Research Note

The Application of Physical Internet in Saudi Arabia: Towards a Logistic Hub in 2030

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Abstract

As a way to diversify its non-oil economy, Saudi Arabia launched a prospective initiative called Vision 2030 to boost its ability as the most prominent middle eastern logistics hub. Given its strategic geographic position at the crossroads of important international trade routes, among three continents - Asia, Europe and Africa, Saudi Arabia has predominant logistical access to the Arabian Peninsula and East Africa, as well as the Asia-Europe trade route. Thanks to the existing infrastructure and all mechanisms already in place in Saudi Arabia, we firmly believe that the Physical Internet presents the true empowerment to these mechanisms by offering improvements in delivery time, costs and environmental impacts.

Keywords: Physical Internet, Logistic hub, Saudi Arabia, Vision 2030

Introduction

The economic program, Vision 2030, launched by the Saudi government in April 2016, aims to lift the country out of its historical dependence on oil and diversify its economy. This program is based in particular on a transition from the growth relay to the private sector and non-oil activities (Moser *et al.*, 2015). Crown Prince Mohammad Bin Salman drives Saudi Arabia's Vision for the future, which is an ambitious blueprint expressing the long-term goals of the country. The plan, Saudi Vision 2030, is structured around 12 operational programs (Moshashai *et al.*, 2018)

The 8th program, called the National Industrial Development and Logistics Program, is the one focused on logistics, which could benefit the most from the essential characteristics of the Physical Internet. Its objective is to develop the industrial potential of Saudi Arabia by encouraging the localization of manufacturing production in the country. Thus, the Kingdom would eventually become a major logistics hub between three continents. The development of industrial zones goes through the MODON (Saudi Industrial Property Authority), which currently manages 34 industrial cities and plans the development of 5 additional cities over the next five years.

In addition, Saudi Arabia is applying several mechanisms that proved to be successful in making a better logistics network, notably in customs paperwork, making any customs operation faster than ever before. For example, the Saudi government has established four new economic cities, the largest of which is the King Abdullah Economic City (KAEC). It includes the largest port in the Red Sea region (Moser *et al.*, 2015). To accompany this development plan and to be able to face the major challenges of globalization, the State is obliged to remain attentive to innovations. The Physical Internet in Saudi Arabia presented a revolution towards an efficient and sustainable logistics, which aims to significantly improve the economic, environmental and social efficiency and sustainability of the current organization (Alshuwaikhat *et al.*, 2017).

This article attempts to bring the elements of the Physical Internet to the reality of the Saudi logistics sector. It highlights the concept and the research projects carried out on the subject, and looks at an overall presentation as well as a SWOT analysis of the logistics and transport sector in Saudi Arabia. This study

aims to present the prospects for developing a Physical Internet Network in the Saudi context.

The Physical Internet

The evolution of current logistical performance must meet contradictory expectations. On the one hand, it has to respect the just-in-time philosophy favored by small and high-frequency shipments. On the other hand, there is the strong desire to improve environmental performance by reducing greenhouse gas emissions. These goals cannot be achieved without limiting the fragmentation of freight flows. In this sense, increasing collaboration among different supply chains or networks is a way to exploit synergies and jointly improve their logistics performance, including transport activities. However, even though horizontal collaboration and bundling of merchandise flows are well-known concepts, only a few implementations are operational today and there is no evidence of widespread scaling up (Sarraj *et al.*, 2013).

We believe that the definition proposed by (Ballot *et al.*, 2010) is exhaustive: “The physical internet is a global logistic system taking advantage of the interconnection of supply networks by a standardized set of collaboration protocols, modular containers and intelligent interfaces for increased efficiency and sustainability”. The physical internet, which mimics the digital Internet’s model, sets itself to follow the Open Systems Interconnection model (OSI). It falls under the OSI model, offering a more vibrant and rigorous presentation through its seven layers. For this reason, the Open Logistics Interconnection (OLI) Model is established for the Physical Internet. The purpose of this model is to specify a general framework for the creation of subsequent consistent standards. The model itself does not define a service, let alone a protocol.

Fig. 1 shows how these layers interact vertically and how the flow evolves from one layer to the others.

