Hôpital général juif
Jewish General Hospital

An Alternative Approach To Modeling A Pre-Surgical Screening Clinic

Phil Troy, Nadia Lahrichi, and Lawrence Rosenberg

HÔPITAL D'ENSEIGNEMENT DE L'UNIVERSITÉ MCGILL | A MCGILL UNIVERSITY TEACHING HOSPITAL

Agenda

- Project background
- Modeling needs
- The initial model
- Related modeling literature
- The revised model
- Final thoughts

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Project Background

- **The Sir Mortimer B. Davis Jewish General Hospital:**
  - **Is a full service university affiliated medical center**
  - **Provides a broad range of inpatient and outpatient services**
  - **Has major tertiary & quaternary cardiovascular, neurosciences, oncology(including robotic surgery) and colo-rectal programmes**
  - **Performs 13,000 - 15,000 operative procedures per year**

Project Background

- **The hospital decided to expand its pre-admission testing clinic into a more comprehensive pre-surgical screening clinic that:**
  - **Would screen and prepare an average of 35 patients a day**
  - **Would provide additional services with just a little more staff**

Project Background

- **In the new clinic the hospital wishes for 35 patients/day to some or all of the following:**
  - **Register for the clinic**
  - **Submit insurance information**
  - **See pharmacist technician**
  - **Change into a gown**
  - **Have ECG taken**
  - **See GP**
  - **See Internist**
  - **Get dressed**
  - **Provide blood and urine samples**
  - **Watch a training video**
  - **Receive individual training**

Project Background

- **Factors complicating the analysis included:**
  - **Patient profile mix**
  - **Uncertainty about times needed for each task**
  - **A few patients need to see pharmacist technician before physician**
  - **No shows and cancellations**
  - **Making sure that staff get breaks and lunch**

Project Background

- **Exam rooms:**
  - **Needed to decide how to allocate exam rooms to physicians**
  - **Needed to determine the total number of exam rooms**

Modeling Needs

- **The model needed to:**
  - **Handle a mix of patient needs**
  - **Model patient flow that:**
    - **Varied by patient**
    - **Could follow different sequences depending of available resources**

Modeling Needs

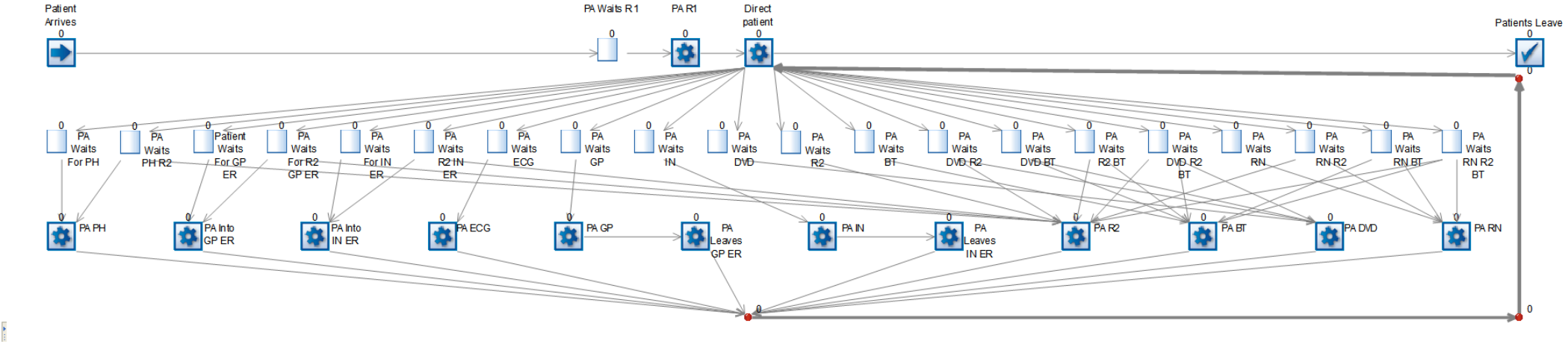
- **The model also needed to support the minimization of**
  - **Physician idle time**
  - **Staff overtime**
  - **Excessive patient waiting**

- **With respect to:**
  - **(2) Physician arrival times**
  - **(5) Staff arrival times, break times and lunch times**
  - **(35) Patient arrival times**

- **By allowing these values to be individualized for:**
  - **Physicians**
  - **Staff**
  - **Patients**

