DO NOT DISTRIBUTE

%^%k%A%/%i%$%"%s%H$Khk%M%C%H%o!<%/?tCM>pJs%7%9%F%` *Ninf* $N@-G=

35MW

%M%C%H%o!<%/?tCM>pJs%7%9%F%` **Ninf** $O!$9-0h%M%C%H%o!<%/$KJ,;6$7$?7W;;q8;$d>pJs;q8;$rMxMQ$7$?D6J,;6JBNs=hM}$N4pHW$rDs6!$9$k%=%U%H%&%'%"%7%9%F%`G"$j!$9bB.!&9b@-G=!&9bIJ<A$J2J3X5;=Q7W;;$r;Y1g9k3H$rL\E*$K@_7W5l$?!%K\9F$G$O Ninf %7%9%F%`$NA4BN9=@.$K$D$$$F=R$Y$k$H$H$b$K!$ Linpack benchmark $rMQ$$$F!$%7%s%0%k / %^%k%A%/%i%$%"%s%HN>4D6-$G$N%3%"%7%9%F%`$N@-G=I>2A$r<B;\$7$?!%$3$N7k2L!$8=<BE*$J9-0hJ,;6MxMQ>r7o$G$N Ninf %7%9%F%`$N<BMQ@-!$7xO4@-$r3NG'$7$?!%$^$?!$4{B8$N%Y%/%H%k%Q%i%l%k%^%7%s$r;O$a$H$9$k%^%k%A%W%m%;%C%5%7%9%F%`$, Ninf KhCF%M%C%H%o!<%/7W;;q8;H7$FM-8z$K3hMQ5lk3Hr<(7?!%

Abstract

To establish a basis for globally-distributed parallel computing in numerial computing, we are currently working on the Ninf (**N**etwork based **Inf**ormation library for High Performance Computing) software system. Basically, the Ninf is based on the server-client model. Thus, servers, distributed in the Internetwork, handle information resources either its numerical libraries or scientific constants databases, and clients are programmed by users or generated by semi-automated tools with the Ninf client API which establishes RPC connections to servers. To evaluate the Ninf system, we perform Linpack Benchmark with the Ninf RPC on Cray J90 vector-parallel supercomputer and DEC Alpha cluster of workstations, and Sun workstations. Results show that the utility and robustness of the network computing with the Ninf, and multicomputers such as vector-parallel computers and MPPs can effectively support network information services via the Ninf.

1 O8aK

2J3X5;=Q7W;;NJ,LnK$*$$$F$O!$$h$jJ#;($J;v>]$N2r L@$N$?$a!$9b@:EY$+$D9b?.Mj@-$N$"$k7W;;rh$j9bB.$K 9b@-G=!&9bIJ<A$K<B9T$9k3$H!$$9Jo$A%o%$%Q%U%)!< %^%s%9%3%s%T%e!<%F%#%s%0 (HPC) $,6/$/5aailF$$ $F$$$k!%$^$?6aG/$N%3%s%T%e!<%?%M%C%H%o!<%/5;=Q$NH/ E8$KH<$$!$ E-mail, FTP, World Wide Web Ey$G<B8= 5l$k%G!<%?;q8;$N6&M-$,2DG=HJC?!%$3Nh$&$J %M%C%H%o!<%/Kh$k>pJs;q8;XN%"%/%;%9$O!$J*M}E*!$ O@M}E*!$;~4VE*$KF)L@G"k3H,=EMW$JMWAG$G$"$k!% 0lJ}!$9bB.%M%C%H%o!<%/5;=Q$NH/E8$rA0Ds$H9l$P!$ CPU $d%9%H%l!<%8$H$$$C$?7W;;q8;$r@Q6KE*$K6&M-$9 k3HG!$B?$/$NBg5,LO7W;;$,2DG=HJ$k!%$3$N<B8=$K $O!$9-0h%M%C%H%o!<%/>e$KE83+$5l?D69-0hJ,;6$KBP1~ 7?7W;;5;=Q$N@.=O$rMW9k!%3&7?D6J,;6JBNs7W;; 5;=Q$r Global Computing $d World Wide Computing $H8F$V!%

2f!9$O%M%C%H%o!<%/?tCM>pJs%7%9%F%`[1] Ninf (**N**etwork based **Inf**omation Library for Global World-Wide Computing Infrastructure) $r2J3X5;=Q7W;;J,Ln$K$*$1$k5!G=$9$k$3$H$r<B>Z$9$k$K$O<B:]$N1?MQ$N7k2L$rBT$?$M Global Computing $r<B8=$9$k4pHW%7%9%F%`H7FD 0F7F$$$k [5, 7, 8]!% Ninf $O9-0h%M%C%H%o!<%/>e$KJ, ;6$5$l$?7W;;q8;$d>pJs;q8;XN%"%/%;%9$rMF0W$K$H 8=$7!$ HPC $r;Y1g$9k3HrL\I8H7$F@_7W$5l?%7 Ninf $O%/%i%$%"%s%H-%5!<%PbG%k$K4p$E$$$F$*$j!$ %M%C%H%o!<%/>e$K@_Dj$5l?J#?t$N%5!<%P$KBP$7!$%5 CO$N%f!<%6$O4{B8$N8@8l$H4J0W$J API $r;H$C$F Ninf$N 5!G=$r8F$S=P9@1G%5!<%S%9$r5}<u$G$-$k!% Ninf$7

Ds6!9k%5!<%S%9$O9b@-G=!&9b@:EY!&9bB.$J?tCM%i%$%V %i%j$r<B9T7F7k2LrJV9%j%b!<%H7W;;%i%$%V%i%j!$J* M}&2=3X!&?t3XEy$N3FJ,Ln$N?tCMDj?t$N8!:w!$E}7W?tCM %G!<%?$dJ88%$X$N URL Link Ey$N%G!<%?%Y!<%9EyG" $k!%

9-0h%M%C%H%o!<%/J,;6JBNs=hM}$NA0Ds$HJkNO!$ DL?.@-G= %P%s%II}$O:#8e$b7rD4$J?-$S$r8+9~$ak,!$ %l%$%F%s%7$NBgI}$JC;=L$OK>a:!$$^$??.Mj@-$K 7g1k$?$a>iD9$JDL?.<jB3$-$,I,MW!% 7W;;@-G= %9!<%Q!<%3%s%T%e!<%?$d MPP Nh$&$K%/%i 0lJ}!$9bB.%M%C%H%o!<%/5;=Q$NH/E8$rA0Ds$H9l$P!$ %$%"%s%H$HHf3S9k$H>o$K05E]E*$K9bB.!% $$$&3HG"$j!$Nc$($P%o!<%/%9%F!<%7%g%s%/%i%9%? $r6K$G!$ PVM, MPI Ey$N%a%C%;!<%8%Q%C%7%s%0%i%$%V BP1~KhCF!VHf3SE*!W:YN3EY$G<B8=$5lk LAN Fb$G 7W;;6JBNs=hM}$H$O0l@~$r2h9k!%3Nh&$JA0Ds$KB(7F!$ Ninf %7%9%F%`$OABN3EY$N%j%b!<%H7W;;%i%$%V%i %j$d$=$liH6(D4$7$FMxMQ9k$KB-$kIU2C2ACM$r;}$D>p Js;q8;$rDs6!$9kHHb$K?.Mj@-$rJ]>Z9kOHAHH7$F %a?%5!<%P [10] $rMQ0U$9$k!%$7$+$7!$$3li$,M-8z$K PJiJ$$!%

Ninf $N%5!<%P$O UNIX %7%9%F%`>e$GF0:n$7F*$j!$ %/%i%$%"%s%H$+iN%"%/%;%9$,=8Cf$7FbB??t$N%W %m%;%9$N%O%s%I%j%s%0$rGKC>$J$/?k9T$9kI,MW,$" $k%0lJ}!$ Ninf $,%5!<%P$NBP>]H7$F$$$k%9!<%Q!<%3 %s%T%e!<%?$d MPP JI$ND69b@-G=7W;;5!$N OS $O!$ UNIX %o!<%/%9%F!<%7%g%s$^$?$O UNIX %5!<%P$HHf3S $F!$B??t$N%W%m%;%9$rF1;~$K<B9T$9k3Hr9MN8$5$l $F$$$J$$!%3liN7W;;5!$N OS $H Ninf $NAH9g$;$G==

[1] http://phase.etl.go.jp/ninf/

J,$J7xO4@-$r0];}9k%7%9%F%`$,MW5a$5lk!%

$^$?!$D69b@-G=7W;;5!!$FC$K%Y%/%H%k%Q%i%l%k7W;;5!!$ MPP Ey$NJBNs7W;;5!$G Ninf %5!<%P%7%9%F%`$r1?MQ$9$k:]!$=g<!E~Ce9k7W;;MW5a$N=hM}J}K!$H7F!$2 DNA*Br$,$"$jF@$k!%[2]

