TagItSmart
Smart tags driven service platform for enabling ecosystems of connected objects

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DuraTag
D1 Platform specification and architecture

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Introduction

In report[1] about Circular Economy from the European Environmental Bureau (EEB), it is highlighted that resource inefficiency could be tackled by adequate information (resource repair and recycle) passing from one business to another, by developing a product passport. The product passport (also called material passport, Circularity passport and Cradle-to-cradle passport) is a document consisting of all the materials that are included in a product or construction. It consist of a set of data describing defined characteristics of materials in products, which give them value for recovery, recycling and re-use.

The goal of this document is to define functional modules and specify platform oriented for generating the product passport for waste processing industry where reusable parts (i.e. Electric motor, Geared motor and Bearings) and its composition materials are available for Circular Economy. This is done by taking into account TagItSmart architecture in order to reuse existing functional blocks and develop missing functionalities for the trial. We have analysed deployment of (so far) identified TagItSmart components: temperature SmartTags, FC-scanner SDK, Service Manager, Encoding and Printing module, etc. Product passport is specified with user stories and its features for managing machine data (add, modify, delete) and data sharing. D1 document provides system specification and enables the implementation task taking place in WP2 to be executed on time and following plan from this document.

The interviews are done with different stakeholder (BankPro and Schneider Electric[2]) to extract data that are required for each machine part. Being a long-term partner and distributor of automation and control products with Schneider Electric, we conducted an intensive analysis of AC motors management principles and protection methods. In order to make a tailored solution for AC motor working temperature tracking, that would possibly be complementary to products and solutions that Schneider Electric is manufacturing, we made interviews with their experts and got valuable input about critical temperatures and set of features to be covered by product passport of AC motors.

The main objectives of this document are:

- Analyse the TagItSmart platform and provide KPIs, implementation methodology and plan for the development of the DuraTag
- Specify requirements, business processes and components for the DuraTag platform providing description of components and product passport

More specifically, the analysis is done in several steps, first by interviewing the stakeholders to identify user stories, then by specifying in more details the components for the platform and analysing the existing TagItSmart architecture to map and identify reusable components and mechanisms. The components are therefore specified separately and provided with APIs, also with the list of reuseable, adapted and contributed components.

1 http://ec.europa.eu/environment/circular-economy/index_en.htm

2 Schneider Electric is a leading global manufacturer of electric components, spanning from energy transmission systems, high and low voltage, industrial automation and control, energy management, to residential applications and software. More importantly, Schneider Electric is leading digital transformation across all industrial automation markets, including machinery control and motor protection. Delivered through architecture and IoT technologies, they offer smart manufacturing and bring revolution to business models for plants and machine builders – increasing profitability and productivity – and end-to-end software delivers efficiency across the complete life cycle.

Section 1 - Methodology

To be able to extract requirements and to specify user functionalities for the platform that needs to be developed, as well as to provide clear roadmap for the integration of the platform, we have first sheduled an interviews with the stakeholders. Results of the interviews have been analysed to draft the product passport for the machines and to specify user functional requirements by using user stories.

1.1 User stories methodology

1.1.1 Initial User Stories (Informal)

In this subsection, a methodology for user stories is given that is being used to sketch the interviews in form of stories (Section 2.1).

The example of user stories is given below, showing its simple and clear form packed in small format, much smaller than other usage requirement artifacts such as use cases or usage scenarios. Each of the statements represents a single user story[3].

- Students can purchase monthly parking passes online.
- Parking passes can be paid via credit cards.
- Parking passes can be paid via PayPal.
- Professors can input student marks.
- Students can obtain their current seminar schedule.
- Students can order official transcripts.
- Students can only enroll in seminars for which they have prerequisites.
- Transcripts will be available online via a standard browser.

