GERMAN ASTROPHYSICAL
GAVO
VIRTUAL OBSERVATORY

Fig. 1

Federal Ministry
of Education
and Research

Fig. 2

1. The Virtual Observatory

(cf. Fig. 1)

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(cf. Fig. 2)

- What it's (not) – and why
- An illustrated journey through. . .
- . . . registry,
- . . . simple services,
- . . . TAP,
- . . . and SAMP.

2. What This Is About

The Virtual Observatory's goal is to make
as **much** astronomical data as possible
discoverable
and **usable**
ideally in an **ad-hoc** fashion
ideally **moving a minimum** of data
ideally under **maximum user control**.

3. The VO is not. . .

. . . a program.

Instead, there are programs and libraries that enable access to VO facilities. The VO is essentially a set of interfaces that actual software can use.

A program useful (let alone sufficient) for all kinds of astronomical uses is impossible to write; and of course, the best program wouldn't solve the hard problems of making data discoverable and giving access to it.

4. The VO is not. . .

. . . a "platform".

At least not if you define platform as something like facebook, where you have one centralised service provider and everyone else just accessing it, typically via a web browser. Instead, everyone can run VO services. There's just one piece of central infrastructure, and it plays no essential role in users' everyday operations.

This is part necessity (no one funds a data center large enough to hold all astronomical data out there), part design (such a structure gives users a choice of tools, data, and services; like the internet, it can "grow from the fringes").

5. The VO is not. . .

. . . a cabal of wise guys.

While it would be great if there were a place to turn to when people feel "the VO should be able to do X", that's not how it works. Standards only get written and discussed if real people do that, and it works much better if these people actually solve their and their users' problems while doing that. And there's essentially no one being paid to develop standards for you anyway.

So: If the VO can't do what you need, please bite the bullet and try to foster consensus with other people doing similar things as you. Write than consensus down. Have it discussed with the other Techies in the VO.

Nobody will thank you (well, I will, probably). But it leads to a much more useful and flexible data infrastructure.

Fig. 3

6. The VO is...

(cf. Fig. 3)

...a load of boring standards. You can browse them at http://ivoa.net/documents/, but that will probably scare you more than doing any good. If you're interested in this kind of thing, the IVOA Architecture document[1], though a bit dated, is probably the preferable source.

7. The VO is...

...about 15000 services compliant with these standards.
- 10^4 cone search services and tables,
- 10^2 each of image and spectral services,
- 10^2 database (TAP) services with 10^4 tables with 10^{12} rows combined

...10^2 software programs, web services, and libraries that can locate and access these services
(cf. http://ivoa.net/astronomers/applications.html)

Fig. 4

8. The VO is...

...two "interoperability" conferences a year, open to all interested parties

...about 10^2 national or regional projects forming the IVOA that organises all this.

In the EU, there's currently Asterics, with a Tech Forum in Strasbourg March 22 and 23. Registration is free, and if you're considering VO activities, that'd be the place to go.

9. The User Perspective. Finally.

Consider the deliberately somewhat whacky use case:

"Are there any conspicuously blue objects close to OH masers that are within the detection cones of high energy neutrinos?"

The default client for the VO: TOPCAT[2].

10. Locating a Neutrino Catalog

The Registry is a set of structured metadata on services in the VO.

Concrete implementations these days come as a 13-table RDBMS schema. It's normally used via some UI (this is part of TOPCAT's VO Cone Search Dialog):
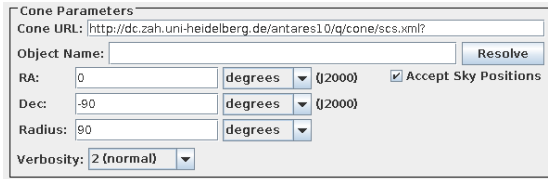
(cf. Fig. 4)

This is using Registry and TAP standards.

[1] http://ivoa.net/documents/Notes/IVOAArchitecture/index.html

[2] http://www.star.bris.ac.uk/~mbt/topcat/

Fig. 5

11. Pulling the Catalog

In this case, we retrieve the entire southern sky (you'll usually try to avoid this in the VO).

This is a 90 degree cone around -90, 0 on the "antares 10" service.

Note that we don't need any further information on the service – the details of the interaction is covered by the standard, and *any* Cone Search service in the world works exactly like this.

