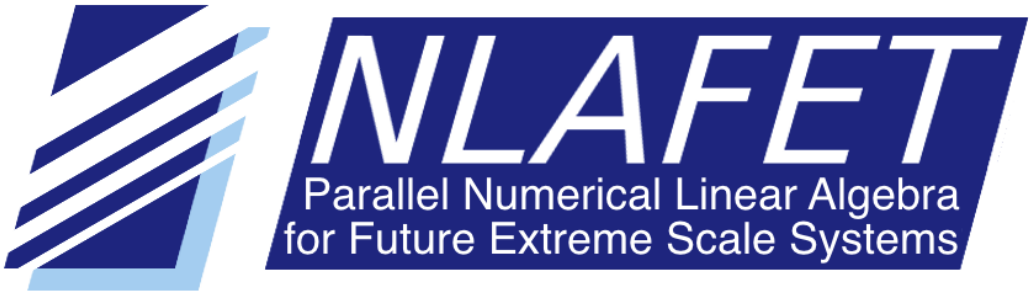

H2020-FETHPC-2014: GA 671633

D7.4
Dissemination report
Period M1-M18

April 2017

Document information

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PU – Public

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Date	Editor	Status	Version	Changes
2017-04-04	Lennart Edblom	Draft	0.1	First draft version
2017-04-07	Lennart Edblom and Bo Kågström	Draft	0.2	Draft for review and further input from NLAFET partners
2017-04-26	Lennart Edblom, Bo Kågström	Final	1.0	Revision including input from other partners

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Contributors

Team members from all partners have contributed to the content.

Copyright

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Table of Contents

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1. Introduction

The Description of Action document (GA Annex 1) states for deliverable D7.4:

"*D7.4: First dissemination report*
The first dissemination report covering M1-M18."

This deliverable is in the context of tasks 7.1-7.4 of WP7: *Dissemination and community outreach*.

The goal and main impact of NLAFET is to develop and deploy new algorithms, tools and library software that leading-edge applications need in order to attain high performance and thereby be able to utilize future extreme-scale systems effectively. To realize the expected impacts and to make NLAFET well known and recognized, we engage in relevant dissemination and outreach activities. Our stakeholders and audience include the world-wide scientific community, hardware and software vendors, application experts, and the general computing community.

In the following, we describe our efforts for achieving the objectives presented in the M3-deliverable D7.1 *Dissemination and community outreach plan*, and present the main results of the activities during the first 18 months.

2. Dissemination and outreach activities

This main section of the document is structured with respect to the four WP7 tasks: *Dissemination* (Task 7.1), *Website* (Task 7.2), *Open source activities* (7.3), and *Community outreach* (Task 7.4).

2.1. Dissemination (Task 7.1)

The dissemination activities reported here include information about public deliverables of the project, scientific publications, presentations at and organization of conferences, workshops, minisymposia, as well as some press releases.

Public NLAFET deliverables

All public deliverables are published on the website as soon as they are approved by the European Commission, and they will be available online at http://www.nlafet.eu/public-deliverables.

Up to now the following deliverable reports are published on the website:

- D7.1 Dissemination and community outreach plan (M3 - UMU)
- D7.2 Collaborative infrastructure (M3 - UMU)
- D7.3 Draft specification for Hybrid BLAS (M6 – UNIMAN))

The following deliverable documents will also be available as soon as they are approved:

- D2.3 Prototype software for different versions of the BLAS (M12 - UNIMAN)
- D4.1 Prototype software, phase 1 (M12 – INRIA)
- D2.1 One-sided matrix factorizations (M18 - UNIMAN)

D2.5 Eigenvalue problem solvers (M18 - UMU)
D2.8 Bi-diagonal factorization (M18 - UNIMAN)
D3.1 Theoretical bounds for communication in sparse operations (M18 - INRIA)
D3.4 Algorithm design for highly unsymmetric factorizations (M18 - STFC)
D4.2 Analysis and algorithm design (M18 - INRIA)
D5.1 Requirements analysis for applications (M18 - STFC)
D6.1 Prototypes for runtime systems exhibiting novel types of scheduling (M18 – UMU)
D6.4 An off-line auto-tuning framework based on heuristic search (M18 – UNIMAN)
D7.4 Dissemination report M1-M18 (M18 - UMU)
D7.5 Beta release of the NLAFET library - Prototype software - Part 1 (M18 – UMU)

Scientific publications - NLAFET Working Notes

In addition to the deliverable documents, progress and results of the NLAFET project are regularly published in the NLAFET Working Notes series. The listing below reflects the status as of April 2017. All reports are available online at http://www.nlafet.eu/working-notes/ .

