New Critical Aspects for the Future Infrastructures of the Physical Internet

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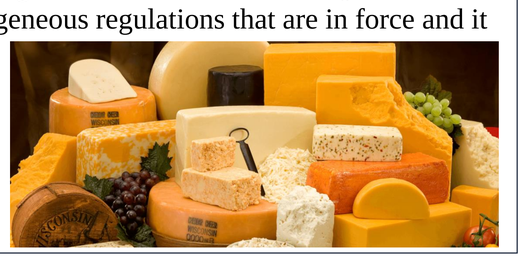
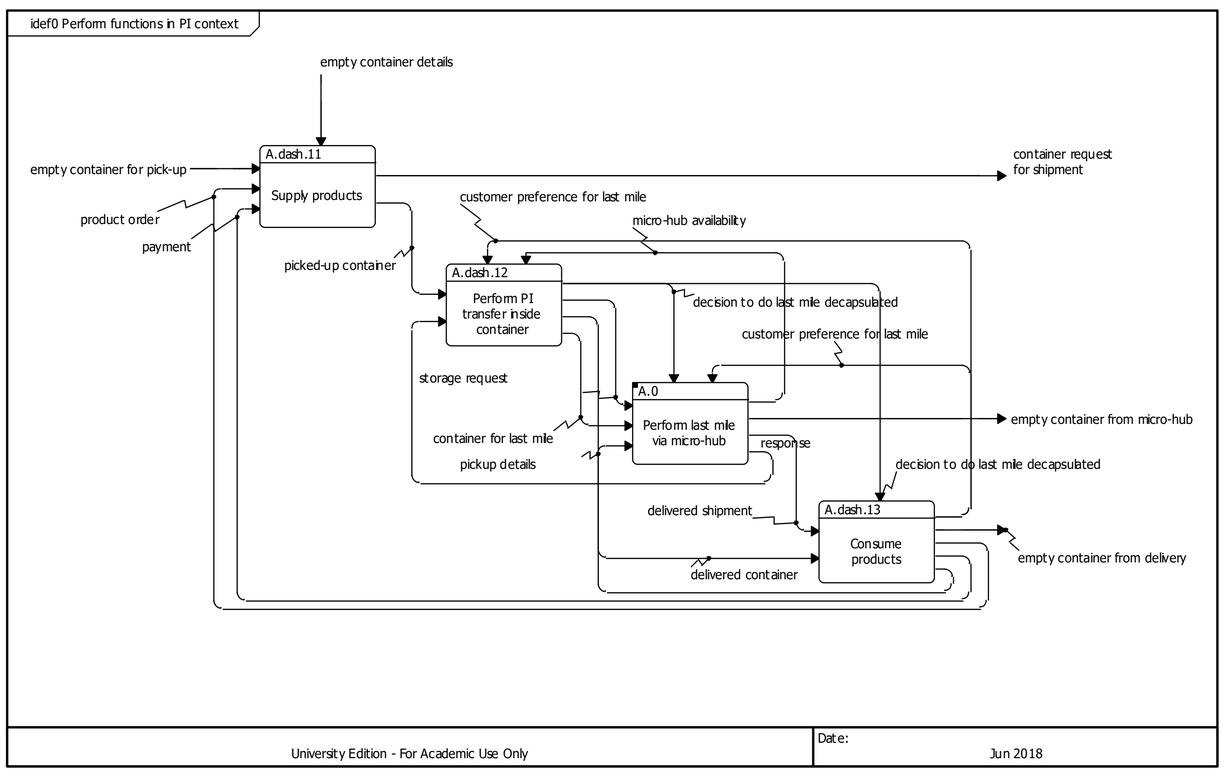
Introduction

Logistics businesses that handle containerized goods are forced to reduce their costs, by becoming more and more efficient. Nowhere is this more important that in the growing volumes of fast moving consumer goods (FMCG). Our research investigated various design related aspects for a subset of FMCG: fresh food (branded and packaged), pharmaceutical materials with special requirements, spirits and beverages that can be spoiled during transport. The case studies done for this design science research are specifically selected from logistics cases for diary products like milk and specialty cheeses. These cases are already exhibiting some of the characteristics envisaged for the future Physical Internet, like specific modularity and special containers. This research proposes an extension of the current proposals for the architecture of the information and communication infrastructure of the intended Physical Internet. These extensions are directly derived from the data accumulated during the case studies and pertain to the autonomous and decentralized activities necessary to achieve the high level of automation desired for the Physical Internet. The functional and physical extensions of the architecture take into account the global nature of the flow of perishable foods, the complexity of cross-border activities, the heterogeneous regulations that are in force and it is assumed that will persist in the future.



