INTERNATIONAL STANDARD

ISO/IEC 11770-4

Second edition
2017-11

AMENDMENT 2
2021-02

Information technology — Security techniques — Key management —

Part 4: Mechanisms based on weak secrets

AMENDMENT 2: Leakage-resilient password-authenticated key agreement with additional stored secrets

Technologies de l'information — Techniques de sécurité — Gestion de clés —

Partie 4: Mécanismes basés sur des secrets faibles

AMENDEMENT 2

Reference number
ISO/IEC 11770-4:2017/Amd.2:2021(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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Information technology — Security techniques — Key management —

Part 4:
Mechanisms based on weak secrets

AMENDMENT 2: Leakage-resilient password-authenticated key agreement with additional stored secrets

Introduction

Insert new list item e) as follows:

e) **Leakage-resilient password-authenticated key agreement with additional stored secrets:** Establish one or more shared secret keys between two entities *A* and *B*, where *A* has a weak secret and a (possibly, insecure) stored secret that might be revealed to or altered by adversaries and *B* has verification data derived from *A*'s weak secret and stored secret. In a leakage-resilient password-authenticated key agreement with additional stored secrets mechanism, the shared secret keys are the result of a data exchange between the two entities; the shared secret keys are established if, and only if, the two entities have used the weak secret, the stored secret and the corresponding verification data; and *A*, *B* and an adversary who has obtained and altered the stored secret are all unable to predetermine the values of the shared secret keys.

NOTE 4 Here, "leakage-resilience" means security against either compromise of stored secrets held by client *A* or compromise of verification data held by server *B*, but not both. This type of key agreement mechanism is able to protect *A*'s weak secret from being discovered by *B*, as well as preventing an adversary from getting *A*'s weak secret from *B*. Also, this type of key agreement mechanism prevents an adversary from performing online dictionary attacks unless the adversary obtains *A*'s stored secret. In other words, an adversary who obtains *A*'s stored secret is restricted to performing online dictionary attacks, and the security level in this case is the same as that of the other mechanisms in this document. A typical application scenario would involve use between a client (*A*) and a server (*B*), where a client user employs a portable device such as a smart phone, USB memory or smart card to save the user's stored secret, or where a client terminal shares a network-attached storage device in an office environment.

Clause 2

Replace Clause 2 with the following:

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 10118 (all parts), *Information technology — Security techniques — Hash-functions*

ISO/IEC 29192-5, *Information technology — Security techniques — Lightweight cryptography — Part 5: Hash-functions*

ISO/IEC 9797 (all parts), *Information technology — Security techniques — Message Authentication Codes (MACs)*

ISO/IEC 29192-6, *IT Security techniques — Lightweight cryptography — Part 6: Message Authentication Codes (MACs)*

ISO/IEC 11770-6, *Information technology — Security techniques — Key management — Part 6: Key derivation*

ISO/IEC 18033-2, *Information technology — Security techniques — Encryption algorithms — Part 2: Asymmetric ciphers*

ISO/IEC 19772, *Information technology — Security techniques — Authenticated encryption*

Clause 3

Insert new term 3.40 as follows:

3.40
Hamming weight
number of non-zero elements in a bit string

Clause 4

Replace definitions as follows:

H	a collision-resistant hash-function taking an octet string as input and giving a bit string as output. One of the hash-functions specified in ISO/IEC 10118 (all parts) or ISO/IEC 29192-5 shall be used
$h(x, L_K)$	a collision-resistant hash-function taking an octet string x and an integer L_K as input and giving a bit string of length L_K (in bits) as output. One of the hash-functions specified in ISO/IEC 10118 (all parts) or ISO/IEC 29192-5 shall be used
$mac(k, m)$	a message authentication code (MAC) function taking a key k and a variable-length message m as input and giving a fixed-length output. One of the MAC algorithms specified in ISO/IEC 9797 (all parts) or ISO/IEC 29192-6 shall be used
G, G_a, G_b	points of order r on E over $F(q)$, where the relative discrete logarithms of G, G_a, G_b are unknown
g, g_1, g_a, g_b	elements of multiplicative order r in $F(q)$, where the relative discrete logarithms of g, g_1, g_a, g_b are unknown
K	a function for deriving a key from a secret value and a key derivation parameter. One of the key derivation functions specified in ISO/IEC 11770-6 shall be used

Add the following definitions:

$\oplus$	bit-wise exclusive-or operation on bit-strings of equal length
AE	an authenticated encryption, (reversible) transformation of data by a cryptographic algorithm to produce ciphertext that cannot be altered by an unauthorized entity without detection, i.e. that provides data confidentiality, data integrity, and data origin authentication. One of the authenticated encryption methods specified in ISO/IEC 19772 shall be used

Clause 5

Replace the last sentence with the following:

It is also assumed that the entities are aware of a common hash-function *H*, one of the hash-functions specified in ISO/IEC 10118 (all parts) or ISO/IEC 29192-5.

Clause 9

Add new Clause 9 as follows:

9 Leakage-resilient password-authenticated key agreement with additional stored secrets

9.1 General

This clause specifies two mechanisms (LKAM1 and LKAM2) for leakage-resilient password-authenticated key agreement with additional stored secrets. These mechanisms, specified in 9.2 and 9.3, require one of the two entities to possess verification data for a weak secret and a stored secret known to the other entity.

The two mechanisms share the following initialization and key establishment processes.

Initialization process: The two entities involved agree to use a set of valid domain parameters, a set of key derivation parameters and a set of functions, all of which may be publicly known. The two entities also agree to use shared password-based information, i.e. one entity has a password-based weak secret and a stored secret, and the other entity has the corresponding verification data.

NOTE In the initialization process, the two entities who only share password-based information can establish a secure channel by performing the key establishment process. In the case of LKAM2, the server first sends an RSA parameter *n*. Through the established secure channel, the two entities can register verification data and stored secrets.

Key establishment process:

a) *Generate and exchange key tokens.* The two entities involved each randomly choose one or more key token factors associated with the domain parameters, create the corresponding key tokens, which may be associated with the password and the stored secret or verification data (a key token associated with the password and the stored secret or verification data is called an "entangled key token"), and then make the key tokens available to the other entity.

b) *Check validity of key tokens.* Depending on the operations for producing key tokens in step a), the two entities involved each choose an appropriate method to validate the received key tokens based on the domain parameters. If any validation fails, the entity involved shall output "invalid" and stop.

c) *Derive shared secret keys.* The two entities involved each apply certain secret value derivation functions to their own key token factor, the other entity's key tokens and/or shared verification data to produce a shared secret value. Each entity further applies a key derivation function to the shared secret value and the key derivation parameters, to derive one or more shared secret keys.

d) *Check key confirmation and update stored secrets.* The two entities involved use the shared secret keys established using the above steps to confirm their awareness of the keys to each other, and to update their stored secrets. This step is mandatory.

9.2 Leakage-resilient key agreement mechanism 1 (LKAM1)

9.2.1 General

This mechanism is designed to achieve leakage-resilient password-authenticated key agreement with additional stored secrets, and establishes one or more shared secret keys between entities A and B. In the mechanism, A has a password-based octet string π and a stored secret s_i, and B has verification data W_i corresponding to π and s_i. This mechanism provides unilateral explicit key authentication and, optionally, mutual key authentication.

This mechanism works in both the DL setting and the EC setting.

NOTE 1 In applications using leakage-resilient password-authenticated key agreement with additional stored secrets, A can play the role of a client and B can play the role of a server.

NOTE 2 This mechanism is based on the work of Shin, Kobara and Imai[35].

9.2.2 Prior shared parameters

Key agreement between two entities A and B takes place in an environment consisting of the following parameters:

— a set of valid domain parameters (either DL domain parameters or EC domain parameters) as specified in Clause 5;

— a counter which stores the value of i (initially $i = 1$);

— the length L_K of a shared secret key K;

— a password-based octet string π and a stored secret s_i, which is an integer of L_K bits used by A;

— a verification element derivation function J, used by A;

— a verification element $W_i = J(\pi, s_i)$, used by A and B;

— a key token generation function D, used by A and B;

— an entangled key token generation function C, used by A;

— a key token check function T, used by A and B;

— two secret value derivation functions V_A and V_B, one for each entity;

— a key derivation function K, used by A and B;

— one or more key derivation parameter octet strings $\{P_1, P_2, ...\}$, where A and B shall agree to use the same values.

9.2.3 Functions

9.2.3.1 Verification element derivation function *J*

The verification element derivation function J takes a password-based octet string π and a stored secret s_i as input and produces an element of $F(q)$, written $J(\pi, s_i)$, as output. Leakage-resilient key agreement mechanism 1 can be used with either of the following two functions J_{DL} and J_{EC}:

— J_{DL} is suitable for use when the mechanism is used with the DL domain parameters, i.e. it operates over the multiplicative group of elements of $F(q)$. Given the DL domain parameters (including g_b and q), a password-based octet string π and a stored secret s_i, J_{DL} is defined as in Formula (40):

$$J_{DL}(\pi, s_i) = g_b^{\text{BS2I}(H(\pi))+s_i \bmod r} \bmod q \quad (40)$$

— J_{EC} is suitable for use when the mechanism is used with the EC domain parameters, i.e. it operates over the additive group of elements in an elliptic curve of $F(q)$. Given the EC domain parameters (including G_b), a password-based octet string π and a stored secret s_i, J_{EC} is defined as in Formula (41):

$$J_{EC}(\pi, s_i) = [\text{BS2I}(H(\pi)) + s_i \bmod r] \times G_b \quad (41)$$

Function BS2I (Bit String to Integer conversion) is described in Annex A.

9.2.3.2 Key token generation function *D*

The key token generation function D takes an integer x from {1, ..., r − 1} as input and produces an element written $D(x)$ as output. Leakage-resilient key agreement mechanism 1 can be used with either of the following two functions D_{DL} and D_{EC}:

— D_{DL} is suitable for use when the mechanism is used with the DL domain parameters, i.e. it operates over the multiplicative group of elements of $F(q)$. Given the DL domain parameters (including g and q) and an input x from {1, ..., r − 1}, D_{DL} is defined as in Formula (42):

$$D_{DL}(x) = g^x \bmod q \quad (42)$$

— D_{EC} is suitable for use when the mechanism is used with the EC domain parameters, i.e. it operates over the additive group of elements in an elliptic curve of $F(q)$. Given the EC domain parameters (including G) and an input x from {1, ..., r − 1}, D_{EC} is defined as in Formula (43):

$$D_{EC}(x) = [x] \times G \quad (43)$$

9.2.3.3 Entangled key token generation function *C*

The entangled key token generation function C takes two inputs, an output W_i of function J and an output X of function D, and produces an element written $C(W_i, X)$ as output. Leakage-resilient key agreement mechanism 1 can be used with either of the following C functions C_{DL} and C_{EC}:

— C_{DL} is suitable for use when the mechanism is used with the DL domain parameters, i.e. it operates over the multiplicative group of elements of $F(q)$. Given the DL domain parameters (including q) and two inputs, the output W_i of function J and the output X of function D, C_{DL} is defined as follows:

  — compute $C_{DL}(W_i, X) = W_i \times X \bmod q$;

  — if $C_{DL}(W_i, X)$ is 0, 1 or q − 1, output "invalid" and stop; otherwise, output $C_{DL}(W_i, X)$.

— C_{EC} is suitable for use when the mechanism is used with the EC domain parameters, i.e. it operates over the additive group of elements in an elliptic curve of $F(q)$. Given the EC domain parameters and two inputs, the output W_i of function J and the output X of function D, C_{EC} is defined as follows:

  — compute $C_{EC}(W_i, X) = W_i + X$;

  — if $[2^n] \times C_{EC}(W_i, X) = 0_E$, output "invalid" and stop; otherwise output $C_{EC}(W_i, X)$.

9.2.3.4 Key token check function *T*

The key token check function T is the same as that defined in 6.2.3.3.

9.2.3.5 Secret value derivation functions V_A and V_B

a) The secret value derivation function V_A takes two inputs, an integer x from {1, ..., r − 1} and an output Y of function D, and produces an element written $V_A(x, Y)$ as output.

b) The secret value derivation function V_B takes three inputs, an integer y from {1, ..., r − 1}, an output X' of function C and an output W_i of function J, and produces an element written $V_B(y, X', W_i)$ as output.

c) V_A and V_B satisfy the condition $V_A(x, Y) = V_B(y, X', W_i)$.

