Building the Library of Simio Models For Health Care Industry.

Dušan Šormaz, Mandvi Malik
Department of Industrial and Systems Engineering
Ohio University, Athens, OH

OHIO UNIVERSITY

Agenda

- Introduction
- Motivation
- Approach
- Custom objects
- Add-Ins
- Case studies

Ohio University

- Ohio University has ~20000 students on Athens Campus
- First University west of Appalachians
  - Founded in 1804 in Athens, OH
- Russ College is home to National Academy of Engineering's Russ Prize

Motivation

- Many hospitals have similar processes
- Both design and operation need to consider alternative arrangements
  - Number of fixed resources – beds
  - Number of health resources – doctors and nurses
- Need for performance evaluations
- Custom objects and add-in provide flexibility and rapid model analysis

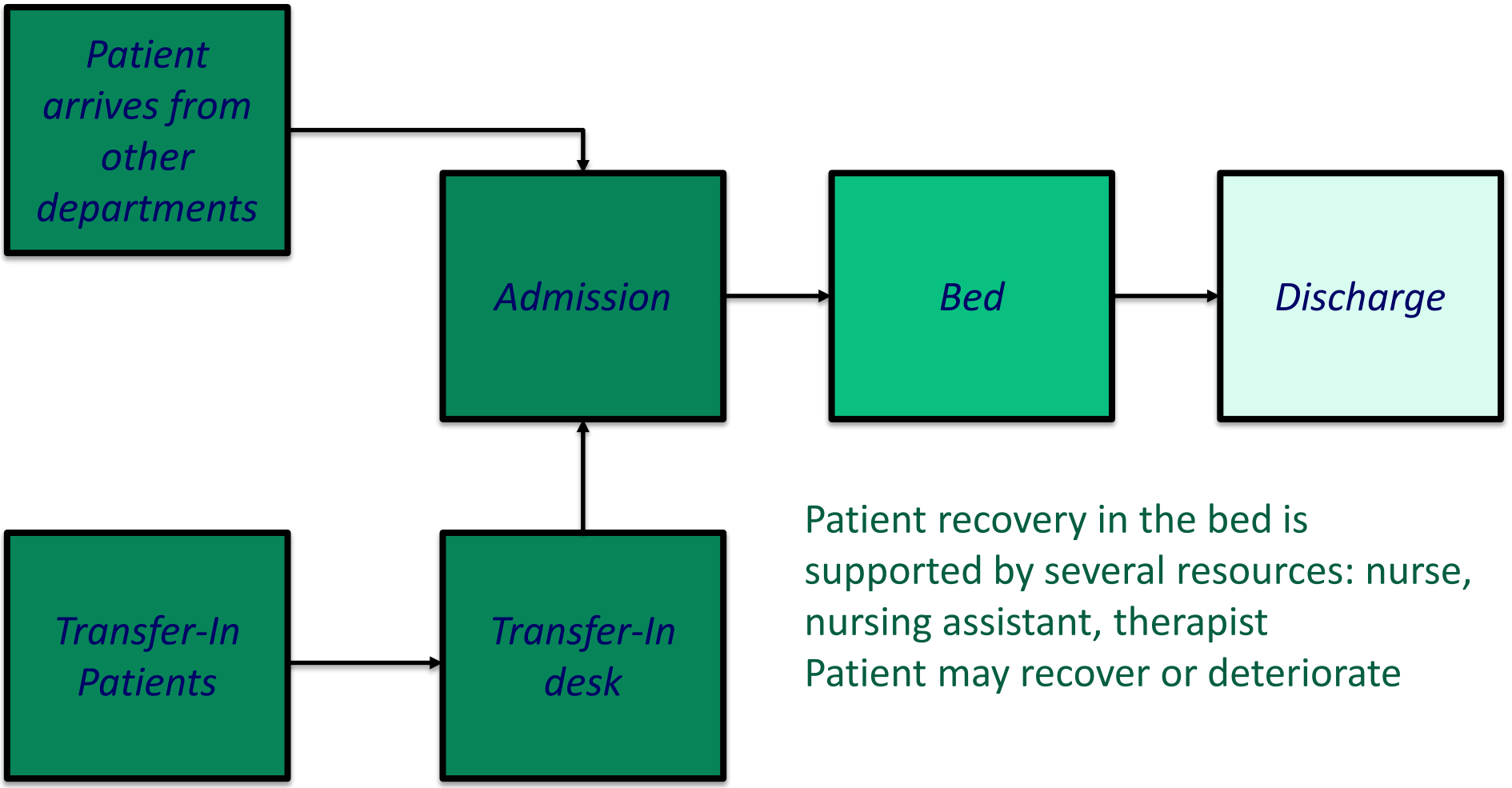
Approach

- Process analysis
- Data analysis
- Define custom objects
- Implement Add-in
- Method evaluation – case studies

Process Analysis

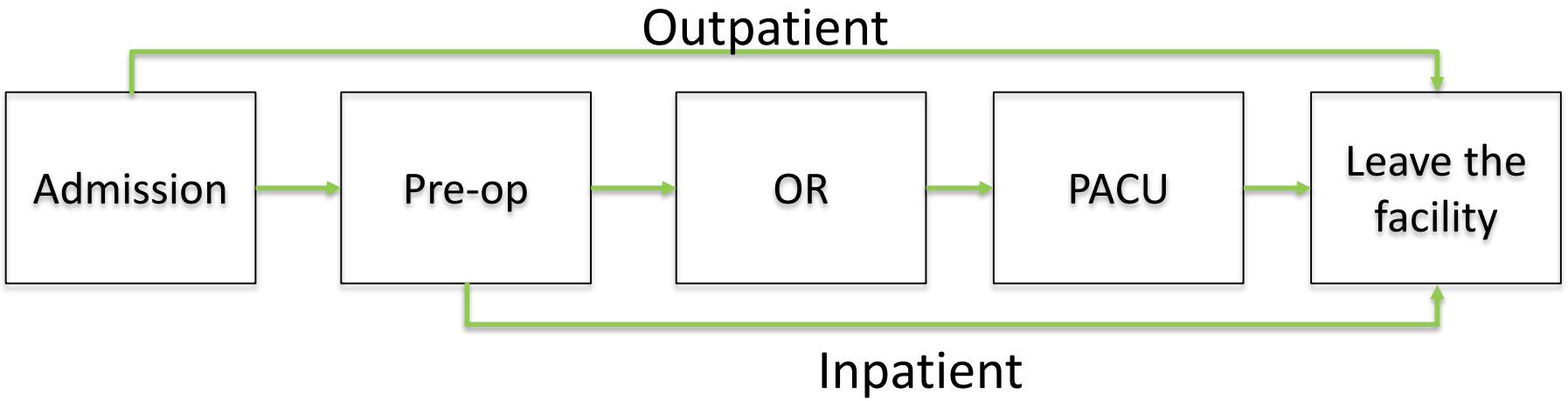
- Visited several hospitals (health systems)
  - Emergency room
  - Progressive care units
  - Operating Theater
- Perform patient and resource flow analysis
- Identify resources needed

Progressive Care Unit



Patient recovery in the bed is supported by several resources: nurse, nursing assistant, therapist
Patient may recover or deteriorate

Operating Room Process



Process details

- *Different surgery types*
- *Multiple resources*
- *Anesthesia can be done in pre-op or OR*
- *Pre-OP and PACU units ay be interchangeable*
- *Circulating nurse and surgeon – not implemented*

Custom Objects

- Progressive Care Unit
  - PCU Patient
  - Bed
- Operating Theater
  - OR Patient
  - Patient Arrival
  - Pre-OP Room
  - Operating Room

PCU Patient

- Patient Type
- Resources
- Treatment times

Properties

RegNurseCheckTime	Expression Property
TherapistCheckTime	Expression Property
AssistantNurseCheckTime	Expression Property
BedStayTime	Expression Property
RegNurseVisitTime	Expression Property
TherapistVisitTime	Expression Property
AssistantNurseNextVisit	Expression Property

