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JSCalendar: A JSON Representation of Calendar Data

Abstract

This specification defines a data model and JSON representation of calendar data that can be used for storage and data exchange in a calendaring and scheduling environment. It aims to be an alternative and, over time, successor to the widely deployed iCalendar data format. It also aims to be unambiguous, extendable, and simple to process. In contrast to the jCal format, which is also based on JSON, JSCalendar is not a direct mapping from iCalendar but defines the data model independently and expands semantics where appropriate.

Status of This Memo

This is an Internet Standards Track document.

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Table of Contents

1. Introduction
 - 1.1. Motivation and Relation to iCalendar and jCal
 - 1.2. Notational Conventions
 - 1.3. Type Signatures
 - 1.4. Data Types
 - 1.4.1. Id
 - 1.4.2. Int
 - 1.4.3. UnsignedInt
 - 1.4.4. UTCDateTime
 - 1.4.5. LocalDateTime
 - 1.4.6. Duration
 - 1.4.7. SignedDuration
 - 1.4.8. TimeZoneId
 - 1.4.9. PatchObject
 - 1.4.10. Relation
 - 1.4.11. Link
2. JSCalendar Objects

- 2.1. Event
- 2.2. Task
- 2.3. Group
- 3. Structure of JSCalendar Objects
 - 3.1. Object Type
 - 3.2. Normalization and Equivalence
 - 3.3. Vendor-Specific Property Extensions, Values, and Types
- 4. Common JSCalendar Properties
 - 4.1. Metadata Properties
 - 4.1.1. @type
 - 4.1.2. uid
 - 4.1.3. relatedTo
 - 4.1.4. prodId
 - 4.1.5. created
 - 4.1.6. updated
 - 4.1.7. sequence
 - 4.1.8. method
 - 4.2. What and Where Properties
 - 4.2.1. title
 - 4.2.2. description
 - 4.2.3. descriptionContentType
 - 4.2.4. showWithoutTime
 - 4.2.5. locations
 - 4.2.6. virtualLocations
 - 4.2.7. links
 - 4.2.8. locale
 - 4.2.9. keywords
 - 4.2.10. categories
 - 4.2.11. color
 - 4.3. Recurrence Properties
 - 4.3.1. recurrenceId
 - 4.3.2. recurrenceIdTimeZone
 - 4.3.3. recurrenceRules
 - 4.3.4. excludedRecurrenceRules
 - 4.3.5. recurrenceOverrides
 - 4.3.6. excluded
 - 4.4. Sharing and Scheduling Properties
 - 4.4.1. priority
 - 4.4.2. freeBusyStatus
 - 4.4.3. privacy
 - 4.4.4. replyTo
 - 4.4.5. sentBy
 - 4.4.6. participants
 - 4.4.7. requestStatus
 - 4.5. Alerts Properties
 - 4.5.1. useDefaultAlerts
 - 4.5.2. alerts
 - 4.6. Multilingual Properties
 - 4.6.1. localizations
 - 4.7. Time Zone Properties
 - 4.7.1. timeZone
 - 4.7.2. timeZones
- 5. Type-Specific JSCalendar Properties
 - 5.1. Event Properties
 - 5.1.1. start
 - 5.1.2. duration
 - 5.1.3. status
 - 5.2. Task Properties
 - 5.2.1. due
 - 5.2.2. start
 - 5.2.3. estimatedDuration
 - 5.2.4. percentComplete
 - 5.2.5. progress
 - 5.2.6. progressUpdated
 - 5.3. Group Properties
 - 5.3.1. entries
 - 5.3.2. source
- 6. Examples
 - 6.1. Simple Event
 - 6.2. Simple Task
 - 6.3. Simple Group

- 6.4. All-Day Event
 - 6.5. Task with a Due Date
 - 6.6. Event with End Time Zone
 - 6.7. Floating-Time Event (with Recurrence)
 - 6.8. Event with Multiple Locations and Localization
 - 6.9. Recurring Event with Overrides
 - 6.10. Recurring Event with Participants
 - 7. Security Considerations
 - 7.1. Expanding Recurrences
 - 7.2. JSON Parsing
 - 7.3. URI Values
 - 7.4. Spam
 - 7.5. Duplication
 - 7.6. Time Zones
 - 8. IANA Considerations
 - 8.1. Media Type Registration
 - 8.2. Creation of the "JSCalendar Properties" Registry
 - 8.2.1. Preliminary Community Review
 - 8.2.2. Submit Request to IANA
 - 8.2.3. Designated Expert Review
 - 8.2.4. Change Procedures
 - 8.2.5. "JSCalendar Properties" Registry Template
 - 8.2.6. Initial Contents for the "JSCalendar Properties" Registry
 - 8.3. Creation of the "JSCalendar Types" Registry
 - 8.3.1. "JSCalendar Types" Registry Template
 - 8.3.2. Initial Contents for the "JSCalendar Types" Registry
 - 8.4. Creation of the "JSCalendar Enum Values" Registry
 - 8.4.1. "JSCalendar Enum Values" Registry Property Template
 - 8.4.2. "JSCalendar Enum Values" Registry Value Template
 - 8.4.3. Initial Contents for the "JSCalendar Enum Values" Registry
 - 9. References
 - 9.1. Normative References
 - 9.2. Informative References
- Acknowledgments
- Authors' Addresses

1. Introduction

This document defines a data model for calendar event and task objects, or groups of such objects, in electronic calendar applications and systems. The format aims to be unambiguous, extendable, and simple to process.

The key design considerations for this data model are as follows:

- * The attributes of the calendar entry represented must be described as simple key-value pairs. Simple events are simple to represent; complex events can be modeled accurately.
- * Wherever possible, there should be only one way to express the desired semantics, reducing complexity.
- * The data model should avoid ambiguities, which often lead to interoperability issues between implementations.
- * The data model should be generally compatible with the iCalendar data format [RFC5545] [RFC7986] and extensions, but the specification should add new attributes where the iCalendar format currently lacks expressivity, and drop seldom-used, obsolete, or redundant properties. This means translation with no loss of semantics should be easy with most common iCalendar files.
- * Extensions, such as new properties and components, should not require updates to this document.

The representation of this data model is defined in the Internet JSON (I-JSON) format [RFC7493], which is a strict subset of the JSON data interchange format [RFC8259]. Using JSON is mostly a pragmatic choice: its widespread use makes JSCalendar easier to adopt and the

ready availability of production-ready JSON implementations eliminates a whole category of parser-related interoperability issues, which iCalendar has often suffered from.

1.1. Motivation and Relation to iCalendar and jCal

The iCalendar data format [RFC5545], a widely deployed interchange format for calendaring and scheduling data, has served calendaring vendors for a long time but contains some ambiguities and pitfalls that cannot be overcome without backward-incompatible changes.

Sources of implementation errors include the following:

- * iCalendar defines various formats for local times, UTC, and dates.
- * iCalendar requires custom time zone definitions within a single calendar component.
- * iCalendar's definition of recurrence rules is ambiguous and has resulted in differing interpretations, even between experienced calendar developers.
- * The iCalendar format itself causes interoperability issues due to misuse of CRLF-terminated strings, line continuations, and subtle differences among iCalendar parsers.

In recent years, many new products and services have appeared that wish to use a JSON representation of calendar data within their APIs. The JSON format for iCalendar data, jCal [RFC7265], is a direct mapping between iCalendar and JSON. In its effort to represent full iCalendar semantics, it inherits all the same pitfalls and uses a complicated JSON structure.

As a consequence, since the standardization of jCal, the majority of implementations and service providers either kept using iCalendar or came up with their own proprietary JSON representations, which are incompatible with each other and often suffer from common pitfalls, such as storing event start times in UTC (which become incorrect if the time zone's rules change in the future). JSCalendar meets the demand for JSON-formatted calendar data that is free of such known problems and provides a standard representation as an alternative to the proprietary formats.

1.2. Notational Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

The underlying format used for this specification is JSON. Consequently, the terms "object" and "array" as well as the four primitive types (strings, numbers, booleans, and null) are to be interpreted as described in Section 1 of [RFC8259].

Some examples in this document contain "partial" JSON documents used for illustrative purposes. In these examples, an ellipsis "..." is used to indicate a portion of the document that has been removed for compactness.

1.3. Type Signatures

Type signatures are given for all JSON values in this document. The following conventions are used:

- "*": The type is undefined (the value could be any type, although permitted values may be constrained by the context of this value).
- "String": This is the JSON string type.

"Number": This is the JSON number type.

"Boolean": This is the JSON boolean type.

"A[B]": The keys are all of type "A" and the values are all of type "B" for a JSON object.

"A[]": There is an array of values of type "A"

"A|B": The value is either of type "A" or of type "B".

Other types may also be given; their representations are defined elsewhere in this document.

1.4. Data Types

In addition to the standard JSON data types, the following data types are used in this specification:

1.4.1. Id

Where "Id" is given as a data type, it means a "String" of at least 1 and a maximum of 255 octets in size, and it MUST only contain characters from the "URL and Filename Safe" base64url alphabet, as defined in Section 5 of [RFC4648], excluding the pad character ("="). This means the allowed characters are the ASCII alphanumeric characters ("A-Za-z0-9"), hyphen ("-"), and underscore ("_").

In many places in JSCalendar, a JSON map is used where the map keys are of type Id and the map values are all the same type of object. This construction represents an unordered set of objects, with the added advantage that each entry has a name (the corresponding map key). This allows for more concise patching of objects, and, when applicable, for the objects in question to be referenced from other objects within the JSCalendar object.

Unless otherwise specified for a particular property, there are no uniqueness constraints on an Id value (other than, of course, the requirement that you cannot have two values with the same key within a single JSON map). For example, two Event objects might use the same Ids in their respective "links" properties or, within the same Event object, the same Id could appear in the "participants" and "alerts" properties. These situations do not imply any semantic connections among the objects.

1.4.2. Int

Where "Int" is given as a data type, it means an integer in the range $-2^{53}+1 \leq \text{value} \leq 2^{53}-1$, the safe range for integers stored in a floating-point double, represented as a JSON "Number".

1.4.3. UnsignedInt

Where "UnsignedInt" is given as a data type, it means an integer in the range $0 \leq \text{value} \leq 2^{53}-1$, represented as a JSON "Number".

1.4.4. UTCDateTime

This is a string in the "date-time" [RFC3339] format, with the further restrictions that any letters MUST be in uppercase, and the time offset MUST be the character "Z". Fractional second values MUST NOT be included unless non-zero and MUST NOT have trailing zeros, to ensure there is only a single representation for each date-time.

For example, "2010-10-10T10:10:10.003Z" is conformant, but "2010-10-10T10:10:10.000Z" is invalid and is correctly encoded as "2010-10-10T10:10:10Z".

1.4.5. LocalDateTime

This is a date-time string with no time zone/offset information. It

is otherwise in the same format as `UTCDateTime`, including fractional seconds. For example, "2006-01-02T15:04:05" and "2006-01-02T15:04:05.003" are both valid. The time zone to associate with the `LocalDateTime` comes from the "timeZone" property of the `JSCalendar` object (see Section 4.7.1). If no time zone is specified, the `LocalDateTime` is "floating". Floating date-times are not tied to any specific time zone. Instead, they occur in each time zone at the given wall-clock time (as opposed to the same instant point in time).

A time zone may have a period of discontinuity, for example, a change from standard time to daylight savings time. When converting local date-times that fall in the discontinuity to UTC, the offset before the transition MUST be used.

For example, in the `America/Los_Angeles` time zone, the date-time 2020-11-01T01:30:00 occurs twice: before the daylight savings time (DST) transition with a UTC offset of -07:00 and again after the transition with an offset of -08:00. When converting to UTC, we therefore use the offset before the transition (-07:00), so it becomes 2020-11-01T08:30:00Z.

Similarly, in the `Australia/Melbourne` time zone, the date-time 2020-10-04T02:30:00 does not exist; the clocks are moved forward one hour for DST on that day at 02:00. However, such a value may appear during calculations (see duration semantics in Section 1.4.6) or due to a change in time zone rules (so it was valid when the event was first created). Again, it is interpreted as though the offset before the transition is in effect (+10:00); therefore, when converted to UTC, we get 2020-10-03T16:30:00Z.

1.4.6. Duration

Where `Duration` is given as a type, it means a length of time represented by a subset of the ISO 8601 duration format, as specified by the following ABNF [RFC5234]:

```
dur-secfrac = "." 1*DIGIT
dur-second  = 1*DIGIT [dur-secfrac] "S"
dur-minute  = 1*DIGIT "M" [dur-second]
dur-hour    = 1*DIGIT "H" [dur-minute]
dur-time    = "T" (dur-hour / dur-minute / dur-second)
dur-day     = 1*DIGIT "D"
dur-week    = 1*DIGIT "W"
dur-cal     = (dur-week [dur-day] / dur-day)

duration    = "P" (dur-cal [dur-time] / dur-time)
```

In addition, the duration MUST NOT include fractional second values unless the fraction is non-zero. Fractional second values MUST NOT have trailing zeros to ensure there is only a single representation for each duration.

A duration specifies an abstract number of weeks, days, hours, minutes, and/or seconds. A duration specified using weeks or days does not always correspond to an exact multiple of 24 hours. The number of hours/minutes/seconds may vary if it overlaps a period of discontinuity in the event's time zone, for example, a change from standard time to daylight savings time. Leap seconds MUST NOT be considered when adding or subtracting a duration to/from a `LocalDateTime`.

To add a duration to a `LocalDateTime`:

1. Add any week or day components of the duration to the date. A week is always the same as seven days.
2. If a time zone applies to the `LocalDateTime`, convert it to a `UTCDateTime` following the semantics in Section 1.4.5.
3. Add any hour, minute, or second components of the duration (in absolute time).

4. Convert the resulting `UTCDateTime` back to a `LocalDateTime` in the time zone that applies.

To subtract a duration from a `LocalDateTime`, the steps apply in reverse:

1. If a time zone applies to the `LocalDateTime`, convert it to UTC following the semantics in Section 1.4.5.
2. Subtract any hour, minute, or second components of the duration (in absolute time).
3. Convert the resulting `UTCDateTime` back to `LocalDateTime` in the time zone that applies.
4. Subtract any week or day components of the duration from the date.
5. If the resulting time does not exist on the date due to a discontinuity in the time zone, use the semantics in Section 1.4.5 to convert to UTC and back to get a valid `LocalDateTime`.

These semantics match the iCalendar DURATION value type ([RFC5545], Section 3.3.6).

1.4.7. SignedDuration

A `SignedDuration` represents a length of time that may be positive or negative and is typically used to express the offset of a point in time relative to an associated time. It is represented as a `Duration`, optionally preceded by a sign character. It is specified by the following ABNF:

```
signed-duration = ["+" / "-"] duration
```

A negative sign indicates a point in time at or before the associated time; a positive or no sign indicates a time at or after the associated time.

1.4.8. TimeZoneId

Where `"TimeZoneId"` is given as a data type, it means a `"String"` that is either a time zone name in the IANA Time Zone Database [TZDB] or a custom time zone identifier defined in the `"timeZones"` property (see Section 4.7.2).

Where an IANA time zone is specified, the zone rules of the respective zone records apply. Custom time zones are interpreted as described in Section 4.7.2.

1.4.9. PatchObject

A `PatchObject` is of type `"String[*]"` and represents an unordered set of patches on a JSON object. Each key is a path represented in a subset of the JSON Pointer format [RFC6901]. The paths have an implicit leading `"/"`, so each key is prefixed with `"/"` before applying the JSON Pointer evaluation algorithm.

A patch within a `PatchObject` is only valid if all of the following conditions apply:

1. The pointer MUST NOT reference inside an array (i.e., you MUST NOT insert/delete from an array; the array MUST be replaced in its entirety instead).
2. All parts prior to the last (i.e., the value after the final slash) MUST already exist on the object being patched.
3. There MUST NOT be two patches in the `PatchObject` where the

pointer of one is the prefix of the pointer of the other, e.g., "alerts/1/offset" and "alerts".

4. The value for the patch MUST be valid for the property being set (of the correct type and obeying any other applicable restrictions), or, if null, the property MUST be optional.

The value associated with each pointer determines how to apply that patch:

- * If null, remove the property from the patched object. If the key is not present in the parent, this a no-op.
- * If non-null, set the value given as the value for this property (this may be a replacement or addition to the object being patched).

A PatchObject does not define its own "@type" property (see Section 4.1.1). An "@type" property in a patch MUST be handled as any other patched property value.

Implementations MUST reject a PatchObject in its entirety if any of its patches are invalid. Implementations MUST NOT apply partial patches.

The PatchObject format is used to significantly reduce file size and duplicated content when specifying variations to a common object, such as with recurring events or when translating the data into multiple languages. It can also better preserve semantic intent if only the properties that should differ between the two objects are patched. For example, if one person is not going to a particular instance of a regularly scheduled event, in iCalendar, you would have to duplicate the entire event in the override. In JSCalendar, this is a small patch to show the difference. As only this property is patched, if the location of the event is changed, the occurrence will automatically still inherit this.

1.4.10. Relation

A Relation object defines the relation to other objects, using a possibly empty set of relation types. The object that defines this relation is the linking object, while the other object is the linked object. A Relation object has the following properties:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "Relation".

relation: "String[Boolean]" (optional, default: empty Object)

This describes how the linked object is related to the linking object. The relation is defined as a set of relation types. If empty, the relationship between the two objects is unspecified.

Keys in the set MUST be one of the following values, specified in the property definition where the Relation object is used, a value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3):

"first": The linked object is the first in a series the linking object is part of.

"next": The linked object is next in a series the linking object is part of.

"child": The linked object is a subpart of the linking object.

"parent": The linking object is a subpart of the linked object.

The value for each key in the map MUST be true.

1.4.11. Link

A Link object represents an external resource associated with the linking object. It has the following properties:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "Link".

href: "String" (mandatory)

This is a URI [RFC3986] from which the resource may be fetched.

This MAY be a "data:" URL [RFC2397], but it is recommended that the file be hosted on a server to avoid embedding arbitrarily large data in JSCalendar object instances.

cid: "String" (optional)

This MUST be a valid "content-id" value according to the definition of Section 2 of [RFC2392]. The value MUST be unique within this Link object but has no meaning beyond that. It MAY be different from the link id for this Link object.

contentType: "String" (optional)

This is the media type [RFC6838] of the resource, if known.

size: "UnsignedInt" (optional)

This is the size, in octets, of the resource when fully decoded (i.e., the number of octets in the file the user would download), if known. Note that this is an informational estimate, and implementations must be prepared to handle the actual size being quite different when the resource is fetched.

rel: "String" (optional)

This identifies the relation of the linked resource to the object. If set, the value MUST be a relation type from the IANA "Link Relations" registry [LINKRELS], as established in [RFC8288].

display: "String" (optional)

This describes the intended purpose of a link to an image. If set, the "rel" property MUST be set to "icon". The value MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3):

"badge": an image meant to be displayed alongside the title of the object

"graphic": a full image replacement for the object itself

"fullsize": an image that is used to enhance the object

"thumbnail": a smaller variant of "fullsize" to be used when space for the image is constrained

title: "String" (optional)

This is a human-readable, plain-text description of the resource.

2. JSCalendar Objects

This section describes the calendar object types specified by JSCalendar.

2.1. Event

Media type: "application/jscalendar+json;type=event"

An Event represents a scheduled amount of time on a calendar, typically a meeting, appointment, reminder, or anniversary. It is required to start at a certain point in time and typically has a non-zero duration. Multiple participants may partake in the event at multiple locations.

The @type (Section 4.1.1) property value MUST be "Event".

2.2. Task

Media type: "application/jscalendar+json;type=task"

A Task represents an action item, assignment, to-do item, or work item. It may start and be due at certain points in time, take some estimated time to complete, and recur, none of which is required.

The @type (Section 4.1.1) property value MUST be "Task".

2.3. Group

Media type: "application/jscalendar+json;type=group"

A Group is a collection of Event (Section 2.1) and/or Task (Section 2.2) objects. Typically, objects are grouped by topic (e.g., by keywords) or calendar membership.

The @type (Section 4.1.1) property value MUST be "Group".

3. Structure of JSCalendar Objects

A JSCalendar object is a JSON object [RFC8259], which MUST be valid I-JSON (a stricter subset of JSON) [RFC7493]. Property names and values are case sensitive.

The object has a collection of properties, as specified in the following sections. Properties are specified as being either mandatory or optional. Optional properties may have a default value if explicitly specified in the property definition.

3.1. Object Type

JSCalendar objects MUST name their type in the "@type" property if not explicitly specified otherwise for the respective object type. A notable exception to this rule is the PatchObject (Section 1.4.9).

3.2. Normalization and Equivalence

JSCalendar aims to provide unambiguous definitions for value types and properties but does not define a general normalization or equivalence method for JSCalendar objects and types. This is because the notion of equivalence might range from byte-level equivalence to semantic equivalence, depending on the respective use case. Normalization of JSCalendar objects is hindered because of the following reasons:

- * Custom JSCalendar properties may contain arbitrary JSON values, including arrays. However, equivalence of arrays might or might not depend on the order of elements, depending on the respective property definition.
- * Several JSCalendar property values are defined as URIs and media types, but normalization of these types is inherently protocol and scheme specific, depending on the use case of the equivalence definition (see Section 6 of [RFC3986]).

Considering this, the definition of equivalence and normalization is left to client and server implementations and to be negotiated by a calendar exchange protocol or defined elsewhere.

3.3. Vendor-Specific Property Extensions, Values, and Types

Vendors MAY add additional properties to the calendar object to support their custom features. To avoid conflict, the names of these properties MUST be prefixed by a domain name controlled by the vendor followed by a colon, e.g., "example.com:customprop". If the value is a new JSCalendar object, it either MUST include an "@type" property, or it MUST explicitly be specified to not require a type designator. The type name MUST be prefixed with a domain name controlled by the vendor.

Some JSCalendar properties allow vendor-specific value extensions. Such vendor-specific values MUST be prefixed by a domain name controlled by the vendor followed by a colon, e.g., "example.com:customrel".

Vendors are strongly encouraged to register any new property values or extensions that are useful to other systems as well, rather than use a vendor-specific prefix.

4. Common JSCalendar Properties

This section describes the properties that are common to the various JSCalendar object types. Specific JSCalendar object types may only support a subset of these properties. The object type definitions in Section 5 describe the set of supported properties per type.

4.1. Metadata Properties

4.1.1. @type

Type: "String" (mandatory)

This specifies the type that this object represents. The allowed value differs by object type and is defined in Sections 2.1, 2.2, and 2.3.

4.1.2. uid

Type: "String" (mandatory)

This is a globally unique identifier used to associate objects representing the same event, task, group, or other object across different systems, calendars, and views. For recurring events and tasks, the UID is associated with the base object and therefore is the same for all occurrences; the combination of the UID with a "recurrenceId" identifies a particular instance.

The generator of the identifier MUST guarantee that the identifier is unique. [RFC4122] describes a range of established algorithms to generate universally unique identifiers (UUIDs). UUID version 4, described in Section 4.4 of [RFC4122], is RECOMMENDED.

For compatibility with UIDs [RFC5545], implementations MUST be able to receive and persist values of at least 255 octets for this property, but they MUST NOT truncate values in the middle of a UTF-8 multi-octet sequence.

4.1.3. relatedTo

Type: "String[Relation]" (optional)

This relates the object to other JSCalendar objects. This is represented as a map of the UIDs of the related objects to information about the relation.

If an object is split to make a "this and future" change to a recurrence, the original object MUST be truncated to end at the previous occurrence before this split, and a new object is created to represent all the occurrences after the split. A "next" relation MUST be set on the original object's "relatedTo" property for the UID of the new object. A "first" relation for the UID of the first object in the series MUST be set on the new object. Clients can then follow these UIDs to get the complete set of objects if the user wishes to modify them all at once.

4.1.4. prodId

Type: "String" (optional)

This is the identifier for the product that last updated the

JSCalendar object. This should be set whenever the data in the object is modified (i.e., whenever the "updated" property is set).

The vendor of the implementation MUST ensure that this is a globally unique identifier, using some technique such as a Formal Public Identifier (FPI) value, as defined in [ISO.9070.1991].

This property SHOULD NOT be used to alter the interpretation of a JSCalendar object beyond the semantics specified in this document. For example, it is not to be used to further the understanding of nonstandard properties, a practice that is known to cause long-term interoperability problems.

4.1.5. created

Type: "UTCDateTime" (optional)

This is the date and time this object was initially created.

4.1.6. updated

Type: "UTCDateTime" (mandatory)

This is the date and time the data in this object was last modified (or its creation date/time if not modified since).

4.1.7. sequence

Type: "UnsignedInt" (optional, default: 0)

Initially zero, this MUST be incremented by one every time a change is made to the object, except if the change only modifies the "participants" property (see Section 4.4.6).

This is used as part of the iCalendar Transport-independent Interoperability Protocol (iTIP) [RFC5546] to know which version of the object a scheduling message relates to.

4.1.8. method

Type: "String" (optional)

This is the iTIP [RFC5546] method, in lowercase. This MUST only be present if the JSCalendar object represents an iTIP scheduling message.

4.2. What and Where Properties

4.2.1. title

Type: "String" (optional, default: empty String)

This is a short summary of the object.

4.2.2. description

Type: "String" (optional, default: empty String)

This is a longer-form text description of the object. The content is formatted according to the "descriptionContentType" property.

4.2.3. descriptionContentType

Type: "String" (optional, default: "text/plain")

This describes the media type [RFC6838] of the contents of the "description" property. Media types MUST be subtypes of type "text" and SHOULD be "text/plain" or "text/html" [MEDIATYPES]. They MAY include parameters, and the "charset" parameter value MUST be "utf-8", if specified. Descriptions of type "text/html" MAY contain "cid" URLs [RFC2392] to reference links in the calendar object by use of

the "cid" property of the Link object.

4.2.4. showWithoutTime

Type: "Boolean" (optional, default: false)

This indicates that the time is not important to display to the user when rendering this calendar object. An example of this is an event that conceptually occurs all day or across multiple days, such as "New Year's Day" or "Italy Vacation". While the time component is important for free-busy calculations and checking for scheduling clashes, calendars may choose to omit displaying it and/or display the object separately to other objects to enhance the user's view of their schedule.

Such events are also commonly known as "all-day" events.

4.2.5. locations

Type: "Id[Location]" (optional)

This is a map of location ids to Location objects, representing locations associated with the object.

A Location object has the following properties. It MUST have at least one property other than the "relativeTo" property.

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "Location".

name: "String" (optional)

This is the human-readable name of the location.

description: "String" (optional)

This is the human-readable, plain-text instructions for accessing this location. This may be an address, set of directions, door access code, etc.

locationTypes: "String[Boolean]" (optional)

This is a set of one or more location types that describe this location. All types MUST be from the "Location Types Registry" [LOCATIONTYPES], as defined in [RFC4589]. The set is represented as a map, with the keys being the location types. The value for each key in the map MUST be true.

relativeTo: "String" (optional)

This specifies the relation between this location and the time of the JSCalendar object. This is primarily to allow events representing travel to specify the location of departure (at the start of the event) and location of arrival (at the end); this is particularly important if these locations are in different time zones, as a client may wish to highlight this information for the user.

This MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3). Any value the client or server doesn't understand should be treated the same as if this property is omitted.

"start": The event/task described by this JSCalendar object occurs at this location at the time the event/task starts.

"end": The event/task described by this JSCalendar object occurs at this location at the time the event/task ends.

timeZone: "TimeZoneId" (optional)

This is a time zone for this location.

coordinates: "String" (optional)

This is a "geo:" URI [RFC5870] for the location.

links: "Id[Link]" (optional)

This is a map of link ids to Link objects, representing external resources associated with this location, for example, a vCard or image. If there are no links, this MUST be omitted (rather than specified as an empty set).

4.2.6. virtualLocations

Type: "Id[VirtualLocation]" (optional)

This is a map of virtual location ids to VirtualLocation objects, representing virtual locations, such as video conferences or chat rooms, associated with the object.

A VirtualLocation object has the following properties.

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "VirtualLocation".

name: "String" (optional, default: empty String)

This is the human-readable name of the virtual location.

description: "String" (optional)

These are human-readable plain-text instructions for accessing this virtual location. This may be a conference access code, etc.

uri: "String" (mandatory)

This is a URI [RFC3986] that represents how to connect to this virtual location.

This may be a telephone number (represented using the "tel:" scheme, e.g., "tel:+1-555-555-5555") for a teleconference, a web address for online chat, or any custom URI.

features: "String[Boolean]" (optional)

A set of features supported by this virtual location. The set is represented as a map, with the keys being the feature. The value for each key in the map MUST be true.

The feature MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3). Any value the client or server doesn't understand should be treated the same as if this feature is omitted.

audio: Audio conferencing

chat: Chat or instant messaging

feed: Blog or atom feed

moderator: Provides moderator-specific features

phone: Phone conferencing

screen: Screen sharing

video: Video conferencing

4.2.7. links

Type: "Id[Link]" (optional)

This is a map of link ids to Link objects, representing external resources associated with the object.

Links with a rel of "enclosure" MUST be considered by the client to be attachments for download.

Links with a rel of "describedby" MUST be considered by the client to be alternative representations of the description.

Links with a rel of "icon" MUST be considered by the client to be images that it may use when presenting the calendar data to a user. The "display" property may be set to indicate the purpose of this image.

4.2.8. locale

Type: "String" (optional)

This is the language tag, as defined in [RFC5646], that best describes the locale used for the text in the calendar object, if known.

4.2.9. keywords

Type: "String[Boolean]" (optional)

This is a set of keywords or tags that relate to the object. The set is represented as a map, with the keys being the keywords. The value for each key in the map MUST be true.

4.2.10. categories

Type: "String[Boolean]" (optional)

This is a set of categories that relate to the calendar object. The set is represented as a map, with the keys being the categories specified as URIs. The value for each key in the map MUST be true.

In contrast to keywords, categories are typically structured. For example, a vendor owning the domain "example.com" might define the categories "http://example.com/categories/sports/american-football" and "http://example.com/categories/music/r-b".

4.2.11. color

Type: "String" (optional)

This is a color clients MAY use when displaying this calendar object. The value is a color name taken from the set of names defined in Section 4.3 of CSS Color Module Level 3 [COLORS] or an RGB value in hexadecimal notation, as defined in Section 4.2.1 of CSS Color Module Level 3.

4.3. Recurrence Properties

Some events and tasks occur at regular or irregular intervals. Rather than having to copy the data for every occurrence, there can be a base event with rules to generate recurrences and/or overrides that add extra dates or exceptions to the rules.

The recurrence set is the complete set of instances for an object. It is generated by considering the following properties in order, all of which are optional:

1. The "recurrenceRules" property (Section 4.3.3) generates a set of extra date-times on which the object occurs.
2. The "excludedRecurrenceRules" property (Section 4.3.4) generates a set of date-times that are to be removed from the previously generated set of date-times on which the object occurs.
3. The "recurrenceOverrides" property (Section 4.3.5) defines date-times that are added or excluded to form the final set. (This property may also contain changes to the object to apply to particular instances.)

4.3.1. recurrenceId

Type: "LocalDateTime" (optional)

If present, this JSCalendar object represents one occurrence of a recurring JSCalendar object. If present, the "recurrenceRules" and "recurrenceOverrides" properties MUST NOT be present.

The value is a date-time either produced by the "recurrenceRules" of the base event or added as a key to the "recurrenceOverrides" property of the base event.

4.3.2. recurrenceIdTimeZone

Type: "TimeZoneId|null" (optional, default: null)

Identifies the time zone of the main JSCalendar object, of which this JSCalendar object is a recurrence instance. This property MUST be set if the "recurrenceId" property is set. It MUST NOT be set if the "recurrenceId" property is not set.

4.3.3. recurrenceRules

Type: "RecurrenceRule[]" (optional)

This defines a set of recurrence rules (repeating patterns) for recurring calendar objects.

An Event recurs by applying the recurrence rules to the "start" date-time.

A Task recurs by applying the recurrence rules to the "start" date-time, if defined; otherwise, it recurs by the "due" date-time, if defined. If the task defines neither a "start" nor "due" date-time, it MUST NOT define a "recurrenceRules" property.

If multiple recurrence rules are given, each rule is to be applied, and then the union of the results are used, ignoring any duplicates.

A RecurrenceRule object is a JSON object mapping of a RECUR value type in iCalendar [RFC5545] [RFC7529] and has the same semantics. It has the following properties:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "RecurrenceRule".

frequency: "String" (mandatory)

This is the time span covered by each iteration of this recurrence rule (see Section 4.3.3.1 for full semantics). This MUST be one of the following values:

- * "yearly"
- * "monthly"
- * "weekly"
- * "daily"
- * "hourly"
- * "minutely"
- * "secondly"

This is the FREQ part from iCalendar, converted to lowercase.

interval: "UnsignedInt" (optional, default: 1)

This is the interval of iteration periods at which the recurrence repeats. If included, it MUST be an integer ≥ 1 .

This is the INTERVAL part from iCalendar.

rscale: "String" (optional, default: "gregorian")

This is the calendar system in which this recurrence rule operates, in lowercase. This MUST be either a CLDR-registered calendar system name [CLDR] or a vendor-specific value (see Section 3.3).

This is the RSCALE part from iCalendar RSCALE [RFC7529], converted to lowercase.

skip: "String" (optional, default: "omit")

This is the behavior to use when the expansion of the recurrence produces invalid dates. This property only has an effect if the frequency is "yearly" or "monthly". It MUST be one of the following values:

- * "omit"
- * "backward"
- * "forward"

This is the SKIP part from iCalendar RSCALE [RFC7529], converted to lowercase.

firstDayOfWeek: "String" (optional, default: "mo")

This is the day on which the week is considered to start, represented as a lowercase, abbreviated, and two-letter English day of the week. If included, it MUST be one of the following values:

- * "mo"
- * "tu"
- * "we"
- * "th"
- * "fr"
- * "sa"
- * "su"

This is the WKST part from iCalendar.

byDay: "NDay[]" (optional)

These are days of the week on which to repeat. An "NDay" object has the following properties:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "NDay".

day: "String" (mandatory)

This is a day of the week on which to repeat; the allowed values are the same as for the "firstDayOfWeek" recurrenceRule property.

This is the day of the week of the BYDAY part in iCalendar, converted to lowercase.

nthOfPeriod: "Int" (optional)

If present, rather than representing every occurrence of the weekday defined in the "day" property, it represents only a specific instance within the recurrence period. The value can be positive or negative but MUST NOT be zero. A negative integer means the nth-last occurrence within that period (i.e., -1 is the last occurrence, -2 the one before that, etc.).

This is the ordinal part of the BYDAY value in iCalendar (e.g., 1 or -3).

byMonthDay: "Int[]" (optional)

These are the days of the month on which to repeat. Valid values are between 1 and the maximum number of days any month may have in the calendar given by the "rscale" property and the negative values of these numbers. For example, in the Gregorian calendar, valid values are 1 to 31 and -31 to -1. Negative values offset from the end of the month. The array MUST have at least one entry if included.

This is the BYMONTHDAY part in iCalendar.

byMonth: "String[]" (optional)

These are the months in which to repeat. Each entry is a string representation of a number, starting from "1" for the first month in the calendar (e.g., "1" means January with the Gregorian calendar), with an optional "L" suffix (see [RFC7529]) for leap months (this MUST be uppercase, e.g., "3L"). The array MUST have at least one entry if included.

This is the BYMONTH part from iCalendar.

byYearDay: "Int[]" (optional)

These are the days of the year on which to repeat. Valid values are between 1 and the maximum number of days any year may have in the calendar given by the "rscale" property and the negative values of these numbers. For example, in the Gregorian calendar, valid values are 1 to 366 and -366 to -1. Negative values offset from the end of the year. The array MUST have at least one entry if included.

This is the BYYEARDAY part from iCalendar.

byWeekNo: "Int[]" (optional)

These are the weeks of the year in which to repeat. Valid values are between 1 and the maximum number of weeks any year may have in the calendar given by the "rscale" property and the negative values of these numbers. For example, in the Gregorian calendar, valid values are 1 to 53 and -53 to -1. The array MUST have at least one entry if included.

This is the BYWEEKNO part from iCalendar.

byHour: "UnsignedInt[]" (optional)

These are the hours of the day in which to repeat. Valid values are 0 to 23. The array MUST have at least one entry if included. This is the BYHOUR part from iCalendar.

byMinute: "UnsignedInt[]" (optional)

These are the minutes of the hour in which to repeat. Valid values are 0 to 59. The array MUST have at least one entry if included.

This is the BYMINUTE part from iCalendar.

bySecond: "UnsignedInt[]" (optional)

These are the seconds of the minute in which to repeat. Valid values are 0 to 60. The array MUST have at least one entry if included.

This is the BYSECOND part from iCalendar.

bySetPosition: "Int[]" (optional)

These are the occurrences within the recurrence interval to include in the final results. Negative values offset from the end of the list of occurrences. The array MUST have at least one entry if included. This is the BYSETPOS part from iCalendar.

count: "UnsignedInt" (optional)

These are the number of occurrences at which to range-bound the recurrence. This MUST NOT be included if an "until" property is specified.

This is the COUNT part from iCalendar.

until: "LocalDateTime" (optional)

These are the date-time at which to finish recurring. The last occurrence is on or before this date-time. This MUST NOT be included if a "count" property is specified. Note that if not specified otherwise for a specific JSCalendar object, this date is to be interpreted in the time zone specified in the JSCalendar object's "timeZone" property.

This is the UNTIL part from iCalendar.

4.3.3.1. Interpreting Recurrence Rules

A recurrence rule specifies a set of date-times for recurring calendar objects. A recurrence rule has the following semantics. Note that wherever "year", "month", or "day of month" is used, this is within the calendar system given by the "rscale" property, which defaults to "gregorian" if omitted.

1. A set of candidates is generated. This is every second within a period defined by the "frequency" property value:

"yearly": every second from midnight on the first day of a year (inclusive) to midnight the first day of the following year (exclusive).

If skip is not "omit", the calendar system has leap months, and there is a "byMonth" property, generate candidates for the leap months, even if they don't occur in this year.

If skip is not "omit" and there is a "byMonthDay" property, presume each month has the maximum number of days any month may have in this calendar system when generating candidates, even if it's more than this month actually has.

"monthly": every second from midnight on the first day of a month (inclusive) to midnight on the first of the following month (exclusive).

If skip is not "omit" and there is a "byMonthDay" property, presume the month has the maximum number of days any month may have in this calendar system when generating candidates, even if it's more than this month actually has.

"weekly": every second from midnight (inclusive) on the first day of the week (as defined by the "firstDayOfWeek" property or Monday if omitted) to midnight seven days later (exclusive).

"daily": every second from midnight at the start of the day (inclusive) to midnight at the end of the day (exclusive).

"hourly": every second from the beginning of the hour (inclusive) to the beginning of the next hour (exclusive).

"minutely": every second from the beginning of the minute (inclusive) to the beginning of the next minute (exclusive).

"secondly": only the second itself.

2. Each date-time candidate is compared against all of the byX properties of the rule except bySetPosition. If any property in the rule does not match the date-time, the date-time is eliminated. Each byX property is an array; the date-time matches the property if it matches any of the values in the array. The properties have the following semantics:

byMonth: The date-time is in the given month.

byWeekNo: The date-time is in the nth week of the year.

Negative numbers mean the nth last week of the year. This corresponds to weeks according to week numbering, as defined in ISO.8601.2004, with a week defined as a seven-day period, starting on the "firstDayOfWeek" property value or Monday if omitted. Week number one of the calendar year is the first week that contains at least four days in that calendar year.

If the date-time is not valid (this may happen when generating candidates with a "skip" property in effect), it is always eliminated by this property.

byYearDay: The date-time is on the nth day of year. Negative numbers mean the nth last day of the year.

If the date-time is not valid (this may happen when generating candidates with a "skip" property in effect), it is always eliminated by this property.

byMonthDay: The date-time is on the given day of the month.

Negative numbers mean the nth last day of the month.

byDay: The date-time is on the given day of the week. If the day is prefixed by a number, it is the nth occurrence of that day of the week within the month (if frequency is monthly) or year (if frequency is yearly). Negative numbers mean the nth last occurrence within that period.

byHour: The date-time has the given hour value.

byMinute: The date-time has the given minute value.

bySecond: The date-time has the given second value.

If a "skip" property is defined and is not "omit", there may be candidates that do not correspond to valid dates (e.g., February 31st in the Gregorian calendar). In this case, the properties MUST be considered in the order above, and:

1. After applying the byMonth filter, if the candidate's month is invalid for the given year, increment it (if skip is "forward") or decrement it (if skip is "backward") until a valid month is found, incrementing/decrementing the year as well if passing through the beginning/end of the year. This only applies to calendar systems with leap months.
2. After applying the byMonthDay filter, if the day of the month is invalid for the given month and year, change the date to the first day of the next month (if skip is "forward") or the last day of the current month (if skip is "backward").
3. If any valid date produced after applying the skip is already a candidate, eliminate the duplicate. (For example, after adjusting, February 30th and February 31st would both become the same "real" date, so one is eliminated as a duplicate.)
3. If a "bySetPosition" property is included, this is now applied to the ordered list of remaining dates. This property specifies the indexes of date-times to keep; all others should be eliminated. Negative numbers are indexed from the end of the list, with -1 being the last item, -2 the second from last, etc.
4. Any date-times before the start date of the event are eliminated (see below for why this might be needed).
5. If a "skip" property is included and is not "omit", eliminate any date-times that have already been produced by previous iterations of the algorithm. (This is not possible if skip is "omit".)

6. If further dates are required (we have not reached the until date or count limit), skip the next (interval - 1) sets of candidates, then continue from step 1.

When determining the set of occurrence dates for an event or task, the following extra rules must be applied:

1. The initial date-time to which the rule is applied (the "start" date-time for events or the "start" or "due" date-time for tasks) is always the first occurrence in the expansion (and is counted if the recurrence is limited by a "count" property), even if it would normally not match the rule.
2. The first set of candidates to consider is that which would contain the initial date-time. This means the first set may include candidates before the initial date-time; such candidates are eliminated from the results in step 4 of the list above.
3. The following properties MUST be implicitly added to the rule under the given conditions:
 - * If frequency is not "secondly" and there is no "bySecond" property, add a "bySecond" property with the sole value being the seconds value of the initial date-time.
 - * If frequency is not "secondly" or "minutely" and there is no "byMinute" property, add a "byMinute" property with the sole value being the minutes value of the initial date-time.
 - * If frequency is not "secondly", "minutely", or "hourly" and there is no "byHour" property, add a "byHour" property with the sole value being the hours value of the initial date-time.
 - * If frequency is "weekly" and there is no "byDay" property, add a "byDay" property with the sole value being the day of the week of the initial date-time.
 - * If frequency is "monthly" and there is no "byDay" property and no "byMonthDay" property, add a "byMonthDay" property with the sole value being the day of the month of the initial date-time.
 - * If frequency is "yearly" and there is no "byYearDay" property:
 - If there are no "byMonth" or "byWeekNo" properties, and either there is a "byMonthDay" property or there is no "byDay" property, add a "byMonth" property with the sole value being the month of the initial date-time.
 - If there are no "byMonthDay", "byWeekNo", or "byDay" properties, add a "byMonthDay" property with the sole value being the day of the month of the initial date-time.
 - If there is a "byWeekNo" property and no "byMonthDay" or "byDay" properties, add a "byDay" property with the sole value being the day of the week of the initial date-time.

4.3.4. excludedRecurrenceRules

Type: "RecurrenceRule[]" (optional)

This defines a set of recurrence rules (repeating patterns) for date-times on which the object will not occur. The rules are interpreted the same as for the "recurrenceRules" property (see Section 4.3.3), with the exception that the initial date-time to which the rule is applied (the "start" date-time for events or the "start" or "due" date-time for tasks) is only considered part of the expansion if it matches the rule. The resulting set of date-times is then removed from those generated by the "recurrenceRules" property, as described in Section 4.3.

4.3.5. recurrenceOverrides

Type: "LocalDateTime[PatchObject]" (optional)

Maps recurrence ids (the date-time produced by the recurrence rule) to the overridden properties of the recurrence instance.

If the recurrence id does not match a date-time from the recurrence rule (or no rule is specified), it is to be treated as an additional occurrence (like an RDATE from iCalendar). The patch object may often be empty in this case.

If the patch object defines the "excluded" property of an occurrence to be true, this occurrence is omitted from the final set of recurrences for the calendar object (like an EXDATE from iCalendar). Such a patch object MUST NOT patch any other property.

By default, an occurrence inherits all properties from the main object except the start (or due) date-time, which is shifted to match the recurrence id LocalDateTime. However, individual properties of the occurrence can be modified by a patch or multiple patches. It is valid to patch the "start" property value, and this patch takes precedence over the value generated from the recurrence id. Both the recurrence id as well as the patched "start" date-time may occur before the original JSCalendar object's "start" or "due" date.

A pointer in the PatchObject MUST be ignored if it starts with one of the following prefixes:

- * @type
- * excludedRecurrenceRules
- * method
- * privacy
- * prodId
- * recurrenceId
- * recurrenceIdTimeZone
- * recurrenceOverrides
- * recurrenceRules
- * relatedTo
- * replyTo
- * sentBy
- * timeZones
- * uid

4.3.6. excluded

Type: "Boolean" (optional, default: false)

This defines if this object is an overridden, excluded instance of a recurring JSCalendar object (see Section 4.3.5). If this property value is true, this calendar object instance MUST be removed from the occurrence expansion. The absence of this property, or the presence of its default value as false, indicates that this instance MUST be included in the occurrence expansion.

4.4. Sharing and Scheduling Properties

4.4.1. priority

Type: "Int" (optional, default: 0)

This specifies a priority for the calendar object. This may be used as part of scheduling systems to help resolve conflicts for a time period.

The priority is specified as an integer in the range 0 to 9. A value of 0 specifies an undefined priority, for which the treatment will vary by situation. A value of 1 is the highest priority. A value of 2 is the second highest priority. Subsequent numbers specify a decreasing ordinal priority. A value of 9 is the lowest priority. Other integer values are reserved for future use.

4.4.2. freeBusyStatus

Type: "String" (optional, default: "busy")

This specifies how this calendar object should be treated when calculating free-busy state. This MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3):

"free": The object should be ignored when calculating whether the user is busy.

"busy": The object should be included when calculating whether the user is busy.

4.4.3. privacy

Type: "String" (optional, default: "public")

Calendar objects are normally collected together and may be shared with other users. The privacy property allows the object owner to indicate that it should not be shared or should only have the time information shared but the details withheld. Enforcement of the restrictions indicated by this property is up to the API via which this object is accessed.

This property MUST NOT affect the information sent to scheduled participants; it is only interpreted by protocols that share the calendar objects belonging to one user with other users.

The value MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3). Any value the client or server doesn't understand should be preserved but treated as equivalent to "private".

"public": The full details of the object are visible to those whom the object's calendar is shared with.

"private": The details of the object are hidden; only the basic time and metadata are shared. The following properties MAY be shared; any other properties MUST NOT be shared:

- * @type
- * created
- * due
- * duration
- * estimatedDuration
- * freeBusyStatus
- * privacy

- * recurrenceOverrides (Only patches that apply to another permissible property are allowed to be shared.)
- * sequence
- * showWithoutTime
- * start
- * timeZone
- * timeZones
- * uid
- * updated

"secret": The object is hidden completely (as though it did not exist) when the calendar this object is in is shared.

4.4.4. replyTo

Type: "String[String]" (optional)

This represents methods by which participants may submit their response to the organizer of the calendar object. The keys in the property value are the available methods and MUST only contain ASCII alphanumeric characters (A-Za-z0-9). The value is a URI for the method specified in the key. Future methods may be defined in future specifications and registered with IANA; a calendar client MUST ignore any method it does not understand but MUST preserve the method key and URI. This property MUST be omitted if no method is defined (rather than being specified as an empty object).

The following methods are defined:

"imip": The organizer accepts an iCalendar Message-Based Interoperability Protocol (iMIP) [RFC6047] response at this email address. The value MUST be a "mailto:" URI.

"web": Opening this URI in a web browser will provide the user with a page where they can submit a reply to the organizer. The value MUST be a URL using the "https:" scheme.

"other": The organizer is identified by this URI, but the method for submitting the response is undefined.

4.4.5. sentBy

Type: "String" (optional)

This is the email address in the "From" header of the email in which this calendar object was received. This is only relevant if the calendar object is received via iMIP or as an attachment to a message. If set, the value MUST be a valid "addr-spec" value as defined in Section 3.4.1 of [RFC5322].

4.4.6. participants

Type: "Id[Participant]" (optional)

This is a map of participant ids to participants, describing their participation in the calendar object.

If this property is set and any participant has a "sendTo" property, then the "replyTo" property of this calendar object MUST define at least one reply method.

A Participant object has the following properties:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "Participant".

name: "String" (optional)

This is the display name of the participant (e.g., "Joe Bloggs").

email: "String" (optional)

This is the email address to use to contact the participant or, for example, match with an address book entry. If set, the value MUST be a valid "addr-spec" value as defined in Section 3.4.1 of [RFC5322].

description: "String" (optional)

This is a plain-text description of this participant. For example, this may include more information about their role in the event or how best to contact them.

sendTo: "String[String]" (optional)

This represents methods by which the participant may receive the invitation and updates to the calendar object.

The keys in the property value are the available methods and MUST only contain ASCII alphanumeric characters (A-Za-z0-9). The value is a URI for the method specified in the key. Future methods may be defined in future specifications and registered with IANA; a calendar client MUST ignore any method it does not understand but MUST preserve the method key and URI. This property MUST be omitted if no method is defined (rather than being specified as an empty object).

The following methods are defined:

"imip": The participant accepts an iMIP [RFC6047] request at this email address. The value MUST be a "mailto:" URI. It MAY be different from the value of the participant's "email" property.

"other": The participant is identified by this URI, but the method for submitting the invitation is undefined.

kind: "String" (optional)

This is what kind of entity this participant is, if known.

This MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3). Any value the client or server doesn't understand should be treated the same as if this property is omitted.

"individual": a single person

"group": a collection of people invited as a whole

"location": a physical location that needs to be scheduled, e.g., a conference room

"resource": a non-human resource other than a location, such as a projector

roles: "String[Boolean]" (mandatory)

This is a set of roles that this participant fulfills.

At least one role MUST be specified for the participant. The keys in the set MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3):

"owner": The participant is an owner of the object. This signifies they have permission to make changes to it that affect the other participants. Nonowner participants may only change properties that affect only themselves (for example,

setting their own alerts or changing their RSVP status).

"attendee": The participant is expected to be present at the event.

"optional": The participant's involvement with the event is optional. This is expected to be primarily combined with the "attendee" role.

"informational": The participant is copied for informational reasons and is not expected to attend.

"chair": The participant is in charge of the event/task when it occurs.

"contact": The participant is someone that may be contacted for information about the event.

The value for each key in the map MUST be true. It is expected that no more than one of the roles "attendee" and "informational" be present; if more than one are given, "attendee" takes precedence over "informational". Roles that are unknown to the implementation MUST be preserved.

locationId: "Id" (optional)

This is the location at which this participant is expected to be attending.

If the value does not correspond to any location id in the "locations" property of the JSCalendar object, this MUST be treated the same as if the participant's locationId were omitted.

language: "String" (optional)

This is the language tag, as defined in [RFC5646], that best describes the participant's preferred language, if known.

participationStatus: "String" (optional, default: "needs-action")

This is the participation status, if any, of this participant.

The value MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3):

"needs-action": No status has yet been set by the participant.

"accepted": The invited participant will participate.

"declined": The invited participant will not participate.

"tentative": The invited participant may participate.

"delegated": The invited participant has delegated their attendance to another participant, as specified in the "delegatedTo" property.

participationComment: "String" (optional)

This is a note from the participant to explain their participation status.

expectReply: "Boolean" (optional, default: false)

If true, the organizer is expecting the participant to notify them of their participation status.

scheduleAgent: "String" (optional, default: "server")

This is who is responsible for sending scheduling messages with this calendar object to the participant.

The value MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3):

"server": The calendar server will send the scheduling messages.

"client": The calendar client will send the scheduling messages.

"none": No scheduling messages are to be sent to this participant.

scheduleForceSend: "Boolean" (optional, default: false)

A client may set the property on a participant to true to request that the server send a scheduling message to the participant when it would not normally do so (e.g., if no significant change is made the object or the scheduleAgent is set to client). The property MUST NOT be stored in the JSCalendar object on the server or appear in a scheduling message.

scheduleSequence: "UnsignedInt" (optional, default: 0)

This is the sequence number of the last response from the participant. If defined, this MUST be a nonnegative integer.

This can be used to determine whether the participant has sent a new response following significant changes to the calendar object and to determine if future responses are responding to a current or older view of the data.

scheduleStatus: "String[]" (optional)

This is a list of status codes, returned from the processing of the most recent scheduling message sent to this participant. The status codes MUST be valid "statcode" values as defined in the ABNF in Section 3.8.8.3 of [RFC5545].

Servers MUST only add or change this property when they send a scheduling message to the participant. Clients SHOULD NOT change or remove this property if it was provided by the server. Clients MAY add, change, or remove the property for participants where the client is handling the scheduling.

This property MUST NOT be included in scheduling messages.

scheduleUpdated: "UTCDateTime" (optional)

This is the timestamp for the most recent response from this participant.

This is the "updated" property of the last response when using iTIP. It can be compared to the "updated" property in future responses to detect and discard older responses delivered out of order.

sentBy: "String" (optional)

This is the email address in the "From" header of the email that last updated this participant via iMIP. This SHOULD only be set if the email address is different to that in the mailto URI of this participant's "imip" method in the "sendTo" property (i.e., the response was received from a different address to that which the invitation was sent to). If set, the value MUST be a valid "addr-spec" value as defined in Section 3.4.1 of [RFC5322].

invitedBy: "Id" (optional)

This is the id of the participant who added this participant to the event/task, if known.

delegatedTo: "Id[Boolean]" (optional)

This is set of participant ids that this participant has delegated their participation to. Each key in the set MUST be the id of a participant. The value for each key in the map MUST be true. If there are no delegates, this MUST be omitted (rather than specified as an empty set).

delegatedFrom: "Id[Boolean]" (optional)

This is a set of participant ids that this participant is acting as a delegate for. Each key in the set MUST be the id of a participant. The value for each key in the map MUST be true. If

there are no delegators, this MUST be omitted (rather than specified as an empty set).

memberOf: "Id[Boolean]" (optional)

This is a set of group participants that were invited to this calendar object, which caused this participant to be invited due to their membership in the group(s). Each key in the set MUST be the id of a participant. The value for each key in the map MUST be true. If there are no groups, this MUST be omitted (rather than specified as an empty set).

links: "Id[Link]" (optional)

This is a map of link ids to Link objects, representing external resources associated with this participant, for example, a vCard or image. If there are no links, this MUST be omitted (rather than specified as an empty set).

progress: "String" (optional; only allowed for participants of a Task)

This represents the progress of the participant for this task. It MUST NOT be set if the "participationStatus" of this participant is any value other than "accepted". See Section 5.2.5 for allowed values and semantics.

progressUpdated: "UTCDateTime" (optional; only allowed for participants of a Task)

This specifies the date-time the "progress" property was last set on this participant. See Section 5.2.6 for allowed values and semantics.

percentComplete: "UnsignedInt" (optional; only allowed for participants of a Task)

This represents the percent completion of the participant for this task. The property value MUST be a positive integer between 0 and 100.

4.4.7. requestStatus

Type: "String" (optional)

A request status as returned from processing the most recent scheduling request for this JSCalendar object. The allowed values are defined by the ABNF definitions of "statcode", "statdesc" and "extdata" in Section 3.8.8.3 of [RFC5545] and the following ABNF [RFC5234]:

```
reqstatus = statcode ";" statdesc [ ";" extdata]
```

Servers MUST only add or change this property when they perform a scheduling action. Clients SHOULD NOT change or remove this property if it was provided by the server. Clients MAY add, change, or remove the property when the client is handling the scheduling.

This property MUST only be included in scheduling messages according to the rules defined for the REQUEST-STATUS iCalendar property in [RFC5546].

4.5. Alerts Properties

4.5.1. useDefaultAlerts

Type: "Boolean" (optional, default: false)

If true, use the user's default alerts and ignore the value of the "alerts" property. Fetching user defaults is dependent on the API from which this JSCalendar object is being fetched and is not defined in this specification. If an implementation cannot determine the user's default alerts, or none are set, it MUST process the "alerts" property as if "useDefaultAlerts" is set to false.

4.5.2. alerts

Type: "Id[Alert]" (optional)

This is a map of alert ids to Alert objects, representing alerts/reminders to display or send to the user for this calendar object.

An Alert object has the following properties:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "Alert".

trigger: "OffsetTrigger|AbsoluteTrigger|UnknownTrigger" (mandatory)

This defines when to trigger the alert. New types may be defined in future documents.

An "OffsetTrigger" object has the following properties:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "OffsetTrigger".

offset: "SignedDuration" (mandatory)

This defines the offset at which to trigger the alert relative to the time property defined in the "relativeTo" property of the alert. Negative durations signify alerts before the time property; positive durations signify alerts after the time property.

relativeTo: "String" (optional, default: "start")

This specifies the time property that the alert offset is relative to. The value MUST be one of the following:

"start": triggers the alert relative to the start of the calendar object

"end": triggers the alert relative to the end/due time of the calendar object

An "AbsoluteTrigger" object has the following properties:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "AbsoluteTrigger".

when: "UTCDateTime" (mandatory)

This defines a specific UTC date-time when the alert is triggered.

An "UnknownTrigger" object is an object that contains an "@type" property whose value is not recognized (i.e., not "OffsetTrigger" or "AbsoluteTrigger") plus zero or more other properties. This is for compatibility with client extensions and future specifications. Implementations SHOULD NOT trigger for trigger types they do not understand but MUST preserve them.

acknowledged: "UTCDateTime" (optional)

This records when an alert was last acknowledged. This is set when the user has dismissed the alert; other clients that sync this property SHOULD automatically dismiss or suppress duplicate alerts (alerts with the same alert id that triggered on or before this date-time).

For a recurring calendar object, setting the "acknowledged" property MUST NOT add a new override to the "recurrenceOverrides" property. If the alert is not already overridden, the "acknowledged" property MUST be set on the alert in the base event/task.

Certain kinds of alert action may not provide feedback as to when the user sees them, for example, email-based alerts. For those

kinds of alerts, this property MUST be set immediately when the alert is triggered and the action is successfully carried out.

relatedTo: "String[Relation]" (optional)

This relates this alert to other alerts in the same JSCalendar object. If the user wishes to snooze an alert, the application MUST create an alert to trigger after snoozing. This new snooze alert MUST set a parent relation to the identifier of the original alert.

action: "String" (optional, default: "display")

This describes how to alert the user.

The value MUST be at most one of the following values, a value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3):

"display": The alert should be displayed as appropriate for the current device and user context.

"email": The alert should trigger an email sent out to the user, notifying them of the alert. This action is typically only appropriate for server implementations.

4.6. Multilingual Properties

4.6.1. localizations

Type: "String[PatchObject]" (optional)

A map where each key is a language tag [RFC5646], and the corresponding value is a set of patches to apply to the calendar object in order to localize it into that locale.

See the description of PatchObject (Section 1.4.9) for the structure of the PatchObject. The patches are applied to the top-level calendar object. In addition, the "locale" property of the patched object is set to the language tag. All pointers for patches MUST end with one of the following suffixes; any patch that does not follow this MUST be ignored unless otherwise specified in a future RFC:

- * title
- * description
- * name

A patch MUST NOT have the prefix "recurrenceOverrides"; any localization of the override MUST be a patch to the "localizations" property inside the override instead. For example, a patch to "locations/abcd1234/title" is permissible, but a patch to "uid" or "recurrenceOverrides/2020-01-05T14:00:00/title" is not.

Note that this specification does not define how to maintain validity of localized content. For example, a client application changing a JSCalendar object's "title" property might also need to update any localizations of this property. Client implementations SHOULD provide the means to manage localizations, but how to achieve this is specific to the application's workflow and requirements.

4.7. Time Zone Properties

4.7.1. timeZone

Type: "TimeZoneId|null" (optional, default: null)

This identifies the time zone the object is scheduled in or is null for floating time. This is either a name from the IANA Time Zone Database [TZDB] or the TimeZoneId of a custom time zone from the "timeZones" property (Section 4.7.2). If omitted, this MUST be presumed to be null (i.e., floating time).

4.7.2. timeZones

Type: "TimeZoneId[TimeZone]" (optional)

This maps identifiers of custom time zones to their time zone definitions. The following restrictions apply for each key in the map:

- * To avoid conflict with names in the IANA Time Zone Database [TZDB], it MUST start with the "/" character.
- * It MUST be a valid "paramtext" value, as specified in Section 3.1 of [RFC5545].
- * At least one other property in the same JSCalendar object MUST reference a time zone using this identifier (i.e., orphaned time zones are not allowed).

An identifier need only be unique to this JSCalendar object. It MAY differ from the "tzId" property value of the TimeZone object it maps to.

A JSCalendar object may be part of a hierarchy of other JSCalendar objects (say, an Event is an entry in a Group). In this case, the set of time zones is the sum of the time zone definitions of this object and its parent objects. If multiple time zones with the same identifier exist, then the definition closest to the calendar object in relation to its parents MUST be used. (In context of Event, a time zone definition in its "timeZones" property has precedence over a definition of the same id in the Group). Time zone definitions in any children of the calendar object MUST be ignored.

A TimeZone object maps a VTIMEZONE component from iCalendar, and the semantics are as defined in [RFC5545]. A valid time zone MUST define at least one transition rule in the "standard" or "daylight" property. Its properties are:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "TimeZone".

tzId: "String" (mandatory)

This is the TZID property from iCalendar. Note that this implies that the value MUST be a valid "paramtext" value as specified in Section 3.1. of [RFC5545].

updated: "UTCDateTime" (optional)

This is the LAST-MODIFIED property from iCalendar.

url: "String" (optional)

This is the TZURL property from iCalendar.

validUntil: "UTCDateTime" (optional)

This is the TZUNTIL property from iCalendar, specified in [RFC7808].

aliases: "String[Boolean]" (optional)

This maps the TZID-ALIAS-OF properties from iCalendar, specified in [RFC7808], to a JSON set of aliases. The set is represented as an object, with the keys being the aliases. The value for each key in the map MUST be true.

standard: "TimeZoneRule[]" (optional)

This the STANDARD sub-components from iCalendar. The order MUST be preserved during conversion.

daylight: "TimeZoneRule[]" (optional)

This the DAYLIGHT sub-components from iCalendar. The order MUST be preserved during conversion.

A TimeZoneRule object maps a STANDARD or DAYLIGHT sub-component from

iCalendar, with the restriction that, at most, one recurrence rule is allowed per rule. It has the following properties:

@type: "String" (mandatory)

This specifies the type of this object. This MUST be "TimeZoneRule".

start: "LocalDateTime" (mandatory)

This is the DTSTART property from iCalendar.

offsetFrom: "String" (mandatory)

This is the TZOFFSETFROM property from iCalendar.

offsetTo: "String" (mandatory)

This is the TZOFFSETTO property from iCalendar.

recurrenceRules: "RecurrenceRule[]" (optional)

This is the RRULE property mapped, as specified in Section 4.3.3. During recurrence rule evaluation, the "until" property value MUST be interpreted as a local time in the UTC time zone.

recurrenceOverrides: "LocalDateTime[PatchObject]" (optional)

This maps the RDATE properties from iCalendar. The set is represented as an object, with the keys being the recurrence dates. The patch object MUST be the empty JSON object ({}).

names: "String[Boolean]" (optional)

This maps the TZNAME properties from iCalendar to a JSON set. The set is represented as an object, with the keys being the names, excluding any "tznparam" component from iCalendar. The value for each key in the map MUST be true.

comments: "String[]" (optional)

This maps the COMMENT properties from iCalendar. The order MUST be preserved during conversion.

5. Type-Specific JSCalendar Properties

5.1. Event Properties

In addition to the common JSCalendar object properties (Section 4), an Event has the following properties:

5.1.1. start

Type: "LocalDateTime" (mandatory)

This is the date/time the event starts in the event's time zone (as specified in the "timeZone" property, see Section 4.7.1).

5.1.2. duration

Type: "Duration" (optional, default: "PT0S")

This is the zero or positive duration of the event in the event's start time zone. The end time of an event can be found by adding the duration to the event's start time.

An Event MAY involve start and end locations that are in different time zones (e.g., a transcontinental flight). This can be expressed using the "relativeTo" and "timeZone" properties of the Event's Location objects (see Section 4.2.5).

5.1.3. status

Type: "String" (optional, default: "confirmed")

This is the scheduling status (Section 4.4) of an Event. If set, it MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3):

"confirmed": indicates the event is definitely happening

"cancelled": indicates the event has been cancelled

"tentative": indicates the event may happen

5.2. Task Properties

In addition to the common JSCalendar object properties (Section 4), a Task has the following properties:

5.2.1. due

Type: "LocalDateTime" (optional)

This is the date/time the task is due in the task's time zone.

5.2.2. start

Type: "LocalDateTime" (optional)

This the date/time the task should start in the task's time zone.

5.2.3. estimatedDuration

Type: "Duration" (optional)

This specifies the estimated positive duration of time the task takes to complete.

5.2.4. percentComplete

Type: "UnsignedInt" (optional)

This represents the percent completion of the task overall. The property value MUST be a positive integer between 0 and 100.

5.2.5. progress

Type: "String" (optional)

This defines the progress of this task. If omitted, the default progress (Section 4.4) of a Task is defined as follows (in order of evaluation):

"completed": if the "progress" property value of all participants is "completed"

"failed": if at least one "progress" property value of a participant is "failed"

"in-process": if at least one "progress" property value of a participant is "in-process"

"needs-action": if none of the other criteria match

If set, it MUST be one of the following values, another value registered in the IANA "JSCalendar Enum Values" registry, or a vendor-specific value (see Section 3.3):

"needs-action": indicates the task needs action

"in-process": indicates the task is in process

"completed": indicates the task is completed

"failed": indicates the task failed

"cancelled": indicates the task was cancelled

5.2.6. progressUpdated

Type: "UTCDateTime" (optional)

This specifies the date/time the "progress" property of either the task overall (Section 5.2.5) or a specific participant (Section 4.4.6) was last updated.

If the task is recurring and has future instances, a client may want to keep track of the last progress update timestamp of a specific task recurrence but leave other instances unchanged. One way to achieve this is by overriding the "progressUpdated" property in the task "recurrenceOverrides" property. However, this could produce a long list of timestamps for regularly recurring tasks. An alternative approach is to split the Task into a current, single instance of Task with this instance progress update time and a future recurring instance. See also Section 4.1.3 on splitting.

5.3. Group Properties

Group supports the following common JSCalendar properties (Section 4):

- * @type
- * uid
- * prodId
- * created
- * updated
- * title
- * description
- * descriptionContentType
- * links
- * locale
- * keywords
- * categories
- * color
- * timeZones

In addition, the following Group-specific properties are supported:

5.3.1. entries

Type: "(Task|Event)[]" (mandatory)

This is a collection of group members. Implementations MUST ignore entries of unknown type.

5.3.2. source

Type: "String" (optional)

This is the source from which updated versions of this group may be retrieved. The value MUST be a URI.

6. Examples

The following examples illustrate several aspects of the JSCalendar data model and format. The examples may omit mandatory or additional

properties, which is indicated by a placeholder property with key "...". While most of the examples use calendar event objects, they are also illustrative for tasks.

6.1. Simple Event

This example illustrates a simple one-time event. It specifies a one-time event that begins on January 15, 2020 at 1 pm New York local time and ends after 1 hour.

```
{
  "@type": "Event",
  "uid": "a8df6573-0474-496d-8496-033ad45d7fea",
  "updated": "2020-01-02T18:23:04Z",
  "title": "Some event",
  "start": "2020-01-15T13:00:00",
  "timeZone": "America/New_York",
  "duration": "PT1H"
}
```

6.2. Simple Task

This example illustrates a simple task for a plain to-do item.

```
{
  "@type": "Task",
  "uid": "2a358cee-6489-4f14-a57f-c104db4dc2f2",
  "updated": "2020-01-09T14:32:01Z",
  "title": "Do something"
}
```

6.3. Simple Group

This example illustrates a simple calendar object group that contains an event and a task.

```
{
  "@type": "Group",
  "uid": "bf0ac22b-4989-4caf-9ebd-54301b4ee51a",
  "updated": "2020-01-15T18:00:00Z",
  "name": "A simple group",
  "entries": [{
    "@type": "Event",
    "uid": "a8df6573-0474-496d-8496-033ad45d7fea",
    "updated": "2020-01-02T18:23:04Z",
    "title": "Some event",
    "start": "2020-01-15T13:00:00",
    "timeZone": "America/New_York",
    "duration": "PT1H"
  },
  {
    "@type": "Task",
    "uid": "2a358cee-6489-4f14-a57f-c104db4dc2f2",
    "updated": "2020-01-09T14:32:01Z",
    "title": "Do something"
  }
]}
}
```

6.4. All-Day Event

This example illustrates an event for an international holiday. It specifies an all-day event on April 1 that occurs every year since the year 1900.

```
{
  "...": "",
  "title": "April Fool's Day",
  "showWithoutTime": true,
  "start": "1900-04-01T00:00:00",
  "duration": "P1D",
  "recurrenceRules": [{

```

```

    "@type": "RecurrenceRule",
    "frequency": "yearly"
  }]
}

```

6.5. Task with a Due Date

This example illustrates a task with a due date. It is a reminder to buy groceries before 6 pm Vienna local time on January 19, 2020. The calendar user expects to need 1 hour for shopping.

```

{
  "...": "",
  "title": "Buy groceries",
  "due": "2020-01-19T18:00:00",
  "timeZone": "Europe/Vienna",
  "estimatedDuration": "PT1H"
}

```

6.6. Event with End Time Zone

This example illustrates the use of end time zones by use of an international flight. The flight starts on April 1, 2020 at 9 am in Berlin local time. The duration of the flight is scheduled at 10 hours 30 minutes. The time at the flight's destination is in the same time zone as Tokyo. Calendar clients could use the end time zone to display the arrival time in Tokyo local time and highlight the time zone difference of the flight. The location names can serve as input for navigation systems.

```

{
  "...": "",
  "title": "Flight XY51 to Tokyo",
  "start": "2020-04-01T09:00:00",
  "timeZone": "Europe/Berlin",
  "duration": "PT10H30M",
  "locations": {
    "1": {
      "@type": "Location",
      "rel": "start",
      "name": "Frankfurt Airport (FRA)"
    },
    "2": {
      "@type": "Location",
      "rel": "end",
      "name": "Narita International Airport (NRT)",
      "timeZone": "Asia/Tokyo"
    }
  }
}

```

6.7. Floating-Time Event (with Recurrence)

This example illustrates the use of floating time. Since January 1, 2020, a calendar user blocks 30 minutes every day to practice yoga at 7 am local time in whatever time zone the user is located on that date.

```

{
  "...": "",
  "title": "Yoga",
  "start": "2020-01-01T07:00:00",
  "duration": "PT30M",
  "recurrenceRules": [{
    "@type": "RecurrenceRule",
    "frequency": "daily"
  }]
}

```

6.8. Event with Multiple Locations and Localization

This example illustrates an event that happens at both a physical and a virtual location. Fans can see a live concert on premises or online. The event title and descriptions are localized.

```
{
  "...": "",
  "title": "Live from Music Bowl: The Band",
  "description": "Go see the biggest music event ever!",
  "locale": "en",
  "start": "2020-07-04T17:00:00",
  "timeZone": "America/New_York",
  "duration": "PT3H",
  "locations": {
    "c0503d30-8c50-4372-87b5-7657e8e0fedd": {
      "@type": "Location",
      "name": "The Music Bowl",
      "description": "Music Bowl, Central Park, New York",
      "coordinates": "geo:40.7829,-73.9654"
    }
  },
  "virtualLocations": {
    "vloc1": {
      "@type": "VirtualLocation",
      "name": "Free live Stream from Music Bowl",
      "uri": "https://stream.example.com/the_band_2020"
    }
  },
  "localizations": {
    "de": {
      "title": "Live von der Music Bowl: The Band!",
      "description": "Schau dir das grÃÃte Musikereignis an!",
      "virtualLocations/vloc1/name":
        "Gratis Live-Stream aus der Music Bowl"
    }
  }
}
```

6.9. Recurring Event with Overrides

This example illustrates the use of recurrence overrides. A math course at a university is held for the first time on January 8, 2020 at 9 am London time and occurs every week until June 24, 2020. Each lecture lasts for one hour and 30 minutes and is located at the Mathematics department. This event has exceptional occurrences: at the last occurrence of the course is an exam, which lasts for 2 hours and starts at 10 am. Also, the location of the exam differs from the usual location. On April 1, no course is held. On January 7 at 2 pm, there is an optional introduction course, which occurs before the first regular lecture.

```
{
  "...": "",
  "title": "Calculus I",
  "start": "2020-01-08T09:00:00",
  "timeZone": "Europe/London",
  "duration": "PT1H30M",
  "locations": {
    "mlab": {
      "@type": "Location",
      "title": "Math lab room 1",
      "description": "Math Lab I, Department of Mathematics"
    }
  },
  "recurrenceRules": [{
    "@type": "RecurrenceRule",
    "frequency": "weekly",
    "until": "2020-06-24T09:00:00"
  }],
  "recurrenceOverrides": {
    "2020-01-07T14:00:00": {
      "title": "Introduction to Calculus I (optional)"
    }
  }
}
```

```

},
"2020-04-01T09:00:00": {
  "excluded": true
},
"2020-06-25T09:00:00": {
  "title": "Calculus I Exam",
  "start": "2020-06-25T10:00:00",
  "duration": "PT2H",
  "locations": {
    "auditorium": {
      "@type": "Location",
      "title": "Big Auditorium",
      "description": "Big Auditorium, Other Road"
    }
  }
}
}
}
}
}

```

6.10. Recurring Event with Participants

This example illustrates scheduled events. A team meeting occurs every week since January 8, 2020 at 9 am Johannesburg time. The event owner also chairs the event. Participants meet in a virtual meeting room. An attendee has accepted the invitation, but, on March 4, 2020, he is unavailable and declined participation for this occurrence.

```

{
  "...": "",
  "title": "FooBar team meeting",
  "start": "2020-01-08T09:00:00",
  "timeZone": "Africa/Johannesburg",
  "duration": "PT1H",
  "virtualLocations": {
    "0": {
      "@type": "VirtualLocation",
      "name": "ChatMe meeting room",
      "uri": "https://chatme.example.com?id=1234567&pw=a8a24627b63d"
    }
  },
  "recurrenceRules": [{
    "@type": "RecurrenceRule",
    "frequency": "weekly"
  }],
  "replyTo": {
    "imip": "mailto:f245f875-7f63-4a5e-a2c8@schedule.example.com"
  },
  "participants": {
    "dG9tQGZvb2Jhci5x1LmNvbQ": {
      "@type": "Participant",
      "name": "Tom Tool",
      "email": "tom@foobar.example.com",
      "sendTo": {
        "imip": "mailto:tom@calendar.example.com"
      },
      "participationStatus": "accepted",
      "roles": {
        "attendee": true
      }
    },
    "em9lQGZvb2GFtcGxlLmNvbQ": {
      "@type": "Participant",
      "name": "Zoe Zelda",
      "email": "zoe@foobar.example.com",
      "sendTo": {
        "imip": "mailto:zoe@foobar.example.com"
      },
      "participationStatus": "accepted",
      "roles": {
        "owner": true,

```

```

        "attendee": true,
        "chair": true
    }
}
},
"recurrenceOverrides": {
    "2020-03-04T09:00:00": {
        "participants/dG9tQGZvb2Jhci5x1LmNvbQ/participationStatus":
            "declined"
    }
}
}
}

```

7. Security Considerations

Calendaring and scheduling information is very privacy sensitive. It can reveal the social network of a user, location information of this user and those in their social network, identity and credentials information, and patterns of behavior of the user in both the physical and cyber realm. Additionally, calendar events and tasks can influence the physical location of a user or their cyber behavior within a known time window. Its transmission and storage must be done carefully to protect it from possible threats, such as eavesdropping, replay, message insertion, deletion, modification, and on-path attacks.

The data being stored and transmitted may be used in systems with real-world consequences. For example, a home automation system may turn an alarm on and off or a coworking space may charge money to the organizer of an event that books one of their meeting rooms. Such systems must be careful to authenticate all data they receive to prevent them from being subverted and ensure the change comes from an authorized entity.

This document only defines the data format; such considerations are primarily the concern of the API or method of storage and transmission of such files.

7.1. Expanding Recurrences

A recurrence rule may produce infinite occurrences of an event. Implementations **MUST** handle expansions carefully to prevent accidental or deliberate resource exhaustion.

Conversely, a recurrence rule may be specified that does not expand to anything. It is not always possible to tell this through static analysis of the rule, so implementations **MUST** be careful to avoid getting stuck in infinite loops or otherwise exhausting resources while searching for the next occurrence.

Events recur in the event's time zone. If the user is in a different time zone, daylight saving transitions may cause an event that normally occurs at, for example, 9 am to suddenly shift an hour earlier. This may be used in an attempt to cause a participant to miss an important meeting. User agents must be careful to translate date-times correctly between time zones and may wish to call out unexpected changes in the time of a recurring event.

7.2. JSON Parsing

The security considerations of [RFC8259] apply to the use of JSON as the data interchange format.

As for any serialization format, parsers need to thoroughly check the syntax of the supplied data. JSON uses opening and closing tags for several types and structures, and it is possible that the end of the supplied data will be reached when scanning for a matching closing tag; this is an error condition, and implementations need to stop scanning at the end of the supplied data.

JSON also uses a string encoding with some escape sequences to encode

special characters within a string. Care is needed when processing these escape sequences to ensure that they are fully formed before the special processing is triggered, with special care taken when the escape sequences appear adjacent to other (non-escaped) special characters or adjacent to the end of data (as in the previous paragraph).

If parsing JSON into a non-textual structured data format, implementations may need to allocate storage to hold JSON string elements. Since JSON does not use explicit string lengths, the risk of denial of service due to resource exhaustion is small, but implementations may still wish to place limits on the size of allocations they are willing to make in any given context, to avoid untrusted data causing excessive memory allocation.

7.3. URI Values

Several JSCalendar properties contain URIs as values, and processing these properties requires extra care. Section 7 of [RFC3986] discusses security risks related to URIs.

Fetching remote resources carries inherent risks. Connections must only be allowed on well-known ports, using allowed protocols (generally, just HTTP/HTTPS on their default ports). The URL must be resolved externally and not allowed to access internal resources. Connecting to an external source reveals IP (and therefore often location) information.

A maliciously constructed JSCalendar object may contain a very large number of URIs. In the case of published calendars with a large number of subscribers, such objects could be widely distributed. Implementations should be careful to limit the automatic fetching of linked resources to reduce the risk of this being an amplification vector for a denial-of-service attack.

7.4. Spam

Calendar systems may receive JSCalendar files from untrusted sources, in particular, as attachments to emails. This can be a vector for an attacker to inject spam into a user's calendar. This may confuse, annoy, and mislead users or overwhelm their calendar with bogus events, preventing them from seeing legitimate ones.

Heuristic, statistical, or machine-learning-based filters can be effective in filtering out spam. Authentication mechanisms, such as DomainKeys Identified Mail (DKIM) [RFC6376], can help establish the source of messages and associate the data with existing relationships (such as an address book contact). However, misclassifications are always possible and providing a mechanism for users to quickly correct this is advised.

Confusable unicode characters may be used to trick a user into trusting a JSCalendar file that appears to come from a known contact but is actually from a similar-looking source controlled by an attacker.

7.5. Duplication

It is important for calendar systems to maintain the UID of an event when updating it to avoid an unexpected duplication of events. Consumers of the data may not remove the previous version of the event if it has a different UID. This can lead to a confusing situation for the user, with many variations of the event and no indication of which one is correct. Care must be taken by consumers of the data to remove old events where possible to avoid an accidental denial-of-service attack due to the volume of data.

7.6. Time Zones

Events recur in a particular time zone. When this differs from the user's current time zone, it may unexpectedly cause an occurrence to

shift in time for that user due to a daylight savings change in the event's time zone. A maliciously crafted event could attempt to confuse users with such an event to ensure a meeting is missed.

8. IANA Considerations

8.1. Media Type Registration

This document defines a media type for use with JSCalendar data formatted in JSON.

Type name: application

Subtype name: jscalendar+json

Required parameters: type

The "type" parameter conveys the type of the JSCalendar data in the body part. The allowed parameter values correspond to the "@type" property of the JSON-formatted JSCalendar object in the body:

"event": The "@type" property value MUST be "Event".

"task": The "@type" property value MUST be "Task".

"group": The "@type" property value MUST be "Group".

No other parameter values are allowed. The parameter MUST NOT occur more than once.

Optional parameters: none

Encoding considerations: This is the same as the encoding considerations of application/json, as specified in Section 11 of [RFC8259].

Security considerations: See Section 7 of this document.

Interoperability considerations: While JSCalendar is designed to avoid ambiguities as much as possible, when converting objects from other calendar formats to/from JSCalendar, it is possible that differing representations for the same logical data or ambiguities in interpretation might arise. The semantic equivalence of two JSCalendar objects may be determined differently by different applications, for example, where URL values differ in case between the two objects.

Published specification: RFC 8984

Applications that use this media type: Applications that currently make use of the text/calendar and application/calendar+json media types can use this as an alternative. Similarly, applications that use the application/json media type to transfer calendaring data can use this to further specify the content.

Fragment identifier considerations: A JSON Pointer fragment identifier may be used, as defined in [RFC6901], Section 6.

Additional information: Magic number(s): N/A

File extensions(s): N/A

Macintosh file type code(s): N/A

Person & email address to contact for further information: calsify@ietf.org

Intended usage: COMMON

Restrictions on usage: N/A

Author: See the "Author's Address" section of this document.

Change controller: IETF

8.2. Creation of the "JSCalendar Properties" Registry

IANA has created the "JSCalendar Properties" registry to allow interoperability of extensions to JSCalendar objects.

This registry follows the Expert Review process ([RFC8126], Section 4.5). If the "Intended Usage" field is "common", sufficient documentation is required to enable interoperability. Preliminary community review for this registry is optional but strongly encouraged.

A registration can have an intended usage of "common", "reserved", or "obsolete". IANA will list registrations with a common usage designation prominently and separately from those with other intended usage values.

A "reserved" registration reserves a property name without assigning semantics to avoid name collisions with future extensions or protocol use.

An "obsolete" registration denotes a property that is no longer expected to be added by up-to-date systems. A new property has probably been defined covering the obsolete property's semantics.

The JSCalendar property registration procedure is not a formal standards process but rather an administrative procedure intended to allow community comment and check it is coherent without excessive time delay. It is designed to encourage vendors to document and register new properties they add for use cases not covered by the original specification, leading to increased interoperability.

8.2.1. Preliminary Community Review

Notice of a potential new registration SHOULD be sent to the Calext mailing list <calsify@ietf.org> for review. This mailing list is appropriate to solicit community feedback on a proposed new property.

Property registrations must be marked with their intended use: "common", "reserved", or "obsolete".

The intent of the public posting to this list is to solicit comments and feedback on the choice of the property name, the unambiguity of the specification document, and a review of any interoperability or security considerations. The submitter may submit a revised registration proposal or abandon the registration completely at any time.

8.2.2. Submit Request to IANA

Registration requests can be sent to <iana@iana.org>.

8.2.3. Designated Expert Review

The primary concern of the designated expert (DE) is preventing name collisions and encouraging the submitter to document security and privacy considerations. For a common-use registration, the DE is expected to confirm that suitable documentation, as described in Section 4.6 of [RFC8126], is available to ensure interoperability. That documentation will usually be in an RFC, but simple definitions are likely to use a web/wiki page, and if a sentence or two is deemed sufficient, it could be described in the registry itself. The DE should also verify that the property name does not conflict with work that is active or already published within the IETF. A published specification is not required for reserved or obsolete registrations.

The DE will either approve or deny the registration request and

publish a notice of the decision to the Calext WG mailing list or its successor, as well as inform IANA. A denial notice must be justified by an explanation, and, in the cases where it is possible, concrete suggestions on how the request can be modified so as to become acceptable should be provided.

8.2.4. Change Procedures

Once a JSCalendar property has been published by IANA, the change controller may request a change to its definition. The same procedure that would be appropriate for the original registration request is used to process a change request.

JSCalendar property registrations may not be deleted; properties that are no longer believed appropriate for use can be declared obsolete by a change to their "intended usage" field; such properties will be clearly marked in the IANA registry.

Significant changes to a JSCalendar property's definition should be requested only when there are serious omissions or errors in the published specification, as such changes may cause interoperability issues. When review is required, a change request may be denied if it renders entities that were valid under the previous definition invalid under the new definition.

The owner of a JSCalendar property may pass responsibility to another person or agency by informing IANA; this can be done without discussion or review.

8.2.5. "JSCalendar Properties" Registry Template

Property Name: This is the name of the property. The property name MUST NOT already be registered for any of the object types listed in the "Property Context" field of this registration. Other object types MAY already have registered a different property with the same name; however, the same name SHOULD only be used when the semantics are analogous.

Property Type: This is the type of this property, using type signatures, as specified in Section 1.3. The property type MUST be registered in the "JSCalendar Types" registry.

Property Context: This is a comma-separated list of JSCalendar object types this property is allowed on.

Reference or Description: This is a brief description or RFC number and section reference where the property is specified (omitted for "reserved" property names).

Intended Usage: This may be "common", "reserved", or "obsolete".

Change Controller: This is who may request a change to this entry's definition ("IETF" for RFCs from the IETF stream).

8.2.6. Initial Contents for the "JSCalendar Properties" Registry

The following table lists the initial entries of the "JSCalendar Properties" registry. All properties are for common use. All RFC section references are for this document. The change controller for all these properties is "IETF".

Property Name	Property Type	Property Context	Reference or Description
@type	String	Event, Task, Group, AbsoluteTrigger, Alert, Link, Location, NDay,	Section 4.1.1, Section 4.5.2, Section

		OffsetTrigger, Participant, RecurrenceRule, Relation, TimeZone, TimeZoneRule, VirtualLocation	1.4.11, Section 4.2.5, Section 4.4.6, Section 4.3.3, Section 1.4.10, Section 4.7.2, Section 4.2.6
acknowledged	UTCDateTime	Alert	Section 4.5.2
action	String	Alert	Section 4.5.2
alerts	Id[Alert]	Event, Task	Section 4.5.2
aliases	String[Boolean]	TimeZone	Section 4.7.2
byDay	NDay[]	RecurrenceRule	Section 4.3.3
byHour	UnsignedInt[]	RecurrenceRule	Section 4.3.3
byMinute	UnsignedInt[]	RecurrenceRule	Section 4.3.3
byMonth	String[]	RecurrenceRule	Section 4.3.3
byMonthDay	Int[]	RecurrenceRule	Section 4.3.3
bySecond	UnsignedInt[]	RecurrenceRule	Section 4.3.3
bySetPosition	Int[]	RecurrenceRule	Section 4.3.3
byWeekNo	Int[]	RecurrenceRule	Section 4.3.3
byYearDay	Int[]	RecurrenceRule	Section 4.3.3
categories	String[Boolean]	Event, Task, Group	Section 4.2.10
cid	String	Link	Section 1.4.11
color	String	Event, Task, Group	Section 4.2.11
comments	String[]	TimeZoneRule	Section 4.7.2
contentType	String	Link	Section 1.4.11
coordinates	String	Location	Section 4.2.5

count	UnsignedInt	RecurrenceRule	Section 4.3.3
created	UTCDateTime	Event, Task, Group	Section 4.1.5
day	String	NDay	Section 4.3.3
daylight	TimeZoneRule[]	TimeZone	Section 4.7.2
delegatedFrom	Id[Boolean]	Participant	Section 4.4.6
delegatedTo	Id[Boolean]	Participant	Section 4.4.6
description	String	Event, Task, Location, Participant, VirtualLocation	Section 4.2.2, Section 4.2.5, Section 4.4.6, Section 4.2.6
description ContentType	String	Event, Task	Section 4.2.3
display	String	Link	Section 1.4.11
due	LocalDateTime	Task	Section 5.2.1
duration	Duration	Event	Section 5.1.2
email	String	Participant	Section 4.4.6
entries	(Task Event) []	Group	Section 5.3.1
estimatedDuration	Duration	Task	Section 5.2.3
excluded	Boolean	Event, Task	Section 4.3.6
excluded RecurrenceRules	RecurrenceRule[]	Event, Task	Section 4.3.4
expectReply	Boolean	Participant	Section 4.4.6
features	String[Boolean]	VirtualLocation	Section 4.2.6
firstDayOfWeek	String	RecurrenceRule	Section 4.3.3
freeBusyStatus	String	Event, Task	Section 4.4.2
frequency	String	RecurrenceRule	Section 4.3.3
href	String	Link	Section 1.4.11

interval	UnsignedInt	RecurrenceRule	Section 4.3.3
invitedBy	Id	Participant	Section 4.4.6
keywords	String[Boolean]	Event, Task, Group	Section 4.2.9
kind	String	Participant	Section 4.4.6
language	String	Participant	Section 4.4.6
links	Id[Link]	Group, Event, Task, Location, Participant	Section 4.2.7, Section 4.2.5, Section 4.4.6
locale	String	Group, Event, Task	Section 4.2.8
localizations	String [PatchObject]	Event, Task	Section 4.6.1
locationId	Id	Participant	Section 4.4.6
locations	Id[Location]	Event, Task	Section 4.2.5
locationTypes	String[Boolean]	Location	Section 4.2.5
memberOf	Id[Boolean]	Participant	Section 4.4.6
method	String	Event, Task	Section 4.1.8
name	String	Location, VirtualLocation, Participant	Section 4.2.5, Section 4.2.6, Section 4.4.6
names	String[Boolean]	TimeZoneRule	Section 4.7.2
nthOfPeriod	Int	NDay	Section 4.3.3
offset	SignedDuration	OffsetTrigger	Section 4.5.2
offsetFrom	UTCDateTime	TimeZoneRule	Section 4.7.2
offsetTo	UTCDateTime	TimeZoneRule	Section 4.7.2
participants	Id[Participant]	Event, Task	Section 4.4.6
participationComment	String	Participant	Section 4.4.6

participationStatus	String	Participant	Section 4.4.6
percentComplete	UnsignedInt	Task, Participant	Section 5.2.4
priority	Int	Event, Task	Section 4.4.1
privacy	String	Event, Task	Section 4.4.3
prodId	String	Event, Task, Group	Section 4.1.4
progress	String	Task, Participant	Section 5.2.5
progressUpdated	UTCDateTime	Task, Participant	Section 5.2.6
recurrenceId	LocalDateTime	Event, Task	Section 4.3.1
recurrenceIdTimeZone	TimeZoneId null	Event, Task	Section 4.3.2
recurrenceOverrides	LocalDateTime [PatchObject]	Event, Task, TimeZoneRule	Section 4.3.5, Section 4.7.2
recurrenceRules	RecurrenceRule[]	Event, Task, TimeZoneRule	Section 4.3.3, Section 4.7.2
rel	String	Link	Section 1.4.11
relatedTo	String[Relation]	Event, Task, Alert	Section 4.1.3, Section 4.5.2
relation	String[Boolean]	Relation	Section 1.4.10
relativeTo	String	OffsetTrigger, Location	Section 4.5.2, Section 4.2.5
replyTo	String[String]	Event, Task	Section 4.4.4
requestStatus	String	Event, Task	Section 4.4.7
roles	String[Boolean]	Participant	Section 4.4.6
rscale	String	RecurrenceRule	Section 4.3.3
sentBy	String	Event, Task, Participant	Section 4.4.5, Section 4.4.6

standard	TimeZoneRule[]	TimeZone	Section 4.7.2
start	LocalDateTime	TimeZoneRule	Section 4.7.2
scheduleAgent	String	Participant	Section 4.4.6
scheduleForceSend	Boolean	Participant	Section 4.4.6
scheduleSequence	UnsignedInt	Participant	Section 4.4.6
scheduleStatus	String[]	Participant	Section 4.4.6
scheduleUpdated	UTCDateTime	Participant	Section 4.4.6
sendTo	String[String]	Participant	Section 4.4.6
sequence	UnsignedInt	Event, Task	Section 4.1.7
showWithoutTime	Boolean	Event, Task	Section 4.2.4
size	UnsignedInt	Link	Section 1.4.11
skip	String	RecurrenceRule	Section 4.3.3
source	String	Group	Section 5.3.2
start	LocalDateTime	Event, Task	Section 5.1.1, Section 5.2.2
status	String	Event	Section 5.1.3
timeZone	TimeZoneId null	Event, Task, Location	Section 4.7.1, Section 4.2.5
timeZones	TimeZoneId [TimeZone]	Event, Task	Section 4.7.2
title	String	Event, Task, Group, Link	Section 4.2.1
trigger	OffsetTrigger AbsoluteTrigger UnknownTrigger	Alert	Section 4.5.2
tzId	String	TimeZone	Section 4.7.2
uid	String	Event, Task, Group	Section 4.1.2
until	LocalDateTime	RecurrenceRule	Section 4.3.3

updated	UTCDateTime	Event, Task, Group	Section 4.1.6
uri	String	VirtualLocation	Section 4.2.6
url	String	TimeZone	Section 4.7.2
useDefaultAlerts	Boolean	Event, Task	Section 4.5.1
validUntil	UTCDateTime	TimeZone	Section 4.7.2
virtualLocations	Id [VirtualLocation]	Event, Task	Section 4.2.6
when	UTCDateTime	AbsoluteTrigger	Section 4.5.2

Table 1: Initial Contents of the "JSCalendar Properties" Registry

8.3. Creation of the "JSCalendar Types" Registry

IANA has created the "JSCalendar Types" registry to avoid name collisions and provide a complete reference for all data types used for JSCalendar property values. The registration process is the same as for the "JSCalendar Properties" registry, as defined in Section 8.2.

8.3.1. "JSCalendar Types" Registry Template

Type Name: the name of the type

Reference or Description: a brief description or RFC number and section reference where the Type is specified (may be omitted for "reserved" type names)

Intended Use: common, reserved, or obsolete

Change Controller: who may request a change to this entry's definition ("IETF" for RFCs from the IETF stream)

8.3.2. Initial Contents for the "JSCalendar Types" Registry

The following table lists the initial entries of the JSCalendar Types registry. All properties are for common use. All RFC section references are for this document. The change controller for all these properties is "IETF".

Type Name	Reference or Description
Alert	Section 4.5.2
Boolean	Section 1.3
Duration	Section 1.4.6
Id	Section 1.4.1
Int	Section 1.4.2
LocalDateTime	Section 1.4.5
Link	Section 1.4.11
Location	Section 4.2.5

NDay	Section 4.3.3
Number	Section 1.3
Participant	Section 4.4.6
PatchObject	Section 1.4.9
RecurrenceRule	Section 4.3.3
Relation	Section 1.4.10
SignedDuration	Section 1.4.7
String	Section 1.3
TimeZone	Section 4.7.2
TimeZoneId	Section 1.4.8
TimeZoneRule	Section 4.7.2
UnsignedInt	Section 1.4.3
UTCDateTime	Section 1.4.4
VirtualLocation	Section 4.2.6

Table 2: Initial Contents of the "JSCalendar Types" Registry

8.4. Creation of the "JSCalendar Enum Values" Registry

IANA has created the "JSCalendar Enum Values" registry to allow interoperable extension of semantics for properties with enumerable values. Each such property will have a subregistry of allowed values. The registration process for a new enum value or adding a new enumerable property is the same as for the "JSCalendar Properties" registry, as defined in Section 8.2.

8.4.1. "JSCalendar Enum Values" Registry Property Template

This template is for adding a subregistry for a new enumerable property to the "JSCalendar Enum" registry.

Property Name: These are the name(s) of the property or properties where these values may be used. This MUST be registered in the "JSCalendar Properties" registry.

Context: This is the list of allowed object types where the property or properties may appear, as registered in the "JSCalendar Properties" registry. This disambiguates where there may be two distinct properties with the same name in different contexts.

Change Controller: ("IETF" for properties defined in RFCs from the IETF stream).

Initial Contents: This is the initial list of defined values for this enum, using the template defined in Section 8.4.2. A subregistry will be created with these values for this property name/context tuple.

8.4.2. "JSCalendar Enum Values" Registry Value Template

This template is for adding a new enum value to a subregistry in the JSCalendar Enum registry.

Enum Value: the verbatim value of the enum

Reference or Description: a brief description or RFC number and

section reference for the semantics of this value

8.4.3. Initial Contents for the "JSCalendar Enum Values" Registry

For each subregistry created in this section, all RFC section references are for this document.

Property Name: action
Context: Alert
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
display	Section 4.5.2
email	Section 4.5.2

Table 3: JSCalendar Enum Values for action (Context: Alert)

Property Name: display
Context: Link
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
badge	Section 1.4.11
graphic	Section 1.4.11
fullsize	Section 1.4.11
thumbnail	Section 1.4.11

Table 4: JSCalendar Enum Values for display (Context: Link)

Property Name: features
Context: VirtualLocation
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
audio	Section 4.2.6
chat	Section 4.2.6
feed	Section 4.2.6
moderator	Section 4.2.6
phone	Section 4.2.6
screen	Section 4.2.6
video	Section 4.2.6

Table 5: JSCalendar Enum Values for features (Context: VirtualLocation)

Property Name: freeBusyStatus
Context: Event, Task
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
------------	--------------------------

Enum Value	Reference or Description
free	Section 4.4.2
busy	Section 4.4.2

Table 6: JSCalendar Enum Values for freeBusyStatus (Context: Event, Task)

Property Name: kind
Context: Participant
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
individual	Section 4.4.6
group	Section 4.4.6
resource	Section 4.4.6
location	Section 4.4.6

Table 7: JSCalendar Enum Values for kind (Context: Participant)

Property Name: participationStatus
Context: Participant
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
needs-action	Section 4.4.6
accepted	Section 4.4.6
declined	Section 4.4.6
tentative	Section 4.4.6
delegated	Section 4.4.6

Table 8: JSCalendar Enum Values for participationStatus (Context: Participant)

Property Name: privacy
Context: Event, Task
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
public	Section 4.4.3
private	Section 4.4.3
secret	Section 4.4.3

Table 9: JSCalendar Enum Values for privacy (Context: Event, Task)

Property Name: progress
Context: Task, Participant
Change Controller: IETF

Initial Contents:

Enum Value	Reference or Description
needs-action	Section 5.2.5
in-process	Section 5.2.5
completed	Section 5.2.5
failed	Section 5.2.5
cancelled	Section 5.2.5

Table 10: JSCalendar Enum Values for progress (Context: Task, Participant)

Property Name: relation
Context: Relation
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
first	Section 1.4.10
next	Section 1.4.10
child	Section 1.4.10
parent	Section 1.4.10

Table 11: JSCalendar Enum Values for relation (Context: Relation)

Property Name: relativeTo
Context: OffsetTrigger, Location
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
start	Section 4.5.2
end	Section 4.5.2

Table 12: JSCalendar Enum Values for relativeTo (Context: OffsetTrigger, Location)

Property Name: roles
Context: Participant
Change Controller: IETF
Initial Contents:

Enum Value	Reference or Description
owner	Section 4.4.6
attendee	Section 4.4.6
optional	Section 4.4.6
informational	Section 4.4.6
chair	Section 4.4.6
contact	Section 4.4.6

Table 13: JSCalendar Enum Values for roles (Context: Participant)

Property Name: scheduleAgent
 Context: Participant
 Change Controller: IETF
 Initial Contents:

Enum Value	Reference or Description
server	Section 4.4.6
client	Section 4.4.6
none	Section 4.4.6

Table 14: JSCalendar Enum Values for scheduleAgent (Context: Participant)

Property Name: status
 Context: Event
 Change Controller: IETF
 Initial Contents:

Enum Value	Reference or Description
confirmed	Section 5.1.3
cancelled	Section 5.1.3
tentative	Section 5.1.3

Table 15: JSCalendar Enum Values for status (Context: Event)

9. References

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