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Dynamic Supply Chain Integration -- An Knowledge-based Decision and Coordination Framework

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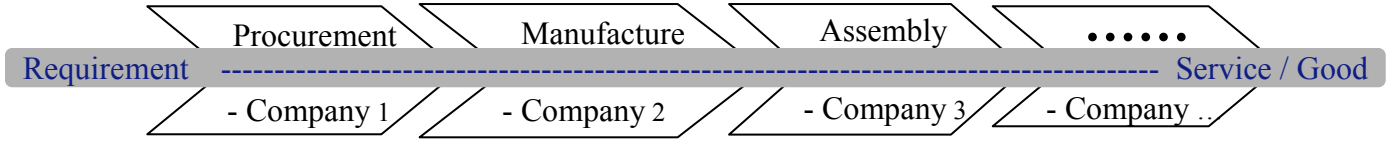
Minhong Wang, et al., "Dynamic Supply Chain Integration through Intelligent Agents", *Proceedings of 40th Hawaii International Conference on System Sciences (HICSS-40)*, IEEE Computer Society Press, Hawaii, US, January 2007.

Background

- What is supply chain
  - A sequence of activities and organizations involved in producing and delivering a good or service.



- E-Supply chain
  - large number of resources from a global market
  - increased uncertainties of both demand and supply
  - more complex and dynamic relationships between supply chain partners

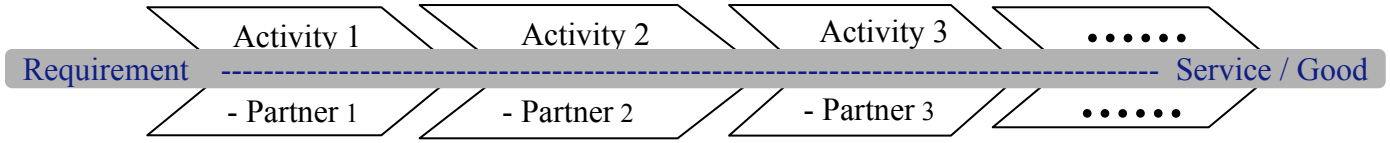
Background (cont)

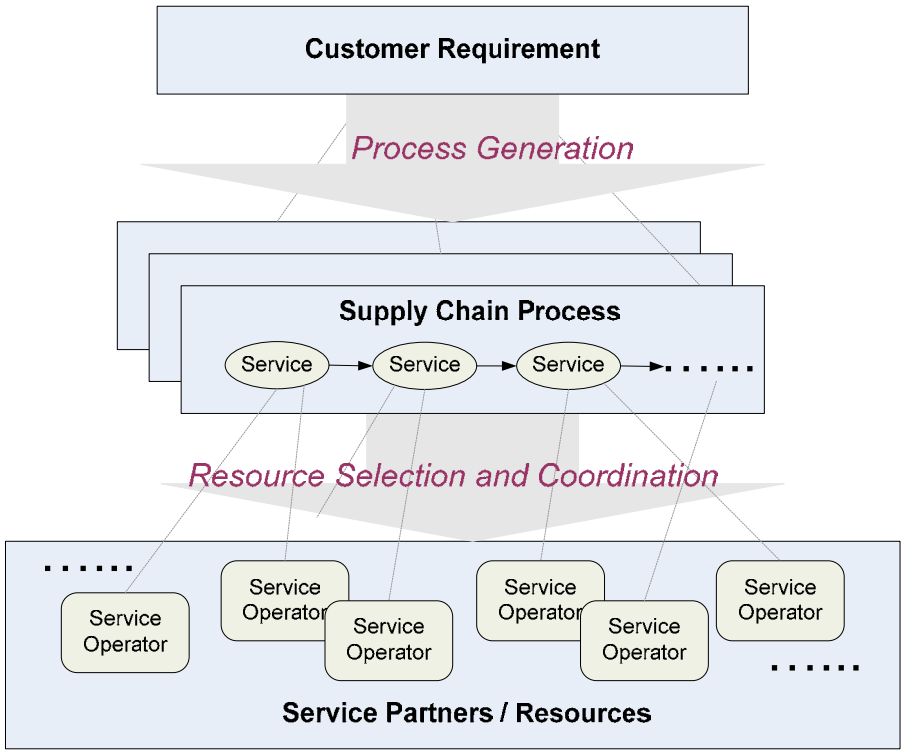
- E-Supply chain requires more flexibility in
  - customer demand
  - partner relationship

