

Agent-based Flexible and Personalized Decision Support in Dynamic Networks

Lessons learned from the Trading Agent Competition for the Smart Home Vision 2020

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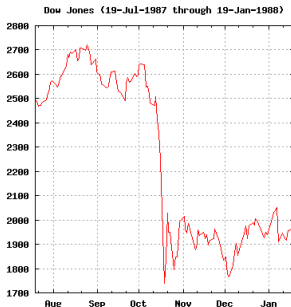
Karlsruhe Institute of Technology, Karlsruhe, Germany
Thursday, 14 May, 2009

Work done with: John Collins, Maria Gini, Andrew Nelson, and Dickens Nyabuti.

Black Monday, October 1987

Motivation

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

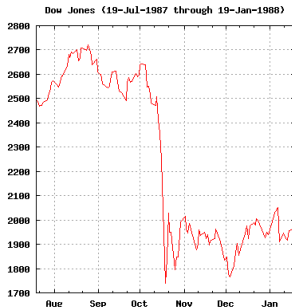


- This was widely blamed on naive computer programs that automatically sold when prices fell.
- Two possible outcomes:
 - Ban automated trading.
 - Learn how to build automated trading systems that exhibit rational behavior.

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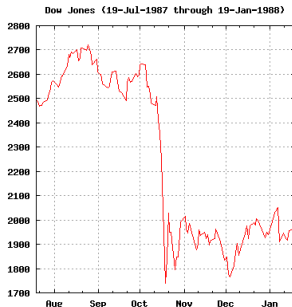


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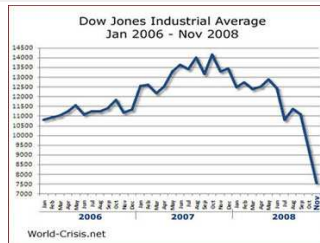


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Financial Crises, October 2008

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Credit crises became visible by the fall of Lehman brothers bank, and started a world-wide chain reaction in the economy.

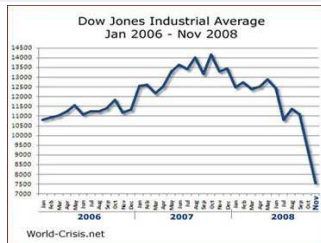


- Only partial network view.
- Risk management was based on individual perspective and not network perspective.
- Lessons learned:
 - Facilitate decision-making in complex business networks.
 - Need to understand network structure that provides high complex products and services.

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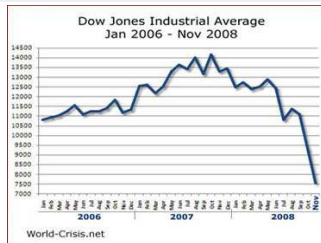


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The Tyranny of Choice

(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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Die Qual der Wahl

(Angela Merkel, Mai 2009)

Top Thema des Deutschen
Verbrauchertages 2009!

“...Konsumalltag meistern,
Wirtschaft gestalten. Damit
aus genervten Familien
selbstbestimmte und
selbtsichere Akteure
werden, müssen neue
Regeln aufgestellt
werden...”



Decision Support for Home Energy Users

Traditional view

- Mix of energy types is chosen a priori.
- People receive simple price signals and make their choices.

Smart Business Network view

- People are able to buy and sell energy in online markets.
- Combinatorial explosion of choices.
- Requires knowledge of:
 - market prediction, and
 - user preferences.

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New Smart Home and Energy Network Vision (1)

Elicitation of User Preferences

- Price
- Quantity
- Comfort
- Time
- Privacy
- Communication frequency

Application of User Preferences in Homes

Optimize patterns of demand along with heating, cooling, lighting, ventilation, refrigeration, etc.

Application of User Preferences in Energy Networks

Engage in continuous learning and adaptation of user preferences on multiple levels.

