Internet Research Task Force
Internet-Draft
Intended status: Informational
Expires: March 16, 2017

Harkins
HP Enterprise

September 12, 2016

PKEX
draft-harkins-pkex-00

Abstract

This memo describes a password-authenticated protocol to allow two devices to exchange "raw" (uncertified) public keys and establish trust that the keys belong to their respective identities.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on March 16, 2017.

Table of Contents

1. Introduction

Many authenticated key exchange protocols allow for authentication using uncertified, or "raw", public keys, for example TLS ([RFC7250]), or IKEv2 ([RFC7670]) Usually these specifications state that "establishing trust in raw public keys is outside the scope of this standard." The Public Key Exchange (PKEX) is designed to fill that gap and enable the establishment of trust in public keys that can subsequently be used to faccilitate authentication in other authentication and key exchange protocols.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

1.2. Notation

This memo describes a cryptographic exchange using sets of elements called groups. Groups can be either traditional finite field or can be based on elliptic curves. The public keys exchanged by PKEX are elements in a group. Elements in groups are denoted in upper-case and scalar values are denoted with lower-case. The generator of the group is G.

When both the initator and responder use a similar, but unique, datum it is denoted by appending an "i" for initiator or "r" for responder,

e.g. if each side needs an element C then the initiator's is Ci and the responder's is Cr.

During the exchange, one side will generate data and the other side will attempt to reconstruct it. The reconstructed data is "primed". That is, if the initiator generates C then when responder tries to reconstruct it, the responder will refer to it as C'. Data that is directly sent and received is not primed.

The following notation is used in this memo:

C = A + B
: The "group operation" on two elements, A and B, that produces a third element, C. For finite field cryptography this is the modular multiplication, for elliptic curve cryptography this is point addition.

C = a * B
: This denotes repeated application of the group operation to B-- i.e. B + B-- (a - 1) times.

a = H(b)
: A cryptographic hash function that takes data b of indeterminate length and returns a fixed sized digest a.

a = F(B)
: A mapping function that takes an element and returns a scalar. For elliptic curve cryptography, F() returns the x-coordinate of the point B. For finite field cryptography, F() is the identity function.

a = KDF(b, c)
: A key derivation function that derives an output key a from an input key b and context c.

c = a | b
: Concatentation of data a with data b producing c.

2. Properties

Subversion of PKEX involves an adversary being able to insert its own public key into the exchange resulting in one of the parties to the exchange believing the adversary's public key actually belongs to the protocol peer.

PKEX has the following properties:

- An adversary is unable to subvert the exchange without knowing the password.
- An adversary is unable to discover the password through passive attack.
- The only information exposed by an active attack is whether a single guess of the password is correct or not.
- Proof-of-possession of the private key is provided.
- At the end of the protocol, either trust is established in the peer's public key or the exchange fails.

3. Assumptions

Due to the nature of the exchange, only DSA ([DSS]) and ECDSA ([X9.62]) keys can be exchanged with PKEX.

PKEX requires fixed elements that are unique to the particular role in the protocol, an initiator-specific element and a responder-specific element. They need not be secret. It is assumed that both parties know the role-specific elements for the particular group in which their key pairs were derived. This memo does not proscribe any way to generate these role-specific elements but the "Hunting and Pecking" technique of [RFC7664] could be used with a slight variation. Instead of inputting a password and generating a secret element, a common string such as "PKEX Initiator Element" can be used to generate a public element. For elliptic curve cryptography, the technique of "hashing into an elliptic curve" from [hash2ec] could be used, again with a common string, to produce role-specific elements.

The following assumptions are made on PKEX:

- Only the peers involved in the exchange know the password.
- The peers' public keys are from the same group.
- The discrete logarithms of the public role-specific elements are unknown, and determining them is computationally infeasible.

4. Protocol Definition

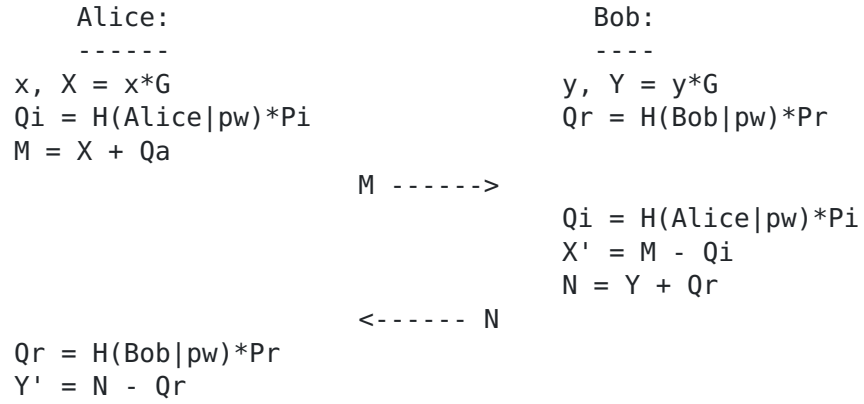
PKEX is a balanced PAKE. The identical version of the password is used by both parties.

PKEX consists of three phases: exchange, commit, and reveal. It is described using the popular protocol participants, Alice (an initiator of PKEX), and Bob (a responder of PKEX).

We denote Alice's role-specific element a Pi and Bob's as Pr. The password is pw. For simplicity, Alice's identity is "Alice" and Bob's identity is "Bob". Alice's public key she wants to share with Bob is A and her private key is a, while Bob's public key he wants to share with Alice is B and his private key is b.

4.1. Exchange Phase

The Exchange phase is essentially the SPAKE key exchange. The peers derive ephemeral public keys, encrypt, and exchange them. Each party hashes a concatentation of his or her identity and the password and operates on the role-specific element to obtain a secret encrypting element. The group operation is then performed with the ephemeral key and the secret encrypting element to produce an encrypted ephmeral key.

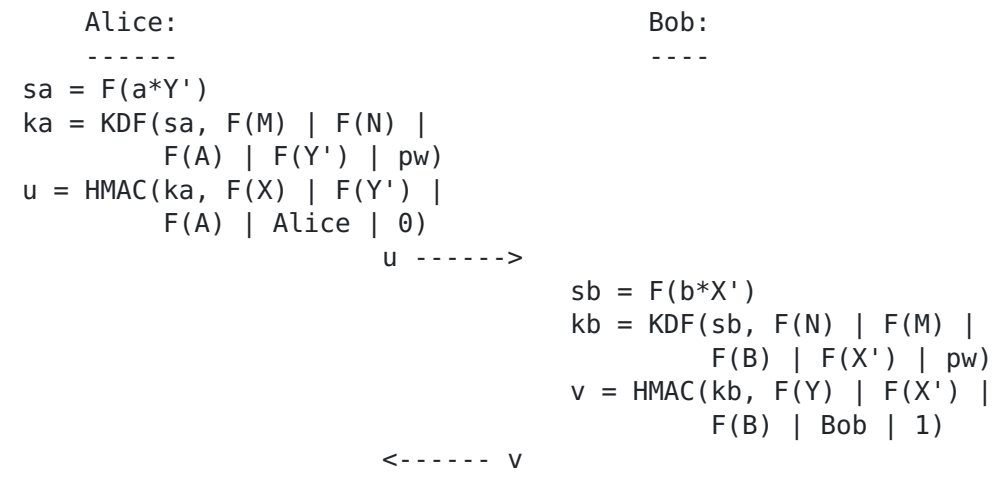


At this point in time the peers have exchanged ephemeral elements that will be unknown except by someone with knowledge of the password. Given our assumptions that means only Alice and Bob can know the elements X and Y.

The secret encrypting elements are irretrievably deleted at this point.

4.2. Commit Phase

In the Commit phase the peers commit to the particular public key they wish to exchange.



where 0 and 1 are single octets of the value zero and one, respectively.

At this point the parties have committed to their public/private key pairs but have net yet exchanged their public keys. There is no proof that either side possesses the private key or whether the public key is really the analog to the private key but they have made irrevocable committments to those statements.

4.3. Reveal Phase

In the Reveal phase the peers encrypt their public keys using a secret element derived from the exchange in the Commit phase. This allows each side to determine the other's public key and verify that the peer holds the private key.

```
        Alice:                              Bob:
        ------                              ----
     Z = x*Y'
     R = A + Z
                           R ------>
                                      Z = y*X'
                                      A' = R - Z
                                      sa' = F(y*A')
                                      ka' = KDF(sa', F(M) | F(N) |
                                                F(A') | F(Y) | pw)
                                      u' = HMAC(ka', F(X') | F(Y) |
                                                F(A') | Alice | 0)
                                      if (u' != u) fail
                                      T = B + Z
                           <------ T
     B' = T - Z
     sb' = F(x*B')
     kb' = KDF(sb', F(N) | F(M) |
               F(B') | F(X) | pw)
     v' = HMAC(kb', F(Y') | F(X) |
               F(B') | Bob | 1)
     if (v'!= v) fail
```

where 0 and 1 are single octets of the value zero and one, respectively.

At this point, if the parties didn't fail they have each other's public key and trust that it belongs to the peer's stated identlty. They can use the public key in another protocol to authenticate that identity. They provided proof of possession by binding their private key to the peer's ephemeral share made during the Exchange phase, they signed their public key with the resulting secret. The ability of the peer to compute this secret and verify the data exchanged during the Commit phase demonstrates the public key is the analog to the private key.

5. IANA Considerations

This memo could create a registry of the fixed public elements for a nice cross section of popular groups. Or not. If it ends up doing so there will be IANA Considerations here, otherwise there won't be.

6. Security Considerations

The encrypted shares exchanged in the Exchange phase MUST be ephemeral. Reuse of these keys, even with a different password, voids the security of the exchange.

The discrete logaritm of the fixed public elements MUST not be known. Knowledge of either of these values voids the security of the exchange.

For PKEX to be useful, a public key is going to be exchanged with a multitude of people and once exchanged the public key is, well, public. This means that an adversary will know the public key that a particular peer wants to exchange in a future run of PKEX. With this knowledge an adversary can attack the Reveal exchange and, knowing A (or B), determine Z for the PKEX exchange and insert her public key. This will fail, though, because A (or B) was committed to in the Commit phase. The adversary is unable to subvert the Commit phase because, while knowing A (or B) she does not know the corresponding private key and does not know the ephemeral share that the peer provided since she does not know the password.

There is no proof of security of PKEX at this time.

7. References

7.1. Normative References

[DSS] U.S. Department of Commerce/National Institute of Standards and Technology, "Digital Signature Standard (DSS)", Federal Information Processing Standards FIPS PUB 186-4, July 2013.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[X9.62] American National Standards Institute, "X9.62-2005", Public Key Cryptography for the Financial Services Industry (ECDSA), 2005.

7.2. Informative References

[RFC7250] Wouters, P., Ed., Tschofenig, H., Ed., Gilmore, J., Weiler, S., and T. Kivinen, "Using Raw Public Keys in Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS)", RFC 7250, DOI 10.17487/RFC7250, June 2014, <http://www.rfc-editor.org/info/rfc7250>.

[RFC7664] Harkins, D., Ed., "Dragonfly Key Exchange", RFC 7664, DOI 10.17487/RFC7664, November 2015, <http://www.rfc-editor.org/info/rfc7664>.

[RFC7670] Kivinen, T., Wouters, P., and H. Tschofenig, "Generic Raw Public-Key Support for IKEv2", RFC 7670, DOI 10.17487/RFC7670, January 2016, <http://www.rfc-editor.org/info/rfc7670>.

[hash2ec] Coron, J-S. and T. Icart, "An indifferentiable hash function into elliptic curves", Cryptology ePrint Archive Report 2009/340, 2009.

Appendix A. Appendix

Maybe show a sample PKEX exchange

Author's Address

Dan Harkins
HP Enterprise
1322 Crossman avenue
Sunnyvale, California 94089
USA

Phone: +1 415 997 9834
Email: dharkins@lounge.org