Time to Revisit the Heterogeneous Telescope Network

Frederic V. Hessman
Institut für Astrophysik, Georg-August-Universität, Germany

1 Introduction

Time-domain astronomy demands a level of flexibility that is still not common in the organization and operation of normal astronomical observatories. With service observations, targets-of-opportunity (ToO), director's discretionary time, and other new-fangled features, many observatories have come a long way, and the increased flexibility has made it possible to perform some time-critical observations in a manner unthinkable within the classic observing-run paradigm. Nevertheless, these improvements have been made at the level of observatory operations and are largely carried out by humans and hence are not scalable to the scientific needs of the 21st century.

While the manner in which large cutting-edge telescopes are operated is inherently inflexible, the same should not be true of smaller telescopes (where "small" nowadays means, say, less than 2-3m). Since the number of potentially available "small" telescopes is large and the pressure factors are generally less than those of larger ones, there is a latent potential which could be used particularly well for classic follow-up purposes – e.g. ToO, surveys,... – if a means could be found to tap into that potential. There are, however, often local political / economical / sociological reasons for not wanting to yield up one's own telescope for a collaborative project. Ideally, then, observatories should be able to "donate" some fraction of the total amount of time available for the benefit of one or more external collaborations in which the observatory participates, knowing that the use of the data provided constitutes both a measurable scientific investment and reflects in some way positively on the donating institution. Given a means of accessing multiple resources within such a collaboration, an intelligent agent – principally a human but probably a piece of software – could allocate the observing time on a global scale and so optimize both the use of individual resources as well as the total scientific output of the collaboration.

This was the original idea behind the "Heterogeneous Telescope Network" (HTN) consortium: a loose interest-group of institutions, individual researchers, and even commercial companies interested in telescope networking. While several international HTN meetings were organized (e.g. Exeter 2005, Göttingen 2006) and various projects

have implemented sub-networks which have probed some of the possibilities, the HTN idea never got much further than to suggest a protocol for the exchange of observatory requests [1][10].

2 The Idea of a Telescope eMarket

The constraints on the operation of a truly flexible heterogeneous telescope network clearly define the sequence of communications between a server (the thing operating a telescope, whether a human or a piece of software) and a client (some intelligent agent trying to get some scientific project done). The analogy with an electronic market is very good, since some bargaining about the conditions of the "contract" is necessary and all of this ideally takes place semi-automatically.

- The client must have an idea of what resources are principally available (e.g. a telescope with a given aperture, camera or spectrograph, a particular filter inserted or removed, perhaps even a particular type of observational sequencing pattern). This information must be either broadcast or queried.
- The client then sends a request for a particular observation based upon the individual characteristics of each resource. Because the client is presumedly querying several resources (not everyone has good weather!), the request is just a "would you in principle be willing and able to do this?" question.
- The server then responds and expresses a principle willingness to perform the observation or rejects the query.
- The client chooses the best resource based on the currently availability and resubmits the request as a formal request for a "contract" to perform the services.
- The server processes the request and either sends an acknowledgement or a refusal, along with a unique ID for the "contract" made between the server and client.
- Requests which take place over extended periods of time may require some sort of status info – if the observations are delayed enough, it could be that they are no longer needed and should be aborted.
- Finally, the successful observation is reported and the metadata and experimental data are transported.

The HTN consortium simply revised a previously extant protocol – "Remote Telescope Markup Language" [7][4] – and added on the additional transactional modes

needed to create a protocol perfectly sufficient to cover all of the steps above. Thus, the API is well-defined and built upon known technologies and tools.

None of this is rocket-science, but it is sufficiently complicated that the whole transaction must be recorded and processed at both ends. While a stripped-down system of

- I know what's out there.
- I know you are willing to be asked.
- When I ask, please do your best and send me an email if it works.

might work for very simple projects and very simple resources, anything more complicated that this requires a substantial subset of what an ideal eMarket for telescope time would require. Thus, it isn't surprising that an HTN didn't simply jump into existence. The reality was, that it simply takes a lot longer to get the hardware and software running and the resources working to a point where they are networkable. Also, the career paths of major players can easily disrupt the process by removing someone who has an important role in the development of a large informal consortium project. Frankly, even simple networks (e.g. our MONET "network" of just 2 telescopes) can be very hard to get and keep running sometimes. Finally, there is no point in doing all of this unless the science drivers are so strong that it becomes necessary to do the effort, thereby overcoming the various sources of sociological and institutional inertia and friction.

