Customer controlled e-logistics

J.T.W. DAMEN
KPN Research, P.O. Box 421, 2260 AK Leidschendam, The Netherlands
Email: J.T.W.Damen@kpn.com

Abstract. The lack of adequate flexibility in logistics is a major obstacle for e-commerce. Logistics service providers can not cope sufficiently with demands for services that fit within the e-commerce paradigm. E-logistics, the logistics part of e-commerce, has to deal with: individualized treatment; full customer control; virtual, decentralized and dynamic environment. In general, logistics systems are mainly based on fixed chains of processes, and therefore are not prepared for e-logistics.

Service Controlled Agile Logistics (SCAL) – a new model for logistics control – is shown to fulfil the requirements for e-logistics. The paper describes the SCAL model in the context of e-logistics and the background from which it has been derived. It briefly shows a simulation and some preliminary results, and puts the model into a broader perspective for future development.

1. Introduction

The "rule of 7 b's" governs e-commerce, particularly the variant known as B-to-C – business to consumer. It states that seven aspects must be dealt with for successful transactions, including: looking, ordering, paying, tailoring, storing, delivering, special servicing (in Dutch, all start with the letter "b"). On Internet, the first three get much attention. The speed by which customers can look, order and pay on the net 24 hours a day has become proverbial for e-commerce. It has created an atmosphere in which the customer expects to receive his ordered goods immediately by the touch of a button… He expects his orderings be delivered fast, at a destination and timewindow he prefers. And he wants the possibility to change them quickly, perhaps several times. He wants a great variability in delivery destinations, not only his own dwelling-place, but also his employer's premises, or somewhere *en route* at a gas station, a mall, a bus station, etc. And if he finds a different interest on the net, the order must easily be undone, and so the delivery.

This puts new requirements on logistics. First of all, e-logistics should be fast. It should be dynamic and individualized; most of the time, it involves just single orders. It must cope with often alterations in place and time. The customer expects a "follow-me", or better still a "stay-ahead-of-me" service. But practice is different. Standard logistics systems are built around major backbones consisting of fixed process chains, of which only capacity can vary – within limits. This is perfectly well suited for mass "production" involving large streams of similar goods with a not too high variance in statistics, like bulk mail. It is *not* for e-logistics. These systems are not sufficiently equipped to treat masses of goods as individual entities for acceptable costs, nor to make fully use of all possibilities available at any moment around the world; for short, to follow the required dynamics of single items.

For e-logistics, a new way must be found to deal with all these requirements. In this paper, we show the new Service Controlled Agile Logistics (SCAL) model, proposing individualized treatment and full customer control within a virtual, decentralized and dynamic environment. It is aimed at: personalized control; dynamic planning of services; dynamic scheduling of logistics activities; flexible reaction upon unpredictable changes.

The paper first takes a closer look at e-logistics requirements. It then investigates the reasons why standard logistics systems are inadequate. To this end, it examines basic processes and the lack of flexibility that results from their particular usage. Next, the SCAL model is described, followed by a comparison between its characteristics and e-logistics requirements. Some experiments with a simulation model and preliminary results are highlighted. Finally, future perspectives and conclusions are given.

2. E-logistics requirements

Speed and individualized treatment are the most prominent e-logistics requirements. Not only should it be fast in terms of the time needed to deliver ordered goods. It also should react flexibly and rapidly to changes. Changes can occur in two ways. One important reason for changes are disruptions or other types of variations from the environment. Situations out of control of the logistics service providers can influence planned operations, like traffic density fluctuations; traffic jams; accidents; strikes. But also large and rapid variations in demand can lead to shortage of available capacities. That may be the result of the other source of changes that stems from the customers themselves. They change destination times or places, or cancel orders completely.

Equally important to reacting upon changes by altering the processing of goods, is reacting by way of communication. Tracking and tracing is not enough; it is only one half of the medal. When progress deviates from what was expected (and probably promised), customers demand influence in a way they can choose from possible alternatives. Worse than not having insight in what is going on, is knowing what goes wrong and not have any influence! E-logistics should be fully customer controlled.

Customers of e-commerce are only interested in the front-end. The interface they see should be concise and logical. They are not concerned about the ins and outs at the back door. For the customer, it does not matter what companies or organisations are involved, but only what functionality they add to the service (for what price). Who and where is unimportant as long as the logical structure according to the requested service is intact. In fact it is this structure that determines how e-logistics must be organized. At best, it should be a virtual organization. A new processing chain should be devised for every newly requested service, for the duration of the service in progress, and changed as needed. It should be completely dynamic in its behaviour to the customer as well as in the way it is itself organized. The proper realization is in a decentralized manner, a co-operation of more or less independent actors, distributed over a worldwide logistics network and accessible via Internet.

