MT MA1 - Semester project

China Hardware Innovation Camp - Vesta

Engineering Report

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1 Introduction

This semester project takes part of the CHIC2015 which is a new project initiated at EPFL by Marc Laperrouza. The goal of this new project is for students develop a project from idea to production in a semester. Indeed a trip to Shenzhen in China is programmed following the end of the semester(july). The prototype will be produced by chinese company called Seeedstudio. They mainly do pcb prototyping but they also mill and 3d print parts.

Three groups of 5 people are created after a brainstorming week-end at the beggining of the semester with for each group one HEC (economy) student, one ECAL (industrial design) student and three engineering students from EPFL. For the project presented in this report, two engineers are from microengineering and one is from material science.

The economy student works on the business part of the project which contains the business model, the market definition and the value proposition. The industrial design student works on the mecanical and software design. The engineering students work on the materials, hardware and software of the project.

After the brainstorming week-end, the rough idea was to connect elderly people to their families with an easy to use electronic device. Many elderly people are excluded from the new technologies and are therefore excluded from modern communications.

Between 2000 and 2050, the number of elderly aged more than 80 years old in the world will be multiplied by 4 to reach 400 millions, according to the world health organisation. The number of connected elderly is growing, around 17 millions people aged more than 65 years own a tablet in Europe in 2014, according to the Forrester Research agency.

2 billions people will be aged 60 and older by 2050 globally.

In figure 1.1 the ageing population is shown for EU 27, Switzerland and Norway.

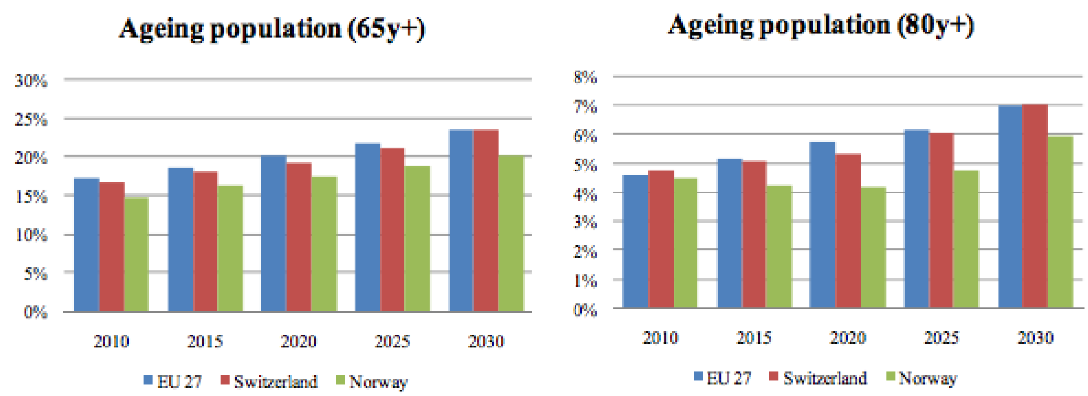

Figure 1.1: Ageing population in the EU, Switzerland and Norway. Source: Eurostat

In this report, the focus will be put on the engineering part of the project especially. An abstract to the market researches will be introduced. The industrial design parts will also be discussed to have a global aspect of the project.

2 Problem and Solution

In this section we will lay out the problematic we wanted to adress during this project. Our chosen solution will be introduced and described.

2.1 Problem

The first part of the project was to define what are the needs of the elderly and their families in term of connectivity.

More and more people are connected to social networks and use internet to communicate. They share pictures or videos, send messages with their smartphones, tablet or PC. A lot of people who follow these new technologies use it everyday with friends or family. A big part of the population is excluded as they are not able to use these new technologies. The goal is not to teach the old people how to use a computer or a smartphone but to have a device that would let them keep connected and included in the digital world.

Especially in occidental countries, when the elderly are not able to take care of themselves, they are sent to an old people's home. Most of them would prefer to stay home longer. A device that would keep the elderly connected with their family, check if everything is alright even make health tests could let the old people stay longer at their place.

2.1.1 Younger generation needs

To determine what are the young people needs, a quiz(survey) was put on internet to ask how young people would like to discuss with their grand parents. The quiz contained questions of the type:

- Do you have any contacts with your grand parents?
- How often do you discuss with your grand parents?
- What is the best way to do it? Social network, phone call, sms, visit them...
- Are they existing communication means adapted to do so with your elders?

Most of them wanted to have more contact with their elders but not through available social networks (facebook, twitter, instagram, google+). This was mainly due to the elderly beeing unfamiliar with these means of communication. They mainly wanted to be able to share text and photos. Some of them would have liked to be able to make video calls.

2.1.2 Elderly needs

To define the needs of the elderly, a visit in an old peoples home (EMS) was organised and some questions about what they want and what they are able to do were asked to them and also some technical questions were asked to the nurses.

The general feeling is that the elderly generation is left out of the new technological world and developpment rarely takes their input into consideration. Old people want to have more contact with their families and especially the young ones.

The questions to the nurses were more about the usage old people have with new technologies, what kind of environment they live in and what kind of objects they have around them. The results that came out of the discussion were that the old people don't hear well sounds and are not able to define where the noises come from. A device with an alarm wouldn't be a good idea. The interface has to be as simple as possible because they are lost if there are too many options. The device has to be big enough and shouldn't break after a shock. The text on the device has to be big enough to be read by old people.

It was also noticed that the elderly do not have the same picto-references. The logos commonly used in user interfaces did not work well with old people.

2.2 Solution

As the majority of the content people wanted to send to each other was text and images, the device at least needs a screen and some kind of user interface. The challenge and purpose of the project was to find a user interface adapted to the elderly. The younger generation could use the internet on any device already available. Different solutions were imagined. A device that connects to the TV with HDMI and display pictures, messages and videos on it.

A device that connects to the web with a 3G chip (don't need the wifi and is more portable) or a device that contains only a wifi chip.

A device with a touch screen or only a screen. With physical buttons or not.

From the visit to the EMS we found out that:

- The device needs to be portable.
- A 7 inch screen was big enough
- A flat device such as existing tablets was not suitable as it could get easily lost under things and the grip was not easy.
- The color of the object is important as elderly tend to have many things and the device should be easily localisable
- Sound was not a good solution to emit notifications, visual stimulis was better.

From these elements we decided to build a portable communication device dedicated to the elderly. This device has a 7 inch touchscreen has wifi and bluetooth capabilities a battery and a no contact charging station. In parallel to this device a website and an app dedicated to the families of the elderly are linked to the device.

The families have an account wich is linked to a or several individual devices. The website and the app then allow the families to send photos and/or text directly to the connected device(s). As soon as the device receives a new message a small LED starts to blink. When the elderly person opens the new message simply by touching the screen this triggers and automatic acknowledgment message to the sender.

The website also allows to adjust certain settings of the device such as screen brightness, in which order are the messages displayed, or the size of the text of the messages. The goal is to have the younger generation deal with all the setting up which might need a little more technological knowledge. The elderly can then relax and not think about anything outside the main purpose of the device. A rendering of the developped device is displayed in figure 2.1.

Figure 2.1: Vesta tablet

3 Value Proposition

To confirm that the problem and solution definitions match, a value proposition canvass was established. The hypothethis is made that the customers and the users of this product are different. Indeed the people buying the device will be the family of the elder(s). While the elders will be the end users. Therefore the needs of the buyers and of the users are different. They will be both using the device but through two different interfaces.

The value proposion canvas template used for the analysis is the one pictured in figure 3.1.

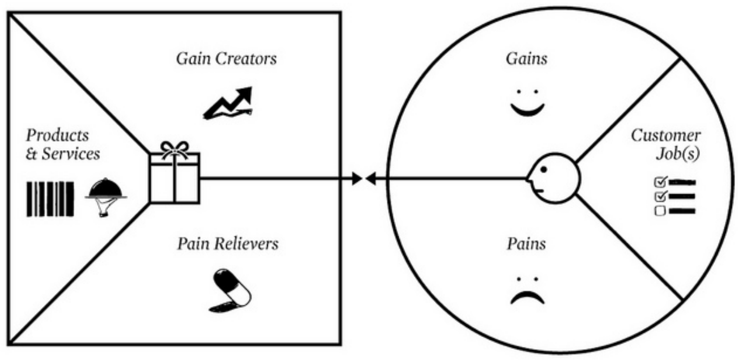

Figure 3.1: Business model canvas

The value propostion canvas for the elderly can be seen in figure 3.2. From this canvas the following pain relievers can be link to corresponding pains

- Be included - be forgotten
- Notification - feel lonely
- Have an occupation - get bored

The following gain creators match de elderly gains:

- Feel cool - contribute
- Reinsuring on others state - be informed
- Feel included - feel loved

Clearly the value map of the device meets the customer profile of the elderly to achieve a fit.

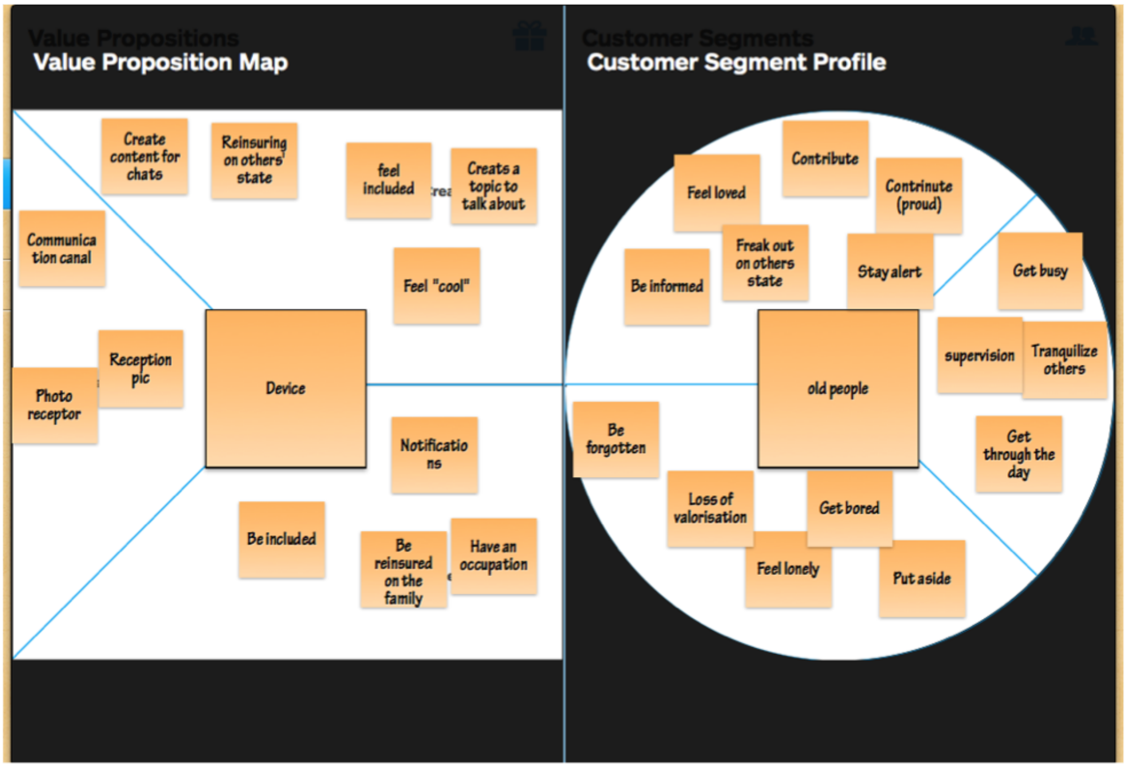

Figure 3.2: Elderly value proposition.