The HTN idea has thus been in a dormant state for almost a decade. Dormant doesn't mean comatose – the interest is there, and there are many relevant activities abuzz in the background. An initial HTN experiment was carried out by the RoboNet / eStar consortium but it depended upon a fairly homogenous software and control model. Thus, no coherent attempt at attaining a truly heterogeneous network has been made. There is a wonderful German word for such a state: "Dornröschenschlaf"[1]. If there was some Prince(ss) Charming willing to work through all of the thorny problems[2], then a final kiss would open up a magical kingdom of totally new scientific possibilities.

The situation has changed. There are many massive surveys which are ongoing like *OGLE* [8], the *Catalina Sky Survey* [4], *Pan-STARRS* [6], and others that are in need of followups. The Las Cumbres Observatory's global network of telescopes (LCOGTN; [3]) is pushing the boundaries of fully homogenous telescope networks – a slightly different but also very similar challenge. The number of potential "minor" and "major" players has increased, not decreased. More ominous is the perspective that massive surveys like that of the *Large Synoptic Survey Telescope* will produce

[1]The name "Dornröschen" or "little thorny rose" was translated into "Sleeping Beauty"

[2]In the original fairy tale, there are grisly descriptions of princely corpses hanging in the rose bush thorns – no sweat, no glory!

millions of events nightly from which hundreds or thousands need to be immediately looked at and for which there is, at present, no guaranteed follow-up system. Thus, there is a distinct need to create and exercise a homogenous telescope network *now* so that we will be able to handle the flood of data which will soon be spilled onto our astronomical doorstep.

3 The Problems

If one assumes that there is a widespread principle interest in providing/sharing resources without the intervention of too cumbersome institutional politics and that there exists a software package which makes it relatively easy to participate in a scientific collaboration using such resources is available, what would there be to prevent or even stop an HTN effort?

The worst show-stopper would be, of course, a lack of scientific benefit : if the scientific need for a HTN isn't large enough, then no one will want to create or maintain such a complicated system, even if it would be fun to try out. Fortunately, the science cases are clear and compelling: it should be obvious that some (but not all) kinds of interesting science would be made possible by an HTN.

Another problem is the heterogeneity of an HTN: unlike the LCOGTN, which has the goal of making the question which telescope actually makes an observation irrelevant, a truly heterogeneous telescope network will consist of resources with very different apertures, different types of instrumentation (cameras, spectrographs), filter systems, fields of view, local weather conditions, elevations, latitudes, and longitudes. The quality of the data coming from each resource will necessarily be highly variable, and the HTN client must be prepared to decide whether the data from a server at a particular time for a particular project is worth asking for.

On the other hand, too much relative homogeneity could also hinder the scientific output of an HTN: it may be great that you can access a range of telescopes capable of providing V-band images of similar fields of view and photometric quality, but if you need a spectrograph to do the next step of followups and your HTN doesn't have one, you may run out of the resources you actually need and not be able to continue profiting from access to a large number of telescopes.

The question of data and publication rights is subtle: some institutions might be simply willing to be acknowledged, but most would rightly like to have the option to be included in the entire process of data analysis, interpretation, and final publication. This is strictly a question of internal consortium politics and so isn't *directly* relevant to the operation and use of an HTN *per se*, but some political solutions may be easier to accept than others. Indeed, there are lots of examples of large astronomical consortia quite willing to pack dozens of consortium participants onto a paper, so a consortium should not have a problem with integrating a real – if sometimes perhaps

minor – contribution within the reasonable constraints of good scientific practice.

