Networking for the Grid: problems and solutions

http://www.grid.ucl.ac.uk/

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UCL Grid/HPC - CoE

- http://www.grid.ucl.ac.uk/
- Many projects - UK and EU funding:
  - RealityGrid, EGSO, DataTAG, e-Protein, etc. **GRS, MB-NG, UKLIGHT, 46PaQ**
- e-Science/Grid Centre of Excellence (CoE) in **Networked Systems:**
  - http://www.grid.ucl.ac.uk/NETSYS.html
  - **high-speed networking**, **QoS** and traffic engineering, **performance**, **network resource control/management**, protocol enhancements and evolution, security, complex systems, monitoring and reporting

Funding

e-Science dti

RESEARCH COUNCILS UK

Information Society Technologies

EUROPEAN RESEARCH AREA

Funding, partners, collaborations

RESEARCH COUNCILS UK
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ist information society technologies
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Cisco Systems Empowering the Internet Generation
hp invent
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GRNET
Fraunhofer FOKUS Institute for Open Communication Systems
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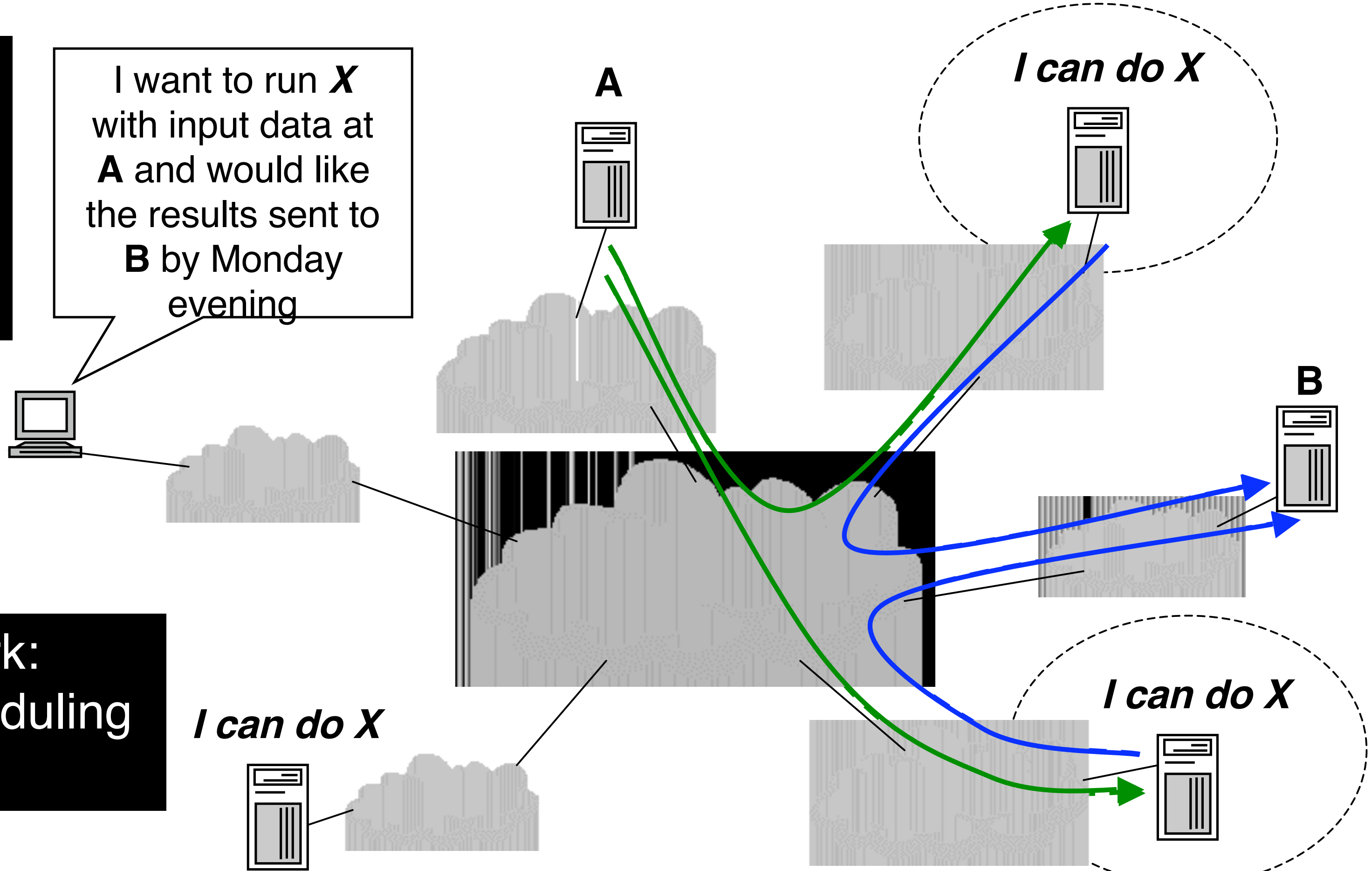
UNINETT

UCL Computer Science

Overall scenario (outline)

