Software Design & Implementation

Project Report

Group Members:

Hannah Ashna Jacob (N0865554)

Jarad Johnson Bailey (N0853071)

Hassaan Naveed (N0898071)

Nicholas McCaig (N0787115)

Lab Tutor:  
Pedro Baptista Machado

# Project Abstract:

# Plagiarism Declaration:

This report and the software it documents is the result of my own work. Any contributions to the work by third parties, other than tutors, are stated clearly below this declaration. Should this statement prove to be untrue I recognise the right and duty of the Board of Examiners to take appropriate action in line with the university’s regulations on assessment.

**Name:** Hannah Ashna Jacob (ID – N0865554)

**Name:** Jarad Johnson-Bailey (ID - N0853071)

**Name:** Hassaan Naveed (ID – N0898071)

**Name:** Nicholas McCaig (ID – N0787115)

# Revision History:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Version** | **Issue Date** | **Stage** | **Changes** | **Author** |
| 1.0.0 |  | Alpha | Created and structured report template per guidelines | Hannah |
| 1.0.1 |  | Alpha | Added Risk Analysis, Requirements List, Contribution guide and Coding Standards guide | Hannah |

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# Introduction:

# Background Research:

An overview of external tools and libraries that were used to implement the application:

* QT
* Boost
* Crypto Library
* MQTT Mosquito

# List of Requirements & Tasks:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **No** | **Requirement** | **Priority** | **Implications** | **Tasks** |
| 1 | Users **must** be able to send, receive and view messages through the application | MUST | Without this feature, the application’s primary function would not be possible as a message exchange platform relies on users being able to send and receive messages | **T2.1.0:** Setup and Configure Client/Server using MQTT  **T4.0.0:** Implement User Interface |
| 2 | Users **must** be able to create chat rooms (rooms with more than two contacts) | MUST | A key feature in a messaging platform is the ability to chat with more than one person simultaneously, hence, the need for chat rooms | **T2.1.1:** Setup and Configure Client/Server using MQTT  **T3.2.0:** Create separate user classes |
| 3 | The user that creates the chat room **must** be classified as Admin | MUST | This is to prevent other users from making modifications to a chat room when they did not create it | **T3.0.0:** Create separate user classes |
| 4 | The moderator **must** be able to invite and remove users from a chatroom | MUST | This allows for a chat room to expand its user base numbers or remove certain members if necessary | **T3.1.1:** Create separate user classes |
| 5 | Moderators **must** inherit all the admin permissions; however, Moderators **cannot** demote the Admin | MUST | The functionality of the Moderator and Admin is essentially the same, however, the Admin is the owner of the chat room, hence, moderators should not be allowed to demote or remove them as owner | **T3.1.0:** Create separate user classes |
| 6 | Application **must** provide a friendly User Interface (UI) | MUST | A welcoming and friendly UI ensures user retention and ease of use. The UI should not drive users away due to its complexity | **T1.0.0:** Design User Interface |
| 7 | Users **must** be able to see the active users in the chat room | MUST | Allowing a user to view other active users allows them to know who is available to chat | **T4.0.2:** Implement User Interface |
| 8 | Users **must** be notified when a new notification is received | MUST | A notification system ensures that users are always up to date with new conversations happening in their chats and chat rooms | **T5.0.0:** Implement event listeners |
| 9 | Clients **must not** connect directly to other clients without a server or a broker | MUST NOT | This is necessary as it would otherwise present itself as a security risk | **T2.0.0:** Setup and Configure Client/Server using MQTT |
| 10 | A server or a broker **must** allow multiple authorised clients to connect to it | MUST | A message exchange platform is going to have several users on it; hence, the broker must be capable of connecting with multiple clients | **T2.0.1:** Setup and Configure Client/Server using MQTT |
| 11 | Users **must** only access their space after the login | MUST | Having users access another user’s space would breach security and privacy protocols | **T6.0.1:** Implement security features and protocols |
| 12 | Passwords **must** be saved securely locally | MUST | This is necessary as it would otherwise present itself as a security risk | **T6.0.0:** Implement security features and protocols  **T9.0.0:** Setup a local text-file |
| 13 | Application **must** adhere to all local (and international) privacy laws | MUST | With laws like the General Data Protection Regulation (GDPR), modern-day applications must respect and handle user data appropriately | **T6.0.2:** Implement security features and protocols |
| 14 | Application **must** list all the personal contacts in the contacts pane | MUST | Users want to be able to view their contacts list and start a chat easily, this method provides them with the necessary tools in an intuitive manner | **T4.0.1:** Implement User Interface |
| 15 | The admin **should** be able to promote and demote users to moderators in chat rooms | SHOULD | This allows the Admin to provide chosen users with privileges to make modifications to the specific chat room; especially useful in cases where it is a large chat room, and the Admin cannot manage this on their own | **T3.0.1:** Create separate user classes |
| 16 | The moderator **should** be able to create and delete channels in the chatroom | SHOULD | Creating discussion threads within a chat room prevents the primary discussion thread from being flooded with several concurrent conversations | **T3.1.2:** Create separate user classes |
| 17 | The moderator **should** be able to delete a user’s messages in the chatroom | SHOULD | In the case a user sends an inappropriate message to a chat room, the moderator can then remove it immediately to avoid the message distressing other chat room members | **T3.1.3:** Create separate user classes |
| 18 | Users **should** be able to change their status | SHOULD | Users may be preoccupied with other tasks or do not wish to be disturbed, hence, would like the ability to modify their availability status within the application | **T7.0.0:** Develop user profile and control panel |
| 19 | Messages **should** be sent and received within 5-10 seconds | SHOULD | A performance requirement so that users do not spend too long waiting on a response from a contact | **T2.2.0:** Setup and Configure Client/Server using MQTT |
| 20 | Users **should** be logged off automatically after a specific amount of time | SHOULD | Prevents the system from being burdened by a user that is not active. This also doubles as a security feature to prevent an unsupervised account being compromised | **T6.1.0:** Implement security features and protocols |
| 21 | User **could** be able to change their details including their picture | COULD | A customization feature that allows a user to share their details with their contacts (i.e., profile photo, name, email) | **T7.1.0:** Develop user profile and control panel |
| 22 | User pictures **could** be displayed in the channels | COULD | An alternative identification method to just using a user’s name | **T4.1.0:** Implement User Interface  **T7.1.1:** Develop user profile and control panel |
| 23 | Application **could** allow the exchange of files with contacts | COULD | Users may wish to share images or other files with another user, hence the need for file transfer capabilities between contacts | **T8.0.0:** Implement file transfer feature |
| 24 | Users **could** be able to send emoji’s | COULD | Implements an interactivity feature to the application, allowing users to express themselves better | **T10.1.0:** Consider the implementation of additional features |
| 25 | Messages **could** come with sent and read receipts | COULD | Allows a user to know who has read their message and who has not. This is especially useful for urgent or messages of high importance | **T10.0.0:** Consider the implementation of additional features |
| 26 | Application **could** display the full history of the conversation when a specific contact is selected | COULD | Conversation history allows a user to rely on the system for information they may have forgotten about, hence, allowing them to refer to their older conversations | **T2.3.0:** Setup and Configure Client/Server using MQTT |
| 27 | Offline messages **could** be stored in the client-side and transmitted to the target user(s) once they are online | COULD | A user may not have internet access but would still like to send a message, this method ensures that as soon as they are connected to the internet, they can send those pending messages | **T9.1.0:** Setup a local text-file |
| 28 | Application **could** run on both macOS and Windows-based desktops and laptops | COULD | Not all users use windows devices, hence, the need for an application that runs on other operating systems | **T10.2.0:** Consider the implementation of additional features |
| 29 | Application **could** have a light and dark mode | COULD | Users with visual impairments may require alternative application colour schemes to make the application usable | **T4.2.0:** Implement User Interface  **T7.2.0:** Develop user profile and control panel |
| 30 | Application **could** have text-size customisation | COULD | Users with visual impairments may require alternative text sizes to be able to read their chat messages | **T4.2.1:** Implement User Interface  **T7.2.1:** Develop user profile and control panel |
| 31 | The application **could** have several language options | COULD | International users may require an application with features written in a language they are familiar with to use it | **T4.3.0:** Implement User Interface  **T7.3.0:** Develop user profile and control panel |