The family's main needs are to keep contact easily with their elders even when they cannot be present. To integrate them in their communication habits. To feel less guilty to let them alone. All these things can be achieved with this device.

4 Industrial design

In this section, the industrial design will presented. The design part was done by the ECAL student. The indutrial designer presented different solutions, they were then discussed together with the other member of the group. The solutions were also presented to the nurses and some old people to define which one is the more understandable and easy to use.

4.1 Tablet

The device has a unique aspect. It has round shapes and is elegant. The color of the case is warm and positive. It also is a visible color and not agressive. The screen size is 7 inches with a resolution of 800x480. It is big enough to display readable messages and images.

The case has a certain thickness to allow the users to have a better grip. The device can have 2 postures, vertical or horizontal. The user can then watch the tablet sitting down and holding it in his hands or the device can be used like a digital photo frame. When the device is on the charging station it is in the vertical position.

The design of the tablet is shown in the figure 4.1.

Figure 4.1: Vesta tablet design

On the left, the vesta tablet on the charging station. On the right, an iphone for scale.

4.2 Charging station

The charging station is quite descrete, takes up little space and is very nice. It can be placed anywher without having to hide it.It is wireless. More and more devices in the market allow to charge the battery wirelessly. To charge the tablet's battery, the tablet need to be located on the charging station. The advantage of this station is that the users don't need to plug a small cable like micro USB into the tablet to charge it. The charging station method is much easier to use.

On the left, the inductive charging station. On the right, the vesta tablet in horizontal position.

Figure 4.2: Charging station

4.3 Software design

The software located on the tablet needs to be very easy to use and understandable by an old person. Different designs were imagined, tested and compared.

The graphical interface of the software is shown in the figure 4.3.

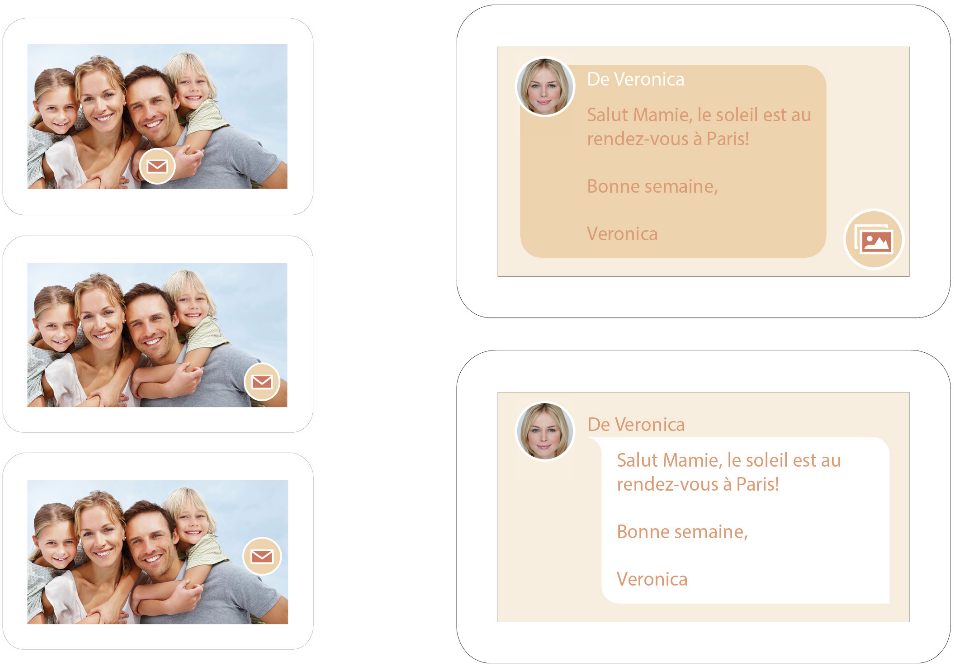

Figure 4.3: Software design

On the left the software design imagined for the picture display with the button to display the text message. And on the right, the design of the text message display with the picture of the sender and the button to return to the picture.

4.4 Visual identity

The visual identity keeps the same tone of colours as the casing of the device. A name a logo and a style were sought for.

In figure 4.4 different logos can be seen.

In figure 4.5 different icons where imagined and evaluated.

Figure 4.4: Search for a visual identity

Figure 4.5: Search for a visual identity specific to icons

5 Hardware

This section is dedicated to show all the chosen electronic components and how they work together. As described earlier the PCB containing all the components will be manufactured by Seeedstudio. They manufacture PCBs with other hardware components and they sell quite a number of different breakout boards and other developpement parts. A request made by CHIC managing team was to source as many components as possible at Seeedstudio. Of course not all components needed were available by them so some of the components are from different sources.

The project was basically building a tablet. However time constraints did not allow the devellopment of a tablet from scratch. There for it was decided to build an add-on to an existing processing unit.

There are a number of different devellopment/tinkering boards available. The most famous one might be the raspberry Pi, although quite capable it seemed a little limited for this application (clocked at 700 mhz for the raspberry pi 1). Another problem was that the raspberry pi is not completely open source. Indeed its schematics and gerber files are not available. One of the requirements of the CHIC project was that it was necessary to work with a totally open source/open hardware platform. For these reasons the raspberry pi was discarded.

Another famous board was chosen: the beagle bone black. Which will further be refered to as the BBB. This board clocked at 1 GHz seemed quite capable. There was lots of documentation, a wide community, and especially it is completelly open source hardware and software.

In fig.5.1 the different components of the device are described.

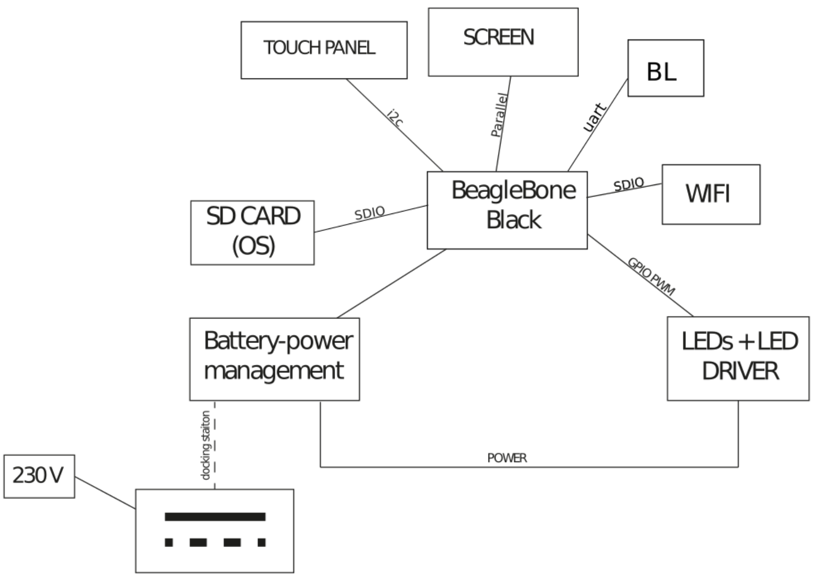

Figure 5.1: Hardware components dependencies.

5.1 Beaglebone Black

The BBB uses an ARM processor from Texas Instruments, the AM335X. It is clocked at 1GHz.

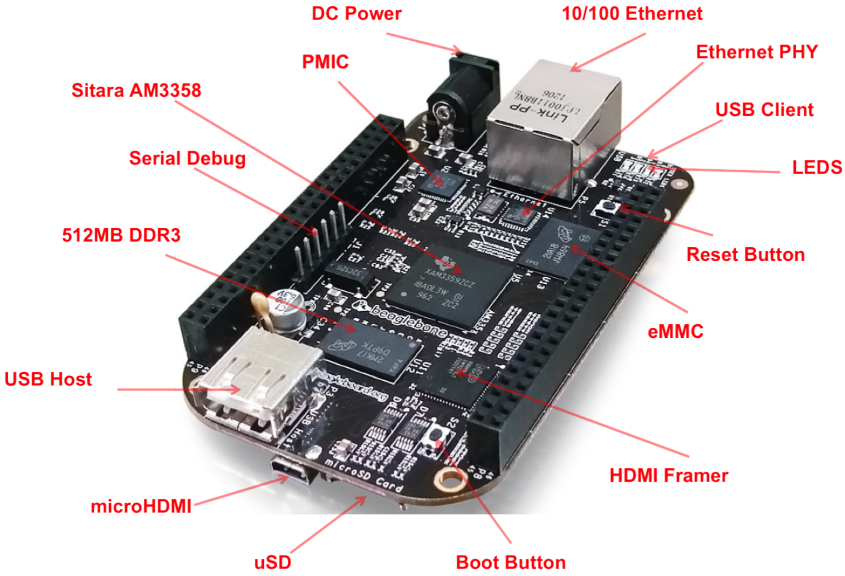

Figure 5.2: Beaglebone black.

The BBB capabilities include:

- AM335x 1GHz ARM® Cortex-A8
- 512MB DDR3 RAM
- 4GB 8-bit eMMC on-board flash storage
- Ethernet
- 2x 46 pin headers
- Open source
- On board Power Management IC
- micro Sd card reader
- Ethernet
- micro HDMI output

The main interface of the BBB are the 92 pins. Many pins can be configured in different modes. The pins and connection are listed in fig.5.3.

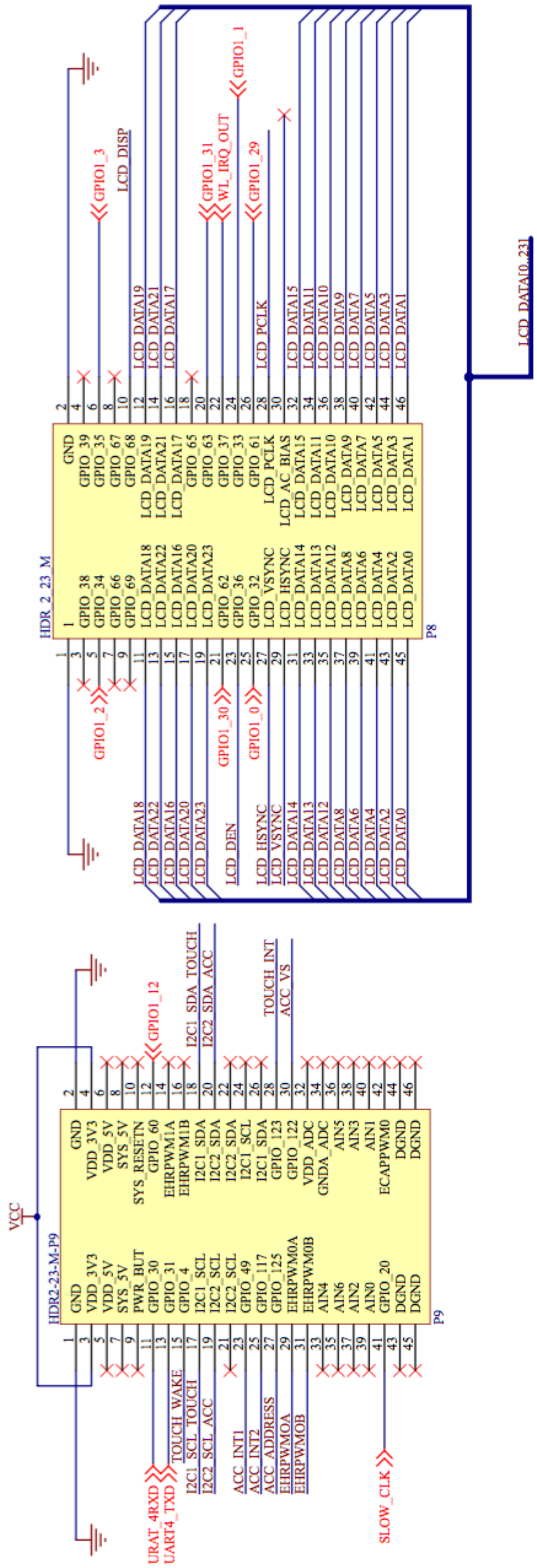

Figure 5.3: Pin usage of the BBB.

