

International Exascale Software Project

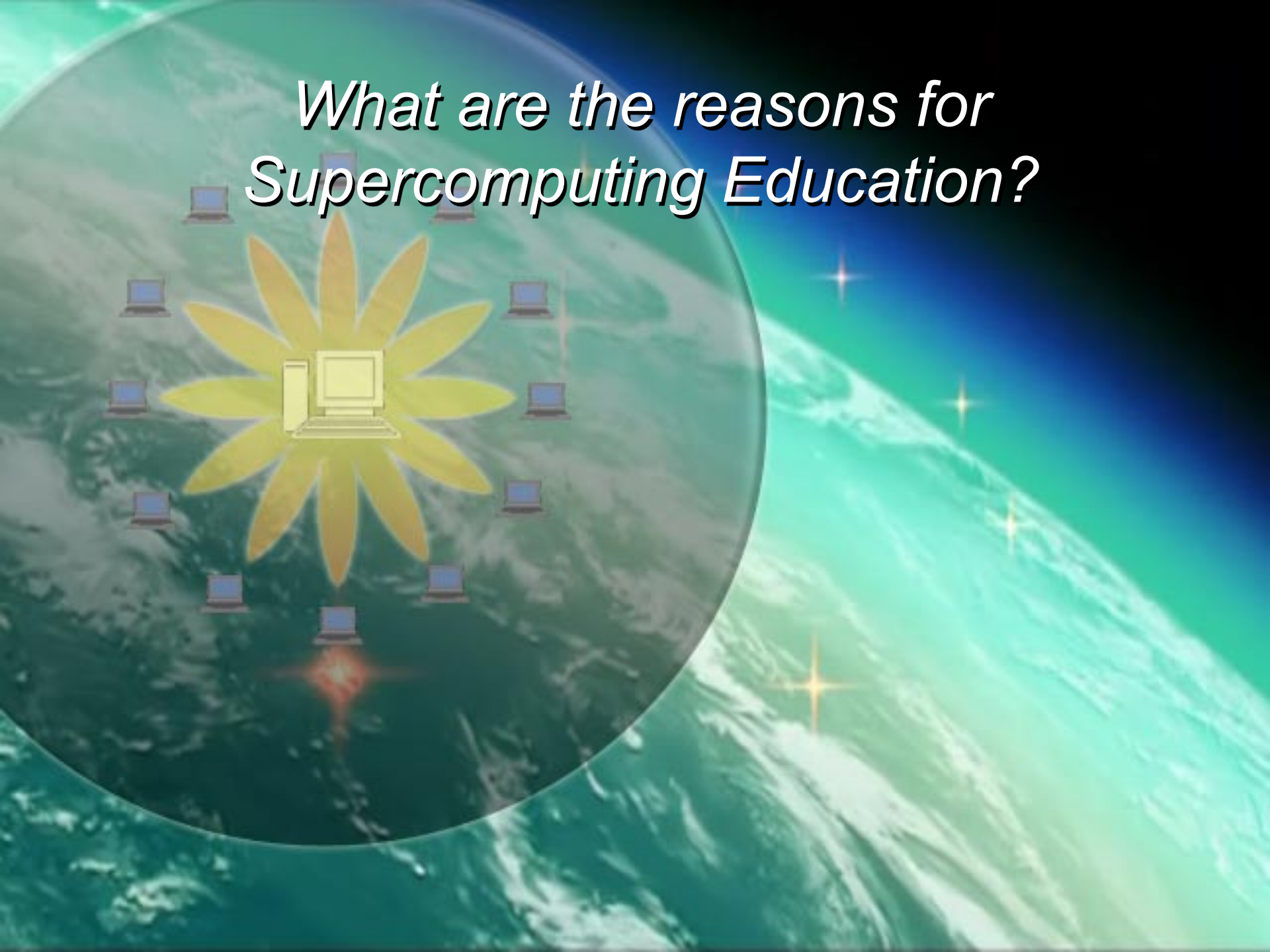
Need for Exascale Education and Training

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October 6-7, 2011 – Cologne, Germany

What are the reasons for Supercomputing Education?



