R&D @ CDS

and other developments

André Schaaff on behalf of the CDS Team

CDS Scientific Council 2016

CENTRE DE DONNÉES ASTRONOMIQUES DE STRASBOURG

IVOA

Asterics
Astronomy ESFRI & Research Infrastructure Cluster

Why R&D ?

- The CDS team has always spent time on R&D activities to follow the technological evolutions
- These evolutions are now very fast and in various fields (interactions, visualization, mobility, components, Big Data & Open data, Clouds, etc.) with a lot of actors in both the commercial and the Open Source domains
- It is becoming hard to test and evaluate everything in addition to the everyday work
- The R&D activity is now well identifed at CDS, it involves several persons of the staff with the help of interns and short contracts
- It provides also topics to present and discuss during the Infusion meetings

□ Internship programme

- We have now an internship programme to hire IT students (11 in 2016) to work with us on several topics, R&D and other developments
- During the three last years
  - 31 interns, 358 weeks / 6.9 years
- + short contracts following a few internships
  - To push the work to the production side
  - To work on short developments during the Summer
- Possible hiring on projects

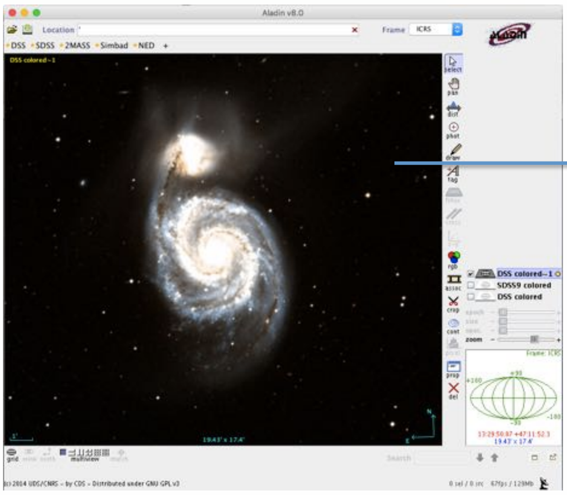
□ Internships in 2016

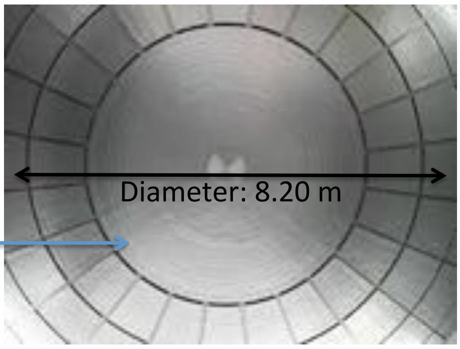
- Aladin fisheye visualization of HiPS surveys
- A monitoring system to track and visualize the number of queries of CDS services
- XObsCoreFits, a user interface to provide data to be ingested into CDS VizieR (images, spectra, time-series)
- Development of Python code for spectral analysis of CALIFA IFU data cubes
- Analysis of photometric flux conservation in the use of HiPS for images and cubes
- “A la découpe” Sky progressive survey (HiPS) server

□ Internships in 2016 (2)

- Development of a system to discover new Virtual Observatory services (VO Alerts)
- 3D visualization in a Web browser (large datasets, interpretation and immersion), → 3 internships
- Apache Spark and X-Match → on going
- "DevOps" at CDS, for the deployment of services in containers (Docker) → on going
- + Collaboration around "Binding Database Metadata with Scientific Papers" with L. Michel → on going
- + Participation to R&D project tutoring at ENSIIE Strasbourg

□ Aladin fisheye visualization of HiPS surveys





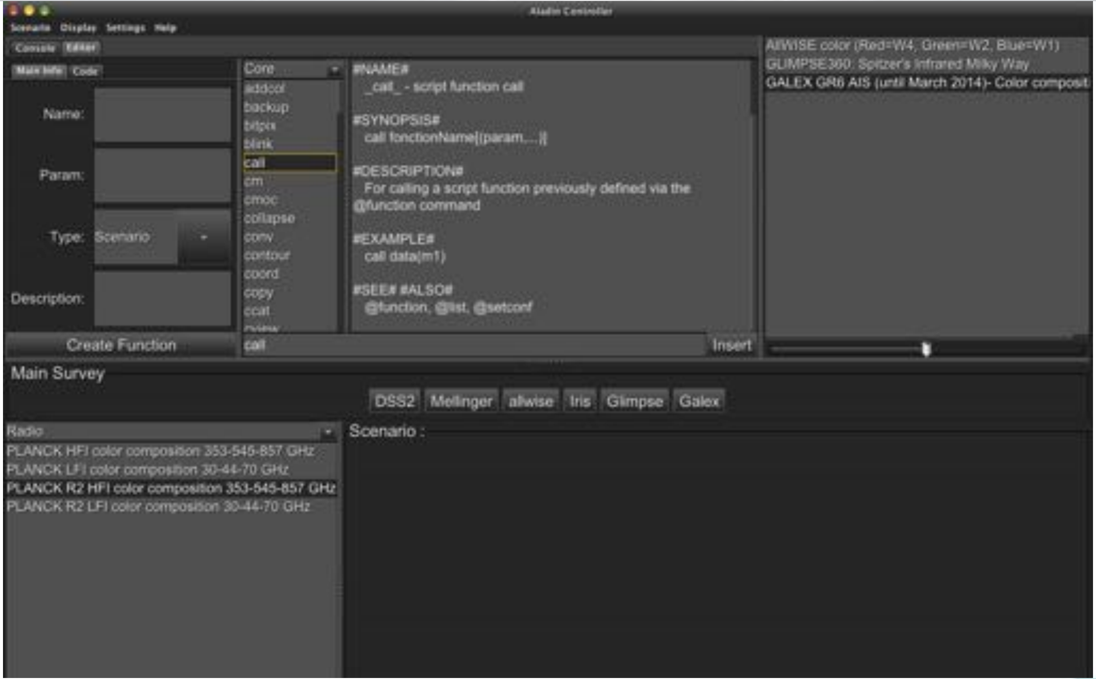
F. Bonnarel, S. Derriere, P. Fernique, A. Schaaff, M. Wendling (JdS), B. Rota (JdS)
Intern: Arnaud Steinmetz (ENSIIE Strasbourg)

Presented at IVOA Trieste

□ From the screen to the dome

- How to display Aladin HiPS surveys on the dome ?
  - The “fisheye” projection we use is actually the ARC (zenithal equidistant) projection
  - In this projection angular distances to the zenith are conserved
  - Well adapted to projection on the sphere
- How to manipulate ?
  - A plugin was the best solution

□ Planetarium plugin



Type: Scenario

```
#NAME#
  _call_ - script function call

#SYNOPSIS#
  call fonctionName[(param,...)]

#DESCRIPTION#
  For calling a script function previously defined via the
@function command

#EXAMPLE#
  call data(m1)

#SEE# #ALSO#
  @function, @list, @setconf
```

