

Flexible Decision Support in a Dynamic Business Network

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Outline

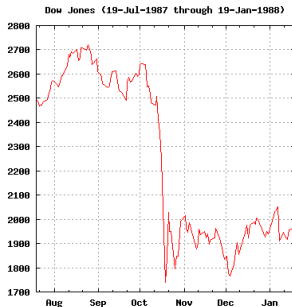
- 1 Introduction
 - Motivation
 - Trading Agents
- 2 TAC SCM
 - MinneTAC
 - Design issues
 - Decision Coordination
- 3 Flexible Decision Support via Intelligent Trading Agents
 - Quick Connect and Disconnect
 - Goal Directed Service Composition
 - Dynamic Business Network Structure Visualization
 - Flexible Economic Dashboard Architecture
- 4 Conclusions and Future Work

Black Monday, October 1987

Motivation

The Dow Jones Industrial Average dropped by over 22% in one day. Before the dust settled, many markets had dropped as much as 45%.

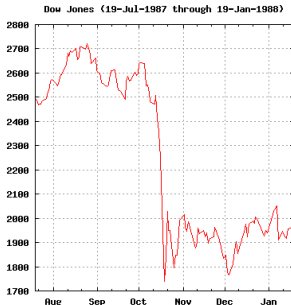
- This was widely blamed on naive computer programs that automatically sold when prices fell.
- Two possible outcomes:
 - Ban automated trading.
 - Learn how to build automated trading systems that exhibit rational behavior.



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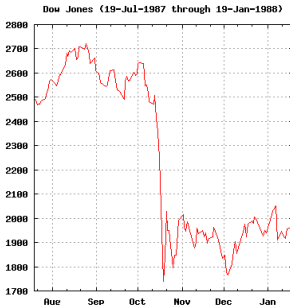


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The Tyranny of Choice

(Barry Schwartz, 2004)

Conventional wisdom:

More choices make people happier, create greater opportunities for business.

Reality:

People can be paralyzed by too many options. Online markets can lead to a combinatorial explosion of possibilities.

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What is a Trading Agent?

as opposed to an “Agent”

*Definition of an autonomous agent
(Wooldridge & Jennings 1995)*

1. Autonomy

Agent has persistent identity, operates without direct control.

2. Social ability

Agent interacts with other agents and/or human users.

- Most (if not all) communication is negotiation or otherwise related to trading - requests, offers, orders, shipments, payment, etc.
- Agents often do not communicate directly with their competitors.

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What is a Trading Agent? (2)

3. Reactivity

Agent perceives its environment, responds appropriately.

- Tracks prices, supply and demand,
- Updates internal models (learning),
- Makes offers, accepts orders.

4. Proactivity

Agent exhibits goal-directed behavior, takes initiative.

- Uses models and market signals to “buy low, sell high.”
- Engages in strategic behavior.
- Evaluates its own market power, drives market in desirable directions.

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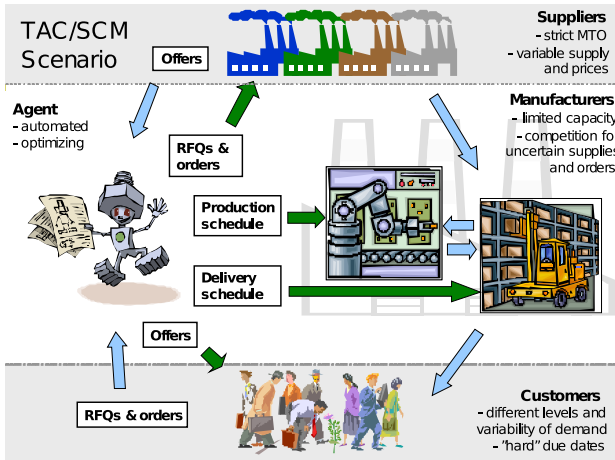
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Applications for trading agents

- EBay instantiates a simple trading agent for each auction.
- EBay snipers manipulate auctions for the benefit of their users.
- Trading securities and commodities.
- Distributed allocation of tasks and resources (example: call routing).
- Logistics and transportation.

