1st International
Physical Internet
Conference

Towards a smart interconnected era
of efficient and sustainable
logistics, supply chains and transportation

May 28-30, 2014 - Québec City, Canada

Assessing the Readiness of Africa for the Physical Internet

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Abstract: *In general, infrastructure is a real handicap to be overcome to achieve business performance in Africa. This raises the problem of truthfulness with rationality, sustainability and logistics efficiency identified by the notion of the Physical Internet. Based on content analysis, this paper reflects the reality of Africa and provides an assessment of African logistics economically, environmentally and socially. The logistics sectors covered in this study are: air, land across the road and rail, maritime and river, and telecommunications. The study highlights the African logistics challenges, weaknesses, threats, strengths and opportunities. It also highlights the level of each sector and how logistics in Africa is implemented at regional and national level (intercontinental) and intercontinental. In order to attract the attention of stakeholders on the challenges, a readiness map is proposed relative to the operationalization of the Physical Internet in Africa.*

Keywords: *Physical Internet, Interconnected Logistics, Africa, Readiness*

1   Introduction

In order to enable more efficient and sustainable logistics worldwide, researchers suggest applying the principles of the Internet to logistics and propose the conceptualization and operationalization of a Physical Internet in order to streamline logistics and transportation in all their forms (Montreuil, 2011, 2013; Montreuil et al., 2013). Thus, as happens on the Internet, the proposal of the Physical Internet would transform logistics so that there are routers, logistics centers and transit points that facilitate the movement and storage of physical objects in a very rational way (Sarraj et al., 2012). In this context, objects and goods to distribute, store, ship, should be packed in containers made for this purpose to minimize the loss of space and to ease their seamless standardized flow through the Physical Internet. This should notably help moving from dedicated point-to-point and hub-and-spoke systems to openly distributed intermodal transportation system minimizing travel cost, time, energy consumption and greenhouse gas emission (Montreuil, 2011, 2013).

The Physical Internet manifesto draws the attention to the fact that throughout the world, logistics is currently done in a way that is neither efficient nor sustainable from economic, environmental and societal perspectives. It is estimated that at the economic level, the logistical burden represents 5-15 % of most countries and is growing faster than world trade. Environmentally, logistics in its current form is one of the largest emitters of greenhouse gases, energy, polluter and waste materials consumer. Socially, the conditions of logistical work are often precarious and there is a lack of accessibility and mobility fast, reliable and affordable Physical goods for the vast majority of the world's population.

Montreuil (2011, 2013) reveals a set of thirteen key symptoms justifying the call for urgent and important change.

In recent years, under the umbrella of the International Physical Internet Initiative, a number of projects have been undertaken to investigate the feasibility and operationalization of the Physical Internet. Research centers, companies and governments in Europe and North America have begun to recognize the power of the Physical Internet vision. China is launching its First Physical Internet Research Lab.

The Physical Internet is an open global logistics system. At term the aim is to have it implemented all across the world, including Third-World and developing countries. This is where this paper takes its roots: what about Africa? What is the current state of African logistics efficiency and sustainability? What about the logistics infrastructure? Could the continent gain from being a part of the Physical Internet? Could this do to logistics in Africa what the mobile phone technology has done to African telecommunications? Could it instill further economic growth while contributing to environmental and social sustainability in Africa, which presents itself as the continent of the future? Among all African countries, which ones are readier than others to contribute to Physical Internet investigation and operationalization?

This paper reflects the reality of Africa in its facets pertinent to the Physical Internet, namely transportation and logistics, yet also security. It provides an assessment of African logistics economically, environmentally and socially. Logistics sectors covered are: air, land across the road and rail, maritime and river, and telecommunications. These sectors are presented via an analysis that highlights issues, weaknesses and threats, strengths and opportunities. The analysis also points at each sector, how logistics is being currently implemented in Africa at intra-continental (regional and national) and intercontinental levels.

The paper is structured in four parts. Section two presents the research methodology. Section three describes the different modes of transportation in relation to the Physical Internet as modules by region and country with respect to socio-economic and environmental issues. The resulting debate is in section four. Finally, section five is devoted to the conclusion that not only provides information on the limitations and directions for future research, but also for conditionality implementation of the Physical Internet in Africa.

2   Methodology

The Physical Internet is an emerging concept for which scientific research is still at the level of conceptualization. The literature has only begun to lay the beacons that guide research in this area. This means that the writings are still rare. This is why we conducted the literature review in both academic and non-academic channels, so as to better grasp the real situation and consider the applicability of the Physical Internet project in Africa.

Content analysis was chosen as the method of analysis, because it is generally considered a useful measurement technique in Social Sciences (Okazaki, 2004: 86). The technique is needed among social scientists who evaluate historical documents, newspaper stories, political speeches, interviews, diplomatic messages, psychological journals and official publications (Weber, 1990: 5).

The information collected was analyzed at several levels (images, words, statistics, etc.), creating a wide range of research opportunities (Lombard et al., 2002: 588) and interpretation. Content analysis refers to the material rather than providing a summary of the current literature.

Other documents consulted are developed by specialized agencies of the United Nations such as the Economic and Social Commission for Africa, the International Office for Transport and the United Nations Environment. For additional data, we also consulted the archives of ministries, organizations of

African civil society, and newspapers that are also rich in information. The interpretation of these documents is the basis of our analysis.

To do this, we first decomposed into its constituent African countries before trying the regions in terms of economic, social and environmental as well as inner and outer connectivity considerations. This allowed subsequently aggregating into a continental outlook on the reality of the logistics infrastructure.

2.1   Collection, preparation and filing of documents

With reference to our research topic, we have proposed to search and analyze papers (atlas, magazines, scientific articles, etc.). All documents necessary for the implementation of this work have been made available. In order to prepare reports on the content analysis, we have listed and ranked documents of our bibliography in alphabetical order.

2.2   Evaluation and preliminary reading documents

Content analysis requires an assessment of the documents to be analyzed (Dépelteau, 2010). It involves reading the contents of documents, identifying initial ideas revealed by these documents, and analyzing them in a rigorous way. A pre-analysis was made to allow us to identify some key ideas to guide the entire analysis toward achieving the objectives. We performed an evaluation of documents, checking their origin and their status. This involved notably to ensure that the documents indeed have information pertinent to help us refine our work. The content of each document was briefly assessed versus the accuracy of the information they contain.

