2 Project Plan

2.1 Project Management/Tracking Procedures

Which of agile, waterfall or waterfall+agile project management style are you adopting? Justify it with respect to the project goals.

For this project, we will be using agile + waterfall management. This approach is being taken since our project is research intensive and our project will ultimately serve as a proof of concept for a later physical implementation.

There are some existing quantum networks that we must research and draw from to suit our clients needs, which is distributing information for quantum cluster computing.

Waterfall approach in the beginning will allow us to do the needed research and coordinate together to ensure a cohesive design. Afterwards we will switch to agile and quickly iterate through as we design the network and companion components.

It's important to keep in mind that our project is considered too big by our advisor to be done as a single undergraduate senior design project. Our work will very likely be built upon by another group.

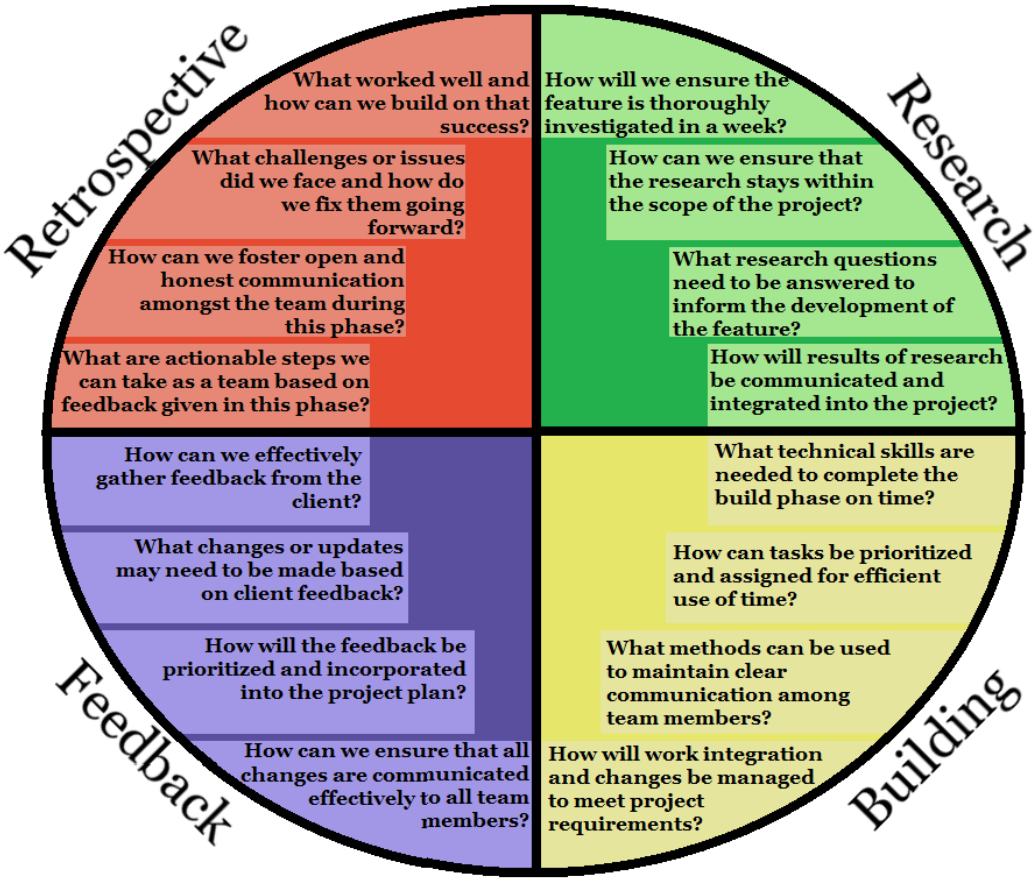


figure : project management cycle

Each section will take about 1 week to complete in earnest.

What will your group use to track progress throughout the course of this and the next semester. This could include Git, Github, Trello, Slack or any other tools helpful in project management.

We're using various tools for tracking our work progress. Below is a list of tools we're using for this project and senior design class.

Discord- general communication tool to set our meeting times and share our recent work in a non-formal way. It also be used as our cloud directory for sharing reading materials and journals

Google drive- all paper works such as ppt slides for a weekly meeting with our advisor are stored in google drive. Collective work for the class is also done in google drive.

Github- we're using github for storing and sharing our code. It is easy to keep track of our working progress and backup history.

