PUF-Based Identification Tags and Blockchain for Supply Chain Management

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Outline

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Object Authentication in Supply Chain Scenario

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- In this scenario, the product item is required to be recognizable and distinguishable in order to be traced individually.
- Authentication mechanisms, therefore, play a crucial role. However, as physical objects such as product items do not have authentication capabilities, an important research issue is to provide an identity to them together with a mechanism to prove it.

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Physically Unclonable Function (PUF) as entropy source for secure key generations, which represents a low-cost and more secure alternative with respect to the conventional non-volatile memory-based solutions for key storage.

Aim of the Presentation

We show how the identification tag can be coupled with physical objects (product items), conferring them a digital fingerprint within a blockchain-based supply chain scenario for traceability and anti-counterfeiting of products. In particular, we illustrate how the identification tag presented here can be employed to confer identity to a product item to be tracked along its supply chain.

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We describe all phases of the supply chain management process by means of the BPMN standard, in particular we use choreography diagrams to model the interactions among all entities involved in the supply chain management in terms of exchanging messages, including those that interface with the blockchain infrastructure.

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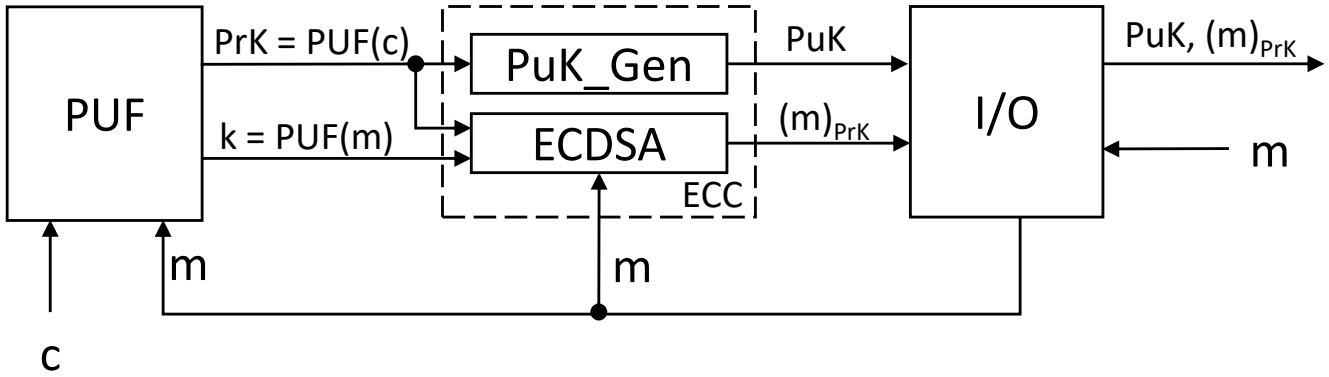
- Signature verification is supported at the verifier side only.

High-level tag architecture



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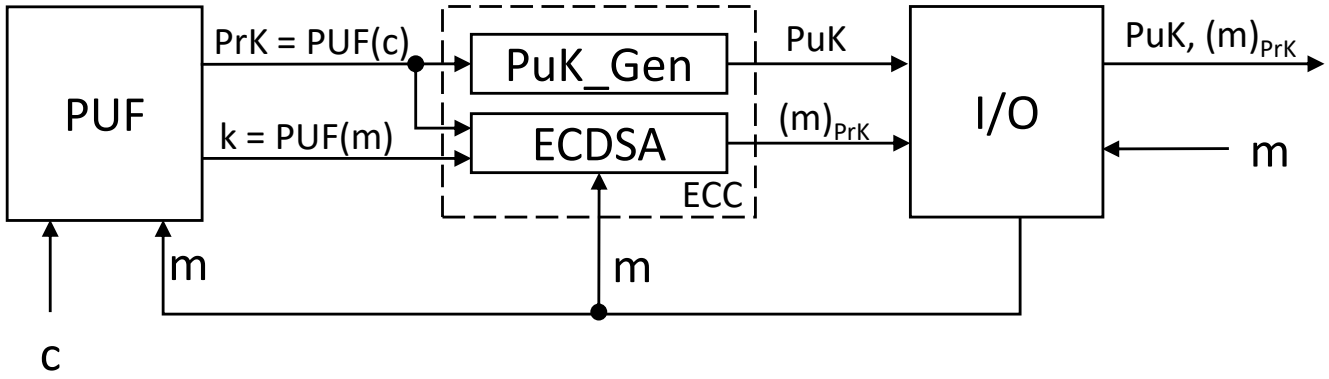

