LOCATION-AWARE INFORMATION SYSTEM

USING GPS, DATABASES, AND THE INTERNET FOR TRACKING AND SENSING

SPECIFICATION

BY
AARIJ ABBASI,
LAM KIN CHEN,
MICHAEL FERCU,
AND ANDREW LEONCZYK.

A SPECIFICATION FOR A LOCATION-AWARE INFORMATION SYSTEM

USING GPS, DATABASES, AND THE INTERNET FOR TRACKING & SENSING

I. PROJECT OBJECTIVE

Statement of Problem and Objective

The location aware information system, or LAIS, is a tracking system that can be employed on any machine, person, animal, or other moving object. The system can provide solutions for a number of tracking and sensing applications. LAIS consists of two basic parts: the mobile unit and the server that runs the LAIS post-processing software. A diagram of the entire system is shown below in Figure 1.

The mobile unit is carried by a person or attached to an object or animal. A GPS signal receiver will receive a time-stamped position (location-data) from orbiting GPS satellites via the GPS unit's antenna. Analogue and/or digital data is read from the attached sensors, which monitor environmental conditions such as barometric pressure, temperature, or light. Any data from analogue sources is first converted to digital via the PICs' A/D converter. The position information along with the sensor data is read by a peripheral interrupt controller (PIC) and is stored as a time-stamped entry into an external SRAM memory. A second PIC is used to transmit the data that has been stored in the memory to the server. The two PICs are connected using a bus interface. The data is sent to the server through either a wired or wireless RS232 serial data connection. Power saving features such as the PIC's sleep instruction will be employed in order to increase battery life.

The server is a PC that is running the LAIS post-processing software. This machine has a database, which is implemented using Microsoft's SQL server 2000. This database efficiently stores all of the data that is collected by the LAIS mobile tracking and sensing device. The tracking data is read from the mobile device through one of the PC's serial ports and is stored into the database. The LAIS post-processing software also obtains data from external information sources such as news, weather, web camera images and other Internet resources. The user may then display various forms of the information on the screen. The user could look at the data from a single trip and overlay maps that were relevant at the time of the trip such as weather data or news events. The user could also display the sensor data and graph relations such as temperature vs. time. The LAIS post-processing software will also be able to compute spatial averages such as the average temperature of a location.

