Taking Control of Your Health Data: A Solid-based Mobile App for Wearable Data Collection and RDF Visualization

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Abstract. While wearables generate valuable health data, proprietary ecosystems limit interoperability and user control. We address this challenge with a user-friendly Android application that seamlessly collects data from diverse wearables via the Web of Things (WoT), converts the collected data into interoperable RDF using the SOSA/SSN ontology, and stores RDF in user-controlled Solid servers. Unlike existing solutions, our approach includes mapping the data to established ontologies and provides a user interface, empowering everyday users to explore their health data through interactive visualizations. We showcase the application's functionalities through live demonstrations – code, demo videos, and an installable apk are publicly available at https://github.com/derwehr/WoT-Solid/.

Keywords: RDF · Solid · Web of Things

1 Introduction

Wearables have become a common tool for tracking daily activities such as running, biking, or simply counting steps. Wearable manufacturers try to bind users to their ecosystem by not adopting a unified interface. As a result, users face two challenges: interacting with devices from different manufacturers requires multiple applications, and the applications store collected data in varying data formats on manufacturer-controlled storage systems.

Research providing parts of the solution to the interoperability and data storage challenges already exists. On the one hand, the W3C recommendation Web of Things (WoT) addresses accessing arbitrary devices using a semantic interface description called Thing Description (TD) [6]. On the other hand, the Social Linked Data (Solid) project focuses on breaking up silos by using the Resource Description Framework (RDF) and giving users back ownership of personal data [7]. However, the two components must be combined to provide a comprehensive end-to-end solution for collecting data from different devices, converting the collected data into an open human- and machine-readable format, and storing it in user-owned storage systems.

Previous authors have implemented the WoT standards to gather measurements from wearables [2], or store health data in Solid servers[1,3]. Research connecting the WoT standard with Solid exists, but it does not map the data gathered via WoT technologies to existing ontologies [5] or lacks a user interface enabling everyday users to use the developed approaches [4].

Our demo paper presents a user-friendly Android application that can seamlessly interact with Bluetooth Low Energy (BLE) wearables described by TDs. The application collects data from wearables converts the collected data into RDF using the Sensor, Observation, Sample, and Actuator (SOSA/SSN) ontology[3], annotates the resulting SOSA observations with additional information such as location and time, and stores the RDF data in the users' Solid server. In addition, the application visualizes measurement data retrieved from Solid servers.

2 Architecture

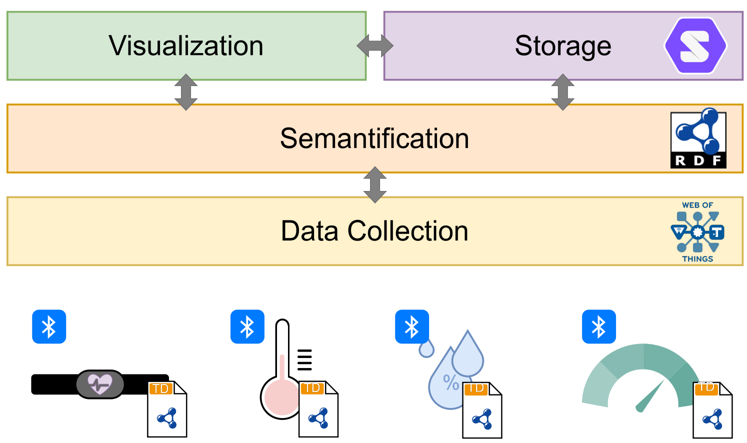

Fig. 1. Layers of the application

Figure 1 shows an overview of the application's layers. The lowest layer, the Data Collection Layer, is responsible for discovering and interacting with BLE devices to collect data. To enable out-of-the-box compatibility for varying devices, the Data Collection layer implements the WoT recommendations. All gathered data passes the Semantification layer, our connection of the WoT with Solid. The Semantification layer converts the measurement data to RDF and adds semantic annotations using the vocabulary of established ontologies by the W3C and the QUDT.org organization. An example of gathered data annotated with these ontologies is shown in Listing 1. Listing 1 shows measurement data containing

[3] https://www.w3.org/TR/vocab-ssn/

```
1 @prefix qudt: <http://qudt.org/2.1/schema/qudt#>.
2 @prefix unit: <http://qudt.org/2.1/vocab/unit#>.
3 @prefix geo: <http://www.w3.org/2003/01/geo/wgs84_pos#>.
4 @prefix sosa: <http://www.w3.org/ns/sosa/>.
5 @prefix xsd: <http://www.w3.org/2001/XMLSchema#>.
6 @prefix s4wear: <https://saref.etsi.org/saref4wear/> .
7
8 _:heartrateObservation1702382040625 a sosa:Observation;
9     sosa:hasFeatureOfInterest <https://ex.solidpod/profile/card#me>;
10    sosa:resultTime "2023-12-12T11:54:00.625Z"^^xsd:dateTime;
11    sosa:observedProperty s4wear:HeartRate;
12    geo:lat "49.594672"^^unit:DEG;
13    geo:long "11.0033571"^^unit:DEG;
14    sosa:hasResult _:heartrateResult1702382040625.
15 _:heartrateResult1702382040625 a sosa:Result;
16    qudt:numericValue "72"^^xsd:decimal;
17    qudt:unit unit:BEAT-PER-MIN;
18    sosa:isResultOf _:heartrateObservation1702382040625.
```

Listing 1: Heart rate measurement data annotated with semantic information

a heart rate observation (lines 8-14) and the observation's result (lines 15-18) in turtle notation. The observation is modelled with the SOSA vocabulary to describe the observation's feature of interest, result time, and the observed property (lines 9-11). The geographic location of the measurement is added to the observation using the W3C's Basic Geo (WGS84 lat/long) vocabulary[4] (lines 12-13), and the SOSA result of the observation is semantically enhanced with the vocabulary of the QUDT ontology to describe the unit of measurement (lines 16-17). To generate annotations, the application retrieves the result time and geographic location each time the Semantification layer creates an observation, i.e., every time the Data Collection layer receives data from a device. The Storage layer provides the Solid WebId, and all other annotations are parsed from the device's TD. Two layers communicate with the Semantification layer: The Visualization and the Storage layers. The Storage layer provides a Solid interface to persist the annotated RDF graphs, and the Visualization layer generates representations for live data and persisted RDF data from Solid servers.

3 Demonstration

To demonstrate our approach, we connect the Polar H9[5] and the Magene heart rate sensors[6] to the application by providing their respective TDs enriched with semantic information. After connecting the devices, we present annotated RDF

[4] https://www.w3.org/2003/01/geo/
[5] https://www.polar.com/en/sensors/h9-heart-rate-sensor
[6] https://www.magene.com/sensors/52-h303-heart-rate-monitor.html

data of the device measurements and live plotting of the RDF data. Additionally, we demonstrate our application's ability to browse and visualize historical measurement data stored in Solid servers.

The application and videos showcasing the above functionalities are publicly available at https://github.com/derwehr/WoT-Solid/.

4 Conclusion

Our demonstration presents an end-to-end solution for collecting and storing heterogeneous data from wearable fitness devices implemented in a user-friendly Android application. The application implements the WoT standards to enable out-of-the-box interoperability with diverse devices and maps the devices' data to RDF annotated with established ontologies to improve data interoperability. The annotated RDF data is stored in Solid servers, providing decentralized storage solutions with fine-grained access control. Moreover, the application generates visualizations for live- and historical data to enable comprehensive analysis.

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