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Supporting FAIR Principles in the Astrophysics Community: the European Experience

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Abstract. FAIR principles have *the intent to act as a guideline for those wishing to enhance the reusability of their data holdings and put specific emphasis on enhancing the ability of machines to automatically find and use the data, in addition to supporting its reuse by individuals.* Interoperability, one core of these principles, especially when dealing with automated systems' ability to interface with each other, requires open standards to avoid restrictions that negatively impact the user's experience. Open-ness of standards is best supported when the governance itself is open and includes a wide range of community participation. In this contribution we report our experience with the FAIR principles, interoperable systems and open governance in astrophysics. We report on activities that have matured within the ESCAPE project with a focus on interfacing the EOSC architecture and Interoperability Framework.

1. Introduction

The Virtual Observatory (VO) ecosystem of standards and technologies, discussed and defined by the International Virtual Observatory Alliance (IVOA), has, since the setup of the Alliance itself (2002), focused on interoperability as a way to provide discovery of and access to distributed resources in the astrophysics research domain and to enable re-use of those same resources.

The above statement explains why VO standards provide a direct support of FAIR principles (Fig. 1 provides a visual support on how FAIR principles fit in the IVOA architecture) and, adding the fact that they're open in definition and governance, allow for an Open Science scenario in astrophysics. VO also pre-dates the FAIR principles

Open Science Cloud (EOSC). Within the project, the CEVO WP has the goal to connect ESFRI projects to EOSC using the VO framework as the means to do so. This involves three main activities: integration of astronomy VO data and services into the EOSC, implementation of FAIR principles for ESFRI data through the Virtual Observatory, and adding value to trusted content in astronomy archives. The activities reported in the subsequent sections of this contribution are mainly performed within CEVO but include cross activities with other ESCAPE WPs.

3. IVOA architecture integration

3.1. Registry integration

Integration of the IVOA Registry of Resources in EOSC has happened with the EUDAT B2FIND service harvesting², through the OAI-PMH protocol, DataCite metadata from the IVOA Registry. Work is ongoing towards adding more metadata, using the B2FIND metadata schema at harvesting, instead of DataCite only. The mapping from VOResource metadata to DataCite is not complete, the most important differences being about mapping per-protocol access URLs and tablesets. The Unified Astronomy Thesaurus top level concepts have been mapped to VOResource subject keywords. A further goal of such mapping and integration could be trying to bridge different disciplines of research. Initial use cases have been drawn for this purpose³.

3.2. EOSC onboarding

The EOSC onboarding procedure shows another possible way of integration, with resources ending up directly visible in the EOSC portal. To test this solution a Provider has been set up (for INAF) and a couple of services (in collaboration with the NEA-NIAS project) have been onboarded successfully. The onboarding procedure will be tested also for registered VO resources, to report guidelines on the procedure in view of avoiding duplication of efforts for providers. The differences in architecture, metadata goals and granularity are the challenges offered to this activity.

4. IVOA standards updates for ESFRI

Interoperability and FAIR-ness inclusion in standards require continuous updates. In ESCAPE, CEVO continues gathering requirements from ESFRIs, using the IVOA interoperability meetings as milestones to report result and help keeping the IVOA standards up to date. Radio astronomy data access, tools and standards to support follow-up of gravitational waves events are among the main results alongside common support to projects and communities.

4.1. Science with interoperable data schools

Re-usability, besides its metadata implications, also requires a community of users that are aware of standards and tools. ESCAPE CEVO continues the sequence of Virtual

²Currently harvested records are visible at <http://b2find.eudat.eu/dataset?groups=ivoa>

³You can find them here: <https://github.com/msdemlei/cross-discipline-discovery>

Observatory schools in Europe that has been an integral part of the EuroVO projects. Gathering feedback from the community is a goal of these events alongside dissemination (see Jiménez-Esteban 2022, for details).

5. Software interoperability

FAIR principles and interoperability are also useful guidelines for open solutions to discover, re-use and interoperate software and services. Open-source scientific Software and Service Repository (OSSR, ESCAPE WP3) activities include easing publication and integration of these non-data resources. Work moves from code versioning on to subsequent publishing in dedicated repositories (like Zenodo and Docker Hub) and, finally, integration in the EOSC marketplace. Software interoperability is also investigated in terms of standardisation of the current heterogeneous scenario of environments and tasks (Jupyter notebooks, containers and other) that differ in terms of interfaces, behaviour, configuration, authentication. Identifying a minimal set of common functionalities, trying to constrain the interfaces require test implementations to help in answering the first questions in interoperability of these environments⁴.

6. Connection to other projects, initiatives

Connections that ESCAPE members are making with other projects and initiatives help in keeping interoperability alive across domain boundaries (project, system or geographical). Among these connections are worth mentioning that with the FAIRsFAIR project, with contributions to activities in turning FAIR principles into reality, and with FREYA project, including discussion on Persistent identifiers usage starting from the experience of IVOA IDs. Part of the activities have been also testing and discussion at RDA level about the FAIR Data Maturity Model and the proposed metrics connected, and the participation to LISA conference to report stewardship, curation and publication related to the ESFRI archives.

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⁴For basic concepts see <https://wiki.ivoa.net/internal/IVOA/InterOpMay2021SPW/20210527-IVOA-canidothis.pdf>