2.3   Selection and definition of codes

According to Dépelteau (2010), the codes are: "Applied to groups of words identifying symbols, collect and classify the different information obtained from interviews, observations, or other means ... they can also be units of meaning, that is to say a special atmosphere situated in the broader context of the document ... they must be comprehensive, clear, objective, relevant, consistent and numbered". As part of this work, the following codes are available:
Examples of valid codes for analyzes: These codes combine sequence numbers, numbered letters followed by 2 sets of numbers. Each component has a special meaning.
- 01, 02 , ..., = numbers of the various documents
- A1 = All relevant and revealing statement designating the rail ;
- A2 = All relevant and revealing statement designating the river ;
- B1 = All relevant and revealing statement designating the sea ;
- B2 = All relevant and revealing statement designating telecommunications;
- C1 = All relevant and revealing statement designating the air;
- C2 = Any statement revealing and relevant designating the road;
- Any figure "X" = page number where the information was found;
- Any figure "Y" = paragraph number where the information was found.

One document can for example have the following code: 01- A1-C1-18-02; meaning Document 01 - Statement meaning " rail " - statement meaning " air " - Page 18 of the report - Paragraph 02 .

2.4   Analysis and interpretation of data

This is the last step of our methodology. This part was made on the basis of a system based on a critical analysis of the results from the content analysis of the studied documents and articles. Analysis and

interpretation of data collected in the various documents allowed us to realize, for example, that North Africa and Southern Africa are the two regions in Africa that have the necessary characteristics for considering implementing the Physical Internet.

Other economic and infrastructural studies meet this choice (RMB, 2013; ICA, 2013). This has helped us to propose the continuation of our work, a cartography of the logistics implications of the Physical Internet on the continent.

Also, to analyze and interpret the data collected, we designed a scorecard system, which allows us to investigate the logistics of the entire African continent. Also sectors, rail, sea, river, air, road and telecommunications in each country of the continent have been reviewed through the amplitude of logistics movement indicators (existence, connectivity, and use), characteristics of "doing business", environmental impact, and social impact based on the following criteria:

- indicator turns green if the performance of the sector belongs to the interval $[\frac{5}{6} - \frac{6}{6}]$
- indicator turns yellow if the performance of the sector belongs to $[\frac{4}{6} - \frac{5}{6}[$
- indicator turns red if the performance of the sector belongs to $[\frac{3}{6} - \frac{4}{6}[$
- the indicator turns gray in the absence of information on the sector's performance
- When the indicator is not applicable to the sector concerned, a square is placed at the place of evaluation.

Similarly, the calculation of the average of each country and the overall average of each sub- continent followed the same scoring system.

As regards the interpretation of the scorecard, different colors denote the level of performance of each segment. This performance is evaluated based on six indicators: sectorial existence of infrastructure, effective connectivity sector use (activity), sectorial Doing business (World Bank, 2013), social impact, and environmental impacts. To this end, the green color with the sign (+) means that the performance of the sector is satisfactory. The yellow color marked (O) means that the sector's performance is moderately satisfactory. Red color with the sign (-) means that the sector's performance is unsatisfactory. In the absence of information, sector performance is not rated and the indicator turns gray. When facing a non-applicable case, a small square is registered instead of the evaluation. The application of all criteria listed above enables to compile and to draw a scorecard as displayed in Table 1 for North Africa or a more detailed scorecard for each country, as Mauritania is reported in Table 2.

Table 1: Scorecard Summary for a region: North Africa

Internet Physique Balanced Scorecard Africa 2014							
Indicators/ Year	**North Africa**						**Average North Africa**
	Mauritania	**Morocco**	**Algéria**	**Tunisia**	**Lybia**	**Egypt**	
Appreciation							
	O	+	+	+	O	+	O

Caption: Green light and dark (with +) = Satisfactory and very satisfying ; Yellow (with O) = Moderately Satisfactory; Red (with -) = Unsatisfactory; Gray = no information; Empty cell framed = Not applicable

Moreover, to distinguish the green we apply the light green color (effervescent) when the performance of the country is very satisfactory and the tern green color for a satisfactory country's performance.

Table 2: Scorecard of a country: Mauritania

Indicators/ Year	Mauritania						Average Country
	River	Rail	Sea	Road	Air	Telecommunication	
Existence	+	+	+	+	+	+	+
Connectivity		O	+	+	+	O	O
Use		O	+	+	+	O	O
Doing Business							-
Social Impact		O	+	O	+	O	O
Environmental Impact		O	+	O	+	O	O

3   Presentation of results

3.1   Logistics connectivity in North Africa

North Africa gathers all the Mediterranean part of the African continent. It consists, in the North, of the Mediterranean coast and, in the South, of a vast desert zone marking the separation with sub-Saharan Africa. Still called the Maghreb, North Africa comprises six countries: Algeria, Egypt, Libya, Morocco, Mauritania and Tunisia. This region covers an area of six million km^2, with a population around 152 million (Atlas, 2009). The most populous countries in the region are Egypt (73.4 million), Algeria (34.1 million) and Morocco (31.7 million). As displayed in Figure 1, the main activities in the region include farming, fishing, minerals and hydrocarbons extraction. Indeed, these features provide increasing development of domestic markets fueling intense import requirements and export needs. The intensity of this international trade requires logistics and transport infrastructure, moreover adapted to the Physical Internet.

Several factors make the southern and eastern Mediterranean a strategic supply chain area for companies targeting Europe, Africa, the Middle East or Central Asia. First, through the Mediterranean is transiting 30 % of the world container traffic, between Port Said in Egypt and Gibraltar in Morocco (Atlas of Africa, 2011). In a context of increased competitive pressure, this zone offers a stopover area and a one-unloading stop for East-to-America lines.

North Africa countries are separated from Europe, their main trading partner, by the Mediterranean Sea, which means that foreign trade is highly dependent on their port infrastructure. These are an obligatory passage point for both exports and imports, and a potential bottleneck (Overmann, 2012). In fact, North Africa via the Mediterranean is a global corridor for goods in transit via Suez, Gibraltar and the Bosphorus, the waterway dominating foreign trade.