Methodology used in this project is as follows:

1. User stories are written by the end-users/stakeholders.
2. Extraction of functional and non-functional requirements and KPIs from the user stories
3. Specification of components and platform
4. APIs for open source components

[3] Agile modeling, user stories http://www.agilemodeling.com/artifacts/userStory.htm#InitialInformal

1.2 Approach for generating Product Passport

In research[4][5] the circular economy is addressed by proposing the closed-loop system with a goal to keep materials in use thus extending the product lifetime and lowering the carbon footprint. The approach used in aforementioned research is extended for the purpose of this project to provide the product passport in the machine industry. The ontology from TagItSmart will be used extended to support the proposed model.

Stakeholders and the products are related via creation nad post-use (repair and reuse) activities with a specific input/output requiring reverse flows. Having in mind that components and parts used in processing industry targeted by this project are reusable in most of other markets, a critical point of success will be to address the distance between these industries. To avoid this issue, as well as to facilitate the exchange the information between these parties, materials are annotated and quantified with information which would be used to get familiar with product composition, condition, reuse potential, disassembly instuctions, location, etc.

4 Elke M. Sauter, Martijn Witjes, "Linked Spatial Data for a Circular Economy Exploring its potential through a Textile Use Case",

5 3XN & GXN Innovation. (2016). 7. Building A Circular Future. Retrieved from https://issuu.com/3xnarchitects/docs/buildingacircularfuture

Section 2 - User stories and KPIs

2.1 User stories

This section presents the result of the interviews with the stakeholders extracted using the user story methodology (explained in section 1.1) which should in most simple form depict required functionalities of the platform.

Roles Descriptions

1. Admin – master administrator who has all permissions and control over every part and entity in system.
2. Stakeholder – machine manufacturer.
   - Admin – purpose of this role is to manage stakeholder operators, machines and product passports.
   - Operator – purpose is to register previously added product passports by scanning them with fc scanner
3. Company – end user of machines / product passports
   - Admin – purpose is to manage company operators.
   - Operator – purpose is to scan smart tags in order to keep track / logs of product passport lifespan.

Admin user stories

1. Admin must log in to use web application.
2. Admin can CRUD all types of users.
3. Admin can CRUD stakeholders.
4. Admin can CRUD companies.

Stakeholder admin user stories

1. User must log in to use web application
2. User can CRUD stakeholder operators.
3. User can CRUD machines.
4. User admin can CRUD product passports.
5. User can add new product with the product details using the web app

Stakeholder operator user stories

1. Machine operator operator must log in to user android application.
2. When machine operator scans the QR code he can see the product details and can enter the feedback about the part
3. Machine can see the list of unregistered parts that has SmartTag on them.
4. Machine can select unregistered part in android application and scan it with FC-scanner in order to register it.

Company admin user stories

1. Company admin must log in to use web application
2. Company admin can CRUD company operators.
3. Company admin can preview logs and various statistics regarding product passport.

Company operator user stories

1. Company Operator must log in to user android application.
2. Company Operator can scan the SmartTag with android application FC-scanner on start of their shift.
3. Company Operator can scan the SmartTag with Android application FC-scanner on end of their shift.
4. Company Operator can scan the SmartTag with Android application FC-scanner in order to see product details.

Commercial user roles

1. Commercial user can preview and use web application for marketplace purpose.
2. Commercial user can search, filter and preview all available machines on marketplace.
3. Commercial user can search, filter and preview all available product passports on marketplace.

Short explanation of the complete cycle:

BankPro as a producer of the machines, tags the crucial machine parts (Electric motor – AC motor, bearings and geared motors), scans the tag with mobile application to pair the machine's part with the QR code. Later, when client buy machine and scan the QR code, they are actually activating the tracking of the machine status, which data is used to build the product passport together with the manual feedback and logs of overhearing and use. Operation of the machine is tracked with the automatic module and manual scanning using two versions of adapted FC-scanner. Marketplace can be used by different stakeholders to search and preview parts of the machine and the machine product passport on the platform.