The Initial Model

- **Focused on patient flow**



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The Initial Model

- Separate queues for each combination of services patients could simultaneously wait for
- Lots of crossed lines
- Treating physicians, exam rooms, . . . as resources made it harder to:
  - Track each resource's state
  - Individually control each resource's arrival, break, lunch and departure time
- Model logic became very complicated
- Modifying the model became very complicated
- Verifying the model was difficult because the state of the individual resources could not be seen

Related Modeling Literature

- **Limitations of flow charting for process analysis, software design:**
  - **Ackoff 1999**
    - **Need to minimize or eliminate crossed lines**
    - **Need to redraw major portions of flow chart to make modifications**
    - **Difficulty in showing interactions between flows of different items**
  - **Marrer 2009**
    - **Difficulty in modeling complex logic in a single page**
    - **Difficulty in organizing and laying out the chart**
    - **Difficulties of translating flow chart logic into software**

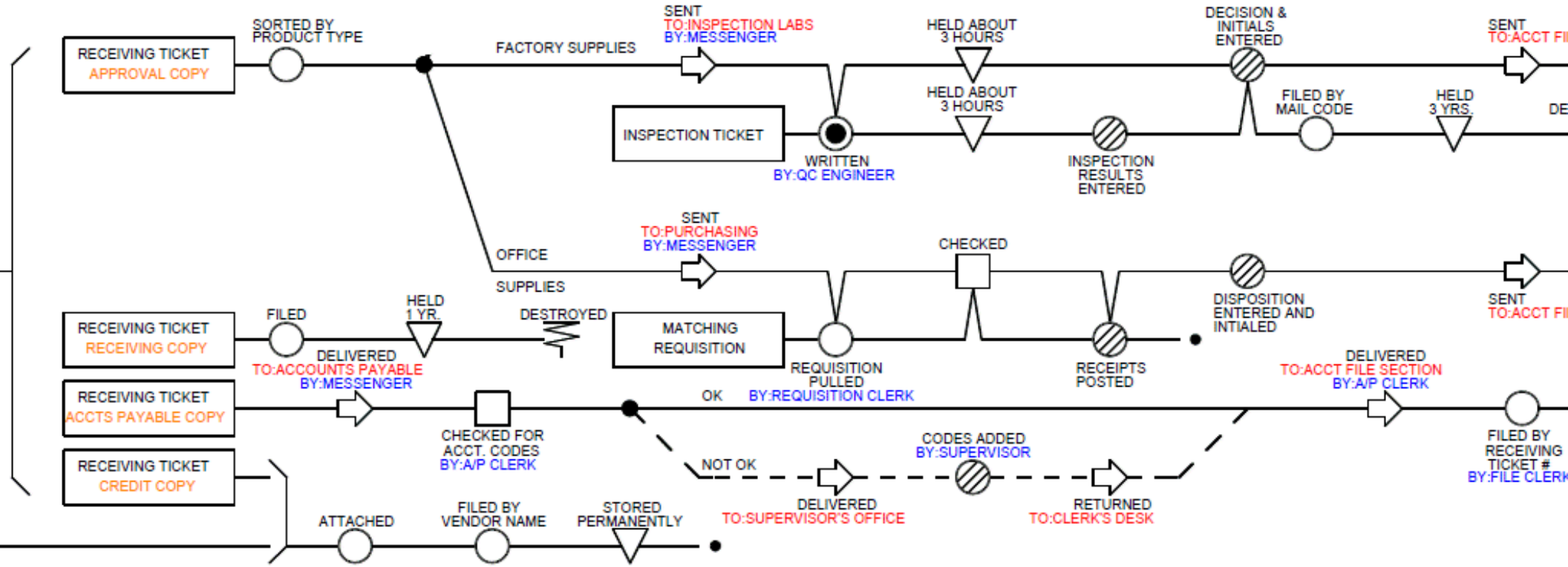
Related Modeling Literature

- **Banks et al. 2010:**
  - **Model is defined in terms of entities that flow through a system and queue for demand resources**
  - **Does not address modeling of processes where different types of entities interact with each other in more complicated ways**

- **Pidd 1999:**
  - **Notes that the modeling process often appears chaotic**

Related Modeling Literature

- **Graham 2008 - Graham Process Mapping:**
  - **Can be used to map multiple work flows and their interactions**
  - **Use ∨ or ∧ to show interactions between flows**



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Related Modeling Literature

- **Modeling entities in multiple queues:**
  - **Tocher 1963 suggested use of duplicate or shadow entities**
  - **Davies 1993 implemented this in Pascal simulation toolkit**

