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# 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**



**Enterprise Integration**



**Supply Chain Integration**



**Dynamic Internet-enabled Supply Chain**



# 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 global view
  - ◆ P2P Challenge: Coordinating negotiation across multiple tiers
  - ◆ Challenge for the Global View:
    - ◆ 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!

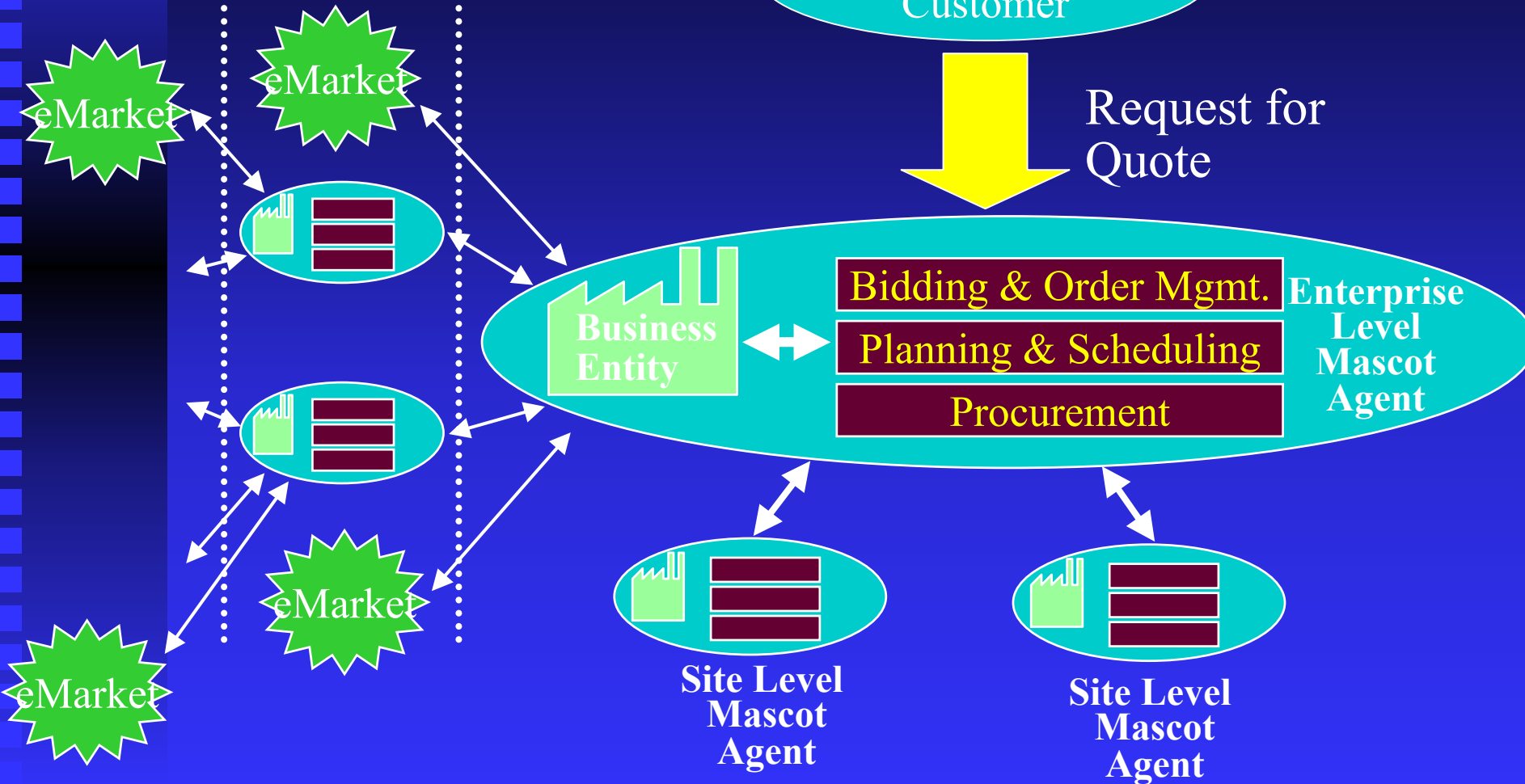


# MASCOT Supply Chain Agent

Tier 1  
Suppliers

Prospective  
Customer

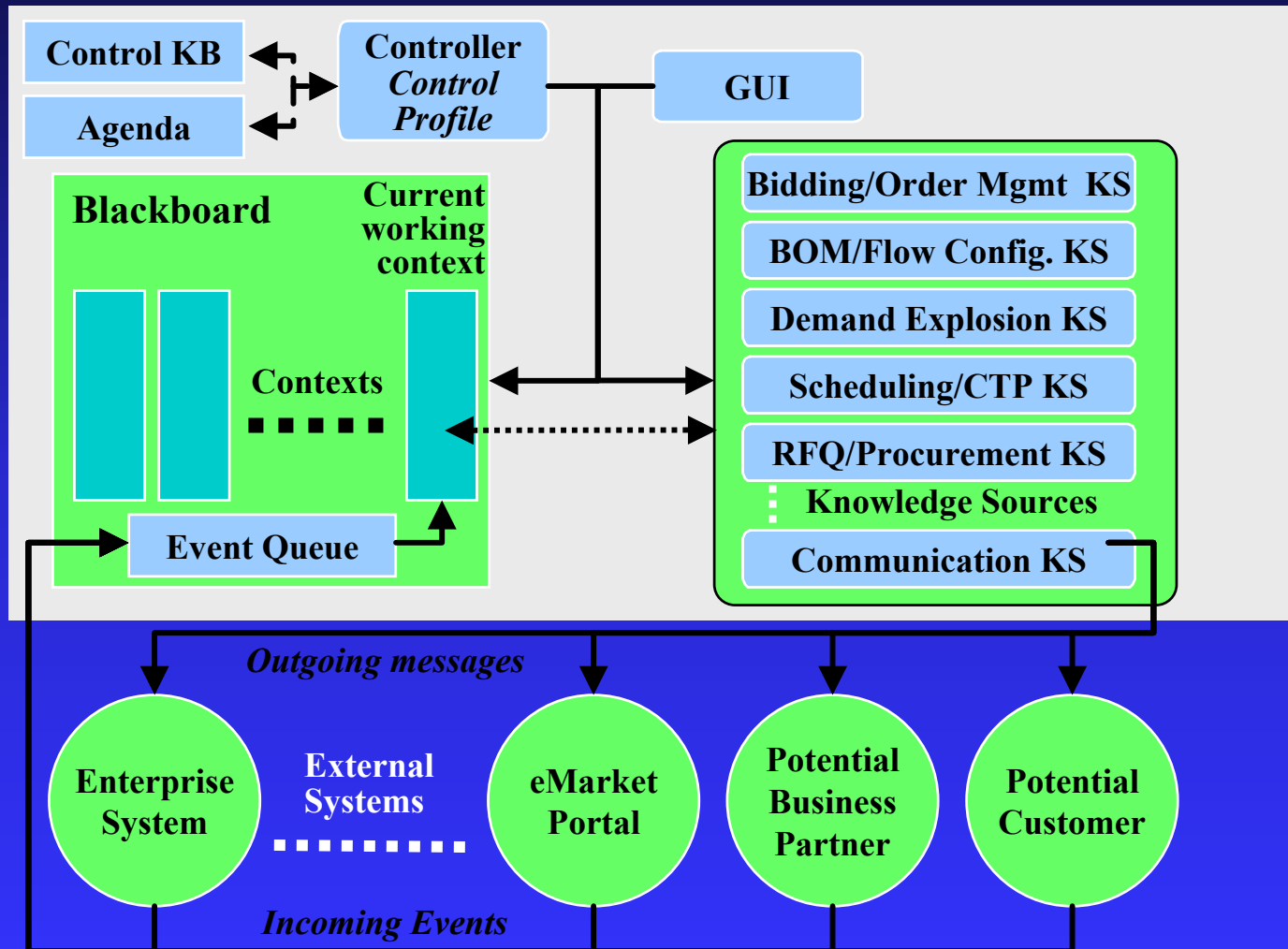
Request for  
Quote



# 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



# 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)

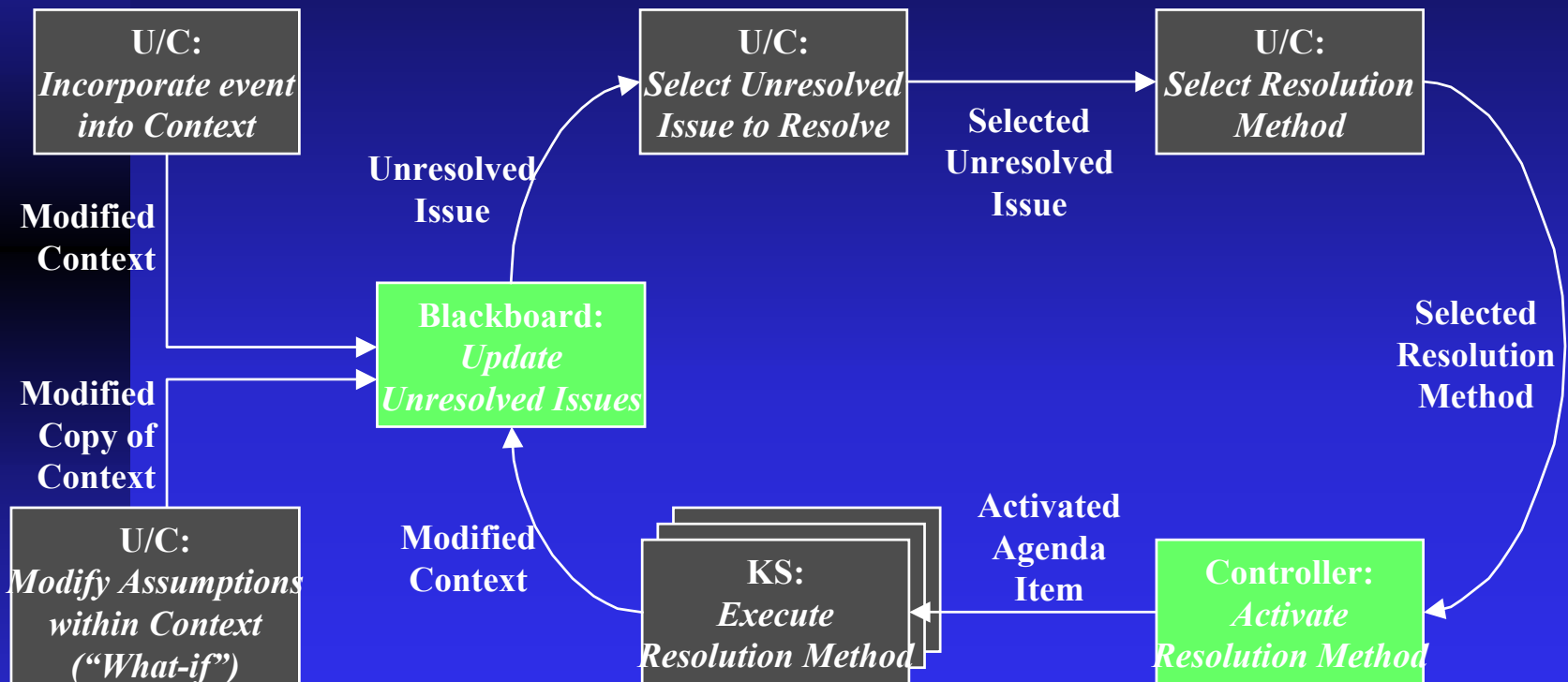
