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

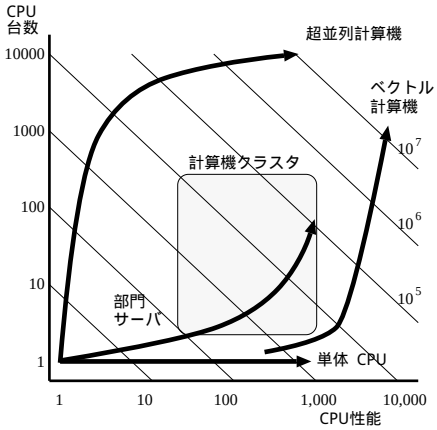
?9 bC0lO: IY ED bC <#

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

1. O8aK

1980 G/Be8eH>$^$G$O, %9!<%Q!<%3%s%T%e!<%?$H$$$(
$P%Y%/%H%k%W%m%;%C%5$G$"$j, JBNs7W;;5!O^$@$^$@
8&5fCJ3,$H$$$C$?46$G$"$C$?$,, :#F|, JBNs=hM}$O8&
5fBP>]$N;~Be$+$i<EMQ2=$N;~BeXH8~$+$$$D$"$k.
3N4V, 2f!9JBNs7W;;5!%"!<%-%F%/%H$O, ?t@i, ?tK|Bf
5,LO$^$G%9%1!<%i%V%k$J%"!<%-%F%/%A%c$N<B8=Ey, B?
$/$N8&5f2]Bj$K<h$jAHsG$-$?[1]. 3Nh&$JJBNs=h
M}5;=Q$NH/E8$H%^%$%/%m%W%m%;%C%59bB.2=$N287Cr&
1F, :#F|B?$/$NJBNs7W;;5!$,:G@hC<$N%9!<%Q!<%3%s
%T%e!<%?H7$F3hLv$7$F$$$k.

0lJ}$G, 3Nh&$JD6JBNs$"$k$$$O9bJBNs7W;;5!$H
$O, 0l@~$r2h7F<EMQE*$JJBNsEY$NJBNs7W;;5!$N3hLv
$bL\N)$CF-$F$$$k. 4k6H$NItLg%l%Y%k$dBg3X$N3X
2J%/%i%9$NAH?%$G$bF~<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.



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

7W;;5!%/%i%9%?$O, C1BN$N%Q!<%=%J%k%3%s%T%e!<%?(PC) $d%o!<%/%9%F!<%7%g%s(WS), >19gKhCF$O PC/WS %5!<%P$H$$$C$?>.5,LOJBNs7W;;5!$r, Hf3$E*MF0W$KF3F~2DG=$JHFMQ$N%M%C%H%o!<%/$G@\B3$7$?0l<o$NJBNs7W;;5!$H8+$J$9$3H,G-$k. %W%m%;%C%5$JiS$K%M%C%H%o!<%/@-G=$N5^B.$J?-$S$r<u$1$F, %3%9%H%Q%U%)!<%^%s%9$KM%l?JBNs7W;;5!H7FNCO0L$rC[$-DD$"$k. JBNs7W;;5!H7FOIAi+$H$$&$H%m!<%(%s%I$JJ,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.

