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

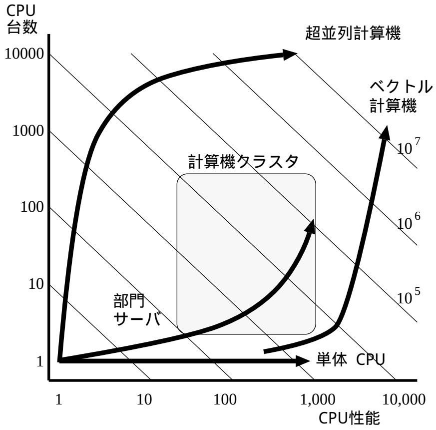
1980G/Be8eH>$^$G$O, %9!<%Q!<%3%s%T%e!<%?$H$$$($P%Y%/%H%k%W%m%;%C%5$G$"$j, JBNs7W;;5!O^$@$^$@L$=O$J5;=Q$H$$$C$?46$G$"$C$?$,, @$3&$NTOP500 Supercomputers[!y] $N:#G/6 7n$NE}7WGO, TOP10$OA4$F512%W%m%;%C%50J>e$ND6JBNs7W;;5!(MPP), TOP30$^$G$,100%W%m%;%C%50J>e$NJBNs7W;;5!$+JBNs%Y%/%H%k5!$G$"$j, 10%W%m%;%C%50J2<$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!%"%-%F%/%H$O, ?t@i, ?tK|Bf5,LO$^$G%9%1!<%i%V%k$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?$K@_7W9Y$-$+JIJI$N8&5f2]Bj$K<hjAHsG-$?. 3Nh&$JJBNs=hM}5;=Q$NH/E8$H%^%$%/%m%W%m%;%C%59bB.2=$N28 7Cr&1F, :#F|, B?$/$NJBNs7W;;5!$,:G@hC<$N%9!<%Q!<%3%s%T%e!<%?$H7F3hLv7F$$$k.

0lJ}$G, 3Nh&$J%9%Q%3%sO)@~rAvkD6JBNs$"$k$$$O9bJBNs7W;;5!HO, 0l@~$r2h$7$F<BMQE*$JJBNsEY$NJBNs7W;;5!$N3hLv$bL\N)$CF-$F$$$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,!V7W;;5!%/%i%9%?!WG"$k.

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

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%5!<%P$H$$$C$?>.5,LOJBNs7W;;5!$r, Hf3SE*MF0W$KF3F~2DG=$JHFMQ$N%M%C%H%o!<%/$G@\B3$7$?0l<o$NJBNs7W;;5!$H8+J9$3$H$,$G$-$k. %W%m%;%C%5JiSK%M%C%H%o!<%/@-G=$N5^B.$J?-Sr<u1F, %3%9%H%Q%U%)!<%^%s%9$KM%$l$?JBNs7W;;5!$H7F$NCO0L$rC[$-$DD"$k.



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

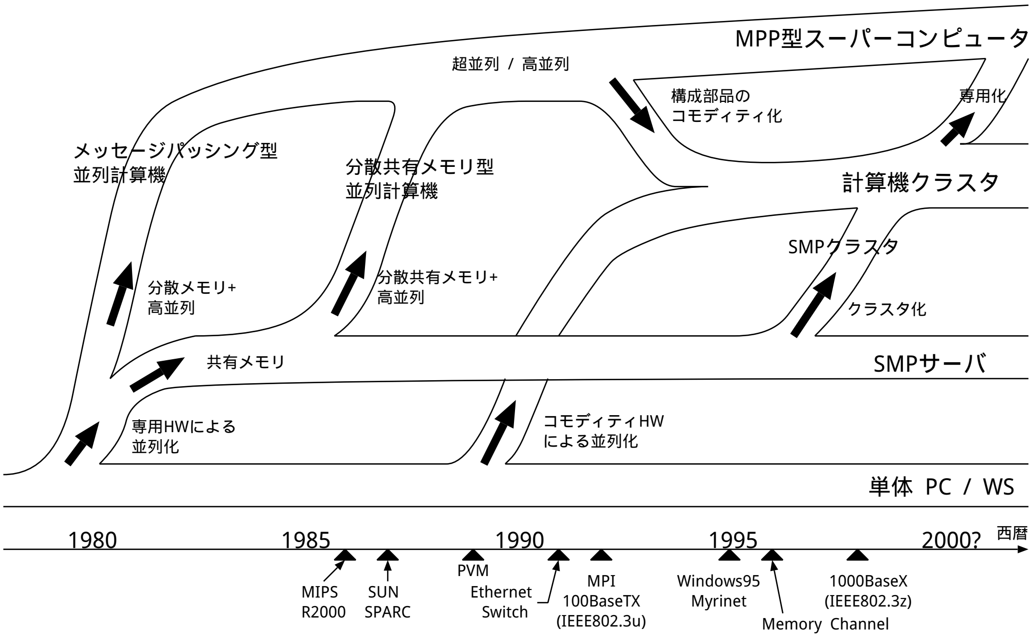
JBNs7W;;5!H7FOIAi+$H$$$&$H%m!<%(%s%I$JJ,N`$KF~$kNG, Ev=i$OJBNs7W;;5!20$O$"$^$j5$$K$+$1$F$$$J$+$C$?$,, <!BhKCNi$L?6$jr7$F$$$kLuKO$$$+J/JCF-$?$NG"$k.