Leakage-resilient key agreement mechanism 1 can be used with either of the following two functions V_{ADL} and V_{AEC}, and either of the following two functions V_{BDL} and V_{BEC}:

a) V_{ADL} is suitable for use when the mechanism is used with the DL domain parameters, i.e. it operates over the multiplicative group of $F(q)$. Given the DL domain parameters (including q), an integer x from {1, ..., r − 1} and an integer Y from {2, ..., q − 2}, V_{ADL} is defined in the following steps:

   — compute $V_{ADL}(x, Y) = Y^x \bmod q$;

   — output $V_{ADL}(x, Y)$.

b) V_{BDL} is suitable for use when the mechanism is used with the DL domain parameters, i.e. it operates over the multiplicative group of $F(q)$. Given the DL domain parameters (including q), an integer y from {1, ..., r − 1}, an integer X' from {2, ..., q − 2} and an integer W_i from {2, ..., q − 2}, V_{BDL} is defined in the following steps:

   — compute $V_{BDL}(y, X', W_i) = (X' / W_i)^y \bmod q$;

   — output $V_{BDL}(y, X', W_i)$.

c) V_{AEC} is suitable for use when the mechanism is used with the EC domain parameters, i.e. it operates over the additive group of elements in an elliptic curve of $F(q)$. Given the EC domain parameters, an integer x from {1, ..., r − 1} and a point $Y(\neq 0_E)$ on E, V_{AEC} is defined in the following steps:

   — compute $V_{AEC}(x, Y) = [x] \times Y$;

   — output $V_{AEC}(x, Y)$.

d) V_{BEC} is suitable for use when the mechanism is used with the EC domain parameters, i.e. it operates over the additive group of elements in an elliptic curve of $F(q)$. Given the EC domain parameters, an integer y from {1, ..., r − 1}, a point $X'(\neq 0_E)$ on E and a point $W_i(\neq 0_E)$ on E, V_{BEC} is defined in the following steps:

   — compute $V_{BEC}(y, X', W_i) = [y] \times (X' - W_i)$;

   — output $V_{BEC}(y, X', W_i)$.

9.2.3.6 Key derivation function *K*

The key derivation function K is the same as that defined in 6.2.3.6.

9.2.4 Initialization operation

In the initialization operation, A chooses an integer s_1 randomly from {1, ..., r − 1}, computes $W_1 = J(\pi, s_1)$, and then securely transfers W_1 to B. While A has the password-based weak secret π and the stored secret s_1 (along with the counter $i = 1$), B has the corresponding verification data W_1 and the counter $i = 1$.

NOTE Entity A can update the password-based weak secret by performing the initialization operation.

9.2.5 Key agreement operation

In the i-th ($i \geq 1$) key agreement operation, this mechanism involves both A and B performing a sequence of up to three steps, numbered A1 to A3 and B1 to B3 (for the steps to be followed by A and B, respectively).

a) Entangled key token construction (A1)

A performs the following steps:

1) compute $W_i = J(\pi, s_i)$ as its verification element;

2) choose an integer x randomly from $\{1, \ldots, r-1\}$ as its key token factor;

3) compute $X = D(x)$ as its key token, and $X' = C(W_i, X)$ as its entangled key token (if the output of function C is "invalid", go back to the above item to choose a different x value at random and try again);

4) make i and X' available to B.

b) Key token construction (B1)

B performs the following steps:

1) receive i and X' from A;

2) check the validity of i: if the received value of i is not the same as the value B has, output "invalid" and stop; otherwise, continue;

3) check the validity of X' using $T(X')$: if $T(X') = 0$, output "invalid" and stop; otherwise, continue;

4) choose an integer y uniformly at random from the range $\{1, \ldots, r-1\}$ as its key token factor;

5) compute $Y = D(y)$ as its key token;

6) compute $z = V_B(y, X', W_i)$ as an agreed secret value;

7) compute $o_B = H(\text{I2OS}(1)||A||B||\text{I2OS}(i)||\text{GE2OS}_X(X')||\text{GE2OS}_X(Y)||\text{GE2OS}_X(W_i)||\text{GE2OS}_X(z))$;

8) make Y and o_B available to A.

c) Key confirmation (mandatory) and shared secret key derivation (A2)

A performs the following steps:

1) receive Y and o_B from B;

2) check the validity of Y using $T(Y)$: if $T(Y) = 0$, output "invalid" and stop; otherwise, continue;

3) compute $z = V_A(x, Y)$ as an agreed secret value;

4) compute $o_B' = H(\text{I2OS}(1)||A||B||\text{I2OS}(i)||\text{GE2OS}_X(X')||\text{GE2OS}_X(Y)||\text{GE2OS}_X(W_i)||\text{GE2OS}_X(z))$;

5) if $o_B \neq o_B'$, output "invalid" and stop; otherwise, continue;

6) compute $o_A = H(\text{I2OS}(2)||A||B||\text{I2OS}(i)||\text{GE2OS}_X(X')||\text{GE2OS}_X(Y)||\text{GE2OS}_X(W_i)||\text{GE2OS}_X(z))$;

7) compute $K_j = K(A||B||\text{I2OS}(i)||\text{GE2OS}_X(X')||\text{GE2OS}_X(Y)||\text{GE2OS}_X(W_i)||\text{GE2OS}_X(z), P_j, L_K)$ as a shared secret key for each key derivation parameter P_j ($j = 1, 2, \ldots$);

8) make o_A available to B.

d) Key confirmation and shared secret key derivation (B2)

B performs the following steps:

1) receive o_A from A;

2) compute $o_A' = H(\text{I2OS}(2)||A||B||\text{I2OS}(i)||\text{GE2OS}_X(X')||\text{GE2OS}_X(Y)||\text{GE2OS}_X(W_i)||\text{GE2OS}_X(z))$;

3) if $o_A \neq o_A'$, output "invalid" and stop; otherwise, continue;

4) compute $K_j = K(A||B||\text{I2OS}(i)||\text{GE2OS}_X(X')||\text{GE2OS}_X(Y)||\text{GE2OS}_X(W_i)||\text{GE2OS}_X(z), P_j, L_K)$ as a shared secret key for each key derivation parameter P_j ($j = 1, 2, \ldots$).

e) Update of stored secrets (A3 and B3)

A performs the following step (A3):

1) compute $s_{(i+1)} = s_i + \text{BS2I}(H(\text{I2OS}(3)||A||B||\text{I2OS}(i)||\text{GE2OS}_X(X')||\ \text{GE2OS}_X(Y)||\ \text{GE2OS}_X(W_i)||\ \text{GE2OS}_X(z))) \bmod r$.

B performs the following step (B3):

1) compute $u = \text{BS2I}(H(\text{I2OS}(3)||A||B||\text{I2OS}(i)||\text{GE2OS}_X(X')||\ \text{GE2OS}_X(Y)||\ \text{GE2OS}_X(W_i)||\ \text{GE2OS}_X(z))) \bmod r$;

2) compute $W_{(i+1)} = W_i \times (g_b)^u \bmod q$ in the DL setting;

3) compute $W_{(i+1)} = W_i + [u] \times G_b$ in the EC setting;

4) check the validity of $W_{(i+1)}$ using $T(W_{(i+1)})$: if $T(W_{(i+1)}) = 0$, output "invalid" and stop.

Entity *A* shall verify the entity *B*'s proof of knowledge of the agreed key before revealing any information derived from the agreed key. Therefore, A2 shall be done before B2 if the latter is performed.

Functions BS2I (Bit String to Integer conversion), I2OS (Integer to Octet String conversion) and GE2OS_X (Group Element to Octet String conversion) are described in Annex A where Annex A shall be referenced for the details of the conversion functions.

Numerical examples can be found in D.1.

NOTE 1 A group element in this mechanism is a point on the curve E in the EC setting, or an integer in the range $\{1, ..., q - 1\}$ in the DL setting.

NOTE 2 In this mechanism, X and Y can be computed before the key agreement operation.

NOTE 3 This mechanism can be extended to provide synchronization, randomized ID and security against server compromise impersonation attacks in the same way as in Section 6 of Reference [36].

9.3 Leakage-resilient key agreement mechanism 2 (LKAM2)

9.3.1 General

This mechanism is designed to achieve leakage-resilient authenticated key agreement with password and untrusted storage using the RSA public key cryptosystem and establishes one or more shared secret keys between entities *A* and *B* with joint key control. In the mechanism, *A* remembers a password (denoted by π when rendered as an octet string), and has, in an untrusted storage device that might be modified or copied by adversaries to impersonate *A* or *B* or to reveal the agreed keys, the RSA parameter n, a stored secret u_j where subscript j denotes a counter and a random pseudo identity A' of *A*. *B* has password verification data v_j corresponding to both π and u_j, a hash value A'' of A', and RSA private key parameters d, p, q and so on. These RSA private and public key parameters shall be generated using ISO/IEC 18033-2:2006, 11.1, and the additional requirement and recommendations for e to be used in this mechanism are explained in 9.3.3. This mechanism provides unilateral explicit key authentication, and optionally mutual key authentication.

NOTE 1 In applications using leakage-resilient authenticated key agreement with password and untrusted storage, *A* can play the role of a client and *B* can play the role of a server.

NOTE 2 This mechanism is based on the work of Shin, Kobara and Imai[36].

9.3.2 Prior shared parameters

Key agreement between two entities *A* and *B* takes place in an environment consisting of the following parameters, in which L_K, e, H, *mac*, K, $\{P_1, P_2, ...\}$ are shared as system parameters among all or a subset of the users of this mechanism:

— the length of a shared secret key L_K which must be a multiple of 8;

— a set of RSA public key parameters, namely a prime integer e and a composite number n generated as specified in ISO/IEC 18033-2:2006, 11.1, where e is specialized for this mechanism as explained in 9.3.3;

— a cryptographic collision-resistant hash-function H giving a $2L_K$-bit output, that shall be chosen from amongst the functions standardized in ISO/IEC 10118 (all parts) or ISO/IEC 29192-5, being truncated as necessary;

— a message authentication code generation function *mac*, that shall be chosen from amongst the functions standardized in ISO/IEC 9797 (all parts) or ISO/IEC 29192-6;

— a counter which stores the value of j (initially j =1);

— a stored secret u_j and corresponding $v_j = J(\pi, u_j)$ where u_j is an octet string of random L_K bits and J is a password verification element derivation function in 9.3.4.1. Both u_j and v_j are set in the initialization operation in 9.3.5, and then used by A and B, respectively;

— a pseudo identity A'_j and a corresponding hash value $A''_j = H(\text{I2OS}(0)||A'_j)$ of the entity A, where A'_j is an octet string of length $L_K/8$ whose constituent bits are generated uniformly at random. Both A'_j and A''_j are set in the initialization operation in 9.3.5 and used by A and B, respectively;

— a key derivation function K, that shall be chosen from amongst the functions standardized in ISO/IEC 11770-6;

— one or more key derivation parameter octet strings $\{P_1, P_2, ...\}$, where A and B shall agree to use the same values.

9.3.3 Additional requirement and recommendations for RSA public key parameter *e*

The following requirements on the choice of the parameter e, additional to those specified in ISO/IEC 18033-2:2006, 11.1, apply.

a) e shall be a prime and $e \geq 2^{L_K}$;

b) the sum of the Hamming weight of the binary representation of e and the bit-length of e should be as small as possible, subject to requirement a);

c) e should be as large as possible within b).

NOTE 1 Requirement a) ensures that the e-residue attack[36], which applies when an adversary can modify the parameter n, is not feasible.

NOTE 2 Recommendation b) is intended to help minimize the computational cost for entity A.

NOTE 3 Recommendation c) is intended to make e-residue attacks as difficult as possible for a given computational cost on A.

NOTE 4 Examples of choices for e satisfying requirement a)-c) are given in C.4.

9.3.4 Functions

9.3.4.1 Password verification element derivation function *J*

The password verification element derivation function J takes a password-based octet string π and a random L_K-bit stored secret u_j as input, and produces as output an octet string password verification data $v_j = H(\text{I2OS}(4)||\pi||A||B) \oplus u_j$.

9.3.4.2 Key token generation function *D*

The key token generation function D takes password verification data v_j, RSA public parameters n, e and integers x_1, x_2 in {1, …, n − 1} as input, and produces as output $Z = D(e, n, x_1, x_2, v_j)$, an integer in the range {0, …, n − 2}. D is calculated as follows:

— compute $y_1 = (x_1)^e \bmod n$;

— compute $W = \text{BS2I}(H(\text{I2OS}(7)||v_j||\text{I2OS}(x_2)))$;

— compute $Z = ((y_1 - 1) + W) \bmod (n - 1)$;

— output Z.

9.3.4.3 Password-entangled key token generation function *C*

The password-entangled key token generation function C takes, as input, password verification data v_j, an integer Z in {1, …, n − 2}, integers y_2, d, p, q in {1, …, n − 1} respectively, and produces an integer x_1 in {1, …, n − 1} as the output of $C(v_j, Z, y_2, d, p, q)$. C is calculated as follows:

— compute $x_2 = (y_2)^d \bmod n$;

— compute $W = \text{BS2I}(H(\text{I2OS}(7)||v_j||\ \text{I2OS}(x_2)))$;

— compute $y_1 = ((Z - W) \bmod (n - 1)) + 1$;

— compute $x_1 = (y_1)^d \bmod n$;

— output x_1.

NOTE $y^d \bmod n$ can be calculated efficiently using p and q and Garner's algorithm[38] with $((((x_p - x_q)/q) \bmod p)q) + x_q$ where $x_p = y^{(d \bmod (p-1))} \bmod p$ and $x_q = y^{(d \bmod (q-1))} \bmod q$.

9.3.4.4 Key derivation function *K*

The key derivation function K is the same as that defined in 6.2.3.6.

9.3.5 Initialization operation

In the initialization operation, A securely transfers the hash value A''_1 associated with the pseudo identity and the password verification element v_1 to B, and B securely transfers the RSA public key parameters e and n to A. While A has the password π, the pseudo identity A'_1 and the stored secret u_1, B has the corresponding password verification data v_1, the hash value A''_1 and the RSA private key parameters d, p, q and so on.