States

WhichTherapist	Transporter Reference State Variable
WhichNurse	Transporter Reference State Variable
WhichAssistantNurse	Transporter Reference State Variable
RegNurseNextVisitSt	Real State Variable
TherapistNextVisitSt	Real State Variable
AssistantNursetNextVisitSt	Real State Variable
RemainingTimeSt	Real State Variable
LastVisitSt	Real State Variable
BedTimeSt	Real State Variable
TherapistCheckTimeState	Real State Variable
RegularNurseChecktimeState	Real State Variable
AssistantNurseCheckTimeState	Real State Variable

OR Patient

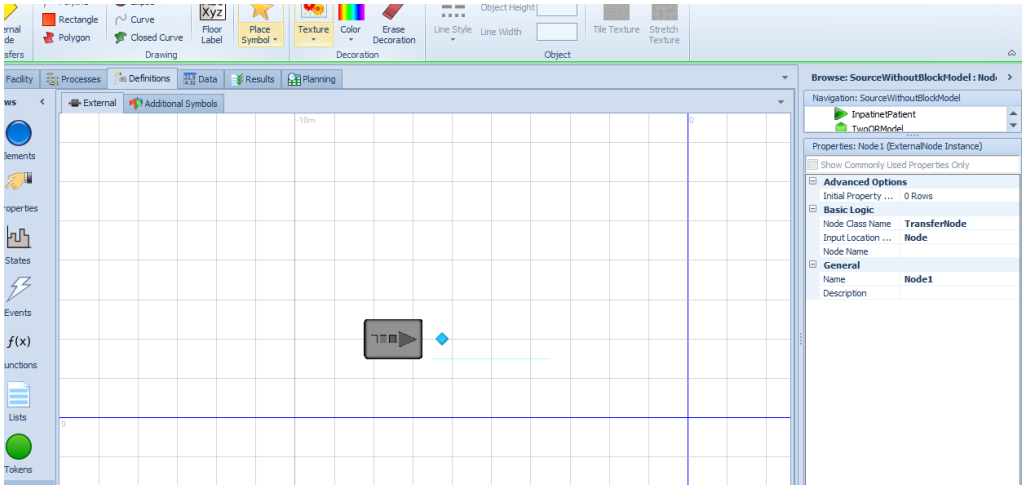
Properties

ORTime	Expression Property	ORTime
PACUTime	Expression Property	PACUTime
PreOpTime	Expression Property	PreOpTime
TransporterListProperty1	Transporter List Property	TransporterListProperty1
CirculatingNurseVisitTime	Expression Property	CirculatingNurseVisitTime
CutTime	Expression Property	CutTime
CloseTime	Expression Property	CloseTime
SurgeonRoundingOUPr	Expression Property	SurgeonRoundingOUPr
SurgeonVisittimeOUPr	Expression Property	SurgeonVisittimeOUPr
SurgeonListOU	Object List Property	SurgeonListOU
ResidentListOU	Object List Property	ResidentListOU
SurgeryEndTime	Real Property	SurgeryEndTime
MaxWaitForScheduling	Real Property	MaxWaitForScheduling
PatientArrivalBeforeSurgery	Expression Property	PatientArrivalBeforeSurgery
FirstPrefferedOR	Object List Property	FirstPrefferedOR
SecondPrefferedOR	Object List Property	SecondPrefferedOR
DressingTime	Expression Property	DressingTime
CleanTime	Expression Property	CleanTime
IncisionTime	Expression Property	IncisionTime
AdmissiontimeOU	Expression Property	AdmissiontimeOU
MaxWaitForResident	Expression Property	MaxWaitForResident
AnesthesiaPrepStart	Expression Property	AnesthesiaPrepStart
ORNode	Node Property	ORNode
CutToCloseOut	Expression Property	CutToCloseOut
MaximumPatientWait	Expression Property	MaximumPatientWait

States

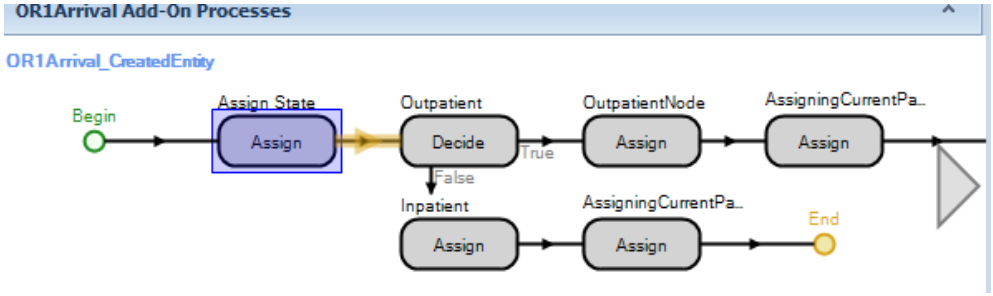
WhichSurgeon	Transporter Reference State Variable
AnesthesiaTimeState	Real State Variable
CutTimeState	Real State Variable
CloseTimeState	Real State Variable
Pre_OpTimeState	Real State Variable
TurnoverTimeState	Real State Variable
AnesthesiaRounding	Real State Variable
CirculatingNurseRounding	Real State Variable
ORPriority	Real State Variable
CurrentPatient	Entity Reference State Variable
WhichORNode	Node Reference State Variable
ScheduledORTime	Date Time State Variable
PreferedOR	Object Reference State Variable
rowCounter	Integer State Variable
WhichNurse	Transporter Reference State Variable
WhichAnesthesiaNurse	Transporter Reference State Variable
WhichOR	Object Reference State Variable

OR Patient Arrival

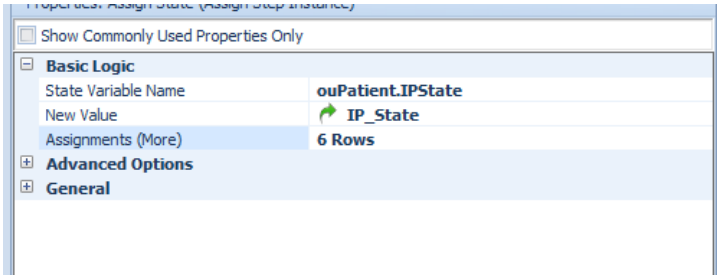


Define arrival properties → Patient comes based on the arrival properties → Patient arrival process is triggered → Patient exit process is triggered

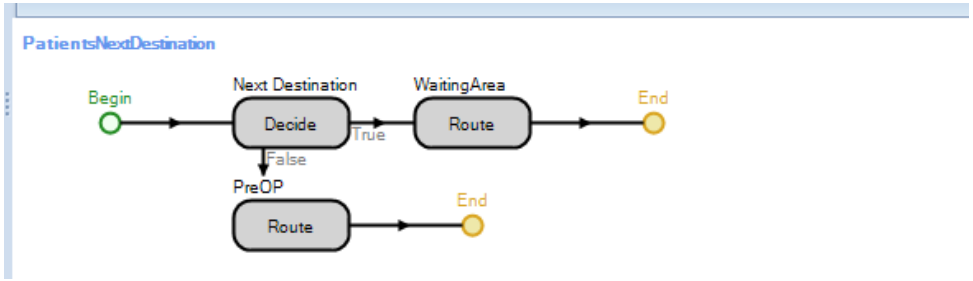
OR Patient Arrival



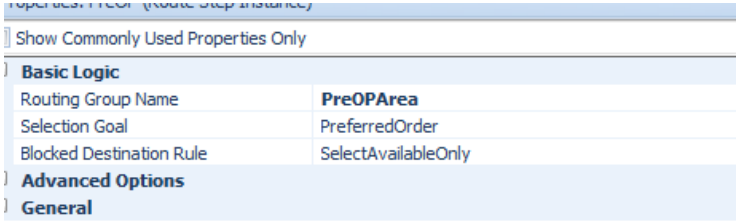
Arrival process is triggered



Inpatient/Outpatient state assigned to patient



Exit process is triggered

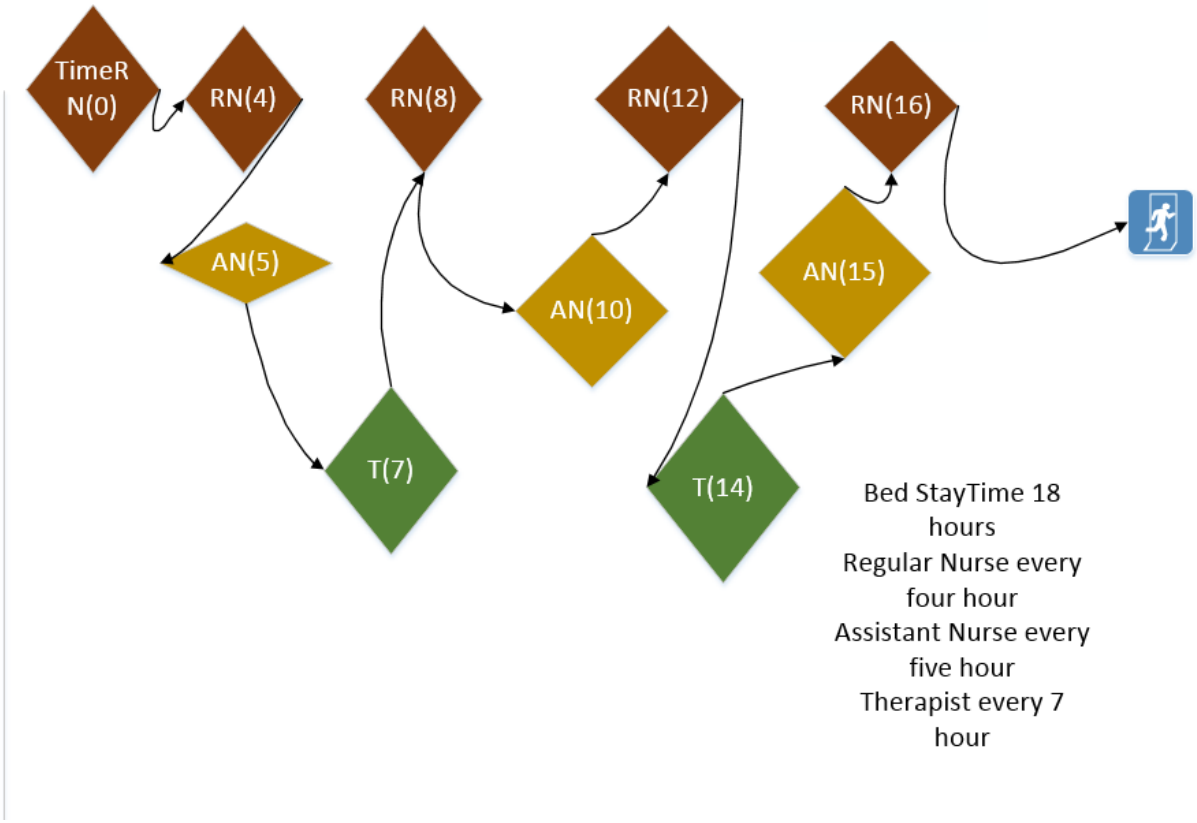


Assigning values to route step

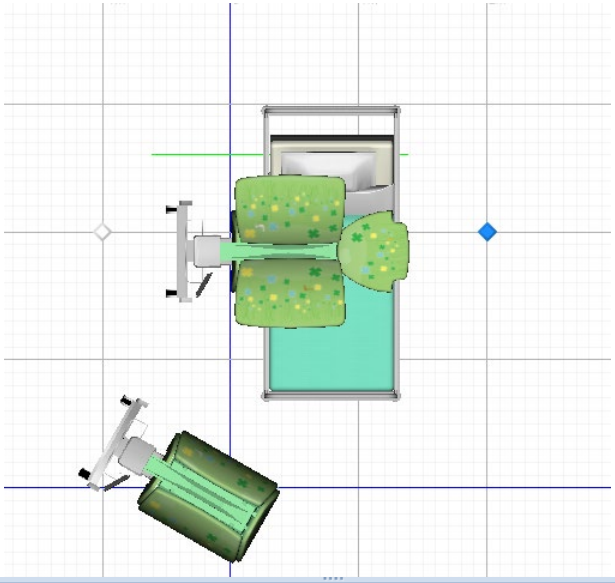
Bed Components

- Capacitated Bed Station element is created
- Bed processing logic
- External view
  - Bed Symbol
  - Basic Node, Transfer Node
  - A Queue

Bed Methodology Overview



Bed Details



Properties: BedStation.Contents (Queue)

Show Commonly Used Properties Only

Animation	
Queue State	**BedStation.Contents**
Visibility Expression	**True**

Queue State Definition

Properties: InputBed (ExternalNode Instance)

Show Commonly Used Properties Only

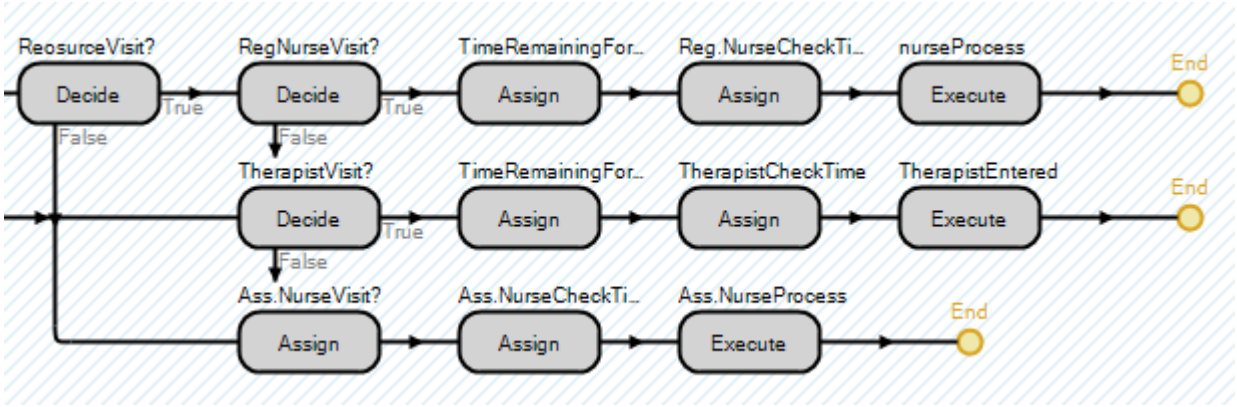
Advanced Options	
Initial Property V...	0 Rows
Basic Logic	
Node Class Name	**BasicNode**
Input Location T...	**Station**
Station Name	**BedStation**
General	
Name	**InputBed**
Description	

Properties of Input Node

Bed Processing Logic

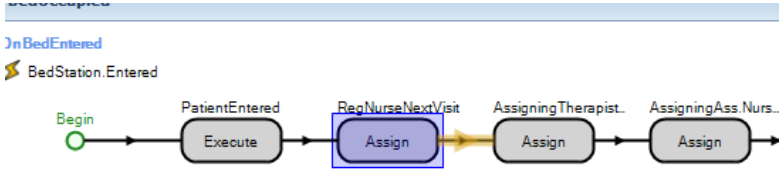
Processes Created

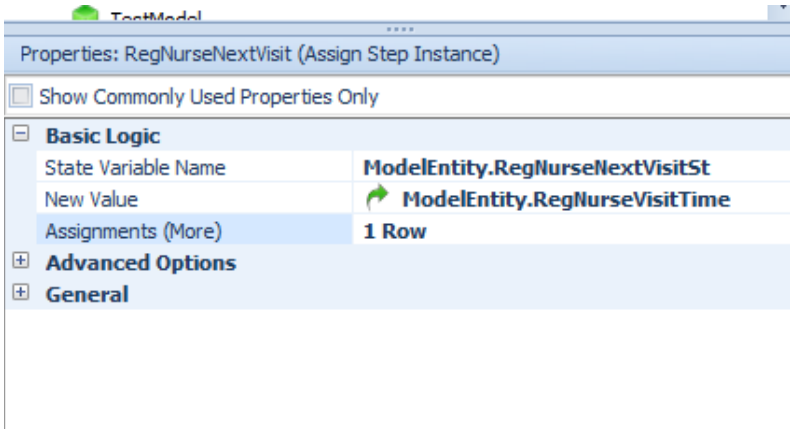
After end of every Visit it is determined who would visit next to patient



