JBNs7W;;5!20$+$i$_$?7W;;5!%/%i%9%?

?9 bC0lO: IY ED bC <#

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

1. O8aK

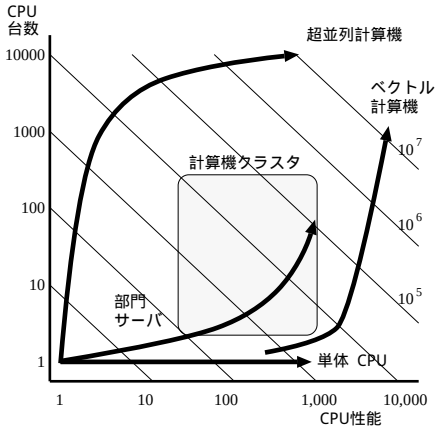
1980 G/Be8eH>$^$G$O, %9!<%Q!<%3%s%T%e!<%?$H$$$(
$P%Y%/%H%k%W%m%;%C%5$G$"$j, JBNs7W;;5!O^$@$^$@L$
=O$J5;=Q$H$$$C$?46$G$"$C$?$,, @$3&$NTOP500 Supercomputers[1y] $N:#G/67n$NE}7WGO, TOP10 $OA4$F512%W%m%;%C%50J>e$ND6JBNs7W;;5!(MPP), TOP30$^$G$, 100%W%m%;%C%50J>e$NJBNs7W;;5!$+JBNs%Y%/%H%k5!$G$"$j, 10%W%m%;%C%50J2<$N%^%7%s$O20 7oKHI^CF$$k. JBNs=hM}$O8&5fBP>]$N;~Be$+$i<BMQ2=$N;~Be$X$H8~$+$$$DD"$k.

3N4V, 2f!9JBNs7W;;5!20$O, ?t@i, ?tK|Bf5,LO$^$G%9%1!<%i%V%k$J%"!<%~F%/%A%cOI$&$"kY$~$+, $^$?, JBNs=hM}%*!<%P%X%C%I$r7Z8:$7:YN3EYJBNs=hM}KBQ(F@$kDc%l%$%F%s%7, 9b%9%k!<%W%C%H$N%a%b%j!?%M%C%H%o!<%/%$%s%?%U%'!<%9$rG!2?$K@_7W9Y$~$+EyJI$N8&5f2]Bj$K<hjAHsG~$?. 3Nh&$JBNs=hM}5;=Q$NH/E8$H%^%$%/%m%W%m%;%C%59bB.2=$N2870Cr&1F, :#F|, B?$/$NJBNs7W;;5!$,:G@hC<$N%9!<%Q!<%3%s%T%e!<%?$H7F3hLv7F$k.

0lJ}$G, 3Nh&$J%9%Q%3%sO)@~rAvkD6JBNs$"$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=$J?t10Bf5,LO$N%W%m%;%C%5rbC?ItLg%5!<%PE*$J%_%C%I%l%s%8$NJBNs7W;;5!G"$k. $=$NCfGb, :G6aCmL\$r=8aF$$kN, !VW;;5!%/%i%9%?!WG"$k.

7W;;5!%/%i%9%?$O, C1BN$N%Q!<%=%J%k%3%s%T%e!<%?(PC) $d%o!<%/%9%F!<%7%g%s(WS), >19gKhCF$OPC/WS $N>.5,LOJBNs7W;;5!$r, Hf3SE*MF0W$KF3F~2DG=$JHFMQ$N%M%C%H%o!<%/$G@\B3$7$?01<o$NJBNs7W;;5!$H8+J9$3$H$,$G$~$k. CPU @~G=$N5^B.$J1dSr<u1F, %3%9%H%Q%U%)!<%^%s%9$KM%$l$?JBNs7W;;5!$H7F$NCO0L$rC[$~$DD"$k.

JBNs7W;;5!H7FOIAi+$H$$$&$H%m!<%(%s%I$J J,N'$KF~$kNG, Ev=i$OJBNs7W;;5!20$O$"$^j5$$K$+$1$F$$$J$+$C$?$,, <!BhKCNi$L?6$jr7$F$$kLuKO$$$+J/JCF~$?$NG"$k.



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

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

2.1 %M%C%H%o!<%/%$%s%U%i$N5^@.D9

Windows95 $NEP>l$KA08e7F%M%C%H%o!<%/%$%s%U%i$N5^B.$J@0Hw, H/E8$,9Tcl, F|>cE*$KMxMQ$9$k%M%C%H%o!<%/$N@~G=$,, 10Mbps $+$i100Mbps KBej, 0lItGO1Gbps $bIa5Z$7;OaF$$$k. $3$3?tG/$G0E2A$G$"$jJ,$i%P%s%II}$N9b$$%M%C%H%o!<%/$N9=C[$,2DG=HJCF$~$?.

