LOGICAL

transnational logistics improvement through cloud computing and innovative cooperative business models

Information Requirements Analysis of SME and Optimization of Supply Chain of Multimodal Logistics

Jerzy Korczak, Marcin Pawęska, Piotr Lipiński

PP4, PP6

Uniwersytet Ekonomiczny we Wrocławiu

CONSULTING i LOGISTYKA Spółka z o.o.

CENTRAL EUROPE COOPERATING FOR SUCCESS.

EUROPEAN UNION EUROPEAN REGIONAL DEVELOPMENT FUND

Outline

Part 1. Information Requirements Analysis

- **Methodology of information requirements analysis**
- **Workshops: Improvement of business processes in the context of usage of the anticipated cloud computing**
- **Ways of logistic processes optimization**
- **Criteria for process selection to the cloud**

Part 2. Optimization of Supply Chain

- **Model of a multimodal logistic provider**
- **Problem statement and benchmarks**
- **Algorithms: MILP, CLP, EA**
- **Preliminary results**

Information Requirements Analysis – Outcome of WP3

1. Introduction
2. Methodology of information requirements analysis
3. Summary of information requirements analysis of
    - Company AAA (shipping)
    - Company BBB (transport and forwarding)
    - Company CCC (manufacturing)
6. Improvement of business processes in the context of usage of the anticipated cloud computing facilities
7. Ways of logistic processes optimization
8. Data protection and security analysis

Methodology of information requirements analysis

I. Profiling the enterprise
- Business profile
- Organizational and decision-making structure
- Information and Communication Technology structure
- Semantic standardization

II. Identification of processes
- Identification of core and support processes
- Identification of dependences in the process structure of the company
- Selection of processes for the application of cloud computing

III. Analysis of logistics processes
- Realization procedure of selected processes (BPMN)
- Synthesis of information requirements of the process
- Setting parameters of the simulation model

Improvement of business processes in the context of usage of the anticipated cloud computing

Expected benefits from the survey

- improve / simplify communication with business partners,
- improve / simplify communication with customers,
- achieve higher quality in logistical services (greater reliability, better supplier loyalty),
- achieve greater transparency in handling data / better information flows,
- achieve better integration of software within company operations.

Ways of logistic processes optimization

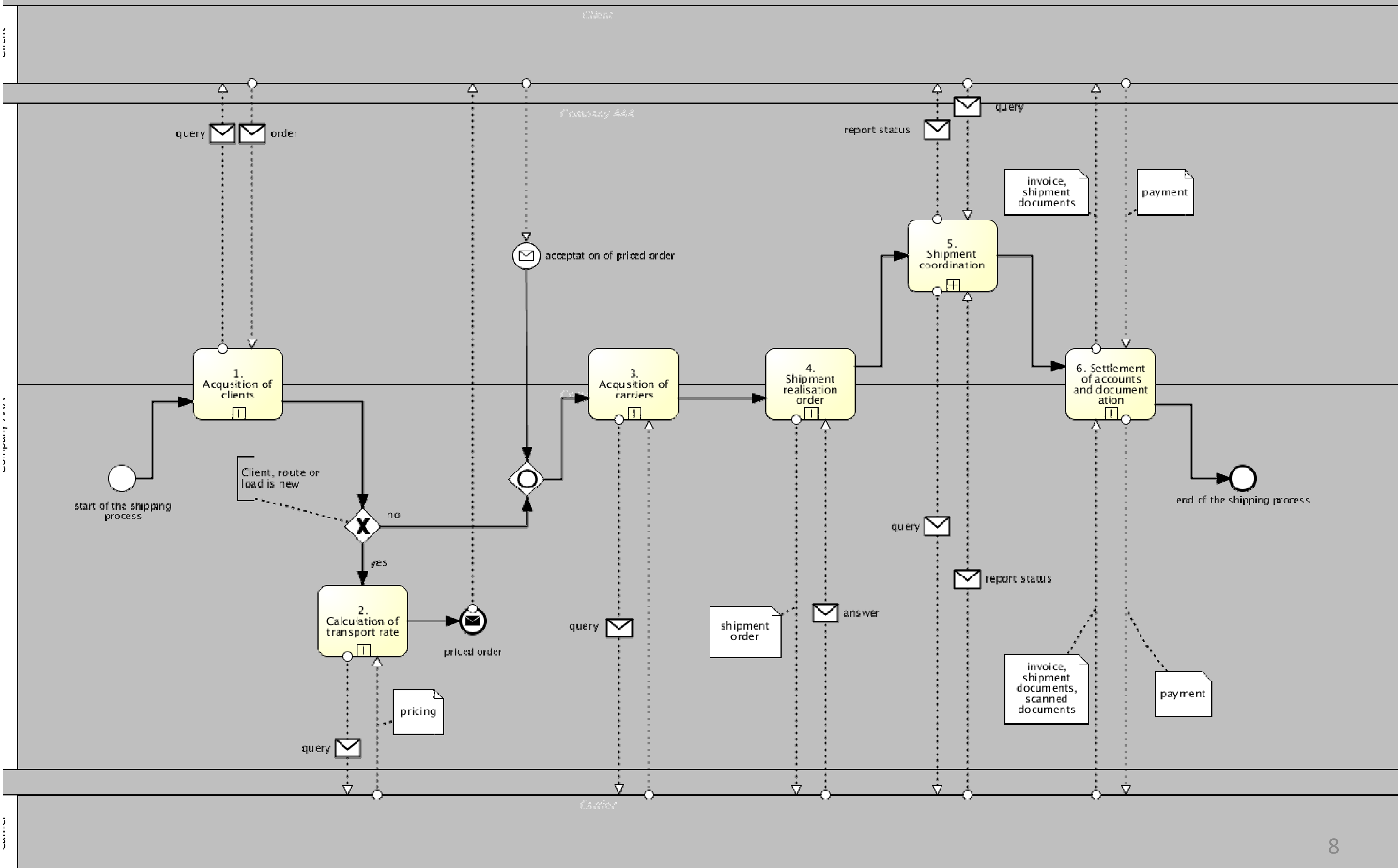
- Idea: provide complex services to customers and simplify management and administration of joint contracts
- cooperation between the companies reduces transportation costs
- matching of demand and supply capacity
- reduction of personnel costs related to the organization of the transport
- common goal functions: cost, reliability, energy consumption, generated traffic, carbon emissions,

What to move to the cloud?

- Best to start with the processes that are frequently performed and which are strongly connected with the business environment

  Examples are processes related to customer acquisition and carrier transport co-ordination processes. Some of these processes can be fully put in the cloud, and some only in part.

