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The Physical Internet Routing Model

The Physical Internet (PI) was proposed in as an alternative model in the transportation of goods as compared to the existing transportation models used today. The data packet routing model of the Internet was used a reference point for this new Physical Internet (B. Montreuil, 2011). The idea of the physical internet was first proposed by an Economist Article in the year 2006. The article was more about the movement in a web of transport networks and did not allude to the physical internet proposed in its current form. (Markillie, 2006)

The e-commerce industry of today is heavily reliant on the physical movement of goods in an efficient way to the end customer in a timely and cost-effective way. There are some problems with the way goods are transported. The logistics cost has been rising due to rising fuel costs and driver shortages. The transport networks are heavily congested and fragile; any minor disruptions can lead to major delays in the delivery schedules. The current fossil fuel based transportation networks are one of the biggest polluters. The Physical Internet transportation model is being proposed as an alternative to solve some of the problems faced by current transportation models of today. (Benoit Montreuil, 2011)

There has been significant work done on the Physical Internet in many countries including the United States, Canada and Europe. The one part missing in the evolution of the PI routing model is the time and cost quantification versus the existing transportation networks.

My research will look at current models of routing freight to the final customer, both Brick and Mortar and web e-commerce and also propose a network for the Physical Internet and compare a typical shipment to the final customer in both the networks.

Current Freight Routing Models

The traditional freight routing models have been derived from passenger transport models. The four step passenger model can be successfully applied to freight transportation. (Shankar and Pendyala, D'Este). (Liedtke & Friedrich, 2012)The main difference between the passenger and freight models is that within each of the four steps the freight models can be significantly different depending on the product being transported

The four steps are: (DE JONG, GUNN, & WALKER, 2004)

- Supply and demand between the origin and destination zones (production and attraction)
- Distribution between supply and demand. The usual unit is tonnage and the flows are predominantly from the supply to demand side, however reverse flows are also prevalent.
- Modes of transport split the tonnage according to the product or commodity carried.
- Assignment of the tonnage to the different networks like truck flows.

A drawback of most freight models is that the freight needs to be consolidated at the hub nodes (Figure 1) and then transported in bulk to another node to take advantage of the economies of scale. An example of this is the line haul movement of freight from the Port of New York to Port of Amsterdam. The freight is further distributed with the use of trucks or trains to the final customer after each node. This leads to freight crisscrossing the globe more than it needs to in order to get to the final customer.

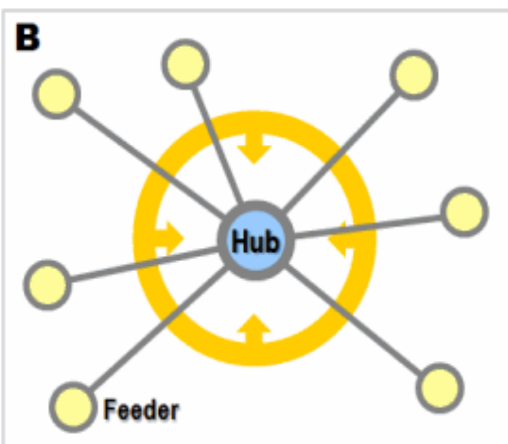

Figure 1: Hub and Spoke Routing Model

The Internet routing model

The internet transmits data packets through hardware equipment called routers using the TCP/IP protocol. The internet is a peer-to-peer network, that has millions of mobile and computing devices connected to each other using an “Information Highway”. The salient features of this ‘Information Highway’ include a self-correcting, distributed and open network. If a link between two nodes is broken or congested, the packets automatically take a different route to the end destination. This network has forever transformed the way we live and do business with an explosion of mobile and computing devices. The peer-to-peer network has the advantage of connecting to any computer in a direct connection. The connection in real world may not be as direct as can be seen in in Figure 2. However it still has error correction and automatic routing its benefits.

