A Survey of Agent Designs for TAC SCM

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Workshop for Trading Agent Design and Analysis at AAAI
Chicago, Monday, 14 July, 2008

Outline

Introduction

- Trading agents present a special set of challenges.
  - Dynamic, uncertain, competitive environment.
  - Actions of competitors are not directly visible.
  - Performance measure: competitive effectiveness.
- Examine the TAC SCM domain and some of the architectural imperatives it imposes.
- Examine a selection of agent design approaches that have been used for TAC SCM.
- Examine the design of MinneTAC.

Introduction

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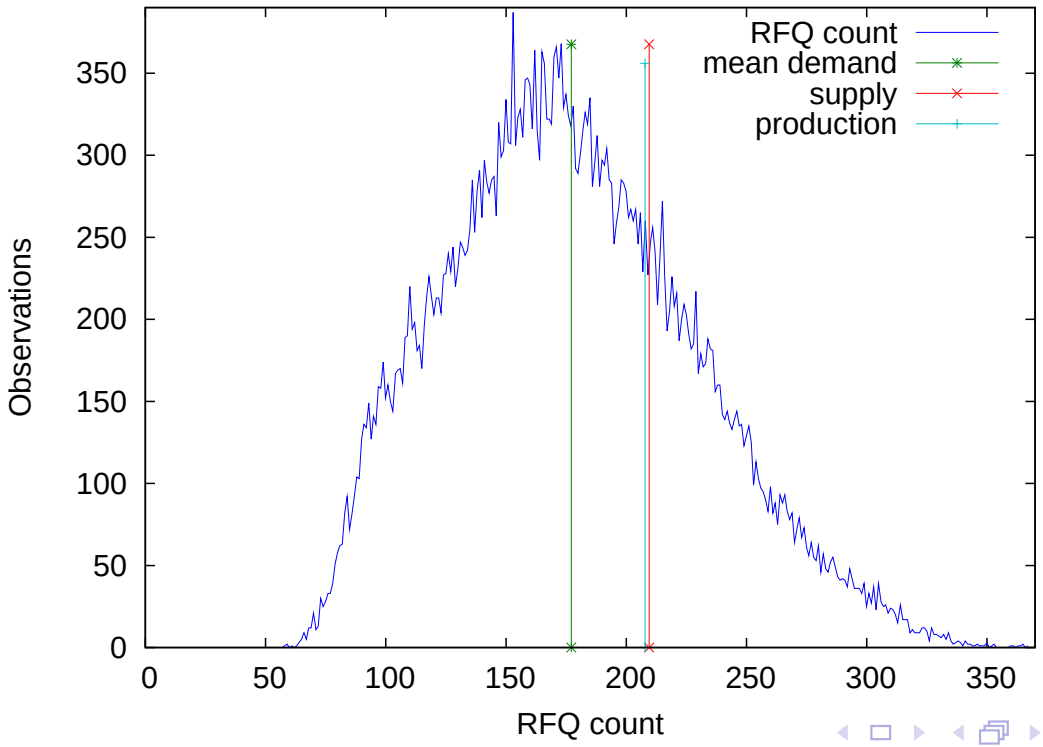
- Examine the design of MinneTAC.

Market balance

- Game parameters have been carefully balanced to defeat simplistic approaches.
- No effective strategic manipulations are known.



Agent design survey

- An attempt to tap the combined wisdom of the community and see what we could discover about agent design.
- Interested in how the TAC SCM problem combined with different research agendas would affect design ideas.
- We found (with some exceptions) that most participants have focused mostly on the problem, and not much on agent design.
- There are a few interesting exceptions.
- MinneTAC is unique.

Survey Participants

Team	University
Botticelli	Brown University
CMieux	Carnegie Mellon
CrocodileAgent	University of Zagreb
DeepMaize	Univ. of Michigan
Foreseer	Cork Constraint Computation Centre
Mertacor	Aristotle University of Thessaloniki
MinneTAC	Univ. of Minnesota
Southampton	Univ. of Southampton
TacTex	University of Texas
Tiancalli	Universidad Autónoma de Puebla

Feedback and Other Interesting Agents

All participants have seen the full results, and had an opportunity to fine-tune their responses.

Team	University
RedAgent	McGill University
PSUTAC	Pennsylvania State University
PhantAgent	Politehnica University of Bucharest

Key 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 try to manipulate the game environment.

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.

