SCM League: An Overview

SCM League Committee

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Abstract

The SCM league models a real-world scenario characterized by profit-maximizing agents that inhabit a complex, dynamic, negotiation environment. It was created with the intent of increasing the relevance of research on autonomous agent negotiations, by going beyond **context-free** negotiation scenarios, where agents decide only how to act in a single static negotiation. Specifically, our aim to further research on the design of **context-aware, situated** agents, who must decide <u>about what</u>, <u>with whom</u>, and <u>when</u> to negotiate, as well as how to best coordinate their actions across multiple concurrent negotiations.

Another distinguishing feature of the SCM league is the fact that agents' utility functions are endogenous, meaning they are the product of the market's evolution, and hence, cannot be dictated to agents in advance of running the simulation. It is an agent's job to devise their utilities for various possible agreements, given their unique production capabilities, and then to negotiate with other agents to contract those that are most favorable to them. Under these conditions, a major determiner of an agent's wealth, and hence, their final score, will be their ability to position themselves well in the market and negotiate successfully.

Overview

The purpose of this document is to provide an overview of the Automated Negotiation Agent Competition (ANAC) Supply Chain Management League (SCML). First, we summarize the rules of the game; then, we explain how to play: i.e., the mechanics of the tournament.

The SCM World

The world modeled by the SCM league consists of five types of entities: factories, miners, consumers, a bank, and an insurance company. In more detail:

Factories Entities that convert raw materials and intermediate products into intermediate and final products by running their manufacturing processes for some time, assuming all inputs and enough time are available to run the processes. Factories have accompanying warehouses in which to store the inputs and outputs of their manufacturing processes.

Different factories are endowed with different capabilities, specified as <u>private</u> production profiles, known only to the factory itself (and its manager agent). For example, two factories may produce the same product using the same inputs but at different costs and at different time scales: e.g., one may produce them faster, but at a higher cost.

Factories negotiate as both buyers and sellers in the SCM world.

Miners Facilities capable of mining raw materials as needed to satisfy their negotiated contracts. Miners act only as sellers in the SCM world.

Consumers Companies interested in consuming a subset of the final products to satisfy some predefined consumption schedule. Consumers act only as buyers in the SCM world.

Bank A single loan provider that provides loans to potential buyers.[1]

Insurance Company A single insurance company that can insure buyers against **breaches of contract** committed by sellers (i.e., failure to deliver promised products on time), and vice versa (i.e., insufficient funds in the buyer's wallet at the time of delivery to pay the seller).

Note that there are no transportation companies. Consequently, the SCM league at present is ignoring logistics. Instead, it is assumed that all products can be transported between all entities free of charge, after a predefined constant delay. In addition, warehouse capacity is currently assumed to be infinite.

Agents In the SCM world, each type of entity is run by a **manager** agent. The organizing committee will provide manager agents for miners, consumers, the bank, and the insurance company. It is the job of the participating teams to develop a **factory manager** agent. The goal of each factory manager agent is to accrue as much wealth (i.e., profit) as possible. The organizing committee will also provide a default agent: i.e., a **greedy factory manager**, instances of which will participate in the competition to ensure sufficiently many trading opportunities. Additionally, participants can base the development of their own agents on this base agent. The buying and selling agents in the SCM world are depicted in Figure 1.

Negotiation Mechanism Figure 2 depicts the role of negotiations in the SCM world. Miner, factory manager, and consumer agents can all buy and sell products based on agreements they reach, and then sign as contracts. Such agreements are generated via bilateral negotiations using a variant of the **alternating offers protocol** typically used in ANAC competitions. The sequences of offers and counteroffers in these negotiations are private to the negotiators.

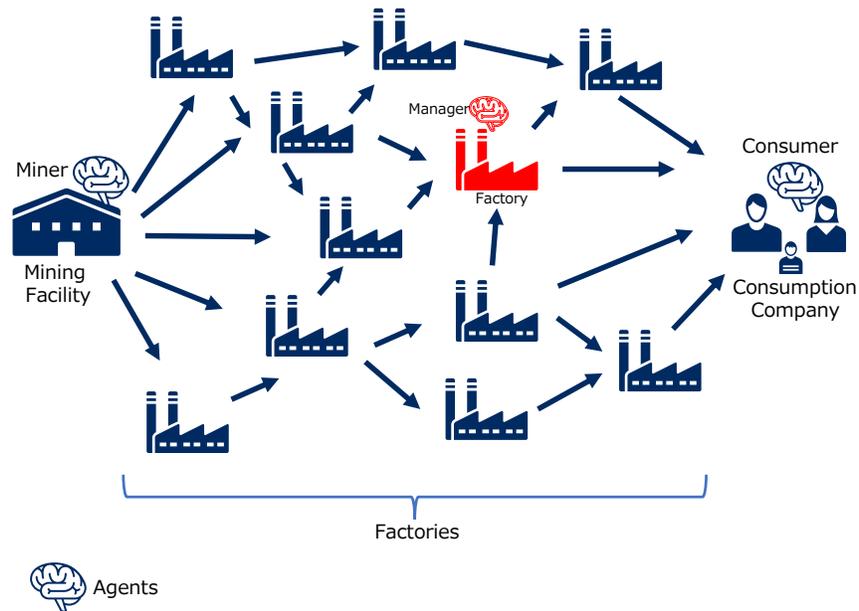[1]The bank is disabled in the 2019 SCML competition.

