The sciebo.RDS Project: Who Says Research Data Management Has to Be Complicated?

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1. ABSTRACT

The project “sciebo Research Data Services (sciebo.RDS)” aims to create easy-to-use, integrated research data management (RDM) workflows for scientists. Based on the established cloud storage service "sciebo", we will develop tools and interfaces that serve this purpose optimally. In concrete terms, tools for creating data management plans, tools for data analyses, and repositories for long-time archiving have to be connected and integrated. The project is oriented towards specific use cases, especially from the humanities, and always closely aligned to the users’ needs.

2. STATUS QUO OF RESEARCH DATA MANAGEMENT

Against the background of the rapidly advancing digitalization of research in numerous disciplines, the importance of and the need for structured RDM can hardly be overestimated. For good reasons, the value of research data depends enormously on whether there is a data management plan with information about how to use the data, whether the data is organized, structured, and clearly named, and whether it is stored securely, accessible and searchable.

However, such an enhancement of research data through metadata comes at a price: It requires a lot of work and resources. But most scientists at universities have neither the time nor the skills for RDM by the book. Due to the fact that several unconnected systems have to be used at the moment, RDM is not only a complex and demanding task, but also tedious due to redundant work. It is hardly surprisingly that this results in a very low implementation rate in practice, as several studies have shown (Sayogo & Pardo, 2013; Savage & Vickers, 2009; Koslow, 2002).

At Münster University, a survey among researchers from various disciplines was conducted in 2014 to find out how digital research data is handled and which requirements have to be met by prospective RDM services (Herwig, Vogl & Rudolph, 2014). The study provides insights into the research practice of the respective departments, e.g. data collection (collection methods, data sources), data quality (formats, volumes), responsibilities and archiving (storage purpose and duration, storage locations and backup copies). The results show that scientists are very interested in RDM issues, but at the same time there is little evidence of active RDM processes. In addition, the study identifies differences between the disciplines. A review of the situation in North Rhine-Westphalia also shows that there are major shortcomings with regard to a professional RDM that complies with the recommendations of the German Research Foundation (DFG) (DV-ISA, 2016). This is due in particular to the lack of easy-to-use tools. To solve this problem, a simplification of the process is necessary and this is exactly where sciebo.RDS starts.

3. SCIEBO RESEARCH DATA SERVICES

The idea of sciebo.RDS is to develop a low-threshold approach to the management of research data that is clearly designed as a service for scientists. The project aims to significantly reduce the effort for RDM processes, to increase the acceptance of professional RDM, and to meet the increased requirements of third-party funders and sponsors. It does not focus on the creation of completely new services, but on the development of a management suite with an easy-to-use interface for flexible integration and coupling with existing services and systems. The sciebo.RDS project will initially be funded for three years by the German Research Foundation (DFG).

Technically, sciebo.RDS is embedded in the cloud storage service “sciebo”, which is based on the open source product ownCloud and has been operated jointly by about 30 universities and research facilities since 2015. This integration has two major advantages: First, sciebo is already used by more than 100,000 users, which means that the acceptance hurdle for integrated services (e.g. in the area of RDM) is low. The basic idea is to create bridge functionalities which allow researchers to deal with RDM in the same environment where they already store their data short-term during the research process. Second, the university cloud forms an established, stable and with 60 servers and 5 petabyte storage capacity very powerful platform, which is designed for the collaborative handling of data from research groups. Consequently, the service already fulfills important conditions that are necessary for effective RDM (Feijen, 2011): a broad infrastructure and a system that is already used in early research phases for the storage, processing and exchange of scientific data.

However, these favorable conditions are not sufficient to turn a project into a successful productive service. In order to move from an innovation to a standard, a high acceptance and adoption rate on the part of the target group is necessary - and this means fulfilling their expectations.

