McMaster University

CAS 4ZP6

Team 9

Capstone Project 2013/2014

Porter Simulation

Design Revision 0

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Contents

1 Revision History

Revision #	Author	Date	Comment
1	Vitaliy Kondratiev, Nathan Johrendt, Tyler Lyn, Mark Gammie	January 11, 2014	Revision 0 Added to repository
2	Vitaliy Kondratiev, Mark Gammie	January 12, 2014	Added diagrams to Latex
3	Tyler Lyn	January 12, 2014	Added dispatch module
4	Vitaliy Kondratiev, Nathan Johrendt	January 13, 2014	Added GUI Component to document
5	Mark Gammie	January 13, 2014	Updated Dependency Diagram to contain algorithms and data structures. Updated dependency diagram with a legend, logging comment and fixed the porter dispatcher dependency
6	Tyler Lyn, Mark Gammie	January 13, 2014	Several Modules Updated
7	Nathan Johrendt	January 13, 2014	Added Appendix
8	Mark Gammie	January 14, 2014	Completed Design Overview

2 Executive Summary

2.1 Introduction

This document outlines the design decisions, style and methodology for the project of Porter Simulation to be completed for Hamilton Health Sciences. A modular design methodology has been chosen as our design principle. This document is based on IEEE Draft Standard for Software Design Descriptions (IEEE P1016/D5.0).

2.2 Purpose

The purpose of this document is to outline the design of each component and how they interface between each other. This document will aid the developers in the development process as well as any future maintenance required.

2.3 Design Overview

Our solution is a discrete event simulation that is implemented using the Python library SimPy. The simulation has three main sections named Import, Export and Core.

The Import section contains modules for accessing three different csv files that are used to control the simulation. The first file contains details about the settings of the simulation such as the number of porters and other configuration values. The second csv stores the description of the hospital's layout in the form of directed edges of a graph and defined wards. The module for accessing this file constructs a heapq data structure. The final file contains any statistical information that may be used in the simulation. All three of these files will be modified using Excel as the interface.

The Export section contains a module for reporting statistics that are generated by the simulation. The module will be called throughout the execution of the simulation to keep track of statistics. Once the simulation concludes, this module will write the data to a csv file that will be interpreted by the user.

The Core section is where the simulation actually occurs. The module Simulation Core contains the command line interface for the simulation and is responsible for initializing the Simulation State, Task List Builder and Dispatcher modules. The Task List Builder module will create a list of tasks using statistical data or a random distribution. This list of tasks will be submitted to the Simulation State to be stored. Once the simulation is started, the Dispatcher module is responsible for receiving the tasks as they become available and assigning them intelligently to any eligible porters. The porters that operate on the tasks follow a finite state machine that creates timeouts based on the time it would take for each state that the porter is transitioning into. There may be cases when all the porters are busy and the amount of assigned tasks piles up, or the porters are stuck waiting on task or equipment to become available. Once the simulation terminates, the export of the statistical data is finalized.

3 Implementation Material

3.1 Language of Implementation

Visual Basic in Excel will be used to interface GUI to Simulation Core module. Python Version 2.7.5 will be used for Simulation Core module and all other modules.

3.2 Supporting Technology and Frameworks

Simulation will be built on the SimPy 3.0.2 library `https://simpy.readthedocs.org/en/latest/`. GUI will be built in Excel 2010.

