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| Burford School – 62225 |
| Room Booking System |
| Keith Collister – 9164 |



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# Analysis

## Client

Client: Burford School

Client Liaisons:

* Mr Wilsdon (Network Manager), for technical information and access to existing system.
* Mrs Denny (Head of Sixth form), for feedback and user testing.

## Background, Description of Current System

At our school we have quite a few rooms that can be booked for classes – mostly computer rooms and engineering workshops, with a few special cases such as the Library, Gym and Main Hall. At the moment, this booking process is done through a web interface (accessible from any computer as it is hosted by an external company). This system is only accessible by teachers – students don’t have a logon.

This can produce some problems – students, in particular sixth-formers, often use such rooms for quiet work areas, and are frequently disturbed by booked classes arriving without warning and using the room. This can have large impacts on academic performance – for example, a student needing to use an engineering workshop to complete some urgent coursework may be forced to leave due to another class using the room, which could potentially damage the student’s grades.

In addition, as the website is hosted externally, were connection to be disrupted/the website to be shutdown, the school’s booking system would be rendered non-functional. Backups are taken and dealt with by the external company, but the school must pay a subscription fee.

The intended solution is therefore to create a system which introduces students into the booking system – not as “bookers”, but as viewers of the bookings. This will allow students to plan their studies around which facilities are available, hopefully assisting their academic lives.

The solution will also provide a replacement to the current (external) booking system – it would not be possible to provide student access without this. The act of replacement does present an opportunity to improve the system for teachers as well, however, so I intend to make full use of this by making improvements to their use of the booking system as well, hopefully by streamlining the process and making it easier to use. The replacement system will be hosted internally on the central school server, providing more reliable access compared to the external website.

## Identification of Users

At the moment there are 2 styles of access: one for teachers and one for administrators – teachers can use a slightly restricted version of CRUD: they can Read all bookings but only Create/Update /Delete their own bookings through the web interface. Administrators can view and edit all bookings. Students are unable to view any bookings, and in fact most are unaware that a booking system is currently used.

The current system doesn’t require much training, although this is recommended by the school so that mistakes aren’t made. Administrators do need training but it’s just so that they are aware of all the features – the system is clear enough to use without extensive training. The current administrators are the network managers who have a high degree of technical knowledge, while the teachers have varying knowledge from basic to advanced.

In the proposed solution, there will be 3 tiers of access: for teachers, administrators, and students. The abilities of teachers and administrators will be almost identical to the current system. Students will be able to view bookings for the current day and possibly the next few days. Administrators should also be able to revoke individual student’s room viewing rights, as a layer of control.

Ideally the solution will be intuitive and easy to understand, meaning most users won’t need training – this is almost necessary in a system with potentially over 1000 users. The students access to the system is very limited and simple, so likely won’t need any training. Teachers may need to be shown how to use the features, although they will be largely the same as those in the existing system. Administrators may need some extra instruction on the usage of more advanced features. Easily accessible help documentation should be included to assist all users.

## Limitations

* Technical
  + Hardware – the server will need to be able to handle connections to many computers around the school. As such it will need a large range of available ports for allocating as needed. High speed in this system isn’t required (although it is obviously desirable!), so the server doesn’t require any special hardware. The school logon server should be able to handle running the software process.  
    The client machines only need to run an application in the background, and it won’t be doing any significant processing, so they won’t need specialised hardware either.  
      
    Ideally, no money should be spent on buying new hardware specifically for this project.
  + Software – if I develop a computerised solution in a .NET language, all the machines running the resultant programs will require the .NET framework installed and updated to at least .NET version 4. This is installed on most computers already, but it would be need to be ensured to be present and updated as a prerequisite of this system.
* Economic – as the proposed systems don’t require any extra hardware the costs should be minimal. Similarly, none of the features of the system require funding. The server machine will need to do more processing so will use more power, but those costs are likely negligible.
* Legal – as my system will be handling data pertaining to living persons (teachers and students) such as names, email addresses, and their probable location at a given time, I need to make sure that all data is encrypted and stored securely (Data Protection Act, 1998).
* Operational – the current system has been used for many years and its uses are deeply ingrained in the minds of the staff; the new solution should therefore be easy to use and intuitive, reflecting the features of the current system, although without being averse to adding new features/streamlining existing ones.
* Scheduling – leading on from the previous limitation, with such a large application to develop I will no doubt be pushed for time. Changes to the user requirements will exacerbate this pressure, so I will need to be very careful in how frequently I check my progress with the client, in order to make sure I spend as little time as possible working “in the wrong direction”.

## Data Sources/Destinations – Existing System

|  |  |  |
| --- | --- | --- |
| Data | Source | Destination |
| List of teachers | Admin input | Website, Database |
| List of students | Admin input | Website, Database |
| List of bookable rooms | Admin input | Website, Database |
| List of preset timeslots (periods) | Admin input | Website, Database |
| List of bookings | Database | Website displayed |
| New/edited booking | Teacher input | Website, Database |
| TODO: More! |  |  |

## Data Sources/Destinations – New system

|  |  |  |
| --- | --- | --- |
| Data | Source | Destination |
| List of teachers | Admin input | Server, Database |
| List of students | Admin input | Server, Database |
| List of bookable rooms | Admin input | Server, Database |
| List of preset timeslots (periods) | Admin input | Server, Database |
| List of bookings | Database | Client |
| New/edited booking | Teacher input | Server, Database |
| TODO: More! |  |  |

## Data Volumes

I intend to store the data in a database – there are quite a few references between records, such as a Booking having a list of Students. A serial access file like a binary file would need loading entirely into memory, and it would be difficult to follow the references. If the server crashed unexpectedly while the data was in memory before being saved to the file, it would be lost. A hierarchical file such as XML wouldn’t be able to represent all the relationships between data, and would also need to load into memory.  
A database allows random access and doesn’t need loading into memory, while also natively supporting references between records.  
The use of the Entity Framework will also allow me to access the data in a C# object-based manner, rather than directly through queries.  
  
An empty SQL database file is around 3MBs in size, and my records are unlikely to use more than 100bytes each. This means that for every 10,000 records the file will increase by 1MB, which is an acceptable scale factor. It’s safe to say that there will never be more than 100,000 records stored, but if there were the file size would still only be around 13MB.

## Data Dictionary (Analysis)

TODO: Fill out different type of data etc.  
  
Describe (in tables) each of the tables in the database – including link tables!

## Data Flow Diagram – Current System

This is a simplified model of the data processes and flow in the current system. It should provide a neat summary of the current system for me to refer to during the design stage. It should be noted that due to the tiered nature of access to the system for different users, colour coding has been used for clarity. Administrators retain access to the same features as Teachers.



## Objectives

As well as observing the current system, I have released a number of surveys and questionnaires to students, teachers, and administrative staff. I feel that as they are the majority users, they will be far more able to identify problems in the current system than I will by observation. My research has yielded the following list of objectives, ranked very loosely from most important to least important, based off the results from the interviews and surveys:

1. Create a client that will allow 3 layers of access to the system for the 3 different users.
2. Allow users to view bookings over different days/months etc. (and possibly limit the scope of viewing for students).
3. Allow teachers to view and book specific rooms around the school site.
4. Allow students to view bookings for rooms around the school site.
5. Prevent unauthorised access to the system for non- students/teachers/admins.
6. Allow administrators to override bookings and revoke student access to viewing bookings.
7. Provide an easy to use interface, so that students can use it without training, and teachers can use it with minimal training.
8. Provide clear and useful error messages that should give teachers an idea of what went wrong, not just that something did go wrong.
9. Allow teachers to set up recurring bookings on varying schemes (daily, weekly, monthly).
10. Provide checks to ensure users aren’t making mistakes when editing bookings.
11. Provide a warning to users when logging onto a computer in a room that’s been booked for that period.
12. Provide email notifications to teacher when they book/cancel a room and when a booking is authorised.
13. Provide useful statistics to teachers about room bookings, including per-teacher and per-department information.
14. Allow the clients to handle loss of connection to the server gracefully, and restore connection and services as soon as possible.
15. Allow students to view where their friends are logged on, provided their friends have marked that they want to be “visible” to that student.
16. Securely hold records of all bookings.
17. Allow the server to be turned on and off with minimal interruption to service (ie doesn’t “forget” bookings).
18. Allow new bookable rooms to be added (by administrators) with ease. Immediate availability of the new room for booking is not required, but is preferred.

## Potential Solutions

The current system was implemented to replace a highly inefficient paper-based system, so it doesn’t make much sense to regress back to a manual system. As such, I only consider electronic solutions.

1. A web-based system, which would allow teachers to book rooms from anywhere (not just school), and let students view the bookings without needing to log onto a computer. However, a website has no way of viewing where people are logged in, so this wouldn’t solve the main problems of students being “disconnected” from the system.
2. A Client-Server based system, where on logon an application starts that communicates with a server process running on the central school server and presents an interface to book/view the rooms. This would let the system know where people are logged on, but presents the problem of accessibility – users need to log onto a school computer to view bookings, which isn’t much use for checking where friends are.
3. A mobile app that provides the same level of interaction as the web-based solution, but is developed as an app (so a client-server system). This would provide the same amount of mobility as the website version, but would allow for a more complex UI.

## Appraisal of Potential Solutions

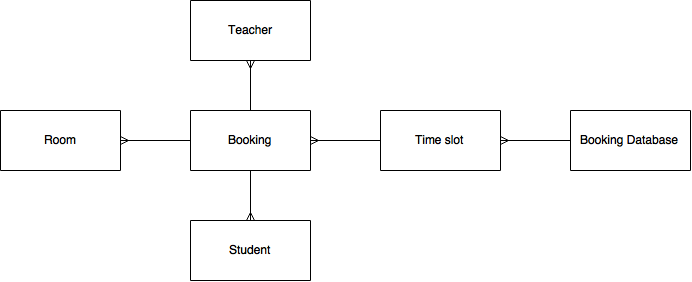
1. Web-based system: While this would provide an easily-accessible system, I have little experience in web-development, so don’t think I would be able to create a satisfactory solution using this approach.
2. Client-Server system: I have the most experience developing solutions of this form, so I would feel comfortable using this design. However, this would need a lot of work as the communications between client-server would need to be designed as well. This has the most room for expansion though, as complex UI and logic can be added fairly easily.
3. Mobile App – I have some experience with mobile technology, but like the website solution not enough to create a satisfactory solution. The mobility factor is a highly demandable feature, as people can browse the bookings without needing to log on.

## Justification of Chosen Solution (Client-Server)

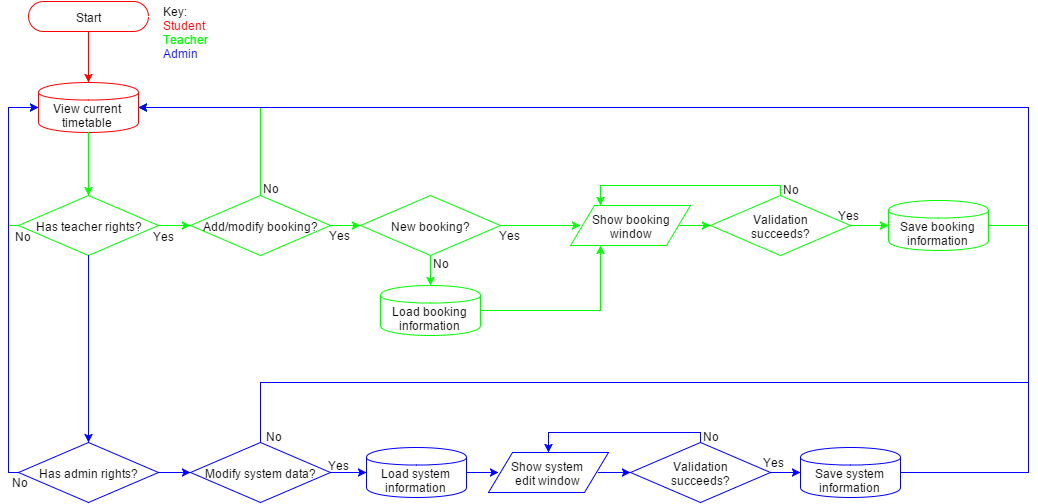
I have chosen to go with the Client-Server solution, as I believe I can make a more robust and effective system using this design rather than the other two possible designs.  
It does mean that mobility is reduced, as students and teachers need to log on to a school computer to see the system, but the application’s GUI can be more responsive and dynamic.

## Entity-Relationship Diagrams

TODO: Needs updating with actual diagram! Still going to be lots of changes during prototyping so leaving it for the moment.



