Broadcasting Commercial Data on Mobile Peer-to-Peer Networks

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ABSTRACT

In our visions of the future, end users rely on their mobile terminals to access a wealth of information, a sizable portion of which will be commercial. But providing the necessary bandwidth for this information at a reasonable cost will be a challenge. However, the emergence of mobile terminals capable of communicating both with infrastructure networks like GPRS and UMTS and with each other in a peer-to-peer fashion opens up new possibilities for content distribution: the peer-to-peer networks, assisted with the infrastructure network, can be made to function as a broadcast channel for commercial data.

In this paper we introduce the concept of using the mobile peer-to-peer networks for distributing commercial broadcast content, taking a news service as an example. In particular, we look at the economic possibilities and legal risks of implementing these services.

Keywords

Mobile, Peer-to-Peer, Content Distribution, Wireless, Certificate.

1. INTRODUCTION

"Sitting in the bus on his way to work, Tom takes out his mobile terminal and starts reading the news. He checks the headlines and notices an interesting article about the current rally sports championships and makes a mental note to check later in the day how the situation is developing. He also watches the highlights of the ice hockey game played last night. Before getting off the bus, he also checks the weather forecast to see, whether he should go swimming after work." The described scenario could be a reality in the near future as the GPRS and the upcoming UMTS networks promise to make internet access ubiquitous.

Both GPRS and UMTS are evolutionary technologies based on the existing digital mobile phone networks. Their big advantage will be large coverage, but the bandwidth they offer has limits, particularly if we envision large scale usage of video and other rich media. Further, the license fees for UMTS operators ended up being so high that the bandwidth is not going to be particularly inexpensive. It will likely be used by businesses, but consumers may be more prudent with their expenses – so, the described news service would probably not become exceedingly popular among consumers, if they would have to pay for the bandwidth used.

But current mobile terminals have already started to offer other networking technology, which create new possibilities. Bluetooth offers fast local connections between the terminals that can be used for ad-hoc peer-to-peer networks and technologies like WLAN could boost the bandwidth and range significantly. The bandwidth is typically an order of magnitude bigger than with the infrastructure network and using these networks is nearly free – the major expense is reduced battery life.

By combining these two networks we could create a new platform that nicely overcomes many limitations of each network type. With just the infrastructure network, each news service subscriber in the bus would have to download all the news articles over the infrastructure network and pay the associated fee. This creates a large amount of redundant traffic – the news articles would in fact already be available in the terminals of other service subscribers. In the new model it suffices that just one user downloads the articles with the infrastructure network. The article is then released in the peer-to-peer networks, where it quickly spreads from device to device, much like a flu virus.

The use of an unreliable and uncontrollable network like peer-to-peer presents some challenges compared to a more traditional situation where the user directly accesses the content distribution server over a secure transport layer like SSL. First, the integrity of the data transmitted has to be maintained, otherwise the readers could not trust the news articles they receive from strange devices. Also, for the content provider to be able to charge for the news service, the articles have to be readable only to service subscribers. Finally, the usage of different types of networks has to be carefully balanced so that the cost advantage can be achieved while maintaining a good quality of service.

In this paper we introduce the concept of using mobile peer-to-peer networks for broadcasting commercial data and study it more closely using a news service as an example of possible data. We discuss the technology used on a general level and put particular emphasis on societal context assessing the relevant legal risks and economic possibilities of this concept.

The rest of the paper is organized as follows: chapter 2 introduces the relevant technologies as well as discusses existing peer-to-peer based business models. Chapter 3 goes over the problem in detail and elaborates on the criteria. Chapter 4 introduces our solution and Chapter 5 discusses future work.

2. BACKGROUND

The proposed concept utilizes existing and upcoming technologies, so we start by looking at some of the technologies. Then, we take a look at some existing business models that use similar technologies to our concept.

2.1 Wireless Technologies

General Packet Radio Service (GPRS) is an enhancement to existing GSM and TDMA networks that introduces packet data transmission enabling "always on" mobility. This means that users can choose to be permanently logged on to network, but usually do not have to pay for services unless sending or receiving information. GPRS increases the maximum communication speed for a mobile terminal to 114kbits/s (the maximum speed is available only if there is no other traffic like voice calls in progress). When EDGE, a further enhancement on GPRS, is added these data rates will increase up to 384kbit/s.