NOTE Entity A can update the password-based weak secret by performing the initialization operation.

9.3.6 Key agreement operation

This mechanism (for $j \geq 1$) involves A and B performing sequences of steps numbered A1 to A6 and B1 to B5 (for the steps to be followed by A and B, respectively). Steps A4 and B3 and later are optional.

a) Key token construction (A1)

A performs the following steps:

1) choose two integers x_1 and x_2 randomly from {1, …, n − 1} as its key token factor;

2) compute $v_j = J(\pi, u_j)$, $y_2 = (x_2)^e \bmod n$ and $Z = D(e, n, x_1, x_2, v_j)$ as its key token;

3) make A'_j, Z and y_2 available to B.

b) Shared secret key derivation (B1)

B performs the following steps:

1) receive A'_j, Z and y_2 from A;

2) compute $A''_j = H(\text{I2OS}(0)||\ A'_j)$;

3) look for an entry corresponding to A''_j in the server's database; if it does not exist, output "invalid" and stop; otherwise, continue;

4) delete other entries for A that do not match with A''_j since they are garbage when communication is cut in the middle of the sequence;

5) choose an L_K-bit random string r_1, and then make r_1 available to A;

6) compute $x_1 = C(v_j, Z, y_2, d, p, q)$;

7) compute $K_s = H(\text{I2OS}(1)||\text{I2OS}(x_1)||A||B||A'_j||r_1||\text{I2OS}(Z)||v_j||\text{I2OS}(y_2))$;

8) compute $K_i = K(K_s, \text{I2OS}(11), L_K)$ as a shared secret key for the following communication;

9) compute $K_m = K(K_s, \text{I2OS}(10), L_K)$ as the MAC key if the key confirmation below completes successfully.

c) Shared secret key derivation (A2)

A performs the following steps:

1) compute $K_s = H(\text{I2OS}(1)||\text{I2OS}(x_1)||A||B||A'_j||r_1||\text{I2OS}(Z)||v_j||\text{I2OS}(y_2))$;

2) compute $K_i = K(K_s, \text{I2OS}(11), L_K)$ as a shared secret key for the following communication;

3) compute $K_m = K(K_s, \text{I2OS}(10), L_K)$ as the MAC key if the key confirmation steps in d) below complete successfully.

d) Key confirmation (B2 and A3) (mandatory)

B performs the following steps (B2):

1) compute $o_B = mac(K_m, \text{I2OS}(2)||K_s||\text{I2OS}(1))$;

2) make o_B available to *A*.

A performs the following steps (A3):

1) receive o_B from *B*;

2) compute $o_B' = mac(K_m, \text{I2OS}(2)||K_s||\text{I2OS}(1))$;

3) if $o_B \neq o_B'$, output "invalid" and stop.

e) Key confirmation (A4 and B3) (optional)

A performs the following steps (A4):

1) compute $o_A = mac(K_m, \text{I2OS}(2)||K_s||\text{I2OS}(0))$;

2) make o_A available to *B*.

B performs the following steps (B3):

1) receive o_A from *A*;

2) compute $o_A' = mac(K_m, \text{I2OS}(2)||K_s||\text{I2OS}(0))$;

3) if $o_A \neq o_A'$, output "invalid" and stop.

f) Storage update (A5, B4, A6 and B5) (optional)

A performs the following steps (A5):

1) choose an L_K-bit random string A'_{j+1}, and then compute $A''_{j+1} = H(\text{I2OS}(0)||A'_{j+1})$;

2) make $AE(K_i, A''_{j+1})$ available to B where $AE(K_i, *)$ is a symmetric authenticated encryption function using K_i as the symmetric key.

B performs the following steps (B4):

1) receive $AE(K_i, A''_{j+1})$ from A, and then extract A''_{j+1} from it;

2) compute $v_{j+1} = v_j \oplus H(\text{I2OS}(2)||K_s)$;

3) add $\{A''_{j+1}, v_{j+1}, A\}$ to the server's database;

4) make $AE(K_i, \text{reply1})$ available to A where reply1 is a reply message.

A performs the following steps (A6):

1) receive $AE(K_i, \text{reply1})$ from B;

2) if the result of decrypting $AE(K_i, \text{reply1})$ is not the same as reply1, output "invalid" and stop;

3) compute $u_{j+1} = u_j \oplus H(\text{I2OS}(2)||K_s)$;

4) update $\{B, A'_j, u_j\}$ to $\{B, A'_{j+1}, u_{j+1}\}$;

5) make $AE(K_i, \text{reply2})$ available to B where reply2 is a reply message.

B performs the following steps (B5):

1) receive $AE(K_i, \text{reply2})$ from A;

2) if the result of decrypting $AE(K_i, \text{reply2})$ is not the same as reply2, output "invalid" and stop;

3) delete all A's records $\{*, *, A\}$ except $\{A''_{j+1}, v_{j+1}, A\}$ from the server's database. The deleted records include old records $\{A''_j, v_j, A\}$ and those that might remain as a result of communication errors between A and B.

Numerical examples can be found in Annex D.2.

NOTE 1 r_1 can be removed if it is acceptable for K_i to be a function only of inputs from A, and joint key control property is not required.

NOTE 2 x_2 can be removed and e can be 3 if n is stored in a location in which adversaries cannot modify it even if they can copy it.

NOTE 3 A' can be replaced with A if anonymity of A against eavesdroppers is not required.

NOTE 4 The octet string of A can be the concatenation of an octet string identifying the user and an octet string identifying the storage or the client terminal.

NOTE 5 After the key agreement, the RSA parameters can be updated by sending a new value of n from B to A encrypted using $AE()$.

NOTE 6 This mechanism can be extended to provide security against server compromise impersonation attacks as in Section 6 of Reference [36].

Annex B

Add the following before `-- Balanced Key Agreement Mechanism 1 --`:

```
id-km-ws-lKAM-1 OID ::= { id-km-ws leakageResilientKeyAgreementMechanism-1(9) }

id-km-ws-lKAM-2 OID ::= { id-km-ws leakageResilientKeyAgreementMechanism-2(10) }
```

Annex B

Add the following before `END -- KeyManagement-WeakSecrets --`:

```
-- Leakage-Resilient Key Agreement Mechanism 1 --

verificationElementDerivation-9 OID ::= {
   id-km-ws-lKAM-1 verificationElementDerivationFunction(1) }

keyTokenGeneration-9 OID ::= {
   id-km-ws-lKAM-1 keyTokenGenerationFunction(2) }

entangledKeyTokenGeneration-9 OID ::= {
   id-km-ws-lKAM-1 entangledKeyTokenGenerationFunction(3) }

keyTokenCheck-9 OID ::= {
   id-km-ws-lKAM-1 keyTokenCheckFunction(4) }

secretValueDerivation-9 OID ::= {
   id-km-ws-lKAM-1 secretValueDerivationFunction(5) }

keyDerivation-9 OID ::= {
   id-km-ws-lKAM-1 keyDerivationFunction(6) }

-- Leakage-Resilient Key Agreement Mechanism 2 --

passwordVerificationElementDerivation-10 OID ::= {
   id-km-ws-lKAM-2 passwordVerificationElementDerivationFunction(1) }

keyTokenGeneration-10 OID ::= {
   id-km-ws-lKAM-2 keyTokenGenerationFunction(2) }

passwordEntangledKeyTokenGeneration-10 OID ::= {
   id-km-ws-lKAM-2 passwordEntangledKeyTokenGenerationFunction(3) }

keyDerivation-10 OID ::= {
   id-km-ws-lKAM-2 keyDerivationFunction(4) }
```

Annex C

Add new Clause C.4 as follows:

C.4 Parameters in leakage-resilient key agreement mechanism 2 (LKAM2)

Examples of the parameter e chosen to meet requirements a)-c) of 9.3.3 are as follows for L_K=112, 128, 192, 224 and 256, respectively:

$e=2^{113}+2^{90}+1=$020000040000000000000000000001 for L_K=112,
$e=2^{129}+2^{127}+1=$028000000000000000000000000000001 for L_K=128,
$e=2^{193}+2^{132}+1=$020000000000000010000000000000000000000000000001 for L_K=192,
$e=2^{225}+2^{182}+1=$020000000004000000000000000000000000000000000000000001 for L_K=224,
$e=2^{257}+2^{132}+1=$02000000000000000000000000000010000000000000000000000000001
for L_K = 256.

Annex D

Add new Annex D as follows:

Annex D
(informative)

Numerical examples

D.1 Numerical examples of LKAM1

This clause lists numerical examples of leakage-resilient key agreement mechanism 1 (LKAM1) with elliptic curve domain parameters.[37]

secp224r1 (SHA224), L_K = 112, HMAC
A (= lrpakeuser1@aist.go.jp) = 6C7270616B6575736572314061697374 2E676F2E6A70
B (= lrpakeserver@aist.go.jp) = 6C7270616B6573657276657240616973742E676F2E6A70
password (= zokang1) = 7A6F6B616E6731
$H(\pi)$ (= SHA512(I2OS(0)||A||B||password)) = 64C0F6239CCA16866612D8E1115B5ADA038D88B2A1376CC24E 3B54F308DCBF18256A008ED70342EB5F32BAB141717BEB59B46EAE36D8E50EBA514287CFA66DDB
G_b = 038C9C85F629134BEED14A1665662BBFC7F517BDFE070C1E470D2BD921
s_1 = 77A29359EA58A369D5F49519334A91C82E2D04A7BA97D56B4B28F9E5
W_1 = 033440F4772CD2AA5BB8452DEA433A3308CE6CE8448148135F6E44DD1E
x = B7F03B2A8293504BCBE4D10593216B46E0FE3EC3DFA0474E041FE99E
X = 020BBDFA70DD45BC4C547E76CE7FF03B4AB32ADA12A52637F82F910D0C
X' = 039C4956146DF34530CB82503A0925497761402B7722C71F26C0B0D4FC
y = 915186FF1942FCC764FEA417CD728909F5C29419E69273BFC5EBE02A
Y = 034E5F87BEE7955E0AFF018DA0D77A12FFFB6C4B130E95602821252304
z = 020A386B68808E33B6DE6A5DF9AF8FA29D4165128CCC2D5E76D6C2FBF7
K_1 (= HMAC(A||B||..., P_1 (= 1), L_K) = B4980CC5943D6C8A1F8EF04866F43B6B89A70959681DC8A13C0AB494
o_B = E26DC0043AA90EBDF33CF4C5B1B1860348D56D2226D0383ED62B56C9
o_A = D2F7F179F71D62B9DA5033A5F1096F4EA75E5E24AA6D0A432EE8DD0A
s_2 = 05F627B8FA25380326AD512536BA467C8C5B989D4A7B7CE2A163F802
W_2 = 02AF9DFB335866BF68D391FBF0F791D195D2EBE6A0FB07AE514E483298

secp256r1 (SHA256), L_K = 128, HMAC
A (= lrpakeuser1@aist.go.jp) = 6C7270616B6575736572314061697374 2E676F2E6A70
B (= lrpakeserver@aist.go.jp) = 6C7270616B6573657276657240616973742E676F2E6A70
$H(\pi)$ (= SHA512(I2OS(0)||A||B||password)) = 64C0F6239CCA16866612D8E1115B5ADA038D88B2A1376CC24E 3B54F308DCBF18256A008ED70342EB5F32BAB141717BEB59B46EAE36D8E50EBA514287CFA66DDB
G_b = 03836362FFB02357EFF24F4881D96618B2128F55791A445D67E301A5A67B57146B
s_1 = 08B637BA75234719211718326BE28CB3C45EF4EA366DEEBAD2A1738D6A77E327
W_1 = 03EDA13583FB00976FA641B29F1DA37D95EC4E38328A3E645A522637C635F7AFB7
x = 36B80344B46ACC4185A40A740D8008C47BCF6F5C183787DD3E8CFF1CA38A26EC
X = 025460E3BA90D478232E64786C016CDC1CA31B67F9C876CBFF5E59CAD80F417896
X' = 02CA2646F82997E01610F25B2BA8858557A193FEF31C4360DBE81537C96D4ECA03

y = 78574F0E3861B458291DF3D3935624E873FF9AB8FECD7FB731E8E4E28312C53A
Y = 02A509BBD2DCA18C790960A7D6A616A29E9361C5B3E8EDCD5474EDDC03F4FF680A
z = 02903FB52457300DC360EE8E29E35C8E2AF029EE2E552F9AC79C7D7414A09BFDAF
K_1 = 642B8E2BAF69CE15311D89111403F530239D324B597998C2E6468F153545BF68
o_B = EA9C1114DA052C9946016F3E13E5071F687C0F397FCE48395EB417854F13FA43
o_A = 7E44AC7A41F74B739B4119288C00117C4EF697E38E4B4CF9CCA75AF48A220633
s_2 = 8674A52EC629B2DB1CA283E9F3C1BAB79A060CA25F8FCB3EFC940EC3A5A6DEF9
W_2 = 02ECCBC141C0BD5663378F7F71DD846ADDD11DFEE0160DB8863583680A014A21E7

secp384r1 (SHA384), L_K = 192, HMAC
A (= lrpakeuser1@aist.go.jp) = 6C7270616B657573657231406169737 42E676F2E6A70
B (= lrpakeserver@aist.go.jp) = 6C7270616B6573657276657240616973742E676F2E6A70
$H(\pi)$ (= SHA512(I2OS(0)||A||B||password)) = 64C0F6239CCA16866612D8E1115B5ADA038D88B2A1376CC24E3B54F308DCBF18256A008ED70342EB5F32BAB141717BEB59B46EAE36D8E50EBA514287CFA66DDB
G_b = 032795D71E027B79FBD173E29AFEC1FEA012EA8E949261351B1B55A057BA2AEB486DAE7864567E295455102A36E80FFABC
s_1 = 172728FF24A8DACA76CB35CD452A5B2965566765284188B170432CB308087F694BA5BE9096646BD841A38CDBF303BA36
W_1 = 0387B53DFD61DBCA7B713EEE1CD97F906BDDDB51545606982047180ED861A334816B9280C680B7D006CE16A791E6D34052
x = 06E32720C444DB089B0FB133C4B76BCB999AF85BE2F0FEE00828F3D2C8F6F461B6C59DD6C50D221BF62893DAE34D170E
X = 024F7E422FAF3CE9B6C41D152810F1219275EF2609C2B773FDDA831042547079A81D6422C333176E4BBEA33B1177A91A29
X' = 0245E1A1AEF8670486F0CEB1B64365C6C880EF523B74ADB8FBA8E98E8B7262479342852EACBE59C97A5B443DA391F84DBC
y = 04AA9BED6A080FEB1AA1989C879EC789FCE09E0DDF31ACE2AD6AAF9B1B74801E5BF4A47FD5C88FC6D340AAA4510D3C2A
Y = 02D07170771E78C29960CD8F2C4BF84C680E0E634D626B4354A29E608746AAF6EF0EE8F6F3916D46AEE0542D0A64945539
z = 02CA358BBFC9048EDEA3F584105E3461F9DE6BE68F8D6FD36A35C206DF9E83AFC9D84D8EEBFC6A9B5AF26166D5324A2B93
K_1 = F053027E04824E247DCBD91922C523DB14936475839F0B5D03FE9D93A6D60129E5C77DEB2219BFC8404BE35805487286
o_B = 786C709D048E9E9CEAB0C2E032596E5E708ECE7AD3BA38CD998DE574DF65C413494922D50D2D869D572A5CF563EA65DB
o_A = 3E9928F723856EA8A9051C1C1AE5B9DBCBF5B71235874C03AFD9FF8A7119B001A87E45310899F4431442604878D50C2A
s_2 = 87926DC8F0C6DD5C833A9BAC88CBC7B10540C3FD6ED95522C14DF050BFDDE4A55B551D50747EBB03DDFBB231AD11FA8B
W_2 = 026B99C3D3216E128D04FCACFBE3BD54BA6D60226406EE9789B6040743302C6A916287178C7E0A9CE3AA1CBCBEF63BF7B7

secp521r1 (SHA512), L_K = 256, HMAC
A (= lrpakeuser1@aist.go.jp) = 6C7270616B657573657231406169737 42E676F2E6A70
B (= lrpakeserver@aist.go.jp) = 6C7270616B6573657276657240616973742E676F2E6A70
$H(\pi)$ (= SHA512(I2OS(0)||A||B||password)) = 64C0F6239CCA16866612D8E1115B5ADA038D88B2A1376CC24E3B54F308DCBF18256A008ED70342EB5F32BAB141717BEB59B46EAE36D8E50EBA514287CFA66DDB

G_b = 0301FC7EA5FABE261338268E4D869C85792F696FED0C4E8DF2C5CC2E1A058870AD34F2075F6AA9EB345E5C7E389A1F6DACDC69E7F2E23E2E6F4FE634B7AF04B96C0000
s_1 = 0145C5774E00ECF1B110F2830121B25AF54DC20AB69DCAB9EB178A8503F9BB0149584FAAF65643FEB5D3D7ADBAB368DCCD7F516D01B1225016EDCE45DD3D35A222A4
W_1 = 02001641396A47DF8E7904722C402F3CF28D0195A9E9F01C9F8587E21DF000EA8FE9F8F5AC190B8433A678D977802A06F54773D2D703DC7C70A31F86CFDE98456B7B6F
x = 3415721DBA0048D8FFA0B55AE61A5A26FDFED7ED27338B57CCB727821DAEFF7ADE71FF07696940EDE7C6F0ECE64CC528CBFA2B1719AA7EC87A7203701BF28974F2
X = 0201789EDE6B436290240CD0560C417E026CFC40189E01E7D60FA8B34104D841F59528A5FB26A5B5BA08DAA8E0731FAA9517D676E8CC6FD18B3423D472CD02417FB32C
X' = 0201E1254B57E3B19B58E5AC4E8C69951695B67B1A6F871ABE1A09F9EF22531624E6676136F8827933C6AFCEB6A9C8C2699FA52A8185A1387F061E51951322F662DAB8
y = 349E027B11682752968B5F81D2A0011AEAC948D879E059DD24FAC570459C431B742D6087ACF370C7EF30D1BAAEC6312A799E8A4408B81BC5CAB320F543DF6B0F96
Y = 0300CCBD31FFF6AD192125F1166FA8315F0862DA0DDFA602A4C16AA285042C1357A91418F8BF94F1AAA23096807205CEC8A88F7E49CCB3FE3E2E99687BC000036A0381
z = 0201DCCEC1D4104F63ECE5733667130E51994AD9AE3326E90778C4D033F24881C105D129FE7188D2A809ED6A200B2B889A7A10FEB2EA1CB6B66C20A61BAE34D29D5FCF
K_1 = 784C12720D21CF9ABE1863130308C215E77A48F33885DAFD0418C18CA5BAF48DBB77B4D1C6CAD146E84BAAA09397C4396375A6203C00E658B99680BDF7483442
o_B = AE16DBDB229E54E861BE925F5FA454348D15DA2268D323FE98F8B5907E35FF938F875130116C41672F4AFFF74E93769A1FE092A71BC04C5868F4C2139E798E86
o_A = 3EEE9798B58D8416432B59BFE2718EDE5B928FC2FB2879883D81B5965ACFC470D3DA3620CB9A4B5C74D563779F116651AF7EE10D6EF6E4FA3B006F6D4909CC58
s_2 = 01460B413E44AC230CAD3226FA37EF303AC5F4BBB25374EA4D6164A74410F89E53B4DF5F4AAB621EA58765738FF1D622D06CC8D092BC11549E4F457A799A09B6C50E
W_2 = 02009C79B87EB0FF1AB99F4E58EC7D73181B675021FEDA0CE34A60F2AEC8FD7346F6156454C88D473120A021C45EC1105487FB4A5FAD01DCF081455E1F05CC3AE6B462

sect233r1 (SHA256), L_K = 128, HMAC
A (= lrpakeuser1@aist.go.jp) = 6C7270616B6575736572314061697373742E676F2E6A70
B (= lrpakeserver@aist.go.jp) = 6C72706164657365727665724061697373742E676F2E6A70
$H(\pi)$ (= SHA512(I2OS(0)||A||B||password)) = 64C0F6239CCA16866612D8E1115B5ADA038D88B2A1376CC24E3B54F308DCBF18256A008ED70342EB5F32BAB141717BEB59B46EAE36D8E50EBA514287CFA66DDB
G_b = 03001C0CBE86CE485C9A31E30AE144FA26FBA67A84B9430DAABD6EE81608D2
s_1 = 80CD565B13979070999D2B733B7C67F8998C8DFCE1CFC7AA2ADAC34ADF
W_1 = 02017FD21812430AE35D6F95604E7D31DF4B9F1734F8618507CAE552E7AC4C
x = BEFE05840C788DB83D76A374442F9D83E473E87E7583A57D41E3860DA3
X = 030121D46772E77EDE102BE7F0D87FE4554432B72B418DC4640F28C13DCB04
X' = 030038B925C51C0FDB139A3B9C983A182271AE94B03186AB76C92E0D0CD615
y = 8B58498C6E9C433DE2602BDFDEBCB501D67C54A418D53DCA5A2D39F5AF
Y = 0201A7B1C1E33EA306523FBAC0978109606B3801C9EEF25F06EEF79EFC4074
z = 0200EFD59D2776243486B7F8A6D70C48901A12737CC8524F016FEB89FDB138
K_1 = 0E3BBDCF9C27AAC8157485433D96CEA88F1195645A7C6B86C79D8B2A4DA8AF20
o_B = E7A8215C6C8113E86197130021D1B3510624B2ACAE5168B6833B143163C92D5F
o_A = 9CBF4ADCD3FC4DE526F520DA805520526AE4162562B8D279AC4F8191953C2BCB
s_2 = 5EC18601AEEC38217E68A867C2FC8F66A0FD6E065F246792C2AAA3F07C
W_2 = 0301ED6A3947172912BC8DBB893691DDFAEAA8AA3CE378F6DE825838B09782

sect283r1 (SHA384), L_K = 192, HMAC
A (= lrpakeuser1@aist.go.jp) = 6C7270616B6575736572314061697374 2E676F2E6A70
B (= lrpakeserver@aist.go.jp) = 6C7270616B6573657276657240616973742E676F2E6A70
$H(\pi)$ (= SHA512(I2OS(0)||A||B||password)) = 64C0F6239CCA16866612D8E1115B5ADA038D88B2A1376CC24E3B54F308DCBF18256A008ED70342EB5F32BAB141717BEB59B46EAE36D8E50EBA514287CFA66DDB
G_b = 0300A28B50B8139FE286B2D2E2C0472F226C08A73E5B46410DC3A855A95E51FC5936EE4CBA
s_1 = 0189B967F2E0578BFF8FF7A91E86AB06C5B8FEEE98755F650C785858977F4CF1EACB3566
W_1 = 020134C6F0D6432C45E17344F56AC1BD32E4773EE5E7FC154B615F70E9232884A6ED89AFCC
x = 6D6EA2F06155FB6EF0A501F700E2D5564168A42A04D0982313155CA99F0DE873858272
X = 020797C2BD11D4B68D95C9339B844137C7271121124DE28EFB74591E8E960DF00CBD0DDCD8
X' = 0304A03C7473B46D6BD7F317BFDE936D12840118C33CF87CFD42EA5D6C05929C6E4C58846F
y = 031C8259C15815B83B5821D6769DE7D1A5749B8F336914EDBB073EB67F26CA36B4F6BED4
Y = 0200D87675C56855A645233E8732CBCD2D0AEFEFB7F432887517A10186A69F6D750B0D3A13
z = 02077C8D10FB2EC7E26F5A25DB4875D9C31B89C90D5609BD0EEDDE9562059AA5DA42371E4E
K_1 = B54951F161350F5DB64CC5C9BA5D8B504C8D11F53622779AA75BFE05582C647D288FADEE074199A038EE88976EA8093
o_B = 8A410DE35B583BD661518CF98D953684E97CC0FAB6149452417277F842D25606C5485C20A27662EBC06F297C37329BC2
o_A = BD7CD009CEE8185B7C6D22513F2BE610A69C9AFEADA6BE24936EEE61073CFE6B5D6E5FB22A865F1F6280886745AD24AC
s_2 = 02805D7E24ACBC7677DA4489A68EABDD7649FEF32C9369BF2CAAA17A7619BBE65135DFD9
W_2 = 0200B77B97EE94A9D75530C47059A6B3BC88D871F86ECC2B7DD4611E7C0B02619CB6501

sect409r1 (SHA512), L_K = 256, HMAC
A (= lrpakeuser1@aist.go.jp) = 6C7270616B6575736572314061697374 2E676F2E6A70
B (= lrpakeserver@aist.go.jp) = 6C7270616B6573657276657240616973742E676F2E6A70
$H(\pi)$ (= SHA512(I2OS(0)||A||B||password)) = 64C0F6239CCA16866612D8E1115B5ADA038D88B2A1376CC24E3B54F308DCBF18256A008ED70342EB5F32BAB141717BEB59B46EAE36D8E50EBA514287CFA66DDB
G_b = 0200708C13AFA3647 04D56E9E96049E700352D76249BB30AC28EFAC3046B62A03D909FBA4D0B0416A1A75EFB48EC1DFEC46A480C99
s_1 = E22E2D8868A7331EE6C9DDF3A5BC71D5833D48ECB2AD63E30C0B3F3242F4AD712AE3AB5325D5A3E22474A536E0A7522AB1EF22
W_1 = 0300E2AB649F26205F689C2C8C860CA3B95A2DAFED5867C306D3540A9ADF1BDA229BCFBA6BAA46A0BDC10FD3E506393B472639538F
x = 88E91481A83B9C19CD4C3DF3B029419A2DBCFA934AB26594981206629F3C6EE9B6110EE91B547A5C85E0BB501D8A12A65548FF
X = 03010D5C610DD654DD3A39ED05CAA6CBA5B75E720F06AFEA0D54CC31C93414230E7673FFD945C755873B55CDA040530460013313C3
X' = 02017330B65524EB502E5C818954320AFE000C39DB6E9CFDDC57E73E20ED5BA0E6CD3F8B8E4EF8F3EA0DB15D62025FD16E52ADFB1D
y = 6E67CB1AE43571006FD3005657B8409926F40BBA28E1E3FA171B31D125C9AEA35F6374D95821526482EE57B81CDDCC4DD2CFA2
Y = 0300879FA3A9295CA8581F878B7A8945868C223F00E007B2C587A0ED727BD06CB845D2D76F9F0B3113E0D840A94B685851C8F944DF
z = 03005B1A6089322D7754BE58303F775967263E113DBA277A12F485FA067FF93139F78F526B58AFB5E54B4E81E4D85CB85BA6C306E3

