JBNs7W;;5!%"!<%-%F%/%H$+$i$_$?7W;;5!%/%i%9%?

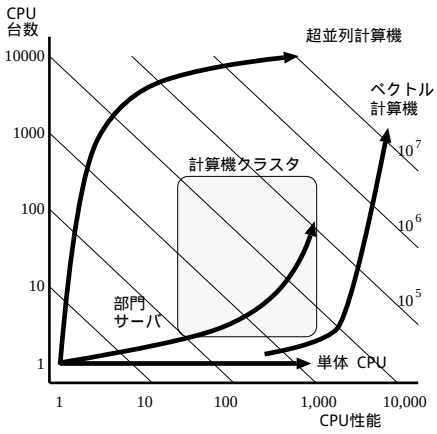
?9 bC0lO: IY ED bC <#

5~ETBg3XBg3X1!>pJs3X8&5f2JDL?.>pJs%7%9%F%'@196

1. O8aK

:#F|, JBNs=hM}$O8&5fBP>]$N;~Be$+$i<EMQ2=$N;~Be$X$H8~$+$$$DD"$j,B?$/$NJBNs7W;;5!$,:G@hC<$N%9!<%Q!<%3%s%T%e!<%?$H7F3hLv7F$$$k.[1)]

0lJ}$G,$3Nh$&$JD6JBNs$"$k$$$O9bJBNs7W;;5!HO,0l@~$r2h$7$F<EMQE*$JJBNsEY$NJBNs7W;;5!$N3hLv$bL\N)$CF-$F$$$k.4k6H$NItLg%l%Y%k$dBg3X$N3X2J%/%i%9$NAH?%GbF~<j2DG=$J?t10Bf5,LC$N%W%m%;%C%5rbC?ItLg%5!<%PE*$J%_%C%I%l%s%8$NJBNs7W;;5!G"$k.$=NCfG$b,:G6aCmL\$r=8aF$$$kN,,!VW;;5!%/%i%9%?!WG"$k.



?^**1** 2a5n10G/4V$N7W;;5!@-G=$N?d0\798~

7W;;5!%/%i%9%?$O,%Q!<%=%J%k%3%s%T%e!<%?(PC)$d%o!<%/%9%F!<%7%g%s(WS),>l9gKhCF$OPC/WS%5!<%P$H$$$C$?>.5,LQJBNs7W;;5!$r,HFMQ$N%M%C%H%o!<%/$G@\B3$7$?0l<o$NJBNs7W;;5!$HB+J9$3$H,G-$k.%W%m%;%C%5$JiS$K%M%C%H%o!<%/@-G=$N5^B.$J?-$S$r<u$l$F,%3%9%H%Q%U%)!<%^%s%9$KM%l?JBNs7W;;5!H7FNCO0L$rC[$-DD$"$k.

0J2<,K\9FGO7W;;5!%/%i%9%?BfF,$NGX7J$rNY,<!$KJBNs7W;;5!$H7F$N7W;;5!%/%i%9%?$NFCD'$r>R2p$7$?8e,6qBNE*$J7W;;5!%/%i%9%?$N8&5f!?3+H/;vNc$r>R2p9k.

