Hypertext Transfer Protocol (HTTP/1.1): Message Syntax and Routing

Abstract

The Hypertext Transfer Protocol (HTTP) is a stateless application-level protocol for distributed, collaborative, hypertext information systems. This document provides an overview of HTTP architecture and its associated terminology, defines the "http" and "https" Uniform Resource Identifier (URI) schemes, defines the HTTP/1.1 message syntax and parsing requirements, and describes related security concerns for implementations.

1. Introduction

The Hypertext Transfer Protocol (HTTP) is a stateless application-level request/response protocol that uses extensible semantics and self-descriptive message payloads for flexible interaction with network-based hypertext information systems. This document is the first in a series of documents that collectively form the HTTP/1.1 specification:

1. "Message Syntax and Routing" (this document)
2. "Semantics and Content" [RFC7231]
3. "Conditional Requests" [RFC7232]
4. "Range Requests" [RFC7233]
5. "Caching" [RFC7234]
6. "Authentication" [RFC7235]

This HTTP/1.1 specification obsoletes RFC 2616 and RFC 2145 (on HTTP versioning). This specification also updates the use of CONNECT to establish a tunnel, previously defined in RFC 2817, and defines the "https" URI scheme that was described informally in RFC 2818.

HTTP is a generic interface protocol for information systems. It is designed to hide the details of how a service is implemented by presenting a uniform interface to clients that is independent of the types of resources provided. Likewise, servers do not need to be aware of each client's purpose: an HTTP request can be considered in isolation rather than being associated with a specific type of client or a predetermined sequence of

application steps. The result is a protocol that can be used effectively in many different contexts and for which implementations can evolve independently over time.

HTTP is also designed for use as an intermediation protocol for translating communication to and from non-HTTP information systems. HTTP proxies and gateways can provide access to alternative information services by translating their diverse protocols into a hypertext format that can be viewed and manipulated by clients in the same way as HTTP services.

One consequence of this flexibility is that the protocol cannot be defined in terms of what occurs behind the interface. Instead, we are limited to defining the syntax of communication, the intent of received communication, and the expected behavior of recipients. If the communication is considered in isolation, then successful actions ought to be reflected in corresponding changes to the observable interface provided by servers. However, since multiple clients might act in parallel and perhaps at cross-purposes, we cannot require that such changes be observable beyond the scope of a single response.

This document describes the architectural elements that are used or referred to in HTTP, defines the "http" and "https" URI schemes, describes overall network operation and connection management, and defines HTTP message framing and forwarding requirements. Our goal is to define all of the mechanisms necessary for HTTP message handling that are independent of message semantics, thereby defining the complete set of requirements for message parsers and message-forwarding intermediaries.

2.1. Client/Server Messaging

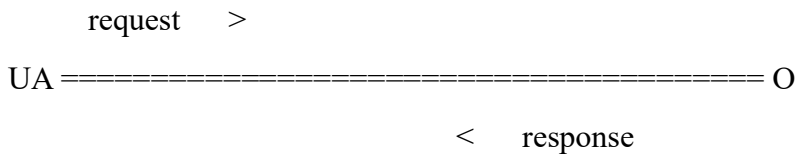
HTTP is a stateless request/response protocol that operates by exchanging messages (Section 3) across a reliable transport- or session-layer "connection" (Section 6). An HTTP "client" is a program that establishes a connection to a server for the purpose of sending one or more HTTP requests. An HTTP "server" is a program that accepts connections in order to service HTTP requests by sending HTTP responses.

The terms "client" and "server" refer only to the roles that these programs perform for a particular connection. The same program might act as a client on some connections and a server on others. The term "user agent" refers to any of the various client programs that initiate a request, including (but not limited to) browsers, spiders (web-based

robots), command-line tools, custom applications, and mobile apps. The term "origin server" refers to the program that can originate authoritative responses for a given target resource. The terms "sender" and "recipient" refer to any implementation that sends or receives a given message, respectively.

HTTP relies upon the Uniform Resource Identifier (URI) standard [RFC3986] to indicate the target resource (Section 5.1) and relationships between resources. Messages are passed in a format similar to that used by Internet mail [RFC5322] and the Multipurpose Internet Mail Extensions (MIME) [RFC2045] (see Appendix A of [RFC7231] for the differences between HTTP and MIME messages).

Most HTTP communication consists of a retrieval request (GET) for a representation of some resource identified by a URI. In the simplest case, this might be accomplished via a single bidirectional connection (===) between the user agent (UA) and the origin server (O).



A client sends an HTTP request to a server in the form of a request message, beginning with a request-line that includes a method, URI, and protocol version (Section 3.1.1), followed by header fields containing request modifiers, client information, and representation metadata (Section 3.2), an empty line to indicate the end of the header section, and finally a message body containing the payload body (if any, Section 3.3).

A server responds to a client's request by sending one or more HTTP response messages, each beginning with a status line that includes the protocol version, a success or error code, and textual reason phrase (Section 3.1.2), possibly followed by header fields containing server information, resource metadata, and representation metadata (Section 3.2), an empty line to indicate the end of the header section, and finally a message body containing the payload body (if any, Section 3.3).

2.2. Implementation Diversity

When considering the design of HTTP, it is easy to fall into a trap of thinking that all user agents are general-purpose browsers and all origin servers are large public

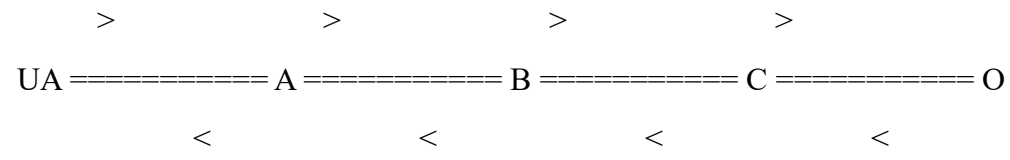
websites. That is not the case in practice. Common HTTP user agents include household appliances, stereos, scales, firmware update scripts, command-line programs, mobile apps, and communication devices in a multitude of shapes and sizes. Likewise, common HTTP origin servers include home automation units, configurable networking components, office machines, autonomous robots, news feeds, traffic cameras, ad selectors, and video-delivery platforms.

The term "user agent" does not imply that there is a human user directly interacting with the software agent at the time of a request. In many cases, a user agent is installed or configured to run in the background and save its results for later inspection (or save only a subset of those results that might be interesting or erroneous). Spiders, for example, are typically given a start URI and configured to follow certain behavior while crawling the Web as a hypertext graph.

The implementation diversity of HTTP means that not all user agents can make interactive suggestions to their user or provide adequate warning for security or privacy concerns. In the few cases where this specification requires reporting of errors to the user, it is acceptable for such reporting to only be observable in an error console or log file. Likewise, requirements that an automated action be confirmed by the user before proceeding might be met via advance configuration choices, run-time options, or simple avoidance of the unsafe action; confirmation does not imply any specific user interface or interruption of normal processing if the user has already made that choice.

2.3. Intermediaries

HTTP enables the use of intermediaries to satisfy requests through a chain of connections. There are three common forms of HTTP intermediary: proxy, gateway, and tunnel. In some cases, a single intermediary might act as an origin server, proxy, gateway, or tunnel, switching behavior based on the nature of each request.



The figure above shows three intermediaries (A, B, and C) between the user agent and origin server. A request or response message that travels the whole chain will pass through four separate connections. Some HTTP communication options might apply

only to the connection with the nearest, non-tunnel neighbor, only to the endpoints of the chain, or to all connections along the chain. Although the diagram is linear, each participant might be engaged in multiple, simultaneous communications. For example, B might be receiving requests from many clients other than A, and/or forwarding requests to servers other than C, at the same time that it is handling A's request. Likewise, later requests might be sent through a different path of connections, often based on dynamic configuration for load balancing.

The terms "upstream" and "downstream" are used to describe directional requirements in relation to the message flow: all messages flow from upstream to downstream. The terms "inbound" and "outbound" are used to describe directional requirements in relation to the request route: "inbound" means toward the origin server and "outbound" means toward the user agent.

A "proxy" is a message-forwarding agent that is selected by the client, usually via local configuration rules, to receive requests for some type(s) of absolute URI and attempt to satisfy those requests via translation through the HTTP interface. Some translations are minimal, such as for proxy requests for "http" URIs, whereas other requests might require translation to and from entirely different application-level protocols. Proxies are often used to group an organization's HTTP requests through a common intermediary for the sake of security, annotation services, or shared caching. Some proxies are designed to apply transformations to selected messages or payloads while they are being forwarded, as described in Section 5.7.2.

A "gateway" (a.k.a. "reverse proxy") is an intermediary that acts as an origin server for the outbound connection but translates received requests and forwards them inbound to another server or servers. Gateways are often used to encapsulate legacy or untrusted information services, to improve server performance through "accelerator" caching, and to enable partitioning or load balancing of HTTP services across multiple machines.

All HTTP requirements applicable to an origin server also apply to the outbound communication of a gateway. A gateway communicates with inbound servers using any protocol that it desires, including private extensions to HTTP that are outside the scope of this specification. However, an HTTP-to-HTTP gateway that wishes to interoperate

with third-party HTTP servers ought to conform to user agent requirements on the gateway's inbound connection.

A "tunnel" acts as a blind relay between two connections without changing the messages. Once active, a tunnel is not considered a party to the HTTP communication, though the tunnel might have been initiated by an HTTP request. A tunnel ceases to exist when both ends of the relayed connection are closed. Tunnels are used to extend a virtual connection through an intermediary, such as when Transport Layer Security (TLS, [RFC5246]) is used to establish confidential communication through a shared firewall proxy.

The above categories for intermediary only consider those acting as participants in the HTTP communication. There are also intermediaries that can act on lower layers of the network protocol stack, filtering or redirecting HTTP traffic without the knowledge or permission of message senders. Network intermediaries are indistinguishable (at a protocol level) from a man-in-the-middle attack, often introducing security flaws or interoperability problems due to mistakenly violating HTTP semantics.

For example, an "interception proxy" [RFC3040] (also commonly known as a "transparent proxy" [RFC1919] or "captive portal") differs from an HTTP proxy because it is not selected by the client. Instead, an interception proxy filters or redirects outgoing TCP port 80 packets (and occasionally other common port traffic). Interception proxies are commonly found on public network access points, as a means of enforcing account subscription prior to allowing use of non-local Internet services, and within corporate firewalls to enforce network usage policies.

HTTP is defined as a stateless protocol, meaning that each request message can be understood in isolation. Many implementations depend on HTTP's stateless design in order to reuse proxied connections or dynamically load balance requests across multiple servers. Hence, a server MUST NOT assume that two requests on the same connection are from the same user agent unless the connection is secured and specific to that agent. Some non-standard HTTP extensions (e.g., [RFC4559]) have been known to violate this requirement, resulting in security and interoperability problems.