$^$?, %$!<%5%M%C%H$N%9%$%C%A%s%0%O%VdATM %9%$%C%AJI$KBeI=$5lkh&$K, LAN $N%"!<%~F%/%A%c$,%P%97?$+$i%9%$%C%A7?$XE>4.9$7$?$?$3HO, 7W;;5!%/%i%9%?$N9b@~G=2=$KGo<Vr+1F$$$k. G$0U$N7W;;5!4V$NDL?.$,B>$NDL?.$NK8$2$KJi$J$$?$aAm0g%9%k!<%W%C%H$,8~>e$7, JBNs7W;;5!$NAj8_7k9gLVH7$F

[1y] J.Dongarra Ey$,H>G/Kh$K=P$7F$$k@$3&$G3hLv$7F$$k9b@~G=%3%s%T%e!<%?TOP500 $N%j%9%H(http://www.top500.org/).:G=i$NE}7W$G!<%?$O1993G/.

$N2ACM$,8~>e9kE@$H, 7W;;5!4V$NJ*M}E*$J5wN%$K4X 9k@)Ls[y$,4KOB$5lk3HKh$j, N%$l$?0LCV$K$" $k7W;;5!$r#1DN%7%9%F%'NCfKHj3'3H$,2DG= KJ$kE@$,Bg$-$J9W8%G"$k.

0lJ}, 1990 G/BeA0H>KO, HFMQ$N%$!<%5!<%M%C%H$H $C0[$J$kFH<+O)@~$G 1Gbps %/%i%9$N%P%s%II}$rL\I8 H7$?%M%C%H%o!<%/$,Aj<!$$GEP>l7?. $=$NB?$/ $,, !¥M%C%H%o!<%/<+BN$N?.Mj@-$,9b$/(%Q%1%C%H%m %9$d%G!<%?%(%i!<$,6KaFDc$$), $+$D, %;%-%e%j%F%# E*Kb?.MjG-$k%7%9%F%'$@1,@\B3$5$l$F$$$k!W$H $$$&A0Ds$N85$K%M%C%H%o!<%/$r@_7W$7$F$$$k. 3N$h $&$J%M%C%H%o!<%/$O !ÍAN!W$KBP7F !ÍAN(System Area Network)!WHb8FP1$F$$$k. SAN $NA0Ds$O =>Mh$NJBNs7W;;5!$NAj8_7k9gLV$NA0Ds$HEy2AG"$k. 7?$,CF, ?.Mj@-$d%;%-%e%j%F%#J];}N?aNITMW $J%W%m%H%3%k=hM}$rJ/7?7ZNI%W%m%H%3%k$N<BAu$, 2DG=HJC?.

Myricom <R$N Myrinet, DEC <R(8=Compaq <R) $N Memory Channel, ANSI/IEEE 1596 $G5,3J$,Dj ail? SCI(Scalable Coherent Interface) JI$, $=$NNcG"$k. FC$K, Myrinet $KCmL\$9kH, Myrinet $O%M%C%H%o!<%/!&$%s%?%U%'!<%9!&+!<%I(NIC) $N ;EMM$r8x3+$7, %f!<%6$,$"$kDxEY%W%m%H%3%k$r%+%9%? %^%$%:2DG=J?$a, JBNs=hM}$rL\;X$98&5f<T$NCmL\$r =8a?. $=$N7k2LH7$F, Myrinet $rA0Ds$H7?@vN} 5l$? API(Application Programmer Interface) $r bC$?%I%i%$%P%=%U%H%&%'%"$,@$3&3FCO$G3+H/5l, Myricom <R$NWWW >e$GAj<!$$G8x3+5l$?. $=$N 7k2L, 3lir;HC?Dc%l%$%F%s%7, 9b%9%k!<%W%C%H $N%M%C%H%o!<%/$,C/GbMF0W$KF~<j2DG=$KJC$?$N$G $"$k[!y!y].

DL?.$N%l%$%F%s%7$K4X$7FO, $^$@$^$@lMQ$K3+H/ 5l$?JBNs7W;;5!KO5ZPJ$$$, >/J/Hb, DL?. %P%s%II}$K4X$7FO%9!<%Q%3%s%T%e!<%?%/%i%9$N@-G= $, PC %l%Y%k$G$b;H$(kh$&$KJCF-$?$NG"$k. 7W;;5!%/%i%9?$r9=C[9k$?$a$N%O!<%I%&%'"4D6-$, @0C?LuG"$k.

2.2 HFMQJBNsDL?.%i%$%V%i%j$NIa5Z

JBNs=hM}$,9-$/Ia5Z7O8akH, %W%m%0%i%'3+H/ <TKHCF#1DNBg$-$JLdBj$,L@$i$+$KJCF-$?. ;T>l$K$O, L%NCE*$J@-G=$r;}$C$?JBNs7W;;5!$,<!!9$K EP>l$9k,, $=$NKXsI$,FH<+$N@lMQDL?.%i%$%V%i%j $r;}$CF*$j, %W%m%0%i%'$N0\?"@-$,Hs>o$K0-$+$C$? NG$"$k.

