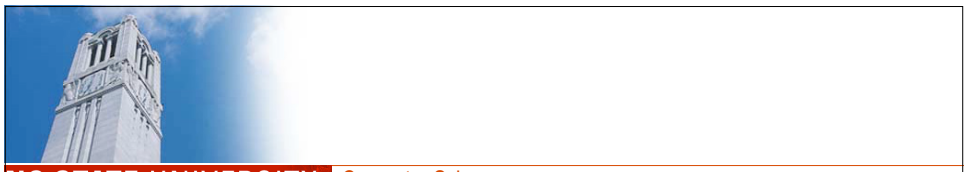


NC STATE UNIVERSITY Computer Science

CSC 774 -- Network Security

Topic 4.1: NetBill

Outline

- Why is NetBill developed?
- NetBill Transaction Model
- NetBill Transaction Protocol
  - Basic Protocol
  - Optimizations for zero-priced goods
- Failure Analysis

E-Commerce over the Internet

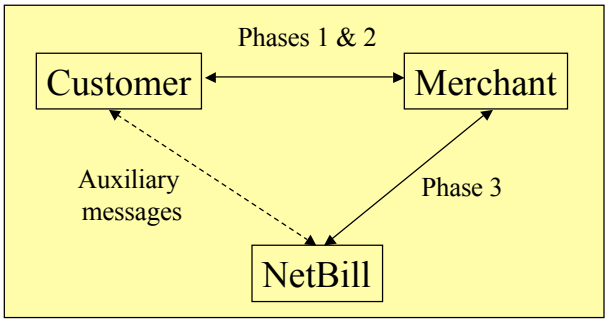
- Internet is attractive for e-commerce
  - Search for suppliers
  - Price negotiation
  - Ordering
  - Payment for goods
  - Delivery of information goods
    - Software, electronic books, etc.
- Challenges
  - No easily identifiable places of business
  - Transactions are subject to observation by their parties
  - Privacy

NetBill

- NetBill is a system developed to facilitate selling and delivery of low-priced information goods over the Internet.
  - Maintain accounts for customers as well as merchants, which are linked to banks
  - Transfer information goods from merchant to customer
  - Transfer money from customer's account to merchant's account.
  - Combine small transactions into larger conventional transactions, reducing transaction cost.

NetBill Transaction Model

- Three phases
  - Phase 1: Price negotiation
  - Phase 2: Goods delivery
  - Phase 3: Payment



NetBill Transaction Objectives

- Only authorized customers can charge against a NetBill account
- The customer and merchant must agree on the purchase item and the price
- A customer can optionally protect her identity from merchants
- Customers and merchants are provided with proof of transaction results from NetBill
- There is a negotiation phase between customer and merchant
- A customer may present credentials identifying her for special treatment
- A customer receives the goods if and only if she is charged for the goods
- A customer may need approval from a fourth party before the NetBill server will allow a transaction.
- The privacy and integrity of communications is protected from observation or alteration by external parties.

NetBill Transaction Protocol

- The basic protocol
  - Phase 1: price negotiation
    - C ⇒ M: price request
    - M ⇒ C: price quote
  - Phase 2: goods delivery
    - C ⇒ M: goods request
    - M ⇒ C: goods, encrypted with a key K
  - Phase 3: payment
    - C ⇒ M: signed electronic payment order (EPO)
    - M ⇒ N: endorsed EPO (including K)
    - N ⇒ M: signed result (including K)
    - M ⇒ C: signed result (including K)

Notations

- $T_{XY}(Id)$: Kerberos ticket proving to Y that X is named by Id, and establish a session key XY shared between them.
- $CC(M)$: cryptographic checksum of M.
- $E_K(M)$: M encrypted using key K.
- $E_{X\text{-}PUB}(M)$: M encrypted using X's RSA public key.
- $E_{X\text{-}Pri}(M)$: M signed using X's RSA private key.
- $[M]_X$: M signed (with RSA) and timestamped by X.
- $[M]_{X\text{-}DSA}$: M signed and timestamped by X with DSA.
- $\{M\}^X$: M encrypted for X using RSA.

