Preliminary Project Report

Rainforest Information Systems: Improving the current limit of technology to collect data from tropical rainforests.

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Degree : BSc Computing and Information Systems

Self-Study : Yes

Supervisor : No

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Submitted as part of the requirements for the award of the Degree in Bsc Computing and Information Systems of the University of London International Programmes.

"Over half of the world's plants and animal species are found in the rainforests,
99% of them have still to be studied by science."

- Eden Project, Rainforest Biome.

Introduction

I chose the subject of the project for a relevant and interesting setting for the specific problem of the project to be addressed within. A setting that can be used to frame the Computing and Information System project within the academic research structure.

The rainforests of the world are of significant scientific, environmental and technical challenge and interest due to their harsh conditions, high precipitation, humidity, temperature, extreme wildlife, destructive insects, accelerated deforestation, illegal poaching and that most of the rainforests of the world are in developing countries. A perfect setting for the attempted innovation of an academic research project. Rainforests are also of personal lifelong interest to me and pairing them with computers was ideal.

The subject of my project was chosen to both increase my understanding of where technology (my other lifelong interest) and rainforests intersect.

The project was chosen to be able to research and showcase in a best light a technical and literary body of work to show respective employers in Rainforest Conservation, Information system development, software engineering, systems analysis, database design and development, Java programming, Javascript web development, server side development, client side data visualization, computer networking and data communications, which, working in, are all areas and professional objective of mine.

To make Information Systems a focus of the project was to reflect and make the work the most relevant to my degree program so that the project could formalize and condense my technical, and theoretical understanding of computing and my efforts in the individual subjects into one complete real-world Information System and project of work. This is designed to show my strengths and showcase my skills as well as improving my understanding of the individual components and subjects, including computing projects management.

Inspired by my interest and love of rainforests and conservation to keep my motivation, to improve my chances of a technical professional career, to learn, to save rainforests and get good marks in the project at the same time !

Relevant courses

- Information Systems: foundations of e-business
- Introduction to Java and object-oriented programming
- Introduction to computing and the Internet
- Database systems
- Graphical object-oriented and internet programming in Java
- Data communications and enterprise networking
- Information systems management
- Software engineering project management

The project is not work related, was not supervised, was self-study, but with considerable self-reflection and feedback from friends, colleagues and family.

Aims and Objectives

Aims of the project :

The aims of the project are to understand :

- The difficulties in collecting data from a rainforest and how they can be improved.
- To understand the current context and difficulties, in the design and implementation of technology, systems and their components that are used in rainforest conditions to collect data.
- To design, implement and test a system that is this improvement.

The aims of the project are focused on these two main industries that use Information Systems and technology in the tropical rainforests of the world :

1. Logging (legal industry forestry and illegal deforestation)
2. Conservation and scientific discovery.

The projects aims can be framed as the following question :

“How and why do technologies have to be specially designed to be used in the environment of tropical rainforests. Where can their design and implementation be improved to gather more or better quality data or make the data more available as part of a greater improved Rainforest Information System.”

The aim of the project is to understand the current state of the field and attempt to improve upon it.

The successful completion of the project can be measured with a traditional Information System value analysis that can be used to analyze the quality of the data collected from the developed system as well as the performance of the system in tropical rainforest conditions.
Information Systems naturally improve with their feedback loop element and a focus on the systems feedback cycle will also be used to evaluate the project, the systems structure, its components and if the project meets its aims and objectives.

There is a focus on the Rainforest environment and the data gathered but also the technical quality and performance of the system.

Objectives of the project :

To :

- Research and understand the current context of technologies used in rainforests.

- From the research, formalize a list of requirements and a specification for an Information System or it's components that can improve the performance of current systems or their approach to gathering data from rainforests.
- Design and Implement a system from the requirements and specification that can network data from a rainforest, to be processed, where the information can be made available easily, reminiscent of an Executive Information System dashboard for overview.
- There is an objective that the system should enable a complete feedback loop for the Information System so that the systems performance and the quality of the data it collects can be improved.
- Test the system's software and hardware technically and for use in rainforest conditions and to evaluate its ability to meet the project's aims.
- The research for the project, the systems design and it's implementation should all consider the socioeconomic and environmental considerations of tropical rainforests that the majority of are located in developing countries where the system is planned for.

Deliverables of the project tied closely to the objectives of the project :

- An academic literary review.
    - To understand the current field of technologies applied in the rainforest.
    - To research sources, approaches, methods and technologies appropriate to use in this project.
    - Tropical rainforest organisations using technology for scientific data collection.
    - Forestry organisations using technologies in tropical rainforests for Forestry Information Systems, their design, their data collection and their project management approaches.
    - Technologies used by conservation organisations to gather data.
    - The networking of field data.
    - How the rainforest environment affects technology, system design and implementation.
- A formalized list of requirements for a Rainforest Information System and its components based on the research of the academic review with relevance to the aims of the project.
- A formalised specification for the hardware and software of the system based on the requirements.
- A test specification for the project based on the requirements defined and research to give a clear measure for its success from the start.
- Software engineering UML plans for the design of the system or its more complicated components where overviews and sketches will prove useful in its implementation.
- Database design diagrams and schemas for the structure of the database.
- An Object oriented iterative prototype software application that can serve as a TPS endpoint of the information system to collect, store and make available the data to other areas of the system.
- Web Application/ webpage to serve as the overview aspect of an executive information system component of the system for data visualization and feedback on the quality of the data.
- An object oriented webserver to serve as the data processing function of the system, to be the destination for the TPS endpoint data, process and communicate it to the database and make it retrievable for the web page data-visualisation aspect of the system.
- Documented testing and analysis for the system and its components to evaluate their internal technical success and performance and how they interconnect.

- Documented testing and analysis for the application of the developed software and hardware in tropical rainforest conditions.

More specifically (as the technical components of the system have been completed) :

- A spring-boot web server with JDBC to
- A Docker PostgreSQL database using http and json to send data to a
- A webGL Earth 3d Globe webpage visualization of the data.
- An Android JAVA application on hardware that's sensors can be used as a rainforest specific designed TPS endpoint data collection component that can send data with http to the server.
- A 'Track and Point' data model that can record duration sets of sensor readings in a tropical rainforest environment.
- This report.
- The Final Project Report.

Justification for how the objectives will enable meeting the stated aims.

The research review, if detailed and conducted well will provide a context for the understanding of the field of technology used in rainforest data collection, its limits and where new improvements can be made so as to not 'reinvent the wheel'.

With derived requirements, a system and test specification for the hardware and software of the system, the project will be more clear in how the proposed system will be meeting its aims by avoiding requirements shifting and being based on the findings of the research.

Using UML plans and software engineering principles to design and model the system with database schematics will give the approach clarity and identify earlier potential problems in the systems design or implementation that will not meet the project's aims.

Using a software development lifecycle approach (explained further in the methods sections) gives the objectives and deliverables an established structure in meeting the project's aims.

An iterative prototype approach to the end point TPS data-collection component of the system will mean it can be revised to improve the quality and accuracy of the data it collects from the feedback of testing analysis and the Information System feedback cycle for it to better meet the aims of the project.

Planned stages of testing (explained further in the project plan section) and analysis together with the test specification from the start of the project in mind will give direction, improve cohesion, technical performance and identify improvements to meet the projects aims in further iterations or in the future.

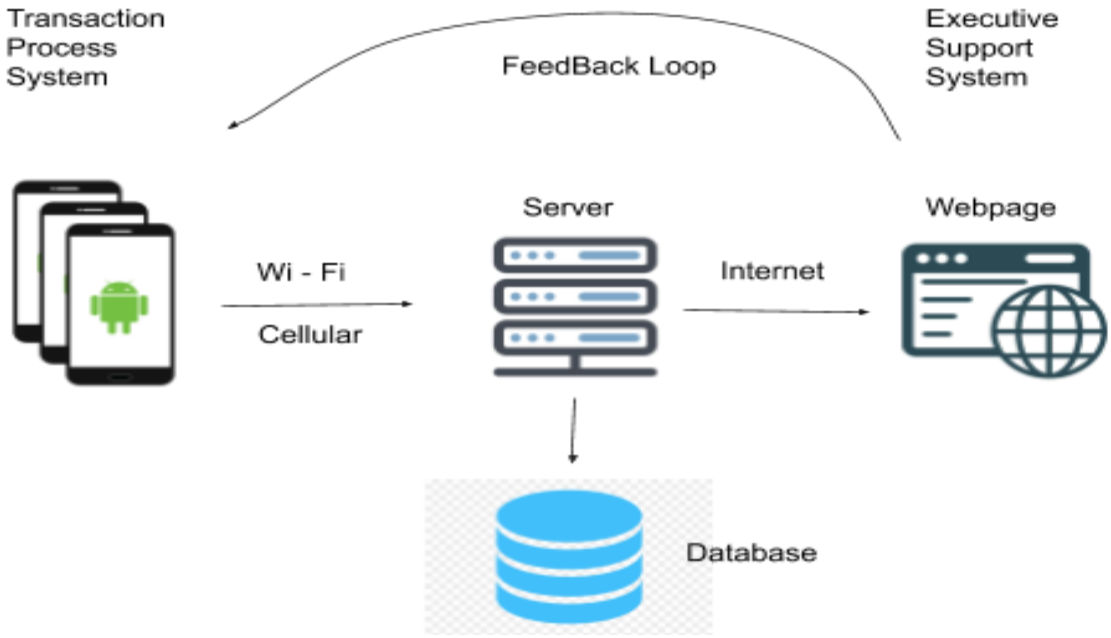
Following an academic research project structure with a principled software engineering approach for the design, implementation and testing of the system will be more successful by taking advantage of a tried and tested project structure that follows an established and successful project management framework.

