Intelligent Agents Based Virtually-Defaultless Check System: SafeCheck System

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Abstract

Issuing a paper checkbook with multiple sheets implies that the authorization is required once for each checkbook at the risk of default due to the missed authorization for each check sheet issuance. However, the check system is an inexpensive way of payment in the high-credit business environment. To complement the defect of missed authorization on the likely-to-be-defaulted check issuance in the paper check system, we devised an agent based electronic check system which can monitor the situation and block the non-allowable check issuance in a distributed manner. The type of allowable service may be adjusted depending upon the check issuer's credibility. To the top credit class, authorization will be required only for each checkbook issuance with distributed monitoring. The second level credit class requires authorization for each check issuance. The third level credit class are allowed to issue checks only within the balance in the check account. The credit level can be dynamically adjusted by the bank depending upon the record of default. To implement such an electronic check system on the Internet, we have designed the SafeCheck System which is composed of three agents: Checkbook Agent at check issuer site, Check-receipt Agent at check receiver site, and Bank's Control Agents at the check issuer's and receiver's banks respectively. For security purpose, SafeCheck has adopted the public key cryptography, digital signature, and certificate schemes just like the SET protocol for the credit card. The essence of a checkbook agent may be stored in the IC card.

Keywords:

Electronic Check Payment; Default Risk; Intelligent Agent; Security

1. Introduction

With the rapid expansion of Electronic Commerce (EC) over the Internet [16][24][33], electronic payment systems have become more and more necessary. Thus, a number of researches are underway for the development of secure and efficient electronic payment systems [6][24][34]. Currently, the most popular payment methods for consumer electronic ordering on the Internet are credit card, electronic fund transfer, and electronic check. Major concern at this stage is security, and the SET protocol [28] is gaining its popularity. Nevertheless, the paper checks are still popular in the U.S.A. for business and personal payments as in Figure 1, and the total payment amount by check is still growing [20]. As the portion of business-to-business EC grows, the electronic check system will become more important.

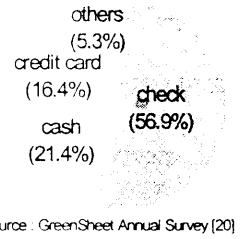


Figure 1. Consumer Spending Ratio in USA at 1996

There have been several attempts at building an electronic version of the paper check system. However, it turns out that the mere electronic version of a paper check system is very similar to the electronic fund transfer (EFT) or credit card system. The electronic check system becomes similar to EFT because the payee's presentment of checks to the payee's bank and the check clearing request by the payee's bank to the payer's bank can be executed electronically almost at the time of check issuance. This implies that the merit of overdraft check issuance is no longer possible, which is bad news from the payer's cash-flow point of view. If the clearing date is institutionally fixed to keep the benefit of credit, the role of electronic check becomes similar to the credit card system. However, a fundamental difference can be left depending upon the frequency of payment authorization. While the credit card system requires an authorization for each payment transaction, the check payment systems can give the authorization by a checkbook level according to the tradition of the paper check system. This means the check system requires less authorization effort at the risk of default.

In the paper check system, the payee cannot check the balance of the payer's checking account, which is necessary to estimate the risk of default, and the payer's bank cannot recognize the bad intentional check issuance until such checks are returned from the payee's side. The only way for a payee to avoid the default risk completely is receiving only the certified checks. But this restriction means a rigid service.

The good news with the electronic check system is that

both the payee and payer's banks can control the relevant information in the payer's electronic checkbook in a distributed manner to avoid abuse of the checkbook. This idea can be realized by adopting the electronic checkbook agent which has dynamic self-control and timely electronic inquiry capability to the control agents at banks. This kind of distributed control capability can reduce the risk of default in advance without an astronomical explosion of authorization effort. Since the default risk can be reduced significantly by using this approach, it will become economically feasible to design a default-risk-free check system probably without any significant extra fee to the payers. An affordable level of risk penalty may be charged to the payers because most of the serious default can be avoided in advance, or the payer bank may bear the default losses in compensation for the increased revenue owing to the payee's preference. There must be several administrative schemes in compensating for the minor default losses inherent in the payer's bank side. This is a matter of the bank's managerial policy.

