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The Shared Memory Management of Distributed Operating System Colonia and Emulator for the Shared Memory Management

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J?@.9G/27n14F|(Feb. 14 1997)

Abstract

Although distributed systems which are spread today enable users to share computer resources, an application program usually can be executed only sequentially by one processor in those systems. Even if several processors execute an application program in parallel, the speed of the execution is not much faster than the execution by one processor, for the late communication between machines.

Then we propose a computer system named "computer colony", which is oriented for the parallel processing of an application program. In addition, the goals of a computer colony are the transparency of the location, the effective utilization of computer resources by dynamic load balancing, and the suitable supply of resources for multi users.

The primary method for communication in a computer colony is shared memory. In systems based on shared memory, the communication of data is treated as the access to memories, and users can communicate fast and safely without interference by operating systems.

We develop a computer colony, which consists of a workstation cluster made of computers connected with fast networks on the basis of shared memory, and an operating system named "Colonia" which works on that workstation cluster.

We import a new executive model named "Mission-Unit model" into Colonia for the fast parallel processing. A "mission" is a task thrown by users into a system, and a "unit" is a part of a mission divided for the system to distribute the load of the mission among processors. Because each unit has its own virtual memory space, it can work independently on separated machines without unnecessary communication. A unit shares a part of its virtual memory space with other units and cooperates with them.

This paper shows a design and development of the management mechanism for shared memory which is the most important method for communication in a computer colony, and a development of an emulator for Colonia to work in an existing operating system.

To keep page tables in which several virtual pages point to a physical page makes a physical memory shared among processors in a machine. Each entry in a reverse page table which shows virtual pages pointed to by a physical page, however, has to keep a list structure because it points to several virtual pages. On the other hand, it lets memories shared among several computers that a real content is located on a memory of a computer, and other computers access that content through networks. Those computers, if needed, keep a cache of the real content on their own memory.

We are developing Colonia with an emulator in an existing operating system in order to implement and evaluate the memory management of Colonia. The emulator works as if it were a part of the kernel of Colonia related with hardwares, such as timer interrupt or dispatch. The kernel of Colonia and units on Colonia act as processes on the emulator. The emulator let units work concurrently by making processes for units work in turn. Besides, the emulator provides each unit its own virtual memory space by making them independent as a process.

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2.2 %M%C%H%o!<%/9=@. 3
2.3 6&M-%a%b%j$HDL?.%\!<%I 3
2.4 %*%Z%l!<%F%#%s%0%7%9%F%`Colonia $N35MW. . . 3
2.4.1 %_%C%7%g%s!&f%K%C%H%b%G%k 4
2.4.2 %a%b%j6&M-N?aN<jB3$- 4

3 6&M-%a%b%j4IM} 5
3.1 %N!<%IF'bGN%a%b%j6&M- 5
3.2 %N!<%I4VGN%a%b%j6&M- 6
3.2.1 %@%_!<%Z!<%8$H%[!<%'%Z!<%8 6
3.2.2 %3%T!<%Z!<%8$H%[!<%'%Z!<%8 7
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4.3 3F5!G=$N%(%_%e%l!<%H 9
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4.3.2 %7%9%F%'%3!<%k 9
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5 $*$ojK 10

1 O8aK

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7+$7!"0l$DNBg-$J;E;v$NIi2Y$rJ#?t$N7W;5!$KJ,;6$5$;$FJBNs<B9T5$;$k!"$H$$$&3HKJkH!"8=:_Ia5Z7F$$$kJ,;6%7%9%F%'KOLdBj$,$"$k!#%M%C%H%o!<%/$rDL7F$NDL?.$OdO$jCY1d$,Bg$-$/!";v<B>e:YN3EY$NJBNs<B9T$OG-$J$$!#

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- DcB.$JI/O %P%9%r2p$7$F~=PNCL?Na$GOJ$/!"%a%b%j%"%/%;%9L?Na$GDL?.$,9T$($k!#$hCF!"%7%9%F%'$KMM!9$J%"!<%-%F%/%A%c$N%^%s%,:.:_$7Fb!"DL?.$K4X$7$FE}0l$7$?07$$$,G-$k!#
- ITEv$J%"%/%;%9$O2>A[%a%b%jKBP9$k5-21J]8n0cH?$H7F07clk?$a!"DL?.$K$*$1$k%;%-%e%j%F%#BNJ]$,MF0WG"$k!#
- 0J>e$NM}M3$Khj!"%*%Z%l!<%F%#%s%0%7%9%F%'$,2p:_$9$k>lLL$,>/J/!"9bB.$JDL?.$,G-$k!#

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7W;5!;q8;$NM-8zMxMQ %M%C%H%o!<%/>e$GIi2Y$,JP$k$?$a$K01It$N7W;5!$,,[$HsIMxMQ5l$J$$>uBV$r2sHr$7!"Ii2Y$r%M%C%H%o!<%/A4BN$GJ?6QE*$KJ,;6$5$;$k!#

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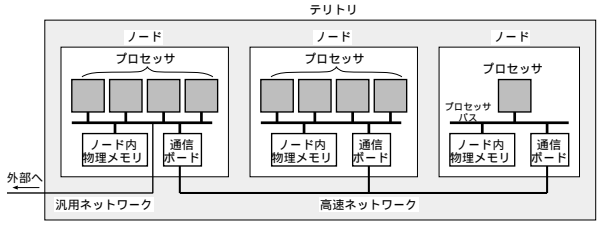

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3lKBP7%3%s%T%e!<%?!&3%m%K!<$O!"9bB.$JDL?.$r9T$&%O!<%I%&%'%"4D6-H7$F!"I/O $d%7%9%F%`3!<%k$r;Ho:$K%a%b%j%"%/%;%9$N$_$GDL?.$,$G$-$k%$%s%?%U%'!<%9$r%f!<%6$KDs6!$7!"6&M-%a%b%j$r<B8=$9$k!#$3N?$a!"@lMQDL?.%\!<%I$r%W%m%;%C%5%P%9$KIU2C$7!"U*M}%a%b%j6u4VKBP9$k%"%/%;%9$rD>@\%M%C%H%o!<%/$K@\B3$9$k!#

%f!<%6$,%a%b%j$K%"%/%;%9$9$k!]KO!"%f!<%6$O2>A[%"%I%l%9$rMQ$$F%"%/%;%9$9$k0lCV$r;XDj$9$k!#2>A[%"%I%l%9$O MMU(Memory Management Unit: %a%b%jJ]8n%f%K%C%H) KhCFJ*M}%"%I%l%9$KJQ4$5$l!"$=$NJ*M}%"%I%l%9$GJ*M}%a%b%j6u4V$K%"%/%;%9$9$k!#J*M}%"%I%l%9$,N!<%IF'b%a%b%j$KBP1~$9$k>19g$O!"3NCJ3,GN!<%IF'b%a%b%j$KD>@\%"%/%;%9$9$k!#BP1~$7$J$$>19g$O!"DL?.%\!<%I$,%W%m%;%C%5%P%9$rN.$l$kJ*M}%"%I%l%9$r8+$FDL?.$NI,MW@-$r8!=P$7!"%"%/%;%9$9$kY-<BBN$r;}$D$N!<%I$KBP7F<B:]$NDL?.=hM}$r9T$&!#

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%_%C%7%g%s!&f%K%C%H%b%G%k Colonia GO!"0lDN%W%m%0%i%`$KAjEv$9$k<B9TC10L$H7F!"¥_%C%7%g%s!W$rMQ0U$7!"0lDN%_%C%7%g%sA4BN$G6&M-$7!"A4BN$G6(D4$7$?2F0:n$rHk3H$,$G$-$k!#b$7!"2>A[%a%b%j6u4V$,%"%/%F%#%S%F%#%4HKFHN)$;$:K9Y$F6&M-$7$F$$k$H!"%"%/%F%#%S%F%#%,JL%N!<%I$KJ,$+1F$$k>19g!"%a%b%j%"%/%;%9$9$4HKDL?.$r9T$oMPJi$J$$!#7$+$7!"%_%C%7%g%s!&f%K%C%H%b%G%kGOI,MW$JItJ,$@$16&M-$7$FDL?.$r9T$&$,!"f%K%C%HFbItGN=hM}$ODL?.$r9To:$K9bB.$K<B9TG-$k!#

%^%$%/%m+!<%M%kJ]<02f!9$O!"%*%Z%l!<%F%#%s%0%7%9%F%`Colonia $r¡¥^%$%/%m+!<%M%kJ]<0!W$G9=@.$9$k!#$3$NJ}<0$G$O!"%7%9%F%`$N5!G=$NDI2C!&HD%$,!"%7%9%F%`%5!<%P$rJQ9$9$k$@$1$G9T$(k!#$^$?!"%G%#%9/$dHFMQ%M%C%H%o!<%/$J$I$NM-L5$K1~$8$F%7%9%F%`%5!<%P$rDI2C9k3H$G%7%9%F%`9=@.$rJQ9$9$k3H$,$G$-$k!#

