SCML–21 Charlie's Agent

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1 Introduction

Charlie's agent maximizes the supply and demand amounts in the market in a balanced way. It is necessary to act both supply and demand-driven to increase market penetration regardless of the production level or other market dynamics. For this reason, before we start new negotiations every day, we plan our business plan in our production horizon (PH) to make a profit while minimizing our risk. Charlie's agent employs an unorthodox method for selecting acceptable contracts using a 3D dispatch method for all three issues. It matches the buyer and seller offers according to their profitability and checks if the constraints are satisfied for other issues. This way, buying and selling offers are considered and compared simultaneously and dynamically instead of considering them separately. Charlie's agent has an adaptive behavior for different scenarios, such as negotiating in a monopoly and generating alternative solutions in case of having a bankrupted partner. It performs generously if it engages with an agent that cares about social welfare and a symbiotic trading atmosphere. Charlie's agent obtains higher signing rates when it interacts with an agent that shows similar behavior. When one of our supplier and demand partners is Charlie's agent, they connect their business plans with a bridge and associate them as a single agent for the Collusion Track.

2 Methodology

Charlie's agent has five modules used in different simulation phases, such as business planner, negotiation controller, contract controller, production scheduler, and analytics. Before the negotiations, the business planner module sets the proposed negotiation issue boundaries and selects reliable partners to engage. The proposals are sent to the agents, and negotiation starts for the accepted responses. During the negotiation, the offers of buyers and sellers are dispatched simultaneously according to the negotiation issues. Once the negotiation is completed, contracts are signed, and productions are scheduled if all processes end successfully.

2.1 Business Planner

Business Planner is the core module that plans and controls all pre-negotiation decisions during the simulation. It is mainly responsible for forming the Base Strategy for each agent before negotiations and making a partner selection to remain robust to volatile market conditions. Base Strategy decides on the negotiation issue boundaries, which are used in the proposals that initiate negotiations. There are different boundaries for the price, quantity, and delivery date for buyers and sellers. The limitations are calculated by the formulations as shown in Figure 1. In addition to the graph, there are calculations for constants too. For price lower boundaries (c_1 and c_2), we are checking a number of available agents rates for suppliers and consumers separately and making discounts on our price if fewer agents are to negotiate with. For example, at the start, if there are five buyers and during negotiation 2 of them is bankrupted, we are diminishing our lower prices so that we can negotiate with fewer agents successfully. For upper quantity boundaries (c_3 and c_4), we are dividing the number of available consumer and supplier counts, respectively, and sending negotiation requests with these boundaries to every agent. So that we will not fill our schedule with one buyer or one seller at each simulation step. For buyer delivery lower bound, we are adding our production level to the minimum boundary to eliminate the illogical negotiation requests that are earlier than our boundary.

Boundaries	Buyer	Seller
P_U	$P_L * 2$	$P_{InCat} + 1$
P_L	$P_{OutCat} * c_1$	$P_{InCat} * c_2$
Q_U	$Q^{Production}_{Availalble<PH>} * c_3$	$Q^{Production}_{Availalble<PH>} * c_4$
Q_L	1	1
D_U	$D_L^{Buyer} + PH$	$D_L^{Seller} + PH$
D_L	$t + 1 + Prod.\ Level$	$t + 1$

Figure 1: Negotiation Issue Boundaries

Two main circumstances affect the decision on partner selection. If a partner has a high probability of bankruptcy before the contract execution day or unsigns successfully completed negotiations very frequently, those situations may leave our agent in a disadvantaged position. In order to negotiate with trusted partners, we consider two main factors; the probability of bankruptcy and the rate of unsigned contracts (rejection rate). The bankruptcy probability and the rejection rate might be increasing or decreasing over time. Therefore,

this selection is considered on every simulation day.

2.2 Negotiation Controller

This module controls the negotiation process after selecting the partners and initiating the negotiation.

