Module Guide for Software Engineering

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1 Revision History

Date	Version	Notes
Date 1	1.0	Notes
Date 2	1.1	Notes

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
Software Engineering	Explanation of program name
UC	Unlikely Change
[etc. —SS]	[... —SS]

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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 specific hardware on which the software is running.

AC2: The format of the initial input data.

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[Anticipated changes relate to changes that would be made in requirements, design or implementation choices. They are not related to changes that are made at run-time, like the values of parameters. —SS]

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: Input/Output devices (Input: File and/or Keyboard, Output: File, Memory, and/or Screen).

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5 Module Hierarchy

This section provides an overview of the module design. Modules are summarized in a hierarchy decomposed by secrets in Table 1. The modules listed below, which are leaves in the hierarchy tree, are the modules that will actually be implemented.

M1: Hardware-Hiding Module

M2: Account Creation Interface

M3: Account Database Connector

M4: Account Database

M5: Account Update Interface

M6: Login Interface

M7: Access Token

M8: Labeler

M9: Client

M10: User

M11: Account Creation Controller

M12: Account Update Controller

M13: Authentication Controller

M14: Satellite Image Request Interface

M15: Satellite Image Request Controller

M16: Satellite Image Request

M17: Project Creation Interface

M18: Project Creation Controller

M19: Project

M20: Service Request Failure Interface

M21: Image Upload Interface

M22: Report Interface

M23: Report Controller

M24: Report

M25: Project Selection Interface

M26: Project Selection Controller

M27: Labeling Interface

M28: Labeling Controller

M29: Image

Level 1	**Level 2**
Hardware-Hiding Module	
Behaviour-Hiding Module	Account Creation Interface
	Account Database
	Account Update Interface
	Login Interface
	Access Token
	Labeler
	Client
	User
	Satellite Image Request Interface
	Satellite Image Request
	Project Creation Interface
	Project
	Service Request Failure Interface
	Image Upload Interface
	Report Interface
	Report
	Project Selection Interface
	Labeling Interface
	Image
Software Decision Module	Account Creation Controller
	Account Database Connector
	Account Update Controller
	Authentication Controller
	Satellite Image Request Controller
	Project Creation Controller
	Report Controller
	Project Selection Controller
	Labeling Controller

Table 1: 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 2.

[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. *Software Engineering* means the module will be implemented by the Software Engineering 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

7.2 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 Account Creation Interface (M2)

Secrets: The design format of the account creation user interface.

Services: Displays a form to collect user information and submits that information to be processed.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.2 Account Database (M4)

Secrets: The data structure, storage, and access mechanisms for account related data.

Services: Can store, insert, update and retrieve user account data.

Implemented By: OrbitWatch

Type of Module: Abstract Data Type

7.2.3 Account Update Interface (M5)

Secrets: The design format of the update account information user interface.

Services: Displays a form with the users current information that can be modified and submits any updated information to be processed.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.4 Login Interface (M6)

Secrets: The design format of the login user interface.

Services: Displays a form to collect login credentials and submits that information to be processed.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.5 Access Token (M7)

Secrets: Token structure, encryption, expiration, and renewal mechanisms.

Services: Can determine if a user's token has expired and allows the token to be renewed.

Implemented By: OrbitWatch

Type of Module: Abstract Data Type

7.2.6 Labeler (M8)

Secrets: The format and structure of Labeler data.

Services: Takes in the necessary data to create a Labeler.

Implemented By: OrbitWatch

Type of Module: Record

7.2.7 Client (M9)

Secrets: The format and structure of Client data.

Services: Takes in the necessary data to create a Client.

Implemented By: OrbitWatch

Type of Module: Record

7.2.8 User (M10)

Secrets: The format and structure of User data.

Services: Takes in the necessary data to create a User.

Implemented By: OrbitWatch

Type of Module: Record

7.2.9 Satellite Image Request Interface (M14)

Secrets: The design format of the interface for requesting satellite images.

Services: Displays a form to collect specifics on the satellite images, calculates estimated cost based on current form entries and submits the form information to be processed.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.10 Satellite Image Request (M16)

Secrets: The format and structure of the data needed for a satellite image request.

Services: Takes in the necessary data to create a satellite image request.

