Project Pre-Proposal Homework
HW #0

Due September 7th at 11pm. All work must be individual and must be typed (though a few hand-drawings are acceptable). Submissions are to be handed in electronically via Gradescope. We will meet on the evening of September 9th to form groups of about five people, with each group selecting a project idea by the end of the meeting.

1. The assignment

This homework is being assigned to generate a pool of project suggestions. You are to submit suggestions for two possible project topics as a single pdf file. All submissions will be combined into one class PDF, so write them to persuade classmates that they would be worth pursuing. Do not include any personal information that you wish not be made public such as student ID number. You may include your name in the pdf if you wish. The project suggestions will be graded by the instructors. Brief descriptions will get brief grades; long suggestions containing lots of fluff will get a fluffy grade. The grades will obviously be judgment calls. Put some effort into your submissions and influence the judgments. When grading we will be mainly looking at: the quality of the idea, your feasibility analysis, and overall clarity.

You are to provide two suggested projects. One will be a well-thought-out project that meets the project goals described below and generally follows the format provided. The other can be a "wacky" idea and in any case will be shorter and less fleshed out. It is expected the first proposal will be about three pages in length while the second should generally be one to one-and-a-half pages. Longer proposals are acceptable but try not to submit more than six or seven pages total. Each suggestion will be graded separately. The first will be graded out of 50 points, the second out of 25.

At this stage we are looking for an "elevator pitch": a quick description that gets people to want to be involved. Think about what *you* would want in a project. Likely you'd be looking for things like:

- Seems interesting to work on
- Has the potential to have a real-world impact
- Is doable in the course of the semester

Your job is to try to come up with an interesting project and then convince others that the project is interesting (and doable). As such we're going to ask for not only the idea, but arguments that the project is doable in the time and budget allowed. You are not expected to have done detailed engineering or part selection yet; reasonable evidence that the project is feasible is sufficient.

1.1 Assignment format

The first proposal should include all of the sections below. For the second proposal, address them where relevant and less detail is expected.

High-level description

This section should describe the purpose the project is fulfilling and how it will work in general. This would likely include: what it does, who would use it, what the finished device looks like, and why it is worth building. You are describing what would be built, but it is also a "pitch" where you are trying to sell your idea to your peers.

Implementation issues

There are a number of questions with respect to implementation. Generally, cost, reliability, safety, and production requirements should be mentioned here. You will not be able to resolve every implementation question at this stage, nor are you expected to. What is desired is that you provide a rough sketch that helps convince people that your suggestion is doable. Briefly try to address the following questions:

> ***What is your (rough) plan for getting this working by the Design Expo?*** Generate a simple 4-6 item schedule. Keep in mind there will be about a 10-day delay from PCB order to arrival—think about how you will use that time. Put in "stretch" goals if appropriate. Remember testing and debug will take quite a while.
>
> ***What is your rough budget?*** Roughly how much do you think you'll spend on parts, PCB manufacture and the like? You have a budget of $250/student, how do you think you will use it? Don't feel obligated to use the whole budget.
>
> ***Are there any other obvious implementation issues?*** Are there any tricky mechanical issues? Do you need access to special facilities? Are there safety issues? Is there an energy budget problem? If so, try to explain why you think those issues are addressable. If you don't see any significant implementation issues, simply say so.

We are well aware that you won't be able to pick the parts you'll be using in the project—in fact picking those is perhaps one of the most important steps of the actual project. Instead, you should indicate why you think things are doable. For example, perhaps you need a low-cost wireless system. So, at this stage you indicate you'd use an ATmega128RFA1 processor for your wireless/microcontroller needs. At $8.00 or so, it seems like a good price point. But you may later find a better device or you may find its 17mA current draw when just listening is unacceptable. That's fine, this whole section is simply trying to show people that the idea is probably doable.