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New Smart Home and Energy Network Vision (2)

“Internet of Energy” requires infrastructure changes:

- Everything has an IP address!
- Standardization
- Locality (transportation of energy is expensive)
- Demand side management (bottom-up instead top-down)
- Renewable resources are unpredictable
- Economic incentives
- Automated trading markets
- Self-organization
- Advanced user interfaces (Economic Dashboards)

Flexible and personalized decision support

Economic Dashboards

Desiderata

- Appropriate separation of concerns
- Concepts have well-defined meaning in business context
- User-defined abstractions
- Transparency
- Easy to experiment and test
- Ability to play out hypothetical scenarios
- Scalability
- Robustness, reliability, availability, etc.
- **Adaptability**

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 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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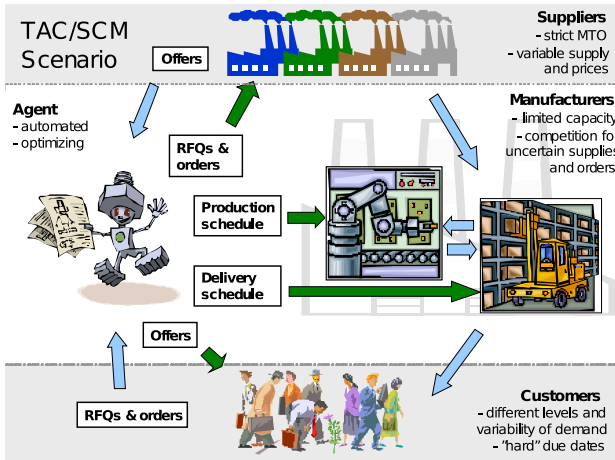
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TAC SCM

Overview – Dynamic Business Network Testbed



TAC SCM

Why hold a competition?

Enabling research

- SCM is too complex and dynamic for a game-theory, 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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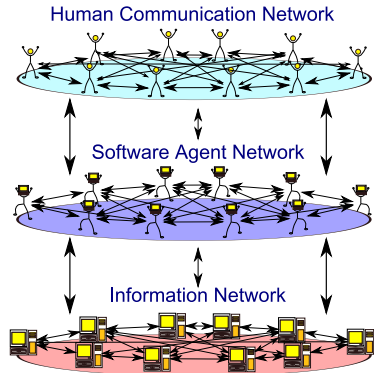
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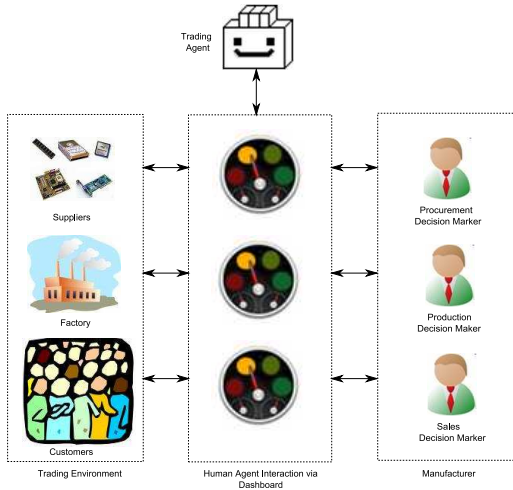
TAC SCM

Lessons learned

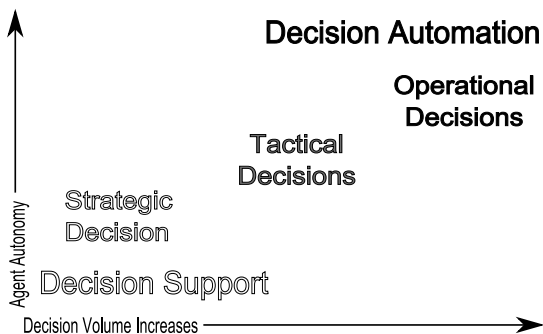
- Businesses don't trust fully autonomous agents.
- Human preferences matter.
- Decision support vs. decision automation.
- Actor vs. network decisions.
- Flexible agent architecture