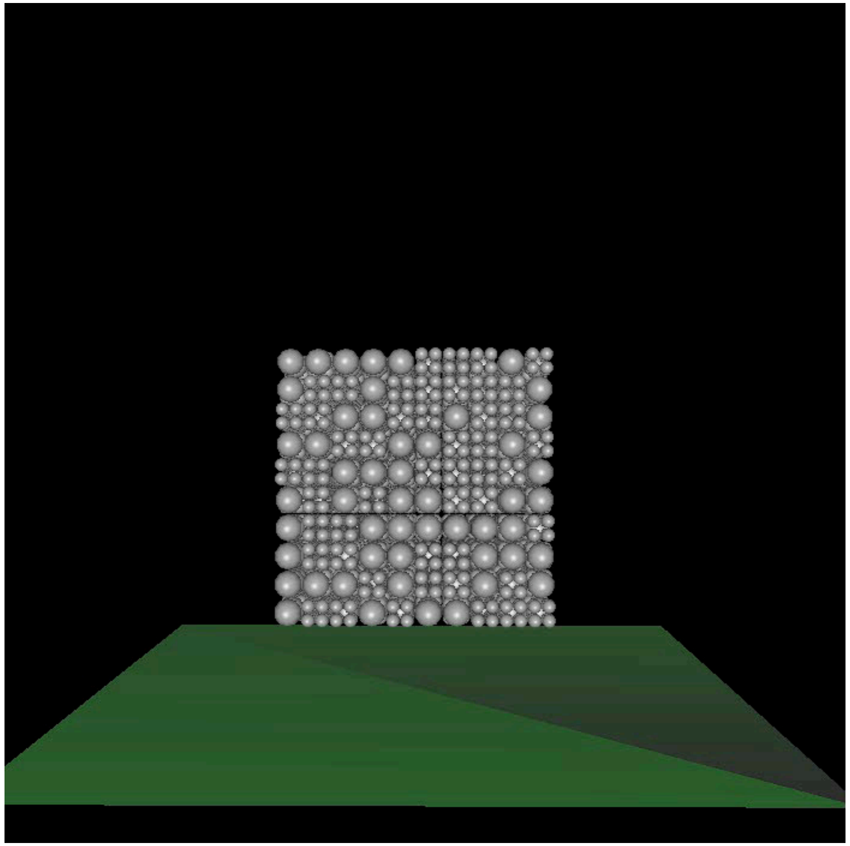
harmonised CPU + network scheduling

GRS work: network scheduling only



UCL *Computer Science*

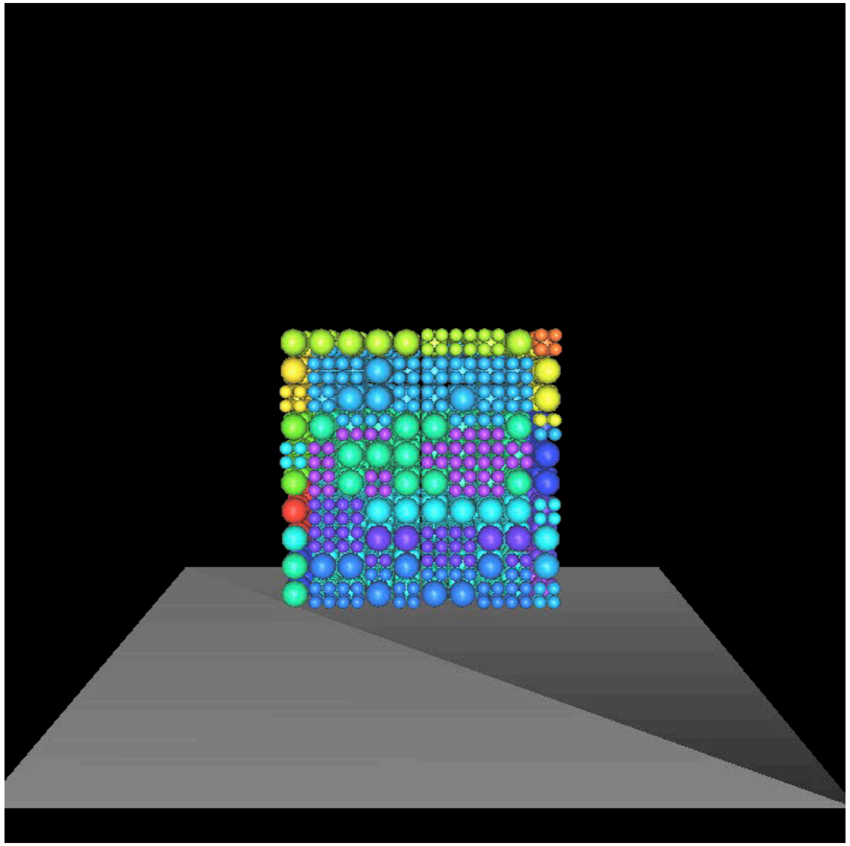
Real example [1]



- ~5000 particles falling onto a surface
- All collisions taken into account in the model.
- Forget the physics - think of the work involved!
- The real models involve ~1,000,000 particles!

thanks to S.Sorensen@cs.ucl.ac.uk

Real example [2]



- ~5,000 particles falling onto a surface
- 18 processors are used in this example
- Processors are colour coded
- Observe colour changes as objects change their "home"

thanks to S.Sorensen@cs.ucl.ac.uk

The Grid networking problem

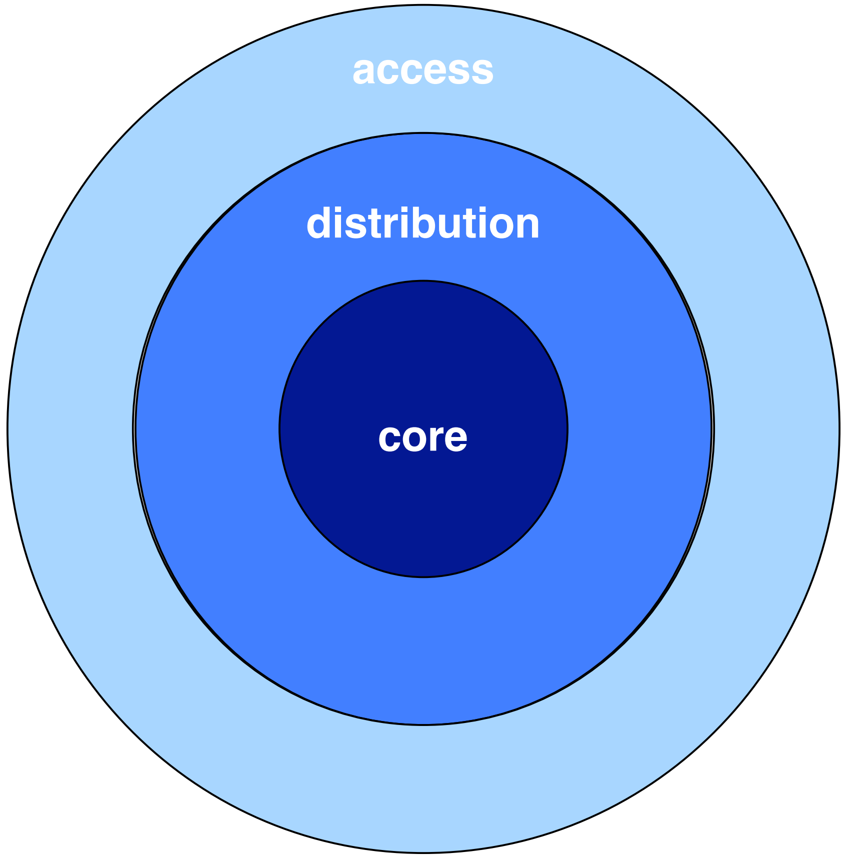
- Data intensive Grid computing:
  - **data** Grids vs. **computational** Grids
  - could be both data and compute intensive
- Data points to highlight the problem:
  - LHC, VLBI: multi Gb/s (10^9) to multi Tb/s (10^{12})
  - distribution of data and processing (CPU usage)
  - 33MHz, 32bit PCI ≈ 1Gb/s (reality: ~50% of this)
  - TCP - problems on long delay, high rate links
- **Data has to get across net fast - but can't!**
- **But what if everyone starts doing this?**
- **Networking is global, end-to-end problem!**

Big data … big problems!

- Particularly relevant to Grid/e-Science
- User in Glasgow wants to access the HGP data
- HGP database:
  - 0.3PB (growing at ~1TB/week)
- SuperJANET4 (SJ4):
  - 10Gb/s backbone (still <2.5Gb/s access in places)
- Extreme case – transfer all of the HGP data
- So, iff user gets all the SJ4 backbone capacity:
  - transfer of HGP data still takes over 55 hours!
  - no one else can use the network at all during this time
- Can't do it! ☹

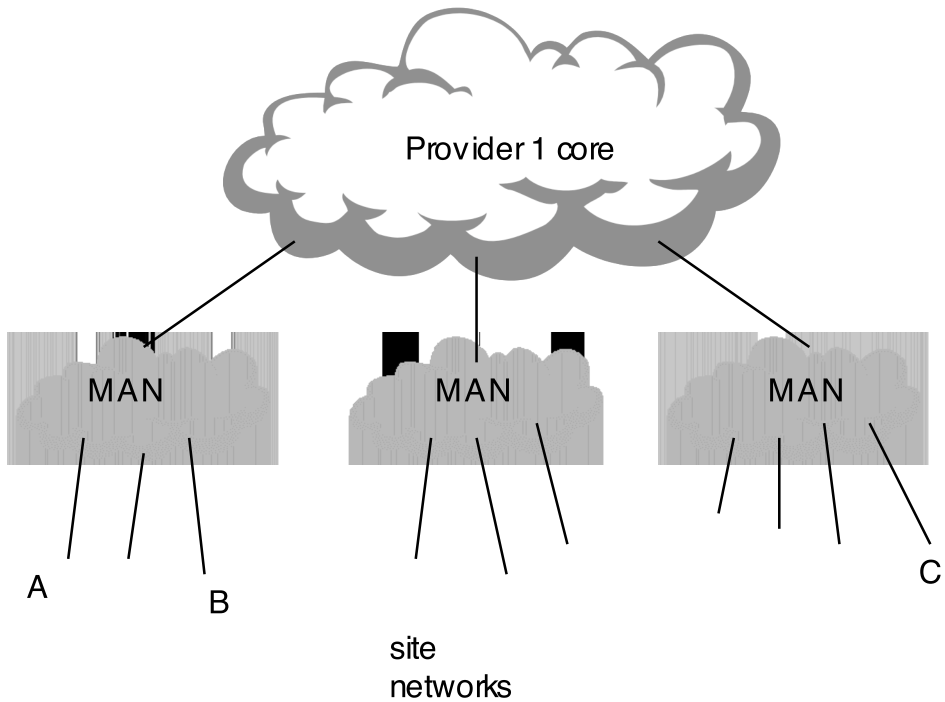
Problem: network hierarchy

- Access network:
  - low multiplexing
  - low volume of traffic
- Distribution network:
  - local level connectivity
  - low multiplexing
  - medium volume of traffic
- Core network – backbone:
  - high volume of traffic
  - high multiplexing
- **Different administrative domains**



