Lifetch

Interim Report

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1. Introduction

Regardless of fast development of technology and human knowledge, so vivid especially during the last few decades, year by year accident statistics in lonesome areas often visited by hikers, such as national parks and mountainous terrains, remain the same. One can reach a conclusion, that existing safety precautions are clearly insufficient. There is no publicly available system operating over a vast area that would improve safety through fast and effective reaction to an emergency situation regardless of the type of the accident and capability of the user to call for help. As of now, lack of feedback from people under threat or those near them makes detecting emergencies virtually impossible.

The discussion summarized above is the result of numerous consultations, brainstorming sessions and a needs analysis. It led us to the idea of designing a system solving all these problems: **Lifetch**. It is based on distributed personal units (we call them ICUs[1]) that combine modules such as: a GPS receiver, a Radio Frequency transceiver and sensors that measure temperature, ambient light and acceleration. These units communicate with each other over RF and exchange information gathered from the sources mentioned above. The ICUs may transmit their data to the Command Center using GPRS or, should it fail, the message passing system working on a Radio Frequency. The Command Center is the heart of our system and maintains its global status. It stores all the information in the database and processes it through several subsystems. The goal of these activities is to help the operator to ensure the safety of the people protected by the system.

2. Benefits of project

In order to find whether our project is justified, we decided on a real-life approach to establish the benefits that come from introducing the **Lifetch** system. Our needs analysis was done in the following way: we carried out research on the archival materials of the Polish Mountain Rescue Organization and selected over 200 mountain accident cases. Over 80 of these cases included fatalities. The outcome of the analysis showed that in 71% of these cases the effects of accidents could be minimized or even avoided if our system had been introduced.

Improvements raising the safety level apply to the following matters:

- Our system automatically discovers potentially dangerous situations such as abnormal behavior of people and therefore opens more possibilities to react to these situations.
- The system enables the park rangers to substantially reduce the time of locating a missing person, therefore increasing his chances of survival.

[1] ICU – Intelligent Communication Unit

- The system also brings the possibility to monitor and analyze the traffic in national parks or other areas. This can become an important factor while making decisions concerning further safety improvements or even running environment protection procedures.
- Furthermore, the system puts a strong emphasis on group cooperation. The group leader has full information about the status of his group, whereas a member can easily locate the group and find the right track even in difficult weather conditions. This can be particularly useful for groups of tourists hiking with a guide, as well as for a team of rangers performing a rescue operation.

3. Innovation

Cellular telecommunication technology is treated as one of the means to solve the safety problem. Undisputedly, many lives have been saved thanks to the services it provides. However, we observed three major shortcomings that limit its application in the field of assuring safety.

- To call for help, the person under threat must be physically able to do it (conscious) and furthermore must be in the GSM network range.
- Localization techniques based on GSM might not work or would provide low precision in sparsely populated areas and require the phone to be turned on.
- In its basic functionality, the GSM network management system does not provide transparent access to location history.

The advantage of our project lies in combining location, multi-sensor and group cooperation services in a single device (**ICU**). **ICU**s are interconnected through a distributed network and submit data for global-scale analysis to a monitoring system acquiring information also from maps, weather services and other sources.

Our system is an overlay over the existing GSM infrastructure to create a distributed safety network that could be operated by a commercial or non-profit organization. Some functionalities could be implemented by adding a dedicated client program on terminals and some management functions over the standard GSM system, however, there are some unique functionalities realized by our system with a specialized hardware unit:

- Our units communicate with the **Command Center** regardless of the condition of the unit owner. This means that even if the person is unconscious and has no possibility to physically call for help, the unit will transmit the information about his location and rescue teams will be able to arrive.
- To decide upon signaling the alarm the system uses a rule-based expert system. Thus this capability does not require the ICU owner to periodically report his state.

- To alleviate the consequences of losing GSM coverage we are using distributed message passing. The ICUs are working as a net of store-and-forward routers without any intervention of their owners.
- We have taken steps to ensure that the users' privacy is not infringed.
- A distance between two ICU unit could be measured by with much greater accuracy then by using the GSM/GPRS system
- There is a possibility to send messages to a selected group of people, whose **ICU**'s parameters comply with certain criteria, for example sending a warning message to people being in an area undergoing a radical change of weather conditions.

4. System organization

The **Lifetch** project consists of various hardware and software modules closely interacting with each other.