$=$1GO, ?^2$r8+$J$,$i, JBNs7W;;5!$NEP>l$+$i7W;;5!%/%i%9%?$NBfF,$^$G$NF;Dx$r$*$CF_h&.

— JBNs7W;;5!$NEP>l —

1980G/:"$O, HFMQ%W%m%;%C%5$NDc2A3J2=KHbJ$$, 3l$i%W%m%;%C%5$r@lMQ$N%O!<%I%&%'%"(HW)$r6n;H7FJBNs@\B3$9$kJBNs7W;;5!$,Aj<!$$$GEP>l7?. %9!<%Q!<%3%s%T%e!<%?JB$N@-G=$rL\;X7F, 8D!9$N7W;;5!Kh$K:GE,2=5l$?%M%C%H%o!<%/7O$d%a%b%j7ONHWN8&5f!?3+H/$,9T$ol?. 3F%W%m%;%C%5Kh$K%a%b%j$rJ,;6G[CV$7%a%C%;!<%8%Q%C%7%s%0$KhC$F%W%m%;%C%54VDL?.$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$&

[!y] J.Dongarra Ey$,H>G/Kh$K=P7F$$$k@$3&$G3hLv7F$$$k9b@-G=%3%s%T%e!<%?TOP500$N%j%9%H(http://www.top500.org/). :G=i$NE}7W%G!<%?$O1993G/.



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

!#8Cf!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%`$N%9%1!<%i%S%j%F%#$NLdBj$r2r7h9k<jK!H7$F, <g5-21$O3F%W%m%;%C%5$KJ,;6G[CV$9k,, %W%m%0%i%^KBP7FO HW $G6&M-%a%b%j%b%G%k$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 —

1990 G/A08eKO, B?$/$NJBNs7W;;5!%Y%s%@$,EP>l$7>&MQ$NJBNs7W;;5!$,?tB?$/3+H/$5l?. $^$?, ?t@i!A?tK|Bf$N CPU $rEk:\$9$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%a%+%K%:%`$G$"$k PVM(Parallel Virtual Machine) $,1989 G/$K3+H/5l$?. PVM $O8D!9$N7W;;5!>e$NDL?.%G!<%b%s%W%m%;%9$r2p7F%a%C%;!<%88r49$r9T$&%a%C%;!<%8DL?.%i%$%V%i%j$G$"$j, FCJL$J HW $r0l@ZI,MW$H$;$:, 8x3+5l$?%=%U%H%&%'%"(SW) $r%$%s%9%H!<%k9k$@$1$G2>A[E*$JJBNs=hM}4D6-$,9=C[$G$-$?. $=$N$?$a, 7Z$$5$;}$GJBNs=hM}$r3Z$7$_$?$$%f!<%6$K;Y;}$5$l9-$/Ia5Z7?[!y]. 3l$,7W;;5!%/%i%9%?[!y!y] $NKk3+$1G"$k.

$=$N?tG/8eKO, IBM $dIY;NDL$JIN%O%$%(%s%I$NJBNs7W;;5!%a!<%+$,, <+<R@=$N UNIX %o!<%/%9%F!<%7%g%s$r@lMQ9bB.%M%C%H%o!<%/$G@\B3$7$?%a%C%;!<%8%Q%C%7%s%07?$NJBNs7W;;5!$r;T>l$KEjF~$7$?. 3N;~E@$G, !V7W;;5!%/%i%9%?!W$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$d 100MBit Ethernet JI$N5;=Q$,0lHLKbIa5Z$7Hf3SE*0B2A$K9b@-G=$J%M%C%H%o!<%/$N9=C[$,2DG=KJC?. 5i$K, Myricom <R$N Myrinet[!y!y!y] $d DEC <R$N Memory Channel 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%HH7FO, @lMQ$NJBNs7W;;5!J_$N?tCMrb$D%M%C%H%o!<%/$N9=C[$b2DG=HJC?. 0lJ}$G, PC $N0lHL2HDm$X$NIa5Z$KH<$&NL;:8z2L$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!%/

[!y] PVM $O%=%U%H%&%'%"$,8x3+5l$?$?aK, JBNs7W;;5!$r4^$`B?$/$N7W;;5!$K0\?"$5$l$?. $^$?, PVM $G$ODL?.%G!<%b%s$,8D!9$N7W;;5!$N%"!<%-%F%/%A%c$N:90[$r5[<}$9$k$?$a, 0[5!<o7W;;5!$r4^$`7W;;5!%/%i%9%?$b<B8=2DG=$G$"$k.

[!y!y] 3NEv;~$N !V7W;;5!%/%i%9%?!W$O35G0E*JbNG, !V7W;;5!%/%i%9%?!W$H8F$VJ*M}E*$J7W;;5!$,B8:_7?o1GO$J$$.

[!y!y!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$?.