TAC SCM

Overview – Dynamic Business Network Testbed



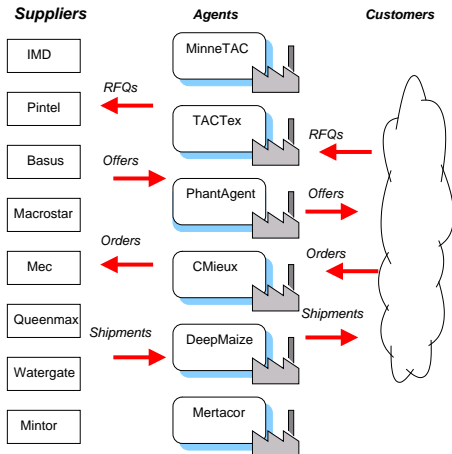
TAC SCM

Introduction

- Competitive supply-chain trading
- Agents must coordinate internal operations with trading in multiple markets
 - Inventory management
 - Production scheduling
 - Logistics
- Uncertain customer demand and supplier capacity
- Actions of other agents not directly visible
- See <http://www.sics.se/tac>

TAC SCM

Scenario – Dynamic Business Network Testbed



TAC SCM

Why hold a competition?

Enabling research

- It's very hard to make progress in this area, because
- The domain is too complex and dynamic for a game-theory approach, but
- It's hard to do experiments with real organizations, and
- We need experimental evaluation to validate ideas.

The "Game"

- An abstraction of a simple three-tier supply chain (Dell).
- Balance between real-world complexity & ease of analysis.
- Lacking a provably-optimal standard of performance, researchers vie for dominance and bragging rights.

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Key Intelligent Agent Design Issues

From Kiekintveld et al. 2004

Uncertainty

Many important details can only be estimated.

- Future customer demand
- Supplier capacity and pricing
- Behavior of other agents

Variability

Customer demand, parts availability vary widely.

Strategic interactions

Agents can be expected to manipulate the game environment to their own advantage.

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Architectural imperatives

driving forces

Performance

Agents must complete all their decision processes within a 13-second window for each cycle.

Transparency

Winning a game is not enough - teams need to be able to analyze agent behavior in detail.

Coordination of multiple decision processes

Required by the game scenario.

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The Coordination Problem

- A key element of performance in TAC SCM agents is their ability to coordinate procurement, sales, and production.
- A solution to the coordination problem includes sales, procurement and production schedules.
- Constraints include production capacity, customer demand, parts availability.
- Approaches to solving this problem vary widely.

The Coordination Problem

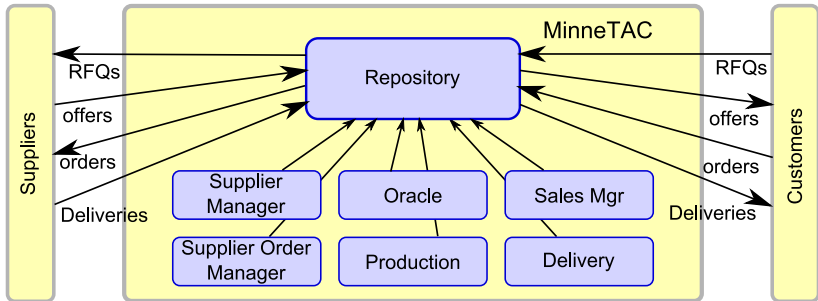
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MinneTAC

*John Collins, Wolf Ketter, Maria Gini,
and many others*



Coordination through the repository, details depend on configuration.