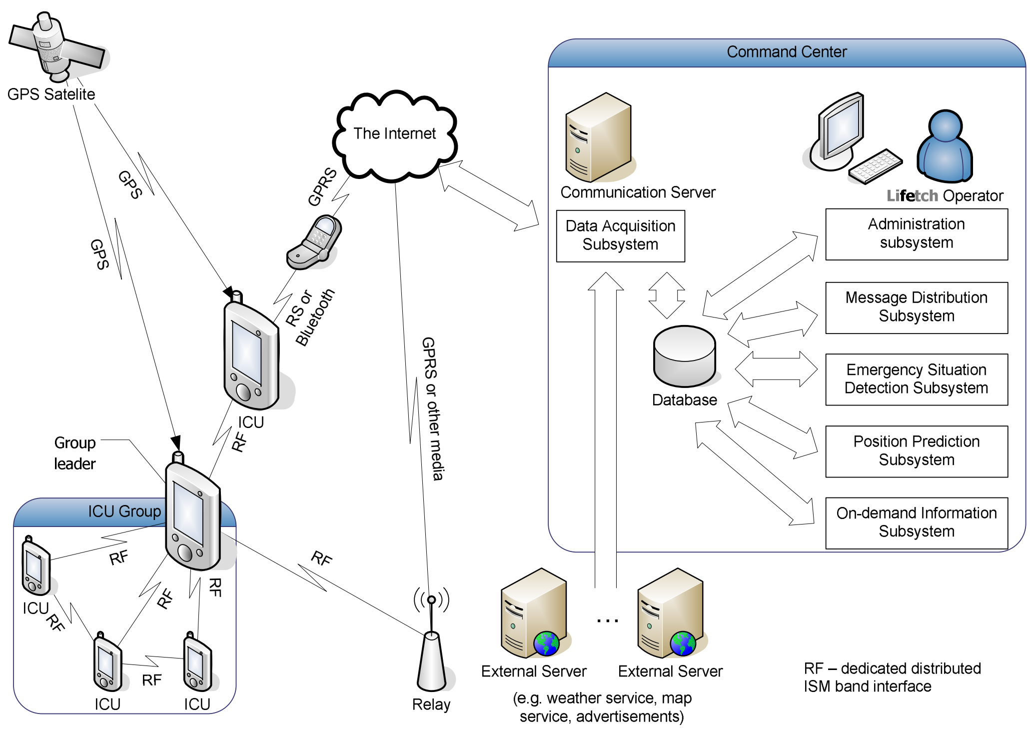

Figure 4.1. System organization and interaction of functions

4.1. Hardware elements

ICU – Intelligent Communication Unit. Each **ICU** is assigned to one person under protection of **Lifetch**. The unit sends messages containing processed information from its sensors to the **Command Center** and to other **ICU**s. The **ICU** contains a GPS receiver and a RF transceiver, operating in the unrestricted band around 900 MHz. Another means of communication is provided by a GPRS-capable cellular phone connected to the **ICU**. The **ICU** can be also used as a monitoring device for the group leader allowing him to control the status of group members.

Relay – The primary role of the **Relay** can be carried out by any device that has an active Internet connection and is able to communicate with the **ICU**s through RF. **Relay** serves as a gateway between the distributed RF network and the **Command Center**.

4.2. The software

Data Acquisition Subsystem – The main responsibility of this module is to communicate with all **Lifetch** devices via Internet. The obtained data is transferred and stored in the Database.

Emergency Situation Detection Subsystem – This is a rule-based subsystem providing information about potentially dangerous situations based on correlations in data gathered from **ICU**s. When such a situation is detected, this subsystem informs the operator who can decide whether there is need for an emergency action or other system measures (e.g. requesting contact from the user) should be undertaken.

Position Prediction Subsystem – This software establishes with a significant accuracy the probable current position of a missing person. A major problem arises when the person is not in the GPRS range. Actual position prediction is performed basing on the last position, information from other **ICU**s ("last seen near" messages), direction and velocity. The system is also terrain aware.

Message Distribution Subsystem – Allows broadcasting messages to people meeting the given criteria – for example informing all the people in a certain area about forecasted rapid changes in weather conditions.

On-demand Information Service Subsystem – Provides **ICU** users with maps or textual information relevant to current or predicted environmental conditions in their vicinity.

Administration Subsystem – Allows the operator to perform maintenance tasks such as registering new **ICU**s or unregistering the returned ones.