%?%9%/%Q%i%l%k 7W;;;q8;$r6u4VJ}8~$KJ,3d$7!$$=l>lN%?%9%/$K3d$jEvFFJBNs$K=hM}!%

%Y%/%H%k%Q%i%l%k!&D6JBNs 9YFN;q8;$r0l$D$N%?%9%/$K3djEvF$FD>Ns$K=hM}!%

3NA*Br$OB?$/$N>l9g!$Ds6!9k%i%$%V%i%j$N@_7W$K4X$o$kLdBj$G$"$k!%D^$j!$%M%C%H%o!<%/%5!<%S%9$K FC2=$5l?7W;;%k!<%A%s$rMQ0U$9kI,MW,$"$k$+!$$"$k$$$OC1$K%^%7%s$N%T!<%/@-G=$r<B8=$9kh$&$K:GE,2=5l$?7W;;%k!<%A%s$GM-8z$K1?MQ$G$-$k$+$,LdBjHJ$k!%

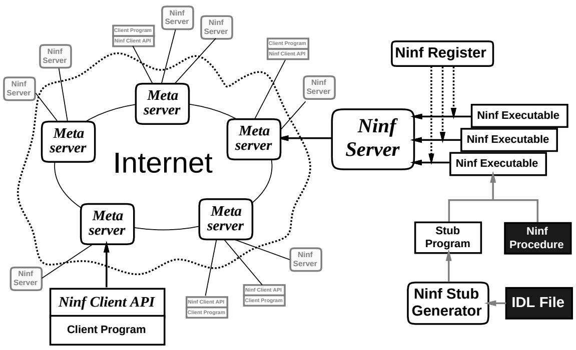
K\9FGO!$ Ninf %7%9%F%`$N35MW$K$D$$$F=R$Y$k$H$H$b$K!$$3$l$i$N=tLdBj$KBP$9$k2rEz$rF@$k$3$H$rL\E*$H$7$F Linpack Benchmark $rMQ$$$F Ninf %5!<%P$N@-G=I>2A<B83$r9T$C$?!%K\%7%9%F%`$rMQ$$$?J}$,%m!<%+%k<B9T$h$j9bB.2=$5lk3HKh$j!$ Ninf Kh$k9-0h%M%C%H%o!<%/J,;6JBNs=hM}$NM-8z@-$r<B>Z7?!%$^$?!$%5!<%P%^%7%s$H7F%Y%/%H%k%Q%i%l%k7W;;5! Cray J90 4PE $d Sun SMP %o!<%/%9%F!<%7%g%s$rMQ$$!$J#?t$N%/%i%$%"%s%H$,JB9T$K%"%/%;%9$9$k4D6-$G$N<B837k2L$+$i!$JBNs7W;;5!MQ OS $H Ninf %7%9%F%`$NAH9g$;$G7xO4$J%M%C%H%o!<%/%5!<%S%9$,Ds6!G-k3Hr3NG'7?!%5i$K!$%Y%/%H%k%Q%i%l%k7W;;5!!$ MPP GO%T!<%/@-G=$r<B8=$9kh$&$K:GE,2=5l$?%i%$%V%i%j$G Ninf %5!<%S%9$rDs6!9k3H$G==J,8zN(NI$/1?MQG-kH$NH=CG$K;jC?!%

2 Ninf %7%9%F%`$N35MW

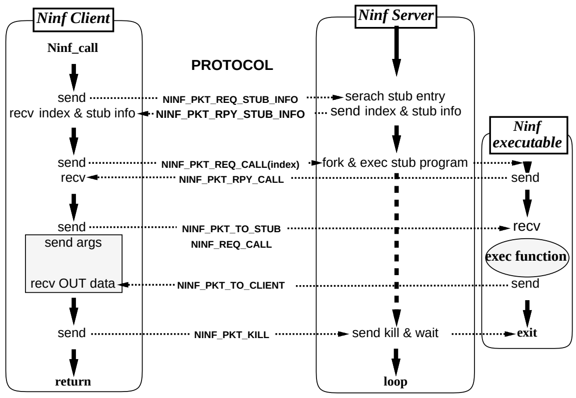
Ninf %7%9%F%`$O%/%i%$%"%s%H-%5!<%P%b%G%k$K4p$E$/!%%/%i%$%"%s%H$+$i$O LAN $d WAN $K@\B3$5$l$?%5!<%P$,Ds6!$9$k%i%$%V%i%j4X?t$r;O$a$H$9$kMM!9$J;q8;$r!$%5!<%P>e$GF0:n$9$k%G!<%b%s%W%m%;%9$r2p$7$FMxMQ$9$k$3$H$,$G$-$k!%?^ 1$K Ninf %7%9%F%`%"!<%-%F%/%A%c$r<($9!%

Ninf %7%9%F%`$O!$ Ninf $N%5!<%S%9$rDs6!9k Ninf %5!<%P!$ Ninf %/%i%$%"%s%H$N%$%s%?%U%'!<%9$rDs6!9k Ninf %/%i%$%"%s%H API !$9-0h%M%C%H%o!<%/$KJ,;6$7$? Ninf %5!<%S%9$N%9%1%8%e!<%j%s%0$r;Y1g$9$k%a%?%5!<%P$JI+$i9=@.$5lk!%3liN9=@.MWAG4V$NDL?.$O Ninf RPC (Remote Procedure Call)[9] $H>N$9$k<jB3$-KhCF<B8=5l$k!% Ninf Stub Generator, Ninf Register $O%5!<%S%9$NDs6!$rH><+F02=$9kD!<%kG"$j!$%5!<%P$NJ]<i$rMF0WK9$k!%

3liNOHAH$rMxMQ$9k3HKhj!$%f!<%6$OHQ;($J<jB3$-J7$K Ninf $N%5!<%S%9$rMQ$$$?9-0hJ,;6JBNs=hM}$r<B8=$9k3H,G-$k!%0J2<$G$O Ninf $r<B8=$9$kMWAG5;=Q$K$D$$$F=RYk!%



?^ 1 Ninf %7%9%F%`%"!<%-%F%/%A%c



?^ 2 Ninf %5!<%P-%/%i%$%"%s%H4VDL?.$N35MW

2.1 Ninf %5!<%P

Ninf %5!<%P$O%j%b!<%H7W;;%i%$%V%i%j$d%G!<%?%Y!<%9Ey$N;q8;$rDs6!$9$k%[%9%H>e$GF0:n9k%G!<%b%s%W%m%;%9$G!$%/%i%$%"%s%H$H$NDL?.$d%5!<%S%9$N3+;O!&=*N;$N4IM}$r9T$&!%Ds6!5l$k;q8;$O!$ Ninf Executable $H>N$9$k%5!<%P>e$G<B9TG-$k%U%!%$%k7A<0$r:N$C$F$$$k!% LAPACK JI$NCxL>$J%i%$%V%i%j$d%[%9%HMQ$K:GE,2=$5l?tCM%i%$%V%i%j$r!$DL?.%i%s%?%$%`$r4^$` stub %k!<%A%s$H%j%s%/$9k@1G!$MF0W$K3liN%i%$%V%i%j$r%j%b!<%H7W;;%i%$%V%i%j$H7FDs6!G-$k!% Ninf Executable $O ninf_register %3%^%s%I$GEPO?9k3H$G%5!<%P%G!<%b%s$N4IM}2<KCV+$l!$E,59 fork&exec 5l$k!%

?^ 2$K Ninf %5!<%P$H%/%i%$%"%s%H4V$NDL?.%W%m%H%3%k Ninf RPC $N35MW$r<($9!% Ninf RPC $N<BAu$ODL?.$K TCP/IP !$DL?.%G!<%?I=8=$K Sun XDR $r:NMQ$7F*$j!$B?$/$N%W%i%C%H%U%)!<%`$KMF0W$K0\?"G-$k!%

2.2 Ninf %/%i%$%"%s%H API

Ninf $N%/%i%$%"%s%H$O!$ C, C++, Fortran, Java, Lisp Ey$N4{B8$N8@8l$H!$3F8@8lMQ$N4J0W$J Ninf %/%i%$%"%s%H API $rMQ$$$F:n@.5l$k!% Ninf %/%i%$%"%s%H API $O Ninf_call $H$$$&M#0l$N%$%s%?!<%U%'!<%9$+$i@.$j!$ Ninf $NA4%5!<%S%9$NMxMQ$KMQ$$$ilk!% Ninf_call $NMxMQNc$H7F9TNs@Q$r<h$j>e2k!%DL>o9TNs@Q$N%k!<%A%s$r8F$S=P$9>l9g!$

```
double A[n][n], B[n][n], C[n][n];
/* declaration */
dmmul(n, A, B, C);
/* calls matrix multiply, C=A*B */
```

[2] 7W;;<gBN$N Ninf GO;~J,3dKD$$$F$O9MN8$9kKCM7J$$!%

Nh$&$K5-=R9k!% dmmul $, Ninf %5!<%P$GMxMQ2DG=$J>l9g$O!$0J2<$Nh&$K=q$-49$($k!%

```
Ninf_call("dmmul", n, A, B, C);
/* call remote Ninf library on server */
```