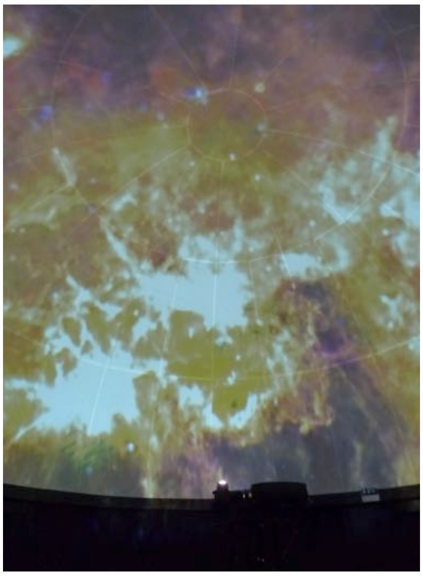
call

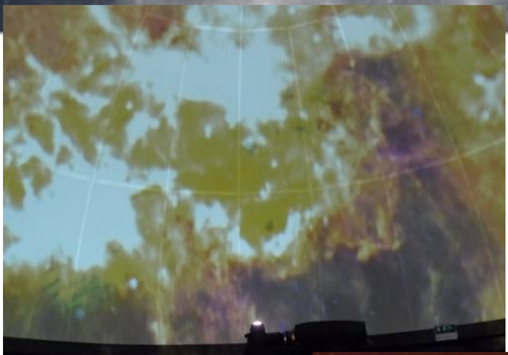
AllWISE color (Red=W4, Green=W2, Blue=W1)
GLIMPSE360: Spitzer's Infrared Milky Way
GALEX GR6 AIS (until March 2014)- Color composit

PLANCK HFI color composition 353-545-857 GHz
PLANCK LFI color composition 30-44-70 GHz
PLANCK R2 HFI color composition 353-545-857 GHz
PLANCK R2 LFI color composition 30-44-70 GHz

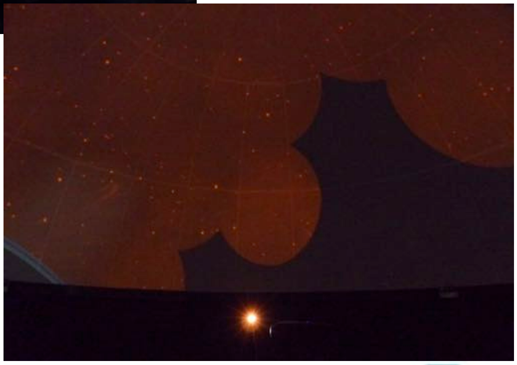
Scenario :

□ Illustrations





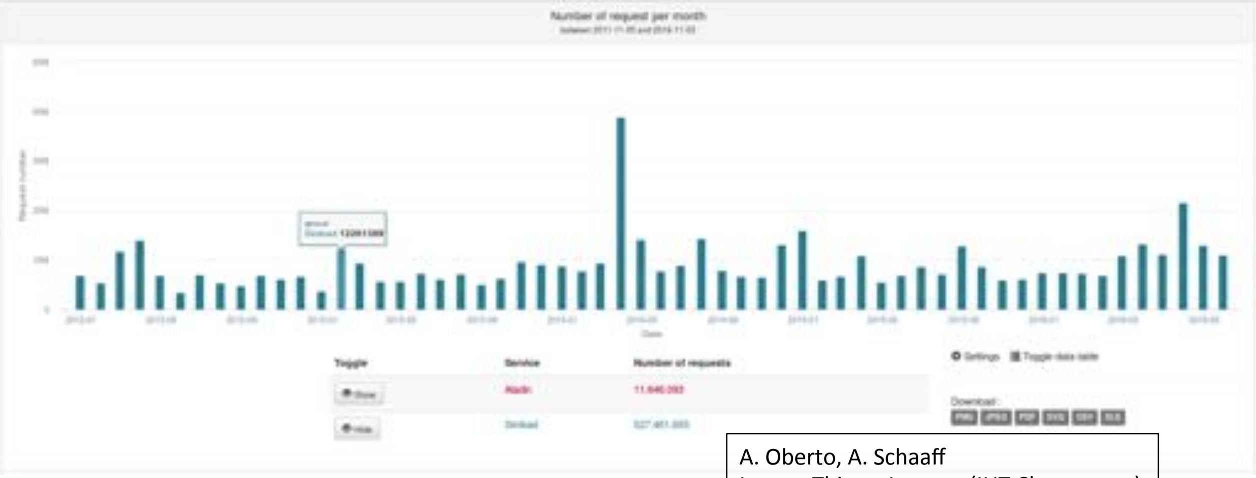
Credits: IRIS



Credits: GALEXGR6

□ A monitoring system to track and visualize the number of queries of CDS services

- Grouping the service logs in one “store” to provide on-demand statistics

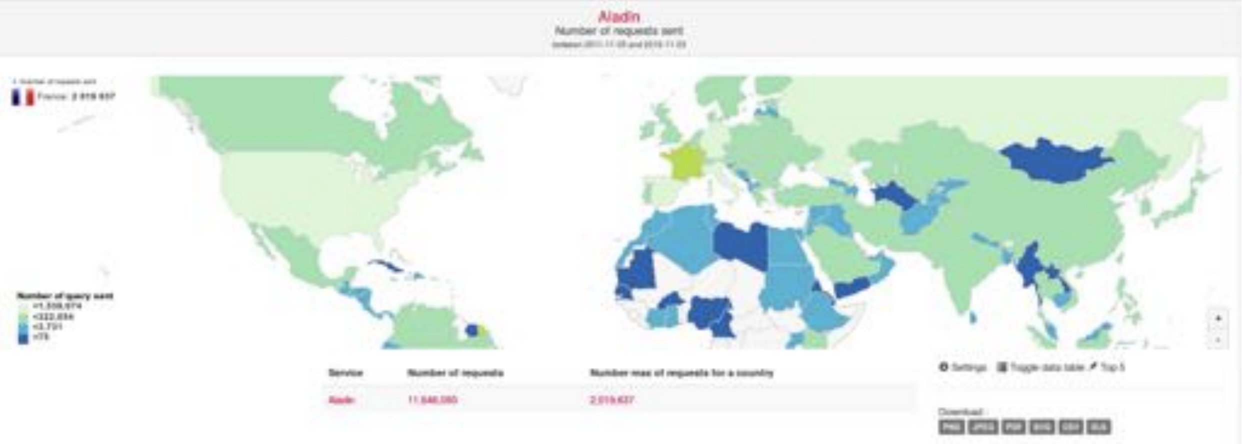


Toggle	Service	Number of requests
Show	Aladin	11,846,293
Hide	Simbad	527,461,305

A. Oberto, A. Schaaff
Intern: Thierry Lacoste (IUT Champagne)

A monitoring system to track and visualize the number of queries of CDS services (2)

- World use of a service…



Service	Number of requests	Number max of requests for a country
Aladin	11,646,060	2,019,637

