

# Multi-Behavior Agent Model for Supply Chain Management

An Application to the Lumber Industry

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# Outline

1. Context
2. FOR@C experimental platform
3. Multi-behavior agent
4. Behavior scenario
5. Current and future work



# Context

- ◆ Companies look to increase supply chain performance by any means possible
  - ◆ Fast reaction to perturbations (demand, execution, supplies)
  - ◆ Reduce inventories
  - ◆ Fast exchange of information through the supply chain
- ◆ **Interdependencies** between enterprises (outsourcing)
- ◆ **Sequential planning** between supply chain partners



Need to increase agility



Need to increase synchronization

# Perturbations in lumber industry

Demand

Execution

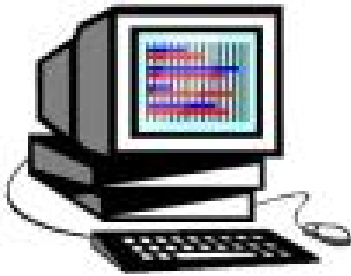
Supplies

Events	Impacts
<b>Demand Variation</b> Changes in product price New purchase order	Changes in demand plan Changes in demand plan
<b>Execution Variation</b> Out of stock Strike Resignation absenteeism Power outage Minor mechanical breakdowns (few hours) Major mechanical breakdowns (few days) Corrective maintenance Stocks lost, misplaced  <u>Particular sawing problems</u> Heterogenous material (wormhole, seam) Bolt diameter different from forecast Wrong type of fiber  <u>Particular drying problems</u> Boiler breakdown Out of fuel Perforated valve Broken door Fan engine burned Drying time different from forecast Wrong product dried  <u>Particular finishing problems</u> Tying machine broken Out of transport ( lack of trucks, wagons)	Execution delay Execution delay Execution delay Execution delay Execution stopped Execution stopped Execution stopped Execution delay Execution delay  Changes in supply Changes in supply Changes in supply  Execution delay Execution delay Execution delay Execution delay Execution delay Execution delay Changes in supply  Execution stopped Delevery delay
<b>Supply Variation</b> Politic disorders (environnementalists, Amerindiens, etc.) Bad weather Woodharvest different from forecast Transportation delay	Execution stopped Execution delayed or stopped Changes in supply Execution delayed or stopped

# Current systems in supply chains

## Information Systems

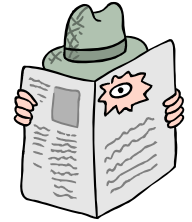
- ✓ ERP (Enterprise resource planning)



## Planning Support Systems

- ✓ MPC (Man. planning & control system)
- ✓ DSS (Decision support systems)
- ✓ SCEM (Supply chain event management)
- ✓ APS (Advanced planning and scheduling)

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**Need of a new planning system to increase agility and synchronization in supply chains**

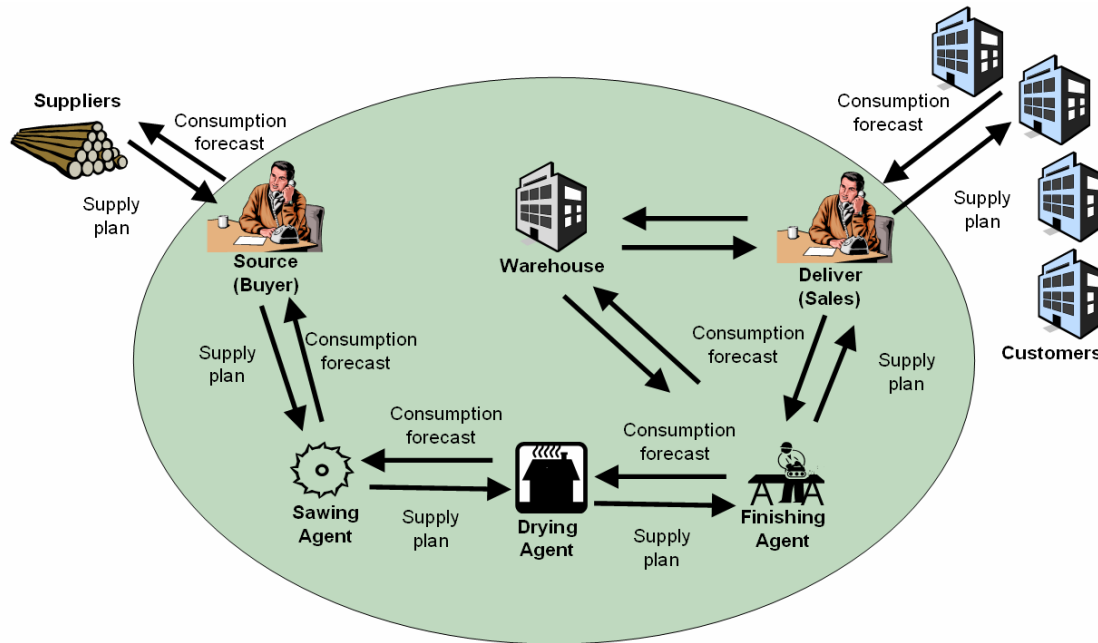


# Agent-based systems

**Agent: Computer system situated in an environment, capable of autonomous actions, in a way to meet its internal objectives (Jennings, 1998).**

