Jornadas sarteco
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Study of Emergency Department by Using High Performance Computing

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OUTLINE

- Introduction of Emergency Department (ED); *What?*
- Model of Emergency Department;
- Execution of the model; *How?*
- Basic experiment and selected results;
- Conclusion and future work. *State?*

INTRODUCTION

➢Emergency Department (ED) is the main entrance to healthcare system, the efficiency and Quality of Service in ED has big influence to the whole healthcare system.

➢Patients arrive the ED without prior appointment, with unstable conditions and must be treated quickly!

➢EDs are overcrowded and work with limited budget.

➢ED is a complex adaptive system!

➢… …

Problems to solve

How to solve these problems?

To make decisions to solve these problems, there are many questions should be answered first to support the decision, e.g.:

- If the number of arrival patients doubled, what will happen?
- If we increase 20 more careboxes, the overcrowd can be solved?
- The budget decreased, which staff can be reduced? doctor? nurse? ... ?
- What is the underlying cause of the overcrowd?
- … …

How can we know the effect of a decision without the commitment of any physical resources or interruption of the system?

How to solve these problems?

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Simulation

What is simulation?

☞Simulation is:

- To create a model which can represent a system;
- To make experiment for understanding behavior of system or evaluating different strategies;
- To observe events, process either properties or behaviors about system with a model;

When to use simulation?

- If system is not available for making experiments;
- If the system is in during design phase;
- If the system or problem are complex;
- If system behavior is analyzed;

What is an ED simulator?

☞Emergency Department:

- Complex system.

☞Model:

- **Agent based model**;
- Generalized & Adaptive.

☞Execution:

- Model was implemented on Netlogo;
- HPC is used to deal with massive data and computing;
- HPC was used to simulate different scenarios

THE ED SIMULATOR WE HAVE NOW

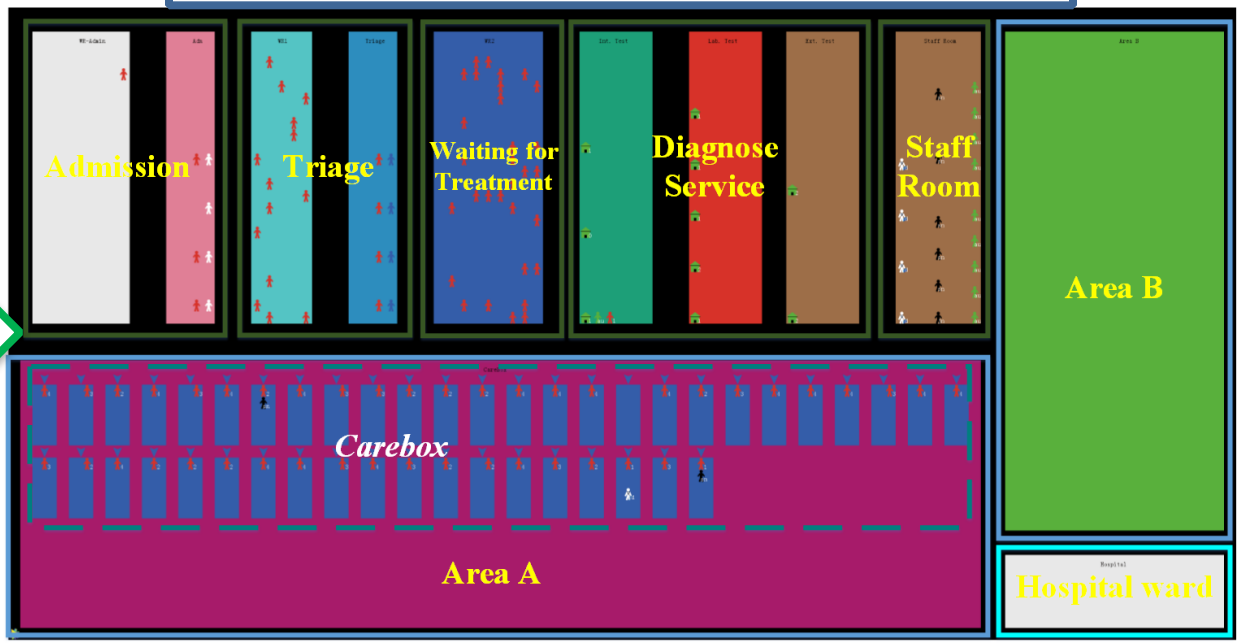
patient(input)

configuration

- ✓admission staff
- ✓triage nurse
- ✓nurse
- ✓doctor
- ✓auxiliary
- ✓carebox
- ✓laboratory test
- ✓internal test
- ✓external test
- ✓hospital ward
- ✓ambulance.
- ✓…

scenario

Two areas: A and B for different patients



Version 2.0

acuity level: 1 → 5

Patient:

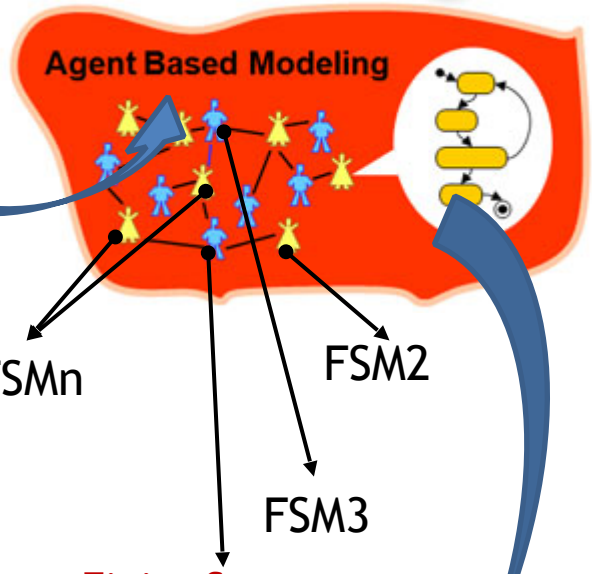
The simulator is not dedicated for any specific ED, that can simulate other EDs who works under the similar healthcare policy by tuning process.

How it works?

Patients

- Sanitary staff
- Physical Resources
- …

Interacting



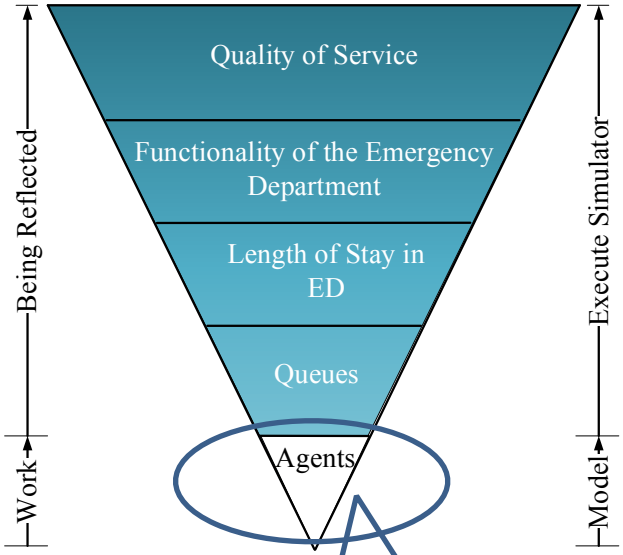
Configuration

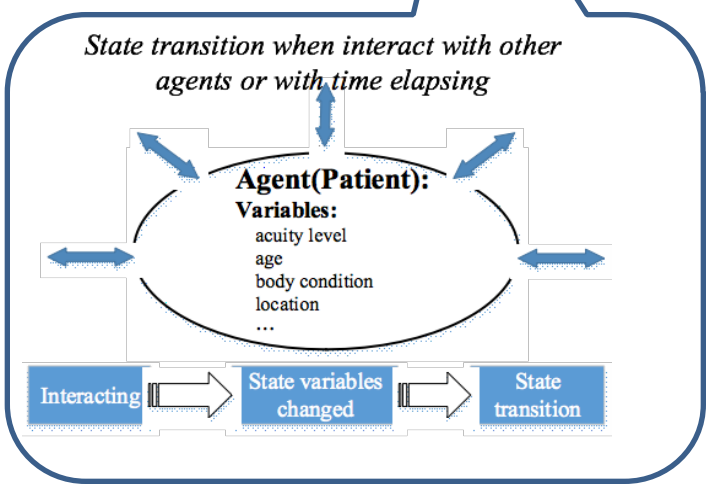
Finite State Machine(FSM1)