Methods

The aims of the project will be met by the chosen objectives and deliverables by using the following methods. These methods have been researched and included as they have been identified to be effective and suitable for this project to successfully meet its aims.
These methods add significant improvement to the way the project is conducted. Allowing it to avoid technical pitfalls that would affect the technical performance and cohesion of its components and to improve the processes of the project's development.

Using an Information System Structure

Using an Information System structure gives a high level of abstraction for understanding how the system will work, will fit together and can be approached in design and development.
The Information System structure makes identifying the environment, the purpose of the system and how they will interface clearer. In this project, technology will meet the rainforest and their alignment will be made more successful with this framework.
The documented structure of MIS (managing information systems) can be applied as a framework for capturing requirements and the systems analysis (detailed further in the Final Project Report).
Using this structure will improve the centralization of data, management of it's flow and with the system's feedback loop be able to improve the quality of the system and its data with a web based dashboard similar to an Executive Information System overview for clearer data and system analysis.
The components of an information system can also be made to correspond to the deliverables of an Agile iterative or Waterfall software development life-cycle.



Requirements freeze and the Literary Review

To avoid requirements changing and causing stages to overrun or possibly derailing the structure of the project's development, more focus and time will be spent on the literary review to interpret more accurate requirements that will then be frozen.

Following a hybrid of an Iterative Agile and Waterfall Software Development life cycle model

Ideally a completely Agile iterative development approach would be used but realistically the project may progress more successfully with a hybrid between a Waterfall and Iterative model.
By dividing the development into the Waterfall phases : Analysis, Design, Implementation and Testing, that are progressed sequentially, together with certain components being conducted with an Agile iterative approach, will mean areas of the project can be completed definitely with the waterfall stages as functioning components of the project and system that are ready to meet the aims of the project, and to give other components time, structure and retrospectives to be able to make additions and improvements in later iterations.
The iterative approach applied to the Android Application, for example, will prioritise important functions of the system and their completion first, resulting in definitive objective-meeting functions that later iterations can expand and improve or add additional functionality to.

Software Engineering principles

Following the advice from the Software engineering module. Any interfaces implemented are better than without. Early development architecture decisions will improve the quality of the system. Low coupling and high cohesive objects will improve modularity, control and complexity. Iterative 6 stage development, implementing basic functionality first and focussing on meeting dates over requirements will be prioritized in this project.

UML Design Diagrams

Class identification and interaction diagrams to show where object calls are made and where processing will take place in the software will be used for overview and detail to give a clearer program flow, component interaction and technical performance.
Diagrams too complex to be hand drawn will be considered too complex to support the project.
Visual UML diagrams will be used over text to improve the clarity of the design and analysis phases of the project as well as to document the project's content.
UML will be used in a refined sketch mode to give understanding and useful detail but not to blueprint the project.

Use Case Models and scenarios

Will be used to capture and define the functional requirements of the system so that they can be made clearer and are better documented.
Use cases will map to a function that will also map as a part of an objective or a deliverable that will in turn map to meeting an aim of the project.

