

**T.C. MARMARA UNIVERSITY  
INSTITUTE FOR GRADUATE STUDIES IN  
PURE AND APPLIED SCIENCES**

**A STUDY ON THE INTERNET AS A COMMERCE  
MEDIUM**

by  
Rüçhan Ziya

Thesis Supervisor  
Prof. Dr. M. Akif Eyler

SUBMITTED FOR PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCES  
IN  
ENGINEERING MANAGEMENT

İstanbul, 1997

**T.C. MARMARA UNIVERSITY  
INSTITUTE FOR GRADUATE STUDIES IN  
PURE AND APPLIED SCIENCES**

**A STUDY ON THE INTERNET AS A COMMERCE  
MEDIUM**

by  
Rüçhan Ziya

SUPERVISOR & COORDINATOR: Prof. Dr. M. Akif Eyler.....  
MEMBER: Associate Prof. Ensar Gül.....  
MEMBER: Assistant Prof. Zafer Gül.....  
MEMBER: Associate Prof. Füsün Tavilođlu.....

SUBMITTED FOR PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCES  
IN  
ENGINEERING MANAGEMENT

İstanbul, 1997



## **Acknowledgments**

I would like to express my thanks to Prof. Dr. M. Akif Eyley for his continuous support throughout the research.

I am also grateful to Mr. Tun Erdal of AlternatifBank for his contributions in the research and understanding of current banking system.

Finally, to many people on the Internet that share my interest in the topic for their comments, expertise and guidance that they have supplied in electronic commerce mailing lists and news groups.

Ruhan Ziya  
<stanbul, 1997  
rziya@yahoo.com

## **Abstract**

For businesses, large and small alike, computing and networking technology is quickly becoming an absolute necessity. Computers are already populating many offices by providing tools such as word processors, databases, and spreadsheets. Towards the late 80's, Local Area Networks (LANs) of computers became a much demanded utility as businesses tried to connect the various departments of their organization together. Now, networking on a much larger scale, nationwide and even global, is becoming the need.

Some businesses have discovered that their area of service naturally extends to a global scale and wish to contact a whole new base clients. Others have found peer organizations and people involved in similar work to share and communicate new ideas for various aspects of their business. Still others have found a whole new way of advertising their company's services or products. Global networks such as the Internet have also become a cost-effective and quicker way to transfer important documents to remote offices than courier services or even fax.

Recent developments and the fast growth has put Internet into a alternative commerce and marketing medium situation. Internet now is a place where online transactions can be realized, where sellers and buyers can meet and discuss, where people can shop. And it seems as a viable alternative to real world classical market. Value added, specialized networks have been in operation for many years but they could not generate the mass demand for online commerce, as they could not offer the high accessibility, low cost of connection that the Internet is offering. Internet offers businesses low cost worldwide access without physically being present, which makes commerce highly attractive especially for goods that can be electronically transmitted.

The Internet and other global on-line networks are creating new commercial opportunities for networked commerce. However, to date development has been limited by the lack of an infrastructure. In the past months, a number of initiatives have been made public for developing secure payment systems on the Internet. These recent developments which could permit the creation of a new cost-effective global payment, commerce system for low value payments that enables the Internet Commerce , the tools and techniques used in areas such as security, authentication, electronic-money and their short-comings are examined in this study. The lack and the need for a new standard that enables cooperation of different systems is also highlighted. This paper also aims at supplying a solid working ground on what the Internet is and its implications on the businesses.

## Özet

Küçük ve büyük ifl\_yerleri için bilgisayar, iletifim ve a teknolojileri hzla büyük bir gereksinim haline geliyor. Bugün pek çok iflyerleri kelime iflem, veri taban ve iflem tablosu gibi araçlar sunan bilgisayarlarla dolu. <flyerlerinin organizasyonlarndaki çeffitli birimleri birbirlerine balamak istemeleri sonucunda ise 80'li yllarn sonuna doru yerel bilgisayar alar büyük bir önem kazand. fiimdi ise daha geniflapl, lke apnda hatta tüm dünya ile balant salamak, bilgisayar alar kurmak en önemli ihtiya.

Baz kuruluflar sunduklar servislerin yaps gerei doal olarak evrensel bir ölçekte alabileceklarini farkettiler ve ulaabilecekleri tüm pazarlara, müfiterilere ulamak istiyorlar. Bazlar ise kendileri ile paralel yada kendilerini tamamlayc olarak alan kifi ve kurumlarn varln keffettiler ve iflerini ilgilendiren yeni fikirleri, iflerinin çeffitli boyutlarn bu kifi ve kurumlarla paylamak, haberlemek istiyorlar. Kimileri ise ürünlerini tantmann yepyeni yollarna kavuftular. Internet gibi genifl alan alar ayn zamanda bilgilerin, belgelerin uzak noktalara transferinde kurye, hatta faks servislerine nazaran daha ucuz ve hzl özümler sunuyorlar.

Son gelimeler ve hzl büyüme Internet'i flu an alternatif bir ticaret ve pazarlama mecras durumuna getirmifl durumda. Internet flu an alifveriflerin gerçekleştirilebilecei, al ve satclarn kar karya gelip konuabilecei, kifilerin alifverifledebilecei bir ortam halinde. Ve gerçek dünyadaki geleneksel pazara ciddi bir alternatif olarak görülüyor. Katma deger salayan, özellemifl alar uzun yllardan beri alıyor olmalarna ramen kolay ulalabilirlik, düük balant ücreti gibi baz kofullar salayamadklarndan bu alar üzerlerinde ticaretin gereklemesi için kitlesel talebi yaratamadlar. Internet ise iflyerlerine fiziksel olarak mevcut olmadan düük maliyetlerle dünya apnda var olma frsat yaratyor. Bu da tüm ürünler özellikle elektronik olarak tanabilen ürünler için son derece çekici bir pazar yaratyor.

Internet ve dier yaygn alar buralara yeni ticari olanaklar salıyorlar. Fakat bugüne kadar ticari bir altyap olmamas gelimeyi oldukça snrl kld. Son bir kaç ylda ise güvenli ödeme sistemleri konusunda pek çok girifim oldu. Bu gelimeler, düük maliyetli, evrensel ve özellikle küçük miktarlarn ödenmesine izin veren bir sistem olufturmay salayabilirler.

Bu alfma da Internet üzerinde ticareti mümkün klan altyap güvenlik, elektronik para gibi alanlardaki teknikler, araçlar ve bunlarn eksiklikleri incelenmifltir. fiu an eksik olan ve elektronik para sistemlerini bütünletirebilecek yeni bir standarda olan ihtiya da gösterilmifltir. Amalardan biri de Internet ve ifl hayat üzerine etkilerinin incelenmesidir.

## Table of Contents

Acknowledgments.....	i
Abstract.....	ii
Özet.....	iii
List of Figures.....	v
1. Internet.....	1
2. Services on the Internet.....	2
3. Commerce on the Internet.....	3
3.1. Market:.....	5
3.2. Transaction.....	9
3.3. Payment Systems.....	10
4. Security - Encryption Techniques.....	20
4.1. Private Key Encryption.....	22
4.2. Public-Key Encryption.....	25
4.3. Blinded Digital Signatures.....	28
4.4. Hash Algorithms.....	28
4.5. Bit commitment.....	32
4.6. Secret Sharing.....	32
4.7. Kerberos.....	32
4.8. Zero-Knowledge Proofs.....	34
5. Cash protocols.....	34
5.1. Digital Checks.....	34
5.2. Digital Cashier's Checks.....	35
5.3. Simple Anonymous Cash:.....	37
5.4. Traceable Anonymous Cash.....	38
5.5. HTTP and Cash.....	40
6. Cash Systems.....	42
6.1. iKP [IKPP97].....	44
6.2. DigiCash [EC97].....	45
6.3. Payment Clearing Systems.....	46
6.4. First Virtual [FV96].....	47
6.5. CyberCash [CC96].....	49
6.6. SET [SET97].....	51
6.7. NetBill [NB97].....	57
6.8. Credit Card-Based Systems.....	58
6.9. Smart Cards [SC97a, SC97b].....	58
6.10. Citibank's Transaction Cards.....	59
6.11 Mondex [MDX97].....	61
6.12 Electronic data interchange (EDI) [EDI96].....	62
7. Policy and Regulatory Issues.....	63
8. Conclusion and further studies.....	66
9. Appendix.....	70
10. References.....	71

## **List of Figures**

Figure 3.1 Transaction costs .....	8
Figure 4.1 The Initial permutation for DES.....	23
Figure 4.2 The Expansion Function used in DES.....	24
Figure 4.3 DES s-box.....	24
Figure 4.4 The P function used in DES .....	24
Figure 4.5 The key transformation.....	25
Figure 4.6 The key selection function.....	25
Figure 4.7 The 16 values of $s_j$ .....	25
Figure 4.8 The rounds of DES .....	25
Figure 4.9 An application of the RSA algorithm.....	26
Figure 5.1 A basic digital cashier's check.....	36
Figure 5.2 An enhanced digital cashier's check.....	36
Figure 5.3 Anonymous cash.....	38

# **1. Internet**

The term "internet" is used to identify any collection of networks into a larger Wide Area Network (WAN). When this definition is concerned any connected networks of AppleTalk-based computers or PCs entirely located over several geographical areas are called "internet". However, "The Internet" or "The Global Internet", as most people call it, is a proper name for a certain internetwork of computers around the world which is also known by other names: "Cyberspace", "Information Superhighway"

The Internet is the unexpected outcome of a project from the 1970's by the US Department of Defense Advanced Research Projects Agency (ARPA). The aim of the project was connecting people in different geographical locations who are working on related projects and improve the speed of research activities by speeding up exchange of information. The first name for the network was ARPANET. In 1973 and 1974, a standard networking protocol, a communications protocol for exchanging data between computers on a network, emerged from the various research and educational efforts involved in this project. This became known as TCP/IP or the IP suite of protocols

The size of the Internet is one of the main questions that a business might ask before putting a step on the Internet and trying to do business. But there is no easy answer to this. Internet consists of ad-hoc connectivity. A user can decide to get connected and do this in a few hours. There is no central authority on the Internet that registers the users. The most impressive numbers regarding the Internet are the growth numbers. The Net continues to double in size approximately every 12-15 months.

The Internet is experiencing rapid growth which is being largely driven by new commercial users of the network. Other commercial on-line services provided by companies such as CompuServe, America On-line and Prodigy are also expanding rapidly. The Internet is estimated to already have in excess of 60 million users, and according to figures published by NSFnet, the network has seen more than a doubling of users over the 12 months to January 1995.

Internet offers various levels of access options that vary with speed, price and available options. Globally these access options can be examined as two different groups. End user and corporate access.

End users are individuals who access the Internet, who browse on the Internet. From commerce point of view these are consumers who wander in the streets and buy things.

## **2. Services on the Internet**

The following are some of the more common services of the Internet. These are, by far, not the only services on the Internet. These services are accessed through various application programs available for a variety of computer operating systems. All these services work over the common network structure of the Internet. The Internet itself is just a massive communication media.

### **Electronic Mail**

Electronic mail (e-mail) is a messaging system which allows you to send communiqués, and reports to users on the Internet. Every computer on the Internet can be addressed uniquely and many of these computers support multiple users.

With e-mail, it is also possible to create group mailing lists where mail sent to one address will cause the information to be distributed to all members of that group. Mailing lists are a very useful way to disseminate textual information such as office memos and reports to a number of people at a time.

### **Electronic News**

Electronic News on the Internet is mainly distributed through the Usenet news system. Usenet news is distributed on a variety of levels from local distribution to the news server on the local machine to world distribution to all other Usenet news systems in the world.

Usenet newsgroups can be thought of as bulletin board systems where users posting to a certain group can inform all other readers of that newsgroups. Each newsgroup concentrates on its own specific topic which also is the general name of the newsgroup.

Newsgroups are a popular form of communicating with the combined intelligence of the much of the Internet on each topic. Asking a question in a newsgroup will produce answers depending on the popularity of the group. Other groups are not as popular and receive only one or two posts a week.

### **Gopher**

The Internet Gopher is a very basic menu-based system which provides interconnected links between files on different computers around the Internet. These files appear to be linked as a series of directories around the Gopher menu which are really located on other computers.

Gopher provides access to text documents. Graphics and digitized vocal annotations can only be included in compound documents which have to be downloaded to the local computer and then viewed with a different program. Gopher also allows access to a few of the other Internet services such as Telnet for remote connectivity.

## **The World Wide Web**

The World Wide Web is a hypertext based information service. It provides access to multimedia and complex documents, databases.

The Web, as its is colloquially known, is one of the most effective methods to provide information because of its visual impact and advanced features. Web application programs can access many of the other Internet services such as Gopher, Usenet news, file transfer, remote connectivity and even special access to data on the local network such as SQL database access and even special custom programs for your own needs.

The Web can be used as a complete presentation media for a companies corporate information or information on all its products and services.

The versatility of the Web has yet to be limited. New, innovative ideas have been developed around the Web.

## **3. Commerce on the Internet**

Internet today represent a huge opportunity to almost every kind of business. The most common and the very first approach to Internet was utilizing Internet as a new medium. That is treating the Internet as a new media type like news papers, radio or TV. Which is a highly natural approach as after the first look Internet seems just like a medium. One can put information in various kinds like text, graphics, sound video and let people learn what they are offering. But this approach oversees the possibilities that Internet offers. Internet is not just a media type. It is more than that. Internet can also be conceived as a marketplace like a shop or a fair. A place where you can realize commerce for that matter.

The medium approach to the Internet has been understood very well by business that have a future insight. As Internet allows you to reach customers around the globe inform them of your offerings, inform them about your products, offer them support. Even take orders via forms. Just like they could do in newspapers. And the advantage that Internet is offering was mainly the cost. Once you're on the Internet you could realize these 24 hours a day, 365 days a year and covering the globe. And the cost of this was no more than a 15 sec spot on a TV channel. And Internet offered other advantages such as the possibility of instant updates. One example could be product specifications, prices. If one wished to change these it would take a week for updating printed material such as brochures, it would take two months to update a TV commercial, it would take a month to prepare a newspaper ad. But on the Internet this could be instantaneous. And this is only for informing the customer.

Internet offers many advantages and new dimensions of commerce simply by promising digital orders and digital shopping malls. These allow people to get up-to-date information that they really want. There is no need to flood the paper mail system with printed catalogs. Both printing costs and postage charges disappear. If a company wants to launch a sale, it can change the current catalog online immediately. Close-out sales,

narrowly targeted marketing and flexible catalogs tailored to past orders become possible instantaneously.

Beyond the real world goods, people are also willing to pay for information. The Internet evolved as a generous place where people freely gave away information, in part because there was no simple way to charge for it. You could ship a megabyte across the globe, but you could not move any cash. With the growth on the internet people no longer want to do more. Now the Internet is not dominated by academic people sharing their research. Instead we have newspapers that digest daily events, process raw data and present you in a clean, accurate way. And these companies need to charge for the information they present in order to continue. What is needed is a convenient, electronic way to pay for these services just like we pay for the ordinary newspaper.

Internet promises a huge potential of transaction growth due to its electronic nature. In the normal world each transaction has a cost. And these costs are not small. You have to pay a cost for transferring money from an account to another. Or in some cases as in credit cards the vendors pay for the costs to cover the expenses of banking system. Therefore in today's world, even the electronic systems are in place small transactions are not feasible as their cost is higher than the transaction value. But Internet is a different case no one is operating the Internet or more accurately everyone is paying on the Internet. So very small transactions could be realized on the Internet leading to growth in the number of transactions. Today many practices are not feasible due to real world constraints, transaction costs. But on the Internet it could be possible to pay for each section of a newspaper. You need not have to buy it as a whole. You could buy the first page stories, and the columns that you are interested in. And pay just for these. You need not have to pay for the horoscope section if you do not want to. What is required for such a possibility is an easy, convenient way of paying electronically across the net. There has been numerous work in the arena of digital cash that can serve as the basis for such a progress.

What we are trying to prove in this paper is Internet is more than a medium. It's a marketplace and the following sections will examine what's needed for a reliable marketplace and what Internet is offering in these areas.

With the rapid expansion of the Internet, there are a number of initiatives underway for the creation of a secure cost-effective payment system which will be able to support growing commercial activities on the network. Although electronic payment systems for large payments have been in operation for some time, rapidly expanding volumes of foreign exchange and securities trading are increasingly at variance with the requirements for a cost-effective and efficient electronic payment system for making low value payments. Current progress in establishing such payment systems on the Internet is examined. It can be argued that the ultimate vision could be for a truly global and virtual marketplace requiring completely new institutional and legal structures and having a similarly profound impact on economic life to the medieval trade fairs which emerged in Europe in the 12th century.

Electronically-based payment systems have been in operation since the 1960s and have been expanding rapidly as well as growing in complexity. However, in most of the major industrialized countries, an inverse relationship exists between the volume and the number of transactions handled electronically. Typically, of business payments

around 85-90% or more of monetary value will be processed electronically, while less than 5-10% of the total number of payment transactions will be handled in this way. This has been due to four related factors:

- (1) proprietary closed networks were developed by banks to handle large and increasingly internationally based payments systems;
- (2) large value payments are increasingly associated with foreign exchange and global securities transactions, thereby becoming divorced from underlying world trade
- (3) large value payment systems were not designed nor are they cost-effective for small value payments; and
- (4), paper-based non-automated payment systems remain an established part of accepted business practice for varying institutional reasons, thereby remaining ingrained in the economic system.

Creation of an Internet electronic payment system will provide opportunities for the creation of completely new sets of global and national trading relationships. The Internet offers the possibility of an 'open systems' payment and settlement system which operates in parallel to existing, more traditional bank-based networks, and which is particularly suited to meet the currently unsatisfied requirements for processing low value payments electronically. However, the institutional framework to exploit these opportunities does not yet exist. Regulatory and policy issues will need to be addressed in order that full advantage can be taken of the new types of commerce which could emerge.

### **3.1. Market:**

In order to call somewhere a commercial place. The basic point is you should have potential buyers with needs, that is demand, and you should have others willing to fulfill these needs, that is supply.

Internet basically supplies these two requirements. There are approximately 60 million users that are everyday consumers. They have diverse needs from clothing to electronic equipment, from daily news to food.

One could argue that this is also true for newspapers, TV channels. There are more millions of people watching TV, reading newspapers that have needs. And the companies are running advertisements that promise to fulfill their needs. But the main difference between Internet is; It is not an advertisement that customer is facing. The customer is directly talking to you (in an electronically way of course) and you can say (i.e. present with a web page ) whatever you want. The customer is not (or does not have to be) examining a static ad, a printed brochure. You could supply him with the most current information (i.e. price, specifications). And this point is the main area where Internet is making its differentiation from a medium. Establishing Internet presence is not making an advertisement. It is opening a branch of your office in another place, on the Internet or using the much hyped term, in the "Cyberspace". Running advertisements on the Internet is totally a different concept which is not in the

scope of this paper. But we will briefly cover the advertisement concept to make the differentiation of Internet from the medium.

In the real world companies run advertisements on TV channels, radio stations, newspapers, or printed press to be more general. And the general point of these advertisements is getting people to be aware of what a company is offering. And the reason of using the above mentioned means is: these are companies with a wide range audience due to the products they are offering, a TV channel, a radio or a newspaper offers entertainment, news, education which has a very wide audience and reaches many people, so companies use these products to inform you of other products. Here the main concern for the advertising medium is their ability to reach many potential customers. Use of other products as an advertising medium is not uncommon in the real world. For example many online services distribute their brochures in computer boxes or fast food companies distribute discount offers via nearby institutions that have attraction such as museums, cinemas.

Advertising on the Internet is no different than the real-world counter part. You want people to be aware of you and consider a purchase. So what you can do is no different than the real world. You make an agreement with an company on the Internet that has wide reach or with a company that offers a product which is complimentary to your product or vice versa. And you present information to people via the other company.

Once you replace the classical voice communication with digital communication (which could and possibly will include voice) there is no difference between a shopkeeper talking to a customer that has entered his shop and an internet user visiting a web site except the physical distance as Internet covers the globe.

Using the current technology it is possible to realize an Internet presence that mimics the relations between a company and a consumer calling the company. The consumer does not have to read pages instead he could be talking to a company representative over the Internet. And with the increasing speed of communication on the Internet the communication mean could be video conferencing. Which is a situation that is unrealizable with TV, radio or printed press. So the Internet is not just a medium that you can run ads. It's an alternative marketplace where the supply and demand are face to face.

## **Size**

Remote networking of PCs is a growing phenomenon. However, it is only recently that PC hardware and software companies have showed interest in broad appeal on-line business, estimated to currently generate revenues of around US dollars 500 million, compared to the US dollars 200 billion which is generated world-wide by the PC business. Since 1990, there has been a rapid rise in the number of subscribers to commercial on-line services with the figure more than doubling every 12 months. This is in addition to the rapidly growing Internet community which at current estimates exceeds more than 60 million users world-wide. The recent developments in the services offered by on-line services, namely their transition to Internet based systems offering direct Internet access, will only accelerate the already rapidly growing Internet user population.

The Internet is acknowledged as the ultimate global system of computer networks. Based on figures provided by NSFnet, as of November, 1996, the Internet linked more than 6 million computers and over 60 million users in 132 countries. In the past 12 months, new users have been hooking up at the rate of one every 1.6 seconds.