$=$NCf$G, 1989 G/$KJF9q Oark Rigde 9qN)8&5f =j$,3+H/$7$? PVM(Parallel Virtual Machine) $O TCP/IP %Y!<%9$N%a%C%;!<%8DL?.%i%$%V%i%j$G$"$j, J#?t$N7W;;5!$N=89gBN$r2>A[E*$K#1BfNBg-$JUBNs7W ;;5!$H7?F8+$;k$?$a%+%K%:%'$rDs6!7?NG$" $k. 3l$,7W;;5!%/%i%9?$N%=%U%H%&%'"4D6-$NKk3+ 1G$"$k. PVM $O WS %/%i%9?$N$?a$N4D6-H7 $F3+H/$5l?$,, $=$N8e, B?$/$NJBNs7W;;5!XN0\?"$, 9T$o$l, JBNs7W;;5!Aj8_4V$G$N0\?"@-$,8~>e7?. $5 iK8=:_GO, PC, WS $+$iD6JBNs7W;;5!$^$G%7!<%' %l%9$JUBNs=hM}4D6-$rDs6!9kEZBfKJCF$$$k.

PVM $,%a%C%;!<%8DL?.$N$?a$N4D6-$=$NbN$rDs 6!$7$?$NKBP7$F, JBNs7W;;5!%a!<%+, 3X=Q5!4X, 4k 6H$N8&5f<T$i$,=8$^CF1992 G/$K%9%?!<%H$7$?MPI Forum $,@)Dj$9$kMPI(Message Passing Interface) $O, PVM GN7P83$b3hMQ7F%a%C%;!<%8DL?.N?a $NAPI;EMM$rDja?. MPIGDja$?API$rDs6!9k %i%$%V%i%j$rINh&$K<BAu$9k+OG0UG"$j, :G 6a$NJBNs7W;;5!KC$=$N7W;;5!$KFC2=$7$?MPI <BAu $,MQ0U$5lF$$$kbN$,B?$$. $^$?, MPI $N<BAuNc$H 7FUJF9q Argonne 9qN)8&5f=j$,0\?"@-$r=E;k7F3+ H/7? MPICH $O%=!<%9$3!<%I$,%U%j!<$G8x3+5l $?$?$a, PVM F1MMB?$/$N%7%9%F%'$K<BAu5lF*$j, :#$O Windows95/NT HG$bB8:_$7$F$$$k.

0lJ}$G, %f!<%6%W%m%;$94V$G%7%9%F%'$3!<%k$r2p$5 $:$KDL?.$r9T$&$?a$N!¥f!<%6%l%Y%kDL?.!W$d, %W%m%H %3%k%9?%C%/4V$NITMW$J%G!<%?%3%T!<$rGS=|9k!¥<%m%3%T!<DL?.!WJI$NDL?.%i%$%V%i%j<+BN$N:GE,2=$, 9Tol, DL?.%=%U%H%&%'"$K5/0x$9$k%l%$%F%s%77Z8: N?a$NB?/$N%=%U%H%&%'%"5;=Q$,3+H/$5l?.

3Nh&$JHFMQJBNsDL?.%i%$%V%i%j$NIa5Z$Khj, JBNs%W%m%0%i%'$N0\?"@-$,Cx7/8~>e$7, B?$/$NJBNs %W%m%0%i%'$,3liN%i%$%V%i%j$rMQ$$$F3+H/5l $?$NG"$k. $=$7$F, JBNs7W;;5!$KD>@\%"%/%;9G$- J+C?f!<%6$b, TCP/IP %Y!<%9$N%M%C%H%o!<%/$G @\B3$5l?J#?t$N%o!<%/%9%F!<%7%gsrMQ$$?JBNs7W ;;5!4D6-$GJBNs=hM}$rBN83$9$k5!2q$,Ds6!$5l?NG $"$k.

2.3 JBNs=hM}NI_5o,2<$,$k

— 7W;;5!%/%i%9?$OJBNs=hM}Ia5Z$N5/Gz:^—

3Nh&$K, 9bB.$J%M%C%H%o!<%/$G@\B3$5l?J#?t $NPC/WS $HHFMQ$NDL?.%i%$%V%i%j$GJBNs=hM}4D6-$, 9=C[$G$-$kh&KJkH, C'<!=hM}$GF|:";H$$Jl? 7W;;5!4D6-2<$GJBNs%W%m%0%i%'$N3+H/$,2DG=$HJj, $*;n$7463P$GJBNs%W%m%0%i%'$K%H%i%$$9$k%f!<%6$,EP >l9k3HKJ$k. $=$3G&$^/9T$/H, bCHJBNs=h M}$rJY6/7F;n7F$_h&$H$$$C$?@5N%U%#!<%I%P%C

[!y] 0lHI$KJBNs7W;;5!$G$O, %&%'!<%V%Q%$%W%i%$%sEy$N9bEY$J5;=Q$r :NMQ7J$$8B$j%W%m%;%;%54V$NJ*M}E*$J5wN%$O%M%C%H%o!<%/$N %P%s%II}$r7hDj9k=EMW$J0x;R$HJk.