%i%9%?$r;H$C$?K\3JE*$JJBNs=hM}XND)@o$,;O$^C?. 3N;~4|$N7W;;5!%/%i%9%?$NFCD'$O, %/%i%9%?$r9=@.9k WS/PC 4V@\B3$N%M%C%H%o!<%/[!y]$r%$%s%?!<%M%C%H@\B3$N$?$a$N%M%C%H%o!<%/$HOJLK@_1?%7%9%F%`$,3+H/$5l?E@G"$k.

0lJ}, SW $NJ}$G$O, %"%W%j%1!<%7%g%s%W%m%0%i%`%$%s%?%U%'!<%9(API) $H$7$F, Message Passing Interface(MPI) $,9-$/Ia5Z$7$?;~4|$G$"$k. $3$l$K$h$jJBNs%W%m%0%i%`$N5-=R@-!?0\?"@-$,Cx7/2~A1$5$l, B?$/$N%W%m%0%i%^KHCFJBNs=hM}NI_5o,0lCJDc$/$JC?. $^$?, %W%m%;%C%54VDL?.$KH<$&%7%9%F%`%3!<%k$N%*!<%P%X%C%I$r7Z8:!?:o=|$9$k;n$_$,B?$/9T$o$l$?. %f!<%6%W%m%;%9$,D>@\%O!<%I%&%'%"$rA`:n9k%f!<%6%l%Y%kDL?.$N<B8=$d%<%m%3%T!<DL?.JI$,$=NcG"$k. Linux $d FreeBSD JI$N%U%j!<$J OS $NIa5Z$,, 3liN;n$_$KGo<V$r2C$(, 0BDj$+$D9b@-G=$J7W;;5!%/%i%9%?8~$1$N%U%j!<$J%=%U%H%&%'%"$,F~<j2DG=$KJC$?.

0B2A$J HW $H%U%j!<$J 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%;%C%5$rEk:\$7$?SMP 7?$N WS $d PC $,Hf3SE*MF0W$KF~<j2DG=KJCF$*$j, 3lir%Y!<%9K7$? SMP %/%i%9%?$,EP>l7F$$$k. %O%$%(%s%I$N SMP %5!<%P$rDs6!$9$k7W;;5!%a!<%+$b, 99Jk%9%1!<%i%S%j%F%#r(k?aK, SMP %5!<%P$rHFMQ$N9bB.%M%C%H%o!<%/$G@\B3$9$k SMP %/%i%9%?$rH/I=$7;O$a$F$$$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.

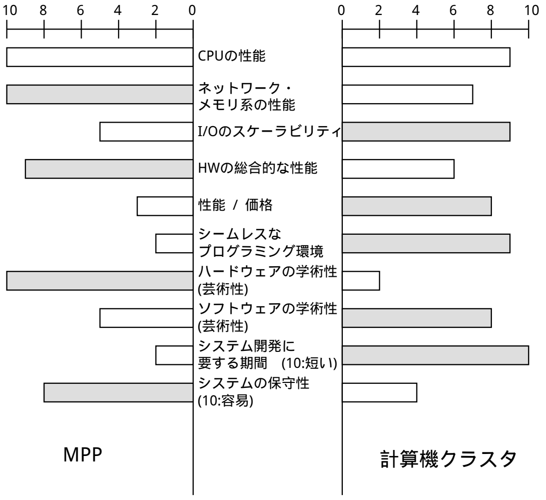
:#8e$O, 99$J$k HW $N9b@-G=2=$H%W%m%0%i%`$N5-=R@-8~>e$rL\;X7F, J,;66&M-%a%b%j$rDs6!$9$k7W;;5!%/%i%9%?$,Ia5Z7F$/$kbN$H9M$(il$k. 8=:_, 3hH/$J8&5f$,9T$olF$$$k$,, SW N_$G2>A[E*$J6&M-%a%b%j%$%a!<%8$rDs6!9kJ}K!$H, HW $G<B:]$K6&M-%a%b%j$r<B8=$9$k%"%W%m!<%A$,$"$k4). 8e<T$O, =>Mh$NJ,;66&M-%a%b%j7?JBNs7W;;5!$GG]$ol?5;=Q$r1~MQ$9kbNG, %O!<%I%&%'%";q8;$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[!y!y].

3N%/%i%9KJCF$/$k$H=>Mh$NJBNs7W;;5!HN%"!<%-%F%/%A%c>e$N:9JL$,$[$HsIJ/JCF/$k. 2f!9$b SMP %5!<%P$K, %O!<%I%&%'%"$KhkJ,;66&M-%a%b%j5!G=rbC?%M%C%H%o!<%/%+!<%I$rEk:\$7, 8w%U%!%$%P$H%/%m%9%P!<%9%$%C%A$G@\B3$7$?J,;66&M-%a%b%j7?JBNs7W;;5! ASURA $r 1992 G/$KDs0F7?$,, $^$5$K:#$G$$$&H3mN%O%$%(%s%I$N SMP %/%i%9%?$KB0$9$kJ*$G$"$C$?.

3. 7W;;5!%/%i%9%?$N0LCV$E$1

8=;~E@GO, 7W;;5!%/%i%9%?$OJBNs7W;;5!$N9=@.<jK!$N#1$DH7$FCO0L$r3NN)7F$$$k. GO, =>Mh$NJBNs7W;;5!$H$O2?$,0c$&$NG"m&$+.

