HFMQD6JBNs%*%Z%l!<%F%#%s%0%7%9%F%`%+!<%M%k SSS–CORE — 4pK\J}<0$*$h$S NOW HG$N<BAuKD$$$F —

Architecture and implementation of the general-purpose massively-parallel operating system: SSS–CORE

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[*1,*2,*6] El5~Bg3X Bg3X1!M}3X7O8&5f2J >pJs2J3X@l96

[*3,*4,*5] M-8B2q<R %"%C%/%9

SSS–CORE $O%o!<%/%9%F!<%7%g%s%/%i%9%?$*$h$SJ,;6%a%b%j7?JBNs7W;;5!$rBP>]H7$?HFMQD6JBNs%*%Z%l!<%F%#%s%0%7%9%F%`$G$"$k!#K\%*%Z%l!<%F%#%s%0%7%9%F%`$O%^%k%A%f!<%6!?%^%k%A%8%g%V$H$$$&HFMQ7;;5!$KIT2D7g$J5!G=$r<B8=$7DD!"3NHFMQ@-$H=>MhAjMF$lJ+C?JBNs7W;;$N8zN($rMn5J$$$?aN3F<5!9=5!G=$r<B8=$9$k!#K\9F$G$O SSS–CORE $N9=@.$HFCD'$r2r@b$7!"8=:_3+H/<BAuCf$N%o!<%/%9%F!<%7%g%s%/%i%9%?HG SSS–CORE $N<BAuJ}<0$JiS$K3+H/>u67$K$D$$$F=RYk!#:G8e$K!"%+!<%M%k%l%Y%k%9%1%8%e!<%j%s%0J}<0$r7hDj$9k?aK9TC?%7%_%e%l!<%7%g%s<B83JiSK3+H/Cf$N<B5!$N SSS–CORE >e$G9T$ol?4JC1$J%a%b%j%Y!<%9DL?.$K4X9k=i4|I>2A<B83$N7k2L$r<($9!#

1 O8aK

%^%$%/%m%(%l%/%H%m%K%/%95;=Q$N5^B.$J?JE8$KH<$$!"%o!<%/%9%F!<%7%g%s$r9bB.%M%C%H%o!<%/$G7k9g7?%o!<%/%9%F!<%7%g%s%/%i%9%?!JNetwork of Workstations: NOW!K$dB??t$N CPU $rEk:\$7$?J,;6%a%b%j7?JBNs7W;;5!$,MF0W$K<B8=2DG=$KJj!"=>Mh%a%$%s%U%l!<%`$N2DG=@-$J$o$ABg7?!?D6Bg7?7W;;5!%7%9%F%`$@1,<B8=2DG=G"C?1~MQJ,LnKBP7FbE,MQ$N2DG=@-$,9b$^$CF-$?!#FC$K!"6aG/$N%3%s%Q%$%iEy8@8l=hM}7OKh$kAj8_7k9gLV$NCY1d1#JC!"%W%m%;%9$d%G!<%?$N:GE,J,3dJ}<0!"F14|:GE,2=J}<0$NF3F~$Khj!"I,9~$$$1~MQJ,LnKBP7$FJ,;6%a%b%j7?$NJBNs7W;;4D6-$r8zN(NI$/MxMQ9k3H$,2DG=$HJjDD$"$k!#7+$7!"$i!"HFMQ@-!J%^%k%A%f!<%6!&%^%k%A%8%g%V!KF3F~Kh$kJ]8n5!G=$N<B8=$d<B;q8;$N2>A[2=$OJBNs=hM}@-G=$NBg$$JDc2<$N860x$HJk$?$a!"8=>u$NJBNs7W;;4D6-$*hSJBNs7W;;5!$O4pK\E*$K%P%C%/%(%s%I%W%m%;%C%5H7FN%A=hM}$G;HMQ$5lk3H$,B?$$!#%"%W%j%1!<%7%g%sKh7F8@$($P!"%P%C%A=hM}$G;Y>c$,$J$$2J3X5;=Q7W;;N_$,JBNs=hM}$5$l!"B>$N%"%W%j%1!<%7%g%s$O<B9TC10L$4HK8DJL$K%W%m%;%C%5$N3djEvF$r<u$1$F!"$[Hs$IHsF14|$KJ,;6=hM}r7$F$$$k$K2a$.$J$$!#$=$N860x$O!"@-$b=RY?h&$KJ]8n$d2>A[2=$rHFMQ@-<B8=$N$?$a$KF3F~$9k3H,JBNs=hM}$KBgI}$J@-G=Dc2<rb$?$i$9$3HK

5/0x9k!#8@$$BX$($k$H!"%=%U%H%&%'%"$KhkMM!9$J:GE,2=J}<0$NE,MQ$*$h$S7Z$$DL?.F14|<jK!$,%7%9%F%`$NFH$jE*;HMQ$rMW5a$7!"%7%9%F%`$N=@Fp$+$DHFMQE*$J;HMQ7ABV$HAjMFlJ$+$C$?$+iG$"$k!#

2f!9$OO0JA0$hj9YF$N CPU $+$iEy5wN%$G%"%/%;%92DG=$J6&M-%a%b%j$r;}$D Uniform Memory Access !JUMA!K7?JBNs7W;;5!$rBP>]$K7F!"%f!<%6Kh$k:GE,2=$r;Y1g9kHFMQ%*%Z%l!<%F%#%s%0%7%9%F%`3K SS–CORE [1]$r8&5f3+H/$7F-$?!# SS–CORE $N8&5f$K$*$$$F$O5DO@$rC1=c2=9k$?$a$K!" UMA 7?JBNs7W;;5!$K7F8BDj$7!"<B%W%m%;%C%5$N;q8;4IM}$KE*$r9JC?8&5f$r9T$C$?!#$7$+$7!"5;=Q$N?JJb$OL\3P7/!" UMA 7?JBNs7W;;5!hj$bB?$/$N%W%m%;%C%5$r@\B32DG=G"$j!"$=$N%9%1!<%i%S%j%F%#$,9b$$ NUMA !JNon-Uniform Memory Access!K7?JBNs7W;;5![1] $,8=:_<BMQ2=$5lDD"$k!#=>$C$F!"HFMQ@-$r;}C?;HMQ7ABVK*$$$F$b NUMA 7?JBNs7W;;5!$r9b$$8zN($G;HMQ$9k?aN%-!<HJ$k%*%Z%l!<%F%#%s%0%7%9%F%`3K **SSS–CORE** !J**Scalable SS–CORE**!K [2]$N3NN)$,Hs>o$K=EMW$HJCFF$$$k!#

2 UMA 7?JBNs7W;;5!MQ OS 3K SSS–CORE

SSS–CORE $K4X$7$F=R$Y$kA0$K!" SSS–CORE $N%Y!<%9$HJC$? SS–CORE $K4X$9$k8&5f$K$D$$$F4JC1$K>R2p

† K\8&5f$O>pJs=hM}?66=;v6H6(2q!VFHAOE*>pJs5;=Q0i@.;v6H!W$N0l4D$H7F9Tol$?$bNG$"$k!#

[1] $3$3GO%o!<%/%9%F!<%7%g%s%/%i%9%?!"J,;6%a%b%j7?JBNs7W;;5!!"J,;66&M-%a%b%j7?JBNs7W;;5!Ey$NAm>N

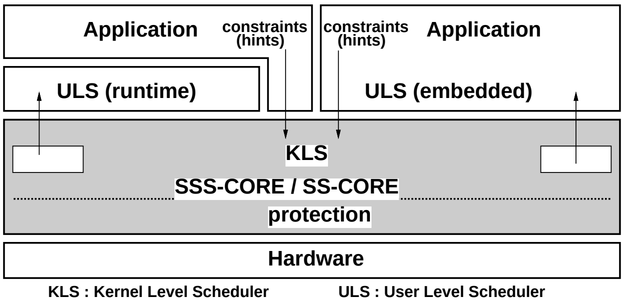

Figure 1 SS–CORE / SSS–CORE $N;q8;4IM}9=B$

9k!# UMA 7?JBNs7W;;5!MQ$N OS 3K$G$"$k SS–CORE $O%f!<%6$KhkJBNs<B9T$N:GE,2=$N$?$a$K!"

- !V;~J,3d5l$?%Q!<%F%#%7%g%K%s%0$Khk%^%k%A%8%g%V!W
- !V;q8;$N%0%k!<%WC10L4IM}!W
- !VE,@Z$JJ]8n$N2<Gf!<%6$X;q8;$r:GBg8B$K2rJ|!W
- !V%+!<%M%k%l%Y%k%9%1%8%e!<%j%s%0>pJsrf!<%6$X3+<(!W
- !V%+!<%M%k%l%Y%k%9%1%8%e!<%j%s%0XN%W%m%0%i%9$N@EE*>pJs$K4p$E$$$?%f!<%6@)Ls!?%R%s%H$N:NMQ!W

$H$$$C$?4pK\J}?K [3] [4]$r;}$D!J?^ 1;2>H!K!#$3$N4pK\J}?K$K4p$E$$$?8&5f$N7k2L!"%W%m%;%C%5;q8;4IM}$K4X$7$F!"@$3&$K@h6n$1$F0J2<$Nh&$JJ}<0!?5!9=$r9M0F7?!#

- %+!<%M%k!?%f!<%6$N;q8;3dEv>u67$d<B9T>u67$K1~$8$F%9%1%8%e!<%j%s%0*%W%7%g%sD-$N%9%T%s%&%'%$%H Snoopy Spin Wait (SS-wait^2) [5]
- %+!<%M%k$K%W%j%(%s%W%H$5l?%W%m%;%C%5%3%s%F%9%H$N%f!<%6%l%Y%k$NI|5l [5]
- <B%W%m%;%C%5%0%k!<%W$r%f!<%6!J%W%m%;%9!K$K3djEvF!"%0%k!<%WFb$N%W%m%;%C%5%9%1%8%e!<%j%s%0$b%f!<%6$K0lG$$9$k%f!<%6!?%+!<%M%k$NFs3,AX%9%1%8%e!<%j%s%0J}<0 [5]
- JBNs%W%m%0%i%`$N@-<A$K$h$kJ,N`H=lrMxMQ7?%+!<%M%k%l%Y%k%9%1%8%e!<%j%s%0 [1]

SSS–CORE $N;q8;4IM}J}?K$O SS–CORE $N4pK\J}?K$r<u$17Q$.!" SS–CORE $N8&5f$K$*$$$F9M0F5l$?5!9=$r!?J}<0$K4X$7FOBP>]7W;;5!%7%9%F%`$r NUMA 7?$KJQ99$7$?3H$KH<$&3HD%$r9T$C$F$$$k!#

3 %a%b%j%Y!<%9DL?.5!G=

SS–CORE GOIN CPU $+$i$bEy5wN%$G%"%/%;%92DG=$J6&M-%a%b%j$rBP>]7W;;5!B&$K2>Dj$7$F$$$?NG!"%f!<%6%l%Y%k$NDL?.F14|$O3N6&M-%a%b%j$r2p$7$F9T$&3H$,2DG=$G$"$k!#$^$?!"%a%b%jKO%a%b%jJ]8n, O@M}!?J*M}$N%"%I%l%9JQ49, 2>A[5-21%5%]!<%H$,$"k?aK!" UMA 7?JBNs7W;;5!K*1k6&M-%a%b%j$r2p$7$?DL?.F14|$O%*%Z%l!<%F%#%s%0%7%9%F%`$ND>@\E*$JCg2pJ7$KJ]8n$H2>A[2=$r<B8=$G$-$k!#5i$K!"%O!<%I%&%'%"$G<B8=5l$?BP>N7?6&M-%a%b%j$N%"%/%;%9B.EY$OB.$$$?$a!"%f!<%6%l%Y%k$N7Z$$$2>A[2=5lJ]8n5l$?DL?.F14|

$,6&M-%a%b%j$rMQ$$$$k$@$1$G<B8=$G$-$k!#

SSS–CORE GOBP>N7?6&M-%a%b%j$r;}$D UMA 7?JBNs7W;;5!$N9b<B8=%3%9%H$H%9%1!<%i%S%j%F%#$N7gG!$rM}M3$K!"BP>]7W;;5!%7%9%F%`$r$h$j01lHLE*$J NUMA 7?JBNs7W;;5!$K@_Dj$7$F$$$k!#$5$i$K!" SSS–CORE $G$ODL?.F14|MQ$NFCJL$J$O!<%I%&%'%"$r2>Dj$7$J$$J}?K$rN)$F$F$*$j!"8=:_<BAuCf$N NOW HG SSS–CORE $G$O;THN$NNL;:%o!<%/%9%F!<%7%g%s$r LAN MQ$N%M%C%H%o!<%/$G@\B3$7$?%7%9%F%`$rBP>]H7$F$$$k!#3N$?$a!"%O!<%I%&%'%"$G<B8=$5l?BP>N7?6&M-%a%b%j$d Memory Based Processor (MBP) [6]Nh$&$J@lMQ%O!<%I%&%'%"$rDL?.F14|$KBP7F;H$&$3HOG-$:!"7Z$$$f!<%6%l%Y%k$NJ]8n$5$l2>A[2=$5l?DL?.F14|$r<B8=$9$kJ}K!$,Bg$-$JLdBjHJ$k!#$3$NLdBj$KBP7F!" SSS–CORE GO%=%U%H%&%'%"Kh$k%a%b%j%Y!<%9DL?. [7]$G2r7h$r?^$C$F$$$k!#A4BNA|$NM}2r$rMF0WK9k?$a!"=>Mh$N%f!<%6%l%Y%k$NDL?.F14|$r9T$&:]$KLdBjHJCF$$$?E@$H!"$3li$NLdBj$r2r7h9k$?$a$N%a%b%j%Y!<%9DL?.$N5;=QE*$JMWE@$r0J2<$K=R$Y$k!#%a%b%j%Y!<%9DL?.$N>\:YJ}<0$K4X$7FO;29FKF5-=R9kM=DjG"$k!#