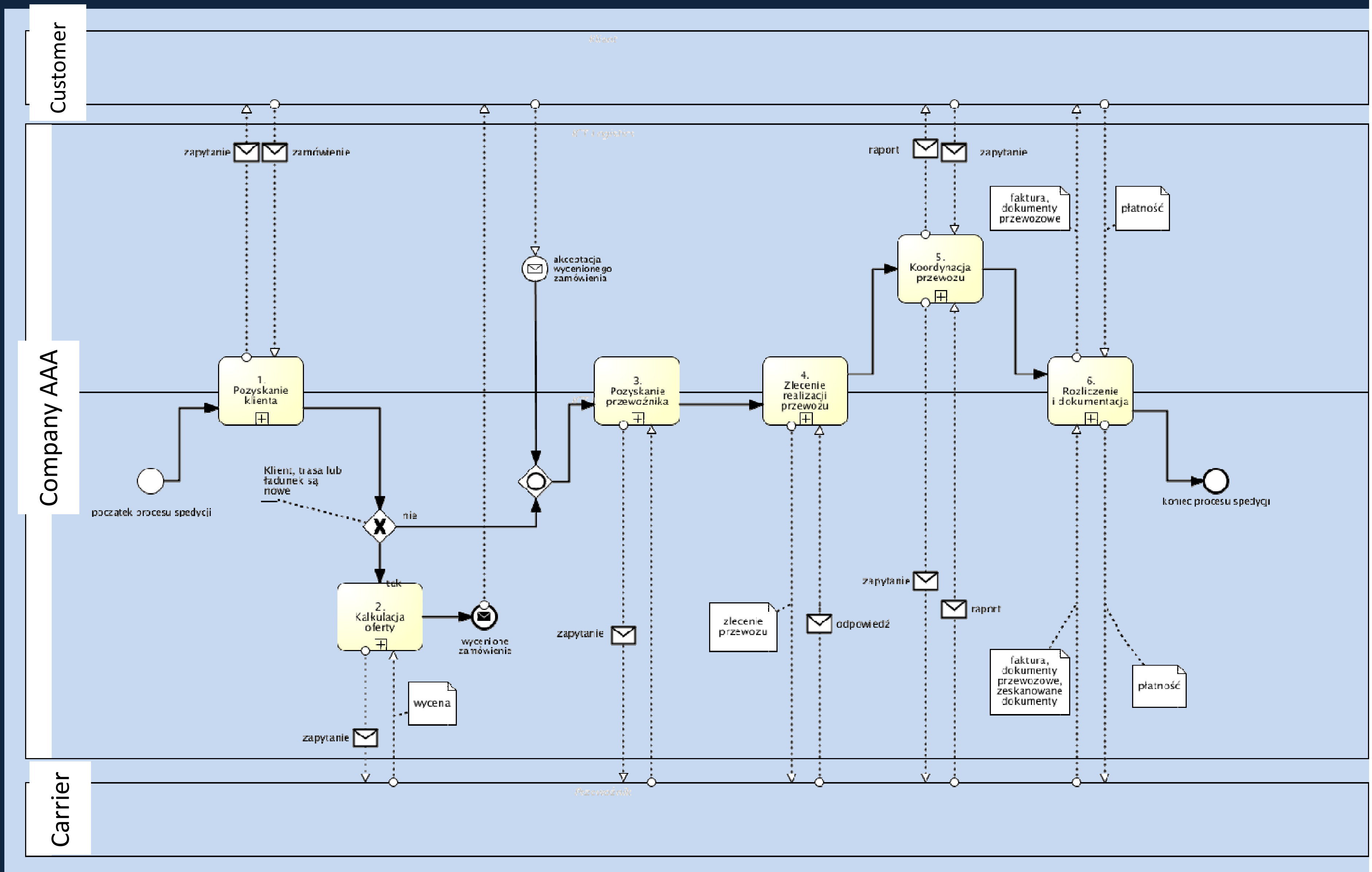
Processes realized with the help of cloud computing – Company AAA example



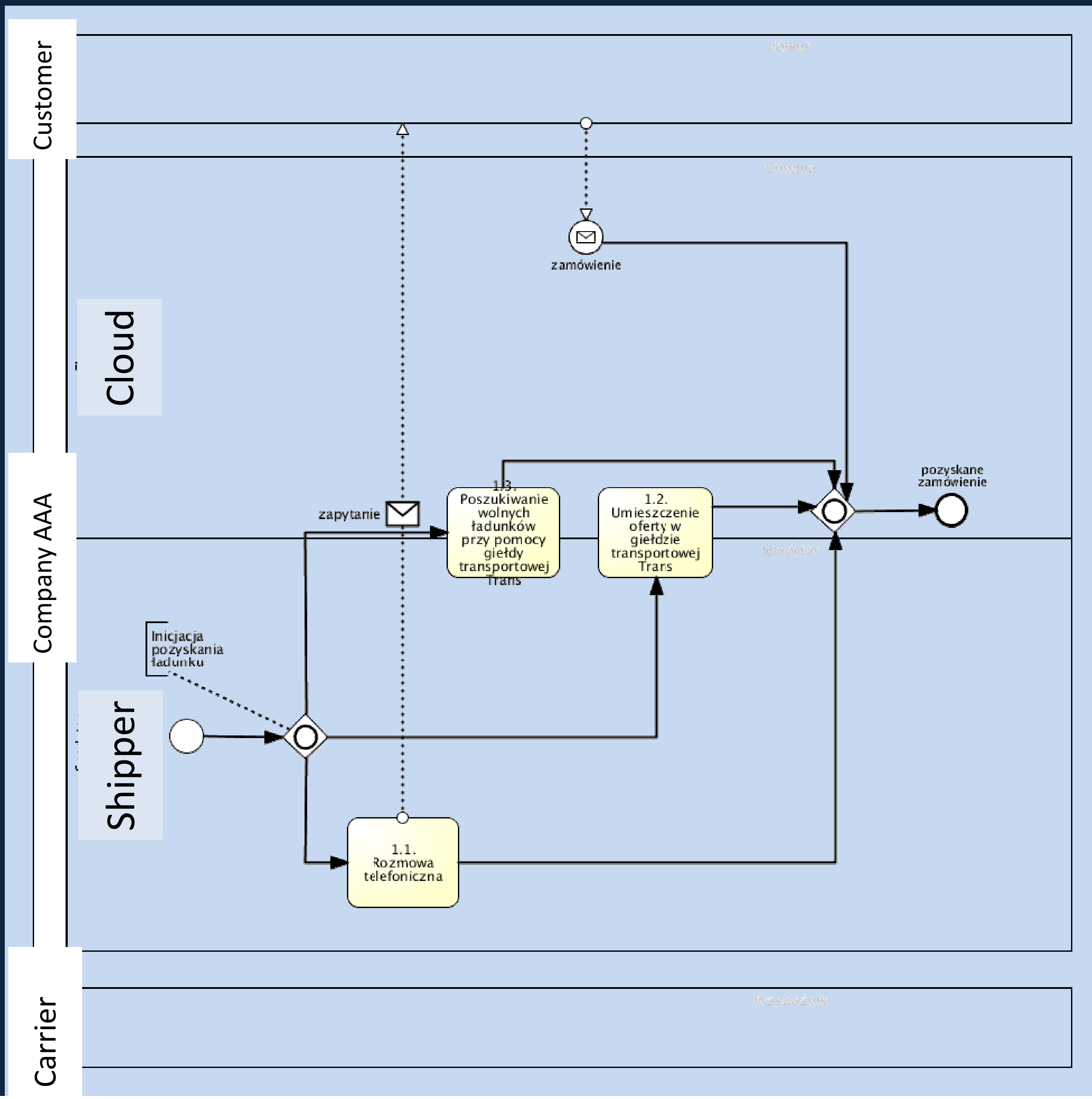
Criteria for processes selection to the cloud

- Integration (coupling) with other applications
- Integracion with existing data structures
- User interaction
- Possibility of process monitoring
- Possibility of verifiction/validation
- Security and data protection
- Cost and efficiency