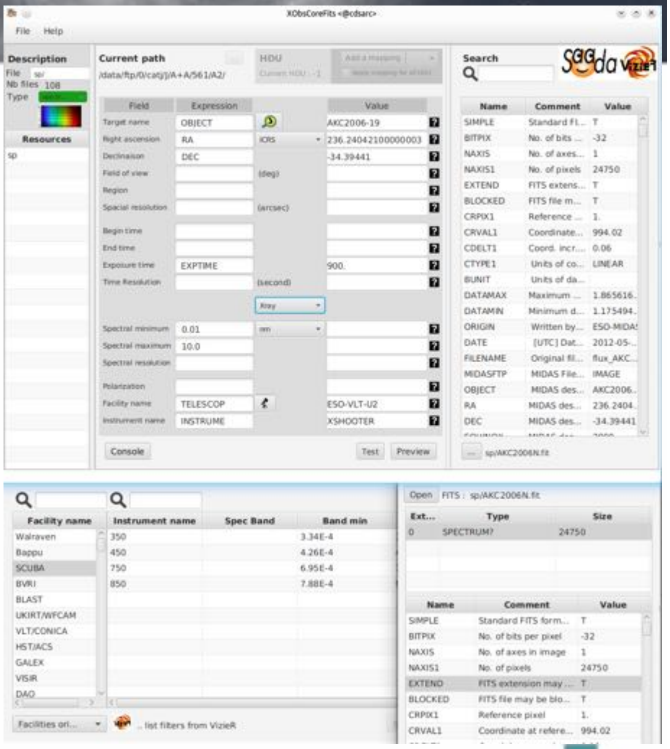
Future R&D aspects: log mining

XObsCoreFits

- Mapping between FITS documents (images, spectra, time-series) and IVOA ObsCore
- Documentalists complete a pre-processing phase done through the Saada API
- VizieR data can also be included

G. Landais, P. Ocvirk, L. Michel
Intern: Félix Royer (IUT Belfort-Montbéliard)

Poster at ADASS Trieste



File sp/
Nb files 108
Type

sp

/data/ftp/0/cat/J/A+A/561/A2/

Field	Expression		Value
Target name	OBJECT		AKC2006-19
Right ascension	RA	ICRS	236.24042100000003
Declinaison	DEC		-34.39441
Field of view		(deg)	
Region			
Spacial resolution		(arcsec)	
Begin time			
End time			
Exposure time	EXPTIME		900.
Time Resolution		(second)	
		Xray	
Spectral minimum	0.01	nm	
Spectral maximum	10.0		
Spectral resolution			
Polarization			
Facility name	TELESCOP		ESO-VLT-U2
Instrument name	INSTRUME		XSHOOTER

Name	Comment	Value
SIMPLE	Standard FI...	T
BITPIX	No. of bits ...	-32
NAXIS	No. of axes...	1
NAXIS1	No. of pixels	24750
EXTEND	FITS extens...	T
BLOCKED	FITS file m...	T
CRPIX1	Reference ...	1.
CRVAL1	Coordinate...	994.02
CDELT1	Coord. incr....	0.06
CTYPE1	Units of co...	LINEAR
BUNIT	Units of da...	
DATAMAX	Maximum ...	1.865616...
DATAMIN	Minimum d...	1.175494...
ORIGIN	Written by...	ESO-MIDAS
DATE	[UTC] Dat...	2012-05-...
FILENAME	Original fil...	flux_AKC...
MIDASFTP	MIDAS File...	IMAGE
OBJECT	MIDAS des...	AKC2006...
RA	MIDAS des...	236.2404...
DEC	MIDAS des...	-34.39441

... sp/AKC2006N.fit

Facility name
Walraven
Bappu
SCUBA
BVRI
BLAST
UKIRT/WFCAM
VLT/CONICA
HST/ACS
GALEX
VISIR
DAO

Instrument name	Spec Band	Band min
350		3.34E-4
450		4.26E-4
750		6.95E-4
850		7.88E-4

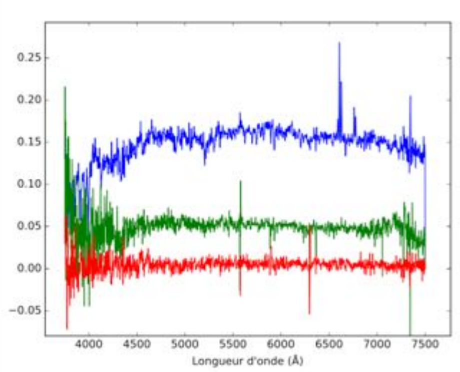
FITS : sp/AKC2006N.fit

Ext...	Type	Size
0	SPECTRUM?	24750

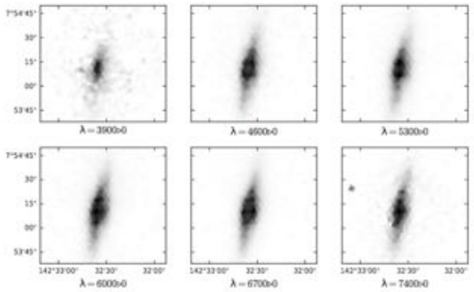
Name	Comment	Value
SIMPLE	Standard FITS form...	T
BITPIX	No. of bits per pixel	-32
NAXIS	No. of axes in image	1
NAXIS1	No. of pixels	24750
EXTEND	FITS extension may ...	T
BLOCKED	FITS file may be blo...	T
CRPIX1	Reference pixel	1.
CRVAL1	Coordinate at refere...	994.02

Spectral analysis of CALIFA IFU data cubes

- CALIFA, a collection of ~600 galaxy images in hyperspectral data cubes
- Build of velocity maps and variance



Spectra in a cube at (40,40)(blue), (20,40)(red), (0,40) (green)

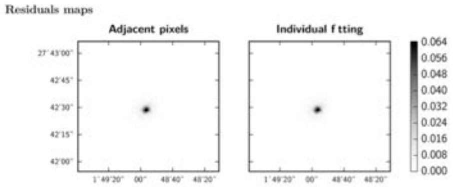


Images from a cube at different wavelengths

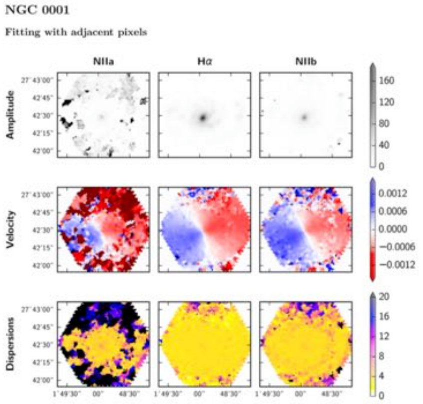
M. Louys, C. Boily
Intern: Thibaut Buchert (ENSIIE Strasbourg)

Spectral analysis of CALIFA IFU data cubes (2)

- The aim of was to improve an existing Python application at several levels: speed, test on a large set of cubes, code quality, documentation, etc.
- Rewriting in C of some parts with a computing time gain: 1 minute for 10 CALIFA cubes, 100 times faster