MinneTAC

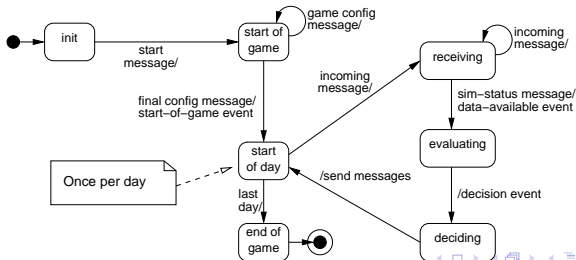
A highly flexible research tool

- The MinneTAC design is a general architecture for blackboard-oriented agents with multiple decision processes.
- Decision processes are encapsulated in replaceable, configurable components.
- Modeling and analysis tools (**Evaluators**) are designed as simple services, strung together at runtime to provide input to decision components.
- All evaluators record their activity, to support offline analysis.
- There are currently at least 20 different viable versions of MinneTAC.

Controlling the daily cycle

At the top level, MinneTAC is essentially reactive.

- Incoming messages arrive in a batch.
- Daily processing in two phases:
 - Data analysis, model updates
 - Decision processing - requests, offers, orders, production and shipping schedules.



Flexible Decision Support

Literature demands the following characteristics of Smart Business Networks (which were not achieved so far):

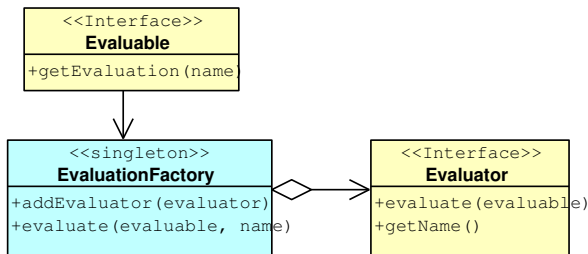
- 1 **Quick Connect and Disconnect** (Goldman, Nagel, and Preiss 1995 & Sanchez 1995 & van Heck and Vervest 2007)
- 2 **Goal Directed Service Composition** (Sirin, Hendler, and Parsia 2002 & van Hillegersberg et al. 2004)
- 3 **Business Network Structure Visualization** (Kambil and Short 1994 & Hoogeweegen et. al. 2006 & van Liere 2007)
- 4 **Flexible Economic Dashboard Architecture** (Adam and Pomerol 2002 & Few 2006)

Quick Connect and Disconnect

Dynamically connect to different nodes of a business network and disconnects them when no longer needed.

Evaluables and Evaluators

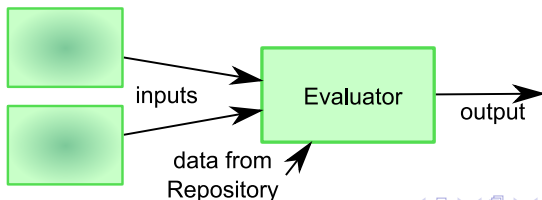
- All shared data elements in the Repository (Products, Components, RFQs, Orders, etc.) are Evaluable.
- Evaluable objects can be associated with any number of named Evaluators.



A typical evaluator

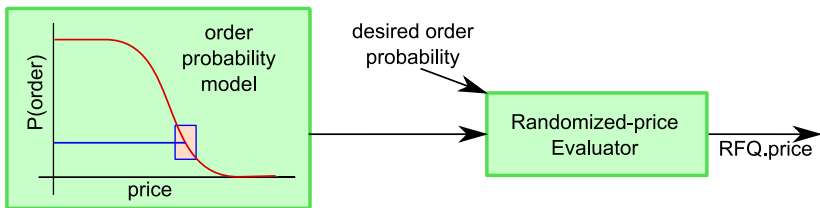
Evaluators can be thought of as “dataflow” components

- Input from the environment (Repository data) is combined with
- Input from some number of other Evaluators, producing
- an Evaluation (usually a numeric array, or an object that can be queried).