Problem: administrative domains

- Network QoS reservations require *state* to be set-up, stored, maintained
- State information:
  - what?
  - where?
  - when?
  - how much?
- General problems:
  - signalling
  - scaling
  - (accounting + charging)

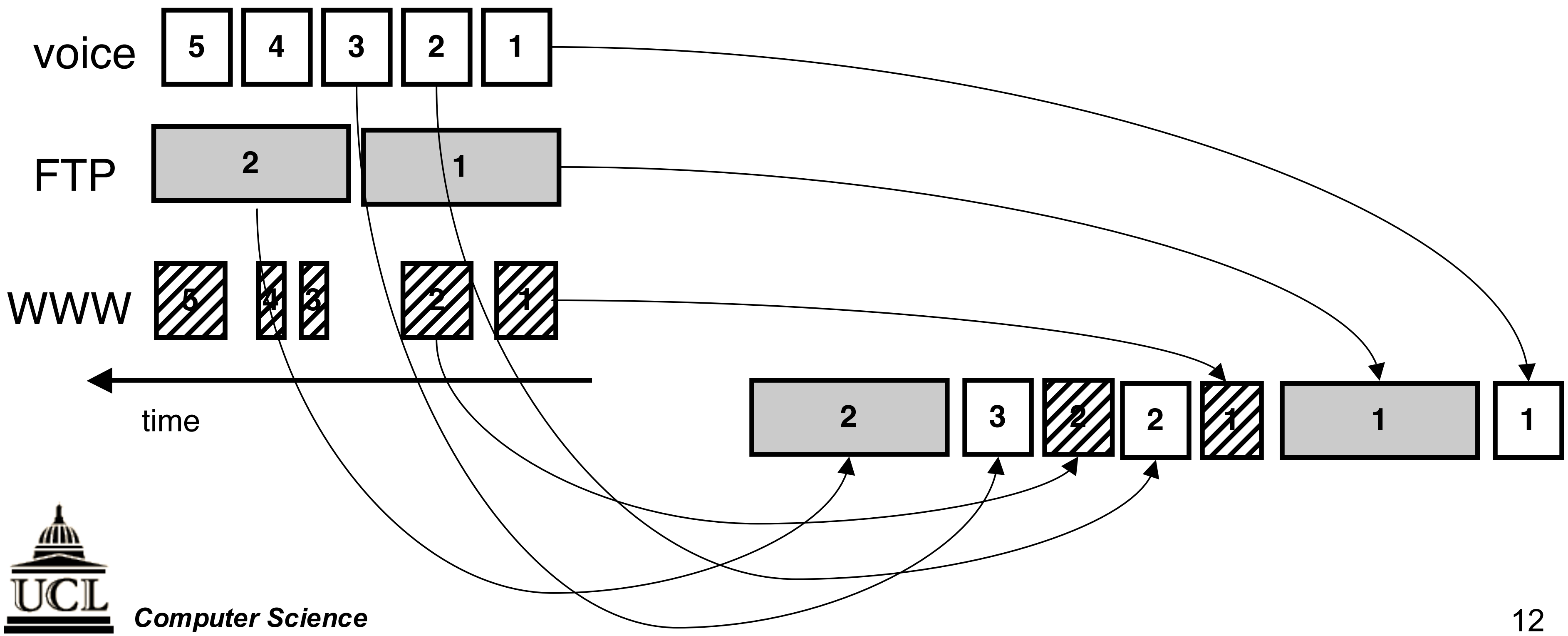


A ⇔ B : localised scope

A ⇔ C: non-localised scope

Problem: mixing traffic

- Example – voice, FTP and WWW traffic through a router:
  - 3 input lines: serviced FCFS at a router
  - 1 output line (1 output buffer)



Problem: modelling traffic

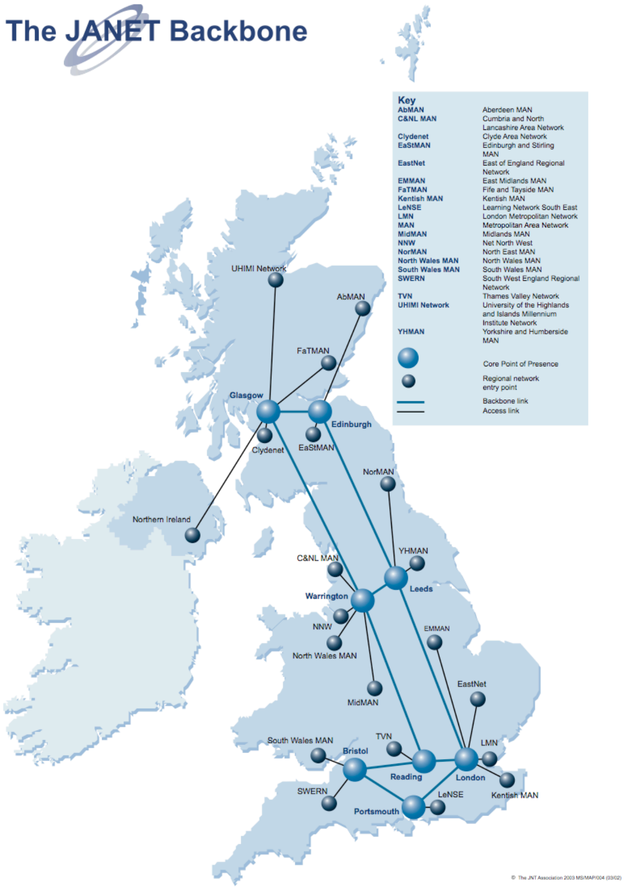
- **Poisson Model used for computational convenience, not for accuracy!**
- V. Paxson, S. Floyd, "*Wide-area Traffic: The Failure of Poisson Modelling*", IEEE/ACM Transactions on Networking, pp.226-244, June 1995.
  http://www.aciri.org/floyd/papers/WAN-poisson.ps.Z
- W. Leland, M. Taqqu, W. Willinger, D. Wilson, "*On the Self-Similar Nature of Ethernet Traffic (Extended Version)*", IEEE/ACM Transactions on Networking, 2(1), pp. 1-15, February 1994.
  http://math.bu.edu/people/murad/pub/source-printed-version-posted.ps
- Mark Crovella, Azer Bestavros, "*Self-similarity in world wide web traffic: Evidence and possible causes*. IEEE/ACM Transactions on Networking, 5(6):835-846, December 1997.
  http://www.cs.bu.edu/fac/best/res/papers/ton97.ps
- V. Paxson, S. Floyd, "*Why We Don't Know How to Simulate the Internet*", Proc. 1997 Winter Simulation Conference, December 1997.
  http://www.aciri.org/floyd/papers/wsc97.ps