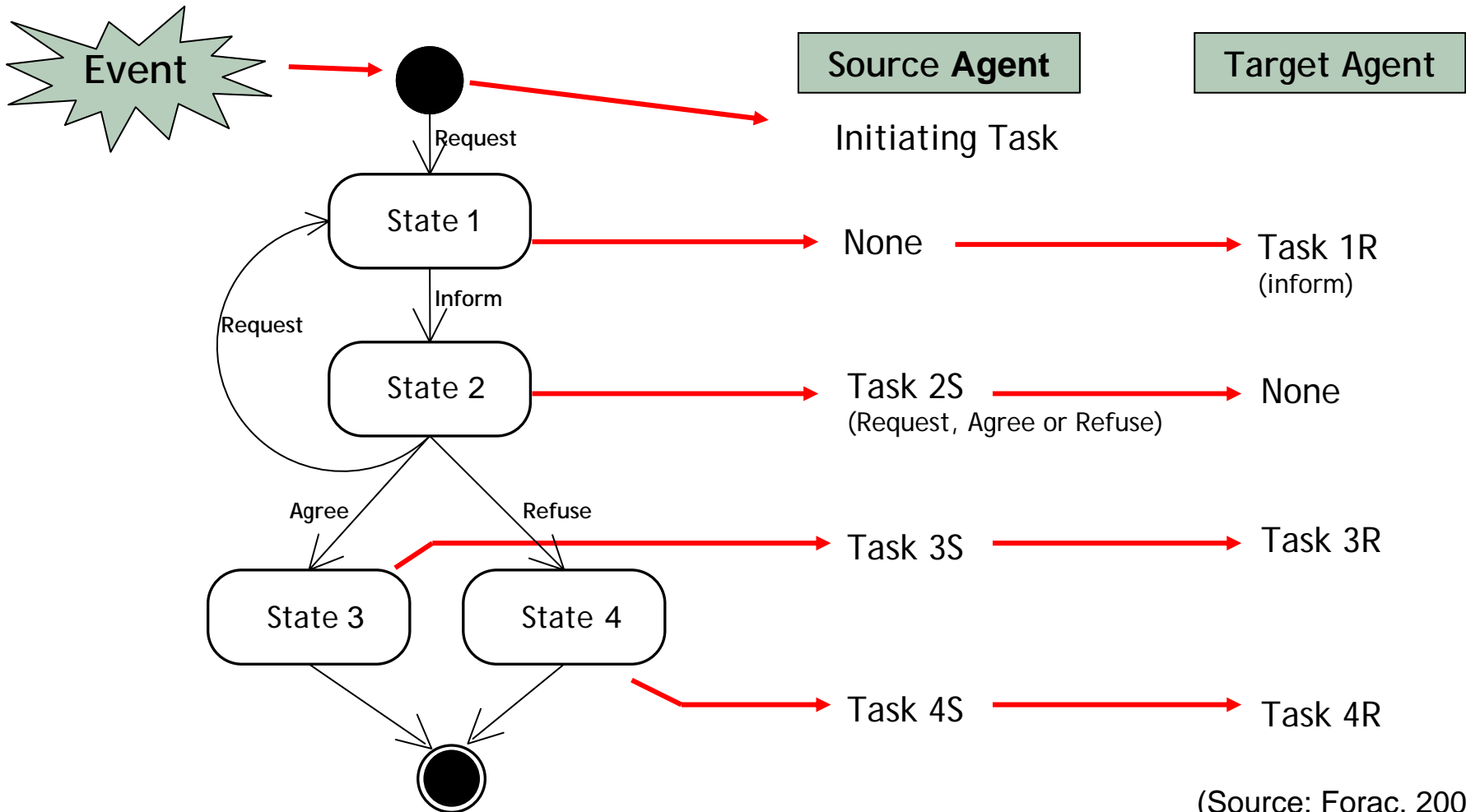
- ◆ **Autonomous decision making and collaboration mechanisms**
- ◆ **Local and collective goal-driven decision making**
- ◆ Particularly adapted to **modular, decentralized, complex and dynamic industries**
- ◆ Possibility to increase agility and synchronization

# FOR@C Experimental Platform



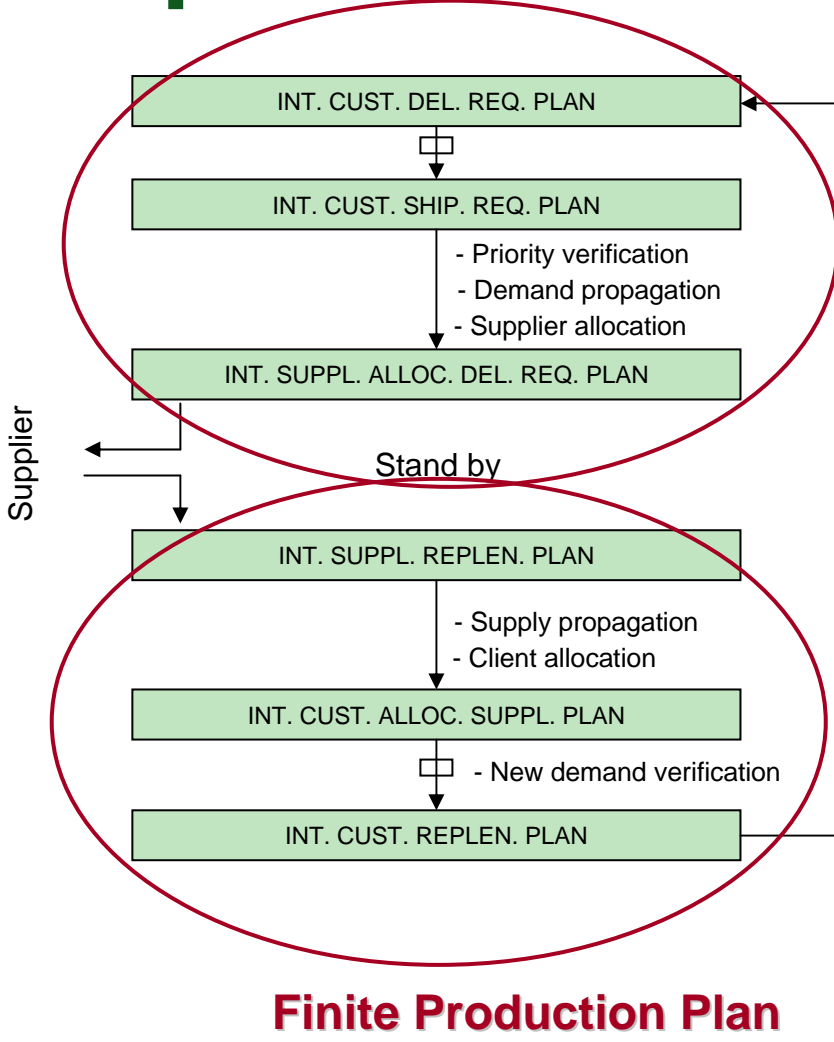
- ◆ A planning platform built on an agent-based architecture for APS, with mechanisms inspired from FIPA standards
- ◆ Combines **agent technology** and **optimization algorithms**
- ◆ Current testing in progress with an international lumber company