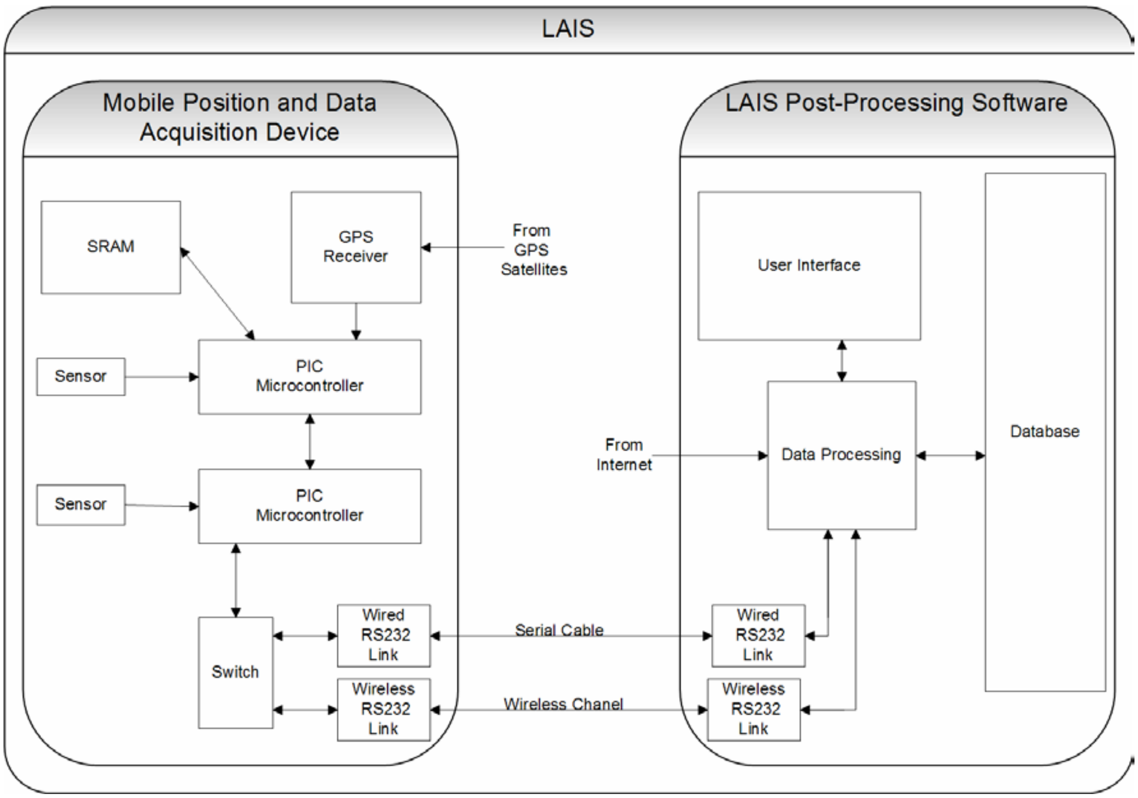


Figure 1 High-level overview of the LAIS

II. APPLICATIONS

Transportation Tracking for Security and Efficiency

The LAIS mobile device can be attached to a bus or other transportation device. While attached to a bus, the LAIS mobile device has the advantage of drawing power from the vehicle's electrical system to power itself during the process of recharging its backup system. This type of operation would allow the LAIS to constantly collect location-data.

Upon returning to the station, the vehicle's location-data could be collected via cable or wireless link by the station's LAIS software. The location-data would then be stored in a data warehouse, post-processed, and compared against historical data. Using the LAIS software, the bus, rental car, or other transportation company could use the database to evaluate the driver's efficiency. The schedule manager of a bus system can evaluate the efficiency of the bus drivers' route and adjust the schedule accordingly. Correlations could also be drawn between weather and the times at which the bus reaches its stops. An alternative "bad weather" schedule could be posted and would take effect during snowy days. The manager of an armored car transporting high-value goods can find if the car made any unscheduled stops. The rental clerk can evaluate if a client has broken any of the rental company's rules, such as exceeding the legal speed limit, crossing state borders, etc.

Location Aware Sensing of Soil Properties

The LAIS mobile device could be equipped onto a harvester to measure soil fertility on a farm. On a large field with varying soil properties, a harvester equipped with a LAIS mobile device and attached grain sensor. Each year, when the harvester collects the grain, the LAIS would be able to record grain yield at each location as the harvester continues to collect grain throughout the field. When the farmer has harvested the field, the unit is returned to the post-processing station where a color-density diagram can be overlaid on the satellite/aerial view of the field and the farmer can determine which areas produced a lot of grain and which areas produced less. Before the next planting season, the farmer could use the device to enumerate samples of soil to be tested for pH level and nutrient content. In the planting season, the farmer can equip the fertilizing machine with a GPS unit and a controller which deploys more fertilizer in low yield areas and less fertilizer in high-yield areas. In terms of cost, if very little to no excess fertilizer is used, crop yield will increase while the cost of fertilization will decrease. In addition, the excess fertilizer run-off will no longer bleed into the water supply and poison local wildlife. Over the course of a few years, a farmer will be able to increase yield, decrease cost, and minimize environmental effects caused by agricultural runoff.

Determining the Behavior of Wild Animals

The LAIS mobile device can be attached to an animal where it will record the daily path of wild animals. A wireless data collection point could be strategically placed in a location where the animal visits on a frequent basis. This could be a den or favorite feeding site. If many animals were tracked with this method, neighboring wireless data collection points could collect data from animals other than the animal for which the collection point was installed.

This data could then be processed to determine the territorial characteristics of the animals being studied. Migratory as well as other patterns could also be analyzed and related to other factors such as weather. Sensor data could also be used to determine if This is a great improvement over the common beacon like tracking collars that only guide researchers toward the general location of the animal. With the LAIS system, trends could be discovered that will tell researchers how every animal that is tracked spends its entire day.

This information could be used as part of environmental studies that will help people to preserve the natural wildlife while developing land for human use. The data could alert developers to areas that are most important for wildlife.