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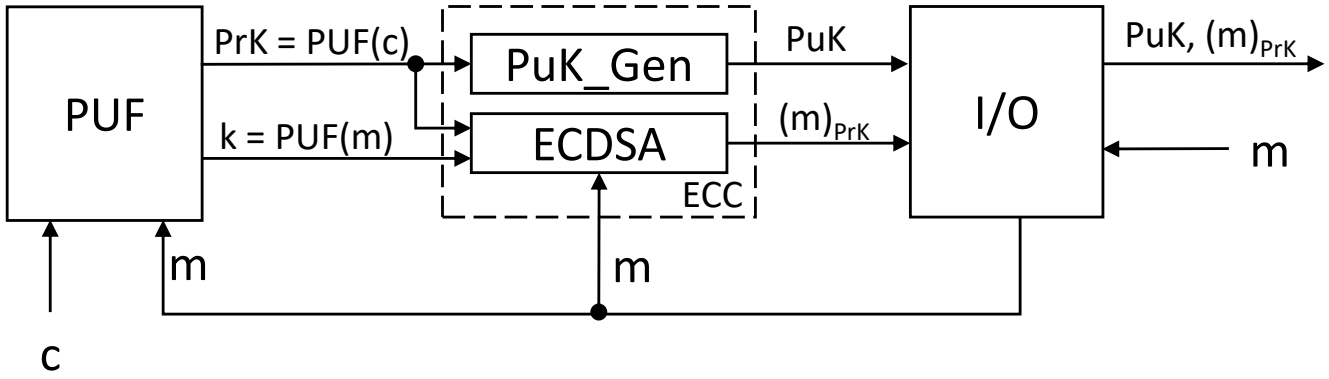

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- The PUF is used to deterministically generate the tag's private key PrK using a hardwired challenge c, and a nonce k.

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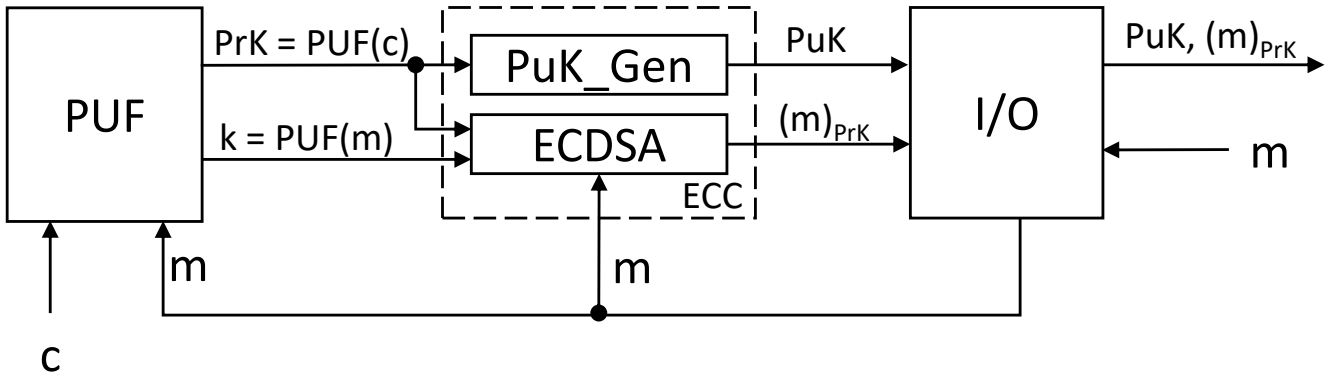

