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# SIP-Specific Event Notification
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## Abstract

This document describes an extension to the Session Initiation Protocol (SIP). The purpose of this extension is to provide an extensible framework by which SIP nodes can request notification from remote nodes indicating that certain events have occurred.

Note that the event notification mechanisms defined herein are NOT intended to be a general-purpose infrastructure for all classes of event subscription and notification.

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## 1. Introduction

The ability to request asynchronous notification of events proves useful in many types of SIP services for which cooperation between end-nodes is required. Examples of such services include automatic callback services (based on terminal state events), buddy lists (based on user presence events), message waiting indications (based on mailbox state change events), and PSTN and Internet Internetworking (PINT) [RFC2848] status (based on call state events).

The methods described in this document provide a framework by which notification of these events can be ordered.

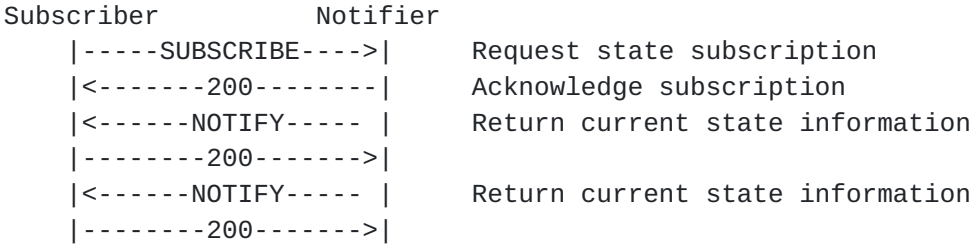
The event notification mechanisms defined herein are NOT intended to be a general-purpose infrastructure for all classes of event subscription and notification. Meeting requirements for the general problem set of subscription and notification is far too complex for a single protocol. Our goal is to provide a SIP-specific framework for event notification which is not so complex as to be unusable for simple features, but which is still flexible enough to provide powerful services. Note, however, that event packages based on this framework may define arbitrarily elaborate rules which govern the subscription and notification for the events or classes of events they describe.

This document does not describe an extension which may be used directly; it must be extended by other documents (herein referred to as "event packages"). In object-oriented design terminology, it may be thought of as an abstract base class which must be derived into an instantiatable class by further extensions. Guidelines for creating these extensions are described in Section 5.

### 1.1. Overview of Operation

The general concept is that entities in the network can subscribe to resource or call state for various resources or calls in the network, and those entities (or entities acting on their behalf) can send notifications when those states change.

A typical flow of messages would be:



Subscriptions are expired and must be refreshed by subsequent SUBSCRIBE requests.

### 1.2. Documentation Conventions

There are several paragraphs throughout this document which provide motivational or clarifying text. Such passages are non-normative, and are provided only to assist with reader comprehension. These passages are set off from the remainder of the text by being indented thus:

> This is an example of non-normative explanatory text. It does not form part of the specification, and is used only for clarification.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

In particular, implementors need to take careful note of the meaning of "SHOULD" defined in RFC 2119. To rephrase: violation of SHOULD-strength requirements requires careful analysis and clearly enumerable reasons. It is inappropriate to fail to comply with "SHOULD"-strength requirements whimsically or for ease of implementation.

The use of quotation marks next to periods and commas follows the convention used by the American Mathematical Society; although contrary to traditional American English convention, this usage lends clarity to certain passages.

## 2. Definitions

Event Package: An event package is an additional specification which defines a set of state information to be reported by a notifier to a subscriber. Event packages also define further syntax and semantics based on the framework defined by this document required to convey such state information.

Event Template-Package: An event template-package is a special kind of event package which defines a set of states which may be applied to all possible event packages, including itself.

Notification: Notification is the act of a notifier sending a NOTIFY request to a subscriber to inform the subscriber of the state of a resource.

Notifier: A notifier is a user agent which generates NOTIFY requests for the purpose of notifying subscribers of the state of a resource. Notifiers typically also accept SUBSCRIBE requests to create subscriptions.

Subscriber: A subscriber is a user agent which receives NOTIFY requests from notifiers; these NOTIFY requests contain information about the state of a resource in which the subscriber is interested. Subscribers typically also generate SUBSCRIBE requests and send them to notifiers to create subscriptions.

Subscription: A subscription is a set of application state associated with a dialog. This application state includes a pointer to the associated dialog, the event package name, and possibly an identification token. Event packages will define additional subscription state information. By definition, subscriptions exist in both a subscriber and a notifier.

Subscription Migration: Subscription migration is the act of moving a subscription from one notifier to another notifier.

## 3. SIP Methods for Event Notification

### 3.1. SUBSCRIBE

The SUBSCRIBE method is used to request current state and state updates from a remote node. SUBSCRIBE requests are target refresh requests, as that term is defined in [RFC3261].

#### 3.1.1. Subscription Duration

SUBSCRIBE requests SHOULD contain an "Expires" header field (defined in [RFC3261]). This expires value indicates the duration of the subscription. In order to keep subscriptions effective beyond the duration communicated in the "Expires" header field, subscribers need to refresh subscriptions on a periodic basis using a new SUBSCRIBE request on the same dialog as defined in [RFC3261].

If no "Expires" header field is present in a SUBSCRIBE request, the implied default MUST be defined by the event package being used.

200-class responses to SUBSCRIBE requests also MUST contain an "Expires" header field. The period of time in the response MAY be

shorter but MUST NOT be longer than specified in the request. The notifier is explicitly allowed to shorten the duration to zero. The period of time in the response is the one which defines the duration of the subscription.

An "expires" parameter on the "Contact" header field has no semantics for the SUBSCRIBE method and is explicitly not equivalent to an "Expires" header field in a SUBSCRIBE request or response.

A natural consequence of this scheme is that a SUBSCRIBE request with an "Expires" of 0 constitutes a request to unsubscribe from an event.

> In addition to being a request to unsubscribe, a SUBSCRIBE request with "Expires" of 0 also causes a fetch of state; see Section 4.4.3.

Notifiers may also wish to cancel subscriptions to events; this is useful, for example, when the resource to which a subscription refers is no longer available. Further details on this mechanism are discussed in Section 4.2.2.

### 3.1.2. Identification of Subscribed Events and Event Classes

Identification of events is provided by three pieces of information: Request URI, Event Type, and (optionally) message body.

The Request URI of a SUBSCRIBE request, most importantly, contains enough information to route the request to the appropriate entity per the request routing procedures outlined in [RFC3261]. It also contains enough information to identify the resource for which event notification is desired, but not necessarily enough information to uniquely identify the nature of the event (e.g., "sip:adam@example.com" would be an appropriate URI to subscribe to for my presence state; it would also be an appropriate URI to subscribe to the state of my voice mailbox).

Subscribers MUST include exactly one "Event" header field in SUBSCRIBE requests, indicating to which event or class of events they are subscribing. The "Event" header field will contain a token which indicates the type of state for which a subscription is being requested. This token will be registered with the IANA and will correspond to an event package which further describes the semantics of the event or event class.

If the event package to which the event token corresponds defines behavior associated with the body of its SUBSCRIBE requests, those semantics apply.

Event packages may also define parameters for the Event header field; if they do so, they must define the semantics for such parameters.

### 3.1.3. Additional SUBSCRIBE Header Field Values

Because SUBSCRIBE requests create a dialog usage as defined in [RFC3261], they MAY contain an "Accept" header field. This header field, if present, indicates the body formats allowed in subsequent NOTIFY requests. Event packages MUST define the behavior for SUBSCRIBE requests without "Accept" header fields; usually, this will connote a single, default body type.

Header values not described in this document are to be interpreted as described in [RFC3261].

## 3.2. NOTIFY

NOTIFY requests are sent to inform subscribers of changes in state to which the subscriber has a subscription. Subscriptions are created using the SUBSCRIBE method. In legacy implementations, it is possible that other means of subscription creation have been used. However, this specification does not allow the creation of subscriptions except through SUBSCRIBE requests and (for backwards-compatibility) REFER requests [RFC3515].

NOTIFY is a target refresh request, as that term is defined in [RFC3261].

A NOTIFY request does not terminate its corresponding subscription; in other words, a single SUBSCRIBE request may trigger several NOTIFY requests.

### 3.2.1. Identification of Reported Events, Event Classes, and Current State

Identification of events being reported in a notification is very similar to that described for subscription to events (see Section 3.1.2).

As in SUBSCRIBE requests, NOTIFY request "Event" header fields MUST contain a single event package name for which a notification is being generated. The package name in the "Event" header field MUST match the "Event" header field in the corresponding SUBSCRIBE request.

Event packages may define semantics associated with the body of their NOTIFY requests; if they do so, those semantics apply. NOTIFY request bodies are expected to provide additional details about the nature of the event which has occurred and the resultant resource

state.

When present, the body of the NOTIFY request MUST be formatted into one of the body formats specified in the "Accept" header field of the corresponding SUBSCRIBE request. This body will contain either the state of the subscribed resource or a pointer to such state in the form of a URI (see Section 5.4.13).

