HFMQD6JBNs **OS** *SSS–CORE* K*1k%9%1%8%e!<%j%s%0J}<0$NI>2

?.9q M[FsO: >>K\ >0   J?LZ 7I

El5~Bg3XBg3X1!M}3X7O8&5f2J>pJs2J3X@l96

1 O8aK

J,;6%a%b%j4D6-GO!"%a%b%jXN%"%/%;%9%3%9%H$,%WN%$K%hCF0[$j!"JBNs%W%m%;%9$N8zN(E*<B9T$N<B8=$KOAj_BPE*K%3%9%H$N9b$$%"%/%;%9$r8:$i$9$3H,5aailk!#J#?t$N%W%m%;%9$,F0:n9kHFMQE*4D6-GO$=$N<B8=J}K!H7$F!"%a%b%j%Z!<%8$JIN<B;q8;$N;HMQ>u67$r9MN8$7$?%9%1%8%e!<%j%s%0$r9T$J$$%7%9%F%`A4BN$N@-G=$r>e2k3H$,2DG=$G$"$k!#$^$?%"%/%;%9%3%9%H$N>.$5$J%a%b%j%Z!<%8$+$iCV49$r9T$J$$!":F%"%/%;%9;~$N%3%9%H$rM^$($k3H$b!"A4BN$N@-G=8~>e$K4sM?$9$k!#

K\9FGO%a%b%j%"%/%;%9%Y!<%9$N3NN(%b%G%k>e$G!"6qBNE*$J%a%b%j4IM}J}<0!?%"%/%;%9IQEY!?%"%/%;%9%3%9%H$rIU2C$7$?%7%_%e%l!<%7%g%s$Khj!"JBNs%W%m%;%9Kh$K=jM-$9$k<B%Z!<%8>pJs$rMxMQ7?%9%1%8%e!<%j%s%0K!"5Z$S%a%b%jCV49J}<0$NI>2A$r9T$&!#

2 SSS–CORE

SSS–CORE[1] $O NUMA 7?JBNsJ,;67W;;5!$rBP>]H7$?HFMQJBNs OS G"$k!#;~J,3d HQ!<%F%#%7%g%K%s%0$rJ;MQ$7$F%^%k%A%f!<%6!?%^%k%A%8%g%V4D6-$rDs6!$7!"JBNs%"%W%j%1!<%7%g%s$N8zN(NI$$<B9T$r<B8=$9k3HrL\E*H9$k!#

SSS–CORE GO!"7W;;5!$NAj8_7k9gLV$N3,AX9=B$$H0lCW7?9=B$$N;q8;4IM}9=B$$rMQ0U7F;q8;>pJs$N4IM}$r9k!# 2 %l%Y%k%9%1%8%e!<%j%s%0$r:NMQ$7!"%+!<%M%kO3$N;q8;>pJs$H3F%W%m%;%9$+$iDs<(5l$k%9%1%8%e!<%j%s%0@)Ls$K7?$,$C$F!"%W%m%;%9C10L$K;q8;$N3dEv$r9TJ&!#

3 %7%_%e%l!<%7%g%s!&%b%G%k

3.1 <g$JFCD'

3l$^$G$N8&5f$GMxMQ7?%b%G%k [2] $r3HD%$7!" OS 4IM}%Y%k$N%7%_%e%l!<%7%g%s$N$?$a2DG=$J8B$j4JN,2=5l$?%b%G%k [3] $r9=C[$7$?!#BP>]$H9kNOJ,;6%a%b%j7W;;5!G"$k!#%a%b%j$H%W%m%;%C%5NBPr%/%i%9%?H7!"Aj8_7k9gLV$OLZ9=B$$G$"$k!#DL?.Ey$N%3%9%H$ODL2a9k%M%C%H%o!<%/$NCJ?t$KHfNc$7!"4pK\%3%9%H$r%Q%i%a!<%?H7$FM?$($k!#%M%C%H%o!<%/>e$N6%9g$OL5;k$9$k!#

3F%W%m%;%9KO6&M-6u4V$HHs6&M-6u4V$r!"$=$l$>$lJL!9$N%Z!<%8C10L$N%a%b%j;2>HIQEYI=Kh$jM?$($k!#0l%/%i%9%?$K$*$1$kJBNs%W%m%;%9$N<B9T%3%s%F%-%9%H$r%9%l%C%I$H8F$S!"3F%9%l%C%I$O0[JC$?6u4V$rM?$($ilk!#%9%1%8%e!<%j%s%0Kh$j3d$jEv$F0LCV$,JQ2=7?%9%l9gKO!"%m!<%+%k%Z!<%8$O%M%C%H%o!<%/$r2p7F 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%7%IM}$O%"%C%W%G!<%HJ}<0$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$A / F14|BT$A0J30$NF0:n ($r7?;~4V / %/%m%C%/?t) 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

