

NETTAB'2002

On the Use of Agents in a Bioinformatics Grid



Luc Moreau,
University of Southampton

Structure

- Background: myGrid
- Architecture
- Use of Agents
- Conclusion



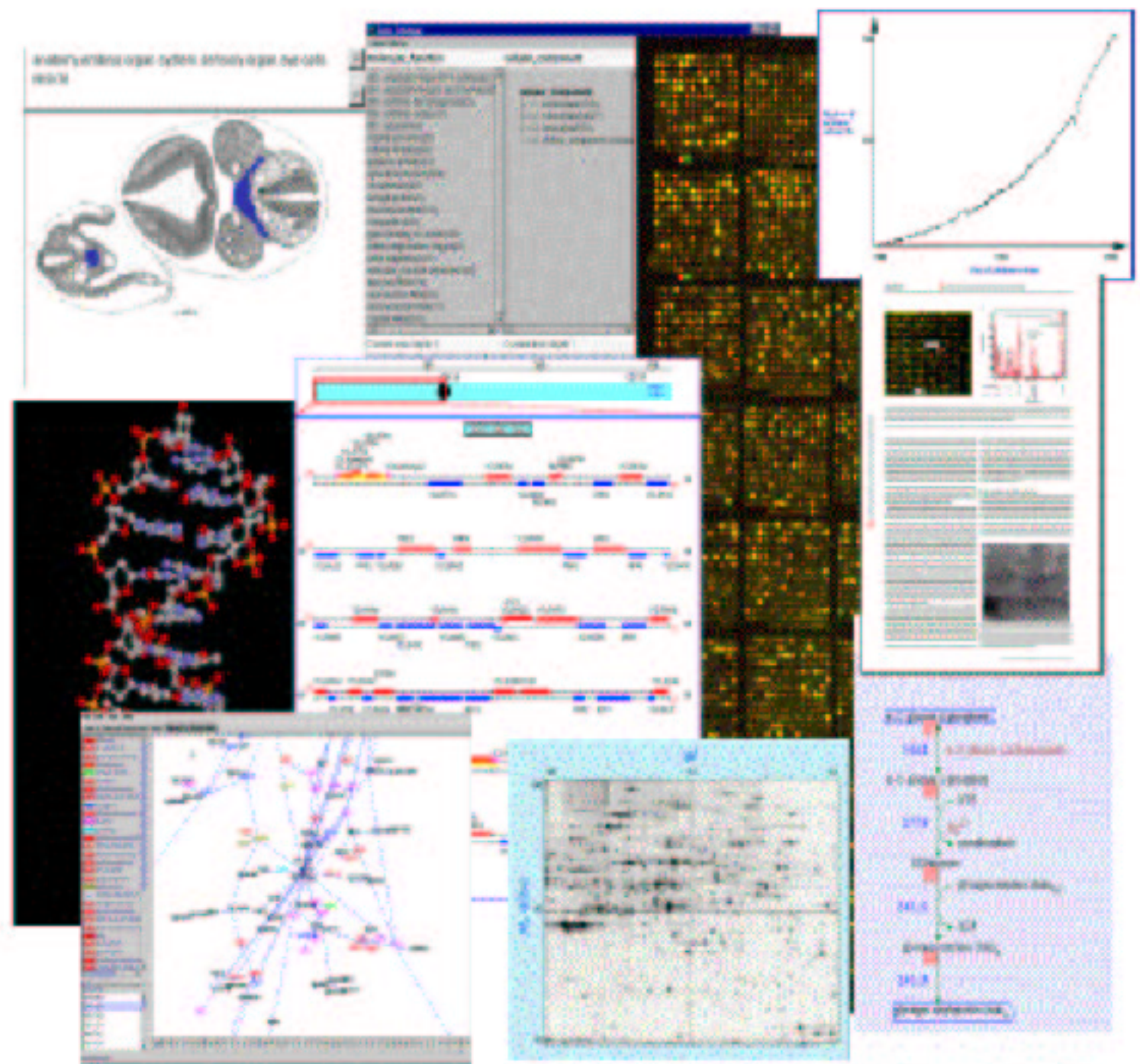
e-Science & Biology

- Biology is a multi-faceted & increasingly multi-disciplinary science
- Bioinformatics is very much an “e-Science”
 - Discovery is done *in silico* on results obtained from experiments using a number of analysis & data resources
- Molecular biology & genomics are the particular focus here



Bioinformatics & Genomics

- Large amounts of data
- Highly heterogeneous
 - Data types
 - Data forms
 - Community
- Highly complex and inter-related
- Volatile



Bioinformatics Data

- Descriptive as well as numeric
- Literature
- Analogy/knowledge-based

Text
Extraction

Database	UniProt
Accession	PF00002; Melatonin_receptor (matches 22 proteins)
Name	Melatonin receptor
Type	Class
Dates	09-OCT-1999 (created) 27-MAR-2000 (last modified)
Significance	PF00002; MELATONINBP (22 proteins)
Family	PF00002; Rhodopsin-like GPCR superfamily (2990 proteins)
Clusters	PF00002; Melatonin 1A receptor (12 proteins) PF00002; Melatonin 1C receptor (5 proteins) PF00002; Melatonin-related 1X receptor (3 proteins)
Location	melatonin_receptor (22,000,000)
Comments	members (22,000,000)
Description	<p>G-protein-coupled receptors (GPCRs) constitute a vast protein family that encompasses a wide range of functions (including various autocrine, paracrine and endocrine processes). They show considerable diversity at the sequence level, on the basis of which they can be separated into distinct groups. We use the term class to describe the GPCRs, as they embrace a group of families for which there are indications of evolutionary relationship, but between which there is no statistically significant similarity in sequence [1]. The currently known class members include the rhodopsin-like GPCRs, the secretin-like GPCRs, the cAMP receptors, the fungal mating pheromone receptors, and the metabotropic glutamate receptor family.</p> <p>The rhodopsin-like GPCRs themselves represent a widespread protein family that includes hormone, neurotransmitter and light receptors, all of which transduce extracellular signals through interaction with guanine nucleotide-binding (G) proteins. Although their activating ligands vary widely in structure and character, the amino acid sequences of the receptors are very similar and are believed to adopt a common structural framework comprising 7 transmembrane (TM) helices [2, 3, 4].</p> <p>Melatonin is secreted by the pineal gland during darkness [5]. It regulates a variety of neuroendocrine functions and is thought to play an essential role in circadian rhythms. Drugs that modify the action of melatonin, and hence influence circadian cycles, are of clinical interest (for example, in the treatment of jet-lag). Melatonin receptors are found in the retina, in the pars tuberalis of the pituitary, and in discrete areas of the brain. The receptor inhibits adenyl cyclase via a pertussis toxin-sensitive G-protein, probably of the G_i type [6].</p>
Examples	<ul style="list-style-type: none">• PF00002 ML1C_OROK• PF00002 ML1A_OROK• PF00002 ML1C_HDLA• PF00002 ML1A_PICOU
References	<ol style="list-style-type: none">1. Atwood T K, Findley J B C. Fingerprinting G-protein-coupled receptors. <i>Protein Eng.</i> 7: 195-203 (1994). PubMed Search PubMed PubMed



