OPTIMAL EMERGENCY ROOM MANAGEMENT SYSTEM

Key Features and Objectives

- Makor has developed a computer-implemented multi-hospital real-time automated optimal emergency room (ER) resources management system for the optimized ER personnel and equipment resources management considering a variety of relevant factors to create an optimal ER management order.

- The optimization is performed by taking into consideration hospital's personnel resources, equipment resources and treatments resources, i.e. a list of treatments.

- Central Emergency Service: the system optimally managing several hospital ERs in one common geographical area such as city / county/state.

- The system calculates estimated time of end of the services for all patients currently receiving care in the ER.

- The system is capable of taking in consideration Factorial (60)=8*10^81 scenarios.

- A computer-based system for displaying optimized treatments schedule will be available for the patients on screens placed throughout the ER and throughout the hospital. Additionally, each patient will be able to use an individual electronic communication device (such as a laptop, PDA or smartphone) for mobile tracking of his or his family members' next treatments schedule.

Need For the System

Hospitals are under regulatory pressure to reduce emergency room costs, improve efficiency, and increase throughput capacity, which ultimately impact hospital revenue and patient satisfaction scores.

The emergency room has taken on an important role as it interfaces with every department of the hospital and healthcare system in some form, impacting the patient healthcare journey overall. The goal of emergency room optimization is to improve performance and quality measures while enhancing the overall patient experience.

In emergency room, there are usually a large number of patients waiting for the medical attention. Several of those patients require more urgent attention than the others; therefore each patient must be prioritized for receiving certain types of medical attention.

From the other hand, there are a limited number of medical resources available in an emergency room; such resources include human personnel resources and equipment resources. Those resources include, for example, particular equipment for special kinds of treatment, the attending doctors who may be specialized on particular kinds of treatment, qualified nurses, necessary instruments, medication and diagnostic devices.

Advantages

- Improving clinical, operational, and financial performance across the entire hospital.

- Helps hospitals reduce patient queuing in emergency rooms, improve patient service and customer experience, and reduce costs by providing the means to optimize the emergency room resources.

The Optimization System Has the Following Main Steps:

- Establishing an emergency room resources database on a computer central hospital server that includes data on hospital personnel, equipment, treatments available and patients enrolled.
- Enrolling new patients at hospital's emergency room, opening a computer file for each new patient and entering personalized data identifying the patient;
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- Entering data regarding particular treatments

Name	Durations	Capacity	Predecessor	Cost	MaxCapacity
1Examination area	15	2	None	1	9
2Plaster area	25	4	None	1	3
3Sewing area	35	1	None	1	2
4Treatment area	22	1	None	1	2
5Bed treatment a...	30	4	None	1	44
6Critical treatmen...	44	5	None	1	6
7Chest-heart trea...	28	1	None	1	10
8Effort examinati...	45	1	None	1	10
9X-ray mobile	15	1	None	1	10
10Ultra sound mo...	21	2	None	1	10
11Angiographies ...	10	1	None	1	10
12CT	33	1	None	1	10
13MRI	18	1	None	1	10
14Ultra sound	42	1	None	1	10
15Blood examina...	10	1	None	1	10

required for the patient following medical examination of the patient;

- Entering data regarding resources required for execution of particular patient treatments;

- Obtaining initial data on availability of the personnel and equipment resources;

- Performing optimization, based on current resources data to establish an updated optimized ER work plan;

- As a result of optimization, an optimized emergency room work plan will be created;

- Optimization will be done perpetually in real-time for a patient not only when he initially arrives to the hospital, but also after each new treatment / medical service has been received by him or, also, when he was asked to undertake a new treatment, thus establishing a new updated optimized work plan.

Optimization Model

Emergency room work plan is continually revised on a real-time basis. This includes entering new patients, equipment, treatments and personnel data, capturing data on availability of resources, updating patient data, and performing a new optimization based on a newly available data, all on a real-time basis. Actually, the emergency room plan is re-calculated on a near real-time basis, say, every minute. Accordingly, the emergency room work plan is produced according to the real-time conditions as well. A real-time and optimized ER work plan assures optimal utilization of resources, and fast optimal response to changing situation.