[!y!y] Myricom <R$, SUN $NSbus MQ$N NIC $rDs6!$7$F$$$?1995 G/:"$O%3%b%G%#%F%#%O!<%I%&%'"$K$ODx1s$+C?$, PCIbus MQ $N NIC $r3+H/$7, @vN}5l$?9b@-G=$J%I%i%$%P=%U%H$,8x3+$5 lkh&KJCF%3%b%G%#%F%#%O!<%I%&%'"H7FNCO1L$r3M F@$7$F$$$C$?.

%/$,$+$+$j, !ŴW;5!%/%i%9%?4D6-!WGNUENs=hM}$,5^B.$KIa5Z7F$/$k3HKJC?LuG"$k.

$^$?, 0lHL$K7W;5!%/%i%9%?$r9=@.9k8D!9$N7W;;5!$CFH<+$NF~=PNCAuCV$rHw$($F$*$j, 7W;5!$NBf?t$K$[$\HfNc$7$FF~=PNC$N%P%s%II}$,9-$,$C$F$$$/. %O%$%(%s%I$NUENs7W;5!$r=|$1$P, F~=PNC@-G=$N%9%1!<%i%S%j%F%#$O=>Mh$NUENs7W;5!hj$b7W;5!%/%i%9%?$NJ}$,M%$lF*$j, 3N@-<A$rMxMQ7?7W;5!%/%i%9%?1~MQ$bL\N)AO8a$F$$$k. 3Nh&$K, 7W;5!%/%i%9%?<+BN$,JENs=hM}1~MQ$N?~Ln$r9-2k$H$$$&8z2L$b=P;O$a$F$$$k.

3. 7W;5!%/%i%9%?$N%$%s%U%i5;=QKh$kJ,N`

IAi+$H$$$&$H%=%U%H%&%'%"<gF3E*$K?JsG$-$?!ŴW;5!%/%i%9%?!WG"k,, :G6a$O@lMQ$N%O!<%I%&%'%"$r@Q6KE*$K<h$jF~$l$?, %O%$%(%s%I$JJENs7W;5!$r;X8~7?7W;5!%/%i%9%?$kEP>l$9kh$&$KJCF~$?.L@3N$J6hJL$,$"kolGOJ$$$,, 0lIt$N8&5f<I$NHcH=$r3P8g$N>e, 3lir !Ø5AD7O!W$H !Ø\7O7O!W$KJ,$F5DO@$7F_h&. N><I$N4pK\J}?K$r4:$($F6hJL9kJi$P, 85AD7O$O !ÑBf$N7W;5!$r;HCF1BfNH$-$K8=<BE*$J;~4V$G=hM}G-$k%G!<%?5%$%:$NNG\$N%5%$%:$N%G!<%?$r07$&3H!WG"$j, K\7O7O$O !ÑBf$NCPU $r;H$C$F, 1CPU NH$-$N7W;;~4V$N1/N $N;~4V$G7W;;G-k3$H!W$G$"$k.

3.1 !Ø5AD!W7W;5!%/%i%9%?

0B2A$J7W;5!$rE,EY$KBt;3$D$J$$G, L@F|KG$bJBNs=hM}$r$7?$$%0%k!<%W$G, !ŴW;5!%/%i%9%?!WAO@$5-$+$i3hLv7F$$kN,, 85AD7OG"$k.

IaDL$N%M%C%H%o!<%/$K@\B3$5$l$?7W;5!>e$GJLCJ$N%O!<%I%&%'%"$NDI2CbJ$/, PVM $d MPI $r;H$C$F%=%U%H%&%'%"$G%/%i%9%?4D6-$r9=@.$9kb$N !Ø&>N$H7F !ŴCK3?M$NUENs=hM}4D6-!W$H$b8F$PlF$$$?!K$+$i, %Q%=%3%s$N%Q!<%D$r>!CF$-$F%*j%8%J%k;EMM$N%Q%=%3%s$r:n$k463P$GD/lk8D?M$G;}$F$kJENs7W;;5!$H7F$N !ŴW;5!%/%i%9%?!W, $=$7$F, %O%$%(%s%I$J7W;5!%/%i%9%?8~$1$N%M%C%H%o!<%/$H7F3+H/5l$?%.%S%C%H%/%i%9$N@lMQ%M%C%H%o!<%/rD$+$C$F9=@.$9$k7W;5!%/%i%9%?$^$GMM!9$G$"$k.

MF0W$KF~<j2DG=$J%3%b%G%#%F%#tIJ$r;H$C$F5$7ZKAH_N)$F, %=%U%H%&%'%"$r:GE,2=7F@-G=$r%A%e!<%s%"%C%W$9kH$$$&7%9%F%'@_7W$,FCD'$G$"$k. %G!<%?%5%$%:$,Bg$-$$$H$$$&A0Ds$,$"kN$G, DL?.%l%$%F%s%7$K4X$9$k@)Ls$,<c434K$/$JCF$$$k.

