

# An Agent-based Resource Allocation System for User Support of Remote Instrumentation

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**Materials Microcharacterization Collaboratory**

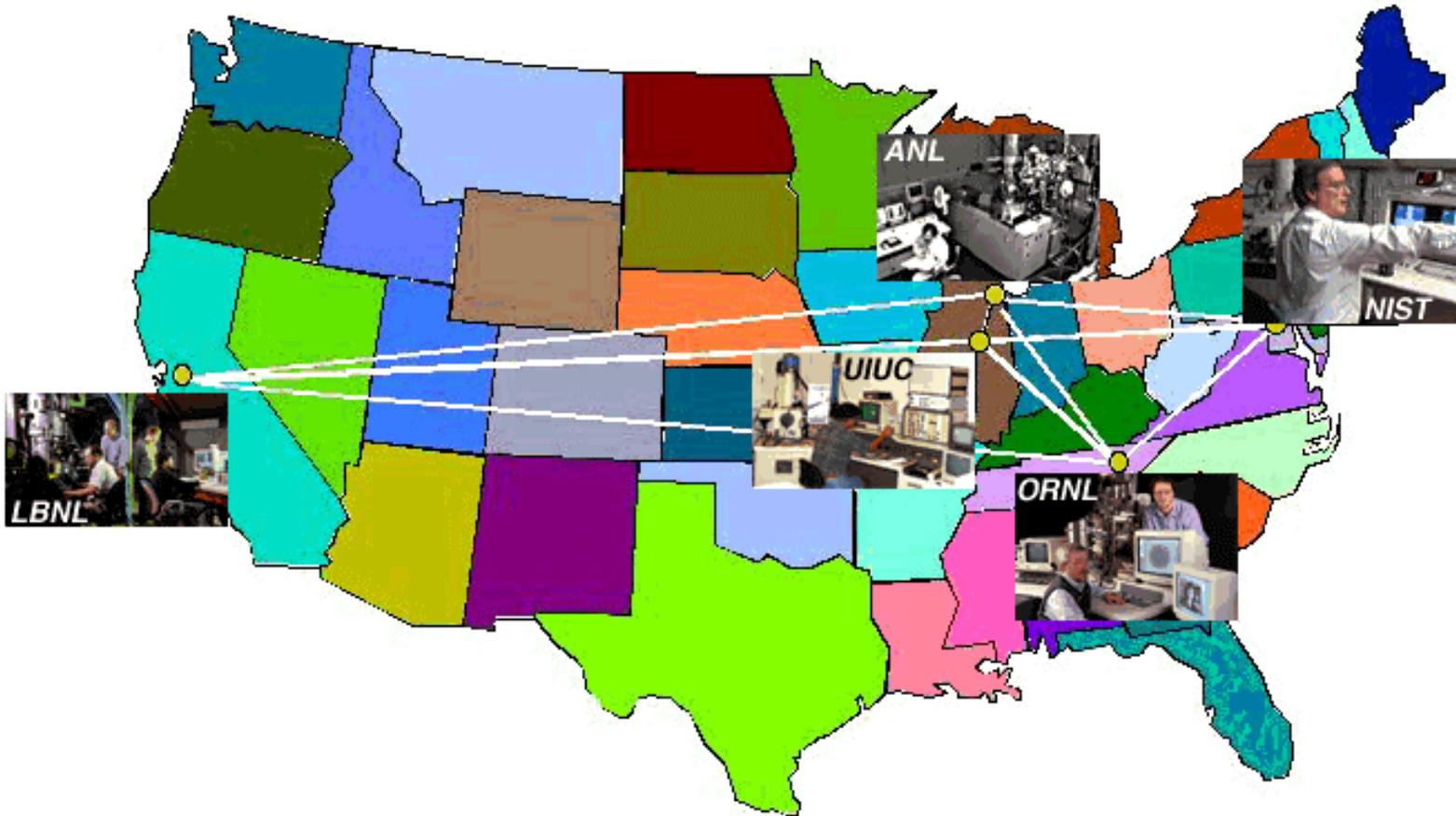
**MMC: a DOE2000 pilot project**

<http://tpm.amc.anl.gov/MMC/HomePage.html>

# What is the MMC?

- ⌘ Materials Microcharacterization Collaboratory
- ⌘ Geographically dispersed expertise and resources:
  - ◆ electron microscopes, diffractometry instruments (neutron beam line, x-rays)
  - ◆ world-renown scientists
- ⌘ Coordination and control of remote instruments
- ⌘ Visualization platforms
- ⌘ Data repositories
- ⌘ Remote data analysis
- ⌘ ORNL has user facilities participating in the MMC:
  - ◆ Diffraction, Thermo-Physical properties, Microscopy

# MMC



Materials Microcharacterization Collaboratory Participants

**ARGONNE**  
National Laboratory



**NIST**

**ornl**

University of **Illinois**  
Urbana-Champaign

Existing MMC  
collaboration  
techniques:  
WebCast of  
microscope  
images

Location: <http://www.ornl.gov/doi2k/html/>

# THE virtual html

HIGH TEMPERATURE MATERIALS LABORATORY

[HTML Hitachi S4700 SEM](#)  
[Live S4700 Microscope Image](#)  
[Stop Video Stream](#)

[HTML Hitachi HF-2000 TEM](#)  
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<http://www.ornl.gov/doi2k/mmc>

# Scientific Lifecycle for MMC users

## ⌘ Proposal cycle

- ◆ proposal forms filled and submitted by external users in cooperation with staff scientists
  - 3 months, email and phone calls
- ◆ proposal reviewed by staff scientists
  - establishing a test matrix for review
  - one month

## ⌘ Formal approval and authorization

- ◆ scheduling scientists and users' time on an instrument
- ◆ security authorizations for site visit
- ◆ safety training, possibly radiation training
- ◆ set-up computer accounts

# Scientific Lifecycle for MMC users...

## ⌘ On-site visit:

- ◆ one-two weeks visit
- ◆ one or two users per institution
- ◆ some collaborators remain at home
- ◆ process and data recording and analysis
- ◆ use of electronic notebooks

## ⌘ Post-experiment

- ◆ extensive communication with scientists
