

## Wireless Handheld Computer as a Tool for Interactive Learning in a Digital System Course

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### Abstract

This paper describes the educational experience gained by the introduction of a wireless handheld computer that is used as an in class and lab tool, in an introductory Digital Design course. The handheld computer provides access to class material and lab tools and makes the learning process more dynamic and interactive and made difficult topics more accessible and easier to understand to the students. The paper concludes with a description of the assessment for the workshop and a discussion of future uses of this technology.

### 1.0 Introduction

The University of Minnesota Duluth (UMD), College of Science and Engineering requires engineering and computer science majors to have a hand-held personal computer with wireless access for use in some of their classes. The purpose of the wireless pocket PC requirement is both to enhance the technological environment of the engineering and computer science classroom and to better prepare UMD students to be competitive in the work world. In particular, UMD students use an iPAQ<sup>1</sup> handheld computer equipped with wireless Internet connections as a learning tool and working tool. The hand-held PC is cutting edge technology, and it has very recently and very rapidly become an important tool of practicing professionals in engineering, industry, business, and information technology.

The main motivation to use the iPAQ handheld and implement the wireless access at UMD, was to provide computing and network access to the faculty and student body without having to carry a heavy laptop with them, and to make the learning experience for the students more interactive from almost any point inside campus.

The main academic interest for the use of the wireless network as a teaching and research tool involves but is not limited to the following applications:

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<sup>1</sup> © Hewlett-Packard Company

- a) Increase interaction between instructor and students in large courses
- b) Enhance communication outside class
- c) Support students software development for mobile computers
- d) Enhance active learning and instruction
- e) In lab data collection and document viewing
- f) In class assessment and evaluation of students, by means of electronic quizzes and polls.
- g) The wireless connectivity facilitates collaborative and interactive learning, and promotes in class participation for the students.

With the integration of this technology in our classes we have made the learning experience more interesting and dynamic, and made difficult topics more accessible and easier to understand to the students. Since the handheld computer provide each student with immediate access to course material such as lecture slides and examples and to CAD tools. Also, the use of the handheld as an interactive media makes students more willing to participate in class discussions.

We take advantage of the iPAQ capabilities and wireless connection for students to have access to databases; simple CAD tools, spreadsheet use and image capture display. Also, students are able to generate or acquire data files during lab or lecture, return to a desktop environment, and continue to work. Software demonstrations and interactive exercises could be downloaded and run in the lab and then carried home for future reference. As they progress, students will be able to write software on their desktops that can be downloaded and run from the handheld. Infrared file transfer from one device to another can be very useful for students in team projects and between faculty and students.

The wireless environment made possible with this device provides efficient and accurate interaction with course material and data free from transcribing errors. The pocket PC also has the capability of loading scientific calculator software that saves students the expense of purchasing a separate scientific calculator. Students are able to use the handheld PC as a personal productivity tool. They also are able to take advantage of the UMD's expanding wireless network, to access the Internet and their email throughout the day without having to go into a computer lab. Many class-related documents (lecture notes, assignments, syllabi, and software) are available through the wireless network.

## **2.0 iPAQ Main Characteristics.**

To ensure standard quality and configuration, the hand-held personal computer must have the following characteristics:

- Compaq iPAQ H3950 (Color Display, 64MB RAM, Protective Slipcover Pack, Li-ion Polymer Battery, AC Adapter)
- Compaq WL100 11 Mbps Wireless LAN PC Card
- Compaq PCMCIA Jacket, Y adapter cable, USB Sync Cradle, ActiveSync Software CD

In order to pay for the cost of this equipment, which is approximately \$800. A charge of \$200 per semester for 4 semesters is added to the student's tuition statement.

### 3.0 Software Package.

In this section we describe the software applications that we developed to be used in the iPAQ handheld computer. In order use and develop the applications for this package, we tried to make use of all the software tools already available in the iPAQ's Microsoft® Windows for Pocket PC operating system [2]. These tools include: iPAQ image viewer, Pocket Word, Pocket Excel, Internet Explorer, Presentation Player, Sound recorder, etc.

