

Emory University Hospital Emergency Department Patient Scheduling

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Emory University Hospital (EUH)



- Emory Healthcare System
- Leading national healthcare provider
- Patients:
 - Inpatients: 24,000/year
 - Outpatients: 80,000/year

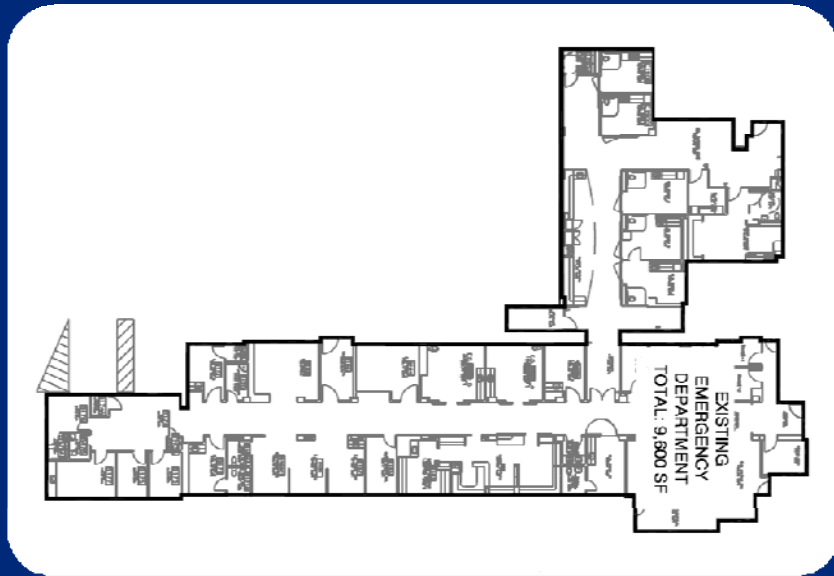
Emory University Hospital Emergency Department (EUH ED)

Patients:

- 32,850/year
- 90/day

Capacity:

- 21 rooms
- 8-10 hall spots



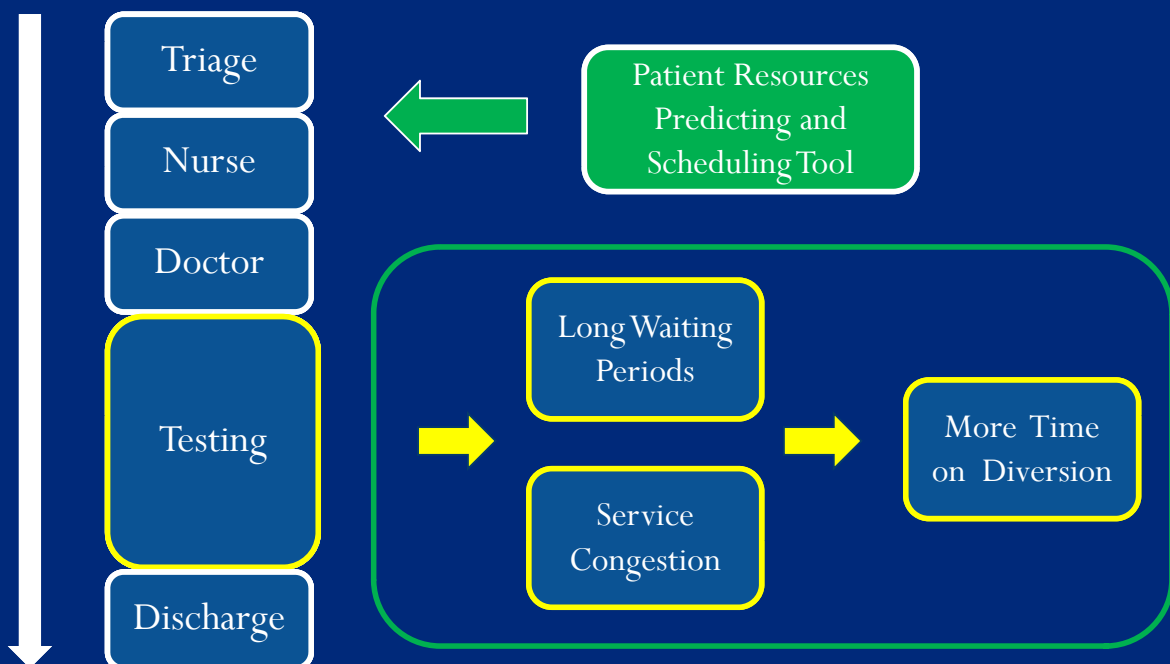
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Project Motivation



