Unit 9 High Performance Distributed Systems

Unit Outcomes. Here you will learn

- how the most powerful computing facilities on Earth are structured, what they are used for
- how clusters and grids are managed, what goes on inside them (but not in depth)
- how one can make use of the ultra-fast message buses inside various supercomputers in a portable way

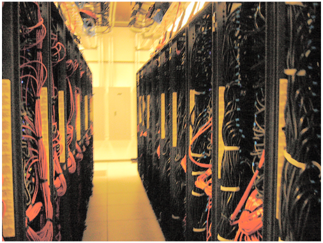
Contents

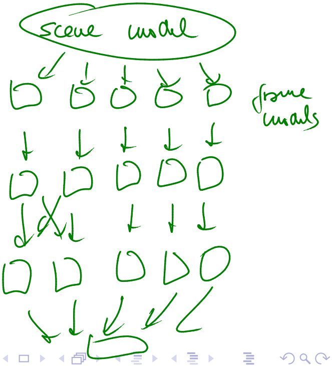
Case studies
Chess playing

- need to keep several *billion* positions at once
  - need to distribute its storage
- generate and analyse
  over 200 million *new* positions per sec
  - needs lots of parallel processing
  - needs very fast communication between distributed nodes
  - normal (10Gb/s) ethernet not fast enough, using 40–120Gb/s

Animation rendering

- eg Pixar's Cars took 2300 CPU **years** to render
- each frame takes 1–10 hours
  - using 1000s of computers, splitting the task by:
    - stages in the pipeline (eg tessellation, shading)
    - areas in the scene
  - sharing distributed virtual disk
    - data exchange, coordination (eg result assembly)





The World-wide telescope

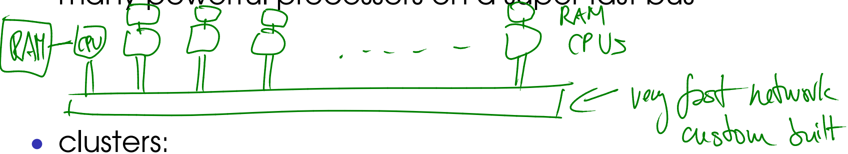
- motivation:
  - many astronomical teams with many telescopes
  - connect their internal clusters and supercomputers
  - combine data from the teams seamlessly
- challenges:
  - how to store all the combined data?
  - how to process and query the data fast enough?
- solution:
  - organisations share their modest resources
    (not only astronomical organisations!)

Other high-throughput applications

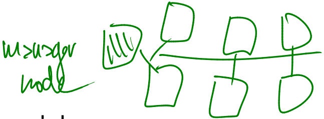
- why do we need more and more powerful computers?
  - financial simulations
  - aero-dynamic simulation
  - climate-change prediction, weather forecast
  - large-scale agent-based modelling
  - protein folding
  -

Architectures overview

- supercomputers:
  many powerful processors on a super-fast bus



- clusters:
  many homogeneous cheap computers on a local network



- grids:
  very many well-coordinated heterogeneous computers

Supercomputers

- characteristics:
  - 10s–100s of expensive reliable CPUs on separate boards
  - conneceted by superfast network
  - jobs allocated to CPUs and do not move
  - jobs communicate with one another frequently
- middleware optimised for message passing (eg MPI)
  - synchonous and asynchronous sending/receiving
  - efficient streaming of large binary data
  - efficient multicast, data splitting and results gathering
- mainly for:
  - solving complex problems with interrelated data fast

Beowulf clusters

- characteristics:
  - 10s–1000s of cheap off-the-shelf computers
  - administered centrally
  - jobs moving between nodes to optimise load
  - scalable: can dynamically add/remove nodes
- middleware not too complex
  - job management, job scheduling, job migration
  - distributed data management (eg distributed file system)
- mainly for:
  - high-availability of services (eg Web search engines)
  - load-distribution for medium-sized tasks (eg animation)