# Risk Analysis:

The risk analysis aspect of the project design stage involves reviewing and planning out solutions for potentials issues that could put the project’s success at risk. Highlighted below at several risks ranging from low to high probability and impact; they are each accompanied by a mitigation plan.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Risk Number** | **Description of Risk** | **Probability** | **Impact** | **Mitigation Plan** |
| 1 | Unclear or unrealistic requirements and scope | 2 | 5 | Ensure that all requirements are reviewed by all members of the team and are thoroughly discussed before being confirmed. In addition to this, actively seek out support from experts (i.e., lecturers and industry professionals) to ensure that the project scope is attainable within the allocated development window |
| 2 | Insufficient knowledge and background research of messaging applications | 3 | 4 | Carry out an intensive research process before beginning the development process to ensure that all team members are well informed |
| 3 | Security breach due to passwords being compromised | 2 | 5 | Add password encryption and (if feasible) two-factor authentication. |
| 4 | Team member falls ill due to ongoing pandemic or is otherwise unable to support the team due to extenuating circumstances | 3 | 4 | Promote the Software Tester to the role available. |
| 5 | Lost data due to technical failure | 2 | 4 | Make regular backups to GitHub and other cloud storage options used by the team. |
| 6 | Tasks go over the allotted time | 2 | 3 | Give buffer for extra time at end of the project - work to a week before the actual deadline |
| 7 | Team member overwrites an existing file's contents on accident | 3 | 1 | Regularly use version control software (i.e., Git - GitHub) so that the file contents can be easily reverted to an older version |
| 8 | Users struggle to use the application due to the unintuitive user interface (UI) | 2 | 2 | Ensure that during the testing stages user feedback is gathered with regards to the usability of the UI |
| 9 | Major bug found in the testing stage | 2 | 2 | Agile development allows for regular testing to prevent large scale bugs at the end of the project. |
| 10 | Team member struggles to engage with the group or is not actively communicating with the rest of the team | 3 | 4 | The team must have frequent check-ins to ensure how all team members are handling their workload and if anyone requires assistance with managing their tasks, they are encouraged to seek help from the rest of the team. |
| 11 | Member conflict occurs due to differing opinions | 3 | 5 | The team makes use of the quality vote to make the final decision to resolve the conflict |
| 12 | Team experiences issues with computational resources | 1 | 3 | Contact the team's assigned tutor for support in gaining access to university resources. |
| 13 | Member experiences issues with handling the workload | 3 | 4 | The team reviews the assigned task to break it down amongst other members to help support the struggling member |

|  |  |  |
| --- | --- | --- |
| **Probability** | **Impact** | **Description** |
| 5 | 5 | A risk event that if it were to occur, will have a **serious** impact on the project achieving its desired result. To the extent that one or more stated outcome objectives will not be achieved. |
| 4 | 4 | A risk event that if it were to occur, will have a **significant** impact on the project achieving its desired result. To the extent that one or more stated outcome objectives will fall below acceptable levels. |
| 3 | 3 | A risk event that if it were to occur, will have a **moderate** impact on the project achieving its desired result. To the extent that one or more stated outcome objectives will fall below goals but above minimum acceptable levels. |
| 2 | 2 | A risk event that if it were to occur, will have a **minor** impact on the project achieving its desired result. To the extent that one or more stated outcome objectives will fall below goals but well above minimum acceptable levels. |
| 1 | 1 | A risk event that if it were to occur, will have a **minimal** impact or **no** impact on achieving outcome objectives. |

# Gantt Chart:

# Diagrams:

# Test Plans:

# Conclusions & Future Work:

# References:

# Individual Contributions:

# Overall Reflection:

# Appendix:

## Coding Contribution Guide:

Before making a contribution to this repository, please first discuss the changes you intend to make via a meeting, text thread or issue

with the other team members/owners of this repository.

As outlined below, please note we have a code of conduct. Do try to ensure that you adhere to it during all your interactions with this project.

### Pull Request Process:

You may merge the Pull Request in once you have the sign-off of all other team members, or if you do not have permission to do that or unable to get a sign-off from all three,

you may request the second reviewer/team member to merge it for you.

### Code of Conduct:

**Our Pledge**

In the interest of fostering an open and welcoming environment, we as contributors and maintainers pledge to make participation in our project a harassment-free experience for everyone, regardless of age, body size, disability, ethnicity, gender identity and expression, level of experience, nationality, personal appearance,

race, religion, or sexual identity and orientation.

