A Brief Investigation in using Linux/PDA as Platform for Wearable Computing

Presented by **Muhammad Majid Ali**
int04mad@cs.umu.se

June, 2006
Master's Thesis in Computing Science, 10 credits
Supervisor at CS-UmU: Dr. Thomas Pederson
Examiner: Dr. Per Lindstrom

Department of computing science
Umeå University
Sweden

Abstract

This thesis presents a brief investigation into the concept of using PDAs as wearable computers. The main focus is to find out that, do PDAs provide a hardware platform for wearable computing? Another important part of the investigation is to find out the suitable software platform (operating system) for proposed PDA based wearable computers. Different computer systems and projects are studied and explained in which PDAs have been used some how as “wearable computers”. A comparison between conceptual properties of a wearable computer and the PDA is made. A comparison between the attributes shown by the systems studied during this investigation, with the properties of wearable computers is also presented.

A comparison between the Linux and other commonly used operating systems for handhelds and wearable computers is also made. A step by step guide for installation of Linux on iPAQ PDA is also prepared.

This thesis shows that PDAs are a promising hardware platform for wearable computing. At the same time Linux is a very hot candidate for software platform, as an operating system for wearable computers.

Contents **Page. No**

List of figures

List of Tables

Chapter 1: Introduction

This thesis is actually a brief investigation into the concept that can PDAs provide a good platform for wearable computing? In coming section a brief introduction to wearable computing and PDAs is given. There is small description of some PDA based systems.
There is a comparison between described PDA based systems and wearable computers/properties of wearable computing. I have also compared different operating systems (palmOS, pocketPC and Linux) available for handhelds. I have also tried to find out the Linux support for sensor specially how to find the drivers for sensors in Linux. In last section of thesis there is a small installation guide for installation of Linux in the PDA. I have also developed a prototype PDA with Linux running on it. In the end I have made my conclusion about the whole concept and idea.

1.1 Goal of my thesis

The basic goal of my thesis is to find out that do PDAs provide a suitable hardware platform for wearable computing? Second goal is to find out is Linux the suitable operating system for wearable computers?
In order to achieve this goal, the thesis attempts to fulfill the following sub-goals.

1. Study some projects where PDAs have provided assistance to wearable computing.

2. A Comparison of the general properties of PDAs and wearable computers.

3. A comparison of Linux with pocketPC and Palm OS.

4. Present a guide towards installing LINUX on a PDA.

1.2 What is a wearable computer?

A wearable computer is a small, portable and interactive computer that is worn on the body. It is always with you, always on and ready to use, it is comfortable and easy to keep and use. Wearable computers are usually either integrated into the user's clothing or can be attached to the body through some other means, like a wristband glasses or waist belt clips. They can also be integrated into everyday objects that are constantly worn on the body, like a wrist watch, cell phone or PDA. The wearable computer has the full functionality of a computer system and is reconfigurable as the familiar desktop or mainframe computer. Wearable computers are especially useful for applications that require computation while the user's hands, voice, eyes or attention are engaged with the physical environment. The main differences between wearable and other mobile computing platforms are the human-computer interface. Primary input and out output interface depends on the application. The primary input to a wearable might be a chording keyboard, gesture, speech recognition or even just passive sensors. Output might be presented via speech, audio tones or a head-mounted display. This output can also be combined with the physical world through a visual or audio augmented reality interface [11].

Definition of "Wearable Computer" (By Prof Steve Mann)
“Wearable computing facilitates a new form of human--computer interaction comprising a small body--worn computer (e.g. user--programmable device) that is always on and always ready and accessible. In this regard, the new computational framework differs from that of hand held devices, laptop computers and personal digital assistants (PDAs). The always ready capability leads to a new form of synergy between human and computer, characterized by long-term adaptation through constancy of user-interface” [1].

1.3 An evolution of computing hardware
Wearable computing is just an evolution of the computing hardware. At first there was the Mainframe computer, after that came the desktop computer enabling people to work in their office, PC (personal computer) enabled people to work at home, then portable PC enabled people to work anywhere, then pocket computers appeared on the market. The size of laptops went smaller giving people more flexibility to work anywhere, in the train, at the library etc. Then palmtops and PDA's appeared, allowing people to work on the move. Wearable computing is just the next step in this process of miniaturization of computing hardware [12].

1.4 Wearable computer-- Why?
What is the need of wearable computing? Why we want to build wearable computers? Here are some examples/applications, which demonstrate the importance and need of wearable computers.

1. In restaurants, serving staff can send in orders by WLAN using PDAs, they can save a fair bit of walking and time in this regard [14].

2. In a plane repairing company the engineers who are using wearable computers do not ask for blueprints but instead keep the blueprint and

the technical data with them all the time during their job, so that they are able to perform their job faster[13].

3. In journalism, pocket PCs can be used to store the notes and enlargements! So there is no need of a laptop or paper. If you have 802.11b WLAN and a hotspot, you can send the report of a story immediately [14].

4. These applications exist in many areas e.g., in hospitality industry, in medicine, in finance and system administration work. The list is endless, it includes any occupation that requires movement coupled with the need to send and receive information that can be shown suitably on small screens [14].

1.5 Conceptual characteristics of wearable computers

A wearable computer is supposed to have more or less the following characteristics [2].

1. **Consistency (Are always on):** The computer runs continuously, and is “always Ready” to interact with the user. Unlike a hand-held device, laptop computer, or PDA, it does not need to be opened up and turned on prior to se. The signal flow from human to computer, and computer to human, runs continuously to provide a constant user-interface.

2. **Are portable while operational:** The most important feature of wearable computers is that it can be used while doing something else e.g. walking, moving around or doing anything. This distinguishes wearable computers from both desktop and laptop computers.

3. **Utilize sensors:** A wearable should have support for attaching sensors to it. e.g. for the physical environment such as location (for example GPS), temperature, humidity and movement measures. For input and out put, microphones, cameras etc.

4. **Enable hands-free use:** Wearable computers should allow hands-free use so that user can perform everyday activities normally. Speech input and heads-up display or voice output, use of chording keyboards, dials, and joysticks can minimize the tying up of a user's hands.

5. **Augmentation:** The assumption of wearable computing is that the user will be doing something else at the same time as doing the computing. Thus the computer should serve to augment the intellect, or augment the senses [1].

6. **Proactive:** A wearable computer should be able to convey information to the user always. For example, if your computer wants to let you know you have new email and who it is from, it should be able to communicate this information to you immediately.

1.6 Research area of wearable computing

A lot of research is undergoing in wearable computing. The main areas of study in wearable computing are:

- Power management
- Networking
- User interface
- Software architecture and hardware architecture
- Sensor networks
- Augmented reality
- Pattern recognition
- Applications related to disabilities
- Electronic textiles and fashion design

Many areas of research in wearable computing are common to mobile computing and ubiquitous computing. Because of the time and space limitations, only power management and User interface are further discussed briefly.

