Module Guide for SFWRENG 4G06 - Capstone Design Process

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1 Revision History

Table 1: Revision History

Date	**Developer(s)**	**Change**
Nov 3, 2025	Fei	Rev -1

2 Reference Material

This section records information for easy reference.

2.1 Abbreviations and Acronyms

symbol	description
AC	Anticipated Change
DAG	Directed Acyclic Graph
M	Module
MG	Module Guide
OS	Operating System
R	Requirement
SC	Scientific Computing
SRS	Software Requirements Specification
SFWRENG 4G06 - Capstone Design Process	Software Engineering Capstone Project
UC	Unlikely Change
AHP	Analytical Hierarchy Process
BWM	Best-Worst Method
SSB	Skew-Symmetric Bilinear
Domain	Research Software Domain
Packages	Software Packages
API	Application Programming Interface
ADT	Abstract Data Type

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3 Introduction

Decomposing a system into modules is a commonly accepted approach to developing software. A module is a work assignment for a programmer or programming team (Parnas et al., 1984). We advocate a decomposition based on the principle of information hiding (Parnas, 1972). This principle supports design for change, because the "secrets" that each module hides represent likely future changes. Design for change is valuable in SC, where modifications are frequent, especially during initial development as the solution space is explored.

Our design follows the rules layed out by Parnas et al. (1984), as follows:

- System details that are likely to change independently should be the secrets of separate modules.
- Each data structure is implemented in only one module.
- Any other program that requires information stored in a module's data structures must obtain it by calling access programs belonging to that module.

After completing the first stage of the design, the Software Requirements Specification (SRS), the Module Guide (MG) is developed (Parnas et al., 1984). The MG specifies the modular structure of the system and is intended to allow both designers and maintainers to easily identify the parts of the software. The potential readers of this document are as follows:

- New project members: This document can be a guide for a new project member to easily understand the overall structure and quickly find the relevant modules they are searching for.
- Maintainers: The hierarchical structure of the module guide improves the maintainers' understanding when they need to make changes to the system. It is important for a maintainer to update the relevant sections of the document after changes have been made.
- Designers: Once the module guide has been written, it can be used to check for consistency, feasibility, and flexibility. Designers can verify the system in various ways, such as consistency among modules, feasibility of the decomposition, and flexibility of the design.

The rest of the document is organized as follows. Section 4 lists the anticipated and unlikely changes of the software requirements. Section 5 summarizes the module decomposition that was constructed according to the likely changes. Section 6 specifies the connections between the software requirements and the modules. Section 7 gives a detailed description of the modules. Section 8 includes two traceability matrices. One checks the completeness of the design against the requirements provided in the SRS. The other shows the relation between anticipated changes and the modules. Section 9 describes the use relation between modules.

4 Anticipated and Unlikely Changes

This section lists possible changes to the system. According to the likeliness of the change, the possible changes are classified into two categories. Anticipated changes are listed in Section 4.1, and unlikely changes are listed in Section 4.2.

4.1 Anticipated Changes

Anticipated changes are the source of the information that is to be hidden inside the modules. Ideally, changing one of the anticipated changes will only require changing the one module that hides the associated decision. The approach adapted here is called design for change.

AC1: The metrics used to assess a domain's state of practice may be updated (e.g. Addition of new metrics, such as code coverage percentage)

AC2: The system should support extension to user authentication (e.g. Using two-factor authentication on top of username and password)

AC3: The ranking algorithm used within a domain for packages may be changed (e.g. Alternatives to AHP, such as BWM, SSB, etc)

AC4: The comparison algorithms used between domains may be changed

AC5: The user access roles available might be expanded (e.g. Admin, User, Contributor)

AC6: Additional languages might be supported (e.g. French, Simplified Chinese)

AC7: The APIs used to extract repository metrics

AC8: The visualization libraries used to display and export data

AC9: Additional export and import file formatting may be added (e.g. CSV, Excel)

4.2 Unlikely Changes

The module design should be as general as possible. However, a general system is more complex. Sometimes this complexity is not necessary. Fixing some design decisions at the system architecture stage can simplify the software design. If these decision should later need to be changed, then many parts of the design will potentially need to be modified. Hence, it is not intended that these decisions will be changed.

