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International Graduate School

Clustering in Autonomous Cooperating Logistic Processes

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Overview

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- Motivation
- Routing
  - Distributed Logistics Routing Protocol
- Clustering
- Analytical Results
- Conclusions & Outlook

Motivation

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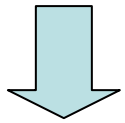
Autonomous Cooperation

- Approach to cope with rising complexity and dynamics in logistic networks
- To deal with complexity: paradigm shift from „non-intelligent“ items to decentralized „intelligent“ items
- Every item might possess the capability of interacting with other items
- Emphasizes the need of rational, reactive and autonomous entities
- Demands a strong need of various technologies RFID, GPS systems, software agents along with communication networks
- Software agent paradigm has much to offer in terms of dynamics involved in logistics
- Agent-based systems reflect the distributed systems to deal with dynamics of planning and execution in real-time settings
- Integration of agent-technology and knowledge-management approaches in logistic processes



Agent Technology + Clustering Techniques

Parallel Routing

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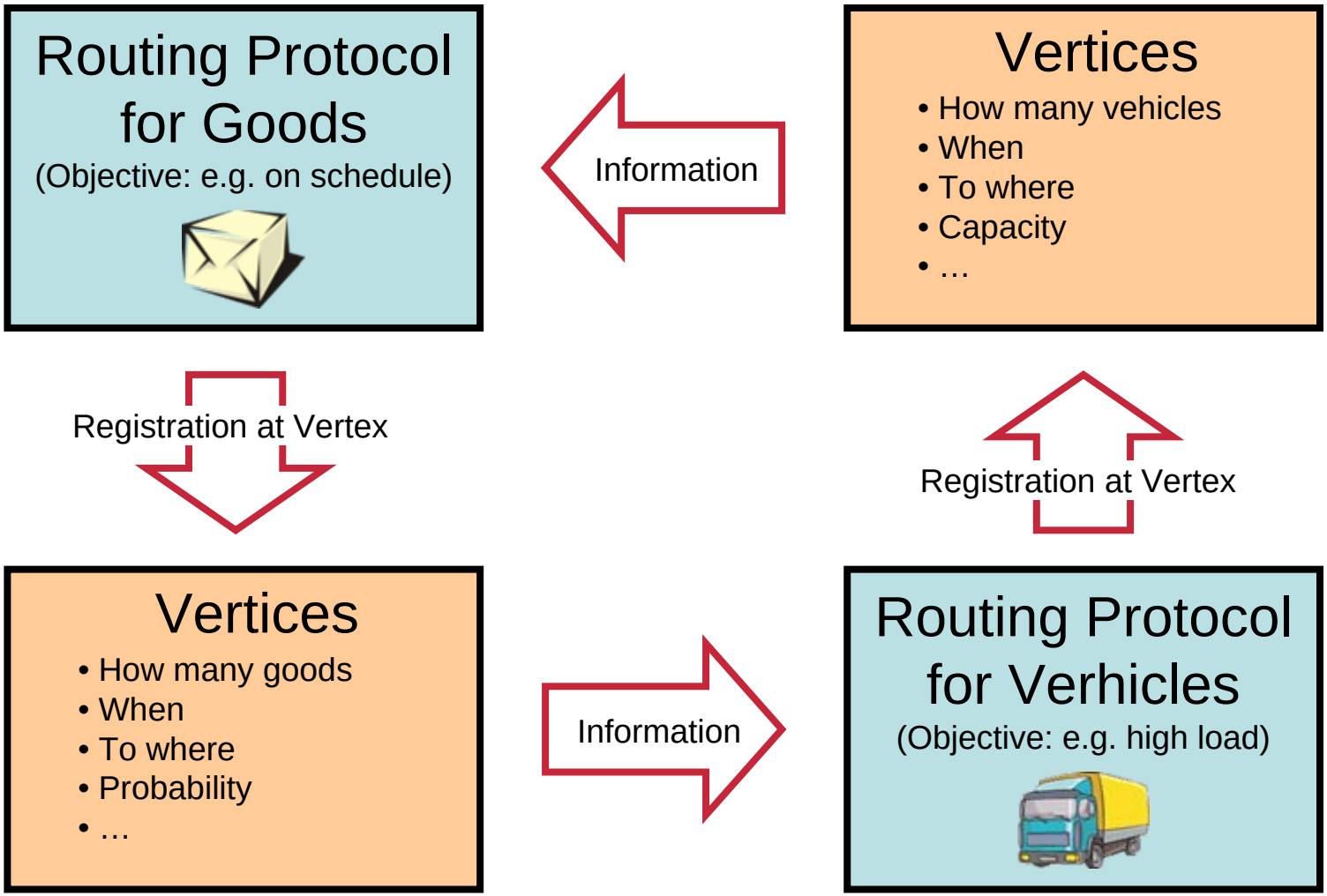

