Indoor Positioning System

Robert Brännström

BACHELOR OF SCIENCE PROGRAMME
COMPUTER ENGINEERING
Skellefteå Campus
PREFACE

This thesis represents my ten week long Bachelor's project at Ericsson Erisoft AB in Ursviken at section N/TA.

This project is the final assignment to get my bachelor's degree in computer engineering at Luleå University of Technology, the institution in Skellefteå.

I would like to give a thank you note to everyone at Erisoft and at Optronic that helped me during this project.

Ursviken 2001-06-01

Robert Brännström
PURPOSE

The purpose of this document is to complete the written part of my bachelor’s project in computer engineering.

First it describes the background and the goal for the project.

Then follows a description of the environment surrounding the application.

A review of the design and functionality of the application is followed by a discussion about the result of the project.
ABSTRACT

Indoor performance is of great interest for the network operators, especially in office buildings and airports. Because current GPS receivers do not work indoors, the need of gaining positions by another tool is crucial.

Ericsson Erisoft AB develops and markets TEMS Automatic, a system that measures the quality of service experienced by the users of the mobile network. The Mobile Test Unit acts as a simulated subscriber and saves measurements together with position information in logfiles.

The purpose of this thesis is to develop an indoor positioning tool, able to generate simulated GPS positions from a map.

The tool should behave like a regular GPS receiver and communicate with a Mobile Test Unit through a com-port by supporting two standard protocols, TAIP and NMEA.

The indoor positioning tool will be included in the TEMS Automatic system.
TABLE OF CONTENTS

PREFACE ..............................................................................................................1

PURPOSE ..............................................................................................................2

ABSTRACT ...........................................................................................................3

1 INTRODUCTION ..............................................................................................5
  1.1 BACKGROUND............................................................................................5
  1.2 GOALS...........................................................................................................5
  1.3 ABBREVIATIONS........................................................................................5
  1.4 THESIS ..........................................................................................................6
  1.5 TUTORIAL, TIME AND PLACE ......................................................................6

2 METHODS..........................................................................................................7
  2.1 HARDWARE.................................................................................................7
  2.2 SOFTWARE..................................................................................................7
  2.3 TEMS AUTOMATIC ....................................................................................8
  2.4 EARTH COORDINATE GEOMETRY ......................................................10

3 APPLICATION ................................................................................................11
  3.1 SYSTEM REQUIREMENTS ......................................................................11
  3.2 DESIGN .......................................................................................................11
  3.3 FUNCTIONALITY ......................................................................................13

4 DISCUSSION....................................................................................................16

5 REFERENCES .................................................................................................17

6 APPENDIX A – DESIGN MODEL ................................................................18

7 APPENDIX B – TAIP AND NMEA PROTOCOLS .....................................19
1 Introduction

1.1 Background

Ericsson Erisoft develops and markets the TEMS product family used for optimization of cellular networks. One of the tools, TEMS Automatic, measures the quality of service experienced by the users of the mobile network.

Indoor performance is of great interest for the network operators, especially in office buildings and airports. Because current GPS receivers do not work indoors, the need of gaining positions by another tool is crucial.

This Bachelor's project is continuing on a pre-study made by a software project at Luleå University of Technology, the institution in Skellefteå.

1.2 Goals

The goal for this thesis is to develop an indoor positioning tool, able to generate simulated GPS positions from a map.

The tool should behave like a regular GPS receiver and communicate with the MTU through a com-port by supporting two standard protocols, TAIP and NMEA.

If possible control the behavior and show status of the connected MTU.

1.3 Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPS</td>
<td>Indoor Positioning System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>TAIP</td>
<td>Trimble ASCII Interface Protocol</td>
</tr>
<tr>
<td>NMEA</td>
<td>National Marine Electronics Association</td>
</tr>
<tr>
<td>MTU</td>
<td>Mobile Test Unit</td>
</tr>
<tr>
<td>TAB</td>
<td>File format for map coordinates</td>
</tr>
<tr>
<td>ROT</td>
<td>File format for waypoint positions</td>
</tr>
<tr>
<td>BMP</td>
<td>Bitmap file format, used for map picture</td>
</tr>
<tr>
<td>WP</td>
<td>Waypoint, corner points building a route</td>
</tr>
<tr>
<td>DR</td>
<td>Dead Reckoning, navigation system</td>
</tr>
</tbody>
</table>
1.4 Thesis

This thesis was carried out as a project according to the Ericsson project management model, PROPS. An assignment specification together with the results from the pre-study was my input to the feasibility study.

During the study I made a project specification and a requirement specification. The project specification contained the purpose and background of the thesis and a time schedule, including milestones and tollgates defining how my work should progress. It also described what documents and presentations the university and Erisoft expected from me.

In the requirement specification I described all requirements, physical and operational, of the product.

In the execution phase I analyzed the applications from the pre-study and presented them to the product management, to let them choose which one to use as construction basis. I then redesigned the architecture and layout of the application and developed what became my solution to an indoor positioning tool.

