

E-Paper The Future of Printed Communications?

Presentation for TLUG (Abridged)



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E-Paper Primer

ePaper – Technology presentation

- ❑ Different technologies available (commercial or sample)
 - EPD/E-Ink (PVI, Seiko Epson):
 - ❑ Based on old technology (1970, Xerox park) but recent improvement in manufacturing process has allowed commercial availability (Sony Librie 2004)
 - ❑ Only commercial and high quantity commercialized product
 - ❑ Sole manufacturer as today: PVI (Taiwan)
 - ❑ Active
 - Nemaptic or Cholesteric LCD (Nemoptic, Fujitsu, Kent, Seiko II):
 - ❑ Polymer stabilized LCD, very low brightness as today
 - ❑ Passive
 - Bridgestone (Bridgestone): QR-LPD Quick Response Liquid Power
 - ❑ Proprietary full polymer-based technology
 - ❑ Passive
- ❑ Many technologies still in development
 - Qualcomm Mems, UniversalDisplay, MAGink

ePaper – Technology presentation

- Key technical Characteristics 1 :
 - Polymer based



Xerox Gyrocon

ePaper – Technology presentation

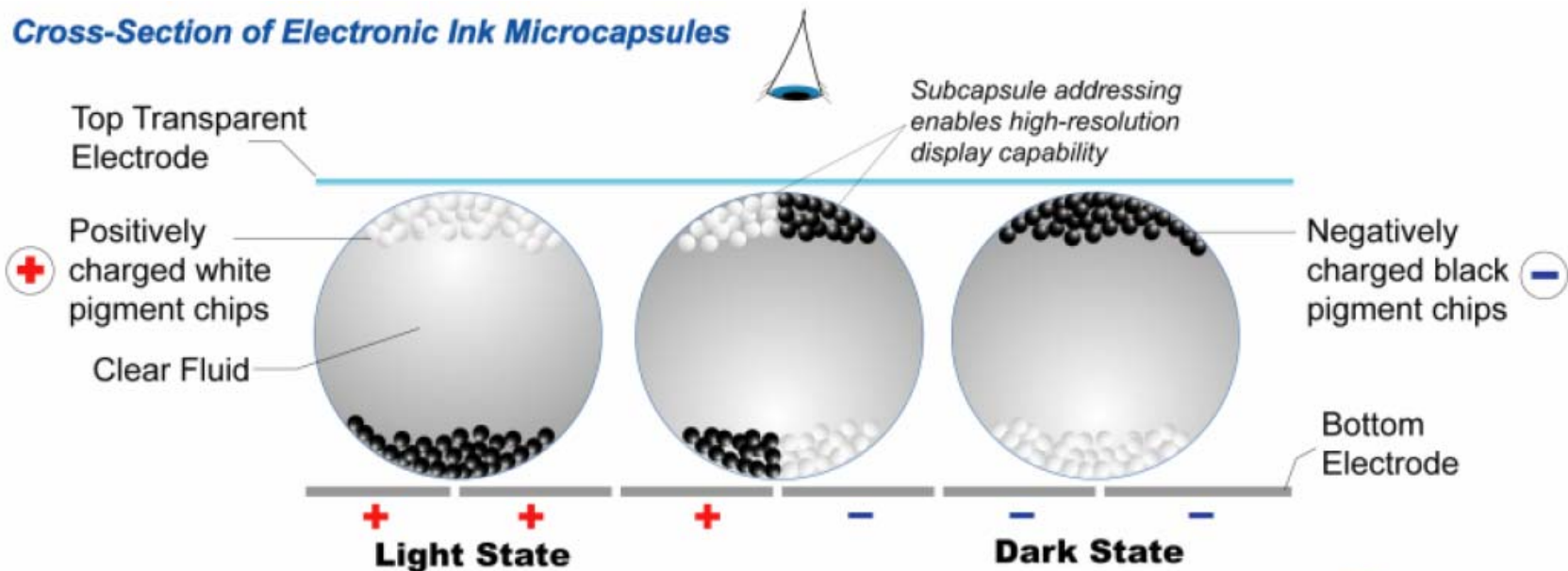
- Key technical Characteristics 1 :
 - Polymer based (vs. LCD)



Xerox Gyrocon

ePaper – Technology presentation

- Key technical Characteristics 2 :
 - Electrophoresis: **Movement of an electrically charged substance under the influence of an electric field**



Note: For illustration purposes only - not drawn to scale. Copyright E Ink Corporation, 2003.