5. Principles of operation

5.1. Hardware construction

We decided to use full-custom hardware for the **ICU** instead of an off-the-shelf PDA, because no PDA now available on the market could support the rich array of sensors and maintain low power operation. We have set a goal of reaching very low current consumption in order to prolong battery life and provide the user with a small and reliable device.

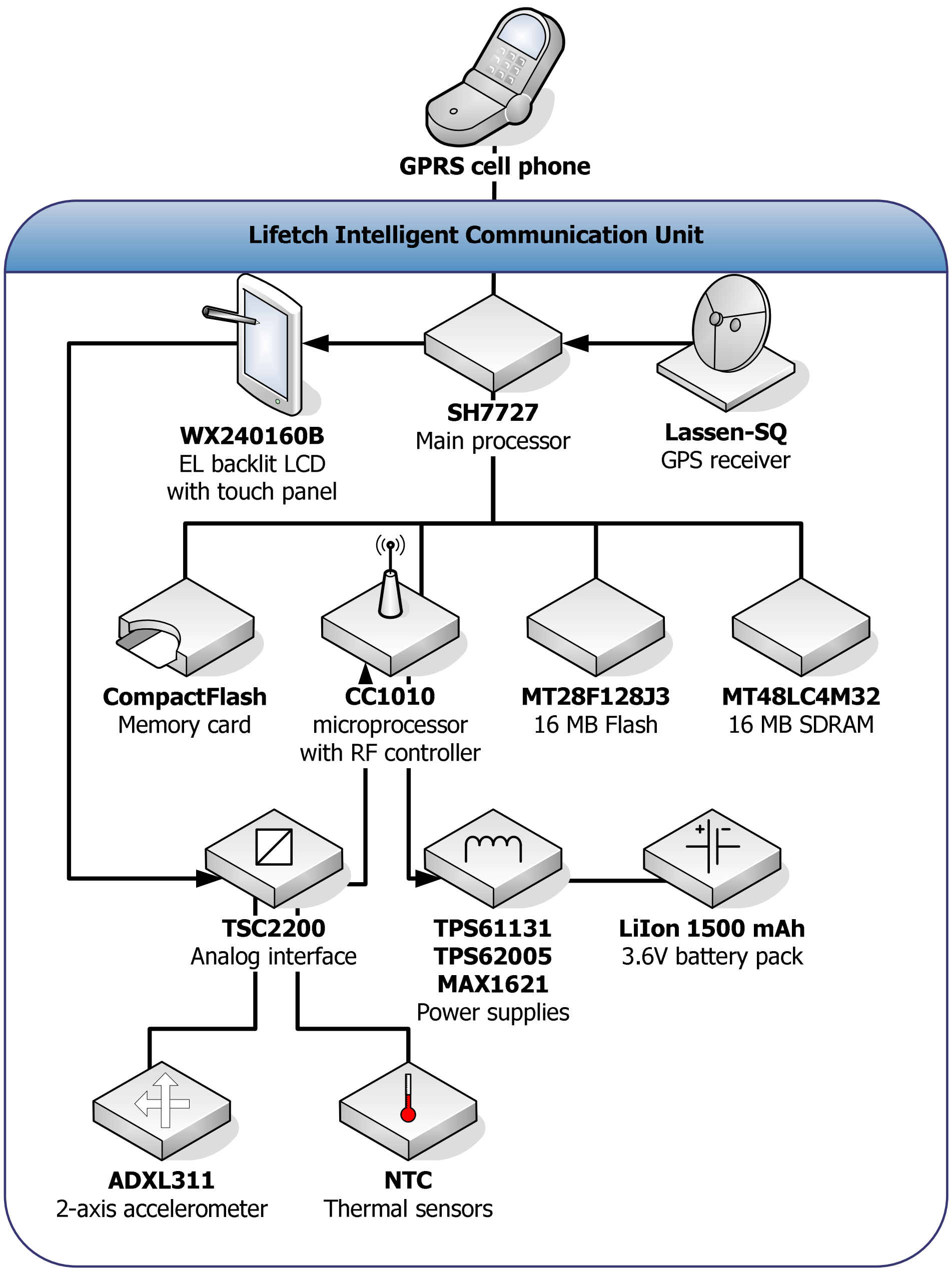

Figure 5.1. Block diagram of a single **ICU**

The **ICU** hardware is built around two processors. The main processor controls GPRS (via Bluetooth or a serial port), GPS access and services the LCD. The RF controller fulfills the tasks of formatting packets, encrypting content, correcting transmission errors (ECC[2]) and waking up the main processor when it is required. The integrated microprocessor in the RF controller monitors the touch panel and analog inputs (temperature, ambient light, acceleration). It also powers up the remaining devices on demand.

