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DNS Terminology
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Abstract

The DNS is defined in literally dozens of different RFCs. The terminology used by implementers and developers of DNS protocols, and by operators of DNS systems, has sometimes changed in the decades since the DNS was first defined. This document gives current definitions for many of the terms used in the DNS in a single document.

This document will be the successor to RFC 7719, and thus will obsolete RFC 7719. It will also update RFC 2308.

Status of This Memo

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1. Introduction

The Domain Name System (DNS) is a simple query-response protocol whose messages in both directions have the same format. (See Section 2 for a fuller definition.) The protocol and message format are defined in [RFC1034] and [RFC1035]. These RFCs defined some terms, but later documents defined others. Some of the terms from [RFC1034] and [RFC1035] now have somewhat different meanings than they did in 1987.

This document collects a wide variety of DNS-related terms. Some of them have been precisely defined in earlier RFCs, some have been loosely defined in earlier RFCs, and some are not defined in any earlier RFC at all.

Most of the definitions here are the consensus definition of the DNS community -- both protocol developers and operators. Some of the definitions differ from earlier RFCs, and those differences are

noted. In this document, where the consensus definition is the same as the one in an RFC, that RFC is quoted. Where the consensus definition has changed somewhat, the RFC is mentioned but the new stand-alone definition is given. See Appendix A for a list of the definitions that this document updates.

It is important to note that, during the development of this document, it became clear that some DNS-related terms are interpreted quite differently by different DNS experts. Further, some terms that are defined in early DNS RFCs now have definitions that are generally agreed to, but that are different from the original definitions. Therefore, this document is a substantial revision to [RFC7719].

The terms are organized loosely by topic. Some definitions are for new terms for things that are commonly talked about in the DNS community but that never had terms defined for them.

Other organizations sometimes define DNS-related terms their own way. For example, the W3C defines "domain" at <https://specs.webplatform.org/url/webspecs/develop/>. The Root Server System Advisory Committee (RSSAC) has a good lexicon [RSSAC026].

Note that there is no single consistent definition of "the DNS". It can be considered to be some combination of the following: a commonly used naming scheme for objects on the Internet; a distributed database representing the names and certain properties of these objects; an architecture providing distributed maintenance, resilience, and loose coherency for this database; and a simple query-response protocol (as mentioned below) implementing this architecture. Section 2 defines "global DNS" and "private DNS" as a way to deal with these differing definitions.

Capitalization in DNS terms is often inconsistent among RFCs and various DNS practitioners. The capitalization used in this document is a best guess at current practices, and is not meant to indicate that other capitalization styles are wrong or archaic. In some cases, multiple styles of capitalization are used for the same term due to quoting from different RFCs.

2. Names

Naming system: A naming system associates names with data. Naming systems have many significant facets that help differentiate them. Some commonly-identified facets include:

- * Composition of names
- * Format of names

- * Administration of names
- * Types of data that can be associated with names
- * Types of metadata for names
- * Protocol for getting data from a name
- * Context for resolving a name

Note that this list is a small subset of facets that people have identified over time for naming systems, and the IETF has yet to agree on a good set of facets that can be used to compare naming systems. For example, other facets might include "protocol to update data in a name", "privacy of names", and "privacy of data associated with names", but those are not as well-defined as the ones listed above. The list here is chosen because it helps describe the DNS and naming systems similar to the DNS.

Domain name: An ordered list of one or more labels.

Note that this is a definition independent of the DNS RFCs, and the definition here also applies to systems other than the DNS. [RFC1034] defines the "domain name space" using mathematical trees and their nodes in graph theory, and the definition in [RFC1034] has the same practical result as the definition here. Using graph theory, a domain name is a list of labels identifying a portion along one edge of a directed acyclic graph. A domain name can be relative to other parts of the tree, or it can be fully qualified (in which case, it begins at the common root of the graph).

Also note that different IETF and non-IETF documents have used the term "domain name" in many different ways. It is common for earlier documents to use "domain name" to mean "names that match the syntax in [RFC1035]", but possibly with additional rules such as "and are, or will be, resolvable in the global DNS" or "but only using the presentation format".

Label: An ordered list of zero or more octets and which makes up a portion of a domain name. Using graph theory, a label identifies one node in a portion of the graph of all possible domain names.

Global DNS: Using the short set of facets listed in "Naming system", the global DNS can be defined as follows. Most of the rules here come from [RFC1034] and [RFC1035], although the term "global DNS" has not been defined before now.

Composition of names -- A name in the global DNS has one or more labels. The length of each label is between 0 and 63 octets inclusive. In a fully-qualified domain name, the first label in the ordered list is 0 octets long; it is the only label whose length may be 0 octets, and it is called the "root" or "root label". A domain name in the global DNS has a maximum total length of 255 octets in the wire format; the root represents one octet for this calculation.

Format of names -- Names in the global DNS are domain names. There are three formats: wire format, presentation format, and common display.

The basic wire format for names in the global DNS is a list of labels ordered by decreasing distance from the root, with the root label last. Each label is preceded by a length octet. [RFC1035] also defines a compression scheme that modifies this format.

The presentation format for names in the global DNS is a list of labels ordered by decreasing distance from the root, encoded as ASCII, with a "." character between each label. In presentation format, a fully-qualified domain name includes the root label and the associated separator dot. For example, in presentation format, a fully-qualified domain name with two non-root labels is always shown as "example.tld." instead of "example.tld". [RFC1035] defines a method for showing octets that do not display in ASCII.

The common display format is used in applications and free text. It is the same as the presentation format, but showing the root label and the "." before it is optional and is rarely done. For example, in common display format, a fully-qualified domain name with two non-root labels is usually shown as "example.tld" instead of "example.tld.". Names in the common display format are normally written such that the directionality of the writing system presents labels by decreasing distance from the root (so, in both English and C the first label in the ordered list is right-most; but in Arabic it may be left-most, depending on local conventions).

Administration of names -- Administration is specified by delegation (see the definition of "delegation" in Section 6). Policies for administration of the root zone in the global DNS are determined by the names operational community, which convenes itself in the Internet Corporation for Assigned Names and Numbers (ICANN). The names operational community selects the IANA Functions Operator for the global DNS root zone. At the time this document is published, that operator is Public Technical

Identifiers (PTI). The name servers that serve the root zone are provided by independent root operators. Other zones in the global DNS have their own policies for administration.

Types of data that can be associated with names -- A name can have zero or more resource records associated with it. There are numerous types of resource records with unique data structures defined in many different RFCs and in the IANA registry at [IANA_Resource_Registry].

Types of metadata for names -- Any name that is published in the DNS appears as a set of resource records (see the definition of "RRset" in Section 4). Some names do not themselves have data associated with them in the DNS, but "appear" in the DNS anyway because they form part of a longer name that does have data associated with it (see the definition of "empty non-terminals" in Section 6).

Protocol for getting data from a name -- The protocol described in [RFC1035].

Context for resolving a name -- The global DNS root zone distributed by PTI.

Private DNS: Names that use the protocol described in [RFC1035] but that do not rely on the global DNS root zone, or names that are otherwise not generally available on the Internet but are using the protocol described in [RFC1035]. A system can use both the global DNS and one or more private DNS systems; for example, see "Split DNS" in Section 7.

Note that domain names that do not appear in the DNS, and that are intended never to be looked up using the DNS protocol, are not part of the global DNS or a private DNS even though they are domain names.

Locally served DNS zone: A locally served DNS zone is a special case of private DNS. Names are resolved using the DNS protocol in a local context. [RFC6303] defines subdomains of IN-ADDR.ARPA that are locally served zones. Resolution of names through locally served zones may result in ambiguous results. For example, the same name may resolve to different results in different locally served DNS zone contexts. The context through which a locally served zone may be explicit, for example, as defined in [RFC6303], or implicit, as defined by local DNS administration and not known to the resolution client.

Fully qualified domain name (FQDN): This is often just a clear way of saying the same thing as "domain name of a node", as outlined above. However, the term is ambiguous. Strictly speaking, a fully qualified domain name would include every label, including the zero-length label of the root: such a name would be written "www.example.net." (note the terminating dot). But because every name eventually shares the common root, names are often written relative to the root (such as "www.example.net") and are still called "fully qualified". This term first appeared in [RFC0819]. In this document, names are often written relative to the root.

The need for the term "fully qualified domain name" comes from the existence of partially qualified domain names, which are names where one or more of the earliest labels in the ordered list are omitted (for example, "www"). Such relative names are understood only by context.