While GPRS and EDGE are enhancements to the current 2nd generation phone systems, the Universal Mobile Telephone Service (UMTS) is the next generation technology intended to enable a new generation of applications like video conferencing. UMTS increases the bandwidth significantly up to 2 Mbit/s, but it is believed to be available in the beginning only in urban areas – the rural areas will be covered by technologies like GPRS.

Bluetooth is an open standard for two-way, short-wave radio communications between different devices. It is meant to replace cables and cords between mobile phones, palmtops, portable PCs and printers, for example. Bluetooth can also have an important role in machine-to-machine communications, which is believed to be one of the largest growth areas in telecommunications in the near future. The range of a Bluetooth connection is 10 meters (in open space – indoors the range will be limited) and the bandwidth is 1 Mbit/s.

A wireless LAN (WLAN) is typically an extension of a wired LAN. WLAN components convert data packets into radio waves or infrared (IR) light pulses and send them to other wireless devices or to an access point that serves as a gateway to the wired LAN. Most WLANs today are based on the IEEE 802.11b standard, which permits data transmissions rates up to 11 Mbps with a range of 100 meters (again, in free space). [17]

2.2 Wireless Mobile Terminals

Our concept is based on the future scenario according to which the number of mobile terminals will keep on growing and users rely on them more and more. The market demand will remain increasing and new consumer groups are introduced to new wireless services. This likely leads to users demanding similar applications and media content to their mobile devices as they are used to on their desktops.

To use these new applications users will also need new, more powerful terminals, which means that users have to replace their current terminals to acquire the necessary technology e.g. for our concept. However, mobile phones – so far the most common mobile terminals in use – have an approximately calculated circulation time of two years. This means that in two years time most of the mobile phones will contain a short-range communication technology such as Bluetooth and Wireless LAN thus being suitable for our purposes.

The short range networks will make it very easy for everybody to exchange data directly from a terminal to another in a peer-to-peer fashion. Even strangers may share their data like they are doing in the various peer-to-peer services on the internet. Also, where many public places like libraries and cafeterias at the moment offer free web accesses via a LAN, the same places may have WLAN base stations for wireless data transfer. It is even possible that the ad-hoc wireless peer-to-peer networks offer routing and access to the internet as long as one of the terminals has the access.

2.3 Peer-to-Peer Technology

On the Internet, peer-to-peer technologies have gathered a lot of attention starting from Napster, the file exchanging service. But peer-to-peer is more than just exchanging files: in general peer-to-peer technology is believed to be an architecture that links all available networked technology, including CPUs, storage, files, data and metadata. In a peer-to-peer network all participants can interact directly without a central hub thus removing a central bottleneck in efficient communications. It can potentially enable users, applications and systems to find network resources in the fastest and cheapest way. The consultancy firm Meta Group predicts peer-to-peer technology will also be a standard part of the e-business infrastructure by 2005 once security flaws have been resolved.

However, no peer-to-peer standards so far exist. W3C has shown some interest in the issue 1 and Intel has formed a peer-to-peer working group [19]. All the popular systems we have seen so far are still far from meeting standard criteria. Expert reports predict them to become soon obsolete because of technical flaws such as limited peer-to-peer capabilities, unreliability and security threats [14]. Some of the most prominent projects that are currently under development are Microsoft's Farsite [6], UC-Berkeley/IBM co-project OceanStore [5], Carnegie-Mellon University's PASIS [8] and Sun Microsystem's JXTA [9].

A mobile peer-to-peer network differs from a fixed peer-to-peer networks in a few significant ways. First, each mobile peer-to-peer network consists of only those devices that are within the range of the network technology whereas a fixed peer-to-peer network can include devices from all over the globe. Second, as the devices move the composition of mobile peer-to-peer networks changes rapidly making them much more transient in nature. This means that many techniques used in existing peer-to-peer networks like indexing the available files in the whole (sub)network no longer make sense as by the time the index would be finished, the files would no longer be available, because the devices have already moved out of reach.

2.4 Existing Peer-to-Peer Business Models

Definitions on digital economy business models vary significantly depending on the author [1]. Not building on any specific theory or definition, the concept is used in this paper to tackle the practical business issues starting from the most obvious: if users can connect directly to one another then who gets paid and how? Will consumers trust transactions that depend on anonymous home computers enough to pay for various services? Existing peer-to-peer businesses are now operating on the fixed network. Below we have shortly described some of them.