0J2<GO, FH<+$K3+H/$5l?@lMQ HW/SW KhCF9=@.5l$k!V8?h$NJBNs7W;;5!!W$NBeI=$H7F$ND6JBNs7W;;5!(MPP) $H, 4pK\E*$K%3%b%G%#%F%# HW/SW KhCF9=@.5l$k!V7W;;5!%/%i%9%?!W$rHf3S9k3H$G7W;;5!%/%i%9%?$N0LCVE1$r9T$&[!y!y!y] (?^3;2>H). J*, 0J2<$NHf3S$O7W;;5!%/%i%9%?$,$I$&$$$&bN$+$rBg;(GD$KM}2r$7$FD:$/$?$a$K, $"$kDxEY0U?^E*$KCx<T$N<g4Q$rF~$l$F9T$C$?Hf3S!?5DO@$G$"$k3Hr4>5CN$*$-4j$$$?$$.



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

CPU @-G=

4pK\E*KO, MPP $b 7W;;5!%/%i%9%?$b;THN$N%W%m%;%C%5$r;HMQ9k$H$$$&E@$GF10l$G$"$k$,, :G6a$N%W%m%;%C%5$O>&6HE*$J@oN,$+$i, %O%$%(%s%I8~$1$H%m!<%(%s%I8~$1$G<c43$N:9$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.

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

[!y!y] IEEE1596 $G5,Dj$5l? Scalable Coherence Interface =`5rNbNr=|1P, B?$/$N>l9g@lMQ$N HW $r;H$&I,MW$"$k$?$a$K, 87L)$K$O7W;;5!%/%i%9%?$H$O8@$($J$$2DG=@-$,$"$k. 7+$7, Myrinet $bEv=i$O%3%b%G%#%F%#HO8@$$$,$?$$$FC<l$J HW G"C?NG, J,;66&M-%a%b%j8~1N@lMQ HW $,%3%b%G%#%F%#ItIJ$KJk$+H]$+$O;T>l<!Bh$G$"$k.

[!y!y!y] 8=:_$O, $3$3$G$$$&!V7W;;5!%/%i%9%?!WH7FN>r7o$rK~B-$9$k MPP $bB8:_$9k,OC$r4JC1$K9k$?$a$KN><T$OFHN)G"kH7FOC$r?J$a$k.

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

MPP O=$N@=IJ8~$1@lMQ LIS $N3+H/$J$I, JBNs=hM}$N$?$a$K:GE,2=$7$?%a%b%j7O$d%M%C%H%o!<%/7O$N%O!<%I%&%'%"$rHw$($kNKBP7F, 7W;;5!%/%i%9%?GO%3%b%G%#%F%#$J PC/WS $r;HMQ$9k?$a, HW $N%l%$%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!y.

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

7W;;5!%/%i%9%?$O8D!9$N WS/PC $,FH<+$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$F MPP GO, %7%9%F%`A4BN$K1 8D$"$k$$$O$"$kDxEY$N%W%m%;%C%5Bf?tKh$K1 8D$N I/O AuCV$r;}$D9=@.$,B?$$. 1 Bf$N I/O AuCV$N@-G=$rHf3S$9kH, 0lHL$K MPP 8~$1$NJ}$,@-G=$,$h$$$bN,B?$$!J2A3Jb=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 $,!N Bf$N CPU $r;H$C$F, 1CPU NH$-$N7W;;;~4V$N 1/N $N;~4V$G7W;;G-k3$H!W$KBP7F, 7W;;5!%/%i%9%?$O!N Bf$N7W;;5!$r;H$C$F1 Bf$NH-$K8=<BE*$J;~4V$G=hM}$G$-$k%G!<%?%5%$%:$N N G\$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=$,F10lG"CF$bAm9gE*$J@-G=$O MPP $NJ}$,M%lF$$$k.

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

%T!<%/@-G=$K6a$$@-G=$r0z$-=P$;$J$$%"%W%j%1!<%7%g%sKBP7$F, 7W;;5!%/%i%9%?$O MPP KHfY$F@-G=$NDc2<798~$,82Cx$G$"$k. 7?$,$CF, G0U$N%"%W%j%1!<%7%g%s$KBP9k%3%9%H%Q%U%)!<%^%s%9$r5DO@$9k3HOG-$J$$. 7+$7, %T!<%/@-G=$r0z$-=P$;$k%"%W%j%1!<%7%g%s$KBP7F$O, 0J2<$N5DO@$,@.N)$9$k.

