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Cloud Computing and Virtualisation

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ITS and IMG group in CS
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Thanks to Ralf Ratering for material on slides 9-18

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Structure and aims

- The lecture seeks to place the phenomenon of Cloud Computing in its context.
- Cloud Computing is a particular form of Distributed Computing which is crucially dependent on the concept of Virtualisation.
- We first discuss previous forms of virtualised distributed computing, in particular the Grid Programming Environment from Intel.
- Then we consider what distinguishes Cloud Computing and why it arouses so much current interest.

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What is Computational Power?

- Power in physics is defined as energy/ time.
- In computing we consider data-processing/time.
- The processing needs of an organisation may vary, with spikes in consumption.
- This leads to the concept of elastic computing, extra resource available as needed.
- Ultimately this is scheduling problem, with a sufficiently large pool of resources, the illusion of elasticity can be provided.

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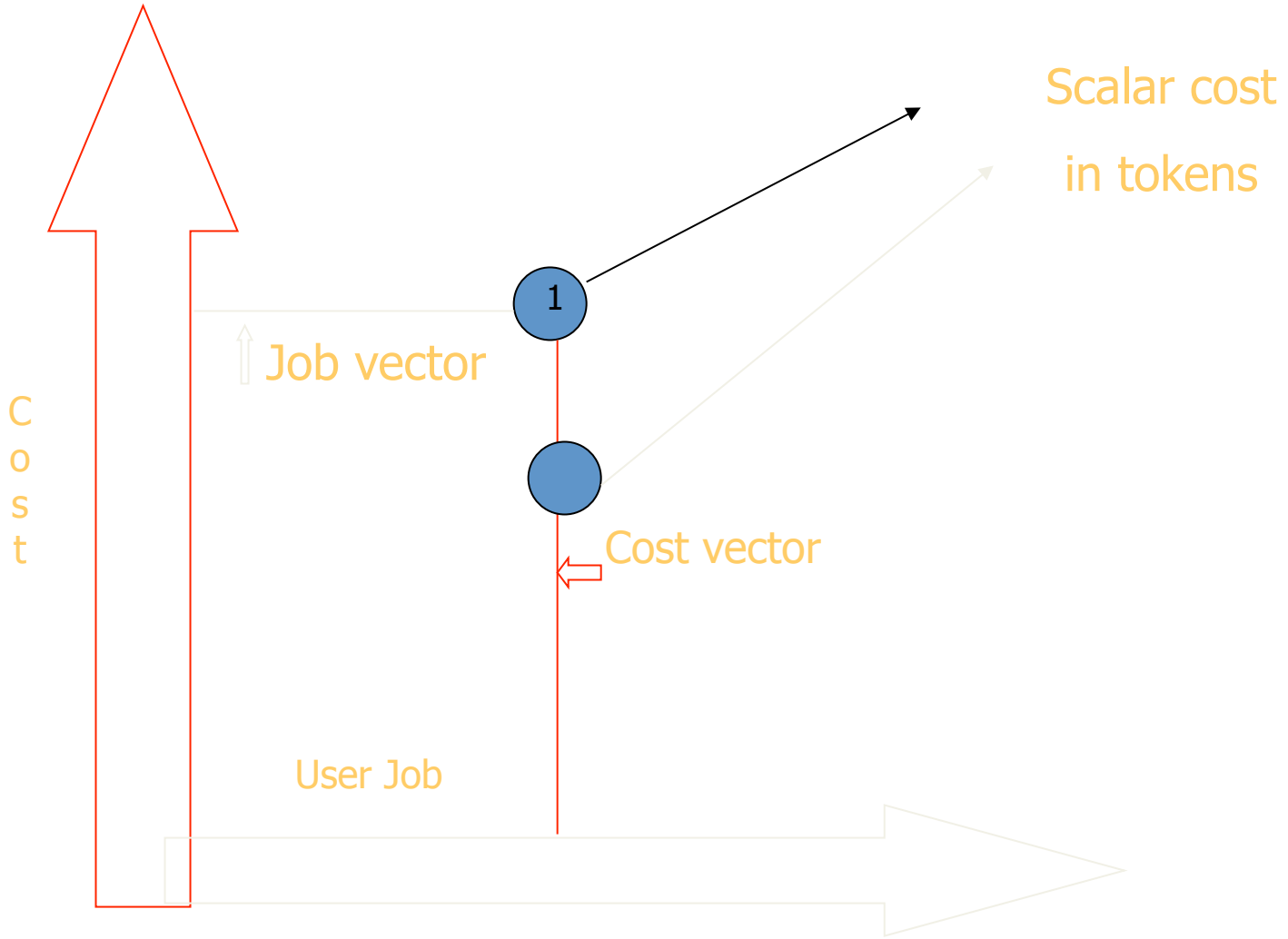
The power of scale

- Organisations such as Amazon, Google, Microsoft own a scale of resources that can be used to support elastic computing.
- However we must introduce uniformity in the computing interfaces, we cannot go looking for libraries, storage spaces, etc.. as we move the computing around the datacenter.
- It is necessary to run virtualised images or services which package all the necessary software dependencies.

Costing computational resource



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Computational Resource

- Computational jobs ask questions about the internal structure of the provider of computational power in a manner that an electrically powered device does not.
- For example, do we require specific compilers, libraries, disk resource, visualization servers?
- What if it goes wrong, do we get support? If we transfer data and methods of analysis over the Internet is it secure?

RR and RP Spaces

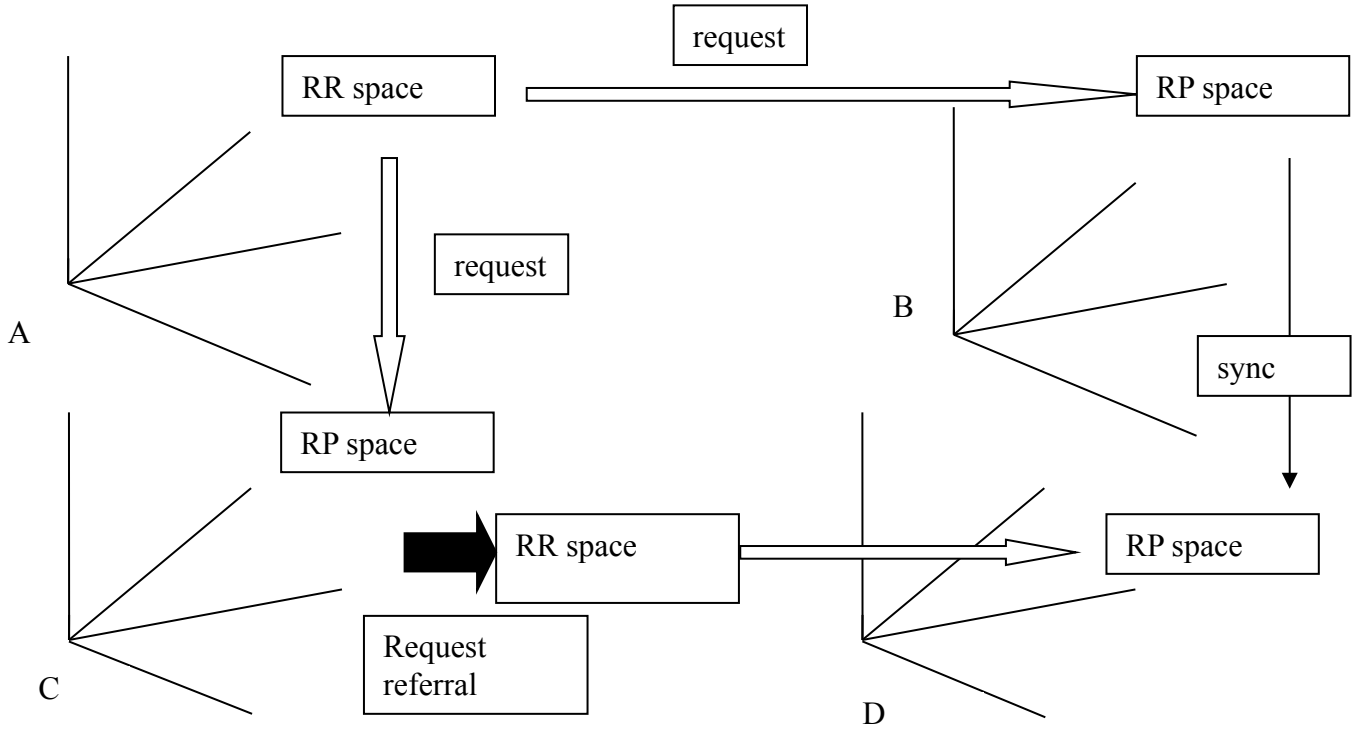
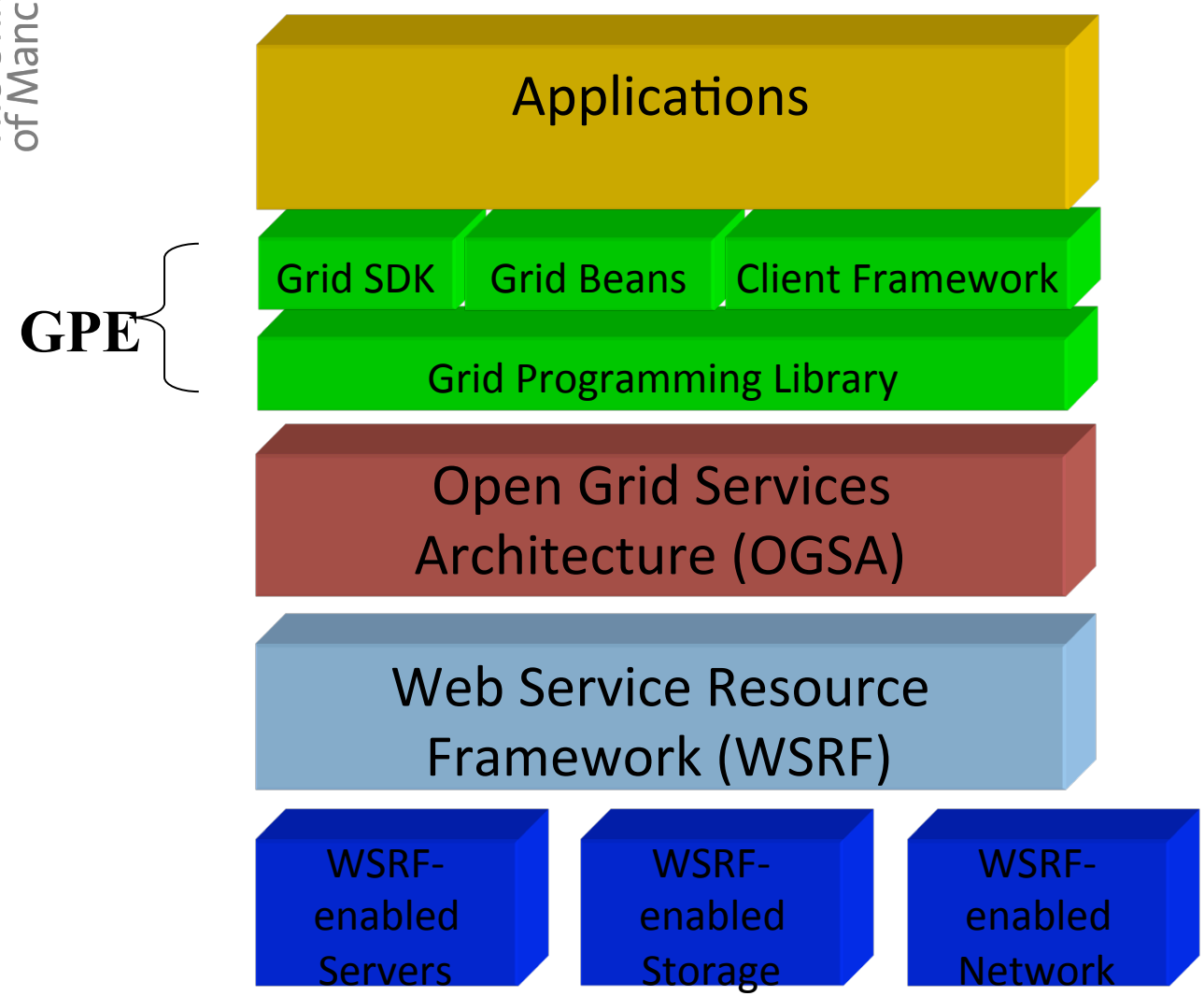


Figure 1: Request from RR space at A mapped into resource providers at B and C, with C forwarding a request formulated in RR space to RP space at D. B and C synchronize at end of workflow before results returned to the initiator A.