5.2. Communication protocol

The communication protocol is based on a dynamic combination of distributed and centralized networks. If an **ICU** is located in an area without GSM coverage or it is deprived of GSM access in any other way, it cannot use GPRS for direct communication with the **Command Center**. In such cases, the **ICU** will fall back to a distributed radio network. This network operates in the unlicensed ISM[3] band and is also used for detection of nearby **ICU**s for position prediction. Appendix B presents two sample diagrams of network interactions.

Data transfers in the distributed network are encrypted and optionally signed to protect user privacy. We are using specialized 3DES hardware and software implementation of hash and public key algorithms.

5.3. Emergency Situation Detection Subsystem

The emergency situation detection subsystem is in fact an expert system. Thus rules are defined on the base of expert knowledge. They take into consideration the following factors: time and position, weather conditions, acceleration, temperature, etc. **ICU**s may be designated to different categories. Appendix C presents some sample rule sets used by the system.

5.4. User interface

The **ICU** user interface is based on a LCD with a touch panel. **ICU** owners can navigate through a simple menu interface. Available views include group member locations (optional), maps and data presented by the On-Demand Information Subsystem, archive of warnings and other system messages. The device performs many of the usual functions of a GPS receiver.

The explicit help request can be issued from any menu level.

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[2] ECC – Error Correcting Codes

[3] ISM – Industrial, Scientific, Medical

6. Development plan

During the planning phase of our project we spent a lot of time to divide the project objectives into well defined tasks. Due to special skills and preferences of the team members, general assignment of work is as follows:

Stanislaw – Hardware development

Wojciech – Firmware development

Krzysztof – Software development

Bartosz – Software development

The duration and dependencies of the particular tasks were constrained. Appendix D shows the exact Gantt diagram representing our work plan prepared using Microsoft Project 2003 Pro.

We plan to develop our **Command Center** software in Microsoft Visual C++ .NET 2003. In order to design our hardware we use Protel 99 SE.

7. Cost

Despite using custom-built hardware we managed to stay well within the 400 USD spending limit. We did not include the cellular phone in our calculations because most potential users would already have one.

Because one of target placements of our device are organized groups, we decided that implementing GPS positioning service in all **ICU**s belonging to a group would be a misallocation of resources. Most of group members keep close to their leader, so it is enough to know the leader's exact position to estimate their locations. A full-screen display is also not needed for members since their activities in the system are limited to acknowledging their presence. Removing the big LCD and the GPS module yielded a cost saving of about 100 USD, which is a half of a price of a complete device.

The complete price list is enclosed in Appendix A.

8. Outcome

The outcome of this project will be a design of a reliable safety system. Thanks to modular design and open architecture the system will be easily extendable.

Appendix A

Detailed price list for the **Lifetch ICU:**

Device	Function	Price (USD)
HD6417727F-160	SuperH microprocessor	22.65
WX240160B (**ICU** "pro")	LCD with touch panel	30.70
MT28F128J3-RG	16 MB Flash memory	8.32
MT48LC4M32B2-TG	16 MB PC-133 SDRAM	6.73
CC1010	SmartRF transceiver	7.50
Lassen-SQ (**ICU** "pro")	GPS receiver module	48.00
GeoHelix-S (**ICU** "pro")	GPS active antenna	23.00
LiIon 1500 mAh	battery (for Nokia phone)	10.00
TSC2200	touch screen controller	2.40
TPS61131	3.3V switching power supply	2.05
TPS62005	1.8V step-down power supply	1.60
TPS2214A	hex power switch for 3.3V	2.85
MAX1621	digitally adjustable LCD bias supply	1.99
ADXL311	low cost dual axis accelerometer	5.10
ADP3820	single cell LiIon charge controller	0.95
TL16C752B	dual UART with 64-byte FIFO	3.10
PC Board	printed circuit board (4-layer)	20.00
glue logic	digital logic for interworking functions	5.00
passives	passive elements (decoupling, power)	8.00
TOTAL for **ICU** "pro"	for all areas – estimated device cost	209.94
TOTAL for **ICU** "econo"	estimated device cost (econo version)	108.24

Table A.1. Hardware price list

Appendix B

In this appendix two sample schemes of **ICU** interaction are presented. The schemes cover typical situations encountered during **ICU** operation.