**Our Standards**

Examples of behaviour that contributes to creating a positive environment include:

1. Using welcoming and inclusive language
2. Being respectful of differing viewpoints and experiences
3. Gracefully accepting constructive criticism
4. Focusing on what is best for the team
5. Showing empathy towards other team members

Examples of unacceptable behaviour by participants include:

1. The use of sexualized language or imagery and unwelcome sexual attention or advances
2. Trolling, insulting/derogatory comments, and personal or political attacks
3. Public or private harassment
4. Publishing other's private information, such as a physical or electronic address, without explicit permission
5. Other conduct which could reasonably be considered inappropriate in a professional setting

**Our Responsibilities**

The Project Manager is primarily responsible for clarifying the standards of acceptable behaviour and are expected to take appropriate and fair corrective action in response to any instances of unacceptable behaviour.

The Software Developer has the right and responsibility to remove, edit, or reject comments, commits, code, wiki edits, issues, and other contributions that are not aligned to this Code of Conduct.

**Scope**

This Code of Conduct applies both within project spaces and in public spaces when an individual is representing the project or its team. Examples of representing a project or team include presenting this project to university staff members, showcasing the project to external parties and receiving feedback on the project.

Representation of a project may be further defined and clarified by project maintainers.

**Enforcement**

Instances of abusive, harassing, or otherwise unacceptable behaviour may be reported by contacting the Project Manager. All complaints will be reviewed and investigated and will result in a response that is deemed necessary and appropriate to the circumstances. The project manager is obligated to maintain confidentiality concerning the reporter of an incident. Further details of specific enforcement policies may be posted separately.

Team members who do not follow or enforce the Code of Conduct in good faith may face temporary or permanent repercussions as determined by other members of the project's leadership.

**Attribution**

This Code of Conduct is adapted from the Contributor Covenant, version 1.4, available at <http://contributor-covenant.org/version/1/4>

## Coding Contribution Standards:

### C++ Version:

Please ensure that you use **C++17** throughout your contributions to this project. With regards to IDE preference, for development, our team will use Eclipse 2020-12 as it is currently the most stable for development.

### Header Files:

Almost every .cc file should have an associated .h file, except for unit tests and small .cc files containing just a main() function.

Correct use of header files can help improve the readability, size and performance of the code. The following advises on how best to implement header files.

**Self-contained Headers**

All header files should be self-contained (compile on their own), they should not require specific conditions to be included, and should have header guards and include all other headers it needs. Header files should usually end in .h, with exception of .inc files used for inclusion. .inc files should only be used where a file designed to be included is not self-contained, for example, it may be in an unusual location. They may not use header guards or include their prerequisites. They should see limited use, however, and in all situations, a self-contained header should be prioritised.

**Define Guards**

Within all header files ensure the use of #Define guards to prevent multiple inclusions and to avoid unnecessary code recursion. Conflicts or recursive errors could result in code failing to build.

Guards should be named uniquely. The standard naming convention is <FILENAME>\_H

**Include What You Use**

The header file should only include all the header files needed for that source and header file, where either uses a symbol defined elsewhere. Transitive inclusions, inclusions where a header is included in one file but both use symbols from each other, should be avoided at all cost. This allows includes to be simply removed without issues being caused elsewhere.

**Forward Declarations**

Forward declarations, declaration of an entity without an associated definition, should be avoided. While they do improve compile-time and reduce the need for recompilation, they are likely to cause more mistakes and use more lines than just including the header.

**Inline Functions**

Functions should not be defined inline, with exception of short, performance-critical functions. While inlining of small individual functions may cause them to generate more efficient object code, overuse may cause an overall decline in program speed as the cost is increased. As a rule, functions should not be inline if they are longer than 10 lines.

**Names and Order of Includes**

To ensure that missing includes are caught early, include headers should be grouped in the following order:

* The Related header e.g. #include "main.h"
* The C system headers e.g. #include <stddef.h>
* The C++ standard library headers e.g. #include <string>
* The other libraries' headers e.g. #include "basictypes.h"
* The project's headers e.g. #include "other.h"

Each group should be separated by one blank line. The exception to this rule is system-specific code which needs conditional includes, these may be put after other includes. System-specific should be small and localized.

