Digital photography and computer technology : a promising field of innovation

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1- Initial purposes

Electronic photography is going gradually to gain parts of chemical photography market. Current implementation of digital camera are limited by technology constraints (limited storage capacity, and poor exchange capability). However, some new components allow to store more than one gigabyte on a single chip (for example the PLEDM™ technology from Hitachi [Hita99]). Even if we expect only one gigabyte of storage capacity, it will be possible to store thousands snapshots on the family digital camera.

We guess that small digital cameras will replace traditional family photographic albums since users could take their cameras everywhere and could visualise their snapshot on their own TV set or on friend's one. However, a large part of the potential customers does not have computer to easily organise or process on their thousands snapshots in this digital photographic album. Moreover, those of the users who have a computer do not have in general skills to manipulate files of images. In all cases, it is necessary to offer to the user various services, for example the possibility to :

- to retrieve and select some snapshots from the digital album
- to visualize them on various display devices such as LCD, TV or PC for preserving the possibilities of image processing for the professionals users (high definition, large sizes, final improvements etc.).
- to print them on printing (Web) service
- to exchange snapshots with another digital camera or with an archival web server through a wide area network.

In this paper, we propose, an architecture to manage the concept of album as a voluminous collection of indexed images on both the digital camera and in the next electronic home environment including PC and STB (Set Top Box) [Mile98] (figure 1). We prototype this architecture using Java-based technologies to validate its functionalities and to evaluate code size of the software components to integrate in the digital camera. This paper is organised as follows: Section 2 describes the architecture components and connection possibilities. Section 3 shows examples of use of the proposed architecture and its functionalities. Section 4 describes the creation of the digital album and introduces the indexing criteria to improve snapshots research and retrieval and enumerates techniques used for each indexing criteria. Section 5 gives a brief idea on security problems and solutions. Section 6 describes the architecture prototype

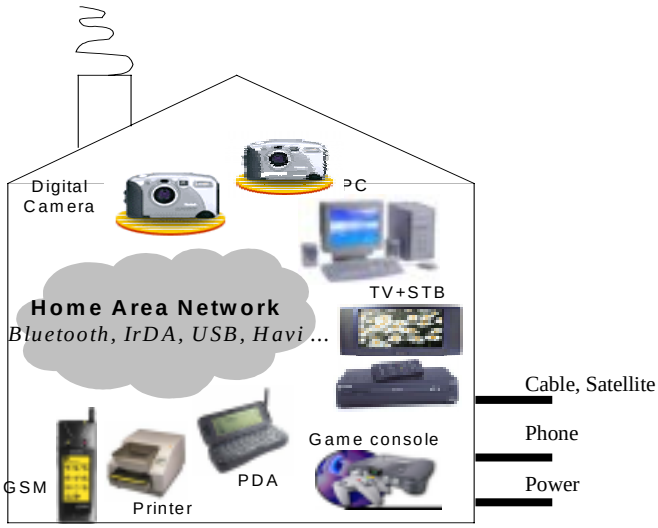

Figure 1: Home electronic Environment

2- Architecture description

Our architecture is composed of two complementary environments: The home environment and the remote environment.

- The home environment is composed of wired devices like PCs, Set-Top-Boxes coupled with a TV screen, game stations, DVD players and printers. Wireless devices like cellular phones and PDAs are also devices of the Home environment.
- The remote environment is mainly constituted of remote servers : archival, print, web servers, Image servers or mail servers.

Communications in the Home Environment

Physical communications between the Home environment devices uses either wired links like the USB or wireless networks like BlueTooth and IRDA.

- USB (Universal Standard Bus)

  Almost recent home electronic devices are equipped with USB connectors. USB link make more efficient a digital transfer between two devices. USB links can be used between two cameras for snapshot exchange or between a camera and a PC for a snapshot transfer or also between a camera to a STB for visualization. Compared to other link (serial, parallel,…), USB provides a dynamic recognition of devices and determines software and hardware features of their peripherals without having to use the Plug and Play

reconfiguration. The USB standard supply also electrical power which avoids multiplying cables. This characteristic is interesting for mobile units such as notebooks, cellular phones and so on.

- Wireless communication

  Our architecture tends also to integrate others wireless forms of connection giving to the user more flexibility and services. IrDA[MOB99] an infrared wireless communication protocol and Bluetooth [MOB99] a radio-waves-based communication protocol are used to enhance communications possibilities among the home environment devices specially between the camera and wireless devices.

Communications outside the home environment

In our architecture , digital camera communicates with remote servers using a home environment device as a proxy. Usually the proxy devices are the STB or the PC but we can imagine a connection to a web server for example using cellular phones or Notebooks. Used technologies for this kind of communications are the WAN(Wide Advanced Network) , the câble or the satellite (figure 2).

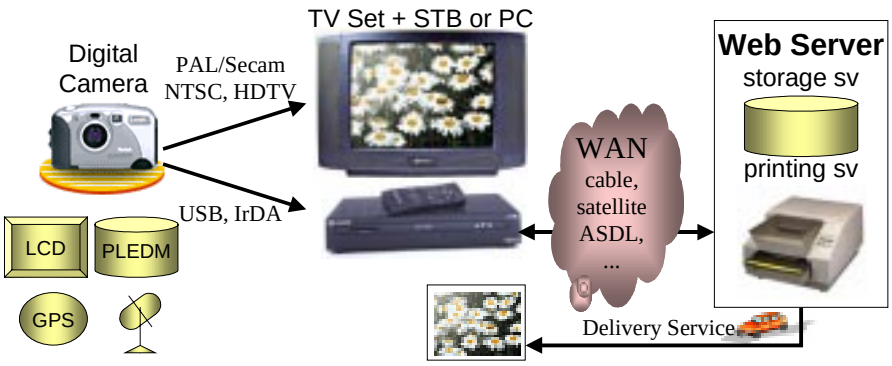

Figure 2

3- Architecture functionalities & possible services

In this paragraph we introduce some possible scenarios of use of our architecture:

- Snapshot transmission

  The camera owner could send to a professional's web site via the Internet network his snapshots for touch up operations, archival or print purposes. Moreover, the user can send by mail to its friends anywhere in the world all snapshots where they appeared for example.

- Snapshots exchange

  Snapshots exchange between two digital cameras or between the camera and a PC is possible. A user select first a subset of his snapshots in the digital album according to various criteria or just by enumerate them then make the transfer.

- Camera as Slide show device

  Camera can contribute to a slide show as a snapshot storage unit: The speaker selects a subset of snapshots, merge them to screen dumps made by a representation-making software like MS-Powerpoint. Using an appropriate camera tool he can play the whole representation by connecting the camera to a video projector or to a TV screen.

- Image server

  Snapshots on the camera can be accessible either from a web server or a web browser for various purposes : snapshots manipulations (for example cropping), research, duplication, and so on. In this case, a snapshot access authorization is required.

- Snapshot visualization

  Snapshots can be visualised either on the camera's small LCD screen or on PC screen or either on the TV screen. For each case an appropriate GUI must be designed to fit the display features and snapshot display constraints if any.

- Snapshot printing

  Snapshots can be printed on a local or a remote professional printer. For the last case, snapshots must be sent first using network capabilities.

4- The digital album

With the emerging of the new non volatile removable memory generation such as the PLED proposed by HITACHI[HIT99] which offers a storage capacity of one gigabyte, several thousands of snapshots can fit simultaneously on the camera's memory. The creation of a digital album on the digital camera is from now on possible.

Current digital cameras organize pictures as a sequential list of files (one JPEG image per file) in a removable media (CompactFlash, SmartMedia, Floppy) and files are named by a sequence number (such as IMG001.JPG) or by a time code (such as IMG991004-103127.JPG). To retrieve a picture, the user can only scan the snapshot one by one.

This organization is not appropriate to visualize thousands snapshot and the user needs other means to retrieve a subset of the album.

Storage and retrieval criteria

- the snapshot place

  Small GPS positioning modules can output spatiotemporal coordinates by an USB link. A professional user (i.e. architect, news photographer, insurance expert…) connects a GPS module to his camera. Each snapshot is marked with GPS position and can be sorted and retrieved by geographic coordinates. These coordinates can be associated to countries all over the world (Japan, France…) and to more precise famous places (Grand Canyon, Eiffel tower, Pompeii…). Information on the user localization may be found in his electronic agenda since camera and palmtop will cooperate.
- the snapshot date

  The user can retrieve snapshots taken within a time interval. Snapshots are dated either by the camera internal clock or by an additional GPS (Global Positioning System) connected to a camera IO port (such as USB). The user can also retrieve snapshots with time concepts such as "In the night" or "At Sunset". The user can also retrieve snapshots by events (birthday party, holidays…) founded in the user electronic agenda.