In Fig. 1 we show the File Manager main menu that displays all the applications and directories available for the students, as can be seen, the hand held PC is a great place to store class information and reference documents.

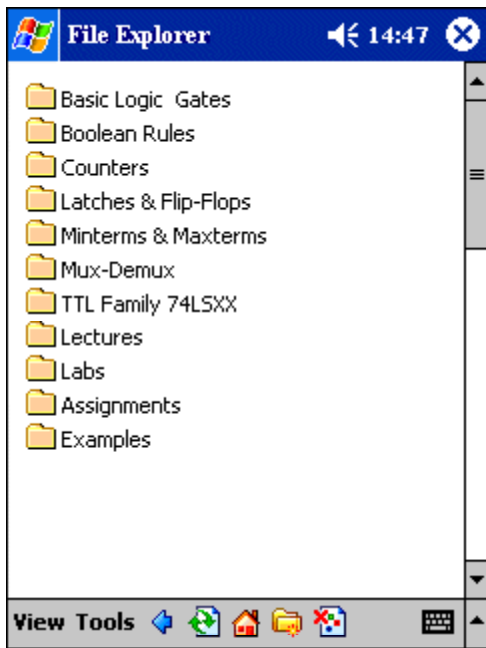


Fig. 1. - Software Utilities

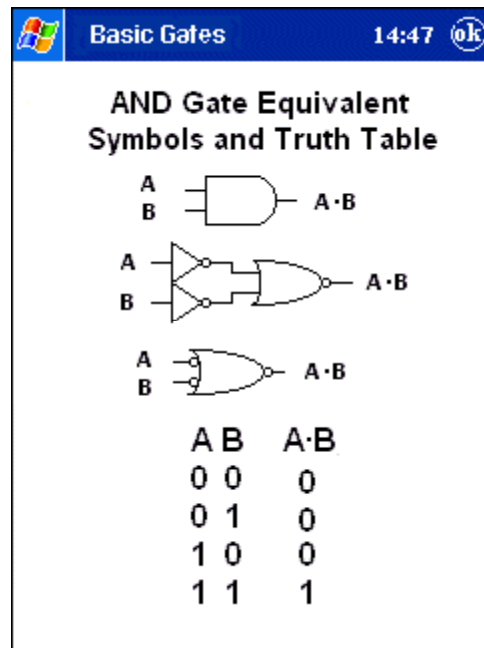


Fig 2. - AND Gate Information

The iPAQ is very handy while students are working on their assignments because they can quickly access information that will help them in their studies or to solve problems. These include, but are not limited to reference tables, truth tables, Boolean algebra, examples, etc.

The iPAQ image viewer is used to display information about the basic logic gates, logic devices in general, and the TTL Logic family. The information displayed can be used during class, in the lab, or for assignments. Some examples of the type of information that can be displayed are shown in Figs. 2 and 3.

Pocket Excel can be used to construct and display truth tables and Minterms and Maxterms information (Fig. 4), as well as to store tables with electrical characteristics of the TTL devices such devices names, number and functions. Also is used to display Input/output voltages, currents, fan-in and fan-out, etc.

Presentation Player is used to display slides from lectures created in PowerPoint so that students can follow the lectures without having to copy this information from the board or overhead projector, and even better, allows them to review this information later on at home.

