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Project Title	**Connected Open Identifiers for Discovery, Access and Use of Research Resources**
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D2.3 PID Services Registry

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Abstract	This report describes the online registry of PID-related services that has been developed by the FREYA project. It discusses the context, presents the technical decisions and bases for the work, and lists the initial content of the registry.
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FREYA project summary

The FREYA project iteratively extends a robust environment for Persistent Identifiers (PIDs) into a core component of European and global research e-infrastructures. The resulting FREYA services will cover a wide range of resources in the research and innovation landscape and enhance the links between them so that they can be exploited in many disciplines and research processes. This will provide an essential building block of the European Open Science Cloud (EOSC). Moreover, the FREYA project will establish an open, sustainable, and trusted framework for collaborative self-governance of PIDs and services built on them.

The vision of FREYA is built on three key ideas: the **PID Graph**, **PID Forum** and **PID Commons**. The PID Graph connects and integrates PID systems to create an information map of relationships across PIDs that provides a basis for new services. The PID Forum is a stakeholder community, whose members collectively oversee the development and deployment of new PID types; it will be strongly linked to the Research Data Alliance (RDA). The sustainability of the PID infrastructure resulting from FREYA beyond the lifetime of the project itself is the concern of the PID Commons, defining the roles, responsibilities and structures for good self-governance based on consensual decision-making.

The FREYA project builds on the success of the preceding THOR project and involves twelve partner organisations from across the globe, representing PID infrastructure providers and developers, users of PIDs in a wide range of research fields, and publishers.

For more information, visit www.project-freya.eu or email info@project-freya.eu.

Executive summary

The FREYA project is building up human and technical resources to support persistent identifier (PID) infrastructure in the European Open Science Cloud (EOSC). One important gap identified during the planning of the project is the lack of a central resource that allows for the discovery of relevant persistent identifier services by all relevant stakeholders. With this deliverable we are closing this gap by providing a PID Services Registry for the EOSC with initially 35 services described.

The PID Services Registry collects standardized information aligned with the EOSC Marketplace, and registers a persistent identifier (a DataCite DOI) with associated metadata for each service. The initial release describes the services provided by FREYA partners, but going forward additional relevant PID services from beyond FREYA will be included, based on standard inclusion criteria and an editorial team from FREYA partners.

The other focus of work going forward is adoption by users, both infrastructure providers needing to integrate with the variety of PID services available today, as well as researchers and other end users.

Service Registries for EOSC are a highly dynamic area that has changed since the beginning of the FREYA project. The two significant contributions FREYA can provide are (a) the technical infrastructure to register services with PIDs and standardized metadata, and (b) the strong connections of FREYA partners with the rest of the PID community, ensuring that PID service providers, infrastructure providers using PIDs, and end users all take advantage of this new PID Services Registry.

Contents

1 Introduction

The persistent identifier (PID) community is built around PIDs for scholarly resources that are provided by a number of organizations via **PID services**. Additional PID services link and integrate these PIDs together, e.g. publication of a journal article where the metadata may include PIDs for the article itself, the references, the authors, the affiliations of these authors, the data and software used for the findings reported in the article, and the funding. This is the basis for FREYA's vision of the **PID Graph**.

One important gap in this infrastructure of existing PID services is the discoverability of available services. It cannot be assumed that all interested parties have a high level of knowledge of about the available PID services. During the FREYA project, we have for example launched four new PID services as production infrastructure (including the PID Services Registry itself).

This work is founded on the EOSC PID Policy that is currently under consideration[1] and that will be finalized by the end of 2020. The policy defines persistent identifiers as identifiers that support and enable research that is FAIR, and that are **globally unique**, **persistent**, and **resolvable**. A PID Service is defined as:

1. A service that works with persistent identifiers as defined in the EOSC PID Policy
2. A service that provides one or more of the following:
    a. Registration of PIDs
    b. Lookup of PIDs and returning metadata, optionally in multiple formats
    c. Linking of different scholarly resources via their respective PIDs
    d. Communication, Training, and Engagement around PIDs
    e. Other services where the persistent identifier is essential for the function of the service
3. A service that is operating in a production environment (Technology Readiness Levels 8 or 9)

The PID Services Registry provides a single web-based resource to discover relevant PID Services, simplifying the process to find relevant PID-related services for researchers and other end-users. The PID Services Registry described here is part of the European Open Science Cloud (EOSC) and the first public version has been launched in June 2020. Going forward the focus will be on service adoption, in terms of:

1. Adding additional PID services relevant to users of the European Open Science Cloud.
2. Raising the awareness of the service to make sure it gets widely used.
3. Adapting the information provided and user interface based on feedback collected.

Formally, the PID Services Registry is a FREYA project deliverable of type "Other" (representing software), but this report accompanies the deliverable to describe the system and provide context and discussion.