4 Process Diagram

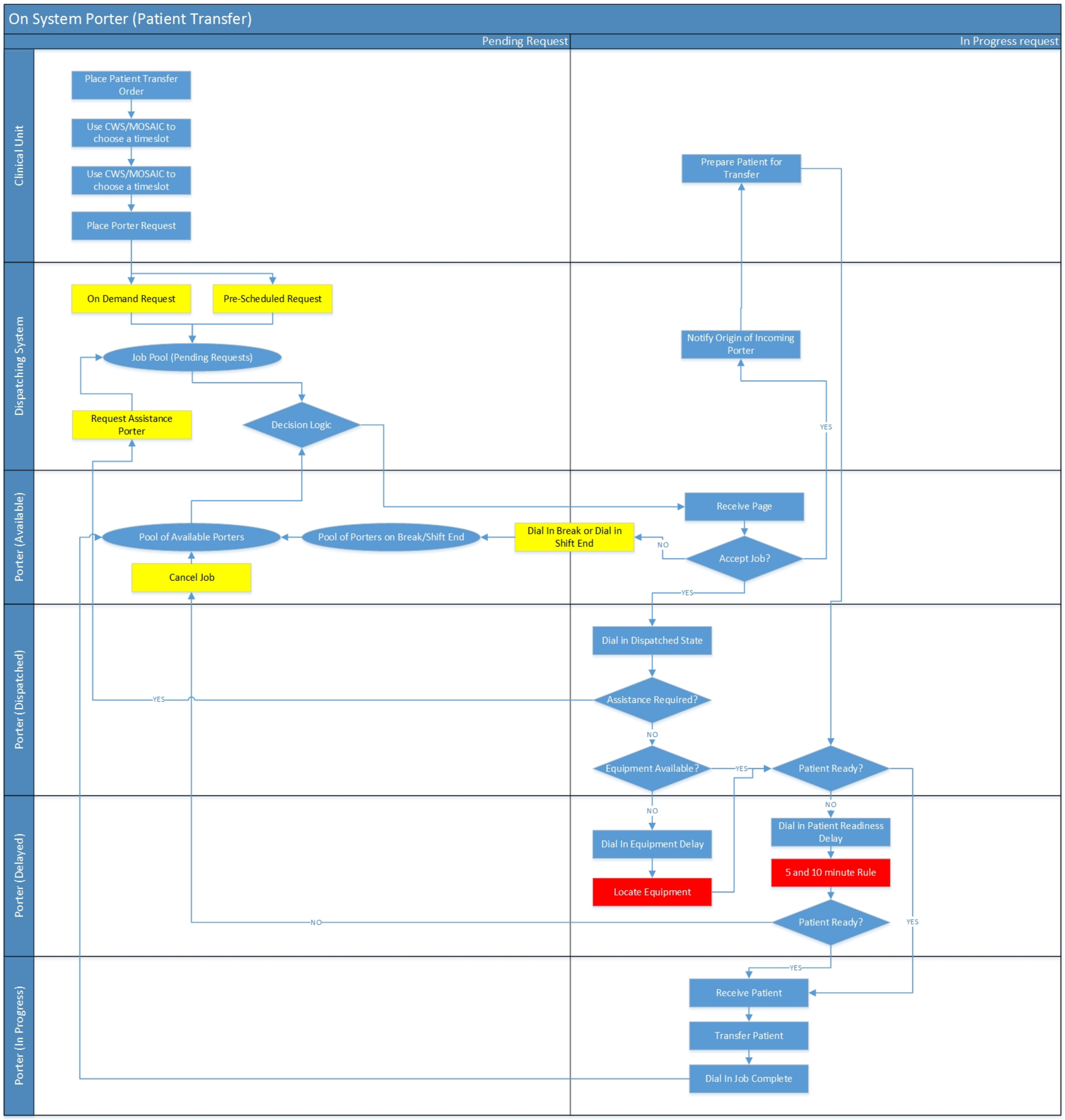


Figure 4.1: Process Diagram

5 Dependency Diagram

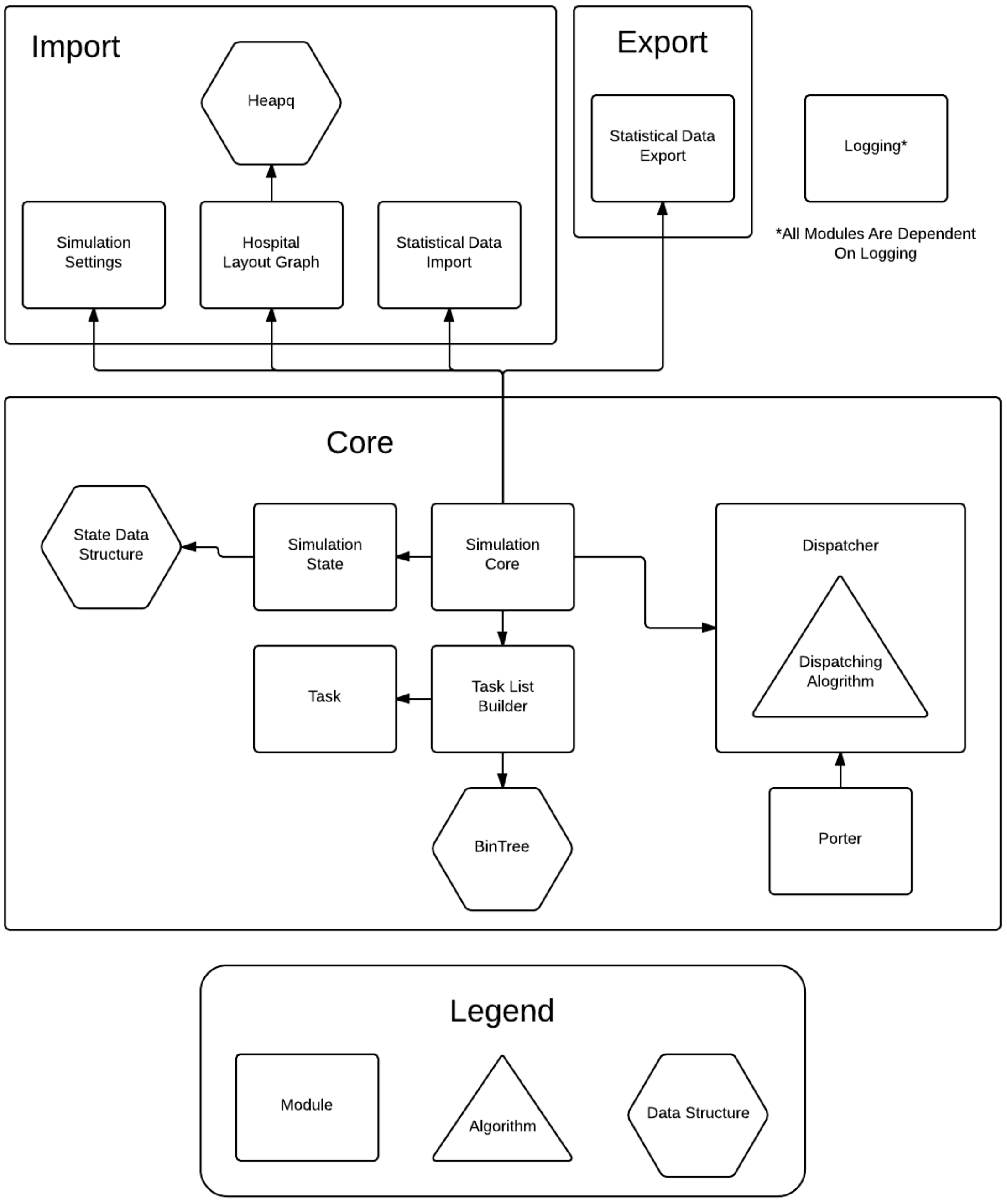


Figure 5.1: Dependency Diagram

6 Decomposition Description

6.1 Core - Simulation Core

Type: Module

Purpose: This module calls the required functions to fetch the import data, initializes the simulation and initializes processes.

Function: This module calls the required import modules (Simulation Settings, Hospital Layout Graph, Statistical Data Import), passes their data so that the Simulation State, Event List Builder and Dispatcher can be initialized.

Interface:
The interface for the Simulation core is the command line used to called it, defined as follows:

SimCore settings_filename graph_filename data_filename

settings_filename: the name of the file containing the simulation settings

graph_filename: the name of the file containing the hospital layout graph

data_filename: the name of the file containing the statistical data

Process Steps: This module first uses the Simulation Settings, Hospital Layout Graph and Statistical data to read in the external data. This data is used to configure other core modules in the simulation.

Once the external data is imported and the core modules are configured, the Simulation Core will begin the simulation and manage the core modules.

Data: None

Error Handling: Catch all on the simulation loop to report pertinent errors and to prevent unexpected termination.

Requirement Reference: 11.5.1

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.2 Core - Simulation State

Type: Module

Purpose: This module's purpose is to be an interface between the simulation and its simulation state data structure.

Function: This module will contain functions that will be used by the simulation to perform queries on the simulation state data structure.

Interface:
initSimulateState():

- Instantiating the simulation state with null values

getSimulationTime():

- Returns the current simulation time

getPorterList():

- Returns a list of the porter objects

getTaskList():

- Returns the task list

Process Steps: This module handles the simulation state data structure and allows the rest of the modules to interact with it. If modules need information about the simulation as a whole, they will communicate with the Simulation State module in order to satisfy their needs.

Data: Simulation state data structure

Error Handling: Catch any null values in the simulation state data structure

Requirement Reference: None

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.3 Core - Task

Type: Module

Purpose: Provide information about a job to the porter.

Function: The task is declared with an origin, destination, required equipment and a priority. This information is necessary to allowing a porter to complete a job.

Interface:
getOriginLocation():

- Returns the origin of a job

getDestinationLocation():

- Returns the destination of a job

getEquipment():

- Returns the equipment required for a job

getPriority():

- Returns the priority of a job

getTime():

- Returns the time that the task will be requested

updatePriority():

- A process that will set the job to a higher priority after a specified amount of time has passed.

Process Steps: Tasks will be initialized once the Simulation Core shares the import modules with the Event List Builder. An initialized task will be able to provide the Dispatcher all the required information to organize a list of tasks. Also, once a task is given to a porter, the porter will then be able to start and complete a transport job.

Data: Transport Job Information

Error Handling: Catch any null values returned by the task's properties

Requirement Reference: None

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.4 CORE - TASK LIST BUILDER

Type: Module

Purpose: Produces the list of tasks for the Simulation Core and Dispatcher modules to process

Function: This module populates a series of tasks following either a distribution or statistical data.

Interface:
addTask(origin, destination, equipment, priority, time):

- Input the origin, destination, equipment and priority of a job. Also include the time the task will be added to the Dispatcher

setTaskBuilderStats(data)

- Input the statistical or distribution data as it is required for creating meaningful data

Process Steps: The Task List Builder will first receive the data from the Simulation Core. This data will allow the Task List Builder to create jobs based on user specified parameters. Secondly, the Task List Builder will generate tasks and append them to the BinTree data structure, to allow for ordering, inserting and retrieval of tasks. Once a task reaches its "time" it will be added to the Dispatcher where it can be given to an available porter.

Data: Task List BinTree

Error Handling: Catch any null tasks

Requirement Reference: 8.1.4

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.5 CORE - PORTER

Type: Module

Purpose: To complete jobs provided by the dispatcher

Function: Completes the transport jobs assigned by the dispatcher. Unless a job is cancelled the porter will traverse through four states ('pending', 'dispatched', 'inprogress', 'complete')

Interface:
setStatePending(state):

- Input the pending state
- Sets the porter's state to pending and waits to be assigned a job

setStateDispatched(state):

- Input the dispatched state
- Sets the porter's state to dispatched and calculates the time between the porter's location and the job's origin

setStateInprogress(state):

- Input the inprogress state
- Sets the porter's state to inprogress and calculates the time between the job's origin and destination

setStateComplete(state):

- Input the complete state
- Sets the porter's state to complete, records the completion time and sets the porter back to the pending state

getAutoLocation():

- Returns the estimated location of a pending porter
- Estimates the current location of a porter based on how many minutes they have been in
- Output the estimated location of a pending porter
- Estimates the current location of a porter based on how many minutes they have been in the pending state.

