

HP-CAST, June 15, 2013

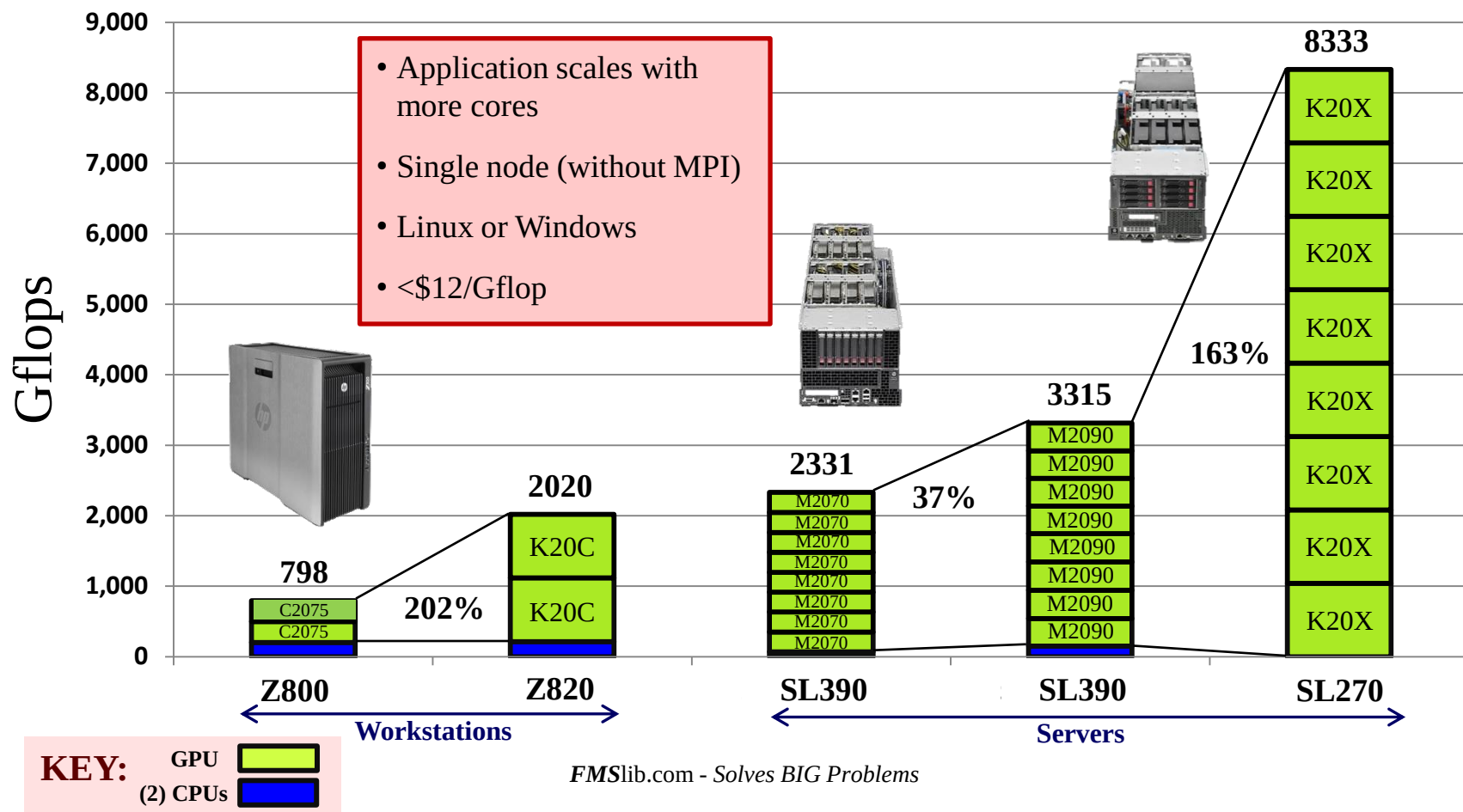
Dr. Ronald Young

Achieving Outstanding Performance
on NVIDIA K20 Accelerators
in HP Z820 Workstations and SL270 Servers