In this research, we design *an electronic check system which can capture the advantage of the paper check (allow the overdraft issuance within a designated limit from the payer's point of view), reduce or eliminate the disadvantage of the paper check (eliminate the default risk from the payee's point of view), and reduce the authorization cost of the credit card system which should take place for every payment.* This can be regarded as a new electronic payment system which can be default-risk-free to the payees and more economical than the credit card systems. This system may be widely accepted by high-credit individuals and business community.

Let us call the proposed electronic check system *SafeCheck*. *SafeCheck* consists of three agents: *Checkbook Agent* at the payer site, *Check-Receipt Agent* at the payee site, and *Bank's Control Agent* at the payer's and payee's bank sites respectively. We need to design the architecture of these agents, messages between agents, and protocol to maintain consistency among agents with the minimum effort of communication. In addition, we need to consider such security issues on the Internet as encryption, non-repudiation, and IC card based authentication.

2. Types of Electronic Payment Systems

2.1. Classification of Electronic Payment Systems

Four typical electronic payment systems that are currently available on the Internet are electronic cash, electronic fund transfer, credit card and electronic check. Typical features that distinguish these systems are anonymity of payer and payee, level of default risk to payee, permission of credit to payer, and issuance authorization frequency as contrasted in Table 1. According to the characteristics of these attributes, electronic payment systems can be classified as shown in Table 1.

(1) Electronic Cash

In most electronic cash systems, the electronic cash can be transferred from the payer's credit card or checking account to the payer's electronic wallet and vice versa. So the received electronic cash has the value of real cash without any default risk. CyberCoin [8] provides such service on the Internet. Most IC card based electronic wallets like VisaCash [46] adopt this "closed" procedure, but so far the

Table 1. Types of Electronic Payment Systems

Attributes	Electronic Cash	Electronic Fund Transfer	Credit Card	Electronic Check	Agent Based Check: SafeCheck
Anonymity of payer and payee	Anonymous	Onymous	Onymous	Onymous	Onymous
Default risk to payee	Risk free	Risk free	Risk free	Risky (unless certified check)	Virtually risk free with the complementary administrative treatment
Permission of credit	Not allowed	Not allowed	Allowed	Allowed	Allowed
Issuance authorization frequency	Self-check the availability of cash in the wallet for every payment	Once for every payment	Once for every payment	In principle, once for every checkbook (A variation is to authorize for every check issuance.)	Once for every checkbook if credible (The level of credibility can be dynamically adjusted.)
Available systems	Ecash[11], NetCash[29], CyberCoin[8], Modex[30], VisaCash[46]	SFNB's QuickPay[39]	CyberCash[7], SET protocol[28]	FSTC's Electronic Check[18], NetCheque[34], VirtualPin[14], NetBill[5], PayNow[9], NetChex[31]	SafeCheck

network for transmission is not the Internet yet although there are movements toward using the Internet. However, Mondex [30] adopts the "open system" which allows the direct transfer between electronic wallets without intervention of bank's account.

(2) Electronic Fund Transfer

The Electronic Fund Transfer (EFT) has been a popular service for several decades on the non-Internet network. Now the EFT service is attempted on the Internet. The QuickPay of SFNB (Security First Network Bank) can be classified as an Internet based electronic fund transfer service [39]. QuickPay has also a complementary paper check feature in case the payee is not equipped with the electronic facility. However this certified check is different from the regular checks in a sense that the amount will be deducted from the payer's account at the time of issuance.