2. 7W;;5!%/%i%9%?BfF,$NGX7J

— JBNs7W;;5!$NEP>l —

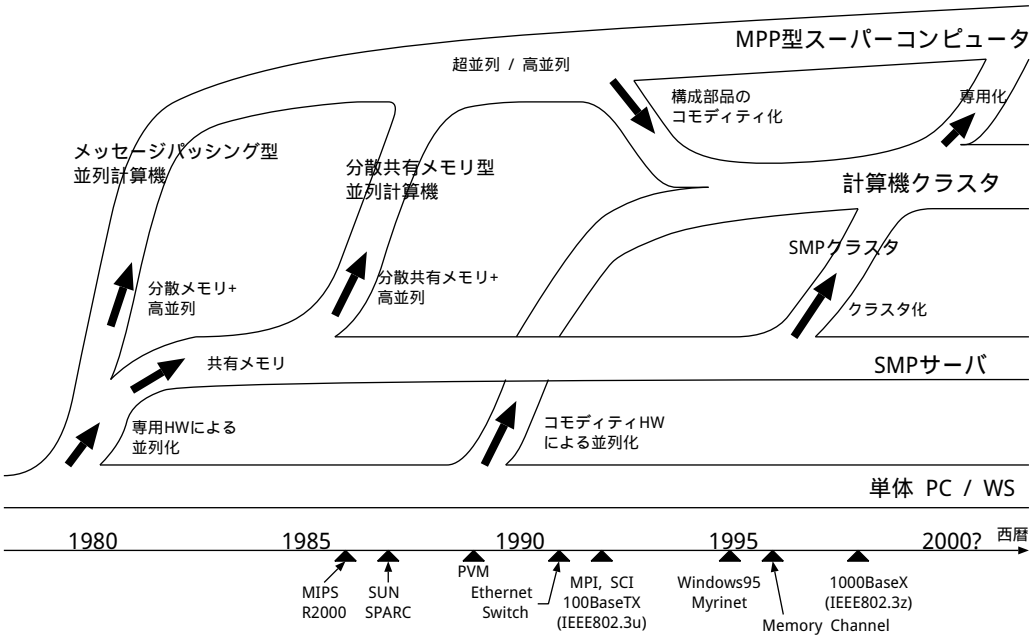
HFMQ$N%^%$%/%m%W%m%;%C%5$r@lMQ$N%O!<%I%&%'%"(HW) $r6n;H$7$FJBNs@\B3$9$kJBNs7W;;5!$N8&5f$O1970G/Be=iF,$K;O$^$j,%9!<%Q!<%3%s%T%e!<%?J_$N@-G=$rL\;X7F,8D!9$N7W;;5!Kh$K:GE,2=5l$?Dc%l%$%F%s%7,9b%9%k!<%W%C%H%N%M%C%H%o!<%/7OJiSK%a%b%j7OHW $N8&5f!?3+H/$,9Tol$?.HFMQ%W%m%;%C%5$NDc2A3J2=KHbJ$$,1980G/BeA0H>KO8&5fMQ%NB?$/$NJBNs7W;;5!$,3+H/$5$l,3F%W%m%;%C%5Kh$K%a%b%j$rJ,;6G[CV$7%a%C%;!<%8%Q%C%7%s%0KhCF%W%m%;%C%54VDL?.$r9T$&%a%C%;!<%8%Q%C%7%s%07?JBNs7W;;5!$H,%W%m%;%C%5$H$CFHN)$K%a%b%j$r=8CfG[CV$7,3N6&M-%a%b%j$r2p$7$F%W%m%;%C%54V$NDL?.$r9T$&!=8Cf!K6&M-%a%b%j7?JBNs7W;;5!(:G6a$O,Symmetric MultiProcessor(SMP) $H8F$Plk3H$,B?$$.) $,EP>l$7$?.

1985G/:"$+$i$O,=8CfG[CV$7$?6&M-%a%b%j%7%9%F%'$K$*$1$k%9%1!<%i%S%j%#NLdB$j$r2r7h$9$k<-jK!$H7F,<g5-21$O3F%W%m%;%C%5$KJ,;6G[CV9k$,,%W%m%0%i%^$KBP7F$OHW $G6&M-%a%b%j4D6-$rDs6!9kJ,;66&M-%a%b%j7?JBNs7W;;5!$,,EP>l$9$k.HFMQ7W;;5!$N;T>l$N0lIt$,,RISC 7?$N%^%$%/%m%W%m%;%C%5$rEk:\$7$?o!<%/%9%F!<%7%g%s$K0\$j;Oa?;~4|Gb$"$j,JBNs7W;;5!$G;HMQ$9$k%W%m%;%C%5$N%3%9%H%Q%U%)!<%^%s%9$,8~>e$7$?.

— 7W;;5!%/%i%9%?$NKk3+$1 —

1990G/A08eKO,B?$/$NJBNs7W;;5!%Y%s%@$,EP>l$7>&MQ$NJBNs7W;;5!$,?tB?$/3+H/$5l?.$^$?,?t@i!A?tK|Bf$NCPU $rEk:\$9$kD6JBNs7W;;5!$N8&5f$,;O$^C?;~4|G"$k.

$=$N0lJ}$G,TCP/IP %Y!<%9$N%M%C%H%o!<%/$G@\B3



?^2 7W;5!%/%i%9%?XNF;Dx

5l$?J#?t$N7W;5!$N=89gBN$r, 2>A[E*$K#1Bf$NBg$-$JUBNs7W;5!H7$F8+$;k?aN%=%U%H&%'%"%a%+%K%:%'G"$kPVM(Parallel Virtual Machine)$,1989G/$K3+H/5l$?[2]. PVM $O8D!9$N7W;5!>e$NDL?.$G!<%b%s%W%m%;%9$r2p$7F%a%C;!<%88r49$r9T$&a%C;!<%8DL?.%i%$%V%i%j$G$"$j, FCJL$JHW $r01@ZI,MW$H$;$:, 8x3+5l$?%=%U%H&%'%"$r%$%s%9%H!<%k$9k@1G2>A[E*$JUBNs=hM}4D6-$,9=C[G-$?. $=$N$?$a, 7Z5;}$GJBNs=hM}$r3Z7_$?$%f!<%6$K;Y;}$5$19-$/Ia5Z7?. 3l$,7W;5!%/%i%9%?$NKk3+1G$"$k.

$=$N?tG/8eKO, IBM $dIY;NDL$JIN%C$%(%s%I$NJBNs7W;5!%a!<%+$,, <+<R@=$NUNIX %o!<%/%9%F!<%7%g%s$r@lMQ9bB.%M%C%H%o!<%/$G@\B3$7$?%a%C;!<%8%Q%C7%s%07?$NJBNs7W;5!'[7),8)] $r;T>l$KEjF~7?. 3N;~E@$G, !VW;5!%/%i%9%?!W$H8FVY$-J*M}E*$J7W;5!(72) $,EP>l$7$?Lu$G$"$k.