Requirements are directly correlated with the user stories and 1 on 1 mapping can be direcly exctracted. Additional functional requirements for components are extracted from Section 3 of this documents. Providing the automatical scanning ability with the camera requires adaptation of the FC-Scanner, and the usability and distance of this will be evaluated.

2.2 Key Performance Indicators (KPIs)

The list of the KPIs was not given in the DuraTag's DoW. We have presented the KPIs during the online workshop with the TagItSmart consortium.

The main technical KPIs are:

- KPI 1 At least 100 feedback from the involved actors and sensors
- KPI 2 Marketplace with product passport for at least 2 machine for waste processing

Section 3 - DuraTag Platform

The platform will consist of native TagItSmart components adapted for the DuraTag needs and additional components develop as modular functional blocks with APIs. Accordingly, the DuraTag will be implemented as a multiple module application:

1. Camera module
2. Mobile application
3. SmartTags
4. Web Service with API
5. Web Application for product passport management
6. Web Application marketplace

Developed and adapted TagItSmart technology including FC scanner camera module, encoding and printing SDK, and specific product passport modules will be fully provided as open source.

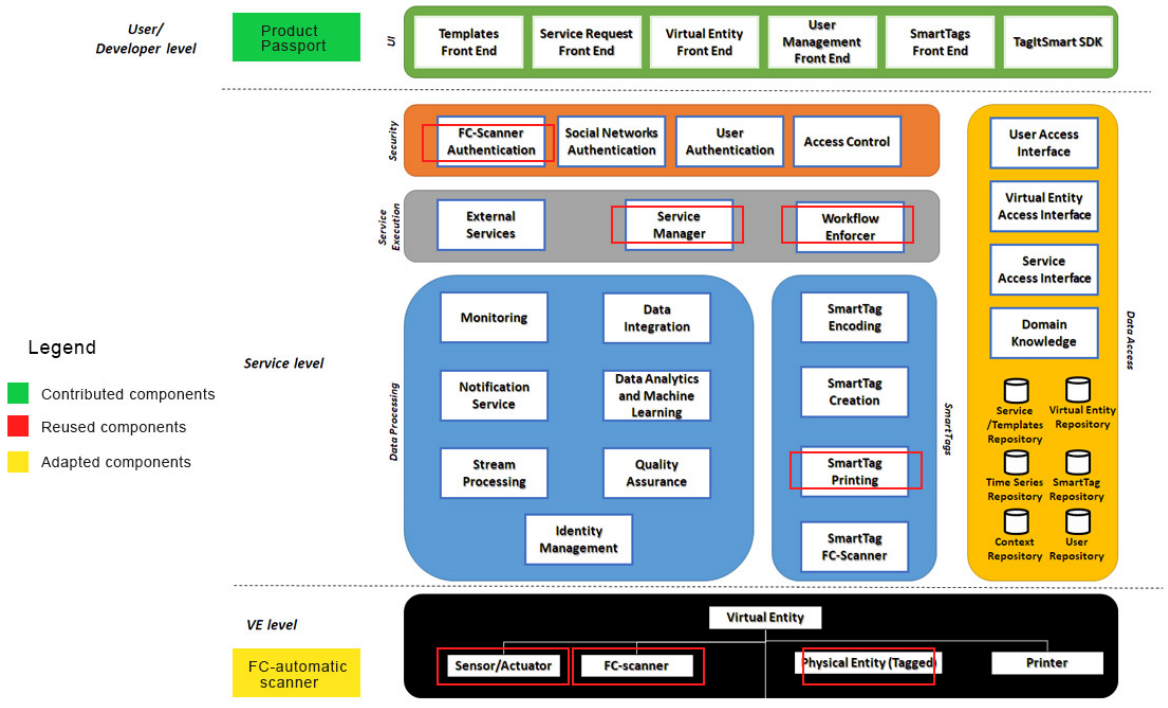

Figure 1 DuraTag extension of the TagItSmart architecture

Two FC-scanner modules will be used, adapted from the original TagItSmart module, one deployed for automatical scanning and one that will be used by the end user. Previously we wanted to use camera to monitor working temperature which should be monitored with reversible tags, but as explained in section 3.3 reversible thermochromic inks are not available at these high temperatures. The automatic camera module feasibility will be evaluated for scanning the small tags size (see section 3.3) for distance and posture of cameras, to enable automatic signalling if the temperature is above limit to turn off the machine. This process will be evaluated as it requires camera deployed in front of each labelled part of the machine.

The manual scanning would be used to generate information for the product passport: when the machine is being used and how many working hours, as well as to provide additional value such as monitoring shifts for workers. Both contexts sensed with two scanner complement each other, manual is used to log the machine state and the automatic camera will provide information if the tag reacted in real time when overheating occurs to be able to stop the machine on time.

3.1 Camera module

Modified FC-Scanner module to support the automatized scanning of the SmartTags. This module will be developed, deployed and evaluated. The usability will strictly depend of the size of the tags, as the size of the components limits the label surface and accordingly limits the distance of the camera and can increase a number of placed cameras. *This module will adapted from FC-scanner and used only for automatic scanning, separately from mobile application.*