WN1*:* Björn Adlerborn, Lars Karlsson, and Bo Kågström. Distributed One-Stage Hessenberg-Triangular Reduction with Wavefront Scheduling. *NLAFET Working Note WN-1*, May, 2016. Also as Report UMINF 16.10, Dept. of Computing Science, Umeå University, SE-901 87 Umeå, Sweden.

WN2: Björn Adlerborn, Bo Kågström, and Daniel Kressner. PDHGEQZ User Guide. *NLAFET Working Note WN-2*, May, 2016. Also as Report UMINF 15.12, Dept. of Computing Science, Umeå University, SE-901 87 Umeå, Sweden.

WN3: Laura Grigori, Sebastien Cayrols, and James W. Demmel. Low rank approximation of a sparse matrix based on LU factorization with column and row tournament pivoting. *NLAFET Working Note WN-3*, May, 2016. Also as INRIA Research Report 8910, Project Team Alpines, France.

WN4: Sven Hammarling. Workshop on Batched, Reproducible, and Reduced Precision BLAS. *NLAFET Working Note WN-4*, July, 2016. Also as MIMS EPrint 2016.41, Manchester Institute for Mathematical Sciences School of Mathematics, The University of Manchester, UK.

WN5: Samuel D. Relton, Pedro Valero-Lara, and Mawussi Zounon. A Comparison of Potential Interfaces for Batched BLAS Computations. *NLAFET Working Note WN-5*, August, 2016. Also as MIMS EPrint 2016.42, Manchester Institute for Mathematical Sciences School of Mathematics, The University of Manchester, UK.

WN6: Jonathan Hogg. A new sparse LDL^T solver using a posteriori threshold pivoting. *NLAFET Working Note WN-6*, November, 2016. Also as Technical Report RAL-TR-2016-017, Science & Technology Facilities Council, UK.

WN7: Iain Duff, Jonathan Hogg, and Florent Lopez. Experiments with sparse Cholesky using a sequential task-flow implementation. *NLAFET Working Note WN-7*, November, 2016. Also as Technical Report RAL-TR-2016-016, Science & Technology Facilities Council, UK.

WN8: Mahmoud Eljammaly, Lars Karlsson, and Bo Kågström. Evaluation of the Tunability of a New NUMA-Aware Hessenberg Reduction Algorithm. *NLAFET Working Note WN-8*, December, 2016. Also as Report UMINF 16.22, Dept. of Computing Science, Umeå University, SE-901 87 Umeå, Sweden.

WN9: Carl Christian Kjelgaard Mikkelsen and Lars Karlsson. Robust solution of triangular linear systems. *NLAFET Working Note WN-9*, March, 2017. Also as Report UMINF 17.09, Dept. of Computing Science, Umeå University, SE-901 87 Umeå, Sweden.

WN10: Björn Adlerborn, Carl Christian Kjelgaard Mikkelsen, Lars Karlsson, and Bo Kågström. Towards Highly Parallel and Compute-Bound Computation of Eigenvectors of Matrices in Schur Form. *NLAFET Working Note WN-10*, April, 2017. Also as Report UMINF 17.10, Dept. of Computing Science, Umeå University, SE-901 87 Umeå, Sweden.

WN11: Mirko Myllykoski, Carl Christian Kjelgaard Mikkelsen, Lars Karlsson, and Bo Kågström. Task-Based Parallel Algorithms for Reordering of Matrices in Real Schur Form. *NLAFET Working Note WN-11*, April, 2017. Also as Report UMINF 17.11, Dept. of Computing Science, Umeå University, SE-901 87 Umeå, Sweden.

WN12: Sven Hammarling: Second Workshop on Batched, Reproducible, and Reduced Precision BLAS. *NLAFET Working Note WN-12,* February 2017. Also as MIMIS EPrint 2017.14, Manchester Institute for Mathematical Sciences School of Mathematics, The University of Manchester, UK.

WN13: Laura Grigori, Olivier Tissot. Reducing the communication and computational costs of Enlarged Krylov subspaces Conjugate Gradient. *NLAFET Working Note WN-13*, April 2017. Also as INRIA Research Report 9023, Project Team Alpines, France.

Scientific publications - journals and proceedings

Peer-reviewed publications of partner members, relevant for NLAFET include:

W. Liu (RAL and Univ. of Copenhagen), A. Li (Eindhoven), J. Hogg, I. Duff (RAL), B Vinter (Univ. Copenhagen): *A synchronization-free algorithm for parallel sparse triangular solves*. Proceedings of Euro-Par 2016, pp 617-630. Springer Verlag 2016. DoI 10.1007/978-3-319-43659-3_45.