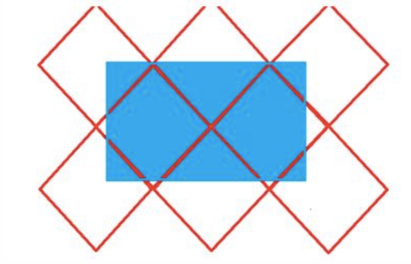


Output examples of the application



□ "A la découpe" Sky progressive survey (HiPS) server

- The aim was to develop a server (based on Java Servlets under Tomcat) to generate on the fly images from progressive surveys
- Use of the IVOA SIAv2 standard



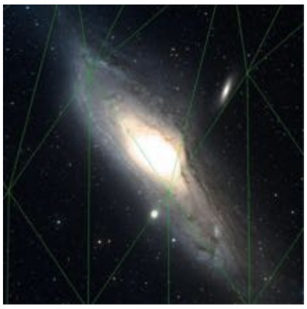


Image generation from "pixels", problems

P. Fernique, T. Boch
Intern: Thomas Janowskyj (IUT Charlemagne)

□ Photometric conservation in HiPS processing

How can we assess aperture photometry degradation after HiPS transformation?

- HiPS is becoming an IVOA standard
- it is based on HealPix tessellation of the sky which defines cells of equal area on all sky and implies transformation of the original data
- We have raised with the help of an intern the question of potential quality degradation in producing the HiPS version

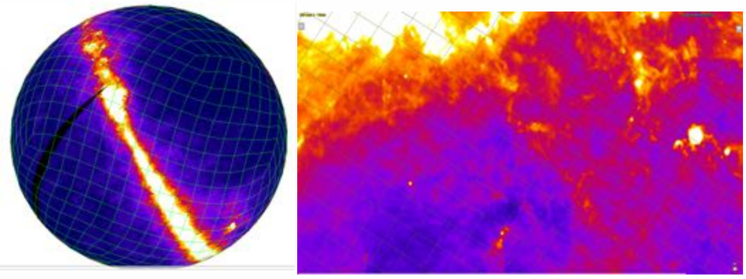


Figure 1: IRIS @100micron HiPS visualisation within Aladin: high resolution on the right

Test data and procedures:

- The IRIS data collection is a reprocessing of the IRAS Sky Survey Atlas , recalibrated using DIRBE and made of 12.5 degrees joint images at 12, 25, 60 and 100 µm
- Mean surface brightness is estimated in circular areas on both original images and corresponding areas in the HiPS representation using ***Aladin*** code controlled via a python module.

Poster at ADASS Trieste

M. Louys, F. Bonnarel, C. Bot, P. Fernique
Intern: Damien Teodori (ENSIIE Strasbourg)

□ Photometric conservation in HiPS processing (2)

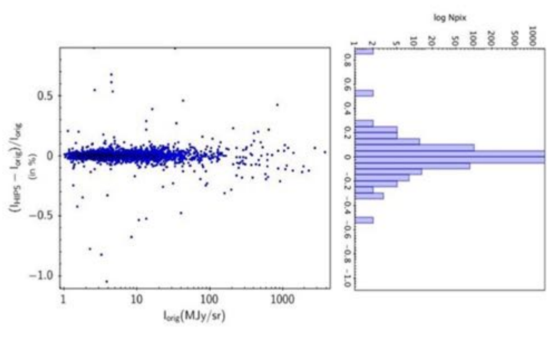


Figure 2: Fractional difference (as a percentage) between the HIPS and original surface brightnesses as a function of the average surface brightness. The histogram of the fractional difference is shown on the right.

Results and conclusions:

- Relative photometric difference is extremely small (< 0.3% !!!) typically much smaller than other sources of uncertainties (fig 2)
- No obvious spatial bias in the results but further tests needed.
- Tests scheduled for source photometry on appropriate surveys
- **For IRAS/IRIS data it is fairly equivalent to measure photometry on data distributed in the HiPS format than on original ones**

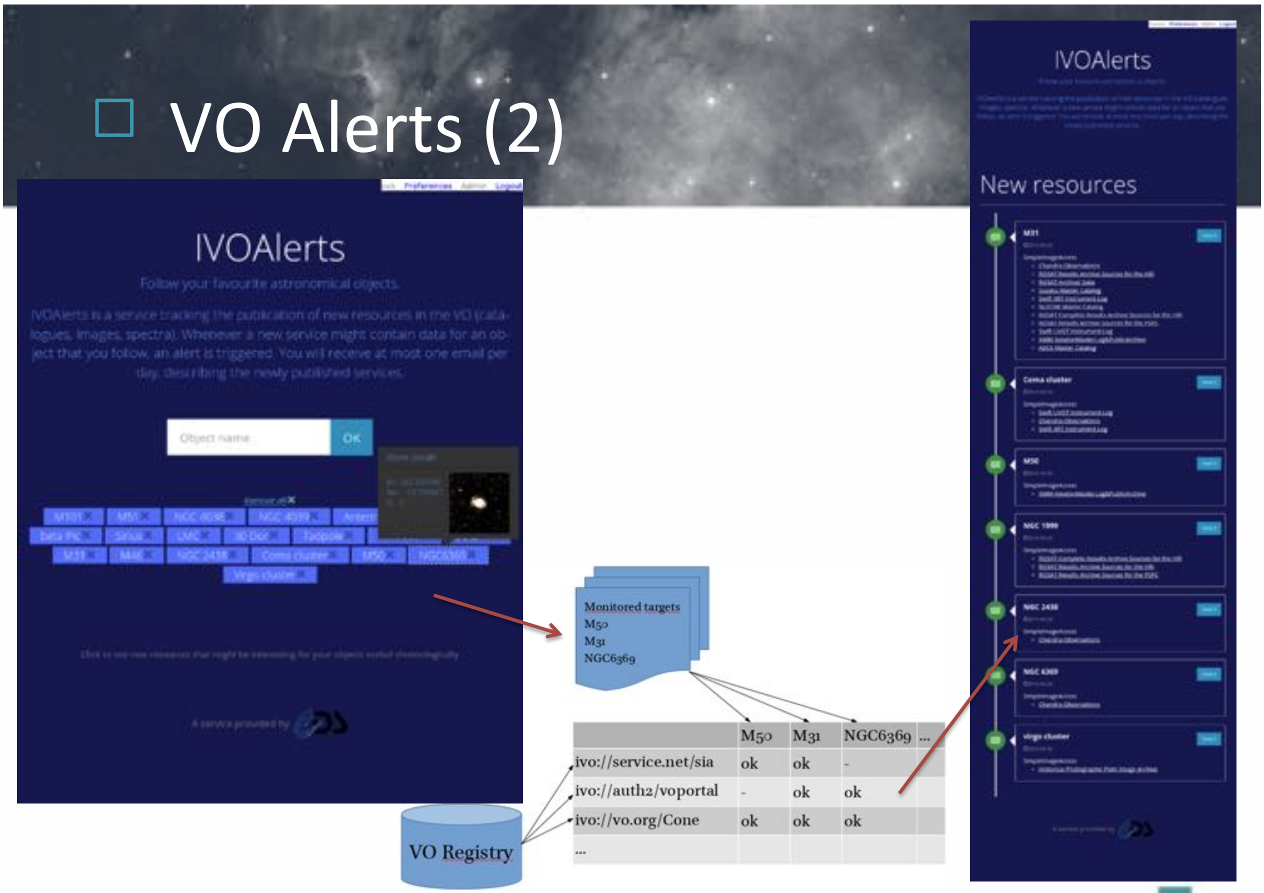
□ VO Alerts

- A service to notify users of newly-published VO resources relevant for a list of sky targets
  - Cone Searches, Simple Image/Spectrum Access
- Motivation: difficult to know what's new in VO
  - CDS news: all new VizieR catalogues
  - VO Registry: information must be pulled, and tested for relevance
- Similar to SimWatch, but for VO services
  - Monitor newly added references for SIMBAD objects