[Scho06i], [Scho06j], [Wen07a]

DLRP - Distributed Logistics Routing Protocol

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Goods

Sending a **RouteRequest**

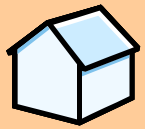
Receiving several **RouteReply**

Route decision

If needed deregistering of previous routes

Sending several **RouteAnnouncements**

Vertices



Forwarding of Information about vehicles‘ and goods‘ routes

Aggregation and updating of information of vehicles‘ and goods‘ routes

Vehicles

Sending a **RouteRequest**

Receiving several **RouteReply**

Route decision

If needed deregistering of previous routes

Sending several **RouteAnnouncement**

[Scho06i], [Scho06j], [Wen07a]

Clustering

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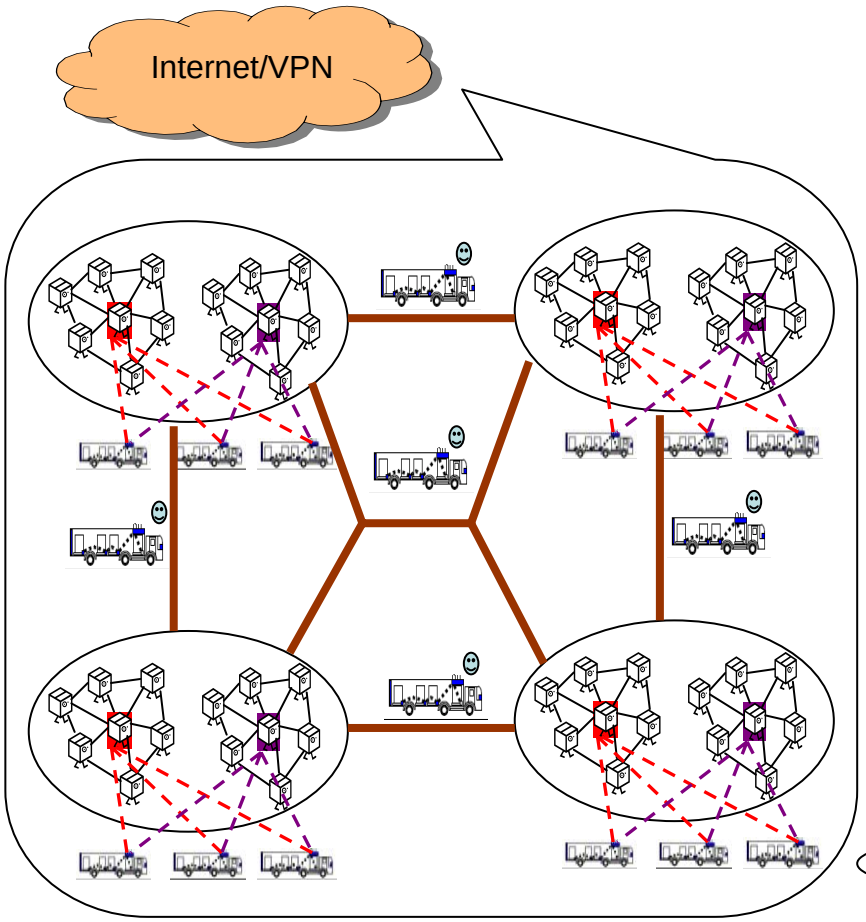
- Definition
  - A Cluster is a collection of objects which are „similar“ between them but are dissimilar to the object belonging to different groups
  - Clustering can be of objects which share the same concept or same data
- The concept of clustering has been proved to be very effective in managing the resources and maintaining a good scalability, e.g. Ad-hoc networks, Sensor networks
- A good clustering imposes a regular, high-level structure on the network
- Why clustering in Logistics:
  - Every entity in logistic network can be represented as software agents which can be static or mobile (dynamic)
  - To group agents with similar objectives or data (e.g. grouping package agents with same destination)
  - A method of clustering agents within a fully decentralized logistic system (Multi-agent system) can be used for better scalability