3Nh&$K%m!<%+%k%i%$%V%i%j$r8F$S=P$9>l9g$HHs>$KN`;w$7$?<jB3$-$G Ninf $N%j%b!<%H%i%$%V%i%j$,MxM$G$-$k!% Ninf_call $O Ninf RPC $r;H$C$F<+F0E*$K4X?t$N0z?t$N?t!&7?$r7hDj$7!$0z?t$r;HCF Ninf %5!<%S%9$rMxMQ$7$?7W;;$r9T$$!$7k2L$rE,@Z$J0z?t$K3JG<9k$H$$$&0lO"$N=hM}$r9T$&!%$3N?$a!$%f!<%6KO<+J,$N%^%7%s>e$G%j%b!<%H%i%$%V%i%j$,<B9T5l$F$$$k$+$Nh&$K8+$($k!%

2.3 Ninf IDL

2.1$G=R$Y$?$h$&$K Ninf RPC GN Ninf Executable $N;EMM (%$%s%?%U%'!<%9>pJs) $K4X$9$k%/%i%$%"%s%H%5!<%P4V$N>pJs6&M-$O!$%/%i%$%"%s%H$,:G=i$K%5!<%Ld$$9go;k3HG<B8=5l$k!%

Ninf IDL (Interface Description Language) O3$N%$%s%?!<%U%'!<%9>pJs$r5-=R$9$k<jCJ$rDs6!9kbN$G!$@h$N9TNs@Q$NNcGO2<Nh$&$KJk!%

```
Define dmmul(long mode_in int n,
             mode_in double A[n][n],
             mode_in double B[n][n],
             mode_out double C[n][n])
/* Description */
"dmmul is matrix multiply for double precision",
/* specify library required by this routine. */
Required "libxxx.o"
/* Use C calling convention */
Calls "C" mmul(n,A,B,C);
```

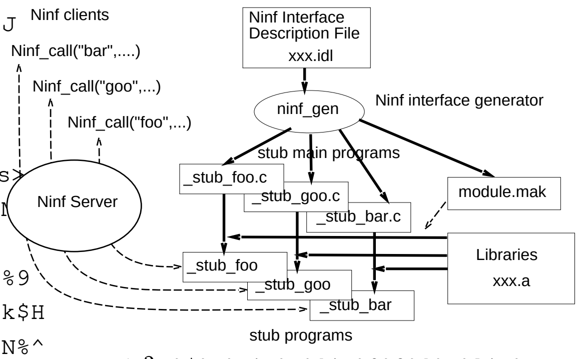
I,?\$N%$%s%?%U%'!<%9>pJs$H7F0z?t$N?t!$7?!$%"%/%;%9%b!<%I!$G[NsNBg-5,;XDjG-$kB>!$5!G=$N@bL@!$ build KI,MWJ%b%8%e!<%k$d%i%$%V%i%j!$%j%s%%*%W%7%g%s!$JLL>Ey$,5-=R$G$-$k!%

%5!<%S%9Ds6!<T$O5!G=%3%"$H%$%s%?%U%'!<%9$r5-=R7? Ninf IDL $rMQ0U$7$5$(9l$P!$0J2<$N<j=g$GH><+F0E*$K Ninf %5!<%S%9$rDI2CG-$k (?^ **3**)!%

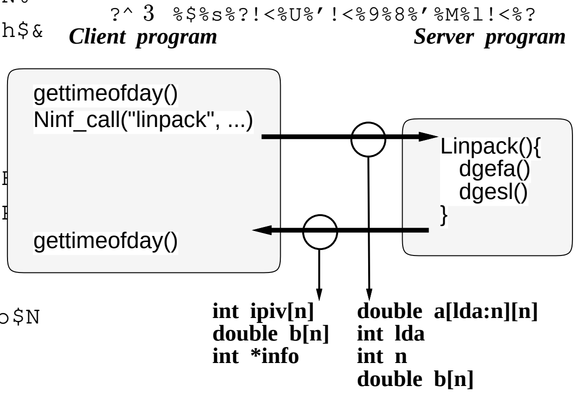
1. Ninf IDL $r5-=R
2. Ninf IDL %3%s%Q%$%i **ninf_gen** Kh$j!$ Makefile 5Z$S Stub %3!<%I (%$%s%?%U%'!<%9>pJs$HDL?.%i%$%?%$%`$r4^$`) $r@8@.
3. makefile $rMQ$$$F Ninf Executable $r@8@.
4. **ninf_register** %3%^%s%I$G Ninf Executable $r Ninf %5!<%P$KEPO?

2.4 %a%?%5!<%P

%a%?%5!<%P$OJ#?t$N Ninf %5!<%P>pJs$r%b%K%?$7!$%/%i%$%"%s%H$+$i$N%j%/%(%9%H$N%9%1%8%e!<%j%s%0$rE,@Z$K9T$&!%%a%?%5!<%P$r2p9k3H$G%f!<%6$OI,MW$J%5!%S%9$rDs6!7F$$$k Ninf %5!<%P$N=j:_$r0U<1$;$:$KMxMQ$G$-$k!%J#?t$N%a%?%5!<%P4V$N>pJs6&M-$b2DG=$G$"$$j!$?7$7$$ Ninf %5!<%P$rMQ0U$9$k>l9g$O:G4sjN%a%?%5!<%P$KEPO?$r9T$($P$h$$!%$^$?!$E,@Z$J Ninf %5!<%P



?^ 3 %$%s%?!<%U%'!<%9%8%'%M%l!<%?



?^ 4 Linpack $GMQ$$$?%W%m%0%i%`$H<x<u%G!<%?

$r%/%i%$%"%s%H$K3d$jEvFk3HKh$j!$ Ninf_call $N=hM};~4V$r:G>.K7!$ Network-Wide $J Ninf %5!<%P4V$NIi2YJ,;6$r<B8=$9$k!%$^$?!$%/%i%$%"%s%H API $N3HD%$Khj!$ Ninf_check_in, Ninf_check_out $N4V$K=q$+$l$? Ninf_call $rJBNs<B9T$9$k!%

3 %7%s%0%k%/%i%$%"%s%H$Khk Linpack $rMQ$$$?%5!<%P@-G=

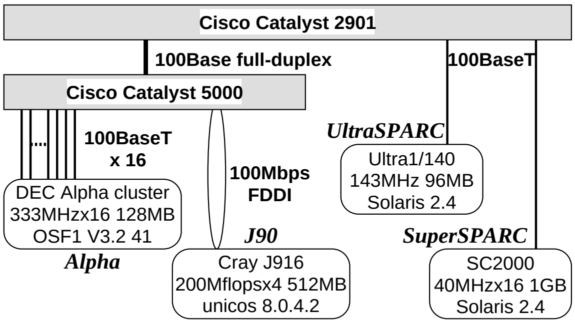
@b0hJ,;6JBNs=hM}K*$$$F$O%G!<%?$NDL?.NL$H7W;;NL$H$N%P%i%s%9$,%7%9%F%`$NM-8z@-$r7hDj$9$k:GBg$NMW0x$G$"$k!%$=$3$G Ninf $NM-8z@-$r<($9$?$a$K!$$^$:%5!<%P$KO1$D$N%/%i%$%"%s%H$, Ninf_call $9$k$H$$$&M}A[E*$JMxMQ>r7o$G$NI>2A<B83$rJ#?t%W%i%C%H%U%)!<%`>e$G9T$C$?!%

3.1 Linpack Benchmark

I>2AKOG\@:EY$N Linpack Benchmark $r<B;\$7$?!% Linpack Benchmark $O%,%&%9$N>C5nK!$rMQ$$$?L)9TNs$NO"N)01<!J}Dx<0$N5a2r (dgefa, dgesl) KMW9$k;~4V$rB,Dj9kbN$G!$1i;;?t$, $\frac{2}{3}n^3 + 2n^2$ $H010U$KDj$^$k3H$+$iIbF0>.?tE@1i;;@-G=$NI8=`$H7Fh/0zMQ5l$F$$$k!%

Ninf $r MQ $$ $? Benchmark $G $O!$ dgefa, dgesl $N 2 Dr Ninf %5!<%P>e$G<B9T9k!%%W%m%0%i%`$NNcH=$N4V$N<x<u%G!<%?$r?^ **4**$K<($9!%0z?t$r4^a?DL?.NL$O $8n^2 + 20n + O(1)$ bytes G"$k!% Ninf_call $N<B9T;~4V T_{Ninf_call} $ODL?.;~4V T_{comm} $H7W;;;~4V T_{comp} $+$i@.$k!%

$$T_{Ninf\_call} = T_{comm} + T_{comp} \tag{1}$$



?^ 5 %/%i%$%"%s%H5Z$S%5!<%P$KMQ$$$?7W;;5!