ePaper – Technology presentation

- Key technical Characteristics 2 :
 - Electrophoresis: **Movement of an electrically charged substance under the influence of an electric field**



ePaper – Technology presentation

- Key technical Characteristics 3 :
 - **Reflective screen**: no back light. Brightness comes from ambient light

ePaper – Technology presentation

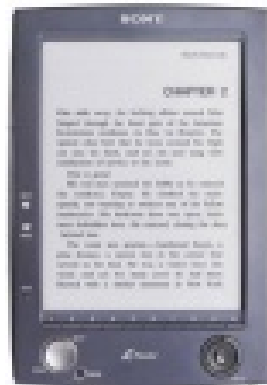
- Main Characteristics of epaper displays:
 - **Bistable**: content is displayed even when power is switched off. Benefit is low electric consumption
 - **Resolution**: Epaper offers 150dpi, better than PC screens (usually 96/72 dpi) but still less than paper (300/400 DPI)
 - **Weight**: latest Fujitsu eBook is less than 180g (module: 60g)
 - **Readability**: EPD use ambient light (vs. LCD screens that emit light). This make ePaper screen readable in any ambient light conditions or angle, but contrast is currently to low (10:1 compared to 10.000:1 for latest LCD)
 - **Ergonomic**: very thin (same as paper) and soon commercial availability of flexible display (2008)
 - **No eye strain**

ePaper-based Devices - 2007

Smart Card



eBook



peripherals



Price Tag



Large display



mobile



Watch



ePaper-based Devices - 2008



IRAQ: THE NEW NORMAL

CHINA'S MODEL PROVINCE

Newsweek

Books Aren't Dead.

(They're Just Going Digital.)

FIVE CENTURIES AFTER
GUTENBERG, AMAZON'S
JEFF BEZOS IS BETTING THAT
THE FUTURE OF READING
IS JUST A CLICK AWAY.

By Steven Levy

amazonkindle



PHOTOGRAPH BY ADRIAN NEESE

NOV. 26, 2007

Amazon CEO Jeff Bezos

ePaper Technology - Conclusion

- ❑ Still low contrast and limited definition
- ❑ Expensive (eInk 9.8" sample ~ 40,000 yen)
- ❑ Not yet fully Polymer-based: Transistor still on glass or metal foil
- ❑ Color display not Active Matrix: each pixel is not individually addressed and long refresh
- ❑ Not killer application yet

Benefits of E-Paper

- ❑ The paper-like display of e-paper produces a stable image, unlike a flickering PC screen. So the reading experience with e-paper is much more comfortable, enabling you to go on for hours without tiring your eyes.
- ❑ The display only consumes power when a page is turned so the power consumptions is very low.
- ❑ Save paper! You no longer need to rely on printed editions of newspapers, books or your own printed documents and notes!

iLiad by iRex Technologies



iLiad by iRex

(E-Ink Based Device)



- ❑ Offers excellent readability outdoors in direct sunlight as in a dimly lit interior settings.
- ❑ Can scale and zoom to suit your own reading comfort or flip to portrait or landscape orientation to get a better view on things
- ❑ Can use included stylus to make notes, underline text and write comments in documents do your favorite crossword or sudoku puzzles or even sketches and draw
- ❑ Can natively view PDF, HTML, text, images
- ❑ Can add 3rd party apps to view RTF and other formats

iLiad by iRex (E-Ink Based Device)

□ Hardware

- 122mm x 163mm 8.1" Electronic Paper Display
- 768x1024 pixels with 16 levels of grey
- USB memory stick, Compact Flash, SD card inputs
- Wired Ethernet and Wi-Fi 802.11g LAN support
- 128MB internal memory available to book contents
- 400 MHz CPU, 64MB RAM



□ Internal Software

- Linux
- X Server
- Java 1.1 Micro Edition
- User installable: Mozilla Minimo web browser



iLiad Development: Negatives



- ❑ Can be “**bricked**” if not careful by accident. During development if you mess up the file system in some way that the device cannot boot, you can’t ssh in to fix your problem.
(Maybe fixed in newest software release that allows reflashing of internal file system from external CF card.)
- ❑ No native Japanese support/**fonts** now nor planned. (Unsupported fonts can be embedded in a PDF but can’t be printed from Java/X or viewed in the web browser or as text files.)
- ❑ **Electronic Ink**: Slow (compared to LCD) and difficult-to-control refresh, artifacts, contrast still needs improvement
- ❑ **Java API** is Micro Edition with reduced functionality
- ❑ **Icon bar/task bar** on bottom of screen cannot be hidden
(maybe possible if you compile your own X window manager?)
- ❑ Tedious text input, **stylus** is a difficult replacement for a mouse
- ❑ Relatively **limited CPU**/memory

iLiad Development: Positives



- ❑ Built in Wi-Fi
- ❑ High contrast & resolution of electronic ink is easy to read
- ❑ Grayscale display can view multicolored maps and images relatively clearly
- ❑ Memory can be easily expanded using flash devices
- ❑ Long battery life
- ❑ Rich Linux, X11, Java development environment allows for a huge variety of apps to be ported or developed
- ❑ Active hacking community is constantly porting new apps
- ❑ iRex supports 3rd party developer community (so far...)