2.4.1 KaZaA

Perhaps the most popular peer-to-peer client in spring 2002 is KaZaA with some 1 - 1.5 million concurrent users. KaZaA is technically very efficient in searching and exchanging files between users but does not include any kind of DRM or payment systems that would benefit content authors. Sherman Networks, the company that owns KaZaA, tries to make money by bundling 3rd party software into KaZaA client and reports that more than 63 million copies have been downloaded so far. There are currently ongoing legal cases litigated against KaZaA network and it is obvious the network will evolve significantly in the future. [10]

2.4.2 Napster

As far as it is publicly known, the new Napster service opening next year will introduce a business model where on monthly basis users pay five to ten dollars and are allowed to make as many as fifty downloads. Also all the content available through Napster's fee-based membership service will be licensed for sharing within the Napster community. Napster has created a new file format NAP that includes a security layer that enables simple Digital Rights Management (DRM). When the rights holder requests it, their music files will be changed in a secure format that defines how the file can be used. Artists and other rights holders can set rules for how their music files are used, check their account status online, and receive quarterly statements. [13]

2.4.3 Lightshare

To address the anarchy of the Internet's wilds, many companies believe that some measure of centralization is inevitable to guarantee transaction safety and file integrity. This dilutes some of the purity of strict peer-to-peer models. One such model is being developed by start-up Lightshare. The company is creating a network that functions with files that can be sold and resold through a string of members. Lightshare monitors files as they progress though the network to ensure the content isn't changed in hopes to create an eBay-like e-commerce network. [11]

2.4.4 Mojo Nation

Mojo Nation's scorekeeping mechanism claims to enable implementation of a peer-to-peer credit and reputation system, which handles distributed trust management and swarm distribution of data. [12]

2.4.5 CenterSpan Communications

CenterSpan Communications is another company which aims to create a secure channel for content distribution using peer-to-peer-like methods. In their model users can't publish any content and also do not have any control, what is stored to their hard drive. To maximize the security the files are sliced to small fractions and encrypted before the sharing. The information about the location of the fractions is centralized. Centerspan has some deals with content industry, but the system is not yet in active use. [7]

2.5 Regulation

A viable peer-to-peer network must meet certain legal requirements. The main regulative areas that must be taken into account in peer-to-peer network design are intellectual property rights (especially copyright) and user privacy rights. Copyright and other intellectual property laws are nowadays substantially similar in the United States and European Union after the US Digital Millennium Copyright Act (DMCA) and EU Copyright and E-Commerce directives. However, in personal privacy legislation the EU has more specific regulations than the US.

According to DMCA and the E-Commerce directive peer-to-peer service provider may have obligations to monitor the use of the network and services but only within the limits of user personal privacy and other laws. This means that for example connecting the personal information of a given user to the data within his device is usually prohibited. When personally identifiable information is collected, the purpose of collecting each item should be clarified. Access to this information must be technically limited and new uses must be audited appropriately. There are no legal definitions on secure information such as which encryption is legally secure. Technical standards in security are context dependent.

There are specific legal rules for take-down procedures in the case of possible infringement of any third party's legal rights. Service provider must always inform the user about the claims and give him enough time to stop infringement.

The issue concerning the copyright liability of a peer-to-peer service provider is still controversial as opposing judgments from KaZaA and Napster cases show [20]. It is clear that copyright law applies in peer-to-peer networks and infringing peers are liable their illegal actions. However, on the peer-to-peer networks the data may originate from unidentifiable users. An unidentifiable user community may be impossible to control by ordinary societal means with legal and economic consequences. Indeed, ad hoc user communities may run above legal and economic realities with purely ideological and other motives.

3. PROBLEMS AND CRITERIA

The goal of our concept is to build a new broadcast channel that offers slightly reduced quality of service (compared to direct access over GPRS/UMTS) but significantly reduced cost and also a legally viable business model. We explain how publisher could gain profit even though published material spreads freely among users. Hence, the solution has three key areas: technical, economical and legal. The channel is suitable for many types of content but our analysis focuses on our example, the news service.