Current architectures

Current functional architectures (as the one depicted below) do not include specific functionality and the critical design aspects considered necessary for the container based logistics for these FMCGs.



Novel Critical Design Requirements and Guidelines

Initially, the main component under investigation was the PI container which will exist in a few modular sizes and will offer special functionalities like cooling, freezing, special atmosphere, monitoring and alarm triggering, detection of spoilage via sensors, communication of status, etc. Current developments in practice (i.e. like the specialized containers used by Envirotainer^{TM}), and the ones proposed by research have been starting points in the constructing a development framework for the future containers for PI that will transport FMCGs. After a methodological approach to engineering design, some – the ones considered the most important - of the original contributions to design guidelines and critical requirements are:

I. First, for the containers themselves:

a. Such containers should be envisaged as two connected but distinct components: one is the physical container itself, with all the necessary functionality, and the other is its associated software agent (or "digital twin"), which is existing in the cloud, and it represents the container in automatic auctions for shipments, reservations for transport, arrangements for routing and hub cross-docking, inspections and regulations related processes, payments, intelligent monitoring, control, alerts, and autonomous decision making – allowing for high levels of automation.
b. For the physical part of the container, it has to provide protection and preservation of quality of the shipment, power generation or acquisition, mechanical strength for all sizes that enable automatic handling and stacking, plus the possibility of automatic inter-lock into appropriate transportation unit sizes. Also related to locking, it needs the capability to share, recharge, and transmit over power and communication links (e.g. a container at the bottom of the stack should be able to be constantly connected to its software agent, but it uses the communication devices of the nearby containers that have a line of sight to an internet connecting point – satellite, Wi-Fi, GPRS).

Hub and cross-docking critical aspects

II. Hub and cross-docking related:

a. The containers for FMCG goods should have a separate fast moving channel through the PI hubs, and be handled and formed into inter-locked transport units together, allocated to faster moving transport.
b. The hub should be also able to solve defective container functionality situations. For example, if a cooled container alerts its owner about an emergency status and potential loss of shipment, the hub (on the request of the owner), shall intervene and transfer the shipment to a working container (the container owner re-directs one of its empty nearby containers).
c. Hubs can offer MRO (maintenance and repair) for containers – this is closely related to requirement above.
d. Hubs can also help with wasted food shipments, container cleaning, and contaminated food waste disposal.

Human process related critical requirements

III. Administrative and heavy human-intervention related processes:

a. Food, especially fast perishable specialty foods (non-frozen meats, living fish and shellfish, artisan cheese, bakery and patisserie products) need special paper work and visual inspection when crossing boundaries and differently regulated areas. Automating this processes is a huge challenge; for example companies like UNILAC (cross-docking cheese shipments through the Netherlands to the whole globe) have 70% of costs related to these processes.
b. The producer and consumer of the product should be heavily involved in the regulation related processes (like export-import tariffs, standards, labeling rules). The idea for further automation is that each shipment is overseen by a triad of software agents: the digital twin of the container, and admin digital twins of the shipper and customer, working in tandem in the digital twins of the regulators and inspectors when necessary, with minimum escalation needed human intervention.

IV. Last mile delivery and container penetration:

a. The PI should enable efficient logistics at the hubs, but also as well at the end consumer, indifferent of the infrastructure that exists in the consumer area.
b. Networks for last mile delivery should extend the envisaged big PI hub network with city and rural micro-hubs, which can play also the role of temporary inventory points.
c. The containers and micro-hubs should accommodate any means of local transportation, especially for the smallest containers, but also for the eventually decapsulated shipments on the last mile.

Next steps and future avenues for research

With respect to the evaluation, assessment, testing, and validation of these design aspects, scenarios have to be developed with the help of current logistic operators, to model the key performance indicators sought for solutions that offer operational interconnectivity over the whole supply chains of various FMCGs. The cost impacts and benefits of the designed solutions have to be assessed together with experts in logistic asset utilization, load handling, administrative issues, etc. In the end, both a simulation-based and field collection data proof of concepts should be gradually implemented, to get a crisper and more credible design framework for an FMCG driven component of the PI.

Both experimental simulation and empirical data collection will help demonstrate the technical, informational, and operational potential of the novel FMCG PI principles, recommend industry standards, and stimulate the logistic industry and market interest in the Physical Internet.

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