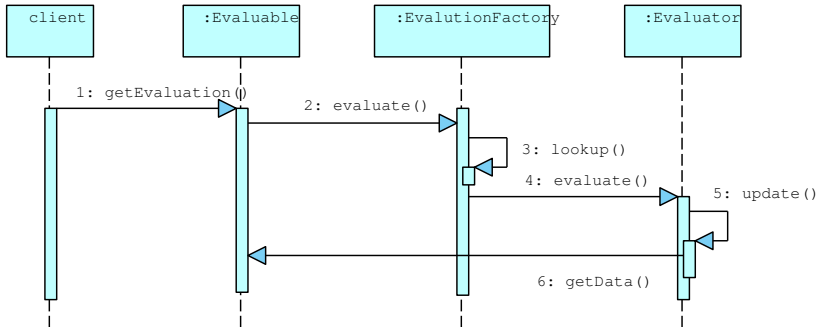
Pricing customer offers

- We want to maximize the price we get for our sales.
- Therefore, we typically set a price that not all customers will accept.
- We can increase the information content of orders by “spreading” prices.



Requesting an Evaluation

- Evaluable delegates to EvaluationFactory.
- EvaluationFactory looks up the name of the requested Evaluator, invokes the correct evaluate() method.

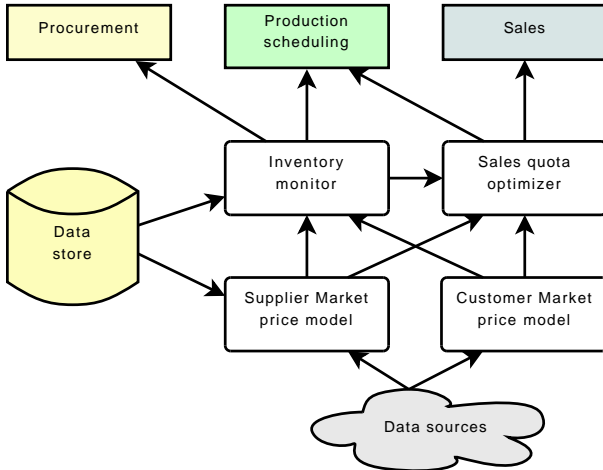


Goal Directed Service Composition

This allows business services with formal semantic descriptions to be composed and validated.

MinneTAC

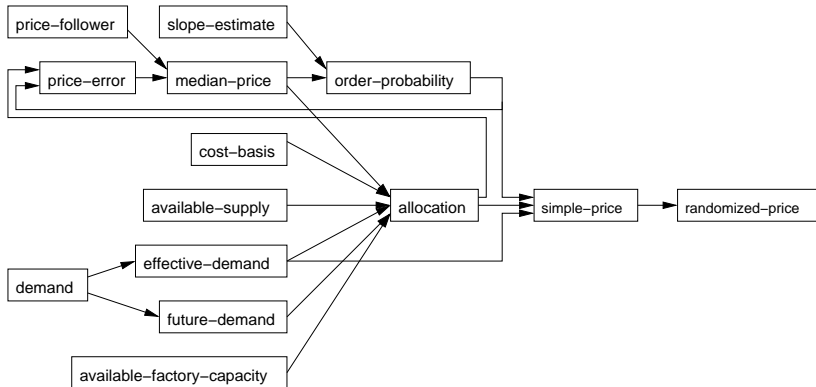
Schematic dataflow view



MinneTAC

Example evaluator chain

This chain produces daily sales quotas, and recommended prices for individual customer requests



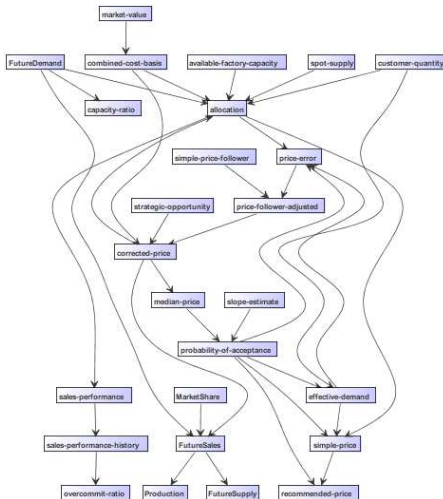
Dynamic Business Network Structure Visualization

A tool that lets managers visualize, understand, and validate the designed decision chain with a graphical representation of the actual network chain.

