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Experimental Mobile Wireless GRASS based GIS for Handheld computers running GNU/Linux

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1 Introduction

Dynamical development of the communication technologies in the last years brings a new dimension to an area of Geographical Information Systems (GIS) and Geoinformation technologies (GIT) in general. That new dimension is a mobility. It brings an ability of simplification to data-mining, processing and presentation no matter from what application field the data is. It is an ideal resource for the applications that require fast data manipulation in the field. There is some complex GIS software for handheld devices available on the market, but until the Mobile Wireless GRASS based GIS (Baby GRASS) was developed during my stage in ITC-irst there was no one Open Source and customized for handheld computers running GNU Linux.

2 Mobile Geoinformation Technologies

Mobile geoinformation technologies could be characterised as information technologies, that are targeted to processing of spatial data and information and are actively using communication technologies to transfer data between mobile clients or mobile clients and control centre. Mobile GIT use knowledge of actual client position for problem solving.

Main technologies used to build mobile GIT are:

- Wireless communication technologies
- Mobile personal computers (mini notebooks, handhelds, smart phones)
- Positioning systems (global or local)
- Geographical information systems
- Other technologies

3 Wireless communication technologies

As it is mentioned in the past chapter, wireless communication technologies are one of the basics that are required to build mobile geoinformational technologies. There are several possibilities for wireless data communications. The most famous in the last years are technologies based on the second, 2.5 (GPRS, HSCSD) and newly third generation (UMTS) of GSM networks. These technologies have an advantage of global range, but require licensing and are mostly maintained by large GSM network providers. The other examples of wireless communication technologies of today are Bluetooth and very fast technology WiFi. These two do not require licensing and are relatively cheep so they can be provided by almost any subject. WiFi is going to be a concurring technology to the 3G of GSM in the next years. It is very rapidly propagated and applied in many commercial and also public based information services.

4 Handheld computers – Compaq iPAQ 3870

The other basic component of the mobile geoinformational technology is mobile computing equipment. For the development and testing of Baby GRASS there was used Compaq iPAQ (model 3870). It is a handheld computer that is equipped with Intel Strong ARM SA 1110 processor - running on frequency of 206 MHz. It has 32 MB of Read Only Memory (ROM) which is by default used to store operating system and then 64 MB of shared Random Access Memory (RAM), which is dynamically allocated into two parts. The first part of RAM is used for data storage and software. The second part of the memory is used as standard RAM for running applications and operating system needs. iPAQ is fitted with colour (65 000+) reflected TFT display (320x240) pixels that also works as touch screen input device. For communication purposes there is an infrared port, a RS-232C serial port, a USB client port, a Bluetooth module and a wide connector for connection of expansion "hot plug" modules. The other hardware features are stereo sound card, built-in microphone and speaker, slot for Secure Digital memory cards and some programmable buttons. External keyboards can be connected to iPAQ. A great variety of expansion modules is available for use (GPS, WLAN cards, CF memory modules or IBM Microdrives,…).

5 Linux on iPAQ handheld

Linux operating system turns iPAQ handheld to very scalable device, that can do tasks starting from digital organizer or gaming console and ending by use as a network server. Even though it is rather little device running Linux it has all the advantages of UNIX based systems. Because Linux is designed for network use, it is very easy to access all kinds of networks with use of any standard way of connection including wireless networks. User defined access to local data stored in secure file system and encrypted data communications (ssh2) are a matter of course same as reliability and stability of the operating system.

iPAQs come from manufacturer (Compaq - HP) with preinstalled Windows CE. They are not designed for easy user feasible change of operating system that is placed in read only memory. iPAQs, same as most of the other handheld computers are a special devices because they have different architecture then standard personal computers use to. They do not have disc drives that will allow use of common installation media like Floppy or Compact discs and also mostly do not have keyboard to define installation options. The only standard possibility to upgrade or to change operating system is by a special proprietary service software running on desktop PC that communicates with iPAQ on serial or USB port. Fortunately there is some "shadow" support for Linux OS users on handheld devices. A special Linux boot loader was designed - by developers that work for Compaq - as more featured replacement of standard Windows CE boot loader. With this boot loader it possible to access and modify data in iPAQs ROM with use of standard Terminal Emulation Software and serial connection to desktop PC.