## ■ Scripts

- ◆ 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



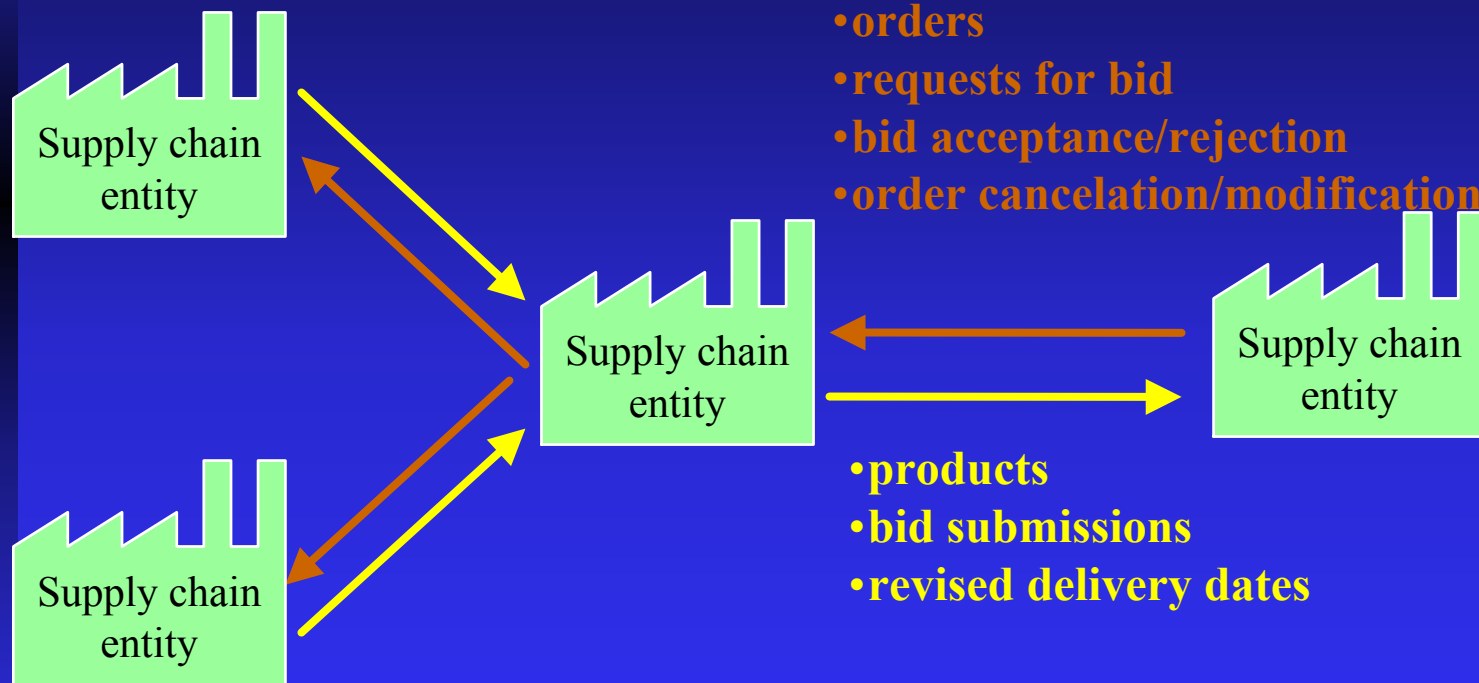
*U/C = User or Controller*

# 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



# 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

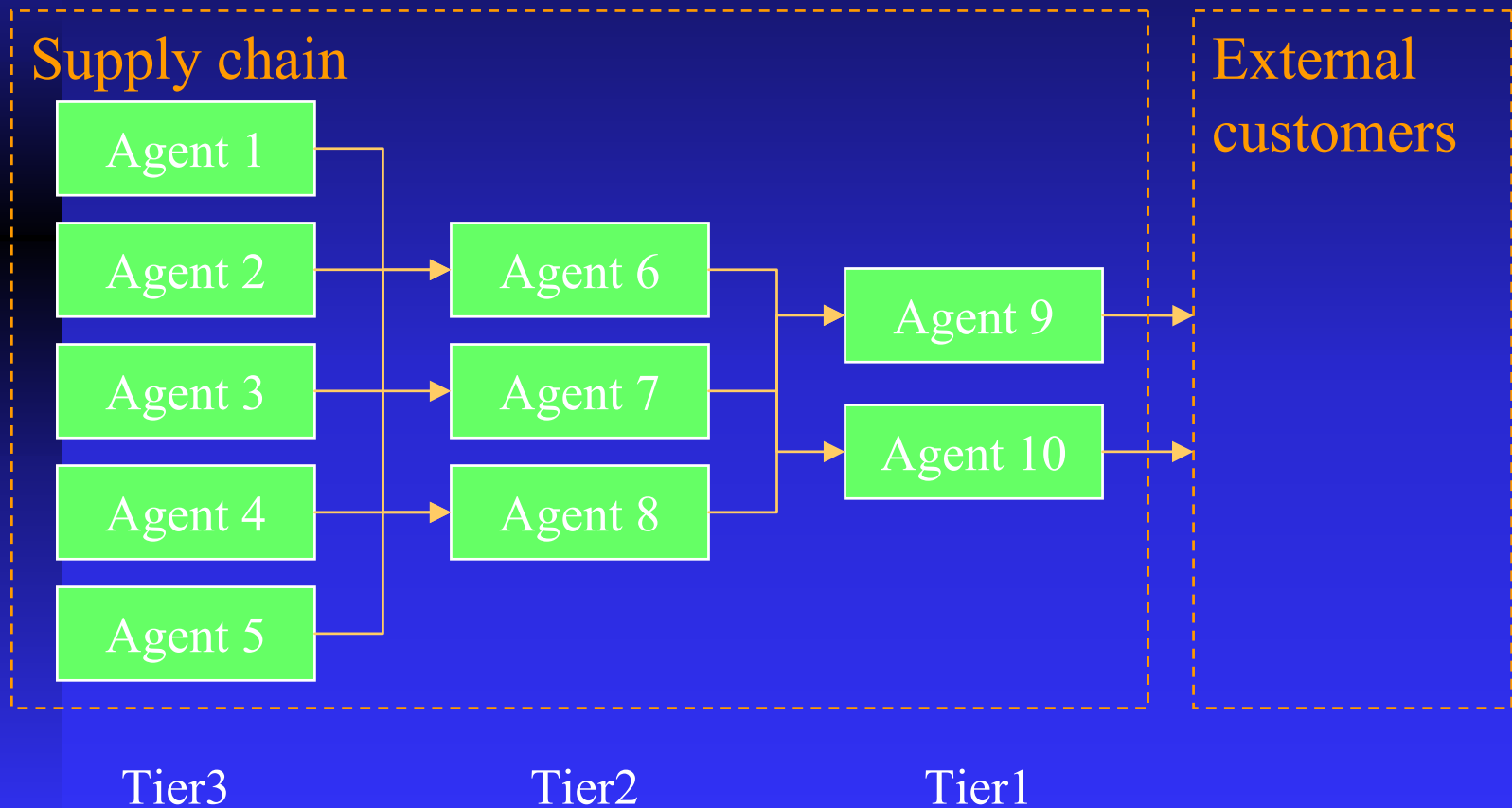
- ◆ A lot-for-lot make-to-order environment
- ◆ Internal sources of uncertainty at each tier due to resource breakdowns and variations in processing times
- ◆ Stochastic order arrival
- ◆ Finite capacity schedules regenerated daily
  - ◆ Micro-Boss scheduling system
  - ◆ JIT objective: minimize sum of tardiness & inventory costs
- ◆ Execution priority in accordance with the latest released schedule

