High Definition multimedia display architecture for tiny mobile Smartphones

Bernd Steinke
Nokia GmbH
Meesmannstr 103
44807 Bochum, Germany
+49 (0)163 984 2221
Bernd.Steinke@Nokia.com

ABSTRACT

Smartphones have a tiny display, since their casing need to fit into a pocket. PCs and Notebook don't suffer from this restriction, but they are by far not that mobile. Recently a trend has observed, that the PC world as well as the Smartphone world has started to grow together.

Several applications and services not useable in mobile domain are nowadays becoming feasible due to the introduction of external display interfaces for Smartphones. This contribution elaborates on which opportunities this new movement introduces. High resolution requiring applications were traditionally bound to stationary devices. These are now becoming ergonomically on a device which is additionally always connected and fully mobile with battery-live practically of at least one day.

A further main topic of this evaluation is the overview and comparison of a selection of possible interfaces for external display devices with a specific emphasis on mobile compliance.

Keywords

Smartphone, High Definition, High Resolution, external Displays, Display interfaces, frame-synchronous, on demand transport

1. INTRODUCTION

Since many years, PCs are shrinking. Laptops and Notebooks have been introduced. They are shrinking as well, but due to a certain standard of xy display resolution and size, the form factor limit has been already reached. Mostly these devices are only becoming slimmer and more lightweight.

The opposite trend had started in the Smartphone world. Due to the requirement and desire to have more pixels on the display available, but human eye are limited in useable pixel-density, the size of the display increases. With this, the mobile phone device size also increases slightly, and is already very much display dominated.

Therefore, which is the still existing, and most serious gap between a Desktop PC and Smartphones?

- Is it RAM or Mass Storage space?

Several devices e.g. N91i with 8 GB HDD sport mass storage sizes considered more than enough a few years ago in the Notebook world. This size appears sill well suited for many applications, such as e.g. office applications.

- Processor performance?

The N93 is able to capture VGA resolution video plus audio with 30fps and compass it to mp4 in real time. During this capture many other features are still acting in multi-tasking mode in the background.

This equipment is sufficient for many applications. It becomes even more obvious, as many Symbian software e.g. office applications are very compatible to desktop office software, but much leaner programmed. It can be roughly compared, that PC processing performance about fife years ago, is now available as cutting-edge Smartphone.

This leads to the question, why Smartphones don't substitute PCs, Notebooks?

One obvious example can be observed in Figure 1, if compared to Figure 2.

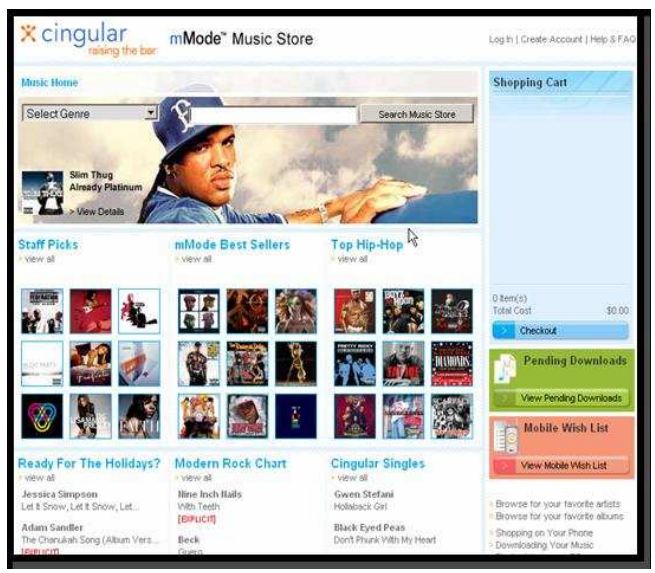

Figure 1. Music shop using high resolution display [2]

The most serious and clearly visible problems are:

- Display resolution & size
- Available overview
- Perceived screen size!

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Figure 2. Music shop on mobile low resolution display [2]

The same music shop used on a lower resolution mobile device restricts the user to just a minor fraction of the whole screen. Therefore the ability to move quickly with their eyes between several parts of the display is severely limited. This leads to the disappointing, overview is missing feeling. If the resolution would be increased, the contend would be come unusable small. Increasing the display size is also no option, as this increases the device size also. The result would be something like a Notebook.