Survey Results

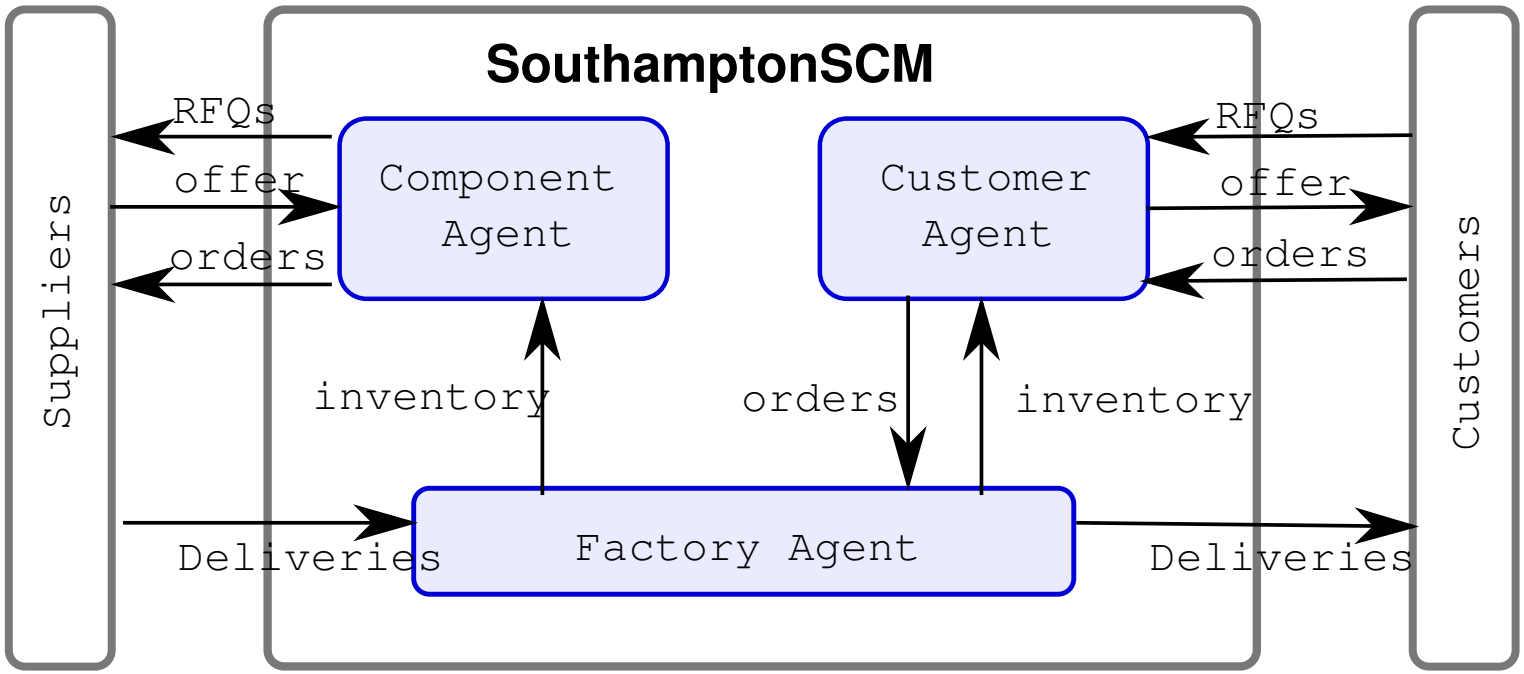
Research Agenda	Architectural Emphasis
Constraint optimization	3rd party packages Internal optimization methods
Machine learning	External analysis framework 3rd party packages
Dynamic supply-chain	Flexibility
Scalability	Distributed Computation
Architecture	IKB model for physical distribution Blackboard architecture with evaluators Knowledge architecture w/ central repository Sequence of internal market places
Empirical game theory	External analysis framework
Decision coordination	Modularity
Dealing with uncertainty	Modularity Simple heuristics

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.

