ECMAScript Internationalization API Specification

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Introduction

The ECMA Script Internationalization API provides key language-sensitive functionality as a complement to the ECMA Script Language Specification, 5.1 edition or successor. Its functionality has been selected from that of well-established internationalization APIs such as those of the Internationalization Components for Unicode (ICU) library, of the .NET framework, or of the Java platform.

The API was developed by an ad-hoc group established by Ecma TC 39 in September 2010 based on a proposal by Nebojša Ćirić and Jungshik Shin.

Internationalization of software is never complete. We expect significant enhancements in future editions of this specification.

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ECMAScript Internationalization API Specification

1 Scope

This Standard defines the application programming interface for ECMAScript objects that support programs that need to adapt to the linguistic and cultural conventions used by different human languages and countries.

2 Conformance

A conforming implementation of the ECMAScript Internationalization API must conform to the ECMAScript Language Specification, 5.1 edition or successor, and must provide and support all the objects, properties, functions, and program semantics described in this specification.

A conforming implementation of the ECMAScript Internationalization API is permitted to provide additional objects, properties, and functions beyond those described in this specification. In particular, a conforming implementation of the ECMAScript Internationalization API is permitted to provide properties not described in this specification, and values for those properties, for objects that are described in this specification. A conforming implementation is not permitted to add optional arguments to the functions defined in this specification.

A conforming implementation is permitted to accept additional values, and then have implementation-defined behavior instead of throwing a RangeError, for the following properties of options arguments:

- The options property localeMatcher in all constructors and supportedLocalesOf methods.
- The options properties usage and sensitivity in the Collator constructor.
- The options properties style and currencyDisplay in the NumberFormat constructor.
- The options properties minimumIntegerDigits, minimumFractionDigits, maximumFractionDigits, minimumSignificantDigits, and maximumSignificantDigits in the NumberFormat constructor, provided that the additional values are interpreted as integer values higher than the specified limits.
- The options property timeZone in the DateTimeFormat constructor, provided that the additional acceptable input values are case-insensitive matches of Zone or Link identifiers in the IANA time zone database and are canonicalized to Zone identifiers in the casing used in the database for the timeZone property of the object returned by DateTimeFormat.resolvedOptions, except that "Etc/GMT" shall be canonicalized to "UTC".
- The options properties listed in table 3 in the DateTimeFormat constructor.
- The options property formatMatcher in the DateTimeFormat constructor.

3 Normative References

The following referenced documents are required for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ECMA-262, ECMAScript Language Specification, 5.1 edition or successor
http://www.ecma-international.org/publications/standards/Ecma-262.htm

NOTE Throughout this document, the phrase "ES5, x", where x is a sequence of numbers separated by periods, may be used as shorthand for "ECMAScript Language Specification, 5.1 edition, subclause x".


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4 Overview

This section contains a non-normative overview of the ECMAScript Internationalization API.

4.1 Internationalization, Localization, and Globalization

Internationalization of software means designing it such that it supports or can be easily adapted to support the needs of users speaking different languages and having different cultural expectations, and enables worldwide communication between them. Localization then is the actual adaptation to a specific language and culture. Globalization of software is commonly understood to be the combination of internationalization and localization. Globalization starts at the lowest level by using a text representation that supports all languages in the world, and using standard identifiers to identify languages, countries, time zones, and other relevant parameters. It continues with using a user interface language and data presentation that the user understands, and finally often requires product-specific adaptations to the user’s language, culture, and environment.

The ECMAScript Language Specification lays the foundation by using Unicode for text representation and by providing a few language-sensitive functions, but gives applications little control over the behavior of these functions. The ECMAScript Internationalization API builds on this by providing a set of customizable language-sensitive functionality. The API is useful even for applications that themselves are not internationalized, as even applications targeting only one language and one region need to properly support that one language and region. However, the API also enables applications that support multiple languages and regions, even concurrently, as may be needed in server environments.

4.2 API Overview

The ECMAScript Internationalization API is designed to complement the ECMAScript Language Specification by providing key language-sensitive functionality. The API can be added to an implementation of the ECMAScript Language Specification, 5.1 edition or successor.

The ECMAScript Internationalization API provides three key pieces of language-sensitive functionality that are required in most applications: String comparison (collation), number formatting, and date and time formatting. While the ECMAScript Language Specification provides functions for this basic functionality (String.prototype.localeCompare, Number.prototype.toLocaleString, Date.prototype.toLocaleString, ...)
Date.prototype.toLocaleDateString, and Date.prototype.toLocaleTimeString), it leaves the actual behavior of these functions largely up to implementations to define. The Internationalization API Specification provides additional functionality, control over the language and over details of the behavior to be used, and a more complete specification of required functionality.

Applications can use the API in two ways:

1. Directly, by using the constructors Intl.Collator, Intl.NumberFormat, or Intl.DateTimeFormat to construct an object, specifying a list of preferred languages and options to configure the behavior of the resulting object. The object then provides a main function (compare or format), which can be called repeatedly. It also provides a resolvedOptions function, which the application can use to find out the exact configuration of the object.

2. Indirectly, by using the functions of the ECMAScript Language Specification mentioned above, which are respecified in this specification to accept the same arguments as the Collator, NumberFormat, and DateTimeFormat constructors and produce the same results as their compare or format methods.

The Intl object is used to package all functionality defined in the ECMAScript Internationalization API to avoid name collisions.

4.3 Implementation Dependencies

Due to the nature of internationalization, the API specification has to leave several details implementation dependent:

- **The set of locales that an implementation supports with adequate localizations**: Linguists estimate the number of human languages to around 6000, and the more widely spoken ones have variations based on regions or other parameters. Even large locale data collections, such as the Common Locale Data Repository, cover only a subset of this large set. Implementations targeting resource-constrained devices may have to further reduce the subset.

- **The exact form of localizations such as format patterns**: In many cases locale-dependent conventions are not standardized, so different forms may exist side by side, or they vary over time. Different internationalization libraries may have implemented different forms, without any of them being actually wrong. In order to allow this API to be implemented on top of existing libraries, such variations have to be permitted.

- **Subsets of Unicode**: Some operations, such as collation, operate on strings that can include characters from the entire Unicode character set. However, both the Unicode standard and the ECMAScript standard allow implementations to limit their functionality to subsets of the Unicode character set. In addition, locale conventions typically don’t specify the desired behavior for the entire Unicode character set, but only for those characters that are relevant for the locale. While the Unicode Collation Algorithm combines a default collation order for the entire Unicode character set with the ability to tailor for local conventions, subsets and tailorings still result in differences in behavior.

5 Notational Conventions

This standard uses a subset of the notational conventions of the ECMAScript Language Specification, 5.1 edition:

- Algorithm conventions, including the use of abstract operations, as described in ES5, 5.2.

- Internal properties, as described in ES5, 8.6.2.

- The List specification type, as described in ES5, 8.8.

**NOTE** As described in the ECMAScript Language Specification, algorithms are used to precisely specify the required semantics of ECMAScript constructs, but are not intended to imply the use of any specific implementation technique. Internal properties are used to define the semantics of object values, but are not part of the API. They are defined purely
for expository purposes. An implementation of the API must behave as if it produced and operated upon internal properties in the manner described here.

In addition, the Record specification type is used to describe data aggregations within the algorithms of this specification. A Record type value consists of one or more named fields. The value of each field is an ECMAScript type value. Field names are always enclosed in double brackets, for example [[field1]]. Field names can also be provided by a variable: The notation "[[<name>]]" denotes a field whose name is given by the variable `name`, which must have a String value. For example, if a variable `x` has the value "a", then `[[x]]` denotes the field `[[a]]`.

In specification text and algorithms, dot notation may be used to refer to a specific field of a Record value. For example, if a record `r` has the value

```
{ ["name1": "value1", "name2": "value2" ] }
```

then `r."name1"` is shorthand for "the field of `r` named "name1"".

For ECMAScript objects, this standard may use variable-named internal properties: The notation "[[<name>]]" denotes an internal property whose name is given by the variable `name`, which must have a String value. For example, if a variable `s` has the value "a", then `[[s]]` denotes the `[[a]]` internal property.

### 6 Identification of Locales, Time Zones, and Currencies

This clause describes the String values used in the ECMAScript Internationalization API to identify locales, currencies, and time zones.

#### 6.1 Case Sensitivity and Case Mapping

The String values used to identify locales, currencies, and time zones are interpreted in a case-insensitive manner, treating the Unicode Basic Latin characters "A" to "Z" (U+0041 to U+005A) as equivalent to the corresponding Basic Latin characters "a" to "z" (U+0061 to U+007A). No other case folding equivalences are applied. When mapping to upper case, a mapping shall be used that maps characters in the range "a" to "z" (U+0061 to U+007A) to the corresponding characters in the range "A" to "Z" (U+0041 to U+005A) and maps no other characters to the latter range.

**EXAMPLES**

- "ß" (U+00DF) must not match or be mapped to "SS" (U+0053, U+0053).
- "ı" (U+0131) must not match or be mapped to "I" (U+0049).

#### 6.2 Language Tags

The ECMAScript Internationalization API identifies locales using language tags as defined by IETF BCP 47 (RFCs 5646 and 4647 or their successors), which may include extensions such as those registered through RFC 6067. Their canonical form is specified in RFC 5646 section 4.5 or its successor.

BCP 47 language tags that meet those validity criteria of section 2.2.9 of RFC 5646 that can be verified without reference to the IANA Language Subtag Registry are considered structurally valid. All structurally valid language tags are valid for use with the APIs defined by this standard. However, the set of locales and thus language tags that an implementation supports with adequate localizations is implementation dependent. The constructors `Collator`, `NumberFormat`, and `DateTimeFormat` map the language tags used in requests to locales supported by their respective implementations.

##### 6.2.1 Unicode Locale Extension Sequences

This standard uses the term "Unicode locale extension sequence" for any substring of a language tag that starts with a separator ",-" and the singleton ",u" and includes the maximum sequence of following non-singleton subtags and their preceding ",-" separators.

##### 6.2.2 IsStructurallyValidLanguageTag(locale)

The `IsStructurallyValidLanguageTag` abstract operation verifies that the `locale` argument (which must be a String value)
• represents a well-formed BCP 47 language tag as specified in RFC 5646 section 2.1, or successor,
• does not include duplicate variant subtags, and
• does not include duplicate singleton subtags.

The abstract operation returns true if `locale` can be generated from the ABNF grammar in section 2.1 of the RFC, starting with Language-Tag, and does not contain duplicate variant or singleton subtags (other than as a private use subtag). It returns false otherwise. Terminal value characters in the grammar are interpreted as the Unicode equivalents of the ASCII octet values given.

6.2.3 CanonicalizeLanguageTag (locale)

The CanonicalizeLanguageTag abstract operation returns the canonical and case-regularized form of the `locale` argument (which must be a String value that is a structurally valid BCP 47 language tag as verified by the IsStructurallyValidLanguageTag abstract operation). It takes the steps specified in RFC 5646 section 4.5, or successor, to bring the language tag into canonical form, and to regularize the case of the subtags, but does not take the steps to bring a language tag into "extlang form" and to reorder variant subtags.

The specifications for extensions to BCP 47 language tags, such as RFC 6067, may include canonicalization rules for the extension subtag sequences they define that go beyond the canonicalization rules of RFC 5646 section 4.5. Implementations are allowed, but not required, to apply these additional rules.

6.2.4 DefaultLocale ()

The DefaultLocale abstract operation returns a String value representing the structurally valid (6.2.2) and canonicalized (6.2.3) BCP 47 language tag for the host environment's current locale.

6.3 Currency Codes

The ECMAScript Internationalization API identifies currencies using 3-letter currency codes as defined by ISO 4217. Their canonical form is upper case.

All well-formed 3-letter ISO 4217 currency codes are allowed. However, the set of combinations of currency code and language tag for which localized currency symbols are available is implementation dependent. Where a localized currency symbol is not available, the ISO 4217 currency code is used for formatting.

6.3.1 IsWellFormedCurrencyCode (currency)

The IsWellFormedCurrencyCode abstract operation verifies that the currency argument (after conversion to a String value) represents a well-formed 3-letter ISO currency code. The following steps are taken:

1. Let `c` be ToString(currency).
2. Let `normalized` be the result of mapping `c` to upper case as described in 6.1.
3. If the string length of `normalized` is not 3, return false.
4. If `normalized` contains any character that is not in the range "A" to "Z" (U+0041 to U+005A), return false.
5. Return true.