3.2 Mobile application

This component will modify FC-Scanner SDK to support envisioned SmartTag scan, and displaying of the product related information. User (Producer) labels the machine part and scan the SmartTag using the FC-Scanner Application in the product screen. Android application will be developed using Xamarin – Microsoft C# based platform for developing cross-platform mobile applications. We chose this approach because TagItSmart SDK is written for Xamaring platform. Application will communicate with Web Service trough RESTfull API, and also with TagItSmart API trough SDK. *This module will be adapted from FC-scanner and used separately from camera module.*

3.3 TagItSmart SmartTags

Before taking into account requirements for the SmartTags (Table 1), we have considered the reversible ink availability for high temperatures. **The highest temperature for reversible inks is 65°C as reversible pigments do not survive high temperatures. However, irreversible inks are available for higher temperatures. Accordingly, we will use irreversible 120°C inks for all components to signal if overheating has occurred.** This will signalize if components are overheated which means that they are damaged. From the other side, it will not be possible to signal for the machine to stop working due to the unavailability of the irreversible tag for 82°C and 95°C.

Table 1 SmartTag requirements

No	Component	Working temperature	Overheating temperature	Tag size	Required Tag features	Chosen tag
1	Electric motor	95°C*	120°C	2x2 cm	Irreversible 120°C	Irreversible 120°C
2	Geared motor	95°C	120°C	2x2 cm	Reversible 95°C Irreversible 120°C	Irreversible 120°C
3	Bearings	82°C	120°C	2x2 cm	Reversible 82°C Irreversible 120°C	Irreversible 120°C

Tags preliminary design is show in the Figure 2. The SmartTags are designed for the red color line to appear if color reached threshold bigger then predefined. Taking into account the size of the mechanical parts that are going to be labelled with the SmartTags, the size of the tags will be as small as 2x2 cm.

Figure 2 DuraTag SmartTag design

3.4 Web Service with API

Web Service will be based on .NET Core 2.0 and will be hosted on Azure in Web App resource. .NET Core 2.0 is powerful web service and web application framework created by Microsoft. Web Service will use MSSQL relational database, which will be hosted on Azure in SQL Database resource. Web Service expose RESTfull API for both android app and web applications usage. Web Service will communicate with TagItSmart trough exposed API. The REST design will be followed to enable **TagItSmart Service Manager, TagItSmart repository** and **TagItSmart Encoding and Printing** module to be integrated during later stage of the project.

1. Api Description

We are describing API endpoints that are reffering to user stories mentioned above.

