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(54) **ADAPTIVE PLAYBACK SPEED OF A MEDIA STREAM BASED ON SYSTEM RESOURCES**

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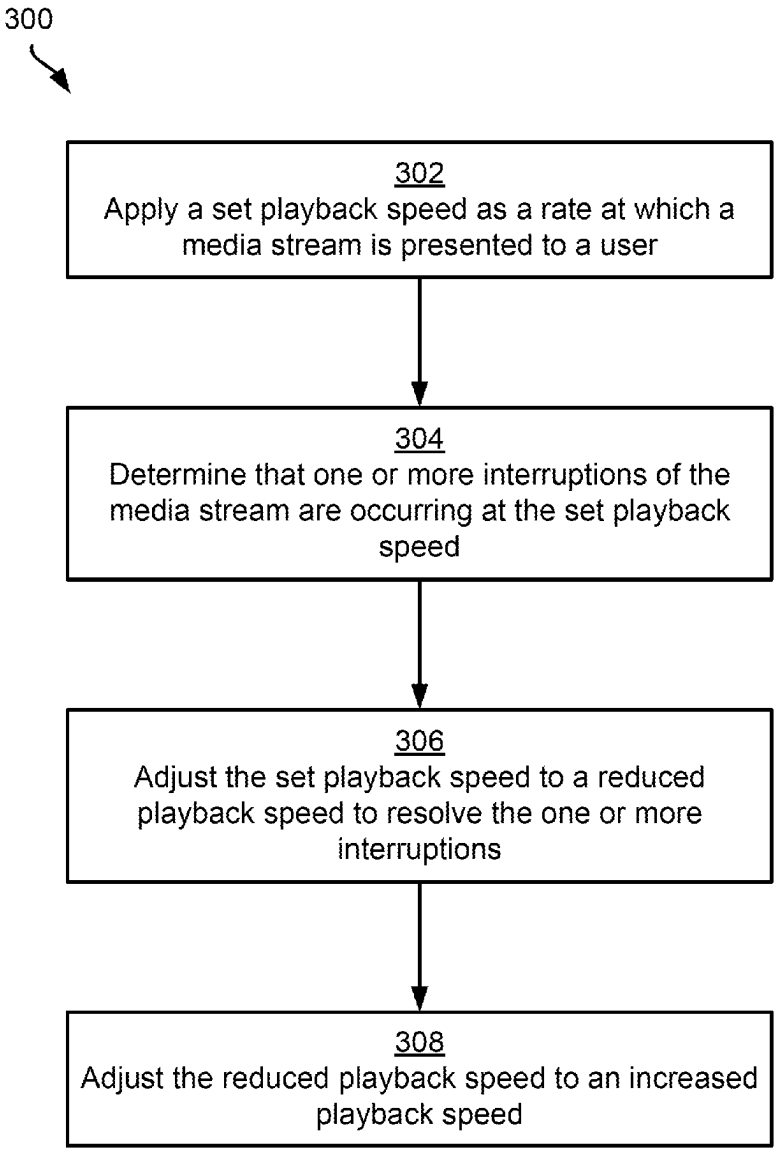
(57) **ABSTRACT**

A media playback system can be used to implement adaptive playback speed of a media stream based on an availability of system resources. In some aspects, the media playback system can apply a set playback speed as a rate at which the media stream is presented to a user. In response to applying the set playback speed to the media stream, the media playback system can determine that one or more interruptions of the media stream are occurring at the set playback speed. In response, the media playback system can adjust the set playback speed to a reduced playback speed to resolve the interruptions. Subsequently, the media playback system can adjust the reduced playback speed to an increased playback speed. The increased playback speed can be further adjusted based on whether the interruptions occur when the media stream is presented at the increased playback speed.



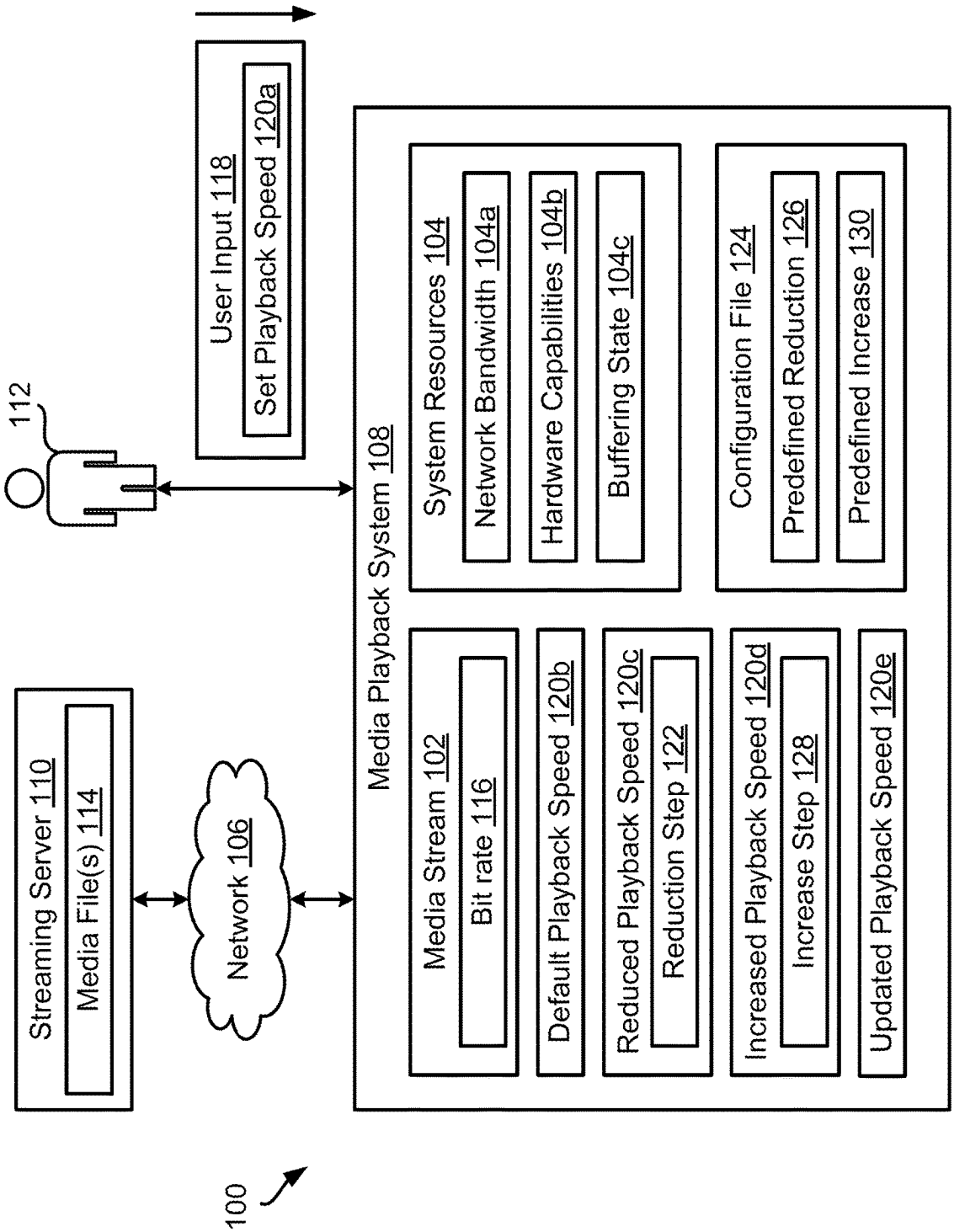

100
Streaming Server 110
Media File(s) 114
Network 106
112
User Input 118
Set Playback Speed 120a
Media Playback System 108
Media Stream 102
Bit rate 116
Default Playback Speed 120b
Reduced Playback Speed 120c
Reduction Step 122
Increased Playback Speed 120d
Increase Step 128
Updated Playback Speed 120e
System Resources 104
Network Bandwidth 104a
Hardware Capabilities 104b
Buffering State 104c
Configuration File 124
Predefined Reduction 126
Predefined Increase 130