Port infrastructure are key elements of national economies and are therefore subject to great works of upgrades to facilitate receiving the largest shippers (Port Said, Tripoli eventually Enfidha, Cap Djinet). For example, large investments have been made in Morocco to make TangerMed one of major "hub" ports of the Mediterranean in particular and Africa in general (Colombo, 2011). Management of Mediterranean ports has also following the global trends, such as with the introduction in recent years of global operators such as Singaporean PSA (TangerMed), Hong Kong's Hutchinson Port Holding (Alexandria), or Emirati Dubai Port World (Algiers) (Network, 2008).

Concerning land transportation, the motorway and road network is unfortunately still fragmented at national borders, which considerably limits the regional transport by land. Its level of connectivity is also not optimal, especially between ports. Rail, mainly used for the transport of bulk, suffers from decades of under-investment in a context of state monopoly. However, the situation is improving rapidly with strong political support for work modernizing highways (Mediterranean bypass in Morocco) and rail networks (TGV high speed trains in Morocco) (Colombo, 2011).

In terms of logistics, situations are quite different depending on the country. Morocco and Tunisia, which have previously been important exporters of manufactured goods, have already begun to make significant progress. According to a World Bank ranking, Morocco has achieved record growth in logistics performance, climbing from the 113th rank in the world in 2007 up to 40th rank in 2012 (Khelifa, 2013) with logistics platforms now covering an area of 1,338 ha. Such logistics platforms are developed in large urban areas and near container platforms, resulting in the establishment of global operators and the development over the recent years of specialized infrastructure in the major economic centers of the country, notably in the areas of Casablanca and Tanger (Barthel and Planel, 2010).

Tunisia follows the same path. It also registers, the establishment of global logistics operators. Yet the supply of logistics space is still very limited and represents a major obstacle to quality development of logistics services in the country.

Egypt shows a paradoxical situation. It represents a huge potential market with a population of nearly 80 million people. Furthermore it has a privileged location in terms of logistics. Indeed it is at the crossroads between Europe, Africa and Orient, and the point of passage between the Mediterranean and Asia. Yet, unfortunately, logistics services are poorly developed in Egypt and there are just a few global operators operating in the country.

Even though it has significant potential, the current logistics situation concerning Algeria is not bright. Indeed, in 2012, the logistics ranking by the World Bank positions Algeria at the 125th position out of 154 countries (World Bank, 2012; Khelifa, 2013).

In addition, the importance of Europe for North Africa economies clearly appears when looking at trade figures: trade (exports plus imports) with Europe represents around two thirds of the total for Algeria (64%), Morocco (63%) and Tunisia (72%). In the case of Egypt, the proportion is minor, but still quite significant (26%) (World Bank, 2012).

The social situation in the region was shaken by economic and political crises that challenge people's expectations. Political reforms and revolutions in countries such as Algeria, Libya and Tunisia are all social realities that have weakened the region and caused some distrust of foreign investment in the region. Even if there are some political tensions between Morocco and Algeria, it is clear that the Maghreb peoples have everything to gain through their union and/or cooperation instead of the interstate separation they endlessly suffer (Guerroua, 2011).

3.2 Logistic Connectivity in Western and Central Africa

West and Central Africa are bounded to the west by the Atlantic Ocean and occupy a south area of the Sahara, bounded on the east by countries from Chad to the Democratic Republic of Congo, DRC (Atlas of Africa, 2009). It is a vast area covering 25 countries with a total population of about 415 million people, which is just over 6% of the world population. Traditionally, the union of West Africa and Central Africa is defined as including the following countries: Benin, Burkina Faso, Cameroon, Cape Verde, Congo, Ivory Coast, Gabon, Gambia, Ghana, Guinea, Equatorial Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Central African Republic, DRC, Sao Tome and Principe, Senegal, Sierra Leone, Chad and Togo (IOM, 2009).

Western and central Africa is singularized by the disparate situation of its railroad network. For example, countries like Congo, Ivory Coast, and Nigeria hold a good rail infrastructure serving multiple locations. Privatization of the railway between Dakar and the Malian capital complements this positive evolution of the regional rail transportation landscape (Atlas de l'Afrique, 2009). Existing railways are mostly a legacy of colonization. Perpendicular to the coast and disconnected from each other, they have as their main function the export of large quantities of ore (iron, bauxite, phosphate). Unlike roads, they now play an integrator role. The takeover by the private sector of the Abidjan - Ouagadougou and Dakar - Bamako lines is now opening new perspectives in rail transportation in this region (Atlas de l'Afrique, 2011).

Regarding roads, only countries of the Mano River (Guinea, Liberia and Sierra Leone) and neighboring Guinea Bissau seem to suffer from a net deficit in road infrastructure. A road is built and then is deteriorating because it is misused and poorly maintained. A long decade of instability and conflict caused a double phenomenon of rapid urbanization and deterioration of communication networks. In addition, some interstate routes remain to be built or improved. The exception is Nigeria where the infrastructure is mainly financed by local resources (Igue, 1995). However, the quality of its network is very variable.

West Africa has twenty commercial seaports with traffic of more than 500,000 tons/year, excluding oil terminals. Five of them are located in Nigeria. The number of vessels approaching the West African coast has increased from 15 000 in the early 90s to over 20,000 during the 2000s. These movements of ships generate a trade volume (excluding crude oil exports) of more than 140 million tons, representing approximately 25% of African maritime traffic, yet only 1.5% of world seaborne trade. The competitiveness of a port depends not only on its infrastructure and its services (Abodohoui, Nie, & Liu, 2010), it also lies in the quality and fluidity of land transport networks that serve mostly regional interconnection routes (Atlas de l'Afrique, 2009).

The supra region of West and Central Africa is one of three navigation areas and maritime regions served by shipping lines of conferences and other maritime companies that are off-conferences; the other two being the East Africa and Southern Africa (Indian Ocean), and North Africa (Mediterranean Sea). Indeed, the economies of countries in the maritime region of West and Central Africa are largely hooked on maritime transport and transit. Twenty coastal states, located along the north and south side of the Atlantic Ocean and five landlocked countries served by the coastal ports, generated in 2003 approximately 247 million tons of cargo, representing 4.8% of the global tonnage amounting to 5,129.4 million (Merckelbagh, 2009).