### Scoping:

**Namespaces**

Code should be placed under a namespace, which divides the global scope into individual named scopes to prevent name collisions. Namespace names must be unique and should be all lowercase and underscored between words. Avoid using abbreviations unless they follow the rules laid out in the naming section.

**Internal Linkage**

Sections of code can be given internal linkage using an unnamed namespace (formatted the same as regular namespaces), and individual functions and variables can also be given internal linkage by declaring them as static. Internal linkage prevents whatever has been declared from being accessed from another file. Therefore, internal linkage should be used when the code doesn’t need to be referenced elsewhere in .cpp files. It should not be used in `.h` files.

**Non-member, Static Member and Global Functions**

Always place non-member functions in a namespace and only use global functions when absolutely necessary. Static members should not be grouped. Non-member functions should not depend on external variables and should instead exist in a namespace.

**Local Variables**

A function variable should be in the narrowest scope possible. Variables should be declared as close as possible to the use. Variables should be initialised when declared, for example; int i = 0. If variables are needed in an object such as an if-statement or for-loop they should be declared just above the constructor.

**Static and Global Variables**

Objects with static storage duration are disallowed unless there are guaranteed trivial destructors. Global/static variable initialization will depend on the initializer, as a general rule one should always allow for a constant expression. An example of one that is allowed is: int id = getid(); is allowed. Dynamic initialisation of static local variables is permitted.

### Classes:

Constructors must not call virtual functions. Do not define an implicit conversion, one should use the explicit keyword for conversion operators and single argument constructors. Type conversion operators should be marked explicit in the class definition. Every class's public interface should say which copy and move operations the class supports which should be done in the public section.

**Structs:**

Structs should only be used for objects that are passive and carry data otherwise use a class.

**Inheritance:**

Prioritise composition over inheritance. All inheritance should be public if done privately they try adding it as a member of the base class instead.

**Access**

Classes' data members should be made private unless they are constants. This helps protect data.

**Structure**

In general, group similar kinds of declarations together and do not put large method definitions inline in the class definition. See the formatting guide below for more info.

### Functions:

Functions should be written using the old-style function definitions for example: string funct(int y); this helps readers and coders who work with other languages understand the code. Default arguments must not be used on virtual functions but they can be used elsewhere.

**Short Functions**

Functions should always be short and focused; keeping code short helps isolate bugs and testing. Look to break up large functions into smaller ones unless it adds unneeded complexity.

**Inputs/Outputs**

Use return values when possible over output parameters, this improves readability. Avoid returning pointers unless it is possible for them to be null, preferably return by value, failing that, return by reference. When having non-optional input parameters they should be constant references or values, while output or input/output ones should generally be references.

**Style**

Cpplint should be used to detect style errors, it is preinstalled on QT creator but can be run separately if needed.

### Naming Conventions:

**Variables / Functions**

Variables will always be named using camel-case. Type names and function names should start with a capital letter for each new word. **DO NOT** use underscores. Class data members should end in an underscore like std::string myvar\_;.

**Constants / Enumerators**

When declaring constants, always capitalise each new word and begin the constant with the letter k, this helps keep code clear. Enumerators should also be named like constants.

Some abbreviations are ok as long as they are common or clear, for example, i/j for iteration or CPU for a central processing unit. When writing a variable think about whether it would hinder the code by using the abbreviation such that it would make it less understandable.

**File Names**

File names should always be lowercase we will use an underscore ‘\_ ‘between words. C++ files should always end in .cpp while header files should end in `.h`. File names should be as specific as possible. Use clear names like:

* main\_menu\_gui.cpp
* admin\_class.cpp
* admin\_class\_test.cpp

Note: Always end a test file in `\_test` for the sake of simplicity.

### Comments:

Comments improve readability and make code more accessible to team members and future developers, improving maintainability as well. While commenting is important, good code should be readable without comments; variables and types with good naming should not need a comment to explain them.

**Comment Style**

The commenting style should be consistent. Comments are to done using the Qt style provided by Doxygen, as seen below:

*/\*! \brief Brief Description*

*Brief Description continued.*

*The detailed description starts here.*

*More detailed description.*

*\*/*

By using Doxygen, the documentation process can be automated, by developing a Doxyfile.