In the context of sciebo.RDS the question is: What requirements do scientists (from different disciplines) have with regard to research data management? The SURFfoundation's meta-study on this issue identifies the following factors that are fundamental in the development of RDM services and tools:

- „Tools and services must be in tune with researchers’ workflows, which are often discipline-specific (and sometimes even project-specific).
- Researchers resist top-down and/or mandatory schemes.
- Researchers favor a ‘cafeteria’ model in which they can pick and choose from a set of services.
- Tools and services must be easy to use.
- Researchers must be in control of what happens to their data, who has access to it, and under what conditions. Consequently, they want to be sure that whoever is dealing with their data (data center, library, etc.) will respect their interests.
- Researchers expect tools and services to support their day-to-day work within the research project; long-term/public requirements must be subordinate to that interest.
- The benefits of the support must be clearly visible - not in three years’ time, but now.
- Support must be local, hands-on, and available when needed“. (Feijen, 2011)

As can be seen from this catalogue of requirements, the success of RDM services depends primarily on their flexibility at various levels. With regard to sciebo.RDS, the following strategic success factors are particularly important as they promise the highest possible flexibility and sustainability:

1) interoperability (with existing working environments),

2) modularity & integrability (of the architecture), and

3) reusability & sustainability.

3.1. Interoperability with the Working Environment

The entire concept of sciebo.RDS is based on the principle "The scientists do not have to come to the service, but the service comes to the scientists". Consequently, a newly developed RDM solution must be integrated into the familiar working environment and everyday working life of researchers in order

to decisively minimize the hurdles for a professional RDM. As mentioned above, many researchers in North Rhine-Westphalia use the service "sciebo" to collaborate on research projects and exchange research data. It therefore makes sense to use sciebo as an already familiar and intuitive entry point into structured RDM and to include corresponding tools.

However, it is explicitly not a question of developing a further repository for research data or further services in the sense of a virtual research environment. Rather, sciebo will be expanded to include functionalities that enable the integration of existing tools, services and systems, thereby supporting researchers in the implementation of RDM throughout the entire research data life cycle (Figure 1) – from project development and operational work to publication and archiving of research data. In this way, the extremely important but still missing technical link between the scientist's work (private and group domain) and the preservation and provision of scientific knowledge (permanent and access domain) – as highlighted in the Curation Domain Model (Forschungsdaten.org, 2015) – is realized.

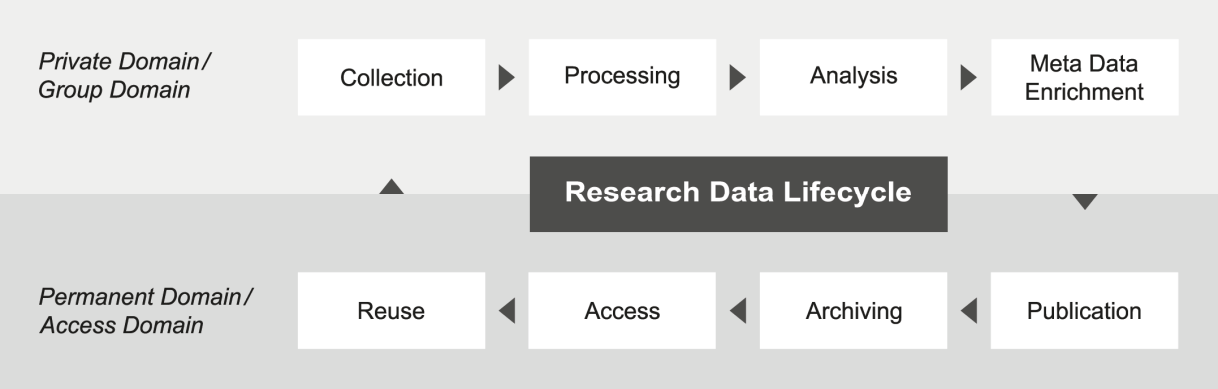

Figure 1: Research Data Lifecycle

In terms of process optimization, the introduction of flexible, but consistent workflows for the transfer of research data stored in sciebo to external publication and archive systems is of enormous value, as maximum process integration reduces fractured workflows and redundant work. Moreover, the consequent focus on user experience ensures that sciebo.RDS is clear and intuitive and that scientists retain control over processes and data.

