Parallel Grid Computing Challenges

eero.vainikko@ut.ee
University of Tartu, Institute of Computer Science
Distributed Systems research group

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In theory, there is NO difference between theory and practice.
But, in practice, there IS.

Jan L. A. van de Snepscheut

- Main driving forces of computational science
- Parallel computing - state of the art
- What is Grid computing?
- Grid computing main challanges
- How we are going to meet the challenges
- Friend-to-friend (F2F) computing framework
- F2F future
- DOUG and DOUG@F2F

1 Driving forces of computational science

1.1 Some predictions

Much-cited legend: In 1947 computer engineer Howard Aiken:

USA will need in the future at most 6 computers!

Why do we need parallel computing at all?

Gordon E. Moore's (founder of Intel) law:

(1965: the number of switches doubles every second year)

1975: - refinement of the above: **The number of switches on a CPU doubles every 18 months**

Until 2020 or 2030 we would reach in such a way to the atomic level or quantum computer

1.2 Grand challenges

***Grand Challenge problems* listed in Wikipedia today:**

- Applied fluid dynamics
- Biomedical imaging and biomechanics
- Fundamental computational sciences
- Meso- to macro-scale environmental modeling
- Molecular biology
- Nuclear power and weapons simulations
- Molecular design and process optimization
- Ecosystem simulations
- Cognition
- Strong artificial intelligence

2 Parallel and Grid computing - state of the art

2.1 What is Grid computing

Grid is a term for a system, where

- geographically remote
  – computers,
  – supercomuters
  – special devices (data storage, censors etc.)

are forming a common resource such a way that user of the system must not know

- where exactly his/her computations and data analysis tasks are being processed
- how exactly the data management is performed

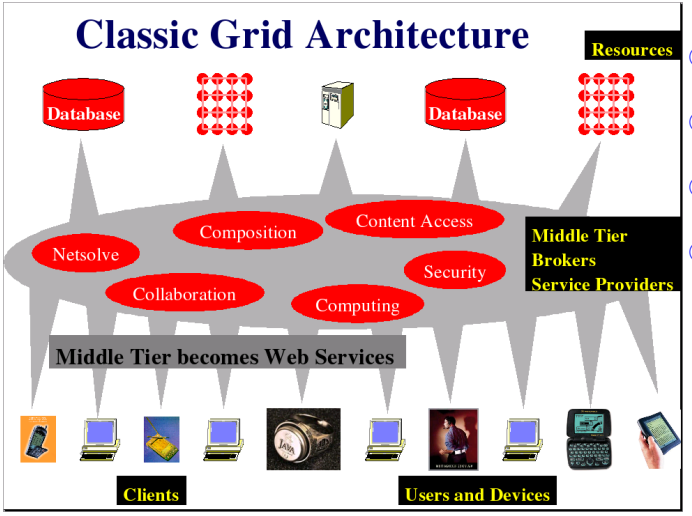
The main purpose of the Grid is to aggregate

- different computers,
- computer centers
- data storages
- special devices

in a way that their use is simple and comfortable also without any deeper knowledge in

- IT
- distributed- and supercomputing

Grid – the next big step after occurrence of the Internet



What was promised:

- As easy as power-grid
- Everywhere
- Accessible to everybody
- Access to any desired resource
  - CPU cycles
  - Storage
  - Special devices

2.2 State of the art

(What we have got so far)

- Batch processing
- - with global scale, though
  - Parallel jobs still available, within a single cluster
  - You really need to know the resource you are running on
- Grid = merely web-services in another wrapping!
- Storage – really unconfortable for user

Problems with existing models

(Not every problem in every middleware)

- Single point of failure
- Lack of scheduling
- Poor scalability
- No means for privacy
- No way for cycle stealing (scavenging)
- Firewall problem
- Requires very large installation
- No economy

Desktop Grids

Possible solution to the problems?