Dynamic Supply chain integration

- supply chains dynamically set up in response to market requirements –
  - flexibly plan the sequence of activities to satisfy the requirement
  - rapidly identify suitable partners/resources from the e-market
  - effectively coordinate partners and their activities throughout the chain

How to achieve flexibility through dynamic supply chain integration?





Separate the requirement from the process

Separate the resources from the process

Analysis on Supply Chain Integration

- Main issue & concept
  - Individual vs. integrated service
  - Partial solution vs. global solution
  - Constraint management for achieving coherence among partial solutions
- Main problem
  - Undetermined requirements/constraints of individual services
  - Unpredicted solutions to individual services

Dynamic constraints management in a distributed environment

Related Work

- Job-shop scheduling, workflow scheduling and resource management
  - Jobs, operations, resources
  - Work out a feasible or optimal job schedule
- QoS aware web service composition
  - Quality of Service (QoS) – capability, quality, cost, time, etc.
  - Work out a feasible or optimal composition plan
- Limitation
  - They assume
    - Requirements of individual service are always determined
    - Possible solutions to individual services are always known
  - Failed to adequately address the dynamics and uncertainties of the operating environments.

Proposed Approach

- Objective
  - Deal with undetermined constraints and unpredicted solutions of the individual services involved in the chain
  - Working out a mutually satisfying solution to the integrated service
- Solution
  - Agent-oriented computing
  - Knowledge-based dynamic decision and coordination

Agent-oriented Computing (AOC)

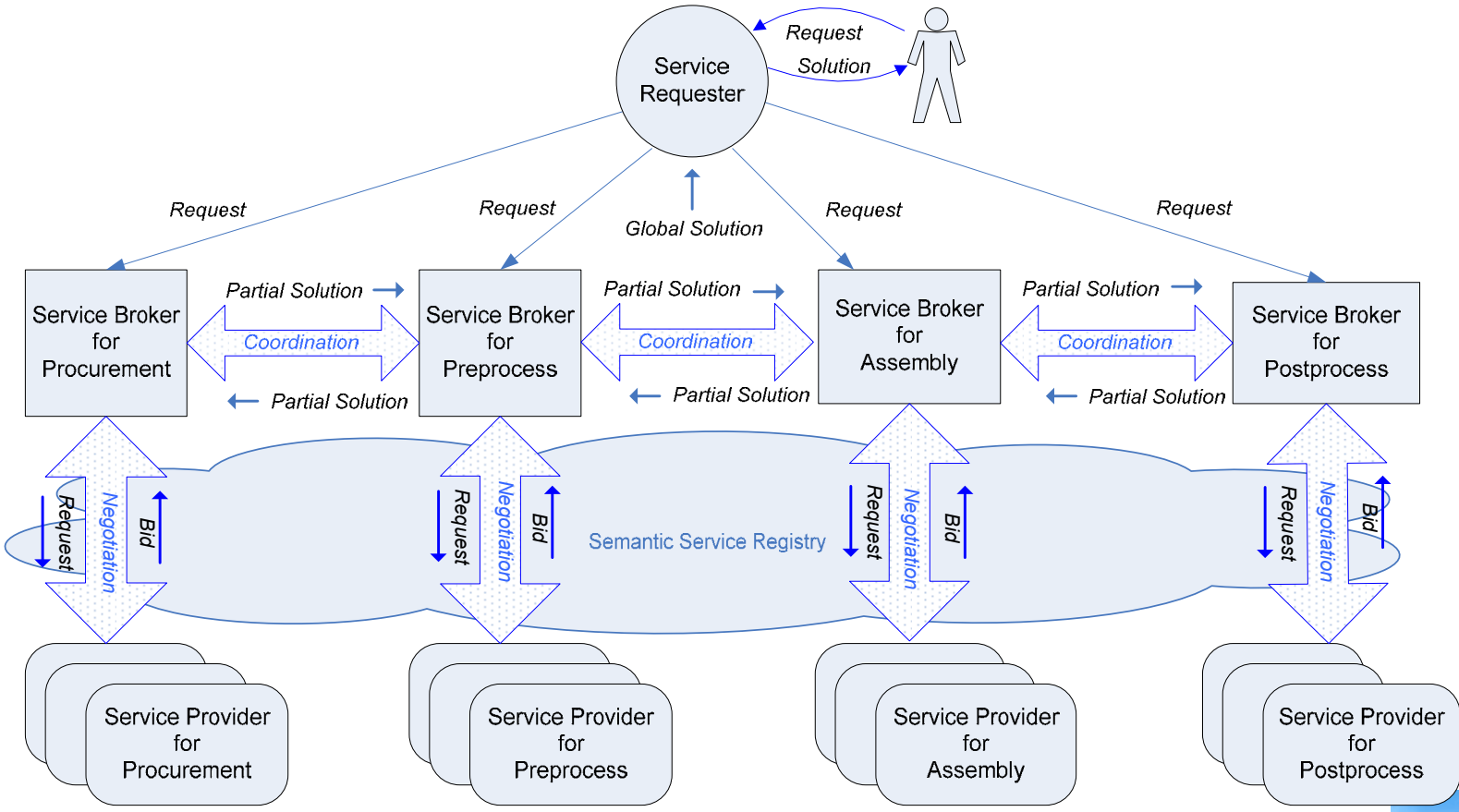
- AOC is to model and construct complex problems by decomposing and assigning them to a number of flexible and interactive autonomous software agents
- Software Agent
  - It is a computer system that enjoys properties as autonomy, reactivity, pro-activity, and social ability
  - A group of agents may interact with one another to collaboratively achieve their goals in a distributed environment
- Agents are suited for applications which
  - are not all known a priori
  - are not fully controllable behaviours
  - must interact through communication and coordination