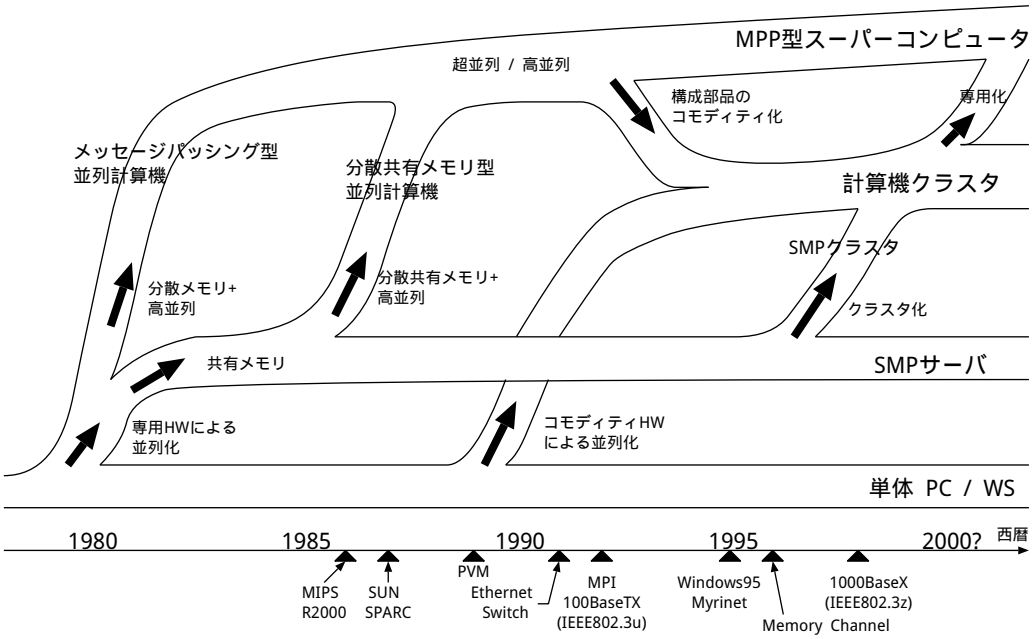
0J2<, K\9FGO7W;;5!%/%i%9%?$BfF,$NGX7JrN$Y, <!$KJBNs7W;;5!H7FN7W;;5!%/%i%9%?$NFCD'$r>R2p7?8e, 6qBNE*$J7W;;5!%/%i%9%?$N8&5f!?3+H/;vNc$r>R2p$9$k.

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

— JBNs7W;;5!$NEP>l —

HFMQ$N%^%$%/%m%W%m%;%C%5$r@lMQ$N%O!<%I%&%'%"(HW) $G6n;H$7$FJBNs@\B3$9$kJBNs7W;;5!$N8&5f$O 1970 G/Be=iF,$K;O$^$C$?. HFMQ%W%m%;%C%5$NDc2A3J2=KHbJ$$, 1980 G/BeA0H>KO8&5fMQ$NB?$/$NJBNs7W;;5!$,3+H/$5l$?. $=$3GO, %9!<%Q!<%3%s%T%e!<%?J_$N@-G=$rL\;X7F, 8D!9$N7W;;5!Kh$K:GE,2=5l$?Dc1%$%F%s%7, 9b%9%k!<%W%M%M%C%H%o!<%/7OJiSK%a%b%j7OHW $N8&5f!?3+H/$,9Tol$?. 3F%W%m%;%C%5Kh$K%a%b%j$rJ,;6G[CV$7%a%C%;!<%8%Q%C%7%s%0KhCF%W%m%;%C%54VDL?.$r9T$&%a%C%;!<%8%Q%C%7%s%07?JBNs7W;;5!$H, %W%m%;%C%5$H$OFHN)$K%a%b%j$r=8CfG[CV$7, 3N6&M-%a%b%j$r2p$7$F%W%m%;%C%54V$NDL?.$r9T$&!"J8Cf!K6&M-%a%b%j7?JBNs7W;;5!(:G6a$O, Symmetric MultiProcessor(SMP) $H8F$Plk3H$, B?$$.) $,EP>l$7$?.

1985 G/:"$+$i$O, =8CfG[CV$7$?6&M-%a%b%j%7%9%F%`$K$*1$k%9%1!<%i%S%f%#NLdBj$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,



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

;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 —

1990 G/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.

$=$NCf$G,TCP/IP %Y!<%9$N%M%C%H%o!<%/$G@\B3$5l?J#?t$N7W;;5!$N=89gBN$r,2>A[E*$K#1BfNBg-$JJBNs7W;;5!$H7F8+$;$k$?$a$N=%U%H%&%'%"%a%+%K%:%'G$"$kPVM(Parallel Virtual Machine)$,1989 G/$K3+H/5l$?. PVM $O8D!9$N7W;;5!>e$NDL?.$G!<%b%s%W%m%;%9$r2p$7$F%a%C%;!<%88r49$r9T$&%a%C%;!<%8DL?.%i%$%V%i%jG"$j,FCJL$JHW $r0l@ZI,MW$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_$?$S%f!<%6$K;Y;}$5$l9-$/Ia5Z7?. 3l$,7W;;5!%/%i%9%?$NKk3+1G$"$k.[1]

$=$N?tG/8eKO,IBM $dIY;NDL$JIN%O%$(%s%I$NJBNs7W;;5!%a!<%+$,,<+<R@=$NUNIX %o!<%/%9%F!<%7%g%s$r@lMQ9bB.%M%C%H%o!<%/$G@\B3$7$?%a%C%;!<%8%Q%C%7%s%07?$NJBNs7W;;5![4),5)] $r;T>l$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 —