1.6.1 Power management

Energy is a big issue in wearable and mobile computing. If user has to use the computer all the time then it needs constant supply of energy also. This section explores the possibility that how the energy generated during the user's everyday actions can be used to generate power for his or her computer. Power can be generated through leg motion, by breath or blood pressure, body heat, finger and limb motion (typing) and through walking. Wearable computing is a step towards making computers part of our everyday lives by embedding them into our clothing, shoes or by creating the form factors which are wearable e.g. garments, shoes, fashion accessories. The hardware has to be reduced in size to achieve this objective but power systems are still a big problem because they are too inconvenient. Energy problem may be alleviated by generating the required energy by the daily actions of the user. Although some of these ideas are still imaginary, each has its own odd benefits and may be applied to other domains such as medical systems, general consumer electronics, and user interface sensors. More attention is given to typing and walking since these processes seem more practical sources of power for general wearable computing. Each of the generation methods has its own strengths and weaknesses, depending on the application. However, power generation through walking seems best suited for general-purpose computing. The user can easily generate power when needed, and, in many cases, the user's everyday walking may be sufficient [3].

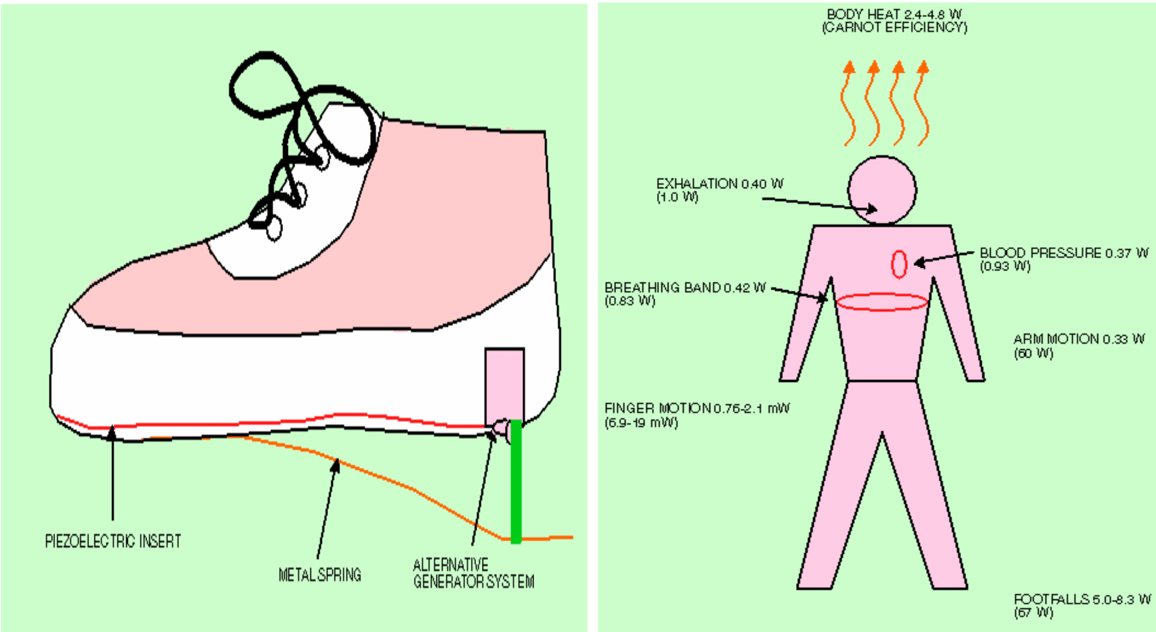


Figure 1.1 Generation of energy from user's actions [3].

1.6.2 User interface

Human computer interaction is another area of research in wearable/mobile computing. The ideal human-computer interface would listens for its user, understands the user, what user has asked, using **speech recognition, gestures, machine vision** and other channels of information, carried out the users request automatically, and presented the results back in appropriate time and in a suitable format. For example; a machine which monitors the users respiratory levels, heart rate and movement, the user may ask "when I fall asleep, turn off those <user pointing> lights''. This type of interaction between user and machine using spoken words and gestures comes under the category of *multi-modal and intelligent user interfaces* [15].

1.7 Applications with Wearable Computers

1. in the army

Application of wearable computing can be found the army of many countries.

In Australia there is a program called Land 125 Soldier Combat System. In this programme soldiers should have intra-section radios, night vision and sighting capability and head up display. In French army there is a

project called FELIN, to enhance the efficiency of the soldier a set of devices were developed with very careful limitations: historically the foot soldier had to carry a lots of burden, the FELIN project limits its load at 25kg. The soldier has got a radio link, a computer and a camera on his weapon (allowing him to open fire from cover). In UK Forces there is a project called
The FIST (Future Integrated Soldier Technology). Tests were conducted on Salisbury Plain to determine if the soldier could access information either 'Head Up' (in a helmet display), 'Head Down' (on a wrist mounted display), via a palmtop computer or if necessary a map [5].

US Forces
The land warrior program is a system made of 5 subsystems cooperating together.

1. A Pentium Computer/Radio Subsystem (C/RS) made by Motorola featuring an integrated GPS receiver
2. The Protective Clothing and Individual Equipment Subsystem (PCIE) made by Gentex
3. The Weapon Subsystem (WS) made by Raytheon
4. The Software Subsystem made by Raytheon
5. The Integrated Helmet Assembly Subsystem (IHAS) made by Honeywell

The location of each squad member will be available through the IHAS, as well as digitized maps and tactical information. Every soldier will have an integrated GPS as well as video recording capabilities. The soldier will have night vision capability as well as deported sighting [5].

2. At the hospital
The Microvison's VRD has been delivered to the Wallace Kettering Neuroscience Institute, Dayton Ohio, for neurosurgery applications. This is not a full featured wearable solution but it is a big step toward the adoption of wearables in health care activity [5].

3. With the firefighters
Firefighters are using thermal cameras in order to see through the smoke, in the next years theses devices should be miniaturized and with wearable firefighters should have both hands free and will have real time access to data such as the map of the building and numerous helpful information[5].

4. Wearable for the disabled.
A wearable computer can be very helpful for the disabled people, for example for blind people a wearable with a GPS receiver, some maps of the surroundings and even more, interacting with its surroundings by means of active beacons can be a very good substitute for a dog [5].

1.8 Form factor in wearable computers

Form factor is an important issue in wearable computing, wearable means the computer that we can wear like our clothes and shoes, so the form or shape of the computer matters computers should be comfortable and feasible to be worn. Then what is the comfortable and feasible form? It depends on the wearer’s need. Following images show some forms of wearable computer, in future we can have even more forms. Figure 1.2 shows some forms of wearable computers.

Wearable screen [28].

Wearable Computer integrated in a Belt [25].

Wearable USB storage device [30].

Wearable mp3 player [27].

Wearable keyboard [26].

Wearable Hub [29].

Figure 1.2 (forms of wearable computers)

Chapter 2: PDAs as platform for Wearable-Computing

In this chapter we will try to study the properties of PDA and some PDA based systems, which make it a promising hardware platform for wearable computing.

2.1 What is a Personal Digital Assistant?

A PDA (personal digital assistant) is a small, handheld device that provides tools to
enhance personal productivity. Basic tools are usually a calendar, a task list, a
contact list, and notes. Most PDAs allow the addition of many other software tools. Most PDAs have ability to synchronies with desktop computer enabling the desktop as a safe repository of the PDA data and enabling the PDA as a mobile device that you can carry around with you. Newer PDAs are coming enhanced with wireless communication capabilities. PDAs can also run various stripped-down computer applications, such as word processors and spreadsheets, and the data can be moved back and forth between the PDA and the desktop [7].

2.2 Using PDA as a wearable device

PDAs are very rapidly evolving device getting common and spreading fast for number of reasons e.g. they are much cheaper as compared to conventional desktop PCs, they are easy carrying, easy to use, smaller and light in size. So from development point of view it is very important to develop applications which are compatible and executable on PDAs because they are the device of the future which every individual will be carrying with him/her for number of reasons as mentioned before. Even more importantly from wearable computing point of view PDAs are much important device of the future because every body can't wear a specially designed, ocward looking and very complicated computer on their body. Physical comfortable, fashion and design are the important issues because they play a major role in our life styles. So PDAs are the device which is comfortable for every body for number of reasons mentioned before, they are compact enough to keep all the time with us. Many individuals, in special cases and exceptions specially designed and specific wearable devices will be required definitely, But PDAs still are going to be (or may be) the very basic, early stage and general purpose wearable computer for general public for general use.

2.3 Alternatives to PDAs

Some of the alternatives to PDAs as platform for wearable computing are the cell phones. Cell phones are becoming more and more wearable and programmable; they can be very close to future wearable computers. Portable MP3 players is another device which is becoming more and more wearable and functions are being added to it, portable MP3 players are another promising future wearable device . There are some other existing wearable systems also, one of them is the Linux based wearable computer at the context computing Group (CCG), Georgia Tech University. It consists of the following hardware, "**System** CharmIT wearable computer. **Input** Twiddler2, one-handed chording keyboard Griffin PowerMate a knob that plugs into a USB port. **Output** MicroOptical VGA head-up display which clips on to glasses" [23].

Figure 2.1: Thad Starner wearing CCG Wearable computer [24]

2.4 Comparison between the properties of PDA and wearable

Consistency (are always on): this is still a challenge area in PDAs as they are needed to be recharged, but this is the case with every electronic device, so there has to be a solution for all electronic devices, solar energy, or mechanical energy can be a good idea to start with.

- **Portable while operational:** Yes PDAs are portable even while you are using them, you can use them on the go,

- **Utilize sensor:** PDAs use sensors e.g. microphone, wireless hand free, GPS, these are all sensors.

- **Enable Hand free use:** this becomes even easier with the use of sensors, e.g. microphone gets the voice input, and you can talk using hand free kit. This is also true for desktop PCs but they are not wearable.

- **Augmentation:** computing is NOT the primary task in PDAs. The user can do something else at the same time as doing the computing e.g. talking on phone or listening to music on the same device.

- **Proactiveness:** PDAs can be proactive if they get the proper input; this becomes even easier with the use of the sensors.

2.4 iPAQ-based wearable computer

An IPAQ-based wearable computer running Linux has been developed as part of the ongoing non-commercial research efforts of the Multimedia Communications Lab (KOM) at Darmstadt University of Technology in Darmstadt, Germany. In the KOM lab, they are dealing with several aspects of Network Multimedia Communication.
Development is going on for a platform for use in experimenting with using mobile
systems as clients for IP telephony scenarios, and they have previously built prototypes
running on an x86 platform, This iPAQ-based wearable prototype (Figure 2.1) is easy to handle, mainly due to the smaller and lighter weight display and also because it needs much less hardware [6].

Figure 2.2: IPAQ wearable with Micro Optical head mounted display and head key twiddler chording keyboard [6].

2.4.1 About the system

The latest prototype is constructed mainly from off-the-shelf components, and it benefits from the PocketPC/Linux IPAQ dual-boot capability. The device combines input from a Twiddler chording keyboard with text display output to a serially attached MicroOptical head mounted display, along with a text-to-speech audio interface. Being equipped with a color graphics Voyager PCMCIA VGA card and operating in dual boot (both Linux and PocketPC) mode, it also lets you prepare and present slides while you are working away from your home environment. The setup has been shown to work successfully in a heterogeneous Voice-over-IP/Internet Telephony scenario [6].

Figure 2.3: IPAQ wearable and MIP 520 wearable (right) that can work together in a WLAN-coupled body area network [6].

2.5 Evolution of PDAs (PDAs as wearable network gent)

PDAs can communicate wirelessly in several different ways, there are three levels of communication for PDAs: the personal area network, the local area network, and the wide area network. Most PDAs can already communicate with one another through their infrared ports. If Bluetooth or some similar short-range wireless technology is widely implemented in devices, it may be possible to eliminate the syncing cradles used now and simply send data between desktops and PDAs wirelessly. This is communication at the personal area network (PAN) level. The idea is to eliminate cabling devices altogether. We can expect PDAs to be able to communicate wirelessly with printers and projectors. At the local area network (LAN) level, PDA can be connected to the network. This can be done by installing wireless access points (WAPs) and connecting those to the network. Then the PDA can communicate wirelessly with the WAP, which is part of the network. The 802.11b wireless protocol is the standard for this type of communication, and a number of vendors are already providing these access points (in USA). A number of vendors are testing the faster 802.11a wireless protocols, which can transmit data at up to 54 Mbps. To get wireless access for your PDA when you are traveling, you will need to access a wide area network, most probably one provided by a commercial vendor. Certainly some commercial vendors will be eager to provide your campus LAN access as well as WAN access [7].

2.6 Pebbles Assistive Technology

At Carnegie Mellon University (Human Computer Interaction Institute), it is being investigated that how handheld devices, such as Personal Digital Assistants (PDAs), PalmOS devices and Pocket PCs, can be helpful for people with physical disabilities. This research is currently progressing along two tracks:

1. Studying the use of a PDA as an alternative input device for computers
2. Looking at how to automatically create remote controls for everyday appliances that will be usable by people with disabilities.

People with Muscular Dystrophy (MD) and certain other muscular and nervous system disorders such as Cerebral Palsy (CP) may lose their gross motor control while retaining fine motor control. The result is that they may have difficulty operating a mouse and keyboard. But, they can control a pencil or stylus using their fingers, so they can use a handheld computer such as a PDA [8].

2.6.1 Hand-Helds as Alternative Input Devices

In the process of research two programs are developed, called Remote Commander and Short Cutter that allow the handheld to substitute for the mouse and keyboard of a PC. Remote Commander allows PDA to perform all mouse and keyboard functions. Short cutter allows custom panels of controls to be created, to make it easier to perform specific common or difficult functions in specific applications [8].

2.6.2 Hand-Helds (PDAs) as Universal Controllers

The Pebbles project [8] investigates how a hand-held can be used as a "*Personal Universal Controller*”. With wireless technologies such as Bluetooth and IEEE 802.11, handhelds will be in close interactive communication with other devices. Cell-phones and pagers are increasingly becoming programmable. An investigation is going on to find out that how hand-held devices can be used to control all kinds of home, office and factory equipment. The idea is that when user’s points hand-held at a light switch, at a photocopier in an office, at a machine tool in a factory, at a DVD player at home, or at almost any other kind of device, the device will send to the hand-held a description of its control parameters. The hand-held uses this information to create an appropriate control panel, taking into account the properties of the controls that are needed, the properties of the hand-held (the display type and input techniques available), and the properties of the user (what language is preferred, whether left or right handed, how big the buttons should be based on whether the user prefers using a finger or a stylus). The user can then control the device using the hand-held [8].

