Dynamically Switching Bluetooth Codec Based on Link Quality

Ray Kuo
DYNAMICALLY SWITCHING BLUETOOTH CODEC BASED ON LINK QUALITY

Abstract

A smartphone using a Bluetooth audio interface can select one of a plurality of available encoder/decoders, or codecs, to process audio data. Based on changes in one or more link quality characteristics, such as signal strength or a number of retransmissions, the smartphone automatically and dynamically changes the codec employed by the audio interface. The smartphone thereby increases the link quality, thereby improving the user experience.

Background

Many smartphones include a Bluetooth audio interface (that is, an audio interface that complies with the Bluetooth standard) to provide audio data to the user. For example, the user can connect a peripheral device, such as a set of headphones, to a smartphone via the Bluetooth audio interface, which employs a codec to encode and decode audio data for provision to the user (See, e.g., U.S. Patent Pub. No. 20200004496, PCT Patent Pub. No. 2003088551A1). Some smartphones include multiple codecs, with each codec complying with a different audio standard and having different encoding and decoding characteristics, such as supporting different bit rates or other audio quality characteristics. The user or a program executing at the smartphone selects one of the audio codecs and the Bluetooth audio interface employs the selected codec when encoding or decoding sound. However, not all codecs provide a satisfactory user experience under all conditions. For example, when the Bluetooth link quality is poor, use of a high-bit-rate codec can cause audio problems, such as choppy audio playback.

Description

As described below, a Bluetooth audio interface of smartphone can dynamically select one of a plurality of available Bluetooth audio codecs based on the quality of a communications link.
associated with the audio interface. To illustrate, an example Bluetooth audio link is illustrated below at Figure 1:

In the illustrated example, the smartphone has established a Bluetooth link with a Bluetooth audio peripheral such as a set of headphones. A processor of the smartphone executes an audio program, such as a game, music program, or video playback program, that provides audio data to an encoder to encode the audio data for transmission to the peripheral via a Bluetooth audio interface of the smartphone.

The audio encoder is configured to encode audio data according to a codec selected from a plurality of available codecs (e.g. codec1 and codec2 illustrated at FIG. 1). Each codec is associated with a different encoding process and therefore different encoding characteristics such as the encoding bit rate. The encoding characteristics in turn affect the audio quality of the audio
data provided to the Bluetooth peripheral. For example, a codec that supports a higher bit rate typically provides higher quality audio under good link conditions.

The Bluetooth audio interface is generally configured to control and manage the Bluetooth link, including provision of the encoded audio data to the Bluetooth audio peripheral. To support provision of the audio data, the Bluetooth audio interface includes a Host Control Interface (HCI) and a link manager. The HCI provides a command interface to the link manager, and access for the audio program or other software to access hardware status and control registers of the Bluetooth audio interface. The link manager is configured to setup, manage and terminate communication channels (links) between devices including the Bluetooth link with the Bluetooth audio peripheral. The link manager also monitors characteristics of the Bluetooth link indicative of the quality of the link. Examples of link quality characteristics include Received Signal Strength Indicators (RSSI), signal-to-noise ratio (SNR), the number of dropped packets, the number of unacknowledged packets, and the unused channel count.

In response to one or more of the link quality characteristics dropping below a corresponding threshold, firmware of the Bluetooth audio interface can issue a report to the HCI, wherein the report indicates the quality characteristics of the link. The HCI provides the report, or portions thereof indicating link quality, to the encoder. In response, the encoder can change the selected codec for encoding the audio data, thereby improving the quality of the Bluetooth link and improving the user experience.

To illustrate via an example, a low-quality Bluetooth link can impact the user experience, such as by causing choppy audio playback at the Bluetooth audio peripheral. These audio issues are sometimes caused, or increased, by a particular characteristic of the codec used to encode the audio. For example, a codec having a higher encoding bit rate can increase the choppiness of the
audio playback when the quality of the Bluetooth link is relatively poor. Accordingly, in
response to the report indicating a low-quality Bluetooth link, the encoder automatically switches
the selected codec from one having a higher bitrate to one having a lower bitrate, thereby
reducing the choppiness issues and improving the user experience.

In response to the link quality falling below a threshold, the codec can be selected in part
based on the type of audio program being executed at the smartphone. For example, a game
program typically requires relatively low latency for audio playback, in order to keep the audio
synchronized with displayed images. Accordingly, when selecting a different codec in response
to poor link quality, and when executing a game program, the encoder selects a codec associated
with lower encoding latency.