244
%O%6!<%I8!=P	97
FC<l%l%8%9%?	785
FC<l%l%8%9%?@)8f	103
HFMQ%l%8%9%?	15,692
IbF0>.?tE@ ID %9%F!<%8	1,849
IbF0>.?tE@ EX %9%F!<%8	127,685
IbF0>.?tE@ MEM %9%F!<%8	1,088
IbF0>.?tE@ WB %9%F!<%8	244
IbF0>.?tE@%Q%$%W%i%$%s@)8f	5,485
IbF0>.?tE@%l%8%9%?	22,467
%W%m%;%C%5%3%" 9g7W	186,438
%l%7!<%V%l%8%9%?	6,811
%P%j%"%f%K%C%H	908
%-%c%C%7%e%3%s%H%m!<%i	1,364
%?%0 RAM (*1 × 1, *2 × 1)	14,948
%-%c%C%7%e%a%b%j (32KByte) (*3 × 8)	137,440
7W	347,909

*1: El<G TC200C/E TC203C/E %7%j!<%: %O!<%I%^%/%m%;%k %3%s%Q%$%i%V%k%;%k ADA018
*2: El<G TC200C/E TC203C/E %7%j!<%: %O!<%I%^%/%m%;%k %3%s%Q%$%i%V%k%;%k ADA004
*3: El<G TC200C/E TC203C/E %7%j!<%: %O!<%I%^%/%m%;%k %3%s%Q%$%i%V%k%;%k ADB008

3N_!$MAPLE$,L\I8H7$F$$$kF0:n<~GH?t$O 50MHz(%/%j%F%#%+%k%Q%9 20ns) G"$j!$9g@.$N7k2L!$:GBgF0:n<~GH?t$O 50.49MHz(%/%j%F%#%+%k%Q%9 19.806ns) HJC?!%Am %2!<%H?t$NH>J,<e$, 1 <!%-%c%C%7%e%a%b%j$G!$;DjNBgI $,IbF0>.?tE@1i;;2sO)$KHqd5lF$$$k3H$,$o$+$k

4.3 =hM}G=NO$NI>2A

4.3.1 I>2A>r7o

@_7W7? MAPLE $NI>2A>r7o$O!$I= 2$N7k2Lhj!$F0:n<~GH?t 50MHz $H2>Dj$7$F$$$k!%$^$?!$%=%U%H%&%'%"@)8f %-%c%C%7%e$K4X$7FO!$8=:_@_7WCf$G$"$k$?$a<BAu5lF $J$$!%:#2sI>2A$KMQ$$$?%W%m%0%i%`$O MAPLE $GA[Dj$7$F $$$k%-%c%C%7%e$KA4$F<}$^$k%5%$%:$JNG!$A4$F$N%G!<%? hSL?Na%-%c%C%7%e%_%9$OL5$/!$%-%c%C%7%e%"%/%;%9$O 1 % %m%C%/$G=*N;$9kbNH9k!%Hf3S$r9T$C$?%W%m%;%C%5$N H=$*$h$S;HMQ OS!$;HMQ%3%s%Q%$%i$rI= 3$K<($9!%MAPLE cc KO:GE,2=%*%W%7%g%s$,L5$$$N$G!$$G$-$k8B$j>r7o$rF 8K9k$?$a!$Hf3SBP>]$N%W%m%;%C%5$NI>2A$K$O%3%s%Q%$ %N:GE,2=%*%W%7%g%s$O;XDj$7$F$$$J$$!% $^$?!$MAPLE UNIX$O%W%m%;%C%5N_$NI>2A$GOJ$/!$40A4$J%7%9%F%`$ $7$F$NI>2A$G$"$k$?$a!$%a%b%j%7%9%F%`$d OS $N%*!<%P!< %X%C%I$r9M$($F$$$J$$ MAPLE $OB?>/>r7o$,M-MxG"$k!