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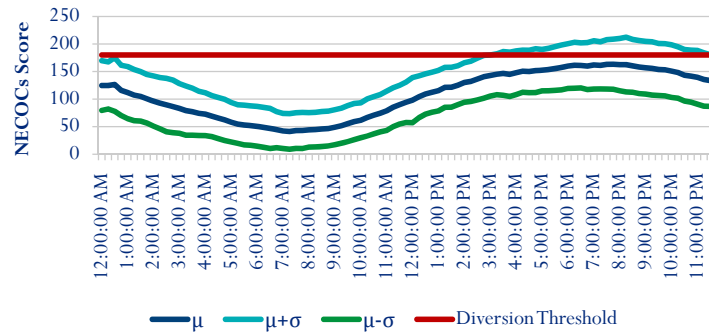
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Diversion Score



Average NEDOCs Score



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Methodology Overview

Patient Resources Predicting and Scheduling Tool

Predict Patient Resources

Schedule Patients

Processing Times

Scheduling Algorithms

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Resources for Predicting and Scheduling

Radiology Tests	2009 Count
X-Ray	12,400
X-Ray Portable	7,400
CT w/ Contrast	4,100
CT w/o Contrast	6,500
Ultrasound	3,100
MRI	1,900
MRA	800

Other Tests	2009 Count
EKG	13,900
Urine Collect	15,400
Blood Draw	22,000

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Predictors of Resource Requirements

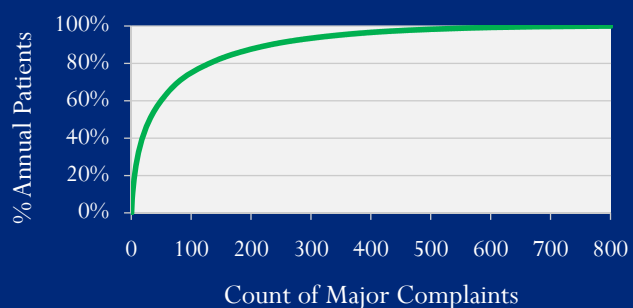
Patient Acuity



Major Complaint

% Complaints	Count
70%	78
80%	131
90%	232
Total Complaints	801

2009 Patient Major Complaints



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Probability of Requiring Resources

Probability of Needing an EKG				
Major Complaint	Acuity			
	1	2	3	4
Chest pain	1.00	0.99	0.97	0.83
Difficulty Breathing	0.97	0.90	0.67	0.40
Altered Mental Status	0.97	0.89	0.80	-
Syncope	1.00	0.97	0.90	1.00
Pain, Abd General	1.00	0.44	0.22	0.07

Determine Threshold

Expected # Adds = Expected # Deletes

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Determining Probability Threshold

Sensitivity

- True Positive Rate
- % of patients correctly predicted to require a test

Specificity

- True Negative Rate
- % of patients correctly predicted to NOT require a test

Predicted Condition	Actual Condition	
	Test Needed	Test Not Needed
	<div>Test Needed</div> <div>True Positive</div> <div>False Negative</div>	<div>Test Not Needed</div> <div>False Positive</div> <div>True Negative</div>

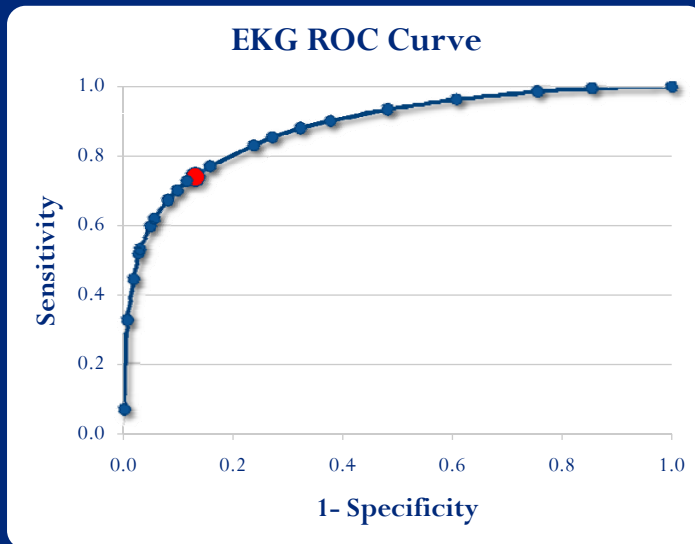
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Receiver Operating Characteristic (ROC) Curves