%F%j%H%j!&9%1%8%e!<%j%s%0 %F%j%H%jA4BN$rBP>]$H7?%9%1%8%e!<%j%s%0$r<B8=$9$k!#f!<%6$,%F%j%H%jKBP7$FEjF~$7$?;E;v$r!"$=$N;~E@GN3F%N!<%I$NF'b%a%b%j$KI/O %P%9$rDL2a$7$J$$$h$&$K!"I4V5wN%$+$iH=CG7FF'OE*$KIi2YJ,;6$9$k!#$^$?!"FCDj$N%N!<%I$K%f%K%C%H$r0\Aw$9$k!#3NH$-!"%f!<%6$,%_%C%7%g%s4H$KMW5a$9$kQoS rG$-k@$1K~B-G-kh$&$JIi2YJ,;6$r9T$&!#Nc$(P!"%j%"%k%?%$%`@-$,MW5a$5lk%^%k%A%a%G%#%"BP1~$N%"%W%j1!<%7%g%s$r<B9T9kH-

$O! "%"%W%j%1!<%7%g%s$K$*$1$k;~4V$NN.lK=hM}$,DI$$IU $/$h$&$J@-G=$r%7%9%F%'$CDs6!9k!#

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0lDN;E;v$NIi2Y$rJ#?t$N%W%m%;%C%5$KJ,;6$7$FJBNs<B9T5; kK$O!"0l$D$N;E;v$rJBNs<B9T2DG=$JC10L$K:YJ,2=9kI,MW$, $"$k!#8=9T$N%*%Z1!<%F%#%s%0%7%9%F%'$K$*$$FDs6!5l$kJB Ns<B9T%b%G%k$K$O!"<g$K<!$NFs<oN'$,$"$k!#

- 0lDN%W%m%;%9$r0l$D$N;E;v$K3djEvF!"$=$NCf$GJ#?t$N %9%1%C%I$r@8@.$7!"UBNs<B9T5;$kJ}K!!#%W%m%;%9$4HK 8GM-$N%"%I%l%96u4V$r;}D,!"$=$lO9YF$N%9%l%C%I$K $*$$F6&DLG"$j!"%9%l%C%I$4HN8GM-6u4V$O;}$?$J$$!# 3N$?$a!"UL$N%a%b%j$KJ,;6$7$?:]K9YF$N%a%b%j%"%/ %;%9$K$D$$FDL?.$r9T$oMPJi$J$$!#

- %W%m%;%9%0%k!<%W$r0l$D$N;E;v$K3djEvF!"U#?t$N%W%m%; %9$rJBNs<B9T5;$kJ}K!!#JBNs<B9TC10L$4HK8GM-6u4V$r ;}$D$,!"$=li$N4V$N%G!<%?8r49$O%W%m%;%94VDL?.$H$J $j!"$^$?%I%l%96u4V$,A4$/0[$Jk?$a%a%b%j$KBP9k=h M}$,HQ;($KJj%*!<%P%X%C%I$,Bg$-$$!#

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%_%C%7%g%s %_%C%7%g%s$O!"%f!<%6$,%7%9%F%'$KEjF~$9$k;E;v$N C10LG"$k!#0l$D$N%"%W%j%1!<%7%g%s%W%m%0%i%'$"$k$$$O 0lDN%3%^%s%I$,0l$D$N%_%C%7%g%s$KAjEv9k!#%_%C%7%g %s$OJ#?t$N%W%m%;%C%5K^$?$,$j!"$=l>lN%W%m%;%C%5 >e$G%f%K%C%H$,F0:n9k3H$G6&DL$NL\E*$rC#@.$9$k!#

%f%K%C%H %f%K%C%H$O!"%_%C%7%g%s$r:YJ,2=7?!"%G%#%9%Q%C%A $NC10L$G$"$k!#%f%K%C%H$OJL!9$N%W%m%;%C%5$KJ,$+$1!"UB Ns$KF0:n9k!#%_%C%7%g%s@8@.;~$K!¥k!<%H%f%K%C%H!W$H 8FPl$k%f%K%C%H$,0l$D@8@.$5$l!"I,MW$K1~8FDI2C@8@. 5l$k!#8GM-$N%a%b%j6u4V$r;}$D$,!"0lIt$r%_%C%7%g%sA4 BN$G6&M-$9$k!#

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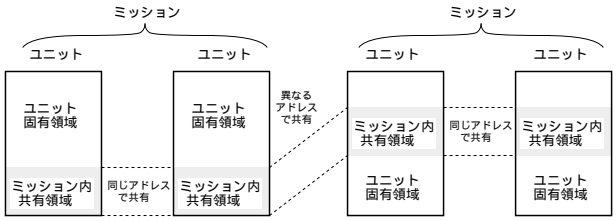
%_%C%7%g%sFb6&M-NN0h$O!"$9YF$N%f%K%C%H$K$*$$FF1$82> A[%"%I%l%9$KG[CV5l$k!#$hCF!"IN%f%K%C%HGbF1$8%]$$ s%?$GF1$8FbMF$r;X$9$3$H$,$G$-$k!#7+$7!"0[$J$k%_%C%7%g %s$N4V$G%G!<%?$r6&M-9k$H!"F1$8%"%I%l%9$K6&M-%a%b%jNN0h $,3NJ]$G$-$kJ]>ZOJ$$?$a!"0lHL$K6&M-%a%b%jNN0h$O0[$J$k 2>A[%"%I%l%9$K3djEvFil$k!#%_%C%7%g%s!"%f%K%C%H$,J#?t $"$k>l9g$N2>A[%a%b%j6u4V$N4X78$r?^2$K<($9!#

%_%C%7%g%s$N@8@. %f!<%6$,%3%^%s%I%i%$%s>e$G%W%m%0%i%'L> $rF~NO$9$k!"$"$k$$$OB>$N%_%C%7%g%sFb$G%_%C%7%g%s@8@.$N%7 %9%F%'$3!<%k$rH/9T$9kH!"?7$7$/%_%C%7%g%s$,@8@.$9$k!#$3 NH$-!"%_%C%7%g%sFb6&M-NN0h$N%"%I%l%9$r;XDj$9$k!#



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%f%K%C%H$N@8@. %k!<%H%f%K%C%H$,%f%K%C%H@8@.$N%7%9%F%'%3!< %k$rH/9T9k3H$G!"$=$NB>$N%f%K%C%H$,@8@.$9$k!#@8@.$5$l $?%f%K%C%H$,5iKULN%f%K%C%H$r@8@.$7Fb$h$$!#3NH-!" %_%C%7%g%s@8@.;~$K;XDj$5l?%a%b%jNN0h$r%_%C%7%g%sFb6&M-NN0h$H7F9YFN%f%K%C%H$G6&M-$9$k!#%f%K%C%H$,F0:n9k %N!<%I$O!"%9%1%8e!<%i$,Ii2Y>u67$dQoS $K1~$8$F7hDj$9$k!# 0lHL$K!"F10l%_%C%7%g%sFb$N%f%K%C%H$O8_$$$K6[L)$KO"Mm$G$- kh$&$K!"%M%C%H%o!<%/>e$N5wN%$,6a$$%N!<%I$KG[CV$5lk!#

%f%K%C%H$N0\Aw FCDj$N%N!<%I$KIi2Y$,=8Cf9k$H!"%9%1%8e!< %i$OF0E*Ii2YJ,;6$r9T$&$?$a!"%f%K%C%HN&$A$$:l+$rB>$N %N!<%I$K0\Aw$9$k;X<($r=P$9!#0\Aw$KH<CF!"%f%K%C%H8GM-NN 0h$NFbMF$rE>Aw9kI,MW$,$"k,!"0\Aw;~K9YFE>Aw9k$N GOJ/!"6&M-$K4X9k@_Dj$@$1$7F*$/$3HG!"0\Aw8e$N9b B.$J<B9T:F3+$,<B8=G-$k!#0\Aw@h$G%f%K%C%H8GM-NN0hKBP7 $F%"%/%;%9$,$"$C$?$H$-$K!"0\Aw85$+$iFbMF$rE>Aw$9lP$h$$!#

2.4.2 %a%b%j6&M-N?aN<jB3$-

%a%b%j$N6&M-$r<B8=9k$?$a$N<jB3$-$O!"F1$8%_%C%7%g%s$NCf K"%f%K%C%HI&7?$G6&M-9k+!"0[Jk%_%C%7%g%s$N%f%K%C %HI&7G6&M-9k$+$G0[JCF/$k!#7+$7!"0lC6%3%M%/%7%g %s$,@.N)7?HO!"C1$K%a%b%j%"%/%;%9L?Na$rH/9T$9lPDL ?.G-k?$a!"%f!<%6$,%7%9%F%'$N0c$$$b$J$$!#

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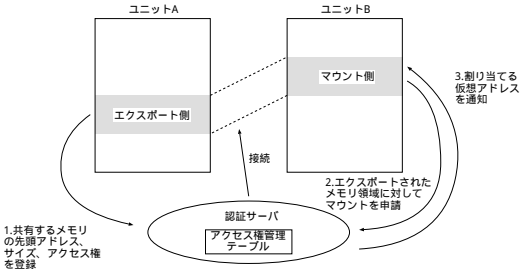
F10l%_%C%7%g%sFb%f%K%C%H4V$N%a%b%j6&M- F10l%_%C%7%g%sFb N9YF$N%f%K%C%H$O!"%_%C%7%g%sFb%G!<%?NN0h$r4^$'0lD j$N %a%b%jNN0h$rI,$:6&M-$9$k!#$3lr%_%C%7%g%sFb6&M-NN0h$H$$ $&!#$3$N%_%C%7%g%sFb6&M-NN0h$N3+;O%"%I%l%9$d5%$:$O!"%_%C %7%g%sFb%G!<%?$H7F%_%C%7%g%s@8@.;~$KDj5A$5lF$$k!#%f %K%C%H@8@.;~KO3liN%_%C%7%g%sFb%G!<%?$,;2>H$5$l!"%_%C %7%g%sFb6&M-NN0h$,<+FOE*$K3NJ]$5lk!#5i$K%f%K%C%H@8@. 8e$K%7%9%F%'%3!<%k$rH/9T$7$FF0E*$K%_%C%7%g%sFb6&M-NN0h$r DI2C$9k3HbG-$k!#$3lb%_%C%7%g%sFb$N%f%K%C%H$9YF $K6&M-$5lk%a%b%jNN0hG"$k!#