The Internet has already advanced a long way since the late 1960s when it started life as a US government-funded program to electronically link researchers at US universities and government laboratories. Commercial activities were formally excluded until only two years ago. Companies such as IBM, Digital Equipment and Apple have become major users of the Internet. Digital alone is estimated to exchange more than 1.7 million e-mail messages per month with contacts outside the company. While commercial activities to date have been limited and companies have been reluctant to trust sensitive business data, purchase orders or credit information to an unregulated network, commercially-based activity is on the increase. For example, a group of Silicon Valley companies and organizations has joined forces in an attempt to pioneer the use of the Internet as a new medium for trade among high technology companies by creating an electronic marketplace called CommerceNet. Marty Tenenbaum, chief executive of Enterprise Integration Technologies (EIT), a research firm leading the development of CommerceNet together with Stanford University, anticipates that the Internet could have a major impact on both regional and foreign trade. Tenenbaum believes that in two to three years there will be as many as 100,000 companies using the Internet as a principal sales and service channel. CommerceNet itself is projected to be handling business transactions for as many as 3,000 companies by the turn of the century [FT94d]

Commerce on the Internet is already a reality. The communication facilities which are on offer are rapidly become integrated as core business tools [Cro94]. There are currently more than 25,000 companies which are using the Internet to conduct business. The volume of US electronic "home shopping" retail business already reached US dollars 2.6 billion in 1993, although this included all online services and interactive television [BIS94]. Business transactions carried out over the Internet are presently estimated to reach US dollars 500 million in 1995 rising to between US dollars 2-5 billion in the year 2000. The emphasis to date has been on use of the Internet for communications with customers and other companies operating on collaborative ventures. However, an increasing number are concentrating on transactions between businesses and on-line sales. The Internet Mall lists some 240 companies offering everything from books to flowers to travel. [BT95]

To date commerce on the Internet has suffered from the fact that there are no readily available means for payment. Payment to date has generally been made by credit card but concerns about the security of e-mail has meant that this information is often sent by fax or conveyed over the telephone. CommerceNet and others are working on secure 'web browsers.' Lee Stein, the founder of First Virtual Holdings, one of a group of new entrepreneurs developing electronic payment systems for the Internet, has observed "Unless the Internet embraces commerce, it runs the risk of going the way of CB radio. If people aren't making money, they won't add value and this won't work". [TE94b]

Banks and the Internet

To date commercial banks have shown only limited interest in the Internet. Given their focus on private, proprietary networks, it is not surprising that banks view with some misgiving a computer network which has been established to facilitate the free exchange of non-sensitive and non-financial information. Some argue that it is the very openness of the Internet which makes it unsuitable for handling transfers of information relating to money or value. The general view taken is that customers will not require Internet-based payment systems for some time to come and that existing payment methods will therefore remain dominant. There are parallel concerns about preserving the integrity of existing investments in payment infrastructure and not to be seen to be promoting less controllable alternatives. Bankers also argue that since the Internet is not owned by anybody and users are spread all over the world, security would be almost impossible to implement because of the different legal, tax and regulatory regimes which would apply.

Nevertheless, commentators within the financial services industry recognize that changes are taking place. On March 25th, 1994, Unipalm, a small British software firm, became the first company to make the prospectus for its forthcoming flotation available to subscribers of Internet. This may be indicative of a future which will see increasing volumes of investor-relevant information made available to end users which was previously restricted to financial intermediaries. Charles Sanford, the Chairman of Banker Trust, anticipates that by 2020, individuals will be in a position to buy and manipulate staggering amounts of information before they make decisions about their investments. The role of intermediary will increasingly be taken by electronic bulletin boards which will match buyers with sellers, borrowers with lenders. Payment and settlement systems will permit transactions to be instantly verified and settled through a global payments system. [TE94]

The most important driving force behind the electronic commerce is the transaction cost. The costs for realizing transactions via different means is as follows.

Branch	\$1
CallCenter	\$0.5
PC	\$0.25
Internet	\$0.15

Figure 3.1. Transaction costs

Another measure of future developments is the level of spending on computer & telecommunications hardware and software. After some years of reduction, investments are again growing. According to the consultants Ernst & Young, financial institutions in the United States are estimated to have spent US dollars 16.35 billion in 1994, with projections that this figure will increase to US dollars 19.8 billion in 1997. [FT94c] Other indicators also point to change. According to a survey by the Electronic Messaging Association (EMA), a trade group based in Arlington, Virginia, commerce in the US is becoming increasingly networked. The number of e-mail sites at head offices and branches of North America's 2,000 biggest companies exploded from 94,000 in 1991 to 180,000 in 1994. The number of users is rising by 17-19 per cent a year. A growing number of companies are extending their e-mail systems to customers and suppliers.

## 3.2. Transaction

One of the vital pieces of commerce is the ability to realize transactions. That's a vendor should be receiving something in exchange of services or products supplied to the customer.

The regular world supports many different forms of payment. There's cash, the bank check, the cashier's check, the traveler's check, the credit card, and the bank wire. All of these are denominated in a government's currency. There are also gold coins, gems, and other valuable items than often act as money in more circumspect situations. In other transactions Treasury bonds, or company bonds serve as cash that is backed by the government or company. The list can be expanded as one relaxes the definition of the payment.

Most of these forms of payment are already computerized. Pieces of paper are still used in many transactions, but computers back up most of the details and keep everything straight. So a natural approach could be as everything is in digital form, isn't it only a matter of a software that can act as a gateway between the systems? The answer to such a question would be: Yes, all of the established methods will be carried on the net but the problem will not be solved by writing a piece of software that will allow anyone with a modem or Internet connection to charge credit cards. Fraud is already a big problem with credit cards and removing physical signatures and phone calls will only add more problems.

The answer to such problems lies in the area of cryptology. People can use digital signatures instead of physical ones, they can use electronic anonymous cash instead of the banknotes and coins.

These alternatives face a number of challenges these are:

- Counterfeiting: The biggest problem with a digital cash system is the ease of copying digital information. Any digital banknote can be copied ad infinitum. Digital signatures can be used as a method of guaranteeing responsibility but as these are also digital they can be easily copied.
- Security level: Credit cards today are not very secure. You can charge a credit card if you know the number so the fraud on credit cards is immense. But apparently, this was a decision taken on purpose by making the transactions very easy the wide spread use has been encouraged. The wide spread use covers the costs of fraud. And this is a critical decision in every digital cash system. You can make a system more and more secure by adding more and more mathematical algorithms. And these require faster and faster computers both on the central computers and the client computers. And higher level of security generally requires more data to be transferred adding to online and storage costs.
- Flexibility: Any digital cash system must take the possibility of failure into account. Computer systems can fail, telecommunications can be down. People would like to trade in the middle of nowhere. A digital cash system should let people trade anywhere. And here is another trade off the simplest digital cash system would require a central computer and force all the transactions through it. But if this central system is

unreachable or down no transaction can take place. More flexible systems require more mathematics and they might not be as secure.

- Integration with the past: One can design a brand new digital cash system but normally it would be of no use if the current transaction systems are not integrated.

One can think of many problems that will arise in a digital cash situation. But what is important is there is not a single correct answer to these questions. And the best answers to tradeoffs might not come from logic. The market acceptance is a highly critical factor and a totally secure digital cash system might fail if people do not use it.

### **3.3. Payment Systems**

#### *National systems of exchange*

The development of money has been inextricably associated with the growth of trade and commerce. In Europe in the 1100s, rudimentary banking and foreign exchange institutions emerged as a direct product of the medieval trade fairs. Monetary exchange and banking systems then developed rapidly as foreign and domestic trade expanded exponentially following the onset of the industrial revolution. Although commodity-based money dates back to antiquity, money in its present primarily token form (i.e., money that does not exist in any physical form but takes the form of financial claims on banks and other financial institutions) has only assumed predominance during the past 100 years. [Cho94]

Money and monetary systems have also been strongly linked to the role of the state. In the medieval period, money largely meant gold or silver coins whose weight and fitness were guaranteed by the ruler under whose authority they were issued. For a long period of history, official mints were established which would convert bullion into an equivalent weight of coins, minus a fee. In the 20th century, issuance of currency has been jealously guarded by the nation state and economic policy increasingly has been exercised indirectly through the monetary system using interest rates. However, over the past 40 years, growth in international trade, which has exceeded the expansion of GDP at the national level, has resulted in a global economy which increasingly has no place for economic and monetary policies which are pursued purely at the national level. Similarly, while the Bretton Woods monetary system established after 1945 reserved special status for the US Dollar, the number of currencies having 'global' status has expanded in number, thereby removing the linkage to their respective political masters.

#### *International systems of exchange*

International trade has grown significantly in the post-war period and with it the associated monetary flows. More recently, deregulation and globalization have led to a spectacular growth in the value of non-trade-related financial transactions. Every transaction whether trade- or non-trade-related gives rise to obligations that need to be settled through a transfer of money between the parties involved. Settlement of non-trade-related and large value trade transactions is increasingly based on the electronic large value payment systems which have been developed since the 1960s. Together this has led to a major expansion in payment and settlement systems. These now handle

payment volumes on a daily basis which collectively dwarf economic output in the main industrial countries.

The increasing emphasis on non-trade-related settlement has created an agenda of concerns which are increasingly divorced from the issues faced by businesses and individuals seeking to make lower value transfers. The huge values created by the foreign exchange and securities businesses operating on a global scale create separate agendas as concerns to mitigate the ever-increasing risks associated with settlement grows. Discussions revolve around reducing systemic failure of the settlement system by either 'netting' and/or real time gross settlement (RTGS). However, these issues remain remote for the millions of individual businesses operating at national and increasingly international levels who remain locked into inefficient and time-consuming paper-based payment and settlement systems, particularly when trading is across national borders and involves different banking systems.

#### *Banking and Securities markets*

Non-trade related international and domestic financial transactions have grown substantially both in absolute terms and relative to the growth in trade. For example, the world foreign exchange market alone is estimated to be worth more than 1 trillion dollars per day in 1995 compared to total world trade in goods and services of only \$4 trillion. In other words, four days of foreign exchange trading equates to the total requirement for trade-related foreign currency purchases over a 12-month period. [Rob90] Elaborate settlement systems are being developed to contain the burgeoning risks which are involved. The overall rate of increase has been substantial in the past 15 years. In Japan, for example, the annual value of transfers of funds jumped from 20 times national output in 1980 to 120 times in 1990. [FT94n]

The past 25 years has seen a progressive globalization of world securities markets. While the speculative flow of funds into the world's emerging equity markets has declined from their peak in 1994, commentators identify them as a key source of future growth in the late 1990s. Standard Chartered Bank estimates that the size of emerging markets in terms of market capitalization is set to double to 4 trillion US dollars within the next five years, whereas others estimate that if present growth rates continue, these new markets could account for around half the world's equity market capitalization by 2015 [FT94m]. McKinsey & Company suggest that world capital markets are being integrated more rapidly than was generally expected. The acceleration of this trend has led to a consequent expansion of the international payment system and a consequent boom in financial assets. McKinsey estimates that the value of world financial assets will rise from Dollars 35 trillion in 1992 to Dollars 83 trillion (Dollars 53 trillion in 1992 prices) by the year 2000. [FT94n]

Attempts to establish universal international payment systems which can be used cost-effectively for the full range of transactions have to date been unsuccessful. A failure to agree on common standards has meant that a major proportion of the instructions which are sent by banks follow a free messaging format. When messages are on free format (unrecognized universally) recipients have to interpret and to rekey them, involving higher levels of cost, more time and making the systems much more prone to the introduction of errors. At the same time there is a countervailing pressure to settle transactions, particularly those relating to securities, more quickly.

The large investment institutions, be they United Kingdom investment trusts, US pension funds or Japanese life insurance companies, are pushing for more rapid settlement periods. Global settlement is increasingly moving towards three-day settlement. Citicorp estimates that by the year 2000, 50-60 per cent of trades will be settled on the day of trade, and the rest within three days. The ISITC (Industry Standardization for Institutional Trade Communication), which is an independent forum of representatives in the US and Europe, is working with the principal electronic payment system providers to extend the use of payment messaging formats which can be used across a range of networks throughout the banking and securities industry. However, there are fears that attempts to create a universal messaging system are being delayed by the lack of a perceived need for consensus [FT94I]. The major global securities clearers are Euroclear and Cedel.

### *Payment & Settlement Systems*

A mixture of different payment systems has evolved to service the growing requirements of both trade- and non-trade-related commerce. In the majority of cases, these systems operate as closed proprietary networks, creating incompatibilities between different systems. There is a particularly sharp division between the payment and settlements systems which are used for large value transfers and those which are available to settle smaller payments, particularly on a cross-border basis. This has led to an inverse relationship between the volume and the number of transactions. It has also further accentuated the division between large multi-national corporations and smaller enterprises wishing to utilize electronic systems for making payments. For example, a large proportion of current global trade is controlled by large multinational companies who are largely trading within their own network of subsidiary companies. These large corporations seek to minimize the costs of transfers within their operations while preserving the legal integrity and tax status of the companies concerned. Smaller companies which do not have access to these networks are forced to rely on a paper-based system of documentary credits. These are generally very time-consuming as well as costly to buyer and seller alike.

This section discusses the various payment systems which are in use and the types of payment transaction for which they are used. As already identified, the issues which concern the operators of the large value payment systems are often different from those which are the focus of smaller traders. Banks which operate the former are increasingly concerned with the systemic risks which are associated with the huge monetary values which are involved. There is a move to more elaborate real time settlement systems which would be inappropriate for the much smaller denominations involved in trading on a cross-border basis by small and medium-sized enterprises (SMEs). Similarly, the degree of direct central bank supervision required for the large value payment systems is much greater and will be at variance with the objective of minimizing cost by achieving automation for low value payments. Companies involved in making trade-related transfers are likely to require less direct supervision in order to achieve the lowest transaction costs and timeliness of transfer. This would suggest that there will be an increasing divergence between large value payment and settlement systems used for a relatively small number of individual transactions. Large value payment systems will focus on the global foreign exchange and financial securities markets that are growing rapidly in size and complexity. These networks can be expected to remain proprietary and closed with close supervision exercised by central monetary authorities. Trade and

commerce-related settlement systems, on the other hand, will need to move to a more open systems environment, minimizing transaction costs and opening up the opportunities which follow when smaller scale transactions can be settled on a cost-effective basis.

According to UNCTAD (the UN Conference on Trade and Development), the costs of paperwork and other complex formalities associated with cross-border trade flows can amount to about 10 per cent of the final value of goods. A typical trade transaction may involve several different parties and different documents, all of which have to be checked, transmitted, re-entered into various information systems, processed and filed. UNCTAD believes that this represents a major impediment to the growth of world trade, particularly for the industrialized countries. UNCTAD believes that unnecessary transaction costs amount to more than US dollars 400 billion a year, which could be reduced by 25 per cent or more by streamlining procedures and extending the use of paperless trading [FT94k]. Providing automated low value payment settlement is likely to be at the center of such changes, although to be effective, other major regulatory and institutional changes will have to follow in due course.

#### *Large National Payment Systems*

Electronic payment systems are not new and have been around in some form for several decades. The volumes passing through wholesale systems are huge and it is useful to provide some indications of the scale of monetary flows which are involved. America's Fedwire and CHIPS handle the equivalent of the GDP of the United States every 2.5 days. The UK's Clearing House Automated Payments System (CHAPS) handles a daily 90 billion worth of payments (equivalent to a quarter of the UK's national GDP) but this is accounted for by on average less than 40,000 individual payments each day. Similarly, according to the Bank for International Settlements (BIS), it takes less than three business days for Japan's interbank funds transfer systems to generate turnover equivalent to the country's annual economic output and around four days in Germany. However, both the volume and scale of these financial flows are increasingly removed from the day-to-day reality of making payments within and across borders for goods and services. Over 45% of the payments represent foreign exchange transactions. These payments are settled on a daily basis with the typical payment amount presently at US dollars 3 million.

Difficulties which have been identified with the present system include the fact that banks run up large and unmonitored overdrafts during the day, exposing members of the system to the risk that one might fail before payments had been completed with a dependence on 'unwinding' payments as the remedy for failure. The collapse of Herstatt Bank in Germany in 1974 revealed the knock-on effects which can result from such unwinding. In the United Kingdom, the Bank of England is proposing real-time gross settlement (RTGS) as the solution with payments made in full throughout the day rather than netted against each other at the end of the day.(7) A major bank failure in the UK would cause currency markets to halt, because 45 per cent of the money passing through CHAPS is the sterling half of foreign exchange contracts. [FT94j]

International large value payments are increasingly intertwined. In Switzerland the proportion of large value payments which are one end of a foreign exchange transaction is already 90%. Expectations are that as finance becomes even more global in scope,

then similar proportions will exist in some of the other major financial centers. This creates a push for real time settlement, ultimately on a global scale linking all the national large payment systems together [TE93].

### *Correspondent Banking*

In contrast to the inter-bank settlement systems which have been developed for large value payments, other cross-border transactions are based on an older payment architecture. This system of making payments has evolved from various networks of correspondent banks that date back in their original form to the 12th century. Correspondent banking networks were first established to service trade flows in medieval Europe and some of the present terminology such as *nostro* and *vostro* accounts predate this period.

Correspondent banking operates on the principle that a bank initiating a payment should be able to select its routing. A payment from an importer to an exporter will be routed through the importer's local bank who will then select its foreign banking correspondent. This bank in turn will contact the bank of the exporter or, in certain cases a further local intermediary payment bank. The system was originally devised to eliminate the need for medieval merchants to settle transactions in gold currency, given the risks involved in transporting valuables through hostile territories. Correspondent banking arrangements have survived and until the 1980s, correspondent banking was an important source of profit for the small number of banks in each country which have historically handled the majority of cross-border transactions. However, in an age of electronic messaging correspondent banking is rapidly becoming a costly anachronism which simply adds to the costs of each payment transfer and is one of the principal obstacles to implementing effective low value cross-border electronic payment networks. International payment systems like SWIFT remain based on the principles of correspondent banking relationships. The correspondent banking system remains widely in use throughout the world. It is also used where banking systems are fragmented, for example the United States, where it is used to facilitate payments between local regional banks by using large money center or payment banks. The correspondent banking system, although now ingrained after centuries of established practice, has become increasingly outdated. Its principal disadvantage lies in the requirement to involve three and sometimes even more parties to carry out the transfer of a single payment.

The inability to establish cost effective cross-border payment systems has become a major political issue in the European Commission (EC) given the aspirations for the creation of a 'single market'. It is estimated that every year individuals and small businesses make more than 200 million cross-border payments within the European Community. A recent study commissioned by the EC has revealed that costs and service levels are very poor. The study was based on a sample of 176 transfers (some by banker's draft and some by telegraphic transfer), each equivalent to 130 ECUs (Dollars 162), made through 22 banks in the EC. The study found that banks required time-consuming bureaucratic paperwork, frequently over-charged payment transfers and took as long as 3 weeks to effect payment. Charges in a number of cases were equivalent to 20% of the value of the ECU 130 payment. Telegraphic transfers frequently proved no faster than bankers' drafts sent by post. The EC is presently preparing recommendations for legislation which would force community banks to reduce costs and improve service

levels [TE92a]. The Maastricht Treaty signed by the EC partners in November, 1993 makes a commitment in principle to moving towards European monetary union. The movement to monetary union will involve large-scale technical changes as funding arrangements and payment systems are overhauled, and the introduction of new bilateral or multilateral payment arrangements in place of the current arcane cross-border payment arrangements. [FT94i]

### Payment Messaging Systems

As the demands for international settlement of currency and securities transactions have increased, electronic payment systems for large payments have developed. SWIFT, which stands for the Society for Worldwide Interbank Financial Telecommunication, currently dominates the field of interbank messaging but is increasingly facing competition from other networks. SWIFT was set up in 1973 and is based in Brussels. It is owned by its members, a consortium of 2,200+ banks. SWIFT provides electronic payment services to around 4,300 financial institutions world-wide and presently processes around 500 million payment messages a year. Shares in SWIFT are based on the volume of message traffic. At present message traffic is dominated by just 35 banks which account for over 50% of the payment messages [FT94h]. SWIFT has been criticized for relying on hub and spoke communications technology which was originally conceived in the 1970s. Although the SWIFT system enjoys world-wide acceptance it is dependent on the same heritage of correspondent banks which form the basis for all low value cross-border transfers.

SWIFT has more recently has been examining other opportunities to provide 'value-added' services including messaging associated with the global securities markets. SWIFT estimates that as a result of the growth in global investment there will be 1 billion securities messages exchanged annually by 1997. There is increasing pressure to use messaging as a result of falling settlement times. These have meant that it is increasingly difficult to trade confirmations in paper form. It is generally accepted that a point will soon be reached where more traditional means of settlement using telex and facsimile will no longer be able to cope [FT94g]. SWIFT is therefore focusing its attention on the requirements for global settlement of large value payments. Its existing proprietary network and charging structure is simply not cost effective when making lower value payments. For example, although the large UK commercial banks are SWIFT's major customers and are capable of effecting SWIFT payments to virtually anywhere in the world, the service is priced at around US 30 dollars per individual payment. Smaller value transactions are generally processed by telegraphic transfer or by mail (bankers order).

In recent years, other competing cross-border electronic payment systems have been established. The Royal Bank of Scotland joined forces with a number of European banks to launch the Interbank Online System (IBOS) in 1991. IBOS attempts to break with the correspondent banking architecture still predominant in international payment transfers. It aims instead to create a virtual banking association, which links the customer networks of the participating banks without reference to existing financial infrastructures. Significantly, IBOS used expertise from British Telecom, Digital Equipment and more recently the US computer services giant Electronic Data Systems (EDS) to establish the system [FT95]. Other payment networks which are being established include the Financial Network Association (FNA) and the UK-based

company Scitor, set up in 1991 by Sita, the airline reservation system co-operative. Although SWIFT has broadened its user base, it has not offered its services directly to major non-bank corporations in order to retain the exclusivity of the payment system for its shareholders. Both IBOS and FNA are attempts to utilize more up-to-date technological solutions for implementing electronic payments. In both cases, significant technical support is being provided by companies with established expertise in information and communication technologies (ICT).

### Checks and Bank Transfers

Despite the development of electronic payment systems, business-to-business payments are still predominantly made using non-electronic funds transfer (checks or telegraphic transfer). In the US, despite the development of an array of automated systems, most businesses continue to bill their customers with paper invoices and to make payments to suppliers using paper checks. The Federal Reserve estimates that in 1993, only 3.8% of business-to-business payments by transaction volume were made electronically using either Clearing House Interbank Payments System (CHIPS), Fedwire or Automated Clearing House (ACH) transfers. Although US businesses issued approximately 59.4 trillion cheques in 1993, in aggregate these only represented 12.5% of the total value of payment transactions which amounted to US dollars 547.5 trillion [KWY94].

The same inverse relationship between payment volume (in terms of transaction volume) and aggregate payment value is mirrored in all the other industrialized countries where the percentage of business-to-business payments made electronically is frequently even lower than the 12.5% in the US. Paper-based payment systems are an increasingly costly anachronism in an age which permits cost effective global electronic communications systems. Nevertheless, important institutional barriers stand in the way of reforming existing payment systems. For example, many European countries including the United Kingdom still do not permit cheque truncation (removing the need for cheques to be physically returned to the bank branch on which they were drawn). Individual businesses have also been reluctant to move to electronic methods, preferring instead to focus on automating internal administrative processes and in some cases capitalizing on the float benefits which accrue as a result of payments in transit. In the UK it is possible to send payments electronically using CHAPS. However, the cost will be similar to making payments using SWIFT and will be priced at around US dollars 30 for each transaction and first requiring the customer to provide original written payment instructions.

### Credit Card Payment Systems

Credit cards in their present form emerged in the United States in 1960s. However, it was not until more recently that credit card usage has expanded significantly outside North America and until the late 1970s the level of penetration in most of Europe was quite limited. Debit cards have been introduced more recently and together they represent the most rapidly growing method of payments in the United Kingdom as well as several other OECD countries.

Credit and debit cards are rapidly growing in significance as the preferred method of settling small value payments associated with the purchase of specific goods and services. Separate electronic clearing and settlement systems have been established by

the major credit card companies. Both MasterCard and Visa have established their own networks which are used for verifying transactions world-wide. Electronic point of sale terminals permit card details to be verified in less than 15 seconds with networks linking the merchant, the credit card processor and the card issuer world-wide. For example, Visa's system, VisaNet, operates out of three super-computer centers, one in the UK at Basingstoke and two in the USA, including San Mateo in California. Extensive communications networks link the centers and merchants using the system. These networks are growing rapidly as the trend for consumers to make payments by credit card in place of writing a cheque continues to grow.

The number of credit cards in use is growing rapidly world-wide. In Europe, credit card ownership stood at around 200 million at the end of 1990. The figure will have increased to 350 million by the end of 1995, according to Battelle, a London-based consultancy. In addition, credit card-holders will use their cards more frequently in place of more traditional payment means such as cash and cheques. Battelle predicts that the number of payment card transactions will rise to 8 billion by the end of 1995, representing a 300% increase over 1990. The number of Visa cards in Italy doubled in 1990; in Spain and France it rose by half. Eurocheque and Eurocard (Visa's smaller rival, which is also owned by banks) are launching a joint electronic debit card to compete with Visa's growing debit business in Europe [TE91] Despite increasing volumes, the credit card business has become increasingly competitive with fees being driven down by new, often non-bank entrants.

The growth in credit card usage confirms the basic demand which exists for more efficient electronically based payment systems. However, there are certain constraints which are likely to prevent credit cards from becoming the comprehensive solution to a global electronic system for making low value payments. Credit cards developed from oil company, restaurant and department store charging accounts which predated the present electronic systems by several decades. In the 1960s and 1970s their use expanded as consumer finance was made more readily available and became an important source of revenues for banks. [Lin94]

Credit cards are distinguished from debit cards by having access to a line of credit made available to the card holder by the card issuer. They generally require four separate parties to each transaction, the card holder, the merchant selling the goods or services, the merchant acquirer processing the credit card payment and the card issuer. In certain cases the merchant acquirer and credit card issuer will be the same company although generally trading under a different legal entity.

Credit card payment systems have proved to be highly vulnerable to fraud. Credit cards can be stolen from their owners and then misused, and merchants accepting credit card payments can fraudulently fail to deliver goods (e.g., when placing orders over the telephone). In either case, credit card issuers or merchant acquirers effectively stand the loss. Losses from credit card fraud by merchants have been significant. As a result merchant acquirers are highly selective in which merchants they are prepared to authorize to receive credit card payments. Similarly, issuance of credit cards has become much more controlled to curtail misuse and fraud by card holders.

Despite these limitations, credit card companies like Visa and MasterCard are currently most active in developing secure payment systems using the Internet. Secure methods of

transferring credit details and ensuring effective authorization will be represent a major improvement over the off-line systems presently in use for making sales of consumer goods and services by phone or by fax. However, credit and also debit cards were designed at a time when the emphasis in the financial services industry was on transaction-based automation. Credit cards may represent too cumbersome and restrictive a system for achieving the possibilities presented by truly global low value electronic payment systems.

#### Cash and Automatic Teller Machines (ATMs)

Despite the development of electronic payment systems, modern industrial economies still function to a large extent on cash payments. In the United Kingdom, around 85% of payments by volume are still made in this way [APACS94]. Although cash payments represent the direct converse of electronic forms of payment, cash delivery is itself increasingly based on the huge base of Automatic Teller Machines (ATMs) which are being increasingly networked together to permit customers to collect cash from different banks as well as in other countries. ATM and credit card networks are linked in that VISA and MasterCard holders have long enjoyed the facility to draw cash from ATMs. This means that 530 million Visa cardholders, for example, have access to around 232,000 ATM locations in 87 different countries. Although originally established by large commercial banks, ATM networks are increasingly being developed by non-banking organizations. In the US, the company currently installing the most ATMs is Electronic Data Systems (EDS), a computer/data processing services company.

A number of companies, including NatWest in the UK, are developing smart card technologies, which may ultimately bridge the gap between ATM networks for delivering cash and the requirement to make electronic payments. NatWest are leading a consortium to develop smart card technology to develop an 'electronic purse' which with suitable equipment could also be used to transact payments on the Internet.

#### Development of Payment systems

One of the first ideas of realizing transactions on the Internet was utilizing the conventional tried and true methods which are external to the Internet. The companies offer their services or goods only after the customer has transferred the required amount to the suppliers bank account or has paid in another way just as he used to do in normal life without using any of the services that the Internet offers. Bank transfers, cash payments, faxing of credit card details etc. The main uses of that kind of transactions were subscriber based services. Companies who used sell subscriptions for information or databases could easily use this way when they begin offering their services via Internet as this would require no change on their or clients' side of transaction, payment processing. Only change would be offering access via a new channel instead of i.e. direct modem, BBS, Fax access. These payments are expensive and take a long time to process, especially when the payment is made from one country to another. Perhaps this is sufficient for long lasting relationships, or frequent users of a certain database. But the one-time user who wants small amounts of data from many sources or a fast answer to a question is not well served by this payment mechanism. And this method is out of scope with the aims of this paper.

Markets of any sort involve transactions, right through to the point when the seller has been paid by the buyer. Until that point, the whole transaction remains uncertain. The more primitive the system, then the longer the delay is between undertaking to pay and actual payment, and the greater is the uncertainty. The Internet offers the prospect of a highly cost effective payment system for low value transactions. The technologies involved are able offer nearly to instantaneous settlement of transactions. However, the fundamental difficulty with establishing electronic payment systems on the Internet is that system was specifically designed to facilitate the free exchange of information. In order to achieve such an objective, security issues will need to be successfully addressed without losing all of the benefits which accrue from its open systems structure.

At present Internet customers have a limited set of options for making payments. The simplest option is to provide details of a credit card number and transmit this information to the merchant vendor usually using an alternative to electronic mail, either the telephone or fax. A number of enterprises currently trading on the Internet have opted for this payment method. However, this method has a number of limitations. It requires the buyer to incur the additional expense and inconvenience of conveying credit card details and requires that the seller is accredited by a merchant acquirer/credit card processor. It is also relatively costly since credit card merchant acquirers generally charge premiums for handling telephone-based sales. A simpler method would be to provide credit card details using e-mail. However, given the open structure of the Internet with messages routed through the network, there is a general unwillingness to make personal credit card details available in this form, since both buyer and seller are exposed to fraud.

The Internet is now acquiring a more commercial character and therefore there is pressure to develop and market a form of electronic payment system which will be as fast, flexible and global as the Internet itself. In general terms, this is one of several instances where advances in communications technology have already moved ahead of the technology presently incorporated into proprietary payments networks. Innovation appears to be led by non-bank, often start-up software-based companies. As well as small entrepreneurial companies, the major credit card companies, Visa and MasterCard are presently leading the race to establish secure payment systems on the Internet.

There are at present four separate approaches to achieving a secure payments solution. Most involve some form of encryption to protect the confidentiality of the sensitive elements of the message. Firstly, there are efforts to develop new digitized forms of electronic money or e-cash. A second line of approach is for a payment service provider to act as a messaging intermediary, often using other established security clearance procedures. Thirdly, efforts are being concentrated on establishing forms of encryption which will permit credit card information to be sent to Internet-based goods and service providers who will then seek separate credit card authorization using the proprietary networks, including those established by Visa and MasterCard. Finally, there is a fourth approach which involves the use of 'smart cards.' Several schemes are presently at the experimental stage, while others such as First Virtual have already declared themselves as open to do business on the Internet. It is worthwhile noting that nearly all the announcements date back less than 9 months. This paper sets out some of the current schemes but developments are moving increasingly rapidly and there are new announcements taking place almost weekly.

## Credit Cards

In order to avoid classical methods, credit card payments on the Internet became the next possibility. If you want to use a commercial service, you simply send your credit card details to the service provider involved and the credit card organization will handle this payment like any other. However, there are some risks to be considered. First of all, your credit card details are transmitted over the Internet. The customer doesn't know exactly how these details will reach the receiver. His or her message can pass through via multiple systems on its way to its final destination and maybe someone, somewhere along the way, is scanning these messages for credit card details; details which could be used for criminal purposes, making this system unsecure.

The approach to solve the security defects of sending critical information over the Internet is the encryption. The basic idea is client encodes the critical information which can only be decrypted by the receiver intended. Which solves the issue of security. There are different approaches to encryption such as SSL, PGP which will be discussed in section encryption. But even when %100 security has been reached there are certain factors to consider. One could be the cost of a credit card transaction itself. Such cost would prohibit low value payments by adding costs to the transaction amounting to more than the payment itself.

## **4. Security - Encryption Techniques.**

In this paper the term security is used as the reliability of communication between the consumer and the commercial Internet site. Due to the nature of the Internet, or generally the computer networks, a packet that contains data travels through different systems, such as routers, computers. It is possible that some third party other than the target destination can intercept the communication and examine the content of the packet. Doing so one can eavesdrop a communication session, or worse one can alter the contents of a network packet. As we'll be discussing later on, the communication between a consumer and a commercial site can contain critical information such as credit card information, or other forms of electronic payment. Access to such information presents a high security treat for both consumer and the vendor. By learning credit card details, the consumer faces the treat of being charged for purchases he did not realize. The third party can use the credit card information to purchase other items or can directly try to charge the credit card via the Banking system. Even though there are regulations and the transactions that a customer denies are thoroughly examined the situation is not different from having your credit card stolen except that you are not aware that it has been stolen as you are still possessing the card. A better analogy could be exactly replicating a card. Credit card do not have physical existence on the Internet. Anyone with the knowledge of a valid credit card number with associated name and expiry date can use the card as easily as the real owner.

It could be argued that the traffic on the Internet is really heavy and the packets containing sensitive information are not differentiated from the others so the probability of a security is very low. But such an argument does not make sense for a commercial medium. In order to solve the security issues there has been a number of initiatives and many of them are being used on the Internet today.

The answer to the security issues lies in the arena of mathematics. And the basis for establishing the authenticity or security of electronic data is the use of *digital signature*. There are complicated mathematical functions that can simulate every feature of manual signatures. These can only be produced by someone knowing a secret key, and they can be verified by anyone.

Digital signatures are often created from several different algorithms or equations. Commonly used basic algorithms are:

- **Private-Key Encryption** These algorithms scramble data that can only be understood by someone holding a single, private key which is used for both locking and unlocking data.

- **Public-key Encryption** These algorithms scramble data with two different keys. One is used for locking and the other is used for unlocking. These keys are not interchangeable. The one used for locking can not be used for unlocking. This system allows two parties to establish secure communication. Each participant publishes one of their keys (public key) and keeps the other secret (private key). Each end then uses the public key of the recipient to encrypt messages which can only be decrypted with the corresponding private key.

In order to implement a digital signature using this method one can encrypt the signature line with his secret key which can be decrypted using the public key which has been made available. By decrypting the encrypted data using the public key one can assure that it has been signed by the owner of the public key.

The most common form of public-key encryption is RSA marketed by RSA Data Security.

- **Secure Hash Functions** Hash functions take a large file and reduce it to a relatively short number (128 to 512 bits) so that this short number can be used as a surrogate for the long file. These functions have two important features that make them usable in the encryption area. First, all of the possible short numbers are equally likely to emerge from the hash function which guarantees that all possible  $2^n$  n bit numbers get used. Second, it should be impossible to recreate a file that generates any particular number.

These functions are used as surrogates to make sure that no one changes the file. After sending a file to another person two people could compare the hash values and make it sure that no one has changed the file. Files are generally digitally signed by computing the secure hash function of a file and then encrypting it with the secret key. So one could verify the signature by decrypting it using the public key and verifying the hash function of the file. This technique is often used because hash functions are faster to compute than public-key encryption. Some hash function algorithms are MD-5. and SHA (Secure Hash Algorithm).

- **Signature-Only Public-Key Systems** Even though standard public-key algorithms can be used to encrypt information, the governments tend to control the use of

encryption. So there has been studies around public-key systems that can only be used to authenticate a signature.

Using these systems only someone who knows the right secret key can generate a digital signature and anyone can verify the authenticity of this signature. But the system theoretically can not be used to encrypt messages so governments can keep an eye on the content. But practically these systems can be modified to send encrypted messages.

Best known example of such algorithms is U.S. Government standard DSA (Digital Signature Algorithm).

- **Blinded Digital Signatures** These systems introduce the concept of signing, validating or authorizing data without knowing the content. Which is a practice that is not employed in the real world as nobody would sign a blank check. As we'll be discussing later these systems have use in anonymous cash systems.

- **Secret Sharing** In the real world there are examples of that kind of systems where banks have to keys for safe deposit boxes. These systems are used when you want  $n$  different parts or people to be available to open a secret key. The simplest systems split data into  $n$  parts and require all  $n$  parts to be present for decryption. More complex systems might allow decryption when only  $k$  ( $k < n$ ) parts are available.

These systems are used in digital cash systems to prevent double spending. A persons identity is split into two parts and if a person spend a digital bill twice you can reconstruct the identity using two pieces of information.

- **Bit Commitment** These protocols are used to lock up something in a way that can't be denied later, You might want to seal a prediction for the future so that people will be able to verify that you made it in the past. These algorithms are also used in digital cash systems.

- **Zero Knowledge Proofs** In all means of communication each side must prove that they are authentic. We do it by using our ID cards, telling our card numbers, etc. There are some problems when you start using electronic systems. You have to prove that you are authentic without revealing your ID number. These systems are neat solutions to prove that you know something without revealing information.

All of these algorithms is used in some form of digital money. Different systems use different algorithms. Generally the more privacy, anonymity a system offers more algorithms are used.

## 4.1. Private Key Encryption

These are the oldest and best-known forms of encryption that use private keys that are known to both the sender and the receiver. The cryptograms in newspapers are simple examples of encryption systems that use a scrambled alphabet as a key. Each "A" might be converted into a "P", each "B" becomes "M", etc. Modern computerized encryption

systems use long collections of bits as the key and can be used to encrypt any digital data.

The most common private-key algorithm used today is still the DES (Digital Encryption Standard).

The basic structure of DES is now well known. Data is encrypted in 64-bit blocks with a 56 bit long key. The algorithm encrypts the data by repeating a basic scrambling in 16 rounds. In each round, the 64 bits are split into two 32-bit halves called the left and right halves. One half is scrambled by combining it with parts of the key and then passing it through a random function called *s-box*. Then the left half is used to modify the right half. [BS91].

DES gathers its strength as the basic scrambling step is repeated 16 times. The cipher gets most of its strength from the composition of the s-box which was part of the design that was classified. One pass through the s-box is simple to break, but 16 passes remains computationally infeasible.

The steps in DES are [BS91] :

1. First, 64 bits are passed through a function called the initial permutation. The order of the bits are rearranged. The first bit, for instance, is placed in the 58th bit slot. The second bit is placed in the 50th slot, and so forth. Figure 4.1 shows a complete permutation.

58	50	42	34	26	18	10	2	60	52	44	36	28
20	12	4	62	54	46	38	30	22	14	6	64	56
48	40	32	24	16	8	57	49	41	33	25	17	9
1	59	51	43	35	27	19	11	3	61	53	45	37
29	21	13	5	63	55	47	39	31	23	15	7	

Figure. 4.1 The Initial permutation for DES.

The bits with the same level of significance from each byte are lined up next to each other. The eighth bits from each byte are lined up in the first byte.

2. The 16 rounds begin. Let  $L_0$  and  $R_0$  stand for the left and right 32-bit halves formed by splitting up the 64 bits. Let  $L_i$  and  $R_i$  stand for the values of these halves after round  $i$ .

3. The values of  $L_i$  and  $R_i$  depend only on the values of  $L_{i-1}$  and  $R_{i-1}$ .  $L_i$  is set to  $R_{i-1}$ .  $R_i$  is computed as  $L_{i-1} \oplus P(S(K_i \oplus E(R_{i-1})))$ . The function  $P$  is a 32-bit permutation,  $S$  is the s-box that takes 48 bits of input and scrambles it to produce 32 bits, and  $E$  is an expansion function that takes 32 bits and returns 48 bits.  $K_i$  is the key used in the  $i$ th round. The symbol  $\oplus$  represents the exclusive or function. The detailed steps of the process are:

(a) At the beginning of round  $i$ , the right half,  $R_{i-1}$  is passed through the expansion function  $E$ . This converts the 32-bits into a 48-bit set by duplicating some of the bits. Figure 4.2

32	1	2	3	4	5	4	5	6	7	8	9	8	9	10	11
12	13	12	13	14	15	16	17	16	17	18	19	20	21	20	21
22	23	24	25	24	25	26	27	28	29	28	29	30	31	32	1

Figure. 4.2 The Expansion Function used in each of DES's 16 rounds. This converts 32 bits of input to 48 bits of output by duplicating some bits. For instance, bit 32 of the input ends up as both the first bit of the output and the 47th bit. The first bit of the input ends up as the second and the 48th.

(b) The key for round  $i$ ,  $K_i$  is XORed with the result of  $E(R_{i-1})$ . This key contains 48 bits of the 56 bits of key material.

(c) The result is passed through the s-box,  $S$ . In practice, the actual description of DES splits the s-box into eight parts,  $S_1 \dots S_8$ . Each of these s-boxes accepts 6-bits as input and returns 4-bits. All eight of them combined convert the 48 bits of  $K_i \oplus E(R_{i-1})$  into 32-bits. Each block of 4 bits is being scrambled in with two of its immediate neighbors. Figure 4.3 shows the first of the eight s-boxes.

000000	->	1110	000001	->	0100	000010	->	1101	000011	->	0001
000100	->	0010	000101	->	1110	000110	->	1011	000111	->	1000
001000	->	0011	001001	->	1010	001010	->	0110	001011	->	1100
001100	->	0101	001101	->	1001	001110	->	0000	001111	->	0111
010000	->	0000	010001	->	1111	010010	->	0111	010011	->	0100
010100	->	1110	010101	->	0010	010110	->	1101	010111	->	0001
011000	->	1010	011001	->	0110	011010	->	1100	011011	->	1011
011100	->	1001	011101	->	0101	011110	->	0011	011111	->	1000
100000	->	0100	100001	->	0001	100010	->	1110	100011	->	1000
100100	->	1101	100101	->	0110	100110	->	0010	100111	->	1011
101000	->	1111	101001	->	1100	101010	->	1000	101011	->	0111
101100	->	0011	101101	->	1010	101110	->	0101	101111	->	0000
110000	->	1111	110001	->	1100	110010	->	1000	110011	->	0010
110100	->	0100	110101	->	1001	110110	->	0001	110111	->	0111
111000	->	0101	111001	->	1011	111010	->	0011	111011	->	1110
111100	->	1010	111101	->	0000	111110	->	0110	111111	->	1101

Figure 4.3 The Table shows how the first DES s-box converts 6-bit values into 4-bit ones. The Function is nonlinear and difficult to approximate with linear functions.

(d) Some extra scrambling is added with another permutation  $P$  as shown in Figure 4.4

16	7	20	21	29	12	28	17	1	15	23	26	5	18	31	10
2	8	24	14	32	27	3	9	19	13	30	6	22	11	4	25

Figure 4.4. The  $P$  function used in each of the 16 rounds of DES. Bit 1 is moved to bit 16, bit 2 is moved to bit 7, and so forth.

(e) Finally the result of  $P(S(K_i \oplus E(R_{i-1})))$  is XORed  $L_{i-1}$ .

4. After all 16 rounds are completed, an inverse of the initial permutation is created. (Figure 4.1)

And the steps for defining the key scheduling algorithm are as follows.

There are 56 bits of key-material used in DES, but only 48 are used in each round. The steps for producing  $K_1 \dots K_{16}$  are:

1. Initially the key may contain 64 bits. The eighth bit is ignored as it is often zero in ASCII text. The rest of the bits are scrambled with a key transformation as in Figure 4.5. giving the result  $k_0$ .

57	49	41	33	25	17	9	1	58	50	42	34	26	18
10	2	59	51	43	35	27	19	11	3	60	52	44	36
63	55	47	39	31	23	15	7	62	54	46	38	30	22
14	6	61	53	45	37	29	21	13	5	28	20	12	4

Figure 4.5 The key transformation used to convert 64 bits of password into 56 bits of key material by both scrambling the data and ignoring the eighth bit.