Threshold 0.50
Sensitivity 0.74
Specificity 0.87

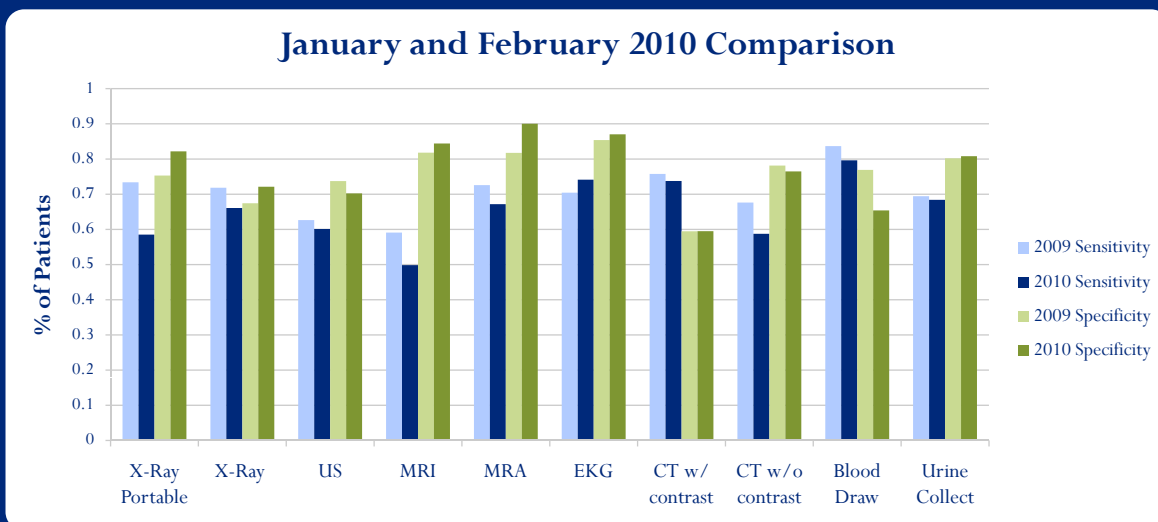
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Testing Thresholds



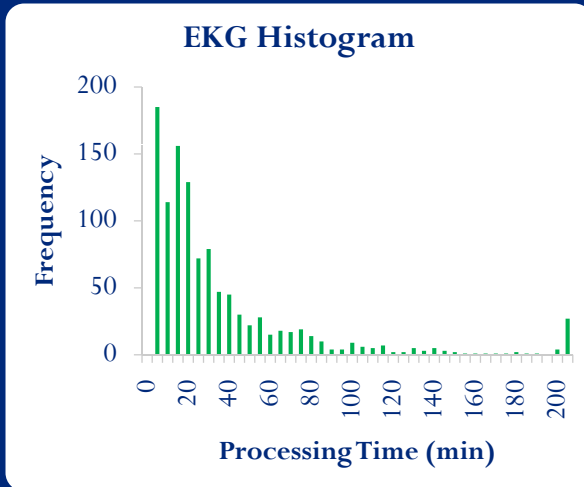
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Processing Times