# Evaluation Criteria

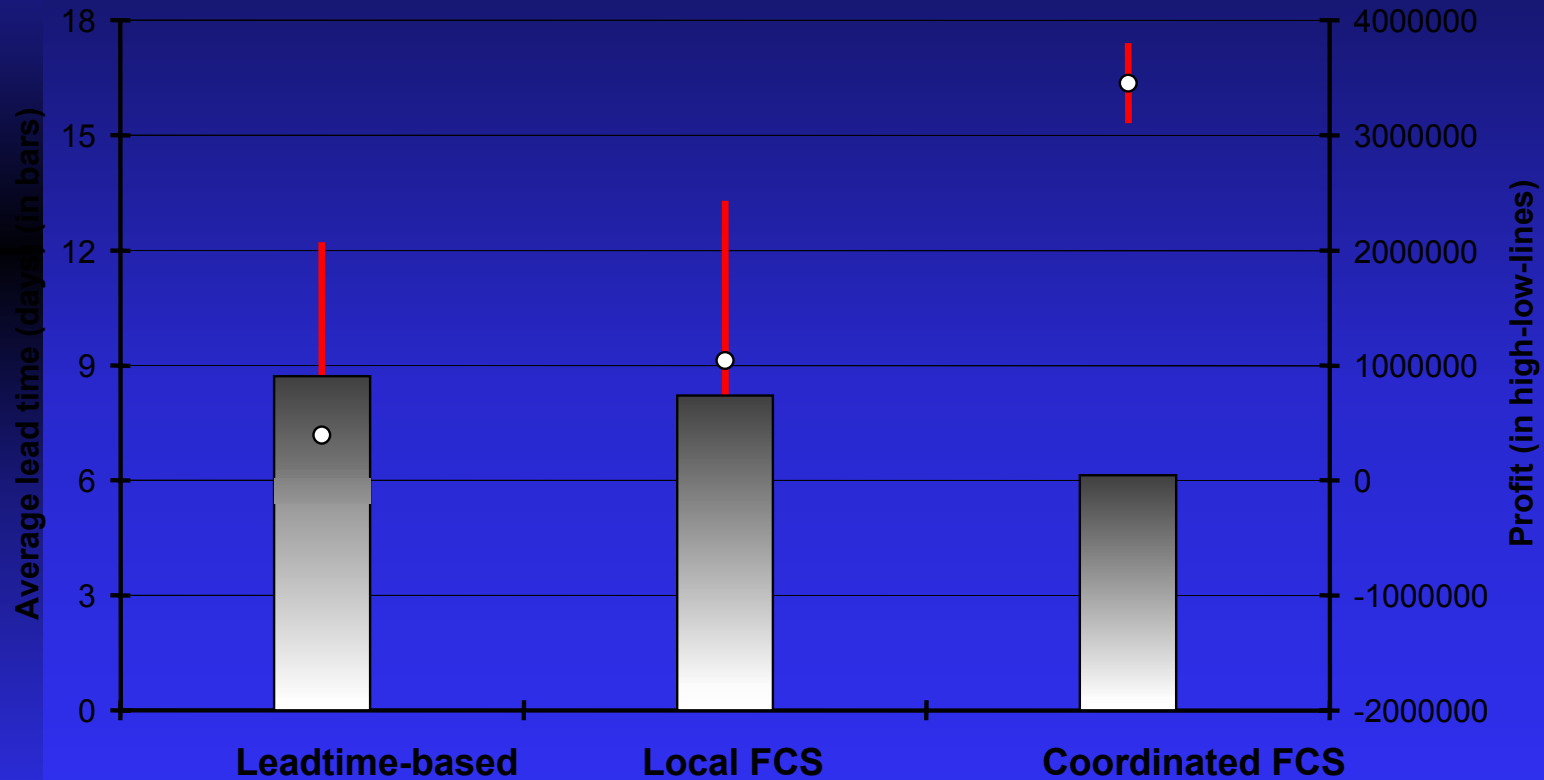
- ◆ Number of bids refused or rejected
- ◆ Number of tardy orders
- ◆ Average utilization of the most utilized resource
- ◆ Average supply chain leadtimes
- ◆ Average due-date adjustment (as part of bid negotiation)
- ◆ Profit (sales revenue minus costs)
  - ◆ Total in-system inventory costs (WIP and finished goods)
  - ◆ Total tardiness costs
- ◆ Promise date accuracy