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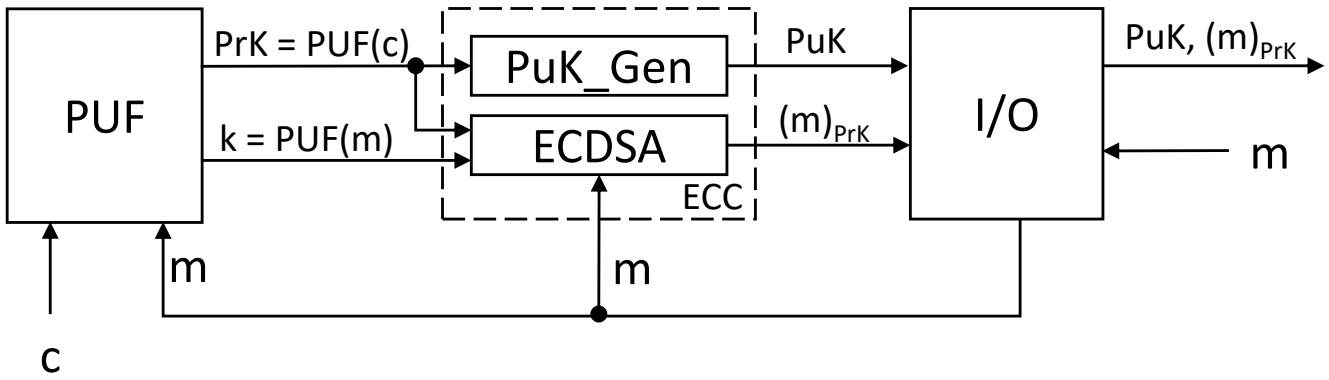

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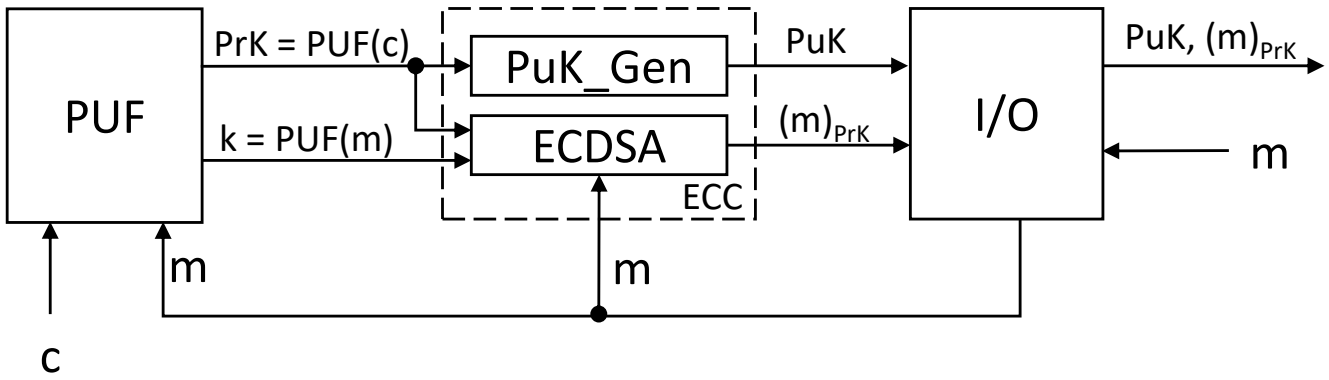