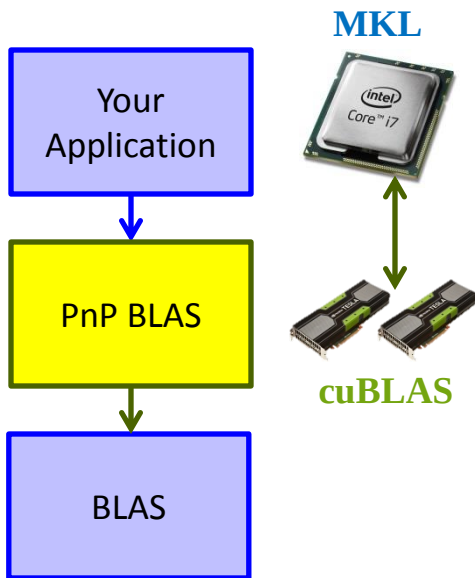
Focusing on:

1. Performance
2. Plug-and-Play BLAS Library
3. **[Matrix]Warrior**

Part 1: Performance



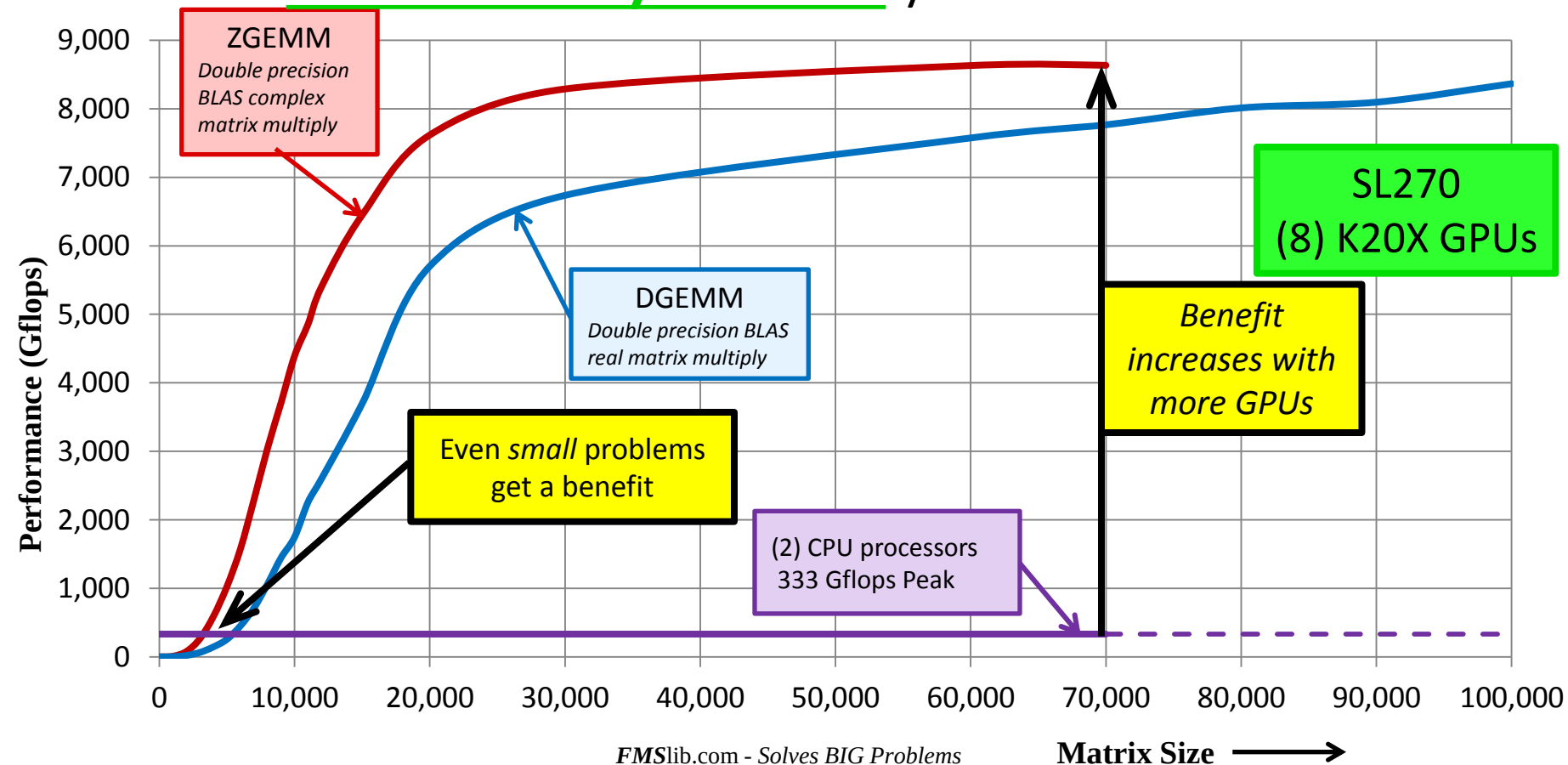
Part 2: Plug-and-Play BLAS



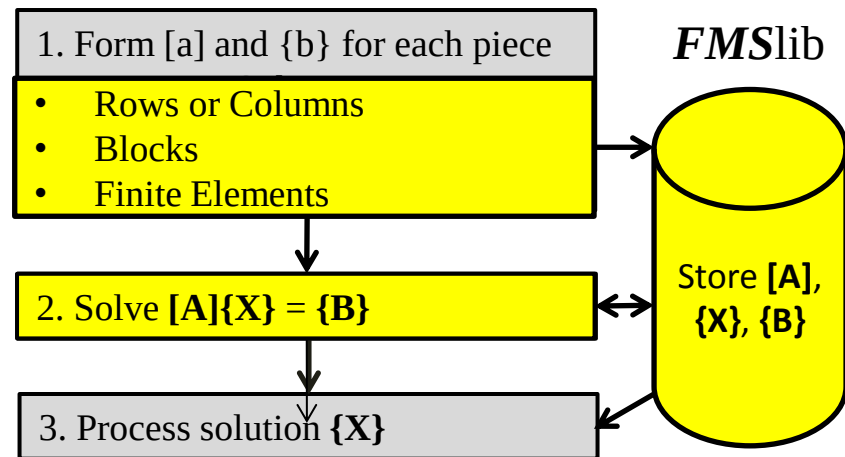
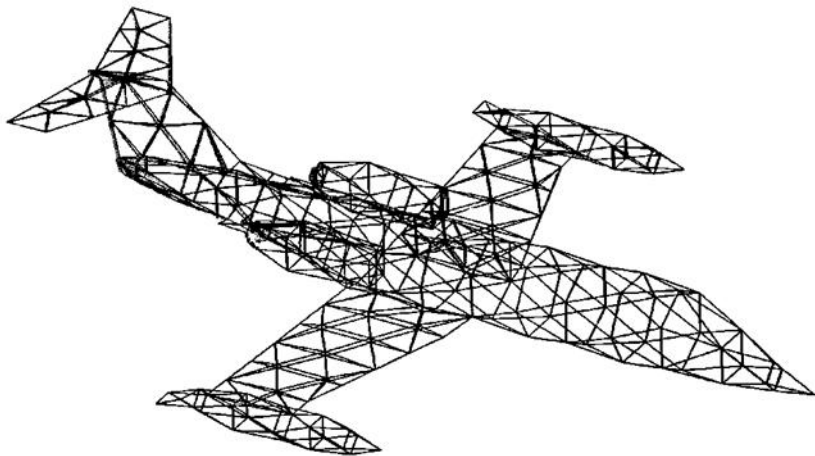
- No programming (same as installing a video card)
- Automatically detects GPUs
- Divides work between CPUs and GPUs (adjusted dynamically at run time)
- Transfers data to/from GPUs (overlapped with processing)
- Linux or Windows
- Uses latest version of **MKL** and **cuBLAS**
- Works on each node of a cluster