— 7W;5!%/%i%9%?$N5^@.D9 —

1995G/A08eKO, %$!<%5%M%C%H%9%$%C%A$d100Mbit Ethernet JI$N5;=Q$,0lHLKbIa5Z$7, Hf3SE*0E2A$K9b@-G=$J%M%C%H%o!<%/$N9=C[$,2DG=KJC?. 5i$K, Myricom <R$N Myrinet[4], DEC <R$N Memory Channel[5], IEEE1596 5,3J$N SCI[6] Ey, 7W;5!%/%i%9%?$r;X8~$7$?@lMQ$N9bB.%M%C%H%o!<%/$,EP>l$7$?. 3lKh$j, %M%C%H%o!<%/$N%9%k!<%W%C%HH7$F, @lMQ$NJBNs7W;5!J_$N?tCM(?tGbps) rb$D%M%C%H%o!<%/$N9=C[$b2DG=$HJC$?. 0lJ}$G, PC $NNL;:8z2I$Khk2A3JDc2<$H, PC 8~$1%W%m%;%C%5$N5^B.$J@-G=8~>eKh$j, %3%9%H%Q%U%)!<%^%s%9$NM%l?7W;5!%/%i%9%?$N<B8=$,2DG=HJC?. 3N;~4|$N7W;5!%/%i%9%?$NFCD'$O, %/%i%9%?$r9=@.9kPC/WS 4V@\B3$N%M%C%H%o!<%/$r%S%s%?!<%M%C%H@\B3N?aN%M%C%H%o!<%/HOJL$K@_$1$?%7%9%F%'$,3+H/5l$?E@$G$"$k.

0lJ}, %=%U%H&%'%"$NU}$G$O, %"%W%j1!<%7%g%s%W%m%0%i%'%S%s%?%U%'!<%9(API) H7$F, B?$/$NJBNs7W;5!%a!<%+$d8&5f<TiGAH?%5l$?MPI Forum $,:vDj$7$?Message Passing Interface(MPI)[3] $,9-$/Ia5Z7?;~4|G"$k. 3lKh$jJBNs%W%m%0%i%'$N5-=R@-!?0\?"@-$,Cx7/2~A1$5$l, B?$/$N%W%m%0%i%^KHCFJBNs=hM}NI_5o,0lCJHDc/$JC?. $^$?, %W%m%;%C%54VDL?.$KH<$&&=%U%H&%'%"$N%*!<%P%X%C%I$r7Z8:!?:o=|9k;n$_$,B?$/9T$ol?;~4|Gb$"$k. %f!<%6%W%m%;%9$,D>@\%O!<%I&%'%"$'A':n9k%f!<%6%l%Y%kDL?.$N<B8=$d%<%m%3%T!<DL?.JI$,, $=$NNcG"$k. Linux $d FreeBSD JI$N%U;j!<$JOS $NIa5Z$,, 3liN;n$_$KGo<V$r2C$(, 0ED;j$+$D9b@-G=$J7W;5!%/%i%9%?8~$1$N%U;j!<$J%=%U%H&%'%"$,F~<j2DG=$KJC$?$NG"$k.

0E2A$J%O!<%I&%'%"(HW) $H%U;j!<$J%=%U%H&%'%"(SW) $r;H$C$?%Q!<%=%J$kJBNs7W;5!H7FN7W;5!%/%i%9%?$,EP>l$7$?;~4|$H$$$CFb$h$$.

— 7W;5!%/%i%9%?$NH/E8 —

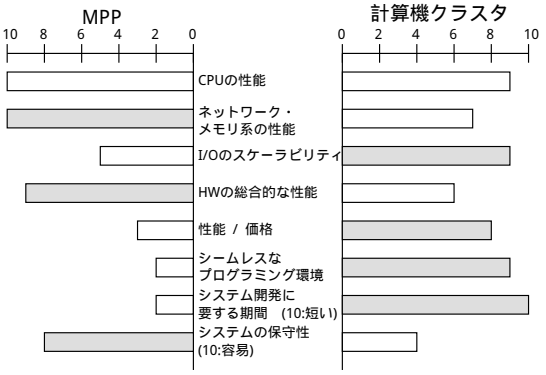
8=:_$O, J#?t$N%W%m%;%C%5$rEk:\$7$?SMP 7?$NWS $dPC $,Hf3SE*MF0W$KF~<j2DG=KJCF$*$j, 3lir%Y!<%9$K7$?SMP %/%i%9%?$,EP>l$7$F$$$k. %O%$%(%s%I$NSMP %5!<%P$rDs6!$9$k7W;5!%a!<%+$b, 99Jk%9%1!<%i%S%j%#$rDI5f$7$F, SMP %5!<%P$rHFMQ$N9bB.%M%C%H%o!<%/$G@\B3$9$kSMP %/%i%9%?$rH/I=$7;OaF$$$k. 7W;5!%/%i%9%?$N@-G=$O, 9G$K%O%$

%(%s%I$J%9!<%Q!<%3%s%T%e!<%?$NNN0h$KE~C#$7DD$"$k$H$$$CFb$h$$. %=%U%H%&%'%"4D6-$bK\3JE*$J%^%k%A%f!<%6BP1~NbN,@0$$;OaF$$k.