4 The Solution

Given the potential benefits and the acknowledged problems, a generic proposal – keeping the Prince(ss) Charming analogy – for kissing this magical idea into existence is clear:

- we need a suite of tools capable of making *any* telescope – manual, remote or robotic – principally HTN-compatible with a "minimum of effort" (whatever that means); and

- we need to encourage the creation of science-driven consortia interested in becoming the client of a HTN-connected network (either a general-purpose one or one created easily for the particular purposes of the consortium).

Neither of these goals is realistically attainable unless the generic goals can be expressed in quite concrete terms. I would like to suggest that it would realistically be possible to enable the creation and use of HTN networks if we somehow joined forces to

- create an open-source HTN-client software suite with

- an absolute minimum level of complexity (use and installation) so that observatories would be tempted to try it out;

- use the transport system already developed for VOEvent (e.g. see [9]);

- provide clear and simple examples of manual and automatic interfaces to the local resources "out of the box" – an important installation demo would, for example, be the capability of showing that the system as simply installed can be easily connected to a test network and that the test client is capable of doing something as simple and potentially immediately useful as putting up a pop-up window saying, "Your XXX consortium partners request you to perform the following observation - please press the "YES" button if you are willing to contribute your time and effort now";

- provide some help in interfacing with the local system (e.g. help in the simple mapping of schemata);

- help define minimum standards of client calibration/participation.

Even better would be to have an equally open-source example of an HTN-Server that potential HTN-client consortia could use as a starting point.

These are realistic goals given a minimum of participation and effort, since the pay-off is potentially very great. A very good model for such a project is John Swinbank's VOEvent broker package, "Comet" (https://github.com/jdswinbank/Comet).

5 Conclusions

The original HTN idea was slightly ahead of it's time: while the scientific benefit of being able to tap in a potentially large pool of astronomical resources was obvious, the effort required to implement a functioning system was too great relative to the on-going efforts of creating and maintaining increasingly automatic observatory systems operated outside of a heterogeneous network. Now, the potential participants have much more experience operating their hardware and software and many new players have appeared. The age of massive all-sky surveys has already started but our capacity to follow up astronomical events covering a wide range of scientific fields has not and will not keep up unless there is a paradigm shift in the way we utilize our telescopic resources. An open-source telescope eMarket package which is so observatory-friendly that there are few excuses left for *not* participating in an HTN would be the sociological game-changer needed.

References

[1] A. Allan, F. Hessman, Bischoff, K., Burgdorf, M., Cavanagh, B., Christian, D., Clay, N., Dickens, R., Economou, F., Fadavi, M., Fraser, S., Granzer, T., Grosvenor, S., Jeness, T., Koratkar, A., Lehner, M., Mottram, C., Naylor, T., Saunders, E., Solomos, N., Steele, I., Tuparev, G., Vestrand, T., White, R., Yost, S., AN 327, 744 (2006).

[2] T. M. Brown, et al., PASP 125, 1031

[3] A. J. Drake, S. G. Djorgovski, A. Mahabal, E. Beshore, S. Larson, M. J. Graham, R. Williams, E. Christensen, M. Catalan, A. Boattini, A. Gibbs, R. Hill, R. Kowalski, ApJ 696, 870 (2009).

[4] F. V. Hessman, AN 327, 751 (2006)

[5] Z. Ivezic, J. Tyson, R. Allsman, J. Andrew, R. Angel, arXiv 0805.2366 (2008)

[6] N. Kaiser, W. Burgett, K. Chambers, L. Denneau, J. Heasley, R. Jedicke, E. Magnier, J. Morgan, P. Onaka, J. Tonry, SPIE 7733, 12 (2010)

[7] C. Pennypacker, M. Boer, R. Denny, F. V. Hessman, J. Aymon, N. Duric, S. Gordon, D. Barnaby, G. Spear, V. Hoette, A&A 395, 727 (2002)

[8] A. Udalski, Acta Astron. 53, 291

[9] P. B. Warner, R. L. Seaman, R. C. Smith, AN 329, 301 (2008)

[10] R. R. White, A. Allan, AN 329, 232 (2008).