Towards Data Interoperability for the Digital Product Passport Ecosystem

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Abstract. The Digital Product Passport (DPP) initiative aims to enhance the circular economy by promoting product sustainability and reducing environmental impact. However, for this to work, the community needs to agree on a shared understanding of what information exactly is part of a DPP definition so that different participants can successfully exchange and complement DPP data using a common schema in an emerging DPP data space.
While there is plenty of documentation describing the concept of DPP, this shared schema is not yet fully clear, which can lead to interoperability issues among different solutions implementing the DPP. In this paper, we propose such common foundational schema, expressed as structural data model that abstracts the key concepts of the DPP and can be extended to specific scenarios. Additionally, we implemented this model using the low-code platform BESSER to demonstrate how we can, based on this schema, quickly generate a complete software DPP infrastructure following a low-code approach.

Keywords: DPP · interoperability · low-code.

1 Introduction to Digital Product Passports

The global generation of waste is significantly high, driven by factors such as consumerism, industrialization, population growth, and inadequate recycling management. The European Union alone generates over 2.2 billion tonnes of waste annually [3], raising substantial environmental and climate concerns. One initiative to address this concern is the Digital Product Passport (DPP) proposed within the Ecodesign for Sustainable Products Regulation (ESPR) by the European Commission [2].

DPP is a European initiative designed to manage, collect, and share crucial information to promote product sustainability and circularity. Its goals include accelerating the transition to a circular economy, enhancing material and energy efficiency, extending product lifespans, and optimizing design, manufacturing, usage, and end-of-life processes [7]. DPP involves several stakeholders beyond just manufacturing companies. For instance, it includes customers who

seek transparent access to sustainable information to make better purchasing decisions; users responsible for verifying governmental product regulations; or even users with social interests in product regulation [5].

However, as the DPP is a recent initiative and implementations are just starting to emerge and mature, the regulation still leaves some issues unclear. For instance, technical concerns regarding protocols, architectures, and technologies used, as well as data-related concerns about who collects the information, who verifies it, what the data scheme entails, and what information is required for the digital passport. In particular, the lack of clarity regarding a standardized data schema creates interoperability problems among platforms and technological solutions implementing this initiative. Each solution may design and implement a different data structural model that is incompatible with others, posing challenges and complications for data integration within the data space. Therefore, a solution based on the principles of the European Data Space is necessary, which aims to facilitate the sharing and interoperability of data across different platforms and stakeholders by providing a common framework and standards for data exchange.

As a contribution to a data space for the DPP, we propose a foundational data structural model that represents the DPP ecosystem. This model abstracts the essential information of the DPP that must be collected at each phase of the product lifecycle. We implemented this model using BESSER [1], a low-code platform, to demonstrate how a DPP infrastructure can be rapidly generated.

2 Modeling the DPP data ecosystem

We have defined a foundational data schema (structural model in Figure 1) that abstracts the essential concepts, drawing inspiration from proposals and initiatives in this direction, such as: (1) the European Commission's ESPR proposal [2], which suggests a list of DPP data requirements; (2) a survey study [4] discussing seven data cluster for DPP, including usage and maintenance, product identification, products and materials, supply chain, environmental data, and compliance; and (3) the Luxembourgish proposal Product Circularity Data Sheet (PCDS) [6], an initiative to develop a globalized open-source industry standard to facilitate the exchange of standardized data throughout the supply cycle.

Figure 1 illustrates our DPP structural model. At its core is the *ProductPassport*, representing a product's DPP. A *ProductPassport* includes essential identification attributes (such as UID, GTIN, product name, product code, and brand), along with the *DataCarrier*, which denotes the technology enabling access to the DPP. Information regarding the product's chemical composition, hazards, and recycled materials is delineated by the *Chemical*, *Hazard*, and *RecycledMaterial* classes (sourced from PCDS [6]). Additionally, details about installation manuals, usage guidelines, disassembly procedures, etc., are encompassed within the Guideline class.

In this model, we consider six stages within a product's lifecycle: *Design*, Use (which can also register *Repair*s), *Manufacturing*, *Collection*, *Distribution*, and *Recycle*. These stages inherit from *LifecycleStage* in the model, allowing for various aspects to be specified for each (the following are relationships of the *LifeycleStage* class in the model):

- *environmental_ impacts*: This relationship enables the specification of a range of values and resource consumption across different stages of the product's lifecycle. For instance, quantifying the water usage during the manufacturing phase.
- *materials*: Each stage allows for the specification of the type and quantity of materials utilized. For example, detailing the raw materials employed in the product's manufacturing process.
- *companies*: At every stage, the associated companies or entities responsible can be designated. For instance, to indicate the company responsible for product distribution.
- *issuer*: each stage's information is created by and attributed to a responsible party, such as a manufacturing employee, a state regulation reviewer, or any other authorized person. This *issuer* relationship allows to specify this responsible person.

3 Using BESSER to generate a DPP application

One of the solutions commonly employed today to support application development is the use of low-code tools, to design and develop applications with minimal hand-coding accelerating its delivery. We utilized BESSER to demonstrate how we can generate and support the development of a DPP application from our DPP structural data model. BESSER is an open-source low-code platform for smart software development. With BESSER, it becomes feasible to define structural models and utilize various code generators to streamline application development and deployment across different technologies.

Following the definition of our DPP structural model in BESSER, we utilized the Django Code Generator to support the development of a web application. BESSER generated the code for the model layer of the web application, which defines the structure and management of data in a relational database. This includes CRUD operations for the entities or classes defined in the DPP structural model. Figure 2 shows the graphical user interface of the admin user for the deployed web application. The left panel contains the list of structural model concepts, while the right side displays the form for creating a new product passport.