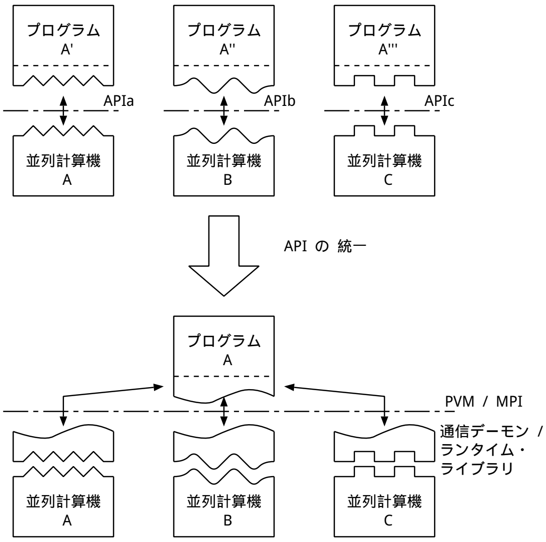
%W%m%;%C%5 100 Bf5,LO$N%7%9%F%`$GHf3S9k$H, MPP $H7W;;5!%/%i%9%?$N=V4V:GBg@-G=$OHf8*$7$F$$$kNG, NL;:8z2L$N9b$$7W;;5!%/%i%9%?$,C12AEv$j$N%T!<%/@-G=$,9b$/%3%9%H%Q%U%)!<%^%s%9$KM%lk$H$$$($k. 7+$7, MPP $O4pK\%3%9%H$O9b$$$,, Bf?t$KHfNc$9$k%W%m%;%C%5#1BfEv$j$N2A3J$O7W;;5!%/%i%9%?KHfY$F0lHL$KDc$$$N$G, 2>$K%W%m%;%C%5 1000 Bf5,LO$N7W;;5!%/%i%9%?$r<B8=7?>l9gKO, %3%9%H%Q%U%)!<%^%s%9$N5UE>$,5/$k2DG=@-$,$"$k.

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

%a%C%;!<%8%Q%C%7%s%07?$NJBNs7W;;5!$K4X7F$O, =>Mh$h$j8D!9$NJBNs7W;;5!$,$=l>lN HW @-G=$rB8J,$KH/4x9k$?$a$NFH<+$N API $rDs6!$7$F$$$?. $=$N$?$a, %W%m%0%i%^$,8D!9$N API $r=$F@7J$$$H%W%m%0%i%`$,=q$1$J$$$H$$$&=i4|$N%*!<%P%X%C%IBg$-$$. $^$?, $"$k7W;;5!$GNI$$%"%W%j%1!<%7%g%s$,3+H/$5lFb, JLN7W;;5!XN0\?"@-$,Hs>o$K0-$$$H$$$&LdBj$,$"C?.

3lKBP7$F7W;;5!%/%i%9%?$G$O, $=$l<+BN$,EP>l$7$?GX7J$K PVM $d MPI $H$$$C$?I8=`E*$J API $,B8:_$7$?$?aK, 5!<o0MB8$N>/$J$$8zN(E*$J%W%m%0%i%_%s%04D6-$,Ds6!5l$F$$$k.!y!y

$^$?, MPP $N OS $O<+<R3+H/$7$?$bN,B?$/, %f!<%6%$%s%?%U%'!<%9$d%7%9%F%`%3!<%k$r=$F@$9kNKb;~4VrMW9kH798~$,$"$k. 3lKBP7$F7W;;5!%/%i%9%?$O!4pK\E*KO!K;THN$N OS $=$NbN$r;HMQ$9k?$a, F|>oE*$K;HCF$$$k PC/WS $HA4$/F10l$N4D6-$,;HMQG-kH$$$&MxE@$,$"$k.



?^**4** API $NE}0l$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$rGcCF$-$FDJ0@1JNG6KO@$H

!y %l%$%F%s%7!HW E*$J=hM}$r0MMj$7$F<B:]$K$=$N=hM}$,3+;O$5lk$^$G$N;~4V%9%k!<%W%C%H!<B:]$K HW E*$J=hM}$r9TCF$$$k:]$N=hM}B.EY

!y!y :G6a$NJBNs7W;;5!$G$O, :G=i$+$i MPI $r<BAu$7$?$bN,=P2skh$&$KJC$?$,, MPI $r;H$&$H MPP $N HW @-G=$,==J,$KH/4x$G$-$:$K7W;;5!%/%i%9%?$H$NM-0U$5$,=P$;$J$$$H$$$&LdBj$,$"$k.

7F$O3X=Q@-$J7G$"$k!y1. L^O@, 9=@.ItIJ$r:n $kHFMQItIJ%a!<%+$G$O, %3%9%H%Q%U%)!<%^%s%98~ >eN?aK@ZbxBvKa$NEXNO$,J5lF$*$j, 3N E@$O==J,$KI>2A9Y$-$G$"$k.

SW $K4X$7FO, 7W;;5!%/%i%9%?<+BN$, SW $K 0MB8$9$kItJ,$,Hs>o$KB?$$$?$a, 5;=QE*$J2]Bj$, Bt;3;D$CF*$j, 4hD%$C$F8&5f$9kH$=$lJj$N @.2L!?@-G=$,=P$;$k2DG=@-$,$"$k. FC$K, ;EMM$N 8x3+$5l?%O!<%I%&%'%"$H%U%j!<$JOS $r%Y!<%9 K7$?8&5f$,3hH/$K9T$olF$$$k. 7+7J$,$i, 3liN8&5f$NB?$/$OMPP Gb;H$($k5;=Q$,B? $$$?$a, 3X=Q@-$N:9$OHW Dx$GOJ$$.