To perform optimization, current data on the availability of all emergency room resources is used, as well as patient data for each particular patient, including current health data.

The constraints for each scheduled treatment are checked on a current basis, and an optimized current plan is produced. If any changes are needed to be made, for example due to changing conditions of a patient, those changes can be entered to patient's file in CHD by a doctor or a nurse through a special modifications user interface.

In order to establish an emergency room scheduling, an initial scheduling is initially performed using the initial data from the CHD. If there is more than one department or discipline needed for providing medical care to the particular patient, then the optimization must take into consideration data available on all those departments of the hospital.

Our goal is to optimize ER services in such a way that patients that are more urgent will be treated first, that the patients will wait less time in emergency room and that monetary cost of the treatment will be as low as possible.

Emergency

Common | Patient&Service | Service&Patient

Patient	Time	Service	Capacity	Priority
p00	26/11/2017 16:24:27	9X-ray mobile	1	200
p00	26/11/2017 16:39:27	6Critical treatment area	5	200
p00	26/11/2017 17:23:27	5Bed treatment area	4	200
p01	26/11/2017 16:24:27	1Examination area	2	100
p01	26/11/2017 16:39:27	13MRI	1	100
p01	26/11/2017 16:57:27	10Ultra sound mobile	2	100
p01	26/11/2017 17:18:27	8Effort examination area	1	100
p01	26/11/2017 18:03:27	5Bed treatment area	4	100
p01	26/11/2017 18:33:27	12CT	1	100
p02	26/11/2017 16:24:27	4Treatment area	1	300
p02	26/11/2017 16:46:27	9X-ray mobile	1	300
p02	26/11/2017 17:01:27	7Chest-heart treatment area	1	300
p03	26/11/2017 16:24:27	20Gynecolog expert	3	700
p03	26/11/2017 16:42:27	5Bed treatment area	4	700
p04	26/11/2017 17:08:27	4Treatment area	1	100
p04	26/11/2017 17:30:27	19Eyes expert	2	100
p04	26/11/2017 17:49:27	9X-ray mobile	1	100
p04	26/11/2017 18:04:27	14Ultra sound	3	100
p04	26/11/2017 18:46:27	3Sewing area	1	100
p05	26/11/2017 16:24:27	11Angiographies mobile	1	600
p05	26/11/2017 17:12:27	5Bed treatment area	4	600
p06	26/11/2017 16:24:27	2Plaster area	4	400
p06	26/11/2017 16:49:27	8Effort examination area	1	400
p07	26/11/2017 16:24:27	2Plaster area	4	100
p07	26/11/2017 17:23:27	6Critical treatment area	5	100
p07	26/11/2017 19:21:27	7Chest-heart treatment area	1	100
p07	26/11/2017 21:51:27	12CT	1	100
p08	26/11/2017 16:24:27	21Pediater expert	3	100

Optimize · Patient · Time · Service · Sort by and place it above 3 combo boxes

Prioritycoeff: 1.5   Total time: 300   Optimization Scenarios

As a result of optimization, an optimal scheduled list of treatments will be created for each patient enrolled. Using it, the patient will be familiar with an order in which the treatments will be performed and the approximate time.

Such information will be available to the patient from the central hospital information system described hereafter in both a per-patient view (one patient per row with treatments as columns) and with a per-treatment view (one treatment per row with patients as columns).

A special module will check if there is a time deviation by a certain parameter from an initial optimized schedule to the current schedule of each patient. The system will adaptively compensate for an unscheduled delay in a treatment activity if such a delay happens (or if a treatment will be performed too soon).

When a large deviation from the scheduled optimization happens – a special message will appear for the attention of the service administrator.

Analytic module

The input for the system analytic module includes a variety of data related to different types of resources, such data will be placed on central hospital server, where it will be stored and accessed for a consequent processing.

This database should be established and maintained according to the general medical practice standards. The database administrator/s will manage the database and grant login privileges to hospital's personnel.

The database will be automatically updated every minute, thus making it a real-time or very-near real-time database.

The database will hold, in particular, information on hospital personnel resources, equipment resources and a full list of treatments available. The data will be available for an immediate use as an input for further processing and optimization.

