# DOMinant

## Discrete Optimization Methods
## In Maritime and Road-based Transportation

Norwegian University of Science and Technology (NTNU),
Molde University College (HiM)
and SINTEF ICT

**Geilo 29.-30. January 2007**

# Outline

- Background
- Project information including main goal
- Transportation problems
- Status
- Plans
- Concluding remarks

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# Background

- HiM, SINTEF ICT and NTNU
  - long term cooperation
  - internationally acknowledged within discrete optimization methods (transportation)
  - complement each other;
    - HiM: Heuristics, road-based transportation
    - SINTEF: Heuristics, road-based transportation (and maritime transportation)
    - NTNU: Exact methods (and heuristics), maritime transportation

- Vehicle routing problems (VRP)
  - generalization of the travelling salesman problem (TSP)
  - belongs to the class of strongly NP-hard optimization problems

- We will study extensions of the VRP
  - that are even more demanding due to additional degrees of freedom
  - Relevant and long experience in solving rich VRP problems
  - A lot of research challenges

# Project information

- Project period: August 2006-December 2009

- Budget: 6.176 MNOK
  - (2 post docs., man-hours SINTEF and operating costs)

- Key personnel
  - Professor Marielle Christiansen, NTNU
  - Professor Arne Løkketangen, HiM
  - Chief Scientist, Dr. Geir Hasle, SINTEF ICT
  - Post Doc. Henrik Andersson, NTNU
  - Post Doc. Arild Hoff, HiM

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# Main objective

- Develop more efficient methods for
  solving rich, industrial variants of
  computationally hard discrete optimization problems
  in maritime and road-based transportation

- Two types of problems:
  - Inventory Routing Problem (IRP)
  - Fleet Size and Mix Vehicle Routing Problem (FSMVRP)

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# Classical VRP(TW)