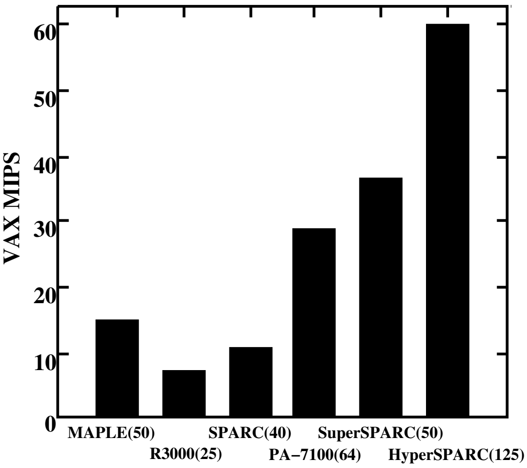
I= 3: Hf3S7?%W%m%;%C%5H=$N OS!$%3%s%Q%$%i

%W%m%;%C%5L>	OS	%3%s%Q%$%i
MAPLE(50)	(J7)	gcc 1.37.1 + dlxpatch
MIPS R3000(25)	NEWS-OS 4.2.1R	gcc 2.7.2.2
SPARC(40)	Sun OS 4.1.4	gcc 2.7.2.3
HP PA-7100(64)	HPUX 10.10	gcc 2.7.2.3
SuperSPARC(50)	SunOS 5.4	gcc 2.8.0
HyperSPARC(125)	SunOS 5.4	gcc 2.8.0

3g8LNCfO%W%m%;%C%5$NF0:n<~GH?t$rI=$9 (0J9_F1MM)

4.3.2 Dhrystone Kh$kI>2A

Dhrystone $O!$VAX MIPS CM$r5a$a$k%W%m%0%i%`$G$"$k!%VAX MIPS CM$H$$$&NO!$Digital Equipment <R$N 32 %S%C%H%9!<%Q%_%K%3%s VAX11/780 $N<B9TB.EY$r 1 VAX MIPS H7$F!$AjBPE*$K VAX11/780 $N2?G\$N@-G=G"k+$r<($9;XI8H7$FDj5A$7$F$$$k!%VAX MIPS CM$r5a$akK$O!$Dhrystone %Y%s%A%^!<%/NCM+$i5a$akN$,47Nc$KJC$F$$$k!%Dhrystone %Y%s%A%^!<%/%F%9%H$r9T$$!$$=NCMr VAX 11/780 $N Dhrystone %Y%s%A%^!<%/$NCM 1757 $G3d$C$?$bN, VAX MIPS CMG"$k!%?^ 8$K MAPLE $HB>$N%W%m%;%C%5KD$$$F!$Dhrystone %Y%s%A%^!<%/$Khj5aa? VAX MIPS CM$r<($9!%