Poster at ADASS Trieste

T. Boch, S. Derriere
Intern: Loïc Gasiorowski (IUT Charlemagne)

VO Alerts (2)



IVOAlerts

Follow your favourite astronomical objects.

IVOAlerts is a service tracking the publication of new resources in the VO (catalogues, images, spectra). Whenever a new service might contain data for an object that you follow, an alert is triggered. You will receive at most one email per day, describing the newly published services.

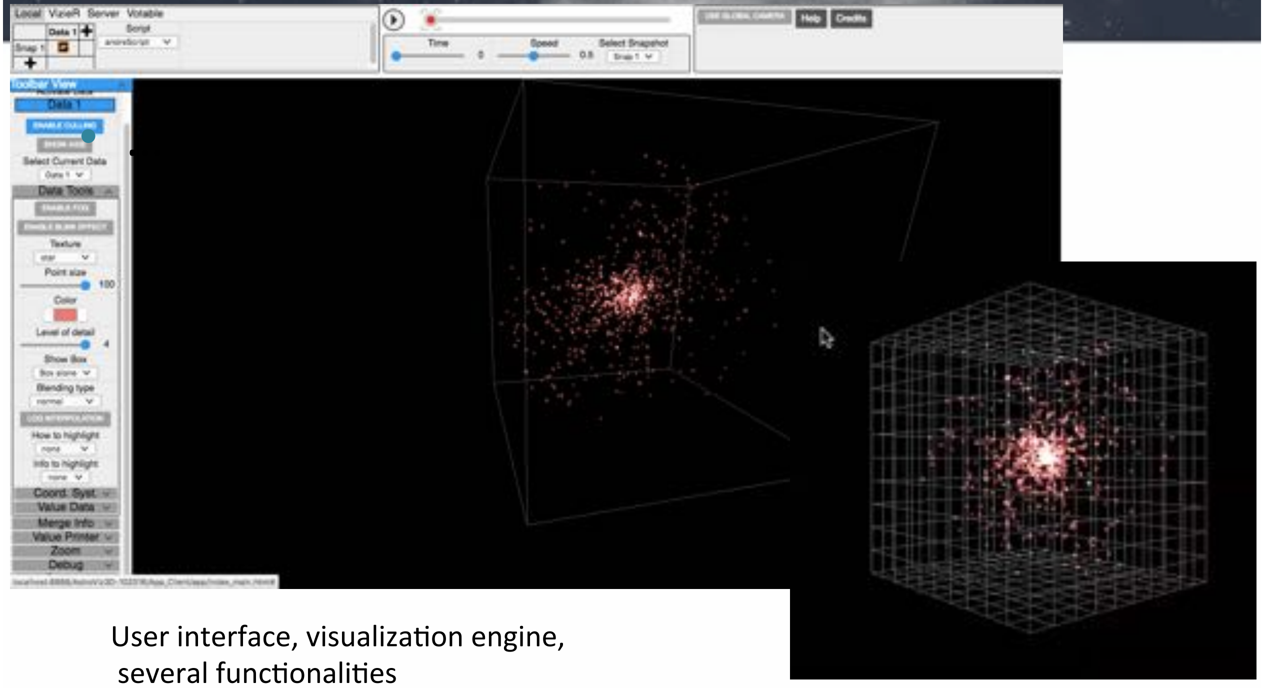
	M50	M31	NGC6369	...
ivo://service.net/sia	ok	ok	-	
ivo://auth2/voportal	-	ok	ok	
ivo://vo.org/Cone	ok	ok	ok	
...				

3D Visualization in a Web browser

- Light tool to visualize several kinds of 3D data in a Web browser (based on WebGL)
- On going work around the visualization of large datasets
  - 4096^3 simulation data cube
  - Too large to be loaded in a Web browser
  - → data on a server + progressive visualization on the client side

A. Schaaff, D. Aubert, N. Deparis, N. Gillet, P. Ocvirk
Interns: Jérôme Desroziers (IUT Charlemagne), Thibault Bouchard et Nicolas Adam (ENSIIE Strasbourg)

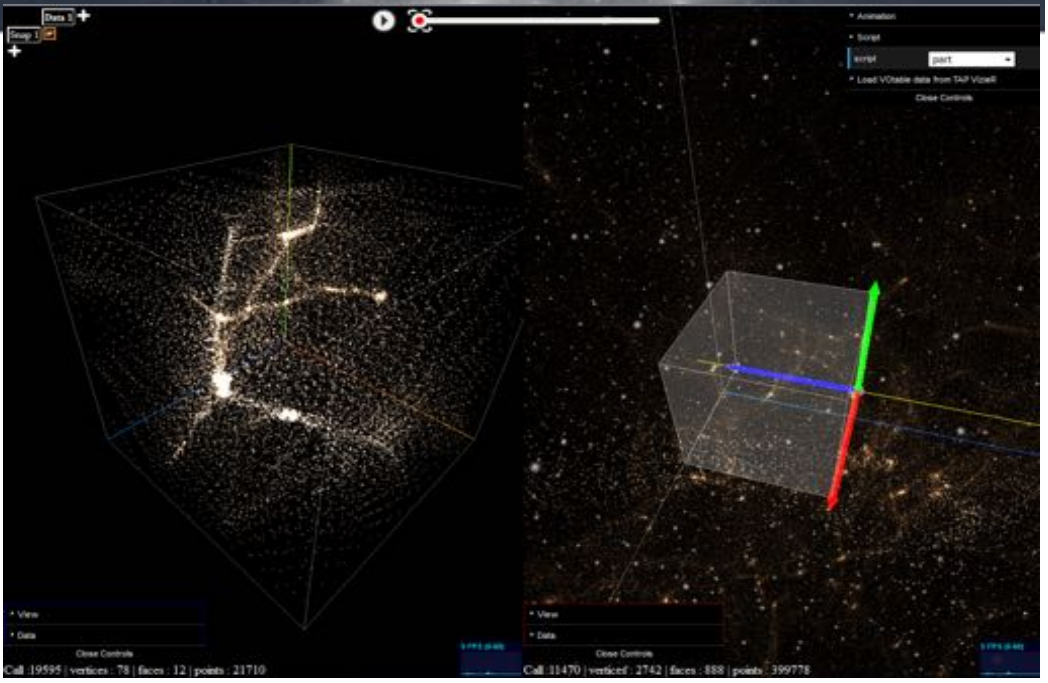
□ Illustration



User interface, visualization engine,
several functionalities

□ Illustration (2)

