Smartcard-Login into Gemstone

An exercise in applied security

by

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Disclaimer

-----BEGIN PGP SIGNED MESSAGE-----
Hash: SHA1

This Material is a copy of the presentation at the ESUG 2003, Bleed,
Slovenia.

It has been developed by Alfred Wullschleger,
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-----BEGIN PGP SIGNATURE-----
Version: PGP 8.0

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Talk and Technical Discussion

- Two Parts
  - first Part (this Talk): Presentation of the ideas
  - second Part: Technical discussion
    - code examples
    - demonstrations
    - details of the implementation
      - as requested by the audience

The Author

- Smalltalker since 1992, never ending enthusiasm
- Project OVID at FIDES Informatik (1992-1999)
- Leading the project OASE at SNB since 1999
  - Financial statistics from Swiss banks and Swiss companies
  - Fully object oriented application using VW3.0 and Gemstone as development base

Motivation

- Gemstone Login uses username and password
  - Both are sent over the network in clear text
  - passwords are typically „trivial“ by User requirement?!
- Smartcards (SC) have many advantages
  - Very high security
    - User must have the card and a password for the card
  - Even relatively trivial passwords are acceptable since the SC is completely disabled after 3 trials

Smartcards at SNB

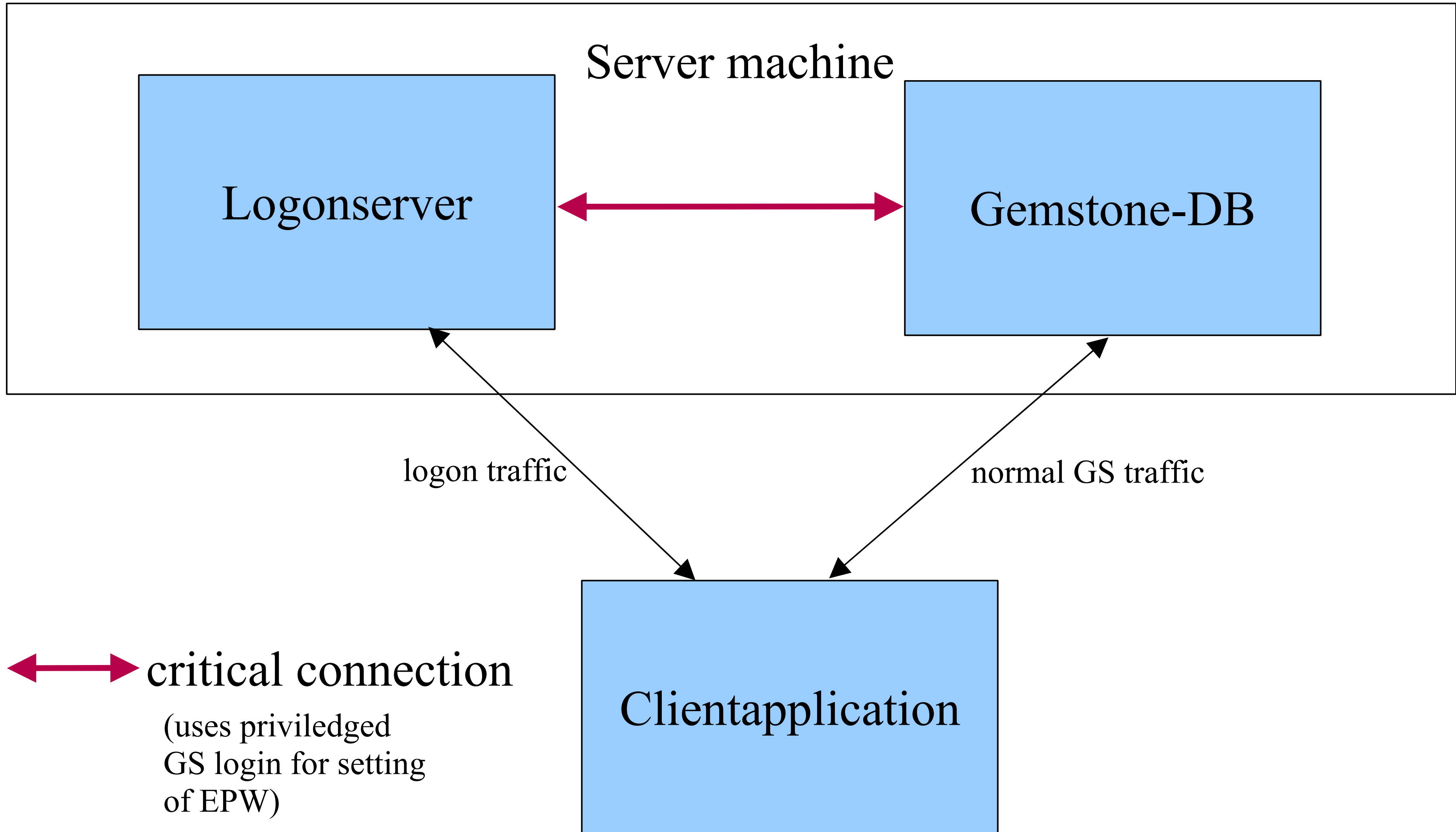
- Smartcards will be introduced in the Bank during 2004
- Goal is Single Signon
  - OASE is one of the first applications which today are ready for Smartcard logon

Smartcard Login

How to implement?