## System Flow Chart



## Fact Finding Methods

Need to talk about observation, questionnaires, interview, and paperwork even if none was collected.

Interview with Mr Wilsdon, Client

What useful features are there in the current system that must to be carried across?

Teachers are emailed when they successfully book a room, cancel a room, or have a pending booking accepted. Multiple users can be imported into the system via CSV file which saves a lot of time, but individual users can be added too without bothering with a CSV. Some important rooms can have bookings requested, which are then approved by a set member of staff. New rooms can be added easily and appear instantly when staff try to book a new room. They can view rooms they’ve booked in timetable layout or as a list.

What features are there that should be carried across if possible?

The current system can show statistics about how many rooms each department or teacher booked over different months – that’s useful for our IT report to the headteacher. It would also be good if the system could handle bookings for all the different types of bookings we do – when students aren’t in school we offer caravan parking on the school fields, which the current system lets us treat as booking venues.

And what features would you like added?

At the moment you can’t have both “period scheduling”, where pre-defined blocks of time are booked, and “time scheduling”, where specific times chunks are booked, at the same time – this is problematics for when we book rooms after school for meetings, as we have to effectively book the 17 hour time chunk of 15:00 – 8:00. Also, some teachers “share” rooms – for example rooms D6 and D12 are next door to each other, so if we’ve got a large IT class in one room, and a much smaller A-level class in the other, sometimes the IT group will use some computers in the other class’s room. I guess that would be hard to implement, but it would certainly be useful.

How much overhead is there for running the system? What extra costs are incurred?

I pay a few hundred pounds a year subscription to the company who host this solution, and I have to buy an SSL certificate to make sure the data is transferred securely. I also need to back-up all the data into two locations to abide by school rules, which can be quite time-consuming.

How frequently would you need to add new rooms/teachers/users?

Obviously I’d need to add new users every year for the year 7’s. Adding teachers would be far less frequent, perhaps once a month maximum. Adding a new room would be very infrequent, once a year perhaps. Although having said that, I’ll need to add all the data to this system at the start anyway, so I will need a method of adding bulk data.

What different types of bookings do you have?

There are the standard bookings, like the computer rooms, and then there are the less used rooms like the conference room, library, gym. Finally we have some strange ones, like the mobile phone and the slots for caravan rallies during holiday times.

Observation of current system

Naturally as the current system is computerised there is no paperwork – in lieu of this I have taken screenshots of multiple views of the current system. The current solution has the following steps:

1. The user logs on. They can choose to log on as an administrator using the shown hyperlink (figure 1.0).



Figure 4.0



Figure 1.0

1. The user can view all the days’ bookings, and edit their bookings (figure 2.0).
   1. Clicking an empty timeslot will bring up a small dialog that enables the user to set some standard settings (figure 2.1), transfer to a page showing advanced settings (see 3.0), and confirm the booking.
   2. Selecting a category will change the shown timetable to the newly selected one (figure 2.2).
   3. Clicking “Week View” or “Category View” at the top switch to different viewing styles (a list of booked rooms or booked rooms by category).



Figure 2.0

1. The “Bookings” tab links to a list of viewed rooms, similar to the “Week View”, but specific to the logged in teacher (figure 3.0).

Figure 2.2



Figure 2.1

* 1. The “Add Booking” tab takes you to the same page as the “Advanced Options” choice on the calendar page did (see 2.1), with a choice of tabs to add extra detail to a booking.
     1. “Booking Notes” contains a textbox labelled “Year/Subject”, but most teachers write notes to the site team instead (figure 3.1.1).
     2. “Recurrence” provides detailed options for the teacher to set up automatic bookings, as well as a button to verify that the bookings don’t clash (figure 3.1.2).
     3. “Attendees” allows other teachers to be notified of a room booking along with the booker themselves (figure 3.1.3(a)). The address book button displays a list of all teachers in the system for easy adding (figure 3.1.3(b)).

1. The “Statistics” page instantly displays the number of bookings the logged-in teacher has made between the shown Start and End dates (defaults to the most recent week). It also displays some extra details as well as a pie chart of actual rooms booked, and a graph showing the number of bookings per day (figure 4.0).