- Deliveries from a single depot
- Given customer demand
- Homogeneous fleet
- Sizes/capacities
- Minimise total transportation cost
- (Single time windows)
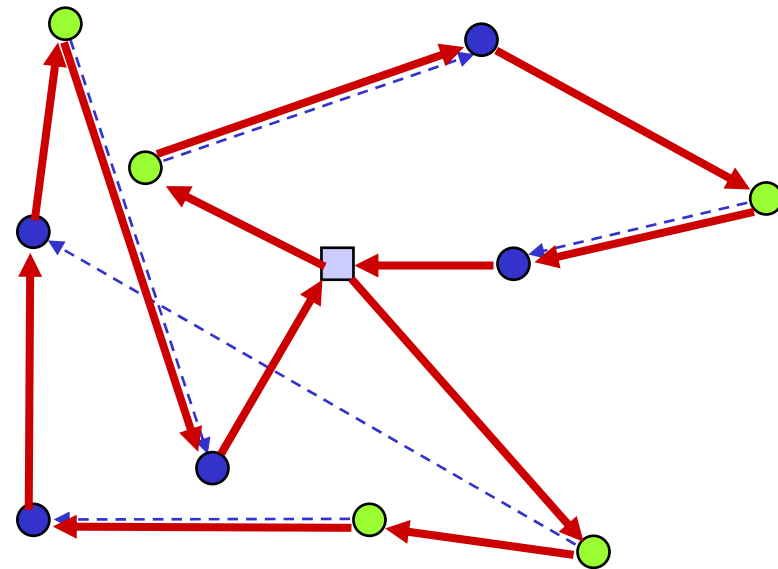
- More than 1000 references
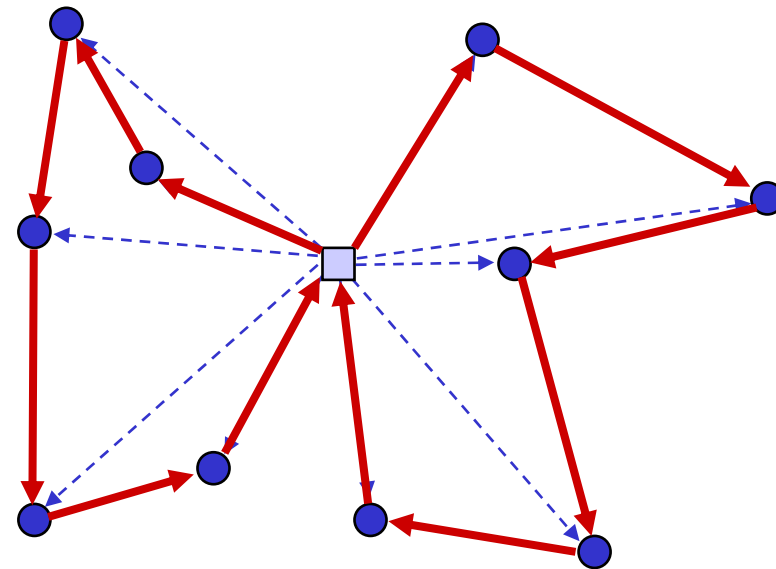
# M-n200-k16: First known feasible solution
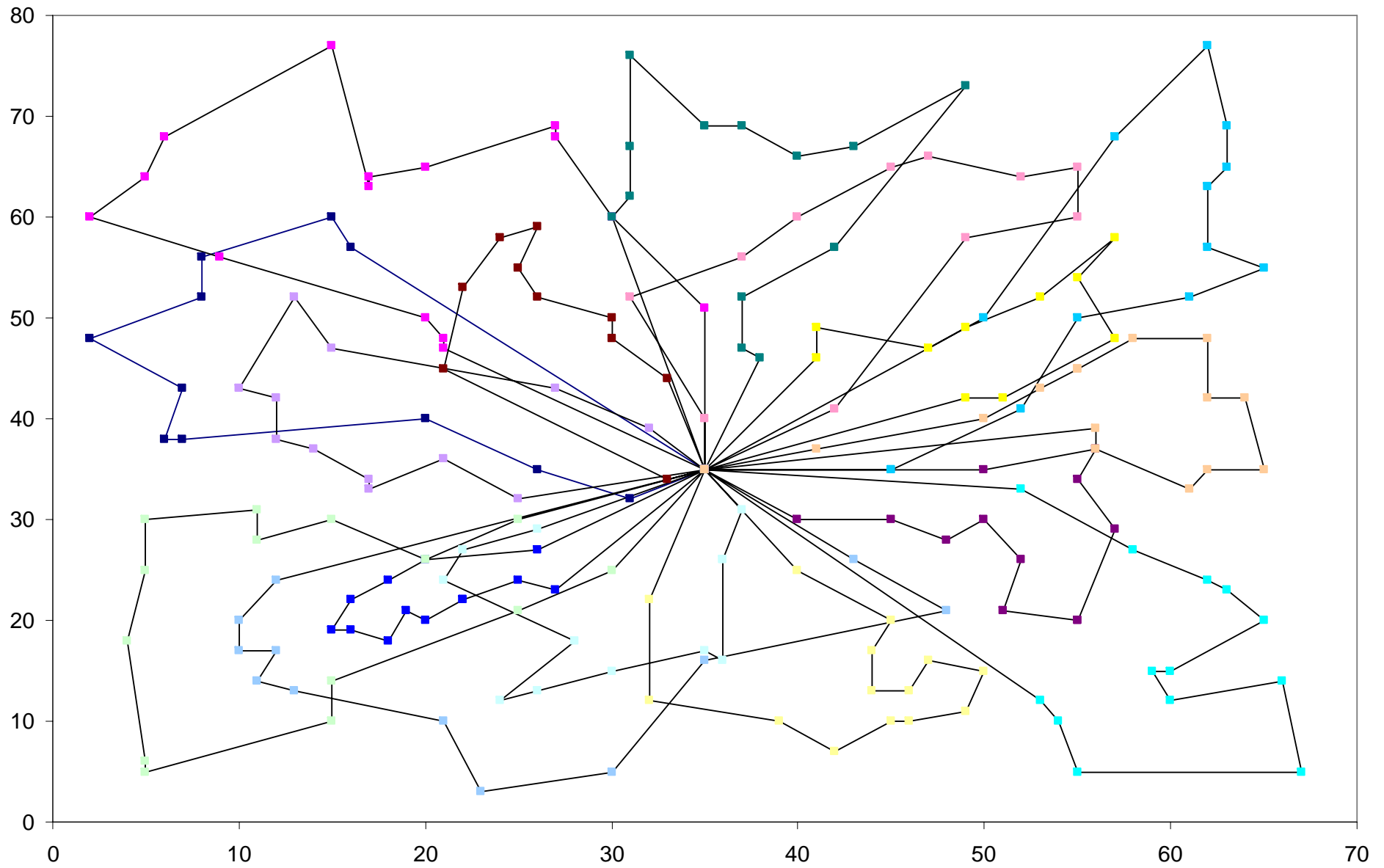
# Classical PDP(TW)

