Annual Report of the VO Functional Working Group

G. Bruce Berriman

Membership

Dr Sebastian Gurovich (Argentina) resigned from the group and the IVOA Executive Committee in April 2024. His place on the VO working Group has been taken by Dr. Priya Hasan (India). Dr Hasan is an expert on the application of VO tools in science and education and has used them as the basis for workshops aimed at students and astronomers in developing countries. Dr Patricia Whitelock (South Africa) retired in December 2024, and her place will be filled in Spring 2025.

The current membership of the group is: G. Bruce Berriman (USA), Priya Hasan (India) Chenzhou Cui (China), Sudanshu Barway (India), Areg Mickaelian (Armenia).

Activities

Participation in the IAU General Assembly, August 6-16, 2024. Cape Town, South Africa

The group organized a session within the Division B Days titled "**Community Engagement , Open Science and the Virtual Observatory."** The session contained five talks:

Mark Allen (CDS, Strasbourg, France): "Scalable visualization of large, distributed data sets enabled by Virtual Observatory standards and tools."

Surveys of the sky with current and future astronomical instruments will lead to very large volumes of data that are distributed in archives around the world. In the context of the international Virtual Observatory, hierarchical approaches have been developed to enable data-access and visualisation of very large data sets. This is based on the computation of multi-resolution representations of sky survey data, using the HEALPix indexation, and international agreement on the Hierarchical Progressive Survey (HiPS) standard of the IVOA. A network of ~20 'HiPS nodes' has been established, which provides access to ~1200 HiPS data sets, and tools and services have been developed for visualisation of these data. I will present the capabilities of this open network using the example of the CDS Aladin service and the integration of Aladin Lite into various science portals. I will also highlight how the multi-resolution approach enables collections of pointed observations to be treated in the same systems as very large wide area surveys, and the new innovative scientific capabilities

that are being built to exploit these rich data sets including cut-out services and use the of time and frequency dimensions of the data.

Russ Taylor (University of Cape Town. University of the Western Cape. Inter-University Institute for Data Intensive Astronomy, South Africa))

Current and next generation radio telescopes on the pathway to the SKA are driving a tremendous challenge of big data in astronomy and changing the sociology of the scientific enterprise. Key science programs generating massive data sets are being executed by large internationally distributed collaborations. A prime example is the South African MeerKAT large survey projects, which dedicate thousands of hours of time undertaking high priority science programs by teams of senior researchers, science, presents challenges for distributed collaborative research, data access, data analytics, data visualization, and interoperability with distributed multi-wavelength data archives. Deployment of data intensive cloud systems along with the Virtual Observatory services offers a mechanism to address these challenges. Such platforms also provide outstanding opportunities for outreach and training to disadvantaged regions where access to data and resources is limited. I will discuss the nature of these challenge and approaches under development at the South African data intensive research cloud facility developed and operated by the Inter-University Institute for Data Intensive Astronomy.

Dr Priya Shah (Maulana Azad National Urdu University, Hyderabad, India)

The Virtual Observatory is a very useful tool for Education, not only in Astronomy, but also in Data Analysis and Statistics. With the help of funds from IAU-OAD, we designed a complete set of Astronomy Data Analysis Lab Experiments for Undergraduate and Postgraduate Students at Copperbelt University, Zambia. The complete manual is ready to be released at the General Assembly and in this talk I will give a brief overview of the Sciences Cases described and the various levels at which students can complete the task. The set of experiments can be useful for any undergraduate and post graduate university program.

Dr Brad Cenko (NASA/GSFC, USA)

Time-domain and multi-messenger astronomy (TDAMM) was highlighted as a frontier science pursuit in the coming decade by the 2020 Decadal Survey in Astronomy and Astrophysics in the United States. Given the rapid response and cross-facility coordination necessary to enable such science, well-defined standards play a critical role in this field reaching its full potential. I provide an overview of some of the most exciting scientific opportunities in the coming years in this science, and highlight the important role played by coordination in enabling those results.

Dr. Bruce Berriman (NASA/IPAC, USA)

The Virtual Observatory (VO) is a global ecosystem of interoperating services that connect worldwide data archives. The VO is implemented in all major astronomy archives through common interfaces developed by the 22 members of the International Virtual Observatory Alliance (IVOA). It was founded in 2002, and the latest members, the SKA Observatory and the Kazakhstan Virtual Observatory, joined in 2022. The IVOA has since its inception supported the goals of Open Science and what are now known as FAIR principles: Findable, Accessible, Interoperable, Reusable. Implementation of the common interfaces, defined and documented as what are called VO protocols, go a long way towards implementing the FAIR principles. A total of eleven of the 16 enumerated FAIR principles are or will be implemented when VO protocols are employed. The remainder are generally out of scope for the IVOA. The VO acts a democratizing influence in astronomy: it provides equal access to worldwide public data sets to under-served communities as to large data centers and enables international participation in scientific research and education. Thus, astronomers from many different communities are positioned to participate in the big science questions emerging in astronomy in the 2020s.

The presentations are available at https://zenodo.org/records/13550169

Bruce Berriman gave a presentation
“The Benefits of the Virtual Observatory to Under-served Communities” in the Session “FM 1 Harnessing ground-based optical telescopes: an opportunity for emerging astronomy in Africa.”

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communities may participate in Virtual Observatory science and educational activities. These include practices for developing VO-compliant data centers and archives, and education and training of developers and end users.

The presentation is available at https://zenodo.org/records/13381868,. The proceedings paper, which has been accepted for publication, is available at https://arxiv.org/pdf/2412.07973.

The VO working group participated in a side-event one-day workshop. organized by CDS, **"Virtual Observatory Tools for Students and Educators in Africa."** It was attended by approximately 30 graduate students and early-career researchers from Africa, and it emphasized hands-on all-sky science and the fusion of data from different archives and telescopes. The VO working group contributed an image processing example: a Jupyter Notebook that uses the Montage mosaic engine to create a three-color mosaic of images in the 2MASS all-sky survey and overlay a MeerKAT (1.28 GHz) map of the Galactic Center. The Notebook will run on all recent Python versions installed on *nix or Mac OS (Intel or Apple silicon chips). Processing requires about 15 minutes on an Apple M2 chip with 24 GB memory. The Notebook is freely available with a BSD 3-clause Open Source license at https://github.com/Caltech-IPAC/MontageNotebooks/blob/main/MeerKAT.ipynb.

The Cross Domain Interoperability Framework

Berriman will represent the IAU in the CODATA "Cross Domain Interoperability Framework (CDIF)" project. Its whose goal is to support FAIR implementation across disciplines by establishing a machine accessible 'lingua franca' of metadata. The work will leverage the IVOA's work on application of FAIR principles in astronomy. In December 2024, Berriman was elected a member of the CDIF working group.