The only way out of this dilemma to still have a tiny device, but useable high definition displays is to find a suitable missing link to huge external displays! This link needs to be mobile complaint, as a Smartphone is and will be powered by a tiny battery at least during mobile usage time.

2. Analysis of feasible interface options

This section discusses existing analogue, digital frame synchronous and finally digital on demand packet based interfaces in the context of mobile compliancy. These are coming from consumer equipment and PC world and have related limitations.

2.1 Analogue

Several more recent Smartphones are already equipped with an composite video output interface.

2.1.1 Composite video

The Composite video is the format of an analog television picture only signal before it is combined with a sound signal and modulated onto an RF carrier. It uses usually a standard format such as NTSC, PAL, or SÉCAM.

These standards are requiring a certain analogue waveform and are typically used with interlaced transport. This means at least DA conversions are required as well as processing intensive filtering to avoid e.g comb-artifacts if the display is also digital.

2.1.2 2-component video: S-Video (Y/C)

S-Video (separated video) separates the Luminance signal (Y) from the Chrominance signal (C) and transports each with a separated ground line to improve electrical interface quality. The protocol is otherwise identical to the composite interface. S-Video is also known as Y/C and (incorrectly) S-VHS.

S-Video will appear a little better than composite video since the television does not have to split the brightness and color information that are found together on composite video. The main advantages of separating these two signals are for better bandwidth of luminance and more effective work of chroma decoder, not to mention reduction of dot crawl.

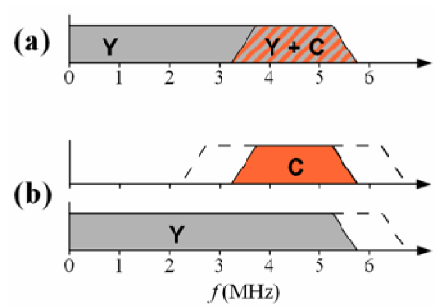

Figure 3. S-video versus Composite spectrum

The mixing of the various signals into the original composite signal reduces quality in the higher part of the Y-band and also the color information.

- Resolution: 768x625
- Visible Picture: <704x576

This resolution limitation appears as a dead end in the light of e.g. office applications. Another limitation origins from the digital nature of Smartphones and also most display devices which leads to repeated cross digital-analogue boundary crossings. This DA - AD conversions are a relevant source of power consumption, which must be avoided.

Analogue interfacing standards are a must due to compatibility requirements of the huge installed basis in consumer equipment domain. However in a digital source (mobile phone) and digital sink (e.g. Near Eye Display, NED display glasses) domain, power consumption due to DA-AD conversion and filtering of artifacts are an enormous drawback.

2.2 Digital frame synchronous

The monitor interface techniques presented in this section try to follow the clocking scheme of the traditional monitor. Hence, they have e.g. a blanking interval. This allows reduction or up to avoidance of framebuffer memory on monitor side. These techniques thus more compatible with hitherto analogue techniques, but significant resources (time-slots and buffer-memory) may be wasted.

2.2.1 DVI – Digital Visual Interface

The Digital Visual Interface (DVI) is a video connector designed to maximize the visual quality of digital display devices such as flat panel LCD computer displays and digital projectors. It was developed by an industry consortium, the Digital Display Working Group (DDWG).

A single DVI link consists of four twisted signal pairs of wire (red, green, blue, and clock) to transmit 24 bits per pixel. The timing of the signal almost exactly matches that of an analogue video signal. The picture is transmitted line by line with blanking intervals between each line and each frame, and without packetization. No compression is used and DVI has no provision for only transmitting changed parts of the image. This means the whole frame is constantly retransmitted. This is the cause for significantly high power consumption!

This connector is additionally much too large for Smartphones.

2.2.2 HDMI – High-Definition Multimedia Interface

The High-Definition Multi-media Interface (HDMI) is an industry-supported, uncompressed, all-digital audio/video interface electrically identical to DVI. HDMI provides an interface between any compatible digital audio/video source, such as a set-top box, DVD player, and A/V receiver and a compatible digital audio and/or video monitor, such as a digital television.