UC1: The schema structure of our domain and metrics systems are designed for long-term use and allows for the addition of new metric types

UC2: The platform of the tool will remain as a web application

UC3: The development stack of our web application will remain the same (React, Django)

UC4: Input types of existing metrics, as outlined in the methodology paper (Smith et al. (October 2021))

UC5: Popular browser compatibility is expected to remain unchanged (e.g. Chrome, Firefox, Edge)

UC6: Tool owner, Dr. Spencer Smith, is not expected to change for the duration of the tool's lifespan

5 Module Hierarchy

This section provides an overview of the module design. Modules are summarized in a hierarchy decomposed by secrets in Table 2. The modules listed below, which are leaves in the hierarchy tree, are the modules that will actually be implemented.

M1: Hardware Hiding Module

M2: Browser Module

M3: Domain View Module

M4: Domain View Module

M5: Data Edit Module

M6: User Authentication Module

M7: User Role Access Module

M8: Automated Metrics Module

M9: Localization Module

M10: Domain Management Module

M11: Notification Module

M12: System API Gateway Module

M13: Ranking Algorithm Module

M14: Graphing Module

M15: File Import Module

M16: File Export Module

M17: Repository API Module

M18: Domain Comparison Module

M19: Database Persistence Module

M20: Logging Module

Level 1	**Level 2**
Hardware-Hiding Module	Browser Module
Behaviour-Hiding Module	Domain View Module Application Layout Module Data Edit Module User Authentication Module User Role Access Module Automated Metrics Module Localization Module Domain Management Module Notification Module
Software Decision Module	System API Gateway Module Ranking Algorithm Module Graphing Module File Import Module File Export Module Repository API Module Domain Comparison Module Database Persistence Module Logging Module

Table 2: Module Hierarchy

6 Connection Between Requirements and Design

The design of the system is intended to satisfy the requirements developed in the SRS. In this stage, the system is decomposed into modules. The connection between requirements and modules is listed in Table 4.

7 Module Decomposition

Modules are decomposed according to the principle of "information hiding" proposed by Parnas et al. (1984). The *Secrets* field in a module decomposition is a brief statement of the design decision hidden by the module. The *Services* field specifies *what* the module will do without documenting *how* to do it. For each module, a suggestion for the implementing software is given under the *Implemented By* title. If the entry is *OS*, this means that the module is provided by the operating system or by standard programming language libraries. *SFWRENG 4G06 - Capstone Design Process* means the module will be implemented by the SFWRENG 4G06 - Capstone Design Process software.

Only the leaf modules in the hierarchy have to be implemented. If a dash (–) is shown, this means that the module is not a leaf and will not have to be implemented.

7.1 Hardware Hiding Modules (M1)

Secrets: The data structure and algorithm used to implement the virtual hardware.

Services: Serves as a virtual hardware used by the rest of the system. This module provides the interface between the hardware and the software. So, the system can use it to display outputs or to accept inputs.

Implemented By: OS

7.1.1 Browser Module (M2)

Secrets: The data structure and algorithm used to implement the browser, which is outside of the scope of the project.

Services: The browser allows all users of the product to view and retrieve the project through the internet, and displays the contents for use.

Implemented By: Web browser

7.2 Behaviour-Hiding Module

Secrets: The contents of the required behaviours.

Services: Includes programs that provide externally visible behaviour of the system as specified in the software requirements specification (SRS) documents. This module serves as a communication layer between the hardware-hiding module and the software decision module. The programs in this module will need to change if there are changes in the SRS.

Implemented By: –

7.2.1 Domain View Module (M3)

Secrets: The data structures and algorithms to retrieve and display domain metrics and packages.

Services: Displays domain content, including it's corresponding packages and metrics..

Implemented By: DomainX

Type of Module: ADT

7.2.2 Application Layout Module (M4)

Secrets: The data structures and visual components to retrieve and display system user interface elements.

Services: Displays user interface elements such as the buttons, sidebars and non-domain view components.

Implemented By: React, DomainX

Type of Module: ADT

7.2.3 Data Edit Module (M5)

Secrets: The data structures and algorithms to edit and update metrics of a domain.

Services: Handles and validates user inputs of domain/package/metric data. Provides user feedback on errors (invalid type, missing field, etc)

Implemented By: React, DomainX

Type of Module: ADT

7.2.4 User Authentication Module (M6)

Secrets: The data structures and algorithms used to securely store, validate and manage user credentials.

Services: Provides user registration, login, and session management services.

Implemented By: DomainX

Type of Module: Library

7.2.5 User Role Access Module (M7)

Secrets: The data structures and algorithms used to store and validate users access level within the system.

Services: Provides user role and capabilities related to the role.