Creating iLiad Apps:

Choices for App Development

- ❑ Ports of X11 applications
- ❑ Ports of Java ME applications. Caveats:
 - There is no Java emulator; files must be compiled on the PC and copied to and tested on the iLiad
 - Not a full Java VM but a JME CDC/PBP one
 - There are some of the of the low-level awt.graphics, but no widgets (just text, lines and images, basically)
 - Screen refresh can be problematic
 - JME JVM has PBP (Personal Basis Profile) on top of CDC (Connected Device Configuration). PBP < PP (PBP is a subset of PP (Personal Profile)).
<http://jcp.org/jsr/detail/036.jsp> (CDC specification JSR 36)
<http://jcp.org/en/jsr/detail?id=129> (PBP specification JSR129)
Support for JNI (since that is part of CDC), so may be able to use some more advanced widgets from other sources that work with GTK...
 - (JME API docs: <http://java.sun.com/javame/reference/apis.jsp>)
- ❑ Tied together by shell scripts
 - Invoke Java, chain other programs together, ...

iLiad Development Step I: Enabling Remote Access



1. Create personal myIRex account on iLiad web site
2. Link iLiad to your account and perform an initial sync
3. Request developer tools package from iRex and re-sync. This enables shell access.
4. Install *mrxvt* xterm application by copying to internal memory over USB
5. Recommended for activating network:
 - Install *connectionMgr_script* package (by copying to device) which provides scripts to start and stop the default network connection as configured by the user and *dropbear* package to enable ssh/scp
6. Start networking using the method installed in the previous step (go to directory you installed it, for example "Newspapers," and click on "connectionMgr_script" directory then click on "start.sh" OR click on "Click on me for establishing a connection" if it appears instead)
7. Run *mrxvt* and set root password with *passwd* and check IP address with *ifconfig*
8. Connect to your iLiad over ssh, using the IP/password from #6

iLiad Dev Useful Apps & Commands:

Summary

- ❑ Tools
 - **mrxvt** – Standard xterm clone
- ❑ Networking
 - network – Scripts to enables/disable continuous Wi-Fi *but* you need to manually edit them first to put in your network password (awkward)
 - **connectionMgr_script** – Starts default networking configuration (Wi-Fi or Ethernet, as configured on iLiad) and leaves it on until shutdown or reboot
 - **dropbear** – Enables ssh/scp; included in unbrickable package
 - unbrickable – Starts Ethernet interface early in boot process; in case boot gets broken, if it boots half-way you can still ssh in and try to fix things (not tested with iLiad OS v2.11)
 - *ifup eth0* – To manually enable the Ethernet interface
 - *ifconfig* – To find your IP address(es)
- ❑ Applications
 - dillo – OK web browser (lacks JavaScript support, Asian fonts, ...)
 - **mozilla-minimo** – Much better pre-installed web browser, but difficult to enter external URLs (needs patching)
 - fbreader – X11 port by user community; enables viewing of additional document types, such as RTF

Screenshot: mrxvt Terminal



```
mrxvt
Terminal
-rwxr-xr-x 1 root root 857276 Jul 9 08:25 libstdc++.so.6.0.3
-rw-r--r-- 1 root root 381114 Jul 9 12:04 libt1.a
-rw-r--r-- 1 root root 772 Jul 9 12:04 libt1.la
lrwxrwxrwx 1 root root 14 Oct 16 07:52 libt1.so -> libt1.so.5.0
.2
lrwxrwxrwx 1 root root 14 Oct 16 07:52 libt1.so.5 -> libt1.so.5
.0.2
-rw-r--r-- 1 root root 322631 Jul 9 12:04 libt1.so.5.0.2
lrwxrwxrwx 1 root root 17 Oct 16 07:52 libxml2.so.2 -> libxml2.
so.2.6.10
-rwxr-xr-x 1 root root 695332 Jul 9 10:36 libxml2.so.2.6.10
lrwxrwxrwx 1 root root 13 Oct 16 07:52 libz.so.1 -> libz.so.1.2
.3
-rwxr-xr-x 1 root root 69536 Jul 9 08:26 libz.so.1.2.3
-rwxr-xr-x 1 root root 182958 Nov 6 12:59 libzip.so.1
drwxr-xr-x 5 root root 1024 Oct 16 07:52 locale
drwxr-xr-x 3 root root 1024 Apr 17 2005 matchbox
lrwxrwxrwx 1 root root 31 Oct 23 20:14 menu -> /mnt/cf/opt/debi
an/usr/lib/menu
drwxr-xr-x 7 root root 1024 Oct 16 07:52 mozilla-minimo
drwxr-xr-x 3 root root 1024 Jul 9 09:04 pango
lrwxrwxrwx 1 root root 17 Oct 23 21:22 terminfo -> ../share/ter
minfo
root@ereader:/usr/lib#
```

