Demonstration of a digital product passport system for second-hand electronic devices

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***Abstract*—The foundation for the Digital Product Passport (DPP) was presented in the recent European Ecodesign for Sustainable Products Regulation (ESPR) in July 2024. DPP systems will provide ICT support to increase the circular economy of products significantly. With the DPP, a significant step forward will be taken by providing comprehensive, trusted, and publicly accessible product information for items or batches regarding digital records. Currently, the DPP building is undergoing a standardization process. Nevertheless, commercial players are preparing DPP systems but mainly with a proprietary implementation, making it difficult for researchers to experiment. In this demo paper, we will show an open-source implementation of a DPP system for managing the lifecycle of second-hand electronic devices such as computers. Our system is oriented towards the use cases of economic actors such as repairers, refurbishers, and the customers of these devices. Our system integrates a blockchain-based registry for the actors to trust the data and operations. The implementation of the demo DPP system is publicly available and can be deployed as a set of microservices.**

***Index Terms*—digital product passport, circular economy**

I. Introduction

The Digital Product Passport (DPP) in Europe has obtained in July 2024 a legal framework with the publication of the Ecodesign for Sustainable Products Regulation (ESPR) [1]. The regulation introduced the foundation of the DPP in its articles 9 to 15, to be further refined in subsequent delegate acts. The DPP aims can be positioned within the different efforts to achieve sustainability, where the DPP as an ICT system will support all actors within a product's value chain to perform the circular economy. On the global scale, there is an ongoing development of the UNTP DPP [2].

The benefits of the DPP include enhanced product traceability with unprecedented transparency, where different actors with different access rights can write to and read the DPP of a product. The DPP information will provide an enhanced supply chain transparency, where an increased effort on steps like repair, refurbishing, and reuse of products will be enabled and documented. However, the technologies to implement the DPP innovation are still emerging and under evaluation in several piloting efforts [3].

While the DPP is recognized as a key circular economy enabler, its technical requirements are considered still not fully clear [4]. However, several key operations on the data have been identified, which consist of data collection, data curation, data sharing, and data leverage. Depending on the type of operation, it will be performed by different stakeholders. For this, trust in the data and access control has to be part of the design of the DPP system.

Distributed Ledger Technology (DLT)-based verifiable registries have been proposed by several prototype implementations of DPP systems. In the work of Nowadcki et al. [5], a technical architecture that employs DLT based on a directed acyclic graph was proposed. The system uses smart contracts to implement DPP write operations and to retrieve DPP information. Canciani et al. [6] related the security and transparency needs of the DPP with the inherent characteristics of blockchains like data immutability. The architectural proposal for both privacy and immutability required by a DPP in supply chain management system consisted of a hybrid system which combines public and private blockchains.

In this demo paper, we show the implementation of a DPP system that is oriented to the lifecycle management of secondary ICT devices. We present the views of different actors to introduce and access product information, such as economic operators of the circular economy and customers of the products. Hence, the demonstration illustrates some of the use cases and the verifiability of future DPP systems.

II. Implementation

For this demo, we use the eReuse DPP system implementation that is publicly available[1].

[1]https://gitlab.com/dsg-upc/ereuse-dpp

An overview of the architecture is given in Figure 1. Two main roles are identified: the economic actors, such as repairers or refurbishers, represented as operators, and end users of the products, represented as customers.

Regarding the operators, authenticated operators upload device descriptions as snapshots to an Inventory web application. Each device obtains a unique identifier. The Inventory stores locally for each device the product information as a DPP with summaries stored in a smart contract of a permissioned blockchain. A Connector API component manages the smart contract read and write access. That component also operates as a wallet for potentially multiple Inventory components. Operations on the same device are captured as events that can be added to the DPP.

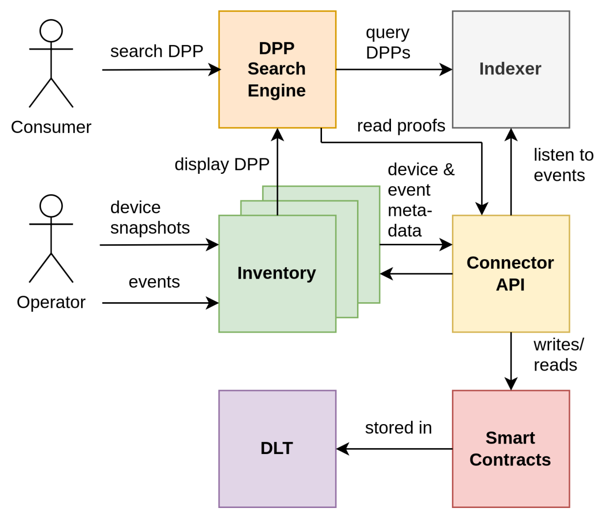

Figure 1. DPP system architecture.

For end-users (customers), the DPP Search Engine offers a search/lookup function and service as a trusted intermediary providing truthful product information. This allows end-users to find and retrieve trusted DPP information from product identifiers. For this, the Indexer component, which provides initial results for a keyword-based search service, is continuously informed about new DPP summaries written to the smart contract. The end user may then ask for more details and verification, which involves the DPP Search Engine service to interact with the Inventory and the Connector API, respectively.

III. Demonstration

In the demonstration, we will show the deployed DPP system from the operator and customer perspective. For this, some of the main views of these actors of the DPP system are presented. In addition, we will explain the current status of our implementation and documentation to facilitate interested parties to initialize experimentation with the DPP system.