Features of supply chain integration

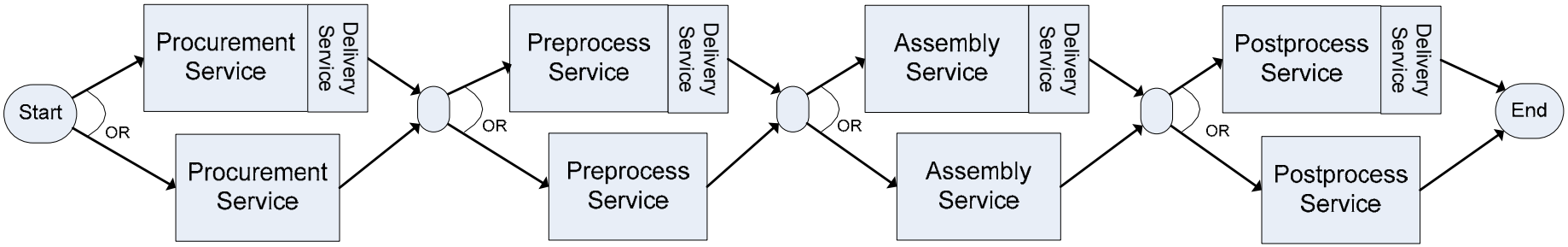
Agent-based Computing in Distributed Constraint Management

- Each service is assigned to an agent
  - service -> variable
- Each agent is to find a solution to the service
  - solution -> value
- Agents coordinate with each other towards a global solution
  - Intra- & inter-agent constraints (time, cost, location, etc.)

