Material available

- **The BOF Programme**
- **A summary of all European HPC Projects**
- **European HPC Handbook**
- **Other project material/posters (**AllScale, Nomad, INTERTWinE, Mont-Blanc 3, MaX, etc.)
- **All of it available on**: http://www.etp4hpc.eu/en/euexascale.html

- **And on the Memory Sticks in this room (up for grabs)**

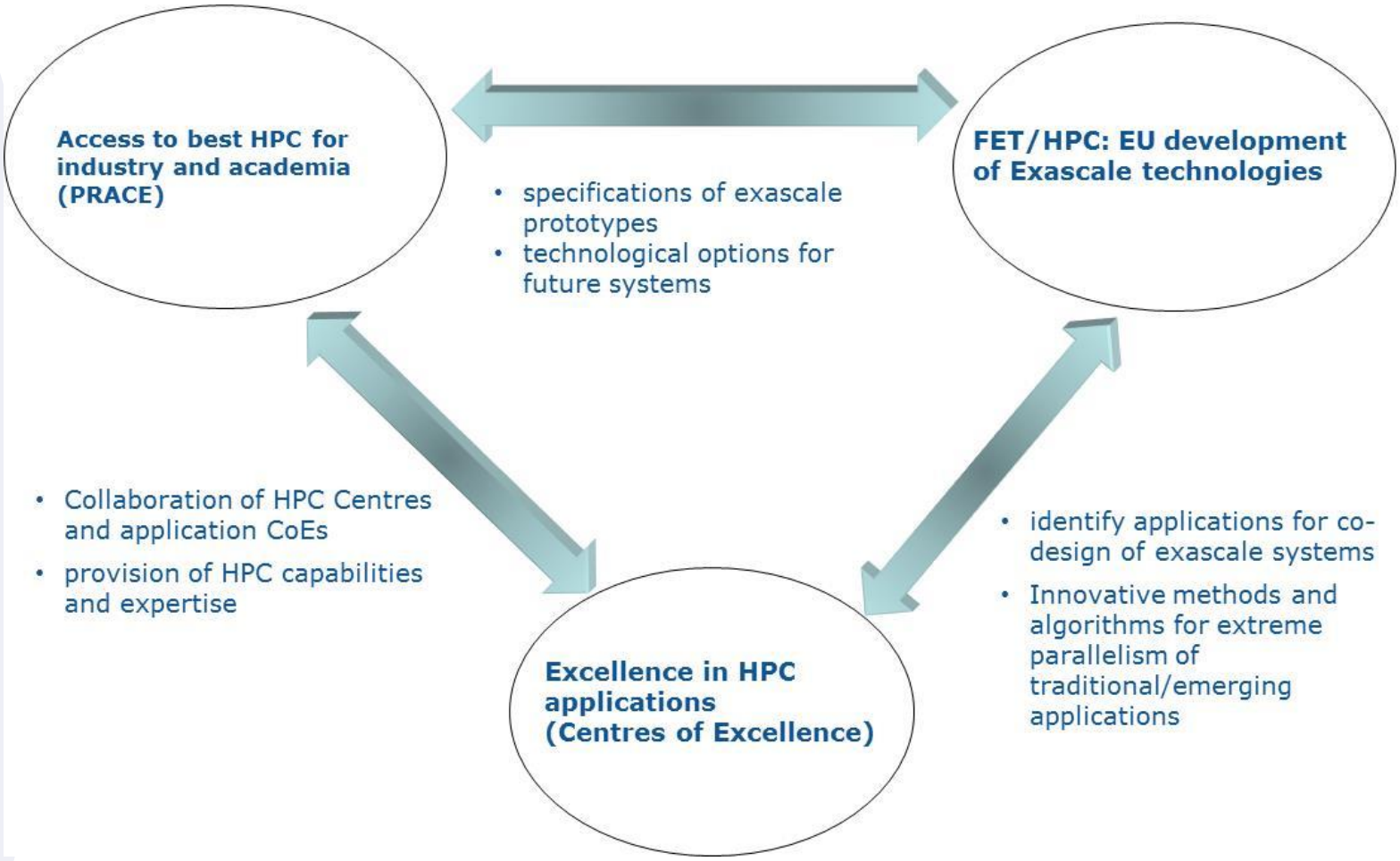
BoF
European Exascale Projects and Their International Collaboration Potential

JF Lavignon

ETP4HPC Chairman

The EXDCI project has received funding from the European Unions Horizon 2020 research and innovation programmed under the grant agreement No 671558.

