Demo Abstract: The Intelligent IoT Integrator Data Marketplace – Version 1

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Abstract—The widespread adoption of IoT in the context of smart cities, along with the emergence of data-driven applications, increases the interest in data marketplaces. Multiple research articles argued the importance of data marketplaces to create scalable IoT applications. Still, there are no open-source data marketplace implementations to help researchers and practitioners to experiment with and develop novel protocols and frameworks for IoT data marketplaces. In this demo, we introduce Intelligence IoT Integrator (I^3) - Version 1, which is an IoT data marketplace developed for smart cities at the University of Southern California. In particular, this demo focuses on user management, product creation, product purchasing, user authentication, and access control.

Index Terms—IoT Data Marketplace, I^3, Smart Cities

I. INTRODUCTION

The maturity of the Internet of Things (IoT), together with the advancements in the field of machine learning and artificial intelligence, encourages the cities to move towards data-driven IoT applications. However, the deployment and management of IoT sensors and actuators at the city scale would incur high costs to the city administration. Therefore, cities are beginning to explore the idea of a community-driven IoT data marketplace, which allows the IoT device owners in the community to sell their data via the data marketplace to help the application developers, including the city administration.

There have been numerous articles in the literature on the topic of the IoT data marketplace, which argues for the importance and the benefits of such systems. Some literature introduces the architecture and building blocks of IoT data marketplaces. In our prior work, we introduced the I^3 data marketplace and its preliminary implementation [1]. However, there is no open-source implementation of the IoT data marketplace to help researchers, practitioners, including cities, to experiment with data marketplaces.

In this demo, we introduce the Intelligent IoT Integrator – Version 1 (I^3-v1), which is an open-source implementation of a data marketplace (https://github.com/ANRGUSC/I3-Core). I^3-v1 enables sellers and buyers to create, sell, and buy data products. This demo provides a high-level overview I^3-v1 and explains its critical functionalities, including user management, identity and access control, product creation as a seller, product purchasing as a seller, and data sharing.

The I^3-v1 IoT data marketplace is discussed in Section II, while Section III provides pointers to I^3-v1 open-source software. Section IV concludes the paper.

II. THE INTELLIGENT IoT INTEGRATOR - VERSION 1 ($I^3 - v1$)

Figure 1 shows the architecture of I^3-v1. It allows administrators to set up and manage the key functionalities of a data marketplace, including payment processes and data sharing. Besides, the sellers can post products by creating an account in the system. And, the buyer interface lets the application developers create accounts and buy data products. The key building blocks of the marketplace is described below:

A. Backend:

The marketplace middleware consists of a backend, which is in charge of managing the users and their data products. We explain the functionalities of backend below:

Django Framework: This component handles the marketplace frontend and manages the web services for creating, posting, and buying data products. It relies on the MySQL database to store and manage the user and product information. Besides, it coordinates with other functional elements in the backend infrastructure to serve sellers and buyers.

Hub, Device, and Product Manager: Our prior work on the I^3 data marketplace [1], which we refer to as I^3-v0, only allowed individual users to create data products. In I^3-v1, we extend the product manager and introduce the concept of hubs and devices. Hubs enable an organization to create a registry for its devices and data products. IoT hardware devices, including sensors and actuators, are registered under the organization's hub. The data products are then created under the organization's hub to manage multiple devices and their data efficiently. One of the advantages of this model is that it allows various administrators from an organization to manage their devices and data products through a single hub. In the future, we can also extend this module to enable fine-grained role-based access control for hubs, devices, and data products. Note that this hub and device abstraction is applicable only for the sellers, since the buyers are just buying individual data products from the marketplace, and their interactions with the marketplace are simple compared to the sellers.

