FP7 Support Action - European Exascale Software Initiative

DG Information Society and the unit e-Infrastructures

Addressing the Challenge of Exascale

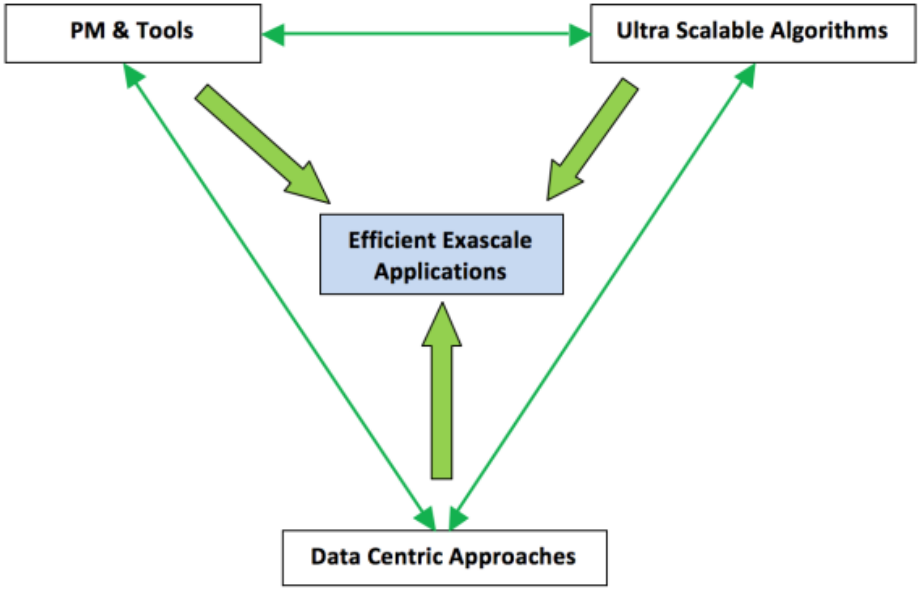
European Exascale Software Initiative EESI

Towards Exascale roadmap implementation

EESI2 – Recommendations

Education Courses and Training Needs

EESI2 recommendations



Educating experts is critical for realising the enabling nature of exascale computing

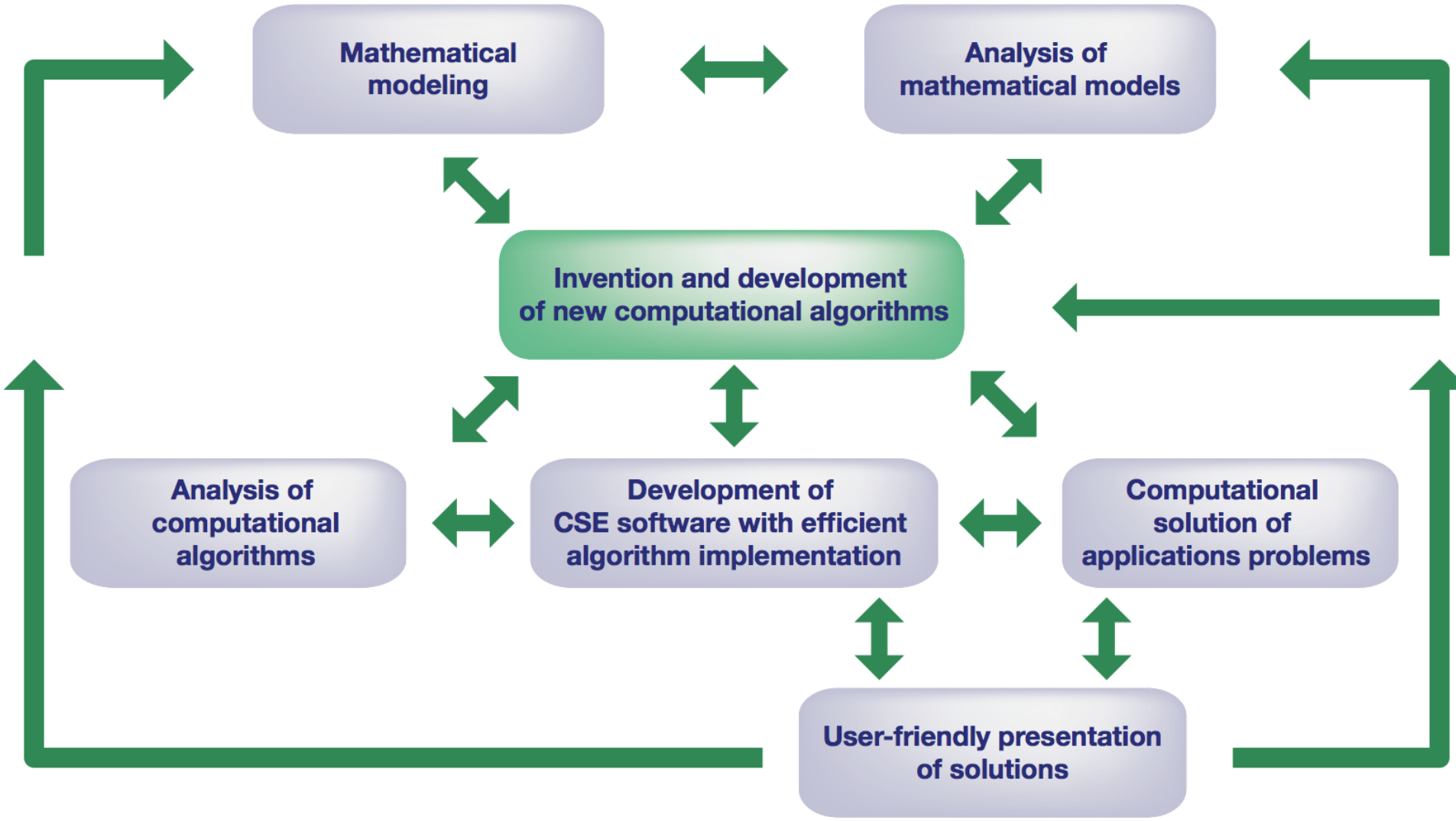
An extreme broadening of the application areas are changing the needs in education and teaching

