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Secure Domain Name System Dynamic Update

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Abstract

Domain Name System (DNS) protocol extensions have been defined to authenticate the data in DNS and provide key distribution services [RFC2065]. DNS Dynamic Update operations have also been defined [RFC2136], but without a detailed description of security for the update operation. This memo describes how to use DNSSEC digital signatures covering requests and data to secure updates and restrict updates to those authorized to perform them as indicated by the updater's possession of cryptographic keys.

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Table of Contents

1. Introduction

Dynamic update operations have been defined for the Domain Name System (DNS) in RFC 2136, but without a detailed description of security for those updates. Means of securing the DNS and using it for key distribution have been defined in RFC 2065.

This memo proposes techniques based on the defined DNS security mechanisms to authenticate DNS updates.

Familiarity with the DNS system [RFC 1034, 1035] is assumed. Familiarity with the DNS security and dynamic update proposals will be helpful.

1.1 Overview of DNS Dynamic Update

DNS dynamic update defines a new DNS opcode, new DNS request and response structure if that opcode is used, and new error codes. An update can specify complex combinations of deletion and insertion (with or without pre-existence testing) of resource records (RRs) with one or more owner names; however, all testing and changes for any particular DNS update request are restricted to a single zone. Updates occur at the primary server for a zone.

The primary server for a secure dynamic zone must increment the zone SOA serial number when an update occurs or the next time the SOA is retrieved if one or more updates have occurred since the previous SOA retrieval and the updates themselves did not update the SOA.

1.2 Overview of DNS Security

DNS security authenticates data in the DNS by also storing digital signatures in the DNS as SIG resource records (RRs). A SIG RR provides a digital signature on the set of all RRs with the same owner name and class as the SIG and whose type is the type covered by the SIG. The SIG RR cryptographically binds the covered RR set to the signer, time signed, signature expiration date, etc. There are one or more keys associated with every secure zone and all data in the secure zone is signed either by a zone key or by a dynamic update

key tracing its authority to a zone key.

DNS security also defines transaction SIGs and request SIGs. Transaction SIGs appear at the end of a response. Transaction SIGs authenticate the response and bind it to the corresponding request with the key of the host where the responding DNS server is. Request SIGs appear at the end of a request and authenticate the request with the key of the submitting entity.

Request SIGs are the primary means of authenticating update requests.

DNS security also permits the storage of public keys in the DNS via KEY RRs. These KEY RRs are also, of course, authenticated by SIG RRs. KEY RRs for zones are stored in their superzone and subzone servers, if any, so that the secure DNS tree of zones can be traversed by a security aware resolver.

2. Two Basic Modes

A dynamic secure zone is any secure DNS zone containing one or more KEY RRs that can authorize dynamic updates, i.e., entity or user KEY RRs with the signatory field non-zero, and whose zone KEY RR signatory field indicates that updates are implemented. There are two basic modes of dynamic secure zone which relate to the update strategy, mode A and mode B. A summary comparison table is given below and then each mode is described.

SUMMARY OF DYNAMIC SECURE ZONE MODES

CRITERIA:	MODE A	MODE B
Definition:	Zone Key Off line	Zone Key On line
Server Workload	Low	High
Static Data Security	Very High	Medium-High
Dynamic Data Security	Medium	Medium-High
Key Restrictions	Fine grain	Coarse grain
Dynamic Data Temporality	Transient	Permanent
Dynamic Key Rollover	No	Yes

For mode A, the zone owner key and static zone master file are always kept off-line for maximum security of the static zone contents.