The European HPC policy



- Acquisition of top systems in 2020 and 2022

Action plan

- Already started WP2014-2015
  - HPC technology research projects : ~100 M€
  - Centres of Excellence : ~50M€
- Already decided WP2016-2017, starting in 2017-2018
  - HPC technology research projects : ~100 M€
- Still in discussion WP2018-2020: 450 M€
  - HPC technology research projects
  - Centres of Excellence
  - Integration effort : Extreme Scale Demonstrators

Today session

- Presentation
  - Guy Lonsdale : overview of the international collaboration opportunities created by the European HPC technology projects, 10’
  - Peter Hopton :The key successes and achievements of the European HPC technology projects , 7’
  - Thomas Eickermann : Extreme Scale Demonstrators, 5’
  - Jesus Labarta : The European Centres of Excellence, 5’
  - **Paul Messina** – US Exascale Computing Project Director, 5’
  - **Mitsuhisa Sato** - Riken of Japan, 5’
- Panel and discussion with the audience, 50’
  - François Bodin – the Scientific Director of EXDCI (Extreme Data and Computing Initiative, the European HPC Strategy Coordination Project)
  - Luis C. Busquets Pérez – The European Commission
  - Paul Messina – US Exascale Computing Project Director
  - Mitsuhisa Sato - Riken of Japan
  - Alison Kennedy - Hartree Centre Director
  - Jesus Labarta – Barcelona Supercomputing Center, leader/member of a number of HPC technology projects
  - Jean-Pierre Panziera - Bull/Atos
  - Sai Narasimhamurthy – Seagate
  - Christian Simmendinger – T-Systems
  - Eric Van Hensbergen - ARM
  - Mark Asch – BDEC (Big Data and Exa-scale Computing)

European HPC Technology Projects

Opportunities for International Collaboration

Guy Lonsdale, Scapos AG

European HPC SC'16 BOF

16th Nov 2016

The EXDCI project has received funding from the European Unions Horizon 2020 research and innovation programmed under the grant agreement No 671558.

- **All projects are open to international collaboration**
- The areas of potential areas of collaboration might not reflect the Project's main profile
- The projects are in various stages of maturity at this point – some of them are more specific about international collaboration than others

- Below, we present:
  - 1. A Breakdown of areas
  - 2. General areas
  - 3. Specific areas
- For more information, please read the **Handbook** (**http://www.etp4hpc.eu/en/euexascale.html**)

Areas

Programming Environment and Applications

Core technologies

Areas

I/O, Interconnect, infrastructure & storage

High-energy efficient compute node

Areas

Algorithms

Other

General Collaboration Areas

- **Parallelism**
- **Application development**
- **Application performance**
- **Programming models**
- **Multiscale Computing**

General Collaboration Areas

- **New Interconnect and Storage solutions**
- **New storage platform**
- **High-energy efficient compute node**

- **Algorithm Development and Improvement**
- **Solvers**
- **PDE engine**

Specific topics

- **Programming Environment and Applications**
  - **Application self-adaptiveness**
  - **Application porting**
  - **Runtime Exploitation of Application Dynamism for Energy-efficient eXascale computing**
  - **Interoperability**

Specific topics

- **HPC core technologies**
  - **ARM-based ecosystem of hardware/software infrastructure for HPC**
  - **Prototype development**
- **Algorithms**
  - **Energy-efficient Scalable Algorithms**
  - **Machine learning algorithms**
  - **Parallel Numerical Linear Algebra**
- **Other**
  - **Reconfigurable computing**

Key Project Highlights

By Peter Hopton
Founder and Technology Director
Iceotope

European HPC SC'16 BOF

16th Nov 2016

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Software Orientated Projects

Nested Parellelism: An Exascale Programming, Multi-objective Optimisation and Resilience Management Environment Based on Nested Recursive Parallelism http://www.allscale.eu

AutoTuning and Adaptivity approach for Energy efficient eXascale HPC systems http://www.antarex-project.eu

Software co-design: Collaborative Research into Exascale Systemware, Tools & Applications http://www.cresta-project.eu

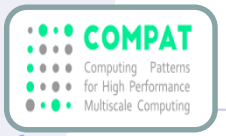
Programming model: Exascale Programming Models http://www.epigram-project.eu

Solver, programming model: Exascale Algorithms and Advanced Computational Techniques http://www.exa2ct.eu

Pde solver: An Exascale Hyperbolic PDE Engine http://exahype.eu

Programming Model: Interoperability ToWards Exascale (INTERTWinE) http://www.intertwine-project.eu/partners

Energy efficiency management: Runtime Exploitation of Application Dynamism for Energy-efficient eXascale computing http://www.readex.eu



New mathematical & algorithmic approaches: Computing Patterns for High Performance Multiscale Computing http://www.compat-project.eu

API and programming environment for extreme-scale; exploits nested recursive parallelism and offers resilience management

Implemented the ADER-DG numerical approach on adaptive spacetree meshes for solving hyperbolic systems of PDE with high performance.

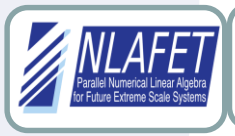
Established a Europe-wide programme of advanced training on parallel and interoperable programming for extreme scale,

Domain Orientated Projects

Weather forecast: Energy-efficient Scalable Algorithms for weather Prediction at Exascale
http://www.ecmwf.int/en/research/projects/escape

Fluid dynamics: Enabling Exascale Fluid Dynamics Simulations http://exaflow-project.eu

Machine learning: Exascale Compound Activity Prediction Engine
http://www.ecmwf.int/en/research/projects/escape



Linear algebra: Parallel Numerical Linear Algebra for Future Extreme-Scale Systems
http://www.nlafet.eu

Engineering: Network for Sustainable Ultrascale Computing
http://www.nesus.eu

Algorithmic improvements for increased performance, scalability and Exascale readiness of major high order, open source computational fluid dynamics codes.