Evaluation and/or testing with regard to real world issues

How will you know your project works? How will you know you are actually meeting the real-world needs you described in the first section? What is the measure of success? These may seem self-evident, but for most projects they really aren't.

1.2 What type of projects can I propose?

We expect that all projects will involve creating an embedded system that does a specific task or set of tasks. This system should be a full-fledged device that includes any needed physical components (enclosure etc.) and is usable in its final form (in terms of weight, battery usage etc.). We do expect that groups will be using a PCB that they design that includes a processor.

An ideal completed project:

- Has a real-world application

- Meets all requirements of that application
- Involves the design and manufacture of a microprocessor-based PCB system
- Either solves a novel problem or solves a non-novel problem in a novel way

Obviously, your project must also be able to come in on time and on budget. As mentioned above, the first proposal should largely meet the "ideal" project specification, while the second *may* be fairly "wacky" and ignore some or all of the above.

Keep in mind you can use pretty much any platform. In lab we'll be using a wide variety of systems and those might be a good starting point. But you can pick whatever works best for your project.

1.3 Sample assignment

See the next page. This sample is primarily intended to illustrate the expected level of detail and style. Some technical details and component choices are a bit dated and the sample schedule is more detailed than needed (mostly to provide guidance about project pacing).

1.4 Note

Because the staff have a lot of other priorities in September (and our graders can't really grade this), expect this assignment to be graded in October.

Low-Cost Car Monitoring for Traffic Control and Safety

More than 30,000 people per year die in vehicle deaths in the US alone[1]. In addition, about 9.2 million barrels of gasoline are used in the US each day (nearly all for vehicles)[2]. Even very simple vehicle-to-vehicle and vehicle-to-base communication schemes can impact these numbers. For example, if a truck driver is "driving drowsy" or is otherwise distracted on a highway and doesn't notice cars in front of him are slowing or have come to a stop he or she could easily ram them. If an in-cab warning system let the driver know that there were low-speed cars in front of him the driver would be more likely to be alert and ready to deal with the issue.

As a different application, if a centralized system was aware of the location of all or most cars, it could more readily control traffic lights for maximum throughput. That would reduce the idle time of cars and save gas (as well as drivers' time).

Ideas like this have been proposed many times. The Vehicle Infrastructure Integration (VII) Initiative was an industry group whose work appears to have been abandoned[3]. The V2V standard was withdrawn in 2023[4]. These schemes didn't result in any universally adopted solution, in part because costs for Wi-Fi-like bandwidths are just too high. So, a low-cost and much simpler system is needed.

Details

As a car goes down the road or highway it would need a way to communicate to others. Rather than using direct vehicle-to-vehicle communication, we propose to have the vehicles talk only to non-mobile base-stations and all relevant information from other vehicles would come up that link. Further these links would be low-speed links only capable of a few KB/second. Vehicles would send simple messages indicating their location (gotten via a GPS) speed and any other relevant information. This would then compress down to about 20 bytes and send it out to the base stations once every second or so. In addition, the base-station would broadcast to all vehicles any important information (traffic slowdowns, emergency situations, suggestions for alternative routes, etc.)

This proposal envisions building a few vehicle-based systems as well as at least one base station. The vehicle-based systems would have a GPS, a wireless radio and a microcontroller. Ideally it would include a CAN connection so that it could get information directly from the car. The base station would include one or more wireless radios to communicate with the vehicles as well as a more generic device (Wi-Fi or cellular most likely) so it can communicate with a centralized system.

Schedule

The dates selected are mostly "lines in the sand" and will almost certainly not be exact though they should be close.