THN$N%o!<%/%9%F!<%7%g%sEy$r%N!<%I$K;HMQ$9k3Hr2>Dj9k$H!"DL?.MQ%$%s%?!<%U%'!<%9XNDc%l%Y%k%"%/%;%9$OJ]8n$N4QE@$+$i%+!<%M%k%b!<%I$G9T$&I,MW$,$"$j!"<u?.%$%s%?%U%'!<%9$ODL>o<u?.%P%C%U%!%a%b%j$KDL?.FbMF$r<u$1<h$k9=@.$HJC$F$$$k$,!"<u?.%P%C%U%!%a%b%j$NNN0h$OM=$a@_Dj7F$*$/I,MW$,$"$j!"MFNL$OM-8BG"$k!#$3N?$a!"<u?.3d$j9~$_%O%s%I%i$rMQ0U7F!"3d$j9~$_%Y!<%9$GE,59<u?.FbMF$r<g5-21>e$KB`Hr$9$kI,MW$,$"$k!#$3$N$h$&$J7W;;5!4D6-$K$*$$$F=>Mh7?%*%Z%l!<%F%#%s%0%7%9%F%`$N>e$G%a%C%;!<%8%Q%C%7%s%0J}<0$NDL?.$r<BAu7?:]$NLdBjE@$O0J2<NDLjG"$k!#

- $b%*!<%P%X%C%I
  - %f!<%6!?%+!<%M%k@ZBX%3%9%H
  - %3%s%F%/%9%H@ZBX%3%9%H
  - %-%e!<A`:n%*!<%P%X%C%I
  - %P%C%U%!A`:n!J%3%T!<Ey!K%*!<%P%X%C%I
  - %N!<%I4V%3%M%/%7%g%s4IM}%*!<%P%X%C%I
- %^%k%A%-%c%9%HDL?.$N%*!<%P%X%C%I
- Acknowledge(Ack) 2s<}$N%*!<%P%X%C%I
- 1s3V<B9TKh$kIT8xJ?@-
- 1s3V<B9TKh$k%-%c%C%7%e!? TLB %]%j%e!<%7%g%s

LdBjE@$,G'<1$5ll$P2r7h:v$O4JC1G"$j!"$=lO6&M-%a%b%j%W%m%0%i%_%s%0%b%G%k$K4p$E$/9b5!G=1s3V%a%b%j%"%/%;%9!"D^$j%a%b%j%Y!<%9DL?.!JF14|!K5!G=G"$k!# SSS–CORE K*1k%a%b%j%Y!<%9DL?.5!G=HO MBP $H6&$KDs0F5l$?9b5!G=J,;66&M-%a%b%j%7%9%F%` !JSMS: Strategic Memory System!K [6]>e$N3F<o%a%b%j%Y!<%9DL?.5!G=$d%a%b%j%Y!<%9F14|5!G= [8]$r!" NOW $dJ,;6%a%b%j7?JBNs7W;;5!$K2DG=$J8B$jDc%*!<%P%X%C%I$N%=%U%H%&%'%"$Khj<BAu7?bNNKB>Ji$J$$!#A05-$NLdBjE@$r2r7h9kMWE@$r4JC1$K@bL@9k!#

1. C1Kf!<%6!?%+!<%M%k$N%b!<%I@ZBX%H%i%C%W$d30It3d9~%O%s%I%iXNH?1~;~4V$@$1$G8+$l$P!"9b@-G=%^%$%/%m%W%m%;%C%5$N%*!<%P%X%C%I$O?t%/%m%C%/!A?t

2 SS–CORE $NL>A0$NM3MhHJ$kF14|J}<0

==%/%m%C%/DxEYG"$k!#=>Mh7?$N%*%Z%l!<%F%#%s%0
%7%9%F%`GOM>J,$J%A%'%C%/$dM>J,$J:F%9%1%8%e!<
%j%s%0$G%3%9%H$rBgI}$KA}Bg$5$;$F$$$k!#$=$3$G
IU?o9k%*!<%P%X%C%I$r:G>.8B$KM^$($k$?$a$K0
2<Nh$&$J<BAu$r9T$&!#%f!<%6%l%Y%k$G;HMQ$9$k
%N!<%I4VDL?.F14|MQ%7%9%F%`%3!<%k$d3d9~%O%s%I
%i$O!" OS $NB>$N I/O 4X78$N%7%9%F%`%3!<%k$d3d9~%l!<
%O%s%I%i$HJ,N%$7$F<BAu$7!"DL?.F14|KHCFM>J,
$J%A%'%C%/Ey$rA4GQ$7!"%+!<%M%k8"8B$G<B9T5l$k
%3!<%I$*$h$S%f!<%6!?%+!<%M%k@ZBX$K:]7FB`HrI$
5l9k%W%m%;%C%5%3%s%F%/%9%H$r:G>.8B$K9k!#$
$NDL?.F14|MQ%7%9%F%`%3!<%k$d3d9~%O%s%I%i$G$O
%-%c%C%7%e%U%i%C%7%e$d TLB %U%i%C%7%e$r9ToJ
$$!#

2. OS $N%W%m%F%/%7%g%s$N2<$G%P%C%U%!$N%3%T!<2s?t
$d%=%U%H%&%'%"%*!<%P%X%C%I$rM^$($k:GNI$NJ}K!
$O!"%a%b%j4IM}5!9=$H6(D4F0:n9k1s3V%a%b%j%"%/
%;%9MQ$N%O!<%I%&%'%"!J$D$^$j MBP Nh$&$JJ*!K
$r;HMQ$9k3HG$"$k!#3N1s3V%a%b%j%"%/%;%9M
%O!<%I%&%'%"$r2>Dj$7$J$$>l9g$O!"DL?.%Q%1%C%HF
$KDL?.Aj<j@h$N%"%I%l%96u4VFb$NL\E*%"%I%l%9$$
3JG<7F$*$-!" 1. $N<BAuJ}?K$K=>CF:nil$?%a%
%;!<%8<u?.MQ$N3d9~%O%s%I%i$,D>@\Aj<j@h$N%f!<%6
6u4VFb$N%a%b%jNN0h$KDL?.%Q%1%C%HFb$N%G!<%?$r
!J<u?.%P%C%U%!NN0h$+$i!K3JG<9k!#%W%m%F%/%7%
%s$O%Q%1%C%H$NH/?.85$H<u?.@h$N>/J/HbIA$
$+0lJ}$G%1%$%Q%S%j%F%#%A%'%C%/$r9T$&$3HG<B8
G-$k!# SSS–CORE $N8=:_$N<BAuGO%Q%9%o!<%I
!J32bit ?tCM!K$rMxMQ$7$?%1%$%Q%S%j%F%#%A%'%C%/
$r<u?.@h$N3d9~%O%s%I%i$G9T$C$F$$$k!#

3. F0E*$JDL?.$O%3%M%/%7%g%s$bF0E*$K@\B3!&2r=|5
kN$G!"B??t$N%3%M%/%7%g%s$rF1;~$KJ];}4IM}9k
$?$a$N%3%9%H$NLdBjO"$^$j@8$8$J$$!#7+$7!"@
E*!J%3%s%Q%$%k;~!K$K!"DL?.Aj<j$dAw?.@h%"%I%l%
$d%U%'%C%A%G!<%?$N%"%I%l%9$,H=$k>l9gKO!"DL?.
Aj<j$dE>Aw@h%"%I%l%9$H$$$C$?%3%M%/%7%g%s$K4X$
$k@EE*>pJs$rMxMQ7?J}$,!"F0E*$J%3%M%/%7%g%s$
D%$k%*!<%P%X%C%I$,2sHrG-kN$G8zN($,NI$$!#J
Ns<B9T$KHs>o$KE,7?%G!<%?%Q%i%l%k!JSPMD!K$N
?tCM7W;;%"%W%j%1!<%7%g%sGO!"O@M}%"%I%l%96u4
$r3F%W%m%;%C%5$G6&DL!J$?$@$7%a%b%j$N<BBN$OJ,
K9k3H,Hs>o$KM-8z$G$"$k!#O@M}%"%I%l%96u4
4V$r6&DL$K9k3HKh$j!"1s3V%a%b%j%"%/%;%9$N
$?$a$N%3%M%/%7%g%s>pJs$O%W%m%0%i%`%3!<%IFb$K
:nBP>]$NO@M}%"%I%l%9!J$H@EE*$KH=L@$9$kO@M}%W%m
%;%C%5!KH7$F3JG<2DG=$KJj!"<B9T;~KOO@M}%W
%m%;%C%5$HJ*M}%W%m%;%C%5!JJ*M}%N!<%I!K$NBP1~
<hk@1GDL?.F14|$,2DG=$G$"$k!#DL?.F14|MW5a$
%1%C%H$N<u?.3d9~%O%s%I%i$,BP>]O@M}%W%m%;%C%5$
O@M}%"%I%l%9$r2r[3]7h$F%a%b%jA`:n$r9T$&!#

4. MBP Kh$k SMS NBg-$JFCD'$K3,AX%^%k%A%-%c%
%9%H$H Ack %3%s%P%$%K%s%0Kh$k update %Y!<%9

$N%-%c%C%7%e$N<B8=$,$"$k!#$3$N update %Y!<%9$N
%-%c%C%7%e%7%9%F%`$O>e5-$N SPMD %W%m%0%i%`$N
cHF1MM$KO@M}%"%I%l%96u4V$r3F%N!<%I$G6&DL$K
hj!"O@M}%"%I%l%9$,F1$8%-%c%C%7%eMQ$N%Z!<%8$r
$F%N!<%I$KMQ0U7F!"3,AX%^%k%A%-%c%9%H$d Ack %3
%s%P%$%K%s%0$r$Q%1%C%H<u?.3d9~%O%s%I%i$G%(%_%e
!<%H9k3H$G<B8=$G$-$k!#4pK\E*$KBg5,LO$J%^
%k%A%-%c%9%H$O3,AX9=B$$rMxMQ7F9Tol!" Ack $N
%3%s%P%$%K%s%0$b3,AX9=B$$rMxMQ7J$$8B$j8zN(2=
G-$J$$!#3N$?$a!" update %-%c%C%7%e$N<B8=J}
0O NOW G"$l!"J,;6%a%b%jJBNs7W;;5!$G$"$l!"
,;66&M-%a%b%jJBNs7W;;5!G"$l!"4pK\J}<0$KJQ$o
jO$J$$!#$=$3$G!" NOW K*$$$F$O%M%C%H%o!<%/
Fb$K3,AXE*$J7PO)$r@EE*$K8+$$=P7F!"$=$l$rMxMQ
7F<B8=5l$k!#

J%V$J%a%C%;!<%86nF0$dMW5a6nF0JI$N%Q%1%C
%HE~Ce6nF0Kh$k<B9T7ABV$r4pK\<B9T7ABVH7$F
A*Br9kKO8=:_$N9b@-G=%^%k%A%W%m%;%C%5$O=hM}
$N6u4VE*;~4VE*6I=j@-$r4|BT$7$9$.$F$$$k!#$^$?!"
6I=j@-$NMxMQ$O!"%3%s%T%e!<%?$N9bB.2=$KHC$F:G
$b=EMW$J;v9`G"k+$i!"IT2DHr$G$"$k!#7+$7!"
hM}7?$$$G!<%?%;%C%H$NBgItJ,$,B>$N%N!<%I$K$"
kh$&$J>l9g$O5U$KDL?.KhCF%3%s%H%m!<%k$r0\
F0$7$?J}$,6I=j@-$,Cj=PG-$k!#$3$N>l9g$K$*$$
Fb!"8=:_<B9TCf$N%8%g%V$+$i CPU $rC%$C$F<B9T
7?NG$O!"8=:_<B9TCf$N%8%g%V$N6I=j@-$NMxMQ$r
K8$2!"%9%1%8%e!<%j%s%0$N8xJ?@-$+$i$bK>$^7/$J
$$!#3N$?$a SSS–CORE GO!" SMS $N Memory-Based Signal $HF1MM$K!"%f!<%6%l%Y%k$N%i%s%-%e!<
$K%Q%1%C%H$H7F1?PlF-$?<B9T%9%l%C%I$rD>@\
3JG<9k3H$G!"%-%c%C%7%e%]%j%e!<%7%g%s$dIT8x
J?@-$r2sHr$9$k!#$3$N%f!<%6%l%Y%k%i%s%-%e!<$N=j
M-<TG"$k%8%g%V$,<B%W%m%;%C%5$K%9%1%8%e!<%j%s
%0$5$l$F$$$k;~7+3N%-%e!<$+$i%9%l%C%I$,5/F0
5lk3HO$J$$!#3N$?$a4X78NJ$$%8%g%V$N
CPU ;~4V$N>CHq$O%-%e!<XNEPO?A`:n!J%G!<%?NL
,B?$$>l9g$O<B:]$N%G!<%?0\F0$O DMA E>Aw!K$N$_
G"$j:G>.8B$G$"$k!#5i$K!"$3$N%9%l%C%I5/F0$O
%"%I%l%96u4V$,$9GK@ZjBXoCF$*$j!"%f!<%6%l
%Y%k$G<B8=$5lkNG!"6KaFDc%3%9%HG"$k!#
$?!"1s3V%a%b%j%j!<%I$d3F<o%a%b%j%Y!<%9F14|5!G=
$N%W5a85$+iN1s3V%a%b%j%"%/%;%9MW5a%Q%1%C%H$NAw
?.$N<u?.;~$K3d9~%O%s%I%iFb$GL\E*%/%i%9%?!J%N!<%I!K
$NL\E*%?%9%/$NBP>]%"%I%l%9$NA`:n!JF14|=hM}$N<oN`
KhCF$OIT2DJ,A`:n!K$*hSMW5a85XNJV$jCM!JJV$j
CM!K$NJVAw!"MW5a85$G$N<u?.3d9~%O%s%I%i$KhkJV$jCM
NJVjCM%"%I%l%9XN=q$-9~$_!JAck $N>l9g$O%+%&%s%H
%"%W$d%+%&%s%H%@%&%s!K$G<B8=5l$k!#
$N<%I4VDL?.F14|$K4XokDc%l%Y%k$N3F<oF14|>pJs$O
9Y$F%f!<%6%l%Y%k$N%U%i%0$KH?1G$5$l!"$3$N%U%i%0$r
MxMQ7F SS-wait KhCFF14|$,9T$olk!#1s3V%a%b
%j%"%/%;%9$N=g=x%b%G%k$K$O4KOB$5l?%a%b%j%"%/
%;%9%b%G%k$rMxMQ$9k3HG@-G=$r8~>e$5$;$k!#1s3V%a%b
%j%"%/%;%9$N=g=x4IM}$O Ack %Y!<%9$N%a%b%j%P%j%"$G
$k!#

[3] 2r7h$H8@$CFbDL>o TLB $rB?$/Hb 1 K\%;%C%H9k$@$1G"
$k!#

9Tolk,!"2DG=$J8B$j Ack $r>JN,$7$F:Q$^$;$kh&
$K<BAu$r9T$&!#$^$?!"<BAu>e$NLdBjH7FO!" Ether $H
FastEther Nh$&$K%G%P%$%9%l%Y%k$G%Q%1%C%H$,>C<:$9
$k2DG=@-$,$"$kDL?.%O!<%I%&%'%"$KBP1~$9k?aK!$Q
%1%C%H$KAw?.%N!<%IKh$K%7%j%"%k%J%s%P!<rD1F4IM
7F$$$k!#

