Simulation Based Optimization Of
A Pre-Surgical Screening Clinic

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- A full service university affiliated medical center
  - Serves a large and diverse population in Montreal
  - Provides a broad range of inpatient and outpatient services
  - Has major tertiary & quaternary cardiovascular, neurosciences, oncology (including robotic surgery) and neo-natology programs

- Approximately 15,000 operative procedures per year
  - This number may grow 2% per year through 2015
  - Approximately 40% require overnight patient stays after the procedure
A Simplified View Of The Peri-Operative Process

1. Patient Is Referred To Surgeon By GP
2. Patient Sees Surgeon In Surgeon's Office
3. Patient Goes Through Screening Process At Hospital
4. Patient Undergoes Procedure At Hospital
5. Patient Recovers
Goals Of Pre-Surgical Screening Clinic

- **Medical**
  - Make sure patient is in good enough shape for procedure
  - Adjust medications
  - Give patient other medical directives

- **Patient logistical preparations**
  - When to arrive
  - Expected length of stay
  - Need for family help after stay is finished

- **Administrative - collect insurance information**
Pre-Surgical Screening Clinic Tasks

• Up to 35 patients/day will need to do some of the following:
  – Register for the clinic
  – Watch a DVD based video orientation at the start of visit
  – See pharmacist
  – Change into a gown
  – Have EKG taken
  – See GP or Internist
  – Get dressed
  – Give blood and urine samples
  – Receive group training
  – Receive individual training
  – Submit insurance information
Management Challenges

- Different patient profiles
- Minimizing space requirements
- Minimizing staffing costs
- Minimizing physician idleness
- Minimizing excessive patient waiting
- Making sure that staff get breaks and lunch
Complicating Factors

- **Uncertainty of patient profile mix**
  - Lack of knowledge about current mix
  - High likelihood of change in mix over the next few years

- **Time needed for each task**
  - Lack of knowledge about distribution of times
  - Randomness of time within distribution for individual patients

- **A few patients need to see pharmacist before seeing physician**

- **Cost of overtime**

- **No shows and cancellations**
Management Decisions

- Capacity sizing
- Workforce sizing
- Staff scheduling
- Appointment scheduling
Possible Tools For Analyzing Management Decisions

- Discrete Event Simulation

- Simulation based optimization
Simulation Model Challenges

- Wished to carefully model entities (i.e. staff, resource and patient):
  - Activities
    - Patient
    - Staff
  - Interactions between patients and activities and staff and resources
    - Patients need to be in an exam room to change into their gown
    - Patients need to be in a gown before having their EKG taken
    - . . .
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Simulation Modeling Approach

- Could have treated:
  - Patients as entities
  - Staff as resources
  - Exam rooms, dvd players, . . . as resources

- Wanted more flexibility for simulating staff

- Treated patients, staff and physical resources all as entities

- Visual display of model is as a console of states for each entity type

- Simulation logic is used to handle
  - Events
  - Logic of entity flow
## Simulation Model Animation

<table>
<thead>
<tr>
<th>Role</th>
<th>Status 1</th>
<th>Status 2</th>
<th>Status 3</th>
<th>Status 4</th>
<th>Status 5</th>
<th>Status 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>EKG Technician</td>
<td>ET Not In PSS 1</td>
<td>ET Idle 0</td>
<td>ET In Bathroom 0</td>
<td>ET On Break 0</td>
<td>ET At Lunch 0</td>
<td>ET Taking EKG 0</td>
</tr>
<tr>
<td>Blood Taker</td>
<td>BT Not In PSS 0</td>
<td>BT Idle 1</td>
<td>BT In Bathroom 0</td>
<td>BT On Break 0</td>
<td>BT At Lunch 0</td>
<td>BT Taking Blood 0</td>
</tr>
<tr>
<td>General Practitioner</td>
<td>GP Not In PSS 2</td>
<td>GP Idle 0</td>
<td>GP In Bathroom 0</td>
<td>GP On Break 0</td>
<td>GP At Lunch 0</td>
<td>GP Seeing Patient 0</td>
</tr>
<tr>
<td>Internist</td>
<td>IN Not In PSS 1</td>
<td>IN Idle 0</td>
<td>IN In Bathroom 0</td>
<td>IN On Break 0</td>
<td>IN At Lunch 0</td>
<td>IN Seeing Patient 0</td>
</tr>
<tr>
<td>Lab</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exam Room</td>
<td>Exam Room Idle 6</td>
<td></td>
<td>Exam Room In Use By GP 0</td>
<td>Exam Room In Use By IN 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DVD Player</td>
<td>DVD Player Idle 12</td>
<td></td>
<td>DVD Player In Use 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient</td>
<td>PA Needing Surgery 0</td>
<td>PA Waits RN Chart Review 1 0</td>
<td>PA RN Chart Review 1 0</td>
<td>PA Waits 1st PSS Visit Call 0</td>
<td>PA Sets 1st PSS Visit 0</td>
<td>PA Waits Register 1 0</td>
</tr>
</tbody>
</table>