SouthamptonSCM

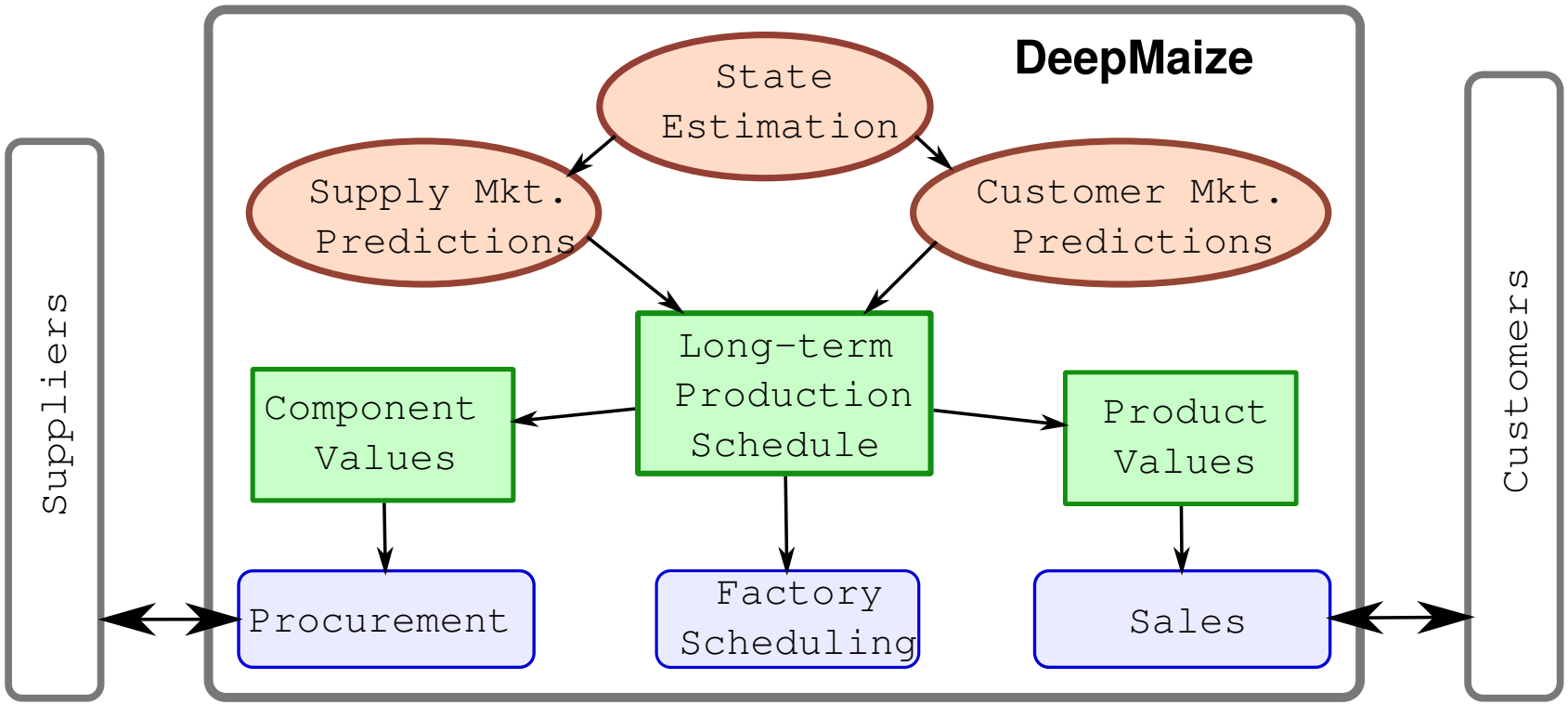
Minghua He, Alex Rogers, Xudong Luo, and Nick Jennings



Coordination through Sales.

DeepMaize

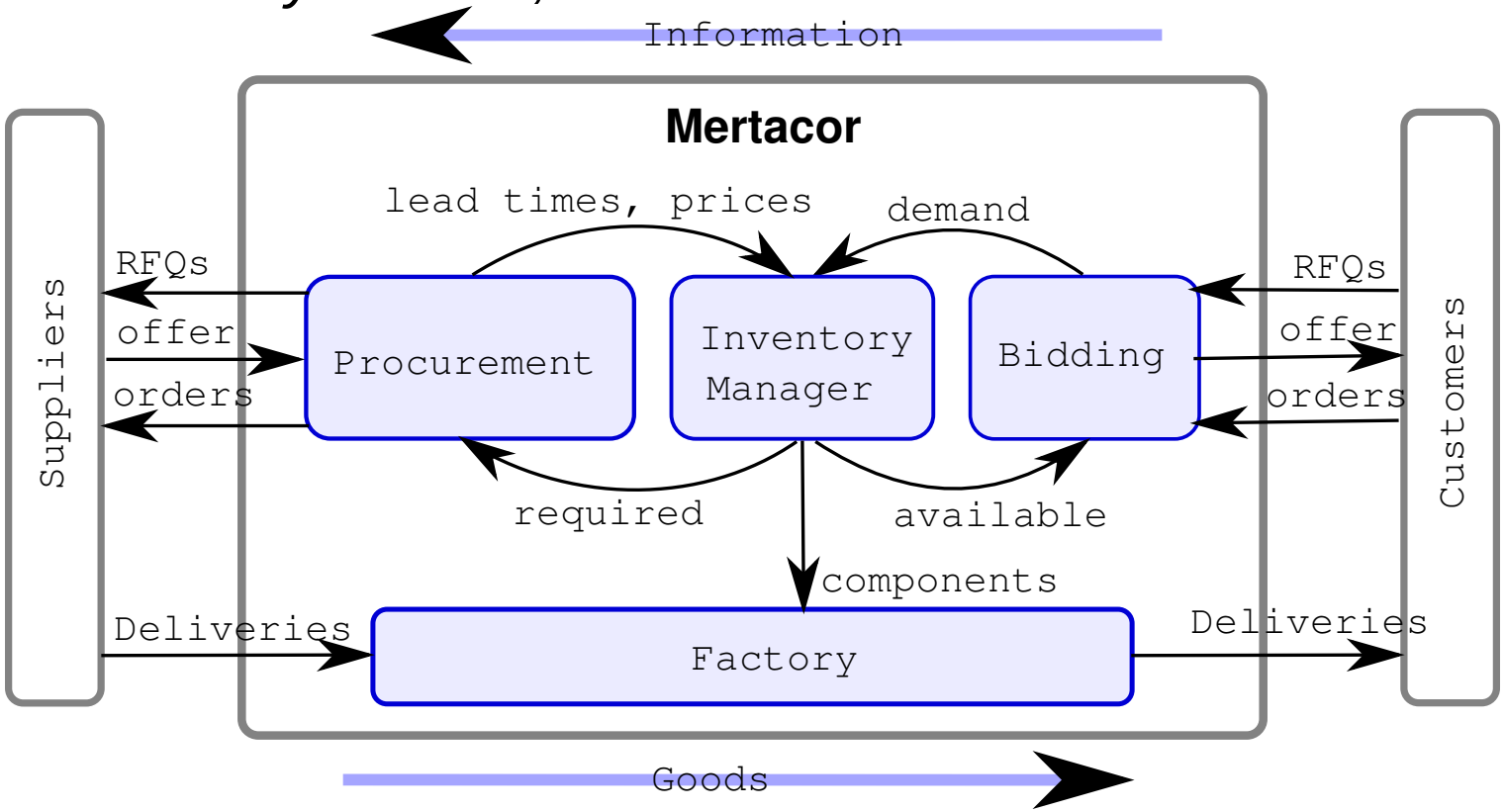
Chris Kiekintveld, Jason Miller, Patrick Jordan, and Michael Wellman



