Logistics: the deciding factor in e-commerce

Inaugural address delivered in an abbreviated form by Dr. Kees Jan Roodbergen in acceptance of the position of Professor of Quantitative Logistics within the Faculty of Economics and Business at the University of Groningen on November 8, 2011.

Mr Rector,

The term "logistics" originates from the Greek word logos (λόγος)[1]. Now the word logos by itself is already worth a treatise, but I will restrict myself. Around 350 BC, Aristotle described in his work *Rhetoric* three means of persuasion: ethos, pathos and logos. Roughly, these means of persuasion can be defined as follows. *Ethos* refers to the character or moral quality of the speaker, as reflected in his speech. *Pathos* refers to addressing the emotions of the audience, for example in the form of a metaphor or an analogy. *Logos* entails the use of logical reasoning and convincing arguments[2]. The modern word logic comes from logos.

Given that the word logistics derives from the word logos, it seems obvious that this address contains a significant amount of logic. I will not give my opinion beforehand on this matter, and leave judgment on the degrees of ethos, pathos and logos to the listener and the reader.

A fairly general definition of logistics is as follows: Logistics entails planning, implementing, and controlling the efficient, effective forward and reverse flows and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements[3]. I personally prefer the shorter version "logistics is all that moves". By truncating the definition in such a manner, however I inadvertently overlook important aspects such as products that are waiting to be moved later, or an e-mail containing the request for a product to be moved. If I add all of this again to the abbreviated version, we are back at the longer definition originally given.

Before I go on to the main theme of this address, I will give a brief sketch of the field by means of an example. This concerns the famous traveling salesman problem, precisely the subject that served as a starting point for my journey into logistics when I was a student. This problem can be stated simply

Suppose a salesman would like to visit several cities. Find a shortest route that visits each city exactly once and returns the salesman back to where he started.

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[1] Throughout the centuries, there have been many words that brought us from the origin *logos* to the current *logistics*. From Merriam-Webster's collegiate dictionary (2004): "**logistics** ...[F *logistique* art of calculating, logistics, fr. Gk *logistike* art of calculating, fr. fem. of *logistikos* of calculation, fr. *logizein* to calculate, fr. *logos* reason] ...".

[2] Online available at http://rhetoric.eserver.org/aristotle/

[3] http://cscmp.org/aboutcscmp/definitions.asp

As you see, this problem can be very easily stated. Yet many books have been written on how the route can best be determined[4,5,6]. It is as difficult to solve as it is simple to state. My predecessor, Professor Gerard Sierksma, in his inaugural lecture already gave a wonderful treatise on the most vital aspects of the traveling salesman problem and its solution methods[7]. Hence I confine myself to giving an outline of two basic approaches.

An algorithm is designed so that it continues to search until an optimal solution is found. A basic approach for this is complete enumeration, in other words, just try all possibilities. For a route visiting 5 cities, there are only 12 unique routes to test. For a route through 10 cities there are 181,440 possible routes. A route through 20 cities has 60,822,550,204,416,000 (60 quadrillion, 822 trillion, 550 billion, 204 million, 416 thousand) options. The workload increases rapidly with a small increase in the number of cities. A good search routine will skip the maximum number of potential solutions. Skipping, however, must be done so that you know that the solution you are looking for will not be skipped. Ten years ago, scientists determined a shortest route to visit 15,112 German cities[8]. If this calculation were done on a normal computer, the result would have taken 22 years of calculation time. In the intervening ten years, since the solution to the German problem, even more difficult problems have been solved. This progress can be attributed to three developments. First, better algorithms, second, faster computers, and third, the networking of more and more computers.

Another approach to solve the TSP is that of heuristics. In the development of algorithms one looks for an optimal solution, no matter how long the search lasts; when designing heuristics, however, we take the search time into account. Thus a heuristic focuses on quickly finding a good, but not necessarily optimal, solution. In many practical situations, the choice for heuristics is crucial. Think of an in-car navigation system. Most people will not want to wait three hours for the best route to be calculated, especially if that route eventually is only 2 minutes faster than one that could have been calculated in just a few seconds.

Logistics plays a major role in society. Applications can be found in road transport, health care, energy, warehouses, inventory management, reuse and recycling, and so on. Still, for this occasion I will confine myself to a single application: the logistics of e-commerce.

But first a fairy tale.

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[4] Lawler, E.L., Lenstra, J.K., Rinnooy Kan A.H.G., Shmoys, D.B. (1985), The traveling salesman problem – a guided tour of combinatorial optimization, John Wiley & Sons.