2. The 48 key bits for each round are selected using the function  $KS$  in Figure 4.6.

14	17	11	24	1	5	3	28	15	6	21	10	23	19	12	4
26	8	16	7	27	20	13	2	41	52	31	37	47	55	30	40
51	45	33	48	44	49	39	56	34	53	46	42	50	36	29	32

Figure 4.6. The Key selection function. Here the data must be interpreted in a different way than the other functions. Here the 14th bit of input is selected to be the first bit of the output. Bit 17 comes second. Bits like 9, 18, 22, 25, 35, 38, 43, and 54 are left out.

3. Each  $K_i$  will be produced by computing  $KS(k_i)$ . Each  $k_i$  is produced by splitting the 56 bits of  $k_{i-1}$  into two 28 bit halves and rotating each half by  $s_i$  bits, where  $s_i$  is given in Figure 4.7

1 1 2 2 2 2 2 2 1 2 2 2 2 2 2 1

Figure 4.7. The 16 values of  $s_i$  used in the key scheduling algorithm.

The 16 rounds of DES is summarized in Figure 4.8.

$$L_k = R_{k-1} \quad R_k = L_{k-1} + f(R_{k-1}, K_k) \quad k=1,2,\dots,16$$

Figure 4.8. How 16 rounds of DES encrypts the two 32-bit halves of the message  $L_0$  and  $R_0$  are assembled using the initial permutation. At the end, they are disassembled using the inverse of this permutation. The function  $f$  is  $P(S(K_i \ E(R_{i-1})))$ .

Decryption of DES is not different from encryption. The algorithm was designed to allow the same steps to be used in decryption. The only difference is that keys must be used in reverse order.

Many other private-key systems use a structure similar to DES. These include IDEA, Blowfish, Shipjack, Khufu.

DES is rapidly losing its dominance. the 56-bit key is widely considered to be too short and some attacks have succeeded in finding weaknesses. Many people are using triple DES which uses three rounds of DES and three different keys or other variants.

## 4.2. Public-Key Encryption

Public-key encryption systems have two keys. One locks the data and the other unlocks it. The important feature is that the key that locks the data can't be used to unlock it.

Only the other key can do this. This allows the owner of a system to publish one key and keep the other secret. If someone wants to send a message that can't be read by anyone else he uses the public key of the recipient to encrypt the message so only the recipient can open it using his private key. And the owner of a pair of keys can generate digital signatures by using the private key for encryption, hence letting anyone to verify it by using the published private key.

The most popular form of public-key encryption is RSA system developed by Ron Rivest, Adi Shamir, and Len Adleman. There are other public-key systems also but they are not widely used. This is not a good situation as sudden developments in mathematics which leads to easy breaking of RSA might leave current systems without choice.

## RSA

The RSA system relies upon mathematics of modulo arithmetic. Both encryption and decryption are completed by raising numbers to a power modulo, a number that is the product of two large primes. The two primes are kept secret. The system can be broken if the two primes are recovered by factoring which is a process that has been proved to be extremely difficult. [RSA97]

To encode a message using RSA, a user needs to create a public and a private key which are chosen as follows:

1. First two large primes (in the range of 200-1000 bits),  $p$  and  $q$  are chosen. The numbers are randomly selected and then primal tests are applied.
2. The primes are multiplied together to yield  $n=pq$ .  $n$  is often 512 or 1024 bits long in practice.
3. The secret key  $e$  is chosen. The greatest common divisor of  $e$  and  $(p-1)(q-1)$  must be 1.
4. The public key  $d$  is the modular inverse of  $e \pmod{(p-1)(q-1)}$
5. The factors  $p$  and  $q$  are discarded. That leaves public key pair  $n$  and  $d$ , secret key pair  $n$  and  $e$ .

1. Let  $p=13$ ,  $q=17$
2.  $n = pq$ ;  $n = 221$
3. Let  $e = 5$
4.  $d = 77$  ( $ed \pmod{(p-1)(q-1)} = 385 \pmod{192} = 1 \pmod{192}$ )
5. Let  $m = 5$ ; Encryption:  $5^{77} \pmod{221} \Rightarrow 31$
6. Decryption:  $31^5 \pmod{221} = 5$ .

Figure 4.9. An application of the RSA algorithm.

For encryption: A message is converted into a number less than  $n$  that is  $m$ . This can be realized with various methods of which the simplest is concatenating bytes. If the

message is longer, encryption must be done in blocks.  $m$  is encrypted by computing  $m^d \bmod n$ . This message is decrypted by computing  $(m^d \bmod n)^e \bmod n$ .

The system relies on the fact that

$$\begin{aligned}(m^d \bmod n)^e \bmod n &= (m^d)^e \bmod n \\ &= m^{de} \bmod n \\ &= m \bmod n.\end{aligned}$$

There are a few possible interpretations of “breaking RSA.” The most damaging would be for an attacker to discover the private key corresponding to a given public key; this would enable the attacker both to read all messages encrypted with the public key and to forge signatures. The obvious way to do this attack is to factor the public modulus,  $n$ , into its two prime factors,  $p$  and  $q$ . From  $p$ ,  $q$ , and  $e$ , the public key, the attacker can easily get  $d$ , the private key. The hard part is factoring  $n$ ; the security of RSA depends on factoring integers being difficult. In fact, the task of recovering the private key is equivalent to the task of factoring the modulus: you can use  $d$  to factor  $n$ , as well as use the factorization of  $n$  to find  $d$ .

Another way to break RSA is to find a technique to compute  $e$ -th roots mod  $n$ . Since  $c = m^e \bmod n$ , the  $e$ -th root of  $c \bmod n$  is the message  $m$ . This attack would allow someone to recover encrypted messages and forge signatures even without knowing the private key. This attack is not known to be equivalent to factoring. No general methods are currently known that attempt to break RSA in this way. However, in special cases where multiple related messages are encrypted with the same small exponent, it may be possible to recover the messages.

The attacks just mentioned are the only ways to break RSA in such a way as to be able to recover all messages encrypted under a given key. There are other methods, however, that aim to recover single messages; success would not enable the attacker to recover other messages encrypted with the same key. Some people also studied whether part of the message can be recovered from an encrypted message [ACG84].

The simplest single-message attack is the *guessed plaintext attack*. An attacker sees a ciphertext, guesses that the message might be “Attack at dawn,” and encrypts this guess with the public key of the recipient; by comparison with the actual ciphertext, the attacker knows whether or not the guess was correct. This attack can be thwarted by appending some random bits to the message. Another single-message attack can occur if someone sends the same message  $m$  to three others, who each have public exponent  $e = 3$ . An attacker who knows this and sees the three messages will be able to recover the message  $m$ ; this attack and ways to prevent it. [Has88]. This attack can also be defeated by padding the message before each encryption with some random bits. There are also some *chosen ciphertext attacks* (or *chosen message attacks* for signature forgery, in which the attacker creates some ciphertext and gets to see the corresponding plaintext, perhaps by tricking a legitimate user into decrypting a fake message. [Dav82, DO86, KR95]

There are also attacks that aim not at RSA itself but at a given insecure implementation of RSA. For example, if someone stores a private key insecurely, an attacker may

discover it. One cannot emphasize strongly enough that to be truly secure RSA requires a secure implementation; mathematical security measures, such as choosing a long key size, are not enough. In practice, most successful attacks will likely be aimed at insecure implementations and at the key management stages of an RSA system.

Current estimates for breaking RSA encryption is about \$1,000,000 in cost and eight months of effort for a 512-bit key. And the key sizes can be increased as the hardware gets faster. RSA is highly strong today, noone would be willing to spend millions to break a transaction which could only worth \$1.00 or even less.

### 4.3. Blinded Digital Signatures

Noone would like signing a blank sheet of paper, but many digital cash schemes require banks to do this. This is due to the anonymity. The customer wants banks to attach their signature without knowing the bits. These systems have been invented by David Chaum [Cha83, Cha85, Cha88a, Cha88b]

Imagine a bank uses the RSA system to sign its bank checks. Ordinarily, it would use some hash function,  $H(m)$ , to compute the hash of a bundle of bits representing the note  $m$ , and then it would compute the  $H(m)^d \bmod n$  using its secret key  $d$  and  $n$ . The problem is that the bank could keep a record of  $m$  and match it to your name. When a merchant returned with the digital note  $m$  the bank would know where you have spent your money.

You can get the bank sign something without knowing what it is by using a *blinding factor*. That is, you ask the bank to sign  $H(m)k^e \bmod n$  where  $k$  is a random number ( $1 \leq k \leq n$ ) and  $e$  is the published key of the bank. You send the bank the value:

$$r = H(m)k^e \bmod n$$

The bank signs it by computing:

$$r^d = (H(m)k^e)^d \bmod n$$

The bank could try to keep a record of this transaction, but you can eliminate this by removing the blinding factor.

$$t = r^d k^{-1} \bmod n = m^d \bmod n$$

This solution works as  $(k^e)^d \bmod n = k^{de} \bmod n = k$

Naturally this is not the whole solution. The bank would like to know whether it is signing a \$100 bill or \$1,000,000 bill. The solution will be presented in other algorithms.

### 4.4. Hash Algorithms

The main purpose of a hash algorithm is to come up with a relatively short number that could be used as a surrogate for a large file. These are quite useful as you can then use a signature algorithm to sign the surrogate instead of the whole file, saving processor time.

The cryptographically secure hash functions make it infeasible for someone to tamper with the file in any way without the tampering changing the final hash value. There are also other hash functions the most common of which is the *checksum*. The procedure is used in many file transfer protocols to determine whether an error occurred. Someone sending a file would add up all of the bytes of data and append this sum to the end of the file. Since there are 8 bits in the checksum byte, there are 256 different possible values and a 1/256 chance that a random error will leave the checksum unchanged. A 32-bit checksum has  $1/2^{32}$  chance of an error going undetected. [Pre93]

The checksums may be quite effective against random error, but they fall quickly to malicious attack. Consider a simple file that is just the value of a money transfer. \$100095. If the checksum is just computed on the digits modulo 10, then the checksum is:  $1+0+0+0+9+5 = 15 \bmod 10 = 5$ .

Which can be manipulated by simply rearranging the digits. A cryptographically secure hash function is very similar to encryption. In fact, a simple hash function, can be built out of a secure encryption function,  $f(k,B)$ , that takes a key,  $k$ , and a block of data  $B$ . As a simple case let  $k,B$  and the output of  $f$  have the same number of bits. If the file to be hashed consists of the blocks of data,  $B_1, B_2, \dots, B_i$  then a hash value could be computed as:

$$f(B_i, f(B_{i-1}, \dots, f(B_2, f(B_1, R)) \dots)).$$

The final answer serves as the hash value for the entire file. The value  $R$  is a random vector that is part of the hash value standard [Win84]

It is very hard to tamper with a hash value of this function. If you want to change the first block of data that hash value will remain unchanged if you can find another value such that  $f(\hat{B}_1, R) = f(B_1, R)$ . But  $f$  needs to encrypt and decrypt successfully, which means that there should be one and only one encrypted block of data for each unencrypted block. This means that there is no other  $\hat{B}_1$ .

One solution is to find a  $\hat{B}_2$  that balances the changes made in  $\hat{B}_1$  so that  $f(B_2, f(B_1, R)) = f(\hat{B}_2, f(\hat{B}_1, R))$ . That means you are looking for a particular key  $\hat{B}_2$  that encrypts  $f(\hat{B}_1, R)$  into  $f(B_2, f(B_1, R))$ . Finding the key that converts one block into another is breaking the encryption with a known plaintext attack. Most good encryption systems, including DES resist this kind of attack. Breaking the hash function would be equivalent to breaking the encryption.

### **MD-4, MD-5, and the SHA**

Many hash functions are based on the same process as the chain of encryption functions, although they are optimized to make the process more efficient. The best

known hash functions are MD-4 and MD-5 created by Ron Rivest [Kal92, Riv91, Riv92]. The Structure of MD-4 was borrowed and modified by the National Institute of Standards and Technology in U.S. to create the Secure Hash Algorithms that is used with the Digital Signature Standard. [Rob94, NIS92].

MD-5 processes data in 512-bit blocks and produces a 128-bit hash value. This is more efficient than using encryption functions like DES which have a block size and a key size that are close to each other. The last block of a file is often not 512 bits, so padding is added in the form of a single bit 1, a flexible amount of 0 bits, and then a 64-bit number representing the number of bits in the file. The extra 0-bits are added until the last block is 512 bits long. The 512-bit block is broken up into sixteen 32-bit blocks.,  $M_0, \dots, M_{15}$ .

There are four 32-bit variables A,B,C and D, that are permuted in four major rounds by each of the sixteen blocks. When this is completed for all 512 bit block in the file, then the four values A,B,C and D, are appended to create the 128-bit hash value.

The four values are permuted by four different mixing functions. Round one consists of using the first function, called *FF*, to mix A,B,C, and D with the sixteen different values of  $M_0$  through  $M_{15}$ . Round two has the same structure but it uses a different function *GG*. Round three uses *HH* and four uses *II*.

These scrambling procedures can be summarized as:

$$\begin{aligned} FF(a,b,c,d,j,s,t) &= a := a + (F(b,c,d) + M_j + t) \lll s \\ GG(a,b,c,d,j,s,t) &= a := a + (G(b,c,d) + M_j + t) \lll s \\ HH(a,b,c,d,j,s,t) &= a := a + (H(b,c,d) + M_j + t) \lll s \\ II(a,b,c,d,j,s,t) &= a := a + (I(b,c,d) + M_j + t) \lll s \end{aligned}$$

The " $\lll$ " stands for left shift.

The basic scrambling functions, F, G, H, and I, are:

$$\begin{aligned} F(X,Y,Z) &= (X \text{ AND } Y) \text{ XOR } (\text{NOT}(X) \text{ AND } Z) \\ G(X,Y,Z) &= (X \text{ AND } Z) \text{ XOR } (Y \text{ AND } (\text{NOT}(Z))) \\ H(X,Y,Z) &= X \text{ XOR } Y \text{ XOR } Z \\ I(X,Y,Z) &= Y \text{ XOR } (X \text{ AND } (\text{NOT}(Z))) \end{aligned}$$

Here,  $\text{AND}$  stands for bitwise AND,  $\text{OR}$  stands for a bitwise OR, and  $\text{XOR}$  stands for bitwise XOR. Three of the basic functions that serve as this foundation are nonlinear. When they are used repeatedly they scramble data.

The entire hashing process is:

1. The file is broken into 512-bit blocks and padded.
2. The four variables A,B, C and D are set to 67452301, efcdab89, 98adcfe, and 10325476, respectively.
3. Each 512-bit block is processed in turn with these four rounds:
  - (a) A copy of A, B, C and D is made. Call them  $\bar{A}$ ,  $\bar{B}$ ,  $\bar{C}$ , and  $\bar{D}$ .

- (b) In round one, the function  $FF$  is used to operate on  $\bar{A}$ ,  $\bar{B}$ ,  $\bar{C}$ , and  $\bar{D}$  sixteen times. In each of these instances, a different part of the 512-bit block,  $M_i$ , is used along with a different constant and shift value  $s$ .
- (c) In round two, the function  $GG$  is used 16 times in the same manner.
- (d) In round three, the function  $HH$  is used 16 times in the same manner.
- (e) In round four, the function  $II$  is used 16 times in the same manner.
- (f) Finally, the values of  $\bar{A}$ ,  $\bar{B}$ ,  $\bar{C}$ , and  $\bar{D}$  are added back into  $A$ ,  $B$ ,  $C$  and  $D$ .
4.  $A$ ,  $B$ ,  $C$  and  $D$  are concatenated to produce the hash value.

The values of  $t$  were chosen using a sine function. The values of  $s$  are chosen to maximize diffusion.

### SHA, the Secure Hash Algorithm

The SHA is based upon MD-4, which is a shorter version of MD-5. The function produces, though, a 160-bit hash value. Which is ideal as DSS uses a 160-bit modulus. [NIS93].

The major similarities and differences between the MD-5 and SHA are:

- The SHA also processes information in 512-bit blocks, The padding is accomplished in the same manner.
- There are five variables  $A$ ,  $B$ ,  $C$ ,  $D$ , and  $E$ , not four, that are used to accumulate the final hash value.
- There are four rounds, but in each round the functions are applied 20 times instead of 16. There are still sixteen 32-bit values in the 512-bit block being processed, but some are reused. So each of the five values  $A$ ,  $B$ ,  $C$ ,  $D$ , and  $E$  are modified four times.
- The scrambling functions used are:

$$F(X, Y, Z) = (X \vee Y) \wedge (\text{NOT}(X) \vee Z)$$

$$G(X, Y, Z) = X \oplus Y \oplus Z$$

$$H(X, Y, Z) = (X \wedge Z) \vee (X \vee Z) \wedge (Y \wedge Z)$$

$$I(X, Y, Z) = X \oplus Y \oplus Z$$

In this case the same function is used in both the second and the fourth rounds.  $\wedge$  stands for bitwise AND,  $\vee$  stands for bitwise OR,  $\oplus$  stands for bitwise XOR.

- In MD-5 the same sixteen 32-bit blocks are used. In the SHA, new versions are created for each of the 80 different rounds using an error correcting code-like scheme. If the sixteen blocks are  $M_0, \dots, M_{15}$ , then the 80 modified blocks are  $\bar{M}_0, \dots, \bar{M}_{79}$ . For  $i$  between 0 and 15  $\bar{M}_i = M_i$ . For  $i$  between 16 and 79,  $\bar{M}_i = M_{i-3} \oplus M_{i-8} \oplus M_{i-14} \oplus M_{i-16}$
- The functions  $FF, GG, HH, II$  are much more complicated. The first,  $FF(A, B, C, D, E)$ , consists of these six steps:

1.  $t = (A \ll 5) + F(B, C, D) + E + \overline{M}_i + 5A827999$
2.  $E = D$
3.  $D = C$
4.  $C = B \ll 30$
5.  $B = A$
6.  $A = t$

- The function  $GG$  is the same, but it uses  $G$  instead of  $F$  and  $6ED9EBA1$  for the additive constant. The function  $HH$  uses  $H$  and  $8F1BBCDC$  and the function  $II$  uses  $I$  and  $CA62C1D1$ .

SHA is regarded as the best hash function available but involvement of NSA raises various questions such as availability of backdoors.

## 4.5. Bit commitment

The bit-commitment protocol was developed to prevent people from changing answers. For instance if you wanted to prove that you knew something before it was made public. You could encrypt your predictions give them to another party. When the time to verify your predictions has come you could give them the key. So that they could verify it. Which may seem logical. But what if there were two keys,  $k_1, k_2$ . that give different answers when used in decryption? You could easily wait for the real answer and give the key according to outcome..

Bit commitment protocols are designed to prevent this. The simplest form is the use of a long, prearranged value,  $V$ .,  $V$  is supplied to you and you encrypt your prediction  $M$ , is encrypted by concatenating  $V$  and  $M$  leading  $f(VM, k)$

## 4.6. Secret Sharing

There are many occasions when splitting a secret among different parties is desirable. Only if  $n$  parts are rejoined can the secret be constructed. [Bla79, Sha79].

The simplest way to split up a secret is with the XOR function. If the secret will have  $k$  bits and it will be split between  $n$  parts, then create  $n-1$  random  $k$ -bit numbers,  $s_1, s_2, \dots, s_{n-1}$ . If the secret is  $S$  then, set  $s_n = s_1 \oplus s_2 \oplus \dots \oplus s_{n-1} \oplus S$ . " $\oplus$ " is a bitwise XOR function. The numbers  $s_1, s_2, \dots, s_n$  are the  $n$  parts of the secret  $S$ .

This system for splitting the secret does not give a holder of one part any information about the entire secret. Even is some one gathers  $n-1$  keys, the task of finding missing part is no easier than finding the secret. A simple but ineffective method could be is simply dividing the secret  $S$  into  $k/n$  bit parts. The problem with this approach is each person knows some of the secret's bits. If the secret is the key is a 56-bit DES key and was shared among seven people. Even if only two people collaborate there would be only 40-unknown bits which is very short for a brute-force attack and can easily be revealed.

## 4.7. Kerberos

One of the big problems in cryptology is key management. If you want to hold a conversation with someone that you've never met before, it is hard to set up a key that both of you can use to create a secure channel. Even a greater problem is knowing that you're really talking to the right person instead of someone who is simply intercepting the messages and pretending to be the right person. Public-key cryptology offers one solution to the problem, and many digital cash systems rely upon public-key pairs that are certified by a central authority. The SSL low-level encryption standard used for secure HTML connections is one example.

The same key management problem can be attacked with private keys. *Kerberos* is one of the most popular models to emerge in common use. It was first developed at MIT where it kept many workstations on campus secure. This model is also used occasionally in digital cash systems. [Ker97].

In a Kerberos secured network, one machine known as the Kerberos server is responsible for keeping a list of everyone's password and everyone's secret key. This server, which is kept in a secure location could use this secret information to establish connections between two machines.

Let's say that user A wants to establish a secure connection with user B with the help of the Kerberos server KS.

1. User A petitions KS for a ticket that would create a connection with B. Both KS and A know A's password but they don't want this to travel across the network. So A's computer keeps it in local memory. The request merely asks for a connection to B.
2. KS receives the request and creates a new random key,  $K_{AB}$ , that A and B will use to communicate. Then it takes this key and encrypts it into two different packets. The first uses the hash of A's password as the key. The second packet uses the hash of B's password as the key. KS sends both of these to A.
3. A receives the two packets. A can decrypt the packet encrypted with the hash of its password, but it can't decrypt the other packet. A's password never traveled over the network so no network eavesdropper could have gotten it. Now A knows  $K_{AB}$ .
4. A sends the second packet to B over the network. Only B could decrypt this packet because only B and KS know B's secret password. When B decrypts it B knows  $K_{AB}$ . The connection is established.

That is the basic mechanism by which a Kerberos server can establish secret links between any of its clients. One of the important features of the system is that it also authenticates two clients to each other. A knows that it could only be talking to B and B knows that it is A on the other end of the line. Or more correctly, the connection joins a person who knows A's password with a person who knows B's.