Prepared machine learning data sets for the pharmaceutical industry, and applied machine learning techniques.

Architecture Projects

Heterogeneous computing: Energy-efficient Heterogeneous Computing at exaSCALE http://www.ecoscale.eu

Cooling, Power, Interconnect, Storage: European Exascale System Interconnect and Storage http://www.exanest.eu

Chiplet, Interposer: European Exascale Processor Memory Node Design http://exanode.eu

Reconfigurable architecture: Exploiting eXascale Technology with Reconfigurable Architectures https://www.extrahpc.eu

Real time control: Green Flash, energy efficient high performance computing for real-time science

Heterogeneous computing: Exploring Manycore Architectures for Next-Generation HPC systems http://www.mango-project.eu

ARM based HPC: European Approach Towards Energy Efficient HPC https://www.montblanc-project.eu

New memory hierarchy: Next Generation I/O for Exascale http://www.nextgenio.eu

Object oriented storage: SAGE http://www.sagestorage.eu

Accelerator: Dynamical Exascale Entry Platform – and it's Extended Reach http://www.deep-project.eu/www.deep-er.eu

Hybrid MPI + OpenCL Programming Environment for FPGAs.
PGAS UNIMEM/UNILOGIC

Next Generation Liquid Cooling & Power
UNIMEM interconnect, Resilient Storage
3840+ FPGA Chips /Rack

High Performance UNIMEM ARM+FPGA Nodes, Multiple FPGA Chiplets on Chips

Defined a new HPC Architecture (HW+SW) to take advantage of NVDIMMS

High Performance Object Orientated Storage for Big Data Extreme Computing

Interested!

Grab a Brochure Or USB Memory Stick

www.etp4hpc.eu Click on European ExaScale

Reach out to a project

Or Contact office@ETP4HPC.eu for an introduction

Many Thanks For Listening.

Extreme scale Demonstrators

SC16 BoF:
European Exascale Projects and their collaboration Potential

Salt Lake City, November 16th 2016

Thomas Eickermann
Marc Duranton

The EXDCI project has received funding from the European Unions Horizon 2020 research and innovation programmed under the grant agreement No 671558.

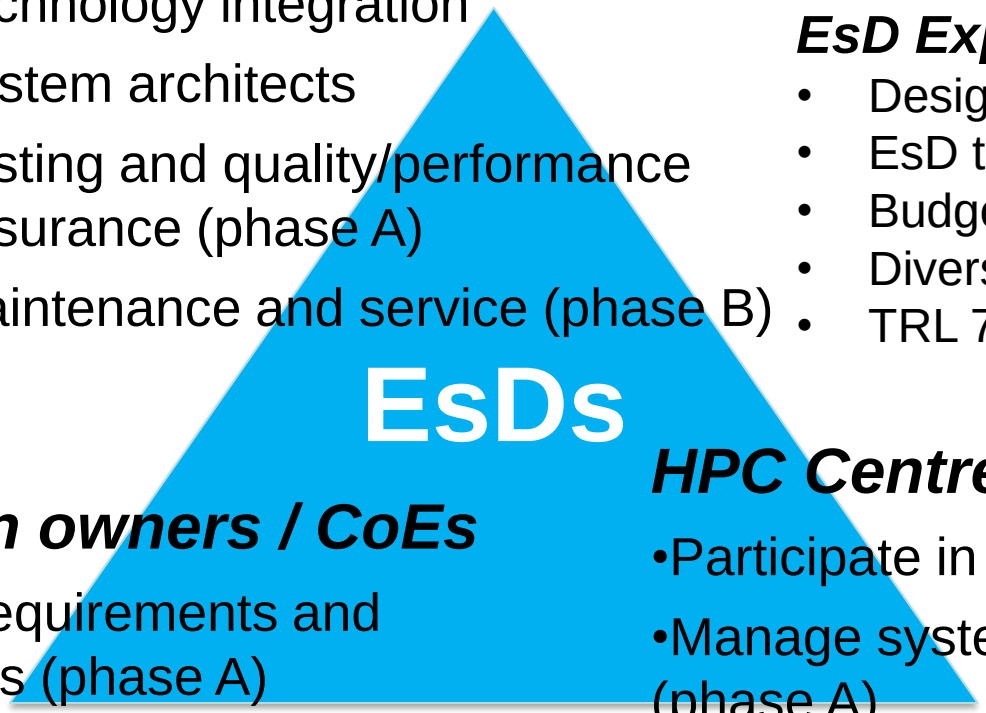
Extreme Scale Demonstrators – Concept

- "The "Extreme-Scale Demonstrators" (EsDs) are vehicles to **optimise and synergise the effectiveness of the** entire **HPC H2020 Programme** through the integration of isolated R&D outcomes into fully integrated HPC system prototypes;
  It is a key step towards establishing European exascale capabilities and solutions." ***(From the ETP4HPC SRA, chapter 8 p.67)***
- EsD will fill critical gaps in the HPC H2020 programme:
  - Bring technologies from FET-HPC closer to commercialisation (TRL 7-8)
  - Combine results from targeted R&D efforts into a complete system (European HPC technology ecosystem)
  - Provide the missing link between the 3 HPC pillars: Technology providers, infrastructure providers, user communities (co-design)