3.1 Technical aspects

A big question is the following: if short-range communication protocols such as Bluetooth and Wireless LAN are to be used to complement the shortages and to offer additions to the new wireless radio-packet-networks, is it then possible to build a satisfying peer-to-peer network using mobile terminals? A mobile concept will add new issues on top of the ones discovered already on fixed peer-to-peer networks. The solution should not differentiate between the different short-range technologies. It is too early to tell, which ones will get acceptance from manufacturers and public, although WLAN and Bluetooth seem to be strong candidates. Needed transfer rate between mobile devices depends largely on delivered data. In any case, short-range communication is easily a decade faster than a radio-packet network.

Some of the key questions are:

- How can we control the validity of the data when it comes from other users? How can the users know that information is accurate and free of viruses or other maladies?
- How can we ensure that only the paying customers or service subscribers can read the data? Maybe the trickiest issue for companies planning to do business on peer-to-peer network is trust. If an anonymous machine is on the other end of a download or transaction, how can anyone trust on payments?
- How do we ensure that the user receives all the data and within a reasonable time frame? A mobile peer-to-peer network is undeterministic in nature and has to be complemented with adequate usage of an infrastructure network without increasing the cost too high.

- How to maintain sufficient end user privacy under usage monitoring? Security and privacy issues have played major part in preventing peer-to-peer to become business [21]. One can argue that it is insane to let someone else have a direct access to the memory of your terminal. Whereas sharing files between individual computers is fundamental cornerstone in the architecture, it can be the technology's most significant drawback.

3.2 Legal aspects

As noted, the main legal challenges in peer-to-peer networks are the proper management of intellectual property rights and user privacy rights. Peer-to-peer developers and companies need to be careful especially with the many requirements posed by the copyright law [1]. The main issue is to implement sufficient DRM into the network. This way the peer-to-peer service provider should reduce its chances to be a legally weak point of the network and potential target for copyright owners' infringement claims.

If content is protected under copyright or any other law it must be licensed through a license certificate that allows desired use. If a specific use is not granted expressly in a license then that use is most probably illegal (unless a specific legal exception applies). In peer-to-peer networks redistribution of the content is usually a central license term. In an ideal peer-to-peer network it should be possible to grant limited and unlimited redistribution rights to any piece of manageable information.

Very differently from centralized data distribution model, an unlimited redistribution right similar to the idea in copyleft license would encourage the distribution of the data by all means. By contrast, without any kind of license or subscription contract the user may only use the content on his personal device under specific legal exemptions. Such may be for example personal or scientific use granted in copyright law; but it should be noted that these exemptions do not usually apply in the case the content is obtained illegally by downloading the content from peer-to-peer network without authorization. Only if the user is ignorant of the content or any information that passes through his device one cannot be held liable.

While intellectual property right issues concern merely companies, privacy issues affect more directly consumer behavior. According to a study conducted by IDC approximately 40% of users have abandoned an online transaction because of privacy concerns [16]. While some consumers over-estimate and are paranoid, there are also some who underestimate their privacy needs and require education. There are privacy standards emerging such as P3P [18] but they are still novel and their usage rare. Ideally, companies could use the proper management of user privacy merely as a competitive advantage than an obstacle to business.

3.3 Economic aspects

A challenge is how to tackle the market demand as next generation mobile networks have limited bandwidth, their scalability is untested and using them is not cheap due to high infrastructure costs like auctioned operator license fees [2][23]. Furthermore, consumers themselves may be reluctant to pay the higher usage price for next generation wireless connections and this may delay adaptation of new services. The new services in turn wait that the number of users exceeds the critical mass before making the market entry and before believing new services could actually be profitable.

In theory, when the peer-to-peer services on the fixed networks are expanded to the mobile networks they may create a fundamentally new distribution channel for m-commerce and media companies. Any entity could upload a file once and then see it hosted by thousands of potential consumers. Those consumers, by offering the file to other peers can subsidize the storage and bandwidth costs of the original distributor by sharing their personal computing resources.

KaZaA and other post-Napster services highlight perhaps the most glaring illustration of peer-to-peer business challenges. Record companies are seeing their music distributed at unprecedented speeds, but they've lost control of the ability to control and profit from the system. Any company that hopes to make money legally from peer-to-peer networks must figure out a way to relinquish the right amount of control to its customers without giving away the business.