FIG. 1

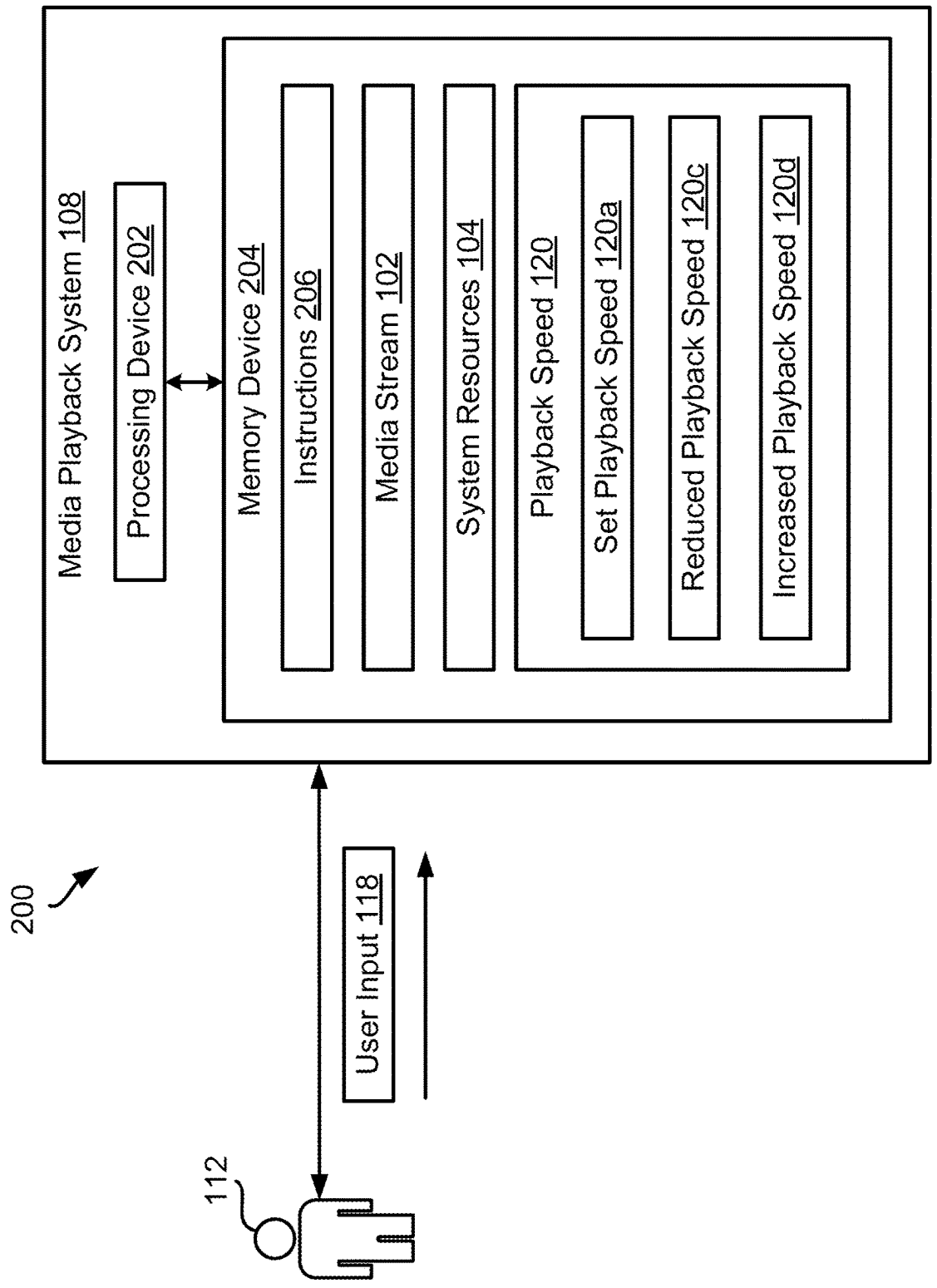

200
Media Playback System 108
Processing Device 202
Memory Device 204
Instructions 206
Media Stream 102
System Resources 104
Playback Speed 120
Set Playback Speed 120a
Reduced Playback Speed 120c
Increased Playback Speed 120d
User Input 118
112

FIG. 2

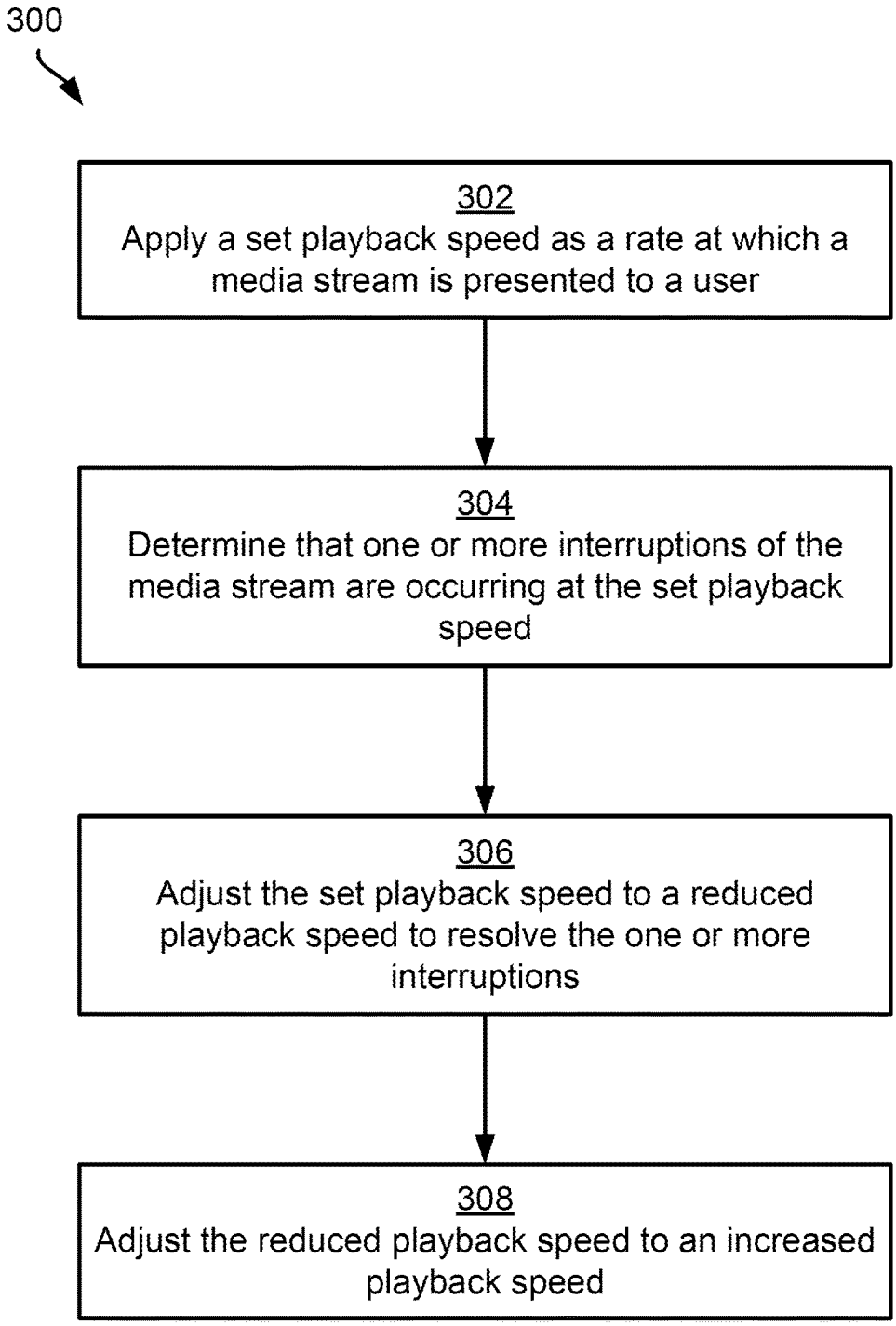

300
302
Apply a set playback speed as a rate at which a media stream is presented to a user
304
Determine that one or more interruptions of the media stream are occurring at the set playback speed
306
Adjust the set playback speed to a reduced playback speed to resolve the one or more interruptions
308
Adjust the reduced playback speed to an increased playback speed

