

Towards a Linked Data Publishing Methodology

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Abstract—Linked open government data (LOGD) can be a catalyst in the development of value-added services and products. The vision of many Linked Open Data (LOD) projects is to make publishing and reuse of linked data as easy as possible for the end user thanks to a thriving marketplace with data publishers, developers, and consumers along the value chain. In the large scale LOD project “Fusepool P3”, tourism-related applications and software components were developed that support data owners and open data enthusiasts in transforming legacy data to linked data. Based on experiences from this project, we present reflections and discuss pitfalls in drawing a linked data publishing methodology. An integrated view on all phases of the publishing process has not been described so far, for the technical phases linked data life-cycles have been identified only. The methodology developed enables stakeholders to transfer the lessons learned to other use cases and application contexts. This allows for better estimation of efforts and skills for future LOD projects.

Keywords: *linked open data, data publishing, linked data life-cycle, publishing methodology, linked data platform*

I. INTRODUCTION

Organizations are progressively adopting linked data for publishing knowledge as open data. Applications with linked data sets such as the BBC Website [1], DBpedia Mobile [2] and other semantic applications [3], [4], [5] show significant added value. The linked data publishing paradigm is particularly suitable for services based on federated data. However, data sources are often internal systems that have little relationship to other data sources and most of the time these silos use established technologies to curate and maintain data.

Publishing data sources as Linked Open Data increases its value and reusability, but it requires a certain amount of work to capture the knowledge of the data owner and domain specialist, and to transform the data to a suitable format (e.g. RDF) based on appropriate vocabularies. As of today, this work is not straightforward to automate. There are tools available supporting the data owner in this process, but they are not easy to integrate and to configure. The Fusepool P3 platform¹ allows to considerably speed up this process by streamlining the publish-process-perform workflow through a common user interface and application programming interface, realized as RESTful API.

Based on several use cases, we observed that data publishers need technical skills at some point when publishing data in a new application context [6]. Leveraging tool usage to a more user-friendly and visually oriented level has the potential to reduce the need for technical skills during the publishing process in the future. For current projects, however, as a means of guidance, we developed a methodology and a template for recording essential process steps during the development of LOD

¹ Fusepool derives its name from the idea of fusing and pooling linked data with analytical processing on top of it. P3 abbreviates the Publish-Process-Perform metaphor which is common to LOD projects.

use cases. This proved to be useful for estimating the necessary efforts and skills for other LOD use cases, thereby serving as orientation for stakeholders intending to reuse a successful LOD approach for their proper application contexts.

In this paper we present reflections and discuss pitfalls in drawing a linked data publishing methodology. The goal is to enhance the applicability of the lessons learned to other application contexts and use cases of linked data publishing by considering different user perspectives. The hypothesis is that the required steps for adopting the platform in other environments are of a generic nature: Sketching the different steps and related efforts systematically simplifies the know-how transfer and provides an orientation for new linked data publishing efforts.

The paper is structured as follows. First, an overview over the Fusepool P3 project and its main achievements are given [7], [8], [9]. Next, the added value through the reuse of linked open (government) data similar to this project is discussed. Subsequently, our approach for a linked data publishing methodology is motivated and aspects about the transfer of the experiences to other application contexts are discussed. Finally, conclusions and further activities are presented.

II. SKETCHING THE FUSEPOOL P3 PROJECT

To improve publishing and reuse of public data, within the Fusepool P3 project software components have been developed that support data owners and open data enthusiasts in transforming legacy data to linked data. It integrates existing and newly developed software components and provides the missing glue and user interfaces to perform the necessary tasks in a sustainable, repeatable way. Within the project, the development team interacts with, and supports the stakeholders in the following ways: Identification of requirements, data publishing (identify data sources to promote business), valorisation process (transform and enrich data to make it actionable) and scalable performance (deliver data for many use cases and devices) [9].

The main goal was to facilitate publishing and reusing of linked data as much as possible, based on a thriving data market economy with data providers, enhancers, and component developers [7]. In order to facilitate publishing and processing of linked data, a set of loosely coupled, modular software components have been developed communicating via HTTP and exposing RESTful APIs exchanging RDF [10], [8]. These software components are compatible with the Linked Data Platform (LDP) best practices [11], working closely together to complete the following tasks, supporting the multilingual data value chain: revealing data from structured and unstructured sources, refining data through text extraction and enrichment, and running the linked data ecosystem through data-driven applications (see Fig. 1).