A4BNE*$J798~$H7F, JENs=hM}N?aN%W%m%0%i%_%s%0%b%G%kH7FO, %a%C%;!<%8%Q%C%7%s%0$rA0Ds$H9kbN$,B?$/, <+$iJENs%W%m%0%i%'$r5-=R9k3HNG$-$k%f!<%6$,@l$i$N%f!<%6$G$"$k.

3.2 !Ø\2H!W7W;5!%/%i%9%?

K\2H7O$r%j!<%I$7$F$$kNO, JENs=hM}$r8&5f$NBP>]H7F*$j, =>Mh$+$iJENs7W;5!$N3+H/$K4X78$7$F$$$?%0%k!<%WG"$k. IAi+$H$$$&$H%O%$%(%s%I;X8~G"$C?:#$^GNUENs=hM}5;=Q$r7W;5!%/%i%9%?$X1~MQ9k3H$G7W;5!%/%i%9%?$N9b@-G=2=$rL\;X$7$F$$$k. 3N%0%k!<%W$O!<%W$N9b@-G=2=$rL\;X$7$F6&M-%a%b%j$r;Y;}9kbN$,B?$$.

=>Mh$NUENs7W;5!$NNr;K$HF1MM, %O%$%(%s%I$J7W;5!%/%i%9%?$b, $^$:$O%a%C%;!<%8%Q%C%7%s%07?$,Ia5Z7F, <!$K6&M-%a%b%j7?$K0\$k798~K"$k. EvA3$N3HJ,$i, %W%m%0%i%_%s%0%9%?$%k$b6&M-%a%b%j;X8~$HJj, PVM/MPI KBeC$F, HPF $d OpenMP JI$N<+F0UENs2=$r0U<1$7?$bN,<gHJ$k. >-MhE*KO, C'<!7W;5!$+$i7W;5!%/%i%9%?, $=$7$FD6JENs7W;5!$K;jk^GN%7!<%'%l%9$JUENs=hM}4D6-$r%=%U%H%&%'%"!?%O!<%I%&%'%"$NN>LL$G<B8=9k3H$rL\I8$H7F$$$k.

$=$N0YKO, %O!<%I%&%'%";q8;$N2>A[2=$dDL?.%l%$%F%s%7$N7Z8:!?1#JC$,I,MW$G$"$j, $=$l$r<B8=$9k?aK%M%C%H%o!<%/$d%a%b%j2s$j$K6/NC$J%O!<%I%&%'%"%5%]!<%H$,$"kN$,FCD'$G$"$k. 3N%/%i%9KJCF$/$k$H=>Mh$NUENs7W;5!HN%"!<%-%F%/%A<e$N:9JL$,$[$HsIJ/JCF/$k. J*, 7W;5!%a!<%+$,65k9kSMP %5!<%P$N<!@$BeHG$O35M3$N7ABV$rHCF$/kH9M$(il$k.

2f!9$bSMP %5!<%P$K, %O!<%I%&%'%"Kh$kJ,;66&M-%a%b%j5!G=$rbC$?%M%C%H%o!<%/$+!<%I$rEk:\$7,8w$U%!$$%P$H%/%m%9P!<%9%$%C%A$G@\B3$7$?2J,;66&M-%a%b%j7?UENs7W;5! ASURA $r 1992 G/$KDs0F7?$,, $^$5$K:#$G$$&H3mN%O%$%(%s%I$NSMP %/%i%9%?$KB0$9$kJ*$G$"$k.

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

4.1 %Y%s%@;vNc[y

B?$/$N%Y%s%@$,<!@$Be%5!<%PH7$F, 7W;5!%/%i%9%?$r;T>l$KEjF~$7?;O%a$F$$$k. $=$NB?$/O, :GBg9=@.$G%7%9%F%'A4BN$N%W%m%;%C%5?t$, 256 BfDxEY$N9bJBNs7W;5!$N0l3Q$r@j$a$F$$$k.

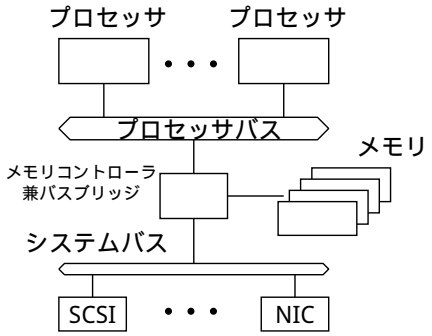
BeI=3J$N#1$D$OSUN $NEnterprise Cluster %7%j!<%:$G, Ultra Enterprise %5!<%P$r1 %N!<%I$H7F:GBg4 %N!<%I$G%/%i%9%?$r9=@.9k%7%9%F%'G"$k. %M%C%H%o!<%/%+!<%I$H7F$OSbus MQ$NSCI %+!<%I$r3+H/$7, 4 %]!<%H$NSCI %9%$%C%A$G@\B3$7$F$$$k. 1999 G/$^$GKO, :GBg12 %N!<%I(1024CPU) $N%/%i%9%?$r

[y] %Y%s%@;vNc$N%G!<%?$O, 1998 G/8 7nKv$N;~E@$G WWW Ey$GF~<j2DG=$J%G!<%?$K4p$E$$F$$k.