1.1 POST
/v1/auth/login
1.2 POST
/v1/users
GET
/v1/users
PUT
/v1/users
DELETE
/v1/users
1.3 POST
/v1/stakeholders
GET
/v1/stakeholders
PUT
/v1/stakeholders
DELETE
/v1/stakeholders

1.4 POST
/v1/companies
GET
/v1/companies
PUT
/v1/companies
DELETE
/v1/companies
2. Stakeholder admin user stories
2.3 POST
/v1/machines
GET
/v1/machines
PUT
/v1/machines
DELETE
/v1/machines
2.4 POST
/v1/passports
GET
/v1/passports
PUT
/v1/passports
DELETE
/v1/passports

3. Stakeholder operator user stories
3.2. GET
/v1/parts
3.3 POST
/v1/passports/scan/register

4. Company admin user stories
4.3. GET
/v1/passports/logs

5. Company operator user stories
5.2. POST
/v1/passports/scan/start
5.3. POST
/v1/passports/scan/end
5.4. POST
/v1/passports/scan/details

3.5 Web Application for product passport management

This application will provide the user (producer) the ability to add all machines and its all components in the platform. Web Application will be developed as single page web application using AngularJS – a JavaScript-based open-source front-end web application framework used for developing single-page applications. Web Application will communicate with Web Service RESTfull API. Producer can add the machine and its all components using the application.

3.6 Web Application marketplace

The component will enable registration of external 3rd parties over the website, specific queries (over the APIs as well as UI) based on the developed ontology to enable different information exchange such as: Which companies produce a certain product composed of certain recycled material; which companies generate outputs of certain material that can be used as input by company for repairing of certain product; which products are in good state (condition) and are available for reuse (post-use activity) from a specific stakeholder; etc.

Section 4 - Product passport

DuraTag was build upon the state of the art [2], [3] documentation available online for the product passport. This previously designed high-level taxonomy is used as a basis and modified as it is showed in Figure 3; to provide processes, elements and activities required for the purpose of DuraTag's outcomes. Stakeholders (actors) and Resources are two most important elements for the circular economy (grey). Stakeholders in this case could be different companies or individuals that interested to be a part of this value chain, as a part of any process. More specifically, the components can be monitored to provide more insights on mechanical materials in different conditions, recycled to enable refurbishing, reusing, recovery and reselling. Resources are further broken down into a hierarchy of parts, starting with the whole part (product) ending with the smaller part (chemicals, out of research scope). *Products may consist of components, but components can also be considered as products elsewhere in the supply chain.*

