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ASSISTED DELIVERY SERVICE FOR NETWORKS

Abstract

Systems and methods are provided for switching computing devices between edge servers and peer groups. One example method includes receiving, at a client computing device and from a first computing device, media content. A request to initiate an assisted delivery service is sent from the client computing device to a second computing device. The assisted delivery service is initiated in response to the request. The assisted delivery service comprises identifying, at the second computing device, one or more peer computing devices receiving the media content. At the second computing device, instructions that enable the client computing device to discover at least one of the peer computing devices are generated. The instructions are sent from the second computing device to the client computing device. At the client computing device, a peer computing device is discovered. A request to receive a portion of the media content is sent from the client computing device to a discovered peer computing device. The portion of the media content is received at the client computing device from the peer computing device.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. patent application Ser. No. 18/631,713, filed Apr. 10, 2024, which is a continuation of U.S. patent application Ser. No. 18/130,581, filed Apr. 4, 2023, now U.S. Pat. No. 11,985,189, which is a continuation of U.S. patent application Ser. No. 17/383,055, filed Jul. 22, 2021, now U.S. Pat. No. 11,652,876, which are incorporated herein by reference in their entirety.

BACKGROUND

[0002] The present disclosure is directed towards systems and methods for switching computing devices between edge servers and peer groups. In particular, systems and methods are provided herein that enable computing devices to be switched between edge servers and peer groups in order to enable improved delivery of media content to a computing device.

SUMMARY

[0003] With the proliferation of media streaming services, there has been a large increase in the bandwidth required to deliver media items from a content delivery network (CDN) to computing devices requesting the media items. Typically, a CDN comprises one or more edge servers that store media items. The media items are typically delivered from an edge server local to a requesting computing device via the internet. In order to mitigate this bandwidth requirement, some streaming providers enable media items to be delivered to an end user via a peer-to-peer CDN in addition to a purely server-based CDN. For example, if a smart TV requests an on-demand video from an over-the-top streaming (OTT) service, the streaming service may first check to see if there are any other computing devices that have already received the on-demand video and are storing at least a part of the video locally. For example, a tablet device may store a part of an on-demand video locally. The OTT service can instruct the smart TV to request the stored part of the on-demand video from the tablet, thereby reducing the bandwidth required between the smart TV and an edge server of the CDN network. In some examples, the smart TV may then store parts of the on-demand video and may send the parts to one or more other computing devices. If a number of computing devices are receiving a stream for, for example, a live soccer match, a server (i.e., a tracker) may coordinate the computing devices such that each of the computing devices receives portions (or segments or fragments) of the live stream from a plurality of the other computing devices that are receiving the live stream. However, in order to deliver media content reliably to a computing device, there may be some circumstances where it is preferable to deliver a media item (or parts of a media item) from an edge server, and there may be other circumstances where it is preferable to deliver a media item (or parts of a media item) via a peer-to-peer CDN.

[0004] In view of the foregoing, it would be beneficial to have a system that is capable of seamlessly switching a computing device between an edge server and a peer-to-peer CDN.

[0005] Systems and methods are described herein for switching computing devices between edge servers and peer groups. In accordance with an aspect of the disclosure, a method is provided for switching computing devices between edge servers and peer groups. The method includes receiving, at a client computing device and from a first computing device, media content. A request to initiate an assisted delivery service is sent from the client computing device to a second computing device. The assisted delivery service is initiated at the second computing device in response to the request. The assisted delivery service comprises identifying, at the second computing device, one or more peer computing devices receiving the media content. Discovery data that enables the client computing device to discover at least one of the peer computing devices is generated at the second computing device. The discovery data is sent from the client computing device to a second computing device. A peer computing device is discovered, based on the discovery data and at the client computing device. A request to receive a portion of the media content is sent from the client computing device to a discovered peer computing device. The portion of the media content is received at the client computing device, from the peer computing device. The client computing device may request the initiation of the assisted delivery service in response to detecting an error-state when receiving media content from the first computing device. At least a portion of the media content may be stored in a buffer at the client computing device, and the request to initiate the assisted delivery service may be sent when the buffer is storing at least a threshold amount of the media content. A portion of the media content may be sent from the client computing device to a peer computing device. In an example system, a user uses a media player running on a smartphone to stream media content, such as a soccer match, from an edge server. If the user experiences playback issues, such as buffering of the stream, due to, for example, an issue with a network path between the edge server and the smartphone, then the media player may utilize an assisted delivery service to attempt to improve the delivery of the media content to the media player running on the smartphone. In some examples, the assisted delivery service may be requested in response to detecting an error-state when receiving media content from the edge server. In other examples, the assisted delivery service may be requested when a threshold portion or the entire buffer of the media player is full. The threshold portion may be established to ensure that there is enough content in the buffer to avoid buffering when the media content is requested from a peer. An assisted delivery service may be initiated by sending a request from the smartphone to a server running the assisted delivery service. The server running the assisted delivery service may keep track of other computing devices (peers) that are streaming the same content. On receiving the request from the smartphone, the assisted delivery server may send data to the smartphone that enables the smartphone to discover the peer computing devices that are streaming the same content. On receiving the discovery data, an application running on the smartphone (which, in some examples, may be the media player itself) may communicate with one or more of the peer computing devices and request at least a portion of the media content being streamed. In response to receiving the request, the peer computing device may send the requested portion of the media content to the smartphone. In some examples, the smartphone may stream the media content solely from one or more peer computing devices. In other examples, the smartphone may stream some portions of the media content from the edge server and other portions of the media content from one or more peer computing devices. In some examples, portions of the media content are sent from the smartphone to one or more other peers.