Gemstone Prerequisites

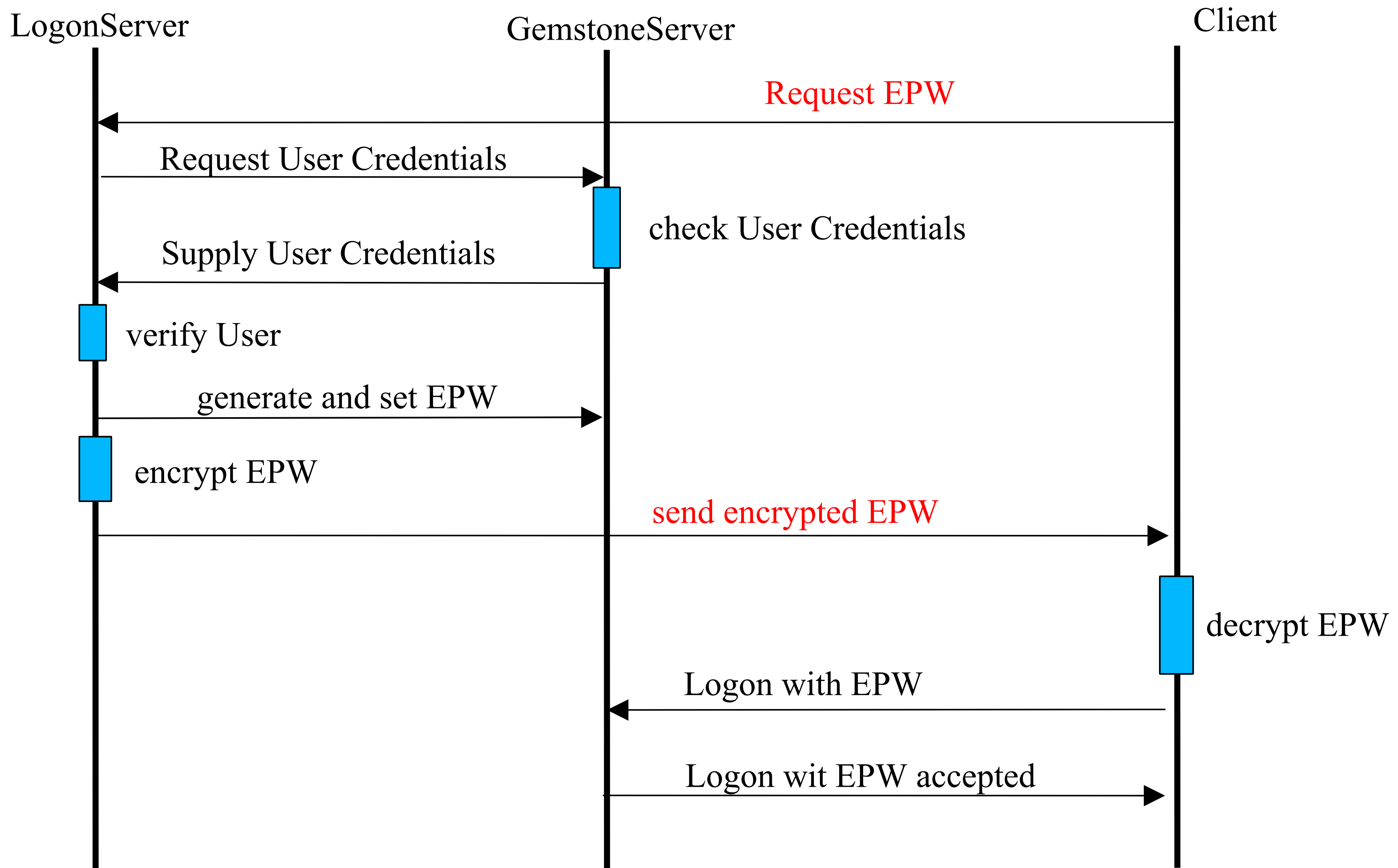
- Logon uses username and password
  - Password size 1024 byte maximum
  - Password expiration can be set to exactely one logon
- So, we can use a „complicated“ One-Time-Password, we call it EPW (from german)
  - format can be choosen appropriate
- Smartcard can be combined with GS:
  - use a Logonserver


Server machine
Logonserver
Gemstone-DB
logon traffic
normal GS traffic
critical connection
(uses priviledged
GS login for setting
of EPW)
Clientapplication

Logonserver (LS)

- LS runs on the same machine as the GS server(s)
  - this guarantees the exchange of critical data with GS without network traffic
  - handles all GS servers on the same machine
  - handles all client logon requests for these servers
  - is implemented as a headless VW3.0 application
    - so it runs wherever we want (AIX, Win2000, Linux, WinXP...)
    - runs as TCP/IP-Server

LS basic operation



LS basic operation

- the client requests his EPW from LS
- LS verifies with GS, that user is ok
  - (i.e. has credentials and a user account)
- LS generates EPW and sets it in GS for one use
- LS encrypts the EPW and sends it to the client
- the client decrypts the EPW and makes normal GS login with his username and the EPW

LS has two concurrent modes

- SC-RSA (Smartcard-RSA-mode)
  - The user uses a Smartcard with RSA-signature keypair
- PW-DH (Password-Diffie-Hellman-mode)
  - The user has no Smartcard
    - a forgotten Smartcard should not prevent the user from logging into GS
    - this mode must be activated in GS for each user individually by administrators, if in SC-RSA-mode before

We need a secure data exchange Client <> LS

- Exchange of secret data through encryption
  - we use Blowfish block cipher
- Each session Client-LS must have a session key
  - can be generated by using Diffie-Hellman (DH) technique
  - how does DH work?