# Basic Supply Chain Configuration

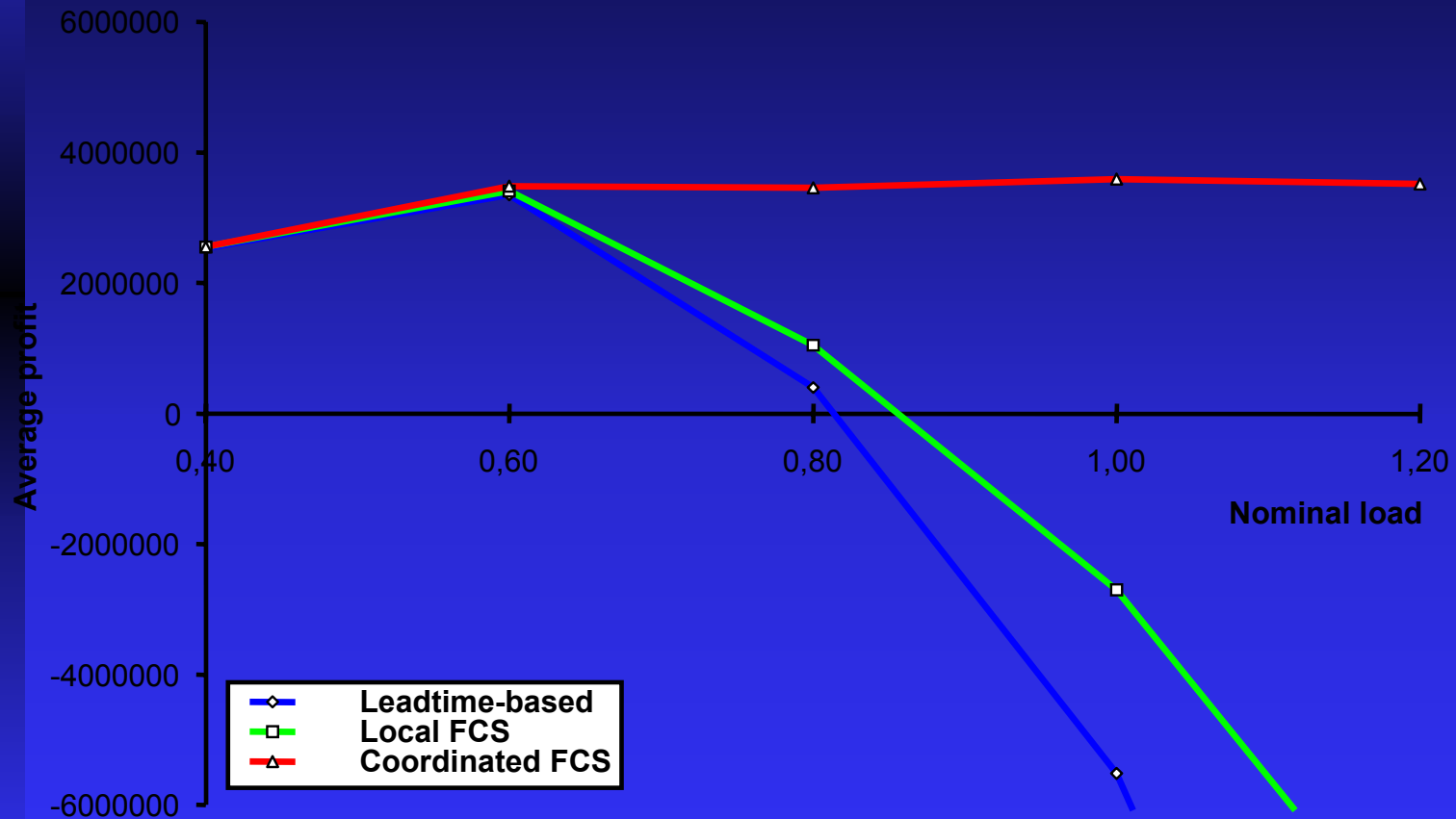


# Benefits of Dynamic Finite Capacity Coordination



*Case