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HTTP Strict Transport Security (HSTS)
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Abstract

This specification defines a mechanism enabling web sites to declare themselves accessible only via secure connections, and/or for users to be able to direct their user agent(s) to interact with given sites only over secure connections. This overall policy is referred to as HTTP Strict Transport Security (HSTS). The policy is declared by web sites via the Strict-Transport-Security HTTP response header field, and/or by other means, such as user agent configuration, for example.

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Table of Contents

1.	Introduction	4
1.1.	Organization of this specification	5
1.2.	Document Conventions	5
2.	Overview	5
2.1.	Use Cases	5
2.2.	HTTP Strict Transport Security Policy Effects	6
2.3.	Threat Model	6
2.3.1.	Threats Addressed	6
2.3.1.1.	Passive Network Attackers	6
2.3.1.2.	Active Network Attackers	7
2.3.1.3.	Web Site Development and Deployment Bugs	7
2.3.2.	Threats Not Addressed	8
2.3.2.1.	Phishing	8
2.3.2.2.	Malware and Browser Vulnerabilities	8
2.4.	Requirements	8
2.4.1.	Overall Requirement	8
2.4.1.1.	Detailed Core Requirements	8
2.4.1.2.	Detailed Ancillary Requirements	9
3.	Conformance Criteria	10
4.	Terminology	10
5.	HSTS Mechanism Overview	12
6.	Syntax	13
6.1.	Strict-Transport-Security HTTP Response Header Field	13
6.1.1.	The max-age Directive	14
6.1.2.	The includeSubDomains Directive	14
6.2.	Examples	15
7.	Server Processing Model	15
7.1.	HTTP-over-Secure-Transport Request Type	15
7.2.	HTTP Request Type	16
8.	User Agent Processing Model	16
8.1.	Strict-Transport-Security Response Header Field Processing	17
8.1.1.	Noting an HSTS Host	18
8.2.	Known HSTS Host Domain Name Matching	18
8.3.	URI Loading and Port Mapping	19
8.4.	Errors in Secure Transport Establishment	20
8.5.	HTTP-Equiv <Meta> Element Attribute	20
8.6.	Missing Strict-Transport-Security Response Header Field	20
9.	Constructing an Effective Request URI	21

9.1.	ERU Fundamental Definitions	21
9.2.	Determining the Effective Request URI	21
9.2.1.	Effective Request URI Examples	22
10.	Domain Name IDNA-Canonicalization	22
11.	Server Implementation and Deployment Advice	23
11.1.	Non-Conformant User Agent Considerations	23
11.2.	HSTS Policy expiration time considerations	23
11.3.	Using HSTS in conjunction with self-signed public-key certificates	24
11.4.	Implications of includeSubDomains	25
12.	User Agent Implementation Advice	26
12.1.	No User Recourse	26
12.2.	User-declared HSTS Policy	27
12.3.	HSTS Pre-Loaded List	27
12.4.	Disallow Mixed Security Context Loads	27
12.5.	HSTS Policy Deletion	28
13.	Internationalized Domain Names for Applications (IDNA): Dependency and Migration	28
14.	Security Considerations	28
14.1.	Non-Conformant User Agent Implications	29
14.2.	Ramifications of HSTS Policy Establishment only over Error-free Secure Transport	29
14.3.	The Need for includeSubDomains	30
14.4.	Denial of Service	31
14.5.	Bootstrap MITM Vulnerability	32
14.6.	Network Time Attacks	33
14.7.	Bogus Root CA Certificate Phish plus DNS Cache Poisoning Attack	33
14.8.	Creative Manipulation of HSTS Policy Store	33
14.9.	Internationalized Domain Names	34
15.	IANA Considerations	34
16.	References	35
16.1.	Normative References	35
16.2.	Informative References	36
Appendix A.	Design Decision Notes	39
Appendix B.	Differences between HSTS Policy and Same-Origin Policy	39
Appendix C.	Acknowledgments	40
Appendix D.	Change Log	41
D.1.	For draft-ietf-websec-strict-transport-sec	41
D.2.	For draft-hodges-strict-transport-sec	48
	Authors' Addresses	49

1. Introduction

The HTTP protocol [[RFC2616](#)] may be used over various transports, typically the Transmission Control Protocol (TCP). However, TCP does not provide channel integrity protection, confidentiality, nor secure host identification. Thus, the Secure Sockets Layer (SSL) protocol [[RFC6101](#)], and its successor Transport Layer Security (TLS) [[RFC5246](#)], were developed in order to provide channel-oriented security, and are typically layered between application protocols and TCP. [[RFC2818](#)] specifies how HTTP is layered onto TLS, and defines the Uniform Resource Identifier (URI) scheme of "https" (in practice however, HTTP user agents (UAs) typically use either TLS or SSL3 depending upon a combination of negotiation with the server and user preferences).

UAs employ various local security policies with respect to the characteristics of their interactions with web resources depending on (in part) whether they are communicating with a given web resource's host using HTTP or HTTP-over-a-Secure-Transport. For example, cookies ([[RFC6265](#)]) may be flagged as Secure. UAs are to send such Secure cookies to their addressed host only over a secure transport. This is in contrast to non-Secure cookies, which are returned to the host regardless of transport (although subject to other rules).

UAs typically announce to their users any issues with secure connection establishment, such as being unable to validate a TLS server certificate trust chain, or if a TLS server certificate is expired, or if a TLS host's domain name appears incorrectly in the TLS server certificate (see [Section 3.1 of \[RFC2818\]](#)). Often, UAs enable users to elect to continue to interact with a web resource's host in the face of such issues. This behavior is sometimes referred to as "click(ing) through" security [[GoodDhamijaEtAl05](#)] [[SunshineEgelmanEtAl09](#)], and thus can be described as "click-through insecurity".

A key vulnerability enabled by click-through insecurity is the leaking of any cookies the web resource may be using to manage a user's session. The threat here is that an attacker could obtain the cookies and then interact with the legitimate web resource while impersonating the user.

Jackson and Barth proposed an approach, in [[ForceHTTPS](#)], to enable web resources to declare that any interactions by UAs with the web resource must be conducted securely, and that any issues with establishing a secure transport session are to be treated as fatal and without direct user recourse. The aim is to prevent click-through insecurity, and address other potential threats.

This specification embodies and refines the approach proposed in [[ForceHTTPS](#)]. For example, rather than using a cookie to convey policy from a web resource's host to a UA, it defines an HTTP response header field for this purpose. Additionally, a web resource's host may declare its policy to apply to the entire domain name subtree rooted at its host name. This enables HSTS to protect so-called "domain cookies", which are applied to all subdomains of a given web resource's host name.

This specification also incorporates notions from [[JacksonBarth2008](#)] in that policy is applied on an "entire-host" basis: it applies to HTTP (only) over any TCP port of the issuing host.

Note that the policy defined by this specification is distinctly different than the "same-origin policy" defined in "The Web Origin Concept" [[RFC6454](#)]. These differences are summarized below in [Appendix B](#).

[1.1.](#) Organization of this specification

This specification begins with an overview of the use cases, policy effects, threat models, and requirements for HSTS (in [Section 2](#)). Then, [Section 3](#) defines conformance requirements. The HSTS mechanism itself is formally specified in [Section 4](#) through [Section 15](#).

[1.2.](#) Document Conventions

NOTE: This is a note to the reader. These are points that should be expressly kept in mind and/or considered.

[2.](#) Overview

This section discusses the use cases, summarizes the HTTP Strict Transport Security (HSTS) policy, and continues with a discussion of the threat model, non-addressed threats, and derived requirements.

[2.1.](#) Use Cases

The high-level use case is a combination of:

- o Web browser user wishes to interact with various web sites (some arbitrary, some known) in a secure fashion.
- o Web site deployer wishes to offer their site in an explicitly secure fashion for both their own, as well as their users', benefit.

2.2. HTTP Strict Transport Security Policy Effects

The effects of the HTTP Strict Transport Security (HSTS) Policy, as applied by a conformant UA in interactions with a web resource host wielding such policy (known as an HSTS Host), are summarized as follows:

1. UAs transform insecure URI references to an HSTS Host into secure URI references before dereferencing them.
2. The UA terminates any secure transport connection attempts upon any and all secure transport errors or warnings.

2.3. Threat Model

HSTS is concerned with three threat classes: passive network attackers, active network attackers, and imperfect web developers. However, it is explicitly not a remedy for two other classes of threats: phishing and malware. Addressed and not addressed threats are briefly discussed below. Readers may wish refer to Section 2 of [[ForceHTTPS](#)] for details as well as relevant citations.

2.3.1. Threats Addressed

2.3.1.1. Passive Network Attackers

When a user browses the web on a local wireless network (e.g., an 802.11-based wireless local area network) a nearby attacker can possibly eavesdrop on the user's unencrypted Internet Protocol-based connections, such as HTTP, regardless of whether or not the local wireless network itself is secured [[BeckTews09](#)]. Freely available wireless sniffing toolkits (e.g., [[Aircrack-ng](#)]) enable such passive eavesdropping attacks, even if the local wireless network is operating in a secure fashion. A passive network attacker using such tools can steal session identifiers/cookies and hijack the user's web session(s), by obtaining cookies containing authentication credentials [[ForceHTTPS](#)]. For example, there exist widely-available tools, such as Firesheep (a web browser extension) [[Firesheep](#)], which enable their wielder to obtain other local users' session cookies for various web applications.