5.2 Screen and Touchscreen

At the current state of the prototype the main function is to view images and text. Therefore a good screen with realistic colors is necessary to have a good user experience. First a resistive touchscreen BBB cape (4DCAPE-70T by 4D systems) available from Seeedstudio was ordered to see how its was made and to see if the resistive technology was applicable to the project. Quickly the resistive touchscreen reveiled to be unsuitable to manipulate photos. Especially the very well known “swipe” gesture to move from one photo to another was impossible to do with the resistive touchscreen. This screens colors were coded on 16 bits and the viewing angle was quite bad. It was decided to use a capacitive touchscreen and more colors if possible. A screen found on Mouser was chosen. It had good documentation and especially there was an existing driver for the touchscreen IC in the linux kernel planned to run on the BBB. The screen is actually a package containing the screen and its driver, the touch-screen and its driver and the backlight LED array. This package can be seen in fig.5.4

Figure 5.4: Screen package.

Individual components are discribed in the following sub chapters.

5.2.1 Screen

The screen is the NHD-7.0-800480EF-ATXV#-CTP from Newhaven Display. The specifications of the screens are listed bellow.

- 7” Diagonal
- Resolution: 800xRGBx480
- 24 bit digital RGB interface
- White led backlight
- 55-65° Top-bottom viewing angle
- 70 ° left-rigth viewing angle

The viewing angle is better than with the 4d cape and the colors more realistic.

5.2.2 Touchscreen

- Capacitive touch panel with built-in Focaltech ft5x06 controller
- i2c interface
- multi-touch compatible (up to 5 simultanious touches)
- linux kernel 3.14 compatible

The touchpanel is very smooth and reactive. The swipe gesture works very well.

5.2.3 Backlight

The backlight is a quite bright white led array consisting of 5x3 LEDs. the configuration can be seen in fig.5.5

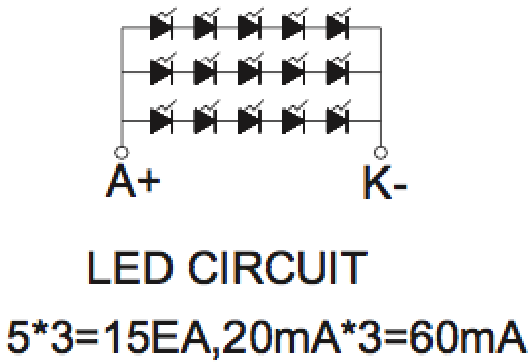

Figure 5.5: Backlight LED array configuration.

This LED array requires 60 mA at 16 V to operate. This power is taken directly from the 3.3v of the BBB and boosted to the required voltage by FAN5333A LED driver from Fairchild semiconductors. This IC is a general purpose LED driver which can be controller with a PWM imput. The implementation of the FAN5333B is pictured in fig.5.6.

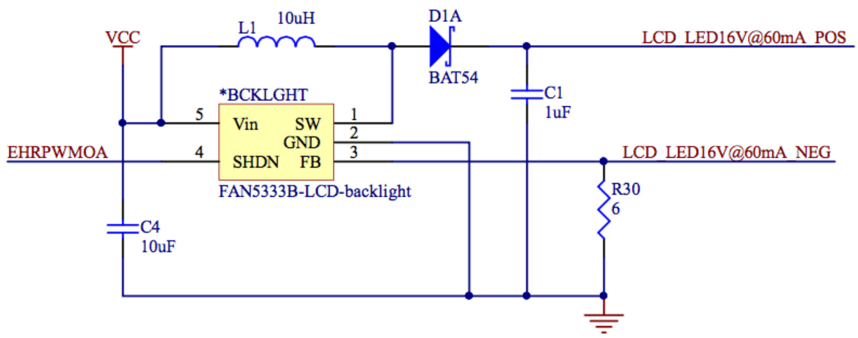

Figure 5.6: FAN5333B Backlight LED driver implementation.

From the data sheet the resistance R30 regulates the current. The net EHRPWMMOA is connected to a pwm pin on the BBB. The brightness of the screen will be adjustable from the website interface.

5.3 Wireless Communication

The device has to connect to the internet over a WLAN to download new messages from the website. The WL1835 chip from Texas instruments was chosen. This IC integrates WlAN, 4.1 bluetooth and BLE. An important point is that TI provides support for the linux kernel planned to run on the AM335x ARM® Cortex-A8.

The chip is provided in a 100-pin MOC package. The pin designation is seen in fig.5.7.

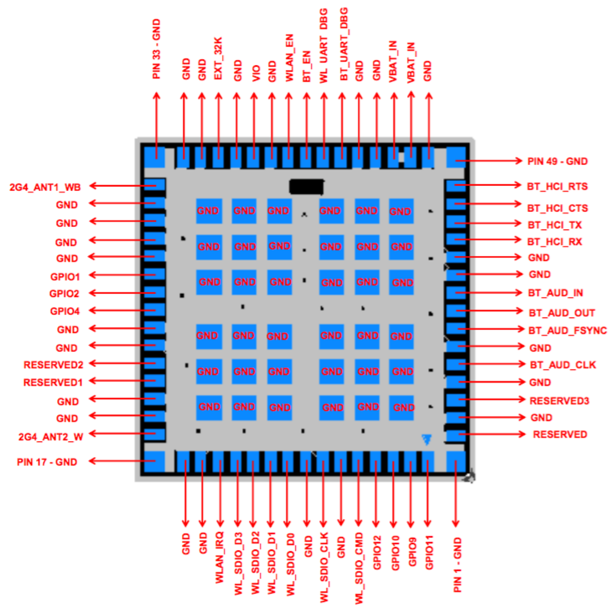

Figure 5.7: Wl1835 pin designation.

To operate the wl1835 needs a few external components. Among others an oscillator and antennas are necessary to for proper operation. The integration of this chip was inspired by a layout example provided by TI as well as by the layout of an existing BBB cape which can be found here http://boardzoo.com/index.php/beaglebone/beaglebone-wl1835mod-w-chip-antenna.html.

The implementation is displayed in fig.5.8

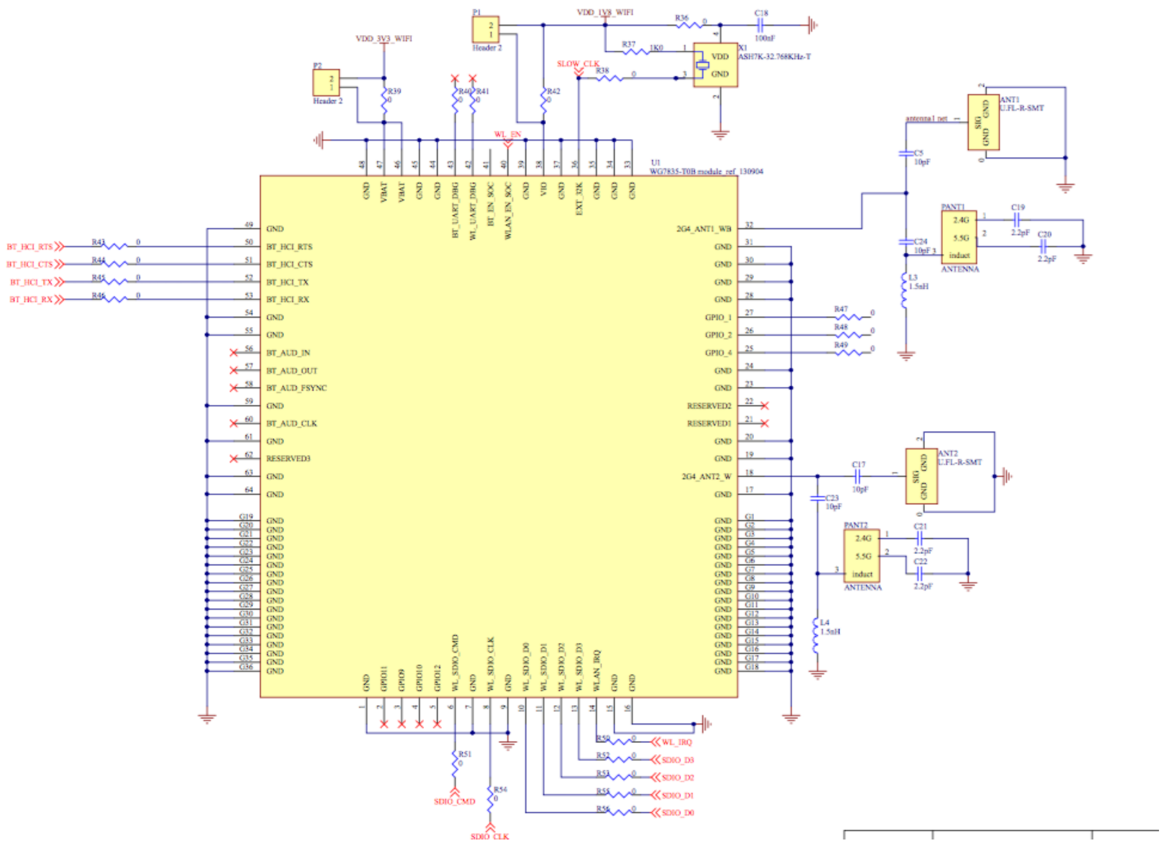

Figure 5.8: Wl1835 implementation.

5.3.1 Wlan

The chip supports the IEEE standards 802.11a/b/g/n. This means it can provide up to 100 MPs with UDP and up to 80 MPs with TCP. It uses a 4 bit SDIO interface to communicate with the BBB. The BBB has 2 SDIO interfaces which are used to communicate with the micro sd card and the onboard EMMC. Therefore using the wl1835 means that access to the emmc is no longer possible. This is not a big issue as the operating system can be located on the sd card.

5.3.2 Bluetooth

The Wl1835 provides 4.1 bluetooth and low energy bluetooth capabilities. Uart host controlled interface is used to communicate through this interface.

The bluetooth interface is not used currently. It is integrated thinking of future development (see chap.7).

5.3.3 Power management

The WL1835 is quite power hungry, it can pull up to about 500 mA (more in calibration mode) of current and requires both 3.3V and 1.8V sources to operate. Therefore it has its own linear regulators which pull their current directly from the battery. For the 1.8V the TPS73618DBVR low voltage dropout regulator is used. It can output a maximum of 400 mA at 1.8V. For the 3.3V the TL1963ADCQT LDO is used. The maximum output current is this time 1.5 A which should be well over the maximum current consumption of the chip.

