Secure, Interoperable, End-to-End Industry 4.0 Service Platform for Lot-Size-One Manufacturing

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***Abstract*—The paper introduces a novel secure, interoperable, and end-to-end industry 4.0 service platform for lot-size-one manufacturing. The challenges faced by the European manufacturing industry that prevent it from embracing such a new paradigm are outlined. Then, the platform architecture and operational steps are summarised.**

***Index Terms*—Cybersecurity; Industry 4.0; Lot-size-one; Manufacturing; Platform.**

I. Introduction

With the increased adoption of digital technologies, the European manufacturing industry is reinventing itself. In parallel, consumer demands for more personalised products delivered at a preferred time are witnessed in both B2C and B2B contexts. Lot-size-one (LSO) [1] manufacturing has emerged as a new trend in the Industry 4.0 domain [2] in this context and is particularly observed in retail and e-commerce sectors. LSO refers to a small quantity of goods manufactured on a single production run and delivered at a specific date request by a customer. There are three main benefits that is driving the adoption of the new paradigm - reduced cost of inventory, customer loyalty, and acquiring new customers.

However, it is challenging for factories to provide the required flexibility supporting LSO manufacturing. To adopt LSO product development, the manufacturers must diversify their production systems, supply chains, and embrace a new business model. But such transition faces lack of (i) estimation of production times for lot-size-one (LSO) products, (ii) communication between shop floor workers and other stakeholders for upcoming production tasks, (iii) information on current state of production & preventive maintenance, (iv) ad-hoc creation of supply network[1], and (v) coordination of deliveries, contracting, and payment. In addition to that, the lack of digital platforms and marketplaces supporting LSO prevents manufacturing companies from embracing the new paradigm.

This paper introduces a novel secure, interoperable, end-to-end industry 4.0 service platform for embracing LSO manufacturing. The platform empowers any manufacturing company to receive lot-size-one product orders, set up an ad-hoc supply chain, perform predictive maintenance on its production line, coordinate delivery of products at the date specified by the customer using secure, interoperable, end-to-end web services. Blockchain based smart contract [3] is employed for supply chain and delivery related contracts creation, management, verification, and payment in real-time. The proposed platform utilises EFPF[2] platform collaboration services. EFPF (European Connected Factory Platform for Agile Manufacturing) is a federated smart factory ecosystem and a digital platform that interlinks different stakeholders of the digital manufacturing domain.

[1]The COVID-19 pandemic has disrupted the supply chain across the globe, https://www2.deloitte.com/global/en/pages/risk/cyber-strategic-risk/articles/covid-19-managing-supply-chain-risk-and-disruption.html

II. Platform Architecture

A high level architecture of the proposed platform and its components are depicted in Fig. 1. The platform follow "mobile-first" approach. The mobile app serves as both customer and manufacturer dashboard depending on the profile of the authenticated user. The customer is able to place an order for delivery on a specific date, view the status of the order, view the status of production, receive an invoice, and make payment. The manufacturer is able to view the placed orders, accept/reject it, initiate a search for ad-hoc supply chain partners, enter into smart contract with them, get a holistic view of the production status, raise an invoice once the production is complete.

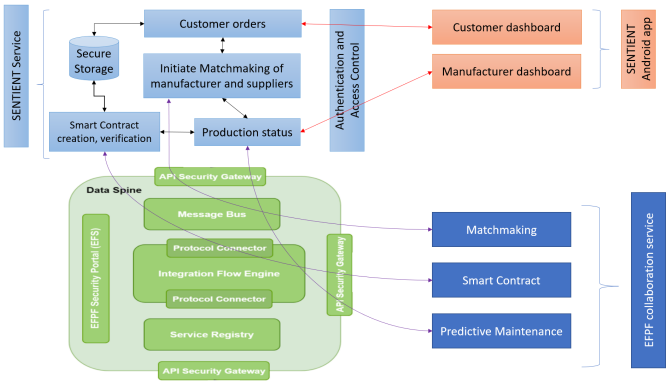

Fig. 1. Architecture of the proposed platform.

The operational steps are described below.

A. Authentication and authorisation

For authentication, the platform supports both basic authentication and OAuth 2.0 mechanisms from the mobile app to the service backend. Upon successful authentication, a JSON Web Token (JWT) is issued to the client app with a validity

[2]EU H2020 EFPF project - https://www.efpf.org/

of 7 days. After that, the token is blacklisted and the client must re-authenticate itself. The valid JWT must be used for accessing the protected routes of the service backend. So, the authorisation to access other web services of the server is determined by the JWT.