FIG. 3

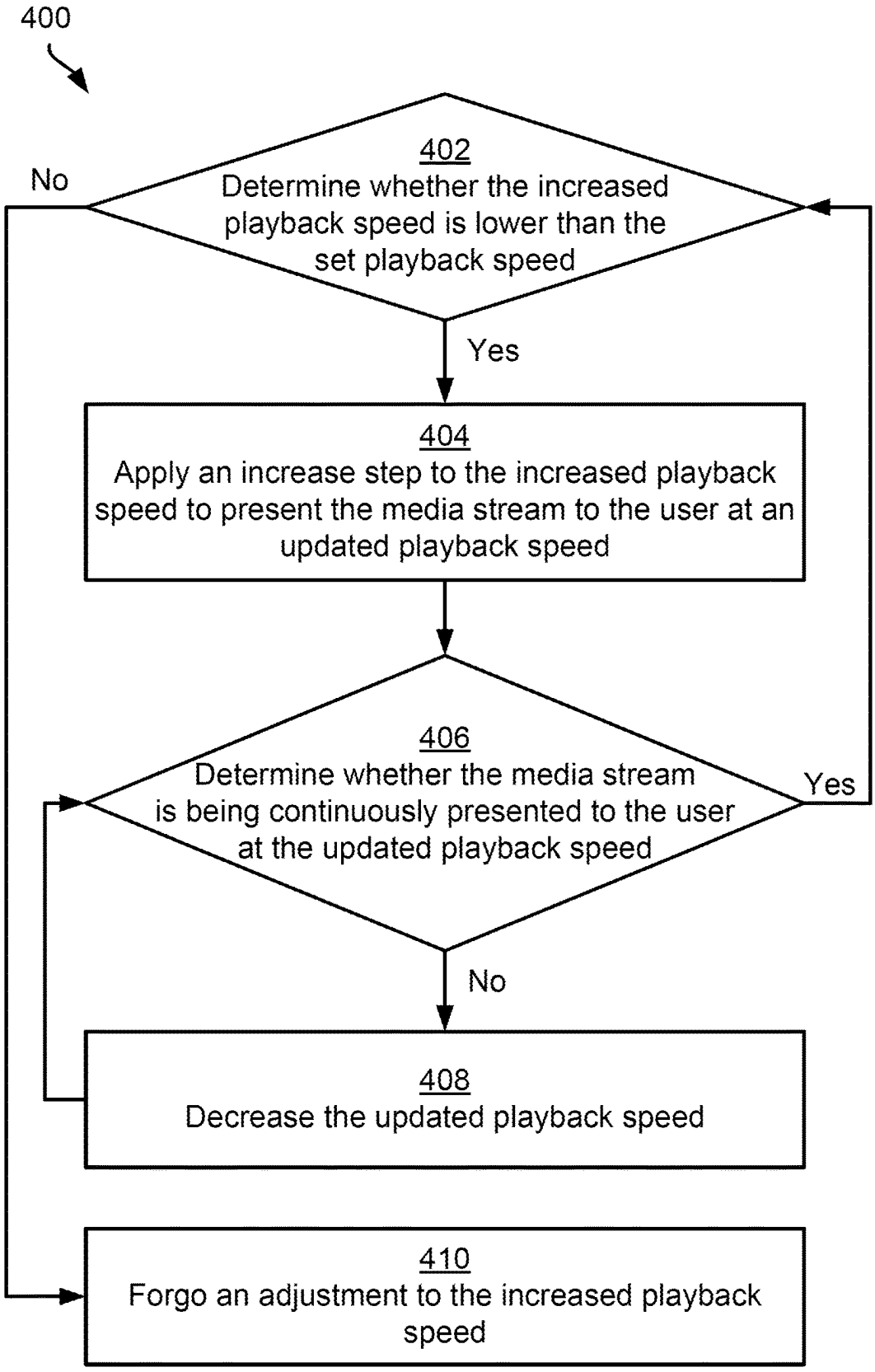

400
402
Determine whether the increased playback speed is lower than the set playback speed
No
Yes
404
Apply an increase step to the increased playback speed to present the media stream to the user at an updated playback speed
406
Determine whether the media stream is being continuously presented to the user at the updated playback speed
Yes
No
408
Decrease the updated playback speed
410
Forgo an adjustment to the increased playback speed

FIG. 4

ADAPTIVE PLAYBACK SPEED OF A MEDIA STREAM BASED ON SYSTEM RESOURCES

TECHNICAL FIELD

[0001] The present disclosure relates generally to media playback. More specifically, but not by way of limitation, this disclosure relates to adjusting a playback speed of a media stream based on system resources.

BACKGROUND

[0002] Media streaming involves a client device connecting to a network including one or more servers used to store and stream media files, such as those used to encode and present movies, television shows, audiobooks, etc. The client device includes functions to adjust a playback speed of a media stream to speed up or slow down the presentation of a media file. The client device can receive user input generated by a user selecting a predefined playback speed via a user interface outputted by the client device.

[0003] The media files are typically divided into one or more segments that can be loaded by the client device for media streaming. Downloading individual portions of the segments to play a media stream can be referred to as buffering. Once the portion of the segments is loaded by the client device, the user can begin receiving the presentation of the media file prior to loading the entire media file. If a connection to the network is briefly interrupted, the client device can continue streaming the pre-loaded segments of the media file such that the presentation of the media file remains uninterrupted for the user.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** is a block diagram of an example of a computing environment for adaptive playback speed of a media stream based on system resources according to some aspects of the present disclosure.

[0005] FIG. **2** is a block diagram of another example of a computing environment for adaptive playback speed of a media stream based on system resources according to some aspects of the present disclosure.

[0006] FIG. **3** is a flowchart of a process for adjusting a playback speed of a media stream based on system resources according to some aspects of the present disclosure.

[0007] FIG. **4** is a flowchart of a process for adjusting an increased playback speed of a media stream based on system resources according to some aspects of the present disclosure.

DETAILED DESCRIPTION

[0008] Playing a media file, such as a digital video presentation from an Internet-based streaming service, involves loading one or more segments of the media file to display video, audio, or a combination thereof as a media stream. A media playback system can select a suitable version of the media file to download based on available system resources, such as bandwidth or processing power, to support the media stream. Each version of the media file can support a different bit rate with respect to data transfer. The media playback system can load one or more segments of the selected version of the media file as part of a buffering process before presenting the media stream to the user.

[0009] Before or while the media playback system presents the media stream to the user, the user can define a set playback speed of the media stream. If the set playback speed causes the media playback system to play the loaded segments faster than the buffering process can load remaining segments of the media file, the user can experience continual interruptions of the media stream. As a result, the user may become frustrated by delays in playing the media file and may manually adjust one or more parameters (e.g., playback speed, video resolution, etc.) associated with playing the media file. But these actions can be disruptive of the user's experience when viewing or listening to the media stream. In some cases, if the media playback system detects one or more interruptions to playing the media file due to a lack of system resources, the media playback system can downgrade to a different version of the media file associated with a relatively low bit rate. But lowering the bit rate of the media file typically reduces the quality of the media stream, such as a resolution of a video, thereby adversely affecting the user's experience of the media stream.

[0010] Some examples of the present disclosure can overcome one or more of the issues mentioned above by adjusting a playback speed of a media stream based on system resources. A media playback system can receive user input indicating a set playback speed at which to present the media stream to the user. Presenting the media stream at the set playback speed may consume more system resources compared to presenting the media stream at a default playback speed. In some cases, the media stream may experience one or more interruptions (e.g., stop intermittently) due to a lack of system resources to support a current bit rate associated with the media file being played to generate the media stream. Based on the interruptions, the media playback system can modify the playback speed of the media stream to resolve the interruptions of the media stream while maintaining the current bit rate used to provide the media stream to the user. Accordingly, by implementing an adaptive playback speed with respect to the media stream, the media playback system can facilitate continuous streaming of the media stream despite fluctuations in an availability of system resources.

[0011] In one particular example, a user may select video content to watch and listen to by interacting with the media playback system. Based on the video content selected by the user, the media playback system can request one or more media files associated with the video content from a streaming server that can store one or more versions of the media files. The media files can include audio files, video files, or a combination thereof. Each version of the media files can correspond to a different quality level, such as different resolution levels. After downloading at least a portion of the media files, the media playback system can initiate a media stream based on the media files to present the video content to the user at a default playback speed. For instance, the media playback system may include instructions to decode the downloaded media files to output audio via a speaker based on audio files and to output suitable pixels via a user interface based on video files.

[0012] While the video content is being presented to the user, the user may provide user input to increase the default playback speed of the media stream, such as by indicating a set playback speed that is faster than the default playback speed of the media stream. The set playback speed may cause the media stream to be presented to the user faster than the media playback system can download additional portions of the media files. Consequently, the media stream may

stop playing until the media playback system can download the additional portions of the media files, resulting in delays associated with experiencing the video content. In other words, the media playback system may detect one or more interruptions in the media stream while presenting the media stream to the user at the set playback speed.