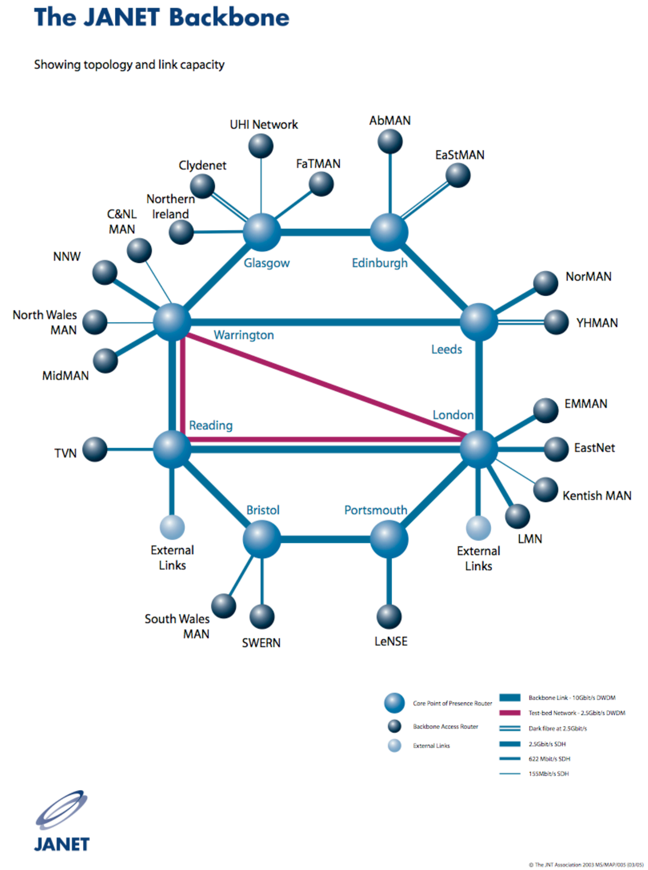
Problem: network traffic profiles

So what can we do about it?

- **Build a new and better network (of course)!**
  - … well … at least the core
  - very high capacity (Gb/s → Tb/s → Pb/s → Eb/s)
  - users can have access from their desktop
  - provide (QoS-)controlled access
- Two broad problems to consider:
  - **control**: *how do we mix different types of traffic and still control the traffic flows in the network sensibly?*
  - **capacity**: *what happens when you run a very high capacity network with very high capacity access links?*
- This talk highlights some of the ***research*** issues:
  - there are also ***operational*** issues! (but that's SEP ☺)

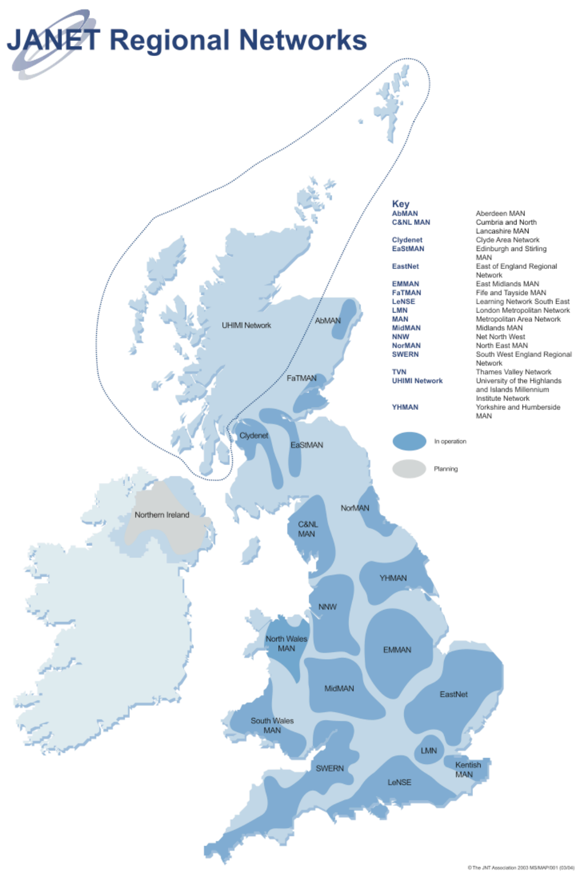
Problem space - networks [1]

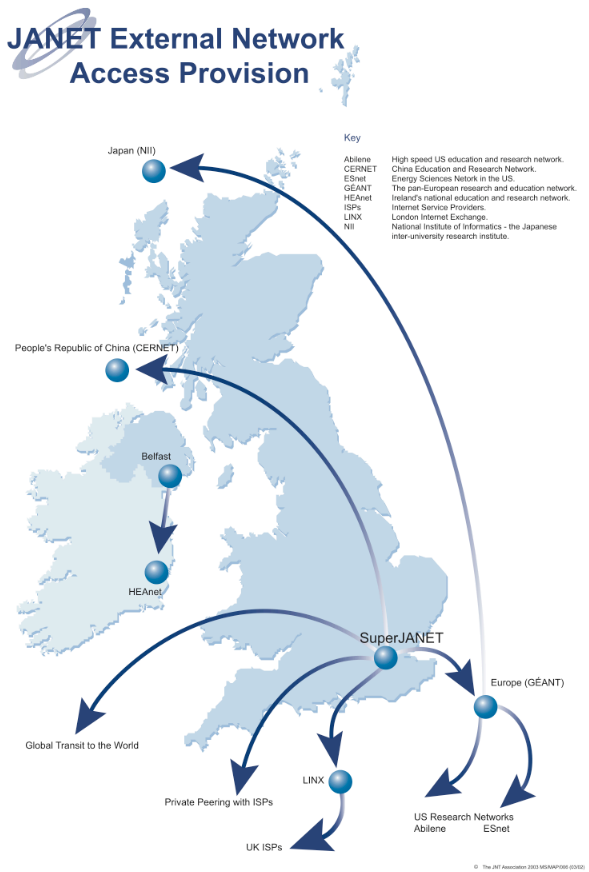




from http://www.ja.net/

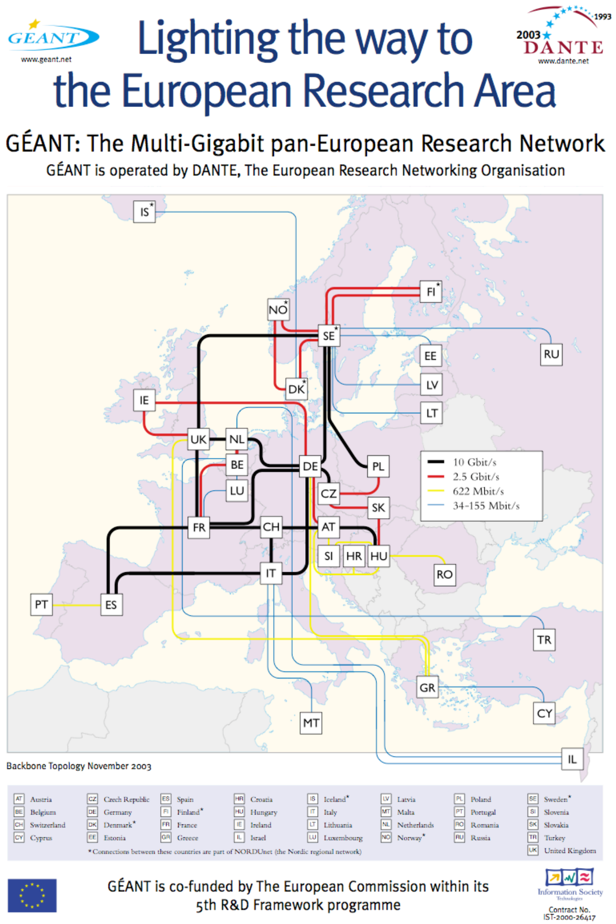
Problem space - networks [2]





from http://www.ja.net/

Problem space - networks [3]