Reflect

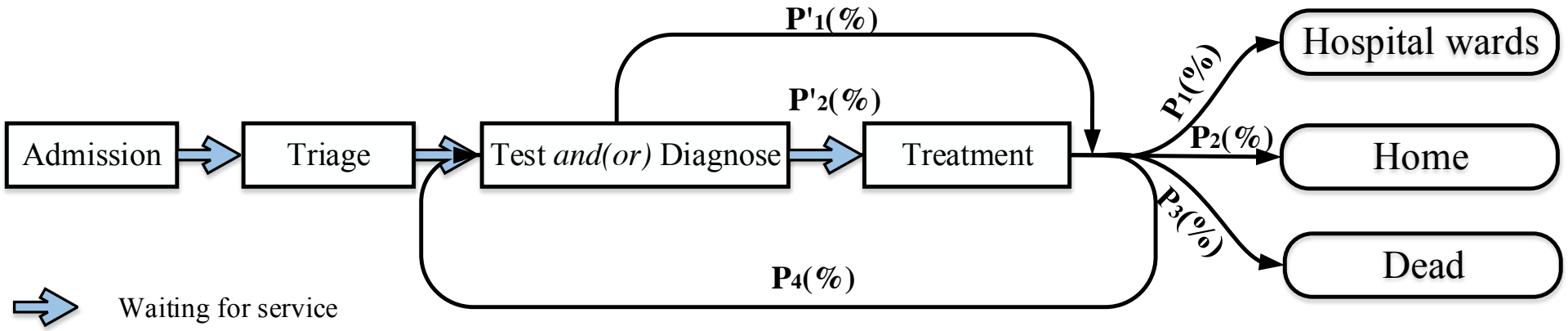
Functionality

Bottom-up-Approach





Process of patient in ED



$$P_i = f(LOS, age, level)$$

$$\sum_{i=1}^{4} P_i = 100\%$$

$$P'_i = f'(ToT, age, level)$$

$$\sum_{i=1}^{2} P'_i = 100\%$$

Execute several times to make result statistically reliable

Parameters for the probability distribution function

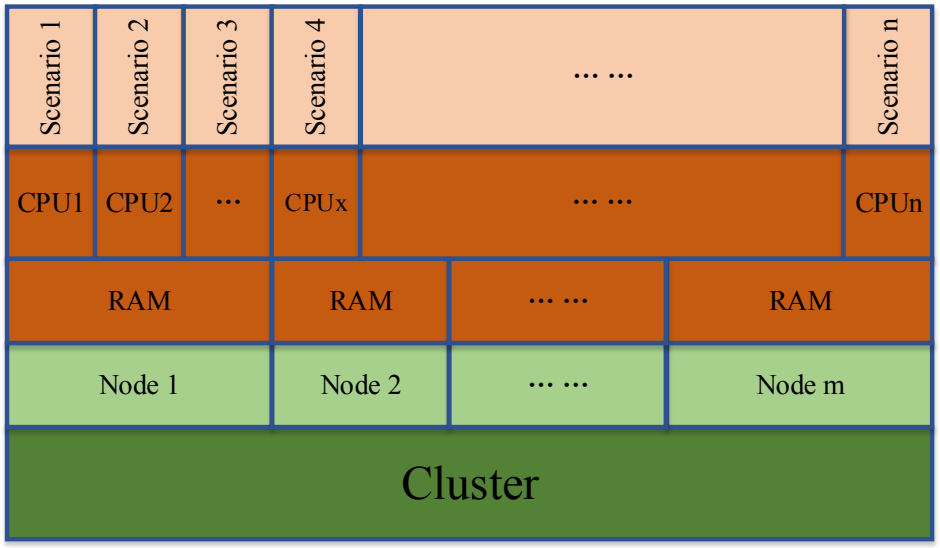
LOS => the patient's length of stay in the carebox.

age => the age of the patient.

level => the acuity level of the patient.

ToT => the type of test and (or) diagnose.

EXECUTION MODEL



result(massive data)

Real Data

tuning result

analyze

answers

Through HPC, the simulator can simulate different scenarios in parallel.

The statistically reliable results can be gotten in an acceptable period of time.

WHAT CAN WE DO WITH SIMULATION?

HPC makes it possible:

- High Performance can provide abundant computational resources and store/process massive data.