There's also the issue of what exactly can be sold or distributed. It's clear that music is a possibility, along with games, movies, software and other files commonly found on the peer-to-peer networks. But there's not a lot of evidence that people will pay for all the material they currently download for free [4]. Economic reality is that hardly anyone has made money so far on peer-to-peer networking.

From an economic point of view the solution is sustainable if it creates more profit to peer-to-peer service providers and content producers. If it saves money in investments, either operator does not need to build as large radio-network as planned or a new entrant can even trust more on peer-to-peer network and lease a radio-packet connection. The concept should enlarge service popularity and bring more paying customers. It should also solve the bottleneck created by the narrow bandwidth and make possible to serve more users, even the users without a current radio-packet network connection, but only an access to another peer.

A possible future business model is based on the idea of leasing the necessary terminal devices to users. The device would be held as service provider's property. This way provider or authorized operator would be gaining some authority and control over the peer-to-peer network. It would make possible to do user profiling more precisely and maybe even have an effect on that terminals are online for the network more often. In general it can be seen that manufacturing costs for electronic devices can be dropped to a point where they do not play any role compared to the prices of mobile operators and software companies. It may as well turn out to be that terminals are even given away for signing a service contract.

4. SOLUTION

The key technical advancement introduced is to replace some of the communications with the infrastructure network, such as GPRS, with short-range peer-to-peer networks based on e.g. Bluetooth or Wireless LAN as depicted in Figure 1. In the figure, a random terminal accesses the infrastructure network and passes the data to the peer-to-peer network.

When used in larger scale in, for instance, a city downtown or a sports arena, wirelessly communicating mobile devices form an ad-hoc peer-to-peer network. Every mobile device receives data from other bypassing users and sends data in return. The data spreads in the mobile network like a virus. The solution saves network bandwidth by distributing most of the data on the edges of the mobile peer-to-peer network.

The architecture of the system is illustrated in Figure 2. The press creates the news articles and stores them in a web server database. Any terminal can then fetch the articles from the web server. This fetching, however, only takes place if the terminal does not receive the articles from the peer-to-peer network. Further, the service provider can introduce additional terminals, "HotSpots", whose function is to keep even larger part of the traffic in the peer-to-peer network.

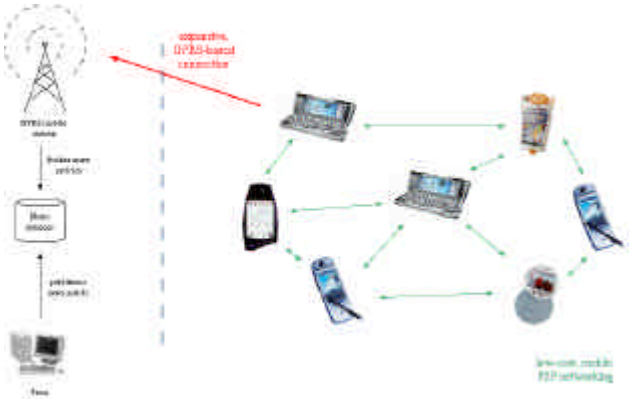

Figure 1. Mobile peer-to-peer network replaces some or all traffic to costly infrastructure network.

We use digital certificates to protect the articles against modifications. A digital certificate is a signed document in fixed form, which is used for adding descriptive information to objects. In this system every news article is complemented with a validity certificate. The certificate includes the publishing time and the information if there are further versions to the article. The signature in the certificate ensures that the news article has not been modified during distribution.

Digital rights management ensures that the news are accessible only to legitimate users regardless of where they have received the data from. All the articles are encrypted in this system. User needs a service contract and a hardware chip to decrypt the articles for reading. The chip can be used in any suitable device and it can be lent to another user.

Because the news articles are spreading freely between users, it is a challenge to ensure that all the users receive all the articles within a reasonable time frame. Every certificate includes an ID and the news article list is based on these ID's. If some articles are unavailable on the peer-to-peer network these articles could be fetched from the server after some period. However, many questions in managed peer-to-peer distribution remain topics for further study.

User privacy is not at risk in this model. Every user transmits all articles without adding any personal data. Hence, it is not possibly to deduce anything from the users own use from the information they transmit. But the service provider might be interested in usage statistics, which would help them develop the service. The design of a suitable solution to implement this requirement without sacrificing privacy is left to future work.