[0013] To resolve the interruptions in the media stream while maintaining the quality of the media stream, the media playback system can modify the playback speed of the media stream at a particular point in time, such as the set playback speed. Iteratively determining whether the media stream has stopped and performing a suitable adjustment to the playback speed can be referred to as adaptive playback speed. For example, the media playback system may modify the set playback speed by applying a reduction step to decrease the set playback speed. In other words, the media playback system can reduce the set playback speed to a reduced playback speed that is slower than the set playback speed. Once the media playback system applies the reduction step to the set playback speed, the media playback system may monitor the media stream to iteratively modify a current playback speed of the media stream based on one or more conditions. For instance, the media playback system may modify the current playback speed of the media stream based on whether the media stream is experiencing interruptions at the current playback speed. Additionally or alternatively, the media playback system can monitor the media stream to whether the current playback speed is lower than the set playback speed indicated by the user.

[0014] After applying the reduction step, the media playback system can determine whether the interruptions are still occurring in the media stream when the media stream is presented to the user at the reduced playback speed. If the media stream continues to have interruptions, the media playback system can further reduce the reduced playback speed by iteratively applying the reduction step until the media stream is continuously presented (e.g., without interruptions) to the user. On the other hand, if the media stream is continuously presented to the user at the reduced playback speed, the media playback system can check whether the reduced playback speed is lower than the set playback speed. If the reduced playback speed is lower than the set playback speed, the media playback system can increase the reduced playback speed by applying an increase step to the reduced playback speed. Conversely, if the reduced playback speed is higher than or the same as the set playback speed, the media playback system can continue to present the media stream to the user at the reduced playback speed.

[0015] Illustrative examples are given to introduce the reader to the general subject matter discussed herein and are not intended to limit the scope of the disclosed concepts. The following sections describe various additional features and examples with reference to the drawings in which like numerals indicate like elements, and directional descriptions are used to describe the illustrative aspects, but, like the illustrative aspects, should not be used to limit the present disclosure.

[0016] FIG. **1** is a block diagram of an example of a computing environment **100** for adaptive playback speed of a media stream **102** based on system resources **104** according to some aspects of the present disclosure. Components within the computing environment **100** may be communicatively coupled via a network **106**, such as a local area network (LAN), wide area network (WAN), the Internet, or any combination thereof. For example, the computing environment **100** can include a media playback system **108** and a streaming server **110** that are communicatively coupled through the network **106**. In some examples, the media playback system can include a computing device, such as a desktop computer, laptop computer, server, mobile phone, or tablet. Through the network **106**, the media playback system **108** can receive source content from the streaming server **110** that is associated with digital media that the media playback system **108** can present to a user **112** as a media stream **102**. Presenting the media stream **102** to the user **112** can involve providing the digital media for display, listening, or other suitable consumption by the user **112**. The media stream **102** can include audio content, video content, or a combination thereof. Examples of the digital media can include audiobooks, podcasts, webcasts, television shows, video games, online videos, etc.

[0017] In some cases, the media playback system **108** may receive the source content as one or more media files **114** hosted by a computing system, such as the streaming server **110**, that can be separate from the media playback system **108**. For example, the streaming server **110** can be remote from the media playback system **108** such that the streaming server **110** and the media playback system **108** may be physically positioned in separate locations. Generating the media files **114** of the source content can involve creating multiple versions of the source content that can be encoded based on compatibility with different system resources, such as bandwidth. For example, an encoder can encode the source content at multiple bit rates to generate the media files **114** of the source content. Each bit rate can support a different amount of data used to represent the source content such that a higher bit rate can provide a media stream with a higher quality compared to a lower bit rate. When obtaining the media files **114** from the streaming server **110**, the media playback system **108** can select a suitable version of the source content based on a current availability of the system resources **104**. In other words, the media playback system **108** can select a particular media file stored in the streaming server **110** to provide a media stream **102** of the source content with a suitable quality level based on the system resources **104** that are currently available.

[0018] The quality level of the media stream **102** can affect an amount of system resources **104** (e.g., processing power, memory, network bandwidth **104***a*, etc.) used by the media playback system **108** to present the media stream **102** to the user **112**. For example, the quality level of a video can correspond to a resolution used to present the video to the user **112**. Providing the video at a higher resolution (e.g., 4K resolution) can require more system resources **104**, such as the network bandwidth **104***a*, compared to providing the video at a lower resolution, such as 1440p. As an illustrative example, 4K resolution can include approximately 4000 pixels in width, whereas 1440p typically includes approximately 2560 pixels in width. Consequently, providing the video using 4K resolution can require larger amounts of data transfer compared to providing the video in **1440***p* resolution, thereby resulting in a higher consumption of the system resources **104**.

[0019] To present the media stream **102** to the user **112**, the media playback system **108** can retrieve (e.g., download or request) the media files **114** from the streaming server **110** via the network **106**. After the user **112** initiates the media stream **102**, the media playback system **108** can initially

request the lowest quality level available with respect to the media files **114**. If the availability of the system resources **104** changes, the media playback system **108** can adjust a bit rate **116** associated with the media stream **102** by selecting a different version of the media stream **102** to provide to the user **112**. For example, the media playback system **108** may detect that a throughput of the network **106** is greater than a bit rate **116** corresponding to the media stream **102**. Accordingly, the media playback system **108** can transmit a request to the streaming server **110** to obtain suitable media files corresponding to a different media stream that has a higher bit rate.

[0020] Each encoding of the source content can be divided into one or more segments (e.g., one or more multi-second sections). In some examples, the media playback system **108** can continually download a portion of the segments, rather than downloading the entire media file **114** at once. For example, the media playback system **108** may store the portion of the segments in a memory buffer (e.g., random access memory (RAM)). Once the portion of the segments is downloaded, the media playback system **108** can load the portion of the segments to present a corresponding subset of the source content to the user **112** while continuing to download additional portions of the segments. This process can be referred to as buffering. Delays in presenting the media stream **102** to the user **112** can occur if the media playback system **108** lacks the system resources **104** to download the additional portions of the segments faster than the media stream **102** is presented. For example, based on the system resources **104** that are available, the media playback system **108** may download an additional portion of the segments in a minute. If the media stream **102** reaches a buffering point after 30 seconds when presented at a playback speed of 2× speed, the user **112** may continue to experience interruptions if the availability of the system resources **104** remains the same.

[0021] In some cases, the user **112** may provide user input **118** to the media playback system **108** adjust a playback speed **120** corresponding to the media stream **102**. For example, the user input **118** can indicate a set playback speed **120***a* of the media stream **102**. The user **112** may interact with a user interface outputted by the media playback system **108** to update a current playback speed of the media stream **102** to the set playback speed **120***a*. In some examples, the current playback speed of the media stream **102** may be a default playback speed **120***b* of the media playback system **108**. In some implementations, the user **112** may provide a set playback speed **120***a* that is faster than the default playback speed **120***b* to experience the media stream **102** using less time compared to the default playback speed **120***b*. For example, the user **112** can consume thirty minutes of video content in fifteen minutes when the video content is presented at a set playback speed **120***a* of 2× speed that is twice as fast as a default playback speed **120***b* of 1× speed. In other implementations, the user **112** can slow down the media stream **102** by indicating a set playback speed **120***a* that is slower than the default playback speed **120***b*. For example, if the user **112** has difficulty understanding an audiobook when played at the default playback speed **120***b*, the user **112** can indicate the set playback speed **120***a* to decrease the default playback speed **120***b*. Adjusting the default playback speed **120***b* may affect an audio pitch of the media stream **102**. Typically, the quality level of the media stream **102** can remain unaffected if the default playback speed **120***b* is modified.

[0022] In some examples, the user **112** may indicate the set playback speed **120***a* while the media stream **102** is being presented to the user **112**, such as while an audiobook is playing. For example, the user can interact with the user interface to indicate a set playback speed **120***a* to replace the current playback speed of an audiobook while the audiobook is playing. In other examples, the user **112** may select or input the set playback speed **120***a* when the media stream **102** is not playing, such as prior to starting to play the media stream **102** or while the media stream **102** is paused.

[0023] The set playback speed **120***a* may be faster or slower than the current playback speed of the media stream **102**. Increasing the current playback speed of the media stream **102** can result in an increased consumption of the system resources **104** used by the media playback system **108** to present the media stream **102** to the user **112**. In some examples, one or more interruptions may occur in the media stream **102** being presented at the set playback speed **120***a*, such as due to a lack of system resources **104** to continue presenting the media stream **102** using the set playback speed **120***a*. The media playback system **108** can differentiate between interruptions affecting the media stream **102** and pauses caused by the user **112** (e.g., by providing user input **118** to temporarily stop the media stream **102**). For example, the media playback system **108** may monitor a progress of the media stream **102** to determine whether the media stream **102** is experiencing interruptions. When monitoring the media stream **102**, the media playback system **108** can check the progress of the media stream **102** at one or more intervals to determine whether the progress has increased as expected based on a comparison with an expected value. If the progress is less than the expected value, the media playback system **108** can determine that the media stream **102** has stopped and for how long the media stream **102** has stopped. Additionally, the media playback system **108** can determine whether the user **112** has provided the user input **118** to pause the media stream **102**. Accordingly, the media playback system **108** can confirm whether the media stream **102** has stopped due to interruptions caused by the lack of system resources **104** or due to the user input **118**.