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

0lHL$K, MPP $, 2G/$+$i3G/$+lF3+H/5l$k NKBP7F, 7W;;5!%/%i%9%?$r9=@.9kWS/PC $O3%v7n$+$iH>G/$*$-$K?7@=IJ$,EP>l$9kN$,8= >u$G$"$k. $=$N7k2LH7$F, F1;~4|$KF~<j2DG=$J MPP $H7W;;5!%/%i%9%?$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 $N0BDj@-$,9b$/%a%s%F%J%s %9$b0QBwG-kNKBP7$F, 7W;;5!%/%i%9%?$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+$7, <+J,<+?H$,Hqd7$?;~4V$KBP9k?M7oHq $OB~$G$"$k$H9M$(kH, 7W;;5!%/%i%9%?$NJ}$,05 E]E*$K%3%9%H$,0B$/$J$k.

0J>e, Cx<T$N<g4Q$r8r$($F MPP $H7W;;5!%/%i%9 %?$rHf3S7F$_$?$,, N><T$HbKJBNs7W;;5!G"k3 HO;v<BG"$k. $^$?, 0l8@$G7W;;5!%/%i%9%?$H$$$C Fb, J*M}E*$J<BBN$NH<oJ$$2>A[E*$J7W;;5!72$+$i, D6JBNs7W;;5!$H$N6hJL2=$,:Fq$J%7%9%F%`$^$GI}9-$/ B8:_7F$*$j, >e5-$N5DO@$,9YFKBP7F@5$7$$$H $O8@$$$,$?$$. 7+$7, 7W;;5!%/%i%9%?$,IsJb$N $+Bg;(GD$J%$%a!<%8$O;}CFD:1?$H;W$&. 0J2<GO, hj6q$BNE*$J7W;;5!%/%i%9%?$N8&5f!?3+H/F08~$r>R2p 9k.

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

4.1 %Y%s%@;vNc!y2

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

IPM $NSP %7%j!<%:$d, IY;NDL$NAP3000 $OD6JB Ns$N%9!<%Q!<%3%s%T%e!<%?H7F, Aa/$+$i;T>l$KEj F~$5lF$$$k7W;;5!%/%i%9%?G"$k. 7W;;%N!<%I$K$O ;THN$NWS MQ$K3+H/$5l?bNr[$\$=N^$^$N7A $G:NMQ$7, J#?t$N!<%I$r@lMQ$Nc~BN$KG<a?bN$r@l MQ$N9bB.%M%C%H%o!<%/!y3 $G@\B3$9$k7ABV$rHk. 7W; %N!<%I$,%b%8%e!<%k2=$5lF$$$k$?$a, 4pK\E*$K%O%b %8%e!<%k$N8r49$@$1$G: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 $NEnterprise Cluster %7%j!< %:$G, Ultra Enterprise %5!<%P$r1 %N!<%I$H7F:GBg 4 %N!<%I$G%/%i%9%?$r9=@.9k%7%9%F%`$G$"$k. %M%C %H%o!<%/%+!<%I$H$7$F$OSbus MQ$NSCI %+!<%I$r3+H/ $7, 4 %]!<%H$NSCI %9%$%C%A$G@\B3$7$F$$$k. 1999 G/ $^$G$K$O, :GBg12 %N!<%I (1024CPU) $N%/%i%9%?$r 3+H/$9$k$H$$$C$F$$$k. 64 %W%m%;%C%5$NUltra HPC 10000 $r4 %N!<%I@\B3$7$?8=:_$N:GBg9=@.%7%9%F%`$O :#G/6 7n$NTOP500 Supercomputer $G43 0L!y4 $K %i%s%/$5lF$$$k.

8 69F<9I.;~E@$G, %5!<%PItLg$NF08~$,$^$@ITL@$G$"$k $,, DEC <R!8=Compaq <R!K$O, <+<R3+H/$NMemory Channel II $r;H$C$?@=IJ$N6!5k$r9T$C$F$$$k. 7W;; %N!<%IH7FO, F1<R$NAlpha %A%C%W$r:GBg120CPU Ek:\$7$3$lir3,AXE*$J%/%m%9%PL$V$G@\B3$7$?SMP %5!<%P$r;HMQ9k. Memory Channel II $N%M%C%H%o!< %/<+BN$b%/%m%9%P!<LV$G, :GBg16 %N!<%I$r@\B32DG=$G $"$k. Memory Channel $O, 6&M-%G!<%?$N=q$-9~$_$K4X 7F<o43FC<l$JA`:n$,I,MW$G$"$k$,!y5, 6&M-%a%b%j$K =`$:$k%f!<%6%$%s%?%U%'!<%9$rDs6!$7F*$j, $=$N5! G=$rMxMQ$7$F:YN3EY$NDL?.KbBP1~G-$k%=%U%H%&%' %"$KhkJ,;66&M-%a%b%j4D6-$N3+H/$r9TCF$$$k.