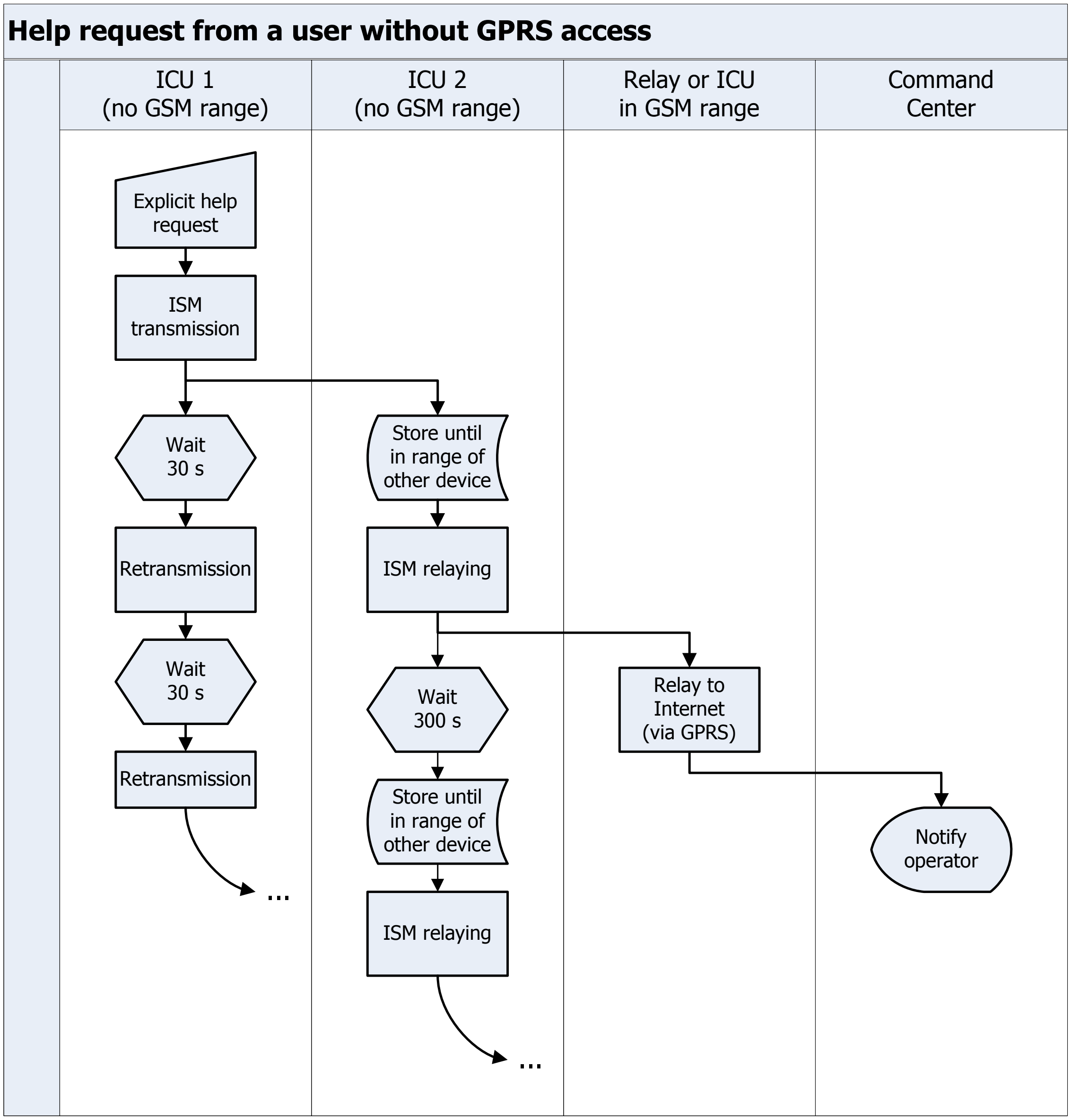

Figure B.1. System message exchange during a help request

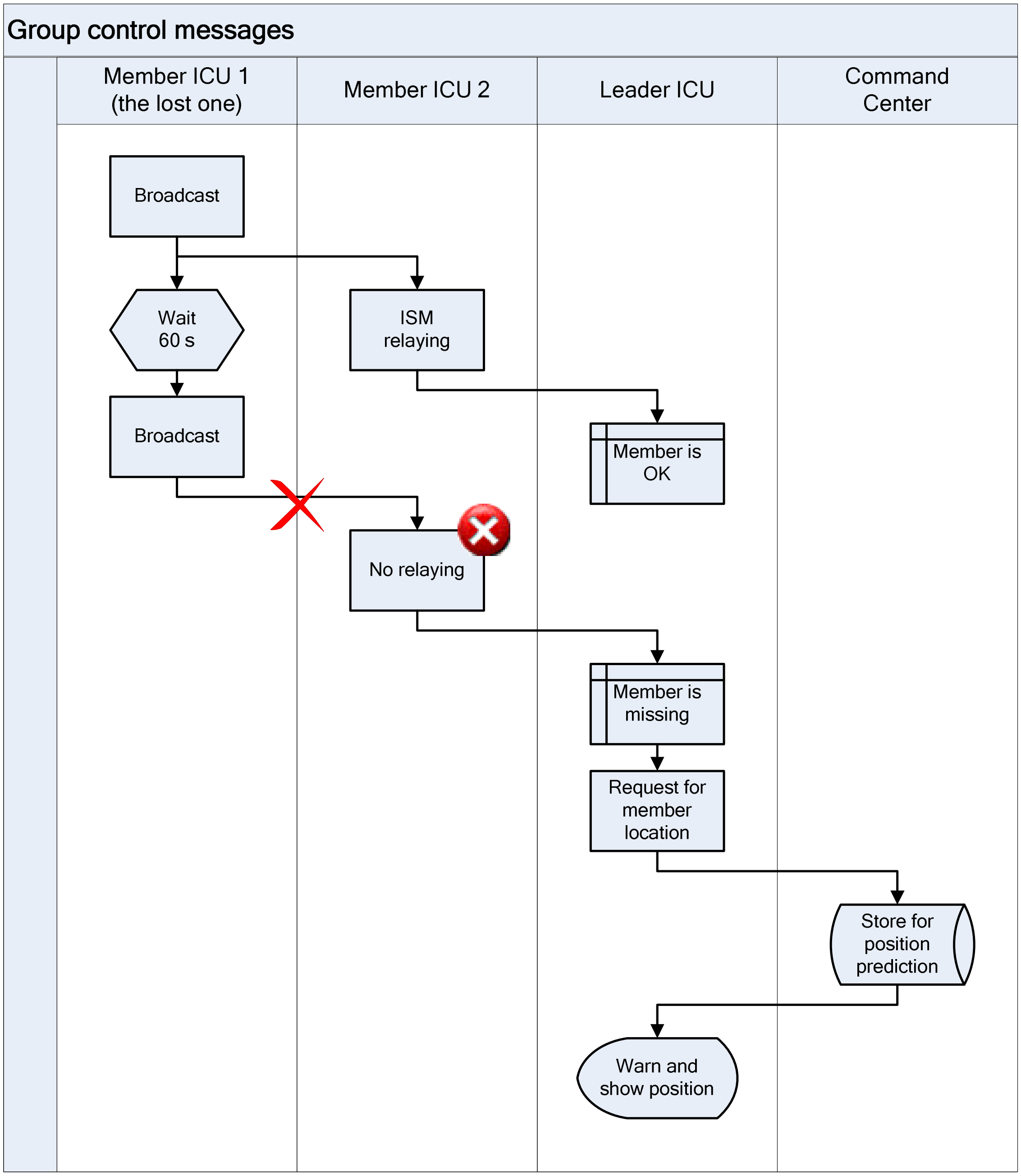

Figure B.2. Group control message exchange

Appendix C

This appendix presents sample rules for the emergency detection subsystem that could be reasonably applied in a national park:

```
if ICU.category is hiker then
      if distance(ICU.position, route) > threshold_distance
            send "are you OK?" to ICU
            set flag expect_response
      if flag expect_response.time_set > threshold_response_time
            signal "-- ICU not responding --"
      if ICU.last_report.position in dangerous_area
            if ICU.reporting
                  send "watch out!" to ICU
            else
                  signal "-- hiker in dangerous area --"
      if ICU.last_report.time - current_time > threshold_report_time
            signal "-- hiker disappeared --"

if ICU.category is paraglider
      if delta(ICU.altitude) > threshold_altitude_change
            signal "-- paraglider falling --"

if ICU.category is ski
      if ICU.acceleration > threshold_acceleration and
         ICU.speed < threshold_speed
            signal "-- ski collision --"
```