- Business Intelligence: Role dependent view
- Partners:
 - ASML
 - Capgemini
 - Dutch Flower Auction
- Grant by University of Minnesota 2008
- Best paper award at the Smart Business Network Conference, Beijing, China, May 2008

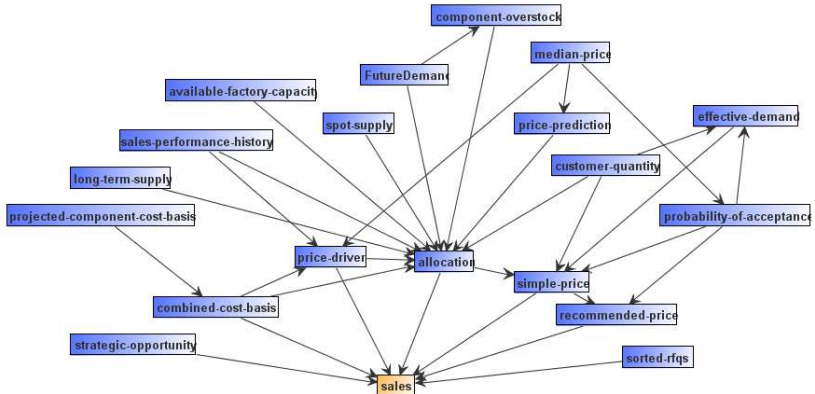
Dynamic Network Structure Visualization

Overall Network



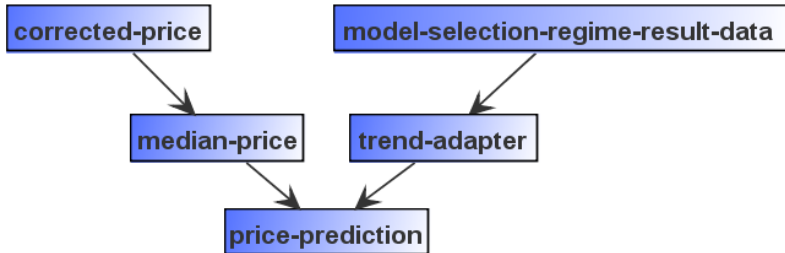
Dynamic Network Structure Visualization

Drill-down capabilities – Example: Sales Decision Chain



Dynamic Network Structure Visualization

Drill-down capabilities – Example: Price Prediction Chain

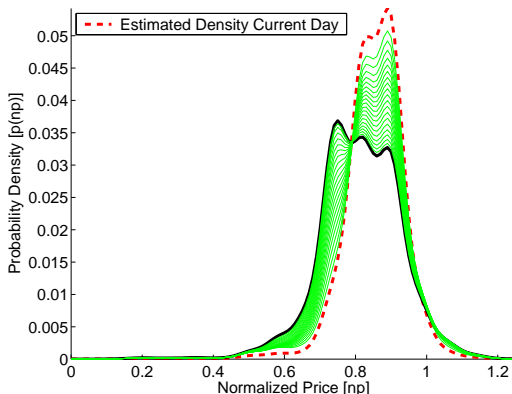


Flexible Economic Dashboard Architecture

Dynamically connect to selected nodes to visualize their real-time status, such as current parts and finished goods inventory positions, risk and reward management, and the like.

