Universal Acceptance

Introduction to Universal Acceptance (UA)

Universal Acceptance Steering Group (UASG)

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About This Document

The Internet's technologies, including its naming components, continually evolve and change. In recent years, new top-level domains (TLDs), some with traditional ASCII characters and some with non-ASCII characters (Internationalized Domain Names), have been approved by the Internet Corporation for Assigned Names and Numbers (ICANN). Examples include .nyc, .संगठन, .eco, and .католик. However, many applications and services have not been updated to manage this expanded range of TLDs. In addition, Internet email standards now allow non-ASCII characters in email addresses, so until software is upgraded, it will not properly handle these domains and addresses. This affects the user experience in multiple ways:

- Valid email addresses are not recognized or accepted.
- Domain names are mistakenly treated as search terms in the address bar of the browser.

Until software recognizes and processes all domain names and email addresses – a state known as Universal Acceptance (UA) – it will not be possible to provide a consistent and positive experience for all Internet users. This document provides a broad introduction to Universal Acceptance and the efforts being made to assist in the development of Universal Acceptance-ready software.

Target Audience

This document is intended to introduce Universal Acceptance to a technical audience (developers, managers, and operators) that may be familiar with some aspects of Internet technology but not necessarily the details of how new IDNs, domain names, and email addresses affect the way in which they should be accepted, validated, stored, processed, and displayed. It represents a starting point for people with diverse technical backgrounds to begin their exploration of Universal Acceptance.

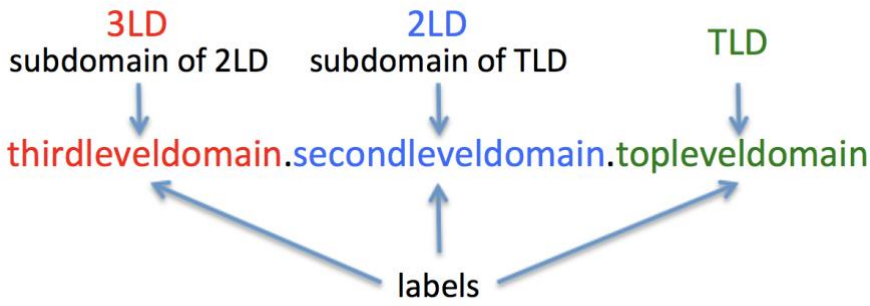
Background Concepts

Domain Names

A domain name is a human-friendly identifier for computers and networks on the Internet. It is customarily represented as a sequence of text labels separated by “dots” (the period or full-stop punctuation mark); for example, www.example.tld. Each label represents a level in the Domain Name System (DNS) hierarchy.

At the highest level or “root” of the hierarchy are top-level domain (TLD) labels such as com, jp, and বাংলা, which appear at the end of a domain name. Because they appear at the end, TLDs are sometimes called “suffixes.”

Proceeding down the DNS hierarchy from the root, the next label identifies a subdomain of the TLD, commonly called a second-level domain; the label after that identifies a subdomain of the second-level domain, commonly called a third-level domain; and so on, with each of the labels separated from its neighbor by a dot. For example, a domain name with three levels might look like this:



Country Code Top-level Domains (ccTLDs)

Some TLDs are delegated to specific countries or territories. These are called country code top-level domains (ccTLDs). In the past, all ccTLDs were two letters matching the ISO 3166 two-letter code assigned to the country or territory by the International Organization for Standardization. Since 2010, there have also been internationalized ccTLDs that represent the name of a country or territory in that country or territory’s own script.

Generic Top-level Domains (gTLDs)

Most TLDs that are not ccTLDs are called generic top-level domains (gTLDs), which are either open to anyone or restricted to the members of a defined community. These include the familiar .com, .net, and .org as well as more recent additions.

Through the New gTLD Program – an initiative coordinated by ICANN – the Domain Name System (DNS) has expanded exponentially through the introduction of new generic top-level domains. These new gTLDs can represent brands, communities of interest, geographic areas (cities, regions), and more.

Domain Name Internationalization

Domain names were originally limited to a subset of ASCII characters (letters a-z, digits 0-9, and the hyphen "-"). Since the earliest .com registration, symbolics.com in 1985, the number and characteristics of domain names have expanded to reflect the needs of the ever-increasing global use of the Internet as a communal resource. Today, the majority of Internet users are non-English speakers; however, the dominant language used on the Internet is English. To help with the internationalization of the Internet, in 2003 the Internet Engineering Task Force (IETF) started releasing standards providing technical guidelines for the deployment of Internationalized Domain Names (IDNs) through a translation mechanism to support non-ASCII representations of domain names in any Unicode-supported script (*e.g.*, 普遍接受-测试.世界, ua-test.كاثوليك,etc.).

The ICANN Board of Directors approved the process to introduce new IDN ccTLDs in October 2009, with the first IDN ccTLDs added to the root zone in May 2010. In June 2011, the Board approved and authorized the launch of the New gTLD Program, which included new ASCII as well as IDN TLDs. The first batch of TLDs from this program was added to the root zone in 2013.

The Need for Universal Acceptance (UA)

A decade after the IETF released its IDN-related guidelines, and through the ICANN New gTLD Program, more than 1,000 new TLDs are now active. However, some software and applications remain outdated and are unable to handle these new TLDs. This causes problems for Internet users, including those who use non-ASCII characters and scripts. Universal Acceptance ensures that all valid domain names and email addresses are accepted, validated, stored, processed, and displayed correctly and consistently by all Internet-enabled applications, devices, and systems. For example, every valid web address resolves to the expected resource on the correct website and every valid email address results in mail delivery to the expected recipient.

The Universal Acceptance Steering Group (UASG) is an Internet community initiative, supported by ICANN, that is tasked with undertaking activities that will effectively promote Universal Acceptance and help ensure a consistent and positive experience for Internet users globally.

U-labels and A-labels

Domain names that use non-ASCII characters are called Internationalized Domain Names (IDNs). The internationalized portion of a domain name can be in any label—not just the TLD.

Since the DNS itself previously only used ASCII, it was necessary to create an additional encoding to allow non-ASCII Unicode code points to be represented as ASCII strings. The algorithm that implements this Unicode-to-ASCII encoding is called Punycode**;** the output strings are called A-Labels. A-Labels can be distinguished from an ordinary ASCII label because they always start with the following four characters:

xn--

These characters are called the ACE prefix.[1]

The Punycode transformation is reversible: it can transform from Unicode to an A-Label and from an A-label back to a string of Unicode characters (known as a U-Label).

The only standard use of the Punycode algorithm is for expressing internationalized domains. While one could hypothetically encode other UTF-8 strings using Punycode, that would be non-standard and would not interoperate with other systems.

Examples of (imaginary) IDNs

U-label version	A-label version
example.みんな	example.xn--q9jyb4c
大坂.info	xn--uesx7b.info
みんな.大坂	xn--q9jyb4c.xn--uesx7b

Email Address Internationalization (EAI)

Email addresses contain two parts:

- A local part (before the “@” character).
- A domain part (after the “@” character).

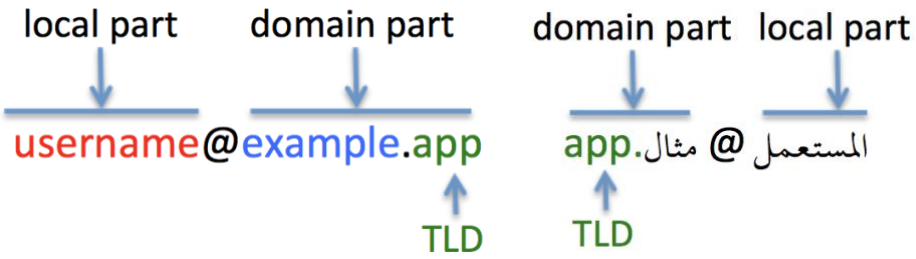
Because both left-to-right (LTR) and right-to-left (RTL) scripts can be used in email addresses and domain names, “before” and “after” should be understood with respect to the directionality of the script.