Maritime and transit transport is not only a vital activity for international trade; it has in itself an international character as it is its modus operandi. Opportunities, problems and policy issues related to maritime and transit transport transcend national boundaries and are best addressed at the ECOWAS, UEMOA, CEMAC regional and international integration levels (Akanni-Honvo, 2003).

Countries in a given maritime region share common problems of demand and supply of maritime transport services, and of security, safety and pollution of marine waters. Therefore, the maritime area lends itself to sectorial integration in this range. Shared concerns often pointing to concerted resolutions include promoting maritime security and environmental protection by the elaboration of effective emergency plans for the prevention and the fight against pollution; strengthening the efficiency of the maritime administrations; and implementing control measures of the flag state and the control of ships by the port State.

It is also necessary to note that West African transport and logistics are reputed to be slow, unpredictable, expensive and not successful with a very weak productivity. It ends in consumer prices pointlessly raised for the goods imported for the region in genera and for the landlocked countries in

particular (Bernault, 2001; Debrie and Steck, 2001). Accordingly, this severely limits the capacity of the companies in the region to compete in continental and global markets. In this case, research has shown that high costs are due to a combination of factors including:

1. Trucking (which represents the majority of the costs of transporting goods) is not competitive. The anti-competitive provisions not only discourage competition but also encourage the use of old trucks that are not roadworthy, making trucking inefficient and expensive.
2. Procedures at ports, borders and final destinations are heavy, entailing significant delays.
3. Customs and other agencies require too many documents, even when the systems are computerized.
4. Informal costs, such as corruption, increases not only transaction costs but also slows the movement of goods, making delivery times unpredictable.
5. Documents and unnecessary costs slower movement and increase costs.
6. Certain rail infrastructures remain to be mine cleared (i.e. DRC) (Wolf and Lusinde, 2012).

In West Africa and Central Africa, people face chronic poverty, recurrent food insecurity and inadequate diets. There are about 50% of the populations who live below the poverty line (Ouattara, 2011). Cyclical drought, overuse of limited natural resources and outdated agricultural practices hinder food production in the Sahel region. In 2010, nearly 10 million people have had to face a severe food crisis and 859,000 children under five years old needed treatment against severe acute malnutrition (Ouattara, 2011). It should also be noted immigration problems reducing the human capital competitiveness of the region. Indeed, a total of 4, 225,066 immigrants in 2000 in target countries from around the world, there were 3,488,592 from ECOWAS (or Mauritania), that is 83 % (DRC, 2007).

3.3   Logistic Connectivity in East Africa

From North and South Sudan to Tanzania, East Africa is a vast and populated area with about 215 million inhabitants. Therein, Kenya (37 million), Tanzania (38.7 million), Uganda (28.5 million) and especially Ethiopia (77 million) concentrate the largest populations.

The landscape shows strong irregularities with collapsed sections (Rift Valleys aligned over 4000 kilometers in a north-south axis) and raised portions such as the Senior highest plateaus over 1,000 meters above sea level and the Ruwenzori massive in Uganda). Even though volcanism completes this rugged landscape, the zone has enabled the development of a diversified agriculture in countries such as Ethiopia, Kenya and Uganda. The Great Lakes region has also favored the establishment of a large population around the practice of fishing and agriculture.

Roads constitute the densest transportation network. Truck based transportation is developed between regional cities. Coastal cities of Dar es Salaam (Tanzania) and Mombasa (Kenya) are homes not only for seaports but also for international airports. Even though landlocked, Uganda has good roads that make this country a hub between Sudan, Kenya, Congo and neighboring Rwanda. Similarly Lake Victoria is a relay with Tanzania.

In addition to roadways, transportation is also provided by airways. Aircraft lines serve major cities leaving the service secondary airports to local companies (Atlas de l'Afrique, 2011).

In the eastern region, lake transportation is more important than river transportation with lakes Tanganyika (natural border with the DRC), Victoria (linking Entebbe, Kisumu, and Mwanza) and Malawi (southern Tanzania).

The rail network evacuates Congo's minerals and various Tanzanian goods (outflows) to the Indian Ocean and transports the incoming flow in the opposite direction. In addition, the Tanzanian rail is operated along a north-south axis connecting the town of Mbeya (near Zambia) to Mwanza (Lake Victoria) via the capital, Dodoma and Tabora (Atlas de l'Afrique, 2011).

From a viewpoint of connectivity between different countries in the region, Ethiopia with Addis Ababa (by road or flight) and Somalia with Mogadishu (road and air) could provide access to the shortcut Asia region by exploiting Djibouti and Mogadishu as important hubs (Atlas of Africa, 2011). Unfortunately, terrorism acts perpetrated in this part of the continent do not allow Djibouti (commercial port, oil terminal) to play its roles in the amount of traffic transit: International autonomous Port, transit Ethiopian and Djibouti International Airport, railway to Addis Ababa (Ethiopia) (Atlas de l'Afrique, 2011).

The succession of dry seasons in this part of the continent coupled with the rising prices of essential commodities, and all-out conflict, has been and still is a problematic situation for the people of this region. This has exacerbated the flow of goods and services, and the difficulty in reaching populations in need. This situation has also left millions of people in Kenya, Somalia, Ethiopia and Djibouti into a humanitarian crisis, the consequences of which are still visible today. According to the UN, at least 13.3 million people, including children, are malnourished and are exposed to disease and violence (CIDA, 2013).

The problem of dilapidated rail and road infrastructure, far from being a problem for some African countries, is a common feature in almost all countries in all regions of Africa, with the road and rail infrastructure dating colonial times. In addition, another important issue is the rapid and progressive desertification (Atlas de l'Afrique, 2011) that threatens the opening of areas already affected by landlocked and long famine.

3.4   Logistics connectivity in Southern Africa and the Indian Ocean

Southern Africa, from Angola, Zambia and Mozambique to South Africa, is a region with 130 million people, corresponding to about 14% of the continent's population and 4% of the world population in 2008 (ADB, 2001). Near Southern Africa, the islands in the Indian Ocean have original physiognomy and demography with the islands of Comoros, Seychelles and Mauritius.