Benchmark Case Studies

The MODULUSHCA Project in the EU

Funded by the EU, the MODULUSHCA project (Modular Logistics Units in Shared Co-modal Networks) has not only explored the different methodological and functional components of a physical internet, but also developed and tested its first applications. By organizing different workshops with the experts from their industrial partners, the project members were able to finalize and develop a framework describing how the physical internet enabled the emergence of an interconnected logistics system for everyday consumer goods (FMCG, for Fast-Moving Consumer Goods). They also highlighted the potential barriers and successful parameters of such a system (Sallez *et al.*, 2016).

The MODULUSHCA team has developed modular units for the consumer goods sector. One unit deals more specifically with the locking mechanism, and the other consists of panels. The team also selected and described the digital interconnectivity algorithms among different computer systems, a sensor-sensing approach for the communication of modular logistics units.

The researchers have developed a road map for this interconnected logistics of consumer goods, highlighting the next steps that will lead to the final implementation of this strategy in Europe around 2030 and its

Fig. 1 Inter-layer Service Description of OLI Model (Source: Montreuil, *et al.*, 2012)

deployment to the entire industrial sector around 2050. The roadmap has been structured around the four essential interconnectivity dimensions of the physical internet: physical, digital, operational and commercial (Pan *et al.*, 2017). An advisory committee composed of experts from 13 industrial and scientific institutions was initiated during the project. The MODULUSHCA project partners thus proposed a long-term vision of fully interconnected logistics networks, based on the progress of physical, digital, operational and commercial interconnectivity.

Mass Distribution in France

The mobility web in the French context is set to facilitate mass distribution through interconnecting several logistic networks, disserved by different third-party logistics (3PLs). As estimated by Ballot *et al.* (2010), the current logistic networks in France generate waste by the proliferation of untimely transport between production and storage sites, often dedicating to each organization and creating round trips and possible transformations into obsolescence and product waste. The reliance on service providers, which could improve the functioning of logistics, is a partial solution because of the difficulty for an atomized market to find

Fig. 2 CRC's Physical Internet Logistics Network in France

Source: <http://www.crc-services.com/reseau-crc/> (accessed on March 12, 2018)

synergies between customers with multiple and antagonistic requirements. The need for a new architecture is conspicuous, one with higher sustainability and optimized flow. As a result, The Physical Internet is created as the new architecture to fulfill the need for logistic network interconnection. The Physical Internet has been experimented since January 2015 in France (Ballot, 2019). The start-up CRC (Center for Collaborative Routing) opened five centers near Strasbourg, Lille, Nantes, Bordeaux and Saint-Martin de Crau (Bouches-du-Rhone). The CRC's primary asset is to open to businesses of all sizes for the possibility of pooling their flows. It presents limited but steady progress in their logistics network, as shown in figure 2.

Eric Ballot claims that after one-year experimentation, the following results were obtained (Ballot, 2019):

- 10% reduction in CO2 emissions
- record on-time delivery rate (99%)
- truck filling rate of up to 90%
- average and target savings of around 30% to 50% on transport and storage

Global Synchronization of Logistic Networks between the USA and Canada

A study on routing optimization is carried out by Fazili *et al.* (2017) for the eastern Canadian region, comparing the efficiency of the conventional logistics systems, the Physical Internet, the hybrid model, and combinations of these systems. The cost performance of each of these logistic systems varies under various traffic and load selection scenarios. In the network featured by a low ratio of packing to the driving costs, the

Fig. 3 Physical Internet's Intercity Network at South of Quebec, Canada and North-eastern Area of USA (Source: Montreuil, 2011)

Physical Internet seems to be the superior logistics system followed by a hybrid system and the conventional system (Fazili *et al.*, 2017). In addition, from an environmental point of view, the Physical Internet achieves a substantial reduction in the carbon footprint of the logistics system from driving and reduces truck traffic on the roads (Fazili *et al.*, 2017).