Host name: This term and its equivalent, "hostname", have been widely used but are not defined in [RFC1034], [RFC1035], [RFC1123], or [RFC2181]. The DNS was originally deployed into the Host Tables environment as outlined in [RFC0952], and it is likely that the term followed informally from the definition there. Over time, the definition seems to have shifted. "Host name" is often meant to be a domain name that follows the rules in Section 3.5 of [RFC1034], the "preferred name syntax". Note that any label in a domain name can contain any octet value; hostnames are generally considered to be domain names where every label follows the rules in the "preferred name syntax", with the amendment that labels can start with ASCII digits (this amendment comes from Section 2.1 of [RFC1123]).

People also sometimes use the term hostname to refer to just the first label of an FQDN, such as "printer" in "printer.admin.example.com". (Sometimes this is formalized in configuration in operating systems.) In addition, people sometimes use this term to describe any name that refers to a machine, and those might include labels that do not conform to the "preferred name syntax".

TLD: A Top-Level Domain, meaning a zone that is one layer below the root, such as "com" or "jp". There is nothing special, from the point of view of the DNS, about TLDs. Most of them are also delegation-centric zones, and there are significant policy issues around their operation. TLDs are often divided into sub-groups such as Country Code Top-Level Domains (ccTLDs), Generic Top-Level Domains (gTLDs), and others; the division is a matter of policy, and beyond the scope of this document.

IDN: The common abbreviation for "Internationalized Domain Name". The IDNA protocol is the standard mechanism for handling domain names with non-ASCII characters in applications in the DNS. The current standard, normally called "IDNA2008", is defined in [RFC5890], [RFC5891], [RFC5892], [RFC5893], and [RFC5894]. These documents define many IDN-specific terms such as "LDH label", "A-label", and "U-label". [RFC6365] defines more terms that relate to internationalization (some of which relate to IDNs), and [RFC6055] has a much more extensive discussion of IDNs, including some new terminology.

Subdomain: "A domain is a subdomain of another domain if it is contained within that domain. This relationship can be tested by seeing if the subdomain's name ends with the containing domain's name." (Quoted from [RFC1034], Section 3.1). For example, in the host name "nnn.mmm.example.com", both "mmm.example.com" and "nnn.mmm.example.com" are subdomains of "example.com".

Alias: The owner of a CNAME resource record, or a subdomain of the owner of a DNAME resource record. See also "canonical name".

Canonical name: A CNAME resource record "identifies its owner name as an alias, and specifies the corresponding canonical name in the RDATA section of the RR." (Quoted from [RFC1034], Section 3.6.2) This usage of the word "canonical" is related to the mathematical concept of "canonical form".

CNAME: "It is traditional to refer to the owner of a CNAME record as 'a CNAME'. This is unfortunate, as 'CNAME' is an abbreviation of 'canonical name', and the owner of a CNAME record is an alias, not a canonical name." (Quoted from [RFC2181], Section 10.1.1)

Public suffix: "A domain that is controlled by a public registry." (Quoted from [RFC6265], Section 5.3) A common definition for this term is a domain under which subdomains can be registered, and on which HTTP cookies ([RFC6265]) should not be set. There is no indication in a domain name whether it is a public suffix; that can only be determined by outside means. In fact, both a domain and a subdomain of that domain can be public suffixes.

There is nothing inherent in a domain name to indicate whether it is a public suffix. One resource for identifying public suffixes is the Public Suffix List (PSL) maintained by Mozilla (<http://publicsuffix.org/>).

For example, at the time this document is published, the "com.au" domain is listed as a public suffix in the PSL. (Note that this example might change in the future.)

Note that the term "public suffix" is controversial in the DNS community for many reasons, and may be significantly changed in the future. One example of the difficulty of calling a domain a public suffix is that designation can change over time as the registration policy for the zone changes, such as was the case with the "uk" TLD in 2014.

3. DNS Header and Response Codes

The header of a DNS message is its first 12 octets. Many of the fields and flags in the header diagram in Sections 4.1.1 through 4.1.3 of [RFC1035] are referred to by their names in that diagram. For example, the response codes are called "RCODEs", the data for a record is called the "RDATA", and the authoritative answer bit is often called "the AA flag" or "the AA bit".

QNAME The most commonly-used rough definition is that the QNAME is a field in the Question section of a query. "A standard query specifies a target domain name (QNAME), query type (QTYPE), and query class (QCLASS) and asks for RRs which match." (Quoted from [RFC1034], Section 3.7.1.). Strictly speaking, the definition comes from [RFC1035], Section 4.1.2, where the QNAME is defined in respect of the Question Section. This definition appears to be applied consistently: the discussion of inverse queries in section 6.4 refers to the "owner name of the query RR and its TTL", because inverse queries populate the Answer Section and leave the Question Section empty. (Inverse queries are deprecated in [RFC3425], and so relevant definitions do not appear in this document.)

[RFC2308], however, has an alternate definition that puts the QNAME in the answer (or series of answers) instead of the query. It defines QNAME as: "...the name in the query section of an answer, or where this resolves to a CNAME, or CNAME chain, the data field of the last CNAME. The last CNAME in this sense is that which contains a value which does not resolve to another CNAME." This definition has a certain internal logic, because of the way CNAME substitution works and the definition of CNAME. If a name server does not find an RRset that matches a query, but it finds the same name in the same class with a CNAME record, then the name server "includes the CNAME record in the response and restarts the query at the domain name specified in the data field of the CNAME record." ([RFC1034] Section 3.6.2). This is made explicit in the resolution algorithm outlined in Section 4.3.2 of [RFC1034], which says to "change QNAME to the canonical name in the CNAME RR, and go back to step 1" in the case of a CNAME RR. Since a CNAME record explicitly declares that the owner name is canonically named what is in the RDATA, then there is a way to

view the new name (i.e. the name that was in the RDATA of the CNAME RR) as also being the QNAME.

This creates a kind of confusion, however, because the answer to a query that results in CNAME processing contains in the echoed Question Section one QNAME (the name in the original query), and a second QNAME that is in the data field of the last CNAME. The confusion comes from the iterative/recursive mode of resolution, which finally returns an answer that need not actually have the same owner name as the QNAME contained in the original query.

To address this potential confusion, it is helpful to distinguish between three meanings:

- * QNAME (original): The name actually sent in the Question Section in the original query, which is always echoed in the (final) reply in the Question Section when the QR bit is set to 1.
- * QNAME (effective): A name actually resolved, which is either the name originally queried, or a name received in a CNAME chain response.
- * QNAME (final): The name actually resolved, which is either the name actually queried or else the last name in a CNAME chain response.

Some of response codes that are defined in [RFC1035] have acquired their own shorthand names. Some common response code names that appear without reference to the numeric value are "FORMERR", "SERVFAIL", and "NXDOMAIN" (the latter of which is also referred to as "Name Error"). All of the RCODEs are listed at <http://www.iana.org/assignments/dns-parameters>, although that site uses mixed-case capitalization, while most documents use all-caps.

NODATA: "A pseudo RCODE which indicates that the name is valid for the given class, but there are no records of the given type. A NODATA response has to be inferred from the answer." (Quoted from [RFC2308], Section 1.) "NODATA is indicated by an answer with the RCODE set to NOERROR and no relevant answers in the answer section. The authority section will contain an SOA record, or there will be no NS records there." (Quoted from [RFC2308], Section 2.2.) Note that referrals have a similar format to NODATA replies; [RFC2308] explains how to distinguish them.

The term "NXRRSET" is sometimes used as a synonym for NODATA. However, this is a mistake, given that NXRRSET is a specific error code defined in [RFC2136].

Negative response: A response that indicates that a particular RRset does not exist, or whose RCODE indicates the nameserver cannot answer. Sections 2 and 7 of [RFC2308] describe the types of negative responses in detail.

Referrals: Data from the authority section of a non-authoritative answer. [RFC1035] Section 2.1 defines "authoritative" data. However, referrals at zone cuts (defined in Section 6) are not authoritative. Referrals may be zone cut NS resource records and their glue records. NS records on the parent side of a zone cut are an authoritative delegation, but are normally not treated as authoritative data. In general, a referral is a way for a server to send an answer saying that the server does not know the answer, but knows where the query should be directed in order to get an answer. Historically, many authoritative servers answered with a referral to the root zone when queried for a name for which they were not authoritative, but this practice has declined.

4. Resource Records

RR: An acronym for resource record. ([RFC1034], Section 3.6.)

RRset: A set of resource records with the same label, class and type, but with different data. (Definition from [RFC2181]) Also spelled RRSet in some documents. As a clarification, "same label" in this definition means "same owner name". In addition, [RFC2181] states that "the TTLs of all RRs in an RRSet must be the same". (This definition is definitely not the same as "the response one gets to a query for QTYPE=ANY", which is an unfortunate misunderstanding.)

Master file: "Master files are text files that contain RRs in text form. Since the contents of a zone can be expressed in the form of a list of RRs a master file is most often used to define a zone, though it can be used to list a cache's contents." ([RFC1035], Section 5.)