Examples of (imaginary) EAI Addresses

user@example.みんな	Uses IDN TLD
user@大坂.info	Uses IDN second-level domain
用戶@example.lawyer	Uses Unicode local part and new gTLD

[1] ASCII Compatible Encoding (ACE) prefix which distinguishes Punycode-encoded labels from other ASCII labels.

Example of Right-to-Left text in an EAI Address



LTR **RTL**

In an internationalized email address, the domain part can contain any domain name, including those with new TLDs, and can contain Unicode U-labels. The local part is not a domain name and can in principle contain nearly any Unicode character, although in practice mail systems will limit the characters used in their mailbox names.

The term Email Address Internationalization (EAI) is often used to describe the use of internationalized addresses in email.

Dynamic Link Generation (Linkification)

Modern software such as popular word processing or spreadsheet applications sometimes allows a user to create a hyperlink simply by typing in a string that looks like a web address, email address, or network path. For example, typing “www.icann.org” into an email message may automatically result in a clickable link to http://www.icann.org if the app recognizes “www.” as a special prefix or “.org” as a special suffix.

When it is used, linkification should work consistently for all well-formed web addresses, email addresses, or network paths, and not just some. Accurate linkification is difficult and depends on the context of the text (for example, in some languages “www” doesn’t indicate a web address), so it is not further addressed here.

The Dynamic Nature of the Root Zone Registry

The DNS is a large distributed database divided into sections called zones. The section that contains all TLDs is called the root zone because it is conceptually at the root of the tree of DNS names. All DNS zones, including the root zone, are updated as required. As new TLDs are added or old TLDs are retired, their names are added to or removed from the root zone.

This means that any fixed list of TLDs, such as a list stored in an application or in a file, will eventually and inevitably become out of date. To reliably validate the TLD in a domain name, software can check it online with a DNS query, or if it uses a file, refresh the file on a regular basis. These are both described in more detail later.

Universal Acceptance in Action

Five Criteria of Universal Acceptance

Universal Acceptance is the state in which all valid domain names and email addresses are accepted, validated, stored, processed, and displayed correctly and consistently by all Internet-enabled applications, devices and systems. The five criteria of Universal Acceptance are described below.

1. Accept[2]	***Accepting* occurs whenever an email address or a domain name is received as a string of characters from a user interface, from a file, or from an API used by a software application or online service.** Applications and services allow domain names and email addresses to be: ▪ Entered via user interfaces, or ▪ Received from other applications and services via APIs.
2. Validate[3]	***Validation* may occur in many places whenever an email address or a domain name is either received or emitted as a string of characters by an application or online service.** Validation is intended to ensure that the entered information is either valid or at least definitely not invalid. Validation ensures the information has the correct syntax and may make other checks. For domain names and email addresses, many programmers have traditionally relied on *ad hoc* validation methods such as checking that a TLD is within length limits, or that the characters are from the ASCII character set. However, these methods are based on assumptions that are no longer applicable because the Internet is changing: ▪ Domain names and email addresses can now include non-ASCII Unicode characters. ▪ The list of TLDs is changing. ▪ Any label in a domain name, including the TLD label, can be up to 63 characters long.[4] It remains possible to validate TLDs using other techniques, as described later.

2 Accepting is treated as distinct from Validating in this document. In practice, the actions may overlap.
3 Accepting and Processing are treated as distinct from Validating in this document. In practice, the actions may overlap.
4 The 63-character length limit applies to the label itself if it is an ASCII label, or to the A-label form of the label if it is an IDN.

3. Store	***Storage* occurs when an email address or a domain name is stored as a string of characters in a database or file used by a software application or online service and later retrieved by the same or other software applications.** Applications and services might require long-term and/or transient storage of domain names and email addresses. Regardless of the lifetime of the data, it must be stored in: ▪ Formats defined by an Internet-standard Request for Comments (RFC), or (less desirably) ▪ Alternative formats that can be translated to and from RFC-defined formats. Although Unicode in DNS names and email addresses are stored as UTF-8, other formats may be encountered in legacy code. See the Good Practices section below.
4. Process[5]	***Processing* occurs when an email address or a domain name is used by an application or service to perform an activity such as searching or sorting a list, or is transformed into an alternative format (such as turning U-labels into A-labels).** Additional validation may occur during processing. The ways in which email addresses and domain names may be processed is limited only by the imagination of application developers, but it is important not to make assumptions (*e.g.*, that email addressed to *pākehā@tetaurawhiri.govt.nz* is intended for a person in New Zealand) that depend on policies outside of the DNS.
5. Display	**The *Display* action occurs when an email address or a domain name is rendered within a user interface.** Displaying domain names and email addresses is usually, but not always, straightforward when the scripts used in the name or address are supported in the underlying operating system and when the strings are stored in Unicode.[6] If these conditions are not met, application-specific transformations may be required. Further, even if the underlying operating system does support the strings, display can be complicated if, for example, RTL and LTR scripts are mixed, or the overall directionality of text is unclear.

[5] Processing is treated as distinct from Validating in this document. In practice, the actions may overlap.

[6] It is important to recognize that display is not straightforward, even when these conditions are met for some complex scripts.

User Scenarios

The examples and definitions above may give the impression that Universal Acceptance is only about computer systems and online services. The reality, however, is that it's also about the people using those systems and services.

Below are some examples of activities that require Universal Acceptance:

Registering a new TLD	An organization adopts a "brand" TLD to offer its customers a differentiated customer experience by providing email addresses in the format: customername @example.brand. Universal Acceptance means: ▪ Web sites and applications accept these "@example.brand" email addresses as they would with older TLDs such as .com, .net, .org.
Accessing a gTLD	A user accesses a website whose domain name contains a new TLD by typing an address into a browser or clicking a link in a document. Universal Acceptance means: ▪ Even though the TLD is new, the user's browser displays the web address in its native form and accesses the site as the user expects. The browser does not display domain names as A-labels to the user unless it benefits the user in some way.
Using an email address containing a new gTLD as an online identity	A user acquires an email address with the domain portion using a new gTLD and uses this email address as their identity for accessing their bank and airline loyalty accounts. Universal Acceptance means: ▪ Even though the domain used in the email address is new, the bank or airline site accepts the address the same way in which it accepts an address in an older TLD such as .biz or .eu.
Accessing an IDN	A user accesses an IDN URL by typing the URL into a browser or clicking a link in a document. Universal Acceptance means: ▪ Even if the domain name contains characters different than the language settings on the user's computer, any browser the user wishes to use will display the web address as expected and access the site successfully.

Using an internationalized email address for email	A user has acquired a new email address which includes non-ASCII characters in the domain name (*e.g.,* ĩnfo@普遍接受-测试.世界). Universal Acceptance means: ▪ The user can send to and receive from any email address, using any email client.
Using an internationalized email address as an online identity	A user acquires a non-ASCII email address and uses this email address as their identity for accessing their bank and airline loyalty accounts. Universal Acceptance means: ▪ The bank or airline site accepts the new identity exactly as if it were any other email identity.
Dynamically creating a hyperlink in an application	A user types a web address into a document or email message. Universal Acceptance means: ▪ The rules used by the application to automatically generate a hyperlink are the same if the address is non-ASCII or contains a new TLD.
Developing an application	A developer writes an app that accesses web resources. Universal Acceptance means: ▪ The tools used by the developers include libraries that enable Universal Acceptance by supporting new TLDs and IDNs.