III. PROJECT PLANNING

Team-member assignments

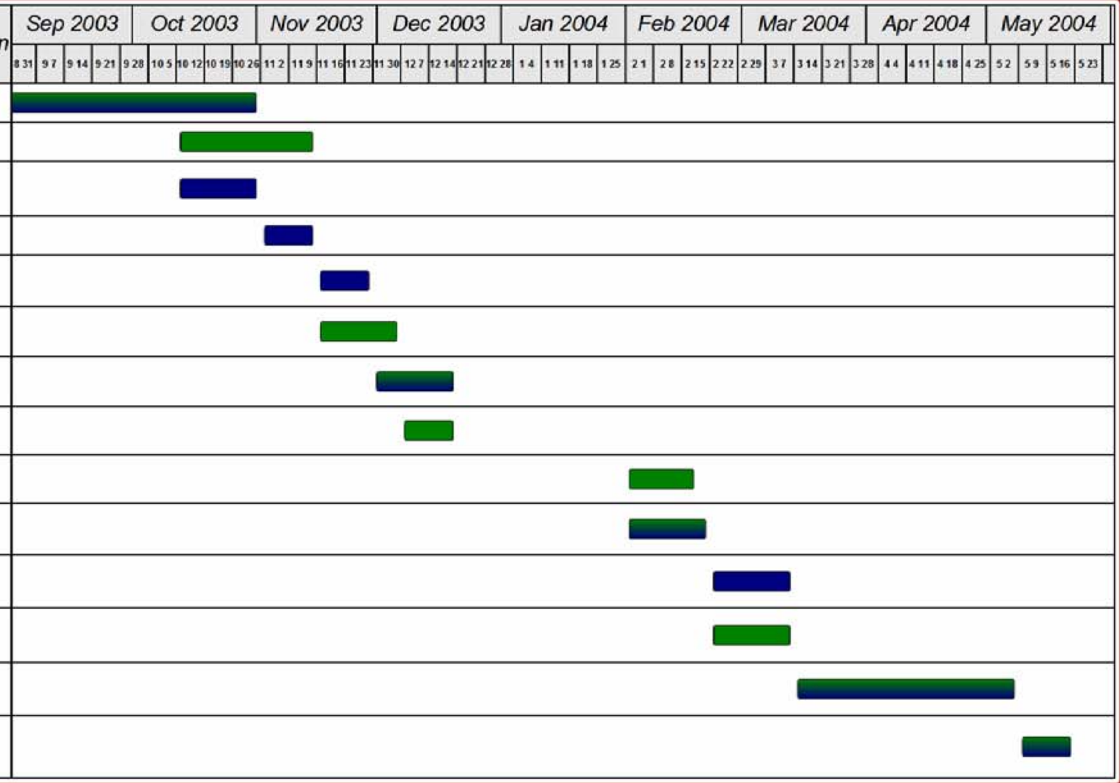
Work will be distributed into two sub-teams: the hardware team, and the software team. The hardware team, Aarij Abbasi and Lam Kin Chen, will be responsible for producing the mobile device and for providing an interface to the location and sensor data stored on the hardware for use by the software team. The software team, Michael Fercu and Andrew Leonczyk, will design a tool for capturing the location and sensor data, importing it into a database, and displaying it in an application with options for post-processing. The software and hardware teams will work in parallel as shown in Figure 2 on the next page.

Hardware Development

The hardware team will need to research information about the hardware. The hardware team will need to learn how each piece of hardware functions. They will also need to learn the format of the data that is used by each device. The hardware team will need to develop a format for storing the data in the SRAM. The hardware team will need to determine the best way for using the PIC microprocessors while keeping power consumption as low as possible. They are also responsible for configuring the wireless serial data link.