Besides, the Physical Internet allows for the structuring of inter-city trips with PI-transits and PI-Hubs, which are strategically deployed by various service providers at key locations in the proximity to national borders, ports, airports, highway intersections and other major roads of the city. Figure 3 shows the Canadian links, with pi-nodes in red and the American nodes in blue. It presents double nodes at the borders, permitting safe passage between countries. Cargos are conveyed and vehicles do not need to cross borders (Montreuil, 2011).

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Fig. 4 Foreign Investments in Saudi Arabia

(Source: World Bank. <https://data.worldbank.org/>, accessed on Nov. 20, 2018)

Current Logistics and Economics in Saudi Arabia

Economic Situation in Saudi Arabia

Saudi Arabia is the largest economy in the Middle East and the Arabian countries, and is the richest in the region. The government has undertaken a policy intervention of large-scale public works, increased foreign direct investment and enhanced the soundness of the financial and banking system. These have provided more potential for its economy to stand out in the region. However, Saudi Arabia's economy relies almost entirely on oil. GDP growth has gradually declined since 2015. In 2017, it came to a point where the economy has shown a historic recession (-0.7%), while the growth was expected at 1.9% with the non-oil economy growing further to 2.3%. The IMF (International Monetary Fund) dropped from 2.4% to 1.9% in Saudi Arabia in 2019, as a result of the regional and global geopolitical tensions and the moderation of oil prices since the end of 2018 (IMF).

To become a logistic hub, Saudi Arabia needs to be an investment hub first, and then turn its economy around towards the openness to foreign investments with more focus on its non-oil economy. On the macro-economic front, Saudi Arabia has been facing a double deficit situation since 2015. The international rating agencies downgraded Saudi Arabia's sovereign rating (Fitch: A+, Moody's: A1), but put it on an outlook list due to its stable fiscal position, high levels of liquidity and large reserves of extractable oils at low cost. On the banking and financial front, in 2015-2016, Saudi Arabia experienced an episode of liquidity crisis caused by the drop in its oil revenue, the freezing of government spending, significant payment arrears and debt issuance on the market. These measures taken by the authorities to resolve the current situation were expected to end the crisis. Nevertheless, the Saudi banking sector has been well regulated and sufficiently

capitalized to cope with this crisis in case that the profitability of the banks might be heavily impacted.

Thus, as the 7th program of Vision 2030, the Strategic Partnerships Program has been developed to deepen the economic partnerships with the countries considered as strategic and potential actors in the success of the scheme. Among these countries, we consider the following countries as major partners: United States, China, Japan, South Korea, Great Britain, France, Germany and Russia.

At the turn of the new millennium, Saudi Arabia also changed its attitude towards foreign investments which were not taken into account until 2004. The total figure reached a peak of 39.456 billion dollars in 2008. These investments are a major contributor to the development of the transport and logistics sectors. However, they have declined since 2008 as shown in Fig. 4. Saudi Vision 2030 is one of the programs aiming to remediate this trend.

Logistics of Saudi Arabia

A broad review of literature offers many diverse opinions on logistics outsourcing in different countries. However, little empirical research has been carried out about the situation in the Arab world and Saudi Arabia, specifically. The kingdom of Saudi Arabia is the largest country in the Middle East and the 12th largest in the world, measuring approximately 2.2 million square kilometers, with the largest Gross Domestic Product (GDP) in the Middle East (Sohail *et al.*, 2005). Saudi Arabia has an impressive transportation network made of 27 airports and 12 seaports connected with 65,000 kilometers of roads and 4,130 kilometers of railroads. The data does not include the unpaved roads and the airports with unpaved runways (Ziadah, 2017).

All ports are owned and maintained by private sector companies under long-term contracts with the country. As part of the Saudi export development initiatives, Saudi Arabia grants a 10-day exemption on export charges and 50% off on port taxes for all export deals. The 27 airports in Saudi Arabia include four in Riyadh, Jeddah, Dammam and Al-Madinah Al-Munawarah. In 2015, more than 81 million passengers transferred in Saudi Arabia, which is a 9.5% increase compared with 2014. Among them, passengers of air flights reached 646,693. Freight and mail handled reached a total of 1.16 million tons, an increase of 14.1% over the previous year. Air flight is the preferred transportation method for passenger transferring in Saudi Arabia because of the relatively long distances between major cities. Several major international airlines offer services inside and outside the country (Fig. 5-1, 5-2, 5-3).