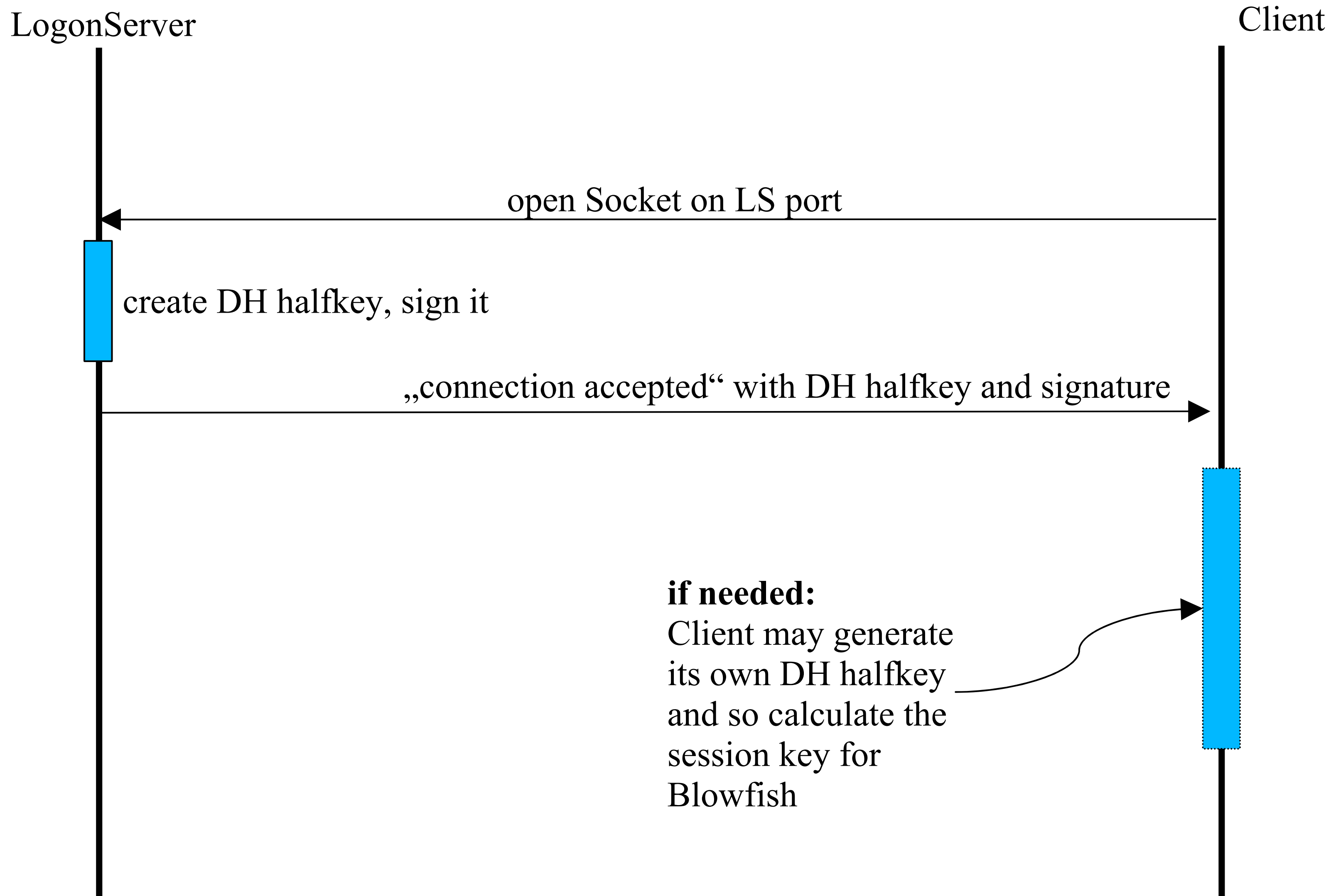
Diffie-Hellman part1

- creation of one secret for two parties
- based on the cyclic group $\boldsymbol{Z_p}$ = {1,2,3...p}, where p is prime.
  - this is equivalent to multiplication of natural numbers modulo p
  - p size large, typically > 256 bits
- use a common base b ∈ $\boldsymbol{Z_p}$, e.g. 65537
- each party selects a secret random number $r_j > 1$, typically large. j=1,2

Diffie-Hellman part2

- each party calculates pub_j = (b ** r_j) mod p, so, $pub_j \in \boldsymbol{Z_p}$
- both parties publicly exchange their pub_j
  - we call pub_j the DH-Halfkey of party j
- each party calculates key = (pub_j)**r_i mod p
  - (j = other, i = self)
- Since (b**r_i)**r_j == (b**r_j)**r_i, both parties get the same key!