Coordination through production schedule, using value-based decomposition.

Mertacor

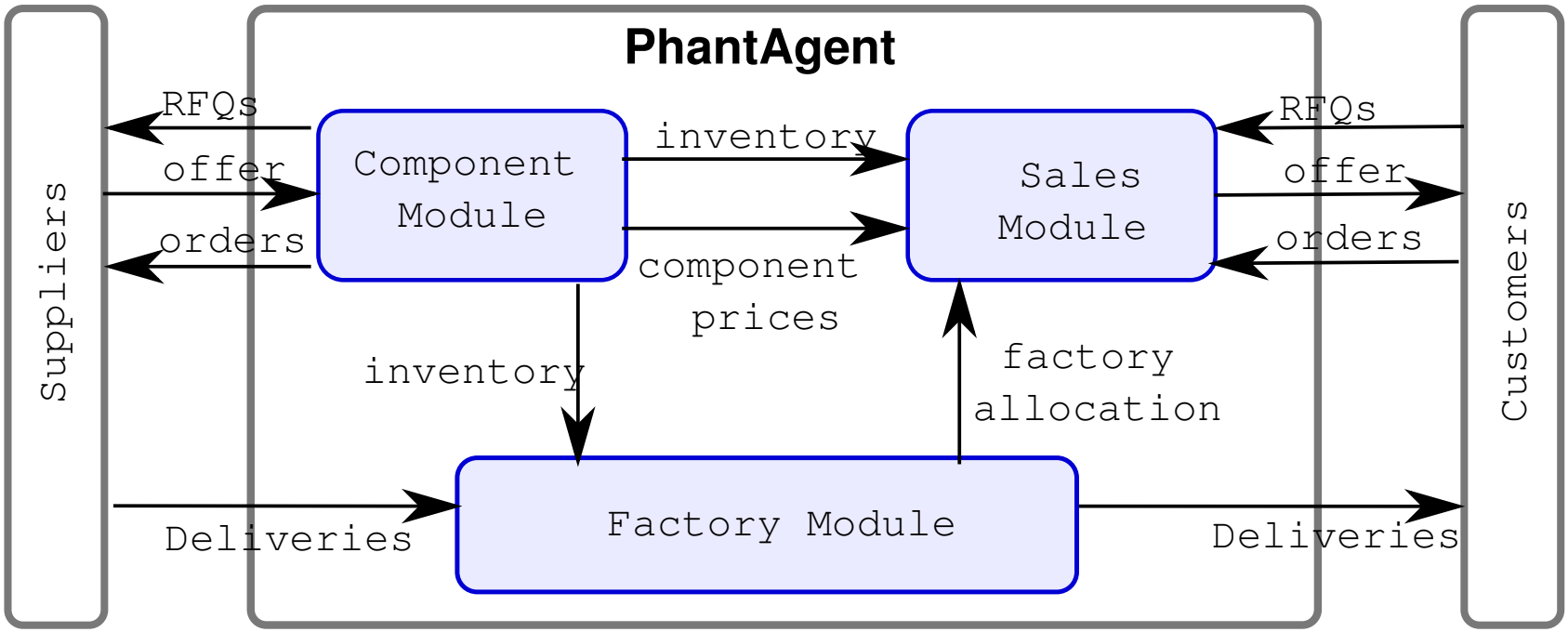
Ioannis Kontogounis, Kyriakos Chatzidimitriou, Andrew Symionidis, and Pericles Mitkas



Coordination through the Inventory Manager.

PhantAgent

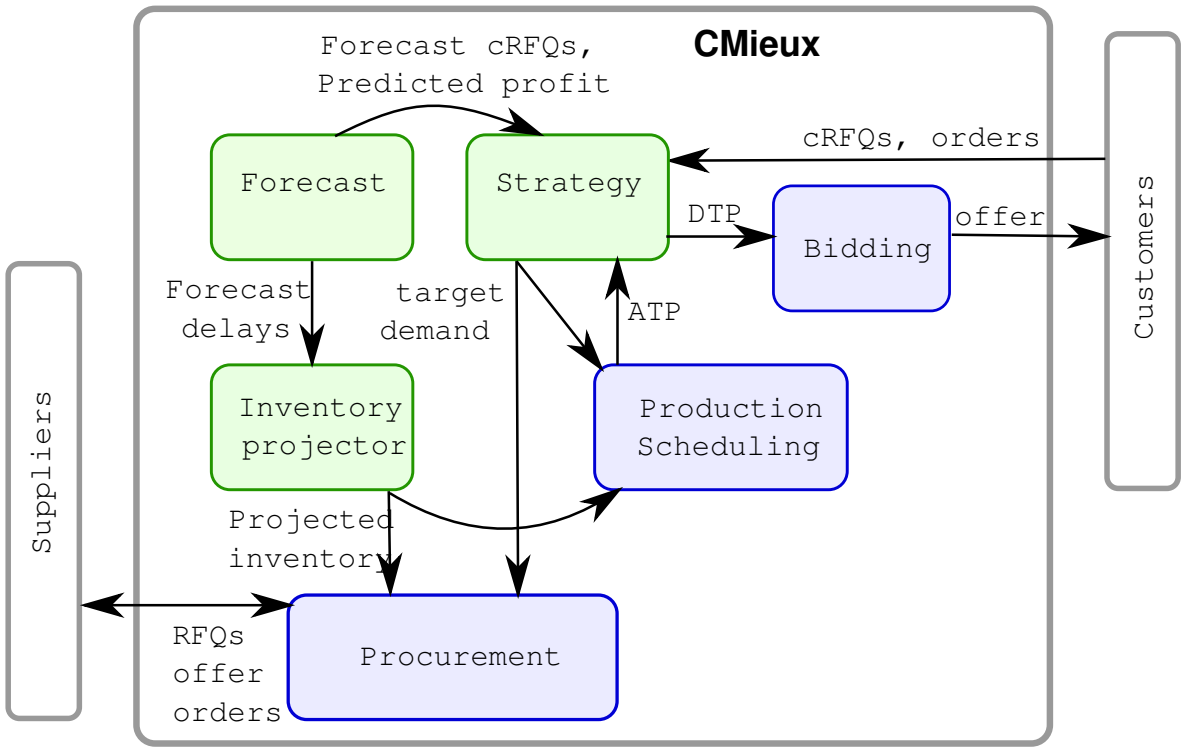
Mihai Stan, Bogdan Stan and Adina Magda Florea



Coordination through inventory management.

CMieux

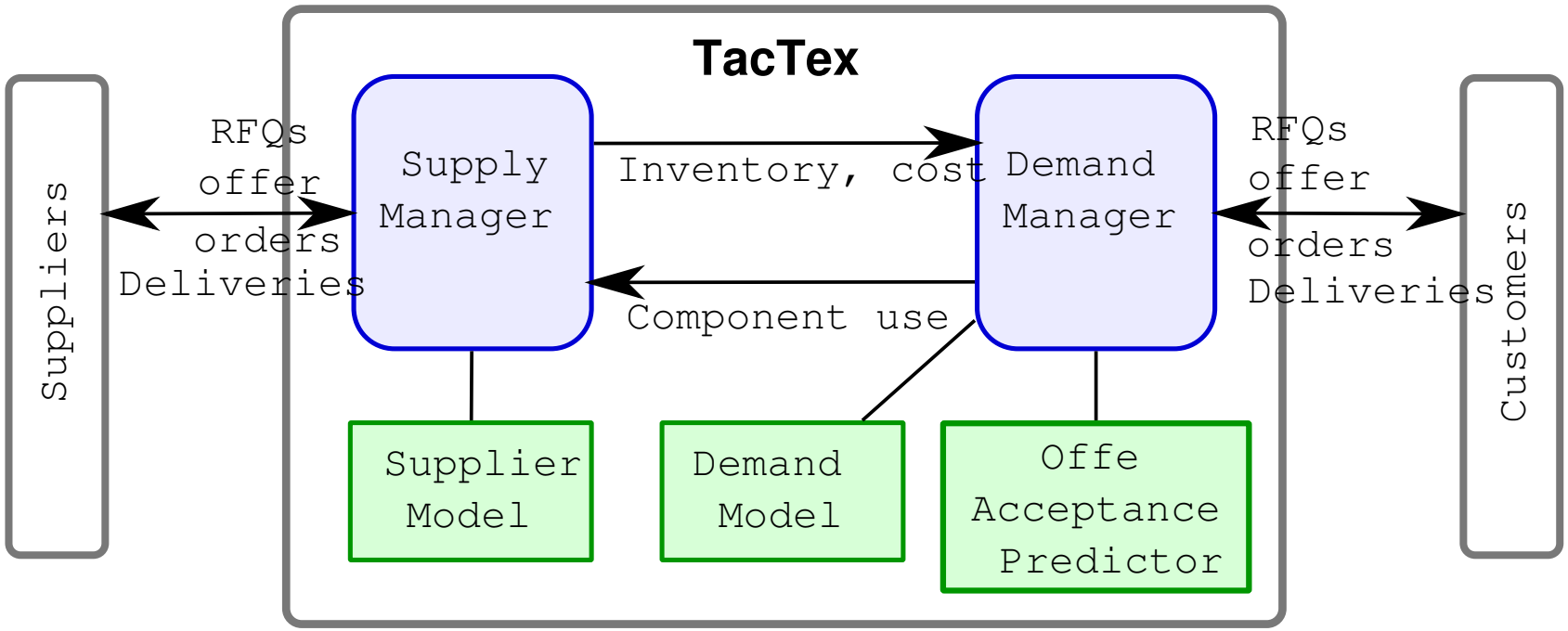
Michael Benisch, Alberto Sardinha, James Andrews and Norman Sadeh



Coordination by central strategy module.