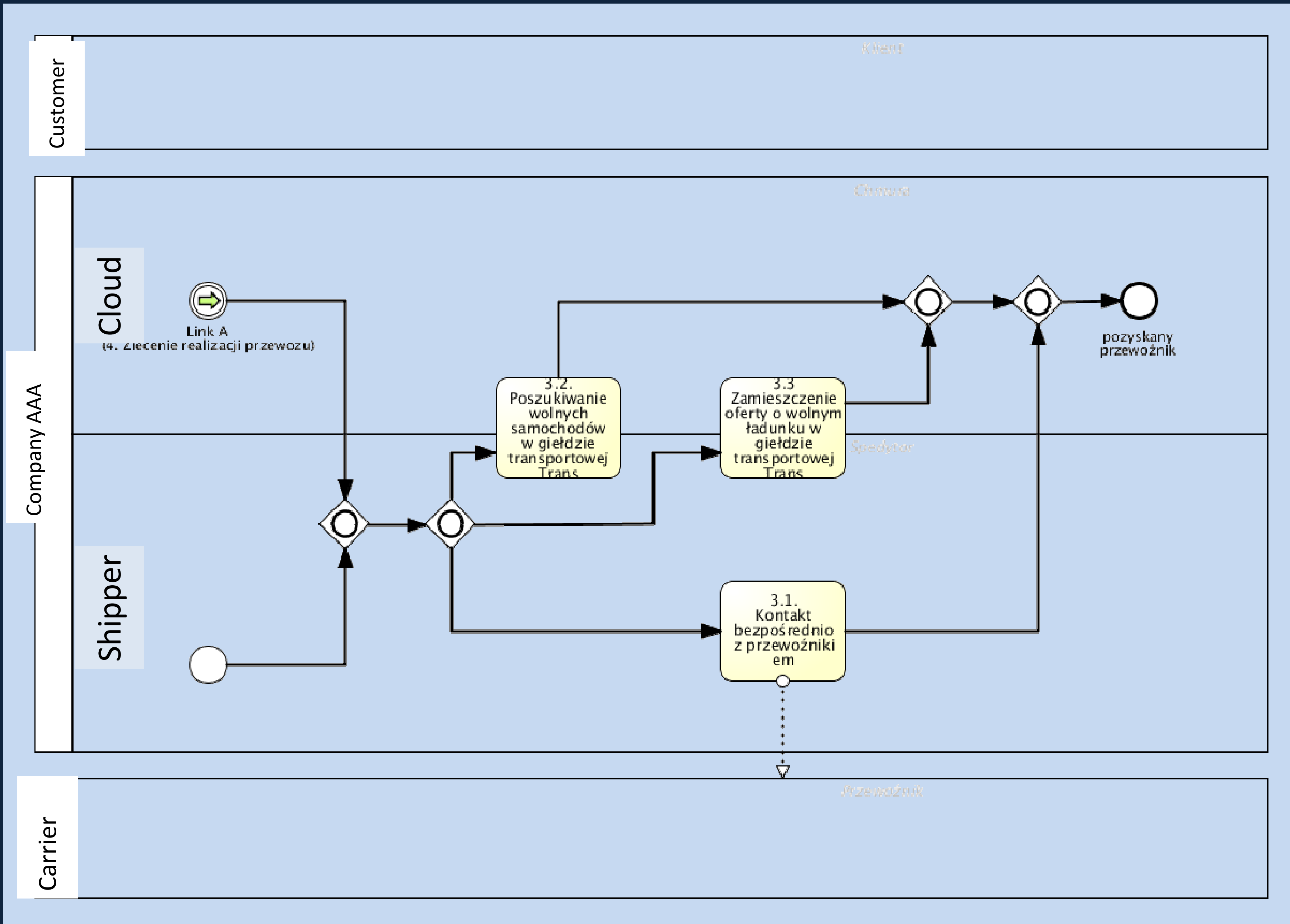
Main map of processes



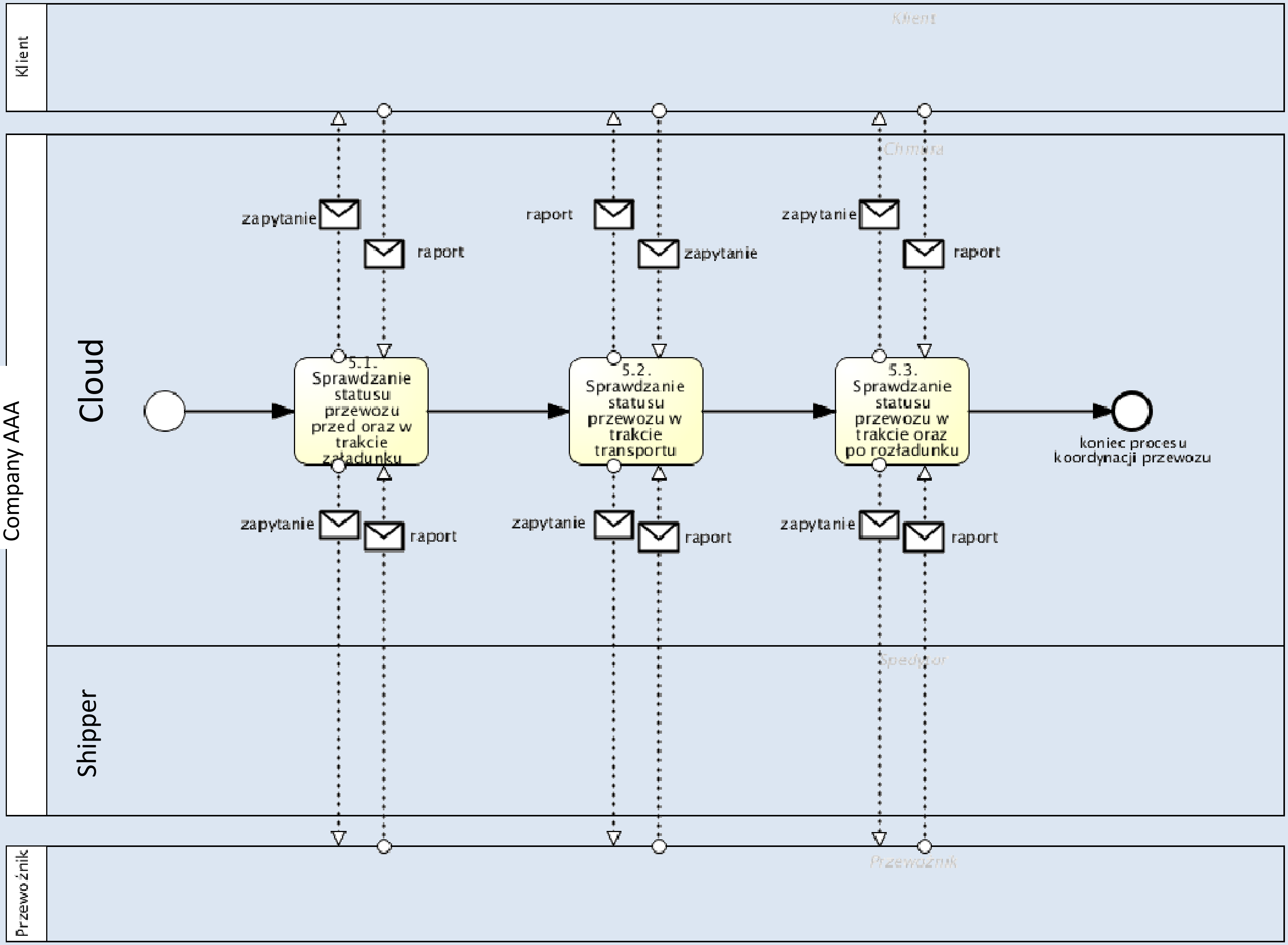
Order acquisition



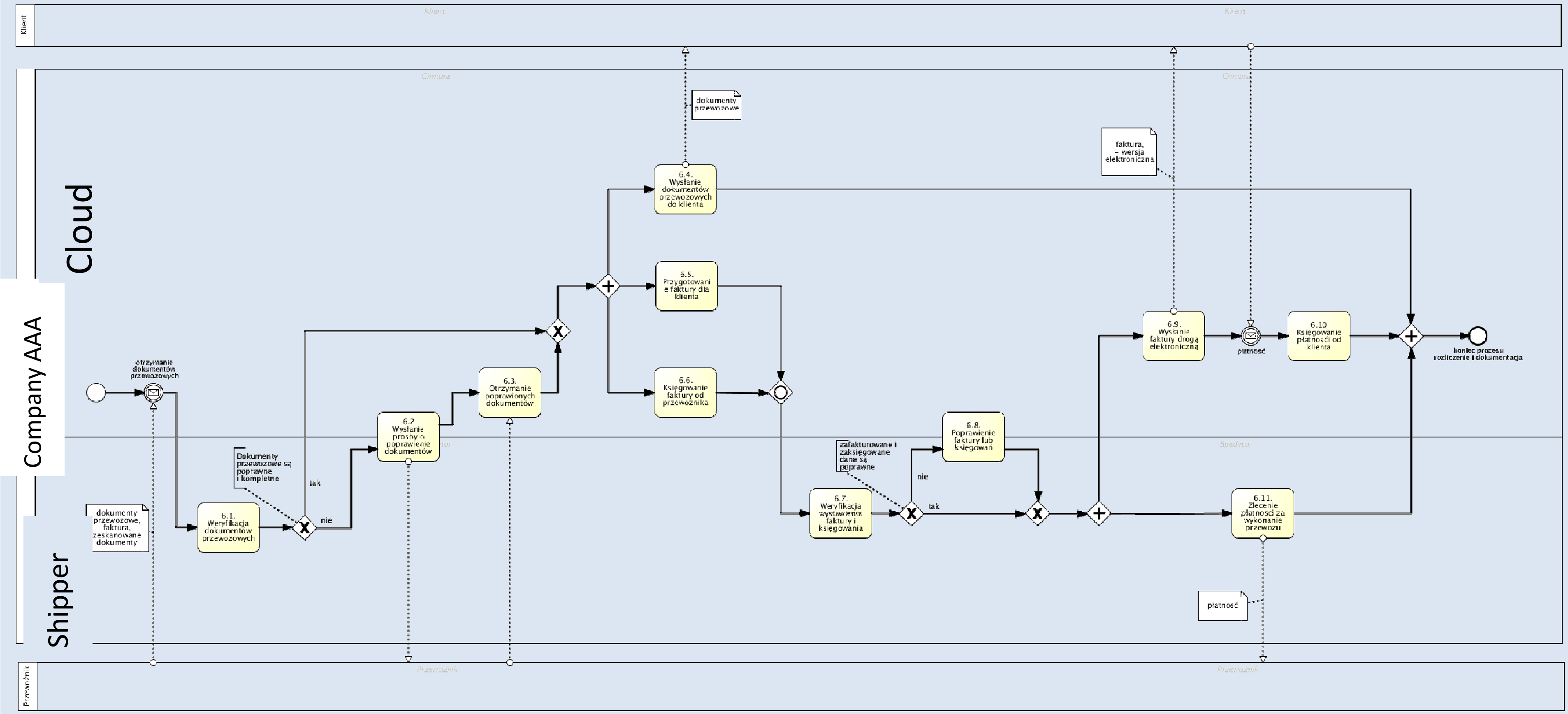
Carrier acquisition

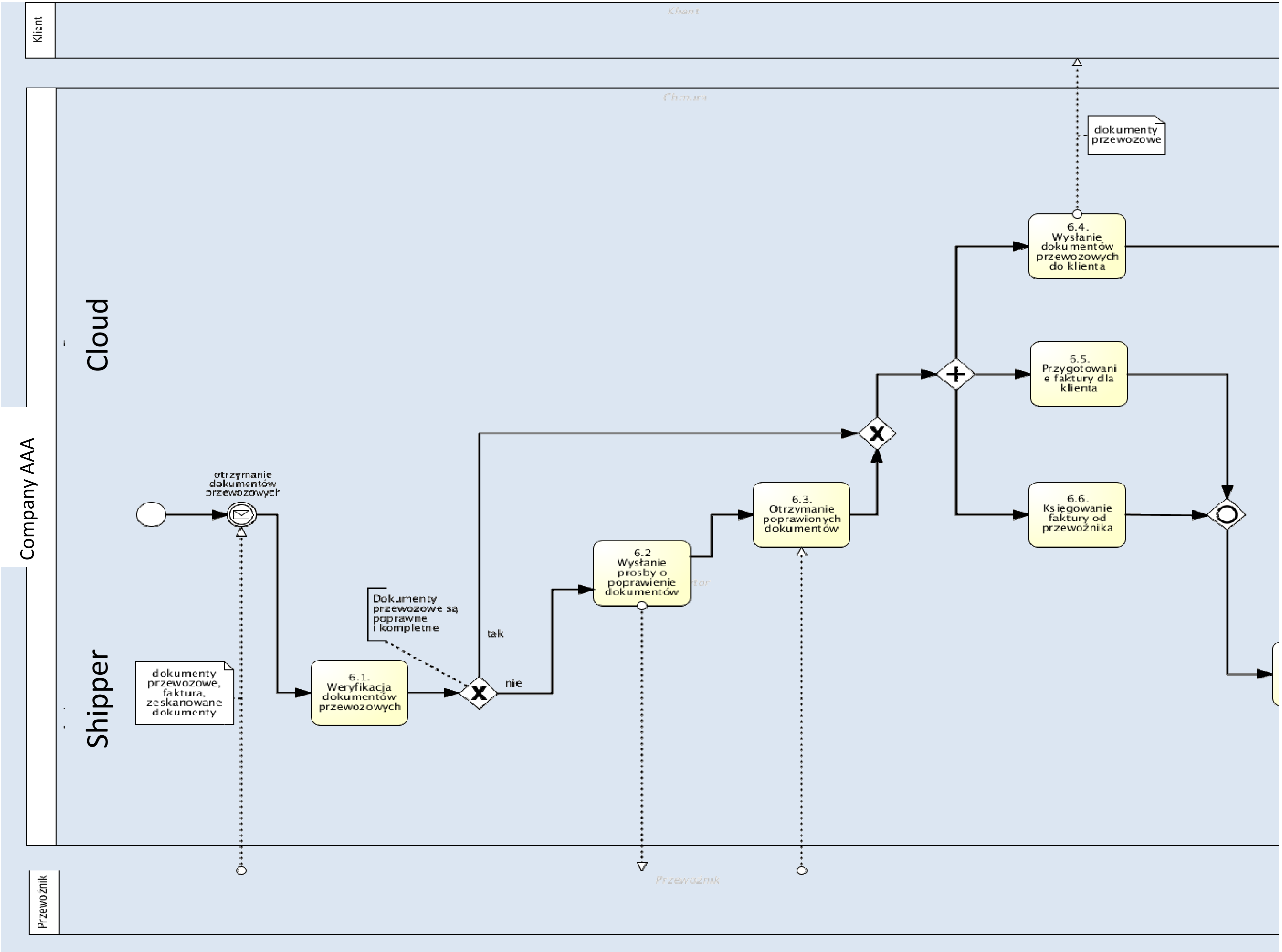


Coordination of transport



Settlement


Klient
Company AAA
Cloud
Shipper
Przewoźnik
dokumenty przewozowe
otrzymanie dokumentów przewozowych
dokumenty przewozowe, faktura, zeskanowane dokumenty
6.1. Weryfikacja dokumentów przewozowych
Dokumenty przewozowe są poprawne i kompletne
tak
nie
6.2 Wysłanie prosby o poprawienie dokumentów
6.3. Otrzymanie poprawionych dokumentów
6.4. Wysłanie dokumentów przewozowych do klienta
6.5. Przygotowanie faktury dla klienta
6.6. Księgowanie faktury od przewoźnika
6.7. Weryfikacja wystawienia faktury i księgowania
zafakturowane i zaksięgowane dane są poprawne
nie
tak
6.8. Poprawienie faktury lub księgowań
faktura, – wersja elektroniczna
6.9. Wysłanie faktury drogą elektroniczną
płatność
6.10 Księgowanie płatności od klienta
6.11. Zlecenie płatnosci za wykonanie przewozu
płatność
koniec procesu rozliczenie i dokumentacja



Klient
Company AAA
Cloud
Shipper
Przewoźnik
otrzymanie dokumentów przewozowych
dokumenty przewozowe, faktura, zeskanowane dokumenty
6.1. Weryfikacja dokumentów przewozowych
Dokumenty przewozowe są poprawne i kompletne
tak
nie
6.2 Wysłanie prosby o poprawienie dokumentów
6.3. Otrzymanie poprawionych dokumentów
6.4. Wysłanie dokumentów przewozowych do klienta
dokumenty przewozowe
6.5. Przygotowanie faktury dla klienta
6.6. Księgowanie faktury od przewoźnika

Benefits of processes transfered to the cloud

- Reducing requirements for their infrastructure
- Reduction or complete elimination of the reporting process;
- Shortening of processes by facilitating access to information
- Improving the process of settlement - to maintain liquidity
