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RO-Crate community update 2024

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Here we give an update of the community development and adoption of RO-Crate for FAIR Digital Object since FDO2022. It is notable that programmatic access and more detailed profiles have received high attention, as well as several FDO implementations that use RO-Crate.

RO-Crate community

The [RO-Crate community](#) supports and promotes FAIRification of research outcomes and provides tools for researchers to improve FAIRness. RO-Crate [[Soiland-Reyes 2022](#)] makes it easy to package research outcomes in the form of digital objects together with their corresponding metadata, using and extending [schema.org](#) to describe an RO-crate package as a dataset and all its elements (i.e, research outcomes). Thanks to the use of [profiles](#), researchers can choose a description that suits best to their needs. A [Profile Crate](#) provides a specification including types and properties tailored to a specific domain and or community.

Workflows and provenance

Workflow Run RO-Crate [[Leo 2023](#)] is a set of three RO-Crate profiles to capture the provenance of computational workflow execution: [Process Run Crate](#), which deals with possibly composite computations not necessarily described by a formal workflow; [Workflow Run Crate](#), which extends Process Run Crate with specifications to represent computations orchestrated by a workflow; [Provenance Run Crate](#), which extends Workflow Run Crate with guidelines on how to represent the execution of the various tools used by the workflow. The profiles are developed by a working group that includes workflow developers and users, workflow engine developers and users and other members interested in the provenance of workflow execution. Workflow Run RO-Crate is already implemented by six workflow engines: Galaxy, COMPSs, StreamFlow, WfExS-backend, Sapporo and Autosubmit, enabling interoperable comparisons between heterogeneous workflow executions.

[LivePublication](#) [[Ellerm 2023](#)] is a proof of concept of an *executable paper*, which interactive visualization and statistical calculations can be regenerated on the fly taking into consideration data sources updated after the paper's publication date. Here RO-Crate enables execution on the Globus infrastructure through an innovative use of individual RO-Crates and containers for each computable element of the paper, nested within a top-level Crate for the paper. This novel approach shows how it is possible to use RO-Crate as a machine-actionable object, which do not rely on bundling an underlying workflow representation in an existing workflow language.

TRE-FX and TREs

Trusted Research Environments (TREs) are used to provide computational analysis access to sensitive data. An architecture for federated analytics running workflows across such TREs [[Giles 2023](#)] developed the [Five Safes Crate](#) profile [[Soiland-Reyes 2023](#)], where the crate goes through manual and automatic review processes which are tracked within the crate and abstracts the workflow run requests so the federated analytics APIs are interoperable across different workflow engines.

RO-Crate and FDO

RO-Crate has previously been proposed as a mechanism for implementing FDO [[Castro 2023](#)], in particular for metadata FDOs. The FAIR Digital Object approach fosters self-contained and machine actionable knowledge units which persistently bind necessary contextual metadata and typed operation semantics to enable processing of their actual content across different data spaces

[[Wittenburg 2023](#)]. In addition to the common development plan for FDOs leveraging i.a. on components such as Handles acting as PIDs resolving to an FDO Record and the Digital Object Interface Protocol (DOIP) for interacting with FDOs [[Blanchi 2023](#), [DONA 2018](#)], an implementation path for web-based or “webby” FDOs has been proposed building on common web technologies involving on top of RO-Crates the provision of structured metadata with schema.org and its extension [Bioschemas](#) [[Gray 2017](#)], and the modelling of typed relationships (links) between resources with [FAIR Signposting](#) [[Soiland-Reyes 2024](#)].

Distributed FDO architectures

The [DeSci Nodes](#) system has developed a concept *Distributed Persistent Identifier* ([dPID](#)) which act as an overlay of Interplanetary File System (IPFS). APIs for the DeSci use detached RO-Crates with dPID references. This is a novel FAIR Digital Object implementation that challenges both the traditional centralised FDO approach using the Handle system, as well as the mostly Web-based RO-Crate ecosystem.

Using the Crate-O editor and building ad-hoc vocabularies

The [Crate-O](#) tool has been developed by Language Data Commons of Australia ([LDaCA](#)) as a general-purpose RO-Crate editor as a successor or alternative to [Describo](#). This Chrome browser-based tool can describe any local folder with resources from the Web as an RO-Crate, supporting any schema.org type and property, pluggable with other rdfs vocabularies. A mode file selection indicates recommended and required properties; mode files combine schema information on classes, properties and defined terms, with RO-Crate profile rules on how they may be defined. Notably this tool is also intended for creation of such “ad-hoc” vocabularies without need of Semantic Web, and is effectively a lightweight user interface for building [Profile Crates](#) using “Schema.org style Schemas” (SOSs). There are a number of [tools](#) associated with Crate-O which can create HTML documentation and Crate-O mode files from SOSs and infer schemas from example documents.

LDaCA

The Language Data Commons of Australia Program ([LDaCA](#)) contributes to cultural heritage preservation by recording Australian Indigenous languages, regional languages of the Pacific, and Australian English, and making such records and annotations publicly available. LDaCA [uses RO-Crate](#) as an interchange and archive format for language data, and is providing data discovery portals and API access to data using RO-Crate-centric APIs. For instance, the [LDaCA data portal](#) uses [detached RO-crates](#) for FDO-style navigation of centralised API resources.

Dataverse

In the research data repository software [Dataverse](#) [[Trisovic 2023](#)], [RO-Crate support](#) is implemented by multiple plugins. The [AROMA](#) (ARP RO-Crate Manager) [[Zoltán 2023](#)], used by Hungarian repository [CONCORDA](#), extends Dataverse for dynamic metadata editing using the Describo Crate Builder Web component. A [FAIR-IMPACT support action](#) in 2023 saw community development of import, [export](#) and [preview](#) plugins for RO-Crate in Dataverse, and [also](#) for the Electronic Lab Notebook format ([ELN](#), which is based on RO-Crate).

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