Implemented By: OrbitWatch

Type of Module: Record

7.2.11 Project Creation Interface (M17)

Secrets: The design format of the project creation interface.

Services: Displays a form to collect project details, calculates an estimated cost using these details and submits that information to be processed.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.12 Project (M19)

Secrets: The format and structure of the data needed for a Project.

Services: Takes in the necessary data to create a Project.

Implemented By: OrbitWatch

Type of Module: Record

7.2.13 Service Request Failure Interface (M20)

Secrets: The design format of the request failure interface.

Services: Displays a warning to users that something went wrong.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.14 Image Upload Interface (M21)

Secrets: The design format of the image upload interface.

Services: Allows users to upload images from their device, and validates they are images of the correct format.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.15 Report Interface (M22)

Secrets: The design format of the summary report interface.

Services: Displays statistics and results of a specific project.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.16 Report (M24)

Secrets: The format and structure of Report data.

Services: Takes in the necessary data to create a Report.

Implemented By: OrbitWatch

Type of Module: Record

7.2.17 Project Selection Interface (M25)

Secrets: The design format of the project selection interface.

Services: Display all available projects that a user can label images from.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.18 Labeling Interface (M27)

Secrets: The design format of the labeling interface.

Services: Displays an image to be labeled, displays label choices which can be selected, and allows images to be skipped.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.2.19 Image (M29)

Secrets: The format and structure of Image data.

Services: Takes in the necessary data to create a Image.

Implemented By: OrbitWatch

Type of Module: Record

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 Account Creation Controller (M11)

Secrets: Form validation and account creation algorithms.

Services: Validates the form information, creates an account with that information, and can upload the account to the database.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.3.2 Account Database Connector (M3)

Secrets: The database access key and database access algorithms.

Services: Can request storage, insertion, updates and retrieval of user account data from the database.

Implemented By: OrbitWatch

Type of Module: Abstract Data Type

7.3.3 Account Update Controller (M12)

Secrets: Form validation and account modification algorithms.

Services: Gets current user information, validates the update form information and can pass account updates to the database.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.3.4 Authentication Controller (M13)

Secrets: Credential validation, access token validation, and access token generation algorithms.

Services: Validates credentials given by user, generates access tokens, and validates access tokens.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.3.5 Satellite Image Request Controller (M15)

Secrets: Form validation and image request algorithms.

Services: Validates the form information, creates and sends a request to a third party for the necessary pictures.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.3.6 Project Creation Controller (M18)

Secrets: Form validation and project creation algorithms.

Services: Validates project information provided and creates a new project.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.3.7 Report Controller (M23)

Secrets: Logic for getting statistics of a project and exporting images onto the users device.

Services: Get statistics and labeled images of project, and exports images to external devices.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.3.8 Project Selection Controller (M26)

Secrets: Logic for getting active projects and redirecting labelers upon selection.

Services: Gets valid projects that are currently available, and redirects labelers to a selected project labeling interface.

Implemented By: OrbitWatch

Type of Module: Abstract Object

7.3.9 Labeling Controller (M28)

Secrets: Algorithms for label creation, removal and submission.

Services: Creates label for an image, removes label from an image, and submits labels to be processed.

Implemented By: OrbitWatch

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	M1, 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 2: Trace Between Requirements and Modules

AC	Modules
AC1	M1
AC2	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??
AC??	M??