Personnel resources mentioned above are further divided into doctors' resources and nurses' resources. This data will include, in particular, a total number of doctors and nurses including their specialization, there work schedule for the current time period, their preferred work hours for the next time period and their preferred vacation days/weeks. In particular, doctors and nurses resources are furthermore divided according to their medical specialization (cardiologists, orthopedists, surgeons, etc.).

Data on personnel' preferences may be gathered from individual profiles of every doctor or nurse. If, e.g., a particular doctor or nurse prefer a special time or equipment to work with, in such a case, that doctor will be scheduled for a certain treatment at time when that equipment will be available.

Analytic module will allow the user to initiate advanced analytics by viewing statistical analysis data. This will add analytical capabilities to enable better viewing and operating capabilities. For example, when the waiting time for a particular treatment is high due to a significant shortage of specific doctors / nurses, there is an option to call-up to the work those doctors / nurses.

In connection with that, maximal and current capacity of each service / procedure can be easily viewed, examined and analyzed.

Number	Service	MaxCapac	Current
			5004
1	Examination area	9	2
2	Plaster area	3	4
3	Sewing area	2	1
4	Treatment area	2	1
5	Bed treatment area	44	4
6	Critical treatment area	6	5
7	Chest-heart treatment area	10	1
8	Effort examination area	10	1
9	X-ray mobile	10	1
10	Ultra sound mobile	10	2
11	Angiographies mobile	10	1
12	CT	10	1
13	MRI	10	1
14	Ultra sound	10	3
15	Blood examination laboratory	10	1
16	Cardiolog Expert	10	1
17	Interior Expert	10	3
18	Nose ear throat expert	10	4
19	Eyes expert	10	2
20	Gynecolog expert	10	3
21	Pediater expert	10	3
22	Neurolog expert	10	1

Furthermore, the system will allow users to simulate possible outcomes using what-if scenario analysis. What-if scenarios will be calculated to predict what will happen if sudden change in work plan will occur. Such scenario analysis will be available to relevant medical personnel of the emergency room.

Service history of each service / procedure can be easily viewed, examined and analyzed as well.

Emergency

Common | Patient&Service | Service&Patient

Service/Time	Capacity	Duration	13:00-0	13:01-1	13:02-2	13:13-13	13:14-14
1Examination area	2	15	p01				
2Plaster area	4	25	p06; p07; p13				
3Sewing area	1	35	p16				
4Treatment area	1	22	p02				
5Bed treatment a...	4	30					
6Critical treatmen...	5	44					
7Chest-heart trea...	1	28					
8Effort examinati...	1	45					
9X-ray mobile	1	15	p00				
10Ultra sound mo...	2	21					
11Angiographies ...	1	10	p05				
12CT	1	33					
13MRI	1	18					
14Ultra sound	3	42					
15Blood examina...	1	10	p10				
16Cardiolog Expert	1	55					
17Interior Expert	3	17	p26				
18Nose ear throa...	4	10	p29				p32
19Eyes expert	2	19					
20Gynecolog exp...	3	18	p03				
21Pediater expert	3	10	p08				
22Neurolog expert	1	1	p19	p20	p21	p32	
*							

Name doctor	Patient name	Service name	Start time	Finish time	Comment	Time wait (minutes)
Doctor1	p00	5Bed treatment a...	25/06/2010 14:02	25/06/2010 14:03		755
Doctor1	p00	5Bed treatment a...	03/11/2010 11:38	03/11/2010 11:39		188495
Doctor3	p00	3Sewing area	10/11/2010 15:43	10/11/2010 15:44		10324
Doctor3	p01	6Critical treatmen...	29/06/2010 11:50	29/06/2010 11:50		2713
Doctor2	p01	11Angiographies ...	30/06/2010 12:38	30/06/2010 12:39		1488
Doctor3	p02	2Plaster area	29/06/2010 15:50	29/06/2010 15:51		2937
Doctor3	p04	2Plaster area	29/06/2010 15:51	29/06/2010 15:51		1645
Doctor3	p04	12CT	31/05/2011 12:28	31/05/2011 12:28		483637
Doctor2	p05	8Effort examinati...	28/06/2010 12:10	28/06/2010 12:11		1185
Doctor1	p05	8Effort examinati...	28/06/2010 12:11	28/06/2010 12:13		0
Doctor2	p05	12CT	28/06/2010 18:29	28/06/2010 18:30		376
Doctor3	p16	12CT	20/10/2010 13:05	20/10/2010 13:10		1449
Doctor2	p16	2Plaster area	21/10/2010 11:01	21/10/2010 11:01		1311
Doctor2	p16	2Plaster area	26/10/2010 14:56	26/10/2010 14:57		7435
Doctor3	p16	2Plaster area	28/10/2010 18:16	28/10/2010 18:16		3079
Doctor5	p18	22Neurolog expert	30/05/2011 14:32	30/05/2011 14:32		289318
Doctor5	p18	18Nose ear throa	30/05/2011 14:38	30/05/2011 14:39		6