4 HsBP>NJ,;66&M-%a%b%j

SSS–CORE GO!"A0=R$N%a%b%j%Y!<%9DL?.5!G=$r;H$C
$F!"?7$7$$%=%U%H%&%'%"J,;66&M-%a%b%j!J%=%U%H%&%'%"
DSM!K$NOHAH$G$"$kHsBP>NJ,;66&M-%a%b%j!JAsymmetric Distributed Shared Memory: ADSM!K [9]$r%f!<%6
$KDs6!$9$k!#1s3V%a%b%j=q$-9~$_$rH<$&2DG=@-$,$"$k>l
9g$K!"=>Mh$N%=%U%H%&%'%" DSM [10]$OC1$J$k store L?Na
$r%3%s%Q%$%i$,MQ0U$7!"%Z!<%8$N=q$-9~$_%H%i%C%W;~$K
%3%s%7%9%F%s%70];}N?aN%3!<%I$r<B9T$7$F$$$?NK
BP7F!" ADSM N?aN%3%s%Q%$%i$O=q$-9~$_BP>]$N
%G!<%?$N=>$&Y-J,;66&M-%a%b%j%W%m%H%3%k$KE,9g$7$?
0lO"$NL?Na!J%3%s%7%9%F%s%70];}%3!<%I$r4^$`!K$r<B9T
%3!<%IH7FKda9~$`!#1s3V%a%b%jFI$_=P7N2DG=@-$K
4X7F$O!"=>Mh$N%=%U%H%&%'%" DSM $HF1MM$K!" load L?
Na$rMQ0U$7%Z!<%8%H%i%C%W$G%-%c%C%7%e%_%9$r8!=P7F
BP=h9k!#1s3V%a%b%jNFI_=P7H=q$-9~$_$N<h$j07$$
$,0[$J$kE@$, ADSM $N:GBg$NFCD'G"$j!"L>A0$NM3Mh
HJCF$$$k!#3N1s3V%a%b%j=q$-9~$_N?aN store
L?Na$r0lO"$NL?NaNsGCV-49$($F7^$&$3HKhj!"
ADSM $N<+M3EY$OHs>o$K8~>e$7F*$j!"MM!9$J%a%b%j%b
%G%k$d%3%s%7%9%F%s%7%W%m%H%3%k!J99?77?$r4^$`!K$r%5
%]!<%H2DG=G"$j!"DL?.NL$*hSDL?.2s?t$r:o8:$9k?
aNDL?.$NF0E*%3%s%P%$%K%s%0$b%3!<%I$H7FKd$a9~$`
3H$,$G$-$k!#5^6^$J%W%m%H%3%k$,<B8=2DG=J3$H
$+$i!" SSS–CORE >e$N ADSM GO%Z!<%8C10L$N%W%m
%H%3%k@ZBX [11]Kh$k:GE,2=$r%5%]!<%H9k!#

>e5-$+$iH=kh$&$K!" ADSM $O%3%s%Q%$%iKh$k:G
E,2=$rA0Ds$H7?%=%U%H%&%'%" DSM G"$k!# Release
Consistency !JRC!K%b%G%k [12]$K4p$E$- false sharing
LdBj$r4KOB$9kO!<%I%&%'%" DSM $*$h$S%=%U%H%&%'%"
DSM $b6&M-=q$-9~$_$,C10l$N store $G:Q$`$H8@$CFb!"
RC %b%G%k$K4p$E$$$?%3!<%I$r@8@.$9$kFC<l$J:GE,2=%3
%s%Q%$%i$,I,MWG"k3HKJQojOJ$$!#$^$?!"99
?77?$*$h$SL58z2=7?$NAPJ}$r%5%]!<%H$9kO!<%I%&%'%"
DSM [6]$OM}A[$GO"k,!"B?$/$N%3%s%7%9%F%s%74IM}
MQ$N%O!<%I%&%'%"$rI,MWH9k?$a!" NOW 4D6-$G$O<B
8=IT2DG=G"$k!#

5 %W%m%0%i%_%s%0%b%G%k

Dc%l%Y%k$N%f!<%6MQDL?.F14|%i%$%V%i%jH7$FDs6!$5
lk%a%b%j%Y!<%9DL?.5!G=$rL@<(E*$K%f!<%6$,D>@\;H$C
$F%W%m%0%i%`$7Fb9=oJ$$!#7+$7!"4pK\E*$K:GE,2=
%3%s%Q%$%i$KhC$F@8@.$5l?%f!<%6**%V%8%'%/%H%3!<
%I$,<B9T$5lk3H$rG0F,$K SSS–CORE $O@_7W$5lF
$$$k!# SSS–CORE >e$N ADSM $K4p$E$/%f!<%6$N%W%m
%0%i%_%s%0%b%G%k$r=R$Y$k!# SSS–CORE GOJBNs<B9T

%3%s%Q%$%i$Khk:GE,2=$r%5%]!<%H$9$k!#
%I!<%I$N@8@.$,,Hf3SE*MF0W$J0J2<$NFsDN%W%m%0%i%_%s
%0%b%G%k$r?d>)%b%G%k$H9k!#

JBNs@-$NCj=P$,MF0W$J!J$b7/$OJBNs@-$rL@<(9k!K
HPF Nh$&$J SPMD %?%$%W$r?d>)%W%m%0%i%_%s%0%b%G
%kH7$F:NMQ$9$k!#$3$N%W%m%0%i%_%s%0%b%G%k$G
$OBg0hJQ?t$N@k8@$KFCD'$,$"$j!"Bg0hJQ?t4H$K ADSM
$N3F<o%W%m%H%3%k$H%[!<%`%N!<%I!JO@M}%W%m%;%C%5HV9f
$G;XDj!K$r@k8@9k[4]:GE,2=%3%s%Q%$%i$OF10l%N!<%I$N
F10l%W%m%H%3%k$NJQ?t$r%Z!<%8C10LG^Ha!"Bg0hJQ?t
XN=q$-9~$_GO%W%m%H%3%k$H%N!<%I$KBP1~7?%3!<%I
%7!<%1%s%9$r@8@.$9$k[5]!#$^$?!"@EE*$KFI$_@Z$l$k>l9g$O
>iD9$J%N!<%I4VDL?.$N:o=|$d%3%s%P%$%K%s%0$r9T$&!#$^
$?!"<B9T;~$NF0E*$J%3%s%P%$%K%s%0%3!<%I$r%f!<%6%l%Y
%k$GA^F~$9$k[6]!#

SSS–CORE $O NUMA 4D6-!JNOW HG SSS–CORE
GO!" ADSM Kh$j NOW $r NUMA H7$F07$&!K$K
UMA 7?$N%/%i%9%?!JNc$($P!"L)7k9g%^%k%A%W%m%;%C%5
7?$N%o!<%/%9%F!<%7%g%s!K$,4^$^$lk3Hr5v7F$$
$k!# SSS–CORE $,?d>)$9kb$&0l$D$N%W%m%0%i%_%s%0
%b%G%k$O%/%i%9%?C10L$N%^%k%A%9%l%C%I%W%m%0%i%_%s
%0$H%/%i%9%?$K8Y$kBg0hG[Ns!"F14|JQ?t!"DL?.JQ?t$K
hk6&M-%a%b%j%"%/%;%9$r5v$9%W%m%0%i%_%s%0%b%G%k
G"$k!#$3$N%b%G%k$r SSS–CORE GO Multi-Thread
Multi-Task !J**MTMT**!K%b%G%k$H8F$V!# UMA ItJ,$,
$J$$>l9g$OC10l%W%m%;%C%5$HIUB0$N%a%b%j$r%/%i%9%?
$H8+Pv$7$F!"$=$NFbIt$G%^%k%A%9%l%C%G%#%s%0$,$J5l
$k!# SPMD %?%$%WHOO[Jj!"8D!9$N%W%m%;%C%5$K%9
%l%8%e!<%k5lkY$-%9%l%C%I$4HK%W%m%0%i%`$,5-=R
5l$F$$$k!#%9%l%C%I4V$N%9%l%8%e!<%k$O8@8lKhCF
Ds6!5l$k%i%s%?%$%`%i%$%V%i%j$d%^%/%m4X?tKh$C
$F9T$olkB>!"FCJL$J%9%l%C%I$G$"$k%f!<%6%l%Y%k%9%l
%8%e!<%i$r%f!<%6$,=q$/$3HbG-$k!#Bg0h6&M-JQ?t$O
SPMD %b%G%k$HF1MM$K%W%m%H%3%k$N<oN`$H%[!<%`$NO@M}
0LCV$r@k8@$9$k!#$3$N MTMT %b%G%k$O=>Mh$N<B9T%b%G
%k$KBP1~$7F*$j!"%/%i%9%?Fb$O%W%m%;%C%5Bf?t$K4X$o
i:40A4$KF10l%"%I%l%96u4V$,<B8=5lF*$j!"%f!<%6
%l%Y%k%9%l%8%e!<%j%s%0KhCF%9%l%C%I$N%9%l%8%e!<
%j%s%0$,$J5l$k!#$?$@$7!"%f!<%6%l%Y%k$G%/%i%9%?$r
8Y$$$GB>$N%/%i%9%?$K%9%l%C%I$N<B9T$r0\F0$5$;k3$H
OG$-$J$$!#!JOS KhCF%/%i%9%?C10L$G%^%$%0%l!<
%7%g%s5l$k2DG=@-$O$"$k!#!K

SSS–CORE KO0J2<$NB0@-$r;}$D%a%b%jNN0h!J%Z!<
%8C10L!K$r;}$D[7]!#$?$@$7!" ADSM H7FN5!G=$r;}$D
%Z!<%8$N=q$-9~$_$O invalidate %Z!<%8$r=|$$$F!"A0=R$N
%a%b%j%Y!<%9DL?.5!G=$rMQ$$$?0lO"$N%3!<%I%7!<%1%s%9
$GC#@.$5lk!#

4 @k8@$,$J$$$H8@8l$N%G%U%)%k%H$N%W%m%H%3%k$,MQ$$$i$l!"%G%U%)%k%H$N%[!<%`%N!<%I$,7h$^$k!#
5 $V@\;2>H$d%]%$%s%?$G@EE*$K%[!<%`%N!<%I$,ITL@$N>l9g$OO@M}%"%I%l%9$+$i%[!<%`%N!<%I$r2r@O9k%3!<%I$b=q$-9~$_%7!<%1%s%9Fb$KKd$a9~$`!#
6 8=:_$N%o!<%/%9%F!<%7%g%s$G$O:YN3EYDL?.$KBQ$($kDL?.G=NOOJ$$!# OS %1%Y%kGb$3%s%P%$%K%s%0$N%5%]!<%H$O9T$&M=Dj!#
7 ADSM GO=q$-9~$_;~$N%f!<%63!<%I$KhC$FNs5s$7$?0J30$N<+M3$J%W%m%H%3%k$r<B8=9k3H$,$G$-$k!#

local %Z!<%8 SPMD %b%G%kK*$$$F3NB0@-$,%G%U%)%k %H$G$"$j!"%/%i%9%?30!"%/%i%9%?FbrLdo$:!"O@M}%W%m %;%C%5$4HKF1l$NO@M}%"%I%l%9$KBP7FJL$NJ*M}NN0h $,3d$jEvFi$l!"%3%s%7%9%F%s%7$N0];}OJ5l$J$$!# MTMT %b%G%kGOB8:_7J$$!#

c_local %Z!<%8 3N%Z!<%8>e$NJQ?t$OF10l%/%i%9%?FbGN $_!"F1$8J*M}NN0h$r;X$9!# MTMT %b%G%kK*1k%m!<%+ %kJQ?tO9YF3N%/%i%9G"$k!#

home_only %Z!<%8 FI$_=q$-rLdo$:1s3V%a%b%j%"%/%;%9 $rMW5a$7!"%3%T!<$rB>%N!<%I$K@8@.7J$$NN0h!#%Z!<%8 0lIt7+MxMQ7J$$$3H,H=CF$$$k;~KOM-Mx!#

invalidate %Z!<%8 ADSM $N0l<o!#%[!<%`0J30$KF10lO@ M}%"%I%l%9$N%3%T!<%Z!<%8$r@8@.9k!#%Z!<%8C10L$NL58z 2=$KhC$F Sequencial Consistency (SC) $G%3%s%7%9%F %s%74IM}$,J5lk!#

ulrc %Z!<%8 ADSM $N0l<o$G%f!<%6%3!<%I;Y1gKh$k Lazy Release Consistency (LRC) [13]$r<B8=$9$k%Z!<%8!#%[!< %`0J30$KF10lO@M}%"%I%l%9$N%3%T!<%Z!<%8$r@8@.9k!# LRC $HF1MM$J%Z!<%8C10LL58z2=Kh$j%3%s%7%9%F%s%74I M}$,J5lk!#

home_update %Z!<%8 ADSM $N0l<o$G Automatic Update Release Consistency (AURC) [14]$r@lMQ%O!<%I %&%'%"ITMQ$G<B8=9k%Z!<%8!#%[!<%`0J30$KF10lO@M}%"%I %l%9$N%3%T!<%Z!<%8$r@8@.$9$k!#=q$-9~$_$O%[!<%`%Z!<%8 XN1s3V%a%b%j=q$-9~$_$H%m!<%+%k%3%T!<$X$N=q$-9~$_$r 9T$$!" AURC $HF1MM$J<jK!Kh$j%3%s%7%9%F%s%74IM}$, J5lk!#

update %Z!<%8 ADSM $N0l<o$G%[!<%`7PM3$N update %W %m%H%3%k$r@lMQ%O!<%I%&%'%"ITMQ$G<B8=$9$k%Z!<%8!#%[!< %`0J30$KF10lO@M}%"%I%l%9$N%3%T!<%Z!<%8$r@8@.$9$k!#%a %b%j%Y!<%9DL?.$N update 5!G=$,=q$-9~$_$G;HMQ5l$k!# RC %Y!<%9$NF14|$,%"%W%j%1!<%7%g%s%3!<%I$KA^F~5l $k!#

update_drct %Z!<%8 ADSM $N0l<o$G%[!<%`$r7PM3$7$J $$ update %W%m%H%3%k$r@lMQ%O!<%I%&%'%"ITMQ$G<B8=$9$k %Z!<%8!#%[!<%`0J30$KF10lO@M}%"%I%l%9$N%3%T!<%Z!<%8 $r%W%m%0%i%`%m!<%I;~$^$?$OBg0hE*$J%a%b%j3d$jIU$1;~ $KMQ0U$9$k!#$3$N%3%T!<%Z!<%8$OBP1~$9$k%[!<%`%Z!<%8$, >C5n5l$J$$8B$j>C5n$5lJ$$!#%a%b%j%Y!<%9DL?.$N update_drct 5!G=$,=q$-9~$_$G;HMQ$5lk!# RC %Y!<%9$NF1 4|$,%"%W%j%1!<%7%g%s%3!<%I$KA^F~$5lk!#