Clustering



- **Technology/Strategy used behind this approach is based on mobile agents**
  - Agent communication
  - Agent migration
  - Sensor networks

Distribution Centre (DC)

Package Agents

Truck Agent

Cluster head Destination1

Cluster head Destination2

Migration (Wired/Wireless)

Package Autonomy

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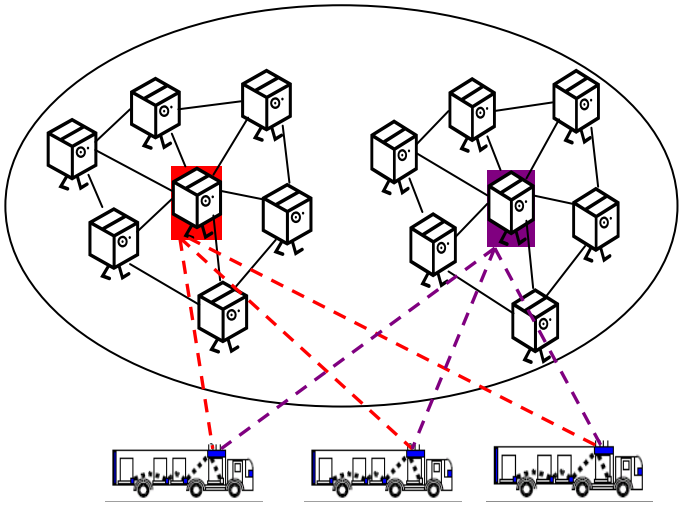
- Package

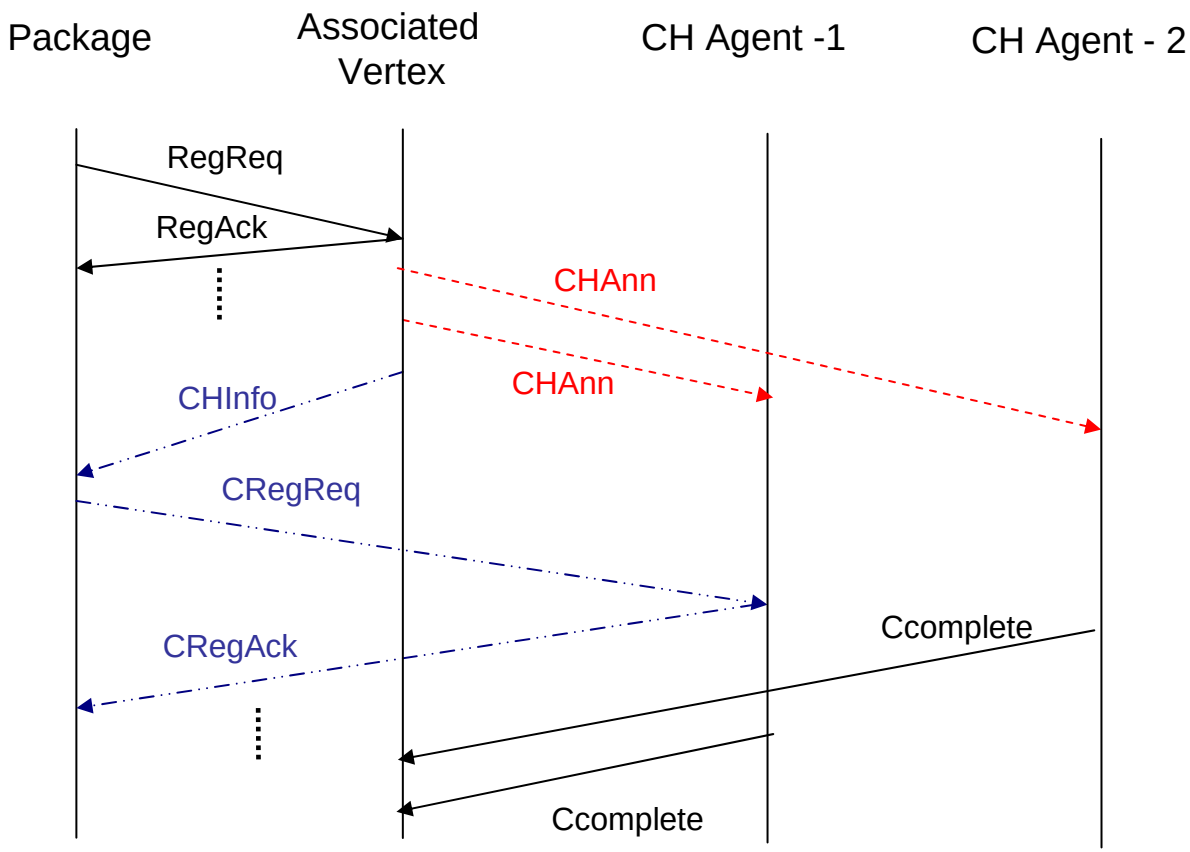
  (Origin, Destination, Location, Type, Priority, Due date, Price, etc.)
- Cluster of Packages

