ECE 6730 Project Presentation

Coffee Shop Simulation

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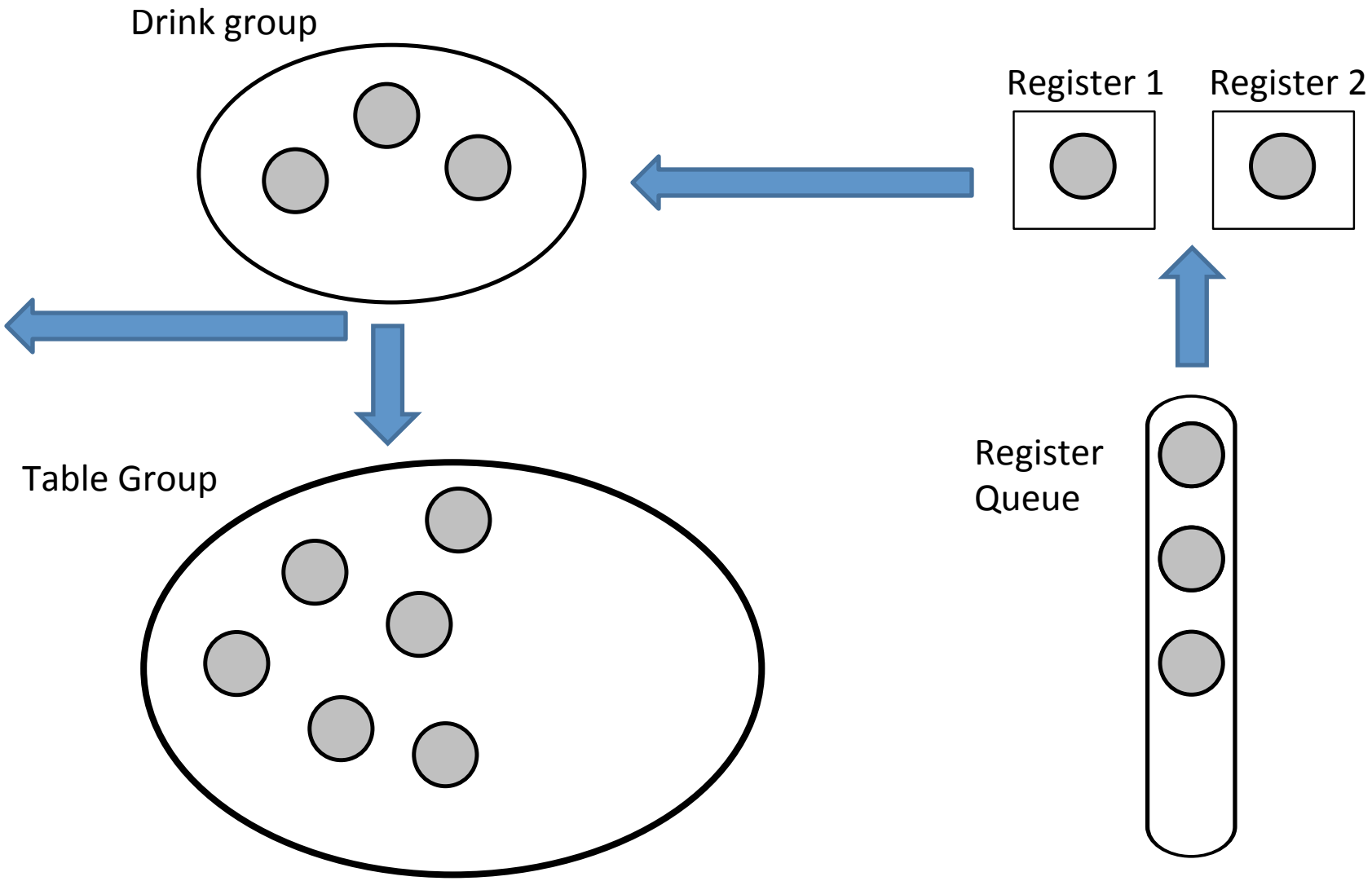
28 April 2010