Grid Computing



High-level Grid API

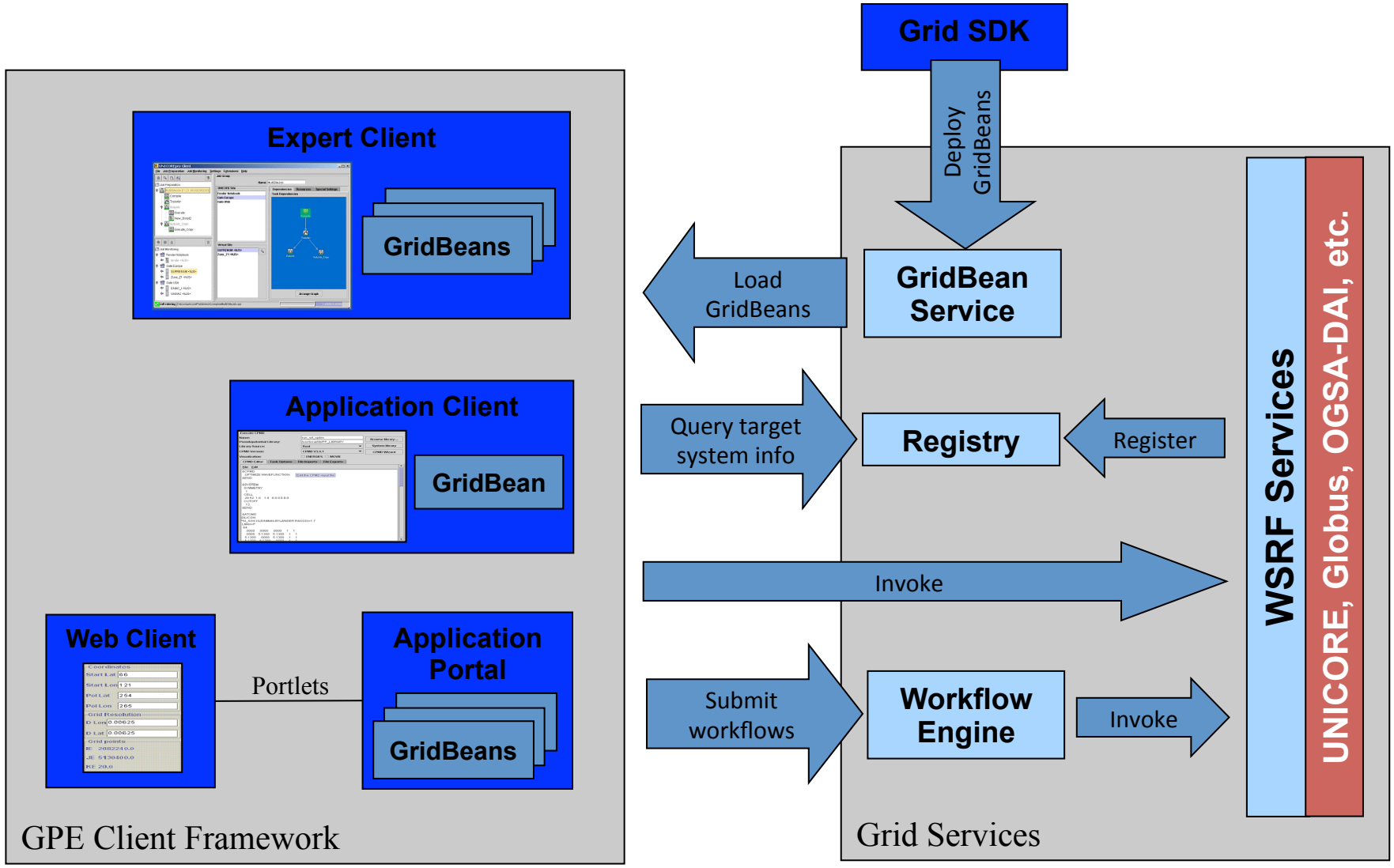
Descriptions
- Resources (CIM)
- Jobs (JSDL)
- Workflows (BPEL)

Operations
- Job management
- File transfers
- Brokering
- Steering, etc.

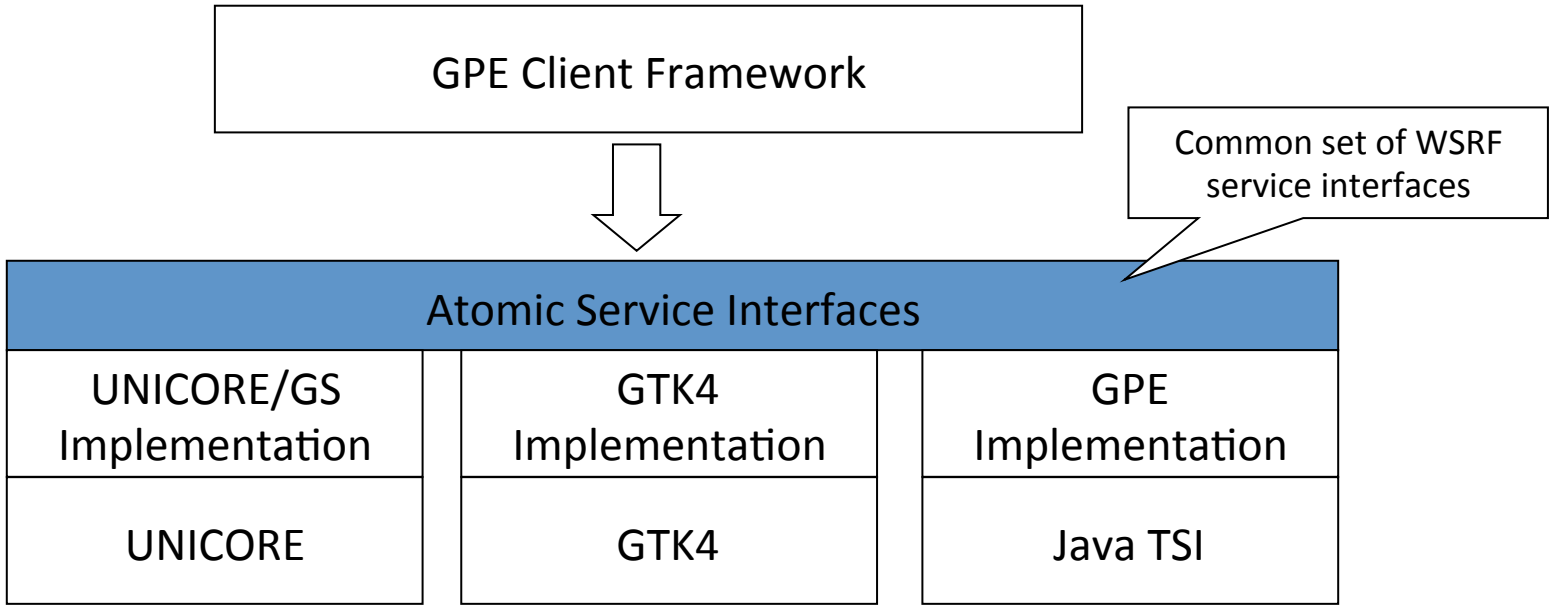
Standards

- **JSDL (Job Submission Description Language)**
  - High level job description that can be submitted to all target systems offering a JSDL interface
- **CIM (Common Information Model)**
  - Used to describe resources
  - Usage of CIM management interfaces for Grid administration
- **BPEL (Business Process Execution Language)**
  - Integration of Grid Bean services into larger business process workflows
- **WS* (WS-Addressing, WSRF, WSN, etc.)**
  - Interoperation with other Grid Middleware
- **OGSA (Open Grid Services Architecture)**
  - Share components with other architectures

GPE Concept

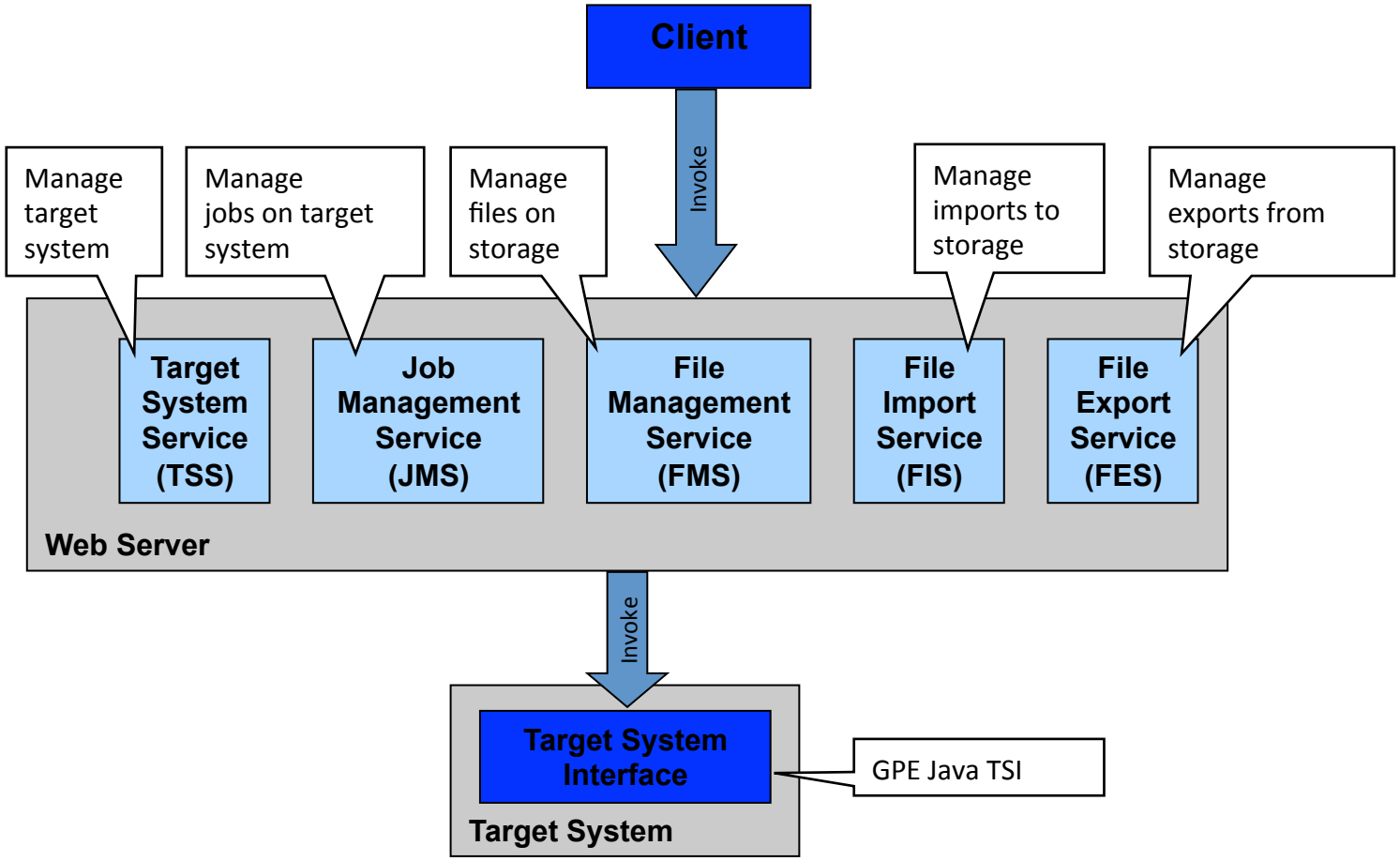

Grid SDK
Deploy GridBeans
Expert Client
GridBeans
Load GridBeans
GridBean Service
Application Client
GridBean
Query target system info
Registry
Register
Invoke
Web Client
Portlets
Application Portal
GridBeans
Submit workflows
Workflow Engine
Invoke
WSRF Services
UNICORE, Globus, OGSA-DAI, etc.
GPE Client Framework
Grid Services

