

IMSL[®] Libraries Accelerated with the ClearSpeed[™] Advance Accelerators

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Visual Numerics, Inc.

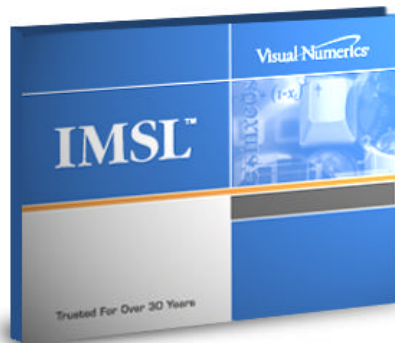
ClearSpeed User Group

June 16, 2008

Outline

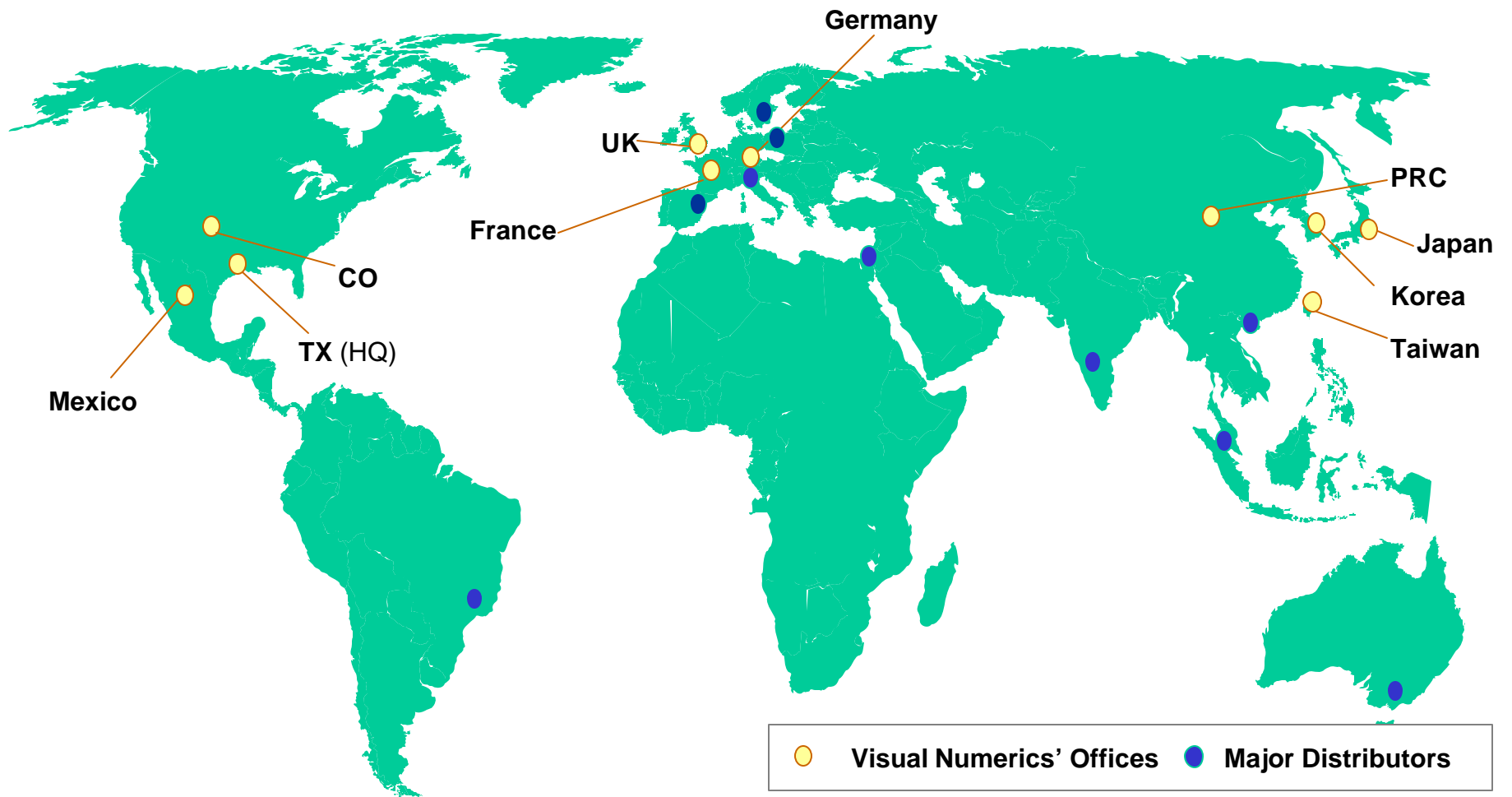
- Brief Visual Numerics Introduction
- IMSL[®] Numerical Library
- Linking IMSL C Numerical Library and ClearSpeed[™]
- Accelerated functions
 - Benchmark results
- Additional information
 - Resources
 - Expanding coverage