System Implementation in Hospitals

For each new patient registering into the hospital, a new patient file will be opened.
Initial patient data will be captured for further processing, in particular, any kind of

patient data relevant to the particular operation. Thus, patient data may include any kind of medical information on the patient, on the particular indication of necessary medical care, personal data, additional information on the patient, e.g. allergies, general health condition, medication for anesthesia as well as patient's registration time. The abovementioned data will be further available to the hospital medical personnel from the central hospital server. So, when a new patient arrives to the emergency room, he usually first signs in at a front desk. Here his new patient file is opened. If person's medical problem needs very urgent attention, he may be taken right in to see a doctor for his urgent initial medical examination.

Patient ID will be automatically assigned for each new patient by the system. Emergency room is working in a non-stop mode therefore shifting for patients' numbers should be made. It means that periodically, records of patients discharged from the hospital will be removed from the database and remaining patients receive new order numbers (0-999) /codes according to their arrival times (it may be also code for large patients' amount (e.g. hexadecimal)).

On the next step, a triage nurse is sorting the patients to make sure that the sickest people get to see the doctors first. Nurse's examination data is entered into the central hospital server database as well. Patient's urgency degree is also examined here as most urgent patients will be treated immediately while most other patient will be guided to the waiting area.

On the next step, the doctor arrives, he or she examines the patient and decides which treatments the patient should undertake and which tests to take first, such as blood or urine tests. These data is inputted into the database as well.

Some patients will be discharged from the hospital after the doctor figures out what the medical problem is and decides how to treat it, such patients may be given some medicine while in the emergency room or a prescription for medicine to pick up at the local pharmacy, others may be given a follow-up local doctor visit recommendation.

Thus, the list of emergency room treatments is created for each patient.

So, each new patient arriving to the hospital receives a list of treatments he has to undertake. These treatments can be categorized according to the urgency of each treatment. Naturally, an urgent treatment must be taken first, and urgent patients must be treated first as well. At the next step described hereafter, an optimization is performed to determine an optimal order and time of each treatment. A CHD will be updated accordingly.

To initialize each treatment, a new treatment request must be opened on a CHD. It may be any kind of medical demand relating to the use of emergency room resources. Thus, requests may be initiated manually by a doctor or by a nurse, or automatically, e.g. by an administrative process in the hospital such as the admission of a patient if the treatment is compulsory for each patient.

Treatment requests may be entered through a special user interface into a computer on which the method is implemented, or transferred to the computer by data transfer means such as a Internet or Ethernet. A treatment request may be compulsory as well as tentative, may be associated to a fixed time or to a preferred time; treatment requests may also be associated with urgency levels, according to the kind of treatment and to the severity of the case. According to the invention, all those data will be captured and employed for subsequent processing and optimization.

Each treatment request is associated with a particular kind of treatment, which is associated with certain resource requirements. Such resources may be in emergency room itself or it may be in other departments of the hospital. For example, an orthopedist must be invited immediately to emergency room to examine a certain patient beyond the scope of examination of an emergency room doctor or special equipment resources non-existent in an emergency room that must be used.

The resources are identified from the CHD. However, the system must take in consideration individual preferences of individual doctors, which will be inputted in the

following optimization steps. Data on resources, preferences, etc. may be stored in a database form and provided to a computer on which the method is implemented.

