Project Pre-Proposal Homework (HW1)

Due by 10pm Sept 10th, 2012. All work must be individual. Hand written homework solutions will not be graded. Submissions are to be handed in electronically as described below.

1. The assignment

This homework is to be submitted in the form of a PDF file attached to an email sent to brehob@eecs.umich.edu. The subject of the email must be "**`498HW1`**" (exactly) and the name of the attached file should of the form **`498p_last_first.pdf`**. Where "last" is replaced by your last name and "first" is your first name. For example I would use **`498p_brehob_mark.pdf`**. Include your full name in the text of your submission. The attached file must be in PDF format.

Please be sure to follow the above directions exactly.

This homework is being assigned as a means to generate a pool of project suggestions. You are to submit suggestions for two possible project topics. The individual PDF files will be merged into a single PDF file that will then be sent to the class mailing list. It is assumed that everyone in the class will at least look at these. Do not include any personal information that you wish not be made public such as student ID number. 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.

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 two pages in length while the second about one page. Longer proposals are fine but try not to submit more than 6-10 pages total. Each suggestion is 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.

1.1 Assignment format

Each suggestion should include the sections listed below.

High-level description

This section should describe the purpose the project is fulfilling and how it will work in general.. Some idea of the physical manifestation of the project (how it will look and function) and basic means of functioning (how it does what it does) should be included. Generally, cost, reliability, safety, and production requirements should be mentioned here. Think of this section as the "pitch" where you are trying to sell your idea to your peers, but also where you describe what would be built.

Implementation issues

There are a number of questions with respect to implementation. Frankly you won't be able to address them all at this point. 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 a 7-10 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 $250/student budget, 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. Some suggestions won't need this section, but others will.

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 a ATmega128RFA1 processor for your wireless/microcontroller needs. At $7.00 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 more a "line in the sand" trying to show people that the idea is probably doable.

Evaluation and/or testing with regard 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 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.

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. You are to propose two different projects for this assignment. The first 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 (from $4.30-$98 running everything from no OS to full-fledged Linux). But you can pick whatever works best for your project.

1.3 Schedule for the project

In class on September 12th project topics will be selected and teams formed. Project topics and team memberships are not generally assigned by the instructor. Project topics are not restricted to those in the PDF collection. If you walk out of the meeting not being a team member or are on a team that doesn’t have at least a tentative project topic, you have a problem. It is likely that once groups are formed, some groups will end up changing what their group is doing. That’s fine.

Over the course of the next few weeks your team will be refining their project goals and turning in more and more detailed project descriptions.

- On Sept 17th you will turn in a two-page document that includes
  - Your purpose statement (generally 1-3 sentences)
  - A list of design requirements (often 4-8 items)
  - A detailed group agreement (generally a full page)
- On Sept 24th you will turn in a short (one or two pages) document that provides the engineering specification for your project.
- On October 1st you will turn in your formal proposal. This will include the above material (likely with a fair number of changes) as well as a budget, Gantt Chart and the like. This generally runs five to ten pages.
- There are two milestone meetings (10/22 and 11/12), but the next major deadline is 11/8 where all PCB orders are to be out to a manufacturer.
- Finally, by 12/5, your project needs to be up and working as you will have a series of demonstrations to give (to your peers, at the design expo and to the instructors).
- All teams are to participate in the Design Expo (likely on 12/6).

1.4 Sample assignment

See the next page.

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 driver's time).

Ideas like this have been proposed many times. The Vehicle Infrastructure Integration (VII) Initiative[3] is the leading industry group in the field. Their work over the last 6-7 years hasn't resulted in any universally adapted solution, in part because costs for WiFi-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 from via a GPS) speed and any other relevant information. The would then compress this 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.

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[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] http://www.vehicle-infrastructure.org/

9/12-10/1	***Planning*** In the three weeks after the project groups are formed, we will need to carefully define our project, research and select parts, get a rough design and write it all down in our proposal. Prototype plans will be solid.
10/1-10/12	***Design and part selection*** It is expected that the first 1.5-2 weeks will be spent further fleshing out the idea, selecting parts and designing the communication algorithms. During this time a few different wireless radios will be tested including the Xbees used in class. A GPS must also be chosen as well as a microcontroller. As soon as a part is selected it will be ordered so as to reduce the lull between ordering parts and being able to start on the design (thus the overlap with the next step).
10/8-10/29	***Breadboard prototype and PCB design*** Once parts are selected and ordered a breadboard design will be implemented for both the vehicle device and the base station. Once we are certain the hardware design is correct PCBs will be ordered. This is expected to take about 3 weeks. Getting the PCB order out by 10/29 puts us 1.5 weeks ahead of the deadline.
10/29-11/12	***Software development and testing on prototype*** While we are waiting for the PCBs to come back, software will be refined and a test plan will be developed. Once the boards arrive we will assemble them (in 2-3 days) and ideally have things working by Nov 12th.
11/12-11/26	***Software development and testing on PCB-based system*** Testing will be done to insure that rapid association is working. Back-end communication schemes (cellular, Wi-Fi or whatever) will first be extensively used. 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 decided upon by this time.
11/27-12/3	***Final testing, additional features, poster and final report*** Targeting project completion at 11/27. At this point we'll do all of our writing and continue to fix any remaining minor bugs.

Budget

While a realistic budge 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. With a team of 4 we would be about $400 under budget if the estimates below are correct. Only 1 base stations and 4 vehicle node 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. 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.