Developers of IMSL Libraries and PV-WAVE



- **IMSL™ Numerical Libraries**
 - IMSL C Numerical Library
 - IMSL C# Numerical Library for Microsoft .NET Applications
 - JMSL™ Numerical Library for Java™ Applications
 - IMSL Fortran Numerical Library for HPC Applications
- **PV-WAVE® Family: Visual Data Analysis (VDA)**
 - PV-WAVE: Broad VDA functionality
 - TS-WAVE™: Advanced times series analysis
 - JWAVE™: Web-based functionality
- **Professional Services**
 - Broad range of technical expertise for building complex and custom numerical analysis and visualization solutions

Visual Numerics Global Footprint



Technical Expertise

- 620 years of platform development and language development
- 180 years of complex data analysis knowledge on staff with average tenure of 15 years at Visual Numerics
- *3000 mathematical and statistical algorithms and supporting utilities developed over 37 years
- 500 years of visualization development

* *Complex algorithms can take up to 3 years to build*

Typical IMSL[®] Library Techniques

Mathematics

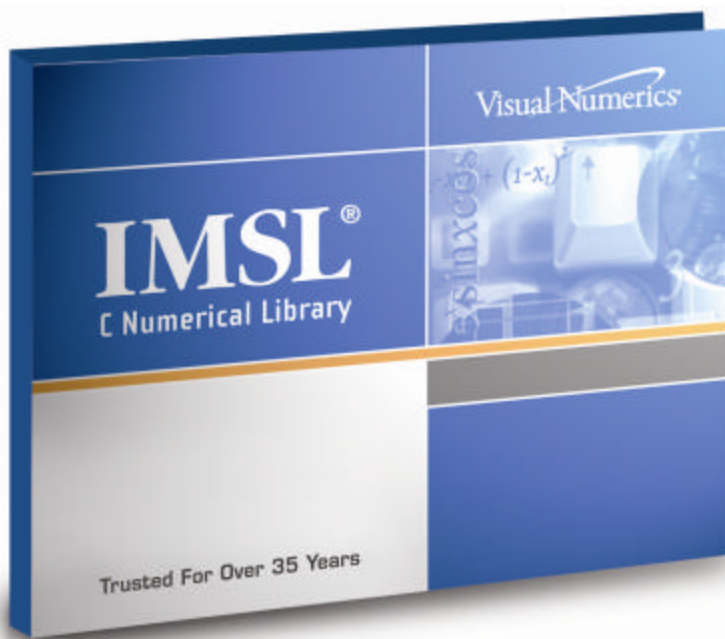
- Basic Types
- Linear Algebra
- Eigensystems
- Interpolation & Approximation
- Quadrature
- Differential Equations
- Nonlinear Equations
- Optimization
- Special Functions
- Finance & Bond Calculations

Statistics

- Basic Statistics
- Time Series & Forecasting
- Nonparametric Tests
- Correlation & Covariance
- Data Mining
- Regression
- Analysis of Variance
- Transforms
- Goodness of Fit
- Distribution Functions
- Random Number Generation
- Neural Networks