All of the abovementioned human and equipment resources are entered therefore into the central hospital server database.

As mentioned above, each new patient entering an emergency room treatment is associated with a particular kind of treatment, which is associated with certain resource requirements. Each patient may need several urgent treatments as well as several less urgent treatments, each treatment is associated with certain treatment duration; treatment requests are also associated with urgency levels, according to the kind of treatment and to the severity of the patient's case.

Login Privileges

To be able to view his own preferences, each member of hospital medical staff will use flexible login credentials system as described hereafter.

To implement that, the hospital server administrator will grant each doctor / nurse with login credentials to enter his preferred work time data from his hospital computer or from elsewhere through the Internet / Ethernet. The login credentials privileges will differ from doctor / nurse to doctor / nurse and from equipment to equipment. Main login credentials privileges will be: to create file, to modify files, to view files, to delete files and no access privileges. Such privileges will differ not only from employee to employee but also from file to file and from treatment to treatment. Each new employee, treatment or entered into the database will be granted a certain privileges level. For example, a certain nurse will be able to view only certain files but he / she will be able to view and to modify other files.

Medical Personnel Information System

The system will also include medical personnel user interface system, which includes an input device that permits a doctor or a nurse to perform data and command entry and input information and a display output facility that provides a user a display image showing a schedule of resources.

An information on work schedule established for each doctor or nurse will be available in a calendar form. A special hospital website will be developed in order to facilitate an easy and immediate access to the abovementioned calendar information to hospital's doctors and nurses.

Similar calendars will be produced for equipment resources available in order to verify availability of each of those resources. That must be done to assure that the required equipment resource is available at the scheduled date and time.

The abovementioned equipment resources are divided according to the types of equipment means. For each type of equipment, complete operational characteristics information will be further provided. In particular, the database will include information on each equipment resource type, quantity, suitability for certain type of treatment, duration time of the treatment on such equipment as well as other operational characteristics. The data will be available in real-time to doctors and nurses for viewing and updating.

A full list of treatments will be inputted into the database. The list will include all possible types of treatments available in the hospital. For each such treatment all relevant treatment properties will be stored and displayed. In particular, this list will include:
• Treatment name
• Treatment short description

• Treatment duration.

For that, a medical expert/s will initially determine a default time duration of each treatment; this default value will be changed lately according to changing conditions, say, faster machinery equipment. A special statistics module will be developed for calculating actual treatment duration and following that statistics, updated adaptive treatment duration will be determined.

• List of resources associated with the treatment, this will include both equipment and personnel resources required to perform a certain treatment.

• "Capacity" of treatments – a maximal number of treatments that could be undertaken simultaneously using available human and equipment resources.

• Cost of treatment - monetary cost of treatment. The default cost will be defined in the database, but authorized staff members with certain level of privileges will be able to modify it later. The cost of treatment will be a function of the initial equipment cost and ongoing equipment and personnel expenses.

Service history will be additionally available for view and analysis of the relevant hospital personnel

Name doctor	Patient name	Action	Date&Time	Comment
Doctor1	p00	Finish	16/07/2017 15:59	
Doctor1	p01	Order	16/07/2017 16:00	
Doctor1	p02	Order	16/07/2017 16:00	
Doctor1	p03	Order	16/07/2017 16:01	
Doctor1	p04	Order	16/07/2017 16:01	
Doctor1	p00	Order	16/07/2017 16:02	
Doctor1	p23	Order	16/07/2017 16:03	
Doctor1	p00	Order	25/07/2017 17:55	
Doctor1	p01	Order	25/07/2017 17:56	
Doctor1	p02	Order	25/07/2017 17:56	
Doctor1	p05	Order	15/08/2017 17:09	
Doctor1	p00	Order	26/09/2017 16:56	
Doctor1	p01	Order	17/10/2017 14:49	
Doctor1	p00	Order	17/10/2017 14:52	
Doctor1	p01	Order	17/10/2017 14:53	
Doctor1	p00	Order	17/10/2017 14:54	
Doctor1	p09	Order	17/10/2017 14:59	
Doctor1	p10	Order	17/10/2017 15:00	
Doctor1	p15	Order	17/10/2017 15:01	
Doctor1	p16	Order	17/10/2017 15:01	
Doctor1	p17	Order	17/10/2017 15:03	