(cf. Fig. 5)

That's using the Cone Search (SCS) protocol.
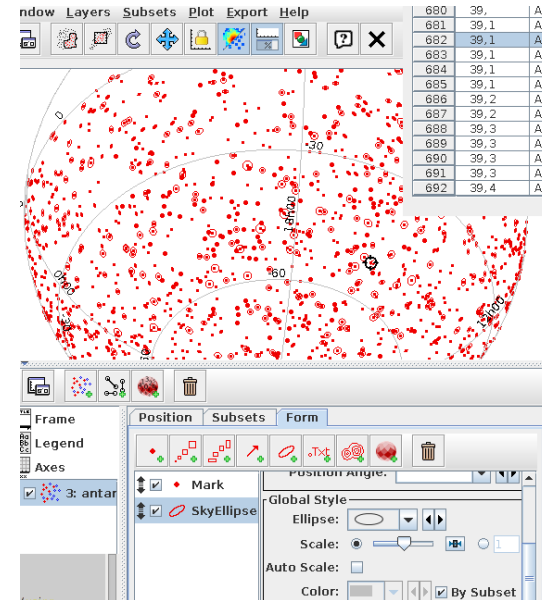
12. Let's have a look

VO data should come with rich metadata.

In this case, TOPCAT can work out by itself how to do a sky plot (using the UCD standard).

Also see Views/Column Info.

(cf. Fig. 6)

13. OH Masers In Our Cones

Can we find OH masers within our $\sim$ 2000 cones? Easy with TAP. Again, a Registry query:

(cf. Fig. 7)

Fig. 6

Fig. 7

14. Writing the Remote Query

TAP lets you run database queries against remote tables and upload your own tables there.

Note how we can again do metadata discovery on columns. TOPCAT uses this metadata, for instance, to generate example queries; these are pretty nifty even if you're an ADQL pro.

Fig. 8

Our query is a bit edited from Examples/Upload/Upload Join (this uses TAP, ADQL, and DALI):

(cf. Fig. 8)

15. Obtaining Photometry

We now have 500 OH Masers that might plausibly related to our mystic sources. Let's use the tricks we learned to pull Gaia and 2MASS photometry.

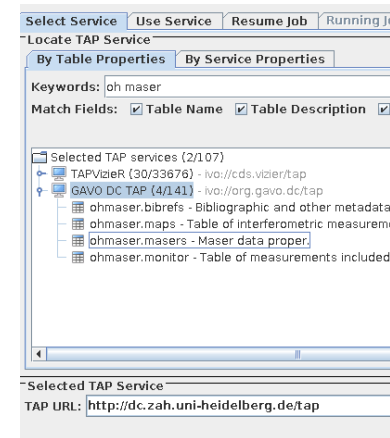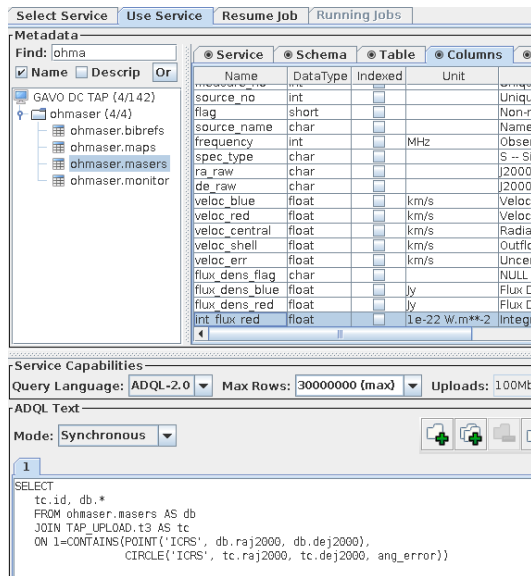We'll do it in two steps (these could come from different services). First step: 2MASS objects in a 30' circle:

```
SELECT DISTINCT
    tc.id, db.raj2000, db.dej2000, jmag, hmag, kmag
    FROM twomass.data AS db
    JOIN TAP_UPLOAD.t6 AS tc
    ON 1=CONTAINS(POINT('ICRS', db.raj2000, db.dej2000),
                  CIRCLE('ICRS', tc.ra, tc.dec, 30./3600.))
```