IMSL[®] C Numerical Library

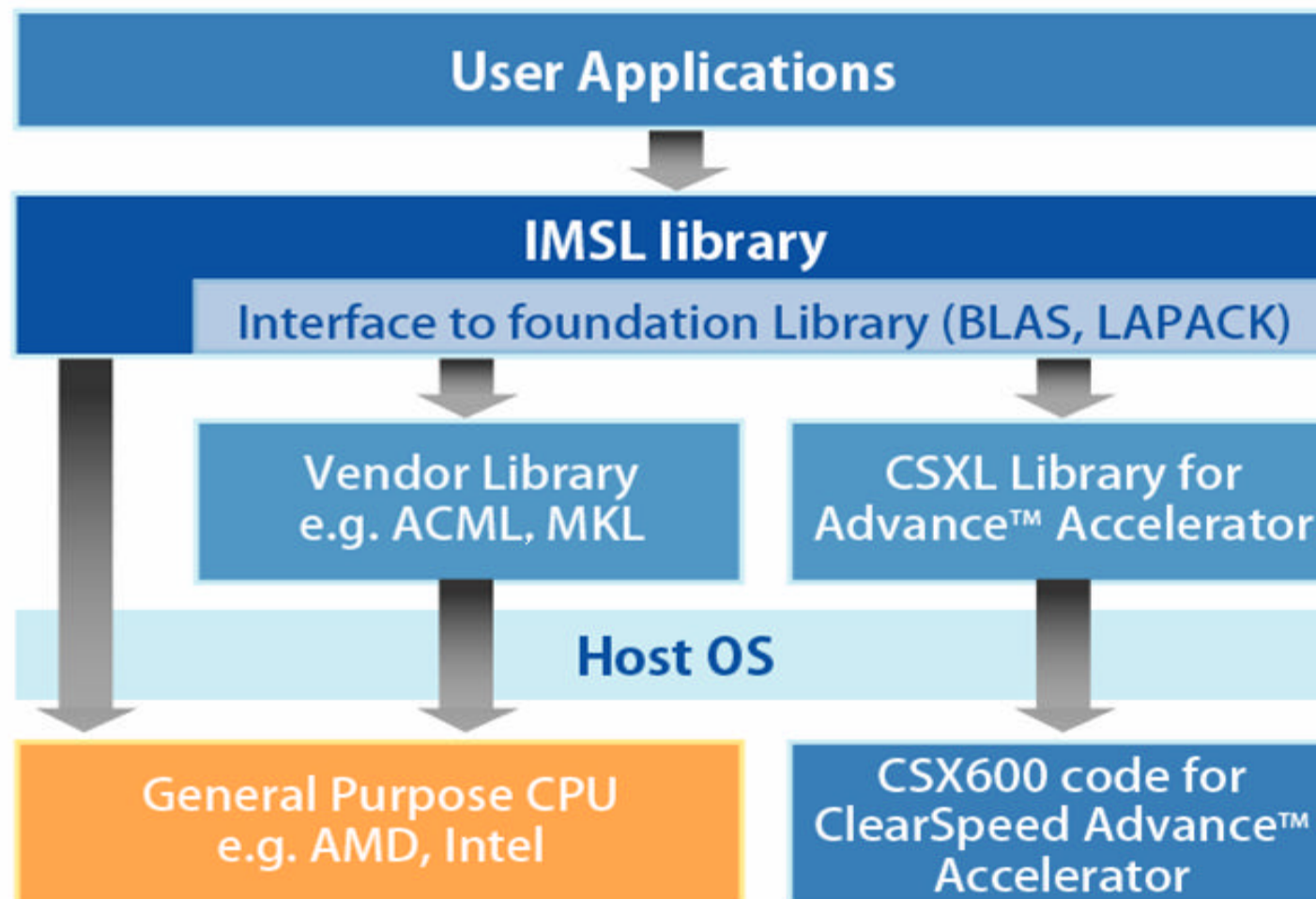
Overview



- Comprehensive libraries of mathematical, statistical, and financial numerical algorithms
- Native C library embeds easily in C/C++ programs
- Thread-Safe
- Leverages high performance vendor software
- Shared and Static versions

