UDP $r;H$C$?J,;67W;;4D6-$H$=$N1~MQ

UDP based Distributed Computation Environment and its Application

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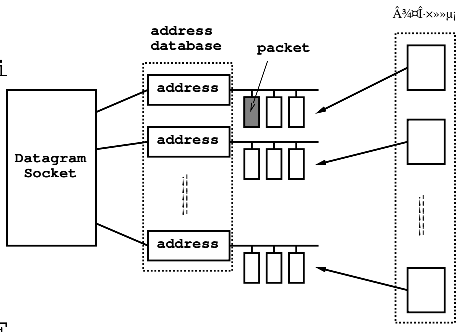
UDP based distributed computation environment is presented. Conventional implemention of distributed system uses TCP stream connection. But it requires many connections and kernel resources for perfect connection. Using UDP connection, only one connection is necessary. Since UDP connections are unreliable, we provide reliable maintenance library for distributed computation. It is also possible to control UDP transimission at User level. An example of Temporal Logic Verification is experimented.

1 J,;67W;;4D6-

Unix>eGNHf3SE*AB$J7k9g>e$G9T$&J,;67W;;$O $b50Bf0J>e$N7W;;5!$r;H$&3H$,MF0W$KJCF- $F$$$k!#=>Mh$NPVM$dMPIJIGO!"TCP Kh $k@\B3$r;HMQ7F$$$kNG!"0lDN%W%m%;%9$GB??t $N%=%1%C%H$r;H$&$3HKJk!#$3$3GO!"0lDN%= %1%C%HGG0U$N7W;;5!$K@\B3G-kh$&$KUDP $r MQ$$$?J,;67W;;4D6-$r:n@.$7F_$?!#$3$N%i%$%V%i %j$N1~MQ$H7F;~AjO@M}$N8!>Z7O$r<BAu7?!#

2 UDP DL?.%i%$%V%i%j

0B2AJPCd!"%9%#%C%A%s%0!&%M%C%H%o!<%/$,MF0W $K<j$K$O$$$k8=:_!"Unix>e$NJ,;67W;;4D6-$O8=<B E*$GJXMx$JbNKJCF$$$k!#Hf3SE*NI$/;H$olF $$$kNOPVM$dMPI$JIG$"$k!#7+$7!"Unix >e$G$N<BAu$N>l9g!"3liN%i%$%V%i%j$O?.Mj@-$N $"$k2s@~7?@\B3G"$kTCP $r;HMQ$7$F$$$k!#2s@~ 7?@\B3$O1BP1$G$"$k$,!"J,;67W;;$GI,MWJN$ON BPN$G$"$j!"40A47k9g$r<B8=$9k?aK$ON K\$N @\B3$r;HMQ$9$k!#N $,10 0J2<$J$IHf3SE*>.$5$$>l 9g$ONI$$$,!"60 0J>eKJkH%W%m%;%9$,3+$1$k%U%! %$%k$N>e8B$K0zC+$+$C$?$j!"%+!<%M%k$KMW5a$9$k q8$,NNL,A}$($?$j9kLdBj$,=PFMhk!#



?^1 **UDP**%i%$%V%i%j$N9=@.

bHbH!"TCP/IPGO!"2<0L%l%Y%kGOIP$H

8FPl$k%3%M%/%7%g%s%l%9$N3,AX$,$"$j!"$=lG UDP %=%1%C%HH7$F;HMQ$9k3H,G-$k!#$7$?!"UDP $O TCP $H0[$J$j?.Mj@-$,$J$$$N$G!"Aw?.=g=x$d:FAwJI$N@)8f$r%f!<%6%l%Y%k$G<BAu$9kI,MW,$"$k!#

J,;64D6-GO N BP N $N40A47k9g$r<B8=9k$?$a$K%3%M%/%7%g%s%l%9$G<BAu9kN,<+A3G"$k!#$7$?!"J,;67W;;$G$O!"C`<!7?$N%W%m%0%i%`$H0[Jj?.KOhj$-$a:Y$+$J@)8f$,I,MW$HJk!#7?$,$C$F!"Aw<u?.%P%C%U%!$r4^aF%f!<%6%l%Y%k$G4IM}$9k3H,$$$:lI,MWG$"$k!#$=$3$G!"$3li$N5!G=$r<B8=7?J,;67W;;4D6-MQ$N%i%$%V%i%j$r:n@.$7$?!#$3li$N%i%$%V%i%j$O!"C$^$?$O Prolog $+$i;HMQ9k3H$,$G$-$k!#