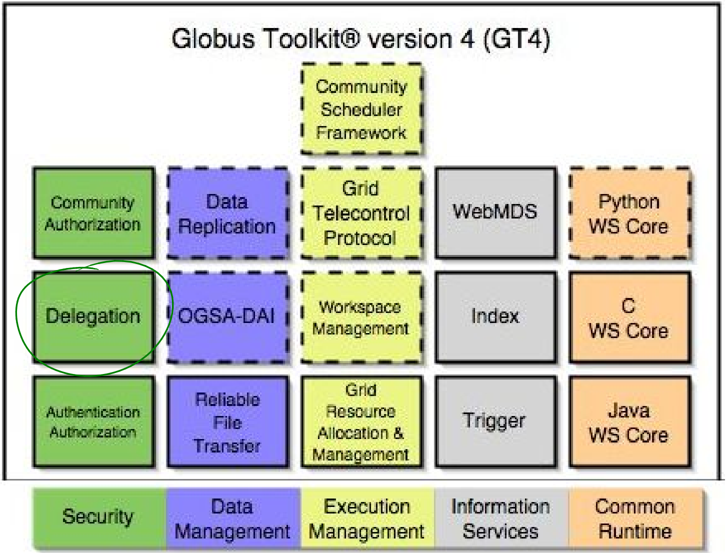
Grids

- characteristics:
  - aim: flexible sharing of computing resources
  - not administered centrally — many *administrative domains*
  - trust among participants is limited
  - based on *open standards* (like SOA)
  - non-trivial *quality of service* achieved
- needs very sophisticated middleware, combining aspects of
  - SOA, P2P, mobile code, mobile agents
- mainly for:
  - processing gigantic scientific data
    (eg CERN Large Hadron Collider — several GB/s)
  - implementing SOA

Comparison of clusters and grids

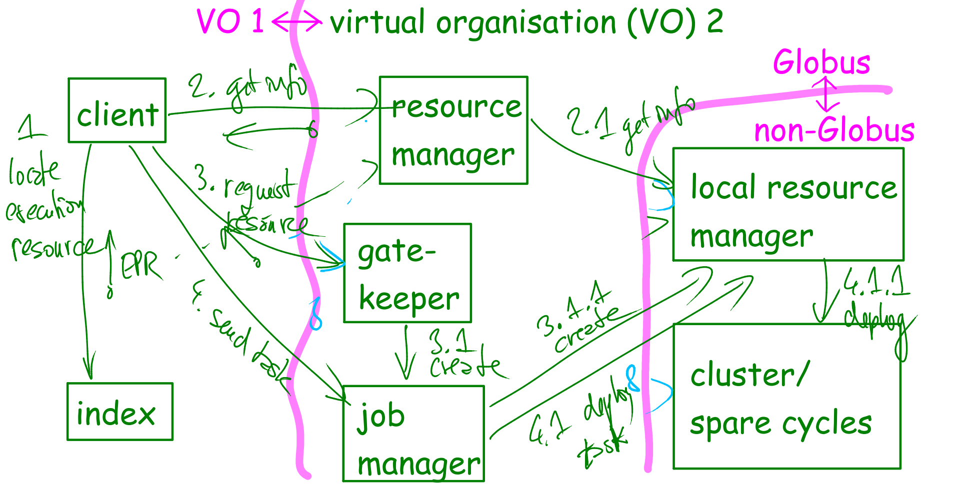
	clusters	**grids**
size	thousands	millions
net speed	1–10Gb/s	much slower
admin	global — central	local — distributed
trust	unlimited – inside one organisation	limited — needs contracts & security
openness	varies	open
middleware	simple, many solutions	very complex, only few solutions

Globus grid infrastructure overview
Overview



Grid Resource Allocation and Management (GRAM)

- allows programs to be started and managed remotely



Learning Outcomes

Learning Outcomes. You should now be able to

- describe the characteristics of clusters and grids
- name several applications that would make good use of clusters/grids and explain why it is the case
- name three important components of Globus and briefly explain their purpose
- describe the purpose of MPI and explain its advantages and disadvantages against RMI and against Web services