Process Steps: The module listens for state changes provided by the dispatcher and updates its' internal components as necessary.

Data: Stores internal data relating to its' current state.

Error Handling: None

Requirement Reference: None

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.6 Core - Dispatcher

Type: Module

Purpose: To organize pending jobs based on a weighted-value and assign them to porters

Function: This module orders pending jobs based off of a Dispatch Value which is computed using several parameters (Proximity Match Value, Weighted Job Priority and Appointment Factor). The pending job with the greatest Dispatch Value will be assigned to the closest available porter. Once the job is assigned to the porter the job will be considered as a dispatched job.

Interface:
assignJob(Task):

- Assigns the job with the greatest Dispatch Value to the closest available porter.

getProxmityMatchValue(TaskOrigin):

- Input the origin of a pending job
- Output a value based on how close an available porter is to a job's origin

getWeightedJobPriority(TaskOrigin, TaskDestination):

- Input the origin and destination of a pending job
- Output a value based on the priority of the pending job

getAppointmentFactor(Task):

- Input a pending job
- Update the value for a job depending on if it was pre-scheduled or on-demand.

getDispatchValue(Task):

- Input a pending job
- Compute the DispatchValue for a job: (ProxmityMatchValue + WeightedJobPriority * AppointmentFactor)

Process Steps: All pending jobs are assessed and given a dispatch value (DV) based on the weighting and values of specified dispatch parameters.

These weights and values are determined using either the location of an available porter or the priority of a pending job.

All of the pending jobs are then ordered from greatest dispatch value to the least. When there is an available porter the pending job with the greatest dispatch value is given to the closest porter.

Data:

- Pending jobs

Error Handling: None

Requirement Reference: None

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.7 Import - Simulation Setting

Type: Module

Purpose: Receives the settings data from the GUI and translates them for use by the simulation core

Function: Receives data in the form of a csv and converts it to a readable format

Interface:
receiveSettings(Settings):

- Load and store setting into module

translateSettings():

- Outputs translated setting from the current loaded setting in the module

Process Steps: the module is called by the GUI from which it receives the settings as a csv file and stores them. Simulation Core calls the module to receive the current setting in the translated format.

Data: Settings

Error Handling: return NULL on incorrect settings received

Requirement Reference: 8.1.1, 8.1.2

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.8 Import - Hospital Layout Graph

Type: Module

Purpose: Receives layout data for the hospital from a .csv file and translates it for use by the simulation core.

Function: Interprets the data from the .csv file into a graph representing a HHS hospital transportation layout for porter movement.

Interface:
receiveLayout(Layout):

- Load and store layout into module

translateLayout():

- Outputs translated layout from the currently loaded .csv file to the module

Process Steps: Simulation core calls the module to receive the translated layout.

Data: Layout Graph

Error Handling: Returns NULL on incorrect settings.

Requirement Reference: 8.1.1, 8.1.2

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.9 IMPORT - STATISTICAL DATA IMPORT

Type: Module

Purpose: Receives statistical data for the hospital from a .csv file and translates it for use by the simulation core.

Function: Interprets the data from the .csv file into statistical data and places them into variables for use by the Simulation Core.

Interface:
receiveStatistics(Statistics):

- Load and store statistics into module

translateStatistics():

- Outputs translated statistics from the currently loaded .csv file to the module

Process Steps: Simulation core calls the module to receive the translated statistical data variables.

Data: Statistic data variables

Error Handling: Returns NULL on incorrect settings.

Requirement Reference: 8.1.1, 8.1.2

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.10 EXPORT - STATISTICAL DATA EXPORT

Type: Module

Purpose: Format and output the raw data from the simulation.

Function: This module will gather all of the raw data from the simulation and format it so that it can be exported into a readable excel file.

Interface: addExportData(data)

- Input raw data

publishExportData()

- This function will format the simulation's raw data, create an excel file and populate the file with the formatted data

Process Steps: All data that is to be exported must be added to this module. Once the simulation's raw data is gathered the module will publish the data. The publishing will generate an excel file and outline the results from the simulation.