Scientific publications - other technical reports

Other technical reports relevant for the NLAFET project include:

J. Dongarra, Univ. of Tennessee, Oak Ridge Natl.Lab and The Univ. of Manchester, I. Duff, J Hogg, STFC (RAL), M. Gates, A. Haidar, Univ. of Tennessee, S. Hammarling, N. J. Higham, P.V.-Lara, S.D. Relton, S. Tomov, M. Zounon, The Univ. of Manchester: *A Proposed API for Batched Basic Linear Algebra Subprograms*. Technical Report, http://eprints.ma.man.ac.uk/2464/01/covered/MIMS_ep2016_25. (A minor revision appears as the report for Deliverable D2.3.)

Overview presentations of the NLAFET project at conferences / workshops

Title of presentation:
NLAFET - Parallel Numerical Linear Algebra for Future Extreme-Scale Systems

In addition to the named presenters below, several members of the NLAFET consortium team contributed.

- *EXDCI HPC Workshop*, Rome, September 29-20. Presentation by Bo Kågström
- *Swedish e-Science Academy,* October 14-15, 2015, Arlandastad. Invited presentation by Bo Kågström
- *SIAM Conference on Parallel Processing for Scientific Computing,* April 12-15, 2016, Paris. Poster presentation by Bo Kågström, Lennart Edblom, Lars Karlsson, Laura Grigori, Iain Duff, Jonathan Hogg, Jack Dongarra and Nick Higham
- *EASC2016: Exascale Applications & Software Conference,* April 24-29, 2016, Stockholm. Presentation by Bo Kågström
- *European HPC Summit week: EXDCI Workshop,* May 9-10, 2016, Prague, Czech Republic. Presentation by Bo Kågström and Lennart Edblom
- *Workshop on Batched*, *Reproducible, and Reduced Precision BLAS*, May 18-19, 2016, Univ. of Tennessee, Knoxville, TN. Invited presentation by Bo Kågström
- *IFIP WG 2.5 Workshop on Numerical Software and Scientific Computing, August 4, 2016, Oxford, UK.* Invited presentation by Iain Duff

Presentations etc related to NLAFET, describing NLAFET work

When there are several authors of a presentation in the listings below, the *speaker* is marked in italics.

- *SIAM Conference on Parallel Processing for Scientific Computing, April 12-15, 2016, Paris*

  Organizing Committee Co-Chair: Laura Grigori, Inria and Université Pierre et Marie Curie, France

  Invited presentation: Scalability of Sparse Direct Codes, Iain Duff, Science & Technology Facilities Council, UK and CERFACS, Toulouse, France

  Minisymposia organization MS60: Advances in Parallel Dense and Sparse Linear Algebra, Jonathan Hogg, Rutherford Appleton Laboratory, UK and Lars Karlsson, Umeå University, Sweden

  Minisymposia MS60 presentations:
  - The Challenge of Strong Scaling for Direct Methods, Jonathan Hogg, Rutherford Appleton Laboratory, UK
  - NUMA-Aware Hessenberg Reduction in the Context of the QR Algorithm, *Mahmoud Eljammaly*, Lars Karlsson, and Bo Kågström, Umeå University, Sweden
  - Low Rank Approximation of Sparse Matrices for LU Factorization Based on Row and Column Permutations, *Laura Grigori* and Sebastien Cayrols, Inria, France; James W. Demmel, Univ. of California, Berkeley, USA
  - Assessing Recent Sparse Matrix Storage Formats for Parallel Sparse Matrix-Vector Multiplication, Weifeng Liu, Univ. of Copenhagen, Denmark

  Minisymposia MS4 presentation: Enlarged GMRES for Reducing Communication When Solving Reservoir Simulation Problems, Hussam Al Daas, UPMC-Inria-TOTAL, France;

Laura Grigori, Inria, France; Pascal Henon, Total E&P, France; Philippe Ricoux, TOTAL SA, France

Poster presentation: A Standard for Batched BLAS routines, Pedro Valero-Lara, Univ. of Manchester, UK; Jack J. Dongarra and UK; Stanimire Tomov, Univ. of Tennessee, Knoxville, USA; Mawussi Zounon, Univ. of Manchester, UK

- *Workshop on Batched, Reproducible, and Reduced Precision BLAS, May 18-19, 2016, Univ. of Tennessee, Knoxville, TN*

  Invited seminar: Scalability of sparse direct codes. Iain Duff, Science & Technology Facilities Council, United Kingdom

- *International Supercomputing (ICS) 2016, June 23, 2016, Frankfurt, Germany*

  Workshop presentation: Form Follows Function – Software, Algorithms & Application Challenges, Jack Dongarra, Univ. of Tennessee, Oak Ridge National Lab, and Univ. of Manchester

