An Internet-Based Interactive Embedded Data-Acquisition System for Real-Time Applications

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Agenda

• An Introduction to Data Acquisition Systems.
• Motivation
• Functional Block Diagram
• Proposed System
  • Hardware
  • Software
  • Direct Access to the Embedded System
  • Establishing a communication link
  • Data Management in the system
• Sample Application
  • Camera
  • GPS
  • Temperature Sensor
• Conclusion
• References
Data Acquisition System

- What is DAQ
- History
- Need of Data Acquisition
Motivation - Drawbacks of Traditional DAQ Systems

- Use data network without minimizing data transfer cost.
- Need to maintain additional server.
- Need to access the server every time.
- Unsuitable for Real Time control applications.
Motivation- Advantages of the Proposed System

- No need of an established server.
- Minimizes the cost of data transfer.
- Direct Communication link between the client and Embedded System.
Hardware

- X-86 Based Standalone unit
- Four Serial Ports, One Serial Port
- 16 MB on board removable flash memory
- Acquisition Units can be varied and added using appropriate interfaces
Software

- Linux 2.4 Kernel with TCP/IP stack included
- Only bare minimum packages installed
  e.g. Console tty, Serial Ports, PPPD, Support for memory and math emulation
- Scaled down version of Linux to reduce memory footprint and complexity
Establishing a Communication Link

- Initiate GPRS connection using GPRS modem.

- Manage the Point to Point Protocol (PPP) connection using PPP Daemon (PPPD)

- GPRS parameters like connection speed are managed by PPPD.
Direct Access to the Embedded System

• For direct access, IP address of the Embedded Device must be known to Client.

• Static IP Vs. Dynamic IP
  • Static IP – Advantages & Disadvantages
  • Dynamic IP – Advantages & Disadvantages
FTP

- Embedded Device updates its IP address

- It is saved in a folder named by its hostname

- This script parses the current and sends it to FTP server
FTP – Continued

Embedded systems

GPRS Dynamic IP information
193.140.221.48

GPRS Dynamic IP information
193.140.221.170

GPRS Dynamic IP information
193.140.221.174

Dummy (FTP) server

http request

internet

http request

clients

WELCOME TO THE EMBEDDED SYSTEM WEB ACCESS

Click the hostname below to be directed to its web page

You have requested the IP information for: mozart
Data Management in the system

- Internet Server is used to decrease data management cost
- Text data is served by Embedded System
- Bulky data is sent only once using GPRS and placed on FTP server
Sample Application

- A camera, Temperature sensor and GPS are integrated into an embedded board to form a sample application.

- A CMOS Camera with built in JPEG controller chip.

- The GPS module - OEM GPS UV40

- A very low cost temperature measurement chip - DS1620.
Camera

- The client initiates the camera control script, which eventually takes a snapshot
- The picture is uploaded to a dummy FTP server
- All the queries to visualize the current picture are automatically relayed to the FTP server

<table>
<thead>
<tr>
<th># of clients at the same time</th>
<th>Σ Duration (sec) to receive pictures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FTP server</td>
</tr>
<tr>
<td>1</td>
<td>21.77</td>
</tr>
<tr>
<td>2</td>
<td>21.77</td>
</tr>
<tr>
<td>3</td>
<td>21.77</td>
</tr>
<tr>
<td>4</td>
<td>21.77</td>
</tr>
</tbody>
</table>
Camera Pseudo code

```plaintext
Snapshot()

Connect Embedded_Board_to_Camera

   Send Synch packages to Synchronize

Wait until response received from camera

Take_Snapshot

   Camera_Execute_Snapshot

Receive_Snapshot

   Store_into_Flash

Upload to FTP site

Close_Connection
```
EMBEDDED LINUX BASED CONTROL and DATA ACQUISITION SYSTEM

Main Menu > > Snapshot

admin@embedded.com.tr
GPS

- The embedded board acquires raw data periodically.
- The program transfers the selected GPS data to the memory after compiling a bulk of raw data.
- The newest GPS data are exchanged with the oldest data using the memory as a FIFO buffer.
Interpreting Raw GPS data