Data: None

Error Handling: Produce warning message if data is missing during the publishing.

Requirement Reference: 8.1.5

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.11 Logging

Type: Module

Purpose: Provide logging capabilities across all Python modules

Function: This module will contain python's native logging library as well provide any additional logging functionality specific to the simulation.

Interface: initializeLogging()

- Initialize python's native logging across the modules

printLogging(module)

- Print a module's simulation log

Process Steps: A logger will be created for each module providing necessary error tracking. Not only this but the Logging module will allow for debugging during the course of development.

Data: Module Logs

Error Handling: Catch any null module logs.

Requirement Reference: 13.1

Critical Revision 0 Component: True

To Be Completed By: 28/01/2014

To Be Tested By: 30/01/2014

6.12 GUI - Basic Settings

Type: User Interface

Purpose: Allows the user to change the basic setting of the simulation and run the simulation

Function:

Number of Porters: specify the number of porters for the simulation to run

Start Date: specify the day the simulation will run from

Start Time: specific time the simulation runs from

End Date: specific time day the simulation will end

End Time: specific time the simulation ends

Job Distribution: users can choose from predefined distributions or base it on existing statistical data

Job Intensity: specify the frequency of job distribution

Correct Equipment Usage: specify the percentage of correct equipment events

Patient Readiness: specify the percentage of ready patients on porter arrival

Porter Wait Time: specify the time a porter waits for patient to be ready before abandoning job

Interface:

Advanced Setting: proceed to Advanced Setting GUI

Simulate: push settings to Simulation Core

Default Settings: reset to default values

Process Steps: Not Available

Data: Not Available

Error Handling: If any of the below values violates its restriction, excel will not allow the information to be sent to the simulation core.

Number of Porters: restricts the number of porters to a positive integer

Start Date: restricts the start date to day/month/year format

Start Time: restricts the start time to 12 or 24 hour time

End Date: restricts the end date to day/month/year format and checks that the date is on the same date or a later date than the start date

End Time: restricts the end time to 12 or 24 hour time and checks that the end time is further in the future than the start time