$^$?!"%_%C%7%g%sFb6&M-NN0hKOF1$8%"%I%l%9$,3djEvF il$k!#$D$^$j!"%_%C%7%g%sFb6&M-NN0hCfN"$kG!<%?,B8:_ 9k%"%I%l%9OI$N%f%K%C%H$+$i8+Fb6&DLG"$k!#hC$F!" 3N$G!<%?,B8:_



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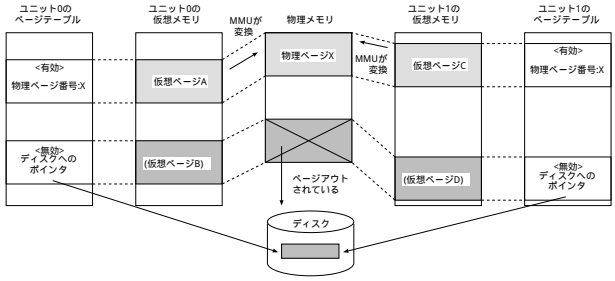

?^4: %Z!<%8%F!<%V%k

7?$$>19gJI$O!"$3$N%G!<%?$X$N%]%$%s%?rEO;Ph$$$3HKJk!#

0[%_%C%7%g%s4V$N%a%b%j6&M− 0[$J$k%_%C%7%g%s$KB0$9$k%f%K%C%HI&7,%a%b%j$r6&M−$9kK$O!"6&M−$7$?$$%a%b%jNN0h$r;}$D%f%K%C%H$,%(%/%9%]!<%H$7!"$=$N%a%b%jNN0h$r;HMQ$7$?$$%f%K%C%H$,%^%&%s%H$NA':n$r9T$&$H$$&%(%/%9%]!<%H/%^%&%s%HJ}<0$G6&M−$r<B8=9k!#

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$^$?!"%(%/%9%]!<%H5l$?%a%b%jNN0h$KBP7F!"ITEv$J%f!<%6$,%^%&%s%H7F%*%V%8%'%/%H$rGK2u$9kNrKI0$?$a!"%^%&%s%HA':n$K4X$7$F%"%/%;%98"@(8f$r9ToJ$/$FOJiJ$$!#3N%"%/%;%98"@(8f$O%7%9%F%'%5!<%P$N0lDG$"$kG'>Z%5!<%P$,9T$&!#Nc$($P!"%f%K%C%HA$,$b$D%a%b%jNN0h$r%f%K%C%HB$H6&M−$9kK$O!"<!$Nh&$J<j=g$rF'$'!#

1. %(%/%9%]!<%HB&$N%f%K%C%HA$,G'>Z%5!<%P$K6&M−$9$k%a%b%jNN0h$H%"%/%;%98"$rEPO?$9$k!#
2. %^%&%s%HB&$N%f%K%C%HB$,G'>Z%5!<%P$K@\B3$N5v2D$r?=@A$9$k!#
3. G'>Z%5!<%P$O%"%/%;%98"$rH=Dj7F!"%"%/%;%92DJi%f%K%C%HB$K@\B35v2D$H3djEvF$k%"%I%l%9$rM?$($k!#

3N7/$_$r?^3$K<($9!#3Nh&$K@\B3$,4ON;9l$P!"6&M−%a%b%j$KBP9k%"%/%;%9$O%a%b%j%"%/%;%9L?Na$@1Gh/!"G'>Z%5!<%P$b4XM?$7$J$$!#$^$?!"%(%/%9%]!<%HB&$H%^%&%s%HB&$H$$&4X78$bDL?.;~$K$O0U<1$7$J$$!#

%(%/%9%]!<%H$H%^%&%s%H$Khk%a%b%j$N6&M−$O!"<g$K0[$J$k%_%C%7%g%s$N%f%K%C%HI&7G9Tol$k!#$3lO!"%5!<%P7?%"%W%j1!<%7%g%s$H%/%i%$%"%s%H7?%"%W%j1!<%7%g%sHN%G!<%?8r49JI!"=>Mh$N%W%m%;%94VDL?.$KAjEv9k:n6H$r9T$&NKMQ$$$ilk!#7+$7!"$3$NU}<0$G6&M−9k%f%K%C%H$O0[$J$k%_%C%7%g%s$NCf$N%f%K%C%H$I$&$7$G6&M−$9k3Hd!"F1$8%f%K%C%H$NCf$G6&M−$9k3Hb5v5l$k!#$hCF!"JL$N%"%I%l%9$GF1$8%*%V%8%'%/%H$K%"%/%;%9$,$K3NU}<0$rMQ$$$k3H$,$G$−$k!#

3 6&M−%a%b%j4IM}

%f!<%6O9YF2>A[%"%I%l%9KhCF%a%b%j%"%/%;%9$r9T$&!#%a%b%j%"%/%;%9$,$"kH!"%W%m%;%C%5$KIUB0$9$kMMU$,%Z!<%8%F!<%V%k$r;2>H$7$F2>A[%"%I%l%9$rJ*M}%"%I%l%9$KJQ49$7!"$=$NJ*M}%"%I%l%9$G!"U*M}%a%b%j$KBP9k%"%/%;%9$,9T$olk!#

F10l%N!<%IFbN_$N%a%b%j6&M−$O!"F10l$NJ*M}%Z!<%8$rJ#?t$N2>A[%Z!<%8$K3djEvFk3HG<B8=5l$k!#$3lK$O!"=>Mh$N%Z!<%8%F!<%V%k$d5U0z$−%Z!<%8%F!<%V%kJI$N%G!<%?9=B$$,I,MWG"$k!#

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K\>OGO!"%N!<%IFb$*$h$S%N!<%I4V$G$N6&M−%a%b%j4IM}$N<BAuJ}K!KD$$F=RYk!#

3.1 %N!<%IFbGN%a%b%j6&M−

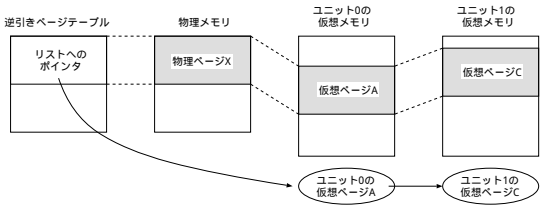
DL>o!"2>A[%a%b%j4IM}KO!"<!NFsD$N%F!<%V%k,I,MW$G$"$k!#

%Z!<%8%F!<%V%k2>A[%Z!<%8$+$iJ*M}%Z!<%8XNBP1~$r5−21

5U0z$−%Z!<%8%F!<%V%kJ*M}%Z!<%8$+$i2>A[%Z!<%8XNBP1~$r5−21

%Z!<%8%F!<%V%k$O%f%K%C%H$,8GM−$K;}$D2>A[%a%b%j6u4VKBP7$F!"$INh$&$KJ*M}%a%b%j6u4V$,3d$jEvFilF$$$k$+$r5−21$9$k!#%Z!<%8%F!<%V%k$OOL>oMMU$,2>A[%"%I%l%9$+$iJ*M}%"%I%l%9$NJQ49$r9k?aK;2>H9kNG!"$=$N9=B$$O%"!<%−%F%/%A%c$K0MB8$9$k!#?^4$K%Z!<%8%F!<%V%k$H!"$=l,<($92>A[%Z!<%8$HJ*M}%Z!<%8$NBP1~$NNc$r<($9!#3NNcGO!"0[Jk%_%C%7%g%s$KB0$9$k%f%K%C%H$,!"0[Jk2>A[%Z!<%8A,C$KF10l$NJ*M}%Z!<%8X$r3d$jEvFF$$$k!#3NH−$O!"%Z!<%8%F!<%V%k$OM−8z%U%i%0$HJ*M}%Z!<%8HV9f$,=q$+$l$F$$$k!#2>A[%Z!<%8B,D$K3d$jEvFilF$$$kFbMF$O%Z!<%8%"%&%H5$lF*j!"%Z!<%8%F!<%V%k$OM−8z%U%i%0$HJ*M}%a%b%j$K%Z!<%8%"%&%H5$lF*j!"%Z!<%8%F!<%V%kKOL58z%U%i%0$H%Z!<%8%"%&%H5$l$?FbMF$X$N%]%$%s%?,=q$+$l$F$$$k!#%Z!<%8sN:]$K!"$3$N%]%$%s%?KhCFJ*M}%a%b%j$KE>Aw$9kY$-FbMF$N0LCVrF'k!#%Z!<%8%"%&%H5$O!"$3NNcG$O%G%#%/%$KBP7F9TCF$$$k$,!"3.2.39'$G=RYkh&$KB>$N!<%I$NJ*M}%a%b%j$K%Z!<%8%"%&%H5$9$k3HbG$−$k!#