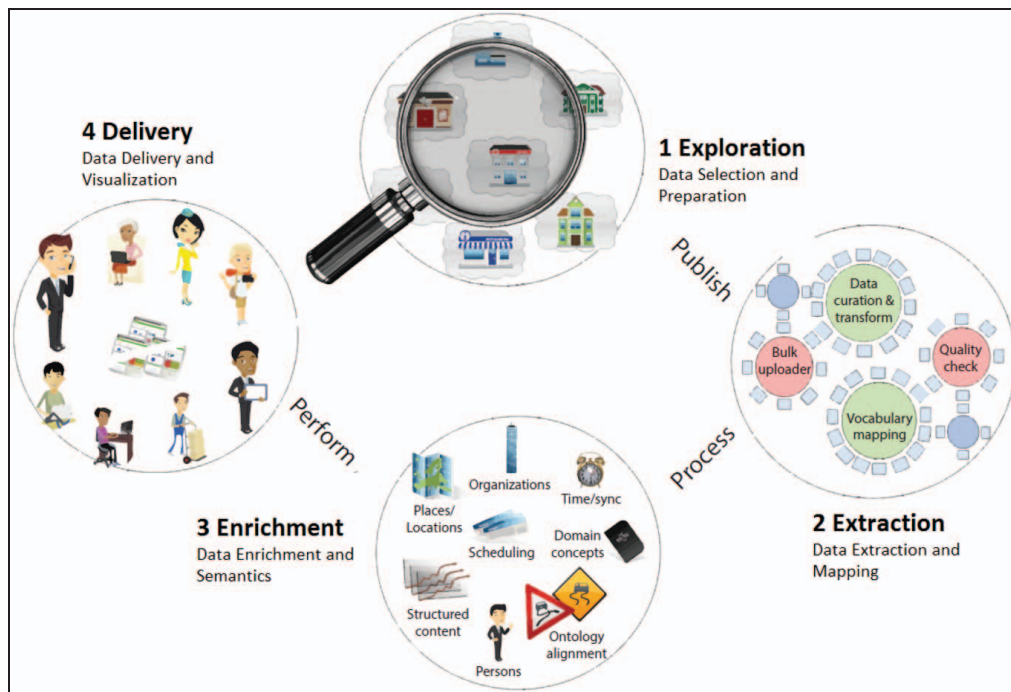


Figure 1: Elements of the Fusepool P3 data value chain [6]

Supported by appropriate backend tools and a high degree of automation in data processing, the Fusepool platform has successfully been deployed in several research projects, including use cases for the preservation of intellectual property of SMEs in the life-science patent domain and also in a tourism context.

Although the lessons learned spread among the project members during the project and proved to be of high value, these experiences had not been externalized with respect to sustainability and for use in future projects. Only in the second half of the project we started to compile the lessons learned into a methodology (see below) that showed to be useful for future projects.

III. CREATING VALUE USING LINKED OPEN GOVERNMENT DATA

LOGD can be a catalyst in the development of value-added services and products exploited by the private sector [5]. Services and products based on government data provide more choice and value for money to consumers as well as increasing government transparency, improving public administration functionality, and providing social value. The value chain of reusing government data covers production, collection, storage, distribution, adoption, marketing and lastly the provision of services to end users [12]. Therefore, it is important to enable data owners to publish their data as linked data. Providing the necessary tools that motivate data owners to invest the extra effort needed for linked data publication is crucial.

Linked open data offers the possibility of using data across domains or organizations for various purposes including statistics, analysis and maps; by linking this knowledge, correlations can be understood quickly, and new conclusions can arise. The best practices in the usage of LOGD can be summarized in the following typologies: a) portals for the supply of LOGD data sets, b) portals providing raw data sets of LOD for public administrations along with technical tools or developer kits for understanding, interpreting, or processing the provided data, c) already existing portals, acting as showrooms for LOGD best practices and d) mobile apps using LOD for public administrations [13], [14].

