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RFC 9471
DNS Glue Requirements in Referral Responses

Abstract

The DNS uses glue records to allow iterative clients to find the addresses of name servers that are contained within a delegated zone. Authoritative servers are expected to return all available glue records for in-domain name servers in a referral response. If message size constraints prevent the inclusion of all glue records for in-domain name servers, the server must set the TC (Truncated) flag to inform the client that the response is incomplete and that the client should use another transport to retrieve the full response. This document updates RFC 1034 to clarify correct server behavior.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at https://www.rfc-editor.org/info/rfc9471.

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1. Introduction

The Domain Name System (DNS) [RFC1034] [RFC1035] uses glue records to allow iterative clients to find the addresses of name servers that are contained within a delegated zone. Glue records are added to the parent zone as part of the delegation process and returned in referral responses; otherwise, a resolver following the referral has no way of finding these addresses. Authoritative servers are expected to return all available glue records for in-domain name

servers in a referral response. If message size constraints prevent the inclusion of all glue records for in-domain name servers over the chosen transport, the server **MUST** set the TC (Truncated) flag to inform the client that the response is incomplete and that the client **SHOULD** use another transport to retrieve the full response. This document clarifies that expectation.

DNS responses sometimes contain optional data in the additional section. In-domain glue records, however, are not optional. Several other protocol extensions, when used, are also not optional. This includes TSIG [RFC8945], OPT [RFC6891], and SIG(0) [RFC2931].

At the time of this writing, addresses (A or AAAA records) for a delegation's authoritative name servers are the only type of glue defined for the DNS.

Note that this document only clarifies requirements for name server software implementations. It does not introduce or change any requirements regarding data placed in DNS zones or registries. In other words, this document only makes requirements regarding "available glue records" (i.e., those given in a zone) but does not make requirements regarding their presence in a zone. If some glue records are absent from a given zone, an authoritative name server may be unable to return a useful referral response for the corresponding domain. The IETF may want to consider a separate update to the requirements for including glue in zone data, beyond those given in [RFC1034] and [RFC1035].

This document assumes a reasonable level of familiarity with DNS operations and protocol terms. Much of the terminology is explained in further detail in "DNS Terminology" [RFC8499].

1.1. Requirements Language

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**NOT RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. Types of Glue in Referral Responses

This section describes different types of glue that may be found in DNS referral responses. Note that the type of glue depends on the QNAME. A particular name server (and its corresponding glue record) can be in-domain for one response and in a sibling domain for another.

2.1. Glue for In-Domain Name Servers

The following is a simple example of glue records present in the delegating zone "test" for the child zone "foo.test". The name servers for foo.test (ns1.foo.test and ns2.foo.test) are both below the delegation point. They are configured as glue records in the "test" zone:

```
    foo.test.                   86400   IN NS     ns1.foo.test.
    foo.test.                   86400   IN NS     ns2.foo.test.
    ns1.foo.test.               86400   IN A      192.0.2.1
    ns2.foo.test.               86400   IN AAAA   2001:db8::2:2
```

A referral response from "test" for "foo.test" with glue for in-domain name servers looks like this:

```
    ;; QUESTION SECTION:
    ;www.foo.test.        IN      A

    ;; AUTHORITY SECTION:
    foo.test.              86400        IN      NS     ns1.foo.test.
    foo.test.              86400        IN      NS     ns2.foo.test.

    ;; ADDITIONAL SECTION:
    ns1.foo.test.          86400        IN      A      192.0.2.1
    ns2.foo.test.          86400        IN      AAAA   2001:db8::2:2
```

2.2. Glue for Sibling Domain Name Servers

Sibling domain name servers are NS records that are not contained in the delegated zone itself but rather are contained in another zone delegated from the same parent. In many cases, glue for sibling domain name servers is not strictly required for resolution, since the resolver can make follow-on queries to the sibling zone to resolve the name server addresses (after following the referral to the sibling zone). However, most name server implementations today provide them as an optimization to obviate the need for extra traffic from iterative resolvers.

Here, the delegating zone "test" contains two delegations for the child zones "bar.test" and "foo.test":

```
    bar.test.                  86400   IN NS    ns1.bar.test.
    bar.test.                  86400   IN NS    ns2.bar.test.
    ns1.bar.test.              86400   IN A     192.0.2.1
    ns2.bar.test.              86400   IN AAAA  2001:db8::2:2

    foo.test.                  86400   IN NS    ns1.bar.test.
    foo.test.                  86400   IN NS    ns2.bar.test.
```

A referral response from "test" for "foo.test" with glue for sibling domain name servers looks like this:

```
    ;; QUESTION SECTION:
    ;www.foo.test.        IN      A

    ;; AUTHORITY SECTION:
    foo.test.              86400        IN      NS     ns1.bar.test.
    foo.test.              86400        IN      NS     ns2.bar.test.

    ;; ADDITIONAL SECTION:
    ns1.bar.test.          86400        IN      A      192.0.2.1
    ns2.bar.test.          86400        IN      AAAA   2001:db8::2:2
```

2.3. Glue for Cyclic Sibling Domain Name Servers

The use of sibling domain name servers can introduce cyclic dependencies. This happens when one domain specifies name servers from a sibling domain, and vice versa. This type of cyclic dependency can only be broken when the delegating name server includes glue for the sibling domain in a referral response.

Here, the delegating zone "test" contains two delegations for the child zones "bar.test" and "foo.test", and each uses name servers under the other:

```
    bar.test.                 86400    IN NS     ns1.foo.test.
    bar.test.                 86400    IN NS     ns2.foo.test.
    ns1.bar.test.             86400    IN A      192.0.2.1
    ns2.bar.test.             86400    IN AAAA   2001:db8::2:2

    foo.test.                 86400    IN NS     ns1.bar.test.
    foo.test.                 86400    IN NS     ns2.bar.test.
    ns1.foo.test.             86400    IN A      192.0.2.3
    ns2.foo.test.             86400    IN AAAA   2001:db8::2:4
```

A referral response from "test" for "bar.test" with glue for sibling domain name servers looks like this:

```
    ;; QUESTION SECTION:
    ;www.bar.test.        IN      A

    ;; AUTHORITY SECTION:
    bar.test.             86400        IN      NS      ns1.foo.test.
    bar.test.             86400        IN      NS      ns2.foo.test.

    ;; ADDITIONAL SECTION:
    ns1.foo.test.         86400        IN      A       192.0.2.3
    ns2.foo.test.         86400        IN      AAAA    2001:db8::2:4
```

In late 2021, the authors analyzed zone file data available from ICANN's Centralized Zone Data Service [CZDS] and found 222 out of approximately 209,000,000 total delegations that had only sibling domain NS Resource Records (RRs) in a cyclic dependency as above.

2.4. Missing Glue

An example of missing glue is included here, even though it cannot be considered as a type of glue. While not common, real examples of responses that lack required glue, and with TC=0, have been shown to occur and cause resolution failures.

The example below, from the dig command [DIG], is based on a response observed in June 2020. The names have been altered to fall under documentation domains. It shows a case where none of the glue records present in the zone fit into the available space of the UDP response, and the TC flag was not set. While this example shows a referral with DNSSEC records [RFC4033]

[RFC4034] [RFC4035], this behavior has been seen with plain DNS responses as well. Some records have been truncated for display purposes. Note that at the time of this writing, the servers originally responsible for this example have been updated and now correctly set the TC flag.

```
    % dig +norec +dnssec +bufsize=512 +ignore @ns.example.net \
          rh202ns2.355.foo.example

    ; <<>> DiG 9.15.4 <<>> +norec +dnssec +bufsize +ignore \
          @ns.example.net rh202ns2.355.foo.example
    ; (2 servers found)
    ;; global options: +cmd
    ;; Got answer:
    ;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 8798
    ;; flags: qr; QUERY: 1, ANSWER: 0, AUTHORITY: 9, ADDITIONAL: 1

    ;; OPT PSEUDOSECTION:
    ; EDNS: version: 0, flags: do; udp: 4096
    ;; QUESTION SECTION:
    ;rh202ns2.355.foo.example.          IN A

    ;; AUTHORITY SECTION:
    foo.example.            86400   IN NS      rh120ns2.368.foo.example.
    foo.example.            86400   IN NS      rh202ns2.355.foo.example.
    foo.example.            86400   IN NS      rh120ns1.368.foo.example.
    foo.example.            86400   IN NS      rh202ns1.355.foo.example.
    foo.example.            3600    IN DS      51937 8 1 ...
    foo.example.            3600    IN DS      635 8 2 ...
    foo.example.            3600    IN DS      51937 8 2 ...
    foo.example.            3600    IN DS      635 8 1 ...
    foo.example.            3600    IN RRSIG   DS 8 2 3600 ...
```

3. Requirements

This section describes updated requirements for including glue in DNS referral responses.

3.1. Glue for In-Domain Name Servers

This document clarifies that when a name server generates a referral response, it **MUST** include all available glue records for in-domain name servers in the additional section or **MUST** set TC=1 if constrained by message size.

At the time of this writing, most iterative clients send initial queries over UDP and retry over TCP upon receiving a response with the TC flag set. UDP responses are generally limited to between 1232 and 4096 bytes, due to values commonly used for the EDNS0 UDP Message Size field [RFC6891] [FLAGDAY2020]. TCP responses are limited to 65,535 bytes.

3.2. Glue for Sibling Domain Name Servers

This document clarifies that when a name server generates a referral response, it **SHOULD** include all available glue records in the additional section. If, after adding glue for all in-domain name servers, the glue for all sibling domain name servers does not fit due to message size constraints, the name server **MAY** set TC=1 but is not obligated to do so.

Note that users may experience resolution failures for domains with cyclically dependent sibling name servers when the delegating name server chooses to omit the corresponding glue in a referral response. As described in Section 2.3, such domains are rare.

3.3. Update to RFC 1034

OLD:

> Copy the NS RRs for the subzone into the authority section of the reply. Put whatever addresses are available into the additional section, using glue RRs if the addresses are not available from authoritative data or the cache. Go to step 4.

NEW:

> Copy the NS RRs for the subzone into the authority section of the reply. Put whatever NS addresses are available into the additional section, using glue RRs if the addresses are not available from authoritative data or the cache. If all glue RRs for in-domain name servers do not fit, set TC=1 in the header. Go to step 4.

4. Security Considerations

This document clarifies correct DNS server behavior and does not introduce any changes or new security considerations.

5. Operational Considerations

At the time of this writing, the behavior of most DNS server implementations is to set the TC flag only if none of the available glue records fit in a response over UDP transport. The updated requirements in this document might lead to an increase in the fraction of UDP responses with the TC flag set and, consequently, an increase in the number of queries received over TCP transport.

6. IANA Considerations

This document has no IANA actions.

7. References

7.1. Normative References

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7.2. Informative References

[CZDS]   ICANN, "Centralized Zone Data Service", <https://czds.icann.org/>.

[DIG]   Wikipedia, "dig (command)", September 2023, <https://en.wikipedia.org/wiki/Dig_(command)>.

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[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>.

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[RFC8945]   Dupont, F., Morris, S., Vixie, P., Eastlake 3rd, D., Gudmundsson, O., and B. Wellington, "Secret Key Transaction Authentication for DNS (TSIG)", STD 93, RFC 8945, DOI 10.17487/RFC8945, November 2020, <https://www.rfc-editor.org/info/rfc8945>.

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