# 4. Node Behavior

## 4.1. Subscriber Behavior

### 4.1.1. Detecting Support for SIP Events

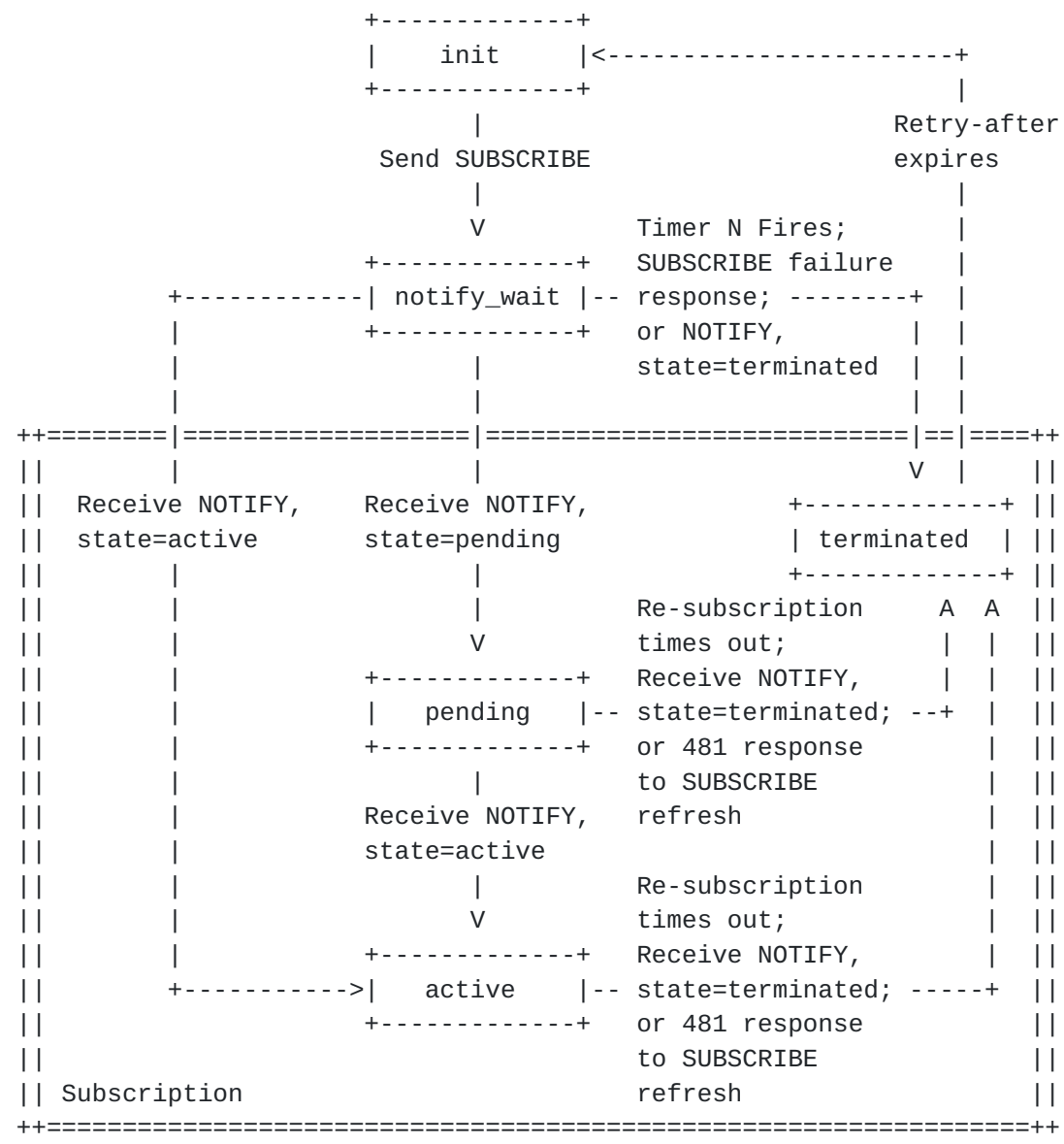
The extension described in this document does not make use of the use of "Require" or "Proxy-Require" header fields; similarly, there is no token defined for "Supported" header fields. Potential subscribers may probe for the support of SIP Events using the OPTIONS request defined in [RFC3261].

The presence of "SUBSCRIBE" in the "Allow" header field of any request or response indicates support for SIP Events; further, in the absence of an "Allow" header field, the simple presence of an "Allow-Events" header field is sufficient to indicate that the node that sent the message is capable of acting as a notifier (see Section 4.4.4.

The "methods" parameter for Contact may also be used to specifically announce support for SUBSCRIBE and NOTIFY requests when registering. (See [RFC3840] for details on the "methods" parameter).

### 4.1.2. Creating and Maintaining Subscriptions

From the subscriber's perspective, a subscription proceeds according to the following state diagram:




In the state diagram, "Re-subscription times out" means that an attempt to refresh or update the subscription using a new SUBSCRIBE request does not result in a NOTIFY request before the corresponding Timer N expires.

Any transition from "notify_wait" into a "pending" or "active" state results in a new subscription. Note that multiple subscriptions can be generated as the result of a single SUBSCRIBE request (see Section 4.4.1). Each of these new subscriptions exists in its own independent state machine, and runs its own set of timers.

#### 4.1.2.1. Requesting a Subscription

SUBSCRIBE is a dialog-creating method, as described in [RFC3261].

When a subscriber wishes to subscribe to a particular state for a resource, it forms a SUBSCRIBE request. If the initial SUBSCRIBE request represents a request outside of a dialog (as it typically will), its construction follows the procedures outlined in [RFC3261] for UAC request generation outside of a dialog.

This SUBSCRIBE request will be confirmed with a final response. 200-class responses indicate that the subscription has been accepted, and that a NOTIFY request will be sent immediately.

The "Expires" header field in a 200-class response to SUBSCRIBE request indicates the actual duration for which the subscription will remain active (unless refreshed).

Non-200 class final responses indicate that no subscription or new dialog usage has been created, and no subsequent NOTIFY request will be sent. All non-200 class responses (with the exception of "489", described herein) have the same meanings and handling as described in [RFC3261]. For the sake of clarity: if a SUBSCRIBE request contains an "Accept" header field, but that field does not indicate a MIME type that the notifier is capable of generating in its NOTIFY requests, then the proper error response is 406 (Not Acceptable).

#### 4.1.2.2. Refreshing of Subscriptions

At any time before a subscription expires, the subscriber may refresh the timer on such a subscription by sending another SUBSCRIBE request on the same dialog as the existing subscription. The handling for such a request is the same as for the initial creation of a subscription except as described below.

If a SUBSCRIBE request to refresh a subscription receives a 404, 405, 410, 416, 480-485, 489, 501, or 604 response, the subscriber MUST consider the subscription terminated. (See [RFC5057] for further details and notes about the effect of error codes on dialogs and usages within dialog, such as subscriptions). If the subscriber wishes to re-subscribe to the state, he does so by composing an unrelated initial SUBSCRIBE request with a freshly-generated Call-ID and a new, unique "From" tag (see Section 4.1.2.1.)

If a SUBSCRIBE request to refresh a subscription fails with any error code other than those listed above, the original subscription is still considered valid for the duration of the most recently known "Expires" value as negotiated by the most recent successful SUBSCRIBE

transaction, or as communicated by a NOTIFY request in its "Subscription-State" header field "expires" parameter.

> Note that many such errors indicate that there may be a problem with the network or the notifier such that no further NOTIFY requests will be received.

When refreshing a subscription, a subscriber starts Timer N, set to 64*T1, when it sends the SUBSCRIBE request. If this Timer N expires prior to the receipt of a NOTIFY request, the subscriber considers the subscription terminated. If the subscriber receives a success response to the SUBSCRIBE request that indicates that no NOTIFY request will be generated -- such as the 204 response defined for use with the optional extension described in [RFC5839] -- then it MUST cancel Timer N.

#### 4.1.2.3. Unsubscribing

Unsubscribing is handled in the same way as refreshing of a subscription, with the "Expires" header field set to "0". Note that a successful unsubscription will also trigger a final NOTIFY request.

The final NOTIFY request may or may not contain information about the state of the resource; subscribers need to be prepared to receive final NOTIFY requests both with and without state.

#### 4.1.2.4. Confirmation of Subscription Creation

The subscriber can expect to receive a NOTIFY request from each node which has processed a successful subscription or subscription refresh. To ensure that subscribers do not wait indefinitely for a subscription to be established, a subscriber starts a Timer N, set to 64*T1, when it sends a SUBSCRIBE request. If this Timer N expires prior to the receipt of a NOTIFY request, the subscriber considers the subscription failed, and cleans up any state associated with the subscription attempt.

Until Timer N expires, several NOTIFY requests may arrive from different destinations (see Section 4.4.1). Each of these requests establish a new dialog usage and a new subscription. After the expiration of Timer N, the subscriber SHOULD reject any such NOTIFY requests that would otherwise establish a new dialog usage with a "481" response code.

Until the first NOTIFY request arrives, the subscriber should consider the state of the subscribed resource to be in a neutral state. Event package specifications MUST define this "neutral state" in such a way that makes sense for their application (see

Section 5.4.7).

Due to the potential for both out-of-order messages and forking, the subscriber MUST be prepared to receive NOTIFY requests before the SUBSCRIBE transaction has completed.

Except as noted above, processing of this NOTIFY request is the same as in Section 4.1.3.

### 4.1.3. Receiving and Processing State Information

Subscribers receive information about the state of a resource to which they have subscribed in the form of NOTIFY requests.

Upon receiving a NOTIFY request, the subscriber should check that it matches at least one of its outstanding subscriptions; if not, it MUST return a "481 Subscription does not exist" response unless another 400- or 500-class response is more appropriate. The rules for matching NOTIFY requests with subscriptions that create a new dialog usage are described in Section 4.4.1. Notifications for subscriptions which were created inside an existing dialog match if they are in the same dialog and the "Event" header fields match (as described in Section 8.2.1).

If, for some reason, the event package designated in the "Event" header field of the NOTIFY request is not supported, the subscriber will respond with a "489 Bad Event" response.

To prevent spoofing of events, NOTIFY requests SHOULD be authenticated, using any defined SIP authentication mechanism.

NOTIFY requests MUST contain "Subscription-State" header fields which indicate the status of the subscription.

If the "Subscription-State" header field value is "active", it means that the subscription has been accepted and (in general) has been authorized. If the header field also contains an "expires" parameter, the subscriber SHOULD take it as the authoritative subscription duration and adjust accordingly. The "retry-after" and "reason" parameters have no semantics for "active".

If the "Subscription-State" value is "pending", the subscription has been received by the notifier, but there is insufficient policy information to grant or deny the subscription yet. If the header field also contains an "expires" parameter, the subscriber SHOULD take it as the authoritative subscription duration and adjust accordingly. No further action is necessary on the part of the subscriber. The "retry-after" and "reason" parameters have no

semantics for "pending".

If the "Subscription-State" value is "terminated", the subscriber MUST consider the subscription terminated. The "expires" parameter has no semantics for "terminated" -- notifiers SHOULD NOT include an "expires" parameter on a "Subscription-State" header field with a value of "terminated," and subscribers MUST ignore any such parameter, if present. If a reason code is present, the client should behave as described below. If no reason code or an unknown reason code is present, the client MAY attempt to re-subscribe at any time (unless a "retry-after" parameter is present, in which case the client SHOULD NOT attempt re-subscription until after the number of seconds specified by the "retry-after" parameter). The reason codes defined by this document are:

deactivated: The subscription has been terminated, but the subscriber SHOULD retry immediately with a new subscription. One primary use of such a status code is to allow migration of subscriptions between nodes. The "retry-after" parameter has no semantics for "deactivated".

probation: The subscription has been terminated, but the client SHOULD retry at some later time. If a "retry-after" parameter is also present, the client SHOULD wait at least the number of seconds specified by that parameter before attempting to re-subscribe.

rejected: The subscription has been terminated due to change in authorization policy. Clients SHOULD NOT attempt to re-subscribe. The "retry-after" parameter has no semantics for "rejected".

timeout: The subscription has been terminated because it was not refreshed before it expired. Clients MAY re-subscribe immediately. The "retry-after" parameter has no semantics for "timeout". This reason code is also associated with polling of resource state, as detailed in Section 4.4.3

giveup: The subscription has been terminated because the notifier could not obtain authorization in a timely fashion. If a "retry-after" parameter is also present, the client SHOULD wait at least the number of seconds specified by that parameter before attempting to re-subscribe; otherwise, the client MAY retry immediately, but will likely get put back into pending state.

noresource: The subscription has been terminated because the resource state which was being monitored no longer exists. Clients SHOULD NOT attempt to re-subscribe. The "retry-after" parameter has no semantics for "noresource".

invariant: The subscription has been terminated because the resource state is guaranteed not to change for the foreseeable future. This may be the case, for example, when subscribing to the location information of a fixed-location land-line telephone. When using this reason code, notifiers are advised to include a "retry-after" parameter with a large value (for example, 31536000 -- or one year) to prevent older, RFC 3265-compliant clients from periodically resubscribing. Clients SHOULD NOT attempt to resubscribe after receiving a reason code of "invariant," regardless of the presence of or value of a "retry-after" parameter.

Other specifications may define new reason codes for use with the "Subscription-State" header field.

Once the notification is deemed acceptable to the subscriber, the subscriber SHOULD return a 200 response. In general, it is not expected that NOTIFY responses will contain bodies; however, they MAY, if the NOTIFY request contained an "Accept" header field.

Other responses defined in [RFC3261] may also be returned, as appropriate. In no case should a NOTIFY transaction extend for any longer than the time necessary for automated processing. In particular, subscribers MUST NOT wait for a user response before returning a final response to a NOTIFY request.

### 4.1.4. Forking of SUBSCRIBE Requests

In accordance with the rules for proxying non-INVITE requests as defined in [RFC3261], successful SUBSCRIBE requests will receive only one 200-class response; however, due to forking, the subscription may have been accepted by multiple nodes. The subscriber MUST therefore be prepared to receive NOTIFY requests with "From:" tags which differ from the "To:" tag received in the SUBSCRIBE 200-class response.

If multiple NOTIFY requests are received in different dialogs in response to a single SUBSCRIBE request, each dialog represents a different destination to which the SUBSCRIBE request was forked. Subscriber handling in such situations varies by event package; see Section 5.4.9 for details.

## 4.2. Notifier Behavior

### 4.2.1. Subscription Establishment and Maintenance

Notifiers learn about subscription requests by receiving SUBSCRIBE requests from interested parties. Notifiers MUST NOT create subscriptions except upon receipt of a SUBSCRIBE request. However, for historical reasons, the implicit creation of subscriptions as defined in [RFC3515] is still permitted.

> [RFC3265] allowed the creation of subscriptions using means other than the SUBSCRIBE method. The only standardized use of this mechanism is the REFER method [RFC3515]. Implementation experience with REFER has shown that the implicit creation of a subscription has a number of undesirable effects, such as the inability to signal the success of a REFER request while signaling a problem with the subscription; and difficulty performing one action without the other. Additionally, the proper exchange of dialog identifiers is difficult without dialog re-use (which has its own set of problems; see Section 4.5).

#### 4.2.1.1. Initial SUBSCRIBE Transaction Processing

In no case should a SUBSCRIBE transaction extend for any longer than the time necessary for automated processing. In particular, notifiers MUST NOT wait for a user response before returning a final response to a SUBSCRIBE request.

> This requirement is imposed primarily to prevent the non-INVITE transaction timeout timer F (see [RFC3261]) from firing during the SUBSCRIBE transaction, since interaction with a user would often exceed 64*T1 seconds.

The notifier SHOULD check that the event package specified in the "Event" header field is understood. If not, the notifier SHOULD return a "489 Bad Event" response to indicate that the specified event/event class is not understood.

The notifier SHOULD also perform any necessary authentication and authorization per its local policy. See Section 4.2.1.3.

The notifier MAY also check that the duration in the "Expires" header field is not too small. If and only if the expiration interval is greater than zero AND smaller than one hour AND less than a notifier-configured minimum, the notifier MAY return a "423 Interval Too Brief" error which contains a "Min-Expires" header field field. The "Min-Expires" header field is described in [RFC3261].

Once the notifier determines that it has enough information to create the subscription (i.e., it understands the event package, the subscription pertains to a known resource, and there are no other barriers to creating the subscription), it creates the subscription and a dialog usage, and returns a 200 (OK) response.

When a subscription is created in the notifier, it stores the event package name as part of the subscription information.

The "Expires" values present in SUBSCRIBE 200-class responses behave in the same way as they do in REGISTER responses: the server MAY shorten the interval, but MUST NOT lengthen it.

> If the duration specified in a SUBSCRIBE request is unacceptably short, the notifier may be able to send a 423 response, as described earlier in this section.

200-class responses to SUBSCRIBE requests will not generally contain any useful information beyond subscription duration; their primary purpose is to serve as a reliability mechanism. State information will be communicated via a subsequent NOTIFY request from the notifier.

The other response codes defined in [RFC3261] may be used in response to SUBSCRIBE requests, as appropriate.

#### 4.2.1.2. Confirmation of Subscription Creation/Refreshing

Upon successfully accepting or refreshing a subscription, notifiers MUST send a NOTIFY request immediately to communicate the current resource state to the subscriber. This NOTIFY request is sent on the same dialog as created by the SUBSCRIBE response. If the resource has no meaningful state at the time that the SUBSCRIBE request is processed, this NOTIFY request MAY contain an empty or neutral body. See Section 4.2.2 for further details on NOTIFY request generation.

Note that a NOTIFY request is always sent immediately after any 200-class response to a SUBSCRIBE request, regardless of whether the subscription has already been authorized.

#### 4.2.1.3. Authentication/Authorization of SUBSCRIBE Requests

Privacy concerns may require that notifiers apply policy to determine whether a particular subscriber is authorized to subscribe to a certain set of events. Such policy may be defined by mechanisms such as access control lists or real-time interaction with a user. In general, authorization of subscribers prior to authentication is not particularly useful.

SIP authentication mechanisms are discussed in [RFC3261]. Note that, even if the notifier node typically acts as a proxy, authentication for SUBSCRIBE requests will always be performed via a "401" response, not a "407;" notifiers always act as a user agents when accepting subscriptions and sending notifications.

> Of course, when acting as a proxy, a node will perform normal proxy authentication (using 407). The foregoing explanation is a reminder that notifiers are always UAs, and as such perform UA authentication.

If authorization fails based on an access list or some other automated mechanism (i.e., it can be automatically authoritatively determined that the subscriber is not authorized to subscribe), the notifier SHOULD reply to the request with a "403 Forbidden" or "603 Decline" response, unless doing so might reveal information that should stay private; see Section 6.2.

If the notifier owner is interactively queried to determine whether a subscription is allowed, a 200 (OK) response is returned immediately. Note that a NOTIFY request is still formed and sent under these circumstances, as described in the previous section.

If subscription authorization was delayed and the notifier wishes to convey that such authorization has been declined, it may do so by sending a NOTIFY request containing a "Subscription-State" header field with a value of "terminated" and a reason parameter of "rejected".

#### 4.2.1.4. Refreshing of Subscriptions

When a notifier receives a subscription refresh, assuming that the subscriber is still authorized, the notifier updates the expiration time for subscription. As with the initial subscription, the server MAY shorten the amount of time until expiration, but MUST NOT increase it. The final expiration time is placed in the "Expires" header field in the response. If the duration specified in a SUBSCRIBE request is unacceptably short, the notifier SHOULD respond with a "423 Interval Too Brief" response.

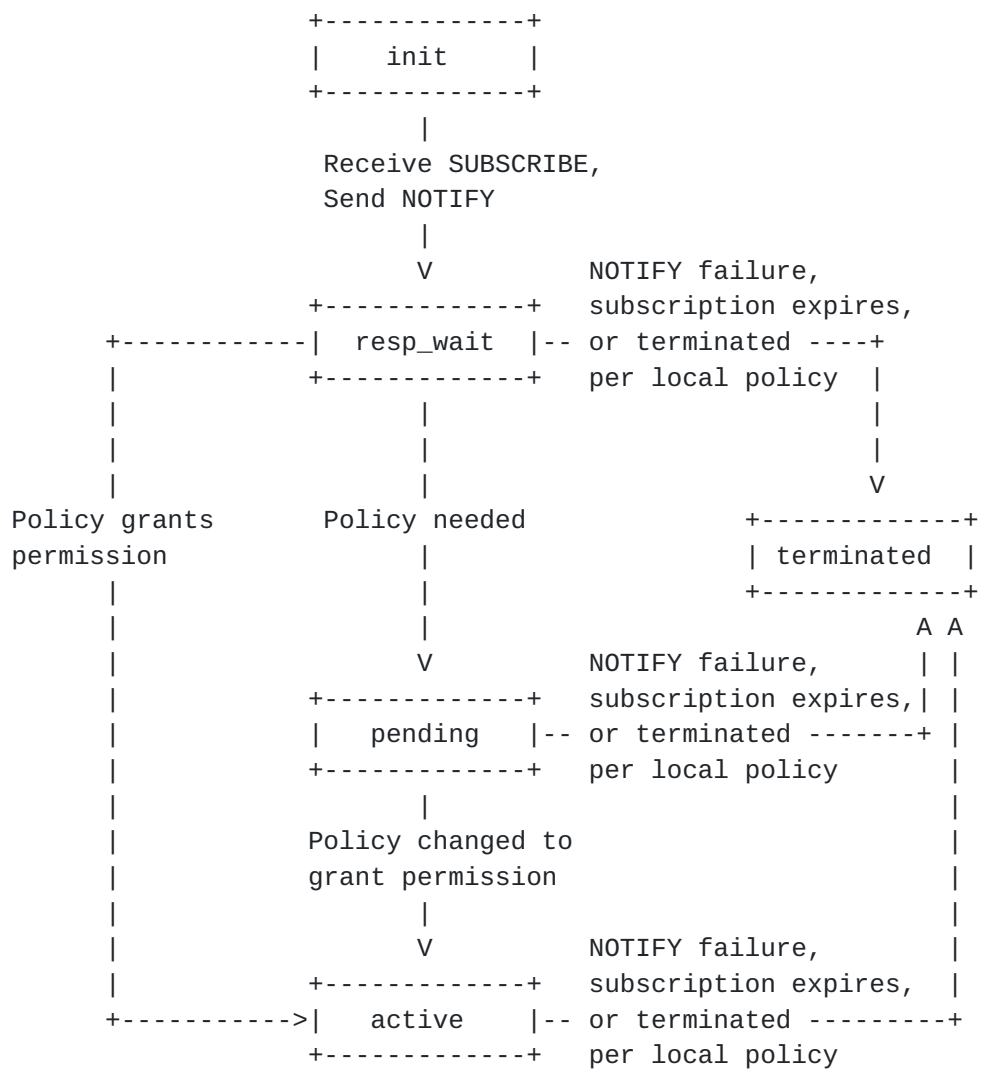
If no refresh for a notification address is received before its expiration time, the subscription is removed. When removing a subscription, the notifier SHOULD send a NOTIFY request with a "Subscription-State" value of "terminated" to inform it that the subscription is being removed. If such a request is sent, the "Subscription-State" header field SHOULD contain a "reason=timeout" parameter.

Clients can cause a subscription to be terminated immediately by sending a SUBSCRIBE request with an "Expires" header field set to '0'. Notifiers largely treat this the same way as any other subscription expiration: they send a NOTIFY request containing a "Subscription-State" of "terminated", with a reason code of "timeout." For consistency with state polling (see Section 4.4.3) and subscription refreshes, the notifier may choose to include resource state in this final NOTIFY request. However, in some cases, including such state makes no sense. Under such circumstances, the notifier may choose to omit state information from the terminal NOTIFY request.

The sending of a NOTIFY request when a subscription expires allows the corresponding dialog usage to be terminated, if appropriate.

### 4.2.2. Sending State Information to Subscribers

Notifiers use the NOTIFY method to send information about the state of a resource to subscribers. The notifier's view of a subscription is shown in the following state diagram:




When a SUBSCRIBE request is answered with a 200-class response, the notifier MUST immediately construct and send a NOTIFY request to the subscriber. When a change in the subscribed state occurs, the notifier SHOULD immediately construct and send a NOTIFY request, subject to authorization, local policy, and throttling considerations.

If the NOTIFY request fails due to expiration of SIP Timer F (transaction timeout), the notifier SHOULD remove the subscription.

This behavior prevents unnecessary transmission of state information for subscribers who have crashed or disappeared from the network. Because such transmissions will be sent multiple times, per the retransmission algorithm defined in [RFC3261] (instead of the typical single transmission for functioning clients), continuing to service them when no client is available to acknowledge them could place undue strain on a network. Upon

client restart or reestablishment of a network connection, it is expected that clients will send SUBSCRIBE requests to refresh potentially stale state information; such requests will re-install subscriptions in all relevant nodes.

If the NOTIFY transaction fails due to the receipt of a 404, 405, 410, 416, 480-485, 489, 501, or 604 response to the NOTIFY request, the notifier MUST remove the corresponding subscription. See [RFC5057] for further details and notes about the effect of error codes on dialogs and usages within dialog (such as subscriptions).

A notify error response would generally indicate that something has gone wrong with the subscriber or with some proxy on the way to the subscriber. If the subscriber is in error, it makes the most sense to allow the subscriber to rectify the situation (by re-subscribing) once the error condition has been handled. If a proxy is in error, the periodic sending of SUBSCRIBE requests to refresh the expiration timer will re-install subscription state once the network problem has been resolved.

NOTIFY requests MUST contain a "Subscription-State" header field with a value of "active", "pending", or "terminated". The "active" value indicates that the subscription has been accepted and has been authorized (in most cases; see Section 6.2). The "pending" value indicates that the subscription has been received, but that policy information is insufficient to accept or deny the subscription at this time. The "terminated" value indicates that the subscription is not active.

If the value of the "Subscription-State" header field is "active" or "pending", the notifier MUST also include in the "Subscription-State" header field an "expires" parameter which indicates the time remaining on the subscription. The notifier MAY use this mechanism to shorten a subscription; however, this mechanism MUST NOT be used to lengthen a subscription.

Including expiration information for active and pending subscriptions is necessary in case the SUBSCRIBE request forks, since the response to a forked SUBSCRIBE request may not be received by the subscriber. [RFC3265] allowed the notifier some discretion in the inclusion of this parameter, so subscriber implementations are warned to handle the lack of an "expires" parameter gracefully. Note well that this "expires" value is a parameter on the "Subscription-State" header field, NOT an "Expires" header field.

> The period of time for a subscription can be shortened to zero by the notifier. In other words, it is perfectly valid for a SUBSCRIBE request with a non-zero expires to be answered with a NOTIFY request that contains "Subscription-Status: terminated;reason=expired". This merely means that the notifier has shortened the subscription timeout to zero, and the subscription has expired instantaneously. The body may contain valid state, or it may contain a neutral state (see Section 5.4.7).

If the value of the "Subscription-State" header field is "terminated", the notifier SHOULD also include a "reason" parameter. The notifier MAY also include a "retry-after" parameter, where appropriate. For details on the value and semantics of the "reason" and "retry-after" parameters, see Section 4.1.3.

### 4.2.3. PINT Compatibility

The "Event" header field is considered mandatory for the purposes of this document. However, to maintain compatibility with PINT (see [RFC2848]), notifiers MAY interpret a SUBSCRIBE request with no "Event" header field as requesting a subscription to PINT events. If a notifier does not support PINT, it SHOULD return "489 Bad Event" to any SUBSCRIBE requests without an "Event" header field.

## 4.3. Proxy Behavior

Proxies need no additional behavior beyond that described in [RFC3261] to support SUBSCRIBE and NOTIFY transactions. If a proxy wishes to see all of the SUBSCRIBE and NOTIFY requests for a given dialog, it MUST add a Record-Route header field to the initial SUBSCRIBE request and all NOTIFY requests. It MAY choose to include Record-Route in subsequent SUBSCRIBE requests; however, these requests cannot cause the dialog's route set to be modified.

Proxies that did not add a Record-Route header field to the initial SUBSCRIBE request MUST NOT add a Record-Route header field to any of the associated NOTIFY requests.

> Note that subscribers and notifiers may elect to use S/MIME encryption of SUBSCRIBE and NOTIFY requests; consequently, proxies cannot rely on being able to access any information that is not explicitly required to be proxy-readable by [RFC3261].

## 4.4. Common Behavior

### 4.4.1. Dialog Creation and Termination

Dialogs usages are created upon completion of a NOTIFY transaction for a new subscription, unless the NOTIFY request contains a "Subscription-State" of "terminated."

Because the dialog usage is established by the NOTIFY request, the route set at the subscriber is taken from the NOTIFY request itself, as opposed to the route set present in the 200-class response to the SUBSCRIBE request.

NOTIFY requests are matched to such SUBSCRIBE requests if they contain the same "Call-ID", a "To" header field "tag" parameter which matches the "From" header field "tag" parameter of the SUBSCRIBE request, and the same "Event" header field. Rules for comparisons of the "Event" header fields are described in Section 8.2.1.

A subscription is destroyed after a notifier sends a NOTIFY request with a "Subscription-State" of "terminated," or in certain error situations described elsewhere in this document. The subscriber will generally answer such final requests with a "200 OK" response (unless a condition warranting an alternate response has arisen). Except when the mechanism described in Section 4.5.2 is used, the destruction of a subscription results in the termination of its associated dialog.

> A subscriber may send a SUBSCRIBE request with an "Expires" header field of 0 in order to trigger the sending of such a NOTIFY request; however, for the purposes of subscription and dialog lifetime, the subscription is not considered terminated until the NOTIFY transaction with a "Subscription-State" of "terminated" completes.

### 4.4.2. Notifier Migration

It is often useful to allow migration of subscriptions between notifiers. Such migration may be effected by sending a NOTIFY request with a "Subscription-State" header field of "terminated", and a reason parameter of "deactivated". This NOTIFY request is otherwise normal, and is formed as described in Section 4.2.2.

Upon receipt of this NOTIFY request, the subscriber SHOULD attempt to re-subscribe (as described in the preceding sections). Note that this subscription is established on a new dialog, and does not re-use the route set from the previous subscription dialog.

The actual migration is effected by making a change to the policy (such as routing decisions) of one or more servers to which the

SUBSCRIBE request will be sent in such a way that a different node ends up responding to the SUBSCRIBE request. This may be as simple as a change in the local policy in the notifier from which the subscription is migrating so that it serves as a proxy or redirect server instead of a notifier.

Whether, when, and why to perform notifier migrations may be described in individual event packages; otherwise, such decisions are a matter of local notifier policy, and are left up to individual implementations.

### 4.4.3. Polling Resource State

A natural consequence of the behavior described in the preceding sections is that an immediate fetch without a persistent subscription may be effected by sending a SUBSCRIBE with an "Expires" of 0.

Of course, an immediate fetch while a subscription is active may be effected by sending a SUBSCRIBE request with an "Expires" equal to the number of seconds remaining in the subscription.

Upon receipt of this SUBSCRIBE request, the notifier (or notifiers, if the SUBSCRIBE request was forked) will send a NOTIFY request containing resource state in the same dialog.

Note that the NOTIFY requests triggered by SUBSCRIBE requests with "Expires" header fields of 0 will contain a "Subscription-State" value of "terminated", and a "reason" parameter of "timeout".

Polling of event state can cause significant increases in load on the network and notifiers; as such, it should be used only sparingly. In particular, polling SHOULD NOT be used in circumstances in which it will typically result in more network messages than long-running subscriptions.

When polling is used, subscribers SHOULD attempt to cache authentication credentials between polls so as to reduce the number of messages sent.

> Due to the requirement on notifiers to send a NOTIFY request immediately upon receipt of a SUBSCRIBE request, the state provided by polling is limited to the information that the notifier has immediate local access to when it receives the SUBSCRIBE request. If, for example, the notifier generally needs to retrieve state from another network server, then that state will be absent from the NOTIFY request that results from polling.

### 4.4.4. Allow-Events header field usage

The "Allow-Events" header field, if present, includes a list of tokens which indicates the event packages supported by a notifier. In other words, a user agent sending an "Allow-Events" header field is advertising that it can process SUBSCRIBE requests and generate NOTIFY requests for all of the event packages listed in that header field.

Any user agent that can act as a notifier for one or more event packages SHOULD include an appropriate "Allow-Events" header field indicating all supported events in all methods which initiate dialogs and their responses (such as INVITE) and OPTIONS responses.

> This information is very useful, for example, in allowing user agents to render particular interface elements appropriately according to whether the events required to implement the features they represent are supported by the appropriate nodes.
> On the other hand, it doesn't necessarily make much sense to indicate supported events inside a dialog established by a NOTIFY request if the only event package supported is the one associated with that subscription.

Note that "Allow-Events" header fields MUST NOT be inserted by proxies.

The "Allow-Events" header field does not include a list of the event template packages supported by an implementation. If a subscriber wishes to determine which event template packages are supported by a notifier, it can probe for such support by attempting to subscribe to the event template packages it wishes to use.

## 4.5. Targeting Subscriptions at Devices

[RFC3265] defined a mechanism by which subscriptions could share dialogs with invite usages and with other subscriptions. The purpose of this behavior was to allow subscribers to ensure that a subscription arrived at the same device as an established dialog. Unfortunately, the re-use of dialogs has proven to be exceedingly confusing. [RFC5057] attempted to clarify proper behavior in a variety of circumstances; however, the ensuing rules remain confusing and prone to implementation error. At the same time, the mechanism described in [RFC5627] now provides a far more elegant and unambiguous means to achieve the same goal.

Consequently, the dialog re-use technique described in RFC 3265 is now deprecated.

This dialog-sharing technique has also historically been used as a means for targeting an event package at a dialog. This usage can be seen, for example, in certain applications of the REFER method [RFC3515]. With the removal of dialog re-use, an alternate (and more explicit) means of targeting dialogs needs to be used for this type of correlation. The appropriate means of such targeting is left up to the actual event packages. Candidates include the "Target-Dialog" header field [RFC4538], the "Join" header field [RFC3911], and the "Replaces" header field [RFC3891], depending on the semantics desired. Alternately, if the semantics of those header fields do not match the event package's purpose for correlation, event packages can devise their own means of identifying dialogs. For an example of this approach, see the Dialog Event Package [RFC4235].

### 4.5.1. Using GRUUs to Route to Devices

Notifiers MUST implement the Globally Routable User-Agent URI (GRUU) extension defined in [RFC5627], and MUST use a GRUU as their local target. This allows subscribers to explicitly target desired devices.

If a subscriber wishes to subscribe to a resource on the same device as an established dialog, it should check whether the remote contact in that dialog is a GRUU (i.e., whether it contains a "gr" URI parameter). If so, the subscriber creates a new dialog, using the GRUU as the request URI for the new SUBSCRIBE request.

> Because GRUUs are guaranteed to route to a a specific device, this ensures that the subscription will be routed to the same place as the established dialog.

### 4.5.2. Sharing Dialogs

For compatibility with older clients, subscriber and notifier implementations may choose to allow dialog sharing. The behavior of multiple usages within a dialog are described in [RFC5057].

Subscribers MUST NOT attempt to re-use dialogs whose remote target is a GRUU.

> Note that the techniques described in this section are included for backwards compatibility purposes only. Because subscribers cannot re-use dialogs with a GRUU for their remote target, and because notifiers must use GRUUs as their local target, any two implementations that conform to this specification will automatically use the mechanism described in Section 4.5.1.

If a subscriber wishes to subscribe to a resource on the same device

as an established dialog and the remote contact is not a GRUU, it MAY revert to dialog sharing behavior. Alternately, it MAY choose to treat the remote party as incapable of servicing the subscription (i.e., the same way it would behave if the remote party did not support SIP events at all).

If a notifier receives a SUBSCRIBE request for a new subscription on an existing dialog, it MAY choose to implement dialog sharing behavior. Alternately, it may choose to fail the SUBSCRIBE request with a 403 response. The error text of such 403 responses SHOULD indicate that dialog sharing is not supported.

To implement dialog sharing, subscribers and notifiers perform the following additional processing:

- When subscriptions exist in dialogs associated with INVITE-created application state and/or other subscriptions, these sets of application state do not interact beyond the behavior described for a dialog (e.g., route set handling). In particular, multiple subscriptions within a dialog are expire independently, and require independent subscription refreshes.

- If a subscription's destruction leaves no other application state associated with the dialog, the dialog terminates. The destruction of other application state (such as that created by an INVITE) will not terminate the dialog if a subscription is still associated with that dialog. This means that, when dialog are re-used, then a dialog created with an INVITE does not necessarily terminate upon receipt of a BYE. Similarly, in the case that several subscriptions are associated with a single dialog, the dialog does not terminate until all the subscriptions in it are destroyed.

- Subscribers MAY include an "id" parameter in SUBSCRIBE request "Event" header field to allow differentiation between multiple subscriptions in the same dialog. This "id" parameter, if present, contains an opaque token which identifies the specific subscription within a dialog. An "id" parameter is only valid within the scope of a single dialog.

- If an "id" parameter is present in the SUBSCRIBE request used to establish a subscription, that "id" parameter MUST also be present in all corresponding NOTIFY requests.

- When a subscriber refreshes a the subscription timer, the SUBSCRIBE request MUST contain the same "Event" header field "id" parameter as was present in the SUBSCRIBE request that created the subscription. (Otherwise, the notifier will interpret the

SUBSCRIBE request as a request for a new subscription in the same dialog).

- When a subscription is created in the notifier, it stores any "Event" header field "id" parameter as part of the subscription information (along with the event package name).

- If an initial SUBSCRIBE request is sent on a pre-existing dialog, a matching NOTIFY request merely creates a new subscription associated with that dialog.

### 4.6. CANCEL Requests for SUBSCRIBE and NOTIFY Transactions

Neither SUBSCRIBE nor NOTIFY requests can be canceled. If a UAS receives a CANCEL request that matches a known SUBSCRIBE or NOTIFY transaction, it MUST respond to the CANCEL request, but otherwise ignore it. In particular, the CANCEL request MUST NOT affect processing of the SUBSCRIBE or NOTIFY request in any way.

UACs SHOULD NOT send CANCEL requests for SUBSCRIBE or NOTIFY transactions.

## 5. Event Packages

This section covers several issues which should be taken into consideration when event packages based on the SUBSCRIBE and NOTIFY methods are proposed. Event package definitions contain sections addressing each of these issues, ideally in the same order and with the same titles as the following sections.

### 5.1. Appropriateness of Usage

When designing an event package using the methods described in this document for event notification, it is important to consider: is SIP an appropriate mechanism for the problem set? Is SIP being selected because of some unique feature provided by the protocol (e.g., user mobility), or merely because "it can be done?" If you find yourself defining event packages for notifications related to, for example, network management or the temperature inside your car's engine, you may want to reconsider your selection of protocols.

Those interested in extending the mechanism defined in this document are urged to follow the development of "Guidelines for Authors of SIP Extensions" [RFC4485] for further guidance regarding appropriate uses of SIP.

Further, it is expected that this mechanism is not to be used in applications where the frequency of reportable events is excessively rapid (e.g., more than about once per second). A SIP network is generally going to be provisioned for a reasonable signaling volume; sending a notification every time a user's GPS position changes by one hundredth of a second could easily overload such a network.

## 5.2. Event Template-packages

Normal event packages define a set of state applied to a specific type of resource, such as user presence, call state, and messaging mailbox state.

Event template-packages are a special type of package which define a set of state applied to other packages, such as statistics, access policy, and subscriber lists. Event template-packages may even be applied to other event template-packages.

To extend the object-oriented analogy made earlier, event template-packages can be thought of as templatized C++ packages which must be applied to other packages to be useful.

The name of an event template-package as applied to a package is formed by appending a period followed by the event template-package name to the end of the package. For example, if a template-package called "winfo" were being applied to a package called "presence", the event token used in "Event" and "Allow-Events" would be "presence.winfo".

Event template-packages must be defined so that they can be applied to any arbitrary package. In other words, event template-packages cannot be specifically tied to one or a few "parent" packages in such a way that they will not work with other packages.

## 5.3. Amount of State to be Conveyed

When designing event packages, it is important to consider the type of information which will be conveyed during a notification.

A natural temptation is to convey merely the event (e.g., "a new voice message just arrived") without accompanying state (e.g., "7 total voice messages"). This complicates implementation of subscribing entities (since they have to maintain complete state for the entity to which they have subscribed), and also is particularly susceptible to synchronization problems.

There are two possible solutions to this problem that event packages may choose to implement.

### 5.3.1. Complete State Information

In general, event packages need to be able to convey a well-defined and complete state, rather than just a stream of events. If it is not possible to describe complete system state for transmission in NOTIFY requests, then the problem set is not a good candidate for an event package.

For packages which typically convey state information that is reasonably small (on the order of 1 KB or so), it is suggested that event packages are designed so as to send complete state information whenever an event occurs.

In some circumstances, conveying the current state alone may be insufficient for a particular class of events. In these cases, the event packages should include complete state information along with the event that occurred. For example, conveying "no customer service representatives available" may not be as useful as conveying "no customer service representatives available; representative sip:46@cs.xyz.int just logged off".

### 5.3.2. State Deltas

In the case that the state information to be conveyed is large, the event package may choose to detail a scheme by which NOTIFY requests contain state deltas instead of complete state.

Such a scheme would work as follows: any NOTIFY request sent in immediate response to a SUBSCRIBE request contains full state information. NOTIFY requests sent because of a state change will contain only the state information that has changed; the subscriber will then merge this information into its current knowledge about the state of the resource.

Any event package that supports delta changes to states MUST include a version number that increases by exactly one for each NOTIFY transaction in a subscription. Note that the state version number appears in the body of the message, not in a SIP header field.

If a NOTIFY request arrives that has a version number that is incremented by more than one, the subscriber knows that a state delta has been missed; it ignores the NOTIFY request containing the state delta (except for the version number, which it retains to detect message loss), and re-sends a SUBSCRIBE request to force a NOTIFY request containing a complete state snapshot.

### 5.4. Event Package Responsibilities

Event packages are not required to reiterate any of the behavior described in this document, although they may choose to do so for clarity or emphasis. In general, though, such packages are expected to describe only the behavior that extends or modifies the behavior described in this document.

Note that any behavior designated with "SHOULD" or "MUST" in this document is not allowed to be weakened by extension documents; however, such documents may elect to strengthen "SHOULD" requirements to "MUST" strength if required by their application.

> In addition to the normal sections expected in standards-track RFCs and SIP extension documents, authors of event packages need to address each of the issues detailed in the following subsections, whenever applicable.

#### 5.4.1. Event Package Name

This section, which MUST be present, defines the token name to be used to designate the event package. It MUST include the information which appears in the IANA registration of the token. For information on registering such types, see Section 7.

#### 5.4.2. Event Package Parameters

If parameters are to be used on the "Event" header field to modify the behavior of the event package, the syntax and semantics of such header fields MUST be clearly defined.

Any "Event" header field parameters defined by an event package MUST be registered in the "Header Field Parameters and Parameter Values" registry defined by [RFC3968]. An "Event" header field parameter, once registered in conjunction with an event package, MUST NOT be re-used with any other event package. Non-event-package specifications MAY define "Event" header field parameters that apply across all event packages (with emphasis on "all", as opposed to "several"), such as the "id" parameter defined in this document. The restriction of a parameter to use with a single event package only applies to parameters that are defined in conjunction with an event package.

#### 5.4.3. SUBSCRIBE Request Bodies

It is expected that most, but not all, event packages will define syntax and semantics for SUBSCRIBE request bodies; these bodies will typically modify, expand, filter, throttle, and/or set thresholds for the class of events being requested. Designers of event packages are

strongly encouraged to re-use existing MIME types for message bodies where practical.

This mandatory section of an event package defines what type or types of event bodies are expected in SUBSCRIBE requests (or specify that no event bodies are expected). It should point to detailed definitions of syntax and semantics for all referenced body types.

### 5.4.4. Subscription Duration

It is RECOMMENDED that event packages give a suggested range of times considered reasonable for the duration of a subscription. Such packages MUST also define a default "Expires" value to be used if none is specified.

### 5.4.5. NOTIFY Request Bodies

The NOTIFY request body is used to report state on the resource being monitored. Each package MUST define what type or types of event bodies are expected in NOTIFY requests. Such packages MUST specify or cite detailed specifications for the syntax and semantics associated with such event body.

Event packages also MUST define which MIME type is to be assumed if none are specified in the "Accept" header field of the SUBSCRIBE request.

### 5.4.6. Notifier processing of SUBSCRIBE requests

This section describes the processing to be performed by the notifier upon receipt of a SUBSCRIBE request. Such a section is required.

Information in this section includes details of how to authenticate subscribers and authorization issues for the package.

### 5.4.7. Notifier generation of NOTIFY requests

This section of an event package describes the process by which the notifier generates and sends a NOTIFY request. This includes detailed information about what events cause a NOTIFY request to be sent, how to compute the state information in the NOTIFY, how to generate neutral or fake state information to hide authorization delays and decisions from users, and whether state information is complete or deltas for notifications; see Section 5.3. Such a section is required.

This section may optionally describe the behavior used to process the subsequent response.

### 5.4.8. Subscriber processing of NOTIFY requests

This section of an event package describes the process followed by the subscriber upon receipt of a NOTIFY request, including any logic required to form a coherent resource state (if applicable).

### 5.4.9. Handling of forked requests

Each event package MUST specify whether forked SUBSCRIBE requests are allowed to install multiple subscriptions.

If such behavior is not allowed, the first potential dialog-establishing message will create a dialog. All subsequent NOTIFY requests which correspond to the SUBSCRIBE request (i.e., match "To", "From", "From" header field "tag" parameter, "Call-ID", "Event", and "Event" header field "id" parameter) but which do not match the dialog would be rejected with a 481 response. Note that the 200-class response to the SUBSCRIBE request can arrive after a matching NOTIFY request has been received; such responses might not correlate to the same dialog established by the NOTIFY request. Except as required to complete the SUBSCRIBE transaction, such non-matching 200-class responses are ignored.

If installing of multiple subscriptions by way of a single forked SUBSCRIBE request is allowed, the subscriber establishes a new dialog towards each notifier by returning a 200-class response to each NOTIFY request. Each dialog is then handled as its own entity, and is refreshed independent of the other dialogs.

In the case that multiple subscriptions are allowed, the event package MUST specify whether merging of the notifications to form a single state is required, and how such merging is to be performed. Note that it is possible that some event packages may be defined in such a way that each dialog is tied to a mutually exclusive state which is unaffected by the other dialogs; this MUST be clearly stated if it is the case.

### 5.4.10. Rate of notifications

Each event package is expected to define a requirement (SHOULD or MUST strength) which defines an absolute maximum on the rate at which notifications are allowed to be generated by a single notifier.

Each package MAY further define a throttle mechanism which allows subscribers to further limit the rate of notification.

### 5.4.11. State Aggregation

Many event packages inherently work by collecting information about a resource from a number of other sources -- either through the use of PUBLISH [RFC3903], by subscribing to state information, or through other state gathering mechanisms.

Event packages that involve retrieval of state information for a single resource from more than one source need to consider how notifiers aggregate information into a single, coherent state. Such packages MUST specify how notifiers aggregate information and how they provide authentication and authorization.

### 5.4.12. Examples

Event packages SHOULD include several demonstrative message flow diagrams paired with several typical, syntactically correct, and complete messages.

It is RECOMMENDED that documents describing event packages clearly indicate that such examples are informative and not normative, with instructions that implementors refer to the main text of the document for exact protocol details.

### 5.4.13. Use of URIs to Retrieve State

Some types of event packages may define state information which is potentially too large to reasonably send in a SIP message. To alleviate this problem, event packages may include the ability to convey a URI instead of state information; this URI will then be used to retrieve the actual state information.

[RFC4483] defines a mechanism that can be used by event packages to convey information in such a fashion.

## 6. Security Considerations

### 6.1. Access Control

The ability to accept subscriptions should be under the direct control of the notifier's user, since many types of events may be considered sensitive for the purposes of privacy. Similarly, the notifier should have the ability to selectively reject subscriptions based on the subscriber identity (based on access control lists), using standard SIP authentication mechanisms. The methods for creation and distribution of such access control lists is outside the scope of this document.

### 6.2. Notifier Privacy Mechanism

The mere act of returning certain 4xx and 6xx responses to SUBSCRIBE requests may, under certain circumstances, create privacy concerns by revealing sensitive policy information. In these cases, the notifier SHOULD always return a 200 (OK) response. While the subsequent NOTIFY request may not convey true state, it MUST appear to contain a potentially correct piece of data from the point of view of the subscriber, indistinguishable from a valid response. Information about whether a user is authorized to subscribe to the requested state is never conveyed back to the original user under these circumstances.

Individual packages and their related documents for which such a mode of operation makes sense can further describe how and why to generate such potentially correct data. For example, such a mode of operation is mandated by [RFC2779] for user presence information.

### 6.3. Denial-of-Service attacks

The current model (one SUBSCRIBE request triggers a SUBSCRIBE response and one or more NOTIFY requests) is a classic setup for an amplifier node to be used in a smurf attack.

Also, the creation of state upon receipt of a SUBSCRIBE request can be used by attackers to consume resources on a victim's machine, rendering it unusable.

To reduce the chances of such an attack, implementations of notifiers SHOULD require authentication. Authentication issues are discussed in [RFC3261].

### 6.4. Replay Attacks

Replaying of either SUBSCRIBE or NOTIFY requests can have detrimental effects.

In the case of SUBSCRIBE requests, attackers may be able to install any arbitrary subscription which it witnessed being installed at some point in the past. Replaying of NOTIFY requests may be used to spoof old state information (although a good versioning mechanism in the body of the NOTIFY requests may help mitigate such an attack). Note that the prohibition on sending NOTIFY requests to nodes which have not subscribed to an event also aids in mitigating the effects of such an attack.

To prevent such attacks, implementations SHOULD require authentication with anti-replay protection. Authentication issues

are discussed in [RFC3261].

### 6.5. Man-in-the middle attacks

Even with authentication, man-in-the-middle attacks using SUBSCRIBE requests may be used to install arbitrary subscriptions, hijack existing subscriptions, terminate outstanding subscriptions, or modify the resource to which a subscription is being made. To prevent such attacks, implementations SHOULD provide integrity protection across "Contact", "Route", "Expires", "Event", and "To" header fields of SUBSCRIBE requests, at a minimum. If SUBSCRIBE request bodies are used to define further information about the state of the call, they SHOULD be included in the integrity protection scheme.

Man-in-the-middle attacks may also attempt to use NOTIFY requests to spoof arbitrary state information and/or terminate outstanding subscriptions. To prevent such attacks, implementations SHOULD provide integrity protection across the "Call-ID", "CSeq", and "Subscription-State" header fields and the bodies of NOTIFY requests.

Integrity protection of message header fields and bodies is discussed in [RFC3261].

### 6.6. Confidentiality

The state information contained in a NOTIFY request has the potential to contain sensitive information. Implementations MAY encrypt such information to ensure confidentiality.

While less likely, it is also possible that the information contained in a SUBSCRIBE request contains information that users might not want to have revealed. Implementations MAY encrypt such information to ensure confidentiality.

To allow the remote party to hide information it considers sensitive, all implementations SHOULD be able to handle encrypted SUBSCRIBE and NOTIFY requests.

The mechanisms for providing confidentiality are detailed in [RFC3261].

## 7. IANA Considerations

(This section is not applicable until this document is published as an RFC.)

### 7.1. Event Packages

This document defines an event-type namespace which requires a central coordinating body. The body chosen for this coordination is the Internet Assigned Numbers Authority (IANA).

There are two different types of event-types: normal event packages, and event template-packages; see Section 5.2. To avoid confusion, template-package names and package names share the same namespace; in other words, an event template-package MUST NOT share a name with a package.

Policies for registration of SIP event packages and SIP event package templates are defined in section 4.1 of [RFC5727].

Registrations with the IANA MUST include the token being registered and whether the token is a package or a template-package. Further, packages MUST include contact information for the party responsible for the registration and/or a published document which describes the event package. Event template-package token registrations MUST include a pointer to the published RFC which defines the event template-package.

Registered tokens to designate packages and template-packages MUST NOT contain the character ".", which is used to separate template-packages from packages.

#### 7.1.1. Registration Information

As this document specifies no package or template-package names, the initial IANA registration for event types will be empty. The remainder of the text in this section gives an example of the type of information to be maintained by the IANA; it also demonstrates all five possible permutations of package type, contact, and reference.

The table below lists the event packages and template-packages defined in "SIP-Specific Event Notification" [RFC xxxx]. Each name is designated as a package or a template-package under "Type".

| Package Name | Type | Contact | Reference |
|---|---|---|---|
| example1 | package | [Roach] | |
| example2 | package | [Roach] | [RFC xxxx] |
| example3 | package | | [RFC xxxx] |
| example4 | template | [Roach] | [RFC xxxx] |
| example5 | template | | [RFC xxxx] |

PEOPLE

[Roach] Adam Roach <adam.roach@tekelec.com>

REFERENCES

[RFC xxxx] A.B. Roach, "SIP-Specific Event Notification", RFC XXXX, Monthname 20XX

### 7.1.2. Registration Template

To: ietf-sip-events@iana.org
Subject: Registration of new SIP event package

Package Name:

(Package names must conform to the syntax described in Section 8.2.1.)

Is this registration for a Template Package:

(indicate yes or no)

Published Specification(s):

(Template packages require a published RFC. Other packages may reference a specification when appropriate).

Person & email address to contact for further information:

## 7.2. Reason Codes

This document further defines "reason" codes for use in the "Subscription-State" header field (see Section 4.1.3).

Following the policies outlined in "Guidelines for Writing an IANA Considerations Section in RFCs" [RFC5226], new reason codes require a Standards Action.

Registrations with the IANA include the reason code being registered and a reference to a published document which describes the event package. Insertion of such values takes place as part of the RFC publication process or as the result of inter-SDO liaison activity. New reason codes must conform to the syntax of the ABNF "token" element defined in [RFC3261].

[RFC4660] defined a new reason code prior to the establishment of an IANA registry. We include its reason code ("badfilter") in the initial list of reason codes to ensure a complete registry.

The IANA registry for reason code will be initialized with the following values:

| Reason Code | Reference |
|---|---|
| deactivated | [RFC xxxx] |
| probation | [RFC xxxx] |
| rejected | [RFC xxxx] |
| timeout | [RFC xxxx] |
| giveup | [RFC xxxx] |
| noresource | [RFC xxxx] |
| invariant | [RFC xxxx] |
| badfilter | [RFC 4660] |

REFERENCES

[RFC xxxx] A.B. Roach, "SIP-Specific Event Notification", RFC XXXX, Monthname 20XX

[RFC 4660] Khartabil, H., Leppanen, E., Lonnfors, M., and J. Costa-Requena, "Functional Description of Event Notification Filtering", September 2006.

## 7.3. Header Field Names

This document registers three new header field names, described elsewhere in this document. These header fields are defined by the following information, which is to be added to the header field sub-registry under http://www.iana.org/assignments/sip-parameters.

Header Name: Allow-Events
Compact Form: u

Header Name: Subscription-State
Compact Form: (none)

Header Name: Event

Compact Form: o

### 7.4. Response Codes

This document registers two new response codes. These response codes are defined by the following information, which is to be added to the method and response-code sub-registry under http://www.iana.org/assignments/sip-parameters.

Response Code Number: 202
Default Reason Phrase: Accepted

Response Code Number: 489
Default Reason Phrase: Bad Event

## 8. Syntax

This section describes the syntax extensions required for event notification in SIP. Semantics are described in Section 4. Note that the formal syntax definitions described in this document are expressed in the ABNF format used in [RFC3261], and contain references to elements defined therein.

### 8.1. New Methods

This document describes two new SIP methods: SUBSCRIBE and NOTIFY.

#### 8.1.1. SUBSCRIBE method

"SUBSCRIBE" is added to the definition of the element "Method" in the SIP message grammar.

Like all SIP method names, the SUBSCRIBE method name is case sensitive. The SUBSCRIBE method is used to request asynchronous notification of an event or set of events at a later time.

#### 8.1.2. NOTIFY method

"NOTIFY" is added to the definition of the element "Method" in the SIP message grammar.

The NOTIFY method is used to notify a SIP node that an event which has been requested by an earlier SUBSCRIBE method has occurred. It may also provide further details about the event.

## 8.2. New Header Fields

### 8.2.1. "Event" Header Field

Event is added to the definition of the element "message-header field" in the SIP message grammar.

For the purposes of matching NOTIFY requests with SUBSCRIBE requests, the event-type portion of the "Event" header field is compared byte-by-byte, and the "id" parameter token (if present) is compared byte-by-byte. An "Event" header field containing an "id" parameter never matches an "Event" header field without an "id" parameter. No other parameters are considered when performing a comparison. SUBSCRIBE responses are matched per the transaction handling rules in [RFC3261].

> Note that the forgoing text means that "Event: foo; id=1234" would match "Event: foo; param=abcd; id=1234", but not "Event: foo" (id does not match) or "Event: Foo; id=1234" (event portion does not match).

This document does not define values for event-types. These values will be defined by individual event packages, and MUST be registered with the IANA.

There MUST be exactly one event type listed per event header field. Multiple events per message are disallowed.

### 8.2.2. "Allow-Events" Header Field

Allow-Events is added to the definition of the element "general-header field" in the SIP message grammar. Its usage is described in Section 4.4.4.

### 8.2.3. "Subscription-State" Header Field

Subscription-State is added to the definition of the element "request-header field" in the SIP message grammar. Its usage is described in Section 4.1.3.

## 8.3. New Response Codes

### 8.3.1. "202 Accepted" Response Code

For historical purposes, the 202 (Accepted) response code is added to the "Success" header field definition.

This document does not specify the use of the 202 response code in

conjunction with the SUBSCRIBE or NOTIFY methods. Previous versions of the SIP Events Framework assigned specific meaning to the 202 response code.

Due to response handling in forking cases, any 202 response to a SUBSCRIBE request may be absorbed by a proxy, and thus it can never be guaranteed to be received by the UAC. Furthermore, there is no actual processing difference for a 202 as compared to a 200; a NOTIFY request is sent after the subscription is processed, and it conveys the correct state. SIP interoperability tests found that implementations were handling 202 differently from 200, leading to incompatibilities. Therefore, the 202 response is being deprecated to make it clear there is no such difference and 202 should not be handled differently than 200.

Implementations conformant with the current specification MUST treat an incoming 202 response as identical to a 200 response, and MUST NOT generate 202 response codes to SUBSCRIBE or NOTIFY requests.

This document also updates [RFC4660], which reiterates the 202-based behavior in several places. Implementations compliant with the present document MUST NOT send a 202 response to a SUBSCRIBE request, and will send an alternate success response (such as 200) in its stead.

### 8.3.2. "489 Bad Event" Response Code

The 489 event response is added to the "Client-Error" header field field definition. "489 Bad Event" is used to indicate that the server did not understand the event package specified in a "Event" header field.

## 8.4. Augmented BNF Definitions

The Augmented BNF definitions for the various new and modified syntax elements follows. The notation is as used in [RFC3261], and any elements not defined in this section are as defined in SIP and the documents to which it refers.

```
   SUBSCRIBEm        = %x53.55.42.53.43.52.49.42.45 ; SUBSCRIBE in caps
   NOTIFYm           = %x4E.4F.54.49.46.59 ; NOTIFY in caps
   extension-method = SUBSCRIBEm / NOTIFYm / token

   Event             =  ( "Event" / "o" ) HCOLON event-type
                        *( SEMI event-param )
   event-type        =  event-package *( "." event-template )
   event-package     =  token-nodot
   event-template    =  token-nodot
   token-nodot       =  1*( alphanum / "-"  / "!" / "%" / "*"
                          / "_" / "+" / "`" / "'" / "~" )

   ; The use of the "id" parameter is deprecated; it is included
   ; for backwards compatibility purposes only.
   event-param      =  generic-param / ( "id" EQUAL token )

   Allow-Events =  ( "Allow-Events" / "u" ) HCOLON event-type
                  *(COMMA event-type)

   Subscription-State   = "Subscription-State" HCOLON substate-value
                          *( SEMI subexp-params )
   substate-value       = "active" / "pending" / "terminated"
                          / extension-substate
   extension-substate   = token
   subexp-params        =   ("reason" EQUAL event-reason-value)
                          / ("expires" EQUAL delta-seconds)
                          / ("retry-after" EQUAL delta-seconds)
                          / generic-param
   event-reason-value   =   "deactivated"
                          / "probation"
                          / "rejected"
                          / "timeout"
                          / "giveup"
                          / "noresource"
                          / "invariant"
                          / event-reason-extension
   event-reason-extension = token
```

## 9. References

### 9.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC2848] Petrack, S. and L. Conroy, "The PINT Service Protocol: Extensions to SIP and SDP for IP Access to Telephone Call

Services", RFC 2848, June 2000.

[RFC3261] Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M., and E. Schooler, "SIP: Session Initiation Protocol", RFC 3261, June 2002.

[RFC3265] Roach, A., "Session Initiation Protocol (SIP)-Specific Event Notification", RFC 3265, June 2002.

[RFC3968] Camarillo, G., "The Internet Assigned Number Authority (IANA) Header Field Parameter Registry for the Session Initiation Protocol (SIP)", BCP 98, RFC 3968, December 2004.

[RFC4483] Burger, E., "A Mechanism for Content Indirection in Session Initiation Protocol (SIP) Messages", RFC 4483, May 2006.

[RFC5226] Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 5226, May 2008.

[RFC5627] Rosenberg, J., "Obtaining and Using Globally Routable User Agent URIs (GRUUs) in the Session Initiation Protocol (SIP)", RFC 5627, October 2009.

[RFC5727] Peterson, J., Jennings, C., and R. Sparks, "Change Process for the Session Initiation Protocol (SIP) and the Real-time Applications and Infrastructure Area", BCP 67, RFC 5727, March 2010.

## 9.2. Informative References

[RFC2779] Day, M., Aggarwal, S., Mohr, G., and J. Vincent, "Instant Messaging / Presence Protocol Requirements", RFC 2779, February 2000.

[RFC3515] Sparks, R., "The Session Initiation Protocol (SIP) Refer Method", RFC 3515, April 2003.

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[RFC3891] Mahy, R., Biggs, B., and R. Dean, "The Session Initiation Protocol (SIP) "Replaces" Header", RFC 3891, September 2004.

[RFC3903] Niemi, A., "Session Initiation Protocol (SIP) Extension for Event State Publication", RFC 3903, October 2004.

[RFC3911] Mahy, R. and D. Petrie, "The Session Initiation Protocol (SIP) "Join" Header", RFC 3911, October 2004.

[RFC4235] Rosenberg, J., Schulzrinne, H., and R. Mahy, "An INVITE-Initiated Dialog Event Package for the Session Initiation Protocol (SIP)", RFC 4235, November 2005.

[RFC4485] Rosenberg, J. and H. Schulzrinne, "Guidelines for Authors of Extensions to the Session Initiation Protocol (SIP)", RFC 4485, May 2006.

[RFC4538] Rosenberg, J., "Request Authorization through Dialog Identification in the Session Initiation Protocol (SIP)", RFC 4538, June 2006.

[RFC4660] Khartabil, H., Leppanen, E., Lonnfors, M., and J. Costa-Requena, "Functional Description of Event Notification Filtering", RFC 4660, September 2006.

[RFC5057] Sparks, R., "Multiple Dialog Usages in the Session Initiation Protocol", RFC 5057, November 2007.

[RFC5839] Niemi, A. and D. Willis, "An Extension to Session Initiation Protocol (SIP) Events for Conditional Event Notification", RFC 5839, May 2010.

## Appendix A. Acknowledgements

Thanks to the participants in the Events BOF at the 48th IETF meeting in Pittsburgh, as well as those who gave ideas and suggestions on the SIP Events mailing list. In particular, I wish to thank Henning Schulzrinne of Columbia University for coming up with the final three-tiered event identification scheme, Sean Olson for miscellaneous guidance, Jonathan Rosenberg for a thorough scrubbing of the -00 draft, and the authors of the "SIP Extensions for Presence" document for their input to SUBSCRIBE and NOTIFY request semantics.

I also owe a debt of gratitude to all the implementors who have provided feedback on areas of confusion or difficulty in the original specification. In particular, Robert Sparks' Herculean efforts organizing, running, and collecting data from the SIPit events have proven invaluable in shaking out specification bugs. Robert Sparks is also responsible for untangling the dialog usage mess, in the form

of RFC 5057 [RFC5057].

## Appendix B. Changes

This section, and all of its subsections, will be consolidated into a single "Changes Since RFC 3265" section prior to publication. Bug numbers refer to the identifiers for the bug reports kept on file at http://bugs.sipit.net/.

### B.1. Changes from draft-ietf-sipcore-rfc3265bis-03 to draft-ietf-sipcore-rfc3265bis-04

Added rationale text to deprecation of 202 response code.

### B.2. Changes from draft-ietf-sipcore-rfc3265bis-02 to draft-ietf-sipcore-rfc3265bis-03

- Clarified scope of Event header field parameters. In RFC3265, the scope is ambiguous, which causes problems with the RFC3968 registry. The new text ensures that Event header field parameters are unique across all event packages.
- Removed obsoleted language around IANA registration policies for event packages. Instead, we now cite RFC5727, which supersedes RFC3265, and is authoritative on event package registration policy.
- Several editorial updates after input from working group, including proper designation of "dialog usage" rather than "dialog" where appropriate.
- Fixed left-over language that allowed implicit subscriptions (in contradiction to text elsewhere in the document)
- Fixed subscriber state machine handling of Timer N
- Clarified two normative statements about subscription termination by changing from plain English prose to RFC2119 language.

### B.3. Changes from draft-ietf-sipcore-rfc3265bis-01 to draft-ietf-sipcore-rfc3265bis-02

- Removed "Table 2" expansions, per WG consensus on how SIP table 2 is to be handled.
- Removed 202 response code.
- Clarified that "Allow-Events" does not list event template packages.
- Clarified that Timer N *does* apply to subscription refreshes.

### B.4. Changes from draft-ietf-sipcore-rfc3265bis-00 to draft-ietf-sipcore-rfc3265bis-01

- Renamed Timer L to Timer N, to avoid a naming conflict.
- Added clarification about proper response when the SUBSCRIBE indicates an unknown MIME type in its Accept header field.
- Clarification around Route and Record-Route behavior.
- Added non-normative warning about the limitations of state polling.
- Added information about targeting subscriptions at specific dialogs.
- Added "Call-Info" header field to RFC 3261 Table 2 expansion.

### B.5. Changes from draft-roach-sipcore-rfc3265bis-00 to draft-ietf-sipcore-rfc3265bis-00

None

### B.6. Changes since RFC 3265

#### B.6.1. Bug 666: Clarify use of expires=xxx with terminated

Strengthened language in Section 4.1.3 to clarify that expires should not be sent with terminated, and must be ignored if received.

#### B.6.2. Bug 667: Reason code for unsub/poll not clearly spelled out

Clarified description of "timeout" in Section 4.1.3. (n.b., the text in Section 4.4.3 is actually pretty clear about this).

#### B.6.3. Bug 669: Clarify: SUBSCRIBE for a duration might be answered with a NOTIFY/expires=0

Added clarifying text to Section 4.2.2 explaining that shortening a subscription to zero seconds is valid. Also added sentence to Section 3.1.1 explicitly allowing shortening to zero.

#### B.6.4. Bug 670: Dialog State Machine needs clarification

The issues associated with the bug deal exclusively with the handling of multiple usages with a dialog. This behavior has been deprecated and moved to Section 4.5.2. This section, in turn, cites [RFC5057], which addresses all of the issues in Bug 670.

#### B.6.5. Bug 671: Clarify timeout-based removal of subscriptions

Changed Section 4.2.2 to specifically cite Timer F (so as to avoid ambiguity between transaction timeouts and retransmission timeouts).

### B.6.6. Bug 672: Mandate expires= in NOTIFY

Changed strength of including of "expires" in a NOTIFY from SHOULD to MUST in Section 4.2.2.

### B.6.7. Bug 673: INVITE 481 response effect clarification

This bug was addressed in [RFC5057].

### B.6.8. Bug 677: SUBSCRIBE response matching text in error

Fixed Section 8.2.1 to remove incorrect "...responses and..." -- explicitly pointed to SIP for transaction response handling.

### B.6.9. Bug 695: Document is not explicit about response to NOTIFY at subscription termination

Added text to Section 4.4.1 indicating that the typical response to a terminal NOTIFY is a "200 OK".

### B.6.10. Bug 696: Subscription state machine needs clarification

Added state machine diagram to Section 4.1.2 with explicit handling of what to do when a SUBSCRIBE never shows up. Added definition of and handling for new Timer N to Section 4.1.2.4. Added state machine to Section 4.2.2 to reinforce text.

### B.6.11. Bug 697: Unsubscription behavior could be clarified

Added text to Section 4.2.1.4 encouraging (but not requiring) full state in final NOTIFY request. Also added text to Section 4.1.2.3 warning subscribers that full state may or may not be present in the final NOTIFY.

### B.6.12. Bug 699: NOTIFY and SUBSCRIBE are target refresh requests

Added text to both Section 3.1 and Section 3.2 explicitly indicating that SUBSCRIBE and NOTIFY are target refresh methods.

### B.6.13. Bug 722: Inconsistent 423 reason phrase text

Changed reason code to "Interval Too Brief" in Section 4.2.1.1 and Section 4.2.1.4, to match 423 reason code in SIP [RFC3261].

### B.6.14. Bug 741: guidance needed on when to not include Allow-Events

Added non-normative clarification to Section 4.4.4 regarding inclusion of Allow-Events in a NOTIFY for the one-and-only package

supported by the notifier.

### B.6.15. Bug 744: 5xx to NOTIFY terminates a subscription, but should not

Issue of subscription (usage) termination versus dialog termination is handled in [RFC5057]. The text in Section 4.2.2 has been updated to summarize the behavior described by 5057, and cites it for additional detail and rationale.

### B.6.16. Bug 752: Detection of forked requests is incorrect

Removed erroneous "CSeq" from list of matching criteria in Section 5.4.9.

### B.6.17. Bug 773: Reason code needs IANA registry

Added Section 7.2 to create and populate IANA registry.

### B.6.18. Bug 774: Need new reason for terminating subscriptions to resources that never change

Added new "invariant" reason code to Section 4.1.3, ABNF syntax.

### B.6.19. Clarify handling of Route/Record-Route in NOTIFY

Changed text in Section 4.3 mandating Record-Route in initial SUBSCRIBE and all NOTIFY requests, and adding "MAY" level statements for subsequent SUBSCRIBE requests.

### B.6.20. Eliminate implicit subscriptions

Added text to Section 4.2.1 explaining some of the problems associated with implicit subscriptions, normative language prohibiting them. Removed language from Section 3.2 describing "non-SUBSCRIBE" mechanisms for creating subscriptions. Simplified language in Section 4.2.2, now that the soft-state/non-soft-state distinction is unnecessary.

### B.6.21. Deprecate dialog re-use

Moved handling of dialog re-use and "id" handling to Section 4.5.2. It is documented only for backwards-compatibility purposes.

### B.6.22. Rationalize dialog creation

Section 4.4.1 has been updated to specify that dialogs should be created when the NOTIFY arrives. Previously, the dialog was

established by the SUBSCRIBE 200, or by the NOTIFY transaction. This was unnecessarily complicated; the newer rules are easier to implement (and result in effectively the same behavior on the wire).

### B.6.23. Refactor behavior sections

Reorganized Section 4 to consolidate behavior along role lines (subscriber/notifier/proxy) instead of method lines.

### B.6.24. Clarify sections that need to be present in event packages

Added sentence to Section 5 clarifying that event packages are expected to include explicit sections covering the issues discussed in this section.

### B.6.25. Make CANCEL handling more explicit

Text in Section 4.6 now clearly calls out behavior upon receipt of a CANCEL. We also echo the "...SHOULD NOT send..." requirement from [RFC3261].

### B.6.26. Remove State Agent Terminology

As originally planned, we anticipated a fairly large number of event packages that would move back and forth between end-user devices and servers in the network. In practice, this has ended up not being the case. Certain events, like dialog state, are inherently hosted at end-user devices; others, like presence, are almost always hosted in the network (due to issues like composition, and the ability to deliver information when user devices are offline). Further, the concept of State Agents is the most misunderstood by event package authors. In my expert review of event packages, I have yet to find one that got the concept of State Agents completely correct -- and most of them start out with the concept being 100% backwards from the way RFC 3265 described it.

Rather than remove the ability to perform the actions previously attributed to the widely misunderstood term "State Agent," we have simply eliminated this term. Instead, we talk about the behaviors required to create state agents (state aggregation, subscription notification) without defining a formal term to describe the servers that exhibit these behaviors. In effect, this is an editorial change to make life easier for event package authors; the actual protocol does not change as a result.

The definition of "State Agent" has been removed from Section 2. Section 4.4.2 has been retooled to discuss migration of subscription in general, without calling out the specific example of state agents.

Section 5.4.11 has been focused on state aggregation in particular, instead of state aggregation as an aspect of state agents.

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