I=1 I>2A$KMQ$$$?%5!<%P$H%/%i%$%"%s%HNAH_9go;

Client	Local	Ninf_call		
		Ultra	J90(1PE)	J90(4PE)
SuperSPARC	!{	!{	!{	!{
UltraSPARC	!{	–	!{	!{
Alpha	!{	–	!{	!{

Linpack $NLdBj%5%$%:$r n H9kH!$

$$T_{comm} = T_{comm0} + \frac{8n^2 + 20n}{B} \quad (2)$$

$$T_{comp} = T_{comp0} + \frac{2/3n^3 + 2n}{P_{calc}} \quad (3)$$

$3$3$G T_{comm0}, T_{comp0} $ODL?.$H7W;;$N%;%C%H%"%C%W$K$+$+$k;~4V$r<($9!%$^$?!$ B $O%/%i%$%"%s%H–%5!<%P4V$NDL?.%9%k!<%W%C%H!$$P_{calc}$ $O%5!<%P$K$*$1$k Linpack $N<B9T@-G=$r<($9!%

$^$?!$ Ninf_call $N<B9T@-G= P_{Ninf_call} $OOJ2<$Nh&$KI=$9$3$H$,$G$-$k!%

$$P_{Ninf\_call} = \frac{2/3n^3 + 2n}{T_{Ninf\_call}} \quad (4)$$

T_{comm} $O $O(n^2)$!$ T_{comp} $O $O(n^3)$ G"k?$a!$ n $,Bg$-$/$JkKDl$FDL?.$N%*!<%P!<%X%C%I$,1#JC$5lk!%7?$,$C$F P_{Ninf_call} $O%/%i%$%"%s%H%^%7%s$N<B9T@-G=$h$j8~>e$9k3H,M=B,G-$k!%

3.2 I>2A4D6-

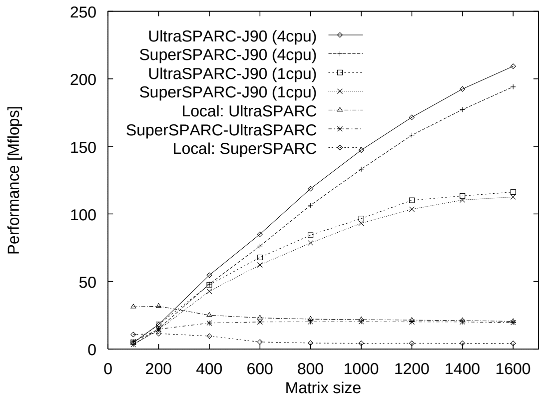
%/%i%$%"%s%H5Z$S%5!<%P$KMQ$$$?7W;;5!H=$N OS $O ?^ 5$K<($9DL$jG"$k!%$3li$N7W;;5!$OEE;R5;=QAm9g8&5f=jNbNrMxMQ7?!%

Linpack $N5a2r%k!<%A%s$H7F!$ J90 GOC1@:EY$NIbF0>.?tE@I=8=$, 8 bytes G"k?$a!$ libSci %i%$%V%i%j$N sgetfa, sgetsl $rMxMQ$7$?!%$5iK 4PE $r@jM-$7$F9bB.$K<B9T9kbN (4PE HG) $H!$ 1PE N_$rMQ$$$F<B9T9kbN (1PE HG) $rMQ0U$7$?!%$=$NB>$N7W;;5!GO LAPACK $N dgefa, dgesl $rMQ$$$?!%LdBj%5%$%:$O 100 $+$i 1600 $rBP>]$H7?!%

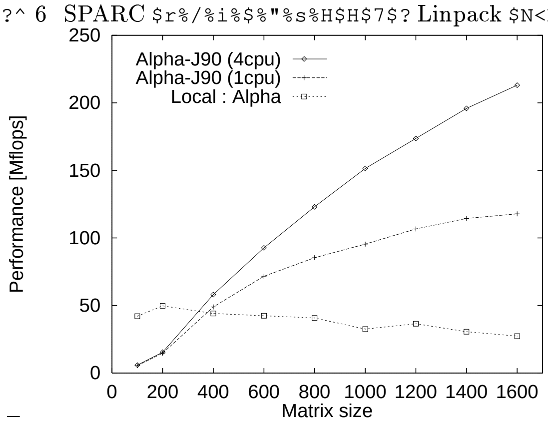
7WB,$r9T$C$?%/%i%$%"%s%H$H%5!<%P$NAH9g$;$rI= 1 $K<($9!% Local $O Ninf $rMQ$$$:$K%/%i%$%"%s%H>e$G<B9T$7$?$bNG$"$k!%

3.3 B,Dj7k2L

?^ 6$K SuperSPARC $H UltraSPARC $r%/%i%$%"%s%HH7$?B,Dj7k2L$r<($9!%2#<4$OBP>]H9$k9TNs$N Bg$-$5!$B($A Linpack $NLdBj%5%$%:$r<($9!%=D<4$O Ninf_call $H Local $N<B9T@-G=$r Mflops $G<($7$F$$$k!%



?^ 6 SPARC $r%/%i%$%"%s%HH7$? Linpack $N<B9T7k2L

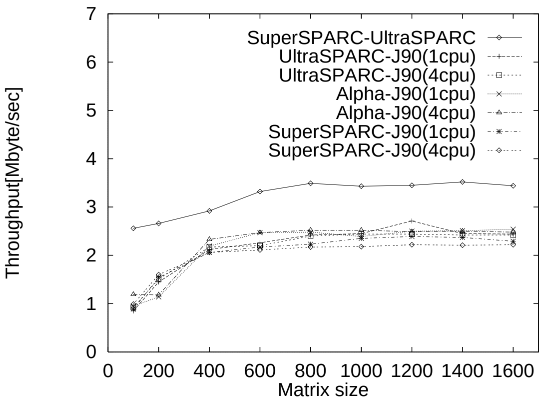


?^ 7 Alpha $r%/%i%$%"%s%HH7$? Linpack $N<B9T7k2L

SuperSPARC $H UltraSPARC $N Local O=l>$l B?>/%-%c%C%7%e$N8z2L$,$"kbNN!$LdBj%5%$%:Khi:$[$\0lDj$N@-G=$rF@$F$$$k!%3lKBP7!$ Ninf_call GO!$ 3.1$G=R$Y$?$h$&$KLdBj%5%$%:$,Bg$-$/JkKDlF@-G=$,8~>e$7!$ SuperSPARC, UltraSPARC HbLdBj%5%$%:$, 200 !A 400 G9GK$=$l$>$l$N%^%7%s$N Local hj$b9b$$@-G=$,F@$ilF$$$k!%$^$? UltraSPARC $N Local $H SuperSPARC $+$i UltraSPARC XN Ninf_call $NB,Dj7k2L$rHf3S9k$H!$ Ninf_call $OLdBj%5%$%:$,Bg$-$/$JkKDl!$ Local $N@-G=$K<}B+7F$$$k!%3l$O<0 (1) K*$$$F $T_{comm} \ll T_{comp}$ HJ$j!$DL?.%*!<%P!<%X%C%I$,1#JC$5lk$?$aG"$k!%$^$?%/%i%$%"%s%H$N@-G=$,0[Jk>l9g$b Ninf_call GO$[$\F1DxEY$N@-G=8~>e$,4QB,5l$?!%

?^ 7$K Alpha $r%/%i%$%"%s%HH7$?B,Dj7k2L$r<($9!% Alpha $NIbF0>.?tE@I=8=$O IEEE 7A<0G"$j!$ CRAY 7A<0$H0[$Jk?$a!$DL?.MQ$G!<%?I=8=$N XDR $H7W;;5!$N%G!<%?I=8=$N4V$NJQ49$K;~4V$rMW9k!% SPARC $HF1MM$KLdBj%5%$%: 400 A08e$G Ninf_call $, Local $N@-G=$r>e2sC?!%

?^ 8 $K Ninf_call $N:]$NDL?.%9%k!<%W%C%H$N<BB,CM$r<($9!% Ninf GO%Q%1C%HC10L$G%G!<%?$rE>Aw7F$*$j!$%/%i%$%"%s%HGN%G!<%?I=8=$NJQ49!$%G!<%?$NE>Aw!$%5!<%PGN%G!<%?I=8=$NJQ49$,JB9T7F5/3C$F$$$k!%7?$,$C$F!$$3$N%9%k!<%W%C%H$K$O%G!<%?I=8=$NJQ



?^ 8 Ninf_call $NDL?.%9%k!<%W%C%H

49KMW9$k;~4V$,4^$^$l$k!%

?^ **8** GO!$%9%k!<%W%C%H$NCMKhCF 2 DN%0%k!<%W$KJ,N`$G$-$k!% 2MB/sec $rD6$($?IU6a$G$[$\K0OB7F$$$k 6 K\$N%0%i%U$O SPARC 5Z$S Alpha $H J90 $N4V$N%9%k!<%W%C%H$r<($9!%3NCfGO Alpha $,N SPARC hj$^%7$s@-G=$,9b$$$?$a!$$d$d9b$$%9%k!<%W%C%H$r<($9!%0lJ}!$%5!<%P$H%/%i%$%"%s%H$K SPARC $rMQ$$$?>l9g$,J?6QLs 3.2 MB/sec $H:G$b9bB.KJC?!%3l$O SPARC 4V$G$"$l$P!$%G!<%?I=8=$NJQ49$N%*!<%P!<%X%C%I$,>.$5$$$?aH9M$($ilk!%