2.7 LifeMinder: A Wearable Healthcare Support System Using User's Context

LifeMinder is a prototype of wearable healthcare support system [9], which consists of a wrist-watch shaped wearable sensor module and a personal digital assistant (PDA). The wearable sensor module consists of sensors of accelerometer, pulse meter, thermometer, galvanic skin reflex (GSR) electrodes and Bluetooth module (to communicate with the PDA). Wearable sensor module monitors the user's health conditions, movements and behaviors. The system guides the user in daily self-care in real time on the basis of this information. This system consists of a wristwatch-shaped wearable sensor module and a PDA, as shown in Figure 2.4. The wearable sensor module measures user's physiological data and recognizes user's movements, and communicates with the PDA via a Bluetooth module in order to provide with complicated wiring between them. The PDA recognizes the user's health condition and behaviors, and provides the healthcare services according to the user's context in real time [9].

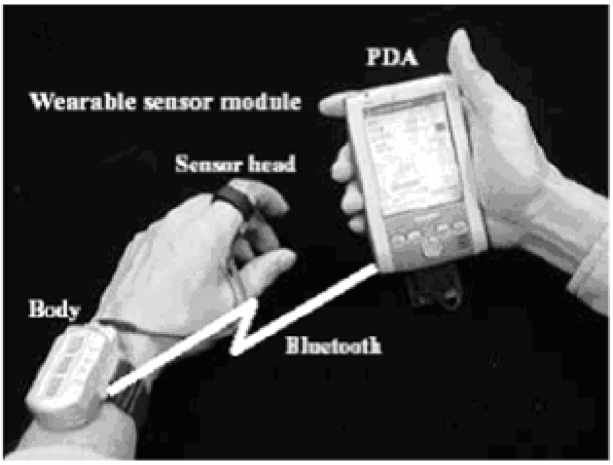


Figure 2.4: LifeMinder system over view [9]

2.7.1 Wearable sensor module

The wearable sensor module consists of a sensor head attached to a finger and a wristwatch-shaped body. The sensor head contains three sensors: pulse meter, thermometer, and GSR electrodes. The wristwatch-shaped body consists of an 8-bit RISC microcontroller (PIC16LF877), a two-axis accelerometer, a lithium-ion battery, and a Bluetooth module to communicate with the PDA [9].

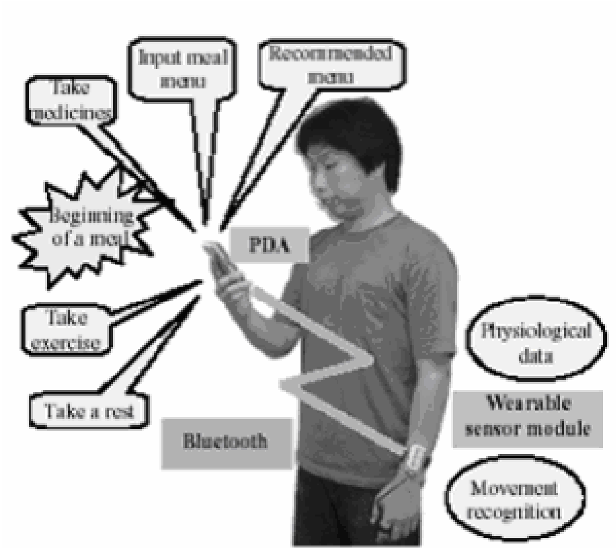


Figure 2.5: LifeMinder application Overview [9]

2.7.2 Application on the PDA

The wearable sensor module sends the data to a PDA via a Bluetooth module. The PDA displays the received data graphically, which consists of pulse rate, movement status, number of steps (if user is walking), GSR value and skin temperature. It receives the data every second and recognizes user's health conditions and behaviors in real time. It also calculates the consumed calories from the number of steps (during walking) and basal metabolism. The system uses this information to guide the user in daily self-care. Figure 2.5 shows an overview of this application. The PDA provides the user with some advice (e.g. "Input meal menu", "Take medicines" and "Measure a blood sugar level" especially for diabetics), according to the recognized eating event. PDA also provides advice to the user, such as showing a recommended menu from the viewpoint of calorie balance and persuading the user to take exercise or take a rest from the record of movements and behaviors [9].

2.8 HP Wearable System for wellness monitoring

Wellness monitoring is a growing area that will benefit from the use of wearable computing systems. Wearable systems can unobtrusively collect physiological data and human annotation to monitor health and predict susceptibility to disease. These systems may enable elderly people and those suffering from chronic illness to live independently longer and receive early warning of and treatment of changes in their health. In countries with aging problem it can reduce healthcare budget and improve the quality of life for many peoples [10].

HP (Hewlett Packard) at Cambridge research laboratory has developed a prototype wearable system for wellness and activity monitoring using ECG and accelerometer sensors [9]. The system provides an application for providing activities, events and potentially important medical symptoms. The hard wear allows data to be transmitted wirelessly from on-body sensor to a handheld device (PDA) using Bluetooth. Data is then transmitted t back-end server for analysis using either a wireless internet connection, if available, or a cellular network. The system hardware consists of off-the-shelf components, an ECG monitor, a two-axes accelerometer and two iPAQ (PDA) units. The iPAQ provides local processing and storage, but are mainly intended to be used a link between the user and a back-end system with far greater resources. The iPAQ allows the wearer to see sensor signals as they are collected and to annotate the record with specific activities, symptoms and medication using, a checklist based wellness diary as shown in figure, voice messages or digital pictures [10].

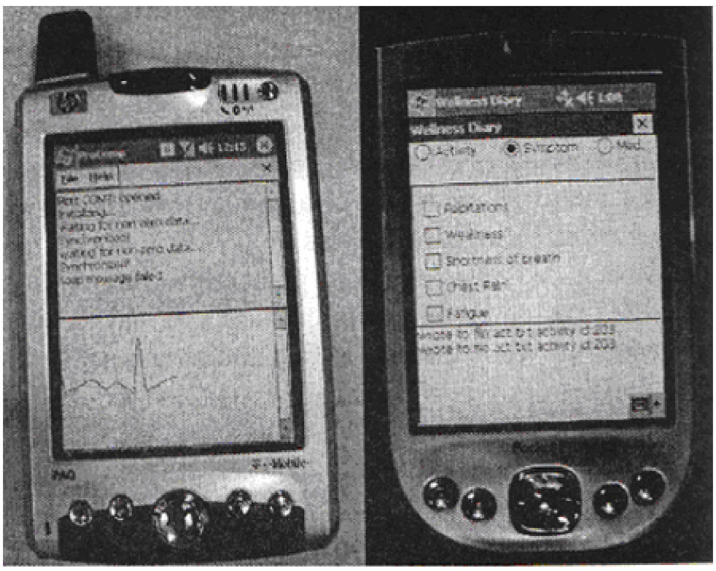


Figure 2.6: The HP system showing wireless real-time ECG capture (left) and the wellness check list [10]

2.9 Comparison between PDA and wearable computers

Following table shows a comparison between the characteristics wearable computer with the different systems in which PDAs are used as wearable computers. X-axes show the general characteristics of a wearable computer and Y-axes show the different systems mentioned earlier. It shows that all the systems support Augmentation, 3 out of 4 are proactive, 3 out of 4 support hands free use, 3 out of 4 support sensors, 3 out of 4 are portable and all of them are consistent.

Table 2.1: showing Comparison between PDA and wearable computers

	Consistancy	Portability	Sensors	Hand-free use	Augmentation	Proactive-ness
iPAQ based system [6]	✓	✓	✓	✓	✓	✓
Pebble assitive technology[8]	✓	✓			✓	
LifeMinder[9]	✓	✓	✓	✓	✓	✓
HP monitoring system [10]	✓		✓	✓	✓	✓

Chapter 3: Software Platform (operating system) for PDAs/wearable computers

Most of the PDAs available in the market today have Microsoft Pocket PC or Palm Os in them. Linux is also becoming hot candidate as another choice. Especially for wearable devices, Linux is very hot candidate. Here in this chapter, I will try to motivate that it is better to run Linux rather than Palm OS or a MS Windows OS on PDAs for wearable applications?