[0006] Initiating the assisted delivery service may further comprise sending location data from the client computing device to the second computing device. The location data may indicate a location of the client computing device. Generating the discovery data may further comprise identifying the one or more peer computing devices based on a proximity of the one or more peer computing devices to the client computing device. Updated location data may be sent from the client

computing device to the second computing device. One or more additional client computing devices may be identified at the second computing device based on the updated location data. Updated discovery data that enables the client computing device to discover the one or more additional client computing devices may be sent, from the second computing device to the client computing device. For example, the assisted delivery server may send discovery data directing the computing device that is streaming the media content to peers that are in the same zip code as the computing device that is streaming the media content. In some examples, if no peers are present in the same zip code, the area that is considered for peers may be incrementally increased. In some examples, this may take into account the underlying topography of the internet as well as the physical location of the peers. For example, if a first peer device is physically farther away than a second peer device, but the first peer device is closer to a highspeed trunk connection, then the first peer device may be prioritized over the second peer device. The proximity of the computing devices may be calculated based on coordinates obtained via, for example, GPS, GLONASS, BeiDou, Galileo, NavIC and/or QZSS. The computing device that is streaming the media content may periodically poll the assisted delivery server in order to receive updated discovery data. This updated discovery data may take into account movement of the computing device that is streaming the media content and/or movement of the peer devices.

[0007] Error-state data may be sent from the client computing device to the second computing device. The error-state data may comprise one or more error-states with respect to the one or more peer computing devices. One or more peer computing devices based on the error-state data may be identified at the second computing device. Updated discovery data that excludes the identified one or more peer computing devices based on error-state data may be generated at the second computing device. The updated discovery data may be sent from the second computing device to the client computing device. For example, if a computing device is streaming media content from one or more peer devices and the computing device experiences an issue receiving one or more portions from one or more of the peer devices then it may be beneficial to send data reflecting the issue to the assisted delivery server. A peer device may, for example, move to an area with a poor connection to the internet, which may prevent it from reliably delivering portions of the media content to other devices. This may present itself as a number of requests that are sent from the computing device to the peer device but for which no response is received. In another example, the time taken to receive portions of the media content from a peer device may considerably increase. The computing device may send data reflecting these scenarios to the assisted delivery server, so that the delivery server can remove and/or deprioritize these peer(s) when sending discovery data.

[0008] A maximum display resolution for the media content may be identified at the client computing device. The maximum display resolution may be the highest resolution that is supported by the client computing device or is based on a setting set at the client computing device. Data indicating the maximum supported resolution may be sent from the client computing device to the second computing device. Generating the discovery data may further comprise identifying the one or more peer computing devices based on whether they enable the media content to be delivered to the client computing device at the maximum resolution. For example, a smartphone streaming content may be able to display high definition content at a 1920×1080 resolution; however, only some of the peer devices may have the bandwidth to deliver content at a 1920×1080 resolution, whereas others may only have the bandwidth to deliver content at a 1280×720 resolution. In this example, the assisted delivery server may send discovery data comprising only the peers that have the bandwidth to deliver content at the 1920×1080 resolution. In other examples, the assisted delivery server may send discovery data comprising all peers but may prioritize the peers based on the resolution they are able to deliver.

[0009] At least a portion of the media content may be stored in a buffer at the client computing device. Generating the discovery data may further comprise indicating a size of the portion of the media content to be received from a peer computing device. The size of the portion may be

determined based on at least one of the amount of media content stored in the buffer and a peer computing device response time. For example, if a user is streaming media content via a smartphone, the cellular signal may vary as the user moves from place to place. If a user has a relatively poor cellular signal, then it may be beneficial for the user to receive smaller portions as they may be received more quickly than larger portions. However, there may be an overhead associated with sending lots of small portions, and it may be beneficial to send larger portions if the cellular signal is relatively strong. In order to address this, data may be sent from the smartphone to the server running the assisted delivery service that reflects the network conditions being experienced by the smartphone and/or the amount of content in the buffer. If, for example, the buffer is relatively empty and/or the network conditions are bad, the assisted delivery service may indicate to the one or more peer devices that smaller chunks should be sent, and if the buffer is relatively full and/or the network conditions are good, the assisted delivery service may indicate that larger chunks should be sent.

[0010] Generating the discovery data may further comprise identifying one or more peer computing devices based on a predetermined ranking. For example, a record of bandwidth available to each peer, percentage of successfully delivered portions of media content and/or a ratio of how much media content is received from peers and how much media content is sent to peers may be maintained at the assisted delivery service server. When the server sends discovery data, the peers may be prioritized (i.e., the order of connection) based on at least one of these factors.