- Pickup and delivery at customer locations
- Homogeneous fleet
- Sizes/capacities
- (Single time windows)
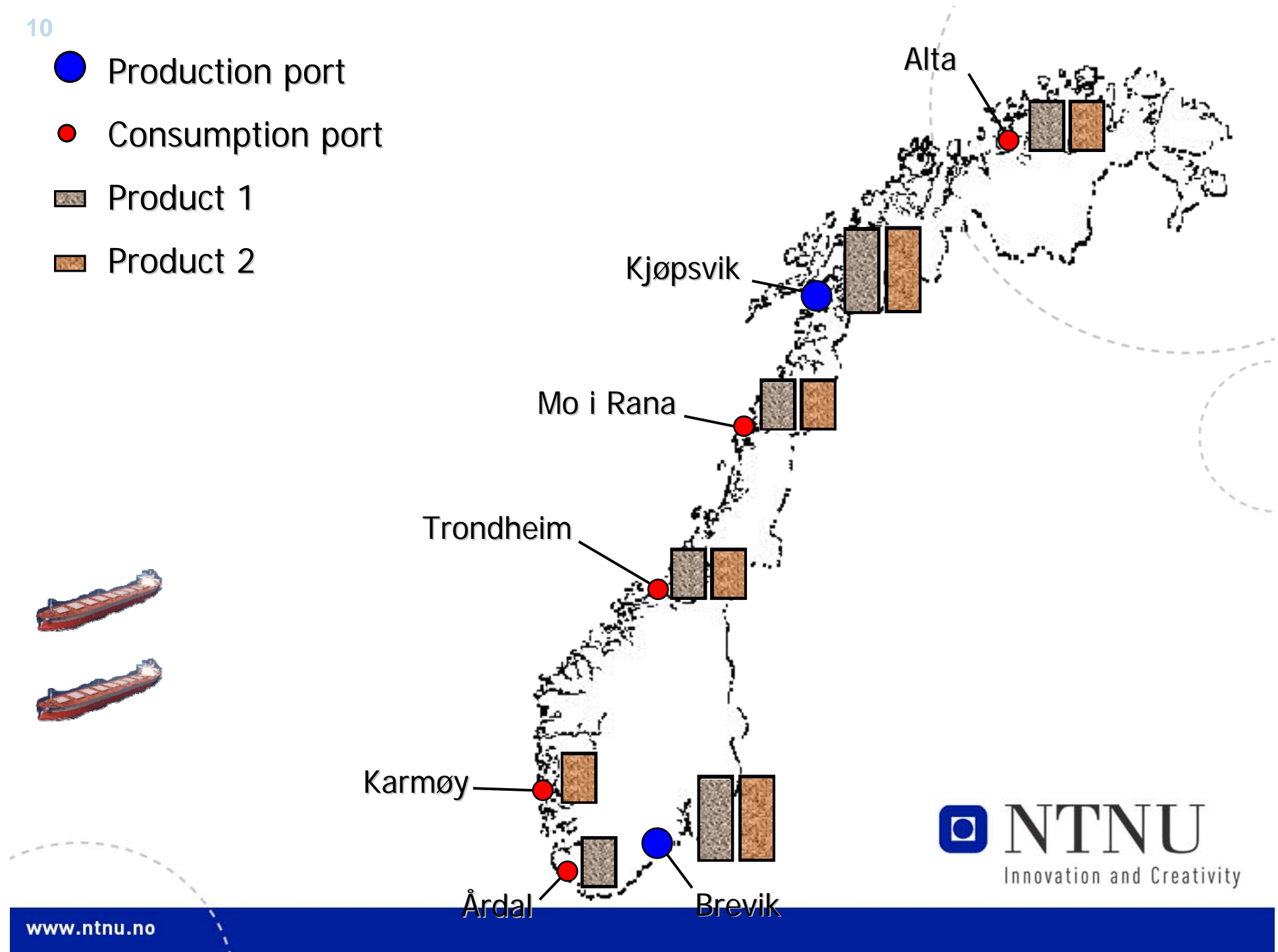
**Inventory level, production**

# Inventory routing problem (IRP)

- Inventories with capacities
- Production/consumption rate
- Heterogeneous fleet
- Design routes that minimize the transportation cost without interrupting production and consumption of the products