Contribution / Role of Participants

Technology providers

- Technology integration
- System architects
- Testing and quality/performance assurance (phase A)
- Maintenance and service (phase B)



EsD Expectations

- Design points ~400-500 Pflops
- EsD target 5% (20-30 Pflops)
- Budget: 20-50 Mio. €
- Diversity of architectures
- TRL 7-8

Application owners / CoEs

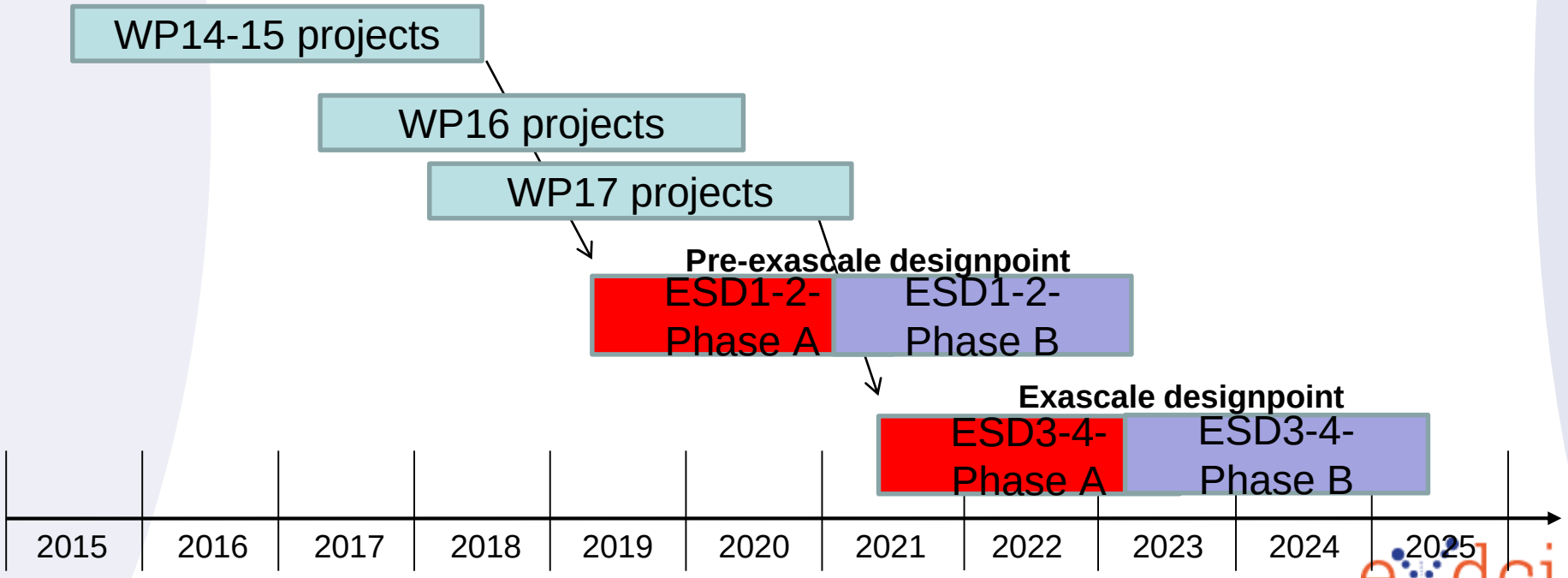
- Application requirements and key challenges (phase A)
- Port, optimize application(s), use them productively (phase

HPC Centres

- Participate in co-design
- Manage system deployment (phase A)
- System operation, validation (phase B)

Proposed Call Timeline

- Two EsD calls, each leading to two projects
  - Calls target technologies developed under H2020 / FP7, but are open
- EsD project structure
  - Phase A (18-24 months): Development, Integration and Testing
  - Phase B (18-24 months): Deployment and Use



Summary, Conclusions, Next Steps

- The concept of Extreme Scale Demonstrators …
  - … has been developed by the ETP4HPC
  - … has been extensively discussed will all stakeholders:

    vendors, HPC centres, application communities, EC
  - … is well understood and welcomed by those stakeholders

- ETP4HPC will propose EsD calls in 2018 / 2020

- See also: http://www.etp4hpc.eu/en/esds.html

ETP 4 HPC

exdci European Extreme Data & Computing Initiative

Centres of Excellence in Computing Applications (CoEs)