Interdisciplinary education becomes a must

Motivations

- High Performance computations must be seen in the wider context of Computational Sciences and Engineering
- The necessary background for a well-educated expert in CSE includes expertise in foundations in Mathematics, an understanding of probability and statistics, a grasp of modern computing (hardware and software)
- The necessary background includes an understanding of foundations of modern science and engineering, including biology, finance, social sciences, data sciences.
- The demand of graduates with expertise in CSE exceeds the supply by far.
- The interdisciplinary constellation is being adapted only hesitatingly in the European educational framework.

Need of interdisciplinary education



Development of suitable interdisciplinary educational structures and programmes

Proposal : Fund Educational Programmes and institutions that:

- Are committed to develope suitable interdisciplinary structures and programmes. The education must be offered on all levels including bachelor, master, and PhD education.

- Infuse the European research expertise into innovative educational concepts in the field of HPC and CSE.

- Emergency and Funding description

The gap between demand and supply of experts

Conclusions of a WTEC Report (April 2009):

- *The demands for CSE educated personnel exceeds the supply;*
- *inadequate education and training threatens the grows of CSE.*

US DoE ASCAC Workforce Subcommittee letter (2014)

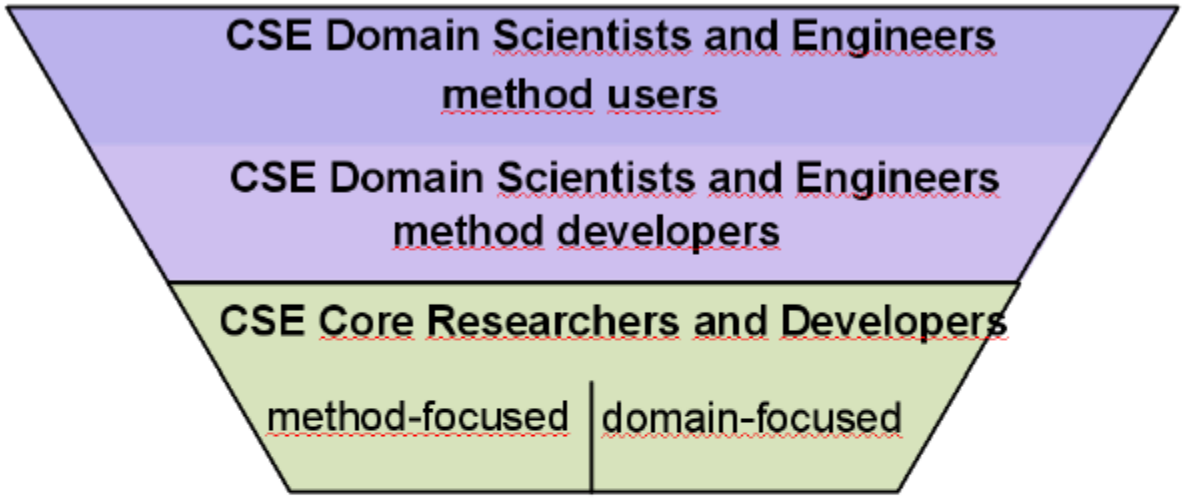
- *"There is a growing national demand for graduates in [...] Computing Sciences that far exceeds the supply from academic institutions. Future projections indicate an increasing workforce gap."*

And many other reports stating the same....

Growing demands on CSE graduates

- Industry, research institutes, government, and broad areas of academic research are making more use of simulations, high-end computing, and simulation-based decision making than ever before
- Demand for a workforce versed in technologies necessary for effective and efficient mathematics-based computational modeling and simulation
- Demand for graduates with the interdisciplinary expertise needed to develop and/or utilize computational techniques and methods to advance the understanding of the real world and to support better decision making
- Demand for a workforce that can take advantage of the transformation that high-performance and data-centric computing offer to industry, economy, health care and society