Part 2: Plug-and-Play BLAS

Automatically increase your BLAS Performance



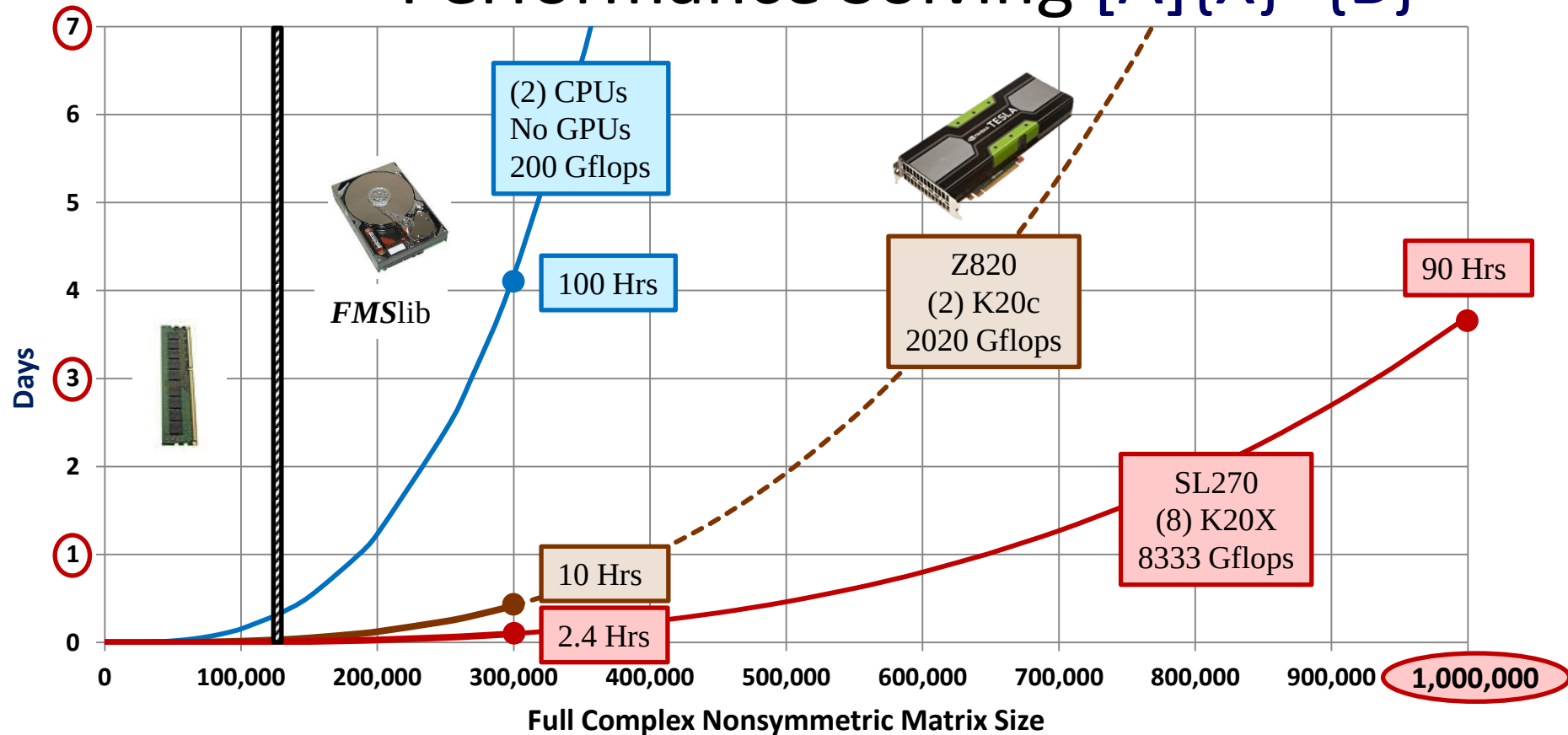
Using PnP BLAS



Part 3: **[Matrix]Warrior**

[Matrix]Warrior			
<i>FMSlib</i>			
PnPBLAS		IO	Display
MKL	cuBLAS		

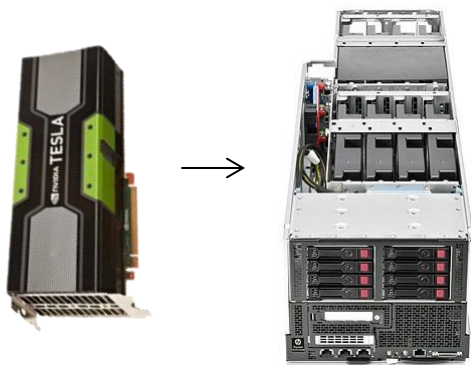
1. Form $[A]$, $\{B\}$ with test data
2. Solve $[A]\{X\}=\{B\}$

Performance Solving $[A]\{X\}=\{B\}$ 

FMSlib Performance History 1978-present



Machine	Year	Flops	\$/Gflop
DEC VAX	1978	97,000	2,000,000,000



(8) NVIDIA GPUs	2013	8,333,000,000,000	12
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86 Million times faster!
166 Million times cheaper!