Expertise Most Needed in HPC

(Reasons for Supercomputing Education)

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- *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

E D U C A T I O N

Why IESP & Education?

Supercomputing Education – why now?

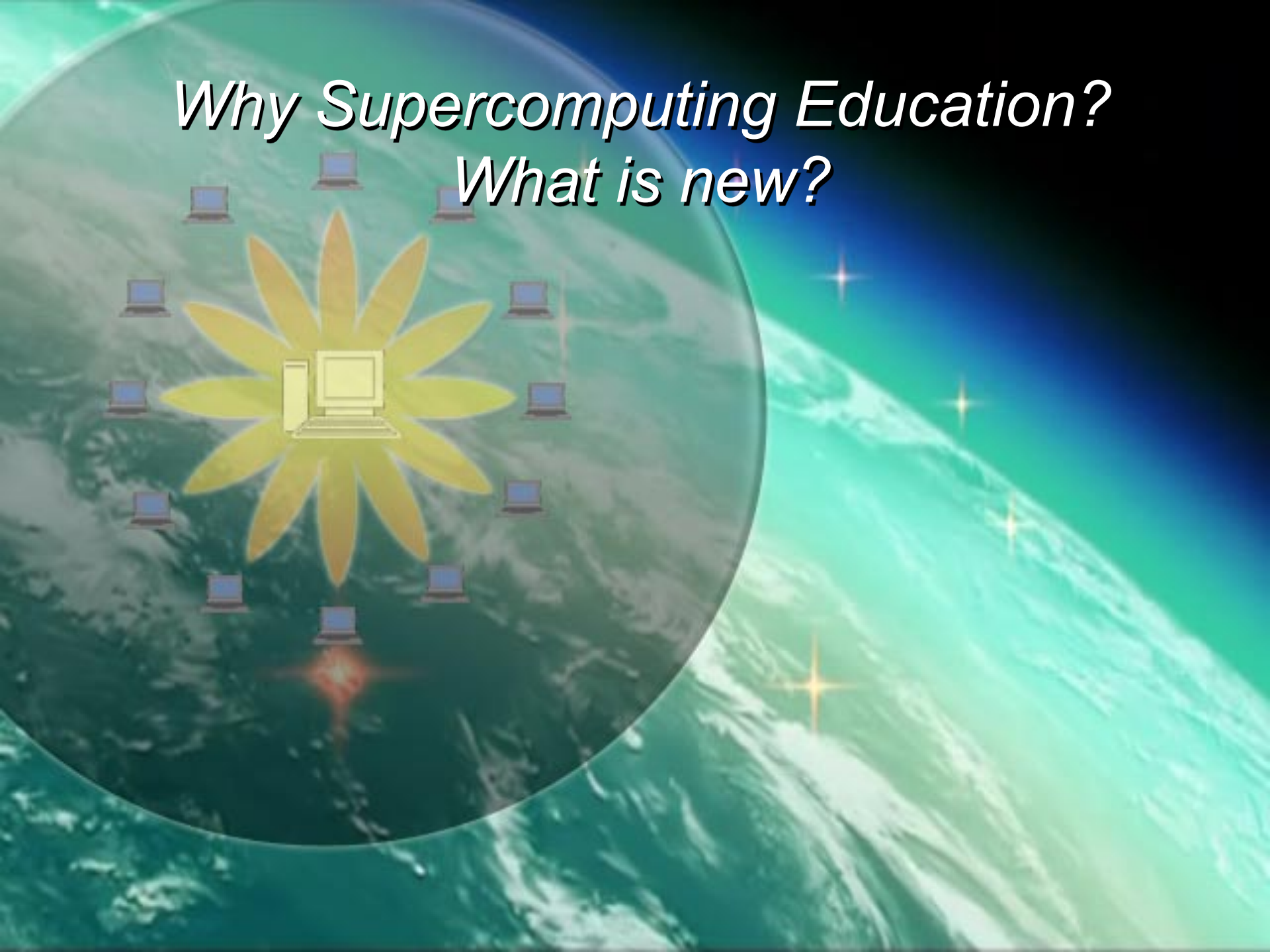
*Bachelor degree – 4 years, Master degree – 2 years,
2012 + 6 years at universities = 2018*