(3) Credit Card

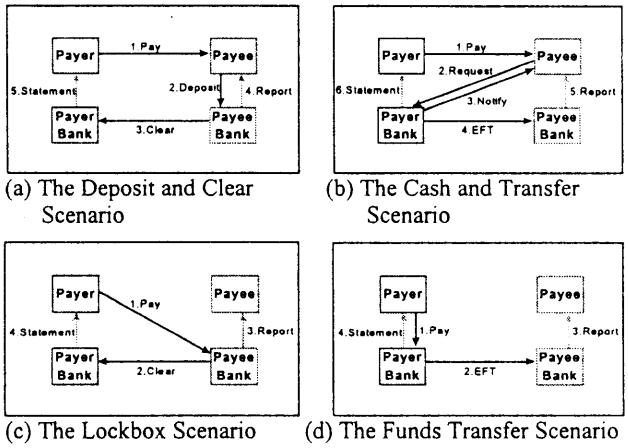
The most popular electronic payment for cybershopping is the credit card system which employs the Secure Socket Layer type encryption scheme [32]. Since the current scheme is not safe from masqueraded users, the SET (Secure Electronic Transaction) protocol, which is equipped with the public key encryption scheme along with the certificate, is proposed by Visa and MasterCard, and is gaining its popularity [28].

(4) Electronic Check

The electronic check is regarded as the mirror of the regular paper check. The FSTC (Financial Services Technology Consortium) project [18] has focused on the security issue by employing technologies like encryption, certification, and IC card for identification, and has proposed four scenarios of functional flows as depicted in Figure 2. We can see that the "Deposit and Clear Scenario" and "Cash and Transfer Scenario" that include the clearing process cannot be completely safe from the risk of default. The other two scenarios are actually the variations of electronic fund transfer, although they are classified as electronic checks. This illustrates the phenomenon of merging the electronic check with electronic fund transfer as mentioned earlier. Note that none of the scenarios has given sufficient attention to the reduction of authorization frequency yet. First Virtual's VirtualPin [14] takes an idiosyncratic variation from other traditional electronic check systems. The VirtualPin system automatically withdraws the issued amount from payer's account at the time the payer approves and deposits the withdrawn amount to the payee's account.

(5) SafeCheck System

As we can see from the table, the agent based SafeCheck System which we propose here is a new type of electronic payment that can avoid (at least reduce) the default risk from the payee's side, reduce the cost of authorization, and permit credit based payment. As mentioned earlier, the SafeCheck System consists of three types of agents: Checkbook, Check-receipt, and Bank's Control Agents as depicted in Figure 3. According to the classification of



(a) The Deposit and Clear Scenario (b) The Cash and Transfer Scenario

(c) The Lockbox Scenario (d) The Funds Transfer Scenario

Figure 2. Scenarios of Functional Flows for Electronic Checks [18]

