ECE 4011 / ECE 4012 Project Summary

Project Title	Mesh Networks for Simultaneous Localization and Communication
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Semester	2019/Spring　　　Circle:　Either　Intermediate (ECE 4011) or Final (ECE 4012)
Project Abstract (250-300 words)	Sailboat regattas are difficult to observe from shore and would greatly benefit from real time tracking. However, the cost of individual GPS modules for each boat combined with a reliable method of transmission can become prohibitive. To solve this problem, we propose a mesh network of radios that use distance measurement techniques to discover the location of each boat on the water. This information can be communicated back to a base station using the same network. The boats will have a node attached: a self-contained unit with electronics required for the unit to function efficiently. The node will be attached to the mast in an easily accessible location, along with an internal or external antenna. Connected to the base station, there will be strategically placed radio towers with precisely known locations. These towers will have similar nodes, with an external power connection to enable higher transmit power. This will enable the base to determine the position of the boats, using different methods depending on the location of the boats. For boats in the direct triangulation area (i.e. within range of at least 2 towers), the base can directly triangulate the location of the node. For boats that are outside the direct triangulation area, each node must measure the distances between it and at least 3 nearby nodes and transfer it to shore using the mesh network. This data can be processed by the base station in order to determine the location of each node. The base station will also contain Wi-Fi equipment to host a network or connect to an existing one. This will allow it to host a web app for viewing the map and offloading visual processing to the client device. It will also allow for site-specific configuration.

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List **codes** and **standards** that significantly affect your project. Briefly describe how they influenced your design.	The IEEE 802.15.4 standard defines the operation of low-rate wireless personal area networks, which our communications fall under. The radios we choose must adhere to this standard. The IEC 60529 standard defines solid and liquid ingress protection. Our finished product must be able to achieve at least an IP58 rating, since there is a risk of complete immersion in water if the boat capsizes. This will influence the enclosure that we choose/design.
List at least two significant **realistic design constraints** that applied to your project. Briefly describe how they affected your design.	The power consumption of each unit must be low enough to ensure that an unit can last for the length of a race, without requiring an oversized power supply. The unit must be no more than 5 lbs and no larger than 5"x3"x10" in size. This size constraint influenced our choice of power supply to power the unit.. Each unit must be affordable enough to justify the cost of multiple units (a minimum of 2 on the shore and 1 on each boat). This will influence our choice of processor and radio hardware, as those are the two most expensive components.
Briefly explain two **significant trade-offs** considered in your design, including options considered and the solution chosen.	Each node needs to be capable of measuring the distance to another node within radio range. Measuring inter-node distance can be done with hardware support from the radio module. This limits our choice of radio, but allows for a more accurate solution with minimal software overhead. Measuring inter-node distance can also be done entirely in software. This can be done with any radio, but comes at the cost of decreased accuracy. We chose to implement distance measurement using hardware support from the radio. Some sort of user interface is necessary to view the generated data. One option is to run the UI directly on the base station. Either the processor must be powerful enough to support the UI without affecting triangulations, or another processor must be added. Both of these options would increase cost significantly. Another option is to have the base station host a server, to which client devices can connect to. The base station only has to process a stream of data, which puts minimal load on the processor. The visual processing can be offloaded to the client device (smartphone, tablet, laptop, etc). We chose the client-server approach to implement the UI.
Briefly describe the **computing aspects** of your projects, specifically identifying **hardware-software** tradeoffs, interfaces, and/or interactions. *Complete if applicable; required if team includes CmpE majors.*	One major computing aspect of the project is the distance calculation between radios. This will be implemented in hardware in the radio, but software will need to be written to interface with that hardware to retrieve the distance measurement. Another computing aspect of the project is the mesh network communication. Work will need to be done to implement a mesh network communication scheme (e.g. Thread) on the radios that we will be using. The last computing aspect of the project will be the user interface. The client interface will need to be designed, and the server software will also need to be written. These two will communicate over a WiFi link.