There are many details that are built into a working system. The tickets, for instance, come with expiration times. All of the clocks in the network are synchronized and a ticket may only be good for a few minutes. This prevents the reuse of a key again.

Many Kerberos implementations also maintain multiple ticket servers. A client that wants access to a particular data server must first ask the Kerberos server for a secure link to a ticket server. Then, it asks this ticket server for a secure link to a data server using the same basic protocol each time.

## 4.8. Zero-Knowledge Proofs

The classic failure of many security systems arise when the attacker learns the password, by eavesdropping, by pure guesswork etc. You have to use your password to access your privileges, bank account etc. During the communication process you reveal your password and if this conversation is trapped by others they can learn your password.

Zero-knowledge systems form the framework for communication between two parties such as even the whole conversation is trapped the listener can not learn anything yet you are able to prove that you are authentic, you know the password. The process is widely known as *challenge and response*. One side comes with a question and the other side answers it.

### A Discrete Log Zero-Knowledge System [CEG88]

In this case, you choose a large prime number  $p$ , as well as three large numbers  $A, B$ , and  $x$  such that  $A^x = B \pmod{p}$ . In this case  $A^x \pmod{p}$  can be used as a digital signature if  $x$  is kept secret. Finding of  $x$  is considered computationally infeasible given  $A, B, p$ .

Assume that you want to prove that you have created a particular signature. In this case challenge and response protocols can be dangerous. If the challenge is "Prove that you are authentic by signing this random string  $V$ " you can not just sign and give away  $V^x \pmod{p}$ . You would have proved yourself but  $V$  could be blank check. You can not apply your signature on anything just like you would not in real world.

An approach could be:

1. You know  $x$ .  $A, B$  and  $p$  are public. You want to prove that you know  $x$  such that  $A^x = B \pmod{p}$  without revealing  $x$ .
2. You choose a random number,  $r < p$  and send  $h = A^r$ .
3. The other end send you a random bit,  $b$ .
4. You send back  $s = r + bx \pmod{p-1}$ .
5. The other end computes  $A^s \pmod{p}$  which should equal  $hB^b \pmod{p}$ . If it is not you do not know  $x$ .

It obvious that there is a 50% of chance that you don't know  $x$  but guessing  $b$  correctly. As there is a random bit involved. But if the procedure is repeated  $n$  times producing correct values for  $h$  and  $s$ . The probability is  $1/2^n$ .

## 5. Cash protocols

### 5.1. Digital Checks

Much of the money used in business transactions flows through paper checks. They are simple to use and popular as they provide a proof of transaction. A check not only shows the intention of a party to pay a certain amount but also the acceptance of payment by the other party.

Electronic transactions can imitate the paper check systems. There are various electronic payment systems such as EFT, but they lack the flexibility of checks. Banks offer payment systems that allow you to transfer money from account to account, or to pay your periodic payments such as credit cards, utility bills. But to use these for your daily transactions you have to know the recipients account number.

A solution could be offering digital checks secured by digital signatures. Such a check would consist of a block of data like this:

$\text{Signed}_{\text{owner}}(\text{Bank Name, Owner's Name, Amount, Destination Name})$

The phrase  $\text{Signed}_{\text{owner}}$  means that the entire block would be signed by the owner's digital signature. The block of data containing the bank's name could also contain an electronic address where the draft could be presented for payment. The owner's name would contain the account number. when the recipient gets the check, he would take it to the bank, which would verify the signature and transfer the amount into his account. the system mimics the normal checks.

The system could offer proof that the check was cashed by returning the entire block signed with recipient's digital signature. The bank receiving the check could add its signature and the bank on which the check was drawn would add its signature before returning the check to the owner. The entire chain would look like this:

$\text{Signed}_{\text{Owner'sBank}}(\text{Signed}_{\text{Recip'sBank}}(\text{Signed}_{\text{Recip}}(\text{Signed}_{\text{Owner}}(\text{details}))))$

A digital check can be strengthened by locking the check so that only the intended recipient can spend it. This can be done by encrypting the message which can be done both by private-key systems and public-key systems. A public-key system allows more flexibility by letting exchange of messages between parties that have not met before. You could use the publicly available public key of a recipient to encrypt part or all of the message, which would also reduce information leakage. The recipient then would use his private key to open this.

## 5.2. Digital Cashier's Checks

Cashier's checks are a common way to guarantee larger sums of money. The bank produces a special check and places a hold on the money promised by the check. People trust the cashier's checks more than an ordinary bank draft as the bank has guaranteed that the funds are available.

Digital cashier's checks can be even more secure. Digital signatures can only be compromised if someone learns the signer's secret key. It is entirely possible that

someone could produce a fairly official looking piece of paper with a bank's name on it without knowing what the bank's real checks looked like.

A simple digital cashier's check might look like a regular check with the bank's signature instead of the owner's:

Signed<sub>Bank</sub>(Bank Name, Owner's Name, Amount, Destination Name)

Which can probably be generated by the owner sending a regular check to the bank and asking the bank to guarantee it. The bank could strip off the owner's signature or leave it. This check then would travel the same way as a regular digital cash.

Figure 5.1 shows an interpretation of a digital cashier's check. First Virtual Bank's signature is like a seal guaranteeing the contents of the details inside the box.

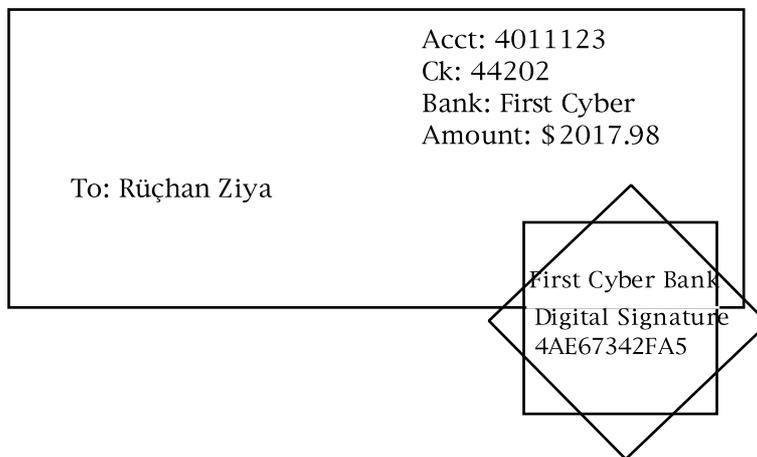


Figure 5.1. A basic digital cashier's check. The bank creates a digital signature for the note by hashing the recipient, the account number, the check number and the amount, and then encrypting this value with its private key.

An enhanced model could hide extra information from others. which is illustrated in figure 5.2.

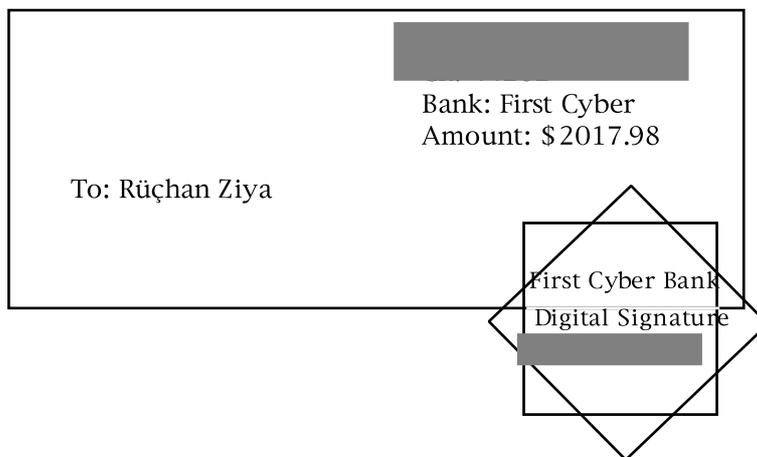


Figure 5.2. An enhanced digital cashier's check. The account and the check number are encrypted with a secret key by the bank. It's signature is encrypted with the public key of the recipient so that only the recipient can cash it.

The structure of this system is definitely not anonymous. The bank must keep a record of all checks that are issued and maintain a block on the accounts. When checks arrive, the transactions are recorded and every bank along the path can know the identity of both halves of the recipient. This information can be quite valuable as the banks and credit card companies already know.

Digital Cashier's checks could be made more anonymous. The bank could transfer the money to another bank account when a customer requests a check and write the draft against this account. This would hide the identity of the sender from the recipient. But the bank would still know both parties as it would create the check.

It is not possible to make the digital cashier's check system more anonymous. Even if the sender has asked the bank to prepare a check to "cash" giving right to anyone to cash the check. The recipient's bank would have the identity of the party who has cashed the check.

If a bank chose to issue cashier's checks made out to "cash" from a central account, then it would be minting a type of digital currency. The bits that made up this check could be passed around several times among different parties before it was presented for a deposit at a particular bank. This system is unlikely to succeed as anyone along the chain could keep a copy of the check and then race to their bank to cash it.

### 5.3. Simple Anonymous Cash:

drafting a check against an anonymous account owned by the bank is not enough to ensure anonymity because the bank can see who presents the check for payment. A true anonymous system can be built which can prevent the bank from discovering any identity information about a bill. The anonymity is preserved through the blinded digital signatures, and a cut-and-choose protocol similar to zero knowledge proofs. Combining these two procedures allows a customer to create a bank certified check without letting the bank to know what it is signing.

1. A customer who wants a unit of anonymous cash creates  $k$  sample units and presents them to the bank. This unit would contain the name of the bank, the value of the unit, and the currency.
2. Each unit is given a random serial number.
3. The data is put in standard format  $m_1 = (\text{bank}, \text{amount}, \text{serial number}, \text{currency}) \dots$   
 $m_k = (\text{bank}, \text{amount}, \text{serial number}, \text{currency})$ .
4. The customer blinds the  $k$  units with random blinding factors  $\{b_1 \dots b_k\}$ . And returns  $m_1 b_1^e \dots m_k b_k^e$  using the bank's public key  $e$  and the associated modulus.
5. The blinding factors  $\{b_1 \dots b_k\}$  prevent the bank to check for contents.
6. The bank requests the blinding factors for  $k-1$  units but the unit number  $i$ .

7. The customer gives the blinding factors except the  $b_i$ . Figure 5.3

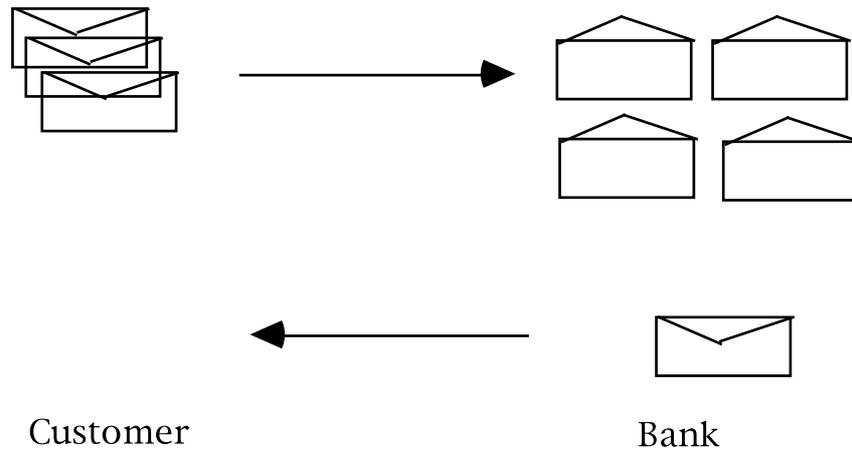


Figure 5.3. A Customer who wants to create anonymous cash must create  $i$  sealed bills, shown here as envelopes. The bank opens up  $i-1$  “envelopes” to check for fraud and returns the last one.

8. The bank unblinds  $k-1$  units to check for their validity.

9. If all checked units are correct. The bank signs the unit  $i$  with its private key.  $(m_i b_i^e)^d = m_i^d b_i$ .

10. The customer unblinds the note by multiplying with  $b_i^{-1}$ .

The chances of fraud is depended on value of  $k$ . But even if  $k$  is 2 then the chance of being caught is 1 to 1. And if the punishment is serious enough the fraud should be inexistant.

There are some shortcomings of the system. How would a bank know the who is the cheater if a bill is spent more than once.

## 5.4. Traceable Anonymous Cash

The simple anonymous cash may be useful, but it still leaves room for fraud. If double spending occurs, the bank can not determine which of the two was the guilty party. A more robust system would allow the bank to catch the guilty one. This system can be created by using the secret-sharing techniques. If a unit is spent twice, then the information in both instances can be used to reveal the cheater.

Two cryptographic algorithms play a part in catching the cheater. The first, secret-sharing is only used in its simplest form. The identity is split into two halves,  $Id$  and  $Id'$  so that  $Id \oplus Id'$  reveals the identity. The second is the bit commitment scheme that prevents someone to present a false key to unlock an identity half. Each of the halves of the identity of the person requesting the unit of cash will be sealed with a bit-commitment protocol so that the half can not be denied later.

The steps are:

1. The customer requesting a unit of cash creates  $k$  sample units as before containing the bank's name, the amount of the draft, the underlying currency, and a unique serial number for the bill.
2. The customer also takes  $j$  copies of his identity and splits them in half using the simple XOR secret sharing system:  $\{Id_1 \dots Id_j\}$  and  $\{Id_1' \dots Id_j'\}$ . If anyone discovers both  $Id_i$  and  $Id_i'$  he would know the identity of the customer creating the bill.
3. Each of the  $2j$  identity halves in each of the  $k$  units is sealed up with its own bit committed encryption key,  $Key_{(a,b)}$ . For Instance, in unit  $m$ , the two halves of the identity  $Id_i$  and  $Id_i'$ , are encrypted as  $f(Id_i G, Key_{(2i,m)})$  and  $f(Id_i' G, Key_{(2i+1,m)})$ . The string  $G$  appended to the identity is a unique string that might be the name of the bank in ASCII. It is added to prevent someone from providing the wrong key later.
4. The  $k$  units are blinded using blinding factors  $\{b_1 \dots b_k\}$  and presented to the bank.
5. The bank asks to inspect the contents of  $k-1$  units. That is customer supplies the keys and blinding factors for all units but one. The bank unblinds these bill and decrypts the identity halves. If each pair properly reveals the customer and other information such as serial numbers is fine. The bank is satisfied.
6. The bank signs the secret bill and sends it back to the customer.
7. The customer unblinds the unit and uses.

These bills are significantly larger than simple anonymous cash because they contain extra  $j$  copies of the identity bound within them.

For a bank to catch double spenders, the people trading the bills must engage in a significantly more complicated process. Simple anonymous cash could be traded by copying it. This traceable variety must be traded with the protocol below, which is designed to reveal the identity to catch the cheater:

1. When a customer arrives at a store to spend coins, the shopkeeper flips a coin  $j$  times and gives the results to the customer.
2. For each time the coin comes heads in bit  $i$ , the customer reveals  $Id_i$  by producing  $Key_{(2i,b)}$ . For the tails, the customer reveals  $Id_i'$  by producing  $Key_{(2i+1,b)}$ . The customer, in the end, has revealed  $j$  different halves of the transaction but the identity can not be revealed as none of them is from a matching pair.
3. The shopkeeper can check that the customer has presented the correct keys because the customer sealed them using a bit-commitment protocol. The special string  $G$  should appear at the end of each message.
4. The shopkeeper can check the validity of the bill by looking at the digital signature and checking to see that it is a valid bank signature.

5. The shopkeeper forwards the note to the bank including the bits holding the flips and the individual keys.

This spending protocol forces the customer to reveal half of his identity at  $j$  different times. If two notes arrive with the same serial number, then this information will reveal the cheater. If the customer is the cheater who spends the bill twice, then there will be two different sets of identity halves. There is a good chance that one half in one note will match the other half in the other note and the identity will be revealed. The chance that the customer would be asked to reveal the same halves in both of the transactions is  $1/2^n$ .

If the identities don't reveal the customer than the cheater is the shopkeeper. The shopkeeper doesn't know the values of different keys so can't decrypt a different set of pairs.

The digital cash produced by this system can't be spent multiple times in a chain. It must be returned to the bank after each transaction because of the identity revealing protocol. This effectively reduces the amount of anonymity. The bank knows who withdraws money and who deposits it, but they don't know how they trade it in between. The trades, however, are only one step away from the bank.

## 5.5. HTTP and Cash

The World Wide Web (WWW) is currently the most popular way for people to publish information over the Internet. It is quite natural that people want to extend the system to send money across the Internet.

In the simplest sense, anyone can use HTML forms to exchange credit card numbers. Some web pages already use this method but it is insecure. It is clear that it is not feasible in the long run. Someone could build a program that watch the traffic for credit card numbers.

Encryption is the obvious solution. And there are two basic approaches S-HTML and SSL. These technologies not only offer a way of transferring credit card numbers securely but they allow the secure exchange of other forms of data.

### **S-HTTP** [RS95]

S-HTTP (Secure Hypertext Transfer Protocol) is a simple extension to HTTP This standard allows the traffic to and from the server to be either encrypted, signed or authenticated. At the beginning of a session client and server choose the right combination. Any combination of nine different options is possible. The standard is not tied to a particular algorithm, negotiation of a mutually compatible set of algorithms is possible.

### **SSL** [Hic95]

The Secure Sockets Layer (SSL) is a basic encryption system developed by Netscape. The software is designed to exist transparently above TCP/IP. Any TCP/IP application

can initiate a TCP/IP connection using SSL. Unlike S-HTTP which is integrated into HTML and requires the negotiations to go through headers SSL is a low level standard on may coexist with S-HTTP.

SSL establishes a secure socket level connection. First the client and the server agree on a cipher and a key. And optionally authenticate the client. In details:

**CLIENT-HELLO** This is the first message that a client sends asking to start a connection with the server. It contains three different types of information: the types of ciphers the client knows to handle, any session ID that might be left over from a broken connection and some random data as challenge to the server.

**SERVER-HELLO** The server responds with two different types of messages. If the server recognizes the old session ID, it confirms this so the connection can begin again and a new set of keys is selected.

If this is a new connection or the ID is not recognized, the server sends back a certificate with its public key that has been authenticated by a certificate authority, the list of ciphers supported, and a random connection number. The challenge is not returned yet.

**CLIENT-MASTER-KEY** The client finishes the key selection. The choice for cipher is sent back. The key is transferred in three blocks. One block contains the extra arguments if the cipher requires. The other two blocks contain the key. The first portion contains the clear portion of the key. If a key is n bits long, the first n-k bits are shipped clear. The other block contains the k bits encrypted with the servers public key. This is due to export regulations.

**CLIENT-FINISH** Client indicates that it is finished with the authentication by sending the session ID encrypted with the current key.

**SERVER-VERIFY** When the server receives the master key, the secret portion is decrypted . And it learns the master key. The challenge data is encrypted using the key and send it back. The client can verify the existence of a secure link by decrypting the challenge.

**REQUEST-CERTIFICATE** This is an optional step for requesting authentication of the client. Includes challenge data.

**CLIENT-CERTIFICATE** If the client is asked for a proof of identity. Client sends a certificate and the encrypted challenge data.

**SERVER-FINISH** When the server is satisfied it sends the session ID encrypted with the master key.

When the master key is created, the protocol requires generation of two new keys which depend on the cipher used.

**JEPI and UPP**

In the real world when you walk in a store you can see what kinds of payment options they accept, which credit cards are accepted. In an electronic commerce as there will be different payment option this negotiation must be realized.

The UPP (Universal Payment Protocol) was developed by CommerceNet and the World Wide Web Consortium as part of the Joint Electronic Payments Initiative (JEPI). The standard allows a client and server to find a payment method acceptable to both. UPP is a subset of the Protocol Extension Protocol (PEP) which allows to see it the other end speaks a particular protocol.

## **6. Cash Systems**

At this time of writing, there are many different companies trying to position their system as the dominant way of transferring money across the Internet. The proposed systems a wide variety to questions like "How much anonymity is good?", "How much flexibility is ideal?" and "How much security is necessary?".

Digital money systems can be examined according to different criteria.

### **On- or Off-line**

Digital money systems that need the help of a distant computer throughout the transaction are said to be "on-line" cash systems. The transaction is monitored by this third party and it blesses it if everything is correct. Addition of a third party takes communication resources, time, and cost so many people are actively exploring "off-line" systems. These are the ones that would allow people to meet on the street and transfer cash to each other even in the midst of a computer blackout. Clearly "off-line" cash is better because it is more flexible and also because communications cost money. If it costs, for instance, \$.02 to clear an online cash transaction people would not want to use it in \$.01 transactions and would also hesitate to use it in small transactions.

One problem is there is no true off-line cash that can be traded ad infinitum without a third party acting as a referee. Paper money or gold coins can be traded for years without being deposited in a bank, but this is because they can't be counterfeited. Digital notes are easy to copy. The cryptographic algorithms can catch the counterfeiters, but only when money is processed through a bank.

This means that even off-line cash is still in a sense on-line. It just means that interaction with the third party, the bank can take place at a more leisurely pace. The people might realize transactions on the street and walk away. Any fraud would be detected later when the digital cash is deposited in the bank.

### **Encryption and Security**

Security is one of the major components of a digital monetary system. And encryption is a way of establishing security. The established systems use a wide range of encryption from none to highly complex. Encryption also has another dimension which has to be paid attention which is the governments tend to have regulation an encryption systems and especially for export. Even though the situation is improving and U.S.

Government has authorized the export of 128-bit encryption in May 1997. Governments would never like criminals exchanging information that can not be intercepted or broken.

## **Certificates and Repudiation**

Certificates are one way that people can add security to public-key systems by arranging for a central, trusted authority to verify and vouch for the public key of someone. This means that a store can start a transaction with a random customer and be certain of his identity when the customer presents a valid certificate.

The main advantage is that certificates prevent someone from denying a transaction later. Naturally, the certificates can be compromised if someone gets a copy of the private key matching the public key endorsed by the certificate. then such a person could masquerade as you. In many cases the private key will be bound in a smart card and protected by PIN.