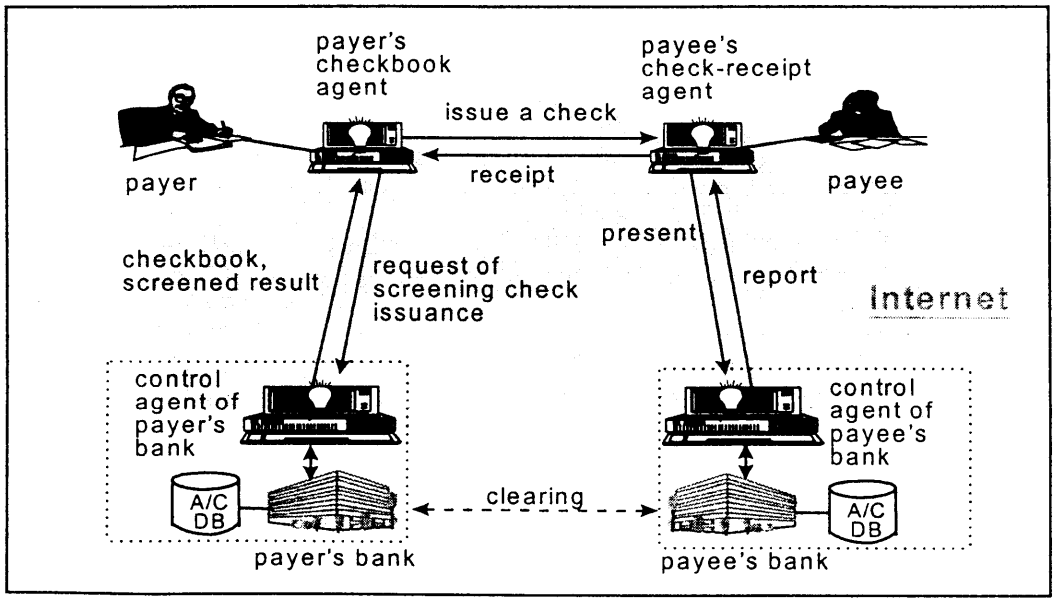


Figure 3. SafeCheck System Architecture

FSTC, the scenario of the SafeCheck System is basically the same as that of "Deposit and Clear".

2.2. Variations of Checks

A variety of variations may be derived from the typical four electronic payment systems. Particular variations from a regular check are the *certified check* and *crossed check*. The *certified check* is similar to the regular check except that its overdraft within a limit should be certified by the check issuer's (payer's) bank. The certification grounds may be a mortgage or the high-credit level of the issuer. The *crossed check* has a particular restriction on the receiving banks and/or purchasable goods. Note that we need a centralized clearing institution which has been essential for the efficient paper check exchanges among multiple banks. However, the centralized clearing service may not be necessary under the electronic check environment if the associated banks can transfer the clearing amount bilaterally on-line.

3. Architecture of Agents for SafeCheck

While there have been a variety of definitions about the intelligent agent [17][19][45], its commonly agreed attributes seem to be autonomy, communication ability, and reasoning and learning capability [17][35]. Intelligent agents are expected to be applicable to financial decisions such as personal banking, electronic payment, budgeting and so on [37].

In the SafeCheck system, each intelligent agent (let us call this SafeCheck Agent) is composed of problem solver and communication controller. In contrast to the traditional expert systems that have a single inference (or solution) engine, a SafeCheck Agent has a problem solving manager and communication controller as depicted in Figure 4. The SafeCheck Agents have adopted the concept of UNIK-AGENT [27]. Although the SafeCheck Agent for each participant (payer, payee, bank) has basically the same architecture, the bank's control agent is the most complex, and has the largest amount of knowledge and data.

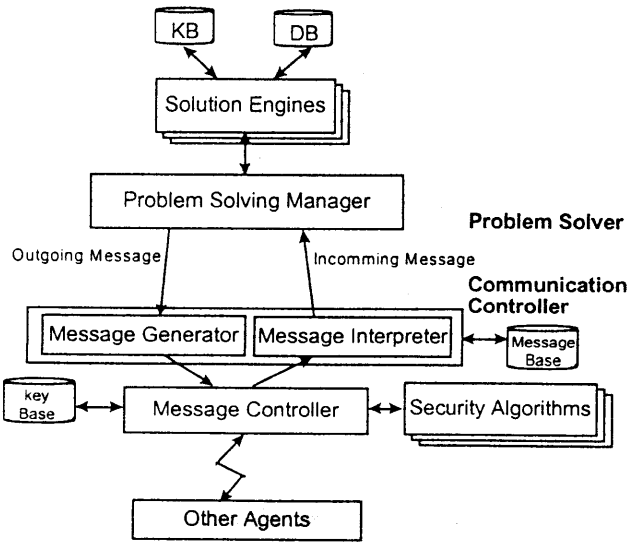
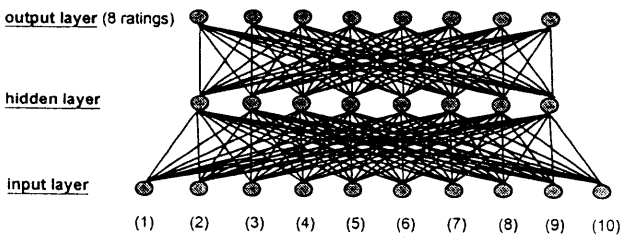