Table 3: 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

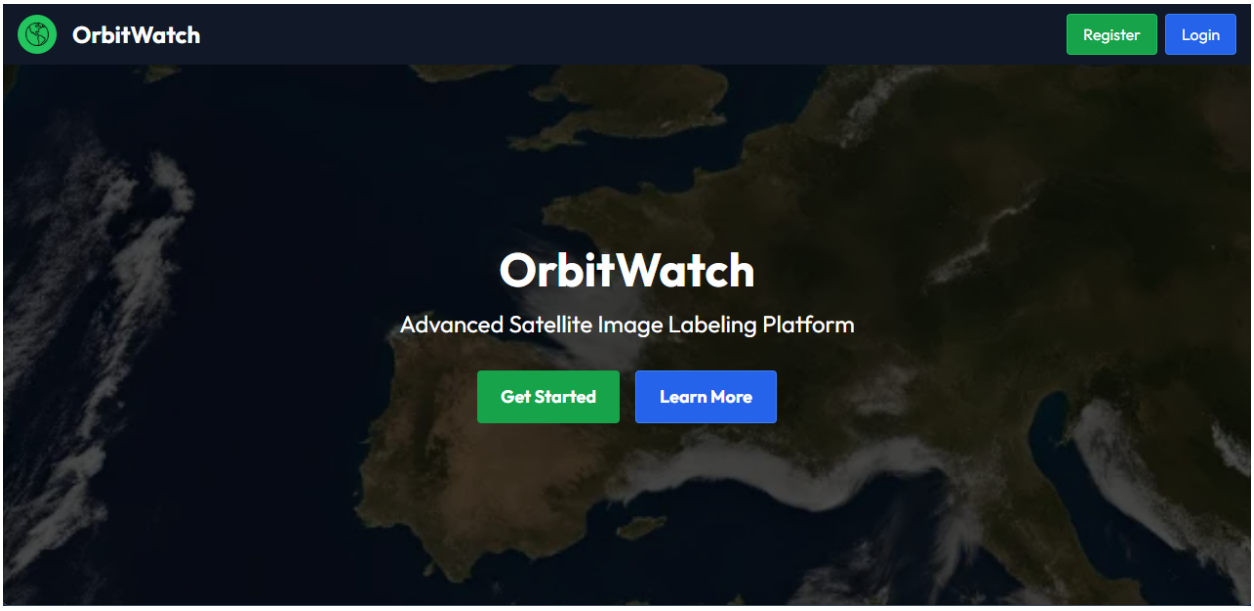

Figure 2: Home Page

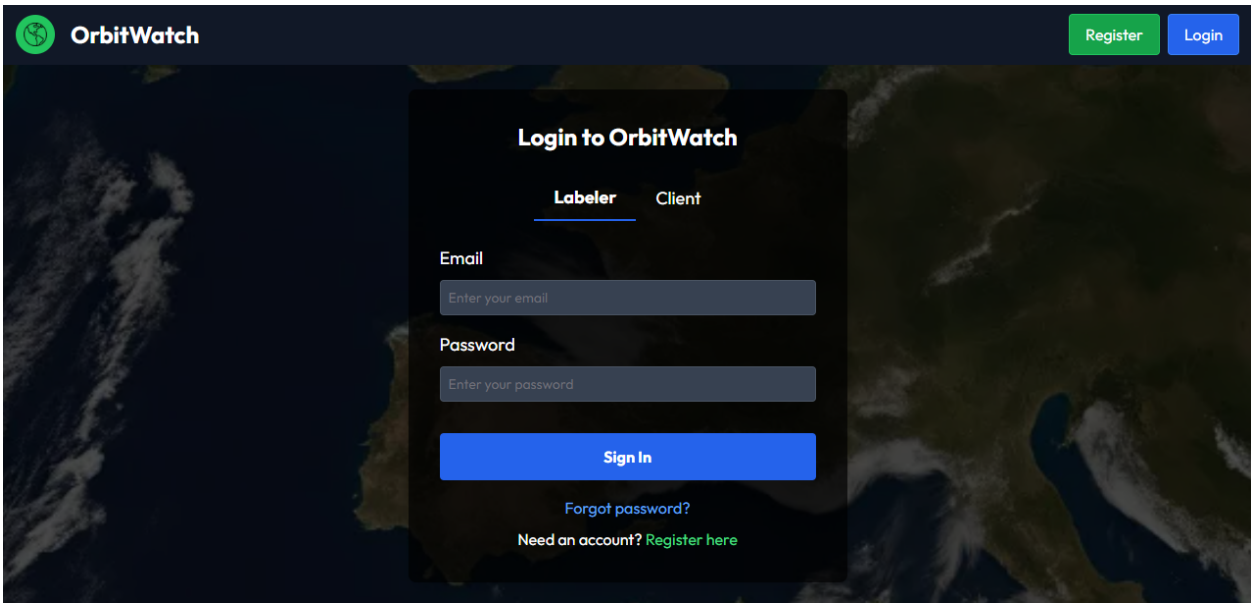

Figure 3: Login Page

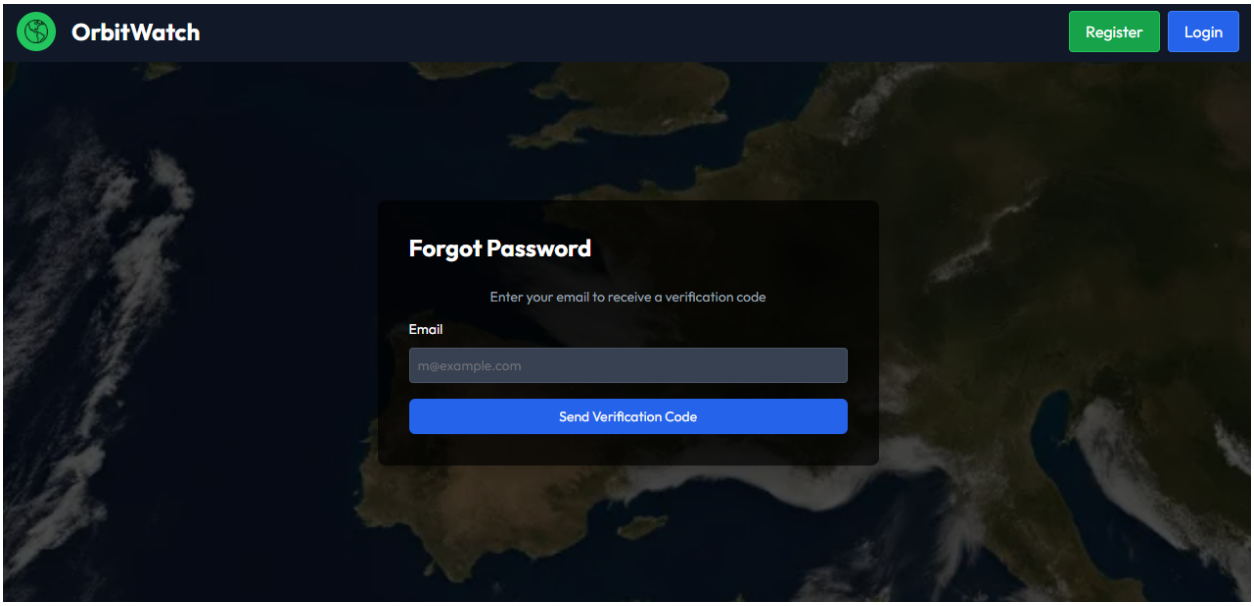

Figure 4: Forgot Password