with competition and negotiable promise dates*

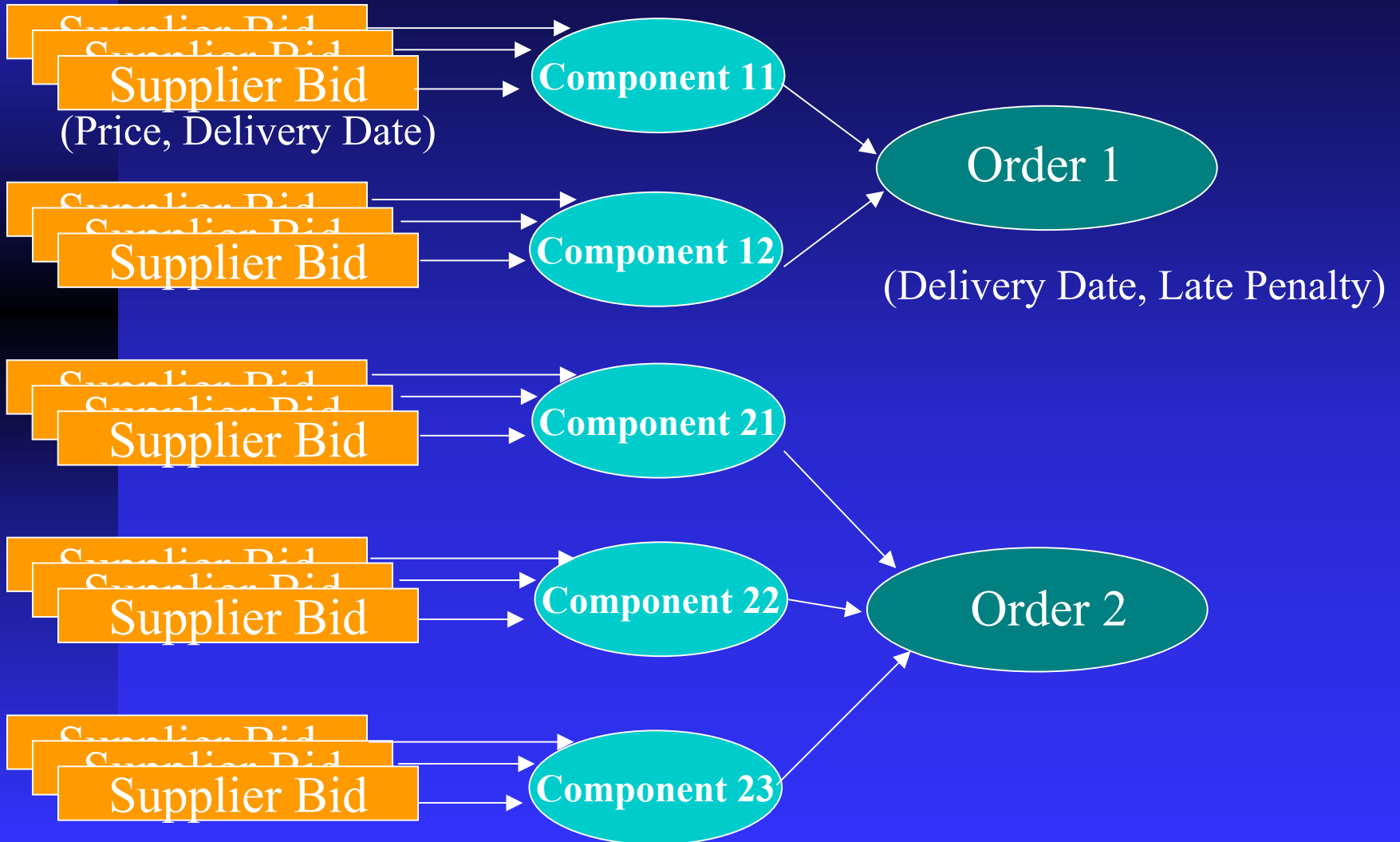
# Benefits of Dynamic Coordination - Contd.