- the snapshot content

  Content criteria can be the dominant colors in some areas of the snapshot or by the presence of specific shapes (portrait, group of standing persons, building…). But the user can also retrieve snapshots by selecting a similar snapshot in the album.
- the keywords extracted from a photographer's comment

  Some cameras (i.e. Epson PC 800) integrate an audio input to record vocal comments of a snapshot. The comment is "recognized" with speech recognition software. The sentences subtitle the snapshot at display time. Moreover, keywords extracted from the sentences are used to retrieve the snapshots.

All these criteria can be combined to refine or to broaden the selection in the album. Several GUI are required to compose criteria in snapshot retrieval in order to fit the device ergonomic (camera 2 inch LCD screen with a 4-kay pad, HDTV screen with remote control pad, PC with a full keyboard and mouse…)

Indexing

Retrieve snapshots in the album can be done with criteria such as the date, the place, and the content of the snapshot but also on keywords extracted from the photographer's comments. This search can be done in a short time only if all snapshots are yet indexed. Several extracting and indexing techniques are required. Main techniques are listed and detailed below.

- The place

  Since common people (unless they are master mariners!) are not able understand GPS polar coordinates, GPS coordinate must be associated with

well-known geographic place such as "Eiffel Tower @ Paris @ France". The association between GPS coordinates and places are stored in a GIS (Geographical Information System). But current GIS stores gigabits of geographical information concerning tourist place or urban cadastral register. We propose to embed a small GIS in the camera to store the shapes (i.e. polygon of GPS coordinates) of countries and main areas in the world (Los Angeles area, Sahara desert…). This embedded GIS can be completed with local maps or thematic maps that are temporary installed. We propose to externalize GPS-to-Place association: when the user connect his camera to a network, the association is requested to a global external GIS for each new GPS coordinates.

- The date

  The GPS date gives both the global time (GMT) and a local time (when the localization is coupled with the time zone) since the internal clock may give a time difference when the user goes into different time zone and does not reset the camera clock. The last drawback may false search with time concept.

- The visual content

  Techniques to extract colors and shapes in images are now classical and industrialized in products such as VIRAGE, IBM QBIC, … We propose to embed simple techniques in the camera such as color characterization of the nine areas of the snapshot or shape segmentation. Others heavy techniques may be applied later when snapshots are upload on a PC or on a server.

- The photographer's comment

  Speech recognition can be used to extract keywords from the photographer's comment; hence snapshots are indexed with these keywords. Some video retrieval servers already use speech recognition to index videos ([Mina98], Informedia [Wact96], Tr@nsdoc [Chen97]). Presently, embedded speech recognition is limited to about a hundred of words: it now widely used in mobile phones (Philips…) to retrieve phone numbers by voice. For a better speech recognition and a better keyword extraction, the comment is uploaded to a PC or a server that extracts keywords. Then the camera downloads the keyword to complete the internal index. Tools such as IBM Via Voice and Dragon Natural Speaking are available on PC.

  All the information on snapshot (color histograms, segmented shapes, spatiotemporal positions and extracted keywords from vocal comments) are stored in a multi-criteria index file for fast searching.

Interchange and synchronization

The former indexing techniques requires an amount of memory (for speech recognition) or a big amount of memory (for GIS database). It is obvious that all these indexing techniques could not be embedded in the camera even in the next decade. The problem will not be the limitation of memory or the power of the processor embedded in the camera. The main reason may be the energy cost of the extraction since camera batteries must have a long autonomy.

We propose to use the CPU and the memory of the PC (or the server) when the photographer uploads the new snapshots on it. The PC can extract all indexing information and then send them back to the camera, which can complete its internal index. This operation named synchronization is done in background when the user uploads snapshots to print them or to archive them.

5- Security

Both in private and professional use, security mechanisms and rules must be provided to protect the pictures and to control access to them. Since the camera can be stolen, lost or lent, the user needs to protect privacy or copyright of his snapshots. A snapshot can be signed by watermarking [Cox97] to attest picture authenticity, or encrypt for storage and transfer. Access lists, display and export modes can be defined. The camera owner can restrict to other camera users to display low quality copies of snapshot with a copyright banner. Similarly, the display can be limited to the LCD or the TV output port.