3.1 Linux vs. Palm OS

It is an assumption in handheld industry think that Linux will soon replace Palm. Why would this be a good replacement? These are some reasons.

- Palm Source/Access is working on a new version of Palm OS that is based on Linux. Linux at the core, familiar Palm OS interface. Supposed to have compatibility with both-Palm OS through emulation, not sure on Linux.

- Other Linux-based mobile devices (the Sharp Zaurus, the Motorola A780) don't have as widely used (or for many, as easy-to-use) interfaces or the same number of applications as Palm OS.

- The biggest benefit is drivers. Almost all hardware makers have reference implementations on Linux for their hardware. That means support for a new radio, memory card; display, etc. would be a no problem. Also, tapping into a pool of millions of developers would be a plus too.

3.2 Linux vs. Pocket PC

- Ongoing upgrades/support: Linux is continually being improved and having security bugs fixed. The OS/application, however, may well be out of support and in many cases cannot be upgraded to later versions. Even in cases where the OS/applications can be upgraded, this is unlikely to be free of charge.

- Freedom: Many users of PDAs prefer to use open source software from an ideological point of view or because they appreciate many other benefits (such as the ability to fix bugs themselves and a strong user community, among others).

- Capabilities: Running Linux opens up a large number of possibilities that are difficult, expensive, or impossible to achieve using PocketPC.
- Applications: By running a standard Linux distribution, you can easily port many applications (some with no changes at all, many with only very few changes).OS

3.3 Some other reasons:

Some other reasons why one can motivate him/herself to use Linux are following.

- Embedded Linux is very hot right now because of its super tiny footprint. So, definitely one can expect to see more upcoming Linux PDAs e.g. Sharp SL-500D.

- A great embedded Linux example is Linux watch by IBM [22] (shown in fig 3.1) that works even better then a PDA. So you can put Linux anywhere, on any wearable device.

- Another advantage to the embedded Linux environment is that it is free. This will give Linux a boost in the embedded OS market.

- It's almost free to relatively inexpensive. Linux can be downloaded off the internet, which makes it free or close to it. Or you can purchase CD-ROMs for very cheap from Linux vendors.

- Source code is included. Source code is available to anyone means that it would be very difficult for someone to charge you hundreds or thousands of dollars for a copy of Linux. If Linux didn't support some operation or piece of equipment you needed, you or someone else could always change the source code to do what you wanted.

- Bugs are fixed quickly. Development in Linux is worldwide. Programmers from all over the world participate in making Linux a better and more stable product. When bugs are found, with thousands of programmers across the globe involved, bugs are often fixed in a matter of hours or days

- Linux is more stable than other modern operating systems. "Uptimes" in the Linux world are on the order of months and years, not days. Usually when a Linux machine is brought down, it is to upgrade the machine or the software.

- Linux is truly multi-user and multi-tasking. From the beginning, Linux was programmed with multiple users and the ability to do many things at once in mind. This came from its UNIX roots. Today, that capability is mature and stable.

- Help is readily available. With programmers and users spread across the world, help is as close as the internet. You can get help via email, or directly from the various Linux vendors. There are also vendors who charge for Linux support, if one wants to go that way.

- Linux has internet connectivity built in. Internet connectivity is part of Linux's UNIX heritage. Every major distribution of Linux comes with tools that can immediately get you up and running on the internet. Most even include Mozilla or Firefox as their browser of choice.

- Linux runs on equipment that other operating systems consider too underpowered. Linux was originally created on a 386 computer, and it still supports small systems like this. A minimum Linux installation is a 386 processor with 4 mega bytes of memory and about a hundred megabytes of hard disk storage (though it can work with less hard disk space). In this configuration, it works well as a departmental, print or web server. But Linux also runs on high powered Alpha machines, Macintoshes, and machines with multiple processors, including mainframe computers.

- Linux has superior security. This is partly because the source code is freely available. There are thousands of eyes which look over Linux all the time, so it would be hard to slip in code to purposely open security holes on your machine. In addition, you normally run as an unprivileged user on your Linux machine, meaning it's hard for a cracker or rogue program to do significant damage to your machine. Linux comes with a built-in firewall which can be tweaked to close your machine off completely from potential attackers. And Linux and its programs are continually being revised and improved. Other popular operating systems don't allow you to see their source code, and only occasionally release security fixes, sometimes long after security holes have been found.

Figure 3.1: IBM watch [22]

Chapter 4: Connecting peripherals and sensors

One of the very important aspects of wearable computing is using sensors for real-world context sensing as well as for creating alternative interaction paradigms. This chapter discusses the issue that if we use Linux as an operating system on wearable computer, then how it deals with the issue of finding drivers for different sensors and peripherals?

Sensors and I/O devices can be used in wearable computing for two different reasons:

1) To act as an alternative user interface to the one inbuilt in the system (e.g. a touch screen/pen) (Thomas Pederson, in his email).

2) Provide the possibility to allow "implicit HCI", i.e. when the system captures information about the user and/or environment without explicitly being asked to do so by the user. This information is typically used at a later stage by the system to disambiguate the situation or to offer the possibility to the user of reviewing past activities performed by the user as a memory enhancing service [Thomas Pederson's email].

4.1 What is a Device driver?

Device driver is the software (piece of code) that controls all the actions of some specified device that is addressed; every physical device attached to computer must have its driver [16].

4.2 What is a Sensor?

A sensor is "A device that responds to a physical stimulus (heat, light, sound, pressure, motion, flow, and so on), and produces a corresponding electrical signal." [17].

4.3 Linux support for sensors

One of the many advantages of Linux is that its internals are open for all to view. Because the source is available to Linux community all over the world, so it makes it easier to develop any particular driver for some special sensor or device because of the huge community's cooperation and involvement.

There are many reasons which make it easier to develop or find drivers in Linux then PocketPC or PalmOS.

1. As the popularity of the Linux system continues to grow, the interest in writing Linux device drivers steadily increases [16].

2. Linux has very good support for almost kinds of cards and device drivers, and they are stable and fast.

3. In Linux programming interface, drivers can be built separately from the rest of the kernel and “plugged in” at runtime when needed. This modularity makes Linux drivers easy to write, to the point that there are now hundreds of them available [16].
4. Most of the principles and basic techniques are the same for all drivers [16], it is easier to change or modify an existing driver to develop a new driver.

4.4 Examples supporting the Linux sensors
Her are some examples or systems which demonstrate more clearly about this issue.

4.4.1 The second generation iPAQ-based wearable computer
The second generation iPAQ-based wearable computer, with Linux installed in it combines input from a Twiddler chording keyboard with text display output to a serially attached MicroOptical head mounted display. It is also equipped with a color graphics Voyager PCMCIA VGA card [6].

Figure 4.1: The second generation iPAQ-based wearable computer [6], with Linux in it and sensors/IO devices attached to it.

In this example following sensor/IO devices are attached to the PDA with Linux installed in it.
1. Twiddler chording keyboard
2. MicroOptical head mounted display
3. Color graphics Voyager PCMCIA VGA card

It shows that drivers for these IO devises/sensors are already available.