Perspectives of the Physical Internet in Saudi Arabia

Transition to PI-Hubs

The PI-Hub, shown in Fig. 4, is an automated cross-dock keeping the same inter-arrival time between incoming and outgoing trucks and the same level of incoming PI-Containers and requests. The characteristics used to describe the cross-dock facility are also the same as the first model (the surface, the distance and the number of incoming and outgoing docks). However, instead of using forklifts, automated loading and

Fig. 5-1 Maps of Road Network in Saudi Arabia

Fig. 5-2 Maps of Railways in Saudi Arabia

Fig. 5-3 Maps of Railways in Saudi Arabia

(Source: <https://www.ic.gov.sa/en/>, accessed on Sept. 8, 2018)

Fig. 6 Classic Cross-docks vs PI-Hubs (Source: Chargui *et al.*, 2016)

unloading resources (PI-docks) connected to a sorting area (PI-sorters) by PI-conveyors are applied (Chargui *et al.*, 2016).

The average speed adopted for the PI-conveyors is 2.77 m/s (10 km/h). In the PI-cross dock, manual forklifts for storing and retrieving products in the temporary warehouse are replaced by an Automated Storage and Retrieval System (AS/RS), which is connected directly to the sorting area with three storage and retrieval machines. When a truck arrives at an incoming dock, the PI-dock unloads the cargos automatically and the cargos will be moved to the PI-sorters by PI-conveyors. The trucks' orders are served in the PI-Hub. The required PI-Containers are picked up by the AS/RS system. Then they come through the sorting area (PI-sorters) to the PI-dock through PI-conveyors. If there is no sufficient quantity to serve the trucks' orders,

or if there is a truck being unloaded in an incoming PI-dock, then the PI-Containers go directly from that incoming PI-dock to the outgoing PI-dock where the PI-Container is requested (Chargui *et al.*, 2016).

Transition to PI-Containers

The PI-Containers are easy to handle, store, transport, seal, snap to a structure, interlock together, load, unload, build and dismantle (Montreuil *et al.*, 2015). The PI-Containers are efficiency for the following characteristics (Montreuil *et al.*, 2010):

- Coming in various modular sizes, from cargo container sizes down to tiny sizes.
- Easy to handle, store, transport, seal, clench, interlock, load, unload, construct, dismantle, panel, compose and decompose.
- Made of environment-friendly materials, with minimal off-service footprint.
- Minimizing packaging materials requirements through the enabling of fixture-based protection and stabilization of their embedded products.
- Coming in various usage-adapted structural grades.
- Having conditioning capabilities (*e.g.*, temperature) as necessary.
- Sealable for security purposes.

The need for Saudi Arabia to switch to PI-Containers is to adhere to the Physical Internet initiative from a practical point of view. The switch would allow goods to be shipped and transited through Saudi Arabia in conformity with the new EU standards in handling FMCG and as mentioned in the MODULUSHCA project (Sallez *et al.*, 2016).

Fig. 7 Generic Characteristics of Physical Internet Containers

(Source: Montreuil *et al.*, 2015)

SWOT Analysis

The SWOT analysis of the main characteristics of the internal and external environments of the Saudi logistics sector, as shown in Table 1, makes it possible to identify multiple assets that have not been sufficiently exploited so far. The result indicates the logistics sector still suffers from several deficiencies that affect it at different levels: economic, technological, environmental, legislative and social. These problems find their way into the foundations of the Physical Internet.