- *9th International Workshop on Parallel Matrix Algorithms and Applications (PMAA16), July 6-8, 2016, Bordeaux, France*

  Invited presentation: Current Trends in High-Performance Computing and Challenges for the Future, Jack Dongarra, Univ. of Tennessee, Oak Ridge National Lab, and Univ. of Manchester

  Minisymposia presentations - Task-based scientific library on top of runtime system
  - Task-based sparse Cholesky solver on top of runtime system, Florent Lopez, Numerical Analysis Group - STFC Rutherford Appleton Laboratory, UK
  - Towards Highly Parallel and Compute-bound Computation of Selected Eigenvectors given a Matrix in Schur Form, *Lars Karlsson*, Björn Adlerborn, Mahmoud Eljammaly, Carl Christian Kjelgaard Mikkelsen, and Bo Kågström, Umeå University

- *2016 SIAM Annual Meeting, July 10-15, 2016, Boston, USA*

  Minisymposia MS73 - Numerical Linear and Multilinear Algebra
  Invited presentation: Revisit to the GEMM-Based Level 3 BLAS and Its Impact on High Performance Matrix Computations, Bo Kågström, Umeå University

- *International Congress on Mathematical Software, July 11, 2016, Berlin, Germany*

  Invited presentation: An Overview of High-Performance Computing and Changing Rules at Exascale, Jack Dongarra, Univ. of Tennessee, Oak Ridge National Lab, and Univ. of Manchester

- *IMA Conference on Numerical Linear Algebra and Optimization, September 7-9, 2016, Birmingham, UK.*

- *Invited plenary presentation:* Enlarged Krylov subspace solvers for reducing communication, L. Grigori, Inria France.

  A Block Krylov Method for the Frechet Derivative of f(A)b. *Samuel Relton,* Univ. of Manchester and P. Kandolf, Univ. of Innsbruck.

  Numerical fault tolerant strategies for resilient parallel eigensolvers. *Mawussi Zounon*, Emmanuel Agullo, Luc Giraud and Pablo Salas.

- *Workshop on Sustainable Software for Science: Practice and Experiences, Sept 12-14, 2016, Manchester, UK.*

  Creating a standardized set of batched BLAS routines. Jack Dongarra, Sven Hammarling, Nicholas J. Higham, *Samuel D. Relton*, Pedro Valero-Lara, and Mawussi Zounon.

- *Eleventh Workshop on Mathematical Modeling of Environmental and Life Sciences Problems, Constanta, Romania. 12-16 October 2016.*

  Invited presentation: Highly scalable solution of large sparse equations. Iain Duff, STFC.

- *The Sixth International Conference on Numerical Algebra and Scientific Computing, Zhejiang University, Hangzhou, China. 22-26 October, 2016.*

  Co-chairman of ANA Prize Committee: Iain Duff, STFC

  Plenary speaker: Highly scalable solution of large sparse equations. Iain Duff, STFC.

- *The Fourth International Conference on Numerical Analysis and Optimization. Sultan Qaboos University, Muscat, Oman. 4-6 January 2017.*

  Plenary invited speaker: Sparse direct solution on parallel computers, Iain Duff, STFC

- *Bath-RAL Numerical Analysis Day. University of Bath, UK. 27th January 2017.*

  Presentation: Experiments with a sparse Cholesky solver using runtime systems, Florent Lopez, STFC

- *International Conference on Domain Decomposition Methods DD XXIV, February 6-10 2017, Longyearbyen, Norway.*

  Invited plenary talk: Communication avoiding iterative solvers and preconditioning, Laura Grigori, Inria, France

  Minisymposia MS01-3: Adaptive enlarged Krylov Conjugate Gradient, Laura Grigori and *Olivier Tissot*

- *Second Workshop on Batched, Reproducible, and Reduced Precision BLAS, February 23-25, 2017, Georgia Tech, Atlanta*

  Workshop presentation: Standardizing the Batched BLAS API and Memory Layout, Jack Dongarra, Nick Higham, *Samuel Relton* and Mawussi Zounon, Univ. of Manchester.

  Invited presentation: The NLAFET Project: Overview and Status Report, Bo Kågström Umeå University

- *2017 SIAM Conference on Computational Science and Engineering, February 27-March 3, 2017, Atlanta, USA*

  Minisymposia organization MS64: Batched Linear Algebra on Multi / Many-Core Architectures. Mawussi Zounon and Pedro Valero-Lara, Univ. of Manchester.

  Minisymposia MS64 presentation:
  - Recent Advances in Batched Linear Algebra Computation. *Samuel Relton*, Mawussi Zounon and Pedro Valero-Lara, Univ. of Manchester, UK.

  Minisymposia organization MS69: Recent Advances in Matrix Functions and Applications. Samuel Relton, University of Manchester.