There are several Linux distributions available. For Baby GRASS development I have selected the Familiar Linux distribution (Familiar) because it is supported by Compaq, Hewlett Packard and DEC systems developers, and it seems to be the most elaborated among all. Familiar Linux project is based in Cambridge Research Laboratories and a great community of volunteer developers cooperate on improvement and development of new packages to support more functions and new features of the recent handheld devices.

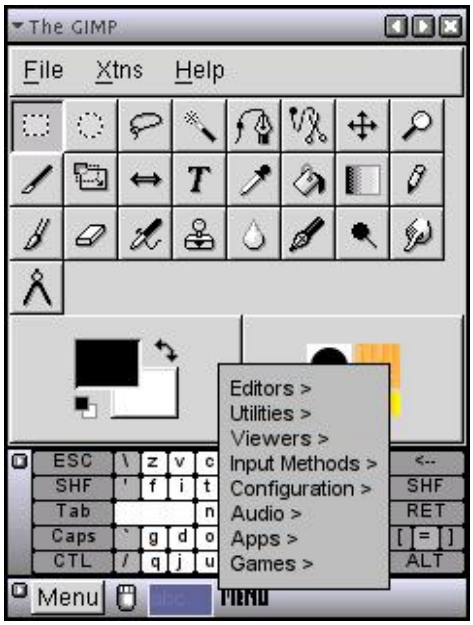

Figure 1: Screenshot of Linux running on iPAQ Handheld

6 Compiling for Strong ARM CPU architecture

There are two ways to compile software for Strong ARM architecture. The first one is crosscompiling. For cross-compilation of new and existing binaries there is a "GNU Toolchain" available. A toolchain is a collection of software tools used for the development and building of software for a particular target architecture. A toolchain is not a complementary group of independent tools, but a matching series of tools that have tightly bound pipelined stages. This chain of tools usually consists of a set of tools for manipulating binary images (binutils), a compiler, libraries, and a debugger. The other possibility of porting software to ARM architecture is in many times easier "native compiling" for which the whole compiling environment running on the computer built on ARM architecture is necessary. Compaq's Cambridge Research Laboratory (CCRL) provides native compiling support to Linux users by running the "Skiff cluster" project. The Skiff Cluster is a group of systems, which may be used by anybody that wishes to do native development and testing of Open Source Software on the Linux armv4l architecture for handheld devices.

7 "Baby GRASS" development

We have defined basic requirements for wireless GIS demonstration system and then we selected GRASS sources and related libraries to build first experimental source package and configuration file. In this part of the work I was getting significant support from GRASS GIS developers in ITC-irst. The first package consisted of basic modules to display raster and vector files and of zoom and pan functions. Special control method was added to zoom module to make it more usable with input limited to touch pen only. I decided to compile the selected sources with use of a native compiling on Skiff cluster. I think that the most of the advanced Baby GRASS users will do some modifications to sources and they will not like to spend a lot of time constructing the Toolchain so I wanted to test how it works. At the time of the first compilation tests there was only a cluster built of some old ARM based machines available at CCRL, but not iPAQs. All our GRASS modules that we compiled there failed with "segmentation fault" while we tried to run them on our iPAQ. I tried to compile some easier software ("Links" Internet browser and shell game) and it worked. We thought that we are doing some mistake or

we are overseeing something in our compilation settings so I have installed debugging modules to our iPAQ and we spent some time looking for the bug and consulting with GRASS developers community. Then we found that the problem was caused by a slightly different Skiff architecture than iPAQ uses, moreover the compiling environment had different type of libraries that we needed to run our complex software package with shared libraries on iPAQ running up to date Linux. Fortunately at the same time was built a new Skiff cluster formed by iPAQs and running the same version of Linux we had installed in our handheld. After several trials for compilation and several bug fixes in the compiling environment of new Skiff we were successful and our modules of first handheld GRASS started to work. We are very thankful to people from CCRL for their support that they had given to us.
A new "Handheld section" has been added to the official GRASS web pages and source package and "configure" file were added to CVS GRASS. Later on binary package (Familiar Linux ipkg module) was prepared and added to the latest Familiar Linux distribution thanks to cooperation with one of the developers of Familiar Linux that is at the same time GRASS user and developer. This person was in fact the first in the World who has done experiments with GRASS GIS on iPAQ.
Then I created several datasets and performed testing of handheld GRASS modules we have compiled. From the beginning I was working only with test datasets that were placed locally in iPAQs RAM. Later I performed several test working with higher amounts of data that were placed on network server using wireless network (WiFi) and NFS mount. All of the tests were successful. After the tests we have extended the abilities of handheld GRASS and I added some new modules.
After completion and testing of the last version of handheld GRASS I customized and reduced TCL/TK GRASS graphic menus to make it more usable on small display of iPAQ.

