Fig. 1

Fig. 2

1. VO: The How And Where

(vgl. Fig. 1)

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(vgl. Fig. 2)

- What does "Standard" mean, then?
- Finding Services
- Catalogs: SCS
- Images: SIAP
- Spectra: SSAP
- Everything: TAP

2. Action

Scenario: Have a look at objects with infrared excess close to OH masers around the galactic center.

We're going to use:

- Registry
- SCS
- TAP
- SAMP
- time permitting, SIAP
- time even more permitting, SSAP

Just watch – you'll not need to know all these horrible acronyms.

3. Finding Services

The union of the metadata of all the data centers in the VO is called the **registry**. There, users can issue queries like:

- Where are image services specialized on radio?
- What data sets are out there containing x-ray fluxes and proper motions?
- What services are out there dealing with time standards?
- What services expose the data associated to a paper?

Clients: WIRR[1], VO Desktop[2], In-Application interfaces.

You can also query the registry using the TAP/ADQL clients mentioned below using the TAP access URL http://dc.g-vo.org/tap. If I (as the author of the respective standards) may say so, this is probably the way to go if you're planning advanced stuff with the registry.

4. Finding Data Sets

The VO has defined "**typed interfaces**" that let you talk to all services in the same fashion. "Typed" means literally types of data. There is, for example, "Simple Cone Search" (SCS) for tables with sky positions in them, the "Simple Image Access Protocol" (SIAP) dealing with images of the sky, and "Simple Spectral Access Protocol" (SSAP) for accessing spectra.

The common language lets programs query many servers at one click. So, you can ask questions like:

- Find all images containing NGC3141
- Are there infrared spectra of a source at 271.8281, +23.42?
- What is known about sources within 2 arcminutes of Geminga?

Clients: TOPCAT[3] for tables, Aladin[4] for images, Splat[5] for spectra, and more.

Upcoming, there's ObsTAP that lets you post even more expressive queries against database tables.

These protocols also usually say how you can get the data once you have located it. There is work in progress on server-side manipulations, though (cutouts, cube cuts, etc) – but standards for that are hard.

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[1] http://dc.g-vo.org
[2] http://www.astrogrid.org/wiki/Install/Downloads
[3] http://www.star.bris.ac.uk/~mbt/topcat/
[4] http://aladin.u-strasbg.fr/aladin.gml
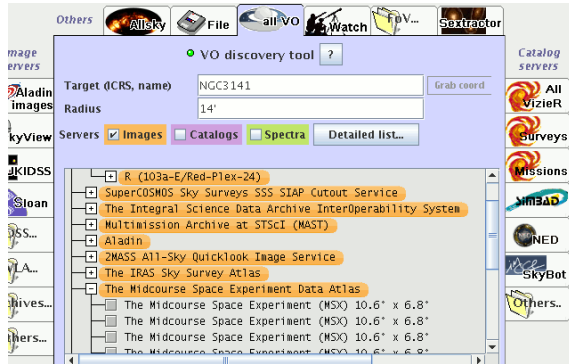[5] http://star-www.dur.ac.uk/~pdraper/splat/splat-vo/

Fig. 3

5. An All-VO Image Search

(vgl. Fig. 3)

This is Aladin's load dialog. You could also use, for example TOPCAT's SIAP dialog to do the same thing, or write your own simple client in a couple of lines of python (and a library, of course).

6. Using Data

The VO uses existing data formats where they are appropriate (e.g., FITS for images). Where they aren't it uses its own: **VOTable**, containing rich metadata. This saves you from having to write code everytime you want to use a new data source.

And it comes with descriptions, units, UCDs, and more. UCDs are a VO thing, too: spelled out, it's unified content descriptors. They are short strings that say what kind of physics a column represents: pos.eq.ra is a right ascension, phot.mag;em.opt.V is a visual magnitude, etc.

The VO also defines data models (e.g., for spectra) that say what metadata items are necessary for a useful description.