Atomic Services

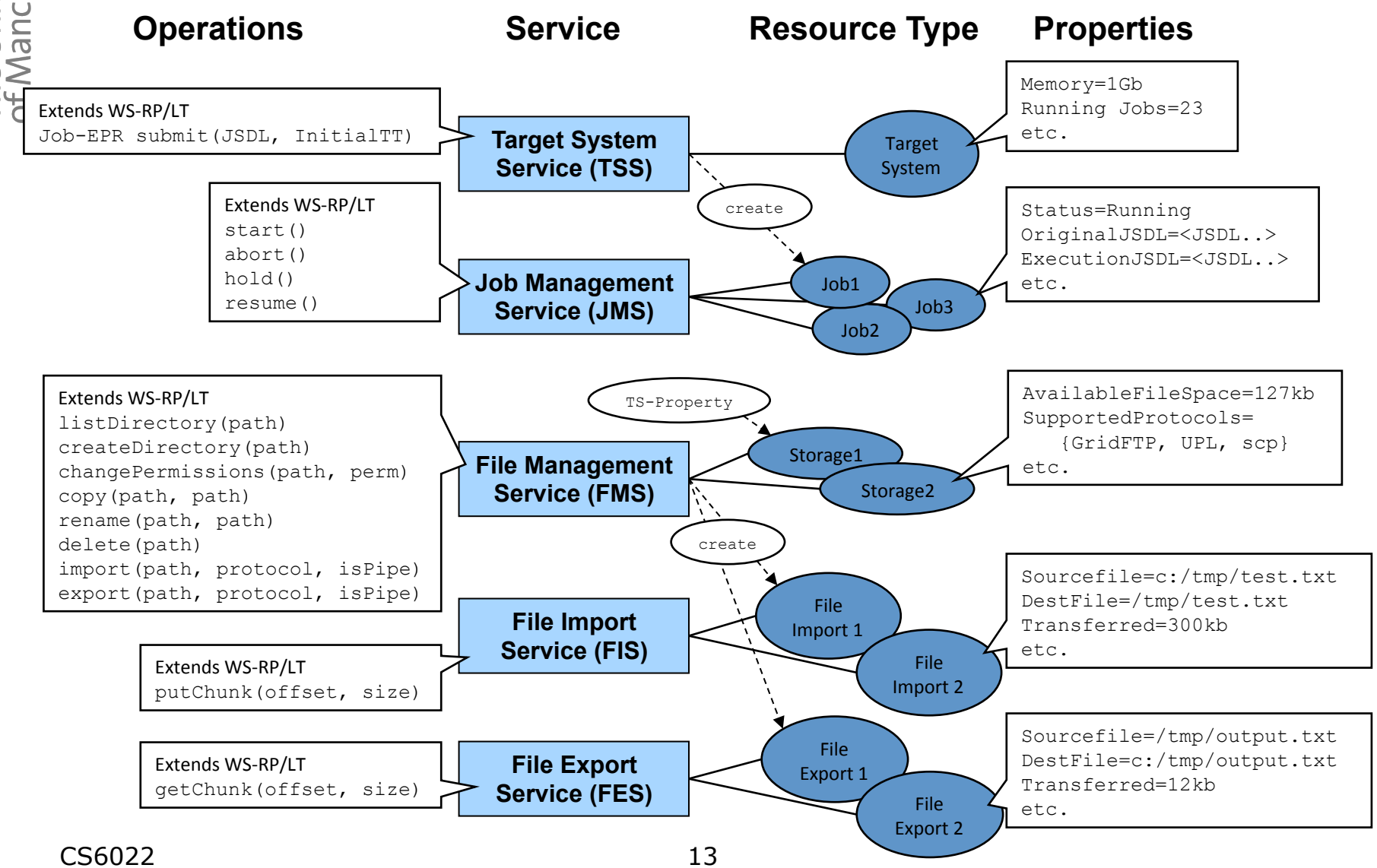


- Atomic service interfaces define basic set of operations and properties that have to be available on a Grid
- Different impementations of interfaces for different infrastructures

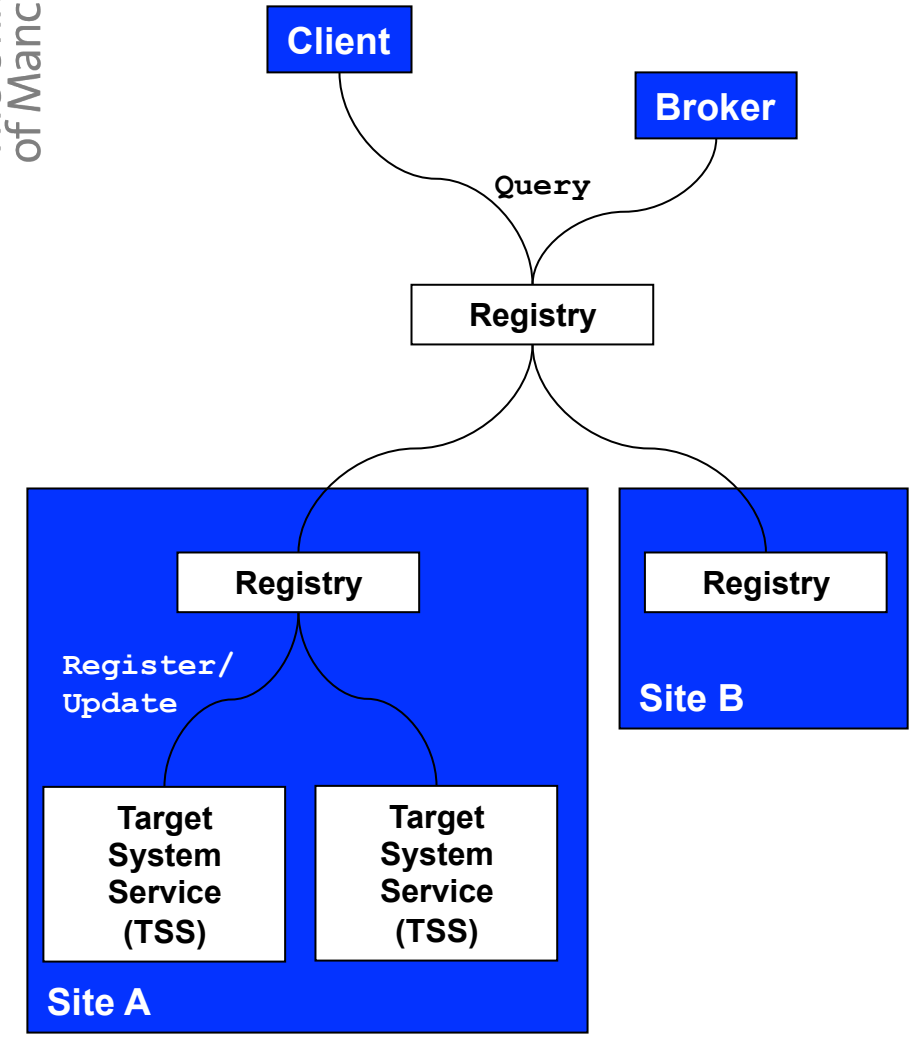
GPE Atomic Services



GPE Atomic Service Interfaces

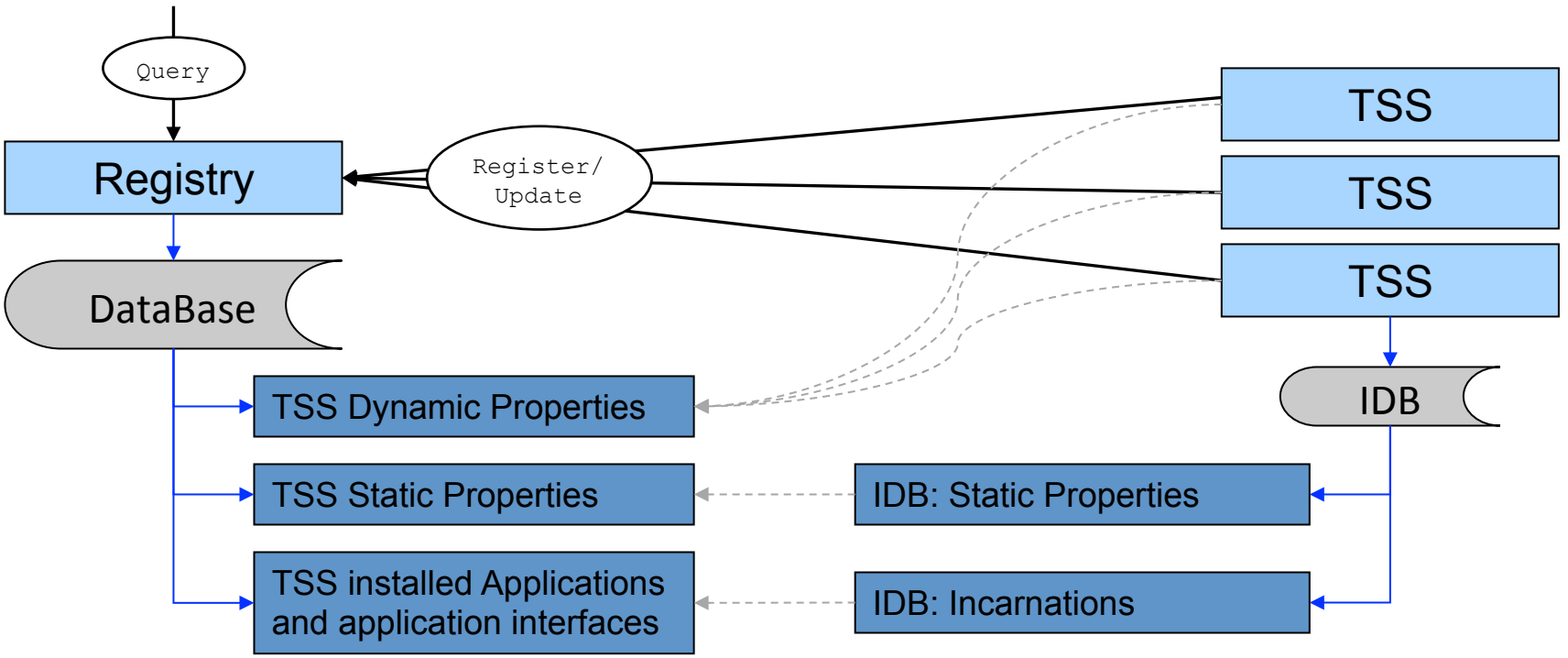


Discovering services: the role of a registry



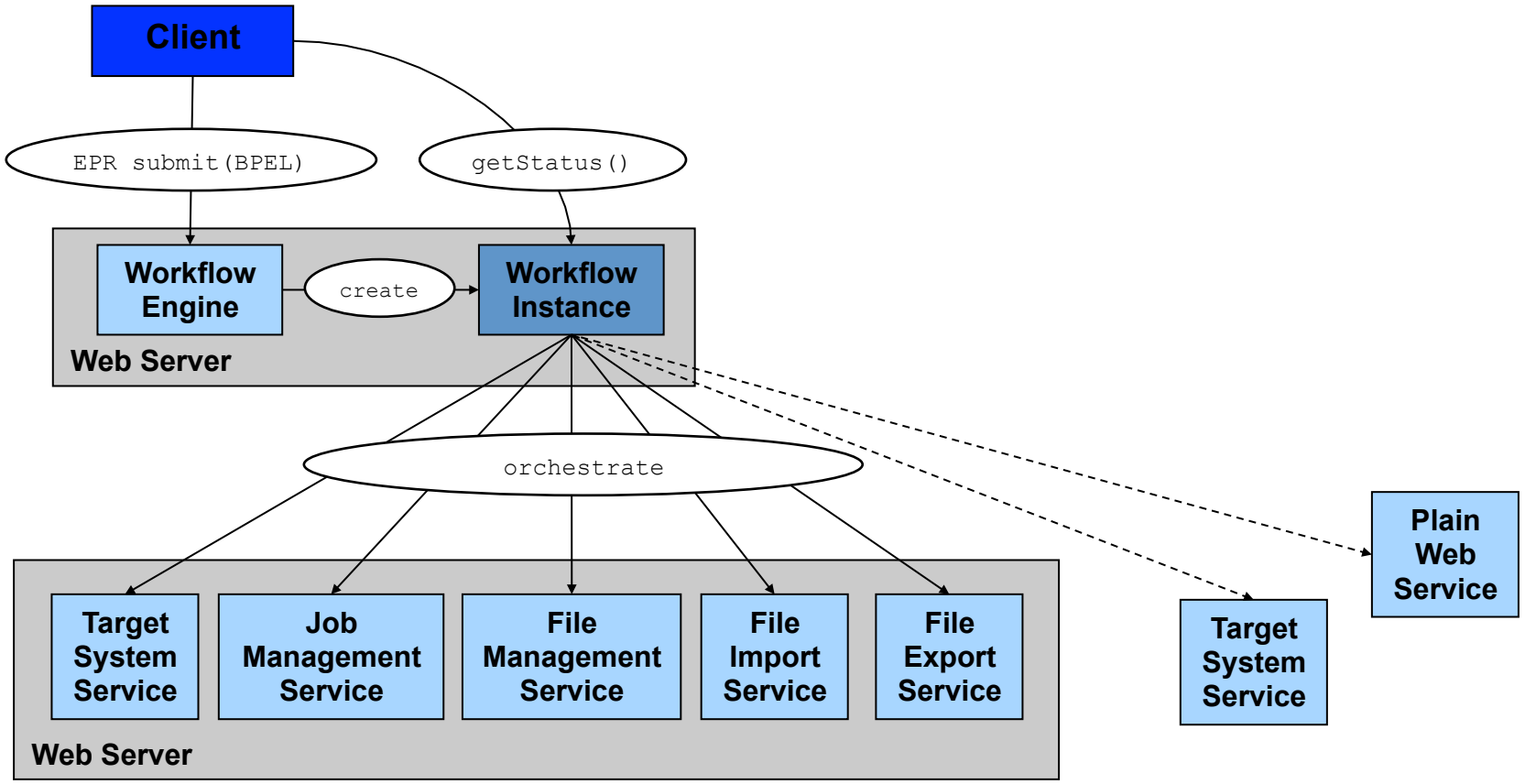
- Registry collects resource properties from target systems
- Target systems notify Registry about property changes
  - WS-Notification
- Registry may be installed
  - per site
  - across different organizations

GPE Registry



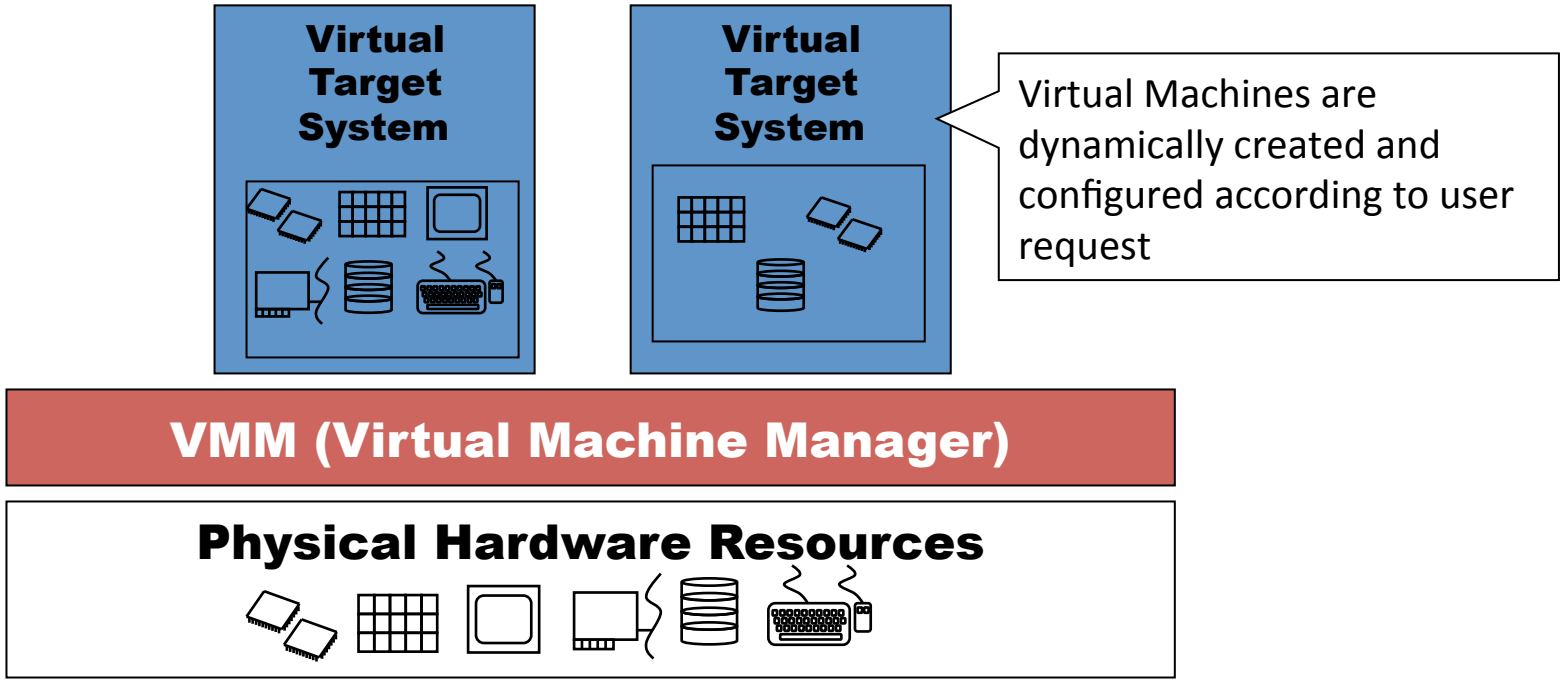
- Registry may be installed on one site/system with the actual TSS, but also can be used across different organizations
- TSS contacts Registry on startup to register and update the information using notifications

GPE Workflows



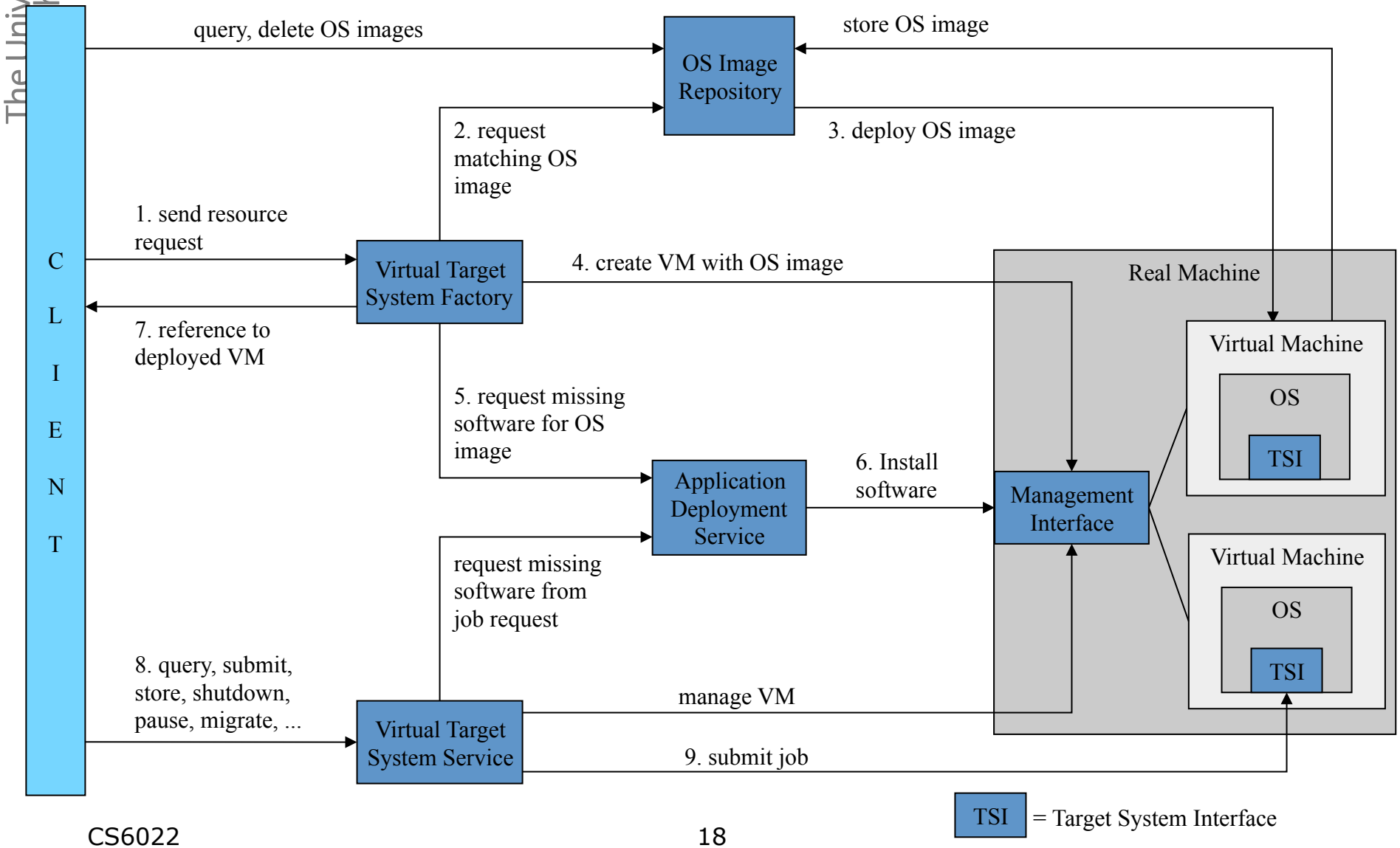
- Use BPEL to orchestrate WSRF services in complex workflows
- Allows integration into larger business processes

Virtualization in Grid Computing



- Protection of sensitive user data
- Other partitions on the same machine will remain unaffected if one partition crashes
- Virtual machines may even migrate during run-time
  - for instance when the hosting hardware is needed from a different user with high priority, when the system needs to shut down, etc.

Virtualization Architecture in GPE



Characteristics of Cloud Computing

As defined by the US NIST

- On-demand self service.
- Broad network access.
- Resource Pooling.
- Rapid elasticity.
- Measured service.

Service oriented computing

NIST defines the following service models

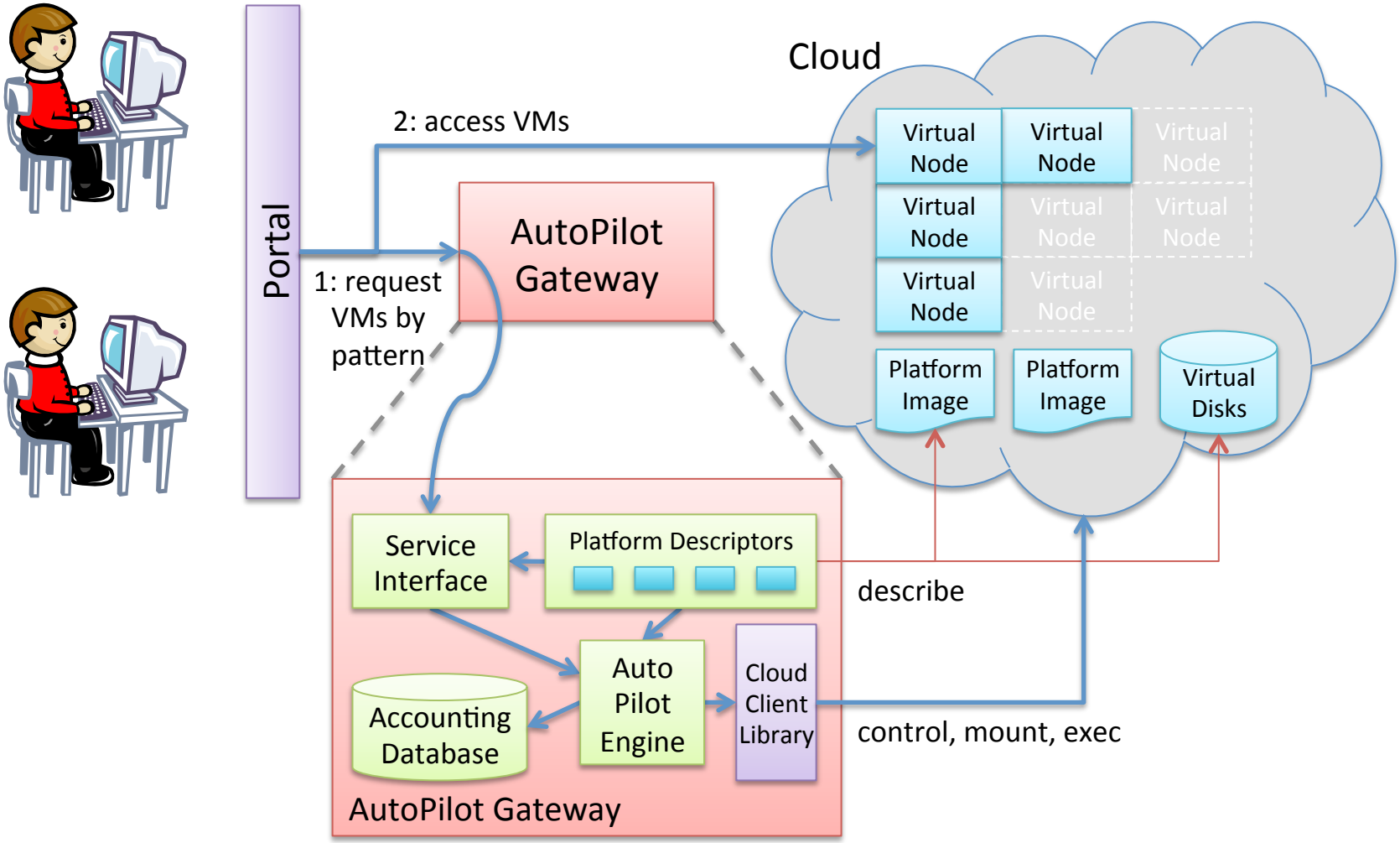
- Software as a Service (SaaS) – example Office 365
- Platform as a Service (PaaS) – example Google Apps.
- Infrastructure as a Service (IaaS) – example Amazon Web Services.