SpringBoot Server

SpringBoot quickly provides production ready standalone applications made from popular frameworks and configuration. Database transactions and RESTful services such as POST and GET can be implemented quickly and stability. This method has been identified to save time, resources and improve the quality of the system.

Object-oriented design and modularity

To avoid a development that is too complex to design, implement or maintain an object-oriented approach will be used to attempt to control the complexity of the system.

Object-oriented design and modular software architecture can more easily be extended and less important but desirable functionality can be added easier in later iterations.

Objects with rich behavior, that is localised will be focused on to avoid a less-performing procedural program with more advantageous distributed control over the focus on one central object.

Attempts to make system components with high cohesive modules and with little coupling (to keep system modules more independent) will be used to give the objects more flexibility and to allow the system to be developed further in future interactions or improved later in the project.

Prototype Development

An iterative prototype approach to the end point TPS data collection component of the system will mean it can be revised to improve the quality and accuracy of the data it collects so as to better meet the aims of the project, make improvements based on testing and analysis.

The android application is allocated more time as it is considered the endpoint element of a TPS of the Rainforest Information System that the other components of the system rely upon for their data and it is considered important to allocate more time to.

Verification and Validation

Verifying that the components of the system are meeting the requirements, specification and use cases, and are in keeping with meeting the objectives and aims of the project.

That the modules of the system perform their function and that they reflect the UML class diagram designs.

This will be completed at the end of each component's code implementation.

Testing

Testing the software, hardware and the system technically, and as a complete Rainforest Information System will include :

- Usability testing - for its ease of use and operation.
- Unit testing - to check modules for bugs and internal states and working.
- Integration testing - that the parts of the system work together.
- System testing - that the system meets the requirements specification.
- Acceptance testing - validation from the end user.

A test specification will be written at the same time the requirements are gathered for clarity and direction.

It is important that the testing is allocated enough time and is completed throughout the iterations of the project life-cycle and findings can be implemented in additional iterations or in the same iteration. Hardware can be tested in tropical environment conditions to see how they perform.

Black box testing would be ideal and will be sought from colleges but as the project is self-study most of the testing will be white-box where the technical details, modules, components and code will be known by me but this will improve my technical understanding (that is technically an objective of the project).

Project Plan

> "large projects overrun, on average, by 50% of the original estimate" (Blackwell, 2007, p.55).

This project's plan is allocated with plenty of reserve time for this reason. This is due to the expectation that many of the technologies and concepts used in the project are new. Bringing many components together and incorporating different subjects into one complete Rainforest Information System and project may take more time than expected.