[1] Hellström, M., Heughebaert, A., Kotarski, R., Manghi, P., Matthews, B., Ritz, R., Conrad, A. S., Weigel, T., & Wittenburg, P. (2020). Second draft Persistent Identifier (PID) policy for the European Open Science Cloud (EOSC) (Version 2.0). Zenodo. https://doi.org/10.5281/ZENODO.3780423

2 Technical implementation

2.1 Service registration using DataCite DOIs

To ensure discoverability and persistence of the PID services in the PID Services Registry, we used PIDs with associated metadata to describe each service. We decided to use DataCite DOIs, as they include "Service" as one of 15 high-level *ResourceTypeGeneral*, and many of the DataCite DOI metadata properties allow the description of relevant information about the services. The DOI resolution functionality of the underlying Handle system resolves the service DOIs to the service endpoint.

PID Service registration can reuse existing infrastructure for service registration and service discovery, enabling for example the distribution of this service information to other indexing services via existing DataCite GraphQL and REST APIs. We created a new central virtual repository to manage the DOIs and metadata of the PID services we register in FREYA; the repository identifier for this is *DATACITE.SERVICES* as DataCite is primarily responsible for the services registry.

2.2 Metadata mapping

The DataCite metadata schema[2] defines *service* as one of 15 allowed *resourceTypeGeneral*, and much information regarding PID services can be mapped to the DataCite metadata schema.

In addition, while considering the data to store regarding services, we worked with members of the EOSC-Hub project to align the metadata we collect with the EOSC Marketplace[3] template which collects information on services to be registered there. We discovered that we can map a proportion of required core fields but there would still be further work as the EOSC Marketplace template collects much more information than can be registered in DataCite DOI metadata, and some of this information is too specific to make sense for the kind of basic metadata applicable to different content types that are typical for DataCite metadata.

Table 1 shows the use of the metadata fields, with illustrative examples.

[2] DataCite Metadata Working Group. (2019). DataCite Metadata Schema Documentation for the Publication and Citation of Research Data v4.3. DataCite. https://doi.org/10.14454/7XQ3-ZF69
[3] https://marketplace.eosc-portal.eu/

Field	DataCite MetaData	Guidance	Example
ID	Identifier		https://doi.org/10.25495/xkya-0g76
PID Type	Subject	subjectScheme="PidEntity" with values of: Publication, Citation, Conference, Researcher, Organization, Data, DataRepository, Grants, Project, Experiment, Investigation, Analysis, Software, Computer Simulation, Software License, Equipment, Sample	Publication, Dataset, Software, Person, Organization, Funder, Repository, Instrument
Service Provider Name	Creator/CreatorName	creatorName with nameType=Organizational	DataCite
Service Provider URL	Creator/NameIdentifier	A ROR Identifier	https://ror.org/04wxnsj81
Service Name	Title	First title will be used	DataCite GraphQL API
Service Description	Description	First description will be used	The DataCite GraphQL API support queries of the DataCite API using the GraphQL query language. DataCite DOIs describe resources such as datasets, samples, software, and publications with rich metadata. An important part of this metadata is the description of connections between resources that use persistent identifiers (PIDs) provided by DataCite and others (Crossref, ORCID, ROR, ISNI, IGSN, etc.). Together these resources and their connections form a graph, the PID Graph.
Service Language	Language	ISO 639-1 language codes	en
Geographic Availability	GeolocationPlace	Worldwide, region e.g. Europe or ISO Country Codes	Worldwide

Service Tagline	Title	type="Subtitle"	Querying the PID Graph
Service Category	Subject	subjectScheme="ServiceCategory" with values of: Service & Discovery, Processing & Analysis, Compute, Storage, Data Management, Networking, Training and Support, Security and Operations	Service & Discovery
Service Tags	Subject	subjectScheme="ServiceTag"	
Scientific Fields	Subject	subjectScheme="Fields of Science and Technology (FOS)", values based on OECD[4]	Computer and information sciences

Table 1 Metadata mapping of important data used within the PID services registry

[4] http://www.oecd.org/science/inno/38235147.pdf

2.3 API

As the PID Services Registry uses DataCite DOIs, all DataCite APIs can be used as API backend:

- The REST and MDS APIs for PID service registration
- The REST, OAI-PMH and GraphQL APIs for retrieval of metadata about the registered PID service

As the number of PID services is small, and will never become extremely large, the easiest way to create and update PID service records is via the DataCite Fabrica web interface (which uses the REST API).

The DataCite GraphQL API that was built as part of the FREYA project allows users to make queries across all DOIs and other related identifiers. As part of the work on the PID Services registry we did additional work on the GraphQL API to ensure we could retrieve additional metadata that are useful for constructing the interface and displaying specific information; specific care went into ensuring we could retrieve facets for filtering based on various subject information.

A query is limited by specifying only *service* as *ResourceTypeGeneral* and in addition only those explicitly listed under *repositoryId* DATACITE.SERVICES. The API can be accessed via https://api.datacite.org/graphql which is also listed as a service within the PID services registry: https://pidservices.org/services/10.25495/xkya-0g76

```
query {
    services(first: 25, repositoryId: "datacite.services") {
        nodes {
            id
            doi
            titles {
                title
            }
        }
    }
}
```

Figure 1 Example PID services query

2.4 Front end

2.4.1 Interface design

The main goal of the front end interface for the PID Services Registry is to provide a searchable interface with the ability to apply relevant filters.

Initial design considerations were put together using ideas from other search portals including the EOSC Marketplace. We constructed a rough idea of how the site would be mapped and then mocked up wireframes to give us an idea of how to proceed, though the final product made some changes to better align styling with other FREYA outputs and final functionality.