Description

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0011] The present disclosure, in accordance with one or more various embodiments, is described in detail with reference to the following figures. The drawings are provided for purposes of illustration only and merely depict typical or example embodiments. These drawings are provided to facilitate an understanding of the concepts disclosed herein and shall not be considered limiting of the breadth, scope, or applicability of these concepts. It should be noted that for clarity and ease of illustration these drawings are not necessarily made to scale.

[0012] The above and other objects and advantages of the disclosure may be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which:

[0013] FIG. 1 shows an exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure;

[0014] FIG. 2 shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure;

[0015] FIG. 3 shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure;

[0016] FIG. 4 shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure;

[0017] FIG. 5 shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure;

[0018] FIG. 6 shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure;

[0019] FIG. 7 shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure;

[0020] FIG. 8 shows a block diagram representing components of a computing device and data flow therebetween for switching a computing device between an edge server and a peer group, in accordance with some embodiments of the disclosure; and

[0021] FIG. 9 is a flowchart of illustrative steps involved for switching a computing device between an edge server and a peer group, in accordance with some embodiments of the disclosure. DETAILED DESCRIPTION

[0022] Systems and methods are described herein for switching a computing device between an edge server and a peer group. The disclosed methods and systems may be implemented on a computing device. As referred to herein, the computing device can be any device comprising a processor and memory, for example, a television, a Smart TV, a set-top box, an integrated receiver decoder (IRD) for handling satellite television, a digital storage device, a digital media receiver (DMR), a digital media adapter (DMA), a streaming media device, a DVD player, a DVD recorder, a connected DVD, a local media server, a BLU-RAY player, a BLU-RAY recorder, a personal computer (PC), a laptop computer, a tablet computer, a WebTV box, a personal computer television (PC/TV), a PC media server, a PC media center, a handheld computer, a stationary telephone, a personal digital assistant (PDA), a mobile telephone, a portable video player, a portable music player, a portable gaming machine, a smartphone, an augmented reality device, a mixed reality device, a virtual reality device, or any other television equipment, computing equipment, or wireless device, and/or combination of the same.

[0023] The media content may be streamed live and/or streamed on demand to a computing device. On-demand content may also be downloaded to a computing device in response to a user request and/or according to a pre-set rule. Content includes audio, video and/or any other media content. Audio includes audio-only content, such as songs. Video includes audiovisual content such as movies and/or television programs. An over-the-top content platform may be accessed via a website and/or an app running on a computing device.

[0024] In embodiments where a computing device, such as a smartphone, and peers communicate directly with each other in a peer-to-peer manner, any method known in the art may be utilized. For example, the peers may communicate via a BitTorrent protocol and/or via a Web Real-Time Communication (WebRTC) protocol. This enables the computing device and the peers to directly communicate with each other and to send media content via a data channel, such as WebRTC data channel. The BitTorrent and/or WebRTC protocol may be directly implemented in an application that received media content. In other examples, a user may be viewing media content via a web browser on a computing device and the web browser may enable a computing device to communicate directly with other peers via the BitTorrent and/or WebRTC protocol. In another example, the computing device may communicate directly with a peer via, for example, Wi-Fi Direct. This enables the computing device to receive media content from peer devices that are relatively close (i.e., as defined by the range of Wi-Fi connection) to one another. Any combination of BitTorrent, WebRTC, Wi-Fi Direct and any other suitable protocol may be utilized.

[0025] The methods and/or any instructions for performing any of the embodiments discussed herein may be encoded on computer-readable media. Computer-readable media includes any media capable of storing data. The computer-readable media may be transitory, including, but not limited to, propagating electrical or electromagnetic signals, or may be non-transitory, including, but not limited to, volatile and non-volatile computer memory or storage devices such as a hard disk, floppy disk, USB drive, DVD, CD, media cards, register memory, processor caches, random access memory (RAM), etc.

[0026] FIG. 1 shows an exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure. A computing device, in this example a smartphone **100** streams media content, in this example a soccer match **102**, via a network **104**, from a server, in this example an edge server **106**. The edge server **106** receives media content **107** from, for example, a broadcaster. The network **104** may be the internet and may comprise wired and/or wireless means for transmitting the streamed soccer match **102** from the edge server **106** to the smartphone **100**. A request for an assisted delivery service is sent, from the smartphone **100**, via the network **104**, to the assisted delivery server **108**.