6 <B9T%b%G%k$H%"%I%l%9%^%C%T%s%0

0lBf$N%W%m%;%C%5$K3djEvFil$k%W%m%0%i%`$N<B 9T$N50@W!JL?NaN.!K$N3H$r%9%l%C%I$H8F$V!#J#?t$N%9 %l%C%I$G1$D$N%W%m%;%9$r9=@.$7!"%W%m%;%9$NFb$GF10l %/%i%9%?$KB0$9$k%9%l%C%I$,%5%V%W%m%;%9$r9=@.9k!# 5i$K!"%W%m%;%9Fb$NO@M}E*KbJ*M}E*Kb40A4$KF1 %b%j6u4V$r6&M-9k%9%l%C%I$,%?%9%/=@.$9$k!#[8] %?%9%/$O%5%V%W%m%;%9$H0lCW$9$k>l9g$b$"$j!"J#?t$N%? %9%/$,0lDN%5%V%W%m%;%9$KJq4^$5lk>l9gb"$k!#$7 $+$7!"%?%9%/$,J#?t$N%5%V%W%m%;%9!JD^$j%/%i%9%?!K $K8Y$C$FB8:_$9k3HO$J$$!#%W%m%;%9$N<1JL;R!J%W%m %;%9 ID!K$O%7%9%F%`$G0l0U$G$"$j!"%W%m%;%9 ID $,0lCW 9k%5%V%W%m%;%9!?%?%9%/!?%9%l%C%I$OF10l%W%m%;%9$K

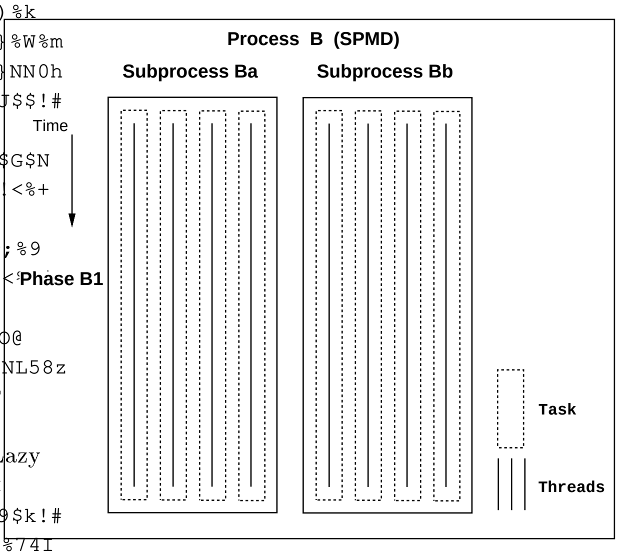

Figure 2 SPMD 7?%W%m%;%9<B9T%b%G%k

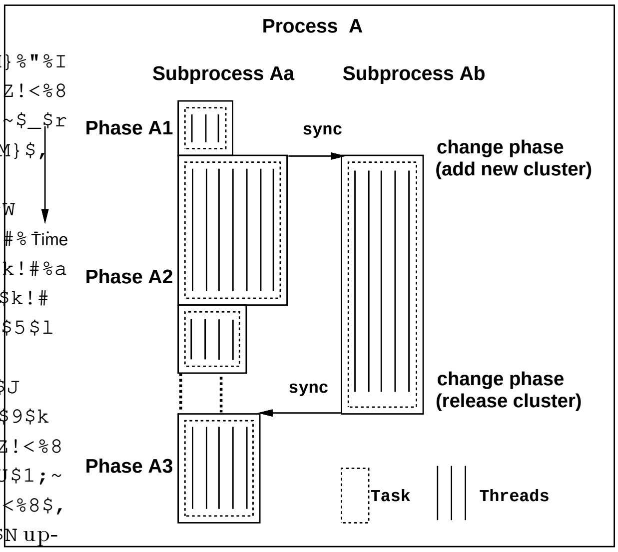

Figure 3 MTMT 7?%W%m%;%9<B9T%b%G%k

B0$7$F$$$k!#%a%b%j%Y!<%9DL?.$OAj<j$NO@M}6u4V%"%I%l %9$GDL?.$,J5lk$?$a!"%?%9%/ ID $GDL?.Aj<j$dAw?. 85$,5-=R$5lk!# SPMD 7?$N%W%m%0%i%`$N%J%$!<%V$J <B9T%b%G%k$G$O 1 %?%9%/$K 1 %W%m%;%C%5$,3d$jEv$F$i$l $F!"F@$G$O 1 %?%9%/$K$*$$$F 1 %9%l%C%I$,<B9T$5$l$k!# $C$F!"%^%k%A%W%m%;%C%59=@.$N%/%i%9%?$r;}$D>l9g$O %5%V%W%m%;%9$KJ#?t$N%?%9%/$,Jq4^$5$l$k!#!J?^ 2!K!# MTMT 7?$N%W%m%0%i%`$G$O%?%9%/$O%/%i%9%?Fb$NJ#?t $N%W%m%;%C%5$N3dEv$rF1;~$K<u1k3H$,$G$-!"J#?t$N %9%l%C%I$,F1;~$K%9%1%8%e!<%k5l$lF@$k!#[9] J#^ 3!K 0lDU$k%5%V%W%m%;%9$KB0$9$k%?%9%/!?%9%l%C%IG"$C FbDL?.$dF14|NI,MWJ%a%b%jNN0hKO>/J/Hb ADSM $N0UL#$NO@M}E*6&M-%a%b%j$,<B8=$5lk!#D^ $j!"F10l%W%m%;%9$G$"$l$P%0%m!<%P%k6&M-JQ?t$O%W%m%0

8 %a%b%j6u4V!J%Z!<%8%F!<%V%k!K$N3d$jEv$FC10L$G$"$j!"=>Mh$N OS GO3N%?%9%/$,%W%m%;%9$H8FPlk3H,B?$$!#2a5n$N SSS–CORE $NJ88%$G$O%5%V%W%m%;%9$,%a%b%j6u4V$N3d$jEv$FC10L $r7s$M$F$$$?!#

9 Mh$N SSS–CORE $N4XO"J88%$G$O MTMT %b%G%k$KAjEv9k <B9T%b%G%k7+<(7F$$$J$+$C$?!#$7$+$7!" SPMD 7?%W%m%0%i%` $N%m!<%+%kJQ?t$r8zN(NI$/%5%]!<%H$9k?aK%?%9%/$N35G0$rF3F~ $7!" SPMD 7?$N<B9T%b%G%k$r?7@_$7$?!#

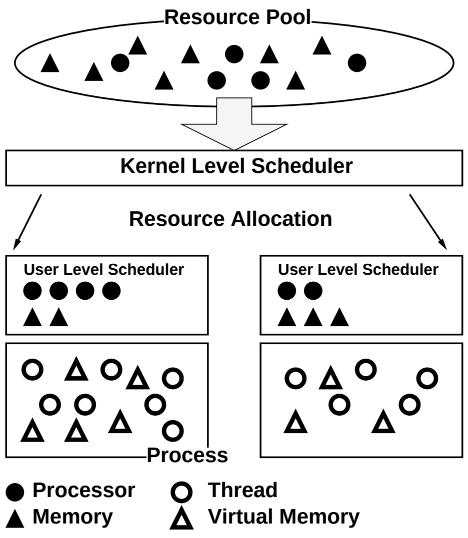

Figure 4 Fs3,AX%9%1%8%e!<%j%s%0

%i%_%s%0%b%G%k>e!"F10l%"%I%l%96u4V$KB0$76&M-5lFj!"
$$$k!#$?$@$7!"%/%i%9%?$d%?%9%/$,0[$J$k%9%l%C%I$N%W
%i%$%Y!<%HNN0h$O$?$H$(<B9T%3!<%I>e$NO@M}%"%I%l%9$,
F10lG"C?H7Fb6&M-5l$J$$!#

%W%m%;%9$N%W%m%;%C%54uK>3d$jEv$FBf?t$d<B%a%b%j3d
jEvFNL$O%"%W%j%1!<%7%g%s%W%m%0%i%`FbGb;~;~9o9o
$HJQ2=$7F*$j!"FC$K%W%m%0%i%`$N7+$jJV$79=B$$,JQ99
5l$?;~E@$GBgI}$KJQ2=$9k3H,$"$k!#3N$?$a!"%5
%V%W%m%;%9$K%U%'!<%:$H$$$&35G0$rF3F~$7!"%5%V%W%m%;
%9$,J#?t$N%U%'!<%:$K;~J,3d$5lk$H9M$(!"%U%'!<%:JQ
99;~KO%9%l%C%I$N<oN`$d%5%V%W%m%;%9%l%Y%k$N;q8;MW
5a?t$rJQ992DG=$K9k!#%W%m%;%9A4BNH7$F;q8;MW5a$N
Bg$-$5$,JQ99$5lk>l9g$O%5%V%W%m%;%94V$GF14|$r<h
$j!"%W%m%;%9A4BN$NMW5aH7$F%+!<%M%k$KMW5a$,=P$5$l
$k!#%+!<%M%k$O%W%m%;%9!J%5%V%W%m%;%9!K$N%m!<%I;~$H
%U%'!<%:JQ99;~!J<B:]$NJQ99$hjbA0$KMW5a$O=P$;$k!K
$K%f!<%6$+iN%+!<%M%k%l%Y%k%9%1%8%e!<%j%s%0N?$a
$N>pJs$rF~<j9k!#%W%m%;%9%l%Y%k$N%+!<%M%k%l%Y%k%9
%1%8%e!<%iKBP9$kMW@A9`L\$K$D$$$F$O8e=R$9$k!#

7 %f!<%6!?%+!<%M%kFs3,AX%9%1%8%e!<%j%s%0

SSS–CORE $b SS–CORE F1MM$K%f!<%6%l%Y%k$G;q8;
J]8n@)LsrGKi$:$K2r7h2DG=$J;q8;4IM}$O%f!<%6%l%Y%k
!J%3%s%Q%$%k;~$N<B9T%3!<%IXNAH$_9~$_!?8@8l%i%s%?
%$%`!?%5!<%P!K$G<B8=9k!#3N$?$a!"%+!<%M%k%l%Y%k
$N5!G=$H7FO-$a:Y$+$J%5!<%S%9$r<B8=9kI,MWOJ
$$!# SS–CORE $,%W%m%;%9$KBP7F<B%W%m%;%C%5%0%k!<
%W$r3d$jEvFF$$$?NHF1MM$K!" SSS–CORE GO<B;q8;
8;72!J%W%m%;%C%5!"%a%b%j%Z!<%8!" HDD $N%H%i%C%/!?
%;%/%?!K$r%+!<%M%k%l%Y%k%9%1%8%e!<%i!J**KLS**!K$,%W
%m%;%9$K3d$jEvFk!J?^ 4;2>H!K!#4pK\E*$K%W%m%;%9Fb
$N;q8;$NJ]8n$O9T$o$:!"0lC6%W%m%;%9$K3djEvFil
$?;q8;$O<+M3$K%f!<%6$,;HMQ9k3H$,$G$-$k!#%W%m%;
%9KO%f!<%6%l%Y%k%9%1%8%e!<%i!J**ULS**!K$,B8:_$7$F
KLS KhCF3djEvFil$?;q8;$r%9%l%C%IKBP7$F
%9%1%8%e!<%j%s%0$9$k!#;q8;4IM}%3%9%H>e$NLdBj$+$i!"

ULS $O%/%i%9%?Fb!J%5%V%W%m%;%9Fb!K$N;q8;$r4IM}$9
$k **CULS** $,=8$^CF9=@.5l!" CULS $,3F%/%i%9%?Fb
$N;q8;$r4IM}9k!#$?$@$7!" ULS $d CULS $O5!G=$NL>
>NG"$j!"<B:]$K$OFHN)$7$?%f!<%6%W%m%0%i%`$d%k!<
%A%s$,B8:_$9kI,MWOJ/!"%"%W%j%1!<%7%g%s%W%m%0%i
%`$N%3!<%I$NCfKAH_9~$^$l$F$$$F$b9=$o$J$$!J?^ 1;2
>H!K!#4pK\E*$K!"?75,$K;q8;$r%7%9%F%`$+$i3MF@$9$k>l
9g$H;q8;$r%7%9%F%`$K2rJ|$9$k>l9g$N$_ KLS $K ULS $O
=hM}0MMj$r9T$&!#$?$@$7!"%W%m%;%9$K3djEvFil$F
$$$k%W%m%;%C%5>e$N%9%l%C%I$N@ZBX$O%f!<%6%l%Y%k$G<B
8=2DG=G"k,!"<B%a%b%j%Z!<%8$NMQES@ZBX!J0c$&O@M}
%"%I%l%9$G;HMQ!K$d HDD >e$N%U%!%$%kNN0h$N:FMxMQ$O
%f!<%6%l%Y%k$G9T$&3H$O8=>u$N%O!<%I%&%'%"9=@.GO
%W%m%;%94V$NJ]8n@)Ls$r<iCF9T$($J$$!#3N$?$a!"%a
%b%j$d%U%!%$%k;q8;$NMQES@ZBX!?:FMxMQ$O%*%Z%l!<%F%#
%s%0%7%9%F%`3KFb$N%+!<%M%k%l%Y%k$N%5!<%S%9%k!<%A%s
$r<BAu>e8F$S=P$9$3HKJk!# KLS $b<BAu>e$O%/%i%9
%?C10L$K;q8;4IM}$r9T$&%W%m%0%i%`!J**CKLS**!K$N=89gBN
G"$j!" CKLS $N6(D4F0:n$KhC$F%7%9%F%`A4BN$N%+!<
%M%k%l%Y%k%9%1%8%e!<%j%s%0$,?k9T$5lk!#