  Minisymposia organization MS101: Parallel Numerical Linear Algebra for Extreme Scale Systems: Nicholas Higham, Univ. of Manchester and Bo Kågström, Umeå University.

  Minisymposia MS101 presentations:
  - The Design and Implementation of a Dense Linear Algebra Library for Extreme Parallel Computers. *Jack Dongarra*, Nick Higham, Samuel Relton, and Mawussi Zounon, Univ. of Manchester, UK.
  - Computing the Low Rank Approximation of a Sparse Matrix**.** *Laura Grigori,* Alan Ayala and Sebastien Cayrols, Inria, France; James W. Demmel, University of California, Berkeley, USA.

  - Sparse Direct Solvers for Extreme Scale Computing. *Iain Duff*, Jonathan Hogg, Florent Lopez, and Stojce Nakov, Rutherford Appleton Laboratory, STFC.
  - Extreme-Scale Eigenvalue Reordering in the Real Schur Form. *Carl Christian Kjelgaard Mikkelsen*, Mirko Myllykoski, Lars Karlsson and Bo Kågström, Umeå University.

- *PARNUM 2017 Workshop, Waischenfeld, Germany. 19-21 April 2017.*

  Keynote speaker: Direct solution of sparse linear equations on parallel computers. Iain Duff, STFC, UK.

Organization of workshops

In addition to the organization of minisymposia at SIAM PP 2016 and SIAM CSE 2017 NLAFET researchers have participated in the organization of the following workshops:

- *Workshop on Batched, Reproducible, and Reduced Precision BLAS, May 18-19, 2016, Univ. of Tennessee, Knoxville*
- *Second Workshop on Batched, Reproducible, and Reduced Precision BLAS, February 23-25, 2017, Georgia Tech, Atlanta*

Submitted conference papers

Jack Dongarra, Sven Hammarling, Nicholas J. Higham, Samuel D. Relton, Pedro Valero-Lara, and Mawussi Zounon. *The design and performance of batched BLAS on modern high-performance computing systems*. In International Conference on Computational Science (ICCS-2017), Zurich, Switzerland, June 2017.

Jack Dongarra, Sven Hammarling, Nicholas J. Higham, Samuel D. Relton, and Mawussi Zounon. *Optimized batched linear algebra for modern architectures*. In Euro-Par 2017, Santiago de Compostela, Spain, August 2017

Ahmad Abdelfattah, Azzam Haidar, Stanimire Tomov, Mawussi Zounon, and Jack Dongarra. The guide and design analysis behind achieving high performance on very small matrices: A case study of batched LU and Cholesky factorisations. In The 46th International Conference on Parallel Processing (ICPP-2017), Bristol, UK, August 2017

Other publications, blog posts, press releases

The publication of press releases is an efficient way to reach a broader audience and is issued by all the partners in the consortium in their respective countries and organizations.

In connection with the NLAFET kick-off meeting at Umeå University in November 2015, a press release that attracted considerable attention was released. Some resulting publicity in newspapers and magazines is displayed on the link http://www.nlafet.eu/on-the-web/ .

After the SIAM Conference on Computational Science and Engineering in February 2017 two blog posts describing NLAFET activities were published:

https://nickhigham.wordpress.com/2017/03/06/parallel-numerical-linear-algebra-for-extreme-scale-systems/

https://samrelton.wordpress.com/2017/03/06/batched-blas-operations-at-siam-cse17/

2.2. Website (Task 7.2)

The NLAFET website is the main dissemination channel for promotion of the project and functions as the public interface of NLAFET. Hence, it contains basic information about the project, the partners involved, how to contact the coordinator, the main focus of the research, and the publication results of the project thus far. It serves as a focal point for everyone interested in the objectives, results, impact, and progress of the project.

The website is available at www.nlafet.eu and has six main sections:

- HOME
- ABOUT; an overview of the background and main aims of the project
- RESEARCH; brief description of the four research-focused work packages WP2-4 and WP6
- USE CASES / APPLICATIONS; describes the work in WP5
- PUBLICATIONS; listings of deliverables and publications
- NEWS

Below, we display a screenshot of the "about" page of the NLAFET public website. The top banner shows the northern lights above part of the Umeå University campus.

Figure 1: The NLAFET web site

After a slow start the website is getting more and more attention. By the end of March 2017 we have recorded visits from almost 11000 unique ip-addresses. Deliverables have been downloaded 126 times to 78 different ip-addresses.

The site is described in more detail in deliverable D7.2: *Collaborative infrastructure,* that can be downloaded from the site.

2.3. Open source activities (Task 7.3)

A GitHub platform has been established for the software developed and deployed in the NLAFET project. The platform can be found using the link https://github.com/NLAFET/.

