Казанский федеральный университет

ИНСТИТУТ вычислительной математики и информационных технологий

Современные тенденции в образовательных стратегиях для устойчивого развития экосистемы высокопроизводительных вычислений

Сергей Мосин,
к.т.н., доцент,
директор института ВМиИТ КФУ

Russian Supercomputing Days
25-26 сентября 2017 г

Outlines:

- Introduction
- The HPC strategies of different countries
- Features of the curricula focused on education in HPC
- Education strategy of Kazan Federal University in the HPC field
- Conclusion

Outlines:

- *Introduction*
- The HPC strategies of different countries
- Features of the curricula focused on education in HPC
- Education strategy of Kazan Federal University in the HPC field
- Conclusion

Introduction:

The State-of-the-Art Features:

- Increasing a demand of the labor market in IT specialists of different levels and qualifications;
- Transition to the competence model in education;
- HPC plays very important role in the sphere of IT;
- The constraints for active involvement the HPC deal with low competence of the regular users, the problem originators and the general IT specialists in the HPC topics.

Introduction:

The Distinctive Features of HPC:

- Complex infrastructure, which needs high quality specialists for use and support.
- High direct and indirect cost on high-performance computer design, implementation, use and maintenance.
- The unique architecture depending on the class of tasks or even specific task which should be solved. Each HPC system is designed for specific task.

Introduction:

The Distinctive Features of HPC:

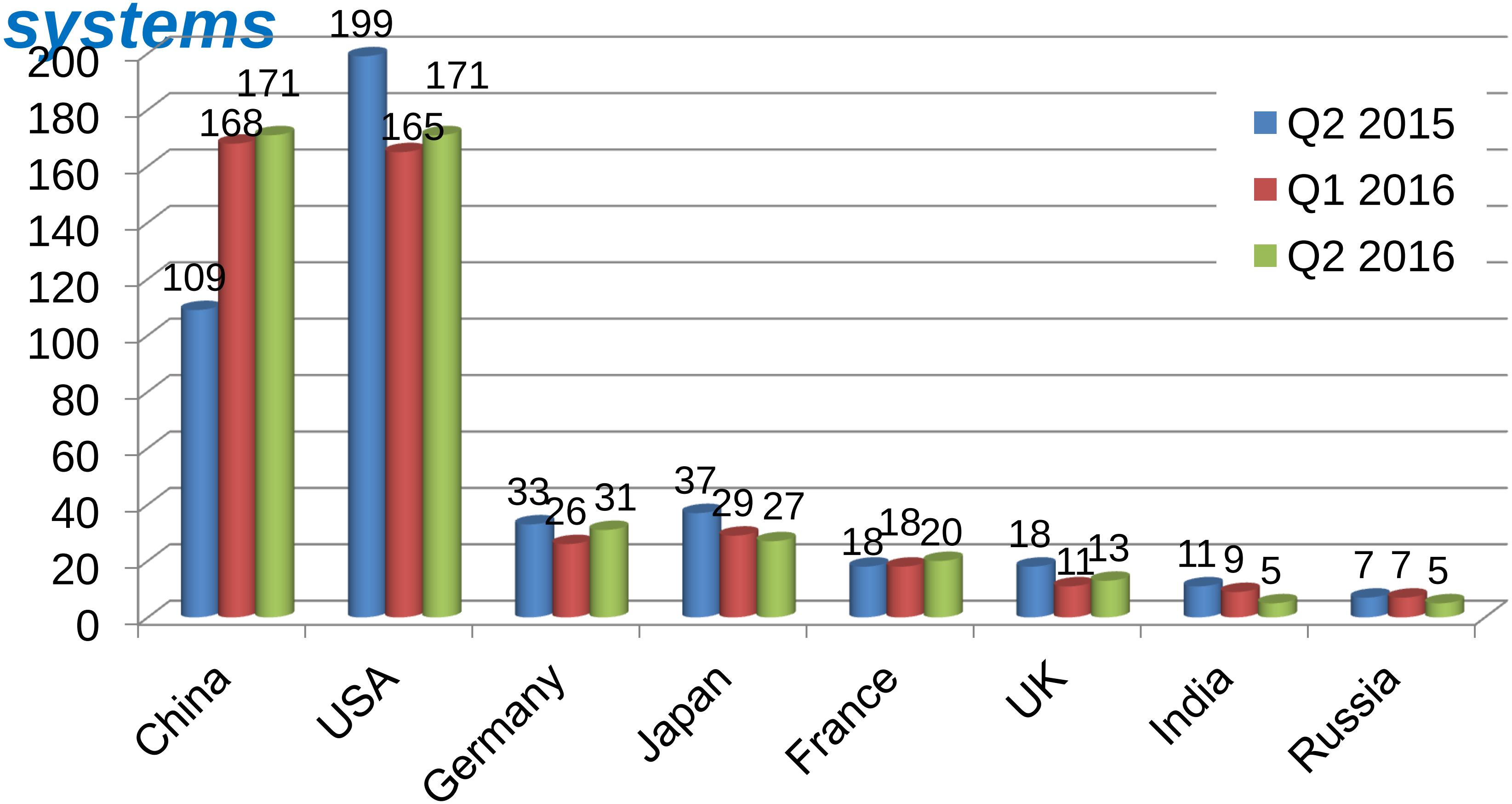
- Essential gap between hardware performance and available software possibilities.
- Non-equal involvement of the HPC into interdisciplinary R&D.
- A lot of skills and knowledge in different areas such as computer science, telecommunications, program engineering, power supply and consumption, applied and computational mathematics, management, etc., are required for efficient HPC user and computational scientists.