1995 G/A08eKO,%$!<%5%M%C%H%9%$%C%A$d100MBit Ethernet JI$N5;=Q$,0lHLKbIa5Z$7,Hf3SE*0B2A$K9b@-G=$J%M%C%H%o!<%/$N9=C[$,2DG=KJC?. 5i$K,Myricom <R$N Myrinet[2)] [y] $d DEC <R$N Memory Channel[3)] Ey,7W;;5!%/%i%9%?$r;X8~$7$?@lMQ$N9bB.%M%C%H%o!<%/$,EP>l$7$?. 3lKh$j,%M%C%H%o!<%/$N9%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 $NNL;:8z2L$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=$,2DG=HJC?.3Nh&&JGX7J$+$i,7W;;5!%/%i%9%?$r;H$C$?K\3JE*$JUBNs=hM}XND)@c$,;O$^C?. 3N;~4|$N7W;;5!%/%i%9%?$NFCD'$O,%/%i%9%?$r9=@.9k PC/WS 4V@\B3$N%M%C%H%o!<%/$/[y][y]$r%$%s%?!<%M%C%H@\B3N?aN%M%C%H%o!<%/HOJL$K@_$1$?%7%9%F%'$,3+H/5l$?E@$G$"$k.

0lJ},%=%U%H%&%'%"$NJ}$G$O,%"%W%j1!<%7%g%s%W%m

[1] PVM $O%=%U%H%&%'%"$,8x3+5l$?$?a$K,JBNs7W;;5!$r4^$'B?$/$N7W;;5!$K0\?"5l$?. $^$?,PVM GODL?.$G!<%b%s%,8D!9$N7W;;5!$N%"!<%-%F%/%A%$%N:90[$r5[<}$9%k$?$a,0[5!<o7W;;5!$r4^$'7W;;5!%/%i%9%?$b<B8=2DG=$G$"$G$?. J*,3NEv;~$N!VW;;5!%/%i%9%?!W$O35G0E*JbNG,!VW;;5!%/%i%9%?!W$H8F$VJ*M}E*$J7W;;5!,B8:_$7$?o$1GO$J$$.

[y] %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=8$a,Myrinet $rA0Ds$H7?@vN}5l$?API(Application Programmer Interface) rbC?%I%i%$%P%=%U%H%&%'%"$,@$3&3FCO$G3+H/5l$?.

[y] $"$/^Gb%3%b%G%#F%#tIJrD+C?%M%C%H%o!<%/G"$k

%0%i%'%$%s%?%U%'!<%9(API) H7$F, B?$/$NJBNs7W;5!%a!<%+$d8&5f<TiGAH?%5l$?MPI Forum $,:vDj$7$?Message Passing Interface(MPI) $,9-$/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?.$KH<$&%7%9%F%'%3!<%k$N%*!<%P%X%C%I$r7Z8:!?:o=|9k;n$_$,B?$/9T$ol?;~4|Gb$"$k. %f!<%6%W%m%;%9$,D>@\%O!<%I%&%'%"$rA':n9k%f!<%6%l%Y%kDL?.$N<B8=$d%<%m%3%T!<DL?.JI$,$=NNcG$"$k. Linux $dFreeBSD JI$N%U%j!<$JOS $NIa5Z$,, 3liN;n$_$KGo<V$r2C$(, 0BDj$+$D9b@-G=$J7W;5!%/%i%9%?8~$1$N%U%j!<$J%=%U%H%&%'%"$,F~<j2DG=$KJC$?$NG"$k.

0B2A$J%O!<%I%&%'%"(HW) $H%U%j!<$J%=%U%H%&%'%"(SW) $r;H$C$?%Q!<%=%J%kJBNs7W;5!$H7F$N7W;5!%/%i%9%?$,EP>l7?;~4|$H$$$CFb$h$$.