Implemented By: DomainX

Type of Module: ADT

7.2.6 Automated Metrics Module (M8)

Secrets: The data structures and algorithms used for retrieving automatable metrics.

Services: Handles any automated data entry into system, uses Repository API module and File Import Module to automate data input.

Implemented By: DomainX

Type of Module: Library

7.2.7 Localization Module (M9)

Secrets: The language files, translation mappings, and locale formatting mechanisms.

Services: Provides translation and formatting of UI text and date/number formats.

Implemented By: react-i18next

Type of Module: Library

7.2.8 Domain Management Module (M10)

Secrets: The data structures and algorithms that handles the creation and publication of domains.

Services: Provides versioning and publication of completed domains.

Implemented By: DomainX

Type of Module: ADT

7.2.9 Notification Module (M11)

Secrets: The data structures and algorithms that handles the internal and external communication with the user.

Services: To notify users of the status of automated metrics, and communication with user outside of the application, such as through email.

Implemented By: DomainX

Type of Module: ADT

7.3 Software Decision Module

Secrets: The design decision based on mathematical theorems, physical facts, or programming considerations. The secrets of this module are *not* described in the SRS.

Services: Includes data structure and algorithms used in the system that do not provide direct interaction with the user.

Implemented By: –

7.3.1 System API Gateway Module (M12)

Secrets: The business logic that coordinates the flow of communication between modules, and the frontend, backend, and database.

Services: Manages application state and serves as the central communication hub for the system

Implemented By: React, Django

Type of Module: Abstract Object

7.3.2 Ranking Algorithm Module (M13)

Secrets: Ranking algorithms and weights (AHP, BWM, SSB).

Services: Computes comparative rankings using configurable methods.

Implemented By: AHPy, DomainX

Type of Module: Abstract Object

7.3.3 Graphing Module (M14)

Secrets: The data structures and algorithms used for graphing data.

Services: Provides the functions related to graphing.

Implemented By: Matplotlib

Type of Module: Abstract Object

7.3.4 File Import Module (M15)

Secrets: The data structures and algorithms used to import data of varying formats (e.g. Excel, CSV).

Services: Facilitates the process of processing a inputted file into data for use by the rest of the system.

Implemented By: pandas

Type of Module: Abstract Object

7.3.5 File Export Module (M16)

Secrets: The data structures and algorithms used to export data in varying formats (e.g. Excel, CSV).

Services: Facilitates the process of transforming system data into an exportable format (e.g. Excel, CSV).

Implemented By: pandas

Type of Module: Abstract Object

7.3.6 Repository API Module (M17)

Secrets: API endpoints, tokens, and rate limit strategies.

Services: Fetches metrics and metadata from external repositories (e.g., GitHub, GitLab).

Implemented By: DomainX

Type of Module: Abstract Object

7.3.7 Domain Comparison Module (M18)

Secrets: The algorithms and parameters used for comparing domains.

Services: Computes and visualizes comparisons across multiple domains.

Implemented By: DomainX

Type of Module: Abstract Object

7.3.8 Database Persistence Module (M19)

Secrets: The algorithms and parameters used for interacting with the database.

Services: Provides database methods related to updating and querying the stored data. As well as the connection to the database itself.

Implemented By: MySQL

Type of Module: Abstract Object

7.3.9 Logging Module (M20)

Secrets: The algorithms and parameters used for logging all interactions that happens with the system.

Services: Provides logging capabilities and logs user actions and system actions, provides a way to retrieve logged details.

Implemented By: Logging (Python)

Type of Module: Abstract Object

8 Tableraceability Matrices

This section shows two traceability matrices: between the modules and the requirements and between the modules and the anticipated changes.

Req.	**Modules**
FR1	M7
FR2	M6, M7
FR3	M6
FR4	M6
FR5	M5, M19
FR6	M10
FR7	M5, M7, M19
FR8	M5
FR9	M5, M7, M8, M15, M20
FR10	M8, M15, M17
FR11	M3, M19
FR12	M13, M3
FR13	M14
FR14	M16
FR15	M14, M16

Table 3: Trace Between Functional Requirements and Modules

Req.	**Modules**
LF-AR1	M4
LF-AR2	M2, M12
LF-AR3	M3, M12
LF-AR4	M4
LF-AR5	M4
LF-AR6	M4
LF-SR1	M4
LF-SR2	M14
LF-SR3	M4
UH-EU1	M4
UH-EU2	M3
UH-EU3	M3, M4
UH-LR1	M4
UH-LR2	M4