Related Modeling Literature

- **Systems analysis based approaches:**
  - **Leung and Lai 1997:**
    - **Analyze needs using Yourdon's Structured Methodology**
    - **Build model from that analysis (but not directly)**
  - **Sonessa 2004:**
    - **Map object oriented analysis directly to models**
    - **Adapted Unified Modeling Language for that purpose**

Related Modeling Literature

- **Systems analysis based approaches:**
  - **Troy and Rosenberg 2009 - use OO to analyze and build the model at the same time:**
    - **Identify entities**
    - **Identify attributes for each entity**
    - **Identify the events to be modeled (including simulation start, end and reset)**
    - **Identify the activities to be performed for each event by each entity**
    - **Identify the types of inter-entity communications each entity must be able to handle**
    - **Specify the details of each activity for each entity**
    - **Specify the states each entity can take on**
    - **Specify the states each entity must be in for each activity**

Related Modeling Literature

- **Systems analysis based approaches:**
  - **Troy and Rosenberg 2009 - use OO to analyze and build the model at the same time:**
    - **Create a class for each entity**
    - **Add entity attributes to the entity classes**
    - **Declare message types for each event and for each type of inter-entity communication**
    - **Create a handler method for each entity that can handle all of its incoming messages**
    - **Create methods for each entity's actions**
    - **Specify the details of each activity for each entity, typically by changing the entity's attributes or by sending messages to other entities**
    - **Declare the states each entity can take on**
    - **Add code to each action to make sure that the entity is in an appropriate state when asked to perform the action**

The Revised Model

- **Motivated by desire to apply object oriented approach to a non object oriented simulation platform:**
  - **Built list of objects to be modeled and implemented *all of them* as work items**
  - **Determined attributes for each type of object (times for patients, staff and physicians and clinic needs for patients) and implemented them either as work item attributes or via tables**
  - **Determined states each object could take on and implemented the states using queue objects**
  - **Arranged these queue objects in swim lane like rows**
  - **Implemented logic of activities using subroutine logic**
  - **Treated events as messages that affected objects**
  - **Implemented messages as subroutine calls**

The Revised Model

- Used Simul8
- Took advantage of Simul8's queue objects ability to:
  - Execute logic on arrival to the queue
  - Execute logic at pre-determined times after arrival to the queue
  - Execute logic on departures from the queue
  - Animate their current state
- Used separate queue for each state in which:
  - Activities were being performed
  - Work items waited for events
  - Work items waited for other work items waiting for a single activity
  - Work items waited for other work items waiting for more than one activity