:#8e$O, 99$J$k HW $N9b@-G=2=$H%W%m%0%i%'$N5-=R@-8~>e$rL\;X7F, J,;66&M-%a%b%j$rDs6!$9$k7W;;5!%/%i%9%?$,Ia5Z7F$/$kbN$H9M$(Bil$k. J,;66&M-%a%b%j$rDs6!9k7W;;5!%/%i%9%?$O, 8=:_3hH/$J8&5f$,9T$olF$$k$,, SW N_$G2>A[E*$J6&M-%a%b%j%$$%a!<%8$rDs6!$9$kJ}K!(K\FC=8$NJL5-;v$r;2>H) $H, HW $G<B:]$K6&M-%a%b%j$r<B8=$9$k%"%W%m!<%A$,$"$k[9),10). 8e<T$O, =>Mh$NJ,;66&M-%a%b%j7?JBNs7W;;5!$GG]$ol?5;=Q$r1~MQ$9kbNG, %O!<%I%&%'%";q8;$N2>A[2=$dDL?.%l%$%F%s%7$N7Z8:!?1#JCN?aK%M%C%H%o!<%/$d%a%b%j2s$j$K6/NO$J HW %5%]!<%H$,$"kN$,FCD'$G$"$k. 3N%/%i%9$N7W;;5!%/%i%9%?$G$O, =>Mh$NJBNs7W;;5!HN%"!<%-%F%/%A%c<e$N:90[$,:FSJ$/$JCF$/$kbN$H9M$(Bil$k.

3. 7W;;5!%/%i%9%?$NFCD'

3Nh&$K, 7W;;5!%/%i%9%?$OJBNs7W;;5!$N9=@.<jK!$N#1DH7FCO0L$r3NN)$7F-$?. GO, =>Mh$NJBNs7W;;5!HO2?$,0c$&$NG"m&$+. 0J2<GO, FH<+$K3+H/5l$?@lMQHW/SW KhCF9=@.5l$k !ØW8?h$NJBNs7W;;5!!W$NBeI=$H7F$ND6JBNs7W;;5!(MPP) $H, 4pK\E*$K%3%b%G%#F%#HW/SW KhCF9=@.5l$k !ØW;;5!%/%i%9%?!W$rHf3S9k3H$G7W;;5!%/%i%9%?$NFCD'E1$r9T$&(?^3;2>H).



?^**3** MPP $H7W;;5!%/%i%9%?$NHf3S

- CPU @-G=

4pK\E*KO, MPP $b7W;;5!%/%i%9%?$b;THN$N%W%m%;%C%5$r;HMQ9k$H$$$&E@$GF101$G$"$k$,, :G6a$N%W%m%;%C%5$O>&6HE*$J@dN,$+$i, %O%$%(%s%I8~$1$H%m!<%(%s%I8~$1$G<c43$N:9$r=P$9@=IJ$,$"kN$G3$N:9$,=P$k2DG=@-$,$"$k. $?$@$7, %7%9%F%'$N3+H/4|4V$NLdBj$,Mm$'$H, 8e=R9kDL$j7W;;5!%/%i%9%?$NJ}$,M-Mx$KJk>19gb"$k.

- %M%C%H%o!<%/!?%a%b%j7O$N@-G=

MPP O=$N@=IJ8~$1$K@lMQLIS $N3+H/$r9T$&$J$I, JBNs=hM}$N$?$a$K:GE,2=$7$?%a%b%j7O$d%M%C%H%o!<%/7O$N%O!<%I%&%'%"$rHw$($kNKBP7F, 7W;;5!%/%i%9%?GO%3%b%G%#F%#JPC/WS $r;HMQ$9k?a, HW $N%1%$%F%s%7$K4X$7$F MPP hjNt$k798~$,$"$k. HW %9%k!<%W%C%H$K4X$7FO, 7W;;5!%/%i%9%?$b MPP $K6a$$@-G=$r=P$7;OaF$$k.

- I/O $N%9%1!<%i%S%j%F%#

7W;;5!%/%i%9%?$O8D!9$N PC/WS $,FH<+$K I/O AuCV$r;}$CF*$j, %W%m%;%C%5Bf?t$KHfNc7F I/O G=NO$,%9%1!<%k%"%C%W$9$k. 3lKBP7$F MPP GO, %7%9%F%'A4BN$K18D, $"$k$$$O, $"$kDxEY$N%W%m%;%C%5Bf?tKh$K18D$N I/O AuCV$r;}$D9=@.$,B?$$. 1Bf$N I/O AuCV$N@-G=$rHf3S$9kH, 0lHL$K MPP 8~$1$NJ}$,@-G=$,$h$$$bN,B?$$!ØA3Jb=lJjK9b$$!K$,, I/O $N%9%k!<%W%C%H$K4X7F$O?t$G>!Ii$N7W;;5!%/%i%9%?$KIi1k798~$,$"$k.