# Current conversation protocol



(Source: Forac, 2004)

# Current demand protocol



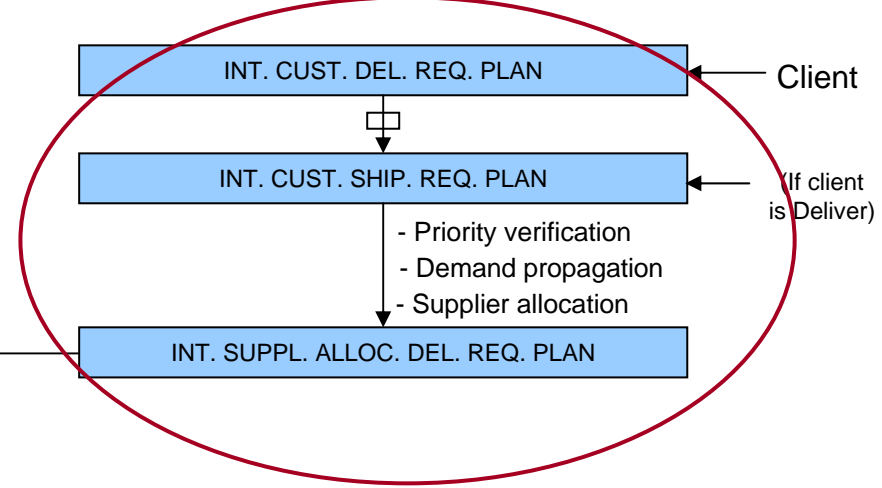
## Finite Production Plan

□ : Logistic agent

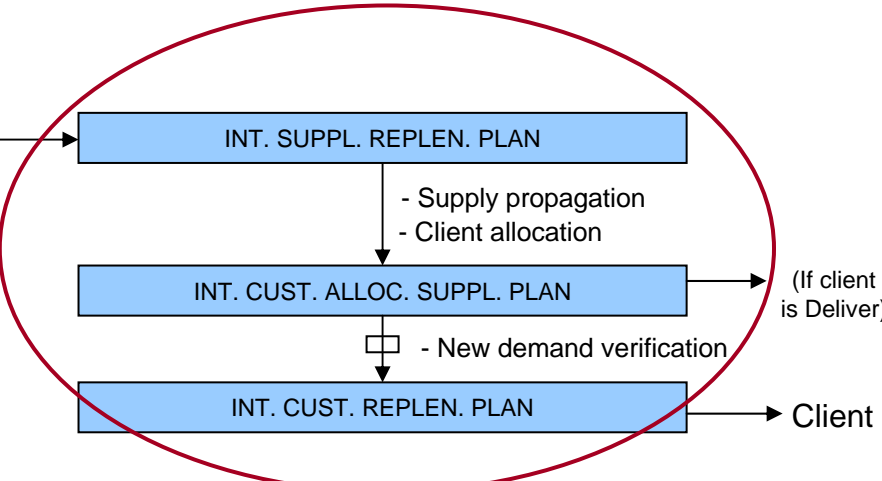