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Admission Staff 32	AS Not In PSS 0	AS In Transition 0	AS Idle 1	AS Idle Needs Break 0	AS Idle Needs Lunch 0	AS Idle Needs To Leave 0	AS In Bathroom 0	AS On Break 0	AS At Lunch 0	AS Register 1 0	AS Register 2 1								
Nurse 32	RN Not In PSS 0	RN In Transition 0	RN Idle 3	RN Idle Needs Break 0	RN Idle Needs Lunch 0	RN Idle Needs To Leave 0	RN In Bathroom 0	RN On Break 0	RN At Lunch 0	RN Call Patient 0	RN Train Patient 0	RN Train Group 0	RN 1st PA Chart Review 0	RN 2nd PA Chart Review 0					
Pharmacy Technician 5	PT Not In PSS 0	PT In Transition 0	PT Idle 0	PT Idle Needs Break 0	PT Idle Needs Lunch 0	PT Idle Needs To Leave 0	PT In Bathroom 0	PT On Break 0	PT At Lunch 0	PT Interview Patient 0	PT Patient Follow Up 0								
ECG Technician 16	ECGT Not In PSS 0	ECGT In Transition 0	ECGT Idle 0	ECGT Idle Needs Break 0	ECGT Idle Needs Lunch 0	ECGT Idle Needs To Leave 0	ECGT In Bathroom 0	ECGT On Break 0	ECGT At Lunch 0	ECGT Taking ECG 1									
Blood Taker 32	BT Not In PSS 0	BT In Transition 0	BT Idle 0	BT Idle Needs Break 0	BT Idle Needs Lunch 0	BT Idle Needs To Leave 0	BT In Bathroom 0	BT On Break 0	BT At Lunch 0	BT Taking Blood 1									
General Practitioner 19	GP Not In PSS 0	GP In Transition 0	GP Idle 0	GP Idle Needs Break 0	GP Idle Needs Lunch 0	GP Idle Needs To Leave 0	GP In Bathroom 0	GP On Break 0	GP At Lunch 0	GP Seeing Patient 2									
Internist 5	IN Not In PSS 1	IN In Transition 0	IN Idle 0	IN Idle Needs Break 0	IN Idle Needs Lunch 0	IN Idle Needs To Leave 0	IN In Bathroom 0	IN On Break 0	IN At Lunch 0	IN Seeing Patient 0									
Changing Room		CR In Transition 0	CR Idle 0							CR In Use 2									
Exam Room		ER In Transition 0	ER Idle 3							ECGT ER In Use 1	GP ER In Use 2	IN ER In Use 0							
DVD Player		DVD Player In Transition 0	DVD Player Idle 12							DVD Player Training 0									
Patient	PA Not In PSS 5	PA Register 1 0	PA PT 0	PA Into CR And Gown 2	PA Into GP ER And Gown 0	PA Into IN ER And Gown 0	PA Into ECGT ER 0	PA ECGT 1	PA Into GP ER 0	PA GP 2	PA Into IN ER 0	PA Internist 0	PA Out Of Gown 0	PA Into CR And Out Of Gown 0	PA DVD Training 0	PA Group Training 0	PA Individual Training 0	PA Register 2 2	PA Blood Taker 1	PA PSS Process Completed 0
		PA Waits R1 0	PA Waits PT 0	PA Waits CR And Into Gown 0	PA Waits GP ER Gown 0	PA Waits IN ER Gown 0	PA Waits ECGT ER 3	PA Waits ECGT 0	PA Waits GP ER 7	PA Waits GP 0	PA Waits IN ER 0	PA Waits Internist 0		PA Waits CR And Out Of Gown 0	PA Waits DVDT 0	PA Waits GT 0	PA Waits IT 0	PA Waits R2 0	PA Waits BT 0	PA Waits Consult 0
			PA Waits PT R2 3	PA Waits CR And Into Gown R2 3	PA Waits GP ER Gown R2 0	PA Waits IN ER Gown R2 0									PA Waits DVDT BT 0	PA Waits GT BT 1	PA Waits IT BT 0	PA Waits BT R2 0		
															PA Waits DVDT R2 0	PA Waits GT R2 5	PA Waits IT R2 0			
															PA Waits DVDT BT R2 0	PA Waits GT BT R2 0	PA Waits IT BT R2 0			

The Revised Model (Non-Patient Work Items And States)

Admission Staff 32	AS Not In PSS 0	AS In Transition 0	AS Idle 1	AS Idle Needs Break 0	AS Idle Needs Lunch 0	AS Idle Needs To Leave 0	AS In Bathroom 0	AS On Break 0	AS At Lunch 0	AS Register 1 0	AS Register 2 1			
Nurse 32	RN Not In PSS 0	RN In Transition 0	RN Idle 3	RN Idle Needs Break 0	RN Idle Needs Lunch 0	RN Idle Needs To Leave 0	RN In Bathroom 0	RN On Break 0	RN At Lunch 0	RN Call Patient 0	RN Train Patient 0	RN Train Group 0	RN 1st PA Chart Review 0	RN 2nd PA Chart Review 0
Pharmacy Technician 5	PT Not In PSS 0	PT In Transition 0	PT Idle 0	PT Idle Needs Break 0	PT Idle Needs Lunch 0	PT Idle Needs To Leave 0	PT In Bathroom 0	PT On Break 0	PT At Lunch 0	PT Interview Patient 0	PT Patient Follow Up 0			
ECG Technician 16	ECGT Not In PSS 0	ECGT In Transition 0	ECGT Idle 0	ECGT Idle Needs Break 0	ECGT Idle Needs Lunch 0	ECGT Idle Needs To Leave 0	ECGT In Bathroom 0	ECGT On Break 0	ECGT At Lunch 0	ECGT Taking ECG 1				
Blood Taker 32	BT Not In PSS 0	BT In Transition 0	BT Idle 0	BT Idle Needs Break 0	BT Idle Needs Lunch 0	BT Idle Needs To Leave 0	BT In Bathroom 0	BT On Break 0	BT At Lunch 0	BT Taking Blood 1				
General Practitioner 19	GP Not In PSS 0	GP In Transition 0	GP Idle 0	GP Idle Needs Break 0	GP Idle Needs Lunch 0	GP Idle Needs To Leave 0	GP In Bathroom 0	GP On Break 0	GP At Lunch 0	GP Seeing Patient 2				
Internist 5	IN Not In PSS 1	IN In Transition 0	IN Idle 0	IN Idle Needs Break 0	IN Idle Needs Lunch 0	IN Idle Needs To Leave 0	IN In Bathroom 0	IN On Break 0	IN At Lunch 0	IN Seeing Patient 0				
Changing Room		CR In Transition 0	CR Idle 0							CR In Use 2				
Exam Room		ER In Transition 0	ER Idle 3							ECGT ER In Use 1	GP ER In Use 2	IN ER In Use 0		
DVD Player		DVD Player In Transition 0	DVD Player Idle 12							DVD Player Training 0				