- HW $NAm9gE*$J@-G=

N><T$N HW @_7W$N4pK\J}?K$r4:$($F6hJL$9kJiP, MPP $, !ÑBf$N CPU $r;H$C$F, 1CPU NH$-$N7W;;~4V$N1/N $N;~4V$G7W;;G-k3$H!W$KBP7F, 7W;;5!%/%i%9%?$O !ÑBf$N7W;;5!$r;H$C$F1Bf$NH-$K8=<BE*$J;~4V$G=hM}$G$-$k%G!<%?%5%$%:$N G\$N%5%$%:$N%G!<%?$r07$&3H!WG"$k. 0lHL$K A0<T$N MW5a$rK~B-9kKO, :YItKEOC$F@-G=$KM>M5rb$?$;$?HW @_7W$,I,MWG"$k. 7?$,CF, %T!<%/@-G=$,F101G"CF$bAm9gE*$J@-G=$O MPP $NU}$,M%lF$$$k.

- %3%9%H%Q%U%)!<%^%s%9

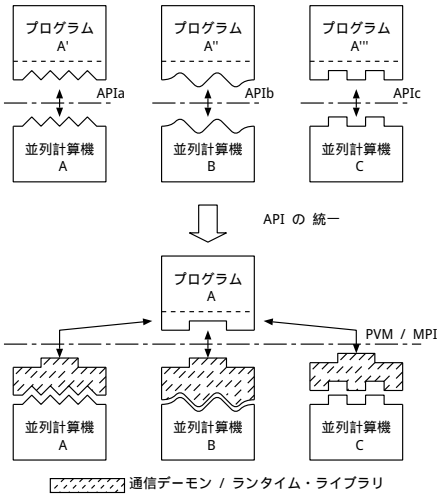
%W%m%;%C%5100Bf5,LO$^$G$N%7%9%F%'$GHf3S9k$H, MPP $H7W;;5!%/%i%9%?$N=V4V:GBg@-G=$OHf8*$7$F$$$k$N, NL;:8z2L$N9b$$7W;;5!%/%i%9%?,C12AEvjN%T!<%/@-G=$,9b$/%3%9%H%Q%U%)!<%^%s%9%KM%lk$H$$$($k. 7+$7, MPP $O4pK\%3%9%H$O9b$$$,, Bf?t$KHfNc$9$k%W%m%;%C%5#1BfEv$j$N2A3J$O7W;;5!%/%i%9%?KHfY$F0lHL$KDc$$$N$G, 2>$K%W%m%;%C%51000Bf5,LO$N7W;;5!%/%i%9%?$r<B8=7?>19gKO, %3%9%H%Q%U%)!<%^%s%9%N5UE>$,5/$k2DG=@-$,$"$k. $^$?, %T!<%/@-G=$K6a$$@-G=$r0z$-=P$;$J$$%W%W%j%1!<%7%gsKBP7F$O, 7W;;5!%/%i%9%?$O MPP KHfY$F@-G=$NDc2<798~$,82Cx$G$"$j, 3N>19gKb3%9%H%Q%U%)!<%^%s%9%,5UE>9k2DG=@-$,$"$k.

- %W%m%0%i%_%s%04D6-

MPP $O, =>Mh$h$j8D!9$NJBNs7W;;5!$,=$l$>$l$N HW @-G=$rB8J,$KH/4x$9k?a$NFH<+$N API $rDs6!$7$F$$?. $=$N$?a, API $N=$F@Ey$N=i4|%*!<%P%X%CBg$-$/, $^$?, $"$k7W;;5!$GN1$$%"%W%j$1!<%7%g$s$,3+H/$5lFbJLN7W;;5!XN\?"@-$,:$Fg$H$$$C?

LdBj$,$"C?. 3lKBP7$F7W;;5!%/%i%9%?$G$O, $=$l<+BN$,EP>l$7$?GX7J$KPVM $dMPI $H$$$C$?I8=`E*$J API $,B8:_$7$?$?aK, 5!<cOMB8$N>/$J$$8zN(E*$J%W%m%O%i%_%s%04D6-$,Ds6!5l$F$$k. [1]

$^$?, MPP $NOS $O<+<R3+H/$7$?b$N$,B?$/, 0lHL%f!<%6$,JBNs=hM}$X8~1?:G=i$N0lJb$rm4m0$9$k860xKbJC$F$$$?. 3lKBP7$F7W;;5!%/%i%9%?$O !4fpK\E*KO!K;THN$NOS $=$NbN$r;HMQ$9k?$a, F|>oE*$K;HCF$$$k PC/WS $HA4$/F10l$N4D6-$,;HMQG-kH$$$&MxE@$,$"$j, JBNs=hM}$NI_5o$r2<$2kH$$$&9W8%r7$F$$$k.



?^4 API $NE}0l$Khk0\?"@-$N8~>e

- %7%9%F%`3+H/KMW9$k4|4V

0lHL$K, MPP $, 2G/$+$i3G/$+1F3+H/5lkNKBP7F, 7W;;5!%/%i%9%?$r9=@.$9$kWS/PC $O3%v7n$+$iH>G/Kh$K?7@=IJ$,EP>l$9kN$,8=>u$G$"$k. $=$N$?$a, F1;~4|$KF~<j2DG=$JMPP $H7W;;5!%/%i%9%?$G%W%m%;%C%5$N@$Be$,0c$&$H$$&8=>]$bH/@8$9$k.