4 %^%k%A%/%i%$%"%s%H$Khk%5!<%P@-G=

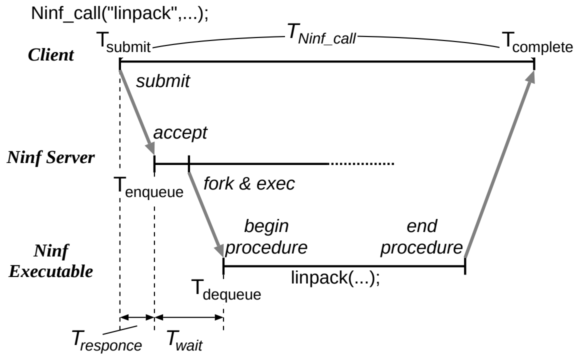
DL>o$N Ninf %5!<%P$N1?MQGO!$0l$D$N%5!<%P$,B??t$N%/%i%$%"%s%H$+$iF1;~$K Ninf_call 5lk3H,A0DsG"$k!% Ninf %7%9%F%`$,M-8z$K5!G=$9kK$O!$$3Nh$&$J>l9gKbJ?6Q=hM}$N;~4V$NCx$7$$A}Bg$r>7$+$:!$$+$D%5!<%P%^%7%s$N2TF/N($r9b$/0];}9k3H$,I,MW$G$"$k!%$=$3$G!$J#?t$N%/%i%$%"%s%H$rMQ$$$?%5!<%P$N@-G=I>2A$r9TC?!%

4.1 I>2A4D6-

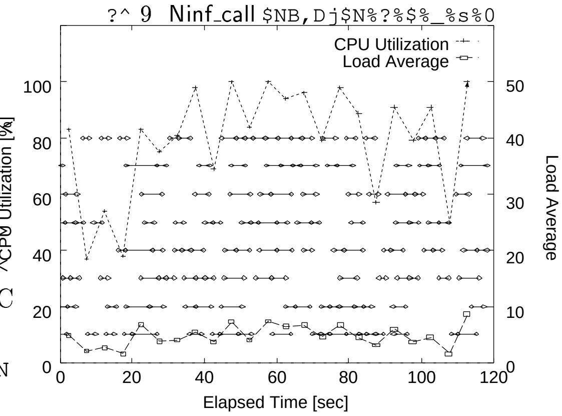
A0@a$NI>2A$GMQ$$$? Cray J90 $r%5!<%P!$ Alpha %/%i%9%?$r%/%i%$%"%s%HH7$FMQ$$$? (?^ **5**)!% Linpack $N5a2r%k!<%A%s$H7FA0@aF1MM!$ 4PE HG$H 1PE HG$rMQ$$$k!%A0<T$O 4PE $r@jM-$7$F9bB.$K<B9T9kBeoj$K F1;~$K 1task 7+<B9TG-$:!$8e<T$O9bB.$GOJ$$Beoj$K 4task JBNs$K<B9TG-$k!%

I>2AKO8=<B$K6a$$ Ninf %/%i%$%"%s%H%W%m%0%i%`$N%b%G%kH7$F!$A0@a$G=R$Y$? Linpack Benchmark %k!<%A%s$r7+$jJV$78F$S=P9bNrMQ0U7?!%3N%b%G%kGO Ninf_call $O%9%F%C%W ($s$ sec) Kh$K0lDj$N3NN(p $GH/@8$9kbNH$7!$%/%i%$%"%s%H?t$O c H9$k!%LdBj%5%$%:$O;n9T$N4V0lDj$G n H9$k!%B,Dj$O!$ $s = 3$!$ $p = 1/2$, $c = 1, 4, 8, 12, 16$, $n = 600, 1000, 1400$ $H$$$&>r7oG9YF$NAH9g$;$r<B;\$7$?!%

<B83GO%5!<%P$N2TF/N(!$Ii2Y!$5Z$S3F Ninf_call KD$$$F!$?^ **9**$K<(9h$&$K%/%i%$%"%s%H$G Ninf_call $r3+;O$7$?;~9o T_{submit}, %5!<%P$G Ninf_call $r<u$1IU1?;~9o $T_{enqueue}$, %5!<%P$G Ninf Excutable $r5/F0$7$?;~9o $T_{dequeue}$, %/%i%$%"%s%H$G Ninf_call $r40N;$7$?;~9o $T_{complete}$!$DL?.5Z$S%G!<%?I=8=$NJQ49$N%9%k!<%W%C%H$r



?^ 9 Ninf_call NB,DjN%?%$%_%s%0



?^ 10 1PE HG, n=600, c=8 $N<B9T7k2L

B,Dj7?!%$3$3$G Ninf_call $N1~Ez;~4V $T_{responce}$, BT$A;~4V T_{wait} $r0J2<$Nh&$KDj5A$9$k!%

$$T_{responce} = T_{enqueue} - T_{submit} \qquad (5)$$

$$T_{wait} = T_{dequeue} - T_{enqueue} \qquad (6)$$

4.2 B,Dj7k2L

?^ **10**$K 1PE HG$G $(n, c) = (600, 8)$!$?^ **11,12,13**$K 4PE HG$G $(n, c) = (600, 8), (600, 12), (1400, 8)$ GN<B9T>u67$r<($9[3]%2#<4$O7P2a;~4V [sec]!$=D<4$O CPU $N2TF/N([%](:8), 5 ICKh$NIi2YJ?6QCM (1&) $r<($9!%%0%i%U>e$N?eJ?@~$O3F%/%i%$%"%s%H$G Ninf_call $r9T$C$F$$$k>uBV$rI=$9!%I= **2**!$I= **3**$K<B9T7k2L$N>\:Y$r<($9!%

?^ **10**$H?^ **11**$rHf3S9k$H!$ 4PE HG$OIi2Y$,9b$$$bNN CPU $N2TF/N($,9b$$!%7?$,$C$F%5!<%P$G$N=hM}3+;O$OCYlk2DG=@-$,$"k,!$ n, c $,$"$^$jBg$-$/$J$$>l9gKO 4CPU HG$NJ}$,NI$$@-G=$,F@$ilk!% n, c $,A}2C$9kH2TF/N($OK0OB$7!$$=$N8e$O%5!<%P$NIi2Y$,<!Bh$KA}2C$7$F$$$/!%?^ **12**$H?^ **13**$rHf3S9k$H!$I= **3**hjIAib$[$\2TF/N($OK0OB$7$F$$$-!$Ii2Y$O$[$\Ey$7$$$,!$ c $,A}2C$7$F$$$/>l9g$OIi2Y$,6Q0l$K>e$,$j!$ n $,A}2C$7$F$$$/>l9g$OIi2Y$N:GBg!&:G>.CM$K:9$,@8$8$k!%3l$OHf3SE*N3EY$,>.$5$$>l9g$OA4 PE $,@jM-$5lk;~4V$,C;$$$,!$N3EY$,Bg$-$$>l9g$OD9$$$3HKhk!% 1PE HGGbF1MM$N7k2L$rF@$?$,!$ 4task F1;~$K=hM}$G$-$k$?$a!$ 4PE HG$G8+$ilkIi2Y$N:9$OG'ailJ$+$C$?!%

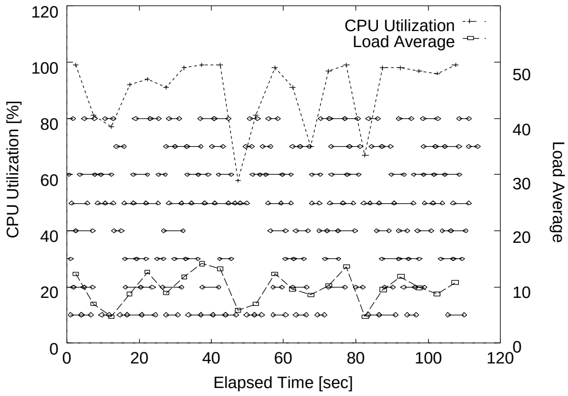
[3]B>$N?^I=$O http://phase.etl.go.jp/~atakefu/jspp97/ ;2>H!%