[5] Gutin, G., Punnen, A.P. (2007), The traveling salesman problem and its variation, Springer.

[6] Applegate, D.L., Bixby, R.E., Chvatal, V., Cook, W.J. (2006), The traveling salesman problem – a computational study, Princeton University Press.

[7] Sierksma, G. (2001), Een kleine stap naar het oneindig grote; over exponentialiteit en logistiek, rede uitgesproken aan de Rijksuniversiteit Groningen d.d. 20 maart 2001.

[8] http://www.tsp.gatech.edu/d15sol/

Shopping in Colorcity - a fairytale

Chantal got a tip from a good friend to go shopping in Colorcity. Actually, Chantal is not really an adventurous type and she generally prefers to shop in her home town. Nevertheless she is quite curious about this shopping destination, is desperately in need of new socks, and has a free Saturday ahead of her. Chantal's friend has warned her that things in Colorcity don't quite work the way she is used to, but that will be self-evident once she is there. Overcome by curiosity, Chantal makes the trip and suddenly finds herself in a sock store in the middle of Colorcity. Chantal has never before seen such a wide variety of socks. Fantastic. After one hour she finally picks a pair of colorful socks and walks to the checkout. Chantal grabs her purse and is already looking for her bank card. "Have you already registered?" the cashier snaps at her. Chantal explains that she does not have nor need a customer card and that she just wants to pay. The cashier remains inexorable. Without a registration form Chantal cannot buy anything. The friend was right, everything is indeed a bit different here. Because Chantal really likes the socks, she goes to the registration desk in the back of the store. She fills out her first name, last name, street address, zip code, city, telephone number, mobile number and email address and then heads back to the checkout where she can finally pay for the socks.

So enchanted with her new socks, Chantal decides to visit a number of other stores in Colorcity. However, she quickly finds out that she must fill out a registration form in every store-- and every time she must enter exactly the same data, otherwise she cannot buy anything. Chantal decides to go home. She walks to the nearest bus stop and sits down on the bench to wait. This gives her some time to quietly think and she decides that the experience was good after all. Even though she experienced a selection dilemma and the registration was cumbersome, she would otherwise never have found these beautiful socks! Soon a bus drives up, but refuses to stop for Chantal, no matter how hard she waves. This repeats itself. Successively a red bus, a white bus, a blue bus, an orange bus, yellow bus, green bus and even a light-blue bus pass. But all buses drive on without stopping.

Meanwhile, more people arrive at the bus stop and sit down next to her. Chantal looks at them. Those people seem to be accustomed to waiting. Chantal enters into a conversation and she soon learns the decision rule that applies in this city for bus transportation. A bus picks up only those passengers that carry a bag with them which is the same color as the bus. *Chantal looks down at the purple bag that she got from the store. She realizes that indeed no purple bus came by so far. She waits. More buses pass. She waits. She now notices that some buses are multicolored. This is a concept that Chantal can appreciate. Apparently,*

already a small start has been made here to improve the effectiveness of transportation. Finally, the purple bus arrives and brings Chantal home. She hopes that her husband is already home, because she has forgotten her house key.

Strange story?

No. This is the way things go every day in e-commerce.

Each webshop has its own digital shopping cart. And for every store you need a new account. Many webshops operate from a single distribution center. Packages are not being sent with the first carrier that arrives at the distribution center, but with a carrier that is either under contract with the distribution center or with the webshop. Once the package arrives at the home of the customer, it is hoped that the customer is actually at home, otherwise the delivery person will need to come back at a later time. I suggest that you, at the reception after this inaugural address, open a discussion on the strategies that you as a passenger in Colorcity could use to get home faster. How could you manage to get on a green bus, despite your purple bag? Perhaps we can find some good new strategies for the logistics of the Netherlands.

Perhaps it is superfluous to say that companies realize sales over the Internet at an almost unstoppable growth rate. Crisis or no crisis. In 2010 a total of 68,850,000 orders were placed in The Netherlands via the Internet, an increase of 29% over the previous year. In total, this gives a turnover of 8.2 billion euros on an annual basis. And to compare your own online purchasing behavior: online shoppers last year placed an average of 7.4 orders with a total annual purchase value of 888 euros. Now it should be noted that these sales figures also include purchases of holidays and usually travel products do not need to be sent in a package; an e-mail suffices in this case.[9]

The following is a description of the logistics behind the Internet orders. Some people will recognize that I made some simplifications, however, this has been done with the intention to ensure that the important aspects get the attention they deserve.