- %7%9%F%`J]<i$N%3%9%H

MPP $OHW/SW $N0ED j@-$,9b$/%a%s%F%J%s%9$b0QBwG-kNKBP7$F, 7W;;5!%/%i%9%?$OHW/SW $N0ED j@-$,Hf3SE*Dc$/, 4pK\E*$K<+J,$G%a%s%F%J%s%9$,I,MWG"k?$aJ]<i%3%9%H$,9b$/$J$k.

0J>e, Cx<T$N<g4Q$r8r$($FMPP $H7W;;5!%/%i%9%?$rHf3S7?. 7W;;5!%/%i%9%?$,$IsJbN$+Bg(GD$J%$%a!<%8$O;}CFD:1?H;W$&. 0J2<$G$O, hj6qBNE*$J7W;;5!%/%i%9%?$N8&5f!?3+H/F08~$r>R2p9k.

4. 7W;;5!%/%i%9%?$N8&5f!?3+H/F08~

4.1 %Y%s%@;vNc

4.1.1 D6JBNs%/%i%9%?7O

IPM $NSP %7%j!<%:$d, IY;NDL$NAP3000 $CD6JBNs$N%9!<%Q!<%3%s%T%e!<%?H7F, Aa/$+$i;T>l$KEjF~$5lF$$k7W;;5!%/%i%9%?G"$k. 7W;;%N!<%I$K$O;THN$NWS MQ$K3+H/$5l?bNr[$\$=N^^N7AG:NMQ$7, J#?t%N!<%I$r@lMQ$Nc~BN$KG<a?bNr@lMQ$N9bB.%M%C%H%o!<%/$G@\B3$9$k7ABVrH$k. 7W;;%N!<%I$,%b%8%e!<%k2=5l$F$$k$?a, 4pK\E*$K$O%b%8%e!<%k$N8r49$@$1$G:G?7CPU $N@-G=$r5}<u9k3H$,$G$-$k. 7?$,$C$F, WS MQ$N?7$7$%b%8%e!<%k$,3+H/$5lkIQEY$G, %7%9%F%`$N99?7$,2DG=$KJC$F$$k.

4.1.2 SMP %/%i%9%?7O

B?$/$N%Y%s%@$,<!@$Be%5!<%PH7$F, 7W;;5!%/%i%9%?$r;T>l$KEjF~$7;OaF$$k. $=$NB?$/$O, :GBg9=@.$G%7%9%F%`A4BN$N%W%m%;%C%5?t$, 256 BfDxEY$N9bJBNs7W;;5!$N0l3Q$r@jaF$$k.

SUN Microsystems <R$O, Ultra Enterprise %5!<%P$r1%N!<%I$H7F:GBg4%N!<%I$G%/%i%9%?$r9=@.9k%7%9%F%`$rDs6!$7$F$$k. %M%C%H%o!<%/%+!<%IH7FOSbus MQ$NSCI %+!<%I$r3+H/$7, 4%]!<%H$NSCI %9%$%C%A$G@\B3$7$F$$k.

DEC <R!8=Compaq <R!K$O, <+<R3+H/$NMemory Channel II $r;H$C$?@=IJ$N6!5k$r9T$C$F$$k. 7W;;%N!<%IH7FO, F1<R$NAlpha %A%C%W$r:GBg120CPU Ek:\$7$3$lir3,AXE*$J/%m%9%PLV$G@\B3$7$?SMP %5!<%P$r;HMQ$9$k. Memory Channel $O, 6&M-%G!<%?$N=q9~$_$K4X7F<c43FC<l$JA`:n$,I,MW$G$"$k$,, 6&M-%a%b%j$K=`$:$k%f!<%6%s%?%U%'!<%9$rDs6!7F$*$j, $=$N5!G=$rMxMQ$7$F:YN3EY$NDL?.KbBP1~G-$k%=%U%H&%'%"$KhkJ,;66&M-%a%b%j4D6-$N3+H/$r9TCF$$k.

Sequent <R$OPentiumPro 4 Bf$NSMP %/%i%9%?$r SCI =`5r$N%j%s%/(Link B.EY8Gbps, J#?t%j%s%/9=@.) $G%j%s%0u$K@\B3$9$kNUMA-Q $r6!5k$7$F$$k. %O!<%I&%'%"$K$h$k4QA4$JJ,;66&M-%a%b%j4D6-$r<B8=$7, :YN3EYJBNs=hM}$r<B8=$9$k. %M%C%H%o!<%/%+!<%I$, NUMA-Q $K$+$J$jFC2=$5$l$F$$k$,, %M%C%H%o!<%/<+BN$O SCI %Y!<%9$NI8=`IJ$G$"$k. N`;w$N%7%9%F%`H7$F, Data General <R$NAV25000 $,$"$k.

4.2 8&5f=j, Bg3X4X78

4.2.1 5f6KN*<j7Z%/%i%9%?

