Course Project

The group course project could be in Option A or Option B.

1. Option A

I would prefer that you propose a project topic that genuinely interests you and is suitable for a simulation study. The simulation project may focus on any application domainfor example, simulating a hospital emergency department, modeling the spread of an infectious disease, or analyzing the operation of Uber services in a city. Alternatively, you may choose a published research paper that uses simulation for performance evaluation, replicate its simulation, and then compare your results and conclusions with those presented in the paper.

Please email me your proposed topic by **November 14, 2025**. Your proposal should include the objective of the simulation study and a brief description of the system you plan to investigate. Option B provides an example of such a proposal (excluding the learning outcomes and the remark).

If you do not have anything in mind, below is a project idea you can work on.

2. Option B: Profit-Maximizing Simulation of Tim Hortons Operations Using a Queueing-Network Model

This project models the daily operations of a typical **Tim Hortons** outlet, focusing on its three primary customer channels: *walk-in counter service*, *drive-thru*, and *mobile orders.* The goal is to maximize daily profit by optimizing staffing, equipment use, and prioritization policies while maintaining acceptable customer service levels. The restaurant operates under stochastic customer demand, with peak loads during breakfast and lunch hours.

Customers enter the system through one of the three order channels. Walk-in customers proceed to the cashier queue at the front counter to place and pay for their orders. Drive-thru customers form a vehicle queue that flows through two nodes: the order station and the payment/pickup window. Mobile orders are submitted ahead of time via app and are released into the system for preparation based on a promised pickup time.

Once an order is placed (via any channel), its items are routed through a shared kitchen production network. The kitchen includes a *beverage station* (for brewed and espresso drinks), a *hot-food line*, and a *finishing/packing station.* After preparation, take-out orders are either placed on a finite-capacity *pickup shelf* (for counter and mobile orders) or sent to the drive-thru pickup window. Dine-in customers collect their trays and proceed to the *seating area*, which has limited capacity and must be cleaned (bussed) before reuse.

The system is modeled as a queueing network. Each node in the network corresponds to a service station with well-defined queueing behavior. The cashier, drive-thru stations, and packing station are modeled as M/M/1 queues. The kitchen consists of parallel sub-queues: a *beverage server* with multiple brewed coffee urns (periodically replenished in batches, with occasional blocking if depleted), an *espresso machine* with limited capacity and maintenance cycles, and a *hot-food line* staffed by multiple cooks. Service times vary by item and are modelled with appropriate distributions defined by you.

The pickup shelf is a finite-capacity buffer; blocking occurs at the pack station when the shelf is full. Reneging is modeled for mobile customers who arrive to find their orders not yet ready. Balking is included for drive-thru customers if the external vehicle queue exceeds lane length.

Daily profit is computed as the revenue from completed transactions minus labor costs (staffing at cashier, hot-food line, barista station, drive-thru windows, and bussers), food and beverage costs, and penalties for customer dissatisfaction (e.g., abandonment or order waste). Decision variables include:

- Staff allocation per shift (e.g., number of cashiers, cooks, baristas, and bussers)
- Beverage policy (e.g., urn size and brew schedule)
- Prioritization at the pack station (e.g., whether mobile or drive-thru orders get precedence)
- Pickup shelf capacity
- Number of toasters or espresso machines

Service-level constraints may include a 90th-percentile time threshold for drive-thru service and a maximum tolerated service-level agreement (SLA) violation rate for mobile pickup readiness.

The simulation is implemented as a discrete-event system over a single operating day, with a warm-up period and multiple replications to enable statistical comparison. The system tracks key metrics, such as throughput by channel, average and tail wait times, utilization of critical resources, food/beverage waste, and the incidence of reneging or balking.

Learning Outcomes

This project proposal aims to enable students to simulate a realistic, high-traffic Quick Service Restaurant (QSR) environment. It demonstrates how small changes in resource allocation or queueing policies can produce measurable differences in profit, throughput, and customer satisfaction. More importantly, it provides data-driven insight into trade-offs between operational cost, service quality, and revenue generationessential knowledge for managing modern restaurant chains like Tim Hortons.

Remark

This project proposal presents only the main idea without specifying all the details. During the group project, you should discuss the operational aspects of the QSR system with your teammates.

If any details are unclear, make reasonable assumptions and clearly state them in your simulation study. Please note that your instructor is not a domain expert in the QSR industry and therefore cannot provide guidance on how a QSR should operate.