As a consequence, any dynamicly added or changed RRs are signed in the secure zone by their authorizing dynamic update key and they are backed up, along with this SIG RR, in a separate online dynamic master file. In this type of zone, server computation is minimized since the server need only check signatures on the update data and request, which have already been signed by the updater, generally a much faster operation than signing data. However, the AXFR SIG and NXT RRs which covers the zone under the zone key will not cover dynamically added data. Thus, for type A dynamic secure zones, zone transfer security is not automatically provided for dynamically added RRs, where they could be omitted, and authentication is not provided for the server denial of the existence of a dynamically added type. Because the dynamicly added RRs retain their update KEY signed SIG, finer grained control of updates can be implemented via bits in the KEY RR signatory field. Because dynamic data is only stored in the online dynamic master file and only authenticated by dynamic keys which expire, updates are transient in nature. Key rollover for an entity that can authorize dynamic updates is more cumbersome since the authority of their key must be traceable to a zone key and so, in general, they must securely communicate a new key to the zone authority for manual transfer to the off line static master file. NOTE: for this mode the zone SOA must be signed by a dynamic update key and that private key must be kept on line so that the SOA can be changed for updates.

For mode B, the zone owner key and master file are kept on-line at the zone primary server. When authenticated updates succeed, SIGs under the zone key for the resulting data (including the possible NXT type bit map changes) are calculated and these SIG (and possible NXT) changes are entered into the zone and the unified on-line master file. (The zone transfer AXFR SIG may be recalculated for each update or on demand when a zone transfer is requested and it is out of date.)

As a consequence, this mode requires considerably more computational effort on the part of the server as the public/private keys are generally arranged so that signing (calculating a SIG) is more effort than verifying a signature. The security of static data in the zone is decreased because the ultimate state of the static data being served and the ultimate zone authority private key are all on-line on the net. This means that if the primary server is subverted, false data could be authenticated to secondaries and other servers/resolvers. On the other hand, this mode of operation means that data added dynamically is more secure than in mode A. Dynamic data will be covered by the AXFR SIG and thus always protected during zone transfers and will be included in NXT RRs so that it can be falsely denied by a server only to the same extent that static data can (i.e., if it is within a wild card scope). Because the zone key is used to sign all the zone data, the information as to who originated the current state of dynamic RR sets is lost, making unavailable the effects of some of the update control bits in the KEY RR signatory field. In addition, the incorporation of the updates into the primary master file and their authentication by the zone key makes then permanent in nature. Maintaining the zone key on-line also means that dynamic update keys which are signed by the zone key can be dynamically updated since the zone key is available to dynamically sign new values.

NOTE: The Mode A / Mode B distinction only effects the validation and performance of update requests. It has no effect on retrievals. One reasonable operational scheme may be to keep a mostly static main zone operating in Mode A and have one or more dynamic subzones operating in Mode B.

3. Keys

Dynamic update requests depend on update keys as described in section 3.1 below. In addition, the zone secure dynamic update mode and availability of some options is indicated in the zone key. Finally, a special rule is used in searching for KEYs to validate updates as described in section 3.3.

3.1 Update Keys

All update requests to a secure zone must include signatures by one or more key(s) that together can authorize that update. In order for the Domain Name System (DNS) server receiving the request to confirm this, the key or keys must be available to and authenticated by that server as a specially flagged KEY Resource Record.

The scope of authority of such keys is indicated by their KEY RR owner name, class, and signatory field flags as described below. In addition, such KEY RRs must be entity or user keys and not have the authentication use prohibited bit on. All parts of the actual update must be within the scope of at least one of the keys used for a request SIG on the update request as described in section 4.

3.1.1 Update Key Name Scope

The owner name of any update authorizing KEY RR must (1) be the same as the owner name of any RRs being added or deleted or (2) a wildcard name including within its extended scope (see section 3.3) the name of any RRs being added or deleted and those RRs must be in the same zone.

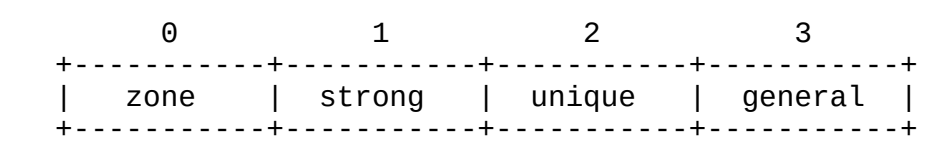
3.1.2 Update Key Class Scope

The class of any update authorizing KEY RR must be the same as the class of any RR's being added or deleted.

3.1.3 Update Key Signatory Field

The four bit "signatory field" (see RFC 2065) of any update authorizing KEY RR must be non-zero. The bits have the meanings described below for non-zone keys (see section 3.2 for zone type keys).

UPDATE KEY RR SIGNATORY FIELD BITS



Bit 0, zone control - If nonzero, this key is authorized to attach, detach, and move zones by creating and deleting NS, glue A, and zone KEY RR(s). If zero, the key can not authorize any update that would effect such RRs. This bit is meaningful for both type A and type B dynamic secure zones.

NOTE: do not confuse the "zone" signatory field bit with the "zone" key type bit.

Bit 1, strong update - If nonzero, this key is authorized to add and delete RRs even if there are other RRs with the same owner name and class that are authenticated by a SIG signed with a different dynamic update KEY. If zero, the key can only authorize updates where any existing RRs of the same owner and class are authenticated by a SIG using the same key. This bit is meaningful only for type A dynamic zones and is ignored in type B dynamic zones.

Keeping this bit zero on multiple KEY RRs with the same or nested wild card owner names permits multiple entities to exist that can create and delete names but can not effect RRs with different owner names from any they created. In effect, this creates two levels of dynamic update key, strong and weak, where weak keys are limited in interfering with each other but a strong key can interfere with any weak keys or other strong keys.

Bit 2, unique name update - If nonzero, this key is authorized to add and update RRs for only a single owner name. If there already exist RRs with one or more names signed by this key, they may be updated but no new name created until the number of existing names is reduced to zero. This bit is meaningful only for mode A dynamic zones and is ignored in mode B dynamic zones. This bit is meaningful only if the owner name is a wildcard. (Any dynamic update KEY with a non-wildcard name is, in effect, a unique name update key.)

This bit can be used to restrict a KEY from flooding a zone with new names. In conjunction with a local administratively imposed limit on the number of dynamic RRs with a particular name, it can completely restrict a KEY from flooding a zone with RRs.

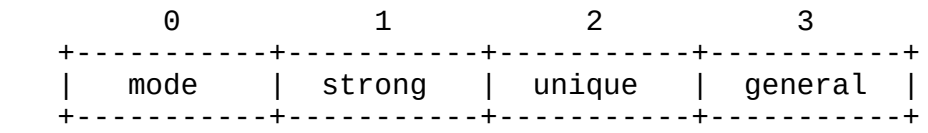
Bit 3, general update - The general update signatory field bit has no special meaning. If the other three bits are all zero, it must be one so that the field is non-zero to designate that the key is an update key. The meaning of all values of the signatory field with the general bit and one or more other signatory field bits on is reserved.

All the signatory bit update authorizations described above only apply if the update is within the name and class scope as per sections 3.1.1 and 3.1.2.

3.2 Zone Keys and Update Modes

Zone type keys are automatically authorized to sign anything in their zone, of course, regardless of the value of their signatory field. For zone keys, the signatory field bits have different means than they they do for update keys, as shown below. The signatory field MUST be zero if dynamic update is not supported for a zone and MUST be non-zero if it is.

ZONE KEY RR SIGNATORY FIELD BITS



Bit 0, mode - This bit indicates the update mode for this zone. Zero indicates mode A while a one indicates mode B.

Bit 1, strong update - If nonzero, this indicates that the "strong" key feature described in section 3.1.3 above is implemented and enabled for this secure zone. If zero, the feature is not available. Has no effect if the zone is a mode B secure update zone.

Bit 2, unique name update - If nonzero, this indicates that the "unique name" feature described in section 3.1.3 above is implemented and enabled for this secure zone. If zero, this feature is not available. Has no effect if the zone is a mode B secure update zone.

Bit 3, general - This bit has no special meeting. If dynamic update for a zone is supported and the other bits in the zone key signatory field are zero, it must be a one. The meaning of zone keys where the signatory field has the general bit and one or more other bits on is reserved.

If there are multiple dynamic update KEY RRs for a zone and zone policy is in transition, they might have different non-zero signatory fields. In that case, strong and unique name restrictions must be enforced as long as there is a non-expired zone key being advertised that indicates mode A with the strong or unique name bit on respectively. Mode B updates MUST be supported as long as there is a non-expired zone key that indicates mode B. Mode A updates may be treated as mode B updates at server option if non-expired zone keys indicate that both are supported.

A server that will be executing update operations on a zone, that is, the primary master server, MUST not advertize a zone key that will attract requests for a mode or features that it can not support.

3.3 Wildcard Key Punch Through

Just as a zone key is valid throughout the entire zone, update keys with wildcard names are valid throughout their extended scope, within the zone. That is, they remain valid for any name that would match them, even existing specific names within their apparent scope.

If this were not so, then whenever a name within a wildcard scope was created by dynamic update, it would be necessary to first create a copy of the KEY RR with this name, because otherwise the existence of the more specific name would hide the authorizing KEY RR and would make later updates impossible. An updater could create such a KEY RR but could not zone sign it with their authorizing signer. They would have to sign it with the same key using the wildcard name as signer. Thus in creating, for example, one hundred type A RRs authorized by a *.1.1.1.in-addr.arpa. KEY RR, without key punch through 100 As, 100 KEYs, and 200 SIGs would have to be created as opposed to merely 100 As and 100 SIGs with key punch through.

4. Update Signatures

Two kinds of signatures can appear in updates. Request signatures, which are always required, cover the entire request and authenticate the DNS header, including opcode, counts, etc., as well as the data. Data signatures, on the other hand, appear only among the RRs to be added and are only required for mode A operation. These two types of signatures are described further below.

4.1 Update Request Signatures

An update can effect multiple owner names in a zone. It may be that these different names are covered by different dynamic update keys. For every owner name effected, the updater must know a private key valid for that name (and the zone’s class) and must prove this by appending request SIG RRs under each such key.

As specified in RFC 2065, a request signature is a SIG RR occurring at the end of a request with a type covered field of zero. For an update, request signatures occur in the Additional information section. Each request SIG signs the entire request, including DNS header, but excluding any other request SIG(s) and with the ARCOUNT in the DNS header set to what it wold be without the request SIGs.

4.2 Update Data Signatures

Mode A dynamic secure zones require that the update requester provide SIG RRs that will authenticate the after update state of all RR sets that are changed by the update and are non-empty after the update. These SIG RRs appear in the request as RRs to be added and the request must delete any previous data SIG RRs that are invalidated by the request.

In Mode B dynamic secure zones, all zone data is authenticated by zone key SIG RRs. In this case, data signatures need not be included with the update. A resolver can determine which mode an updatable secure zone is using by examining the signatory field bits of the zone KEY RR (see section 3.2).

5. Security Considerations

Any zone permitting dynamic updates is inherently less secure than a static secure zone maintained off line as recommended in RFC 2065. If nothing else, secure dynamic update requires on line change to and re-signing of the zone SOA resource record (RR) to increase the SOA serial number. This means that compromise of the primary server host could lead to arbitrary serial number changes.

Isolation of dynamic RRs to separate zones from those holding most static RRs can limit the damage that could occur from breach of a dynamic zone’s security.

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[RFC2136] Vixie, P., Editor, Thomson, T., Rekhter, Y., and J. Bound, "Dynamic Updates in the Domain Name System (DNS UPDATE)", RFC 2136, April 1997.

[RFC1035] Mockapetris, P., "Domain Names - Implementation and Specifications", STD 13, RFC 1035, November 1987.

[RFC1034] Mockapetris, P., "Domain Names - Concepts and Facilities", STD 13, RFC 1034, November 1987.

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