[0024] In some implementations, if the media stream **102** is being continuously presented to the user **112**, the media playback system **108** may continue to present the media stream **102** to the user **112** at the set playback speed **120***a*. In other implementations, if the media playback system **108** detects the interruptions in the media stream **102**, the media playback system **108** can implement a reduced playback speed **120***c* to resolve the interruptions. The reduced playback speed **120***c* can refer to a playback speed that is slower than the set playback speed **120***a*. The media playback system **108** can generate the reduced playback speed **120***c* by applying at least one reduction step **122** to the set playback speed **120***a*. In some examples, prior to implementing the reduced playback speed **120***c*, the media playback system **108** can determine whether the set playback speed **120***a* is lower than the default playback speed **120***b* associated with the media stream **102**. For example, by default, the media playback system **108** may present the media stream **102** at **1**× speed as the default playback speed **120***b*. The default playback speed **120***b* can correspond to

how media content provided in the media stream **102** was created. For example, when a podcast is presented at the default playback speed **120***b*, the user **112** can listen to the podcast based on a speech tempo of a podcast creator as recorded. Slowing the playback speed **120** past the default playback speed **120***b* can adversely affect the user's experience of the media stream **102**. As a result, the media playback system **108** may avoid decreasing the playback speed **120** of the media stream **102** to below the default playback speed **120***b*.

[0025] If the set playback speed **120***a* is equal to or lower than the default playback speed **120***b*, the media playback system **108** can adjust the bit rate **116** of the media stream **102** to resolve the interruptions of the media stream **102**. As described above, adjusting the bit rate **116** of the media stream **102** can modify an amount of the system resources **104** used to present the media stream **102** to the user **112**, thereby affecting the quality level of the media stream **102**. For example, the media playback system **108** can decrease the bit rate **116** by selecting the media files **114** from the streaming server **110** that correspond to another version of the source content that is encoded for a lower bit rate. By decreasing the bit rate **116**, the media playback system **108** can reduce the system resources **104** used to present the media stream **102** to the user **112**. This process of adjusting the bit rate **116** can be referred to as adaptive bit rate streaming.

[0026] In examples in which the set playback speed **120***a* is higher or faster than the default playback speed **120***b*, the media playback system **108** can apply the reduction step **122** to the set playback speed **120***a*. The media playback system **108** may obtain the reduction step **122** from a configuration file **124** of the media playback system **108** that can indicate a predefined reduction **126** corresponding to the reduction step **122**. For example, the media playback system **108** can read the configuration file **124** to determine that the set playback speed **120***a* is to be reduced by a predefined reduction **126** of 0.25× speed. The predefined reduction **126** may vary based on whether the reduction step **122** is being applied to a set playback speed **120***a* indicated by the user **112**. For example, the predefined reduction **126** may have a different value (e.g., a higher value or a lower value) if the reduction step **122** is being applied to the set playback speed **120***a* compared to another playback speed that has already been modified. In other examples, the media playback system **108** may determine the reduction step **122** based on the system resources **104** that are available to present the media stream **102** to the user **112**.

[0027] Examples of the system resources **104** can include the network bandwidth **104***a*, hardware capabilities **104***b* associated with the media playback system **108**, a buffering state **104***c*, or a combination thereof. In some cases, the network bandwidth **104***a* can correspond to a maximum rate of data transfer between the media playback system **108** and the streaming server **110** via the network **106**. Additionally or alternatively, the network bandwidth **104***a* can indicate an average rate of successful data transfer between the media playback system **108** and the streaming server **110**. The hardware capabilities **104***b* of the media playback system **108** can correspond to a utilization of hardware components such as a central processing unit (CPU), a graphics processing unit (GPU), data storage, random access memory (RAM), etc. The buffering state **104***c* can indicate how much (e.g., a percentage) of the segments has already been buffered (e.g., downloaded). The media playback system **108** can present the segments that have already been buffered to the user **112** without interruptions.

[0028] Once the media playback system **108** has applied the reduction step **122** to the set playback speed **120***a*, the media playback system **108** can monitor the media stream **102** while presenting the media stream **102** to the user **112** at the reduced playback speed **120***c*. In some cases, the media playback system **108** may determine that the interruptions in the media stream **102** are ongoing, such as based on the media stream **102** having stopped at least once when presented at the reduced playback speed **120***c*. To resolve the interruptions, the media playback system **108** can iteratively reduce the playback speed **120** of the media stream **102** by applying the reduction step **122** to modify the reduced playback speed **120***c* to resolve the interruptions. The playback speed **120** can refer to a current playback speed of the media stream **102**, such as after applying the reduction step **122** to the reduced playback speed **120***c*. The media playback system **108** may iteratively reduce the playback speed **120** of the media stream **102** until the interruptions are resolved or until the playback speed **120** is equal to the default playback speed **120***b*. The playback speed **120** can update with each iteration to reflect the current playback speed. For example, after each iteration of applying the reduction step **122**, the media playback system **108** can check whether the interruptions have been resolved to determine whether to continue reducing the playback speed **120**. Additionally, the media playback system **108** can compare the playback speed **120** to the default playback speed **120***b* after each iteration of applying the reduction step **122** to avoid reducing the playback speed **120** lower than the default playback speed **120***b*. In some implementations, the media playback system **108** may reduce the reduced playback speed **120***c* by the predefined reduction **126** used to decrease the set playback speed **120***a* to the reduced playback speed **120***c*. In other implementations, the reduction step **122** applied at each iteration may be determined by the media playback system **108** based on the system resources **104** that are available at a corresponding point in time.

[0029] In some examples, the media playback system **108** may determine that presenting the media stream **102** at the reduced playback speed **120***c* resolves the interruptions of the media stream **102**. The media playback system **108** then can compare the reduced playback speed **120***c* to the set playback speed **120***a* to determine whether to increase the reduced playback speed **120***c*. In some cases, the media playback system **108** may compare the reduced playback speed **120***c* to the set playback speed **120***a* after a predefined time window has passed. For example, the media playback system **108** can confirm that the media stream **102** has been uninterrupted for at least one minute when presented at the reduced playback speed **120***c* before comparing the reduced playback speed **120***c*. In any case, if the media playback system **108** determines that the reduced playback speed **120***c* is lower than the set playback speed **120***a*, the media playback system **108** can increase the reduced playback speed **120***c*. For example, the media playback system **108** can apply at least one increase step **128** to the reduced playback speed **120***c* to present the media stream **102** at an increased playback speed **120***d*. In some cases, the increased playback speed **120***d* may be faster than the reduced playback speed **120***c* while being slower than the set playback

speed **120***a*. Consequently, the media playback system **108** may apply at least one additional increase step to modify the increased playback speed **120***d* of the media stream **102** to match the set playback speed **120***a*.

[0030] Similar to the reduction step **122** described above, the media playback system **108** can obtain the increase step **128** from the configuration file **124** or based on the system resources **104** that are available. For example, the configuration file **124** may indicate a predefined increase **130** corresponding to the increase step **128** to increase the reduced playback speed **120***c*. As another example, the media playback system **108** can determine the increase step **128** by implementing a calculation process that accounts for the system resources **104** as variables that affect a magnitude of the increase step **128**. A respective impact of each system resource on the magnitude of the increase step **128** may be different such that the calculation process may assign a different weight to each system resource when determining the increase step **128**. For example, the network bandwidth **104***a* may have a greater impact on how much the reduced playback speed **120***c* is increased compared to CPU usage. The calculation process described above with respect to determining the increase step **128** similarly can be implemented to determine the reduction step **122**.

[0031] The media playback system **108** can adjust the increased playback speed **120***d* based on whether the media stream **102** is continuously presented to the user **112** at the increased playback speed **120***d*. In some examples, increasing the reduced playback speed **120***c* can cause the media stream **102** to stop for buffering (e.g., to load additional segments of the media files **114**). For example, the media playback system **108** may have insufficient system resources to continuously present the media stream **102** to the user **112** at the increased playback speed **120***d*. Consequently, the media playback system **108** may reduce the increased playback speed **120***d* to resolve the interruptions to the media stream **102**. For example, the media playback system **108** can revert the increased playback speed **120***d* to the reduced playback speed **120***c*, such as by applying a reduction step **122** that is equal in magnitude to the increase step **128**. As another example, the media playback system **108** may reduce the increased playback speed **120***d* by a reduction step **122** determined based on an availability of the system resources **104** at a current time. Accordingly, the reduction step **122** may be greater than or less than in magnitude compared to the increase step **128**.

