Agent-Oriented Supply-Chain Management

by

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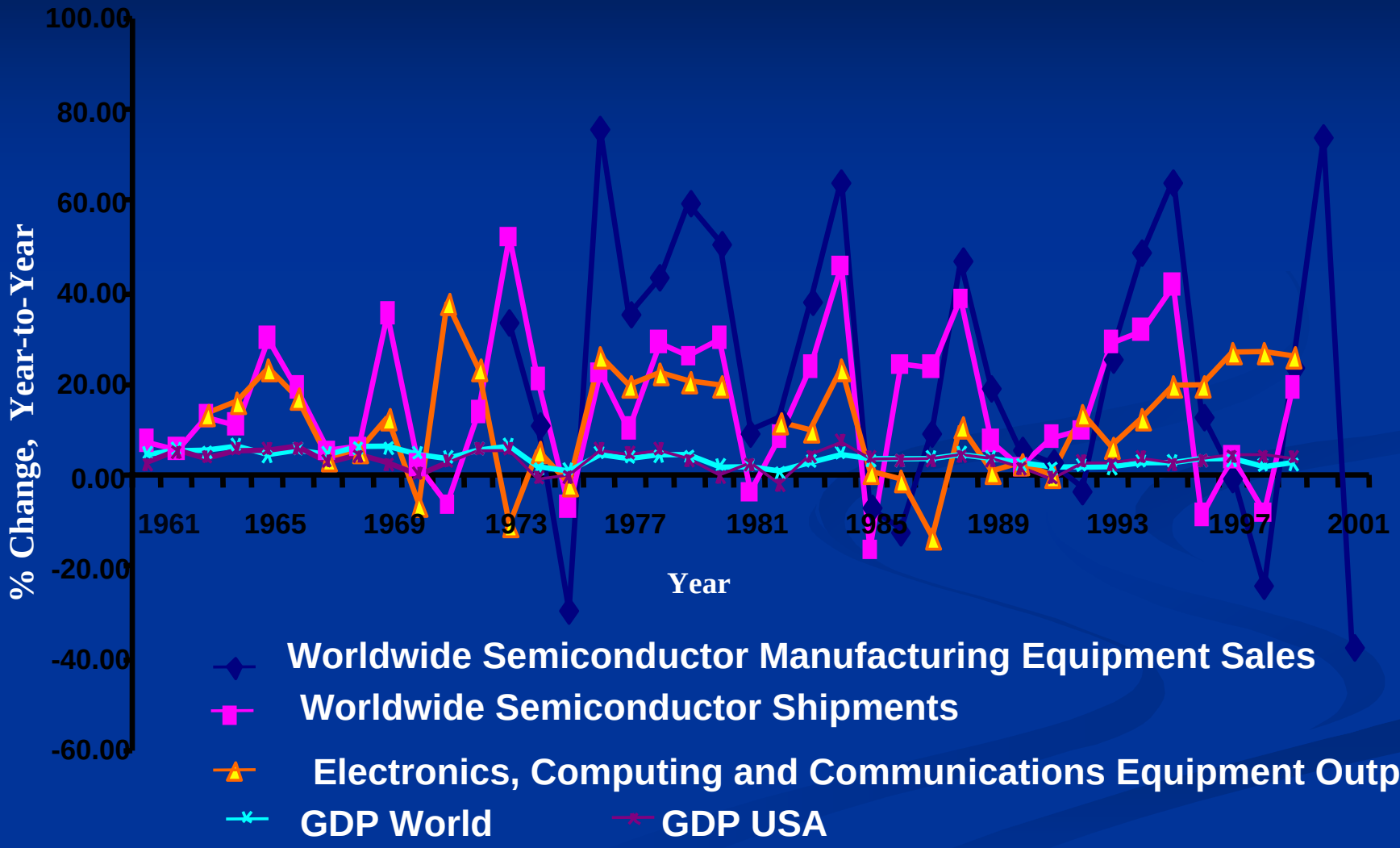
October 28th, 2003