From a technical perspective, many government organizations currently publish open data on portals such as CKAN, a data management system for publishing data, providing tools to locate and use data. The data quality depends on the data provider, however, since the platforms do not offer data quality improvement features. Raw data can be downloaded and has to be processed using specific extract, transform and load (ETL) steps for importing in applications. Reuse of updated data is difficult when data source formats change.

There is more knowledge in these data sets available than what is visible and accessible to the open data developer. However, in its scattered form, this knowledge is not accessible. Inspired by the ideas of holism we come to the conclusion that a data set should be viewed as a gestalt, not as collections of parts. This leads to synergy, which is the creation of a whole that is greater than the simple sum of its parts. Linked data enables synergy for separate, unconnected data sets. Where open data is mostly about political and administrative interoperability, linked open data is about technical and organizational interoperability [9].

The Fusepool experience showed that in order to create an added value for concrete use cases resp. business sectors, it is suitable from a methodological point of view to adopt a user-driven focus and involve users, especially (public) data owners, in all agile development process phases.

IV. EXPERIENCES AND A METHODOLOGY DRAFT

In the context of the Fusepool P3 project, several use cases in different domains were defined and implemented on the P3 platform. Different stakeholders should ensure that Fusepool P3 creates real value for both the involved project partners and future stakeholders. It was relevant to understand their motivation and needs as data owners and public agencies in an early stage of the process. Initially, it took time to integrate them and their requirements into the development process, but after a while the whole team benefited since the use cases had a real world background.

A. Integrating Stakeholders and Creating Use Cases in the Field of Tourism

The project partners Provincia Autonoma di Trento (PAT) and Regione Toscana (RET) gained valuable experience in data creation, maintenance and publication. Their goal was to support and push tourism by identifying and publishing valuable data sets. Public administrations have a long history of providing services for citizens. After having published their first data sets, the agencies realized that there is additional value in the data, if the datasets from different sources and systems were (inter-)linked with each other and semantically enriched through mapping to appropriate vocabularies.

The regions PAT and RET hoped to change the culture in administrations in a positive way. Currently, many administrations seem to be afraid of opening up data, among others because data with poor quality could occur in public data sets and have a negative impact on the administration. By illustrating that third parties start to use their data in a different, productive way, administrations are motivated to change their attitude and to release more data. Providing an appropriate set of technologies that facilitates the open data publishing process also supports this culture change. Linked data addresses some of the mentioned problems users have with opening up data [9].

B. A Linked Data Publishing Methodology (LIDAPUME)

Depending on the nature and complexity of each use case, different analysis, design and implementation steps were carried out, but based on reflection and abstraction a common methodology could be distilled, consisting of seven steps, each of which allows annotating experiences from ongoing or completed use cases. It turned out to be very helpful to externalize the methodology in a conceptual framework in order to use it as orientation and guideline when developing use cases in similar contexts, and to learn from annotated methodology templates from completed projects.

The use of this Linked Data Publishing Methodology (see Fig. 2) proved to have benefits for the development of use cases during the P3 project and is currently evaluated in a similar scenario outside the project context. In publications on other LOD projects such as LOD2 [15], LATC [16] and GeoKnow [17], the below steps seem to be applicable to these contexts as well. These and other approaches also propose linked data methodologies. In contrast to our approach these are focused on the technical steps of linked data life-cycles only, while we adopt a more comprehensive approach taking into account all phases during development of a LOD use case.