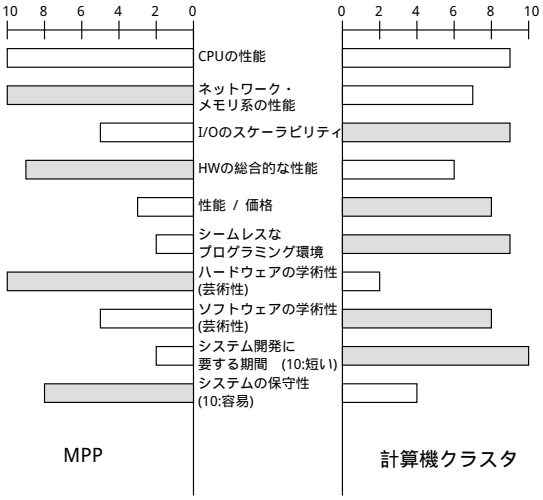
— 7W;5!%/%i%9%?$NH/E8 —

8=:_$O, J#?t$N%W%m%;%C5$rEk:\$7$?SMP 7?$NWS $dPC $,Hf3SE*MF0W$KF~<j2DG=KJCF$*$j, 3lir%Y!<%9K7$?SMP %/%i%9%?$,EP>l7F$$k. %O%$%(%s%I$NSMP %5!<%P$rDs6!$9$k7W;5!%a!<%+$b, 99Jk%9%1!<%i%S%j%F%#$rD I5f$7$F, SMP %5!<%P$rHEMQ$N9bB.%M%C%H%o!<%/$G@\B3$9$kSMP %/%i%9%?$rH/I=$7;OaF$$$k. 7W;5!%/%i%9%?$N@-G=$O9G$K, %O%$%(%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$kHW $N9b@-G=2=$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$rDs6!9kJ}K!(K\FC=8$NJL5-;v$r;2>H) $H, HW $G<B:]$K6&M-%a%b%j$r<B8=$9$k%"%W%m!<%A$,$"$k[6),7). 8e<T$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$JHW %5%]!<%H$,$"kN$,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 !VW8?h$NJBNs7W;5!!W$NBeI=$H7F$ND6JBNs7W;5!(MPP) $H, 4pK\E*$K%3%b%G%#%F%#HW/SW KhCF9=@.5l$k !VW;5!%/%i%9%?!W$rHf3S9k3H$G7W;5!%/%i%9%?$NFCD'E1$r9T$&[y] (?^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@$GF10l$G$"$k$,, :G6a$N%W%m%;%C%5$O>&6HE*$J@dN,$+$i, %O%$%(%s%I8~$1$H%m!<%(%s%I8~$1$G<o43$N:9$r=P$9@=IJ$,$"kNG3$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>l9gb"$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(kNKBP7$F, 7W;5!%/%i%9%?$G$O%3%b%G%#%F%#$JPC/WS $r;HMQ$9k?a, HW $N%l%$%F%s%7$K4X$7$F MPP hjNt$k798~$,$"$k. HW %9%k!<%W%C%H%K4X7F $O, 7W;5!%/%i%9%?$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 $N%9%k!<%W%C%H$K

[y] 8=:_$O, $3$3$G$$$& !VW;5!%/%i%9%?!WH7FN>r7o$rK~B-$9$k MPP $bB8:_$9k,,OC$r4JC1$K9k?a$kN><T$CFHN)G"kH7FOC$r?J$a$k.

4X7F$O?t$G>!Ii$N7W;;5!%/%i%9%?$KIi1k798~$,$"$k.

HW $NAm9gE*$J@-G=

N><T$NHW @_7W$N4pK\J}?K$r4:$($F6hJL$9kJiP, MPP $, !ÑBf$NCPU $r;H$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%$:$NNG\$N%5%$:$N%G!<%?$r07$&3H!WG"$k. 0lHL$K A0<T$NMW5a$rK~B-9kKO, :YItKEOC$F@-G=$KM>M5rb$?$;$?HW @_7W$,I,MWG"$k. 7?$,CF, %T!<%/@-G=$,F101G"CF$bAm9gE*$J@-G=$OMPP $NJ}$,M%lF$$$k.