The user support of sciebo.RDS will be based on existing support structures – particularly those of sciebo - as this is not only efficient, but also user-friendly in the sense of a single point of contact. In addition, Münster University operates a service point for RDM, which serves as a central contact point and is closely involved in the sciebo.RDS project. Connections to state-wide support structures complete the portfolio: The Digitale Hochschule NRW (digital university NRW) is currently establishing a coordination and contact point for the National German Research Data Infrastructure (NDFI), in which Münster University is involved.

3.2. Architectural Concept: Modularity & Integrability

Due to the numerous systems to be connected, the differing demands of the scientific disciplines and the high development dynamics in the context of RDM, the flexibility and interoperability of the architectural concept are without doubt the decisive factors with regard to the success and sustainability of sciebo.RDS. With this in mind, the underlying architecture is characterized by a modular approach at hardware, application and workflow level which couples different systems and services with sciebo and, where appropriate, connects them to continuous workflows (Figure 2).

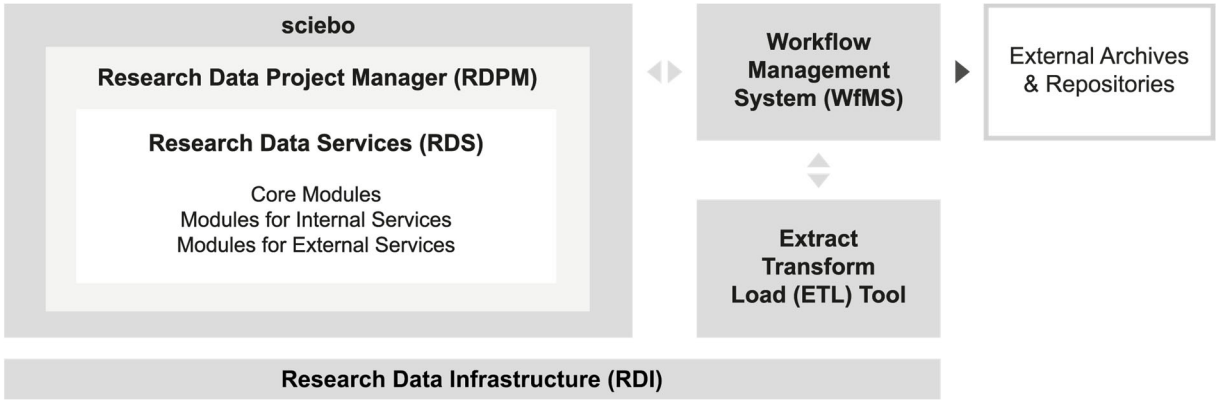

Figure 2: Schematic Illustration of Important System Components of sciebo.RDS

At the system level, sciebo.RDS is based on an on-premise cloud infrastructure. This cloud is mainly a kubernetes cluster on a hyperconverged commodity hardware platform. The next generation sciebo platform will have ownCloud run directly in the kubernetes cluster, whereas for general IaaS requirements from research projects (needing compute and storage), an OpenStack environment is provided. The software defined storage (SDS) in this hyperconverged large scale Research Data Infrastructure (RDI) is Ceph. It has to be noted though, that for the sciebo environment, IBM Spectrum Scale (formerly General Parallel File System – GPFS) will also be used for compatibility with the legacy system. The Open Stack and Ceph based RDI (Figure 3), also dubbed the eScience cloud infrastructure (with out-of-the-box services of varying granularity, incl. IaaS, PaaS, SaaS) together with the ownCloud system (sciebo) form the foundation for the reliable and scalable operation of sciebo.RDS. On the basis of this adaptable infrastructure designed for sustainable operation, a wide variety of application scenarios can be realized.