Sequent <R$OPentiumPro 4 Bf$NSMP %/%i%9%?$r SCI =`5r$N%j%s%/(Link B.EY8Gbps) $G%j%s%0>u$K@\ B3$9$k NUMA-Q $r;T>l$K=P$7$F$$$k. B?$/$N7W;; 5!%/%i%9%?$,, NIC $r%7%9%F%`%P%9$K@\B3$9$k9=@.$r HkNKBP7F, NUMA-Q $OCPU $d%a%b%j$,@\B3 5l$k%W%m%;%C%5%P%9$KSCI =`5r$N%M%C%H%o!<%/%" %@%W%?$r@\B3$9$k3H$G, %O!<%I%&%'%"$Khk4OA4$J J,;66&M-%a%b%j4D6-$r<B8=$7, :YN3EYJBNs=hM}$r<B8= 9k. NIC $, NUMA-Q K+JjFC2=5l$F$$$k$,,

---

[!y1] HW $G2?$+3X=QE*J3HrL\O@$`$H7k2IE*$K MPP KJCF 7^$&2DG=@-$,$"$k.

[!y2] %Y%s%@;vNc$N%G!<%?$O, 1998 G/8 7nKv$N;~E@$G WWW Ey$G F~<j2DG=$J%G!<%?$K4p$E$$$F$$$k.

[!y3] SP %7%j!<%:MQ$N%M%C%H%o!<%/$O, 8=:_$OC1BN$G$b9XF~2DG=$G$" $k.

[!y4] LINPACK 80K×80K $G100GFLOPS

[!y5] 99?7$9$Y$-6&M-%G!<%?$N%"%I%l%9=NbNGOJ$/, %7%9%F%`%P %9>e$NNIC $N%G!<%?=q$-$_@lMQNNO$h$X=q$-9~$_$r9T$&I,MW$,$"$k

%M%C%H%o!<%/<+BN$O SCI %Y!<%9$NI8=`'IJG"kN$G%j%9%H%"%C%W$7$?.

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%&%'%"$H%U%j!<%=%U%H%&%'%"$@1G:ni1F*$j, DEC $N Alpha 68 Bf$K%U%j!<$J PC UNIX $N01$DG"$k Linux $rEk:\$7, DI>o$N FastEthernet $G@\B3$7$?%7%9%F%`$G$"$k. %M%C%H%o!<%/$O, 36 %]!<%H$N FastEthernet %9%$%C%A4 Bf$H, $3$1iN%9%$%C%A$rAj8_$K@\B3$9$k12 %]!<%H$N GigabitEthernet %9%$%C%A 1 Bf$G9=@.$5$1$F$$$k.

$3$1$@$1%7%s%W%k$J%7%9%F%`$G TOP500 Supercomputer $N 315 0L$K%i%s%-%s%0$5$1$k7rF.$V$j$G$"$k. 0x$K, <+A0$G%7%9%F%`$rAH$_N)$F, 15 K|%I%k$G 19GFLOPS $rC#@.$7F*$j, 15$/MFLOPS $N%3%9%H%Q%U%)!<%^%s%9$G$"$k. ?tCM$N>e$G$O64 %W%m%;%C%5$N Origin 2000 KIE(9k@-G=G"$k. C"$7, FastEthernet $N@-G=$r==J,$KO z$-=P9?aK, 01It$NMPI 4X?t$rFH<+$K3+H/$7$?$bNr Linux >e$K<BAu$7F*$j, NAS Parallel Benchmark $N7k2L$G$OMPICH KHfY$F2 G\6a$$%a%C%;!<%8%P%s%II}$rF@$F$$$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/$5$1$F$$$k Myrinet %Y!<%9$N7W;;5!%/%i%9%?[5]$O, D6JBNs7W;;5!$HHf3S$7$FB=?'$N$J$$@-G=$r=P$9$3$H$rL\I8$H7F$k. Avalon $,4pK\E*$KHW/SW $NA4$F$r4{@=I J$G9=@.7?NKBP7F, RWC GO, HW $OA4$F%3%b%G%#%F%#ItIJG"k,, NIC %+!<%I$N%I%i%$%P, OS, DL?.%i%$%V%i%j, 8@8l=hM}7O$H$$$C$?SW A4BN$KEOCFFH<+$K3+H/[!y]$7$?%7%9%F%`$G$"$k. >\:Y$OK\FC=8$N5-;v Ey$r;2>H$5$1$?$$.

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

%+%j%U%)%k%K%"Bg3X%P!<%/%1%9;;GO, 1990 G/Be$N=iF,$+$i Network of Workstations(NOW) $N8&5f$,9To1$F$$$k. IAi+$H$$$&$H, OS $d%G%#%9%/2s$j$N8&5f$,Cf?4G"$k. 8=:_$O, Solaris %^%7%sH7$F100 Bf$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%`Fb$K$O500-1000 Bf$N%O!<%I%G%#%9%/$,$"$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/4 7n;~E@$N@$3&5-O?$rC#@.7F$$$k.