SCM

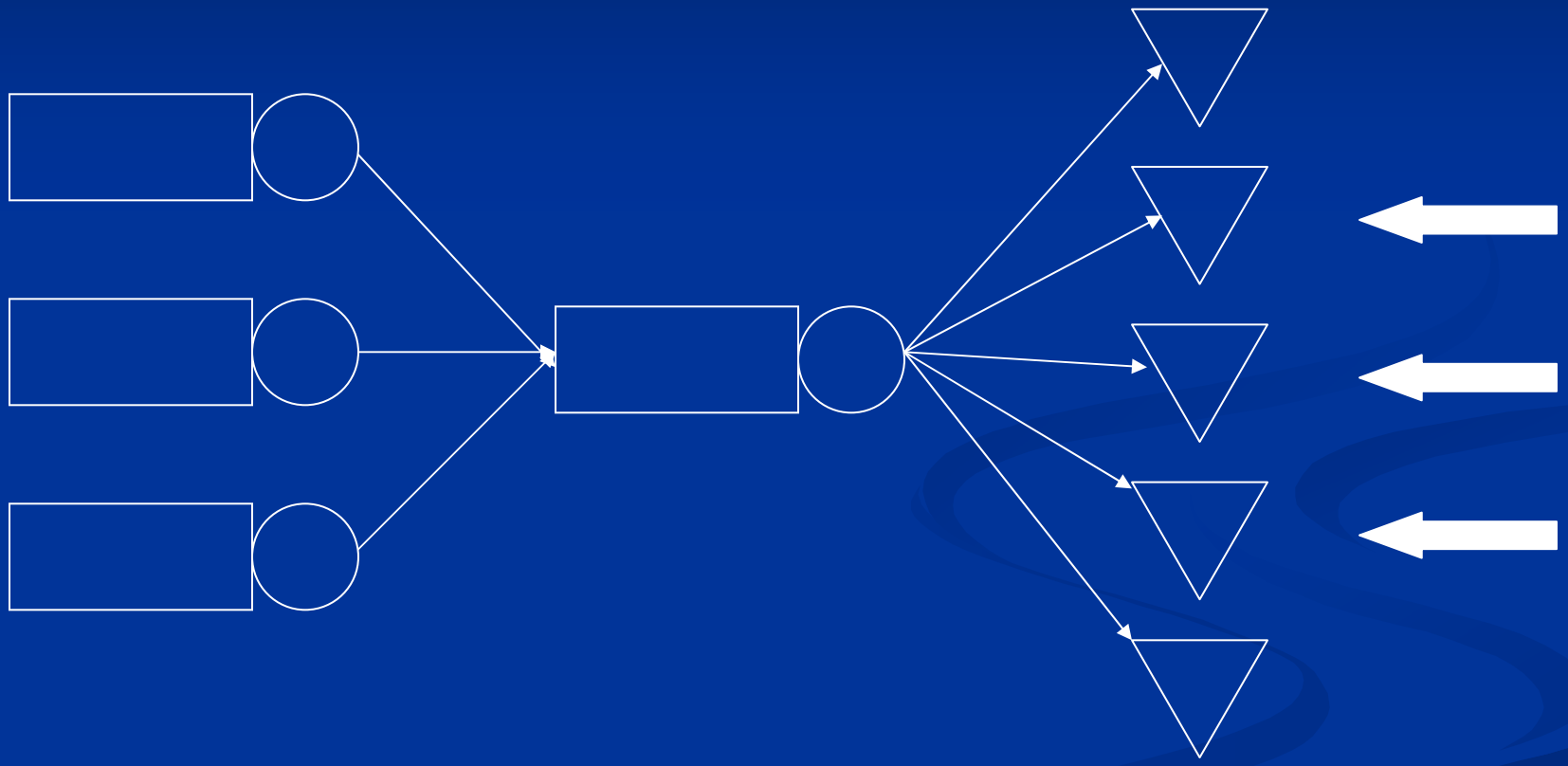
- **Why is it difficult?**
  - A complex network with various entities having different, conflicting objectives
  - Finding best system wide-strategy is hard
    - Global Optimization is difficult
  - Managing Uncertainty
    - Matching supply and demand
    - Inventory and back-order levels fluctuate greatly
    - Forecasts are almost always wrong