## Infinite Production Plan

Supplier

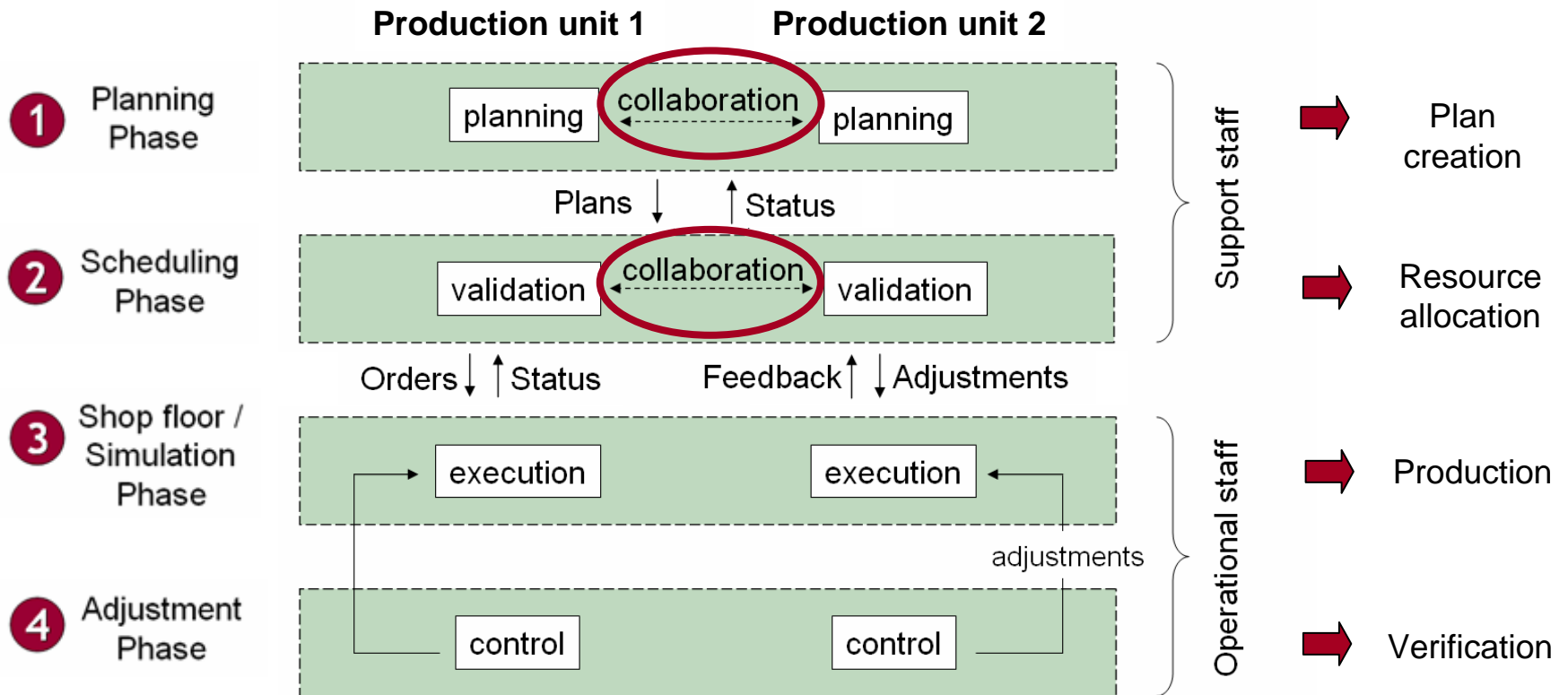
Client



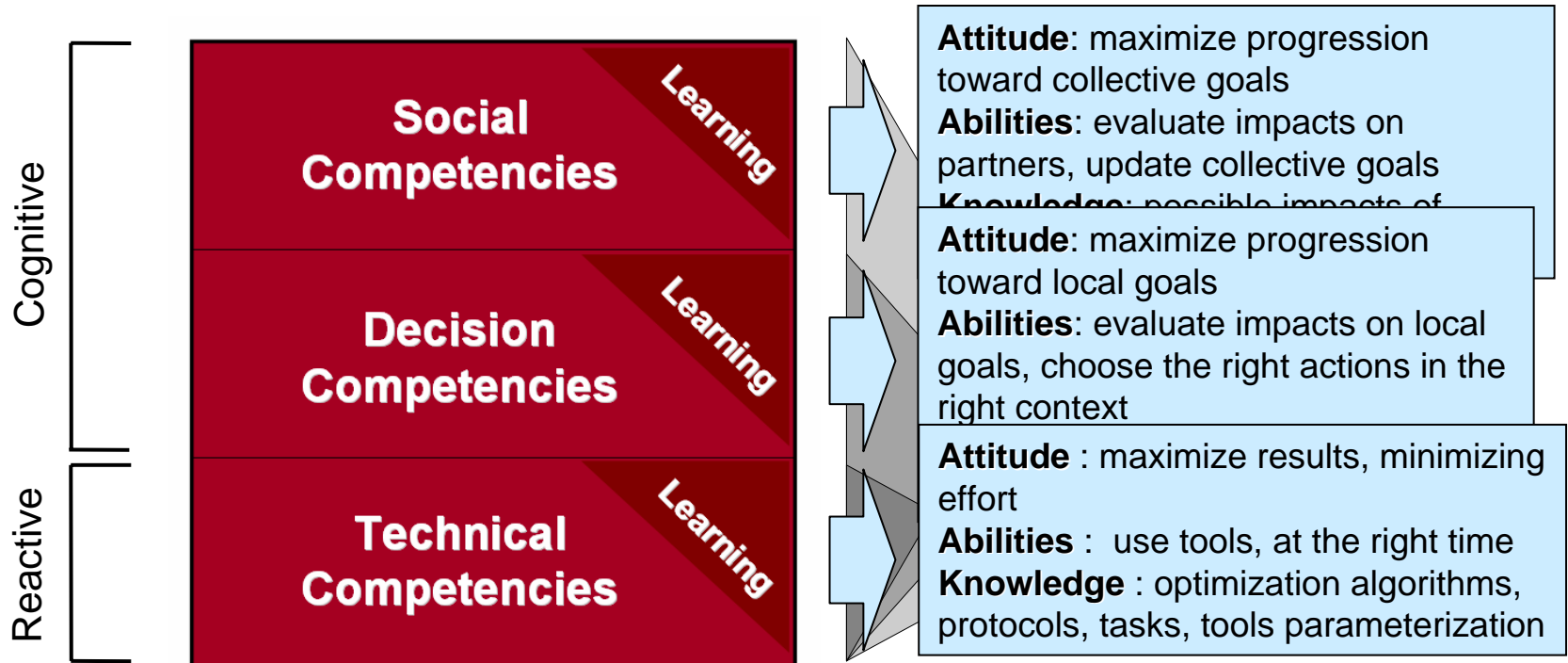
## Finite Production Plan



# Collaborative Event Management