Jesus Labarta
Barcelona Supercomputing Center

European HPC SC'16 BOF

16th Nov 2016

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Excellence in HPC, in scientific and industrial domains

- Key words:
  - Path to exascale
  - Community building, orchestration
  - application providers for co-design
  - Service orientation: developing, optimising, …
  - end-user needs
  - Impact, value added, sustainability
  - International cooperation

Excellence in HPC, in scientific and industrial domains

- **1st round** funded (40m Euro) and running since 2015 (9 CoEs)
- **2nd round** planned for 2017 (fewer projects, more focuses/merged)

Activities

- Code optimization
- Development of workflows
- Service
- Training
- Share methodologies, develop best practices
- → Standardization

The centers

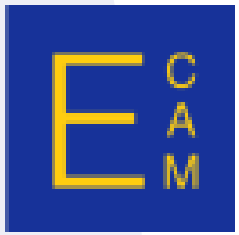
Materials

Climate

Bio

Energy

Global systems



NOVEL MATERIALS DISCOVERY

Performance analysis and programming models

Some apps. / frameworks

Materials	Climate	Bio	Energy	Global systems
Quantum Espresso Siesta aIIDA Gaussian, VASP, Gromacs, NAMD GPAW, CASINO Yambo Fleur Aiida	OpenIFS NEMO OASIS 3 MCT XIOS Cylc ICON EC-EARTH MPI_ESM2 XIOS CYLC	Gromacs HADDOCK CPMD Chaste HemeLB Alya Palabos AceMD OpenSim Vizualization Galaxy, Taverna, OpenPHACTS and KNIME	MetalWall Gysela Alya	Pandora (Repast HPC) Self-developed graph-based simulation tool (no name so far) Hadoop Spark

BSC tools, Score-P, Scalasca, Vampir, …

Performance analysis and programming models

Activities

- Code optimization
- workflows
- Share methodologies, develop best practices
- → Standardization

- Service
- Training
- Seminars

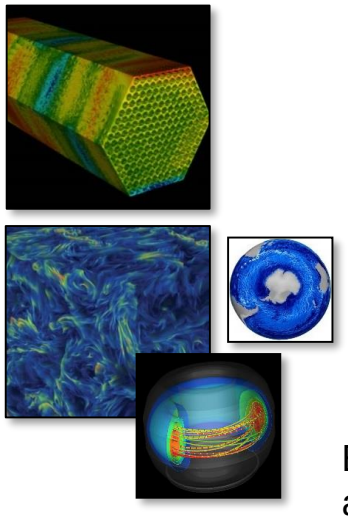
Collaboration opportunities

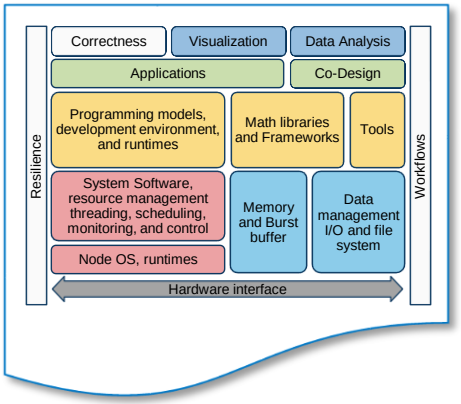
- Point to point collaborations already in place
- Possibility to share
  - Methodologies, best practices
  - Specific codes, tools, development efforts, …
- Coordination events:
  - training, …
  - Participation in standardization bodies
- Trying to minimize divergence/replication

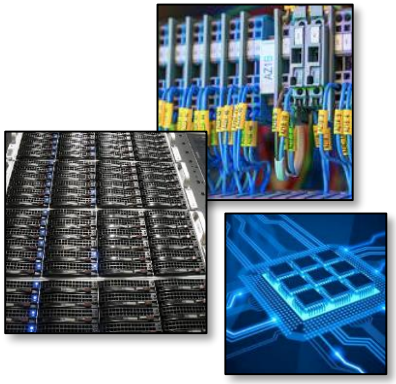
- Actual joint programs and funding ?

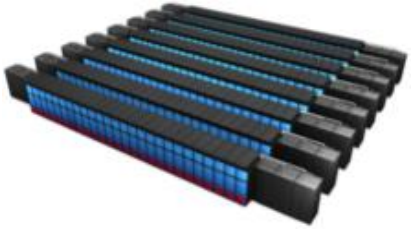
ECP has formulated a holistic approach that uses co-design and integration to achieve capable exascale

Application Development	Software Technology	Hardware Technology	Exascale Systems
Science and mission applications	Scalable and productive software stack	Hardware technology elements	Integrated exascale supercomputers









ECP's work encompasses applications, system software, hardware technologies and architectures, and workforce development

EXASCALE COMPUTING PROJECT

ECP AD, ST and CD Awards

NEWS RELEASE

The Exascale Computing Project Awards $34 Million for Software Development

OAK RIDGE, Tenn., Nov. 10, 2016 – The Department of Energy's Exascale Co
(ECP) today announced the selection of 35 software development proposals
research and academic organizations.