2.2 Task Decomposition

In order to solve the problem at hand, it helps to decompose it into multiple tasks and subtasks and to understand interdependence among tasks. This step might be useful even if you adopt agile methodology. If you are agile, you can also provide a linear progression of completed requirements aligned with your sprints for the entire project.

Our project consists of two parts, building a quantum router which takes jobs and makes each node conduct corresponding jobs and building a quantum communication network between quantum router and quantum nodes. Regardless of the name of the quantum router, it's actually highly dependent on classical network and computing architecture. Unlike quantum routers, quantum communication networks between quantum nodes are highly dependent on quantum circuits and quantum computing. Thus we divided our project into these two.

It is important to note that although our project goal of building a quantum network for quantum cluster computing is clear to us, since it is so research intensive and is meant to serve as a prototype for a potential physical implementation, our design and its requirements are subject to change as we continue to clarify with our client on what they want this design to be and accomplish. This is also well noted at section 2.1

Making quantum network components

- Building quantum router :
    - Take quantum information and dummy jobs.
    - Analyze jobs and determine how this job will be distributed each node
    - Depending on the degree of centralization, track job status for each node and summarize output.
    - Ensure the router is capable of reading routing information and flag signals.
    - Test before the integration process using dommy job whether it is working correctly or not
- Building quantum communication network and quantum switches :
    - Design the quantum circuit to use the EPR pair in our quantum network.
    - Research and implement communication protocol to make our quantum network more efficient. The degree of efficiency will be kept modified through maintenance progress.

    - Research and development quantum switches for swapping quantum information between quantum networks.
    - Test before the integration process using simple network protocol whether it is working correctly or not.

System integration and testing

- Integrate our network system and run our network on the quantum computer via simulation(one quantum computer, simulating our network). Testing is also done using a quantum computer environment.

Maintenance

- Keep tracking our work progress and get feedback from our advisor. Ensure the project is on the right track and modify our design requirements accordingly by analyzing advisors' needs and realizable goals.

2.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

What are some key milestones in your proposed project? It may be helpful to develop these milestones for each task and subtask from 2.2. How do you measure progress on a given task? These metrics, preferably quantifiable, should be developed for each task. The milestones should be stated in terms of these metrics: Machine learning algorithm XYZ will classify with 80% accuracy; the pattern recognition logic on FPGA will recognize a pattern every 1 ms (at 1K patterns/sec throughput). ML accuracy target might go up to 90% from 80%.

In an agile development process, these milestones can be refined with successive iterations/sprints (perhaps a subset of your requirements applicable to those sprint).

Milestones for making our quantum network are the same as below.

- Create quantum router for having two nodes
    - Identify jobs from user
    - Sent job instruction to each nodes
    - Track job status for each node
    - Send instructions to quantum switches which are part of the quantum communication network.
- Create rudimentary quantum communication network and quantum switches
    - Design quantum network protocol packet for implementation of feature which our advisor needed
    - Design quantum network switches for two nodes which can swap quantum information using the EPR pair.
- Integrate two parts
    - Integrate rudimentary quantum router with quantum communication network / switches.

- Improve quantum network performance
    - Improve our network to make it can hold more than two nodes. Specific number of nodes will be settled during the maintenance.
    - Improve our quantum communication network that can hold more than two EPR pairs for quam information exchange. This determines the availability of implementation of security features.
    - Improve our quantum communication network protocol algorithm. Specific requirements will be settled during the maintenance. It also depends on the client's needs.

2.4 Project Timeline/Schedule

• A realistic, well-planned schedule is an essential component of every well-planned project

• Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity

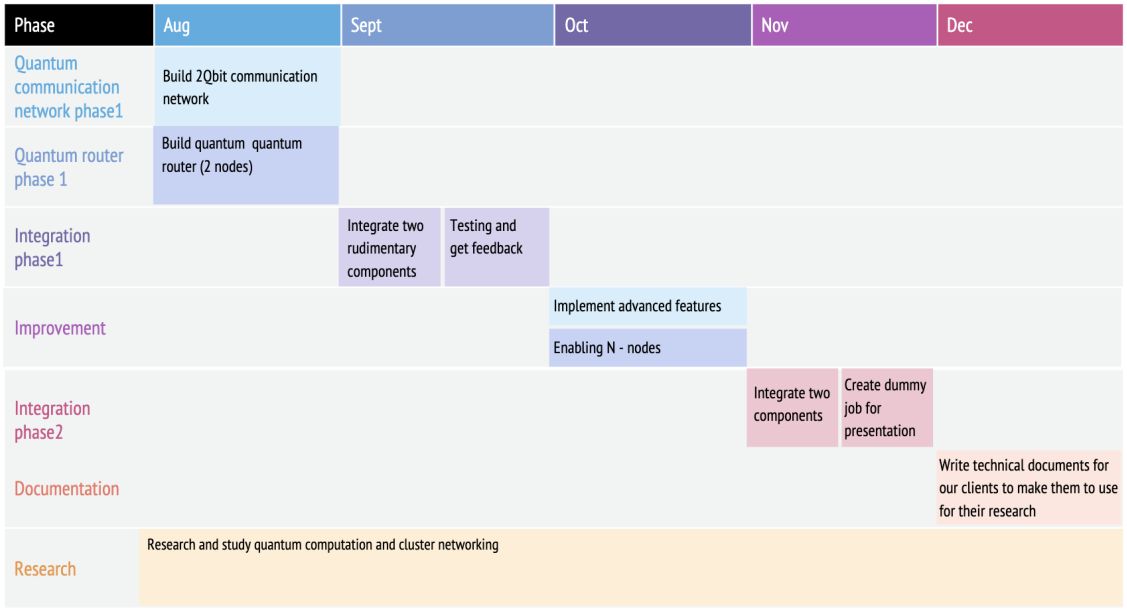
• A detailed schedule is needed as a part of the plan:

– Start with a Gantt chart showing the tasks (that you developed in 2.2) and associated subtasks versus the proposed project calendar. The Gantt chart shall be referenced and summarized in the text.

– Annotate the Gantt chart with when each project deliverable will be delivered

• Project schedule/Gantt chart can be adapted to Agile or Waterfall development models. For agile, a sprint schedule with specific technical milestones/requirements/targets will work.

Quantum network for quantum cluster computing Project Timeline



2.5 Risks And Risk Management/Mitigation

Consider for each task what risks exist (certain performance targets may not be met; certain tools may not work as expected) and assign an educated guess of probability for that risk. For any risk factor with a probability exceeding 0.5, develop a risk mitigation plan. Can you eliminate that task and add another task or set of tasks that might cost more? Can you buy something off-the-shelf from the market to achieve that functionality? Can you try an alternative tool, technology, algorithm, or board?

Planning and Design - Nonworking Design.

Probability - 0.3

Implementation 1 to 1 - Issues with simulation not working as intended.

Probability - 0.2

Creating rudimentary quantum router - Issues concerning communication with quantum nodes.

Probability - 0.7

Mitigation - quantum router, although it's mainly dealing with classical information and very similar with classical computing architecture, is the most complex unit especially we have to add communication with quantum communication network / quantum switches. We have researched classical routing protocols and our design will be mimicking an already existing design.

On top of this, we plan on meeting with professors who are well versed in networking and routing protocols and get feedback on if our design is feasible.

Troubleshooting - Design issues could cause full rebuild / redesign of the project.

Probability - 0.6

Mitigation - We will keep in close contact with our advisors and tell them our designs before we spend time implementing them so that they can give feedback on if they will work or not and why.

Presentation Preparation - Not communicating our project enough where the audience cannot understand it.

Probability - 0.4

For a lot of our project, buying something off the shelf is not an option because nothing exists that can do this reliability. There are some algorithms that we can use in our design which have been tested but these are unrelated to the end goal of our project to route quantum information.

2.6 Personnel Effort Requirements

Include a detailed estimate in the form of a table accompanied by a textual reference and explanation. This estimate shall be done on a task-by-task basis and should be the projected effort in total number of person-hours required to perform the task.

Task	Person	Hours
Planning and design	All	30
Implementing 1 to 1 connection	Ohik & Derrik	70
Creating classical network packet	Steven & Ben	70
Implementing classical network in quantum network	Ohik & Steven	70
Troubleshooting	All	30
Documentation	Derrik & Ben	20
Presentation prep	All	20

2.7 Other Resource Requirements

Identify the other resources aside from financial (such as parts and materials) required to complete the project.

Our project will require other resources such as quantum computer simulators as well as possibly some server space. These resources are either all provided or free off the internet therefore should cause no issues in the completion of our project.

IBM Q system One - We're using IBM Q system for simulating our quantum network. We can use up to 7 qbits without any extra charge.