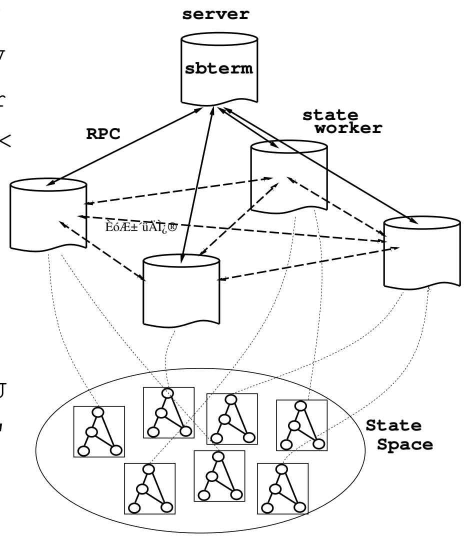
UDP KO?.Mj@-$,$J$$$,!"K\%i%$%V%i%j$G$O?.Mj@-$rDs6!9k!#TCP Stream $N%3%M%/%7%g%s$NBeoj$K!"UDP Stream Kh$K%"%I%l%9%G!<%?%Y!<%9$r;}$D!#3N%G!<%?%Y!<%9$N:n@.$O%f!<%6$,9T$&!#%"%I%l%9%G!<%?%Y!<%9$O!"$=l>$l%V%m%C%-%s%0!&%G%V%m%C%-%s%0$r9T$&%-%e!<9=B$$r;}$D!#$7$?$,CF%V%m%C%/NBg-5O!"%M%C%H%o!<%/$N MTU(Maximum Transfer Unit) $K 1F6A$5lJ$$!#SICStus Prolog/Quintus Prolog $N fast read/write library $H6&$K;H$&$3HKhj8zN($NNI$$DL?.$r9T$&3H$,$G$-$k!#(?^1)

UDP XN%"%/%;%9$O!"Stream $r7PM3$7F*3J$&$h$&$KJCF*$j!"%a%C%;!<%8Aw?.$Nh&$JFCJL$J9=J8$r;H$&I,MWOJ$$!#Prolog $N>l9g$O!"Stream $rMQ$$$? API $r;HMQ$7$F$$$k (I=2)!#

Stream GO$"$k$,!"<B:]$NDL?.$O UDP JN$G!"%V%m%C%/C10LGNDL?.$HJk!#%V%m%C%/$NE~Ce=g=x$OJ]>Z5l$J$$!#Stream $N flush Kh$K01DN%V%m%C%/$r9=@.$9$k!#DL>o$H0[JkNO!"%a%C%;!<%8NAwj@h$r;XDj$9$k9=J8$,$"$k3HG"$k!#$3N&$J9=B$$K9k3HKh$j!"%U%)!<%^%C%HJ8$@1N%W%m%0%i%`8@8l$=$NbN$d!"$=$N%i%$%V%i%jKJ$$$9$kK-IY$JI=<(5!G=$r!"$=N^$^DL?.$KMQ$$$k3H$,$G$-$k!#

3 J,;6=hM}$N<+F08!>Z

3N%i%$%V%i%j$N1~MQ$N0l$DH7$F6h4V;~AjO@M} (ITL) [1] KBP9$k%?%V%m!<K!$rJ,;67W;;2=7F$_$?[2]!#%?%V%m!<K!$N7W;;$O!"=i4|>uBV<0$+$i<!$N;~19$N>uBV<0$N=89g$r@8@.9k3H$KAjEv$9$k!#?7$7$$>uBV<0$,@8@.$5lJ$/$JC?;~E@$G7W;;$O=*N;9k!#>uBV<0$O!"Hs7hDj@-$r@8$8$J$$$h$&$K@8@.5l$k (Deterministic Tableau)!#$^$?!">uBV<0$O!";~AjO@M}1i;;;R$r%N!<%IK7$?FsJ,7hDjLZ (Binary Subterm Diagram) $GI=$5lk!#$jDLZ$rJBNs$K<B9T$9k?aK!">uBV<0$NE83+$KhC$F@8@.$5l?>uBV<0$N=89g$rJ,3d$7!"$=$NE83+$r%G!<%?JBNsE*$K9T$&!#J,3d$O!">uBV<0$rI=$9 Binary Subterm Diagram $K%O%C%7%e4X?t$rDj5A9k3H$G9T$&!#$?$@$7!"ItJ,9`$O6&M-$5$l$F$$$k$b$N$H$9$k!#ItJ,9`$r6&M-7J$$$H!"Binary Subterm Diagram $N7A$N010U@-$rJ]>Z$9k3HOG-$J$$!#ItJ,9`$N6&M-$O!"ItJ,9`%5!<%PKh$j unique ID $r3d$jEvFk3HKh$j9T$&!#(?^3)