The logistics of Internet orders often starts before the customer has placed the order. Somewhere in the world a manufacturer makes socks, because somewhere a trader thinks he will be able to sell those over the Internet. The socks are shipped from the manufacturer, perhaps first by container ship to the port of Rotterdam and then trucked to a distribution center in Eindhoven, for example. There the socks remain in stock until a customer places an order on the website.

The customer order is relayed to the distribution center where an employee collects the required socks. These are then packed and the resulting package will be transported by truck to a sorting center belonging to the package carrier, for example, in Dordrecht. There, all incoming

[9] Thuiswinkel Markt Monitor 2010 op http://www.thuiswinkel.org/

packages are sorted by destination. The package continues on its path and will end at the customer's home in The Hague, for example.

It would be too easy to conclude that many kilometers have been traveled in vain because the product has gone back and forth between the Randstad and Eindhoven. After all, when the ship arrived in Rotterdam, it was not known that a pair of socks on that ship was eventually going to go to The Hague.

The problem is not so much the wrong routing. The basis of the problem is also not just that parties look only at their own supply chain and try to optimize it independently. It starts with the lack of a common standard for the exchange of both information and goods. I will give an example[10,11].

In the first half of the nineteenth century, the Netherlands had different time regimes. Each city had its own time, derived from the position of the sun. A first step towards harmonization was put in place by the telegraafwet *of 1852. It was determined that all clocks of all telegraph offices should be synchronized to the average Amsterdam time. But then again, the opening times of the offices were still allowed to be displayed in the city's own time. Later the railways adopted the telegraph time too, but the city clocks did not. Between cities and even within cities different times existed.*

It is hard to imagine how logistics would function without a single unified time. A promise such as "Ordered before 22:00? Delivered the next day." would take on a completely different meaning.

<u>An open ICT platform</u>

Changing the e-commerce logistics structure starts with all stakeholders agreeing on uniform information collection and information exchange, or as Topteam Logistiek says: "Seamless information in the logistics system, an open IT platform." I will give you my views on this. Such a system will need to be able to do more than just organize information for containers or trucks. It will need to be able to function at the smallest level, that of individual products. Only then can we achieve a major break-through in the logistics for e-commerce.

Now I feel compelled to say that while writing this piece, I was inadvertently reminded of the Dutch Electronic Patient Record bill (*Elektronisch Patiëntendossier*) that the Senate did not approve[12]. Without pretending to give a complete analysis in this text, I will state some observations. The Electronic Patient Record bill sought to achieve an exchange of information, in which the patient did not have any influence on the distribution of his/her health data. If the intent of the open ICT platform was for the data to be "open" in the sense of "open access",

[10] Rozendaal, S. (2010), Hoe laat is het?, *Elsevier* 66(44), 6 november 2010, p. 99
[11] http://www.staff.science.uu.nl/~gent0113/wettijd/wettijd.htm
[12] http://www.eerstekamer.nl/wetsvoorstel/31466_elektronisch

then, in my opinion, the project is doomed to fail. The project should not focus on the exchange of information, but on the interchangeability of data. Everyone must speak the same language.

In this context, a useful comparison is with Facebook. With this social network, the information exchange occurs via a uniform concept. Each individual decides for him/herself whether or not to participate. Each participant then determines by him/herself who his/her friends are and who are not. More information is accessible to friends than to others. And even within the group of friends distinctions can be made regarding exactly who sees what information. That categorization can be changed every minute of the day.

We first have to define who the potential participants are for the open ICT platform. I would say every person, every building and every business. Probably each entity would also have multiple identities. Wouldn't it be nice as a consumer if you could go to the website of the open ICT platform, fill out your personal page, and be able, for example, to specify that your packages may be delivered to the neighbors on the left, but not to the neighbors on the right? And, even though specified only once, all delivery companies would follow this instruction? Wouldn't that also serve to improve customer satisfaction for the web shops? Companies can choose exactly who they label as a friend and what information is shared within that relationship. The discussions that reach the news regarding data privacy on Facebook only show us how important it is that these designations must be properly managed.

As part of the open ICT platform, I also mention a study that we started into the possibilities and impossibilities of a standardized online shopping cart for multiple online stores. This is part of the Dinalog project "Cross-chain order fulfillment Coordination for Internet sales". In this concept, several webshops use the same shopping cart so that consumers can put together products from multiple online stores, pay in one go, and have all products delivered to their home in one delivery. This is somewhat like what some larger online stores do with their shop-in-shop concept, but for the whole country, or at least for a large number of webshops.