Figure 4. Architecture of SafeCheck Agent

3.1. Problem Solver

Problem solving manager and solution engines are the main components of the problem solver. Problem solving manager selects an adequate solution engine based on context and the received messages from human or other agents. Solution engines are a collection of a variety of problem solving methods such as data retrieval, knowledge based reasoning, neural network based estimation or classification, specific functions, and outgoing messages generation. Each agent may be equipped with different solution engines depending upon its role. So the domain-specific analysis for the design of solution engines and messages is essential in the first place. Nevertheless, the agent should be able to maintain a standard architecture to be compatible with additional solution engines, messages and data that may take place in the future.

For instance for the bank's control agent, a neural network model is adopted for the credit evaluation model as depicted in Figure 5. The adequacy of neural network models for credit evaluation is empirically studied in earlier studies [1][36][42][44]. The incoming message to this agent should include input data to this model, and the generated outgoing message must have utilized the output from the model. On the other hand for the checkbook agent, a rule-based system along with functions is adopted for the decisions concerning overdraft check issuance [4][38][40]. In this manner, the key roles, solution engines, and the origin/destination of messages of each agent are designed as Table 2.



(1) average balance of saving accounts for recent 3 months
(2) holding period of saving account
(3) kind of credit card possessed
(4) period of wage or pension transfer to the saving account
(5) yearly amount of public charges from saving account
(6) yearly amount of property tax in the recent year
(7) length of time working at current job
(8) current-year monthly wage or pension
(9) applicant age
(10) single, marriage or number in family

Figure 5. A Neural Network Model for Credit Scoring

3.2. Communication Controller

Communication controller is composed of Incoming Message Interpreter, Outgoing Message Generator, Message Controller, and Security Algorithms. The message interpreter interprets and validates incoming messages and initiates the problem solving procedure. The message generator generates outgoing messages that are appropriate to other agents and relevant human. Message Controller transmits or receives the encrypted messages through

Table 2. Solution Engines for SafeCheck Agents

Agents	Key Roles	Solution Engines	Origin or Destination of Messages
Checkbook Agent	Request the opening of a checking account or blank check sheets	Generate outgoing message for check account opening and blank check request	Bank Control Agent
	Confirm legitimacy of the issuing check	Rule-based checking	
	- If the check is legitimate, issue a check.	Generate outgoing check message	Check-receipt Agent
	- Otherwise, hold the issuance and report to the bank's control agent.	Generate a message that explains the check cannot be issued and send it with record of issued checks	Bank Control Agent
	- If the credit level is not high enough, request the authorization for each issuance.	Generate outgoing check message for issuance authorization	Bank Control Agent
	Receive a message about rule based model	Modify the rule based model	Bank Control Agent
	Keep the record of issued checks	Append or update to internal database	Bank Control Agent
Check-receipt Agent	Check the legitimacy of received checks and return receipt	Rule-based checking and receipt generation	Checkbook Agent
	Present the paid checks	Generate outgoing message for check deposit	Bank Control Agent
	Receive a message about rule based model	Modify the rule based model	Bank Control Agent
	Keep the record of paid checks	Append or update to internal database	Bank Control Agent
Bank Control Agent	Decide the opening of a checking account and inform the result	Rule-based decision with appraisal formula and generation of message with digital certificate	Checkbook Agent
	Credit scoring of a checking account	Neural network-based credit scoring	Checkbook Agent
	Decide credit limit of each account and notify	A numerical function and message generation	Checkbook Agent
	Change checking account modality with a new digital certificate or suspension	Rule-based changing of checking account modality	Checkbook Agent
	Decide number of blank check sheets and limit	A formula and message generation	Checkbook Agent
	Urgent blocking of the check issuance	Generate outgoing message according to the alert from user or other systems	Checkbook Agent
	Authorize the issuance for lower credit customer	Rule-based authorization using bank's database	Checkbook Agent
	Update account balances for cleared checks and report periodically including non-electronic withdrawals	Clearing process with other systems	Checkbook Agent, Check-receipt Agent
	Send messages about rule modification	Generate outgoing messages for updating rules	Checkbook Agent, Check-receipt Agent
	Send digital certificates to customer agents	Generate outgoing message of digital certificate	Checkbook Agent, Check-receipt Agent

TCP/IP or X.25 protocols using an appropriate security protocol as described in section 5.