Private and public clouds

Clouds can be classified by accessibility

- Private Cloud, entirely owned by one organisation – very like a private Grid
- Community Cloud – pooled between organisations, again like a Grid.
- Public cloud widely available over the Internet, payment models.
- Hybrid cloud, private but allows "Cloudbursting"

A model for portal access to Clouds



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Taverna in the cloud

- Taverna is a widely used system for running workflows that process scientific data mainly from the life sciences.
- Taverna currently runs mainly on desktop machines, however they do not have the power to process the quantities of data coming from modern genomics sequencing (called Next Generation Sequencing)
- A possible solution is to run Taverna in the Cloud via a server side component, Taverna Server

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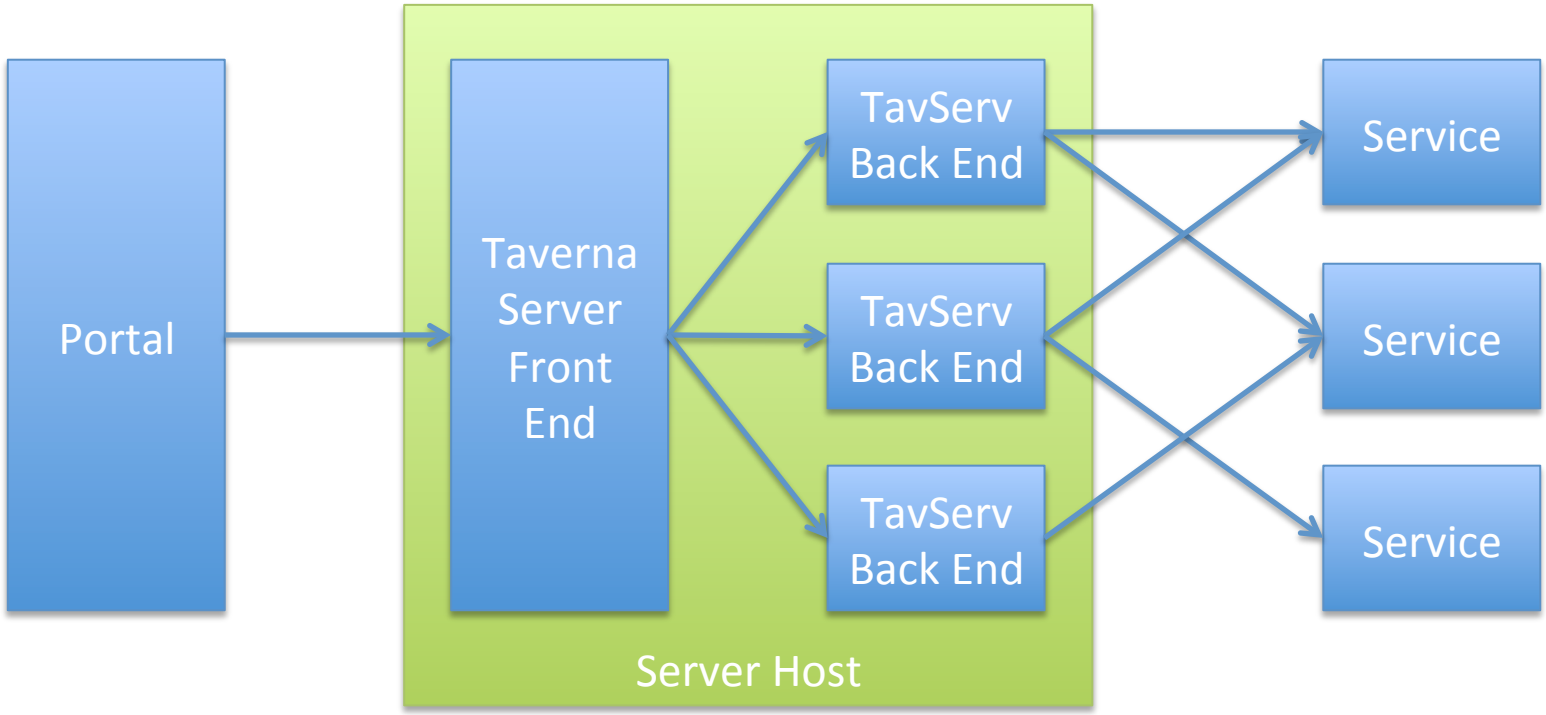
Standard View of Taverna Server



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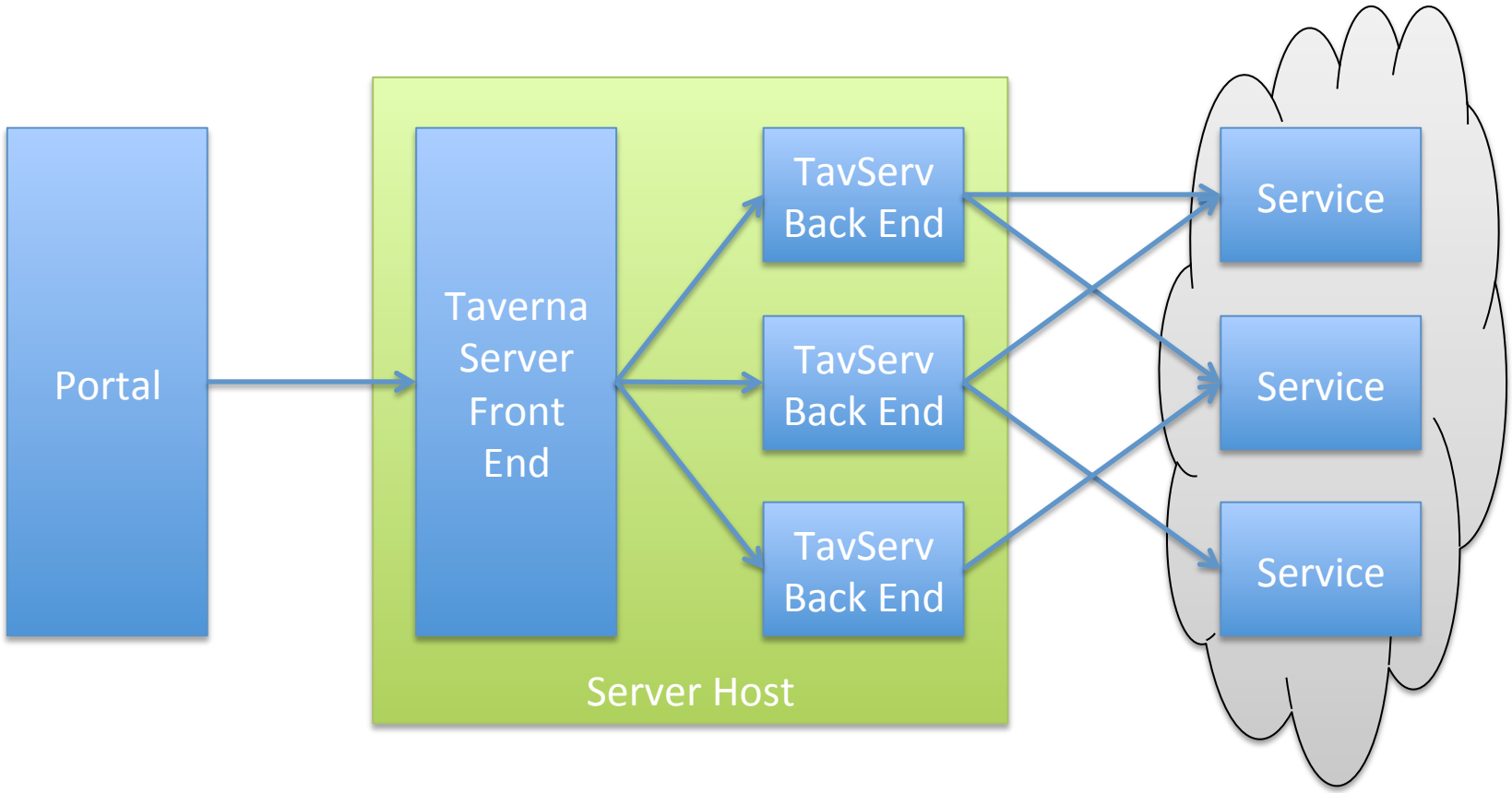
Cloud Back-End Services



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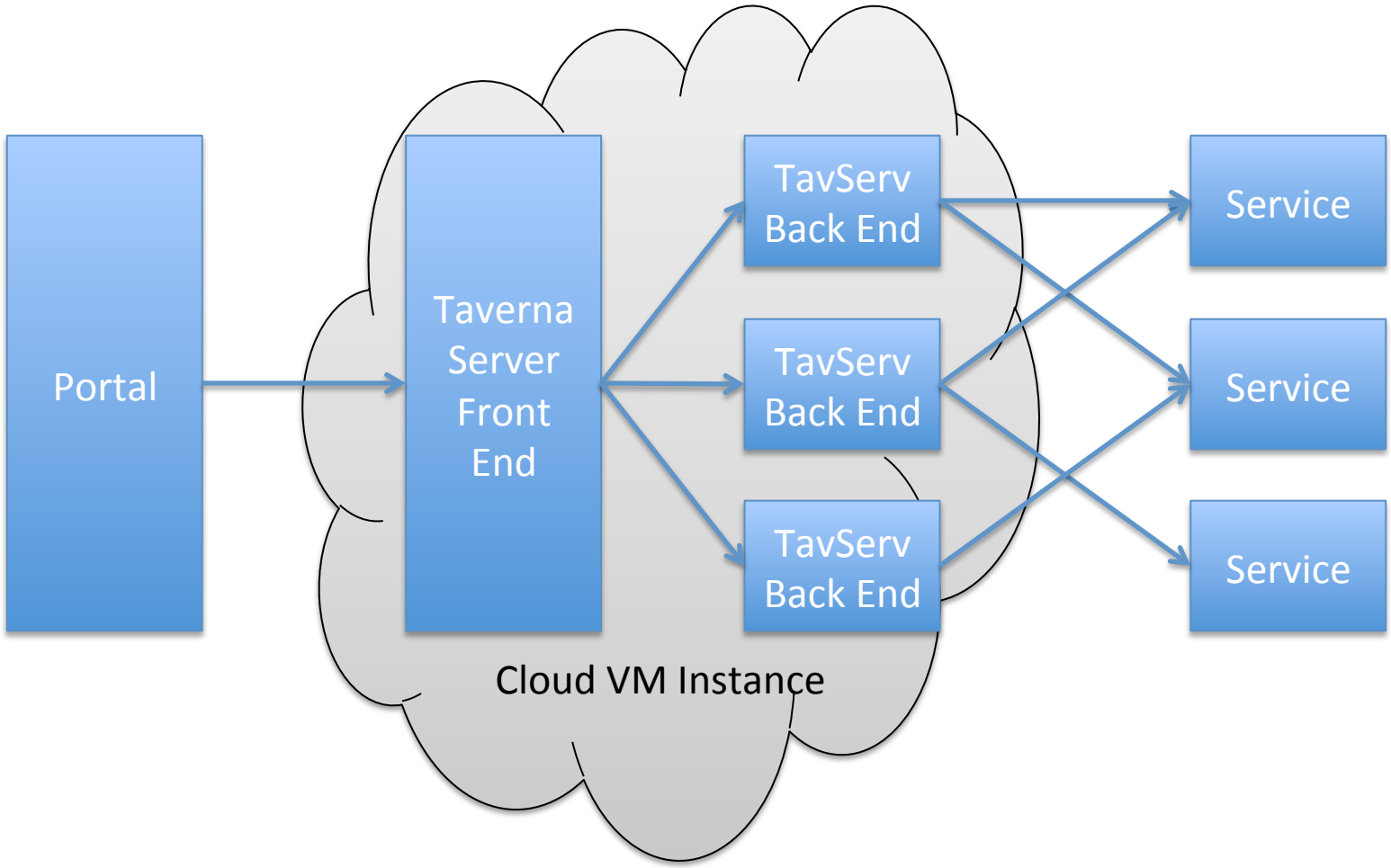
Simple Taverna Cloud