What do we plan to do:

- We describe an agent based model of an emergency department and its utility for evaluating decision/changes. (**decision support**)

- Help us to better understand and manage emergency departments. (**mining knowledge of ED**)

- Provide a **platform** for ED related problem studying.

BASIC EXPERIMENT RESULTS

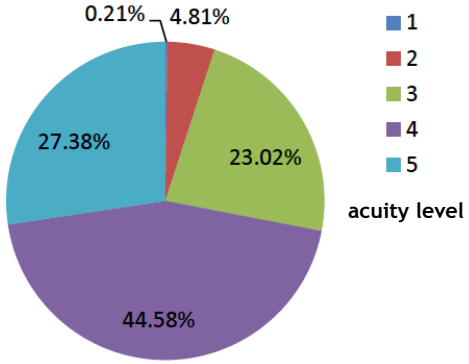
Simulation condition:

Simulation Time: 9000 hours(around 1 year)

Execution Time: 15 minutes per scenarios per core

Patient arrival (input)

Real



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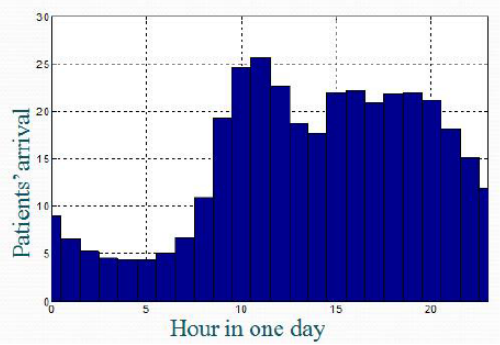


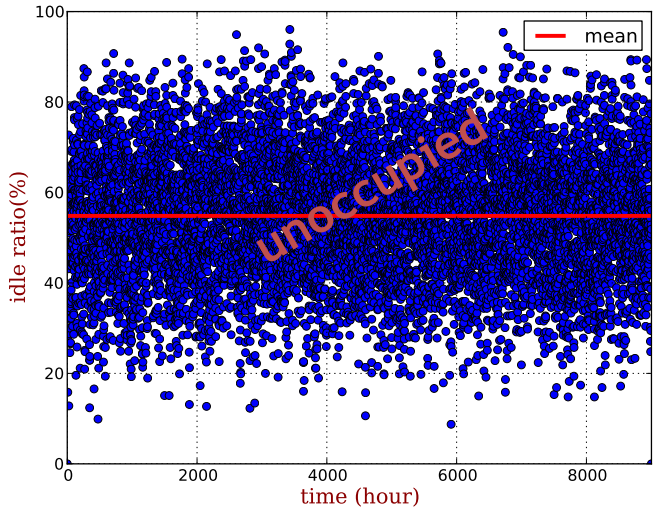
Virtual ED

Scenario configuration

Index	Parameter Name	Value
1	n-of-adm	4
2	n-of-tn	4
3	n-of-janA	1
4	n-of-sanA	7
5	n-of-janB	1
6	n-of-sanB	2
7	n-of-jdA	3
8	n-of-sdA	3
9	n-of-jdB	2
10	n-of-sdB	2
11	n-of-auxi	10
12	n-of-cb	65
13	n-of-int-tr	4
14	n-of-lab-tr	9
15	n-of-ext-tr	3
16	n-of-ambulance	8
17	area-b-capacity	70