4. Multi-leveled Default Prevention Facility

The checkbook agent actually prevents the issuance of a risky check according to the rules in the agent. However, the rules are updated by the models in the bank's control agent. The rules include not only the level of overdraft limit, but also the type of allowed services depending upon the level of credit. The checking account in SafeCheck can have one of the following three modalities which may be adjusted dynamically depending upon the credit level.

(1) Customers in the highest credit category (for example, 'AAA', 'AA' or 'A' levels in Standard & Poor's ratings [41]) will be qualified for the issuance of overdraft. This implies that the authorization for a check issuance will be asked only for each checkbook, not for each sheet. During the check issuance of an allowed checkbook, only extraordinary issuance may be blocked by the rules in the checkbook agent. The overdraft limit may be adjusted depending upon the credit level within this category. The fee for this service will be much lower than the credit card and electronic fund transfer.

(2) If the customer's credit level is not high enough to qualify for the checkbook, such a customer's check is

required to get authorization for each check sheet issuance. In this sense, this procedure becomes the same as that of *credit card*, and the fee for this service may be adjusted to the level of credit card service. A difference from the conventional credit card system is that the fee is not charged to the paid vendor, but the paying check issuer.

(3) If the customer's credit level is not even high enough to qualify for the credit-based issuance, the check can be issued only if a positive balance remains in the account, and the amount cannot exceed the balance. In this sense, this check becomes the same as *debit card* (actually the same as the electronic fund transfer) or *certified check* whose ground is the positive balance. This service may not cause the transaction cost to be higher than the credit card service, however the fee may be charged higher as a penalty for low credit to motivate the recovery of the credit.

Judging from the feature of dynamically adjustable service levels, SafeCheck can be regarded as a flexible and adaptive payment method which seeks the minimal payment transaction cost and maximal credit allowance without shifting the default risk to payees.

5. Messages among Agents

5.1. Message Composition

Conventionally, Financial Electronic Data Interchange (FEDI) can be used to exchange messages for authorization, receipt of payment, and documents for clearing [15]. However FEDI is not sufficiently commercialized yet on the Internet [15], and Interactive EDI [22] for independent payment participants in the open network is in an embryonic stage. What FEDI has sought is the efficiency and compatibility of communication. In the meantime, the agent community has developed the agent communication language like KQML (Knowledge Query and Manipulation Language) which pursues a richer expressiveness. So the agent communication language can be regarded as a frame of logical expressions between agents, while FEDI is a format for efficient physical transmission. In this sense, the FEDI engine needs to be equipped with the facility of transforming the KQML message to FEDI. However, during the research stage, the KQML message may be exchanged without transformation. Instead, we need to take the security into consideration.

To ensure security, we have adopted the schemes used in the SET protocol [28]: public key cryptography, digital signature, and certificates [3][28]. In this context, the bank's control agent needs to play the role of Certificate Authority (CA) for payers and payees, and the certificate may be stored in the checkbook and check-receipt agents. Upper level CA may endorse the banks. Let us call the checks which adopt the SET-like security scheme SET-Checks. In this regard, SafeCheck can be a SET-Check.