- ◆ use of electronic notebooks
- ◆ joint publications

# Needs for enhanced collaboration tools



⌘ Automating some tasks preliminary to the actual use of instrument and site visit

- ◆ information requests, user proposals, and proposal reviews
- ◆ scheduling on an instrument
- ◆ administer safety and security training prior to visit

⌘ Ensuring access control, authorization, and authentication

⌘ Timely and synchronous visualization of partial results during an experiment on site and at home institution

⌘ Enhanced communication tools for face-to-face and voice interaction during an experiment

⌘ Offering support tools that promote efficient and effective use of resources

# Desired Functionality

- ⌘ On-demand and online access to structured information
  - regarding the existence, capabilities, availability and use of MMC resources
- ⌘ Support for the production of user proposals
- ⌘ A scheduling system for MMC instruments
- ⌘ A safety and security training module
- ⌘ Integration of security features
- ⌘ Intelligent processing of images and analytical data including image recognition, feature extraction, and image interpretation based on simulation

# Proposed Agent Services

## ⌘ Benefits of using agents

- Integration of existing heterogeneous, distributed, high level components in a single architecture
- Execution on client machines for some agents (except control and instruments)
- Scalable (may add users and instruments)
- Extensible (may add agents)

## ⌘ An agent-based resource allocation system

- Dynamic scheduling
- Query handling
- Training
- Authentication and access control

# ISE: a multi-agent system using intelligent software agents

⌘ Integration of existing heterogeneous, distributed, high level components in a single architecture

⌘ Execution on client machines for some agents (except control and instruments)



A Controller Agent (CA)  
authorizes users to access other agents



A Proposal Agent (PA)  
distributes proposals to experts



A Query Agent (QA)  
answers user questions

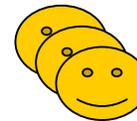


A Training Agent (TA)  
administers remote tutorials

⌘ Scalable (add users and instruments)