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:

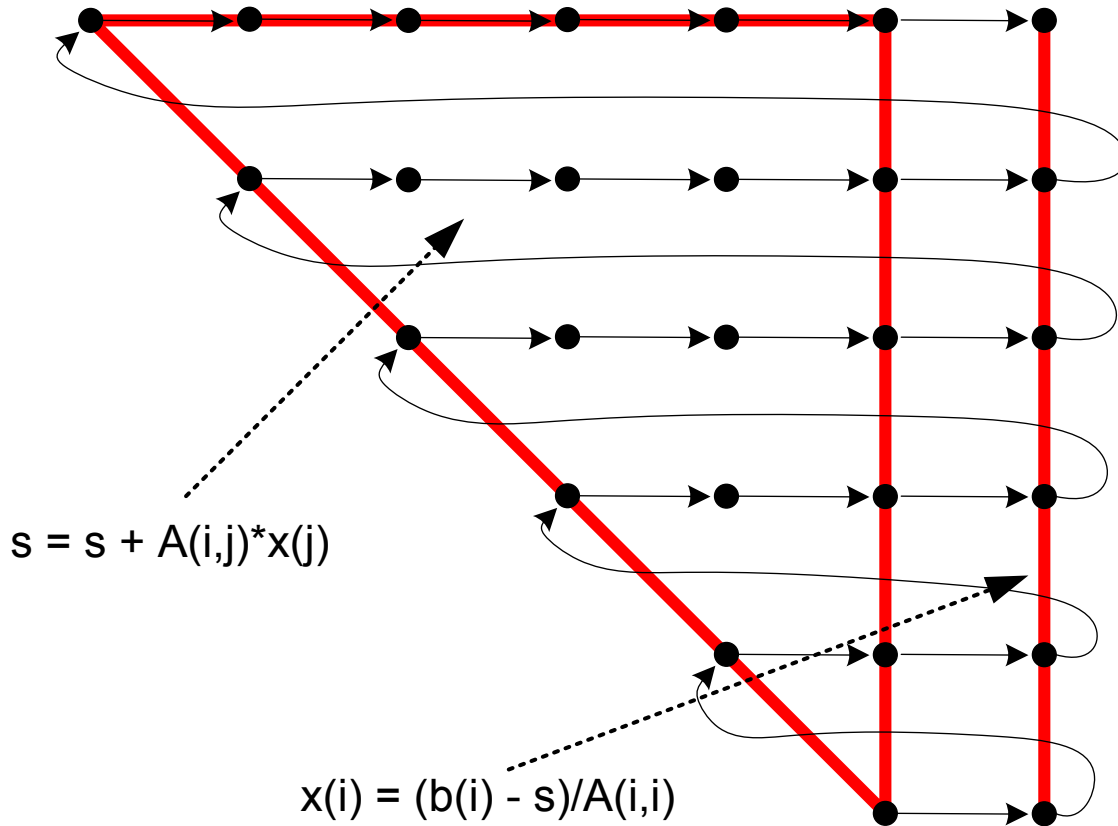
- *Informational (parallel) structure of algorithms and programs*

Supercomputing Education must address these issues.

In current IT/CS&E - education? No.

