Internet-of-Things paradigm in food supply chains control and management

Riccardo Accorsi\textsuperscript{a,}\textsuperscript{*}, Marco Bortolini\textsuperscript{a}, Giulia Baruffaldi\textsuperscript{b}, Francesco Pilati\textsuperscript{a}, Emilio Ferrari\textsuperscript{a}

\textsuperscript{a}Department of Industrial Engineering, Alma Mater Studiorum Bologna University, Viale del Risorgimento, 2 – 40136 Bologna (Italy)
\textsuperscript{b}Department of Management and Engineering, Padova University, Stradella San Nicola, 3 – 36100 Vicenza (Italy)

Abstract

Starting from the definition of the Internet-of-Things (IoT) paradigm, this paper discusses goals and strategies for the design and building of an IoT architecture aiding the planning, management and control of the Food Supply Chain (FSC) operations. A comprehensive architecture of the entities, the physical-objects, the physical and informative flows, the stages and the processes to be sensed, tracked, controlled and interconnected is given to illustrate the interdependencies between the observed supply chain and the exogenous environment.

A simulation gaming tool embedding the IoT paradigm for the FSC management is also proposed and illustrated to showcase the potential benefits and opportunities for more direct integration of the physical food ecosystems into virtual computer-aided control environment.

© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing

Keywords: Food supply chain, Internet-of-Things, Simulation, Data architecture, Food ecosystem

* Corresponding author. Tel.: +39 051 2093415; fax: +39 051 2093411.
E-mail address: riccardo.accorsi2@unibo.it
1. Introduction

The growing food demand to meet the increasing world population is forcing the conversation on reconciling the economic growth and industry production development with the environmental sustainability and safety issues [1-3]. This compels considering the extant as well as the new developing food supply chains (FSCs) over a global holistic perspective going beyond the current boundaries of the existing food ecosystems. Not only agriculture, processing, packaging, logistics and distribution operations, but also the interdependent relations among growing and consumption locations, urban and rural landscapes, carbon mitigation strategies, waste management and energy supplies [4].

To control and best manage the slight and mutual influences of such entities and processes directly related to the efficiency and the sustainability of the food supply ecosystems, new cross-disciplinary and integrated approaches are expected [5]. The design and control of integrated food supply ecosystems is challenging, while research contributions and scientific efforts are still limited and focused on design of branches of such networks.

Food supply ecosystems are constrained by a mix of interdependent issues dealing with [6]:

- the location of crops and farms;
- the climate, soil and environmental conditions;
- the access to water, energy and land resources;
- the set of harvesting areas and their allocation to processing and packaging facilities;
- the presence or set up of logistic infrastructures and distribution networks making connections to the urban areas;
- the regulatory and technological environments;
- the food distribution channels;
- the demand profiles.

In such a complex environment, decision-making has to be aided by the analysis of both the physical (e.g., raw materials, packaging, food, energy, water) and the informative flows. The former lies on the latter since the efficient control of the dynamic production-supply-consumption [6] pattern throughout the FSC stages and process requires handling a wide set of data and knowledge that are often neglected. The typical labor-intensive and human-made nature of the food sector increases the complexity of providing, gathering, storing and exploiting in-field data. Thus, the claims for developing and applying food process virtualization, food traceability and Internet-of-Things (IoT) paradigm to tackle the well-known sector’s issues, that are recently characterizing the academic and industry debate [7-10], sound as at least ambitious and still tremendously challenging. Implementing the IoT paradigm in FSC means developing and extended virtualization of the items, infrastructures, resources, stages, actors and flows contributing to model the production-transformation and distribution activities. The virtualization of the FSC passes through better understanding the inside dynamics of the food supply ecosystem as a whole, the interdependencies between the flow of resources, the study of the physical and information infrastructures [11].

Starting from the definition of the IoT paradigm [12-14], the aim of this paper is to discuss goals and expected strategies for the design and building of an IoT environment aiding the planning, management and control of the FSCs operations. To this purpose, this paper aims at gradually approaching to the implementation of the IoT paradigm by proposing a simulation tool to study the extant dynamics underling the FSC as a whole. Instead of focusing on specific supply chains and processes, the proposed simulation tool generalizes the main FSC stages and processes and virtualizes the associated entities, items, resources and infrastructures. Indeed, the proposed tool can be applied to generic FSCs, which handle different products and varieties, but share the processing and logistics chain, including processing and packaging, storage, and distribution to the retailers. The illustrated tool seeks to achieve the following fourfold purposes. First, (1) modelling the connections between the aforementioned supply chain entities over a quantitative system dynamics approach. Then, it (2) explores the criticalities throughout the supply chain (e.g., bottlenecks, cold-chain breakdowns, delays, impacts on the environment and society) and accounts the associated performances. Third, the tool performs (3) feasibility studies and multi-factor analyses for the implementation of data traceability and real-time process control architecture toward the IoT regime. Lastly, the tool (4) realizes an educational game for consumers, practitioners and students to experience the impacts and inside bullwhip effects resulting by their decisions and choices at different stages.
دریافت فوری
متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات