Intelligent e-Supply Chain Decision Support

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Outline

- Supply Chain Management: New Context
- Agent-Based Collaborative Decision Support
  - ◆ Mascot
- Available-To-Promise/Capacity-To-Promise Functionality
- Empirical Results
- Dynamic Supply Chain Management Practices
  - ◆ Early Results
  - ◆ TAC'03: A Supply Chain Trading Competition
- Summary and Concluding Remarks

Supply Chain Management

- Planning and coordinating procurement, production and distribution activities
  - From raw material suppliers to manufacturers …to distribution centers …to retailers and consumers
- Trillions of dollars annually
- Good practices directly impact the competitiveness of companies
  - Timely and cost-effective delivery of products to customers
  - Extends to product design and configuration

Why is SCM Difficult?

- Involves multiple organizations
- Each organization tries to satisfy multiple objectives
  - Cost, timeliness, quality, market share, etc.
- Each organization operates subject to:
  - Internal Considerations:
    - Finite capacity, existing inventory, etc.
  - External Considerations
    - Available suppliers and their capacities, order quantities and due dates, contractual arrangements, transportation constraints, etc.
- Numerous sources of uncertainty
  - Capacity, supplies, demand, etc.

Historical Perspective

Functional Silos

Purchasing — Inventory Control — Production — Sales — Distribution

Enterprise Integration

Suppliers — Materials Management — Manufacturing Management — Distribution — Customers

Supply Chain Integration

Suppliers — Internal Supply Chain — Customers

Dynamic Internet-enabled Supply Chain

e-Commerce
e-Markets/Exchanges
e-Supply Chains

Buyers/Sellers — Buyers/Sellers — Buyers/Sellers — Buyers/Sellers

Beyond the Early eMarket Hype

- Dynamic business practices are mainly confined to MRO
- Suppliers don't like being evaluated solely based on price
    - Covisint, E2open exchanges: more emphasis on supporting collaboration
    - Requires richer environments
        - Multiple attributes – not just price
    - Lack of adequate standards
- Lack of adequate decision support tools
    - Evaluate a large number of options
- Standardization efforts are taking time

Some Open Research Issues

- Long vs. Short term contracts
- Information exchange
- Collaborative decision support
- Multi-attribute negotiation
- Peer-To-Peer/local view vs. more lobal view
  - ◆ <u>P2P Challenge</u>: Coordinating negotiation across multiple tiers
  - ◆ <u>Challenge for the Global View</u>:
    - ◆ Creating the right incentives for information sharing
    - ◆ How global? How often do you clear? etc.
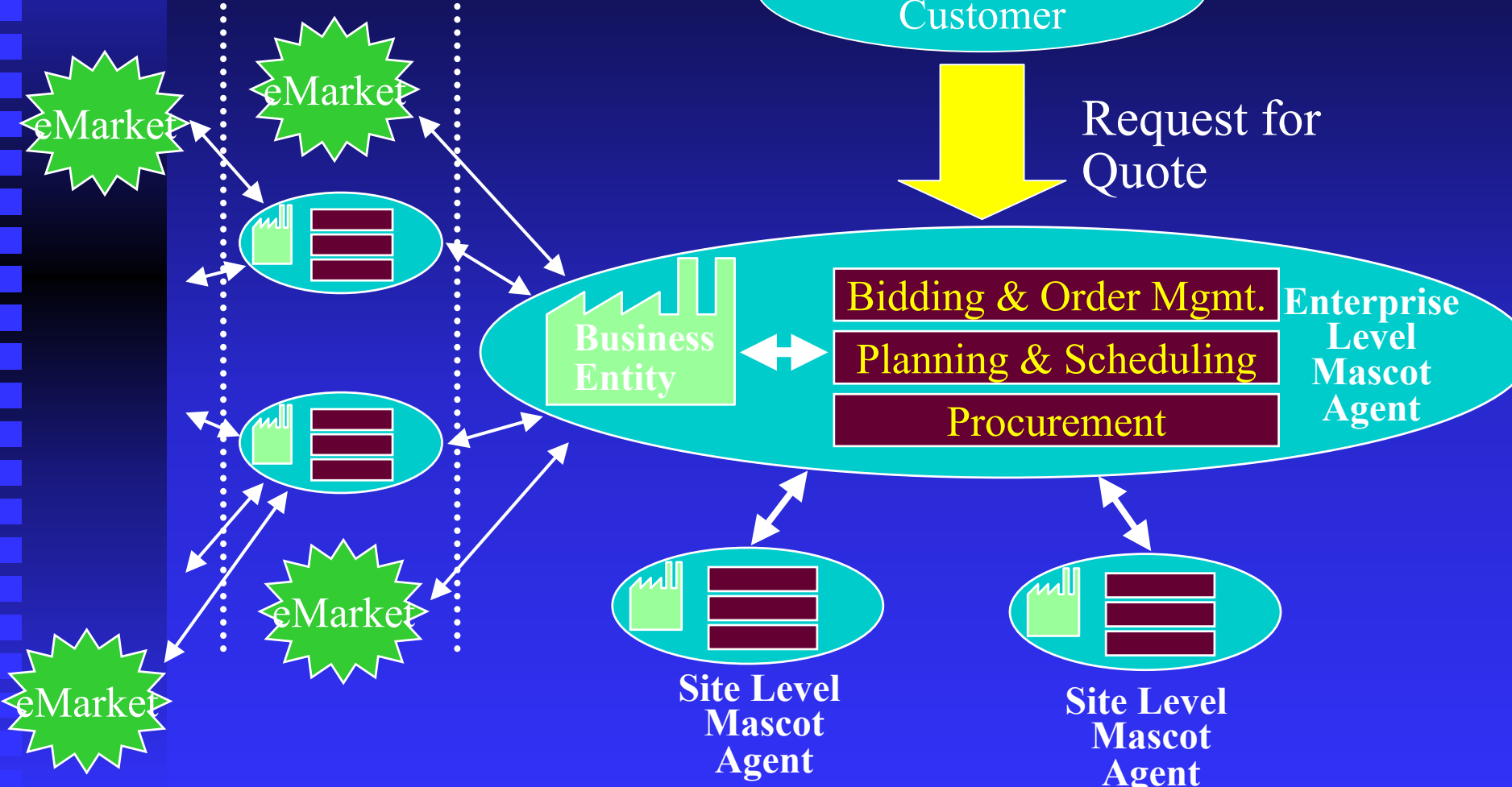
MASCOT: Collaborative Decision Support

- Decisions are evaluated in collaboration with potential business partners

- Supply chains can be dynamically set up in response to changing market requirements

- Emphasis on Mixed Initiative Decision Support
  - Don't try to automate everything!

MASCOT Supply Chain Agent

Tier 1 Suppliers

eMarket

eMarket

eMarket

eMarket

Prospective Customer

Request for Quote

Business Entity

Bidding & Order Mgmt.

Planning & Scheduling

Procurement

Enterprise Level Mascot Agent

Site Level Mascot Agent

Site Level Mascot Agent
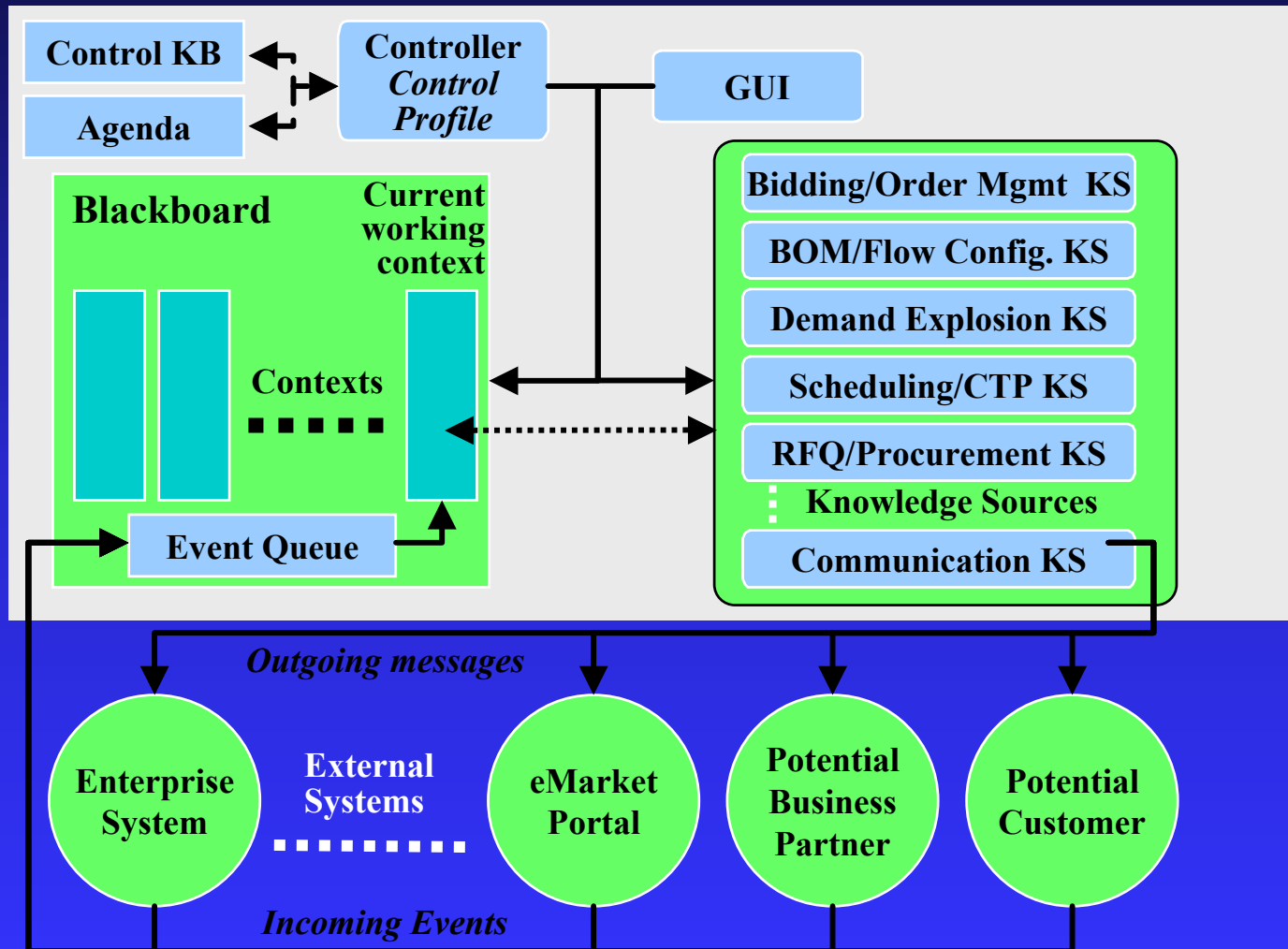
MASCOT: Overall Objectives

- Leverage benefits of finite scheduling
- Rapid and accurate evaluation of partner-dependent decisions :
    - Bids & Requests for Quotes
        - including real-time ATP/CTP
    - Alternative product/subcomponent designs
    - Make-or-buy decisions
- Customizable mixed-initiative functionality
    - Collaborative solution development, workflow management
- Facilitate integration with legacy systems

A Customizable Agent Wrapper

Control KB

Agenda

Controller *Control Profile*

GUI

Blackboard

Current working context

Contexts

Event Queue

Bidding/Order Mgmt KS

BOM/Flow Config. KS

Demand Explosion KS

Scheduling/CTP KS

RFQ/Procurement KS

Knowledge Sources

Communication KS

Outgoing messages

Enterprise System

External Systems

eMarket Portal

Potential Business Partner

Potential Customer

Incoming Events

Main Architectural Features

- Blackboard Contexts: "What-if"
  - ◆ Different assumptions (e.g. demand, resources, suppliers) and different solutions
  - ◆ Unresolved issues
- Extensible set of Knowledge Sources (KSs)
  - ◆ Allows for modular & reusable KSs
  - ◆ Provides for easy integration with legacy systems
- Mixed Initiative Control
  - ◆ Customizable user profile

Unresolved Issues

- Help keep track of incomplete, inconsistent and unsatisfactory aspects of a context solution
  - ◆ Examples: unprocessed RFQ, insufficient availability of supplies, missed prior delivery commitment
- Automatically updated as the solution is modified
- Supports flexible mixed initiative workflow management
  - ◆ Associated with KS activations, scripts and goals

Three Levels of Problem Solving

- **Knowledge Source Activations**
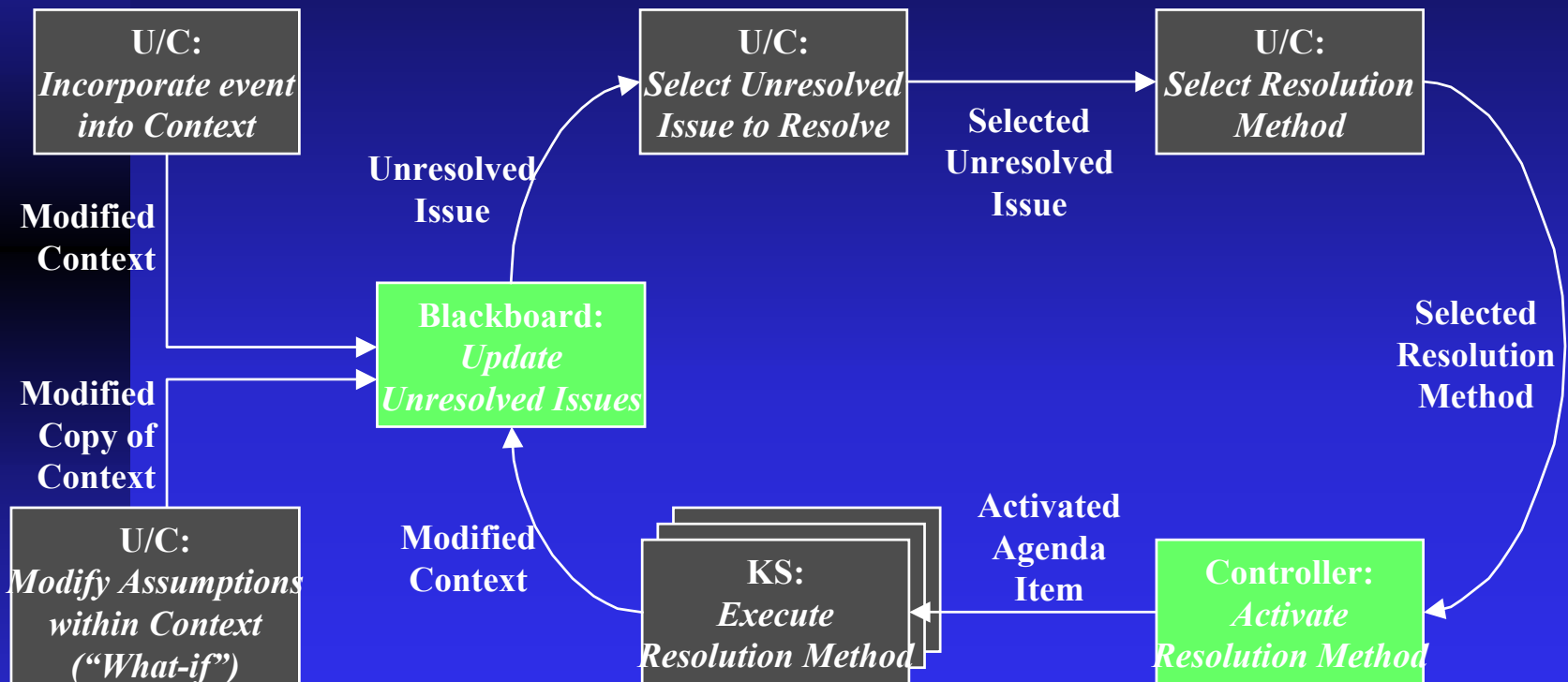 - ◆ e.g. Demand Explosion (RFQ1)
- **Scripts**
  - ◆ e.g. Evaluate (RFQ1)

  > 1. Copy_Current_Context
  > 2. Incorporate(RFQ1)
  > 3. Demand_Explosion (RFQ1)
  > 4. Reoptimize_Schedule_with_Net_Demand (RFQ1)
  > 5. Procure_Subcomponents_Net_Demand(RFQ1)
  > 6. etc.

- **Goals:** Search among multiple options
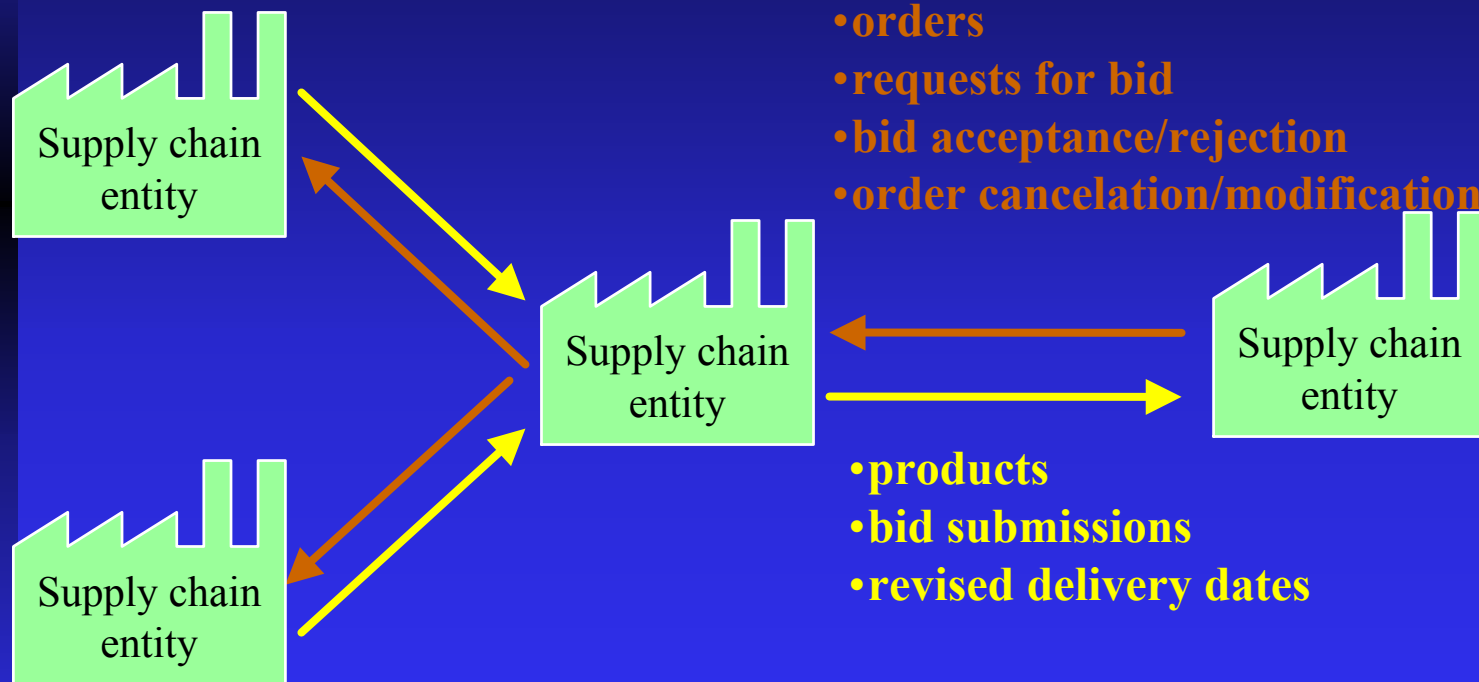
Mixed Initiative Workflow Management

U/C: *Incorporate event into Context*

Modified Context

Modified Copy of Context

U/C: *Modify Assumptions within Context ("What-if")*

Blackboard: *Update Unresolved Issues*

Unresolved Issue

U/C: *Select Unresolved Issue to Resolve*

Selected Unresolved Issue

U/C: *Select Resolution Method*

Selected Resolution Method

Modified Context

KS: *Execute Resolution Method*

Activated Agenda Item

Controller: *Activate Resolution Method*

U/C = User or Controller

Status

- Customized to support coordination between a machine shop and a tool shop at Raytheon
  - Over 150 machine centers & over 100 people
  - 50% of incoming orders require new tools
    - alternative BOM & process planning options
  - Reduced tardiness by 23 percent
    - Integration of process planning & scheduling
    - Tighter coordination
- Used to study the benefits of different supply chain coordination policies and different order promising policies

Dynamic Supply Chain Coordination

Supply chain entity

Supply chain entity

Supply chain entity

Supply chain entity

Supply chain entity

•**orders**
•**requests for bid**
•**bid acceptance/rejection**
•**order cancelation/modification**

•**products**
•**bid submissions**
•**revised delivery dates**

The Coordination Challenge

- Generate robust yet competitive and cost-effective promise dates
  - Multi-tier "capacity-to-promise" functionality
- Sources of uncertainty are both internal and external
  - incoming orders, supplies, internal capacity, etc.
- Is it possible, through dynamic coordination, to reap the benefits of finite scheduling, while offsetting the brittleness of its solutions ?

Real-Time Promising(RTP): General Considerations

- **Net Demand**: Inventory Allocation & Demand Explosion
- Scheduling
  - Available vs. modified capacity
  - Schedule around prior commitments vs. reoptimization
  - Schedule Reoptimization
    - Assess impact on prior commitments
    - Costs & Priorities: order priorities, late delivery penalties, inventory costs, etc.
    - Other Tradeoff: Speed versus "optimality"
- Assess desirability & decide whether to submit quote
- Micro-Boss RTP module: real-time reoptimization - user specifies desired response time (Sadeh et al. '94-99)

RTP: Further Refinements

- Profitable-To-Promise
- Selective RTP Validation

Profitable-To-Promise

- *Overall Profit = Total_Revenue - Total_Costs*
    - *Total_Revenue:* Sum over all orders
    - *Total_Costs:* Production costs, inventory costs (raw materials, in-process, finished goods), late delivery penalties, etc.
    - Takes into account impact on prior commitments
        - e.g. late delivery penalty when another order gets bumped
- Bid only if overall profit increases
    - Other variations can be considered
        - e.g. strategic customers, market share considerations

Empirical Study: Multiple RFQ Processing Policies

- **Response:**
  - ◆ Always bid - no due date negotiation
  - ◆ Only submit a bid if overall profit increases
  - ◆ Bid conditional on acceptance of possibly relaxed promise date
- **Capacity-To-Promise Computation**
  - ◆ Leadtime-based
  - ◆ Local finite capacity scheduling & supply leadtimes
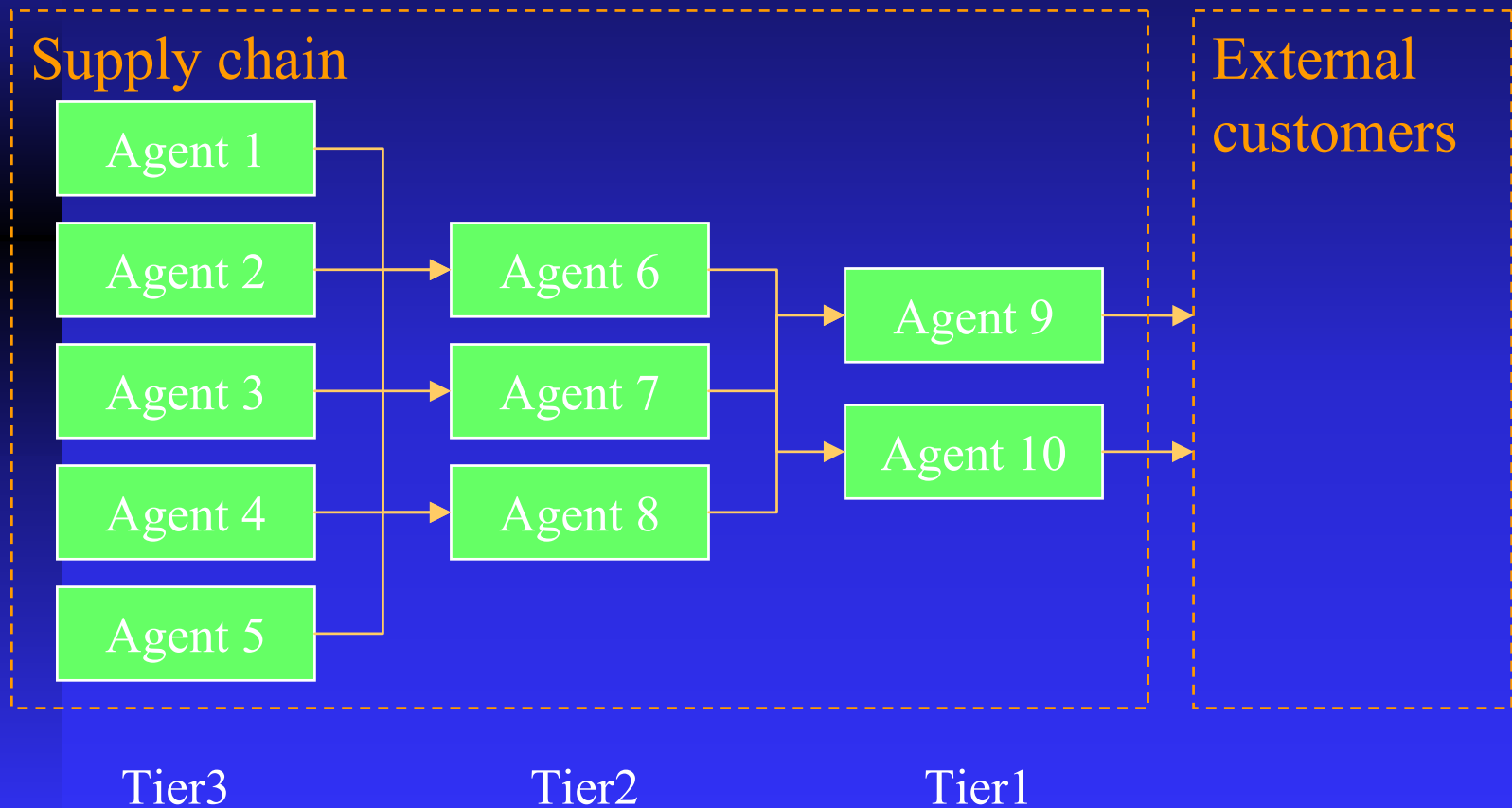 - ◆ Coordinated finite capacity scheduling

Empirical Study: Assumptions

- A lot-for-lot make-to-order environment

- Internal sources of uncertainty at each tier due to resource breakdowns and variations in processing times

- Stochastic order arrival

- Finite capacity schedules regenerated daily

  - Micro-Boss scheduling system

  - JIT objective: minimize sum of tardiness & inventory costs

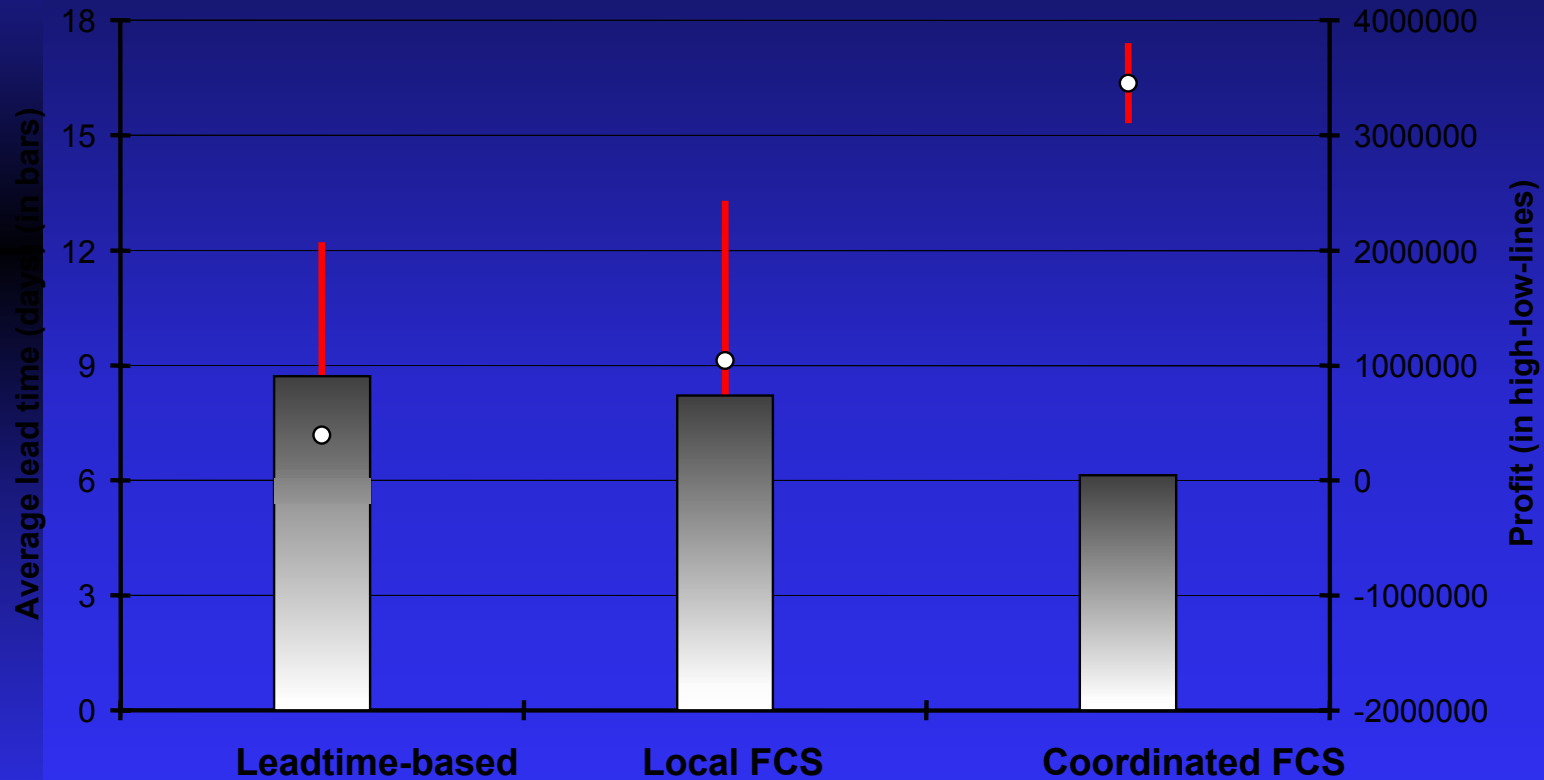- Execution priority in accordance with the latest released schedule

Evaluation Criteria

- Number of bids refused or rejected

- Number of tardy orders

- Average utilization of the most utilized resource

- Average supply chain leadtimes

- Average due-date adjustment (as part of bid negotiation)

- Profit (sales revenue minus costs)

  - Total in-system inventory costs (WIP and finished goods)

  - Total tardiness costs

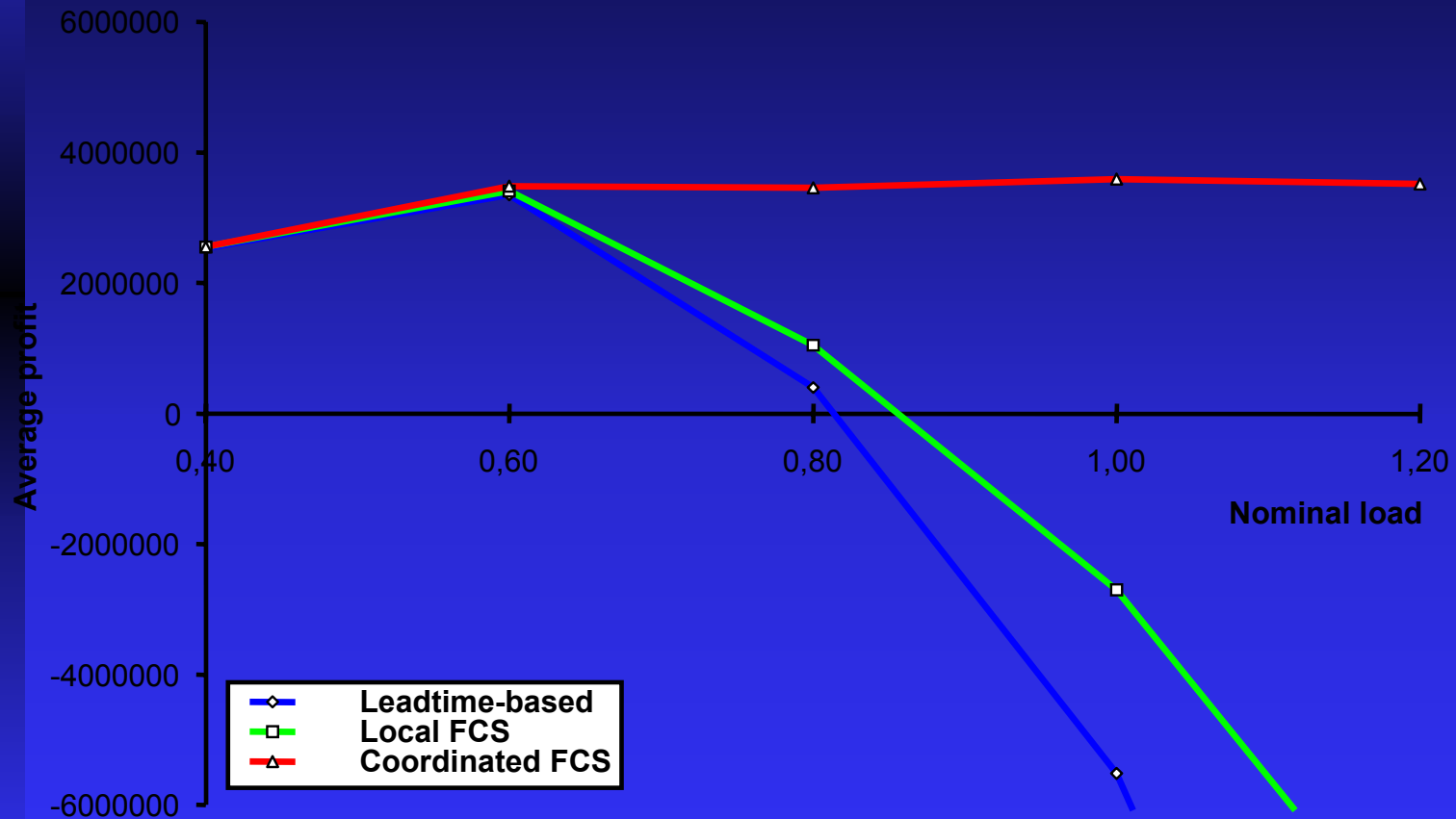- Promise date accuracy

Basic Supply Chain Configuration

Supply chain

External customers

| Agent 1 |
| Agent 2 | → | Agent 6 |
| Agent 3 | → | Agent 7 | → | Agent 9 | →
| Agent 4 | → | Agent 8 | → | Agent 10 | →
| Agent 5 |

Tier3   Tier2   Tier1

Benefits of Dynamic Finite Capacity Coordination

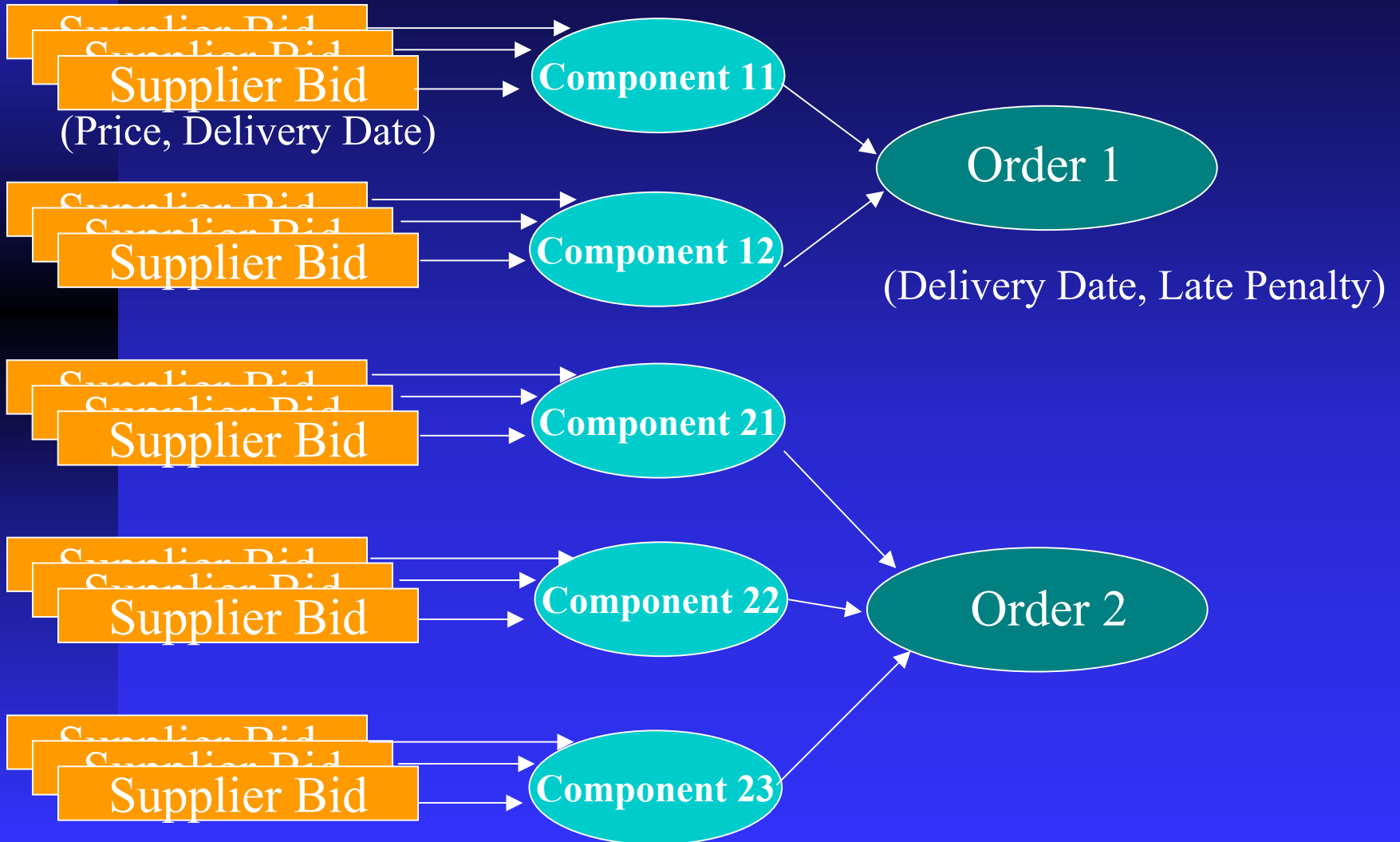*Case with competition and negotiable promise dates*

Benefits of Dynamic Coordination - Contd.

Dynamic Supplier Selection

- A manufacturer has a given set of customer orders to satisfy
- Each order has a required delivery date along with a penalty for missing that date
- The manufacturer's capacity is finite
- Each order requires a number of components for which suppliers have submitted bids
 - Supply bids include a price and delivery date

Supplier Bid Selection

Supplier Bid
Supplier Bid
Supplier Bid
(Price, Delivery Date)

Supplier Bid
Supplier Bid
Supplier Bid

Supplier Bid
Supplier Bid
Supplier Bid

Supplier Bid
Supplier Bid
Supplier Bid

Supplier Bid
Supplier Bid
Supplier Bid

Component 11

Component 12

Component 21

Component 22

Component 23

Order 1

(Delivery Date, Late Penalty)

Order 2

Trading Agent Competition

- TAC Classic: Travel Agent Scenarios
  - About 20 entries in the past
- TAC'03: Supply Chain Trading Competition
  - Agents compete for supplies and demand
  - Fixed Assembly Capacity
  - RFQs from customers – delivery date and tardiness penalty
  - RFQs to suppliers
  - Interests on money borrowed from the bank

A TAC Day
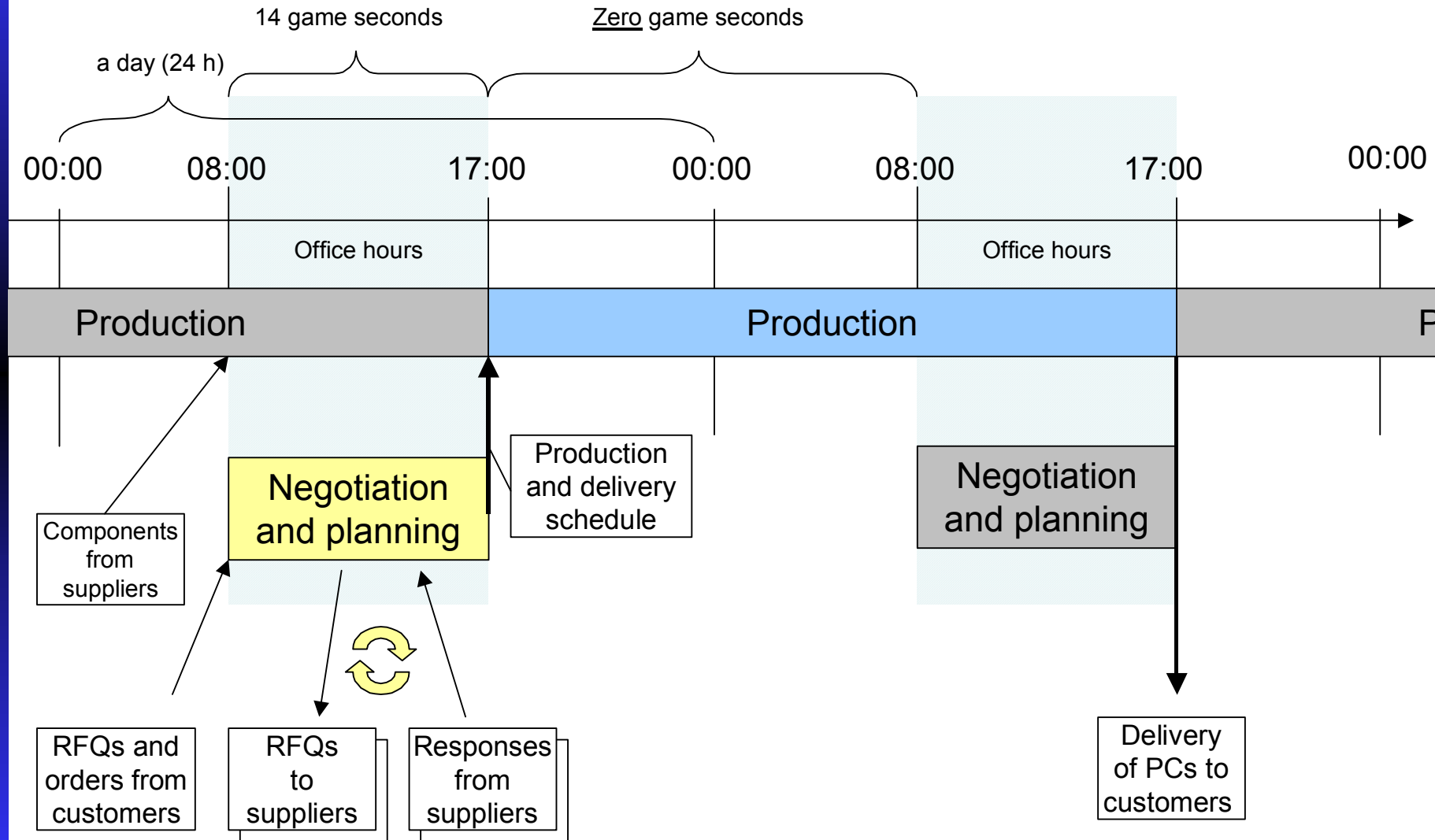
Summary

- e-SCM is about more open and more dynamic business practices
- Mascot:
  - ◆ Rapid evaluation of partner-dependent decisions
  - ◆ Mixed initiative decision support
  - ◆ Coordinated real-time Profitable-To-Promise functionality
- Ongoing work:
  - ◆ Combine e-SCM and multi-attribute negotiation – together with the Univ. of Michigan
  - ◆ Dynamic Supplier Selection
  - ◆ Trading Agent Competition

Q&A

WILEY
TIMELY. PRACTICAL. RELIABLE.

M-Commerce

Technologies,
Services, and
Business
Models

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