Req.	Modules (continued)
UH-UP1	M4
UH-UP2	M4
UH-UP3	M4
UH-AR1	M4
UH-AR2	M2, M4
PR-SL1	M13
PR-SC1	M6
PR-SC2	M6, M11
PR-SC3	M5, M7
PR-PA1	M8
PR-RFT1	M12
PR-RFT2	M19
PR-RFT3	M19
PR-CR1	M12
PR-CR2	M19
PR-CR3	M12, M19
PR-SE1	M3, M5, M19
PR-SE2	M7
PR-LR1	M12, M19
PR-LR2	M19
OE-EPE1	M12
OE-EPE2	M1, M2, M12
OE-EPE3	M1, M2, M12
OE-WE1	M2, M12, M17
OE-WE2	M1
OE-WE3	M2
OE-IA1	M17
OE-IA2	M19
OE-IA3	M14
OE-IA4	M12, M17
OE-PR1	Not Relevant
OE-PR2	Not Relevant
OE-PR3	Not Relevant
OE-PR4	M16

Req.	Modules (continued)
OE-RR1	Not Relevant
OE-RR2	Not Relevant
OE-RR3	Not Relevant
OE-RR4	Not Relevant
MS-MR1	Not Relevant
MS-MR2	Not Relevant
MS-MR3	Not Relevant
MS-MR4	Not Relevant
MS-MR5	Not Relevant
MS-MR6	Not Relevant
MS-MR7	M20
MS-MR8	M3, M4, M14, M18, M19
MS-SR1	Not Relevant
MS-SR2	Not Relevant
MS-SR3	M20
MS-SR4	Not Relevant
MS-AR1	M12
MS-AR2	M19, M5, M3
MS-AR3	M13
MS-AR4	M1, M2, M12
MS-AR5	M3, M4, M5, M19
SR-AC1	M3, M4, M5, M7
SR-AC2	M7
SR-AC3	M5, M7
SR-AC4	M7
SR-AC5	M4, M11
SR-AC6	M13, M17, M19
SR-INT1	M5
SR-INT2	M5, M19
SR-INT3	M5, M19
SR-INT4	M4, M5, M8, M19
SR-INT5	M19, M20
SR-INT6	M5, M10, M12
SR-INT7	M12, M16

Req.	Modules (continued)
SR-P1	M19, M6
SR-P2	M19, M6
SR-AU1	M19, M20
SR-AU2	M20
SR-AU3	M20, M7
SR-IM1	M19
SR-IM2	M4, M5
SR-IM3	M17
SR-IM3	Not Relevant
CU-CR1	M9
CU-CR2	M9, M4
CU-CR3	M4
CU-CR4	Not Relevant
CR-LR1	Not Relevant
CR-LR2	Not Relevant
CR-LR3	Not Relevant

Table 4: Trace Between Non-Functional Requirements and Modules

AC	Modules
AC1	M3, M4, M19
AC2	M5
AC3	M13
AC4	M18
AC5	M6
AC6	M8
AC7	M17
AC8	M14
AC9	M15, M16

Table 5: Trace Between Anticipated Changes and Modules

9 Use Hierarchy Between Modules

In this section, the uses hierarchy between modules is provided. Parnas (1978) said of two programs A and B that A *uses* B if correct execution of B may be necessary for A to complete the task described in its specification. That is, A *uses* B if there exist situations in which the correct functioning of A depends upon the availability of a correct implementation of B. Figure 1 illustrates the use relation between the modules. It can be seen that the graph is a directed acyclic graph (DAG). Each level of the hierarchy offers a testable and usable subset of the system, and modules in the higher level of the hierarchy are essentially simpler because they use modules from the lower levels.

[The uses relation is not a data flow diagram. In the code there will often be an import statement in module A when it directly uses module B. Module B provides the services that module A needs. The code for module A needs to be able to see these services (hence the import statement). Since the uses relation is transitive, there is a use relation without an import, but the arrows in the diagram typically correspond to the presence of import statement. —SS]

[If module A uses module B, the arrow is directed from A to B. —SS]

Figure 1: Use hierarchy among modules

10 User Interfaces

[Design of user interface for software and hardware. Attach an appendix if needed. Drawings, Sketches, Figma —SS]

11 Design of Communication Protocols

[If appropriate —SS]

12 Timeline

[Schedule of tasks and who is responsible —SS]

[You can point to GitHub if this information is included there —SS]

References

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