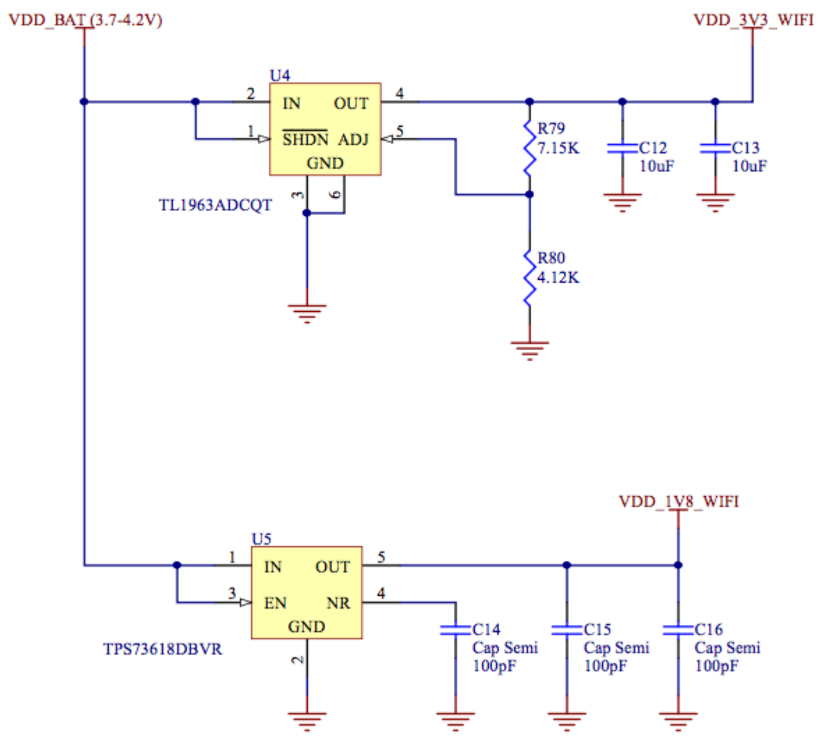

Figure 5.9: Wl1835 power management implementation.

5.3.4 Buffering

As the signals that come in and out of the wl1835 are 1.8V and the BBB only works with 3.3V, a bidirectional Voltage-Level translator was needed. The same ones which were implemented in the existing wl1835 cape(see chapter 5.3) were chosen. The TXS0108EPWR from TI.

The implemention of these voltage converters is displayed in fig.5.10.

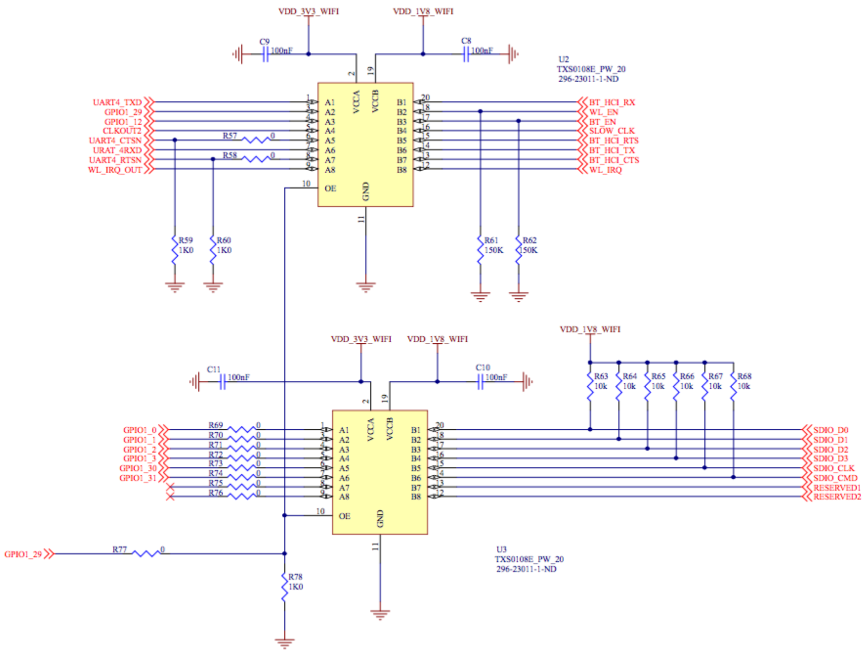

Figure 5.10: TXS0108EPWR buffering chip implementation.

5.3.5 Antennas

This chip can handle two antennas although only one is compulsory. Again following the TI design guide as well as the schematics of the wl1835 BBB cape mentioned in chapter 5.3 we implemented a dual antenna design. A ceramic chip was used for the on board antennas. The layout and custom footprints designed for this part are further described in chap.5.8.

5.4 Front LED

The LED is there to inform the user of a new message. As it is only a notification LED and a 20 mA warm white LED is enough. Another PWM pin of the BBB is used to make the LED blink.

5.5 Accelerometer

A ADXL345 accelerometer from Analog Devices and distributed by Seeedstudio was used. It is mainly used to detect in which current orientation the device is. The screen is then turned accordingly. It may be used for further applications (see chap.7).

The accelerometer measures on three axis, has very low power consumption (as low as 23 µA in measurement mode) and can be interfaced by i2c or spi. The former is used.

Implementation is portrayed in figure5.11.

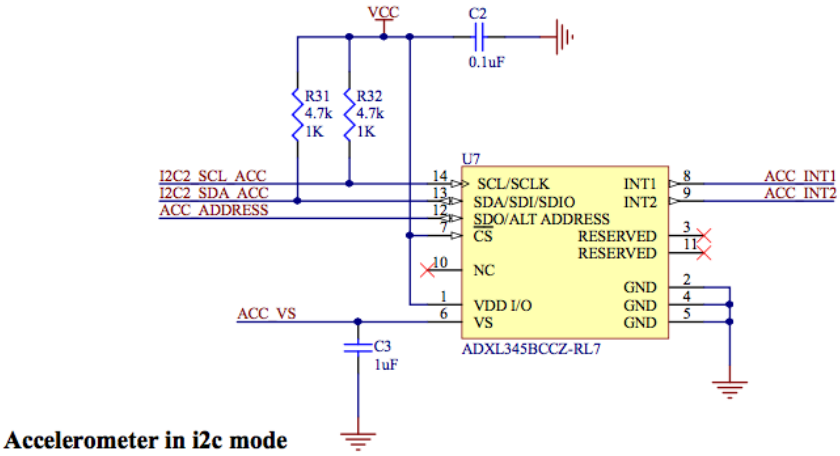

Figure 5.11: Accelerometer implementation.

5.6 Batteries and charger

The battery is a 3.7V Lithium-ion battery with a capacity of 6000mAh from Seeedstudio. The voltage of such batteries range from 3.7V to 4.2V which is in the range of input voltage of the BBB. Seeedstudio also sell a li-ion battery charger and wireless power transmission coils. The battery charger is based on the CN3065 chip. It is a complete constant-current/constant voltage linear charger for single cell Li-ion and Li Polymer rechargeable batteries.

The power transmission coils are ready to use out of the box. They provide a constant 5V output of up to 600 mA. The receiver coil is directly connected to the charging chip via an smd JST 2 pin connector soledered to the PCB. The transmitter coil is powered by a micro USB port.

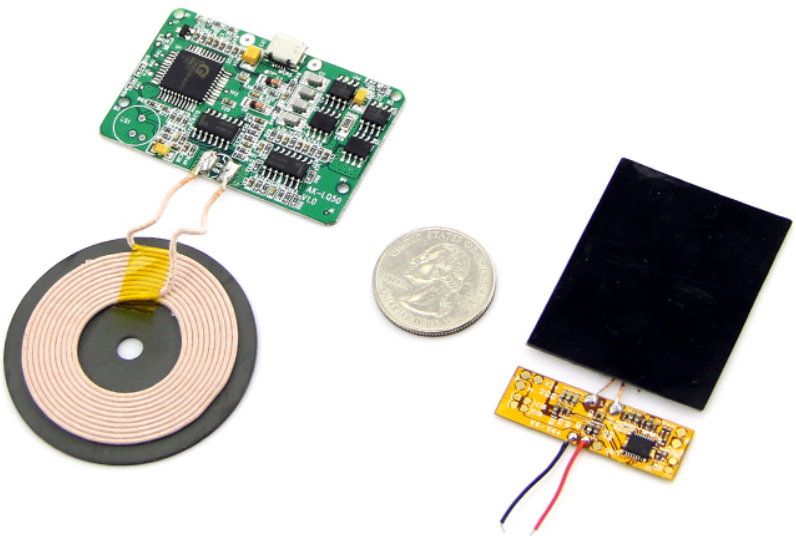

Figure 5.12: Wireless power transmission coils.

5.7 Power management

The power source of the device is of course the battery. From the battery the power is channeled into two main groups. The BBB and the wl1835 wireless chip. The BBB provides power to the different components via its on board PMIC while the wireless chip has its dedicated PMIC. This is due to the great amount of current the wl1835 potentialy needs. It also requires a 1.8V source which the BBB doesn't provide. The power flow is detailed in figure 5.13.

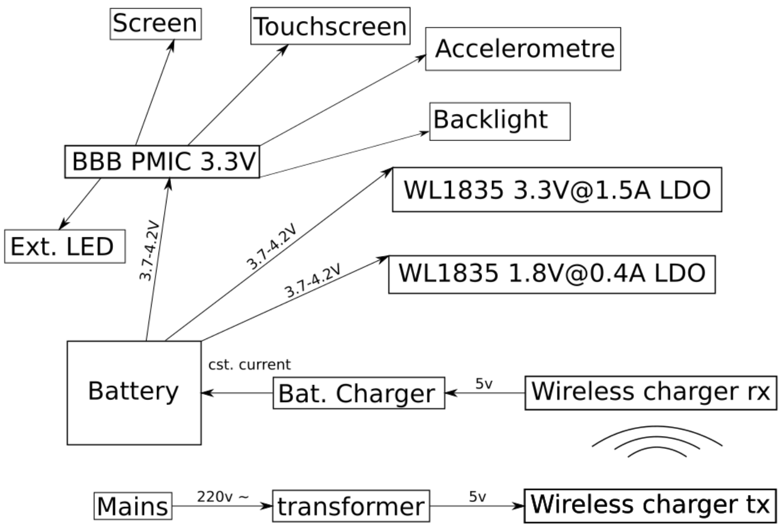

Figure 5.13: Eelctrical flow from the wall outlet to the different components of the device.

5.8 PCB

The PCB was designed in Altium Designer 15. Unfortunatly at this stage no prototype of the PCB has been made. All the components apart the wl1835 have been tested with the BBB on a breadboard. The complex package of the wl1835 chip prevents from connecting it to the BBB with wires. The cape mentionned in chap.5.3as source for the wl1835 implementation.

5.8.1 Overall description

As can be seen in figures 5.14 and 5.15 both boards are quite similar. Indeed both boards have components on only one side to be able to stick the board on the back of the screen metal casing. The board is fixed to the case by 4 screws inserted in the mounting holes on the PCB. Male smd headers on which the BBB is inserted are soldered to the PCB. The friction between the 92 pins and the headers is enough to hold the BBB in place.

The PCB is composed of four layers. The layer thicknesses, copper thicknesses as well as materials and all other rules were mainly dictated by Seeedstudios fabrication guidelines. The layers are described in table.1.

The power plane is set to the 3.3v of the BBB as it is the most used power line. The wl1835 3.3V and 1.8V power lines are located on the component side layer.

