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INCREASING EFFICIENCY OF FRESH MEAL PRODUCTION USING SIMULATION

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1 INTRODUCTION

The pandemic period has witnessed a rapid growth of online delivery services in various sectors, especially in the domain of fresh produce e-commerce (He et al. 2019). Numerous companies now offer fresh meal options to consumers through e-commerce platforms, resulting in significant growth in online sales of fresh produce. Gousto, for instance, provides a meal subscription service where customers select their meals for a week, and subsequently receive a box containing all the required ingredients (fruits, vegetables, meat, cereals, herbs, etc.) along with step-by-step cooking instructions for the chosen recipes.

However, recent global economic challenges have led to inflation in many countries, including Gousto's main market, the UK. As a response, Gousto is currently prioritising its efficiency to reduce cost and to continue providing affordable meals to its customers while expanding the variety and convenience of options. Gousto has been working on a simulation model, which was presented at the 2022 Winter Simulation Conference and has evolved into a digital twin and was quickly utilised to work on improving an existing order routing algorithm.

2 SIMULATION CONTEXT

Before our simulation work, Gousto's station utilisation was 67% over several months, consistent with historical reports. Given the significant labour costs and the requirement for a picker to be present at each station at all times, increasing the station utilisation is key to improve efficiency. The routing of orders to stations had long been identified as the key lever to increase station utilisation: prior to our work, boxes were routed to stations without considering the production state. We believed that the station utilisation could significantly increase by incorporating real-time line information into the routing algorithm (e.g. stock availability, work-in-progress status).

However, transitioning to this technology required substantial investments, and developing/validating a new algorithm posed serious challenges. Leveraging previous simulation work, we aimed to fully utilise our simulation model as a comprehensive digital twin by integrating the code of the baseline algorithm for box routing in the simulation model (using Anylogic's Pypeline connector). We could then develop the new algorithm, and compare it with the baseline algorithm by feeding both algorithms with real-time information from the simulation model.

The simulation includes 48 picking stations, each capable of accommodating up to 60 ingredients. Starting from an initial stock position, it models replenishment as well as consumption of stock as orders are picked at each station. The time boxes spend at each station is dynamic, and calculated by a processing time model derived from production data: considering factors like the number of ingredients picked, individual picker performance, and variability. The dynamic routing of boxes through stations involves sending snapshots from the simulation (e.g. box positions, picking states, stock positions) to the Python

module every 15 minutes, mirroring the frequency (and data structures) of real-world operations. The algorithm then returns the routing decisions to Anylogic. This feedback loop was not possible with the more simplistic methods used to evaluate the algorithm before simulation.

3 DESIGN OF EXPERIMENTS

After conducting several iterations on the new algorithm, the simulation model first helped to identify and resolve issues while validating all assumptions. Then, a large-scale simulation experiment was conducted to measure the potential benefits of the new order routing algorithm. This software release marked the 5th major iteration of our order routing algorithm and was named ORA V5.

The simulation experiment encompassed four distinct scenarios: ORA V4, ORA V5 pessimistic, ORA V5 base, and ORA V5 optimistic. ORA V4 was the software in production at that time and served as the baseline for comparison. Subsequently, we explored three scenarios for ORA V5, each with different factory settings. These settings entailed various factory parameters that could be modified upon the release of ORA V5 to enhance its performance. However, considering operational perspectives, the more parameter changes introduced, the higher the associated risks. ORA V5 pessimistic reflected the minimum parameter changes required. ORA V5 optimistic involved fine-tuning all parameters based on our research findings. ORA V5 base represented a pre-agreed compromise for the release.

Each of the four scenarios was executed using the same data: 5 consecutive weeks, with 10,000 orders sampled per week. Since the week-on-week results exhibited remarkable consistency (variations around 1%), we simplified the presentation of results by showcasing only the average across the five weeks.

4 NUMERICAL RESULTS

In the ORA V4 (baseline) scenario, our simulation recorded an average station utilisation of 69% (consistent with the 67% observed in production), and we normalised the hourly throughput to 100. Moving on to the ORA V5 pessimistic scenario, the average station utilisation increased to 76% (a 10% improvement), and the normalised throughput reached 107. In the ORA V5 base scenario, the average station utilisation further increased to 83% (a 20% improvement), with the normalised throughput reaching 117. Lastly, in the ORA V5 optimistic scenario, the average station utilisation showed a significant increase to 88% (a remarkable 26% improvement), and the normalised throughput reached 126.

5 DEPLOYMENT, REAL-LIFE MEASUREMENT AND FUTURE WORK

Following the launch of ORA V5 in mid-April 2023, with settings close to our pessimistic scenario, we made significant progress. By mid-May, our 4-week trailing average station utilisation had already improved to 77%. Continuing our efforts to optimise factory parameters, by mid-July, the average station utilisation further rose to 79% over the 4-week period, with our latest 2 weeks achieving an impressive 82% station utilisation.

Our normalised station throughput has also seen remarkable growth, reaching 154, although it is important to note that other factory improvements have contributed to this increase.

These series of enhancements have played a vital role in boosting Gousto's efficiency and effectively mitigating a significant portion of the cost of living crisis that affected the UK in 2023. As we continue to scale up our latest factory, simulation has become a pivotal element in our continuous improvement process. We are actively working on multiple iterations of ORA and other algorithms, and are confident in our ability to keep improving our efficiency for the foreseeable future.

REFERENCES

He, B., X. Gan, and K. Yuan. 2019. "Entry of Online Presale of Fresh Produce: A Competitive Analysis". *European Journal of Operational Research* 272(1):339–351.