

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)	<p>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 proposed a mesh network of radios that use distance measurement techniques to discover the location of each boat on the water. This information was communicated back to a base station using the same network.</p> <p>The boats had node attached: a self-contained unit with electronics required for the unit to function efficiently. The node was attached to the mast during testing phase in an easily accessible location, along with an external antenna.</p> <p>Connected to the base station, we strategically placed radio towers with precisely known locations. These towers had similar nodes, with an external power connection to enable higher transmit power. This enabled the base to determine the position of the boats, using different methods depending on the location of the boats.</p> <p>For boats in the direct triangulation area (i.e. within range of at least 2 towers), the base could directly triangulate the location of the node. For boats that were outside the direct triangulation area, each node had to measure the distances between it and at least 3 nearby nodes and transfer it to shore using the mesh network. This data was processed by the base station in order to determine the location of each node. The base station contained laptops in position of Wi-Fi equipment to host a network. This allowed us to host a web app for viewing the map and offloading visual processing to the client device. It also allowed for site-specific configuration.</p>

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List codes and standards that significantly affect your project. Briefly describe how they influenced your design.	<p>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.</p> <p>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.</p>
List at least two significant realistic design constraints that applied to your project. Briefly describe how they affected your design.	<p>The power consumption of each unit was low enough to ensure that an unit can last for the length of a race, without requiring an oversized power supply. The unit was 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..</p> <p>Each unit was affordable enough to justify the cost of multiple units (a minimum of 2 on the shore and 1 on each boat). This influenced our choice of processor and radio hardware, as those are the two most expensive components.</p>
Briefly explain two significant trade-offs considered in your design, including options considered and the solution chosen.	<p>Each node was capable of measuring the distance to another node within radio range. Measuring inter-node distance was done with hardware support from the radio module. This limited our choice of radio, but allowed for a more accurate solution with minimal software overhead. Measuring inter-node distance could have also been done entirely in software. This could have been done with any radio, but came at the cost of decreased accuracy. We chose to implement distance measurement using hardware support from the radio.</p> <p>Some sort of user interface was necessary to view the generated data. One option was to run the UI directly on the base station. Either the processor would have to be powerful enough to support the UI without affecting triangulations, or another processor would be required. Both of these options would increase cost significantly. Another option was to have the base station host a server, to which client devices could connect to. The base station would only have to process a stream of data, which puts minimal load on the processor. The visual processing could then be offloaded to the client device (smartphone, tablet, laptop, etc). We chose the client-server approach to implement the UI.</p>
<p>Briefly describe the computing aspects of your projects, specifically identifying hardware-software tradeoffs, interfaces, and/or interactions.</p> <p><i>Complete if applicable; required if team includes CmpE majors.</i></p>	<p>One major computing aspect of the project is the distance calculation between radios. This was implemented using the microcontrollers on each node device, in coordination with their transceiver radios.</p> <p>All inter-node communication was handled by the microcontrollers and much of the data was piggy-backed on messages required for measuring distance. Doing so reduced the number of messages required to asynchronously transfer data throughout the network.</p> <p>The user interface and localization algorithm were hosted on a supporting laptop computer which received distance measurements from the main base station. The localization algorithm incorporates a recursive triangulation scheme capable of resolving node location even when out of direct range of the base stations.</p>