Outlines:

- Introduction
- *The HPC strategies of different countries*
- Features of the curricula focused on education in HPC
- Education strategy of Kazan Federal University in the HPC field
- Conclusion

The HPC strategies of different countries:

The dynamic of changes the number of HPC-systems



Source: https://www.top500.org

The HPC strategies of different countries:

HPC specification for top 10 countries (48th

Country	Count	System Share (%)	Rmax (GFlops)	Rpeak (GFlops)	Cores
USA	171	34,2	228,032,809	327,303,955	11,660,816
China	171	34,2	223,571,136	394,013,392	21,546,512
Germany	31	6,2	36,501,435	45,628,388	1,600,240
Japan	27	5,4	54,486,820	77,371,577	3,946,560
France	20	4	25,398,803	31,727,765	1,158,428
UK	13	2,6	27,602,596	31,682,369	1,148,968
Poland	7	1,4	6,162,214	8,157,370	208,284
Italy	6	1,2	14,062,113	21,140,514	606,312
India	5	1	3,092,368	4,456,051	133,172
Russia	5	1	4,411,812	6,515,928	181,070

Source: https://www.top500.org

The HPC strategies of different countries:

HPC specification for top 10 countries (49th

Country	Count	System Share (%)	Rmax (GFlops)	Rpeak (GFlops)	Cores
USA	168	33,6	250,904,433	366,319,668	12,207,986
China	160	32	235,115,292	406,993,366	20,925,100
Japan	33	6,6	62,481,816	91,275,837	7,242,076
Germany	28	5,6	37,497,153	47,583,121	1,598,152
France	18	3,6	25,722,027	32,378,441	1,166,988
UK	17	3,4	30,717,835	36,231,323	1,229,176
S. Korea	8	1,6	8,534,877	12,016,411	293,968
Italy	8	1,6	17,308,313	25,930,658	683,112
Canada	6	1,2	5,612,415	10,146,305	261,184
Poland	6	1,2	5,739,053	7,666,938	190,324
S. Arabia	6	1,2	10,062,165	14,404,496	418,168

Source: https://www.top500.org

The HPC strategies of different countries:

Short specification of the national HPC

Country	HPC Strategy / Program	Investment, $
USA	National Strategic Computing Initiative (NSCI)	320 million/year
China	13th Five-Year Development Plan (Develop Multiple Exascale Systems)	200 million/year (for next five years)
European Union	ETP4HPC; PRACE; ExaNeSt	1.1 in billion total allocated through 2020
Japan	Flagship2020 Program	@$200 million/year (for next five years)
India	National Supercomputing Mission	140 million/year (for 2016-2020)
South Korea	National Supercomputing Act	20 million/year (for 2016-2020)

The HPC strategies of different countries:

National Strategic Computing Initiative in USA was launched to advance the USA leadership in HPC.