The red traces in figure **??** are on the top component layer. Most of the traces are located on this layer. The blue traces are located on the bottom component layer. The blue traces are mainly the LCD 24 bit interface.

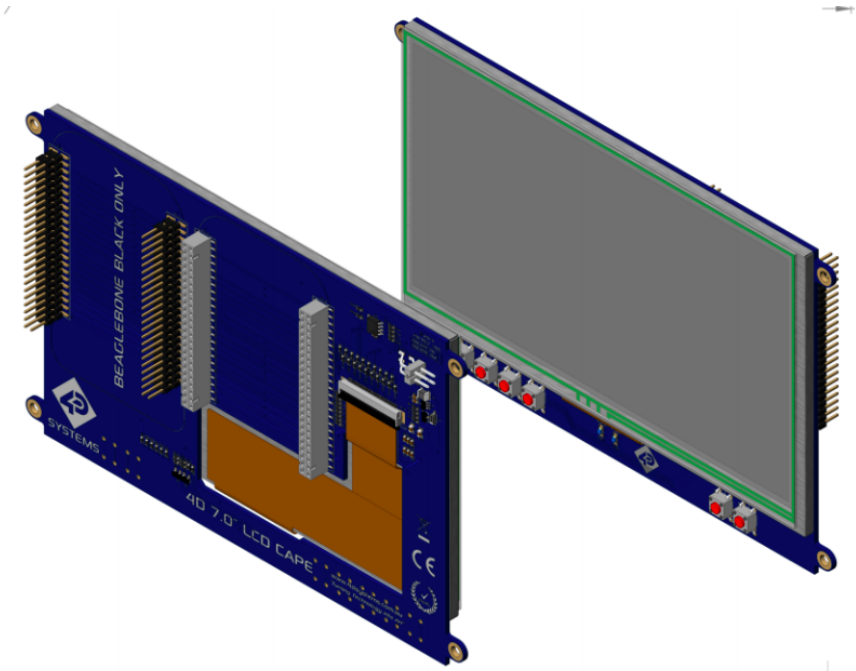

Figure 5.14: Existing BBB cape with 7" inch screen and resistive touchscreen.

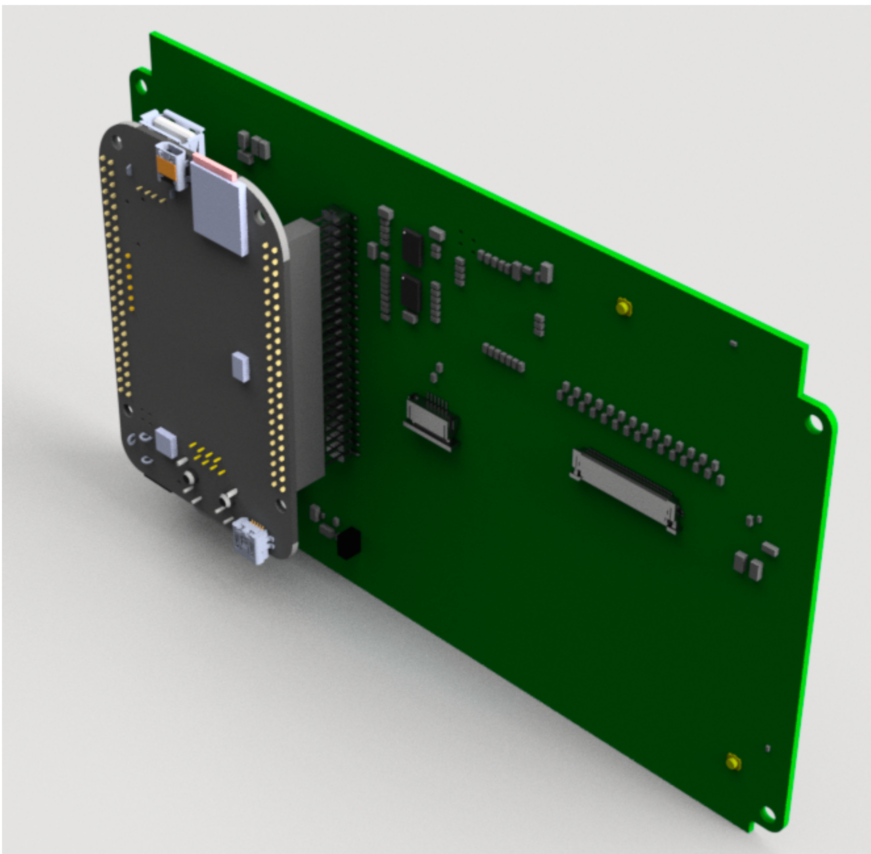

Figure 5.15: Rendering of the pcb of the Vesta device.

In figure 5.17 a polygon pour has been added as well as via stitching.

Layer name	type	Material	Thickness [mm]
Top Overlay	Overlay		
Top solder	solder mask	surface material	0.01
Component side	signal	copper	0.03
Dielectric 1	Dielectric	FR-4	0.2
Ground	GND	copper	0.018
Dielectric 1	Dielectric	FR-4	1.1
Power	VCC	copper	0.18
Dielectric 1	Dielectric	FR-4	0.2
Bottom side	signal	copper	0.035
Bottom solder	solder mask	surface material	0.01
Bottom overlay			

Table 1: Pcb layer description

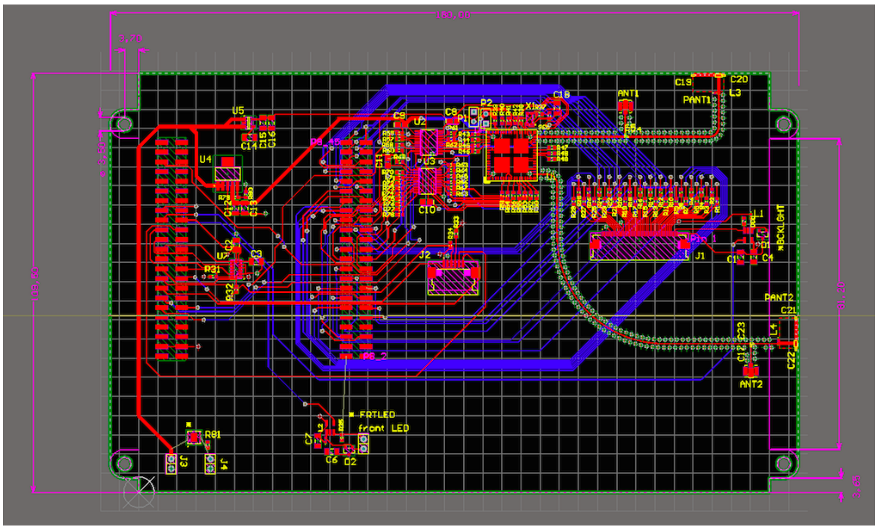

Figure 5.16: Pcb layer stack and component placement.

5.8.2 Antennas

The chip antennas are the ANT016008LCD2442MA1 from TDK. The datasheet and previously mentioned examples were used to design the custom footprint. The main considerations described by the aforementioned sources for the antennas to have maximum efficiency are:

- the antennas are orthogonal to each other
- They must be distanta of >76 mm which is a half wave length
- RF traces must have 50-Ωimpedance
- RF traces must not have sharp corners
- RF traces must have via stitching on the ground plane beside the RF trace on both sides
- RF traces must be as short as possible. The antenna, RF traces, and module must be on the edge of the PCB product in consideration of the product enclosure material and proximity

Following the guidelines of the manufacturer the antennas were placed on the edge of the pcb, via shielding was applied and they were set more than the minimum distance appart. They also slightly stick out of the pcb so that they are not over the metal casing of the screen. This implementation is shown in figure 5.19.

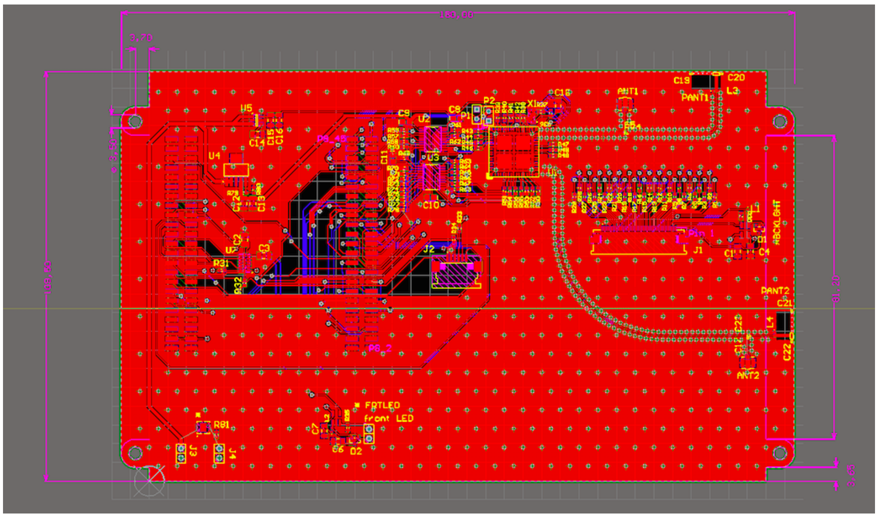

Figure 5.17: Pcb polygon pour and via stitching.

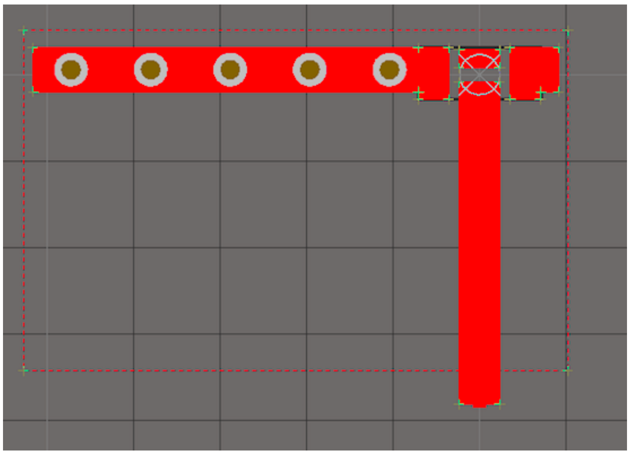

Figure 5.18: PCB antenna custom footprint.

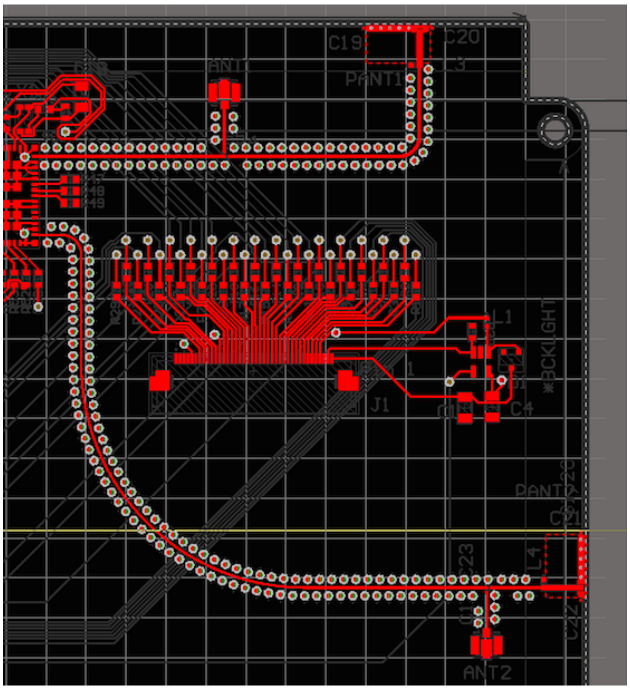

Figure 5.19: PCB antenna implementation.