In order to achieve a desired high security level the terminal needs to act as a trusted hardware device, which guards the technology required for decrypting the data [22]. Mass-market software based solutions are doomed to be cracked as the recent DeCSS case shows [3]. Naturally, hardware based solutions can and have also been cracked, but the cost can be made much higher thus discouraging cracking. In practice, there could be a security chip (much like a SIM chip used in the GSM system). The user receives the trusted hardware chip as a part of a operator's starting package for instance. The chip contains a securely stored terminal private key, a processor and enough memory to store the coming keys. The aim is that the stored keys in the chip cannot be ripped off by any means, not even by the service provider who provided the chip to the user in the first place.

After this, the service provider can encrypt any data with the symmetrical session key and send it to be delivered by any means, on a mobile peer-to-peer network in our case. Only the terminals which have the symmetrical session key in their secured chips can open and view the data. Of course, this system can not prevent a user from sending the material from his or her terminal after he or she has decrypted the sent data.

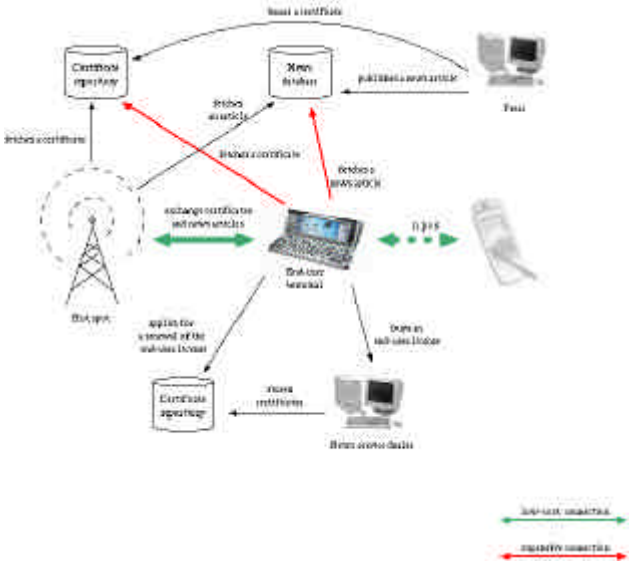

Figure 2. Concept architecture with the main data flows and the news distributing example.

When the session key expires, the new key will be received from the provider via infrastructure network, if the service contract is still valid. The service provider has a useful control over the keys and certificates accompanying the keys. By defining different kind of expire dates and other rule sets into certificates, the service can be tailored for different kind of users, content channels and price categorizes.

As a starting point, our research project has examined a business model where everyone who wants to read the news has to be a subscribing customer to the service. Only the paying customer has the chip which contains the essential decrypting technology. With the certificates the service provider can personalize news to contain e.g. only sports news. Subscription periods can vary from user to user. Service provider acts as both content provider and operator. Additional business models are also a subject to further research.

5. FUTURE WORK

Our research has already raised a number of points and questions for further exploring. Many of the questions concern managed distribution in a network consisting of peers.

The economic key question is how to allow free data spreading while still ensuring compensation to rights holders and service providers. How to implement a copyright license paradigm change, which would mean a shift from reduced usage rights to a model of encouraging free distribution without violating the content producers' compensation?

How to implement profiling that is important to service provider considering privacy issues and the fact that a mobile peer is quite seldom contacted to service provider? Is it possible to categorize users by their information need, and hence the subscription fee could be more for the users who need specific data more rapidly?

A practical improvement to the introduced business model would be to take into account user's location. News broadcaster could hire data broadcasting hot spots to cafeterias, busses and such public places where users would read news in a similar fashion as they would read the afternoon newspaper. The same hot spots could be used for distributing location specific data like tailored commercials.

A more fundamental improvement would be the implementation of a distributed micro payment system. It is counter intuitive to charge the user who is feeding a large number of users around her, although she gains the data herself at first. We should motivate the peer users to distribute data and to release space from their devices for use as network cache. Also, the peer-to-peer network could be open for data produced by anyone. All this could be possible to implement with some kind of payment and credit system similar to airline mileage accounts. It could be further extended to function as a common currency in the peer-to-peer network. Understandable, there are many unsolved questions with these issues.

6. ACKNOWLEDGMENTS

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8. BIOGRAPHIES AND AFFILIATION

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