5U0z$−%Z!<%8%F!<%V%k$O!"J*M}%Z!<%8$,$I$N2>A[%Z!<%8$K;HMQ5l$F$$$k$+$r5−21$9$k!#0lHL$KJ*M}%Z!<%8$OJ#?t$N2>A[%a%b%j6u4V$K3djEvFilF*j!"5U0z$−%Z!<%8%F!<%V%k$OJ#?t$N2>A[%Z!<%8$r<(5JiJPJiJ$$$N$G!"<B:]$O%j%9%H9=B$$X$N%]%$%s%?$r5−21$7$F$$$k!#6&M−7F$$k%Z!<%8$r%Z!<%8%$%s!"$$k$$$O%Z!<%8%"%&%H7?:]$K!"%Z!<%8U%)%k%H$r5/$3$7$?%f%K%C%H0J30$N%Z!<%8%F!<%V%k$bJQ99$7J1lP!"%Z!<%8$NFbMF$N09g@−$,$HlJ$/$J$j!"8m$C$?FbMF$K%"%/%;%9$9$k2DG=@−$,$"$k!#%Z!<%8%$%s%KH<$&%Z!<%8%F!<%V%k$NM−8z2=!"$*$h



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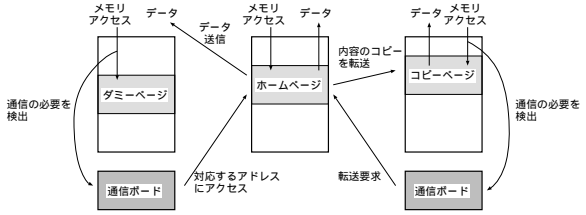


?^6: %[!<%`%Z!<%8!&@%_!<%Z!<%8!&3%T!<%Z!<%8

$S%Z!<%8%"%&%H$KH<$&%Z!<%8%F!<%V%k$NL58z2=$N:]$K$O!"$3$N 5U0z$-%Z!<%8%F!<%V%k$r;2>H$7F9YF$N2>A[%Z!<%8$NM-8z2=!" L58z2=$r9T$&!#?^4$KBP1~$9$k5U0z$-%Z!<%8%F!<%V%k$r!"?^5 $K<($9!#

3.2 %N!<%I4VGN%a%b%j6&M-

%N!<%I4V$NDL?.$r07$&DL?.%\!<%I$O!"?^1Nh$&$K%W%m%;%C%5 %P%9KDJ,CF$*$j!"%"%/%;%9$,9T$olkJ*M}%"%I%l%9$r8+ k3H,G-$k!#J*M}%"%I%l%9$,%N!<%IF%b%a%b%jKBP7$FM-8z G"lP%N!<%IF%b%a%b%j$K%"%/%;%9$9k,!"L58zG"lPDL?. %\!<%I$,B>%N!<%I$H$NDL?.=hM}$r9T$&!#DL?.%\!<%I$O!"U*M}%Z!< %8$NC10L$G%N!<%I4VGN6&M-$r<B8=$9$k!#J*M}%Z!<%8$K$O!"<! $N3<cN`$,$"$k!#3lir?^6$K<($9!#

%[!<%`%Z!<%8 J*M}%a%b%j$,<BAu$5$l$F$$$kJ*M}%"%I%l%9$K0L CV$7!"%a%b%j>e$K%G!<%?$N<BBN$,B8:_$9$k!#%N!<%I4V6&M- $N:]$K$O!"B>$N%N!<%I$,%M%C%H%o!<%/$rDL$7$F%[!<%`%Z!< %8$K%"%/%;%9$9$k!#%[!<%`%Z!<%8$,$"$k%N!<%I$r!¥[!<%` %N!<%I!W$H$$&!#

%@%_!<%Z!<%8 J*M}%a%b%j$,<BAu$5lF$$$J$J*M}%"%I%l%9$K 0LCV$7!"D>@\$N%"%/%;%9$O%G$-$J$$!#%@%_!<%Z!<%8KBP9 $k%"%/%;%9$,$"$k$H!"DL?.%\!<%I$,8!=P$7!"BP1~$9$k%[!< %`%Z!<%8$K%"%/%;%9$9$Y$/%N!<%I4VDL?.$r9T$&!#%@%_!<% Z!<%8$KBP9k%"%/%;%9$O!"I,MW$J%"%I%l%9$N_$KBP9k %j%b!<%H%"%/%;%9HJ$j!"%-%&%C%7%s%0$O9ToJ$$!#%3$N $?$aJ*M}%a%b%j$,05Gw$5lk3HOJ$$!#

%3%T!<%Z!<%8 J*M}%a%b%j$,<BAu$5lF$$$kJ*M}%"%I%l%9$K0L CV$7!"%[!<%`%Z!<%8$NFbMF$r%-%&%C%7%s%0$9$k!#L58z$G$" $k$H$-$K%"%/%;%9$9$k$H!"%@%_!<%Z!<%8$K%"%/%;%9$7$?H $-$HF1MM$K%j%b!<%H%"%/%;%9$r9T$$!"%[!<%`%Z!<%8$NFbMF $rE>Aw$9$k!#$3l,9Tol$F$$k%Z!<%8KD$$$F$O!"U*M} %a%b%j$KBP7FE,@Z$J%3%R!<%l%s%9@)8f$r9T$&!#

DL?.%\!<%I$O!"%W%m%;%C%5%P%9$KN.lkJ*M}%"%I%l%9$,%@ %_!<%Z!<%8$"$k$$$O%3%T!<%Z!<%8$r;X$7$F$$k3H$r8!=P$9$k $H!"%[!<%`%Z!<%8$KBP7F%j%b!<%H%"%/%;%9$r9T$&!#

3.2.1 %@%_!<%Z!<%8$H%[!<%`%Z!<%8

%@%_!<%Z!<%8KBP9$k%a%b%j%"%/%;%9$O!"%=%N!<%I$NDL?.%\!< %I$+$i%M%C%H%o!<%/$rDL7F%[!<%`%N!<%I$NDL?.%\!<%I$KEA$( $i$l!"%[!<%`%Z!<%8XN%"%/%;%9KCV-4$9($ilk!#

%[!<%`%N!<%I$K$*$l$k%[!<%`%Z!<%8$N;XDj$K$O!"2>A[%Z!< %8$rMQ$$$k!#3l$O!"U*M}%Z!<%8$G;XDj7F$b!"%[!<%`%N!<%I$K $*$$F%Z!<%8%"%&%H$,9T$olkH=$NOLCV$,FCDjG-J/Jk $?$aG"$k!#2>A[%Z!<%8$+$iJ*M}%Z!<%8$X$NUQ49$OdO$j%Z!< %8%F!<%V%k$rMQ$$$k$,!";2>H$9Y-%Z!<%8%F!<%V%k$rFCDj$9$k $?$a!"$=$N%Z!<%8%F!<%V%k$r;D$7!"3Nh&$K%W%m%;%C%5 %P%9$K%D%J$,$CF*$j!"$3Nh$&$K9$r;XDj$9$k!#

%M%C%H%o!<%/rDL7$?%a%b%j%"%/%;%9$N<j=g$O<!$NDLjG $"$k!#3Nh&$K9$r!"?^7$K<($9!#

1. %f!<%6$O%f%K%C%H$K3djEvFil$?2>A[%"%I%l%9$KBP7F %"%/%;%9$r9T$&!#
2. %W%m%;%C%5$NMMU $,%Z!<%8%F!<%V%k$r;2>H$7!"2>A[%" %I%l%9$rJ*M}%"%I%l%9$KJQ49$7$F%W%m%;%C%5%P%9$KN.$9!#
3. %W%m%;%C%5%P%9$KN.$l$?J*M}%"%I%l%9$,!"%[!<%`%Z!< %8$r;X$7$F$$$l$P%N!<%IF%b%a%b%j$KBP$7$F%"%/%;%9$,9T$o$l$k $,!"%@%_!<%Z!<%8$r;X$7$F$$$l$P!"%W%m%;%C%5%P%9$K$D$J $,$C$F$$$kDL?.%\!<%I$,$=$NJ*M}%"%I%l%9$r=&$$!"%[!<%` %N!<%IXNDL?.$r9T$&!#
4. DL?.%\!<%I$,Aw?.%F!<%V%k$r;2>H$7!"%@%_!<%Z!<%8$KBP1~ 9k%[!<%`%N!<%I$NOLCV!"@\B3@h$N%f%K%C%H!"$=$N%f%K%C %H$,;}$D2>A[%a%b%j6u4V$K$*$1$k2>A[%Z!<%8HV9f$rF@$F!" %[!<%`%N!<%I$K%"%/%;%9$rMW5a$r=P$9!#
5. %[!<%`%N!<%I$NDL?.%\!<%I$,MW5a$r<u?.$7!";XDj$5$l$? %f%K%C%H$N%Z!<%8%F!<%V%k$r;2>H$7$F%[!<%`%Z!<%8$NJ* M}%Z!<%8HV9f$rF@$k!#%3$NH-!"%Z!<%8U%)%k%H$,5/$3$l $PDL>o$HF1$8$h$&$K%Z!<%8s%0$d%F!<%V%k$NUQ99$,9T$o lk!#
6. %[!<%`%Z!<%8$KBP$9$k%"%/%;%9$,9T$o$l$k!#FI$_9~$_MW 5a$G$"$l$P!"%[!<%`%Z!<%8$NFbMF$rFI$_!"DL?.%\!<%I$,%@ %_!<%Z!<%8$B&$X:F$S%M%C%H%o!<%/$rDL7F%G!<%?$rE>Aw 9k!#