JF9q$N%m%9%"%i%b%99qN)8&5f=j$,3+H/7?7W;;5!%/%i%9%?Avalon $O, %3%b%G%#%F$$!&O!<%I&%'%"Kh$kHU%j!<%=%U%H&%'%"$@1G:nilF*$j, DEC $NAlpha 68 Bf$K%U%j!<$JPC UNIX $N0l$DG"$k Linux $rEk:\$7, DL>o$NFastEthernet $HGigabitEthernet $G

[1] :G6a$NJBNs7W;;5!$O, :G=i$+$i MPI $r<BAu$7?bN$,B?$$$,, MPI $r;H&$H MPP $NHW@-G=$,==J,$KH/4x$G$:$K7W;;5!%/%i%9%?HNM-0U:9$,=P$;$J$$H$$&LdBj$,$"$k.

@\B3$7$?%7%9%F%`$G$"$k. <j:n$j%7%9%F%`rAH_N) $F, 15 K|%I%k$NEj;q$G 19GFLOPS $rC#@.$7F*$j, 15$/MFLOPS $N%3%9%H%Q%U%)!<%^%s%9%G$"$k.

4.2.2 D6JENs7W;;5!$NBeBX$H7F$N7W;;5!%/%i%9%? 2f$,9q$N?7>pJs=hM}3+H/5!9=(RWC) $G3+H/$5$1$F $$kMyrinet %Y!<%9%N7W;;5!%/%i%9%?[1)] $O, D6JENs7W;;5!$HHf3S7FB=?'NJ$@-G=$r=P$9%3$H$rL\I8$H$7 Fk. Avalon $,4pK\E*$KHW/SW $NA4$F$r4{@=IJ$G 9=@.7?NKBP7F, RWC $N%/%i%9%?$G$O, HW $O A4$F%3%b%G%#%F%#ItIJG"k,, NIC %+!<%I$N%I%i%$ %P, OS, DL?.%i%$%V%i%j, 8@8l=hM}7O$H$$$C$?SW A4 BN$KEOCFFH<+$K3+H/!?2~NI$7$?%7%9%F%`$G$"$k. 8e =R$N NOW %W%m%8%'%/%H$N Active Message, %$%j%N %$Bg3X$NFast Message[13)] $H8*$rJBYFCxL>$JUENsDL ?.%i%$%V%i%jPM $r3+H/$7$F$$k. >\:Y$OK\FC=8$N JL5-;vEy$r;2>H$5l?$$.

4.2.3 7W;;5!%/%i%9%?Kh$k%9%1!<%i%V%k**I/O**

%+%j%U%)%k%K%"Bg3X%P!<%/%l%$9;$G$O, 1990 G/Be$N =iF,$+$iNetwork of Workstations(NOW) $N8&5f$, 9Iol$F$$k[12)]. IAi+$H$$$&$H, OS $d%G%#%9%/ 2s$j$N8&5f$,Cf?4G"$k. 8=:_$O, 140 Bf$NWS(OS $OSolaris) $H35 Bf$NPC(OS $OPC UNIX $"$k$$$O WindowsNT) $rMyrinet %Y!<%9%N%M%C%H%o!<%/$G@\ B3$7$F$$$k. %7%9%F%`Fb$K$O1000 Bf6a$,$%O!<%I%G%# %9%/$,$"$j, FH<+$K3+H/$7$?%5!<%P%l%9!&U%!%$%k%7 %9%F%`xFS $r;HMQ$7$Fdisk-to-disk %=!<%H$N%Y%s%A %^!<%/$G1997 G/4 7n;~E@$N@$3&5-O?$rC#@.7F$$k.

xFS $O, !¥m!<%+%k%G%#%9%/>e$N%G!<%?hj$b, B> $N7W;;5!$N<g5-21K"$k%G!<%?$NJ}$,B.$/%"%/%;%9$G $-$k!W$H$$$&H/A[$N85$K, %G!<%?$r;HMQ$9$k%/%i%$%" %s%H$N<g5-21$r0%m!<%P%k$J6&M-%U%!%$%k%-%&C%7%e H7$F;HMQ$9$k cooperative caching $d, J#?t7W;;5! $N%G%#%9%/$K8YCF%9%H%i%$%T%s%0$r9T$&%=%U%H%&%' %"RAID $N<jK!$JIrl~MQ9k3H$G%9%1!<%i%V%k $G2DMQ@-$N9b$$%U%!%$%k%7%9%F%`$r<B8=7F$$k.