  (Location = e.g. Bremen, Destination = e.g. Hamburg, etc...)

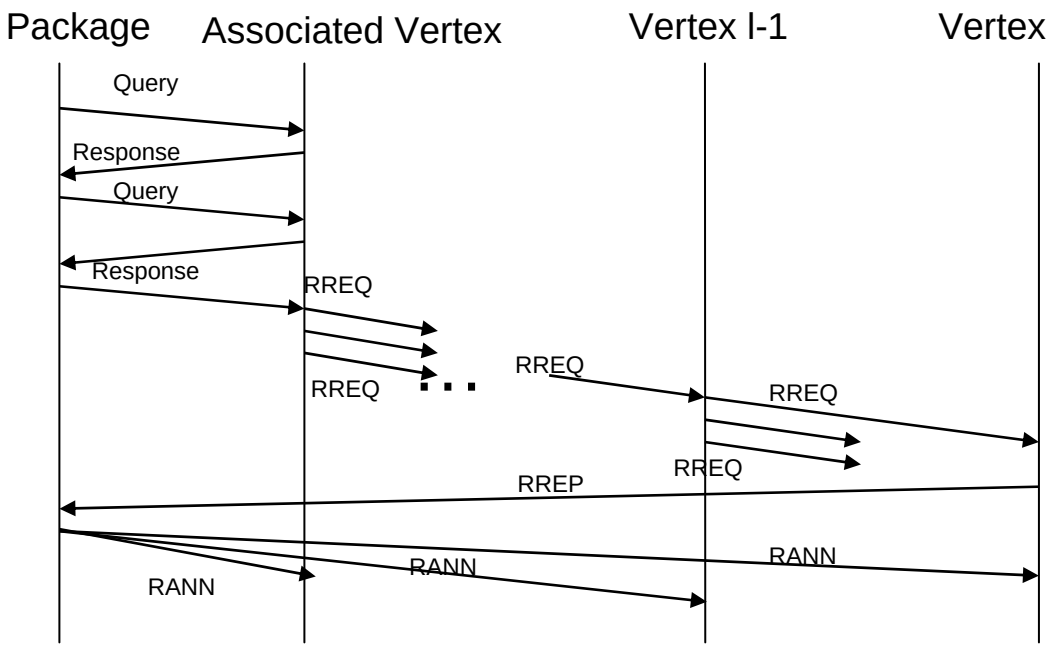


- Clustering of Packages
  - Cluster-head agent selection from package clusters
- Truck negotiation
  - Cluster-head agent get info from all the trucks
- Package negotiation for trucks
  - Availability/capacity
  - Destination (more specific)
  - Lifetime
  - Handling different types of items (food items/breakable items)
- Transportation Problem
  - Usage of web services for greater dynamism
  - Change of route (accident/spontaneous mishaps)
  - Change of order
  - Negotiation between trucks over the route

Messages for Clustering



Messages for Routing



Notation

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- Number of packages stored in a DC = N_packs
- Number of destinations = N_dests
- Number of Clusters = N_Clusters
- Cluster size = Cl_size
- Total number of Register Request (RegReq) = N_packs
- Total number of Register Acknowledge (RegAck) = N_packs