Five strategic objectives in the government collaboration with industry and academia:

1) Accelerating delivery of a capable exascale computing system;
2) Increasing coherence between the technology base used for modeling and simulation and that used for data analytic computing;
3) Establishing, over the next 15 years, a viable path forward for future HPC systems;

The HPC strategies of different countries:

National Strategic Computing Initiative in USA

Five strategic objectives in the government collaboration with industry and academia (cont.):

4) Increasing the capacity and capability of an enduring national HPC ecosystem by employing a holistic approach that addresses relevant factors such as networking technology, workflow, foundational algorithms and software, accessibility, and workforce development;
5) Developing an enduring public-private collaboration.

The HPC strategies of different countries:

National Strategic Computing Initiative in USA

According to NSCI the National Science Foundation (NSF) should:

1) Provide leadership in learning and workforce development to encompass support of basic HPC training for a broad user community as well as support for career path development for computational and data scientists;
2) Increase engagement with industry and academia through existing programs;

The HPC strategies of different countries:

National Strategic Computing Initiative in USA

According to NSCI the National Science Foundation (NSF) should (cont.):

3) Support the broad deployment of NSCI techno-logies to increase the capacity and capability of the HPC ecosystem;
4) Lead the development of domestic and interna-tional collaborations that will advance transfor-mative computational science and engineering with an integrated approach to high-end computing, data, networking, facilities, software, and multidisciplinary expertise.

The HPC strategies of different countries:

European HPC Strategy

Three pillars:

1) Developing the next generation of HPC technologies, applications and systems towards exascale;
2) Providing access to the best supercomputing facilities and services for the industry (including SMEs) and academia (Partnership for Advanced Computing in Europe – PRACE);
3) Achieving excellence in HPC application delivery and use through establishment of Centers of Excellence in HPC applications.

The HPC strategies of different countries:

European HPC Strategy

The PRACE ensures the wide availability of HPC resources on equal access terms, in order to strengthen the position of European industry and academia in the use, development and manufacturing of advanced computing products, services and technologies.

All EU state programs in the field of HPC are oriented onto strengthening the position of European industry and academia in the use, development and manufacturing of advanced computing products, services and technologies

Outlines:

- Introduction
- The HPC strategies of different countries
- ***Features of the curricula focused on education in HPC***
- Education strategy of Kazan Federal University in the HPC field
- Conclusion

Features of the curricula focused on education in HPC:

One of the key tasks in national strategies is **development of educational platform** ensuring the training a huge number of required high qualified personnel responsible for effective use of existent hardware and software tools as well as generating a new knowledges and technologies in the HPC area, training the next generation of scientists, designers, engineers, users and task managers.

Features of the curricula focused on education in HPC:

The efficient training of HPC professionals should be realized in the framework of computer science / computer engineering curricula by including the new specialized courses.

Many universities develop curricula on HPC based on **ACM CS/CE Curricula** and/or **NSF/IEEE-TCPP Curriculum Initiative on Parallel and Distributed Computing**.

Features of the curricula focused on education in HPC:

ACM CS/CE Curricula

The **ACM/IEEE Computer Engineering curriculum** considers the following main aspects of HPC:

1) Computer architecture and organization with instruction-level and processor-level parallelism (multicore processor and multiprocessor system);
2) Distributed system architectures, high performance computing and networks, memory hierarchy architecture for single core and multicore systems;
3) Parallel algorithms and multi-threading;

Features of the curricula focused on education in HPC:

ACM CS/CE Curricula

4) Introduction to High Performance Computing, which covers the organization of high performance computer, design methods of parallel programming, performance model of programs, performance evaluation and optimization techniques, programming in MPI and OpenMP and algorithms in high performance computing.