In the conclusion phase I wrote this report and other documents needed to install and use the IPS.

1.5 Tutorial, time and place

For tutor I was designated Lars Boman, software engineer at section N/TA at Ericsson Erisoft AB in Urviken.

The Bachelor's project was performed at Ericsson Erisoft AB during the period 2001-03-20 to 2001-06-01.
2 Methods

2.1 Hardware

The IPS consists of an application running on a handheld computer (Compaq iPAQ H3630) with Microsoft Pocket PC (Windows CE 3.0) and a Mobile Test Unit.

Serial communication is used between the Pocket PC COM port to the MTU's GPS/DR port. A serial cable with a special connector must be used. A battery and a GSM antenna must be connected to the MTU.

Fig 1. - IPS consists of a Handheld PC and a MTU.

2.2 Software

The software is written in C++ in the Microsoft eMbedded Visual C++ 3.0 environment in Windows NT 4.0.

When I redesigned the application I used Rational Rose RealTime to create an object-oriented architecture with UML notation.

The TEMS product family follows a TEMS standard. I followed the design guidelines in my layout to achieve the specific TEMS look.

The IPS application is built of a number of components and an all-enclosing executable.

The application components are implemented in separated objects to ensure that one task is only done at one place.
2.3 TEMS Automatic

System Overview

Ericsson Erisoft AB has developed a product family called TEMS.

TEMS Automatic is a system for analyzing the signal quality and accessibility in wireless networks. Its main functions are to verify the network quality, to provide information for network optimization and to verify the quality experienced by the users of the mobile network service.

The system consists of Mobile Test Units, MTUs, usually placed in vehicles on the move in the operator's network area, and one or more administration centers with Communication Servers and Operator Consoles for system administration. TEMS Presentation, TEMS Statistics and TEMS Report are tools for data analysis and presentation.

Each MTU acts as a simulated subscriber. It initiates and receives calls at certain times and in certain places, as prescribed in the measurement orders sent from the administration center. A set of modems and a Communication Server constitute the fixed side of the communication link.

TEMS Automatic operates autonomously. This means that all the measurement, as well as the result collection; result storage and transmission of data are done automatically according to the measurement orders set up by the operator.
Mobile Test Unit (MTU)

The MTU contains an air interface measurement device and the hardware and software needed to perform the field measurements. It is usually installed in a vehicle to enable collection of measurement data in realistic conditions with respect to geography, movement, radio environment, etc.

The MTU stores all the measurements as logfiles, which later are sent to the central server over the air in the GSM data channel.

The MTU has two DSUB 25 female connectors, COM A and COM B. Via the COM B port the RS232 port used for GPS and DR communication are accessible.

![Pin configuration of serial cable between MTU and iPAQ.](image)

Fig 3. – Pin configuration of serial cable between MTU and iPAQ.

![Mobile Test Unit.](image)

Fig 4. - Mobile Test Unit.
2.4 Earth coordinate geometry

Latitude – Angle from the Equator plane to a circle parallel to the Equator. Range from 0° – 90° designated as North (+) or South (-). The Equator is the Latitude of Origin, Lat = 0°.

Longitude – Angle between the prime meridian and a meridian circle (passing through North and South poles). Prime meridian – Greenwich, is the Longitude of Origin, Long=0°. Range from 0° – 180° designated as East (+) or West (-).

Sample: Ericsson Erisoft in Ursviken
Lat: 64° 41′ 54.51432″ (deg/min/sec) or 64.6984762° (deg)
Long: 21° 11′ 21.69591″ (deg/min/sec) or 21.1893600° (deg)

1° (deg) = 60′ (min), 1′ (min) = 60″ (sec)

Length of lines on earth:

Meridional lengths (latitude) is not constant because of polar flattering (< 1m / deg). Parallel length (longitude) decreases towards the poles (see fig. 6).

Fig. 5, 6 - Longitude and Latitude, 15° angle between lines.

3 Application
3.1 System Requirements

To use the Indoor Positioning System the handheld must be connected to the MTU by using the appropriate serial cable.

A work order must be prepared to enable MTU measurement.

The application needs to be activated on the handheld before the user turn on the MTU.

3.2 Design

The whole application is built of a number of components and an all-enclosing executable. The relationship between components is described in Appendix A.

The IPS application is built as a Single Document Template from the Microsoft Foundation Class library, which implements the single document interface (SDI). The document template defines the relationship between a document class, a view class and a frame window class.

Important components in the IPS system and their objectives:

**IPSA**

Application “main” object.
The main frame interface for the user.
Holds a toolbar and a menubar.
Handles menubar selections.
Connects all other objects.

**GraphicView**

Handles the graphical view (scrolling, drawing the blueprint, waypoints etc.). Handles toolbar button selections, Navigator button selections and screen input.
SerialCOM

Handles the serial communication with the MTU.
Creates a thread to read messages from the port.
Offers a public method to send messages on the port.

ConfigData

Stores all data needed by the application.
Offers methods to get and set various data.