The Revised Model (Patient States)

PA Not In PSS 5	PA Register 1 0	PA PT 0	PA Into CR And Gown 2	PA Into GP ER And Gown 0	PA Into IN ER And Gown 0	PA Into ECGT ER 0	PA ECGT 1	PA Into GP ER 0	PA GP 2
	PA Waits R1 0	PA Waits PT 0	PA Waits CR And Into Gown 0	PA Waits GP ER Gown 0	PA Waits IN ER Gown 0	PA Waits ECGT ER 3	PA Waits ECGT 0	PA Waits GP ER 7	PA Waits GP 0
		PA Waits PT R2 3	PA Waits CR And Into Gown R2 3	PA Waits GP ER Gown R2 0	PA Waits IN ER Gown R2 0				

PA Into IN ER 0	PA Internist 0	PA Out Of Gown 0	PA Into CR And Out Of Gown 0	PA DVD Training 0	PA Group Training 0	PA Individual Traiging 0	PA Register 2 2	PA Blood Taker 1	PA PSS Process Completed 0
PA Waits IN ER 0	PA Waits Internist 0		PA Waits CR And Out Of Gown 0	PA Waits DVDT 0	PA Waits GT 0	PA Waits IT 0	PA Waits R2 0	PA Waits BT 0	PA Waits Consult 0
				PA Waits DVDT BT 0	PA Waits GT BT 1	PA Waits IT BT 0	PA Waits BT R2 0		
				PA Waits DVDT R2 0	PA Waits GT R2 5	PA Waits IT R2 0			
				PA Waits DVDT BT R2 0	PA Waits GT BT R2 0	PA Waits IT BT R2 0			

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The Revised Model

- **Used logic to assign staff to patient needs:**
  - **Assigning waiting staff to patients when patients become available:**

```
Call _TryToAssignClinicResourceToPatient_MultipleResourceSources
    taskGPExam,                          '  The task to be performed
    PA Waits GP,                         '  Existing patient state
    PA GP,                               '  New patient state
    GP Seeing Patient,                   '  New staff state
    2,                                   '  # of GP states to be checked
    GP Idle, GP Idle Needs Break         '  GP states to be checked
```

  - **Assigning waiting patients to staff when staff become available:**

```
Call _TryToAssignPatientToClinicResource_MultiplePatientSources
    taskGPExam,                          '  The task to be performed
    GP Idle,                             '  Existing staff state
    GP Seeing Patient,                   '  New staff state
    PA GP,                               '  New patient state
    1,                                   '  Number of patient states to be checked
    PA Waits GP                          '  Patient states to be checked
```

The Revised Model

- **The revised model simplified:**
  - **Simplified the building *and modification* of the model**
  - **Simplified the addition of rules regarding when staff could take breaks, take lunch, and leave**
  - **Simplified the prioritization of tasks**
  - **Made it easy to see the exact state of the system at any point in time**
  - **Made it easy to visualize and check state transitions**

The Revised Model

- Optimization was performed using a simple heuristic
- There were some issues regarding:
  - Number of runs
  - When to accept an improved solution
- Was able to reduce average cost per day
  - For physicians very close to 0
  - For staff very low
  - For patients an average of 3 minutes excessive waiting

Final Thoughts

- **It is my sense that:**
  - **Easy to use modeling approaches and platforms may make it harder to build more complex models**
  - **It might be helpful if those platforms were extended to include more object oriented capabilities**

Final Thoughts

- **I found it very helpful to be able to see the aggregate state of the whole system in a console like display**

- **I wonder if it might be helpful to start including such a display in more simulations and simulation platforms**

Final Thoughts

- **A lot of the literature focuses on rules**

- **I wonder whether we should be more interested in developing algorithms and heuristics that can be used more dynamically**