In this example, the assisted delivery server **108** is separate from the edge server **106**, but in some examples, the functionality provided by the edge server **106** and the assisted delivery server **108** may be combined at a single server. In some examples, there may be more than one assisted delivery server, and the smartphone **100** may send a request to the nearest assisted delivery server and/or the assisted delivery server with the lowest ping. On receiving the request, the assisted delivery server **108** identifies one or more peer computing devices, for example, peer smartphones **110**, from which the smartphone **100** can receive one or more portions of the streamed soccer match **102**. The assisted delivery server **108** generates discovery data **109** based on the identified peers **110** and sends the discovery data, via the network **104**, to the smartphone **100**. The discovery data enables the smartphone **100** to discover at least one of the peer computing devices **110** via a network, in this example the network **104**. The discovery data may comprise, for example, an IP address and/or a MAC address of one or more peer computing devices **110**. In other examples, the peers may be located via a local network (i.e., a Wi-Fi and/or wired network), which is separate from the internet. On receiving the discovery data, the smartphone discovers at least one peer device **110** and sends a request to a peer device **110** for a portion of the media content via the network **104**. On receiving the request, the peer device **110** sends the requested portion of the media content via the network **104** to the smartphone **100**. An application, such as a media player, running on the smartphone **100** may use the received piece of media content to generate the media content for display. In some examples, the smartphone **100** may receive media content solely from the peer devices **110**. In other examples, the smartphone **100** may receive some portions of the media content from the peer devices **110** and other portions of the media content from the edge server **106**.

[0027] FIG. 2 shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure. The arrangement is similar to that shown in FIG. 1; however, the assisted delivery service is initiated in response to the media content buffering **212** on a computing device, such as a smartphone **200**. A computing device, in this example a smartphone **200**, streams media content, via a network **204**, from a server, in this example an edge server **206**. The edge server **206** receives media content **207** from, for example, a broadcaster. The network **204** may be the internet and may comprise wired and/or wireless means for transmitting the streamed media content from the edge server **206** to the smartphone **200**. If an issue is detected with the stream, for example at a media player that generates the media content for display, then a request for an assisted delivery service is sent, from the smartphone **200**, via the network **204**, to the assisted delivery server **208**. In this example, the media player detects that the media content is buffering **212**. The media player running on the smartphone **200** may send the request in some examples. In other examples, another application running on the smartphone may monitor the content being streamed by the media player and may send the request when buffering is detected. In this example, the assisted delivery server **208** is separate from the edge server **206**, but in some examples, the functionality provided by the edge server **206** and the assisted delivery server **208** may be combined at a single server. In some examples, there may be more than one assisted delivery server, and the smartphone **200** may send a request to the nearest assisted delivery server and/or the assisted delivery server with the lowest ping. On receiving the request, the assisted delivery server **208** identifies one or more peer computing devices, for example, peer smartphones **210**, from which the smartphone **200** can receive one or more portions of the streamed media content. The assisted delivery server **208** generates discovery data **209** based on the identified peers **210** and sends the discovery data, via the network **204**, to the smartphone **200**. The discovery data enables the smartphone **200** to discover at least one of the peer computing devices **210** via a network, in this example the network **204**. The discovery data may comprise, for example, an IP address and/or a MAC address of one or more peer computing devices **210**. In other examples, the peers may be located via a local network (i.e., a Wi-Fi and/or wired network) that is separate from the internet. On receiving the discovery data, the

smartphone discovers at least one peer device **210** and sends a request to a peer device **210** for a portion of the media content via the network **204**. On receiving the request, the peer device **210** sends the requested portion of the media content via the network **204** to the smartphone **200**. An application, such as a media player, running on the smartphone **200** may use the received piece of media content to generate the media content for display. In some examples, the smartphone **200** may receive media content solely from the peer devices **210**. In other examples, the smartphone **200** may receive some portions of the media content from the peer devices **210** and other portions of the media content from the edge server **206**.

[0028] FIG. **3** shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure. The arrangement is similar to that shown in FIG. **1**; however, the assisted delivery service takes into account the location of the computing device streaming the media content and the peers from which content is streamed. A computing device, in this example a smartphone **300**, streams media content, in this example a soccer match **302**, via a network **304**, from a server, in this example an edge server **306**. The edge server **306** receives media content **307** from, for example, a broadcaster. The network **304** may be the internet and may comprise wired and/or wireless means for transmitting the streamed soccer match **302** from the edge server **306** to the smartphone **300**. A request for an assisted delivery service is sent, from the smartphone **300**, via the network **304**, to the assisted delivery server **308**. In this example, the assisted delivery server **308** is separate from the edge server **306**, but in some examples, the functionality provided by the edge server **306** and the assisted delivery server **308** may be combined at a single server. In some examples, there may be more than one assisted delivery server, and the smartphone **300** may send a request to the nearest assisted delivery server and/or the assisted delivery server with the lowest ping. On receiving the request, the assisted delivery server **308** identifies one or more peer computing devices, for example, peer smartphones **310**, from which the smartphone **300** can receive one or more portions of the streamed soccer match **302**. The assisted delivery server **304** also receives location data associated with the smartphone **300**. In this example, the smartphone **300** sends location coordinates to the assisted delivery server **308** that have been obtained via one or more GPS satellites **314**. In addition, the assisted delivery server caches location information from the peers **310**. This cache may be updated periodically and/or in response to the delivery sending a request to one or more of the peer devices **310** for updated location data. The peer devices **310** may also provide coordinates obtained via one or more GPS satellites **314**. In other examples, location data may be inferred from an IP address and/or a MAC address of a Wi-Fi router by, for example, querying a database of IP addresses and/or MAC addresses and associated location data. The assisted delivery server **308** generates discovery data **309** based on the identified peers **310** and the location data **315** and sends the discovery data, via the network **304**, to the smartphone **300**. The discovery data enables the smartphone **300** to discover at least one of the peer computing devices **310** via a network, in this example the network **304**. The discovery data may comprise, for example, an IP address and/or a MAC address of one or more peer computing devices **310**. In other examples, the peers may be located via a local network (i.e., a Wi-Fi and/or wired network), which is separate from the internet. In this example, a group of peers **310a** are determined to be closest to the smartphone **300**. On receiving the discovery data, the smartphone discovers at least one peer device **310** of the peer group **310a** and sends a request to a peer device **310** of the peer group **310a** for a portion of the media content via the network **304**. On receiving the request, the peer device **310** sends the requested portion of the media content via the network **304** to the smartphone **300**. An application, such as a media player, running on the smartphone **300** may use the received piece of media content to generate the media content for display. In this example, the user is a passenger in a car **316** and is using their smartphone **300** while the vehicle is in motion. Updated location data is periodically sent from the smartphone **300**, via the network **304**, to the assisted delivery server **304**. In response, if the assisted delivery server **304** identifies a more suitable peer group **310b**,