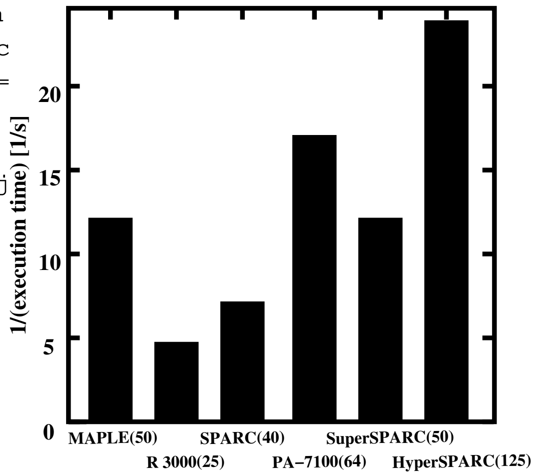


?^ 8: Dhrystone $N7k2L

?^$N1&B&$K$"$k 3 %W%m%;%C%5$O!$$$$:lb%9!<%Q%9%+%i%"!<%-%F%/%A%c$,:NMQ$5lF$*$j!$$=liO9YF9b$$@-G=$r<($7$F$$$k!%Dhrystone $K4X$7FOF0:n<~GH?t$,9b$$$bN[$I@-G=$,NI$/$JCF$$$k;v$,J,$+$k!%C"$7!$SuperSPARC $NF0:n<~GH?t$O 50MHz G"k,!$%Q%$%W%i%$%s%5%$%/%k$O 10ns G"kN$G!$<B:]KO 100MHz $GF0:n$9$k%W%m%;%C%5$H9M$($F$bNI$$!%MAPLE $O!$R3000 $d SPARC hj9bB.G"k,!$PA-7100 $O MAPLE $N 2 G\6a$$@-G=HJCF$$$k!%MAPLE GO!$%3%s%Q%$%k;~$N@EE*M=B,$r2DG=K9k?aK!$$"$($F%7%s%W%k$J%Q%$%W%i%$%s9=@.$r<hCF$$$k$?$a!$%W%m%;%C%5C1BN$G$N@-G=$,%9!<%Q%9%+%i%"!<%-%F%/%A%c%W%m%;%C%5KHfY$F@-G=$,Dc$$!%7$+$7!$%O!<%I%&%'%"NL$NLLGO%9!<%Q%9%+%i%"!<%-%F%/%A%cKHfY$+$J$jMMx$G$"$k!%MAPLE $r%^%k%A%W%m%;%C%5%7%9%F%`$H$7$FF0:n$5$;$?>l9g!$%9!<%Q%9%+%i%W%m%;%C%5$,9T$C$F$$$k$h$$JL?Na%l%Y%k$NJBNs@-(:YN3EYJBNs=hM})$r9T$o$J$$Be$o$$K!$6a:YN3EYJBNs=hM}$K$h$j%9%F!<%H%a%s%H%l%Y%k$G$NJNs@-$r9T$&$3$H$,$G$-$k!%$=$N$?$a!$%W%m%;%C%5Bf?t$,B$/$J$l$P$J$k$[$I!$%^%k%A%W%m%;%C%59=@.$r<h$k ASCA %7%9%F%`$NJ}$,M-MxKJkH9M$($ilk!%

4.3.3 FFT Kh$kI>2A

MAPLE $N FFT(9bB.%U!<%j%(JQ49)$NI>2A$O!$F~NO%G!<%?$N8D?t$r $1024(2^{10})$ H7$?!%$^$?!$Hf3SBP>]H7$?%W%m%;%C%5$OF1?t$N%G!<%?%5%$%:$G%3%s%Q%$%k$r9T$$!$1000 2s<B9T$7$?J?6Q;~4V$r5aa?!%?^ 9$O MAPLE $*$h$SB>$N%W%m%;%C%5KD$$$F$N!$FFT $N<B9T;~4V$N5U?t$r<($7F*$j!$Dhrystone $HF1MM$K!CM,Bg$-$$$[$I9b$$@-G=$r<($7$F$$$k!%



?^ 9: FFT $N7k2L

?^$r8+$k$H!$VAX MIPS $N7k2L$HHfYF!$C1=c$K<~GH?t$K0MB8$7$?7k2L$KOJCF$$$J$$$3H,o+$k!%FC$KHP-7100 $O9b$$@-G=$r<($7$F$$$k!%SPARC $d R3000 Nh$&$J%W%m%;%C%5$O!$Ev;~$N%W%m%;%C%5$=GOIbF0>.?tE@1;;N?aN@lMQ2sO)$r<BAu$9k3H,Fq7+C?!%$=$N$$a!$CPU HOJL$N%A%C%W$K<BAu5l$F$$$?$j!$==J,$K%Q%$%W%i%$%s2=$5lF$$$J$$$?$a!$@0?t%W%m%0%i%`hj$bB>$9%@-G=$J%W%m%;%C%5$KHf$Y@-G=:9$,82CxKJCF$$$k!%