K_1 = E30D0863036B3EBF9E271AB0F8A32219368E5D946054F57E97DE368F8CFB3D23519BCBB16B3CA09FC757B EC803877FCD44703F2346327F319128F6A7F923CF95
o_B = 0CA98948D9D7F2A9A05EB156AD51B4CA6389D78AB2FBE3069389C3BBBDD6D290C275EE504E50C4D4B2FDB 709954B9BECCBFB65F84FD34036CD0CB294AEE513F4
o_A = 14E97AC5FD6F0C4A43E107E70F505E6CBD70C1F7ADE5E8B4E1EBC6CE8CEE883E14E65AD49A154E2641652 35D9E15BF0E9E5BF34024ED3124D10D80141D6BD863
s_2 = D95C91FCA449ED36273C6708A132DB34C7F93DF3DDFCBEC1D21C99313397FB308E8D4CAC53D9F8CEF4BD3 85E91BD2DA8BE7766
W_2 = 0200986D96C4D23EB65C8915EC257C29A0F35A2EC5B4D07B6EC0F80175636421BC023AD2FAA3F6CAA297 868D5F5D6E09500A71191F

sect571r1 (SHA512), L_K = 256, HMAC
A (= lrpakeuser1@aist.go.jp) = 6C7270616B6575736572314061697374 2E676F2E6A70
B (= lrpakeserver@aist.go.jp) = 6C7270616B6573657276657240616973742E676F2E6A70
$H(\pi)$ (= SHA512(I2OS(0)||A||B||password)) = 64C0F6239CCA16866612D8E1115B5ADA038D88B2A1376CC24E 3B54F308DCBF18256A008ED70342EB5F32BAB141717BEB59B46EAE36D8E50EBA514287CFA66DDB
G_b = 0207BBB9AB624978D634EAB74C381AE69EDE5377095CDB8F68E111FBCB4DCE7898C37E32A8E50B3CC1AF5 177E6876EC5A56C953C493DB21603EC8DCBFB210F0354824B6173D2550FDD
s_1 = 0260AC86F64047E56070B76A0345DFB594AB33BFDF233554AA8B0B9413FF6620A2D4E50639DD0886FDD17 7DA5E7DC7353E5AB8A0B3B31699F0A0697742DCD2C60CEE20C331219780
W_1 = 020349A54418ADAE8F71EB4F5339023FEF1922C2FB5AFF86AE7501AFBDC9FAC2AC82ACDDCEB259BB740C 6EEE530B189777215CD4AEA995C7060A15D795042266DAAC4B03608FFDFBC8
x = 017E33C05B015B4A1E7ADD458C08BCCBECA494525987BF8[illegible]08BB2F570E28AC50C9DC1A6E1A688F9D7E4CB 21DE6177C8EC4B88DC293FD6E36684B0FFF91163133E4935400A75761E
X = 0204E4685B756105248DB2D31870E8162C3488B620BB9CCFA9A484EB15677582036132B21C1099A20BE927 221F6BD070CB26C53584A5BF9CEC2C6FA7AEAF0B48497F266FA3E99EBAF9
X' = 03013417D0989691E426E081AF15E177518AACE9B37A57496B6342616BD5968CB7DBC47F40A24451E018A 61F3F73A56C4E816C784D6F3712018CCFD1F8C8AB6A75618E36B81FEB6B7F
y = 025A9F76667645F39A4B2EBDDEBF55249E9135D7EDABECB69C8E2089E5BC2B17E16FBCDF1F61F4C07F310A AE6FAE4236FF2FB5B01870777ABAEB0FF8E6C6FF65CCDFE9FDFF05E3E9
Y = 03004A4DF3A5337772EAC17E0B4DB1D4AF5293C74868C8EA0859FB1867FA9C567A8B49EF877646420A8230 39E446D2EE4EC461A577FEBEFDC43E74016A37A258356FC95AD746D56786
z = 020252EE40059B7DF364A605776EFADD349495D85DAADBAF82C3340E369AD6A520053C2BB1E0973228D521 698F83CE83E6856C90D8B05ABAC6CD9877299226769CB1BB807D6DC7A01F
K_1 = BA7D494A386089990A39C5C2064AFDD263AFB4038B5A2E2AEB9875F0409A5606C8B18064C1F288C4FACD6 436FCC449FCACE685626B8DA5C3C635DB50FC79AEF4
o_B = F3BFC7CD8CA2BDF01EABE89BDE570D524808473DE20C6A679FF4C142D959BF47EC76F06E83A9E5854F054 05966FAE07FCADDFD2D3DE3A1887C42A70A4D8D5C4F
o_A = C715CE1E8CA379F71AFCE59198128184A51FA2EB31F621317CAF0B248F9BAD30D0C65DA73814F2BEA5458 3DF970C5F8D988195CF97440EFA9E06C5ED84ABAB8D
s_2 = 0260A086F64047E5C18A0497B18FDF47BD60F821B7BA96A7F6D18E26D1FF09CEAE8CDC1756BDCA316DAEB 2E01885B525BD9AF5DE7140F4944872604FA1DCB1E556369203B20C3834
W_2 = 0206390807781A7BC0C8BEE076C88B321DEDCAD6BCAEDD76BFFA6EB67011ED4E77B950B3C040A615C482 1A2257C4CF304FD0D606859ACABA891BD4A2810C2292B4C261F1447F99CADE

D.2 Numerical examples of LKAM2

This clause lists numerical examples of leakage-resilient key agreement mechanism 2 (LKAM2) with the parameters in C.4.

e = 020000040000000000000000000001 for L_K = 112 (RSA-2 048, SHA224), HMAC

A (= lkam2user1@aist.go.jp) = 6C6B616D32757365723140616973742E676F2E6A70
B (= lkam2server@aist.go.jp) = 6C6B616D32736572766572406169737 42E676F2E6A70
password (= zokang1) = 7A6F6B616E6731
H(I2OS(4)||password||A||B) = 45AEDB90B740E9DE9CA7526A7EFDADDBD6E40F6628BF15DE14288687
A'_1 = 87E73FDEF41F684342D1A1B898AEFB7E7D5CBA39AC5AB757EA194B36
A''_1 = DE1AD38862B96C40FB702F3539644EAFDD5116DB4D32C60A81F6110E
n = BB0DDDDE835EB966C0F03A215ABFA7998AAC98B9C2C72245C6FEE4C1B71C0BA39BBF6D20D3CA39CD62E0DB EE89A490D0ECE2DF87CC6FF6F9DCA313543DB3A61E14FBF4C10187A15A4C6A69E7B35B3211C1A3741234F94BC 26C82F665B27F70122F40CA0EDB13CE1D04809FB2DA53D4BFC11065696DC36A2F8466E7DC7C741D3F061474F3 66BE172757350A3C15D41FF78EB163101414DDCBD3001BE93B0B348D4FCBCF59C902CC76893FFC1EED277F6C5 FE86BE9FF69CEB0C05648977ACEB60F169741F08B64F7983B2331364C0EE274FB521BB6BAD4E1D0B3B9F6EC65 82B61B6636EBAD9EA8A77247E16E80C4BB228D4A5B62BACAD716EB249343E683CA3E81
d = 900BC7F2D740FC02BB42204DB6DA1465BB8782C28EB66F070D8EF151B9A3BDDAEA77D8EE832C5DE693118E A4C66F3F4D252E6FB47F6997E7C0E0232251FD6AD0F363CD53AA4BE2BE7C60ADD8F8B803D76B9964F7999E586 EE7D5B49B43F72887A4D917EBE5C96DA5D22D7B7BBA6D26EBAA687FD7AD7B24A563C8EC403D29F475C3705AAC F39331E39A6876F85D621F5853D4BEC23198100CBEE39417A4593CEFB97A64DBBC244F4FD237CBEEFC8DCC649 4BE22952DAF68F64543C347D090A8327A5A66183CD1E8E5DE86C7F59A67C5F0FE092310094856369315534F94 025AD3E731467D241B301D56DCD2A3CAB0F12379E1E72E82821247A4F570C4E526CD99
u_1 = DEFF10A3DCEA53B9CDA7C210C1E9AA0DF590FF8F96A4E280772D29A5
v_1 = 9B51CB336BAABA675100907ABF1407D62374F0E9BE1BF75E6305AFE2
x_1 = 90A25DFA4B7011F513794F8DC539CAF8296D1AC5734B0326214 615F1BAB4B95A06EC95046C4E15DF0FC6 7D67E63EAD2F4A85DF121481944CED4CDBDE8FF4DF40CC0FEE82E34D16B4017E1D49D86AA29B34EBBBED4253E 9A516F4D2DD17D6FE9D92D6782497A45F583AE96F708588EBD436A2382E7AD520786A6C1FE398F9038984E5C6 FF76DAB893002A2197C41F7D6768F6E24E69EDA12336FCEB7EF67C59E64016B88C26BAC81D443A6B92378B8A5 67BCB38840801CE3C10B2CC1E14D27FEA87E724A1E60DD99FB066A2E46858629C827D0526BD8F981315A34A4F 226C31C9E3D782722BBA6394650ECE5E186F77F31541C33352EB408C7215A5AA860028C
x_2 = 49BD832F7E7782027BD193619BA875A472CF60AAE58EBFA08E49FD74A382D858366D199922743817D72C4 DC628ED3700FEB4A00DB5FD78CC871E48941A1EEC9EEDD5A242317F7D7288A43FF791C31BBD6967A1568E0777 39781842A5307082471117A3452E8842F7898C9CA5AD01CC57B28AB0EF92B3942EB3ED76856074CC8DC428B97 E1ADEC4CBD8CBEB4F86D4285BAD8FF950F3D7486D4188FFF9E6381CB2BC463E4463E413F01B77AB969D7B5627 A61BFE88F541EAC8B89A8549A3926402C43377AC57A5978C89B550FAB723E09ED04849069092322 93AB76EAA 935ED4A50959D6AD2A307FD6E04542798EC24D0785E4911FBB83822BAFB5C7F0CB931F
y_1 = 96E8259D67F21A85678E8C1E5D5DE247CC4E29562A8838C18409A94DF453FC72EE02ACECDC7812A5E4BF5 E31CBE6595B76269C0E9F5DF5BCE86D05625C7822F41B4569A57E10DB612FE4127275E59BEE0F80BF34B9DFD6 5846A65E87BB9D33250E57952DBC24994A9B3F236F3A1DA1C84044183596A464C61C2F9BD0C95E221C4987861 D7197F6B35FBE14B9B7B5B4F2E537813EAC3D8264A762D2FAE28A1BD0D94DECF98CDAA954BEA25AE9621A4054 3301FF9D35971C83928B5F2AF27469ABED085141E834CFB93910E50CA238CD289F105210033778DDD836B8B96 35B821260BB73B002D78E6F2C4A870D7DB253848AFD0530BC1FCCC5E10ADE7713C4850A
y_2 = 7DF9DC446A691B3C3514A502DA0F733A6EE3C3C59899A8E6345BDED78B8A0C737D564718042D95B055575 6868010E2A63DF17BAD02B28D585F96E6F85DF7976ED8B2713D61B08E0817225B4EDE3BEE7791A0947CA4D4F0 61281AED58BD0CACB3E850D64841AD322AB9DCD4BC3083D490F1A9B8E5CF75CF0FFC999139D3716BCA406111 C3B1AD7F6D5637CE0F710061C442E5FB10A09F279CF210CE499D19241529E380CC4BD5930B5D8B888110F096 8AAFE1EF2BB79746B2059997B8437ED77A0A17987D2AA874BA753C3B82F7AB12DB242FA1B9C18317ABE4E61 DB93522C9A0A68A274F362699FC87AAA9D454EDEBDD13C1E533805FD1831084CF858745E52
W = D07DEDBDE93A7E376A50B05417B35C62E92C5777CBDAF44FBE90926F
Z = 96E8259D67F21A85678E8C1E5D5DE247CC4E29562A8838C18409A94DF453FC72EE02ACECDC7812A5E4BF5E 31CBE6595B76269C0E9F5DF5BCE86D05625C7822F41B4569A57E10DB612FE4127275E59BEE0F80BF34B9DFD65 846A65E87BB9D33250E57952DBC24994A9B3F236F3A1DA1C84044183596A464C61C2F9BD0C95E221C4987861D 7197F6B35FBE14B9B7B5B4F2E537813EAC3D8264A762D2FAE28A1BD0D94DECF98CDAA954BEA25AE9621A40543 301FF9D35971C83928B5F2AF27469ABED085141E834CFB93910E50CA238CD289F105210033778DDD836B8B963 5B821260BB73B0D3557D2D15850544E80303D8A2B06193A54C243DACE5D2C6D2551778
r_1 = 30655322A2C0EF24383D7C067E5604C31734F2496ACCE4B82EC69367
K_s = 987D985F935BCA9B8A8A9B957FE86E17A54258C6709B452FFEE98ABB
K_i = 8A8DA8F8E2A5A423D7241ED5A75A098FC2BA4A5AE4F4BC6F03F915F02CEA5ABC
K_m = 129E32E1A344038C10A4C0F362F8EE88E4EEB17D060010E56E62D415A7995060
o_A = BD5031C6826659E0E67B013D14BEF2A46C235DD8816B9564DABBE2F2
o_B = 1822C7497A6D1C62001ED42017279C28430BF9259E7E9D16DF75CC9B