based on the updated location, then updated discovery data is sent to the smartphone **300**. In a similar manner to before, the smartphone **300** discovers at least one peer **310** of the second peer group **310b** and receives at least a portion of the media content from at least one peer of the second peer group **310b**. In some examples, the smartphone **300** may receive media content solely from the peer devices **310**. In other examples, the smartphone **300** may receive some portions of the media content from the peer devices **310** and other portions of the media content from the edge server **306**.

[0029] FIG. 4 shows an exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure. The arrangement is similar to that shown in FIG. 1; however, the assisted delivery service takes into account preferred peers. A computing device, in this example a smartphone **400**, streams media content, in this example a soccer match **402**, via a network **404**, from a server, in this example an edge server **406**. The edge server **406** receives media content **407** from, for example, a broadcaster. The network **404** may be the internet and may comprise wired and/or wireless means for transmitting the streamed soccer match **402** from the edge server **406** to the smartphone **400**. A request for an assisted delivery service is sent, from the smartphone **400**, via the network **404**, to the assisted delivery server **408**. In this example, the assisted delivery server **408** is separate from the edge server **406**, but in some examples, the functionality provided by the edge server **406** and the assisted delivery server **408** may be combined at a single server. In some examples, there may be more than one assisted delivery server and the smartphone **400** may send a request to the nearest assisted delivery server and/or the assisted delivery server with the lowest ping. On receiving the request, the assisted delivery server **408** identifies one or more peer computing devices, for example, peer smartphones **410**, from which the smartphone **400** can receive one or more portions of the streamed soccer match **402**. The assisted discovery server **408** also queries a database of preferred peers **418**. For example, the preferred peers may be those peers that have the available bandwidth and computing power that enable them to upload content at a high resolution of, for example, 1920×1080, 3840× 2160 and/or 7680×4320. The assisted discovery server **408** may maintain the database of preferred peers **418** by periodically polling peers to ensure that they continue to be able to deliver content in the expected resolution and updating the database accordingly. In other examples, the peers advertise their current capabilities to the assisted delivery server **408**. The assisted delivery server **408** generates discovery data **409** based on the identified peers **410** and the preferred peer list and sends the discovery data, via the network **404**, to the smartphone **400**. The discovery data enables the smartphone **400** to discover at least one of the peer computing devices **410** via a network, in this example the network **404**. The discovery data may comprise, for example, an IP address and/or a MAC address of one or more peer computing devices **410**. In other examples, the peers may be located via a local network (i.e., a Wi-Fi and/or wired network), which is separate from the internet. On receiving the discovery data, the smartphone identifies those peers that are able to deliver content in a required resolution, for example a maximum display resolution of the smartphone and/or a resolution identified based on a setting set by the user in a user interface of, for example, a media player running on the smartphone; discovers at least one peer device **410** based on the capabilities of the peers; and sends a request to a peer device **410** for a portion of the media content via the network **404**. On receiving the request, the peer device **410** sends the requested portion of the media content via the network **404** to the smartphone **400**. An application, such as a media player, running on the smartphone **400** may use the received piece of media content to generate the media content for display. In some examples, the smartphone **400** collects statistics on the parts received from the peer devices **410** and if, for example, a peer device **410** consistently fails to deliver parts of the media content in a timely manner then the smartphone **400** may communicate this to the assisted delivery server **408**. On receiving the data from the smartphone **400**, the assisted delivery server **408** may update the preferred peers database **418** in order to reflect the capacities of the peer devices **410**. In some

examples, the smartphone requests high resolution content from a first peer device **410a**, but also queries second and third peer devices **410b**, **410c** which are lower down in the preferred peer list. This enables the smartphone **400** to seamlessly (or relatively seamlessly) receive lower resolution content in the event that the network connection between the smartphone and the peer group **410** degrades, for example, if the smartphone moves from an area with a strong cellular signal to an area with a relatively weak cellular signal. The switch to a peer **410b**, **410c** serving lower resolution content may be made in response to the amount of buffered content at the smartphone **400** falling below a threshold level. In some examples, the smartphone **400** may receive media content solely from the peer devices **410**. In other examples, the smartphone **400** may receive some portions of the media content from the peer devices **410** and other portions of the media content from the edge server **406**.