%@%_!<%Z!<%8$+$i%[!<%`%Z!<%8$r;2>H$9$k:]$K$O!"%"%/%; %9$7$?%"%I%l%9$K4X$7$F$N$_%[!<%`%N!<%I$G%"%/%;%9$r9T$$!" <+%N!<%I$NJ*M}%a%b%j>e$K%[!<%`%Z!<%8$NFbMF$r%-%&%C%7%s%0

7J$$!#3N$?$a!"<+%N!<%IFb%a%b%j$r@aLs$9k3H,G-!"=q$-9~$_@lMQ$N%Z!<%8$JIKET9g$,NI$$!#7+$7!"J*M}%a%b%j>e$K%-%d%C%7%s%0O7$J$$,!"%W%m%;%C%5B&$N%-%d%C%7%e%a%b%j$K%-%d%C%7%s%0$r9T$C$F$$k$?$a!"%[!<%'Z!<%8B&$KJQ9$,$"$C$?>l9g$JIK!"%-%d%C%7%e$N%3%R!<%l%s%9@)8f$,I,MWKJ$k!#

DL>o!"%N!<%IFb$N%W%m%;%C%54V$G$N%3%R!<%l%s%9@)8f$O%O!<%I%&%'%"$,9T$&!#7+$7!"%N!<%I4V$N%3%R!<%l%s%9@)8f$O Colonia $,9T$oMPJi$J$$!#0lDN2r7h:vH7$F!"%G%#%l%/%H%jJ}<0$,9M$($ilk!#3l$O!"%N!<%I4V$N6&M->uBV$r5-21$9$k%G%#%l%/%H%j$rJ];}9k3H$G%3%R!<%l%s%9@)8f$r9T$&$bNG$"$k!#

3.2.2 %3%T!<%Z!<%8$H%[!<%'Z!<%8

%@%_!<%Z!<%8Kh$k%j%b!<%H%"%/%;%9$O!"I,MW$J%G!<%?$N$_$N%"%/%;%9G"$j!">/NI$N%G!<%?DL?.G"lP%M%C%H%o!<%/$NIiC4$O7Z$$!#7+$7!"F1$8%[!<%'Z!<%8KBP7$FIQHK$K%"%/%;%9$,$"$k>l9g$K$O!"%M%C%H%o!<%/$rDL7?%j%b!<%H%"%/%;%9$NlI|$HJj!"%*!<%P%X%C%I$,Bg$-$$!#$=$3$G!"%@%_!<%Z!<%8$HOJLK%3%T!<%Z!<%8$rMQ0U$9$k!#%3%T!<%Z!<%8$KBP7F%"%/%;%9$9$k:]$K!"%[!<%'Z!<%8$NFbMF$r<-+%N!<%IFb$N%a%b%j$K%-%d%C%7%s%0$7F*$/$3HG!"IQHK$J%j%b!<%H%"%/%;%9$r%m!<%+%k%"%/%;%9KCV-49$($k3H$,$G$-$k!#$?$@$7!"%[!<%'Z!<%8$K@\B3$9$k$^$G$N<j-g$O3.2.19'$G=R$Y$?%@%_!<%Z!<%8$N>l9g$HF1MM$G$"$k!#

%3%T!<%Z!<%8$K%[!<%'Z!<%8$NFbMF$r%-%d%C%7%s%0$9k3HG!"%3%T!<%Z!<%8$N%3%R!<%l%s%9@)8f$,I,MWKJ$k!#$3lK$O!"%@%_!<%Z!<%8$r07$&:]$KI,MWHJ$k!"%W%m%;%C%5$4HN%-%d%C%7%e$N%3%R!<%l%s%9@)8f$K2C$($F!"%N!<%IFb%a%b%j$NL582z=$JI$r<B9T$7J1lPJi$J$$!#

3.2.3 %Z!<%8%s%0$N3HD%

Colonia GO!"%M%C%H%o!<%/rDL7$?DL?.$N$?$a$K!"%[!<%'Z!<%8!"%@%_!<%Z!<%8!"%3%T!<%Z!<%8$H$$$&&I$N07$$J}$rMQ0U$7$F$$k$,!"$3lK1~8F%Z!<%8%s%0$N07$$J}$b0[$JCF$/$k!#$=$l$>$l$KBP1~$9$k%Z!<%8%s%0$NJ}K!$r<!$K=RYk!#

%[!<%'Z!<%8 %Z!<%8%"&&H$N:]$K$O!"%G%#%9%/$@1GJ/%M%C%H%o!<%/rDL7$FB>%N!<%I$NJ*M}%a%b%jKBP7Fb9T$&$3H,G-$k!#$3$NJ}K!$Khj!"%G%#%9%/$r;}$?$J$$%N!<%IGb%Z!<%8%"&&H$r9T$&3H$,$G$-$k!#I/O $r2p$7$?%G%#%9%/$X$N=q$-=P7hjb!"9bB.%M%C%H%o!<%/$r2p$7$?B>%N!<%I$NJ*M}%a%b%jXN=q$-=P$7$NJ}$,9bB.G"$k!#^$?!"BP1~9k%@%_!<%Z!<%8$d%3%T!<%Z!<%8$r;}DJ$I!"$=$N%Z!<%8$rMxMQ9k$f%K%C%H$,F0:n7F$$k%N!<%I$XE>Awe$9k3HG!"E>Awe@hGN%f%K%C%H$NF0:n$,9bB.2=9k3H$,4|BI$G$-$k!#B>%N!<%IK"$k%Z!<%8$r%Z!<%8%s%9$k:]$K$O!"FC$KI,MW$,$J1l$PE>Aw$O$;$:!"%@%_!<%Z!<%8$"$k$$$O%3%T!<%Z!<%8H7$F07$&!#

%@%_!<%Z!<%8 %Z!<%8%s%s!"%Z!<%8%"&&HHb!"07$&Z!<%8>e$K<B:]$NFbMF$OB8:_7J$$$N$G!"%a%b%jE>Aw$OI,MWJ/!#%Z!<%8%"&&H$N:]$K$O!"%[!<%'Z!<%8$rFCDj9k3H$,$G$-$k$h&$K!"Aw?.%F!<%V%k$NFbMF$KAjEv9kbN$r%Z!<%8%F!<%V%k$KJ]B8$7$F$*$/!#

%3%T!<%Z!<%8 %@%_!<%Z!<%8$HF1$8$/!"%[!<%'Z!<%8$K<B:]$NFbMF$,B8:_9k$?$a!"%G%#%9%/XN%Z!<%8%"&&HOI,MWJ$/!"%[!<%'Z!<%8$rFCDj9k$?$a$N>pJs$N$_J]B8$9lP$h$$!#$?$@$7!"%[!<%'N!<%I$K$*$$F%[!<%'Z!<%8$,$G%#%9%/$K%Z!<%8%"&&H$5lF$$kH-KO!"%3%T!<%Z!<%8$r%[!<%'Z!<%8$KJQ9$7$F<+%N!<%I$N%G%#%9%/$K%Z!<%8%"&%H9k3H$b9M$(il$k!#

4 %(%_%e&l!<%?$N9=@.

2f!9$,%3%s%T%e!<%?!&3%m%K!<$r3+H/9k>eGI,MWJNO=%U%H%&%'%"G"$k%k%l!<%F%#%s%0%7%9%F%'Colonia $H!"%O!<%I%&%'%"$G$"$kDL?.%\!<%IG"$k!#DL?.%\!<%I$N2L$?$9Y$-Lr3d$O!"$*$*$^$+KO9bB.$J%N!<%I4VDL?.$G$"$k$,!"$>\:Y$J%s%s?%U%'!<%9;EMM$O9b%l%Y%k$N%N!<%I4VDL?.$N;EMM$K9g$o$;$J$J1$lPJiJ$$!#

hG$F!"Colonia $r%"!<%-%F%/%A%dHs0MB8ItJ,$H%"!<%-%F%/%A%d0MB8ItJ,$KJ,$1!"$^$:%"!<%-%F%/%A%dHs0MB8ItJ,$+$i3+H/$7Dc%l%Y%kItJ,$KBP9kMW5ar^Ha$?$N$A!"$=$NMW5a$rK~$?$9h&$K%"!<%-%F%/%A%d0MB8ItJ,$HDL?.%\!<%I$r3+H/$9kH$$$&J}?K$r:NMQ$9$k!#

Colonia $N%"!<%-%F%/%A%dHs0MB8ItJ,$,F0:n$9kK$O!"%O!<%I%&%'%"$G$"$k%H%"!<%-%F%/%A%d0MB8ItJ,$,I,MW$G$"$k$,!"8=CJ3,$GO=NIAi$b40@.$7$F$$J$$?$a!"$=lKBeokbN$,I,MW$HJk!#K\&5fGO!"G=*E*$KSun Microsystems <R$N%o!<%/%9%F!<%7%g$sSPARC station 20 N_$G%o!<%/%9%F!<%7%g$s%i%9%?$r9=@.$7!"$=$N>e$G%*%Z%l!<%F%#%s%0%7%9%F%'Colonia $rF0:n$5$;$k!#$=$N$?$a$N3+H/4D6-$H7F$O!"SPARC station 20 $N>e$GF0:n9kSolaris $rMQ$$$k!#8=:_!"Solaris >e$GF0:n$9$k%(%_%e&l!<%?$HColonia $N%"!<%-%F%/%A%dHs0MB8ItJ,$r9g$o$;$F3+H/7F$$k!#