- No pickup and delivery pairs
- Quantity loaded unknown
- Number of visits unknown

UB

LB
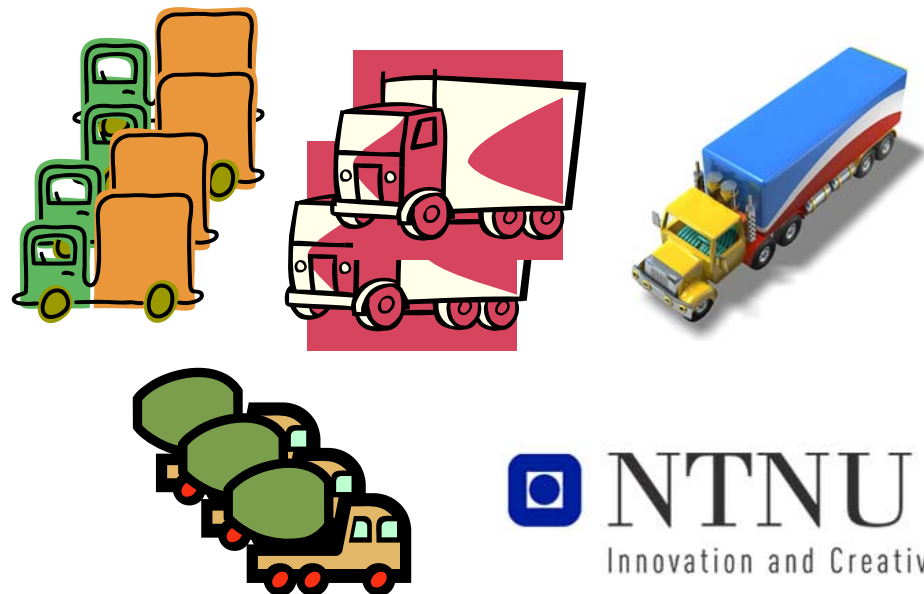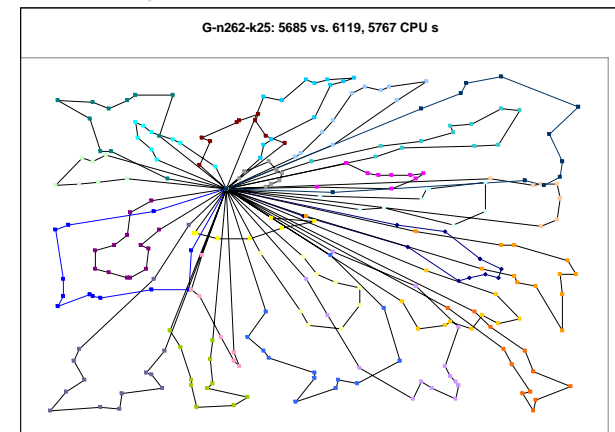
Time

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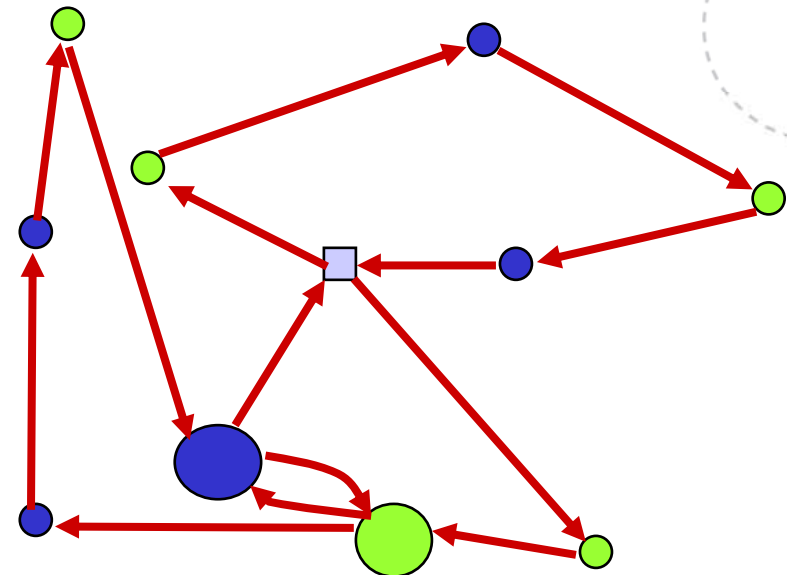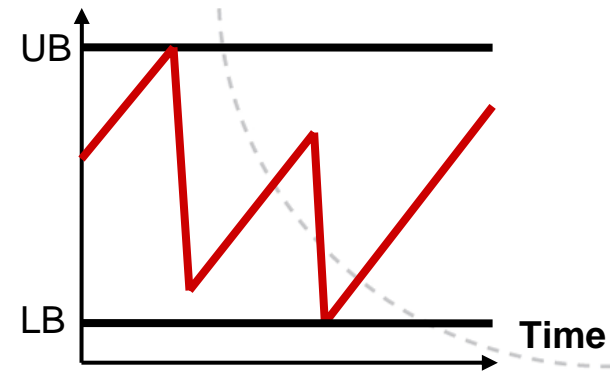
# Practical applications - IRP