Features of the curricula focused on education in HPC:

ACM CS/CE Curricula

The latest **ACM/IEEE-CS Joint Task Force: Computer Science Curricula** proposal vastly upgraded the coverage of parallel thinking proposing topics:

1) Parallel and Distributed Computing;
2) Parallelism Fundamentals;
3) Parallel Decomposition;
4) Parallel Algorithms, Analysis, and Programming;
5) Parallel Architecture;
6) Parallel Performance;
7) Distributed Systems; and
8) Cloud Computing.

Features of the curricula focused on education in HPC:

NSF/IEEE-TCPP Curriculum Initiative on PDC

This document provides guidance and support for departments looking to expand the coverage of parallel and distributed topics in **undergraduate programs**. According to the recommendations the problems of parallel and distributed computing fall into the following four knowledge areas:

1) Architecture.

2) Programming.

3) Algorithms.

4) Cross Cutting and Advanced Topics.

Outlines:

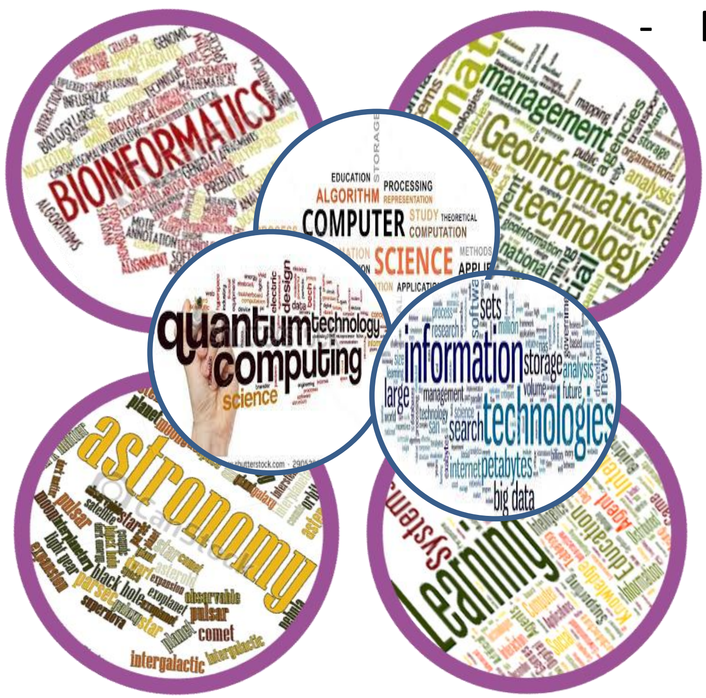
- Introduction
- The HPC strategies of different countries
- Features of the curricula focused on education in HPC
- ***Education strategy of Kazan Federal University in the HPC field***
- Conclusion

Education strategy of KFU in the HPC field:

Strategic Academic Unit

«Трансляционная 7П медицина»
- Нейроинформатика и когнитивные технологии;
- ООП «Биоинформатика».

«ЭкоНефть»
- Геоинформатика;
- Геостатистика;
- ГИС.



«Астровызов»
- квантовые коммуникации;
- квантовая криптография;
- математическое и численное моделирование.

«Учитель XXI века»
- Электронные образовательные технологии (MOOC);
- Персонально-определяемое образование.

Education strategy of KFU in the HPC field:

The educational process uses the practical skills-driven model. The professional courses combine theoretical knowledge and practical skills.

The laboratory works are constructed in such way to master different technologies and tools of parallel and distributed programming.

Bachelor degree students receive basic competences in parallel and distributed computing. The master and Ph.D. students study advanced courses and combine training with R&D. Such multilayer education system allows generating different specialists for the local and global HPC ecosystems.

Outlines:

- Introduction
- The HPC strategies of different countries
- Features of the curricula focused on education in HPC
- Education strategy of Kazan Federal University in the HPC field
- *Conclusion*

Conclusion:

The increased use of computational and information technologies brings innovation and efficiency in many production and business processes, generates products and services favoring the growing of industry, science and economy.

The preparation and implementation the professional courses to train the new generation of specialists with knowledge and skills in mathematical simulation and modelling, intellectual data analysis and HPC using, administrating and management are very important tasks for future development the HPC ecosystems.

Спасибо за внимание!