The impact of standardized, universal payment schemes on consumer behavior were seen with the introduction of the iDEAL payment. The popularity of iDEAL increased from 44% by mid-2009 to 54% by mid-2010. This is the power of e-commerce – concepts appreciated by consumers can grow almost immediately[13].

But the shopping cart and payment are not the only factors. Recent research shows that even frequent online buyers return to buying in a store when a new store opens near their home[14].

An open network

Why don't we set the bar even higher? Not only an open ICT platform for the logistics world, but an open network structure. By an open network structure, I mean that for every product at each

[13] Rapport online betalen 2011, www.thuiswinkel.org

[14] Forman, C., Ghose, A., Goldfarb, A. (2009), Competition Between Local and Electronic Markets: How the Benefit of Buying Online Depends on Where You Live, *Management Science* 55(1), 47-57.

moment in time, the product can choose "by itself" from all possible options for storage, material handling, packaging, labeling and transportation. I use the phrase "all options" here to literally mean all the possible options offered by participating companies throughout the network.

To make this concept more specific I will give an example.

Imagine, a salesman of socks allowing all of his socks to decide for themselves where to remain in stock. The socks could choose a warehouse close to the region where their type is frequently sold or a warehouse close to another pair of socks that they frequently travel with in the same order. Thick woolen socks, for example, can choose to go to a gardening equipment warehouse and position themselves next to the wooden shoes. What is the probability that all of the socks belonging to this salesman will choose to go on stock in the same place?

In this concept, products will group themselves based on customer preferences and behavior, rather than based on who the seller is. The question remains: who takes care of managing all these movements and positionings? Will the webshop specify where its products will be held in stock? Will the logistics service provider decide that? Or is there a Cross Chain Control Center that makes these decisions? In a proper open network structure, all three possibilities coexist. A webshop with its own warehouse can "tell" its products to only be on stock in its own warehouse, but to use a variety of carriers. Alternatively, a webshop can outsource the logistics management to a Cross Chain Control Center, which then sends the products to various parties for storage and transportation.

At this point, the Physical Internet initiative of Professor Ben Montreuil from Canada must be mentioned. There are some important parallels with that concept, but the main difference is that the Physical Internet initiative has standardized load carriers as its starting point, which is not the case in the concept outlined here[15,16].

In practical terms, many obstacles must be cleared to achieve the described ideal. For example, if a distribution center places a label on a package, then that label must be readable by any other participant and for each participating carrier in the network. Also, an owner of products, though all scattered throughout the country, must be able to see real-time stock levels.

Although these are very important points to bear in mind, I will not dwell on them any longer. I have two more parts to deal with in this story. First, the academic view on the concept presented and second, a view from practice. In this second part, I will mention a number of advantages which in my opinion far outweigh any disadvantages during the start-up phase.

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[15] Montreuil, B., Meller, R.D., Ballot, E. (2010), Towards a physical internet: the impact on logistics facilities and material handling systems design and innovation, Progress in Material Handling Research: 2010, Gue et al. (eds.), Material Handling Industry of America.

[16] Montreuil, B. (2011), Toward a Physical Internet: meeting the global logistics sustainability grand challenge, *Logistics Research* 3, 71-87.

The academic perspective

A very interesting issue is to determine which product must be waiting where for an order; what methods can be developed to solve this problem? I call this the product location problem. From a modeling perspective this problem is related to facility location problems[17]. The models available in the literature for this problem class, however, do not sufficiently take into account the different characteristics of different locations. For example, it is not a good idea to try to store hanging clothes in a warehouse for machine parts. Also, *a priori,* given capacities and fluctuations in capacity will have to be taken into account. But most importantly, work needs to be done with a different granularity. It is about positioning tens of thousands of products per webstore, where all decisions again depend on the decisions of others.

It is extremely unlikely that the product location problem, as a whole, is solvable to optimality. Such a strategy also does not seem to be practically relevant. Rather, the research will focus on models from the perspective of one or more parties in interaction with the activities of others in the network. It is therefore the aim to make operational, tactical and strategic choices for use in a dynamic, network context.

The product location problem is also close to inventory management theory[18]. In contrast to the product location problem, which assumes given quantities of products, inventory theory considers the quantity of products as a variable. Certainly, the combination of the two cases can lead to interesting models and solutions. Such problems should also take into account the service level. In standard theory, the distribution of products across multiple locations may be perceived as reverse pooling, with the resulting conclusion that the total stock level should be increased. That is not the intention, nor necessary, provided that all sites can deliver to all destinations. There does, however, seem to be a need for a certain classification of priorities and assignment of products to categories[19].