Figure 1: The SCM world: mining facilities (controlled by miners), consumption companies (controlled by consumers), and factories (controlled by factory manager agents). Participating ANAC teams develop agents that act as factory managers. Arrows represent the flow of products as they are bought and sold.
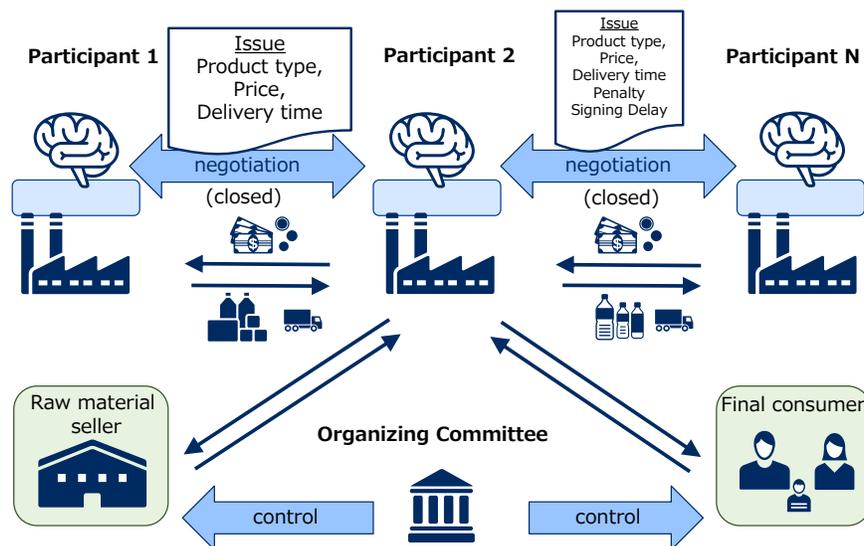

Figure 2: The role of negotiation in the SCM world. Agreements are only reachable through closed (i.e., private) bilateral negotiations using the alternating offers protocol.

An offer must specify a buyer, a seller, a product, a quantity, a delivery time, and a unit price. Optionally, an offer can also specify a grace period for converting the offer into a contract, during which time either party may opt out without penalty; and a penalty term, which would be incurred by the seller in the event they commit a breach of contract.

When a contract comes due, the simulator tries to execute it (i.e., move products from the seller's inventory to the buyer's, and move money from the buyer's wallet to the seller's). If this execution fails, a breach of contract can occur. Breaches can also occur if either party decides not to honor the contract. (Figure 3 depicts the two potential breach conditions.) In all cases of potential breaches, the simulator offers the agents involved the opportunity to renegotiate.

To find negotiation partners, agents publish their interest in negotiating on a bulletin board that lists **call-for-proposals** (CFPs). Each such CFP specifies the publisher and the proposed negotiation issues. Interested agents then request a negotiation. Initiating such negotiation implies acceptance of the negotiation agenda (i.e., the proposed negotiable issues). If an agent instead does not accept the negotiation agenda, they can publish their own CFP listing alternative negotiation issues.

Public Information Contracts are private; they are not posted on the bulletin board. However, whenever renegotiation fails after a breach of contract, the breach is published on the bulletin board, on a **breach list**, which indicates the perpetrator and the level of the breach. If an agent goes bankrupt, this news is published on the bulletin board, on a **bankruptcy list**.

In addition to the breach list and the bankruptcy list, which may help agents decide who <u>not</u> to trade with, **quarterly reports** are also published on the bulletin board listing, for each factory manager agent, their assets, including their balance and the value of the products in their inventory (valued at catalog prices), and their liabilities, including the value of their outstanding loans, and their credit rating.