User Agents (UA)  
represent individual users



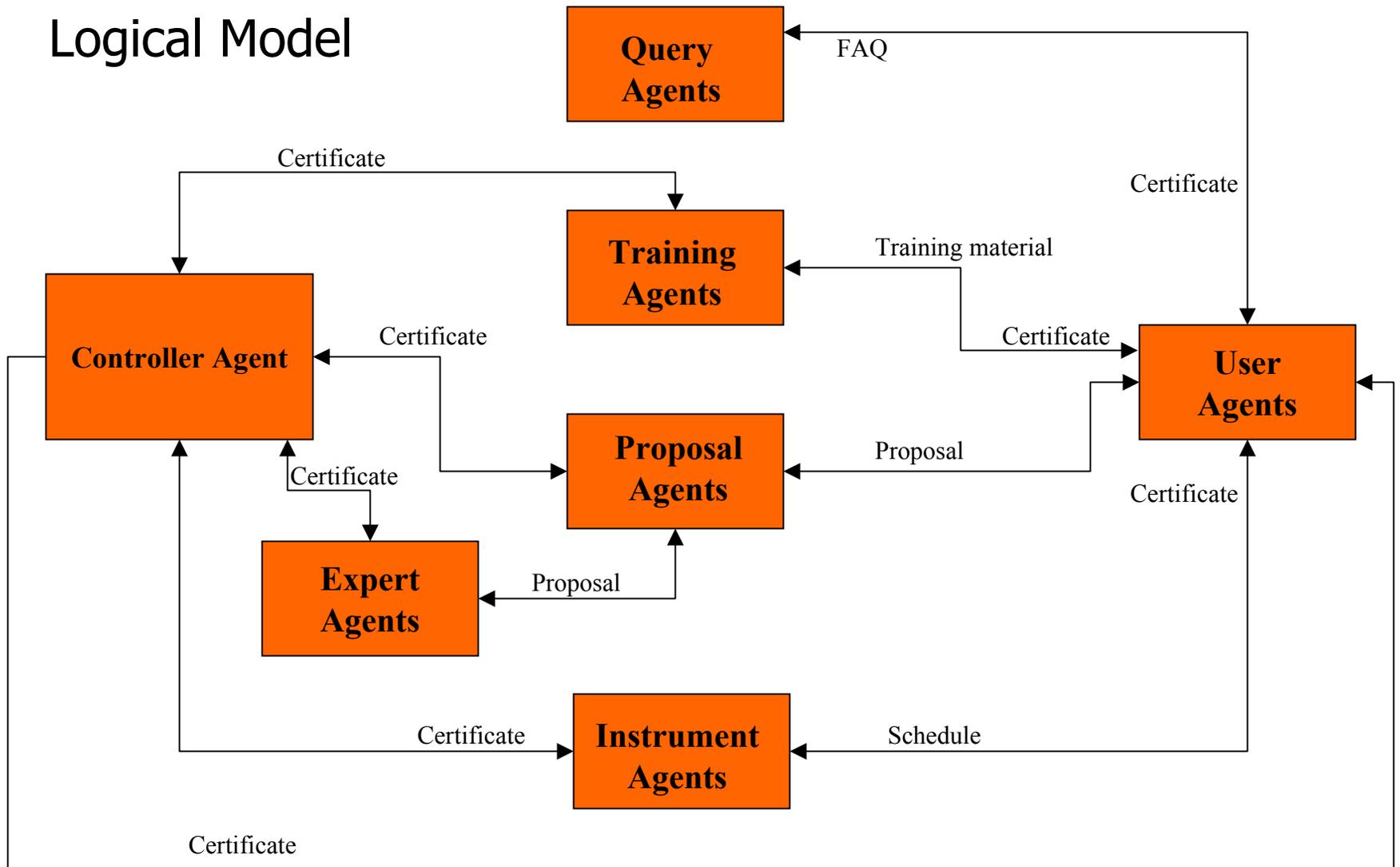
Instrument Agents (IA)  
schedule users on individual instruments