Match against Gaia left as an exercise for the reader.
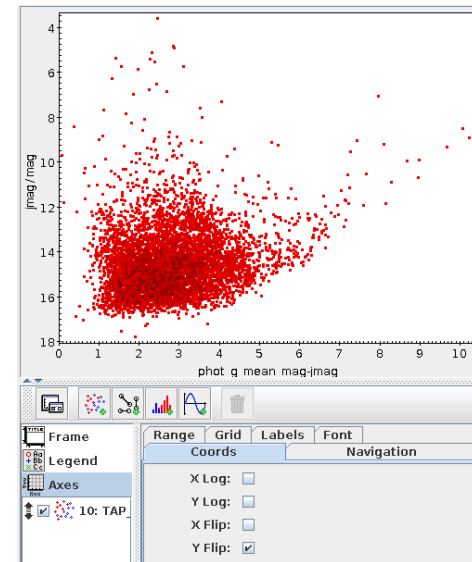
Fig. 9

16. A CMD

Now plot, say, phot_g_mean_mag-jmag against jmag.

(We'd be interested with those with far more G than J, and yes, with a bit of care we can to better in terms of the "blue" photometry, but never mind that.

(cf. Fig. 9)

17. Viewing Things

In TOPCAT, configure "Transmit coordinates" as activation action and start Aladin (a different client from a different vendor!). Choose a data source and zoom in.

Then click on "interesting" points in TOPCAT's plot (this uses the SAMP, and HiPS standards).

(cf. Fig. 10)

Fig. 10

Fig. 11

18. Further Investigations

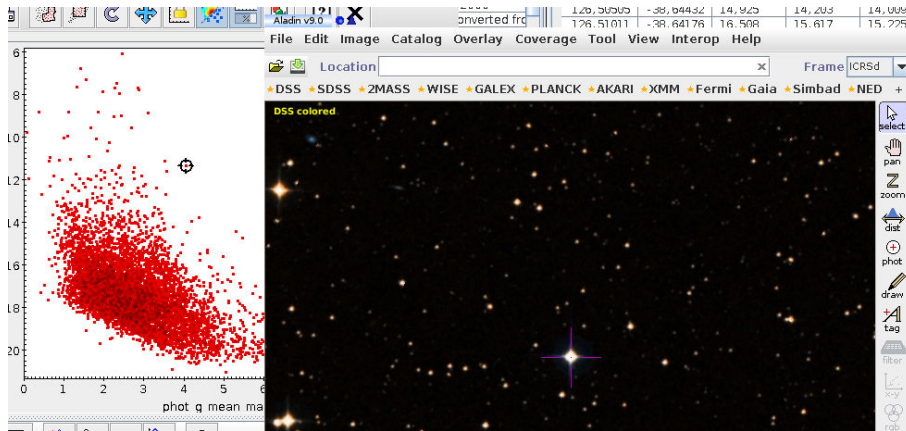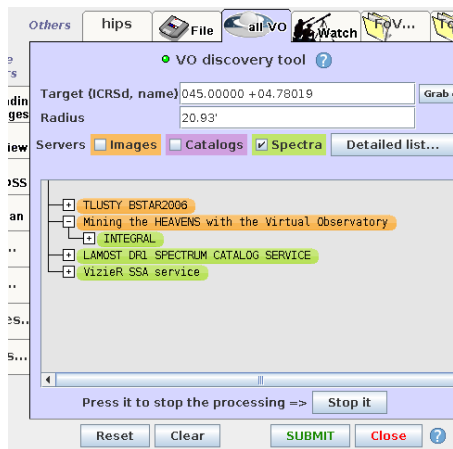From this, you can do an all-VO search for spectra of this object from within Aladin.

This uses SSAP, so (ideally) all spectra services can be uniformely queried.

If you feel so inclined, get a copy of SPLAT and send any spectrum you find over there for further analysis.

(cf. Fig. 11)

19. The Point I Tried to Make

- The VO has come up with a load of standards. . .
- . . . that produce a fairly nicely integrated environment. . .
- . . . that's distributed in space, responsibilities, maintenance, development. . .
- . . . suitable for quite a few sorts of data use and dissemination.

20. And You?

As a user: GAVO gladly does house calls. Talk to me to schedule a VO day teaching all this at your institute.

As a developer: Try to avoid sinking too much work into web pages, however much the PIs clamor for them. They'll break quickly. And it's much more useful to develop UIs that work for all standards-compliant data out there anyway.Join us for the Asterics Tech Forum.

As a scientist: Publish your data. VO-compatibly. Soon. And pressure your consortia to do so, too. All this only works because others did so before you.

21. Oh, and. . .

If you have data to publish   by all means contact us
                                                   gavo@ari.uni-heidelberg.de