Human-Agent Interaction in TAC SCM



Decision Support vs. Decision Automation



Flexible Decision Support

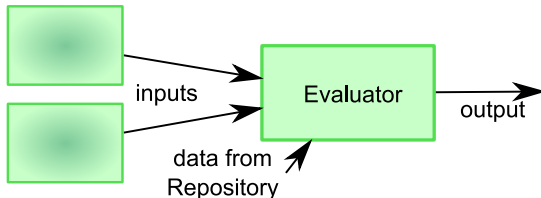
Literature demands the following characteristics of Smart Business Networks (which were not achieved so far):

- 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)
- 5 **Ontology-driven decision support (ODDS)**

Quick Connect and Disconnect: Evaluators

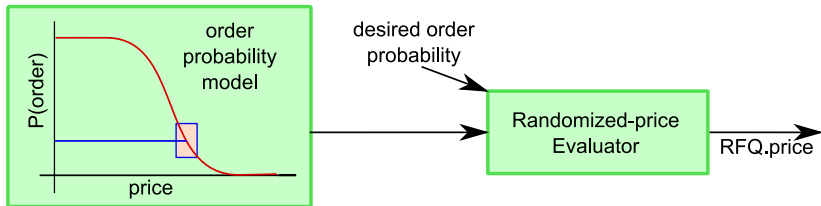
Evaluators can be thought of as “dataflow” components

- Input from the environment is combined with
- Input from some number of other Evaluators, producing
- Output (Evaluation).



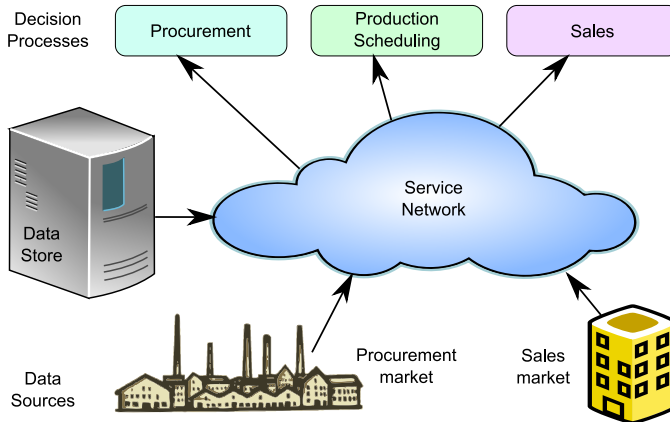
Example: Pricing customer offers

- 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.



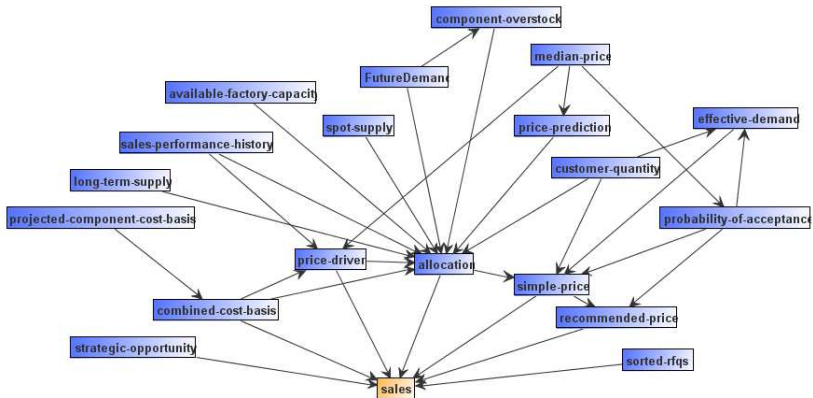
Goal Directed Service Composition: MinneTAC