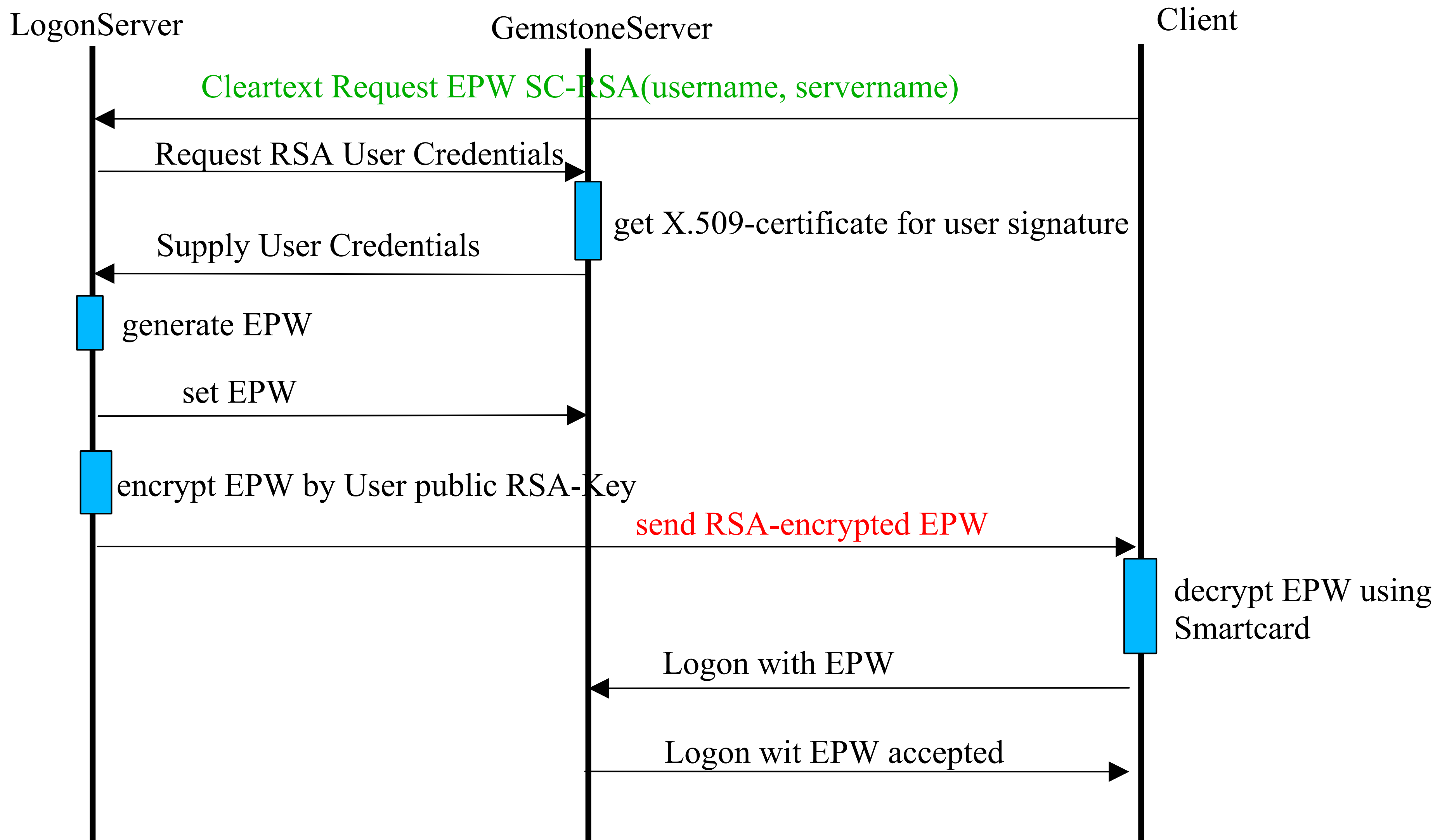
LS connection start



LS connection start (both modes)

- As soon as a connection to LS is established
  - LS creates a Diffie-Hellman halfkey for generation of a session key
  - LS signs this halfkey, so that a user can verify, that he is connected to a legal LS
  - LS sends this information as a „connection accepted“ message to the client
  - this is done irrespective of the mode wished by the client

