The Technology and Applications of the New Generation of Electronic Books

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Abstract: Following the publication of the first electronic books at the end of 1998, VTT Information Technology has carried out several studies to evaluate the technical and commercial potential of electronic book technology. This research compares the latest models of electronic books with the first generation of e-books and the conventionally printed products. The technical comparisons include, for example, the image quality factors affecting text quality. The readability and usability of electronic books are evaluated and expectations regarding the technology are investigated. Several pilot projects have also been launched for applying electronic book technology to new publishing processes. This paper will describe the initial experiences with e-book publishing in different environments, such as universities and libraries.

Our studies reveal that electronic publishing and electronic books offer several advantages to publishers, consumers, and authors and may result in radical changes in the publishing industry. This will require that publishers adopt a new way to distribute their publications and that the technology develops as expected. All in all, it is very difficult to predict a time when the electronic and the printed book will truly compete with each other, but it seems quite inevitable that successful electronic books will emerge in the course of time.

Introduction

Digitalisation, networking and wireless communications enable the production of new types of electronic publications. For example, most of the daily

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newspapers in the United States have electronic versions, which are very popular in some cases. The most famous example of such a publication is The Wall Street Journal Interactive Edition, which has announced that it has 500,000 paying subscribers. Many special magazines, like trade journals, are delivered only by the Internet. Also the archives of libraries are rapidly becoming digitised. These are some of the reasons why electronic publishing is expected to be the most profitable publishing sector in the future. At the moment, most of the electronic publications are read on the CRT screen of a PC, but the developing display and computer technologies enable the manufacture of light, portable information carriers. The electronic books which are already on the market are examples of this development.

In this study, the electronic book is defined as a simple and easy-to-use hand-held computer which is specially designed for the reading of text. Programs have also been developed to read electronic books with palmtop and laptop computer. The success of hand computers has paved the way for electronic books, but also technical advances such as the development of electronics, batteries and displays have enabled devices. Nevertheless, the most important element is the Internet which allows a fast, cheap and easy distribution of book files which can be bought from the virtual bookstores of the Internet. Also many magazines, like Time, Newsweek and Fortune, have produced an electronic book version of their magazines.

What You can Do with It

Electronic books are very user friendly devices. You can switch electronic book on, depending on the model, by pushing the on/off button or by just opening the cover of the book. From two to six control buttons can usually be found otherwise the device is controlled by using display menus. For example, you can flip the pages of an electronic book page by page forward and backward by just pushing buttons or a control bar. You can also make a bookmark by tapping the corner of the page, causing it to fold virtually. By just tapping another button you can check what is in the electronic library of the book. And you can select a book by just pushing its name in the display. Reading and search tools are conveniently available in a pull-down menu and you can, for example, make annotations directly on the page. You can also underline or highlight text or check the meaning of a word from a dictionary by just clicking that word with a display pen. There is also a toolbar which tells you the current page number, its relative location and the location of bookmarked pages. The electronic book can be plugged directly into the phone line, because there is a built-in modem and the device will automatically find the nearest bookshop where you can purchase books and magazines. You can also expand the storage capacity of your electronic book by using Flash cards.

Table 1. The properties of e-book readers

	Rocketbook	REB1100	Softbook	REB1200
Price [USD]	199	299	599	699
Weight [g]	620	510	1390	940
Size [cm] (Diagonal)	14	14	24	21
Battery life [h]	20	20	5	5
LCD Display	Monochrome	Monochrome	Monochrome	Colour
Resolution of the display [dpi]	106	106	72	98
Built-in Modem	No	Yes	Yes	Yes

The first electronic book, called Rocketbook, was published at the end of 1998 by Nuvomedia. Originally the price of this device was USD 499, within a year the price fell rapidly to USD 199. Rocketbook is about the size of a paperback and the display is a 14 cm diagonal monochrome display with a resolution of 106 dpi. Rocketbook weighs 620 grams and the battery life of the device is about 20 hours. 55,000 pages can be loaded into it. There are about 3,500 titles available at the moment and many magazines and papers, such as the New York Times, and the Wall Street Journal have created special versions for the device. The properties of the electronic books are shown in Table 1.

The manufacturer of Softbook, called Softbook Press, announced that the device was designed to be used in companies and it did not try to to compete with Rocketbook in terms of the price, which was constant USD 600 for several years. This device is equipped with a 24 cm diagonal monochrome display which has resolution of a 72 dpi. Softbook weighs 1390 grams and the battery life is only five hours. 85,000 pages can be loaded into Softbook and 2,400 titles and magazines such as Time, Fortune, the Wall Street Journal are available.

Gemstar International Group Limited acquired SoftBook Press and NuvoMedia and made a strategic agreement with Thomson Multimedia to jointly pursue the electronic books market worldwide. Under the agreement, Thomson has licensed e-book technology from Gemstar. Thompson has released the next generation models of both Nuvomedia's Rocketbook and Softbook Press's Softbook.

The new Rocketbook, called REB1100, has the same size and resolution LCD screen than the original RocketBook, but it weighs only 510 grams. The price of this equipment is USD 299 and the battery life is about 20 hours. 70,000 pages can be loaded into it. It has a built-in modem that supports its analog phone-based internet connection. The new Softbook, called REB1200, is smaller than the original one with a 21 cm diagonal colour display with resolution a of 98 dpi. It weighs 940 grams and the battery life is 5 hours. Its memory is expandable to 120 MB. It also has a built-in modem.

Peanut Reader is free book reader software for Palm PDAs. Over 2,000 titles are available and this service is very popular. This is because over 7 million Palms have been sold worldwide. On March 2001, Palm acquired e-book developer and publisher, Peanutpress company, including its e-book reader. Because of its position as a market leader in PDAs, Palm has the potential to compete with the big vendors like Gemstar.

Microsoft published its Microsoft reader program in August 2000. The program is meant for Windows CE devices. Titles for Microsoft Reader can be bought from the electronic bookshops of Barnes & Noble and Amazon. This program uses ClearType technology, which can, according to the company, improve the visual resolution of LCD displays by up to 300 %. This quality improvement will especially benefit low resolution displays of present electronic books.

Glassbook, nowadays owned by Adobe, is reader software for Windows CE systems. Tools have also been developed for the distribution, transfer and library use of book files. Adobe will integrate Glassbook programs with its own e-book reader. The company has developed a very similar system to Microsoft for the quality improvement of low resolution LCD displays, called CoolType. There is tight competition between Microsoft and Adobe in this market area.

Benefits of Electronic Books

Electronic publishing and electronic books offer many advantages to publishers, consumers and authors. Delivery, printing and marketing expenses make up almost 50 % of the price of a printed book. Although marketing is also needed with electronic books, book printing and delivery expenses could be saved. Without printing expenses very small editions could be published profitably. In addition 40 % of all printed books are returned to the publishers because of no demand, while some editions run out of print. These are some of the reasons why publishers could sell cheaper books and/or make greater profits by electronic publishing. Other benefits are the user-specific databases of the sold books which enable profiled direct marketing. It is also very cheap to store a large number of electronic book files and the data is much easier to update and distribute.

Electronic books and magazines are cheaper for consumers and it is easy and fast to purchase the books. It is also possible to have a large number of book files which do not use up and require space on the bookshelf. The data processing functions, such as search, improve usability and the backlight allows reading in the dark.

Electronic publishing may also benefit authors quite remarkably. The most famous example is Stephen King who published his short novel "Riding the Bullet" in March 2000 only as an electronic version. The price of the book was

USD 2.5 and it could be downloaded from electronic bookstores on the Internet. 400,000 copies of the book were sold on the first day which is much more than the ususal number of bestsellers at bookstores. King is said to have earned some half a million dollars within a few days. Because the unexpectedly massive demand for the book swamped the billing system, the book was eventually given away for free - but King still got his royalties.

Stephen King continued his crusade and published the first chapter of his serial novel "The Plant" in July 2000 only as an electronic version - this time completely without a publisher. Within a week 150,000 copies were downloaded. Here we gained an interesting business model: although there was no copy protection, 76 % of the 150,000 readers were still willing to pay the requested USD 1. King finished his experiment after installment number VI in December 2000. King reported at his net site that he again earned almost half a million dollars with this novel.

Many big publishers in the States were surprised at the success of King's "Riding the Bullet" and they have spent tens of millions of dollars to start their own e-bookstores. Random House opened an e-bookstore at the end of July and a hard competitor Time Warner a day later. The electronic book pioneer, Barnes & Noble, believes that soon all new books will be in both paper and electronic form in the near future.

The First Applications of Electronic Books

Studies have revealed that the first likely applications for electronic books will be in the study environment. There are several reasons for this. First of all, professional literature is expensive and one can spend thousands of dollars for printed books during studies. Because electronic book files are cheaper than printed books students can save considerable amounts of money. Books are also heavy, but nowadays a large electronic archive can easily be carried. The electronic distribution of books and other documents is timely and cost effective, and makes interactive studying possible. Reading appliances can also be connected via wireless networks. In addition different kinds of search functions are possible when the content is in electronic form and for example finding a glossary definition for a term by simply clicking it, is a handy function. Students are also more willing to use new technology. For example, 90 % of college students own access to Internet at home and 16 % own laptops in the United States.