Structure of Community

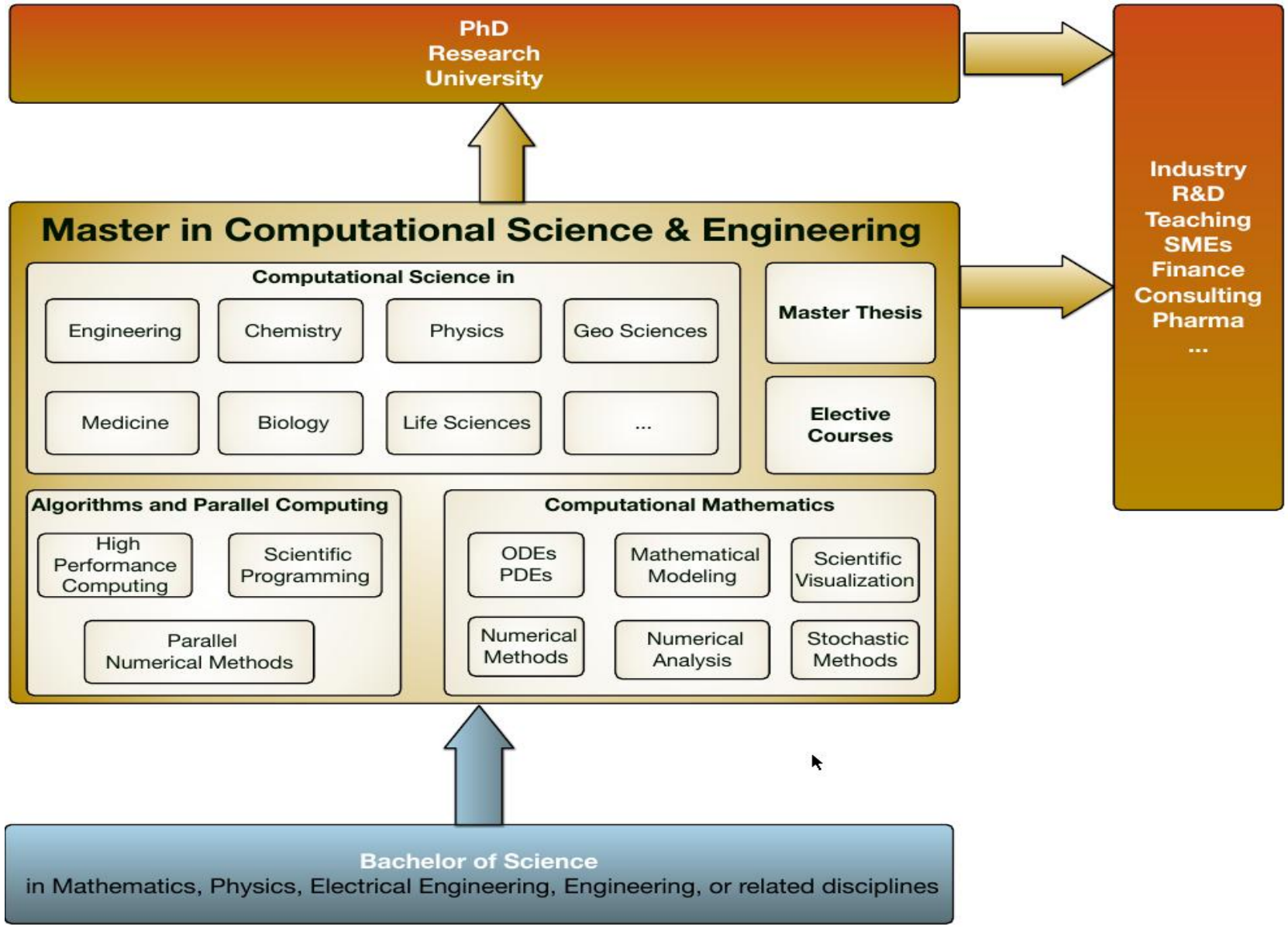


- *Core Researchers and Developers*: engaged in the conception, analysis, development, and testing of algorithms and software
- *Domain Scientists and Engineers*: engaged in applying core algorithms and software in particular science, engineering, medical, ... campaigns

Nessary landscape in education and training

- Need for educational programmes on all levels of HE:
  - first, second, third cycle
  - continuing education
- Need for programmes that satisfy the needs of the whole community:
  - focused on the core (e.g., BE/BSc, ME/MSc, PhD in CSE)
  - programmes that infuse some CSE training within another degree structure

CSE programme structure



Graduate programmes

- Breadth and depth of topics covered depend on the specific degree focus
- All graduates should have:
  - a solid foundation in modern mathematics
  - an understanding of probability and statistics
  - a grasp of modern computing, computer science, networks, programming languages, principles of software engineering, and high-performance computing
  - an understanding of foundations of modern science and engineering, including biology, finance, social sciences, data sciences
  - *skills in teamwork, multidisciplinary collaboration, and leadership, responsibility*
- Foundations should be complemented by deep knowledge in a specific area of science, engineering, mathematics and statistics, or computer science.

Continuing and professional education

- Opportunities to engage with industry to create and offer short courses
  - target general CSE skills for the non-CSE specialist
  - target more advanced skills in timely opportunity areas (such as parallel and extreme-scale computing, and computing with massive data)
- Demand for training in CSE-related topics exists more broadly among graduate students and researchers in academic institutions and research institutions