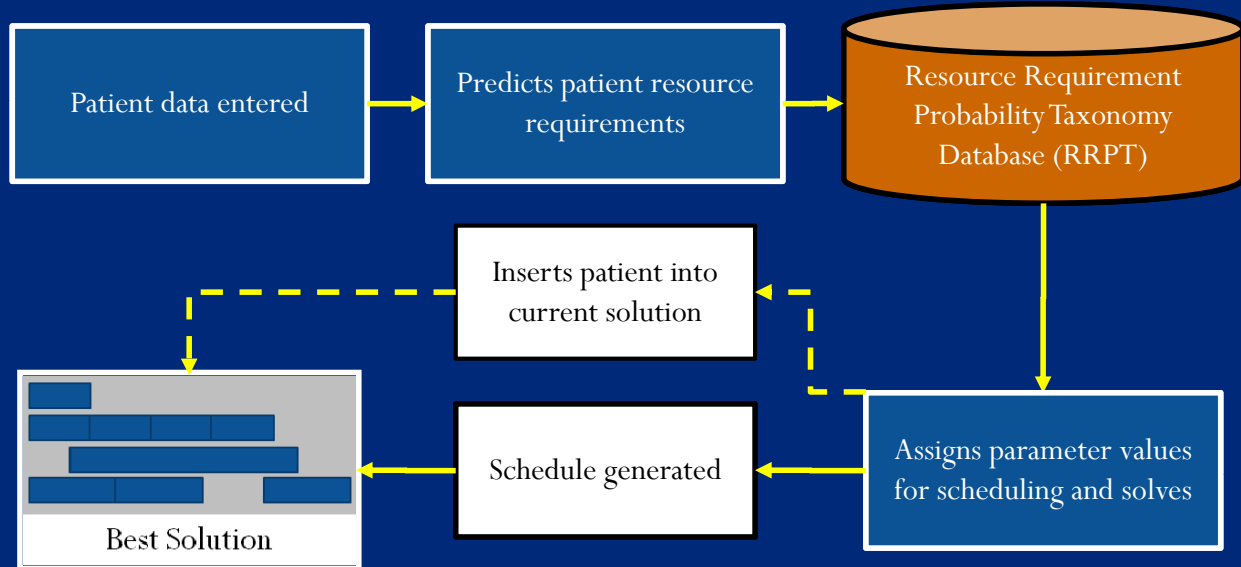


Test	Median	μ	σ
MRA	48	56	34
X-Ray Portable	18	42	36
X-Ray	14	31	59
Ultrasound	24	26	12
MRI	50	74	54
EKG	18	29	27
CT w/o Contrast	13	31	21
CT w/ Contrast	21	18	13

OSCAR: Scheduling Tool

Operational
Scheduling of
Care
And
Resources

OSCAR: Scheduling Tool



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Solver Module Methodology

Objective

Minimize Length of Stay (LOS) for each patient

Inputs

Primary: Patient Name, Acuity, Major Complaint
Secondary: Doctor and Nurse Validation

Constraints

1 patient / resource at a given time
1 resource / patient at a given time
Schedule beyond visibility parameter
Patients weighted by acuity

Outputs

Expected resources required
Operation start times for near optimal schedule
Expected LOS for each patient

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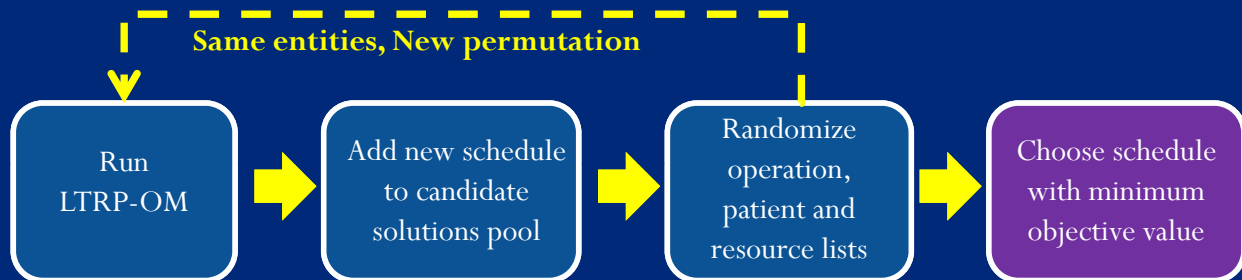
Solver Module Methodology

Listing Algorithm

LTRP-OM : Longest Total
Remaining Processing Time on
Other Machines

When a resource becomes
available, schedule on it the
patient with the LTRP-OM

Scheduling Heuristic



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OSCAR : Patient Scheduling

Tasks

Add Patient

Schedule Patient

Add/Remove Test

Reschedule

The screenshot shows a 'New Patient' form. It includes input fields for 'First Name', 'Last Name', 'Sex' (with a dropdown menu showing 'Male'), 'Age', and 'Acuity' (with a dropdown menu showing '1'). To the right of these fields is a list of medical conditions: 'abdominal distention', 'abdominal pain', 'abdominal pain - pregnant', 'abdominal pain re-eval', 'abdominal problem', 'abnormal diagnostic test', 'abrasion facial - minor', and 'abrasion head - minor'. There are arrows pointing from this list to a larger empty box on the right. At the bottom right of the form are 'Add' and 'Cancel' buttons.