A'_2 = 336340FCA1772464BC92C7FA5FA634EA8D57C6D2C6A8FA537DD3A267
A''_2 = AABE1BE5A6C800EAC7F35671C5DEBC6B7106A23F65C1BDA248FE35EF
u_2 = 7D2C7C1F5E92D8797D41DD1A3C5ECB54CFA3A5432D2E1988737A5933
v_2 = 9B51CB336BAABA675100907ABF1407D62374F0E9BE1BF75E6305AF22

e = 028000000000000000000000000000001 for L_K = 128 (RSA-3 072, SHA256), HMAC
A (= lkam2user1@aist.go.jp) = 6C6B616D32757365723140616973742E676F2E6A70
B (= lkam2server@aist.go.jp) = 6C6B616D32736572766572406169737 42E676F2E6A70
H(I2OS(4)||password||A||B) = E8F2C5A73E78E95ADE261F29CE9ABB008E4BABD2B8B1CA6EA2C52005CB2C705F
A'_1 = B83D73D145CA980A5C4D69D83236205C58B436668CDAE250E26DCC073475F9A2
A''_1 = 8F3B63C968E2E24BE9AB40677BFB7D3F1EE68FEF9B16E8C35F23B101C13FD0DB
n = A9C583F716E704397B805A482B4C150223D1CEA6BBCDC878D8EE254D6A10B3111C322C07C89057CD5AAF32 6E75138227FB6D0B7FB5DB3CE202A34D5461EEE7813B4DFA356E9890C4843369B93D787EB01D7F62C752A4B5 0F9B194AC36D19ED9CB64B29F30E795572F9354785876597F71B03FAD997CB57499B9498C7CDDF4DC236DAAE B52BF3087107FA52749DC354DF60AC4A96C9012CDDD6E7FF07203B3578D3CE716B787E911044D0FE289EB7794 2437B88DF6ABF9859FB33A53725C4AD36F03328AD07F7459BC82679CFD109FC2BC44D4812380CAE9152D8D453 CAACB8F85F6FD0293803F745739FB65417D5E732DE54478762A5D68261A03E30BCE7C24880B1501BE7728F340 5A616CBA966B56BA210F340FA16784EA41FD0129BA2AE915FA8C8C7FBCC9BFE3E09FE56A08A6A3FEDB4B1A29E 08BEF0461F10A53B5B3E998AB0928094038C5B4A18F4E8D89694857ECAE8FFEBB110E1110E06B33000F3DDE6E 6CAD39DF905E1D57C0C382333778D36BD5C247DB02E25017E2232316C2
d = 77CE26735E4EFEBA4C0C542F42CF47CBE56454739C991AFD85405DC1655733BD7EA1EAAFBC7964DEE11FC6 66CE4A56416B0E0FD4C5F3635B29EE813E9D1947C8F3CF8922FFD4E83A238026962652AF6EC3A14F70D801385 EF99E056285E3C42E7E5A10A7E9B69521C837D29624BB2B09E5DBED8927E005597D7A0A03F39AEBD4D23BA33 1CFAB88D2D4188757F3B1B89BD878BB7CC2D88076A41279262B9457B047CA9900FAE7258388DF6CAD36A3D3A8 FD44619DB02EC54C86369E44122B4CE6098E3A769BE44406FE93C1E50DC2AF99E9F19F2F66F07AF47716BC0FA CD712CC84A3640D6D5E0AA66773D3BA7AFE0BE3AB4B5EAC08E643121D716EBED7C40380EA23F3DAC0949C8FF5 6EC419AF19598F616A75A6AA8423F7028509D2222E89B8A155DDE689A508EDE33468B0E8B7964730AA8B54488 7CA1FB0B4CF8E6B43311F89C096F92D5711FBFEDACE0D974DED09182A7F6B9C1A4B35A393639F0A6DC3A302DD A491E0EA73CB74F4813F4487686A5051FA36F6E81E1B38702B1380003A9
u_1 = E66117C724A338F4BE799CBB62BDFF59840483D56071125D6404975ECE321015
v_1 = 0E93D2601ADBD1AE605F8392AC2744590A4F2807D8C0D833C6C1B75B051E604A
x_1 = 5C6FA7C304D3963962F88FBD93161BFA6AAC95C119C548FAD411390D09E864BFEC3D5565992D805599F5 0B85B13A51BF2AA57BCB5073AE3ED01C05B4AE09EEB0E6C9C7F8250985462DBF6327A99115D582C832F4C86B6 A840B3594D48B0D4E08FB0780D75CA6B1E64CE4244C95DFFC09A4E73AF0F142DF8FC0BDA04223A11A71316F9E D89794B02F8D5A83B9CAA65C22D60C066B6CAF7DE69F1DE1BFC9B2BA3F84F300C444293477AC85A96740DF758 0F3EF90E207129F1A2AE8E7B9FBB319DBDD90348AD28088BC4C26CE70B6B5058009FF0847EB1EF223EE0B87B 972A7CCAE0DFEA345595D1120AA6A4BEB967EB4798A89F9247EBA8F523AD7F48A469844A9124FDCE243CD4E92 3AFC24AD0B87EE380991E45D4AE3F49867C936F8EBA75EA7550FEEDE221A6FBCC2ED4A746B139BAAA2DD5DC73 749C544FBC356C7F976D3E5B8775F4689C41EE1E74CAD1B649CBABD35747D76694BAD48F0CDEBD5AAF362BDC2 540A97D7EC74801D89B16953E263339A278C619421CBA4BE698A5B177272
x_2 = 98FD69C9B7EC99BC3BC5BB8654A05F2579275817F7623C327BEE5E1ECB6380A709905BDE1F13678268E07 554C099C6E06BC9B6751C994AA2B6064CDC3812CBE2ED0D98C9CEF00741ADFE1E982FEB3E20775AEF65416EC 43289FDA302A88FD630413C79F232CD5E553B2EDEC978710EBAC9A9B687A7E0D396591322BD89DD99027379A C3B5FEE8C037449344EF23D5EAE39664B07ABA081B87074FEDE1E3F547BDA679DA472B2E7490E8FD07617CE8 765C1E1992CD540089FFFCA1155B98F8E97D686144D3F2A2793E08E417A4848881980153303706 5B1FFCFC6BF 5E55829912FA06564FEF4A21B1B5DF62262BE274F6B375280DF05BC904D32D5D6D86BF1FBE898D18C0D1947D2 F39E8D997BD3B48C3A1790BCB37D9A31A48DCB05EB6F08244EF44AC8021FF2FFB277F66352A8CACEA5403DAA5 90B2ACEED664A1E8D757D3050023E5050EEA050B4EB0A65084DACA41BA7EB5FF557322E8CD36DA51B27CDCEDE B483DFA3F73D7A7523E30405BBE584FB0B245DD079B7DF38EFDC7F1561BC5
y_1 = 7D8EAC856546CDB16684FAEC8E07D4A0D84B9DA80077CC27ABF42858805DD6CD65FDD3D5747D5FECB9A43 FA1D2F465240657248A475A0979A1750888729289841A0110DE638A2EB09C68FD93552B9FA092A22DD9A1A2F 94E95BF426303682C6B2E6D1107274C767D43DDF6C4081BBB3400026ABAB3FD81FEE601166ECE7DC15E60878 825842068DB34D161F6312A371F727BE9D75B0A99E8E2C31433ED48F905ED7D727C81DCBA3F4D2FA3147DB71 FC7B9EE8DD0C8621F617ED58DB6A5C2C14DA4556329F08688230C1321EAEBB3A7BA571D45B70CE65485555F81 0C91912DBFF2887468BF3AF37F9D41999500BDD67F29ADD95C23486EB0E0589B14EC675B54BF5D836F1E23C3E E2F2D681631B7B7AB12C9B59DFDB5460C611F35D8F2A38A97E0F90B6D1575D475F09CF973512F6F60B49DA9A1 F30378007B65FD4CD54D52EA6FFAE7DCC29B5C02E320A629D25BAF54AD1EF108538A270F2E70256E8853F1D76 D186928E2A15420FDC80A23825F25CC449CCEB2A8B0DD46D6FAF68FD2C9552F

y_2 = 2C8A6DF1B203B2E011B1C8875E1596C2E6B1DD84B6F4534F6636A4AE78344166713C3BA96C84A3CD7D5FD 54191A67C41A0BB1FD139AC6ED732B728B702EE2621AA4434090540E4C971CA4F8514B7C64DA680993492725D 82CDE2CB54EAA5A3751D2535B0FBD6954B9C9B77A0B8E58363831CF46150CF93387891C562CCA0354E802C91D D4639D09F82B790CA716D93836B6F7C1EBADD28011E81A70A64B336A7D7BDA82669593BD120BEF1A129883BBD 1A74FA47FC7010EDE380540F6E0B2AE84A2DAF2103A21CD96DFC6ACA012A02E80AC2A4811543E54B1BC747D11 9BE086EAE06FFFD846C78239AE5B7913E528D884AE07DF5E4F79BE93CC2EA5C64E11E5043392E28AE35A3D841 06E0852B912A7E9F671CEA4590BB374371A15D10454E7DDF110108EB45BF9E8A5B4F8DF9C3AF014212D30913F 97F482AE05138A9723006038DB326D797D2224849B38097FEF6F36A3907E460E0FA797EAB74EA2912ACEC7082 A22705AD750AD001777A45565910DE3BD7519F371486858154FC5A7AABFA
W = E1FEA7B6D80C4B5A13D0D98EF24DB4C9D9D02EBAE38F2705E8FA45ECFB3D6366
Z = 7D8EAC856546CDB16684FAEC8E07D4A0D84B9DA80077CC27ABF42858805DD6CD65FDD3D5747D5FECB9A43F A1D2F465240657248A475A0979A1750888729289841A0110DE638A2EB09C68FD93552B9FA092A22D9A1A2F94 E95BF426303682C6B2E6D1107274C767D43DDF6C4081BBB3400026ABAB3FD81FEE601166ECE7DC15E60878825 842068DB34D161F6312A371F727BE9D75B0A99E8E2C31433ED48F905ED7D727C81DCBA3F4D2FA3147DB71FC7B 9EE8DD0C8621F617ED58DB6A5C2C14DA4556329F08688230C1321EAEBB3A7BA571D45B70CE65485555F810C91 912DBFF2887468BF3AF37F9D41999500BDD67F29ADD95C23486EB0E0589B14EC675B54BF5D836F1E23C3EE2F2 D681631B7B7AB12C9B59DFDB5460C611F35D8F2A38A97E0F90B6D1575D475F09CF973512F6F60B49DA9A1F303 78007B65FD4CD54D52EA6FFAE7DCC29B5C02E320A629D25BAF54AD1EF108538A270F2E70256E8853F1D84F171 0DFBAAD9F7B1198E3B274ACDA961E6CFD6D8C40044CBFF53C7CCE06B894
r_1 = 78C97D9136553807560C4875AC2BAB38C5CBE606475B6E44FC1E8D1CAA704430
K_s = 7450EA83A3FAB147F53FFA4BCF60559A9216B9273C57747133C0BEFEC7C565CB
K_i = C1D82EAE7028BACB6C948C381F7D9D175F8A4688DA71E194781E4EE9319965AB
K_m = E51AA895087F407A2F3E42AACD0AC15DBCF9A7CED6545838E88FE9BFA9221C9
o_A = 4A488828E5B4563C3DBEE507EBEC1D83BA1DE591807AC808B496C0CC8A4CB79F
o_B = B6DED2C0A85FBB790B101B4C465AC7C93A4BEE12FB5383348E9CB550F1DDDA4
A'_2 = B9F9FBF632C9F7244B3F011E37A5C1FEA6998A8DE5E440A6727727DDE316998F
A''_2 = 8F6468143D5844391E03C681079AA8F49C76B679F7B4350722AA8320A4A84E3E
u_2 = 651B0E50B6BDB1E1504EBF55AF3AFAAB7D6EB7E92B768E896A53D98E0CB3D9A1
v_2 = 0E93D2601ADBD1AE605F8392AC2744590A4F2807D8C0D833C6C1B75B051E604A

e = 02000000000000001000000000000000000000000000000001 for L_K = 192 (RSA-7 680, SHA384), HMAC
A (= lkam2user1@aist.go.jp) = 6C6B616D32757365723140616973742E676F2E6A70
B (= lkam2server@aist.go.jp) = 6C6B616D32736572766572406169737 42E676F2E6A70
H(I2OS(4)||password||A||B) = CB908AEE4BD284D7C19B8F43CC7C74C1B931321BC6E32E56021917BD1E23775 58542A89F683B269533A072056C2EE1F9
A'_1 = 2AD88DFCDF78FB6E2077AC9CCE6ADCB6270A4DFC00B1A79045B87B8FB9F2B09AA3D25291663F52514AA5 DA873D938ECB
A''_1 = 460998F3EEB2D24D181AB66F4E58EB847B6C6A4F729F8113F37ABC538CB3C5DA85A4449CF6BF496153C8 1AF36FFEFD82