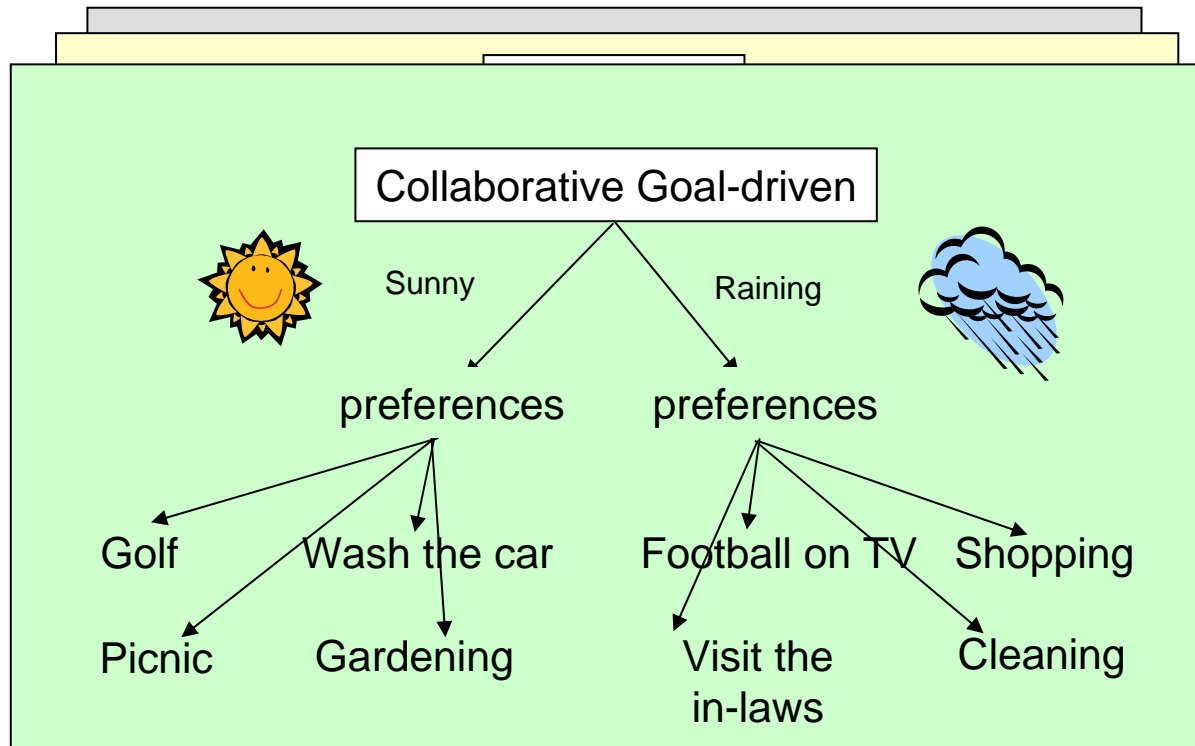
# A conceptual agent model



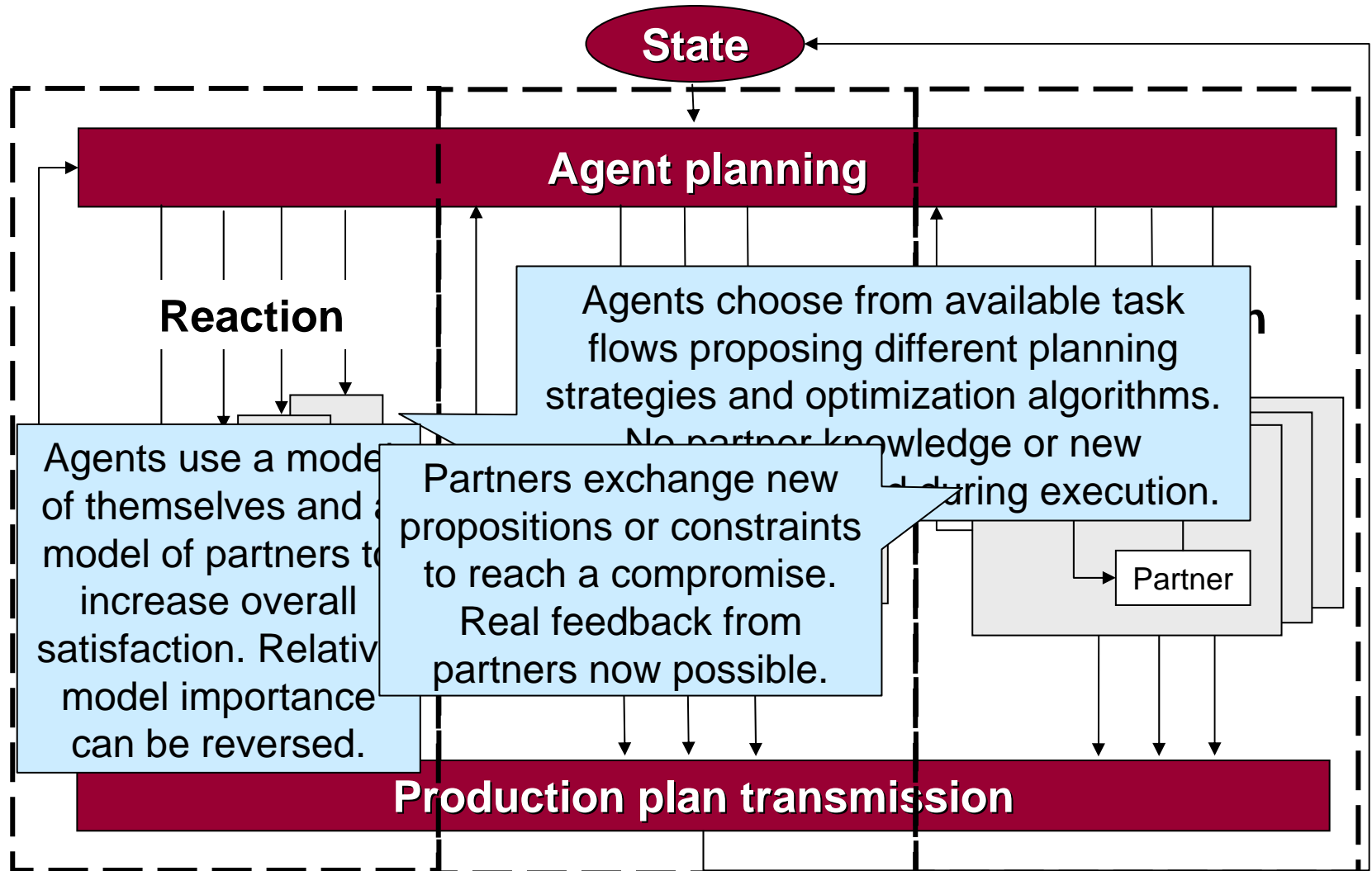
- ◆ Objectives: **better reaction to perturbations, better collaboration, improve SC performances**