Job Distribution: user is restricted to a set series of options

Job Intensity: user is restricted to a set series of options

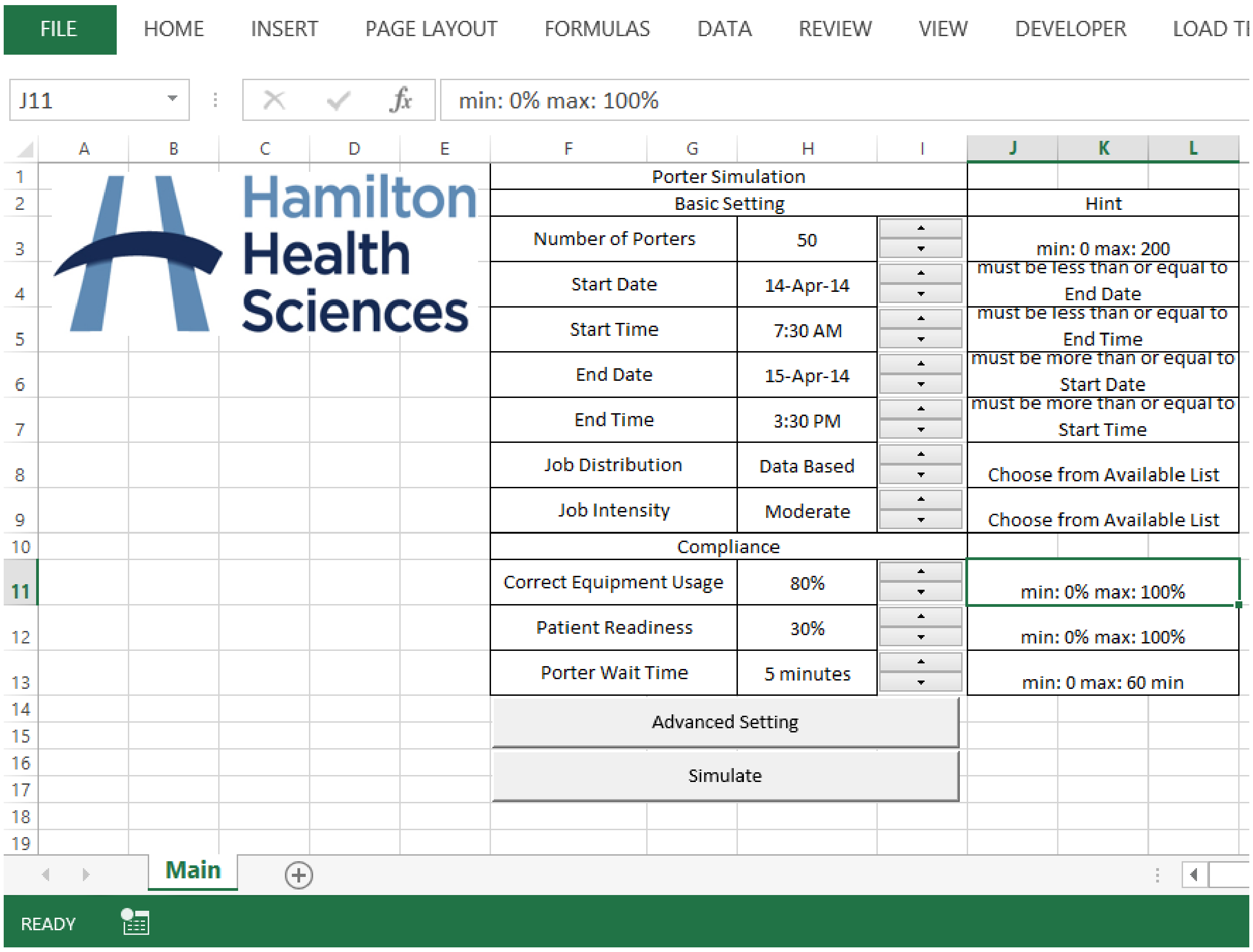
Correct Equipment Usage: restricts the value between 0 and 100 percent

Patient Readiness: restricts the value between 0 and 100 percent

Porter Wait Time: restricts the value to a minimum of 0

Requirement Reference: 10.1.1, 10.1.2, 10.1.3, 10.1.4

Critical Revision 0 Component: True



min: 0% max: 100%

Porter Simulation		
Basic Setting		**Hint**
Number of Porters	50	min: 0 max: 200
Start Date	14-Apr-14	must be less than or equal to End Date
Start Time	7:30 AM	must be less than or equal to End Time
End Date	15-Apr-14	must be more than or equal to Start Date
End Time	3:30 PM	must be more than or equal to Start Time
Job Distribution	Data Based	Choose from Available List
Job Intensity	Moderate	Choose from Available List
Compliance		
Correct Equipment Usage	80%	min: 0% max: 100%
Patient Readiness	30%	min: 0% max: 100%
Porter Wait Time	5 minutes	min: 0 max: 60 min

Figure 6.1: Basic GUI

7 Anticipated Changes

1 Specific interface design will be guided by initial testing with HHS stakeholders, changes to the GUI are expected.

2 The functionality of the Logging module may change if HHS stakeholders require additional information about the modules.

8 Appendicies

8.1 Figure Appendix

(a) Figure 4.1: Process Diagram.jpg - the process flow diagram details the process modeled by the simulation.

(b) Figure 5.1: Dependency Diagram.png - layout of the module, algorithm and data structure dependencies.

(c) Figure 6.1: Basic GUI.png - prototype design of the GUI associated for use with the simulation.

8.2 Algorithm Appendix

(a) Dispatching Algorithm - main dispatcher algorithm used to assign jobs to porters based on a number of factors. Functionality outlined by section 6.6 of this document.

(b) Dijkstra's Algorithm - will be used to compute the shortest path between two hospital location.