Project Goals

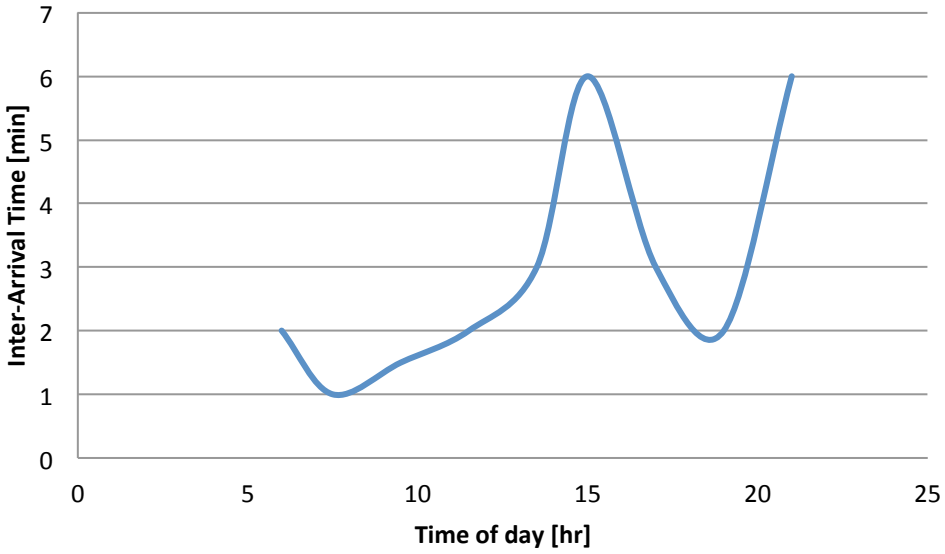
- Create model of coffee shop
  - Customer arrivals (FIFO queue)
  - Registers serving customers
  - Baristas making drinks
  - Customers
- Choose baseline and characterize store performance metrics
  - Average customer wait time
  - Average order to delivery time
  - Peak register line length
  - # lost customers
  - Employee idle time
- Use model to simulate various operational scenarios
  - # cashiers, # tables, # baristas
- Evaluate resulting store performance metrics for varying operational scenarios, compare to baseline
- Improve my understanding of simulating activities (all prior software development done with either discrete time-stepped simulations, physical single-agent systems, e.g. bullet trajectories)

Coffee Shop Model



Customer Arrivals

- Customer inter-arrival times drawn from exponentially distributed random variable with piece-wise constant mean μ
- Shop is busiest in the morning and evening (peak at about 60 customers/hour) and slowest in the late afternoon
- Shop is closed between 10pm and 6am



Customer Life Cycle

- Arrives at shop, waits in FIFO queue for a free register
  - Randomly defined as “take-out” or “stay-in” upon arrival
  - If queue > 20 people, customer balks
- Moves to register to place order
  - Ordering takes U(1,2) minutes
- Moves to drink group to wait for drink
  - Drink preparation takes U(m_1,m_2) minutes, where m_1,m_2 are a function of # baristas

Number Baristas	Min Drink Prep Time (m_1)	Max Drink Prep Time (m_2)
1	2 min	6 min
2	1.5 min	5 min
3	1 min	4 min

Customer Life Cycle (cont.)

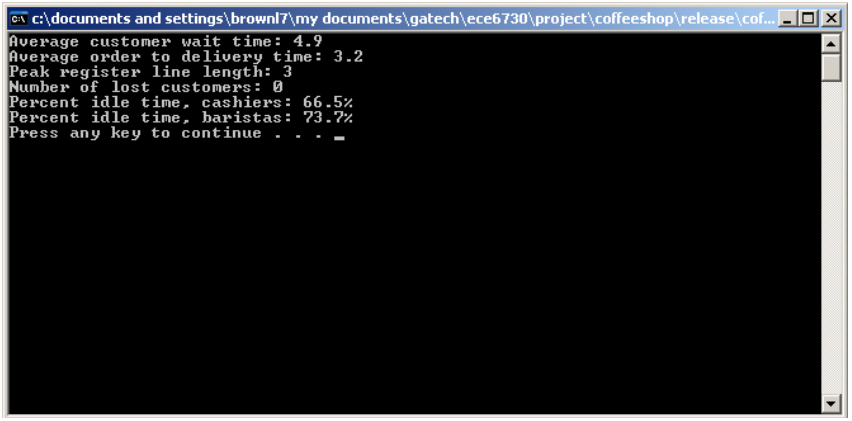
- If “stay-in” and a table is available, sits at table. Otherwise, leaves store
  - T_{stay} chosen upon sitting, U(5,60) minutes
- If still re-order conditions are met, orders another drink.
- If crowd-out conditions are met, leaves store
- If max stay time conditions are met, leaves store