- Archiving of data
- Enable easy evaluation of the processes - information from all stakeholders in one place
- Ability to create virtual connections, facilitating the establishment of cooperation
- Reducing the duration of "break-in" cooperating companies
- Able to access the system via mobile devices - access for the driver!

How to estimate the cost of logistic services ?

Methods:

- **Cost-plus pricing.** This standard method of pricing in logistics seeks to first determine the cost of providing a service, and then add an additional amount to represent the desired profit. To determine cost, you need to figure out direct costs, indirect costs, and fixed costs.
- **Competitors' pricing.** come from competitor websites, phone calls, talking to friends and associates who have used a competitor's services, published data, etc
- **Perceived value to the customer.** This is where a lot of the subjectivity comes in when setting a price for a service.

Part 2. Introduction to SC optimization

- The **supply chain** is commonly seen as a collection of various types of companies (raw materials, production, trade, logistics, services, etc.) working together to improve the flow of products, information and finance.
- Huang et al. [3] studied the shared information of supply chain production. They considered and proposed **four classification criteria**:
  - supply chain structure (convergent, divergent, conjoined)
  - decision level (strategic, tactical and operational),
  - modeling approach (LP, MILP, CLP etc.)
  - shared information (resources, inventory, production, transport, demand, etc.)

Introduction (2)

- The aim of **supply chain management** (SCM) is to increase sales, reduce costs and take full advantage of business assets by improving interaction and communication between all the actors forming the supply chain.