[0030] In some examples, the maximum display resolution may be determined via a device type communicated in a User-Agent request header that is sent to the assisted delivery server from the computing device. For example, the User-Agent request header may indicate a make and model of the computing device that is requesting header. Based on this information, the assisted delivery server may identify the maximum resolution suitable for the device. For example, the assisted delivery server may query a database of devices and maximum resolutions. Such a database may be stored locally on the assisted delivery server. In other examples, the assisted delivery server may query an internet-based service in order to identify the maximum resolution suitable for the device. In other examples, the User-Agent request header itself may indicate a maximum display resolution that is suitable for a computing device.

[0031] FIG. 5 shows an exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure. The arrangement is similar to that shown in FIG. 1; however, the assisted delivery service creates a manifest file that enables the assisted delivery service to dictate the size of the portions of the media content that are sent from peer devices **510**. A computing device, in this example, a smartphone **500** streams media content, in this example a soccer match **502**, via a network **504**, from a server, in this example an edge server **506**. The edge server **506** receives media content **507** from, for example, a broadcaster. The network **504** may be the internet and may comprise wired and/or wireless means for transmitting the streamed soccer match **502** from the edge server **506** to the smartphone **500**. A request for an assisted delivery service is sent, from the smartphone **500**, via the network **504**, to the assisted delivery server **508**. In this example, the assisted delivery server **508** is separate from the edge server **506**, but in some examples, the functionality provided by the edge server **506** and the assisted delivery server **508** may be combined at a single server. In some examples, there may be more than one assisted delivery server, and the smartphone **500** may send a request to the nearest assisted delivery server and/or the assisted delivery server with the lowest ping. On receiving the request, the assisted delivery server **508** identifies one or more peer computing devices, for example, peer smartphones **510**, from which the smartphone **500** can receive one or more portions of the streamed soccer match **502**. In addition to identifying peers **510** from which the smartphone **500** can receive portions from the assisted delivery server **508** generates a manifest file **520** for different portion sizes of the media content. The assisted delivery server **508** generates discovery data **509** based on the identified peers **510**. The assisted delivery server **508** sends the discovery data and the manifest file **520**, via the network **504**, to the smartphone **500**. The discovery data enables the smartphone **500** to discover at least one of the peer computing devices **510** via a network, in this example the network **504**. The discovery data may comprise, for example, an IP address and/or a MAC address of one or more peer computing devices **510**. In other examples, the peers may be located via a local network (i.e., a Wi-Fi and/or wired network), which is separate from the internet. The manifest file **520** enables the smartphone **500** to seamlessly (or at least substantially seamlessly) request portions of the media content that are different sizes from the peers **510**. The discovery data and the manifest data may be combined

at the assisted delivery server **508**, such that the smartphone can request a portion of media content of a particular size from a specific peer **510**. In other examples, the peers **510** may dynamically adjust the portion size of media content in response to a request from the smartphone **500**. On receiving the discovery data, the smartphone discovers at least one peer device **510** and sends a request to a peer device **510** for a portion of the media content of a specific size via the network **504**. The request for a specific portion size of media content may be based on, for example, an amount of media content that is present in a buffer at the smartphone **500**. In other examples, the size may be based on a peer **510** response time, wherein larger response times dictate smaller portion sizes and smaller response times dictate larger portion sizes. On receiving the request, the peer device **510** sends the requested portion of the media content via the network **504** to the smartphone **500**. An application, such as a media player, running on the smartphone **500** may use the received piece of media content to generate the media content for display. In some examples, the smartphone **500** may receive media content solely from the peer devices **510**. In other examples, the smartphone **500** may receive some portions of the media content from the peer devices **510** and other portions of the media content from the edge server **506**.