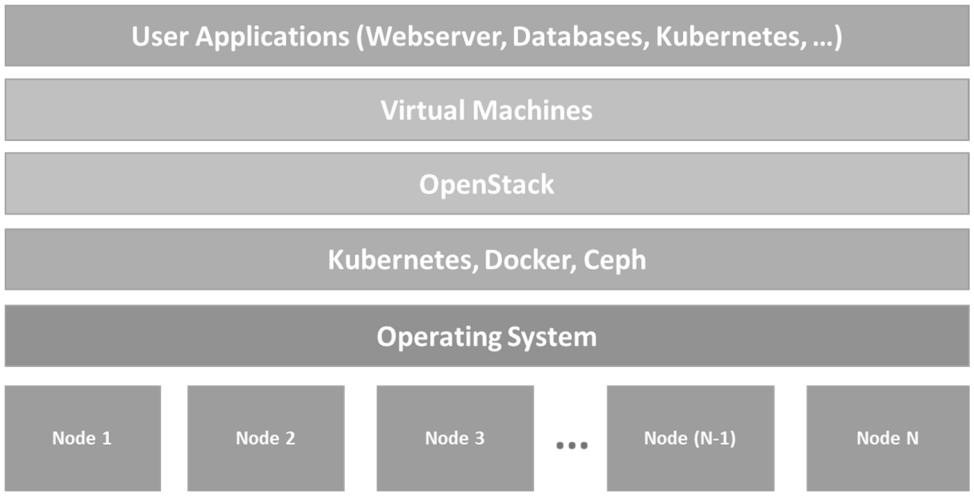

Figure 3: Schematic Illustration of the eScience cloud architecture based on Ceph and OpenStack for the Research Data Infrastructure

At the application level, an architecture approach oriented to microservices is pursued in which application software is composed of small, functionally independent processes that communicate with each other via a programming interface. At the heart of this approach is the *Research Data Project Manager (RDPM)*, which serves as the organizational framework for the Research Data Services (RDS). It provides basic functionalities for creating and controlling projects as well as for integrating and managing the RDS. The RDPM defines which information has to be entered by the individual RDS in order to implement value-added services such as integrated work processes. Control mechanisms ensure the consistency of data, metadata and structures so that they can be processed with connected

tools and meet the requirements for publication and archiving. For implementation into the sciebo platform, the ownCloud apps technology is used, which makes it possible to seamlessly extend the ownCloud web interface with additional functionalities via a defined API.

The *Research Data Services (RDS)* are tools that provide specific functionalities for the management of research data in sciebo. Each module can be used separately or as part of a project managed with the RDPM. For each module, the RDPM defines what information needs to be captured to ensure the consistency of coupled work processes. Within the sciebo.RDS project, four core modules will be developed, which are of central importance for RDM and therefore highly relevant for many scientists. These include:

1. RDS Data Management Plan: Module for the creation and maintenance of data management plans and their automated analysis for the rule-based control of user interfaces and work processes in the context of sciebo. Decisions made by the researcher in the DMP are passed on to the RDPM and determine all further workflows. The web application developed in the DFG-funded project "Research Data Management Organiser (RDMO)" serves as the basis.
2. RDS Taxonomy: Module for the creation and administration of taxonomies and the corresponding classification of research data.
3. RDS Metadata Capture: Module for the creation and administration of metadata schemata and the indexing of research data based on these schemata.
4. RDS Information Package Export: Module for exporting data from a project in the form of a package with long-term archiving capability.

As part of a connectivity study, further modules will be developed to connect internal services such as CRIS@WWU (Current Research Information System) and external tools such as CLARIN-D (web-based research infrastructure), Adobe Photoshop Lightroom (image editing and management software) and the oXygen XML Editor (coding tool for marking XML-based documents). In this way, the connectivity and control mechanisms of the RDPM can be tested.