3D Dispatcher

Charlie's agent applies a matching algorithm among his buyers and sellers in order to dispatch the products. Instead of using utility functions to decide on agreements, it matches the sellers and buyers according to their profitability, deliverable timelines, and risk rates using the 3D dispatcher. In many markets, the decisions on price and quantity are taken by considering the intersection of supply and demand. However, in this domain, there is an additional negotiation issue, 'delivery time'. Therefore, the 2D dispatch mechanism is extended to 3D by adding the delivery time. 3D Dispatcher Module sorts the offers simultaneously by their prices, matches them according to their profits per unit, and checks if it is deliverable according to the offered delivery dates and quantities, predicted bankruptcy probability, and the risk rate. During the negotiations, the dispatcher checks all offers and labels the possible matches based on three conditions:

- Matched: Matching all issues among sellers and buyers,
- Quantity Surplus: Having quantity surplus after all agents are matched,
- Unmatched: Having issues that not allow for a match among agents.

Negotiation Strategy

Beside the actions for different labels, Boulware is used as the main negotiation strategy shown in Equation 1 represents the adopted concession function where t denotes the scaled time $t \in [0,1]$ and P_0, P_1, P_2 are the maximum value, the curvature, and minimum value of the curve respectively. According to the labels decided by the dispatcher, Charlie's agent employs different negotiation strategies. In case of not having a match among the agents, Charlie forces the unmatched issues to be matched in the next negotiation rounds. If there is a match but surplus quantity, we try to remove the surplus quantity in the next offer. If there is an exact match, we try to increase and decrease the price of the deal depending on whether the opponent is a buyer or a seller. The matched offers are accepted at negotiation step ≥ 18.

$$T_{Issue}^{Value} = (1-t)^2 \times P_0 + [2 \times (1-t) \times t \times P_1] + t^2 \times P_2 \quad (1)$$

2.3 Contract Controller

This module considers the regular actions for after negotiations and the actions for unwanted situations like having an unsigned contract or having bankrupted partners.

Charlie automatically signs a contract once both agents agree upon it. However, if Charlie signs and the partner agent unsigns the contract, Charlie generates a pseudo buyer/seller and reflects this treatment to the rejection rate of the unsigned agent. He tries to compensate his losses by finding a match to pseudo agents in the upcoming negotiations. The rejection rates directly affect the partner selection process after the 10^{th} day of simulation. This rate increases if this treatment repeats and decreases if it does not happen in the subsequent negotiations. If the rate becomes greater than 75 percent, Charlie stops engaging with that partner. In case of having a bankrupted partner, Charlie clears the production schedule for that contract and creates pseudo agents to compensate for the loss. By generating the pseudo agents, Charlie tries to find new buyers or sellers for the canceled contracts.

2.4 Production Scheduler

Production Scheduler decides on the production days for signed contracts. During the negotiations, it is also used to check if offered delivery dates are in line with the available schedules and production capacity. If the offered production quantities and delivery dates are not appropriate for the previously set schedules and availability, that offer will not be suitable for acceptance.

2.5 Analytics

Analytics Module is responsible for creating predictions for acceptable negotiation issues for the partners and bankruptcies. We collected the negotiations that end with partners' acceptances for predicting acceptable offers to update proposal boundaries from the simulations. For bankruptcy prediction, we collected the financial reports and analyzed their impact on the bankruptcy situation. We used the cash value from the reports for bankruptcy predictions. Bankruptcy prediction is used in the partner selection process. Both predictions are created by using linear regression.

3 Evaluation

We prepared six different versions of the agent during the development process. Before the submission, we started a 100-day-simulation, 224 configurations with four versions of our agent and MMM (2020 winner updated on collusion) and SteadyMgr (2020 winner) agents. The simulation results show in Figure 2 that both mean and median scores of Charlie's agent versions are outperforming others for simulated configurations. It is also observed that Charlie's agent shows a reliable behavior since the signing rate over registered negotiations is 37% for Charlie, whereas it is 25% for SteadyMgr and 27% for MMM.

Agent	median	mean	std	25%	50%	75%
Charlie's Agent V6	18.10%	25.80%	31.50%	-6.10%	18.10%	53.90%
SteadyMgr	4.80%	12.10%	19.20%	-2.00%	4.80%	29.70%
MMM	0.00%	11.50%	35.30%	-3.80%	0.00%	32.70%

Figure 2: Simulation Results

4 Collusion Track

Our agent searches for the allied agent; if a buyer or seller is also Charlie's agent, they connect their business plans with a bridge and associate them as a single agent. Thus, they can plan for more than one production level without taking another supplier among themselves. Otherwise, Charlie's agent continues to work in a social welfare-oriented manner due to its nature.