5.9 Assembly

In Figure 5.20 an assembly of the components of the device is shown.

5.10 Cost estimates

Component	number of units	Price per unit [CHF]
Screen	1	90
BBB	1	45
wl1835	1	25
Battery	1	20
PCB	1	20
Case parts	1	10
Wireless coils	1	20
Resistors	40	4
capacitors	20	4
Inductors	5	2
miscallenous ICs	10	15
Connectors	10	10
micro SD card	1	10
usb charger	1	10
Total	94	285

Table 2: Prototype cost estimates

The costs in table 2 are the prices paid for single components. The screen takes up nearly one third of the cost but can easily be lowered.

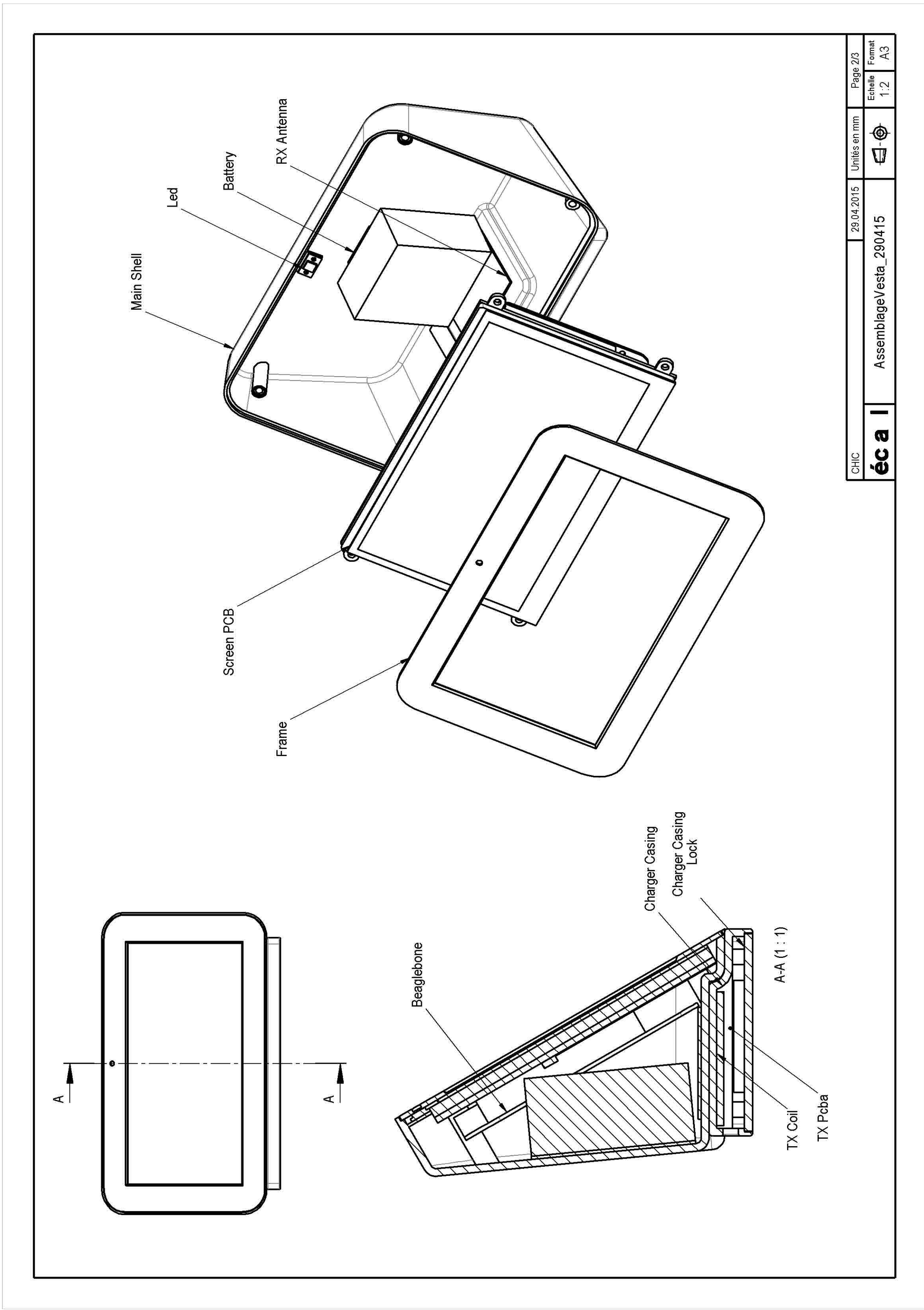

Figure 5.20: Device assembly.

6 Software

The software of this project contains 3 parts:

- The operating system configuration and modification to be fully compatible with the hardware used.
- The website that is used by the young users to send pictures and messages to the old users.
- The Vesta tab software that is used on the tablet to display the differents messages and pictures received by the old users.

The concept of this software is easy to understand. Every tablet has a unique id like a phone number. The young user knows this id and can send messages and pictures to the wanted tablet through the website. The tablet just needs to be configured to connect to the wifi and get messages sent by the young user. The old person has almost nothing to do, the pictures are displayed automatically. He can naviguate in the old messages by swiping the pictures on the tablet.

It is similar to a digital photo frame but the pictures are not put on the tablet by the tablet owner but by the young user.

The figure 6.1 shows the web interactions between the website and the Vesta software on the tablet.

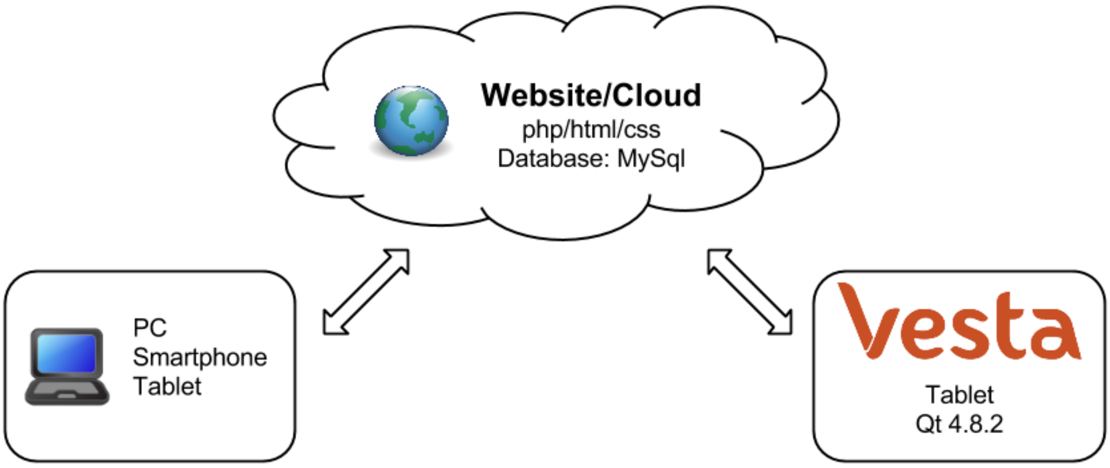

Figure 6.1: Web connections

The figure 6.2 shows the interactions between the website and the Vesta software on the tablet. All the files are stored on the website on the mySQL database. When the pictures are sent, the vesta tablet receives a message and can open/display it. The vesta software on the tablet works on a linux OS that manages the hardware.

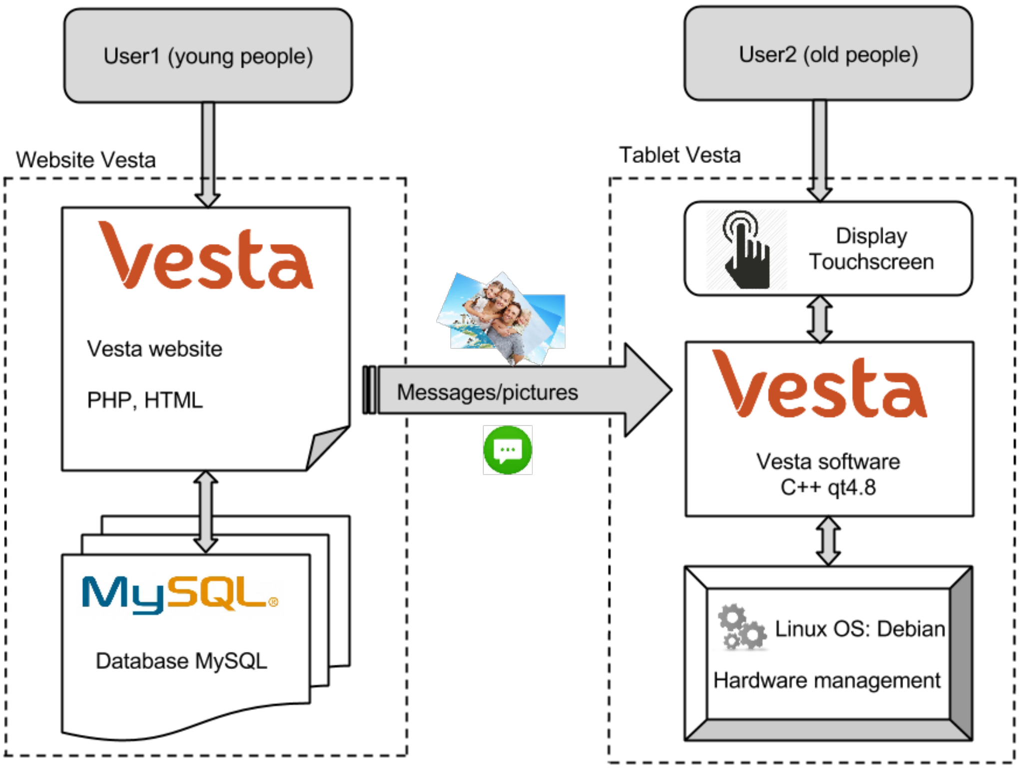

Figure 6.2: Basic user flow.

6.1 Operating system

The OS used for this project is a debian. Debian is a linux distribution and was given by the conceptors of the beaglebone black.

The original OS is available on the beaglebone black developer website: http://beagleboard.org/latest-images

The figure 6.3 shows how the are the interactions between the OS and the hardware or the software.

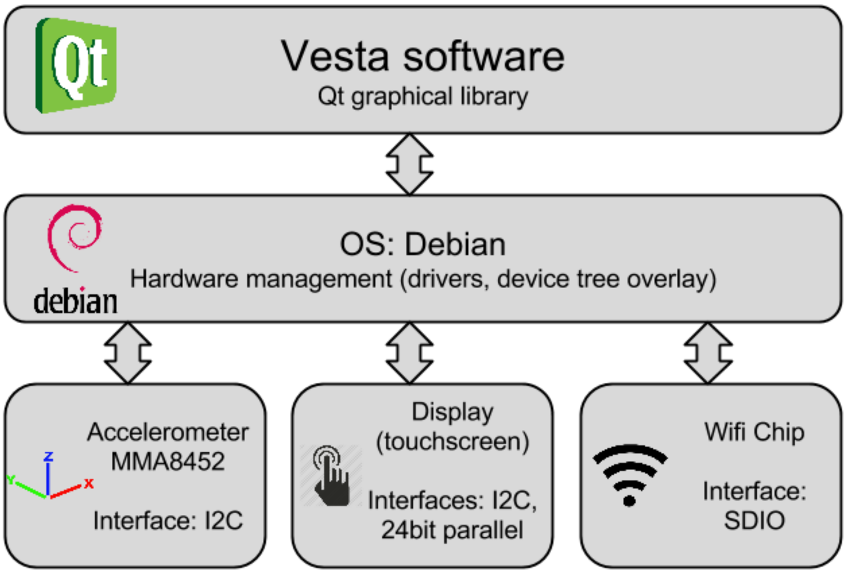

Figure 6.3: Interactions between the operating system and the hardware/software.