Several companies, like Adobe and Microsoft, are running pilot projects in this area and many trade publishers are converting their book files to e-book formats. Also new companies, such as an MIT-based startup called Tetrawave Inc. are designing digital publishing systems for academic publishers. Tetrawave has also demonstrated a prototype of a dedicated e-book reader

device. Tetrawave uses proprietary encryption technology and stores e-book files in its own server. The system is optimised for PDF format. The non-copyrighted material can be read on other PDF-based e-book devices, such as the Adobe eBook Reader, but the copyrighted material can only be read on Teterawave's own platform. One possibility is that teachers could create their own e-books by taking segments of different titles and putting them together into one electronic text. Other services, like online libraries, are also being planned. In library use ebooks also have several advantages such as instant delivery, no need for shelf space and easily replaceable titles.

Goreader Inc. has designed a dedicated reader which is especially meant for the higher education and corporate use. The Goreader device is being beta-tested in a few universities and colleges in the Chicago area and will be available for purchase in Summer 2001, with a possible price range of USD 400-600. Goreader has announced a strategic partnership with the Douglas Steward Company to provide electronic textbooks to 3,000 college and university bookstores nationwide. Announcements of partnerships with textbook publishers like Harcourt College Publishers, West Group, Addison Wesley and Key College Publishing have also been made.

Experimental Work

Readability and usability tests were arranged to evaluate how well the electronic book manage to gain the acceptance and confidence of computer-orientated information technology professionals of VTT Information Technology. Ten research scientists took part in the tests in which reading a Rocketbook was compared with reading a paper. Two magazine articles were given to the test group, one in electronic book form and the other printed on paper. These articles were selected so that their lengths matched an A4 sheet, and the order of the articles was varied between the persons. The average reading times were measured. The test persons were also given the possibility to make a closer examination of the electronic book. After that, questions were asked about the usability and the readability of the device.

Image technical measurements were also carried out. The font and dot quality of a Rocketbook and a conventionally printed book were compared. The conventional book in the comparisons was a novel which was offset-printed in a 14-points Century Schoolbook font. This book was selected because the font size matched the size of the original font used in Rocketbook. The test field was written in the same font and entered in Rocketbook. Small dots were also used in the analysis. Two models of electronic books, Rocketbook and REB1100, were compared. This time a 14-points Verdena font was used, because this is the default font of both e-books. The image properties were measured by using an image analysis system consisting of a microscope, a CCD camera and a PC with tailored analysis software.

The size and intensity and the standard deviation of the intensity of the e-fonts and intensity and the standard deviation of the intensity of the background were measured from the electronic and printed books. The intensity value indicates the darkness of the print: the lower the value is, the darker the print will be. The total number of the intensity levels produced by an 8-bit CCD camera is 256, where 0 is black and 255 is white. The area and the roundness of the dot were also measured in both media. The roundness values range from 0 to 1, so that 1 is a perfect circle. All the measurements were carried out in office illumination.

Readability and Usability Tests

Table 2. The results of the reading test

	E-book	Paper
Text A	121	116
Text B	175	143

Two one-page long articles were read by the test persons, one being an electronic book and the other printed on paper. The results of the test are in Table 2. Although the articles were short, the results are clear. It took 116 seconds to read text A on paper, while in the electronic book the reading time was 121 seconds. Text B was read in 143 seconds on paper and in 175 seconds in the electronic book form. From this test we concluded that it is faster to read a text on paper than on a low resolution display of an electronic book.

The test group was also asked about their expectations of the electronic book technology. The e-book was expected to weigh 200-300 grammes and its price was USD 20-80. Our test group wanted to pay 20-50 % less for the book files than for conventional printed books. One person would have paid only 10 % of the price af a paper book. The batteries were expected to last from 10 to 12 hours, although one person expected them to last for a month.

Only one member of the test group preferred to read an e-book rather than a paper book and they all liked reading an e-book much better than an office PC. It was quite surprising that none of our IT professionals found the high-tech electronic book to be more stylish than the traditional, hardback book. None of them wanted to read a long novel or morning newspaper in an e-book, but half of the test group would have read a short recipe electronically.

The greatest advantages were found to be the data processing functions, such as search, the use of a dictionary, the backlight, and the small size and user-friendliness of the device. The greatest disadvantages were the poor readability, the reflections on display, the difficulty in making annotations and in assessing the length of the document. The electronic book was also found to be too heavy

and the display too small. The test group was also concerned about breaking the device or emptying the batteries.