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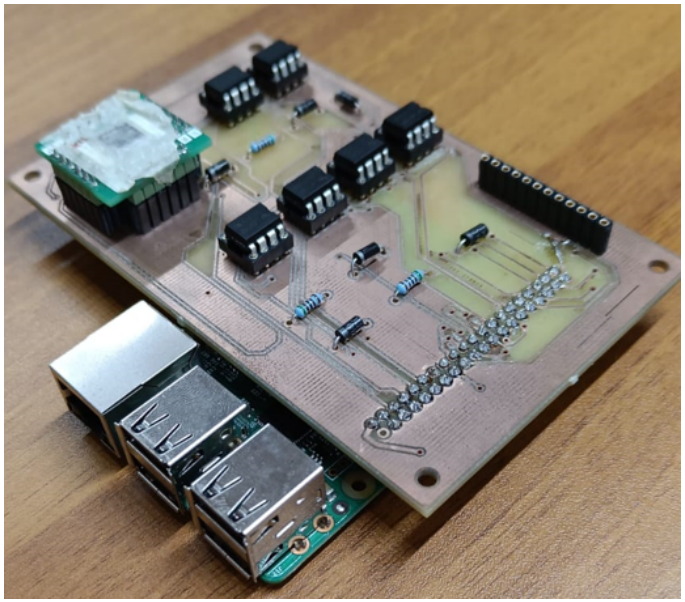
- To enable plain text message input reception (256 bits maximum) and signed message and public key output transfer (1024 bits maximum).
- To supply power to the identification tag, being it passive in itself.

ID Tag Prototype



The PUF itself is ad-hoc hardware, fabricated through the EUROPRACTICE Consortium, connected to a Raspberry Pi board by means of a signal-levelling custom interfacing printed circuit, connected to the expansion pins. We leverage the board's already available software substrate for the other components.

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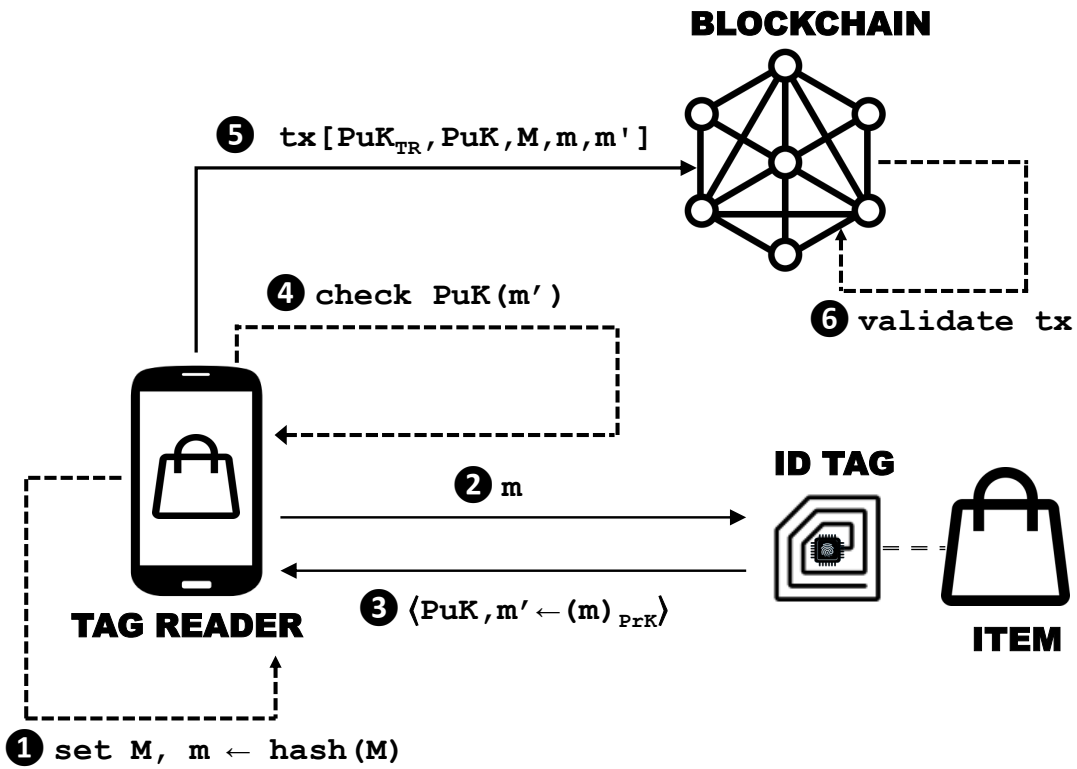
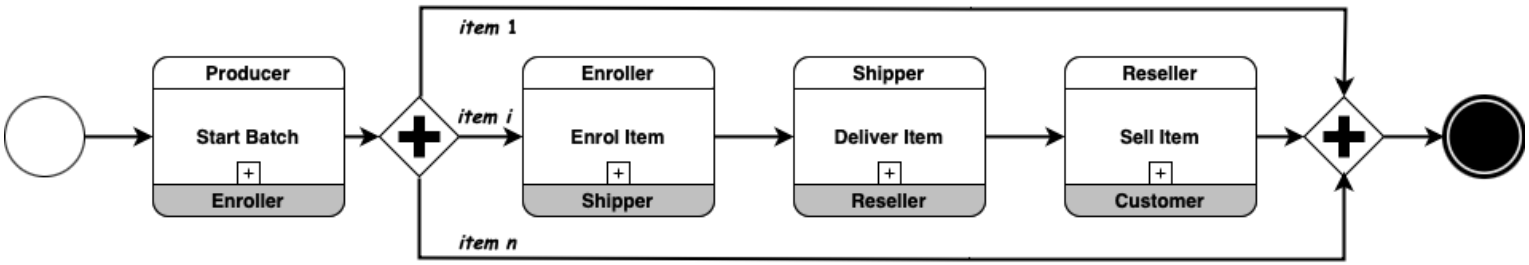
- The item is then traced by means of other tag readers in the various phases along the entire supply chain. Readers collect relevant information about the phase into a transaction that is sent to the blockchain to be validated by a suitable smart contract checking the status of product distribution, thus enabling supply chain actors (e.g., producer, distributor, and consumer) to track and trace their entire production and delivery