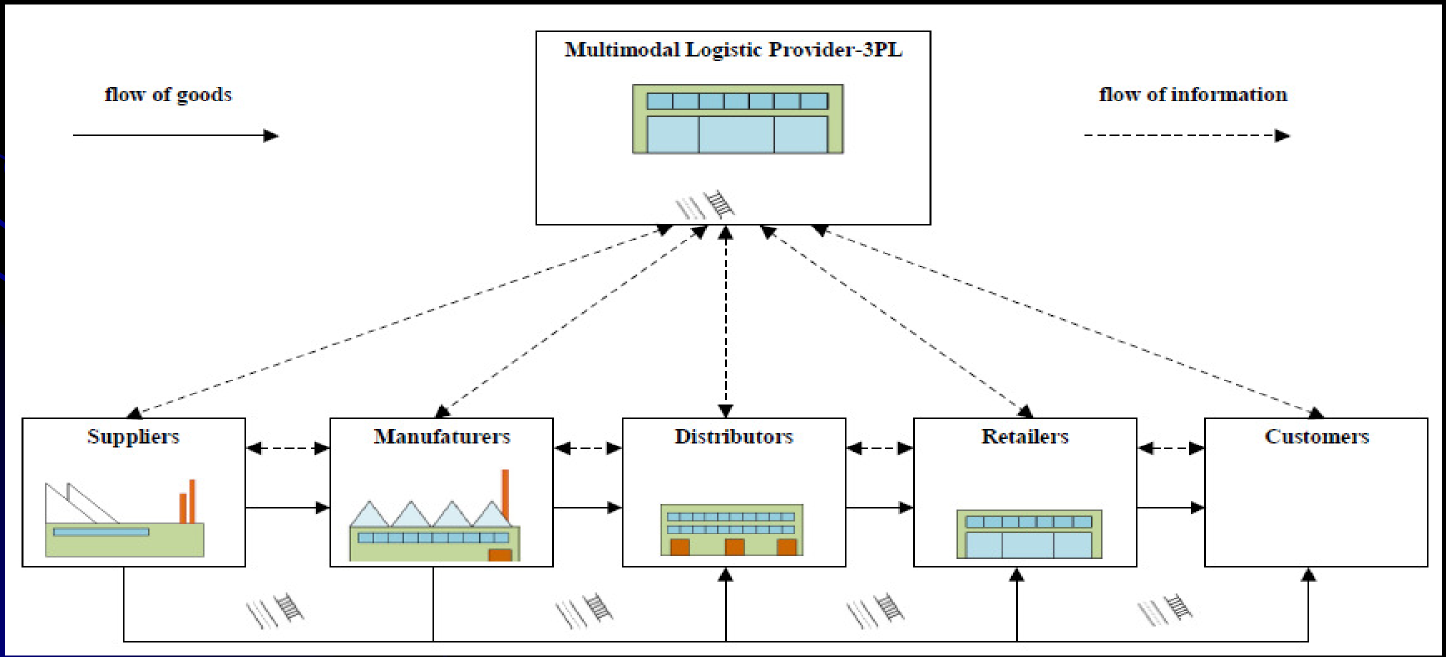
- The supply chain management is a **decision process** that not only integrates all of its participants but also helps to coordinate the basic flows: products/services, information and funds.

- Changes in the global economy and the increasing globalization lead to the widespread use of IT tools, which enables continuous, real-time communication between the supply chain links.

- This direction contributed to the development of logistics outsourced operators known as 3PL, 4PL, or 5PL.

Model of multimodal logistic provider

- a model of a multimodal logistic provider:
  - suppliers, manufacturers, distributors, retailers and customers
- one of the objectives is to optimize logistics and entrust it to specialized companies.
- this direction contributed to the development of logistics outsourced operators known as 3PL, 4PL, or 5PL.



Problem Statement

- A key step in many decision-making and design processes is the optimization phase, which itself contains several stages.
- The purpose of the optimization process in our approach is to help determine realistic and practical outcomes of management decision-making and design processes in the supply chain.
- In this model, shared information process includes such parameters as resources, inventory, production, transport, demand etc.

Benchmark Generator

Parameters specified by user (*positive integers*):

- **N** – number of manufacturers,
- **M** – number of customers,
- **E** – number of distributors,
- **O** – number of product types,
- **L** – number of modes of transport,
- **rand_max** – arbitrary large constant (random number generator upper bound),
- **CW** – arbitrary large constant (global upper bound)

Auto-generated parameters

- **Fs** – fixed cost of distributor s
  vector of E random positive integers < rand_max

- **Pk** – area occupied by product k
  *vectof of O random positive integers < 0.1 * rand_max*

- **Vs** – maximum capacity of distributor s
  vector of E random positive integers < CW

- **Wik** – production capacity at factory i for product k
  matrix of N x O random positive integers < CW

- **Cik** – cost of product k at factory i
  matrix of N x O random positive integers < rand_max

- **Rsk** – can distributor s deliver product k?
  matrix of E x O random binary values

Auto-generated parameters

- **Tpsk** – time needed for distributor s to prepare shipment of product k
  matrix of E x O random positive integers < rand_max
- **Tcjk** – cut-off time of delivery to customer j of product k
  matrix of M x O random positive integers < CW
- **Zjk** – customer j demand for product k
  matrix of M x O random positive integers < rand_max
- **Ztd** – number of transport units using mode of transport d
  *vector of E random positive integers < 10 * CW*
- **Ptd** – capacity of transport unit using mode of transport d
  vector of L random positive integers < rand_max
- **Tfisd** – time of delivery from manufacturer i to distributor s using mode of transport d
  matrix of N x E x L random positive integers < rand_max

Auto-generated parameters

- **K1iskd** – variable cost of delivery of product k from manufacturer i to distributor s using mode of transport d
  matrix of N x E x O x L random positive integers < rand_max
- **R1isd** – can manufacturer i deliver to distributor s using mode of transport d?
  matrix of N x E x L random binary values
- **Aisd** – fixed cost of delivery from manufacturer i to distributor s using mode of transport d
  matrix of N x E x L random positive integers < rand_max
- **Koaisd** – total cost of delivery from manufacturer i to distributor s using mode of transport
  matrix of N x E x L random positive integers < rand_max
- **Tm sjd** – time of delivery from distributor s to customer j using mode of transport d
  matrix of E x M x L random positive integers < rand_max

Auto-generated parameters

- **K2sjkd** – variable cost of delivery of product k from distributor s to customer j using mode of transport d
  matrix of E x M x O x L random positive integers < rand_max
- **R2sjd** – can distributor s deliver to customer j using mode of transport d?
  matrix of E x M x L random binary values
- **Gsjd** – fixed cost of delivery from distributor s to customer j using mode of transport d
  matrix of E x M x L random positive integers < rand_max
- **Kogsjd** – total cost of delivery from distributor s to customer j using mode of transport d
  matrix of E x M x L random positive integers < rand_max
- **Odd** – environmental cost of using mode of transport d
  vector of L random positive integers < rand_max

Optimization algorithms: MILP

- MILP (Mixed Integer Linear Programming) algorithm (Sitek, 2012)
  - The model was implemented in "LINGO" by LINDO Systems.
  - LINGO" Optimization Modeling Software is a powerful tool for building and solving mathematical optimization models (linear, nonlinear, quadratic, integer and stochastic).
  - Optimization was performed for six examples: P1.. P6
  - All the examples relate to the supply chain with two manufacturers (i=1..2), three distributors (s=1..3), four recipients (j=1..4), four mode of transport (d=1..4) and five types of products (k=1..5).