What is needed is agility in logistics. In the area of manufacturing, the need for agility has already been recognized for some time. According to Gunasekaran [1], agile manufacturing can be defined as the capability to survive in an environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services. Kidd [2] says, that the aim in agile manufacturing is to develop the agility to form virtual corporations rapidly so that changes in markets and windows of opportunity can be exploited.

Agile *logistics* lags behind. Greis e.a. [3] recognizes, that the role of logistics is gradually changing from a distinct support function to a core business function. But Taylor [4] merely states, that agile logistics is the efficient movement of material throughout an organization in response to market demand. Evers e.a. [5] has developed a concept of service-oriented agile logistics and presents a generic apparatus for constructing agile logistics systems. Service Controlled Agile Logistics [6] is a new model, placing logistics control completely in the hands of the customer and his requested service.

3. Process controlled logistics are inadequate

3.1 Basics

Why are standard logistics systems inadequate for the e-commerce paradigm? The answer can be found in an earlier study [7] about the (*in*)flexibility of processing bulk mail. The main train of thought has been as follows. Every process, whatever flexible or variable it might be, always has a kernel that does not change, being fundamental and characteristic. If it is possible to find that kernel, flexibility can be studied right from the basics. So it makes sense to distinguish between steady and fundamental parts (or aspects) and all the rest of a system. Flexibility, in principle, must be searched for within these other parts (or aspects).

For mail processing, generic basic functions – only 6! – have been found as a kernel, sufficient to describe the physical handling of any mail processing system. These functions are generic enough to be sufficient also for any distribution or express delivery logistics system, or even for production logistics. The basic functions are: *transporting* and *buffering*, *packing* and *unpacking*, *merging* and *splitting*. The abstraction of all goods into one basic concept, the *Transport Unit* (TU), has been an important factor. All goods within the system are treated as passive elements, and are covered by the TU.

3.2 Lack of flexibility

Accurate modelling and analysis of mail processing by means of the 6 basic functions has revealed the reasons current logistics systems are often so rigid. Each basic function has a number of fixed characteristics, closely related to the function itself. A number of parameters determine the way the function is carried out at any particular moment. These *degrees of freedom* establish the flexibility available in each function. In current logistics systems, all parameters important for flexibility have been set beforehand, at the time the system was designed; these systems are inherently inflexible. Goods *flows* are defined inside such logistics systems. Each flow corresponds to a single type of service delivered to clients (e.g. 24 hour or 48 hour delivery). A separate chain of processes is used for each service type. Any individual process can be used for more flows, but only if processed separately, be it by space or by time. Necessary capacities, technical alternatives, and organizational contexts, are important criteria for the design of those systems. And once designed and implemented, they hardly change any more. But what is worse, a changing “outside world” inevitably necessitates the system to be redesigned and re-implemented.

4. Service Controlled Agile Logistics model

4.1 Principles of a flexible logistics system

If it is possible to translate basic functions into basic processes, a kind of construction kit for logistics systems can be realised. If, additionally, all degrees of freedom are kept available as long as possible, the ingredients for a flexible logistics system are all there. Basic processes are the basis of a flexible logistics system. The infrastructure is defined in a network, which is not rigid and is changeable at any moment. This physical network consists of nodes, connected by transport processes. Within the nodes, processing of TU’s takes place, particularly packing, unpacking and splitting (choosing different routes). Important for flexibility is, that variables – parameters, degrees of freedom – are not set beforehand. Hence, a process does not know ahead what to do exactly, until a TU has arrived to be processed. Data necessary for processing, being the values for its parameters, either have to travel with the TU itself, or have to reach the process by a separate route. If the data is coupled to the TU itself, it is difficult to co-ordinate all the processes, such that they together yield a good overall service quality for this TU. Except in the case co-ordination is set beforehand, as with letter mail processing.

For a flexible logistics system, this is the wrong way! Major conclusions from [7] for the principles of a flexible logistics system have been: (a) information processing must be separated from goods handling processes; (b) decisions necessary to realize requested services in the most flexible way must be taken in the information domain; (c) from this domain, parameters for individual physical processes are controlled; (d) the greater the "granularity" of its processes, the more variable and flexible the system can be.