Presentation format: The text format used in master files. This format is shown but not formally defined in [RFC1034] and [RFC1035]. The term "presentation format" first appears in [RFC4034].

EDNS: The extension mechanisms for DNS, defined in [RFC6891]. Sometimes called "EDNS0" or "EDNS(0)" to indicate the version number. EDNS allows DNS clients and servers to specify message sizes larger than the original 512 octet limit, to expand the response code space, and potentially to carry additional options that affect the handling of a DNS query.

OPT: A pseudo-RR (sometimes called a "meta-RR") that is used only to contain control information pertaining to the question-and-answer sequence of a specific transaction. (Definition from [RFC6891], Section 6.1.1) It is used by EDNS.

Owner: The domain name where a RR is found ([RFC1034], Section 3.6). Often appears in the term "owner name".

SOA field names: DNS documents, including the definitions here, often refer to the fields in the RDATA of an SOA resource record by field name. Those fields are defined in Section 3.3.13 of [RFC1035]. The names (in the order they appear in the SOA RDATA) are MNAME, RNAME, SERIAL, REFRESH, RETRY, EXPIRE, and MINIMUM. Note that the meaning of MINIMUM field is updated in Section 4 of [RFC2308]; the new definition is that the MINIMUM field is only "the TTL to be used for negative responses". This document tends to use field names instead of terms that describe the fields.

TTL: The maximum "time to live" of a resource record. "A TTL value is an unsigned number, with a minimum value of 0, and a maximum value of 2147483647. That is, a maximum of $2^{31} - 1$. When transmitted, the TTL is encoded in the less significant 31 bits of the 32 bit TTL field, with the most significant, or sign, bit set to zero." (Quoted from [RFC2181], Section 8) (Note that [RFC1035] erroneously stated that this is a signed integer; that was fixed by [RFC2181].)

The TTL "specifies the time interval that the resource record may be cached before the source of the information should again be consulted". (Quoted from [RFC1035], Section 3.2.1) Also: "the time interval (in seconds) that the resource record may be cached before it should be discarded". (Quoted from [RFC1035], Section 4.1.3). Despite being defined for a resource record, the TTL of every resource record in an RRset is required to be the same ([RFC2181], Section 5.2).

The reason that the TTL is the maximum time to live is that a cache operator might decide to shorten the time to live for operational purposes, such as if there is a policy to disallow TTL values over a certain number. Also, if a value is flushed from the cache when its value is still positive, the value effectively becomes zero. Some servers are known to ignore the TTL on some RRsets (such as when the authoritative data has a very short TTL) even though this is against the advice in RFC 1035.

There is also the concept of a "default TTL" for a zone, which can be a configuration parameter in the server software. This is often expressed by a default for the entire server, and a default

for a zone using the \$TTL directive in a zone file. The \$TTL directive was added to the master file format by [RFC2308].

Class independent: A resource record type whose syntax and semantics are the same for every DNS class. A resource record type that is not class independent has different meanings depending on the DNS class of the record, or the meaning is undefined for classes other than IN (class 1, the Internet).

5. DNS Servers and Clients

This section defines the terms used for the systems that act as DNS clients, DNS servers, or both. In the RFCs, DNS servers are sometimes called "name servers", "nameservers", or just "servers". There is no formal definition of DNS server, but the RFCs generally assume that it is an Internet server that listens for queries and sends responses using the DNS protocol defined in [RFC1035] and its successors.

For terminology specific to the public DNS root server system, see [RSSAC026]. That document defines terms such as "root server", "root server operator", and terms that are specific to the way that the root zone of the public DNS is served.

Resolver: A program "that extract[s] information from name servers in response to client requests." (Quoted from [RFC1034], Section 2.4) "The resolver is located on the same machine as the program that requests the resolver's services, but it may need to consult name servers on other hosts." (Quoted from [RFC1034], Section 5.1) A resolver performs queries for a name, type, and class, and receives answers. The logical function is called "resolution". In practice, the term is usually referring to some specific type of resolver (some of which are defined below), and understanding the use of the term depends on understanding the context.

A related term is "resolve", which is not formally defined in [RFC1034] or [RFC1035]. An imputed definition might be "asking a question that consists of a domain name, class, and type, and receiving some sort of answer". Similarly, an imputed definition of "resolution" might be "the answer received from resolving".

Stub resolver: A resolver that cannot perform all resolution itself. Stub resolvers generally depend on a recursive resolver to undertake the actual resolution function. Stub resolvers are discussed but never fully defined in Section 5.3.1 of [RFC1034]. They are fully defined in Section 6.1.3.1 of [RFC1123].

Iterative mode: A resolution mode of a server that receives DNS queries and responds with a referral to another server. Section 2.3 of [RFC1034] describes this as "The server refers the client to another server and lets the client pursue the query". A resolver that works in iterative mode is sometimes called an "iterative resolver".

Recursive mode: A resolution mode of a server that receives DNS queries and either responds to those queries from a local cache or sends queries to other servers in order to get the final answers to the original queries. Section 2.3 of [RFC1034] describes this as "The first server pursues the query for the client at another server". A server operating in recursive mode may be thought of as having a name server side (which is what answers the query) and a resolver side (which performs the resolution function). Systems operating in this mode are commonly called "recursive servers". Sometimes they are called "recursive resolvers". While strictly the difference between these is that one of them sends queries to another recursive server and the other does not, in practice it is not possible to know in advance whether the server that one is querying will also perform recursion; both terms can be observed in use interchangeably.

Full resolver: This term is used in [RFC1035], but it is not defined there. RFC 1123 defines a "full-service resolver" that may or may not be what was intended by "full resolver" in [RFC1035]. This term is not properly defined in any RFC.

Full-service resolver: Section 6.1.3.1 of [RFC1123] defines this term to mean a resolver that acts in recursive mode with a cache (and meets other requirements).

Recursive resolver: A resolver that acts in recursive mode. In general, a recursive resolver is expected to cache the answers it receives (which would make it a full-service resolver), but some recursive resolvers might not cache.

Priming: "The act of finding the list of root servers from a configuration that lists some or all of the purported IP addresses of some or all of those root servers." (Quoted from [RFC8109], Section 2.) Priming is most often done from a configuration setting that contains a list of authoritative servers for the root zone.

Root hints: "Operators who manage a DNS recursive resolver typically need to configure a 'root hints file'. This file contains the names and IP addresses of the authoritative name servers for the root zone, so the software can bootstrap the DNS resolution

process. For many pieces of software, this list comes built into the software." (Quoted from [IANA_RootFiles])

Negative caching: "The storage of knowledge that something does not exist, cannot give an answer, or does not give an answer."
(Quoted from [RFC2308], Section 1)

Authoritative server: "A server that knows the content of a DNS zone from local knowledge, and thus can answer queries about that zone without needing to query other servers." (Quoted from [RFC2182], Section 2.) It is a system that responds to DNS queries with information about zones for which it has been configured to answer with the AA flag in the response header set to 1. It is a server that has authority over one or more DNS zones. Note that it is possible for an authoritative server to respond to a query without the parent zone delegating authority to that server. Authoritative servers also provide "referrals", usually to child zones delegated from them; these referrals have the AA bit set to 0 and come with referral data in the Authority and (if needed) the Additional sections.

Authoritative-only server: A name server that only serves authoritative data and ignores requests for recursion. It will "not normally generate any queries of its own. Instead, it answers non-recursive queries from iterative resolvers looking for information in zones it serves." (Quoted from [RFC4697], Section 2.4)

Zone transfer: The act of a client requesting a copy of a zone and an authoritative server sending the needed information. (See Section 6 for a description of zones.) There are two common standard ways to do zone transfers: the AXFR ("Authoritative Transfer") mechanism to copy the full zone (described in [RFC5936], and the IXFR ("Incremental Transfer") mechanism to copy only parts of the zone that have changed (described in [RFC1995]). Many systems use non-standard methods for zone transfer outside the DNS protocol.

Secondary server: "An authoritative server which uses zone transfer to retrieve the zone" (Quoted from [RFC1996], Section 2.1). [RFC2182] describes secondary servers in detail. Although early DNS RFCs such as [RFC1996] referred to this as a "slave", the current common usage has shifted to calling it a "secondary". Secondary servers are also discussed in [RFC1034].

Slave server: See secondary server.

Primary server: "Any authoritative server configured to be the source of zone transfer for one or more [secondary] servers" (Quoted from [RFC1996], Section 2.1) or, more specifically, "an authoritative server configured to be the source of AXFR or IXFR data for one or more [secondary] servers" (Quoted from [RFC2136]). Although early DNS RFCs such as [RFC1996] referred to this as a "master", the current common usage has shifted to "primary". Primary servers are also discussed in [RFC1034].