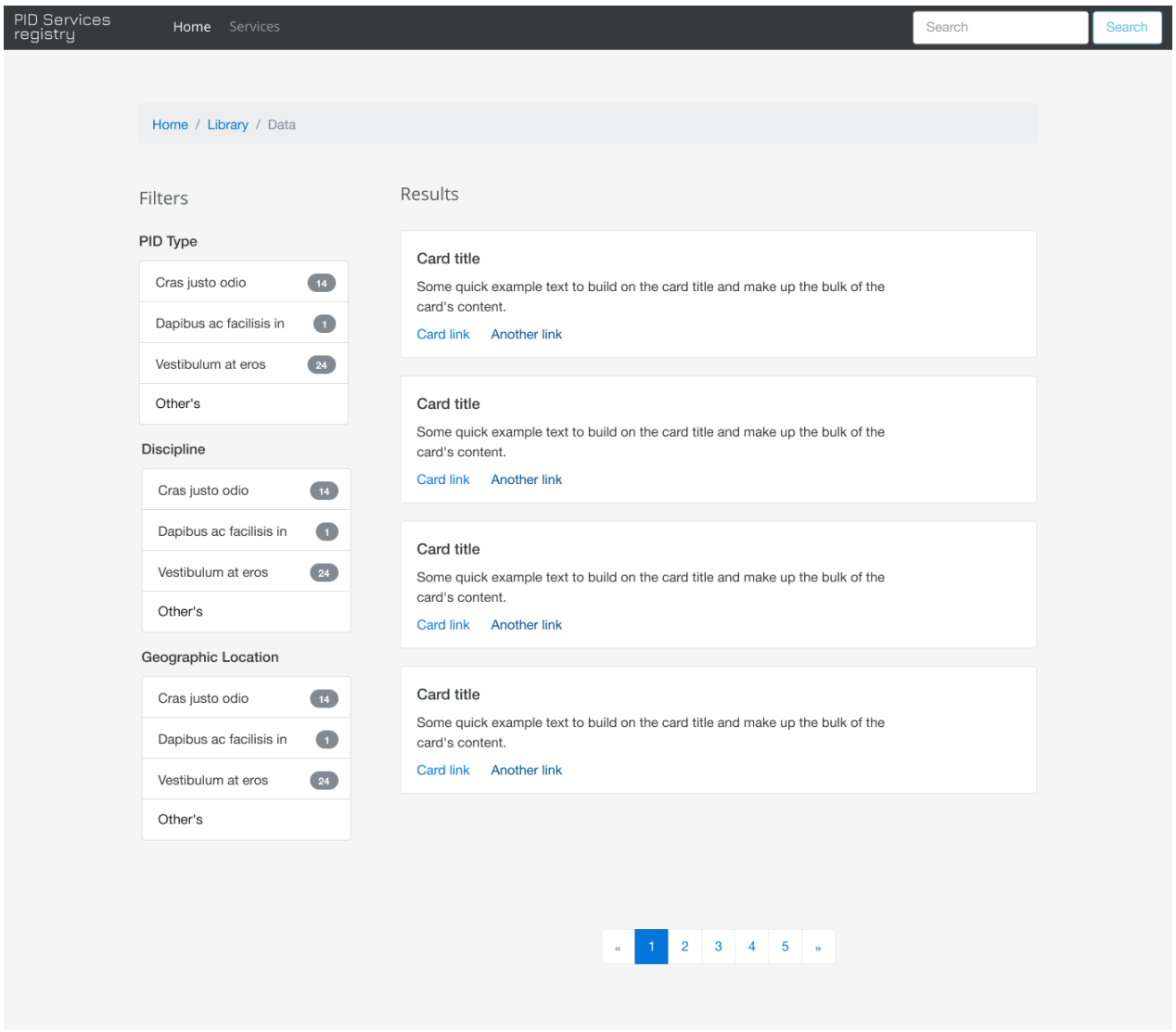

Figure 2 Search listing

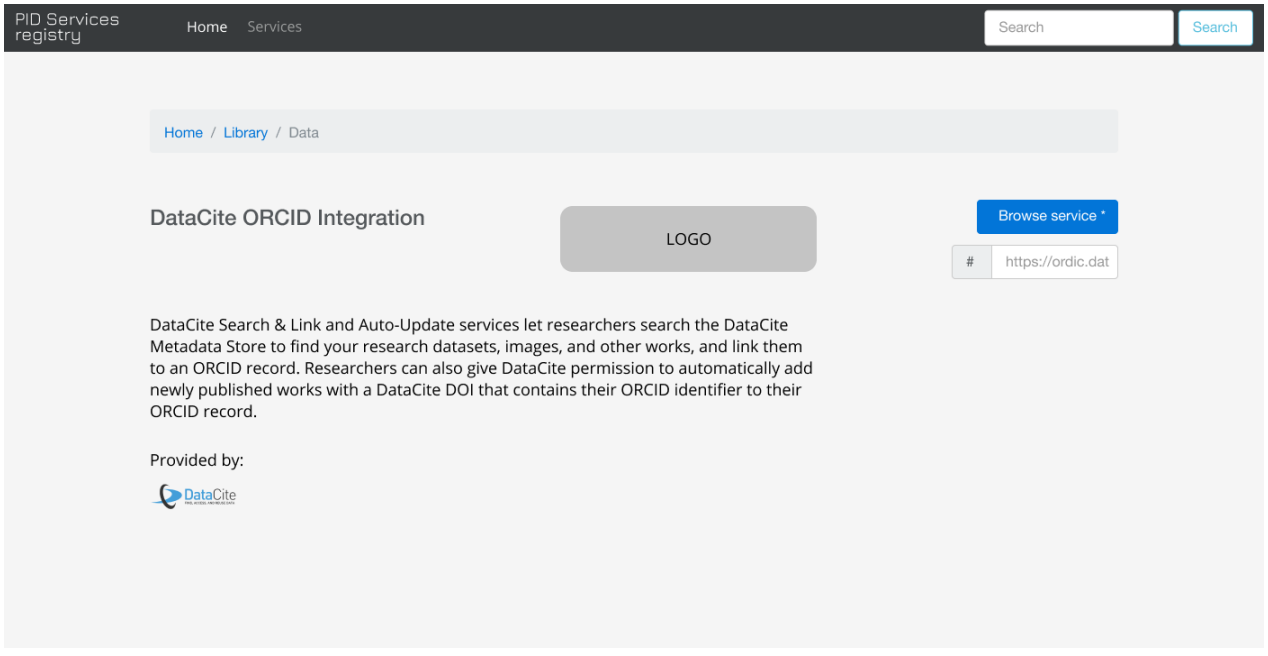

Figure 3 Search details view

2.4.2 Technology decisions

When assessing the technology to implement the PID Services Registry, we considered different front end technologies, with a focus on single page applications (SPAs). Two main technologies we assessed were React and Vue, both of which have been used by FREYA partners.

We decided upon using React as this is a modern framework with broad support and backing from different organizations, in addition it pairs well with the GraphQL technology of the API, offering a seamless development process.

2.4.3 Implementation

Using a react starter template[5], we constructed a base platform that could integrate with GraphQL, supported by the Apollo client library https://www.apollographql.com/docs/react/. We used the GraphQL API to perform full text queries as well as additional facet filtering by the related PID type and which disciplines they interact with. Services can be accessed via resolving through DOIs, links were added to both the search interface and the service detail page.