South Africa, with its demographic superiority and its stronger economy carries an undeniable political leadership across the region. Countries are industry oriented with oil (Angola), agriculture and livestock, mining (Botswana), commercial ports and fishing harbors. Southern Africa has great potential for the production of electricity, but the low level of investment results in shortages. Intra-regional trade as a share of total trade remains very low compared to other developing regions. Manufactured goods dominate intra-regional exports, while exports on the world market are mainly raw materials (Atlas de l'Afrique, 2011).

Compared to other regions, Southern Africa has more infrastructures required to support the exchange as described above. Take railways as an example, Southern African railways have 36% of the operated lines on the African level (Atlas de l'Afrique, 2011). Similarly, the capacity of air, road and sea transportation are better developed, because of the location and the presence of South Africa that acts as an engine in this sub-continent. For example, this country alone holds a large share of the global reserves of rare and precious metals that allow it to develop its export. It is the world's largest gold producer, second in chromium and titanium, and third when it comes to manganese (Atlas of Africa, 2009).

As in other parts of Africa, most of the trade is done on road, rail and air infrastructures. In addition, the country itself has railways, of which more than two thirds that are electrified, to form a complete network connected to neighboring countries. It totals 182,600 km of roads, 7 international level ports including several that are specialized like Richard's Bay with 75 million tons in 2006.

Also, many foreign companies operate, connect and facilitate trade between countries in the region. Commercial trade between the region, other regions of Africa and the world are very facilitated by

these large groups. For example, to facilitate the movement of goods, the French group Bolloré has 85,000 m² of parks and warehouses across South Africa. Anchored in Southern Africa, this group operates not only the global maritime transport / transit, but also the overall air transport departing from South Africa to the rest of the region, other regions of Africa and outside the continent. The international way is also used for land trade. However, despite a relatively advanced level in infrastructure, compared to the other sub-regions of Africa, these facilities need to be developed in countries such as Lesotho.

There are social issues related to logistics and transportation in Southern Africa. Despite the availability of infrastructure, some areas remain isolated, such as Zambia, Zimbabwe, Malawi and Botswana. Even in South Africa, where the availability of infrastructure is higher, many communities remain isolated because they lack economic interest towards investments. In the other countries of Southern Africa, including Namibia, Mozambique, and Zimbabwe, isolation and displacement remains a major challenge (Atlas de l'Afrique, 2011),

In Southern Africa, the environmental problem does not arise in the case of many logistical infrastructures. Trains are not part of the list of biggest emitters of greenhouse gases. The reason is that these old steam trains that once emanated huge columns of smoke are no longer widely used due to too outdated rail infrastructure and bankruptcy declared by state companies that ran the railways. If we stick to the countries of the region that still use the railways for the movement of mineral resources and goods, it must be admitted that the infrastructure is partly renovated, as well as the locomotives (Atlas de l'Afrique, 2011),

4   Analysis of results

From the analysis of the above results of different sectors (rail, sea, river, air, road, telecommunication), we created a map of Africa displayed in Figure 2 that highlights not only the current state of logistics, but also in a pictorial way, the readiness of the countries relative to the operationalization of the Physical Internet.

When considering the different regions, a rather heterogeneous picture emerges. Many African countries are facing extremely heterogeneous economic situations. The map of Figure 2 enables to understand the state of the continental logistics efficiency and to introduce a typology of countries (light green, dull green, yellow and red) relative to Physical Internet readiness. We hereafter analyze in further detail what the readiness map has synthesized.

For the six states of North Africa, despite the identification of certain barriers such as inefficient trucking and low transportation volume, aggressive customs authorities, low and inconsistent quality of products, as well as ineffective border transit procedures (Devlin et al. , 2005 : 1) , it remains that the countries of this region have a certain capacity for Physical Internet readiness. Indeed, four countries in this region meet our criteria for potential contribution to the operationalization of the Physical Internet. These are Algeria, Egypt, Morocco and Tunisia. It should nevertheless be noted that Algeria, Morocco and Tunisia are geographically interconnected countries. Thus, much improved border connections can be beneficial for the implementation of our project. Being separated from the Western block of North Africa by Libya that is not ready for adhering to Physical Internet principles at the time being, Egypt is disconnected by land and will have to wait for logistics capacity in Libya to be improved to get interconnected through land with the rest of North Africa.. Meanwhile Mauritania has not met, like Libya, the conditions conducive to Physical Internet readiness. In addition to individual state efforts, governments join regional economic organizations or communities. Thus, the North African Arab states, except Egypt, belong to the Arab Maghreb Union (AMU). The development of the Physical