The awards for the first year of funding total $34 million and cover many co
software stack for exascale systems, including programming models and ru
mathematical libraries and frameworks, tools, lower-level system software,
and I/O, as well as in situ visualization and data analysis.

NEWS RELEASE

The Exascale Computing Project Announces $48 Million to Establish Four Exascale Co-Design Centers

OAK RIDGE, Tenn., Nov. 11, 2016 – The Department of Energy's Exascale Computing Project (ECP) today announced that it has selected four co-design centers as part of a 4 year, $48 million funding award. The first year is funded at $12 million, and is to be allocated evenly among the four award recipients.

The ECP is responsible for the planning, execution, and delivery of technologies necessary for a capable exascale ecosystem to support the nation's exascale imperative including software, applications, hardware, and early testbed platforms.

According to Doug Kothe, ECP Director of Application Development, "Co-design lies at the heart of the Exascale Computing Project. ECP co-design, an intimate interchange of the best that hardware technologies, software technologies, and applications have to offer each other, will be a catalyst for delivery of exascale-enabling science and engineering solutions for the U.S." Kothe continued, "By targeting common patterns of computation and communication, known as "application motifs", we are confident that these ECP co-design

NEWS RELEASE

For Immediate Distribution

The Exascale Computing Project (ECP) Announces $39.8 million in First-Round Application Development Award

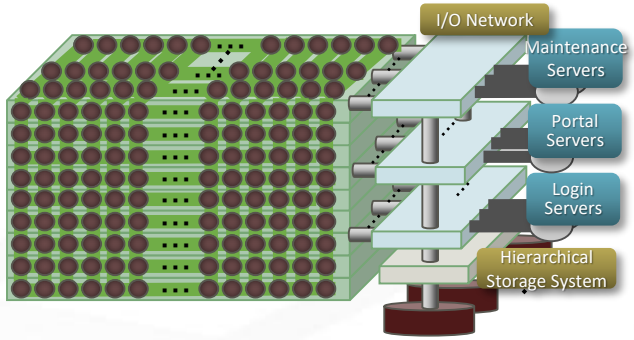
OAK RIDGE, Tenn., Sept. 07, 2016 – The Department of Energy's Exascale Computi
(ECP) today announced its first round of funding with the selection of 15 applicatio
development proposals for full funding and seven proposals for seed funding, repr
teams from 45 research and academic organizations.

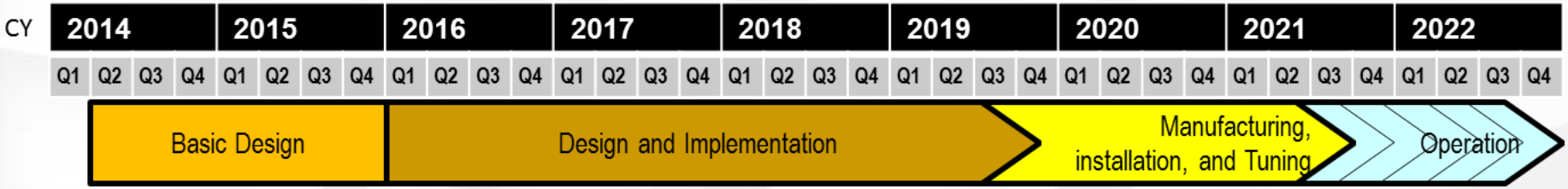
The awards, totaling $39.8 million, target advanced modeling and simulation solu
specific challenges supporting key DOE missions in science, clean energy and nati
as well as collaborations such as the Precision Medicine Initiative with the Nation
Health's National Cancer Institute.