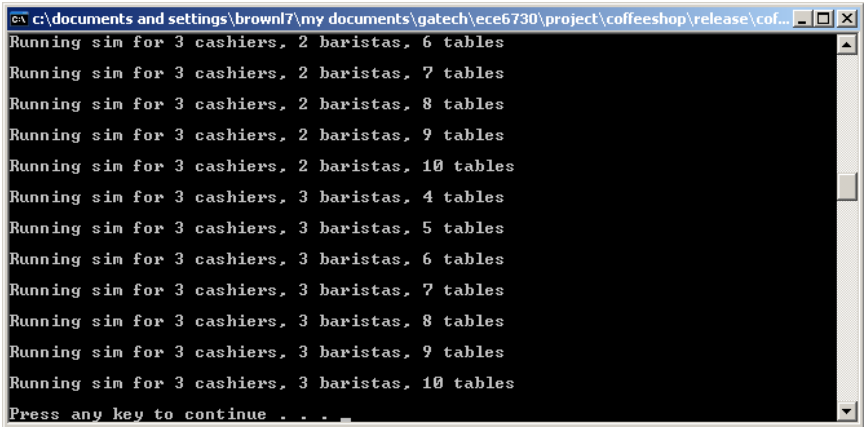
Customer Behavior

- Re-order conditions:
  - Customer has been at table > 30 minutes
  - register line contains less than 3 people
- Crowd-out conditions:
  - Customers has been at table for > 30 minutes
  - Register line length + drink line length > 10 people
- Balk conditions:
  - Register line contains > 20 people
- Max stay time conditions:
  - Customer has been at table > t_{stay} (decided upon sitting, U(5,60) minutes)

Implementation

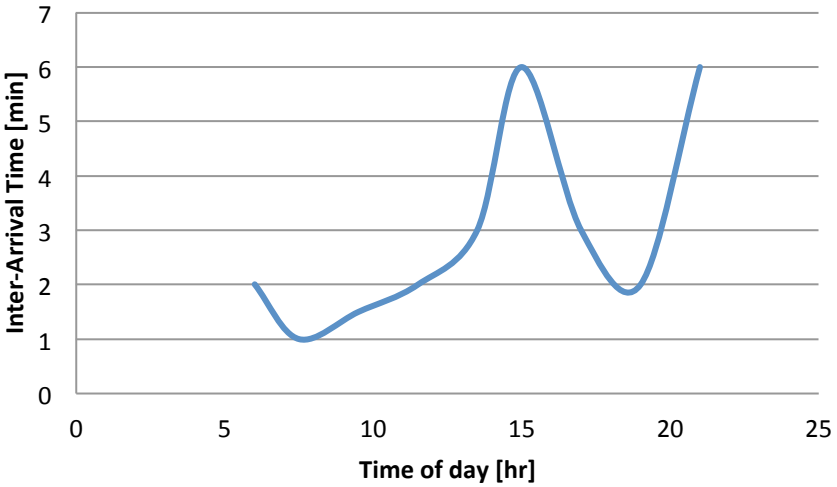
- C++ console application
- Single and batch modes →
- Simulation provides previously discussed performance metrics for user-defined input parameters