4.2.4 6&M-%a%b%j4D6-$rL\;X$7$F

%=%U%H%&%'%"Kh$k6&M-2>A[5-21%7%9%F%`(SVM) $rDs0F$7$?%W%j%s%9%H%sBg3X$NK.Li iN%0%k!<%W$O 4-Way PentiumPro $r%Y!<%9$K7?SMP %/%i%9%? SHRIMP $r3+H/$7$F$$k[14)]. SHRIMP GO, %M%C%H %o!<%/%$%s%?%U%'!<%9%r2>A[2=$7, %W%m%F%/%7%g%s$r 4K$a$:$K%f!<%6%l%Y%kDL?.$r2DG=$K9k5!9=H7$F, 2>A[%"%I%l%96u4V$K%M%C%H%o!<%/%$%s%?%U%'!<%9$N %A%&M%k$r%^%C%T%s%0$9$kVirtual Memory Mapped Channel $rDs0F$7, 3l$r<B8=$9$k?$a$N@lMQ%M%C%H %o!<%/%$%s%?%U%'!<%9%+!<%I%r3+H/7F$$k. #2DN %W%m%;%94V$G0lC6, %A%&M%k$r@_D j9k$H, $=$l0J8e $N%W%m%;%94VDL?.$O$=$N%A%&M%k$KBP1~$9$kNN0h$r6& M-%a%b%jH7$F;HMQ$9k3H,G-, DL?.NEYK%7%9 %F%`%3!<%k$r2p$9I,MW$,$J$/$J$k.

5. $*$ojK

%9!<%Q!<%3%s%T%e!<%?$H$$($P%Y%/%H%k7W;;5!$G $"$C?10 G/A0, !0B2A$JHFMQ%^%$%/%m%W%m;%G5$rBt ;3$D$J$$G, %Y%/%H%k7W;;5!KIE(9k@-G=$r=P$9!W $H$$&N,JENs7W;;5!NkpJ86gG"$C?. $=$7$F:# F|, !IPC $"$k$$$OWS rE,EYKDJ$$G@lMQJENs7W ;;5!KIE(9k@-G=$r=P$9!WHkpG$F$$$kN,7W;;5! %/%i%9%?G"$k. A0<T$N>l9g, !0V<!=hM}!W$+$i!JENs =hM}!W$H$$&?$K5;=QE*$JJQ3W$,$"C?NKBP$7, 8e <T$O !¥/H$$d$9$5!W$d!¥3%9%H%Q%U%)!<%^%s%9!W$NDI 5f$H$$&, JENs=hM}5;=Q$N!¥/E8!W$+$i!0V.=O!W$X$N JQ3W$G$"$k$H$$($k.

7W;;5!%/%i%9%?$NIa5Z$KhC$FJENs=hM}$NI_5o$,2< $,$j, hjB?$/$N%W%m%0%i^$,JENs=hM}$rBN83$9$k5! 2qrbC?3HOHs>o$KM-0U5A$G$"$k. 3Nh&$J%V %l!<%/%9%k!<$KhCFJENs=hM}$,0lIt$N8&5f<TN?a $N5;=Q$GOJ$/, 4/0lHLNEv?$jA0$N5;=QHJk3 Hr4j$&<!BhG"$k.

;2 9M J8 8%

1) IYEDbC<#, "JENs%3%s%T%e!<%?)3X," ><98F2, 1996.
2) Al Geist, et al., PVM:Parallel Virtual Machine A Users' Guide and Tutorial for Networked Parallel Computing, MIT Press.
3) MPI forum, MPI:A Message Passing Interface Standard, 1995.
4) Nanette J. Boden, et al., "Myrinet: A Gigabit-per-Second Local Area Network," *IEEE Micro*, pp 29–36, 1995 Feb.
5) Marco Fillo and Richard B. Gillet, "Architecture and Implementation of MEMORY CHANNEL2", *DIGITAL Technical Journal*(on line), 28 Aug. 1997. (http://www.digital.com/info/DTJP03/DTJP03HM.HTM)
6) IEEE Standard for Scalable Coherence Interface(SCI), IEEE Std 1596-1992.
7) T. Agerwala, et al., "SP2 System Architecture," *IBM SYSTEM JOURNAL*, Vol. 34, No.2, 1995.
8) AP3000 $4>R2p;qNA, IY;NDL3t<02q<RHPC K\It, 1995.
9) S.Mori, et al., "A Distributed Shared Memory Multiprocessor:ASURA — Memory and Cache Architectures —," *Proc. of SUPERCOMPUTING 1993*, pp.740–749, 1993 Nov.
10) @DLZ, B>, "6&M-%a%b%j%Y!<%9%N%7!<%'%l%9$JUENs7W;;5!4D6-$r<B8=9k*%Z%l!<%F%#%s%0%7%9%F%`$N9=A[," >pJs=hM}3X2q8&5f2qJs9p, 97-OS-74, pp.195–200, 1997 G/2 7n.
11) <jDM, KY, @P@n, "%o!<%/%9%F!<%7%g%s%/%i%9%MQDL?.%i%$%V%i %jPM $N@_7W$H<BAu," *JSPP'96*, pp.41-48, 1996 June.
12) T.E. Anderson, et al., "A Case for NOW(Networks of Workstations)", *IEEE Micro*, pp.54–64, 1995 Feb.
13) High Performance Virtual Machines %[!<%'%Z!<%8 (http://www-csag.cs.uiuc.edu/projects/hpvm.html)
14) Matthias A. Blumrich, et al., "Virtual Memory Mapped Network Interface for the SHRIMP Multicomputer," Proc. of Int'l Symp. on Comp. Arch., pp.142–153, 1994.