To mitigate such threats, some Web sites support, but usually do not force, access using end-to-end secure transport -- e.g., signaled through URIs constructed with the "https" scheme [[RFC2818](#)]. This can lead users to believe that accessing such services using secure transport protects them from passive network attackers.

Unfortunately, this is often not the case in real-world deployments as session identifiers are often stored in non-Secure cookies to

permit interoperability with versions of the service offered over insecure transport ("Secure cookies" are those cookies containing the "Secure" attribute [[RFC6265](#)]). For example, if the session identifier for a web site (an email service, say) is stored in a non-Secure cookie, it permits an attacker to hijack the user's session if the user's UA makes a single insecure HTTP request to the site.

2.3.1.2. Active Network Attackers

A determined attacker can mount an active attack, either by impersonating a user's DNS server or, in a wireless network, by spoofing network frames or offering a similarly-named evil twin access point. If the user is behind a wireless home router, an attacker can attempt to reconfigure the router using default passwords and other vulnerabilities. Some sites, such as banks, rely on end-to-end secure transport to protect themselves and their users from such active attackers. Unfortunately, browsers allow their users to easily opt-out of these protections in order to be usable for sites that incorrectly deploy secure transport, for example by generating and self-signing their own certificates (without also distributing their certification authority (CA) certificate to their users' browsers).

2.3.1.3. Web Site Development and Deployment Bugs

The security of an otherwise uniformly secure site (i.e. all of its content is materialized via "https" URIs), can be compromised completely by an active attacker exploiting a simple mistake, such as the loading of a cascading style sheet or a SWF (Shockwave Flash) movie over an insecure connection (both cascading style sheets and SWF movies can script the embedding page, to the surprise of many web developers, plus some browsers do not issue so-called "mixed content warnings" when SWF files are embedded via insecure connections). Even if the site's developers carefully scrutinize their login page for "mixed content", a single insecure embedding anywhere on the overall site compromises the security of their login page because an attacker can script (i.e., control) the login page by injecting code (e.g., a script) into another, insecurely loaded, site page.

NOTE: "Mixed content" as used above (see also Section 5.3 in [[W3C.REC-wsc-ui-20100812](#)]) refers to the notion termed "mixed security context" in this specification, and should not be confused with the same "mixed content" term used in the context of markup languages such as XML and HTML.

2.3.2. Threats Not Addressed

2.3.2.1. Phishing

Phishing attacks occur when an attacker solicits authentication credentials from the user by hosting a fake site located on a different domain than the real site, perhaps driving traffic to the fake site by sending a link in an email message. Phishing attacks can be very effective because users find it difficult to distinguish the real site from a fake site. HSTS is not a defense against phishing per se; rather, it complements many existing phishing defenses by instructing the browser to protect session integrity and long-lived authentication tokens [[ForceHTTPS](#)].

2.3.2.2. Malware and Browser Vulnerabilities

Because HSTS is implemented as a browser security mechanism, it relies on the trustworthiness of the user's system to protect the session. Malicious code executing on the user's system can compromise a browser session, regardless of whether HSTS is used.

2.4. Requirements

This section identifies and enumerates various requirements derived from the use cases and the threats discussed above, and lists the detailed core requirements HTTP Strict Transport Security addresses, as well as ancillary requirements that are not directly addressed.

2.4.1. Overall Requirement

- o Minimize, for web browser users and web site deployers, the risks that are derived from passive and active network attackers, web site development and deployment bugs, and insecure user actions.

2.4.1.1. Detailed Core Requirements

These core requirements are derived from the overall requirement, and are addressed by this specification.

1. Web sites need to be able to declare to UAs that they should be accessed using a strict security policy.
2. Web sites need to be able to instruct UAs that contact them insecurely to do so securely.
3. UAs need to retain persistent data about web sites that signal strict security policy enablement, for time spans declared by the web sites. Additionally, UAs need to cache the "freshest" strict

security policy information, in order to allow web sites to update the information.

4. UAs need to re-write all insecure UA "http" URI loads to use the "https" secure scheme for those web sites for which secure policy is enabled.
5. Web site administrators need to be able to signal strict security policy application to subdomains of higher-level domains for which strict security policy is enabled, and UAs need to enforce such policy.

For example, both example.com and foo.example.com could set policy for bar.foo.example.com.

6. UAs need to disallow security policy application to peer domains, and/or higher-level domains, by domains for which strict security policy is enabled.

For example, neither bar.foo.example.com nor foo.example.com can set policy for example.com, nor can bar.foo.example.com set policy for foo.example.com. Also, foo.example.com cannot set policy for sibling.example.com.

7. UAs need to prevent users from clicking-through security warnings. Halting connection attempts in the face of secure transport exceptions is acceptable. See also [Section 12.1](#) "No User Recourse".

NOTE: A means for uniformly securely meeting the first core requirement above is not specifically addressed by this specification (see [Section 14.5](#) "Bootstrap MITM Vulnerability"). It may be addressed by a future revision of this specification or some other specification. Note also that there are means by which UA implementations may more fully meet the first core requirement; see [Section 12](#) "User Agent Implementation Advice".

[2.4.1.2](#). Detailed Ancillary Requirements

These ancillary requirements are also derived from the overall requirement. They are not normatively addressed in this specification, but could be met by UA implementations at their implementor's discretion, although meeting these requirements may be complex.

1. Disallow "mixed security context" loads (see [Section 2.3.1.3](#)).
2. Facilitate user declaration of web sites for which strict security policy is enabled, regardless of whether the sites signal HSTS Policy.

3. Conformance Criteria

This specification is written for hosts and user agents (UAs).

[[IESG NOTE: the next two paragraphs are for readers with a background in W3C specification style, of which we expect many. RFC Editor, please remove this note before publication.]]

A conformant host is one that implements all the requirements listed in this specification that are applicable to hosts.

A conformant user agent is one that implements all the requirements listed in this specification that are applicable to user agents.

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 [\[RFC2119\]](#).

4. Terminology

Terminology is defined in this section.

ASCII case-insensitive comparison:

means comparing two strings exactly, codepoint for codepoint, except that the characters in the range U+0041 .. U+005A (i.e. LATIN CAPITAL LETTER A to LATIN CAPITAL LETTER Z) and the corresponding characters in the range U+0061 .. U+007A (i.e. LATIN SMALL LETTER A to LATIN SMALL LETTER Z) are considered to also match. See [\[Unicode\]](#) for details.

codepoint: is a colloquial contraction of Code Point, which is any value in the Unicode codespace; that is, the range of integers from 0 to 10FFFF(hex) [\[Unicode\]](#).

domain name: domain names, also referred to as DNS Names, are defined in [\[RFC1035\]](#) to be represented outside of the DNS protocol itself (and implementations thereof) as a series of labels separated by dots, e.g., "example.com" or "yet.another.example.org". In the context of this specification, domain names appear in that portion of a URI satisfying the reg-name production in "Appendix A. Collected ABNF for URI" in [\[RFC3986\]](#), and the host component from the Host HTTP header field production in [Section 14.23 of \[RFC2616\]](#).

NOTE: The domain names appearing in actual URI instances and matching the aforementioned production components may or may not be a fully qualified domain name.

domain name label: is that portion of a domain name appearing "between the dots", i.e. consider "foo.example.com": "foo", "example", and "com" are all domain name labels.

Effective Request URI:
is a URI, identifying the target resource, that can be inferred by an HTTP host for any given HTTP request it receives. Such inference is necessary because HTTP requests often do not contain a complete "absolute" URI identifying the target resource. See [Section 9](#) "Constructing an Effective Request URI".

HTTP Strict Transport Security:
is the overall name for the combined UA- and server-side security policy defined by this specification.

HTTP Strict Transport Security Host:
is a conformant host implementing the HTTP server aspects of the HSTS Policy. This means that an HSTS Host returns the "Strict-Transport-Security" HTTP response header field in its HTTP response messages sent over secure transport.

HTTP Strict Transport Security Policy:
is the name of the combined overall UA- and server-side facets of the behavior defined in this specification.

HSTS: See HTTP Strict Transport Security.

HSTS Host: See HTTP Strict Transport Security Host.

HSTS Policy: See HTTP Strict Transport Security Policy.

Known HSTS Host: is an HSTS Host for which the UA has an HSTS Policy in effect. I.e., the UA has noted this host as a Known HSTS Host.

Local policy: comprises policy rules deployers specify and which are often manifested as configuration settings.

MITM: is an acronym for man-in-the-middle. See "man-in-the-middle attack" in [[RFC4949](#)].

Request URI: is the URI used to cause a UA to issue an HTTP request message. See also "Effective Request URI".

UA: is a an acronym for user agent. For the purposes of this specification, a UA is an HTTP client application typically actively manipulated by a user [[RFC2616](#)] .

unknown HSTS Host: is an HSTS Host that the user agent in question has not yet noted.

5. HSTS Mechanism Overview

This section provides an overview of the mechanism by which an HSTS Host conveys its HSTS Policy to UAs, and how UAs process the HSTS Policies received from HSTS Hosts. The mechanism details are specified in [Section 6](#) through [Section 15](#).