I= 2 1PE HG$N%^%k%A%/%i%$%"%s%HKh$k<B9T7k2L

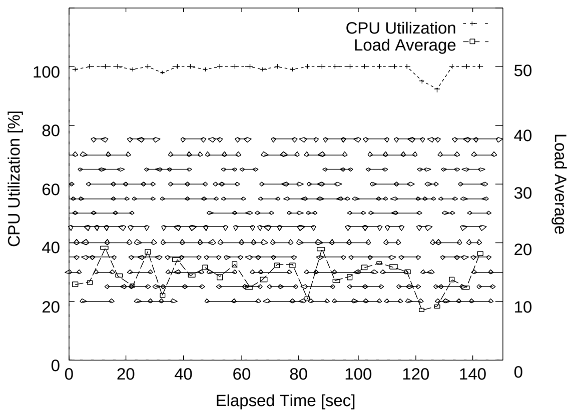
n	c	Performance[Mflops] max/min/mean	$T_{response}$ [sec] max/min/mean	T_{wait} [sec] max/min/mean	Throughput [MB/s] max/min/mean	CPU Utilization	Load average	times
600	1	72.71/69.90/71.17	0.03/ 0.02/ 0.02	0.03/ 0.02/ 0.03	2.57/ 2.42/ 2.48	12.63	0.68	29
	4	72.01/43.85/67.06	1.01/ 0.02/ 0.06	0.04/ 0.02/ 0.03	2.53/ 2.01/ 2.36	42.71	2.01	60
	8	72.04/17.44/49.35	5.04/ 0.02/ 0.16	0.05/ 0.02/ 0.03	2.55/ 0.64/ 1.89	79.88	4.81	109
	12	66.37/ 9.13/31.26	5.02/ 0.02/ 0.18	0.14/ 0.02/ 0.04	2.38/ 0.35/ 1.23	98.20	8.96	146
	16	64.13/ 8.12/20.89	5.03/ 0.01/ 0.35	0.74/ 0.02/ 0.04	2.23/ 0.24/ 0.87	97.74	12.96	204
1000	1	95.06/93.13/93.40	0.02/ 0.01/ 0.02	0.03/ 0.02/ 0.03	2.58/ 2.49/ 2.53	21.40	1.06	30
	4	93.64/59.92/81.49	0.20/ 0.02/ 0.03	0.05/ 0.02/ 0.03	2.54/ 1.47/ 2.10	76.76	3.55	62
	8	83.91/32.63/48.43	0.40/ 0.01/ 0.03	0.05/ 0.02/ 0.03	2.39/ 0.79/ 1.39	98.92	7.35	95
	12	48.74/19.98/29.56	5.05/ 0.00/ 3.08	0.07/ 0.02/ 0.03	2.44/ 0.51/ 0.98	97.89	10.09	158
	16	27.29/15.61/20.78	5.04/ 0.01/ 0.52	0.08/ 0.03/ 0.04	0.77/ 0.35/ 0.53	100.00	16.32	58
1400	1	115.01/112.26/113.65	0.02/ 0.01/ 0.01	0.03/ 0.02/ 0.02	2.58/ 2.51/ 2.54	24.27	1.19	30
	4	109.42/75.41/93.42	5.02/ 0.01/ 0.24	0.04/ 0.02/ 0.03	2.44/ 1.80/ 2.20	88.81	4.19	67
	8	60.49/43.20/49.79	1.85/ 0.01/ 0.07	0.04/ 0.02/ 0.03	1.72/ 0.92/ 1.18	100.00	8.55	36
	12	37.12/26.07/31.98	0.22/ 0.00/ 0.02	0.04/ 0.02/ 0.03	0.96/ 0.53/ 0.73	100.00	12.81	42
	16	27.71/20.01/23.83	5.02/ 0.01/ 0.29	0.05/ 0.03/ 0.03	0.74/ 0.40/ 0.50	100.00	16.92	20

I= 3 4PE HG$N%^%k%A%/%i%$%"%s%HKh$k<B9T7k2L

n	c	Performance[Mflops] max/min/mean	$T_{response}$ [sec] max/min/mean	T_{wait} [sec] max/min/mean	Throughput [MB/s] max/min/mean	CPU utilization	Load average	times
600	1	94.05/81.76/91.46	0.21/ 0.01/ 0.02	0.04/ 0.03/ 0.03	2.55/ 2.40/ 2.47	14.89	0.87	50
	4	92.18/21.70/76.74	5.01/ 0.02/ 0.19	0.05/ 0.03/ 0.04	2.50/ 1.52/ 2.16	56.80	4.04	64
	8	89.35/26.92/52.22	0.66/ 0.01/ 0.05	0.12/ 0.03/ 0.05	2.50/ 0.60/ 1.38	87.71	9.75	111
	12	63.96/12.95/29.65	1.55/ 0.01/ 0.06	0.65/ 0.04/ 0.08	1.69/ 0.27/ 0.74	99.67	14.77	153
	16	56.73/ 9.43/18.92	5.02/ 0.01/ 0.07	1.09/ 0.04/ 0.11	1.66/ 0.21/ 0.47	100.00	19.75	200
1000	1	150.96/70.39/141.43	5.02/ 0.01/ 0.31	0.04/ 0.03/ 0.03	2.56/ 2.46/ 2.51	28.64	1.45	30
	4	134.26/61.01/93.89	0.04/ 0.01/ 0.02	0.08/ 0.03/ 0.04	2.32/ 0.98/ 1.55	88.34	5.87	66
	8	67.14/27.76/44.76	5.01/ 0.01/ 0.27	0.20/ 0.03/ 0.05	1.21/ 0.42/ 0.68	99.90	11.42	112
	12	42.50/20.22/27.85	5.02/ 0.01/ 0.12	0.72/ 0.03/ 0.06	0.66/ 0.29/ 0.41	99.99	18.04	164
	16	32.22/14.22/20.33	1.30/ 0.01/ 0.06	1.42/ 0.03/ 0.09	0.50/ 0.21/ 0.30	99.97	24.59	79
1400	1	196.08/174.28/193.03	1.08/ 0.01/ 0.08	0.04/ 0.03/ 0.03	2.54/ 2.47/ 2.51	40.87	1.86	29
	4	119.26/77.95/97.69	5.03/ 0.01/ 0.53	0.11/ 0.03/ 0.05	2.16/ 0.94/ 1.29	95.65	7.39	57
	8	59.39/34.23/47.74	0.91/ 0.01/ 0.05	0.06/ 0.03/ 0.04	0.81/ 0.43/ 0.58	99.96	15.56	32
	12	38.81/26.99/31.90	5.02/ 0.00/ 0.37	0.08/ 0.03/ 0.04	0.55/ 0.30/ 0.39	100.00	22.67	37
	16	28.06/19.27/23.21	0.63/ 0.01/ 0.03	0.89/ 0.03/ 0.06	0.34/ 0.21/ 0.27	100.00	28.97	51



?^ 11 4PE HG, n=600, c=8 $N<B9T7k2L



?^ 12 4PE HG, n=600, c=12 $N<B9T7k2L

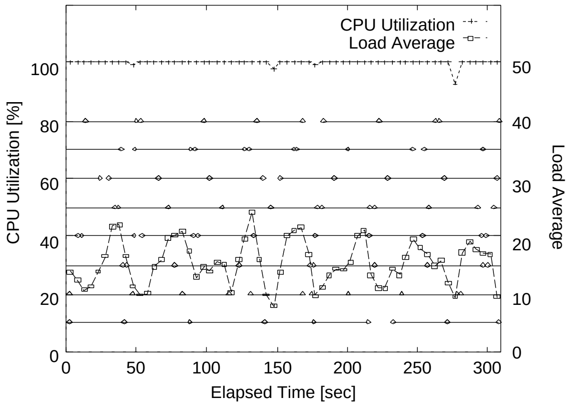
Ninf_call $N1~Ez;~4V5Z$SBT$A;~4V$O Ninf_call $N%?%$%_%s%0Kh$jD9$/JkbN$,$o$:$+K"kbNN$J?6QCM$G$O n, c 5Z$S 1PE/4PE HG$Khk1F6AO"$^$j8+ilJ+C?!%3l$O%9%?%V>pJs$NDs6!$H Ninf Executable $N fork&exec KOJ#?t$N%/%i%$%"%s%H$+$iMW5a$,$"$k>l9gKb%/%i%$%"%s%HrBT?$;$:=hM}9k3H$r<($9!%

LdBj%5%$%: n Kh$k<B9T@-G=$N798~$O!$ c $,>.$5$$>l9g$O n $,Bg$-$$J}$,DL?.$H XDR $NJQ49$N3d9g$,>$5$/$Jk?aK9b$$@-G=$,F@$ilk$,!$ c $,Bg$-$/$JkKDl 4PE $,@jM-$5lk;~4V$,D9$/Jj!$DL?.%9%k!<%W%C%H$,Dc2<9k7k2L!$A4BN$N@-G=$,Dc2<$9$k!%

Ninf_call $N<B9T@-G=$K4X7F$O!$ c $,>/$J$$>l9g$K4PE HG$G$OHs>o$K9b$$@-G=$,F@$il?!% 4PE HG$O7W;;$3$"$N=hM}B.EY$,9bB.$J$?$a!$0l;~E*$K 4PE $,@jM-$5lF$b Ninf_call $NJ?6Q<B9T;~4V$,Dc2<7J$$!%$^$? c $,A}2C$9kH Ninf_call $NA}2C$KhkDL?.%9%k!<%W%C%H$NDc2<$Khj!$ 1PE/4PE Hb$KBgI}$K<B9T@-G=$,Dc2<$9$k!%$3$N:]!$ 4PE HGGO%9%1%8%e!<%j%s%0$N%*!<%P!<%X%C%I$Khj 1PE HGhj$bBgI}$K@-G=$,Dc2<$9k3H,M=B,5lk,!$<B9T@-G=$N:9O"$^$j8+il$J