Navigation in
the data



Call :19595 | vertices : 78 | faces : 12 | points : 21710

Call :11470 | vertices : 2742 | faces : 888 | points : 399778

□ Apache Spark and X-Match

- Evaluation of Spark in the frame of a use case, the “cross-match” of source catalogues:
  - Improvement of the existing service (one server) ?
  - Up to scale capability ?
  - Which cost (€, manpower, performances) ?
- Spark is a kind of MapReduce done mostly in memory

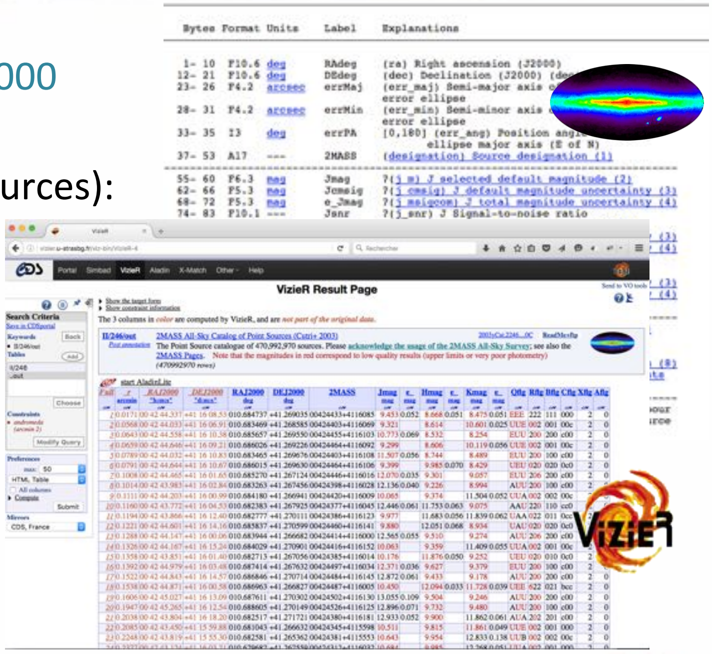
A. Schaaff, F.-X. Pineau, Julien Nauroy (Université Paris Sud)
Interns: Paul Trehiou (UTBM), (Noémie Wali (UTBM) in 2015)

Oral at ADASS Trieste

Presented at IVOA Trieste

□ The data…

- Source catalogues (>10,000 available)
- Examples (number of sources):
  - 2MASS[1], 470,992,970
  - SDSS[2] DR9, 469,053,874



```
 Bytes Format Units   Label     Explanations

  1- 10  F10.6 deg     RAdeg     (ra) Right ascension (J2000)
 12- 21  F10.6 deg     DEdeg     (dec) Declination (J2000) (dec
 23- 26  F4.2  arcsec  errMaj    (err_maj) Semi-major axis o
                                 error ellipse
 28- 31  F4.2  arcsec  errMin    (err_min) Semi-minor axis o
                                 error ellipse
 33- 35  I3    deg     errPA     [0,180] (err_ang) Position angle
                                        ellipse major axis (E of N)
 37- 53  A17   ---     2MASS     (designation) Source designation (1)
----------------------------------------------------------------------
 55- 60  F6.3  mag     Jmag      ?(j_m) J selected default magnitude (2)
 62- 66  F5.3  mag     Jcmsig    ?(j_cmsig) J default magnitude uncertainty (3)
 68- 72  F5.3  mag     e_Jmag    ?(j_msigcom) J total magnitude uncertainty (4)
 74- 83  F10.1 ---     Jsnr      ?(j_snr) J Signal-to-noise ratio
```

VizieR Result Page

The 3 columns in color are computed by VizieR, and are not part of the original data.

II/246/out 2MASS All-Sky Catalog of Point Sources (Cutri+ 2003) 2003yCat.2246....0C ReadMe+ftp
Post annotation The Point Source catalogue of 470,992,970 sources. Please acknowledge the usage of the 2MASS All-Sky Survey; see also the 2MASS Pages. Note that the magnitudes in red correspond to low quality results (upper limits or very poor photometry)
(470992970 rows)

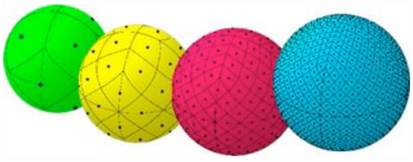
Full	_r arcmin	_RAJ2000 "h:m:s"	_DEJ2000 "d:m:s"	RAJ2000 deg	DEJ2000 deg	2MASS	Jmag mag	e_ mag	Hmag mag	e_ mag	Kmag mag	e_ mag	Qflg	Rflg	Bflg	Cflg	Xflg	Aflg
1	0.0171	00 42 44.337	+41 16 08.53	010.684737	+41.269035	00424433+4116085	9.453	0.052	8.668	0.051	8.475	0.051	EEE	222	111	000	2	0
2	0.0568	00 42 44.033	+41 16 06.91	010.683469	+41.268585	00424403+4116069	9.321		8.614		10.601	0.025	UUE	002	001	00c	2	0
3	0.0643	00 42 44.558	+41 16 10.38	010.685657	+41.269550	00424455+4116103	10.773	0.069	8.532		8.254		EUU	200	200	c00	2	0
4	0.0659	00 42 44.646	+41 16 09.21	010.686026	+41.269226	00424464+4116092	9.299		8.606		10.119	0.056	UUE	002	001	00c	2	0
5	0.0789	00 42 44.032	+41 16 10.83	010.683465	+41.269676	00424403+4116108	11.507	0.056	8.744		8.489		EUU	200	100	c00	2	0
6	0.0791	00 42 44.644	+41 16 10.67	010.686015	+41.269630	00424464+4116106	9.399		9.985	0.070	8.429		UEU	020	020	0c0	2	0
7	0.1008	00 42 44.465	+41 16 01.65	010.685270	+41.267124	00424446+4116016	12.070	0.035	9.301		9.057		EUU	206	200	c00	2	0
8	0.1014	00 42 43.983	+41 16 02.84	010.683263	+41.267456	00424398+4116028	12.136	0.040	9.226		8.994		AUU	200	100	c00	2	[illegible]
9	0.1111	00 42 44.203	+41 16 00.99	010.684180	+41.266941	00424420+4116009	10.065		9.374		11.504	0.052	UUA	002	002	00c	[illegible]	[illegible]
10	0.1160	00 42 43.772	+41 16 04.53	010.682383	+41.267925	00424377+4116045	12.446	0.061	11.753	0.063	9.075		AAU	220	110	cc0	[illegible]	[illegible]
11	0.1194	00 42 43.866	+41 16 12.40	010.682777	+41.270111	00424386+4116123	9.977		11.683	0.056	11.839	0.062	UAA	022	011	0cc	[illegible]	[illegible]
12	0.1221	00 42 44.601	+41 16 14.16	010.685837	+41.270599	00424460+4116141	9.880		12.051	0.068	8.934		UAU	020	020	0c0	[illegible]	[illegible]
13	0.1288	00 42 44.147	+41 16 00.06	010.683944	+41.266682	00424414+4116000	12.565	0.055	9.510		9.274		AUU	206	200	c00	[illegible]	[illegible]
14	0.1326	00 42 44.167	+41 16 15.24	010.684029	+41.270901	00424416+4116152	10.063		9.359		11.409	0.055	UUA	002	001	00c	[illegible]	[illegible]
15	0.1358	00 42 43.851	+41 16 01.40	010.682713	+41.267056	00424385+4116014	10.176		11.876	0.050	9.252		UEU	020	010	0c0	2	[illegible]
16	0.1392	00 42 44.979	+41 16 03.48	010.687414	+41.267632	00424497+4116034	12.371	0.036	9.627		9.379		EUU	200	100	c00	2	[illegible]
17	0.1522	00 42 44.843	+41 16 14.57	010.686846	+41.270714	00424484+4116145	12.872	0.061	9.433		9.178		AUU	200	200	c00	2	0
18	0.1538	00 42 44.871	+41 16 00.58	010.686963	+41.266827	00424487+4116005	10.450		12.094	0.033	11.728	0.039	UEE	622	021	bcc	2	0
19	0.1606	00 42 45.027	+41 16 13.09	010.687611	+41.270302	00424502+4116130	13.055	0.109	9.504		9.246		AUU	200	200	c00	2	0
20	0.1947	00 42 45.265	+41 16 12.54	010.688605	+41.270149	00424526+4116125	12.896	0.071	9.732		9.480		AUU	200	100	c00	2	0
21	0.2038	00 42 43.804	+41 16 18.20	010.682517	+41.271721	00424380+4116181	12.933	0.052	9.900		11.862	0.061	AUA	202	201	c00	2	0
22	0.2085	00 42 43.450	+41 15 59.88	010.681043	+41.266632	00424345+4115598	10.511		9.815		11.861	0.049	UUE	002	001	000	2	0
23	0.2248	00 42 43.819	+41 15 55.30	010.682581	+41.265362	00424381+4115553	10.643		9.954		12.833	0.138	UUB	002	002	00c	2	0