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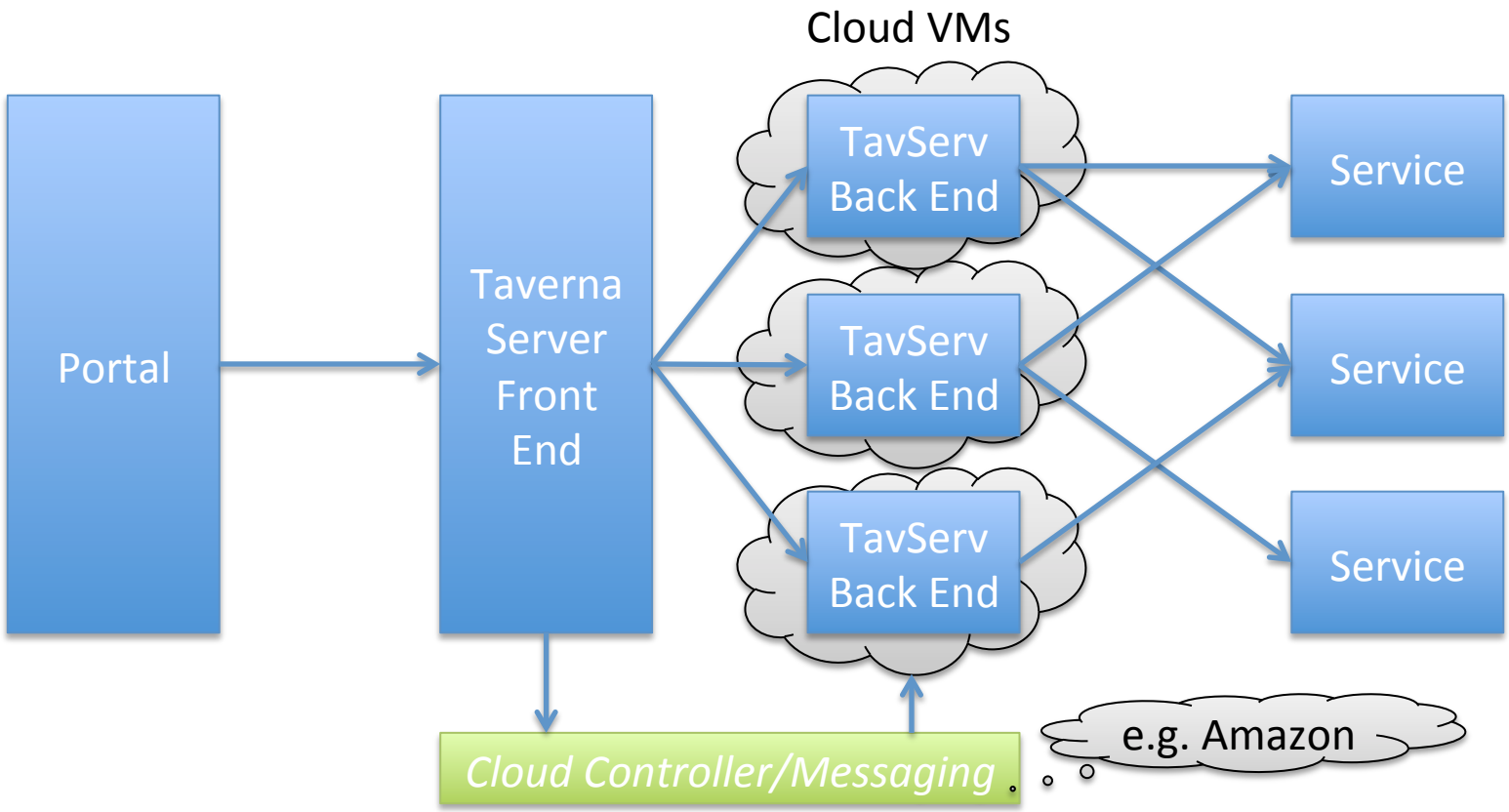
Discretized Taverna Cloud



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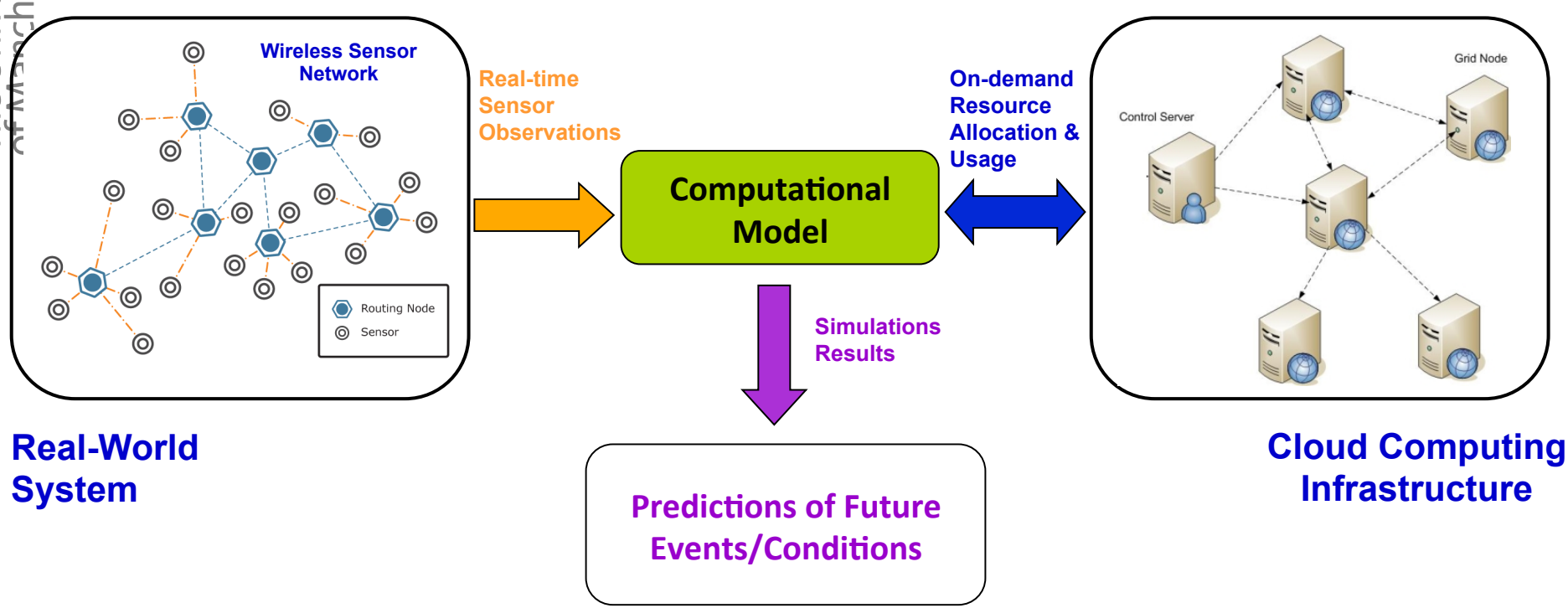
Cloud Computing and Mobile Computing

- Cloud computing and mobile computing can be very complementary, Cloud is the server side and mobile is the the agile interface.
- Cloud allows data and applications to be accessed from multiple devices and locations without time consuming and error prone data copying e.g Apple's IoS links to the Apple Cloud.
- Cloud provides extra power to mobile devices, e.g. Siri.

Case study: supporting water engineers



- Sensor-Grid Computing = WSN + Cloud Computing
- Allows constructing real-time models
- Applications includes the monitoring and control of natural hazards, built environment and target/human surveillance

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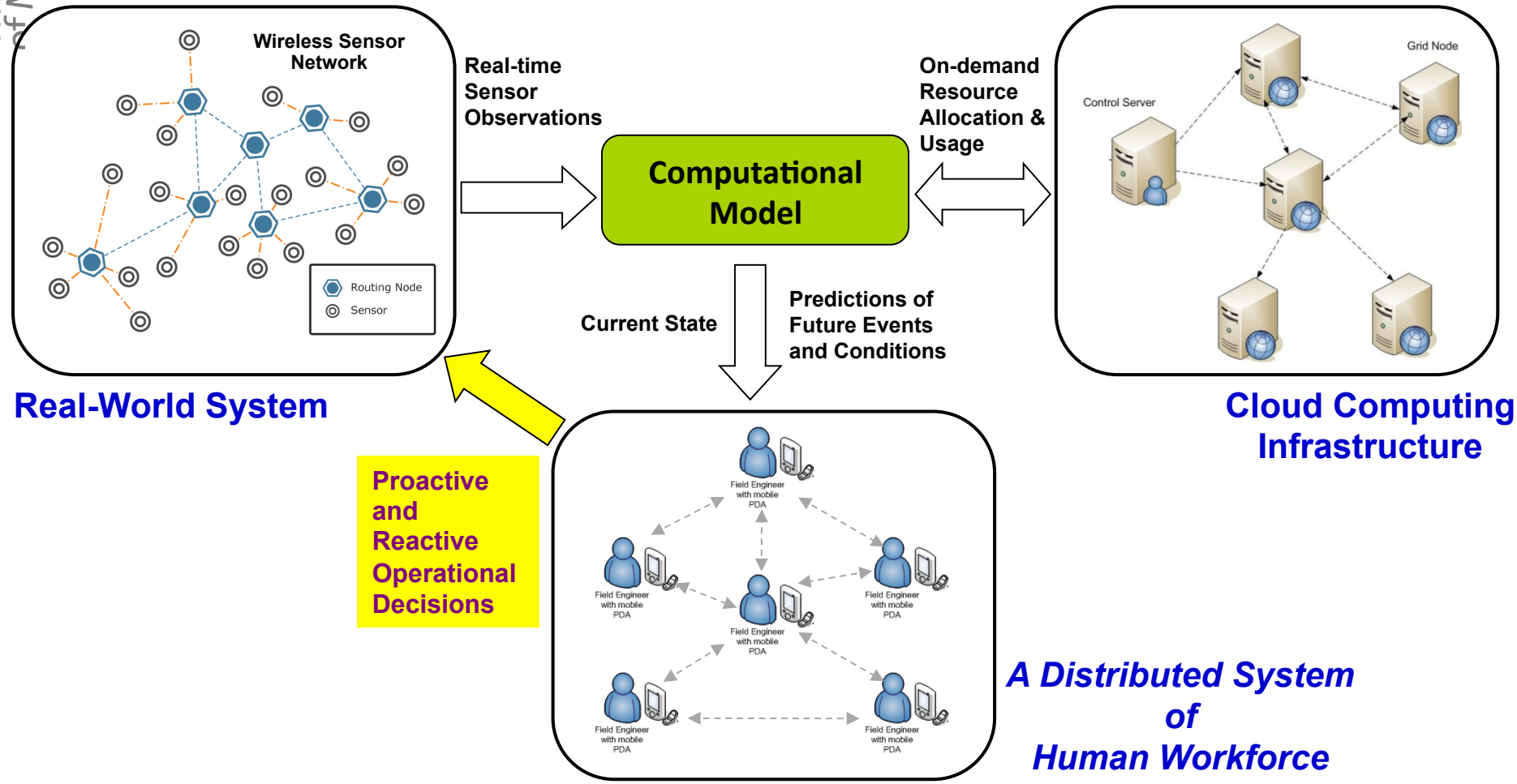
Integration of a distributed workforce with mobile devices



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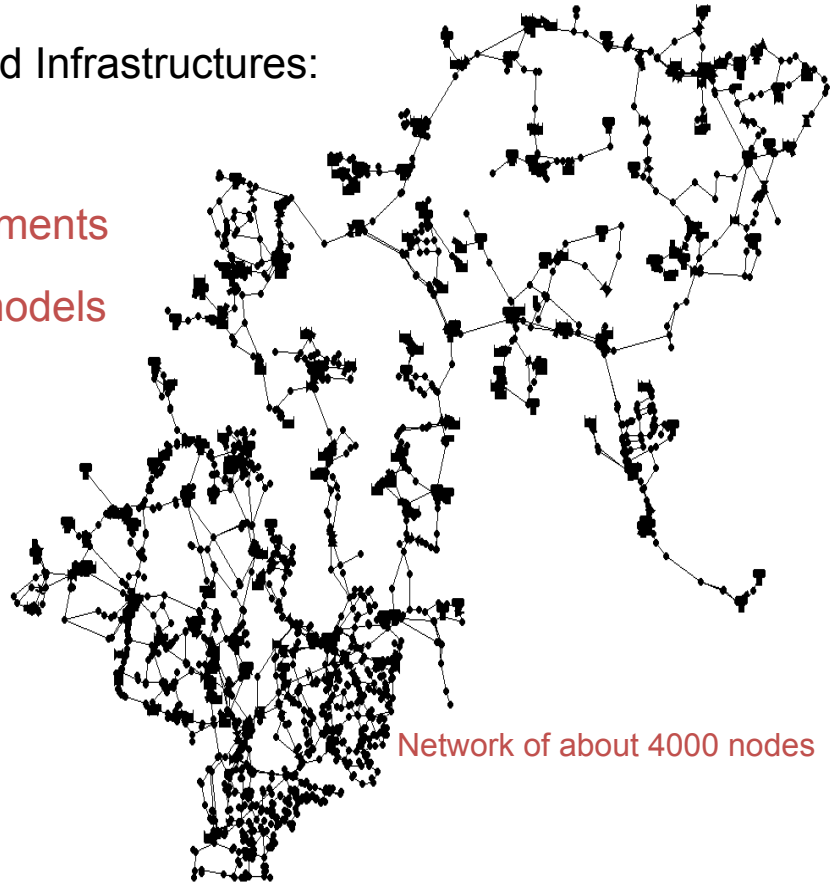
Managing physical infrastructure

