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E. Burger
Cantata Technology, Inc.
M. Dolly
AT&T Labs

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A Session Initiation Protocol (SIP) Event Package for Key Press Stimulus (KPML)

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Abstract

This document describes a SIP Event Package "kpml" that enables monitoring of Dual Tone Multi-Frequency (DTMF) signals and uses Extensible Markup Language (XML) documents referred to as Key Press Markup Language (KPML). The kpml Event Package may be used to support applications consistent with the principles defined in the document titled "A Framework for Application Interaction in the Session Initiation Protocol (SIP)". The event package uses SUBSCRIBE messages and allows for XML documents that define and describe filter specifications for capturing key presses (DTMF Tones) entered at a presentation-free User Interface SIP User Agent (UA). The event package uses NOTIFY messages and allows for XML documents to report the captured key presses (DTMF tones), consistent with the filter specifications, to an Application Server. The scope of this package is for collecting supplemental key presses or mid-call key presses (triggers).

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1. Introduction

This document describes a SIP Event Package "kpml" that enables monitoring of key presses and utilizes XML documents referred to as Key Press Markup Language (KPML). KPML is a markup [14] that enables presentation-free User Interfaces as described in the Application Interaction Framework [15]. The Key Press Stimulus Package is a SIP Event Notification Package [5] that uses the SUBSCRIBE and NOTIFY methods of SIP. The subscription filter and notification report bodies use the Keypad Markup Language, KPML.

The "kpml" event package requires the definition of two new MIME types, two new URN sub-namespaces, and two schemas for the KPML Request and the KPML Response. The scope of this package is for collecting supplemental key presses or mid-call key presses (triggers). This capability allows an Application Server service provider to monitor (filter) for a set of DTMF patterns at a SIP User Agent located in either an end-user device or a gateway.

In particular, the "kpml" event package enables "dumb phones" and "gateways" that receive signals from dumb phones to report user key-press events. Colloquially, this mechanism provides for "digit reporting" or "Dual Tone Multi-Frequency (DTMF) reporting." The capability eliminates the need for "hair-pinning" (routing media into and then out of the same device) through a Media Server or duplicating all the DTMF events, when an Application Server needs to trigger mid-call service processing on DTMF digit patterns.

A goal of KPML is to fit in an extremely small memory and processing footprint.

The name of the XML document, KPML, reflects its legacy support role. The public switched telephony network (PSTN) accomplished signaling by transporting DTMF tones in the bearer channel (in-band signaling) from the user terminal to the local exchange.

Voice-over-IP networks transport in-band signals with actual DTMF waveforms or RFC 2833 [10] packets. In RFC 2833, the signaling application inserts RFC 2833 named signal packets as well as, or instead of, generating tones in the media path. The receiving application receives the signal information in the media stream.

RFC 2833 tones are ideal for conveying telephone-events point-to-point in a Real-time Transport Protocol (RTP) stream, as in the context of straightforward sessions like a 2-party call or a simple, centrally mixed conference. However, there are other environments where additional or alternative requirements are needed. These other environments include protocol translation and complex call control.

An interested application could request notifications of every key press. However, many of the use cases for such signaling show that most applications are interested in only one or a few keystrokes. Thus a mechanism is needed for specifying to the user's interface what stimuli the application requires.

1.1. Conventions Used in This Document

RFC 2119 [1] provides the interpretations for the key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" found in this document.

The Application Interaction Framework document [15] provides the interpretations for the terms "User Device", "SIP Application", and "User Input". This document uses the term "Application" and "Requesting Application" interchangeably with "SIP Application".

Additionally, the Application Interaction Framework document discusses User Device Proxies. A common instantiation of a User Device Proxy is a Public Switched Telephone Network (PSTN) gateway. Because the normative behavior of a presentation-free User Interface is identical for a presentation-free SIP User Agent and a presentation-free User Device Proxy, this document uses "User Device" for both cases.

2. Protocol Overview

The "kpml" event package uses explicit subscription notification requests using the SIP SUBSCRIBE and NOTIFY methods. An Application that wants to collect digits creates an application/kpml-request+xml document with the digit patterns of interest to the Application and places this document in its SUBSCRIBE request. SIP SUBSCRIBE messages are routed to the User Interface using standard SIP request routing. KPML Subscriptions do not fork. The KPML request contained in the SUBSCRIBE message identifies the target media stream by referencing the dialog identifiers corresponding to the session responsible for the media stream. Once a subscription is established, the User Interface sends application/kpml-response+xml documents in NOTIFY requests when digits are collected or when timeouts or errors occur.

A KPML subscription can be persistent or one-shot. Persistent requests are active until the subscription terminates, the Application replaces the request, the Application deletes the request by sending a null document on the dialog, or the Application explicitly deletes the subscription by sending a SUBSCRIBE with an expires value of zero (0).

One-shot requests terminate the subscription upon the receipt of DTMF values that provide a match. The "persist" KPML element specifies whether the subscription remains active for the duration specified in the SUBSCRIBE message or if it automatically terminates upon a pattern match.

NOTIFY messages can contain XML documents. If the User Interface matches a digitmap, the NOTIFY message (response) contains an XML document that indicates the User Input detected and whether the User Interface suppressed the representation of User Input, such as tones, or RFC 2833, from the media streams. If the User Interface encountered an error condition, such as a timeout, this will also be reported.

3. Key Concepts

3.1. Subscription Duration

KPML recognizes two types of subscriptions: one-shot and persistent. Persistent subscriptions have two sub-types: continuous notify and single-notify.

One-shot subscriptions terminate after a pattern match occurs and a report is issued in a NOTIFY message. If the User Interface detects a key press stimulus that triggers a one-shot KPML event, then the User Interface (notifier) MUST set the "Subscription-State" in the NOTIFY message to "terminated". At this point, the User Interface MUST consider the subscription expired.

Persistent subscriptions remain active at the User Interface, even after a match. For continuous-notify persistent subscriptions, the User Interface will emit a NOTIFY message whenever the User Input matches a subscribed pattern. For single-notify persistent subscriptions, the user device will emit a NOTIFY message at the first match, but will not emit further NOTIFY messages until the Application issues a new subscription request on the subscription dialog.

> NOTE: The single-notify persistent subscription enables lock-step (race-free) quarantining of User Input between different digit maps.

The "persist" attribute to the <pattern> tag in the KPML subscription body affects the lifetime of the subscription.

If the "persist" attribute is "one-shot", then once there is a match (or no match is possible), the subscription ends after the User Interface notifies the Application.

If the "persist" attribute is "persist" or "single-notify", then the subscription ends when the Application explicitly ends it or the User Interface terminates the subscription.

If the User Interface does not support persistent subscriptions, it returns a NOTIFY message with the KPML status code set to 531. If there are digits in the buffer and the digits match an expression in the SUBSCRIBE filter, the User Interface prepares the appropriate NOTIFY response message.

The values of the "persist" attribute are case sensitive.

3.2. Timers

To address the various key press collection scenarios, three timers are defined. They are the extra, critical, and inter-digit timers.

- The inter-digit timer is the maximum time to wait between digits. Note: unlike Media Gateway Control Protocol (MGCP) [11] or H.248 [12], there is no start timer, as that concept does not apply in the KPML context.

- The critical timer is the time to wait for another digit if the collected digits can match more than one potential pattern.

- The extra timer is the time to wait for another digit if the collected digits can only match one potential pattern, but a longer match for this pattern is possible.

The User Interface MAY support an inter-digit timeout value. This is the amount of time the User Interface will wait for User Input before returning a timeout error result on a partially matched pattern. The application can specify the inter-digit timeout as an integer number of milliseconds by using the "interdigittimer" attribute to the <pattern> tag. The default is 4000 milliseconds. If the User Interface does not support the specification of an inter-digit timeout, the User Interface MUST silently ignore the specification. If the User Interface supports the specification of an inter-digit timeout, but not to the granularity specified by the value presented, the User Interface MUST round up the requested value to the closest value it can support.

The purpose of the inter-digit timeout is to protect applications from starting to match a pattern, yet never returning a result. This can occur, for example, if the user accidentally enters a key that begins to match a pattern. However, since the user accidentally entered the key, the rest of the pattern never comes. Moreover, when the user does enter a pattern, since they have already entered a key,

the pattern may not match or may not match as expected. Likewise, consider the case where the user thinks they entered a key press, but the User Interface does not detect the key. This could occur when collecting ten digits, but the device actually only receives 9. In this case, the User Interface will wait forever for the tenth key press, while the user becomes frustrated wondering why the application is not responding.

The User Interface MAY support a critical-digit timeout value. This is the amount of time the User Interface will wait for another key press when it already has a matched <regex> but there is another, longer <regex> that may also match the pattern. The application can specify the critical-digit timeout as an integer number of milliseconds by using the "criticaldigittimer" attribute to the <pattern> tag. The default is 1000 milliseconds.

The purpose of the critical-digit timeout is to allow the application to collect longer matches than the shortest presented. This is unlike MGCP [11], where the shortest match gets returned. For example, if the application registers for the patterns "0011", "011", "00", and "0", the critical-digit timeout enables the User Interface to distinguish between "0", "00", "011", and "0011". Without this feature, the only value that the User Interface can detect is "0".

The User Interface MAY support an extra-digit timeout value. This is the amount of time the User Interface will wait for another key press when it already has matched the longest <regex>. The application can specify the extra-digit timeout as an integer number of milliseconds by using the "extradigittimer" attribute to the <pattern> tag. The default is 500 milliseconds. If there is no enterkey specified, then the User Interface MAY default the exteradigittimer to zero.

The purpose of the extra-digit timeout is to allow the User Interface to collect the enterkey. Without this feature, the User Interface would match the pattern, and the enterkey would be buffered and returned as the next pattern.

3.3. Pattern Matches

During the subscription lifetime, the User Interface may detect a key press stimulus that triggers a KPML event. In this case, the User Interface (notifier) MUST return the appropriate KPML document.

The pattern matching logic works as follows. KPML User Interfaces MUST follow the logic presented in this section so that different implementations will perform deterministically on the same KPML document given the same User Input.

A kpml request document contains a <pattern> element with a series of <regex> tags. Each <regex> element specifies a potential pattern for the User Interface to match. The Section 5.1 describes the DRegex, or digit regular expression, language.

The pattern match algorithm matches the longest regular expression. This is the same mode as H.248.1 [12] and not the mode presented by MGCP [11]. The pattern match algorithm choice has an impact on determining when a pattern matches. Consider the following KPML document.

```
<?xml version="1.0" encoding="UTF-8"?>
<kpml-request xmlns="urn:ietf:params:xml:ns:kpml-request"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-request kpml-request.xsd"
      version="1.0">
  <pattern>
    <regex>0</regex>
    <regex>011</regex>
  </pattern>
</kpml-request>
```

Figure 1: Greedy Matching

In Figure 1, if we were to match on the first found pattern, the string "011" would never match. This happens because the "0" rule would match first.

While this behavior is what most applications desire, it does come at a cost. Consider the following KPML document snippet.

```
  <regex>x{7}</regex>
  <regex>x{10}</regex>
```

Figure 2: Timeout Matching

Figure 2 shows a typical North American dial plan. From an application perspective, users expect a seven-digit number to respond quickly, not waiting the typical inter-digit critical timer (usually four seconds). Conversely, the user does not want the system to cut off their ten-digit number at seven digits because they did not enter the number fast enough.

One approach to this problem is to have an explicit dial string terminator. Often, it is the pound key (#). Now, consider the following snippet.

```
<regex>x{7}#</regex>
<regex>x{10}#</regex>
```

Figure 3: Timeout Matching with Enter

The problem with the approach in Figure 3 is that the "#" will appear in the returned dial string. Moreover, one often wants to allow the user to enter the string without the dial string termination key. In addition, using explicit matching on the key means one has to double the number of patterns, e.g., "x{7}", "x{7}#", "x{10}", and "x{10}#".

The approach used in KPML is to have an explicit "Enter Key", as shown in the following snippet.

```
<pattern enterkey="#">
  <regex>x{7}</regex>
  <regex>x{10}</regex>
</pattern>
```

Figure 4: Timeout Matching with Enter Key

In Figure 4, the enterkey attribute to the <pattern> tag specifies a string that terminates a pattern. In this situation, if the user enters seven digits followed by the "#" key, the pattern matches (or fails) immediately. KPML indicates a terminated nomatch with a KPML status code 402.

> NOTE: The enterkey is a string. The enterkey can be a sequence of key presses, such as "**".

Some patterns look for long-duration key presses. For example, some applications look for long "#" or long "*".

KPML uses the "L" modifier to <regex> characters to indicate long key presses. The following KPML document looks for a long pound of at least 3 seconds.

```
<?xml version="1.0" encoding="UTF-8"?>
<kpml-request xmlns="urn:ietf:params:xml:ns:kpml-request"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-request kpml-request.xsd"
      version="1.0">
  <pattern long="3000">
    <regex>L#</regex>
  </pattern>
</kpml-request>
```

Long Pound

The request can specify what constitutes "long" by setting the long attribute to the <pattern>. This attribute is an integer representing the number of milliseconds. If the user presses a key for longer than "long" milliseconds, the Long modifier is true. The default length of the long attribute is 2500 milliseconds.

User Interfaces MUST distinguish between long and short input when the KPML document specifies both in a document. However, if there is not a corresponding long key press pattern in a document, the User Interface MUST match the key press pattern irrespective of the length of time the user presses the key.

As an example, in the following snippet in Figure 6, the User Interface discriminates between a long "*" and a normal "*", but any length "#" will match the pattern.

```
<pattern>
  <regex tag="short_star">*</regex>
  <regex tag="long_star">L*</regex>
  <regex>#</regex>
</pattern>
```

Figure 6: Long and Short Matching

Some User Interfaces are unable to present long key presses. An example is an old private branch exchange (PBX) phone set that emits fixed-length tones when the user presses a key. To address this issue, the User Interface MAY interpret a succession of presses of a single key to be equivalent to a long key press of the same key. The Application indicates it wants this behavior by setting the "longrepeat" attribute to the <pattern> to "true".

The KPML document specifies if the patterns are to be persistent by setting the "persist" attribute to the <pattern> tag to "persist" or "single-notify". Any other value, including "one-shot", indicates

the request is a one-shot subscription. If the User Interface does not support persistent subscriptions, it returns a KPML document with the KPML status code set to 531. If there are digits in the buffer and the digits match an expression in the KPML document, the User Interface emits the appropriate kpml notification.

Note the values of the "persist" attribute are case sensitive.

Some User Interfaces may support multiple regular expressions in a given pattern request. In this situation, the application may wish to know which pattern triggered the event.

KPML provides a "tag" attribute to the <regex> tag. The "tag" is an opaque string that the User Interface sends back in the notification report upon a match in the digit map. In the case of multiple matches, the User Interface MUST choose the longest match in the KPML document. If multiple matches match the same length, the User Interface MUST choose the first expression listed in the subscription KPML document based on KPML document order.

If the User Interface cannot support multiple regular expressions in a pattern request, the User Interface MUST return a KPML document with the KPML status code set to 532. If the User Interface cannot support the number of regular expressions in the pattern request, the User Interface MUST return a KPML document with the KPML status code set to 534.

> NOTE: We could mandate a minimum number of regular expressions that a User Interface must support per subscription request and globally. However, such minimums tend to become designed-in, hard-coded limits. For guidance, one should be able to easily handle tens of expressions per subscription and thousands globally. A good implementation should have effectively no limits. That said, to counter possible denial-of-service attacks, implementers of User Interfaces should be aware of the 534 and 501 status codes and feel free to use them.

3.4. Digit Suppression

Under basic operation, a KPML User Interface will transmit in-band tones (RFC 2833 [10] or actual tone) in parallel with User Input reporting.

> NOTE: If KPML did not have this behavior, then a User Interface executing KPML could easily break called applications. For example, take a personal assistant that uses "*9" for attention. If the user presses the "*" key, KPML will hold the digit, looking for the "9". What if the user just enters a "*" key, possibly

because they accessed an interactive voice response (IVR) system that looks for "*"? In this case, the "*" would get held by the User Interface, because it is looking for the "*9" pattern. The user would probably press the "*" key again, hoping that the called IVR system just did not hear the key press. At that point, the User Interface would send both "*" entries, as "**" does not match "*9". However, that would not have the effect the user intended when they pressed "*".

On the other hand, there are situations where passing through tones in-band is not desirable. Such situations include call centers that use in-band tone spills to initiate a transfer.

For those situations, KPML adds a suppression tag, "pre", to the <regex> tag. There MUST NOT be more than one <pre> tag in any given <regex> tag.

If there is only a single <pattern> and a single <regex>, suppression processing is straightforward. The end-point passes User Input until the stream matches the regular expression <pre>. At that point, the User Interface will continue collecting User Input, but will suppress the generation or pass-through of any in-band User Input.

If the User Interface suppressed stimulus, it MUST indicate this by including the attribute "suppressed" with a value of "true" in the notification.

Clearly, if the User Interface is processing the KPML document against buffered User Input, it is too late to suppress the transmission of the User Input, as the User Interface has long sent the stimulus. This is a situation where there is a <pre> specification, but the "suppressed" attribute will not be "true" in the notification. If there is a <pre> tag that the User Interface matched and the User Interface is unable to suppress the User Input, it MUST set the "suppressed" attribute to "false".

A KPML User Interface MAY perform suppression. If it is not capable of suppression, it ignores the suppression attribute. It MUST set the "suppressed" attribute to "false". In this case, the pattern to match is the concatenated pattern of pre+value.

At some point in time, the User Interface will collect enough User Input to the point it matches a <pre> pattern. The interdigittimer attribute indicates how long to wait for the user to enter stimulus before reporting a time-out error. If the interdigittimer expires, the User Interface MUST issue a time-out report, transmit the suppressed User Input on the media stream, and stop suppression.

Once the User Interface detects a match and it sends a NOTIFY request to report the User Input, the User Interface MUST stop suppression. Clearly, if subsequent User Input matches another <pre> expression, then the User Interface MUST start suppression.

After suppression begins, it may become clear that a match will not occur. For example, take the expression

<regex><pre>*8</pre>xxx[2-9]xxxxxx</regex>

At the point the User Interface receives "*8", it will stop forwarding stimulus. Let us say that the next three digits are "408". If the next digit is a zero or one, the pattern will not match.

> NOTE: It is critically important for the User Interface to have a sensible inter-digit timer. This is because an errant dot (".") may suppress digit sending forever.

Applications should be very careful to indicate suppression only when they are fairly sure the user will enter a digit string that will match the regular expression. In addition, applications should deal with situations such as no-match or time-out. This is because the User Interface will hold digits, which will have obvious User Interface issues in the case of a failure.

3.5. User Input Buffer Behavior

User Interfaces MUST buffer User Input upon receipt of an authenticated and accepted subscription. Subsequent KPML documents apply their patterns against the buffered User Input. Some applications use modal interfaces where the first few key presses determine what the following key presses mean. For a novice user, the application may play a prompt describing what mode the application is in. However, "power users" often barge through the prompt.

User Interfaces MUST NOT provide a subscriber with digits that were detected prior to the authentication and authorization of that subscriber. Without prohibition, a subscriber might be able to gain access to calling card or other information that predated the subscriber’s participation in the call. Note that this prohibition MUST be applied on a per-subscription basis.

KPML provides a <flush> tag in the <pattern> element. The default is not to flush User Input. Flushing User Input has the effect of ignoring key presses entered before the installation of the KPML subscription. To flush User Input, include the tag

<flush>yes</flush> in the KPML subscription document. Note that this directive affects only the current subscription dialog/id combination.

Lock-step processing of User Input is where the User Interface issues a notification, the Application processes the notification while the User Interface buffers additional User Input, the Application requests more User Input, and only then does the User Interface notify the Application based on the collected User Input. To direct the User Interface to operate in lock-step mode, set the <pattern> attribute persist="single-notify".

The User Interface MUST be able to process <flush>no</flush>. This directive is effectively a no-op.

Other string values for <flush> may be defined in the future. If the User Interface receives a string it does not understand, it MUST treat the string as a no-op.

If the user presses a key that cannot match any pattern within a <regex> tag, the User Interface MUST discard all buffered key presses up to and including the current key press from consideration against the current or future KPML documents on a given dialog. However, as described above, once there is a match, the User Interface buffers any key presses the user entered subsequent to the match.

> NOTE: This behavior allows applications to receive only User Input that is of interest to them. For example, a pre-paid application only wishes to monitor for a long pound. If the user enters other stimulus, presumably for other applications, the pre-paid application does not want notification of that User Input. This feature is fundamentally different than the behavior of Time Division Multiplexer (TDM)-based equipment where every application receives every key press.

To limit reports to only complete matches, set the "nopartial" attribute to the <pattern> tag to "true". In this case, the User Interface attempts to match a rolling window over the collected User input.

KPML subscriptions are independent. Thus, it is not possible for the current document to know if a following document will enable barging or want User Input flushed. Therefore, the User Interface MUST buffer all User Input, subject to the forced_flush caveat described below.

On a given SUBSCRIBE dialog with a given id, the User Interface MUST buffer all User Input detected between the time of the report and the receipt of the next document, if any. If the next document indicates a buffer flush, then the interpreter MUST flush all collected User Input from consideration from KPML documents received on that dialog with the given event id. If the next document does not indicate flushing the buffered User Input, then the interpreter MUST apply the collected User Input (if possible) against the digit maps presented by the script's <regex> tags. If there is a match, the interpreter MUST follow the procedures in Section 5.3. If there is no match, the interpreter MUST flush all of the collected User Input.

Given the potential for needing an infinite buffer for User Input, the User Interface MAY discard the oldest User Input from the buffer. If the User Interface discards digits, when the User Interface issues a KPML notification, it MUST set the forced_flush attribute of the <response> tag to "true". For future use, the Application MUST consider any non-null value, other than "false", that it does not understand to be the same as "true".

> NOTE: The requirement to buffer all User Input for the entire length of the session is not onerous under normal operation. For example, if one has a gateway with 8,000 sessions, and the gateway buffers 50 key presses on each session, the requirement is only 400,000 bytes, assuming one byte per key press.

Unless there is a suppress indicator in the digit map, it is not possible to know if the User Input is for local KPML processing or for other recipients of the media stream. Thus, in the absence of a suppression indicator, the User Interface transmits the User Input to the far end in real time, using either RFC 2833, generating the appropriate tones, or both.

3.6. DRegex

3.6.1. Overview

This subsection is informative in nature.

The Digit REGular EXpression (DRegex) syntax is a telephony-oriented mapping of POSIX Extended Regular Expressions (ERE) [13].

KPML does not use full POSIX ERE for the following reasons.

- KPML will often run on high density or extremely low power and memory footprint devices.

- Telephony application convention uses the star symbol ("*") for the star key and "x" for any digit 0-9. Requiring the developer to escape the star ("*") and expand the "x" ("[0-9]") is error prone. This also leads DRegex to use the dot (".") to indicate repetition, which was the function of the unadorned star in POSIX ERE.

- Implementation experience with MGCP [11] and H.248.1 [12] has been that implementers and users have a hard time understanding the precedence of the alternation operator ("|"). This is due both to an under-specification of the operator in those documents and conceptual problems for users. Thus, the SIPPING Working Group concluded that DRegex should not support alternation. That said, each KPML <pattern> element may contain multiple regular expressions (<regex> elements). Thus, it is straightforward to have pattern alternatives (use multiple <regex> elements) without the problems associated with the alternation operator ("|"). Thus, DRegex does not support the POSIX alternation operator.

- DRegex includes character classes (characters enclosed in square brackets). However, the negation operator inside a character class only operates on numbers. That is, a negation class implicitly includes A-D, *, and #. Including A-D, *, and # in a negation operator is a no-op. Those familiar with POSIX would expect negation of the digits 4 and 5 (e.g., "[^45]") to include all other characters (including A-D, R, *, and #), while those familiar with telephony digit maps would expect negation to implicitly exclude non-digit characters. Since the complete character set of DRegex is very small, constructing a negation class using A-D, R, *, and # requires the user to specify the positive inverse mapping. For example, to specify all key presses, including A-D and *, except #, the specification would be "[0-9A-D*]" instead of "[^#R]".

The following table shows the mapping from DRegex to POSIX ERE.

DRegex	POSIX ERE
*	*
.	*
x	[0-9]
[xc]	[0-9c]

Table 1: DRegex to POSIX ERE Mapping

The first substitution, which replaces a star for an escaped star, is because telephony application designers are used to using the star for the (very common) star key. Requiring an escape sequence for this common pattern would be error prone. In addition, the usage found in DRegex is the same as found in MGCP [11] and H.248.1 [12].

Likewise, the use of the dot instead of star is common usage from MGCP and H.248.1, and reusing the star in this context would also be confusing and error prone.

The "x" character is a common indicator of the digits 0 through 9. We use it here, continuing the convention. Clearly, for the case "[xc]", where c is any character, the substitution is not a blind replacement of "[0-9]" for "x", as that would result in "[[0-9]c]", which is not a legal POSIX ERE. Rather, the substitution for "[xc]" is "[0-9c]".

NOTE: "x" does not include the characters *, #, R, or A through D.

Users need to take care not to confuse the DRegex syntax with POSIX EREs. They are NOT identical. In particular, there are many features of POSIX EREs that DRegex does not support.

As an implementation note, if one makes the substitutions described in the above table, then a standard POSIX ERE engine can parse the digit string. However, the mapping does not work in the reverse (POSIX ERE to DRegex) direction. DRegex only implements the normative behavior described below.

3.6.2. Operation

White space is removed before parsing DRegex. This enables sensible pretty printing in XML without affecting the meaning of the DRegex string.

The following rules demonstrate the use of DRegex in KPML.

Entity	Matches
c	digits 0-9, *, #, R, and A-D (case insensitive)
*	the * character
#	the # character
R	The R (Register Recall) key
[c]	Any character in selector
[^d]	Any digit (0-9) not in selector
[r1-r2]	Any character in range from r1 to r2, inclusive
x	Any digit 0-9
{m}	m repetitions of previous pattern
{m,}	m or more repetitions of previous pattern
{,n}	At most n (including zero) repetitions of previous pattern
{m,n}	At least m and at most n repetitions of previous pattern
Lc	Match the character c if it is "long"; c is a digit 0-9 and A-D, #, or *.

DRegex Entities

For ranges, the A-D characters are disjoint from the 0-9 characters. If the device does not have an "R" key, the device MAY report a hook flash as an R character.

Example	Description
1	Matches the digit 1
[179]	Matches 1, 7, or 9
[2-9]	Matches 2, 3, 4, 5, 6, 7, 8, 9
[^15]	Matches 0, 2, 3, 4, 6, 7, 8, 9
[02-46-9A-D]	Matches 0, 2, 3, 4, 6, 7, 8, 9, A, B, C, D
x	Matches 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
*6[179#]	Matches *61, *67, *69, or *6#
x{10}	Ten digits (0-9)
011x{7,15}	011 followed by seven to fifteen digits
L*	Long star

DRegex Examples

3.7. Monitoring Direction

SIP identifies dialogs by their dialog identifier. The dialog identifier is the remote-tag, local-tag, and Call-ID entities defined in RFC 3261 [4].

One method of determining the dialog identifier, particularly for third-party applications, is the SIP Dialog Package [17].

For most situations, such as a monaural point-to-point call with a single codec, the stream to monitor is obvious. In such situations the Application need not specify which stream to monitor.

But there may be ambiguity in specifying only the SIP dialog to monitor. The dialog may specify multiple SDP streams that could carry key press events. For example, a dialog may have multiple audio streams. Wherever possible, the User Interface MAY apply local policy to disambiguate which stream or streams to monitor. In order to have an extensible mechanism for identifying streams, the mechanism for specifying streams is as an element content to the <stream> tag. The only content defined today is the <stream>reverse</stream> tag.

By default, the User Interface monitors key presses emanating from the User Interface. Given a dialog identifier of Call-ID, local-tag, and remote-tag, the User Interface monitors the key presses associated with the local-tag.

In the media proxy case, and potentially other cases, there is a need to monitor the key presses arriving from the remote user agent. The optional <stream> element to the <request> tag specifies which stream to monitor. The only legal value is "reverse", which means to monitor the stream associated with the remote-tag. The User Interface MUST ignore other values.

> NOTE: The reason this is a tag is so individual stream selection, if needed, can be addressed in a backwards-compatible way. Further specification of the stream to monitor is the subject of future standardization.

3.8. Multiple Simultaneous Subscriptions

An Application MAY register multiple User Input patterns in a single KPML subscription. If the User Interface supports multiple, simultaneous KPML subscriptions, the Application installs the subscriptions either in a new SUBSCRIBE-initiated dialog or on an existing SUBSCRIBE-initiated dialog with a new event id tag. If the User Interface does not support multiple, simultaneous KPML

subscriptions, the User Interface MUST respond with an appropriate KPML status code.

Some User Interfaces may support multiple key press event notification subscriptions at the same time. In this situation, the User Interface honors each subscription individually and independently.

A SIP user agent may request multiple subscriptions on the same SUBSCRIBE dialog, using the id parameter to the kpml event request.

One or more SIP user agents may request independent subscriptions on different SIP dialogs, although reusing the same dialog for multiple subscriptions is NOT RECOMMENDED.

If the User Interface does not support multiple, simultaneous subscriptions, the User Interface MUST return a KPML document with the KPML status code set to 533 on the dialog that requested the second subscription. The User Interface MUST NOT modify the state of the first subscription on account of the second subscription attempt.

4. Event Package Formal Definition

4.1. Event Package Name

This document defines a SIP Event Package as defined in RFC 3265 [5]. The event-package token name for this package is:

"kpml"

4.2. Event Package Parameters

This package defines three Event Package parameters: call-id, remote-tag, and local-tag. These parameters MUST be present, to identify the subscription dialog. The User Interface matches the local-tag against the to tag, the remote-tag against the from tag, and the call-id against the Call-ID.

The ABNF for these parameters is below. It refers to many constructions from the ABNF of RFC 3261, such as EQUAL, DQUOTE, and token.

```
call-id     =  "call-id" EQUAL ( token / DQUOTE callid DQUOTE )
                 ;; NOTE: any DQUOTEs inside callid MUST be escaped!
remote-tag  =  "remote-tag" EQUAL token
local-tag   =  "local-tag" EQUAL token
```

If any call-ids contain embedded double-quotes, those double-quotes MUST be escaped using the backslash-quoting mechanism. Note that the call-id parameter may need to be expressed as a quoted string. This is because the ABNF for the callid production and the word production, which is used by callid (both from RFC 3261 [1]), allow some characters (such as "@", "[", and ":") that are not allowed within a token.

4.3. SUBSCRIBE Bodies

Applications using this event package include an application/kpml-request+xml body in SUBSCRIBE requests to indicate which digit patterns they are interested in. The syntax of this body type is formally described in Section 5.2.

4.4. Subscription Duration

The subscription lifetime should be longer than the expected call time. Subscriptions to this event package MAY range from minutes to weeks. Subscriptions in hours or days are more typical and are RECOMMENDED. The default subscription duration for this event package is 7200 seconds.

> Subscribers MUST be able to handle the User Interface returning an Expires value smaller than the requested value. Per RFC 3265 [5], the subscription duration is the value returned by the Notifier in the 200 OK Expires header.

4.5. NOTIFY Bodies

NOTIFY requests can contain application/kpml-response+xml (KPML Response) bodies. The syntax of this body type is formally described in Section 5.3. NOTIFY requests in immediate response to a SUBSCRIBE request MUST NOT contain a body unless they are notifying the subscriber of an error condition or previously buffered digits.

Notifiers MAY send notifications with any format acceptable to the subscriber (based on the subscriber’s inclusion of these formats in an Accept header). A future extension MAY define other NOTIFY bodies. If no "Accept" header is present in the SUBSCRIBE, the body type defined in this document MUST be assumed.

4.6. Subscriber Generation of SUBSCRIBE Requests

A kpml request document contains a <pattern> element with a series of <regex> tags. Each <regex> element specifies a potential pattern for the User Interface to match. Section 5.1 describes the DRegex, or digit regular expression, language.

KPML specifies key press event notification filters. The MIME type for KPML requests is application/kpml-request+xml.

The KPML request document MUST be well formed and SHOULD be valid. KPML documents MUST conform to XML 1.0 [14] and MUST use UTF-8 encoding.

Because of the potentially sensitive nature of the information reported by KPML, subscribers SHOULD use sips: and MAY use S/MIME on the content.

Subscribers MUST be prepared for the notifier to insist on authentication of the subscription request. Subscribers MUST be prepared for the notifier to insist on using a secure communication channel.

4.7. Notifier Processing of SUBSCRIBE Requests

The user information transported by KPML is potentially sensitive. For example, it could include calling card or credit card numbers. Thus the User Interface (notifier) MUST authenticate the requesting party in some way before accepting the subscription.

User Interfaces MUST implement SIP Digest authentication as required by RFC 3261 [4] and MUST implement the sips: scheme and TLS.

Upon authenticating the requesting party, the User Interface determines if the requesting party has authorization to monitor the user's key presses. The default authorization policy is to allow a KPML subscriber who can authenticate with a specific identity to monitor key presses from SIP sessions in which the same or equivalent authenticated identity is a participant. In addition, KPML will often be used, for example, between "application servers" (subscribers) and PSTN gateways (notifiers) operated by the same domain or federation of domains. In this situation a notifier MAY be configured with a list of subscribers which are specifically trusted and authorized to subscribe to key press information related to all sessions in a particular context.

The User Interface returns a Contact URI that may have GRUU [9] properties in the Contact header of a SIP INVITE, 1xx, or 2xx response.

After authorizing the request, the User Interface checks to see if the request is to terminate a subscription. If the request will terminate the subscription, the User Interface does the appropriate processing, including the procedures described in Section 5.2.

If the request has no KPML body, then any KPML document running on that dialog and addressed by the event id, if present, immediately terminates. This is a mechanism for unloading a KPML document while keeping the SUBSCRIBE-initiated dialog active. This can be important for secure sessions that have high costs for session establishment. The User Interface follows the procedures described in Section 5.2.

If the dialog referenced by the kpml subscription does not exist, the User Interface follows the procedures in Section 5.3. Note the User Interface MUST issue a 200 OK to the SUBSCRIBE request before issuing the NOTIFY, as the SUBSCRIBE itself is well formed.

If the request has a KPML body, the User Interface parses the KPML document. The User Interface SHOULD validate the XML document against the schema presented in Section 5.2. If the document is not valid, the User Interface rejects the SUBSCRIBE request with an appropriate error response and terminates the subscription. If there is a loaded KPML document on the subscription, the User Interface unloads the document.

In addition, if there is a loaded KPML document on the subscription, the end device unloads the document.

Following the semantics of SUBSCRIBE, if the User Interface receives a resubscription, the User Interface MUST terminate the existing KPML request and replace it with the new request.

It is possible for the INVITE usage of the dialog to terminate during key press collection. The cases enumerated here are explicit subscription termination, automatic subscription termination, and underlying (INVITE-initiated) dialog termination.

If a SUBSCRIBE request has an expires of zero (explicit SUBSCRIBE termination), includes a KPML document, and there is buffered User Input, then the User Interface attempts to process the buffered digits against the document. If there is a match, the User Interface MUST generate the appropriate KPML report with the KPML status code of 200. The SIP NOTIFY body terminates the subscription by setting the subscription state to "terminated" and a reason of "timeout".

If the SUBSCRIBE request has an expires of zero and no KPML body or the expires timer on the SUBSCRIBE-initiated dialog fires at the User Interface (notifier), then the User Interface MUST issue a KPML report with the KPML status code 487, Subscription Expired. The report also includes the User Input collected up to the time the expires timer expired or when the subscription with expires equal to zero was processed. This could be the null string.

Per the mechanisms of RFC 3265 [5], the User Interface MUST terminate the SIP SUBSCRIBE dialog. The User Interface does this via the SIP NOTIFY body transporting the final report described in the preceding paragraph. In particular, the subscription state will be "terminated" and a reason of "timeout".

Terminating the subscription when a dialog terminates ensures reauthorization (if necessary) for attaching to subsequent subscriptions.

If a SUBSCRIBE request references a dialog that is not present at the User Interface, the User Interface MUST generate a KPML report with the KPML status code 481, Dialog Not Found. The User Interface terminates the subscription by setting the subscription state to "terminated".

If the KPML document is not valid, the User Interface generates a KPML report with the KPML status code 501, Bad Document. The User Interface terminates the subscription by setting the subscription state to "terminated".

If the document is valid but the User Interface does not support a namespace in the document, the User Interface MUST respond with a KPML status code 502, Namespace Not Supported.

4.8. Notifier Generation of NOTIFY Requests

Immediately after a subscription is accepted, the Notifier MUST send a NOTIFY with the current location information as appropriate based on the identity of the subscriber. This allows the Subscriber to resynchronize its state.

The User Interface (notifier in SUBSCRIBE/NOTIFY parlance) generates NOTIFY requests based on the requirements of RFC 3265 [5]. Specifically, if a SUBSCRIBE request is valid and authorized, it will result in an immediate NOTIFY.

The KPML payload distinguishes between an initial NOTIFY and a NOTIFY informing of key presses. If there is no User Input buffered at the time of the SUBSCRIBE (see below) or the buffered User Input does not match the new KPML document, then the immediate NOTIFY MUST NOT contain a KPML body. If User Interface has User Input buffered that results in a match using the new KPML document, then the NOTIFY MUST return the appropriate KPML document.

The NOTIFY in response to a SUBSCRIBE request has no KPML if there are no matching buffered digits. An example of this is in Figure 10.

If there are buffered digits in the SUBSCRIBE request that match a pattern, then the NOTIFY message in response to the SUBSCRIBE request MUST include the appropriate KPML document.

```
NOTIFY sip:application@example.com SIP/2.0
Via: SIP/2.0/UDP proxy.example.com
Max-Forwards: 70
To: <sip:application@example.com>
From: <sip:endpoint@example.net>
Call-Id: 439hu409h4h09903fj0ioij
Subscription-State: active; expires=7200
CSeq: 49851 NOTIFY
Event: kpml
```

Figure 10: Immediate NOTIFY Example

All subscriptions MUST be authenticated, particularly those that match on buffered input.

KPML specifies the key press notification report format. The MIME type for KPML reports is application/kpml-response+xml. The default MIME type for the kpml event package is application/ kpml-response+xml.

If the requestor is not using a secure transport protocol such as TLS for every hop (e.g., by using a sips: URI), the User Interface SHOULD use S/MIME to protect the user information in responses.

When the user enters key presses that match a <regex> tag, the User Interface will issue a report.

After reporting, the interpreter terminates the KPML session unless the subscription has a persistence indicator. If the subscription does not have a persistence indicator, the User Interface MUST set the state of the subscription to "terminated" in the NOTIFY report.

If the subscription does not have a persistence indicator, to collect more digits, the requestor must issue a new request.

> NOTE: This highlights the "one shot" nature of KPML, reflecting the balance of features and ease of implementing an interpreter.

KPML reports have two mandatory attributes, code and text. These attributes describe the state of the KPML interpreter on the User Interface. Note the KPML status code is not necessarily related to the SIP result code. An important example of this is where a legal SIP subscription request gets a normal SIP 200 OK followed by a NOTIFY, but there is something wrong with the KPML request. In this

case, the NOTIFY would include the KPML status code in the KPML report. Note that from a SIP perspective, the SUBSCRIBE and NOTIFY were successful. Also, if the KPML failure is not recoverable, the User Interface will most likely set the Subscription-State to "terminated". This lets the SIP machinery know the subscription is no longer active.

If a pattern matches, the User Interface will emit a KPML report. Since this is a success report, the code is "200", and the text is "OK".

The KPML report includes the actual digits matched in the digit attribute. The digit string uses the conventional characters '*' and '#' for star and octothorpe, respectively. The KPML report also includes the tag attribute if the regex that matched the digits had a tag attribute.

If the subscription requested digit suppression and the User Interface suppressed digits, the suppressed attribute indicates "true". The default value of suppressed is "false".

> NOTE: KPML does not include a timestamp. There are a number of reasons for this. First, what timestamp would it include? Would it be the time of the first detected key press? The time the interpreter collected the entire string? A range? Second, if the RTP timestamp is a datum of interest, why not simply get RTP in the first place? That all said, if it is really compelling to have the timestamp in the response, it could be an attribute to the <response> tag.

Note that if the monitored (INVITE-initiated) dialog terminates, the notifier still MUST explicitly terminate the KPML subscriptions monitoring that dialog.

4.9. Subscriber Processing of NOTIFY Requests

If there is no KPML body, it means the SUBSCRIBE was successful. This establishes the dialog if there is no buffered User Input to report.

If there is a KPML document, and the KPML status code is 200, then a match occurred.

If there is a KPML document, and the KPML status code is between 400 and 499, then an error occurred with User Input collection. The most likely cause is a timeout condition.

If there is a KPML document, and the KPML status code is between 500 and 599, then an error occurred with the subscription. See Section 6 for more on the meaning of KPML status codes.

The subscriber MUST be mindful of the subscription state. The User Interface may terminate the subscription at any time.

4.10. Handling of Forked Requests

Forked requests are NOT ALLOWED for this event type. This can be ensured if the Subscriptions to this event package are sent to SIP URIs that have GRUU properties.

4.11. Rate of Notifications

The User Interface MUST NOT generate messages faster than 25 messages per second, or one message every 40 milliseconds. This is the minimum time period for MF digit spills. Even 30-millisecond DTMF, as one sometimes finds in Japan, has a 20-millisecond off time, resulting in a 50-millisecond interdigit time. This document strongly RECOMMENDS AGAINST using KPML for digit-by-digit messaging, such as would be the case if the only <regex> is "x".

The sustained rate of notification shall be no more than 100 Notifies per minute.

The User Interface MUST reliably deliver notifications. Because there is no meaningful metric for throttling requests, the User Interface SHOULD send NOTIFY messages over a congestion-controlled transport, such as TCP.

> Note that all SIP implementations are already required to implement SIP over TCP.

4.12. State Agents and Lists

KPML requests are sent to a specific SIP URI, which may have GRUU properties, and they attempt to monitor a specific stream that corresponds with a specific target dialog. Consequently, implementers MUST NOT define state agents for this event package or allow subscriptions for this event package to resource lists using the event list extension [18].

4.13. Behavior of a Proxy Server

There are no additional requirements on a SIP Proxy, other than to transparently forward the SUBSCRIBE and NOTIFY methods as required in SIP.

5. Formal Syntax

5.1. DRegex

The following definition follows RFC 4234 [2]. The definition of DIGIT is from RFC 4234, namely, the characters "0" through "9". Note the DRegexCharacter is not a HEXDIG from RFC 4234. In particular, DRegexCharacter includes neither "E" nor "F". Note that DRegexCharacter is case insensitive.

```
DRegex           = 1*( DRegexPosition [ RepeatCount ] )
DRegexPosition   = DRegexSymbol / DRegexSet
DRegexSymbol     = [ "L" ] DRegexCharacter
DRegexSet        = "[" 1*DRegexSetList "]"
DRegexSetList    = DRegexCharacter [ "-" DRegexCharacter ]
DRegexCharacter  = DIGIT / "A" / "B" / "C" / "D" / "R" / "*" / "#" /
                         "a" / "b" / "c" / "d" / "r"
RepeatCount      = "." / "{" RepeatRange "}"
RepeatRange      = Count / ( Count "," Count ) /
                           ( Count "," ) / ( "," Count )
Count            = 1*DIGIT
```

ABNF for DRegex

Note that future extensions to this document may introduce other characters for DRegexCharacter, in the scheme of H.248.1 [12] or possibly as named strings or XML namespaces.

5.2. KPML Request

The following syntax for KPML requests uses the XML Schema [8].

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema targetNamespace="urn:ietf:params:xml:ns:kpml-request"
 xmlns="urn:ietf:params:xml:ns:kpml-request"
 xmlns:xs="http://www.w3.org/2001/XMLSchema"
 elementFormDefault="qualified"
 attributeFormDefault="unqualified">
  <xs:element name="kpml-request">
    <xs:annotation>
      <xs:documentation>IETF Keypad Markup Language Request
      </xs:documentation>
    </xs:annotation>
    <xs:complexType>
      <xs:sequence>
        <xs:element name="stream" minOccurs="0">
          <xs:complexType>
            <xs:choice>
              <xs:element name="reverse" minOccurs="0"/>
              <xs:any namespace="##other"/>
            </xs:choice>
          </xs:complexType>
        </xs:element>
        <xs:element name="pattern">
          <xs:complexType>
            <xs:sequence>
              <xs:element name="flush" minOccurs="0">
                <xs:annotation>
                  <xs:documentation>
                    Default is to not flush buffer
                  </xs:documentation>
                </xs:annotation>
                <xs:complexType>
                  <xs:simpleContent>
                    <xs:extension base="xs:string"/>
                  </xs:simpleContent>
                </xs:complexType>
              </xs:element>
              <xs:element name="regex" maxOccurs="unbounded">
                <xs:annotation>
                  <xs:documentation>
                    Key press notation is a string to allow
                    for future extension of non-16 digit
                    keypads or named keys
                  </xs:documentation>
                </xs:annotation>
```

```
      <xs:complexType mixed="true">
        <xs:choice>
          <xs:element name="pre" minOccurs="0">
            <xs:complexType>
              <xs:simpleContent>
                <xs:extension base="xs:string"/>
              </xs:simpleContent>
            </xs:complexType>
          </xs:element>
          <xs:any namespace="##other"/>
        </xs:choice>
        <xs:attribute name="tag" type="xs:string"
                      use="optional"/>
      </xs:complexType>
    </xs:element>
  </xs:sequence>
  <xs:attribute name="persist" use="optional">
    <xs:annotation>
      <xs:documentation>Default is "one-shot"
      </xs:documentation>
    </xs:annotation>
    <xs:simpleType>
      <xs:restriction base="xs:string">
        <xs:enumeration value="one-shot"/>
        <xs:enumeration value="persist"/>
        <xs:enumeration value="single-notify"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:attribute>
  <xs:attribute name="interdigittimer"
                type="xs:integer"
                use="optional">
    <xs:annotation>
      <xs:documentation>Default is 4000 (ms)
      </xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="criticaldigittimer"
                type="xs:integer"
                use="optional">
    <xs:annotation>
      <xs:documentation>Default is 1000 (ms)
      </xs:documentation>
    </xs:annotation>
  </xs:attribute>
  <xs:attribute name="extradigittimer"
                type="xs:integer"
                use="optional">
```

```
              <xs:annotation>
                <xs:documentation>Default is 500 (ms)
                </xs:documentation>
              </xs:annotation>
            </xs:attribute>
            <xs:attribute name="long" type="xs:integer"
                          use="optional"/>
            <xs:attribute name="longrepeat" type="xs:boolean"
                          use="optional"/>
            <xs:attribute name="nopartial" type="xs:boolean"
                          use="optional">
              <xs:annotation>
                <xs:documentation>Default is false
                </xs:documentation>
              </xs:annotation>
            </xs:attribute>
            <xs:attribute name="enterkey" type="xs:string"
                          use="optional">
              <xs:annotation>
                <xs:documentation>No default enterkey
                </xs:documentation>
              </xs:annotation>
            </xs:attribute>
          </xs:complexType>
        </xs:element>
      </xs:sequence>
      <xs:attribute name="version" type="xs:string"
                    use="required"/>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

Figure 12: XML Schema for KPML Requests

5.3. KPML Response

The following syntax for KPML responses uses the XML Schema [8].

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema targetNamespace="urn:ietf:params:xml:ns:kpml-response"
 xmlns:xs="http://www.w3.org/2001/XMLSchema"
 xmlns="urn:ietf:params:xml:ns:kpml-response"
 elementFormDefault="qualified"
 attributeFormDefault="unqualified">
  <xs:element name="kpml-response">
    <xs:annotation>
      <xs:documentation>IETF Keypad Markup Language Response
      </xs:documentation>
    </xs:annotation>
    <xs:complexType>
      <xs:attribute name="version" type="xs:string"
                    use="required"/>
      <xs:attribute name="code" type="xs:string"
                    use="required"/>
      <xs:attribute name="text" type="xs:string"
                    use="required"/>
      <xs:attribute name="suppressed" type="xs:boolean"
                    use="optional"/>
      <xs:attribute name="forced_flush" type="xs:string"
                    use="optional">
        <xs:annotation>
          <xs:documentation>
            String for future use for e.g., number of digits lost.
          </xs:documentation>
        </xs:annotation>
      </xs:attribute>
      <xs:attribute name="digits" type="xs:string"
                    use="optional"/>
      <xs:attribute name="tag" type="xs:string" use="optional">
        <xs:annotation>
          <xs:documentation>Matches tag from regex in request
          </xs:documentation>
        </xs:annotation>
      </xs:attribute>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

XML Schema for KPML Responses

6. Enumeration of KPML Status Codes

KPML status codes broadly follow their SIP counterparts. Codes that start with a 2 indicate success. Codes that start with a 4 indicate failure. Codes that start with a 5 indicate a server failure, usually a failure to interpret the document or to support a requested feature.

KPML clients MUST be able to handle arbitrary status codes by examining the first digit only.

Any text can be in a KPML report document. KPML clients MUST NOT interpret the text field.

Code	Text
200	Success
402	User Terminated without Match
423	Timer Expired
481	Dialog Not Found
487	Subscription Expired
501	Bad Document
502	Namespace Not Supported
531	Persistent Subscriptions Not Supported
532	Multiple Regular Expressions Not Supported
533	Multiple Subscriptions on a Dialog Not Supported
534	Too Many Regular Expressions

Table 4: KPML Status Codes

7. IANA Considerations

This document registers a new SIP Event Package, two new MIME types, and two new XML namespaces.

7.1. SIP Event Package Registration

Package name: kpml
Type: package
Contact: Eric Burger, <e.burger@ieee.org>
Change Controller: SIPPING Working Group delegated from the IESG
Published Specification: RFC 4730

7.2. MIME Media Type application/kpml-request+xml

MIME media type name: application
MIME subtype name: kpml-request+xml
Required parameters: none
Optional parameters: Same as charset parameter application/xml as specified in XML Media Types [3]
Encoding considerations: See RFC 3023 [3].
Security considerations: See Section 10 of RFC 3023 [3] and Section 8 of RFC 4730
Interoperability considerations: See RFC 2023 [3] and RFC 4730
Published specification: RFC 4730
Applications which use this media type: Session-oriented applications that have primitive User Interfaces.
Change controller: SIPPING Working Group delegated from the IESG
Personal and email address for further information: Eric Burger <e.burger@ieee.org>
Intended usage: COMMON

7.3. MIME Media Type application/kpml-response+xml

MIME media type name: application
MIME subtype name: kpml-response+xml
Required parameters: none
Optional parameters: Same as charset parameter application/xml as specified in XML Media Types [3]
Encoding considerations: See RFC 3023 [3].
Security considerations: See Section 10 of RFC 3023 [3] and Section 8 of RFC 4730
Interoperability considerations: See RFC 2023 [3] and RFC 4730
Published specification: RFC 4730
Applications which use this media type: Session-oriented applications that have primitive User Interfaces.
Change controller: SIPPING Working Group delegated from the IESG
Personal and email address for further information: Eric Burger <e.burger@ieee.org>
Intended usage: COMMON

7.4. URN Sub-Namespace Registration for urn:ietf:xml:ns:kpml-request

URI: urn:ietf:params:xml:ns:kpml-request

Registrant Contact: The IESG <iesg@ietf.org>

XML:

```
<?xml version="1.0"?>
<!DOCTYPE html PUBLIC "-//W3C/DTD XHTML Basic 1.0//EN"
          "http://www.w3.org/TR/xhtml-basic/xhtml-basic10.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <head>
    <meta http-equiv="content-type"
          content="text/html;charset=iso-8859-1"/>
    <title>Key Press Markup Language Request</title>
  </head>
  <body>
    <h1>Namespace for Key Press Markup Language Request</h1>
    <h2>urn:ietf:params:xml:ns:kpml-request</h2>
    <p>
<a href="ftp://ftp.rfc-editor.org/in-notes/RFC4730.txt">RFC 4730</a>.
    </p>
  </body>
</html>
```

7.5. URN Sub-Namespace Registration for urn:ietf:xml:ns:kpml-response

URI: urn:ietf:params:xml:ns:kpml-response

Registrant Contact: The IESG <iesg@ietf.org>

XML:

```
<?xml version="1.0"?>
<!DOCTYPE html PUBLIC "-//W3C/DTD XHTML Basic 1.0//EN"
          "http://www.w3.org/TR/xhtml-basic/xhtml-basic10.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
  <head>
    <meta http-equiv="content-type"
          content="text/html;charset=iso-8859-1"/>
    <title>Key Press Markup Language Response</title>
  </head>
  <body>
    <h1>Namespace for Key Press Markup Language Response</h1>
    <h2>urn:ietf:params:xml:ns:kpml-response</h2>
    <p>
<a href="ftp://ftp.rfc-editor.org/in-notes/rfc4730.txt">RFC 4730</a>.
    </p>
  </body>
</html>
```

7.6. KPML Request Schema Registration

Per RFC 3688 [7], IANA registered the XML Schema for KPML as referenced in Section 5.2 of RFC 4730.

URI: urn:ietf:params:xml:schema:kpml-request

Registrant Contact: <iesg@ietf.org>

7.7. KPML Response Schema Registration

Per RFC 3688 [7], IANA registered the XML Schema for KPML as referenced in Section 5.3 of RFC 4730.

URI: urn:ietf:params:xml:schema:kpml-response

Registrant Contact: IETF, SIPPING Work Group <sipping@ietf.org>, Eric Burger <e.burger@ieee.org>.

8. Security Considerations

The user information transported by KPML is potentially sensitive. For example, it could include calling card or credit card numbers. This potentially private information could be provided accidentally if the notifier does not properly authenticate or authorize a subscription. Similarly private information (such as a credit card number or calling card number) could be revealed to an otherwise legitimate subscriber (one operating an IVR) if digits buffered earlier in the session are provided unintentionally to the new subscriber.

Likewise, an eavesdropper could view KPML digit information if it is not encrypted, or an attacker could inject fraudulent notifications unless the messages or the SIP path over which they travel are integrity protected.

Therefore, User Interfaces MUST NOT downgrade their own security policy. That is, if a User Interface policy is to restrict notifications to authenticated and authorized subscribers over secure communications, then the User Interface must not accept an unauthenticated, unauthorized subscription over an insecure communication channel.

As an XML markup, all of the security considerations of RFC 3023 [3] and RFC 3406 [6] MUST be met. Pay particular attention to the robustness requirements of parsing XML.

Key press information is potentially sensitive. For example, it can represent credit card, calling card, or other personal information. Hijacking sessions allow unauthorized entities access to this sensitive information. Therefore, signaling SHOULD be secure, e.g., use of TLS and sips: SHOULD be used. Moreover, the information itself is sensitive so S/MIME or other appropriate mechanisms SHOULD be used.

Subscriptions MUST be authenticated in some manner. As required by the core SIP [4] specification, all SIP implementations MUST support digest authentication. In addition, User Interfaces MUST implement support for the sips: scheme and SIP over TLS. Subscribers MUST expect the User Interface to demand the use of an authentication scheme. If the local policy of a User Interface is to use authentication or secure communication channels, the User Interface MUST reject subscription requests that do not meet that policy.

User Interfaces MUST begin buffering User Input upon receipt of an authenticated and accepted subscription. This buffering is done on a per-subscription basis.

9. Examples

This section is informative in nature. If there is a discrepancy between this section and the normative sections above, the normative sections take precedence.

9.1. Monitoring for Octothorpe

A common need for pre-paid and personal assistant applications is to monitor a conversation for a signal indicating a change in user focus from the party they called through the application to the application itself. For example, if you call a party using a pre-paid calling card, and the party you call redirects you to voice mail, digits you press are for the voice mail system. However, many applications have a special key sequence, such as the octothorpe (#, or pound sign) or *9, that terminate the called party session and shift the user’s focus to the application.

Figure 16 shows the KPML for long octothorpe.

```
<?xml version="1.0"?>
<kpml-request xmlns="urn:ietf:params:xml:ns:kpml-request"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-request kpml-request.xsd"
      version="1.0">
  <pattern>
    <regex>L#</regex>
  </pattern>
</kpml-request>
```

Figure 16: Long Octothorpe Example

The regex value L indicates the following digit needs to be a long-duration key press.

9.2. Dial String Collection

In this example, the User Interface collects a dial string. The application uses KPML to quickly determine when the user enters a target number. In addition, KPML indicates what type of number the user entered.

```
<?xml version="1.0"?>
<kpml-request xmlns="urn:ietf:params:xml:ns:kpml-request"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-request kpml-request.xsd"
      version="1.0">
  <pattern>
    <regex tag="local-operator">0</regex>
    <regex tag="ld-operator">00</regex>
    <regex tag="vpn">7[x][x][x]</regex>
    <regex tag="local-number7">9xxxxxxx</regex>
    <regex tag="RI-number">9401xxxxxxx</regex>
    <regex tag="local-number10">9xxxxxxxxxx</regex>
    <regex tag="ddd">91xxxxxxxxx</regex>
    <regex tag="iddd">011x.</regex>
  </pattern>
</kpml-request>
```

Figure 17: Dial String KPML Example Code

Note the use of the "tag" attribute to indicate which regex matched the dialed string. The interesting case here is if the user entered "94015551212". This string matches both the "9401xxxxxxx" and

"9xxxxxxxxxx" regular expressions. Both expressions are the same length. Thus the KPML interpreter will pick the "9401xxxxxxx" string, as it occurs first in document order. Figure 18 shows the response.

```
<?xml version="1.0"?>
<kpml-response xmlns="urn:ietf:params:xml:ns:kpml-resposne"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-response kpml-response.xsd"
      version="1.0"
      code="200" text="OK"
      digits="94015551212" tag="RI-number"/>
```

Figure 18: Dial String KPML Response

10. Call Flow Examples

10.1. Supplemental Digits

This section gives a non-normative example of an application that collects supplemental digits. Supplemental digit collection is where the network requests additional digits after the caller enters the destination address. A typical supplemental dial string is four digits in length.

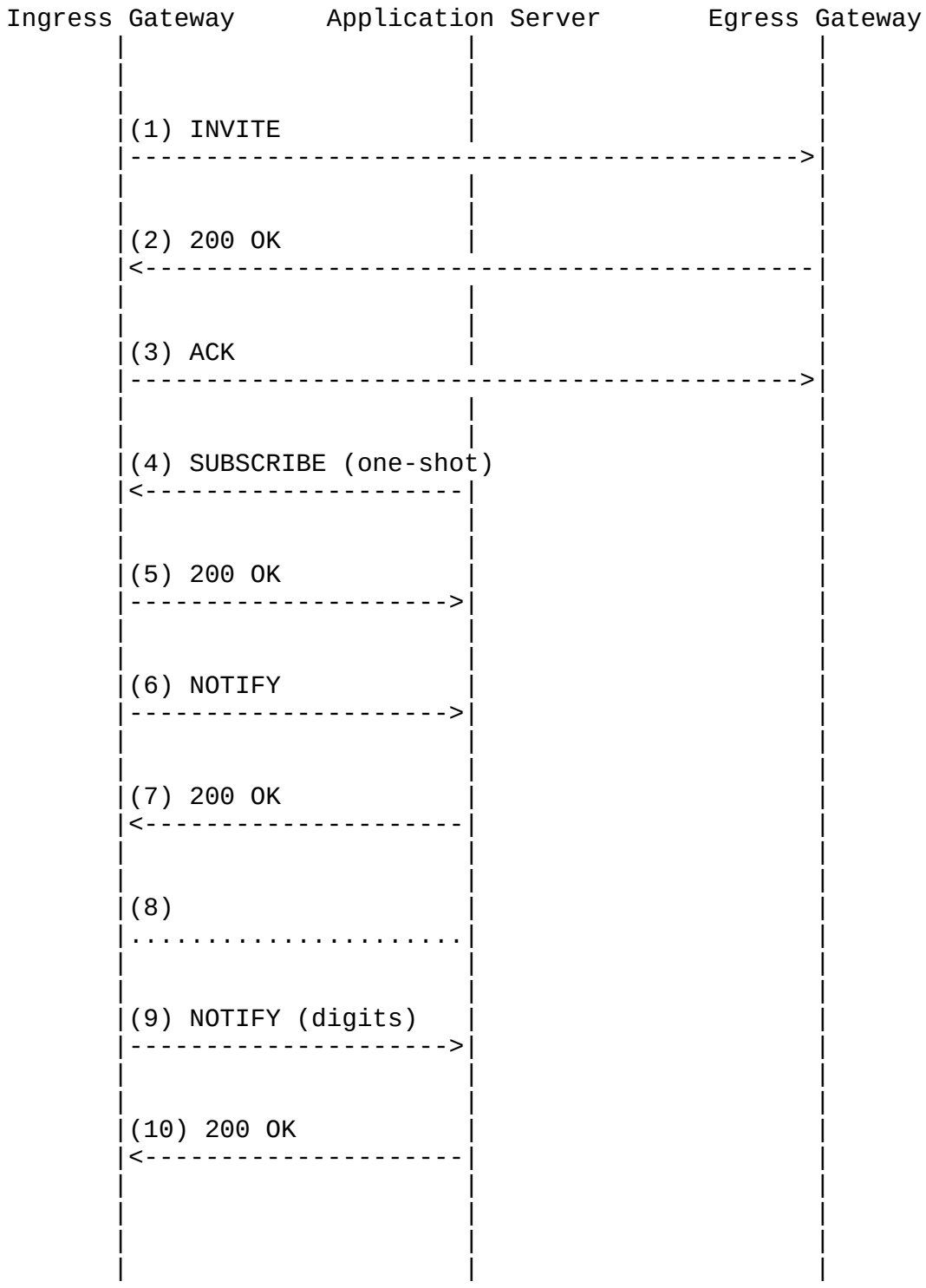


Figure 19: Supplemental Digits Call Flow

In messages (1-3), the ingress gateway establishes a dialog with an egress gateway. The application learns the dialog ID through out-of-band mechanisms, such as the Dialog Package or being co-resident with the egress gateway. Part of the ACK message is below, to illustrate the dialog identifiers.

```
ACK sip:gw@subA.example.com SIP/2.0
Via: ...
Max-Forwards: ...
Route: ...
From: <sip:phn@example.com>;tag=jfh21
To: <sip:gw@subA.example.com>;tag=onjwe2
Call-ID: 12345592@subA.example.com
...
```

In message (4), the application the requests that gateway collect a string of four key presses.

```
SUBSCRIBE sip:gw@subA.example.com SIP/2.0
Via: SIP/2.0/TCP client.subB.example.com;branch=q4i9ufr4ui3
From: <sip:ap@subB.example.com>;tag=567890
To: <sip:gw@subA.example.com>
Call-ID: 12345601@subA.example.com
CSeq: 1 SUBSCRIBE
Contact: <sip:ap@client.subB.example.com>
Max-Forwards: 70
Event: kpml ;remote-tag="sip:phn@example.com;tag=jfh21"
            ;local-tag="sip:gw@subA.example.com;tag=onjwe2"
            ;call-id="12345592@subA.example.com"
Expires: 7200
Accept: application/kpml-response+xml
Content-Type: application/kpml-request+xml
Content-Length: 292

<?xml version="1.0" encoding="UTF-8"?>
<kpml-request xmlns="urn:ietf:params:xml:ns:kpml-request"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation=
      "urn:ietf:params:xml:ns:kpml-request kpml-request.xsd"
    version="1.0">
  <pattern persist="one-shot">
    <regex>xxxx</regex>
  </pattern>
</kpml-request>
```

Message (5) is the acknowledgement of the subscription request.

```
SIP/2.0 200 OK
Via: SIP/2.0/TCP subB.example.com;branch=q4i9ufr4ui3;
     received=192.168.125.12
From: <sip:ap@subB.example.com>;tag=567890
To: <sip:gw@subA.example.com>;tag=1234567
Call-ID: 12345601@subA.example.com
CSeq: 1 SUBSCRIBE
Contact: <sip:gw27@subA.example.com>
Expires: 3600
Event: kpml
```

Message (6) is the immediate notification of the subscription.

```
NOTIFY sip:ap@client.subB.example.com SIP/2.0
Via: SIP/2.0/UDP subA.example.com;branch=gw27id4993
To: <sip:ap@subB.example.com>;tag=567890
From: <sip:gw@subA.example.com>;tag=1234567
Call-ID: 12345601@subA.example.com
CSeq: 1000 NOTIFY
Contact: <sip:gw27@subA.example.com>
Event: kpml
Subscription-State: active;expires=3599
Max-Forwards: 70
Content-Length: 0
```

Message (7) is the acknowledgement of the notification message.

```
SIP/2.0 200 OK
Via: SIP/2.0/TCP subA.example.com;branch=gw27id4993
To: <sip:ap@subB.example.com>;tag=567890
From: <sip:gw@subA.example.com>;tag=1234567
Call-ID: 12345601@subA.example.com
CSeq: 1000 NOTIFY
```

Some time elapses (8).

The user enters the input. The device provides the notification of the collected digits in message (9). Since this was a one-shot subscription, note the Subscription-State is "terminated".

```
NOTIFY sip:ap@client.subB.example.com SIP/2.0
Via: SIP/2.0/UDP subA.example.com;branch=gw27id4993
To: <sip:ap@subB.example.com>;tag=567890
From: <sip:gw@subA.example.com>;tag=1234567
Call-ID: 12345601@subA.example.com
CSeq: 1001 NOTIFY
Contact: <sip:gw27@subA.example.com>
Event: kpml
Subscription-State: terminated
Max-Forwards: 70
Content-Type: application/kpml-response+xml
Content-Length: 258

<?xml version="1.0" encoding="UTF-8"?>
<kpml-response xmlns="urn:ietf:params:xml:ns:kpml-response"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-response kpml-response.xsd"
      version="1.0"
      code="200" text="OK"
      digits="4336"/>
```

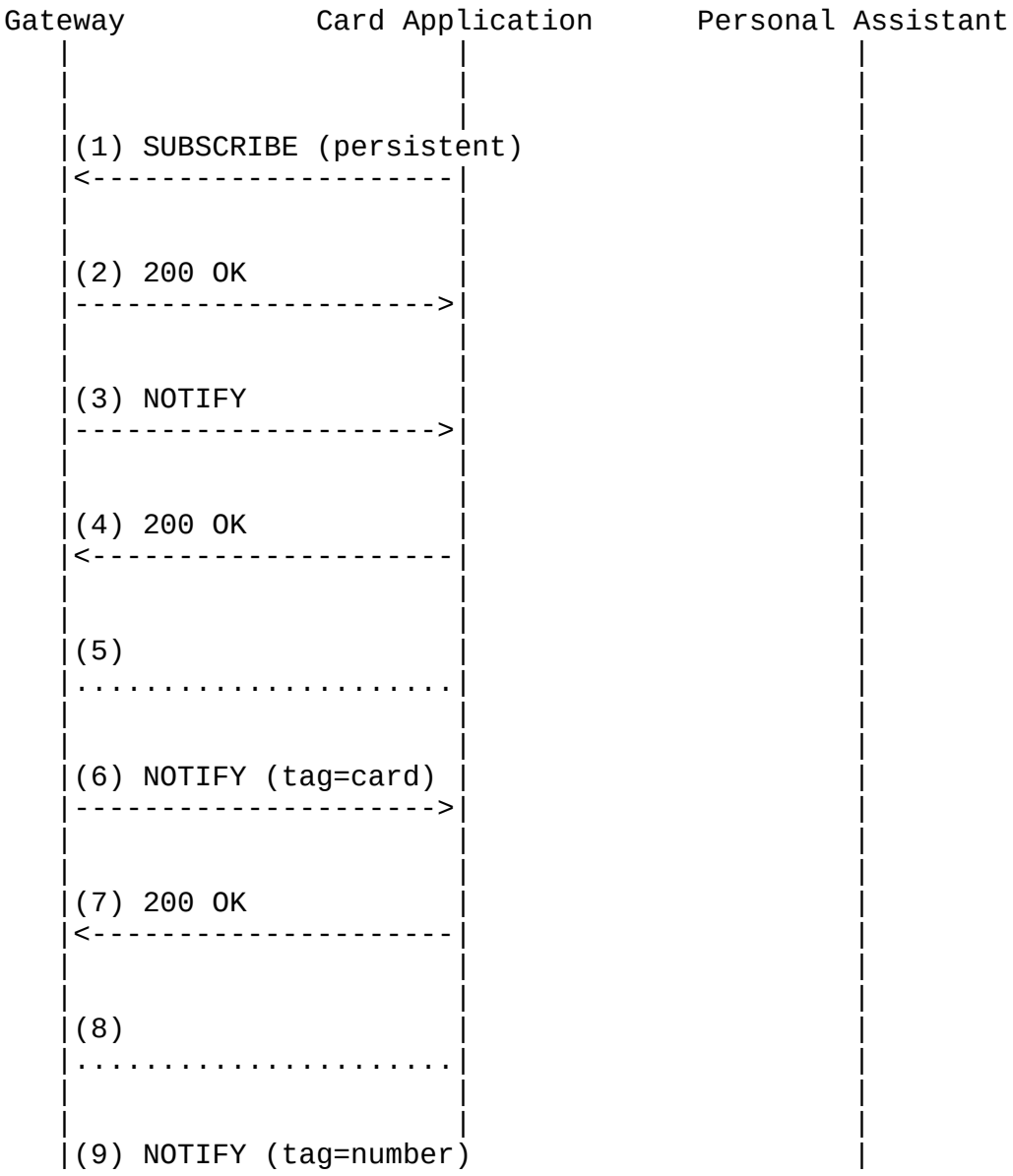
Message (10) is the acknowledgement of the notification.

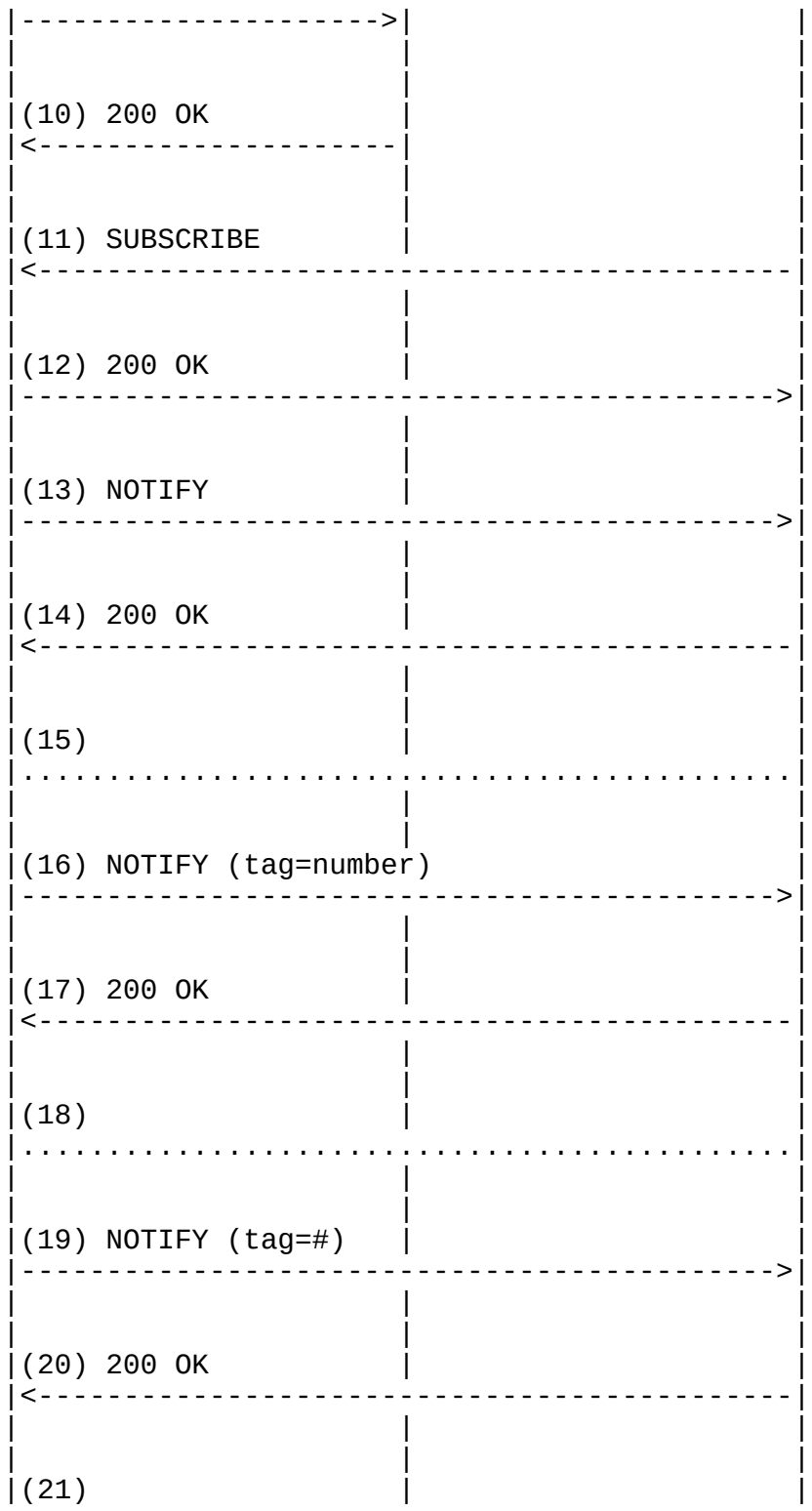
```
SIP/2.0 200 OK
Via: SIP/2.0/TCP subA.example.com;branch=gw27id4993
To: <sip:ap@subB.example.com>;tag=567890
From: <sip:gw@subA.example.com>;tag=1234567
Call-ID: 12345601@subA.example.com
CSeq: 1001 NOTIFY
```

10.2. Multiple Applications

This section gives a non-normative example of multiple applications. One application collects a destination number to call. That application then waits for a "long pound." During the call, the call goes to a personal assistant application, which interacts with the user. In addition, the personal assistant application looks for a "short pound."

For clarity, we do not show the INVITE dialogs.




(10) 200 OK
(11) SUBSCRIBE
(12) 200 OK
(13) NOTIFY
(14) 200 OK
(15)
(16) NOTIFY (tag=number)
(17) 200 OK
(18)
(19) NOTIFY (tag=#)
(20) 200 OK
(21)

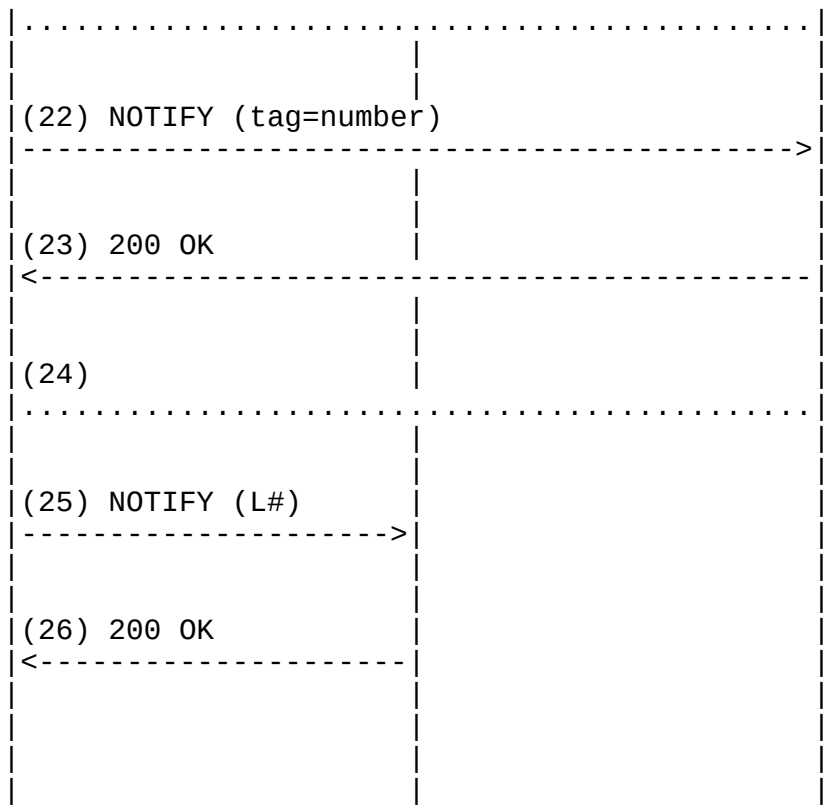


Figure 27: Multiple Application Call Flow

Message (1) is the subscription request for the card number.

```
SUBSCRIBE sip:gw@subA.example.com SIP/2.0
Via: SIP/2.0/TCP client.subB.example.com;branch=3qo3j0ouq
From: <sip:ap@subB.example.com>;tag=978675
To: <sip:gw@subA.example.com>
Call-ID: 12345601@subA.example.com
CSeq: 20 SUBSCRIBE
Contact: <sip:ap@client.subB.example.com>
Max-Forwards: 70
Event: kpml ;remote-tag="<sip:phn@example.com;tag=jfi23>"
            ;local-tag="sip:gw@subA.example.com;tag=oi43jfq"
            ;call-id="12345598@subA.example.com"
Expires: 7200
Accept: application/kpml-response+xml
Content-Type: application/kpml-request+xml
Content-Length: 339
```

```
<?xml version="1.0" encoding="UTF-8"?>
<kpml-request xmlns="urn:ietf:params:xml:ns:kpml-request"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-request kpml-request.xsd"
      version="1.0">
  <pattern persist="persist">
    <regex tag="card">x{16}</regex>
    <regex tag="number">x{10}</regex>
  </pattern>
</kpml-request>
```

Messages (2-4) are not shown, for brevity. Message (6) is the notification of the card number.

```
NOTIFY sip:ap@client.subB.example.com SIP/2.0
Via: SIP/2.0/UDP subA.example.com;branch=3qo3j0ouq
To: <sip:ap@subB.example.com>;tag=978675
From: <sip:gw@subA.example.com>;tag=9783453
Call-ID: 12345601@subA.example.com
CSeq: 3001 NOTIFY
Contact: <sip:gw27@subA.example.com>
Event: kpml
Subscription-State: active;expires=3442
Max-Forwards: 70
Content-Type: application/kpml-response+xml
Content-Length: 271

<?xml version="1.0" encoding="UTF-8"?>
<kpml-response xmlns="urn:ietf:params:xml:ns:kpml-response"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-response kpml-response.xsd"
      version="1.0"
      code="200" text="OK"
      digits="9999888877776666"/>
```

Message (7) is the acknowledgement of the notification. Time goes by in (8). Message (9) is the notification of the dialed number.

```
NOTIFY sip:ap@client.subB.example.com SIP/2.0
Via: SIP/2.0/UDP subA.example.com;branch=3qo3j0ouq
To: <sip:ap@subB.example.com>;tag=978675
From: <sip:gw@subA.example.com>;tag=9783453
Call-ID: 12345601@subA.example.com
CSeq: 3001 NOTIFY
Contact: <sip:gw27@subA.example.com>
Event: kpml
Subscription-State: active;expires=3542
Max-Forwards: 70
Content-Type: application/kpml-response+xml
Content-Length: 278

<?xml version="1.0" encoding="UTF-8"?>
<kpml-response xmlns="urn:ietf:params:xml:ns:kpml-response"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-response kpml-response.xsd"
      version="1.0"
      code="200" text="OK"
      digits="2225551212" tag="number"/>
```

Message (11) is the request for long-pound monitoring.

```
SUBSCRIBE sip:gw@subA.example.com SIP/2.0
Via: SIP/2.0/TCP client.subB.example.com;branch=3qo3j0ouq
From: <sip:ap@subB.example.com>;tag=978675
To: <sip:gw@subA.example.com>
Call-ID: 12345601@subA.example.com
CSeq: 21 SUBSCRIBE
Contact: <sip:ap@client.subB.example.com>
Max-Forwards: 70
Event: kpml ;remote-tag="<sip:phn@example.com;tag=jfi23>"
            ;local-tag="sip:gw@subA.example.com;tag=oi43jfq"
            ;call-id="12345598@subA.example.com"
Expires: 7200
Accept: application/kpml-response+xml
Content-Type: application/kpml-request+xml
Content-Length: 295
```

```
<?xml version="1.0" encoding="UTF-8"?>
<kpml-request xmlns="urn:ietf:params:xml:ns:kpml-request"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-request kpml-request.xsd"
      version="1.0">
  <pattern persist="single-notify">
    <regex>L#</regex>
  </pattern>
</kpml-request>
```

Message (13) is the request from the personal assistant application for number and pound sign monitoring.

```
SUBSCRIBE sip:gw@subA.example.com SIP/2.0
Via: SIP/2.0/TCP pahost.example.com;branch=xzvsadf
From: <sip:pa@example.com>;tag=4rgj0f
To: <sip:gw@subA.example.com>
Call-ID: 93845@pahost.example.com
CSeq: 21 SUBSCRIBE
Contact: <sip:pa12@pahost.example.com>
Max-Forwards: 70
Event: kpml ;remote-tag="<sip:phn@example.com;tag=jfi23>"
            ;local-tag="sip:gw@subA.example.com;tag=oi43jfq"
            ;call-id="12345598@subA.example.com"
Expires: 7200
Accept: application/kpml-response+xml
Content-Type: application/kpml-request+xml
Content-Length: 332

<?xml version="1.0" encoding="UTF-8"?>
<kpml-request xmlns="urn:ietf:params:xml:ns:kpml-request"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-request kpml-request.xsd"
      version="1.0">
  <pattern persist="persist">
    <regex tag="number">x{10}</regex>
    <regex tag="#">#</regex>
  </pattern>
</kpml-request>
```

Message (18) is the notification of the number collected.

```
NOTIFY sip:pa@example.com SIP/2.0
Via: SIP/2.0/UDP subA.example.com;branch=xzvsadf
To: <sip:pa@example.com>;tag=4rgj0f
From: <sip:gw@subA.example.com>;tag=9788823
Call-ID: 93845@pahost.example.com
CSeq: 3021 NOTIFY
Contact: <sip:gw27@subA.example.com>
Event: kpml
Subscription-State: active;expires=3540
Max-Forwards: 70
Content-Type: application/kpml-response+xml
Content-Length: 278

<?xml version="1.0" encoding="UTF-8"?>
<kpml-response xmlns="urn:ietf:params:xml:ns:kpml-response"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-response kpml-response.xsd"
      version="1.0"
      code="200" text="OK" digits="3335551212" tag="number"/>
```

Message (21) is the notification of pound sign detected.

```
NOTIFY sip:pa@example.com SIP/2.0
Via: SIP/2.0/UDP subA.example.com;branch=xzvsadf
To: <sip:pa@example.com>;tag=4rgj0f
From: <sip:gw@subA.example.com>;tag=9788823
Call-ID: 93845@pahost.example.com
CSeq: 3022 NOTIFY
Contact: <sip:gw27@subA.example.com>
Event: kpml
Subscription-State: active;expires=3540
Max-Forwards: 70
Content-Type: application/kpml-response+xml
Content-Length: 264

<?xml version="1.0" encoding="UTF-8"?>
<kpml-response xmlns="urn:ietf:params:xml:ns:kpml-response"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-response kpml-response.xsd"
      version="1.0"
      code="200" text="OK"
      digits="#" tag="#"/>
```

Message (27) is the notification of long pound to the card application.

```
NOTIFY sip:ap@client.subB.example.com SIP/2.0
Via: SIP/2.0/UDP subA.example.com;branch=3qo3j0ouq
To: <sip:ap@subB.example.com>;tag=978675
From: <sip:gw@subA.example.com>;tag=9783453
Call-ID: 12345601@subA.example.com
CSeq: 3037 NOTIFY
Contact: <sip:gw27@subA.example.com>
Event: kpml
Subscription-State: active;expires=3216
Max-Forwards: 70
Content-Type: application/kpml-response+xml
Content-Length: 256

<?xml version="1.0" encoding="UTF-8"?>
<kpml-response xmlns="urn:ietf:params:xml:ns:kpml-response"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation=
        "urn:ietf:params:xml:ns:kpml-response kpml-response.xsd"
      version="1.0"
      code="200" text="OK"
      digits="#"/>
```

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Appendix A. Contributors

Ophir Frieder of the Illinois Institute of Technology collaborated on the development of the buffer algorithm.

Jeff Van Dyke worked enough hours and wrote enough text to be considered an author under the old rules.

Robert Fairlie-Cuninghame, Cullen Jennings, Jonathan Rosenberg, and we were the members of the Application Stimulus Signaling Design Team. All members of the team contributed to this work. In addition, Jonathan Rosenberg postulated DML in his "A Framework for Stimulus Signaling in SIP Using Markup" draft.

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Rohan Mahy did a significant reorganization of the content, as well as providing considerable moral support in the production of this document.

That said, any errors, misinterpretation, or fouls in this document are our own.

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Scott Hollenbeck provided XML and MIME review. Tim Bray pointed out the general issue of UTF-8 versus UTF-16 with XML.

Authors' Addresses

Eric Burger
Cantata Technology, Inc.
18 Keewaydin Dr.
Salem, NH 03079
USA

EMail: eburger@cantata.com

Martin Dolly
AT&T Labs

EMail: mdolly@att.com

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