FileHandler

Handles the “disk access”.
Load BMP / TAB / ROT-files.
Save TAB / ROT-files.

PositionHandler

Simulates the positions from a GPS.
Uses the positioned map to calculate the current position on to real coordinates.
Calculates new speed when reaching a waypoint.
Creates GPS messages and send via SerialCOM.

Calculator

Calculates Angle to the North and Scale on blueprint.
Calculates Heading and converts screen pixels to GPS positions.

GPSMessage (TAIP & NMEA)

The two protocols, that will be in use for communication with the MTU.
TAIP – messages [AL, CP, ID, LN, PT, PV, RM, ST, TM, VR, X1]
NMEA – messages [GGA, GLL, GSV, RMC, VTG, GSA]

3.3 Functionality
The application basis is a positioned map that all the calculations build on. The first thing the user has to do is to open an already positioned map (TAB) or open a bitmap (BMP) and position it.

Fig 7. – File \Open menu.

Configuration dialog
The configuration dialog has three tabs. The first is used to position a bitmap, the second to alter communication settings and the third to set walking speed and message timing.

**Route**

Fig 8. – Map positioning dialog.

Then the user chooses a route to walk either by opening a predefined route or by adding waypoints to the map.

- ![Add WP](image)
- ![Delete WP](image)

When the Add WP button is active, the user can add a waypoint to the map by tapping the screen.

With the Delete WP button, the user can delete a waypoint by tapping the screen.
By pressing play the application starts sending current position and activates the pause function.

![Pause Button]

By pressing the unpause button the virtual user (👤) starts to move along the route.

![Unpause Button]

The pause and stop buttons can be pressed to pause and stop the movement.

![Pause and Stop Buttons]

It is possible to zoom in and out.

It is also possible to go to normal zoomfactor, focus on first or last waypoint and send a message to the MTU.

![Zoom and Options Menu]

Fig 9. – File \ Options menu.

4 Discussion
This thesis shows that it is possible to generate simulated GPS positions from a map, and send them via standard protocols to a Mobile Test Unit, which performs measurements.

The progress of my Bachelor’s project has followed the stated time schedule and tollgates and milestones have been passed on time.

Early in the project I detected that other communication than GPS positioning with the MTU was difficult to achieve. The MTU sends TRACE messages that could be used for status indication, but on another port. The iPAQ has only one COM port as standard. Another problem was that the MTU is not possible to control from a COM port. These problems were discussed at Erisoft and they realized that there has to be changes in the MTU before these functions can work. They decided that these problems should not be dealt with in my project. A new project was initialized to deal with the changes needed to include the indoor solution in the TEMS Automatic system. I have prepared the application to meet this functionality.

Another problem I detected was that the calculations of map corners and the positioning on the map did not work when the map was turned at an angle versus the North. I had to adjust the calculations done in the pre-study.

In the pre-study there was no test of the TAIP messages and I found out that it was not correctly implemented. I had to do some studying of the TAIP protocol before I got it right.

The TAIP protocol is used bi-directional between the MTU and the handheld. Because of this the application has to be able to read from the COM port and answer the messages arriving. This was not implemented in the pre-study.

The IPS needs to be active on the handheld because at initiation, the MTU send a request for version and time to the GPS / IPS. It also sets the frequency to send different messages.

The IPS answers with version and time and starts to send positions to the MTU.

The positions sent to the MTU are N90°, E90° (North Pole) because of there is no current position before the user has opened a map, set a route and pressed play.

5 References
On the Web:

http://www.lantmateriet.com
“Specialists in geographic information”

http://www.mercat.com/QUEST/gpstutor.htm
“The GPS tutor”

http://www.ericsson.com/tems
“Ericsson external web, TEMS products”

http://www.sa.erisoft.se
“Ericsson Erisoft internal web”

Literatures:

Trimble Navigation Limited
System Designer Reference Manual

Ericsson Project Management Institute
PROPS – A general model for project management in a multiproject organization

6 Appendix A – Design model
### 7 Appendix B – TAIP and NMEA protocols
The IPS application supports both the Trimble ASCII Interface Protocol and the National Marine Electronics Association protocol.

Both are based on ASCII characters and include a computed checksum.

**TAIP**

IPS supports messages AL, CP, ID, LN, PT, PV, RM, ST, VR and X1.

TAIP message format is in printable uppercase ASCII characters. Each sentence starts with a “>” and ends with a “<”.

First in the message there is a qualifier and a two character message identifier. Then the message information follows and an optional two character checksum.

Sample: Time/Date report

>`RTM0857590002205200100602100000;*61<`

**NMEA**

IPS supports messages GGA, GLL, GSV, RMC, VTG and GSA.

NMEA messages are limited to 79 characters or less. Each message starts with a “$” and ends with [CR][LF].

Sample: GPS Fix Data message

`$GPGGA,090752,6441.9797,N,02111.2337E,1,04,0.9,000.0M,46.9M,,*,*?`