- Both road-based and maritime transportation
  - One/multiple products
  - VRP and PDP structure (with and without depot)
  - Variable production/consumption rate
  - Stochastic demand/production
  - Combining inventory routing with other planning aspects (production, allocation,..)

- Industry cases
  - Ammonia –Yara
  - LNG - Suez Energy International, Statoil, RasGas, QuatarGas
  - Cement - Norcem
  - Fuel oil - Hydro Texaco
  - Animal fodder - Landbruksdistribusjon, Felleskjøpet

- Existing literature (15 M.T., 100 R.-B.T.)

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# Fleet Size and Mix Vehicle Routing Problem (FSMVRP)

- VRP, PDP (or IRP) structure

- Variable heterogeneous vehicle fleet
  - capacities
  - acquisition costs….

- **Objective:** find a fleet composition and a corresponding routing plan that minimizes the sum of routing and vehicle acquisition/depreciation/ rental costs



G-n262-k25: 5685 vs. 6119, 5767 CPU s

# Practical applications - FSMVRP

- Both road-based and maritime transportation
  - Strategic and tactical fleet dimensioning
  - One/multiple products
  - VRP and PDP structure (with and without depot)
  - Stochastic demand and price/cost structure

- Industry cases
  - Cars - Høegh Autoliners
  - LNG – Statoil
  - dairy products - Tine Midt-Norge
  - Newspapers - Aftenposten, Dagblad
  - Ice cream - Henning Olsen, Diplom is
  - local distribution - Linjegods
  - Chemicals – Broström
  - Cement – Norcem
  - Animals-Norsk Kjøtt, Gilde

- Existing literature (3 M.T., 50 R.-B.T.)

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# Status

- Recruited two post docs
- Accepted abstracts for all five key personnel at Tristan conference (June 2007)
- 4 workshops/meetings
- Web page (http://www.iot.ntnu.no/forskning/forskerprosjekt/dominant)
- E-room
- 1 paper on FSMVRP submitted to *Transportation Science*
- 1 paper on IRP submitted to *Encyclopedia of optimization*
- Started on two survey papers (FSMVRP and IRP). All 5 key personnel will contribute
- Presented DOMinant for some industry partners

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# Research approach

- Develop mathematical formulations of rich industrially relevant variants of the IRP and FSMVRP

- Develop solution methods
  - Exact methods (Column generation and Lagrangian relaxation)
  - Bounds, relaxations and reductions
  - Approximation methods (heuristic column generation, metaheuristics)
  - Hybrid methods (combining exact methods and metaheuristics)

- Develop prototype solvers

- Perform computational experiments on instances from the literature and industry

# Conference plans in DOMinant

- Tristan 2007, a 2-days pre-conference workshop

-  Organizing the Nordic Optimization Symposium, 19-20 October 2007, Oslo

- National conference on transport optimization at Geilo, January  2008

- International conference, invitations only, Norway, May-June 2008

- Promote Tristan 2010 in Tromsø.

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# Sub goals

- 10 journal papers

- 15 talks at international conferences

- 20 popular dissemination actions

- Stronger collaboration between NTNU, HiM and SINTEF ICT

- Enhanced international scientific network

- International scientific workshops

# Concluding remarks

- Industrial variants of the VRP are very complex

- Focus: Inventory routing problems and fleet size and mix vehicle routing problems

- Low attention in the literature

- A lot of research challenges
  - Mathematical modelling
  - Solution methods
  - Testing large, real world instances

- DOMinant will enhance the collaboration in Norway and abroad

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