A Simulator of Emergency Departments for Decision Support and QoS Improving

Hospital de Sabadell

High Performance Computing for Efficient Applications and Simulation(HPC4EAS) of Universitat Autònoma de Barcelona

Tomàs Cerdà Computer Science School Universitat Autònoma de Barcelona

Zhengchun Liu, Emilio Luque, Dolores Rexachs, Francisco Epelde, Eduardo Cabrera, Manel Taboada González

{liu.zhengchun, cabrera.eduardo}@caos.uab.es, {emilio.luque, dolores.rexachs}@uab.es, fepelde@tauli.cat, manel.taboada@eug.es

http://grupsderecerca.uab.cat/hpc4eas/

Objective

➤ Efficiently investigate and improve the healthcare system with the support of High Performance Computing (HPC).

➤ Find the underlying problem of the healthcare system fast and accurately.

➤ Provide simulation based statistically reliable results to answer the questions during the process of decision making for the management of ED.

Contributions

➤ Developed one simulator which included all zones of Emergency Departments (EDs). The simulator can simulate different EDs by tuning process. With the support of HPC, the statistically reliable results can be got in an acceptable period of time.

➤ The way to optimize the configuration (the optimal, the sub-optimal …) of ED resources with multiple constraints.

Motivation

➤ The Emergency Department (ED) is the one of the key components of the healthcare system. The efficiency and Quality of Service (QoS) in ED has big influence to the whole healthcare system.

➤ Provide quantitative reference to promotion decision-making.

➤ Provide a platform to study healthcare system related problems.

Demo Applications

➤ When make some decisions to solve some problems. It is better to know the expected results of the decisions before the actual execution.

➤ Image that, when plan to add more carebox to solve the overcrowd problem, change the configuration of doctor, nurse …, deal with the suddenly increasing arrival patients. It is difficult to make decision without reliable reference.

➤ Following is four demo "Question – Answer" references in area A of one ED.

J -> Junior S -> Senior

J -> Junior S -> Senior

Level 1: 3.5%; Level 2: 17%; Level 3: 79.6%

Approach - ABMS

Agents

Patient
Doctor
Nurse
…

Interacting

Functionality

➤ The EDs is a complex system. With the increasing number of arrival patients, it becomes more and more complex. The functionality of ED is almost impossible to model directly.

➤ The Agent-Based Modeling and Simulation (ABMS) is a bottom-up approach, the functional behavior of the system can be reflected by executing the model.

➤ The agents are modeled by using Finite State Machine (FSM), which is described by a set of states indicated by the value of their state variables.
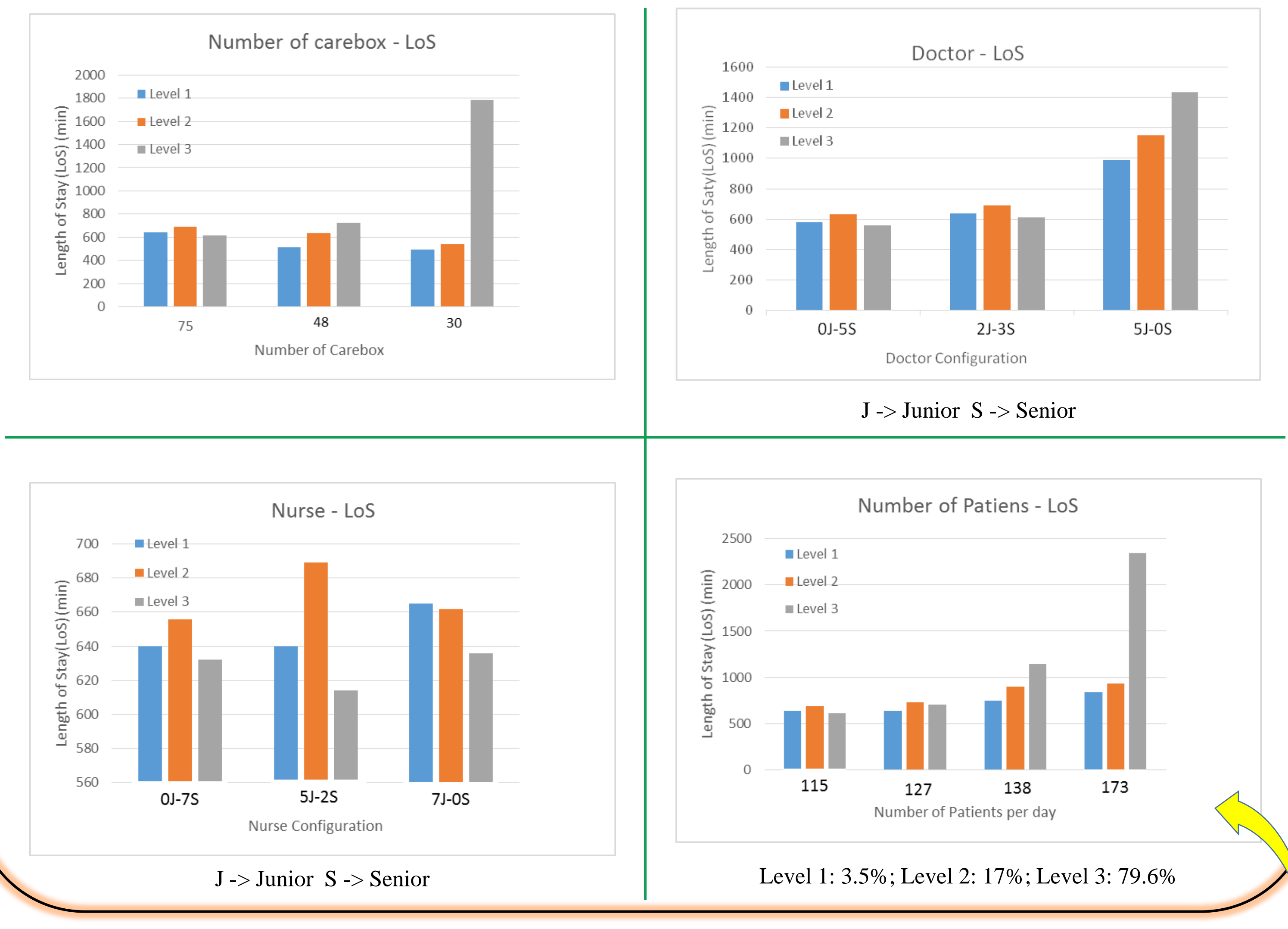
The model

Patients' Evolution in ED

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

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

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

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

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.

✓ The state of the agents is represented by the value of their state variables.

✓ The values of the state variables are changed by interaction or time elapse.

State transition when interact with other agents or with time elapsing

Agent(Patient):
Variables:
acuity level
age
body condition
location
…

Interacting → State variables changed → State transition

The simulator

➤ The simulator of the whole ED has been implemented by using Netlogo. The latest version (Version 2.0) of our simulator considered the following agents: patient, admission staff, triage nurse, nurse, doctor, auxiliary, carebox, laboratory test, internal test, external test, hospital ward and ambulance.

Configuration

Tuning Result

➤ All the agents are configurable, the users can verify their proposed decisions for ED before actual deployment through simulation.

➤ The tuning results can get rid of differences between EDs.