6.4 Time Zone Names

The ECMAScript Internationalization API defines a single time zone name, "UTC", which identifies the UTC time zone.

The Intl.DateTimeFormat constructor allows this time zone name; if the time zone is not specified, the host environment’s current time zone is used. Implementations shall support UTC and the host environment’s current time zone (if different from UTC) in formatting.

NOTE The Conformance clause allows implementations to accept additional time zone names under specified conditions.
7 Requirements for Standard Built-in ECMAScript Objects

Unless specified otherwise in this document, the objects, functions, and constructors described in this standard are subject to the generic requirements and restrictions specified for standard built-in ECMAScript objects in the ECMAScript Language Specification 5.1 edition, introduction of clause 15, or successor.

8 The Intl Object

The Intl object is a standard built-in object that is the initial value of the Intl property of the global object.

The value of the [[Prototype]] internal property of the Intl object is the built-in Object prototype object specified by the ECMAScript Language Specification.

The Intl object does not have a [[Construct]] internal property; it is not possible to use the Intl object as a constructor with the new operator.

The Intl object does not have a [[Call]] internal property; it is not possible to invoke the Intl object as a function.

8.1 Properties of the Intl Object

The value of each of the standard built-in properties of the Intl object is a constructor. The behaviour of these constructors is specified in the following clauses: Collator (10), NumberFormat (11), and DateTimeFormat (12).

9 Locale and Parameter Negotiation

The constructors for the objects providing locale sensitive services, Collator, NumberFormat, and DateTimeFormat, use a common pattern to negotiate the requests represented by the locales and options arguments against the actual capabilities of their implementations. The common behaviour is described here in terms of internal properties describing the capabilities and of abstract operations using these internal properties.

9.1 Internal Properties of Service Constructors

The constructors Intl.Collator, Intl.NumberFormat, and Intl.DateTimeFormat have the following internal properties:

- [[availableLocales]] is a List that contains structurally valid (6.2.2) and canonicalized (6.2.3) BCP 47 language tags identifying the locales for which the implementation provides the functionality of the constructed objects. Language tags on the list must not have a Unicode locale extension sequence. The list must include the value returned by the DefaultLocale abstract operation (6.2.4), and must not include duplicates: Implementations must include in [[availableLocales]] locales that can serve as fallbacks in the algorithm used to resolve locales (see 9.2.5). For example, implementations that provide a "de-DE" locale must include a "de" locale that can serve as a fallback for requests such as "de-AU" and "de-CH". For locales that in current usage would include a script subtag (such as Chinese locales), old-style language tags without script subtags must be included such that, for example, requests for "zh-TW" and "zh-HK" lead to output in traditional Chinese rather than the default simplified Chinese. The ordering of the locales within [[availableLocales]] is irrelevant.
- [[relevantExtensionKeys]] is an array of keys of the language tag extensions defined in Unicode Technical Standard 35 that are relevant for the functionality of the constructed objects.
- [[sortLocaleData]] and [[searchLocaleData]] (for Intl.Collator) and [[localeData]] (for Intl.NumberFormat and Intl.DateTimeFormat) are objects that have properties for each locale contained in [[availableLocales]]. The value of each of these properties must be an object that has properties for each key contained in [[relevantExtensionKeys]]. The value of each of these properties must be a non-empty array of those values defined in Unicode Technical Standard 35 for the given key that are supported by the implementation for the given locale, with the first element providing the default value.
EXAMPLE  An implementation of DateTimeFormat might include the language tag "th" in its [[availableLocales]] internal property, and must (according to 12.2.3) include the key "ca" in its [[relevantExtensionKeys]] internal property. For Thai, the "buddhist" calendar is usually the default, but an implementation might also support the calendars "gregory", "chinese", and "islamicc" for the locale "th". The [[localeData]] internal property would therefore at least include "th": (ca: ["buddhist", "gregory", "chinese", "islamicc"]).

9.2 Abstract Operations

Where the following abstract operations take an [[availableLocales]] argument, it must be an [[availableLocales]] List as specified in 9.1.

9.2.1 CanonicalizeLocaleList (locales)

The abstract operation CanonicalizeLocaleList takes the following steps:

1. If locales is undefined, then
   a. Return a new empty List.
2. Let seen be a new empty List.
3. If locales is a String value, then
   a. Let locales be a new array created as if by the expression new Array(locales) where Array is the standard built-in constructor with that name and locales is the value of locales.
4. Let O be ToObject(locales).
5. Let lenValue be the result of calling the [[Get]] internal method of O with the argument "length".
6. Let len be ToUint32(lenValue).
7. Let k be 0.
8. Repeat, while k < len
   a. Let Pk be ToString(k).  
   b. Let kPresent be the result of calling the [[HasProperty]] internal method of O with argument Pk.
   c. If kPresent is true, then
      i. Let kValue be the result of calling the [[Get]] internal method of O with argument Pk.
      ii. If the type of kValue is not String or Object, then throw a TypeError exception.
      iii. Let tag be ToString(kValue).
      iv. If the result of calling the abstract operation IsStructurallyValidLanguageTag (defined in 6.2.2), passing tag as the argument, is false, then throw a RangeError exception.
      v. Let tag be the result of calling the abstract operation CanonicalizeLanguageTag (defined in 6.2.3), passing tag as the argument.
      vi. If tag is not an element of seen, then append tag as the last element of seen.
   d. Increase k by 1.
9. Return seen.

NOTE  Non-normative summary: The abstract operation interprets the locales argument as an array and copies its elements into a List, validating the elements as structurally valid language tags and canonicalizing them, and omitting duplicates.

NOTE  Requiring kValue to be a String or Object means that the Number value NaN will not be interpreted as the language tag "nan", which stands for Min Nan Chinese.

9.2.2 BestAvailableLocale (availableLocales, locale)

The BestAvailableLocale abstract operation compares the provided argument locale, which must be a String value with a structurally valid and canonicalized BCP 47 language tag, against the locales in availableLocales and returns either the longest non-empty prefix of locale that is an element of availableLocales, or undefined if there is no such element. It uses the fallback mechanism of RFC 4647, section 3.4. The following steps are taken:

1. Let candidate be locale.
2. Repeat
   a. If availableLocales contains an element equal to candidate, then return candidate.
   b. Let pos be the character index of the last occurrence of "-" (U+002D) within candidate. If that character does not occur, return undefined.
c. If \( \text{pos} \geq 2 \) and the character "~" occurs at index \( \text{pos}-2 \) of \( \text{candidate} \), then decrease \( \text{pos} \) by 2.

d. Let \( \text{candidate} \) be the substring of \( \text{candidate} \) from position 0 to position \( \text{pos}-1 \).

9.2.3 LookupMatcher (availableLocales, requestedLocales)

The LookupMatcher abstract operation compares \( \text{requestedLocales} \), which must be a List as returned by CanonicalizeLocaleList, against the locales in \( \text{availableLocales} \) and determines the best available language to meet the request. The following steps are taken:

1. Let \( i \) be 0.
2. Let \( \text{len} \) be the number of elements in \( \text{requestedLocales} \).
3. Let \( \text{availableLocale} \) be \( \text{undefined} \).
4. Repeat while \( i < \text{len} \) and \( \text{availableLocale} \) is \( \text{undefined} \):
   a. Let \( \text{locale} \) be the element of \( \text{requestedLocales} \) at \( 0 \)-originated list position \( i \).
   b. Let \( \text{noExtensionsLocale} \) be the String value that is \( \text{locale} \) with all Unicode locale extension sequences removed.
   c. Let \( \text{availableLocale} \) be the result of calling the BestAvailableLocale abstract operation (defined in 9.2.2) with arguments \( \text{availableLocales} \) and \( \text{noExtensionsLocale} \).
   d. Increase \( i \) by 1.
5. Let \( \text{result} \) be a new Record.
6. If \( \text{availableLocale} \) is not \( \text{undefined} \), then
   a. Set \( \text{result}[[\text{locale}]] \) to \( \text{availableLocale} \).
   b. If \( \text{locale} \) and \( \text{noExtensionsLocale} \) are not the same String value, then
      i. Let \( \text{extension} \) be the String value consisting of the first substring of \( \text{locale} \) that is a Unicode locale extension sequence.
      ii. Let \( \text{extensionIndex} \) be the character position of the initial "~" of the first Unicode locale extension sequence within \( \text{locale} \).
      iii. Set \( \text{result}[[\text{extension}]] \) to \( \text{extension} \).
      iv. Set \( \text{result}[[\text{extensionIndex}]] \) to \( \text{extensionIndex} \).
7. Else
   a. Set \( \text{result}[[\text{locale}]] \) to the value returned by the DefaultLocale abstract operation (defined in 6.2.4).
8. Return \( \text{result} \).

NOTE The algorithm is based on the Lookup algorithm described in RFC 4647 section 3.4, but options specified through Unicode locale extension sequences are ignored in the lookup. Information about such subsequences is returned separately. The abstract operation returns a record with a [locale] field, whose value is the language tag of the selected locale, which must be an element of availableLocales. If the language tag of the request locale that led to the selected locale contained a Unicode locale extension sequence, then the returned record also contains an [extension] field whose value is the first Unicode locale extension sequence, and an [extensionIndex] field whose value is the index of the first Unicode locale extension sequence within the request locale language tag.

9.2.4 BestFitMatcher (availableLocales, requestedLocales)

The BestFitMatcher abstract operation compares \( \text{requestedLocales} \), which must be a List as returned by CanonicalizeLocaleList, against the locales in \( \text{availableLocales} \) and determines the best available language to meet the request. The algorithm is implementation dependent, but should produce results that a typical user of the requested locales would perceive as at least as good as those produced by the LookupMatcher abstract operation. Options specified through Unicode locale extension sequences must be ignored by the algorithm. Information about such subsequences is returned separately. The abstract operation returns a record with a [locale] field, whose value is the language tag of the selected locale, which must be an element of availableLocales. If the language tag of the request locale that led to the selected locale contained a Unicode locale extension sequence, then the returned record also contains an [extension] field whose value is the first Unicode locale extension sequence, and an [extensionIndex] field whose value is the index of the first Unicode locale extension sequence within the request locale language tag.
9.2.5 ResolveLocale (availableLocales, requestedLocales, options, relevantExtensionKeys, localeData)

The ResolveLocale abstract operation compares a BCP 47 language priority list requestedLocales against the locales in availableLocales and determines the best available language to meet the request. availableLocales and requestedLocales must be provided as List values, options as a Record.

The following steps are taken:

1. Let matcher be the value of options.[[localeMatcher]].
2. If matcher is "lookup" then
   a. Let r be the result of calling the LookupMatcher abstract operation (defined in 9.2.3) with arguments availableLocales and requestedLocales.
3. Else
   a. Let r be the result of calling the BestFitMatcher abstract operation (defined in 9.2.4) with arguments availableLocales and requestedLocales.
4. Let foundLocale be the value of r.[[locale]].
5. If r has an [[extension]] field, then
   a. Let extension be the value of r.[[extension]].
   b. Let extensionIndex be the value of r.[[extensionIndex]].
   c. Let split be the standard built-in function object defined in ES5, 15.5.4.14.
   d. Let extensionSubtags be the result of calling the [[Call]] internal method of split with extension as the this value and an argument list containing the single item "-".
   e. Let extensionSubtagsLength be the result of calling the [[Get]] internal method of extensionSubtags with argument "length".
6. Let result be a new Record.
7. Set result.[[dataLocale]] to foundLocale.
8. Let supportedExtension be "-u".
9. Let i be 0.
10. Let len be the result of calling the [[Get]] internal method of relevantExtensionKeys with argument "length".
11. Repeat while i < len:
   a. Let key be the result of calling the [[Get]] internal method of relevantExtensionKeys with argument ToString(i).
   b. Let foundLocaleData be the result of calling the [[Get]] internal method of localeData with the argument foundLocale.
   c. Let keyLocaleData be the result of calling the [[Get]] internal method of foundLocaleData with the argument key.
   d. Let value be the result of calling the [[Get]] internal method of keyLocaleData with argument "0".
   e. Let supportedExtensionAddition be "".
   f. Let indexOf be the standard built-in function object defined in ES5, 15.4.4.14.
   g. If extensionSubtags is not undefined, then
      i. Let keyPos be the result of calling the [[Call]] internal method of indexOf with extensionSubtags as the this value and an argument list containing the single item key.
      ii. If keyPos ≠ -1 then
         1. If keyPos + 1 < extensionSubtagsLength and the length of the result of calling the [[Get]] internal method of extensionSubtags with argument ToString(keyPos + 1) is greater than 2, then
            a. Let requestedValue be the result of calling the [[Get]] internal method of extensionSubtags with argument ToString(keyPos + 1).
            b. Let valuePos be the result of calling the [[Call]] internal method of indexOf with keyLocaleData as the this value and an argument list containing the single item requestedValue.
            c. If valuePos ≠ -1, then
               i. Let value be requestedValue.
               ii. Let supportedExtensionAddition be the concatenation of "-", key, "-" and value.
9.2.6 LookupSupportedLocales (availableLocales, requestedLocales)

The LookupSupportedLocales abstract operation returns the subset of the provided BCP 47 language priority list requestedLocales for which availableLocales has a matching locale when using the BCP 47 Lookup algorithm.