Example of a ReadMe file associated to 2MASS source catalogues available through the VizieR service

[1] 2MASS, Two Micron All Sky Survey,
[2] SDSS, Sloan Digital Sky Survey

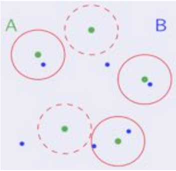
…and the CDS “cross-match” service

- The “cross-match” service does a cross correlation of sources between (very) large catalogues (current size: 10^9), for the full sky, a cone or a HEALPix cell.

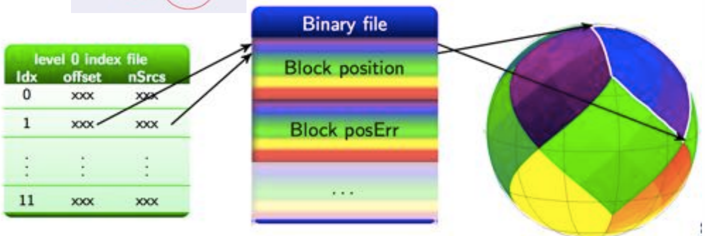


Credits: http://healpix.jpl.nasa.gov/

Fuzzy join between 2 tables (A and B) of several hundred millions of data



Data is not distributed but organised and stored on one server



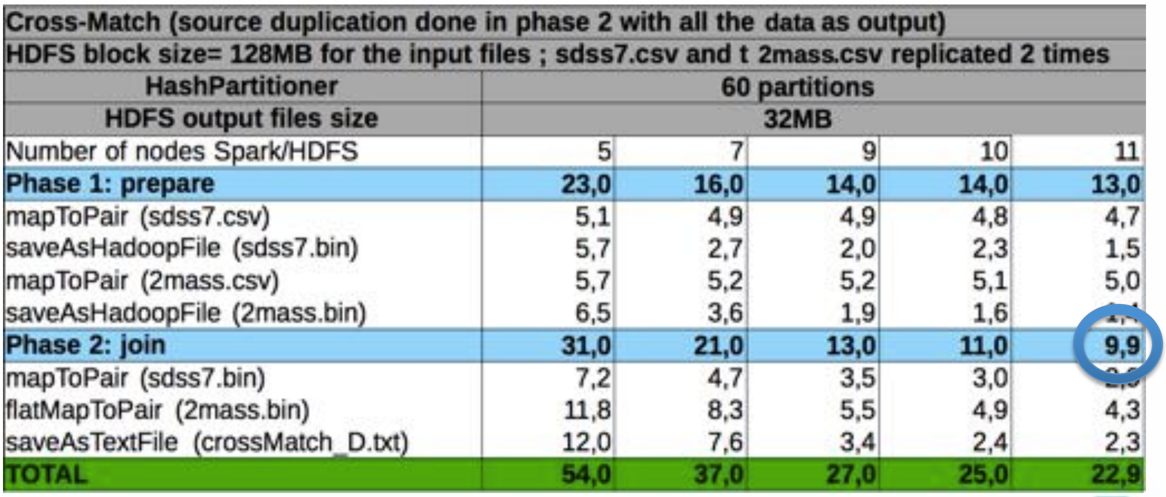
level 0 index file		
Idx	offset	nSrcs
0	xxx	xxx
1	xxx	xxx
⋮	⋮	⋮
11	xxx	xxx

The sky is cut into diamonds of the same size, pixels, each source or sky object is a numbered pixel.

First experiment result

- Input data (SDSS DR7 (primary sources) and 2MASS): 54GB and 58GB file size; 357 175 411 and 470 992 970 elements
- Output data: 49 208 820 elements

X-Match service reference time was: 10 minutes



Cross-Match (source duplication done in phase 2 with all the data as output)					
HDFS block size= 128MB for the input files ; sdss7.csv and t 2mass.csv replicated 2 times					
HashPartitioner	60 partitions				
HDFS output files size	32MB				
Number of nodes Spark/HDFS	5	7	9	10	11
Phase 1: prepare	**23,0**	**16,0**	**14,0**	**14,0**	**13,0**
mapToPair (sdss7.csv)	5,1	4,9	4,9	4,8	4,7
saveAsHadoopFile (sdss7.bin)	5,7	2,7	2,0	2,3	1,5
mapToPair (2mass.csv)	5,7	5,2	5,2	5,1	5,0
saveAsHadoopFile (2mass.bin)	6,5	3,6	1,9	1,6	1,4
Phase 2: join	**31,0**	**21,0**	**13,0**	**11,0**	**9,9**
mapToPair (sdss7.bin)	7,2	4,7	3,5	3,0	2,6
flatMapToPair (2mass.bin)	11,8	8,3	5,5	4,9	4,3
saveAsTextFile (crossMatch_D.txt)	12,0	7,6	3,4	2,4	2,3
TOTAL	**54,0**	**37,0**	**27,0**	**25,0**	**22,9**