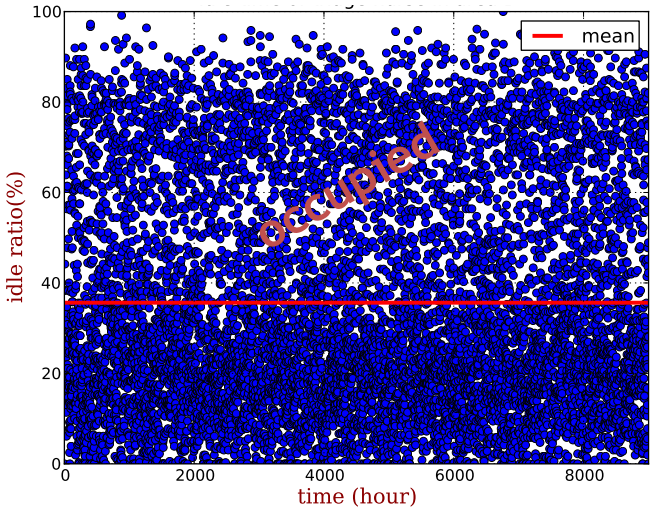
Workload of sanitary staff

Nurse in area A



n = number of nurse in area A

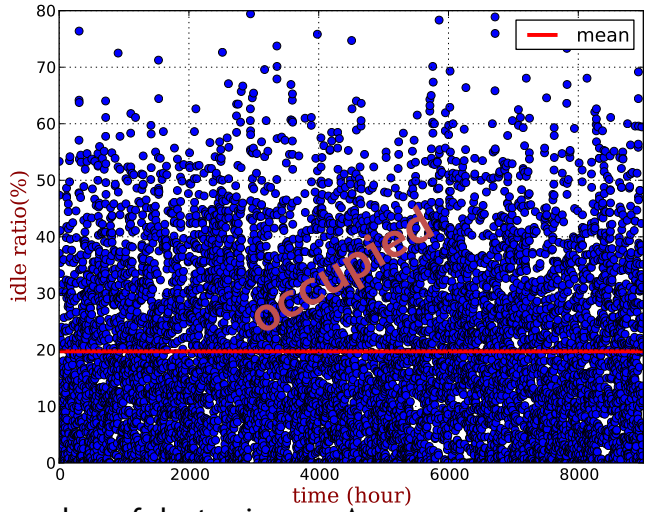
Nurse in area B



n = number of nurse in area B

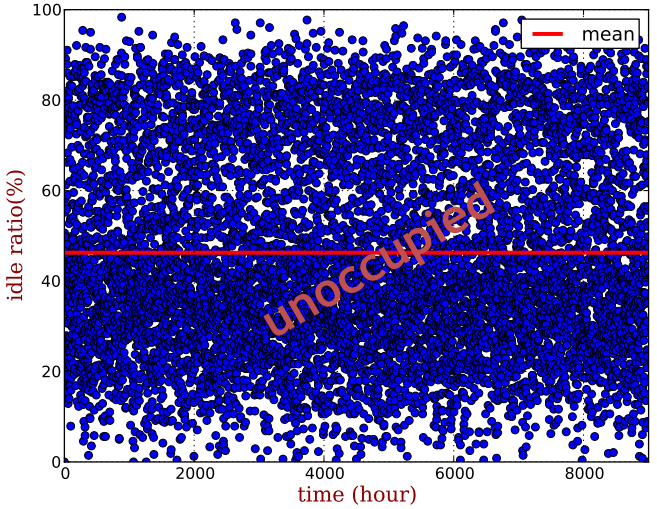
$$idle\_rate = \frac{\sum_{i=0}^{n} length\_of\_idle\_time}{n \times length\_of\_working\_time} \times 100\%$$

