Star-P®: Multilingual Platform for High Performance Computing

Alan Edelman
Massachusetts Institute of Technology
Professor of Applied Mathematics
Computer Science and AI Laboratories
Interactive Supercomputing  Chief Science Officer

Trademark Usage Notice: STAR-P® and the "star" logo are registered trademarks of Interactive Supercomputing, Inc.  MATLAB® is a registered trademark of The MathWorks, Inc. Other product or brand names are trademarks or registered trademarks of their respective holders.  ISC's products are not sponsored or endorsed by The Mathworks, Inc. or by any other trademark owner referred to in this document.
Star-P Functional Overview
Star-P Functional Overview

Very High Level Language
Star-P Functional Overview
Multilingual Computing

- As ISC built the multilingual platform, what did we learn?
Multilingual Computing

- As ISC built the multilingual platform, what did we learn?

  - All languages sort of the same
  - All languages sort of different
    - Time is ripe for standards
    - MATLAB® historical shining leader in floating point, IEEE 754, now time to go beyond floating point.
Research @ISC

- Stream processing

- Hardware Accelerators: FPGAs, GPUs
Multilingual Examples

• Wigner’s Semicircle Law
Example: Star-P with the M language of Mathworks MATLAB®

```matlab
>> n=2000;
>> a=randn(n,p); s=(a+a')/(sqrt(8*n)); e=eig(s,'sym');
>> [y,x]=hist(ppfront(e),25); bar(x, (y/n)/(x(2)-x(1)))
>> x=-1:.01:1; hold on; plot(x,(2/pi)*sqrt(1-x.^2),'r','LineWidth',5)
```
Example: Star-P with Python®

```python
import starp, numpy, pylab, matplotlib

starp.defaultConnect('kong', '/usr/local/starp-versions/7790', nodashboard=1)

n = 2000
a = starp.random.randn(n, n)
s = (a+a.T)/numpy.sqrt(8*n)
e = starp.linalg.eigvals(s)

# Create histogram plot
x = numpy.linspace(-1, 1, 21)-.04
(h, bins) = starp.histogram(e, 21, normed=True)
pylab.bar(x, h.ppfront(), width = 0.08)

# Create solid line
y = (2/numpy.pi)*numpy.sqrt(1 - x*x)
pylab.plot(x, y, 'r', lw=3)

# Show plots
pylab.show()
```
Example: Star-P with R®

(In Development)

R is a collaborative project with many contributors.
Type 'contributors()' for more info.
Type 'citation()' on how to cite R or R packages.
Type 'demo()' for some demos, 'help()' for help.
Type 'help.start()' for an HTML browseable help
database with searching capability.
Type 'q()' to quit R.

> n<2000;
> a<-matrix(rnorm(n*n),ncol=n*p);s<-(a+t(a))/sqrt(8*n);
> e=eigen(s,symmetric=T,only.values=T)$values;
> hist(e,25,freq=F,col='blue');curve((2/pi)*sqrt(1-x^2),-1,1,col='red',lwd=5,add=T)
Example: Star-P with Mathematica®
(In Development)

```
<< Statistics`NormalDistribution`
<< Graphics`Graphics`
n = 2000;
a = RandomArray[NormalDistribution[], {n, n*P}];
s = (a + Transpose[a]) / Sqrt[8 * n];
e = Eigenvalues[s];

In[56]:= hist = Histogram[e, HistogramCategories -> 25, HistogramScale -> 1];
semicircle = Plot[(2/Pi)*Sqrt[1 - x^2], {x, -1, 1}, DefaultColor -> Red];
Show[hist, semicircle]
```
The need for language standards

The views here are my own at the moment and not that of ISC or the NMC, but based heavily on what I have learned from the experience of these groups.

The “transparent market” for high level languages

IEEE 754 story for floating point Needs repetition for library functions

Goals
1. Some mathematical standards are set by mathematics e.g. prod([])=1 other answers just wrong
2. Some standards are arbitrary and some committee ought to fix
3. Some should allow for a portfolio of solutions, nobody should dictate and users should be able to readily compare – main point: more information

Optimization is my “poster child” example. Need a consumer magazine style comparison.
Cholesky: upper or lower?

Answer: It doesn’t matter of course, but
Cholesky: upper or lower?

Answer: It doesn’t matter of course, but

```matlab
>> chol(a)
ans =
    9.9970    0.0380   -0.1875    0.0569    0.0315    0.0212    0.0088
     0    9.9493    0.0438   -0.0259    0.1450    0.0238   -0.0639
     0     0    10.0428   -0.0364   -0.0350   -0.1001   -0.0553
     0     0     0    9.9849    0.0625   -0.0747    0.0440
     0     0     0     0    10.0385    0.1075   -0.0942
     0     0     0     0     0    9.9920    0.0791
     0     0     0     0     0     0    10.0272
```
Sorting

$\gg x=[-1 \ 1 \ 2]$ 
$x = \\
-1 \ 1 \ 2$ 
$\gg$ sort($x$) 
$ans = \\
-1 \ 1 \ 2$ 

$\gg x=[-1 \ 1 \ 2i]$ 
$x = \\
-1.0000 \quad 1.0000 \quad 0 + 2.0000i$ 
$\gg$ sort($x$) 
$ans = \\
1.0000 \quad -1.0000 \quad 0 + 2.0000i$ 

$\gg 1 < (2i)$ 
$ans = \\
0$ 

$\gg 1 > (2i)$ 
$ans = \\
0$ 

$\gg$ max($1,i$) 
$ans = \\
1$ 

$\gg$ min($1,i$) 
$ans = \\
1$ 

$\gg$ max($i,1$) 
$ans = \\
0 + 1.0000i$ 

$\gg$ min($i,1$) 
$ans = \\
0 + 1.0000i$ 

$\gg a=[-2 \ -1 \ 1 \ 2 \ 3]$; roots(poly($a$))' 
$ans = \\
3.0000 \quad -2.0000 \quad -1.0000 \quad 2.0000 \quad 1.0000$
Branch cuts

- Arctan(i*x) (for x large)
  pi/2 or –pi/2 ??

- Standard proposes counterclockwise continuity

```matlab
>> atan( i * 1e100 )
an =
1.5708 + 0.0000i
```

```matlab
>> atan( i * 1e200 )
an =
-1.5708 + 0.0000i
```
Conclusions

• Star-P Multilingual Platform
  – MATLAB®, Python®, R®
• All functionality available from all languages!
• Organizations want multilingual service, individuals often do not realize they can have choice, but the “download, next, next, next” languages are catching on

• Visit ISC at booth 370.