GitHub is a web-based application for managing source codes that relies on the version control system Git (https://git-scm.com/). In the NLAFET project the basic structure is to create a repository for each piece of software that we are developing and deploying. However, many of the repositories include several pieces of software that together form a package of routines for a subset of fundamental linear algebra operations considered in the NLAFET project. Typically, such a package is organized in directories or even subdirectories to reflect different types of functionality, tools and solvers.

For a given repository, the main three levels of access rights that we are interested in are:

- Read/Write access for a particular team within the project and no access to any other users.
- Read/Write access for a particular team plus a Read or Read/Write access for another team in the context of a collaboration. By default, members of the projects have Read access to any repository.
- Read/Write access for a particular team or teams and a public Read access when the code is ready to be released.

These examples are the three main options used in the project but these rules might be modified in many ways to allow further collaboration at various testing stages or for potential reviewers. In particular, we will make repositories public whenever the codes are robust enough to be released. In addition, new repositories will be added and occasionally some existing repositories will be merged. Public releases will occur at several times during the project.

The current repositories cover the following topics:

- Dense matrix factorizations and solvers.
- Solvers and tools for standard and generalized dense eigenvalue problems.
- Sparse direct factorizations and solvers.
- Communication optimal algorithms for iterative methods.
- Cross-cutting tools.

A description of the content and organization of the repositories can be found in Deliverable D7.5, *Beta release of the* NLAFET *library. Prototype software, Part 1.*

2.4. Community outreach (Task 7.4)

The outreach activities reported here include standardization efforts, promotion materials, other Horizon 2020 and international collaborations, and finally a few honours and awards appointed to members of the NLAFET Team during the reporting period.

Draft specification for Hybrid (batched) BLAS

As part of our objective to promote the creation of standards related to the project we have proposed an API for Batched Basic Linear Algebra Subprograms (Batched BLAS). The details are described in deliverable D7.3. Researchers from the project have participated actively in two workshops on Batched BLAS:

- *Workshop on Batched*, *Reproducible, and Reduced Precision BLAS*, May 18-19, 2016, Univ. of Tennessee, Knoxville.
- *Second Workshop on Batched*, *Reproducible, and Reduced Precision BLAS*, February 23-25, 2017, Georgia Tech, Atlanta

The purpose of these workshops was to consider defining a standard interface for the Batched BLAS, Reproducible BLAS, and Reduced Precision BLAS. Hardware and software vendors and developers described what they have and what they need in terms of numerical linear algebra software for today's and future systems. The authors of the Batched, Reproducible, and Reduced Precision BLAS presented the current proposals and various implementations (reference and more specific ones). Discussions on various aspects followed.

Promotional material, other dissemination or outreach activities

Promotion materials are a great way of giving out information about the project for personal contact with interested people, e.g., at conferences, fairs or workshops. We have produced a **flyer** that has been distributed, e.g. at the "Spelplan Europa" event described below. The flyer includes an overall description of NLAFET, an explanation of what makes the project unique, as well as contact details. The two A4-pages of the flyer are shown below; they are meant to be printed double-sided and folded in three parts to create a 6-page flyer.

Expected impact and validation

The main impact will be to develop, deploy and make software available to the scientific community and industry by providing novel tools for their computational challenges. This effort also includes collaboration with hardware and software vendors.

The validation and dissemination of results will be done by integrating new software solutions into challenging scientific applications in materials science, power systems, study of energy solutions, and data analysis in astrophysics. The software will be packaged into open-source library modules.

Kebnekaise@HPC2N

State-of-the-art HPC System (Lenovo - Intel – nVIDIA – Mellanox) funded by SNIC/VR and Umeå University.

Partners

Umeå University (coordinator)

University of Manchester

Institute National de Recherche en Informatique et en Automatique, INRIA

Science and Technology Facilities Council

NLAFET has received funding from the European Union's Horizon 2020 Research and Innovation Programme, call *FET Proactive – towards exascale high-performance computing,* under grant agreement 671 633.

Budget: € 3.9 million

Project period: November 2015 – October 2018

NLAFET
Parallel Numerical Linear Algebra for Future Extreme Scale Systems

Parallel Numerical Linear Algebra for Future Extreme Scale Systems

For more information please contact: Professor Bo Kågström or Lennart Edblom

Web: www.nlafet.eu

E-mail: info@nlafet.eu

European Commission

The problem

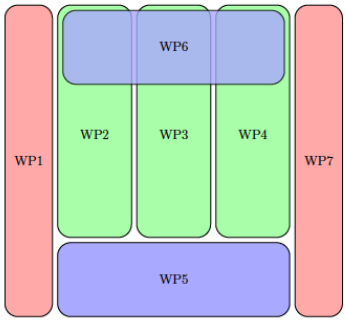
Today's largest HPC systems have a serious gap between the peak capabilities of the hardware and the performance realized by high-performance computing applications. Extreme-scale systems present new challenges that could widen the gap so much that it prevents the productive use of future Exascale computers. Communication costs present an especially notable technical challenge.