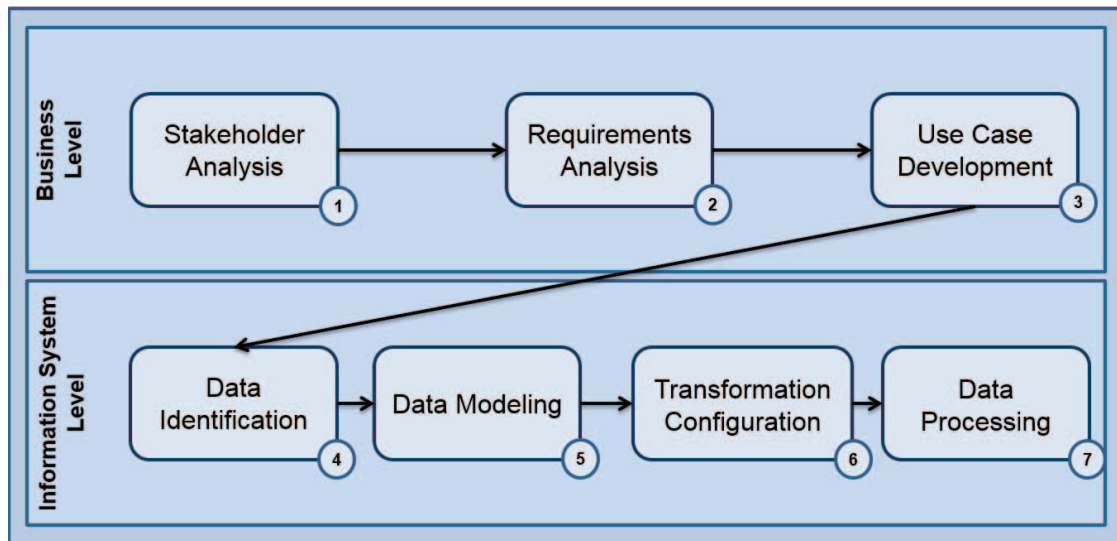


Figure 2: the seven steps of LIDAPUME, the Linked Data Publishing Methodology

Following the methodology and using the below template for recording efforts and skills through annotations during the development of a linked data use case shows several advantages:

- Documentation of essential tasks, which proved to be helpful answering questions of potential users and developers such as “How long will it take to develop a use case with this platform?” or “How many technical skills are necessary in order to achieve this?”
- It serves as a suitable starting point for linked data use case planning, comprising aspects such as completeness of the planning, necessary project skills and duration of completed projects.
- Shortening the learning curve: having experiences from completed projects at hand in a structured form allows for better estimation of work load and necessary skills for future LOD projects.

The steps of the proposed methodology are detailed as follows:

- 1) **Stakeholder analysis:** identification of key stakeholders for the use case. Typical key stakeholders are product owners and end users on the application layer, as well as data owners resp. publishers with regard to the data layer.
- 2) **Requirements analysis:** classical analysis such as conduction of in-depth interviews in the respective domain with key stakeholders or classical analysis of artefacts.

- 3) **Use Case development:** mapping of requirements and expectations to functionality forming the basis for the development of use cases. The resulting use cases proved to be good starting points for conceptual and functional test models.
- 4) **Data identification:** Selection of potentially value-adding data sources based on application scenarios and use cases that provide a concrete benefit for the key stakeholders. Ideally, these data are likely to be reused by others and other applications and integrate well into the existing Linked Open Data cloud (<http://lod-cloud.net>). Data quality aspects and the ease of data consumption as e.g. described by the 5-star model [18] are to be identified here as well.
- 5) **Data modelling:** Identification of existing taxonomies, ontologies and vocabularies to model the data at hand. It is strongly recommended by the (scientific) community to define data models that use existing approaches and schemas in order to model relational and other data sources. This also holds for standard structural and descriptive metadata.
- 6) **Transformation Configuration:** Specific transformers are configured and if necessary implemented according to the data formats identified in the “data modelling” step. This configuration can be done in particular user interfaces (like OpenRefine), through domain specific languages (DSL) like XSLT or through plain programming if necessary. A typical outcome of such a transformer maps some non-RDF source to appropriate RDF data. This step needs some technical skills, because at the time of writing it is not foreseeable that these tasks can be leveraged on a significantly reduced technical level e.g. through visual specifications. On the other hand, this effort occurs only through development of a linked data system. Once the system is operational, updated raw data (such as monthly events or other regularly updated items) are automatically digested.
- 7) **Data Processing:** The data life-cycle process is guided through a set of transformation steps depending on the formats of the raw data (or text) sets, the level of enrichment and interlinking. In general, LOD platforms offer configuration possibilities for defining transformation steps, in the case of Fusepool P3 a configuration front-end facilitates this process.