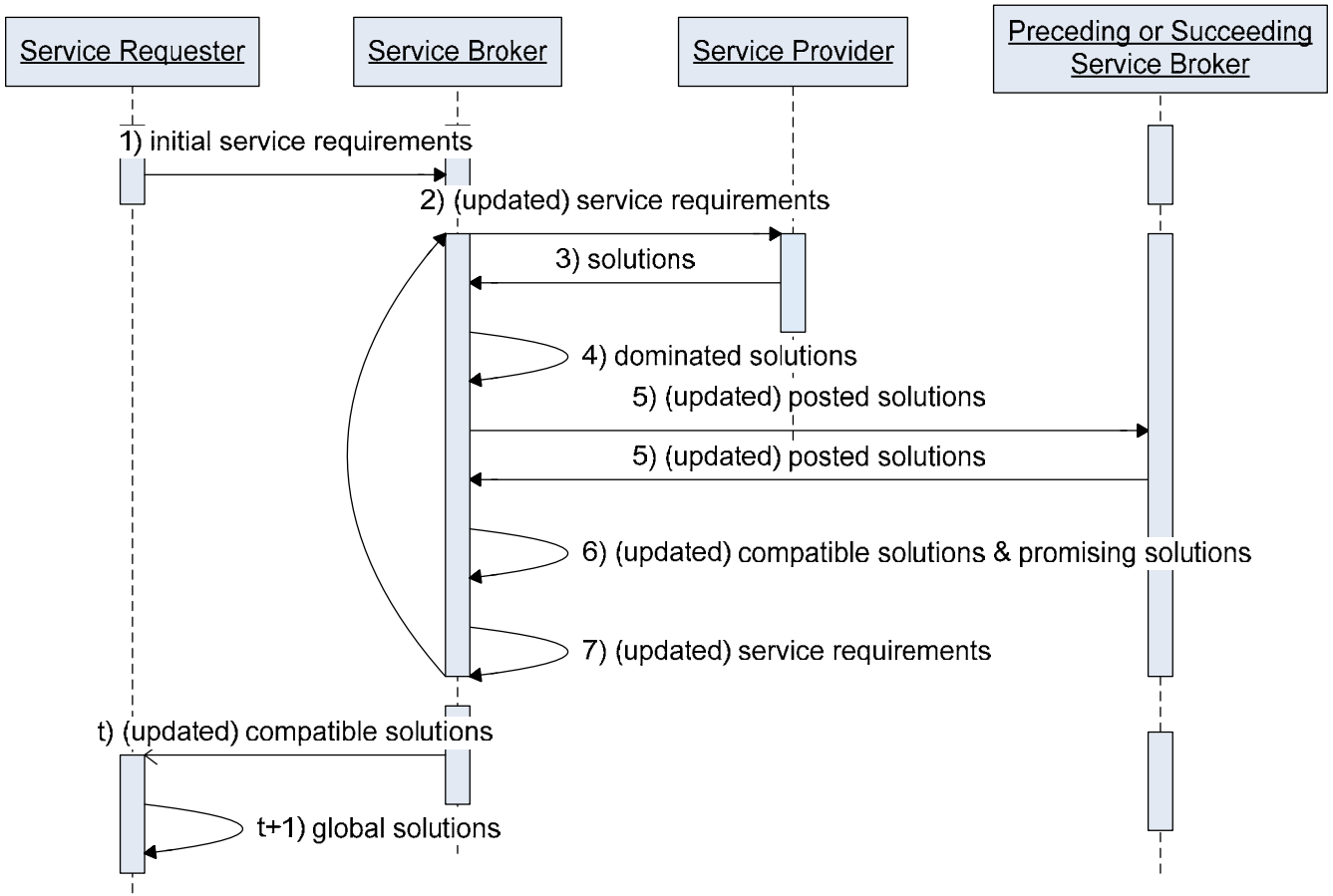
Framework


Service Requester
Request
Solution
Request
Request
Global Solution
Request
Request
Service Broker for Procurement
Service Broker for Preprocess
Service Broker for Assembly
Service Broker for Postprocess
Partial Solution
Coordination
Partial Solution
Partial Solution
Coordination
Partial Solution
Partial Solution
Coordination
Partial Solution
Request
Negotiation
Bid
Request
Negotiation
Bid
Semantic Service Registry
Request
Negotiation
Bid
Request
Negotiation
Bid
Service Provider for Procurement
Service Provider for Preprocess
Service Provider for Assembly
Service Provider for Postprocess