Schematic dataflow view



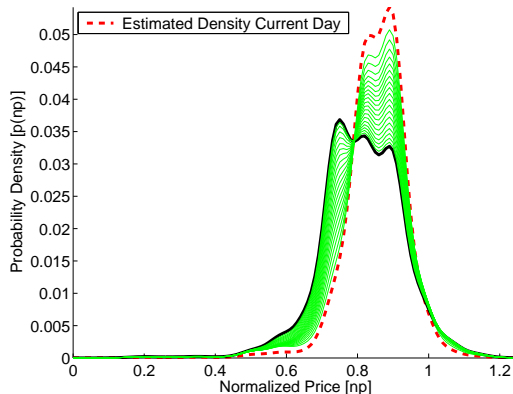
Dynamic Business Network Structure Visualization

Drill-down capabilities – Example: Sales Decision Chain



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
- SBN 2008 - Best paper award

Introduction

TAC SCM

Flexible Decision Support

Personalized Decision Support

Conclusions and Future Work

Quick Connect and Disconnect

Goal Directed Service Composition

Dynamic Business Network Structure Visualization

Flexible Economic Dashboard Architecture

Ontology-driven decision support (ODDS)

Ontology-driven decision support (ODDS)

Highly configurable, transparent decision processes that are fully described in terms that end users can understand.

Human Agent Interaction

Radically rethink user-agent interaction by:

- Offering just-in-time information.
- Highly relevant to a unique user and their current focus of attention.
- In non-disruptive, easily accessible, privacy protecting way.

Essential steps:

- 1 Preference modeling
- 2 Decision recommendation
- 3 Feedback

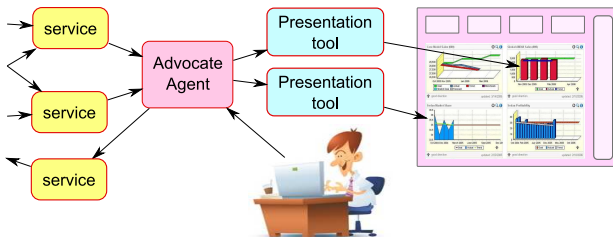
Using an Advocate Agent in Smart Homes

Enhanced functionality

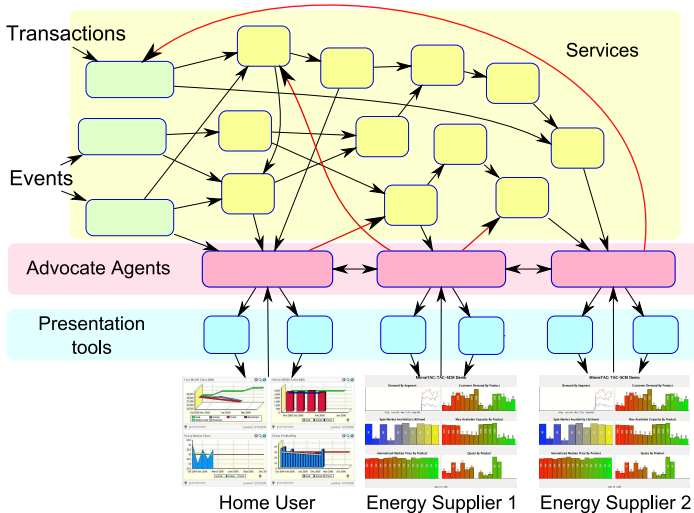
- Multiple user roles
- Alerts
- Control appliances
- Control batteries

Adapting to the user

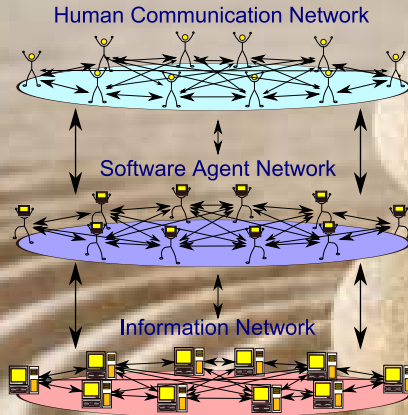
- Learn preferences
- Reduce cognitive load
- Focus on human judgement



Energy Service Networks with Advocate Agents



Learning Agents Research Group at Erasmus



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Flexible Decision Support
Personalized Decision Support
Conclusions and Future Work

LARGE Vision
Questions?
Contact

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