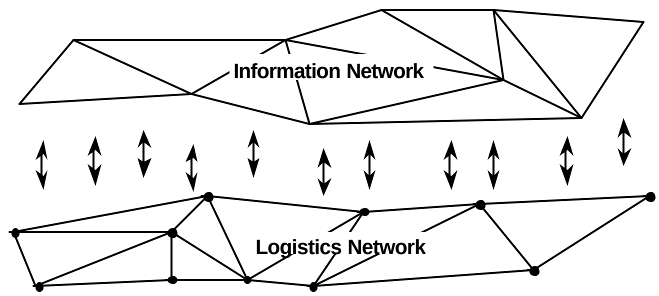

Figure 1 Network Logistics

This gives rise to a logistics system consisting of two networks: a physical network processing goods, and an information network taking control (Figure 1). Application of such a system is called *network logistics*. The mentioned flexibility study resulted in a simulation of a just-in-time delivery system according to this principle, but with a dedicated control layer. In SCAL, a generic control model has been defined, consisting of object classes, in a certain sense analoguous to the basic functions of the physical network.

4.2 "Basic functions" in the information domain

When high granularity, and hence independence of processes is a precondition for flexibility, who is going to guarantee the quality of service? When flexibility means processes dynamically adapt to changing environments, who is going to stay stable and control this? The answer is: the very service itself – and hence, the client! From this idea, the control of a flexible logistics system has been conceived by completely turning upside down the old control concept. The "classical" system emphasizes the different types of process chains responsible for the various types of services. Information about the progress of individual goods can be deduced from these chains; compare tracking and tracing. (But not without extra effort: the identity of individual goods is not known in classical process chains: everything in the flow is the same, and can – in principle – not be distinguished).

SCAL focusses on individual client and service; service as a product, not as a process. It is defined as a "one-time supply chain": *a time bound path through the physical network,* i.e. a list of (instances of) basic processes, at what time they must act, and how long it takes. The service-as-a-product is translated into a sequence of steps with times, dependent on the situation of the moment. The translation is done by an "agent", originated – in principle – by the client itself.

4.3 Object model

Basic to SCAL is an object model, shown in Figure 2. At the top level are *client* and *logistics operator* (owner of logistics resources). The *service* requested by the client concerns one (or more) *TU*(s) to be processed by *resources*, which can be basic processes or higher level aggregates. The service is effectuated according to a *service plan* holding all *operations* necessary for its completion. An operation is a logistic activity carried out by one resource on one TU. All operations each resource is dealing with are held in a *resource schedule*. Hence, every operation must be referenced twice, once in a plan and once in a schedule. A plan is made by a *service planner*, the "agent" as mentioned above. This agent makes the plan and controls the progress when effectuated by the resources. It negotiates with *resource schedulers* of all relevant resources about operations that must be carried out. Resource schedulers make the schedule, and maintain it. Part of the planner is a "world model" containing up-to-date knowledge about the logistics domain, specifically about what resources are present and where, and how these are accessible through Internet.

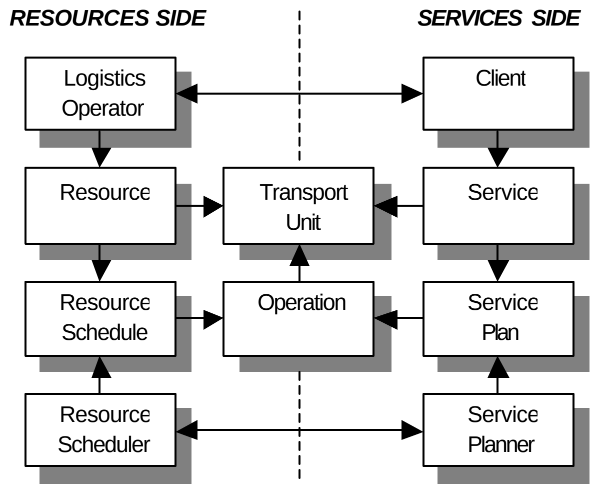

Figure 2 Object Model

While planning, service planners generate and evaluate relevant alternatives and choose the best they can find according to some criterion. If in reality things change, a new plan is made taking the actual situation as a starting point. This may happen, if interruptions out-of-control take place making the plan as-is incompatible, or when the planner discovers a better way for service fulfilment, for instance due to introduction of new, additional resources.

5. SCAL fulfils e-logistics requirements

According to GLORI (Global Logistics Research Initiative, a world-wide co-operation between universities and industry [8]), an agile logistics system should have the following characteristics. It should: (a) be distributed; (b) be scalable up or down in a linear fashion; (c) consist of highly autonomous players; and (d) operate as a virtual organisation.

SCAL does have all these characteristics. A logistics system is distributed by nature. The object based model emphasizes this again; control by objects is very well suited for distributed implementation. Mutual dependence between resources have been reduced to an absolute minimum. Therefore, they operate autonomously and that makes the system linearly scalable. Organization of process chains, as long as needed, has been reduced to activities of schedulers of independent resources and negotiations with "travelling agents" of services. Physical (geographic) positions are of course important for resources, but not for the control elements (resource schedulers and service planners). This creates a highly virtual organization. The only dependence left arises from services making use of the same resource simultaneously (e.g. parcels transported in a truck together).