The Simulation Each simulation of the SCM world runs for multiple (say, 100) steps. Before the first step, each factory agent is assigned a (private) manufacturing profile. In addition, catalog prices for all products are posted, and an initial balance is deposited into each agent's wallet. Then, during each step:

1. Factories make their loan payments. All contracts that come due are executed, and any breaches that arise are handled.

2. Factory manager agents then engage in negotiations for multiple steps (say, 10). During this time, they are also free to read the bulletin board, post CFPs, and respond to CFPs.

3. Finally, all production lines in all factories advance one time step, meaning required inputs are removed from inventory, generated outputs are stored in inventory, and profile-specific production costs are subtracted from the factories' balances.

Utility Functions The SCM world does not endow agents with utility functions. On the contrary, all utility functions are endogenous, meaning they are engendered by the simulator's dynamics and agents' interactions with other agents. Endogenous utility functions that arise as the market evolves are a distinguishing feature of the SCM league. It is an agent's job to design their utilities for various possible agreements, given their unique production capabilities, and then to negotiate with other agents to contract those that are most favorable to them. Under these conditions, a major determiner of an agent's wealth, and hence, their final score, will be their ability to position themselves well in the market and negotiate successfully.

Demand-driven Markets The current rendition of the SCM world is demand driven, meaning proactive consumers drive demand by posting buy CFPs. Default factory manager agents react by responding to the consumers' buy CFPs (offering to sell), and then post their own buy CFPs further down the chain. Miners at the other end of the chain are similarly reactive.
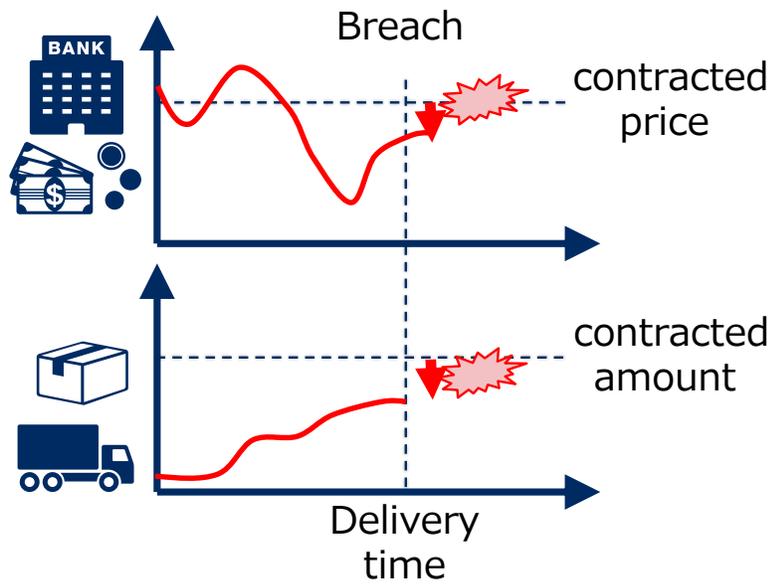
Figure 3: The two potential breach conditions: insufficiently many products and insufficient funds.
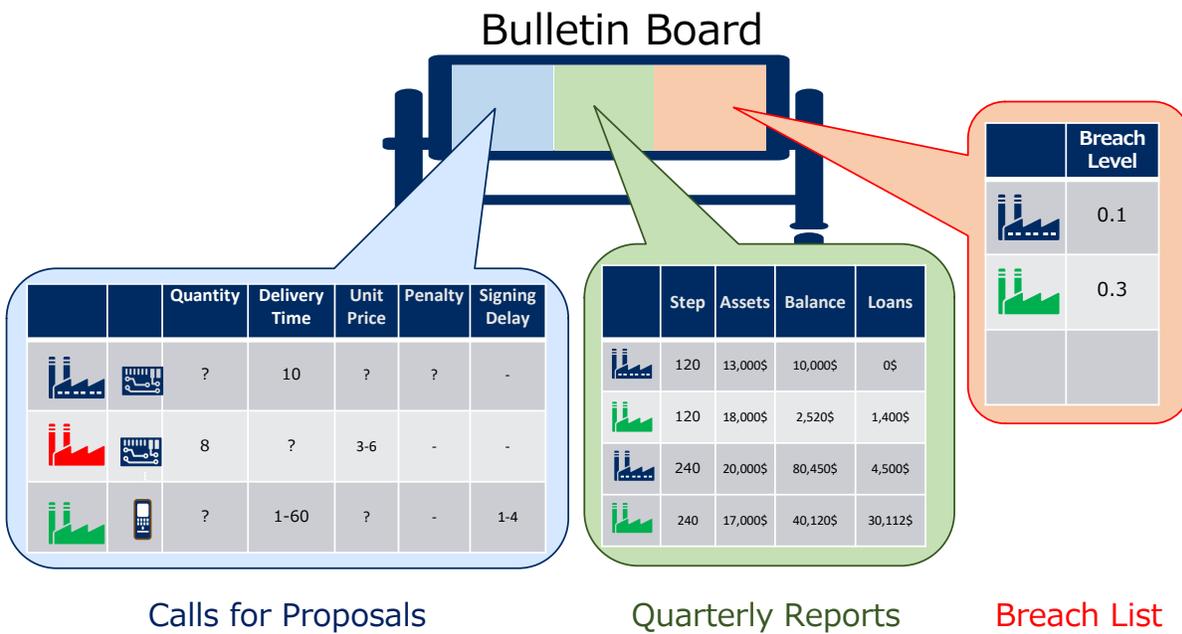