EXASCALE COMPUTING PROJECT

FLAGSHIP 2020 Project

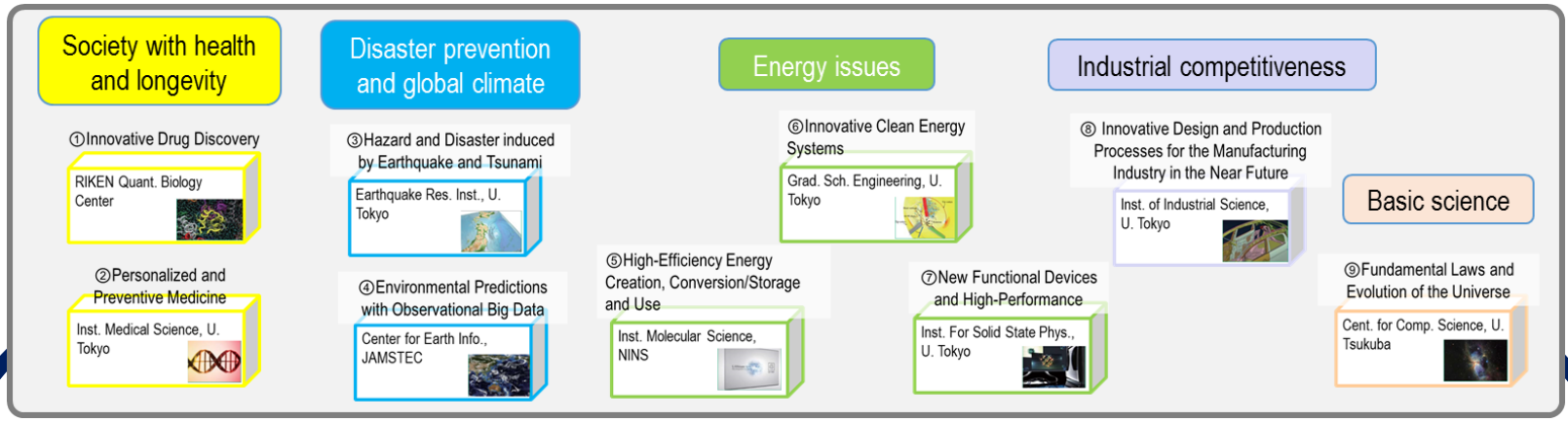
- **Missions**
  - Building the Japanese national flagship supercomputer, Post K, and
  - Developing wide range of HPC applications, running on Post K, in order to solve social and science issues in our country.
- **Post K Computer**
  - RIKEN AICS is in charge of development
  - Fujitsu is selected as a vendor partner
  - Started from 2014, installation around 2020
  - Features of Post-K system
    - Manycore-based computing node
    - ARM v8 + SVE (SIMD) ISA
    - 3-level storage (SSD, HDD, archive)





R&D Organization

The Japanese government selected 9 social & scientific priority issues and their R&D organizations.



FUJITSU

RIKEN AICS

Communities

- HPCI Consortium
- PC Cluster Consortium
- OpenHPC
- …

Domestic Collaboration

- Univ. of Tsukuba
- Univ. of Tokyo
- Univ. of Kyoto

International Collaboration

- DOE-MEXT
- JLESC
- …

International Collaborations in past and present

- **IESP (International Exascale Software Project) 2009-2019**
  - White paper and human-networking
- **G8 Research Councils Initiative on Multilateral Research Funding for exascale computing (2010-2013)**

- **JLESC: Joint Laboratory for extreme scale computing (2014～)**
  - NCSA, ANL, INRIA, BSC, JSC, RIKEN
  - Two F2F meeting in a year to organize projects and discussions

- **Bilateral international collaborations**
  - Japan-France ANR-JST ICT project: FP3C (Framework and Programming for Post Petascale Computing) 2010～2014
  - SPP-EXA II project by Germany, Japan and France (2015～2017)

International Collaborations in past and present

- SPP-EXA II project by Germany, Japan and France (2015～2017)
  - JST post-petascale CREST PI was eligible to apply
  - Funding is provided as a part of JST CREST funding
- JST CREST: Development of System software technologies for Post-petascale high performance computing

The research area aims at developing system software technologies as well as related systems to be used for hig h performance computing in the post generations of the Japanese national supercomputer K.

CREST
Core Research for Evolutionary Science and Technology

Visit booth # 4266

Research Themes, Research Directors, and Research Period

	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Adopted FY2010	Development of an Eigen-Supercomputing Engine using a Post-Petascale Hierarchical Model ■Research Director: Tetsuya Sakurai / Professor, University of Tsukuba							
	System Software for Post Petascale Data Intensive Science ■Research Director: Osamu Tatebe / Professor, University of Tsukuba							
	ppOpen-HPC: Open Source Infrastructure for Development and Execution of Large-Scale Scientific Applications on Post-Peta-Scale Supercomputers with Automatic Tuning (AT) ■Research Director: Kengo Nakajima / Professor, The University of Tokyo							
	Parallel System Software for Multi-core and Many-core ■Research Director: Atsushi Hori / Researcher, RIKEN							
	Highly Productive, High Performance Application Frameworks for Post Petascale Computing ■Research Director: Naoya Maruyama / Research Team Leader, RIKEN							
Adopted FY2011		Development of a Numerical Library based on Hierarchical Domain Decomposition for Post Petascale Simulation ■Research Director: Ryuji Shioya / Professor, Toyo University						
		An evolutionary approach to construction of a software development environment for massively-parallel heterogeneous systems ■Research Director: Hiroyuki Takizawa / Associate Professor, Tohoku University						
		Software development for post petascale supercomputing ― Modularity for Supercomputing ■Research Director: Shigeru Chiba / Professor, The University of Tokyo						
		Development of Scalable Communication Library with Technologies for Memory Saving and Runtime Optimization ■Research Director: Takeshi Nanri / Associate Professor, Kyushu University						
		Advanced Computing and Optimization Infrastructure for Extremely Large-Scale Graphs on Post Peta-Scale Supercomputers ■Research Director: Katsuki Fujisawa / Professor, Kyushu University						
Adopted FY2012			Software Technology that Deals with Deeper Memory Hierarchy in Post-petascale Era ■Research Director: Toshio Endo / Associate Professor, Tokyo Institute of Technology					
			Power Management Framework for Post-Petascale Supercomputers ■Research Director: Masaaki Kondo / Associate Professor, The University of Tokyo					
			Framework for Administration of Social Simulations on Massively Parallel Computers ■Research Director: Itsuki Noda / Research Team Leader, National Institute of Advanced Industrial Science and Technology					
			Research and Development on Unified Environment of Accelerated Computing and Interconnection for Post-Petascale Era ■Research Director: Taisuke Boku / Professor, University of Tsukuba					

