ANSI X9.63 Overview

Key Agreement and Key Transport
Using Elliptic Curve Cryptography

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Overview

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- What is ANSI X9.63?
- Overview of ANSI X9.63
  - Goals
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What is ANSI X9.63?

- Standard being developed by ANSI X9F1
- Primarily designed to meet the needs of the financial services industry, but also generally applicable
- Specifies key agreement and key transport schemes using elliptic curve cryptography
- Specifies a variety of schemes to meet the diverse security needs of communications protocols
- Specifies mathematical primitives needed to completely implement schemes
- Ballot due in near future

ANSI X9.63 - Goals

Specify schemes capable of meeting common security needs. Security goals identified by the cryptographic community include:

- Implicit key authentication (IKA)
- Explicit key authentication (EKA)
- Entity authentication (EA)
- Known-key security (K-KS)
- Forward secrecy (FS)
- Key-compromise impersonation (K-CI)
- Etc

ANSI X9.63 - Goals (2)

Specify schemes that as far as possible provide additional desirable attributes like:

- Minimal number of passes
- Low communication overhead
- Low computation overhead
- Limited reliance on timestamping
- Limited reliance on hash functions
- Etc

Efficiency goals particularly important for schemes using elliptic curve cryptography.

ANSI X9.63 - Primitives

A number of primitives (mathematical building blocks) must be specified in order to build schemes.

Domain parameter generation & validation primitives:

- Fp and F2^m fields allowed
- m prime to avoid Weil descent
- Polynomial and normal bases allowed for F2^m
- 2^160 minimum size
- Curves selected in any manner. Verifiably random selection option
- Mandatory to avoid known attacks
- List of recommended parameters provided

ANSI X9.63 - Primitives (2)

Key generation & validation primitives:

- Secret keys selected randomly or pseudorandomly
- Key pairs bound to domain parameters
- Public key validation checks mathematical properties of key to ensure it's plausible
- Public key validation necessary in many circumstances to avoid attacks like small subgroup attacks
- Public key validation or partial validation specified
- Usually required to 'receive assurance' of validity of key

ANSI X9.63 - Primitives (3)

Diffie-Hellman primitives:

- Standard and cofactor Diffie-Hellman primitives specified
- Cofactor Diffie-Hellman provides efficient resisitance to some attacks

MQV primitive:

- Derives shared secret value from two key pairs from each entity
- Particularly efficient manner to provide some security services

ANSI X9.63 - Primitives (4)

Key derivation function:

- Derives keying material from shared secret value
- Simple hash function construction specified
- ASN.1 encoding may or may not be used

Asymmetric encryption scheme:

- Bellare and Rogaway’s ECIES
- Based on elliptic curve Diffie-Hellman, XOR encryption, and a MAC
- Efficient, “provably secure” way to provide desirable security properties

ANSI X9.63 - Primitives (5)

In addition, a number of other building are required. These are "borrowed" from other ANSI standards:

- ANSI-approved hash function (SHA-1)
- ANSI-approved random and pseudorandom number generators
- ANSI-approved MAC (HMAC with SHA-1)
- ECDSA

ANSI X9.63 - Ephemeral UM

U → $Q_{e,U}$ → V

U ← $Q_{e,V}$ ← V

U:

$Z_e = [h] d_{e,U} Q_{e,V}$

$KeyData = kdf(Z_e)$

V:

$Z_e = [h] d_{e,V} Q_{e,U}$

$KeyData = kdf(Z_e)$

ANSI X9.63 - 1-Pass DH

$Q_{s,V}$

$U \longleftarrow V$

$Q_{e,U}$

$U \longrightarrow V$

$Z = [h] d_{e,U} Q_{s,V}$

$KeyData = kdf(Z)$

$Z = [h] d_{s,V} Q_{e,U}$

$KeyData = kdf(Z)$

ANSI X9.63 - Static UM

$Q_{s,U}$ →

U V

← $Q_{s,V}$

$Z_s = [h]d_{s,U}Q_{s,V}$

$KeyData = kdf(Z_s)$

$Z_s = [h]d_{s,V}Q_{s,U}$

$KeyData = kdf(Z_s)$

ANSI X9.63 - 1-Pass UM

U $\xrightarrow{Q_{s,U}}$ V

U $\xleftarrow{Q_{s,V}}$ V

U $\xrightarrow{Q_{e,U}}$ V

U:

$$Z_s = [h]d_{s,U}Q_{s,V}$$

$$Z_e = [h]d_{e,U}Q_{s,V}$$

$$KeyData = kdf(Z_e \| Z_s)$$

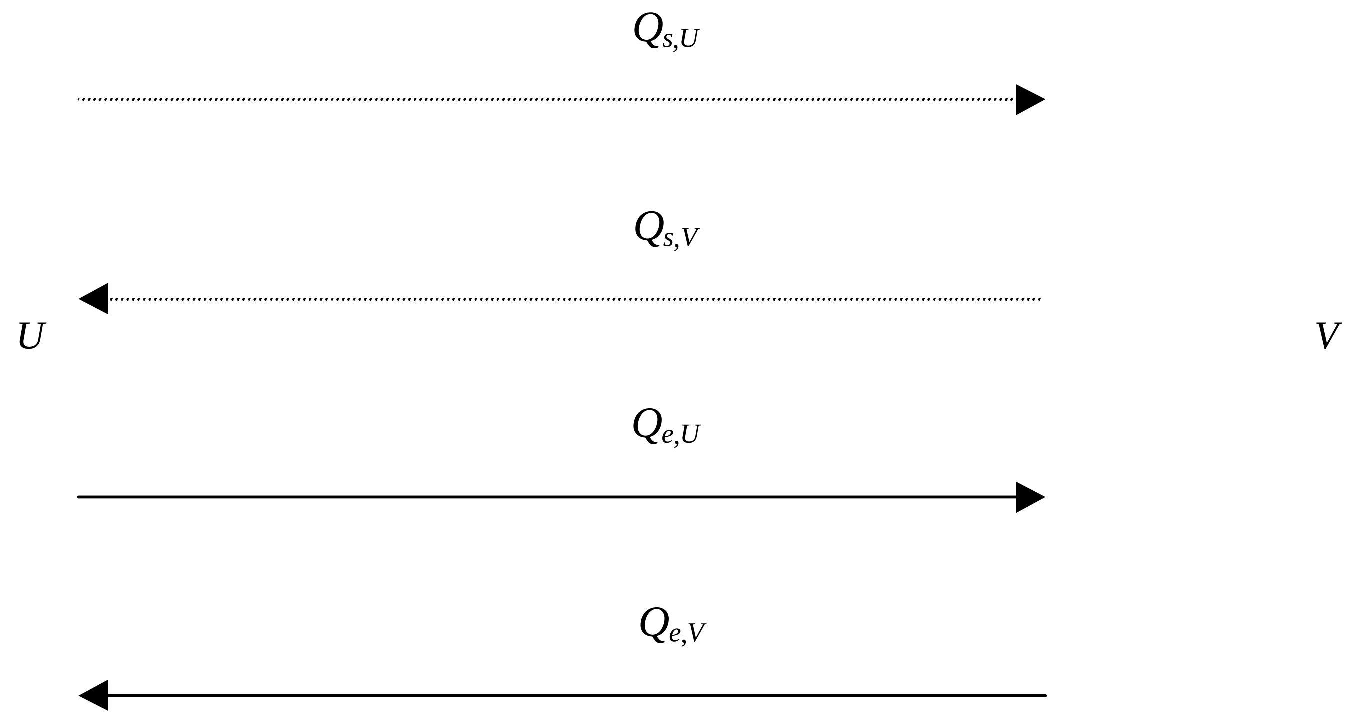
V:

$$Z_s = [h]d_{s,V}Q_{s,U}$$

$$Z_e = [h]d_{s,V}Q_{e,U}$$

$$KeyData = kdf(Z_e \| Z_s)$$

ANSI X9.63 - Full UM



U	V
$Z_s = [h]d_{s,U}Q_{s,V}$	$Z_s = [h]d_{s,V}Q_{s,U}$
$Z_e = [h]d_{e,U}Q_{e,V}$	$Z_e = [h]d_{e,V}Q_{e,U}$
$KeyData = kdf(Z_e \| Z_s)$	$KeyData = kdf(Z_e \| Z_s)$

ANSI X9.63 - 1-Pass MQV

U → V: $Q_{s,U}$

V → U: $Q_{s,V}$

U → V: $Q_{e,U}$

U:

$implicitsig_U = d_{e,U} + avf(Q_{e,U})\, d_{s,U}$

$R = h \times implicitsig_U \times (Q_{s,V} + avf(Q_{s,V})\, Q_{s,V})$

$Z = x_R$

$KeyData = kdf(Z)$

V:

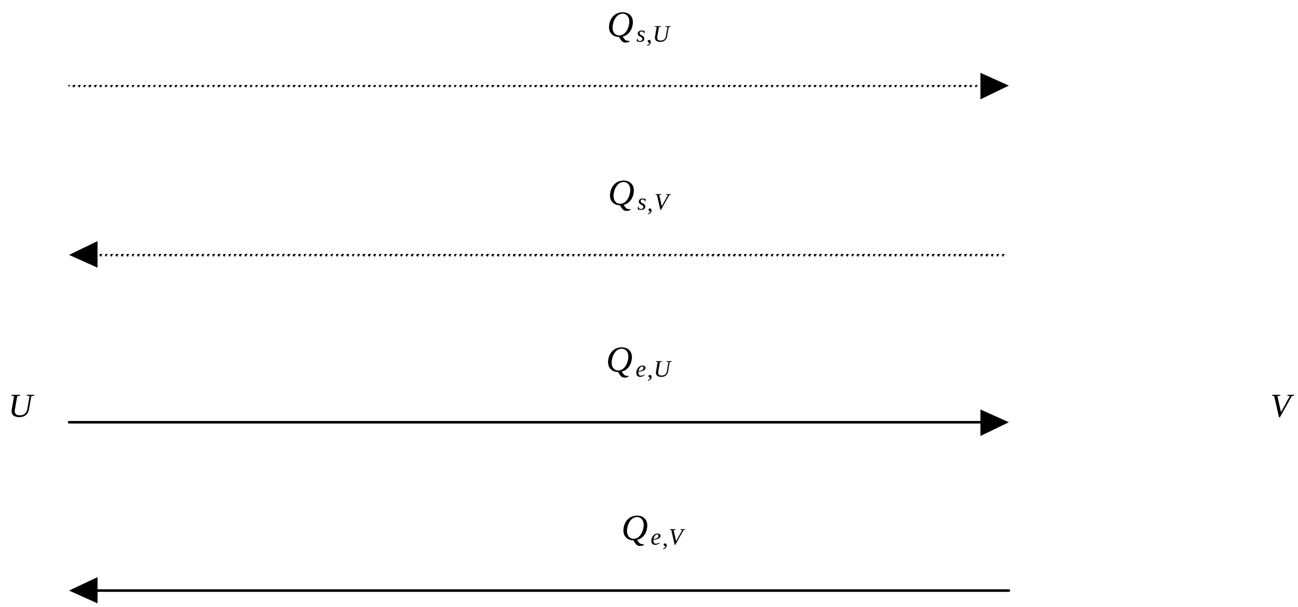
$implicitsig_V = d_{s,V} + avf(Q_{s,V})\, d_{s,V}$

$R = h \times implicitsig_V \times (Q_{e,U} + avf(Q_{e,U})\, Q_{s,U})$

$Z = x_R$

$KeyData = kdf(Z)$

ANSI X9.63 - Full MQV



U	V
$implicitsig_U = d_{e,U} + avf(Q_{e,U})\, d_{s,U}$	$implicitsig_V = d_{e,V} + avf(Q_{e,V})\, d_{s,V}$
$R = h \times implicitsig_U \times (Q_{e,V} + avf(Q_{e,V})\, Q_{s,V})$	$R = h \times implicitsig_V \times (Q_{e,U} + avf(Q_{e,U})\, Q_{s,U})$
$Z = x_R$	$Z = x_R$
$KeyData = kdf(Z)$	$KeyData = kdf(Z)$

ANSI X9.63 - 1-Pass Transport

$Q_{enc,V}$

U ⟵ V

$ENC_{Q_{enc,V}}(U \| KeyData)$

U ⟶ V

$KeyData = KeyData$

$U \| KeyData =$
$DEC_{d_{enc,V}}(ENC_{Q_{enc,V}}(U \| KeyData))$

$KeyData = KeyData$

ANSI X9.63 - Additional Schemes

ANSI X9.63 also specifies a variety of schemes that provide explicit key authentication and entity authentication:

- Combined UM with key confirmation
- Full UM with key confirmation
- Station-to-Station
- Full MQV with key confirmation
- 3-pass key transport

(Explicit key authentication and entity authentication are often essential in applications.)

Does X9.63 meet NIST's needs?

ANSI X9.63 is designed to meet the financial services industry's needs but also appears suitable for government needs.

Elliptic curve cryptography offers extra efficiency suitable for securing advanced applications like e-commerce and smart card based security

Standard relies on NIST approved building blocks like SHA-1

Does X9.63 meet NIST’s needs? (2)

Patent call has been issued and patent letters have been received from Certicom and IBM

Standard aligned with ANSI X9.42, FIPS 196, IEEE P1363, ISO 9798-3, ISO 11770-3, ISO 15946-3

Conclusion

- ANSI X9.42, X9.44, and X9.63 appear to provide a suitable basis for a key establishment FIPS
- Variety of schemes allows future application developers to meet the needs of a diverse range of applications
- Choice of schemes will be limited by application requirements
- This policy could lead to development of “FIPS compliant versions of existing standards like IPSec, S/MIME, TLS
- Future standards could be developed with FIPS in mind.