Then we come to the distribution of products to consumers. This in itself, in the current situation, already poses an interesting challenge, which is academically in the area of the well-known Vehicle Routing Problem with Time Windows. Now I add to this the choice of the number of vehicles, and also the fact that cost differences between vehicles arise from the vehicle's fill rate. In addition, in an open network structure, every store, every distribution center and every carrier can develop models for themselves to determine which route should be taken by the packages, which routes are offered and at what price and under what conditions services are offered. These interactions will undoubtedly lead to interesting new models and solution methods.

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[17] Melo, M.T., Nickel, S., Saldanha-da-Gama, F. (2009), Facility location and supply chain management - a review, *European Journal of Operational Research* 196, 401-412.

[18] Wang, Z., Yao, D.Q., Huang, P. (2007), A new location-inventory policy with reverse logistics applied to B2C e-markets of China, *International Journal of Production Economics* 107(2), 350-363.

[19] Teunter, R.H., Babai, M.Z., Syntetos, A.A. (2010), ABC Classification: Service Levels and Inventory Costs, *Production and Operations Management* 19(3), 343-352.

The practical perspective

The university is in the service of society. On the one hand by educating its students and on the other hand by creating new knowledge. For me that new knowledge only attains its maximum value if that knowledge can be used in practice. Let me therefore at the end of this talk present my ideas with a perspective from practice.

- The hardest part for practice will be right at the beginning. I am referring here, to both the open ICT platform as well as the definition of the open network structure. This requires a certain critical mass of companies that are behind the initiative and together look for a description of the logistics language by which everyone can exchange information and goods[20].

- The Netherlands has a leading position in Internet use: both the penetration rate and the percentage of internet users shopping online, is in the top five in Europe. Netherlands is also a leader in the development of concepts such as Cross Chain Control Centers, which are at the right place in an open network structure. Newly developed concepts can be implemented in other countries.

- For large businesses many opportunities are provided by an open network structure. Through proper management they can use an open network structure to attract exactly those activities that the company would like to perform. Activities that are performed at a loss -as part of a major outsourcing contract- may be omitted, because they are automatically picked up by other parties. Each party may therefore focus on its strengths and the best routes[21].

- An open network is not only attractive for large parties, but also for smaller companies. The scalability and flexibility yields a reduced risk for all participants. Webshops and startups can connect with a smoothly running logistics machine, so they can immediately deliver quality. New logistics service providers can specify exactly what services they can and cannot deliver and draw exactly the work that suits their skills.

- The total available logistics capacity will become more flexible due to the entry and exit of small businesses, depending on demand. Just like numerous self-employed persons play a distinct role in the software industry.

- The system is not only suitable for packages with non-perishable products. It can also be a very attractive concept for foods such as fresh fruits and vegetables. This type of product comes from a large number of locations in the region and through Internet orders again spreads over a large number of households, mostly in the same region.

[20] Partituur naar de top, Adviesrapport Topteam Logistiek, juni 2011.
[21] Roodbergen, K.J. (2011), Kijk eens naar het hele speelveld, *Logistiek*, 23 september 2011.

- Also the option of placing a product type at multiple locations may be considered. This would result in unparalleled network reliability. If a system disruption occurs in a distribution center or if major delays on the road occur, the delivery can be shifted seamlessly to other parts of the network.
- The concept is potentially suitable for developing countries and countries with less developed logistics markets. This is because no requirements exist in terms of the size of the participating companies; many small parties can form a network together. The risk of entering such a market can therefore be reduced.
- Smooth integration with the city or urban distribution concepts is possible because the open network structure does not see this as a troublesome exception, but as just an additional party with specific skills.
- A better overview and better exchange of data can lead to a higher load factor of vehicles, yielding beneficial effects on CO_2 and NO_x emissions.
- It is possible to start today. For example, two or more webshops can introduce together an online shopping cart and stock each other's top-10 fastest sellers for combined shipment. Such measures could even be implemented in single, large webshop companies that have multiple warehouses or multiple independently positioned webstores.
- I'm sure people from industry will have many additions to this list. I will gladly listen.

Finally

Will all of this happen next year? No. At least not everything. But the first steps can certainly be made. I always tell my students that they must first figure out what the ultimate goal is that they would like to achieve. If you know that, then all you need to do next, is to try to get as close to the goal as possible. It's basically like having an in-car navigation system. The underlying logistic techniques can only work well, if you know where you want to go.

I have spoken.