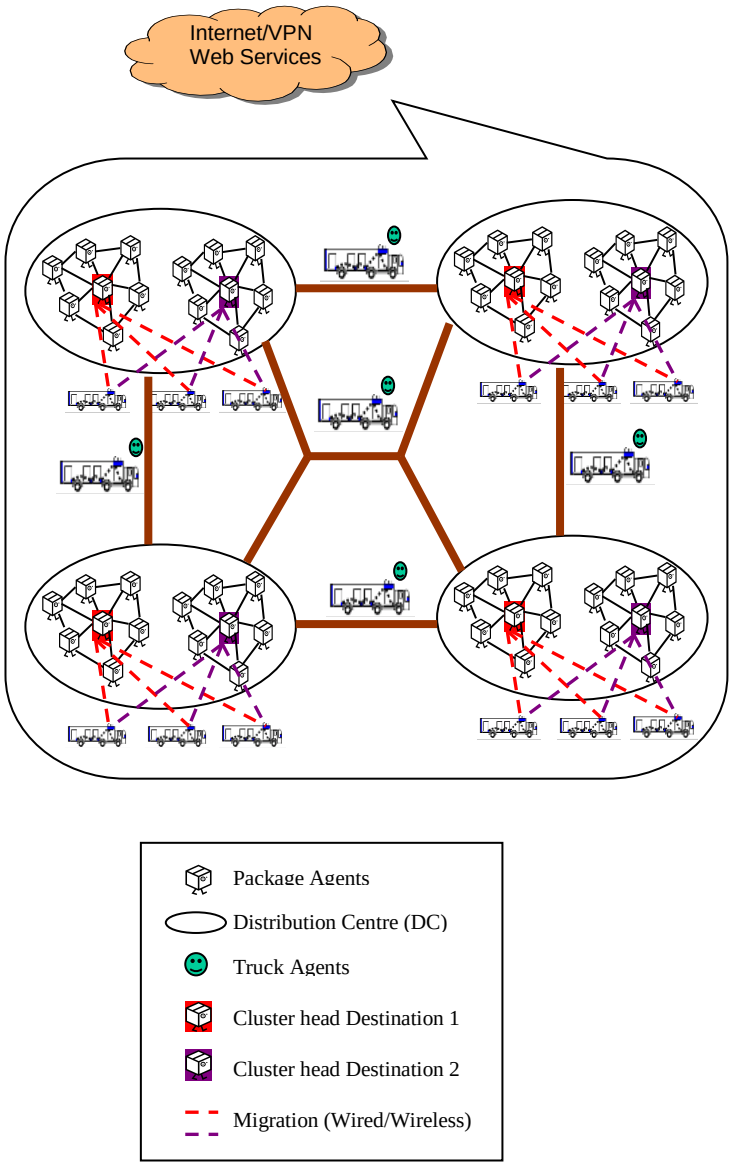
LogDynamics
International Graduate School

Agent-based Clustering Approach for Autonomous Cooperation in Transport Logistics

One of the main goals of a supply chain organization is to meet the customer requirements. This can be achieved by improved processes of planning, implementing, and controlling the flow and storage of raw materials efficiently and cost effectively. This additionally calls for in-process inventory of finished goods and distribution of related information from point of origin to point of consumption. In order to enable an efficient flow of goods, it is necessary to identify the entities and flows responsible for carrying out this key operation. These flows can be composed of material, information, etc. and they are subject to dynamic changes.

The dynamics within a logistics network can effect the planning, implementation, efficient control of goods and eventually the cost of the overall operations. This dynamism in a network is the result of the distribution of the entities and control flows across various geographical locations. This in turn necessitates cooperation which eventually needs an efficient communication or information sharing. To handle the dynamics, a paradigm shift of autonomous co-operation was introduced by the CRC 637 several years ago. This paradigm shift is facilitated by the availability of a wide range of information and communication technologies that can be utilized to move decision making down to the level of an entity, and indeed the individual item in the logistics chain as depicted in Fig.1. The distribution of planning and decision-making to autonomous components is a widely accepted promising solution to handle complex problems. Additionally the logistic problems are both distributive in nature, and require extensive intelligent decision-making. Thus in the last few years, multi-agent systems have been a preferred tool for solving logistics network problems wherein it provides the means of creating autonomous, intelligent and interactive software entities that are assumed to be capable of supporting autonomous decision-making by effective coordination and communication.



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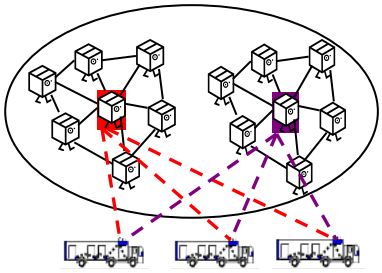
Methodology

In current logistics networks, routing and assignment of transport orders to vehicles are done by a dispatching system or a human dispatcher. Until now, more research on this is being done in CRC 637 using some heuristic approaches, e.g. evolutionary algorithms or Tabu search or by applying “rules” that are gained from experience. Here the approach is presented within the software agent framework. The agents decide autonomously, based on information that is exchanged between the agents exploiting the protocols of communication networks. The idea is to see how effective this method is in terms of communication as well as the delay associated with this paradigm of autonomous cooperation.

Software agent technology has much to offer in terms of the dynamics involved in logistics. Logistic entities like packages, vehicles, containers etc are represented as software agents. These agents use different interaction protocols for communication via exchanging messages and help in efficient information exchange (destination, route etc) between the packages, containers, vehicles etc. But implementing this approach might result in overwhelming requests and responses resulting in a substantial communication overhead. Thereby, the required communication between the individual logistic components needs to be optimized with better negotiating and decision making capabilities.



Communication optimization can be achieved by reducing the number of messages exchanged between the logistic entities. This may require exploiting the concept of clustering, which to a certain extent can reduce the communication overhead and as well give a better negotiating capability to the individual logistic components. For example the logistic entities may have common aims, e.g., several goods that are at the same location and have the same destination. In such a case, it can be sensible to form communities of those components and determine a community leader that acts on behalf of all members. Hence, this work identifies the challenges of clustering these autonomous logistic components and its effect on the communication optimization that arises from the distributed decision process and the interacting components.

However, the most important question is by which parameters the logistic entities can be clustered and what effect will it have on handling the dynamics of the logistics? In this context, clustering can be done based on route, location etc. For example by route and location, it means the route the vehicle is travelling to deliver the goods and the location where they need to be delivered. This can aid in an efficient utilization of the truck in addition to the cost saving on travelling with the best choice of available route. Dynamics implies a sudden change in the decisions of the route due to some mishap of the vehicle or change of order which can use the concept of merging and splitting of the clusters. Thus, the idea of integrating the approaches like clustering and software agent technology and their influence on handling dynamics in logistics is proposed.

Clustering has been studied in a variety of fields, notably statistics, pattern recognition and data mining. Clustering is also a research topic in communication networks like sensor networks, ad-hoc networks etc. The goal of this study involves mapping of models and clustering algorithms of communication networks like ad-hoc networks, sensor networks as well as other clustering strategies applied in software clustering in computer networks, data mining etc. to logistics. A logistics system based on the above principles allows the transfer of more decision competence from the logistics service provider to autonomous representatives of the logistics network. These representatives in far reaching scenarios may be a single package agent or vehicle agent who will then take the autonomous decisions

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