[1] http://en.wikipedia.org/wiki/List_of_motor_vehicle_deaths_in_U.S._by_year
[2] http://www.eia.gov/oog/info/twip/twip_gasoline.html#demand
[3] https://en.wikipedia.org/wiki/Vehicle_infrastructure_integration
[4] https://en.wikipedia.org/wiki/Vehicle_infrastructure_integration

9/10-9/23	***Planning*** In the two weeks after the project groups are formed, brainstorm other approaches and start discussing the communication protocol we hope to use. Research two or three radio platforms and select one as the best fit (based on power consumption, cost, range and usability). Do something similar for the GPS and also begin estimation of our requirements of the processor (CPU, memory and I/O). Hopefully identify a microprocessor (or at least a family). Write the draft proposal by 9/18.
9/24-10/6	***Design and part selection*** Once the proposal meetings are done, order at least two radios and the selected GPS solution. Select a processor and see if there is a board/devkit available for it that might work well for our prototype (has needed I/O available etc.). Bring up a prototype/board in a minimal fashion (blinking lights, can talk to radio and GPS even if not meaningfully). Submit the final proposal by 10/1. All parts we *think* we need for the prototype will have been ordered by the 4th.
10/7-10/25	***Breadboard prototype and PCB design*** Get both prototypes working with basic functionality (can send messages back and forth using a reasonable protocol, can initialize GPS and parse location data returned) implemented. Try to include hardware hooks for back-end schemes (cellular, Wi-Fi, or whatever). Order PCBs by the 26th (a bit more than a week before the PCB deadline).
10/26-11/10	***Software development and testing on prototype*** While waiting for the PCBs to come back, complete the communication protocol using the devkits and prototypes. Get GPS 100% working on prototype. Have all functionality written and most tested by the 10th on the prototypes. Start on back-end schemes. Get PCBs assembled (hopefully correctly) by 11/8. Identify solutions to all non-electronic issues (enclosure, etc.) and get all things ordered on that front.
11/11-11/25	***Software development and testing on PCB-based system*** Testing PCB. Once basics working on PCB, testing will be done to ensure that rapid association is working. Back-end communication schemes will be developed on prototype if not done (or not done correctly) for PCB. Accuracy of GPS will be tested. Bugs will be found and fixed. PCB issues resolved. If needed PCB revisions will be made. Any additional features/stretch goals will be researched and decided upon by this time.
11/26-12/9	***Final testing, additional features, poster and expo*** Targeting project completion 12/3. At this point we'll get our poster done and start on the final report. Continue to fix any remaining minor bugs.
12/10-12/11	***Finish final report***

Budget

While a realistic budget is difficult at this time, the numbers below are a reasonable first pass. If other costs came up (and they likely will) having only 2 or 3 GPS systems is probably enough and would be a way to cut costs. PCB manufacturing costs might be underestimated. With a team of 4 we would be under budget. Only 1 base station and 4 vehicle nodes would be built—the extra are there as spares

(and in the case of the base station because ordering 5 is nearly the same price as 2).

What	Quanity	Cost per	Cost total
ATmega128RFA1	8	$7.00	$56.00
PCB--vehicle	5	$15.00	$75.00
PCB-base	5	$15.00	$75.00
GPS	5	$40.00	$200.00
Misc parts	1	$100.00	$100.00
Shipping	1	$75.00	$75.00
Total			$581.00

Issues

The largest concerns at this time are

1. Developing the algorithms needed for the rapid communication
2. Interfacing with the GPS
3. Soldering the surface mount radio/microcontroller
4. Having to design two different systems/boards
5. Wi-Fi/Cellular communication

Issue 1 is a complete unknown but *seems* reasonable. Issue 2 may be a challenge, but http://www.adafruit.com/products/99 makes it seem likely a number of hobbyists have been successful with it. Issue 3 seems a bit difficult, but the instructor says it is doable if we pick our parts carefully. Issue 4 is perhaps the most difficult as it in effect doubles parts of our work. Issue 5 will be addressed by dropping that functionality if needed—it is a "stretch goal". Each issue seems manageable and it is almost certainly something unforeseen at this time that will be the real problem.

Additional stretch goal

While the Wi-Fi/Cellular part is already a stretch goal, if time allows we will see if we can use a solar cell to keep the base station running.