CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

Simulating Patient Flow through a Phlebotomy Clinic

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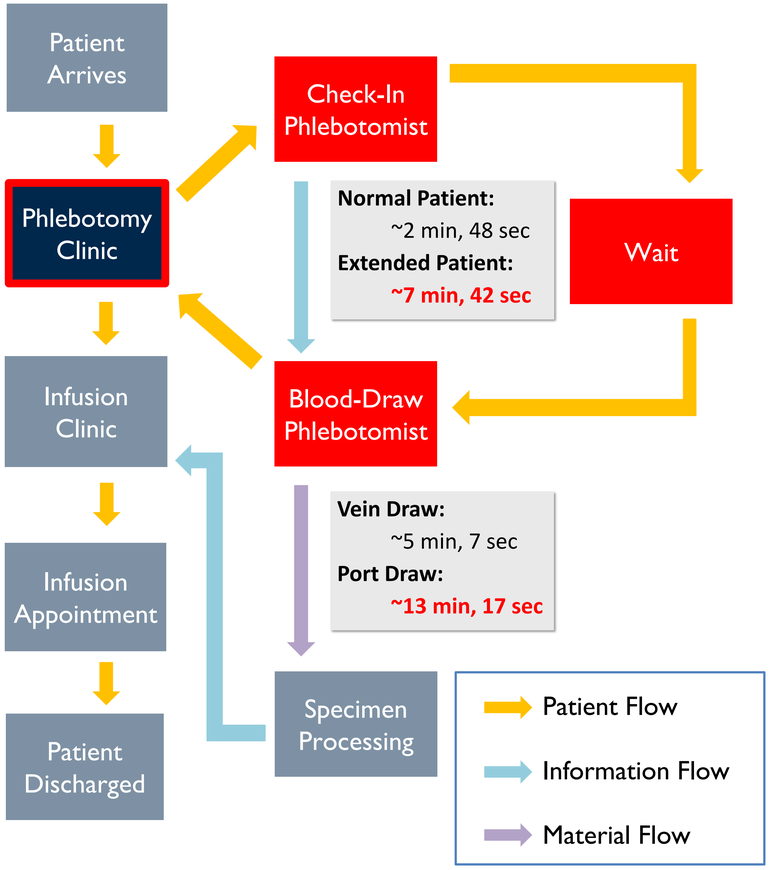
Problem Statement

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

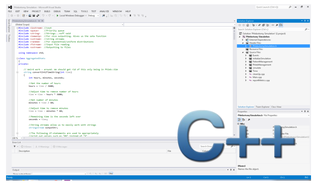
2. Build Model

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

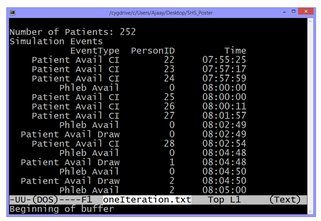
```
Simulation_Start_Time:   06:30:00
Simulation_End_Time:     18:00:00
Phlebotomist_Schedule:   schedule.txt
PatientArriva
```

```
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
```

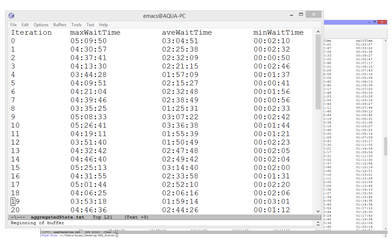
4. Load

Change custom parameters via several *.txt* files



5. Run

Simulate random patient arrivals and phlebotomist activity



6. Review

Examine patient and phlebotomist activity reports

Inputs and Outputs

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

→

Outputs: (TXT)
- 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~~

The event demands a resource, e.g., a patient requires a check-in phlebotomist.

If the resource is unavailable:
- Place the event on standby.

If the resource is available:
- Extract the resource and add "concluding" events to the event queue.

Available Check-In Patients

ID	Time
0	07:53:00

Available Phlebotomists

ID	Time
1	07:52:00

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