?^3 J,;6<+F08!>Z7O$N9=@.

ItJ,9`%5!<%P$H$NDL?.$O!"%H%i%s%6%/%7%g%s$r9=@.$9$k$N$G!"7W;;$N=*N;$N$?$a$NDL?.$r4^$a$F!"F14|@-$N RPC (Remote Procedure Call) $rMQ$$$k!#%"%I%l%9%G!<%?%Y!<%9$NDL?.$O!"%9%k!<%W%C%H=E;k$J$N$G!"HsF14|7?$N%9%H%j!<%`DL?.KhCF9Tol$k!#

>uBV6u4V$NDL?.$O!"%P%C%U%!$rMQ$$$F!"E83+$N9g4V$KHsF14|$K9T$olk!#3lKBP7ItJ,9`%5!<%PXO!"UDP %i%$%V%i%j$r;HCF:n@.5l$? Remote Procedure Call $r;HMQ$7!"F14|E*$K%"%/%;%9$9$k!#

module ;XDj	`?-use_module(library(datagram)).`
Stream Open	`?-datagram(+IP_host:IP_port,-Stream).`
Address EPO?	`?-datagram_address_registration (+Stream,+IP_host:IP_port,-Id).`
Aw?.@hA*Br	`?-datagram_destination(+Stream,+Id).`
%Q%1%C%H$N%A%'%C%	`/?-datagram_ready(+Stream,+Timeout,Ready).`

?^**2 UDP** %i%$%V%i%j

4 <B837k2L

$3$3GO!"5?M$NE/3X<T$N?);vLdBjKD$$$F3Bf$N%W%m%C%5$KhjJ,;68!>Z$r9T$C$?!#Hf3S$N$?$a$K!"1Bf$N%W%m%C%5$G9T$JC?>l9g$N%G!<%?$b<($9!#(?^4)

$3$3$G;HMQ$7$?%W%m%;%C%5$O!"MMX Pentinum 200MHz, 64MB memory $G!"SICStus Prolog 3 #6 $r;HMQ$7$?!#SICStus Prolog $O!"Pentinum GO native compiler $,$J$$$N$G!"$3lO!"WAM code interpreter Kh$k<B9T$G$"$k!#>uBV6u4V$N%G!<%?%Y!<%9$O!"Prolog $N assert Kh$j<B8=$5lF$$$k!#

$3$3$G!"CPU time $O!"DL?.$N%"%$%I%k;~4V$r4^sG$$$J$$!#8D!9$N?tCM$O!"8D!9$N%W%m%;%C%5Fblt$G$N?t$rI=7F$$$k!#States $O@8@.$5l??7$7$$>uBVG"$j!"$=$N%W%m%;%C%5$KBP1~9k%O%C%7%eCM$r;}$DbN$@$1J/!"B>$N%O%C%7%eCM$r;}DbNG$b!"$=$N%W%m%;%C%5$G@8@.5l$?$bNO9Y$F4^$^lF$$$k!#State transitions $O!">uBVA+0\$N?tG"$j!"C%?%V%m!<E83+$N2s?t$KAjEv$9$k!#export/import $O!">uBV$r30KAwj=P7??t/>uBV$r<u$1F~l??tG"$k!#

single %W%m%;%C%5$N>l9g$O!"$3.28 = 7496.414/(725.896+843.71+713.055)$ Nh$&$KJBNs$N>l9g$N9g7W$N3G\0J>e$N;~4V$,$+$+$C$F$$$k!#7+$7!"$3lO!"DL?.;~4V$r4^$s$G$$$J$$$N$G!"<B:]$N;~4V:9O3lhjb$+$J$j>.$5$$!#3l$O!"%G!<%?%Y!<%9$,>.5/Jk3HKh$j!"8D!9$N%W%m%C%5GN>uBV$NC5:w;~4V$,C;$/$Jk3$H!"$"$k$$$O!"%a%b%j6u4V$,>.$5$/$Jk3HKhk swap $N8:>/!"%-%c%C%7%e$N8z2L$NA}Bg!"GC $N8:>/$JIN<BAu>e$NM}M3$Khk%9!<%Q!<%j%K%"$N8z2L$,GF$$$k3H$,$"$k!#JBNs8!>Z%"%k%4%j%:%`<+BNKO%9!<%Q!<%j%K%"8z2LOJ$$!#7+$7!"0lBf$"$?$j$N%a%b%j$,$"$k!#