In silico experimentation

- Discovery, interoperation, fusion, sharing
- **Process** is as important as outcome
- Science is dynamic – **change** happens
- Scientific discovery is **personal** & global
- **Provenance** and history

myGrid: facts

- EPSRC funded pilot project
- Generic middleware with application setting
- 36 month period
- Start 1st October
 - 16 full-time post docs altogether
 - 1 technical project manager
 - 1 system manager
 - 1 secretarial post

myGrid: facts

- Scientific team
 - Biologist and Bioinformaticians
 - GSK, AZ, Meck KGaA, Manchester, EBI
- Technical Team
 - Manchester, Southampton, Newcastle, Sheffield, EBI, Nottingham
 - IBM, SUN
 - GeneticXchange
 - Network Inference, Epistemics Ltd

myGrid Outcomes

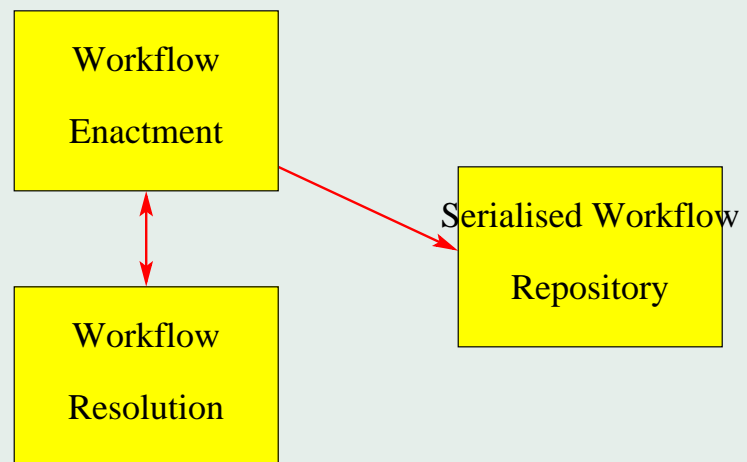
- e-Scientists

- Gene function expression analysis using *S. cerevisiae*
- Annotation workbench for the PRINTS pattern database

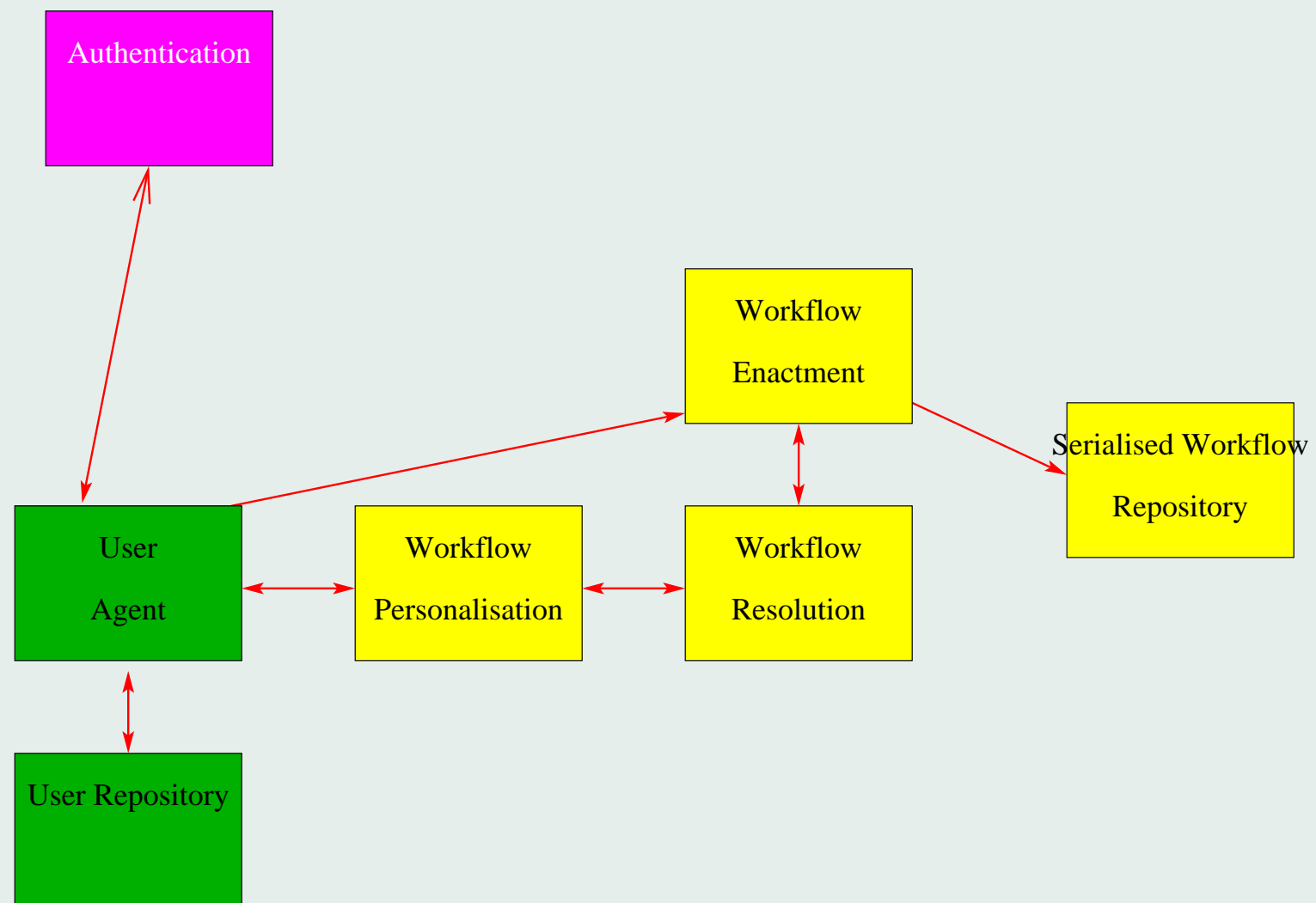
- Developers

- myGrid-in-a-Box developers kit
- Re-purposing DAS, AppLab and OpenBSA
- Integrating ISYS & GlaxoSmithKline platforms