4.4.2 Digital Camera with Linux in it.

The RDC-i700 is the digital camera shipped by Ricoh; it has 3.2 mega pixels CCD, a PCMCIA and a CF slot, 3.5 inch touch screen LCD. Linux is ported onto it to make it *programmable camera* [18].
Ricoh RDC-i700 Linux based digital camera has two types of peripherals, PC-like peripherals and camera-related peripherals.

Figure 4.2: Ricoh RDC-i700 Linux based digital camera [18].

PC-like Peripherals

PC-like peripherals include Hitachi SH7709A CPU, PCMCIA controller allowing users to use PCMCIA card and a CF card, input device (touch panel), output device (LCD).

Camera-related Peripherals

IPP chip, CCD Controller, front-end chip of CCD, and Image SD-RAM.

Mechanical Parts

Mechanical Parts include zoom, focus, iris and mechanical shutter. Because these parts need high precision movement, stepping motors are used. The CPU has to set ports of the motor at a quite fast frequency in order to make the motor move rapidly. In that case the timer period is only several milliseconds.
All these peripherals (PC-like and camera-related) and mechanical parts do run and function properly on Linux platform which shows the Linux support for them [18].

4.4.3 DigiTemp

Digitemp is the software for measuring temperature Sensors for Linux. DigiTemp software works with Linux and other UNIX and UNIX-like operating systems. DigiTemp is a simple to use program for reading values from 1-wire devices. Its main use is for reading temperature sensors, but it also reads counters, and understands the 1-wire hubs with devices on different branches of the network. DigiTemp supports the following 1-wire temperature sensors: DS18S20 (and DS1820), DS18B20, DS1822, the DS2438 Smart Battery Monitor, DS2422 and DS2423 Counters, DS2409 Micro LAN Coupler (used in 1-wire hubs), and the AAG TAI-8540 humidity sensor [19].

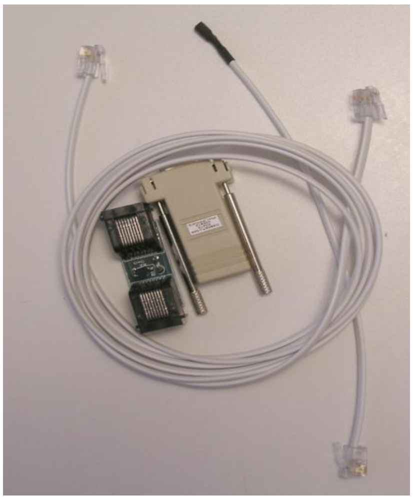


Figure 4.3: DigiTemp Linux Toys Kit [19].

4.4.4 Phidgets Support for Linux

Phidgets are an easy to use set of building blocks for low cost sensing and control from the PC [20]. Phidgets have just released the beta version of first Linux driver. The beta Linux driver can be found and downloaded from Phidgets web site: http://www.phidgetsusa.com/downloads-beta.asp

4.4.5 Availability of Linux based sensors

A number of Linux based sensors are available now days; here are few available from only one company. http://www.ipenabled.com
Sensors Available from http://www.ipenabled.com/Linux, include following.

Linux based IP sensor SensorProbes allow control and advanced customization of sensors using Linux operating system. Linux SensorProbes feature a 32-bit ARM processor, an advanced Sensor

Notification Matrix, support up to 4 External Cameras, and software for auto-recovery from errors [21].

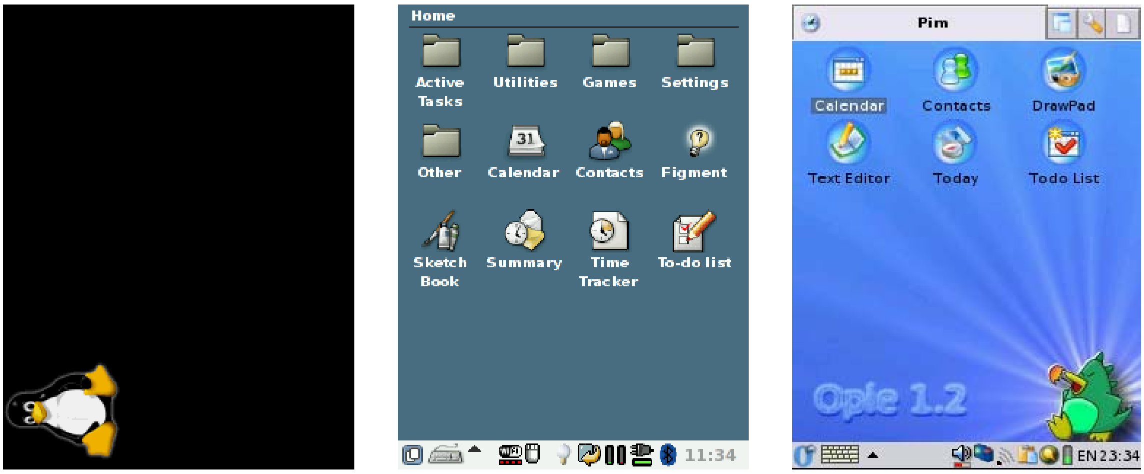
SensorProbes supported Sensor Types
Temperature, Temperature and Humidity, Water, Airflow, Security, AC Voltage, DC Voltage, Dry Contacts, Motion Detector, Smoke Detector, and more [21].

4.5 Conclusion

In my understanding, finding drivers for the sensors on Linux plat form is not such a big problem. “For each piece of hardware supported by Linux, some body somewhere has written a driver to make it work with the system” [16]. Few examples given in this chapter show that attaching sensors to a Linux based device is not a big problem, in fact it is much easier to find the drivers for Linux because of the its open source nature, huge Linux community, “drivers can be built separately from the rest of the kernel, and "plugged in" at runtime”[16].
Because of the increasing popularity of Linux in general and embedded Linux in particular, manufacturers will have to provide the Linux support for the obvious reason of business.

Chapter 5: A Guide to Installing Linux on a PDA

Familiar is the famous Linux distribution for PDAs, Familiar 0.8.2 is the latest version available for the installation. Familiar 0.8.2 has three Users interface available as shown below, you can choose the one you need or like.



Bootstrap, a bare-bones screenless system for developers

GPE, a GTK-based GPL/LGPLed graphical interface

Opie, a Qtopia-based GPL graphical interface

Figure 5.1 (Different GUI for familiar 0.8.2, Linux distribution for PDAs) [32].

5.1 Familiar 0.8.2 Prerequisites

Familiar 0.8.2 supports iPAQ H3600, H3700, H3800, H3900, H5100, H5400, and H5500 units fully.

H51xx, H54xx, and H55xx: The bootldr does not support the display or CF/PCMCIA, so the root images must be installed via serial port.
The iPAQ H2200 and iPAQ H1900 are not yet supported [31].

5.2 Hardware requirements

As well as the iPAQ itself, you will need either:

- a CompactFlash memory card and a suitable sleeve; or
- a host machine running a terminal emulator, connected to the iPAQ with a serial cradle or cable [31].

Note: a USB-only connection is not sufficient.

Some form of Internet connectivity is strongly recommended. Familiar supports these types of network connection:

- CF/PCMCIA Ethernet
- CF/PCMCIA wireless LAN
- PPP over a serial line
- USB connection to a host PC (requires special drivers on the host)
- LAP or PAN connection using Bluetooth

5.3 Installing Linux step by step

All the necessary downloads; updates and installation guidelines are available on line at http://familiar.handhelds.org/.