I= 4 SMP $N%^%k%A%/%i%$%"%s%HKh$k<B9T7k2L

n	c	Performance[Mflops] max/min/mean	$T_{response}$ [sec] max/min/mean	T_{wait} [sec] max/min/mean	Throughput [MB/s] max/min/mean	CPU utilization	Load average	times
600	4	4.38/3.17/3.81	1.36/1.09/1.20	0.21/0.13/0.16	1.82/0.21/0.46	20.10	6.08	67
	8	4.25/2.73/3.52	2.10/1.19/1.32	0.24/0.13/0.16	1.05/0.14/0.38	28.92	8.84	114
	16	3.77/2.08/2.83	5.54/0.00/0.35	1.23/0.14/0.20	1.40/0.11/0.35	47.36	15.37	211



?^ 13 4PE HG, n=1400, c=8 $N<B9T7k2L

$+$C$?!%$3lO 4PE $,@jM-$5lF$$$k>l9gGbDL?.$,F1;~$K9Tol$F$$$k3H!$7W;;%3%"$N<B9TB.EY$N0c$$$KhkbN$H9M$(il$k!%

;29M$^$G$KI= 4$K%5!<%PH7$F Cray J90 NBeojK SuperSPARC $N 16 Bf9=@.SMP(?^ 5;2>H) $rMQ$$$?>l9g$N7k2L$r<($9!%%/%i%$%"%s%H?t$NA}2C$KH<$&@-G=$NDc2<$, J90 KHfY$F>.$5$$/!$1~Ez;~4V5Z$SBT$A;~4V$bA}Bg7J$$!%$^$?!$ $c = 16$ Gb CPU 2TF/N($KM>M5$r;D7F$$$k!%3l$O7W;;@-G=$,Hs>o$KDc$$$?aK I/O %M%C%/$,82:_2=$;$:!$$^$?J#?t$W%m%;%9%O%s%I%j%s%0$N%*!<%P!<%X%C%I$,>.$5$$ UNIX %5!<%P%7%9%F%`G"k?aH9M$($ilk!%

5 5DO@

5.1 Ninf Kh$k9-0hJ,;6JBNs=hM}$N2DG=@-

9-0hJ,;6JBNs=hM}GO!$%/%i%$%"%s%H-%5!<%P4V$NDL?.$ODcB.$G?.Mj@-$K7g1k$,!$%5!<%PH7$FMQ$$$kD69b@-G=7W;;5!$N@-G=$O%/%i%$%"%s%H$r05E]E*$K>e2s$C$F$$$k!% Ninf O3Nh$&$J4D6-$KE,$7$?J,;6JBNs=hM}$N$?$a$KABN3EY$N%j%b!<%H7W;;%i%$%V%i%j$d$=$liH6(D4$7$FMxMQ9k$KB-$kIU2C2ACM$r;}$D>pJs;q8;$rDs6!$7!$$$?.Mj@-$rJ]>Z$9$kOHAH$bMQ0U9k!%

3>O$NI>2A<B83$G$O!$ Ninf %5!<%PKHCFM}A[E*$J>r7o$rM?$($k%7%s%0%k%/%i%$%"%s%H4D6-$K$*$$$F!$$9lN%W%i%C%H%U%)!<%`GbHf3SE*>.$5$$LdBj%5%$%:$G$"$l$P!$ Ninf $rMQ$$$?J}$,%m!<%+%k<B9T$h$j9bB.$5lk$H$$$&7k2L$rF@$?!%7+$b!$%/%i%$%"%s%H$N%*%s@-G=$O Ninf_call $N@-G=$K$[$HsI1F6A$rM?$(J+C?!%3liN7k2L$O!$8=;~E@$G Ninf Kh$k9-0hJ,;6JBNs=hM}$N8=<BE*$JM-8z@-$r<B>Z9kbNG"$k!%

5.2 Ninf %5!<%P$N<B:]E*$J1?MQ>e$N7xO4@-

Ninf %5!<%P%^%7%sH7$FMQ$$$ilk%9!<%Q!<%3%s%T%e!<%?$d MPP JI$ND69b@-G=7W;;5!$N OS $O!$ UNIX %o!<%/%9%F!<%7%g%sEy$N OS $HHf3S$7$F!$B??t$N%W%m%;%9$rF1;~$K<B9T$9k3Hr9MN8$5$l$F$$$J$$$,!$%/%i%$%"%s%H$+$i$N Ninf_call $,=8Cf$7FbB??t$N%W%m%;%9$N%O%s%I%j%s%0$rGKC>$J$/?k9T$9kI,MW,$"$k!%

4>O$NI>2A<B83$G$O!$:GBg 16 8D$N%/%i%$%"%s%H$+$i Ninf_call $r9T$$!$%5!<%P$NIi2Y$O:GBg 30 $KC#$7$?$,!$GKC>$9k3HJ$/5!G=$7$?!%$3lO!$>&MQ$N%9!<%Q!<%3%s%T%e!<%?$d MPP >e$N UNIX %7%9%F%`$K4{$K%^%k%A%W%m%;%C%7%s%0$r;Y1g$9$k$K==J,$J?.Mj@-$,$"$j!$$+$D Ninf %7%9%F%`$,%(%i!<$KBP7F7xO4$K:n$ilF$$$k$?$aG"$k!%$^$?!$EvA3J,$i SMP %7%9%F%`$G$b7xO4$+$D8zN(NI$/5!G=9k!%

5.3 %?%9%/%Q%i%l%k$+%Y%/%H%k%Q%i%l%k!&D6JBNs$+?

%Y%/%H%k%Q%i%l%k5!!$ MPP $G Ninf %5!<%P%7%9%F%`$rI?MQ9k:]!$=g<!E~Ce$9$k Ninf_call $N=hM}J}K!$H7F!$7W;;;q8;$r6u4VJ}8~$KJ,3d$7!$$=l>lN%?%9%/$K3d$jEvFFJBNs$K=hM} (%?%9%/%Q%i%l%k) 9k$+!$$9YF$N;q8;$r0lDN%?%9%/$K3d$jEvFFD>Ns$K=hM} (%Y%/%H%k%Q%i%l%k!&D6JBNs) 9k$+A*Br$G$-$k!%

4>O$NI>2A<B83$N7k2LGO!$LdBj%5%$%:$NBg>.$K4Xoi$:!$%/%i%$%"%s%H?t$, 1 !A 8 8D$^$G$N4W;6$J>uBVGO 4PE HG!$ 8 !A 16 $^$G$NHKK;$J>uBVGO 1PE HG $NJ}$,9b$$J?6Q<B9T@-G=$r<($7$?!%$^$?!$4W;6;~KO 4PE HG $NJ}$,BgI}$K 1PE HG$KHfYF@-G=$,9b$/!$5U$KHKK;;~$N 1PE HG$N%"%I%P%s%F!<%8$O7h$7FBg-$/$J$+$C$?!%$^$?!$$$$:lN>l9gGb1~Ez;~4V5ZSBTA;~4V$K4X$7$F 4PE HG$,Cx7/ITMxKJk3HOJ+C?!%

0J>e$+$i!$%Y%/%H%k%Q%i%l%k7W;;5!!&D6JBNs7W;;5!GO%T!<%/@-G=$r<B8=$9kh$&$K:GE,2=5l$?%i%$%V%i%j$G Ninf %5!<%S%9$rDs6!9lPh$/!$%%M%C%H%o!<%/%5!<%S%9MQ$KFC2=$9kI,MWO$J$$$HH=CGG-$k!%$3lO4{$K:n$il?%i%$%V%i%j$N:FMxMQ@-$,9b$$$H$$$&3H$KB>$JiJ$$!%

5.4 %5!<%P$N%8%g%V%O%s%I%j%s%0%a%=%C%I

Ninf %7%9%F%`$, 3>O$Nh&$KM}A[E*>uBV$GMxMQG-$J$$>l9g$KMW5a$5lk3H$O<!$N 2 E@G"$k!%$9Jo$A!$1~Ez;~4V$NJ?6Q$rC;$/$9k3HH!$ CPU $N2TF/N($r>e5;k3HG$"$k!%

4>O$N<B83$GOI$N>r7o$G$b1~Ez;~4V$,Cx7/A}Bg9k3HOJ$+$C$?!%$7$?$,CF!$%5!<%P$N:.;(>uBV$K9g$o$;$FB>%5!<%P$X re-submit $r9T$&JI$N@oN,$r:NMQ7?>l9gKb8zN($rB;$JoJ$$HH=CGG-$k!%

Ninf_call $N%8%g%V$O I/O $r4p=`$K9M$($1$P==J,ABN3EY$G$"$k$?$a!$ I/O %M%C%/$,82:_2=$7$K$/$$!%$^$?!$7W;;<gBN$G$"$k$3$H$r9M$($k$H>.$5$$%?%$%`%9%i%$%9$G;~J,3d=hM}$5lkhj$O!$0lC6%9%1%8%e!<%k5l$?%8%g