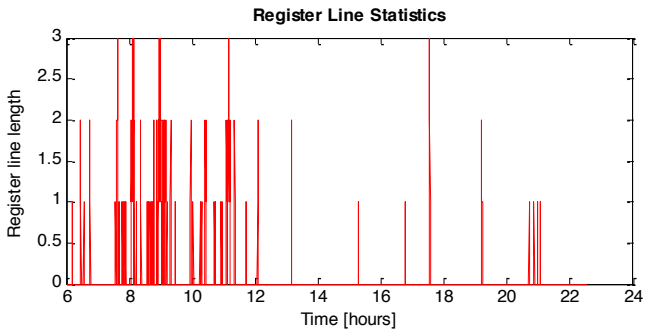


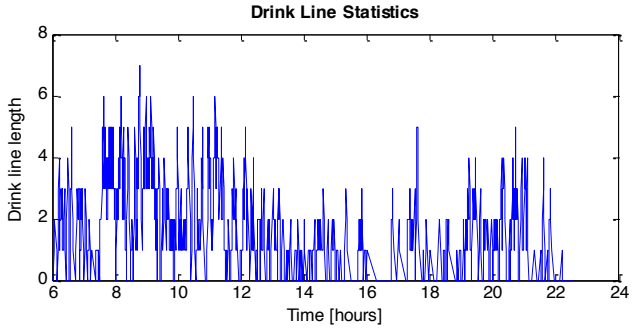


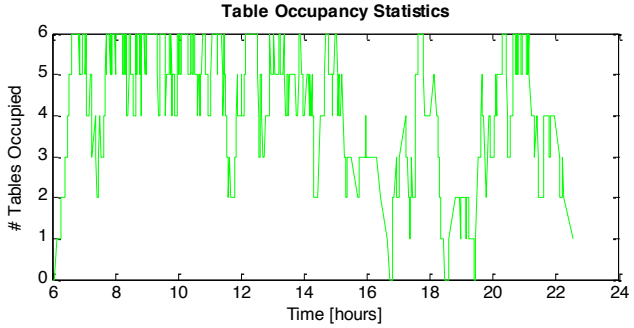
Preliminary Results

- Intermediate output statistics to evaluate is model is behaving realistically









Preliminary Results

- Simulated baseline
  - 2 cashiers, 2 baristas, 6 tables
- Simulated various deviations from baseline
  - # cashiers = [1 2 3]
  - # baristas = [1 2 3]
  - # tables = [4 6 8 10]

Cashiers	Baristas	Tables	Avg Reg Wait	Avg Drink Wait	Peak Reg Line	Lost customers	Cashier % idle time	Barista % idle time
1	1	4	15.81139	3.974943	21	25	0.349698	0.814361
1	1	6	14.39484	4.051052	21	15	0.312468	0.85137
1	1	8	17.56531	4.022442	21	29	0.312064	0.82153
1	1	10	16.16237	4.096446	21	24	0.292431	0.834147
1	2	4	18.76285	3.257236	21	37	0.299548	0.818842
1	2	6	16.94224	3.358911	21	33	0.289412	0.833238
1	2	8	16.71619	3.240279	21	46	0.297853	0.834104
1	2	10	16.15966	3.275058	21	51	0.330716	0.809767
1	3	4	12.98888	2.513035	21	1	0.347695	0.776164
1	3	6	17.01679	2.483516	21	32	0.340691	0.798081
1	3	8	14.92481	2.573546	21	34	0.308598	0.769804
1	3	10	14.59835	2.511178	21	39	0.353903	0.780377
2	1	4	5.849467	4.069831	5	0	0.634551	0.726872
2	1	6	5.778016	4.002014	5	0	0.647329	0.748442
2	1	8	5.939995	4.087262	8	0	0.642107	0.76422
2	1	10	5.695267	3.945316	5	0	0.654288	0.744145
2	2	4	5.045999	3.311014	4	0	0.639983	0.73073
2	**2**	**6**	**5.132746**	**3.226617**	**6**	**0**	**0.630859**	**0.755954**
2	2	8	5.080697	3.252239	6	0	0.661185	0.705215
2	2	10	5.029648	3.287059	4	0	0.622861	0.755251
2	3	4	4.475199	2.482505	7	0	0.59404	0.725594
2	3	6	4.988419	2.526396	12	0	0.602113	0.723408
2	3	8	4.432953	2.472329	7	0	0.639468	0.697638
2	3	10	4.393243	2.476626	8	0	0.652146	0.695315
3	1	4	5.528115	3.993044	3	0	0.76507	0.738032
3	1	6	5.628798	4.070673	4	0	0.743329	0.755993
3	1	8	5.506555	3.968861	3	0	0.749969	0.735644
3	1	10	5.494464	3.940489	3	0	0.765724	0.722479
3	2	4	4.7857	3.217387	3	0	0.748193	0.751079
3	2	6	4.801332	3.239497	4	0	0.77446	0.711183
3	2	8	4.763092	3.22698	3	0	0.744778	0.712673
3	2	10	4.871137	3.30636	5	0	0.742829	0.721161
3	3	4	4.102163	2.549539	3	0	0.753559	0.713529
3	3	6	3.991812	2.440579	3	0	0.758126	0.663791
3	3	8	4.043113	2.500255	3	0	0.747044	0.6759
3	3	10	4.037703	2.486697	4	0	0.755935	0.706146

Remaining Work

- Thorough analysis of results
  - Examine correlation between input parameters and performance metrics
  - Which performance metrics are the most sensitive?
  - Why?
- Possibly (time permitting)
  - Make stay-in, take-out a function of time of day
  - Investigate making stay-time Gaussian rather than uniform (rare cases where someone lingers for hours)

Questions?