Doctor in area A



n = number of doctor in area A

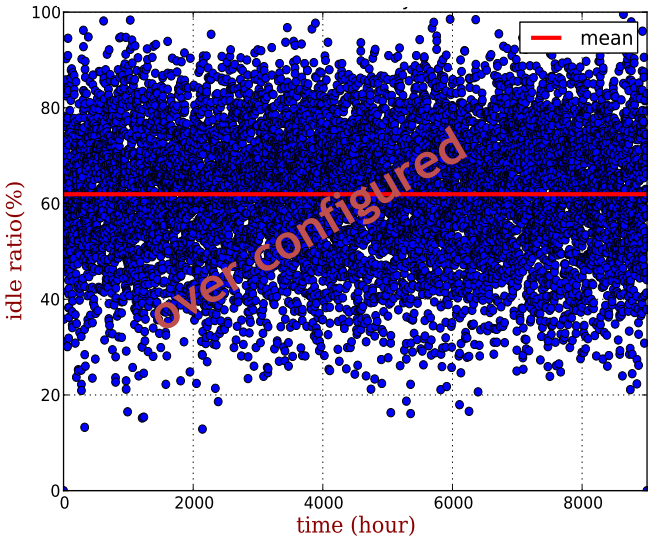
Doctor in area B



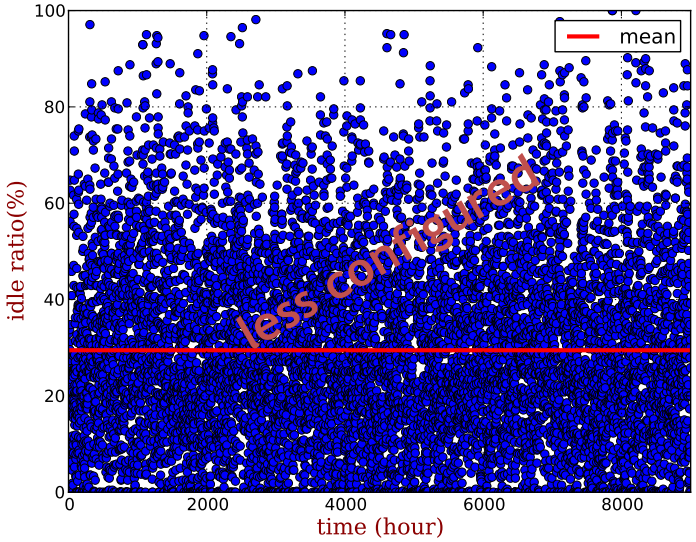
n = number of doctor in area B

Workload of physical resource

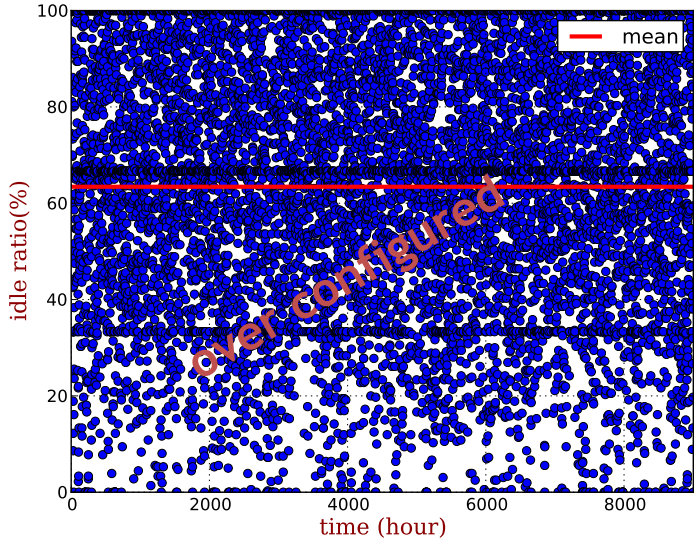
Laboratory test



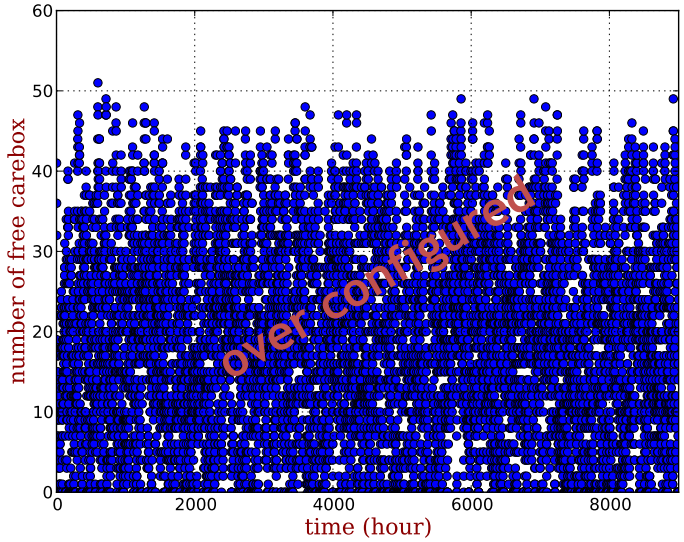