8 %+!<%M%k%l%Y%k%9%1%8%e!<%i$N;q8;4IM}

8.1 %f!<%6Kh$k **KLS** $N@)Ls>r7o

%?%$%`%9%i%$%9$4$H$K KLS $O%W%m%;%9$KBP7FF0E*
$JM%@hEY4IM}$r9TCF!"M%@hEY$N9b$$%W%m%;%9$+$i@)Ls
>r7o$K4p$E$$$F!";q8;3djEvF$r9T$&!#%?%$%`%9%i%$%9
$N4V3V$O 100msec $+$i 300msec DxEY$NHf3SE*Bg$-$JC1
0L$r9M$(F*$j!"%9%1%8%e!<%j%s%0$N$?$a$N=hM}%3%9%H
$OL5;k$G$-$k!#$3$3$G;HMQ$5lk@)Ls>r7o$O@EE*$J%W
%m%0%i%`2r@O!?:GE,2=$+$iF@ilkbNG$"$j!"%W%m%;
%9$N%m!<%I;~$*hS%U%'!<%:$NJQ99;~$K ULS $+$i KLS
$K;X<($5lk!#%W%m%;%9B&$+$i KLS $K;X<($G$-$k@)Ls
>r7oKD$$$F@bL@9k!#

1. %W%m%;%C%5Bf?t@)Ls

1–a. Bf?t0l0U;XDj:: <B9T%3!<%I$K8GDjBf?t$Khk:G
E,2=$,;\$5lF$$$k>l9g!#4uK>Bf?t$N>e2<8B$,0lCW
5;$?$b$N!#

1–b. 4uK>Bf?t!J2<8B!">e8B!K:: KLS $O2<8B0J>e!"
>e8B0J2<$N%W%m%;%C%5$rF1;~$K3d$jEvFk!#

1–c. =i4|Bf?t2DJQ!J2<8B!">e8B!K:: KLS $O%m!<%I
;~$N%9%1%8%e!<%j%s%0$K$*$$$F!"2<8B0J>e!">e8B0J
2<$N%W%m%;%C%5$rF1;~$K3d$jEvFk!#FsEYL\0J9_
$N%9%1%8%e!<%j%s%0$G$O=i2s$HF1$8Bf?t$r3djEvF
$k!#

2. %W%m%;%C%54VDL?.%3%9%H@)Ls

2–a. %W%m%;%C%53dEvNN0h7A>u8GDj:: %W%m%;%C%54V$H
$N%m%8$r8GDj7?:GE,2=$,<B9T%3!<%I$K;\$5lF$$
$k>l9g!#

2–b. %W%m%;%C%54VDL?.%3%9%H>e8B:: %W%m%;%C%54V$N
DGBg5wN%$N>e8B$r;X<(9k!#%7%9%F%`$,3,AX9=B$$r
;}$D>l9g$O3,AX$K1~$8$?N%;6CM$r<h$k!#

3. %a%b%j%"%/%;%9%3%9%H@)Ls

10 %+!<%M%k%l%Y%k%9%1%8%e!<%j%s%0$NJBNs<B9TJ}<0$d7ZNL2=$O:#8e$N8&5f2]BjG"$k!#

3–a. <+%/%i%9%?%Z!<%8%"%m%1!<%7%g%sN_:: <B%a%
%j$rMW5a$7$?>l9g$K<+%/%i%9%?0J30$KNN0h$r%R%
3H$r5v$5$J$$!#<+%/%i%9%?Fb$K6u$-NN0h$,$J1
$P!"B>$N%W%m%;%9!J<B9TBT5!Cf$N%W%m%;%9$rM%@h!
$N%a%b%j$rB>%/%i%9%?$^$?$OFs<!5-21$K swap out
9k!#

3–b. %/%i%9%?4V5wN%>e8B:: %a%b%jMW5a;~$K<+%/%i%9
%?$N%a%b%j$,9Y$F;HMQ$5lF$$$k>l9g!";XDj5wN%
Fb!J%"%/%;%9%3%9%H$,$"$kHO0O$KM^$($ilk!K$K6u
$-NN0h$,$"$l$P!"<+%W%m%;%9$N%Z!<%8$r swap out
7FNN0h$r3NJ]$9$k!#;XDj5wN%Fb$K$b6u$-NN0h$,$
$$>l9g$O!"B>%W%m%;%9!J<B9TBT5!Cf$N%W%m%;%9$rM%
@h!K$N%a%b%j$rB>%/%i%9%?$^$?$OFs<!5-21$K swap
out 9k!#

4. %^%$%0%l!<%7%g%s%3%9%H@)Ls

4–a. %/%i%9%?4V5wN%>e8B:: :F%9%1%8%e!<%j%s%0
$K!";XDj5wN%Fb$N%/%i%9%?XN%W%m%;%9$N%^%$%
%l!<%7%g%s$r5vMF$9$k!#$?$@$7!"%7%9%F%`Ii2YJ,;6
$,Cx$7$/6Q9U$r7g$/>l9g!"$3$N>e8B$rL5;k7F6/@)
%^%$%0%l!<%7%g%s$,9Tol$k>l9g$,$"$k!#%7%9%F%`
$,Hs>o$KBg5,LO$J>l9g$K$O!"6/@)%^%$%0%l!<%7%g%s
KBP9$k5wN%$N>e8B$b@_$1kI,MW,$"$k!#

4–b. %Z!<%8;DB8N(2<8B:: ;XDj0J2<$N3d9g$N2>A[%Z!<
%8$7$+<B%a%b%j>e$K;D$C$F$$$J$$>l9g$K!"%^%$%0
%l!<%7%g%s$r9T$&!#

;q8;3djEvFKBP7$F%f!<%6$,6/$$@)Ls$r2]$9kH!"3d
Ev$,K~$?5l$?>l9g$N%(%$%8%s%0$NEY9g$,Bg$-$/$9k3
HG!"<e$$@)LsrIU1$?%W%m%;%9$rM%6x9k!#

8.2 KLS $N;q8;3d$jEv$FJ}<0

;q8;!J%W%m%;%C%5!"%a%b%j!K3djEvFJ}<0$N35N,$r<
$9!#%/%i%9%?4V%M%C%H%o!<%/$,3,AX9=B$$r;}$D%7%9%F%
GO$=$N3,AX9=B$$K1~8?%/%i%9%?4IM} tree $r!"%U%i%
%H$J%a%C%7%e9=B$!JDL>oFs<!85%a%C%7%e!K$N>l9g$O 2 $N
<!85?tQQ>h$N tree 9=B$$N%/%i%9%?4IM} tree $r2>A[E*$K
9=@.9k!#3N4IM} tree $N3F%N!<%I$K$*$$$F!"$=$N2<A
$K0LCV$9$k%/%i%9%?Fb$N;q8;>pJs$r4IM}$9$k!#4IM}$5$
$k;q8;9`L\$O0J2<NH$*$jG"$k!#

- 3,AXFb$GAv9TCf$N3F%W%m%;%9 ID
- %W%m%;%9Kh$N@jM-%W%m%;%C%5?t
- %W%m%;%9!JBT5!Cf%W%m%;%9$r4^$`!KKh$N<B%Z!<%
- 3,AXFb$U%j!<%Z!<%8$NAm?t

3NB>$K4IM} tree $N root GO0J2<$N>pJs$rJ];}9k!#

- %W%m%;%9Kh$N KLS @)Ls>r7o
- %W%m%;%9Kh$N;HMQESCf$N2>A[%Z!<%8Am?t
- 3,AXKh$N;q8;Am?t
- 3,AXFb$U%j!<%W%m%;%C%5$NAm?t

%?%$%`%9%i%$%9$4$H$K KLS $O%W%m%;%9$KBP7FF0E*$J
M%@hEY4IM}$r9T$C$F!"M%@hEY$N9b$$%W%m%;%9$+$i6
tree $N>pJs!J@)Ls>r7o$r4^$`!K$K4p$E$$$F!";q8;3d$j
9T$&!#%?%$%`%9%i%$%9;~E@$G%9%1%8%e!<%j%s%0$9$Y$
>]$r8GDj2=$9k?$a!"$3$N%9%1%8%e!<%j%s%0$OM%@hEY$
hS@)Ls>r7oIU$-$N@EE*$J:GE,2=LdBj$G$"$k!#@EE*$J
:GE,2=LdBjG"k?$a!"I>2A4X?t$rDj$a%"%K!<%j%s%

%aGA $G2r$/3HbG$-$k$,!" SSS–CORE GO0J2<$N
<%j%9%F%#%C%/$r;HMQ$9$kM=Dj$G$"$k!#

1. M%@hEY$N9b$$%W%m%;%9$+$i%W%m%;%C%5;q8;$N3dEv$r
4IM} tree $N subtree C10L$G7hak!# subtree C10L$N
A*BrKG0U@-$,$"$k>l9g$O!"<B%a%b%j$N8=:_$N3dEv
>u67$rMxMQ$7$F!"<B%a%b%j;DN1?t$,B?$$ subtree $r
A*Br9k!#$?$@$7!"6/@)%^%$%0%l!<%7%g%sCf$N%W%m
%;%9O3$N8B$jGO$J$$!#
2. >e5-Nh$&$K subtree C10L$G%W%m%;%C%5;q8;$N3dEv
$r7hDj$9k,!"3dEvBP>]%W%m%;%9$N<B%a%b%j$N;DN1
?t$,%Z!<%8;DB8N($N2<8B$r2<2s$k>l9gb7$/$O%W%m
%;%9$,?75,3d$jEvFN>l9g$O!"NN0h$N3dEv!J0LCV7h
Dj!K$O<B%a%b%j3dEv>u67$HL54X78$K7hDj$7!"$=$N3d
Ev$,2>3dEv$G$"$k3H$,H=$kh&$K3dEv>pJs$K%^!<
%/$r9T$&!#
3. ~M%@hEY$N4X78$G<B%a%b%j$N;DN1?t$,B?$$NN0h$K3d$j
EvFilJ$+$C$?%W%m%;%9$K4X7F!"
   (a) <B%a%b%j3dEv>u67$+$iK>$^$7$$NN0h$,2>3dEv$N
   %W%m%;%9$K@jNN$5lF$$$k>l9g$O!"$=$N2>3dEv
   $N%W%m%;%9$,B>$N subtree $K0\F0$G$-$J$$$+D4
   $Y!"0\F02DG=$G$"$l$P!"K>$^$7$$NN0h$K%W%m%;
   %9$r3d$jEv$F!"2>3dEv$N%W%m%;%9$O?7$7$$NN0h
   $G2>3dEv$H5l$k!#B>$N subtree $K0\F0$G$-$J
   $$>l9g$O!"K>$^$7$$NN0hXN3dEv$O8+Aw$k!#
   (b) <B%a%b%j3dEv>u67$+$iK>$^$7$$NN0h$,M%@hEY$,
   9b$/0\F0$G$-$J$$%W%m%;%9$K@jNN$5lF$$$k>l
   9g$O!"%^%$%0%l!<%7%g%s@)Ls$r%A%'%C%/$7$F!"
   @)Ls$,K~$?5l$kHO0OFb$G3dEv2DG=$J6uNN0h$r
   C5$9!#@)LsFb$KNN0h$,8+$D$+$i$J$$>l9g$O!"$3
   $N%?%$%`%9%i%$%9$K$*$1$k;q8;3dEv$r8+Aw$k!#
4. 9YFN%W%m%;%9$N3dEv$N%A%'%C%/$,=*N;$7FbL$
3dEvNN0h$,0MA3B8:_$7!"NN0h3dEv$r8+Aw$C$?%W%m%;
%9Cf$K%^%$%0%l!<%7%g%s@)LsN_E,9g7J$$$bN,
B8:_9k>l9g!"6/@)E*K3$N%W%m%;%9$r$=$NL$3dEv
NN0h!J$N0lIt!K$K3djEvF$k!#$?$@$7!"3l$O%7%9
%F%`$NIi2YJ,;6$N$?$a$N6/@)%^%$%0%l!<%7%g%sG"
j!"6/@)%^%$%0%l!<%7%g%s$NH/@8$rM%@hEY$N:F7W;;
$d:F%9%1%8%e!<%j%s%0$G9MN8$9$k!#

%9%1%8%e!<%j%s%0$N7k2L!"F10lNN0h$G<B9T$,7QB3$5lk
%W%m%;%9$K4X$7$F!" KLS $N<B9T$HL54X78$J%W%m%;%C%5
%Z%W%j%(%s%W%H5l$:$K%W%m%;%9$N<B9T$r7QB3$9$k!#

8.3 M%@hEY:F7W;;J}<0

KLS KBP7$F%f!<%6$Khk@)Ls>r7o$,2]$;ilk?
$a!";q8;$N fair share $J%9%1%8%e!<%j%s%0$r9Tolkh
$&$J!"M%@hEY:F7W;;J}<0$r;HMQ$9kI,MW,$"$k!#D^
$j!";q8;$rB?$/@jM-$7$?%W%m%;%9!"87$7$$>r7o$r KLS
$K2]$7$?%W%m%;%9$K$OAj1~$N%Z%J%k%F%#$r2]$7$F!"%f!<
%6$`$d$_$K>r7o$rIU2C$9k3H,ITMx$KF/$/h&K9
kI,MW,$"$k!#3N$?$a!"4pK\J}?KH7FO;q8;$N@jM-
NL$HBP@jM-;~4V$N@Q$K@)Ls>r7o$N87$7$5$d>r7o$NK~B-EY$r
2C$($?M%@hEY$N%(%$%8%s%0$r9T$&!#<B:]KO!"%?%$%`
%9%i%$%9;~$K0J2<$N%Q%i%a!<%?$r;HMQ7FM%@hEY$N:F7W
;;$r9T$&!#

- FH@j%W%m%;%C%5?t$H;HMQ;~4V$N@Q n_p (t ($0 < t < 1$)
- 3djEvFNN0hFb$K3MF@$7$F$$$?<B%Z!<%8?tH=$NNN0h$X$N<B9T3d$jEv$F;~4V$N@Q n_m (t)
- @)Ls>r7o$N87$7$5 ($0 \leq r_c < 2$)!"@)Ls>r7o$NK~B-EYBT$A0J30$NF0:n ($0 < s_c \leq 1$)
- L5BLKJC?%W%m%;%C%5;q8;$HL5BL$KJC$?;~4V$N@Q$rM-8z$KMxMQ5l$?NN0h$G2C=EG[J, n_{wp} ($t\frac{n_p}{\sum n_p}$)
- 3djEvFBTANB>$N%W%m%;%9$,B8:_9k$+ ($f_{wait}$ = 0 or 1)
- 6/@)%^%$%0%l!<%7%g%s3d$j0z$-N(($f_{mg}$ = C_{mg} or 1, $0 < C_{mg} < 1$)
- <cJV$j78?t$H<B9TBT$A;~4V$N@Q (C_r (1 − t))