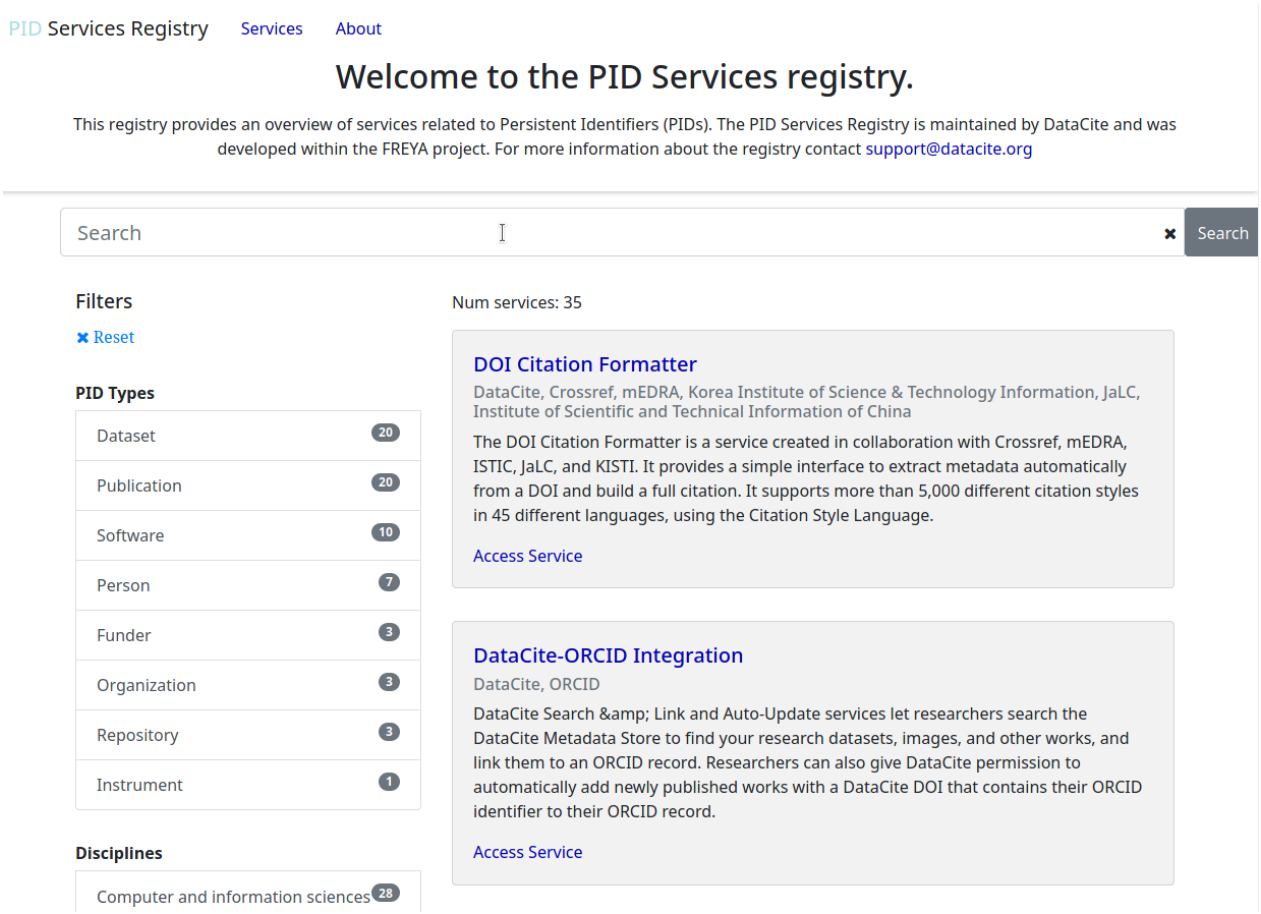

Figure 4 Search interface screenshot

[5] https://reactjs.org/docs/create-a-new-react-app.html

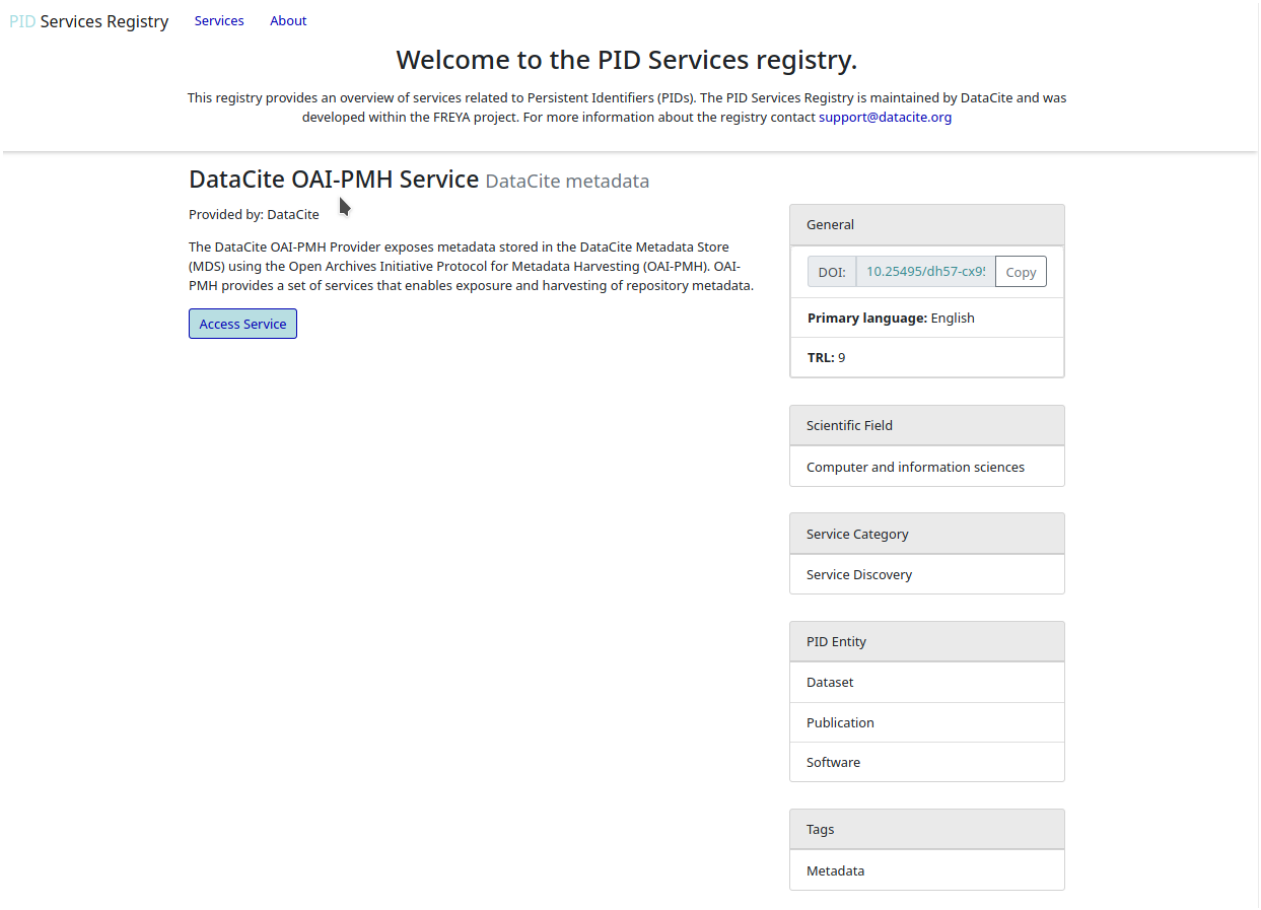

Figure 5 Service detail screenshot

2.4.4 Open Source licence

The front end code is open source, under the MIT License and available via https://doi.org/10.14454/e0f7-zs08[6] or directly at https://github.com/datacite/beagle. The DOI metadata acknowledges the FREYA funding. One of the side benefits of this publicly available source code is an additional demonstration of working with the GraphQL API to retrieve data from the FREYA PID Graph.