⌘ Extensible (add agents)

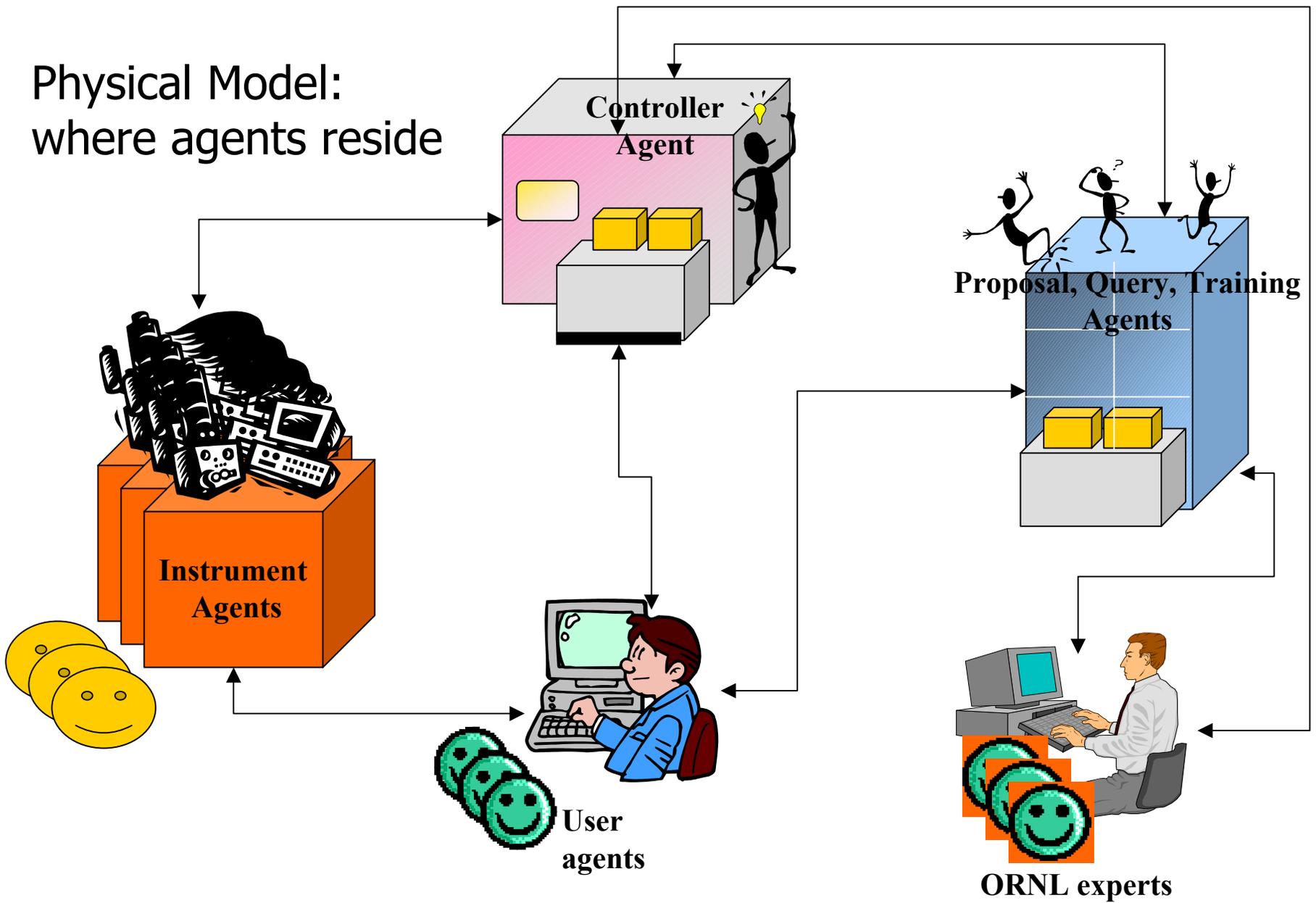


Expert Agents (EA)  
represent experts

# Logical Model



Physical Model:  
where agents reside



# Design

- ⌘ Five agents for user support
  - ◆ Controller, Query, Training, Proposal Agents
- ⌘ Resource agents
  - ◆ Instrument, Expert Agents
- ⌘ Agent roles and responsibilities
  - ◆ Key role for the Controller Agent
  - ◆ Use of certificates under evaluation
- ⌘ Technologies
  - ◆ FIPA Agent Communication Language
  - ◆ XML-tagged data for databases queries