SC-RSA Overview



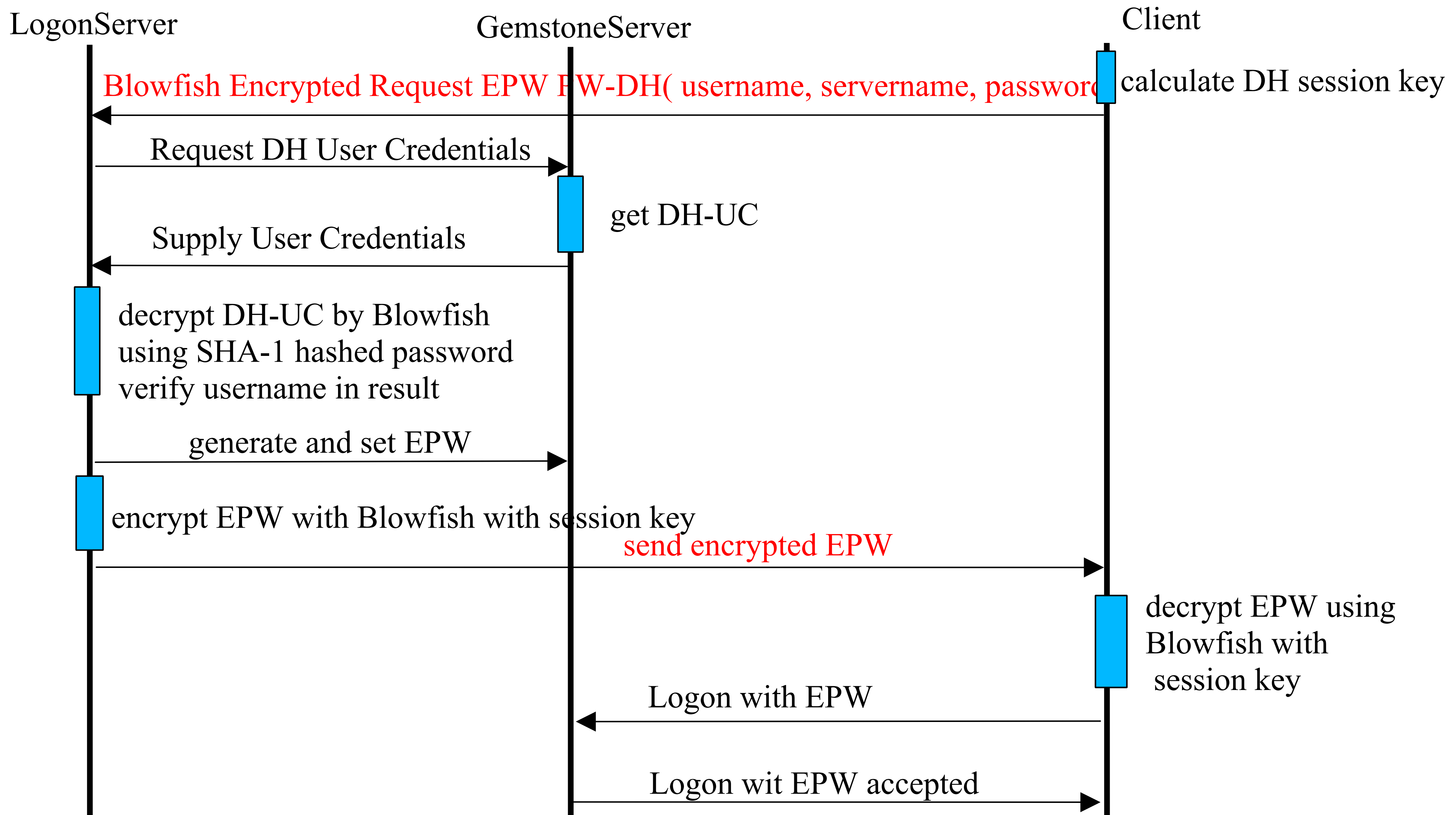
SC-RSA part1

- User requests EWP in SC-RSA-mode
  - parameters: GS servername, GS username
  - sent in clear text to LS
- LS requests X.509-Certificate for the user from GS
  - LS generates EPW and sets it in GS
  - LS RSA-encrypts EPW using signaturekey from the X.509-Certificate

SC-RSA part2

- LS sends encrypted EPW to client
  - if the user has the corresponding Smartcard, he can decrypt the EPW, if not, the information from LS is useless
- user decrypts EPW with his Smartcard
  - makes login in GS, using GS username and EPW

PW-DH Overview



PW-DH part1

- client requests EWP in PW-DH-mode
  - parameters: GS servername, GS username, password
  - client generates halfkey for DH-Keyexchange
  - creates with the halfkey from LS the session key for blowfish encryption
  - sends EPW request encryted to LS together with his halfkey
- LS decrypts EPWrequest
  - by that gets servername, username and password

PW-DH part2

- LS gets encrypted PW-DH-credentials for username from GS
  - GS stores PW-DH-credentials as blowfish-encrypted username plus randomdata
  - password is hashed with SHA-1 to get a blowfish key
    - Watch out: hashing does not help if password is trivial
  - These data are generated by interaction of an administrator with the user
    - when RSA-SC is used, PW-DH-credentials are ereased

PW-DH part3

- LS decrypts PW-DH-credentials using the password, if ok:
  - LS generates EPW and sets it in GS
  - LS blowfish-encrypts EPW using the sessionkey
- client receives and decrypts EPW
  - makes login in GS, using GS username and EPW

Implementation issues

Encryption,
Formats of EPW etc.

RSA basics

- use two secret primes p and q:
  - get n = p*q, a large number (1024 bit)
  - select a number e with gcd(e,(p-1)*(q-1))=1
  - e typically 65537 (or 17 or 3)
    - n and e form the public key for encryption
  - calculate d so that ed == 1 mod(p-1)*(q-1)
    - n and d form the secret decryption key

RSA implementation

- Security is based on factorization being a hard problem
- RSA is fully implemented in VW7.*
  - we have ported it to VW3.0
    - was very easy

Blowfish

- Block cipher defined by Bruce Schneier, 1994
  - encrypts 64-bit-Blocks
- uses keylength between 128 and 448 bit
  - we use 256 bit keys
- we use CBC-Mode
  - each block is XORed with the preceeding encryptedBlock, first block with an InitialVector

Sizes

- RSA-keys on SC and signing key of LS: 1024bit
- Diffie-Hellman parameters
  - p: currently 256 bit
  - base = 65537
- EPW
  - 20-byte random ByteArray converted to LargePositiveInteger
    - giving a passwordstring of 48 to 49 digit characters

XML for all requests/responses

- XML as exchange format between Client and LS
  - To avoid escape sequences like ' etc., we are using integer formats throughout all exchanges which use encryption
  - The ByteArrays are converted using „asLargePositiveInteger"
    - this is compatible with PKCS#1-specification of conversion between bytes and integers

LS Answer on Socket accept:

- <XmlResponse>
  <Validation>true</Validation>
  <DhCode>15883425833416642465360808848836377119677827852925265980146286745390962263576</DhCode>
  <ServerDHSignatur>183709006026842385792416705349556245188475128876202759601481894750869790269995927978776405195325121051883508886524132786861869875368718986668112950424220306601831492161585675580495028687106941544499429842209447096825728927211059446466436584972168382665360133253168788716612548951267550854884951583394172645 34</ServerDHSignatur>
  </XmlResponse>

- User can verify the Signature of the LS

SNB
BNS

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA

SC-RSA basic format

- SC-RSA-request from client to LS is unencrypted:
  - <RSAEPWRequest>
    <Server>lightning</Server><User>rog</User>
    </RSAEPWRequest>
- SC-RSA-response from LS to client:
  - <EinmalPasswort>25403648156676275885066008022408475387522358683839072136920924589230875478943511911386973276958545070613995304664027444844259941647099339694254712622465008895928176115059189039910207366590660509176631584961534508759536105592032741240560953779756974615610233367097913666219451704733004530461339320939262107515</EinmalPasswort>