3+H/9k$H$$$C$F$$k. 64 %W%m%;%C%5$N Ultra HPC 10000 $r4%N!<%I@\B3$7$?8=:_$N:GBg9=@.%7%9%F%'$O:#G/67n$N TOP500 Supercomputer $G430L[y] $K%i%s%/$5lF$$k.

869F<9I.;~E@$G,%5!<%PItLg$NF08~$,$^$@ITL@$G$"$k$,, DEC <R!8=Compaq <R!K$O,<+<R3+H/$N Memory Channel II $r;H$C$?@=IJ$N65k$r9T$C$F$$k. 7W;;%N!<%IH7FO,F1<R$N Alpha %A%C%W$r:GBg120CPU Ek:\$7$3$lir3,AXE*$J%/%m%9%PLV$G@\B3$7$?SMP %5!<%P$r;HMQ$9$k. Memory Channel II $N%M%C%H%o!<%/<+BN$b%/%m%9%P!<LV$G,:GBg16 %N!<%I$r@\B32DG=G"$k. Memory Channel $O,6&M-%G!<%?$N=q9~$_$K4X7F<c43FC<l$JA':n$,I,MWG"k,[y][y], 6&M-%a%b%j$K='$:$k%f!<%6%$%s%?%U%'!<%9$rDs6!$7F*j,$=$N5!G=$rMxMQ$7$F:YN3EY$NDL?.KbBP1~G-$k%=%U%H&&'%"$KhkJ,;66&M-%a%b%j4D6-$N3+H/$r9TCF$$k.

Sequent <R$O PentiumPro 4 Bf$N SMP %/%i%9%?$r SCI='5r$N%j%s%/(Link B.EY8Gbps) $G%j%s%0>u$K@\B3$9$k NUMA-Q $r;T>l$K=P7F$$k. B?$/$N7W;;5!%/%i%9%?$,, ?^2$Nh&$K NIC $r%7%9%F%'%P%9$K@\B3$9$k9=@.rHkNKBP7$F, NUMA-Q $O CPU $d%a%b%j$,@\B3$5$l$k%W%m%;%C%5%P%9$K SCI='5r$N%M%C%H%o!<%/%"%@%W%?$r@\B3$9$k3H$G,%O!<%I&&'%"$Khk40A4$JJ,;66&M-%a%b%j4D6-$r<B8=$7,:YN3EYJBNs=hM}$r<B8=9k. NIC $, NUMA-Q K+JjFC2=5l$F$$k$,, %M%C%H%o!<%/<+BN$O SCI %Y!<%9$NI8='IJ$G$"$kNG%j%9%H%"%C%W7?. K\2H7O$N7W;;5!%/%i%9%?$KB0$9%7%9%F%'$G$"$k.



?^2 PC $dWS $NBeI=E*$J%N!<%I9=@.

Hs>o$KH=CG$,Fq$7$$N$,, IPM $N SP %7%j!<%:$dIY;NDL$N AP3000, $=$7$F HP $N Exampler X (5l Convex $N SPP2000) %7%j!<%:$G$"$k. A0<T#2DO,4pK\E*$K7W;;%N!<%I$O;THN$N%o!<%/%9%F!<%7%g$sMQ$K3+H/$5l?bN$r,@lMQ$N9bB.%M%C%H%o!<%/$G@\B3$7,@lMQ$Nc~BN$KG<a?bNG"$k. 3lKBP7$F,Exampler X %7%j!<%:$O 7W;;%N!<%I$O2<0L%/%i%9$N SMP %5!<%P$rSCI='5r$N@lMQ%M%C%H%o!<%/$G@\B3$7$?J*G"$k. 3liN5!<o$O3<RHb=>Mh$NJBNs7W;;5!G"kHJ,N'7F$$k$,, 7W;;5!%/%i%9%?$H$N6-3&NN0h$K0LCV9k$H9M$(il$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?Beowulf 7?$N7W;;5!%/%i%9%?Avalon $O,%3%b%G%#%F%$!&O!<%I%&'%"HU%j!<%=%U%H&&'%"$@$1$G:n$ilF$*j,DEC $N Alpha 68 Bf$K%U%j!<$J PC Unix $N0l$DG"$k Linux $rEk:\$7,DL>o$N FastEthernet $G@\B3$7$?7%9%F%'$G$"$k. %M%C%H%o!<%/$O,36 %]!<%H$N FastEthernet %9%$%C%A4Bf$H,3liN%9%$%C%A$rAj8_$K@\B3$9$k12 %]!<%H$N GigabitEthernet %9%$%C%A1Bf$G9=@.5l$F$$k.