iLiad Java Development: Specifics



- ❑ Install JDK on host PC (recent version is OK)
- ❑ Copy irex.jar file from iLiad
- ❑ Compile and package your code like:
`javac -classpath irex.jar -source 1.3 -target 1.1 Test1.java`
`jar cf Test1.jar Test1*.class`
- ❑ Copy JAR to iLiad via scp
`scp Test1.jar java.sh root@10.193.243.146:/home/intent/.`
- ❑ ssh to iLiad and invoke script to run JAR file:
`cd /home/intent`
`java.sh Test1.jar Test1`
intent (Linux boot loader)
Copyright (c) Tao Systems Ltd 1997-2000

0x564E24 bytes read
Booting image at 0x401ce000-0x405ce400
.....

java.sh



```
#!/bin/sh
EXECPATH=sys/platform/linux/taoref/er10xx
IMGPATH=$EXECPATH
export DISPLAY=:0
export ELATE_FB_TTY=/dev/tty0
#export ELATE_KTRACE=/tmp/ktrace.log
export ELATE_DEBUGSTUB=7990

cd /home/intent/
if [ ! -d /home/intent/ROOTDIR ]
then
    ln -s / ROOTDIR
fi

JVMARGS="-v -classpath $1;MobipocketCoreReader.jar;kxml2-2.3.0.jar;irex.jar
$2 $3"
OPTIONS="-capp/stdio/jcode $JVMARGS"

exec $EXECPATH/elate -B $IMGPATH/target.img -g2 -I $EXECPATH "$OPTIONS"
```

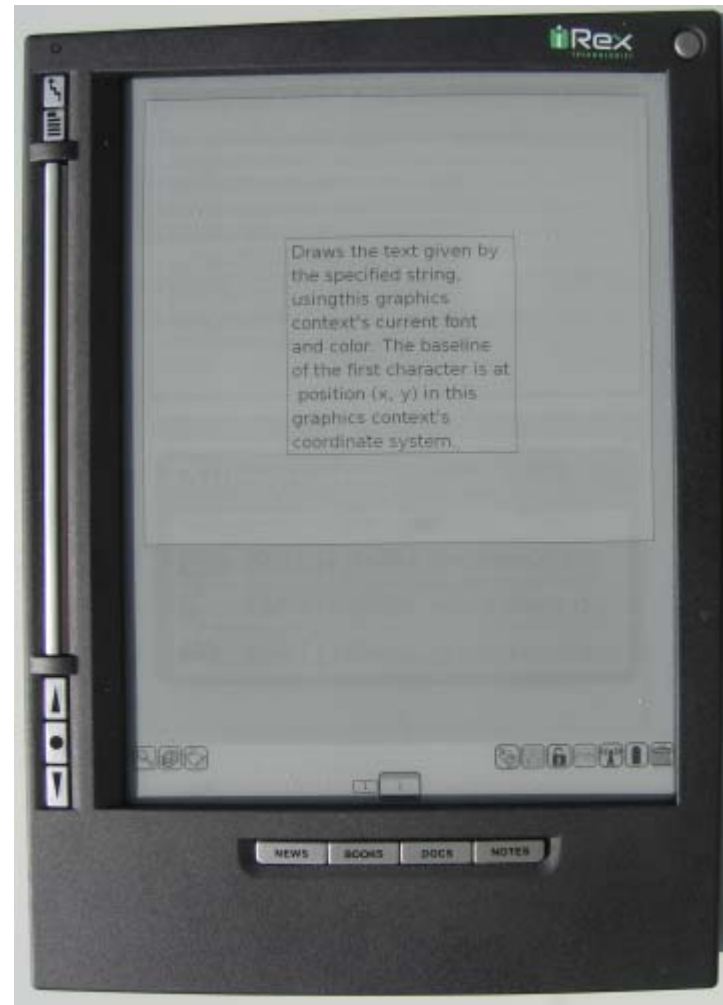
Notes:

- ▣ Uncomment /tmp/ktrace line to send System.out to file instead of the console
- ▣ Remove -v in JVMARGS to stop printing out dump of all classes loaded

