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Key Exchange Delegation Record for the DNS

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ABSTRACT

This note describes a mechanism whereby authorisation for one node to act as key exchanger for a second node is delegated and made available via the Secure DNS. This mechanism is intended to be used only with the Secure DNS. It can be used with several security services. For example, a system seeking to use IP Security [RFC-1825, RFC-1826, RFC-1827] to protect IP packets for a given destination can use this mechanism to determine the set of authorised remote key exchanger systems for that destination.

1. INTRODUCTION

The Domain Name System (DNS) is the standard way that Internet nodes locate information about addresses, mail exchangers, and other data relating to remote Internet nodes. [RFC-1035, RFC-1034] More recently, Eastlake and Kaufman have defined standards-track security extensions to the DNS. [RFC-2065] These security extensions can be used to authenticate signed DNS data records and can also be used to store signed public keys in the DNS.

The KX record is useful in providing an authenticatible method of delegating authorisation for one node to provide key exchange services on behalf of one or more, possibly different, nodes. This note specifies the syntax and semantics of the KX record, which is currently in limited deployment in certain IP-based networks. The

reader is assumed to be familiar with the basics of DNS, including familiarity with [RFC-1035, RFC-1034]. This document is not on the IETF standards-track and does not specify any level of standard. This document merely provides information for the Internet community.

1.1 Identity Terminology

This document relies upon the concept of "identity domination". This concept might be new to the reader and so is explained in this section. The subject of endpoint naming for security associations has historically been somewhat contentious. This document takes no position on what forms of identity should be used. In a network, there are several forms of identity that are possible.

For example, IP Security has defined notions of identity that include: IP Address, IP Address Range, Connection ID, Fully-Qualified Domain Name (FQDN), and User with Fully Qualified Domain Name (USER FQDN).

A USER FQDN identity dominates a FQDN identity. A FQDN identity in turn dominates an IP Address identity. Similarly, a Connection ID dominates an IP Address identity. An IP Address Range dominates each IP Address identity for each IP address within that IP address range. Also, for completeness, an IP Address identity is considered to dominate itself.

2. APPROACH

This document specifies a new kind of DNS Resource Record (RR), known as the Key Exchanger (KX) record. A Key Exchanger Record has the mnemonic "KX" and the type code of 36. Each KX record is associated with a fully-qualified domain name. The KX record is modeled on the MX record described in [Part86]. Any given domain, subdomain, or host entry in the DNS might have a KX record.

2.1 IPsec Examples

In these two examples, let S be the originating node and let D be the destination node. S2 is another node on the same subnet as S. D2 is another node on the same subnet as D. R1 and R2 are IPsec-capable routers. The path from S to D goes via first R1 and later R2. The return path from D to S goes via first R2 and later R1.

IETF-standard IP Security uses unidirectional Security Associations [RFC-1825]. Therefore, a typical IP session will use a pair of related Security Associations, one in each direction. The examples below talk about how to setup an example Security Association, but in practice a pair of matched Security Associations will normally be

used.

2.1.1 Subnet-to-Subnet Example

If neither S nor D implements IPsec, security can still be provided between R1 and R2 by building a secure tunnel. This can use either AH or ESP.

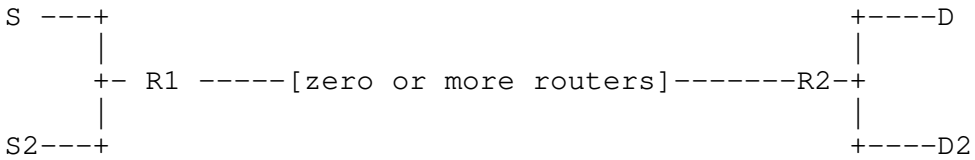


Figure 1: Network Diagram for Subnet-to-Subnet Example

In this example, R1 makes the policy decision to provide the IPsec service for traffic from R1 destined for R2. Once R1 has decided that the packet from S to D should be protected, it performs a secure DNS lookup for the records associated with domain D. If R1 only knows the IP address for D, then a secure reverse DNS lookup will be necessary to determine the domain D, before that forward secure DNS lookup for records associated with domain D. If these DNS records of domain D include a KX record for the IPsec service, then R1 knows which set of nodes are authorised key exchanger nodes for the destination D.

In this example, let there be at least one KX record for D and let the most preferred KX record for D point at R2. R1 then selects a key exchanger (in this example, R2) for D from the list obtained from the secure DNS. Then R1 initiates a key management session with that key exchanger (in this example, R2) to setup an IPsec Security Association between R1 and D. In this example, R1 knows (either by seeing an outbound packet arriving from S destined to D or via other methods) that S will be sending traffic to D. In this example R1's policy requires that traffic from S to D should be segregated at least on a host-to-host basis, so R1 desires an IPsec Security Association with source identity that dominates S, proxy identity that dominates R1, and destination identity that dominates R2.

In turn, R2 is able to authenticate the delegation of Key Exchanger authorisation for target S to R1 by making an authenticated forward DNS lookup for KX records associated with S and verifying that at least one such record points to R1. The identity S is typically given to R2 as part of the key management process between R1 and R2.

If D initially only knows the IP address of S, then it will need to perform a secure reverse DNS lookup to obtain the fully-qualified domain name for S prior to that secure forward DNS lookup.

If R2 does not receive an authenticated DNS response indicating that R1 is an authorised key exchanger for S, then D will not accept the SA negotiation from R1 on behalf of identity S.

If the proposed IPsec Security Association is acceptable to both R1 and R2, each of which might have separate policies, then they create that IPsec Security Association via Key Management.

Note that for unicast traffic, Key Management will typically also setup a separate (but related) IPsec Security Association for the return traffic. That return IPsec Security Association will have equivalent identities. In this example, that return IPsec Security Association will have a source identity that dominates D, a proxy identity that dominates R2, and a destination identity that dominates R1.

Once the IPsec Security Association has been created, then R1 uses it to protect traffic from S destined for D via a secure tunnel that originates at R1 and terminates at R2. For the case of unicast, R2 will use the return IPsec Security Association to protect traffic from D destined for S via a secure tunnel that originates at R2 and terminates at R1.

2.1.2 Subnet-to-Host Example

Consider the case where D and R1 implement IPsec, but S does not implement IPsec, which is an interesting variation on the previous example. This example is shown in Figure 2 below.

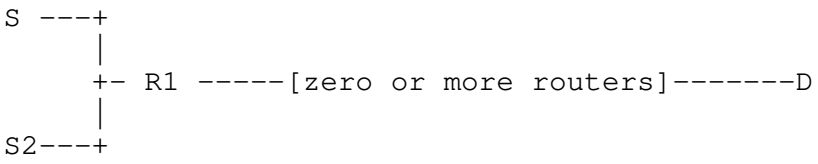


Figure 2: Network Diagram for Subnet-to-Host Example

In this example, R1 makes the policy decision that IP Security is needed for the packet travelling from S to D. Then, R1 performs the secure DNS lookup for D and determines that D is its own key exchanger, either from the existence of a KX record for D pointing to D or from an authenticated DNS response indicating that no KX record exists for D. If R1 does not initially know the domain name of D, then prior to the above forward secure DNS lookup, R1 performs a

secure reverse DNS lookup on the IP address of D to determine the fully-qualified domain name for that IP address. R1 then initiates key management with D to create an IPsec Security Association on behalf of S.

In turn, D can verify that R1 is authorised to create an IPsec Security Association on behalf of S by performing a DNS KX record lookup for target S. R1 usually provides identity S to D via key management. If D only has the IP address of S, then D will need to perform a secure reverse lookup on the IP address of S to determine domain name S prior to the secure forward DNS lookup on S to locate the KX records for S.

If D does not receive an authenticated DNS response indicating that R1 is an authorised key exchanger for S, then D will not accept the SA negotiation from R1 on behalf of identity S.

If the IPsec Security Association is successfully established between R1 and D, that IPsec Security Association has a source identity that dominates S's IP address, a proxy identity that dominates R1's IP address, and a destination identity that dominates D's IP address.

Finally, R1 begins providing the security service for packets from S that transit R1 destined for D. When D receives such packets, D examines the SA information during IPsec input processing and sees that R1's address is listed as valid proxy address for that SA and that S is the source address for that SA. Hence, D knows at input processing time that R1 is authorised to provide security on behalf of S. Therefore packets coming from R1 with valid IP security that claim to be from S are trusted by D to have really come from S.

2.1.3 Host to Subnet Example

Now consider the above case from D's perspective (i.e. where D is sending IP packets to S). This variant is sometimes known as the Mobile Host or "roadwarrier" case. The same basic concepts apply, but the details are covered here in hope of improved clarity.

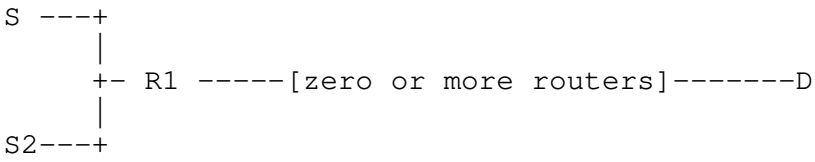


Figure 3: Network Diagram for Host-to-Subnet Example

In this example, D makes the policy decision that IP Security is needed for the packets from D to S. Then D performs the secure DNS lookup for S and discovers that a KX record for S exists and points at R1. If D only has the IP address of S, then it performs a secure reverse DNS lookup on the IP address of S prior to the forward secure DNS lookup for S.

D then initiates key management with R1, where R1 is acting on behalf of S, to create an appropriate Security Association. Because D is acting as its own key exchanger, R1 does not need to perform a secure DNS lookup for KX records associated with D.

D and R1 then create an appropriate IPsec Security Security Association. This IPsec Security Association is setup as a secure tunnel with a source identity that dominates D's IP Address and a destination identity that dominates R1's IP Address. Because D performs IPsec for itself, no proxy identity is needed in this IPsec Security Association. If the proxy identity is non-null in this situation, then the proxy identity must dominate D's IP Address.

Finally, D sends secured IP packets to R1. R1 receives those packets, provides IPsec input processing (including appropriate inner/outer IP address validation), and forwards valid packets along to S.

2.2 Other Examples

This mechanism can be extended for use with other services as well. To give some insight into other possible uses, this section discusses use of KX records in environments using a Key Distribution Center (KDC), such as Kerberos [KN93], and a possible use of KX records in conjunction with mobile nodes accessing the network via a dialup service.

2.2.1 KDC Examples

This example considers the situation of a destination node implementing IPsec that can only obtain its Security Association information from a Key Distribution Center (KDC). Let the KDC implement both the KDC protocol and also a non-KDC key management protocol (e.g. ISAKMP). In such a case, each client node of the KDC might have its own KX record pointing at the KDC so that nodes not implementing the KDC protocol can still create Security Associations with each of the client nodes of the KDC.

In the event the session initiator were not using the KDC but the session target was an IPsec node that only used the KDC, the initiator would find the KX record for the target pointing at the

KDC. Then, the external key management exchange (e.g. ISAKMP) would be between the initiator and the KDC. Then the KDC would distribute the IPsec SA to the KDC-only IPsec node using the KDC. The IPsec traffic itself could travel directly between the initiator and the destination node.

In the event the initiator node could only use the KDC and the target were not using the KDC, the initiator would send its request for a key to the KDC. The KDC would then initiate an external key management exchange (e.g. ISAKMP) with a node that the target's KX record(s) pointed to, on behalf of the initiator node.

The target node could verify that the KDC were allowed to proxy for the initiator node by looking up the KX records for the initiator node and finding a KX record for the initiator that listed the KDC.

Then the external key exchange would be performed between the KDC and the target node. Then the KDC would distribute the resulting IPsec Security Association to the initiator. Again, IPsec traffic itself could travel directly between the initiator and the destination.

2.2.2 Dial-Up Host Example

This example outlines a possible use of KX records with mobile hosts that dial into the network via PPP and are dynamically assigned an IP address and domain-name at dial-in time.

Consider the situation where each mobile node is dynamically assigned both a domain name and an IP address at the time that node dials into the network. Let the policy require that each mobile node act as its own Key Exchanger. In this case, it is important that dial-in nodes use addresses from one or more well known IP subnets or address pools dedicated to dial-in access. If that is true, then no KX record or other action is needed to ensure that each node will act as its own Key Exchanger because lack of a KX record indicates that the node is its own Key Exchanger.

Consider the situation where the mobile node's domain name remains constant but its IP address changes. Let the policy require that each mobile node act as its own Key Exchanger. In this case, there might be operational problems when another node attempts to perform a secure reverse DNS lookup on the IP address to determine the corresponding domain name. The authenticated DNS binding (in the form of a PTR record) between the mobile node's currently assigned IP address and its permanent domain name will need to be securely updated each time the node is assigned a new IP address. There are no mechanisms for accomplishing this that are both IETF-standard and widely deployed as of the time this note was written. Use of Dynamic

DNS Update without authentication is a significant security risk and hence is not recommended for this situation.

3. SYNTAX OF KX RECORD

A KX record has the DNS TYPE of "KX" and a numeric value of 36. A KX record is a member of the Internet ("IN") CLASS in the DNS. Each KX record is associated with a <domain-name> entry in the DNS. A KX record has the following textual syntax:

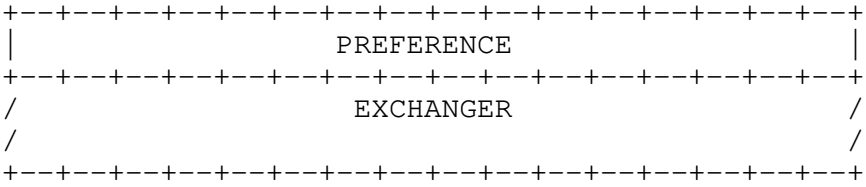
```
<domain-name>  IN  KX  <preference> <domain-name>
```

For this description, let the <domain-name> item to the left of the "KX" string be called <domain-name 1> and the <domain-name> item to the right of the "KX" string be called <domain-name 2>. <preference> is a non-negative integer.

Internet nodes about to initiate a key exchange with <domain-name 1> should instead contact <domain-name 2> to initiate the key exchange for a security service between the initiator and <domain-name 2>. If more than one KX record exists for <domain-name 1>, then the <preference> field is used to indicate preference among the systems delegated to. Lower values are preferred over higher values. The <domain-name 2> is authorised to provide key exchange services on behalf of <domain-name 1>. The <domain-name 2> MUST have a CNAME record, an A record, or an AAAA record associated with it.

3.1 KX RDATA format

The KX DNS record has the following RDATA format:



where:

PREFERENCE — A 16 bit non-negative integer which specifies the preference given to this RR among other KX records at the same owner. Lower values are preferred.

EXCHANGER — A <domain-name> which specifies a host willing to act as a mail exchange for the owner name.

KX records MUST cause type A additional section processing for the host specified by EXCHANGER. In the event that the host processing the DNS transaction supports IPv6, KX records MUST also cause type AAAA additional section processing.

The KX RDATA field MUST NOT be compressed.

4. SECURITY CONSIDERATIONS

KX records MUST always be signed using the method(s) defined by the DNS Security extensions specified in [RFC-2065]. All unsigned KX records MUST be ignored because of the security vulnerability caused by assuming that unsigned records are valid. All signed KX records whose signatures do not correctly validate MUST be ignored because of the potential security vulnerability in trusting an invalid KX record.

KX records MUST be ignored by systems not implementing Secure DNS because such systems have no mechanism to authenticate the KX record.

If a node does not have a permanent DNS entry and some form of Dynamic DNS Update is in use, then those dynamic DNS updates MUST be fully authenticated to prevent an adversary from injecting false DNS records (especially the KX, A, and PTR records) into the Domain Name System. If false records were inserted into the DNS without being signed by the Secure DNS mechanisms, then a denial-of-service attack results. If false records were inserted into the DNS and were (erroneously) signed by the signing authority, then an active attack results.

Myriad serious security vulnerabilities can arise if the restrictions throuhout this document are not strictly adhered to. Implementers should carefully consider the openly published issues relating to DNS security [Bell95,Vixie95] as they build their implementations. Readers should also consider the security considerations discussed in the DNS Security Extensions document [RFC-2065].

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