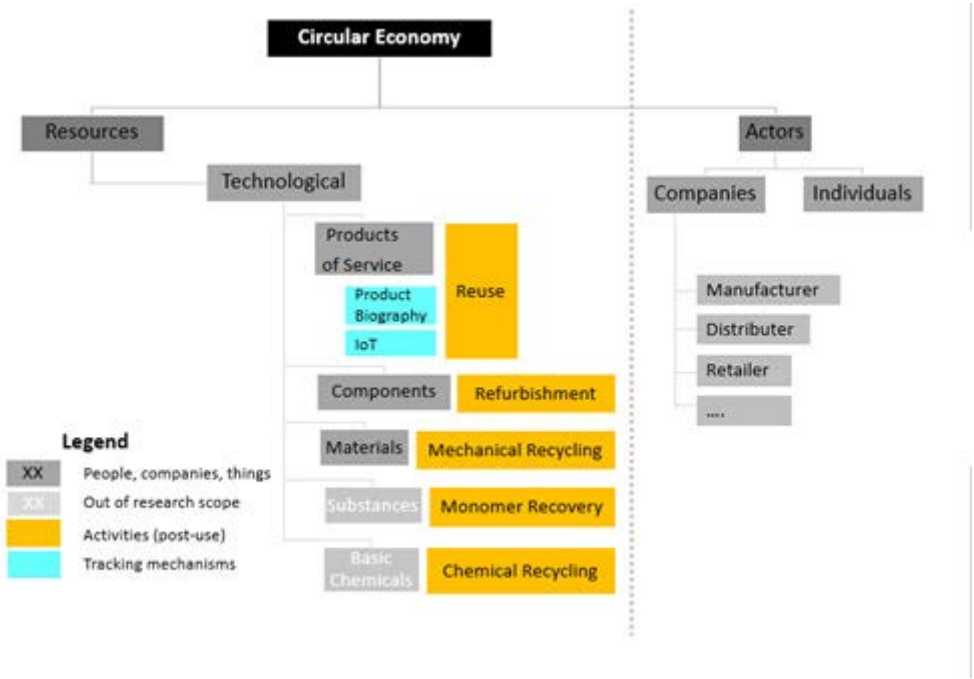

Figure 3 Circular economy taxonomy for processing industry

After the resource finishes its use cycle, different post-use activities are applied on the resource (yellow) and these are different based on restrictions for the post-use activities' input materials. Having in mind the each product is tracked through a product biography using SmartTags (cyan), the **product passport** will be generated to enable collaboration between companies and individuals using these iformation.

4.1.1 Product passport ontologies

The Circular Economy ontology will be developed with products as the main focus unit, since **product passports** will account for the main data source. The passports will be provided on the marketplace for the stakeholders and should store information about:

- Product provenance: creation and use of the product with the details about the companies or individuals involved in the product's creation. The company's profile will annotate the company's location, inputs, outputs, certifications (i.e. BankPro) and post-use activities (along with the reverse logistics mechanisms) offered by the company. Moreover, for the product's use stage, the owner will be annotated for the different use cycles.
- Product Qualification: the characteristics related to the availability, condition and location of a product are stored. This section will also annotate possible post-use activities for a product which will ultimately link to the post-use activities offered by companies.