Authentication and Access Control: This is one of the critical components of a data marketplace. When sellers create data products on the marketplace, they are made available to the buyers. Besides, the seller is required to publish sensor data to the marketplace's data broker. To prevent unauthorized sell-
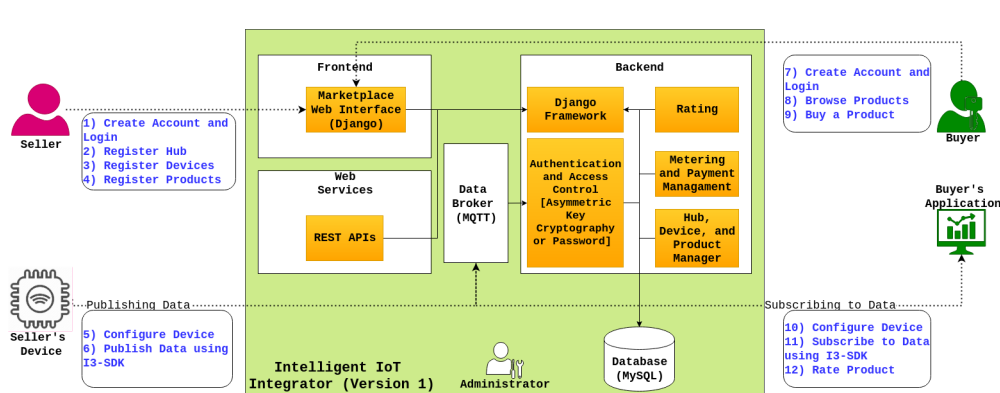
Fig. 1. Architecture of I^3-v1.

ers and devices from publishing to the marketplace's broker, we introduce two authorization schemes for the sellers:

- **Password-based Authentication:** Through this scheme, the seller can create a password for his device, which should then be used when connecting the device to the marketplace's MQTT broker. In I^3-v0, the marketplace middleware generated the password for the user. Here, we allow the seller to register his or her preferred password when registering the device.
- **Asymmetric key cryptography:** This scheme is newly introduced in I^3-v1, which allows the seller to use public-key cryptography to authenticate their device securely. Under this scheme, the seller is required to register his or her public key when registering the device. When connecting the device to the marketplace's broker, the seller is required to generate a *JSON Web Token* and sign the message using his or her private key. Upon receiving the connection request from the device, the marketplace's broker decrypts and authorizes the device using the device's public key, which was recorded in the middleware at the time of device registration.

For the buyers, the marketplace auto-generates the password, which should then be used by the buyer when connecting his device to the marketplace's broker for receiving the data.

Metering and payment management: This component is responsible for handling the payment for the data based on the amount purchased by the buyer. In I^3-v1, we do not handle real payments, but fiat or cryptocurrency payment platforms can be integrated.

Rating: This module is used to keep track of the reputation of the sellers and their data products. If a buyer purchases a data product, he or she is then allowed to rate the product based on his experience.

B. Frontend, Data Broker, and REST APIs

Frontend: The marketplace allows the users, including the sellers and buyers, to set up an account, create hubs, devices, and products, along with support for searching and rating. This module is implemented using Django's web templates.

Data broker: This module is one of the critical components of I^3-v1 data marketplace since this lets the seller share his or her data with the authorized buyer. We used MQTT, which is one of the well-known and widely used publish-subscribe brokers. This broker is integrated with authentication and access control module through MosquittoAuth plug-in, which authorizes the sellers and buyers following the schemes discussed in Section II-A. And, an open-source SDK for of I^3-v1 data broker is available at the following link: https://github.com/ANRGUSC/I3-SDK.

REST APIs: In addition to the graphical user interface, I^3-v1 also exposes a collection of REST APIs to enable the sellers and buyers to create and manage data products.

III. OPEN-SOURCE SOFTWARE

We have released the open-source software to help researchers and practitioners to experiment with IoT data marketplace, which is available at https://github.com/ANRGUSC/I3-Core. The SDK for the sellers and buyers are available at: https://github.com/ANRGUSC/I3-SDK.

IV. CONCLUSION

In this demo, we have introduced the Intelligent IoT Integrator - Version 1, which is an IoT data marketplace for smart cities. Besides, we have shown how the key functionalities, such as user creation, product management, authentication and access control, data sharing, and rating, are handled. We believe that the researchers and practitioners interested in the IoT data marketplace would benefit from this open-source software.

ACKNOWLEDGMENT

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