HDMI supports standard, enhanced, or high-definition video, plus multi-channel digital audio on a single cable as also DVI. The only differences are the significant smaller plug, and the High-bandwidth Digital Content Protection (HDCP) is mandatory. HDMI is thus backwards-compatible with the single-link DVI used on modern computer monitors and graphics cards. This means that a DVI source can drive an HDMI monitor, or vice versa, by means of a suitable mechanical adapter or cable if all frame rates and resolutions are supported. The audio and remote control features of HDMI may not be available.

A serious legacy is limiting the efficiency of both digital frame synchronous interfaces discussed here. The interface transports the whole display-image with e.g. 60 frames per second even nothing changes during that time. This leads a considerable burden on mobile applications, which would limit the battery runtime severely.

2.3 Digital packet based on demand

The interface techniques presented in this chapter are packet based and can be fully independent on the monitor's pixel / frame clock. They intentionally do not try to follow the clocking scheme of the traditional monitor. Hence, they can exploit power down schemes to be active only if something changes, and act as general data links where the monitor is just one sink. Some have special isochronous modes that allows reduction or up to avoidance of framebuffer memory on monitor side. These solutions are thus more comparable with hitherto universal bus respective network techniques than with traditional monitor interfaces.

2.3.1 IEEE 1394, "Firewire"

Firewire is high-speed serial bus that integrates well with most IEEE standard 32-bit and 64-bit parallel buses, as well as such non-bus interconnects as the IEEE Std 1596-1992, Scalable Coherent Interface. It is intended to provide a low-cost interconnect between cards on the same backplane, cards on other backplanes, and external peripherals [4].

Although this interface is widespread used in digital video camera domain, it's so far not at all used in Smartphone domain. The IEEE 1394 specification for high-speed data rates has allowed applications that were once only possible in movie and TV studios to be done with consumer-electronic systems, such as capturing movies to disk or using a camcorder as a TV simply by "plugging in".

2.3.2 USB – Universal Serial Bus

USB is known from the PC world as truly universal external interconnect. USB operates as a master-slave serial communications protocol that provides host systems and peripheral devices with an economical, versatile data exchange channel, able to perform at low (1.5 Mbps), full (12 Mbps) or high (480 Mbps) transmission speeds.

The USB cable consists of four wires: two transmit power and two are for data. Maximum USB cable length is five meters, and a single cable can carry signals of different speeds.

In the USB architecture, the host manages all activity on the bus, including power, transfers and bandwidth. In addition, the host initiates all data transfers. This architecture supports a multitiered-star bus topology that works in a hierarchical model. The host controller (the master of the master/slave architecture) resides at the top of the hierarchy and oversees various configurations of hubs and their attached devices that run downward through the hierarchy.

For video application the "USB Video Class – UVC" is well known. This class groups all functions that can interact with USB-compliant video data streams such as e.g. web-cams. For any video function, the only requirement is that it exposes one VideoControl interface. No further interaction with the function is mandatory, although most functions in the video class will support one or more optional video streaming interfaces for consuming or producing one ore more video data streams.

The introduction of USB OTG addresses an effective solution for PDAs, mobile phones, and other handheld devices to communicate among themselves, as well as with any USB peripheral. USB OTG reduces the former huge USB overhead and energy consumption through allowing reduction to certain use-cases. USB 2.0 hosts, which do not implement the OTG 1.0a supplement must support sourcing of 500mA (2,5W) per port. OTG reduces the minimum to 8 mA, but allows up to 500mA.

An USB OTG based display-output mobile solution allows connecting numerous other USB devices through the same standardized connector. An USB based display link solution adds value to the terminal as well as to the display, since it enables both devices to connect to a variety of USB-based accessories. These benefits do not come for free: Significant HW and SW on the terminal side as well as on the display side is required, but is practically already ubiquitous in Smartphones available. Thus such display output solutions can be realized in software only.