Internet in North Africa could spread rapidly in some countries of West Africa (via Senegal, Mali and Niger) and Central Africa (via Chad)
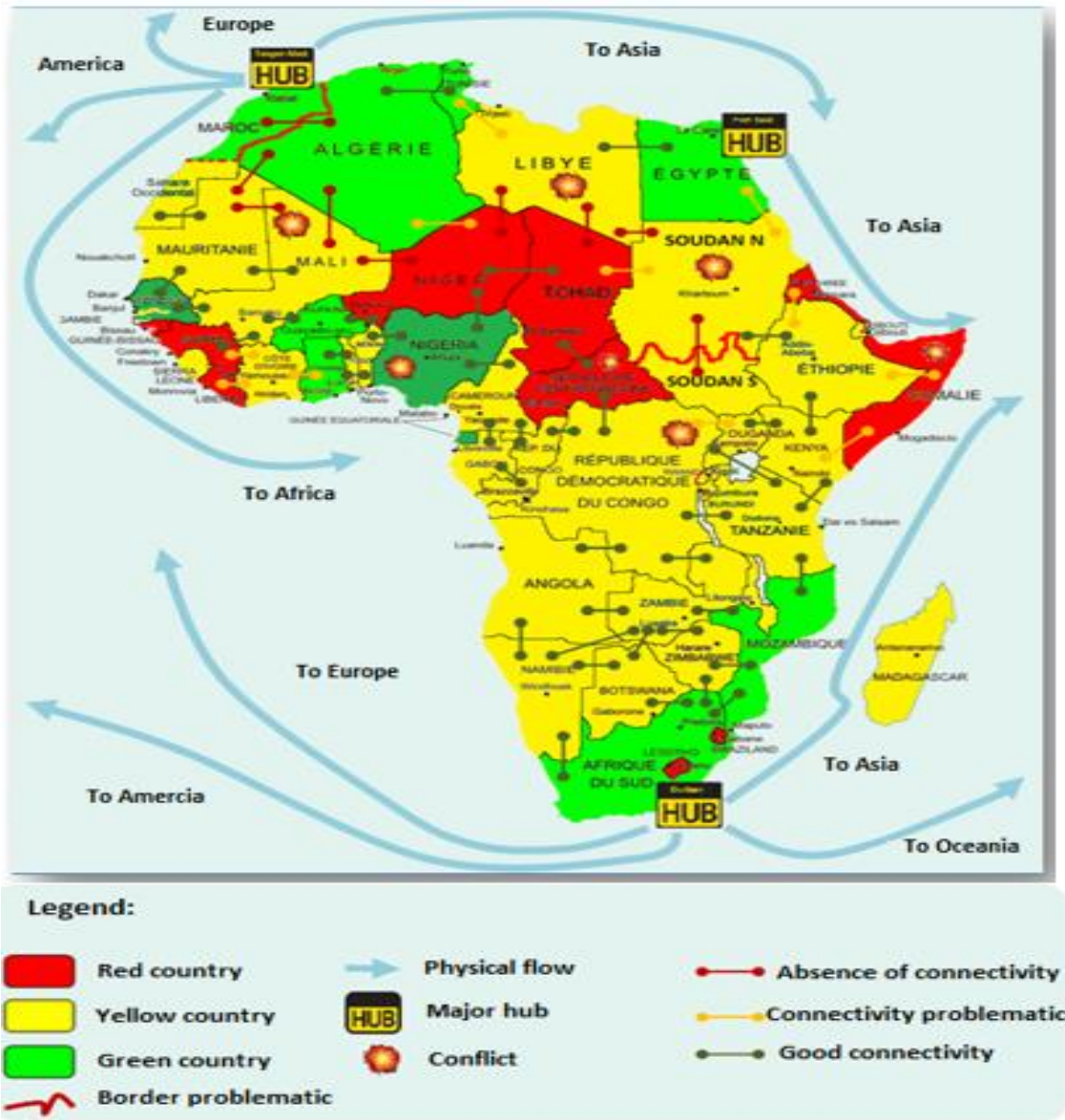

Figure 2: Physical Internet Readiness Map of Africa, as of 2014

However, the weaknesses in these countries mortgage any possible link. Indeed, in this region, most countries have a yellow readiness ranking. By cons, there are still countries that have an almost unbearable logistics capacity. Countries along the west coast (Guinea Bissau, Guinea and Liberia) and those in the south of Algeria (such as Niger, Chad and the Central African Republic) are red; they are an obstacle to the development of the Physical Internet. Their logistical capacity is very low. The Sahel is probably for something in this situation. Algeria, a paradoxical country, has many advantages such as a very large domestic market, a strategic geographical position, yet it still has a low level of connectivity with the southern region. So the short-term priority is mainly to complete the network infrastructure and promote its East-West and North-South integration. In the medium term, because of

its many strategic assets, the situation in Algeria will be such that it will become essential to develop logistics platforms and foster the development of international logistics operators as do its neighbors.

Senegal and Nigeria show intermediate readiness level (countries in dull green). But the distance from the green countries postpones the applicability of the Physical Internet. The Community of Sahel-Saharan States (CEN-SAD) is an international organization of 28 African states. Among its key objectives are promoting foreign trade through a policy of investment in the member states, as well as increasing land based and air based transportation and communication between the member states through the implementation of joint projects (African Union, 2014).

However, several countries in East and Central Africa have a relatively low level of Physical Internet readiness (yellow countries). Among them, there are two that, thanks to their potential for intra-regional and interregional connectivity, could consolidate the implementation of an African PI. This is the Cameroon and the DRC. These "regional connectors" respectively would link the West with the Centre and the Centre with the East and the South. The DRC is at the same time a member of Common Market for Eastern and Southern Africa (COMESA) and the Southern African Development Community (SADC) and Economic Community of Central African States (ECCAS). In contrast, the economic life in West Africa is structured around the Economic Community of West Africa States (*ECOWAS*) (AfDB, 2011).

In Southern Africa, two countries have been positively evaluated Physical Internet readiness: South Africa and Mozambique. Compared to other countries in the sub-region, they are very advanced regarding the development of infrastructure. Their coastal contiguity and their mutual trade intensity should proof fertile ground for Physical Internet implementation. This is also a real asset for the trade between the different cities of the two countries. The proximity of the South Africa-Mozambique duo and Madagascar is a factor that benefits the future extension of the Physical Internet Network (PIN) to countries in yellow of neighboring areas. Similarly, the fact that these two countries are coastal promotes the development of intercontinental exchanges. With Tanzania, Madagascar and Seychelles, the countries of southern Africa are governed by the South African Development Community (SADC) (AfDB, 2011).

At the moment, it would be difficult to start PI projects in East Africa simply because there is no green ranked country in the region. However, if some countries in the region were to be drained by countries of Northern or Southern Africa, the strategy of interconnecting regions would be possible. In addition, Burundi, Kenya, Rwanda, Tanzania and Uganda are organized in East African Community (EAC) (AfDB, 2011).

Moreover, beyond natural disasters, Africa is also, on one hand, a scene of conflicts that threaten the political, economic and social stability of nations. Six states are home for fratricidal wars (Libya, Mali, Niger, Sudan, CAR, DRC and Somalia). It is surprising that these countries delimit the countries in red in the northern hemisphere of the continent. Secessionist tendencies, that divided Sudan in the East, have not yet given birth to an independent state in the north (Western Sahara). The cold diplomatic climate between Morocco and Algeria, the recurrent tensions between the DRC and its eastern neighbors (Rwanda, Uganda) and the recent unrest in the former Sudan hamper the effective connectivity between these countries whose target boundaries are far from the preparation of a fertile ground (red borders on the map) for the Physical Internet project. On the other hand, due to the new map of jihad in the Sahel, the renewed activity of several jihadist groups in a vast territory on the borders of Mali, Algeria and Libya worries the intelligence services. This, combined with the non-flow connectivity in North Africa, argues in favor of Southern Africa as the readiest area for launching PI projects.