Locales appear in the same order in the returned list as in requestedLocales. The following steps are taken:

1. Let len be the number of elements in requestedLocales.
2. Let subset be a new empty List.
3. Let i be 0.
4. Repeat while i < len
   a. Let locale be the element of requestedLocales at 0-originated list position i.
   b. Let noExtensionsLocale be the String value that is locale with all Unicode locale extension sequences removed.
   c. Let availableLocale be the result of calling the BestAvailableLocale abstract operation (defined in 9.2.2) with arguments availableLocales and noExtensionsLocale.
   d. If availableLocale is not undefined, then append locale to the end of subset.
   e. Increment i by 1.
5. Let subsetArray be a new Array object whose elements are the same values in the same order as the elements of subset.
6. Return subsetArray.

9.2.7 BestFitSupportedLocales (availableLocales, requestedLocales)

The BestFitSupportedLocales abstract operation returns the subset of the provided BCP 47 language priority list requestedLocales for which availableLocales has a matching locale when using the Best Fit Matcher algorithm.

Locales appear in the same order in the returned list as in requestedLocales. The steps taken are implementation dependent.
9.2.8 SupportedLocales (availableLocales, requestedLocales, options)

The SupportedLocales abstract operation returns the subset of the provided BCP 47 language priority list requestedLocales for which availableLocales has a matching locale. Two algorithms are available to match the locales: the Lookup algorithm described in RFC 4647 section 3.4, and an implementation dependent best-fit algorithm. Locales appear in the same order in the returned list as in requestedLocales. The following steps are taken:

1. If options is not undefined, then
   a. Let options be ToObject(options).
   b. Let matcher be the result of calling the [[Get]] internal method of options with argument "localeMatcher".
   c. If matcher is not undefined, then
      i. Let matcher be ToString(matcher).
      ii. If matcher is not "lookup" or "best fit", then throw a RangeError exception.
2. If matcher is undefined or "best fit" then
   a. Let subset be the result of calling the BestFitSupportedLocales abstract operation (defined in 9.2.7) with arguments availableLocales and requestedLocales.
3. Else
   a. Let subset be the result of calling the LookupSupportedLocales abstract operation (defined in 9.2.6) with arguments availableLocales and requestedLocales.
4. For each named own property name P of subset,
   a. Let desc be the result of calling the [[GetOwnProperty]] internal method of subset with P.
   b. Set desc.[[Writable]] to false.
   c. Set desc.[[Configurable]] to false.
   d. Call the [[DefineOwnProperty]] internal method of subset with P, desc, and true as arguments.
5. Return subset.

9.2.9 GetOption (options, property, type, values, fallback)

The GetOption abstract operation extracts a value of the property named property from the provided options object, converts it to the required type, checks whether it is one of a List of allowed values, and fills in a fallback value if necessary.

1. Let value be the result of calling the [[Get]] internal method of options with argument property.
2. If value is not undefined then
   a. Assert: type is "boolean" or "string".
   b. If type is "boolean" then let value be ToBoolean(value).
   c. If type is "string" then let value be ToString(value).
   d. If values is not undefined, then
      i. If values does not contain an element equal to value, then throw a RangeError exception.
3. Else return fallback.

9.2.10 GetNumberOption (options, property, minimum, maximum, fallback)

The GetNumberOption abstract operation extracts a property value from the provided options object, converts it to a Number value, checks whether it is in the allowed range, and fills in a fallback value if necessary.

1. Let value be the result of calling the [[Get]] internal method of options with argument property.
2. If value is not undefined then
   a. Let value be ToNumber(value).
   b. If value is NaN or less than minimum or greater than maximum, throw a RangeError exception.
3. Else return fallback.
10 Collator Objects

10.1 The Intl.Collator Constructor

The Intl.Collator constructor is a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

10.1.1 Initializing an Object as a Collator

10.1.1.1 InitializeCollator (collator, locales, options)

The abstract operation InitializeCollator accepts the arguments collator (which must be an object), locales, and options. It initializes collator as a Collator object.

Several steps in the algorithm use values from the following table, which associates Unicode locale extension keys, property names, types, and allowable values:

Table 1 – Collator options settable through both extension keys and options properties

<table>
<thead>
<tr>
<th>Key</th>
<th>Property</th>
<th>Type</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>kn</td>
<td>numeric</td>
<td>&quot;boolean&quot;</td>
<td></td>
</tr>
<tr>
<td>kk</td>
<td>normalization</td>
<td>&quot;boolean&quot;</td>
<td></td>
</tr>
<tr>
<td>kf</td>
<td>caseFirst</td>
<td>&quot;string&quot;</td>
<td>&quot;upper&quot;, &quot;lower&quot;, &quot;false&quot;</td>
</tr>
</tbody>
</table>

The following steps are taken:

1. If collator has an [[initializedIntlObject]] internal property with value true, throw a TypeError exception.
2. Set the [[initializedIntlObject]] internal property of collator to true.
3. Let requestedLocales be the result of calling the CanonicalizeLocaleList abstract operation (defined in 9.2.1) with argument locales.
4. If options is undefined, then
   a. Let options be the result of creating a new object as if by the expression new Object() where Object is the standard built-in constructor with that name.
   b. Else let options be ToObject(options).
5. Let u be the result of calling the GetOption abstract operation (defined in 9.2.9) with arguments options, "usage", "string", a List containing the two String values "sort" and "search", and "sort".
6. Set the [[usage]] internal property of collator to u.
7. Let Collator be the standard built-in object that is the initial value of Intl.Collator.
8. If u is "sort", then let localeData be the value of the [[sortLocaleData]] internal property of Collator; else let localeData be the value of the [[searchLocaleData]] internal property of Collator.
9. Let opt be a new Record.
10. Let matcher be the result of calling the GetOption abstract operation with arguments options, "localeMatcher", "string", a List containing the two String values "lookup" and "best fit", and "best fit".
11. Set opt.[[localeMatcher]] to matcher.
12. For each row in Table 1, except the header row, do:
   a. Let key be the name given in the Key column of the row.
   b. Let value be the result of calling the GetOption abstract operation, passing as arguments options, the name given in the Property column of the row, the string given in the Type column of the row, a List containing the Strings given in the Values column of the row or undefined if no strings are given, and undefined.
   c. If the string given in the Type column of the row is "boolean" and value is not undefined, then
      i. Let value be ToString(value).
   d. Set opt.[[<key>]] to value.
13. Let relevantExtensionKeys be the value of the [[relevantExtensionKeys]] internal property of Collator.
14. Let r be the result of calling the ResolveLocale abstract operation (defined in 9.2.5) with the [[availableLocales]] internal property of Collator, requestedLocales, opt, relevantExtensionKeys, and localeData.
16. Set the [[locale]] internal property of collator to the value of r.[[locale]].
17. Let \( i \) be 0.
18. Let \( len \) be the result of calling the [[Get]] internal method of relevantExtensionKeys with argument "length".
19. Repeat while \( i < len \):
   a. Let \( key \) be the result of calling the [[Get]] internal method of relevantExtensionKeys with argument ToString().
   b. If \( key \) is "co", then
      i. Let \( property \) be "collation".
      ii. Let \( value \) be the value of \( r.[[co]] \).
      iii. If \( value \) is null, then let \( value \) be "default".
   c. Else use the row of Table 1 that contains the value of \( key \) in the Key column:
      i. Let \( property \) be the name given in the Property column of the row.
      ii. Let \( value \) be the value of \( r.[[key]] \).
      iii. If the name given in the Type column of the row is "boolean", then let \( value \) be the result of comparing \( value \) with "true".
   d. Set the [[<property>]] internal property of collator to \( value \).
   e. Increase \( i \) by 1.
20. Let \( s \) be the result of calling the GetOption abstract operation with arguments \( options \), "sensitivity", "string", a List containing the four String values "base", "accent", "case", and "variant", and undefined.
21. If \( s \) is undefined, then
   a. If \( u \) is "sort", then let \( s \) be "variant".
   b. Else
      i. Let \( dataLocale \) be the value of \( r.[[dataLocale]] \).
      ii. Let \( dataLocaleData \) be the result of calling the [[Get]] internal operation of \( dataLocale \) with argument dataLocale.
      iii. Let \( s \) be the result of calling the [[Get]] internal operation of \( dataLocaleData \) with argument "sensitivity".
22. Set the [[sensitivity]] internal property of collator to \( s \).
23. Let \( ip \) be the result of calling the GetOption abstract operation with arguments \( options \), "ignorePunctuation", "boolean", undefined, and false.
24. Set the [[ignorePunctuation]] internal property of collator to \( ip \).
25. Set the [[boundCompare]] internal property of collator to undefined.
26. Set the [[initializedCollator]] internal property of collator to true.

### 10.1.2 The Intl.Collator Constructor Called as a Function

#### 10.1.2.1 Intl.Collator.call (this [, locales [, options]])

When Intl.Collator is called as a function rather than as a constructor, it accepts the optional arguments locales and options and takes the following steps:

1. If locales is not provided, then let locales be undefined.
2. If options is not provided, then let options be undefined.
3. If this is the standard built-in Intl object defined in 8 or undefined, then
   a. Return the result of creating a new object as if by the expression new Intl.Collator(locales, options), where Intl.Collator is the standard built-in constructor defined in 10.1.3.
4. Let \( obj \) be the result of calling ToObject passing the this value as the argument.
5. If the [[Extensible]] internal property of \( obj \) is false, throw a TypeError exception.
6. Call the InitializeCollator abstract operation (defined in 10.1.1.1) with arguments \( obj \), locales, and options.
7. Return \( obj \).

### 10.1.3 The Intl.Collator Constructor Used in a new Expression

#### 10.1.3.1 new Intl.Collator ([locales [, options]])

When Intl.Collator is called as part of a new expression, it is a constructor: it initializes the newly created object.
The [[Prototype]] internal property of the newly constructed object is set to the original Intl.Collator prototype object, the one that is the initial value of Intl.Collator.prototype (10.2.1).

The [[Extensible]] internal property of the newly constructed object is set to true.

Collator-specific properties of the newly constructed object are set using the following steps:

1. If locales is not provided, then let locales be undefined.
2. If options is not provided, then let options be undefined.
3. Call the InitializeCollator abstract operation (defined in 10.1.1.1), passing as arguments the newly constructed object, locales, and options.

### 10.2 Properties of the Intl.Collator Constructor

Besides the internal properties and the length property (whose value is 0), the Intl.Collator constructor has the following properties:

#### 10.2.1 Intl.Collator.prototype

The value of Intl.Collator.prototype is the built-in Intl.Collator prototype object (10.3). This property has the attributes {[[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false}.

#### 10.2.2 Intl.Collator.supportedLocalesOf (locales [, options])

When the supportedLocalesOf method of Intl.Collator is called, the following steps are taken:

1. If options is not provided, then let options be undefined.
2. Let availableLocales be the value of the [[availableLocales]] internal property of the standard built-in object that is the initial value of Intl.Collator.
3. Let requestedLocales be the result of calling the CanonicalizeLocaleList abstract operation (defined in 9.2.1) with argument locales.
4. Return the result of calling the SupportedLocales abstract operation (defined in 9.2.8) with arguments availableLocales, requestedLocales, and options.

The value of the length property of the supportedLocalesOf method is 1.

#### 10.2.3 Internal Properties

The value of the [[availableLocales]] internal property is implementation defined within the constraints described in 9.1.

The value of the [[relevantExtensionKeys]] internal property is an array that must include the element "co", may include any or all of the elements "kn", "kk", "kf", and must not include any other elements.