The Price Request Phase

1. C ⇒ M: T_{CM}(Id), E_{CM}(Credentials, PRD, Bid, RequestFlags, TID)
2. M ⇒ C: E_{CM}(ProductID, Price, RequestFlags, TID)

- T_{CM}(Id): prove the identity of the customer
- Credentials: establish the customer's membership
- PRD: product description
- RequestFlags:
  - Message 1: request for the disposition of the transaction (e.g., Delivery method)
  - Message 2: merchant's response to customer's request
- TID:
  - Message 1: if this is a repeated request
  - Message 2: if this is not supplied by the customer

The Goods Delivery Phase

3. C ⇒ M: T_{CM}(Id), E_{CM}(TID)
4. M ⇒ C: E_K(Goods), E_{CM}(CC(E_K(Goods)), EPOID)

- M sends to C
  - An encrypted version of the goods
  - The cryptographic checksum of the encrypted goods
  - EPOID: electronic purchase order ID.
    - Merchant ID + a timestamp (delivery time) + a serial number
- Intuition:
  - Reduce the transaction to a fair exchange of K and the payment from C.
  - This fair exchange depends on the NetBill server.

The Payment Phase

5. C ⇒ M: T_{CM}(Id), E_{CM}([EPO]$_C$)

- EPO consists of
  - Clear part:
    - C's ID, Product ID, Price, M's ID
    - CC(E_K(Goods)), CC(PRD), CC(CAcct, AcctVN)
    - EPOID
  - Encrypted part:
    - T_{CN}(TrueID)
    - E_{CN}(Authorization, CAcct, AcctVN, Cmemo)

The Payment Phase (Cont'd)

6. M ⇒ N: T_{MN}(M), E_{MN}([[EPO]$_C$, MAcct, MMemo, K]$_M$)

- The merchant endorse and submit the EPO
  - MAcct: Merchant's NetBill account
  - MMemo: merchant's memo field
  - K: the key used to deliver the goods
- Point of no return
  - The merchant cannot reverse the transaction.

The Payment Phase (Cont'd)

7. $N \Rightarrow M: E_{MN}([Receipt]_{N\text{-}DSA}, E_{CN}(EPOID, CAcct, Bal, Flags))$

- The NetBill server makes decision based on verification of
  - The signatures
  - Privileges of the users involved
  - Customer's account balance
  - Uniqueness and freshness of the EPOID
- Receipt
  - Result, Identity, Price, ProductID, M, K, EPOID
  - The signed receipt certifies the transaction

The Payment Phase (Cont'd)

8. $M \Rightarrow C: E_{CM}([Receipt]_{N\text{-}DSA}, E_{CN}(EPOID, CAcct, Bal, Flags))$

- Merchant forwards NetBill server's response to customer
  - M needs to decrypt and re-encrypt

Status Query Exchange

- Needed when there is communication failure

The merchant requests the transaction status from NetBill

1. M ⇒ N: T_{MN}(M), E_{MN}(EPOID)
2. N ⇒ M: E_{MN}([Receipt]$_{N\text{-}DSA}$, E_{CN}(EPOID, CAcct, Bal, Flags))

The customer requests the transaction status from the merchant

1. C ⇒ M: T_{CM}(Id), E_{CM}(EPOID)
2. M ⇒ C: E_{CM}([Receipt]$_{N\text{-}DSA}$, E_{CN}(EPOID, CAcct, Bal, Flags))

Status Query Exchange (Cont'd)

The customer requests the transaction status from NetBill

1. C ⇒ N: T_{CN}(TrueId), E_{CN}(EPOID)
2. N ⇒ C: E_{CN}([Receipt]$_{N\text{-}DSA}$, E_{CN}(EPOID, CAcct, Bal, Flags))

The customer requests the transaction status from the merchant for a non-NetBill transaction

1. C ⇒ M: T_{CM}(Id), E_{CM}(EPOID)
2. M ⇒ C: E_{CM}(Result, K)

Zero-Priced Goods

- Protocol can be simplified
- Four variations
  - Type indicated in *RequestFlags* in the price request message
  - Zero-price certified delivery
  - Certified delivery without NetBill server
  - Verified delivery
  - Unverified delivery