$GPBOD – Bearing, origin to destination
$GPBWC – Bearing and distance to waypoint, great circle
$GPGGA – Global Positioning System Fix Data
$GPGLL – Geographic position, latitude / longitude
$GPGSA – GPS DOP and active satellites
$GPGSV – GPS Satellites in view
$GPHDT – Heading, True
$GPR00 – List of waypoints in currently active route
$GPRMA – Recommended minimum specific Loran-C data
$GPRMB – Recommended minimum navigation info
$GPRMC – Recommended minimum specific GPS/Transit data
$GPRTE – Routes
$GPTRF – Transit Fix Data
$GPSTN – Multiple Data ID
$GPVVBW – Dual Ground / Water Speed
$GPVTG – Track made good and ground speed
$GPWPL – Waypoint location
$GPXTE – Cross-track error, Measured
$GPZDA – Date & Time
# Interpreting GPS data

## $GPGGA

Global Positioning System Fix Data

<table>
<thead>
<tr>
<th>Name</th>
<th>Example Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentence Identifier</td>
<td>$GPGGA</td>
<td>Global Positioning System Fix Data</td>
</tr>
<tr>
<td>Time</td>
<td>170834</td>
<td>17:08:34 Z</td>
</tr>
<tr>
<td>Latitude</td>
<td>4124.8963, N</td>
<td>41d 24.8963' N or 41d 24' 54&quot; N</td>
</tr>
<tr>
<td>Longitude</td>
<td>08151.6838, W</td>
<td>81d 51.6838' W or 81d 51' 41&quot; W</td>
</tr>
<tr>
<td>Fix Quality:</td>
<td>1</td>
<td>Data is from a GPS fix</td>
</tr>
<tr>
<td>- 0 = Invalid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1 = GPS fix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 2 = DGPS fix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Satellites</td>
<td>05</td>
<td>5 Satellites are in view</td>
</tr>
<tr>
<td>Horizontal Dilution of Precision (HDOP)</td>
<td>1.5</td>
<td>Relative accuracy of horizontal position</td>
</tr>
<tr>
<td>Altitude</td>
<td>280.2, M</td>
<td>280.2 meters above mean sea level</td>
</tr>
<tr>
<td>Height of geoid above WGS84 ellipsoid</td>
<td>-34.0, M</td>
<td>-34.0 meters</td>
</tr>
<tr>
<td>Time since last DGPS update</td>
<td>blank</td>
<td>No last update</td>
</tr>
<tr>
<td>DGPS reference station id</td>
<td>blank</td>
<td>No station id</td>
</tr>
<tr>
<td>Checksum</td>
<td>*75</td>
<td>Used by program to check for transmission errors</td>
</tr>
</tbody>
</table>

Courtesy of [Brian McClure, N8PQI](http://www.n8pq.com).
GPGGA Information

- The GPGGA information is parsed from the raw data and stored in a file.

<table>
<thead>
<tr>
<th>Type</th>
<th>$GPGGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTC time</td>
<td>151732</td>
</tr>
<tr>
<td>Latitude</td>
<td>3952.1503,N</td>
</tr>
<tr>
<td>Longitude</td>
<td>3244.1166,E</td>
</tr>
<tr>
<td>Number of Satellites Connected</td>
<td>03</td>
</tr>
<tr>
<td>Altitude</td>
<td>1172.4,M</td>
</tr>
</tbody>
</table>
Visually tracking the system using GPS

• The system can be set to visually track the current location of the embedded system on a map.

• An icon that represents a vehicle is inserted into the location using basic frames in html, utilizing the latest coordinate information from the GPS data.

• The GPS accuracy of the measurements is less than 15 m.
EMBEDDED LINUX BASED CONTROL and DATA ACQUISITION SYSTEM

Main Menu

- LAST INFORMATION
- VELOCITY GRAPHICS
- ALTITUDE GRAPHICS
- VELOCITY ARCHIVE
- TEMPERATURE
- LAST NEW PHOTO

admin@embedded.tr

BACK <<
Temperature

• Low cost temperature measurement chip (DS1620) is used to collect ambient temperature

• Accuracy of 0.5 °C.

• This chip is attached to the parallel port of the embedded board.

• A daemon is initiated at boot time to sample and display the temperature every 30 s for a time interval of 15 min.
Embedded Linux Based Control and Data Acquisition System
Conclusion

• Compared with traditional DAQ systems, this system has following advantages
  • Allowing direct bidirectional communication
  • Reducing overhead.
  • The operational costs have been reduced

• Future Scope:
  • Power Conservation
References

1. http://aprs.gids.nl/nmea/
2. GPS fix data - Courtesy of Brian McClure, N8PQI. www.slat.org/project
3. www.wikipedia.com
4. Photos Retrieved From: Google Image Search