A Supply Chain Process



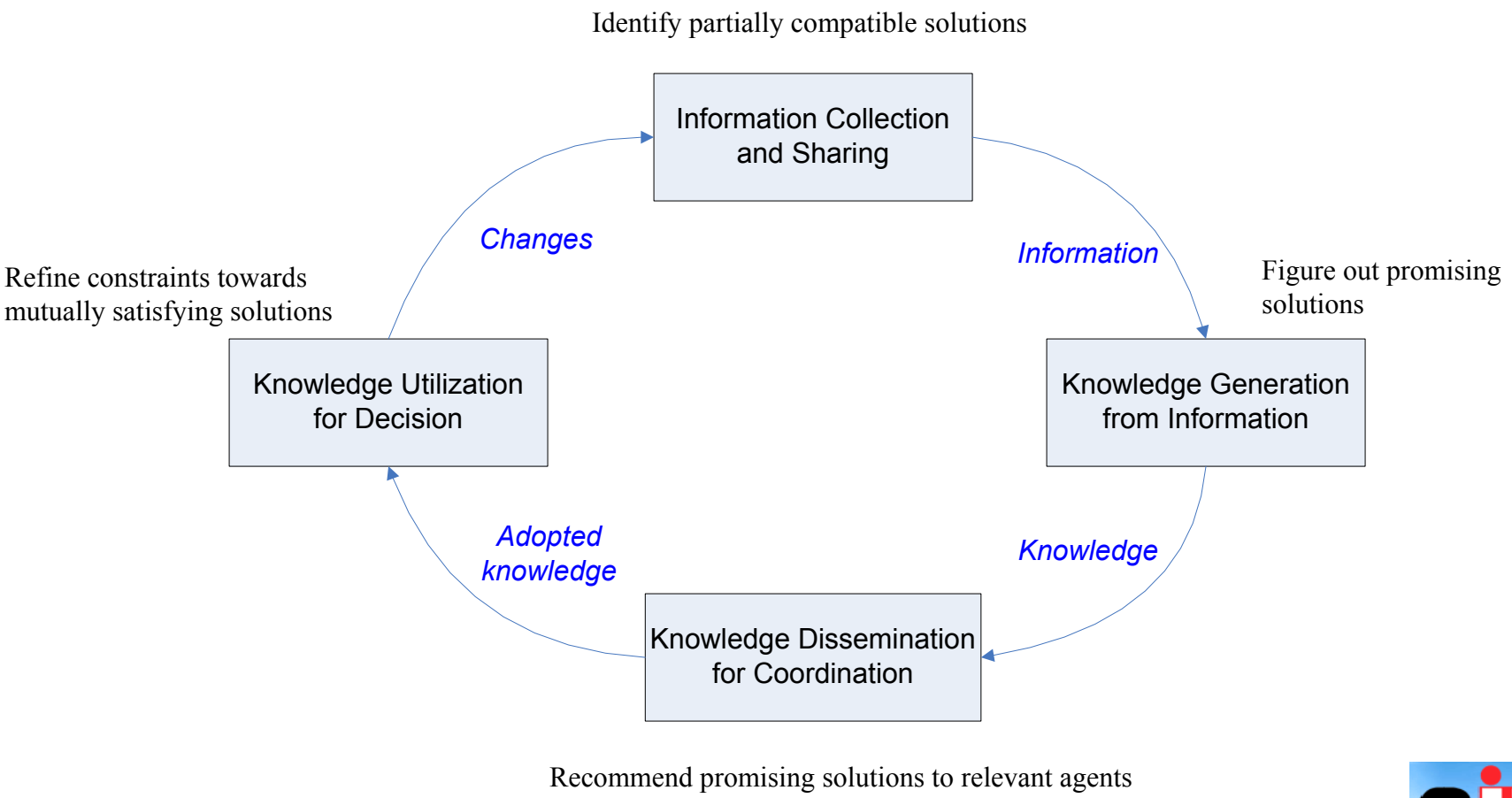
Decision and Coordination Process



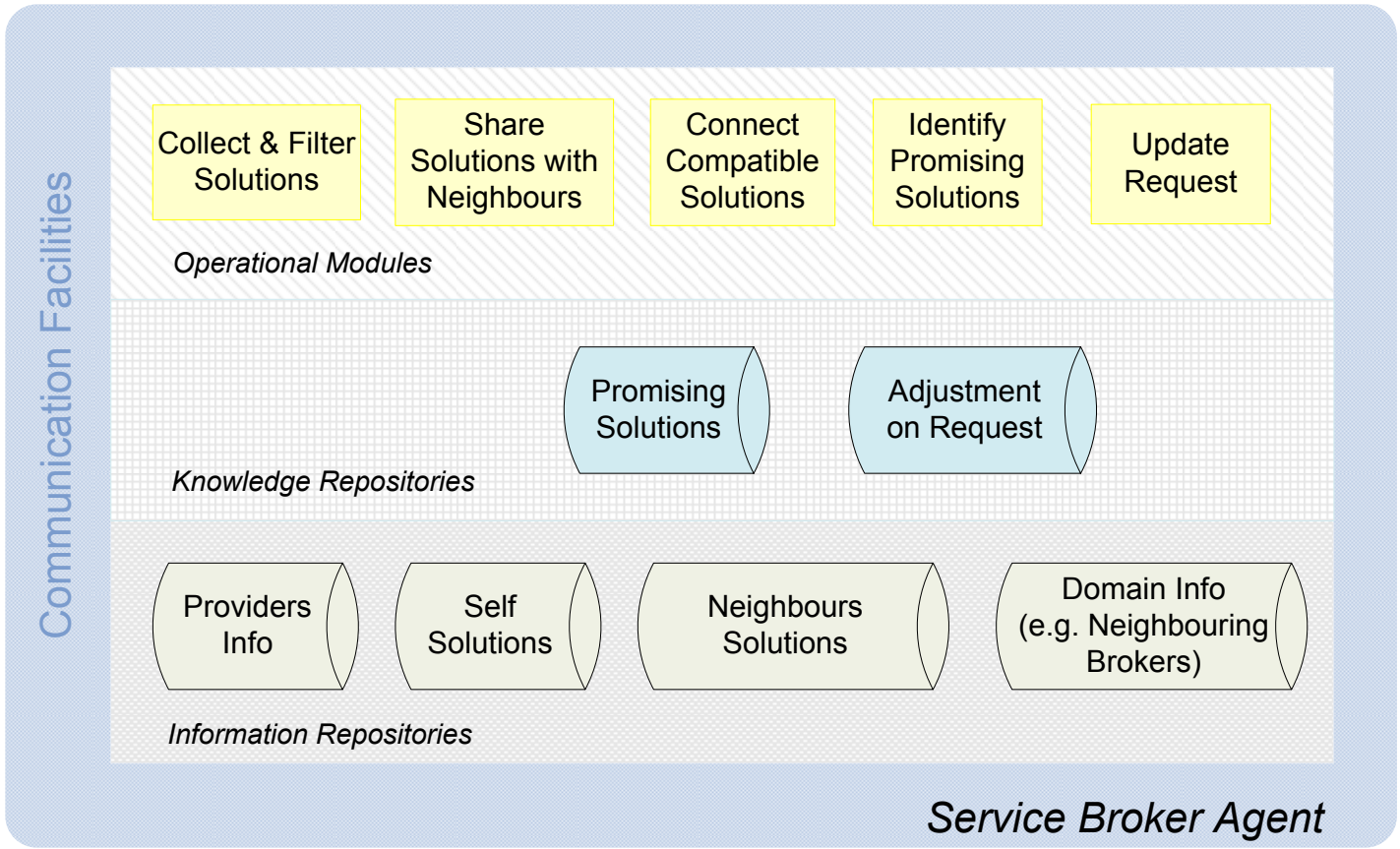
Key Steps

- Identify partially compatible solutions
  - *Information collecting and sharing*
- Figure out promising solutions
  - *Knowledge generation from information*
- Recommend promising solutions to relevant agents
  - *Knowledge dissemination for coordination*
- Refine constraints towards mutually satisfying solutions
  - *Knowledge utilization for dynamic decision*

