LOW-POWER DESIGN FOR GPS NAVIGATION SYSTEMS

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ABSTRACT

This paper addresses the low-power design of GPS navigation systems which communicate over the GSM cellular network. The suggested design guide minimizes the system power consumption by exploiting the idleness of the major components: GPS receivers and microcontrollers. We introduce a request rejection mode for areas where a normal fix can not be obtained. Moving as much as possible functionality from hardware to software improves the power efficiency as well.

Keywords – Embedded systems, power minimization, GPS, GSM.

1. Introduction

In this paper we assume that the navigation and tracking system is composed of two major devices - tracking device with LCD display and digital maps, named Viewer; and tracked device with GPS receiver and communication module, named Locator. We adopt this architecture to develop a hardware platform for validation of power saving concepts. The system is based on a modular approach and can match different applications. The Locator and the Viewer may be linked to form a moving map system.

Figure 1 shows the system architecture viewed at two hierarchical levels. Under the first level we distinguish between a different number of Locators, Viewers, GSM mobile phones and PCs. The devices are linked by a GSM cellular network. At the lower hierarchical level the Locator and the Viewer are composed of GPS and GSM modules. Microcontrollers bring intelligence to the Locator and the Viewer. The communication within the system is based on two serial links. The architecture allows different GPS receivers to be connected. We assume that the GPS receivers are compatible with the protocols NMEA-0183 and SiRF. Also, the GSM cellular phones have integrated modems for data communication.

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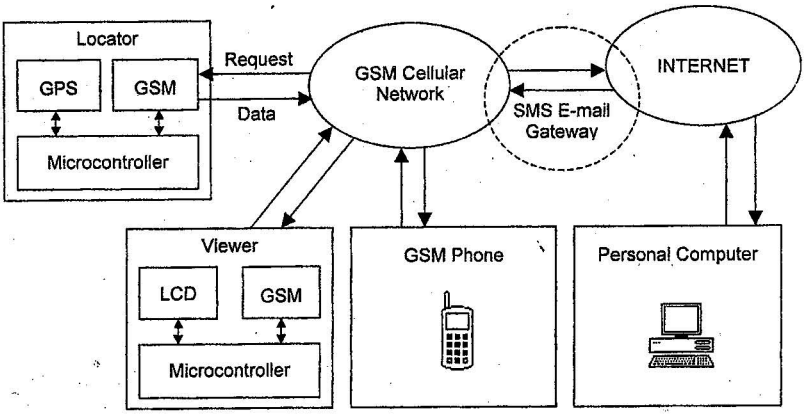

Figure 1 The system architecture

2. The Locator

The Locator receives data from the GPS receiver and transmits it over the GSM cellular network. The GPS module dominates the power consumption. In that regard, we distinguish between three states of the GPS module. First, the module is tracking satellites and gathering data. The receiver is active and the module is full-powered. Second, after a position fix is obtained, the receiver is switched off and the power consumption is declined. The CPU is still active to transmit an ASCII character stream which contains the measured latitude and longitude. Finally, the CPU is clocked off and the GPS module enters a power saving mode. The sequence of states occur either arbitrary, when a fix is requested, or repeatedly, after a certain period of time.