Clients: TOPCAT[6] and STILTS[7] for generic VOTables; the clients for typed interfaces also consume VOTables. See also Astropy and many other libraries

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[6] http://www.star.bris.ac.uk/~mbt/topcat/
[7] http://www.star.bristol.ac.uk/~mbt/stilts/

7. Trawling the Sea of Bytes

ADQL lets you write simple programs, **TAP** lets you run them on remote servers, upload your tables, and retrieve the results.

If you know CASJobs: about the same thing, only with a solid standard and supported by more services.

Clients: TOPCAT[8] and STILTS[9], tapsh[10], seleste[11], TAPHandle[12]

Learn it: ADQL course[13]

8. Freedom of Choice

The VO is about standards. Any client implementing a standard can query any server implementing a standard. This gives users a choice of software, and using libraries or frameworks, they can simply write their own clients.

Plus, most VO software interoperates – you can send tables, selections, etc. from one program to the next using a protocol called **SAMP**. Try it, it's fun.

Clients: Almost all of them. You won't even notice.

9. Demo time

Put together
- Registry
- SCS
- TAP
- SAMP

for a nice visual encounter with sources with infrared excess around galactic OH masers not too far from the Galactic center.

Here's what to do:

Getting the OH masers

Start TOPCAT, select VO/Cone search

Put in OH masers as keywords. You should get back about 20 resources, if it's less, use a different registy (this is using the Registry standards).

In the lower part of the dialog, enter Sgr A as object, hit Resolve, enter 30 as Radius.

In the service list, look for the service with short name engels_ohmasers and double click it (this is using the Cone Search standard).

Plot the resulting table on a sphere to make sure it looks plausible.

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[8] http://www.star.bris.ac.uk/~mbt/topcat/
[9] http://www.star.bristol.ac.uk/~mbt/stilts/
[10] http://vo.ari.uni-heidelberg.de/soft/tapsh
[11] http://neo.cfa.harvard.edu/seleste/
[12] http://saada.unistra.fr/taphandle
[13] http://docs.g-vo.org/adql

Getting objects close to the masers

We're going to use the supercosmos data (that's basically objects within DSS). You could locate them using the registry, but we're taking a short cut.

Still in TOPCAT, do VO/TAP Query. In TAP URL, enter `http://dc.g-vo.org/tap`, hit "Enter Query".

In the top part of the dialog, select the table `supercosmos.sources`. Then, from "Examples" below, select "Upload Join" and edit the resulting query to look like this:

```
SELECT
   TOP 100000
   db.*
   FROM supercosmos.sources AS db
   JOIN TAP_UPLOAD.t11 AS tc
   ON 1=CONTAINS(POINT('ICRS', db.raj2000, db.dej2000),
                 CIRCLE('ICRS', tc.raj2000, tc.dej2000, 20./3600.))
```

(i.e., raise the match limit in TOP, change the select list to `db.*`, and raise the match radius to 20 arcsec).

You may need to adapt TAP_UPLOAD.t11; the 11 must be the little number in front of the table with the masers in TOPCAT's table list.

Execute the query. This takes a while since it's inspecting the vicinities of 4000 objects in a catalog with roughly 10^9 rows). The result is about 60000 objects.

Add infrared magnitudes

Again, we're taking a shortcut by using 2MASS from a known location. Try using WISE by asking the registry.

In TOPCAT, again to VO/TAP Query. Select `twomass.data` fromt the table list, pick "Upload join" from the examples. This time, change the match size to 1/3600. (both catalogs have good astrometry, and we don't expect our objects to move fast) and the match limit to 100000. Send away the query. Again, this may take a minute or so.

Inspect the result

Plot gcormagb agains kmag, flip kmag.

Now have a look at the weird objects in the upper part of the display: Start Aladin, in TOPCAT, do Interop/Send Table to/Aladin. Also set the activation action to: "transmit coordinates".

In Aladin, activate "Optical" and zoom in. Then click on suspicious points and gawk at them in Aladin.

For the curious: Can you get Spectra for these?