GAUSS elimination: method and algorithm

(informational structure)

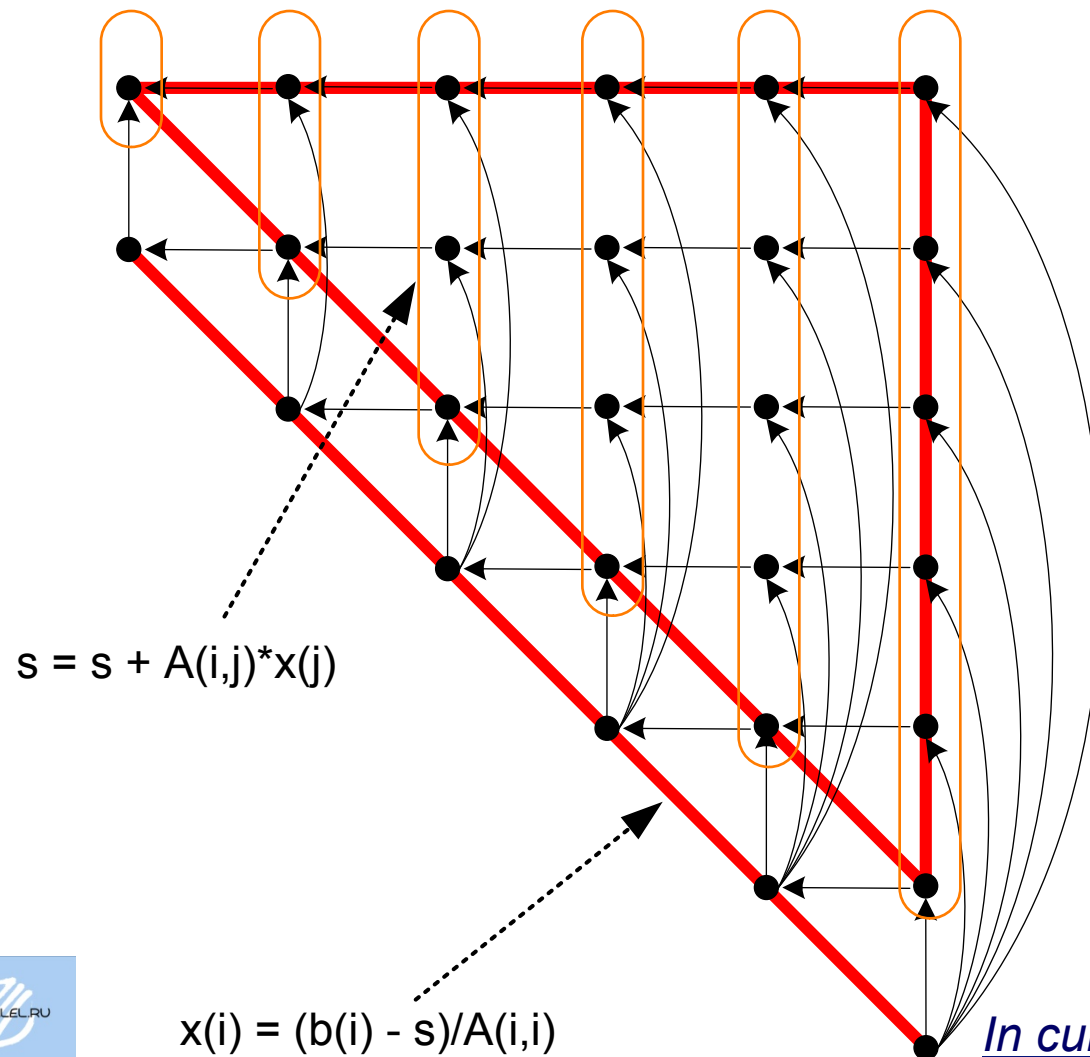


```

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)
end do
    
```