TacTex

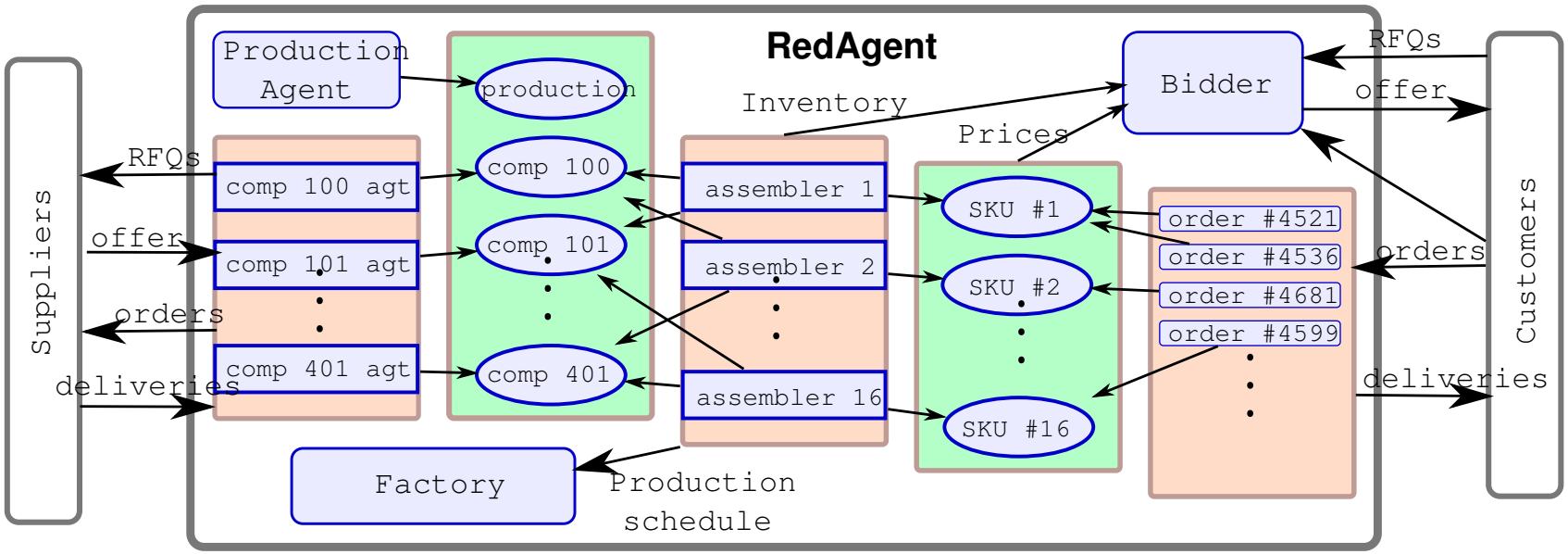
David Pardoe, Peter Stone, and Mark VanMiddlesworth



Coordination by communication of inventory, cost, and projected usage data.