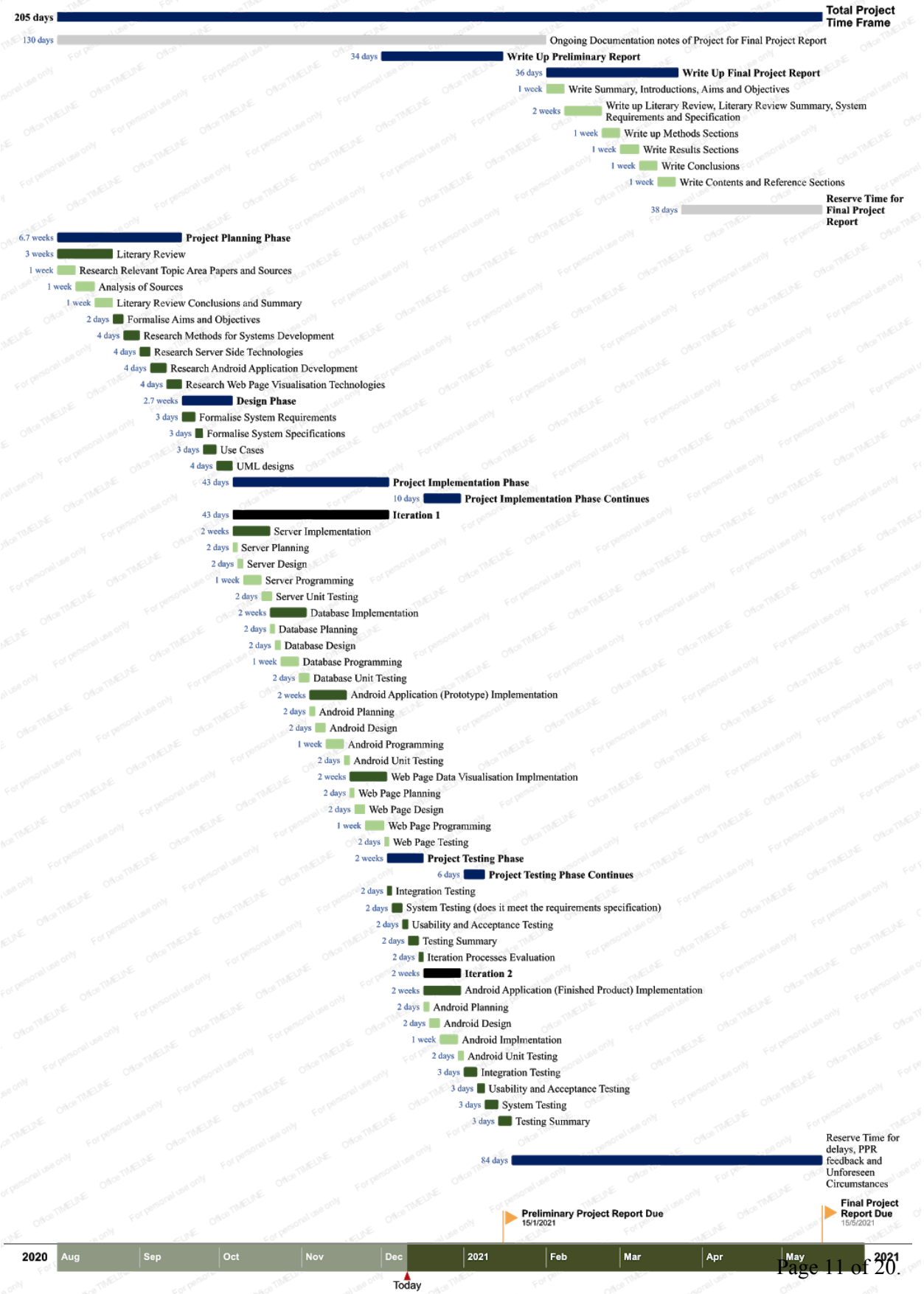
A complete Schedule detailing all the tasks required to complete the project is shown below in the Gantt Project Management chart. The project plan is an ideal but necessarily vague in areas where detail at this stage may be less useful but is defined in this section and in the chart to be a helpful illustration.

Key milestones and project stages are indicated with different colours.
Larger tasks are broken down into detailed smaller sub-tasks.
Advice from the project guide is taken to allocate a maximum of 2 weeks duration to these tasks.

Maximum time will be available by starting the project early in the year.

Agile iterations are detailed here as a technical exercise where, time permitting, more iterations may be completed. The Agile framework has been used in the project to better understand the process as well as to give the project a more open ended starting point.

Project Management Plan - Gantt Chart -



Progress to date

All technical components (hardware and software) of the Rainforest Information System have been completed. The Input, processing and output sections of the system as well as the feedback loop have been completed.

Videos of all components of the system are available at :
https://www.youtube.com/user/markstart00/videos

An overview of the technical components of the system completed so far include :

- DuckDNS available Spring Boot Server with JDBC interface to the
- Postgres Database run in a Docker container with Hikari.
- Javascript WebGL Earth 3d Globe Web Page that can visualize data from the server and database with http.
- Java Android Application (prototype) that can collect, store and send 'Track and Point' data to the server via http.
- Java Android Application (Second Iteration) with improved functionality, modularity and UI with applied feedback from the Information System feedback loop, system testing and analysis. Improvements to the quality of the data and the input into the system the Android Applications has were made from these findings as well.

Stages of the Project completed so far include:

- Planning Stage
- Literary Review
- Design Phase
- System requirements and specifications.
- UML designs and diagrams (detailed below).
- Project implementation Phase (including technical components detailed above).

Testing for the system has been completed but documentation in the final project report has not been completed.

UML Diagrams completed :

- Scenarios
- Use Cases.
- Noun phrases
- Class Identifications
- Physical View Diagram
- Class Diagram (Recording Track Point Sensor Data in t he Android Application)
- Sequence Diagram (for the same)

Other completed sections :

- View of server's request and CRUD response architecture
- Database analysis, conceptual, logical and physical design.
- Database schema
- Database implementation
- Database testing

The final project report has been started and currently includes completed sections :

- Title page.
- Summary and Introductions.
- Literature review.