Master server: See primary server.

Primary master: "The primary master is named in the zone's SOA MNAME field and optionally by an NS RR". (Quoted from [RFC1996], Section 2.1). [RFC2136] defines "primary master" as "Master server at the root of the AXFR/IXFR dependency graph. The primary master is named in the zone's SOA MNAME field and optionally by an NS RR. There is by definition only one primary master server per zone." The idea of a primary master is only used by [RFC2136], and is considered archaic in other parts of the DNS.

Stealth server: This is "like a slave server except not listed in an NS RR for the zone." (Quoted from [RFC1996], Section 2.1)

Hidden master: A stealth server that is a primary server for zone transfers. "In this arrangement, the master name server that processes the updates is unavailable to general hosts on the Internet; it is not listed in the NS RRset." (Quoted from [RFC6781], Section 3.4.3). An earlier RFC, [RFC4641], said that the hidden master's name "appears in the SOA RRs MNAME field", although in some setups, the name does not appear at all in the public DNS. A hidden master can also be a secondary server itself.

Forwarding: The process of one server sending a DNS query with the RD bit set to 1 to another server to resolve that query. Forwarding is a function of a DNS resolver; it is different than simply blindly relaying queries.

[RFC5625] does not give a specific definition for forwarding, but describes in detail what features a system that forwards need to support. Systems that forward are sometimes called "DNS proxies", but that term has not yet been defined (even in [RFC5625]).

Forwarder: Section 1 of [RFC2308] describes a forwarder as "a nameserver used to resolve queries instead of directly using the authoritative nameserver chain". [RFC2308] further says "The forwarder typically either has better access to the internet, or maintains a bigger cache which may be shared amongst many

resolvers." That definition appears to suggest that forwarders normally only query authoritative servers. In current use, however, forwarders often stand between stub resolvers and recursive servers. [RFC2308] is silent on whether a forwarder is iterative-only or can be a full-service resolver.

Policy-implementing resolver: A resolver acting in recursive mode that changes some of the answers that it returns based on policy criteria, such as to prevent access to malware sites or objectionable content. In general, a stub resolver has no idea whether upstream resolvers implement such policy or, if they do, the exact policy about what changes will be made. In some cases, the user of the stub resolver has selected the policy-implementing resolver with the explicit intention of using it to implement the policies. In other cases, policies are imposed without the user of the stub resolver being informed.

Open resolver: A full-service resolver that accepts and processes queries from any (or nearly any) stub resolver. This is sometimes also called a "public resolver", although the term "public resolver" is used more with open resolvers that are meant to be open, as compared to the vast majority of open resolvers that are probably misconfigured to be open. Open resolvers are discussed in [RFC5358]

View: A configuration for a DNS server that allows it to provide different answers depending on attributes of the query. Typically, views differ by the source IP address of a query, but can also be based on the destination IP address, the type of query (such as AXFR), whether it is recursive, and so on. Views are often used to provide more names or different addresses to queries from "inside" a protected network than to those "outside" that network. Views are not a standardized part of the DNS, but they are widely implemented in server software.

Passive DNS: A mechanism to collect DNS data by storing DNS transactions from name servers. Some of these systems also collect the DNS queries associated with the responses. Passive DNS databases can be used to answer historical questions about DNS zones such as which answers were witnessed at what times in the past. Passive DNS databases allow searching of the stored records on keys other than just the name and type, such as "find all names which have A records of a particular value".

Anycast: "The practice of making a particular service address available in multiple, discrete, autonomous locations, such that datagrams sent are routed to one of several available locations." (Quoted from [RFC4786], Section 2)

Instance: "When anycast routing is used to allow more than one server to have the same IP address, each one of those servers is commonly referred to as an 'instance'." "An instance of a server, such as a root server, is often referred to as an 'Anycast instance'." (Quoted from [RSSAC026])

Split DNS: "Where a corporate network serves up partly or completely different DNS inside and outside its firewall. There are many possible variants on this; the basic point is that the correspondence between a given FQDN (fully qualified domain name) and a given IPv4 address is no longer universal and stable over long periods." (Quoted from [RFC2775], Section 3.8)

6. Zones

This section defines terms that are used when discussing zones that are being served or retrieved.

Zone: "Authoritative information is organized into units called 'zones', and these zones can be automatically distributed to the name servers which provide redundant service for the data in a zone." (Quoted from [RFC1034], Section 2.4)

Child: "The entity on record that has the delegation of the domain from the Parent." (Quoted from [RFC7344], Section 1.1)

Parent: "The domain in which the Child is registered." (Quoted from [RFC7344], Section 1.1) Earlier, "parent name server" was defined in [RFC0882] as "the name server that has authority over the place in the domain name space that will hold the new domain". (Note that [RFC0882] was obsoleted by [RFC1034] and [RFC1035].) [RFC0819] also has some description of the relationship between parents and children.

Origin:

(a) "The domain name that appears at the top of a zone (just below the cut that separates the zone from its parent). The name of the zone is the same as the name of the domain at the zone's origin." (Quoted from [RFC2181], Section 6.) These days, this sense of "origin" and "apex" (defined below) are often used interchangeably.

(b) The domain name within which a given relative domain name appears in zone files. Generally seen in the context of "\$ORIGIN", which is a control entry defined in [RFC1035], Section 5.1, as part of the master file format. For example, if

the \$ORIGIN is set to "example.org.", then a master file line for "www" is in fact an entry for "www.example.org.".

Apex: The point in the tree at an owner of an SOA and corresponding authoritative NS RRset. This is also called the "zone apex". [RFC4033] defines it as "the name at the child's side of a zone cut". The "apex" can usefully be thought of as a data-theoretic description of a tree structure, and "origin" is the name of the same concept when it is implemented in zone files. The distinction is not always maintained in use, however, and one can find uses that conflict subtly with this definition. [RFC1034] uses the term "top node of the zone" as a synonym of "apex", but that term is not widely used. These days, the first sense of "origin" (above) and "apex" are often used interchangeably.

Zone cut: The delimitation point between two zones where the origin of one of the zones is the child of the other zone.

"Zones are delimited by 'zone cuts'. Each zone cut separates a 'child' zone (below the cut) from a 'parent' zone (above the cut). (Quoted from [RFC2181], Section 6; note that this is barely an ostensive definition.) Section 4.2 of [RFC1034] uses "cuts" as 'zone cut'."

Delegation: The process by which a separate zone is created in the name space beneath the apex of a given domain. Delegation happens when an NS RRset is added in the parent zone for the child origin. Delegation inherently happens at a zone cut. The term is also commonly a noun: the new zone that is created by the act of delegating.

Glue records: "[Resource records] which are not part of the authoritative data [of the zone], and are address resource records for the [name servers in subzones]. These RRs are only necessary if the name server's name is 'below' the cut, and are only used as part of a referral response." Without glue "we could be faced with the situation where the NS RRs tell us that in order to learn a name server's address, we should contact the server using the address we wish to learn." (Definition from [RFC1034], Section 4.2.1)

A later definition is that glue "includes any record in a zone file that is not properly part of that zone, including nameserver records of delegated sub-zones (NS records), address records that accompany those NS records (A, AAAA, etc), and any other stray data that might appear" ([RFC2181], Section 5.4.1). Although glue is sometimes used today with this wider definition in mind, the context surrounding the [RFC2181] definition suggests it is

intended to apply to the use of glue within the document itself and not necessarily beyond.

In-bailiwick: An adjective to describe a name server whose name is either subordinate to or (rarely) the same as the zone origin. In-bailiwick name servers may have glue records in their parent zone (using the first of the definitions of "glue records" in the definition above). "In-bailiwick" names are divided into two type of name server names: "in-domain" names and "sibling domain" names:

- * **In-domain** -- an adjective to describe a name server whose name is either subordinate to or (rarely) the same as the owner name of the NS resource records. An in-domain name server name **MUST** have glue records or name resolution fails. For example, a delegation for "child.example.com" may have "in-domain" name server name "ns.child.example.com".
- * **Sibling domain**: -- a name server's name that is either subordinate to or (rarely) the same as the zone origin and not subordinate to or the same as the owner name of the NS resource records. Glue records for sibling domains are allowed, but not necessary. For example, a delegation for "child.example.com" in "example.com" zone may have "sibling" name server name "ns.another.example.com".

Out-of-bailiwick: The antonym of in-bailiwick. An adjective to describe a name server whose name is not subordinate to or the same as the zone origin. Glue records for out-of-bailiwick name servers are useless.

Authoritative data: "All of the RRs attached to all of the nodes from the top node of the zone down to leaf nodes or nodes above cuts around the bottom edge of the zone." (Quoted from [RFC1034], Section 4.2.1) It is noted that this definition might inadvertently also include any NS records that appear in the zone, even those that might not truly be authoritative because there are identical NS RRs below the zone cut. This reveals the ambiguity in the notion of authoritative data, because the parent-side NS records authoritatively indicate the delegation, even though they are not themselves authoritative data.

Root zone: The zone of a DNS-based tree whose apex is the zero-length label. Also sometimes called "the DNS root".

Empty non-terminals (ENT): "Domain names that own no resource records but have subdomains that do." (Quoted from [RFC4592], Section 2.2.2.) A typical example is in SRV records: in the name

"_sip._tcp.example.com", it is likely that "_tcp.example.com" has no RRsets, but that "_sip._tcp.example.com" has (at least) an SRV RRset.

Delegation-centric zone: A zone that consists mostly of delegations to child zones. This term is used in contrast to a zone that might have some delegations to child zones, but also has many data resource records for the zone itself and/or for child zones. The term is used in [RFC4956] and [RFC5155], but is not defined there.

Wildcard: [RFC1034] defined "wildcard", but in a way that turned out to be confusing to implementers. Special treatment is given to RRs with owner names starting with the label "*". "Such RRs are called 'wildcards'. Wildcard RRs can be thought of as instructions for synthesizing RRs." (Quoted from [RFC1034], Section 4.3.3) For an extended discussion of wildcards, including clearer definitions, see [RFC4592].

Asterisk label: "The first octet is the normal label type and length for a 1-octet-long label, and the second octet is the ASCII representation for the '*' character. A descriptive name of a label equaling that value is an 'asterisk label'." (Quoted from [RFC4592], Section 2.1.1)

Wildcard domain name: "A 'wildcard domain name' is defined by having its initial (i.e., leftmost or least significant) label be asterisk label." (Quoted from [RFC4592], Section 2.1.1)

Closest encloser: "The longest existing ancestor of a name." (Quoted from [RFC5155], Section 1.3) An earlier definition is "The node in the zone's tree of existing domain names that has the most labels matching the query name (consecutively, counting from the root label downward). Each match is a 'label match' and the order of the labels is the same." (Quoted from [RFC4592], Section 3.3.1)

Closest provable encloser: "The longest ancestor of a name that can be proven to exist. Note that this is only different from the closest encloser in an Opt-Out zone." (Quoted from [RFC5155], Section 1.3)

Next closer name: "The name one label longer than the closest provable encloser of a name." (Quoted from [RFC5155], Section 1.3)

Source of Synthesis: "The source of synthesis is defined in the context of a query process as that wildcard domain name immediately descending from the closest encloser, provided that

this wildcard domain name exists. 'Immediately descending' means that the source of synthesis has a name of the form: <asterisk label>.<closest encloser>." (Quoted from [RFC4592], Section 3.3.1)

Occluded name: "The addition of a delegation point via dynamic update will render all subordinate domain names to be in a limbo, still part of the zone, but not available to the lookup process. The addition of a DNAME resource record has the same impact. The subordinate names are said to be 'occluded'." (Quoted from [RFC5936], Section 3.5)

Fast flux DNS: This "occurs when a domain is found in DNS using A records to multiple IP addresses, each of which has a very short Time-to-Live (TTL) value associated with it. This means that the domain resolves to varying IP addresses over a short period of time." (Quoted from [RFC6561], Section 1.1.5, with typo corrected) It is often used to deliver malware. Because the addresses change so rapidly, it is difficult to ascertain all the hosts. It should be noted that the technique also works with AAAA records, but such use is not frequently observed on the Internet as of this writing.

Reverse DNS, reverse lookup: "The process of mapping an address to a name is generally known as a 'reverse lookup', and the IN-ADDR.ARPA and IP6.ARPA zones are said to support the 'reverse DNS'." (Quoted from [RFC5855], Section 1)

Forward lookup: "Hostname-to-address translation". (Quoted from [RFC2133], Section 6)

arpa: Address and Routing Parameter Area Domain: "The 'arpa' domain was originally established as part of the initial deployment of the DNS, to provide a transition mechanism from the Host Tables that were common in the ARPANET, as well as a home for the IPv4 reverse mapping domain. During 2000, the abbreviation was redesignated to 'Address and Routing Parameter Area' in the hope of reducing confusion with the earlier network name." (Quoted from [RFC3172], Section 2.)

Infrastructure domain: A domain whose "role is to support the operating infrastructure of the Internet". (Quoted from [RFC3172], Section 2.)

Service name: "Service names are the unique key in the Service Name and Transport Protocol Port Number registry. This unique symbolic name for a service may also be used for other purposes, such as in DNS SRV records." (Quoted from [RFC6335], Section 5.)

7. Registration Model

Registry: The administrative operation of a zone that allows registration of names within that zone. People often use this term to refer only to those organizations that perform registration in large delegation-centric zones (such as TLDs); but formally, whoever decides what data goes into a zone is the registry for that zone. This definition of "registry" is from a DNS point of view; for some zones, the policies that determine what can go in the zone are decided by superior zones and not the registry operator.

Registrant: An individual or organization on whose behalf a name in a zone is registered by the registry. In many zones, the registry and the registrant may be the same entity, but in TLDs they often are not.

Registrar: A service provider that acts as a go-between for registrants and registries. Not all registrations require a registrar, though it is common to have registrars involved in registrations in TLDs.

EPP: The Extensible Provisioning Protocol (EPP), which is commonly used for communication of registration information between registries and registrars. EPP is defined in [RFC5730].

WHOIS: A protocol specified in [RFC3912], often used for querying registry databases. WHOIS data is frequently used to associate registration data (such as zone management contacts) with domain names. The term "WHOIS data" is often used as a synonym for the registry database, even though that database may be served by different protocols, particularly RDAP. The WHOIS protocol is also used with IP address registry data.

RDAP: The Registration Data Access Protocol, defined in [RFC7480], [RFC7481], [RFC7482], [RFC7483], [RFC7484], and [RFC7485]. The RDAP protocol and data format are meant as a replacement for WHOIS.

DNS operator: An entity responsible for running DNS servers. For a zone's authoritative servers, the registrant may act as their own DNS operator, or their registrar may do it on their behalf, or they may use a third-party operator. For some zones, the registry function is performed by the DNS operator plus other entities who decide about the allowed contents of the zone.

8. General DNSSEC

Most DNSSEC terms are defined in [RFC4033], [RFC4034], [RFC4035], and [RFC5155]. The terms that have caused confusion in the DNS community are highlighted here.

DNSSEC-aware and DNSSEC-unaware: These two terms, which are used in some RFCs, have not been formally defined. However, Section 2 of [RFC4033] defines many types of resolvers and validators, including "non-validating security-aware stub resolver", "non-validating stub resolver", "security-aware name server", "security-aware recursive name server", "security-aware resolver", "security-aware stub resolver", and "security-oblivious 'anything'". (Note that the term "validating resolver", which is used in some places in DNSSEC-related documents, is also not defined in those RFCs, but is defined below.)

Signed zone: "A zone whose RRsets are signed and that contains properly constructed DNSKEY, Resource Record Signature (RRSIG), Next Secure (NSEC), and (optionally) DS records." (Quoted from [RFC4033], Section 2.) It has been noted in other contexts that the zone itself is not really signed, but all the relevant RRsets in the zone are signed. Nevertheless, if a zone that should be signed contains any RRsets that are not signed (or opted out), those RRsets will be treated as bogus, so the whole zone needs to be handled in some way.

It should also be noted that, since the publication of [RFC6840], NSEC records are no longer required for signed zones: a signed zone might include NSEC3 records instead. [RFC7129] provides additional background commentary and some context for the NSEC and NSEC3 mechanisms used by DNSSEC to provide authenticated denial-of-existence responses. NSEC and NSEC3 are described below.

Unsigned zone: Section 2 of [RFC4033] defines this as "a zone that is not signed". Section 2 of [RFC4035] defines this as "A zone that does not include these records [properly constructed DNSKEY, Resource Record Signature (RRSIG), Next Secure (NSEC), and (optionally) DS records] according to the rules in this section". There is an important note at the end of Section 5.2 of [RFC4035] that defines an additional situation in which a zone is considered unsigned: "If the resolver does not support any of the algorithms listed in an authenticated DS RRset, then the resolver will not be able to verify the authentication path to the child zone. In this case, the resolver SHOULD treat the child zone as if it were unsigned."

NSEC: "The NSEC record allows a security-aware resolver to authenticate a negative reply for either name or type non-existence with the same mechanisms used to authenticate other DNS replies." (Quoted from [RFC4033], Section 3.2.) In short, an NSEC record provides authenticated denial of existence.

"The NSEC resource record lists two separate things: the next owner name (in the canonical ordering of the zone) that contains authoritative data or a delegation point NS RRset, and the set of RR types present at the NSEC RR's owner name." (Quoted from Section 4 of RFC 4034)

NSEC3: Like the NSEC record, the NSEC3 record also provides authenticated denial of existence; however, NSEC3 records mitigate against zone enumeration and support Opt-Out. NSEC resource records require associated NSEC3PARAM resource records. NSEC3 and NSEC3PARAM resource records are defined in [RFC5155].

Note that [RFC6840] says that [RFC5155] "is now considered part of the DNS Security Document Family as described by Section 10 of [RFC4033]". This means that some of the definitions from earlier RFCs that only talk about NSEC records should probably be considered to be talking about both NSEC and NSEC3.

Opt-out: "The Opt-Out Flag indicates whether this NSEC3 RR may cover unsigned delegations." (Quoted from [RFC5155], Section 3.1.2.1.) Opt-out tackles the high costs of securing a delegation to an insecure zone. When using Opt-Out, names that are an insecure delegation (and empty non-terminals that are only derived from insecure delegations) don't require an NSEC3 record or its corresponding RRSIG records. Opt-Out NSEC3 records are not able to prove or deny the existence of the insecure delegations. (Adapted from [RFC7129], Section 5.1)

Insecure delegation: "A signed name containing a delegation (NS RRset), but lacking a DS RRset, signifying a delegation to an unsigned subzone." (Quoted from [RFC4956], Section 2.)

Zone enumeration: "The practice of discovering the full content of a zone via successive queries." (Quoted from [RFC5155], Section 1.3.) This is also sometimes called "zone walking". Zone enumeration is different from zone content guessing where the guesser uses a large dictionary of possible labels and sends successive queries for them, or matches the contents of NSEC3 records against such a dictionary.

Validation: Validation, in the context of DNSSEC, refers to the following:

- * Checking the validity of DNSSEC signatures
- * Checking the validity of DNS responses, such as those including authenticated denial of existence
- * Building an authentication chain from a trust anchor to a DNS response or individual DNS RRsets in a response

The first two definitions above consider only the validity of individual DNSSEC components such as the RRSIG validity or NSEC proof validity. The third definition considers the components of the entire DNSSEC authentication chain, and thus requires "configured knowledge of at least one authenticated DNSKEY or DS RR" (as described in [RFC4035], Section 5).

[RFC4033], Section 2, says that a "Validating Security-Aware Stub Resolver... performs signature validation" and uses a trust anchor "as a starting point for building the authentication chain to a signed DNS response", and thus uses the first and third definitions above. The process of validating an RRSIG resource record is described in [RFC4035], Section 5.3.

[RFC5155] refers to validating responses throughout the document, in the context of hashed authenticated denial of existence; this uses the second definition above.

The term "authentication" is used interchangeably with "validation", in the sense of the third definition above. [RFC4033], Section 2, describes the chain linking trust anchor to DNS data as the "authentication chain". A response is considered to be authentic if "all RRsets in the Answer and Authority sections of the response [are considered] to be authentic" ([RFC4035]). DNS data or responses deemed to be authentic or validated have a security status of "secure" ([RFC4035], Section 4.3; [RFC4033], Section 5). "Authenticating both DNS keys and data is a matter of local policy, which may extend or even override the [DNSSEC] protocol extensions" ([RFC4033], Section 3.1).

The term "verification", when used, is usually synonym for "validation".

Validating resolver: A security-aware recursive name server, security-aware resolver, or security-aware stub resolver that is applying at least one of the definitions of validation (above), as appropriate to the resolution context. For the same reason that the generic term "resolver" is sometimes ambiguous and needs to be

evaluated in context (see Section 5), "validating resolver" is a context-sensitive term.

Key signing key (KSK): DNSSEC keys that "only sign the apex DNSKEY RRset in a zone." (Quoted from [RFC6781], Section 3.1)

Zone signing key (ZSK): "DNSSEC keys that can be used to sign all the RRsets in a zone that require signatures, other than the apex DNSKEY RRset." (Quoted from [RFC6781], Section 3.1) Note that the roles KSK and ZSK are not mutually exclusive: a single key can be both KSK and ZSK at the same time. Also note that a ZSK is sometimes used to sign the apex DNSKEY RRset.

Combined signing key (CSK): "In cases where the differentiation between the KSK and ZSK is not made, i.e., where keys have the role of both KSK and ZSK, we talk about a Single-Type Signing Scheme." (Quoted from [RFC6781], Section 3.1) This is sometimes called a "combined signing key" or CSK. It is operational practice, not protocol, that determines whether a particular key is a ZSK, a KSK, or a CSK.

Secure Entry Point (SEP): A flag in the DNSKEY RDATA that "can be used to distinguish between keys that are intended to be used as the secure entry point into the zone when building chains of trust, i.e., they are (to be) pointed to by parental DS RRs or configured as a trust anchor. Therefore, it is suggested that the SEP flag be set on keys that are used as KSKs and not on keys that are used as ZSKs, while in those cases where a distinction between a KSK and ZSK is not made (i.e., for a Single-Type Signing Scheme), it is suggested that the SEP flag be set on all keys." (Quoted from [RFC6781], Section 3.2.3.) Note that the SEP flag is only a hint, and its presence or absence may not be used to disqualify a given DNSKEY RR from use as a KSK or ZSK during validation.

The original definition of SEPs was in [RFC3757]. That definition clearly indicated that the SEP was a key, not just a bit in the key. The abstract of [RFC3757] says: "With the Delegation Signer (DS) resource record (RR), the concept of a public key acting as a secure entry point (SEP) has been introduced. During exchanges of public keys with the parent there is a need to differentiate SEP keys from other public keys in the Domain Name System KEY (DNSKEY) resource record set. A flag bit in the DNSKEY RR is defined to indicate that DNSKEY is to be used as a SEP." That definition of the SEP as a key was made obsolete by [RFC4034], and the definition from [RFC6781] is consistent with [RFC4034].

Trust anchor: "A configured DNSKEY RR or DS RR hash of a DNSKEY RR. A validating security-aware resolver uses this public key or hash as a starting point for building the authentication chain to a signed DNS response." (Quoted from [RFC4033], Section 2)

DNSSEC Policy (DP): A statement that "sets forth the security requirements and standards to be implemented for a DNSSEC-signed zone." (Quoted from [RFC6841], Section 2)

DNSSEC Practice Statement (DPS): "A practices disclosure document that may support and be a supplemental document to the DNSSEC Policy (if such exists), and it states how the management of a given zone implements procedures and controls at a high level." (Quoted from [RFC6841], Section 2)

Hardware security module (HSM): A specialized piece of hardware that is used to create keys for signatures and to sign messages. In DNSSEC, HSMs are often used to hold the private keys for KSKs and ZSKs and to create the RRSIG records at periodic intervals.

Signing software: Authoritative DNS servers that supports DNSSEC often contains software that facilitates the creation and maintenance of DNSSEC signatures in zones. There is also stand-alone software that can be used to sign a zone regardless of whether the authoritative server itself supports signing. Sometimes signing software can support particular HSMs as part of the signing process.

9. DNSSEC States

A validating resolver can determine that a response is in one of four states: secure, insecure, bogus, or indeterminate. These states are defined in [RFC4033] and [RFC4035], although the two definitions differ a bit. This document makes no effort to reconcile the two definitions, and takes no position as to whether they need to be reconciled.

Section 5 of [RFC4033] says:

A validating resolver can determine the following 4 states:

Secure: The validating resolver has a trust anchor, has a chain of trust, and is able to verify all the signatures in the response.

Insecure: The validating resolver has a trust anchor, a chain of trust, and, at some delegation point, signed proof of the non-existence of a DS record. This indicates that subsequent branches in the tree are provably insecure. A validating resolver may have a local policy to mark parts of the domain space as insecure.

Bogus: The validating resolver has a trust anchor and a secure delegation indicating that subsidiary data is signed, but the response fails to validate for some reason: missing signatures, expired signatures, signatures with unsupported algorithms, data missing that the relevant NSEC RR says should be present, and so forth.

Indeterminate: There is no trust anchor that would indicate that a specific portion of the tree is secure. This is the default operation mode.

Section 4.3 of [RFC4035] says:

A security-aware resolver must be able to distinguish between four cases:

Secure: An RRset for which the resolver is able to build a chain of signed DNSKEY and DS RRs from a trusted security anchor to the RRset. In this case, the RRset should be signed and is subject to signature validation, as described above.

Insecure: An RRset for which the resolver knows that it has no chain of signed DNSKEY and DS RRs from any trusted starting point to the RRset. This can occur when the target RRset lies in an unsigned zone or in a descendent [sic] of an unsigned zone. In this case, the RRset may or may not be signed, but the resolver will not be able to verify the signature.

Bogus: An RRset for which the resolver believes that it ought to be able to establish a chain of trust but for which it is unable to do so, either due to signatures that for some reason fail to validate or due to missing data that the relevant DNSSEC RRs indicate should be present. This case may indicate an attack but may also indicate a configuration error or some form of data corruption.

Indeterminate: An RRset for which the resolver is not able to determine whether the RRset should be signed, as the resolver is not able to obtain the necessary DNSSEC RRs. This can occur when the security-aware resolver is not able to contact security-aware name servers for the relevant zones.

10. Security Considerations

These definitions do not change any security considerations for the DNS.

11. IANA Considerations

None.

12. References

12.1. Normative References

[IANA_RootFiles]

Internet Assigned Numbers Authority, "IANA Root Files", 2016, <<http://www.iana.org/domains/root/files>>.

- [RFC0882] Mockapetris, P., "Domain names: Concepts and facilities", RFC 882, DOI 10.17487/RFC0882, November 1983, <<https://www.rfc-editor.org/info/rfc882>>.
- [RFC1034] Mockapetris, P., "Domain names - concepts and facilities", STD 13, RFC 1034, DOI 10.17487/RFC1034, November 1987, <<https://www.rfc-editor.org/info/rfc1034>>.
- [RFC1035] Mockapetris, P., "Domain names - implementation and specification", STD 13, RFC 1035, DOI 10.17487/RFC1035, November 1987, <<https://www.rfc-editor.org/info/rfc1035>>.
- [RFC1123] Braden, R., Ed., "Requirements for Internet Hosts - Application and Support", STD 3, RFC 1123, DOI 10.17487/RFC1123, October 1989, <<https://www.rfc-editor.org/info/rfc1123>>.
- [RFC1996] Vixie, P., "A Mechanism for Prompt Notification of Zone Changes (DNS NOTIFY)", RFC 1996, DOI 10.17487/RFC1996, August 1996, <<https://www.rfc-editor.org/info/rfc1996>>.
- [RFC2136] Vixie, P., Ed., Thomson, S., Rekhter, Y., and J. Bound, "Dynamic Updates in the Domain Name System (DNS UPDATE)", RFC 2136, DOI 10.17487/RFC2136, April 1997, <<https://www.rfc-editor.org/info/rfc2136>>.
- [RFC2181] Elz, R. and R. Bush, "Clarifications to the DNS Specification", RFC 2181, DOI 10.17487/RFC2181, July 1997, <<https://www.rfc-editor.org/info/rfc2181>>.
- [RFC2182] Elz, R., Bush, R., Bradner, S., and M. Patton, "Selection and Operation of Secondary DNS Servers", BCP 16, RFC 2182, DOI 10.17487/RFC2182, July 1997, <<https://www.rfc-editor.org/info/rfc2182>>.
- [RFC2308] Andrews, M., "Negative Caching of DNS Queries (DNS NCACHE)", RFC 2308, DOI 10.17487/RFC2308, March 1998, <<https://www.rfc-editor.org/info/rfc2308>>.
- [RFC4033] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "DNS Security Introduction and Requirements", RFC 4033, DOI 10.17487/RFC4033, March 2005, <<https://www.rfc-editor.org/info/rfc4033>>.
- [RFC4034] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "Resource Records for the DNS Security Extensions", RFC 4034, DOI 10.17487/RFC4034, March 2005, <<https://www.rfc-editor.org/info/rfc4034>>.

- [RFC4035] Arends, R., Austein, R., Larson, M., Massey, D., and S. Rose, "Protocol Modifications for the DNS Security Extensions", RFC 4035, DOI 10.17487/RFC4035, March 2005, <<https://www.rfc-editor.org/info/rfc4035>>.
- [RFC4592] Lewis, E., "The Role of Wildcards in the Domain Name System", RFC 4592, DOI 10.17487/RFC4592, July 2006, <<https://www.rfc-editor.org/info/rfc4592>>.
- [RFC5155] Laurie, B., Sisson, G., Arends, R., and D. Blacka, "DNS Security (DNSSEC) Hashed Authenticated Denial of Existence", RFC 5155, DOI 10.17487/RFC5155, March 2008, <<https://www.rfc-editor.org/info/rfc5155>>.
- [RFC5358] Damas, J. and F. Neves, "Preventing Use of Recursive Nameservers in Reflector Attacks", BCP 140, RFC 5358, DOI 10.17487/RFC5358, October 2008, <<https://www.rfc-editor.org/info/rfc5358>>.
- [RFC5730] Hollenbeck, S., "Extensible Provisioning Protocol (EPP)", STD 69, RFC 5730, DOI 10.17487/RFC5730, August 2009, <<https://www.rfc-editor.org/info/rfc5730>>.
- [RFC5855] Abley, J. and T. Manderson, "Nameservers for IPv4 and IPv6 Reverse Zones", BCP 155, RFC 5855, DOI 10.17487/RFC5855, May 2010, <<https://www.rfc-editor.org/info/rfc5855>>.
- [RFC5936] Lewis, E. and A. Hoenes, Ed., "DNS Zone Transfer Protocol (AXFR)", RFC 5936, DOI 10.17487/RFC5936, June 2010, <<https://www.rfc-editor.org/info/rfc5936>>.
- [RFC6561] Livingood, J., Mody, N., and M. O'Reirdan, "Recommendations for the Remediation of Bots in ISP Networks", RFC 6561, DOI 10.17487/RFC6561, March 2012, <<https://www.rfc-editor.org/info/rfc6561>>.
- [RFC6781] Kolkman, O., Mekking, W., and R. Gieben, "DNSSEC Operational Practices, Version 2", RFC 6781, DOI 10.17487/RFC6781, December 2012, <<https://www.rfc-editor.org/info/rfc6781>>.
- [RFC6840] Weiler, S., Ed. and D. Blacka, Ed., "Clarifications and Implementation Notes for DNS Security (DNSSEC)", RFC 6840, DOI 10.17487/RFC6840, February 2013, <<https://www.rfc-editor.org/info/rfc6840>>.

- [RFC6841] Ljunggren, F., Eklund Lowinder, AM., and T. Okubo, "A Framework for DNSSEC Policies and DNSSEC Practice Statements", RFC 6841, DOI 10.17487/RFC6841, January 2013, <<https://www.rfc-editor.org/info/rfc6841>>.
- [RFC6891] Damas, J., Graff, M., and P. Vixie, "Extension Mechanisms for DNS (EDNS(0))", STD 75, RFC 6891, DOI 10.17487/RFC6891, April 2013, <<https://www.rfc-editor.org/info/rfc6891>>.
- [RFC7344] Kumari, W., Gudmundsson, O., and G. Barwood, "Automating DNSSEC Delegation Trust Maintenance", RFC 7344, DOI 10.17487/RFC7344, September 2014, <<https://www.rfc-editor.org/info/rfc7344>>.
- [RFC7719] Hoffman, P., Sullivan, A., and K. Fujiwara, "DNS Terminology", RFC 7719, DOI 10.17487/RFC7719, December 2015, <<https://www.rfc-editor.org/info/rfc7719>>.

12.2. Informative References

- [IANA_Resource_Registry] Internet Assigned Numbers Authority, "Resource Record (RR) TYPES", 2017, <<http://www.iana.org/assignments/dns-parameters/>>.
- [RFC0819] Su, Z. and J. Postel, "The Domain Naming Convention for Internet User Applications", RFC 819, DOI 10.17487/RFC0819, August 1982, <<https://www.rfc-editor.org/info/rfc819>>.
- [RFC0952] Harrenstien, K., Stahl, M., and E. Feinler, "DoD Internet host table specification", RFC 952, DOI 10.17487/RFC0952, October 1985, <<https://www.rfc-editor.org/info/rfc952>>.
- [RFC1995] Ohta, M., "Incremental Zone Transfer in DNS", RFC 1995, DOI 10.17487/RFC1995, August 1996, <<https://www.rfc-editor.org/info/rfc1995>>.
- [RFC2133] Gilligan, R., Thomson, S., Bound, J., and W. Stevens, "Basic Socket Interface Extensions for IPv6", RFC 2133, DOI 10.17487/RFC2133, April 1997, <<https://www.rfc-editor.org/info/rfc2133>>.
- [RFC2775] Carpenter, B., "Internet Transparency", RFC 2775, DOI 10.17487/RFC2775, February 2000, <<https://www.rfc-editor.org/info/rfc2775>>.

- [RFC3172] Huston, G., Ed., "Management Guidelines & Operational Requirements for the Address and Routing Parameter Area Domain ("arpa")", BCP 52, RFC 3172, DOI 10.17487/RFC3172, September 2001, <<https://www.rfc-editor.org/info/rfc3172>>.
- [RFC3425] Lawrence, D., "Obsoleting IQUERY", RFC 3425, DOI 10.17487/RFC3425, November 2002, <<https://www.rfc-editor.org/info/rfc3425>>.
- [RFC3757] Kolkman, O., Schlyter, J., and E. Lewis, "Domain Name System KEY (DNSKEY) Resource Record (RR) Secure Entry Point (SEP) Flag", RFC 3757, DOI 10.17487/RFC3757, April 2004, <<https://www.rfc-editor.org/info/rfc3757>>.
- [RFC3912] Daigle, L., "WHOIS Protocol Specification", RFC 3912, DOI 10.17487/RFC3912, September 2004, <<https://www.rfc-editor.org/info/rfc3912>>.
- [RFC4641] Kolkman, O. and R. Gieben, "DNSSEC Operational Practices", RFC 4641, DOI 10.17487/RFC4641, September 2006, <<https://www.rfc-editor.org/info/rfc4641>>.
- [RFC4697] Larson, M. and P. Barber, "Observed DNS Resolution Misbehavior", BCP 123, RFC 4697, DOI 10.17487/RFC4697, October 2006, <<https://www.rfc-editor.org/info/rfc4697>>.
- [RFC4786] Abley, J. and K. Lindqvist, "Operation of Anycast Services", BCP 126, RFC 4786, DOI 10.17487/RFC4786, December 2006, <<https://www.rfc-editor.org/info/rfc4786>>.
- [RFC4956] Arends, R., Kosters, M., and D. Blacka, "DNS Security (DNSSEC) Opt-In", RFC 4956, DOI 10.17487/RFC4956, July 2007, <<https://www.rfc-editor.org/info/rfc4956>>.
- [RFC5625] Bellis, R., "DNS Proxy Implementation Guidelines", BCP 152, RFC 5625, DOI 10.17487/RFC5625, August 2009, <<https://www.rfc-editor.org/info/rfc5625>>.
- [RFC5890] Klensin, J., "Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework", RFC 5890, DOI 10.17487/RFC5890, August 2010, <<https://www.rfc-editor.org/info/rfc5890>>.
- [RFC5891] Klensin, J., "Internationalized Domain Names in Applications (IDNA): Protocol", RFC 5891, DOI 10.17487/RFC5891, August 2010, <<https://www.rfc-editor.org/info/rfc5891>>.

- [RFC5892] Faltstrom, P., Ed., "The Unicode Code Points and Internationalized Domain Names for Applications (IDNA)", RFC 5892, DOI 10.17487/RFC5892, August 2010, <<https://www.rfc-editor.org/info/rfc5892>>.
- [RFC5893] Alvestrand, H., Ed. and C. Karp, "Right-to-Left Scripts for Internationalized Domain Names for Applications (IDNA)", RFC 5893, DOI 10.17487/RFC5893, August 2010, <<https://www.rfc-editor.org/info/rfc5893>>.
- [RFC5894] Klensin, J., "Internationalized Domain Names for Applications (IDNA): Background, Explanation, and Rationale", RFC 5894, DOI 10.17487/RFC5894, August 2010, <<https://www.rfc-editor.org/info/rfc5894>>.
- [RFC6055] Thaler, D., Klensin, J., and S. Cheshire, "IAB Thoughts on Encodings for Internationalized Domain Names", RFC 6055, DOI 10.17487/RFC6055, February 2011, <<https://www.rfc-editor.org/info/rfc6055>>.
- [RFC6265] Barth, A., "HTTP State Management Mechanism", RFC 6265, DOI 10.17487/RFC6265, April 2011, <<https://www.rfc-editor.org/info/rfc6265>>.
- [RFC6303] Andrews, M., "Locally Served DNS Zones", BCP 163, RFC 6303, DOI 10.17487/RFC6303, July 2011, <<https://www.rfc-editor.org/info/rfc6303>>.
- [RFC6335] Cotton, M., Eggert, L., Touch, J., Westerlund, M., and S. Cheshire, "Internet Assigned Numbers Authority (IANA) Procedures for the Management of the Service Name and Transport Protocol Port Number Registry", BCP 165, RFC 6335, DOI 10.17487/RFC6335, August 2011, <<https://www.rfc-editor.org/info/rfc6335>>.
- [RFC6365] Hoffman, P. and J. Klensin, "Terminology Used in Internationalization in the IETF", BCP 166, RFC 6365, DOI 10.17487/RFC6365, September 2011, <<https://www.rfc-editor.org/info/rfc6365>>.
- [RFC7129] Gieben, R. and W. Mekking, "Authenticated Denial of Existence in the DNS", RFC 7129, DOI 10.17487/RFC7129, February 2014, <<https://www.rfc-editor.org/info/rfc7129>>.
- [RFC7480] Newton, A., Ellacott, B., and N. Kong, "HTTP Usage in the Registration Data Access Protocol (RDAP)", RFC 7480, DOI 10.17487/RFC7480, March 2015, <<https://www.rfc-editor.org/info/rfc7480>>.

- [RFC7481] Hollenbeck, S. and N. Kong, "Security Services for the Registration Data Access Protocol (RDAP)", RFC 7481, DOI 10.17487/RFC7481, March 2015, <<https://www.rfc-editor.org/info/rfc7481>>.
- [RFC7482] Newton, A. and S. Hollenbeck, "Registration Data Access Protocol (RDAP) Query Format", RFC 7482, DOI 10.17487/RFC7482, March 2015, <<https://www.rfc-editor.org/info/rfc7482>>.
- [RFC7483] Newton, A. and S. Hollenbeck, "JSON Responses for the Registration Data Access Protocol (RDAP)", RFC 7483, DOI 10.17487/RFC7483, March 2015, <<https://www.rfc-editor.org/info/rfc7483>>.
- [RFC7484] Blanchet, M., "Finding the Authoritative Registration Data (RDAP) Service", RFC 7484, DOI 10.17487/RFC7484, March 2015, <<https://www.rfc-editor.org/info/rfc7484>>.
- [RFC7485] Zhou, L., Kong, N., Shen, S., Sheng, S., and A. Servin, "Inventory and Analysis of WHOIS Registration Objects", RFC 7485, DOI 10.17487/RFC7485, March 2015, <<https://www.rfc-editor.org/info/rfc7485>>.
- [RFC8109] Koch, P., Larson, M., and P. Hoffman, "Initializing a DNS Resolver with Priming Queries", BCP 209, RFC 8109, DOI 10.17487/RFC8109, March 2017, <<https://www.rfc-editor.org/info/rfc8109>>.
- [RSSAC026] Root Server System Advisory Committee (RSSAC), "RSSAC Lexicon", 2017, <<https://www.icann.org/en/system/files/files/rssac-026-14mar17-en.pdf>>.

Appendix A. Definitions Updated by this Document

The following definitions from RFCs are updated by this document:

- o Forwarder in [RFC2308]
- o Secure Entry Point (SEP) in [RFC3757]; note, however, that this RFC is already obsolete

Appendix B. Definitions First Defined in this Document

The following definitions are first defined in this document:

- o "Alias" in Section 2
- o "Apex" in Section 6
- o "arpa" in Section 6
- o "Class independent" in Section 4
- o "Delegation-centric zone" in Section 6
- o "Delegation" in Section 6
- o "DNS operator" in Section 7
- o "DNSSEC-aware" in Section 8
- o "DNSSEC-unaware" in Section 8
- o "Forwarding" in Section 5
- o "Full resolver" in Section 5
- o "Fully qualified domain name" in Section 2
- o "Global DNS" in Section 2
- o "Hardware Security Module (HSM)" in Section 8
- o "Host name" in Section 2
- o "IDN" in Section 2
- o "In-bailiwick" in Section 6
- o "Label" in Section 2
- o "Locally served DNS zone" in Section 2
- o "Naming system" in Section 2
- o "Negative response" in Section 3
- o "Open resolver" in Section 5

- o "Out-of-bailiwick" in Section 6
- o "Passive DNS" in Section 5
- o "Policy-implementing resolver" in Section 5
- o "Presentation format" in Section 4
- o "Priming" in Section 5
- o "Private DNS" in Section 2
- o "Recursive resolver" in Section 5
- o "Referrals" in Section 3
- o "Registrant" in Section 7
- o "Registrar" in Section 7
- o "Registry" in Section 7
- o "Root zone" in Section 6
- o "Secure Entry Point (SEP)" in Section 8
- o "Signing software" in Section 8
- o "Stub resolver" in Section 5
- o "TLD" in Section 2
- o "Validating resolver" in Section 8
- o "Validation" in Section 8
- o "View" in Section 5
- o "Zone transfer" in Section 5

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