RedAgent

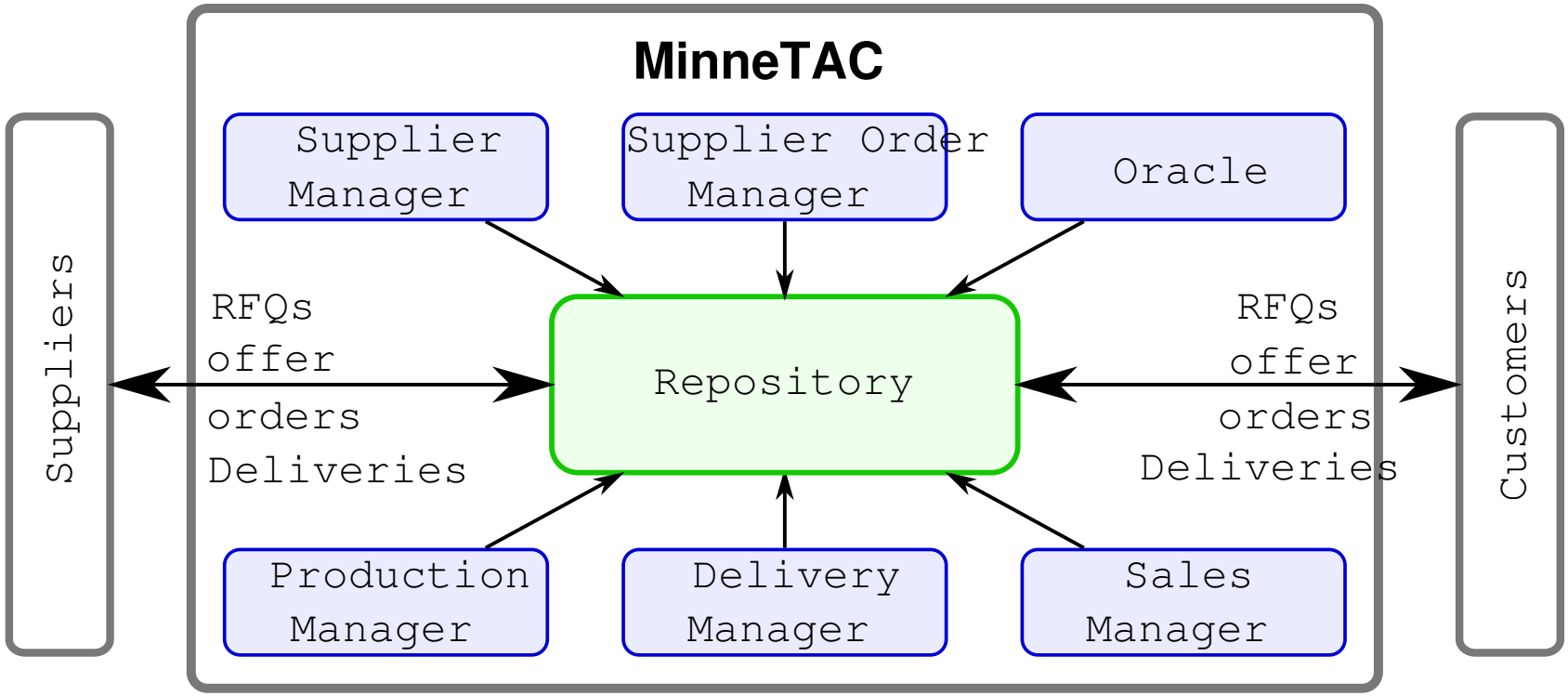
Philipp Keller, Felix-Olivier Duguay, and Doina Precup



Coordination through a sequence of internal markets.

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.

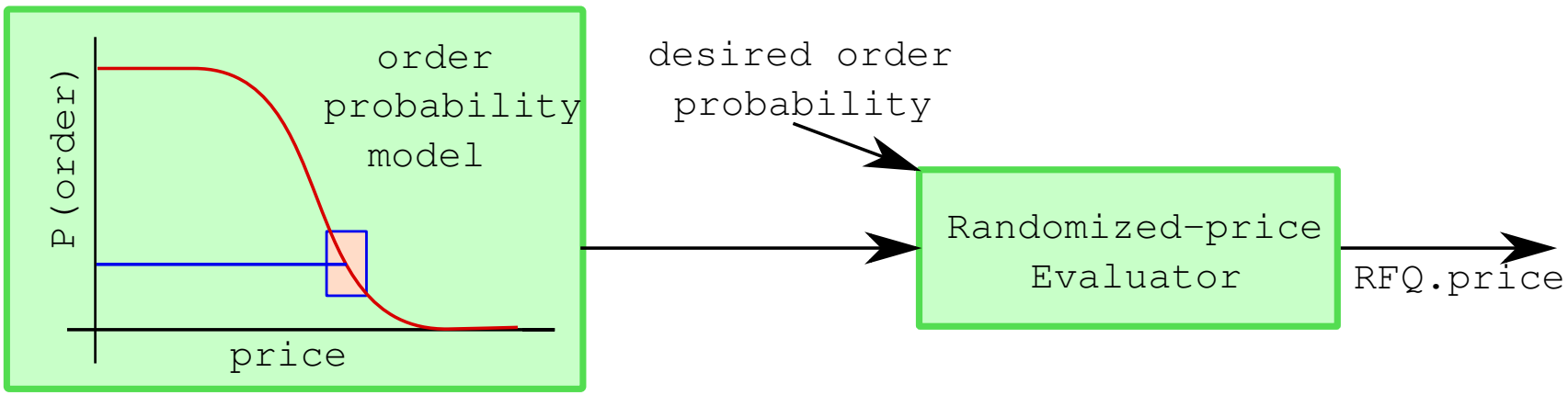
A typical evaluator

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.