- *Cluster-head Announcement / Information:*
  - Total number of Cluster-head Information (CH_Info) or Cluster-head Announcements (CH_Ann) = N_packs
  - Total number of Cluster-head Announcements (CH_Ann) = N_dests
  - Total number of Cluster-head Information (CH_Info) = N_packs – N_dests
- *Clustering Process:*
  - Total number of Cluster Register Request (CRegReq) = N_packs – N_dests
  - Total number of Cluster Register Acknowledge (CRegAck) = N_packs – N_dests
  - *Total Clustering Volume = (5 * N_packs - 2 * N_clusters)*
    - where *N_clusters = N_dests * roundup (N_packs / (N_dests * Cl_size))*

Analysis of Communication

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- Assuming an average branching factor b and an average route length of l hops, the amount of route replies is b^{l-1}, while the total number of route requests sent in the network is $\sum_{i=0}^{l-1} b^i$.

Parameters

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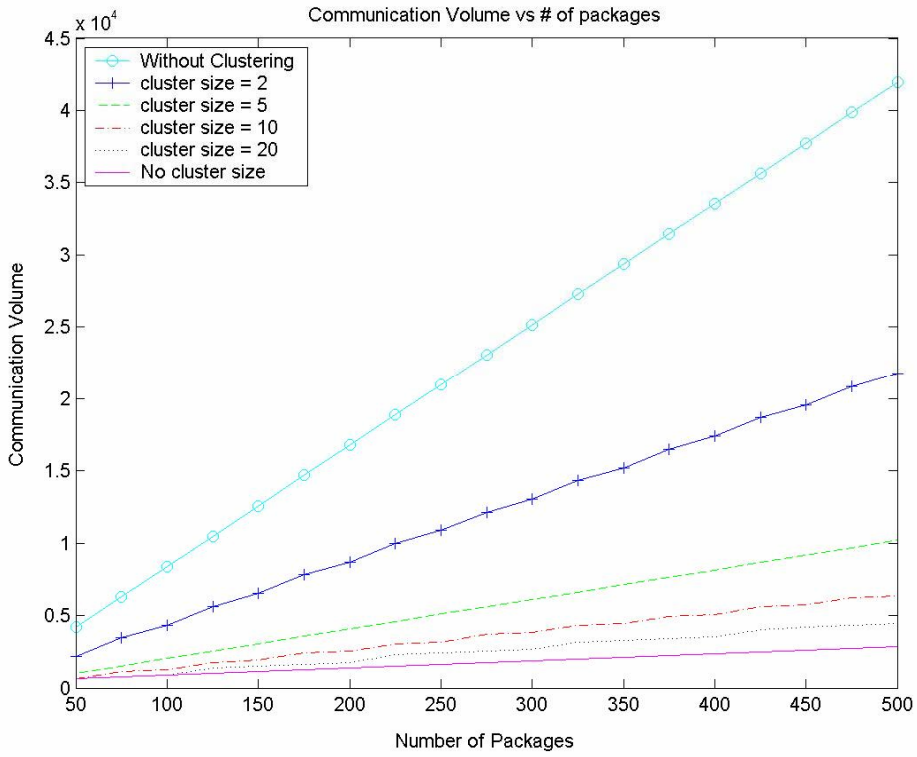
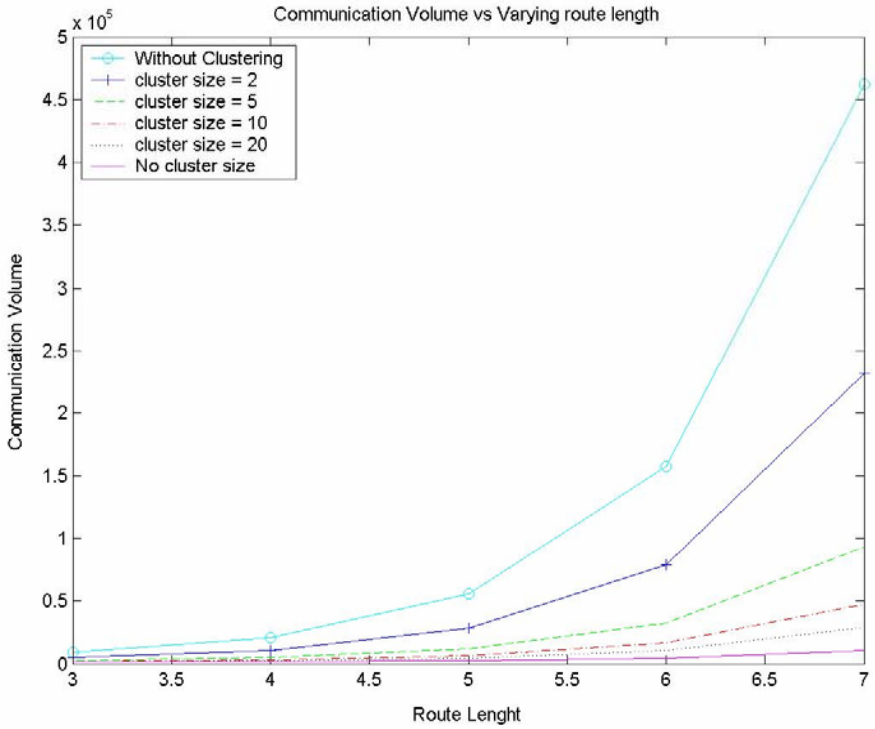
Parameters	*Representation*	*Value*
Number of Packages	N_packs	Min 50 Max 500
Number of Destinations	N_dests	5
Route Length		Min 3 Max 7
Branching Factor		Min 1 Max 8
Number of alternate routes		3
Cluster size	Cl_size	Min 2 Max 20