[0032] Additionally, the media playback system **108** can adjust the increased playback speed **120***d* based on whether the increased playback speed **120***d* is lower than the set playback speed **120***a*. In some examples, if the media playback system **108** determines that the increased playback speed **120***d* is lower than the set playback speed **120***a*, the media playback system **108** can further increase the increased playback speed **120***d*. For example, the media playback system **108** can apply an increase step **128** to the increased playback speed **120***d* to present the media stream **102** to the user **112** at an updated playback speed **120***e*. Once the media playback system **108** is presenting the media stream **102** at the updated playback speed **120***e*, the media playback system **108** can determine whether the media stream **102** is experiencing interruptions. If the media playback system **108** detects that the interruptions are present and caused by a lack of the system resources **104**, the media playback system **108** can decrease the updated playback speed **120***e* to resolve the interruptions.

[0033] In other examples, the media playback system **108** can determine that the increased playback speed **120***d* is equal to or higher than the set playback speed **120***a*. Consequently, the media playback system **108** can forgo an adjustment (e.g., applying the reduction step **122** or increase step **128**) to the increased playback speed **120***d*. In some cases, the set playback speed **120***a* can function as a playback speed threshold such that increases to the increased playback speed **120***d* are determined by the media playback system **108** to meet but not exceed the set playback speed **120***a*.

[0034] While FIG. **1** depicts a specific arrangement of components, other examples can include more components, fewer components, different components, or a different arrangement of the components shown in FIG. **1**. For instance, in other examples, the media playback system **108** may be communicatively coupled via the network **106** with more than one streaming server to stream different types of media content. Each streaming server may host a respective type of media content. Additionally, any component or combination of components depicted in FIG. **1** can be used to implement the process(es) described herein. As described herein, the playback speed **120** can refer to any suitable playback speed of the media stream **102** during an adaptive playback speed process. For example, the playback speed **120** may refer to the set playback speed **120***a*, the default playback speed **120***b*, the reduced playback speed **120***c*, the increased playback speed **120***d*, or the updated playback speed **120***e*.

[0035] FIG. **2** is a block diagram of another example of a computing environment **200** for adaptive playback speed of a media stream **102** based on system resources **104** according to some aspects of the present disclosure. The computing environment **200** can include a processing device **202** communicatively coupled to a memory device **204**. In some examples, the computing environment **200** may include additional components not pictured in FIG. **2**, such as an input device, an output device, etc.

[0036] The processing device **202** can include one processing device or multiple processing devices. The processing device **202** can be referred to as a processor. Non-limiting examples of the processing device **202** include a Field-Programmable Gate Array (FPGA), an application-specific integrated circuit (ASIC), and a microprocessor. The processing device **202** can execute instructions **206** stored in the memory device **204** to perform operations. In some examples, the instructions **206** can include processor-specific instructions generated by a compiler or an interpreter from code written in any suitable computer-programming language, such as C, C++, C#, Java, Python, or any combination of these.

[0037] The memory device **204** can include one memory device or multiple memory devices. The memory device **204** can be non-volatile and may include any type of memory device that retains stored information when powered off. Non-limiting examples of the memory device **204** include electrically erasable and programmable read-only memory (EEPROM), flash memory, or any other type of non-volatile memory. At least some of the memory device **204** includes a non-transitory computer-readable medium from which the processing device **202** can read instructions **206**. A computer-readable medium can include electronic, optical, mag-

netic, or other storage devices capable of providing the processing device **202** with the instructions **206** or other program code. Non-limiting examples of a computer-readable medium include magnetic disk(s), memory chip(s), ROM, random-access memory (RAM), an ASIC, a configured processor, and optical storage.

[0038] In some examples, the processing device **202** can implement an adaptive playback speed technique to adjust a playback speed **120** at which a media stream **102** is presented to a user **112**. The adaptive playback speed technique can involve adjusting the playback speed **120** of the media stream **102** based on system resources **104** that are available at a particular point in time. Presenting the media stream **102** to the user **112** can involve loading a media file **114** that has been divided into one or more portions. Once a particular portion of the media file **104** has been loaded, the processing device **202** can begin presenting the media stream **102** based on the particular portion of the media file **114**. The processing device **202** can receive a set playback speed **120***a* provided by the user **112**, such as via an input/output device (e.g., a keyboard, a mouse, a touchscreen, etc.).

[0039] After receiving the set playback speed **120***a*, the processing device **202** can apply the set playback speed **120***a* to the media stream **102**. Once the media stream **102** is being presented to the user **112** at the set playback speed **120***a*, the processing device **202** can determine whether one or more interruptions of the media stream **102** are occurring at the set playback speed **120***a*. For example, the processing device **202** can detect that the media stream **102** has stopped to allow for a buffering process to load additional portions of the media file **114** to continue the media stream **102**. In response to determining that the interruptions of the media stream **102** are occurring at the set playback speed **120***a*, the processing device **202** can adjust the set playback speed **120***a* to a reduced playback speed **120***c* to resolve the interruptions. After resolving the interruptions of the media stream **102**, the processing device **202** can adjust the reduced playback speed **120***c* to an increased playback speed **120***d*. If the processing device **202** detects any interruptions to the media stream **102** when presenting the media stream **102** to the user **112** at the increased playback speed **120***d*, the processing device **202** can reduce the increased playback speed **120***d*. For example, the processing device **202** may revert the adjustment from the reduced playback speed **120***c* to the increased playback speed **120***d* until the system resources **104** can support the increased playback speed **120***d*.

[0040] FIG. **3** is a flowchart of a process **300** for adjusting a playback speed **120** of a media stream **102** based on system resources **104** according to some aspects of the present disclosure. In some examples, the processing device **202** can perform one or more of the steps shown in FIG. X. In other examples, the processing device **202** can implement more steps, fewer steps, different steps, or a different order of the steps depicted in FIG. **3**. The steps of FIG. **3** are described below with reference to components discussed above in FIGS. **1-2**.

[0041] In block **302**, the processing device **202** applies a set playback speed **120***a* as a rate at which a media stream **102** is presented to a user **112**. The processing device **202** can receive the set playback speed **120***a* as part of user input **118** generated by the user **112**, for example by the user **112** interacting with an input device that can be communicatively coupled to the processing device **202**. After determining the set playback speed **120***a* based on the user input **118**, the processing device **202** can apply the set playback speed **120***a* to configure the rate at which the media stream **102** is presented to the user **112**. In some examples, applying the set playback speed **120***a* may involve increasing or decreasing a default playback speed **120***b* (e.g., 1× speed) associated with the media stream **102**. For example, the processing device **202** may apply a set playback speed **120***a* of 1.25× speed to increase the default playback speed **120***b* of 1× speed for an audiobook being presented to the user **112** using a mobile device.

[0042] In block **304**, the processing device **202** determines that one or more interruptions of the media stream **102** are occurring at the set playback speed **120***a*. The interruptions can be caused by a lack of system resources **104** (e.g., network bandwidth **104***a*, hardware capabilities **104***b*, buffering state **104***c*, etc.). For example, the processing device **202** may detect that the media stream **102** has stopped at least once to enable a media file **114** corresponding to the media stream **102** to continue loading via a buffering process. In some cases, the processing device **202** can differentiate the interruptions of the media stream **102** that are caused by the lack of the system resources **104** from a pause of the media stream **102** initiated by the user **112**. Continuing the example provided in block **302**, the processing device **202** can detect that the user **112** has interacted with a user interface of the mobile device to pause the media stream **102** corresponding to the audiobook. As a result of determining that a particular interruption to the media stream **102** is initiated or related to the user **112**, the processing device **202** can avoid modifying the set playback speed **120***a* based on the particular interruption.