Nonconformance to Universal Practices

The following are considered to be poor practice:

✕	Displaying A-labels to the user without a corresponding user benefit, such as to show the mapping between a U-label and a A-label.
✕	Requiring a user to enter A-labels when signing up for a new email address or requiring a user to enter A-labels when signing up for a new hosted domain.
✕	Validating the syntax of domain name or email address using out of date criteria or non-authoritative online domain name resources.
✕	Using an outdated list of TLDs even though new TLDs are regularly being added and deleted.
✕	Exposing internal use of A-labels to users. For example, converting domains in EAI addresses to A-labels when replying to an EAI user.

✕	Treating some domain names as search terms rather than as domain names because the application does not recognize them as such.
✕	Setting spam blockers to automatically block entire (new) TLDs without evidence of abuse.

Technical Requirements for UA Readiness

For an application or website to be UA-ready, it must meet a variety of requirements.

High-Level Requirements

An application or service that supports Universal Acceptance (UA):

1. **Supports all domain names regardless of length or character set.**
See RFC 5892.

2. **Allows all of the character sets that are valid for domain names and email addresses.**

Accept Unicode code points as well as ASCII.

3. **Can correctly render all code points in Unicode strings.**

See RFC 3490. Note that Unicode regularly adds new code points, so this is a moving target.

4. **Can correctly render right-to-left (RTL) strings such as those in Arabic and Hebrew.**

For information about RTL scripts, see RFC 5893.

5. **Can communicate data between applications and services in UTF-8 and, where needed, other encodings that can be converted to and from UTF-8.**

For information about UTF-8, see RFC 3629.

6. **Offers public and private APIs that support UTF-8.**

Private APIs apply only to inter-service calls by the same vendor.

7. **Treats EAI addresses correctly.**

In particular, doesn't convert IDNs in addresses to A-labels.

8. **Can send email to and receive email from recipients regardless of domain name or character set.**

See RFC 6530.

9. Stores user data in formats that support Unicode and is convertible to and from UTF-8.

Such conversions would be visible only to the operator of the product or service.

10. Supports all top-level domain names in the authoritative ICANN TLD list regardless of length or character set.

See the authoritative list at https://data.iana.org/TLD/.

Developer Considerations

Since many existing software systems contain hardcoded assumptions about domains and email addresses, code changes may be required to recognize IDNs, new TLDs, and EAI mail addresses. This section discusses how developers can incorporate code changes that will enable Universal Acceptance.

Designing Software for Compatibility and Flexibility

The Robustness Principle, as articulated by Jon Postel in RFC 793, is a general design guideline for software development:

"Be conservative in what you do; be liberal in what you accept from others."

That is, be conservative in what you send: in any area in which a specification might be ambiguous or unclear, avoid anything that could surprise others. On the other hand, when receiving, accept anything that is plausibly valid. This does *not* mean changing code to work around clear mistakes in other implementations since that leads to an undocumented and "undebuggable" mess.

Good Practices for Developing and Updating Software to Achieve UA-Readiness

Accept	
✓	Display names as Unicode whenever possible. Users should be allowed, but not required, to enter domain names as A-labels rather than U-labels. However, U-labels should be shown by default, with A-labels shown to the user only when it provides a benefit.
!	**Don't** generate EAI addresses with A-labels but **do** be able to handle them if presented by someone else's software.
✓	Any user interface element requiring a user to type a domain name or email address must accept long names. ASCII domain names can have up to 63 characters in each label and can be in total up to 253 bytes. UTF-8 labels can be much longer than ASCII labels and the total length can be up to 670 bytes.

	Remember that the UTF-8 code for most Unicode code points takes more than one byte. ▪ See RFC 1035.

Validate	
✓	Validate only as appropriate**.** **Validate only if it is required for the operation of the application or service.** This is the most reliable way to ensure that all valid domain names are accepted into your systems.
✓	Recognize that syntactically correct inputs may represent domain names or email addresses that are currently in use on the Internet. That may or may not be valid depending on the application.
!	When you validate, consider the following: ▪ Verify the TLD portion of a domain name against an authoritative table. IANA publishes the list of top-level domains at: ∗ https://data.iana.org/TLD/tlds-alpha-by-domain.txt ∗ See also: https://www.icann.org/en/system/files/files/sac-070-en.pdf ▪ Query the domain name against the DNS. ∗ The GETDNS API (http://getdnsapi.net/) is a highly portable way to query the DNS. ∗ Most operating systems also have a native DNS query API. ▪ Require repeated entry of an email address to detect typing errors. ▪ Validate the characters in labels by checking that each label follows the Internationalizing Domain Names in Applications (IDNA 2008) rules. ∗ See RFC 5892 ▪ Limit validation of labels itself to a small number of whole-label rules defined in the RFCs. ∗ See RFC 5894 ▪ Ensure that the product or feature handles numbers correctly. ∗ For example: Arabic-Indic digit characters should be treated as numbers in numeric input fields, as well as ASCII digits. ∗ Note that Arabic-Indic digits are valid in U-labels but are not considered equivalent to ASCII digits in that context.

Store	
✓	Applications and services should support the most current Unicode standards.
✓	Information should be stored in the UTF-8 format whenever possible. Some systems may require legacy support for UTF-16 as well, but generally UTF-8 is preferred. UTF-7 is obsolete, and UTF-32 is too bulky for file storage. The strings should be normalized when appropriate (some normalization can in some context result in loss of information).
!	Consider all end-to-end scenarios before converting between A-Labels and U-Labels when storing. In new applications, it is better to maintain only U-Labels in a file or database, because it simplifies searching, sorting, and presentation. However, conversion may have implications when interoperating with older, non-Unicode-enabled applications and services.
✓	Tag email addresses and domain names as such in storage for easier access. Filing email addresses and domain names in the “author” field of a document or “contact info” in a log file have led to the loss of the original address.
✓	Regardless of the way addresses and domain names are stored, you must be able to match strings in multiple formats. For example, a search for example.みんなshould also find example.xn--q9jyb4c.

Process	
✓	Ensure all web server and MIME mail responses have UTF-8 specified in the content type.
✓	Specify UTF-8 in the web server http header. ▪ It is important to ensure that the encoding is specified on every response.
!	Consider context before converting A-Labels to U-Labels and vice versa during processing. It is desirable to maintain only U-Labels in a file or database as it simplifies searching and sorting. However, conversion may have implications when interoperating with older, non-Unicode-enabled applications and services.

✓	Ensure that the product or feature handles sort order, searches, and collation according to locale and language specifications, and that it addresses multilanguage searching and sorting.
✗	Don't use percent encoding for labels in domain names: ▪ example.みんな is correct ▪ example.%E3%81%BF%E3%82%93%E3%81%AA is not correct.
✓	Since the Unicode standard is continually expanding, code points not defined when the application or service was created should be checked to ensure they don't produce erroneous or confusing output. Missing fonts in the underlying operating system may result in non-displayable characters (frequently a small box is used to represent these), but this situation should not result in a crash or error message.
✓	Use supported Unicode-enabled APIs.
✓	Use the latest Internationalized Domain Names in Applications (IDNA 2008) Protocol and Tables documents for IDNs: ▪ RFC 5891 ▪ RFC 5892
✓	Process text in UTF-8 format wherever possible.
✓	Coordinate upgrades of applications and the services they depend on. If the server is Unicode and client is non-Unicode, or vice versa, the data will need to be converted in every transaction, which is error prone and can be slow.
✓	When doing character transformation, text strings may grow or shrink substantially. Each UTF-8 code point may be from 1 to 4 bytes, and in some cases a single character in another encoding may correspond to several UTF-8 code points or vice versa.

Display	
✓	Display all Unicode code points that are supported by the underlying operating system. Modern operating systems all have Unicode support, but their rendering engines are not always correct for all scripts and languages. Provide character rendering in applications only when correct rendering is not available from the target operating system(s).
✓	When developing an app or a service consider the languages supported and make sure operating systems and applications cover those languages.