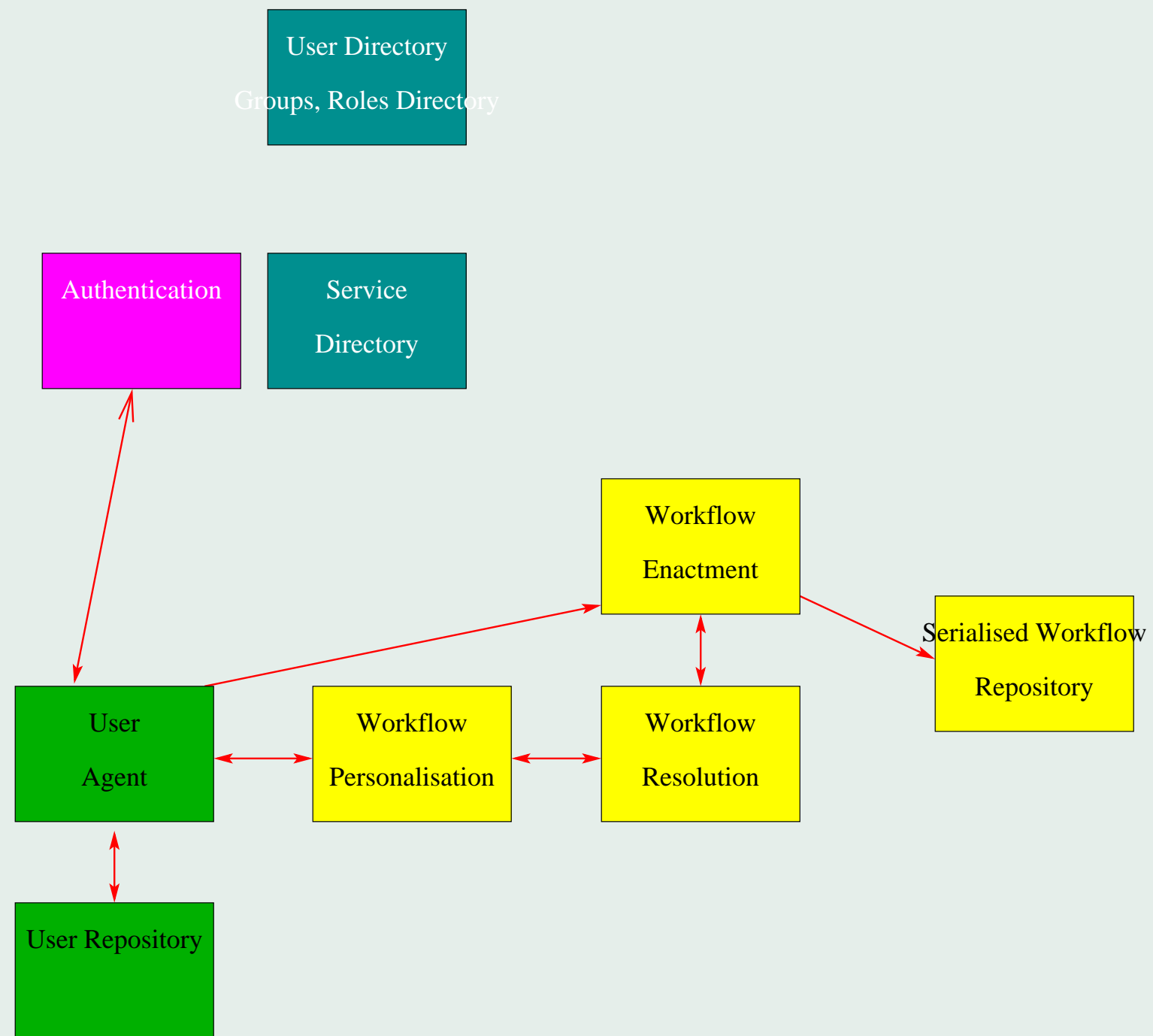
Architecture



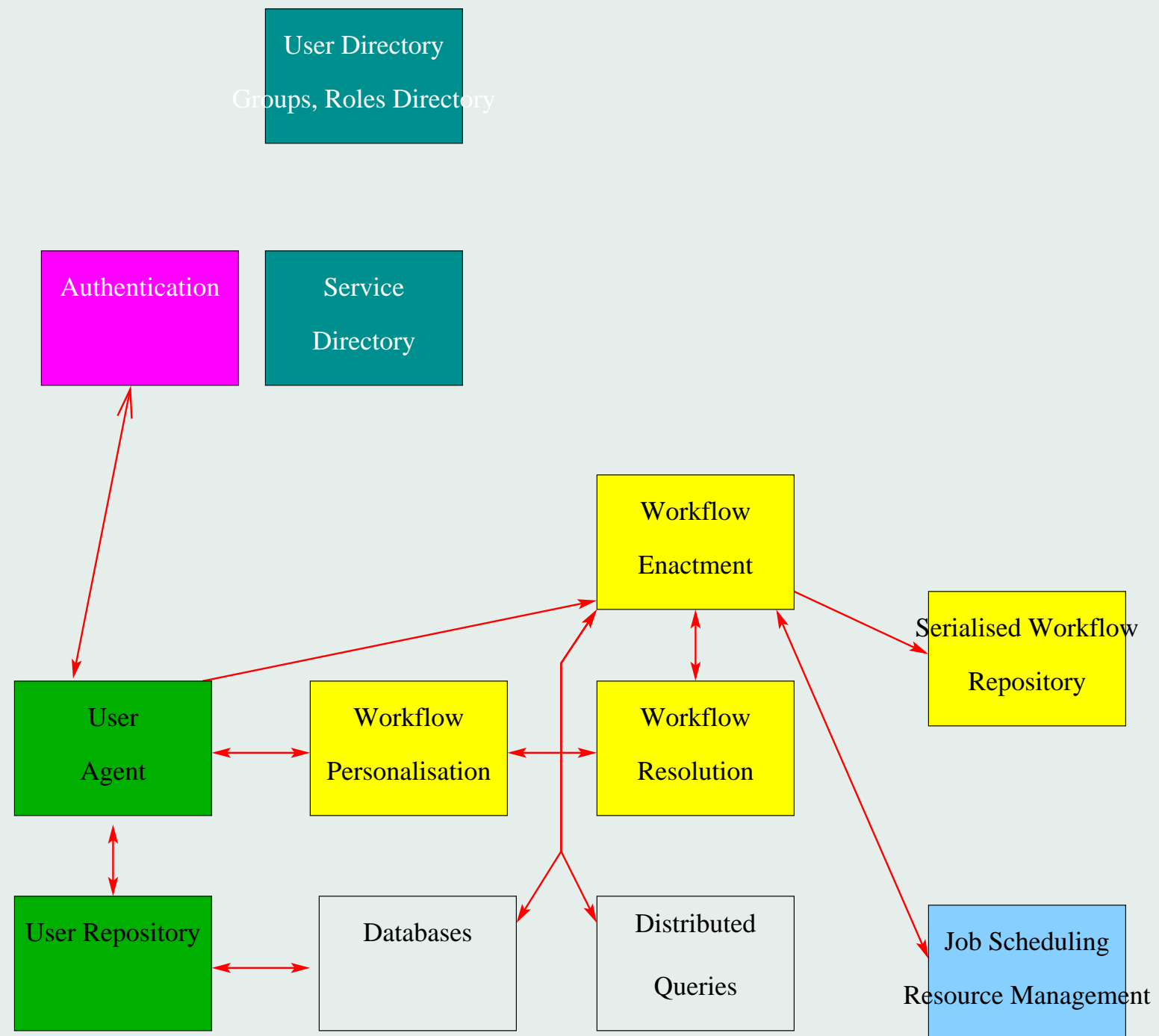
Architecture



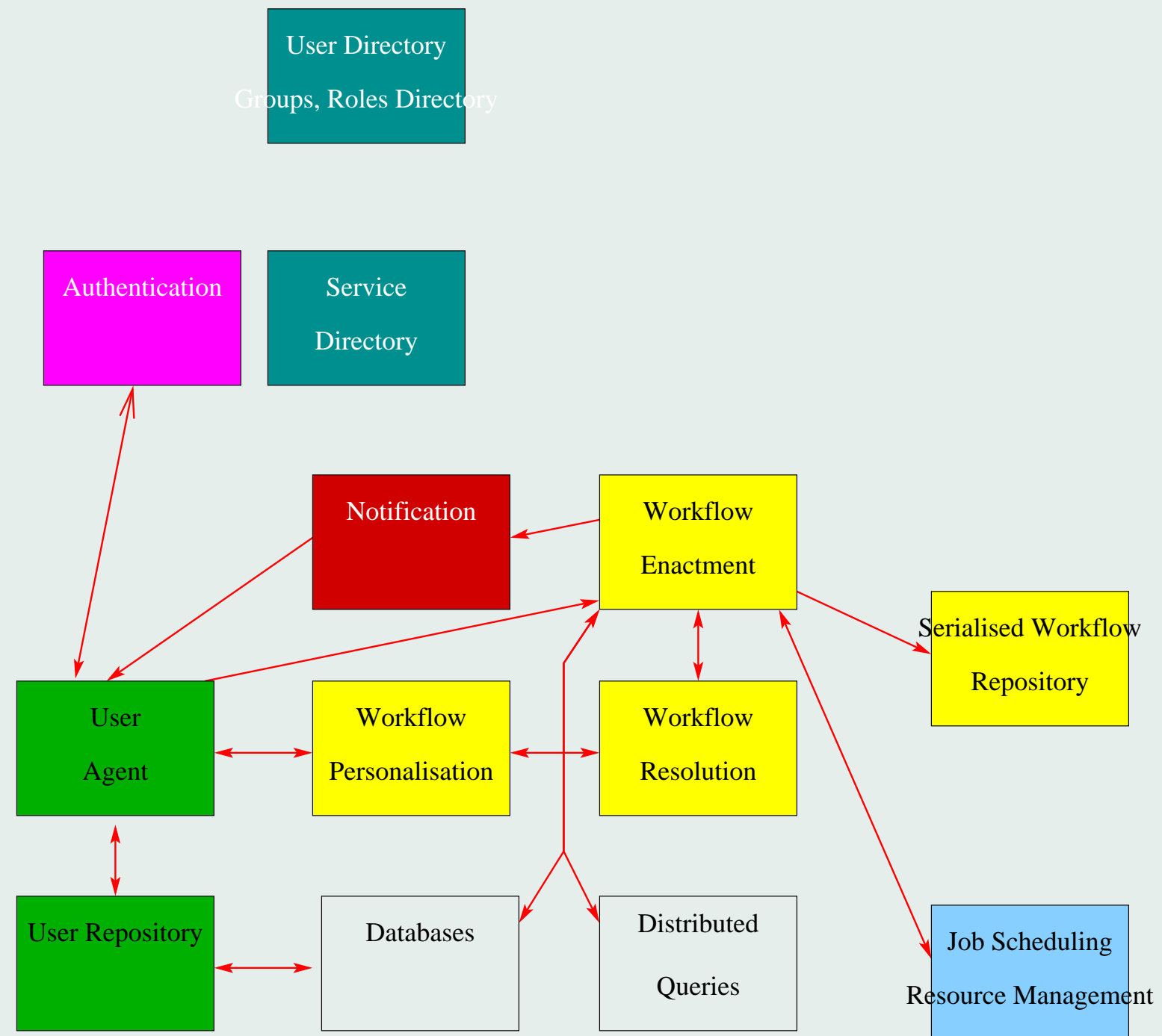
Architecture



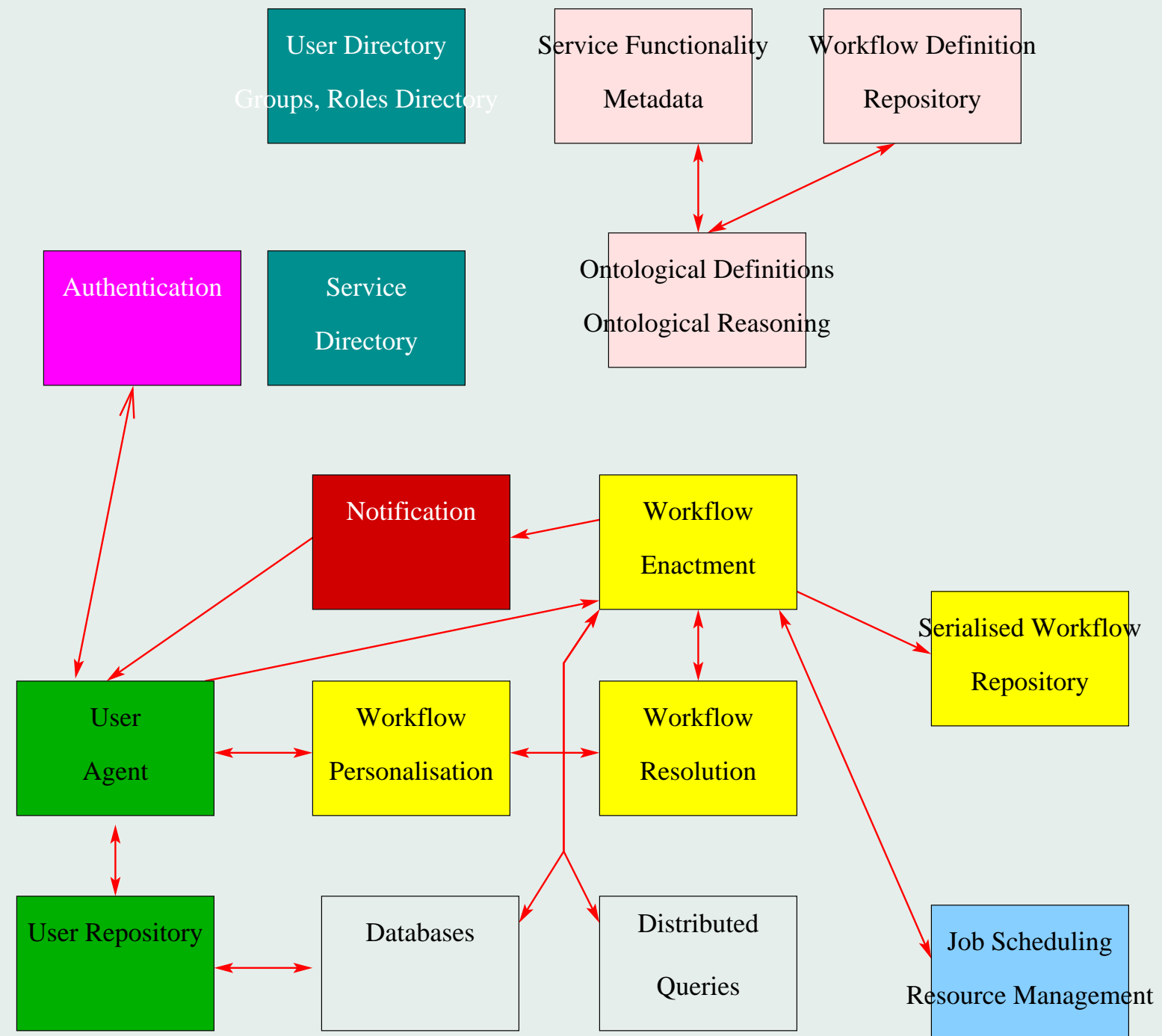
Architecture



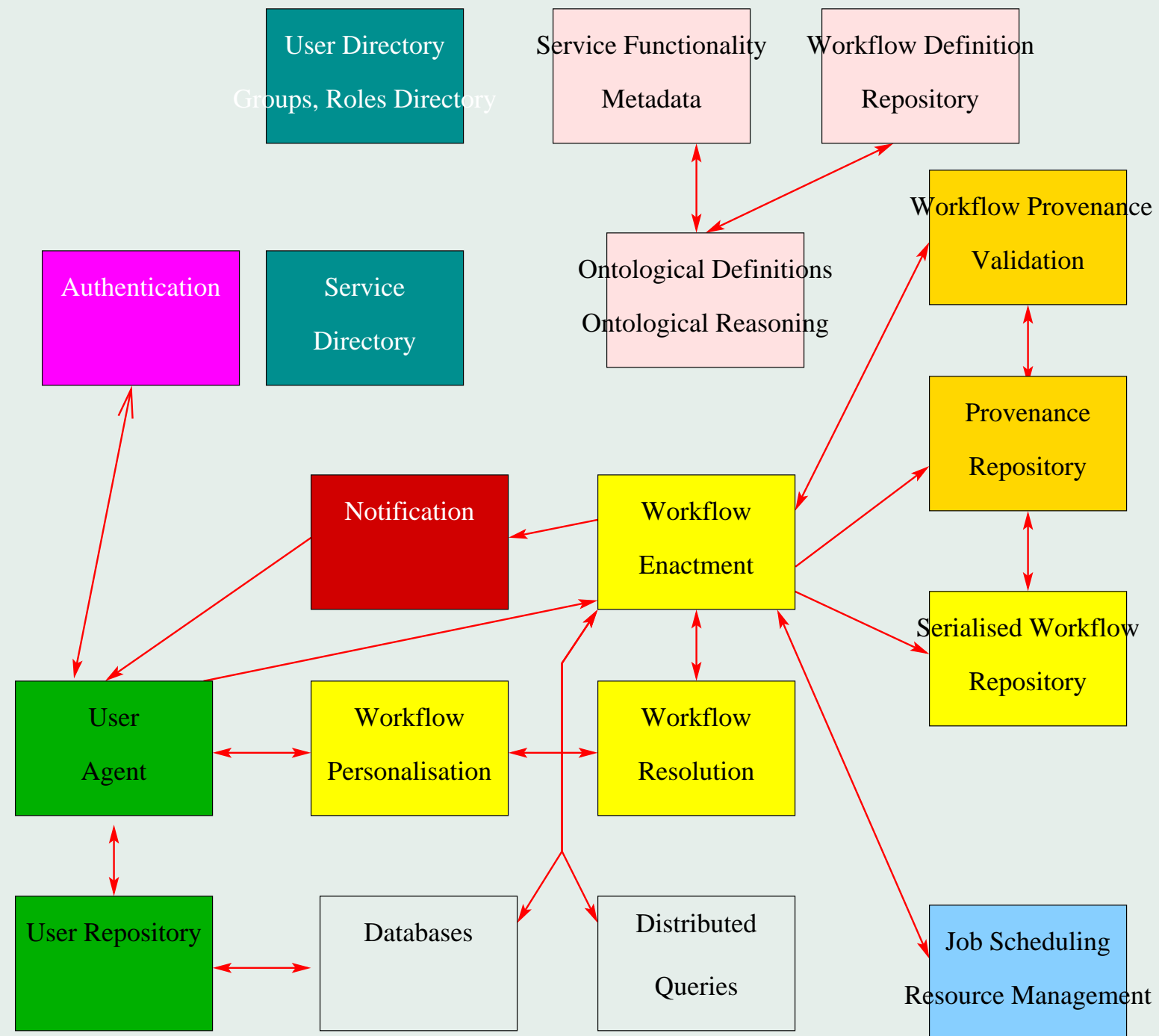
Architecture



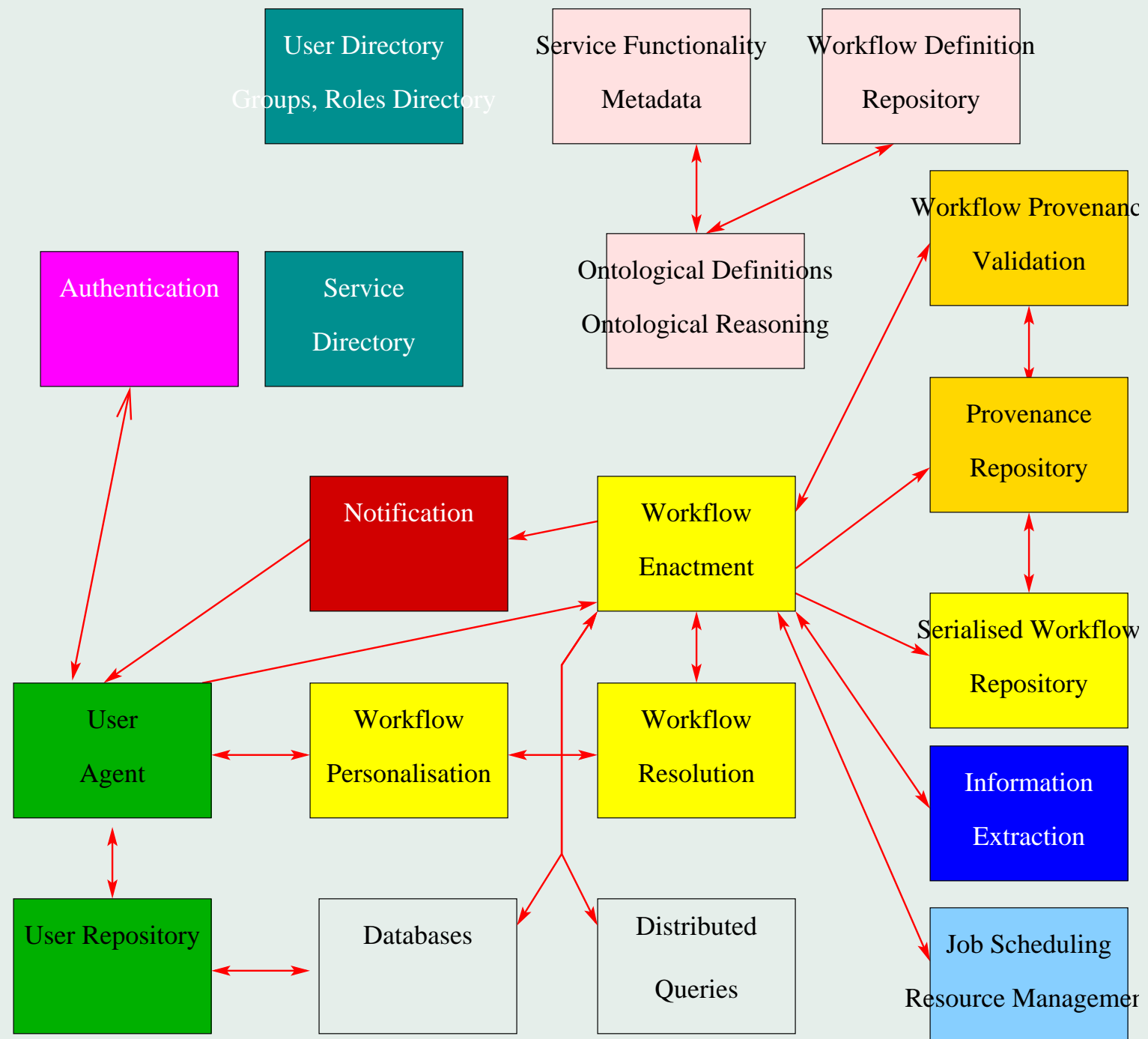
Architecture



Architecture



Architecture



Agents in Bioinformatics Grids

The bioinformatics domain is characterised by rapid and substantial change over time.

- **Change** in the resources available to the bioscientist poses problems: new resources can appear, old ones can disappear, and some can simply change.
- **Limiting** a system to a **fixed set** of resources (e.g. well-known and highly regarded databases) could impose undesirable constraints.
- Thus, any system intended for application to the bioinformatics domain should be able to cope with this **dynamicism and openness**.

Agents in Bioinformatics Grids

Agents are **the** technology to cope with dynamism and openness.

- Agents are **flexible**, **autonomous** components designed to undertake overarching **strategic goals**, while at the same time being able to respond to the **uncertainty inherent** in the environment.
- Agents provide an appropriate paradigm or abstraction for the design of **scalable** systems aimed at this kind of problem.

Agents in Bioinformatics Grids

The field of agent-based computing offers a set of technologies that may be used for particular purposes in certain aspects of the system, including:

- personalisation,
- communication,
- negotiation.

User Agent

The **user agent** is an agent in the sense that:

- it **represents a user** within the myGrid system;
- it can be seen as a **personal agent** [Maes CACM94];
- it can autonomously provide the personal preferences and conditions of a user to other parts of the system.
- Three roles:
 - personalisation
 - contact point
 - “bag man”

User Agent: personalisation

When a workflow is being enacted and a choice of services becomes available:

- the choice should not be made arbitrarily,
- the choice should be based on the priorities and circumstances of the particular user,
- e.g., a user may have greater trust in the ability of one service to produce accurate results than another.

User Agent: personalisation

- The user should not have to be queried each time a service must be chosen;
- these preferences and previous choices can be recorded and acted upon by the user agent to select from each set of options presented to it;
- We call this function **personalisation**.

User Agent: contact point

The user agent is also a contact point between services within myGrid and the user.

- The user agent is an **intermediary** able to receive, e.g.:
 - requests from services for the user to enter data or
 - notifications about changes to remote databases,
- These messages can then be **forwarded to the user** only when the user is able and willing to receive them.

User Agent: the “bag man”

The user can **delegate tasks** to the user agent,

- such as authenticating itself with a service before use,
- for personalisation of workflows.

Agent Communication Language (ACL)

A key requirement of myGrid is the design of a **future proof** environment in which collaborative distributed bioinformatics applications may be developed.

Bioinformatics is not a green field, and multiple protocols and standards are already supported by the community.

Our methodology is to design a **generic architecture** able to support multiple existing protocols, languages and standards, and which hopefully will be able to accommodate future developments.

In particular, we want to design an **abstract communication architecture** that we can map onto concrete communication technologies.

ACL: Web Services

In the eBusiness community, **Web Services** have emerged as a set of open standards, defined by the World Wide Web consortium, and ubiquitously supported by IT suppliers and users.

Web Services rely on XML, SOAP, WSDL, and UDDI.

Web Services look very appealing for Grid Computing:

Open Grid Service Architecture (OGSA) which extends Web Services with support for the dynamic lifecycle management of Grid Services. [Foster Kesselman 02]

ACL: Speech Acts

In agent systems, it is common practice to:

- **separate intention from content** in communicative acts,
- abstract and classify communicative acts according to Searle's speech act theory.

An agent's communications are structured and classified according to a predefined set of "message categorisations", usually referred to as **performatives**.

That is what we call an "agent communication language" (cf. KQML and FIPA ACL).

ACL: Communication Model

In SoFAR, the **Southampton Framework for Agent Research**, we have adapted a key concept of the Nexus communication layer [Foster, Kesselman, Tuecke JPDC96] to the world of agents.

Communications between agents take place over a **virtual communication link**, identified by a startpoint and an endpoint.

An **endpoint** identifies an agent's ability to receive messages using a specific communication protocol. An endpoint extracts messages from the communication link and passes them onto the agent.

A **startpoint** is the other end of the communication link, from which messages get sent to an endpoint. Given a startpoint, one can communicate with a remote agent, by activating a performative on the startpoint, passing the message content.

ACL: Agents as Web Services

In [Moreau CCGRID2002, Avila Moreau AgentCities2002],

- agent communication language
- startpoint/endpoint communication model

can be mapped onto the communication stack of Web Services.

ACL: Agents as Web Services

Two phases:

1. ACL performatives and message contents can be encoded in SOAP [Moreau:CCGRID2002]
2. Agents can be described using WSDL, registered and discovered in UDDI. [Avila Moreau AgentCities2002]

Hence, agents can be seen and reused any as Web Services.

ACL: Agents as Web Services

- Promising approach, as declarative communication semantics promotes
 - inter-operability,
 - openness,
 - dynamic discovery and reuse of agents.
- Opens the agent world to the Web Services community,
 - to enable more complex interactions.

Negotiation Broker

Another application of research from the agent field is in the area of **negotiation**.

Service users and service providers have differing criteria over the preferable quality and content of the service.

Negotiation Broker: Notification Service

In myGrid, negotiation is particularly useful for **notification support**.

- The providers of various services may want to send out into the wider system notifications concerning improvements to tools, changes to databases or updates concerning the state of enacted workflows, etc.
- Other services or agents will want to register to receive some subset of these notifications.
- We support asynchronous messages, and manage their distribution using a notification service.

Negotiation Broker: Quality of Service

The subjects over which negotiation takes place include the following forms of **quality of service**.

- The **cost** of receiving the notification,
- the **topic** (event category) of the notifications,
- the **frequency** with which notifications are received, e.g. every time a change occurs, daily, hourly,
- the **generality** of the change described by the notifications

- the **form** in which the information in the notification message is supplied,
- the **accuracy** of information contained within a notification

Here, quality of service refers:

- **what** a publisher produces, and
- **how** a publisher produces it.

- A publisher of notifications will be able to produce notifications matching (or exceeding, where appropriate) one or more measures of quality of service.
e.g. a publisher may be able to publish notifications on a particular topic every minute or every hour.
- A consumer of notifications may prefer, or demand, one measure of quality of service over another.

If demands cannot be met exactly:

- the consumer may choose to negotiate with the publisher to find the next best quality of service that the publisher can provide.

For example, if the consumer desires notifications weekly and the publisher can provide daily or fortnightly notifications, the subscriber must find this out from the publisher and then decide between them, or decide not to subscribe at all, based on the subscribers particular priorities.

Alternatively, the publisher may be able to exceed the quality of service in several ways which the subscriber may be unaware of, which could also lead to negotiation.

The notification service must provide notification support for a potentially large and varying number of consumers.