Internal test



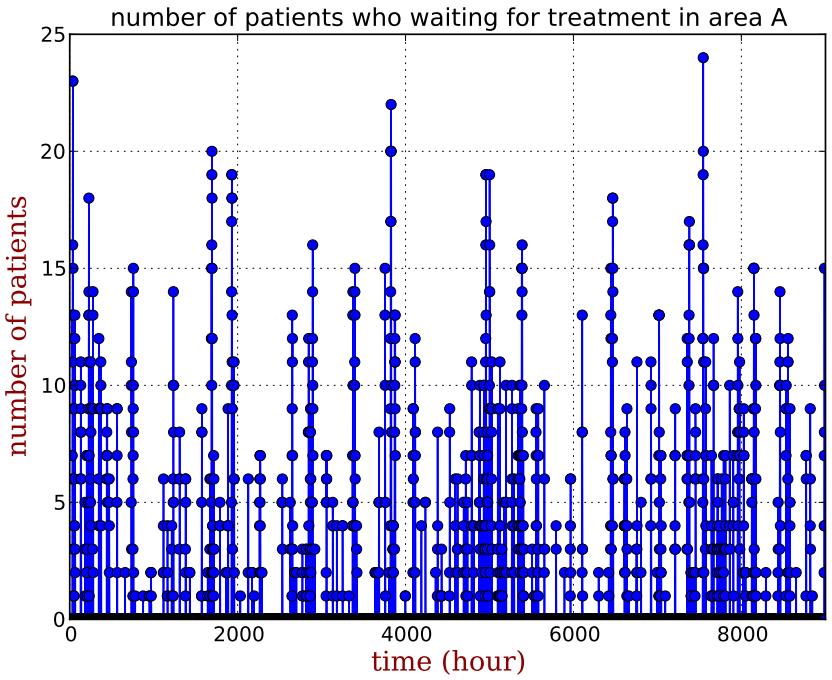
External test

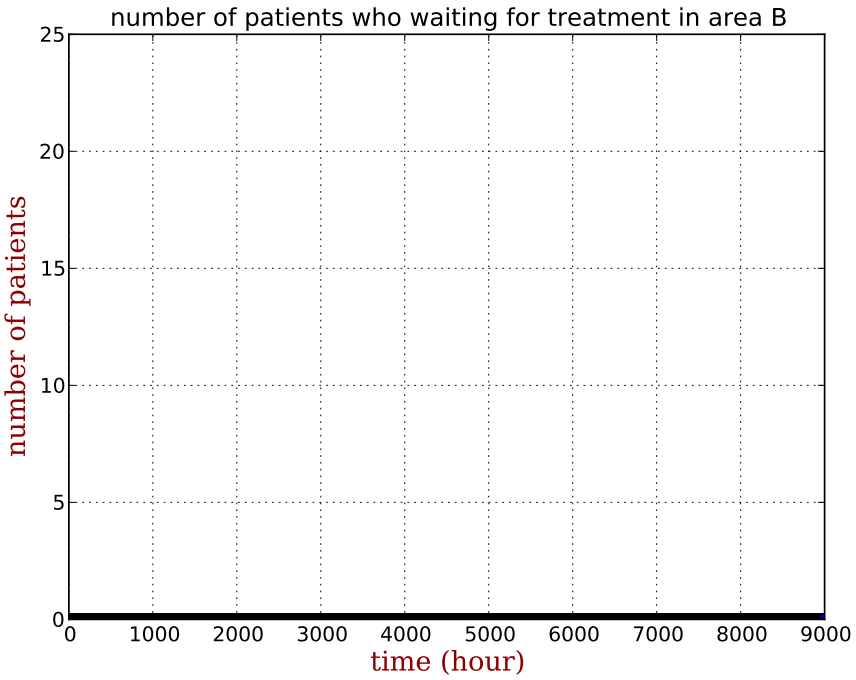


Carebox



Number of patients in waiting room

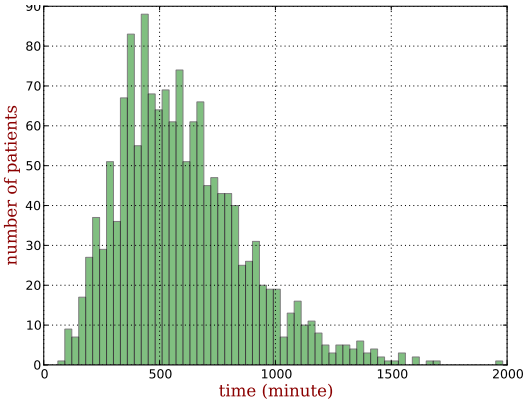




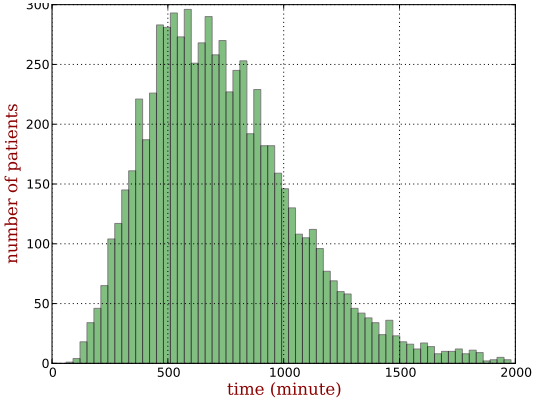
an overplus service resource!