**NOTE** Unicode Technical Standard 35 describes ten locale extension keys that are relevant to collation: "co" for collator usage and specializations, "ka" for alternate handling, "kb" for backward second level weight, "kc" for case level, "kn" for numeric, "kh" for hiragana quaternary, "kk" for normalization, "kf" for case first, "kr" for reordering, "ks" for collation strength, and "vt" for variable top. Collator, however, requires that the usage is specified through the usage property of the options object, alternate handling through the ignorePunctuation property of the options object, and case level and the strength through the sensitivity property of the options object. The "co" key in the language tag is supported only for collator specializations, and the keys "kb", "kh", "kk", and "vt" are not allowed in this version of the Internationalization API. Support for the remaining keys is implementation dependent.

The values of the [[sortLocaleData]] and [[searchLocaleData]] internal properties are implementation defined within the constraints described in 9.1 and the following additional constraints:
• The first element of [[sortLocaleData]] and [[searchLocaleData]] must be null for all locale values.
• The values "standard" and "search" must not be used as elements in any [[sortLocaleData]] or [[searchLocaleData]] array.
• [[searchLocaleData]] must have a sensitivity property with a String value equal to "base", "accent", "case", or "variant" for all locale values.

10.3 Properties of the Intl.Collator Prototype Object

The Intl.Collator prototype object is itself an Intl.Collator instance as specified in 10.4, whose internal properties are set as if it had been constructed by the expression Intl.Collator.call() with the standard built-in values of Intl.Collator and Function.prototype.call.

In the following descriptions of functions that are properties of the Intl.Collator prototype object, the phrase “this Collator object” refers to the object that is the this value for the invocation of the function; a TypeError exception is thrown if the this value is not an object or an object that does not have an [[initializedCollator]] internal property with value true.

10.3.1 Intl.Collator.prototype.constructor

The initial value of Intl.Collator.prototype.constructor is the built-in Intl.Collator constructor.

10.3.2 Intl.Collator.prototype.compare

This named accessor property returns a function that compares two strings according to the sort order of this Collator object.

The value of the [[Get]] attribute is a function that takes the following steps:

1. If the [[boundCompare]] internal property of this Collator object is undefined, then:
   a. Let F be a Function object, with internal properties get as specified for built-in functions in ES5, 15, or successor, and the length property set to 2, that takes the arguments x and y and performs the following steps:
      i. If x is not provided, then let x be undefined.
      ii. If y is not provided, then let y be undefined.
      iii. Let X be ToString(x).
      iv. Let Y be ToString(y).
      v. Return the result of calling the CompareStrings abstract operation (defined below) with arguments this, X, and Y.
   b. Let bind be the standard built-in function object defined in ES5, 15.3.4.5.
   c. Let bc be the result of calling the [[Call]] internal method of bind with F as the this value and an argument List containing the single item this.
   d. Set the [[boundCompare]] internal property of this Collator object to bc.

2. Return the value of the [[boundCompare]] internal property of this Collator object.

NOTE The function returned by [[Get]] is bound to this Collator object so that it can be passed directly to Array.prototype.sort or other functions.

The value of the [[Set]] attribute is undefined.

When the CompareStrings abstract operation is called with arguments collator (which must be a Collator object), x and y (which must be String values), it returns a Number other than NaN that represents the result of a locale-sensitive String comparison of x with y. The two Strings are compared in an implementation-defined fashion. The result is intended to order String values in the sort order specified by the effective locale and collation options computed during construction of collator, and will be negative, zero, or positive, depending on whether x comes before y in the sort order, the Strings are equal under the sort order, or x comes after y in the sort order, respectively. String values must be interpreted as UTF-16 code unit sequences, and a surrogate pair (a code unit in the range 0xD800 to 0xDBFF followed by a code unit in the range 0xDC00 to 0xDFFF) within a string must be interpreted as the corresponding code point.

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The sensitivity of **collator** is interpreted as follows:

- **base**: Only strings that differ in base letters compare as unequal. Examples: \(a \neq b, a = \acute{a}, a = A\).
- **accent**: Only strings that differ in base letters or accents and other diacritic marks compare as unequal. Examples: \(a \neq b, a = \acute{a}, a \neq A\).
- **case**: Only strings that differ in base letters or case compare as unequal. Examples: \(a \neq b, a = \acute{a}, a \neq A\).
- **variant**: Strings that differ in base letters, accents and other diacritic marks, or case compare as unequal. Other differences may also be taken into consideration. Examples: \(a \neq b, a \neq \acute{a}, a \neq A\).

**NOTE** In some languages, certain letters with diacritic marks are considered base letters. For example, in Swedish, "ö" is a base letter that’s different from "o".

If the collator is set to ignore punctuation, then strings that differ only in punctuation compare as equal.

The interpretation of options settable through extension keys, see Unicode Technical Standard 35.

The **CompareStrings** abstract operation with any given **collator** argument, if considered as a function of the remaining two arguments \(x\) and \(y\), must be a consistent comparison function (as defined in ESS, 15.4.4.11) on the set of all Strings.

The actual return values are implementation-defined to permit implementers to encode additional information in the value, but the method is required to define a total ordering on all Strings and to return 0 when comparing Strings that are considered canonically equivalent by the Unicode standard.

**NOTE 1** It is recommended that the CompareStrings abstract operation be implemented following Unicode Technical Standard 10, Unicode Collation Algorithm (available at [http://unicode.org/reports/tr10/](http://unicode.org/reports/tr10/)), using tailorings for the effective locale and collation options of **collator**. It is recommended that implementations use the tailorings provided by the Common Locale Data Repository (available at [http://cldr.unicode.org/](http://cldr.unicode.org/)).

**NOTE 2** Applications should not assume that the behavior of the **CompareStrings** abstract operation for **Collator** instances with the same resolved options will remain the same for different versions of the same implementation.

### 10.3.3 Intl.Collator.prototype.resolvedOptions ()

This function provides access to the locale and collation options computed during initialization of the object.

The function returns a new object whose properties and attributes are set as if constructed by an object literal assigning to each of the following properties the value of the corresponding internal property of this Collator object (see 10.4): **locale**, **usage**, **sensitivity**, **ignorePunctuation**, **collation**, as well as those properties shown in Table 1 whose keys are included in the [[relevantExtensionKeys]] internal property of the standard built-in object that is the initial value of Intl.Collator.

### 10.4 Properties of Intl.Collator Instances

Intl.Collator instances inherit properties from the Intl.Collator prototype object. Their [[Class]] internal property value is "Object".

Intl.Collator instances and other objects that have been successfully initialized as a Collator have [[initializedIntlObject]] and [[initializedCollator]] internal properties whose values are true.

Objects that have been successfully initialized as a Collator also have several internal properties that are computed by the constructor:

- [[locale]] is a String value with the language tag of the locale whose localization is used for collation.
- [[usage]] is one of the String values "sort" or "search", identifying the collator usage.
- [[sensitivity]] is one of the String values "base", "accent", "case", or "variant", identifying the collator’s sensitivity.
The following steps are taken:

- [[ignorePunctuation]] is a Boolean value, specifying whether punctuation should be ignored in comparisons.
- [[collation]] is a String value with the "type" given in Unicode Technical Standard 35 for the collation, except that the values "standard" and "search" are not allowed, while the value "default" is allowed.

Objects that have been successfully initialized as a Collator also have the following internal properties if the key corresponding to the name of the internal property in Table 1 is included in the [[relevantExtensionKeys]] internal property of Intl.Collator:

- [[numeric]] is a Boolean value, specifying whether numeric sorting is used.
- [[normalization]] is a Boolean value, specifying whether strings should be normalized before comparison.
- [[caseFirst]] is a String value; allowed values are specified in Table 1.

Finally, objects that have been successfully initialized as a Collator have a [[boundCompare]] internal property that caches the function returned by the compare accessor (10.3.2).

11 NumberFormat Objects

11.1 The Intl.NumberFormat Constructor

The NumberFormat constructor is a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.

11.1.1 Initializing an Object as a NumberFormat

11.1.1.1 InitializeNumberFormat (numberFormat, locales, options)

The abstract operation InitializeNumberFormat accepts the arguments numberFormat (which must be an object), locales, and options. It initializes numberFormat as a NumberFormat object.

The following steps are taken:

1. If numberFormat has an [[initializedIntlObject]] internal property with value true, throw a TypeError exception.
2. Set the [[initializedIntlObject]] internal property of numberFormat to true.
3. Let requestedLocales be the result of calling the CanonicalizeLocaleList abstract operation (defined in 9.2.1) with argument locales.
4. If options is undefined, then
   a. Let options be the result of creating a new object as if by the expression new Object() where Object is the standard built-in constructor with that name.
   Else
   a. Let options be ToObject(options).
5. Let opt be a new Record.
6. Let matcher be the result of calling the GetOption abstract operation (defined in 9.2.9) with the arguments options, "localeMatcher", "string", a List containing the two String values "lookup" and "best fit", and "best fit".
7. Set opt.[[localeMatcher]] to matcher.
8. Let NumberFormat be the standard built-in object that is the initial value of Intl.NumberFormat.
9. Let localeData be the value of the [[localeData]] internal property of NumberFormat.
10. Let localeData be the value of the [[localeData]] internal property of NumberFormat.
11. Let r be the result of calling the ResolveLocale abstract operation (defined in 9.2.5) with the [[availableLocales]] internal property of NumberFormat, requestedLocales, opt, the [[relevantExtensionKeys]] internal property of NumberFormat, and localeData.
12. Set the [[locale]] internal property of numberFormat to the value of r.[[locale]].
13. Set the [[numberingSystem]] internal property of numberFormat to the value of r.[[mu]].
14. Let dataLocale be the value of r.[[dataLocale]].
15. Let s be the result of calling the GetOption abstract operation with the arguments options, "style", "string", a List containing the three String values "decimal", "percent", and "currency", and "decimal".
16. Set the [[style]] internal property of numberFormat to s.
17. Let \( c \) be the result of calling the \( \text{GetOption} \) abstract operation with the arguments \( \text{options}, \text{"currency"}, \text{"string"}, \text{undefined}, \text{and undefined} \).
18. If \( c \) is not undefined and the result of calling the \( \text{IsWellFormedCurrencyCode} \) abstract operation (defined in 6.3.1) with argument \( c \) is \text{false}, then throw a \text{RangeError} exception.
19. If \( c \) is \text{"currency"} and \( c \) is \text{undefined}, throw a \text{TypeError} exception.
20. If \( c \) is \text{"currency"} then
   a. Let \( c \) be the result of converting \( c \) to upper case as specified in 6.1.
   b. Set the \([\{\text{currency}\}]\) internal property of \( \text{numberFormat} \) to \( c \).
   c. Let \( \text{cDigits} \) be the result of calling the \( \text{CurrencyDigits} \) abstract operation (defined below) with argument \( c \).
21. Let \( \text{cd} \) be the result of calling the \( \text{GetOption} \) abstract operation with the arguments \( \text{options}, \text{"currencyDisplay"}, \text{"string"}, \) a List containing the three String values \text{"code"}, \text{"symbol"}, and \text{"name"}, and \text{"symbol"}.
22. If \( c \) is \text{"currency"} then set the \([\{\text{currencyDisplay}\}]\) internal property of \( \text{numberFormat} \) to \( \text{cd} \).
23. Let \( \text{mnid} \) be the result of calling the \( \text{GetNumberOption} \) abstract operation (defined in 9.2.10) with arguments \( \text{options}, \text{"minimumIntegerDigits"}, 1, 21, \text{and 1} \).
24. Set the \([\{\text{minimumIntegerDigits}\}]\) internal property of \( \text{numberFormat} \) to \( \text{mnid} \).
25. If \( c \) is \text{"currency"} then let \( \text{mnfdDefault} \) be \( \text{cDigits} \); else let \( \text{mnfdDefault} \) be \( 0 \).
26. Let \( \text{mnfd} \) be the result of calling the \( \text{GetNumberOption} \) abstract operation with arguments \( \text{options}, \text{"minimumFractionDigits"}, 0, 20, \text{and mnfdDefault} \).
27. Set the \([\{\text{minimumFractionDigits}\}]\) internal property of \( \text{numberFormat} \) to \( \text{mnfd} \).
28. If \( c \) is \text{"currency"} then let \( \text{mxfdDefault} \) be \( \text{max(mnfd, 0)} \); else let \( \text{mxfdDefault} \) be \( \text{max(mnfd, 3)} \).
29. Let \( \text{mxfd} \) be the result of calling the \( \text{GetNumberOption} \) abstract operation with arguments \( \text{options}, \text{"maximumFractionDigits"}, \text{mnfd}, 20, \text{and mxfdDefault} \).
30. Set the \([\{\text{maximumFractionDigits}\}]\) internal property of \( \text{numberFormat} \) to \( \text{mxfd} \).
31. Let \( \text{mxfd} \) be the result of calling the \([\{\text{Get}\}]\) internal method of \( \text{options} \) with argument \text{"maximumFractionDigits"}.
32. Let \( \text{mxfd} \) be the result of calling the \([\{\text{Get}\}]\) internal method of \( \text{options} \) with argument \text{"minimumSignificantDigits"}.
33. If \( \text{mxfd} \) is not \text{undefined} or \( \text{mxfd} \) is not \text{undefined}, then:
   a. Let \( \text{mxfd} \) be the result of calling the \( \text{GetNumberOption} \) abstract operation with arguments \( \text{options}, \text{"minimumSignificantDigits"}, 1, 21, \text{and 1} \).
   b. Let \( \text{mxfd} \) be the result of calling the \( \text{GetNumberOption} \) abstract operation with arguments \( \text{options}, \text{"maximumSignificantDigits"}, \text{mxfd}, 21, \text{and 21} \).
   c. Set the \([\{\text{minimumSignificantDigits}\}]\) internal property of \( \text{numberFormat} \) to \( \text{mnfd} \), and the \([\{\text{maximumSignificantDigits}\}]\) internal property of \( \text{numberFormat} \) to \( \text{mxfd} \).
34. Let \( g \) be the result of calling the \( \text{GetOption} \) abstract operation with the arguments \( \text{options}, \text{"useGrouping"}, \text{"boolean"}, \text{undefined}, \text{and true} \).
35. Set the \([\{\text{useGrouping}\}]\) internal property of \( \text{numberFormat} \) to \( g \).
36. Let \( \text{dataLocale} \) be the result of calling the \([\{\text{Get}\}]\) internal method of \( \text{localeData} \) with argument \( \text{dataLocale} \).
37. Let \( \text{patterns} \) be the result of calling the \([\{\text{Get}\}]\) internal method of \( \text{dataLocaleData} \) with argument \text{"patterns"}.
38. Assert: \( \text{patterns} \) is an object (see 11.2.3).
39. Let \( \text{stylePatterns} \) be the result of calling the \([\{\text{Get}\}]\) internal method of \( \text{patterns} \) with argument \( s \).
40. Set the \([\{\text{positivePattern}\}]\) internal property of \( \text{numberFormat} \) to the result of calling the \([\{\text{Get}\}]\) internal method of \( \text{stylePatterns} \) with the argument \text{"positivePattern"}.
41. Set the \([\{\text{negativePattern}\}]\) internal property of \( \text{numberFormat} \) to the result of calling the \([\{\text{Get}\}]\) internal method of \( \text{stylePatterns} \) with the argument \text{"negativePattern"}.
42. Set the \([\{\text{boundFormat}\}]\) internal property of \( \text{numberFormat} \) to \text{undefined}.
43. Set the \([\{\text{initializedNumberFormat}\}]\) internal property of \( \text{numberFormat} \) to \text{true}.

When the \( \text{CurrencyDigits} \) abstract operation is called with an argument \text{currency} (which must be an upper case String value), the following steps are taken:

1. If the ISO 4217 currency and funds code list contains \text{currency} as an alphabetic code, then return the minor unit value corresponding to the \text{currency} from the list; else return 2.

Unknown
Field Code Changed
11.1.2 The Intl.NumberFormat Constructor Called as a Function

11.1.2.1 Intl.NumberFormat.call (this [, locales [, options]])

When Intl.NumberFormat is called as a function rather than as a constructor, it accepts the optional arguments locales and options and takes the following steps:

1. If locales is not provided, then let locales be undefined.
2. If options is not provided, then let options be undefined.
3. If this is the standard built-in Intl object defined in 8 or undefined, then
   a. Return the result of creating a new object as if by the expression new Intl.NumberFormat(locales, options), where Intl.NumberFormat is the standard built-in constructor defined in 11.1.3.
4. Let obj be the result of calling ToObject passing the this value as the argument.
5. If the [[Extensible]] internal property of obj is false, throw a TypeError exception.
6. Call the InitializeNumberFormat abstract operation (defined in 11.1.1.1) with arguments obj, locales, and options.
7. Return obj.

11.1.3 The Intl.NumberFormat Constructor Used in a new Expression

11.1.3.1 new Intl.NumberFormat ([locales [, options]])

When Intl.NumberFormat is called as part of a new expression, it is a constructor: it initializes the newly created object.

The [[Prototype]] internal property of the newly constructed object is set to the original Intl.NumberFormat prototype object, the one that is the initial value of Intl.NumberFormat.prototype (11.2.1).

The [[Extensible]] internal property of the newly constructed object is set to true.

NumberFormat-specific properties of the newly constructed object are set using the following steps:

1. If locales is not provided, then let locales be undefined.
2. If options is not provided, then let options be undefined.
3. Call the InitializeNumberFormat abstract operation (defined in 11.1.1.1), passing as arguments the newly constructed object, locales, and options.

11.2 Properties of the Intl.NumberFormat Constructor

Besides the internal properties and the length property (whose value is 0), the Intl.NumberFormat constructor has the following properties:

11.2.1 Intl.NumberFormat.prototype

The value of Intl.NumberFormat.prototype is the built-in Intl.NumberFormat prototype object (11.3).

This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

11.2.2 Intl.NumberFormat.supportedLocalesOf (locales [, options])

When the supportedLocalesOf method of Intl.NumberFormat is called, the following steps are taken:

1. If options is not provided, then let options be undefined.
2. Let availableLocales be the value of the [[availableLocales]] internal property of the standard built-in object that is the initial value of Intl.NumberFormat.
3. Let requestedLocales be the result of calling the CanonicalizeLocaleList abstract operation (defined in 9.2.1) with argument locales.
4. Return the result of calling the SupportedLocales abstract operation (defined in 9.2.8) with arguments availableLocales, requestedLocales, and options.
The value of the length property of the supportedLocalesOf method is 1.

11.2.3 Internal Properties

The value of the [[availableLocales]] internal property is implementation defined within the constraints described in 9.1.

The value of the [[relevantExtensionKeys]] internal property is ["nu"].

NOTE Unicode Technical Standard 35 describes two locale extension keys that are relevant to number formatting, "nu" for numbering system and "cu" for currency. Intl.NumberFormat, however, requires that the currency of a currency format is specified through the currency property in the options objects.

The value of the [[localeData]] internal property is implementation defined within the constraints described in 9.1 and the following additional constraints:

- The array that is the value of the "nu" property of any locale property of [[localeData]] must not include the values "native", "tradition", or "scientific".
- [[localeData]][locale] must have a patterns property for all locale values. The value of this property must be an object, which must have properties with the names of the three number format styles: "decimal", "percent", and "currency". Each of these properties in turn must be an object with the properties positivePattern and negativePattern. The value of these properties must be string values that contain a substring "{number}"; the values within the currency property must also contain a substring "{currency}". The pattern strings must not contain any characters in the General Category "Number, decimal digit" as specified by the Unicode Standard.

NOTE It is recommended that implementations use the locale data provided by the Common Locale Data Repository (available at http://cldr.unicode.org/).

11.3 Properties of the Intl.NumberFormat Prototype Object

The Intl.NumberFormat prototype object is itself an Intl.NumberFormat instance as specified in 11.4, whose internal properties are set as if it had been constructed by the expression Intl.NumberFormat.call({}) with the standard built-in values of Intl.NumberFormat and Function.prototype.call.

In the following descriptions of functions that are properties of the Intl.NumberFormat prototype object, the phrase "this NumberFormat object" refers to the object that is the this value for the invocation of the function; a TypeError exception is thrown if the this value is not an object or an object that does not have an [[initializedNumberFormat]] internal property with value true.

11.3.1 Intl.NumberFormat.prototype.constructor

The initial value of Intl.NumberFormat.prototype.constructor is the built-in Intl.NumberFormat constructor.

11.3.2 Intl.NumberFormat.prototype.format

This named accessor property returns a function that formats a number according to the effective locale and the formatting options of this NumberFormat object.

The value of the [[Get]] attribute is a function that takes the following steps:

1. If the [[boundFormat]] internal property of this NumberFormat object is undefined, then:
   1. Let F be a Function object, with internal properties set as specified for built-in functions in ES5, 15, or successor, and the length property set to 1, that takes the argument value and performs the following steps:
      i. If value is not provided, then let value be undefined.
      ii. Let x be ToNumber(value).
The following steps are taken:

1. Let $negative$ be $false$.
2. If the result of `isFinite(x)` is $false$, then
   a. If $x$ is $NaN$, then let $n$ be an ILD String value indicating the $NaN$ value.
   b. Else
      i. Let $n$ be an ILD String value indicating infinity.
      ii. If $x < 0$, then let $negative$ be $true$.
3. Else
   a. If $x < 0$, then
      i. Let $negative$ be $true$.
      ii. Let $x$ be $-x$.
   b. If the value of the $[[style]]$ internal property of $numberFormat$ is "$percent$", let $x$ be $100 \times x$.
   c. If the $[[minimumSignificantDigits]]$ and $[[maximumSignificantDigits]]$ internal properties of $numberFormat$ are present, then
      i. Let $n$ be the result of calling the ToRawPrecision abstract operation (defined below), passing as arguments $x$ and the values of the $[[minimumSignificantDigits]]$ and $[[maximumSignificantDigits]]$ internal properties of $numberFormat$.
   d. Else
      i. Let $n$ be the result of calling the ToRawFixed abstract operation (defined below), passing as arguments $x$ and the values of the $[[minimumIntegerDigits]]$, $[[minimumFractionDigits]]$, and $[[maximumFractionDigits]]$ internal properties of $numberFormat$.
   e. If the value of the $[[numberingSystem]]$ internal property of $numberFormat$ matches one of the values in the "Numbering System" column of Table 2 below, then
      i. Let $digits$ be an array whose 10 String valued elements are the UTF-16 string representations of the 10 digits specified in the "Digits" column of Table 2 in the row containing the value of the $[[numberingSystem]]$ internal property.
      ii. Replace each digit in $n$ with the value of $digits[digit]$.
   f. Else use an implementation dependent algorithm to map $n$ to the appropriate representation of $n$ in the given numbering system.
   g. If $n$ contains the character ".", then replace it with an ILND String representing the decimal separator.
   h. If the value of the $[[useGrouping]]$ internal property of $numberFormat$ is $true$, then insert an ILND String representing a grouping separator into an ILND set of locations within the integer part of $n$.

NOTE The function returned by $[[Get]]$ is bound to this NumberFormat object so that it can be passed directly to Array.prototype.map or other functions.

The value of the $[[Set]]$ attribute is $undefined$.

When the FormatNumber abstract operation is called with arguments $numberFormat$ (which must be a NumberFormat object) and $x$ (which must be a Number value), it returns a String value representing $x$ according to the effective locale and the formatting options of $numberFormat$.

The computations rely on String values and locations within numeric strings that are dependent upon the implementation and the effective locale of $numberFormat$ ("ILD") or upon the implementation, the effective locale, and the numbering system of $numberFormat$ ("ILND"). The ILD and ILND Strings mentioned, other than those for currency names, must not contain any characters in the General Category "Number, decimal digit" as specified by the Unicode Standard.

NOTE It is recommended that implementations use the locale data provided by the Common Locale Data Repository (available at http://cldr.unicode.org/).

The following steps are taken:

1. Let $negative$ be $false$.
2. If the result of $isFinite(x)$ is $false$, then
   a. If $x$ is $NaN$, then let $n$ be an ILD String value indicating the $NaN$ value.
   b. Else
      i. Let $n$ be an ILD String value indicating infinity.
      ii. If $x < 0$, then let $negative$ be $true$.
3. Else
   a. If $x < 0$, then
      i. Let $negative$ be $true$.
      ii. Let $x$ be $-x$.
   b. If the value of the $[[style]]$ internal property of $numberFormat$ is "$percent$", let $x$ be $100 \times x$.
   c. If the $[[minimumSignificantDigits]]$ and $[[maximumSignificantDigits]]$ internal properties of $numberFormat$ are present, then
      i. Let $n$ be the result of calling the ToRawPrecision abstract operation (defined below), passing as arguments $x$ and the values of the $[[minimumSignificantDigits]]$ and $[[maximumSignificantDigits]]$ internal properties of $numberFormat$.
   d. Else
      i. Let $n$ be the result of calling the ToRawFixed abstract operation (defined below), passing as arguments $x$ and the values of the $[[minimumIntegerDigits]]$, $[[minimumFractionDigits]]$, and $[[maximumFractionDigits]]$ internal properties of $numberFormat$.
   e. If the value of the $[[numberingSystem]]$ internal property of $numberFormat$ matches one of the values in the "Numbering System" column of Table 2 below, then
      i. Let $digits$ be an array whose 10 String valued elements are the UTF-16 string representations of the 10 digits specified in the "Digits" column of Table 2 in the row containing the value of the $[[numberingSystem]]$ internal property.
      ii. Replace each digit in $n$ with the value of $digits[digit]$.
   f. Else use an implementation dependent algorithm to map $n$ to the appropriate representation of $n$ in the given numbering system.
   g. If $n$ contains the character ".", then replace it with an ILND String representing the decimal separator.
   h. If the value of the $[[useGrouping]]$ internal property of $numberFormat$ is $true$, then insert an ILND String representing a grouping separator into an ILND set of locations within the integer part of $n$. 

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4. If negative is true, then let result be the value of the [[negativePattern]] internal property of numberFormat; else let result be the value of the [[positivePattern]] internal property of numberFormat.

5. Replace the substring "\{number\}" within result with n.

6. If the value of the [[style]] internal property of numberFormat is "currency", then:
   a. Let currency be the value of the [[currency]] internal property of numberFormat.
   b. If the value of the [[CurrencyDisplay]] internal property of numberFormat is "code", then let cd be currency.
   c. Else if the value of the [[CurrencyDisplay]] internal property of numberFormat is "symbol", then let cd be an ILD string representing currency in short form. If the implementation does not have such a representation of currency, then use currency itself.
   d. Else if the value of the [[CurrencyDisplay]] internal property of numberFormat is "name", then let cd be an ILD string representing currency in long form. If the implementation does not have such a representation of currency, then use currency itself.
   e. Replace the substring "{currency}" within result with cd.

7. Return result.

When the ToRawFixed abstract operation is called with arguments x (which must be a finite non-negative number), minPrecision, and maxPrecision (both must be integers between 1 and 21) the following steps are taken:

1. Let p be maxPrecision.
2. If x = 0, then
   a. Let m be the String consisting of p occurrences of the character "0".
   b. Let e be 0.
3. Else
   a. Let e and n be integers such that \(10^{-1} \leq n < 10^p\) and for which the exact mathematical value of \(n \times 10^{-e+1}\) is as close to zero as possible. If there are two such sets of e and n, pick the larger set.
   b. Let m be the String consisting of the digits of the decimal representation of n (in order, with no leading zeroes).
4. If e ≥ p then
   a. Return the concatenation of m and \(e-p+1\) occurrences of the character "0".
5. If e = p-1 then
   a. Return m.
6. If \(e \geq 0\) then
   a. Let m be the concatenation of the first \(e+1\) characters of m, the character ".", and the remaining \(p-(e+1)\) characters of m.
7. If \(e < 0\) then
   a. Let m be the concatenation of the String "0","\(,-(e+1)\) occurrences of the character ",", and the string m.
8. If m contains the character ",", and maxPrecision > minPrecision, then
   a. Let cut be maxPrecision − minPrecision.
   b. Repeat while cut > 0 and the last character of m is ",":
      i. Remove the last character from m.
      ii. Decrease cut by 1.
   c. If the last character of m is "", then
      i. Remove the last character from m.
9. Return m.

When the ToRawFixed abstract operation is called with arguments x (which must be a finite non-negative number), minInteger (which must be an integer between 1 and 21), minFraction, and maxFraction (which must be integers between 0 and 20) the following steps are taken:

1. Let f be maxFraction.
2. Let n be an integer for which the exact mathematical value of \(n + 10^{-f} \times x\) is as close to zero as possible. If there are two such n, pick the larger n.
3. If \(n = 0\), let m be the String "0". Otherwise, let m be the String consisting of the digits of the decimal representation of n (in order, with no leading zeroes).
4. If \(f \neq 0\), then
a. Let $k$ be the number of characters in $m$.
b. If $k \leq f$, then
   i. Let $z$ be the string consisting of $f-1-k$ occurrences of the character "0".
   ii. Let $m$ be the concatenation of Strings $z$ and $m$.
   iii. Let $k = f$.
c. Let $a$ be the first $k-f$ characters of $m$, and let $b$ be the remaining $f$ characters of $m$.
d. Let $m$ be the concatenation of the three Strings $a$, ",", and $b$.
e. Let $int$ be the number of characters in $a$.

5. Else let $int$ be the number of characters in $m$.

6. Let $cut = \text{maxFraction} - \text{minFraction}$.

7. Repeat while $cut > 0$ and the last character of $m$ is "0":
   a. Remove the last character from $m$.
   b. Decrease $cut$ by 1.

8. If the last character of $m$ is ",", then
   a. Remove the last character from $m$.

9. If $int < \text{minInteger}$, then
   a. Let $z$ be the string consisting of $\text{minInteger}-int$ occurrences of the character "0".
   b. Let $m$ be the concatenation of Strings $z$ and $m$.

10. Return $m$.

**Table 2 – Numbering systems with simple digit mappings**

<table>
<thead>
<tr>
<th>Numbering System</th>
<th>Digits</th>
</tr>
</thead>
<tbody>
<tr>
<td>arab</td>
<td>U+0660 to U+0669</td>
</tr>
<tr>
<td>arabext</td>
<td>U+06F0 to U+06F9</td>
</tr>
<tr>
<td>beng</td>
<td>U+09E6 to U+09EF</td>
</tr>
<tr>
<td>deva</td>
<td>U+0966 to U+096F</td>
</tr>
<tr>
<td>fullwide</td>
<td>U+FF10 to U+FF19</td>
</tr>
<tr>
<td>guj</td>
<td>U+0AE6 to U+0AEF</td>
</tr>
<tr>
<td>guru</td>
<td>U+0A66 to U+0A6F</td>
</tr>
<tr>
<td>hanidec</td>
<td>U+3007, U+4E00, U+4E8C, U+4E09, U+56DB, U+4E94, U+516D, U+4E03, U+516B, U+4E5D</td>
</tr>
<tr>
<td>khmr</td>
<td>U+17E0 to U+17E9</td>
</tr>
<tr>
<td>knda</td>
<td>U+0CE6 to U+0CEF</td>
</tr>
<tr>
<td>laoo</td>
<td>U+0ED0 to U+0ED9</td>
</tr>
<tr>
<td>latn</td>
<td>U+0030 to U+0039</td>
</tr>
<tr>
<td>mlym</td>
<td>U+0D66 to U+0D6F</td>
</tr>
<tr>
<td>mong</td>
<td>U+1810 to U+1819</td>
</tr>
<tr>
<td>mynr</td>
<td>U+1040 to U+1049</td>
</tr>
<tr>
<td>orya</td>
<td>U+0BE6 to U+0BEF</td>
</tr>
<tr>
<td>tamidec</td>
<td>U+0BE6 to U+0BEF</td>
</tr>
<tr>
<td>telu</td>
<td>U+0C66 to U+0C6F</td>
</tr>
<tr>
<td>thai</td>
<td>U+0E50 to U+0E59</td>
</tr>
<tr>
<td>tibt</td>
<td>U+0F20 to U+0F29</td>
</tr>
</tbody>
</table>

11.3.3 Intl.NumberFormat.prototype.resolvedOptions ()

This function provides access to the locale and formatting options computed during initialization of the object.
The function returns a new object whose properties and attributes are set as if constructed by an object literal assigning to each of the following properties the value of the corresponding internal property of this NumberFormat object (see 11.4): locale, numberingSystem, style, currency, currencyDisplay, minimumIntegerDigits, minimumFractionDigits, maximumFractionDigits, minimumSignificantDigits, maximumSignificantDigits, and useGrouping. Properties whose corresponding internal properties are not present are not assigned.

11.4 Properties of Intl.NumberFormat Instances

Intl.NumberFormat instances inherit properties from the Intl.NumberFormat prototype object. Their [[Class]] internal property value is "Object".

Intl.NumberFormat instances and other objects that have been successfully initialized as a NumberFormat have [[initializedIntlObject]] and [[initializedNumberFormat]] internal properties whose values are true.

Objects that have been successfully initialized as a NumberFormat also have several internal properties that are computed by the constructor:

- [[locale]] is a String value with the language tag of the locale whose localization is used for formatting.
- [[numberingSystem]] is a String value with the "type" given in Unicode Technical Standard 35 for the numbering system used for formatting.
- [[style]] is one of the String values "decimal", "currency", or "percent", identifying the number format style used.
- [[currency]] is a String value with the currency code identifying the currency to be used if formatting with the "currency" style. It is only present when [[style]] has the value "currency".
- [[currencyDisplay]] is one of the String values "code", "symbol", or "name", specifying whether to display the currency as an ISO 4217 alphabetic currency code, a localized currency symbol, or a localized currency name if formatting with the "currency" style. It is only present when [[style]] has the value "currency".
- [[minimumIntegerDigits]] is a non-negative integer Number value indicating the minimum integer digits to be used. Numbers will be padded with leading zeroes if necessary.
- [[minimumFractionDigits]] and [[maximumFractionDigits]] are non-negative integer Number values indicating the minimum and maximum fraction digits to be used. Numbers will be rounded or padded with trailing zeroes if necessary.
- [[minimumSignificantDigits]] and [[maximumSignificantDigits]] are positive integer Number values indicating the minimum and maximum fraction digits to be shown. Either none or both of these properties are present, if they are, they override minimum and maximum integer and fraction digits – the formatter uses however many integer and fraction digits are required to display the specified number of significant digits.
- [[useGrouping]] is a Boolean value indicating whether a grouping separator should be used.
- [[positivePattern]] and [[negativePattern]] are String values as described in 11.2.3.

Finally, objects that have been successfully initialized as a NumberFormat have a [[boundFormat]] internal property that caches the function returned by the format accessor (11.3.2).

12 DateTimeFormat Objects

12.1 The Intl.DateTimeFormat Constructor

The Intl.DateTimeFormat constructor is a standard built-in property of the Intl object. Behaviour common to all service constructor properties of the Intl object is specified in 9.1.
12.1.1 Initializing an Object as a DateTimeFormat

12.1.1.1 InitializeDateTimeFormat (dateTimeFormat, locales, options)

The abstract operation InitializeDateTimeFormat accepts the arguments dateTimeFormat (which must be an object), locales, and options. It initializes dateTimeFormat as a DateTimeFormat object.

Several DateTimeFormat algorithms use values from the following table, which provides property names and allowable values for the components of date and time formats:

<table>
<thead>
<tr>
<th>Property</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>weekday</td>
<td>&quot;narrow&quot;, &quot;short&quot;, &quot;long&quot;</td>
</tr>
<tr>
<td>era</td>
<td>&quot;narrow&quot;, &quot;short&quot;, &quot;long&quot;</td>
</tr>
<tr>
<td>year</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>month</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;, &quot;narrow&quot;, &quot;short&quot;, &quot;long&quot;</td>
</tr>
<tr>
<td>day</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>hour</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>minute</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>second</td>
<td>&quot;2-digit&quot;, &quot;numeric&quot;</td>
</tr>
<tr>
<td>timeZoneName</td>
<td>&quot;short&quot;, &quot;long&quot;</td>
</tr>
</tbody>
</table>

The following steps are taken:

1. If dateTimeFormat has an [[initializedIntlObject]] internal property with value true, throw a TypeError exception.
2. Set the [[initializedIntlObject]] internal property of dateTimeFormat to true.
3. Let requestedLocales be the result of calling the CanonicalizeLocaleList abstract operation (defined in 9.2.1) with argument locales.
4. Let options be the result of calling the ToDateTimeOptions abstract operation (defined below) with arguments options, "any", and "date".
5. Let opt be a new Record.
6. Let matcher be the result of calling the GetOption abstract operation (defined in 9.2.9) with argument options, "localeMatcher", "string", a List containing the two String values "lookup" and "best fit", and "best fit".
7. Set opt.[[localeMatcher]] to matcher.
8. Let DateTimeFormat be the standard built-in object that is the initial value of Intl.DateTimeFormat.
9. Let localeData be the value of the [[localeData]] internal property of DateTimeFormat.
10. Let r be the result of calling the ResolveLocale abstract operation (defined in 9.2.5) with the [[availableLocales]] internal property of DateTimeFormat, requestedLocales, opt, the [[relevantExtensionKeys]] internal property of DateTimeFormat, and localeData.
11. Set the [[locale]] internal property of dateTimeFormat to the value of r.[[locale]].
12. Set the [[calendar]] internal property of dateTimeFormat to the value of r.[[ca]].
13. Set the [[numberingSystem]] internal property of dateTimeFormat to the value of r.[[nu]].
14. Let dataLocale be the value of r.[[dataLocale]].
15. Let tz be the result of calling the [[Get]] internal method of options with argument "timeZone".
16. If tz is not undefined, then
   a. Let tz be ToString(tz).
   b. Convert tz to upper case as described in 6.1.
   c. If tz is not "UTC", then throw a RangeError exception.
17. Set the [[timezone]] internal property of dateTimeFormat to tz.
18. Let hr12 be the result of calling the GetOption abstract operation with arguments options, "hour12", "boolean", undefined, and undefined.
Let dataLocaleDate be the result of calling the [[Get]] internal method of localeData with argument dataLocale.

If hr12 is undefined, then let hr12 be the result of calling the [[Get]] internal method of dataLocaleDate with argument "hour12".

Set the [[hour12]] internal property of dateTimeFormat to hr12.

Let opt be a new Record.

For each row of Table 3, except the header row, do:

a. Let prop be the name given in the Property column of the row.

b. Let value be the result of calling the GetOption abstract operation, passing as argument options, the name given in the Property column of the row, "string", a List containing the strings given in the Values column of the row, and undefined.

c. Set opt.[[prop]] to value.

Let formats be the result of calling the [[Get]] internal method of dataLocaleDate with argument "formats".

Let matcher be the result of calling the GetOption abstract operation with arguments options, "formatMatcher", "string", a List containing the two String values "basic" and "best fit", and "best fit".

If matcher is "basic" then

a. Let bestFormat be the result of calling the BasicFormatMatcher abstract operation (defined below) with opt and formats.

 Else

a. Let bestFormat be the result of calling the BestFitFormatMatcher abstract operation (defined below) with opt and formats.

For each row in Table 3, except the header row, do

a. Let prop be the name given in the Property column of the row.

b. Let pDesc be the result of calling the [[GetOwnProperty]] internal method of bestFormat with argument prop.

c. If pDesc is not undefined, then

i. Let p be the result of calling the [[Get]] internal method of bestFormat with argument prop.

ii. Set the [[initializedDateTimeFormat]] internal property of dateTimeFormat to p.

26. Let pattern be the result of calling the [[Get]] internal method of bestFormat with argument "pattern".

30. Set the [[pattern]] internal property of dateTimeFormat to pattern.

31. Set the [[boundFormat]] internal property of dateTimeFormat to undefined.

32. Set the [[initializedDateTimeFormat]] internal property of dateTimeFormat to true.

When the ToDateTimeOptions abstract operation is called with arguments options, required, and defaults, the following steps are taken:

1. If options is undefined, then let options be null, else let options be ToObject(options).

2. Let create be the standard built-in function object defined in ES5, 15.2.3.5.

3. Let options be the result of calling the [[Call]] internal method of create with undefined as the this value and an argument list containing the single item options.

4. Let needDefaults be true.

5. If required is "date" or "any", then

a. For each of the property names "weekday", "year", "month", "day":

i. If the result of calling the [[Get]] internal method of options with the property name is not undefined, then let needDefaults be false.

6. If required is "time" or "any", then

a. For each of the property names "hour", "minute", "second":

i. If the result of calling the [[Get]] internal method of options with the property name is not undefined, then let needDefaults be false.

7. If needDefaults is true and defaults is either "date" or "all", then

a. For each of the property names "year", "month", "day":

i. Call the [[DefineOwnProperty]] internal method of options with the property name, Property Descriptor ([[Value]]: "numeric", [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true, and false.

8. If needDefaults is true and defaults is either "time" or "all", then

a. For each of the property names "hour", "minute", "second":

i. Call the [[DefineOwnProperty]] internal method of options with the property name, Property Descriptor ([[Value]]: "numeric", [[Writable]]: true, [[Enumerable]]: true, [[Configurable]]: true, and false.
9. Return options.

When the BasicFormatMatcher abstract operation is called with two arguments options and formats, the following steps are taken:

1. Let removalPenalty be 120.
2. Let additionPenalty be 20.
3. Let longLessPenalty be 8.
5. Let shortLessPenalty be 6.
7. Let bestScore be -Infinity.
8. Let bestFormat be undefined.
9. Let i be 0.
10. Let len be the result of calling the [[Get]] internal method of formats with argument "length".
11. Repeat while i < len:
   a. Let format be the result of calling the [[Get]] internal method of formats with argument ToString(i).
   b. Let score be 0.
   c. For each property shown in Table 3:
      i. Let optionsProp be options.["property"].
      ii. Let formatPropDesc be the result of calling the [[GetOwnProperty]] internal method of format with argument property.
      iii. If formatPropDesc is not undefined, then
          1. Let formatProp be the result of calling the [[Get]] internal method of format with argument property.
          iv. If optionsProp is undefined and formatProp is not undefined, then decrease score by additionPenalty.
          v. Else if optionsProp is not undefined and formatProp is undefined, then decrease score by removalPenalty.
          vi. Else
              1. Let values be the array ["2-digit", "numeric", "narrow", "short", "long"].
              2. Let optionsPropIndex be the index of optionsProp within values.
              3. Let formatPropIndex be the index of formatProp within values.
              4. Let delta be max(min(formatPropIndex - optionsPropIndex, 2), -2).
              5. If delta = 2, decrease score by longMorePenalty.
              6. Else if delta = 1, decrease score by shortMorePenalty.
              7. Else if delta = -1, decrease score by shortLessPenalty.
              8. Else if delta = -2, decrease score by longLessPenalty.
          d. If score > bestScore, then
             i. Let bestScore be score.
             ii. Let bestFormat be format.
          c. Increase i by 1.

When the BestFitFormatMatcher abstract operation is called with two arguments options and formats, it performs implementation dependent steps, which should return a set of component representations that a typical user of the selected locale would perceive as at least as good as the one returned by BasicFormatMatcher.

12.1.2 The Intl.DateTimeFormat Constructor Called as a Function

12.1.2.1 Intl.DateTimeFormat.call (this [, locales [, options]])

When Intl.DateTimeFormat is called as a function rather than as a constructor, it accepts the optional arguments locales and options and takes the following steps:

1. If locales is not provided, then let locales be undefined.
2. If options is not provided, then let options be undefined.
3. If this is the standard built-in Intl object defined in 8 or undefined, then
12.1.3 The Intl.DateTimeFormat Constructor Used in a new Expression

12.1.3.1 new Intl.DateTimeFormat ([locales [, options]])

When Intl.DateTimeFormat is called as part of a new expression, it is a constructor: it initializes the newly created object.

The [[Prototype]] internal property of the newly constructed object is set to the original Intl.DateTimeFormat prototype object, the one that is the initial value of Intl.DateTimeFormat.prototype (12.2.1).

The [[Extensible]] internal property of the newly constructed object is set to true.

DateTimeFormat-specific properties of the newly constructed object are set using the following steps:

1. If locales is not provided, then let locales be undefined.
2. If options is not provided, then let options be undefined.
3. Call the InitializeDateTimeFormat abstract operation (defined in 12.1.1.1), passing as arguments the newly constructed object, locales, and options.

12.2 Properties of the Intl.DateTimeFormat Constructor

Besides the internal properties and the length property (whose value is 0), the Intl.DateTimeFormat constructor has the following properties:

12.2.1 Intl.DateTimeFormat.prototype

The value of Intl.DateTimeFormat.prototype is the built-in Intl.DateTimeFormat prototype object (12.3).

This property has the attributes { [[Writable]]: false, [[Enumerable]]: false, [[Configurable]]: false }.

12.2.2 Intl.DateTimeFormat.supportedLocalesOf (locales [, options])

When the supportedLocalesOf method of Intl.DateTimeFormat is called, the following steps are taken:

1. If options is not provided, then let options be undefined.
2. Let availableLocales be the value of the [[availableLocales]] internal property of the standard built-in object that is the initial value of Intl.DateTimeFormat.
3. Let requestedLocales be the result of calling the CanonicalizeLocaleList abstract operation (defined in 9.2.1) with argument locales.
4. Return the result of calling the SupportedLocales abstract operation (defined in 9.2.8) with arguments availableLocales, requestedLocales, and options.

The value of the length property of the supportedLocalesOf method is 1.

12.2.3 Internal Properties

The value of the [[availableLocales]] internal property is implementation defined within the constraints described in 9.1.

The value of the [[relevantExtensionKeys]] internal property is {“ca”, “nu”}.
NOTE Unicode Technical Standard 35 describes three locale extension keys that are relevant to date and time formatting, "ca" for calendar, "tz" for time zone, and implicitly "nu" for the numbering system of the number format used for numbers within the date format. DateTimeFormat, however, requires that the time zone is specified through the timeZone property in the options objects.

The value of the [[localeData]] internal property is implementation defined within the constraints described in 9.1 and the following additional constraints:

- The array that is the value of the "nu" property of any locale property of [[localeData]] must not include the values "native", "traditional", or "finance".
- [[localeData]] at locale must have an hour12 property with a Boolean value for all locale values.
- [[localeData]] at locale must have a formats property for all locale values. The value of this property must be an array of objects, each of which has a subset of the properties shown in Table 3, where each property must have one of the values specified for the property in Table 3. Multiple objects in an array may use the same subset of the properties as long as they have different values for the properties. The following subsets must be available for each locale:
  - weekday, year, month, day, hour, minute, second
  - weekday, year, month, day
  - year, month
  - month, day
  - hour, minute
  - hour, minute, second
  - hour, minute, second
  - hour, minute, second, pattern: "{hour}:{minute}:{second}".

Each of the objects must also have a pattern property, whose value is a String value that contains for each of the date and time format component properties of the object a substring starting with "{", followed by the name of the property, followed by "}".

EXAMPLE An implementation might include the following object as part of its English locale data: {hour: "numeric", minute: "2-digit", second: "2-digit", pattern: "{hour}:{minute}:{second}"}.

NOTE It is recommended that implementations use the locale data provided by the Common Locale Data Repository (available at http://cldr.unicode.org/).

12.3 Properties of the Intl.DateTimeFormat Prototype Object

The Intl.DateTimeFormat prototype object is itself an Intl.DateTimeFormat instance as specified in 12.4, whose internal properties are set as if it had been constructed by the expression Intl.DateTimeFormat.call({}) with the standard built-in values of Intl.DateTimeFormat and Function.prototype.call.

In the following descriptions of functions that are properties of the Intl.DateTimeFormat prototype object, the phrase "this DateTimeFormat object" refers to the object that is the this value for the invocation of the function; a TypeError exception is thrown if the this value is not an object or an object that does not have an [[initializedDateTimeFormat]] internal property with value true.

12.3.1 Intl.DateTimeFormat.prototype.constructor

The initial value of Intl.DateTimeFormat.prototype.constructor is the built-in Intl.DateTimeFormat constructor.

12.3.2 Intl.DateTimeFormat.prototype.format

This named accessor property returns a function that formats a date according to the effective locale and the formatting options of this DateTimeFormat object.

The value of the [[Get]] attribute is a function that takes the following steps:

1. If the [[boundFormat]] internal property of this DateTimeFormat object is undefined, then:
a. Let \( F \) be a Function object, with internal properties set as specified for built-in functions in ES5, 15, or successor, and the length property set to 0, that takes the argument \( date \) and performs the following steps:

i. If \( date \) is not provided or is \texttt{undefined}, then let \( x \) be the result as if by the expression \( \text{Date.now()} \) where \( \text{Date.now} \) is the standard built-in function defined in ES5, 15.9.4.4.

ii. Else let \( x \) be \( \text{ToNumber}(date) \).

iii. Return the result of calling the FormatDateTime abstract operation (defined below) with arguments \( this \) and \( x \).

b. Let \( bind \) be the standard built-in function object defined in ES5, 15.3.4.5.

c. Let \( bf \) be the result of calling the \([\text{[[Call]]}] \) internal method of \( bind \) with \( F \) as the \( this \) value and an argument list containing the single item \( x \).

d. Set the \([\text{[[boundFormat]]}] \) internal property of this DateTimeFormat object to \( bf \).

2. Return the value of the \([\text{[[boundFormat]]}] \) internal property of this DateTimeFormat object.

NOTE The function returned by \([\text{[[Get]]}] \) is bound to this DateTimeFormat object so that it can be passed directly to \( \text{Array.prototype.map} \) or other functions.

The value of the \([\text{[[Set]]}] \) attribute is \texttt{undefined}.

When the FormatDateTime abstract operation is called with arguments \( dateTimeFormat \) (which must be a DateTimeFormat object) and \( x \) (which must be a Number value), it returns a String value representing \( x \) (interpreted as a time value as specified in ES5, 15.9.1.1) according to the effective locale and the formatting options of \( dateTimeFormat \).

1. If \( x \) is not a finite Number, then throw a \texttt{RangeError} exception.

2. Let \( locale \) be the value of the \([\text{[[locale]]}] \) internal property of \( dateTimeFormat \).

3. Let \( nf2 \) be the result of creating a new NumberFormat object as if by the expression
   \[ \text{Intl.NumberFormat}([\text{locale}], \{\text{useGrouping: false}\}) \]
   where \( \text{Intl.NumberFormat} \) is the standard built-in constructor defined in 11.1.3.

4. Let \( nf2 \) be the result of creating a new NumberFormat object as if by the expression
   \[ \text{Intl.NumberFormat}([\text{locale}], \{\text{minimumIntegerDigits: 2, useGrouping: false}\}) \]
   where \( \text{Intl.NumberFormat} \) is the standard built-in constructor defined in 11.1.3.

5. Let \( nf \) be the result of calling the \( \text{ToLocalTime} \) abstract operation (defined below) with \( x \), the value of the \([\text{[[calendar]]}] \) internal property of \( dateTimeFormat \), and the value of the \([\text{[[timeZone]]}] \) internal property of \( dateTimeFormat \).

6. Let \( \text{result} \) be the value of the \([\text{[[pattern]]}] \) internal property of \( dateTimeFormat \).

7. For each row of Table 3, except the header row, do:

   a. If \( dateTimeFormat \) has an internal property with the name given in the Property column of the row, then:
      i. Let \( p \) be the name given in the Property column of the row.
      ii. Let \( f \) be the value of the \([\text{[[p]]}] \) internal property of \( dateTimeFormat \).
      iii. Let \( v \) be the value of \( \text{vm}([\text{f}]) \).
      iv. If \( p \) is \texttt{"month"}, then increase \( v \) by 1.
      v. If \( f \) is \texttt{"numeric"}, then
         1. Let \( fv \) be the result of calling the \( \text{FormatNumber} \) abstract operation (defined in 11.3.2) with arguments \( nf2 \) and \( v \).
         6. Else if \( f \) is \texttt{"2-digit"}, then
            1. Let \( fv \) be the result of calling the \( \text{FormatNumber} \) abstract operation with arguments \( nf2 \) and \( v \).
            2. If the length of \( fv \) is greater than 2, let \( fv \) be the substring of \( fv \) containing the last two characters.
         vi. Else if \( f \) is \texttt{"narrow"}, \texttt{"short"}, or \texttt{"long"}, then let \( fv \) be a String value representing \( f \) in the desired form; the String value depends upon the implementation and the effective locale and calendar of \( dateTimeFormat \). If \( p \) is \texttt{"month"}, then the String value may also depend on whether \( dateTimeFormat \) has a \([\text{[[DST]]}] \) internal property. If \( p \) is \texttt{"timeZoneName"}, then the String value may also depend on the value of the \([\text{[[IDST]]}] \) field of \( \text{vm} \).
      vii. Replace the substring of \( \text{result} \) that consists of \( \{4", p, \text{ and } "1\} \), with \( fv \).

8. Return \( \text{result} \).
When the abstract operationToLocalTime is called with arguments date, calendar, and timeZone, the following steps are taken:

1. Apply calendrical calculations on date for the given calendar and time zone to produce weekday, era, year, month, day, hour, minute, second, and inDST values. The calculations should use best available information about the specified calendar and time zone. If the calendar is "gregory", then the calculations must match the algorithms specified in ES5, 15.9.1, except that calculations are not bound by the restrictions on the use of best available information on time zones for local time zone adjustment and daylight saving time adjustment imposed by ES5, 15.9.1.7 and 15.9.1.8.

2. Return a Record with fields [[weekday]], [[era]], [[year]], [[month]], [[day]], [[hour]], [[minute]], [[second]], and [[inDST]], each with the corresponding calculated value.

NOTE It is recommended that implementations use the time zone information of the IANA Time Zone Database.

12.3.3 Intl.DateTimeFormat.prototype.resolvedOptions ()

This function provides access to the locale and formatting options computed during initialization of the object.

The function returns a new object whose properties and attributes are set as if constructed by an object literal assigning to each of the following properties the value of the corresponding internal property of this DateTimeFormat object (see 12.4): locale, calendar, numberingSystem, timeZone, hour12, weekday, era, year, month, day, hour, minute, second, and timeZoneName. Properties whose corresponding internal properties are not present are not assigned.

NOTE In this version of the ECMAScript Internationalization API, the timeZone property will remain undefined if no timeZone property was provided in the options object provided to the Intl.DateTimeFormat constructor. However, applications should not rely on this, as future versions may return a String value identifying the host environment's current time zone instead.

12.4 Properties of Intl.DateTimeFormat Instances

Intl.DateTimeFormat instances inherit properties from the Intl.DateTimeFormat prototype object. Their [[Class]] internal property value is "object".

Intl.DateTimeFormat instances and other objects that have been successfully initialized as a DateTimeFormat have [[initializedIntlObject]] and [[initializedDateTimeFormat]] internal properties whose values are true.

Objects that have been successfully initialized as a DateTimeFormat also have several internal properties that are computed by the constructor:

- [[locale]] is a String value with the language tag of the locale whose localization is used for formatting.
- [[calendar]] is a String value with the "type" given in Unicode Technical Standard 35 for the calendar used for formatting.
- [[numberingSystem]] is a String value with the "type" given in Unicode Technical Standard 35 for the numbering system used for formatting.
- [[timeZone]] is either the String value "UTC" or undefined.
- [[hour12]] is a Boolean value indicating whether 12-hour format (true) or 24-hour format (false) should be used.
- [[weekday]], [[era]], [[year]], [[month]], [[day]], [[hour]], [[minute]], [[second]], and [[timeZoneName]] are each either absent, indicating that the component is not used for formatting, or one of the String values given in Table 3, indicating how the component should be presented in the formatted output.
- [[pattern]] is a String value as described in 12.2.3.

Finally, objects that have been successfully initialized as a DateTimeFormat have a [[boundFormat]] internal property that caches the function returned by the format accessor (12.3.2).
13 Locale Sensitive Functions of the ECMAScript Language Specification

The ECMAScript Language Specification, edition 5.1 or successor, describes several locale sensitive functions. An ECMAScript implementation that implements this Internationalization API shall implement these functions as described here.

NOTE The Collator, NumberFormat, or DateTimeFormat objects created in the algorithms in this clause are only used within these algorithms. They are never directly accessed by ECMAScript code and need not actually exist within an implementation.

13.1 Properties of the String Prototype Object

13.1.1 String.prototype.localeCompare (that, locales, options)

This definition supersedes the definition provided in ES5, 15.5.4.9.

When the `localeCompare` method is called with argument `that` and optional arguments `locales`, and `options`, the following steps are taken:

1. Call `CheckObjectCoercible` passing the `this` value as its argument.
2. Let `S` be the result of calling `ToString` passing the `this` value as its argument.
3. Let `That` be `ToString`(`that`).
4. If `locales` is not provided, then let `locales` be `undefined`.
5. If `options` is not provided, then let `options` be `undefined`.
6. Let `collator` be the result of creating an object as if by the expression `new Intl.Collator(locales, options)` where `Intl.Collator` is the standard built-in constructor defined in 10.1.3.
7. Return the result of calling the `CompareStrings` abstract operation (defined in 10.3.2) with arguments `collator`, `S`, and `That`.

The value of the `length` property of the `localeCompare` method is 1.

NOTE 1 The `localeCompare` method itself is not directly suitable as an argument to `Array.prototype.sort` because the latter requires a function of two arguments.

NOTE 2 The `localeCompare` function is intentionally generic; it does not require that its `this` value be a String object. Therefore, it can be transferred to other kinds of objects for use as a method.

13.2 Properties of the Number Prototype Object

13.2.1 Number.prototype.toLocaleString (locales, options)

This definition supersedes the definition provided in ES5, 15.7.4.3.

When the `toLocaleString` method is called with optional arguments `locales` and `options`, the following steps are taken:

1. Let `x` be this Number value (as defined in ES5, 15.7.4).
2. If `locales` is not provided, then let `locales` be `undefined`.
3. If `options` is not provided, then let `options` be `undefined`.
4. Let `numberFormat` be the result of creating a new object as if by the expression `new Intl.NumberFormat(locales, options)` where `Intl.NumberFormat` is the standard built-in constructor defined in 11.1.3.
5. Return the result of calling the `FormatNumber` abstract operation (defined in 11.3.2) with arguments `numberFormat` and `x`.

The value of the `length` property of the `toLocaleString` method is 6.
13.3 Properties of the Date Prototype Object

13.3.1 Date.prototype.toLocaleString ([locales [, options]])

This definition supersedes the definition provided in ES5, 15.9.5.5.

When the toLocaleString method is called with optional arguments locales and options, the following steps are taken:

1. Let x be this time value (as defined in ES5, 15.9.5).
2. If x is NaN, return "Invalid Date".
3. If locales is not provided, then let locales be undefined.
4. If options is not provided, then let options be undefined.
5. Let options be the result of calling the ToDateTimeOptions abstract operation (defined in 12.1.1) with arguments options, "any", and "all".
6. Let dateTimeFormat be the result of creating a new object as if by the expression new Intl.DateTimeFormat(locales, options) where Intl.DateTimeFormat is the standard built-in constructor defined in 12.1.3.
7. Return the result of calling the FormatDateTime abstract operation (defined in 12.3.2) with arguments dateTimeFormat and x.

The value of the length property of the toLocaleString method is 0.

13.3.2 Date.prototype.toLocaleDateString ([locales [, options]])

This definition supersedes the definition provided in ES5, 15.9.5.6.

When the toLocaleDateString method is called with optional arguments locales and options, the following steps are taken:

1. Let x be this time value (as defined in ES5, 15.9.5).
2. If x is NaN, return "Invalid Date".
3. If locales is not provided, then let locales be undefined.
4. If options is not provided, then let options be undefined.
5. Let options be the result of calling the ToDateTimeOptions abstract operation (defined in 12.1.1) with arguments options, "date", and "date".
6. Let dateFormat be the result of creating a new object as if by the expression new Intl.DateTimeFormat(locales, options) where Intl.DateTimeFormat is the standard built-in constructor defined in 12.1.3.
7. Return the result of calling the FormatDateTime abstract operation (defined in 12.3.2) with arguments dateFormat and x.

The value of the length property of the toLocaleDateString method is 0.

13.3.3 Date.prototype.toLocaleTimeString ([locales [, options]])

This definition supersedes the definition provided in ES5, 15.9.5.7.

When the toLocaleTimeString method is called with optional arguments locales and options, the following steps are taken:

1. Let x be this time value (as defined in ES5, 15.9.5).
2. If x is NaN, return "Invalid Date".
3. If locales is not provided, then let locales be undefined.
4. If options is not provided, then let options be undefined.
5. Let options be the result of calling the ToDateTimeOptions abstract operation (defined in 12.1.1) with arguments options, "time", and "time".
6. Let `timeFormat` be the result of creating a new object as if by the expression `new Intl.DateTimeFormat(locales, options)` where `Intl.DateTimeFormat` is the standard built-in constructor defined in 12.1.3.

7. Return the result of calling the `formatDateTime` abstract operation (defined in 12.3.2) with arguments `dateTimeFormat` and `x`.

The value of the `length` property of the `toLocaleTimeString` method is 0.