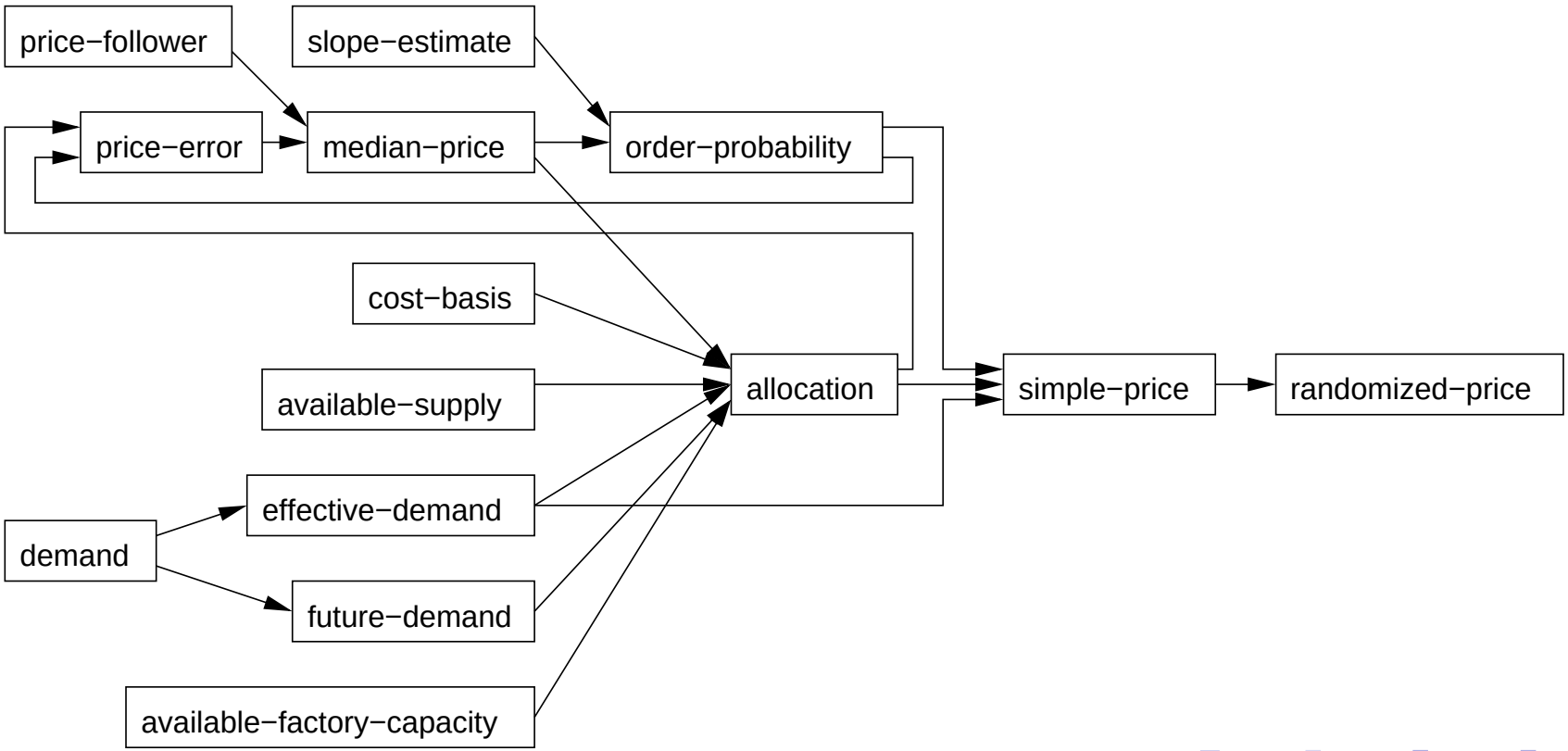
Pricing customer offers

- 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.



MinneTAC
Example evaluator chain

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



Conclusions

- Autonomous, utility-maximizing agents will become increasingly important in online market environments.
- Interesting market environments are dynamic and uncertain.
  - At best we can maximize utility only in expectation.
  - At worst, we face difficult combinatorial problems that defy optimal solution.
- TAC SCM agents must coordinate internal operations with activity in multiple markets.
- A wide variety of design approaches have been tried.
- There is no apparent correlation between agent design complexity and tournament performance.

Future Work

- Repeat survey in 2 to 3 years to compare results, and measure progress.
- Can we find the agent “brick?”

Acknowledgements

Many thanks to the TAC SCM community and especially to all the participants in this survey for the detailed and insightful feedback!

TAC SCM Design Questionnaire

1. Which team do you represent? What has been your role on the team?
2. What are the main goals of your design apart from winning the game?
3. What are your organizing design principles (architectural style, major modules and responsibilities)?
4. What are the strengths and weaknesses of your design? In other words, what is easy and what is hard to do given your design? To what extent do you feel your design has met your goals?
5. If you have been in the competition for more than two years, have you made significant changes in your design and why?
6. Does your design represent a significant departure from the Agentware package?
7. Which significant 3rd party packages have you used, e.g. Weka, CPlex, Apache Excalibur, Jade, etc.?
8. Have you based your design on a publicly-available agent design, like TacTex, GeminiJK, or MinneTAC?
9. Have you published information about your agent design? If yes, where?

Detailed Survey Results

Research Agenda	Team	Architectural Emphasis
Constraint optimization	B, CM, F, MT	3rd party packages
	CM, DM	Internal optimization methods
Machine learning	CM, DM, MT, TT	External analysis framework, 3rd party packages
Dynamic supply-chain	CM, F, M, T	Flexibility
Scalability	CA	Distributed Computation
Architecture	CA	IKB model for physical distribution
	MT	Blackboard architecture with evaluators
	P	Knowledge-based architecture with central repository
	R	Sequence of internal market places
Empirical game theory	DM	External analysis framework
Decision coordination	CM, DM, M, PA, R, S	Modularity
Dealing with uncertainty	B, F, S, MT	Modularity
	PA	Simple heuristics