The technical progress of the project has been well documented in notes, video, screenshots and version controls of code but needs to be organised and incorporated clearly into the final project report and annotated well.

Literary Review Summary

Research of sources, their analysis and their write up in the Final Project Report have all been completed.

Sources including :

- Smithsonian Tropical Research Institute
- Norweigian Polar Institute
- Rainforest connection
- Global Forest Watch
- International Tropical Timber Council

Have been explored to set and understand the context of the field of tropical rainforest data collection and to establish the technical and functional considerations of a system that can meet this project's aims.

Existing Forestry Information Systems, technologies used in the rainforest, GPS tracking collars and field data collection applications have been explored, researched and considered for their performance, strengths and weaknesses and how their design and approach or similar approaches and technologies can be applied for this project.

Comparison of software and systems used in tropical rainforests have been explored for their performance in the tropical environment and to collect data.

Technologies researched included :

- How to network data, with, radio telemetry, satellites, the web, GMS.
- Web visualization approaches and libraries. (ArcGIS, LeafletJS, WebGL Earth).
- Field data collection software with web accessible databases, databases for GPS coordinates and scientific data.
- Tropical rainforest suitability of hardware.

And concluded, along with the other areas of the literary review, with the resulting requirements and specifications for the hardware and software for the system to meet the aims of the project (summaries below and detailed in the final project report).

The literary review also revealed project and software engineering approaches that were identified to be more successful from the analysis of Forestry Information Systems and other scientific research projects that could be applied in this project, including :

- User stories over feature lists.
- Deciding on critical features before choosing technologies.
- Data structures that align with the aim of the project.

Software engineering principles and project management approaches of this project resulted from the Literary Review and its completion have helped to more clearly define the project and its methods.

More detailed technical summary of completed work and context

Technologies and the data model were chosen to align with the aims of the project, to, improve the limits of data collection form the rainforest environment.

A Java Android application was chosen as recycled smartphones and tablets are cheap and have built in sensors and networking capabilities (the web, GMS) and can be coded in JAVA which I would be able to learn quickly. They can also run linux and linux software which is free and has other advantages. Smartphones and tablet hardware is designed to be used in the field. Hardware was chosen that's specifications meet the requirements of the tropical rainforest environment (high humidity and temperature tolerance) and that had the built in sensors (temperature, GPS, humidity) needed, and was within budget that could be made available to peoples in developing countries where most of the tropical rainforests of the world are found.

The spring boot server was chosen to speed up the deployment of the backend and is also written in JAVA, is well documented and a good framework to learn. The web accessible backend was decided due to limits on telecommunications and internet access in remote areas of the jungle so that it would be better to store the data offline until in a less remote area.

PostgreSQL was chosen for suitability with scientific data and as a popular relational database to add to my experience.

The Docker container was chosen to make the interaction between the spring boot server and the database easier on the linux system used to develop the project.

The JavaScript webpage with WebGL library was used to map the data on a 3d globe to avoid vendor lock-in and could be deployed fairly quickly. The UI choices were chosen from the recommendation that 'track and point' sensor data is best displayed on a map or globe discovered in the literary review. The webpage makes the data easily available in the world.

Http was chosen to network the data through the web between the components to avoid complicated or expensive GMS or satellite communications of data.

The data model chosen was ‘track and point’ to pair sensor data with GPS coordinates over time.
This data model was chosen to make the serialisation, networking, processing, storage and visualization of the data objects easier.

It was concluded that this approach can improve rainforest data collection as it is cheap, the technology is accessible to developing countries, easy to use, mostly automated and makes data collection and its visualization easily accessible to anyone with a smartphone and access via the web page and the internet.

Detail of Technical Components completed :

Database and server

The Spring Boot RESTful API server is completed and unit tested. It’s functionality is complete for the project to be able to :

- Be sent POST Http JSON data objects.
- Parse the ‘track and point’ data from the objects collected sent from the JAVA Android Application.
- Can write data to the Postgres Database through a Docker container using JAVA JDBC database access.
- Is exportable as a Jar file to be easily deployed on a machine or a cloud.
- Can serve data with GET Http requests made from the webpage using JSON.