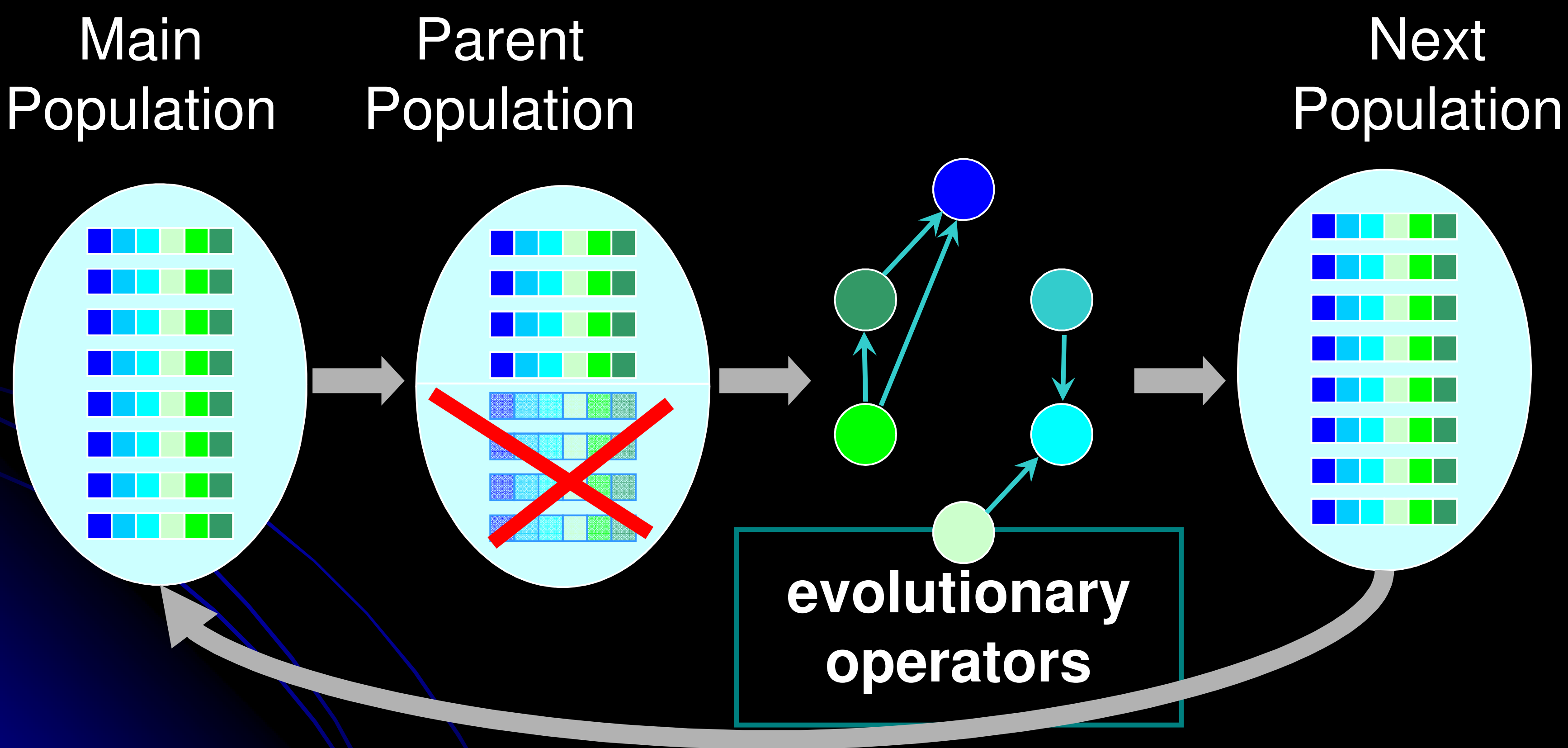
Optimization algorithms: EA

- Evolutionary algorithm with structural cross-over and mutation operators, a random immigrant strategy and additional heuristic improvement operators
  - The model was implemented in Matlab (for testing purposes only) and may be easly rewritten in ANY programming language
  - Optimization was performed for about 40 examples, generated automatically by the benchmark generator
  - All the examples relate to the supply chain with multiple manufacturers, multiple distributors, multiple recipients, multiple mode of transport and multiple types of products (i, s, j, d, k vary in different examples)

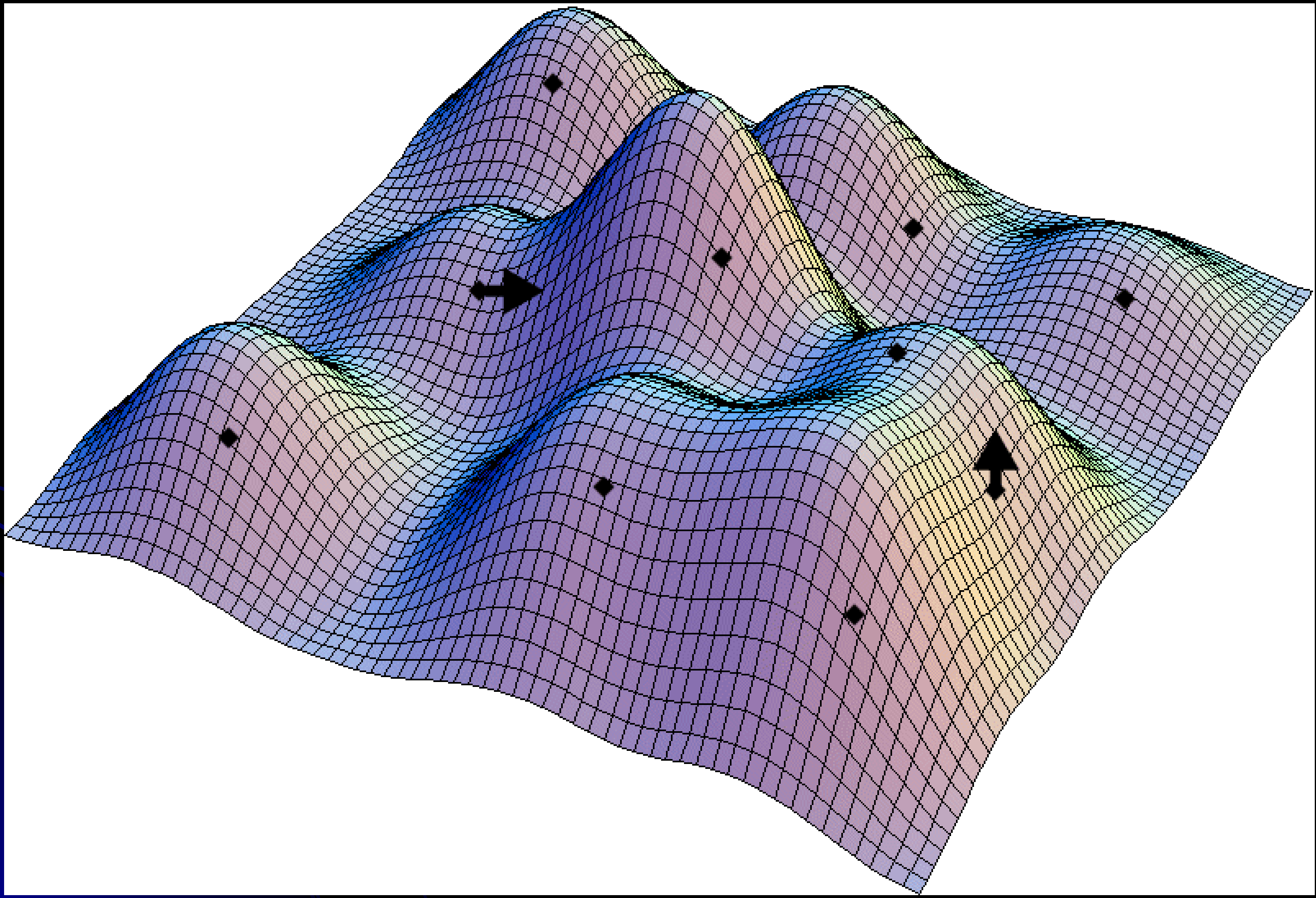
Evolutionary algorithm

```
P = Initial-Population
Population-Evaluation(P)

while not Termination-Condition(P) do
        Parent-Selection(P)

        Matrix-Structural-CrossOver
        Vector-Standard-CrossOver
        Matrix-Structural-Mutation
        Vector-Standard-Mutation

        Heuristic-Improvement(P)

        Population-Evaluation(P)
        Replacement(P)
```