Volatility in the Electronics & Semiconductors Supply Chain

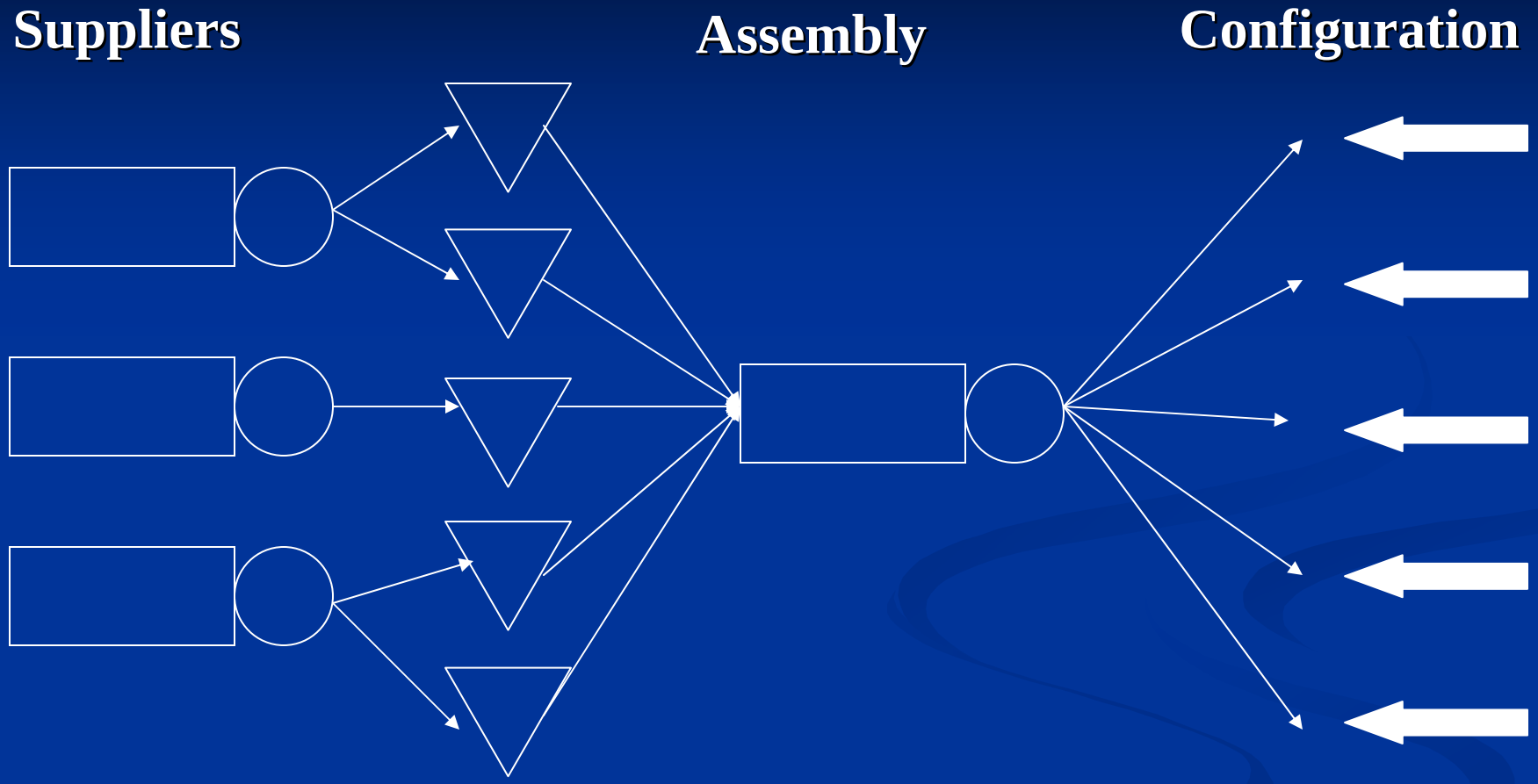


From Make-to-Stock Model…. [Dutta]

