Dear Editor,

First, we thank the reviewers for their insightful feedback and appreciate their positive response to the article. We detail below our response to each reviewer's specific comments. Their comments are highlighted in italics with our response below.

We look forward to your further consideration of the article.

Regards,

Stian Soiland-Reyes, Prof. Carole Goble, Prof. Paul Groth

2023-11-16

Reviewer 1

R1-C1: The only comment refers to "to form an ecosystem of rich digital objects" – it would be suggested to elaborate on what "rich" DO stands for, i.e. while this can be understood by the community, it should be suited for other communities as well, as well as it is always beneficial to set a common ground of understanding of the used terms.

We agree that "rich" is not well defined. In our Introduction we briefly explained the vision that is defined in the EOSC Interoperability Framework:

> "The EOSC Interoperability Framework puts particular emphasis on how interoperability can be achieved technically, semantically, organisationally, and legally -- laying out a vision of how data, publication, software and services can work together to form an ecosystem of digital objects that are extensively described by connecting to range of information ranging from protocols and presentations to hardware designs and scientific workflows including extensive metadata for all this information.."

We now modified the Introduction to avoid "rich digital objects":

> "ecosystem of digital objects that are extensively described. Such description for interoperability connect a range of information – from protocols and presentations, to hardware designs and scientific workflows, including extensive metadata of the information itself."

R1-C2: It would be beneficial to conclude the Introduction with a brief section-based overview.

We have added an overview as follows:

> "The rest of this paper is organised as follows: We begin with a background primer on FDO and Linked Data to provide a foundation for the work. In the Methods section, we introduce the conceptual frameworks we use for comparison. Subsequently, in the Results section, we systematically step through the outcomes of applying these frameworks to both FDO and Linked Data. For each framework, we derive key observations. We end with a discussion of these results and their implications for both approaches and conclude."

R1-C2. "The premise of systematically building an ecosystem of such digital objects is to give researchers a way to organise complex digital entities, associated with identifiers, metadata, and supporting automated processing" – while it is definitely true, yet another point to be mentioned here for both buildings and maintaining such ecosystems is governance.

We've added the following to address governance with the authors suggested reference:

> "Recently, it has been noted that the practical use of FDOs to achieve interoperability requires governance in particular with respect to assessing such interoperability (M. Wilkinson et al. 2023)."

R1-C3. At the same time according to the community, incl. EOSC emphasize that DO can be more than a single object with the reference to IS that can also be considered as DO and hence FAIR principles should be followed for them as well. This would be yet another point I would expect to see.

We have addressed this in the introduction and added the following to our discussion of FAIR digital objects:

> "As mentioned previously, this ecosystem is envisioned to consist of a wide variety of digital entities and contextual information ranging from software to articles to even descriptions of experimental infrastructures (Azeroual et al. 2022)."

R1-C4. When referring to RDA, GO-FAIR, EOSC etc. I would suggest adding the relevant references for the sake of simplicity for the reader to access them easily – these could be footnotes

These links are embedded in the PDF on first mention (e.g. you can click on the organizations). We think this makes the document less busy. We will clarify with PeerJ in typesetting phase how hyperlinks are rendered.

R1-C5: The "Next steps for FDO" section could benefit of restructuring into a general overview of the further steps with the reference to those documents or just listing them instead of referring to each of them..

We agree that this section was too long and was not focused on the key point. Hence, we have shortened the "Next steps for FDO" section and moved the listing of documents and their description to an appendix as a reference for the interested reader.

R1-C6. "As these documents clarify the future aims and focus of FAIR Digital Objects (Lannom, 100 Schwardmann, Christophe Blanchi, et al. 2022), we provide a brief summary of each" – please comment of how "each" was selected, i.e. whether they come from a single source? Or was this rather the result of the literature review or similar?

These documents stem from the official FAIR Digital Objects Forum outputs, as we discuss in the text and also cite as (FDO Specs 2022) which point to the overview https://fairdo.org/specifications/. The quoted sentence is now removed and the summaries moved to the appendix.