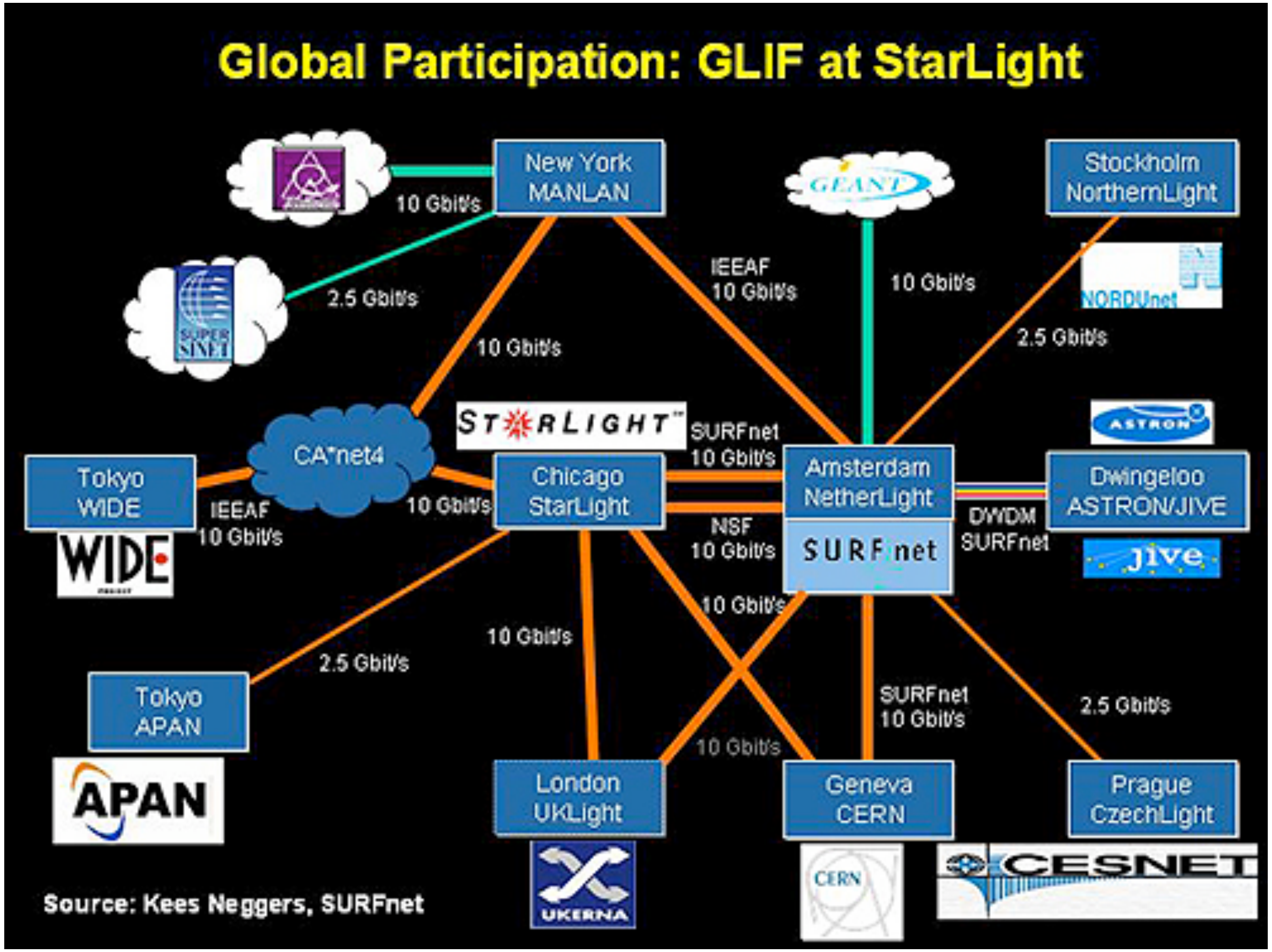


from http://www.dante.net/geant/

UKLIGHT - networking research

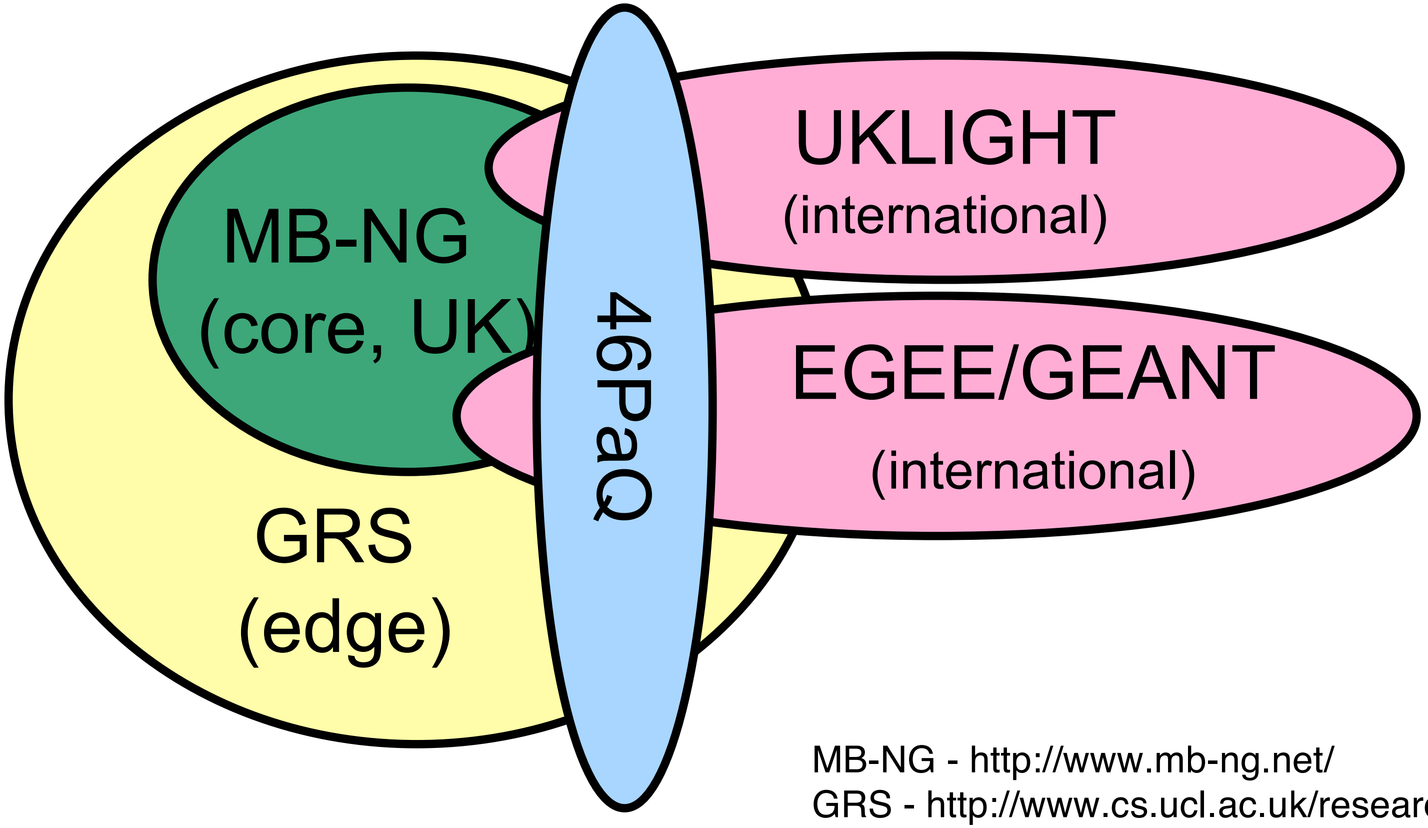
- High-speed networking **research**:
  - no production/service traffic
  - high-speed optical
  - ~£4.6M from HEFCE
- http://www.ja.net/development/UKLight/
- Connectivity to other national high-speed networks:
  - global research infrastructure
- UK/UKERNA founding member of GLIF:
  - http://www.glif.is/