**File Comments**

File comments describe the contents of a file. Due to the nature of the project, being non-commercial, the file comments should not need to include an author line or copyright notice. However, if a .h file declares multiple abstractions, a file-level comment should be used to describe the file contents and how the abstractions are related. The comment should be short, as the detailed documentation of individual abstractions should be in the region of said abstractions. If a file declares, implements, or tests exactly one abstraction that is documented by a comment at the point of declaration, then file comments are not required. All other files must have file comments. File comments should not be duplicated in the .cc as well as the .h, as they would likely end up diverging.

**Class Comments**

Every class or struct declaration where their use is not immediately evident should have a comment that describes its usage. The description should be as clear and concise as possible while covering all relevant information on how to correctly use the class. All information included would extend to how (such as an example use of the class) and when to use the class, and any additional considerations such as synchronisation or threading. Specifically, comments describing the use of a class would be included with its declaration, and comments about the class operation and implementation should accompany the implementation of the class's methods.

**Function Comments**

Similar to class comments, comments describing the use of a function should be at the function declaration and comments to describe the implementation of the function should be included with the function definition.

Function comments should not be unnecessarily verbose and should only cover what is not immediately obvious. At the function declaration, a comment may be an example of how to use the function. At the function definition, the comments should cover areas where the implementation is overly complex or not clear and not repeat comments in the function declaration. There should be very few comments on the function definition as good code should be clear on what it does without the need for any comments.

**Variable Comments**

Variables should be named clearly enough to not need comments, however, comments may be needed in certain cases. For class data members, comments may be used for Sentinel Values, those used as flags or pointers, where their use is not immediately clear. Another circumstance is Global Variables, which should cover their use and why they are global.

**Implementation Comments**

While good code should need few comments, where the implementation may confuse, comments should be used. Complicated blocks of conde may have a proceeding comment to explain the purpose of the entire block. Individual lines of code where their use is not clear, or specific choices may not be clear, may also require commenting to prevent future problems.

Where the arguments of a function are not obvious, comments should be a last resort. Alternatives may include using named constants over literals, avoiding nesting functions in functions over using variables, replacing bool arguments with enum arguments.

**Punctuation, Spelling and Grammar**

Comments should be easy to read themselves, so they should have good punctuation, spelling, and grammar; including proper capitalisation, punctuation and complete sentences. Shorter, single line, comments may be written in a less formal shorthand as long as they are still readable, however, whole sentences should be the priority.

**TO-DO Comments**

TODO comments may be used for short-term tasks, such as something you may do the next day. They should be written in the format: // TODO (<NAME>): <TASK>. By using TODO as a standard keyword, TODO messages can be easily searched for using a refactoring tool. TODO messages must be removed when the task is complete. The name attached to the task should almost always be the name of the task writer, to make sure that everyone is aware of who the task belongs to. If the task is addressed to another person, that person should also be informed directly of the task having been added.

### Formatting:

Code formatting is arbitrary but following the same guide helps keep consistency and make code easier to understand.

**Line length**

A line of code should always remain under 80 characters, this helps keep the code readable and understandable. It will be common that function declarations and returns will exceed the 80-character limit in this case it should be broken up onto separate lines.

Parameter names should be short but clear if possible, to assist in keeping code short.

The use of tabs is preferred in this project and should be used in favour of spaces.

Boolean expressions should also be broken up while the logical operators should always be at the end of the line.

**Class format**

Sections should be placed in order, public, protected and private.

**Whitespace**

Try to minimise vertical white space, they should be considered the ending to a paragraph and used sparingly to help separate ideas. Overuse of whitespace will make code more difficult to follow. Simply use them where they are thought to be appropriate, such as separating comments and functions.

### Other C++ Features:

**Boost**

Boost Guidelines: <https://www.boost.org/doc/libs/1_45_0/libs/test/doc/html/utf/usage-recommendations/generic.html>

You should use tests that are specific and precise, try to avoid a complex test in favour of smaller tests. You should prefer `BOOST\_CHECK\_EQUAL` over `BOOST\_CHECK`. This is because you will see the incorrect value when the code failure.

**Group tests together**

You should aim to group similar tests and name each test so you know what it is checking to help with the debugging later on.