The original OS contains:

- kernel 3.8: The linux kernel (an old one)
- X11: The graphical server
- lxdm: The user session management
- lxde: A desktop (light)

The OS manages the communications with the different hardware. The accelerometer is controled by I2C (to read datas and write configurations). The screen uses different interfaces, I2C for the touch panel and 24bit parallel for the display. The WIFI chip is connected with SDIO and it replaces the emmc memory.

Every protocol and every pins input or output have to be declared in a file called device tree source. In the 3.14 kernel, this file is compiled and becomes a device tree blob. The compiled version of the file is executed at the OS startup. It initiates the loading of the drivers and configures the pins as input, output, pwm or interrupt. Some pins can be configured as i2c, spi, SDIO or some other protocols.

Packets installed on the original debian OS:

- libqt4-core: Defaults tools for Qt software execution
- libqt4-gui: Needed to display GUI software developped with Qt
- dtc: Device tree compiler used to create pin configuration at the OS startup

- wicd: Network manager for WIFI connections
- evtest: Tool for interruption event, used especially to debug the touchscreen

6.1.1 Drivers

A lot of work on this linux distribution was made to be fully compatible with the chosen hardware. The touch screen driver edt-ft5x06 had problems with the original 3.8 kernel of the distribution used. The driver was not loading correctly from the device tree overlay. An upgrade to the 3.14 kernel resolved the problem. Then the scale of the touchscreen was not correct. When a touch event occured on the right-down corner, the mouse pointer moved to the center of the screen. Some configuration scripts had to be modified for the X11 graphical display server.

The edt-ft5x06 uses an interrupt line and I2C to get the touch events and the positions of the clicks.

Another driver is used for the WIFI connection with the wl1835mod. This driver uses the protocol SDIO. It also has to be declared and initialized at the OS startup in the device tree blob. As the beaglebone's processor has only one SDIO protocol possible and it is used by the emmc memory, the emmc is replaced by the WIFI chip and the emmc is unusable.

An example of the configuration of the I2C1 of the beaglebone black as an entry for the touch panel (driver edt-ft5x06) in the device tree source (dts) is shown in the listing below.

```
i2c@4802a000 {
        compatible = "ti,omap4-i2c";
        ti,hwmods = "i2c2";
        reg = <0x4802a000 0x1000>;
        interrupts = <0x47>;
        status = "okay";
        pinctrl-names = "default";
        pinctrl-0 = <0x29>;
        clock-frequency = <0x61a80>;

        edt-ft5306@38 {
                status = "okay";
                compatible = "edt,edt-ft5306", "edt,edt-ft5x06";
                pinctrl-names = "default";
                pinctrl-0 = <0x2a>;
                reg = <0x38>;
                interrupt-parent = <0x1c0>;
                interrupts = <0x15 0x0>;
                touchscreen-size-x = <0x320>;
                touchscreen-size-y = <0x1e0>;
        };
};
```

i2c@4802a000 corresponds to the I2C1 of the beaglebone black (even if it defines I2C2 in ti,hwmods, this is due to a problem in the kernel 3.14 the pins are not named correctly). The following commands init the I2C1 at the clock frequency 0x61a80. The line starting with edt-ft5306@38 declare that the driver edt-ft5x06 has to be link to the I2C1 and the I2C adress is 0x38. Different inputs are declared in the brackets, the interrupt-parent and interrupts defines the interrupt line when a touch event occurs. Reg is the I2C adress of the Focaltech chip (ft5x06). The pin <0x1c0 0x15 0x0> corresponds to the pin 25 of the beaglebone black. The touchscreen size is also given: 800*480 (0x320*0x1e0).

6.1.2 Display

The touch screen works with a 24 bits parallel interface so the X11 configuration file had to be modified to work correctly. The LCD output was initialy configured in 16 bits parallel interface. In the blob file, the driver for the touch panel was declared and the interrupt pins was defined. The resolution and frequency of the display is also configured in this script. The wifi chip also needs to load drivers at startup and tell the OS to connect to internet via this chip and with the SDIO protocol. The file is located in /boot/dtbs/3.14xx/ and is called vesta.dtb (compiled) and the source is called vesta.dts. The file uEnv.txt located in /boot/ also needs to define which device tree blob(dtb) the OS has to load at startup.

The following listing shows how to define the display output on the pins of the beaglebone black. It is a critical step and need to be declared like this.

```
display-timings {
        native-mode = <0x1c5>;

        800x480 {
                clock-frequency = <0x1c9c380>;
                hactive = <0x320>;
                vactive = <0x1e0>;
                hfront-porch = <0x1>;
                hback-porch = <0x2d>;
                hsync-len = <0x1e>;
                vback-porch = <0x16>;
                vfront-porch = <0xc>;
                vsync-len = <0x2>;
                hsync-active = <0x1>;
                vsync-active = <0x1>;
                de-active = <0x1>;
                pixelclk-active = <0x0>;
                linux,phandle = <0x1c9>;
                phandle = <0x1c9>;
        };
};
```

The native-mode defines that it is a 16/9 screen. The clock frequency is 30MHz and the resolution 800x480. hactive and vactive define respectively the horizontal number of active pixel and the vertical number of pixel active (in our case 800x480). Other configuration modes are defined then. For more informations about the configurations, check the Newheaven touchscreen's datasheet.

6.2 Website

The website is used by the young users to send messages and pictures to the old user's tablet. The website contains a MySQL database, a php/html page that let the young user send a message and a php script used to parse the database to XML to be readable by the tablet.

The figure 6.4 shows the architecture of the interactions between the webpage, the database and the connections by the tablet through a script.

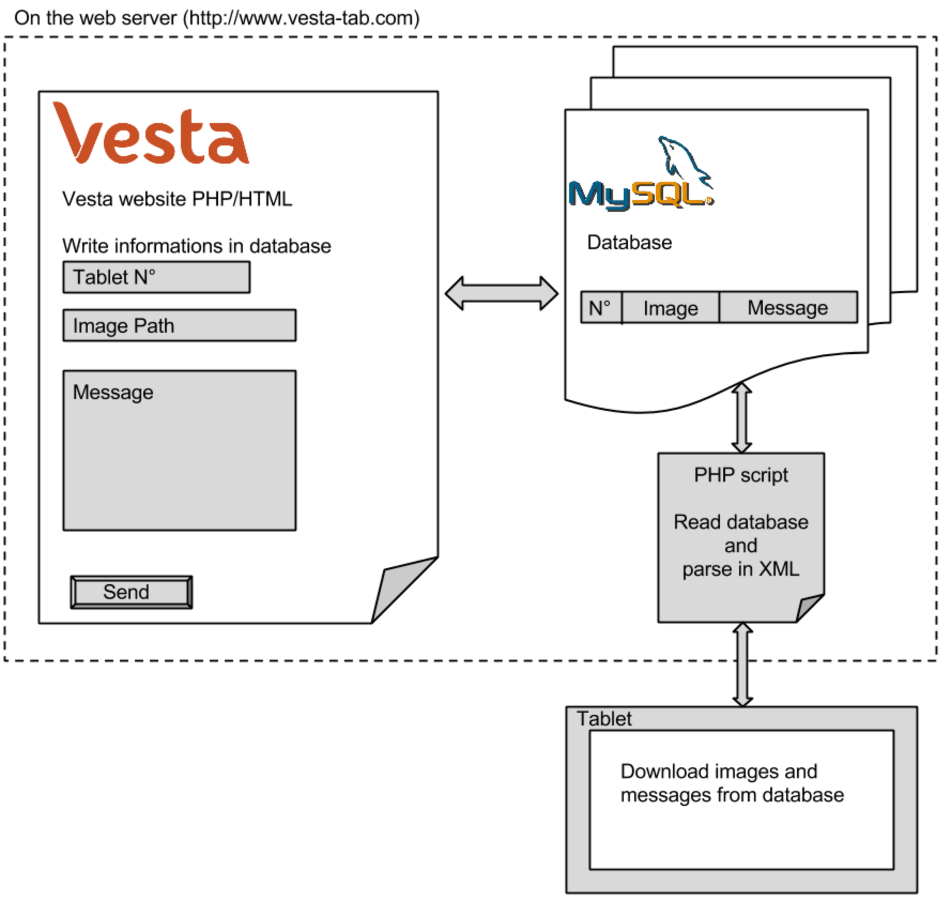

Figure 6.4: Vesta website architecture.

The steps of the vesta tablet connecting to the database are:

1. The tablet connects to a php script
2. The php script open a connection with the MySQL database and get the datas wanted
3. The php script parse the datas in XML, and sends it
4. The tablet get the XML code and unparse it
5. The tablet displays the messages and pictures

The website connects directly to the database to store the input picture and messages.

6.2.1 Webpage

The webpage let the young user send a message to a wanted tablet. Every tablet has an id like a phone number known by the tablet owner. It is possible to select a picture on the user's computer and write a text message. When the "send" button is clicked, the picture and text message is saved in the MySQL database.

The php script called when the send button is clicked downloads the picture contained in the file input, verify if the file downloaded is a picture and if the size is not too big. If everything went well the picture and the other datas are saved in the MySQL database else some error messages are displayed. The date is automatically written at the current time.

The figure 6.5 shows the actual webpage used to send messages to a tablet.

Figure 6.5: Webpage

This webpage is not finished but is fonctionnal. For security and privacy reason, a login and session creation page should be done to prevent people sending to the wrong tablet. A blocking system needs to be implemented if someone sends adverts or inapropriate messages.

6.2.2 Database and XML parsing

The MySQL database is where all the messages and pictures are stored. The webpage connects and save the datas into the database when the user send a message.

An example of entries on the tablet's MySQL database are shown in the table3.

id	type	name	sender	text	img	date
7	image/jpeg	family.jpg	Jean	Hello! A message for you	BLOB - 300KB	14.05.2015
8	image/jpeg	cat.jpg	Marie	Look at my cat :)	BLOB - 350KB	27.05.2015

Table 3: Example of entries in the vesta table on the MySQL database

BLOB is the file format of the pictures stored in the database.

When the tablet update the data, it connects to a script contained on the server. This script connects to the database and parses the information needed by the tablet in XML.The tablet then unparses the data, downloads the pictures, and displays them.

XML is a markup language that facilitates the transfer of data and the readability of them. It is mainly used in the RSS flux.

An example of XML code is shown below:

```xml
<?xml version="1.0"?>
<vesta>
  <item>
    <title>family.jpg</title>
    <sender>Jean</sender>
    <date>2015-04-18 17:08:45</date>
    <image>http://www.vesta-tab.com/jo/getImage.php?id=7</image>
    <message>Hello! A message for you</message>
  </item>
  <item>
    <title>cat.jpg</title>
    <sender>Marie</sender>
    <date>2015-04-23 14:34:12</date>
    <image>http://www.vesta-tab.com/jo/getImage.php?id=8</image>
    <message>Look at my cat</message>
  </item>
</vesta>
```

This XML file defines 2 messages: family.jpg and cat.jpg. The senders are Jean and Marie at respectively 17:08:45 the 18th april 2015 and 14:34:12 the 23th april 2015. The images are available at the URL defined between the image markups. The text message is between the message markups.