[6] Hallett, R., Fenner, M., & Fokianos, P. (2020). Beagle: the code for the FREYA PID Services Registry (Version 1.0.3) [Computer software]. DataCite. https://doi.org/10.14454/E0F7-ZS08

3 Results

The initial version of the service released in June 2020 includes 35 PID services from FREYA partners, all listed in Annex A.

As seen in Figure 4, the service covers a variety of PID entities, including 20 entries for dataset and publication, and 10 for software. Not surprisingly—given that the registry only includes services with TRL8 or TRL9—new PID entities such as research organizations and instruments, are less frequent. All entries currently in the registry have the participation of at least one FREYA partner, with a significant number of services run jointly by more than one organization.

Services listed include both services from PID providers such as ORCID or Crossref, as well as services by FREYA disciplinary partners such as CERN that make heavy use of PIDs.

The registry only includes services with Technology Readiness Level (TRL) 8 or 9, and only a small number of services in discipline-specific, e.g. five services for the physical sciences and three services for the biological sciences. Almost all services are for a worldwide audience, which is not surprising given that PIDs are usually globally unique identifiers with a global audience.

4 The future

4.1 Adoption

After the launch of the PID Services Registry we will now approach other PID Service Providers, to also include them in the PID Services Registry. This includes both PID Service Providers in EOSC, as well as other PID Providers, e.g. outside of Europe. Until the end of the FREYA project this will be a collective effort by the partners involved in the WP2 work, i.e. PANGAEA, EMBL-EBI and DataCite, together with the Engagement Team in WP5.

In parallel we will also look at usage of the service and user feedback provided via FREYA webinars and the PID Forum. Going forward we will adjust the functionality of the registry based on this user feedback. By the end of the FREYA project in November 2020, and in coordination with WP6 Sustainability, we will have developed a process for maintaining the PID Services Registry, and a governance model regarding the future direction of the service.

We are tracking the usage of the PID Service Registry. This allows us to track two Key Performance Indicators for service adoption:

1. Number of services registered in the PID Services Registry
2. Number of monthly users accessing the service

4.2 EOSC coordination

The PID services registry has been developed with consideration of the various existing EOSC projects, namely the EOSC hub and associated marketplace. The system has been developed (where possible) to align the data for PID services with these projects (see metadata section above).

In addition, partners manually submitted their PID services to the EOSC hub via the existing forms. We used the information submitted to the EOSC hub to complete the data and register service in the PID Services Registry (https://pidservices.org/).

We will continue to engage with EOSC stakeholders to find ways that the PID Services Registry can be coordinated with related EOSC activities, including the EOSC Portal and Marketplace[7], either via direct API integration or aligning data and sharing links between portals. This will be dependent on future plans for service registries within EOSC, and interest in the use of PIDs to register EOSC services, where the FREYA PID Services Registry is the first example implementation at TRL8 of this approach.

4.3 Sustainability of the service

For FREYA both the API and the front end are built and maintained by DataCite, the technology involved for the site ensures a cost effective and easy to maintain site and DataCite is committed to supporting this service beyond FREYA along with the API.

DataCite has listed all its services in the PID Service Registry and will integrate the Service Registry into the DataCite infrastructure to facilitate the discovery and use of PID services. Decisions about PID services included in the Registry and overall governance will be provided by a group of organizations, with the process decided by the end of the FREYA project in November 2020.

[7] https://marketplace.eosc-portal.eu/

Annex A: Registered services in FREYA PID Services Registry as of June 2020

Service Name	Service Providers	Service Description
DOI Citation Formatter https://doi.org/10.25495/t300-g895	DataCite, Crossref, mEDRA, Korea Institute of Science & Technology Information, JaLC, Institute of Scientific and Technical Information of China	The DOI Citation Formatter is a service created in collaboration with Crossref, mEDRA, ISTIC, JaLC, and KISTI. It provides a simple interface to extract metadata automatically from a DOI and build a full citation. It supports more than 5,000 different citation styles in 45 different languages, using the Citation Style Language.
DataCite-ORCID Integration https://doi.org/10.25495/70rz-nv40	DataCite, ORCID	DataCite Search & Link and Auto-Update services let researchers search the DataCite Metadata Store to find your research datasets, images, and other works, and link them to an ORCID record. Researchers can also give DataCite permission to automatically add newly published works with a DataCite DOI that contains their ORCID identifier to their ORCID record.
Registry of Research Data Repositories (re3data) https://doi.org/10.25495/vtta-vn25	Karlsruhe Institute of Technology, Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences, Humboldt University of Berlin, Purdue University West Lafayette, DataCite	re3data.org is a global registry of research data repositories that covers research data repositories from different academic disciplines. It presents repositories for the permanent storage and access of data sets to researchers, funding bodies, publishers and scholarly institutions. re3data.org promotes a culture of sharing, increased access and better visibility of research data.
DataCite OAI-PMH Service https://doi.org/10.25495/dh57-cx95	DataCite	The DataCite OAI-PMH Provider exposes metadata stored in the DataCite Metadata Store (MDS) using the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH). OAI-PMH provides a set of services that enables exposure and harvesting of repository metadata.
DataCite DOI Registration Service https://doi.org/10.2549	DataCite	In order to create new DOIs and assign them to your content, it is necessary to become a DataCite member or work with one of the current members. Through the Fabrica web interface or of the DataCite APIs (REST, MDS,