Nevertheless, some regional economic communities are working toward regional integration in Africa and invest in a convergent manner towards the establishment of a continental free trade zone (CEA, 2012a; 2012b).

5 Physical Internet and logistical involvement

The efforts for bringing the African continent into the PI initiative should consider three types of entities: countries, regions and continents. These entities are intimately intertwined so that the operation of logistics within each entity, the operation of logistics between entities as well as the connection of Africa in world trade are crosscutting concerns whose mechanisms should be defined and established modularly. This involves grouping functions interconnected by interfaces, which will be local (central and peripheral) and/or service interconnection with overseas modules. These functional connections or interfaces are sorely lacking for sectorial level transport, so that the gap within countries and regions, and even the continent, between urban (centers of manufacturing, consumption of services) and rural (agricultural producers) has deepened.

Internally, communication networks exist in several countries, but the continent suffers from logistical obsolescence and inefficient interconnection between sectors. Aided by the global donor funds (such as China, the European Union, multilateral development banks, and regional development banks), different economic communities and national governments have engaged in work to resolve this national issue at the regional level.

Externally, Africa's main cargo ports are pivotal for it to do business in world trade. Mundy and Penfold (2008) found in Sub-Saharan Africa that the port of Durban and Port Said in Sudan handle nearly 9 million tons of annual cargo through its transiting freighters. The container ports Tanger Med, Port Said and Durban handle close to 3.5 million TEUs (Institute of Shipping Economics and Statistics, 2010). These ports provide access to major shipping routes as follows:
- *Tangier Med* by the Atlantic Ocean to northern Europe , North America, South America , West Africa and South Africa ; to Asia via Port Said.
- *Port Said*, to Asia and to East Africa, also to *Tanger Med*
- *Durban* by the Indian Ocean to Africa, Asia , Oceania; by the Atlantic Ocean to West Africa , South America , North Africa and Europe.

These three ports are not only connected to major extra-continental shipping routes, they also allow intra-continental connectivity by road, air and/or rail. In this sense, they are major hubs and are recognized internationally as a symbol of regional integration of African trade.

Southern Africa has one of the three largest hubs of the continent and serves regional, interregional and international (transcontinental) transportation needs. South Africa is a green-ranked country due to the existence, use and connectivity of logistics infrastructure. It offers many more opportunities for cross and internal connectivity than the other two (Morocco with *Tangier Med*, Egypt with *Port Said*). In addition, the European Development Fund (EDF, 2006) has identified eight priority corridors for transportation in Africa starting in South Africa until the others countries without leaving any region. South Africa, Botswana, Tanzania, Rwanda, Burundi, Angola, Mozambique, Namibia, Chad, Sudan, Kenya, Nigeria, Djibouti, Senegal, among others, are the main countries related to that program. In addition, the ongoing construction of a line of railway between Kinshasa and the river port Ilebo Kasai will bring the whole of Africa to the South African port of Durban.

Two key observations result from our study. The first is related to the management of logistics in Africa by foreign private companies, such as the *Bolloré group*. States seem to be satisfied with the collection of taxes, but did not participate in innovative thinking relative to the transport sector that has

significant impact on entrepreneurship and the economy. The second is related to our assumptions with respect to the effective implementation of the Physical Internet in Africa.

Regarding the first observation, the review articles and other documents allow us to examine companies using facilities available to transshipping goods and, through these, connecting various African countries with other continents. For example, through its African subsidiaries the *Bolloré Group* has over 85,000 m^2 of parks and warehouses distributed across the South African territory and it has an important fleet of trucks. Expert in logistics management of industrial projects, mining infrastructure sectors, energy and gas, *Bolloré* bases its strength on its meshed pan-African network to connect South Africa to all landlocked countries of Southern Africa. However, the strategy of multimodal solutions for deliveries to locations across the continent applied by *Bolloré* is subject to an uneven mesh because (1) it uses transportation axes that are without alternatives and (2) it is designed for use by a single actor, being dedicated to Bolloré. For example, its tracking policy is designed and built only for goods ordered by its customers.

With the Physical Internet, logistics and transportation are not only multimodal. It is also about intermodal and technological efficiency and reliability that engages and interconnects an entire social community of operators, enablers and users (economic, social, environmental, government and civil society). In addition, the rational management and implementation of PI-enabled interconnected logistics foster potential order-of-magnitude improvement in environmental, social and economic efficiency and sustainability. Table 1 contrasts for key characteristics the Physical Internet with the current logistics system as pertinent to Africa. This remains here at a qualitative level as there is a huge lack of data supporting a quantitative assessment. In this context, a preliminary study estimating the economic, environmental and societal costs of current logistics on the continent would be highly pertinent and beneficial.

Table 1: Key comparisons of current vs. Physical Internet logistics systems as pertinent to Africa

	Before PI	**After PI**
Intermodal logistics	Weak	High
Asset utilization/exploitation	Personal	Public
Performance of critical parameters *	Isolated, private, sensitive	Synchronic, collective, superior

* Speed, service levels, reliability, safety and security (Source: created by the authors)

The African PI implementation would gain from adopting the common objectives of the Regional Economic Communities (RECs) and of the International Physical Internet Initiative. Growing the PI implementation in two majors Free Economic Zone (FEZ) in Africa should be considered: (1) the South East FEZ group including COMESA, SADC, EAC and IGAD along the South Africa, and (2) the Northwest Centre FZE group including ECOWAS, CEN-SAD, ECCAS and AMU along the Morocco - Mauritania - Senegal – DRC axis. The full logistic interconnectivity of the continent would then be based on the East-Central and South-Central junction. From another perspective, all African countries should independently and collectively address how the PI can help them develop sustainably and building a pragmatic roadmap from their current logistics system to an interconnected logistics system, providing an opportunity to interconnect in priority the readiest regions to build success and momentum and to pull the overall continent.