Figure 3.0



Figure 3.1.1



Figure 3.1.2

Figure 3.1.3(a)



Figure 3.1.3(b)

## Benefits of the proposed system

Many students (in particular sixth-formers) feel that being forced to leave bookable rooms is a major disruption to their work. This system will hopefully alleviate that problem, by making it easier to see which rooms are available when. Even if they don’t check on the booking system themselves, one of the most strongly supported features is an automated message on logon informing them that they’re in a booked room, ensuring they’re aware.

There are also a few other problems that have been identified in the current system, such as the inability of the website to support both block-based and time-based scheduling, and unclear error messages. These I hope to fix during the implementation of the new system, as well as adding the new functionality.

# Design

## Overall System Design

A hybrid solution of the web-based and the client-based proposed solutions – the main system will be accessible through an application available to computer users, which connect to a central server process running on the either an external server or more likely the internal school server. Upon logon, an application will start in the background which will present the current bookings. In the background, it will inform the server that the user has logged on, automatically sending relevant information such as the username and computer name. This will cause the server to update its internal model and distribute the change to all logged on clients.

## Solution Limitations

The solution will be developed in C#, which I am comfortable with, but will have to use fairly advanced features of the language such as TCP/IP communications and multithreading, as well as producing a user-friendly interface using the Windows Presentation Foundation (WPF). I may also need to use multiple paradigms – primarily Imperative/Procedural, although the use of C# will naturally result in Object Oriented code, and in producing a responsive user interface I will use basic Event-driven programming. Also, as I will likely need to use multiple threads, I will need to use a blocking paradigm to ensure operations perform synchronously. As such I expect there will be lots of bugs in the development versions.

Also, students need to log on to a computer in order to see where other students are logged on – it’s not quite as easy to use as the website solution would be. However, I have little experience developing websites, and this solution allows for a far more powerful and responsive interface than that of a web UI.

## Description of Modular Structure

Client

A process running on each school computer; it runs on user logon and continues in the background. Presents a GUI to the logged in user that allows them to perform actions as allowed by their access rights (determined by a search of the database for the windows username). Also communicates with the server to send/receive updates to the booking model. No special hardware is needed for this constituent – it isn’t particularly demanding.

Server

A process running on the school server; it provides information about the bookings to clients as well as updating the database. This is the only constituent with access to the database – all other access is through the server, allowing a central mechanism of ensuring validity of inputs. The only special hardware required for this constituent is a machine that’s online all the time. The Server load won’t be massive as there will be fewer than 500 clients (machines) running, and if more are ever added, load will only increase roughly linearly.

NetCore

This assembly should be referenced by both the Client and the Server and will provide access to the networking framework. This will increase code reuse, saving time during development and making refactoring easier.

The networking framework will be developed as an event-oriented system, as it best matches the logic of the client-server relationship: A client will send a booking message to the server, which upon receiving it will update the database and distribute the change to the clients. Upon receiving these messages, the clients will update their UI.

Data

This assembly will be referenced only by the Server – I still intend to create it as a separate assembly however, as I feel that its logic is sufficiently different to that of the server to warrant the separation.

I intend to use the Entity Framework Code First framework to provide access to the database. This will let me design the model using C# code, and the database schema will then be generated and applied independently. Because the model is developed using C#, I can interact with it easily from the rest of my program logic without needing to perform queries within code – they are abstracted to properties within the model classes.

Shared

This assembly is the result of the need to abstract out even further from the NetCore and Data assemblies – the NetCore assembly must have access to the classes defined in the Data assembly in order to create messages that carry the database models, but at the same time the Data models need to specify how they should be serialised to the network. This would create a circular dependency, so I’ve been forced to create a separate assembly to provide interfaces (descriptions of the behaviour of a class, rather than the class itself) that remove the conflict.

## Processing and Algorithms

The following are high-level descriptions of some of the algorithms I intend to use – a lot is taken for granted, such as sending a message, which would require a significant amount of development in the background to work.  
  
I use the keyword “Upon” to introduce a function that is called upon an event occurring, to distinguish it from a normal procedure.

Client

// Called when the user tries to add a booking  
Upon BookingAdded(NewBooking) Do  
 If Invalid(NewBooking) Then  
 ShowErrorMessage()  
 EndIf  
 SendNewBookingMessage(Server, NewBooking)  
End.  
  
// Logic for when the server acknowledges the new booking  
Upon BookingAcknowledgementReceived(Message) Do  
 If BookingFailed(Message) Then  
 ShowErrorMessage(Message)  
 EndIf  
End.