✓	Convert A-labels to U-labels before display. For example, the end user should see “example.みんな” rather than “example.xn--q9jyb4c”. (This conversion is an example of UA-ready processing).
✓	Display domain names as U-labels by default. Display A-labels to the user only when it provides a benefit.
!	Be aware that mixed-script domain names are possible. ▪ Some Unicode characters may look the same to the human eye, but different to computers; for example, Latin O, Cyrillic O, and Greek omicron O. ▪ Mixed-script strings are common in closely related scripts (*e.g.*, Japanese Kanji, Katakana, Hiragana, and Romaji.) Otherwise mixed scripts may be intended for malicious purposes, such as phishing. Use Unicode Technical Standard #39, Unicode Security Mechanisms,[7] to check that the scripts in a Unicode sequence follow good practice. ▪ If the user interface calls the strings to the user’s attention, be sure that it does so in a way that is not prejudicial to users of non-Latin scripts. Learn more about Unicode Security Considerations at: http://unicode.org/reports/tr36.
✓	Be aware of unassigned and disallowed characters for domain names. ▪ See RFC 5892

Unicode	
✓	Use supported Unicode-enabled APIs.
✗	Use standard, well-debugged APIs for: ▪ String format conversions. ▪ Determining which script comprises a string. ▪ Determining if a string contains a mix of scripts. ▪ Unicode normalization/decomposition.

[7] See https://www.unicode.org/reports/tr39/#Restriction_Level_Detection

✗	Don't use UTF-7 and limit the use of UTF-32. ▪ UTF-7 is obsolete. ▪ UTF-32 uses four bytes for each code point. Since each code point takes the same amount of space and can be directly indexed in arrays, it's convenient to use within program code, but may be too bulky for storage in files and databases.
✗	Don't use UTF-16 except where it is explicitly required (as in certain Windows APIs, and Javascript applications). In UTF-16, 16 bits can only represent characters from 0x0 to 0xFFFF. Values above this range (0x10000 to 0x10FFFF) use pairs of pseudo-characters known as surrogates. If handling of surrogate pairs is not thoroughly tested, it may lead to tricky bugs and potential security holes.
✓	Use UTF-8 in cookies so they can be read correctly by applications.
✓	Use IDNA 2008 Protocol and Tables documents: ▪ RFC 5891 ▪ RFC 5892
✗	Do not use IDNA 2003 which has been superseded by IDNA 2008.
!	Maintain IDNA and Unicode tables that are consistent with regard to versions. For example, unless the application actually executes the classification rules in the Tables document to interpret code points as entered (RFC 5892), its IDNA tables must be derived from the version of Unicode that is supported on the system. The tables do not need to reflect the latest version of Unicode, but they must be consistent.
✓	Validate labels using IDNA 2008 whole-label rules. ▪ In some contexts, further validation may be appropriate; for example, if the application knows what scripts are allowed in the domain names it uses.

General	
✓	Use authoritative resources to validate domain names. Do not make outdated *ad hoc* assumptions, such as "all TLDs are 6 characters or shorter."
✓	Ensure that the product or feature handles numbers correctly. For example, ASCII numerals and Asian ideographic number representations should all be treated as numbers in numeric contexts.

!	Look for mail addresses that may be EAI addresses in unexpected places: ▪ Artist/author/photographer/copyright metadata. ▪ Font metadata. ▪ DNS contact records. ▪ Binary version information. ▪ Support information. ▪ OEM contact information. ▪ Registration, feedback, and other forms.
!	Restrict the code points allowed when generating new domain names and email addresses: All products that use email addresses must accept internationalized email addresses, allowing most UTF-8 printing characters in the local part. However, an app or service need not allow all of these characters when a user creates a new IDN or EAI address. Preventing certain IDNs or email addresses from being created in the first place can mitigate some likely security and accessibility concerns. (NOTE: Good practice would still require software to accept such strings if presented.)
!	Be aware that Universal Acceptance cannot always be measured through automated test cases alone. For example, testing how an app or protocol handles network resource may not always be possible and sometimes it is best to verify the compliance through functional spec and design review.
!	Don't assume that because a component does not directly call name-resolution APIs or directly use email addresses, it does not affect it. Understand how domain names are obtained by the component—it is not always through user interaction. The following are some examples on how the component can get a domain name: ▪ Group policy. ▪ LDAP query. ▪ Configuration files. ▪ Windows Registry. ▪ Transferred to or from another component or feature.
✓	Perform code reviews to avoid buffer overflow attacks. ▪ In Unicode, strings may expand or shrink when case folded or normalized. ▪ When doing character conversion, text may grow or shrink substantially.

Other challenges

Mechanism to detect and convert character sets	Some older email applications used local character encodings and did not have a way to detect and convert text to and from UTF-8 as needed. This was especially true for the email headers (TO, CC, BCC, Subject).
Managing multiple email addresses as a single user identity	When a user has multiple email addresses it may be tricky to manage these addresses as a single user identity. Email programs can direct traffic addressed to such aliases to the same mailbox, but applications may still treat the addresses as different identities.

Authoritative Sources for Domain Names: DNS Root Zone and IANA Lists

There are two sources for the authoritative list of TLDs. The first source is the DNS root zone itself. It is Domain Name Security Extensions (DNSSEC)-signed, so its contents can be authenticated by a DNSSEC-aware name server, although its contents are fairly hard to parse as a text file. Another source is the text file of TLDs that IANA publishes (one TLD per line in alphabetical order). These files are on https web servers, so it is good practice to check that the site's Transport Layer Security (TLS) certificate is valid when downloading to be sure you're getting the right file.

You can obtain the list of TLDs from either of the following links:

- https://www.internic.net/domain/root.zone (root zone file)
- https://data.iana.org/TLD/tlds-alpha-by-domain.txt (text TLD file)

Email with IDNs and Why It Is Not the Same as EAI

Email Address Internationalization (EAI) mail prefers UTF-8 domain names; ASCII coded A-Labels are discouraged. Some mail systems have made partial provisions for email addresses that include IDNs rather than provide full EAI support. Because IDNs can be represented as ASCII A-labels, some existing software allows the IDNs in an email address to be represented in ASCII or Unicode. For example, some software will treat these two IDN addresses equivalently for all purposes (sending, receiving, and searching):

user@example.みんな **=** user@example.xn--q9jyb4c

However, some software will not treat these addresses as equivalent even though both are valid, because it does not convert an A-label ("xn--q9jyb4c") into its U-label equivalent ("みんな") before comparing. This can result in an unpredictable user experience. The user experience may become especially confusing if some software converts U-labels into A-labels for "compatibility." As the messages are replied-to or forwarded, the addresses that are visibly different to a user, or which fail to search and sort as expected, may increase.

As in the example below, some software may attempt to convert the local part of the email address using Punycode, the algorithm that is used to convert A-labels into U-labels (and *vice versa*). This sort of conversion is invalid and will create invalid, undeliverable addresses.

Never try to convert the local part of an email address into a different form

- ✓ 用戶@example.みんな
- ✗ xn--youq53b@example.xn--q9jyb4c

Robust UA-ready software and services should be able to handle and treat all these formats correctly and should be able to handle both UTF-8 local parts and UTF-8 U-labels in addresses, while also accepting A-labels in addresses for backward compatibility.

Linkification and Its Challenges

Modern software sometimes allows a user to automatically create a hyperlink simply by typing in a string that looks like a web address, email name, or network path. For example, typing “www.icann.org” into an email message may automatically result in a clickable link to http://www.icann.org if the application recognizes “www.” as an initial label or “.org” as a TLD.

Linkification is the action whereby an application accepts a string and dynamically determines whether it should create a hyperlink to an Internet Location (http:// or https://) or an email address (mailto:). Linkification, if it happens, should work consistently for all well-formed web addresses, email names, and network paths.

Linkification uses algorithms and rules created by software developers to determine whether or not a string should be interpreted as a link. Related to this is how people can identify a string as a domain name. While browsers, email clients, and word processors are obvious places, there are many more applications that make these decisions.

Good Practice Recommendations

1. Attempt to linkify based on explicit protocol prefixes (*e.g.* “https://”, ftp://”, “mailto:”) but only complete the action if the rest of the string is well-formed.

Example String	**Expected Behavior/ Result**
example.com	No linkification because protocol is absent and not inferred.
http://example.com	Create hyperlink because protocol is explicit.
http:example.com	No linkification because of bad syntax (missing //).
http://example.a	No linkification because “a” is not a TLD.
http://example..ab	No linkification because of bad syntax (consecutive dots).
http://普遍接受-测试.世界	Create hyperlink because protocol is explicit.

2. Attempt to linkify based on implicit protocol prefixes (*e.g.* “www” infers “http://www”).

Example String	Expected Behavior/ Result
www.example.com	Create hyperlink because protocol is implied[8]
label@example.com	Create mailto: label@example.com because protocol is implied.

3. The HTML surrounding URLs that contain bidirectional text may include codes that affect the direction in which text is displayed. The linkified version should keep the same display direction.

4. If TLDs are used as a “special token” to determine linkability, then all TLDs must be included. A list of TLDs should be updated on a frequent basis.

Unicode—Background and Code Point Attributes

The Unicode standard has been evolving since it was first published as Unicode 1.0 in 1991. Each version since has added more characters and code points to handle more languages and scripts. The current version is 12.1.

In Unicode, every code point has a set of properties, such as Uppercase_Letter, Decimal_Number, or Nonspacing_Mark. Many characters have a script property such as Latin, Han (Chinese), or Arabic, while others, such as punctuation, do not.

As described below, IDNA uses code point attributes to determine which characters are allowed in IDNs. UAX#44, Unicode Character Database, describes the database of code point attributes.

UTF8, UTF16, and Other Encoding Methods

A Unicode code point can have a numeric value ranging from zero to 0x10FFFF. Since a single byte can hold only values from 0 to 0xFF, some sort of multi-byte encoding is needed to store Unicode code points.

The original version of Unicode had fewer than 64K (0xFFFF) code points, so each code point could fit in a 16 bit integer. This led to a two-byte encoding known as UCS or UCS-2. When Unicode expanded past 64K code points, UCS was extended into UTF-16[9], which uses pairs of otherwise invalid 16-bit code points known as *surrogates* to represent values greater than 64K. While this works, it has led to debugging problems since surrogates add complexity to any code that counts the number of code points in a string, or that sorts strings into code point order. An additional problem is that some computers such as those made by IBM store the high byte of a 16-bit value first (“big-endian”), and some such as those made by Intel store the low byte first (“little-endian”). As a result, UTF-16 has two storage variants:

[8] Note: the actual website might be https-only and require https:// instead of http://. If this is the case, then the hyperlink may not resolve.

[9] See section 3.10 of the Unicode standard for technical details of UTF-8, UTF-16, and UTF-32, at https://www.unicode.org/versions/Unicode12.0.0/ch03.pdf.

UTF-16BE and UTF-16LE. There are techniques to detect and fix endian problems but they can lead to bugs. At this point, UTF-16 is primarily used in existing applications with Microsoft Windows APIs, and the Java and Javascript languages.

An alternative encoding is UTF-8, which encodes each code point as a variable length string of one to four bytes. UTF-8 has several advantages over UTF-16, including that the ASCII subset of Unicode is encoded as a single byte so any ASCII string is automatically a UTF-8 string. UTF-8 is usually more compact than its UTF-16 equivalent, and is easier to sort because UTF-8 strings sorted in byte order are automatically in code point order. IDNA and EAI all require UTF-8 coding.

UTF-32 is a simple format that stores each code point in a 32-bit integer. It is convenient for internal processing in programs since the code points in an array of UTF-32 can be indexed directly, but it is rarely used in storage because of its bulk.

IDNA – A Brief History and Current State

Internationalized Domain Names in Applications (IDNA) was first defined by the IETF in 2003 as what is now known as IDNA2003[10]. It included an algorithm to map Unicode code points into a standard form in domain name labels known as Nameprep, and an algorithm to encode Unicode code point labels in ASCII known as Punycode. Nameprep includes transformations such as mapping upper to lower case.

After some experience with IDNA, the IETF developed and published a revised spec known as IDNA2008 in 2010[11]. IDNA2008 created the terms U-label and A-label and removed the Nameprep step, advising that applications should do a mapping appropriate for the locale and application environment. IDNA2008 was updated for Unicode 6.0 by RFC 6452 in 2011 and continues to be reviewed by the IETF.

In practice, too many implementations are still using IDNA2003. A few libraries do use tables (like the ones included in IDNA2003) created for IDNA2008. No locale mappings exist for IDNA2008 except the standard case folding and normalization rules included in the Unicode Standard.

One exception is that there are a few mappings from UTS#46, Unicode IDNA Compatibility Processing. This specifies whether a few common characters that are mapped in IDNA2003 but allowed as characters in IDNA2008 should be accepted or mapped. It is important for applications to treat these characters according to IDNA2008 and not IDNA2003, and that if UTS#46 is in use, it is used in a way that is compatible with IDNA2008.

Use Cases for Testing

Software that is intended to handle IDNs and EAI mail addresses should be tested with a wide range of domain names and addresses. See UASG 004, *Use Cases for UA Readiness Evaluation*, for a set of test cases.

10 The definition is in RFCs 3490, 3491, and 3492.
11 The definition is in RFCs 5890, 5891, 5892, 5893, 5894, and 5895.

Upgrading Software for EAI

EAI conformance requires upgrades to mail servers, submission and delivery software, mail user agents and web mail, and any application that handles email addresses and sends mail.

For a detailed overview of EAI, its issues, and how to implement it, see UASG 012, *Email Address Internationalization (EAI): A Technical Overview.*

Advanced Topics

Complex Scripts

The details of complex scripts may be of limited interest to those who are not developers creating their own string parsing or display libraries. Nevertheless, a summary is included here to ensure that all readers have sufficient awareness to recognize code bugs related to these scripts when encountered in user experiences.

For formatted HTML text in web pages and email, the HTML standards have elaborate features for handling and displaying complex and bidirectional text, which developers should understand and use to render text. See the WHATWG HTML standard section on rendering[12], and the corresponding section of the W3C HTML standard[13].

Right-to-Left Languages and Unicode Conformance

Some scripts, such as Latin and Devanagari, display characters from left to right when text is presented in horizontal lines. Other scripts, such as Arabic or Hebrew, display characters from right to left. The text can also be bidirectional when a right-to-left script uses digits that are written from left to right or when it uses embedded words from English or other languages that are written using left-to-right scripts.

Challenges and ambiguities can occur when the horizontal direction of the text is not uniform. To solve this issue, there is an algorithm to determine the directionality for bidirectional Unicode text.

There is a set of rules that should be applied by the application to produce the correct order at the time of display which are described by the Unicode Bidirectional Algorithm. We generally refer to this as the “Bidi algorithm”.

The Bidi Algorithm

The Bidi algorithm describes how software should process text that contains both left-to-right (LTR) and right-to-left (RTL) sequences of characters. The base direction[14] assigned to the

12 Available at https://html.spec.whatwg.org/multipage/rendering.html
13 Available at https://www.w3.org/TR/2018/WD-html53-20181018/rendering.html
14 In HTML the base direction is either inherited from the default direction of the document, which is left-to-right, or explicitly set by the nearest parent element that uses the “dir” direction attribute.

phrase will determine the order in which text is displayed. This can be either left-to-right or right-to-left and defines the order in which sequences of characters are displayed. In this document, the base direction is left to right so all sequences of characters are displayed with the first sequence to the left of the second sequence.

To know if a sequence is left-to-right or right-to-left, each character in Unicode has an associated directional property. Most letters are strongly typed (strong characters) as LTR (left-to-right) or RTL (right-to-left) depending on the script of which they are a part. A sequence of strongly typed RTL characters will be displayed from right to left. This is independent of the surrounding base direction. For example:

(LTR) example - مثال (RTL).

Text with different directionality can be mixed in line. In such cases, the Bidi algorithm produces a separate directional run out of each sequence of contiguous characters with the same directionality.

Spaces and most punctuation are not strongly typed as either LTR or RTL in Unicode because they may be used in either type of script. They are therefore classified as neutral or weak characters. Weak characters are those which are generally used in one direction, but in some contexts may be used in the other. Examples of this type of character include:

- European digits.
- Eastern Arabic-Indic digits.
- Arithmetic and currency symbols.
- Punctuation symbols that are common to many scripts, such as the colon, comma, full-stop, and the no-break space.

The directionality of neutral characters is indeterminate without context. Some examples include:

- Tabs.
- Paragraph separators.
- Most other whitespace characters.

When a neutral character is between two strongly typed characters that have the same directional type, it will also assume that directionality. For example, a neutral character between two RTL characters will be treated as an RTL character itself, and will have the effect of extending the directional run:

- نطاق.مثال

Even if there are several neutral characters between the two strongly typed characters, they will all be treated in the same way.

When a space or punctuation falls between two strongly typed characters that have different directionality, the neutral character(s) will be treated as if it has the same directionality as the prevailing base direction. For example:

- example. مثال

Remember that this document has left to right as its base sequence so *example* is the second level domain and مثال the TLD.

Unless a directional override is present, numbers are always encoded and entered high-order digit first, and the numerals rendered LTR. The weak directionality applies only to the placement of the number in its entirety.

The full details of the Bidi algorithm are described in Unicode Technical Report #9.

The Bidi Rule for Domain Names

A Bidi domain name is one that contains at least one RTL label. The Bidi rule for domain names, specified in RFC 5893[15], limits the code points in names so that there are no two names that are different sequences of code points but display the same due to bidirectional display rules.

Joiners

Some languages use alphabetic scripts in which single phonemes are written using two characters called a digraph. In other words, a digraph is a group of two successive letters that represent a single sound (or phoneme).

Examples of digraphs in English		
ch (as in church) ph (as in phony)	th (then) th (think)	sh (shoe) gh (rough)

Some digraphs are fully joined as ligatures. In writing and typography, a ligature occurs where two or more graphemes or letters are joined as a single glyph. An example is the ampersand character (*&*), which evolved from the adjoined Latin letters *e* and *t* (“et” means “and”). In typeset English, fi and ffi often are displayed as ligatures.

If ligatures and digraphs have the same interpretation in all languages that use a given script, Unicode normalization generally resolves the differences and makes them match. When they have different interpretations, matching must use alternative methods (likely chosen at the registry level) or users must be educated to understand that matching will not occur. An example of different interpretation can be found in Section 4.3 of RFC 5894[16]. The Unicode Consortium lists two main strategies to determine the joining behavior of a particular character after applying the Bidi algorithm to deal with zero width joiner characters known as ZWJ and ZWNJ. (To learn more about these joiners see http://www.unicode.org/L2/L2005/05307-zwj-zwnj.pdf.)

[15] *Right-to-Left Scripts for Internationalized Domain Names for Applications (IDNA)*, RFC 5893, https://www.rfc-editor.org/info/rfc5893

[16] *Internationalized Domain Names for Applications (IDNA): Background, Explanation, and Rationale*, RFC 5894, https://www.rfc-editor.org/rfc/rfc5894.html#section-4.2

- When shaping, an implementation can refer back to the original backing store to see if there were adjacent ZWNJ or ZWJ characters.
- Alternatively, the implementation can replace ZWJ and ZWNJ by an out-of-band character property associated with those adjacent characters, so that the information does not interfere with the Bidi algorithm and the information is preserved across rearrangement of those characters. Once the Bidi algorithm has been applied, that out-of-band information can then be used for proper shaping.

Domain name registries and any other entity that allows the creation of domain names (*e.g.* applications that create third- and lower-level labels) must follow the Bidi Rule for Domain Names to ensure that names will display consistently and to prevent confusing names that can be used for homograph attacks.

To learn more about joiners, see Section 4.3 of RFC 5894.

Homoglyphs and Similar Characters

Homoglyphs are characters that, due to similarities in size and shape, appear identical or confusingly similar. They frequently occur when mixing Latin, Cyrillic, and Greek scripts. For example, Latin “o” (code U+006f), Cyrillic small letter “o” (code U+043e), and Greek small letter omicron “o” (code U+03bf.) In some cases, there are homoglyphs in a single script, such as the small Croatian letter “lj” (code U+01c9) and the two letters “lj” (code U+006c U+006a). See the table at http://homoglyphs.net/ for more examples.

To prevent domain names with homoglyphs, registries should use Label Generation Rules (LGRs) that limit the code points in a label to a set from a single script or compatible scripts. Each registry should have LGRs for each script in which it accepts registrations[17].

To learn more about Unicode security mechanisms for confusable detection, see:

- http://www.unicode.org/reports/tr39/#Confusable_Detection

To learn more about confusingly similar characters and good practice, see:

- M3AAWG Unicode Abuse Overview and Tutorial https://www.m3aawg.org/sites/default/files/m3aawg-unicode-tutorial-2016-02.pdf
- M3AAWG Best Practices for Unicode Abuse Prevention https://www.m3aawg.org/sites/default/files/m3aawg-unicode-best-practices-2016-02.pdf

Normalization, Case Folding, and String Preparation

Unicode Normalization helps to determine whether any two Unicode strings are equivalent to each other and provides standard forms to use to process and store strings. Some characters can be represented in Unicode by several code sequences. This is called Unicode equivalence. Unicode provides two types of equivalences:

[17] IANA has a collection of registry LGRs in its Repository of IDN Practices at https://www.iana.org/domains/idn-tables.

- Canonical
- Compatibility

Sequences representing the same visual character are called canonically equivalent. These sequences have the same appearance and meaning when printed or displayed. For example:

U+006E (Latin lowercase “n”) followed by U+0303 (the combining tilde “◌̃”)	= ñ
U+00F1 (lowercase letter “ñ” of the Spanish alphabet)	= ñ

Unicode defines NFC (Normalization Form C) as Canonical Decomposition, followed by Canonical Composition. This reduces text to a minimal number of code points while not changing its appearance. It should be noted that in this example, three characters above are valid to be used according to IDNA2008.

Compatibility equivalents are sequences which can appear different, but in some contexts the same meaning. It is a weaker type of equivalence between characters or sequences of characters. For example:

U+FB00 (the typographic ligature “ﬀ”)	= ff
U+0066 U+0066 (two Latin “f” letters)	= ff

In the example above, the code point U+FB00 is defined to be compatible, but not canonically equivalent to the sequence U+0066 U+0066. Sequences that are canonically equivalent are also compatible, but the opposite is not always true.

It should be noted that the code point U+FB00 is not valid according to IDNA2008. Unicode defines NFKC (Normalization Form KC) a Compatibility Decomposition, followed by Canonical Composition. This reduces text to a standard set code points and may change its appearance. For example, NKFC turns the ligature “ﬀ” into the two letters “f f” and the ante meridian symbol ㏂ (U+33C2) into the four characters “a.m.” (U+0061 U+002E U+006D U+002E.)

To avoid interoperability problems arising from the use of canonically equivalent, yet different, character sequences, the W3C recommends using NFC for all text.

To see a list of all characters that may change in any of the Normalization Forms, see: http://www.unicode.org/charts/normalization.

Some other points to note:

- The characters in IDN labels must be in NFC form.
- When two applications share Unicode data, but normalize them differently, errors and data loss can occur.
- The Unicode consortium asserts that Normalization Forms must remain stable over time. In other words, a string must remain normalized under all future versions of Unicode for backward compatibility.

- As pointed out earlier, be conservative when looking at what code points to allow in a domain name.

Tips for software developers	
✗	Don't attempt to normalize by converting to uppercase or ignoring non-spacing characters, because this makes sorting, data copying import and export, and data retrieval by client applications difficult and may result in data loss or corruption.
✗	Never allow code points in domain names which are not allowed according to IDNA2008.

To learn more about Unicode normalization, see:

- http://www.w3.org/TR/charmod-norm
- http://unicode.org/reports/tr15

Case Folding and Mapping

Case folding and mapping is the process of turning all of the characters in a string into the same case, usually lower case. Mapping upper case [A-Z] to lower case [a-z] works for ASCII-only text documents, but is far more complex in languages that use additional characters. Case mapping can be context-dependent, with the mapped character depending on the context in which it occurs, *e.g.*, various forms of the Greek sigma. It can also be locale-dependent, with the mapped character depending on the locale in which the text is interpreted, *e.g.*, Turkish dotted and undotted upper and lower case I. Case folding is locale-independent, for strings that will be interpreted by software, while case mapping is locale-dependent and is intended for text to be read by people. Finally, mapping to upper case and mapping to lower case are **not** inverse functions.

For IDNs, IDNA2008 allows applications to use any appropriate case mapping because the mapping takes place before the validation of code points. In practice, locale-specific identifier mappings do not exist and everyone uses the mappings from Unicode's UTS#46[18].

Tips for software developers	
✓	Consider the desired goal before attempting case mapping: is it a generic map for labels, a string in a known language, or something else?
✓	Perform Unicode Normalization before case folding.

[18] UTS#46, *Unicode IDNA Compatibility Processing*, https://www.unicode.org/reports/tr46/#Mapping

Glossary and Other Resources

Glossary

A-label	The ASCII-compatible encoded (ACE) representation of a label in an Internationalized Domain Name, used internally within the DNS protocol. A-labels always begin with the ACE prefix “xn--”. An A-label can be converted to a U-label and back without loss of information.
ACE prefix	ASCII Compatible Encoding Prefix “xn--”.
ASCII	American Standard Code for Information Interchange. ASCII includes unaccented Latin characters and the European-Arabic digits. ASCII is a subset of Unicode: every ASCII character is also a Unicode character.
API	An Application Programming Interface (API) is a set of routines, protocols, and tools for building software and applications. An API may be for a web based system, operating system, or database system, and it provides facilities to develop applications for that system using a given programming language.
Codespace	Range that defines the lower and upper bounds for an encoding.
Code point	A code point is a numerical value in a code space. Code points are used to distinguish a numerical value from its encoding as a sequence of bits, and to distinguish an abstract character from a particular graphical representation of it (glyph).
DNS Root Zone	The root zone is the central directory for the DNS, which is a key component in looking things up in DNS; for example, translating host names into IP addresses.
EAI	Email Address Internationalization allows UTF-8 characters in an email address—the domain name, the local part, or both.

IANA	Internet Assigned Numbers Authority. Its functions include: ▪ Management of the DNS Root, the .int and .arpa domains, and an IDN practices resource. ▪ Coordination of the global pool of IP and AS numbers, primarily providing them to Regional Internet Registries (RIRs). ▪ Internet Protocols' numbering systems are managed in conjunction with standards bodies.
ICANN	ICANN's mission is to help ensure a stable, secure, and unified global Internet. To reach another person on the Internet, you need to type an address – a name or a number – into your computer or other device. That address must be unique so computers know where to find each other. ICANN helps coordinate and support these unique identifiers across the world. ICANN was formed in 1998 as a not-for-profit public-benefit corporation with a community of participants from all over the world.
IDN	Internationalized Domain Name. IDNs are domain names that include UTF-8 characters beyond the twenty-six letters of the basic Latin alphabet "a-z", the numbers 0-9, and the hyphen "-".
IDNA	Internationalized Domain Names in Applications.
IDN ccTLD	Country code top-level domain that includes characters beyond the twenty-six letters of the basic Latin alphabet "a-z". Examples: ▪ .рф (Russia) ▪ .صر (Egypt) ▪ .السعودية (Saudi Arabia)
IETF	The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. It is open to any interested individual. The IETF develops Internet Standards, in particular, the standards related to the Internet Protocol Suite (TCP/IP) and the protocols used for the web like HTTP and TLS.
Language	The method of human communication, either spoken or written, consisting of the use of words in a structured and conventional way.
Punycode	An algorithm that represents UTF-8 in the limited character subset of ASCII supported by the Domain Name System (DNS). Punycode is used in A- labels in the Internationalized Domain Names in Applications (IDNA) framework.

Registrar	An organization where domain names are registered by users. The registrar keeps records of the contact information and submits the technical information to a central directory known as the “registry”.
Registry	The authoritative, master database of all domain names registered in each top-level domain (TLD).
RFC	A Request for Comments (RFC) is a formal document from the Internet Engineering Task Force (IETF) that is the result of committee drafting and subsequent review by interested parties. Some (but not all) RFCs document approved Internet standards.
Script	The collection of letters or characters used in writing, representing the sounds of a language.
Second-level domain name	In the Domain Name System (DNS) hierarchy, a second-level domain (SLD or 2LD) is a domain that is directly below a top-level domain (TLD). For example, in example.com, example is the second-level domain of the .com TLD.
U-label	A U-label is an IDNA-valid string of Unicode characters including at least one non-ASCII character. It can be converted to an A-label and back without loss of information.
UA-ready software or UA-readiness	Software that has the ability to accept, store, process, validate, and display all top-level domains, IDNs, and email addresses equally.
Unicode	A universal character encoding standard. It defines the way individual characters are represented in text files, web pages, and other types of documents. Unicode was designed to support characters from all languages around the world. It can support roughly 1,000,000 characters. See: http://unicode.org.
UTF	Unicode Transformation Format. It is a way of representing Unicode code points as a stream of bytes. UTF-8 is the preferred UTF for handling IDN and EAI. UTF-8 converts Unicode to 8-bit bytes.
M3AAWG	The Messaging, Malware and Mobile Anti-Abuse Working Group (M3AAWG) is where the industry comes together to work against botnets, malware, spam, viruses, DoS attacks, and other online exploitation. See: https://www.m3aawg.org/.
W3C	The World Wide Web Consortium (W3C) is an international community where member organizations, a full-time staff, and the public work together to develop web standards like HTML. See: https://www.w3.org/.

WHATWG	The Web Hypertext Application Technology Working Group (WHATWG) is a community of people interested in evolving the web through standards and tests. The WHATWG was founded by individuals of Apple, the Mozilla Foundation, and Opera Software in 2004, after a W3C workshop. See https://whatwg.org/.
ZWJ	Zero-Width Joiner is non-printing character used in the computerized typesetting of some scripts, including Arabic and all of the Indic scripts. When placed between two characters that would otherwise not be connected, a ZWJ causes them to be printed in their connected form.
ZWNJ	Zero-Width Non-Joiner is a non-printing character used in the computerization of writing systems that make use of ligatures. For some languages and scripts, many of the letters of the alphabet naturally connect with the following letter when written in a word, forming a ligature. In order to correctly display certain prefixes, suffixes, and compound words, however, the ZWNJ is used to override this natural behavior of joining letters and prevent them from joining the following letter (but without adding a space between the two).

For a complete ICANN glossary, go to: https://www.icann.org/icann-acronyms-and-terms/.

RFCs and Key Standards

IDN RFCs	
RFC 3492	**Punycode: A Bootstring encoding of Unicode for Internationalized Domain Names in Applications (IDNA)** RFC 3492 describes Punycode as: "*a simple and efficient transfer encoding syntax designed for use with Internationalized Domain Names in Applications (IDNA)*" Punycode transforms uniquely and reversibly a Unicode string into an ASCII string. This RFC defines a general algorithm called Bootstring. This algorithm allows a string of basic code points to uniquely represent any string of code points drawn from a larger set. https://tools.ietf.org/html/rfc3492

RFC 5890	**Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework** This RFC describes the usage context and protocol for a revision of Internationalized Domain Names for Applications (IDNA). https://tools.ietf.org/html/rfc5890
RFC 5891	**Internationalized Domain Names in Applications (IDNA) Protocol** This RFC specifies the protocol mechanism, called Internationalized Domain Names in Applications (IDNA), for registering and looking up IDNs in a way that does not require changes to the DNS itself. https://tools.ietf.org/html/rfc5891
RFC 5892	**The Unicode Points and Internationalized Domain Names for Applications (IDNA)** The RFC 5892 specifies rules for deciding whether a code point, considered in isolation or in context, is a candidate for inclusion in an Internationalized Domain Name (IDN). https://tools.ietf.org/html/rfc5892
RFC 5893	**Right-to-left scripts for Internationalized Domain Names for Applications (IDNA)** This RFC provides a new Bidi rule for Internationalized Domain Names for Applications (IDNA) labels, for the use of right-to-left scripts in Internationalized Domain Names. https://tools.ietf.org/html/rfc5893
RFC 5894	**Internationalized Domain Names for Applications (IDNA): Background, Explanation and Rationale** This informational document provides an overview of a revised system to deal with newer versions of Unicode and provides explanatory material for its components. https://tools.ietf.org/html/rfc5894
RFC 5895	**Mapping Characters for Internationalized Domain Names in Applications (IDNA) 2008** This RFC describes the actions that can be taken by an implementation between receiving user input and passing permitted code points to the new IDNA protocol (2008). It describes an operation that is to be applied to user input in order to prepare that user input for use in an “on the network” protocol. It also includes a general implementation procedure for mapping. https://tools.ietf.org/html/rfc5895

EAI RFCs	
RFC 6530	**Overview and Framework for Internationalized Email** This standard introduces a series of specifications that define mechanisms and protocol extensions needed to fully support internationalized email addresses. This document describes how the various elements of email internationalization fit together and the relationships among the primary specifications associated with message transport, header formats, and handling. https://tools.ietf.org/html/rfc6530
RFC 6531	**SMTP Extension for Internationalized Email** The document defines a Simple Mail Transfer Protocol extension so servers can advertise the ability to accept and process internationalized email addresses and internationalized email headers. https://tools.ietf.org/html/rfc6531
RFC 6532	**Internationalized Email Headers** This document specifies an enhancement to the Internet Message Format and to MIME that allows use of Unicode in mail addresses and most header field content. This document specifies an enhancement to the Internet Message Format (RFC 5322) and to MIME that permits the direct use of UTF-8, rather than only ASCII in header field values, including mail addresses. A new media type, message/global, is defined for messages that use this extended format. This specification also lifts the MIME restriction on having non-identity content-transfer-encodings on any subtype of the message top-level type so that message/global parts can be safely transmitted across existing mail infrastructure. https://tools.ietf.org/html/rfc6532
RFC 6533	**Internationalized Delivery Status and Disposition Notifications** This specification adds a new address type for international email addresses so an original recipient address with non-ASCII characters can be correctly preserved even after downgrading. This also provides updated content return media types for delivery status notifications and message disposition notifications to support use of the new address type. https://tools.ietf.org/html/rfc6533

RFC 8398	**Internationalized Email Addresses in X.509 Certificates** This document defines a new name form for inclusion in the otherName field of an X.509 Subject Alternative Name and Issuer Alternative Name extension that allows a certificate subject to be associated with an internationalized email address. https://tools.ietf.org/html/rfc8398.
RFC 8399	**Internationalization Updates to RFC 5290** The updates to RFC 5280 described in this document provide alignment with the 2008 specification for Internationalized Domain Names (IDNs) and add support for internationalized email addresses in X.509 certificates. https://tools.ietf.org/html/rfc8399

Key Standards

ISO 10646 (Unicode)	To provide a common technical basis for the processing of electronic information in various languages, the International Organization for Standardization (ISO) has developed an international coding standard called ISO 10646. The ISO 10646 provides a unified standard for the coding of characters in all major languages in the world, including traditional and simplified Chinese characters. This large character set is called the Universal Character Set (UCS). The same set of characters is defined by the Unicode standard, which further defines additional character properties and other application details of great interest to implementers. Unicode is a character coding system designed by the Unicode Consortium to support the interchange, processing and display of the written texts of all major languages in the world. ISO 10646 and Unicode define several encoding forms of their common repertoire: UTF-8, UCS-2, UTF-16, UCS-4 and UTF-32. http://www.iso.org/iso/home/store/catalogue_ics/catalogue_detail_ics.htm?csnumber=63182
GB18030 (China)	GB 18030-2000 is a Chinese government standard that specifies an extended code page for use in the Chinese market in addition to UTF-8. The internal processing code for the character repertoire can and should be Unicode; however, the standard stipulates that software providers must guarantee a successful round-trip between GB18030 and the internal processing code. All products currently sold or to be sold in China must plan the code page migration to support GB18030

	without exception. GB18030 is a “mandatory standard” and the Chinese government regulates the certification process to reinforce GB18030 deployment. http://icu-project.org/docs/papers/unicode-gb18030-faq.html

Online Resources

APIs	Windows Application Programming Interfaces (APIs) https://www.msdn.microsoft.com/enus/library/windows/desktop/ff818516%28v=vs.85%29.aspx SharePoint APIs https://msdn.microsoft.com/en-us/library/office/jj860569.aspx Public Suffix List https://publicsuffix.org/list/public_suffix_list.dat ICANN Authoritative TLD list http://data.iana.org/TLD/tlds-alpha-by-domain.txt Android APIs http://developer.android.com/guide/index.html MAC IOS APIs https://developer.apple.com/library/mac/navigation .Net Framework https://msdn.microsoft.com/en-us/library/system.text.encoding(v=vs.110).aspx
Unicode security	Unicode security considerations http://www.unicode.org/reports/tr36 Unicode security mechanisms http://www.unicode.org/reports/tr39
Unicode character groupings	Unicode code planes https://www.unicode.org/versions/Unicode12.0.0/ch02.pdf; pp. 44-54 Overview of GB18030 http://icu-project.org/docs/papers/gb18030.html Authoritative mapping table between BG18030-2000 and Unicode http://source.icu-project.org/repos/icu/data/trunk/charset/data/xml/gb-18030-2000.xml Unicode normalization https://unicode.org/reports/tr15/

Unicode exploits	Section 3.1, “UTF-8 Exploits” in Unicode Technical Report #36 http://unicode.org/reports/tr36/#UTF-8_Exploit M3AAWG Best Practices for Unicode Abuse Prevention https://www.m3aawg.org/sites/default/files/m3aawg-unicode-best-practices-2016-02.pdf M3AAWG Unicode Abuse Overview and Tutorial https://www.m3aawg.org/sites/default/files/m3aawg-unicode-tutorial-2016-02.pdf See also: http://www.unicode.org
Miscellaneous	URIs http://tools.ietf.org/html/rfc3986 The Domain Name System: A Non-Technical Explanation—Why Universal Resolvability Is Important http://www.internic.net/faqs/authoritative-dns.html ICANN glossary https://www.icann.org/icann-acronyms-and-terms/

Need more information?

The Universal Acceptance Steering Group (UASG) and community are available to provide advice to software developers and implementers.

- Contact us to share your ideas and suggestions on the topic at info@uasg.tech.
- Join the Universal Acceptance discussion list at http://tinyurl.com/ua-discuss.
- To learn more about the effort, visit http://www.icann.org/universalacceptance.