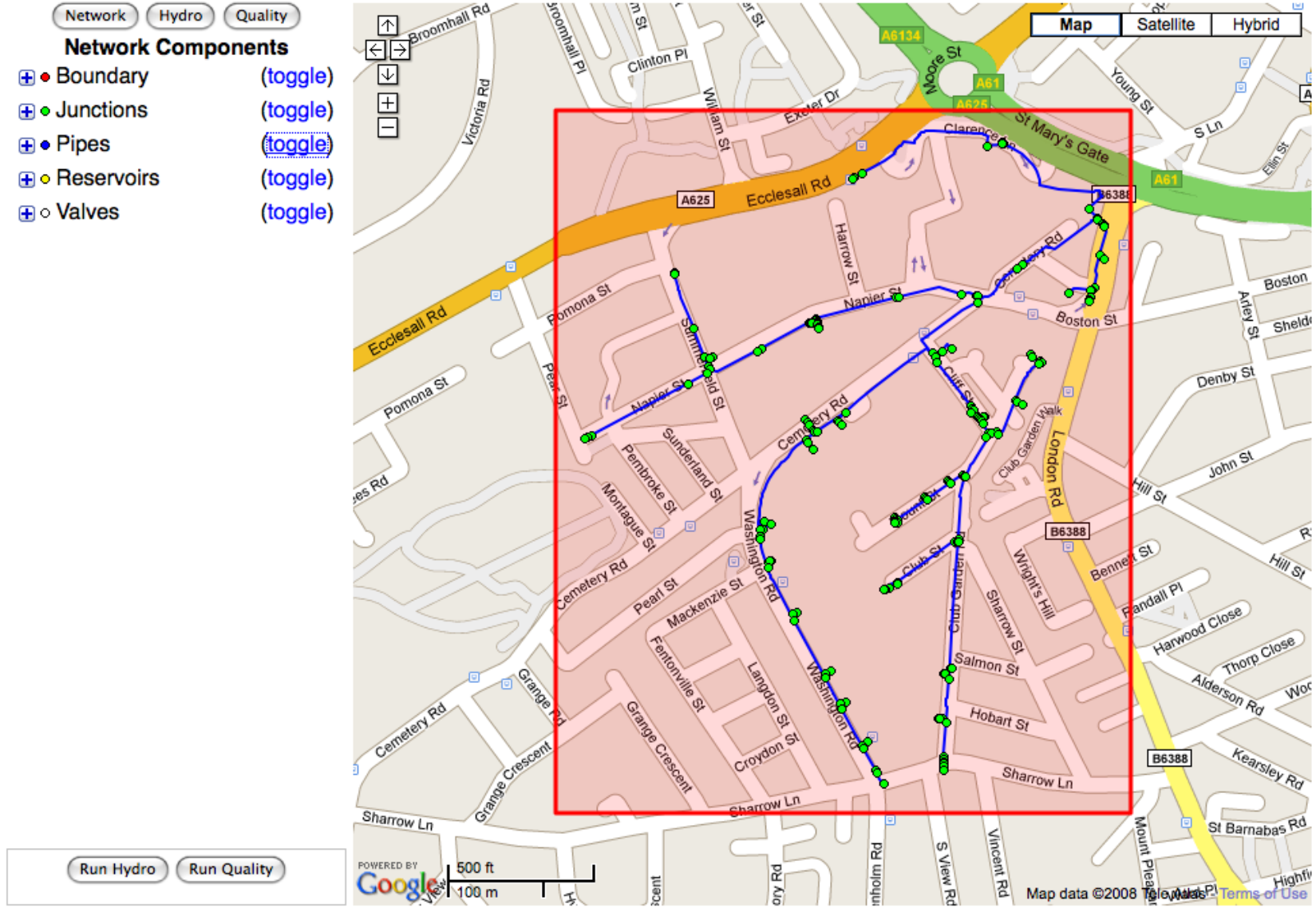
- Focus of research work is on existing distributed Infrastructures:
  - cover longer distances
  - comprise of hundreds of thousands of elements
  - having complex topologies e.g. all-main models
  - operate for long period up to a century
- Examples of Distributed Infrastructure:
  - Water Distribution System
  - Electricity Grids
  - Oil and Gas Network



Network of about 4000 nodes

- UK water distribution and sewer pipes
  - Water pipes - 397,401 km (Earth - Moon: 384,403 km)
  - Sewer pipes - 354,066 km

Junctions and pipes overlay



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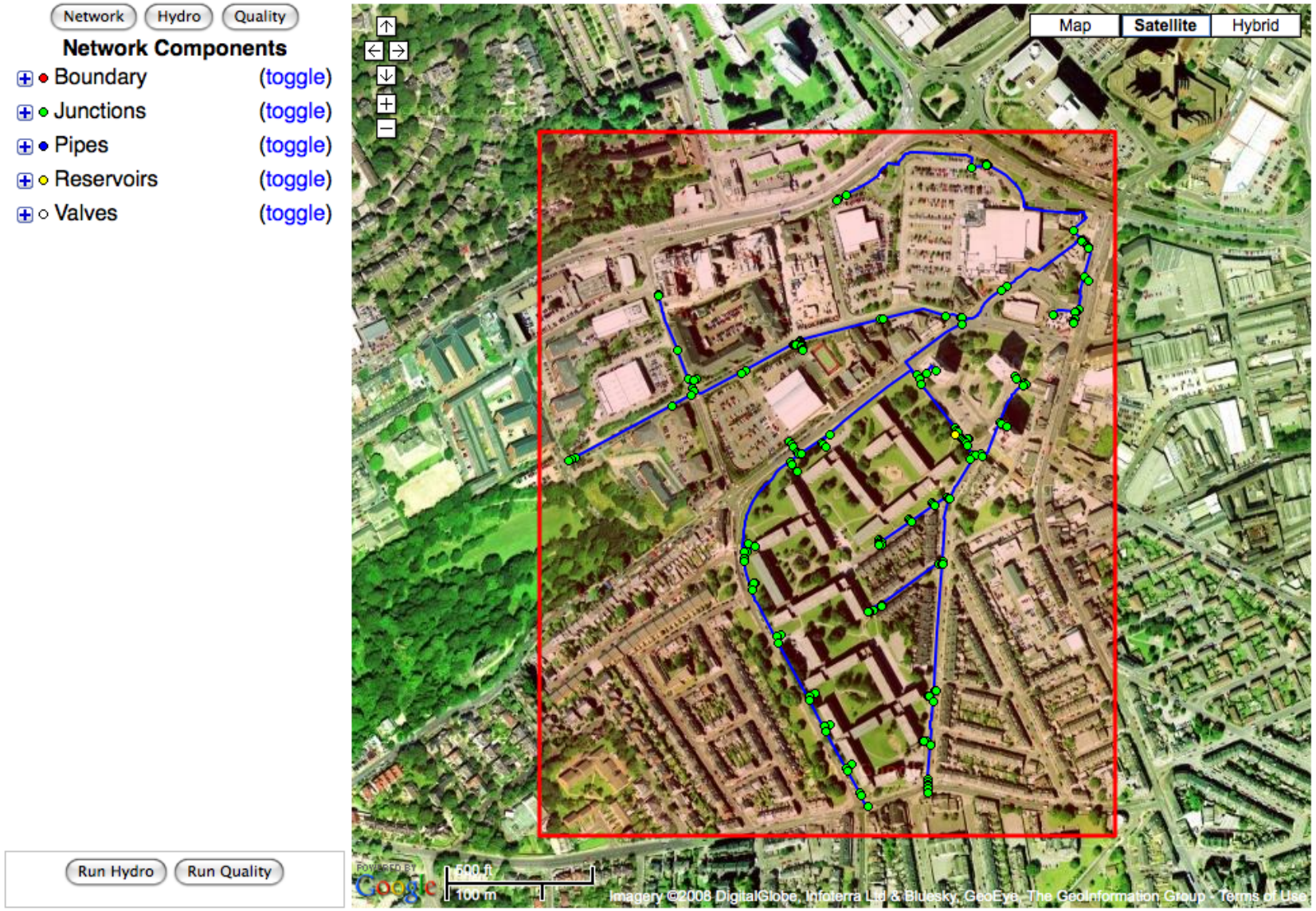
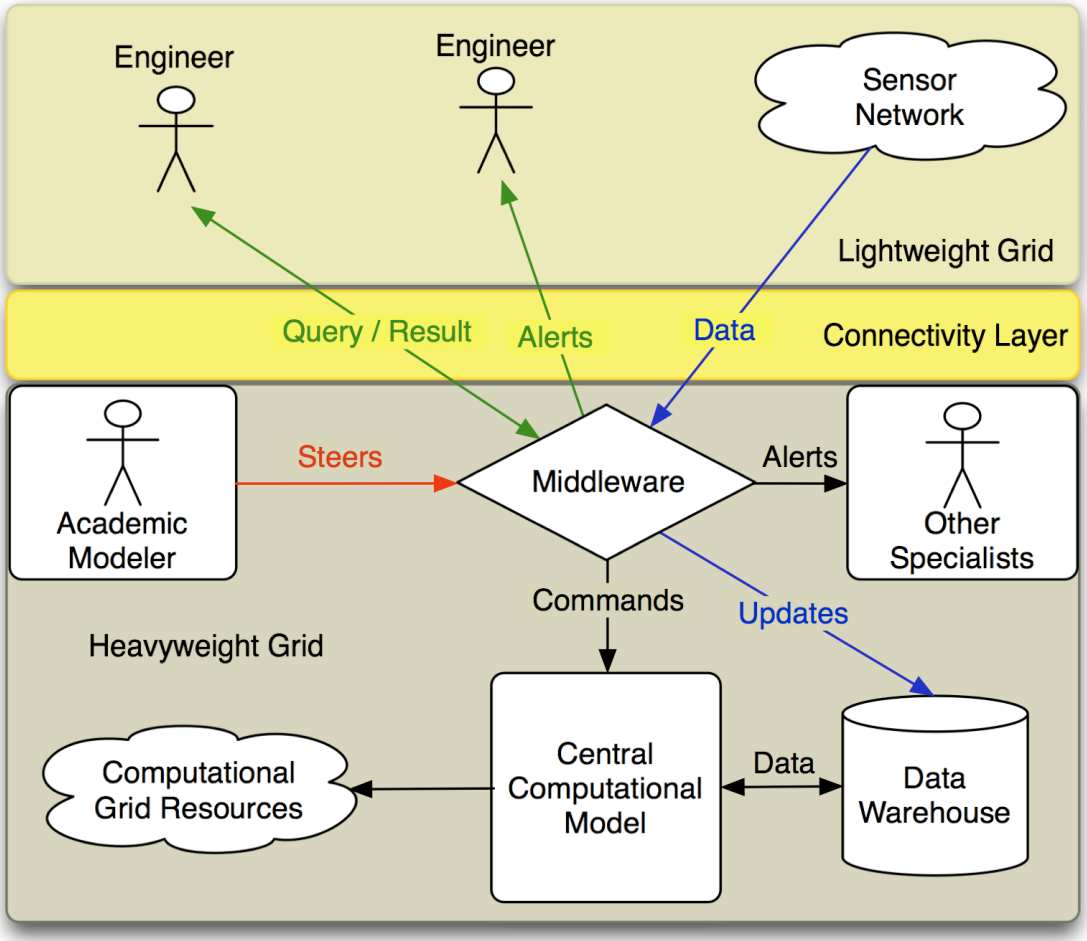
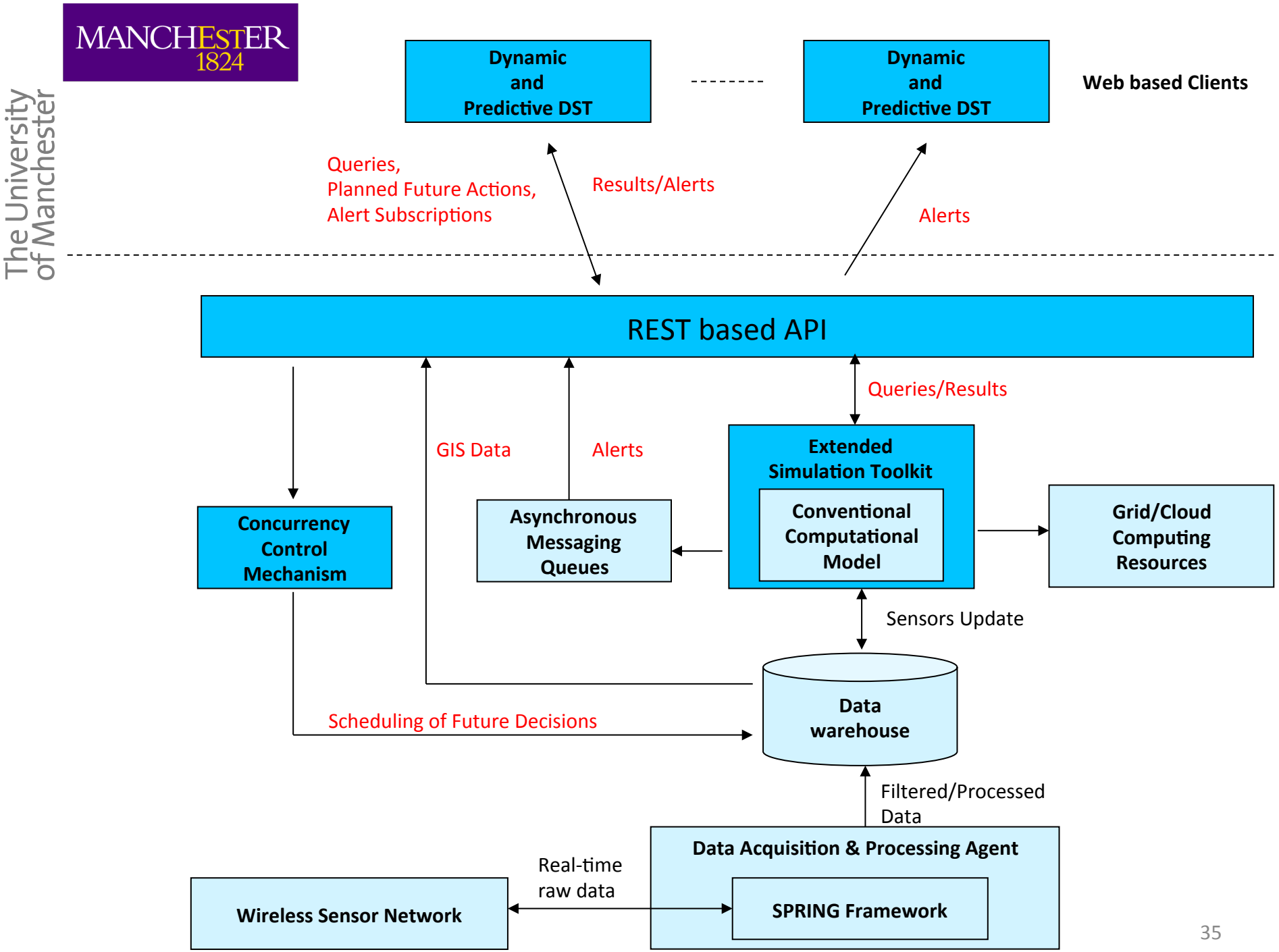
Satellite view