GAUSS elimination: method and algorithm

(informational structure)



```

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In current IT/CS&E - education? No.

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)

(1/2)

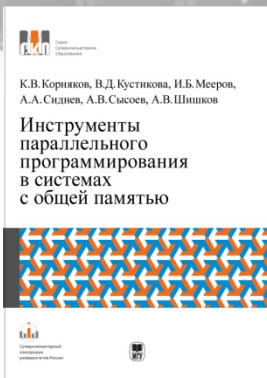
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- A large supercomputing system with many server racks and cables. The racks are black and have the word "FANTOM" on them. The cables are white and are connected to the racks. The system is in a room with a white floor and a white wall.
- 1. Network 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)

(2/2)

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,

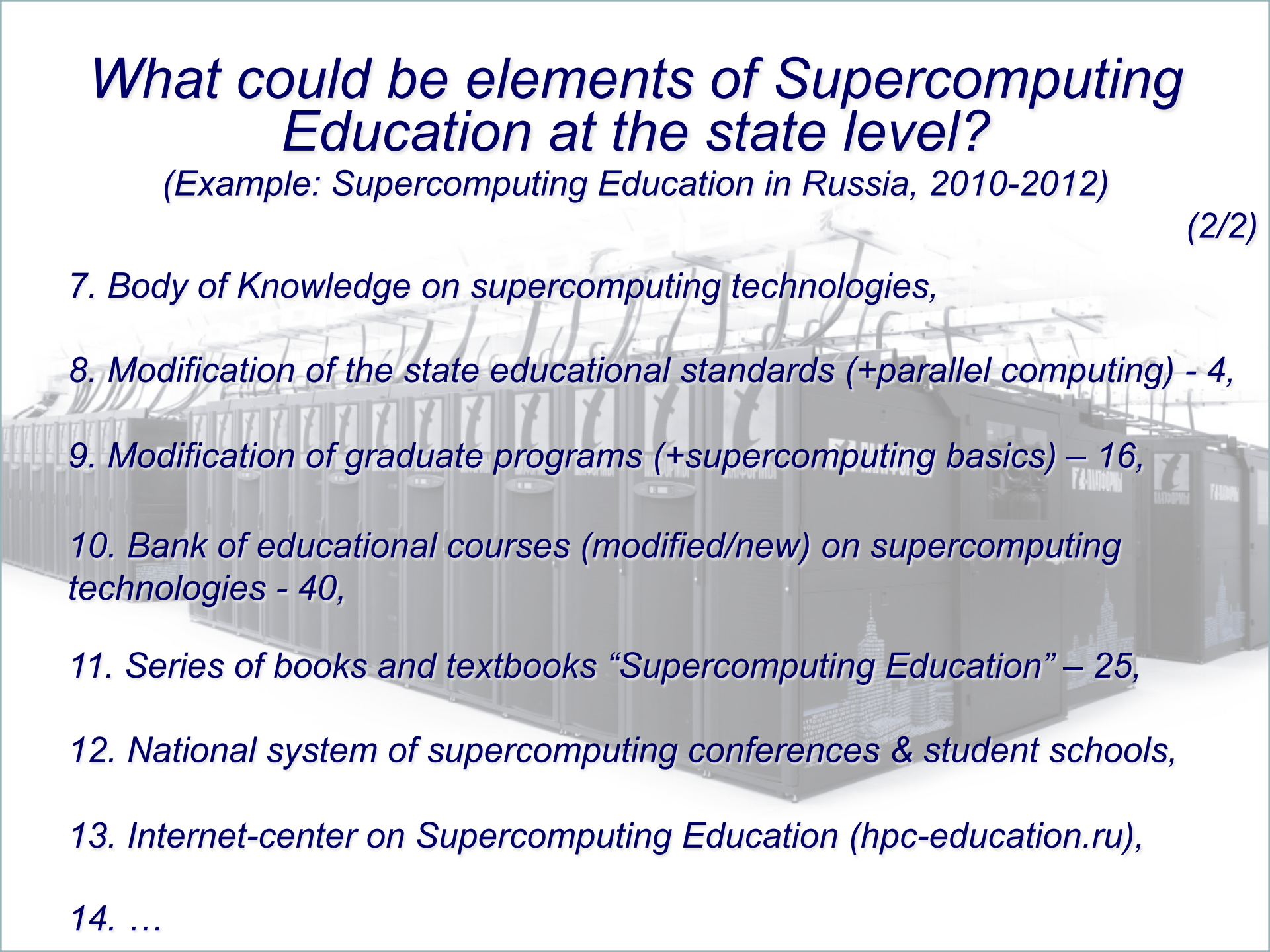


...

What could be elements of Supercomputing Education at the state level?

(Example: Supercomputing Education in Russia, 2010-2012)

(2/2)

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- 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,*
 - 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.*