R1-C7. Table 3 – due to current deficiencies of the paper structure, referring the reader back and towards many times, it is not obvious what is the source of those guidelines aka requirements in the text in Table 3? Are they extracted from those documents reviewed before? Please specify and emphasize this clearly.

We clarified this in the text as follows:

> In Table 3 on the following page, we evaluate completeness of the guidelines in two current FDO realisations: 1) DOIPv2 (DOIPV2.0 2018) and 2) Linked Data Platform (Speicher et al.

2015), as proposed by Bonino da Silva Santos et al. (2022). We provide our analysis of each realisation with respect to the FDO Guideline and also provide suggestions for that realisation to meet the given guideline.

R1-C8. Table 3 evaluates completeness of the guidelines, however, while some detail regarding how this was conducted are provided, more detail would be expected on how this was actually done rather than referring the reader to external documents only. This would contribute to the replicability and reproducibility of the study. Also, whether the validity of both extraction of those guidelines/requirements and their assessment was conducted? How was this done? Or, if not, why it is not needed?

We have added a paragraph describing our approach to our method of analysis. Specifically, our approach is detailed reading of all associated specifications and consultation with technical specs associated with a realization in Linked Data or FDO to produce a mapping between each conceptual model and the given realization. The validity of our mapping can be verified through the traceability of our statements to the underlying specifications. The paragraph we added was as follows:

> "For all our comparisons, our process was to perform a mapping between the relevant specifications and/or implementation and the given conceptual model through detailed reading of the defining documents. We aim in all cases for traceability between the given specification and our mapping such that readers can validate our analysis."

R1-C9 "The FAIR principles (Mark D. Wilkinson et al. 2016) encourage sharing of scientific data…" – it is highly suggested to put the reference either at the end of the sentence, or, alternatively, rewording the sentence,

We have chosen to keep our approach to early citation when first introducing a concept.

R1-C10. "see Next steps for FDO on the following page" – instead of referring to another page, I would suggest referring the reader to the specific section. Please do so for other occurrences of the above as well.

This particular reference was removed after refactoring Next Steps, added citation (FDO Specs 2022).

We are unfortunately severely limited by the PeerJ house style not having section numbering, which makes cross-sectional navigation difficult or repetitive.

We encourage PeerJ CS editors to improve support for cross-referencing in the LaTeX template wlpeerj.cls, particularly in combination with the hyperref package so that such section* references can also be hyperlinked in the HTML rendering at PeerJ.

Due to the repetitive and distracting nature of title-based cross-references like "*Having considered FDO and the Web architecture as interoperability frameworks (section Considering FDO/Web as interoperability framework for Fast Data)*" we have now removed all section cross-references in the Discussion section.

Reviewer 2

R2-C1. For the reader a more precise description about the generality and specificity of the frameworks wrt. FAIRness would be helpful in order to get a better overview of the covered landscape. Whether additionally a rearrangement of the framework subsections in the Results section in an order of generality will improve readability should be left to the authors.

We added the following to point readers about the generality of the conceptual frameworks.

> "Conceptual framework 1, 3, 5 consider more general views of interoperability between systems, whereas frameworks 2 and 4 are developed specifically for addressing FAIR principles"

R2-C2 A missing aspect in the article is the role of profiles for FDOs.

> We added the following text to point out the importance of profiles however we wanted to focus on what was currently practice and hence did not delve into this in the comparisons.
>
> "Going forward a key strategy of the Forum is the use of profiles to help define specific attributes in metadata that are necessary for domains or application contexts. However, these are not yet fully implemented in the implementations considered here. "

R2-C3 It would be advantageous for the reader to easily recognize the conclusions drawn from the deeper analysis along each of the five frameworks, because these conclusions are the main guidelines for improvements.

We agree and have added a headline for each “Observations” subsection for the conceptual frameworks, to better demarcate our analysis conclusions.

R2-C4 Typos

We have fixed all the identified typos.