International Collaborations in past and present

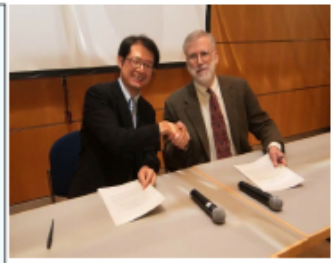
- US-JP DOE-MEXT collaborations under the agreement at government-level for system software of high-performance computing
  - The framework will be revised by new US ECP

- Plans with other countries on high-performance computing are under discussions …

International Collaboration between DOE and MEXT

PROJECT ARRANGEMENT
UNDER THE IMPLEMENTING ARRANGEMENT
BETWEEN
THE MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY OF JAPAN
AND
THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA
CONCERNING COOPERATION IN RESEARCH AND DEVELOPMENT IN ENERGY AND RELATED FIELDS

CONCERNING COMPUTER SCIENCE AND SOFTWARE RELATED TO CURRENT AND FUTURE HIGH PERFORMANCE COMPUTING FOR OPEN SCIENTIFIC RESEARCH



Yoshio Kawaguchi (MEXT, Japan) and William Harrod(DOE, USA)

Purpose: Work together where it is mutually beneficial to expand the HPC ecosystem and improve system capability
- Each country will develop their own path for next generation platforms
- Countries will collaborate where it is mutually beneficial

- Joint Activities
  - Pre-standardization interface coordination
  - Collection and publication of open data
  - Collaborative development of open source software
  - Evaluation and analysis of benchmarks and architectures
  - Standardization of mature technologies

Technical Areas of Cooperation
- Kernel System Programming Interface
- Low-level Communication Layer
- Task and Thread Management to Support Massive Concurrency
- Power Management and Optimization
- Data Staging and Input/Output (I/O) Bottlenecks
- File System and I/O Management
- Improving System and Application Resilience to Chip Failures and other Faults
- Mini-Applications for Exascale Component-Based Performance Modelling

6

Comments

- Collaboration only by exchanging information and software is easy ...
- But, to make collaborations effective and realistic, we need funds.
- Funding must be done by funding agency of each country
  - It is difficult to provide funds to other countries.
  - Bilateral project is easy, but multi-lateral is difficult.
- International arrangement with funding agencies are important.

- Besides, human networking is a key for international collaborations as well.

Which projects are present?


DEEP/-ER: Prof Dr Norbert Eicker
INTERTWINE
Christian Simmendinger (T-Systems)
Nick Brown (Edinburgh)
Daniel Holmes (Edinburgh)
Valeria Bartsch (Fraunhofer)
???
SAGE: Sai Sai Narasimhamurthy
Mont-Blanc 3: Pascale Bernier-Bruna
BioExcel CoE & ExaFLOW FET`: Erwin Laure
NOMAD: Hermann Lederer
POP: Jesus Labarta
E-CAM: Michael Lysaght
EoCoE: Audit Edouard
MaX CoE: Carlo Cavazzoni
HPC Ecosystem
EXDCI
Eurolab-4-HPC
NESUS
Centres of Excellence
MAX NOMAD E-CAM EoCoE ESiWACE COEGSS BioExcel CompBioMed PoP
Project Start: Autumn 2015
Memory & Sto
Interconnect
DEEP/DEEP-ER
Compute
MONT-BLANC
NLAFET
ECOSCALE
Algorithms
Programming tools
Data-intensive rea
ExaFLOW
ExCAPE
CRESTA
ComPat
EXA2CT
ESCAPE
ExaHYPE
NLAFET
READEX
ALLScale
INTERTWINE
NLAFET
EPiGRAM


SAGE
NEXTGenIO
Memory & Storage
NUMEXAS
ExaFLOW
CRESTA
ExCAPE
ComPat
EXA2CT
ExaNEST
DEEP/DEEP-ER
Interconnect
NLAFET
ExaHYPE
Mathematics
Algorithms
ExaHYPE
ESCAPE
NLAFET
Programming tools
READEX
ALLScale
ECOSCALE
INTERTWINE
NLAFET
ExaNoDe
ANTAREX
Mont-Blanc 3
EPiGRAM
EXTRA
HPC
Ecosystem
Compute
EXDCI
Mango
Data-intensive real-time
MONT-BLANC
Eurolab-4-HPC
GreenFLASH
NLAFET
NESUS
Centres of Excellence
MAX NOMAD E-CAM EoCoE ESiWACE COEGSS BioExcel CompBioMed PoP
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