Zero-Price Certified Delivery

1.	C ⟹ M	T_{CM}(Identity), E_{CM}(Credentials, PRD, Bid, RequestFlags, TID)
2/4.	M ⟹ C	E_{CM}(ProductID, Price(=0), RequestFlags, TID), E_K(Goods), E_{CM}(CC(E_K(Goods)), EPOID)
5.	C ⟹ M	T_{CM}(Identity), E_{CM}([EPO]$_C$)
6.	M ⟹ N	T_{MN}(M), E_{MN}([[EPO]$_C$, MAcct, MMemo, K]$_M$)
7.	N ⟹ M	E_{MN}([Receipt]$_{N\text{-}DSA}$, E_{CN}(EPOID, CAcct, Bal, Flags))
8.	M ⟹ C	E_{CM}([Receipt]$_{N\text{-}DSA}$, E_{CN}(EPOID, CAcct, Bal, Flags))

Price negotiation can be omitted.

But delivery must be certified by NetBill.

Certified Delivery without NetBill

1.	C ⟹ M	T_{CM}(Identity), E_{CM}(Credentials, PRD, Bid, RequestFlags, TID)
2/4.	M ⟹ C	E_{CM}(ProductID, Price(=0), RequestFlags, TID), E_K(Goods), ECM(CC(E_K(Goods)), EPOID)
5.	C ⟹ M	T_{CM}(Identity), E_{CM}(EPOID, CC(E_K(Goods)))
8.	M ⟹ C	E_{CM}(Result, K)

- No need to go through NetBill.
- But C cannot recover if M decides not to send message 8.

Verified Delivery

1.	C ⟹ M	T_{CM}(Identity), E_{CM}(Credentials, PRD, Bid, RequestFlags, TID)
2/4.	M ⟹ C	E_{CM}(ProductID, Price(=0), RequestFlags, TID, Goods, CC(Goods), EPOID)
5.	C ⟹ M	T_{CM}(Identity), E_{CM}(EPOID, CC(Goods))
8.	M ⟹ C	E_{CM}(Result)

- Goods is encrypted with shared session key.
- C doesn't have to wait for K.

Unverified Delivery

1.	C ⟹ M	T_{CM}(Identity), E_{CM}(Credentials, PRD, Bid, RequestFlags, TID)
2/4.	M ⟹ C	E_{CM}(ProductID, Price(=0), RequestFlags, TID, Goods, CC(Goods))

- Eliminate the acknowledgement of goods delivery.

Failure Analysis

- Customer complaints
  - Incorrect or damaged goods
    - Can be resolved with the EPO, which contains a cryptographic checksum of the encrypted goods
      - Cannot deal with false advertisement
  - No decryption key
    - Can be resolved by a status query exchange with the NetBill server

Failure Analysis (Cont'd)

- Transaction dispute
  - Inconsistent price
    - Can be resolved by checking the EPO signed by the customer
  - Fraudulent transactions
    - Same resolution as above.

Failure Analysis (Cont'd)

- Merchant Complaints
  - Insufficient payment
    - Can be resolved by checking the receipt signed by NetBill

Identification and Authentication

- Public key based Kerberos
  - Each entity has public/private key pair with a certificate for the public key
  - Public key certificate is used to obtain a Kerberos server ticket

1. $C \Longrightarrow M \quad [\{\text{Identity, M, Timestamp, K}\}^{M}]_{C}$
2. $M \Longrightarrow C \quad E_{K}(T_{CM}(\text{Identity}), CM)$

Privacy protection

- Pseudonym mechanism
  - Implemented through a pseudonym-granting server P.
  - Two methods
    - Per transaction
      - Use a unique pseudonym for each transaction
    - Per merchant
      - Use a unique pseudonym for each customer-merchant pair

Authorization

1.	C $\Longrightarrow$ A	T_{CA}(Identity), E_{CA}(M, ProductID, Price, CC(E_K(Goods)), EPOID, CAcct)
2.	A $\Longrightarrow$ C	E_{CA}($E_{A\text{-}PRI}$(CC(Identity, M, ProductID, Price, CC(E_K(Goods), EPOID, CAcct)))

- Performed through an access control server A.
  - Message returned by A is used as the authorization token in an EPO.