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

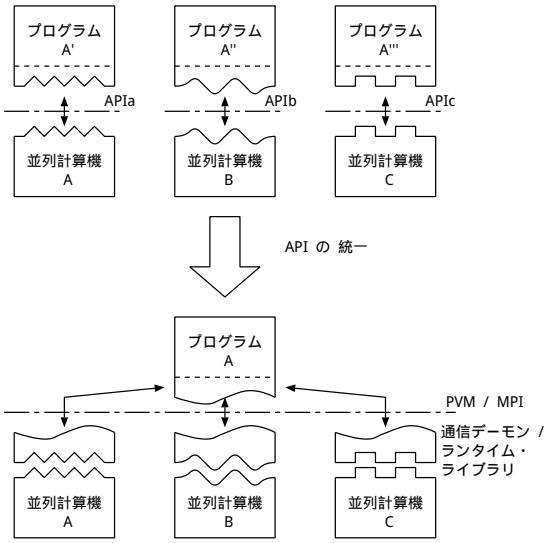
%W%m%;%C%5100 Bf5,LO$^$G$N%7%9%F%`$GHf3S9k$H, MPP $H7W;;5!%/%i%9%?$N=V4V:GBg@-G=$OHf8*$7$F$$$kNG, NL;:8z2L$N9b$7W;;5!%/%i%9%?$,C12AEv$j$N%T!<%/@-G=$,9b$/%3%9%H%Q%U%)!<%^%s%9$KM%lk$H$$$($k. 7+$7, MPP $O4pK\%3%9%H$O9b$$$,, Bf?t$KHfNc$9$k%W%m%;%C%5#1BfEv$j$N2A3J$O7W;;5!%/%i%9%?KHfY$F01HL$KDc$$$N$G, 2>$K%W%m%;%C%51000 Bf5,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%j%1!<%7%g%sKBP7FO, 7W;;5!%/%i%9%?$OMPP KHfY$F@-G=$NDc2<798~$,82CxG"$j, 3N>19gKb%3%9%H%Q%U%)!<%^%s%9$,5UE>$9$k2DG=@-$,$"$k.

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

%a%C%;!<%8%Q%C%7%s%07?$NJUBNs7W;;5!$K4X7F$O, =>Mh$h$j8D!9$NJUBNs7W;;5!$,$=l>lNHW @-G=$rB8J,$KH/4x9k$?$a$NFH<+$N API $rDs6!$7$F$$$?. $=$N$?$a, API $N=$F@Ey$N=i4|%*!<%P%X%C%IBg$-$$. $^$?, $"$k7W;;5!$GNI$$%"%W%j%1!<%7%g%s$,3+H/$5lFb, JLN7W;;5!XN0\?"@-$,:$Fq$H$$&LdBj$,$"C?.

3lKBP7$F7W;;5!%/%i%9%?$G$O, $=$l<+BN$,EP>l$7$?GX7J$K PVM $d MPI $H$$$C$?I8=`E*$J API $,B8:_$7$?$?aK, 5!<c0MB8$N>/$J$$$8zN(E*$J%W%m%0%i%_%s%04D6-$,Ds6!5l$F$$$k. [1y]

$^$?, MPP $NOS $O<+<R3+H/$7$?$bN,B?$/, 01HL%f!<%6$,JBNs=hM}$X8~$1$?:G=i$N0lJb$rm4m0$9$k860x$KbJCF$$$?. 3lKBP7$F7W;;5!%/%i%9%?$O!ÑpK\E*KO!K;THN$NOS $=$NbN$r;HMQ$9k?$a, F|>cE*$K;HCF$$$kPC/WS $HA4$/F10l$N4D6-$,;HMQG-kH$$$&MxE@$,$"$j, JBNs=hM}$NI_5o$r2<$2kN$K9W8%$r7F$$$k.



?^4 API $NE}01$Khk0\?"@-$N8~>e

HW/SW $N3X=Q@-!?7]=Q@-

JBNs=hM}8&5f<T$NL\$G$_$?LIGr$5, ?75,@-$NB?5NHf3SG"$k. $^$:HW $K4X$7FO, 7W;;5!%/%i%9%?$OItIJ$rGcCF$-$DJ0$@$1JNG6KO@H7FO3X=Q@-J7G"$k[1y1y]. L^O@, 9=@.ItIJ$r:n$kHFMQItIJ%a!<%+$G$O, %3%9%H%Q%U%)!<%^%s%98~>eN?a$K@ZbxBvKa$NEXNO$,$J$5$1F*$j, 3NE@$O=J,$KI>2A9Y$-G"$k. 0lJ}SW $K4X$7FO, 7W;;5!%/%i%9%?<+BN$,SW $K0MB8$9$kItJ,$,Hs>o$KB?$$?a, 5;=QE*$J2]Bj$,Bt;3;DCF$*$j, 4hD%GF8&5f9kH=lJjN@.2L!?@-G=$r=P$9$3$H$,$G$-$k. FC$K, ;EMM$N8x3+5l$?%O!<%I%&%"%U%&%a$H%U%j!<JOS $r%Y!<%9$K7?8&5f$,B?$/$N@.2L$r$"$2$F$$$k. 7+7J$,$i, 3liN8&5f$NB?$/$OMPP Gb;H$($k5;=Q$,B?$$?a, 3X=Q@-$N:9$OHW DxGOJ.