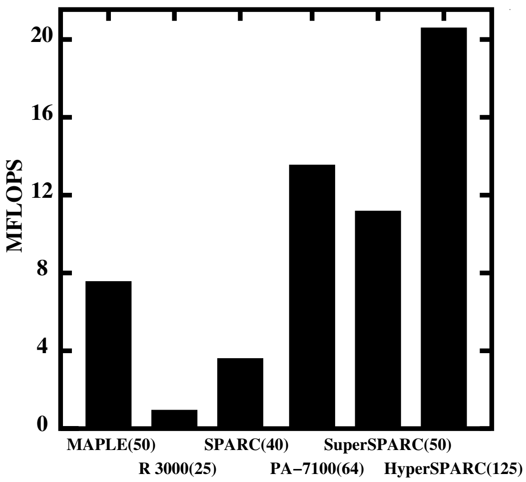
4.3.4 flops Kh$kI>2A

99$KIbF0>.?tE@1i;;$KBP9k@-G=$rD4$Yk?aK!$%W%m%0%i%` flops[13] $rMQ$$$F%W%m%;%C%5$NI>2A$r9TC?!%flops $O 8 DNFHN)7?7W;;%b%8%e!<%k$+$i@.CF$*$j!$3F%b%8%e!<%k$NFb 1 DO%^%/%m!<%j%sE83+KhCF1_<~N($r7W;;$7!$;D$j$N 7 DO?tCM@QJ,$r9TCF$$$k!%$=$7F=li$N7k2L$rAH$_9g$o$;$k3H$G!$:G=*E*$K MFLOPS(1)!AMFLOPS(4) $H$$$& 4 DN FLOPS CM$r=PNO$9$k!%$3li 4 DO!$IbF0>.?tE@=|;;L?Na$N4^$^$l$k3d9g$H!$%Y%/%H%k2=$,:FqJ%b%8%e!<%k$,4^$^lF$$$k$+$I$&$+$N 2 E@$r<g$K9MN8$7$F3F%b%8%e!<%k$N7k2L$NA*Br$r9TCF$$$k!%MFLOPS(1)!A MFLOPS(4) $NFCD'$H!$MAPLE $NI>2A7k2L$rI=4$K<($9!%

I= 4: MFLOPS(n) $NFCD'$H MAPLE GN7k2L

n	=|;;$N3d9g [%]	%Y%/%H%k2= :$Fq%b%8%e!<%k	MFLOPS(n) (MAPLE)
1	9.6	4^$`	6.07
2	9.2	4^$^$J$$	6.63
3	3.4	4^$^$J$$	7.54
4	0	4^$^$J$$	8.20

B>$N%W%m%;%C%5$NHf3SKO!$4 DNCf$G=|;;$N3d9g$N%P%i%s%9$,:GbHlF$$$k$H9M$(il$k MFLOPS(3) $rMQ$$$?!%$=$N7k2L$,?^ 10$K<(5l$F$$$k!%



?^ 10: MFLOPS(3) $NB>%W%m%;%C%5$H$NHf3S

flops $N7k2L$b FFT $HF1MM$K!$PA-7100 $,Hf3SE*NI9%$J7k2L$rF@$F$$$k!%$^$?!$R3000!$SPARC $H MAPLE $N:9$O99KBg-$/$JCF$*$j!$MAPLE $NF0:n<~GH?t$O!$R3000 N=lN 2 G\$G$"$kKb4Xoi$:!$MAPLE $O R3000 $N 7.9 G\$b9bB.$K7W;;$r9TCF$$$k!%<BAu$r9T$C$? MAPLE %3%"$O!$F0:n<~GH?t$N3d$K9b$$@-G=$r<($7$F$$$k!%ASCA $O!$IbF0>.?tE@1i;;$,B?$$2J3X5;=Q7W;;$r<B9T$9k3Hr9M$($F$$$k?$a!$$=$N9=@.MWAG%W%m%;%C%5$HJk MAPLE $O!$%O!<%I%&%'%"NL$NA}2C$hjb%9%T!<%I=E;k$N@_7W$KJC$F$$$k?aG$"$k!%

0J>e$N7k2L$h$j!$@_7W7? MAPLE %3%"$O@0?t1i;;$K4X7F$O!$F0:n<~GH?tAj1~$N<B9TB.EY$,F@ilk3H,$+$C$?!%IbF0>.?tE@1i;;$K$D$$$F$b!$F1$8<~GH?t$GF0:n9k%W%m%;%C%5$HF1Ey!$$b7/O=lhjb9bB.$K1i;;2DG=$G$"$k!%

5 7k O@

K\O@J8$O%=%U%H%&%'%"<gF37?JBNs%"!<%-%F%/%A%cASCA MQ9=@.MWAG%W%m%;%C%5 MAPLE KD$$$F<(7?!%MAPLE $O%9%?%F%#%C%/%9%1%8%e!<%j%s%0$r9T$&NKE,7?9=@. <h$j!$$J$*$+$DC1BN%A%C%W$H7F$b1i;;!$FC$KIbF0>.?tE 1i;;$N=hM}G=NO$rB;$Mk3HN$J$$@_7Wr7$F$$$k3H$ 3N$+$ail$?!%:#8e$O!$%=%U%H%&%'%"%-%c%C%7%e$Nhj6 BNE*$J@_7W$H!$SPEC95 %Y%s%A%^!<%/$Nh&$J5,LO$NBg$- $J%W%m%0%i%`$rI>2AG-kh$&$J4D6-$r9=C[$7$F$$$/$H6 $k!$MAPLE $r%^%k%A%W%m%;%C%59=@.$K7?H-$N@-G=$r D4Yk!%

