Need for Exascale Education and Training

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What are the reasons for Supercomputing Education?
Expertise Most Needed in HPC
(Reasons for Supercomputing Education)

• Expertise in parallel programming for highly parallel HPC systems
• Expertise in creating advanced software algorithms
• The ability to port and optimize applications for new hardware architectures, including heterogeneous architectures that include newer processor types

According to the IDC report:
“IDC Recommendations Report: For EU HPC Leadership In 2020” by Earl Joseph, Steve Conway and Jie Wu
Supercomputing, Computing, IT…
(Reasons for Supercomputing Education)

- Supercomputing Education
- Parallel Computing Education
- Computational Science & Engineering Education
- IT Education

Remarks:
- Supercomputing Today – Computing Tomorrow …
- Exa-2018/20 is not a final point, it is a beginning of the new HyperParallel computing epoch …
- Currently IESP Roadmap is composed by a few experts but computing community will use all these notions in 2020, masses – in 2025 …
Why IESP & Education?
(Roadmap components)

4.1 System Software
4.1.1 Operating Systems
4.1.2 Runtime Systems
4.1.3 I/O Systems
4.1.4 Systems Management
4.1.5 External Environments

4.2 Development Environments
4.2.1 Programming Models
4.2.2 Frameworks
4.2.3 Compilers
4.2.4 Numerical Libraries
4.2.5 Debugging

4.3 Applications
4.3.1 Application Element: Algorithms
4.3.2 Application Support: Data Analysis and Visualization
4.3.3 Application Support: Scientific Data Management

4.4 Cross-Cutting Dimensions
4.4.1 Resilience
4.4.2 Power Management
4.4.3 Performance Optimization
4.4.4 Programmability
Why IESP & Education?

Supercomputing Education – why now?

Bachelor degree – 4 years, Master degree – 2 years,
2012 + 6 years at universities = 2018
If we start SCE now then we get first graduate students at the Exa-point…
Why Supercomputing Education?
What is new?
Why Supercomputing Education?
(What’s new?)

The primary goal of Supercomputing:
• Performance

The primary notion of Supercomputing:
• Informational (parallel) structure of algorithms and programs

Supercomputing Education must address these issues.

In current IT/CS&E - education? No.
GAUSS elimination: method and algorithm
(informational structure)

```
do i = n, 1, -1
  s = 0
  do j = i+1, n
    s = s + A(i,j)*x(j)
  end do
  x(i) = (b(i) - s)/A(i,i)
diag...
```

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Simple questions?
(ask your students…)

• How to construct a communication free algorithm for a particular problem?
• What is parallel complexity of an algorithm? Why do we need to know a critical path of an informational graph?
• How to detect and describe potential parallelism of an algorithm? How to extract potential parallelism from a code?
• How to estimate data locality in my application?
• How to estimate scalability of an algorithm and/or application? How to improve scalability of an application?
• How to express my problem in terms of Google’s MapReduce model?
• ...

In current IT/CS&E - education? No.
What could be elements of Supercomputing Education at the state level?
(Example: Supercomputing Education in Russia, 2010-2012)

1. Network of centers on supercomputing research and education in Federal Districts of Russia – 8,

2. Supercomputing (parallel computing) Education, intro level – massive,

3. Supercomputing Education, basic&advanced level – 500,

4. Leading Russian universities involved in Supercomputing Education – 25,

5. Qualified teachers on supercomputing technologies – 150,

6. International activities. Collaboration with universities worldwide,
What could be elements of Supercomputing Education at the state level?
(Example: Supercomputing Education in Russia, 2010-2012)

7. Body of Knowledge on supercomputing technologies,
8. Modification of the state educational standards (+parallel computing) - 4,
9. Modification of graduate programs (+supercomputing basics) – 16,
10. Bank of educational courses (modified/new) on supercomputing technologies - 40,
11. Series of books and textbooks “Supercomputing Education” – 25,
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11. Series of books and textbooks “Supercomputing Education” – 25,

12. National system of supercomputing conferences & student schools,

13. Internet-center on Supercomputing Education (hpc-education.ru),

14. …
IESP + Education = ?

- **New chapter in the IESP Roadmap:**
  - "Perspectives on Cooperation between IESP and University Communities”.
- **First output** – an overview “Supercomputing Education in the world” (“CS&E Education in the world”?)
- **Expected outputs:** a roadmap and set of recommendations to universities and government agencies on curricula, bachelor/master/PhD programs, etc… to be developed to support an Exascale generation of supercomputers.