UKLIGHT connectivity



from http ://www.glif.is/

Project links



MB-NG - http://www.mb-ng.net/
GRS - http://www.cs.ucl.ac.uk/research/grs/
UKLIGHT - http://www.ja.net/development/UKLight/
EGEE - http://public.eu-egee.org/
GEANT - http://www.dante.net/geant/
46PaQ - TBA

Project links - info

- MB-NG:
  - core network: capacity + QoS
- GRS:
  - edge-edge/site-site QoS control
- 46PaQ:
  - performance and QoS monitoring
- EGEE/GEANT:
  - international Grid connectivity
- UKLIGHT:
  - international high-speed networking research

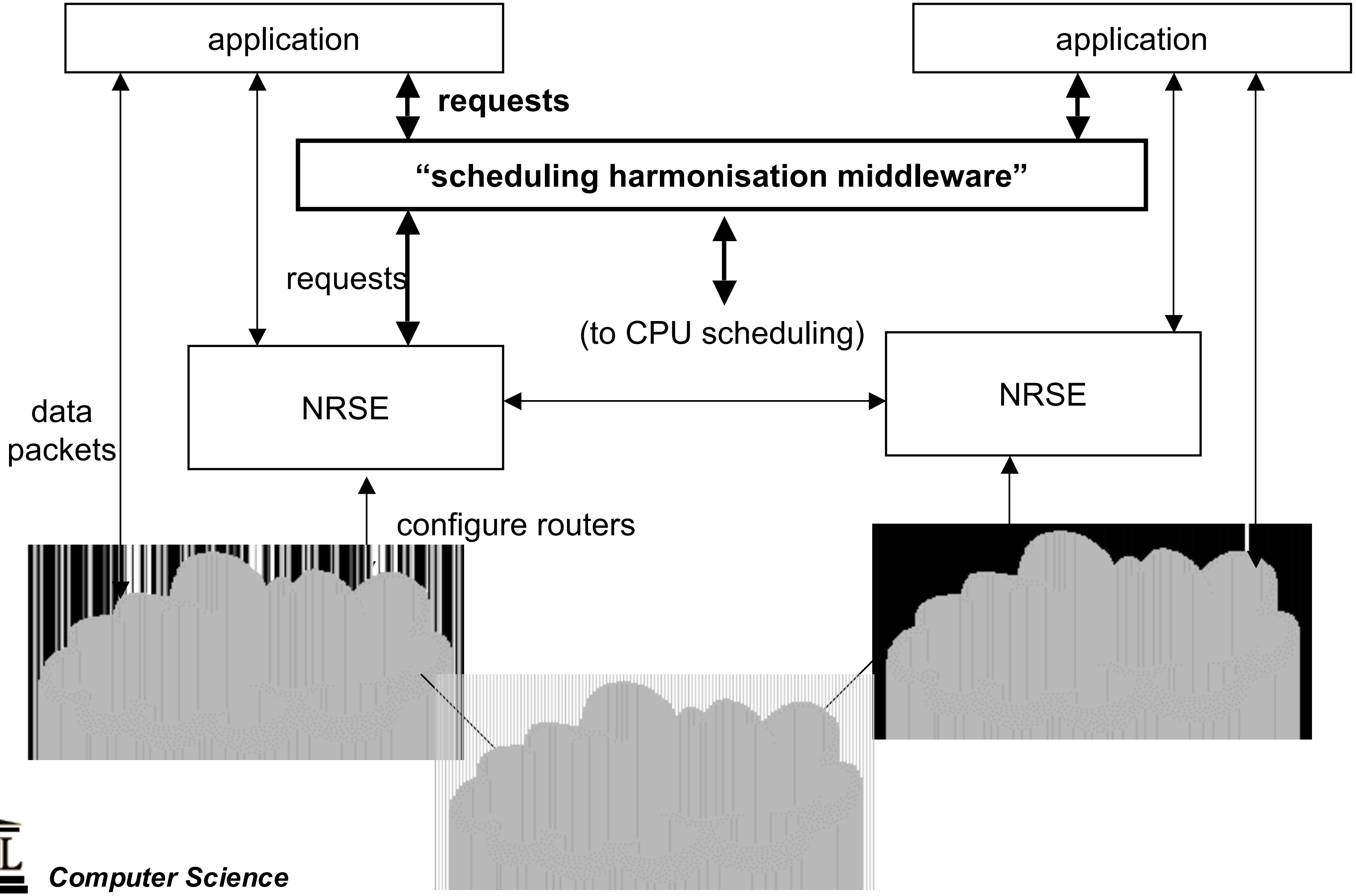
GRS project outline [1]

- Mar 2002 – Sep 2004
- 3 Phases:
  - 3 incremental development phases
  - currently at **Phase 2**

GRS project outline [2]

- **Architecture for dynamically configurable network reservations system**
- **Micro-management of flows at sites:**
  - **in this case DIFFSERV aggregates**
- Focus on **state management** and **signalling**
- Assume DIFFSERV network (for now):
  - architecture **will not** be restricted to DIFFSERV
  - assume BE and EF per-hop behaviours
- Initial development on Linux (using tc):
  - architecture **not** restricted to Linux
  - current work-in-progress to port to CiscoIOS

Outline architecture



General problem space

	Homogenous: bottleneck at edge		Heterogeneous
	single domain	multiple domain	multiple domain
Dynamic reservations	current GRS work		
Advance reservations	current GRS work difficult		very difficult