# A conceptual agent model

- ◆ Ex. Weekend planning

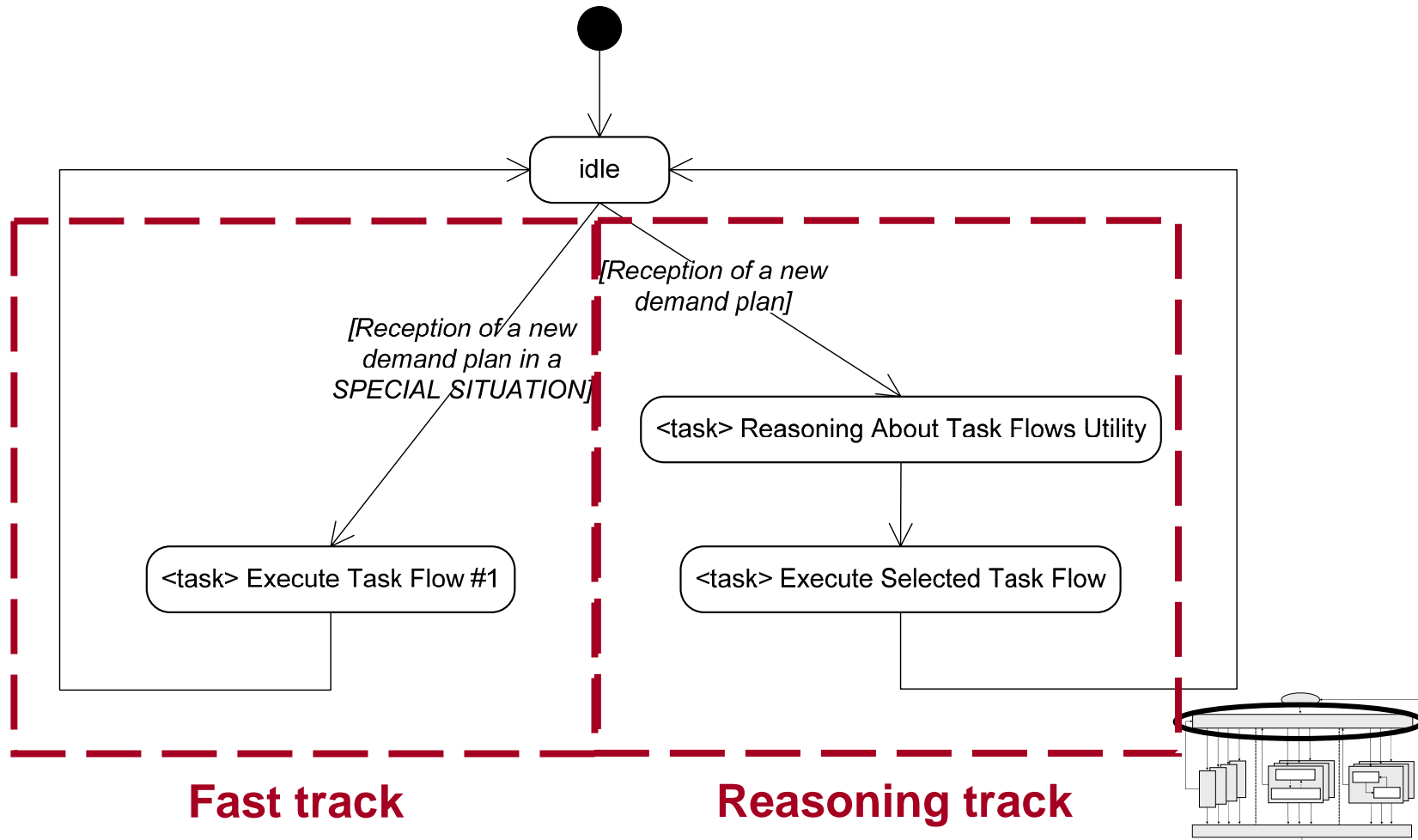


# Multi-behavior agent model



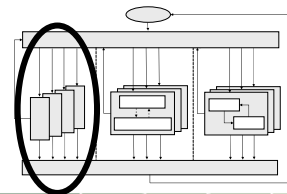
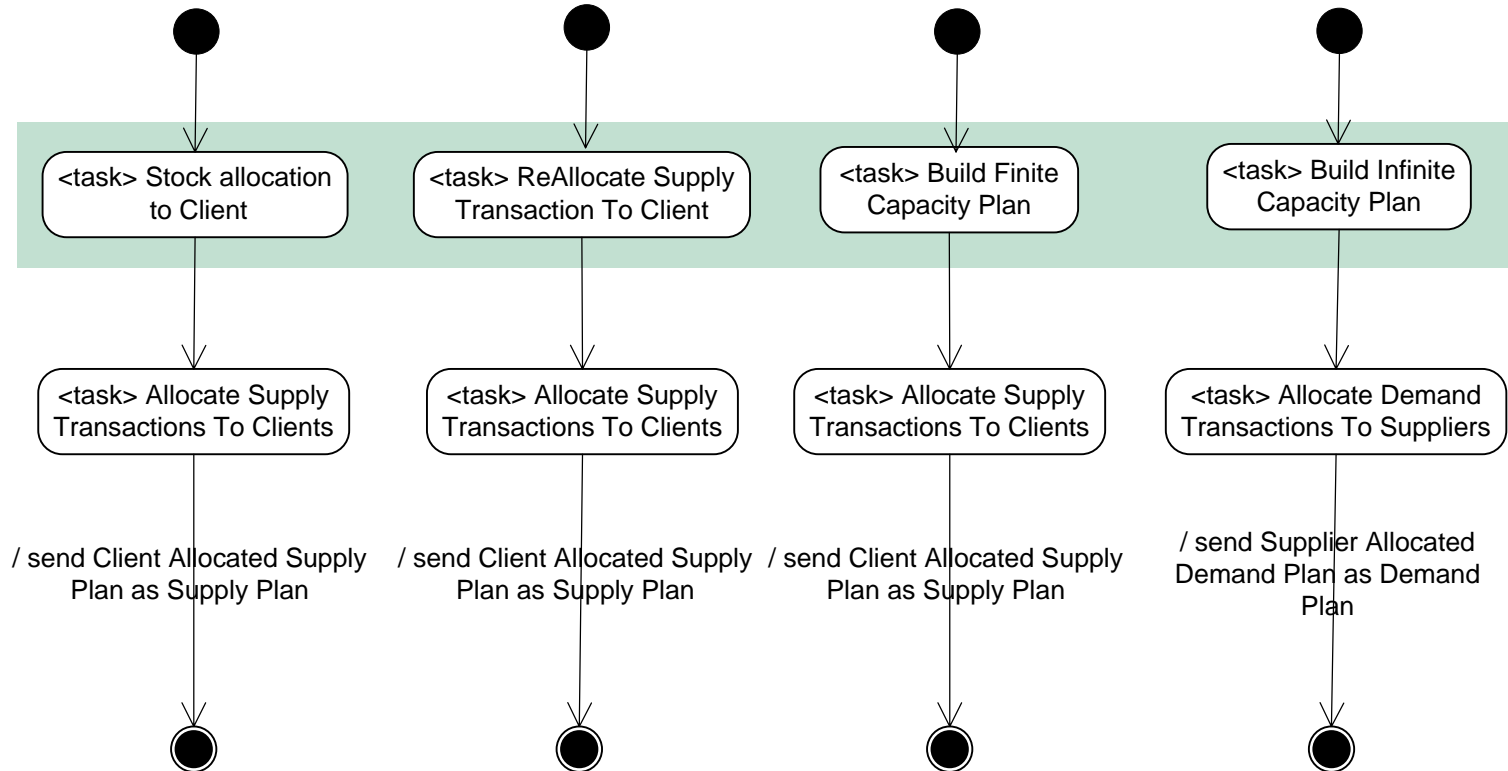