A generic authentication phase for supply chain management



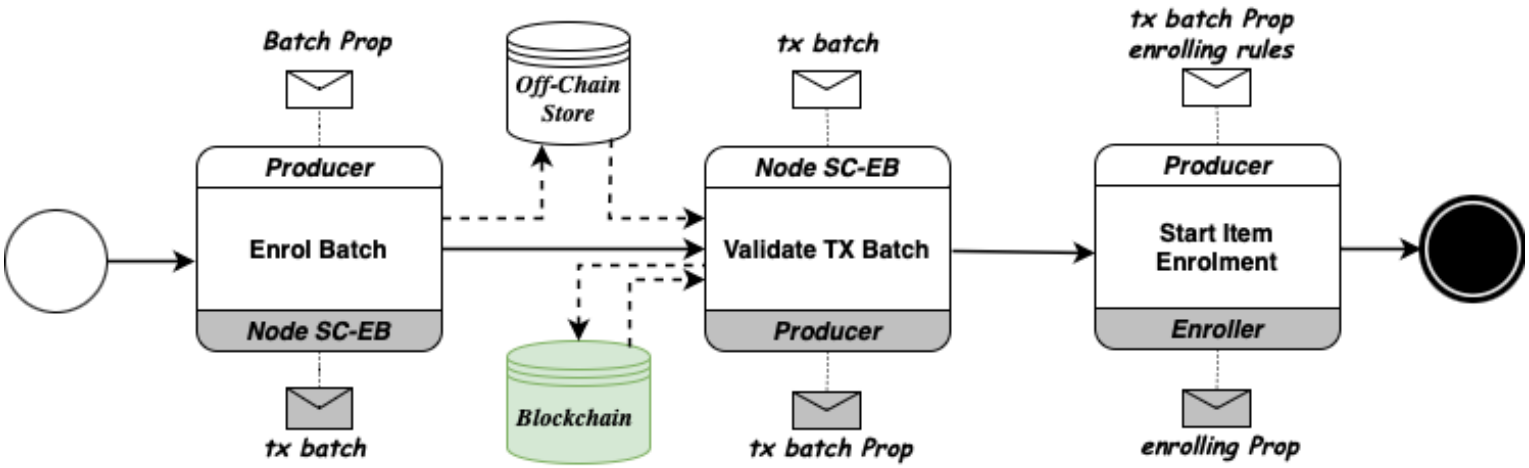
The figure describes the steps of a generic phase in the blockchain application scenario.