# Prototype and ontology

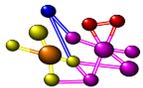
- Some facts in the ontology →
- Agents roles in the prototype



An Expert Agent (EA)  
authorizes users to access other agents



A User Agent (UA)  
represent individual users



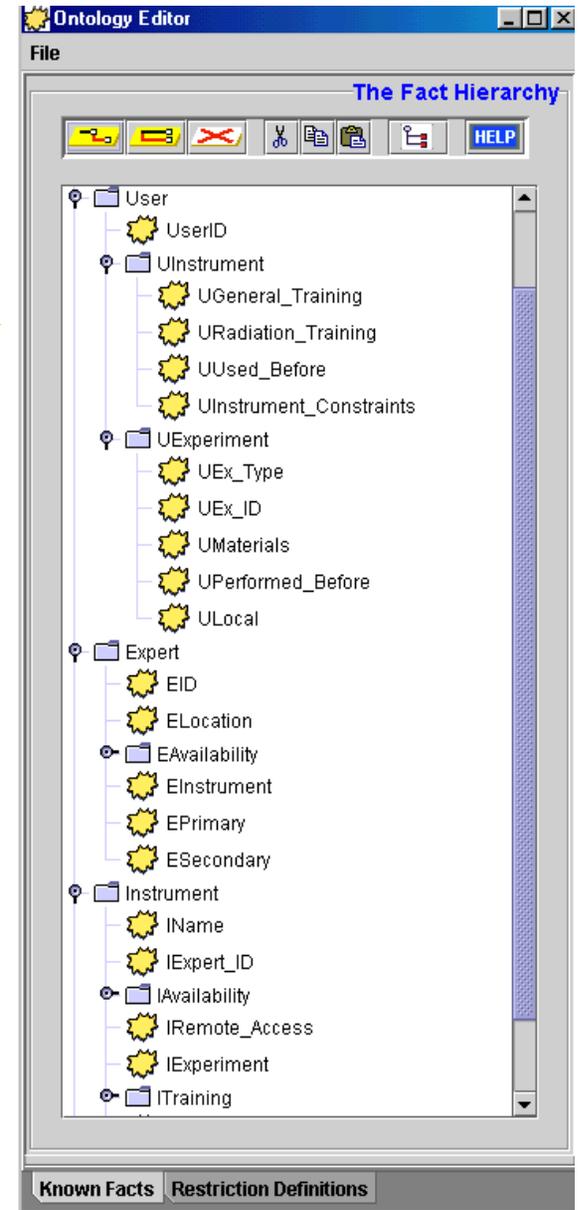
An Experiment Agent (ExA)  
distributes proposals to experts