□ Comments

- On going work: we expect a significant improving of the performances, with a reasonable hardware cost
- In 2016, we were invited to present this work during 2 workshops in Paris (70 attendees) and Clermont Ferrand (55 attendees)
  - Proposals to collaborate and to provide us computing and storage facilities, other invitations
- Presentations and discussions at IVOA Sydney, Cape Town and Trieste

□ "DevOps" at CDS

- The use of components (light virtualization) is becoming one of the most popular technologies with Docker as flagship
- We use it to deploy Apache Spark on the clusters
- Study of possible applying to CDS services like VizieR for the mirroring maintenance
- A major topic is to implement a prototype allowing a user "to move his code to the data" through components

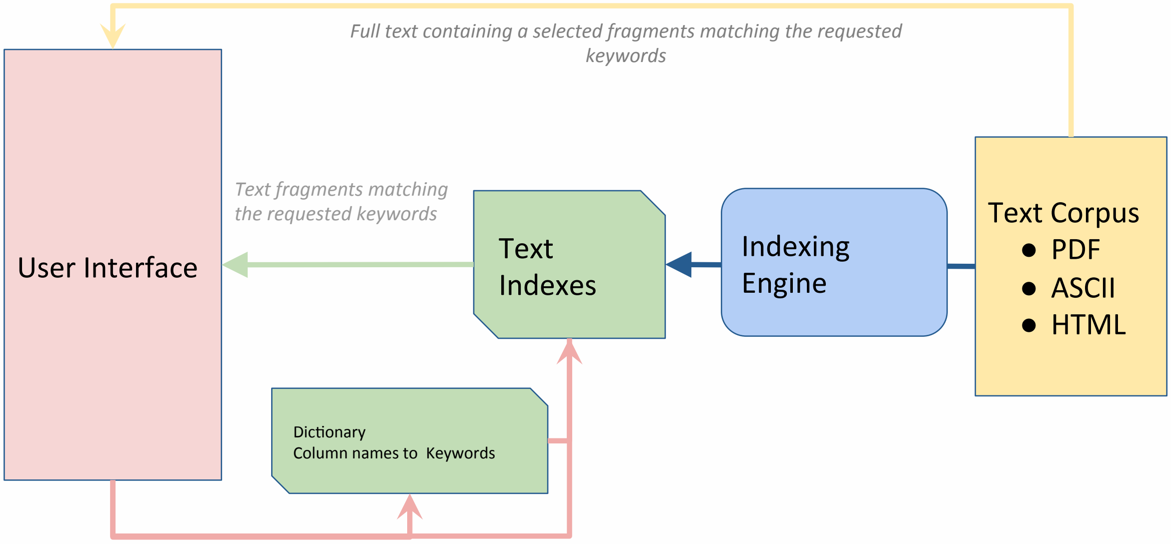
A. Schaaff, F.-X. Pineau, G. Landais, L. Michel
Interns: Paul Trehiou (UTBM)

Binding Database Metadata with Scientific Papers

- Objectives
  - Providing database users with a relevant description of the exposed data.
  - Helping users to locate resources described or mentioned in a text corpus
  - Exploring possible ways to facilitate the job of the documentalists
- Principle
  - Bringing together a text corpus related to the service
  - Indexing the corpus with a text search engine
  - Integrating this text search facility inside this service
- Foreseen Applications
  - XMM-Newton Catalogue: providing users with a scientific description of the catalogue columns
  - Vizier: searching catalogues by querying the corpus of README files as a whole

L. Michel (SSC XMM-Newton Strasbourg) in collaboration with the CDS (engineers and documentalists)
Intern: Sinan Acar (UTBM)

Binding Database Metadata with Scientific Papers (2)


Full text containing a selected fragments matching the requested keywords
User Interface
Text fragments matching the requested keywords
Text Indexes
Indexing Engine
Text Corpus
● PDF
● ASCII
● HTML
Dictionary
Column names to Keywords

Operation workflow

Data preparation workflow

R&D project tutoring at ENSIIE Strasbourg

- Not an internship, the work is done with the engineer school facilities, integrated in the semester
- Each student has 150 hours to spend on it
- Subjects around Immersive 3D Visualization, multi-Google Cardboard management from a laptop, interactions, etc.
- Students: Nicolas Buecher, Jonathan Chastenet, Mélody Deloffre, Jonathan Hurter, Pauline Kobersi, Raoul Le Perlier, Vincent Stébé, Damien Teodory

And "after internship" short contract examples (2016)

- Thierry Lacoste: CDS logs to an operational version
- Felix Royer: improvement of XObsCoreFits
- Jérôme Desroziers: new (IVOA) VOTable Javascript parser (used in CDS Portal, AstroDeep, and soon in Aladin Lite), presented at IVOA Trieste
- Joris Vigneron (intern 2015): cleaning in Simbad database

□ Future investigation plans 2018-2020

- Interfaces and interactions
  - High resolution (4K and perhaps more…) screens will be common, merging between (OS, multitouch) smartphone / tablet / laptop / desktop is on going and will probably be done during the period
  - Other kinds of interactions are emerging (voice, gesture, …)
  - Balance between standalone apps / Web apps is moving
  - Continuous R&D in this frame is crucial

□ Future investigation plans 2018-2020 (2)

- "Big Data"
  - Providing the data: a continuous R&D effort is needed to provide an added value on the access mechanisms to the data which include both the organisation of the data, the metadata and the technologies
  - Providing the tools: to access and explore all the CDS data (and external data in the context of the interoperability)
    - Knowledge databases, machine learning, etc.
  - Log Mining: capitalize on the centralization of the CDS logs to learn about the user workflow to improve the integration of the services

Future investigation plans 2018-2020 (3)

- Immersive 3D-Visualization
  - Oculus Rift & similar devices: take into account the 2 previous years (after the public release of these devices) and continue (or not) the studies (and implementations) done previously
  - Continuous R&D around this topic
- Clouds
  - Following previous experiments (HiPS in the clouds), identify and implement in the cloud services (probably mirrors) of the CDS

Future investigation plans 2018-2020 (4)

- Social networks
  - Probably one of the main evolution of the services
  - Deepest involving of the users at several levels
  - Astronomers, developers, documentalists: the fourth part of the team could be build in this frame
- Connected objects
  - A large variety of devices around 2020
  - Could be seen as gadgets in astronomy
  - (But) Probably many use cases (alerts, news, etc.) which are not yet well identified in the Science field

□ Conclusion

- Large spectrum from the system/hardware to the Data/Text mining
- The R&D activity is a way to update and improve the services... and the skills of the permanent staff
  - New technologies
  - Presentation of the work at the end of the internships
  - Etc.
- It is also a “transversal” activity making people work together
- It is not only technical...
- Special thanks to Sandrine Langenbacher, Thomas Keller and Jean-Yves Hangouet