The latest released version (7/2002) of Baby GRASS consists of the following modules:

d.mon	To establish and control use of a graphics display monitor
d.erase	Erase the contents of the active display frame
d.pan	Pan (move spatially) or zoom a raster, vector, or site map
d.vect	Display a vector map in the display window
d.what.vect	Query a vector map layer within the current geographic region
d.rast	Display a raster map and raster overlays in the display window
d.what.rast	Query the category contents of multiple raster map
d.sites	Displays points from a sites file in the display window
d.what.sites	Allows the user to interactively query site list descriptions
d.site.labels	Labels points from a sites file in the display window
d.where	Query the geographic coordinates of a point on the display
d.measure	Measures the lengths and areas of features drawn by the user
d.zoom	Zoom a raster, vector or site map
g.gisenv	Query present location and mapset
g.region	Set region to match default region, any map,...
r.in.ascii	Convert an ASCII raster text file into a (binary) raster map layer
g.list	List the maps, icons, labels, regions, groups, 3D views
g.remove	Remove maps, icons, labels, regions, groups, or 3dviews
g.copy	Copy maps, icons, labels, regions, groups, or 3dviews
g.rename	Rename maps, icons, labels, regions, groups, or 3dviews
s.in.ascii	Convert ASCII listing of site locations into a GRASS site list file
g.mapsets *	Query presently accessible mapsets or change access
TCL/TK GRASS	Graphical user interface

Several scripts.

* This module works with problems if used to access data stored on remote server. Locally it works without known problems.

8 Screenshots of Baby GRASS

Figure 2: Screenshot of GRASS shell on iPAQ

Figure 3: Screenshot of raster (BW ortofoto) with vector overlied (streets)

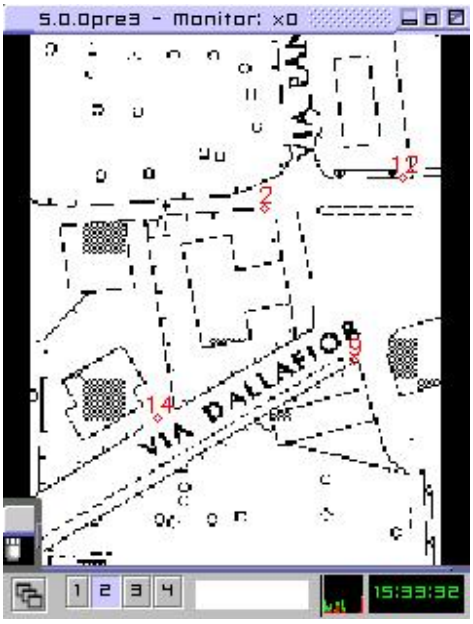

Figure 4: Screenshot of binary raster with labelled sites overlied

Figure 5: Screenshot of TCL/Tk menus

9 Some possible practical applications of Baby GRASS

- Wireless Internet and Location Management Architecture (WILMA) project in Trento
- Instant tourist guides - from mapping + GPS support to just in place related information
- Intelligent car navigation systems with online actualisation of the best path, automatic download of maps
- Civil defence applications, crisis management, navigation, visualization, general information support

- Police logging of transgressions and online transmission to the central database
- Data capture in the field - geology, botany, …
- Technical infrastructure companies (water, gas,…) navigation to the site, logging of the position, …

10 Plans for future development

There is still a lot to improve on Baby GRASS. The main problem is a need of special graphic user interface for touch pen input and small sized display. At this moment we are working on GPS support and in the next months vector features input from touch screen and from GPS, local and wireless database connectivity functions, automatic synchronization functions between local and central databases with use of wireless network features will be added.

11 Important weblinks

http://handhelds.org - Support for Linux on handheld PC
http://grass.itc.it/grasshandheld.html - Baby GRASS page
http://www.wilmaproject.org - WILMA project pages

References

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