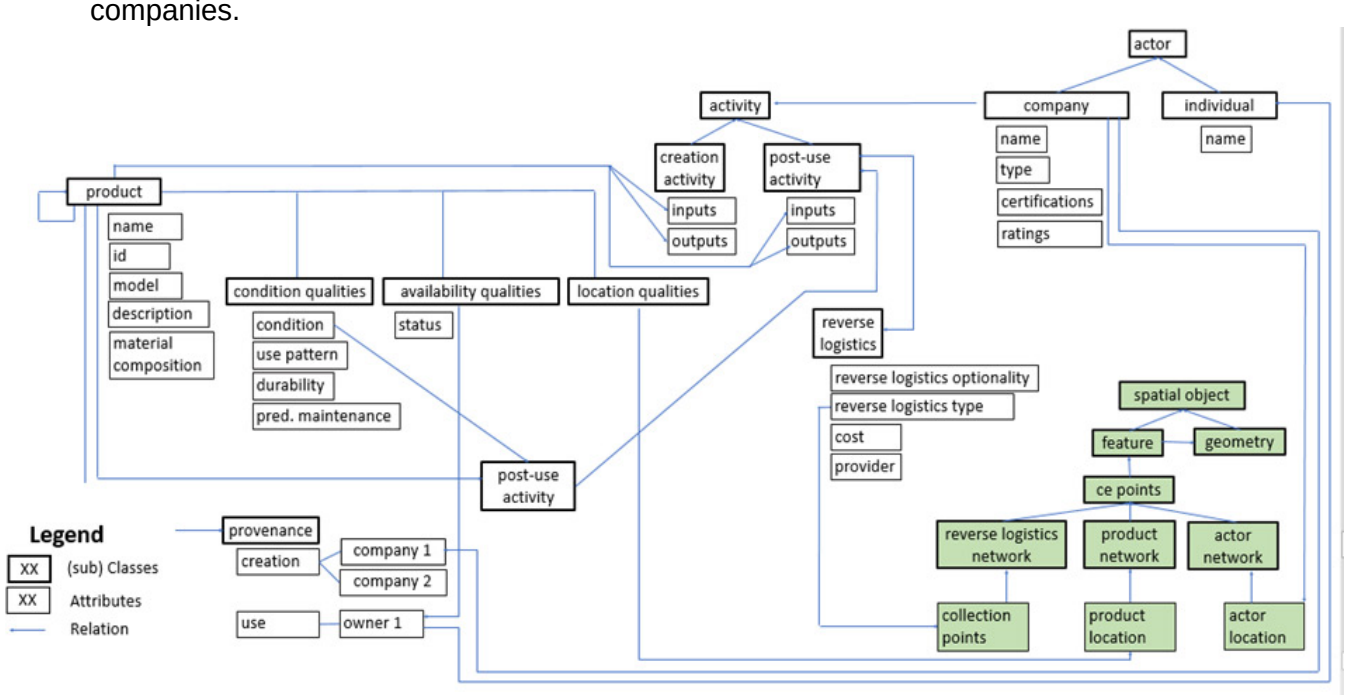

Figure 4 Ontology for circular economy

In table 2, product passport data are presented which are envisioned to be able to extracted from the DuraTag platform. Part of the data, such as one presented with "Data analytics" in the "mean of collection" row, could not be extracted directly. The third party will have possibility to manually compose it from different aggregated data using e.g. history of user logins when scanning the machines' QR code during shift to determine the usage data.

Table 2 The product passport data

Product passport	Data	Mean of data collection
Product/Component	Name, Image, Model, Description, material composition	Added manually by the user
Product/Component	Location	FC-scanner collects location
Product/Component	Material	Added manually by the user
Product/Component	Availability	Data analytics
Product/Component	Year of manufacturing	Added manualy by the user
Product/Component	Condition	Data analytics: Feedback from the FC-scanner automatical and manual. Manual can be submitted by form in an app when product detals are shown on SmartTag scan
Product/Component	Use pattern	Data analytics
Product/Component	Durability	Data analytics
Product/Component	Prediction maintaince	Data analytics
Product/Component	Disassembly instructions	Added manualy by user
Company profile	Profile, Link	Added manualy by user
Service book: History of repairs	Service description	Added manually by the user

One of the goals that we want to achieve with the product passport is to enable circular economy by providing an information to the ecosystem for availability of different materials from obsolete products. These are main compounds for our targeted machine parts:

- Electric motor (EC) and geared motor:
  - Motor cases are graycast or silumina (AlSi12),
  - Power parts: Alloy steel
  - Fans: polipropilena (PP), magneta, copper
  - Gear, worm gear in reproductors: copper
  - Mineral or sintetic oils and lithium and sintetic lubricants
- Bearings:
  - Cases: Alloy steel - stainless or chromium
  - Balls: Stainless or chromium steel, cheramic materials, silicone nitride (Si3N4)
  - Lubricants: lithium or sintetic

4.1.2 DuraTag Semantic Model for SmartTags

The semantic model for the DuraTag use case is presented at the Figure 5.