SC-RSA improved

- we could improve the protocol by requesting, that the client has to sign the LS halfkey
  - so, we avoid setting EPW for a user, who has no corresponding X.509-certificate on GS for the SC
    - has more computing overhead
  - could avoid denial-of-service-attacks
    - disable user, if repeatedly illegally requesting an EPW
- this is implemented for ticket requests (see later)

PW-DH request

- Internal PW-DH-Request:
  - <XmlEPWRequest>
<Server>lightning</Server>
<User>awu</User><Password>xxxxxx</Password></XmlEPWRequest>
- encrypted PW-DH-Request:
  - <XmlEPWRequest>
<DhCode>281574748271158343297420533227126327934689087781014207105602432679325465102 64</DhCode>
<EinmalPasswortRequest>42170146095638651584330954627501148111195214290485313498389165669484140998639678401900317185968075492053120111139089385114866495946563018655593550775694587428583677231448885711958259445637238672195235016034223474372862471711709551746300760031120608509510132548629714428</EinmalPasswortRequest>
</XmlEPWRequest>

PW-DH response

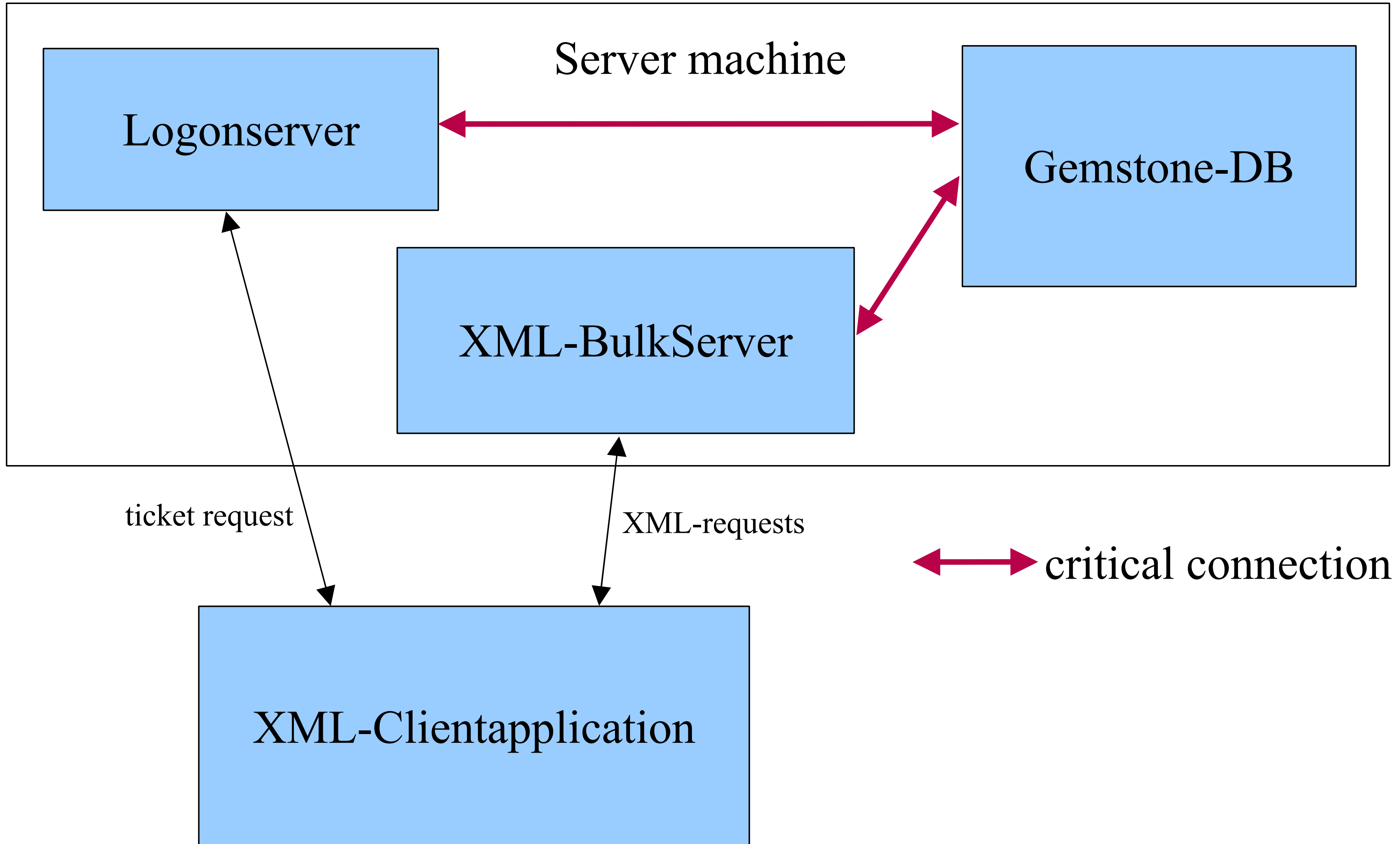
- Encrypted Response from LS:
  - <EinmalPasswort>39101687102161078272434121164568457066871259497097936869261979591784192846211854573079584829211200321873938068169308035706515761190918837390618022514077795
</EinmalPasswort>

