

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 laid 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](#)

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: User Authentication Module

M5: User Role Access Module

M6: Metrics Storage Module

M7: Package Storage Module

M8: Domain Storage Module

M9: Visualization Module

M10: File Import Module

M11: File Export Module

M12: Automated Metrics Module

M13: System API Gateway Module

M14: AHP Calculation Module

M15: Graphing Module

M16: File Input Module

M17: File Export Module

Level 1	Level 2
Hardware-Hiding Module	Browser Module
Behaviour-Hiding Module	?
	Domain View Module
	User Authentication Module
	User Role Access Module
	Metrics Storage Module
	Package Storage Module
	Domain Storage Module
	Visualization Module
	File Import Module
	File Export Module
	Automated Metrics Module
Software Decision Module	System API Gateway Module
	AHP Calculation Module
	Graphic Module
	File Input Module
	File Export 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 3.

[The intention of this section is to document decisions that are made “between” the requirements and the design. To satisfy some requirements, design decisions need to be made. Rather than make these decisions implicit, they are explicitly recorded here. For instance, if a program has security requirements, a specific design decision may be made to satisfy those requirements with a password. —SS]

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:

Services: Displays the data of a specific domain.

Implemented By: DomainX

Type of Module: Library

7.2.2 User Authentication Module (M4)

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

7.2.3 User Role Access Module (M5)

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: Library

7.2.4 Metrics Storage Module (M6)

Secrets: The schema and mechanisms used to store, index, and retrieve package metrics.

Services: Manages the storage and retrieval of metrics for a specific package from a specific domain and any associated metadata. Ensures data security and organization to support comparison functionalities.

Implemented By: DomainX

Type of Module: Record

7.2.5 Package Storage Module (M7)

Secrets: The schema and mechanisms used to store, index, and retrieve packages.

Services: Manages the storage and retrieval of packages from a specific domain and any associated metadata. Ensures data security and organization to support comparison functionalities.

Implemented By: DomainX

Type of Module: ADT

7.2.6 Domain Storage Module (M8)

Secrets: The schema and mechanisms used to store, index, and retrieve domains.

Services: Manages the storage and retrieval of domains and any associated metadata. Ensures data security and organization to support comparison functionalities.

Implemented By: DomainX

Type of Module: ADT

7.2.7 Visualization Module (M9)

Secrets: The data structures and algorithms used to display the visualization of the metric data.

Services: Gathers and structure data, generates the visualization based on user request.

Implemented By: DomainX

Type of Module: Library

7.2.8 File Import Module (M10)

Secrets: The data structures and algorithms used to handle the import of data into the system.

Services: Validates and verifies provided user input file, and the associated processing to store it in the system. Throws error when issues occur due to the processing of imported file.

Implemented By: DomainX

Type of Module: Library

7.2.9 File Export Module (M11)

Secrets: The data structures and algorithms used to handle the export of system data in user's format.

Services: Gathers and structure data that user has requested, and exports it in user's preferred format.

Implemented By: DomainX

Type of Module: Library

7.2.10 Automated Metrics Module (M12)

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

Services: Uses API Module to retrieve metrics from package’s repository and validate and store in system.

Implemented By: DomainX

Type of Module: Library

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 (M13)

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 AHP Calculation Module (M14)

Secrets: The implementation of the AHP for package comparisons.

Services: Provides the resulting ranking of inputted data using the AHP.

Implemented By: [AHPy](#)

Type of Module: Abstract Object

7.3.3 Graphing Module (M15)

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 (M16)

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 (M17)

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

8 Traceability Matrix

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

Req.	Modules
R1	M??, M??, M??, M??
R2	M??, M??
R3	M??
R4	M??, M??
R5	M??, M??, M??, M??, M??, M??
R6	M??, M??, M??, M??, M??, M??
R7	M??, M??, M??, M??, M??
R8	M??, M??, M??, M??, M??
R9	M??
R10	M??, M??, M??
R11	M??, M??, M??, M??

Table 3: Trace Between Requirements and Modules

AC	Modules
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??

Table 4: 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

David L. Parnas. On the criteria to be used in decomposing systems into modules. *Comm. ACM*, 15(2):1053–1058, December 1972.

David L. Parnas. Designing software for ease of extension and contraction. In *ICSE '78: Proceedings of the 3rd international conference on Software engineering*, pages 264–277, Piscataway, NJ, USA, 1978. IEEE Press. ISBN none.

D.L. Parnas, P.C. Clement, and D. M. Weiss. The modular structure of complex systems. In *International Conference on Software Engineering*, pages 408–419, 1984.