It is difficult to assess the need for repudiation. The banks need to solve this problem already with ATM machines, stolen checks, and credit cards. Although public-key certificates can be mathematically very convincing, they are not much secure than ATM cards. People will need to store the corresponding private key in a file or a smart card and unlock it with a PIN. These smart cards would be moderately more secure than an ATM card because it would not be possible to simply create one from an account statement and knowledge of the PIN number. It is possible to forge an ATM card if you know the account number, which can be gained from the statement, and the PIN number, which can be picked up by looking over someone's shoulder. finding the private key that matches the public one bound into a certificate is a hard problem that is currently intractable.

## **Anonymity**

Anonymity is one of the most debated features of digital cash. There are two main views on the issue one sees it as dangerous because it will protect criminals. The other view sees it as an essential component that we should use to preserve freedom. The systems supply a wide variety of anonymity. Many systems do not offer any anonymity where as some protect the identity of the customer from the merchant but reveal it to the bank and some keep everyone in the dark.

## **Digitized 'e-cash' Systems**

A number of companies are developing payment systems which permit direct payments to be made anonymously. Payment takes the form of encoded messages representing the encrypted equivalent of digitized money. The aim is to be able to effect payment directly without requiring the use of intermediaries. A number of trials are presently under way to test the concepts which are involved.

Besides the system examined here there are many other systems that have been proposed namely: NetCash, NetCheque, CheckFree, OpenMarket, CAFE, Millicent, MicroMint, PayWord, MagicMoney. These systems generally resemble the others presented here but they may offer less anonymity, more security. Or the difference lies

in the arena of trust. That is a system should trust the customer or merchant. Shall I charge first and send the goods or shall I sent the goods first and if customer is satisfied I can charge. The systems have trade-offs between anonymity, security, flexibility.

## **6.1. iKP [IKPP97]**

IBM recently published a proposal for securely transferring money over a network. The system is designed to work with existing bank systems. The most important feature of the system is it provides a complete cryptographic protection and audit trail. Embedded security systems like SSL provide secure channels but how the channel is used is up to the programmer.

There are three different levels of the protocol, that has different levels of sophistication. The lowest level, 1KP only requires that a central authority publish a certificate guaranteeing its public key. There is no need for general public-key certificates to be issued to everyone. Which means that it can be adopted quickly due to the lack of need for a large-scale public-key infrastructure. The second, 2KP, requires each merchant to publish a public-key that is certified. the third level 3KP requires customers to have certified keys.

Even though iKP protocol is unlikely to be used the SET standard is highly close to iKP.

### **1KP**

There are three entities in the *iKP* model: C, the customer, M, the merchant, and A, the acquirer or the bank.

1. When the customer chooses an item, the merchant makes an offer containing the cost, the currency for the transaction, the date and the merchant's ID number. The merchant also provides the public key and the certificate for the bank that will process the transaction.
2. The customer checks the certificate and adds his credit card number, the expiry date and PIN to the bundle. And encrypts it with the banks public key which is sent to the merchant who can't read the contents.
3. The merchant adds the secure hash of transaction details he knows and sends them to the bank.
4. The bank compares secure hash values of transaction details. If they are equal the credit card is charge. And a signed transaction approval or denial is sent to the merchant.
5. The merchant can check whether the transaction is approved or not and hand the goods.

1KP provides several forms of security for parties involved. The customer is totally anonymous to the merchant. The merchant has the authorization of transaction. The bank can be sure of mutual approval of transaction.

## **2KP**

The second level offers greater accountability. Each merchant needs to have a certified public-key pair. The difference is the merchant adds his signature to the packet containing the customer's encrypted credit card info and transaction details. Now the merchant can not deny the transaction. The customer can also check the merchant. And if the merchant supplies a signed receipt the customer can keep this as a proof.

## **3KP**

Now the customer who also has a public-key pair signs the encrypted details and the transaction details. And these can be used as proofs that the customer has actually spent money.

## **6.2. DigiCash [EC97]**

One of the leading firms which is developing an 'e-cash' system is DigiCash, which has previously been involved in developing smart card technologies. DigiCash is a Dutch company based in Amsterdam created by David Chaum to build the software to use his cryptographic inventions. It has been running trials since November, 1994, involving the transmission of what is effectively electronic money using more than thirty sellers linked to the Internet. Test sites include the Encyclopedia Britannica. Payments consist of uniquely coded digital tokens which are established in such a way as to prevent duplication or fraud. Under the DigiCash scheme, customers would use local currency to buy an equivalent amount of digital cash from a bank. Instructions would then be sent from the bank's to the DigiCash user's personal computer, enabling payment instructions to be sent directly to sellers of goods and services on the Internet.

The structure of the DigiCash system includes both account based money and token based money. Each person maintains a central bank account with DigiCash that is filled with their larger denominations. Each person also gets a DigiCash wallet that can be filled with token based digital coins subtracted from an account. These coins are bundles of bits created with the basic digital cash algorithm. The bank automatically dispenses the coins in sizes that grow exponentially. This approach increases the number of times that someone must break a bill. If a merchant must break a coin, it must interrupt the transaction to go to the bank for the right change.

The current system only provides anonymity for the buyer. When the digital coins are whit drawn from the bank, they're created with blinded signatures and this prevents the bank from matching a serial number with a user. The merchants however do not have any anonymity because they must return the coins immediately upon receipt. The incoming amount is credited to their DigiCash account. It is argued that this form of cash is worthless to the lawless as records are kept. A drug dealer would have to deposit them in his account if he accepts DigiCash.

In theory, people could subvert the system by exchanging disks with cash stored on them. At the most extreme people would trade laptops, full of cash. So people could exchange coins without the involvement of DigiCash computers. The system has no cryptographic protection against double payment. DigiCash keeps a record of serial numbers.

The key to the DigiCash system is anonymity. A person who spends one of its electronic tokens does not need to reveal his or her identity to the buyer nor to any third party except when there is an attempt at fraud, i.e., when the same piece of digital money is presented twice for payment. At this point it is possible to unravel the digital token to reveal the entity to which it was originally issued. DigiCash is attempting to license its e-cash system to banks and other financial institutions. One of its key attractions is that it avoid the time and expense associated with becoming an approved credit card accepting merchant. Anyone will be able to set up a business and receive e-cash once the system is operating fully. However, DigiCash will require the direct involvement of a bank for its system of digital cash issuance and this may yet prove to be a significant obstacle to the realization of the scheme. A bank is integral to the scheme, since it is required to hold collateral and to provide ultimate settlement of e-cash to more directly convertible currencies.

Ecash defines three different parts in clearing, realizing transactions The client, the merchant and the issuer. The issuer is normally a bank who has issued the Ecash. In order to be able to accept a specific type of Ecash merchants make agreements with issuers so that they can clear the transactions on line. The clients also deal with the issuer so that they own some Ecash to be used in transactions. As the issuers are normally banks they can offer ecash in exchange for real money. The clients can transfer their money from their account to their ecash accounts and then transfer the money to their computers using their ecash client software. This money is analogous to the money in our pockets or wallets. When a client wants to shop in a ecash accepting merchant the merchant checks for validity of the ecash that the client is offering by contacting the issuer. The issuer can only identify his signature on the ecash he can't identify the client which supplies the anonymity of the client just like the real money.

DigiCash is based on pre-defined valued electronic notes like the real world money.

The system has been in operation for a while with the Mark Twain Bank as the first issuer, with Deutche Bank in line. Mark Twain Bank has been issuing DigiCash for about a year now. And there are about 100 merchants that accept digi-cash.

### **6.3. Payment Clearing Systems**

A number of companies are attempting to overcome the security issues involved in handling payments on the Internet by establishing electronic clearing systems. Essentially the service on offer involves a system of secure messages which permit buyer and seller to communicate with each other, while also permitting instructions to make payment to be sent via the message/payment clearer, frequently using existing proprietary networks.

One other approach is the introduction of a third party: a company that collects and approves payments from one client to another. After a certain period of time, one credit card transaction for the total accumulated amount is completed. There are, however, other factors to consider when using third party (or credit card) payments. For one, there is always a possibility that a payment is refused because the spending limit has been reached. For another, all payment details of a person are gathered in one centralized system: where they buy, when they buy and sometimes what they buy is stored. The collection of this data tells much about the person involved and this can conflict with the individual's right to privacy.

#### **6.4. First Virtual [FV96]**

First Virtual Holdings is one of the first companies to offer a digital money transfer system created for the Internet. First Virtual has developed a system for linking credit card, banks and processing agents with the Internet. It has developed a closed loop payment system which involves First Virtual's providing a mailbox from which instructions to make the payment and to credit the seller's account are made. The system depends on the "off-line" network provided by EDS which is used to transfer credit card/bank account information, with First Virtual effectively acting as a message clearing house. In effect the buyer sends a message to First Virtual which passes this on to EDS. EDS in turn acts under instruction from First Virtual to pass on the account details to the seller. When the transaction is confirmed, First Virtual sends a message to the buyer to confirm that the transaction should still go ahead, at which point payment is effected.

The First Virtual system has been in operation since October, 1994, and is seen to have the advantage that it does not require encrypted messages as do other credit card-based systems. First Virtual checks with the buyer that a particular transaction is to go ahead before arranging the appropriate account debit. First USA Merchant Services have been contracted to provide clearing, settlement, and authorization for the credit card transactions. First Virtual is significant in that its payment system was created almost entirely independently of the banking system. The President and Chief Executive of First Virtual is quoted as stating "There was no traditional banking mechanism set up to deal with the Internet". First Virtual's initial aim is to permit businesses to receive income for services (such as publications) over the Internet where traditional payment methods would be uneconomic.

A First Virtual transaction includes several steps:

1. The buyer opens up a First Virtual account. This can be done by sending electronic mail to [apply@card.com](mailto:apply@card.com), telnetting to [card.com](http://card.com) or connecting to the WWW page <http://www.fv.com/html/setup.html>. The buyer needs to be ready to provide a Visa or MasterCard charge number because all bills will be sent to the buyer as a charge against this card. The substeps are:
  - (a) The potential buyer fills out a form including his name, address, e-mail address, and requested passcode. The e-mail address is used for confirmation messages. The passcode is used as the account name and password.

- (b) If the application is processed correctly, First Virtual's automatic software will send a confirmation note to the e-mail address contained in the application. This note will include a temporary account number and a telephone number.
- (c) The potential buyer calls First Virtual's computer and inputs the temporary account number and the credit card number.
- (d) First Virtual charges \$2.00 as a new account fee.

2. A potential seller must first get a buyer's account. This account can be converted into two different types of seller's accounts. The first, known as a *pioneer seller*, can be opened when the potential seller mails a paper check to First Virtual for \$10.00. The check is cashed as a new seller's account fee and the bank account number is recorded. When First Virtual wants to deliver money it will send it electronically to this checking account. The pioneer seller account is intended for small, relatively unorganized businesses. There is no credit check, which forces First Virtual to withhold payment for at least 91 days until the purchaser actually pays the bill. Which is a defense against credit card fraud by dishonest merchants. Larger or more organized businesses can receive money within four days if they open an express seller account which costs \$350 for a credit check.

3. When the seller attracts a buyer, they negotiate the price and then the buyer gives a copy of his account ID to the seller.

4. The seller sends a transfer request to First Virtual through a variety of ways. The simplest is an e-mail message that looks like:

```
To:transfer@card.com
From:seller's e-mail account
Subject:
BUYER: buyer's account code
SELLER: seller's account code
AMOUNT: numerical amount
CURRENCY: currency ID
DESCRIPTION: A description of the description for future
identification.
```

The First Virtual receives this transaction request and begin processing.

5. First Virtual sends a request for a confirmation to the purchaser's e-mail account. The purchaser can answer with three different responses:

**YES:** All is well. The buyer authorizes First Virtual to bill the credit card on file for the amount.

**NO:** The buyer is refusing to pay. This is a significant event and First Virtual keeps record of this. If a buyer does this too often, First Virtual might terminate the account. First Virtual will make this because it does not want people to take advantage of sellers by refusing payment.

**FRAUD:** The buyer never authorized the transaction and First Virtual should investigate.

6. If the seller requests it, First Virtual sends along a transfer notification or payment authorization which is digitally signed.

7. When it is clear that the buyer has actually paid the credit card company, First Virtual deposits the correct amount in the checking account of the seller after subtracting the fees. The cost is \$.29 plus %2 of the total amount.

One feature missing from this system is content encryption. The signing of transfer notification is recent development and the company may add additional layers in the future. Even though the credit card numbers never travel across the Internet the account numbers do. The security is based on the assumption that the e-mail account is secure and customers can deny transaction they have not realized.

This system has advantages as encryption is not used the system does not have to obey encryption export regulations. And the customer does not need to have complicated software. All a customer needs is transferring the account number which can be done by phone, e-mail or fax.

First Virtual relies on its partners such as banks and credit card companies if fraud occurs these institutions will also be involved to stop, investigate and make sure that it does not repeat.

### **Shortcomings**

The simplest attack on the First Virtual is as follows:

1. Attacker gains access to the electronic mail of someone's account.
2. Attacker opens a bank account with a fake name.
3. Attacker creates a seller's account and registers it with the bank account.
4. Attacker learns the buyer's account code by reading mail.
5. Attacker starts a transaction with the buyer and his seller account.
6. Attacker confirms the First Virtual confirmation message using buyer's account.
7. When the money is deposited, the attacker withdraws it and disappears.

### **6.5. CyberCash [CC96]**

This is the electronic clearance technology developed by CyberCash Inc.

CyberCash Inc. is a small start-up company set up in August, 1994, in Reston, Virginia. Its founder is William Melton, who was responsible for the creation of Verifone Inc., currently the leading supplier in the United States of POS (point of sale) credit card authorization systems. CyberCash is developing an on-line payment service and on December 12, 1994 announced that it had signed an agreement with Wells Fargo to run a pilot service. Initially the system will provide a secure means of providing credit card details and thereby effecting payment electronically. One of the features of the systems being developed by CyberCash is that it will be 'browser independent.' This stems from the breakthrough which Verifone made in supplying authorization terminals which can handle all the principal credit card services. William Melton is quoted as saying "The Internet is going to happen, with or without the bankers. But the bankers, the bright ones, are going to make this an opportunity".

The basic credit card transactions are very similar in nature to the iKP system. Merchants sign up with CyberCash to clear their credit card transactions and list the bank that clears the transaction.

The customers set up accounts by obtaining copies of software from CyberCash and filling out a form. The customer includes the credit card number that they intend to use. CyberCash creates an individualized file that includes the card numbers and digital signatures assigned by CyberCash.

1. Once a price has been negotiated with the merchant, the customer is sent an on-line invoice detailing the purchase information together with a statement confirming the total charges
2. The customer's software presents the user with the preprocessed payment options. Which include or may include in the future credit cards, debit cards, bank accounts. The customer adds credit card number or debit card information, including personal identification number (PIN) where appropriate. This information is then sent to the merchant in encrypted form together with the original invoice.
3. The merchant adds identification information and forwards all the information to the CyberCash server.
4. CyberCash checks whether they agree on transaction details. CyberCash then initiates a standard credit card or debit authorization request to the merchant's bank or designated merchant acquirer (processing center).
5. After the authorization request has been processed, CyberCash forwards a response to the merchant including a second packet encrypted with customers public-key. who then completes the transaction. Involvement on the part of CyberCash is completely automated and runs off its Internet file server.
6. The merchant may return the customer's receipt and deliver the goods.

In addition to facilitating debit or credit card payments, CyberCash will also provide independent electronic payment services.

Accounts are established directly with CyberCash and maintained on the basis of an account holder's CyberCash key and not on direct user identity. CyberCash accounts are non-interest-bearing holding accounts for cash which the account holder intends to transfer or has received through CyberCash. There are neither float nor checks, only signed receipts that can be sent to receivers to indicate that a transfer has occurred. The only way to place cash into or remove cash from a CyberCash account will be through a demand deposit account in a bank. Consequently, any funds in CyberCash accounts remain within the participating banks. CyberCash accounts are particularly suitable for electronic cash payments that are too small to be processed cost effectively as discrete credit card or debit card payments. This service is expected to permit the processing of the large volume of small payments which are expected to arise from a projected explosion in entrepreneurial electronic information publishing and commerce.

The technique used in CyberCoin is based on realizing electronic transactions between bank and credit card accounts. Unlike E-Cash there is no concept of coins and no actual transfer of money to users computer. The encryption technology used is RSA encryption.

## 6.6. SET [SET97]

Visa and MasterCard produced SET to be their standard for processing credit card transactions that travel over networks. The system includes a large amount of strong cryptology to authenticate transactions and ensure that the system remains secure. A large portion of the cryptography is based on public-key systems, and SET makes heavy demands upon a certification authority for support.

The SET system is similar to other credit card front-ends like CyberCash or iKP.

While using credit cards in the conventional way. The customer negotiates with a merchant to buy a product. When the price is set, the merchant calls the acquirer to request authorization for the customer. The acquirer is most likely a bank, that processes transactions with the issuer and asks for the amount to be set aside to cover the transaction. If the credit is available, the merchant receives authorization and delivers the goods.

Later the merchant posts the transaction by officially requesting repayment. This may occur several days or even months afterwards because the merchant may not deliver the goods immediately after authorization. During this time the amount  $n$  can not be used because it has been set aside even though the charge has not been officially made. Hotels can serve as an example here as they ask for large authorizations to cover extra charges.

when the charge is posted the acquirer informs the issuer of the new amount. The credit is consumed, the charge is made to the customer and the issuer gives the acquirer the funds. The merchants receives the payment after a certain amount of time which may differ from contract to contract.

SET is aimed to support all these operations over the Internet through a mixture of digital signatures and encryption.

The wide variety of people and companies in the SET universe sign their transactions with digital signatures. Such a wide spread use of digital signatures requires a solid infrastructure for maintaining certificates guaranteeing public-keys. These certificates form a chain of responsibility that vouches for the public part of every key pair so people know whether to trust it or not. A certificate is like a letter of credit as someone it states that someone is willing to stand behind this signature.

The SET standard relies on a particularly strong chain of *certificate authorities* (CA's), that is, an organization that offers to back up a person's signature and vouch for its authenticity. A customer or card holder using the SET system will have his own public-key pair and the public part will be packaged in a certificate that includes the digital signature of the issuer. This is generated by the *cardholder certificate authority* (CCA),

which works in cooperation with the issuer. Any merchant can examine the certificate and see that the issuer is going to stand behind the charges as the public-key was signed by the CCA.

How could you be sure of the CCA's signature? It might come with another certificate by a higher authority. And this can go on forever. As this chain has to stop eventually. At the top is the *root certificate authority* or Root CA. This Root CA may guarantee the signatures of many groups. Beneath the Root CA is the *Brand CA*, which is set up by each brand (e.g. Visa, MasterCard or AMEX). The SET also imagines that there may be optional geopolitical CA that would guarantee local signatures.

If a customer begins to sign off on a charge, the merchant must check at least four digital signatures and certificates. The customer's signature is backed up by signature of CCA, which is backed by Brand CA, which in turn is backed by Root CA. A geopolitical CA could also exist in the chain.

But this check need not to be done for every transaction. Many customers will have their cards issued by the same bank hence backed by the same CCA.

There is also a similar organization for the merchants, and acquirers. The merchants have their digital signature pairs that are backed up by the *merchant certificate authority* (MCA). A customer might want to check out the signature of a merchant on a receipt and MCA stands behind. There is also the *acquirer payment gateway certificate authority* (PCA), that backs up the acquirer signatures.

Certificates in essence are like the plastic cards today. If a CCA issues a certificate it is willing to stand behind. But if a customer abuses limits credit card issuers might want to draw the card back. The solution in SET is the revoked certificates. Which is very much alike the denial lists that were being and still distributed which contain the card numbers that will be denied by the issuer.

But this is not a smart solution and is very time consuming. The easiest solution is giving each certificate an expiry date minimizing the size of the list.. SET includes a technique known as thumbprint, which is used to surrogate the revoked certificates list which is the hash of the entire list. Someone who wants to check a certificate must return to the certificate authority to get a list of the revoked certificates.

The thumbprint allows a merchant to maintain a list of revoked certificates. When a new customer offers a card, the merchant can check its local list to see if the certificate is there. If not then the merchant can ask CCA for the thumbprint and compare it with hash value of the local list. If the hash values match he can be sure that his list is up-to-date.

The certificates act as a match between a cardholder and the digital signature. In many ways, they are just like the plastic cards in use today. These cards contain the expiration date, the account number, the person's name and even a photograph. The SET certificates could contain all of this information, but they don't.

In fact, no personal information is to be gotten from a SET certificate. The name is not included and the account number is blinded from the view. So the merchant may receive

a signature and make sure that it was generated by the private key matching the certificate, but he can not extract the name of the customer or the account number. Which prevents fraud by dishonest merchants.

The blinding algorithm uses a *keyed hash algorithm* that acts like a public-key signature. The card holder and the CCA agree on a shared secret by exchanging random values. This acts as a key to the hash of the actual credit card number when it is appended to the credit card data before the hash function is computed. The result is a unique value that acts like a pseudonym for the customer. It uniquely identifies the customers, but it won't reveal their actual identities or their account numbers.

The certificates for merchants and the acquirer clearing houses contain extra information. Their name and identity are left clear as there is little value in keeping them anonymous. In fact, their whole authority derives from their stability and reputation. The certificates can also contain data about transaction limitations.

SET imagines that certificates will not be used in the beginning because of the large overhead involved in distributing the keys and certificates to all card holders. So merchants will be able to present the charges without customer's signatures or certificates. Eventually, the acquirers will require the merchants to provide this.

The possibilities in the electronic environment may offer new opportunities in the arena such as transaction limits. Which may force the card holder not to spend below or above a certain amount for a transaction. Which may prove to be useful.