Other Functions of LS

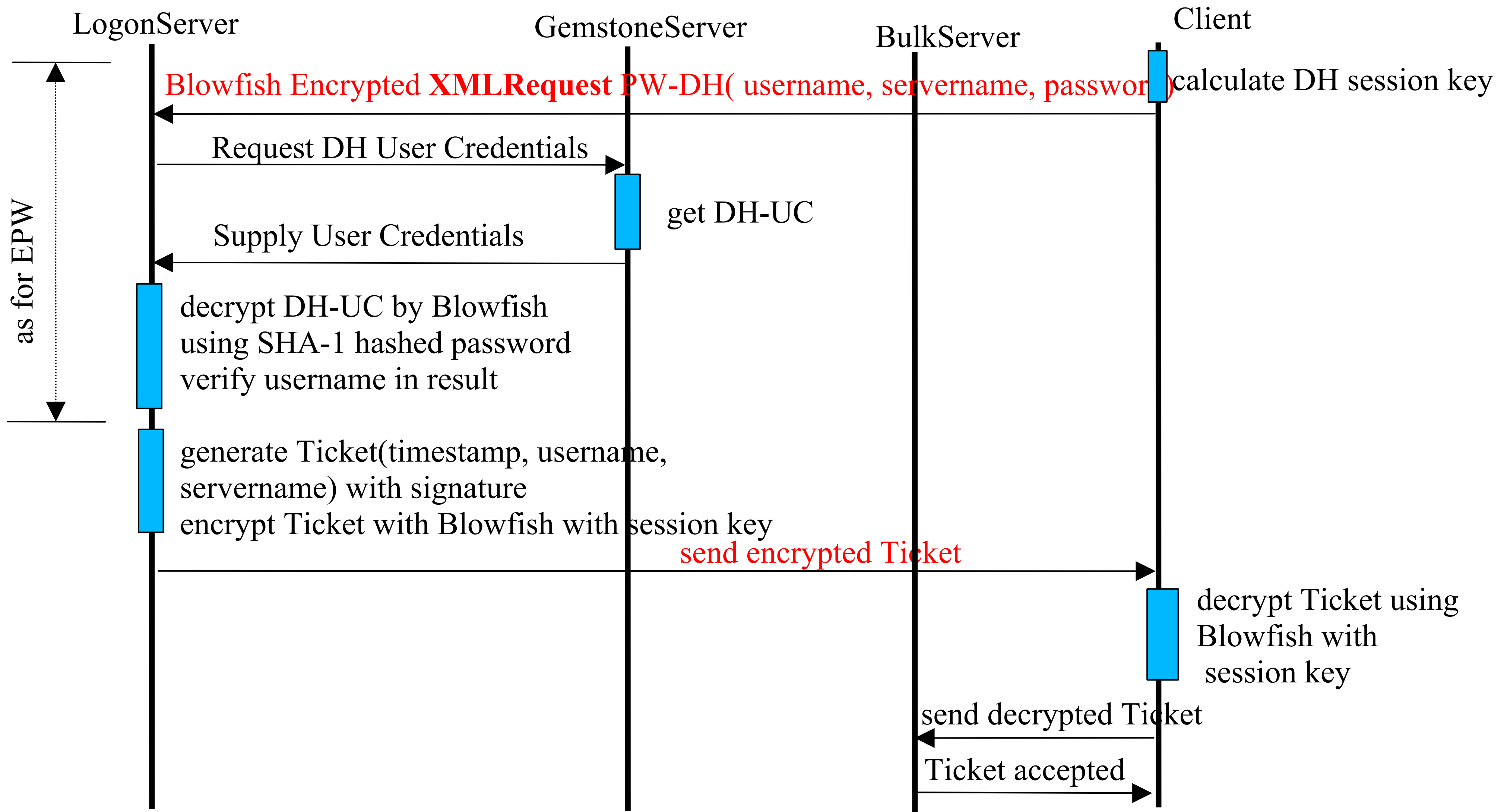
Tickets

XML-Bulkserver

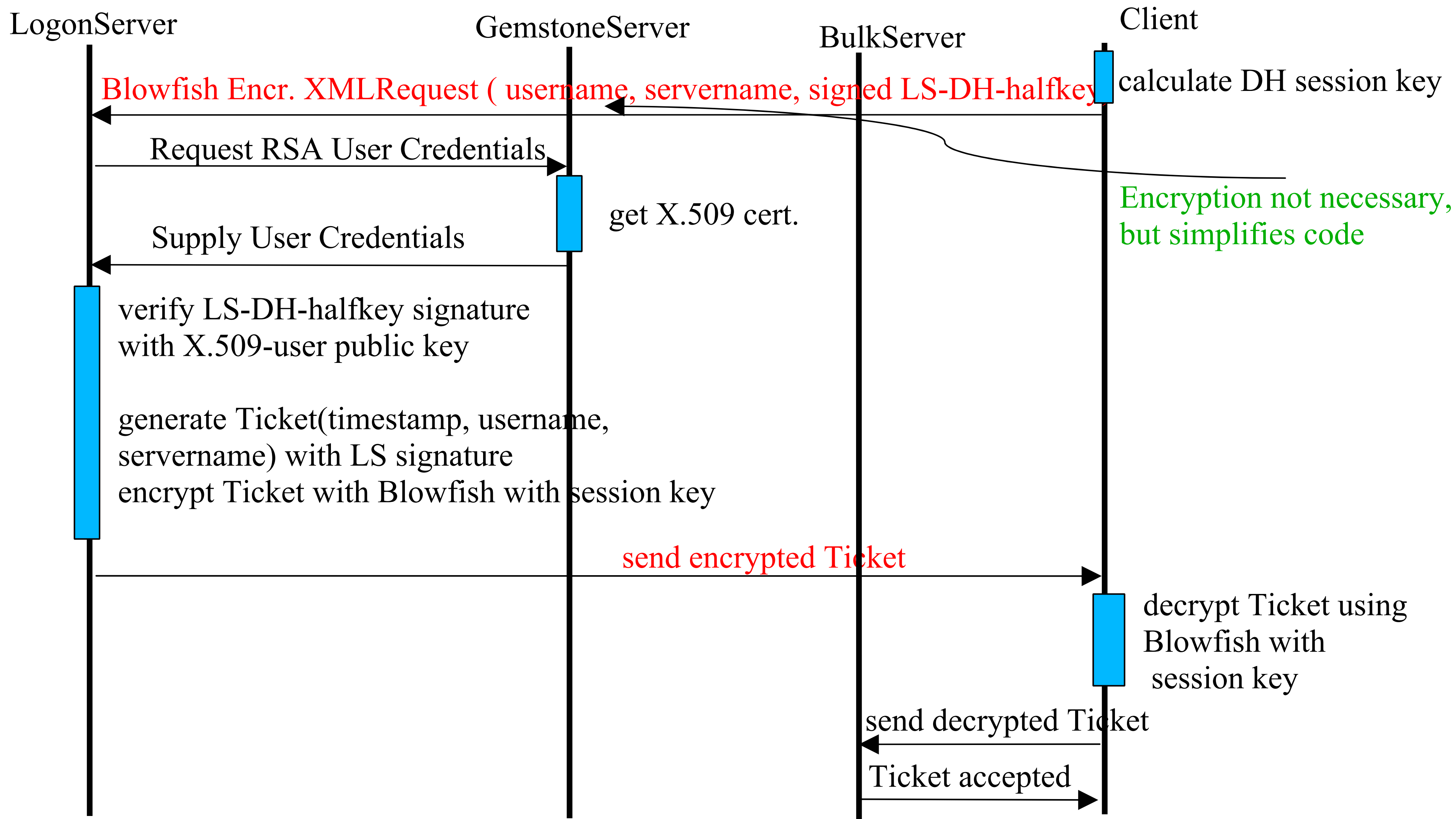
- OASE data can be requested from the so called XML-Bulkserver which is fully XML-based
  - Like LS a headless VW3.0-application
- The user must login into GS to access the data
- How can this be achieved when the user must supply an EPW?
  - by an XML-Ticket which allows access to GS


Server machine
Logonserver
Gemstone-DB
XML-BulkServer
ticket request
XML-requests
critical connection
XML-Clientapplication

XML-Ticket Overview for PW-DH



XML-Ticket Overview for SC-RSA



XML-Ticket basics

- The user requests an XML-Ticket from the LS
- When the user is allowed to access the database, LS creates a ticket
  - contains servername, username and a timestamp for validity checking.
  - the ticket is signed by LS
- The ticket must be presented to the Bulkserver within a short period (currently < 10 seconds).

XML-Ticket checking

- The Bulkserver checks the ticket:
  - verifies the signature of LS
  - checks the timestamp
    - also verifies, that this ticket has not already been used
  - uses the servername to access GS
    - today, we do not restrict access for read for legal users, because of that there is no check necessary for the username

XML-Ticket modes

- PW-DH and SC-RSA use the same technique for sending the ticket to the client:
  - the ticket format has no difference for both modes
  - the ticket is encrypted using blowfish with the DH-sessionkey

XML-Ticket formats

- The TicketRequest differs for both modes
  - parameters: servername and username
- in SC-RSA the user signs the DH-halfkey from the LS with his signing key
- in PW-DH the credentials for servername, username are checked as for EPW using password
- these requests are both sent encrypted by blowfish

TicketResponse

– <XMLTicket>
<Server>dpssM700</Server><User>awu</User>
<XMLTicketTime>3233767397000</XMLTicketTime>