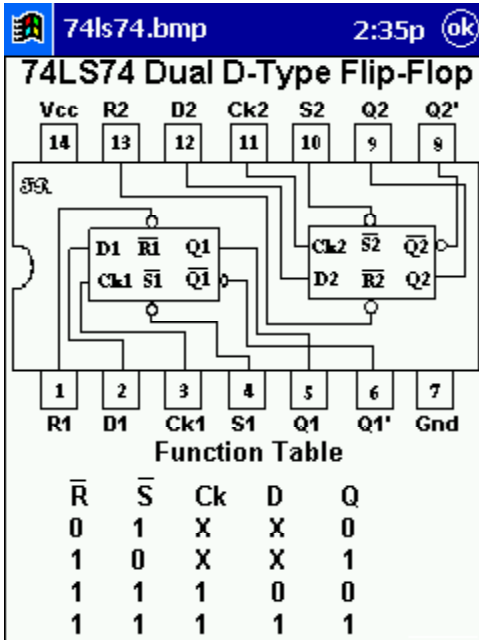


Fig. 3. - TTL Device Information

**Pocket Excel**

A11	A	B	C	D
1	0	0	0	1
2	0	0	1	1
3	0	1	0	0
4	0	1	1	1
5	1	0	0	1
6	1	0	1	1
7	1	1	0	1
8	1	1	1	1
9	$n(A,B,C) = A'B'C' + A'B'C$			
10	$+ A'BC + AB'C' + AB'C + ABC$			

Fig. 4. - Truth Table and Minterms in Excel

Pocket Word can be used to make notes and annotations to the lectures, or can also be used to display text files given in class such as assignments and lab descriptions. One very interesting characteristic of this program is that students can make notes using the handwriting and character recognition capabilities of this tool.

Internet Explorer can be used together with the wireless card to connect to the Internet and be used to access the class WebPages, to transfer files, and to answer in class quizzes and polls. The WebPages are formatted so that they fit the small display of the handheld computer. Best of all, it can use at any time, anywhere to improve student skills. The handheld PC provides true mobile computing and is a valuable resource with or without access to the Internet. While on campus the iPAQ allows students to instantly access the Internet from a variety of locations. These include class and lab rooms, the UMD library, the cafeteria and various rooms in the engineering building. The iPAQ also supports wireless email using the iMAP program.

The iPAQ is also the repository for interactive quizzes and a host of material that will help you study for upcoming exams. It is a very good exam study aid.

Also, students can use the sound recording capability of the iPAQ for recording limited segments of lecture material, or to reproduce sound and music files.

Finally, some programs of the package were developed using the pocket PC toolbox available from Microsoft; we implemented these programs using Visual Basic and Java.

Among the programs developed using these languages are a K-Map solver (Fig. 5), a Quine-McCluskey minimization program (Fig. 6), and interactive programs to simulate logic gates and digital devices operation.

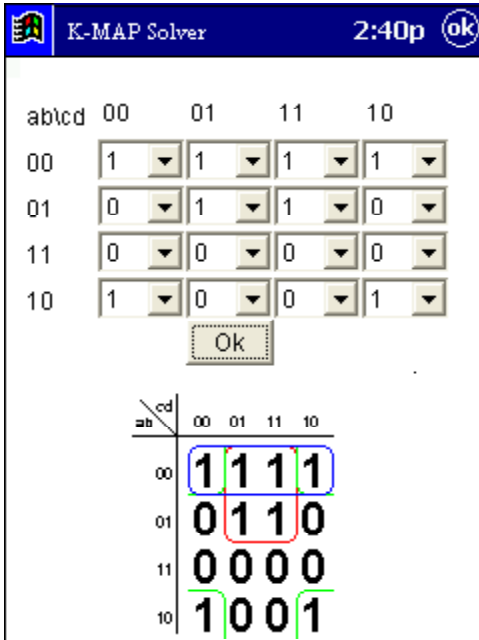


Fig. 5. - K-Map Solver Program

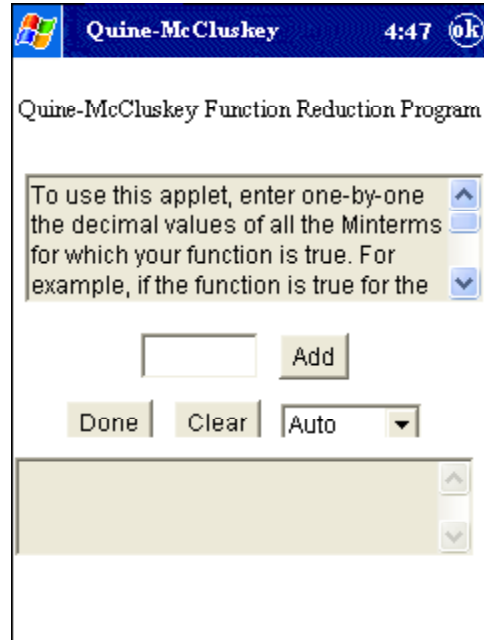


Fig. 6. - Quine-McCluskey Program

#### 4.0 Student Survey

Since we integrated the use of the handheld computer in the introductory digital system design course in the fall of 2001, we have made a survey among students to find their opinion about the use of the iPAQ in class, an example and result of the survey are displayed in Figures 7 and 8 next.