  - summer schools, short courses
- Professional societies should create systematic facilities for pursueing some of these ideas in continuing and professional education

Education in parallel and extreme-scale computing

- Broad and fundamental need to educate a wide spectrum of engineers and scientists to be better prepared for the age of ubiquitous parallelism
- *Focus must be shifted to the complexity of parallel algorithms and the real-life cost to solve a computational problem*
- Education in programming techniques needs to be augmented with parallel programming elements and a distinctive awareness of performance and computational cost (including power consumption)
- Current trends are characterized by a growing complexity in the design of the computer architectures

Conclusions

1. Strengthening and broadening education in parallel computing and HPC is of vital importance for research and development in Europe, since parallelism has become ubiquitous for all uses of computers in science and technology.
2. A well-balanced system of educational offerings is the basis for shaping the HPC ecosystem that is necessary to give computing-based research its foundations and which is necessary to leverage its benefits.
3. HPC training must be seen embedded in the larger problem of education in Computational Science and Engineering (CSE). Considering HPC education without CSE is like considering the engines but forgetting the car that it should power. The engines without the cars would get us nowhere.
4. HPC and CSE education must respect the three levels of expertise that are defined analogous to the structure of the HPC community. Thus HPC education must be organised according to the following classification: *method users, method developers, core researchers.*

Acknowledgements

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- Wih contribution of a large group of experts