Port forwarding on my home router and DuckDNS software were configured on my linux machine to be able to make the server available to outside my LAN because of compilations with the dynamic IP addresses issued by my ISP. DuckDNS coordinates the updates of new ISP dynamic IP addresses so that the server can be pointed to as a subdomain of DuckDNS :
http://markstart.duckdns.org:8000/rainforestGlobe.html

The docker container has been configured to house the PostgreSQL database.

The Relational PostgreSQL Database is complete and unit tested.
It's logically planning and physical design have actually been completed and implemented beyond the scope of the rest of the system.
More tables and relations are defined and populated with test data that cannot be accessed through the rest of the system.
Including further detail and data about the world's tropical rainforests, such as size and location, tables for their regions and sub-regions.

The database (together with the server) is complete to :

- Create, Read, Update and Delete ‘Track and Point’ sensor data.

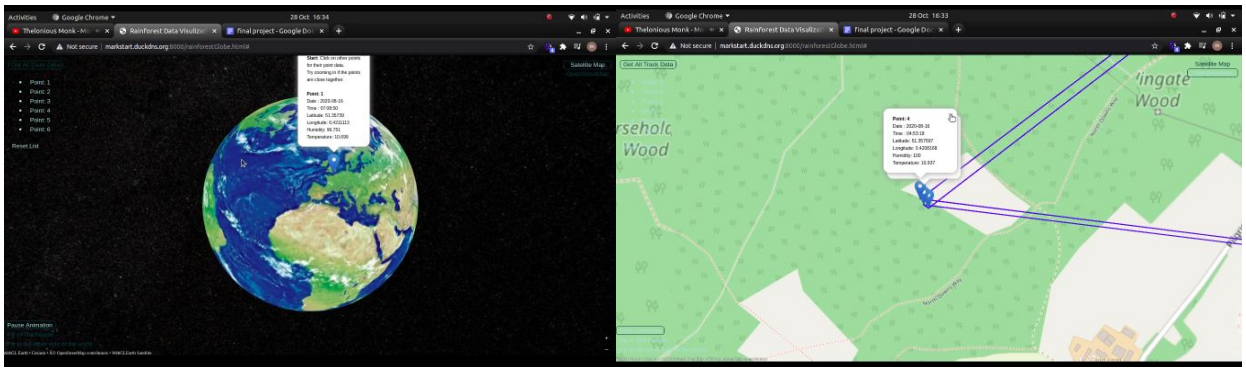
- The database data is only available to be retrieved from the webpage or added to with http JSON requests.
- Data can only be deleted or updated through the Postgres CLI. This is an area that could be developed further in further iterations.
- The database extends to forests, koppen types, regions and subregions that are not used in the rest of the system.

Data visualization webpage

The webpage data visualization methodology research is complete as well as the implementation and unit testing. The client side Javascript written is not as clean as it should be.

The webpage data visualization 3d globe is complete to :

- Retrieve Track and Point sensor data from the database through the server through http GET requests JSON and the internet.
- Map the 'track and point' data at the GPS locations and draw polylines between points. To illustrate the track.
- Show the Point data at each point with point ID's, sensor data, timestamps and GPS coordinates.
- Change map layers between Satellite and a Street Map.
- Zoom, navigate and animate the 3d globe to rotate in space.
- List and make selectable to navigate to, all track and point data.



Android Application

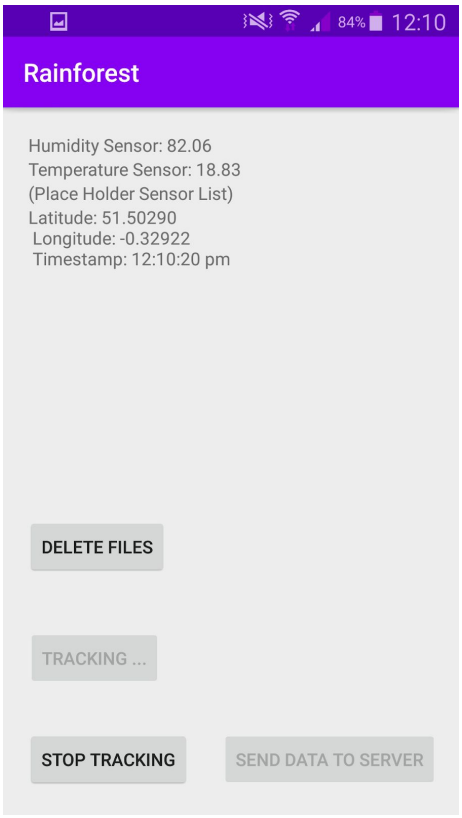
Two Iterations have been completed for the Android application (screenshots below). A prototype and a version with improved code modularity, structure and UI presentation.