### Simulation Based Optimization Of A Pre-Surgical Screening Clinic
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Simulation Model Data Requirements

- Patient profiles
- Service time distributions
- Count of tasks needing to be done each day
Actual Simulation Model Data

- **Patient profiles**
  - Guesstimates from subject matter experts in existing (PAT) clinic

- **Service time distributions**
  - Triangular distribution guesstimates from subject matter experts
  - Patient self-time studies (in progress)

- **Count of tasks needing to be done each day**
  - Use patient profiles and historical total non-emergent procedure count
Simulation Model Miscellaneous Issues

• Needed to determine rooms allocated to each type of physician
  – Can not pool rooms when GP and Internist worked at same time
  – For Internist
    • When alone allocate all of the rooms
    • When with GP, allocate 2 for each Internist
Validating The Simulation Model

- Was difficult

- Received feedback from management
  - PSS Clinic Nursing Coordinator
  - Another analyst
  - The Chief Of Surgical Services
  - Associate Director Of Professional Services

- Tested against schedule with deterministic service times

- It was known that results were sensitive to service time distribution estimates which were at best guesstimates
Optimization Issues

- Need to start day early to get everyone done by 21:00
- Certain staff had to arrive before other staff
- Breaks and lunches had to fit into 8 hour day
Static Optimization Of Management Decisions

• Initial goal was to
  – Minimize physician idle time
  – Subject to:
    • Staff and patient availability constraints
    • Getting everyone out by 21:00

• Decision Variables
  – Number of each type of staff and resource
  – Staff and patient start times
  – Staff break and lunch times
Static Optimization Of Management Decisions - Cont'd.

• Trials consisting of 10-20 one day runs with pre-defined patient profiles with random times for each patient task

• Optquest - for initial analysis and for generating initial schedules
  – Objective function including penalty for not seeing all patients by 21:00
  – Lower and upper bounds for each decision variable
  – Constraints on break and lunch times
Progress To date

- Original model has been built and tested
- Optquest has been used to minimize physician idle time with respect to staff and patient start times
  - Moved one GP from morning to afternoon
  - Indicated need to control rooms allocated to each type of physician
  - Suggested that EKG technician break and lunch times are important
Best Decision Variable Values Found To Date

• Depends on time distributions

• Using preliminary guesstimates (based on small study of existing PSS)
  – Space requirements
  – Scheduling of start times
  – Scheduling of breaks

• Using guesstimates from EKG machine salesrep, and slower dressing times
  – Space requirements
  – Scheduling of start times
  – Scheduling of breaks
To Do – Short Term

- Revise model to:
  - Add other costs
    - Overtime
    - Excessive patient waiting
    - Cost of using rooms
  - Schedule screening so as to ensure that:
    - Screening doesn't expire (after 3 months) before procedure
    - It does not delay patient procedures
To Do – Medium Term

- Improve quality of data:
  - Hope to use RFID to monitor patient and staff times
  - Plan to analyze data to try to identify correlation between task times for patients, possibly based on their age, preliminary surgeon evaluation, . . .
  - Plan on revising decision variables using updated data
To Do – Longer Term

- Address changing patient profile mix
- Address no shows and cancellations
- Adapt for other clinics
- Adjust break and lunch schedule dynamically within day