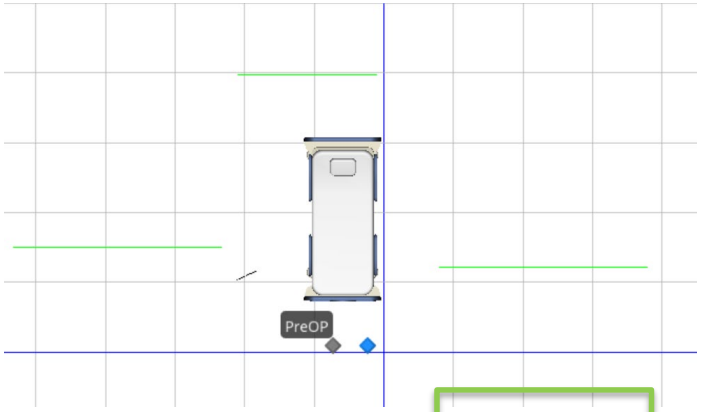
Bed Resource Assignments

- Patient stay time, resource visit and check time is assigned
- Patient remembers resources from the first visit





Pre-op Room



Patient comes to Pre-op when it is available

Anesthesia nurse comes when is available

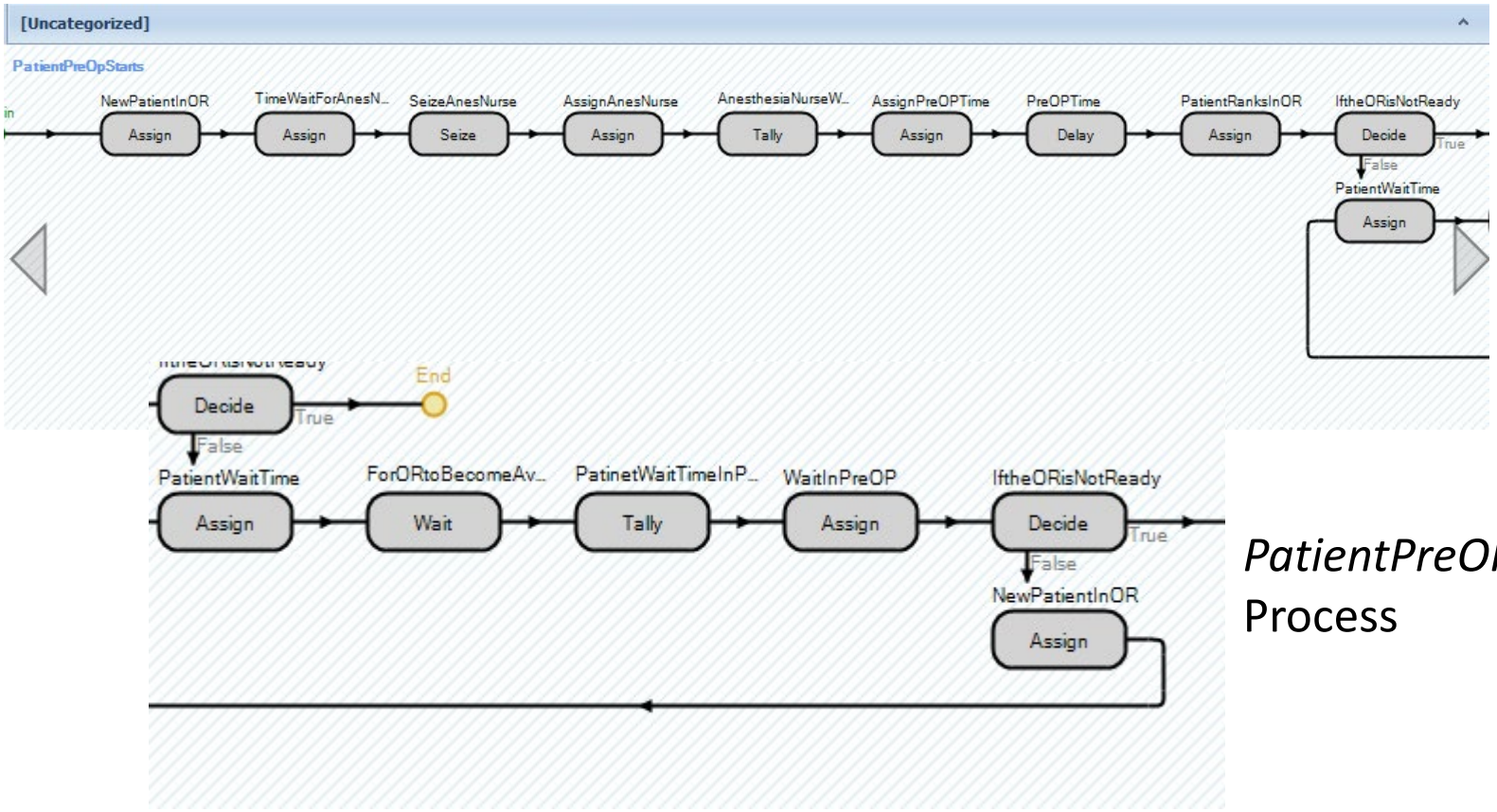
Stay until Pre-op evaluation

Moves to OR

OR not available

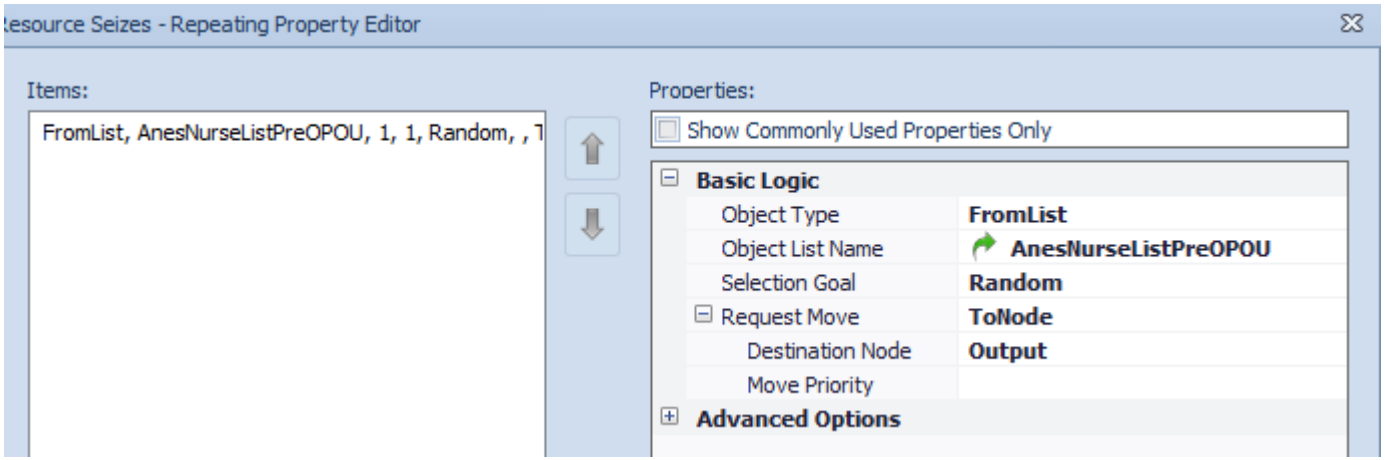
Wait in Pre-op

Pre-op



PatientPreOPStarts Process

Pre-op

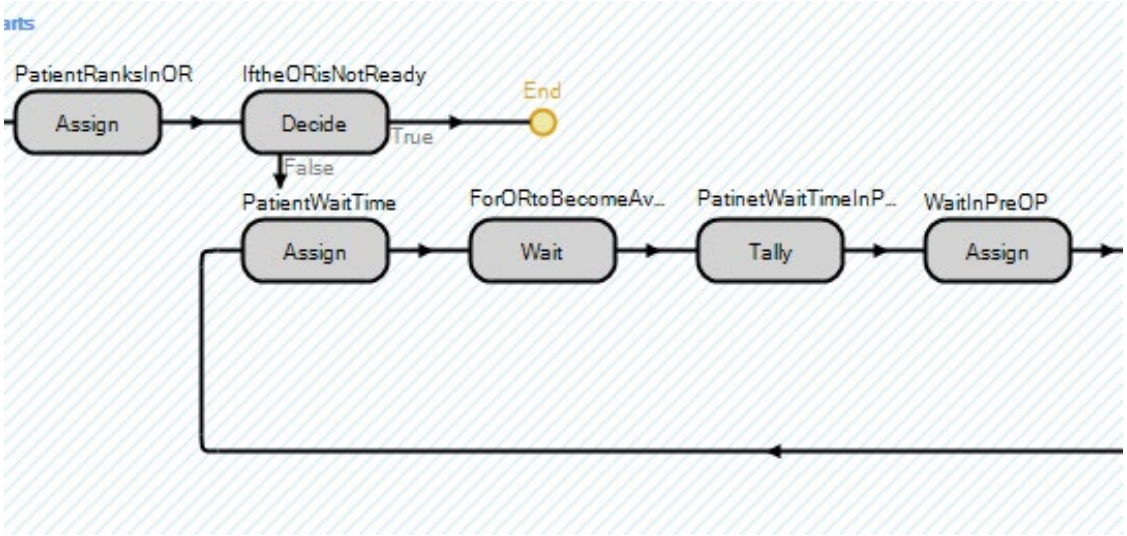


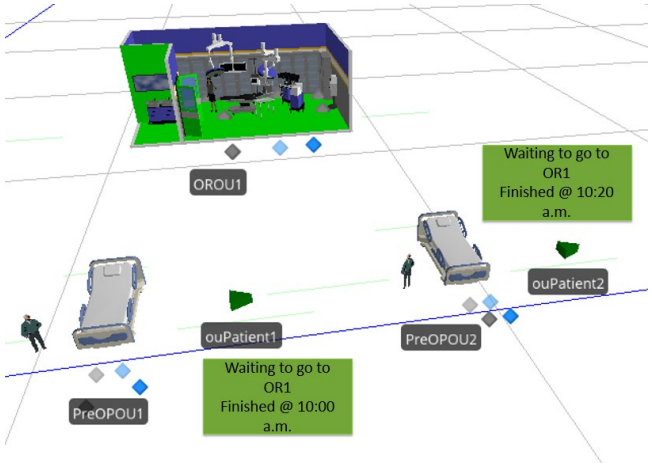
Seizing of resource in Pre-op

Properties

AnesNurseListPreOPOU	Object List Property	AnesNurseListPreOPOU
ORNode	Node List Property	ORNode

Pre-op





First in first out process created in Pre-op for OR

Show Commonly Used Properties Only

Basic Logic	
State Variable Name	**ouPatient.RankToEntity**
New Value	**ouPatient.WhichOR.MyOR.RankToPatients+1**
Assignments (More)	**1 Row**
Advanced Options	
General	

Operating Room

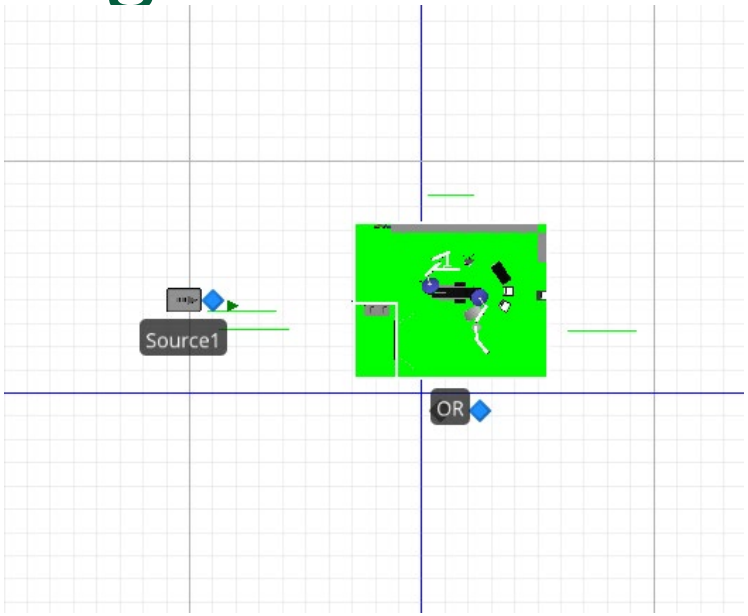
Patient and anesthesia nurse arrives

Anesthesiologist comes & anesthesia induction is done

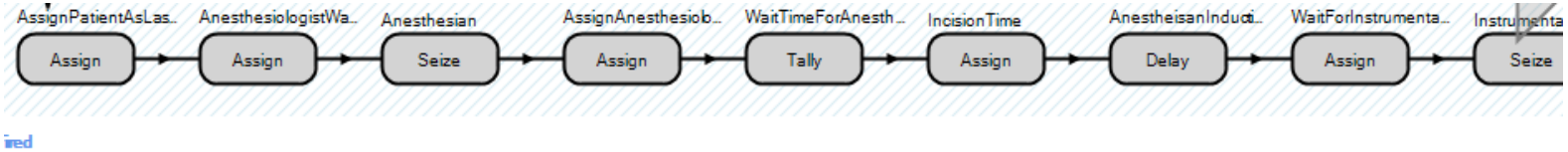
Surgeon and surgery staff comes

Surgery starts

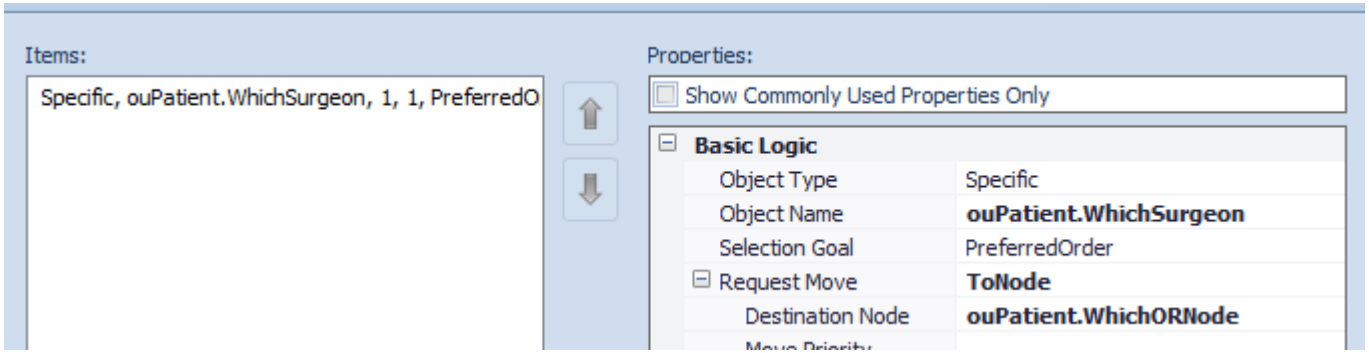
Transfer to PACU & turnover starts



OR

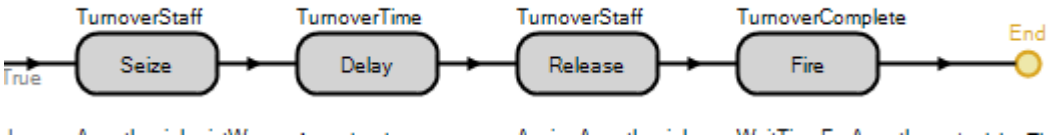


Patient entered OR process

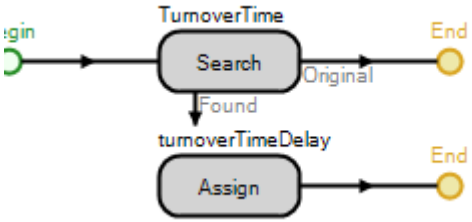


Patient remembers surgeon

OR Turnover (Scrubing)



Turnover logic in OR



Last patient	New patient	Turnover time
Colorectal	Colorectal	20
Colorectal	General	30

Colorectal

Delay

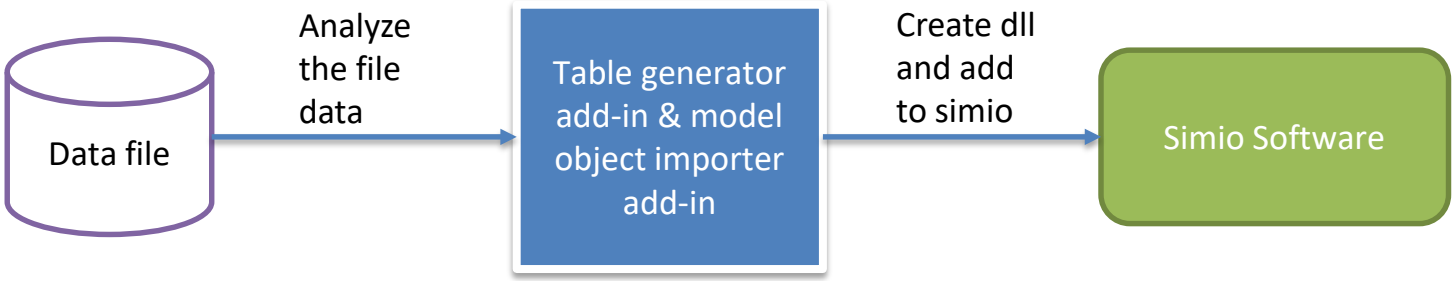
General

Simio Add-ins

- Allow for data-driven model generation
- Implemented PCU Add-in
- Implemented Operating Theater Add-in

PCU Add-ins

- Data table generator add-in
  - Tables are: hospital data, resources and links
- Model object importer creator add-in
  - Objects are created



OR Data-driven add-in

- Four Add-ins were created

  Table generator add-in

  Object creator add-in

  List creator add-in

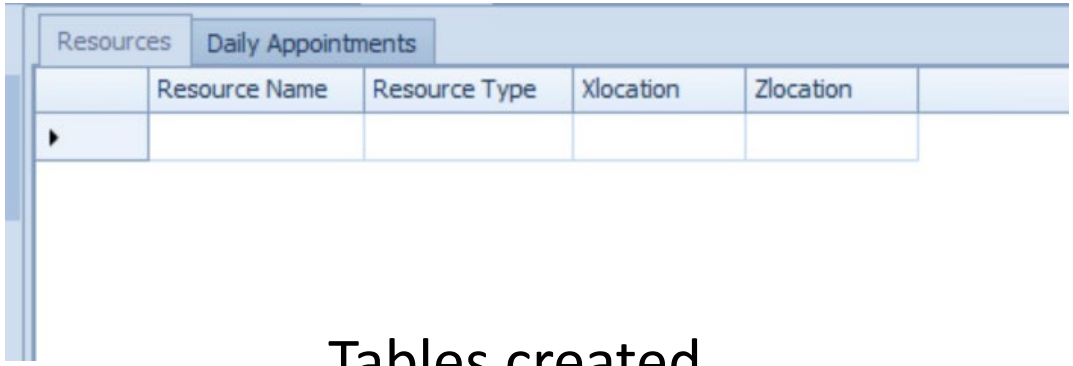
  Properties creator add-in

Table generator add-in

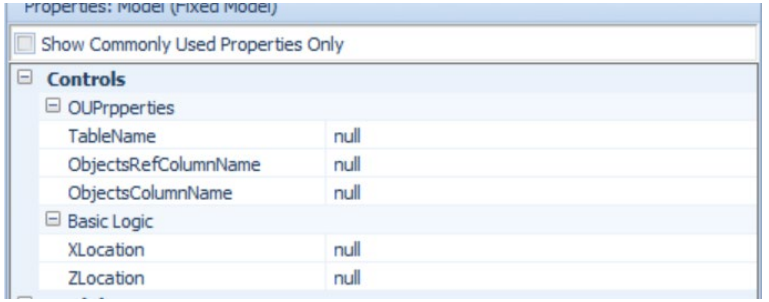
A1 | Resources

	A	B	C	D	E	F	G	H
1	Resources							
2	ResourceName;AddObjectReferenceColumn	ResourceType;AddObjectTypeReferenceColumn	Xlocation;AddRealColumn	Zlocation;AddRealColumn				
3	DailyAppointments							
4	PatientTypes;AddEntityReferenceColumn	AppointmentTime;AddDateTimeColum	AdmissionTime;AddExpres:	PreTime;AddExpressionColu	InRoomTc	PACUTime	InpatientC	CleanTime T
5								
6								
7								
8								
9								
10								
11								
12								
13								

CSV file



Tables created



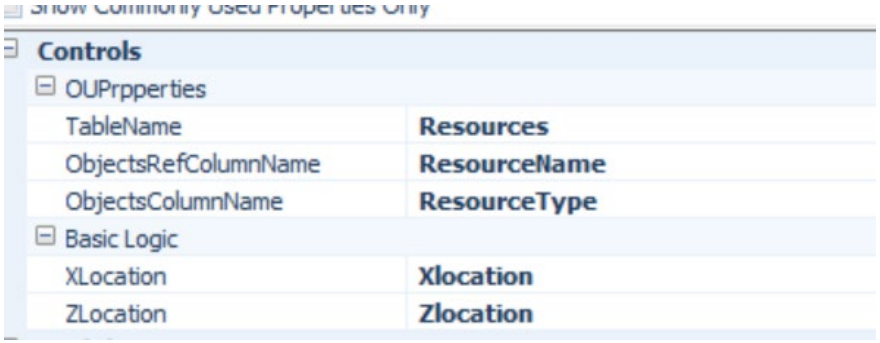
Properties created in table generator add-in