Dynamic Network Node Visualization

Price Distribution Prediction using Economic Regimes

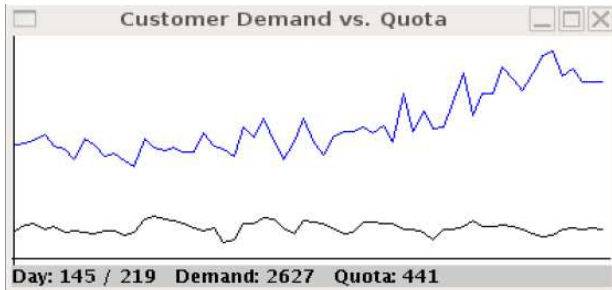


Economic Regimes – Market Modeling:

- UoM 2005 - Best research design award
- UoM 2006 - Most commercially research impact award
- AAI 2006 - Top 10 thesis award
- Ketter DSS 2008

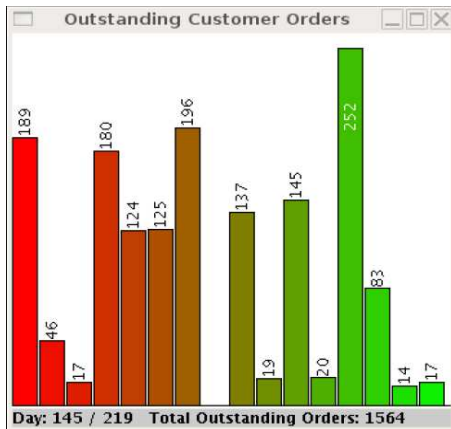
Dynamic Network Node Visualization

Demand and Sales Quotas



Dynamic Network Node Visualization

Outstanding customer orders



Business Insights

- Interdisciplinary research involving real companies!
- The solution architecture can greatly empower managers in their understanding of the overall business network structure and facilitate real-time decision making. The architecture is:
 - Scalable
 - Flexible
 - Responsive
- Autonomous, utility-maximizing agents will become increasingly important in online market environments.
- Interesting market environments are dynamic, strategic, and uncertain.
- Business network agents must coordinate internal operations with activity in multiple markets.

Smart Business Networks

Contributions

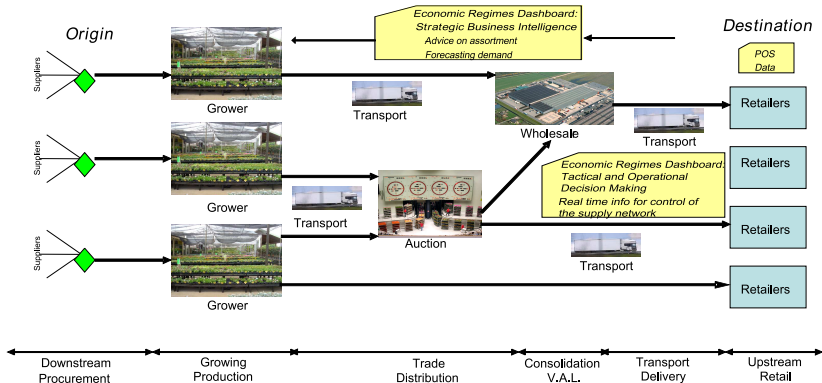
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Flexible Economic Dashboard Architecture Dynamically connect to selected nodes to visualize their real-time status.

Business Intelligence: Dutch Flower Auction



Teaching Tool

- Business and Economic Schools
- Computer Science Schools

Related Projects

- LARGE – Learning Agents Research Group at Erasmus (www.large.rsm.nl)
- Advocate Agents
 - Preference Elicitation: Observation of the Decision Maker
 - Social Networks
 - Harvesting the Power of the Semantic Web

Join us!

Questions?

?

Contact

Email: wketter@rsm.nl
URL: www.ketter.ws

Demand in the customer market

- Customer requests specify (product, quantity, leadtime, reserve price)
- Daily demand N is generated by a stochastic process:

$$N = \text{poisson}(Q_d)$$

$$Q_{d+1} = \min(Q_{max}, \max(Q_{min}, \tau_d Q_d))$$

$$\tau_{d+1} = \max(\tau_{min}, \min(\tau_{max}, \tau_d + \text{random}(-0.01, 0.01)))$$

Customer market

Supply and demand

- Customer requests specify reserve price between 75% and 125% of nominal component cost.
- Supply limited by agent inventory, production capacity, availability of parts.