In the SafeCheck System, KQML is adopted as the outer language, and the message is composed of three layers to be specific to electronic check system as depicted in Figure 6: Agent Communication Language (ACL), Security and Check layers. The *ACL layer* consists of the performative

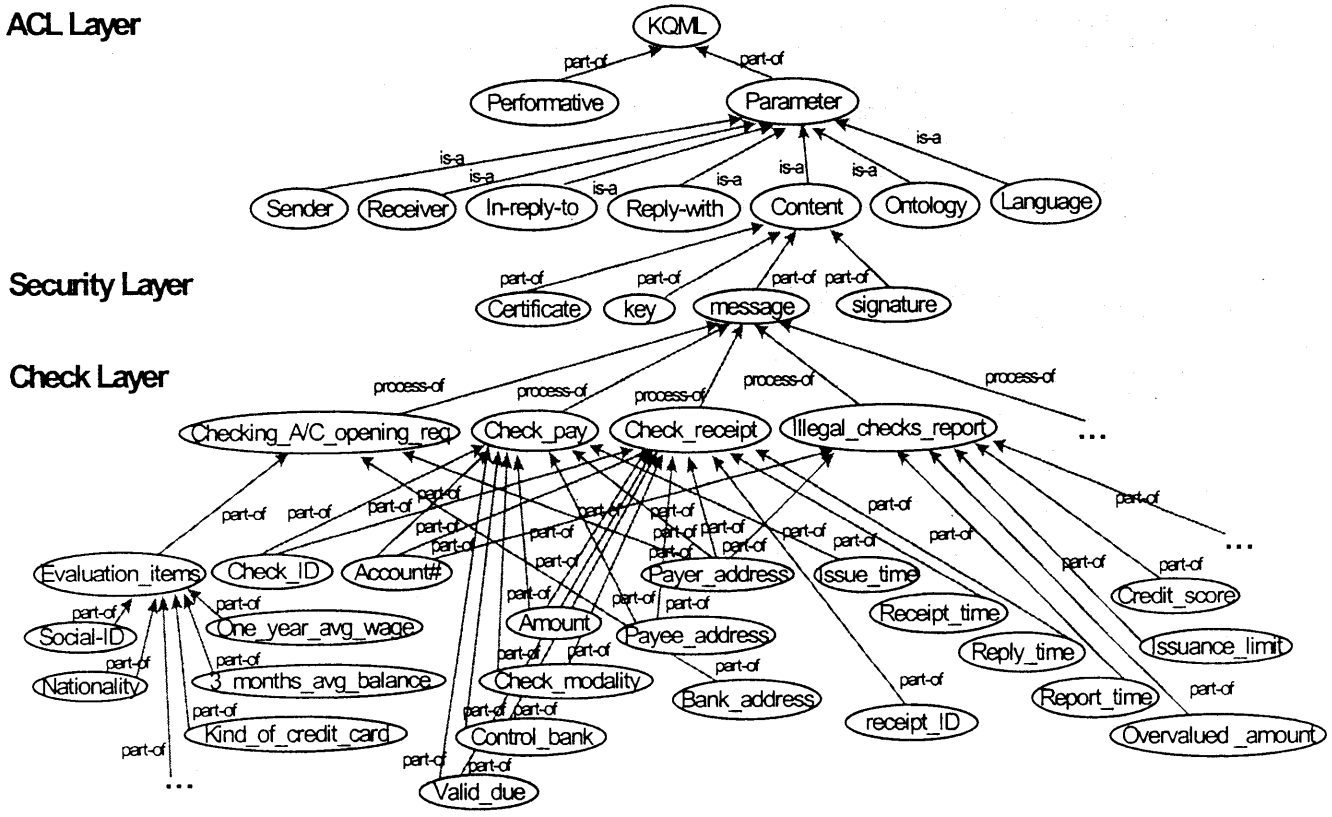


Figure 6. Message Layers in SafeCheck

and its parameters independently of domain. To prevent a wiretap, the message IDs in the parameters of ":in-reply-to" and ":reply-with" are encrypted with the receiver's public key.

The *Security Layer* is arranged in the parameter *content* to include the features for SET-Check as follows.