Overall supply chain process



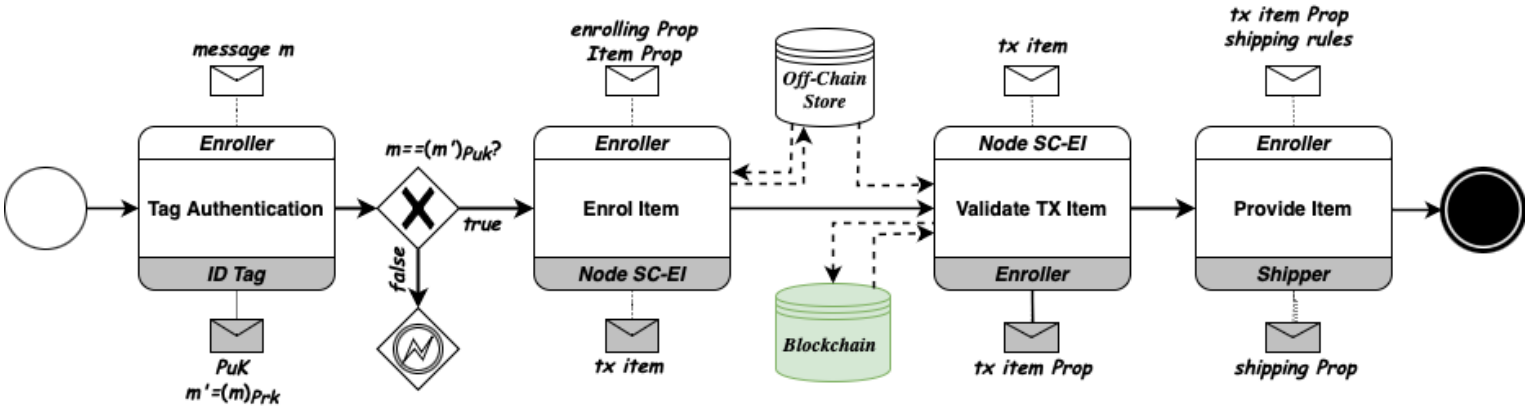
The figure describes the overall process. The reference context is a company of luxury products (items) that are packaged in batch of n items.

Enrolling a batch of items



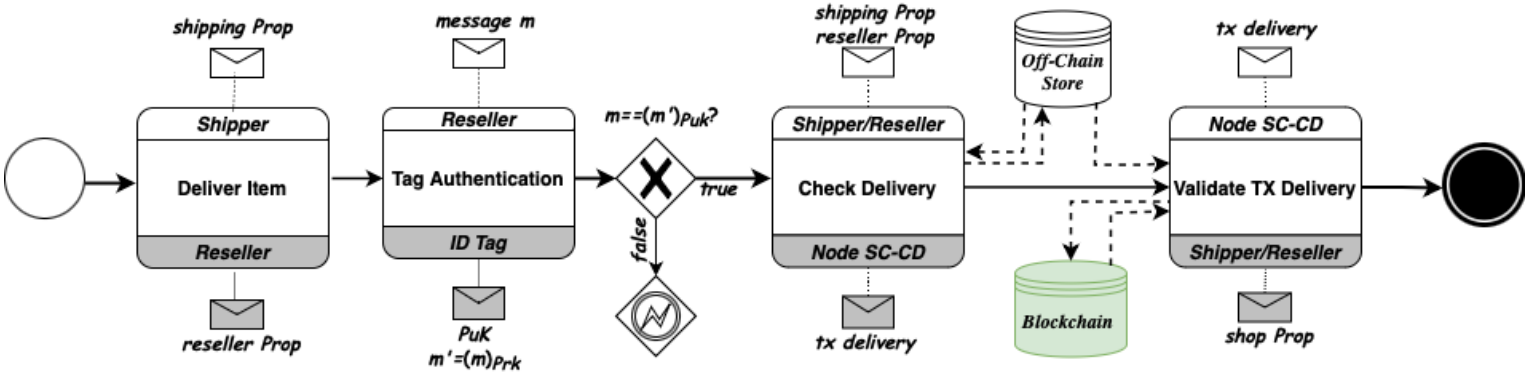
The Producer stores the main batch properties in a repository (called *O -Chain Store*) and registers the batch enrolment as a blockchain transaction. With a little abuse of BPMN notation, the interaction with the blockchain is represented by including an entity called *Node SC-EB* that is in charge of interfacing an ad-hoc Smart Contract (SC) to enrol a batch (EB).