[0043] In block **306**, in response to determining that the one or more interruptions of the media stream **102** are occurring, the processing device **202** adjusts the set playback speed **120***a* to a reduced playback speed **120***c* to resolve the interruptions of the media stream **102**. For example, if the processing device **202** determines that the audiobook has stopped to continue downloading the audiobook from a streaming server **110**, the processing device **202** may apply a reduction step **122** to the 1.25× speed of the audiobook. In some examples, the processing device **202** may determine the reduction step **122** based on a predefined reduction **126** defined in a configuration file **124** accessible by the processing device **202**. For example, the processing device **202** can obtain a predefined reduction **126** of 0.25× speed from the configuration file **124** and apply the predefined reduction **126** as the reduction step **122** to decrease the set playback speed **120***a*. Accordingly, the processing device **202** may apply the reduction step **122** to the set playback speed **120***a* of 1.25× speed to present the audiobook at a reduced playback speed **120***c* of 1× speed.

[0044] In other examples, the processing device **202** can determine the reduction step **122** by analyzing the system resources **104** that are available to support the media stream **102**. For example, the processing device **202** may calculate the reduction step **122** based on an amount of the network bandwidth **104***a* that is available to download the media file **114** associated with the audiobook from the streaming server **110**. As another example, the processing device **202** may provide a respective indication of the system resources **104** that are available to a machine-learning model trained to output the reduction step **122** based on an amount of available system resources.

[0045] In block **308**, subsequent to resolving the one or more interruptions of the media stream **102**, the processing device **202** adjusts the reduced playback speed **120***c* to an increased playback speed **120***d*. In some examples, the processing device **202** may apply an increase step **128** to the reduced playback speed **120***c* based on a predefined increase **130** to present the media stream **102** at the increased playback speed **120***d*. For example, the processing device **202** can read a configuration file **124** to identify a predefined increase **130** of 0.1× speed indicated in the configuration file **124** to modify the reduced playback speed **120***c* of 1× speed for the audiobook. After obtaining the predefined increase **130** from the configuration file **124**, the processing device **202** can increase the reduced playback speed **120***c* by the predefined reduction **126** of 0.1× speed. In other examples, the processing device **202** can determine the increase step **128** based on an availability of the system resources **104** as described above with respect to determining the reduction step **122** in block **306**.

[0046] In some examples, the processing device **202** can further adjust the increased playback speed **120***d* based on whether the one or more interruptions occur when the media stream **102** is presented at the increased playback speed **120***d*. For example, if the media stream **102** experiences interruptions while being presented at the increased playback speed **120***d*, the processing device **202** can reduce the increased playback speed **120***d* as described above with respect to block **306**. As another example, if the media stream **102** is continuously presented to the user **112** at the increased playback speed **120***d*, the processing device **202** can continue providing the media stream **102** to the user **112** at the increased playback speed **120***d*. Additionally, if the increased playback speed **120***d* is lower than the set playback speed **120***a*, the processing device **202** can further increase the increased playback speed **120***d* (e.g., incrementally or at once) to match the set playback speed **120***a*. Additional details regarding adjusting the increased playback speed **120***d* are provided below with respect to FIG. **4**.

[0047] FIG. **4** is a flowchart of a process **400** for adjusting an increased playback speed **120***d* of a media stream **102** based on system resources **104** according to some aspects of the present disclosure. In some examples, the processing device **202** can perform one or more of the steps shown in FIG. X. In other examples, the processing device **202** can implement more steps, fewer steps, different steps, or a different order of the steps depicted in FIG. **4**. The steps of FIG. **4** are described below with reference to components discussed above in FIGS. **1-2**. In some implementations, the steps of FIG. **4** can correspond to a continuation of the steps of FIG. **3** described above.

[0048] In block **402**, the processing device **202** determines whether the increased playback speed **120***d* of the media stream **102** is lower than the set playback speed **120***a*. After determining that the increased playback speed **120***d* is lower than the set playback speed **120***a*, the processing device **202** can apply an increase step **128** to the increased playback speed **120***d* as described below with respect to block **404**. On the other hand, if the increased playback speed **120***d* is equal to or higher than the set playback speed **120***a*, the processing device **202** can forgo an adjustment to the increased playback speed **120***d* as described below with respect to block **410**. In other words, the process **400** may continue to block **404** if the processing device **202** determines that the increased playback speed **120***d* is lower than the set playback speed **120***a* or to block **410** if vice versa.

[0049] In block **404**, in response to determining that the increased playback speed **120***d* is lower than the set playback speed **120***a*, the processing device **202** applies the increase step **128** to the increased playback speed **120***d* to present the media stream **102** to the user **112** at the updated playback speed **120***d*. For example, the increased playback speed **120***d* of 1.1× speed corresponding to the audiobook is slower than the set playback speed **120***a* of 1.25× speed. Consequently, the processing device **202** can modify the increased playback speed **120***d* of the audiobook to be closer to the set playback speed **120***d*. In some examples, the processing device **202** may determine the increase step **128** to apply to the increased playback speed **120***d* based on a predefined increase **130** defined in a configuration file **124**. In other examples, the processing device **202** can determine the increase step **128** based on an availability of the system resources **104** used by the processing device **202** to present the media stream **102** at the updated playback speed **120***d*.

[0050] In block **406**, subsequent to applying the increase step **128** to the increased playback speed **120***d*, the processing device **202** determines whether the media stream **102** is being continuously presented to the user **112** at the updated playback speed **120***e*. For example, the processing device **202** can determine if applying the increase step **128** causes the media stream **102** to experience interruptions related to insufficient system resources. If the processing device **202** determines that the media stream **102** is being continuously presented to the user **112** at the updated playback speed **120***e*, the process **400** can return to block **402** to compare the updated playback speed **120***e* with the set playback speed **120***a*. For example, if the updated playback speed **120***e* is lower than the set playback speed **120***a*, the processing device **202** can proceed to block **404** to further increase the updated playback speed **120***e*.

[0051] In block **408**, the processing device **202** can decrease the updated playback speed **120***e* in response to detecting the interruptions of the media stream **102** caused by insufficient system resources. For example, the processing device **202** can apply a reduction step **122** determined based on the predefined reduction **126** indicated in the configuration file **124** or based on the system resources **104** that are available. After applying the reduction step **122**, the processing device **202** may continue monitoring the media stream **102** to determine whether the reduction step **122** has resolved the interruptions of the media stream **102**. If the interruptions have not been resolved, the processing device **202** can iteratively reduce the playback speed **120** of the media stream **102** until the interruptions are resolved. For example, the process **400** may loop between block **406** and block **408** until the interruptions of the media stream are resolved. If the reduction step **122** resolves the interruptions, process **400** can proceed to block **402** to modify the playback speed **120** to match the set playback speed **120***a*.

[0052] In block **410**, in response to determining that the increased playback speed **120***d* is equal to or higher than the set playback speed **120***a*, the processing device **202** forgoes the adjustment to the increased playback speed **120***d*. In other words, the processing device **202** can continue to present the media stream **102** to the user **112** at the increased playback speed **120***d* if the increased playback speed **120***d* is equal to or higher than the set playback speed **120***a*. In some examples, after block **408**, the process **400** can involve

continuing to monitor the media stream **102** to determine whether the media stream **102** experiences interruptions at the increased playback speed **120***d*. For example, the processing device **202** can repeat the steps described above with respect to blocks **304**, **306**, and **308** in process **300** to adjust the increased playback speed **120***d* if the media stream **102** experiences interruptions. The processing device **202** can iteratively perform the steps of process **300** or process **400** described above until the media stream **102** finishes streaming (e.g., the user **112** reaches an end of a video, podcast, audiobook, etc.).

[0053] The foregoing description of certain examples, including illustrated examples, has been presented only for the purpose of illustration and description and is not intended to be exhaustive or to limit the disclosure to the precise forms disclosed. Numerous modifications, adaptations, and uses thereof will be apparent to those skilled in the art without departing from the scope of the disclosure.

What is claimed is:

1. A system comprising:

a processing device; and

a memory device including instructions that are executable by the processing device for causing the processing device to perform operations comprising:

applying a set playback speed as a rate at which a media stream is configured to be presented to a user;

in response to applying the set playback speed to the media stream, determining that one or more interruptions of the media stream are occurring at the set playback speed;

in response to determining that the one or more interruptions of the media stream are occurring, adjusting the set playback speed to a reduced playback speed to resolve the one or more interruptions; and

subsequent to resolving the one or more interruptions of the media stream, adjusting the reduced playback speed to an increased playback speed, the increased playback speed being configured to be adjusted based on whether the one or more interruptions occur when the media stream is presented at the increased playback speed.