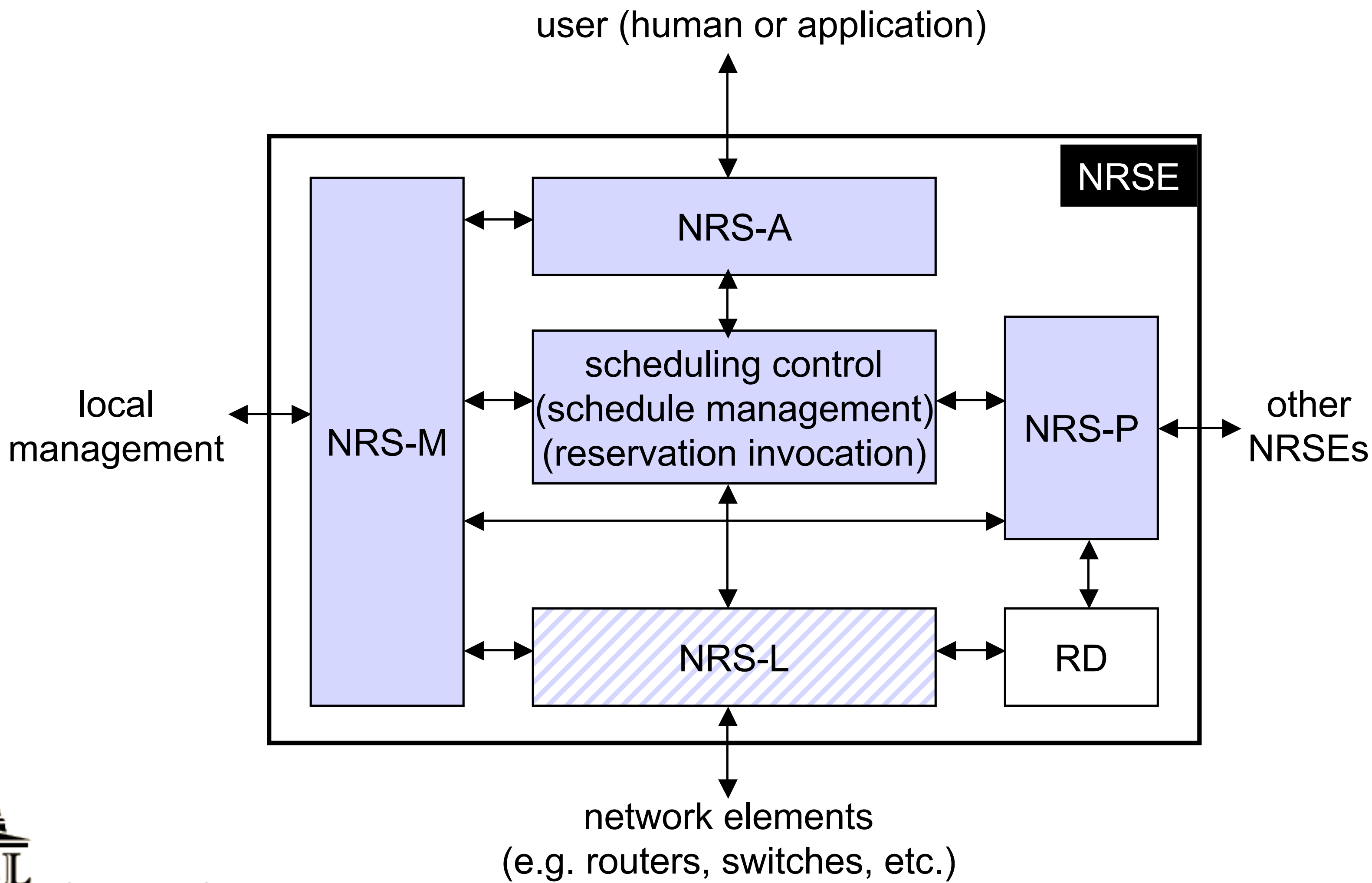
New in GRS:

- Reservation types: real-time & non-real-time
- Application paradigms: notifications and deadlines

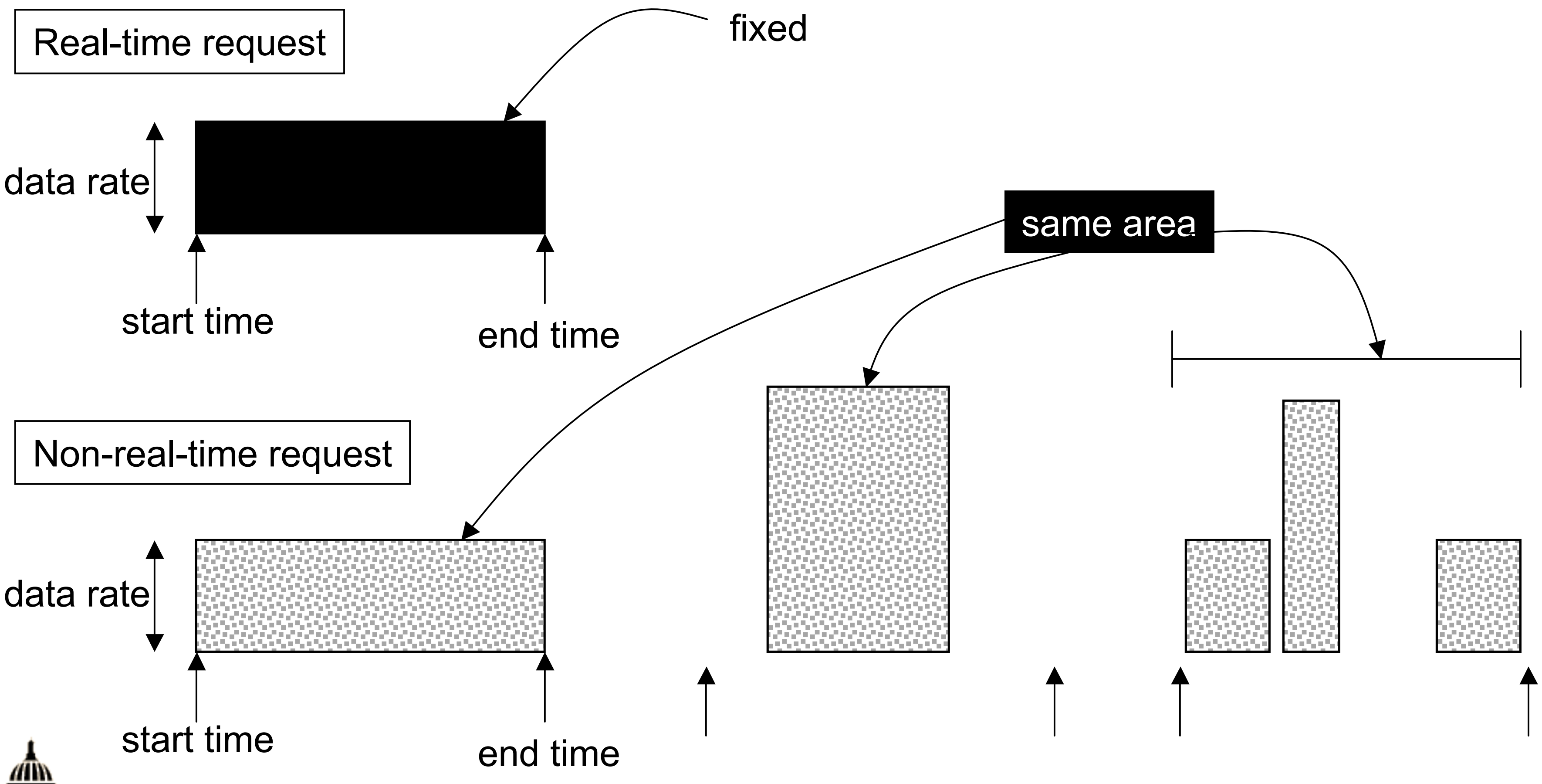
Approach

- Assume:
  - **end-users are willing to co-operate**
  - **highly de-centralised**
  - **users form a community**
  - similar properties to peer-to-peer (p2p) systems
- NRS users form a **community**:
  - share resources between sites
  - network scheduling is between sites in the community
  - micro-management of flows at sites