According to the generic approach, the workflows for data publication and archiving are realized on the basis of the established Workflow Management System Activiti as well as an Extract Transform Load (ETL) tool. With ETL tools, any data source can be adapted, data can be transformed and stored, and target systems can be supplied with data. The individual tasks and jobs are designed in such a way that they can be adjusted, exchanged and passed on with little effort. Specific connectors are required for the various research data repositories and long-term archiving systems, for example. For the target system selected by the scientist, the system-specific metadata is queried via automatically adapted input masks and a data package with a system-specific format is generated and delivered. The information packets are then transferred to the target system, persistent identifiers are assigned, and the data is registered with DataCite. In this context, it will also be examined whether the technology for creating independently verifiable authenticity certificates for data records using block-chain technology (e.g. based on BigChainDB) is useful for research data.

In summary, it can be stated that the final infrastructure is characterized by a high degree of integration capability and adaptability, both from a technical point of view and at the level of the concrete process flows.

3.3. Reusability & Sustainability

One of the goals of the sciebo.RDS project is to enable easy re-use by research institutions. All aspects are aimed at interoperability and flexibility. This is achieved by a strict alignment to standards, formats and interfaces. The use of open source software and open source technologies is seen as a strategic factor. Proprietary or commercial tools are not used, so that the technologies are fully transparent and modifiable. The open source products ownCloud (via the cloud platform sciebo), Docker and a not yet defined workflow management system (e.g. Activiti or jBPM) form the foundation.

The open source software ownCloud is widely used in the scientific community (e.g. CERNBox, EUDAT, SURFdrive, SWITCHdrive, CloudStor) and is also the backbone of the university cloud service sciebo. With sciebo, the project is based on a steadily growing, currently state-wide platform that has a high level of acceptance within the research community. The results of the project are thus available to all users of the service immediately after completion. In addition, the project's development results are available to all other ownCloud-based cloud services. The software's high diffusion rate ensures

that the developed modules can be easily reused, since sciebo.RDS use the programming interface (API) of ownCloud. The continuous development of ownCloud is actively supported by the scientific community (e.g. cooperation with CERN).

Docker is an open source software that is used to isolate applications in containers using operating system virtualization. The containers then contain all the necessary (software) packages and can be easily transported and installed as files. This simplifies the provision of applications, facilitates reusability and ensures the sustainability of the sciebo.RDS project results.

Open source software will also be used as the workflow engine. Here the workflow management systems Activiti or jBPM are feasible options. In addition, the modeling of workflows using the Business Process Modeling Language (BPML) is being considered.

4. PILOT PHASE

Although RDM has some generalizable aspects that apply to all departments, it is strongly influenced by the culture of the respective discipline. It is therefore important to take this culture into account and not to impose general structures. At the same time, every technical solution must be adapted to the existing support structures, research processes, policies and technical infrastructures of the respective faculty and university in order to offer researchers a straightforward approach. In particular, established subject-specific repositories should be considered, which are generally regarded as the primary location for the long-term archiving of research data and in most cases have different mandatory fields.

Therefore, sciebo.RDS initially concentrates on a limited number of disciplines for which integrated scientific work processes are sketched out and implemented in exemplary form - from the creation of a data management plan to collaborative work and short-term data storage in the research process to data processing and data transfer to a repository. Thinking of potential users of an RDM service, the focus is usually on data-intensive branches of research from the natural and life sciences, which have had to deal with very large amounts of data for some time. However, these research areas have comparatively well-established structures and a high level of technical know-how.