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OSCAR : Patient Scheduling

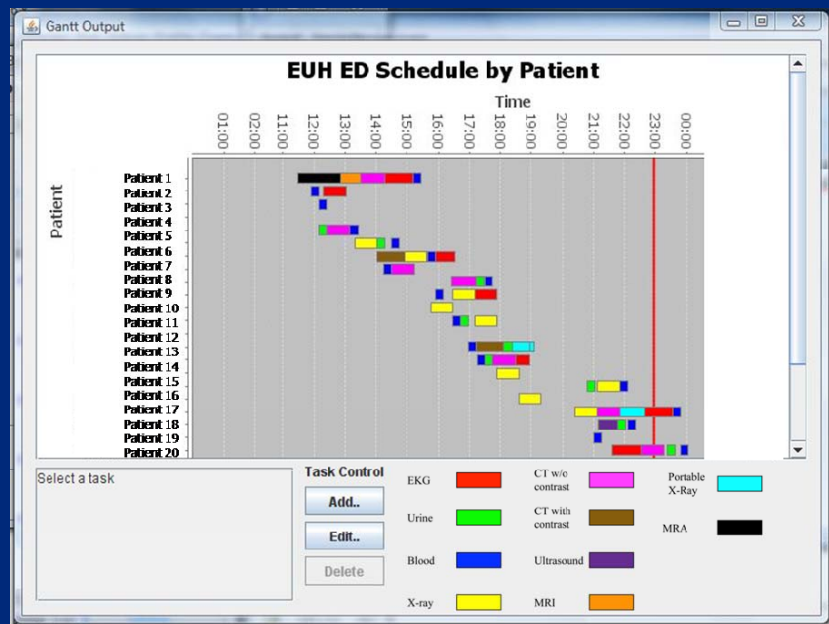
Tasks

Add Patient

Schedule Patient

Add/Remove Test

Reschedule



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OSCAR : Patient Scheduling

Tasks

Add Patient

Schedule Patient

Add/Remove Test

Reschedule

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OSCAR : Patient Scheduling

Tasks

Add Patient

Schedule Patient

Add/Remove Test

Reschedule

ID	Patient Name	Sex	Age	Acuity	Complaints	Arrival Time	Next Operation	Estimated LOS
24	John Doe	M	43	2	Chest Pain	15:35	EKG	4:15
17	Mary Smith	F	75	3	Fall	13:00	X-Ray	3:45
23	James Miller	M	23	4	Fever	14:20	Blood Draw	2:00
20	Cindy Brown	F	38	2	Abd Pain	14:15	Urine Collect	3:15

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Validating Schedules

	# Operations	# Patients	Permutations	Runtime	Best Solution	Gap
IP Model	16	3	5,000	1:37:57	541	optimal
OSCAR tool				0:00:27	547	1.1%
IP Model	30	7	10,000	4:22:05	1,336	optimal
OSCAR tool				0:00:01	1,483	9.0%
IP Model*	52	13	20,000	2:29:13	3,266	46.1%
OSCAR tool				0:04:28	3,272	7.3%

* Xpress failed; IP Model value represents the best solution found at the listed runtime.