Object Creator Add-in

Resources | Daily Appointments

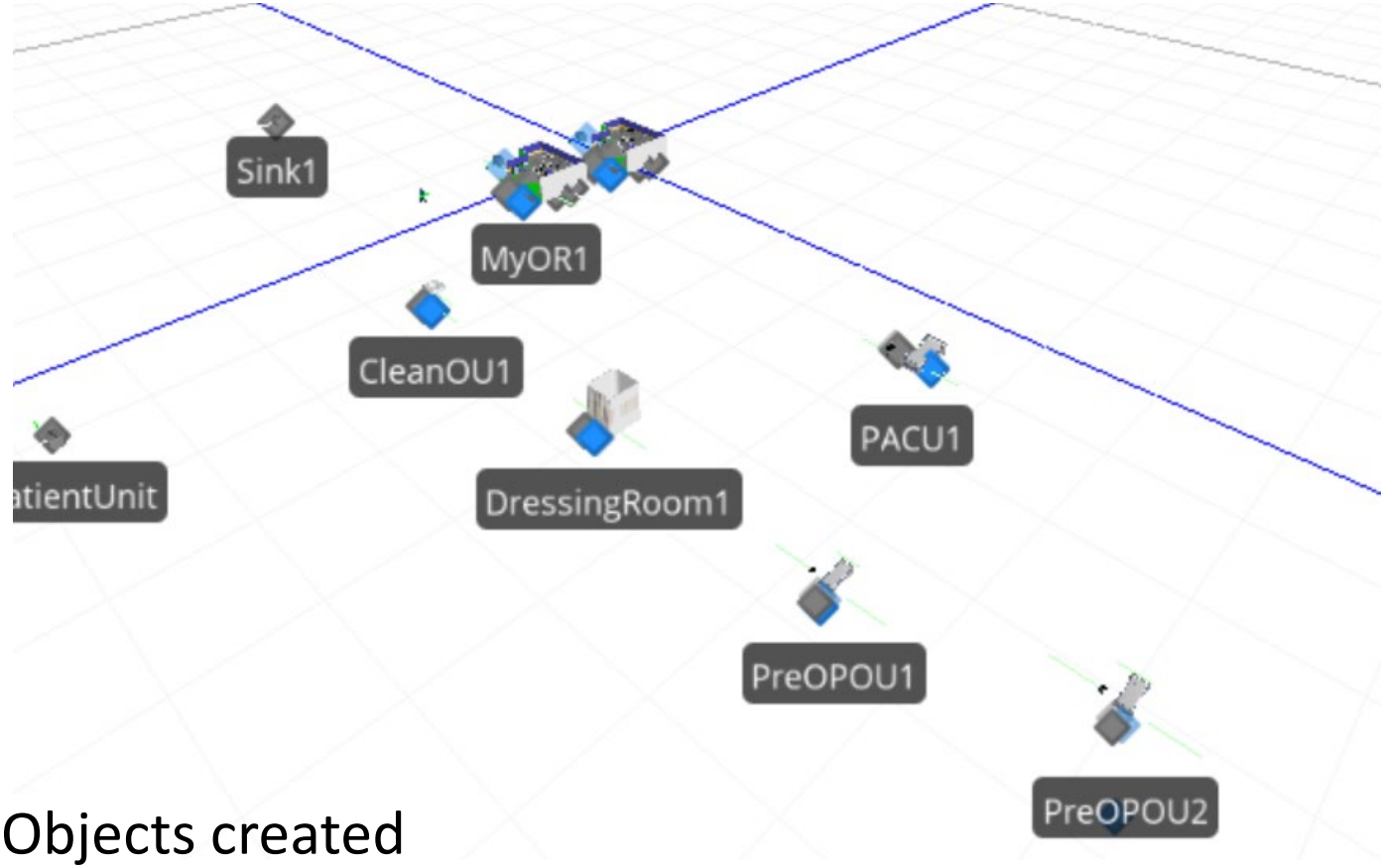
	Resource Name	Resource Type	Xlocation	Zlocation
▸ 1	colorectal	ouPatient	2.5	100
2	AnesthesiaSurgeon1	AnesthesiaSurgeon	30	120
3	ColorectalSurgeon1	ColorectalSurgeon	38	121
4	Nurse1	Nurse	-6	90
5	Nurse2	Nurse	-6	91
6	Nurse3	Nurse	-6	92
7	Nurse4	Nurse	-6	94
8	AnesthesiaNurse1	AnesthesiaNurse	-40	85
9	Anesthesian1	Anesthesian	-57	82
10	SourceWithoutBlockModel1	SourceWithoutBlockModel	41.25	88.43
11	AdmissionDesk1	AdmissionDesk	65	84
12	Home	Sink	0	77
13	InpatientUnit	Sink	11	67.5
14	CleanOU1	CleanOU	31	55
15	DressingRoom1	DressingRoom	42	55
16	PreOPOU1	PreOPOU	50	55
17	PreOPOU2	PreOPOU	60	55
18	PACU1	PACU	34	9

Tables loaded with data



Properties values added in the facility view

Object Creator Add-in



Objects created

List creator add-in

A	B	C	D
PreOPList;AddNodeList			
Input@PreOPOU1	Input@PreOPOU2		
PACUList;AddNodeList			
Node1@PACU1	Node1@PACU2		
CleanList;AddNodeList			
Node1@CleanOU1			
DressList;AddNodeList			
Input@DressingRoom1			
HomeNode;AddNodeList			
ouPatient.HomeNode			
AdmissionWaitingArea;AddNodeList			
Node1@AdmissionDesk1			
ORNode;AddNodeList			
ouPatient.WhichORNode			
DummySink;AddNodeList			
Input@Sink1			
NurseList;AddTransporterList			
Nurse1	Nurse2	Nurse3	Nurse4
AnesthesiaNurseList;AddTransporterList			
AnesthesiaNurse1			

CSV file with list information

List creator add-in

Processes | Definitions | Data | Results | Planning

Name	Object Type	Display Name
Nodes		
PreOPList	Nodes	PreOPList
PACUList	Nodes	PACUList
CleanList	Nodes	CleanList
DressList	Nodes	DressList
HomeNode	Nodes	HomeNode
AdmissionWaitingArea	Nodes	AdmissionWaitingArea
ORNode	Nodes	ORNode
DummySink	Nodes	DummySink
Transporters		
NurseList	Transporters	NurseList
AnesthesiaNurseList	Transporters	AnesthesiaNurseList

Node
Input@PreOPOU1
Input@PreOPOU2

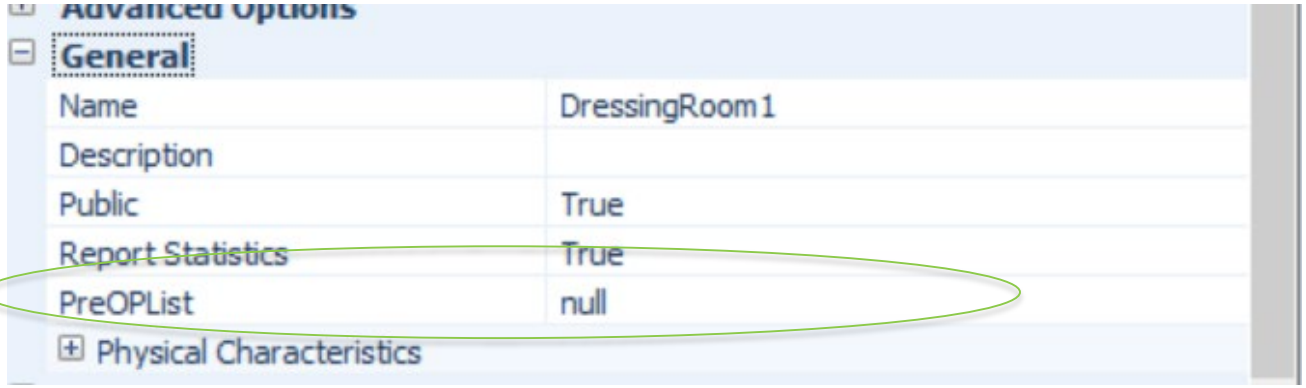
Lists created

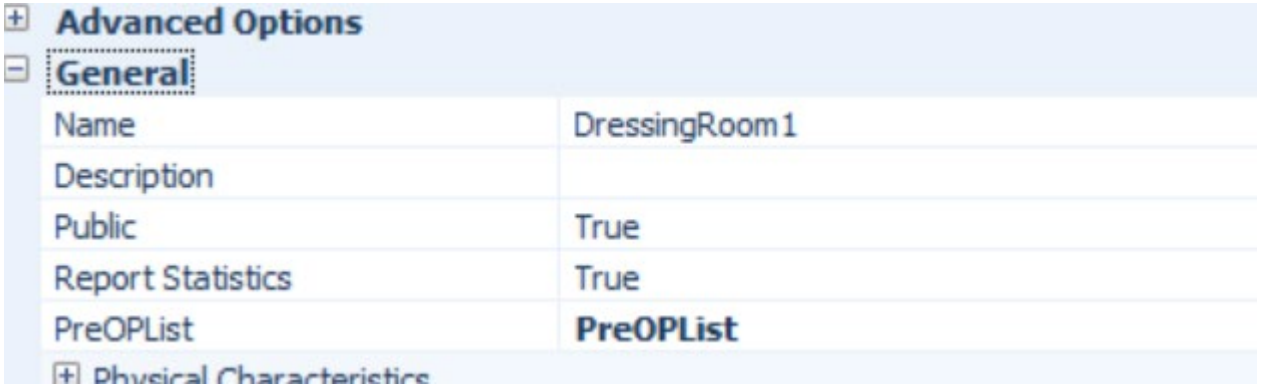
Adding properties values creator add

	A	B	C	D	E	F	G	H	I
1	SourceWithoutBlockModel1;PreOPList;PreOPList	SourceWit	SourceWithoutBlockModel1;WaitingArea;AdmissionWaitingArea						
2	AdmissionDesk1;Clean_List;CleanList								
3	CleanOU1;DressingRoomList;DressList								
4	DressingRoom1;PreOPList;PreOPList								
5	Nurse1;CapacityType;Fixed								
6	Nurse2;CapacityType;Fixed								
7	Nurse3;CapacityType;Fixed								
8	Nurse4;CapacityType;Fixed								
9	PreOPOU1;AnesNurseListPreOPOU;AnesthesiaNu	PreOPOU1;ORNode;ORNode							
10	PreOPOU2;AnesNurseListPreOPOU;AnesthesiaNu	PreOPOU2;ORNode;ORNode							
11	PACU1;HomeNodeList;HomeNode								
12	MyOR1;ORAnestheisanListOU;Anesthesian	MyOR1;OI	MyOR1;OI	MyOR1;Rc	MyOR1;Du	MyOR1;TurnoverStaffOU;TurnoverStaff			
13									
14									