C10L;~4V4V3V$r 1 H7!"4V3VESCf$N?75,3dEv!?3dEv2r=|$r9MN8$7$F!";~4V4V3VFb$N%W%m%;%93djEvF;~4V$r $t(0 < t \leq 1)$ H9$k!#4JC1$N$?$a%a%b%j@jM-NN0h$N;~4V4V3VFb$NA}8:$OL5;k$9$k!#M%@hEY$N%?%$%`%9%i%$%9K*1k99?72C;;NL!J%(%$%8%s%0!K7W;;<0$OO0J2<Nh$&$KJk!#J*!"CM$,>.$5$$$[$IM%@hEY$,9b$$!#

$$((C_p n_p + C_m n_m) r_c s_c + C_{wp} n_{wp} \frac{n_p}{\sum n_p}) f_{wait} f_{mg} t - C_r (1-t)$$

9 %Z!<%8CV49J}<05Z$S%+!<%M%k%9%1%8%e!<%j%s%0J}<0$N%7%_%e%l!<%7%g%sI>2A

K\@aGO *SSS–CORE* K*1kJ,;66&M-%a%b%j$rA[Dj$7$?%Z!<%8CV49J}<0$H!"%+!<%M%k%9%1%8%e!<%j%s%0J}<0$N%7%_%e%l!<%7%g%s$KhkI>2AKD$$$F=RYk!#

9.1 %7%_%e%l!<%7%g%s%b%G%k

3l$^$G$N8&5f$GMxMQ7?%b%G%k [15]$r3HD%$7!" OS %l%Y%k$N%7%_%e%l!<%7%g%s$N$?$a2DG=$J8B$j4JN,2=5l$?%b%G%k [16]$r9=C[7?!#%b%G%k$N>\:Y$K$D$$$F$O [17]$r;2>H5l$?$$!#0J2<4JC1$K@bL@$9$k!#

BP>]H9kN$OJ,;6%a%b%j4D6-$G!"%a%b%j$H%W%m%;%C%5$NBP$r%/%i%9%?$H$7!"Aj8_7k9gLV$OLZ9=B$$G$"$k!#Aj8_7k9gLV$OFs=E2=$5l?%9%$%C%A%s%0%M%C%H%o!<%/$G$"$j%9%$%C%A%s%0$N!<%IK*$$$F%a%C%;!<%8$r%P%C%U%!%j%s%0$9$k%o%s%[%C%WDL?.$r9TJ&!#

3F%W%m%;%9KO6&M-6u4V$HHs6&M-6u4V$r!"$=$l$>$l$NJL!9$N%Z!<%8C10L$N%a%b%j;2>HIQEYI=$KhjM?$($k!#0l%/%i%9%?K*1kJBNs%W%m%;%9$N<B9T%3%s%F%-%9%H$r%9%l%C%I$H8F$S!"3F%9%l%C%I$OO0[$JC?6u4V$rM?$(il$k!#%9%1%8%e!<%j%s%0$Khj3djEvF0LCV$,JQ2=$7$?>l9g$K$O!"%m!<%+%k%Z!<%8$O%M%C%H%o!<%/$r2p$7$F on-demand $K0\F0$9$k!#3F%W%m%;%9$OMW5a%W%m%;%C%5Bf?t$HF1?t$N%9%l%C%IKh$j9=@.$5lk!#JBNsEY$O0lDj$G!"@8@.;~$+$i=*N;;~$^$GJQ2=7J$$!#%Z!<%8$,%j%b!<%H$K$bB8:_$7$J$$>l9gKO!"%G%#%9%/%"%/%;%9$r@8$8$k!#6&M-6u4V$KBP7F$OJ,;66&M-%a%b%j%7%9%F%`$r9=C[$7!"%W%m%;%9$N3F%9%l%C%I$O;2>HIQEYI=$r6&M-9k!#%3%R!<%l%s%74IM}$O%"%C%W%G!<%HJ}<0$G!"%Z!<%8$OCV49$5lJ$$8B$j%a%b%j$K;D$k!#$^$?!"%a%b%j;2>H%3%9%H$O%/%i%9%?Fb ≪ %/%i%9%?4V ≪ #2<!5-21G"kH2>Dj9k!#

%W%m%;%9$N<B9T$O%/%m%C%/%Y!<%9$N3NN(%b%G%k$G!"2DG=G"lPKh%/%m%C%/%j!<%IKt$O%i%$%H$N%a%b%j;2>H$r9TJ&!#$^$?%W%m%;%9$N%9%l%C%I$O!"%Q%i%a!<%?$GM?$(il$?;~4V4V3V$G%i%s%@%`$JAH9g$;$GF14|$r5/$3$9!#$3$3$GM-8z<B9T (;~4V / %/%m%C%/) HO!"%Z!<%8BT$A / F14|$N3HG"$k!#I=1$K:#2s$N%7%_%e%l!<%7%g%s>r7o$r<($9!#

Table 1 3F<o%3%9%H5Z$S%Q%i%a!<%?

9‘L\	CM
%G%#%9%/%"%/%;%9	10000 clk
%j%b!<%H%"%/%;%9	100 clk
DL?.	10 clk
%W%m%;%C%5?t	16 Bf
1 %a%b%j$N%Z!<%8?t	400 pages
1 %Z!<%8$N%5%$%:	4096 Byte
Am%a%b%jNL	25.6 Mbyte
1 quantum	100000 clk

9.2 %9%1%8%e!<%j%s%0K!

%7%_%e%l!<%?>e$K#5$D$N%9%1%8%e!<%j%s%0K!$r<BAu7?!#%?%$%`%9%i%$%9Kh$K;q8;$N@jM-!?>CHq>u67$K1~$8$?M%@hEY7W;; [15]$r9T$J$$!"M%@hEY$N9b$$%W%m%;%9$+$i=g$K!"$=$l$>$l0J2<$K<($9J}K!$G;q8;4IM}LZ9=B$$rMxMQ$7$F%9%1%8%e!<%j%s%0$r9T$J$&!#0J2<$G%[!<%`%N!<%I$H$O4IM}LZ9=B$>e$N!"%W%m%;%9$NMW5aBf?t0J>e$N%W%m%;%C%5$r4^$`:G2<0L%l%Y%k$N%N!<%I$G!"A02s$N3djEvFNN0h$rBP>]=$9kbNG$"$k!#

algo4 %Z!<%8N"$k%/%i%9%?$N$_$r3djEvF$kJ}<0

algo3 %[!<%`%N!<%I0J2<$NNN0h$G%Z!<%8N"kH3m$+$i3djEvF$kJ}<0

algo2 =iaK%[!<%`%N!<%I0J2<$NNN0h$K3dEv$r;n$_!"<:GT7?>l9gKO%k!<%H%N!<%I0J2<$NNN0h$G!"<+J,$N%Z!<%8$,B8:_9kNN0h$+$i3djEvF$kJ}<0

algo1 ;q8;4IM}LZ>e$NC<$+$i=g$KO"B3$7$?%W%m%;%C%5rI,MWJ$@$13djEvF$kJ}<0

algo0 %i%s%@%`KI,MWJ?t$@$1%/%i%9%?$rA*Br$73djEvF$kJ}<0

3NJ}<0N&$A algo2, algo3, algo4 $,;q8;4IM}LZ9=B$$rMxMQ9kJ}<0G"$k!#$3$N 3 J}<0$N0c$$$O%W%m%;%9XN%W%m%;%C%5$N3d$jEv$FNN0h$,!";HMQCf$N<B%a%b%j%Z!<%8$N0LCV$K8G<9$9$kEY9g$K$"$k!#

9.3 %Z!<%8CV49J}<0

J,;6%a%b%j4D6->eGOJ,;66&M-%a%b%j$r2>Dj$9kH!";2>HIQEY5Z$S:F%"%/%;%9;~$N%"%/%;%9%3%9%H$N0c$$$Khj%Z!<%8$rJ,N`$9$k$3$H$,2DG=$G$"$k!#$3$NJ,N`$r4p$K!";2>HIQEY$,>/J/:F%"%/%;%9;~$N%3%9%H$,>.$5$$%Z!<%8$+$iCV49BP>]H9$k8zN(E*$JJ}<0$,2DG=$HJk!#Nc$($P!"L@i+$K<B9TCf$N%W%m%;%9$,MxMQ$9$k%Z!<%8$hjO!"$=$l0J30$N%W%m%;%9$,=jM-9k%Z!<%8$NJ}$,%"%/%;%9$5$lK/$$!#$^$?0lDN%W%m%;%9$N%Z!<%8$NCfGb!"%/%i%9%?$K%m!<%+%k$J%Z!<%8hj$O6&M-%Z!<%8$X$N%"%/%;%9$NJ}$,0lHLE*$K>/$J$$!#$^$?6&M-%Z!<%8O=l,J#?tB8:_9k%3%T!<N&AN0lDG$"$l$P!":F%"%/%;%9;~$K$O1s3VCO$+$i%M%C%H%o!<%/$r7PM3$7$F!"Dc%3%9

Table 2 %W%m%;%9!&%;%C%H!J%;%C%H **J2**!K

#DP	#PS	Hs6&M-6u4V%5%$%:*%W%m%;%9?t
4	4	$30pages*2, 80pages*2$
8	4	$30pages*4, 80pages*1$
16	2	$30pages*2$
AmJBNsEY 80	AmHs6&M-6u4V 3200pages	

#DP: MW5a%W%m%;%C%5?t, #PS: %W%m%;%9?t

Table 3 %W%m%;%9!&%;%C%H!J%;%C%H **K2**!K

#DP	#PS	Hs6&M-6u4V%5%$%:*%W%m%;%9?t
3	5	$50pages*5, 80pages*2$
6	5	$50pages*5, 80pages*1$
13	1	$30pages*1$
16	1	$30pages*1$
AmJBNsEY 74	AmHs6&M-6u4V 3120pages	

#DP: MW5a%W%m%;%C%5?t, #PS: %W%m%;%9?t

%H$G%"%/%;%9$9k3H,2DG=G"$k!#$=1KBP7F!":F%"%/%;%9;~$K%G%#%9%/%"%/%;%9$r@8$8$kh&$J%Z!<%8CV49$O6KNOM^$($?J}$,F@$G$"$k!#$=$3$G%Z!<%8$N<oN`Kh$j!"<!$Nh&$KCV49BP>]$H9k=g=x$rM?$(k3H,G-$k!#0J2<$G$O%3%T!<$r;}$?$J$$6&M-%Z!<%8$r!"JX59E*$K%i%9%H%o%s!&%Z!<%8$H8F$V!#

1. B>$N%W%m%;%9$N6&M-%3%T!<%Z!<%8
2. <B9TCf%W%m%;%9$N6&M-%3%T!<%Z!<%8
3. B>$N%W%m%;%9$N%i%9%H%o%s!&%Z!<%8
4. B>$N%W%m%;%9$N%m!<%+%k%Z!<%8
5. <B9TCf%W%m%;%9$N%i%9%H%o%s!&%Z!<%8
6. <B9TCf%W%m%;%9$N%m!<%+%k%Z!<%8

CV49J}<0H7FO!"CV49BP>]H9$k%W%m%;%9=g$rINh&$KA*Br$9k+Kh$j!"J#?t$N@oN,$,2DG=$G$"$k!#$=$3$N%7%_%e%l!<%7%g%s$G$O!"<!$NFsDNCV49J}<0$r<BAu$7Hf3S$r9T$JC?!#

J}<0 **1** %Z!<%8$N<oN`!?%W%m%;%9$N6hJLJ7$K!"C1=c$J LRU =g

J}<0 **3** %9%1%8%e!<%j%s%0M%@hEY$NDc$$%W%m%;%9$+$i!">e5-$N%Z!<%8$N<oN`=g$KA*Br!#3F%W%m%;%9$N6&M-!?Hs6&M-6u4VKh$K LRU =g$r4IM}9k

%W%m%;%9$N%9%1%8%e!<%j%s%0$OM%@hEY [17]$N9b$$=g$K9T$Jolk?$a!"M%@hEY$NDc$$%W%m%;%9$N%Z!<%8$[$I;2>H$5lK$/$$!#J}<0 3 O3$N@-<A$rMxMQ9k!#$?$@7IiNJ}<0$b!"014S@-=hM}Cf$N6&M-%Z!<%8$N>l9g$OCV49$5$l$J$$!#

9.4 7k2L5Z$S9M;!

A0=R$N%b%G%k$rMQ$$$FI= 1Nh$&$J%Q%i%a!<%?Kh$k%7%_%e%l!<%7%g%s$rI= 2, 3K"2?%W%m%;%9$NAH9g$;KBP7$F9T$JC?!#3F%W%m%;%9OIlb 80 %Z!<%8$N6&M-6u4V$r;}$A!" 1000 M-8z<B9T%/%m%C%/Kh$KF14|$9$k!#2^5$,$=$N<B9T7k2LG"$k!#3F%9%1%8%e!<%j%s%0J}<0 J2#<4!KKBP7$F!"%7%9%F%`A4BN$NM-8z<B9TN(!J=D<4!K$r<($7$?!#$J$*%G!<%?$N<hF@$O%7%_%e%l!<%7%g%s3+;O8e!"01$DL\$N%W%m%;%9$,=*N;!J20 %?%$%`%9%i%9%9J,$NM-8z<B9T!K7?D>8e$N;~J,3d$N;~E@$G9T$JC?!#3F%a%b%jCV49J}<0$r:NMQ$7$?>l9g$N7k2L$r<($7F"$k!# 16 Bf9=@.$N>.5,LO%7%9%F%`GN8GDjBf?t@)Ls$rMxMQ$7$?>u67$G$O!"