Part 3: **[Matrix]Warrior**

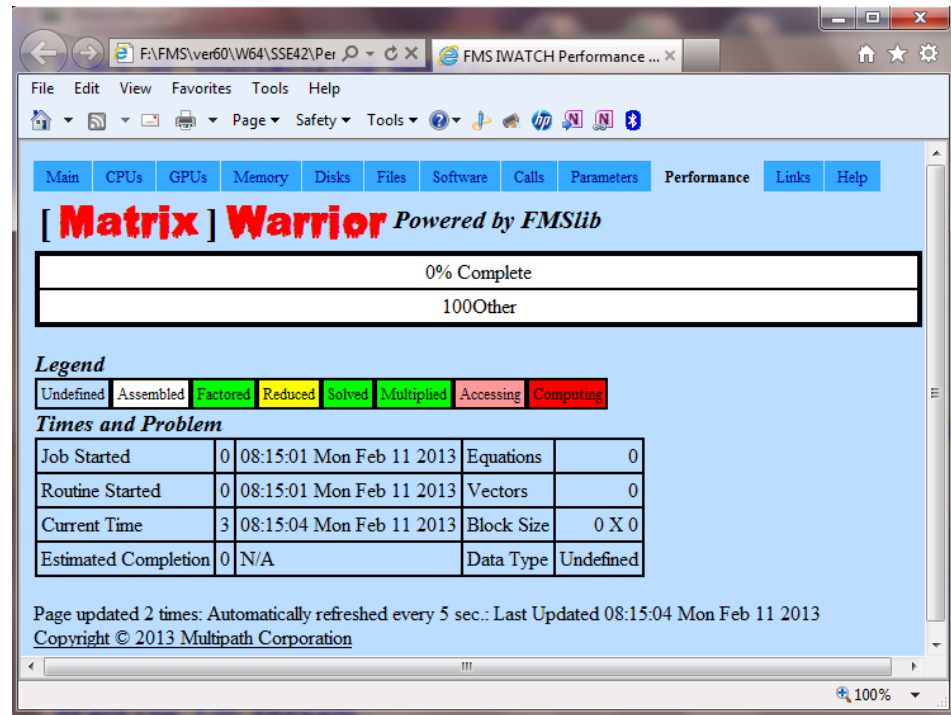
[Matrix]Warrior is an application that can:

1. Demonstrate machine performance
(Easily change CPUs, GPUs, Memory, Disks)
2. Benchmark different machine configurations
3. Burn-in a new machine
4. Serve as a hardware acceptance test
5. Validate new hardware designs
6. Demonstrate state-of-the-art performance for direct matrix solutions.
7. Facilitate teaching matrix algebra and computer science

Part 3: **[Matrix]Warrior**

Running **[Matrix]Warrior**

Do you want to open your browser to view them(y or n)[Y]?>



The screenshot shows a web browser window displaying the FMSlib Performance Monitor interface. The browser's address bar shows the file path F:\FMS\ver60\W64\SSE42\Per. The page has a blue header with navigation tabs: Main, CPUs, GPUs, Memory, Disks, Files, Software, Calls, Parameters, Performance (selected), Links, and Help. Below the header, the title is "[Matrix] Warrior Powered by FMSlib". A progress bar indicates "0% Complete" and "100Other". A legend section shows various status colors: Undefined, Assembled, Factored, Reduced, Solved, Multiplied, Accessing, and Computing. Below the legend is a table titled "Times and Problem".

Times and Problem				
Job Started	0	08:15:01 Mon Feb 11 2013	Equations	0
Routine Started	0	08:15:01 Mon Feb 11 2013	Vectors	0
Current Time	3	08:15:04 Mon Feb 11 2013	Block Size	0 X 0
Estimated Completion	0	N/A	Data Type	Undefined

Page updated 2 times: Automatically refreshed every 5 sec.: Last Updated 08:15:04 Mon Feb 11 2013
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Part 3: **[Matrix]Warrior**

Running **[Matrix]Warrior**

Do you want to open your browser to view them(y or n)**[Y]!>**

Enter the type of matrix you want to solve (1 to 5)

1 = Real Symmetric

2 = Real Nonsymmetric

3 = Complex Hermitian

4 = Complex Symmetric

5 = Complex Nonsymmetric

(1-5)**[5]>**

	Storage	Processing
1. Real Symmetric	1	1
2. Real Nonsymmetric	2	2
3. Complex Hermitian	2	4
4. Complex Symmetric	2	4
5. Complex Nonsymmetric	4	8