xFS $O, !¥m!<%+%k%G%#%9%/>e$N%G!<%?hj$b, System Area Network >e$NB>$N7W;;5!$N<g5-21$K$"$k%G!<%?$NJ}$,B.$/%"%/%;%9$G$-$k!W$H$$$&H/A[$N8 5$K, %G!<%?$r;HMQ$9$k%/%i%$%"%s%H$N<g5-21$r%0%m!<%P%k$J6&M-%U%!%$%k%-%c%C%7%eH7$F;HMQ$9$k cooperative caching $d, J,;66&M-%a%b%j7?JBNs7W;;5!K*1k%-%c%C%7%e0l4S@-@)8f$N<jK!$r1~MQ7F file C10L$N4IM}%N!<%I$rF0E*$KJ,;6$9$k<jK!, J#?t7W;;5!$N%G%#%9%/$K8Y$G$F%9%H%i%$%T%s%0$r9T$&%=%U%H%&%'%" RAID $N<jK!$JIr1~MQ7F, $"$kFCDj$N7W;;5!$,%U%!%$%k%7%9%F%`A4BN$N4IM}$rC4Ev$9$k$H$$$C$?>u67$,5/$i$J$$$h$&$K$7$F$$$k. $3$1$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%?$N I/O %7%9%F%`$N%9%1!<%i%S%j%F%#$H%3%9%H%Q%U%)!<%^%s%9$,NI$/8=$1$F$$$k.

4.2.4 6-L\$N$J$$JBNs=hM}4D6-$rL\;X$7$F

%$%j%N%$$Bg3X$N A. Chen Ey$N%0%k!<%W$O, %O!<%I%&%'%"$N@-G=$r2DG=$J8B$j0z$-=P$9%a%C%;!<%8%Y!<%9$NDL?.%i%$%V%i%j FM(Fast Message) $r<BAu$7$?%W%i%C%H%U%)!<%`>e$G$N%7!<%`%1%9$J7W;;5!4D6-HPVM(High Performance Virtual Machine) $N8&5f$r9TCF$$$k. $=$N0l4DH7$F7W;;5!%/%i%9%?$N8&5f$r9T$CF*$j, Myrinet %Y!<%9$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<BAu7F$*$j, 7W;;5!%/%i%9%?$+$iD6JBNs7W;;5!$^$G%W%m%0%i%`$N9b$$0\?"@-$,J]>Z$5$1$F$$$k.

H`i,3+H/7?7W;;5!%/%i%9%?$NBh;0@$Be%^%7%s$O%9!<%Q!<%/%i%9%?$H8FP1F*$j, F1Bg3X$N NSCA $KF3F~$5$1$F$$$k. 300MHz Pentium II Processor $N2-Way SMP, <g5-21512MB, %O!<%I%G%#%9%/4GB 9=@.$N%N!<%I$r128 %N!<%I Myrinet $H100Mbit Ethernet $G@\B3$7$?9=@.$G$"$k.

4.2.5 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$N K.Li iN%0%k!<%W$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:$K%f!<%6%1%Y%kDL?.$r2DG=K9$k5!9=$H7F, 2>A[%"%I%1%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, $3$1$r<B8=$9k?aN@lMQ$M%C%H%o!<%/%$%s%?%U%'!<%9%+!<%I$r3+H/$7$F$$$k. #2DN%W%m%;%94V$G0lC6 Channel $r@_Dj$9kH, $=$10J8e$N%W%m%;%94VDL?.$O Channel $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$?$aKO,

[!y] 01It$O%U%j!<%=%U%H$N2~NI

%W%m%;%C%5Fb$GH/@8$7$?%G!<%?$NJQ99$r8!=P$9kI,MW,$"$k. $=$NL\E*N?aK, %W%m%;%C%5%P%9$K%P%94F;k$N$?$a$N%O!<%I%&%'%"$r@_$1, $=$N%O!<%I%&%'%"Kh$j%G!<%?$N0l4S@-J];}$NI,MW@-$rH=CG$7, I,MW$G$"$l$P6qBNE*$J=hM}$O%7%9%F%`%P%97PM3$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$$$oPCrE,EYKDJ$$$G@lMQJBNs7W;;5!KIE(9k@-G=$r=P$9!WHkpC$F$$$kN,7W;;5!%/%i%9%?G"$k. A0<T$N>l9g, !0V`<!=hM}!W$+$i!JJBNs=hM}!W$H$$$&??$K5;=QE*$JJQ3W$,$"C?NKBP$7, 8e<T$O!}VH$$$d$9$5!W$d!V3%9%H%Q%U%)!<%^%s%9!W$NDI5f$H$$$&, JBNs=hM}5;=Q$N!N/E8!W$+$i!0V.=O!W$X$NJQ3W$G$"$k$H9M$($k.

$^$?, =>Mh$NJBNs7W;;5!$N8&5f!?3+H/$,%O!<%I%&%'%"<gF37?$G$"$C$?$NKBP7$F, :r:#$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$,Dc$/Jj, hjB?$/$N%W%m%0%i%^$,JBNs=hM}$rBN83$9$k5!2qrbC?3H$OHs>o$KM-0U5AG"$k. 3Nh&$J%V%l!<%/%9%k!<KhCFJBNs=hM}$,0lIt$N8&5f<TN?aN5;=QGOJ/, 4/0lHLNEv?$jA0$N5;=QHJk3Hr4j$&<!Bh$G$"$k.

;2 9M J8 8%

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