To reach these secutity specifications, we will re-use works done previously on smartcards [Alex95] and results from the french-australian project named MIM in which our labs collaborate.

6- Architecture and Prototype

We actually develop, in our laboratory, a prototype including all the functionality listed above. We simulate the next generation digital camera, the STB, and the printing (Web) server with a network of PCs limited by several hardware and software constraints (such as specific interface, LCD screen, tactile screen or functional keyboard) in order to obtain realistic results.

All the components of this prototype will be realized by using Java Technology and APIs. We plan that Java technologies will be adopted by electronic consuming manufacturers in two or three years. For example camera will support Embedded Java, or television, JavaTV.

In order to assume the interoperability and the communication between all this different components, we use the JINI technology, which is also based on Java [Sun99b]. In fact, JINI technology provides simple mechanisms (which employs the RMI protocol) which enable devices to form a community. These devices will be able to communicate together without any planning, installation or human intervention (figure 3).

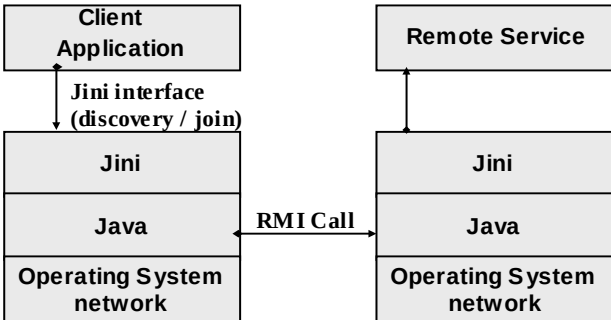

figure 3 : Communication with the JINI technology

Moreover, JINI technology does not require any particular network (for example, TCP/IP, IRDA or wireless network can be used) or operating system (all of the operating system being proposed in our architecture provide the features necessary to support Jini).

With this architecture, the client application will be the same on a PC (running under Windows operating system and using the TCP/IP network protocol) and a digital camera (running under javaOS operating system and using an IRDA for the network connection).

The figure 4 describe the communication between the different components present in our prototype. In this example, a digital camera is linked to a SetTop Box to display the photography on the TV screen. The Set-Top-Box will also provide an access to web services, to download, or to export photography on the Internet network.

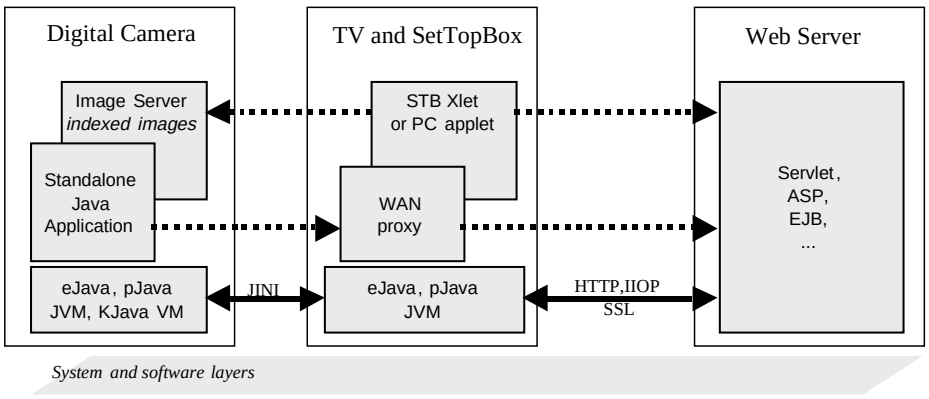

Fig. 4 : **Digital camera in the "home area network"**

7- Conclusion

In this paper, we propose to integrate the digital camera in the Home Environment composed of several wired and wireless devices. The aim of this integration is to enhance camera's interoperability and consequently its ability to provide services. Digital camera will provide not only local but remote services too. In the last case, local devices serves as proxies to communicate with remote servers. The efficiency of the services offered will depend on snapshots organisation and retrieval on the camera and the memories capacity. The recent memory evolution allows to solve the last problem. To solve the snapshot organisation problem, we have proposed to use multicriteria indexing techniques. Our proposed architecture will contribute consequently to make digital cameras more attractive and more expanding.

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