First, the hardware team will design a method for retrieving all of the data from the GPS receiver. The data will be read into the PIC and displayed using the PIC's serial connection on a terminal. Once they are able to read the data from the GPS, the hardware team will implement a method for storing the data in memory. The functionality of this stage will be verified by writing data to the memory, then recalling and displaying it. Next, the hardware team will attach the second PIC to the first PIC. This interface will be verified by sending data over the connection. The second PIC's UART will then be configured to send data to the LAIS server. The data can be viewed by connecting the output to a terminal device. When the code to read data from a serial connection is implemented on the server, the hardware will be tested with it. After data can be sent over the wired serial connection, the wireless serial connection will be implemented. The same methods for testing will be implemented here as in the wired serial connection. Upon completion of that, the hardware team will create sensors that can observe the local environment. The sensor values will be checked for accuracy. If there is enough time and money a second mobile devise will be assembled. It will be identical with the exception of the wireless serial link.

ID	Task Name	Start	Finish	Duration
1	Planning and Research	01 Sep 03	31 Oct 03	45d
2	Database Design	13 Oct 03	14 Nov 03	25d
3	Reading GPS Data Into PIC	13 Oct 03	31 Oct 03	15d
4	Storing Data In SRAM	03 Nov 03	14 Nov 03	10d
5	Attaching Second PIC to First	17 Nov 03	28 Nov 03	10d
6	Internet Data Retrieval Methods	17 Nov 03	05 Dec 03	15d
7	Sending Data Over Serial Link	01 Dec 03	19 Dec 03	15d
8	Data Processing Methods	08 Dec 03	19 Dec 03	10d
9	Data Processing Methods	02 Feb 04	17 Feb 04	12d
10	Sending Data Over Wireless Serial Link	02 Feb 04	20 Feb 04	15d
11	Reading Data From Sensors	23 Feb 04	12 Mar 04	15d
12	Graphical User Interface	23 Feb 04	12 Mar 04	15d
13	Revision, and Data Collecting	15 Mar 04	07 May 04	40d
14	Presentation Preparation	10 May 04	21 May 04	10d



Key:
Hardware Tasks
Software Tasks
Combined Tasks

Figure 2

Software Development

In order to develop the software, the software team will need to research various topics. The software team will need to learn database concepts and how to implement them using SQL and Visual Studio.net. The software team will also need to develop code that retrieves information form the Internet and stores it in an efficient manner. An intuitive and robust graphical web interface will be developed as well.

First the database will be created using SQL. Dummy data will be stored in the database in order to test its functionality. After the database is completed, code will be written that can read data from the mobile device over the serial port. Connecting the serial port to the serial input of a terminal device can test the code. Next, methods will be developed for obtaining data from Internet sources. Once that is complete, methods for processing the data that is received will be created.

Demonstration

The demonstration for this project will consist of a person who walks around with the mobile devise. The device will collect data about their current location. Upon returning to the base station, the device will load the data into the server. The path of the person will then be plotted and compared to information in the database. Various other data will be overlaid. Graphs relating to sensor readings will also be displayed. Historical information and the data created from it will also be shown.

Budget

We chose our supplies carefully to remain within our $500 budget. Our preliminary budget is shown below in Table 1.

Item	Qty	Cost/Unit	S&H	Extended Cost
IP address for LAIS server	1	$50.00		$50.00
GPS Receiver	2	$60.00	$15.00	$135.00
Wireless RS232 Link	1	$219.00	$15.00	$234.00
PC Boards/PICs/Miscellaneous. Parts				$50.00
Total				$419.00
Budget Remaining				$81.00

Table 1 Expectated Expenses

IV. CONCLUSION AND OUTLOOK

We expect to complete the project according the timeline shown above. We expect the LAIS to be capable to track a moving object for a reasonable amount of time after completing the fourth stage. By the end of the fall semester, we should have a devise that can track itself and send the data to the base station. The server will be able to store the data in a database and be able to display crude representations of that data. We anticipate the ability to post-process location and sensor data in order to resources gathered from the Internet directly into the database for easy user access. Some sample resources that we anticipate adding by May '04 are: weather, news, sports information and local businesses. These pattern-finding tools will facilitate and enhance LAIS, allowing the user to spend his/her time and resources more efficiently.

V. RESOURCES

[1] Microsoft Teraserver 09 Sept. 2003 < http://terraserver.microsoft.com >.

[2] Microsoft Press 09 Sept. 2003 < http://www.microsoft.com/mspress/developer >.

[3] LAIS Website 09 Sept. 2003 < http://www.ecs.umass.edu/ece/sdp/sdp04/wolf >.