3l$@$1%7%s%W%k$J%7%9%F%'$G TOP500 Supercomputer $N 315 0L$K%i%s%-%s%0$5$l$k7rF.$VjG$"$k. 0x$K,<+A0$G%7%9%F%'rAH_N)$F,15 K|%I%k$G19GFLOPS $rC#@.$7F*j,15$/MFLOPS $N%3%9%H%Q%U%)!<%^%s%9$G$"$k. ?tCM$N>e$G$O 64 %W%m%;%C%5$N Origin 2000 KIE($9%k@-G=$G$"$k. C"$7,FastEthernet $N@-G=$r==J,$K0z$-=P9?aK,0lIt $N MPI 4X?t$rFH<+$K3+H/$7$?$bNr Linux >e$K<BAu$7$F$$k. NAS Parallel Benchmark $N7k2L$G$O,MPICH KHfY$F2G\6a$$%a%C;!<%8%P%s%II}$rF'@$F$$kh&$@.

4.2.2 %/%i%9%?3%s%T%e!<%F%#%s%0$NBg8f=j

%+%j%U%)%k%K%"Bg3X%P!<%/%/%l%$%O,%/%i%9%?3%s%T%e!<%F%#%s%0$NBg8f=jE*B8:_$G$"$j,1990 G/Be$N=iF,$+$i Network of Workstations(NOW) $N8&5f$r9TCF$$k. IAi+$H$$$&$H,OS $d%G%#%9%/2s$j$N8&5f$,Cf?4G"$k. 8=:_$O,Solaris %^%7%sH7$F 100 Bf$N UltraSPAC-I, 40 Bf$N SPARCstation, Windows NT $"$k$$$O PC UNIX %^%7%sH7$F 35 Bf$N PC $r Myrinet %Y!<%9$N Fattree $G@\B3$7$F$$$k. %7%9%F%'FbKO500-1000 Bf$N%O!<%I%&%'%"$j,$"$j,FH<+$K3+H/$7$?5!<%P%1%9!&U%!%$%k%7%9%F%'xFS $r;HMQ$7$F disk-to-disk %=!<%H$N%Y%s%A%^!<%/$G1997 G/47n;~E@$N@3&5-O?$rC#@.$7$F$$k.

xFS $O,!¥m!<%+%k%G%#%9%/>e$N%G!<%?jj,System Area Network >e$NB>$N7W;;5!$N<g5-21$K$"$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%!%$%k%-%c%C%7%eH7$F;HMQ$9$k cooperative caching $d,J,;66&M-%a%b%j7?JBNs7W;;5!K*1k%-%c%C%7%e014S@-@)8f$N<jK!$r3HD%7F, file C10L$N4IM}%N!<%I$r@E*$KJ,;6$9$k<jK!, Log-structured

[!y] LINPACK 80K×80K $G100GFLOPS

[!y!y] 99?7$9%Y$-6&M-%G!<%?$N%"%I%l%9=$NbNGO,J$/,%7%9%F%'%P%9>e$NNIC $N%G!<%?=q9~$_@lMQNN0h$X=q9~$_$r9T$&I,MW$,$"$k

File System(LFS) $K4p$E$/%=%U%H%&%'%"RAID $N9b B.2=<jK!Ey$r1~MQ7F, $"$kFCDj$N7W;5!$,%U%!%$%k %7%9%F%`A4BN$N4IM}$rC4Ev$9$k$H$$C$?>u67$,5/$i$J $$h$&$K$7$F$$k. $3$l$K$h$j%9%1!<%i%V%k$G2DMQ@-$N9b$%U%!%$%k%7%9%F%`$r<B8=7F$$k.

=>Mh$NJBNs7W;5!$KBP9k, 7W;5!%/%i%9%?$NI/O %7%9%F%`$N%9%1!<%i%S%j%F%#$H%3%9%H%Q%U%)!<%^%s%9 $,NI$/8=lF$$k.

4.2.3 6-L\$NJJBNs=hM}4D6-$rL\;X$7$F

%$%j%N%$Bg3X$N A. Chen Ey$N%0%k!<%W$O, %O!<%I%&%'%"$N@-G=$r2DG=$J8B$j0z$-=P$9%a%C%;!<%8%Y !<%9$NDL?.%i%$%V%i%jFM(Fast Message) $r<BAu$7 $?%W%i%C%H%U%)!<%`>e$G$N%7!<%`%l%9$J7W;5!4D6-HPVM(High Performance Virtual Machine) $N8&5f $r9T$G$F$$k. $=$N0l4DH7$F7W;5!%/%i%9%?$N8&5f $r9T$GF*j, Myrinet %Y!<%9$N7W;5!%/%i%9%?$K, FM $r<BAu$7, $=$N>e$KMPI $dput/get $rMQ$$?6&M-%a%b%j%$%s%?%U%'!<%9Ey$r<BAu7F$$k. A4$/F1$8 %f!<%6%$%s%?%U%'!<%9$r Cray <R$N T3D Kb<BAu$7 F*j, 7W;5!%/%i%9%?$+$iD6JBNs7W;5!$^$G%W%m%0 %i%`$N9b$$0\?"@-$,J]>Z$5lF$$k.