3.2 %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;; [2] $r9T$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$N3djEvFNN0h$rBe=$9kbNG$"$k!#

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

algo3 %[!<%`%N!<%I0J2<$NNN0h$G%Z!<%8N"kH3m$+$i3djEvF$k!#

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

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

algo0 %i%s%@%`KI,MWJ?t$@$1%W%m%;%C%5$rA*Br$73djEvF$k!#

%W%m%;%9$K3d$jEvFil?%/%i%9%?XN%9%l%C%I$N%9%1%8%e!<%j%s%0$O!"0J2<NDLjG"$k!#

An Evaluation of Scheduling Methods for General Purpose Operating System *SSS–CORE*

Yojiro NOBUKUNI, Takashi MATSUMOTO, Kei HIRAKI
nobukuni@is.s.u-tokyo.ac.jp

Table 2: %W%m%;%9!&%;%C%H

#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: 1 CJ 16 ?J9=@.$G RA $rA}2C$5$;$?7k2L

RA	CV49 J}<0	algo0	algo1	algo2	algo3	algo4
100	J}<0 1	46.20	49.12	46.07	46.07	58.64
	J}<0 3	85.93	87.99	90.41	90.41	95.15
300	J}<0 1	39.18	36.28	42.01	42.01	56.92
	J}<0 3	64.69	71.75	78.17	78.17	90.21

RA!'%j%b!<%H%"%/%;%9!&%3%9%H!"CM$OM-8z<B9TN([%]

- A02s$N3dEv$H=EJk%/%i%9%?KOF1$8%9%l%C%I$r %1%8%e!<%k9k!#
- $=$10J30$N%/%i%9%?$K$O!";D$j$N%9%l%C%I$r=g$K%9 %1%8%e!<%k$9$k!#

3.3 %Z!<%8CV49J}<0

%Z!<%8$NCV49$O!":F$S;2>H$5lk2DG=@-$NDc$$$b$N!"$^$?:F%"%/%;%9$N%3%9%H$,>.$5$$$bN+$iCV49$NBP>]H7$?J}$,@-G=8~>e$K4sM?$9$k!#$7$?$,CF!"0lHL$KA}BP E*$K%"%/%;%9IQEY$N9b$$%m!<%+%k%Z!<%8hj$b6&M-%Z!<%8!"$^$?%3%T!<$r;}$?$J$$6&M-%Z!<%8!J0J9_JX59E*% %9%H%o%s!&%Z!<%8$H8F$V!Khj$b6&M-%3%T!<%Z!<%8$+$iCV49$NBP>]H9$k!#$^$?8=:_<B9TCf$N%W%m%;%9hjO=$NB>$N%W%m%;%9$KB0$9$k%Z!<%8$NJ}$,;2>H$5lk2DG=@-$,Dc$$!#$=$3$G%Z!<%8$N<oN`Kh$j!"<!$Nh&$KCV49BP>]$H9k=g=x$rM?$(k3H,G-$k!#

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

:#2s$O!"<!$NFsDNCV49J}<0$NHf3S$r9TJC$?!#

J}<0 **3** M%@hEY$NDc$$%W%m%;%9$+$i@h$K!">e5-$N%Z!<%8$N<oN`=g$KA*Br!#

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

$?$@$7N><T$H$b!"0l4S@-=hM}Cf$N6&M-%Z!<%8$N>l9g$OCV49BP>]H7$J$$!#

4 7k2L5Z$S9M;!

A0=R$N%b%G%k$rMQ$$$FI=1Nh$&$J%Q%i%a!<%?Kh$k%7%_%e%l!<%7%g%s$rI=2K"2?%W%m%;%9$NAH9g$;KBP7$F9T$JC?!#3F%W%m%;%9OIlb 80 %Z!<%8$N6&M-6u4V$r;}$A!"1000 M-8z<B9T%/%m%C%/Kh$KF14|$9$k!#?^1$ $=$N<B9T7k2LG"$k!#3F%9%1%8%e!<%j%s%0K!$KBP7F!"3F%M%C%H%o!<%/7A>uK*$$$FN>%a%b%jCV49J}<0$r:NMQ$7$?;~$N!"%7%9%F%`A4BN$NM-8z<B9TN($r=D<4$K<($7$?!#$J$*%G!<%?$N<hF@$O%7%_%e%l!<%7%g%s$r3+;O8e!"0l$DL\$N%W%m%;%9$,=*N;!J20 %?%$%`%9%i%$%9J,$NM-8z<B9T!K7?D>8e$N%?%$%`%9%i%$%9$K9TJC$?!#

