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S.F. Friedl
Cisco Systems, Inc.
A. Popov
Microsoft Corp.
A. Langley
Google Inc.
E. Stephan
France Telecom - Orange

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Transport Layer Security (TLS) Application Layer Protocol Negotiation Extension
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Abstract

This document describes a Transport Layer Security (TLS) extension for application layer protocol negotiation within the TLS handshake. For instances in which the TLS connection is established over a well known TCP/IP port not associated with the desired application layer protocol, this extension allows the application layer to negotiate which protocol will be used within the TLS session.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on October 27, 2013.

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1. Introduction

Increasingly, application layer protocols are encapsulated in the TLS security protocol [RFC5246]. This encapsulation enables applications to use the existing, secure communications links already present on port 443 across virtually the entire global IP infrastructure.

When multiple application protocols are supported on a single server-side port number, such as port 443, the client and the server need to negotiate an application protocol for use with each connection. It is desirable to accomplish this negotiation without adding network round-trips between the client and the server, as each round-trip will degrade an end-user's experience. Further, it would be advantageous to allow certificate selection based on the negotiated application protocol.

This document specifies a TLS extension which permits the application layer to negotiate protocol selection within the TLS handshake. This work was requested by the HTTPbis WG to address the negotiation of

HTTP version ([RFC2616], [I-D.ietf-httpbis-http2]) over TLS, however ALPN facilitates negotiation of arbitrary application layer protocols.

With ALPN, the client sends the list of supported application protocols as part of the TLS ClientHello message. The server chooses a protocol and sends the selected protocol as part of the TLS ServerHello message. The application protocol negotiation can thus be accomplished within the TLS handshake, without adding network round-trips, and allows the server to associate a different certificate with each application protocol, if desired.

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. Application Layer Protocol Negotiation

3.1. The Application Layer Protocol Negotiation Extension

A new extension type ("application_layer_protocol_negotiation(16)") is defined and MAY be included by the client in its "ClientHello" message.

```
enum {
    application_layer_protocol_negotiation(16), (65535)
} ExtensionType;
```

The "extension_data" field of the ("application_layer_protocol_negotiation(16)") extension SHALL contain a "ProtocolNameList" value.

```
opaque ProtocolName<1..2^8-1>;

struct {
    ProtocolName protocol_name_list<2..2^16-1>
} ProtocolNameList;
```

"ProtocolNameList" contains the list of protocols advertised by the client, in descending order of preference. Protocols are named by IANA registered, opaque, non-empty byte strings, as described further in Section 6 "IANA Considerations" of this document. Implementations MUST ensure that an empty string is not included and that no byte strings are truncated.

Experimental protocol names, which are not registered by IANA, will start with the following sequence of bytes: 0x65, 0x78, 0x70 ("exp").

Servers that receive a client hello containing the "application_layer_protocol_negotiation" extension, MAY return a suitable protocol selection response to the client. The server will ignore any protocol name that it does not recognize. A new ServerHello extension type ("application_layer_protocol_negotiation(16)") MAY be returned to the client within the extended ServerHello message. The "extension_data" field of the ("application_layer_protocol_negotiation(16)") extension SHALL be structured the same as described above for the client "extension_data", except that the "ProtocolNameList" MUST contain exactly one "ProtocolName".

Therefore, a full handshake with the "application_layer_protocol_negotiation" extension in the ClientHello and ServerHello messages has the following flow (contrast with section 7.3 of [RFC5246]):

```
Client                                              Server

ClientHello                      -------->       ServerHello
  (ALPN extension &                                  (ALPN extension &
   list of protocols)                                 selected protocol)
                                                  Certificate*
                                                  ServerKeyExchange*
                                                  CertificateRequest*
                                 <--------        ServerHelloDone
Certificate*
ClientKeyExchange
CertificateVerify*
```

```
[ChangeCipherSpec]
Finished                        -------->
                                                [ChangeCipherSpec]
                                <--------       Finished
Application Data                <------->       Application Data
```

Figure 1

An abbreviated handshake with the "application_layer_protocol_negotiation" extension has the following flow:

```
Client                                                  Server

ClientHello                     -------->       ServerHello
  (ALPN extension &                               (ALPN extension &
   list of protocols)                              selected protocol)
                                                [ChangeCipherSpec]
                                <--------       Finished
```



```
[ChangeCipherSpec]
Finished                        -------->
Application Data                <------->       Application Data
```

Figure 2

Unlike many other TLS extensions, this extension does not establish properties of the session, only of the connection. When session resumption or session tickets [RFC5077] are used, the previous contents of this extension are irrelevant and only the values in the new handshake messages are considered.

3.2. Protocol Selection

It is expected that a server will have a list of protocols that it supports, in preference order, and will only select a protocol if the client supports it. In that case, the server SHOULD select the most highly preferred protocol it supports which is also advertised by the client. In the event that the server supports no protocols that the client advertises, then the server SHALL respond with a fatal "no_application_protocol" alert.

```
enum {
    no_application_protocol(120),
    (255)
} AlertDescription;
```

The "no_application_protocol" fatal alert is only defined for the "application_layer_protocol_negotiation" extension and MUST NOT be sent unless the server has received a ClientHello message containing this extension.

The protocol identified in the "application_layer_protocol_negotiation" extension type in the ServerHello SHALL be definitive for the connection. The server SHALL NOT respond with a selected protocol and subsequently use a different protocol for application data exchange.

4. Design Considerations

The ALPN extension is intended to follow the typical design of TLS protocol extensions. Specifically, the negotiation is performed entirely within the client/server hello exchange in accordance with established TLS architecture. The "application_layer_protocol_negotiation" ServerHello extension is intended to be definitive for the connection and is sent in plaintext to permit network elements to provide differentiated service for the

connection when the TCP/IP port number is not definitive for the application layer protocol to be used in the connection. By placing ownership of protocol selection on the server, ALPN facilitates scenarios in which certificate selection or connection rerouting may be based on the negotiated protocol.

Finally, by managing protocol selection in the clear as part of the handshake, ALPN avoids introducing false confidence with respect to the the ability to hide the negotiated protocol in advance of establishing the connection. If hiding the protocol is required, then renegotiation after connection establishment, which would provide true TLS security guarantees, would be a preferred methodology.

A namespace will be assigned for experimental protocols, comprising

byte strings which start with the following sequence of bytes: 0x65, 0x78, 0x70 ("exp"). Assignments in this namespace do not need IANA registration.

5. Security Considerations

The ALPN extension does not impact the security of TLS session establishment or application data exchange. ALPN serves to provide an externally visible marker for the application layer protocol associated with the TLS connection. Historically, the application layer protocol associated with a connection could be ascertained from the TCP/IP port number in use.

6. IANA Considerations

The IANA has updated its Registry of TLS ExtensionType Values to include the following entry:

- 16 application_layer_protocol_negotiation

This document also requires the IANA to create a registry of Application Layer Protocol Negotiation protocol byte strings, initially containing the following entries:

- "http/1.1": HTTP/1.1 [RFC2616];

- "http/2.0": HTTP/2.0 [I-D.ietf-httpbis-http2];

- "spdy/1": (obsolete) SPDY version 1;

- "spdy/2": SPDY version 2;

- "spdy/3": SPDY version 3.

We propose that this new registry be created in a new page entitled: "Application Layer Protocol Negotiation (ALPN) Protocol IDs" beneath the existing heading of "Transport Layer Security (TLS)".

7. Acknowledgements

This document benefitted specifically from the NPN extension draft authored by Adam Langley and from discussions with Tom Wesselman and

Cullen Jennings both of Cisco.

8. References

8.1. Normative References

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8.2. Informative References

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Authors' Addresses

Stephan Friedl

Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134
USA

Phone: (720)562-6785
Email: sfriedl@cisco.com

Andrei Popov
Microsoft Corp.
One Microsoft Way
Redmond, WA 98052
USA

Email: andreipo@microsoft.com

Adam Langley
Google Inc.
USA

Email: agl@google.com

Emile Stephan
France Telecom - Orange
2 avenue Pierre Marzin
Lannion F-22307
France

Email: emile.stephan@orange.com