Screenshot: Displaying Map Image from Java



Screenshots: Displaying Text from Java



Screenshots: Displaying Widgets from Java

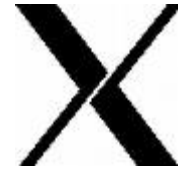


Linux Cross-Development for X11 (Untested)

- ❑ VMware image is available containing the toolchain and libraries all installed:
 - A cross compiling environment
 - An emulator to compile and test the programs (scratchbox, which simulates native compiling; no cross-compiling headaches, it's done transparently for you)
 - Some scripts to aid in downloading/patching/compiling programs from Debian for the iLiad
 - Some scripts to aid in preparing packages for the iLiad
 - Patched libX11 (See next slide)
- ❑ Applications can then be written and tested over local VNC! (no need for iLiad at all)

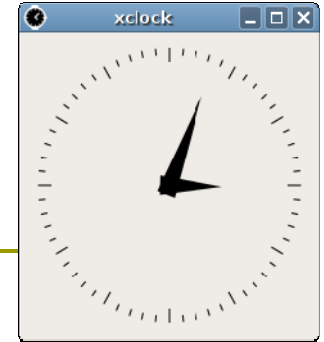


iLiad X11 Development: Specifics



- ❑ Existing X11 applications can be ported by recompiling with the iLiad toolchain, tested using local VLC on one's workstation then recompiled again for iLiad (ARM)
- ❑ Hacked libX11 for iLiad provides automatic refreshing of screen without need to change X11 application code to insert new calls to refresh display
- ❑ Application package is created consisting of a shell script that invokes the application with appropriate set-up (such as pointing LD_LIBRARY_PATH to use the hacked libX11, etc)
- ❑ Files can be packaged in 2 ways
 - As a single .ipkg file installable with ipkg tool
 - As a folder of files with a shell script to invoke

iLiad as X Display for PC



□ X Terminal

- Allow X server to accept connections. Change /etc/rc5.d/S99start:
`/usr/bin/Xfbdev -screen 768x1024x8 -3button -dpi 160 -br -nolisten tcp &
TO
/usr/bin/Xfbdev -screen 768x1024x8 -3button -dpi 160 -br -ac &`
 - On client (PC), launch an xterm from one terminal, linked to screen:
`DISPLAY=ereader:0 xterm -hold -e screen`
 - On client (PC), connect to the screen (from a different terminal)
`screen -x`
 - On server (iLiad), start refresh process to refresh screen every second:
`root@ereader: ~# displayMgrClient -d 127.0.0.1 -r 1
(W)displayMgrClient.c: 156,main() Server address 127.0.0.1`
 - On client, start an X application:
`xclock &`
- Only one app can be displayed at once unless app is modified to make all windows dialogs

Screenshots:

Remote X Display (xeyes, xclock)