n = B5A4678602A7AA2B1F3290854AF40C8B99ACF9BC5787B9CE1349E9F27A8A845ABDE5693FF9C1446CE08B14 B2CEF444028948E5171F485B99629D2EABA6826EC328A82F424741F84E5E57E70B7555BCFF538AFB2EA4F7E8B 64FDF9EC8466A4A03AAE81D1952517AE982F162FD5D4B63FC5C468DC024F7064A76FE64E763C77235B9447770 0931A56D034716E182B7061308D858BBA54AF8DEE5DB6DA3653B6951D31D74AD313D4BE3F99ED3CEB6734C972 D97710AC8E1A07AB2ED5BD0879CC52EE108686E450C4649D392F765712C362F25A8A9936BEF3E928478D44970 8F0FD2705D26914DB7035B7A6A108F1AF04408CA1A801BBF8ED38FBBDC2CBBFB7166562FB18BE0E1A1733F124 2DD0AA17D955EB4D631858AB8107677DCC5682F64FFFF11F4AB14EFDC13ECF3232E2D7C6D44DE15382A0E4161 7DCD8CD7B046849E69311A505036C82576F45DF7C53AE7D30D07CEE6091DD925399F3E3D97915164A1C015E95 4EA5B696C680284B6311294D4D0E4D56E8F26347353943FBEB113124569409027622133 8B8DC5B7DE61659381 85C0DAF25E440655E792B7C8E413861571FDFA80935B0250D7E33B3290C61CDB3B2D90C5F9347D8889741117A 1F2163F290CDA615136203C90AE82B40B368AED0FEF88045CBC68AE4814FF9AFB717AB58529D196A94D2D44D7 DC9622E632CCA0DA76EB4837410A6991F880CBF7B20C99C1B0AB82A25B95C3C2E913C0B6E9FB12373B479CE42 D60AC9E673EA6A6B6FCD9886039D483BA59527F4362FD39F3833AA1795F843B4D425798DF8FA2BDFDC5761106 276B94D7CD5DCBC5B58CDCC3CD7B3566F030FA52A64D6B5A16A9D4141175B262EF2B2174120EDF213DB08A7D4 AE3D507AAB8F624AE7FCAE75CB966336661130FE04EE087AD68A28CFF8FE269106F269583065EC75261268CC9 801166ACCEE90071902D259EC6CFB87925016381C34549DED12F8467960371F9B17FD88F9E047B45DB8C9F1B3 3AE194649A24FEDD9C3D7DC04A122BDF11E681FC66293B324C064DF227A690117462FF3CDE7777E732886DCCF 8CEB6B1A948F99420E25CA3F226EF462FE311AC6A9BB2DA0C35D5E219FBB1D73973226D213467C7B5D50A893 F33E8DB6251110A42034B967FFA2ACD8C546EBE18603E2473166FEFA5D7F1CD2419D23702B52CDBD4B524808E BCD93B83D69CE182F0F4E8BF94FF2799335083736FA0DBE6B92C08D4004C3B9E2043DE86D537F77BE65C48A3F 7C24DB17824297C70C15E7DF1C926CAD52954D7DD3125C028D9F0466BCAA105D462A423FBC8E81EEE348826F1 FA3DF3AE5931CFC435E8D82022641AF3A7BDC18916C4B6CE41313F
d = 9459A737844885ACF7F22D576CB398C424BF9939EF09A54EC32BF858934E646ABADEFC356B620869E9CA05 F00DB29150D6DF24917CAB34BD562E123CC9AC3DBD3FA3A8E67A7DCB8562311EE49BFF3B3FDEBA1D21D616501 980EBF981FED57A57FD8EB1BF8DDC32358C9DBA0F1A5FB4AB52C0D5B293E0BD2FA55780BC91284C0413AF593 4385B2A269650256CEDC4974E8AB44D4C9CFD15BA337A186C145CDD608F8E83D5D0F82F95D4E867362C91AE1A 6BDB746A86CA44F9D76A05EE8CBC6051F3ACA8AAB133EAE8C1117336CA6E5C387384809235D2C456DF1C44D99 97DE5138B1957C80D9F0270699CCE2812DC0DD4B3B6A518277DE5489C4A5D54314C88083F603F3779B49984D3 C9745A50DE4C1D6E0F2543431A260DCCE81883DC0830B4BFB6739F159968994B64A0C04FAB82BCDF0801A98DC 3A6E7A9EB89ED00E4D69E7CD3A27A43C46E9C8ABDD8ADE77EF7D053E18C398ABFB21BC320B7A100D377580B0B 11E43EB3D364BC9D32B2BCD443BA79117301B89F7AE9A3A597D685B2CF728B3B2B1D1AC3AC4866627F54E7396 9AFA64407FA3189F80344B863878D4AEDD9F56C6F79919223143CD47BEB04FEA271B91F255A668F44A6503335 596AC532FC82E43E5557ABA77103FF01C9403FF3C94981306B8047639AE1B9399F1E04C85146BD785B75F2DBC 2230409C59D2BAFBEF49D26257573E9EE8817B6C88B76907BB40A04D4C67597AC1741BE172D929FF425A713B7 33839AD13639AAEB814ECD53306AF2C3E0CCC17AF199714121D8E7BC111501F1A98188A12BE01F17D41F8E619 D43E14ECEF720255DC97EEF65CF70D79F44F6046BD0A66A14DDC80617E01F8C792CD71A03EF23922966F8B3C3 4BC6DBD4A484CE2C90E858099DEFED5AD4D2F0352B45D252F9136F28E1539FC9464ADB398AD51D19901C24CE7 FCE6372088C1CA64628DDB1D8C96E963359C9FCC406A8D024CB897E82D0965473C3BB1644DD8B97E65C9710C4 A597E34D47FDCB6DB3B9E3A7D348C71BAB4CC994BB225F9DEDCA1D83E685A84CB3F0870348723AEEC2E567A3C 93B0FC855865D2258CF5ED26B943586FC8FCB746E0410674EAC0DA76794F9F6BD1E80381AFEC23662780E9B26 DDA124B606A2DCB05582092DFA73915D725D09B9209A967BE7BC37AEFC58FD9E499CF7A85B09C57959B957C90 1D3515A47EC7C67E7C95A3164C4B95DF1B7ACF382570AB716BF39F557B4D4B8FE9DFB5FF9CF4F10470F9AAC49 32D194B67BF8D789CC8D66526FFBF1AE989DE61BD772B864168A89A527B574D16BD0A618BD0E854EF8828980 3929AEC2A0EEF14AF99280F11BFF9016EE389EDB3D063226249749
u_1 = 5A62851B9A0CB2D2AD34BE3332BA68CCD1B239BE00DCBB4EF6864FA48F923F55EC3D4CFB92E15309D4909 599E4B5E81B
v_1 = 91F20FF5D1DE36056CAF3170FEC61C0D68830BA5C63F9518F49F581991B14800697FE464FADA759CE730E 79C889B09E2

x_1 = 93A8601D782445DC1EBAC0F9120927A8A4182F8FEA6911242919B07E8DC865A2E606AB07D090F9E770D64
1F90B1E3136B4DC212843C54C901198779F35EB480C196BB7B6E17E0B510654CB7A979B3F59B7B21C2827ED76
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x_2 = 09FD33030A7821B9E43C16C7557C87DFC6E98F1A4A671668D6C7F92EAF9ADC8F39ADDE212F41719249B16
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CFE2A9A2B7C548A12E9C3BBCA133F3BBC5B011EADB25E89659D4CB5

y_1 = 0A97F7C49E6D6ACAF496B7971C842F549D10CD350F34B69132F055B938CF1A7FF95B4B17993D0256A777F
B9A5186F18A53F7D6AE32F6879E3DDD947B2AC53A58FBA85F7C37AC98059F43CC5D35071D7C9FF6327B04DB
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84BF606B560DE14F73FD6F7ED021A6D12CFB161CF75F324E81923BF3F4616302BB6970A4743D2AD9AC29F12D6
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533CAFBD5D6526197AD24E5BF5B3D99F24093D26398751219A642AE54E54B879D8E135B33D9934D90690E3E08
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16E78E3DC13C729DD65DD0A0A14CB93FD582A88846338E94543CC1909FFCB0DE7B3653DF434C7E1B174463B4D
E7C90EF1EDCF57CA0F088C997796956BD21CE5CD5743401BB0AA979CB142937275FCB64672CD12109DB06215A
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y_2 = 02AC72611D95F6D5043F9B94D7C1E3BB9AB9C7B82AB41DAD21C99AD81B21A90DA555308D548FEAA9FFB745A92BF68A704F5BBD6C804B9357C05D0A3B48FBB45DAE68E2092FE066692E7E61CE10D8E161136D46E6D3A4E50A5AF1234CB26D439BBEB2F1588ED369DBDD1C42E93CB40766BF4C0F506B499B36E34110606BD150DAD9A14DA0F8D6C8445CD128A25AAC4D88BE4774D3485BA8B5498E5CCBB70A68344D02E6DA82E650BD6DCA9034D82D7A63C61DF9E41061791DE306F1A30C01C5178DDAF8D2A77B093CEF7BBDBD77CCB7ADAAE057F4261AB4CB4BB2EA29DBD66C22CA666389CDFA4569A5FF597EE6D7138B46323E04A358C0EB89BC234D01C026AB72A8C500CC4790E7E3C2A2D84C581EFB27C86D9AA68B77F079699E79D76C7A6B221404257205C679FA3FBEDC063AD2CDFE5A61E383FABAECF5D2C2D34434D8321D2C48AC520B716C0C25BA5EA710FE6CCC266C9F26C495F56D6EE2F3D9A7AD03DB6EECCF4B678D10AC0ADF952780CA07375AE1B1F9559B45E240DF2FEB4C819CCEBE1D21C9FEE88C053776C9565E699C6AC12B491296DD851DFB84602C2C81548838358360A0B0A53E643B5B116488E8A43F1DF26E1B4FE374A85DA2C9874E939128B0E26C32B3E61CE5995A48CEE1A956F8FFA90C8747CD4E6075BEA8A1CE91D32E3514113902353A1EEBB4DFF4F84DEBD5DE50C17742641C109314FD6D1D69F415D108B2ED8A924A1632CAD2E924FE7BA8E4B79DCEDA4CFEE70586642B29908E6A19FCD0DD57BBB0EEFAF036156388018CA4CE5D862EEAB13BEBA8CA43CA9953BBF95A50E4AABE1D41233153DD205E98C7271EF5122816461592C9AB1A4FDB50A9AC90744886F144839E1C482B2509FAB3C41EEA5A7D7EA1A84D1390922DC8D62C5314360731DBB958506FE08C6E51E71726D0043E3257C47251E32C5EE1B8B8AE4C8A0A3F988A4B0978051EED06C33ABA2473C50D18F5EE67EA8CE148593AAE7E71C29C5ABA2DBBC123194AAF8BD63D450B03C23CBEE18623E7C1E1CF6D9271396AB8D186C5655F99BF4C0087C0ABCD8F5D71A0F30D80510830B530D7E8BE6AC231EB528379109A8EE4A2709CF492B9DCD6EF006DD92E93D47C9C223B6AEE3C2CE3CE71115A98CA41DAA22E7B2CF7E7B764FB878D2787A06298AE8C8276F131E32E316BAC153499B856C4A9401E573AD9024A584D2EF772F944D377D032A6CAAEE998F05C8C11B8DF19BD62C8E199A1B59AA76A24044AD50867526BEEE1E295BD7668B40CD010F655292E4C22BB87B6425B5EDC6AB115CF505B8B3A4C64BCB81AC855C232433ABABB492DCDE2E2329F5A030EB11760DBB2B90E130AC7A
W = AF166E359F433B2EF82CFE0AAF61C20256578692F108F1277E3B255AEE41F87CC1FB181093D4A29BD40B29EC2069CFF4
Z = 0A97F7C49E6D6AC4F496B7971C842F549D10CD350F34B69132F055B938CE1A7FF95B4B17993D0256A777FB9A5186F18A53F7D04FE32F6879E3DDD947B2AC53A58FBA85F7C37AC98059F43CC5D35071D7C9FF6327B04DBD060B742EF2577C09A895E0AC08E7B37BE7FCB717A423B691055FC90A40B29BF848996D39233721C65953E25FCB8B2AF5F928900164DBC208A559830131E2590C7CE900376CF096381251E14FF67C0CD8B26FE616CFE26AA40E964DDA8484328A3E3E16D63A703FBBCAA7DDB73A04A665375C65E390AA68B602626C0C31394B4B7C1F57F631F581B9BD6493AB103C59A08EDCDBCC587484D5724A7511CB551334FC2DA897779D7D8A2EA9986DD790BDA15B30F9614063C0AC5F40A318E171A44D02095F0ED08FDF5954BE625E0AC41227A5D5428FA149D70307C1043A9AEFD72A3AE7A6EF8E139286DC7CA952AFD95F478B0E71B91303F234513DAE34CA1DC24A13262A8CB621E86A1D173E08EB5A236E6DC80E2710C31502A6031F83C18B7986FBFA9F9D29D172AE22566590104001FB260AF1340435184BE606B560DE14F73FD6F7ED021A6D12CFB161CF75F324E81923BF3F4616302BB6970A4743D2AD9AC29F12D6CEDC9B855424C40F9187843A2AB368A6BACA0BBDD1530BF24DCBDA410F50177A791A78E1ADF4778292F0A7824533CAFBD5D6526197AD24E5BF5B3D99F24093D2639875219A642AE54E54B879D8E135B33D9934D90690E3E08604B1442A415AD0BB02F3693F7D55F6135637BC653M45AF830939B12A2BCC539A4CD72D04D84716D60A642C38C24A4653632BB863B01FD2C3806452E34267C2AD3369ECCC5F5B6B1F749B3BD9BB48D02C7337077396ECC40CF2DB77F92C4F8474907EE87C607C9D2BC5A8F39BB2AD2CF6754FA5836CA88EC1320FD020014142CAE9DA9F5744392F92B9501B9D887507089BC4369B125EDA068078254C57F08E76807B1DC2A9F1DE52A32D58119FAD45FC2626AFC7F07F9273C11161164EECF7AD8F5B40820C25143D64954E6BCC9B983681228F2791D99E1331534D92BDA50FD529685072D071A851E4D484D2E2DB9BC34E127EAB636F4DA07EF365086C1C7B1BDB27E6FDF603CA24E44DD4224FE0DC6DF6BE969D2255E8CA224D328BBB710B45F7CE5D6A0D3459BE9127112E6DA86B0063DC897880316E78E3DC13C729DD65DD0A0A14CB93FD582A88846338E94543CC1909FFCB0DE7B3653DF434C7E1B174463B4DE7C90EF1EDCF57CA0F088C997796956BD21CE5CD5743401BBB9BFE800B36C725657F86271DC32E30C315DA7ED1454D8F139255BBAED1051FF340F9C9C726973A47111621F13DFFA27
r_1 = 4309185486A772069C990EBE263177A7D7C04C0A5F6EA68CD47FDE6418CF2E61A4A88A0D82DDBE329CEBA8428B570FA0
K_s = CEE44B1E0A9526F24896D8A6DDAAE1BE32119AFB1778F3D2E9B8FBE3777F33D191D6AB5B5CD1602B2BA534D0D8A4D0DB
K_i = 3D91FE92FEEF4E0D5DF7216BDD1195AE79B7117AECF310803DA7CCA3E6A7653D
K_m = 0A7169591AD386DD260AD9E9646172FCB8F7ACE21D4C3365E35734F96849D94F
o_A = 9767 0EDC5E22426AA6981937D58BE6958D3B924AC0ED15BD6002B569745BBAF8AAA474CD4BF2137B85B819F0AA7D430
o_B = 00D9E7420DA93D12B42B1BA67283FA4FD83BECED41E31AB9A8514775118B561AAD7555F04B87C2E82B4C5C550DCBFEB1
A'_2 = 5F0E2CD39855B80A7429EFA92393EC249F07DDC3639943AF14306F08874C32F44E02CBCABDF2F986028246BFA9BD5BEE
A''_2 = 8C0244895B7594E9092C487D5C2BE85B4C68DE6F76EECD8B1125FA5E72F050B538E8F4FE5FD775D1A7063BF0A6C52A0B
u_2 = AAC834DB0AA695B18FBC70F7BC2D763181386B992B7D5D2F32D6E175D8E43443BD329D4F507A166389BDF73F6B63F2B6

v_2 = 91F20FF5D1DE36056CAF3170FEC61C0D68830BA5C63F9518F49F581991B14800697FE464FADA759CE730E79C889B09E2

e = 020000000000400000000000000000000000000000000000000000000000000001 for L_K = 224 (RSA-15 360, SHA512), HMAC
A (= lkam2user1@aist.go.jp) = 6C6B616D32757365723140616973742E676F2E6A70
B (= lkam2server@aist.go.jp) = 6C6B616D32736572766572406169737 42E676F2E6A70
H(I2OS(4)||password||A||B) = 403ACE79AFC2A31D2C84DD89BA6DDE18F0173827CB0FE94EC5DC04E31BD934900BAEC3BD98C205BD1AFB34EFF4686CEF8376D72A8C0DDB61C27936AE2D5F13E5
A'_1 = F2ED23688D292688B6F9884F99ACB0BD5F57B7820BAB2732F1EC8B9E0C734791DF2764E5BE9C59CA87627C693FE1FE7B86FD688018D25964EF455815BA4632AB
A''_1 = 32A217F531944B5E315A07C6439BA2BBAAE2338F4A80E79A2A17B0E62DA906D34628CD21D3387DC315DF25784BB5BD4C8F03365648F2045DBC2DBF8003F9D385
n = BCCDA660BD5655CD1CA173652995A4B36CA2B0C4F77CE2117C858E5D6FBA6BFBDE00EF540B33BAE3B805DEC0C0A7C529CBEEBAEDE6E27EF631840EF91A9BFE4BFCF48283C104F2F9925B685F6BCB15252B526DC4CE9660E4DDD4DCAF65927F5C2A370DC5AB2EF34840826C472FF9A5C2996ED2DDF1B7DE71C0F8C9BBB0C9DE7C503415BC2CFC1A0E70695BF88E55530355F865A64065C16709AE9096A9B0E805E60F08BA4173697E5270BA5CDAA82FC992D9AEF0338C6F47D580A73BAE409D086FC488263224CC7C8C23AE1A7B17121FFEBA501A357740FAD98BE7670DF257DD50EFBB5E6937A7D9FEAEA34CC4F0AD19CEE0D79EC2A706748EB783089786115EA28BF13FF2656D35D29E73A117F8043AD43F69EDF648999A20A7801D79AD7455E96F1F1E73DAE8844CA0BD1303E993B4CD3EB3357A5ABE71D668D97DAB98BFF62DE6949A03EBEF5E774AC047A0830957414FCDC0FE7A90A7F9A2729B46A69DE28E4D2BCEB0A479BA256F49312788EBC6158A4E85C3EC889D304E7D5287790EFF581B6F3ADC6248399F64EFD2A70DDA2867445DD631A037462F2A892272A65BD1B599092403F8A86A1B51537C12D9CB1CEEDE34603E4147613919F66BCB48193462E39085148022E540B87B556960484C1A63985EA1E4B57205F8A9F84345C96DC54C75B132C63038C629533A47F267597AFFA1AE24883AD2608252B44EFAAC6F29F4041DD20150B098877995A0ED983C56A85F16B6A8ADE550A3C1FBFAA17F32CAE7925A0C3C426A2430B6C7692469A6BB07F8C810D1E7AD0A6C674D5FDC88384B26B09E6B024440639CD70C1ABB4DEB535AD0809FA7E90450B6065AEC05361E6D5222A04F9F4F2B6BFE29854BA06E10D86AFD71158191B59D7FB83806B628392A7D4E32228DEE84220830616E57B46F8284C53C4975223003B986B23E62FF858DF284B76BC958B71ECECD7184A806C90F0FBFD678E8B65C9076CEFC05A28A93F5CACE7E3C72A693D7C992546063098E53C581CA5E2DADEB644CACB0E803A591B6CBCB580CF7BC12945554AEE11D980E5F68FAE76322B1B71641060534FB1E924AC45EBAE903A17B1C88164C3448C1632C2BE3E61930BAEFB85C9FB5900D19FE7BCF1DCA19CABDCC9DF35170C6222B271A7C770F99CF5AAFD245DB7AE1ED3DF773AB9285DA63DD1183F499951E0A9752B3343D9863C8F80A6BB2D85675ED49D2814253B09B7F0EF034F196E271CD87F43D86EB6CF19448DDB51F40F41A7F6A62837654E0DDC30DAC90040E0299461471285F9F87E3917DD8D90ED210764CA5654A301B2418975F321F14068B3DB20516EAF234CD9AD7E6D14E0B2BD9D94472A24D54ED5BB83F0323242862BE797496B2027B8E4EFE4C0DFBB08D3C8D658C6135AE67AB7A00B3D8395146B89CE7B8A17C4CF5D34FCE96B19A4D3A4AF183250F1F9AA99A91160BC7A67A10F605A4E4AF04A05AE62E6EB86060F2BA6587FE8BF3BF3348DFE544129C50F3FF2D3BF1A2E2667BA55577C217CD718A576D4E9030A45A44012D3ED7134331FCD2A9F037E6653F42DEBA1B55A7760B2803D9A6C98185143570E7C5F975DD8CE0F7BC83385A6BF433959AB8255B04268DACDCFF84335CCFCC6B9B035378C1463D4EABF2C5CFAC92974C1C492722242E73F09E838418F6AF01571A45E556E657F2D2266793D8452DF03794340EED30FC32610432F1A630C10337A55153503FBB114969AA851A2E2BE4EA78F9F64D0B14E9C5CADFC770DB7D65ED714573E9882903558CE9D502CE3ECA89B19BB08A3D5A111DE3998E89DEED5AB4185EEBB9F9AD13BC8E42EC20320D601974DC162DA2B2FC28190E1C7E3CCF065A4C574C0FF18E5357F0CB1217E14B213EFEDB17E5AB4F2D9441117C7C3B726666ED4ED10110CA102DD129CD6BC38D0DF6819B0F8920A65A9C13B4DB6B20805361B1DF25D826A81C9BE2B9108C5D740214EE4479BD7311F57A19C0A3C069BB325C34BFAD5F8DD52F0B51D534F5210573CD7C550EE0429D6BFFE749AE03C21C7B677DF5BFBD2EBE9E5FFF338049D31BC43C81574AA8B1DA2B5C3734A6711BD5C4C0C8FB69C4EEAA2A4CF245FD28E10D25643B231A03C2297726AD4E1D6F3C858CC4BD65B436C362EE0B6CA30E7CD524FDDDB68763A90BCD0B994205F232A1C4E65427B2D39B8670FBAEE8479908F7B38C6A88883AD3142A7DDFF0EB9A289A7C6FDDCB324343283D157755C0A1D6E525CF2C0F169CC00250B37EAC2C8ECA6C195421D5855851FE5C38A7B65EC930FCBAF286DA2F23E213ADCA00A5B379AE22A7ED1E50DE3D0AD917702DB0BE86BBFFF30E7D6FE4D1953CA96451C65E01C32F41200B493299767A8459AAEE9EE01240E92887ABAC7B4115551E5F86C49CEDC9116F6A2F8C947AC1344D59DE437AE92CCC04D7C7A9B99B5F474778E1C3A8BD295CADEF85C5147B7DAE01F414CA3F71E3C87BF2D9C6881244D198F11804709C73F42B97899D343627C630795BB5BB8BEB69F6BFC37E33B0C81ABBA4A954C562DB5D7FEE26229FD351A36BAD3098C5972874D65DD39ADCFF7225074193C406E388A0AFDBEBA91CBD48DD04D76ECD7528089147E6C4CD4771BBA96967D34DFA98E40C1E781C6E87CFB61269E394688C51C333C36BAD3D10035AB91D2265964AC66616776CEDA0DEF01675FA0B6B12CD70E013D13F56DBE365A970AD07299

d = 7038515FFACAD2B32EBE019470882E44EB3C32526713441F23C1DED845B214CDD001839429C0867BB1FC2
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r_1 = 0F274329DE32A41AB862AA6F2A133003999DDABB4EE9B9DA184C46159429C90BE93D43B365E8C6D4709EB A73F9095CB34CD9CAE76B6581F700E8F698C6E4806
K_s = D411C17E9EF99AC3C9EA219444EAF16C98E6C501E66EB8F3F9EA44371E623A90A3574484217B720ECAD52 209C61A1A25A765112B2E2C483E7CD49B459261E8C2
K_i = E532EA72755FBAE2EE90F898BF74DEC92B8C0CFE583AF0EC667AA11500949C9A
K_m = 350FB5D79B79A7E52696FEC3E393781FE33B4FCE47D5237E30DB1C9A3E414641
o_A = F81DF642047CB3E6839B74C90769F11A877BDC2F8E0C8422AA306342E1DB8322DDFD87E99399F8E7DA97B 19F70AD1F57C30FE9EB552094D33B9D68F21FD237A0
o_B = 86823B6BD9A3B05632D596CF95A2DE0B6F7390E6674F89C0799C2ECF1E2A96AD011F27C0C54AFD2E14811 E3D91E681F81D76BD227055968EE7DF0E9E37152110
A'_2 = 9828A952FC383373C545645A0F55566563E6388A7E4C4B4B9A2CA6B9D44FED5C5E43515FE3FAE29F8454 52F415EB747969C9116209B83D6A2B3F4FF0B9A0AAB7
A''_2 = 2A3A220C175BAF8CD0992F74E7932FA1A358D57EB5E23466D7542D5C430F344435E61830CBB6F18263CD C8892A8B7A803DD59DF3D6508B2799A3F3BE2D95A0A4
u_2 = 2548B0FDCBE747981F69F7B49839F0F08D18B797C3D1D3071DCD969EC504A864FC5921A6DAC5D4743412D 115F360A7604BDC0978875352377D54B4B0820B51AF
v_2 = D24C427D3DA227B001A8CD18FA9B0872A3B2E650A11B726A4A6C63B4F5018636243AD4F8A91791773EBC1 4E26B05D6A2AF834F1A15D3ED48C87C4FC43432F50F