The template in table 1 is a blueprint of the methodology concept for a specific use case in a given application context or. Its annotations allow to record important activities of each step, necessary skills and the technical level and skill if applicable, as well as the effort (i.e. time) used for completing the step. The effort to set up an executable platform is not under consideration; for now, we assume that a LOD project is developed on top of an executable platform.

TABLE I. TEMPLATE FOR AN LOD USE CASE ACCORDING TO LIDAPUME

Step	Activities	Skills	Effort
Stakeholder Analysis			
Requirements Analysis			
Use Case Development			
Data Identification			
Data Modelling			
Transformation Configuration			
Data Processing			

V. VALIDATION OF THE FRAMEWORK

In this section, we present the annotated template from table 1 for three LOD use cases that have been realized in the context of the Fusepool P3 project: ALOD, a Swiss Federal Archive application, a keyword clustering application which serves as a large scale validation use case for P3, and an event explorer, realized as a smartphone app.

In the following, for each use case we present the context followed by the annotated template. The section concludes with a discussion about our findings.

A. Swiss Archive Use Case

Since autumn 2014, the Swiss Federal Archive and the archives of four cantons (Basel, Geneva, Neuchâtel and Valais) run a common platform and SPARQL endpoint where they experiment with providing archival data as linked data. The goal of the prototype is to understand the requirements and opportunities of providing archival information as linked data. A central aspect is to prove that data maintained decentralized can be better searched by providing linked data. Based on the results of the Fusepool P3 transformations a prototype interface was developed and tested with stakeholders and external users of the archives [19]. Table 2 contains the recorded information for the development of this use case.

TABLE II. LIDAPUME TEMPLATE FOR THE SWISS ARCHIVE USE CASE (1D = 1 EFFORT-DAY)

Step	Activities	Skills	Effort
Stakeholder Analysis	Identifying Swiss cantonal archives that want to participate in the user case. Partially given as it was initiated by some of the archives itself (5 stakeholders).	Analytical	1D
Requirements Analysis	Interviews with each archive. Identifying a topic available in all archives.	Analytical	1D
Use Case Development	Developing ideas of an initial user interface for the use case.	Analytical, prototyping	1D
Data Identification	In-place work with each stakeholder, data source analysis and data export options.	Analytical, technical	2D
Data Modelling	Identifying appropriate vocabularies. Mapping data from the data source with OpenRefine or XSLT configurations. Partially in-place at stakeholder.	Domain knowledge, modelling, technical	5D
Transformation Configuration	Enhancing data with named entity recognition and interlinking with reference datasets such as GND ² .	Modelling, technical	3D
Data Processing	Execution of transformation, indexing of data. Making it available on the final SPARQL endpoint.	Modelling, technical	3D

B. Library Keyword Clustering Use Case

This use case grew over time. The stakeholder participated at hackathons and developed the initial idea of using Fusepool functionality for enhancing the FU Berlin library content. Within the project lifetime it got integrated as an official use case for the project and extended in size as large scale validation use case of the platform. Large datasets from DBpedia got loaded in the platform and pre-processed along the GND norm. The transformations are focusing on named entity extraction and interlinking, not on RDF generation itself as the input data is available in RDF already. In this use case there was a lot of refinement necessary as it works with large data sets. Some of the problems were only identified during the processing itself and thus the processing had to be triggered again. The execution of the data processing took several days due to its size. Table 3 contains the recorded information for the development of this use case.

TABLE III. LIDAPUME TEMPLATE FOR THE LIBRARY KEYWORD CLUSTERING

Step	Activities	Skills	Effort
Stakeholder Analysis	Initial development of the use case at public Fusepool hackathons by participants (1 Stakeholder).	Analytical	1D
Requirements Analysis	Refining ideas into a specific library use case.	Analytical	2D
Use Case Dev.	Defining success metrics for interlinking.	Analytical	1D

² GND (German): Gemeinsame Normdatei; aka: Universal Authority File; http://www.dnb.de/DE/Standardisierung/GND/gnd_node.html