An HSTS Host conveys its HSTS Policy to UAs via the Strict-Transport-Security HTTP response header field over secure transport (e.g., TLS). Receipt of this header field signals to UAs to enforce the HSTS Policy for all subsequent connections made to the HSTS Host, for a specified time duration. Application of the HSTS Policy to subdomains of the HSTS Host name may optionally be specified.

HSTS Hosts manage their advertised HSTS Policies by sending Strict-Transport-Security HTTP response header fields to UAs with new values for policy time duration and application to subdomains. UAs cache the "freshest" HSTS Policy information on behalf of an HSTS Host. Specifying a zero time duration signals to the UA to delete the HSTS Policy for that HSTS Host.

[Section 6.2](#) presents examples of Strict-Transport-Security HTTP response header fields.

6. Syntax

This section defines the syntax of the Strict-Transport-Security HTTP response header field and its directives, and presents some examples.

[Section 7](#) "Server Processing Model" then details how hosts employ this header field to declare their HSTS Policy, and [Section 8](#) "User Agent Processing Model" details how user agents process the header field and apply the HSTS Policy.

6.1. Strict-Transport-Security HTTP Response Header Field

The Strict-Transport-Security HTTP response header field (STS header field) indicates to a UA that it MUST enforce the HSTS Policy in regards to the host emitting the response message containing this header field.

The ABNF (Augmented Backus-Naur Form) syntax for the STS header field is given below. It is based on the Generic Grammar defined in [Section 2 of \[RFC2616\]](#) (which includes a notion of "implied linear whitespace", also known as "implied *LWS").

```
Strict-Transport-Security = "Strict-Transport-Security" ":"  
                           [ directive ] *( ";" [ directive ] )
```

```
directive                  = directive-name [ "=" directive-value ]  
directive-name             = token  
directive-value            = token | quoted-string
```

where:

```
token                      = <token, defined in \[RFC2616\], Section 2.2>  
quoted-string             = <quoted-string, defined in \[RFC2616\], Section 2.2>
```

The two directives defined in this specification are described below. The overall requirements for directives are:

1. The order of appearance of directives is not significant.
2. All directives MUST appear only once in an STS header field. Directives are either optional or required, as stipulated in their definitions.

3. Directive names are case-insensitive.
4. UAs MUST ignore any STS header fields containing directives, or other header field value data, that does not conform to the syntax defined in this specification.
5. If an STS header field contains directive(s) not recognized by the UA, the UA MUST ignore the unrecognized directives and if the STS header field otherwise satisfies the above requirements (1 through 4), the UA MUST process the recognized directives.

Additional directives extending the semantic functionality of the STS header field can be defined in other specifications, with a registry (having an IANA policy definition of FOO [[RFC5226](#)]) defined for them at such time.

NOTE: Such future directives will be ignored by UAs implementing only this specification, as well as by generally non-conforming UAs. See [Section 14.1](#) "Non-Conformant User Agent Implications" for further discussion.

[6.1.1.](#) The max-age Directive

The REQUIRED "max-age" directive specifies the number of seconds, after the reception of the STS header field, during which the UA regards the host (from whom the message was received) as a Known HSTS Host. See also [Section 8.1.1](#) "Noting an HSTS Host". The delta-seconds production is specified in [[RFC2616](#)].

The syntax of the max-age directive's REQUIRED value (after quoted-string unescaping, if necessary) is defined as:

max-age-value = delta-seconds

delta-seconds = <1*DIGIT, defined in [[RFC2616](#)], [Section 3.3.2](#)>

NOTE: A max-age value of zero (i.e., "max-age=0") signals the UA to cease regarding the host as a Known HSTS Host.

[6.1.2.](#) The includeSubDomains Directive

The OPTIONAL "includeSubDomains" directive is a valueless flag which, if present, signals to the UA that the HSTS Policy applies to this HSTS Host as well as any subdomains of the host's domain name.

6.2. Examples

The below HSTS header field stipulates that the HSTS Policy is to remain in effect for one year (there are approximately 31 536 000 seconds in a year), and the policy applies only to the domain of the HSTS Host issuing it:

```
Strict-Transport-Security: max-age=31536000
```

The below HSTS header field stipulates that the HSTS Policy is to remain in effect for approximately six months and the policy applies to the domain of the issuing HSTS Host and all of its subdomains:

```
Strict-Transport-Security: max-age=15768000 ; includeSubDomains
```

The max-age directive value can optionally be quoted:

```
Strict-Transport-Security: max-age="31536000"
```

7. Server Processing Model

This section describes the processing model that HSTS Hosts implement. The model comprises two facets: the first being the processing rules for HTTP request messages received over a secure transport (TLS [[RFC5246](#)], SSL [[RFC6101](#)], or perhaps others), the second being the processing rules for HTTP request messages received over non-secure transports, such as TCP.

7.1. HTTP-over-Secure-Transport Request Type

When replying to an HTTP request that was conveyed over a secure transport, an HSTS Host SHOULD include in its response message an STS header field that MUST satisfy the grammar specified above in [Section 6.1](#) "Strict-Transport-Security HTTP Response Header Field". If an STS header field is included, the HSTS Host MUST include only one such header field.

Establishing a given host as a Known HSTS Host, in the context of a given UA, MAY be accomplished over the HTTP protocol by correctly returning, per this specification, at least one valid STS header field to the UA. Other mechanisms, such as a client-side pre-loaded Known HSTS Host list MAY also be used. E.g., see [Section 12](#) "User Agent Implementation Advice".

NOTE: Including the STS header field is stipulated as a "SHOULD" in order to accommodate various server- and network-side caches and load-balancing configurations where it may be difficult to uniformly emit STS header fields on behalf of a given HSTS Host.

7.2. HTTP Request Type

If an HSTS Host receives a HTTP request message over a non-secure transport, it SHOULD send a HTTP response message containing a status code indicating a permanent redirect, such as status code 301 ([Section 10.3.2 of \[RFC2616\]](#)), and a Location header field value containing either the HTTP request's original Effective Request URI (see [Section 9](#) "Constructing an Effective Request URI") altered as necessary to have a URI scheme of "https", or a URI generated according to local policy with a URI scheme of "https").

NOTE: The above behavior is a "SHOULD" rather than a "MUST" due to:

- * Risks in server-side non-secure-to-secure redirects [[owaspTLSGuide](#)].
- * Site deployment characteristics. For example, a site that incorporates third-party components may not behave correctly when doing server-side non-secure-to-secure redirects in the case of being accessed over non-secure transport, but does behave correctly when accessed uniformly over secure transport. The latter is the case given a HSTS-capable UA that has already noted the site as a Known HSTS Host (by whatever means, e.g., prior interaction or UA configuration).

An HSTS Host MUST NOT include the STS header field in HTTP responses conveyed over non-secure transport.

8. User Agent Processing Model

This section describes the HTTP Strict Transport Security processing model for UAs. There are several facets to the model, enumerated by the following subsections.

This processing model assumes that the UA implements IDNA2008 [[RFC5890](#)], or possibly IDNA2003 [[RFC3490](#)], as noted in [Section 13](#) "Internationalized Domain Names for Applications (IDNA): Dependency and Migration". It also assumes that all domain names manipulated in this specification's context are already IDNA-canonicalized as outlined in [Section 10](#) "Domain Name IDNA-Canonicalization" prior to the processing specified in this section.

The above assumptions mean that this processing model also specifically assumes that appropriate IDNA and Unicode validations and character list testing have occurred on the domain names, in conjunction with their IDNA-canonicalization, prior to the processing specified in this section. See the IDNA-specific security considerations in [Section 14.9](#) "Internationalized Domain Names" for rationale and further details.

8.1. Strict-Transport-Security Response Header Field Processing

If an HTTP response, received over a secure transport, includes an STS header field, conforming to the grammar specified in [Section 6.1](#) "Strict-Transport-Security HTTP Response Header Field", and there are no underlying secure transport errors or warnings (see [Section 8.4](#)), the UA MUST either:

- o Note the host as a Known HSTS Host if it is not already so noted (see [Section 8.1.1](#) "Noting an HSTS Host"),

or,

- o Update the UA's cached information for the Known HSTS Host if either or both of the max-age and includeSubDomains header field value tokens are conveying information different than that already maintained by the UA.

The max-age value is essentially a "time to live" value relative to the reception time of the STS header field.

If the max-age header field value token has a value of zero, the UA MUST remove its cached HSTS Policy information if the HSTS Host is known, or, MUST NOT note this HSTS Host if it is not yet known.

If a UA receives more than one STS header field in a HTTP response message over secure transport, then the UA MUST process only the first such header field.

Otherwise:

- o If an HTTP response is received over insecure transport, the UA MUST ignore any present STS header field(s).
- o The UA MUST ignore any STS header fields not conforming to the grammar specified in [Section 6.1](#) "Strict-Transport-Security HTTP Response Header Field".

8.1.1. Noting an HSTS Host

If the substring matching the host production from the Request-URI (of the message to which the host responded) syntactically matches the IP-literal or IPv4address productions from [Section 3.2.2 of \[RFC3986\]](#), then the UA MUST NOT note this host as a Known HSTS Host.