A. Customer views

Figure 2 exemplifies a result of the search service sent as a response to the customer. The results contains metadata of the product. The customer can chose from the list an item for further inspection.

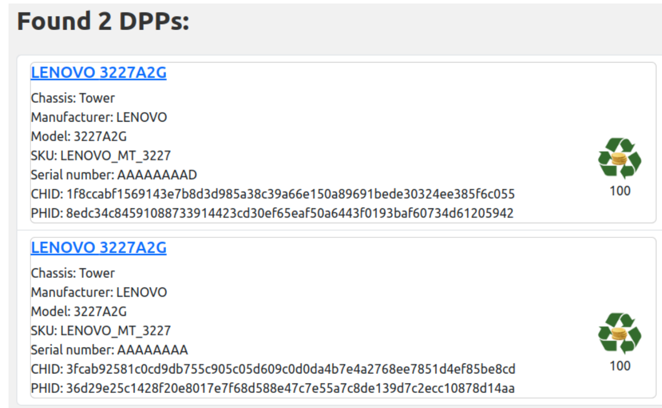

Figure 2. Demonstration of search results for a product showing two matching product items.

In Figure 3 the information given to the customer after requesting proofs for the data verification is shown. The Search service retrieves this information by communicating with the Connector API. More detailed information and component data can also be requested, for which the search service would interact with the Inventory.

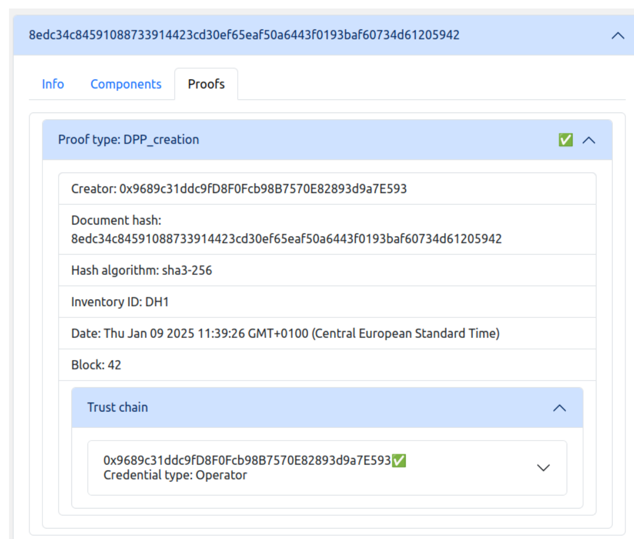

Figure 3. Demonstration of the trust chain verification of actors involved in a given DPP.

B. Operator views

Authenticated users can access the Inventory. A typical Inventory user is an operator of a repairer or refurbisher. The operator can upload snapshots of device descriptions, typically provided in JSON format. Using a unique identifier, the DPP is created for this product, with the metadata of the item being written to the smart contract. For the user, the DPP data for this item can be rendered as an HTML document (Figure 4), while offering a machine-readable JSON-LD view according to the requested content type.

Figure 4. Demonstration of an HTML rendering of a DPP.

The Inventory also supports other use cases of the operator, such as accessing the list of devices (Figure 5).

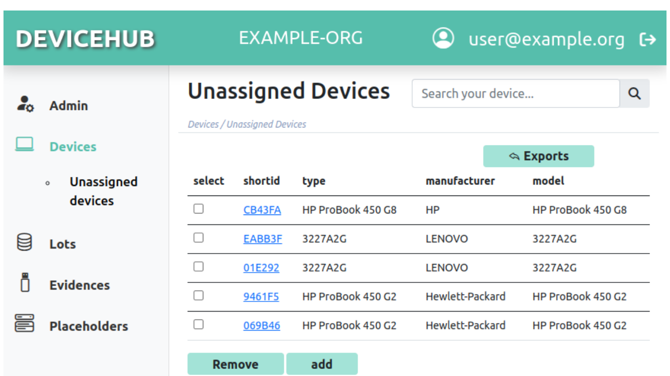

Figure 5. Demonstration of a product inventory service instance of a given refurbisher with a list of recently introduced product items.

Besides showing the experimentation, the demonstration will also provide practitioners with the opportunity to review the detailed design decisions we incorporated, how they relate to the EU DPP [1] with manufacturer's DPPs, the business-to-business interactions as defined by the UNTP DPP [2], our best practice experiences so far, and how we integrated this system into the product item flows for new, refurbished second-hand devices and recycling items.

Both DeviceHub and DPP Search with a verifiable registry are open source and available in publicly accessible git repositories. The implementation is operational for prototyping circular economy computer repair, reuse and refurbishment applications among computer owners, donors, refurbished and second-hand users. The repositories include examples that enable the community to start using the implementation.

C. Deployment and usage

The presented prototype is available in a public Git repository and can be downloaded as release 2. For all components, Docker files have been prepared so that the system can be deployed as containers. A Docker compose file has also been made available to facilitate the coordinated deployment of the set of microservices.

The system can be deployed as is, but the modular design of the components, as illustrated in Figure 1 of Section II, suggests that third parties may replace components relatively easily. This may help experiment with alternative implementations or explore other technologies. While open source DPP systems have not become broadly available, the prototype can be an interesting, freely available tool to become familiar with the DPP.

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