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DNS wire-format over HTTP
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Abstract

This memo introduces a way to tunnel DNS data over HTTP. This may be useful in any situation where DNS is not working properly, such as when there is middlebox misbehavior.

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Table of Contents

1.	Introduction	2
2.	Methodology and Configuration	3
3.	DNS-over-HTTP Message Format	4
3.1.	Start-line	5
3.2.	Header Fields	6
3.3.	Message Body	6
4.	Security Considerations	7
5.	IANA considerations	8
6.	Acknowledgments	8
7.	References	8
	Authors' Addresses	9

[1.](#) Introduction

[RFC 1035](#) [[RFC1035](#)] specifies the wire format for DNS messages. It also specifies DNS transport on UDP and TCP on port 53, which is still used today. However, there are other ways to access DNS database, for example in a different data format or via alternative DNS transport. These approaches are summarized in [[draft-shane-review-DNS-over-http](#)].

One of alternative way of DNS described in that document is to transport DNS binary data inside HTTP, with the goal of improving DNS service availability. The DNS traffic is simply sent as web traffic using port 80/443 over HTTP. It can bypass badly behaving middle boxes like firewalls, proxies or traffic shaping devices on path which might interfere with normal DNS traffic [[RFC5625](#)] [[DOTSE](#)] [[SAC035](#)].

This approach has the advantage that HTTP usually makes it through even the worst coffee shop or hotel room firewalls, as Internet users expect web browsing to always work. It also benefits from HTTP's support for persistent TCP connections (see [section 6.3 in \[RFC7230\]](#)). Note that 5966bis [[I-D.ietf-dnsop-5966bis](#)] specifies the persistent feature for DNS on TCP port 53, but current DNS software does not generally support this mode of operation. Finally, HTTPS provides data integrity and privacy.

One alternative idea is to simply use a VPN, rather than a custom protocol for this purpose. While this is possible, the DNS over HTTP wire format protocol presented here works on an actual HTTP server, so it can be hosted on a machine that also serves web pages. This

means that DNS over HTTP is slightly more "stealthy" than a VPN, in that it can be indistinguishable from normal web traffic.

Unlike a REST DNS API using JSON [[I-D.bortzmeyer-dns-json](#)] or XML [[I-D.mohan-dns-query-xml](#)] encoding for DNS data, in this approach wire-format data is wrapped with a HTTP header and transmitted on port 80 or 443. The protocol is intended to serve as a sort of DNS VPN, and does not introduce another format of DNS data. It is also possible as a new DNS APIs for advanced usage in application development. For example, web developers can create arbitrary HTTP/HTTPS queries and get DNS responses in their JavaScript apps.

This memo aims to describe how the DNS binary over HTTP concept works. Hopefully implementations by different developers following this memo can speak with each other.

This mechanism is designed for client stub resolver to recursive server. DNS zone transfer, DNS updates, and anything other than simple DNS queries are out-of-scope for this document.

2. Methodology and Configuration

As mentioned in introduction, the basic methodology is wrapping the DNS wire-format data into an HTTP header and transmitting on port 80 or 443. However, there are two different scenarios for implementation.

Scenario 1:

The DNS server implementation handles DNS queries and responses via both UDP and TCP on port 53, and HTTP on port 80 or 443. It works as follows:

1. The client creates a DNS query message.
2. The client encapsulates the DNS message in a HTTP message body and assigns parameters with the HTTP header.
3. The client connects to the server and issues an HTTP POST request method. This may re-use an existing HTTP connection.
4. The server decapsulates the HTTP packet to get the DNS query, and resolves the DNS query.
5. The server encapsulates the DNS response in HTTP and sends it back via the HTTP session.

Scenario 2:

In this scenario there is a DNS-HTTP proxy sitting between stub-resolver and the recursive server. The stub uses a client proxy and the recursive server uses a server proxy. This works like a DNS VPN and transmits wire-format DNS messages over HTTP between the proxy client and a server, as follows:

1. The stub-resolver sends a DNS query (over UDP or TCP) to the proxy client.
2. The proxy client encapsulates the DNS message in an HTTP message body and assigns parameters with the HTTP header.
3. The proxy client connects to the proxy server and issues an HTTP POST request method. This may re-use an existing HTTP connection.
4. The proxy server decapsulates the HTTP packet to get the DNS query, and sends it to a real DNS server over UDP/TCP.
5. The proxy server encapsulates the DNS response in HTTP and sends it back via the HTTP session.
6. The proxy client decapsulates the DNS message from the HTTP response and sends it back to the stub-resolver via previous DNS session (either UDP or TCP).

It is possible that these scenarios are mixed. The server may speak DNS over HTTP directly and the client use a proxy, or the other way around.

Note that the proxy client can be implemented listening to a loop-back address in the same host with stub-resolver. The proxy server can be implemented as a caching server as well. It is also possible to use the proxy server as a regular web server at the same time that is acting as a proxy server.

3. DNS-over-HTTP Message Format

Although this document simply proposes that HTTP be used for DNS message exchange, it is informative to explore the context with HTTP-specific semantics, such as the HTTP request method, specific request-target, HTTP-version, and HTTP header field, all of which have impact on interoperability as well as performance.

In HTTP 1.1 specification [section 3 in RFC 7230](#) [RFC7230], an HTTP message consists of three parts: start-line, header fields, and message body with an empty line between header fields and message body. The DNS over HTTP message also contains these parts.

3.1. Start-line

By definition the HTTP start-line is either a request-line (for requests) or a status-line (for responses). A request-line consists of the request method, request-target, and HTTP-version with a CRLF in the end.

For a DNS query over HTTP, the request is always POST [[section 4.3.3 in RFC 7230](#) [[RFC7230](#)]]. If a GET is sent to the server, it optionally returns a human-readable page showing its web server environment.

- Note that choosing POST (not GET) as the request method for DNS wire-format over HTTP is mainly based on two reasons. One is that the protocol is designed using HTTP as a tunnel-like technology carrying data from one side to another, not a web service with RESTful framework. Another is that from the view of implementation some servers may ignore undefined entity-body if using GET; and HTTP libs vary on supporting GET with payload.

Usually the target URI is provided explicitly by the services provider. Derived from the target URI, the request-target in request-line identifies the target resource upon which to apply the request. To avoid URI conflicts and enhance interoperability, a well-known URI is necessary to allow interoperability. As defined in [RFC 5785](#) [[RFC5785](#)], it begins with the characters `"/.well-known/"` and the name `"dns-wireformat"`. So the request-target for DNS wire-format over HTTP SHOULD be `'/.well-known/dns-wireformat'`.

DNS transaction over HTTP has no specific requirement for transport protocol; developers can use any version of HTTP to accomplish the transaction. But developers should be aware that HTTP/1.1 [RFC 7230](#) [[RFC7230](#)] and HTTP/2 [RFC 7540](#) [[RFC7540](#)] do have differences in performance regarding multiplexing. HTTP/2 is fully multiplexed, instead of ordered and blocking. Because there is a general desire to achieve similar performance with DNS over UDP, the modern HTTP/2 is preferred for DNS over HTTP implementation. Note that there should be no problem for advanced HTTP protocol in the future deployed for DNS over HTTP.

As an example, given HTTP-version is "HTTP/1.1", the request-line is:

```
POST /.well-known/dns-wireformat HTTP/1.1
```

The status-line returns the status-code [[Section 6 of RFC 7231](#) [[RFC7231](#)]], which only reflects status of HTTP connection. If the request has succeeded, the status-line is:

HTTP/1.1 200 OK

If the request fails, the proxy server will supply an appropriate error code, typically 4xx (client error) if the client has provided a query that the server cannot understand for some reasons, or 5xx (server error) if some server-side problem prevented a query from succeeding.

3.2. Header Fields

By definition header fields are key:value pairs that can be used to communicate data about the message, its payload, the target resource, or the connection (for example control data).

The Content-Type: header should be set to "application/dns-wireformat".

We add one a new header field:

Proxy-DNS-Transport: xyz

Where xyz is either UDP or TCP, which is the client's indication of how it received the underlying DNS query, and which the server will use when sending the query to the far-end DNS server. This means if a stub DNS client asks for TCP, then that's what the far-end DNS server will see, and likewise for UDP. This header field is used for both request and response, for all DNS over HTTP message.

Exposing the transport protocol of the query allows the HTTP server proxy to send DNS queries to the recursive resolver that look like those that the DNS client is sending to the client proxy. If the stub resolver sent a UDP packet, then this allows the recursive resolver to implement the logic of truncating the packet properly, instead of requiring that the HTTP client proxy somehow manage that functionality.

For a stub resolver that connect directly via HTTP to the HTTP server proxy then this flag should be set to TCP, as the entire response can always be delivered so truncation is never required.

The client MUST include this option. If it is missing then it is an error and the server should respond with HTTP code 400 (bad request).

3.3. Message Body

As mentioned, the message body is DNS wire-format data. It is worth mentioning that DNS messages sent over TCP connections is prefixed with a two-byte length field which gives the message length[section

4.2.2 in [RFC 1035](#) [[RFC1035](#)]], excluding the two-byte length field. This length field allows the low-level processing to assemble a complete message before beginning to parse it. In the context of HTTP, there is content-length header field [[section 3.3.2 in RFC 7230](#) [[RFC7230](#)]] in which the field-value is the same with two bytes length field in DNS over TCP.

Since this two-byte length field is redundant, when the client proxy receives a DNS message over TCP, it MUST NOT include the length field in the message sent to the server. The length in the content-length header is only the size of the DNS message itself, and MUST NOT include this two-byte length header.

4. Security Considerations

This protocol does not introduce any new security considerations since it is built on the DNS and HTTP protocols.

Since this protocol transmits DNS messages, all of the security concerns that stub resolvers and recursive resolvers have with DNS messages apply. However, since HTTP uses TCP as the underlying protocol, DNS reflection or amplification attacks are not possible.

Since HTTP is used, all of the security concerns of HTTP are also present.

Servers and clients SHOULD use TLS for communication. It provides privacy and integrity for HTTP sessions. If TLS is used, then all of the security concerns of TLS are also present.

As specified in [RFC 5246](#) [[RFC5246](#)], both the HTTP server and client can be authenticated or not authenticated. Clients SHOULD authenticate the certificate of the HTTP server they connect to. The DNS service providers can decide whether to authenticate the client side based on their own requirement for security and privacy. For example, clients of an open resolver do not require authentication.

Note that the ability to perform DNS queries in this way may allow users to bypass local DNS policy. This is problematic in any environment where administrators need to enforce specific DNS behavior, such as an enterprise environment. The protocol outlined here does not introduce any new capabilities in this area, but by creating a more standardized way of doing this it may cause operational problems for enterprise administrators.

5. IANA considerations

Registration for a new Media Type: dns-wireformat

Registration for a new HTTP header field: Proxy-DNS-Transport

Registration for a new Well-Known URI: "dns-wireformat"

6. Acknowledgments

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