2. The system of claim **1**, wherein the operations further comprise, subsequent to the step of increasing the reduced playback speed to the increased playback speed:

determining whether the increased playback speed is lower than the set playback speed, wherein the set playback speed is received as user input provided by the user;

in response to determining that the increased playback speed is lower than the set playback speed, applying an increase step to the increased playback speed to present the media stream to the user at an updated playback speed;

subsequent to applying the increase step to the increased playback speed, determining whether the media stream is being continuously presented to the user at the updated playback speed, wherein the system is configured to decrease the updated playback speed in response to detecting the one or more interruptions of the media stream; and

in response to determining that the increased playback speed is equal to or higher than the set playback speed, forgoing an adjustment to the increased playback speed.

3. The system of claim **1**, wherein the operation of presenting the media stream to the user at the reduced playback speed comprises:

determining a reduction step based on system resources available to present the media stream to the user, wherein the system resources include at least one of: i) network bandwidth or ii) hardware capabilities associated with the system; and

applying the reduction step to the set playback speed of the media stream to present the media stream at the reduced playback speed.

4. The system of claim **1**, wherein the operation of presenting the media stream to the user at the reduced playback speed comprises:

obtaining a reduction step from a configuration file of the system, wherein the configuration file indicates a predefined reduction corresponding to the reduction step; and

applying the predefined reduction as the reduction step to the set playback speed of the media stream to present the media stream at the reduced playback speed.

5. The system of claim **1**, wherein the operations further comprise, subsequent to the operation of presenting the media stream to the user at the reduced playback speed:

determining that the one or more interruptions of the media stream are resolved based on the media stream being continuously presented to the user at the reduced playback speed; and

based on the reduced playback speed being lower than the set playback speed, presenting the media stream to the user at the increased playback speed by applying an increase step to the reduced playback speed.

6. The system of claim **5**, wherein the operation of presenting the media stream to the user at the increased playback speed comprises:

determining the increase step based on system resources available to present the media stream to the user, wherein the system resources include at least one of: i) network bandwidth or ii) hardware capabilities associated with the system; and

applying the increase step to the reduced playback speed of the media stream to present the media stream at the increased playback speed.

7. The system of claim **5**, wherein the operation of presenting the media stream to the user at the increased playback speed comprises:

obtaining the increase step from a configuration file of the system, wherein the configuration file indicates a predefined increase corresponding to the increase step; and

applying the predefined increase as the increase step to the reduced playback speed of the media stream to present the media stream at the increased playback speed.

8. The system of claim **1**, wherein the operations further comprise, subsequent to the operation of determining that the one or more interruptions of the media stream are occurring at the set playback speed:

determining whether the set playback speed is lower than a default playback speed associated with the media stream;

in response to determining that the set playback speed is higher than the default playback speed, applying a reduction step to the set playback speed to present the media stream at the reduced playback speed; and

in response to determining that the set playback speed is equal to or lower than the default playback speed associated with the media stream, adjusting a bit rate of the media stream to resolve the one or more interruptions of the media stream.

9. A method comprising:

applying, by one or more processing devices of a media playback system, a set playback speed as a rate at which a media stream is configured to be presented to a user;

in response to applying the set playback speed to the media stream, determining, by the one or more processing devices, that one or more interruptions of the media stream are occurring at the set playback speed;

in response to determining that the one or more interruptions of the media stream are occurring, adjusting, by the one or more processing devices, the set playback speed to a reduced playback speed to resolve the one or more interruptions; and

subsequent to resolving the one or more interruptions of the media stream, adjusting, by the one or more processing devices, the reduced playback speed to an increased playback speed, the increased playback speed being configured to be adjusted based on whether the one or more interruptions occur when the media stream is presented at the increased playback speed.

10. The method of claim **9**, further comprising. subsequent to adjusting the reduced playback speed to the increased playback speed:

determining whether the increased playback speed is lower than the set playback speed, wherein the set playback speed is received by the media playback system as user input provided by the user;

in response to determining that the increased playback speed is lower than the set playback speed, applying an increase step to the increased playback speed to present the media stream to the user at an updated playback speed;

subsequent to applying the increase step to the increased playback speed, determining whether the media stream is being continuously presented to the user at the updated playback speed, wherein the media playback system is configured to decrease the updated playback speed in response to detecting the one or more interruptions of the media stream; and

in response to determining that the increased playback speed is equal to or higher than the set playback speed, forgoing an adjustment to the increased playback speed.

11. The method of claim **9**, wherein presenting the media stream to the user at the reduced playback speed comprises:

determining a reduction step based on system resources available to present the media stream to the user, wherein the system resources include at least one of: i) network bandwidth or ii) hardware capabilities associated with the media playback system; and

applying the reduction step to the set playback speed of the media stream to present the media stream at the reduced playback speed.

12. The method of claim **9**, wherein presenting the media stream to the user at the reduced playback speed comprises:

obtaining a reduction step from a configuration file of the media playback system, wherein the configuration file indicates a predefined reduction corresponding to the reduction step; and

applying the predefined reduction as the reduction step to the set playback speed of the media stream to present the media stream at the reduced playback speed.

13. The method of claim **9**, further comprising, subsequent to presenting the media stream to the user at the reduced playback speed:

determining that the one or more interruptions of the media stream are resolved based on the media stream being continuously presented to the user at the reduced playback speed; and

based on the reduced playback speed being lower than the set playback speed, presenting the media stream to the user at the increased playback speed by applying an increase step to the reduced playback speed.

14. The method of claim **13**, wherein presenting the media stream to the user at the increased playback speed comprises:

determining the increase step based on system resources available to present the media stream to the user, wherein the system resources include at least one of: i) network bandwidth or ii) hardware capabilities associated with the media playback system; and

applying the increase step to the reduced playback speed of the media stream to present the media stream at the increased playback speed.

15. The method of claim **13**, wherein presenting the media stream to the user at the increased playback speed comprises:

obtaining the increase step from a configuration file of the media playback system, wherein the configuration file indicates a predefined increase corresponding to the increase step; and

applying the predefined increase as the increase step to the reduced playback speed of the media stream to present the media stream at the increased playback speed.

16. The method of claim **9**, further comprising, subsequent to determining that the one or more interruptions of the media stream are occurring at the set playback speed:

determining whether the set playback speed is lower than a default playback speed of the media playback system;

in response to determining that the set playback speed is higher than the default playback speed, applying a reduction step to the set playback speed to present the media stream at the reduced playback speed; and

in response to determining that the set playback speed is equal to or lower than the default playback speed of the media playback system, adjusting a bit rate of the media stream to resolve the one or more interruptions of the media stream.

17. A non-transitory computer-readable medium comprising program code executable by a processing device of a media playback system for causing the processing device to perform operations comprising:

applying a set playback speed as a rate at which a media stream is configured to be presented to a user;

in response to applying the set playback speed to the media stream, determining that one or more interruptions of the media stream are occurring at the set playback speed;

in response to determining that the one or more interruptions of the media stream are occurring, adjusting the set playback speed to a reduced playback speed to resolve the one or more interruptions; and

subsequent to resolving the one or more interruptions of the media stream, adjusting the reduced playback speed to an increased playback speed, the increased playback speed being configured to be adjusted based on whether the one or more interruptions occur when the media stream is presented at the increased playback speed.

18. The non-transitory computer-readable medium of claim **17**, wherein the operations further comprise, subsequent to the operation of increasing the reduced playback speed to the increased playback speed:

determining whether the increased playback speed is lower than the set playback speed, wherein the set playback speed is received by the media playback system as user input provided by the user;

in response to determining that the increased playback speed is lower than the set playback speed, applying an increase step to the increased playback speed to present the media stream to the user at an updated playback speed;

subsequent to applying the increase step to the increased playback speed, determining whether the media stream is being continuously presented to the user at the updated playback speed, wherein the processing device is configured to decrease the updated playback speed in response to detecting the one or more interruptions of the media stream; and

in response to determining that the increased playback speed is equal to or higher than the set playback speed, forgoing an adjustment to the increased playback speed.

19. The non-transitory computer-readable medium of claim **17**, wherein the operation of presenting the media stream to the user at the reduced playback speed comprises:

determining a reduction step based on system resources available to present the media stream to the user, wherein the system resources include at least one of: i) network bandwidth or ii) hardware capabilities associated with the media playback system; and

applying the reduction step to the set playback speed of the media stream to present the media stream at the reduced playback speed.

20. The non-transitory computer-readable medium of claim **17**, wherein the operations further comprise, subsequent to the operation of presenting the media stream to the user at the reduced playback speed:

determining that the one or more interruptions of the media stream are resolved based on the media stream being continuously presented to the user at the reduced playback speed; and

based on the reduced playback speed being lower than the set playback speed, presenting the media stream to the user at the increased playback speed by applying an increase step to the reduced playback speed.

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