?^1$N%0%i%U$O35$M1&>e$,jG!"%9%1%8%e!<%j%s%0J}<0 algo4 $,:GNI$N7k2L$r<($7$F$$$k!#$^$?%a%b%j$NCV49J}<0$K$D$$$F$_$k$H!"%M%C%H%o!<%/$N7A>u$H%9%1%8%e!<%j%s%0J}<0$NINAH9g$;$N>l9gKb!"CV49J}<0 3 $,J}<0 1 $K>!$C$F$$$k!#

I=3$O%M%C%H%o!<%/$,1 CJ$N>l9g$K!"%j%b!<%H%"%/%;%9$N%3%9%H$r 300 H7$?<B837k2L$G$"$k!#%M%C%H%o!<%/>e$N%3%9%H$,A}2C9k$H!"%9%1%8%e!<%j%s%0J}<04V$N@-G=:9$,9-$,$k!#%M%C%H%o!<%/>e$N6%9g$rL5;k7F$$$k$?$a!"6%9g$N5/$-d9$$$3Nh$&$J%U%i%C%H$J7A>u$N>l9gKO!"%j%b!<%H%"%/%;%9$N%3%9%H$,100 $N>l9g$N@-G=:9$O!"<B:]$hjb>.5/JC$F$$$k$H?dDj$5lk!#

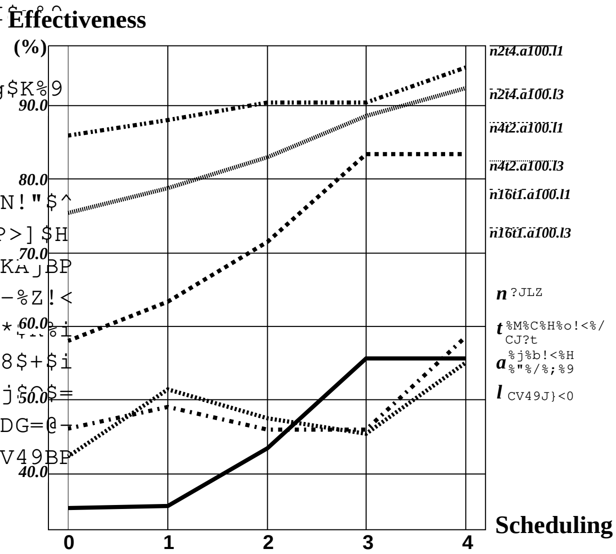

Figure 1: %7%_%e%l!<%7%g%s7k2L

5 $*$ojK

%7%_%e%l!<%7%g%sKh$j!"%W%m%;%9$N%a%b%j;2>H;~$N%3%9%H$rJkY/M^$($kh&$K!"%W%m%;%9$K$O%Z!<%8$r;}$D%/%i%9%?$r3djEvF!"%Z!<%8$N0\F0$dCV49Kh$k0-1F6A$rM^$($k$H8zN($E*$J<B9T$,G-k3H,<(5l$?!#0J>e$N7k2LrbHK!" *SSS–CORE* $N<BAu$K<h$j3]$+$k!#

<U<-

K\8&5f$O>pJs=hM}?66=;v6H2q!J#I#P#A!K$,<B;\$7$F$$$kFHAOE*>pJs5;=Q0i@.;v6H$N0l4D$H7F9TJC$?!%

References

[1] >>K\>0, 8EAq?J01, J?LZ7I. HFMQD6JBNs%*%Z%l!<%F%#%s%0%7%9%F%`SSS–CORE. F|K\%=%U%H%&%'%"2J3X2qBh 11 2sBg2q O@J8=8, pp. 13–16, October 1994.

[2] ?.9qM[FsO:, >>K\>0, J?LZ7I. HFMQJBNs#O#SN?aN;q8;>pJs$rMxMQ$7$?%9%1%8%e!<%j%s%0J}<0$N8!F$. ?.3X5;Js, Vol. 95, No. 210, pp. 111–118, August 1995.

[3] ?.9qM[FsO:, >>K\>0, J?LZ7I. JBNs#O#S$N@-G=M=B,$r2DG=K9$k%7%_%e%l!<%7%g%s%b%G%k. >p=h8&Js 96-ARC-117, Vol. 96, No. 23, pp. 19–24, March 1996.