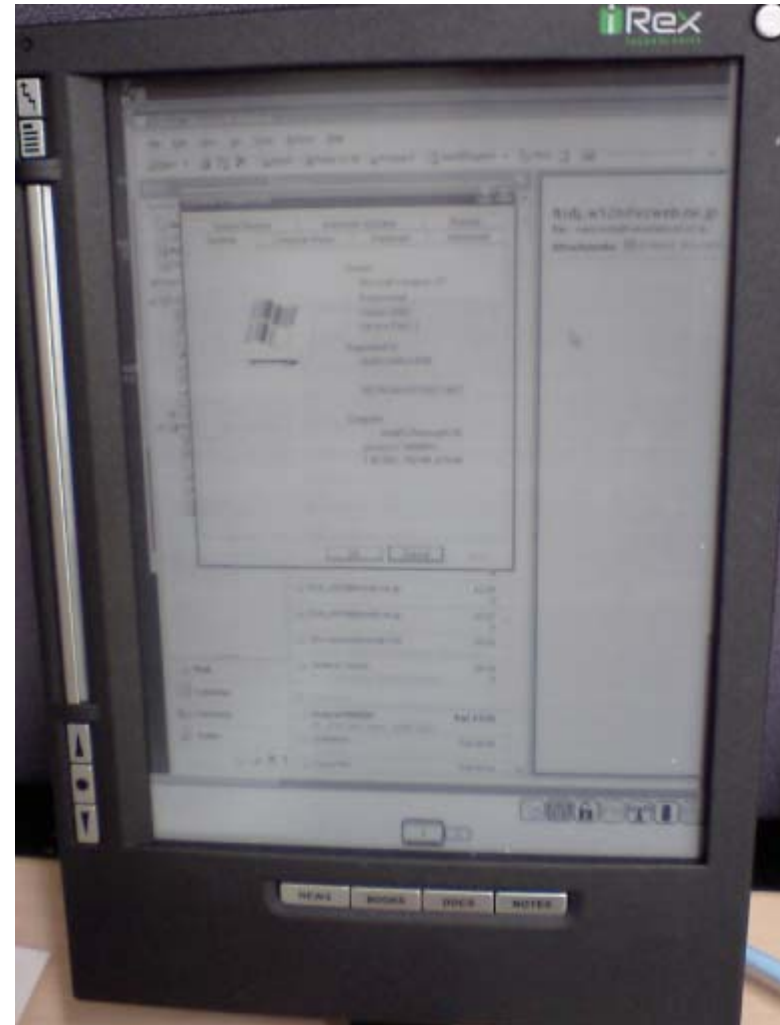
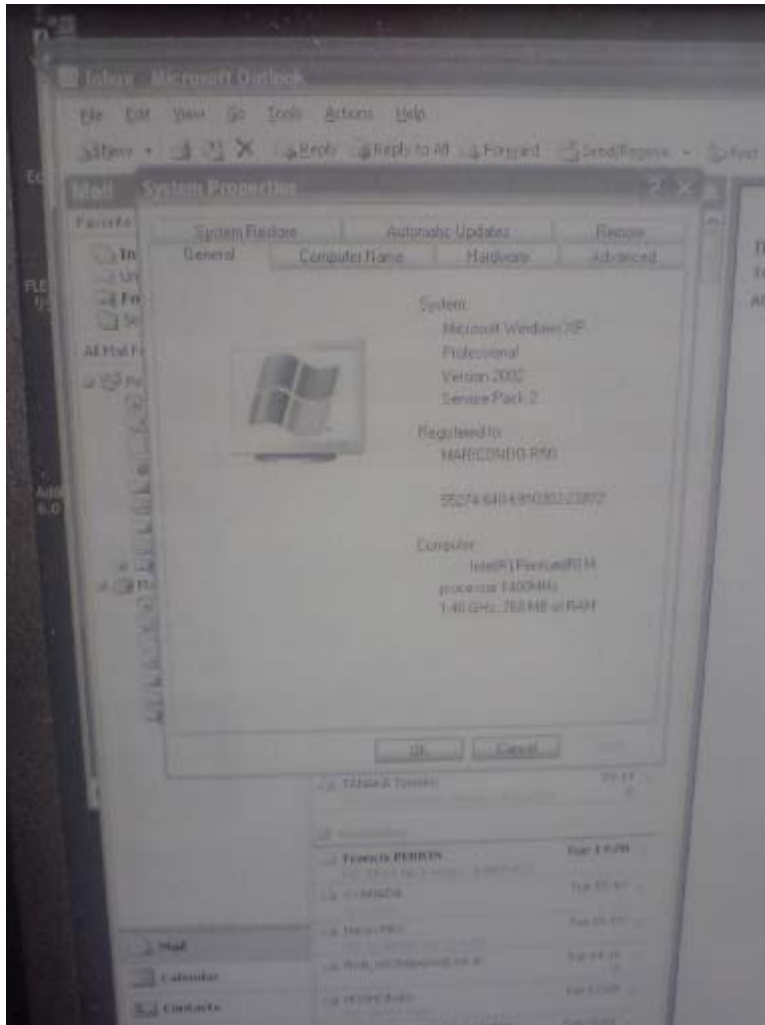
iLiad as VNC Client

- ❑ Start VNC Server on PC (<http://www.realvnc.com/>)
- ❑ Install VNC on iLiad by copying vnc.tar.gz to CF card
- ❑ ssh to iLiad and unpack and start VNC viewer:

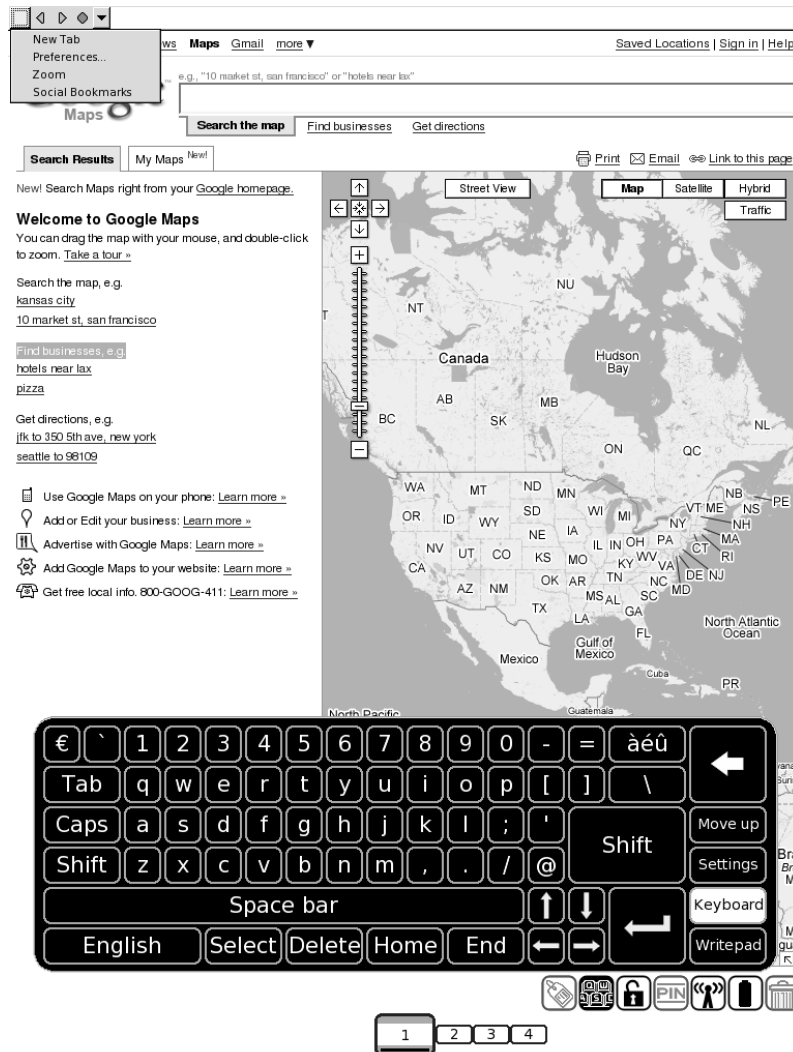
```
cd /media/cf tar xzf vnc.tar.gz  
cd vnc  
LD_LIBRARY_PATH=/media/cf/vnc/lib ./vncviewer -display=:0 [PC IP address]
```
- ❑ You can now use the iLiad as a PC display, but cursor will not update frequently enough (only every 1s) to use the mouse effectively
- ❑ iLiad VNC Server also available but not tested
- ❑ Make screen update every 1s; start a second ssh and run:

```
displayMgrClient -d 127.0.0.1 -r 1
```
- ❑ Caveats:
 - Mouse refresh still slow (minor)
 - Lots of refresh artifacts (major)
 - VNC scroll bars visible on left and bottom of screen (minor)
 - Does not render images as nicely as Java app; better to downscale images on PC?
- ❑ iLiad as VNC Server also possible but not tested

Screenshots: Windows on iLiad (VNC)



Hacked Built-in Minimo Web Browser



- Supports JavaScript so works with AJAX sites like Google maps, Gmail...
- Created by modifying built in Minimo application (currently used to view local HTML only) to use patched libX11 and different chrome files
- Screen refresh can be problematic
- Doesn't support SSL; complex JavaScript runs very slowly

iLiad Development Summary ①



□ Java – Difficulty: Medium-Low

- Summary: Java server app stays running on iLiad, listening for messages via Wi-Fi. When message is received, Java app on iLiad updates the display.
- Text: No Japanese fonts on iLiad – may be difficult to display Japanese text
- Images: Dithering of source color images on B&W display is very good
- Requires no PC overhead; a single PC can update many iLiads
- JME API much easier than X11

□ X11 – Difficulty: Medium-High

- Summary: X program runs *remotely* on PC or *locally* on iLiad (if ported) using iLiad as a X display. You can use full capabilities and richness of X11 development to create an application to display data to the user
- Text: No Japanese fonts on iLiad – may be difficult to display Japanese text
- Image: Effectiveness of dithering unknown
- *Remote X application*: Requires minimal PC overhead, but perhaps significant network overhead for X server display data; a single PC can update many iLiads, network resources permitting
- *Local X application*: Just like Java; requires no PC overhead; a single PC can update many of iLiads

iLiad Development Summary ②



- ❑ VNC Client – Difficulty: Easy
 - Summary: iLiad display is synchronized with PC display. Any program on the PC can be viewed on the iLiad
 - Artifacts can become severe
 - Dithering of source color images on B&W display is not so great
 - Requires one PC (VNC Server) per iLiad
- ❑ Web Browser (Minimo) – Difficulty: Easy
 - Control iLiad display through a AJAX/JavaScript web site, eliminating the need for a Java or X application
 - Pages can be formatted in HTML allowing for many styling options, and mixing of text and images
 - Screen refresh can be problematic
 - Sometimes JavaScript stops working
 - Many unsupported features (including SSL)
 - JavaScript applications can also be used with FLEPIa