IMSL Library

Usage with ClearSpeed™



IMSL[®] C Numerical Library

Usage

Wide use of environment variables

- `icl $CFLAGS prog.c LINK_CNL_STATIC`
- `$LINK_CNL` includes all required libraries

Support for vendor supplied high performance libraries

- `icl $CFLAGS prog.c $LINK_CNL_SMP_STATIC`
- On Intel systems: Utilize MKL BLAS and LAPACK functions instead of IMSL versions

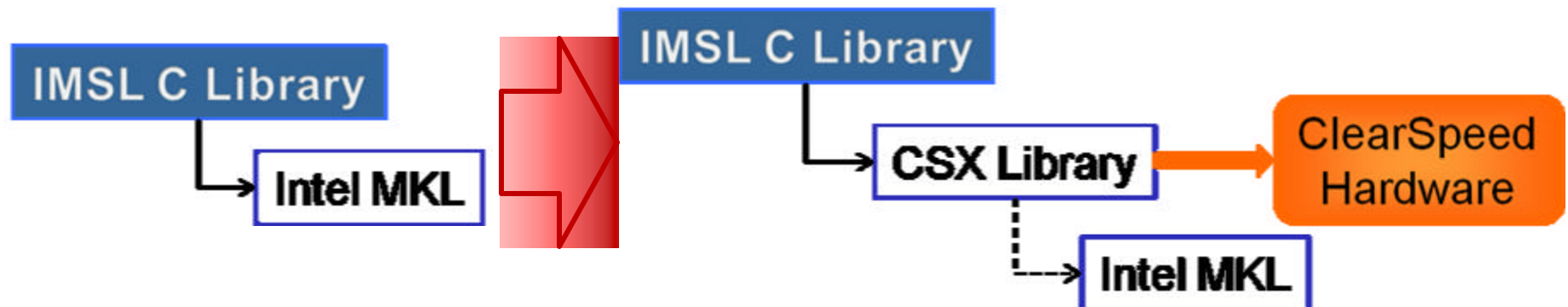
IMSL[®] C Numerical Library

Usage with ClearSpeed[™]

- Modify environment variables to pick up CSX libraries

add path: `-L/opt/clearspeed/.../lib`

add lib: `-lcsx1`



Complete description under Supported Platforms on VNI Forum

Accelerated Functions

ClearSpeed's CSXL accelerates a subset of the BLAS and LAPACK

- DGEMM, ZGEMM (matrix multiply)
- DTRSM (back solve)
- DGESV, DGETRF, DGETRS (General LU factor & solve)
- DPOSV, DPOTRF, DPOTRS (Positive Definite factor & solve)
- DGEQRF, DORGQR, DORMQR (orthogonal matrix factorization, generation, and multiply)

Accelerated Functions

- IMSL Linear Algebra functions utilize a wide variety of Level 1,2,3 BLAS and LAPACK
- Overlap with ClearSpeed routines include:
 - d_lin_sol_gen
 - d_lin_sol_posdef
 - d_lin_least_squares_gen
 - d_bounded_least_squares
 - d_nonlin_least_squares