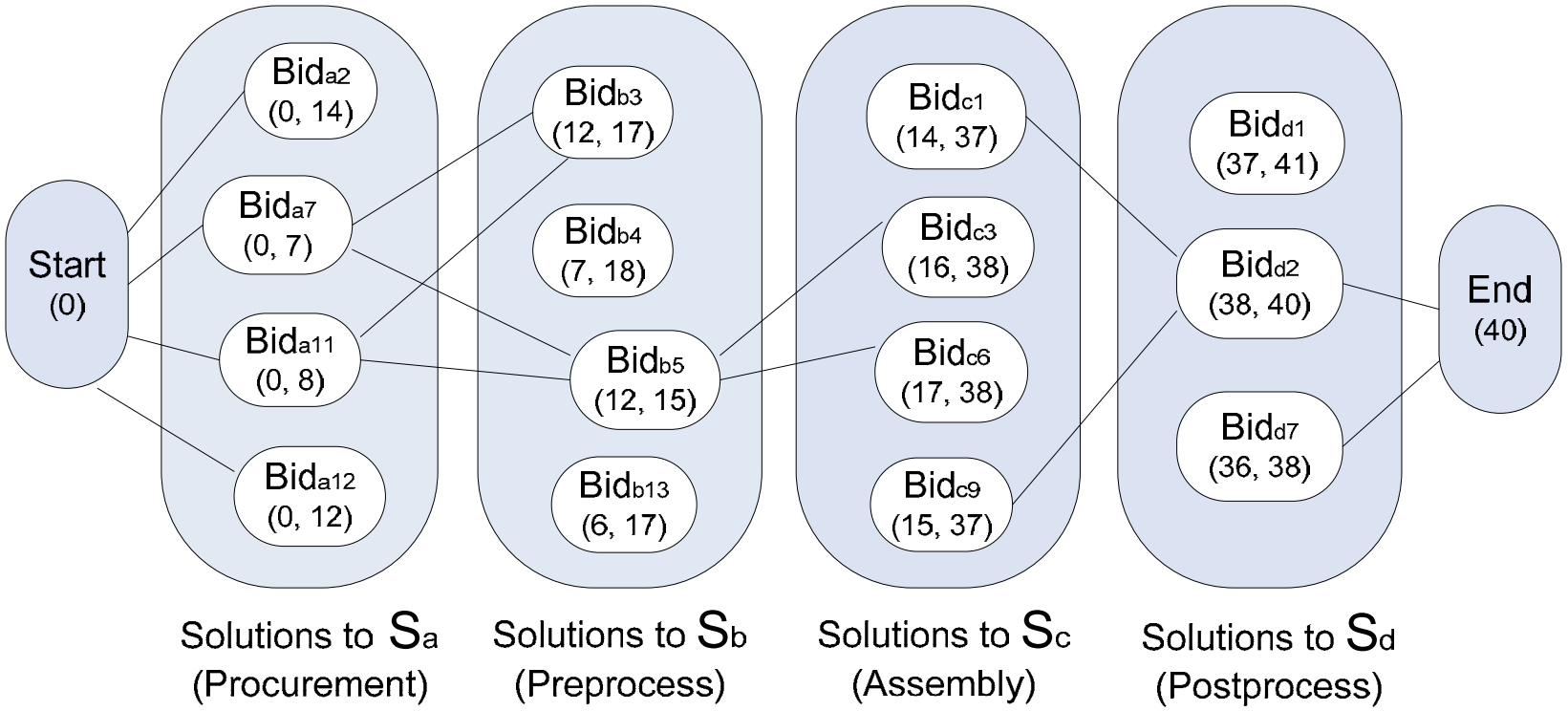
Knowledge-oriented Cycle



Agent Architecture



How to figure out promising solutions?