$,8:$k3HKh$k8z2L$OBg$-$$$H9M$($ilk!#<B:]$N:FAwIQEY$O!"E>Aw?tN&$A1/10 DxEY$G$"$C$?!#$7$+$7!">uBV%9%H%j!<%`GO!"BgNL$N%Q%1%C%H$rAw$j=P$7F7$^$C$F$$$kNG:FAw?t$OB?$/JC$F$$$k!#3NLdBj$O!"UDP %i%$%V%i%j%l%Y%k$GD4@0$G$-$kO:G"$k!#$3$N<B83$G$O!"%9%#%A%s%0%O%V$HA4Fs=E Ethernet $rMQ$$$F$$$F$$$kNGM}O@E*KO%9%#%C%A%s%0%O%VFbIt$NmUmT0J30$G$O:FAw$O5/$-$J$$$O$:$G$"$k!#<B:]!"%Q%1%C%H$N>WFM$JIO8!=P5l$F$$$J$$!#7+$7!"%9%#%C%A%s%0%O%VFbIt$d Unix kernel FbIt$G%G!<%?$,Mn5l$k>l9g$,$"$k$H;W$olk!#RPC $OItJ,9`$NF14|E*$JDL?.$K;H$o$l$F$$$F!"1~Ez@-=E;k$G%W%m0%i%`$5lF$$$k!#7+$7!"state DL?.$NJ}$O%9%k!<%W%C%H=E;k$G$"$j!"JkY/0lEYK?$/$5sAwkh&KJCF$$$k!#=>CF%Q%1%C%HNFI_Mn7,5/$-$d$9$$!#(?^4)

CPU	type	send count	resend count
1	state	2666	6148
2	state	1430	5509
3	state	2512	7312
1	RPC	228	0
2	RPC	146	0
3	RPC	236	0

?^**5** Am%Q%1%C%H?t$H:FAw?.?t

5 Hf3S$H9M;!

JBNs8!>Z%7%9%F%`H7FO!"CMU $G8&5f$5lF$$$k BDD (Binary Decision Diagram) $r6&M-%a%b%j%^%7%s$G=hM}$7%b%G%k8!>Z$r9T$&$bN,CNil$F$$$k!#%b%G%k8!>ZGO7W;;$O5pBg$J BDD $r@8@.

CPU	time (sec)	States	Subterm	trans	export	import
1	725.896	945	71	6479	493	596
2	843.71	937	71	8306	382	335
3	713.055	907	71	6324	547	491
single	7496.414	1365	60	21075	-	-

?^4 5 dining philosophers using UDP Library

9k!#7+$b!"$=li$OK\<AE*$K6&M-5lkI,MW,
$"$k!#7?$,$C$F!"BDD $r;HMQ$7$?%b%G%k8!>Z$O
$O!"6&M-%a%b%j%7%9%F%`0J30KO<BAuG-$J$$$N
$,IaDL$G$"$k!#$^$? ICOT GO!"LTTL $N8!>Z7O
$r GHC KhCFJBNs<B9T9kbN$,:n@.$5lF
$$$k!#3liO$$$:lb!"6&M-%a%b%j>e$G=hM}$9
kbNG$"$j!"Bg5,LO$J>uBV6u4V$N=hM}GO8B3&$
$"$k!#