Suppliers **Assembly** **Configuration**



….to Assemble-to-Order Model



- Push-pull Strategy

Agent Technology

- **Agent Communication Languages**
  - KQML (USA), FIPA-ACL (Europe): language and protocol for exchanging information and knowledge
  - Will standardization help in all applications ?
  - Agent-to-Human interaction?
- **Social Knowledge Management**
  - How to acquire, manipulate, store and exploit social knowledge, centrally, in agents ?
  - Separation between social interaction know-how and individual problem-solving know-how
- **Coordination mechanisms**
  - Cultural Assumption problems? Too strong? Other e.g. ?
  - Market mechanisms, investigation of truthfulness, trust, CNP
  - Optimization over entire supply chain and uncertainty at various levels ?

Agent Technology (contd…)

- **Coordination Language**
  - It is a multi-agent system anyway?
  - Is finite state automata to represent conversations just hard coding?
- Conversation plans – Logistics Execution
  - Is it optimal? Multiple-solutions? What about global state ?
  - Would these conversation models be used both internally and externally?
- **Individual Agent Architectures**
  - Reasoning Process
- **Agent Community Architectures**
  - Organization, roles, hierarchy
- Agent Spawning

Agent Technology (contd…)

- **Multi-agent planning** - Decomposition and task distribution.
  - Why centralize functions of logistics agents ?
  - Individual agents' conflict resolution ? What if overlap occurs?
- **Knowledge management**
  - Knowledge sharing and ontologies
- **Negotiation Strategies**
  - Auction mechanism design
- **Learning** – Does it happen ?
- **Monitoring, meta-reasoning, fault tolerance, failure**
- **Coalition Formation and Teamwork** – Necessary even after coordination ?
- **Large multi-echelon SCM** – Can present approach scale to it?
- Anytime Algorithms

MDP and Value Iteration [LPK 1996]

- Framework for modeling single-agent sequential decision making
  Definition: An agent that takes a view of the environment and generates actions that affect the environment.
- Goal: How an agent can *learn* an optimal behavioral strategy

$MDP: \langle S, A, R, T \rangle$

Set of States: S, Set of Actions: A

Reward Function: $R: S \times A \rightarrow \mathbf{R}$

State Transition Function: $T: S \times A \rightarrow \Pi(S), \quad T(s,a,s')$

Optimal value of state: $V^*(s) = \max_{\pi} E\left(\sum_{t=0}^{\infty} \gamma^t r_t\right)$

Optimal Value function is unique and is soln of :

$$V^*(s) = \max_a \left(R(s,a) + \gamma \sum_{s' \in S} T(s,a,s') V^*(s') \right), \forall s \in S$$

Optimal Policy: $\pi^*(s) = \arg\max_a \left(R(s,a) + \gamma \sum_{s' \in S} T(s,a,s') V^*(s') \right)$

Other Questions

- Linear combination of criteria and value iteration convergence
- "Global criterion" to compute to reorder the rules in current state
- Possible performance metrics
  - Actual Demand/Forecasted Demand
  - Inventory turn-over ratio
  - Others?
- Effect of coordination strategies
  - Gains from delivery plans, notification -Modest? Non-agent comparison?
  - Two local maxima
- Optimal error recovery mechanisms
- Modeling Supply Chain Dynamics : A Multi-agent Approach
  - Swaminathan et al, 1997, Decision science

The MIT Beer Game

- Players
  - Retailer, Wholesaler, Distributor and Manufacturer.
- Goal
  - Minimize system-wide (chain) long-run average cost.
- Information sharing Mail.
- Demand: Deterministic.
- Costs
  - Holding cost: $1.00/case/week.
  - Penalty cost: $2.00/case/week.
- Leadtime: 2 weeks physical delay

1. New shipments delivered.
2. Orders arrive.
3. Fill orders plus backlog.
4. Decide how much to order.
5. Calculate inventory costs.

Bullwhip Effect Example (P & G)

Lee et al., 1997, *Sloan Management Review*