The NLAFET Solution

NLAFET is a direct response to the demand for new mathematical and algorithmic approaches that will make it possible to use the peak capabilities of today's and future extreme-scale computing systems. NLAFET will enable a radical improvement in the performance and scalability of a wide range of real-world applications relying on linear algebra software, by developing novel architecture-aware algorithms and software libraries, and the supporting runtime capabilities to achieve scalable performance and resilience on heterogeneous architectures.

Parallel library software and tools

The NLAFET project will deliver a new generation of computational tools and software for problems in numerical linear algebra. These tools will be developed with a focus on extreme-scale systems. Linear algebra is both fundamental and ubiquitous in computational science and its vast application areas. This means that the results of NLAFET will have applicability to computational science in general. Many of the methodologies, functionalities and solutions developed within NLAFET will also be applicable to the development of numerical solutions for a wide range of applications.



Research objectives

The main research objectives are: (i) development of novel algorithms that expose as much parallelism as possible, exploit heterogeneity, avoid communication bottlenecks, respond to escalating fault rates, and help meet emerging power constraints; (ii) exploration of advanced scheduling strategies and runtime systems focusing on the extreme scale and strong scalability in multi/many-core and hybrid environments; (iii) design and evaluation of novel strategies and software support for both offline and online auto-tuning.

The work is divided into 7 work packages:

WP1: Management and coordination

WP2: Dense linear systems and eigenvalue problem solvers

WP3: Direct solution of sparse linear systems

WP4: Communication-optimal algorithms for iterative methods

WP5: Challenging applications – a selection

WP6: Cross-cutting issues

WP7: Dissemination and community outreach

Figure 2: The NLAFET flyer

On October 26, 2016 VINNOVA[1] arranged the European Policy Conference *Spelplan Europa* (Playing Ground Europe), which gathered more than 200 representatives from the European Commission, Swedish government, and stakeholders from academia, industry and the public sector. NLAFET was one of 11 Horizon 2020 projects that were invited to be presented at the event; Figure 3 shows a photo of eagerly interested listeners.