# Behavior scenario

## 1. Reception of a new demand plan – Agent planning



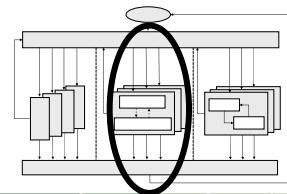
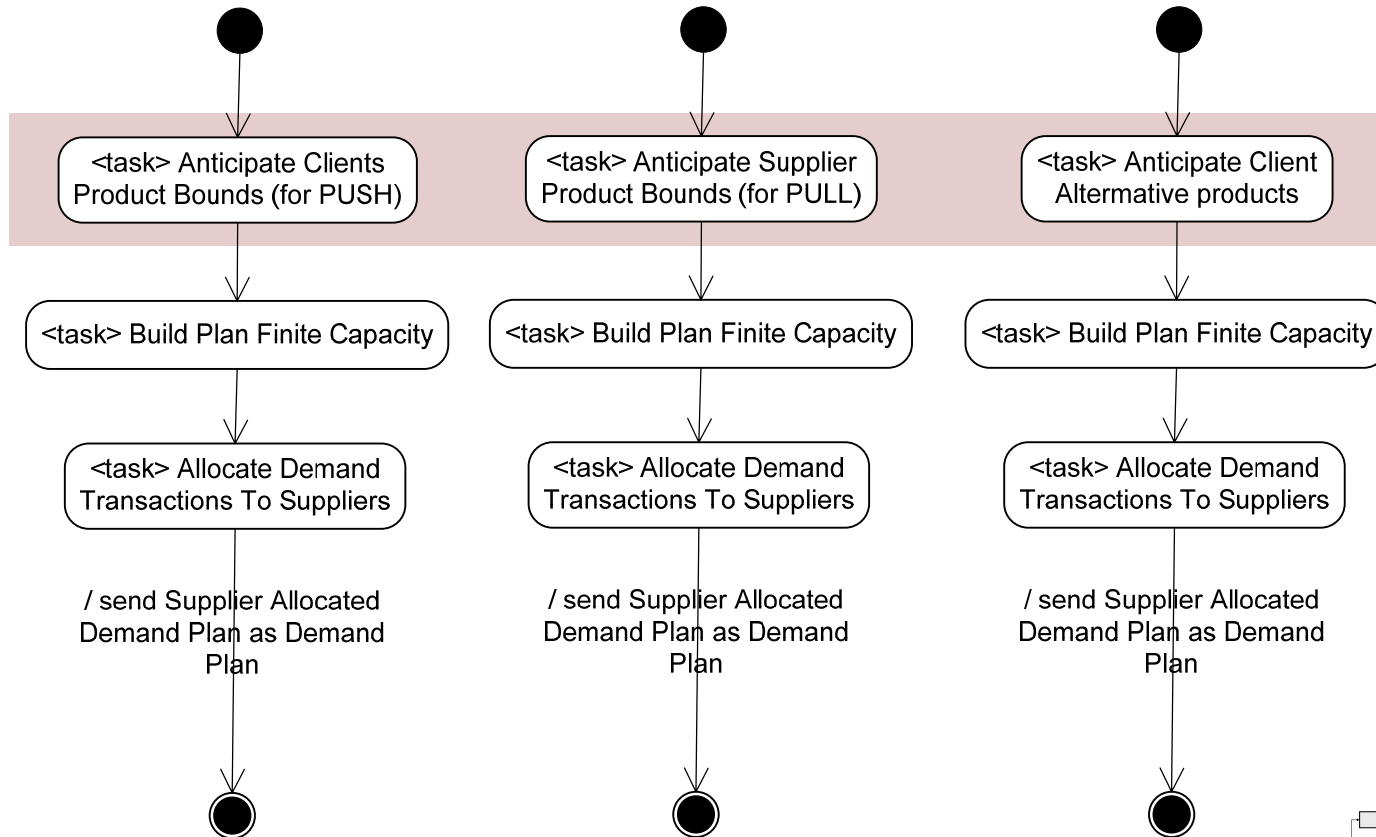
# Behavior scenario