- BOINC www.boinc.org
  - Seti@home, Einstein@home, Proteins@home, Africa@home, SZTAKI@home, Folding@home
- Condor
- ALCHEMI
- JNGI
- **Minimum Intrusion Grid**

But still, for major parallel computational problems we need a Grid of computing nodes that can communicate with each other

- Automatic best available network/protocol choice
- Ability to traverse firewalls
- Setup as easy as *Skype*
- Interplay with social networking trust

Friend-to-friend Computing

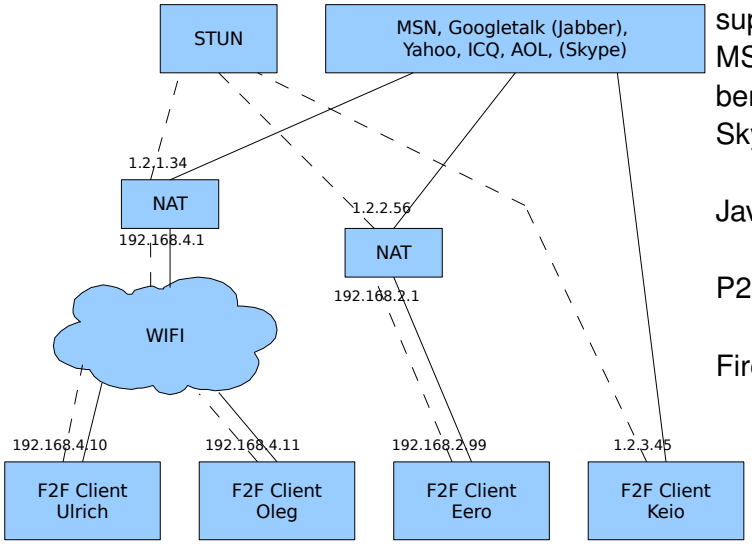
3 Parallel Grid Computing

3.1 Friend-to-friend Computing

Friend-to-friend Computing (F2F); Called also: Spontaneous Desktop Grid

- Developed at the Institute of Computer Science, University of Tartu (U.Norbisrath and E.Vainikko) f2f.ulno.net
- Computing environment based on spontaneous groups
- Instant Messaging friend groups used for triggering the Computing Grid Environment
- Merging ideas from
  - Peer-to-peer
  - High Performance Computing
  - Social networks in instant messaging
- Extremely easy concept for
  - authentication
  - authorization
    based on inherent trust between friends

3.2 F2F Architecture



IM protocols/solutions supported:
MSN, GoogleTalk (Jabber), Yahoo, ICQ, AOL, Skype

Java implementation

P2P-MPI

Firewall hole punching

Ulrich Norbisrath, Keio Kraaner, Eero Vainikko, and Oleg Batraĺev, Friend-to-Friend Computing Instant Messaging Based Spontaneous Desktop Grid. Accepted for The Third International Conference on Internet and Web Applications and Services (ICIW 2008), pp. 245-256, June 2008, Athens/Greece, IEEE Computer Society Press

3.3 F2F - next steps

- F2F kernel C-implementation - work in progress
  - Support for
    - other languages (Python, C, Fortran,...)
    - other devices (Mobile, PDA-s, Supercomputers)
- Interfacing with other Grid infrastructures
- Virtualisation
- ...F2F2F...
- Security
  - Authorisation
  - Encryption
  - Fault tolerance
  - Proof of non-vulnerability

- **Porting real applications to F2F**

4 DOUG

4.1 Domain Decomposition on Unstructured Grids

DOUG (*University of Bath, University of Tartu*) 1997 - 2008
I.G.Graham, M.Haggers, R. Scheichl, L.Stals, E.Vainikko, M.Tehver, K. Skaburskas, O. Batrašev

Parallel implementation based on:

- **MPI, UMFPACK , METIS, BLAS**
- Automatic parallelisation and load-balancing
- Systems of PDEs
- Highly heterogeneous 2D & 3D problems
- 2-level Additiivne Schwarz method
- 2-level partitioning using aggregation
- Automatic Coarse Grid generation
- Adaptive refinement of the coarse grid

4.2 DOUG Strategies

- Iterative solver based on Krylov subspace methods
  - **PCG**
  - **MINRES**
  - **BICGSTAB**
  - 2-layered **FPGMRES** with left or right preconditioning.
- Non-blocking communication where at all possible
  $\Rightarrow$ communication/computation overlap
- **Best algorithms possible for highly variable coefficients** - an ongoing research on parallel algorithm design

Porting DOUG to F2F

4.3 DOUG @ F2F

- Currently, DOUG written in Fortran95
- => research in the area of **re-engineering parallel applications / parallel application modernisation**
  - parsing (fortran) codes
  - parallel computation modelling
  - communication and data dependency derivation
  - automatic code generation

Some challenges (DOUG algorithms and F2F framework itself):

- Load balancing
- Fault tolerance
- Parallel efficiency

In conclusion: Wake up – the computing power is under your own fingertips

(...image commented out as I do not know whether there might be any copyright issue...)

Contents