6 Conclusion

Sustainable development of the continent relies to a large extent on infrastructure and services associated with logistics and transportation. Networks and well developed, safe and affordable transport services are essential for true mobility and timely accessibility to goods and services.

The African transportation system lags behind the rest of the world, with a level of development still lower than other developing countries in Asia (CEA, 2012a). For many, the African continent remains associated with roads dotted with crevasses; flood in rainy seasons; and overloaded, old and outdated railways; inefficiently exploited inland waterways; and often inexistent or capacity-lacking airways. At ports, containers of different sizes are sometimes half full and disintegrate gradually due to the rain and sun.

However, this not-shining portrait of African infrastructure is progressively modified. This has led some foreign operators to get active in the continent, amid redefinition of transport policies in Africa, including Bolloré Africa Logistics (BAL), DHL, Dubai World, Getma (NCT Necotrans), Maersk, Mediterranean Shipping Company (MSC) and Mitsui OSK Safmarine. These are very interested in the development of transportation and logistics in Africa and in developing strategies to cover enough sectors to expand their market.

The Physical Internet builds on the network effect, getting ever more effective as it gathers more users. It must gather critical mass, first exploiting existing infrastructures and means, then gradually fostering innovation. Even though it is to be ultimately global it will have to grow first in fertile domains, to be collaboratively supported by key leaders from industry, government and academia (Montreuil, 2011)

On African soil, several reforms are undertaken in various sectors to support the economic recovery of the countries. Virtually all African countries, whether democratic or not, are making efforts to access the Digital Internet and to realign their infrastructure (Beche, 2012; Pelgrum and Law, 2004). Still others create the institutional structures or organizations responsible for regulating these reforms in the telecommunications and implementation of transport infrastructure. In terms of facilitation, safety and security of transport, several international and bilateral agreements and protocols to simplify and harmonize trade and interstate transportation have been signed in Africa. Central, Southern, Eastern and Western African States have signed conventions and protocols, many of which are implemented. These instruments relate to road-based goods transportation, multimodal transport, regulation of transport of dangerous goods, rules of the road and civil aviation, maritime cooperation, common vehicle insurance schemes, common border posts, and corridors management mechanisms. Focusing on the Millennium Development in Africa, these agreements and protocols have the support of the UN, ADB, the European Commission, the World Bank and the Secretariat of the African Infrastructure Consortium (CEA, 2012a). In addition, the 2013-2022 integration strategy toward the transformation of Africa by the African Development Bank includes chapters on transportation and telecommunications (BAD, 2013).

Preparatory studies finding, diagnosis and planning conducted by several institutions (ICA, The Infrastructure Consortium for Africa; AICD, Africa Infrastructure Country Diagnostic, and World Bank, PPIA, ADB, African Development Bank; ECA, etc.) have passed to the operating phase in infrastructure development. In 2012, funding provided U.S. $ 18.7 billion from various sectors ranging from public to private. Disbursements of ICA members totaled $ 12.7 billion, which the energy received the lion's share (37.5 %), followed by transportation (32.3%), water (20, 7%), multi-sector projects (3.9%), and ICT (1.9%), with 3.7% unallocated. African national governments and external sources (public and private funds) finance the development of Africa's infrastructure. Key groups of actors include Asia (China, Japan, South Korea, and India), the group of Arab coordination, Europe

(EC, France, Germany and the United Kingdom), the Americas (Canada, USA and Brazil), multilateral development banks and regional development banks (ICA, 2013).

This means that, overall, there are opportunities for the realization of the Physical Internet in Africa. Moreover, our study revealed the existence of certain areas with green-ranked logistics readiness for the Physical Internet.

If nothing is done to support reforms and maintain focus, lethargy and vices of underdevelopment helping, the already bleak conditions will worsen, thereby reducing the chances of achieving the Physical Internet across the African continent.

Getting engaged in the International Physical Internet Initiative would enable Africa to conceive and implement interconnected logistics solutions to the situation of each country and region. Overall there is an opportunity for reversing the decay state of transportation networks and drastically improving the currently weak connectivity. Indeed, taking into account economic, social and human aspects, the initiative focuses on the logical PI logistics intermediation between geographical points. Hubs built in "Zone of contacts and exchanges" also represent the interfaces between management, organization and computer (Lalo et al , 1970: 26). In this logic, it will therefore be necessary to conduct detailed studies on specific themes in the various sectors related to logistics. This would notably analyze in operational and strategic terms how Africa could progressively implement the Physical Internet on the extent of the continent. Air, land and maritime telecommunication infrastructure should be allowed to assist in the development of Africa through the implementation of the Physical Internet. The primary condition is that the States through their leaders are involved, including private operators on the continent. Beyond the realization of investments for the modernization and rehabilitation of infrastructure in all its forms, the challenge for Africa in the coming decades is to strengthen the interconnection of existing networks. Countries also need to invest in the construction of new lines to avoid traffic congestion and provide circulatory alternatives to develop intra-African and intercontinental trade. As Physical Internet engages in this sense, its planned deployment should be beneficial, yet it will have to overcome numerous challenges. The security challenge is in top list. It is not just about terrorism and natural disasters. Aircraft accidents and traffic are likely to disturb the smooth operation of the PI whose effectiveness lies in a continuous functional system.

This work has significant limitations. The first is the scarcity of statistics on the goods transportation and warehousing. The inaccessibility of these secondary data makes difficult the quantification of Physical Internet readiness. A thorough research should be continued in this direction. Secondly, the gray literature requires considering the information conveyed with caution. Reliability cannot always be guaranteed. As a research avenue, in the light of the regional division of Africa, is to dwell on the study of Physics Internet zones, allowing for a closer view of the current reality superimposed on the potential realization of this great initiative.

Transportation and logistics are strategic sectors playing a key role in efforts to achieve sustainable economic growth and to reduce poverty, thereby enabling the sustainable development of Africa. For this sector to play their role, they must be developed in a coordinated manner with the ultimate objective of establishing an interconnected logistics and transportation system for both people and goods that is reliable, efficient, safe and environmentally friendly. The PI initiative is exactly suited to respond to this overriding concern.

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