6.3 Vesta software on the tablet

The Vesta software is used by the old users to receive and display the messages and pictures sent by the young users. It is located on the tablet and working with debian. The software is written in C++ with Qt4.8/Qt quick 1.0.

6.3.1 Qt library

Qt is a free library used mainly to design software with graphical user interfaces (GUI). It is cross platform so with the same code it is possible to compile for linux,windows and mac. The library contains also a lot of utils to facilitate the development of emmbedded interfaces and manages the touchscreen events like swipes, clicks and more. A lot of documentation is available and a lot of users develop with it.

There are differents GUI library like Gtk+, CEGUI etc... The choice of Qt was done especially because it is cross platform but also because it's compatible with emmbedded systems. Qt can be used also with android and IOS and is really made for apps with touchscreen. Qt quick is very powerful for emmbedded applications. The last version of Qt was downloaded over 1 million times and is ranked number 1 of all cross-platform tools.

Qt creator is the official development environnment for Qt. It is used to develop and cross-compile the software for the beaglebone black. A visual GUI editor is available and greatly simplify the development of the software GUI.

6.3.2 Overall operations

At the startup, the vesta tablet inits and checks the wifi connection. The touchscreen creates an event when someone touches it and changes the displayed image. It lets the user naviguate between the different messages. Every minute the soft checks if a new message has arrived.

The software is quite simple and not a lot of functionnalities are implemented. The goal was to have a really easy to use software for old people.

The figure 6.6 shows how the software works.

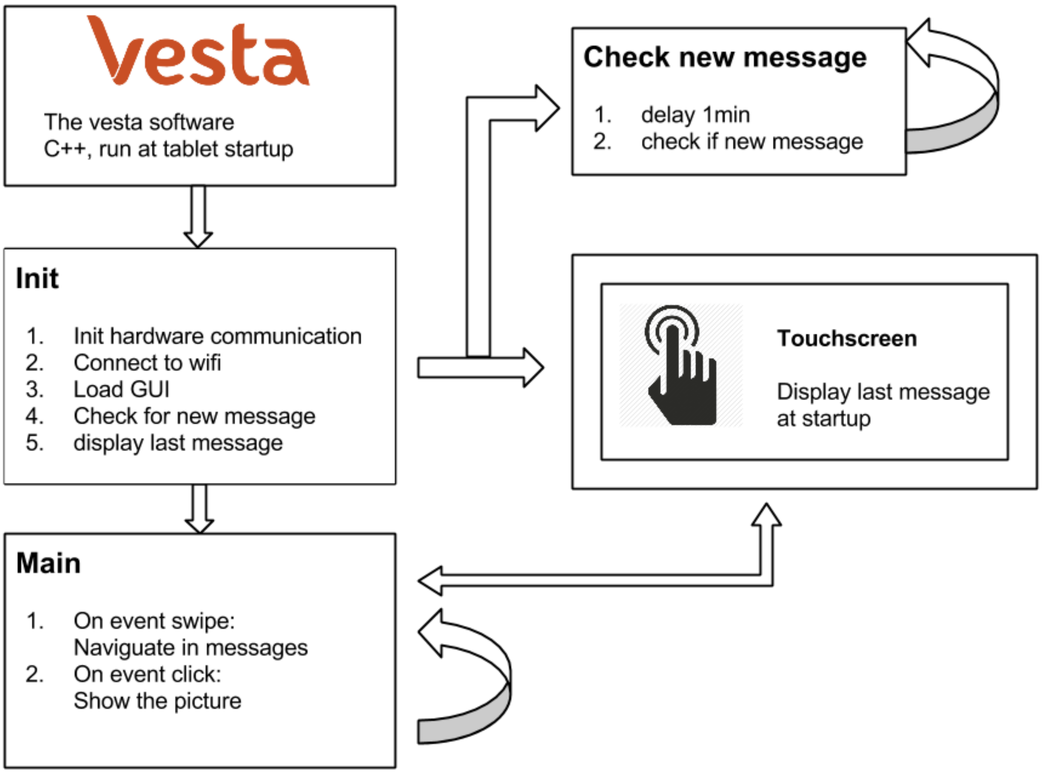

Figure 6.6: Vesta software architecture.

6.3.3 Graphical interface

The graphical interface is composed of an horizontal listview and some buttons. The listview allows swipe events to naviguate between the different pictures and messages.

A task bar is always visible on the top of the GUI. The list view displays the actual picture, the date when the messages was sent and the text message.

The figure 6.7 shows how the GUI is constructed.

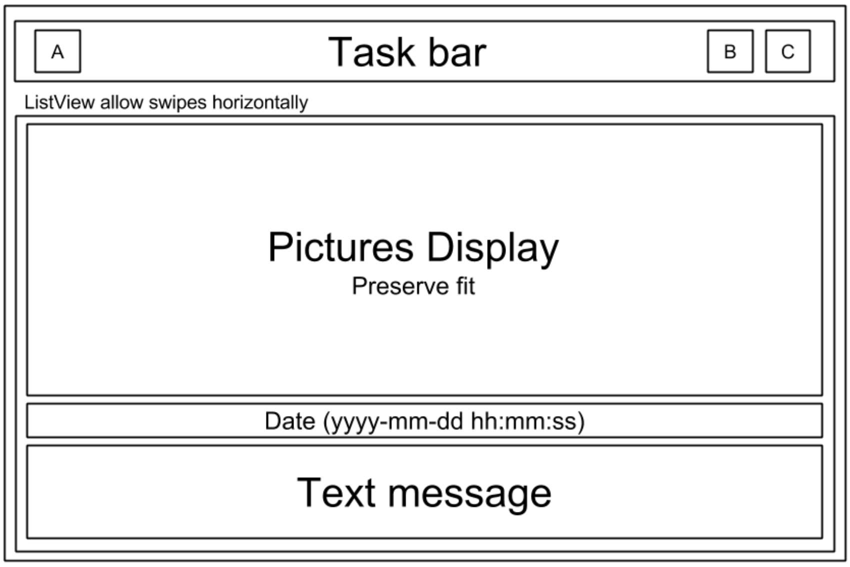

Figure 6.7: Graphical interface diagram, A:Refresh button, B:WIFI RSSI indicator, C:Battery state indicator

The buttons let the user configure the wifi or display the new messages.

- The button A refresh the messages and display the last one.
- The button B goes to the WIFI configuration and indicates the RSSI of the WIFI.
- The indicator C show the battery level

The figure 6.8 shows the actual GUI.

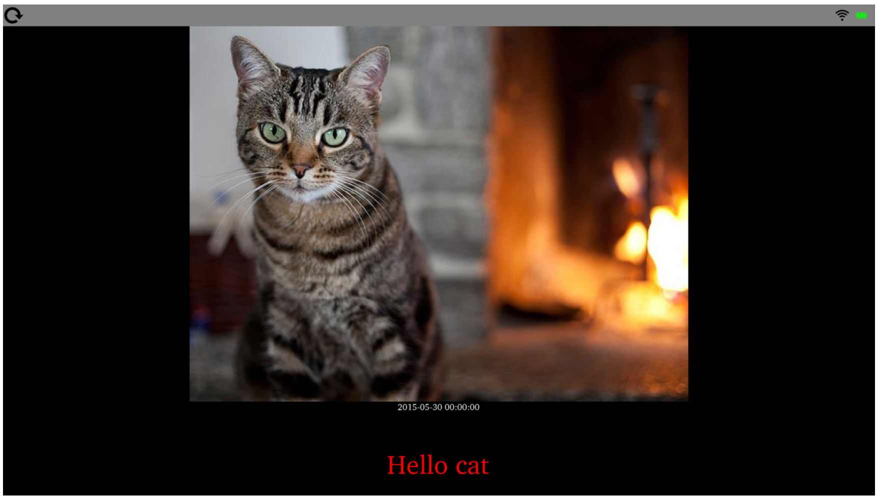

Figure 6.8: Vesta software graphical interface

7 Next steps

In the beginning of july, a first prototype will be made in Shenzen (China) with an industrial partner (Seeedstudio). A final presentation of the project is going to take place in october with the prototypes.

A lot of fonctionnalities could be easily implemented after this prototyping step. An activity monitoring or an emergency call system for example. Another fonctionnality can be a videoconference system with a camera like Skype does. This device has a lot of unused connections that could be used to connect other sensors for medical assistance for example. It could become a connected electrocardiogram monitor. The advantage is that the hardware is powerful enough to do almost everything a computer can do in term of connectivity. Everything that can be done with a tablet can be done with this device and more.

The device contains bluetooth integrated in the wl1835 chip and is not currently used. Bluetooth could be used to have more interactions with other devices or to configure the tablet. For example the configuration and selection of the WIFI network can be done via an app on a smartphone with bluetooth. Or an activity tracker bracelet could upload the data to the tablet. The tablet would be used to display the activity in some plots. The family would have a remote monitoring facility.

The software can be changed relatively easily to do a completely different task. Qt is a well known library that let the programmer creates interfaces very fast. This device may become a developpement board.

Currently the only way to send messages or pictures is trough the website. A next step could be to develop an app on IOS and android to send pictures directly from a smartphone or a tablet.

8 Problems encountered

The main problems encountered were about the OS configuration and compatibility with the hardware components. The driver for the I2C capacitive touch panel chip wasn't working with the kernel 3.8. The driver was loading at the OS startup but no input was available to read it. This problem was resolved by upgrading the kernel to the 3.14 version. The scale of the touchscreen was also not working. The events were readable but they were wrong, the clicks were not synchronized with the screen size. Some calibration configurations of the X11 config file resolved the problem.

Having no knowledge of PCB design prior to this project, the learning curve was steep. Information was sometimes sparse on specific subjects such as for the antenna footprints.

Getting information on some parts especially from chinese providers was sometimes impossible. For these reasons some of the parts were very expensive.

9 Conclusion

The software is not finished yet but the hardware and industrial design are already well implemented. The priority was placed on the hardware and the design. These two parts must be finished before going to China but the software can be finished afterwards.

This device can be really interesting for different projects that need a screen. As the beaglebone black has unused GPIOs it is possible to connect some sensors or other devices to it. Bluetooth is not used at the moment but can be really interesting to have it for some applications.

The first iteration of the PCB will be made this summer but different tests were done with the hardware. The touchscreen is fully recognized by the OS and works perfectly. The accelerometer also works. The WIFI/bluetooth chip couldn't be tested yet because no development kit was available for the beaglebone black at the moment (a cape is made by boardzoo but will be available in the middle of june only). This chip shouldn't cause any problem but the critical step will be its recognition by the linux OS.

For the industrial design, the case will be 3d printed but every part is compatible with the plastic molding production technic. The industrial designer worked with the engineers for the assembly to be sure that everything fits in the case.

This project was really interesting and instructive. Working in a team with students from different schools and sections is something new and corresponds to the real work of an engineer in a company. It was sometimes difficult to communicate with the same words as everybody has a different background. The timetable was quite short for the complexity of the project but it was very stimulating. Hopefully we will come back this summer with a fully functionnal prototype.