%W%m%;%C%5$NMxMQ8zN($,Bg$-$/I>2A$K1F6A$9$k!#$3$N4D6-$G<B:]$N%7%9%F%`$K$*$$$F==J,$J%W%m%;%C%5$NMxMQ8zN($,$"$k>l9g$NI>2A$r9T$J$&$?$a!"3dEv$+$i1L$l$?%W%m%;%C%5$N<B9T$OM-8z<B9T$K%+%&%s%H7F$?!#

$^$:%a%b%j$NCV49J}<0$K$D$$$F$_$k$H!"$I$N>l9g$K$bCV49J}<0 3 $,J}<0 1 $K>!$C$F$$$k!#:G$b8zN($NNI$+$C$?%;%C%H J2 $N 4 ?J 2 CJ$N>l9g$G8+$k$H!"CV49$NMM;R$OI= 4$Nh&KJCF$$$k!#J}<0 3 GO%W%m%;%9$N6&M-%Z!<%8$,CV49$5$lkNKBP7$F!"J}<0 1 GO%W%m%;%9$N%m!<%+%k6u4V$N%Z!<%8$d%i%9%H%o%s6&M-%Z!<%8$,CV49$5$lk3H,J,$+$k!#

Table 4 %Z!<%8<oN`Kh$NCV492s?t (%;%C%H **J2, 4** ?J **2** CJ)

%Z!<%8<oN`	0	1	2	3	4	5
J}<0 1	2815	661	60	1707	46	281
J}<0 3	7820	0	0	0	0	0

%Z!<%8<oN`$O 9.3@a$G$NJ,N`>e$NHV9f

$^$?!"%9%1%8%e!<%j%s%0J}<0KD$$$F$_$F$_$k$H!"$I$N>l9g$K$b%9%1%8%e!<%j%s%0J}<0 algo4 $,:GNI$N7k2L$r<($7$F$$$k!# algo4!" 3!" 2 $rHf3S$9kH!"%W%m%;%9

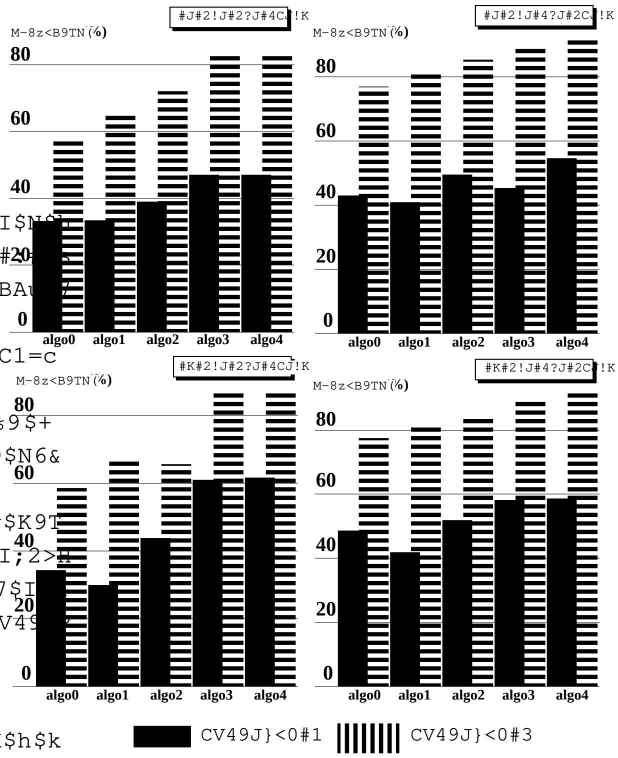

Figure 5 %7%_%e%l!<%7%g%s7k2L

$r<B%Z!<%8$r=jM-9kNN0h$K3d$jEvFk798~$,9b$$J}<0$[$I!"<B9T8zN($,9b$$$3H,o+$k!#%;%C%H J2 $N 4 ?J 2 CJ$N>l9gGN<B9T;~4V$NFbLu!JI= 5!K$rNc$K8+$k$H!"DL?.!J<g$K%Z!<%8MW5a$d%Z!<%80\F0!K$dF14|KMW7$?;~4V$K:9$,$"k3H,J,$+$k!#

3l$O!";2>HIQEY$N9b$$%m!<%+%k6u4V$N%Z!<%8$N0\F0$,>/$J$/$Jkh$&$K%9%1%8%e!<%j%s%0$9$k8z2L$,1F6A$7$?$H?dDj5l$k!#$5iK%W%m%;%9$N3d$jEv$FNN0h$rIQHK

Figure 6 NOW HG SSS–CORE $NF0:n4D6-

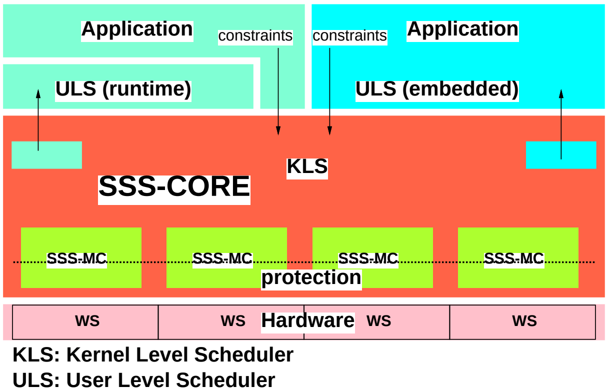

Figure 7 NOW HG SSS–CORE $N9=@.

$KJQ99$9kH!"3F%/%i%9%?$K3F%W%m%;%9$N%a%b%j$$F8qE;$r%W%m%;%9$K%9%1%8%e!<%j%s%0$9$k%+!<%M%k%1%Y
7F7^$$!"8_$$$K<B%Z!<%8$NC$$$9g$$$r5/$3$9N%K$9%1%8%e!<%i!JKLS!K$O!"4pK\E*$J9M$(J}$OJ8%[2]
2C9k$?$a!" algo4 KHfY$F algo3!" algo2 $,8zN($,$K<($5$1$F$*$j!JK\9F$NBh 8 @a$K$b:F7G$5$1$F$$$k!K!"
$/$JCF$$$k!#

Table 5 F14|/DL?.;~4V (%;%C%H J2, 4 ?J 2 CJ, CV49J}<0 3)

type	algo0	algo1	algo2	algo3	algo4
M-8z<B9T	57.48	65.81	71.99	82.88	82.88
F14|	9.70	7.56	6.71	5.42	4.21
DL?.	13.47	11.48	7.96	4.87	3.32
%G%#%9%/	0.04	0.05	0.06	0.05	0.06

10 NOW HG SSS–CORE $N3+H/8=>u

8=:_!" NOW HG SSS–CORE $N Sun Microsystems <R $N SPARCstation 20 $^$?O3$N8_495!$r EtherNet $G @\B3$7$?4D6-$GF0:n7F$$$k!J?^ 6!K!# SSS–CORE $N WS C1BNC4EvItJ,!JSSS-MC: Micro Core ?^ 7;2>H!K$G $O!"%a%b%jJ]8n!"%?%$%`%7%'%"%j%s%0!"%W%m%;%94IM}!" UDP DL?.!" TCP/IP DL?.!"%-!<F~NO!"2hLL=PNO!"30It UNIX %o!<%/%9%F!<%7%g%s$+$i$N%U%!%$%k$NFI$_=q$-!? %W%m%0%i%`%m!<%I!?<B9TEy$,<BAu$5$1$F$$$k!#%a%b%j %Y!<%9DL?.5!G=$O:G$b%Y!<%9HJ$k1s3V%a%b%j=q$-9~$

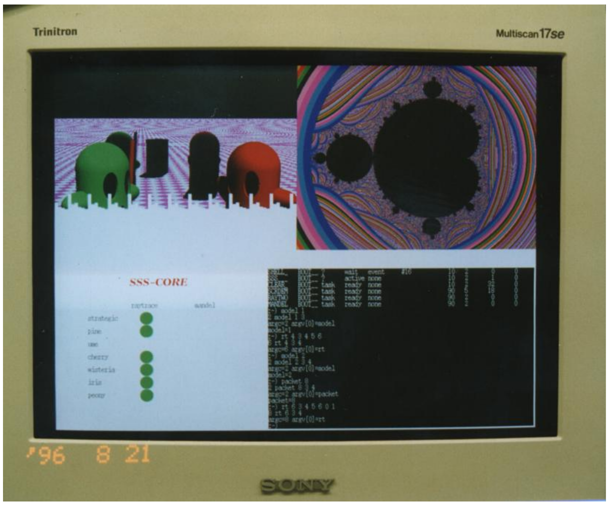

Figure 8 NOW HG OS >eGN%"%W%j%1!<%7%g%s<B9T 1

$,$9GK<BAu$5$1F*$j!"8=:_B>$N%W%j%_%F%#%V$r1T0U :n@.Cf$G$"$k!#1s3V%a%b%j=q$-9~$_$rMxMQ$7$?JBNs%1%$ %H%l!<%7%s%0$dJBNs%^%s%G%k%V%m!<=89gI=<(%W%m%0%i%` $,8=;~E@$N SSS–CORE >e$GJBNs<B9T2DG=$G$"$k!#?^ 8$*$h$S?^ 9$K NOW HG SSS–CORE >e$G!"%1%$%H%F!< %7%s%0$J$i$S$K%^%s%G%k%V%m!<=89gI=<(%W%m%0%i%`$r<B 9TCf$N=PNO2hLL$r7G:\$9$k!#?^ 8$O%1%$%H%l!<%7%s%0$r 6 Bf$N%W%m%;%C%5$GJBNs<B9TCf$N2hLL$G$"$j!"?^ 9$O%1 %$%H%l!<%7%s%0$r 3 Bf!"%^%s%G%k%V%m!<%W%m%0%i%`$r 6 Bf$G<B9TCf!J$?$@$7!" 3 Bf$OFsDN%"%W%j%1!<%7%g%s$r ;~J,3d$G<B9T!K$N2hLL$G$"$k!#

%a%b%j%Y!<%9DL?.5!G=$N<BAu$,:Q$_<!Bh!" ADSM $N <BAu$KCe<j9k!#%f!<%6$N%9%1%8%e!<%j%s%0@)Ls$r<i$C K\9FBh 9 @a$K$b4JC1$K7G:\$7$?3NN(%b%G%k$N@:L)$J%7 %_%e%l!<%7%g%s$G%9%1%8%e!<%j%s%0%]%j%7$N5M$a$,$J $5$1$F$$$k [17]!#3N%7%_%e%l!<%7%g%s7k2L$r;29M$K!" KLS $N:G=i$N%P!<%8%g%s$,<BAu$5$1$kM=DjG"$k!#

11 %a%b%j%Y!<%9DL?.$N=i4|I>2A

%a%b%j%Y!<%9DL?.$N4pK\$HJk1s3V%a%b%j=q$-9~$_$r ;H$C$?:YN3EY$NDL?.G=NO$K4X$7$F=i4|I>2A$r9TC?!#I> 2A$K;HMQ$7$? NOW 4D6-$O Axil 320 model8.1.2 (Sun SS20 8_495!, 85MHz SuperSPARC CPU !_ 2) 6 Bf$r 10BaseT $N%O%V$G EtherNet @\B3$7$?bNG"$k!#

$^$:!"4pK\@-G=rCMH7F!"Aw?.;~!?<u?.;~$N%*!<%P %X%C%I$OI=6$K<($9DLjG$"$k!#;~4V$O 0.5$\mu$sec C10L $N;~7W$G7WB,7?!# I=6$K<($5$1$k%*!<%P%X%C%IO9 GK$+$JjJDc$$CMG"k,!"Aw<u?.%k!<%A%s40@.$+$i F|$,@u$$$?$a!"$^$@:GE,2=$NM>COO"kH9M$($i1k!# J*!"3N7WB,$K;H$C$?<u?.$G$O%"%/%;%9%3%9%H$N9b$$ %U%l!<%`%P%C%U%!$KD>@\=q$-9~$_$r9TCF$$$k!# EtherNet GO:G>.%Q%1%C%H%5%$%:$, 76byte AjEvG"k? $a!" 10Mbps $N 10BaseT GOIN%1!<%9GbL@i+$K

Table 6 1s3V%a%b%j=q$-9~$_$NAw<u?.%*!<%P%X%C%I

E>Aw%5%$%: (byte)	64	32	16	8	4	2	1
Aw?.%3%9%H (μsec)	11	10	9	9	8	6.5	6.5
<u?.%3%9%H (μsec)	15	10.5	8.5	7.5	7	7.5	7