Image Technical Measurements

Table 3. The image technical comparison of a printed and an electronic book

	Paper	Rocket
Area of the e-font [μm^2]	420000	430000
Intensity of the e-font	34	38
Stdev of intensity of the e-font	12	19
Intensity of the background	246	90
Stdev of intensity of the background	7	20
Area of the dot [μm^2]	68000	71000
Roundness of the dot	0.60	0.24

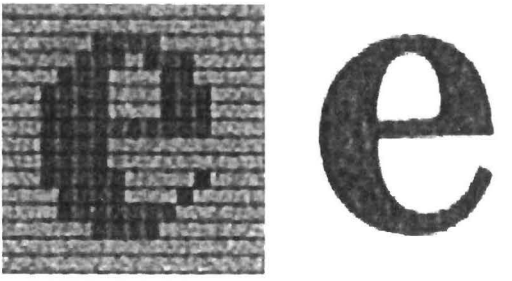

Figure 1. Comparison of e-fonts in an electronic book (left) and on paper (right).

Image technical measurements of the e-fonts and the small dots in a Rocketbook and on paper were made. The results are in Table 3 and the comparison of the e-fonts is in Figure 1. The contrast between the font and the background is small in the Rocket ebook. The darkness of the font is also smaller in the electronic book and the standard deviation of the intensity is greater. This is because of the grey, uneven background and the strong surface reflection of the display. There is a lot of raggedness in the diagonal and circular shapes because of the limited resolution. This can be seen especially when the small dots are compared as in Figure 2. The dot is significantly less round in an electronic book than on paper.

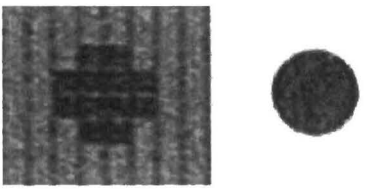

Figure 2. Comparison of the dots in an electronic book (left) and on paper (right).

Image technical comparisons of the e-fonts and small dots in a Rocketbook and a REB1100 were also made. The results are in Table 4 and the comparison of the e-fonts is in Figure 3. The size and the shape of the fonts and dots are almost identical because of the same screen resolution. The biggest differences between these two pieces of equipments is in the contrast between the font and the background and in the evenness of the background. The background is much whiter and more even in the REB1100 than in the Rocketbook. All in all, the readability of this new model is much better.

Table 4. The image technical comparison of two ebook models

	Rocket	REB1100
Area of the e-font [μm^2]	360000	350000
Intensity of the e-font	37	50
Stdev of intensity of the e-font	18	18
Intensity of the background	88	152
Stdev of intensity of the background	20	9
Area of the dot [μm^2]	71000	70000
Roundness of the dot	0.24	0.22

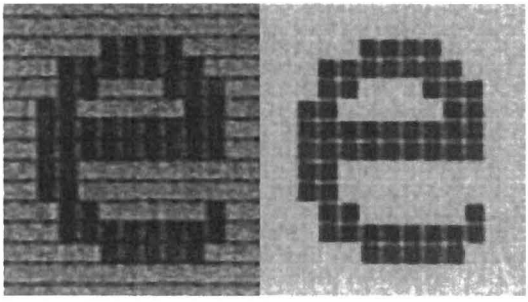

Figure 3. Comparison of the dots in a Rocketbook (left) and a REB1100 (right).

The low resolution and the low contrast of the display decrease the readability of an electronic book, because it is difficult for the reader to distinguish the fonts and to perceive their shapes. People strain their eyes and it is very hard to read long texts. This is the reason why the reading speed of the text was slower and the test group preferred the printed book in our readability tests. The shape and the contrast of the fonts, and therefore readability, are the best in a white non-glossy printed product. Electronic books were also considered to be too heavy and the operating time of the battery too short. They also break and get wet easily. Besides, the devices and the book files seem to be too expensive. The user interface is not at the same level as the printed book. Our tests revealed that the printed book is a superior reading medium at the present level of electronic book technology.

New technical solutions are needed for electronic books to produce the same reading enjoyment as traditional books do. But in our tests the image technical properties of the next generation electronic book, REB1100, were much better than its precursor Rocketbook, so it seems quite obvious that technically more advanced and economically more attractive devices will be introduced in the near future. The many financial benefits for publishers, consumers and writers will promote the development of electronic book technology. For example, International Data Corporation forecasts that 2.8 million e-books will be sold in 2004. This will require that publishers adopt the new way of distributing their publications and that the technology develops as expected. All in all, it is very difficult to predict a time when the electronic and printed book will truly compete with each other, but it seems quite inevitable that very successful electronic books will emerge in the course of time.