5/wx3s-fz46		or EZ API) you will be able to submit a DOI name, a metadata description following the DataCite Metadata Schema and an URL for the object described by DOI metadata. Once created, information about this DOI is available through a variety of DataCite different services, as well as via the services of other organizations.
DOI Content Negotiation https://doi.org/10.25495/c48c-vx78	DataCite, Crossref, mEDRA, Korea Institute of Science & Technology Information, JaLC, Institute of Scientific and Technical Information of China	DOI content negotiation allows you to retrieve DOI metadata from most DOI Registration Agencies in different formats. A content negotiated request to a DOI resolver is very similar to a standard HTTP request, but based on the list of acceptable content types.
PID Services Registry https://doi.org/10.25495/yw94-sp56	DataCite	This registry provides an overview of services related to Persistent Identifiers (PIDs). The PID Services Registry is maintained by DataCite and was developed within the European Commission-funded FREYA project.
DataCite Profiles Service https://doi.org/10.25495/2cha-z969	DataCite	DataCite Profiles integrates DataCite services from a user's perspective and provides tools for personal use. In particular, it is a key piece of integration with ORCID, where researchers can connect their profiles and automatically update their ORCID record when any of their works with a DataCite DOI include their ORCID ID in the metadata.
DataCite Statistics https://doi.org/10.25495/5a6j-1h22	DataCite	DataCite provides statistics for both DOI registrations and DOI resolutions, filtered by Member, Repository or Prefix via our DataCite Statistics service. Registration statistics relate to datasets that have been uploaded and received a DataCite DOI, while resolution statistics provide information on how often a DOI has been used to access a dataset.
DataCite Search https://doi.org/10.25495/1fk6-4p20	DataCite	DataCite search is a web interface where you can explore the complete collection of publicly available DataCite DOIs. You can search, filter, cite results, push them to your ORCID profile, and more.

DataCite GraphQL API https://doi.org/10.25495/xkya-0g76	DataCite	The DataCite GraphQL API supports queries of the DataCite API using the GraphQL query language. DataCite DOIs describe resources such as datasets, samples, software, and publications with rich metadata. An important part of this metadata is the description of connections between resources that use persistent identifiers (PIDs) provided by DataCite and others (Crossref, ORCID, ROR, ISNI, IGSN, etc.). Together these resources and their connections form a graph, the PID Graph.
DataCite DOI Provenance API https://doi.org/10.25495/x8j5-z806	DataCite	Metadata provenance is describing the history of a particular DataCite DOI metadata record, i.e. what changes were made when and by whom. This information is stored and provided via an API for all DataCite DOI registrations since March 2019.
DataCite Usage Reports API https://doi.org/10.25495/gt9s-5p78	DataCite	The DataCite Usage Reports API allows repositories to deposit data usage metrics with DataCite that are made available via the DataCite REST and GraphQL APIs. These usage reports need to follow the COUNTER Code of Practice for Research Data, and the SUSHI protocol for reporting.
Crossref/DataCite Event Data https://doi.org/10.25495/ea8f-q646	Crossref, DataCite	Event Data is a joint service by Crossref and Datacite to collect and expose links to Crossref and DataCite DOIs. For DataCite DOIs Event Data provides links to other DOIs from DataCite, Crossref, or other DOI registration agencies, as well as usage statistics sent to DataCite as usage reports. The DataCite REST and GraphQL APIs provide a query API for the Event Data service, and allows users to retrieve events filtered by DOI or DOI prefix, source of the event, relation type of the event, and/or year and month the event occurred. Event Data is powering the Scholix API provided by Crossref.
HEPData https://doi.org/10.25495/7tyd-6c29	Durham University, European Organization for Nuclear Research	HEPData is a unique open-access repository for publication-related data in the field of High-Energy Physics with a long history going back to the 1970s. It currently comprises the data points from plots and tables related to several thousand publications including

		those from the Large Hadron Collider. The HEPData service is operated by Durham University (UK) in partnership with CERN (Switzerland).
INSPIRE https://doi.org/10.25495/c4ry-b522	European Organization for Nuclear Research	INSPIRE is a trusted community hub that helps researchers to share and find accurate scholarly information in high energy physics.
CERN Open Data Portal https://doi.org/10.25495/mk0f-y192	European Organization for Nuclear Research	The CERN Open Data portal hosts more than two petabytes of collision, simulated and derived datasets, accompanied with configuration files, documentation, virtual machines and runnable analysis examples that were released into the public domain by the LHC and other particle physics related experiments.
CDS (CERN Document Server) https://doi.org/10.25495/rt3a-0b29	European Organization for Nuclear Research	The CERN Document Server (CDS) is CERN's institutional repository that provides archival, search and collaborative tools to manage collections of documents produced at CERN. The collections include HEP documents, Multimedia documents, Bulletins, Administrative (Directorate, HR, Finance) documents, EU Project documents (OpenAire, EMi), Library and Project document types, among others.
NARCIS - National Academic Research and Collaborations Information System https://doi.org/10.25495/0cwj-cd03	Data Archiving and Networked Services	NARCIS aggregates research information metadata in the Netherlands. Within NARCIS different content types (publications, datasets, research projects, researchers and research organisations) are connected by persistent identifiers (PIDs) and by linking these items NARCIS shows research in context.
Dutch National URN:NBN Resolver https://doi.org/10.25495/ax1f-gm29	Data Archiving and Networked Services	Within the Dutch research Research Information infrastructure, universities and other major research institutes use an URN:NBN to identify objects in their institutional repositories. The Dutch National Library (KB) archives all objects for long term preservation purpuse. Plans are made to put both locations (local and KB) in the National Resolver to guarantee persistent access.