Indeed, the Physical Internet envisages universal interconnectivity that will be concretized by a set of collaboration protocols, allowing all Saudi logistic actors to adjust their service to universal standards. This will have important repercussions on several elements: the improvement of the service quality, the human skills and the working conditions; reinforcement of the maturity of the principals and the transparency on the market; as well as the consolidation of the laws governing the sector. The standardization of the collaboration

Table 1 SWOT Analysis for Saudi Logistics

Strengths	Weaknesses
<ul style="list-style-type: none"> • A quarter of the world's oil reserves and OPEC's largest producer • Major economic and regional role • Economy in the process of diversification strengthened by the Saudi Vision 2030 program • Solid financial position due to low debt and considerable assets • Robustness of the banking system 	<ul style="list-style-type: none"> • High dependence on the hydrocarbon sector, low job creation, and increasing domestic demand for energy • High unemployment rate of nationals • Fragility of governance darkening the business climate • Unstable geopolitical environment • Economy dependent on public expenditure
Opportunities	Threats
<ul style="list-style-type: none"> • Saudi Arabia benefits from a strategic geographical position, within a conjuncture point of three continents: Asia, Europe and Africa • The creation of a Public Investment Fund: the new domestic assets under management of the Public Investment Fund are expected to reach 20% of the total portfolio by 2020 • Implementation of a privatization program: BOO (Build, Operate, Own,) and BOT (Build, Operate, Transfer) models will be generalized for infrastructure construction. 	<ul style="list-style-type: none"> • Legislation protecting the interests of principals is distinguished by its fragility • Access to land is one of the main obstacles in the sector • The national economy is characterized by vulnerability to EU, asian and north american countries. • Competition from public logistics structures is tough • Human and financial investments in research and development are very limited

protocols will also facilitate effective circulation of physical and moral entities to avoid ravaging the world.

The Physical Internet offers an efficient and resilient open global system that realizes a reliable distribution of encapsulated goods to a multitude of open Pi-Hubs around the world. This system adopts multimodal transfer, removes the detours at warehouses and lowers the transport costs and storage costs. Thus, a significant reduction in logistics costs is expected for the Saudi business market. In all, the homogeneity of intelligent technologies and the application of automation structure on a global scale, proposed by the Physical Internet, presage an optimization of the current logistical costs.

Simulation and Results

We simulate PI-Containers road-deliveries in a Physical Internet environment between several PI-Hubs, which are situated in major cities and industrial compounds, and next to seaports and airports as a hypothesis. Generally speaking, road delivery system is the easiest to tweak yet they are the least optimized. We run our simulation on AnyLogic with the OpenStreetMap API following the PI-BGP routing algorithm (Gontara *et al.*, 2018) and the PI-enabled mobility web (Hakimi *et al.*, 2012).

We use the following estimates as parameters in our simulation (Wiki, 2015)

- Delivery/pick-up per person per day;
- Delivery/pick-up per economic activity per week;
- Between 300 and 400 freight vehicle trips per 1,000 persons per day;
- Between 30 and 50 tonnes per person per year.

Fig. 8 shows the simulation result of the Physical Internet network in Saudi Arabia in AnyLogic with map data from OpenStreetMap. The simulation runs the equivalent of 1000 days of deliveries through the Physical Internet. The generated data in Fig. 9 shows the time it takes to fulfill each kind of delivery for all the possible PI-Hubs combinations as indicated on the map. The mean delivery time is 21 hours, and the maximum delivery time is 47 hours for the furthest PI-Hubs, which is under the two days mark. It is significant progress considering how large the kingdom of Saudi Arabia is.

Conclusion

In order to gain from the benefits of resource sharing, the Physical Internet must be adopted on a universal scale. Hence, the idea of studying development prospects in an emerging country such as Saudi Arabia will contribute to the global growth of the world in the related fields. The study of the internal and external environments of the Saudi logistics sector has shown that the Physical Internet will be a continuity in ambitions described in the national strategy of Saudi Arabia to enhance its logistics competitiveness.

Our single simulation reported above demonstrates the benefits of using the Physical Internet in Saudi Arabia for significant gains in delivery times through adoption of new routing protocols and shipping techniques. Other benefits, ranging from social to environmental levels, are also at hand and need to be measured

Fig. 8 Simulation of Physical Internet Network in Saudi Arabia via AnyLogic and OSM

Fig. 9 Deliveries Time Chart

through further experimentations.

The Saudi Vision 2030 of its 8th program proposes a constructive idea about the enhancement of its logistics system through the creation of the Physical Internet model. Presumably, it will become a competitor of the advanced logistics networks implemented in the European Union and provides the possibility to be integrated into the conceptual framework of the global logistics structure.

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