<XMLTicketSignature>150227959672771554223658356609188848131504930433885153358415628484046533885074283485204708129887432046841005815553609797690724046154100779363097261513324905718435929147111194229037132871109267790706342077618299796649268994761120827180240661674334688850191633869392302702031009392187738491257307568961771360 37</XMLTicketSignature>
</XMLTicket>

- identical for both modes

Encrypted TicketRequest Format

- both modes send encrypted with Blowfish:
  - <XMLLogonRequest>
<DhCode>40219239307692214180145053340545080877353522480766790930681240902947674828299</DhCode>
<EncryptedXMLLogonRequest>101377057082959074520545822832481995281355486029905747935665003154347311601168913300557488907343971523088523696699844827287172410408573882043716659853473297753681242918145743635996082099283667341448648205936302301062332051528870082493408610500435018279009052905430115234</EncryptedXMLLogonRequest>
</XMLLogonRequest>

Internal SC-RSA TicketRequest

– <XMLRSARequest>
<Server>dpssM700</Server><User>awu</User>
<Password>10694266580389396165223778257128233571575284804865
488271645277633172859414869405045021075475426683763871005096
512550742078122566663290545340367303214617163684950078288221
884273972865236822265399295831080513274720629788515005292693
213055680355212564287254503022928044905763429004378965569364
748530842326832384</Password>
</XMLRSARequest>

- <Password> contains the signature of the DH halfkey of the LS

Internal PW-DH TicketRequest

- <XmlEPWRequest>
  <Server>dpssM700</Server><User>awu</User>
  <Password>xxxxxxx</Password>
  </XmlEPWRequest>

- Same format as for EPW

Batch-Tickets

- We plan, to introduce also Tickets for Batch-Processing
  - the user requests a ticket for a batch job at some time at some date
  - the LS delivers the ticket
    - the batch job is responsible for the secure deposit of the ticket until used
  - the batch job presents the decrypted ticket at the correct time/date and can be processed

That's it!

Questions?