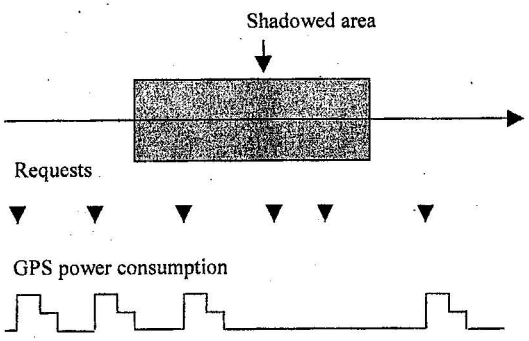

Figure 2 The request rejection mode

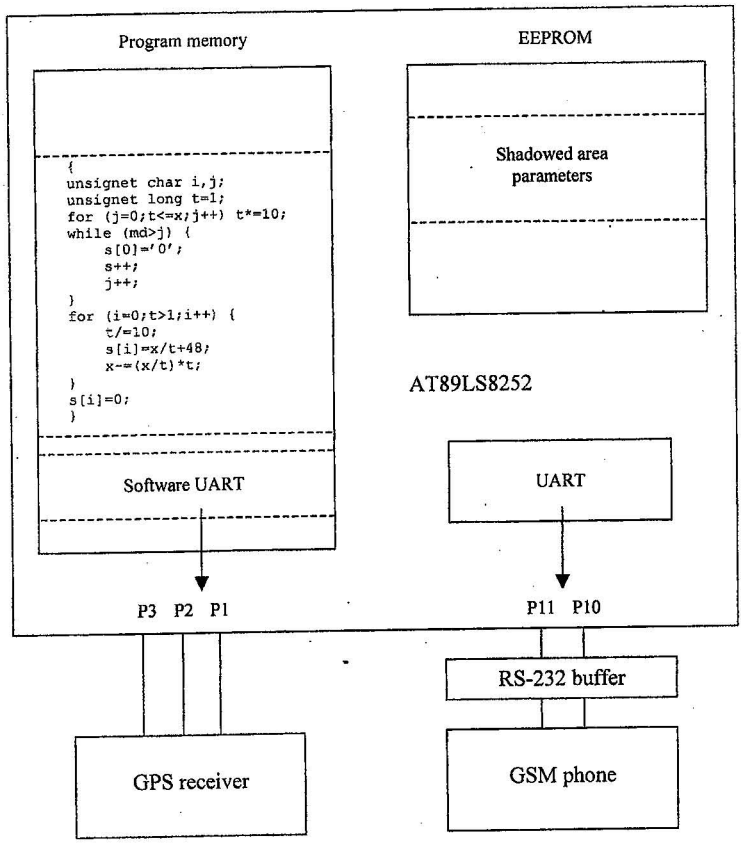

Figure 3 The Locator architecture

In order to avoid redundant activation of the GPS receiver we introduce a Request Rejection Mode (RRM). Once the system is in RRM, the first unsuccessful attempt to obtain a fix signals that the Locator may has entered a shadowed area such as a tunnel. The system compares the latest available latitude and longitude with the parameters of the known shadowed areas. If the current position of the Locator is bound to a shadowed area, the GPS receiver will not be activated for a predefined period. For all requests which are overlapped by that time interval, the Locator will send back only the identifier of the shadowed area. The GPS receiver stays in the power saving mode.

Figure 3 shows the Locator architecture. An AT89LS8252 microcontroller links the GPS receiver and the GSM phone. The microcontroller is capable of operating in the range of 2.7 to 6.0V supply voltage. The embedded UART communicates with the GSM phone. A "software" UART interacts with the GPS receiver. Typically, the on-chip Program Memory is a limited resource and the compilers should generate an efficient memory footprint. For example, the chunk of C code laid out in Figure 3 belongs to the software that converts the coordinates into a relevant internal representation to avoid flouting point arithmetic. A baud rate of 19200 bps for communication with the GSM phone determines a floor of the clock frequency of 3.6864 MHz [1].

3. Viewer

The prototype of the Viewer is based on the AT89LS8252 microcontroller and a graphical LCD display. The low-power design for this device is confined to the microcontroller's power management and the clock optimization. Again, the GSM phone can be replaced by a GSM engine.

4. Conclusion

A distinctive feature of the GPS navigation systems is that the power consumption can be strongly influenced by the environment. If trapped in a shadowed area, the system may perform many unsuccessful attempts to obtain a fix which will result in significant increase of the power consumption. A reasonable trade-off is the proposed request rejection mode. The RRM is feasible for applications where the location of the shadowed areas is known in advance.

5. References

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