7+$7!"$3$3$G;HMQ7?ITL $N8!>Z7O$O!"Hf3S
E*>.$5$$BDD $r3F7W;;5!>e$KCV$/$3HG>uBV6u4V
$rJ,;6$5$;$k3H$r2DG=$K7F$$$k!#$^$?!"ItJ,9`
%5!<%PKh$jJ,;6$5l?%G!<%?9=B$>e$G$b BDD $N
7A$N0l0U@-$rJ]>Z7F$$$k!#$?$@$7!"%b%G%k8!>Z
$H0[$J$j!"L@<(E*$J>uBV$N?t$(>e2r9kNG!"A4
BNH7FN7W;;$N<j4V$OA}$($k!#3N%7%9%F%`$r
PVM $G<BAu$9kH N+1 BfKBP7$F!"$=l>$l 2N
$N%=%1%C%H$,I,MWHJ$k!#UDP %i%$%V%i%jGO1
BfKIU-0lDGNI$$!#

C`<! Prolog $KDL?.$rAH$_9g$o$;$kJ}K!$O$$$/
D+CNil$F$$$k!#=i4|$N Delta Prolog b=$&$G
$"$k!#K\%7%9%F%`$N Remote Procedure Call $O!"
Delta Prolog $HF1Ey$G$"$k!#SICStus Prolog $,
:NMQ7F$$$k Linda $O!"TCP Stream $r;H$C$F
<B8=5l$F$$$k!#$^$?!"PVM $H Prolog HNAH
$_9g$o$;$bB8:_7F$$$k!#PVM GO!"DL?.$O!"
TCP Stream G"$j!"8D!9$N%W%m%;%C%5$N4V$KF0
E*$K TCP Stream @\B3$H@ZCG$r9T$&!#

UDP $r;H$&J}K!$O!"0J2<$NE@$G!"$3li$NJ}<0
KHfY$FM-Mx$G$"$k!#

- TCP Stream $r;H$&>l9gKHfY$F9bB.$G$"$k
- DL?.$N%M%C%/$HJk%5!<%PrI,MWH7J$$
- DL?.O)$NF0E*$J@\B3$H@ZCG$rI,MWH7$J$$
- 8D!9$NDL?.$O!"Prolog $N Stream G"$j!"FC<l
$J=R8l$rI,MWH7$J$$

UDP %i%$%V%i%j$O!" ?.Mj@-$r<B8=$9kI,MW,
$"$kNH!"Blocking/De-blocking $rMW5a$9kN$G!"
<B:]$NDL?.$O!"DL?.@hKh$KC`<!2=$5lk!#=>CF!"
<B:]$NDL?.$N<j4V$O!"TCP $G@\B3$9kNHJQo$i
$J$$!#3N%i%$%V%i%j$G$b!"MQ$$$F$$$kNO sliding
window %"%k%4%j%:%`G"$j!"8D!9$NDL?.$N<j4V$O
JQoi$J$$!#0c$$$O%f!<%6%l%Y%k$GJ#?t$N Stream
$r@)8f$9k3HG$"$k!#

6 $^$H$a

K\O@J8GO!"UDP $r;HMQ$7$?JBNsJ,;64D6-$N<B
Au$H<B837k2L$K$D$$$F=RY?!#UDP XN%"%/%;%9
$r Stream $rMQ$$$F$*$3J&3HKh$j!"J,;6%W%m
%0%i%`$rFCJL$J9=J8L5$7$G:n@.9k3H$,$G$-$k!#
$^$?!"UDP $N%3%M%/%7%g%s%l%9$N@-<AKh$j!"40
A47k9g$rA[Dj$7$?J,;6%W%m%0%i%`$N:n@.$,MF0W$K$J
$k!#$7$+$7!"UDP $N%i%$%V%i%j$O!"TCP $rMQ$$$k
bNKHfY$FJ#;($G$"$j!"?.Mj@-$N9b$$%i%$%V%i%j
$r:n$j>e2k3HOFq7$$!#$^$?!"FCD'$N0l$DG"
$kFbIt%P%C%U%!$X$N%"%/%;%9$N$?$a$N API $O!"$^
$@IT==J,$G$"$kNG!"3liND4@a$r9T$&3HKh
$j!"$h$j8zN($NNI$$%i%$%V%i%j$rDs6!G-kH9M$(
$F$$$k!#

;29MJ88%

[1] Masahiro Fujita and Shinji Kono. Synthesis of Contrllers from Interval Temporal Loigc Specification. In *International Conference on Computer Design*, October 1993.

[2] 2OLn ??<# and CSB< @5G7>uBV=89g$NJ,3d$Khk;~Aj O@M}8!>Z$NJBNs2=. In EE5$3X2q!&EE;R>pJsDL?.3X2q9gF19V 1i2q Dec 1998.