Part 3: **[Matrix]Warrior**

Running **[Matrix]Warrior**

Do you want to open your browser to view them(y or n)[Y]?>

Enter the type of matrix you want to solve (1 to 5)

1 = Real Symmetric

2 = Real Nonsymmetric

3 = Complex Hermitian

4 = Complex Symmetric

5 = Complex Nonsymmetric

(1-5)[5]>

Do you want to use disks(y or n)[N]?>

Top 500
Benchmark



Part 3: **[Matrix]Warrior**

Running **[Matrix]Warrior**

Do you want to open your browser to view them(y or n)[Y]?>

Enter the type of matrix you want to solve (1 to 5)

1 = Real Symmetric

2 = Real Nonsymmetric

3 = Complex Hermitian

4 = Complex Symmetric

5 = Complex Nonsymmetric

(1-5)[5]>

Computed from:

- Data Type & Matrix Symmetry (1-5)
- Storage Location (Memory, Disk)

Do you want to use disks(y or n)[N]?>

Enter the size of the matrix [12676]>5000

A_{11}	A_{12}	A_{13}	...	A_{1n}
A_{21}	A_{22}	A_{23}	...	A_{2n}
...	...	...	...	...
A_{n1}	A_{n2}	A_{n3}	...	A_{nn}

Part 3: **[Matrix]Warrior**

Running **[Matrix]Warrior**

Do you want to open your browser to view them(y or n) **[Y]**?>

Enter the type of matrix you want to solve (1 to 5)

1 = Real Symmetric

2 = Real Nonsymmetric

3 = Complex Hermitian

4 = Complex Symmetric

5 = Complex Nonsymmetric

(1-5)**[5]**>

Do you want to use disks(y or n) **[N]**?>

Enter the size of the matrix **[12676]**>5000

Enter the number of solution vectors **[0]**>

$$\begin{bmatrix} A_{11} & A_{12} & A_{13} & \dots & A_{1n} \\ A_{21} & A_{22} & A_{23} & \dots & A_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ A_{n1} & A_{n2} & A_{n3} & \dots & A_{nn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \dots \\ X_n \end{bmatrix} = \begin{bmatrix} B_1 \\ B_2 \\ \dots \\ B_n \end{bmatrix}$$

Part 3: **[Matrix]Warrior**

Running **[Matrix]Warrior**

Do you want to open your browser to view them(y or n) **[Y]**?>

Enter the type of matrix you want to solve (1 to 5)

1 = Real Symmetric

2 = Real Nonsymmetric

3 = Complex Hermitian

4 = Complex Symmetric

5 = Complex Nonsymmetric

(1-5)**[5]**>

Do you want to use disks(y or n) **[N]**?>

Enter the size of the matrix **[12676]**>5000

Enter the number of solution vectors **[0]**>

You may now alter any FMS Parameter.

When you are finished, type the letters RETURN

FMSSET>

$$\begin{bmatrix} A_{11} & A_{12} & A_{13} & \dots & A_{1n} \\ A_{21} & A_{22} & A_{23} & \dots & A_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ A_{n1} & A_{n2} & A_{n3} & \dots & A_{nn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \dots \\ X_n \end{bmatrix} = \begin{bmatrix} B_1 \\ B_2 \\ \dots \\ B_n \end{bmatrix}$$

<http://www.fmslib.com/fmsman/doc/parameters.html>

The screenshot shows a web browser window with the URL <http://www.fmslib.com/fmsman/doc/parameters.html>. The page has a navigation bar at the top with buttons for HOME, UP, PREVIOUS, and NEXT. The main heading is "D. FMS Parameters". Below it is a list of 11 links, each preceded by a bullet point. Red arrows point from the text on the right to the following links: "D1. Hardware Parameters", "D2. GPU Parameters", and "D5. Printing and Performance Report Parameters". At the bottom of the page, there is another set of navigation buttons (HOME, UP, PREVIOUS, NEXT) and a copyright notice: "Copyright © Multipath Corporation".

