Disruptive Technologies

Iain Duff

STFC Rutherford Appleton Laboratory and CERFACS

Exascale Applications and Software Conference.
Edinburgh, Scotland. 9-11 April 2013
The European Exascale Software Initiative completed its report in the autumn of 2011.

A follow-up project called EESI-2, led by Philippe Ricoux of TOTAL, with principal partners TOTAL and PRACE, has recently been funded.

The kick-off meeting was held in Paris on 18th September 2012.
EESI-2

EESI-2 will continue for 30 months until 2015.

Several talks at this meeting are from people involved in EESI-2.

A description of the EESI-2 project can be found through the web page: [www.eesi-project.eu/pages/menu/homepage.php](http://www.eesi-project.eu/pages/menu/homepage.php)
Disruptive Technologies

The term Disruptive Technologies is used 25 times in the DOW (Description of Work) document and is the title of three working groups in three different work packages out of the eight in EESI-2.
Disruptive Technologies

The term **Disruptive Technologies** is used **25 times** in the DOW (Description of Work) document and is the title of three working groups in three different work packages out of the eight in EESI-2.

I had hoped to report on the status of “Disruptive Technologies” within EESI-2, but it was felt that we should await some feedback from other Working Groups before proceeding so there is **little to report on** just now.
Disruptive Technologies

The term *Disruptive Technologies* is used **25 times** in the DOW (Description of Work) document and is the title of three working groups in three different work packages out of the eight in EESI-2.

I had hoped to report on the status of “Disruptive Technologies” within EESI-2, but it was felt that we should await some feedback from other Working Groups before proceeding so there is **little to report on** just now.

SO
Disruptive Technologies

What does the term *Disruptive Technologies* mean?
Disruptive Technologies

What does the term *Disruptive Technologies* mean?

My intention is to *stimulate* thought and discussion.

The following notes are constructed after discussions with many colleagues in EESI-2 and beyond.
Some historic disruptive technologies

- Printing press
Some historic disruptive technologies

- Printing press
- Telephone
Some historic disruptive technologies

- Printing press
- Telephone
- Internet
Some historic disruptive technologies

- Printing press
- Telephone
- Internet
- Mobile communications
Some historic disruptive technologies

- Printing press
- Telephone
- Internet
- Mobile communications
- Facebook and twitter
Some historic disruptive technologies in numerical algorithms

- Programmable computers
Some historic disruptive technologies in numerical algorithms

- Programmable computers
- Backward error analysis
Some historic disruptive technologies in numerical algorithms

- Programmable computers
- Backward error analysis
- DFT
Some historic disruptive technologies in numerical algorithms

- Programmable computers
- Backward error analysis
- DFT
- DFP algorithm for optimization
Some historic disruptive technologies in numerical algorithms

- Programmable computers
- Backward error analysis
- DFT
- DFP algorithm for optimization
- Interior point methods
Some historic disruptive technologies in numerical algorithms

- Programmable computers
- Backward error analysis
- DFT
- DFP algorithm for optimization
- Interior point methods
- Preconditioning
Some historic disruptive technologies in numerical algorithms

- Programmable computers
- Backward error analysis
- DFT
- DFP algorithm for optimization
- Interior point methods
- Preconditioning
- Sparse direct methods based on dense kernels
Some historic disruptive technologies in numerical algorithms

- Programmable computers
- Backward error analysis
- DFT
- DFP algorithm for optimization
- Interior point methods
- Preconditioning
- Sparse direct methods based on dense kernels
- Multigrid
Future Disruptive Technologies
Future Disruptive Technologies

Easier to name the Grand National winner
Future Disruptive Technologies

Easier to name the Grand National winner

However, can give some suggestions to provoke the ongoing debate
Disruptive technologies in hardware

It could be argued that the Disruptive Technologies in hardware necessary for Exascale have already happened.
Disruptive technologies in hardware

It could be argued that the Disruptive Technologies in hardware necessary for Exascale have already happened.

Multi-core chips

and

GPUs
Disruptive technologies in hardware

It could be argued that the Disruptive Technologies in hardware necessary for Exascale have already happened.

Multi-core chips

and

GPUs

Others in pipeline
Disruptive technologies in hardware

It could be argued that the Disruptive Technologies in hardware necessary for Exascale have already happened.

Multi-core chips
and
GPUs

Others in pipeline
Stacked memory and
Photonics – optical interconnect
Disruptive technologies in software

- Domain Specific Languages (DSLs)
Disruptive technologies in software

- Domain Specific Languages (DSLs)
- New programming models
Disruptive technologies in software

- Domain Specific Languages (DSLs)
- New programming models
- Auto-tuning
Disruptive technologies in software

- Domain Specific Languages (DSLs)
- New programming models
- Auto-tuning
- Tiling
Disruptive technologies in software

- Domain Specific Languages (DSLs)
- New programming models
- Auto-tuning
- Tiling
- Memory management
Disruptive technologies in software

- Domain Specific Languages (DSLs)
- New programming models
- Auto-tuning
- Tiling
- Memory management
- Automatic vectorization!
Disruptive technologies in algorithms

- Communication reducing algorithms
- Communication hiding algorithms
- Synchronization reducing algorithms
Disruptive technologies in algorithms

- Communication reducing algorithms
- Communication hiding algorithms
- Synchronization reducing algorithms
- Mixed precision computations
Disruptive technologies in algorithms

- Communication reducing algorithms
- Communication hiding algorithms
- Synchronization reducing algorithms
- Mixed precision computations
- Low rank compression
  - Low rank approximation
  - Fast multipole methods
  - Model reduction
  - Compressed sensing
Disruptive technologies in algorithms

- Communication reducing algorithms
- Communication hiding algorithms
- Synchronization reducing algorithms
- Mixed precision computations
- Low rank compression
  - Low rank approximation
  - Fast multipole methods
  - Model reduction
  - Compressed sensing
- Hybrid algorithms and solvers
Disruptive technologies in algorithms

- Communication reducing algorithms
- Communication hiding algorithms
- Synchronization reducing algorithms
- Mixed precision computations
- Low rank compression
  - Low rank approximation
  - Fast multipole methods
  - Model reduction
  - Compressed sensing
- Hybrid algorithms and solvers
- Stochastic PDEs
Disruptive technologies in algorithms
Disruptive technologies in algorithms

- New techniques
  - Tensor calculus
  - Novel algebras
  - Stochastic programming
Disruptive technologies in algorithms

- New techniques
  - Tensor calculus
  - Novel algebras
  - Stochastic programming
- “New” algorithms
  - Chaotic relaxation
  - Contour integration
  - Monte-Carlo techniques
  - Vectorization
Conclusions

- **Disruptive technology** means many and different things to different people
Conclusions

- **Disruptive technology** means many and different things to different people
- They are usually only recognized as such after the event
Conclusions

- Disruptive technology means many and different things to different people
- They are usually only recognized as such after the event
- They will be crucial for exploiting Exascale machines
Conclusions

- Disruptive technology means many and different things to different people
- They are usually only recognized as such after the event
- They will be crucial for exploiting Exascale machines
- We might be able to identify some, but where do we get them from?
Conclusions

▶ Disruptive technology means many and different things to different people
▶ They are usually only recognized as such after the event
▶ They will be crucial for exploiting Exascale machines
▶ We might be able to identify some, but where do we get them from?
▶ One role of EESI-2 experts is to detect and encourage disruptive technologies
THANK YOU FOR YOUR ATTENTION

iain.duff@stfc.ac.uk