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

0lHL$K, MPP $, 2G/$+$i3G/$+1F3+H/5lkNKBP7$F, 7W;;5!%/%i%9%?$r9=@.9kWS/PC $O3%v7n$+$iH>G/$*$-$K?7@=IJ$,EP>l$9kN$,, 8=>u$G$"$k. $=$N7k2LH7$F, F1;~4|$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 $O HW/SW $N0BDj@-$,9b$/%a%s%F%J%s

[1y] :G6a$NJUBNs7W;;5!$G$O, :G=i$+$i MPI $r<BAu$7$?b$N$,=P2s$kh&KJC?, MPI $r;H$&H MPP $N HW @-G=$,=J,$KH/4x$G$:$K7W;;5!%/%i%9%?HNM-0U:9$,=P;$J$$$H$$&LdBj$,$"$k.

[1y1y] HW $G2?$+3X=QE*$J3$H$rL\O@$'$H7k2lE*$K MPP KJCF7^$&2DG=@-$,$"$k.

%9$b0QBw$G$-$kNKBP7F, 7W;5!%/%i%9%?$O HW/SW $N0BDj@-$,Hf3SE*Dc$/, 4pK\E*$K<+J,$G %a%s%F%J%s%9$,I,MWG"k?$aJ]<i%3%9%H$,9b$/ Jk. 7+$7, =jM-<T8D?M$,Hqd7$?;~4VKBP9 $k?M7cHq$OB~G"kH9M$($k$H, 7W;5!%/%i%9%? $NJ}$,05E]E*$K%3%9%H$,0B$/$J$k.

0J>e, Cx<T$N<g4Q$r8r$(B FMPP $H7W;5!%/%i%9%? $rHf3S$7$?. 7W;5!%/%i%9%?$,IsJbN+Bg;(GD$J %$%a!<%8$O;}$C$FD:$1$?$H;W$&. 0J2<$G$O, hj6qBN E*$J7W;5!%/%i%9%?$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 $N SP %7%j!<%:$d, IY;NDL$N AP3000 $OD6JB Ns$N%9!<%Q!<%3%s%T%e!<%?H7F, Aa/$+$i;T>l$KEj F~$5lF$$$k7W;5!%/%i%9%?G"$k. 7W;%N!<%I$K$O ;THN$N WS MQ$K3+H/$5l?bNr[$\$=N^$^$N7A $G:NMQ$7, J#?t%N!<%I$r@lMQ$Nc~BN$KG<$a$?$bNr@l MQ$N9bB.%M%C%H%o!<%/[1] $G@\B3$9$k7ABV$rHk. 7W;%N!<%I$,%b%8%e!<%k2=$5lF$$$k$?$a, 4pK\E*KO%b %8%e!<%k$N8r49$@1G:G?7CPU $N@-G=$r5}<u9k$3 H,G-$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$$k. $=$NB?$/$O, :GBg9=@. $G%7%9%F%'A4BN$N%W%m%;%C%5?t$, 256 BfDxEY$N9bJB Ns7W;5!$N0l3Q$r@jaF$$k.

BeI=3J$N#1$D$OSUN $N Enterprise Cluster %7%j!< %:$G, Ultra Enterprise %5!<%P$r1 %N!<%I$H7F:GBg 4 %N!<%I$G%/%i%9%?$r9=@.9k%7%9%F%'G"$k. %M%C %H%o!<%/%+!<%I$H7F$OSbus MQ$N SCI %+!<%I$r3+H/ $7, 4 %]!<%H$N SCI %9%$%C%A$G@\B3$7$F$$k.