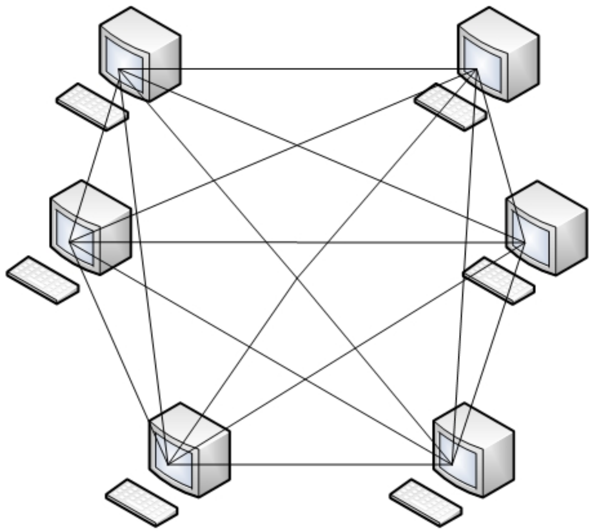

Figure 2: Peer to Peer Network

There are fundamental differences between the PI and the data internet, for example data travels at the speed of light, while in the physical internet the speed of the freight is constrained by the maximum speed of the arc or mode they are travelling in and is typically a couple of miles an hour. The PI aims to emulate the data internet topology for the distribution of freight and goods. (Magnanti & Wong, 1984)The PI is intended to be an open global logistics system founded on basis of open connectivity of all systems. As can be seen in Figure 3, the physical internet is proposed to have open links with the digital internet and the internet of things, and the smart grid. The smart freight packet in the physical internet is smart and can broadcast its position and destination in a group of freight packets and the materials handling systems can position it to reach its destination in a timely manner, without much human intervention. (Scellato, Fortuna, Frasca, Gómez-Gardeñes, & Latora, 2009)

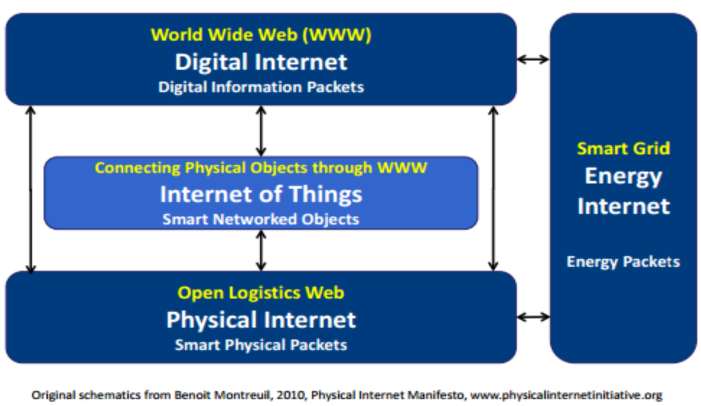

Figure 3: Physical Internet Positioning ((Atzori, Iera, & Morabito, 2010; Chui, Löffler, & Roberts, 2010)

The goods in the PI are encapsulated in modular, smart containers, which can be reused and can be easily handled in multiple modes of transportation.

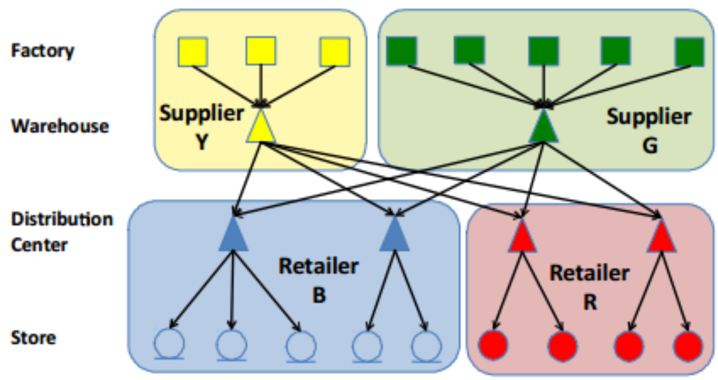

Figure 4: Traditional Supply Web

Figure 4 displays two private retail networks displaying supply from two suppliers and in Figure 5 the transport of goods from the vendors to the private retailer is consolidated using open logistics connectivity of the physical internet. According to the authors, this has led to lower overall logistics costs as well as reduced greenhouse gas emissions. (Ballot et al., 2012).

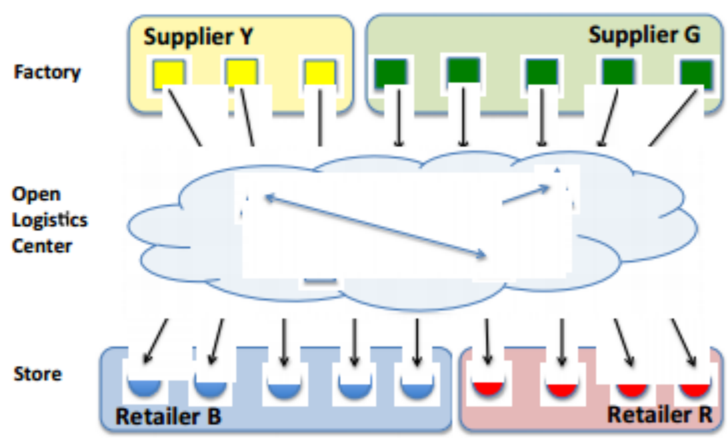

Figure 5: Physical Internet Enabled Supply Network

Future and Ongoing Research

Future work will be focused on creating a routing model of the hub and spoke network and the proposed physical internet routing model. The physical internet model will be based in TCP/IP data routing model with restrictions added for how the physical freight moves through the current transport network. New connection and technologies will be needed as the project progresses to address problems like congestion, natural disaster disruptions and man-made disruptions. The next steps are to model the flow of freight in a sample or simulated network to find actual cost savings and greenhouse gas emission reductions. The research will also attempt to find answers to the impact on transport capacity and infrastructure investments need to make the Physical Internet possible.

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