A Scheduling Agent (SA)  
administers remote tutorials



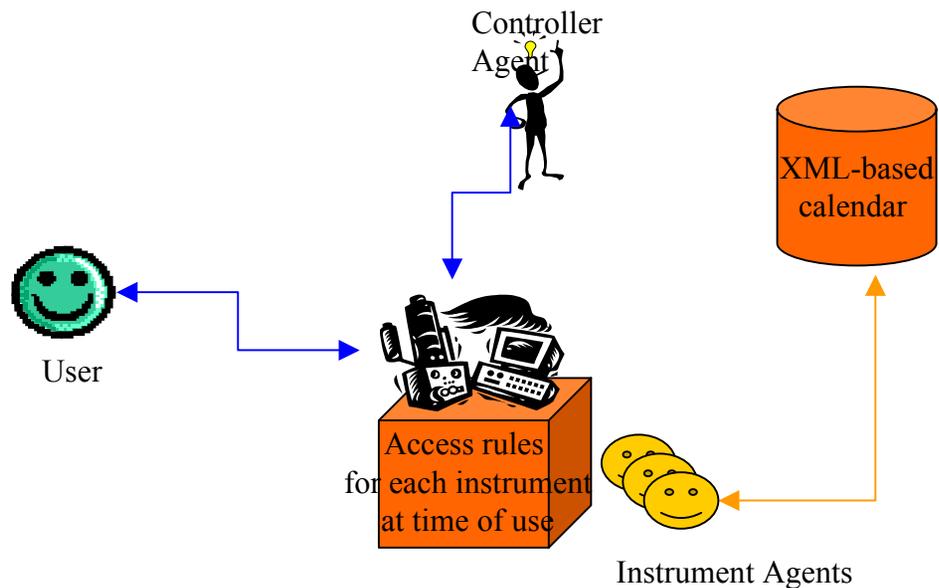
An Instrument Agent (IA)  
schedule users on individual instruments



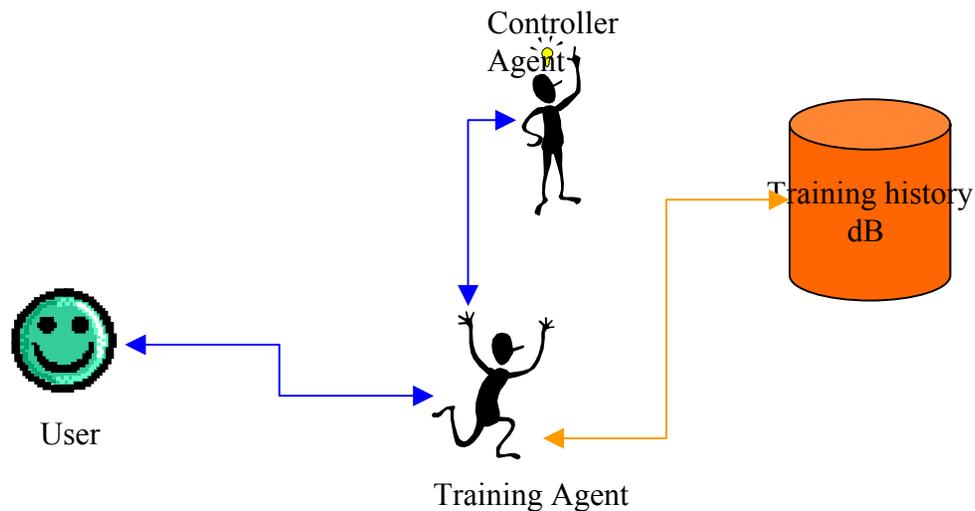
# Interaction Models

- ⌘ The Controller Agent allows other agents to perform tasks on users' behalf according to:
  - ◆ user profile -- affiliation, experience
  - ◆ training
  - ◆ paid fees
- ⌘ The Training and Query Agents interact with XML-tagged web pages and databases
- ⌘ Future addition: a DeepView agent