# 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

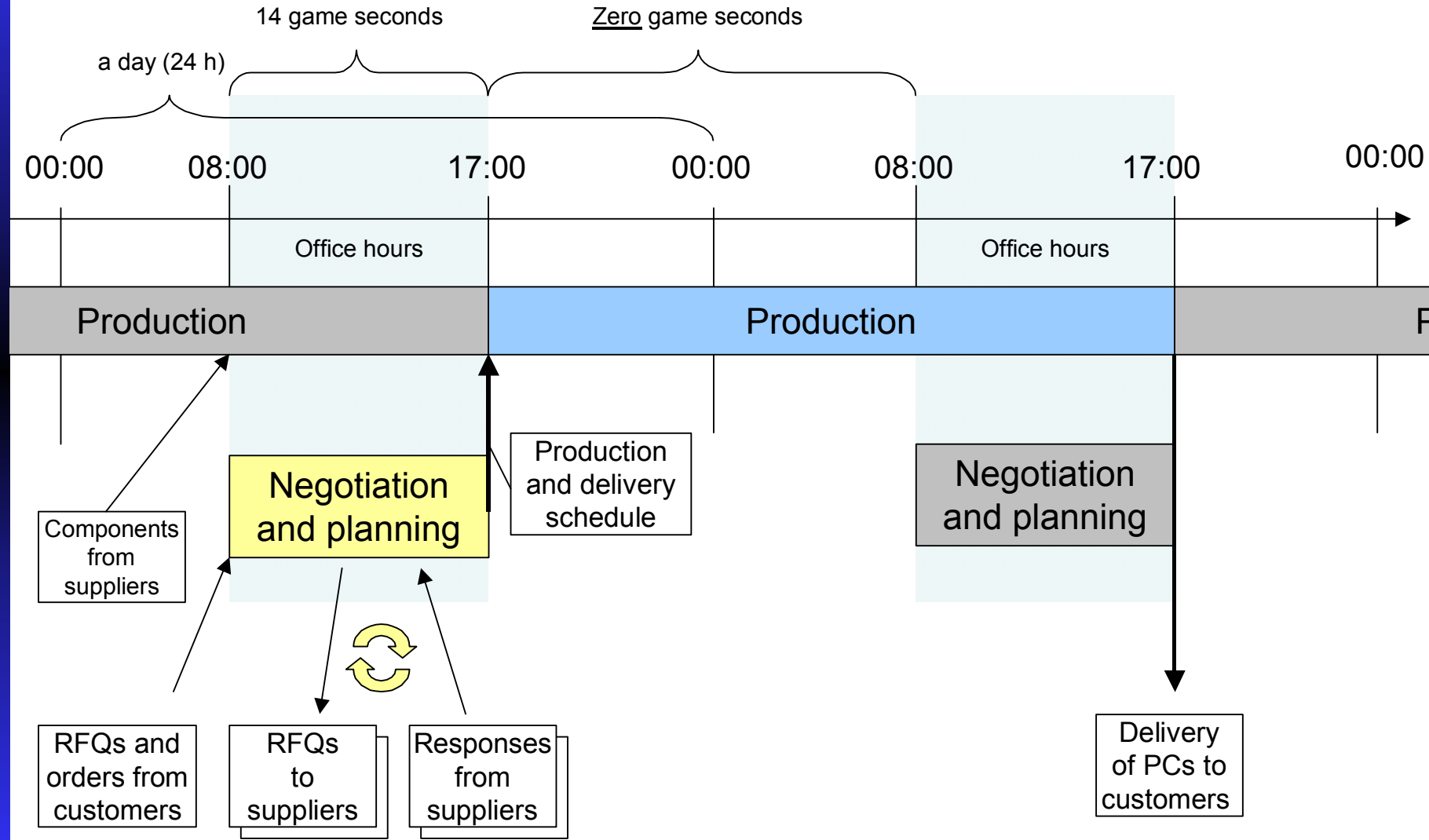
# Supplier Bid Selection



# 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