In addition to support web application development, BESSER provides other code generators for creating complete software infrastructures for different technologies. Using these code generators and the DPP structural model, we could speed up the development of software for DPP domain such as creating a database, REST APIs services, mobile applications, and other software solutions that adhere to the defined data schema to ensure interoperability in a data space.

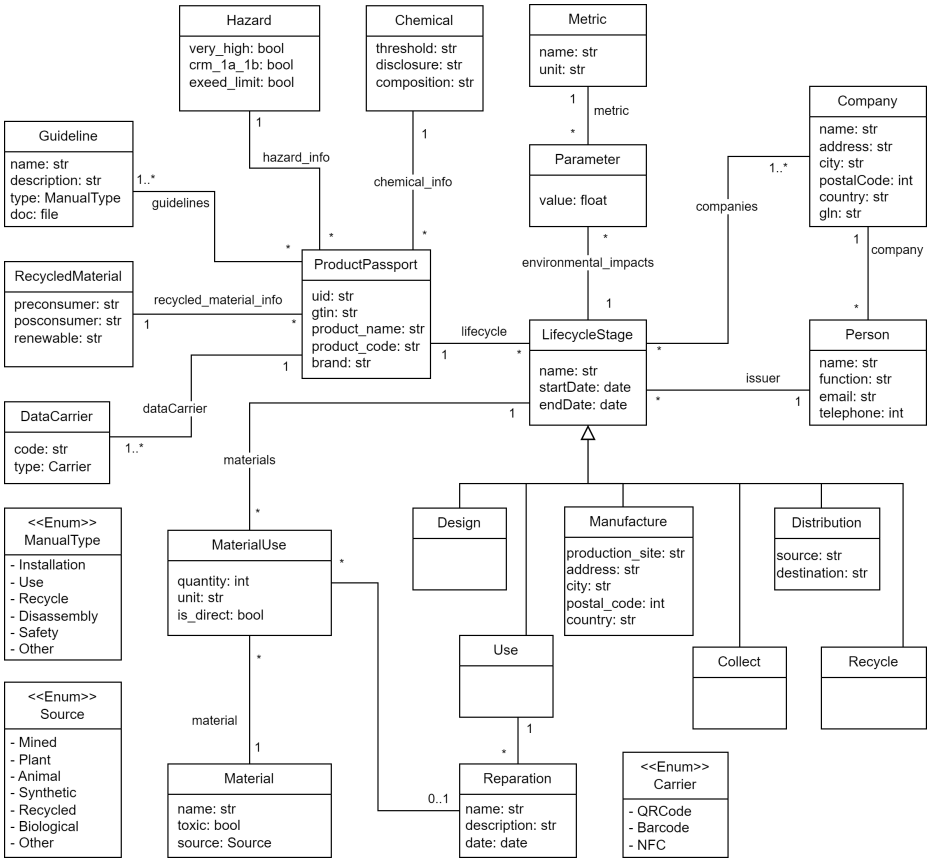

Fig. 1. DPP model domain

4 Summary

The DPP concept promises to be a valuable initiative for enhancing the circular economy in the coming years and reducing environmental impact due to consumerism, waste generation, and poor recycling management. However, there are still challenges to be addressed in implementing this initiative, such as formalizing the DPP schema to favour data interoperability. In this paper, we present an initial version of a structural model to be used as the basis for such schema if adopted by the community. While our structural model covers essential concepts, it can be extended to specific scenarios that require detailed information for certain types of products. Additionally, we utilized BESSER, a low-code tool, to accelerate the development of a web infrastructure to manage the DPP domain. A similar approach could be used to semiautomate the generation of a software infrastructure for other existing data spaces.

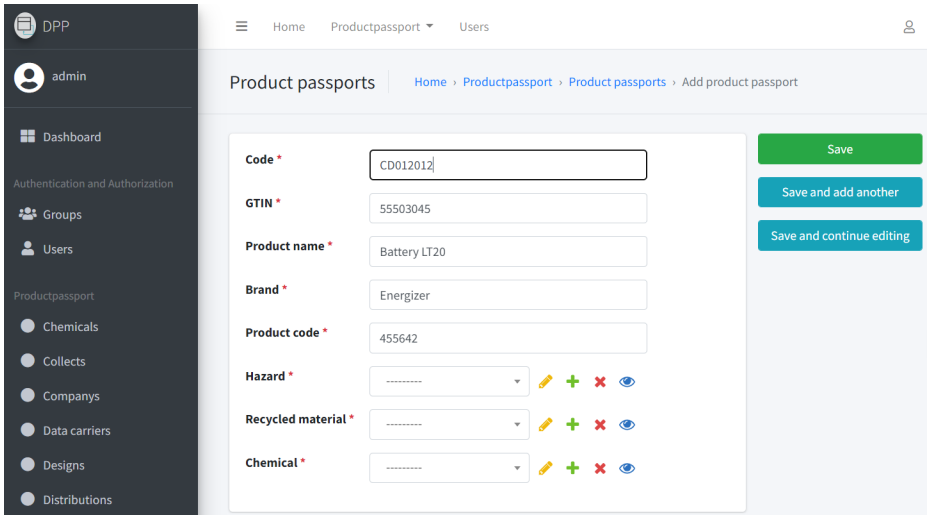

Fig. 2. DPP web application

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