Calculate the Promising Value of a Solution

- Promising Preceding Solution
  - *Pre_prom (Bidij) = w_conn * Pre_conn (Bidij) + w_tf * Pre_tf (Bidij)*
- Promising Succeeding Solution
  - *Suc_prom (Bidij) = w_conn * Suc_conn (Bidij) + w_tf * Suc_tf (Bidij)*

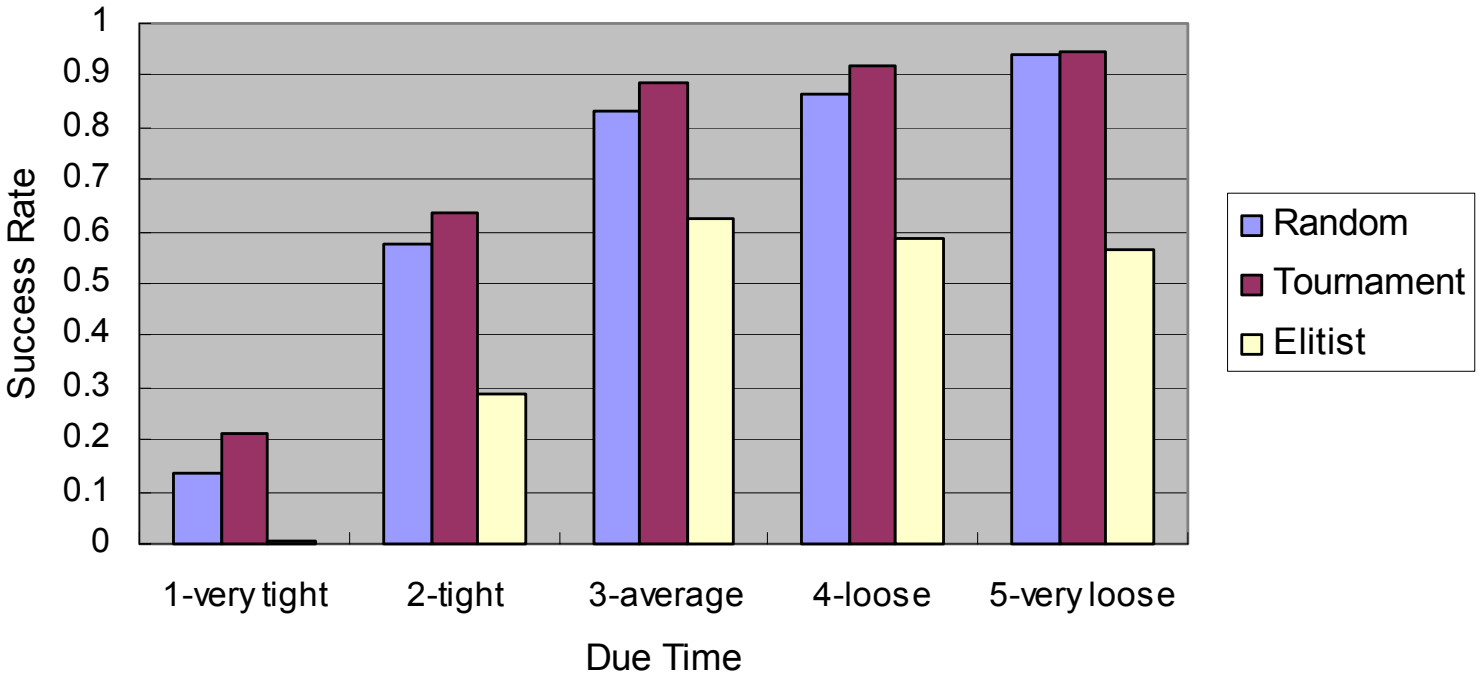
Strategies for Selecting a Promising Solution

- Elitist strategy
  - Selects the best bid
- Random selection strategy
  - Choose a bid at random
- Tournament selection strategy
  - If the tournament size is higher, weak individuals have a smaller chance to be selected
  - Equivalent to elitist strategy when the tournament size is the population size
  - Equivalent to random selection when the tournament size is 1

(random constructions - to avoid being entrapped in a local optima by diversifying the search in the vicinity of local optima)

Experiments

- Build a prototype to simulate the supply chain integration process
  - Test the feasibility of the proposed approach in different situations
  - Compare the impact of three strategies of selecting a promising solution
    - Elitist strategy
    - Tournament selection
      - Tournament size
    - Random selection



Comparison of three selection strategies

Discussion

- Implication
  - Knowledge-based decision and coordination with dynamics and uncertainties
  - Agent-oriented computing for complex problems
- Future work
  - Consideration of human interaction with the automatic system
  - More investigation on complex supply chain structure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Thank you!