## 2. Reception of a new demand plan – Reaction



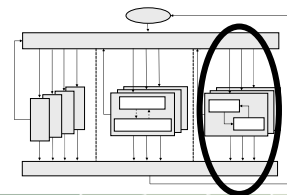
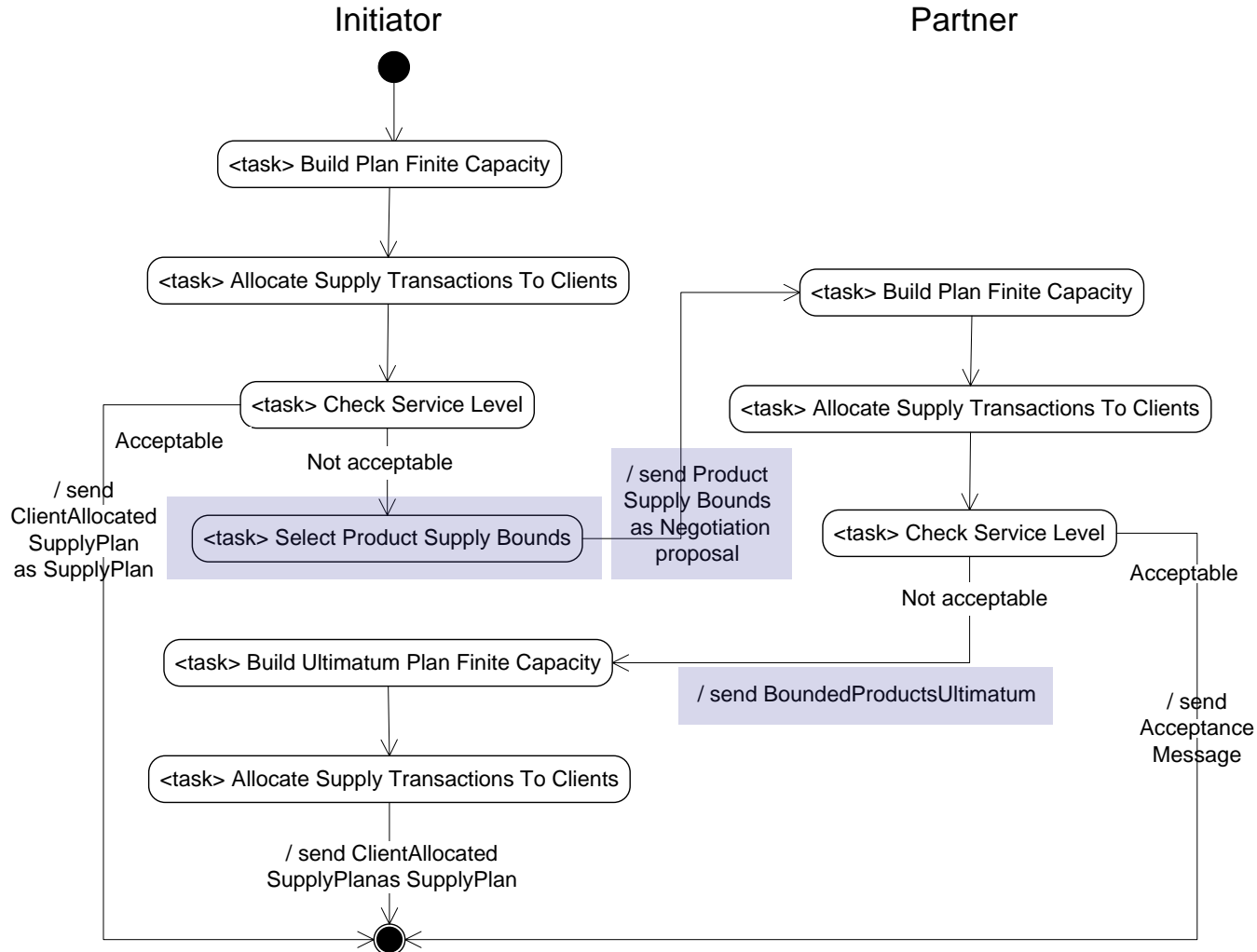
# Behavior scenario

## 3. Reception of a new demand plan – Anticipation



# Behavior scenario

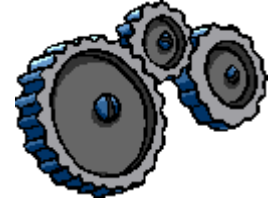
## 4. Reception of a new demand plan – Negotiation



# Advantages of Multi-behavior agents



- ✓ **Different planning strategies** to adapt to perturbations
- ✓ **Reaction behavior** for standard perturbations
- ✓ Anticipation and negotiation lead to **profitable solutions for partners**
- ✓ Possibility to **anticipate partner goals** when communication is not possible
- ✓ Agent model designed to increase quality of planning, increasing supply chain performance



# Current and future work

- ◆ **Implementation** of the Multi-behavior agent in the FOR@C experimental platform, in real-world planning situations
- ◆ **Simulation, testing & analyses** of different agent configurations
- ◆ Study of the implications of the **learning competency** in agent performance

***Kiitos!***



***Questions***