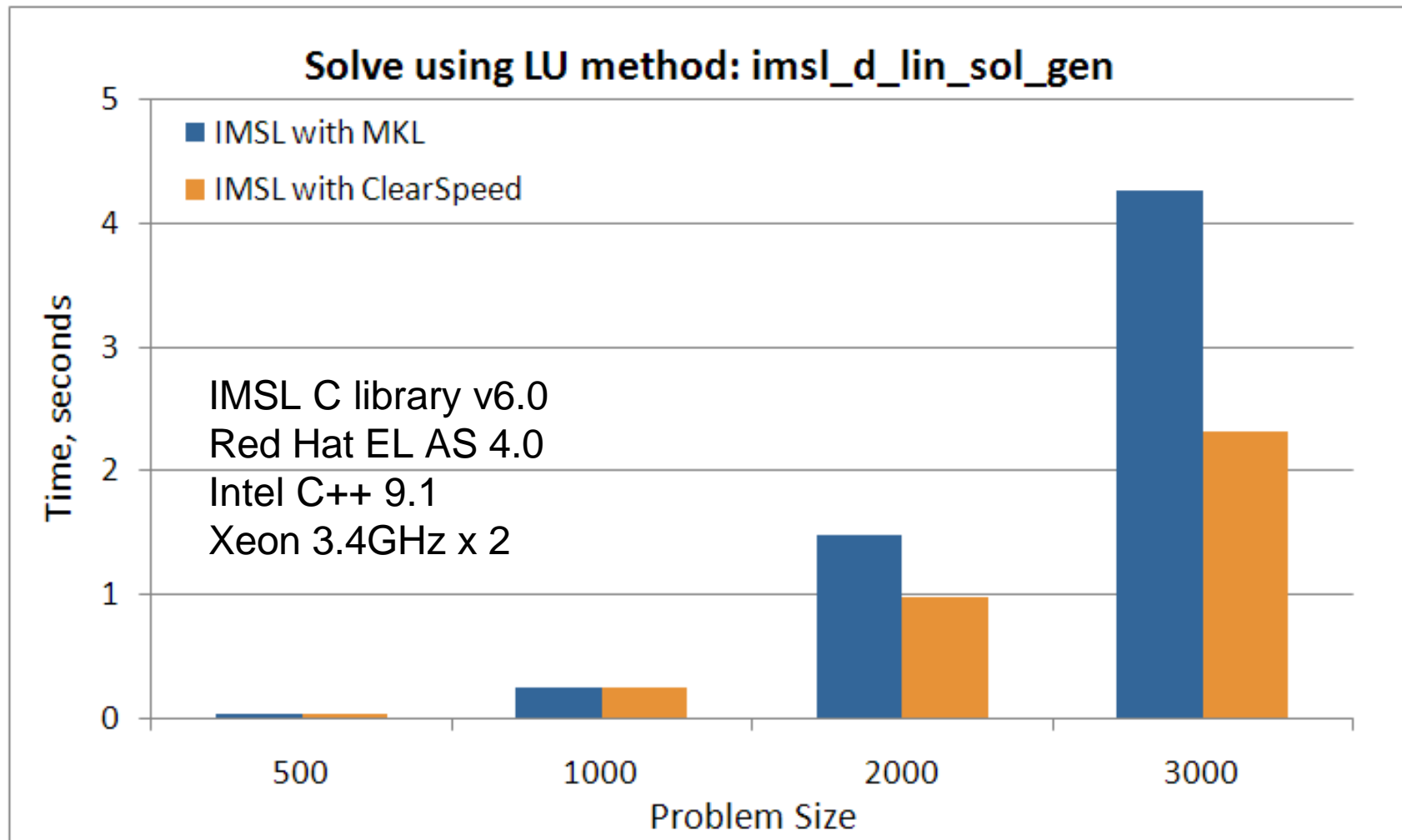
Accelerated Functions

- Some IMSL Library functions do not map directly but may see acceleration
 - z_lin_sol_gen (complex LU) for example
 - Several additional functions fall in this category, but the total number has not been researched