Data file used to add properties values

Adding properties values creator add-in





Pre-op list value added after using add-in

Case Studies

- Progressive Care Unit
  - Central Ohio Hospital
  - 10 beds
  - Analyze bed needs
- Operating Theater
  - North Ohio Large Hospital
  - Several surgery departments
  - Pilot on a small operating theater

PCU Case Study

Types of Patient

- Low Acuity
- Medium Acuity
- High Acuity

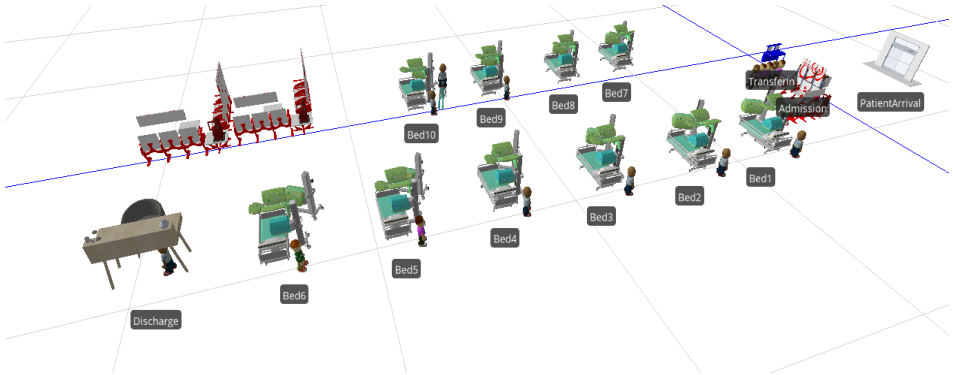
Inpatient Staffing Levels

- Number of Beds - 10
- Regular Nurse - 3
- Assistant Nurse - 2
- Therapist - 1

PCU Case Study

Hospital Data | Resources | Link Table

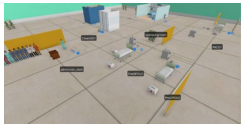
	Resource Name	Resource Type	XLocation (Meters)	ZLocation (Meters)
1	Bed1	Bed	1	-2
2	Bed2	Bed	9	-2
3	Bed3	Bed	17	-2
4	Bed4	Bed	1	12
5	Bed5	Bed	9	12
6	Bed6	Bed	17	12
7	Bed7	Bed	26	-2
8	Bed8	Bed	32	-2
9	Bed9	Bed	26	12
10	Bed10	Bed	32	12
11	source1	MySource	-14	5
12	TransferIn	Server	-4	2
13	Admission1	Admission	-4	7
14	LowAcuity	Patient	-14	-3
15	MediumAcuity	Patient	-14	1



Results

- Five scenarios were created
- Identify average time a patient waits for a resource

	Therapist		Regular Nurse		Assistant Nurse	
Scenarios	No. of staff	Average Time Waiting	No. of staff	Average Time Waiting	No. of staff	Average Time Waiting
1	1	56.7	5	1.87	2	0
2	2	4.01	4	2.48	1	0.07
3	2	3.95	3	3.73	1	0.08
4	3	2.09	2	8.71	1	0.09
5	2	3.76	2	8.19	1	0.1

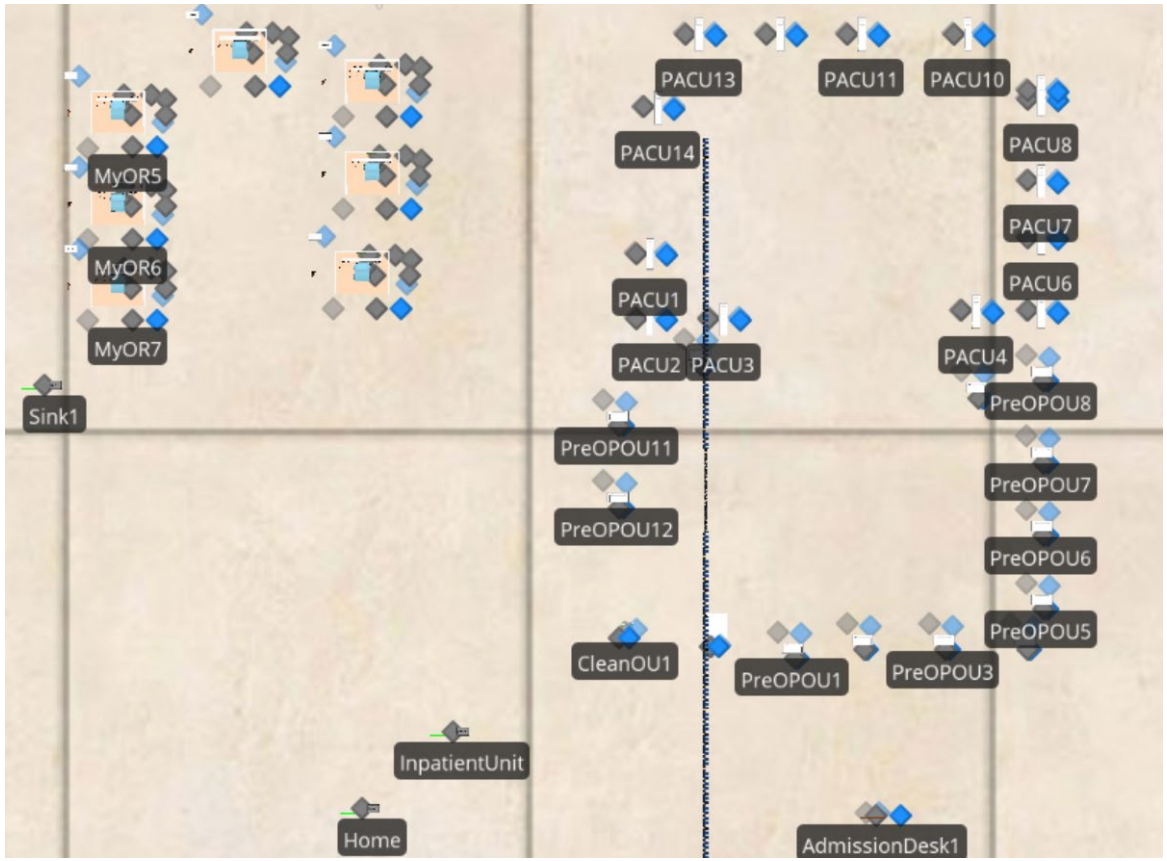


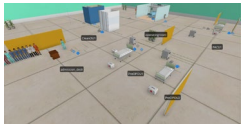
OR Case Study

Resources	Number
OR	7
Pre-op	12
PACU	14

Surgery Type	Surgery Count
Anesthesia	1132
Colorectal Surgery	420
General Surgery	855
Gynecology	534
Hematology/Oncology	14
Neurosurgery	1
Ophthalmology	343
Orthopedic Surgery	451
Pediatric Surgery	1
Plastic Surgery	57
Podiatory	2
Radiation Oncology	100
Urology	1387
Vascular	1

Data-driven simulation model of OR unit





OR Performance

OR	Average patient time (Minutes)	Utilization (Percent)
OR1	67.12	49.17
OR2	75.49	49.45
OR3	70.66	39.99
OR4	83.40	51.72
OR5	66.95	50.60
OR6	69.92	50.13
OR7	42.59	48.046

Conclusion and Future Work

- Customized objects are reusable
- Four flexible add-ins of operating rooms are not limited to operating rooms
- Reconfiguration of data-driven model is faster
- Model will help to determine the resource requirements in their unit
- Two models can be integrated where patient after PACU transferred to PCU for recovery
- PCU bed can be used in other departments of hospital where similar rounding procedure is carried out like ICU
- Database connection

Create
for Good.
1804
OHIO
UNIVERSITY