Figure 4: The bulletin board: the Call for Proposals, the Quarterly Reports, the Breach List.

We call the current SCM world design a **pull economy**. The opposite extreme would involve proactive miners at one end of the chain, and reactive consumers at the other: i.e., a **push economy**. We expect future renditions of the SCM league to involve some combination of pulling and pushing.

ANAC 2019 SCM League   The ANAC 2019 SCM league utilizes a simplified version of the SCM world in which there is a single raw material, a single final product, all factories have identical production lines, and no loans are allowed (i.e., the bank is disabled), among other simplifications.   See the ANAC SCM league's detailed documentation for a full list of the simplifications.

Tournament Mechanics

How to Participate   All you need to do to participate in the SCM league is write and submit code for an autonomous agent that acts as a factory manager. While the structure of the production graph will be fixed for the 2019 SCM league, your agent should be robust enough to handle any manufacturing profile, because its particular profile will not be revealed until seconds before each simulation begins.

In addition to agents submitted by the community, the SCM world will be inhabited by miner, consumer, and default factory manager agents designed by the organizing committee. The organizing committee will provide a description of the behavior of these agents, including the miners' and consumers' (exact) utility functions, the factory managers' scheduling algorithm, and an estimation method for the factory managers' utility functions. The negotiation algorithms that the organizing committee's agents employ will not be announced, but will likely be standard choices, such as tit-for-tat or aspiration-level negotiators. Participants are free to use any or all components of the default factory manager agent, or they can develop their own.

How to Compete   There will be three separate competitions in the 2019 SCM league. In the first, the basic competition, at most one instantiation of each team's agent will run in each simulation. In some of these simulations, all the other agents will be greedy factory manager agents. In others, agents submitted by other teams will also participate, but again at most one instantiation of each.

In the second, the collusion competition, multiple instantiations of the same team's agent may run during a single simulation (with multiple greedy factory manager agents as well). The exact number of instantiations of each will vary across simulations, and will not be announced in advance. In this competition, it is possible for instances of the same agent to try to collude with one another to corner the market, or exhibit other collusive behaviors.

The final, the sabotage competition, is intended to uncover fragile aspects of the SCML design. Teams who enter this competition should try to sabotage the market, for example, by preventing trades, or by negatively impacting the profits accrued by others. Sabotaging agents will not compete against one another directly; they will be evaluated independently in the presence of non-sabotaging agents only. Furthermore, they will be excluded from the other two competitions.

How to Win   An agent's performance will be measured by its score. In the basic and collusion competitions, an agent's score will be the average profits accrued by all its factories in all its instantiations in all simulations. In the sabotage competition, agents' profits will not factor into their score; only their ability to sabotage the market/game will matter.

The three competitions will be conducted in two rounds, a qualifying round and a final round. All entrants that are not judged to break any of the SCML and ANAC submission rules will be entered into the qualifying rounds. Top-scoring agents in the qualifying round will then be entered in the final round.

The teams that built the top-scoring agents will be notified in June, with the final results and awards announced at IJCAI 2019. It is expected that finalists will send a representative to the ANAC workshop at IJCAI 2019, where they will be given the opportunity to give a brief presentation describing their agent. Three awards will be announced at IJCAI 2019 (with associated monetary rewards) corresponding to the three competitions (basic, collusion, and sabotage).

The organizing committee will determine the number of simulations needed in each round to ensure a fair comparison among all submitted agents. In addition to identifying the winner of each competition, all teams whose agents achieve scores that are not statistically different from the winner's will be inducted into the SCM league's **hall of fame**.