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Test Cases

Actual versus OSCAR LOS (hours) January 2010

	Actual		OSCAR		% Difference
Acuity	μ	σ	μ	σ	μ
1	5.9	3.2	4.0	1.6	-13%
2	7.1	4.6	4.2	1.5	-23%
3	6.1	4.1	4.0	1.8	-18%
4	3.5	2.2	3.0	1.4	-1%
5	1.3	0.1	1.2	0.1	-5%
Overall	6.1	4.2	3.9	1.7	-17%

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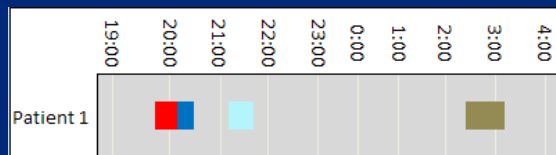


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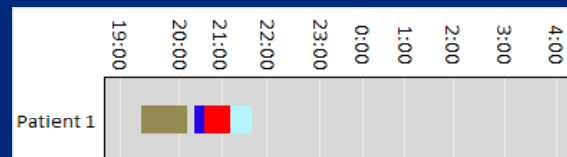


Sample Patient Schedules

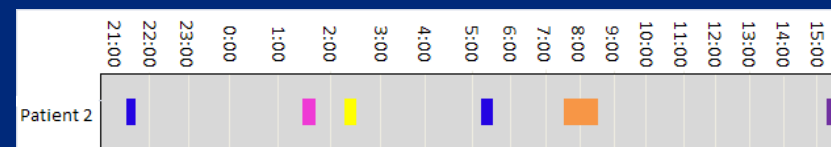
Actual



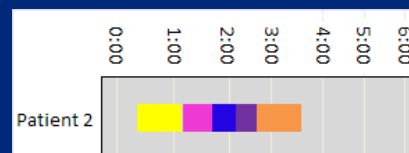
OSCAR



Actual



OSCAR



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OSCAR: User views

User

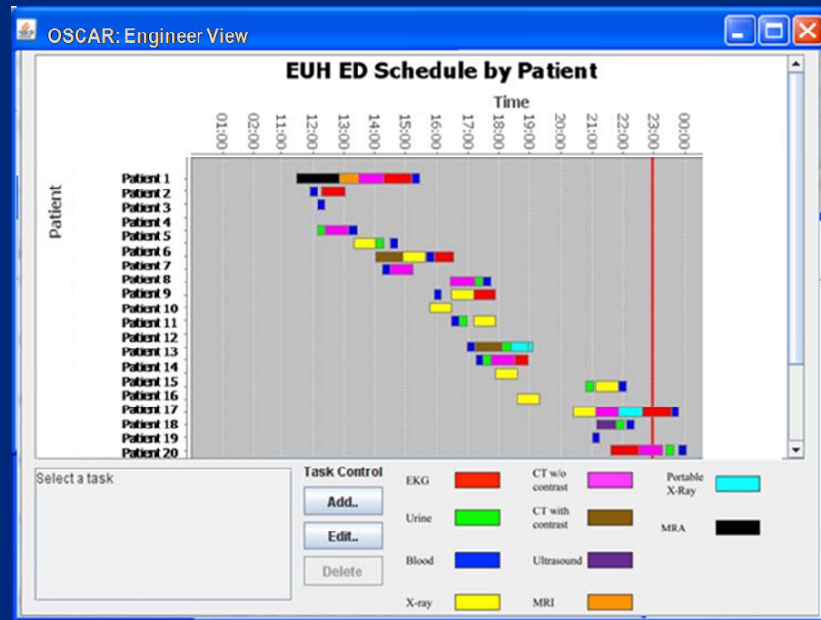
Engineer

Resource

Doctor

Nurse

Patient



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OSCAR: User views

User

Engineer

Resource

Doctor

Nurse

Patient

OSCAR: Resource View - X-Ray

Resource View

X-Ray

Current Time: 15:00

Patient Test Schedule

Patient Name	Scheduled Start Time	Expected Completion Time
John Doe	17:00	17:30
Jack Watson	19:00	19:30

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OSCAR: User views

User

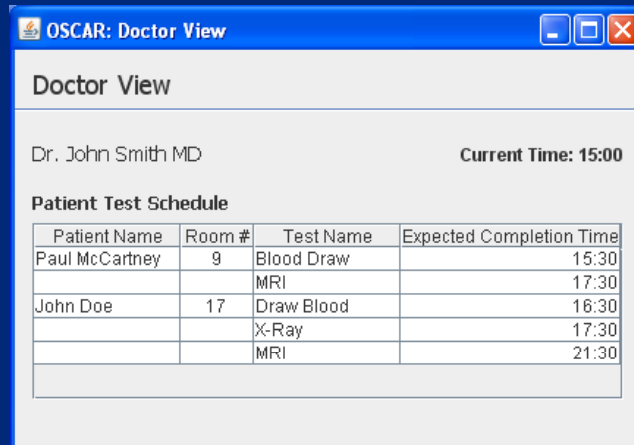
Engineer

Resource

Doctor

Nurse

Patient



Patient Name	Room #	Test Name	Expected Completion Time
Paul McCartney	9	Blood Draw	15:30
		MRI	17:30
John Doe	17	Draw Blood	16:30
		X-Ray	17:30
		MRI	21:30