PANGAEA https://doi.org/10.25495/sh9r-dm82	Alfred Wegener Institute For Polar And Marine Research, Marum	The information system PANGAEA is operated as an Open Access library aimed at archiving, publishing and distributing georeferenced data from earth system research. The system guarantees long-term availability of its content through a commitment of the hosting institutions. Most of the data are freely available and can be used under the terms of the license mentioned on the data set description. A few password protected data sets are under moratorium from ongoing projects. The description of each data set is always visible and includes the principle investigator (PI) who may be asked for access.
ROR (Research Organization Registry) https://doi.org/10.25495/4308-7v56	Crossref, DataCite, California Digital Library	The Research Organization Registry is a community-led project to develop an open, sustainable, usable, and unique identifier for every research organization in the world.
Identifiers.org Central Registry https://doi.org/10.25495/y1ev-9337	European Bioinformatics Institute	The Identifiers.org Central Registry service provides a centralized directory of Compact Identifiers. This information is used by the Identifiers.org Resolution Service, which provides consistent access to life science data using Compact Identifiers. Compact Identifiers consist of an assigned unique prefix and a local provider designated accession number (prefix:accession). The Identifiers.org Registry also makes it possible for review and curation of its information.
Identifiers.org Resolution Services https://doi.org/10.25495/zeke-px83	European Bioinformatics Institute	The Identifiers.org Resolution Service provides consistent access to life science data using Compact Identifiers. Compact Identifiers consist of an assigned unique prefix and a local provider designated accession number (prefix:accession). The resolving location of Compact Identifiers is determined using information that is stored in the Identifiers.org Registry.
The PID Forum https://doi.org/10.25495/fxd6-ba56	Data Archiving And Networked Services, British Library, DataCite	The PID Forum is a global information and discussion platform about persistent identifiers (PIDs). The PID Forum aims to bring together the various communities working with PIDs in the research world. It's a virtual place to share best practices,

		announce events, ask questions and have discussions about PIDs. The PID Forum was initiated by the FREYA project which is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 777523.
Crossref Metadata Retrieval https://doi.org/10.24495/jsz0-9275	Crossref	The collective power of our members' metadata is available to use through a variety of tools and APIs—allowing anyone to search and reuse the metadata in sophisticated ways.
Crossref Metadata Plus https://doi.org/10.24495/ydbw-bk33	Crossref	Metadata Plus gives you enhanced access to all supported Crossref APIs, guarantees service levels and support, and additional features such as snapshots and priority service/rate limits. To use Metadata Plus, an optional paid-for service, you do not need to be a Crossref member.
Crossref Content Registration https://doi.org/10.24495/svpr-dm22	Crossref	Content registration allows members to register and update metadata via machine or human interfaces. When you join Crossref as a member you are issued a DOI prefix. You combine this with a suffix of your choice to create a DOI, which becomes active once registered with Crossref. Content registration allows members to register a DOI and deposit or update its associated metadata, via machine or human interfaces.
Crossref Reference Linking https://doi.org/10.24495/8q6n-ga35	Crossref	Reference linking enables researchers to follow a link from the reference list to other full-text documents, helping them to make connections and discover new things. To link references, you don't need to be a Crossref member. Reference linking means including Crossref DOIs (displayed as URLs) when you create your citation list. This enables researchers to follow a link from a reference list to other full-text documents, helping them to make connections and discover new things. And because it's a DOI rather than just a link, it will remain persistent.
Crossref Funder Registry https://doi.org/10.2549	Crossref	The Funder Registry and associated funding metadata allows everyone to have transparency into research funding and its

5/yvpt-e759		outcomes. It's an open and unique registry of persistent identifiers for grant-giving organizations around the world.
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Repository Finder https://doi.org/10.2549	DataCite, Karlsruhe Institute of Technology, American Geophysical Union	Repository Finder can help you find an appropriate repository to deposit your research data. You can find repositories by searching by keywords or using the list of

5/gq9a-pb90		repositories recommended by the Enabling FAIR Data Project or FAIRsFAIR Project.
ORCID iDs https://doi.org/10.25495/fdpp-vg79	ORCID	ORCID provides an open registry of persistent identifiers for individuals. These identifiers can be used in all stages of the research process and interconnected with other identifiers (for research production, institutions, funders, etc.).