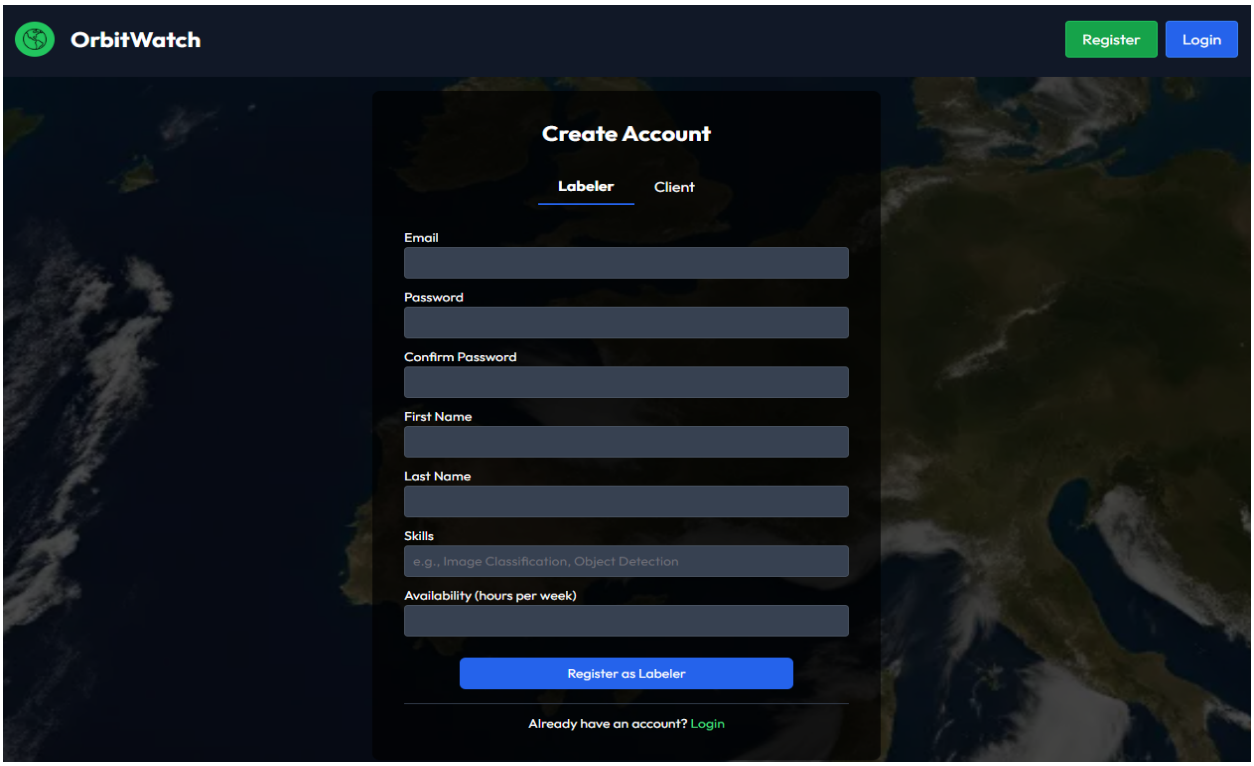

Figure 5: Register Page

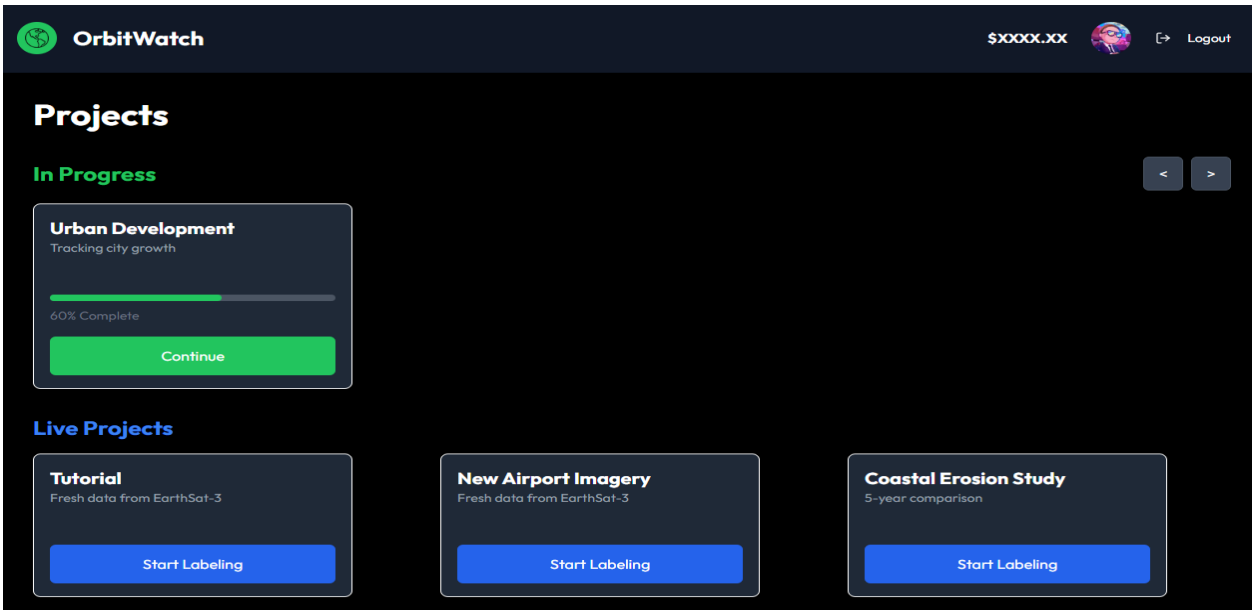

Figure 6: Projects to Label Page