H`i,3+H/7?7W;5!%/%i%9%?$NBh;0@$Be%^%7%s$O %9!<%Q!<%/%i%9%?$HBFPlF*j, 300MHz Pentium II Processor $N2-Way SMP, <g5-21512MB, %O!<%I %G%#%9%/4GB 9=@.$N%N!<%I$r 128 %N!<%I Myrinet $H 100Mbit Ethernet $G@\B3$7$?$bNG, F1Bg3X$N NSCA $KF3F~$5lF$$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) $r Ds0F$7$?%W%j%s%9%H%sBg3X$NK.Li iN%0%k!<%W$O4-Way PentiumPro $rMQ$$?SMP %/%i%9%?SHRIMP $r3+H/$7$F$$k. SHRIMP GO, %M%C%H%o!<%/%$%s%?%U%'!<%9$r2>A[2=$7, %W%m%F%/%7%g%s$r4Ka:$K%f!<%6%l%Y%kDL?.$r2DG=K9$k5!9=$H7F, 2>A[%"%I%l%96u4V $K%M%C%H%o!<%/%$%s%?%U%'!<%9$N%&%$%s%I%&(Channel) $r%^%C%T%s%0$9$k Virtual Memory Mapped Channel(VMMC) $rDs0F$7, 3l$r<B8=$9k?%a$N@lMQ%M%C %H%o!<%/%$%s%?%U%'!<%9%+!<%I$r3+H/$7$F$$k. #2$D $N%W%m%;%94V$G0lC6, Channel $r@_Dj$9kH, $=$l0J 8e$N%W%m%;%94VDL?.$OChannel $KBP1~$9$k%&%$%s%I %&$r6&M-%a%b%j$H7F;HMQ9k3H$,$G$-, DL?.$NEY $K%7%9%F%`%3!<%k$r2p$9I,MW$,J/Jk.

3Nh&$JJ,;66&M-%a%b%j4D6-$rDs6!9k$?%a$K$O, %W%m%;%C%5Fb$GH/@8$7$?%G!<%?$NUQ99$r8!=P9kI,MW $,$"$k. $=$NL\E*N?%a$K, %W%m%;%C%5%P%9$K%P%94F ;kN?%a$N%O!<%I%&%'%"$r@_$1, $=$N%O!<%I%&%'%"$K hj%G!<%?$N0l4S@-J];}$NI,MW@-$rH=CG$7, I,MWG" lP6qBNE*$J=hM}$O%7%9%F%`%P%97HM3$G9T$&$H$$&J} <0rHCF$$k.

5. $*$ojK

%9!<%Q!<%3%s%T%e!<%?$H$$($P%Y%/%H%k7W;5!$G $"$C$?10G/A0, !0VB2A$JHFMQ%^%$%/%m%W%m%;%C%5$rBt ;3DJ$$G, %Y%/%H%k7W;5!KIE(9k@-G=$r=P$9!W $H$$&N,JBNs7W;5!$Nkp$$J86gG"C?. $=$7$F:# F|, !WS $"$k$$$OPC rE,EYKDJ$$$G@lMQJBNs7W ;5!KIE(9k@-G=$r=P$9!WHkpC$F$$kN,7W;5! %/%i%9%?G"$k. A0<T$N>l9g, !0V<!=hM}!W$+$i !VBNs =hM}!W$H$$&?%K5;=QE*$JUQ3W$,$"$C$?$NKBP7, 8e <T$O !VH$$d$9$5!W$d !¥3%9%H%Q%U%)!<%^%s%9!W$NDI 5f$H$$&, JBNs=hM}5;=Q$N !W/E8!W$+$i !0V.=O!W$X$N JQ3W$G$"$k$H9M$($k.

$^$?, =>Mh$NJBNs7W;5!$N8&5f!?3+H/$,%O!<%I%&%' %"<gF37?$G$"$C$?$NKhkf!?r:#$N7W;5!%/%i%9%? $N8&5f!?3+H/$O%=%U%H%&%'%"$k$$$O%f!<%6<gF3G" kH$$&NO, FCI.9Y$-E@$G$"$m$&.

7W;5!%/%i%9%?$NIa5Z$KhC$FJBNs=hM}$NI_5o$,Dc $/$J$j, hjB?$/$N%W%m%0%i%^$,JBNs=hM}$rBN83$9$k 5!2qrbC?3H$OHs>o$KM-0U5AG"$k. 3Nh&$J %V%l!<%/%9%k!<$KhC$FJBNs=hM}$,0lIt$N8&5f<T$N$? aN5;=QGOJ/, 4/0lHLNEv?$jA0$N5;=QHJ$k 3H$r4j$&<!BhG"$k.

;2 9M J8 8%

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