The quality of the data collected as well as some bugs were discovered in the component, compatibility and system testing phases of the project. These findings became the content of the initial stages of the next iteration.

The other components of the system were planned to be completed in 1 iteration but designed and implemented in a way that can be extended. The android application was allocated more development time as it is considered the endpoint element of a TPS of the Rainforest Information System that the other components of the system rely upon for input and data and it became considered to be more important to allocate more time to.

Both android applications versions can :

- Record Track and Point sensor data (temperature, humidity, GPS, time).
- Store the data offline.
- Connect and transmit the data to the server with JSON http and the internet.



(Prototype 1 and iteration 2).

Progress to date compared with the Project Plan

Completed work has followed the Gantt chart very closely and the chart is a good reference of what has been completed as of today (11/01/2021).
The technology used in the project as well as the subject of the rainforest is of great personal interest so that some of the research for the project's sources, methods and technologies used were completed earlier in the year before the project officially started out of interest and anticipation.

The progress was completed slightly faster than expected, some time frames have been over allocated. Because I am self studying while working in Cambridge some of the project was completed outside of the timeframes in my spare time. Stages slightly blurred and progress became easier by being less formal with the timeframes of each phase.

Planned Work

The technical components of the systems, it's hardware, software and the documentation of the project's progress have all been completed.
Completed work has followed the Gantt chart very closely and the chart is a good reference of what has been completed as of today (11/01/2021). In keeping with its schedule the completion of this Preliminary Project Report and the Final Project Report are the only stages of the project left to complete.

The main focus of planned work is the Final Project Report. Including to complete sections :

- Contents Page
- Methods
- Results
- Discussion
- Conclusion

Detailed documentation of the project's code, design and progress were updated continuously throughout and can now be included in the Final Project Report where it is needed.

With the extra time the literary review that has already been completed can be reviewed and edited but there is little expectation that there is much improvement to be made but to bring out more clarity.

Testing for the system has been completed but it's documentation needs to be included in the Final Project Report.

I expect in completing the Final Project Report other areas of the project will be revealed to need completion as well, but cannot say what they will be at this time.

The reserve time allocated that is not used for the Final Project Report can be used to improve projects sections, for additional iterations or more time for revision.

Future iterations for the Server, Database, Data Visualization Webpage and Android Application could all be used to develop the functionality of the system further as they were designed and implemented to be modular and expandable in this way.

The most interesting areas and features of the project to be expanded would be :

- To gather more data from the Android Application sensors as only a subset of the list of sensors for the hardware were implemented. This would include expanding the database, the processing and serving of data from the database and its visualization in the webpage.
- Improving the battery consumption of the Android Application and to make the parameters for the Track and Points data to be adjustable that were identified as problems in testing and analysis.
- UI changeable parameters for how the GPS coordinates are generated and its accuracy.
- Making the Android application portable for other devices with better quality sensors.

- Focused data analysis and organisation of data to identify where the system or its data can more successfully meet the aims of the projects.

I don't expect I will have much time for future iterations. It was a good use of time to start the project as early in the summer as I did and leaving the project concluded but open ended is a refreshing finishing point.

Results from the testing and analysis phases identified these problem areas in the system that the additional time could be used to improve :

- The client side Javascript is clean but not as clean as it should be, including the clients approach to error handling and more modern JavaScript best practices.
- It was found that JDBC was batch inserting data into the database. This could be made more efficient as extra error handling to handle duplicate inserts was causing the server but not PostgreSQL to crash.
- The Android Application's Toast messages to inform the user that 'Files sent' are being shown for each file sent not just once, giving the appearance of being frozen.

I plan to focus on the remaining phases of the project to complete, the Final Project Report and revision for the exam but look forward to incorporating the feedback from the preliminary report into the project with the time remaining.

I have learned alot from the Project so far and have enjoyed seeing the value of the project as it has progressed.

Reference list

T. Blackwell, 2007, ‘Software engineering algorithm design and analysis volume 1’, University of London study guide.

The Eden Project, Rainforest Biome, Introductory Information board when first entering the biome [Quote on page 2 of preliminary report].