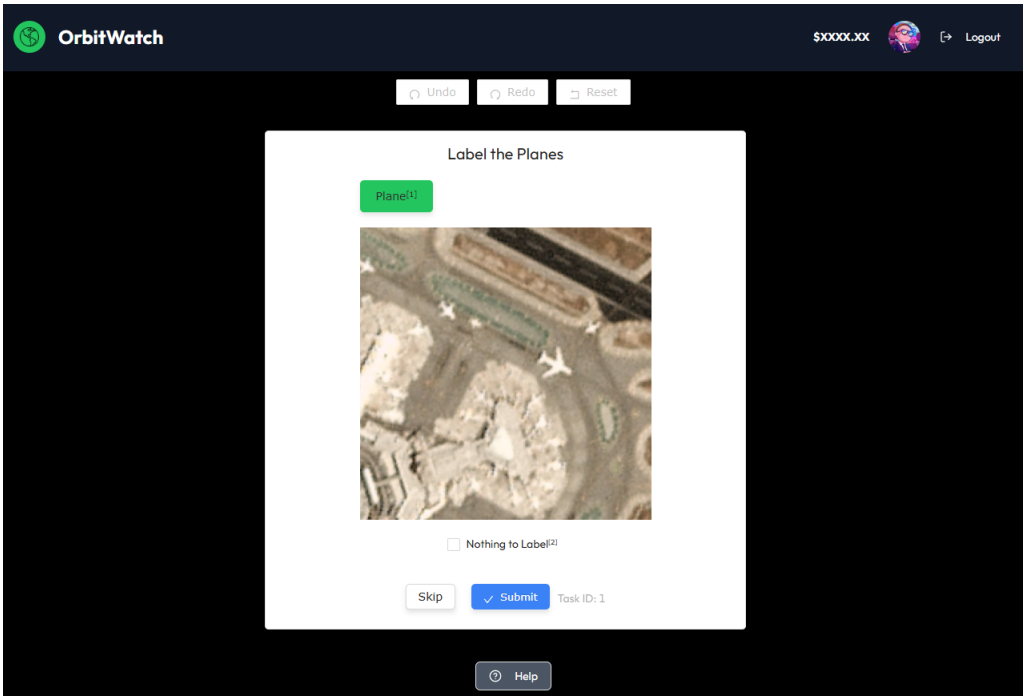

Figure 7: Label Page

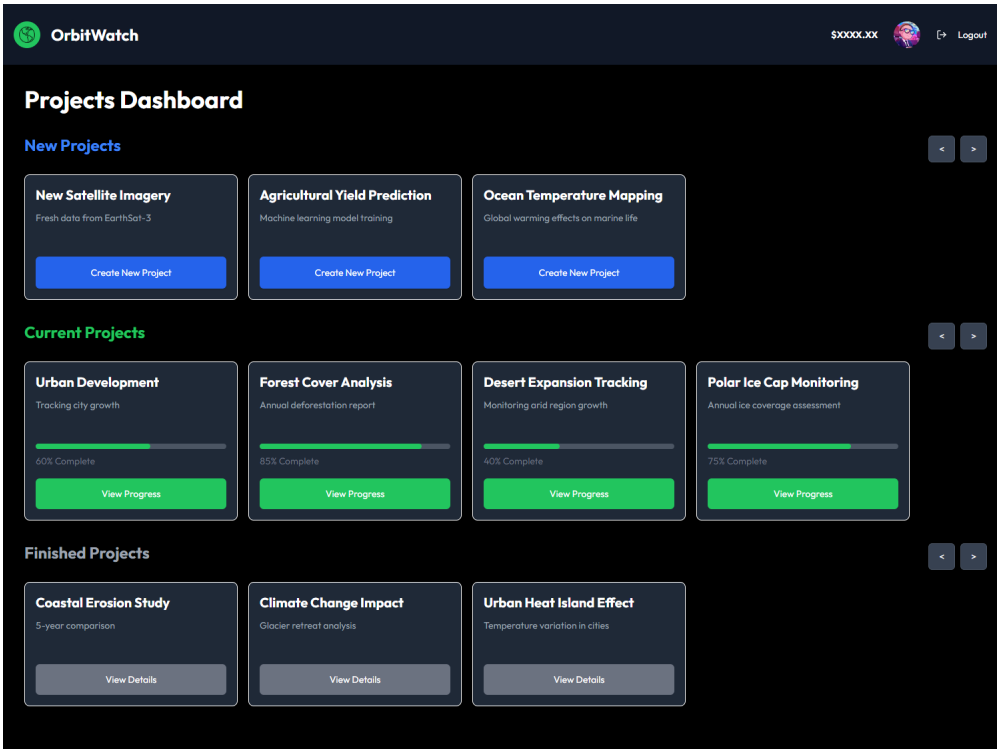

Figure 8: Client Projects Page