Design of the functionality of the system



We build on current Grid middleware for computation (heavyweight Grid/ Cloud) and link it to mobile and roaming devices with a role-based lightweight architecture based on messaging protocols. In this way we include the engineering process.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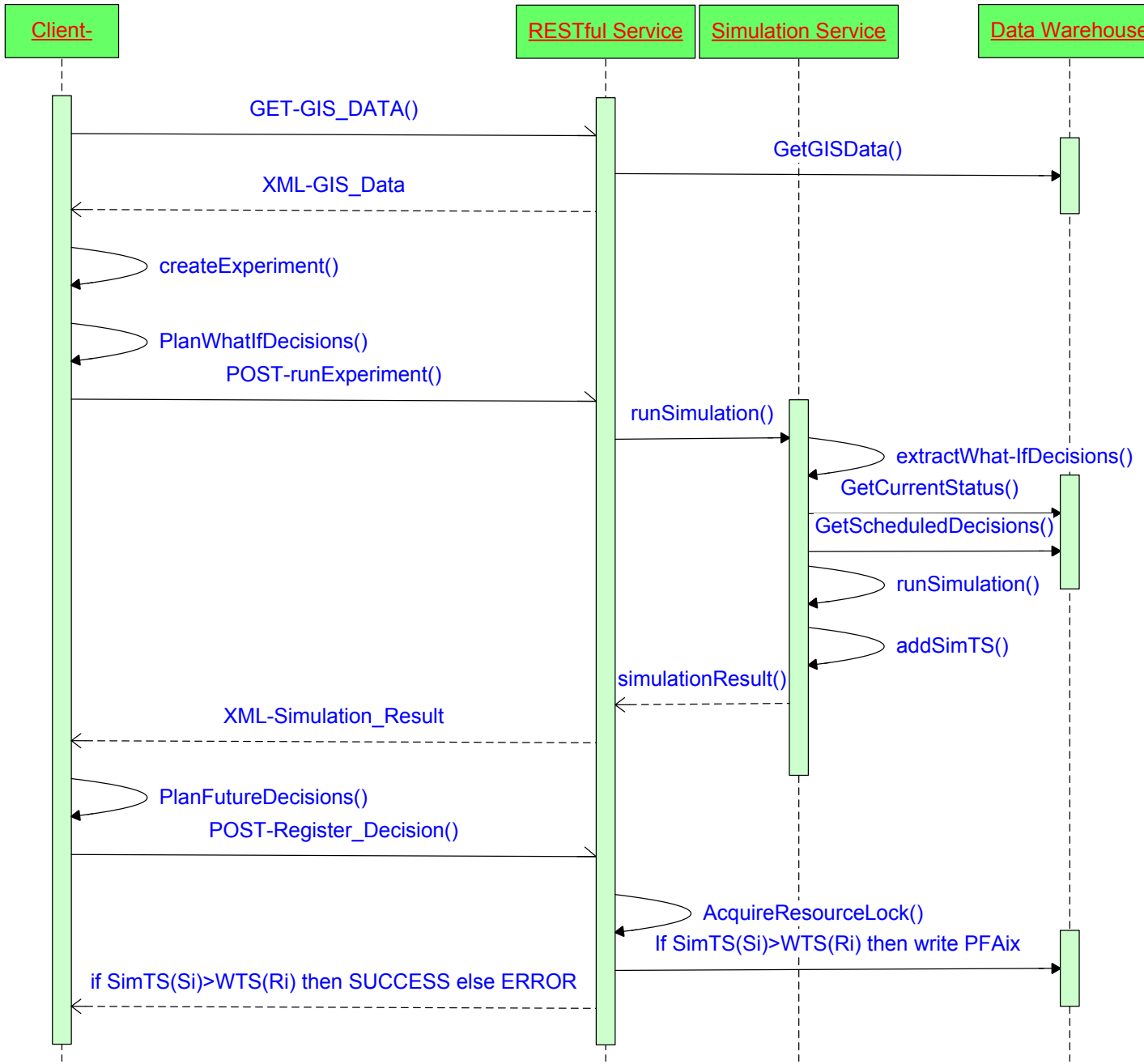
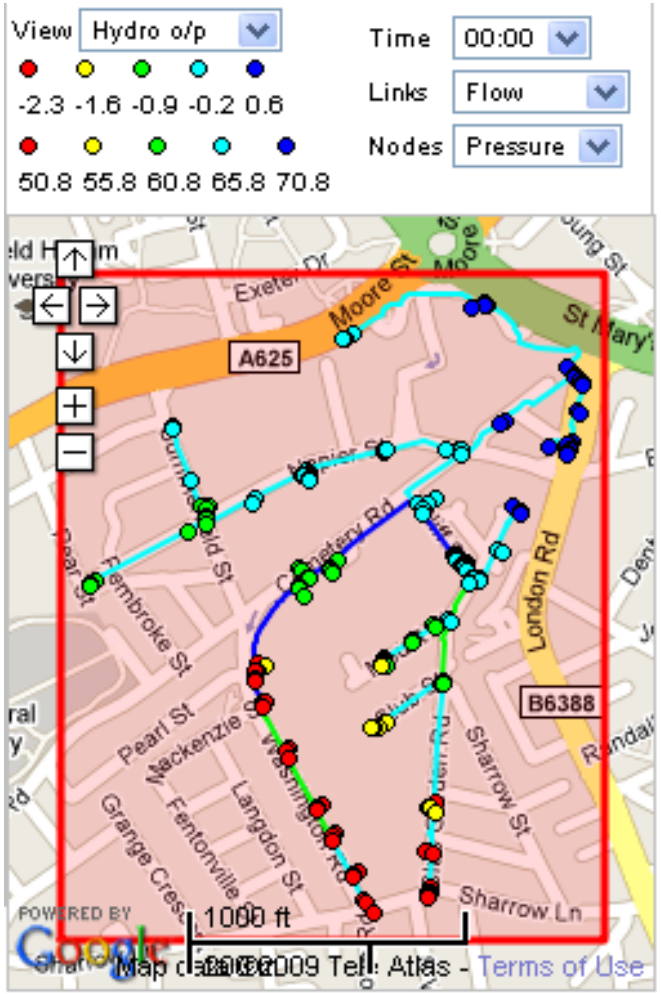
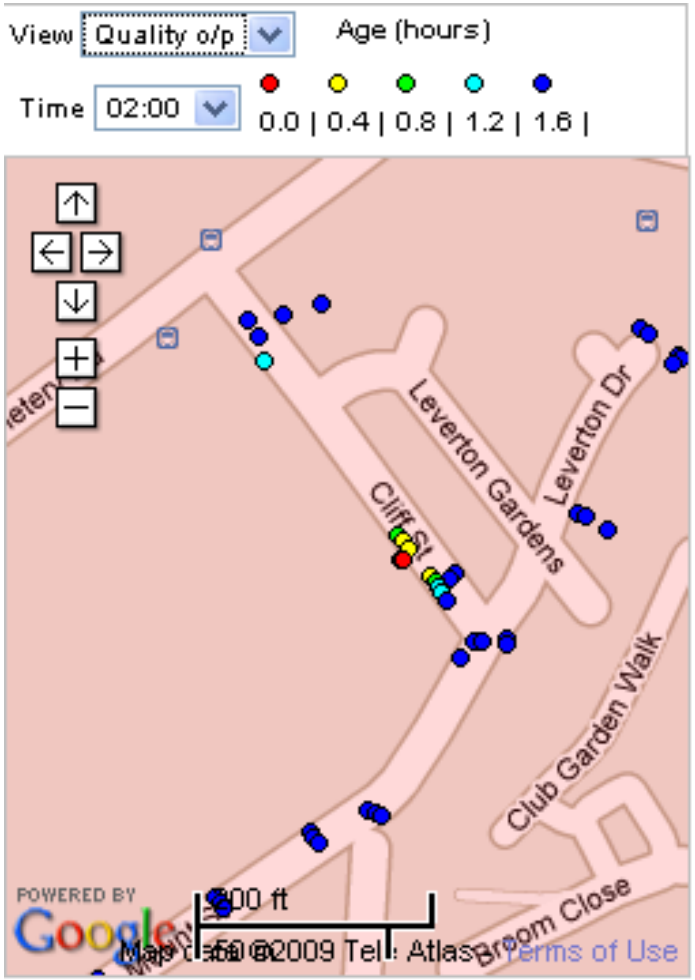
Dynamic and Predictive DST
Dynamic and Predictive DST
Web based Clients
Queries, Planned Future Actions, Alert Subscriptions
Results/Alerts
Alerts
REST based API
Queries/Results
GIS Data
Alerts
Extended Simulation Toolkit
Conventional Computational Model
Concurrency Control Mechanism
Asynchronous Messaging Queues
Grid/Cloud Computing Resources
Sensors Update
Data warehouse
Scheduling of Future Decisions
Filtered/Processed Data
Data Acquisition & Processing Agent
Real-time raw data
Wireless Sensor Network
SPRING Framework

Interaction of DST with RESTfull Service



Implementation on PDAs and SmartPhones

- 



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Reasons for current success of Cloud Model

- Easy to understand business model. Payment by credit card or by subscription.
- Organisations with data centres that are on a scale where “elastic computing” and economies of scale become possible.
- A user is now represented by multiple devices, several of them mobile. A central virtual repository is needed to keep the user’s data consistent. Dropbox is the classic example of this.

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Potential problems for Cloud Model

- Compared to Grid Computing standards in the Cloud world are very undeveloped. Strong risk of vendor lock-in.
- With Cloud not only your software but also your data and even your identity become locked to vendors. Controversies over Facebook show the the very high stakes here.
- For very high performance applications, virtualisation is a performance hit.
- Network access is expensive and slow relative to all other features of Cloud Computing.

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More information

- Amazon AWS documentation gives a good description of how IaaS works.
- www.gridcafe.org a good source for Grid computing information.
- http://en.wikipedia.org/wiki/Cloud_computing .
- There are lots of books, I have used Cloud Computing Bible by Barry Sosinsky for general information and Programming Amazon EC2 by van Vliet and Paganelli, O'Reilly books for hands-on.