Sharing and Protecting Networked Digital Life Memories

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***Abstract*- The increasing power of computers, increasing capacity of digital memory and wider availability of a great variety of input devices such as cameras and video recorders, has resulted in an astonishing growth in the use of multimedia and the production of user generated content. It's now becoming feasible to store a digital record of everything that a person sees and hears throughout their life, all using cheap and easily obtainable commodity hardware. Such possibilities have given rise to the idea of a digital human life memory, able to store all of the video, photographs, documents and communications that relate to us as we travel through our lives. We explore how networked systems can be used to extend the capabilities of digital human life memory stores. Not only through the networking of the memory stores themselves, but also through the use of networked appliances, networked virtual worlds and wireless sensors network technologies. As well as the benefits, the massive increase in multimedia networking also presents drawbacks that include the potential for breaches of privacy and the need for content protection. We will also therefore consider our work in the area of security that aims to address some of these challenges, and maintain a balance between the competing benefits of sharing and protection of multimedia and sensory data.**

I. INTRODUCTION

Over several decades, computers have continued to grow in power and capabilities at an exponential rate. In 1965 Gordon Moore famously predicted that "the number of transistors on a chip will double about every two years," and this remained largely true for the next thirty years. At the same time, digital storage space has improved exponentially, both in terms of capacity and price, so that average users are now able to have terabytes of storage space at their disposal.

This description, however, doesn't really do justice to the change that many people have experienced over the thirty years in the way they interact with computers. The real changes have not been just quantitative, but qualitative as well. With computers and broadband networks now near-ubiquitous in many countries, people's lives and experiences have been transformed by modern computing. Devices that in the past would have been seen as standalone (often mechanical) devices in their own right – cameras, video recorders, phones, books – now not only connect to and interoperate with computers, but are in fact computers in their own right.

Just one of the many exciting consequences of these changes has been the potential for and growth of user generated content (UGC). There is clearly a huge appetite for people to not just consume content and media, but also to create it, to describe their thoughts on personal blogs, to share their experiences on social networking sites and to catalogue their lives in photos on photo sharing sites. While the need to share experiences isn't new, the opportunities certainly are. As we can see from the data of Gemmel *et al.* in Table 1 [1], a terabyte of storage will allow the recording of more audio than an individual can realistically generate in a year. In the not too distant future users will be in a position to record every waking (and sleeping) moment of their lives in 2D video.

TABLE I
FILLING A TERABYTE OF DATA IN A YEAR [1]

Item	Items/TB	Items/day
300 KB JPEG picture	3.6M	9800
1 MB document	1.0M	2900
1 hour 256 Kb/s audio	9.3K	26
1 hour 1.5 Mb/s video	290	4

In this paper we will explore these ideas further, considering the importance of a human life memory store, how it will extend through the growth of the Internet of Things and some of the security considerations that might result.

II. HUMAN LIFE MEMORY STORE

The massive quantity of data that we encounter and generate through our lives has given rise to the idea of a digital human life memory. This would be capable of storing all of the video, images, documents and communications that relate to us as we travel through our lives. Computers have given us the means to capture and store such information, however the real challenge that motivates the need for a human life memory store is not the desire to capture and store, but more the desire to manage and organise these vast quantities of data. Although surely we have seen improvements in this area, the design of an efficient management tool for all of this data – able to rival the brain's own ability to handle and recall memories – remains a significant challenge.

However, the challenge is not a new one. In 1945 Vannavar Bush published a groundbreaking article "As We May Think" [2] that explored the possibility of developing a *Memex* device able to store and retrieve all of his books, records, communications and so on. At this early stage, Bush envisaged a desk-like device with screens able to show data recorded on microfiche. He even considered the possibility of recording memories using a head-mounted camera.

More recently the focus has been turned to computers to achieve similar ends. The ongoing Microsoft *MyLifeBits*

project [3] aims to fulfil the Memex vision using a database of annotated photographs and other media. Microsoft developed the *SenseCam* to take digital photographs prompted automatically by significant changes in sensory data, such as light or temperature levels. Media can be browsed in the form of a timeline to allow the user to quickly identify relevant memories.

The Companions project [4] aims to make the interaction between humans and machines easier using techniques that allow the computer to learn about an individual through their memories. For example, the computer may ask questions about a recently uploaded photograph ("Who is in this picture? Is it the same person that you were with yesterday afternoon?") thereby allowing the image to e appropriately tagged and the information used to augment future conversations between the user and computer.

Indeed the need to store, manage and share memories is often seen as being a defining trait of humanity and one which underpins the persistence of human cultures. This has been recognised by the UNESCO *Memory of the World* programme [5], which aims to store cultural documents and material that might otherwise be lost, and guard against "collective amnesia". Ironically, the rapidly changing world of computing has often hindered rather than promoted this aim, as data stored on legacy systems becomes unreadable by newer computers and ultimately lost. The need to tackle all of these issues has also been recognised by research funding bodies, for example having been designated as a Grand Challenge for Computing in the UK [6].

III. Sharing Memories

Although retention and management of memories are of course crucial, our own work has looked at another aspect which is equally important; that of sharing memories.

There are already a variety of tools that allow sharing of different types of multimedia file and often these are web-based in nature. Social networking sites also provide an attractive means for users to share personal information with others in their community. However, from an architectural perspective such systems are not ideal. They are inevitably centralised in nature and require that the user relinquishes control of their personal data to the website owner. It can be difficult to transfer data between sites and should one site disappear a user's data may be lost with it. Moreover the methods made available for annotating, organising and searching data may be restrictive.

Previous work has shown that peer-to-peer networks provide a very successful, decentralised architecture that has been used widely in applications where sharing large amounts of data is a primary concern [7]. Moreover, the characteristics of social networks have also been shown to be similar to those of peer-to-peer networks, which could provide an opportunity to create an efficient system by reflecting the social network structure into that of the peer-to-peer network. Our work has therefore looked at how a peer-to-peer network could be used as a means of storing and creating a human life memory store. This has allowed us to improve existing methods to implement a novel peer-to-peer architecture that represents a decentralised and user-controlled network for sharing memories.

IV. Networked Memories

Although the prospect of integrating human life memory stores with peer-to-peer networks provides great potential in allowing people to share memories between each other seamlessly, we believe the true benefit extends well beyond this. By developing our human life memory network as a service on top of our existing Service Utilisation Framework [8] (itself designed as a peer-to-peer architecture), we are immediately able to integrate other software and hardware services and devices to provide additional functionality. The framework allows networked appliances and other devices to interoperate and compose to provide new services. For example, data from a home multimedia device, phone or networked appliance could be fed directly into the human life memory store to provide additional annotation about additional aspects of a person's life. Such additional information might include the type of films that someone watches, what type of food someone enjoys or logs of device usage. Future wireless sensor networks integrated in the system can be utilised in a similar manner.

V. Security

Although the growth of the technologies we have been discussing presents a wealth of exciting opportunities and applications, it will also inevitably present new security threats and difficulties. The ability for memories to flow seamlessly between interested parties represents a key property of the systems that we are developing. To allow this, while preventing serious privacy concerns, new security methods will be needed. For this reason we are also considering distributed security techniques able to work flexibly, but without the need for centralised control. We believe the use of distributed techniques, especially through the use of mobile agents [9] and community-based security mechanisms [10]. Community mechanisms utilise the intrinsic nature of the peer-to-peer data sharing network – that they are based on users with shared interests who are sharing data – to improve the overall security of a system by allowing the community itself to perform the 'policing', rather than rely on any centralised mechanism.

VI. Conclusion

As technology develops users will continue to use and generate huge quantities of information and documents. The need to store, organise and manage this information will only increase, and with it the desire for users to share it with friends, family members and others who may be interested. We believe peer-to-peer networks present an ideal technology that can allow not only effective management and sharing of life memories, but which will also allow future developments in networked appliances to be integrated naturally, thereby providing an even richer and more effect method to manage our memories.

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