%(%_%e&l!<%?$rMxMQ$9k3HKhC$F!"%_%C7%g$s!&f%K%C%H$NF0:n$d@@@.!"%&M-%a%b%j4IM}JI!"%^%$%/%+!<%M%k$MW$J5!G=$rSolaris >e$G<B8=$G$-$k!#3Nh&K7$F3+H/$7$?%"!<%-%F%/%A%dHs0MB8ItJ,$O!"$[Hs$I=$N$^^40@.IJ$KAH$_9~$s$G;HMQ$G$-$k!#

K\>OGO!"%(%_%e&l!<%?$rMQ$$$?Colonia $N3+H/J}?K$H%(%_%e&l!<%?$NF0:n86M}$K$D$$F=RYk!#

4.1 Colonia $N3+H/J}?K

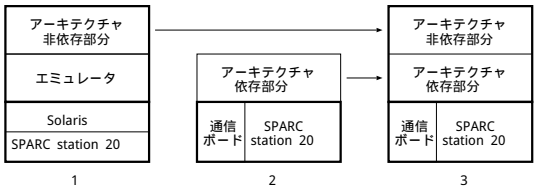
K\&5fGO!"Colonia $N%"!<%-%F%/%A%dHs0MB8ItJ,$H%O!<%I%&%'%"$G$"$N%(%_%e&l!<%?$rMQ$$$k3HKhCF!"<!Nh$&$J<j-g$GColonia $r3+H/$9$k!#$3Nh$&$9r?^8$K<($9!#

1. %(%_%e&l!<%?$rSolaris >e$GF0:n5;!"$=$N>e$G%"!<%-%F%/%A%dHs0MB8ItJ,$r3+H/$9$k!#
2. SPARC station 20 >e$GD>@\F0:n$9$k%"!<%-%F%/%A%d0MB8ItJ,$r3+H/9k!#F1;~$KDL?.%\!<%I$N3+H/$b?J$a$k!#
3. %(%_%e&l!<%?ItJ,rO$:$7!"%"!<%-%F%/%A%dHs0MB8ItJ,$H%"!<%-%F%/%A%d0MB8ItJ,$r7k9g5;$k!#

3. K*$$FG-k@$1JQ9$;$:$K7k9gG-kh&$K!"1. $G%"!<%-%F%/%A%dHs0MB8ItJ,$H%(%_%e&l!<%?$N6hJL$rL@3N$K7!"2. $G%"!<%-%F%/%A%dHs0MB8ItJ,KBP9$k%"!<%-%F%/%A%d0MB8ItJ,$N%$%s%?%U%'!<%9$,(%_%e&l!<%?$HF1$8;EMMKJkh&$K3+H/$9kI,MW,$"$k!#

Colonia K*$$F!"%"!<%-%F%/%A%dHs0MB8ItJ,$H%"!<%-%F%/%A%d0MB8ItJ,$,2L$?$9Y$-Lr3d$O!"$=$l$>$l<!Nh&KJ$k!#

%"!<%-%F%/%A%dHs0MB8ItJ, %9%1%8%e!<%j%s%O!"<B9T2DG=%-%e!<A':n!"%Z!<%8%s%0$N;X<(!"6&M-%a%b%j4IM}$K4X9k%F!<%V



?^8: Colonia $N3+H/J}?K

%kA`:n!"%_%C%7%g%s!&f%K%C%H$K4X$9$k%G!<%?9=B$$N4IM}!"%(%/%9%]!<%H/%^%&%s%HJ}<0Kh$k6&M-4X78$N4IM}!"%7%9%F%"%3!<%k$N<uM}$J$I

%"!<%-%F%/%A%c0MB8ItJ,%?%$%^3d$j9~$_$N4IM}!"%N!<%I4VDL?.!"2>A[%a%b%j6u4V$HJ*M}%a%b%j6u4V$N%^%C%T%s%0!"%G%#%9%Q%C%A!"I/O $ND>@\A`:n!"%G%#%9%/$X$N%Z!<%8%"%&%H!"%G%#%9%/$+iN%Z!<%8%$%s!"%f%K%C%H$N0\Aw$J$I

%(%_%e%l!<%?$O%"!<%-%F%/%A%c0MB8ItJ,$,2L$?$9Y-Lr3d$rSolaris$GMQ0U5l$F$$$k%i%$%V%i%jEy$rMQ$$F?k9T9k!#LdBjHJkN$O!"%f%K%C%H$N%G%#%9%Q%C%A$H!"2>A[%a%b%j6u4V$HJ*M}%a%b%j6u4V$N%^%C%T%s%0$G$"$k!#

Colonia K*$$F$O!"%f%K%C%H$,$=$l$>$lFHN)7?2>A[%a%b%j6u4V$r;}$A!"3djEvFil$?;~4V$@$1%W%m%;%C%5$rMxMQ9k3H$,$G$-$k!#MxMQ4|4V$,=*N;$9kH!"%W%m%;%C%5OJLN%f%K%C%H$K<B9T$r0\$9$,!"$3NH$-2>A[%a%b%j6u4V$r@ZjBX(!"J]B8$7$F$$$?%3%s%F%/%9%H$rI|5"$7J1lPJi$J$$!#3l$rD>@\9T$&KO%"%;%s%V%jKh$kFC8"L?Na$,I,MWKJk?$a!"4{B8$N%*%Z%l!<%F%#%s%0%7%9%F%'>e$G%f!<%6$,<B9T9k3HOG$-$J$$!#

3l$rSolaris>e$G<B8=9k$?$a!"%f%K%C%H4H$K%W%m%;%9$rBP1~E1$k!#%W%m%;%9$OFHN)7?2>A[%a%b%j6u4V$H%3%s%F%/%9%H$r;}D?$a!"$3lr@ZjBX(lP%f%K%C%H$N@Z$jBX$($r%(%_%e%l!<%HG-$k!#F1;~$KF0:n9k%f%K%C%H$O01$DG"k,!"3l$O!"01$D$N%W%m%;%9$N$_$rF0:n5;!"B>$N%W%m%;%9$OCd;_5;k3HG<B8=9k!#

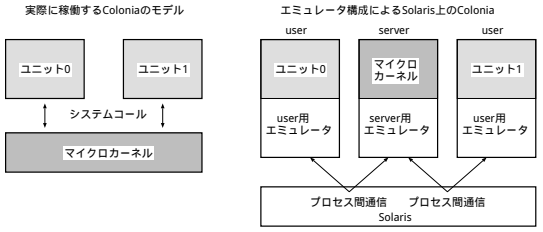
01DN%W%m%;%9NCfGJB9TF0:n5;$k%^%k%A%9%l%C%I$bSolaris>e$GMxMQ2DG=$G$"$k$,!"$3lO$"$/^Gb%W%m%;%9$O01$DG"$j!"%9%l%C%I$=l>l,FHN)7?2>A[%a%b%j6u4V$O;}$?$J$$$?a!"%9%l%C%I$G%f%K%C%H$r%(%_%e%l!<%H9k3HOG$-$J$$!#

>e$K=R$Y$?!"%f%K%C%H$4HKJL%W%m%;%9$r@8@.$9kH$$$&J}K!$G3%s%F%/%9%H%9%$%C%A$r%(%_%e%l!<%H$9kH$-!"%^%$%/%m%+!<%M%k$r2TF/$5$;$kJ}<0KO!"<!$N2<cN`$,9M$($l$k!#

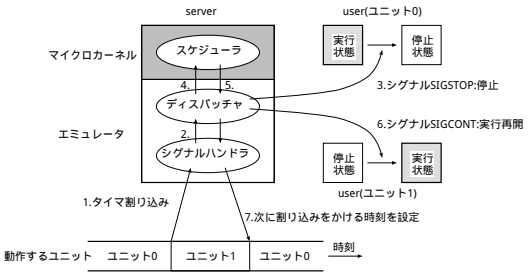
- 3F%W%m%;%9$4$H$KF1$8%3!<%I$N%^%$%/%m%+!<%M%k$r4X?t$H7FIU2C7F2TF/5;$kJ}<0!#%^%$%/%m%+!<%M%k$,07$&JQ?t$O6&M-%a%b%j$rMQ$$F9YFN%W%m%;%9K*$$F0lCW5;$k!#%f%K%C%H$+$i%^%$%/%m%+!<%M%kXNMW5a$,!"C1$J$k4X?t8F$S=P7G9Tolk?$a!"%7%9%F%'%3!<%k$N<B8=$,MF0W$G$"$k!#

- %^%$%/%m%+!<%M%k$NF/$-$r9k%5!<%P%W%m%;%9rJLK5/$3$9J}<0!#%^%$%/%m%+!<%M%k$N<BBN$C01$DG"k?$a!"UQ?t$N6&M-$r9M$(kI,MWO$J$$!#%f%K%C%H$+$i%^%$%/%m%+!<%M%k$X$NMW5a$K$O!"%W%m%;%94VDL?.$r9ToJ$/$FOJiJ$$!#