Appendix D

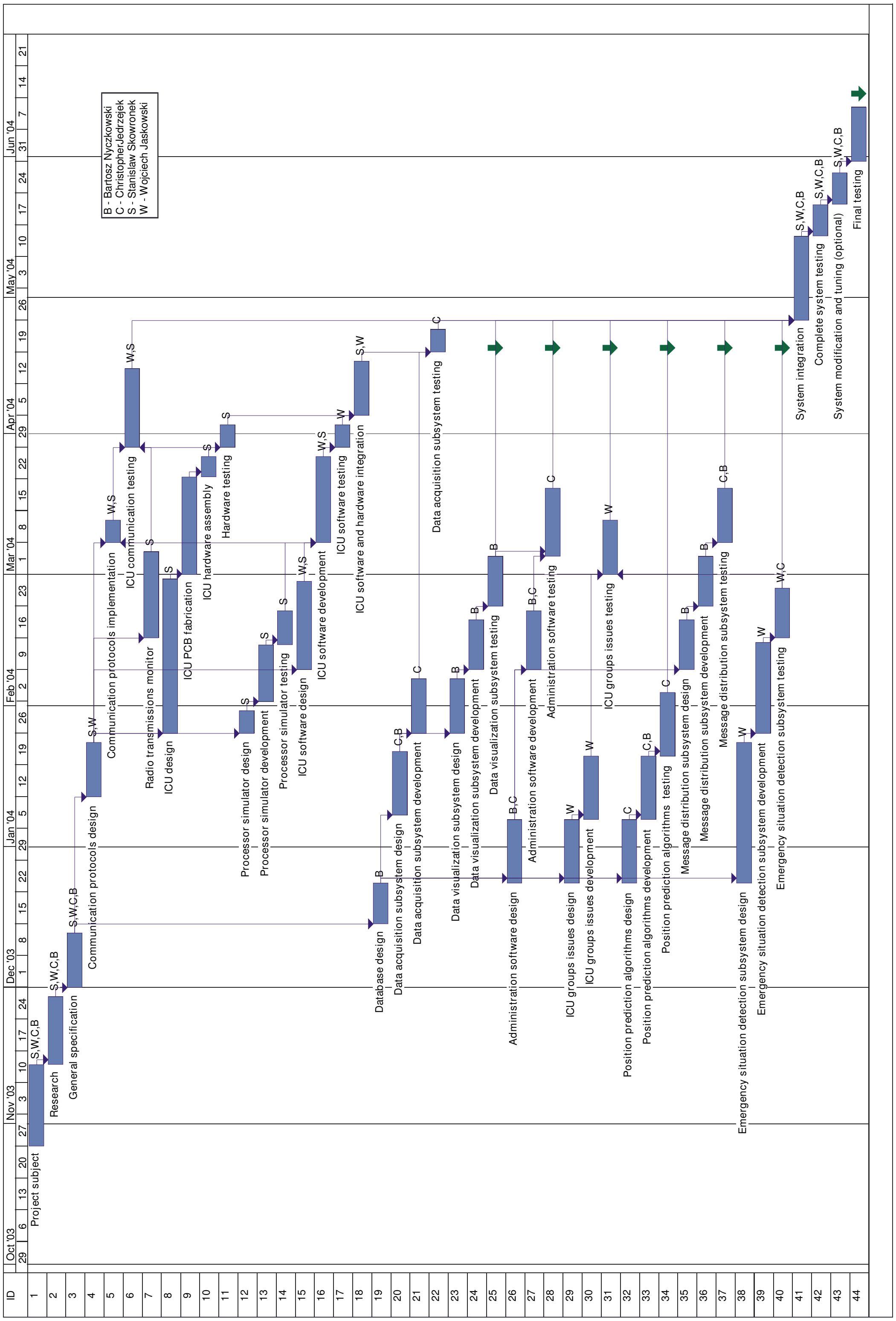

Figure D.1. Development plan – Gantt chart