(message	<*encrypted-message-content*>)
(key	<*encrypted-key*>)
(certificate	<*own-certificate*> <*CA-certificate*>)
(signature	<*digital-signature*>)

The <*encrypted-message-content*> in the message statement includes the message in the Check Layer encrypted by a symmetric algorithm like DES. The component "key" contains a symmetric key encrypted by RSA (Ravist-Shamir-Adelman) algorithm. The "certificate" carries certificates of the sender and its certificate authority. The <*digital-signature*> is the encrypted hash of the message in the Check Layer, and uses a hash algorithm like MD5 and sender's private key.

The *Check Layer* defines the items specific to checks like checking account opening request, check payment and so on. The messages for electronic check issuance include the components depicted in Figure 6. An illustrative three layered message for check issuance is demonstrated in Figure 7.

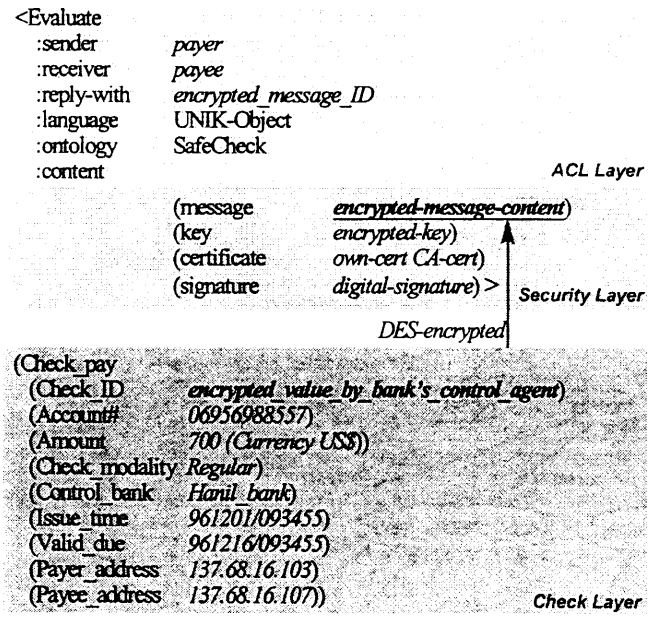


Figure 7. An Example of Message for Check Issuance

5.2. Message Exchange and Security

Between SafeCheck Agents, messages in KQML form are exchanged through TCP/IP communication protocol. Two performatives like "Evaluate" and "Reply" are basically adopted. "Evaluate" is used by the sending agent, while "Reply" by the receiving agent to confirm the receipt of messages.

Security requirements like integrity, confidentiality and authentication can be satisfied by the security layer. Non-repudiation can also be guaranteed by keeping the sender's digital signature and received message. Especially to identify the origin of checks and to prevent its forgery, the Check Layer has the "Check-ID" which contains the concatenation of encrypted check identification with the public key and digital signature of check issuer's bank.

6. Conclusion

In this paper, we proposed a virtually defaultless electronic check system using three kinds of intelligent agents: checkbook agent at check issuer site, check-receipt agent at check receiver site, and bank's control agents at the check issuer's and receiver's banks respectively. Owing to the checkbook agent's autonomous monitoring capability, ill-intentioned check issuances can be prevented in advance. Bank's control agent may adjust the rules in the checkbook agent depending upon the customer's credit level.

To the top credit class, authorization is required only for each checkbook issuance with the complement of distributed monitoring. Overdraft is allowed and the fee for payment for this class is lower than the credit card, so this service is appropriate for business-to-business electronic commerce. However, the second-level credit class is required to get authorization for each check issuance, and the third-level credit class is allowed to issue checks only within the balance in the check account. The customer's credit level is designed to be dynamically adjustable by the neural network model in the bank's control agent.

To implement the SafeCheck System in a secure way, the schemes used in the SET protocol are adopted. By allowing to store the essence of the checkbook agent in the IC card, the system can be most safely deployed.

Since the SafeCheck System can protect bad defaults, commercial banks can utilize this system without imposing any risk of default on the payee's side. A minor default loss may be charged to the lower credit payers as a penalty fee, or may be absorbed by the increased revenues owing to the payee's preference.

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