# Interaction Model for Scheduling (right)



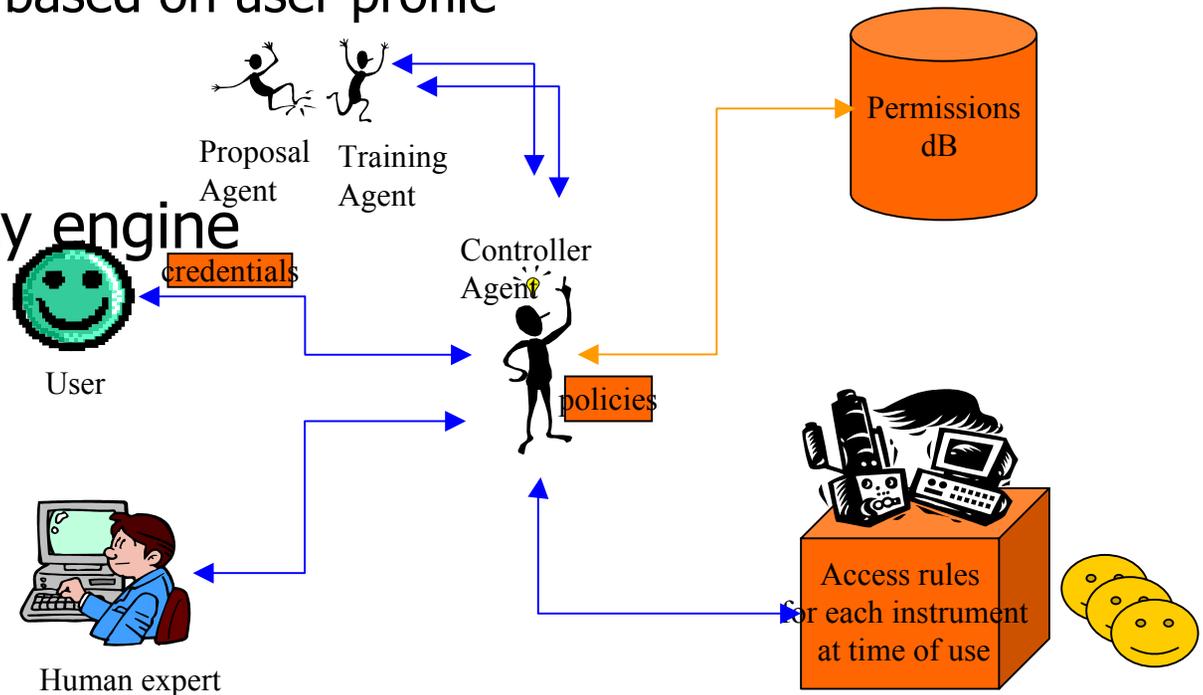
# Interaction Model for Training Agent (left)



# The Controller Agent

- ⌘ X 509.3 user identity certificates
  - ⌘ user attributes — based on user profile
  - ⌘ use conditions for instruments
- ⌘ Requires a policy engine

Interaction Model for the Controller Agent



# Certificate requirements

⌘ Fast access to certificate servers

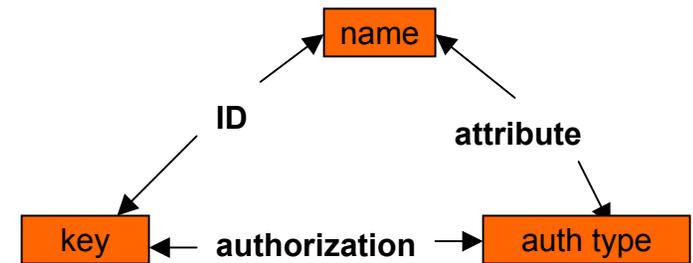
◆ Certificates must be checked

⌘ Policy engines must check authorization

⌘ Reliability. If the servers are not up, the user is denied access

There can be a significant amount of overhead to set up a circuit for a short transaction

<http://mmc.ciit.y12.doe.gov/jar/MMCCerts.html>



# Scalability issues

- ⌘ 7 main agents (CA, QA,TA, PA,IA, UA, EA)
  - ◆ QAs, PAs, TAs, UAs, and EAs run on user client
  - ◆ CA can create a bottleneck
- ⌘ Total number of agents vary according to:
  - ◆ users (in practice several simultaneous users)
  - ◆ instruments (in practice a dozen)
- ⌘ Adding new users is simple
- ⌘ Adding a new role is possible

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# Summary and future work



- ⌘ A multi-agent system for supporting users in a scientific environment (real-world problem)
- ⌘ Integration with the DeepView collaborative framework
- ⌘ Can be applied to other collaboratories and collaborative problem-solving
- ⌘ Integrate intelligence in agents for helping scientists with domain problems (image recognition and feature extraction)
  - ◆ present alternative solutions
  - ◆ execute alternative solutions