iLiad: Important Points

- ❑ Screen
 - Supports regional screen refresh
 - Full screen black/white refresh is slow and flickers
 - Grayscale screen cannot display some color images well
 - Bottom icon bar cannot easily be hidden
- ❑ Artifacts
 - Without a regular black/white refresh, artifacts build up on screen
 - Some types of images leave bad artifacts without full refresh
 - BUT with enough black/white refresh cycles they will eventually disappear
 - Depending on pattern of use, artifacts can occur more easily
- ❑ Web Browser
 - Minimo is limited

iLiad Development Resources

- ❑ MobileRead Forums – iLiad Developer's Corner
 - <http://www.mobileread.com/forums/index.php>
 - The main gathering place for 3rd party developers
 - Active community
- ❑ iRex Official Forums
 - <http://forum.irexnet.com/index.php>
 - Provides the corporate official stance on various issues
 - Only occasionally useful
- ❑ Cool iLiad apps & blogs
 - <http://syngrithy.org.uk/index.php?pT=7>
 - <http://blog.adamrb.com/>
 - <http://i-to-i.irexnet.com/>

E-Paper/iLiad Conclusions

❑ Negatives

- Lack of specially formatted content; difficult to zoom, pan, and scroll large PC PDFs
- Slow speed in rendering complex PDF files
- No native support for RTF or Word files
- Sluggish CPU
- No (supported) web browser
- Small screen, a bit thick and bulky, non-color
- No backlight; can't be read in the dark or in very low light conditions

❑ Positives

- Highly readable, paper-like feel
- Environmental friendly
- Built in Wi-Fi
- Linux based, can write or port your own X11 and Java apps
- Long battery life
- Slimmer than a regular LCD or laptop/tablet computer
- Looks great in direct light or sunlight; big improvement over LCD/plasma in terms of thinness, energy consumption, and readability in sunlight

iLiad vs. Other Consumer Devices

- Amazon Kindle and Sony Librie
 - Uses same display (E-INK)
 - Proprietary software / closed system
 - Can't display PDF
 - Can't develop own applications
 - ...

Future of E-Paper

- ❑ Technological improvements
 - Flexible polymer based e-paper devices
 - Color
 - Faster updating
 - Higher DPI
 - Larger displays
 - Cheaper
- ❑ Advertisements in retail spaces: stores, trains
- ❑ Interactive digital signage
- ❑ Link to mobile phone
- ❑ Put an e-paper display in your paper calendar/planner 手帳
- ❑ Environmental benefits



Appendix

Quick Comparison: iLiad vs. FLEPia

	iLiad 2 nd Edition	FLEPia (Prototype)
Display	768x1024 16 shade grayscale	768x1024 4096 Color
Display Size	122mm x 163mm	184.3mm x 245.7mm (A4) 123.6mm x 164mm (A3)
Refresh Speed	2 seconds	15 seconds (3-pass) 5 seconds (1-pass)
Contrast	Excellent	Fair
Development Phase	Shipping 2 nd edition	Early stage prototype
Display Type	E-Ink (Active)	Fujitsu Proprietary (Passive)
Operating System Environment	Linux / X11 / Java (JME)	Windows CE 5.00

FLEPia by Fujitsu

(Proprietary; Not For Sale)

- ❑ Announced by Fujitsu in April 2007
 - <http://www.frontech.fujitsu.com/en/release/20070420.html>
- ❑ Large display 12 mm thick
- ❑ Weighs 320g (A5-size model)
- ❑ Can run 50 hours continuously with a fully charged battery



FLEPia

FLEPia by Fujitsu

(Proprietary; Not For Sale)



FLEPia

□ Hardware

- 184.3mm x 245.7mm (A4) or 123.6mm x 164mm (A3)
- 768x1024 pixels with 4096 colors
- SD card input; Wi-Fi 802.11g LAN support
- XScale RISC CPU
- 38MB RAM

□ Internal Software

- Windows CE 5.00
- Internet Explorer 6.0
- Proprietary Fujitsu Applications



FLEPia

Pros and Cons

□ Positive

- First shipping color e-paper display; color is nice
- Display looks beautiful in direct sunlight
- Built in Wi-Fi, SD card expansion
- Lightweight, long battery life
- Windows CE is robust
 - 1 second power-off and power-on (sleep mode)
 - Internet Explorer is a reliable web browser

□ Negative

- Due to touch sensitivity, screen is far too reflective; makes a great mirror more than a display sometimes
- Screen refresh is too slow and cannot be interrupted; this also makes responsiveness to user interactivity as a sign challenging
- Prototype units sometimes lock up and crash
- Wi-Fi networking occasionally gets disconnected (need to restart web browser and/or whole device)
- Contrast is rather poor under low light conditions
- Cannot (yet) write our own native applications; have to use JavaScript/IE





Q&A