3. Applications becoming feasible now

A high definition display equipped Smartphone is able to conveniently provide applications. Considered case:

- Office Appliances (Word processing, Spreadsheet, etc.)
- Internet browsing
- Audio Video recorder, editor, collector and playback
- Gaming

3.1 Smart docking station

The first grown together case is the smart docking station, which connects through the available USB connection of the Smartphone and Keybord, a Mouse and nowadays also a huge high resolution display. Due to the much slower user behavior in comparison of frame rate, the Smartphone is mostly in idle mode during office and internet browsing usage. Compressed video will be decompressed locally in display and matches therefore always perfectly to the optimally native display resolution and further properties (e.g. color gamut).

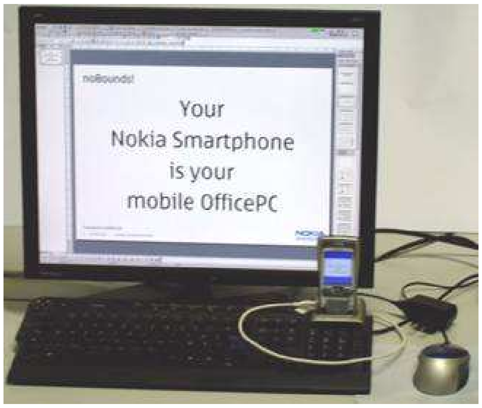

Figure 4. Smartphone docked with USB keyboard & mouse

During that time the mobile device is charged, as mains is anyway available. If the user likes to be mobile, he simply plugs it out.

3.2 Virtual Reality (VR) mobile use

In VR case the special mobile heritance of Smartphones can be utilized during e.g. traveling in a railway or airplane. The device connects to a Head Mounted Device (HMD), which shows an arbitrary huge and high resolution image.

Figure 5. Nokia E70 Smartphone with NED mockup [3]

This HMD produces only as much light as required for the eyes, no light-scatter occurs. This is optimally energy efficient. This is perfect privacy, no one con look over the shoulder. Here the fully mobile usage is highly demanding, through USB, the Smartphone battery powers also the HMD.

3.3 Meeting Room: Presentation & Sharing

After the travel conveniently connecting the same Smartphone to a bit flat panel device (TFT or plasmaTV) or a beamer allows conveniently presenting and sharing the results. This may happen through more and more upcoming native USB interfaces, or temporarily through a cheap legacy converter dongle.

Figure 6. Smartphone using Beamer for huge display

4. Conclusion

This contribution has elaborated on the fast converging worlds of PC, Notebooks and Smartphone with recognizing the specific advantages coming from the different origins. This is specifically the display size which in an accelerating pace determined der device sizes. To attach on demand external displays, the next section has analyzed a set of most relevant display interfaces with respect to be used in Smartphone doman. This is predominantly efficiency and often therefore also legacy avoidance in terms of power consumption and battery live-time.

Finally can be concluded, that analogue composite should be supported temporarily due to compatibility requirements of the huge installed basis of devices. Resolution of these standards is limited to about VGA; hence it is a dead end. However, this is up to now sufficient for movie use cases. But it comes with the most serious cost for fully mobile systems: Useless power consumption. Since mobile phones and most mobile displays as e.g. Near Eye Displays are in the digital domain two conversions are required: DA – AD. Due to further compatibility issues like interlacing and a comely analogue color coding several artifacts (comb artifacts) occur, which should be reduced by digital signal processing. This together let an analogue fully mobile solution (mobile phone together with NED) become very unfavorable.

Therefore staying in the digital domain seems much more desirable. For higher resolution use cases like Word-processing and web-browsing no other way seems reasonable. Several options have been compared. USB addresses an effective solution for Smartphones, and other handheld devices to communicate among themselves, as well as with any USB peripheral. An USB OTG based display-output mobile solution allows connecting numerous other USB devices through the same standardized connector. An USB based display link solution adds value to the terminal as well as to the display, since it enables both devices to connect to a multiplicity of USB-based accessories.

It can thus be concluded that USB will be apparently the most widespread interface for the terminal external connectivity and as digital on demand display interface cater high performance demands while being optimally efficient during the next years.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] E²R2 "End-to-End Reconfigurability II", http://www.e2r2.motlabs.com

[2] http://musicstore.mymmode.com/home.do

[3] http://www.inkfilling.com/show_mp3-sunglasses-256mb.html

[4] IEEE1394, Firewire http://ieeexplore.ieee.org/servlet/opac?punumber=3871