How do these characteristics fulfil e-logistics requirements? From the very moment a customer has completed his order, a "client" object is called into being, a service planner created and a logistics service defined. So, literally by the touch of a button. The planner translates the service request into alternative paths through the logistics network, and starts negotiating with all relevant schedulers. The customer has chosen a criterion, e.g. some balancing between time and price, according to which the planner evaluates applicable routes and finds the best one for that moment. It then starts the realization of the service. Speed and individualized treatment is evident. From the start to the delivery of the ordered goods, this service planner escorts the service for this client. It follows the progress and intervenes if something deviates from planned. It also comes into action if for some reason a better service is possible, for instance when a newly added resource has been found. Or if the customer wants to change the delivery (time, place) or the order completely. The planner then replans the service anew, starting from the point of progress. This way, it behaves fully dynamic. The customer is concerned with only one service planner, opening up the way to a single, concise, possibly fully personalized interface.

The resources, carrying out logistics operations, are loosely coupled by the red threads of the requested services. And in these volatile relationships, no one is principal nor main contractor. Only the functionality of the resources is requested for. The geographic coupling is covered completely by transport processes, so the organization is virtual and decentralized. This all makes the SCAL system perfectly suited for e-logistics.

6. Some experiments and future perspectives

A mini simulation system has been built to examine the feasibility of the model. Express parcel services have been simulated with a network representing a European-wide road network. Besides evaluating alternative routes, flexibility was tested by having road trucks delayed such that services could not be fulfilled as planned; replanning was established for all parcels involved. Simulations have shown that the model forms a suitable basis for flexible logistics systems. Furthermore, available resources are better utilised than in a "classical" system, especially when the whole system is heavily loaded.

Simulations also offered some experience in how service planners have to make plans. Two ways were experimented with: one using an algorithm to find an optimal path directly through the graph representing the logistics network, the other one establishing first a number of alternatives and then evaluating each, and choosing the best. "Intelligent" behaviour of service planners will decisively determine the overall behaviour of the system. As soon as services have to make use of the same resources, they influence each other. This will happen often in logistics. It is therefore important to better understand the mutual impact of service planners and their services. This will be the main topic of future research.

Another future topic will be the development of a fully balanced supply and demand SCAL system. From Figure 2, it can be seen that the model is fully symmetric. This implies a behaviour of the resources as dynamic as the services. By nature, resources behave more static: fixed geographical position within the physical network, set capacities, time tables, etc. But they are not at all confined to that; resources could advertise their static information as well as their time dependent capacity availability on Internet. Service planners should "publish" their interests on Internet too. Consequently, a totally dynamic interaction system could develop, in which resources look for whoever could be interested in their offerings, and service planners look for all kinds of possibilities to realize services the best way they can find.

Industrial significance can be high. It is believed, that traditional logistics do not fit the e-commerce paradigm. When this means, that the finishing settlement of transactions is disappointing for the customer, he will hesitate and not come back. He will experience no big advantage compared with traditional shopping around the corner. In an emanating market with big growth potential, this could be the difference between success and failure. But there is more. Customer controlled e-logistics could be the enabler for future customer controlled (agile) manufacturing, with new possibilities reaching far beyond e-commerce as just a substitute for "old days" shopping. It could become a place where customers develop their wishes regarding e-commerce products, orders, transactions, etcetera, interactively with the system behind. The SCAL model has all ingredients for this to happen.

7. Conclusions

E-logistics, the logistics part of e-commerce, puts special requirements on logistics systems. Fast respons, dynamic behaviour, individualized treatment are mandatory. Current logistics systems can not cope sufficiently with these requirements. Since inflexibility is inherent in the very way these systems are controlled, it is believed that a radical paradigm shift in logistics control is needed to solve this problem.

Service Controlled Agile Logistics has all the characteristics to suit well the e-logistics requirements. It turns the "old" control concept upside down and places logistics control completely in the hands of the customer and his requested service. Service planners, acting like mobile agents, take over and escort the effectuation of any single service. They negotiate with resources and plan the to do actions. They change plans if necessary, due either to disruptions or to better possibilities coming up dynamically. Simulations have shown the feasibility of this approach; the SCAL model is suitable for flexible control of logistics systems. Preliminary results have revealed that resources are better used, especially when systems are heavily loaded.

Future research should give better insight into the optimal behaviour of the planning agents, especially where they influence each other when making use of the same resources. Next, the balance in dynamic behaviour between customers and their services and logistics operators and their resources should be studied. Finally, the impact of the right "look and feel" upon the satisfaction of the e-commerce customer should become more clear.

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