Various surveys among researchers conducted at German universities in recent years (Simukovic, Kindling & Schirmbacher, 2013; Simukovic et al., 2014; Rudolph, Thoring & Vogl, 2015; Hauck et al., 2016; Glitsch & Helmkamp, 2015; Paul-Stüve, Rasch & Lorenz, 2014; Krähwinkel, 2015; Feldsien-Sudhaus & Rajski, 2016; Lemaire et al., 2016) show that there is still a considerable backlog in RDM, especially in the humanities and social sciences. Although complex data and the technical possibilities for its evaluation are also increasingly available in these disciplines, there is still a lack of technical infrastructures and the necessary know-how. Support structures, policies and subject-specific repositories are also still being set up. Sciebo.RDS therefore has the opportunity to become part of an integrated RDM process right from the start, which prevents acceptance problems. In addition, those departments with comparatively little affinity to technology will benefit most from the low-threshold approach of sciebo.RDS. An initial focus on the humanities and social sciences can also be seen in the selection of external tools, which will be integrated into sciebo.RDS from the very beginning (CLARIN-D, oXygen XML Editor).

In the pilot phase, selected scientists and working groups will be involved to design their use cases. What these participants have in common is that they are already using sciebo or other cloud storage systems intensively for their research projects. In concrete terms, the areas of application are:

- University of Münster: Center for Digital Humanities – Virtual Desktop Digital Humanities
- University of Münster: Cluster of Excellence “Religion and Politics” – Online Editions
- University of Duisburg-Essen: Research Training Group „User-Centred Social Media“
- University of Bielefeld: Center for Interdisciplinary Research, Institute for Advanced Study

The use cases cover various professional cultures and universities, ensuring that sciebo RDS does not become an isolated solution for very special requirements, but addresses as many areas as possible - within the above-mentioned limits.

5. CONCLUSION

Guiding scientists of various disciplines through the complex task of RDM is an ambitious goal in many ways, but inevitable and worthwhile in terms of scientific exchange and progress in the digital age. With sciebo.RDS we do not want to re-invent RDM, but create new, clear structures and continuous user-friendly workflows by designing central RDM functionalities, integrating and adapting external research data services and expert tools, and offering bridge functionalities. Bridging the gap between the scientists' working environment (sciebo) and the necessary information infrastructures for the exchange, archiving and publication of research data introduces flexible, continuous workflows and, thus, is of enormous value in terms of process optimization.

Moreover, we attach great importance to creating a basic framework for all researchers and at the same time taking into account the different cultures of the disciplines through a modular, dockable architecture. Such an architecture achieves maximum flexibility, reusability and sustainability at system level (virtualization based on Docker), at application level (standardized integration using ownCloud API) and at process level (use of workflow engines to model, configure and execute automated process flows). On the basis of this dynamic process level, a sustainable data model is generated whose well-defined interfaces ensure connectivity to established and future research processes. The resulting infrastructure is characterized by a high level of integration and adaptability, both in technical terms and at the level of the concrete process flows.

However, it is not possible to do equal justice to all departments within the framework of a three-year project. Therefore, the focus of sciebo.RDS is on implementing the basic RDM mechanisms and key workflows and on developing selected functionalities that simplify RDM for as many scientists as possible. In addition, the focus is on disciplines such as the humanities and social sciences, which still have comparatively large deficits in the area of RDM. In order to ensure that the design of sciebo.RDS is in the researchers' interest, quality assurance measures (interviews, usability test) are regularly conducted during process, application and surface development. The exemplary realization of continuous scientific work processes using real use cases also serves this purpose.

Finally, it should be noted that no other current project known to the authors focuses as much on the creation of smooth, consistent and redundancy-free RDM workflows as sciebo.RDS. For example, the EUDAT project focuses on the creation of basic services. The Open Science Framework, which is currently under development, is a collaboration platform in which basic services can be integrated. The GeRDI (Generic Research Data Infrastructure) project aims to establish a distributed and networked infrastructure for research data allowing scientists to search for data across disciplines. Continuous, adaptable workflows, though, are not at the center of any of these projects, which makes sciebo.RDS an ideal complement as it closes a significant gap with its objectives to reduce the complexity in RDM for a wide user group.

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