HOME UP PREVIOUS NEXT

D. FMS Parameters

- [D1. Hardware Parameters](#)
- [D2. GPU Parameters](#)
- [D3. NUMA Parameters](#)
- [D4. File Parameters](#)
- [D5. Printing and Performance Report Parameters](#)
- [D6. Matrix File Initialization Parameters](#)
- [D7. Matrix Assembly Parameters](#)
- [D8. Matrix Factoring Parameters](#)
- [D9. Solving Parameters](#)
- [D10. Multiply Parameters](#)
- [D11. Error Handling Parameters](#)

HOME UP PREVIOUS NEXT

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Hardware Parameters:

MAXCPU (Number of CPU cores to use)

MEMPCT (% of system memory to use)

GPU Parameters:

MAXGPU (Number of GPUs to use)

IMMPCT, ITRPCT (% of work done by CPUs)

GPUCPU (Bind GPU threads to CPU cores)

Performance Report Parameters:

IWATCH (Set WEB report options)

SHOW (Just enter for options)

[Matrix]Warrior

	1% Complete	
	33% Other	67% DIA

Routine	All	CPU's	GPU 1	GPU 2
Routine Overall	487	5	266	257

Undefined	Assembled	Factored	Reduced	Solved	Multiplied	Accessing	Computing
-----------	-----------	----------	---------	--------	------------	-----------	-----------

Times and Problem

I/O Compute Ratio

Page updated 5 times: Automatically refreshed every 10 sec.: Last Updated 12:43:02 Wed Mar 13 2013
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Status Bar
% Time

Performance

Application
specific
graphic

Part 3:

[Matrix]Warrior

[Matrix] Warrior Powered by FMSlib

Performance Analysis for Subroutine **CNDF** ; Time used=02:41

24% Complete				
9% I/O	8% Other	31% MM	39% TR	13% DIA

Performance (Gflops)

Routine	All	CPU's	GPU 1	GPU 2
Routine Overall	605	24	308	304

Legend

Undefined	Assembled	Factored	Reduced	Solved	Multiplied	Accessing	Computing
-----------	-----------	----------	---------	--------	------------	-----------	-----------

L1,1	U1,2	U1,3	A1,4
L2,1	L2,2	M2,3	A2,4
L3,1	L3,2	A3,3	A3,4
A4,1	A4,2	A4,3	A4,4

Times and Problem

Job Started	0	12:42:02 Wed Mar 13 2013	Equations	50000
Routine Started	43	12:42:46 Wed Mar 13 2013	Vectors	0
Current Time	204	12:45:26 Wed Mar 13 2013	Block Size	12544 X 12544
Estimated Completion	701	12:53:43 Wed Mar 13 2013	Data Type	Complex

I/O Compute Ratio

Compute Rate (Gflops)	605
Read Rate (MBytes/Sec.)	0
Reuse	25088
IO Compute Ratio	0.00

Part 3:

[Matrix]Warrior

[Matrix] Warrior Powered by FMSlib

Performance Analysis for Subroutine **CNDF** ; Time used=04:10

				41% Complete	
6% I/O	6% Other	49% MM		30% TR	8% DIA

Performance (Gflops)

Routine	All	CPU's	GPU 1	GPU 2
Routine Overall	618	24	310	306

Legend

Undefined	Assembled	Factored	Reduced	Solved	Multiplied	Accessing	Computing
-----------	-----------	----------	---------	--------	------------	-----------	-----------

L1,1	U1,2	U1,3	A1,4
L2,1	L2,2	U2,3	A2,4
L3,1	L3,2	D3,3	A3,4
A4,1	A4,2	A4,3	A4,4

Times and Problem

Job Started	0	12:42:02 Wed Mar 13 2013	Equations	50000
Routine Started	43	12:42:46 Wed Mar 13 2013	Vectors	0
Current Time	293	12:46:56 Wed Mar 13 2013	Block Size	12544 X 12544
Estimated Completion	652	12:52:55 Wed Mar 13 2013	Data Type	Complex

I/O Compute Ratio

Compute Rate (Gflops)	618
Read Rate (MBytes/Sec.)	0
Reuse	25088
IO Compute Ratio	0.00

Part 3:

[Matrix]Warrior

[**Matrix**] **Warrior** *Powered by FMSlib*

Performance Analysis for Subroutine **CNDF** ; Time used=05:05

				49% Complete	
7% I/O	6% Other	48% MM		28% TR	10% DIA

Performance (Gflops)

Routine	All	CPU's	GPU 1	GPU 2
Routine Overall	618	24	311	307

Legend

Undefined	Assembled	Factored	Reduced	Solved	Multiplied	Accessing	Computing
-----------	-----------	----------	---------	--------	------------	-----------	-----------