SET involves three parties: the card holder, the merchant, the acquirer. At the highest level, the cardholder asks to purchase something, the merchant asks the acquirer for enough credit, the acquirer responds. If all is fine the merchant delivers the goods and asks the acquirer to finalize the payment. The transaction in a bit more detailed is as follows:

**PInitReq - The Initialization Request** This is an optional message that the card holder's machine may generate to start the transaction. Its main job is to introduce the card holder, select the card brand and synchronize the certificates. The cardholder will make a list of certificates it holds and send the hash to the merchant.

**PInitRes - The Merchant's Response** The merchant decodes the message and starts a record for the upcoming transaction. The most important phase is to check through the list of certificates to make sure that the card holder has the latest certificates.

**PReq - The Payment Request** When ready to pay, the cardholder sends this message containing the data about the card and the amount. The details of the order are transmitted "out of band" that is SET protocol does not care about this.

This message is broken into two parts, The order information (OI) is for the merchant and the payment information (PI) is for the acquirer. The merchant does not touch the PI and is not able to read it.

The OI's main job is to carry a hash value of order data, This prevents disagreeing with the purpose of the transaction. When the merchant receives OI, it is compared against

the hash value of his order details. The merchant will also send this to the acquirer who can be sure that all parties agree on the transaction by comparing it to the hash value which is also contained in PI.

The PI contains information for the acquirer, including the customer's description of the transaction. Merchant's ID number, the amount, scrambled version of customer's account number, and hash of the order data. There is also a slot for a random key for establishing a secure link between customer and the acquirer.

The OI and PI are mixed together with a "dual signature". PI is encrypted with the public key of the acquirer. Before this is done, the OI and the PI are hashed together in a fairly complicated procedure to ensure that neither can be changed without affecting the final signature, The result is signed by the cardholder.

If the cardholder has no certificate, then the result is simply hashed together and the PI information is encrypted with the public key of the acquirer.

**Pres - The Merchant's Response** The Merchant acknowledges the cardholder's request with this message. Before sending it, the merchant must verify some of the information in PReq. That is, the hash of the order data must correspond to the merchant's idea of what is being ordered. Also, the merchant may check to see that the challenge values produced during the optional PINit phase are copied over correctly. This value is copied over again and again in this transaction to prevent replay attacks.

The merchant can also check to make sure whether the correct signature is in place. Eventually, the acquirer will require all customers to have certificates and refuse to process transactions without certificate-based signatures. This requirement is noted in the acquirer's certificate, which the merchant already has on hand. A quick check is all the merchant needs to make sure that the acquirer will accept the transaction. This is one advantage of distributing information through the certificates.

At this point, the SET protocol leaves the merchant several options. The Pres message is issued only when the merchant is willing to sign off on the transaction. This usually will be after the merchant receives authorization from the acquirer but not necessarily. The merchant may choose to announce that the transaction is complete before authorization to save time. If the amount is small enough and the loss is small, the risk often is worth taking.

The merchant also can delay sending the PRes message until after capture is over; that is, until after the merchant and the acquirer have completed the transaction and the acquirer is sending the money directly to the merchant. This adds an additional delay, but the merchant may choose to do this.

The PRes includes all of the available information. At the very least it includes the transaction ID, and a code indicating the status of the transaction. If either the authorization or the capture is finished, then the result codes are added to the end. This may include a separate message from the acquirer back to the cardholder.

The entire message is signed by the merchant.

**InqReq - A Status Request** The cardholder may request information on the status of the transaction any time after sending the Preq message. This message is quite short and it only contains a new challenge number and a copy of the transaction ID. The random challenge numbers ensure that the merchant will be able to distinguish between multiple InqReq messages.

This message also may be sent after the merchant has approved the transaction. The cardholder may want to find out additional information about the authentication and capture of data. These might not have been present in the merchant's first approval message if the merchant chose to send approval before everything was processed.

If the card holder has a certificate, then he will sign this message.

**InqRes - The Merchant Responds** The merchant responds by sending the current version of the PRes in the same format, which includes the latest value of the challenge number, the transaction ID, and a code indicating the status. If there are either authentication or capture responses from the acquirer, then they are included in this message.

The response code encapsulates all of the various responses from the merchant. These include the finality of the transaction and any potential errors.

This is signed by the merchant.

**AuthReq - The Merchant Requests Authorization** When the merchant requests authorization for a payment, this message carries the data. It is normally sent by the merchant before responding to the customer but it may be sent afterward if the merchant chooses to absorb the risk.

This message has two jobs: to synchronize certificates with the acquirer and to pass along the transaction data. The merchant has a copy of both the customer's and the acquirer's certificate. This message includes a thumbprint of both of these certificates to ensure that they are current. A merchant who doesn't have these values must pause and exchange PcertReq messages to get all of the right certificates.

If all of these are available, then the merchant must send along the PI information from the PReq message. This is the customer's card data and the customer's version of the transaction. The merchant includes its hash of the order data so the acquirer can confirm later that both are in agreement concerning the terms of the transaction.

The merchant may also include additional data about the customer's address that may be used to verify the cardholder. Merchant's often refuse to ship to anything other than the billing address on the card. If the merchant is suspicious about the customer, an additional flag can be sent to alert the acquirer to take special care to check for the signs of credit card fraud.

The final information depends on the details of the transaction. If the merchant wants only to authorize a card for payment, then the message includes the authorized amount. This may be larger than the initial charge if the merchant wants to both authorize and

capture the money from the transaction, this can be accomplished in a single transaction by setting the appropriate flags.

If the merchant chooses to separate the authorization and capture phases, then the merchant later must send a CapReq message requesting capture.

**AuthRes - The Authorization Response** The acquirer checks out the request for a transaction and sends this response back if everything is in order and the money is available. Otherwise, it sends an error message.

The acquirer checks the copy of the PI from the cardholder's PReq has a valid signature, if it is required. Then it makes sure that both the card holder and the merchant agree on the hash value of the order data.

The customer's account number is bound up in a scrambled field (PAN) that must be decoded. After it is in the clear, the account is checked and the appropriate authorization and capture is done. This account number may be returned to the merchant in the AuthRes message if the merchant is set to receive it. Many Merchants keep spending records on their customers. This data traditionally was provided to them. If the merchant and the acquirer agree to it, then the merchant gets this information and the transaction is not anonymous.

If the merchant's version of the certificates is wrong, then the acquirer would include new copies in this message as well as new thumbprints.

The message also contains proper response codes to the authentication and capture requests. These are sent on to the cardholder when the merchant receives the AuthRes and generates the Pres message.

**CapReq - A Separate Capture Request** When the merchant chooses to separate authentication from capture, the merchant must follow up with this message at a later date. This message can close out multiple transactions.

The data identifies the transaction and is returned with the authorization so the acquirer can correlate them.

**CapRes - The Capture Response** When the capture requests are processed, the acquirer sends this message and begins the transfer of the money.

**AuthRevReq - Reducing the Authorized Amount** This is a message used to reduce the authorization for a transaction. Contains the transaction ID, challenge number, authorization limits. And is signed by the merchant.

**AuthRevRes - The Acquirer Approves** When the authorization is reduced, the acquirer responds with a signed message.

**CapRevReq - Capture Reversal** This message is almost the same as the CreditReq. They return money from the merchant to acquirer for the cancellation of a previous transaction.

CapRevRes - **Capture Reversal Response** This message signs the approval of the credit.

CredRevReq - **Credit Reversal** This is sent if something goes wrong with CapRevReq or CreditReq.

CredRevRes - **Credit Reversal Response** The response to CredRevReq.

PCertReq - **Request for More Certificates** When the merchant determines that it lacks the proper certificates. This message is sent requesting the new certificates.

PCertRes - **The Certificates** The certificates and the thumbprint arrive in this message.

In summary the three parties involved, the card holder, the merchant and the acquirer hold certificates issued by different certificate authorities. These certificates are backed by a chain of signatures, that ends with Root CA.

Each party keeps a list of certificates to verify signatures. A card holder, might hold the certificates of several merchants, the merchant's CA, the Brand CA and the Root CA. When two parties begin to exchange messages, they also exchange the list of certificates they hold and a thumbprint, which is a hash of certificates. This allows them to make sure that they hold the same certificates.

The card holder encrypts the account number and a hash of payment information in the PI. The merchant adds its own version of payment information and passes it. The merchant can't see the cardholder's data. The acquirer compares the two versions of transaction and processes if two sides agree.

The SET standard is being backed by great players in the Arena such as VISA and MasterCard and various governments are backing the initiative. In June 1997 the first transaction using SET has been realized. But the widespread use, and universal acceptance is not a reality yet.

## 6.7. NetBill [NB97]

Information Networking Institute of Carnegie Mellon University is sponsoring 'NetBill,' which is a scheme which would broker transactions through a third-party financial institution, similar to the system of debit cards which is already in existence. The system requires both the customer and merchant to maintain accounts with the third party acting as the broker. When a customer wants to make a purchase of goods or services, a message is sent using the NetBill software to the third party financial institution instructing a transfer of the relevant amounts to the seller's account. Similarly, the Information Sciences Institute at the University of Southern California is developing both a cash/cheque model and a debit card model based on a similar structure. Selection can then be made according to whether the buyer is or is not seeking anonymity. ISI is working with a several banks including Bank of America and Citibank. [FT94b]

## **6.8. Credit Card-Based Systems**

The major credit companies have been the only established financial institutions actively investing in future payment systems on the Internet. Credit card based payment systems have some limitations already identified earlier in the paper. Nevertheless, telephone-based credit card payments currently account for the majority of Internet commercial transactions. A secure and efficient method to transmit credit card details will clearly be welcomed as a major step forward. A number of initiatives are underway. Both of the major credit card companies have linked up with software houses to develop the encryption software systems which will be required.

On November 9, 1994, Visa and Microsoft announced that they were jointly developing software based on a security architecture which will enable customers to make purchases using coded credit card, debit card and charge card numbers on-line. The intention is to add future optional upgrades to the PC-based Windows operating system which will permit card details to be encrypted so that payment will be secure. The intention is to make the software available as part of future optional upgrades to the Windows operating system, which will also incorporate a user-friendly interface to the Internet as standard. Visa International is controlled by its members, the banks that issue VISA credit cards. Voting rights are in proportion to the volume of business transacted. In common with other credit card-based systems, Visa's Internet payment system will be limited to merchants who have been approved by the organization to accept their credit cards.

In January, 1995, MasterCard announced that it will start providing banking services on the Internet. MasterCard will base their services on the Netscape computer software, which is designed to encrypt transactions and keep them secure. Netscape has already successfully developed a suite of programs for accessing the Internet which are sold commercially. Netscape is also working with Bank of America and with First Data Corp as well as MasterCard International.

## **6.9. Smart Cards [SC97a, SC97b]**

Some observers believe that the only way in which payments over the Internet can be made secure is to physically separate authentication from the process which provides the communication links between buyer and seller.

The major smart card systems will place the value "on the card". That is, the card will be considered the repository for the money. If it is lost or stolen the, the money may be gone, although the central companies may have the ability to replace it like traveler's checks.

The main difference between the smart card systems and the other systems is the amount of central control. The smart cards act like branch offices of a business. They have the ability to transfer money in and out without getting permission from the central office. For instance, two people can meet on the street and move money between their Mondex smart cards without discussing the matter with a central computer. Systems like DigiCash must get central approval before any money moves.

The most obvious advantage in the lack of central control is cost. The network infrastructure required to process all of the payments is extremely high, which will most likely be amortized over the costs of the cards in forms of fees or interests.

A number of companies are therefore examining the use of smart card readers linked to a personal computer. A smart card used to store money in the same way as a phone card would make it possible to separate authentication from the payment process. Smart cards technology would permit them to be charged up with cash at an ATM or separately using a proprietary bank network. The value in the smart card could then be transferred securely and anonymously over the Internet.

## **6.10. Citibank's Transaction Cards.**

Citibank has announced that it is experimenting with a smart card based digital cash. The system is quite similar to digital cashier's checks. The packets that contain the information about the bank and the amount are signed by the Bank's signature.

The smart card maintains a secure file system that catalogs the cash on the hand and apply a secure digital signature to back up each transaction. The current version of the system can support multiple currencies, credit lines. Each can be exchanged and two smart cards can buy and sell foreign currencies between themselves.

The transactions in the system are straightforward. Each note consists of the name of the bank, a serial number, the amount, and a certificate used to guarantee the note. This package of bits is signed with an RSA signature produced by the key pairs in the certificate. The initial note is produced by a special sealed module kept secure by the Bank.

When money is transferred from one smart card to another, the spending smart card wraps a new layer of bits at the end of the note. This data includes, the amount being transferred, the smart card's identification number, the time and the smart card's certificate. The smart card then signs the entire package, effectively guaranteeing that it obtained the note legitimately and is now offering it legitimately. The notes can travel through several smart cards before returning to the bank. Through each step, each smart card in the chain adds its own signature building a chain of custody for the note and the value it contains. This chain can be used to reconstruct the flow of money through the economy to either stop money laundering or trace fraud.

The notes can also be split in parts. If your smart card contains a \$10.00 note and you want to spend \$0.50 the smart card will create a new note worth \$0.50. This note will contain the old \$10.00 note at its core and the outside wrap of the data will specify that only \$0.50 of its value is being transferred to this new note. The smart card may then split off other fractions from the same \$10.00, making sure that all of them add up to \$10.00.

Each note can be split into parts by each smart card that holds it in the chain. So each note can spawn a wide variety of notes with fractional values. And when these bills return to the bank they can be checked whether they add up to the value of the original bill.

The smart card receiving the money must validate it to make sure it is correct. By the time a note arrives at a particular card, it might have passed through ten other smart cards. Each card added its own signature and a certificate used to validate the signature. The receiver checks each signature in the chain to make sure it is valid and matches the certificate. This is a fairly secure chain of custody. In this system the accepting smart card will trust a bill without checking with the central server.

When two cards are used for a transaction the following steps are followed:

**Authentication** The two "trusted agents" authenticate each other by exchanging digital signatures backed by certificates. That is,

- (a) The first produces a random number,  $r_1$ , signs it and sends it to the second.
- (b) The second checks the signature, signs  $r_1$  and returns it. Then it generates a second random number,  $r_2$ , signs it, and sends it on.
- (c) The first checks the signature on  $r_1$ , and  $r_2$ . Then it signs  $r_2$  and returns it.
- (d) Now both cards have established that they both know the secret keys to the public-key pair backed up by certificates.

**Secure Channel** The two random numbers can be combined to make a key that will be used to encrypt all further communication.

**Exchange of Data** If the transaction is being used to sell data or software over the network, the seller encrypts the data and sends it.

**Cash is Tendered** The purchaser's smart card produces a collection of notes that add up to the correct amount and sends these to the reader's smart card.

**Cash Verification** The seller's card examines the digital signatures in notes received. If they check out, then the seller's card send a receipt  $R_1$ , acknowledging that the notes arrived safely.

**Purchaser Accepts the Transaction** When the purchaser's card receives the acknowledgment . the notes are marked as spent and another receipt ( $R_2$ ) releasing the cash is issued.

**Seller Accepts Money** When the second receipt is received the notes are marked as owned.

**Seller Releases Data** The seller supplies the key to the data.

Any disputes about the transaction can be solved later. The bank can investigate the status of transaction that has ended with frozen cash.

These cards also introduce another concept credit-lines along with digital cash. Which is something in-between digital cash and credit cards. These cards can also contain notes backed with credits from other institutions. But unlike normal cash these can not be transferred from card to card. They have to be returned to the issuer after being used. Which is for abiding by the regulation as otherwise it would be equivalent of issuing money.

The system is quite decentralized and allows off-line transactions. Which lowers the costs. The system relies on the integrity of the smart cards to prevent double spending. Double spending is technically possible but only if one is able to break into the smart card and duplicate what it does.

The design of the system also includes several layers of protection. The smart cards lack the ability to mint money. They can only spend notes that were produced by the central money creator. Every transaction must be guaranteed by a digital signature. If double spending occurs, the bank can determine which card is double spending. This may not identify the cheating person immediately, but it can produce a good trail of where the notes were spent.

The decentralized nature also means that it is impossible for the bank to shut down a rogue smart card. If someone found a way to work around the tamper-resistant packaging of a smart card and turn it to do his bidding, then the bank could not shutdown this person. Even the bank would be able to identify the card from the multiple spent bills, they would not be able to stop the card so that it would not appear as legitimate to the other cards. The solution is periodically changing certificates, which would stop the identified rogue cards.

The system also requires that the money "age". That is, each note comes with an expiration date. After that, the notes must be exchanged for new notes from the bank. This forces the notes to flow through the bank every n days and allows the bank to identify any fraud or double spending at that time. This can be done behind the scenes and in the background whenever the customer interacts with the bank via ATM or Internet or smart phones.

## **6.11 Mondex [MDX97]**

National Westminster Bank is one of several organizations developing smart card technology to create what is referred to as an 'electronic purse'. While the magnetic strip on a credit card can only hold one or two lines of information, smart cards can store several pages of text. This permits credit card-sized smart cards to be used to transfer cash amounts which can then be 'spent' using special terminals. The initial applications will involve replacing small cash payments made to retailers (e.g., for newspapers, confectionery) or to pay for services like public telephones or public transport.

NatWest's longer range vision is for Mondex to be used on a more global basis to buy goods from suppliers on the Internet. Payments would involve having a special smart card reading device linked to the PC and software that recognized the card reader. Although this may prove a cumbersome alternative compared with more direct payment methods, NatWest and other smart card developers believe there would be a key benefit

from the inherent security which is built into smart cards. Smart cards could also be more readily integrated into the existing networks of ATMs, integrating with what is likely to remain the predominant form of payment transaction, namely cash.

## **6.12 Electronic data interchange (EDI) [EDI96]**

Money is not the only element needed for realizing transactions. And electronic commerce needs more than that before exchanging money.

Electronic data interchange (EDI) involves the exchange of structured business documents, such as orders and invoices, directly between computers. Financial EDI extends this process to the payment and settlement process performed by banks. At present EDI is principally used for inter-company communication, removing the need for paper-based transmission of orders and remittance information. Although EDI standards were developed in the early 1980s, actual implementation has been very modest to date [FT94f]. Out of several million individual businesses which are registered in the United States, currently only 44,000 companies are using EDI to exchange business data electronically. Furthermore, of this group, only 10% are also using financial EDI (4,400), with the rest ending their electronic links with a paper-based payment trail to their respective banks. [FRB94]

The experience in the United States is mirrored in Europe and Japan. In Europe, regular users of EDI have only recently increased to 40,000 companies, compared to 20,000 in 1990, and it is now acknowledged that in order for electronic commerce to happen, a whole series of changes both technical and organizational have to be implemented. Actual implementation rates vary significantly from country to country and are further constrained by the fact that currently only 50% of European EDI traffic is based on the international United Nations-based EDIFACT standard [FT94e]. Successful EDI implementations remain largely the preserve of major retailers such as Sears Roebuck in the US and Marks & Spencer in the UK. Other examples include General Motors, which in 1993 collected US dollars 12 billion from its US auto dealers using an ACH based financial EDI system. In Europe, EDI service providers like IBM, BT, AT&T as well as INS/General Electric Information Services (Geis) are gearing up for substantial future growth. Low take-up rates to date have been explained in terms of high start-up costs, lack of familiarity, as well as overall low take-up rates, which frequently require businesses to maintain dual paper-based and electronic remittance systems in parallel.

One of the main reasons that EDI did not take off immediately was the lack of global networks and the complexity of the X.12 standard that served as the basis for implementations was a bit complex for daily use.

In June 1997, various players in the arena of digital commerce including IBM, Sun, VISA have announced that they are working on a new standard that would serve as an infrastructure for business communication. The new standard is called "OBI" and at the time of this writing not enough details are supplied to the public.

These high level standards are the most important barriers in front of the electronic commerce. The theoretical and practical infrastructure for establishing secure communications and secure financial transactions is already present. Establishment of

mid-layer standards that may work one layer above SSL, that can cover the negotiation of kind of encryption, cash system that will be used for a transaction described universally will be the ultimate solution for now. In the future when more complex systems can find easier application, such as when public phone are modified to accept smart cards the transactions will become totally different. But now, and even then, there will be a need to cover different standards to enable them to work in their current form. [Ley93, Emm90]

## **7. Policy and Regulatory Issues**

The development of electronic payment systems based on the Internet raises a whole range of legal and regulatory issues. A effective global low value electronic payment system will certainly remove what is currently a major obstacle to the expansion of trade and commerce. Significant costs are associated with the present system, which in turn permits a raft of regulatory and bureaucratic controls to be maintained that are becoming increasingly irrelevant to the demands of the 21st century. Certain writers have argued that electronic or e-cash will not be permitted by governments precisely because regulation will be too difficult. Others suggest that we are moving to a future where many of the traditional national boundaries which have applied to money flows will be superseded by new 'cyber currencies' operating in 'cyberspace'. An American bank, First Union, has even registered "Cyberbank" as a trademark.

The emergence of an electronic payment system which is easy to use and cheap to process is likely to have a range of only partly anticipated side effects. It could, for example, result in a push for greater convertibility and the creation of truly global currencies. This will in turn have important economic implications, perhaps accelerating the move towards currency union in Europe or reinforcing the dominance of currencies like the Deutschmark and the US Dollar. Overall, such developments will create a more globalized economy which will be less subject to the direct political wills and whims of national governments. Ironically, such developments will undermine existing large value electronic payment systems which function largely in order to service the transaction amounts generated by the international foreign exchange markets.

There are concerns that more widely available systems to make electronic payments could exacerbate the problems currently being created by illegal money flows. According to estimates made by British intelligence, laundered money may amount to some US Dollars 500 billion per annum. Over half the total is estimated to be accounted for by illegal trade in drugs, with the balance from other forms of organized crime and terrorism. However, in many respects a move to electronic payments is likely to permit more rather than less control of payment transfers, since there will be greater information capture. High levels of activity in the 'black economy' are generally associated with cash based payment transfers and generally result in lower use of electronic payment systems like credit and debit cards. The introduction of e-cash and electronic payment methods may therefore permit greater rather than less monitoring of the payments system with correspondingly more control over the money laundered, drug smuggler and tax evader.