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OSCAR: User views

User

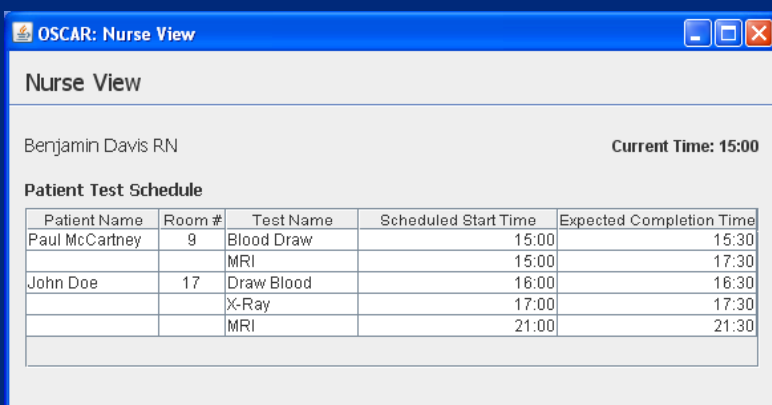
Engineer

Resource

Doctor

Nurse

Patient



Patient Name	Room #	Test Name	Scheduled Start Time	Expected Completion Time
Paul McCartney	9	Blood Draw	15:00	15:30
		MRI	15:00	17:30
John Doe	17	Draw Blood	16:00	16:30
		X-Ray	17:00	17:30
		MRI	21:00	21:30

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OSCAR: User views

User

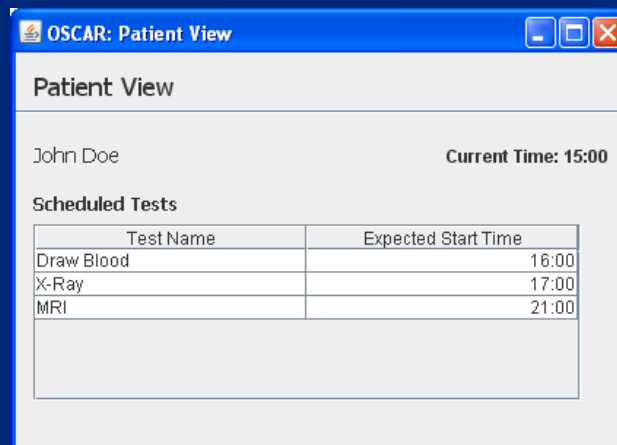
Engineer

Resource

Doctor

Nurse

Patient



OSCAR: Patient View

Patient View

John Doe Current Time: 15:00

Scheduled Tests

Test Name	Expected Start Time
Draw Blood	16:00
X-Ray	17:00
MRI	21:00

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NEDOCs Score Parameters

- Total number of patients in ED
- Total number of beds in ED
- Total number of hospital beds at hospital
- Total number of Acuity Level 1 patients, ICU bed requests
- Total number of patients waiting in ED for hospital admission
- Longest waiting time in ED Waiting Room
- Longest waiting time for hospital admission for ED patients

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Value

Parameter	ED	OSCAR
NEDOCs Score μ	152.5709	146.4024
NEDOCs Score σ	10.7159	12.85131
% Reduction NEDOCs Score	4%	
Jan Times on Diversion	24	16
% Diversion Reduction	33%	
Increase EMS Patients	8	

Additional Monthly Revenue	\$5,048
Additional Yearly Revenue	\$60,576

Next Steps

- Tool submitted for a Technical Review
 - Integration into Cerner system
 - Estimated cost from EUH Information Services
- Grant proposal for continued development and implementation

Questions