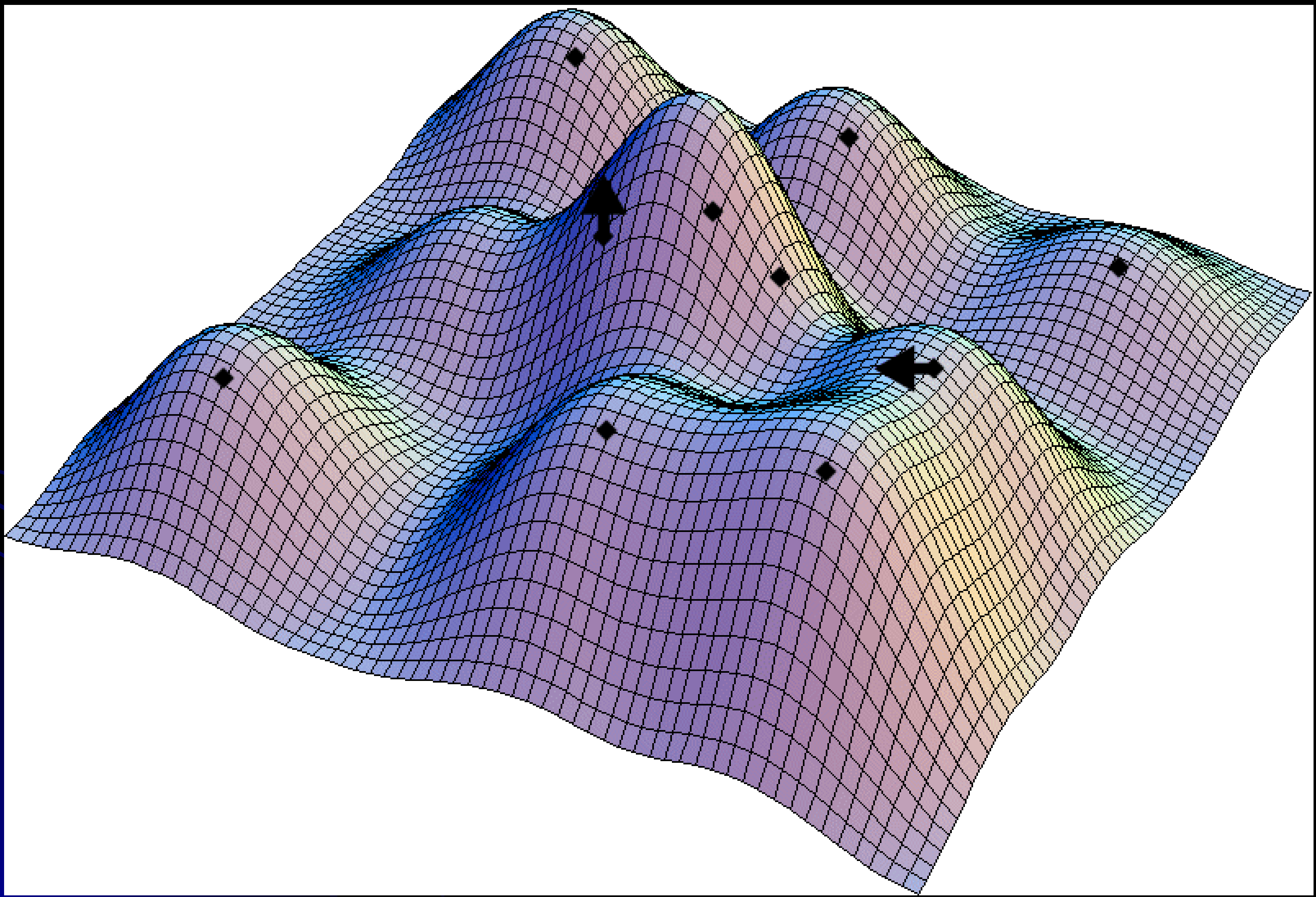
Evolutionary Algorithm



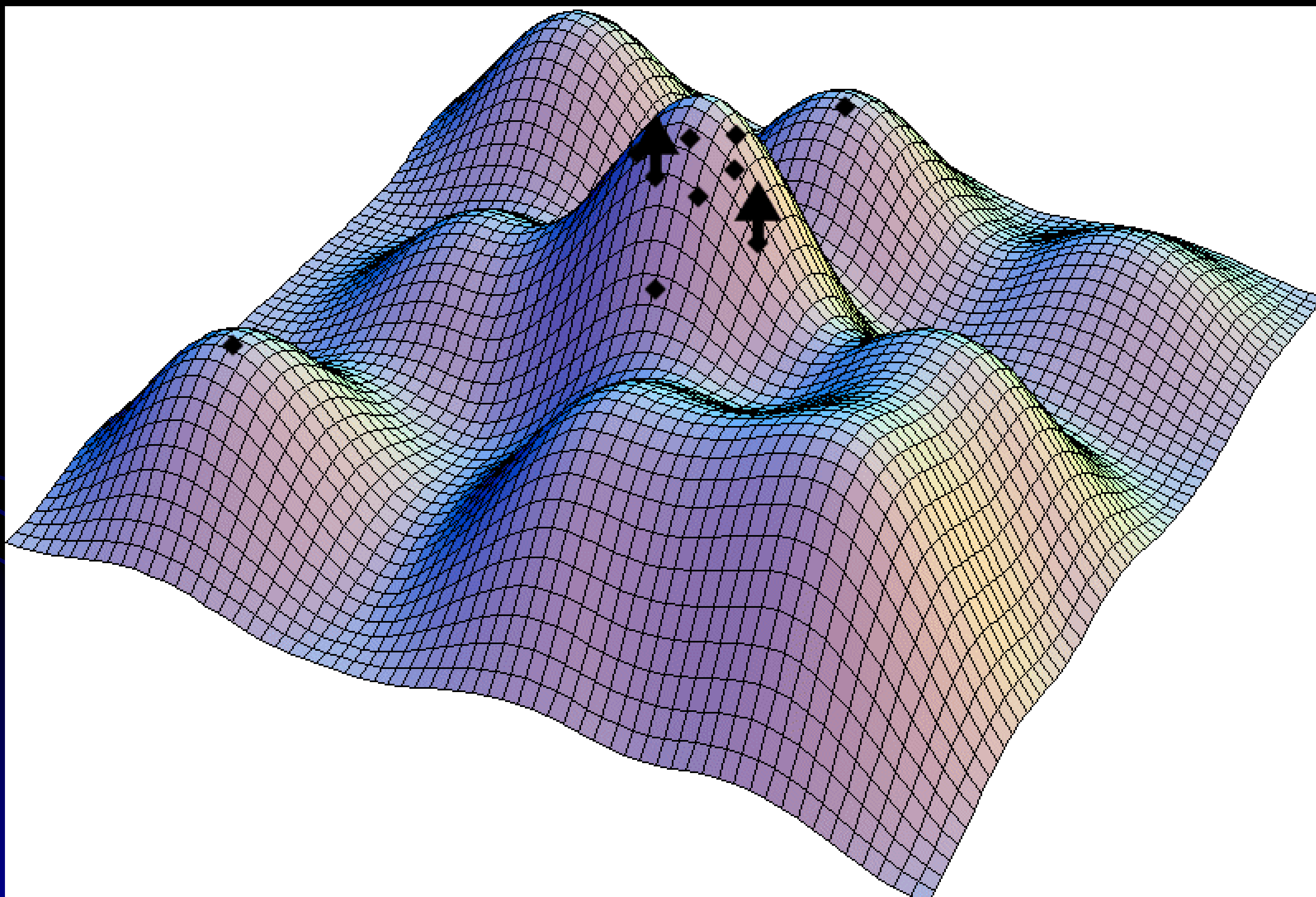
Evolutionary Algorithms : initial population