Enrolling an item



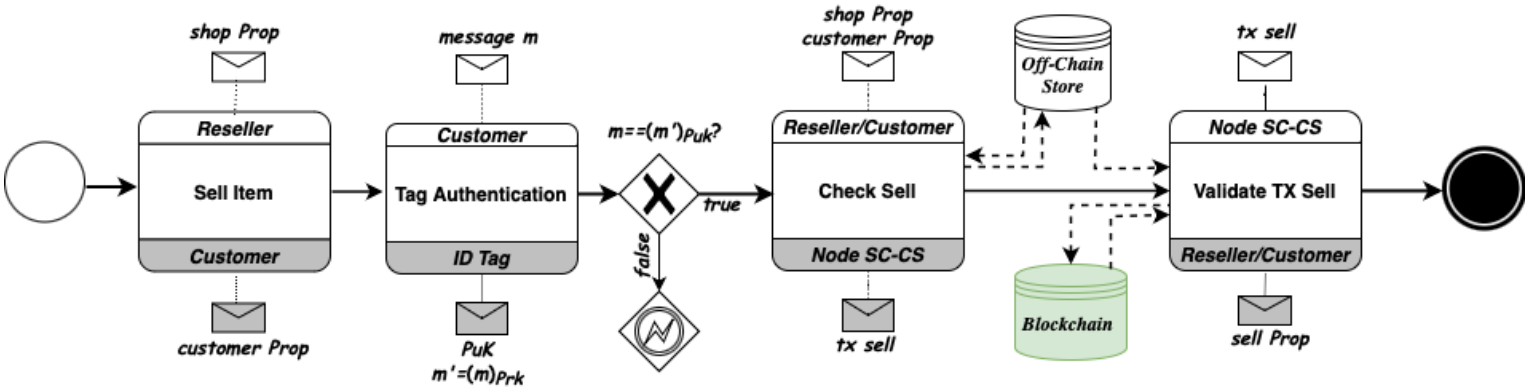
After having successfully authenticated the ID Tag associated to a batch item, the specific product properties (e.g., pictures or video of it) are stored in the Off-Chain Store, the transaction for the item enrolment (including the ID Tag public key *PuK* and the hash of relevant off-chain data) is registered on the blockchain and, then, the item is entrusted for the delivery to a shipper – for simplicity, the two participants are assumed to belong to the same company.

Delivering an item



The main task is *Check Delivery*: after ID Tag authentication, the Reseller is required to recognize the features characterizing the item that have been stored in the repository with hash registered in the blockchain – a simple solution is an ad-hoc app displaying pictures or videos, with potential Machine Learning use as an improvement to be investigated further. The Shipper is also included as initiating participant to express the fact that the transaction must be signed by both Shipper and Reseller.

Selling an item



The figure describes the selling item sub-process, which is similar to delivering item sub-process. The main difference is in the task *Check Sell*, for which multi-signed blockchain transactions should be avoided for the customer's (and business' as well) sake. The customer acknowledgment for the transaction is to be differently registered - also this issue is to be further investigated.

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Main Results

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Further Work

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In particular, two architectures based on deep convolutional neural networks and adversarial machine learning have been proposed, which cover two different scenarios based on whether the products of interest represent an item in a batch of similar products, or vice-versa, a unique object with its own characteristics.

Thank you for your attention.