Data Identification	Identifying and collecting external data sets, used in the use case.	Analytical, domain knowledge	2D
Data Modelling	Identification of textual labels which will be used as input for named entity extraction and keyword interlinking.	Modelling, domain knowledge	5D
Transformation Configuration	Configuration of the enhancement pipelines. Integrating external (domain specific) reference data sets for interlinking.	technical	5D
Data Processing	Execution of the enhancement pipeline. Initially with manual tests for quality control and according refinements.	Domain knowledge, technical	5D

C. Event Explorer Use Case

An *event explorer* application was created as an outcome of a hackathon. The stakeholders Provincia Autonoma di Trento (PAT) and Regione Toscana (RET) contributed initial datasets like XML files containing event information from their regions. In the hackathon a team decided to use these data as a starting point and created a linked data driven web application presenting the semantically enriched events (<http://explorer.nexacenter.org>). Table 4 contains the recorded information for the development of this use case.

TABLE IV. LIDAPUME TEMPLATE FOR THE EVENT EXPLORER

Step	Activities	Skills	Effort
Stakeholder Analysis	Understanding the project stakeholders PAT and RET and their expectations.	Analytical	2D
Requirements Analysis	Identifying datasets which are low hanging fruits.	Analytical	1D
Use Case Development	Defining initial requirements for transformers to be added to the Fusepool P3 platform.	Analytical, prototyping	1D
Data Identification	Analysing initial data sets, gap analysis to understand what is missing in it.	Analytical, technical	1D
Data Modelling	Analysing available schemas, mapping to schema.org.	Domain knowledge, modelling, technical	3D
Data Processing	Execution of first transformations, quality control.	Modelling, technical	3D
Transformation Configuration	Implementing basic transformers for XML and CSV based data sets. Implementing first entity interlinking pipeline.	Modelling, technical	5D

D. Discussion

Based on discussions with project members, the template structure needed several iterations until it converged into its current form. There is a bandwidth in several characteristics of the template where we had to find a compromise in accordance with the anticipated added value for future LOD projects: complexity of the template, detail of description, structure of annotations (i.e. template entries).

With respect to acceptability of the methodology and its template, we tried to use an approach with little formalism only, but with a reasonable degree of structure for guidance and orientation. Initially, the number of steps oscillated between 5 and 10 and converged after early iterations. We experimented with the detail of descriptions, starting with explicit listing of transformation scripts, its lengths etc. Eventually we could identify an advantage for a small percentage of users/developers only profiting from detailed description, such that we propose a few-line summary only in the Activities column that can be understood by most readers. Unless future feedback and validation of the methodology resp. the template will give better insight, currently free text entries proved to be sufficient for the project members, although the use of certain conventions in the Skills and Effort columns is recommended as can be seen in the above annotated templates.

Based on the above templates for concrete use cases, in all projects a range of skills is needed, from *analytical* and *domain knowledge* in early steps to *modelling* and *technical* skills in later steps, which reflects typical IT project

characteristics. It may seem surprising that all projects could be developed in a few weeks only. Taking into account that the measure of one effort-day (1D in figures 5-7) is defined by pure productive time, the numbers have to be set into context in a respective project with all its friction losses and “unproductive” work for administrative and overhead work.

VI. CONCLUSION AND OUTLOOK

In the course of several linked data projects, the process of publishing and processing data could be managed with increased quality and efficiency due to a better understanding of the problems involved and an improved technology stack. However, based on the project context and specific problem domain, during early projects there seemed to be no common methodical and reusable approach. Only after reflecting the process steps after completion of several projects, we were able to abstract, to distil and to externalize a common methodology behind our linked data projects during the last years.

LIDAPUME, an acronym based on *Linked Data Publishing Methodology*, consists of seven steps, each of which allows annotating experiences from ongoing or completed linked data use cases in a specific template. It is intended to be useful for orientation and guideline when developing other linked data use cases, be it in learning from annotated methodology templates from completed projects, or for planning and documentation purposes in ongoing linked data projects.

Currently, in the context of sustainable dissemination activities, a transfer project is set up in order to prove the usability of our project results in a different setting and also to execute another validation case for the methodology described above. At the time of writing the steps of the analytical level are finished, so far the annotation of the template together with the experiences which have been externalized in the above annotated templates turns out to help a lot in orientation and planning of the transfer project. It is planned to evaluate the usage of the methodology and the template at the end of the transfer project.

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