DEC <R!8=Compaq <R!K$O, <+<R3+H/$N Memory Channel II $r;H$C$?@=IJ$N6!5k$r9T$C$F$$$k. 7W;%N!<%IH7FO, F1<R$N Alpha %A%C%W$r:GBg120CPU Ek:\$7$3$lir3,AXE*$J%/%m%9%PLV$G@\B3$7$?SMP %5!<%P$r;HMQ$9$k. Memory Channel II $N%M%C%H%o!<%/<+BN$b%/%m%9%P!<LV$G, :GBg16 %N!<%I$r@\B32DG=$G $"$k. Memory Channel $O, 6&M-%G!<%?$N=q9~$_$K4X 7F<c43FC<l$JA';n$,I,MWG"k,[2], 6&M-%a%b%j$K =';$k%f!<%6%$%s%?%U%'!<%9$rDs6!7F$*j, $=$N5!G=$rMxMQ$7$F:YN3EY$NDL?.KbBP1~G-$k%=%U%H&%' %"$KhkJ,;,66&M-%a%b%j4D6-$N3+H/$r9TCF$$k.

Sequent <R$O PentiumPro 4 Bf$N SMP %/%i%9%?$r SCI='5r$N%j%s%/(Link B.EY8Gbps, J#?t%j%s%/9=@.) $G%j%s%0u$K@\B3$9$k NUMA-Q $r;T>l$K=P7F$$ $k. B?$/$N7W;5!%/%i%9%?$,, NIC $r%7%9%F%'%P%9$K @\B3$9$k9=@.rHkNKBP7$F, NUMA-Q $O CPU $d%a%b%j$,@\B3$5$l$k%W%m;%C%5%P%9$K SCI='5r$N %M%C%H%o!<%/%"%@%W%?$r@\B3$9$k3HG, %O!<%I%&%' %"Kh$k40A4$JJJ,;66&M-%a%b%j4D6-$r<B8=$7, :YN3EY JBNs=hM}$r<B8=$9$k. NIC $, NUMA-Q K+JjFC 2=5l$F$$k$,, %M%C%H%o!<%/<+BN$O SCI %Y!<%9$NI8 ='1JJ$G$"$kNG%j%9%H%"%C%W7?. NUMA-Q $KN';w 7?7%9%F%'H7$F, Data General <R$N AV25000 $, $"$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%&%'%"$H%U %j!<%=%U%H%&%'%"$@1G:nilF*j,[3] DEC $N Alpha 68 Bf$K%U%j!<$JPC UNIX $N0l$DG"$k Linux $rEk:\$7, DL>o$N FastEthernet $H GigabitEthernet $G@\B3$7$?7%9%F%'$G$"$k.

<+A0$G%7%9%F%'$rAH$_N)$F, 15K|%I%k$G19GFLOPS[4] $rC#@.$7F*j, 15$/MFLOPS $N%3%9%H%Q%U%)!<%^ %s%9$G$"$k.

4.2.2 D6JBNs7W;5!$NBeBX$H7F$N7W;5!%/%i%9%? 2f$,9q$N?7>pJs=hM}3+H/5!9=(RWC) $G3+H/$5lF $$k Myrinet %Y!<%9$N7W;5!%/%i%9%?[8]$O, D6JBNs7W ;5!$HHf3S$7$FB=?'$NJ@-G=$r=P$9$3$H$rL\I8$H$7 Fk. Avalon $,4pK\E*$K HW/SW $NA4$F$r4{@=IJ$G 9=@.7?NKBP7F, RWC $N%/%i%9%?$G$O, HW $O A4$F%3%b%G%#%F%#ItIJG"k,, NIC %+!<%I$N%P, OS, DL?.%i%$%V%i%j, 8@8l=hM}7O$H$$$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[10]$H8*rJBY$FCxL>$JJBNsDL ?.%i%$%V%i%j PM $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%kI/O

%+%j%U%)%k%K%"Bg3X%P!<%/%l%$$;GO, 1990 G/Be$N =iF,$+$i Network of Workstations(NOW) $N8&5f$, 9Tol$F$$$k[9]. IAi+$H$$$&$H, OS $d%G%#%9%/ 2s$j$N8&5f$,Cf?4G"$k. 8=:_$O, 140 Bf$N WS(OS $OSolaris) $H35 Bf$N PC(OS $OPC UNIX $"$k$$$O WindowsNT) $rMyrinet %Y!<%9$N%M%C%H%o!<%/$G@\

[1] SP %7%j!<%:MQ$N%M%C%H%o!<%/$O, 8=:_$OC1BN$G$b9XF~2DG=$G$" $k. AP3000 $N@lMQ%M%C%H%o!<%/$CF1<R$NJBNs7W;5!AP1000 MQ$K3+H/5l$?%M%C%H%o!<%/$G$"$k.