<U<-

8&5fKEv?CF!$5.=E$J LSI CAD %D!<%k72$r;HMQ$5$; $FD:$-$^$7$?%a%s%?!<%0%i%U%#%C%/%9!&%8%c%Q%s$K46<UC 7^$9!%$^$?!$K\8&5f$N0lIt$O!$3t<02q<RH>F3BNM}9)3X8 5f%;%s%?!< (STARC) $NJd=u$r<u1F$$$^$9 (%W%m%8%'%/ %H!V%9%?%F%#%C%/%9%1%8%e!<%j%s%02DG=$J%^%k%A%W%m%; %54pK\%A%C%W!W)!%

;29MJ88%

[1] 4d0f 7<Je, F#86 ?r, ?9B< CN90, E7Ln 1Q@2, LZB< 7<Fs, Hx7A 9R, 3^86 GnFA, "%^%k%A0%l%$%sJBNs=hM}MQ%^%k%A%W%m%;%C %5%7%9%F%`", EE;R>pJsDL?.3X2q CPSY 97, Aug. 1997

[2] 2,K\ 2mL&, 9gED 7{?M, 5HED L@@5, 3^86 GnFA, @.ED @?G72p "<B MQ%l%Y%k$N%^%k%A0%l%$%s *FORTRAN* %3%s%Q%$%i$N3+H/" >pJs=hM}3X2q8&5fJs9p, 96 ARC Oct. 1996

[3] 3^86 GnFA, @.ED @?G7=u, 66K\ ?F, "OSCAR(Optimally SCheduled Advanced multiprocessoR) $N%"!<%-%F%/%A%c", EE;R>pJsDL?.3X2qO@J8;o D, Vol. J71-D No. 8 Aug. 1988

[4] Hx7A 9R, 5HED L@@5, 9gED 7{?M, 2,K\ 2mL&, 3^86 GnFA, "%9%? %F%#%C%/%9%1%8%e!<%j%s%0$rMQ$$$?%^%k%A%W%m%;%C%5%7%9 %F%`>e$NL5F14|6a:YN3EYJBNs=hM}", JBNs=hM}%7%s%]%8%&%` JSPP'93,1993

[5] ?9B<CN90, 4d0f7<Je, E7Ln1Q@2 "B?=E%P%9$r%(%_%e%l!<%H$9 $kB?CJ7k9gLV *R-Clos*" EE;R>pJsDL?.3X2q. CPSY 97, Aug. 1997

[6] John L. Hennessy, and David A. Patterson, "COMPUTER ARCHITECTURE A QUANTITATIVE APPROACH SECOND EDITION", Morgan Kaufmann Publishers,1996

[7] Philip M. Sailer, and David R. Kaeli, "The DLX Instruction Set Architecture Handbook" Morgan Kaufmann Publishers,1996

[8] :dK\>!?M, F#86?r, @n8}5.M5, 4d0f7<Je, ?9B<CN90, E7Ln1Q@2, "%^%k%A0%l%$%sJBNs=hM}$rMxMQ7?%=%U%H%&%'%"@)8f%-%c% %7%e$N3+H/", EE;R>pJsDL?.3X2q CPSY 98, Apr. 1998

[9] The Institute of Electrical and Electronics Engineers, Inc., "IEEE standard for Binary Floating-Point Arithmetic, ANSI/IEEE Std 754-1985(IEEE 754)", 1985

[10] Stuart F. Oberman, Hesham Al-Twaijry, Michael J. Flynn, "The SNAP Project: Design of Floating Point Arithmetic Units", Proc. of the 13th IEEE Symposium on Computer Arithmetic, Jul. 1997

[11] 9bLZ D>;K, 0B1: 42?M, LpEg f{;0, ">iD9 2 ?JI=8=$rMxMQ$7 $?VLSI 8~$-9bB.=|;;4o", EE;RDL?.3X2qO@J8;o, Vol. J67-D No. 4, Mar. 1984

[12] "http://www.fastsys.co.kr/jwpark/Outside/Comp/EDA/dlx.html", DLX 4XO"$N%=!<%9 (dlxasm, dlxcc, etc.)

[13] "ftp://ftp.nosc.mil/pub/aburto/flops/", flops %W%m%0%i%`$N%=!<%9