Installing Boot loader using ActiveSync

Transfer BootBlaster and bootldr to your iPAQ using Microsoft ActiveSync.

1. Copy the BootBlaster and bootldr files that came with your Familiar Linux distribution to your Windows PC if they're not already there. The files are named BootBlaster_1.19.exe and bootldr-sa/2.21.12.bin.

2. Plug the iPAQ cradle into an AC power outlet.

3. Connect the USB connector or serial cable from the cradle to the Windows PC.

4. Slide the iPAQ into its cradle.

5. Copy BootBlaster_1.19.exe to the default folder on the iPAQ by clicking Explore in ActiveSync and dragging their icons there. Do the same thing for bootldr-sa-2.21.12.bin.

Start BootBlaster

6. Select "Start -> Programs" on the iPAQ touch screen.

7. Tap on File Explorer.

8. Tap on BootBlaster

Save your PocketPC image for later restoration, if desired.

9. Execute "Flash -> Save Bootldr.gz Format" in BootBlaster to save the bootloader in file "\My Documents\saved_bootldr.gz" on the iPAQ.

10. Execute "Flash -> Save Wince .gz Format" in BootBlaster to save the PocketPC image in file "\My Documents\wince_image.gz" on the iPAQ.

Copy saved_bootldr.gz and wince_image.gz to your Windows PC

11. Select "View -> Refresh" in the ActiveSync Explore window on the PC. Icons for the
saved_bootldr.gz and wince_image.gz files should appear.

12. Drag the saved_bootldr.gz and wince_image.gz icons from the ActiveSync Explore
window to a local folder on your PC.

Install the bootloader

Before continuing, be sure that the iPAQ is plugged into external power, and that the battery is charged, to protect against the small chance of power failure during the very limited period the iPAQ is reprogramming the bootloader flash. Do NOT touch the power button or reset button on your iPAQ until you have performed the "Verify" step below.

13. From the "Flash" menu on BootBlaster, select "Program".

A file dialog will open allowing you to select the bootloader to use. Select bootldr.bin.gz,

Wait patiently. It takes about 15 seconds to program the bootloader. Do not interrupt this process, or the iPAQ may be left in an unusable state.

14. From the "Flash" menu on BootBlaster, select "Verify".

Note: If it does not say that you have a valid bootloader, do NOT reset your iPAQ, and do NOT turn off your iPAQ. Instead, try programming the flash again.

Installing Familiar 0.8.2 with a serial line

You will need a serial sync cable or serial sync cradle. The dual USB/Serial cradle that comes with the H3800 and H3900 will also work. You will need to use a terminal program such as minicom, kermit, or Hyperterminal.

If you use minicom or kermit, you will need to use an external ymodem program such as sb, which is available in the Linux lrzsz package.

15. Hold down the joypad and push the reset button on the iPAQ. You will need to remove it

From the cradle to access the reset button.

- For non-H5xxx: When the bootloader splash screen appears, release the joypad.
- For H5xxx: When the iPAQ buzzes, release the joypad. The screen will not change from whatever was previously displayed (blank, PocketPC, etc). If the iPAQ does not stop vibrating, remove the AC adapter and the battery, then reinsert the battery and the AC adapter and perform try this step again.

16. Press the calendar button on the iPAQ. This is the leftmost action button, labelled "Serial Bootldr Console" on the screen.

17. Make sure the terminal emulator is up and running, and is properly interacting with the bootloader. Proper interaction consists of being able to issue commands, and get responses (e.g. the help command should return the bootloader usage). Your terminal emulator must be set to **115200 8N1 serial configuration, no flow control, no hardware handshaking**. Failing to use these settings will lead to trouble, so double and triple check all settings?
If you cannot interact with the bootloader, make sure your terminal settings are correct, the iPAQ is properly connected to the host computer, and the iPAQ is actually on. If everything seems fine, try restarting the host terminal emulator and resetting the iPAQ again.
Hyperterminal is particularly ill-behaved. Sometimes it uses 100% of the CPU without allowing any interaction with the iPAQ. In that case, you will need to use the task manager to terminate HyperTerminal before you can restart it.

18. At the "boot>" prompt, issue the following command: load root

19. Proceed to send or "upload" the jffs2 file (from the tarball that you downloaded earlier) with ymodem, using the terminal emulator. If you have not used ymodem before or you have any trouble with this command, please see handhelds-faq/getting-started.html#USING-XYZMODEM.

Note that the bootldr now expects ymodem by default, not xmodem as in earlier versions. If you are unable to use ymodem for some reason, you can revert to xmodem operation with the command set ymodem 0

20. At the "boot>" prompt, issue the following command: boot
Linux now starts booting.

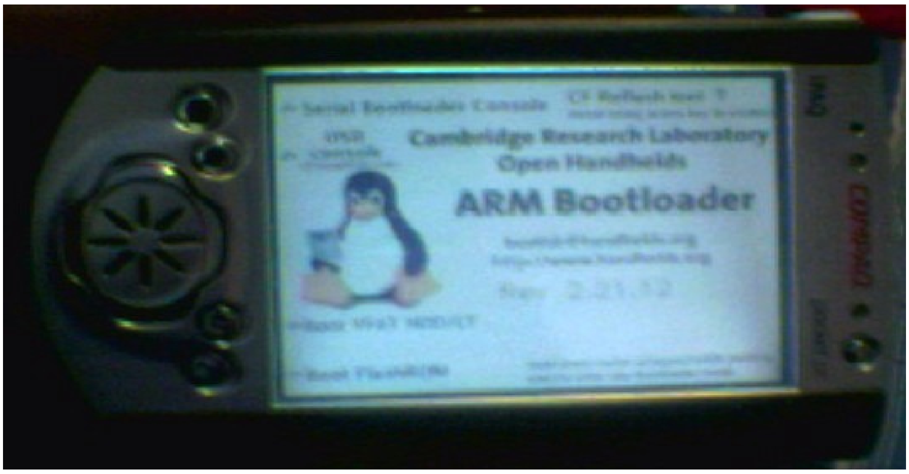


Figure 5.2 (Boot loader starting)

Figure 5.3 (IPAQ Booting)

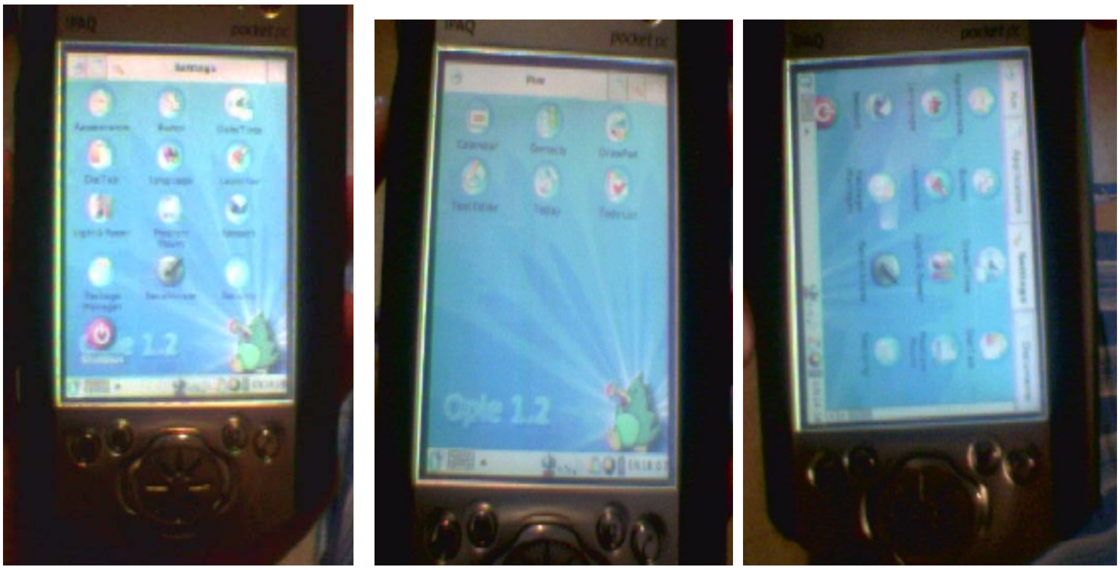


Figure 5.4 (Linux running successfully on IPAQ 3750)