#### 5.0 Conclusions.

Based in the survey responses from students, and our own experience in class, we find the response to the use of the iPAQ handheld computer generally acceptable. With the use of the handheld in class we have noticed an increment in class participation for part of the students and a faster dynamic in the class environment. The main complaint we get from students is about the cost of the handheld computer. Since the cost of the handheld computer, with all its added components for wireless communication, is getting closer to the price of the lower end laptop, which is around the thousand dollar mark. Then it makes the option to buy the laptop more appealing rather than the handheld more attractive. However, the main attraction for the students in using the iPAQ is the real portability characteristic of the handheld over the laptop, since carrying a laptop all day is not that attractive to them.

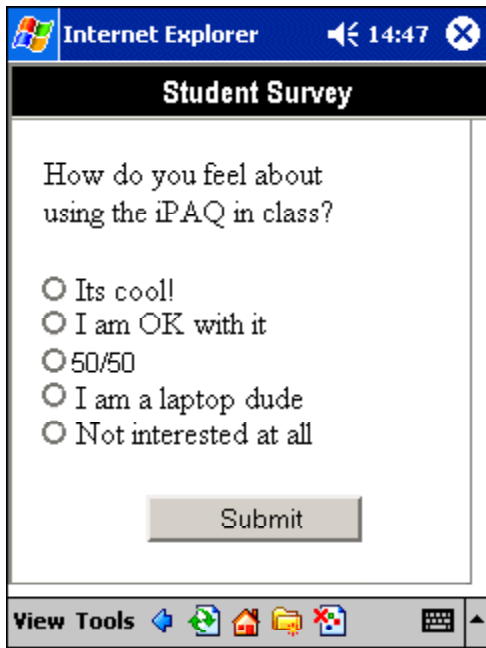


Fig. 7. - Student Survey Question

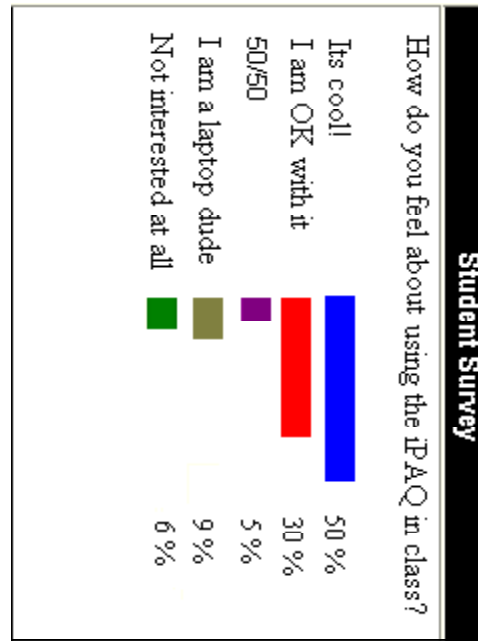


Fig. 8. - Survey Results

Also, as more technological advances are developed, the handheld computer will add more capabilities that will make their use more attractive and universal, such as cell phone and GPS connection capabilities. Another advantage is that with the Bluetooth technology already available, it is possible to use the handheld computer as a universal remote control, and also allow the communications to hundreds of peripherals such as wireless keyboard, mouse, printer, etc. As these technologies become more popular the price of the handheld will tend to decrease too, so that the handheld PC will be more attractive and universal tool to use in general, which will give our students an advantage in the long run.

#### References

[1] Hewlett-Packard Company, Handheld Devices, Palo Alto, CA; URL:  
<http://www.hp.com/country/us/eng/prodserv/handheld.html>

[2] Microsoft® Windows for Pocket PC, URL:  
<http://www.microsoft.com/mobile/pocketpc/learnmore/default.a>

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