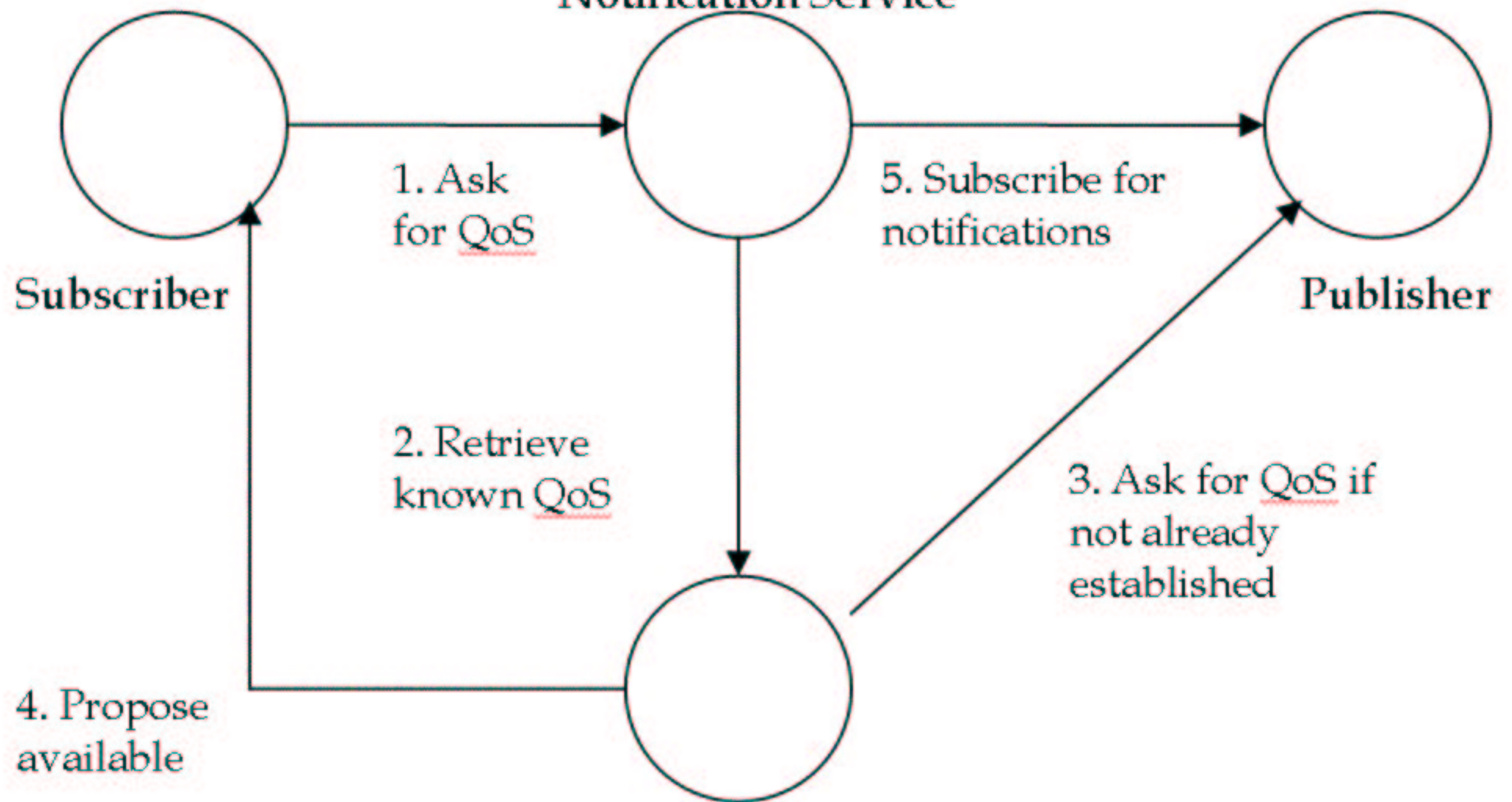
The notification service should have some **control** over the quality of service agreed upon.

The notification service should **limit the interaction** between the publisher and consumer so that the knowledge of one by the other is limiting for reasons of privacy.

The **quality of service broker**:

- is an agent conceptually **contained** within the notification service.
- **negotiates on behalf of each consumer** wishing to receive notifications of a specified quality, then provides a final proposal to the consumer.
- can **negotiate with any of the publishers** known to the notification service, and also limit the agreed quality of service to that acceptable to the notification service.

Notification Service



Quality of Service Broker

- the quality of service broker must be able to negotiate with publishers produced by various providers,
- we use the concept of **pluggable negotiation algorithms**, allowing the quality of service broker to select the appropriate protocol for negotiating with a publisher.

Conclusion

- We have presented the myGrid architecture and overview possible use of agents.
- MyGrid aims to provide a **personalised** environment for the bioscientists, which helps them to automate, repeat and therefore better achieve their experiments.
- Agents are particularly useful in **tailoring** the myGrid system to the priorities of individual scientists, personalising each step of a workflow and negotiating on their behalf.

Conclusion

It can be seen that:

- with dynamic **workflow enactment**,
- standardisation of data semantics via **ontologies**, and
- the many other facilities of myGrid,

agents can make conducting in-silico experiments **flexible** and more easily controlled by the individual or collaborating scientists.

Conclusion

The examples of use of agency we have presented:

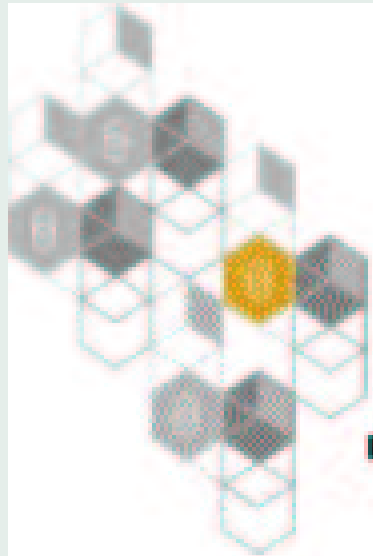
- already offer a capability inexistent in current bioinformatics environment,
- still remain **rather localised** to some specific services (user agent or negotiation over quality of service of notification service), or components such as a communication layer.

Conclusion

Longer term agent-based computing techniques enable individual components to collaborate or to compete with others in the provision of services. For example,

- **virtual organisations**, where different services come together in some coherent whole subsystem for a particular purpose
- regulation of **open societies** of services through the use of norms and electronic institutions.

Use of sophisticated auction mechanisms, or electronic marketplaces, for obtaining the best resources at the least cost to the user.



www.mygrid.org.uk

www.aboutmygrid.org



EMBL
European Bioinformatics Institute

