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eSTAR: Astronomers, Agents and when Robotic Telescopes aren't...

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Abstract. The eSTAR Project[1] uses intelligent agent technologies to carry out resource discovery, submit observation requests and analyse the reduced data returned from a network of robotic telescopes. The agents are capable of data mining and cross-correlation tasks using on-line catalogues and databases and, if necessary, requesting additional data and follow-up observations from the telescopes on the network. We discuss how the agent technologies used in the eSTAR prototype have matured and have now been deployed in the field on research class telescopes that on first inspection don't fit into the autonomous robotic telescope paradigm.

1. Unique Ideas...

The two fundamental ideas behind the project which makes it unique are that we treat telescopes and databases in a similar manner, both being made available on the Observational Grid, and that the main user of the Grid should not be humans, but autonomous intelligent software agents.

2. What is an Intelligent Agent?

Loosely, an agent is a computational entity which according to Green et al. (1997),

- Acts on behalf of another entity in an autonomous fashion.
- Performs its actions with some level of proactivity and/or responsiveness.

[1] http://www.estar.org.uk/

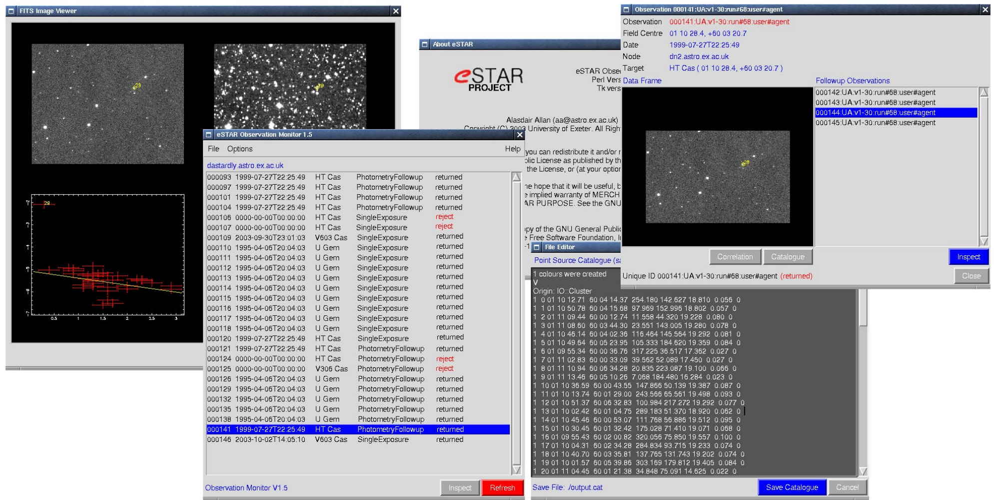

Figure 1. A screenshot of the main interface into the eSTAR user agent. This allows the astronomer to inspect previous, ongoing and planned observation programmes. The main observation window is shown centre field, with the results windows on the right. The results of a real time cross-correlation of a returned field are shown on the left.

- Exhibits some level of the key attributes of learning, co-operation and mobility.

We can view the system as a unified information grid, within which intelligent agents live. We anticipate that agents will eventually be developed by astronomers to address their own science drivers, these agents being able to request and interpret data.

3. Deploying the system

Moving away from the contract model of our prototype system (Allan et al. 2003) the current generation of software (see Figure 1) is built around the collaborative agents paradigm, and makes use of contextual web services (Parastatidis et al. 2003), with a number of different agents pooling their expertise to solve a problem.

We have now (as of Aug. 2003) deployed our agents in the field onto a non-robotic research class telescope, UKIRT, which proved to be a far simpler task than we initially estimated. Observation requests are made by the user's intelligent agent to an agent embedded at the Joint Astronomy Centre (JAC), where the request in Robotic Telescope Markup Language[2] (RTML) (Pennypacker et al. 2002) was automatically translated to the JAC's internal Telescope

[2] `http://alpha.uni-sw.gwdg.de/~hessman/RTML/`

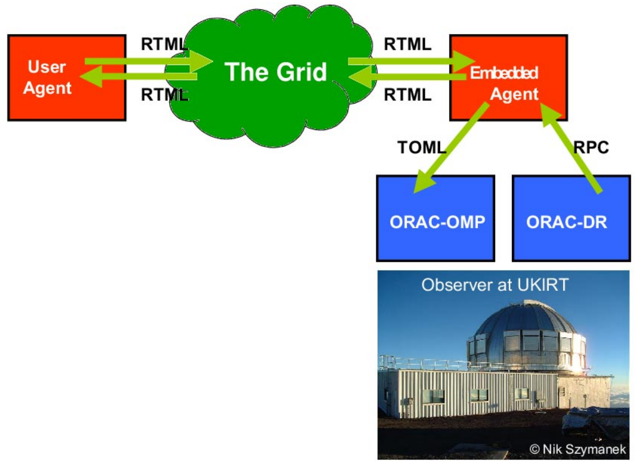

Figure 2. Observing at UKIRT using the eSTAR system. Th presence of a human in the observing loop is irrelevant as the embedded agent acts as a translation layer to hide their presence.

Observation Markup Language[3] (TOML) format (de Witt et al. 2004, in prep.), see Figure 2.

All aspects of an observation programme at the JAC are either software readable or software controllable via the Observation Management Project[4] (OMP) (see Economou et al. 2002 and Delorey et al. 2004). This allows the embedded agent to fully specify an observation, which is placed in the queue as a high priority target of opportunity (TOO) which is seen when the observer next requests an observation. When the data is taken by the observer it is automatically reduced in real time by the ORAC-DR (Economou et al. 1999) system which returns the fully reduced data to the embedded agent, which forwards the result back to the user's intelligent agent. To the user's agent it's irrelevant that there is a human in the loop.

4. γ-Ray Burst Programme

In semester 04A the agents we have deployed onto UKIRT and the JCMT will be used to provide rapid followup to γ-Ray bursts. Alerts from the GCN[5] will be filtered by an agent and any meeting the pre-derfined criteria (e.g. positional accuracy) will trigger target of opportunity observations.

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[3] `http://omp.jach.hawaii.edu/schema/TOML`

[4] `http://omp.jach.hawaii.edu/`

[5] `http://gcn.gsfc.nasa.gov/`

5. Brokering and Software as Services

Agents are both providers and consumers of services. However since we operate in real time the reliability of these services must be high, for instance reliable access to catalogues is vital to the project. We therefore have deployed a testbed catalogue brokering service[6]. This service which will attempt to retrieve the desired catalogue from Vizier, SkyCat and other sources, falling back to a secondary source if the primary source is unavailable. The broker service will also parse and return the catalogue in a user specified format, irrespective of the format in which it was originally retrieved.

6. Where now?

We intend to broaden the abilities of the eSTAR network by deploying our agents onto more telescopes, including the Liverpool and Faulkes Telescopes, and to distribute an agent tool kit to allow the easy construction of intelligent agent by astronomers. This is essential for further progress and widespread adoption of the technologies we've developed. In summary,

- It is important that, as much as possible, federated databases and telescopes share a common interface.
- We believe that the power users of the Grid will use intelligent agent technology, not "dumb" applications.

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[6] `http://www.estar.org.uk/services/services.html`