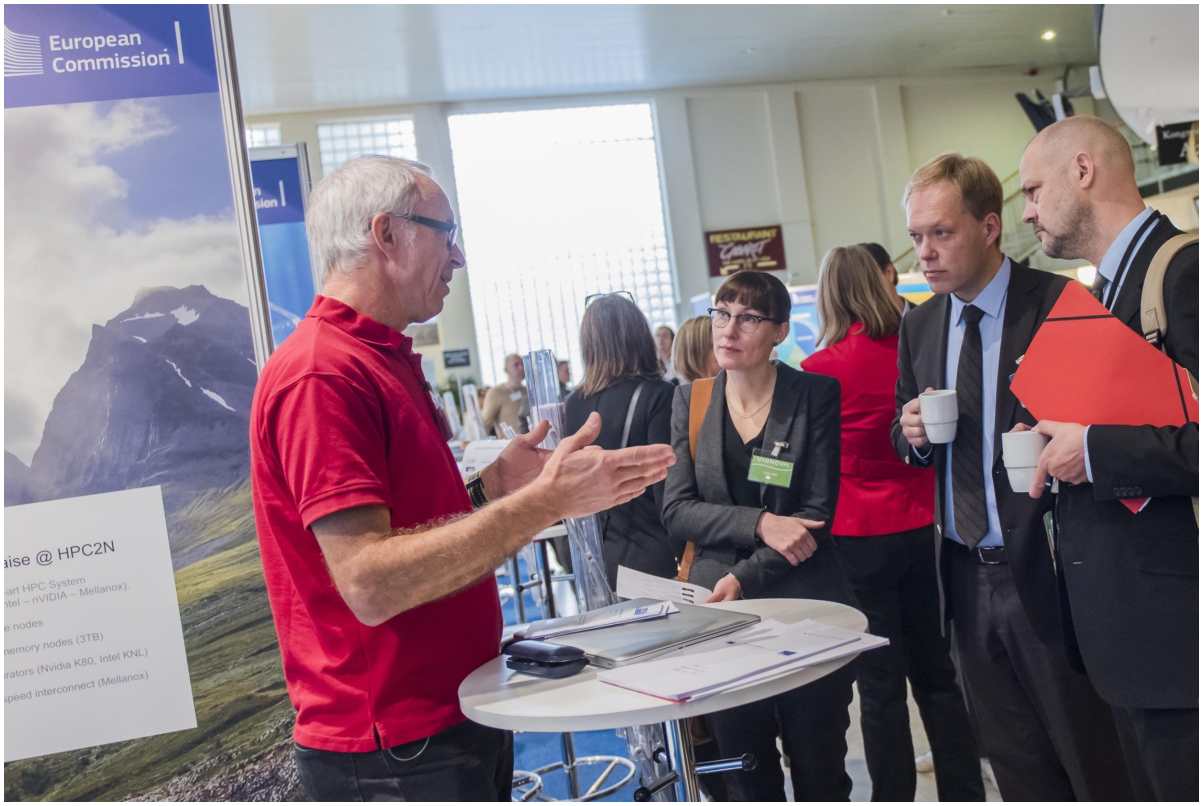


Figure 3: Lennart Edblom, Umeå University, presents the NLAFET project for Linda Bell, Head of EU R&D Relations, Vinnova, Kurt Vandenberghe, Director, Policy Development and Coordination, European Commission's DG Research and Innovation, and Niklas Johansson, State Secretary, Ministry of Enterprise and Innovation.

INRIA, Alpines group, was the leader of two projects that took place during the CEMRACS 2016 summer school on topics related to WP4. This summer school was organized in Marseille, France, during 6 weeks, and Laura Grigori (INRIA) was a co-organizer. Students worked on these projects during 5 weeks. One of the projects was in collaboration with EDF, Yvan Fournier, and its goal was also to facilitate the collaboration with EDF, on the application described in WP5. These projects (Alora and Enlak) can be found on the following webpage:

http://smai.emath.fr/cemracs/cemracs16/research/conf.php

[1] Vinnova is a Swedish government agency working under the Ministry of Enterprise and Innovation and acts as the national contact agency for the EU Framework Programme for R&D. Vinnova is also the Swedish government's expert agency within the field of innovation policy.

Collaboration with other projects, programmes, working groups, initiatives etc

Bo Kågström and Lars Karlsson participated in the EXDCI HPC meeting in Rome, September 29-30, 2015 where Bo presented the NLAFET project. The EXDCI project (European eXtreme Data and Computing Initiative) – hosted a workshop for FET projects and Centres of Excellence (CoE) related to HPC.

On May 9-10, 2016 EXDCI arranged a new workshop, this time in Prague. The aim was to update the status of the ongoing FETHPC projects, the European Exascale projects and the CoEs in order to better understand the development of the HPC ecosystem for all the participants and stakeholders. Bo Kågström and Lennart Edblom participated and represented the NLAFET project.

Iain Duff is involved in the Centre of Excellence EoCoE that is managed by the Maison de la Simulation in Paris. He is particularly involved in Task 1.2 of Work Package 1 that is concerned with linear algebra and the use of linear algebra codes in large scale simulations. We have recently been collaborating directly with colleagues in EoCoE on block iterative methods that are the topic of Task 3.4.

A cooperation with the ExaHype FETHPC project has been initiated. One person from this project has spent several months at Umeå university. Another researcher from ExaHype has visited University of Manchester, and future cooperation was discussed.

Moreover there are three Horizon 2020 FETHPC projects that focus on auto-tuning:

- AllScale: http://www.allscale.eu/home
- ANTAREX: http://www.antarex-project.eu/
- READEX: http://www.readex.eu/

We anticipate to have discussions with them and possibly exchange of results in the future.

Close relationships are maintained with INTERTWinE, another FETHPC project in which UNIMAN is a partner. INTERTWinE focuses on interoperability of programming models suitable for exascale. A particular focus for interaction with INTERTWinE was the porting of the PLASMA library from its own runtime system QUARK to the OpenMP runtime system, on which both projects participated. NLAFET team members also attended the European exascale applications workshop (http://www.maths.manchester.ac.uk/news-and-events/european-exascale-applications-workshop.htm) organised jointly by INTERTWinE, EXA2CT, EPiGRAM, and AllScale projects at the University of Manchester in October 2016.

Awards and honours

During the 18 months since the project started, several of the NLAFET Team members have received prestigious international honours and awards:

- Jack Dongarra, UNIMAN has been appointed Foreign Member of the Computer Science division of the Russian Academy of Science.
- Laura Grigori, INRIA and co-authors J. Demmel, M. Hoemmen, and J. Langou have been awarded the SIAM Activity Group on Supercomputing Best Paper Prize 2016.
- Nick Higham, UNIMAN has been appointed and started his period 2017-18 as President of the Society of Industrial and Applied Mathematics (SIAM).
- Bo Kågström, UMU has been appointed SIAM Fellow 2016.