[2] 99?7$9%Y$-6&M-%G!<%?$N%"%I%l%9=$NbNGOJ$/, %7%9%F%'%P %9>e$NNIC $N%G!<%?=q9~$_@lMQNN0h$X=q9~$_$r9T$&I,MW$,$"$k

[3] 3Nh&$J%7%9%F%'$r Beowulf 7?$N7W;5!%/%i%9%?$H$b8F$V.

[4] ?tCM$N>e$G$O64%W%m%;%C%5$N Origin 2000 KIE(9k@-G=.

B3$7$F$$k. %7%9%F%'FbKO500-1000 Bf$N%O!<%I%G%#%9%/$,$"$j, FH<+$K3+H/$7$?%5!<%P%l%9!&U%!%$%k%7%9%F%`xFS $r;HMQ$7$F disk-to-disk %=!<%H$N%Y%s%A%^!<%/$G1997 G/4 7n;~E@$N@$3&5-O?$rC#@.7F$$k.

xFS $O, !¥m!<%+%k%G%#%9%/>e$N%G!<%?hj$b, B>$N7W;;5!$N<g5-21$K$"$k%G!<%?$NU}$,B.$/%"%/%;%9$G$-$k!W$H$$$&H/A[$N85$K, %G!<%?$r;HMQ$9$k%/%i%$%"%s%H$N<g5-21$r0%m!<%P%k$J6&M-%U%!%$%k%-%&C%7%eH7$F;HMQ$9$k cooperative caching $d, J#?t7W;;5!$N%G%#%9%/$K8Y$C$F%9%H%i%$%T%s0$r9T$&%=%U%H%&%'%"RAID $N<jK!$JIr1~MQ9k3HG%9%1!<%i%V%k$G2DMQ@-$N9b$$%U%!%$%k%7%9%F%`$r<B8=7F$$k.

=>Mh$NUBNs7W;;5!$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$/8=$l$F$$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$NK.Li iN%0%k!<%W$O4-Way PentiumPro $r%Y!<%9$K7?SMP %/%i%9%?SHRIMP $r3+H/$7$F$$k[11). 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%s0$9$k Virtual Memory Mapped Channel(VMMC) $rDs0F$7, 3l$r<B8=$9k?%W%m%;%94V$G0lC6, Channel $r@_Dj$9kH, $=$l0J8e$N%W%m%;%94VDL?.$O Channel $KBP1~$9$k%&%$%s%I&$r6&M-%a%b%j$H7F;HMQ9k3H,G-, DL?.NEYK%7%9%F%`%3!<%k$r2p$9I,MW$,$J$/$J$k.

5. $*$ojK

=>Mh$NUBNs7W;;5!$N8&5f!?3+H/$,%O!<%I%&%"%<gF37?$G$"$C?10G/A0, !ØE2A$JHFMQ%^%$%/%m%W%m%;%C%5$rBt;3$D$J$$G, %Y%/%H%k7W;;5!KIE(9k@-G=$r=P$9!W$H$$&N,JBNs7W;;5!$Nkp$$J86gG"$C?. $=$7$F:#F|, !ÐC $"$k$$$O WS rE,EYKDJ$$G@lMQJBNs7W;;5!KIE(9k@-G=$r=P$9!WHkpC$F$$$kN,7W;;5!%/%i%9%?G"$k. A0<T$N>l9g, !Ø'<!=hM}!W$+$i !ØBNs=hM}!W$H$$&?$K5;=QE*$JUQ3W$,$"C?NKBP$7, 8e<T$O !ÝH$$d$9$5!W$d !¥3%9%H%Q%U%)!<%^%s%9!W$NDI5f$H$$&, JBNs=hM}5;=Q$N !Ø/E8!W$+$i !Ø.=O!W$X$NJQ3W$G"kH$$($k.

7W;;5!%/%i%9%?$NIa5Z$KhC$FJBNs=hM}$NI_5o$,2<$,$j, hjB?$/$N%W%m%0%i%^$,JBNs=hM}$rBN83$9$k5!2qrb$C?3HOHs>o$KM-0U5AG"$k. 3Nh&$J%V%l!<%/%9%k!<$KhC$FJBNs=hM}$,0lIt$N8&5f<T$N?aN5;=QGOJ/, 4/0lHINEv?$jA0$N5;=QHJk3Hr4j$&<!Bh$G$"$k.

;2 9M J8 8%

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