%W%m%;%9$4$H$K%^%$%/%m%+!<%M%k$,IUB0$9$kJ}<0$G$O!"DL>o%f%K%C%H$H%^%$%/%m%+!<%M%k$N4V$N%W%m%;%94VDL?.$OITMWG"$k!#$3lr:n!"%_%C7%g%s!&f%K%C%H$K4X$9$k%G!<%?9=B$$N4IM}!"%(%/%9%]!<%H/%^%&%s%HJ}<0Kh$k6&M-4X78$N4IM}!"%7%9%F%'



?^ 9: <B:]$N Colonia $H% (%_%e&l!<%?$rMQ$$$? Solaris >e$N Colonia



?^ 10: %(%_%e&l!<%?>eGN%G%#%9%Q%C%A

4.3 3F5!G=$N%(%_%e&l!<%H

4.3.1 %9%1%8%e!<%j%s%0$H%G%#%9%Q%C%A

<B:]$N Colonia K*$$F!"0lDN%W%m;%C%5$O!"F1;~$K$C0l$D$N%f%K%C%H$N=hM}7+G-$J$$!#D^$j!"0l$D$N%f%K%C%H$,F0:n7F$$$k4V$O!"B>$N%f%K%C%H$O;_$^CF$$$k!#$=$N%f%K%C%H$KM?$(il$?;~4V$@$1%W%m;%C%5$,=hM}$r9T$&$H!"%W%m;%C%5$OJL$N%f%K%C%H$K%G%#%9%Q%C%A5l$k!#

Solaris >eGbF1MM$K!"0l$D$N%f%K%C%H$@$1<B9T>uBV$H$7!"B>$N%f%K%C%H$CDd;_>uBV$H9k3HG3lr%(%_%e&l!<%H9k!#D^$j!"server $N%(%_%e&l!<%?$,user $K%7%0%J%k$rH/9T9k3H$G!"%f%K%C%H$N<B9T$"$k$$$CDd;_$N>uBV$r4IM}9k!#<j=gH7FO!"<!Nh$&$JCJ3,$r7P$k!#3N7/$_$r!"?^10$K<($9!#

1. %?$%^3d$j9~$_$,$+$+kH!"%7%0%J%kSIGALRM $,H/9T$5$l!"%7%0%J%k%O%s%I%i$K=hM}$,0\$k!#
2. %7%0%J%k%O%s%I%i$O%(%_%e&l!<%?$NCf$N%G%#%9%Q%C%A%c$K@)8f$r0\$9!#
3. %G%#%9%Q%C%A%c$O8=:_F0:n$7$F$$$kuser KBP7$F%7%0%J%kSIGSTOP $rH/9T$7$FDd;_$5$;$k!#
4. %G%#%9%Q%C%A%c$O%9%1%8%e!<%i$N;X<($K=>$$!"L\E*$Nuser $K%7%0%J%kSIGCONT $rH/9T$7$FF0:n$r:F3+5;$k!#
5. %7%0%J%k%O%s%I%i$O!"<!$K%G%#%9%Q%C%A$r9T$&;~9o$K3d$j9~$_$,$+$+kh$&$K!"%?%$%^$r@_Dj9k!#

4.3.2 %7%9%F%'%3!<%k

Colonia K*$$F!"%7%9%F%'KBP9$kMW5a;v9'$O%7%9%F%'%3!<%kH7$F%^%$/%m+!<%M%kKAwk!#%^%$/%m+!<%M%k$O$=$lKBP9$k=hM}$r9T$$!"7k2LrJVjCMH7$F%f%K%C%H$KJV$9!#

Solaris >eGO!"user MQ%(%_%e&l!<%?$,%f%K%C%H$KBP7F%7%9%F%'%3!<%k$N%s%s%?%U%'!<%9$rDs6!9k!#3l$O4X?t8F$S=P7H7F07ol!"%f%K%C%HFb%G!<%?$N<hF@$J$I!"user MQ%(%_%e%l!<%?$G07$($kItJ,$Ouser MQ%(%_%e&l!<%?$,=hM}$r9T$&!#

%f%K%C%H$N@8@.$J$I!"server $K=hM}$r0MMj9kI,MW$,=P$F$-$?>l9gKO!"server $H%W%m;%94VDL?.$r9T$&!#user MQ%(%_%e%l!<%?$Oserver KBP7$F%a%C;!<%8$rAw$j!"server $,$=lKBP1~7?=hM}$r9T$&!#user MQ%(%_%e&l!<%?$Oserver $+$iJV;v$r<u$1<h$j!"UV;v$K1~8?=hM}$r9T$GF+$i%f%K%C%H$K=hM}rLa9!#

4.3.3 2>A[%a%b%j4IM}

Colonia K*1k2>A[%a%b%j4IM}$O!"%f!<%6$,;XDj7?2>A[%"%I%l%9r!"MMU $,%Z!<%8%F!<%V%k$r;2>H9k3HKhCFJ*M}%"%I%l%9$KJQ4$9$7!"J*M}%a%b%j$K%"%/%;%9$9$k$H$$$&<j=g$G9T$olk!#user $N%(%_%e&l!<%?$O!"J*M}%a%b%j$r%U!%$%k$GBeMQ$7!"%U!%$%k$r2>A[%"%I%l%9$K^%C%W$9$k4X?tmmap $rMxMQ$7$F<+F0%"%/;%9$r%(%_%e&l!<%H9k!#

2>A[%Z!<%8$,L$;HMQ$N>uBV$G%"%/;%9kH!"$3$3KO^$@%U!%$%k$,3d$jEvFilF$$$J$$N$G5-21J]8n0cH?$HJj!"%W%m;%9user KO%7%0%J%kSIGSEGV $,H/9T$5lk!#3N%70%J%k$r=hM}$9$k%7%0%J%k%O%s%I%i$r@_D;j7F$*$-!"%7%0%J%k%O%s%I%i$+$i2>A[%a%b%j4IM}$k!<%A%s$r8F$S=P$;$P!"%Z!<%8%U)%k%H$KH<$&2>A[%a%b%j4IM}$,%(%_%e&l!<%HG-$k!#

%Z!<%8%F!<%V%kEyO9Y$Fserver $,4IM}$9k?$a!"%7%0%J%k%O%s%I%i$G$Oserver $N2>A[%a%b%j4IM}$k!<%A%s$r8F$S=P$9Y$/%a%C;!<%8DL?.$r9T$&!#server O3lK1~8F%Z!<%8%$%s!"%Z!<%8"%&%H!"%F!<%V%k$NUQ99Ey$r9T$&!#$3$N<j=g$r?^11$K<($9!#

$?$@$7!"user $N2>A[%a%b%j6u4V$H%U!%$%k$N^%C%T%s%0$Oserver $,JQ99$9k3HG$-$J$$$?a!"server $O%Z!<%8F!<%V%k$rJQ99$7$?>user $=$l$>$lKBP7$F^%C%T%s%0JQ99$N;X<($r%a%C;!<%8$GAw?.9k!#

%Z!<%8%F!<%V%k$NL58z2=$O!"^%C%T%s%0$r2r=|$9$k4X?tmunmap KhGF%(%_%e&l!<%H9k!#3l$r<B9T$7$F^%C%T%s%0$r2r=|7?2>A[%a%b%jNN0h$K%"%/;%9$9kH!"L\;HMQ;~$HF1$8$/5-21J]8n0cH?$HJj!"%Z!<%8%U)%k%H$N%(%_%e&l!<%H$,G-$k!#

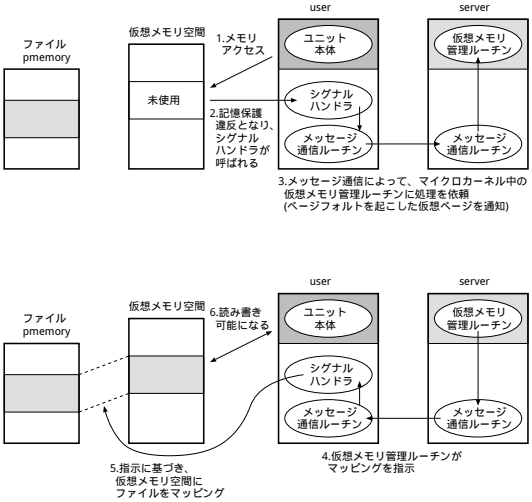
4.3.4 %N!<%I4VDL?.

