Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 109C (2017) 672–679

Procedia Computer Science

www.elsevier.com/locate/procedia

The 8th International Conference on Ambient Systems, Networks and Technologies (ANT 2017)

Toward Leveraging Smart Logistics Collaboration with a Multi-Agent System Based Solution

Nafaa Jabeur[a]*, Taiseera Al-Belushi[b], Mohamed Mbarki[c], Hana Gharrad[b]

[a]*German University of Technology in Oman, Muscat, Sultanate of Oman*
[b]*Sultan Qaboos University, Muscat, Sultanate of Oman*
[c]*University of Sousse, Sousse, Tunisia*

Abstract

In this paper, we address the problem of collaboration between logistics objects. This collaboration aims to effectively plan, implement, and control the flow of services and goods between a point of origin and a point of destination while ensuring their secure, optimized, and efficient distributions to consumers anytime, anywhere. To this end, we propose a multi-agent based solution where the architecture of each agent includes concurrent individual and collective Belief-Desire-Intension (BDI) structures to support and balance self and collaborative objectives. Our solution, which is adapted and applied to the context of smart logistics, puts a special focus on the important issue of logistics risk management.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: Smart logistics; Multi-agent system; Belief-Desire-Intension; Logistics risk management.

1. Introduction

Part of the supply chain process, logistics is roughly about an effective and efficient planning, implementation, and control of forward and reverse flow and storage of services, goods, and related information between a point of origin and a point of destination according to some customers' requirements. To meet this end, logistics systems are being implemented to respond rapidly to the growing requirements of today's global supply chains and

* Corresponding author. Tel.: +968 2206 1189; fax: +0-000-000-0000 .
E-mail address: nafaa.jabeur@gutech.edu.om

Peer-review under responsibility of the Conference Program Chairs.
10.1016/j.procs.2017.05.374

transportation systems in providing resource-efficient, secure, sustainable, and timely distribution of services and products to their beneficiaries anytime, anywhere. Thanks to the growing availability of affordable sensing technologies, which are capable of capturing real-time data about Logistics Objects (LOs) and reporting on-time data about environmental changes, innovative solutions are revolutionizing the logistics processes[13]. These solutions are particularly aiming to make these processes flexible, extendable, and intelligent, leading thereby to the paradigm of smart logistics.

Smart logistics is attracting increasing attention worldwide. Extensive research and development works are aiming to enhance the capability of tracking, monitoring, and predicting the progress of ongoing logistics processes[5]. Because of their proven abilities to solve distributed, uncertain, and dynamic environments, multi-agent systems have been used to meet the requirements of smart logistics. Although the proposed solutions have been successful in modelling and implementing logistics processes, they were not successful in implementing efficient collaboration between LOs. This collaboration was, indeed, either assigned to a centralized entity that decides and plans the collaboration actions or left to individual objects to decide their own actions for their own benefits. In addition, the proposed solutions do not integrate risk management mechanisms within their collaboration frameworks. In order to boost collaborations between the LOs, we propose in this paper a new multi-agent solution where agents are designed according to a novel Belief-Desire-Intension (BDI) architecture. The architecture supports logistics risk management and includes concurrent structures to serve individual and collective logistics objectives. In the remainder of this paper, Section 2 outlines the issues of smart logistics and their related works. Section 3 highlights the challenges of smart logistics and maps them with the capabilities of multi-agent systems. Section 4 presents our multi-agent system solution. Section 5 outlines a proof of concept of our solution.

2. Related work

2.1. Smart logistics

Logistics has been defined as an efficient and cost-effective approach that coordinates the plan, design and control of the supply chain processes[1]. It's a well-known logistic requirement to have the right product, in the right condition, at the right time, and at the right place[2]. Due to the multidisciplinary and highly dynamic nature of the logistics environment, the complexity to fulfil such requirements is growing continuously. For instance, large numbers of machines, vehicles, and people are daily packing, moving, and tracking millions of freights around the world within complex ecosystems known for their large operational scales and unpredictable spatio-temporal events[3]. On the other hand, recent progress on ubiquitous and mobile computation and communication technologies are bringing new solutions and approaches where a myriad of everyday things are being transformed into active and/or reactive logistics entities. These technologies, which are contributing largely to the emergent paradigm of Internet of Things (IoT) particularly rely on deploying data acquisition mechanisms (e.g., sensors, GPS, RFID), communication technologies (e.g., 4G), and data processing solutions (e.g. , Hadoop) to interconnect the physical world where the logistics operations are taking place and the virtual world where decisions are being taken. Therefore, integrating a wide range of heterogeneous assets and allowing them to interoperate in timely fashion while generating customized, dynamic, and automated services to customers require elastic, intelligent solutions[3].

Several research and development works have attempted to make logistics operations intelligent, leading thereby to the notion of smart logistics. No agreement had been made yet on a single definition of smart logistics as it is closely linked to the changing deployed technologies[2]. Nevertheless, it is accepted that smart logistics is basically aiming to efficiently aligning planning and scheduling, Information and Communication Technology (ICT) infrastructure, people and governmental policymaking[1] are the four main pillars of smart logistics. ICT infrastructure supports the planning and scheduling processes with the relevant information resources at the right time and place. These processes are interpreted and implemented by people who should be sufficiently trained to properly understand and manage the inherent complexity. Governmental policymaking represent an important player in smart logistics especially since policy has a central impact on logistics costs[1].

Several works have investigated the advantages of using multi-agent system approaches in logistics operations. These works have been particularly motivated by the proven flexibility, autonomy, and intelligence of software agents to solve complex problems within highly dynamic, constrained, and uncertain environments. An example of