CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

Simulating Patient Flow through a Phlebotomy Clinic

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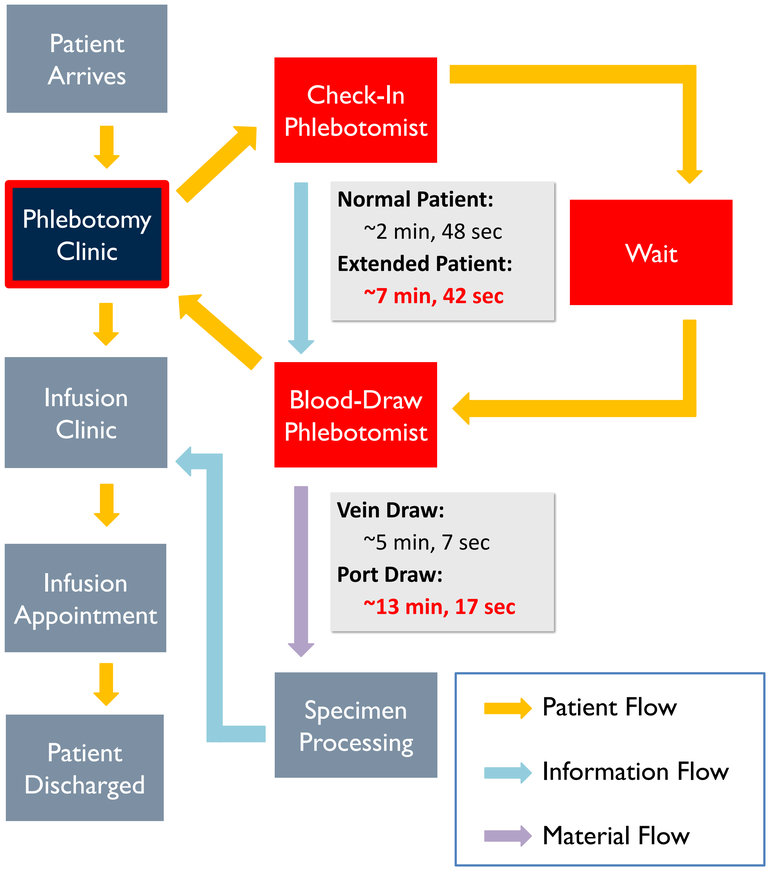
Problem Statement

Context:

The University of Michigan Health System Comprehensive Cancer Center is a stage for ~97,000 outpatients visits and ~58,000 infusion treatments annually, with these numbers consistently increasing.[1]

An outpatient's experience consists of several interrelated stages. Among these stages, the steps conducted in the phlebotomy clinic can be a significant bottleneck for the center's overall patient flow.



Problem:

Extensive waiting times in phlebotomy cause delays to ripple through a patient's experience and negatively impact the entire hospital system.

Goal:

Develop a computer simulation to aid hospital management in instituting policy changes that would increase patient throughput at phlebotomy.

Waiting Time ↓

Patient Throughput ↑

Solution Approach

1. Gather Data

Conduct time studies and discuss clinic operations with management

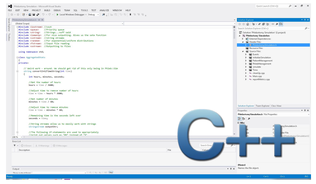
2. Build Model

Define elements of Discrete Event Simulation (DES)

Data Structure Names

QUEUE NAMES:
- eventQueue
- patientsReadyToCheckInQ
- patientsReadyToDrawQ
- phlebsReadyToCheckInQ
- phlebsReadyToDrawQ

EVENT NAMES:
- PatientArrived
- PatientFinishedCheckIn
- PhlebFinishedCheckIn
- PhlebFinishedDraw



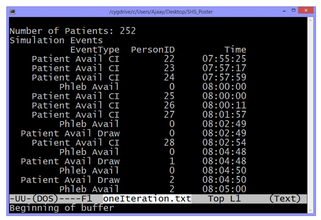
3. Implement

Encode model with Visual C++ 2012

4. Load

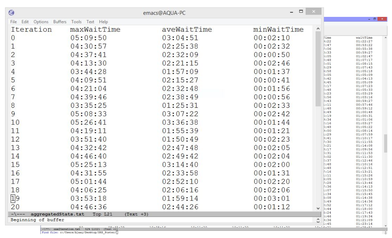
Change custom parameters via several *.txt* files

```
Simulation_Start_Time:  06:30:00
Simulation_End_Time:    18:00:00
Phlebotomist_Schedule:  schedule.txt
PatientArriva Num_patient_arrival_rates: 11
              rate_1:  3.00 time_1: 06:45:00
              rate_2:  36.67 time_2: 07:00:00
              rate_3:  33.33 time_3: 07:15:00
              rate_4:  36.00 time_4: 07:30:00
              rate_5:  26.33 time_5: 07:45:00
              rate_6:  31.33 time_6: 08:00:00
Num_Phlebotomists: 3
phlebID  Role1    Role1Time  Role2  Role2Time
0        CHECKIN  08:00:00   DRAW   15:00:00
1        DRAW     08:30:00   LUNCH  12:00:00
2        DRAW     08:05:00
```



5. Run

Simulate random patient arrivals and phlebotomist activity



6. Review

Examine patient and phlebotomist activity reports

Inputs and Outputs

Inputs:
- Start/End time
- Daily patient arrival rates
- Phlebotomist schedule
- Check-In/Draw activity rates

Outputs:
- Number of patient arrivals
- Max/Min/Average wait times
- Phlebotomist activity summary
- More to come...

Simulation Model

Premise:

Maintain a priority queue of events that will occur throughout the day, with the earliest events having the highest priorities.

Event Type	Person ID	Time
Patient Available for Check-In	**0**	**07:53:00**
Draw Phlebotomist Available	2	07:55:00
Patient Available for Draw	**0**	**7:58:00**

Priority ↑

Simulation Logic:

While the event queue is not empty, extract the earliest event and process it.

~~Patient Available for Check-In~~	~~0~~	~~07:53:00~~

If the event demands a resource, e.g. a patient requires a check-in phlebotomist:

- Extract the resource and add "concluding" events to the event queue—if the resource is available.
- Place the event on standby—if the resource is not available

Available Phlebotomists

ID	Time
1	07:52:00

Available Check-In Patients

ID	Time
0	07:53:00

Future Work

Our future work is geared towards incorporating hospital management feedback regarding the clinical environment and its daily operations. Some short-term goals include:

1. Queue rejection thresholds (reneging)
2. User-selected output metrics
3. User-interface enhancements
4. Expanded event and activity details

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[1] http://www.mcancer.org/about/facts-and-figures