[0032] FIG. **6** shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure. The arrangement is similar to that shown in FIG. **1**; however, the assisted delivery service takes into account the type of content being streamed. For example, an action movie with many detailed, fast-moving scenes may require substantially higher bandwidth to deliver at a desired resolution than a cartoon. As such, different groups of peers may be suitable for delivering the content. In this example, peers with lower available bandwidth may be more suitable for delivering the cartoon, and peers with higher available bandwidth may be more suitable for delivering the action movie. By delivering the cartoon from peers with lower available bandwidth, the peers with higher available bandwidth may be reserved for users requesting, for example, the action movie. In this way a higher quality of service may be maintained overall. A computing device, in this example a smartphone **600**, streams media content, in this example a soccer match **602**, via a network **604**, from a server, in this example an edge server **606**. The edge server **606** receives media content **607** from, for example, a broadcaster. The network **604** may be the internet and may comprise wired and/or wireless means for transmitting the streamed soccer match **602** from the edge server **606** to the smartphone **600**. The type of media content **622** is identified at the smartphone **600**. This may be performed by parsing, for example, electronic program guide (EPG) data or querying a database via the internet. In other examples, a trained artificial intelligence model may determine the type of content that is being streamed. In some examples, a user may manually input the type of content that is being streamed. A request for an assisted delivery service is sent, from the smartphone **600**, via the network **604**, to the assisted delivery server **608**. In addition, the type of media content that is being streamed is sent from the smartphone **600** to the assisted delivery server **608**. In this example, the assisted delivery server **608** is separate from the edge server **606**, but in some examples, the functionality provided by the edge server **606** and the assisted delivery server **608** may be combined at a single server. In some examples, there may be more than one assisted delivery server, and the smartphone **600** may send a request to the nearest assisted delivery server and/or the assisted delivery server with the lowest ping. On receiving the request, the assisted delivery server **608** identifies one or more peer computing devices, for example, peer smartphones **610**, from which the smartphone **600** can receive one or more portions of the streamed soccer match **602**. In addition, the assisted delivery server takes into account the content that is being streamed to the smartphone and identifies the peers **610** based on the content that is being streamed **624**. The assisted delivery server **608** generates discovery data **609** based on the identified peers **610** and the identified content **624** and sends the discovery data, via the network **604**, to the smartphone **600**. In this example, a soccer match **602** requires relatively high bandwidth, so the discover data comprises peers **610** that have reported having relatively high bandwidth available.

The discovery data enables the smartphone **600** to discover at least one of the peer computing devices **610** via a network, in this example the network **604**. The discovery data may comprise, for example, an IP address and/or a MAC address of one or more peer computing devices **610**. In other examples, the peers may be located via a local network (i.e., a Wi-Fi and/or wired network), which is separate from the internet. On receiving the discovery data, the smartphone discovers at least one peer device **610** and sends a request to a peer device **610** for a portion of the media content via the network **604**. On receiving the request, the peer device **610** sends the requested portion of the media content via the network **604** to the smartphone **600**. An application, such as a media player, running on the smartphone **600** may use the received piece of media content to generate the media content for display. In some examples, the smartphone **600** may receive media content solely from the peer devices **610**. In other examples, the smartphone **600** may receive some portions of the media content from the peer devices **610** and other portions of the media content from the edge server **606**.

[0033] FIG. 7 shows another exemplary environment in which a computing device is switched between an edge server and a peer group, in accordance with some embodiments of the disclosure. The arrangement is similar to that shown in FIG. 1; however, the assisted delivery service takes into account a fairness algorithm **726**. For example, peers who consistently upload media content may be prioritized if they utilize the assisted delivery service. A computing device, in this example a smartphone **700**, streams media content, in this example a soccer match **702**, via a network **704**, from a server, in this example an edge server **706**. The edge server **706** receives media content **707** from, for example, a broadcaster. The network **704** may be the internet and may comprise wired and/or wireless means for transmitting the streamed soccer match **702** from the edge server **706** to the smartphone **700**. A request for an assisted delivery service is sent, from the smartphone **700**, via the network **704**, to the assisted delivery server **708**. In this example, the assisted delivery server **708** is separate from the edge server **706**, but in some examples, the functionality provided by the edge server **706** and the assisted delivery server **708** may be combined at a single server. In some examples, there may be more than one assisted delivery server, and the smartphone **700** may send a request to the nearest assisted delivery server and/or the assisted delivery server with the lowest ping. On receiving the request, the assisted delivery server **708** identifies one or more peer computing devices, for example, peer smartphones **710**, from which the smartphone **700** can receive one or more portions of the streamed soccer match **702**. In addition, the assisted delivery server **708** may take into account a fairness algorithm **726** when identifying peers **710**. For example, a user may request content to be delivered at a priority rate in return for committing to uploading received portions of the media content for, for example, a certain period of time to other peers. This may be especially useful if certain portions of the media content are not widely available in the peer group and/or bandwidth is constrained within the peer group. In order to inform the user whether they have uploaded the committed amount of media content, an indication such as a counter can be displayed to the user via a display of the smartphone **700** to indicate to the user that their committed contribution has been met. In another example, based on a previous behavior observed from the smartphone **700**, for example only watching portions of media content rather than the whole media content, such a user might be chosen as a “seeder,” (i.e., an uploader of media content) or one of the seeders in the peer group, if the network conditions permit. In another example, the order of seeders can be prioritized on clients that are likely to disconnect from the peer group after a short period of time when such potential seeders are capable of serving the content. The fairness algorithm may keep track of all users that have been part of a peer group **710** as well as their overall contributions. For example, a unique ID can be associated with each of the clients based on their device ID. This may be generated based on a device MAC address and/or a device software and hardware profile. A profile can be generated for such user devices that includes their contributions, the number of media content streams they uploaded portions for and/or the number of times that they relied on a peer or a peer group for assisted content delivery. In another