Emergency

Time table   Reload   Clear   Help

Services | Cluster of treatments | Patients | Assignments | Actions history | Employees | Service history

Filtering:

Patients:
[All]

Doctors:
[Doctor2]

Services:
[All]

Name doctor	Service name	Patient name	Start time	Finish time
Doctor2	10Ultra sound mo...	p26	14/11/2017 18:40	14/11/2017 18:42
Doctor2	4Treatment area	p27	14/11/2017 18:47	14/11/2017 18:48

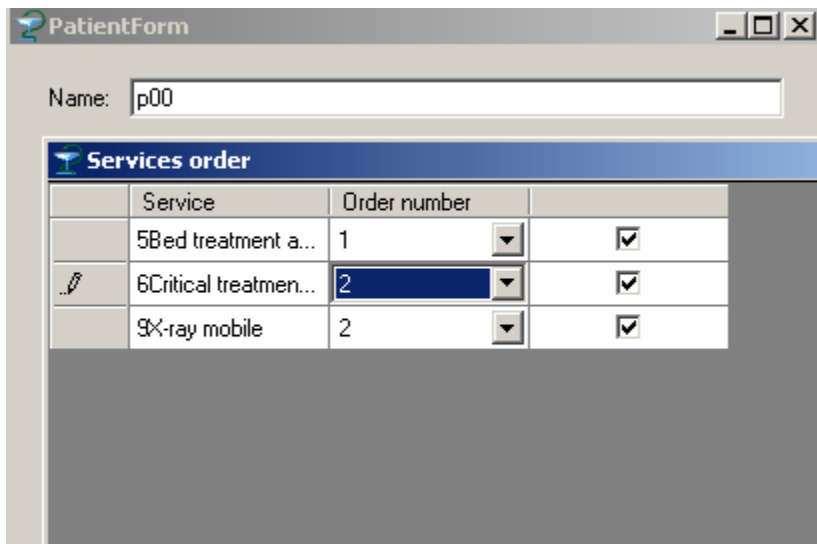**Central Hospital Patient Information System**

A system for displaying optimal treatments schedule will be available to the patients from the screens throughout the ER, and throughout the hospital in general, such displays interactively connected to the Central Hospital Database (CHD).

Additionally, each patient upon his enrollment into the hospital will have an option to receive / to rent an individual computer device, such as laptop or cell phone. An SMS-notification option will be also available for the patient to receive individual notifications, i.e., a notification of the changed treatment start time.

The system will obtain data from the CHD, including data on individual treatment schedule lists for each patient as well personnel and equipment resources availability information and their current and future availability, data on scheduled treatment procedures and data containing information indicating current and future patient location.

The system will present an overall view of treatments for each patient, showing a schedule of treatments indicating their status, duration of use, priority of use, and time of availability that adaptively compensates for an unscheduled delay in an activity.

Upon patient's enrollment to the ER, his access to the central hospital patient information system will be granted and further administered by privileges security and identification unit. Such a unit will also grant the patient username / password login credentials to be able to view his personalized medical data.

Central Emergency Service – CES

The CES system was developed for optimally managing several hospital emergency rooms in one common geographical area, such as city, county, or a state. In CES, there will be one CIS central computer server that will obtain data from all individual hospitals computer servers, analyze such a data, determine in which hospital the current patient waiting time is the shortest and produce an optimized plan as to which hospital to send each new patient.

Optimized work plan will be obtained from each hospital enrolled to the CES system. When an emergency service (like 911 in USA) receives a new ambulance service request – it dispatches an ambulance, the ambulance personnel performs physical examination of the patient and submits the patient data to CES. Then, CES sends a request to all the systems installed in the ER.

Each request is comprised of client's location and brief description of the problem. The CES gets responses from the management system installed in the interrogated ER that includes the estimated total time comprised of treatment time and travel time. The ER with the shortest time of arrival is given as an answer.

A special multi-hospital website will be developed in order to facilitate a multi-hospital access to the emergency room data, such as a general waiting time, a specific waiting time for the particular emergency room treatment and a general arriving time / distance.