Evolutionary Algorithms : next population

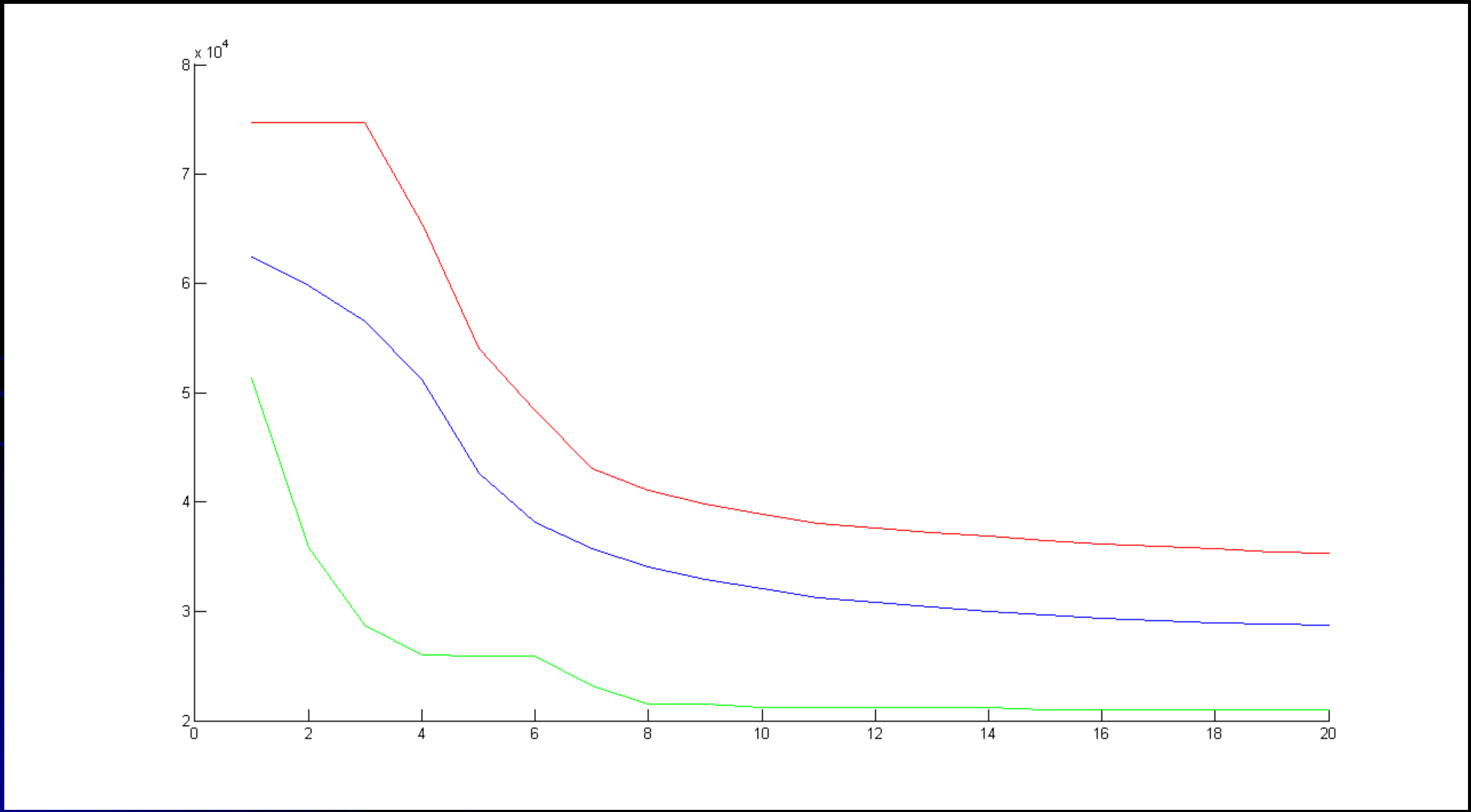


Evolutionary Algorithms : final population



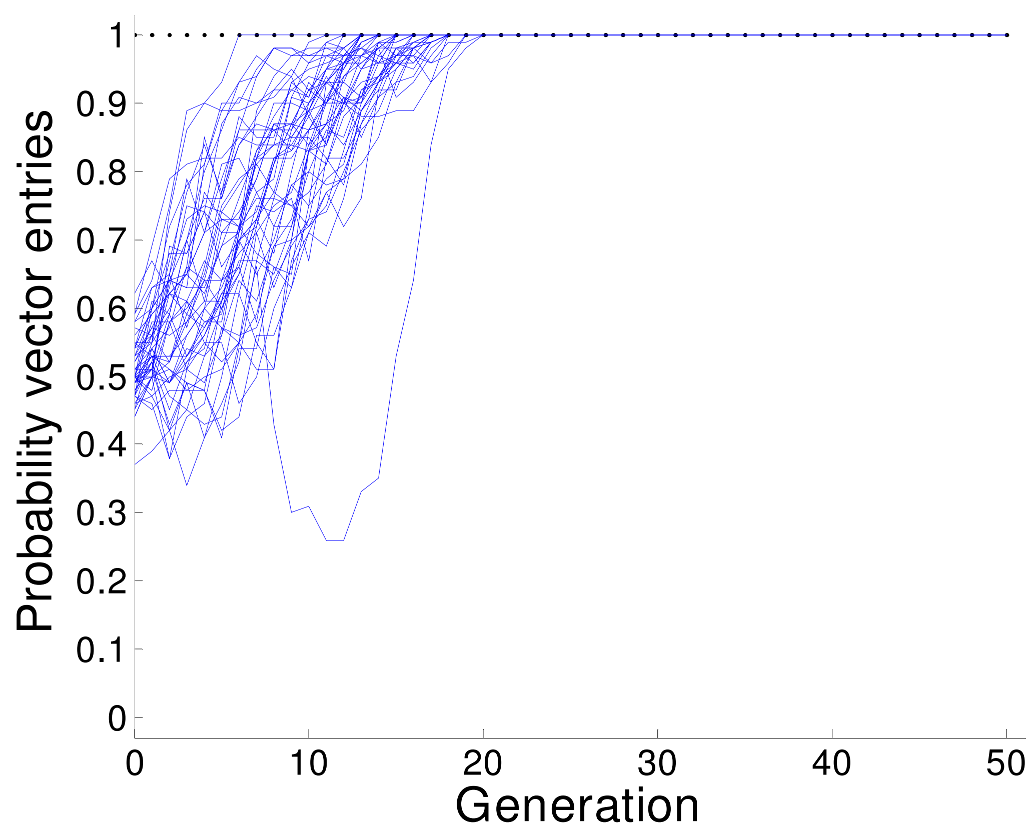
Preliminary Results

- Figure shows typical performance of the evolutionary algorithm on benchmark datasets.
- After about 20 iterations, the cost function is reduced about 2x.



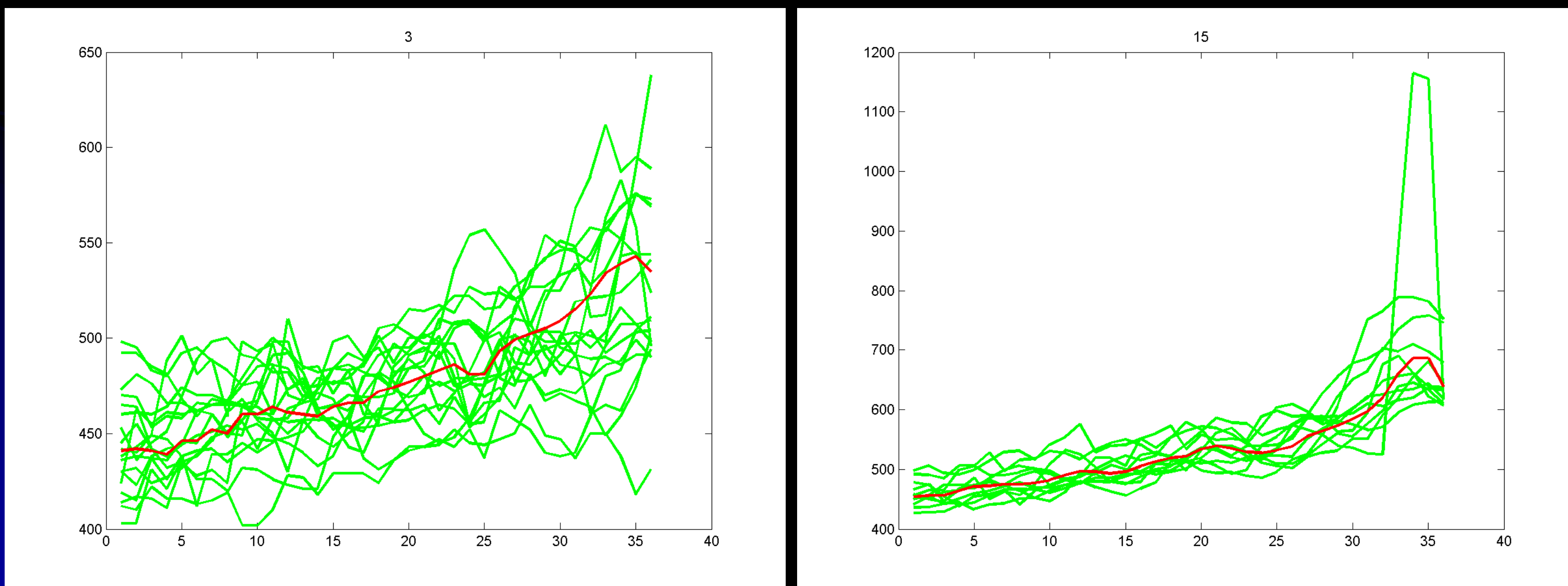
Preliminary Results

- **Figure shows typical convergence of candidate solutions in successive iterations of the evolution process.**
- **After about 20 iterations, the similarity measure of candidate solutions, based on the probability of being accepted as a problem solution, reach 1.**



Preliminary results

- Figure shows typical population diversity at the beginning of the evolutionary search (left side) and at the end (right side).
- Each line represents one candidate solution from the current population in a 36-dimensional coordinate system based on principal components mapping.
- At the beginning, candidate solutions are different at a large extent.
- At the end, candidate solutions are rather similar (focussing on the global optima of the objective function).



Conclusion

- Optimization SCML- the challenging problem
- Generic model is defined – it has to be validated by business partners
- The benchmark is generated but the real data have to be provided
- The current approaches have to be identified and evaluated
- Two phase approach is proposed

  1- Prototyping phase – the feasibility study - 2 months

  2- Desing and implementation of multimodal optimization system – 6 months