Area A

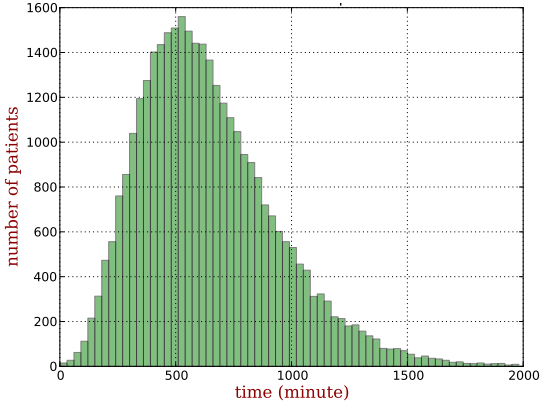
Patients with level 1



Patients with level 2



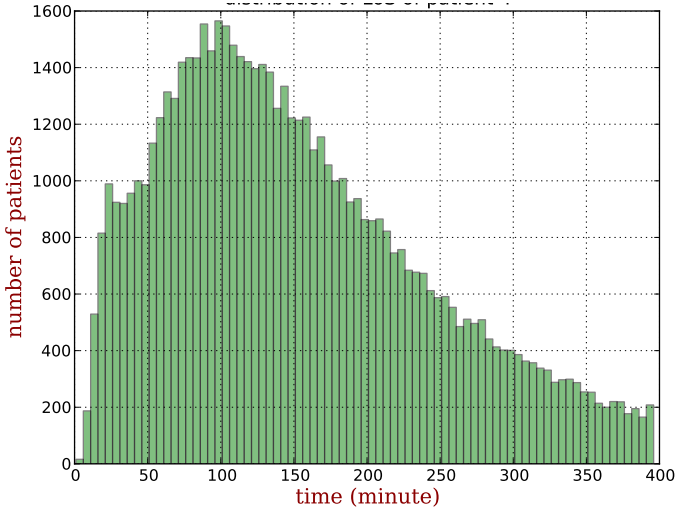
Patients with level 3



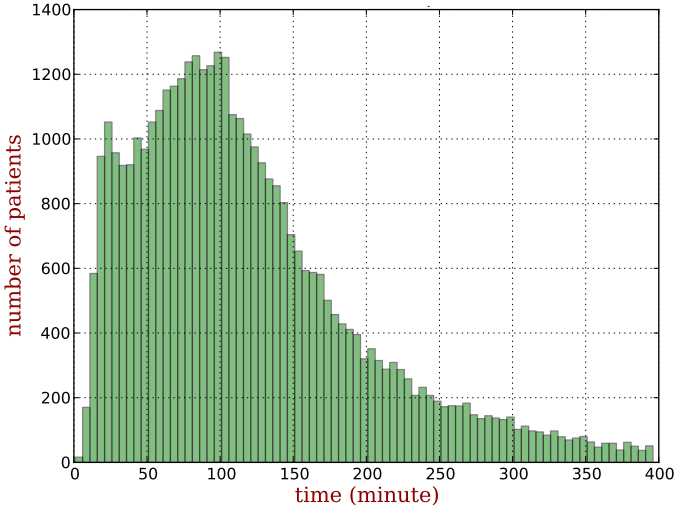
LoS distribution

Area B

Patients with level 4



Patients with level 5



CONCLUSION AND FUTURE WORK

- First, we implemented the model in Netlogo simulation environment.
- Then, we performed verification to debug the model and ensure that it performed as intended.
- Next, we will complete validation of the model to ensure that it behaved as it would in real life and that it accurately represented the patient flow at Emergency Department.
- Perform data mining to discover interesting knowledge about ED and try to answer some interesting question for decision making.

Thanks!

¡Gracias!

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