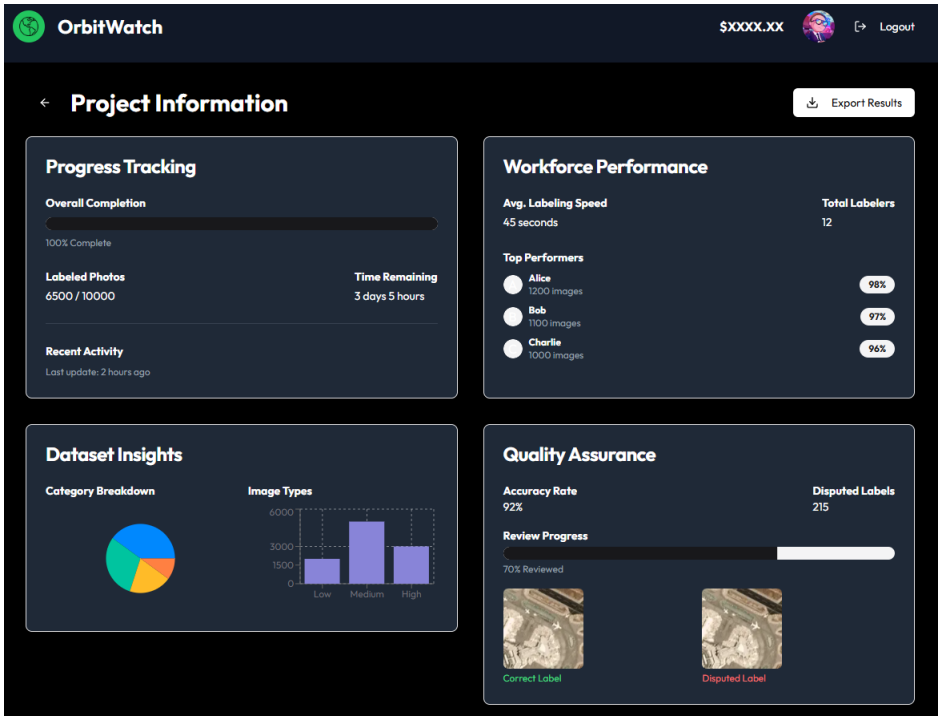

Figure 9: Project Status Page

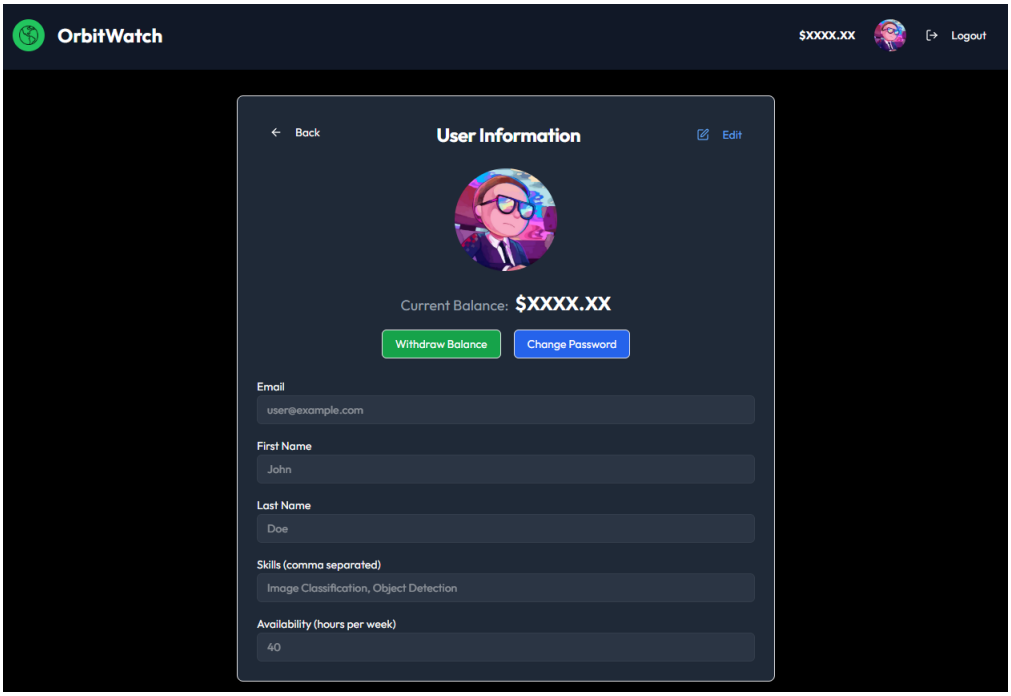

Figure 10: User Information Page