L1,1	U1,2	U1,3	A1,4
L2,1	L2,2	U2,3	A2,4
L3,1	L3,2	L3,3	A3,4
L4,1	T4,2	A4,3	A4,4

Times and Problem

Job Started	0	12:42:02 Wed Mar 13 2013	Equations	50000
Routine Started	43	12:42:46 Wed Mar 13 2013	Vectors	0
Current Time	348	12:47:50 Wed Mar 13 2013	Block Size	12544 X 12544
Estimated Completion	657	12:53:00 Wed Mar 13 2013	Data Type	Complex

I/O Compute Ratio

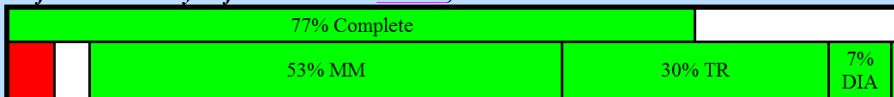
Compute Rate (Gflops)	618
Read Rate (MBytes/Sec.)	0
Reuse	25088
IO Compute Ratio	0.00

Part 3:

[Matrix]Warrior

[**Matrix**] **Warrior** *Powered by FMSlib*

Performance Analysis for Subroutine **CNDF** ; Time used=07:27



Performance (Gflops)

Routine	All	CPU's	GPU 1	GPU 2
Routine Overall	633	24	315	312

Legend

Undefined	Assembled	Factored	Reduced	Solved	Multiplied	Accessing	Computing
-----------	-----------	----------	---------	--------	------------	-----------	-----------

L1,1	U1,2	U1,3	U1,4
L2,1	L2,2	U2,3	U2,4
L3,1	L3,2	L3,3	M3,4
L4,1	L4,2	L4,3	A4,4

Times and Problem

Job Started	0	12:42:02 Wed Mar 13 2013	Equations	50000
Routine Started	43	12:42:46 Wed Mar 13 2013	Vectors	0
Current Time	491	12:50:13 Wed Mar 13 2013	Block Size	12544 X 12544
Estimated Completion	619	12:52:22 Wed Mar 13 2013	Data Type	Complex

I/O Compute Ratio

Compute Rate (Gflops)	633
Read Rate (MBytes/Sec.)	0
Reuse	25088
IO Compute Ratio	0.00

Part 3:

[Matrix]Warrior

[**Matrix**] **Warrior** Powered by FMSlib

Performance Analysis for Subroutine **CNDF** ; Time used=09:44

COMPLETED			
6% I/O		57% MM	25% TR
			7% DIA

Performance (Gflops)

Routine	All	CPU's	GPU 1	GPU 2
Routine Overall	633	24	315	311

Legend

Undefined	Assembled	Factored	Reduced	Solved	Multiplied	Accessing	Computing
-----------	-----------	----------	---------	--------	------------	-----------	-----------

L1,1	U1,2	U1,3	U1,4
L2,1	L2,2	U2,3	U2,4
L3,1	L3,2	L3,3	U3,4
L4,1	L4,2	L4,3	L4,4

Times and Problem

Job Started	0	12:42:02 Wed Mar 13 2013	Equations	50000
Routine Started	43	12:42:46 Wed Mar 13 2013	Vectors	0
Current Time	627	12:52:30 Wed Mar 13 2013	Block Size	12544 X 12544
Estimated Completion	627	12:52:30 Wed Mar 13 2013	Data Type	Complex

I/O Compute Ratio

Compute Rate (Gflops)	633
Read Rate (MBytes/Sec.)	341
Reuse	25088
IO Compute Ratio	1.69

More Information fmslib.com

FREE Download
[Matrix]Warrior

NVIDIA GTC Presentations
[Matrix]Warrior
FMSlib

Fast Matrix Solver



World's fastest solutions for

$$[A]\{X\} = \{B\}$$

Now Available Free

[Matrix] Warrior

MANUAL

CONTACT

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[MATRIX] WARRIOR

FMSLIB

Watch Presentations

NVIDIA GPU Technology Conference

Mar 21, 2013

Benchmark your GPUs with MatrixWarrior

May 17, 2012

Teraflop GPU Acceleration Of Large Matrix Algebra

DESCRIPTION

WHY FMS?

WHY GPUS?

WHY DISKS?

APPLICATIONS

BENEFITS

FEATURES

EASE OF USE

BENCHMARKS