// This is the logic for when a message containing a new booking layout is received  
Upon BookingChangeMessageReceived(Bookings) Do  
 If *User isn’t actively making a new booking* Then  
 UpdateBookingUI(Bookings)  
 EndIf  
End.

Server

// Called when a new booking message is received from a client  
Upon NewBookingMessageReceived(Sender, Booking) Do  
 If Invalid(Booking) Then  
 SendAcknowledgeMessageFailed(Sender)  
 Return  
 EndIf  
 ThreadLock(Database) Then  
 If *Booking clashes with existing database* Then  
 SendAcknowledgeMessageFailed(Sender)  
 Return  
 EndIf  
 EndLock  
 SendAcknowledgeMessageSuccess(Sender)  
  
 AddBookingToDatabase(Booking)  
 ForEach Client in ConnectedClients Do  
 SendBookingChangeMessage(*Bookings from database*)  
 End  
End.  
  
// Called when a new client connects  
Upon ClientConnectMessageReceived(Sender, Username, ComputerName) Do  
 ThreadLock(Database) Then  
 SendAccessLevelMessage(Sender, GetAccessLevel(Database, Username))  
 SetCurrentUser(Database, ComputerName, Username)  
 EndLock  
End.

## Storage Material and Format

The data will be stored in an SQL database on the server’s HDD. As covered in the Data Volumes section of the analysis, the maximum file size of the database is under 15MB, so the existing hard drives can be used to save hardware expenses. An SSD could be used, but fast read speeds aren’t necessary.

The data stored isn’t entirely critical, so backups can be taken once a week, likely as part of the school server backup.

## Human-Computer Interface

TODO: Add hand-drawn UI diagrams? Books seems to imply hand drawn is better :/  
TODO: Show Mr Wilsdon the prototype UI and record his feedback, make changes based on his thoughts and show changes.

## Sample of Data Entry

## Sample of Valid Output

## Security & Integrity

In order to access the application that provides access to the server, the user needs to log on – the application then sends the server the logged on username, and only if the username is registered in the database as an allowed username does the server provide the information about the bookings etc. This provides a fairly safe system. I intend to write a user manual to help people, and integrated help documentation in the form of UI tooltips and explanatory UI messages.  
Validation???

## System Security

As my system is dealing with personal information, I do need to ensure that the security is up to scratch. I do have the significant advantage that the whole system will be hosted inside the school’s network, which is already secured in accordance with regulations – it has firewalls and password-protected access. As such, many security requirements are already fulfilled by the school – the network is kept secure, and physical access to the servers is restricted. SQL provides integrated security as well, requiring authentication to access the database. The school server is in a dedicated room that has a smoke detector and burglar alarm installed.  
To prevent data loss from fires/burglary etc, backups need to be taken frequently (this can happen along with the school server’s automated backups). Ideally a copy of the system data would also be stored off-site for a greater strength of fall-back backups.

## Test Plan

Due to the size of the solution I intend to use multiple test strategies on different parts of the system. For example, because the Data and NetCore assemblies are independent modules, I can test them using one technique, and then test the Client UI with another technique.

|  |  |  |
| --- | --- | --- |
| Module | Test Method(s) | Description |
| NetCore | Black Box | I intend to make a simple project to test this module, which sends various messages to the server and reports if any responses are incorrect. This will also allow me to stress test the server to see if it can handle high load, and check for memory leaks which are a major issue in servers. |
| Data | Black Box | As this module doesn’t have much built-in logic, it simply provides the classes for other projects to use, this won’t take much testing. |
| Client | Mixed-level, Integration | Some parts of this module will be fairly free of bugs, while others may be heavily affected. Using mixed-level testing I can dedicate more time to the high risk areas. This module integrates heavily with NetCore, so needs to be tested for bugs related to the interfacing. |
| Server | White Box, Integration | As perhaps the most important module, I will test this assembly thoroughly using White Box testing to make sure I can catch any obvious bugs. I will also use integration testing as this module references the NetCore and Data modules, so is the most likely to suffer from bugs caused by the interfacing. |
| Shared | Black Box | This assembly provides only very basic algorithms – the majority of the code is providing interfaces, which don’t specify any algorithms. As such, this module will not need extensive testing, and I can infer that it works by seeing if the function calls by other modules return the correct value. |