J*M}%Z!<%8$O%(%_%e&l!<%?$G$O%U!%$%k,BeMQH7$F07$olk$,!"$=lKBP7F%[!<%'%Z!<%8!"%@%_!<%Z!<%8!"%3%T!<%Z!<%8$,$=l>lI$N%h$&$K07$olk$+$r<!$K<($9!#

%[!<%'%Z!<%8 %U!%$%k,B8:_$9$kNN0h$KG[CV5l$k!#%^%C%T%s%0$,@.N)9l$P!"2>A[%"%I%l%9$K%"%/;%9$9$k3H$GD>@\FI$_=q$-$,2DG=$G"$k!#

%@%_!<%Z!<%8 %U!%$%k,B8:_$7$J$$NN0h$KG[CV$5lk!#%^%C%T%s%0$,@.N)$7Fb!"%"%/;%9;~KO%"%/;%9$9$kY-%G%#%9%/>e$NNN0h$,B8:_7J$$?$a%7%0%J%kSIGBUS $,H/9T$5lk!#user $N%(%_%e&l!<%?$O3l$r8!=P$7!"%N!<%I4VDL?.$N%k!<%A%s$KJ,4t9k!#

%3%T!<%Z!<%8 %3%T!<$,M-8z$G$"$kH-$O%[!<%'%Z!<%8$HF1$8$/%U!%$%k,B8:_$9$kNN0h$K"L58zG"kH$-$O%@%_!<%Z!<%8$HF1$8$/%U!%$%k,B8:_7J$$NN0h$KG[CV$5lk!#L58zG"kH$-$O%k!<%A%s$C



?^11: 2>A[%a%b%j4IM}

$F%[!<%'%Z!<%8$NFbMF$r<hF@$7$F%3%T!<%Z!<%8$rM-8z2=9k!#

%@%_!<%Z!<%8!"%3%T!<%Z!<%8K*1k%N!<%I4VDL?.$NI,MW@-$O!"user $N%(%_%e&l!<%?$,%7%0%J%kSIGBUS $r<u?.$9k3HKhC$F8!CN$9k,,!"%N!<%I4VDL?.KI,MWJAw?.%F!<%V%k$Oserver $,07$&$?$a!"user $+$iserver $K%a%C%;!<%8DL?.$r9TCF!"server $,<B:]$N%N!<%I4VDL?.$r9T$&!#$3$1$O!"%N!<%IFb$N%a%C%;!<%8DL?.$HF1$8$/!"%=%1%C%H$Khk%a%C%;!<%8DL?.$rMxMQ$7$F%(%_%e&l!<%H$9$k!#

Colonia K*$$F%N!<%I4V$G%Z!<%8$r6&M-9k>19gKO!"%3%R!<%1%s%9@)8f$,I,MW$G$"$k!#%[!<%'%Z!<%8$NFbMF$d!"$=$1$r5-21$7$F$$k%-%&C%7%e$,JQ99$5$1$?>19g$O!"%Z!<%8$NL58z2=$,I,MW$G$"$k!#

%(%_%e&l!<%?GO!"6&M-%Z!<%8$NUQ99$N;~N_3%R!<%1%s%9@)8f$r9T$&$?$a!"%U%!%$%k$r2>A[%a%b%jNN0h$K%^%C%T%s%0$9kH$-$K!"$=$N2>A[%a%b%jNN0h$NB0@-$rFI$_9~$_;~KO2?$b5/$3i:KFI_9~$_$,G-k,!"!=q$-9~$_;~KO5-21J]8n0cH?$,5/$3$k!#$3$1$KBP9k%7%0J%k%O%s%I%i$G!"%3%R!<%1%s%9@)8f$N%k!<%A%s$KJ,4t$7!"I,MW$J=hM}$r9T$&!#

5 $*$ojK

K\9FGO!"JBNs%"%W%j%1!<%7%g%s$N<B9T$r;X8~7?%7%9%F%'G"$k%3%s%T%e!<%?!&3%m%K!<$rDs0F$7!"$=$N4D6-$GF0:n9k%*%Z%l!<%F%#%s%0%7%9%F%'Colonia $N@_7W$K$D$$F=RY?!#

%o!<%/%9%F!<%7%g%sJINJ,LnK$*$1$k@-G=$N8~>e$*$h$SDc2A3J2=$OCx$7$$bN,$"j!"Hs>o$KB??t$N7W;;5!$,MxMQ2DG=$J>uBV$KJC$F$$k!#Am9g9l$PG|Bg$J=hM}G=NOHJk3liN7W;;5!;q8;$r:GBg8B$K3hMQ$7!"9bB.$+$D=@Fp$K;E;v$r=hM}$G$-$kh&$J4D6-$rDs6!9k$H$$&0UL#$G!"K\8&5f$OHs>o$K0U5A?<$$bNH9M$($k!#

JBNs%"%W%j%1!<%7%g%s$N<B9T$H$$&L\I8$rC#@.$9k?aKIT2D7gG"kDL?.2=NbB.2=N?aK!"2f!9$O6&M-%a%b%j$r<B8=9k$?$a$N%G!<%?9=B$$d=hM}<j=g$r@_7W$7!"$=$l$r4{B8$N3+H/4D6-$N>e$GF0:n5;kY$/!"Dc%l%Y%kItJ,$r%(%_%e&l!<%?KhCFBe9T5;$F3+H/$r?JaF$$k!#

Colonia $N6&M-%a%b%j4IM}$K$*$$F:#8e$N2]Bj$H7F;D5l$F$$kbN$N0l$D$O!"%M%C%H%o!<%/$rDL7?DK*1k!"6&M-%a%b%jNN0h$N%3%R!<%1%s%9@)8f$G$"$k!#%W%m%;%C%5$=$l$>$l$,;}$D%-%&C%7%e%a%b%j!"$*$h$S%N!<%IFb$NJ*M}%a%b%j$K%-%&C%7%s%0$5lF$$k6&M-%a%b%jNN0h$NF|MF$N014S@-$rJ]$DKO!"%O!<%I%&%'%"$N%Z!<%8$rNBgJ$-$J2]BjG"$k!#

$^$?!"8zN(hIi2YJ,;6$r9T$&$?$a$N%9%1%8e!<%i$N@_7W$b!"%3%s%T%e!<%?!&3%m%K!<$N=hM}B.EY$*$h$S=@Fp@-$KBg$-$/4XoCF/$k!#%9%1%8e!<%i$O!"%N!<%I$N%W%m%;%C%5?t$d=hM}@-G=!"Ii2Y$N>u67!"%f!<%6$,MW5a9kQoS!"%N!<%I4V$N5wN%$JI$+$i!"Am9gE*$K%f%K%C%H$NG[CV$rH=CG$9$k!#$^$?!"%N!<%I4V$NIi2YKJPj$,@8$8kH!"%f%K%C%H$N0\Aw$r;X<(9k!#3N%9%1%8e!<%i$N@_7W$K4X$7F$O!"MM!9$J3QEY$+$i9M;!!"@-G=I>2A$r9ToJ$/$FCJiJ$$!#

K\8&5f$O!"%*%Z%l!<%F%#%s%0%7%9%F%'$N@_7W!"3+H/$K4X7FC^$@;C$^C?P+jG$"$k!#3l$^$GRY$?;v9'0J30$K$b!"MM!9$J2]Bj$,;D5$l$F$$k!#8=:_$"$^$j;HMQ$5lF$$J$7W;;5!$rM-8z3hMQ$7!":GBg8B$N=hM}G=NO$rH/4x$5;k?aK!"3liN2]BjKBP7$F:GA1$NEz$r=P$5J1lPJi$J$$!#

<U<-

K\8&5f$N5!2q$rM?$($F2<5C$?!"K\8&5f<<$NIYEDbC<#65<x$K?<S$J$k<U0U$rI=7^$9!#

K\8&5fK*$$F?t!9N4;XF3$rD:$$$?!"CfEg9@=u65<x!"?9bC0lO:=u65<x!"8^Eg@5M5=u<j7W;;5!9=@.J,Ln$N=t;a$K?<$/46<U$N0U$rI=$7$^$9!#

:G8e$K!"MM!9$J3QEY$+$i$4=uNCD:$$$?!"K\8&5f$N6&F18&5f<T$G$"$k@DLZ=(5.;arO8a!"7W;;5!9)3X9V:B7W;;5!9=@.J,Ln$N=t;a$K46<UCW7^$9!#

;29MJ88%

[1] SPARC International, INC. (Aj1[9n5W,EDCfD98wLu/B?ED9%9n4FLu): SPARC %"!<%-%F%/%A%c!&^%K%e"%k%P!<%8%g%s8, %H%C%Q%s(1992).

[2] A. S. %?%M%s%P%&'(0zCO?.9T,0zCOH~7C;RLu): OS $N4pAC$H1~MQ— @_7W$+$i<BAu,DOS $+$iJ,;6OS Amoeba $^$G,%H%C%Q%s(1995).

[3] J. %Y!<%3%s(F#ED><J?,<DEDM[01,:#@t5.;KLu): JB9TJ,;6%7%9%F%'— %*%Z%l!<%F%#%s%0%7%9%F%',$G!<%?%Y!<%9,J,;6%^%k%A%a%G%#%"%7%9%F%'XNE}9gE*%"%W%m!<%A,%H%C%Q%s(1996).

[4] A0@n<i,=j?2M}M:,@6?e8,B@O/:J,;6%*%Z%l!<%F%#%s%0%7%9%F%'— UNIX $N<!$K$/$b$N,6&N)=PHG(1991).

[5] Gk869(,DEED9'IW,Bg5WJ]1Q;L:8=Be%*%Z%l!<%F%#%s%0%7%9%F%'$N4pAC,%*!<%'<R(1988).

[6] @DLZ=(5.,;3E:Gn;K,8^Eg@5M5,?9bC0lO:,CfEg9@,IYEDbC<#:6&M-%a%b%j%Y!<%9%N%7!<%'%l%9$JJNs7W;;5!4D6-$r<B8=9k%*%Z%l!<%F%#%s%0%7%9%F%'$N9=A[,>p=h8&Js,97-OS-34(1997).