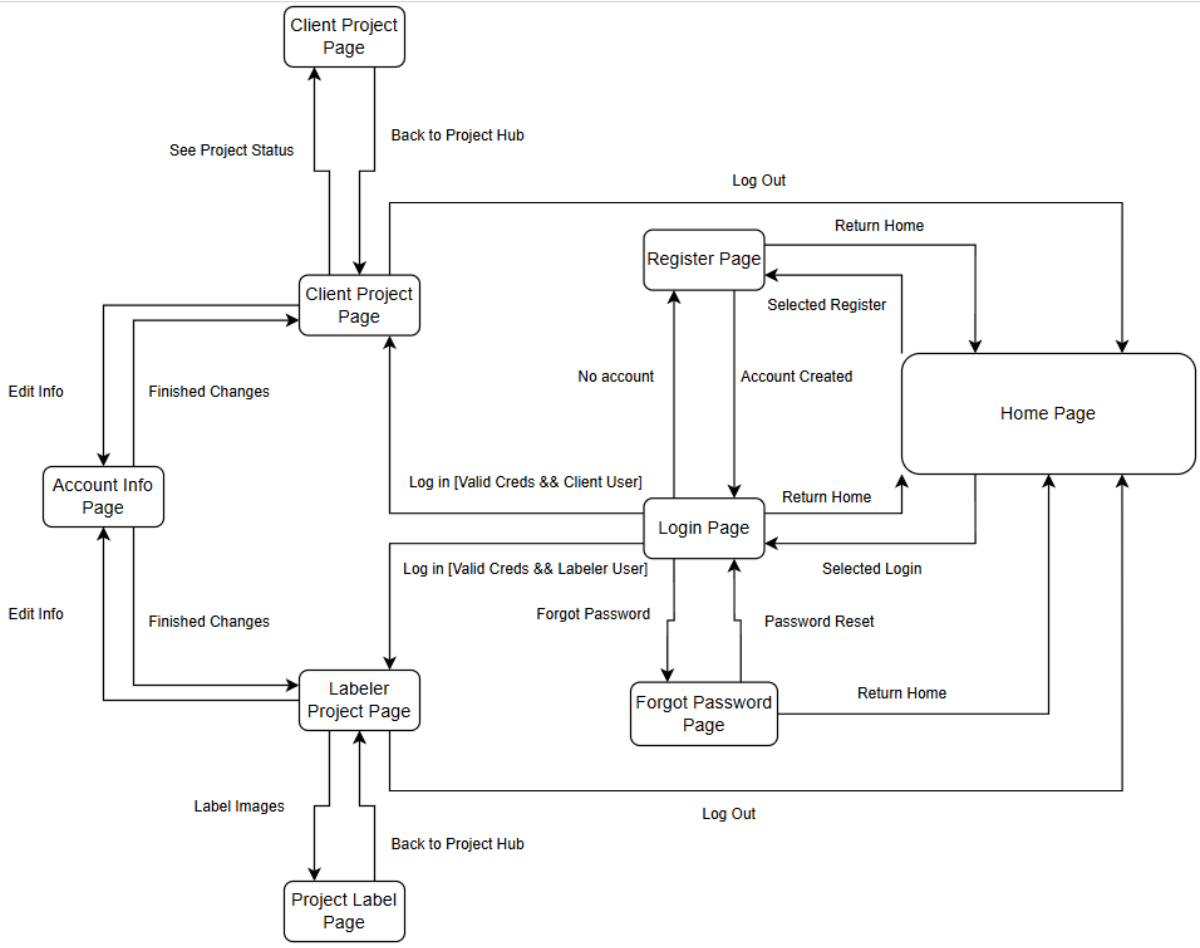

Figure 11: Page Flow Diagram

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.