Commercial Issues

An expanding ability to order and pay for goods electronically will have important implications for Anglo-Saxon contract law, which attaches great importance to the existence of an offer and acceptance, as evidence that the parties to an asserted contract have in fact agreed. Lawyers are trying to deal with issues such as electronic ordering and payment, within the existing legal framework which distinguishes between instantly agreed contracts made orally, and delayed agreements which apply to written communications such as letters and telegrams. With the advent of electronic messaging, the situation becomes more complicated as there are no accepted standards regarding when a message has been received.

Other similar issues concern authentication. Contract law remains ambiguous regarding the use of electronic signatures. In principle, Personal Identification Numbers (PIN) used in conjunction with credit or debit cards should have the same treatment as a signature in law, but the area remains relatively untested.

### Encryption Issues

Computer-based encryption using PCs is, in principle, capable of becoming sufficiently secure to prevent unauthorized access. However, the ability to encrypt messages is presently restricted by the requirements of nation states to have access to all written communications, a right that was in the past enshrined in controls placed on postal, telegraph and telephone services. Any company establishing encryption systems which cannot be 'broken' by the nation's security services is therefore subject to prosecution. This inevitably limits the efficacy of encryption, giving it a role similar to fitting window locks as a means to prevent burglary. Such devices will generally deter entry but with a degree of perseverance and know-how they can usually be overcome.

Currently a legal dispute is going on between RSA Data and the US government's rival digital signature technology called Clipper. A number of software companies are presently developing encryption software, some of which is based on patented algorithms which have been developed by RSA. [FT94a] Encryption has become a key element in discussions concerning commerce on the Internet. The most widely used browsers are now shipping with added 'public-key cryptography' capabilities. Public-key cryptography makes it possible to 'sign' a document so that the recipient can be assured that the source of the message is authentic as well as to 'seal' a document, ensuring that no one except for the recipient can open or change it. The encryption technology will be based on algorithms which have been developed by the company, RSA Data Security. Encryption facilitates services that require privacy, such as home-banking and electronic money-transfer between businesses.

### Structure of Trade

No one knows what impact new opportunities for conducting electronic commerce will have on world trading relationships. To date, despite the substantial growth in international trade which has occurred since the Second World War, a large percentage of trade remains in the control of a relatively small number of global companies. Furthermore, a major proportion of what shows up in national statistics as exports and imports represents trading transactions conducted between the different subsidiaries of the same multi-national corporation.

There are some historical precedents when considering the radical changes in trading relationships which may shortly be upon us. In Europe, medieval trade fairs grew to prominence as trade across kingdoms and principalities revived in the 11th century. At the time, these fairs represented a radical break with the past and participants had to develop what was virtually a completely new separate political and legal system. Merchants had to negotiate rights of passage and protection from archaic feudal as well as ecclesiastical laws and customs acting as impediments to trade. The period saw the emergence of credit-based banking systems and financial instruments such as bills of exchange, which remain with us in their modified form to this day [Cho94].

#### Money established by fiat

Modern societies have long adjusted to the fact that money is created by government fiat and has no intrinsic redeemable value other than that by law a creditor must accept it in settlement of any outstanding claims by her or his debtors. The emergence of electronic commerce may be leading to a further evolutionary stage, a monetary system in which convertibility into legal tender ceases to be a condition for electronic money. Some electronic money might be backed by governments, others by private issuers which enjoy the absolute confidence of the market. Such private issuers could be viewed as more secure than many governments (as is already the case in the international bond securities markets). The ultimate electronic money would be a currency without a country which is infinitely exchangeable at defined rates with other more traditional currencies. It may constitute itself as a wholly new currency with its own denomination - the 'cyber-thaler', harking back to early trans-European currencies and the forerunner of the US dollar.

There are signs of increasing divergence between the existing electronic large value payment systems and the requirement for a globally-based electronic payment system which can process low value payments cost effectively. The former systems are based on proprietary closed systems architectures whose underlying technology is often mainframe-based and where communications are restricted to leased circuits. In addition, large value payment systems are increasingly becoming devoted to the processing of large foreign exchange and securities transactions which are largely divorced from the real trade in goods and services. This aggravates the inverse relationship which already exists between a large volume of transactions which are being processed in paper form compared to a much smaller number of very large payments which are processed electronically.

New trading opportunities are being established as a result of the growth of the Internet and other on-line networks. At the same time there is increasing pressure to move from existing paper-based payment systems to electronic transfer. Microsoft's chairman, Bill Gates, is not alone in believing that the convergence of money, commerce and personal computers represents one of the great new markets of modern times. New and unforeseen opportunities can be expected to arise once a secure and cost effective 'mass' market electronic system for making low value payments is successfully established. Serious efforts to establish such a system on the Internet are still less than 24 months old. However, the coming 12 months should witness some interesting developments as small entrepreneurs, such as DigiCash and First Virtual, battle it out with the credit card

companies and, to a lesser extent, with the commercial banks to establish new standards for electronic payments.

Many bankers remain skeptical that Internet-based payment can and will emerge. They believe that they will prove to be largely peripheral to established unchanged patterns of retailing and commerce along with their associated payment systems. However, the evidence is pointing to an alternative consensus. The result is likely to be the creation of a new global commercial market place which permits goods to be ordered and paid for electronically irrespective of location. This will require new institutional structures to be formed as well as changes to existing outdated legal and commercial systems. The changes brought about by electronic commerce may be similar in scope to those experienced when the medieval trade fairs were established in Europe in the 11th century. The comparison is particularly apt, since that period saw the emergence of many of the banking institutional structures and payment instruments which remain in use today.

## **8. Conclusion and further studies**

Led by the commercial sector, Electronic Commerce is growing explosively on the Internet. Before the end of this decade, millions of individuals and companies will be buying, selling, bidding, brokering and collaborating on a daily basis, as the Internet merges with other branches of the information superhighway. The resulting economies of scale will drastically lower the cost of implementing and maintaining a procurement infrastructure. Nobody will be able to ignore the impact of making e-commerce services widely available at reasonable rates.

The biggest promise of electronic commerce is the low transaction costs. It is generally believed that when micro payments become a possibility the use of electronic means will explode. And the way businesses are run will be changed. People will have their options of paying only what they need or what they use.

The main role of the banking system today is not gathering savings from the public and taking a risk by supplying the funds that need them. The most important function the banks are realizing today is transferring money from one city to another, from a country to another country and from a wallet to another wallet or more accurately from an account to another account. But generally people are not interested in transferring money from one account to another. This is a concept that the current system imposes. The banks have assumed this role due to the fact that they are widely spread and can communicate between branches and with each other. The post offices were in more common use before banks were in infancy state which demonstrates the importance of high availability and communications. If a person wanted to transfer his money to another person which can be located in another place. He could personally travel and hand the money or use a courier service. The means are not that important as long as the money is transferred. The electronic commerce promises to get rid of intermediaries. If you could transfer your money to someone else using the Internet or using public phone system you would not need to use the banks. The banks are losing their classical functionality and they are rapidly becoming transfer agents integrated with investment

houses. The banks and other financial institutes are aware of this and actively seeking to take part in the new economies of tomorrow.

It is quite possible to imagine a scenario for digital commerce in which the banks of today have no role. Money in today's form has a very interesting story. History notes the use of many different items as money, such as sea shells, diamonds, gold coins, even tobacco leaves. As a common element in barter. All had their advantages and disadvantages. Later on governments or other institutions have issued backed, guaranteed papers, bonds that promised to pay a definite amount of a material to the holder of these bonds. And today generally the money is only a paper that the government issues. It is not backed by any material. People use it, accept it as a form of payment as the others will also accept. In that view money is only a trust. You trust the money as the others will also trust. The money is backed by everything that people are willing to exchange it with.

Digital commerce is generally open to any kind of currency. And there is no limit for new ones. The ones that only exist in the digital arena. A company could easily issue digital cash and if people use it it would have a value which is a problem of trust. Today people have trust in the banks they are depositing their money in them and using the banks for everyday use. So it is only natural that, in order to have ties with real currency today the banks will be involved.

The digital payment system that can widely be used must be able to work offline as people should be able to trade anywhere they wish as today's hard currency. The smart cards seem to offer a viable alternative to the problem. The electronic coins can have expiry dates, to prevent cheating. And that kind of currency is more reliable than today's under the light of current cryptology. The system could offer the replacement of lost coins. The system could make sure that people agree on details. The system could offer you very high customization and automation. The system could offer you flexibility such as daily limits, per purchase limits for digital cash or merchant specific digital cash and these can prove to be useful in business world. If a company is sending someone to someplace to buy a specific item, the purchaser could be supplied with cash which can only do that.

In the absence of universal acceptance for EDI transactions, new standards and services should be developed. OBI is a good promise to fill the need. A standard internal representation and services that translate between its formats and those supported by trading partners is a must for electronic commerce. This approach reduces dependence on industry schedules for adopting standards, and avoids the pitfalls of an-imposed solution by either governments or companies.

One of the most important findings in the paper is the vital misunderstanding of Internet as medium. Many companies today think Internet as a different way of publishing and many Internet companies are forcing and helping for this perception which essentially limits the Internet as a commerce medium. This perception must be and will be changed in the future. The reality that on the Internet people are digitally face to face will be understood day by day. The first implications of this fact is the growing number of interactive technologies and their use on the Internet. And this will soon be applied to commerce. Many companies are already aware of that and are offering unique

capabilities to their customers such as custom tailoring of PC orders, internet special promotions.

The current legal systems will have to be updated to the digital era, which is an issue that Turkey will face. The electronic data will have to be as legitimate as printed. Digital signatures should be as valid as analog signatures.

Internet in Turkey is still in its infancy and still struggling with infrastructure problems. The currently estimated number of Internet users is somewhere between 20,000 and 100,000. Which is not enough for viable commerce and the academic users form a large portion of that. The very few commerce activities involve the use SSL and the transfer of credit card numbers securely. The other approaches are not regarded as commerce on the Internet.

The banks and other institutions are actively seeking for electronic commerce systems. Some banks have announced their phone/PC banking systems in the form of private systems. But there is no reason that they won't be public when the infrastructure is there. The PC banking systems have been in operation for a while in other countries especially in U.S. and now they are being replaced with Internet based systems. There are also other systems in the form of cards. The Istanbul municipality have started the use of "Intelligent Tickets" for public transportation, some banks have issued cash cards, which are more closed forms of digital cash.

Under the light of this study development the digital commerce lacks a high level standard which can cover different forms of digital transactions. The development of a standard that covers different transaction, encryption systems, which can also enable transactions between two parties that uses different cash systems will serve as a stepping stone to ultimate digital cash.

Such a standard could use exchange points for conversion of incompatible payment systems. There is no reason for not implementing an exchange point between any two transaction processing system say First Virtual and DigiCash. Such an exchange point would have both merchant and customer accounts for systems supported. Having the ability of both accepting and giving money, the exchange point can process a transaction by pretending to be the merchant (Virtual Merchant) for a customer and transfer funds or digital cash to exchange point wallet or account. Later these funds can be transferred to the actual merchant by pretending to be the customer (Virtual Customer). This system can even process transactions between different currencies.

With the establishment of such a system the current commerce initiatives will likely have a boost. The various payment systems make it difficult for a customer and for a merchant to make a decision. Use of such exchange points will even make the use of classical credit card systems against advanced smart card based systems such as Citibank's Transaction Cards. Any merchant that accepts one form of payment will be able to use all other forms supported. This will greatly improve the status of digital commerce.

All of the systems examined have ways to coexist with the current payment and banking system. But using the classical systems as a gateway between them will not be a viable

alternative due to the time lag and costs involved. And this study has not found alternatives that has been proposed or implemented.

This study forms the infrastructure for digital commerce, digital exchange system with a focus on the Internet as the Internet is the most widely available publicly accessible electronic communication mean. What should be expected from digital commerce, and how can these be realized, what are the implications expected, what are the features that a digital commerce system must have are the questions that have been answered in this study. Further studies should use the answers to questions for the implementations of digital cash systems. And the first step should be the development of a high level exchange system. Currently proposed systems make intelligent use of underlying mathematics and all involve trade-offs. Further improvement in these areas is not expected in the near future and the current level of functionality is sufficient for global implementations. As there is no option as the best system, the integration of these various systems should be the first goal. The exchange points, Virtual Merchant and Virtual Client concepts should be the priority number one for studies that will be following on.

## **9. Appendix**

### **Internet Sources**

*<http://www.fv.com/>* The home page of the First Virtual system.

*<http://www.commerce.net/>* The home page of CommerceNet, a non-profit consortium that is creating protocols for secure Web usage.

*<http://www.digicash.com/>* The home page of Digicash.

*<http://www.zurich.ibm.ch/Technology/Security/sirene/projects/cate/index.html>* CAFE (Conditional Access For Europe) is a European coalition of companies and universities developing portable electronic wallets.

*<http://www.cybercash.com/>* The home page for CyberCash.

*<http://www.ini.cmu.edu:80/netbill/>* The NetBill is a project of the information Networking Institute at Carnegie-Mellon University.

*<http://nii-server.isi.edu/info/NetCheque/>* The home page of the NetCheque system developed at the Information Sciences Institute and the University of Southern California.

*<http://www.openmarket.com/about/technical/payment/>* Open Market page describing its payment system.

*<http://www.u-net.com/gmlets/>* The home page of LET system that runs Manchester Money.

*<http://www.netchex.com/>* The home page of NetChex.

*<http://www.cts.com/>* The home page for CTSNET's marketplace.

*<http://www.amazon.com/>* The home page for online bookstore that accepts various payment options.

*<http://www.cdnow.com/>* The home page for online music store.

## **10. References**

- [ACG84] W. Alexi, B. Chor, O. Goldreich, and C.P. Schnorr. RSA and Rabin functions: Certain parts are as hard as the whole. *SIAM Journal of Computing*, October 1984.
- [APACS94] Association for Payment Clearing Services (APACS) (1994). Annual report, p. 28.
- [BIS94] BIS Strategic Decisions (1994). Projected growth of the U.S. home shopping industry. Interactive Consumer Media & Electronics.
- [BLA79] G.R. Blakley. Safeguarding cryptographic keys. AFIPS Conference Proceedings,49. 1979
- [BS91] E. Biham, A.Shamir. Differential cryptanalysis of DES like crypto-systems. *Advances in Cryptology - CRYPTO 90 Proceedings*, Springer - Verlag, 1991
- [BT95] Banking Technology (1995, March 25). The next generation - Internet.
- [CC96] CyberCash System, 1996  
<<http://www.cybercash.com/cybercash/about/index.html>>
- [CEG88] D.Chaum, J.H.Everste, J.V.Graff Demonstrating possession of a discrete algorithm without revealing it - *Advances in Cryptology - EUROCRYPT 87*, Berlin 1988, p 127-141
- [Cha83] D. Chaum. Blind signatures for untraceable payments. In *Advances in Cryptology: Proceedings of Crypto 82*. Plenum Press, 1983
- [Cha85] D.Chaum. Security without identification: Transaction systems to make big brother obsolete. *Communications of the ACM*, October 1985.
- [Cha88a] D. Chaum. Blind signature systems. U.S. Patent #4,759,063, July 1988.
- [Cha88b] D.Chaum. Blinding for unanticipated signatures. In *Advances in Cryptology - EUROCRYPT '87 Proceedings*. Springer-Verlag, 1988
- [Cha92] D.Chaum. Achieving electronic privacy. *Scientific American*, August 1992
- [Cho94] Chown, J. F. (1994). A history of money from AD 800. London : Routledge, pp 3-41.
- [Cro94] Cronin, M. J. (1994). Doing business on the Internet - How the electronic highway is transforming American companies. New York : Van Nostrand Reinhold.

[Dav82] G. Davida. *Chosen signature cryptanalysis of the RSA public key cryptosystem*. Technical Report TR-CS-82-2, Department of EECS, University of Wisconsin, Milwaukee, 1982.

[DO86] Y. Desmedt and A.M. Odlyzko. A chosen text attack on the RSA cryptosystem and some discrete logarithm schemes. In *Advances in Cryptology — Crypto '85*, pages 516–522, Springer-Verlag, 1986.

[EC97] E-Cash, Digicash Inc. 1997 <<http://www.digicash.com/ecash/ecash-home.html>>

[EDI96] The EDI Standards <<http://www.premenos.com/standards/>>

[Emm90] Margaret A. Emmelhainz. *Electronic Data Interchange: A Total Management Guide*. Van Nostrand Reinhold, New York, 1990

[FRB94] Federal Reserve Bulletin (1994), Vol 80 No. 4.

[FT94a] Financial Times (1994, September 13). International Capital Markets.

[FT94b] Financial Times (1994, October 13). World Trade News: Taking the paper out of trade - The quest for more efficient commerce.

[FT94c] Financial Times (1994, November 15). Survey of Computers in Finance .

[FT94d] Financial Times (1994, June 6). Media Futures: Doing cyber business -

[FT94e] Financial Times (1994, October 26). Survey of Technology in the Office

[FT94f] Financial Times (1994, June 28). Survey of Computer Networking

[FT94g] Financial Times (1994, November 29). Survey of Global Custody

[FT94h] Financial Times (1994, November 15). Survey of Computers in Finance

[FT94i] Financial Times (1994, September 13). International Capital Markets

[FT94j] Financial Times (1994, October 9). What to do when chaps can't cope: Reform of UK Bank settlements procedures aims to reduce risk to the financial system.

[FT94k] Financial Times (1994, October 13). World Trade News: Taking the paper out of trade - The quest for more efficient commerce.

[FT94l] Financial Times (1994, November 29). Survey of Global Custody : Getting the right message across.

[FT94m] Financial Times (1994, November 29). Survey of Global Custody: Oil for the world's investment machinery.

- [FT94n] Financial Times (1994, August 8). Economics Notebook: Payments and settlements.
- [FT95] Financial Times (1995, November 15). Survey of Computers in Finance.
- [FV96] First Virtual System, <<http://www.fv.com/demo/>>
- [Has88] J. Hastad. Solving simultaneous modular equations of low degree. *SIAM Journal of Computing*, 17: 336–241, 1988.
- [Hic95] K.E.B. Hickman. The SSL Protocol. December 1995. <<http://www.netscape.com/newsref/std/ssl.html>>
- [IKPP97] Internet Keyed Payment Protocols, 1997 <<http://www.zurich.ibm.com/Technology/Security/extern/ecommerce/iKP.html>>
- [Kal92] B.S. Kaliski. The MD-2 message digest algorithm. Technical report, RSA laboratories. Inc, April 1992
- [Kee95] L. Keeler. . CyberMarketing. AMACOM, 1995.
- [Ker97] Kerberos: The Network Authentication Protocol. <http://web.mit.edu/kerberos/www/>
- [KR95] B.S. Kaliski Jr. and M.J.B. Robshaw. The secure use of RSA. *CryptoBytes*, 1(3): 7–13, 1995.
- [KWY94] Knudson, S. E, Walton II, J. K, & Young, F. M. (1994). Business-to-business payments and the role of financial electronic data interchange. *Federal Reserve Bulletin* Vol 80, No. 4, pp 269-278.
- [Ley93] Valerie A. Leyland. *Electronic Data Interchange: A Management View*. Prentice-Hall, New York, 1993.
- [Lin94] Lindsey, I. (1994). *Credit cards - The authoritative guide to credit and payment cards*. London : Rushmere Wynne.
- [Mat97] M. Mathiesen. *Marketing on the Internet*. Maximum Press, 1997.
- [MDX97] Mondex Technology, 1997 <<http://www.mondex.com/mondex/cgi-bin/printpage.pl?english+global&technology.html>>
- [NB97] About Net Bill, <<http://www.netbill.com/netbill/about.html>>
- [NIS92] NIST. Proposed Federal Information Processing Standard for Secure Hash Standard. *Federal Register*, 57(21), January 1992
- [NIS93] National Institute of Standards and Technology. FIPS Publication 180: Secure Hash Standard (SHS). May 1993.

- [Pre93] B. Preeneel. Analysis and Design of Cryptographic Hash Functions. Ph.D Thesis, Katholieke University, Leuven, 1993
- [Riv91] R.Rivest. The MD-4 message digest algorithm. In *Advances in Cryptology-CRYPTO '90 Proceedings*. Springer-Verlag, 1991
- [Riv92] R.Rivest. The MD-5 message digest algorithm. Technical Report RFC 1321, RSA Data Security, Inc. April 1992
- [Rob90] Roberts, J. \$1000 billion a day - Inside the foreign exchange markets. London : Harper Collins, 1990.
- [Rob94] M.J.B. RobShaw. MD2, MD4, MD5, SHA and other hash functions. Technical Report TR-101, RSA Laboratories, July 1994
- [RS95] E. Rescorla, A. Schiffman. The Secure HyperText Transfer Protocol. Internet-Draft, July 1995.
- [RSA97] Cryptology Frequently Asked Questions.  
<<http://www.rsa.com/rsalabs/LABSFAQ.PDF>>
- [SC97a] SmartCards  
<<http://ctl77.nectec.or.th/~nopporn/smartcard/whatsmartcard.html>>
- [SC97b] SmartCard Technology <<http://www.smartcard.co.uk/technology.html>>
- [SET97] Secure Electronic Transactions, May 1997  
<<http://www.mastercard.com/set/set.htm>>
- [Sha79] A. Shamir. How to Share a secret. *Communications of the ACM*, 22, 1979
- [TE91] The Economist (1991, June 29). Plastic community: European payment cards.
- [TE92a] The Economist (1992, November 7). European payment systems
- [TE92b] The Economist (1992, October 17). Hand over the money: Central bankers want to bring payment systems closer
- [TE93] The Economist (1993, September 11). The future surveyed: The challenge of global money
- [TE94b] The Economist (1994, November 26). Electronic money:
- [TE94] The Economist (1994, March 26). Bankers Trust's 2020 vision
- [Win84] R.S. Winternitz. Producing one way hash functions built from DES. *Advances in Cryptology: Proceedings of Crypto 83*.