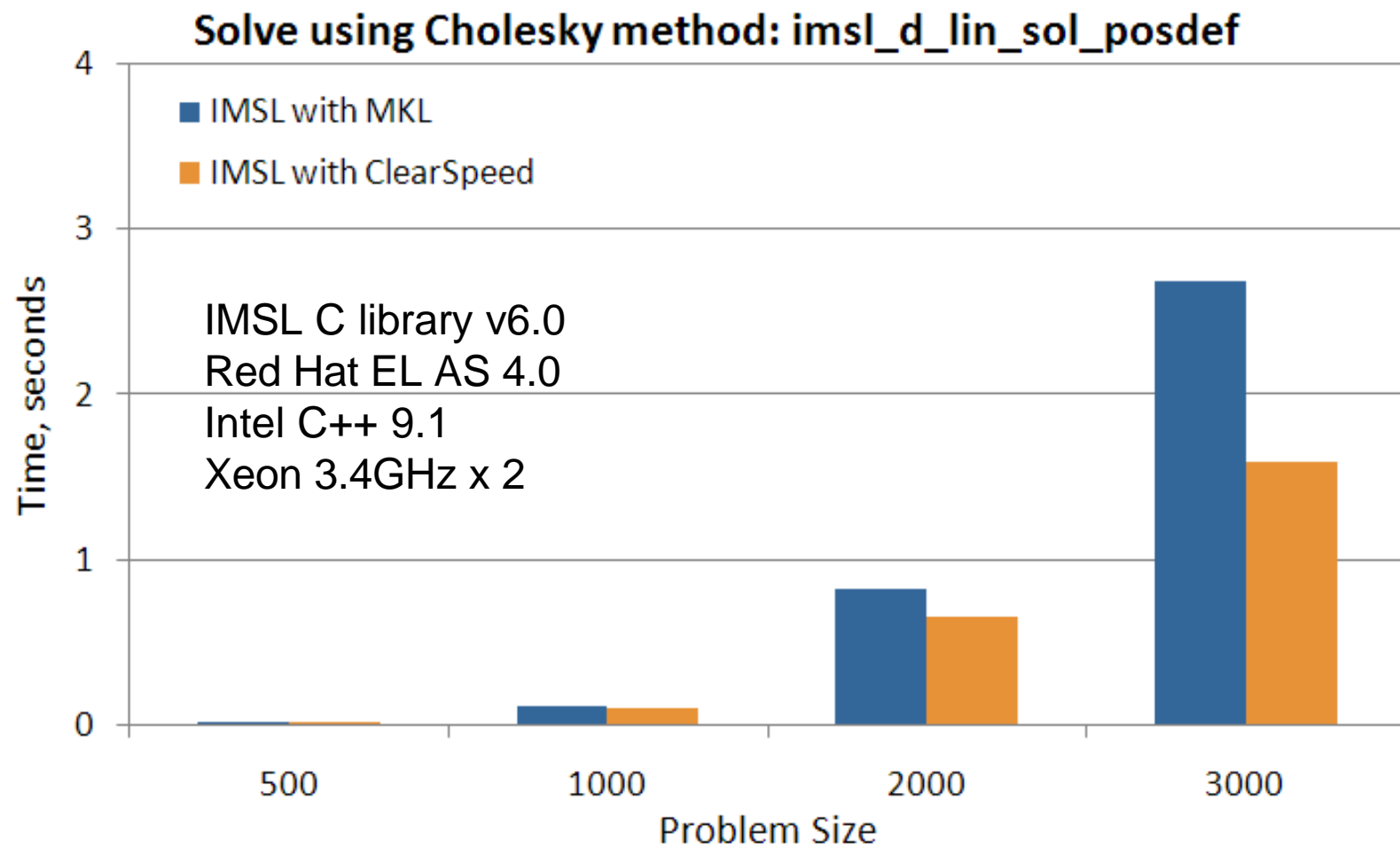
Benchmark Results

- Details of the system
 - IMSL C Numerical Library 6.0
 - Red Hat EL AS 4.0
 - Intel C++ 9.1
 - ClearSpeed system “cyclon”

LU Decomposition



Cholesky Factorization



Additional Resources

- IMSL C Numerical Library Product
 - www.vni.com
 - Documentation
 - Download for evaluation
 - Forum
- IMSL Library and ClearSpeed Details.pdf

Expanding Functionality

- Accelerated algorithm coverage can be achieved in two ways:
 - Additional BLAS and LAPACK support by the CSXL acceleration library
 - Re-write an IMSL Library algorithm source code using the ClearSpeed SDK and Cn compiler
 - Please contact Visual Numerics with information regarding this type of opportunity
 - Our Consulting Services arm could work with ClearSpeed engineers in this area

$$\frac{1}{n} \sum_{i=1}^n f_i(x)$$

Questions?

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