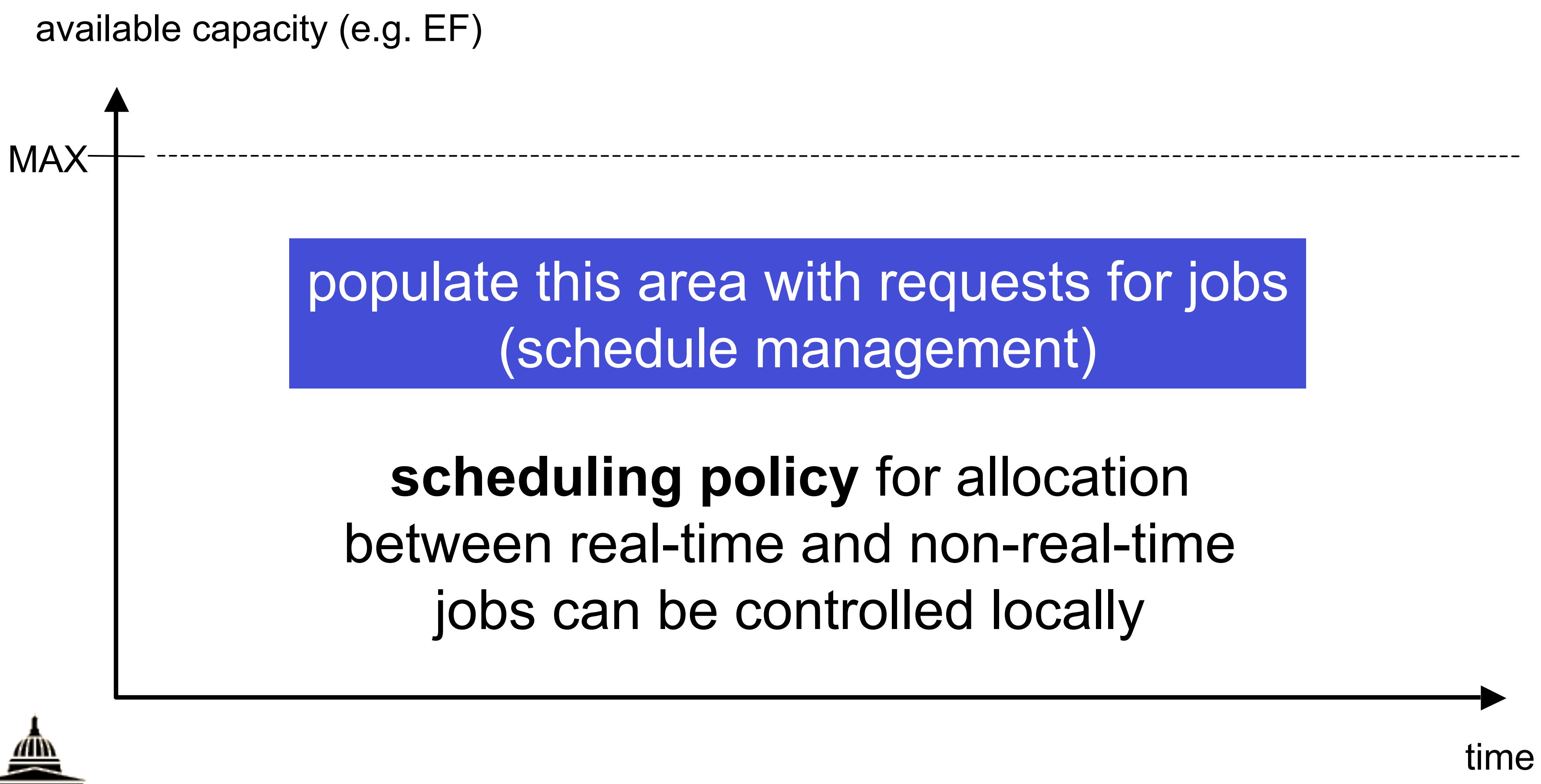
NRSE Design (in progress)



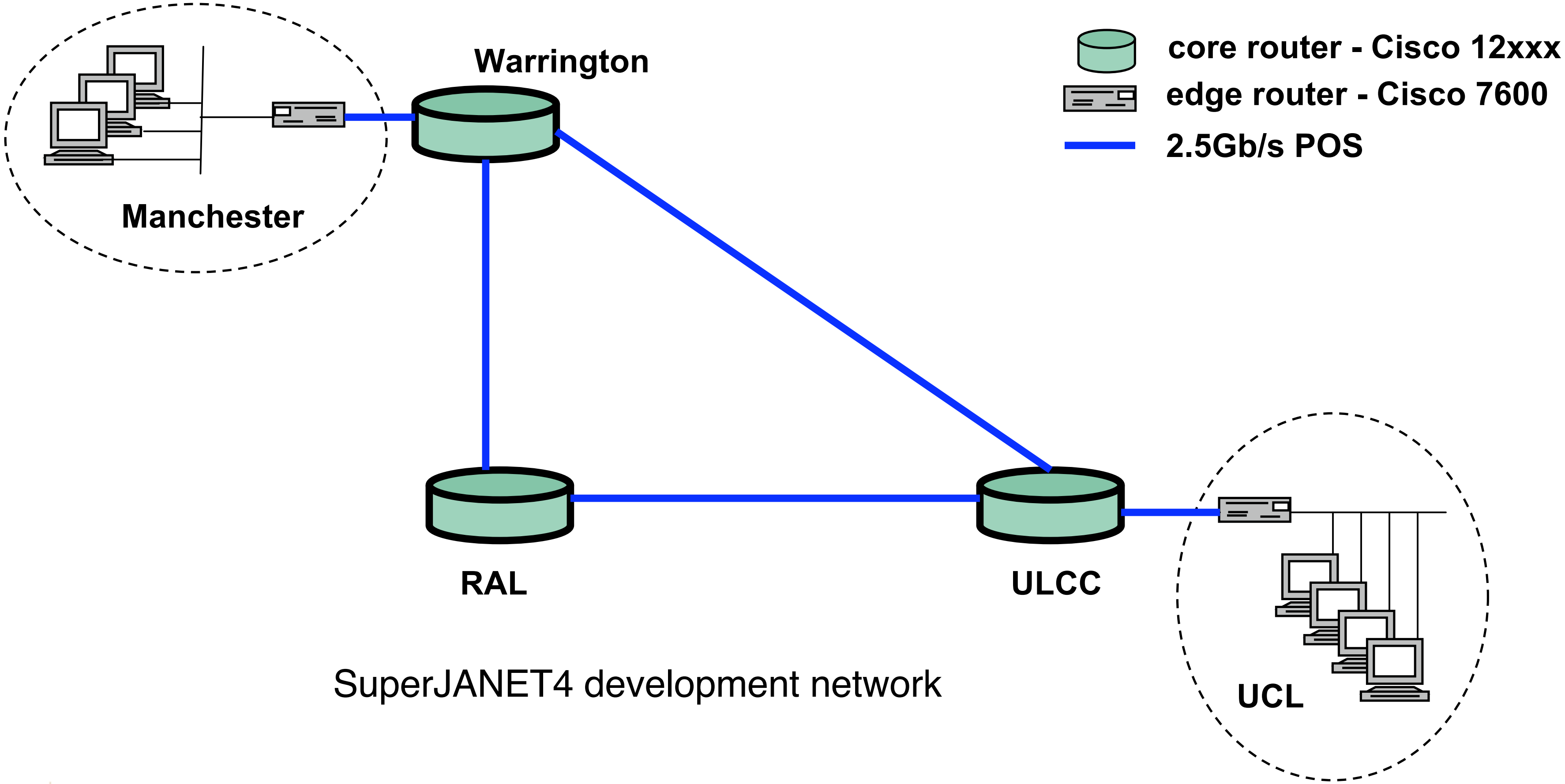
Scheduling control principle [1]



Scheduling control principle [2]



Current status: testing on SJ4dev



SuperJANET4 development network

Application synchronisation

Deadlines

- File transfers
- Use with non-real-time reservations

Notifications

- Event-driven synchronisation:
  - **reservation-begin** and **reservation-finish**
- Notifications for:
  - QoS violations
  - administrator intervention
  - SLA changes …

Needs re-design of APIs and applications

Future

- NRSE:
  - extend to “full” network reservation platform
  - scheduling policies
  - management interface
- 46PaQ:
  - IPv4 + IPv6 Performance and QoS
  - QoS and monitoring deployment and use
- General signalling platforms and systems:
  - state management
  - optical and hybrid-optical

Questions?

A good way to get answers