Conclusions

After all the research and information gathered during this master thesis and all the experiments done, I have come to the conclusion that wearable computing can play a very important role in our future lives, its use can cover almost all the application domains. Conventional computing may not be able to cope with all our future needs. Wearable computing can just be the answer.

PDAs can play a very important role in wearable computing because they provide a promising hardware platform for a wearable computing, because of there size, weight, price, and other qualities and applications mentioned earlier. In future PDAs may be used entirely different then the way they are used today.

From software platform point of view Linux is very hot candidate for the all or at least most wearable devices. Because of its global nature and source code availability, a global participation in its development is observed. This global participation is very useful for the writing device drivers and other advancements. It has already performed the desirable job on different wearable devices (IBM Linux Watch) and it promises to be very hot candidate for the future wearable devices.

Acknowledgments

First of all, I must say thanks to my Allah, the God most beneficial and merciful. It is the blessing of God that I have been able to finish my master thesis and completed my Master studies.

I would also like to express my heartiest gratitude to my supervisor Thomas Pederson, for his guidance, support and valuable suggestions. He has also taught me the course of Ubiquitous Computing where he inspired me to work with him. Beside a good teacher, researcher and scientist he is also a very good human being. I learnt a lot from him.

I would also like to thank my mother who has always prayed for me, she has done the best for me, whatever she could have done. It is because of her sheer dedication, support, efforts and everlasting prayers that I am at this point in my life. Thank you mom.

I would also like to thank my friends here in Sweden and back home who have always supported and encouraged me. Specially the friends in Sweden with whom I had some very good time of my life.

Last but not the least, I must say thank to my study advisor here at Umeå university Dr. Per Lindström, who always helped and guided me not only in my studies but in any matter I discussed with him. He indeed, is a very kind and great man and I appreciate the great work he is doing at the department.

Muhammad Majid Ali
Umeå University, 2006

References:

1. Steve Mann's (May 1998) Keynote Address entitled "wearable computing as means for personal empowerment" presented at the International Conference on Wearable Computing ICWC-98, Fairfax VA

2. Barry Crabtree & Bradley Rhodes. (July 1998) Wearable computing and the remembrance agent. BT Technology Journal, 16(3), 118-124

3. T. Starner (1996). Human-powered wearable computing, IBM system journal, VOL 35, NOS 3&4

4. Billinghurst, M. (2002). Wearable Appliances: The Future of Wearable Computing Appliance Design, 2, 5-6.

5. Lionel, trollhunter Bouchpan-Lerust-Juéry. (November 2000), http://www.faqs.org/docs/Linux-HOWTO/Wearable-HOWTO.html#ss16.1 (last visited on 07-06-2006)

6. Ralf Ackermann, Manuel Goertz, Martin Karsten, and Ralf Steinmetz. (2001) Prototyping a PDA based Communication Appliance. In Proceedings of Softcom 2001, Split, Croatia

7. Linda Deneen. (5 October 2001), Handheld PDAs and Wearable Computing Devices, University of Minnesota Duluth

8. Research at the school of computing science, department of human computer interaction Carnegie Mellon University,
web source**:** http://www.pebbles.hcii.cmu.edu/assistive/index.php (last visited 07-06-2006)

9. Kazushige Ouchi, Takuji Suzuki, and Miwako Doi. (2002), LifeMinder: A Wearable Healthcare Support System Using User's Context. Proceedings of the 22 nd International Conference on Distributed Computing Systems Workshops (ICDCSW'02). IEEE p-791

10. Jeninifer Healey and Beth Logan. (2005), proceedings of the 9th International Symposium on Wearable Computers (ISWC 2005)

11. http://en.wikipedia.org/wiki/Wearable_computer (last visited on 08-06-2006).

12. http://www.faqs.org/docs/Linux-HOWTO/Wearable-HOWTO.html#ss3.2 (last visited on 08-06-2006).

13. http://www.faqs.org/docs/Linux-HOWTO/Wearable-HOWTO.html#ss3.1 (last visited on 08-06-2006).

14. John Littler http://www.linuxdevcenter.com/pub/a/linux/2003/11/13/linux_pocket_pc.html (last visited on 08-06-2006).

15. The Sulawesi project. http://en.tldp.org/HOWTO/Wearable-HOWTO-7.html (last visited on 08-06-2006).

16. Linux Device Drivers, 2nd Edition By Alessandro Rubini & Jonathan Corbet

17. http://www.ueidaq.com/support/glossary/S/ (last visited on 08-06-2006).

18. Shigeki Ouchi (2004).Linux on a Digital Camera, Proceedings of the Linux Symposium 2004, ottawa.Canada.

19. http://www.digitemp.com (last visited on 08-06-2006).

20. http://www.phidgetsusa.com/linux.asp (last visited 08-06-2006)

21. http://www.ipenabled.com/Linux (last visited 08-06-2006)

22. http://www.research.ibm.com/WearableComputing/linuxwatch/linuxwatch.html (last visited 08-06-2006)

23. http://www-static.cc.gatech.edu/gvu/ccg//wear/hw.html (last visited 08-06-2006).

24. http://www-static.cc.gatech.edu/gvu/ccg//wear/index.html (last visited 08-06-2006)

25. QBIC, a Wearable Computer integrated in a Belt http://www.wearable.ethz.ch/qbic.0.html (last visited 08-06-2006)

26. Wearable Keyboard http://www.terralogic.co.uk/product_info.php?products_id=47 (last visited 08-06-2006).

27. Virgin’s Wearable mp3 player http://www.engadget.com/2004/07/19/virgins-wearable-mp3-player/ (last visited 08-06-2006)

28. Eyetop Centra, the wearable screen http://www.mikimoto-japan.com/beans/beans_hmd/next/products/eyetop_centra/eyetop_c.htm (last visited 08-06-2006).

29. CeBIT 2005: 'Wearable Hub' for Communications in the Home http://www.physorg.com/news3417.html (last visited 08-06-2006)

30. The Yak Alert wearable USB storage device http://www.smh.com.au/news/breaking/firm-gets-award-for-wearable-usb-device/2005/12/02/1133422092645.html (last visited 08-06-2006)

31. http://familiar.handhelds.org/releases/v0.8.2/install/prerequisites.html (last visited 08-06-2006).

32. http://familiar.handhelds.org/releases/v0.8.2/install/download.html (last visited 08-06-2006).