B. Customer order and matchmaking

This is a web service that keep track of customer orders. An authenticated customer navigates through the advertised products and selects one for customisation. Through the client app, customer places an order for the LSO product. This web service receives the order, creates a unique order ID, and stores it. Then it initiates a matchmaking to the EFPF matchmaking service to obtain a list of suppliers needed for that product manufacturing. Once that is obtained, the customer order web service will accept the order, calculate a price for the product, and send a push notification to the client app with order ID, and price quotation. If the customer confirms the price, then the order ID status is updated in the secure storage. These data flow are shown in Fig. 2. The matchmaking component of the proposed platform is a client to the EFPF matchmaking service (which acts as the server).The interaction between the SENTIENT matchmaking client and EFPF matchmaking web service occurs in three steps. This is depicted in Fig. 3. At the first step, the SENTIENT matchmaking client authenticates itself with he EFPF secure API gateway to receive an access token. The username and password used for the this step are same as the EFPF portal login. In the response, the API gateway returns the access token. The token is then used as a Bearer token at the HTTP Authorization header for subsequent two GET requests. The next step is to send a GET request to the EFPF service registry to obtain a list of service descriptions. Upon parsing the received descriptions, SENTIENT client extracts the base URL for EFPF federated search web service. In the final step, the client sends another GET request with query parameters to the federated search or matchmaking web service of EFPF which returns a list of suppliers with name, price, material, type etc

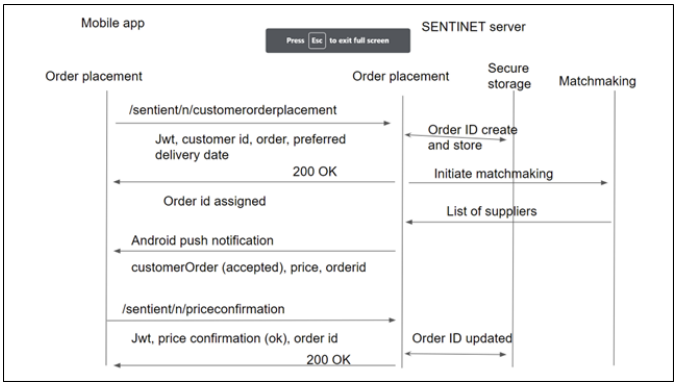

Fig. 2. Customer order web service.

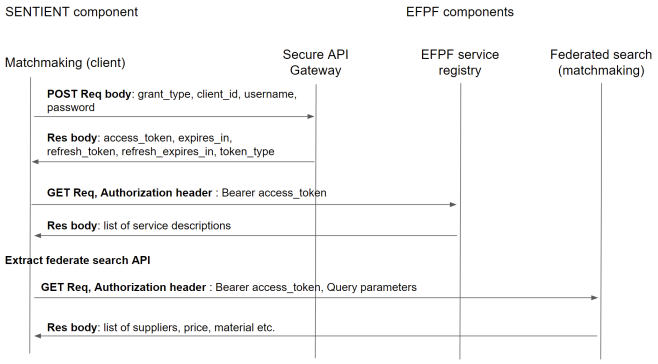

Fig. 3. Matchmaking for adhoc supply chain setup.

C. Smart contract creation and deployment

Once the customer order is confirmed, the smart contract component of the platform is activated. The matchmaking client is sending the information to be written into the smart contract to the SENTIENT smart contract client. The data exchange is shown in Fig. 4. DAML is chosen as EFPF is using DAML 1.7.0 to specify contracts. Upon successful smart contract creation, it generates a DAR file. Thereafter, the smart contract client must authenticate itself to the EFPF identity management web service to receive the access token. This access token is used to authenticate itself at the EFPF ledger in the next step. Finally, the DAR file is deployed via an instance of a JSON-API to the EFPF ledger.

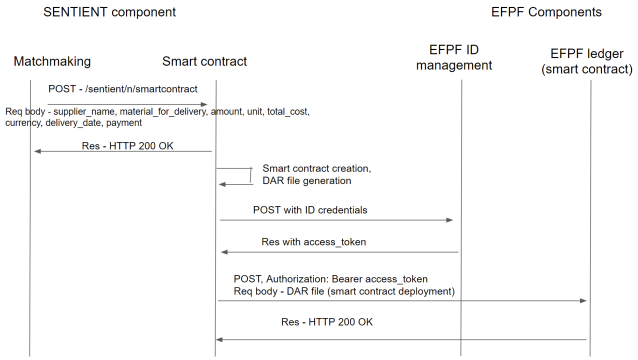

Fig. 4. Smart contract data flow.

D. Production Status

This web service keeps a track of the status related to each order placed by the customer. As soon as the order status changes (i.e., order place, accepted, smart contract created etc.). These statuses are then available in the mobile app for both customer and manufacturing interfaces.

III. Conclusion

This paper provides an overview to a secure, interoperable, end-to-end service platform realising lot-size-one production.

The platform will empower European manufacturing companies to quickly embrace the new paradigm of LSO. The platform architecture and its main component are summarised. Currently, the mobile app and platform components are evaluated for resource consumption and scalability.

IV. Acknowledgments

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