Otherwise, if the substring does not congruently match a Known HSTS Host's domain name, per the matching procedure specified in [Section 8.2](#) "Known HSTS Host Domain Name Matching", then the UA MUST note this host as a Known HSTS Host, caching the HSTS Host's domain name and noting along with it the expiry time of this information, as effectively stipulated per the given max-age value, as well as whether the includeSubDomains flag is asserted or not. See also [Section 11.2](#) "HSTS Policy expiration time considerations".

The UA MUST NOT modify the expiry time nor the includeSubDomains flag of any superdomain matched Known HSTS Host.

8.2. Known HSTS Host Domain Name Matching

A given domain name may match a Known HSTS Host's domain name in one or both of two fashions: a congruent match, or a superdomain match. Or, there may be no match.

The below steps determine whether there are any matches, and if so, of which fashion:

Compare the given domain name with the domain name of each of the UA's Known HSTS Hosts. For each Known HSTS Host's domain name, the comparison is done with the given domain name label-by-label (comparing only labels) using an ASCII case-insensitive comparison beginning with the rightmost label, and continuing right-to-left. See also [Section 2.3.2.4. of \[RFC5890\]](#).

*** Superdomain Match**

If a label-for-label match between an entire Known HSTS Host's domain name and a right-hand portion of the given domain name is found, then this Known HSTS Host's domain name is a superdomain match for the given domain name. There could be multiple superdomain matches for a given domain name.

For example:

Given Domain Name: qaz.bar.foo.example.com

Superdomain matched

Known HSTS Host DN: bar.foo.example.com

Superdomain matched

Known HSTS Host DN: foo.example.com

* Congruent Match

If a label-for-label match between a Known HSTS Host's domain name and the given domain name is found -- i.e., there are no further labels to compare -- then the given domain name congruently matches this Known HSTS Host.

For example:

Given Domain Name: foo.example.com

Congruently matched

Known HSTS Host DN: foo.example.com

- * Otherwise, if no matches are found, the given domain name does not represent a Known HSTS Host.

8.3. URI Loading and Port Mapping

Whenever the UA prepares to "load", also known as "dereference", any "http" URI [[RFC3986](#)] (including when following HTTP redirects [[RFC2616](#)]), the UA MUST first determine whether a domain name is given in the URI and whether it matches a Known HSTS Host, using these steps:

1. Extract from the URI any substring described by the host component of the authority component of the URI.
2. If the substring is null, then there is no match with any Known HSTS Host.
3. Else, if the substring is non-null and syntactically matches the IP-literal or IPv4address productions from [Section 3.2.2 of \[RFC3986\]](#), then there is no match with any Known HSTS Host.
4. Otherwise, the substring is a given domain name, which MUST be matched against the UA's Known HSTS Hosts using the procedure in [Section 8.2](#) "Known HSTS Host Domain Name Matching".

5. If when performing domain name matching, any superdomain match with an asserted includeSubDomains flag is found, or, if no superdomain matches with asserted includeSubDomains flags are found and a congruent match is found (with or without an asserted includeSubDomains flag), then before proceeding with the load:

The UA MUST replace the URI scheme with "https" [[RFC2818](#)], and,

if the URI contains an explicit port component of "80", then the UA MUST convert the port component to be "443", or,

if the URI contains an explicit port component that is not equal to "80", the port component value MUST be preserved, otherwise,

if the URI does not contain an explicit port component, the UA MUST NOT add one.

NOTE: These steps ensure that the HSTS Policy applies to HTTP over any TCP port of an HSTS Host.

[8.4.](#) Errors in Secure Transport Establishment

When connecting to a Known HSTS Host, the UA MUST terminate the connection (see also [Section 12](#) "User Agent Implementation Advice") if there are any errors, whether "warning" or "fatal" or any other error level, with the underlying secure transport. For example, this includes any errors found in certificate validity checking UAs employ such as via Certificate Revocation Lists (CRL) [[RFC5280](#)], or via the Online Certificate Status Protocol (OCSP) [[RFC2560](#)].

[8.5.](#) HTTP-Equiv <Meta> Element Attribute

UAs MUST NOT heed http-equiv="Strict-Transport-Security" attribute settings on <meta> elements [[W3C.REC-html401-19991224](#)] in received content.

[8.6.](#) Missing Strict-Transport-Security Response Header Field

If a UA receives HTTP responses from a Known HSTS Host over a secure channel, but they are missing the STS header field, the UA MUST continue to treat the host as a Known HSTS Host until the max-age value for the knowledge of that Known HSTS Host is reached. Note that the max-age value could be effectively infinite for a given Known HSTS Host. For example, this would be the case if the Known HSTS Host is part of a pre-configured list that is implemented such that the list entries never "age out".

9. Constructing an Effective Request URI

This section specifies how an HSTS Host must construct the Effective Request URI for a received HTTP request.

HTTP requests often do not carry an absoluteURI for the target resource; instead, the URI needs to be inferred from the Request-URI, Host header field, and connection context ([RFC2616], Sections 3.2.1, 5.1.2, and 5.2). The result of this process is called the "effective request URI (ERU)". The "target resource" is the resource identified by the effective request URI.

9.1. ERU Fundamental Definitions

The first line of an HTTP request message, Request-Line, is specified by the following ABNF from [RFC2616], Section 5.1:

```
Request-Line = Method SP Request-URI SP HTTP-Version CRLF
```

The Request-URI, within the Request-Line, is specified by the following ABNF from [RFC2616], Section 5.1.2:

```
Request-URI = "*" | absoluteURI | abs_path | authority
```

The Host request header field is specified by the following ABNF from [RFC2616], Section 14.23:

```
Host = "Host" ":" host [ ":" port ]
```

9.2. Determining the Effective Request URI

If the Request-URI is an absoluteURI, then the effective request URI is the Request-URI.

If the Request-URI uses the abs_path form or the asterisk form, and the Host header field is present, then the effective request URI is constructed by concatenating:

- o the scheme name: "http" if the request was received over an insecure TCP connection, or "https" when received over a TLS/SSL-secured TCP connection, and,
- o the octet sequence "://", and,
- o the host, and the port (if present), from the Host header field, and

- o the Request-URI obtained from the Request-Line, unless the Request-URI is just the asterisk "*".

If the Request-URI uses the `abs_path` form or the asterisk form, and the Host header field is not present, then the effective request URI is undefined.

Otherwise, when Request-URI uses the authority form, the effective request URI is undefined.

Effective request URIs are compared using the rules described in [\[RFC2616\] Section 3.2.3](#), except that empty path components MUST NOT be treated as equivalent to an absolute path of `"/`.

9.2.1. Effective Request URI Examples

Example 1: the effective request URI for the message

```
GET /pub/WWW/TheProject.html HTTP/1.1
Host: www.example.org:8080
```

(received over an insecure TCP connection) is `"http"`, plus `"://"`, plus the authority component `"www.example.org:8080"`, plus the request-target `"/pub/WWW/TheProject.html"`. Thus it is: `"http://www.example.org:8080/pub/WWW/TheProject.html"`.

Example 2: the effective request URI for the message

```
OPTIONS * HTTP/1.1
Host: www.example.org
```

(received over an SSL/TLS secured TCP connection) is `"https"`, plus `"://"`, plus the authority component `"www.example.org"`. Thus it is: `"https://www.example.org"`.

10. Domain Name IDNA-Canonicalization

An IDNA-canonicalized domain name is the output string generated by the following steps. The input is a putative domain name string ostensibly composed of any combination of "A-labels", "U-labels", and "NR-LDH labels" (see [Section 2 of \[RFC5890\]](#)) concatenated using some separator character (typically `"."`).

1. Convert the input putative domain name string to a order-preserving sequence of individual label strings.

2. When implementing IDNA2008, convert, validate, and test each A-label and U-label found among the sequence of individual label strings, using the procedures defined in Sections [5.3](#) through [5.5](#) of [\[RFC5891\]](#).

Otherwise, when implementing IDNA2003, convert each label using the "ToASCII" conversion in [Section 4 of \[RFC3490\]](#) (see also the definition of "equivalence of labels" in [Section 2](#) of the latter specification).

3. If no errors occurred during the foregoing step, concatenate all the labels in the sequence, in order, into a string, separating each label from the next with a %x2E (".") character. The resulting string, known as a IDNA-canonicalized domain name, is appropriate for use in the context of [Section 8](#) "User Agent Processing Model".

Otherwise, errors occurred. The input putative domain name string was not successfully IDNA-canonicalized. Invokers of this procedure should attempt appropriate error recovery.

See also [Section 13](#) "Internationalized Domain Names for Applications (IDNA): Dependency and Migration" and [Section 14.9](#) "Internationalized Domain Names" of this specification for further details and considerations.

[11.](#) Server Implementation and Deployment Advice

This section is non-normative.

[11.1.](#) Non-Conformant User Agent Considerations

Non-conformant UAs ignore the Strict-Transport-Security header field, thus non-conformant user agents do not address the threats described in [Section 2.3.1](#) "Threats Addressed". Please refer to [Section 14.1](#) "Non-Conformant User Agent Implications" for further discussion.

[11.2.](#) HSTS Policy expiration time considerations

Server implementations and deploying web sites need to consider whether they are setting an expiry time that is a constant value into the future, or whether they are setting an expiry time that is a fixed point in time.

The constant value into the future approach can be accomplished by constantly sending the same max-age value to UAs.

For example, a max-age value of 7776000 seconds is 90 days:

```
Strict-Transport-Security: max-age=7776000
```

Note that each receipt of this header by a UA will require the UA to update its notion of when it must delete its knowledge of this Known HSTS Host.

The fixed point in time approach can be accomplished by sending max-age values that represent the remaining time until the desired expiry time. This would require the HSTS Host to send a newly-calculated max-age value on each HTTP response.

A consideration here is whether a deployer wishes to have the signaled HSTS Policy expiry time match that for the web site's domain certificate.

Additionally, server implementers should consider employing a default max-age value of zero in their deployment configuration systems. This will require deployers to wilfully set max-age in order to have UAs enforce the HSTS Policy for their host, and protects them from inadvertently enabling HSTS with some arbitrary non-zero duration.

11.3. Using HSTS in conjunction with self-signed public-key certificates

If all four of the following conditions are true...

- o a web site/organization/enterprise is generating its own secure transport public-key certificates for web sites, and
- o that organization's root certification authority (CA) certificate is not typically embedded by default in browser and/or operating system CA certificate stores, and
- o HSTS Policy is enabled on a host identifying itself using a certificate signed by the organization's CA (i.e., a "self-signed certificate"), and
- o and this certificate does not match a usable TLS certificate association (as defined by [Section 4](#) of the TLSA protocol specification [[I-D.ietf-dane-protocol](#)]),

...then secure connections to that site will fail, per the HSTS design. This is to protect against various active attacks, as discussed above.

However, if said organization wishes to employ its own CA, and self-

signed certificates, in concert with HSTS, it can do so by deploying its root CA certificate to its users' browsers or operating system CA root certificate stores. It can also, in addition or instead, distribute to its users' browsers the end-entity certificate(s) for specific hosts. There are various ways in which this can be accomplished (details are out of scope for this specification). Once its root CA certificate is installed in the browsers, it may employ HSTS Policy on its site(s).

Alternatively, that organization can deploy the TLSA protocol; all browsers that also use TLSA will then be able to trust the certificates identified by usable TLS certificate associations as denoted via TLSA.

NOTE: Interactively distributing root CA certificates to users, e.g., via email, and having the users install them, is arguably training the users to be susceptible to a possible form of phishing attack. See [Section 14.7](#) "Bogus Root CA Certificate Phish plus DNS Cache Poisoning Attack". Thus care should be taken in the manner in which such certificates are distributed and installed on users' systems and browsers.

11.4. Implications of includeSubDomains

The includeSubDomains directive has some practical implications. For example, if an HSTS Host offers HTTP-based services on various ports or at various subdomains of its host domain name, then they will all have to be available over secure transport in order to work properly.

For example, certification authorities often offer their CRL distribution and OCSP services [[RFC2560](#)] over plain HTTP, and sometimes at a subdomain of a publicly-available web application which may be secured by TLS/SSL. For example, `<https://ca.example.com/>` is a publicly-available web application for "Example CA", a certification authority. Customers use this web application to register their public keys and obtain certificates. Example CA generates certificates for customers containing `<http://crl-and-ocsp.ca.example.com/>` as the value for the "CRL Distribution Points" and "Authority Information Access:OCSP" certificate fields.

If `ca.example.com` were to issue an HSTS Policy with the includeSubDomains directive, then HTTP-based user agents implementing HSTS that have interacted with the `ca.example.com` web application would fail to retrieve CRLs, and fail to check OCSP for certificates, because these services are offered over plain HTTP.

In this case, Example CA can either:

- o not use the `includeSubDomains` directive, or,
- o ensure HTTP-based services offered at subdomains of `ca.example.com` are also uniformly offered over TLS/SSL, or,
- o offer plain HTTP-based services at a different domain name, e.g., `crl-and-ocsp.ca.example.NET`, or,
- o utilize an alternative approach to distributing certificate status information, obviating the need to offer CRL distribution and OCSP services over plain HTTP (e.g., the "Certificate Status Request" TLS extension [[RFC6066](#)], often colloquially referred to as "OCSP Stapling").

NOTE: The above points are expressly only an example and do not purport to address all the involved complexities. For instance, there are many considerations -- on the part of CAs, certificate deployers, and applications (e.g., browsers) -- involved in deploying an approach such as "OCSP Stapling". Such issues are out of scope for this specification.

12. User Agent Implementation Advice

This section is non-normative.

In order to provide users and web sites more effective protection, as well as controls for managing their UA's caching of HSTS Policy, UA implementers should consider including features such as:

12.1. No User Recourse

Failing secure connection establishment on any warnings or errors (per [Section 8.4](#) "Errors in Secure Transport Establishment") should be done with "no user recourse". This means that the user should not be presented with a dialog giving her the option to proceed. Rather, it should be treated similarly to a server error where there is nothing further the user can do with respect to interacting with the target web application, other than wait and re-try.

Essentially, "any warnings or errors" means anything that would cause the UA implementation to announce to the user that something is not entirely correct with the connection establishment.

Not doing this, i.e., allowing user recourse such as "clicking-through warning/error dialogs", is a recipe for a Man-in-the-Middle attack. If a web application advertises HSTS, then it is opting into this scheme, whereby all certificate errors or warnings cause a

connection termination, with no chance to "fool" the user into making the wrong decision and compromising themselves.

12.2. User-declared HSTS Policy

A User-declared HSTS Policy is the ability for users to explicitly declare a given Domain Name as representing an HSTS Host, thus seeding it as a Known HSTS Host before any actual interaction with it. This would help protect against the [Section 14.5](#) "Bootstrap MITM Vulnerability".

NOTE: Such a feature is difficult to get right on a per-site basis. See the discussion of "rewrite rules" in Section 5.5 of [\[ForceHTTPS\]](#). For example, arbitrary web sites may not materialize all their URIs using the "https" scheme, and thus could "break" if a UA were to attempt to access the site exclusively using such URIs. Also note that this feature would complement, but is independent of, an "HSTS Pre-Loaded List" feature (see [Section 12.3](#)).

12.3. HSTS Pre-Loaded List

An HSTS Pre-Loaded List is a facility whereby web site administrators can have UAs pre-configured with HSTS Policy for their site(s) by the UA vendor(s) -- a so-called "pre-loaded list" -- in a manner similar to how root CA certificates are embedded in browsers "at the factory". This would help protect against the [Section 14.5](#) "Bootstrap MITM Vulnerability".

NOTE: Such a facility would complement a "User-declared HSTS Policy" feature.

12.4. Disallow Mixed Security Context Loads

"Mixed security context" loads happen when an web application resource, fetched by the UA over a secure transport, subsequently causes the fetching of one or more other resources without using secure transport. This is also generally referred to as "mixed content" loads (see [Section 5.3](#) "Mixed Content" in [\[W3C.REC-wsc-ui-20100812\]](#)), but should not be confused with the same "mixed content" term that is also used in the context of markup languages such as XML and HTML.

NOTE: In order to provide behavioral uniformity across UA implementations, the notion of mixed security context will require further standardization work, e.g., to define the term(s) more clearly and to define specific behaviors with respect to it.

12.5. HSTS Policy Deletion

HSTS Policy Deletion is the ability to delete a UA's cached HSTS Policy on a per HSTS Host basis.

NOTE: Adding such a feature should be done very carefully in both the user interface and security senses. Deleting a cache entry for a Known HSTS Host should be a very deliberate and well-considered act -- it shouldn't be something users get used to just "clicking through" in order to get work done. Also, implementations need to guard against allowing an attacker to inject code, e.g. ECMAScript, into the UA that silently and programmatically removes entries from the UA's cache of Known HSTS Hosts.

13. Internationalized Domain Names for Applications (IDNA): Dependency and Migration

Textual domain names on the modern Internet may contain one or more "internationalized" domain name labels. Such domain names are referred to as "internationalized domain names" (IDNs). The specification suites defining IDNs and the protocols for their use are named "Internationalized Domain Names for Applications (IDNA)". At this time, there are two such specification suites: IDNA2008 [[RFC5890](#)] and its predecessor IDNA2003 [[RFC3490](#)].

IDNA2008 obsoletes IDNA2003, but there are differences between the two specifications, and thus there can be differences in processing (e.g., converting) domain name labels that have been registered under one from those registered under the other. There will be a transition period of some time during which IDNA2003-based domain name labels will exist in the wild. In order to facilitate their IDNA transition, user agents SHOULD implement IDNA2008 [[RFC5890](#)] and MAY implement [[RFC5895](#)] (see also [Section 7 of \[\[RFC5894\]\(#\)\]](#)) or [[UTS46](#)]. If a user agent does not implement IDNA2008, the user agent MUST implement IDNA2003.

14. Security Considerations

This specification concerns the expression, conveyance, and enforcement of the HSTS Policy. The overall HSTS Policy threat model, including addressed and unaddressed threats, is given in [Section 2.3](#) "Threat Model".

Additionally, the below sections discuss operational ramifications of the HSTS Policy, provide feature rationale, discuss potential HSTS

Policy misuse, and highlight some known vulnerabilities in the HSTS Policy regime.

14.1. Non-Conformant User Agent Implications

Non-conformant user agents ignore the Strict-Transport-Security header field, thus non-conformant user agents do not address the threats described in [Section 2.3.1](#) "Threats Addressed".

This means that the web application and its users wielding non-conformant UAs will be vulnerable to both:

- o Passive network attacks due to web site development and deployment bugs:

For example, if the web application contains any insecure, non-"https", references to the web application server, and if not all of its cookies are flagged as "Secure", then its cookies will be vulnerable to passive network sniffing, and potentially subsequent misuse of user credentials.

- o Active network attacks:

For example, if an attacker is able to place a man-in-the-middle, secure transport connection attempts will likely yield warnings to the user, but without HSTS Policy being enforced, the present common practice is to allow the user to "click-through" and proceed. This renders the user and possibly the web application open to abuse by such an attacker.

This is essentially the status-quo for all web applications and their users in the absence of HSTS Policy. Since web application providers typically do not control the type or version of UAs their web applications interact with, the implication is that HSTS Host deployers must generally exercise the same level of care to avoid web site development and deployment bugs (see [Section 2.3.1.3](#)) as they would if they were not asserting HSTS Policy.

14.2. Ramifications of HSTS Policy Establishment only over Error-free Secure Transport

The User Agent Processing Model defined in [Section 8](#), stipulates that a host is initially noted as a Known HSTS Host, or that updates are made to a Known HSTS Host's cached information, only if the UA receives the STS header field over a secure transport connection having no underlying secure transport errors or warnings.

The rationale behind this is that if there is a man-in-the-middle

(MITM) -- whether a legitimately deployed proxy or an illegitimate entity -- it could cause various mischief (see also [Appendix A](#) "Design Decision Notes", item 3, as well as [Section 14.5](#) "Bootstrap MITM Vulnerability"), for example:

- o Unauthorized notation of the host as a Known HSTS Host, potentially leading to a denial of service situation if the host does not uniformly offer its services over secure transport (see also [Section 14.4](#) "Denial of Service").
- o Resetting the time-to-live for the host's designation as a Known HSTS Host by manipulating the max-age header field parameter value that is returned to the UA. If max-age is returned as zero, this will cause the host to cease being regarded as an Known HSTS Host by the UA, leading to either insecure connections to the host or possibly denial-of-service if the host delivers its services only over secure transport.

However, this means that if a UA is "behind" a MITM non-transparent TLS proxy -- within a corporate intranet, for example -- and interacts with an unknown HSTS Host beyond the proxy, the user could possibly be presented with the legacy secure connection error dialogs. Even if the risk is accepted and the user clicks-through, the host will not be noted as an HSTS Host. Thus, as long as the UA is behind such a proxy the user will be vulnerable, and possibly be presented with the legacy secure connection error dialogs for as yet unknown HSTS Hosts.

Once the UA successfully connects to an unknown HSTS Host over error-free secure transport, the host will be noted as a Known HSTS Host. This will result in the failure of subsequent connection attempts from behind interfering proxies.

The above discussion relates to the recommendation in [Section 12](#) "User Agent Implementation Advice" that the secure connection be terminated with "no user recourse" whenever there are warnings and errors and the host is a Known HSTS Host. Such a posture protects users from "clicking through" security warnings and putting themselves at risk.

[14.3.](#) The Need for includeSubDomains

Without the includeSubDomains directive, a web application would not be able to adequately protect so-called "domain cookies" (even if these cookies have their "Secure" flag set and thus are conveyed only on secure channels). These are cookies the web application expects UAs to return to any and all subdomains of the web application.

For example, suppose example.com represents the top-level DNS name for a web application. Further suppose that this cookie is set for the entire example.com domain, i.e. it is a "domain cookie", and it has its Secure flag set. Suppose example.com is a Known HSTS Host for this UA, but the includeSubDomains flag is not set.

Now, if an attacker causes the UA to request a subdomain name that is unlikely to already exist in the web application, such as "https://uxdhbpahpdsf.example.com/", but that the attacker has managed to register in the DNS and point at an HTTP server under the attacker's control, then:

1. The UA is unlikely to already have an HSTS Policy established for "uxdhbpahpdsf.example.com", and,
2. The HTTP request sent to uxdhbpahpdsf.example.com will include the Secure-flagged domain cookie.
3. If "uxdhbpahpdsf.example.com" returns a certificate during TLS establishment, and the user clicks through any warning that might be presented (it is possible, but not certain, that one may obtain a requisite certificate for such a domain name such that a warning may or may not appear), then the attacker can obtain the Secure-flagged domain cookie that's ostensibly being protected.

Without the "includeSubDomains" directive, HSTS is unable to protect such Secure-flagged domain cookies.

14.4. Denial of Service

HSTS could be used to mount certain forms of Denial-of- Service (DoS) attacks against web sites. A DoS attack is an attack in which one or more network entities target a victim entity and attempt to prevent the victim from doing useful work. This section discusses such scenarios in terms of HSTS, though this list is not exhaustive. See also [[RFC4732](#)] for a discussion of overall Internet DoS considerations.

o Web applications available over HTTP

There is an opportunity for perpetrating DoS attacks with web applications that are -- or critical portions of them are -- available only over HTTP without secure transport, if attackers can cause UAs to set HSTS Policy for such web applications' host(s).

This is because once the HSTS Policy is set for a web application's host in a UA, the UA will only use secure transport

to communicate with the host. If the host is not using secure transport, or is not for critical portions of its web application, then the web application will be rendered unusable for the UA's user.

An HSTS Policy can be set for a victim host in various ways:

- * If the web application has a HTTP response splitting vulnerability [[CWE-113](#)] (which can be abused in order to facilitate "HTTP Header Injection").
- * If an attacker can spoof a redirect from an insecure victim site, e.g., <http://example.com/> to <https://example.com/>, where the latter is attacker-controlled and has an apparently valid certificate, then the attacker can set an HSTS Policy for example.com, and also for all subdomains of example.com.
- * If an attacker can convince users to manually configure HSTS Policy for a victim host. This assumes their UAs offer such a capability (see [Section 12](#) "User Agent Implementation Advice"). Or, if such UA configuration is scriptable, then an attacker can cause UAs to execute his script and set HSTS Policies for whichever desired domains.

o Inadvertent use of includeSubDomains

The includeSubDomains directive instructs UAs to automatically regard all subdomains of the given HSTS Host as Known HSTS Hosts. If any such subdomains do not support properly configured secure transport, then they will be rendered unreachable from such UAs.

[14.5.](#) Bootstrap MITM Vulnerability

The bootstrap MITM (Man-In-The-Middle) vulnerability is a vulnerability users and HSTS Hosts encounter in the situation where the user manually enters, or follows a link, to an unknown HSTS Host using a "http" URI rather than a "https" URI. Because the UA uses an insecure channel in the initial attempt to interact with the specified server, such an initial interaction is vulnerable to various attacks (see Section 5.3 of [[ForceHTTPS](#)]).

NOTE: There are various features/facilities that UA implementations may employ in order to mitigate this vulnerability. Please see [Section 12](#) "User Agent Implementation Advice".

14.6. Network Time Attacks

Active network attacks can subvert network time protocols (such as Network Time Protocol (NTP) [[RFC5905](#)]) - making HSTS less effective against clients that trust NTP or lack a real time clock. Network time attacks are beyond the scope of this specification. Note that modern operating systems use NTP by default. See also [Section 2.10](#) of [[RFC4732](#)].

14.7. Bogus Root CA Certificate Phish plus DNS Cache Poisoning Attack

An attacker could conceivably obtain a victim HSTS-protected web application's users' login credentials via a bogus root CA certificate phishing plus DNS cache poisoning attack.

For example, the attacker could first convince users of a victim web application (which is protected by HSTS Policy) to install the attacker's version of a root CA certificate purporting (falsely) to represent the CA of the victim web application. This might be accomplished by sending the users a phishing email message with a link to such a certificate, which their browsers may offer to install if clicked on.

Then, if the attacker can perform an attack on the users' DNS servers, (e.g., via cache poisoning) and turn on HSTS Policy for their fake web application, the affected users' browsers would access the attackers' web application rather than the legitimate web application.

This type of attack leverages vectors that are outside of the scope of HSTS. However, the feasibility such threats can be mitigated by including in a web application's overall deployment approach appropriate employment, in addition to HSTS, of security facilities such as DNS Security Extensions [[RFC4033](#)], plus techniques to block email phishing and fake certificate injection.

14.8. Creative Manipulation of HSTS Policy Store

Since an HSTS Host may select its own host name and subdomains thereof, and this information is cached in the HSTS Policy store of conforming UAs, it is possible for those who control an HSTS Host(s) to encode information into domain names they control and cause such UAs to cache this information as a matter of course in the process of noting the HSTS Host. This information can be retrieved by other hosts through clever loaded page construction causing the UA to send queries to (variations of) the encoded domain names. Such queries can reveal whether the UA had prior visited the original HSTS Host (and subdomains).

Such a technique could potentially be abused as yet another form of "web tracking" [[WebTracking](#)].

[14.9.](#) Internationalized Domain Names

Internet security relies in part on the DNS and the domain names it hosts. Domain names are used by users to identify and connect to Internet hosts and other network resources. For example, Internet security is compromised if a user entering an internationalized domain name (IDN) is connected to different hosts based on different interpretations of the IDN.

The processing models specified in this specification assume that the domain names they manipulate are IDNA-canonicalized, and that the canonicalization process correctly performed all appropriate IDNA and Unicode validations and character list testing per the requisite specifications (e.g., as noted in [Section 10](#) "Domain Name IDNA-Canonicalization"). These steps are necessary in order to avoid various potentially compromising situations.

In brief, some examples of issues that could stem from lack of careful and consistent Unicode and IDNA validations are things such as unexpected processing exceptions, truncation errors, and buffer overflows, as well as false-positive and/or false-negative domain name matching results. Any of the foregoing issues could possibly be leveraged by attackers in various ways.

Additionally, IDNA2008 [[RFC5890](#)] differs from IDNA2003 [[RFC3490](#)] in terms of disallowed characters and character mapping conventions. This situation can also lead to false-positive and/or false-negative domain name matching results, resulting in, for example, users possibly communicating with unintended hosts, or not being able to reach intended hosts.

For details, refer to the Security Considerations sections of [[RFC5890](#)], [[RFC5891](#)], and [[RFC3490](#)], as well as the specifications they normatively reference. Additionally, [[RFC5894](#)] provides detailed background and rationale for IDNA2008 in particular, as well as IDNA and its issues in general, and should be consulted in conjunction with the former specifications.

[15.](#) IANA Considerations

Below is the Internet Assigned Numbers Authority (IANA) Permanent Message Header Field registration information per [[RFC3864](#)].

Header field name: Strict-Transport-Security
Applicable protocol: HTTP
Status: standard
Author/Change controller: IETF
Specification document(s): this one

16. References

16.1. Normative References

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This specification is referenced due to its ongoing relevance to actual deployments for the foreseeable future.

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This specification is referenced due to its ongoing relevance to actual deployments for the foreseeable future.

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Appendix A. Design Decision Notes

This appendix documents various design decisions.

1. Cookies aren't appropriate for HSTS Policy expression as they are potentially mutable (while stored in the UA), therefore an HTTP header field is employed.
2. We chose to not attempt to specify how "mixed security context loads" (AMA "mixed content loads") are handled due to UA implementation considerations as well as classification difficulties.
3. An HSTS Host may update UA notions of HSTS Policy via new HSTS header field parameter values. We chose to have UAs honor the "freshest" information received from a server because there is the chance of a web site sending out an erroneous HSTS Policy, such as a multi-year max-age value, and/or an incorrect includeSubDomains flag. If the HSTS Host couldn't correct such errors over protocol, it would require some form of annunciation to users and manual intervention on the users' part, which could be a non-trivial problem for both web application providers and their users.
4. HSTS Hosts are identified only via domain names -- explicit IP address identification of all forms is excluded. This is for simplification and also is in recognition of various issues with using direct IP address identification in concert with PKI-based security.
5. The max-age approach of having the HSTS Host provide a simple integer number of seconds for a cached HSTS Policy time-to-live value, as opposed to an approach of stating an expiration time in the future was chosen for various reasons. Amongst the reasons are no need for clock synchronization, no need to define date and time value syntaxes (specification simplicity), and implementation simplicity.

Appendix B. Differences between HSTS Policy and Same-Origin Policy

HSTS Policy has the following primary characteristics:

HSTS Policy stipulates requirements for the security characteristics of UA-to-host connection establishment, on a per-host basis.

Hosts explicitly declare HSTS Policy to UAs. Conformant UAs are obliged to implement hosts' declared HSTS Policies.

HSTS Policy is conveyed over protocol from the host to the UA.

The UA maintains a cache of Known HSTS Hosts.

UAs apply HSTS Policy whenever making a HTTP connection to a Known HSTS Host, regardless of host port number. I.e., it applies to all ports on a Known HSTS Host. Hosts are unable to affect this aspect of HSTS Policy.

Hosts may optionally declare that their HSTS Policy applies to all subdomains of their host domain name.

In contrast, the Same-Origin Policy (SOP) [[RFC6454](#)] has the following primary characteristics:

An origin is the scheme, host, and port of a URI identifying a resource.

A UA may dereference a URI, thus loading a representation of the resource the URI identifies. UAs label resource representations with their origins, which are derived from their URIs.

The SOP refers to a collection of principles, implemented within UAs, governing the isolation of and communication between resource representations within the UA, as well as resource representations' access to network resources.

In summary, although both HSTS Policy and SOP are enforced by UAs, HSTS Policy is optionally declared by hosts and is not origin-based, while the SOP applies to all resource representations loaded from all hosts by conformant UAs.

[Appendix C](#). Acknowledgments

The authors thank Devdatta Akhawe, Michael Barrett, Ben Campbell, Tobias Gondrom, Paul Hoffman, Murray Kucherawy, Barry Leiba, James Manger, Alexey Melnikov, Haevard Molland, Yoav Nir, Yngve N. Pettersen, Laksh Raghavan, Marsh Ray, Julian Reschke, Tom Ritter, Peter Saint-Andre, Sid Stamm, Maciej Stachowiak, Andy Steingrubl, Brandon Sterne, Martin Thomson, Daniel Veditz, Jan Wrobel, as well as

all the websec working group participants and others for their various reviews and helpful contributions.

Thanks to Julian Reschke for his elegant re-writing of the effective request URI text, which he did when incorporating the ERU notion into the HTTPbis work. Subsequently, the ERU text in this spec was lifted from Julian's work in the updated HTTP/1.1 (part 1) specification and adapted to the [RFC2616] ABNF.

Appendix D. Change Log

[RFCEditor: please remove this section upon publication as an RFC.]

Changes are grouped by spec revision listed in reverse issuance order.

D.1. For [draft-ietf-websec-strict-transport-sec](#)

Changes from -11 to -12:

1. Addressed various issues in Ben Campbel's Gen-ART LC review. See this message for details: <<https://www.ietf.org/mail-archive/web/websec/current/msg01324.html>>

Changes from -10 to -11:

1. Various minor editorial fixes based on Barry Leiba's AD review, as well as ID-Nits warnings.
2. Clarification addition of directive-name and directive-value to Strict-Transport-Security ABNF in [Section 6.1](#), from Barry's AD review. <<https://www.ietf.org/mail-archive/web/websec/current/msg01265.html>>
3. Moved ref to [RFC5894](#) to Informational since it is a truly informational reference.

Changes from -09 to -10:

1. Added "(including when following HTTP redirects [[RFC2616](#)])" to [section 8.3](#). This addresses issue ticket #47. <<http://trac.tools.ietf.org/wg/websec/trac/ticket/47>>
2. Fixed max-age value in [section 10.1](#). Substituted 7776000 (actually 90 days) for 778000 (only 9 days). This addresses issue ticket #48. <<http://trac.tools.ietf.org/wg/websec/trac/ticket/48>>

3. Added mention of "Certificate Status Request" TLS extension [RFC6066] aka "OCSP stapling" to example in [section 10.3](#). This addresses issue ticket #49.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/49>>

Changes from -08 to -09:

1. Added IESG Note to [Section 3](#) "Conformance Criteria" per Barry Leiba's suggestion on the mailing list. <<https://www.ietf.org/mail-archive/web/websec/current/msg01200.html>>
2. Added additional requirement #5 to requirements for STS header field directives in [Section 6.1](#) per Alexey's review. This completes the addressing of issue ticket #45.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/45>>
3. Addressed editorial feedback in Murray's AppsDir review of -06.

Most all of these changes were addressing detailed/small editorial items, however note the addition of a couple of introductory paragraphs in the Security Considerations section, as well as a re-written and expanded [Section 14.6](#) "Bogus Root CA Certificate Phish plus DNS Cache Poisoning Attack", as well the new item #5 to [Appendix A](#) "Design Decision Notes".

This addresses issue ticket #46.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/46>>

Changes from -07 to -08:

1. Clarified requirement #4 for STS header field directives in [Section 6.1](#), and removed "(which "update" this specification)". Also added explicit "max-age=0" to [Section 6.1.1](#). Reworked final sentence in 2nd para of [Section 13](#). This addresses issue ticket #45.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/45>>

Changes from -06 to -07:

1. Various minor/modest editorial tweaks throughout as I went through it pursuing the below issue tickets. Viewing a visual diff against -06 revision recommended.
2. fixed some minor editorial issues noted in review by Alexey, fixes noted in here: <<https://www.ietf.org/mail-archive/web/websec/current/msg01163.html>>

3. Addressed ABNF exposition issues, specifically inclusion of quoted-string syntax for directive values. Fix STS header ABNF such that a leading ";" isn't required. Add example of quoted-string-encoded max-age-value. This addresses (re-opened) issue ticket #33.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/33>>
4. Reworked sections [8.1](#) through [8.3](#) to ensure matching algorithm and resultant HSTS Policy application is more clear, and that it is explicitly stipulated to not muck with attributes of superdomain matching Known HSTS Hosts. This addresses issue ticket #37.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/37>>
5. Added reference to [[I-D.ietf-dane-protocol](#)], pared back extraneous discussion in [section 2.2](#), and updated discussion in 10.2 to accomodate TLSA (nee DANE). This addresses issue ticket #39.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/39>>
6. Addressed various editorial items from issue ticket #40.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/40>>
7. Loosened up the language regarding redirecting "http" requests to "https" in [section 7.2](#) such that future flavors of permanent redirects are accommodated. This addresses issue ticket #43.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/43>>
8. Reworked the terminology and language in [Section 9](#), in particular defining the term "putative domain name string" to replace "valid Unicode-encoded string-serialized domain name". This addresses issue ticket #44.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/44>>

Changes from -05 to -06:

1. Addressed various editorial comments provided by Tobias G. This addresses issue ticket #38.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/38>>

Changes from -04 to -05:

1. Fixed up references to move certain ones back to the normative section -- as requested by Alexey M. Added explanation for referencing obsoleted [[RFC3490](#)] and [[RFC3492](#)]. This addresses issue ticket #36.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/36>>

2. Made minor change to Strict-Transport-Security header field ABNF in order to address further feedback as appended to ticket #33. This addresses issue ticket #33.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/33>>

Changes from -03 to -04:

1. Clarified that max-age=0 will cause UA to forget a known HSTS Host, and more generally clarified that the "freshest" info from the HSTS Host is cached, and thus HSTS Hosts are able to alter the cached max-age in UAs. This addresses issue ticket #13. <<http://trac.tools.ietf.org/wg/websec/trac/ticket/13>>
2. Updated section on "Constructing an Effective Request URI" to remove remaining reference to [RFC3986](#) and reference [RFC2616](#) instead. Further addresses issue ticket #14.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/14>>
3. Addresses further ABNF issues noted in comment:1 of issue ticket #27. <<http://trac.tools.ietf.org/wg/websec/trac/ticket/27#comment:1>>
4. Reworked the introduction to clarify the denotation of "HSTS Policy" and added the new [Appendix B](#) summarizing the primary characteristics of HSTS Policy and Same-Origin Policy, and identifying their differences. Added ref to [[RFC4732](#)]. This addresses issue ticket #28.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/28>>
5. Reworked language in [Section 2.3.1.3](#). wrt "mixed content", more clearly explain such vulnerability, disambiguate "mixed content" in web security context from its usage in markup language context. This addresses issue ticket #29.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/29>>
6. Expanded Denial of Service discussion in Security Considerations. Added refs to [[RFC4732](#)] and [[CWE-113](#)]. This addresses issue ticket #30.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/30>>
7. Mentioned in prose the case-insensitivity of directive names. This addresses issue ticket #31.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/31>>
8. Added [Section 11.4](#) "Implications of includeSubDomains". This addresses issue ticket #32.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/32>>

9. Further refines text and ABNF definitions of STS header field directives. Retains use of quoted-string in directive grammar. This addresses issue ticket #33.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/33>>
10. Added [Section 14.8](#) "Creative Manipulation of HSTS Policy Store", including reference to [[WebTracking](#)]. This addresses issue ticket #34.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/34>>
11. Added [Section 14.2](#) "Ramifications of HSTS Policy Establishment only over Error-free Secure Transport" and made some accompanying editorial fixes in some other sections. This addresses issue ticket #35.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/35>>
12. Refined references. Cleaned out un-used ones, updated to latest RFCs for others, consigned many to Informational. This addresses issue ticket #36.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/36>>
13. Fixed-up some inaccuracies in the "Changes from -02 to -03" section.

Changes from -02 to -03:

1. Updated section on "Constructing an Effective Request URI" to remove references to [RFC3986](#). Addresses issue ticket #14.
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/14>>
2. Reference [RFC5890](#) for IDNA, retaining subordinate refs to [RFC3490](#). Updated IDNA-specific language, e.g. domain name canonicalization and IDNA dependencies. Addresses issue ticket #26
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/26>>.
3. Completely re-wrote the STS header ABNF to be fully based on [RFC2616](#), rather than a hybrid of [RFC2616](#) and httpbis. Addresses issue ticket #27
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/27>>.

Changes from -01 to -02:

1. Updated [Section 8.3](#) "URI Loading and Port Mapping" fairly thoroughly in terms of refining the presentation of the steps, and to ensure the various aspects of port mapping are clear. Nominally fixes issue ticket #1
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/1>>

2. Removed dependencies on [I-D.[draft-ietf-httpbis-p1-messaging-15](#)]. Thus updated STS ABNF in [Section 6.1](#) "Strict-Transport-Security HTTP Response Header Field" by lifting some productions entirely from [I-D.[draft-ietf-httpbis-p1-messaging-15](#)] and leveraging [[RFC2616](#)]. Addresses issue ticket #2
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/2>>.
3. Updated Effective Request URI section and definition to use language from [I-D.[draft-ietf-httpbis-p1-messaging-15](#)] and ABNF from [[RFC2616](#)]. Fixes issue ticket #3
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/3>>.
4. Added explicit mention that the HSTS Policy applies to all TCP ports of a host advertising the HSTS Policy. Nominally fixes issue ticket #4
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/4>>
5. Clarified the need for the "includeSubDomains" directive, e.g. to protect Secure-flagged domain cookies. In [Section 14.3](#) "The Need for includeSubDomains". Nominally fixes issue ticket #5
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/5>>
6. Cited Firesheep as real-live threat in [Section 2.3.1.1](#) "Passive Network Attackers". Nominally fixes issue ticket #6
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/6>>.
7. Added text to [Section 12](#) "User Agent Implementation Advice" justifying connection termination due to tls warnings/errors. Nominally fixes issue ticket #7
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/7>>.
8. Added new subsection [Section 8.6](#) "Missing Strict-Transport-Security Response Header Field". Nominally fixes issue ticket #8
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/8>>.
9. Added text to [Section 8.4](#) "Errors in Secure Transport Establishment" explicitly note revocation check failures as errors causing connection termination. Added references to [[RFC5280](#)] and [[RFC2560](#)]. Nominally fixes issue ticket #9
<<http://trac.tools.ietf.org/wg/websec/trac/ticket/9>>.
10. Added a sentence, noting that distributing specific end-entity certificates to browsers will also work for self-signed/private-CA cases, to [Section 11](#) "Server Implementation and Deployment Advice" Nominally fixes issue ticket #10

[<http://trac.tools.ietf.org/wg/websec/trac/ticket/10>](http://trac.tools.ietf.org/wg/websec/trac/ticket/10).

11. Moved "with no user recourse" language from [Section 8.4](#) "Errors in Secure Transport Establishment" to [Section 12](#) "User Agent Implementation Advice". This nominally fixes issue ticket #11
[<http://trac.tools.ietf.org/wg/websec/trac/ticket/11>](http://trac.tools.ietf.org/wg/websec/trac/ticket/11).
12. Removed any and all dependencies on [I-D.[draft-ietf-httpbis-p1-messaging-15](#)], instead depending on [[RFC2616](#)] only. Fixes issue ticket #12
[<http://trac.tools.ietf.org/wg/websec/trac/ticket/12>](http://trac.tools.ietf.org/wg/websec/trac/ticket/12).
13. Removed the inline "XXX1" issue because no one had commented on it and it seems reasonable to suggest as a SHOULD that web apps should redirect incoming insecure connections to secure connections.
14. Removed the inline "XXX2" issue because it was simply for raising consciousness about having some means for distributing secure web application metadata.
15. Removed "TODO1" because description prose for "max-age" in the Note following the ABNF in [Section 6](#) seems to be fine.
16. Decided for "TODO2" that "the first STS header field wins". TODO2 had read: "Decide UA behavior in face of encountering multiple HSTS headers in a message. Use first header? Last?". Removed TODO2.
17. Added [Section 1.1](#) "Organization of this specification" for readers' convenience.
18. Moved design decision notes to be a proper appendix [Appendix A](#).

Changes from -00 to -01:

1. Changed the "URI Loading" section to be "URI Loading and Port Mapping".
2. (HASMAT) reference changed to (WEBSEC).
3. Changed "server" -> "host" where applicable, notably when discussing "HSTS Hosts". Left as "server" when discussing e.g. "http server"s.

4. Fixed minor editorial nits.

Changes from [draft-hodges-strict-transport-sec-02](#) to [draft-ietf-websec-strict-transport-sec-00](#):

1. Altered spec metadata (e.g. filename, date) in order to submit as a WebSec working group Internet-Draft.

D.2. For [draft-hodges-strict-transport-sec](#)

Changes from -01 to -02:

1. updated abstract such that means for expressing HSTS Policy other than via HSTS header field is noted.
2. Changed spec title to "HTTP Strict Transport Security (HSTS)" from "Strict Transport Security". Updated use of "STS" acronym throughout spec to HSTS (except for when specifically discussing syntax of Strict-Transport-Security HTTP Response Header field), updated "Terminology" appropriately.
3. Updated the discussion of "Passive Network Attackers" to be more precise and offered references.
4. Removed para on normative/non-normative from "Conformance Criteria" pending polishing said section to IETF RFC norms.
5. Added examples subsection to "Syntax" section.
6. Added OWS to maxAge production in Strict-Transport-Security ABNF.
7. Cleaned up explanation in the "Note:" in the "HTTP-over-Secure-Transport Request Type" section, folded 3d para into "Note:", added conformance clauses to the latter.
8. Added explanatory "Note:" and reference to "HTTP Request Type" section. Added "XXX1" issue.
9. Added conformance clause to "URI Loading".
10. Moved "Notes for STS Server implementers:" from "UA Implementation Advice" to "HSTS Policy expiration time considerations:" in "Server Implementation Advice", and also noted another option.
11. Added cautionary "Note:" to "Ability to delete UA's cached HSTS Policy on a per HSTS Server basis".

12. Added some informative references.

13. Various minor editorial fixes.

Changes from -00 to -01:

1. Added reference to HASMAT mailing list and request that this spec be discussed there.

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