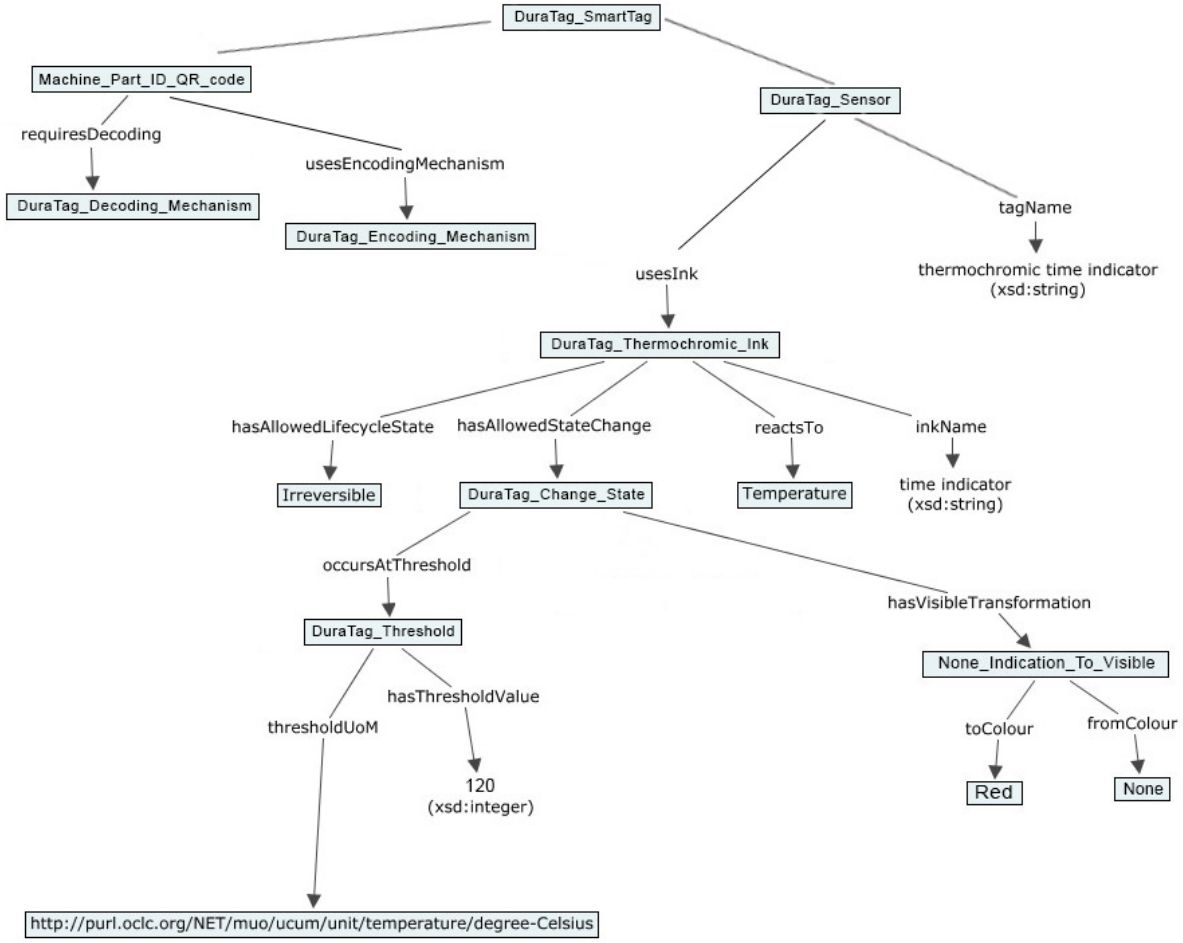

Figure 5 DuraTag SmartTag Semantic model

Section 5 - Conclusions

In this document the DuraTag's platform is presented with the goal to specify and later develop the product passport in processing industry that could enable reuse, refurbish, and repair of materials, thus boosting the circular economy. This was done by interviewing two big stakeholders in the region, BankPro and Schneider Electric. The results of the interviews in form of user stories are used to specify components for the platform and product passport with draft version of the APIs. As product passport is stll not introduced in this market, having in mind that the focus was exclusively on hosting the product details, we have used product passport ontology from textile use case and modified it for the purpose of waste management industry. We believe that exposing this data to the higher auditorium by connecting it to a cross-industry information ecosystem will will facilitate circular exchanges.

Section 6 - References

1. Elke M. Sauter, Martijn Witjes, Linked Spatial Data for a Circular Economy http://ceur-ws.org/Vol-2044/paper10/paper10.html#_Ref490914724
2. MBDC. (2003). Cradle to Cradle Design Guidelines.
3. Ellen MacArthur Foundation. (2013). Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition.