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Presser

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(54) **METHOD AND APPARATUS FOR INTELLIGENT DUAL-TONE MULTI-FREQUENCY (DTMF) DECODING AND IDENTIFICATION**

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H04M 1/57 (2006.01)
H04Q 1/45 (2006.01)

(52) **U.S. Cl.**
CPC ***H04Q 1/46*** (2013.01); ***H04M 1/57*** (2013.01); ***H04Q 1/45*** (2013.01); *H04Q 2213/13096* (2013.01)

(58) **Field of Classification Search**
CPC H04M 1/271; H04M 1/505; H04M 1/6041; H04M 1/663; H04M 2201/40; H04M 2250/74; H04M 3/323; H04M 3/36; H04M 3/487; H04M 3/493; H04M 3/51; H04M 3/523; H04M 1/64; H04M 1/654; H04M 1/66; H04M 1/82; H04M 3/14; H04M 3/4931
USPC 379/32.01, 88.01, 386, 112.01, 112.06, 379/133, 135, 23, 27.02, 355.01, 357.03
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,796,809	A *	8/1998	Baek	H04N 1/32741 358/468
6,418,147	B1 *	7/2002	Wiedeman	H04B 7/18532 370/468
6,779,030	B1 *	8/2004	Dugan	H04M 3/42136 379/221.08
7,039,044	B1 *	5/2006	Whitfield	H04M 7/1295 370/356
2001/0043681	A1 *	11/2001	Brablec	H04M 1/64 379/80
2009/0040052	A1 *	2/2009	Cameron	G08B 21/0415 340/573.1
2010/0329441	A1 *	12/2010	Smith	H04M 3/382 379/207.11

* cited by examiner

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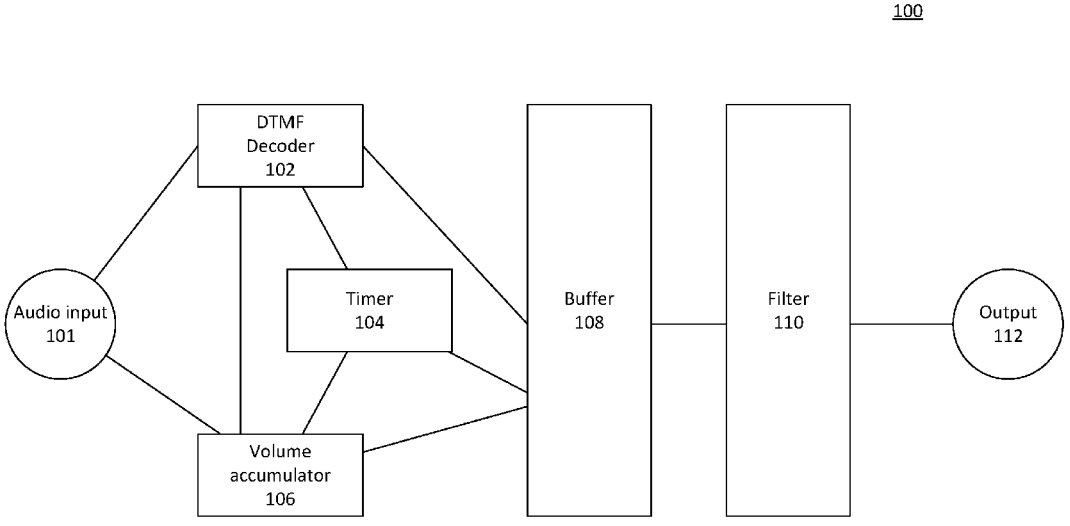
(57) **ABSTRACT**

A dual-tone multi-frequency (DTMF) decoder may decode DTMF symbols received in an audio input and transfer the symbols to a buffer. A volume accumulator may determine whether the audio input includes audio with volume above a predetermined threshold. The buffer may receive instructions from the timer or volume accumulator to transfer stored DTMF symbols to a filter, which may identify a characteristic of information conveyed by the DTMF symbols and send the identified characteristic information to an output device. The timer may determine a time associated with when each DTMF symbol was received and transfer each associated time to the buffer, which may transfer each associated time to a group boundary detector that may determine a predetermined number of longest time durations in between the DTMF symbols. The presence of a predetermined number of longest time durations in between the DTMF symbols may indicate a telephone number format.

21 Claims, 6 Drawing Sheets



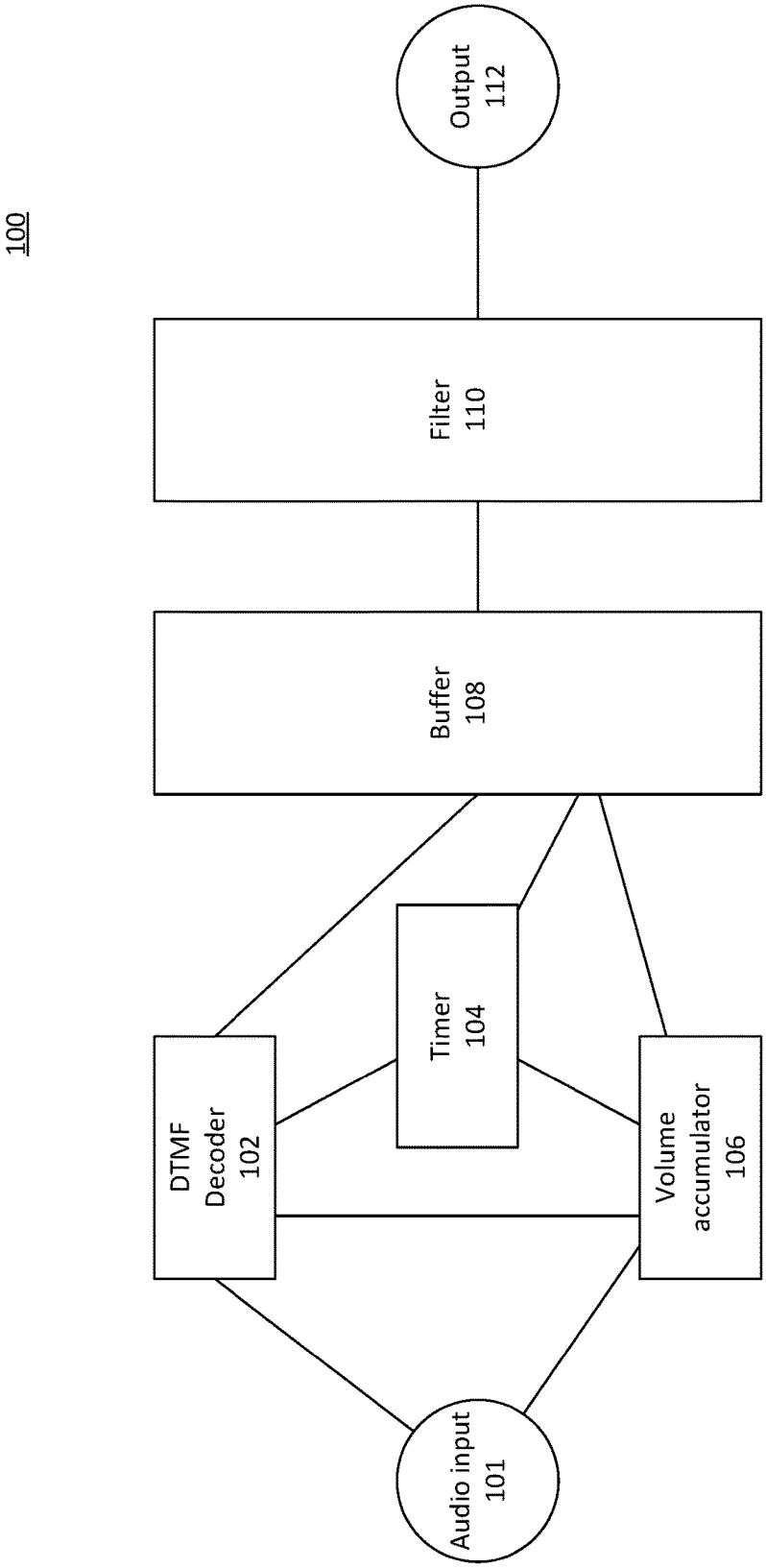

100
Output
112
Filter
110
Buffer
108
Timer
104
DTMF
Decoder
102
Volume
accumulator
106
Audio input
101

Fig. 1

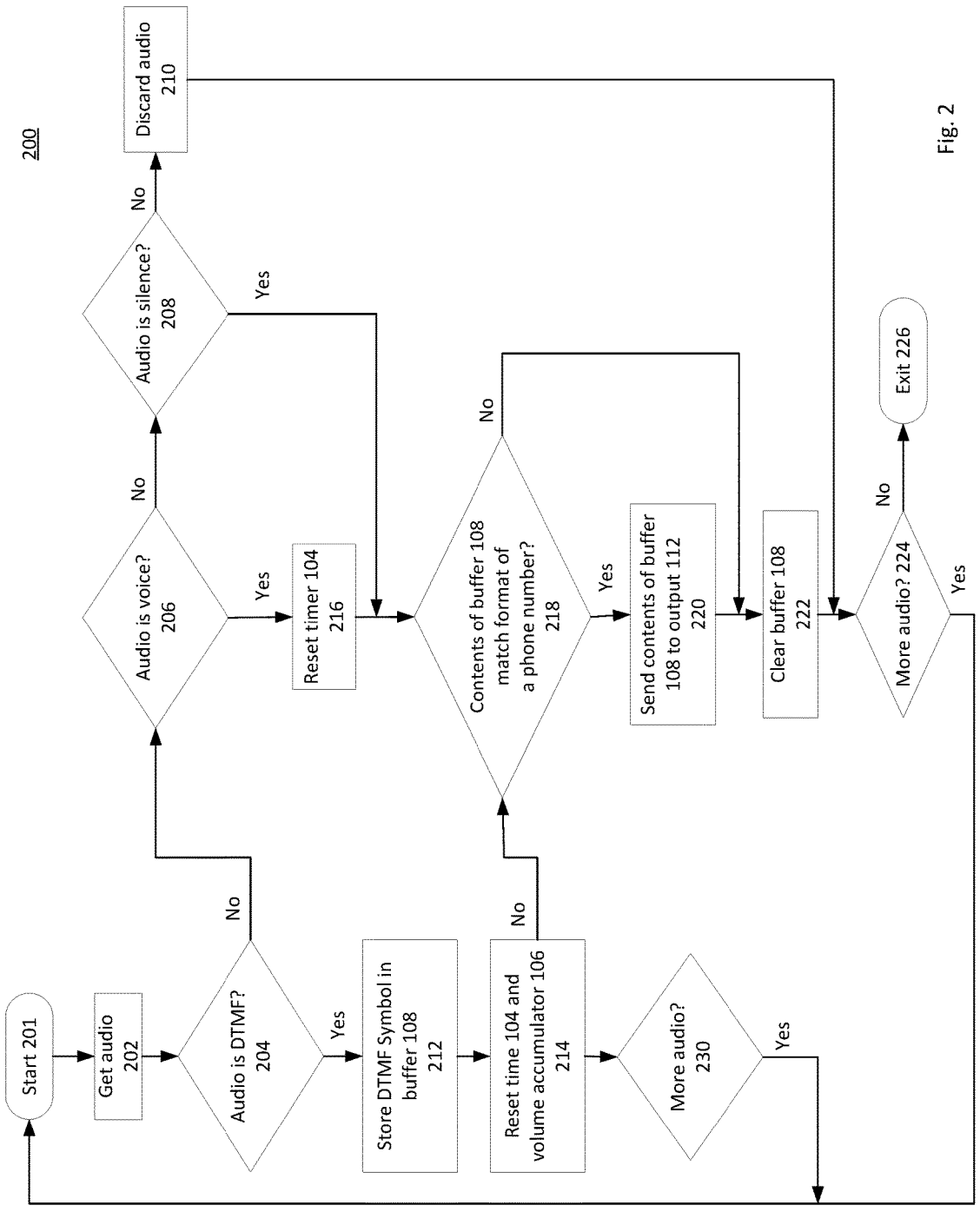

200
Start 201
Get audio 202
Audio is DTMF? 204
Yes
No
Store DTMF Symbol in buffer 108 212
Reset time 104 and volume accumulator 106 214
More audio? 230
Yes
No
Audio is voice? 206
Yes
No
Reset timer 104 216
Audio is silence? 208
Yes
No
Discard audio 210
Contents of buffer 108 match format of a phone number? 218
Yes
No
Send contents of buffer 108 to output 112 220
Clear buffer 108 222
More audio? 224
Yes
No
Exit 226

Fig. 2

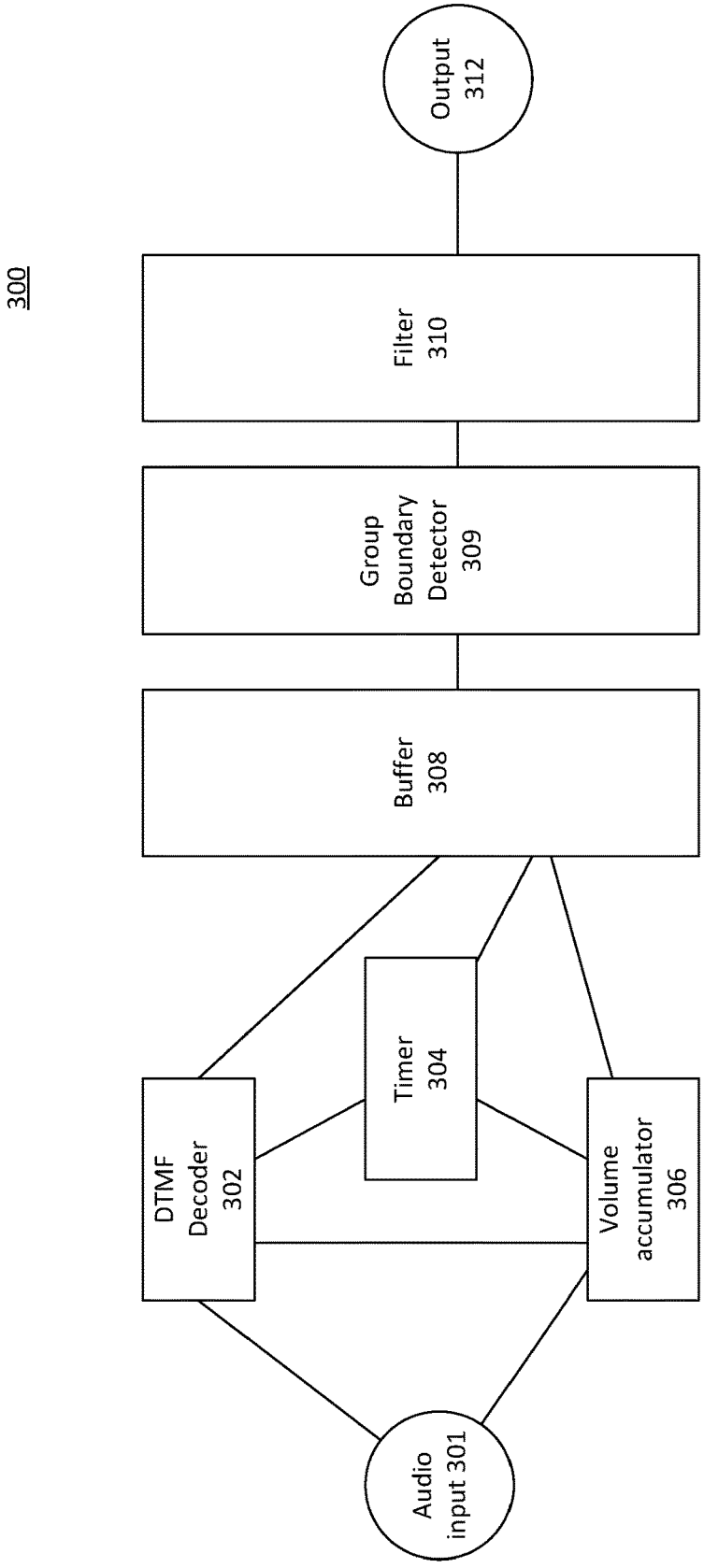

300
Output 312
Filter 310
Group Boundary Detector 309
Buffer 308
Timer 304
DTMF Decoder 302
Volume accumulator 306
Audio input 301

Fig. 3

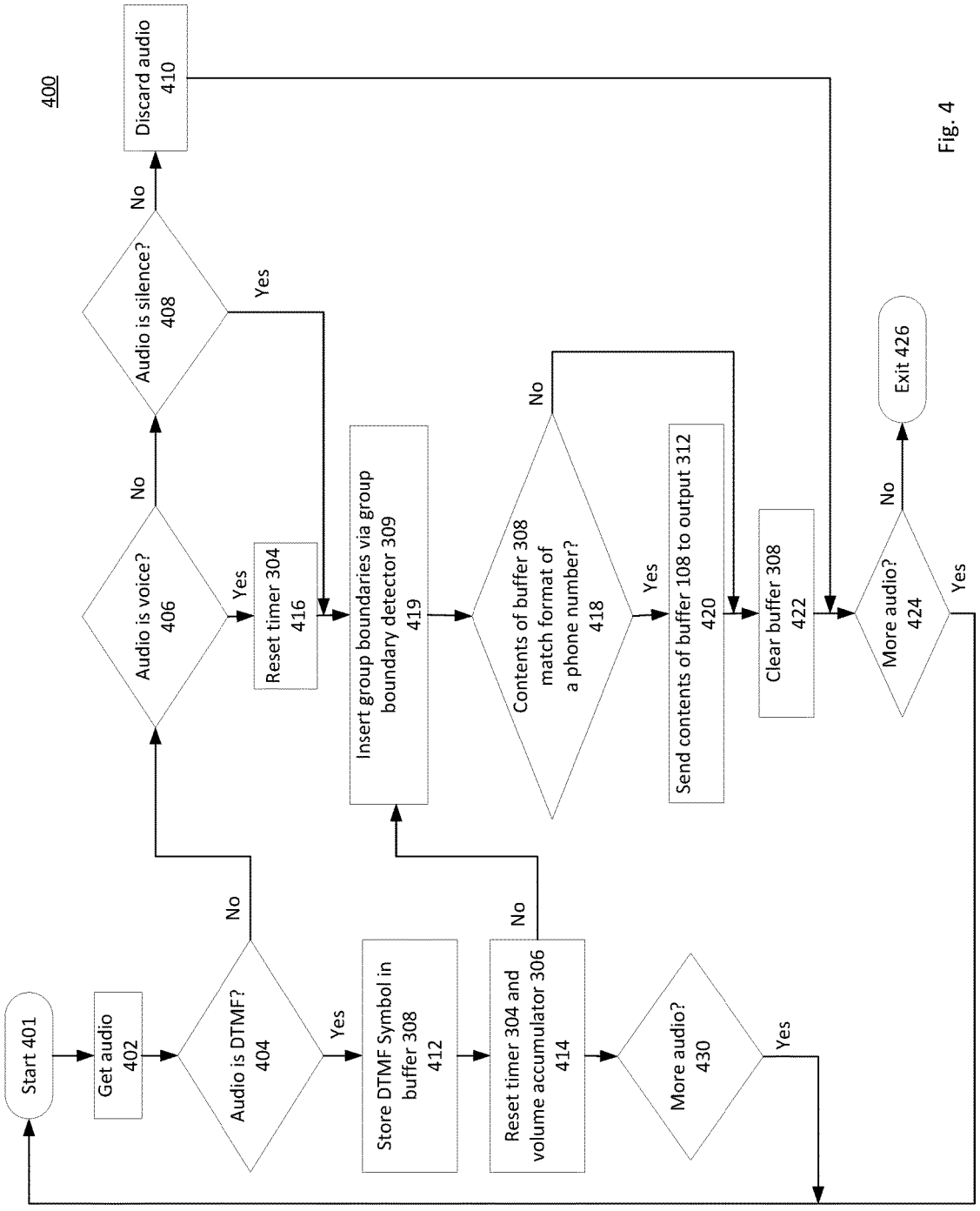

400
Start 401
Get audio 402
Audio is DTMF? 404
Yes
No
Store DTMF Symbol in buffer 308 412
Reset timer 304 and volume accumulator 306 414
More audio? 430
Yes
Audio is voice? 406
Yes
No
Reset timer 304 416
Audio is silence? 408
Yes
No
Discard audio 410
Insert group boundaries via group boundary detector 309 419
Contents of buffer 308 match format of a phone number? 418
Yes
No
Send contents of buffer 108 to output 312 420
Clear buffer 308 422
More audio? 424
Yes
No
Exit 426

Fig. 4

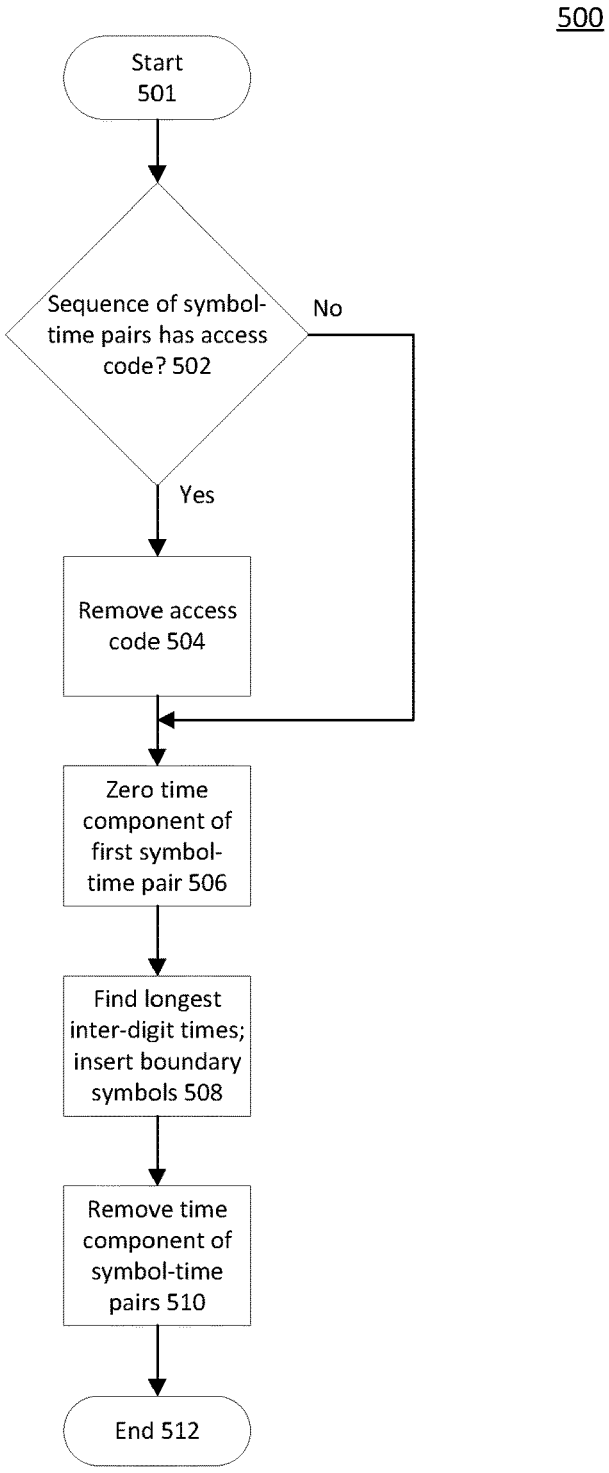

500
Start
501
Sequence of symbol-time pairs has access code? 502
No
Yes
Remove access code 504
Zero time component of first symbol-time pair 506
Find longest inter-digit times; insert boundary symbols 508
Remove time component of symbol-time pairs 510
End 512

Fig. 5

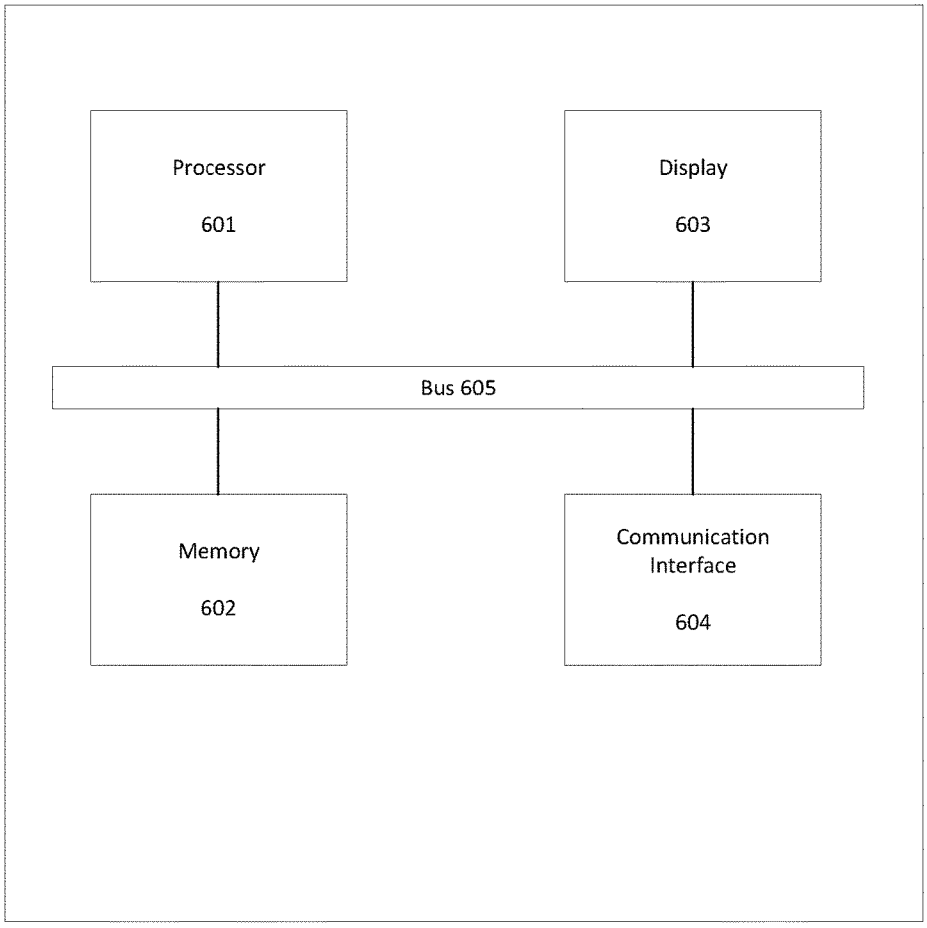

600
Processor
601
Display
603
Bus 605
Memory
602
Communication Interface
604

Fig. 6

METHOD AND APPARATUS FOR INTELLIGENT DUAL-TONE MULTI-FREQUENCY (DTMF) DECODING AND IDENTIFICATION

FIELD OF INVENTION

The present invention relates to communication systems, and in particular, systems and methods for decoding and identifying dual-tone multi-frequency (DTMF) based information.

BACKGROUND

Dual-tone multi-frequency (DTMF) signaling is an in-band telecommunication signaling system using the voice-frequency band over telephone lines between telephone equipment and other communications devices and switching centers. DTMF telephone keypads provide keys that each represent a digit, symbol, or letter used to convey a telephone number or other information or data. When a user presses a key on the DTMF telephone keypad, a DTMF symbol comprising a combination of two frequencies is sent over the telephone line.

A traditional automated telephone system is implicitly aware of what information is requested (e.g., telephone number to call), the number of expected symbols (e.g., **10**) and other information. Because of this foreknowledge of the structure of the audio, a traditional DTMF decoder does not need to differentiate dialed telephone routing data (e.g., a phone number) from other dialed symbols contained within telephone audio content. However, there is a need, for example, in the law enforcement context, to be able to capture only the telephone routing data without capturing the non-routing symbols or other content within the telephone audio.

SUMMARY

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Furthermore, the claimed subject matter is not limited to limitations that solve any or all disadvantages noted in any part of this disclosure.

In accordance with various embodiments, the device may use information about the timing of DTMF symbols and the volume of audio between symbols in order to group DTMF symbols. After grouping the symbols, the device examines them to determine if they match the format of a phone number or other routing data. If a group of symbols is identified as a phone number or other routing data, the device outputs them via an output. The device may partition the input audio into non-overlapping sections. These sections may include: (1) DTMF symbol(s), (2) audio above a volume threshold for a long enough duration to trigger the volume accumulator of the device (i.e. voice), (3) periods of non-DTMF symbol audio of a long enough duration to trigger the timer of the device (i.e. silence), or (4) audio which does not meet the criteria of the previous categories (referred to herein as "other"). The grouping of DTMF symbols is performed by storing symbols in a buffer of the device until silence or voice is detected. Detection of silence or of voice is used to separate groups of DTMF symbols. The contents of any voice or silence sections is then discarded. "Other" audio may be discarded without having any effect because it does not meet the criteria to be voice or silence, and it is not used to separate groups of DTMF symbols.

In accordance with one embodiment, a device is configured to determine information conveyed by DTMF symbols. The apparatus may include communication circuitry configured to receive an audio input and a DTMF decoder coupled to the communication circuitry that is configured to decode each DTMF symbol included in the audio input. The DTMF decoder may be configured to transfer each DTMF symbol to a buffer to be stored. The apparatus may further include a timer coupled to the communication circuitry and the DTMF decoder that is configured to determine a time associated with when each DTMF symbol was received in the audio input and that is configured to transfer each time to the buffer to be stored. The apparatus may also include a volume accumulator coupled to the communication circuitry, the DTMF decoder, and the timer and that is configured to determine whether the audio input includes audio with volume above a predetermined threshold and that is configured to reset the timer when the audio input includes audio with volume above the predetermined threshold. The buffer may be configured to receive an instruction from the timer or the volume accumulator to transfer each stored DTMF symbol and associated time to a filter. The filter may be configured to determine information conveyed by each DTMF symbol and associated time and further configured to send the determined information to an output device.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to facilitate a more robust understanding of the application, reference is now made to the accompanying drawings, in which like elements are referenced with like numerals. These drawings should not be construed to limit the application and are intended only to be illustrative.

FIG. **1** is a block diagram of an implementation of the invention in accordance with one embodiment;

FIG. **2** is an example flow diagram of a process that may be performed by the implementation of FIG. **1**;

FIG. **3** is a block diagram of an implementation of the invention in accordance with another embodiment;

FIG. **4** is an example flow diagram of another process that may be performed by the implementation of FIG. **3**;

FIG. **5** is an example flow diagram of a process that may be performed by the group boundary detector of the implementation of FIG. **3**; and

FIG. **6** is a block diagram of an example device that may implement any of the embodiments described herein.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Described herein are methods and devices for extracting and identifying telephone numbers and other telephone routing data from unstructured telephone audio. The device may detect and decode dual-tone multi-frequency (DTMF) symbols contained within the telephone audio and may then update a recording device, such as for example a pen register or other electronic device, with the information conveyed by the DTMF symbols. This capability is useful in the law enforcement context, where law enforcement personnel and agencies may only be permitted to capture telephone routing data (i.e., they must not capture any non-routing symbols), but they do not have advance knowledge of where in a telephone call such telephone routing data is located.

Accordingly, the methods and devices described herein result in the update of recording devices in a way that complies with both the modern telephone use paradigm and modern Fourth Amendment jurisprudence related to the capture of telephone metadata.

FIG. **1** is an example block diagram layout of the device **100** in accordance with one embodiment, which may be used in combination with any of the embodiments described herein. The device **100** may include processor(s), memory, and a receiver, transmitter, or other communication circuitry in order to connect to a network or telephone line and process and store data associated with unstructured telephone audio as described in the embodiments herein. As shown in the example of FIG. **1**, the logical layout of the device **100** may include an audio input **101**, an output **112**, and a plurality of modules. The modules included in the example of FIG. **1** are a DTMF decoder **102**, a volume accumulator **106**, a timer **104**, a buffer **108**, and a filter **110**.

The device **100** may use information about the timing of DTMF symbols and the volume of audio between symbols in order to group DTMF symbols and optionally identify the type of information being conveyed by the DTMF symbols. In a traditional DTMF decoder, this timing and volume information is discarded. After grouping the symbols, the device **100** examines them to determine, for example, if they match the format of a phone number or other routing data. If a group of symbols is a telephone number or other routing data, the device outputs them via output **112**.

The device **100** may partition the input audio into non-overlapping sections. These sections may include: (1) DTMF symbol(s), (2) audio above a volume threshold for a long enough duration to trigger the volume accumulator **106** (i.e. voice), (3) periods of non-DTMF symbol audio of a long enough duration to trigger the timer **104** to expire (i.e. silence), or (4) audio which does not meet the criteria of the previous categories (referred to herein as "other"). Each section of audio is checked against these types in order and placed in one of these groups. The grouping of DTMF symbols is performed by storing symbols in the buffer **108** until silence or voice is detected. Detection of silence or of voice separates groups of DTMF symbols. The contents of any voice or silence sections is then discarded. "Other" audio may be discarded without having any effect because it does not meet the criteria to be voice or silence, and it is not used to separate groups of DTMF symbols.

The audio input **101** may provide audio via a receiver or other communication circuitry in the device **100** in a format understood by the other elements of the device **100**. The DTMF decoder **102** may receive audio from the audio input **101**. DTMF symbols may represent numbers 0-9, letters A-D, an asterisk (*), or an octothorpe/pound/hash sign (#). When an audio section includes a DTMF signal, the DTMF decoder **102** may detect and decode the DTMF symbols. The decoded symbols may then be transferred to the buffer **108** to enable the device **100** to output the corresponding symbol(s). The DTMF decoder **102** may reset the timer **104** and volume accumulator **106** whenever a DTMF symbol is decoded in order to ensure that that section of audio is counted only once.

The volume accumulator **106** may detect whether a non-DTMF section of audio has volume above a predetermined volume threshold (i.e., has a minimum amplitude) for a predetermined time duration. When these conditions are met, the volume accumulator **106** may determine that the non-DTMF section of audio is voice and may reset the timer **104** in order to ensure that that section of audio is counted only once. The volume accumulator **106** may send an instruction to the buffer **108** to output its contents including any stored DTMF symbol(s) because the presence of audio content with a volume above the predetermined volume threshold for the predetermined time duration in between DTMF symbol(s) may indicate the end of a potential telephone number or other telephone routing data.

The timer **104** may trigger detection of long periods of audio (e.g., silence) that do not meet the requirements that trigger the DTMF decoder **102** or volume accumulator **106**. When such a period is detected because the timer **104** has not been reset by either the DTMF decoder **102** or the volume accumulator **106**, the timer **104** may send an instruction to the buffer **108** to output its contents including any stored DTMF symbol(s) because the presence of silence in between DTMF symbol(s) may indicate the end of a potential telephone number or other telephone routing data.

The buffer **108** may store the symbols sent from the DTMF decoder **102** via the data bus of the device **100**. When instructed by the volume accumulator **106** or timer **104** to output its contents, the buffer **108** may transfer its contents (DTMF symbol(s)) to the filter **110**. After receiving a DTMF symbol(s) from the buffer **108**, the filter **110** may determine whether the DTMF symbol(s) conveys information such as a valid phone number or is valid routing data.

The filter **110** may perform analysis of the DTMF symbol(s) including but not limited to a pattern match in order to determine whether the DTMF symbol(s) convey information such as a valid phone number or other valid telephone routing data. If the DTMF symbol(s) is a valid phone number or is valid telephone routing data, the filter **110** may then transfer it to the output **112**. If the DTMF symbol(s) is not a valid phone number or other telephone routing data, the filter **110** may discard the DTMF symbol(s).

The output **112** may convey results in a format useful to humans or send the results to an output device. The output **112** may, for example, output to paper tape, create a record such as an electronic record for storage in memory on a computer, or send the results to an output device such as another computer or electronic device including but not limited to an electronic recording device.

FIG. **2** is an example flow diagram of a process **200** that may be performed by the device **100**. While each step of the process **200** in FIG. **2** is shown and described separately, multiple steps may be executed in a different order than what is shown, in parallel with each other, or concurrently with each other.

The device **100** starts at step **201** and may acquire an audio input (step **202**). The device **100** may then determine whether the audio includes DTMF symbols (step **204**), whether the audio is voice (step **206**), or whether the audio is silence (step **208**). If it is determined that a section of audio includes a DTMF symbol, the device **100** may store the DTMF symbol in buffer **108** (step **212**). The device **100** may then reset the timer **104** and the volume accumulator **106** (step **214**) in order to ensure that that section of audio is counted only once. Whenever a DTMF symbol is present, the timer **104** is reset so that the next section of audio begins after the DTMF symbol ends. After the device **100** has stored the DTMF symbol in the buffer **108** and reset the timer **104** and the volume accumulator **106**, the device **100** may then determine whether there is more audio (step **230**). If the device **100** determines that there is more input audio to process, the device **100** may execute the process **200** again.

If at step **204** it is determined that the section of audio is not a DTMF symbol, the device **100** may determine whether

the section of audio meets the criteria to be voice (step **206**), which may indicate the end of a telephone number or other telephone routing data. To be voice, the audio must be above a predetermined volume threshold for a predetermined time duration and not contain any DTMF symbols. If a section of audio is voice, the device may reset the timer **104** (step **216**) in order to ensure that the audio is counted only once. The process then continues.

If at step **206** it is determined that the section of audio is not voice, the device **100** may determine whether the audio is silence (step **208**), which may indicate the end of a telephone number or other telephone routing data. To be silence, the section of audio, as determined by the timer **104**, must be longer than a predetermined duration of time (resulting from the timer **104** expiring because it was not reset by the DTMF decoder **102** or the volume accumulator **106**) and not contain either DTMF symbol(s) or voice as defined above. If the section of audio is not silence, the device **100** may discard the current section of audio (step **210**) because it is categorized as "other" audio.

After the device **100** has determined whether the section of audio includes DTMF symbol(s), is voice, or is silence, the filter **110** of the device **100** may then examine the contents of the buffer **108** to determine whether the stored contents convey information such as the format of a telephone number or other telephone routing data (step **218**). For example, this may include the filter **110** determining that the contents of the buffer **108** include ten consecutive DTMF symbols without voice or silence in between and each representing a number with the first DTMF symbol of the ten not representing a 0 or 1, which indicates a match to a domestic telephone number in the format of the United States. In another example, the filter **110** may determine that the contents of the buffer **108** match the format of an international telephone number. For example, if the contents of the buffer **108** included five consecutive DTMF symbols representing **44020** followed by eight other consecutive DTMF symbols each representing a number without voice or silence in between, the filter **110** would determine that those thirteen DTMF symbols represent a telephone number in London, United Kingdom.

If the contents of the buffer **108** do not convey information such as a valid telephone number or valid telephone routing data, the device **100** may then clear the contents of the buffer **108** (step **222**). If at step **218** it is determined that the contents of the buffer **108** do match a format or characteristic of a valid telephone number or valid telephone routing data, the device **100** may send the contents of the buffer **108** to the output **112** (step **220**). The device **100** may then clear the contents of the buffer **108** (step **222**), which serves to reset the device **100** to begin processing a next group of DTMF symbols.

After the device **100** has determined whether the audio includes DTMF symbols (step **204**), whether the audio is voice (step **206**), or whether the audio is silence (step **208**) and the device **100** has sent the contents of the buffer **108** to output **112** (step **220**) and/or cleared buffer **108** (step **222**), the device **100** may then determine whether there is more audio (step **224**). If there is no more audio, the device **100** exits (step **226**). If the device **100** determines that there is more input audio to process, the device **100** may execute the process **200** again (step **201**).

FIG. **3** is an example block diagram layout of device **300** in accordance with another embodiment, which may be used in combination with any of the embodiments described herein. The device **300** may include processor(s), memory, and a receiver, transmitter, or other communication circuitry in order to connect to a network or telephone line and process and store data associated with unstructured telephone audio as described in the embodiments herein. As shown in the example of FIG. **3**, the logical layout of the device **300** may include an audio input **301**, an output **312**, and a plurality of modules. The modules included in the example of FIG. **3** are a DTMF decoder **302**, a volume accumulator **306**, a timer **304**, a buffer **308**, a group boundary detector **309**, and a filter **310**.

As described above in reference to device **100**, the device **300** may use information about the timing of DTMF symbols and the volume of audio between symbols in order to group DTMF symbols. Studies have shown that the time period in between individual DTMF symbols is typically less than that between groups of DTMF symbols, since, for example, users pause after dialing an area code and before dialing the rest of a telephone number. As described above, after grouping the symbols, the device **300** examines them to determine if they convey information such as, for example, the format of a phone number or other routing data. The device **300** may detect groups of DTMF symbols via the group boundary detector **309**, which may determine the amount of time in between DTMF symbols as stored in the buffer **308**. The group boundary detector **309** may determine a predetermined number of longest time durations between DTMF symbols, which would indicate the time period between groups of DTMF symbols, as opposed to shorter time periods between individual DTMF symbols of a group. For example, grouping DTMF symbols based on a determination that there were two inter-symbol time durations that were longer than the other inter-symbol time durations may indicate a telephone number in the format XXX-XXX-XXXX indicating a domestic telephone number in the format of the United States. In another example, the group boundary detector **309** may determine a predetermined number of longest time durations between groups of DTMF symbols indicating an international telephone number format. The group boundary detector **309** may also determine DTMF symbol group boundaries based on statistics and determine a longest difference between an observed time duration and an expected time duration. For example, the group boundary detector **309** may scan the times stored and determine a user's dialing speed. The group boundary detector **309** may then determine the group boundary when an observed time duration between DTMF symbols is outside of the determined dialing speed. If a group of symbols is identified as having a format of a telephone number or other routing data, the device **300** outputs them via output **312**.

The device **300** may partition the input audio into non-overlapping sections. These sections may include: (1) DTMF symbol(s), (2) audio above a volume threshold for a long enough duration to trigger the volume accumulator **306** (i.e. voice), (3) periods of non-DTMF symbol audio of a long enough duration to trigger the timer **304** to expire (i.e. silence), or (4) audio which does not meet the criteria of the previous categories (referred to herein as "other"). Each section of audio is checked against these types in order and placed in one of these groups. The grouping of DTMF symbols is performed by storing symbols in the buffer **308** until silence or voice is detected. Detection of silence or of voice separates groups of DTMF symbols. The contents of any voice or silence sections is then discarded. "Other" audio may be discarded without having any effect because it does not meet the criteria to be voice or silence, and it is not used to separate groups of DTMF symbols.

The audio input **301** may provide audio via a receiver or other communication circuitry in the device **300** in a format

understood by the other elements of the device **300**. The DTMF decoder **302** may receive audio from the audio input **301**. DTMF symbols may represent numbers 0-9, letters A-D, an asterisk (*), or an octothorpe/pound/hash sign (#). When an audio section includes a DTMF signal, the DTMF decoder **302** may detect and decode the DTMF symbols. The decoded symbols and their associated times as determined by the timer **304** may then be transferred to the buffer **308** to enable the device **300** to output the corresponding symbol-time pairs. The DTMF decoder **302** may reset the timer **304** and volume accumulator **306** whenever a DTMF symbol is decoded in order to ensure that that section of audio is counted only once.

The volume accumulator **306** may detect whether a non-DTMF section of audio has volume above a predetermined volume threshold (i.e., has a minimum amplitude) for a predetermined time duration. When these conditions are met, the volume accumulator **306** may determine that the non-DTMF section of audio is voice and may reset the timer **304** in order to ensure that that section of audio is counted only once. The volume accumulator **306** may send an instruction to the buffer **308** to output its contents including any stored DTMF symbol(s) because the presence of audio content with a volume above the predetermined volume threshold for the predetermined time duration in between DTMF symbol(s) may indicate the end of a potential telephone number or other telephone routing data.

The timer **304** may trigger detection of long periods of audio (e.g., silence) that do not meet the requirements that trigger the DTMF decoder **302** or volume accumulator **306**. When such a period is detected because the timer **304** has not been reset by either the DTMF decoder **302** or the volume accumulator **306**, the timer **304** may send an instruction to the buffer **308** to output its contents including any stored DTMF symbol(s) because the presence of silence in between DTMF symbol(s) may indicate the end of a potential telephone number or other telephone routing data.

The buffer **308** may store the symbols sent from the DTMF decoder **302** via the data bus of the device **300**. The buffer **308** may also store the time received from the timer **304** that is associated with each symbol received from the DTMF decoder **302**. This enables the buffer **308** to store the DTMF symbols and their associated times as symbol-time pairs. When instructed by the volume accumulator **306** or timer **304** to output its contents, the buffer **308** may transfer its contents (symbol-time pairs) to the group boundary detector **309** so that the device **300** may determine a predetermined number of longest time durations between DTMF symbols and may insert group boundaries between the symbol-time pairs with the predetermined number of longest time durations.

The group boundary detector **309** may then drop the time component of the symbol-time pairs and transfer the DTMF symbol(s) with any inserted group boundaries to the filter **310**. The filter **310** may determine whether the DTMF symbol(s) convey information such as a valid phone number or is valid routing data.

The filter **310** may perform analysis of the DTMF symbol(s), including but not limited to, a pattern match in order to determine whether the DTMF symbol(s) convey information such as a valid phone number or other valid telephone routing data. If the DTMF symbol(s) is a valid phone number or is valid telephone routing data, the filter **310** may then transfer it to the output **312**. If the DTMF symbol(s) is not a valid phone number or other telephone routing data, the filter **310** may discard the DTMF symbol(s).

The output **312** may convey results in a format useful to humans or send the results to an output device. The output **312** may, for example, output to paper tape, create a record such as an electronic record for storage in memory on a computer, or send the results to an output device such as another computer or electronic device including but not limited to an electronic recording device.

FIG. **4** is an example flow diagram of a process **400** that may be performed by the device **300**. While each step of the process **400** in FIG. **4** is shown and described separately, multiple steps may be executed in a different order than what is shown, in parallel with each other, or concurrently with each other.

The device **300** starts at step **401** and may acquire an audio input (step **402**). The device **300** may then determine whether the audio includes DTMF symbols (step **404**), whether the audio is voice (step **406**), or whether the audio is silence (step **408**). If it is determined that a section of audio includes a DTMF symbol, the device **300** may store the DTMF symbol in buffer **308** (step **412**). The device **300** may then reset the timer **304** and the volume accumulator **306** (step **414**) in order to ensure that that section of audio is counted only once. Whenever a DTMF symbol is present, the timer **304** is reset so that the next section of audio begins after the DTMF symbol ends. After the device **300** has stored the DTMF symbol in the buffer **308** and reset the timer **304** and the volume accumulator **306**, the device **300** may then determine whether there is more audio (step **430**). If the device **300** determines that there is more input audio to process, the device **300** may execute the process **400** again.

If at step **404** it is determined that the section of audio is not a DTMF symbol, the device **300** may determine whether the section of audio meets the criteria to be voice (step **406**), which may indicate the end of a telephone number or other telephone routing data. To be voice, the audio must be above a predetermined volume threshold for a predetermined time duration and not contain any DTMF symbols. If a section of audio is voice, the device may reset the timer **304** (step **416**) in order to ensure that the audio is counted only once. The process then continues.

If at step **406** it is determined that the section of audio is not voice, the device **300** may determine whether the audio is silence (step **408**), which may indicate the end of a telephone number or other telephone routing data. To be silence, the section of audio, as determined by the timer **304**, must be longer than a predetermined duration of time (resulting from the timer **304** expiring because it was not reset by the DTMF decoder **302** or the volume accumulator **306**) and not contain either DTMF symbol(s) or voice as defined above. If the section of audio is not silence, the device **300** may discard the current section of audio (step **410**) because it is categorized as "other" audio.

After the device **300** has determined whether the section of audio includes DTMF symbol(s), is voice, or is silence, the device **300** may insert group boundaries via the group boundary detector **309** (step **419**). The filter **310** of the device **300** may then examine the contents of the buffer **308** to determine whether the stored contents convey information such as the format of a telephone number or other telephone routing data (step **418**). If the contents of the buffer **308** do not match a valid telephone number or valid telephone routing data, the device **300** may then clear the contents of the buffer **308** (step **422**).

If at step **418** it is determined that the contents of the buffer **308** do match a valid telephone number or valid telephone routing data, the device **300** may send the contents

of the buffer **308** to the output **312** (step **420**). The device **300** may then clear the contents of the buffer **308** (step **422**), which serves to reset the device **300** to begin processing a next group of DTMF symbols.

After the device **300** has determined whether the audio includes DTMF symbols (step **404**), whether the audio is voice (step **406**), or whether the audio is silence (step **408**) and the device **300** has sent the contents of the buffer **308** to output **312** (step **420**) and/or cleared buffer **308** (step **422**), the device **300** may then determine whether there is more audio (step **424**). If there is no more audio, the device **300** exits (step **426**). If the device **300** determines that there is more input audio to process, the device **300** may execute the process **400** again (step **401**).

FIG. **5** is an example flow diagram of a process **500** that may be performed by the group boundary detector **309** of the device **300**. While each step of the process **500** in FIG. **5** is shown and described separately, multiple steps may be executed in a different order than what is shown, in parallel with each other, or concurrently with each other. The group boundary detector **309** starts (step **501**) and then determines whether a sequence of symbol-time pairs (as received from the buffer **308**) has an access code (step **502**). An access code is a sequence of DTMF symbols dialed in order to access specific functionality in the telephone network. For example, in the United States, users are often required to dial 1 before the telephone number in order to access long distance dialing or to dial 011 for international dialing. If the sequence of symbol-time pairs has an access code, the group boundary detector **309** may remove the access code (step **504**). After removing the access code or if the symbol-time pairs does not have an access code, the group boundary detector **309** may zero the time component of the first symbol-time pair (step **506**). The group boundary detector **309** may then determine the longest inter-digit times and insert boundary symbols during those times (step **508**). The group boundary detector **309** may then remove the time component of the symbol-time pairs (step **510**) and end (step **512**) the process **500**.

FIG. **6** is a block diagram of an example device **600** that may implement any of the embodiments described herein. The device **600** may include a processor **601**, a memory **602**, a display **603**, and a communication interface **604** which may include a receiver, transmitter, or transceiver that is capable of communicating in a wired or wireless network, and which all may be in communication with one another and with any other associated components of the device **600** using any suitable type of communication such as via a bus **605**. The memory **602** may be any computer-readable medium or suitable device for electronic data storage. The processor **601** may be a programmed processor capable of executing computer-executable instructions that may be stored in memory **602** causing the device **600** to perform any of the methods described herein.

Having thus described the various embodiments, it is to be appreciated and will be apparent to those skilled in the art that the present embodiments are to be considered in all respects as illustrative and not restrictive. Although features and elements are described above in particular combinations, it is to be appreciated that each feature or element can be used alone or in any combination or sub-combination with or without the other features and elements. Any single embodiment described herein may be supplemented with one or more elements from any one or more of the other embodiments described herein. Any single element of an embodiment may be replaced with one or more elements from any one or more of the other embodiments described herein.

What is claimed:

1. An apparatus configured to identify a characteristic of information conveyed by dual-tone multi-frequency (DTMF) symbols, the apparatus comprising:

communication circuitry configured to receive an audio input;

a DTMF decoder coupled to the communication circuitry that is configured to decode DTMF symbols included in the audio input received from the communication circuitry and configured to transfer the decoded DTMF symbols to a buffer to be stored;

a timer coupled to the DTMF decoder and the buffer;

a volume accumulator coupled to the communication circuitry and the timer and configured to determine whether the audio input includes audio with volume above a predetermined threshold and configured to reset the timer when the audio input includes audio with volume above the predetermined threshold;

the buffer configured to receive an instruction from the timer or the volume accumulator to transfer each stored DTMF symbol to a filter; and

the filter configured to identify a characteristic of information conveyed by the DTMF symbols and further configured to send the identified characteristic information to an output device.

2. The apparatus of claim **1**, wherein the filter is further configured to identify a characteristic of the information conveyed by the DTMF symbols by matching the DTMF symbols to a pattern.

3. The apparatus of claim **2**, wherein the pattern is selected from the group consisting of a telephone number format and a telephone routing information format.

4. The apparatus of claim **1**, wherein the timer is configured to determine a time associated with when each DTMF symbol was received in the audio input and configured to transfer each associated time to the buffer to be stored, and wherein the buffer is further configured to transfer each associated time to a group boundary detector that is configured to receive the DTMF symbols and associated time from the buffer and determine a predetermined number of longest time durations in between certain of the DTMF symbols.

5. The apparatus of claim **4**, wherein the group boundary detector is further configured to identify groups of DTMF symbols where the time duration between symbols in a group is less than a time duration between groups of symbols.

6. The apparatus of claim **4**, wherein the predetermined number of longest time durations in between certain of the DTMF symbols is determined by a longest difference between an observed time duration and an expected time duration.

7. The apparatus of claim **4**, wherein the group boundary detector is further configured to determine whether the predetermined number of longest time durations indicate a domestic or international telephone number format.

8. The apparatus of claim **1**, wherein the timer is further configured to expire after a predetermined duration of time indicating silence included in the audio input.

9. The apparatus of claim **1**, wherein audio with volume above the predetermined threshold indicates voice included in the audio input.

10. The apparatus of claim **1**, wherein the output device is an electronic device with a memory for storage.

11. A method for identifying a characteristic of information conveyed by dual-tone multi-frequency (DTMF) symbols, the method comprising:

receiving, by communication circuitry, an audio input;

decoding, by a DTMF decoder coupled to the communication circuitry, each DTMF symbol included in the audio input received from the communication circuitry;

transferring, by the DTMF decoder, the decoded DTMF symbols to a buffer to be stored;

determining, by a volume accumulator coupled to the communication circuitry and a timer, whether the audio input includes audio with volume above a predetermined threshold;

resetting, by the volume accumulator, the timer when the audio input includes audio with volume above the predetermined threshold;

transferring, by the buffer, each stored DTMF symbol to a filter when instructed by the timer or the volume accumulator;

identifying, by the filter, a characteristic of information conveyed by the DTMF symbols; and

sending, by the filter, the identified characteristic information to an output device.

12. The method of claim 11, wherein the identifying comprises matching the DTMF symbols to a pattern.

13. The method of claim 12, wherein the pattern is selected from the group consisting of a telephone number format and a telephone routing information format.

14. The method of claim 11, wherein the timer is configured to determine a time associated with when each DTMF symbol was received in the audio input and configured to transfer each associated time to the buffer to be stored, and wherein the buffer is further configured to transfer each associated time to a group boundary detector that is configured to receive the DTMF symbols and associated time from the buffer and determine a predetermined number of longest time durations in between certain of the DTMF symbols.

15. The method of claim 14, wherein the group boundary detector is further configured to identify groups of DTMF symbols where the time duration between symbols in a group is less than a time duration between groups of symbols.

16. The method of claim 14, wherein the predetermined number of longest time durations in between certain of the DTMF symbols is determined by a longest difference between an observed time duration and an expected time duration.

17. The method of claim 14, wherein the group boundary detector is further configured to determine whether the predetermined number of longest time durations indicate a domestic or international telephone number format.

18. An apparatus configured to identify a characteristic of information conveyed by dual-tone multi-frequency (DTMF) symbols, the apparatus comprising:

communication circuitry configured to receive an audio input;

a programmed processor coupled to memory and configured to execute instructions stored in the memory;

the programmed processor further configured to determine whether the audio input includes at least one DTMF symbol;

if the audio input includes at least one DTMF symbol, the programmed processor further configured to store in the memory the at least one DTMF symbol;

the programmed processor further configured to determine whether the audio input includes audio with volume above a predetermined threshold;

if the audio input does not include audio with volume above the predetermined threshold, the programmed processor further configured to determine whether a timer expired;

if the audio input includes audio with volume above the predetermined threshold or the timer expired, the programmed processor further configured to determine whether the stored at least one DTMF symbol indicates a format of a telephone number; and

if the stored at least one DTMF symbol indicates the format of a telephone number, the communication circuitry further configured to send the stored at least one DTMF symbol to an output device.

19. The apparatus of claim 18, wherein the programmed processor is further configured to store in the memory a time associated with when the at least one DTMF symbol was received in the audio input and to determine a predetermined number of longest time durations in between certain of the stored at least one DTMF symbol.

20. The apparatus of claim 19, wherein the programmed processor is further configured to identify groups of DTMF symbols where the time duration between symbols in a group is less than a time duration between groups of symbols.

21. An apparatus configured to identify a characteristic of information conveyed by dual-tone multi-frequency (DTMF) symbols, the apparatus comprising:

communication circuitry configured to receive an audio input;

a DTMF decoder coupled to the communication circuitry that is configured to decode DTMF symbols included in the audio input received from the communication circuitry and configured to transfer the decoded DTMF symbols to a buffer to be stored;

a timer coupled to the DTMF decoder and the buffer;

a voice activity detector coupled to the communication circuitry and the timer and configured to determine whether the audio input includes voice information and configured to reset the timer when the audio input includes voice information for longer than a predetermined length of time;

the buffer configured to receive an instruction from the timer or the voice detector to transfer each stored DTMF symbol to a filter; and

the filter configured to match the DTMF symbols to a pattern and further configured to send the matched DTMF symbols to an output device.

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