%V$OB>$N%8%g%V$KM%@h$7$F:G8e$^$G?k9T$5$1$kJ}$,%3$H7F$$$k!%3Nh&$J>l9g!$9-$/CN$ilF$$$kh&$K%5!<%P$G$N%8%g%V%9%1%8%e!<%j%s%0$O Shortest Job First $r:NMQ$9kN$,M-8z$G$"$k!%

8=>u$N Ninf %5!<%P$OC1=c$KMW5a$,MhkHB(:B$K fork&exec 9kN_$G First-Come, First-Serve $G=hM}$5lk$?$a!$ CPU $KM>NO$N$"$k>l9gK=$l0J>e2TF/N0 $5!<%P$N8%g%V$9%1%8%e!<%j%s%0$r8~>e5;k3H,G-$J$$!%0lJ}!$ Ninf_call $ODL%P $N%W%m%;%9$H$O0[$J$j!$Nc($P Ninf IDL $K%"%k%4%j %:%`$NJ#;($5$r5-=R$7$F$*$/$J$I$9$k$3$H$G!$%8%5 $N runlength $,Hf3SE*@53N$KM=A[$G$-$k$?$a!$%5!<%P $G%8%g%V$r%-%e!<%$%s%0$7$F$*$-!$ Shortest Job First $G fork&exec $9$k$3$H$OMF0W$K<B8=$G$-$k>e$K!$$I$N %W%i%C%H%U%)!<%`$G$b6&DL$K:NMQG-$k!%

6 4XO"8&5f

ETH $N Remote Computation System (RCS)[1] $O J#?t$N%9!<%Q!<%3%s%T%e!<%?$rE}0l$7$?%$%s%?%U%'!<%9$GMxMQ$9k?aN RPC $rDs6!$9$k!%DL?.%l%$%d$K PVM $rMQ$$$F$*$j9-0hJ,;6$KE,$7F*i:!$7W;;q8;4V$NIi2YJ,;6$r9T$&$,%a%?%5!<%P$Nh&$KJBNs7W;;Y1g$O9ToJ$$!%$^$?!$%/%i%$%"%s%H API $, Ninf HO0[Jj3HD%@-$K7g1k!%

%F%M%7!<Bg$N NetSolve[2] $O Ninf_call $KN`;w$N API $rDs6!$9$k%7%9%F%`$G$"$j!$ Agent $H>N$9$k%W%m%;%9 DL$7$F%a%?%5!<%P$HF1MM$N5!G=$rDs6!9k!%7+$7!$%$%s%?%U%'!<%95-=R5!G=$rHw$($F$$$J$$$?$a!$9-0hJ,;6$7$?%5!<%P$N1?MQ$KE,5J$$!%

Legion[4] %W%m%8%'%/%H$O9-0hJ,;64D6-$G$NJ,;6%W%m%0%i%_%s%0$r;Y1g9k%*%V%8%'%/%H;X8~8@8l Mentat[3] $r;H$C$F!$B?$/$N7W;;q8;$rE}9g$7$?2>A[7W;;5!$r<B8=9k!% Mentat $O%W%m%0%i%_%s%08@8l$G$"$k$?$a!$J,;6%7%9%F%`FCM-$N:GE,2=$d5!G=$,<B8=$,MF0W$G$"$k!%$3$l$KBP$7!$ Ninf $OFCDj$N8@8l$r2>Dj$7$J$$$?$a!$%f!<%6$K$H$C$F$O4{B8$N%7%9%F%`$H$NO"B3@-$,0];}G-!$%5!<%P1?MQ>e$N0BA4@-$O9b$$$H8@$($k!%

Aa0pEDBg$N%a%?%3%s%T%e!<%?%7%9%F%` [6] $O!$<+F0JBNs2= FORTRAN %3%s%Q%$%i$rMQ$$$FLdBj$rJ,3d$7!$%M%C%H%o!<%/>e$N%5!<%P$K%3!<%IM"Aw$7!$%5!<%P>e$G%3!<%I$+$i<B9T7A<0$r@8@.$7$F<B9T$9$k%7%9%F%`G"$k!%%3!<%I$N0BA4@-!$9-0hJ,;6<B9T$KE,7?N3EY$NCj=P$K5?Ld$,;D$k!%

7 $^$HaH:#8e$N2]Bj

K\9FGO!$2J3X5;=Q7W;;J,Ln$K$*$1$k9-0h%M%C%H%o!<%/>e$NJ,;6JBNs=hM}$r<B8=$9$k4pHW%7%9%F%`$rL\;X$7$? Ninf %7%9%F%`$N35@b$r9T$&HHbK!$%7%9%F%`$N3KHJ$k Ninf %5!<%P$N!$%7%s%0%k / %^%k%A%/%i%$%"%s%H4D6-GN Linpack Benchmark Kh$k@-G=I>2A$r9TC?!%$=$N7k2L!$ Ninf Kh$k9-0hJ,;6JBNs=hM}$N2DG=@-$r<B>Z$9kHHb$K!$<B:]E*$J1?MQ>r7o$G$N7xO4@-!$FC$K%Y%/%H%k%Q%i%l%k%^%7%s$KBeI=5l$k!$=>Mh!V7W;;@lMQ%^%7%s!WH7$F;H$olF$-$?7W;;5!GN7xO4@-$r3NG'$9$k K>$H$,$G$-$?!%$^$?!$JBNs7W;;5!%7%9%F%`$r Ninf %5!<%RH7$FMxMQ$9$k>l9g!$Ds6!9k%i%$%V%i%j$O%M%C%H%o!<%/%5!<%S%9$KFC2=$9kI,MWOJ/!$C1BN$G:G9b@-G=$rH/4x$9kbNrMxMQ9kN,K>$^$7$$$HH=CGG-$?!%$D$^$j!$4{$K:nil$?%i%$%V%i%j$N:FMxMQ@-$,9b$$$3HKB>Ji$J$$!%

0lJ}$G%5!<%P$N%8%g%V%9%1%8%e!<%j%s%0!$%a%?%5!<%r8~>e$5$;$k3H$,$G$-$J$$!%0lJ}!$ %oKh$k Network-Wide %9%1%8%e!<%j%s%0Ey$r4^$a$? Ninf %7%9%F%`$NM-8z@-$r8!>Z$9k?aK$O!$>/?t$N<B%g%V$N<B83GOIT==J,G"$k!%:#8e$N2]BjOh$jJ#;($J;Fb>]$r07$(kM%C%H%o!<%/%7%_%e%l!<%?$r:n@.$7$F2r@O$r9T$&$3HG$"$k!%

<U<-

;29MJ88%

[1] P. Arbenz, W. Gander, and M. Oettli. *The Remote Computational System, High-Performance Computation and Network*, Vol. 1067 of *Lecture Note in Computer Science*, pp. 662–667. Springer, 1996.

[2] H. Casanova and J. Dongarra. NetSolve: A Network Server for Solving Computational Science Problems. In *Proceedings of Supercomputing '96*, 1996.

[3] A. S. Grimshaw. Easy to Use Object-Oriented Parallel Programing with Mentat. *IEEE Computer*, pp. 39–51, 1993.

[4] A. Grimshaw, W. Wulf, J. French, A. Weaver, and P. Reynolds, Jr. Legion: The Next Logical Step Toward a Nationalwide Virtual Computer. Technical Report CS-94-21, University of Virginia, 1994.

[5] S. Sekiguchi, M. Sato, H. Nakada, S. Matsuoka, and U. Nagashima. — Ninf —: Network based Information Library for Globally High Performance Computing. *Parallel Object-Oriented Methods and Applications, Santa Fe*, 1996.

[6] Kazuyuki Shudoh and Youichi Muraoka. http://www.muraoka.info.waseda.ac.jp/sc96/, 1996.

[7] 4X8}CR;L, CfED=(4p, :4F#;05W, D9Eh1@J<, >>2,Ao. %M%C%H%o!<%/?tCM>pJs%i%$%V%i%j Ninf - %7%9%F%`<BAu$HI>2A. >pJs=hM}3X2q8&5fJs9p 96-HPC-62, pp. 153–158, 1996.

[8] :4F#;05W, CfED=(4p, 4X8}CR;L, >>2,Ao, D9Eh1@J<, 9bLZ9@8w. Ninf: World-Wide Computing ;X8~$N%M%C%H%o!<%/?tCM>pJs%i%$%V%i%j. %$%s%?!<%M%C%H%3%s%U%!%l%s%9'96 O@J8=8, pp. 73–80, 1996.

[9] CfED=(4p, :4F#;05W, 4X8}CR;L. %M%C%H%o!<%/?tCM>pJs%i%$%V%i%j Ninf N?aN RPC %7%9%F%`$N 35MW. Technical Report TR95-28, EE;R5;=QAm9g8&5f=j, 1995.

[10] CfED=(4p, ApLn5.G7, >>2,Ao, 4X8}CR;L, :4F#;05W. %M%C%H%o!<%/?tCM>pJs%i%$%V%i%j Ninf K*1k%a%?%5!<%P%"!<%-%F%/%A%c. >pJs=hM}3X2q8&5fJs9p 96-HPC-60, 1996.