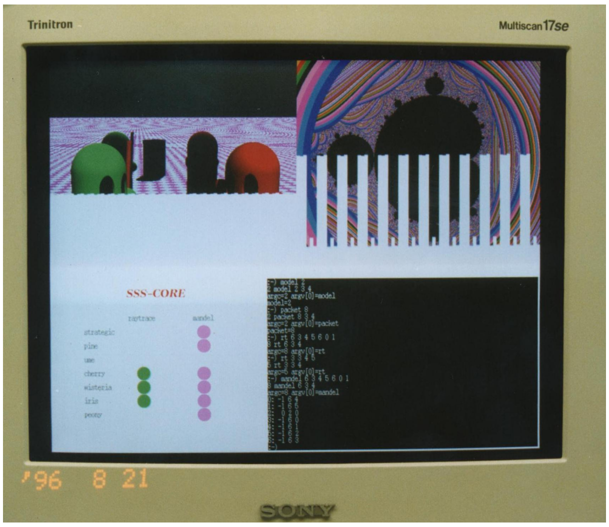

Figure 9 **NOW** HG **OS** >eGN%"%W%j%1!<%7%g%s<B9T **2**

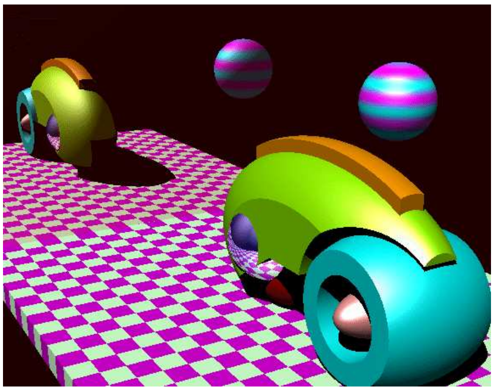

Figure 10 %1%$%H%12hA|!J<B:]$O **256** ?'%+%i!<!K

%;%C%5$r;HMQ$7!"3F%W%m%;%C%5O9YF 576 !_ 450 2s$N %k!<%W$r2s$j!"%T%/%;%k$,<+J,$NC4EvNN0h$+I&$+<B 9T;~$KH=CG$7!"C4Ev30$G$"$1$P%9%-%C%W$7$F$$$k!#;~ 4V$O 100msec C10L$G7WB,7?!#<B837k2L$rI=7$K<($9!# K\<B83$K$*$1$k 1 %T%/%;%kEv$?jN7W;;~4V$OJ?6QLs 70$\mu$sec(%T%/%;%k>e$N3($NJ#;($5KhCFBgI}$KJQ2=)$G $"$k!#I=7$G%"%9%?%j%9%/$,IU$$$F$$$k9`L\$O EtherNet $NDL?.6%9g$K$h$jBgI}$K%W%m%;%C%5$4$H$N<B9T;~4V$,JQ F0$7=hM}A4BN$N<B9T;~4V$b0BDj$7$J$$!J9`L\$Kbhk, 7k2L$K!^ 0.3sec DxEY$NI}$,B8:_$9$k!K<B839`L\$G$"$k!# I=FbKO 3 2sB,Dj7?J?6Q$,5-F~$5$1$F$$$k!#E>Aw%5%$ %:$, 32byte 0J2<$N%Q%1%C%HGO%X%C%@!<$d%@%_!<Ey$b 4^aF 76 %P%$%HJ,$N%Q%1%C%H$,Kh2s Ether $GDL?.$5$1 $F$$$k!#Nc$($P!" 4byte %Q%1%C%H$NDL?.$G$O 4.92Mbyte bN%Q%1%C%H$,Aw$i1k7W;;HJ$k!#$3$1$+$i 4byte/5 Bf$N EtherNet $NE>Aw%1!<%H$O 648 Kbyte/sec HJ$j!" $[$\K0OB>uBVG"$k!#B>$N%"%9%?%j%9%/$N9`L\$bF1MM$G $"$k!#$J$*!"8=:_$N<BAu$N SSS–CORE $O 16 2s:FAw$7 $FAw$1$J$$%Q%1%C%H$OAw?.$rD|$a$F$$$k$?$a!"%"%9%?%j %9%/$N9`L\$G$O%T%/%;%k$,2?E@$+7g$1$k>l9g$,$"$k!#$^ $?!"<B9T;~$N%Q%1%C%H$N%3%s%P%$%K%s%0r3$N<B83$G$O 9T$C$F$$$J$$!# 1 Bf$N7W;;~4V$, 4byte 0J2<KJkH$Q %1%C%H?tA}2C$KhkAw?.%3%9%H$NA}2C$rBgI}$K>e2s$k<B 9T;~4V$NA}2C$,H/@8$9$k!#$3$1$O7W;;~4V$GDL?.$,1#$; J/JC$?$?aG$"$k!#Hf3SE*Bg$-$JN3EY$NDL?.$G$b!" Bf?t$K4X7F%j%K%"%9%T!<%I%"%C%W$KC#$7$F$$$J$$$N $O!"3F%W%m%;%C%5$,C4Ev0J30$N%T%/%;%k$KBP7F<c43$N =hM}$r9TCF$$$k3H$H Ether DL?.$N>WFM$K5/0x$9kb NG$"$k!#

I=8$OI=7$HF10l>r7o$GF0E*%3%s%P%$%K%s%0$H1s3VB? =E=q$-9~$_!J1 %Q%1%C%H$GJ#?t$NBP>]%"%I%1%9$K=q$-9~ $'!K$r%5%]!<%H7?>l9g$N<B9T;~4V$G$"$k!#%3%s%P%$ %K%s%0$OAw?.%P%C%U%!!J8 %Q%1%C%HJ,!K$,K~GU$G=q$-9~ aJ$+C?>l9g$KN_9Tol!"0l;~E*$KAw?.%O!<%I%&%' %"$HL54X78$JB>$N%P%C%U%!K3$N%Q%1%C%H$rJ]4I7F$*

E>Aw$,%\%H%k%M%C%/$KJC$F$$$k!#

<!$K!"JBNs%1%$%H%l!<%7%s%0%W%m0%i%`!J0J2<$H$9$k![11] $r;H$C$F!" SSS–CORE >e$G1s3V%a%b%j=q$-9~$_ $G%U%l!<%`%P%C%U%!I=<($r9T$&<B83$r9T$C$?!#<B83$K;H MQ7? 3D %=%j%C%I%b%G%k$N40@.;~$N3($r?^ 10$K<($9!# 3N3($r 576 !_ 450 $N2rA|EY$GJBNs7W;;$r9T$C$?!#JBNs 7W;;$NJ}K!$O%5%$%/%j%C%/$K N %T%/%;%k$:Dr3d$jEv $F!" N %T%/%;%k$N%+%i!<CM!JR,G,B 3F 8bit!K$r7W;; $?8e!" dither JQ49$r3]1? N %T%/%;%kJ,$N Nbyte %G %?$r 1 %Q%1%C%HH7$FI=<(%N!<%I$N%U%l!<%`%P%C%U%! 1s3V%a%b%j=q$-9~$_$GD>@\=q$-9~$`!J6 Bf$NFb 1 Bf$O %@ <(@lMQH7$?!K!#$?$@$7!"3F%/%i%9%?KD$- 1 Bf$N%%

%T%/%;%kJ,$N7W;;$r9T$$$<!$N%Q%1%C%H$r5a$a!"?7$$%Q%1%C%H$HB`Hr$7F*$$$?%Q%1%C%H$r%^!<%8$7$FAw?.$r;n$_$k!#3NH-$^$@Aw?.%P%C%U%!$,6u$$$FJ1$1$P!#$N%Q%1%C%H$r7W;;$7%3%s%P%$%K%s%0$9$k$H$$$C$?<j=g$rHk!#%3%s%P%$%K%s%0$KhjJV7$F$$$/!#3N%1%$%H%l!<%7%s%0%"%W%j%1!<%7%g%sGOAw?.N3EY$, 4byte 0J2<$NNN0h$G%3%s%P%$%K%s%0$N8z2L$,8+i1!"%3%s%P%$%K%s%0$,$J$$>u67GOK0OB$N?$aJBNs<B9TKh$k%9%T!<%I%"%C%W$,F@i1$J$$NN0hGb%"$[$\%j%K%"$J%9%T!<%I%"%C%W$,F@i1$F$$$k!#SSS–CORE $N7Z$$%a%b%j%Y!<%9DL?.$H UNIX K*$$$F7Z$$$H8@o1$F$$$k UDP $r;H$C$?%=%1%C%HDL?.$Khk@-G=$r;29M$N$?$a$K<($9!#3N$?$a$K UDP $N%Q%1%C%H$GDL?.9k%W%m0%i%`$KA05-%1%$%H%1$r=q$-49

11 KL3$F;Bg3X$N;3K\@h@8$N%W%m0%i%`[18]$r C 8@81$G=q$-D>7? Ns2=7?J*$r;HMQ$7$F$$$k!#

Table 7 E>Aw%5%$%:$HBf?tKh$kJBNs%l%$%H%l7W;;;~4V

E>Aw%5%$%: (byte)	64	32	16	8	4	2	1
1 Bf7W;;~4V (sec)	18.1	18.2	18.4	19.0	20.5	27.0	37.7
2 Bf7W;;~4V (sec)	9.3	9.4	9.5	9.7	10.5	14.1	28.2
3 Bf7W;;~4V (sec)	6.8	6.5	6.5	6.7	8.0	*14.3	*26.9
4 Bf7W;;~4V (sec)	4.9	4.9	5.0	5.2	*7.8	*13.8	*25.3
5 Bf7W;;~4V (sec)	4.0	4.0	4.1	*4.3	*7.6	*13.7	*25.5

Table 8 F0E*%3%s%P%$%K%s%0$r;HC?JBNs%l%$%H%l7W;;;~4V

%5%$%: (byte)	64	32	16	8	4	2	1
1 Bf7W;;~4V (sec)	17.0	17.0	17.1	17.3	17.6	18.4	19.7
2 Bf7W;;~4V (sec)	8.8	8.9	9.0	9.0	9.1	9.5	10.2
3 Bf7W;;~4V (sec)	6.5	6.1	6.2	6.2	6.3	6.6	7.0
4 Bf7W;;~4V (sec)	4.6	4.7	4.7	4.7	4.8	5.0	5.3
5 Bf7W;;~4V (sec)	3.8	3.8	3.8	3.9	3.9	4.1	4.3

Table 9 **UDP** DL?.Kh$kJBNs%l%$%H%l7W;;;~4V

E>Aw%5%$%: (byte)	64	32	16	8	4	2	1
1 Bf7W;;~4V (sec)	17.6	18.5	19.5	22.2	29.7	41.5	68.4

$($?bN$rMQ0U$7$F!"I=<(%W%m%0%i%`$O SunOS 4.1.3 $N X11R6 $GI=<($7!J$?$@$7 XFlush $O$7$J$$!K!"7W; %W%m%0%i%`$O Solaris 2.4 >e$GF0$+7?!#;HMQ%^%7%s 6-$O SSS–CORE MQ$N4D6-$N OS $r8r49$7F^C?$/Ht 8K7?!#%"%W%j%1!<%7%g%s$N%3%s%Q%$%k>r7o$bF1 %3%s%Q%$%i$rMQ$$!":GE,2=%*%W%7%g%s!JO4!K$bF10l$K$7 $?!#I=9$K<B837k2L$r<($9!#B,Dj$O<B;~4V$G9T$$!"$N DL?.$NAw?.B&$OAw?.%P%C%U%!$K=q$-9~$a$J$$>l9g$O 9~$ak^GBTDh&$K%W%m%0%i%`$7$?$,!"%*!<%P $rI,MW0J>e$KA}d5$J$$$?$a!"$=$l0J>e$NE>Aw$NJ 9T$oJ+C?!#3N3HKh$j!" 2 Bf0J>e$N<B9T$G ?.$N>WFMKh$jBgI}$K%T%/%;%k$r<h$j3\$9!#3N 1 Bf$G%l%$%H%l$r<B9T$7!" 1 Bf$GI=<($7$?>l9g$N 9$K<($9!# 64byte E>AwK*$$$F$O UNIX >e$N UDP $ >!CF$$$k$,!"$3lOIbF0>.?tE@$k!<%A%s$,0[J %Y!<%9@-G=$N0c$$$G$"$k!#E>Aw$NN3EY$,:Y$+$/J lF!" SSS–CORE $N<B9T;~4V$hjbD9$/$+$+$kh Jk!#

12 $*$ojK

SSS–CORE $O%o!<%/%9%F!<%7%g%s/%i%9%?!JNOW!K $*$h$SJ,;6%a%b%j7?JBNs7W;;5!>e$G%Q!<%F%#%7%g%s%0 $H;~J,3d%9%1%8%e!<%j%s%0$Khk%^%k%A%f!<%6!?%^%k%A %8%g%V$r<B8=$9$kHFMQD6JBNs%*%Z%l!<%F%#%s%0%7%9%F%` $G$"$k!# SSS–CORE $O%=%U%H%&%'%"$K$h$k%a%b%j%Y!< %9DL?.5!G=!"HsBP>NJ,;66&M-%a%b%j!"%+!<%M%k!?%f!<%6 $N6(D4F0:n%$%s%?%U%'!<%9!"%+!<%M%k%l%Y%k%9%1%8%e!< %i$X$N%f!<%6@)Ls;XDj!";q8;;HMQNL$K1~$8$?<B9TM%@hEY $N8xJ?@-$N3NJ] $H$$$C$?%9%1!<%i%V%k$JJBNs%*%Z%l!< %F%#%s%0%7%9%F%`N?aN?7$7$$5!G=$rM-$7!"2>A[2=$5 $lJ]8n$5l?4D6-2<$GJBNs%"%W%j%1!<%7%g%s$N8zN($NNI $JBNs<B9T$r2DG=H9$k!#

K\9FGO$^$: SSS–CORE $N4pK\J}<0$JiS$K SSS–CORE N?aK3+H/5lDs0F7F$$$k3F<o5!G=KD$$$F 2r@b7?!#?75!G=N&$A%+!<%M%k%l%Y%k%9%1%8%e!<%j%s %0J}<0$H%Z!<%8%j%W%l!<%9J}<0$K4X7F$O3NN(%Y!<%9$N %7%_%e%l!<%7%g%s<B83$N7k2L$r<(7?!#$=$N7k2L!"2f!9 $NDs0FJ}<0$,=>Mh$NJ}<0$KHf$YNI9%$J%W%m%;%C%5M-8z MxMQ$r<($F@ilk3H,<($;$?!#<!$K!"8=:_8&5f3+H/Cf $N NOW HG SSS–CORE $N3+H/>u67$r=R$Y!"$=$N>e$G%a %C%;!<%8DL?.5!G=$N4pK\5!G=$K4X9k<BB,$r9T$C$?7k 2L$rDL$($7$?!#<BB,$Khk$H 32byte 0J2<$N:YN3EY1s3V=q $-9~$_G"lP!"Aw<u?.6&$K?t µsec DxEY$N%*!<%P%X%C %I$G 2s$NDL?.$,2DG=$G$"$k!#3N3H$O 100BaseT $d 9;B.8w%j%s%/Ey$NB.$$DL?.%M%C%H%o!<%/$r;HMQ$7$?>l9g KEyNf!<%6%l%Y%kDL?.F14|@lMQ%O!<%I%&%'%"$,$J$/$F$b 9b$$@-$DJ]8n$5$l2>A[2=$5l?$f!<%6%l%Y%kDL?.F14|$, <B8=G-$k2DG=@-$r<(:6$7$F$$$k!#

:#8e$O%+!<%M%k%l%Y%k%9%1%8%e!<%i$N<B5!$X$N<BAuEy $r9T$$ NOW HG SSS–CORE $N40@.EY$r>e2kHH$b $K!"<B5!>e$G$N3F<o<B83%G!<%?$r<}=8$9$kM=DjG"$k!# $^$?!"2>A[5-21$r%5%]!<%H$9k?aN DISK I/O Ji$S $K DISK I/O $N%l%$%F%s%7$r1#JC$9k?aN%9%1%8%e!< %j%s%0J}<0$K4X$7$F8&5f3+H/$r9T$$&M=DjG"$k!#

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[15] ?.9q M[FsO:, >>K\ >0, J?LZ 7I: HFMQJBNs OS N?aN ;q8;>pJs$rMxMQ$7$?%9%1%8%e!<%j%s%0J}<0$N8!F$. ?.5;Js, CPSY 95–64, pp.111–118 (August 1995).

[16] ?.9qM[FsO:, >>K\>0, and J?LZ7I: JBNs OS $N@-G=M=B, $r2DG=$K9k%7%_%e%l!<%7%g%s%b%G%k. >p=h8&Js 96-ARC-117, 96(23):19–24, (March 1996).

[17] ?.9q M[FsO:, >>K\ >0, J?LZ 7I: HFMQJBNs OS SSS–CORE K*1k%+!<%M%k%9%1%8%e!<%j%s%0J}<0 — >\:Y3N N(%b%G%kKh$k@-G=I>2A —. >pJs=hM}3X2q8&5fJs9p 96–OS–73, >pJs=hM}3X2q, Vol.96, No.79, pp.79–84 (August 1996).

[18] ;3K\ 6/: The 3 Dimensional Computer!& Graphics. CQ =PHG (1983).