Analytical Results I



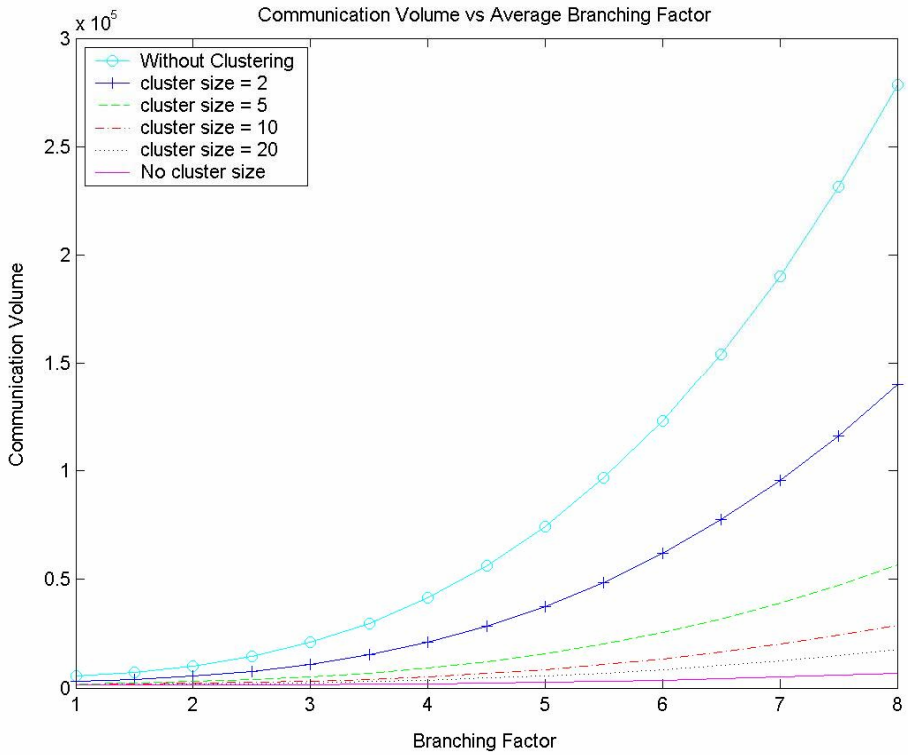
- Linear increase of the communication volume with regard to the number of packages

Analytical Results II



- Quadratic increase of the communication volume with regard to the route length

Analytical Results III



- Quadratic increase of the communication volume with regard to the branching factor

Conclusions & Outlook

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- Clustering of the entities reduces the communication volume
- Larger cluster sizes lead to less communication between the logistical entities
- Communication needed for cluster formation is only local

- Outlook
  - Implementation of the clusterized DLRP in the multi-agent based simulation system ‘Plasma’
  - Investigation by means of simulation