example, the peers that are preferred, based on the fairness algorithm, may be rotated or updated throughout the content and/or as network conditions change and as more devices stream the media content, in order to make sure that all peers are contributing to the delivery. The assisted delivery server **708** generates discovery data **709** based on the identified peers **710** and the fairness algorithm and sends the discovery data, via the network **704**, to the smartphone **700**. The discovery data enables the smartphone **700** to discover at least one of the peer computing devices **710** via a network, in this example the network **704**. The discovery data may comprise, for example, an IP address and/or a MAC address of one or more peer computing devices **710**. In other examples, the peers may be located via a local network (i.e., a Wi-Fi and/or wired network), which is separate from the internet. On receiving the discovery data, the smartphone discovers at least one peer device **710** and sends a request to a peer device **710** for a portion of the media content via the network **704**. On receiving the request, the peer device **710** sends the requested portion of the media content via the network **704** to the smartphone **700**. An application, such as a media player, running on the smartphone **700** may use the received piece of media content to generate the media content for display. In some examples, the smartphone **700** may receive media content solely from the peer devices **710**. In other examples, the smartphone **700** may receive some portions of the media content from the peer devices **710** and other portions of the media content from the edge server **706**.

[0034] FIG. **8** shows a block diagram representing components of a computing device and data flow therebetween for switching a computing device between an edge server and a peer group, in accordance with some embodiments of the disclosure. Computing device **800** (e.g., a smartphone **100, 200, 300, 400, 500, 600, 700**, as discussed in connection with FIGS. **1-7**) comprises input circuitry **804**, control circuitry **808** and an output module **826**. Control circuitry **808** may be based on any suitable processing circuitry (not shown) and comprises control circuits and memory circuits, which may be disposed on a single integrated circuit or may be discrete components and processing circuitry. As referred to herein, processing circuitry should be understood to mean circuitry based on one or more microprocessors, microcontrollers, digital signal processors, programmable logic devices, field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), etc., and may include a multi-core processor (e.g., dual-core, quad-core, hexa-core, or any suitable number of cores). In some embodiments, processing circuitry may be distributed across multiple separate processors or processing units, for example, multiple of the same type of processing units (e.g., two Intel Core i9 processors) or multiple different processors (e.g., an Intel Core i5 processor and an Intel Core i7 processor) and/or a system on a chip (e.g., a Qualcomm Snapdragon **888**). Some control circuits may be implemented in hardware, firmware, or software.

[0035] A user provides an input **802** that is received by the input circuitry **804**. The input circuitry **804** is configured to receive a user input related to a computing device. For example, this may be via a touchscreen, keyboard, mouse, microphone and/or infra-red controller of the computing device **800**. The input circuitry **804** transmits **806** the user input to the control circuitry **808**.

[0036] The control circuitry **808** comprises a media receiving module **810**, an assisted delivery request module **814**, a discovery data receiving module **818**, a peer discovery module **822** and an output module **826**. The user input is transmitted **806** to the media receiving module **810**. At the media receiving module **810**, media content is received, for example, an audiovisual media file. If an issue, such as buffering, is identified at the media receiving module **810**, a request is transferred **812** to the assisted delivery request module **814**. The assisted delivery request module **814** transfers the request, via a network, to a second computing device (not shown). The assisted delivery request module **814** transfers **816** an indication to the discovery data receiving module **818** that discovery data is to be received. At the second computing device, discovery data is generated and is transmitted, via the network, to the discovery data receiving module **818**. On receiving the discovery data, the discovery data receiving module **818** transmits **820** the discovery data to the

peer discovery module **822**. The peer discovery module **822** discovers peers that are making portions of the media content available. The peer discovery module transmits **824** an indication to the media portion receiving module **828** that a portion of the media content is to be received. On receiving the portion of media content, the media portion receiving module **828** generates the media content for display.

[0037] FIG. **9** is a flowchart of illustrative steps involved for switching a computing device between an edge server and a peer group, in accordance with some embodiments of the disclosure. Process **900** may be implemented on any of the aforementioned computing devices (e.g., smartphone **100**, **200**, **300**, **400**, **500**, **600**, **700**). In addition, one or more actions of the process **900** may be incorporated into or combined with one or more actions of any other process or embodiments described herein.

[0038] At **902**, media content is received at a client computing device from a first computing device. At **904**, a request to initiate an assisted delivery service is sent from the client computing device to a second computing device. At **906**, the assisted delivery service is initiated at the second computing device in response to the request. At **908**, one or more peer computing devices receiving the media content are identified at the second computing device. At **910**, discovery data is generated at the second computing device, wherein the discovery data enables the client computing device to discover at least one of the peer computing devices. At **912**, discovery data is sent from the second computing device to the client computing device. At **914**, a peer computing device is discovered, at the client computing device, based on discovery data. At **916**, a request to receive a portion of the media content is sent from the client computing device to a discovered peer computing device. At **918**, a portion of the media content is received at the client computing device from the peer computing device.

[0039] The processes described above are intended to be illustrative and not limiting. One skilled in the art would appreciate that the steps of the processes discussed herein may be omitted, modified, combined, and/or rearranged, and any additional steps may be performed without departing from the scope of the disclosure. More generally, the above disclosure is meant to be exemplary and not limiting. Furthermore, it should be noted that the features and limitations described in any one embodiment may be applied to any other embodiment herein, and flowcharts or examples relating to one embodiment may be combined with any other embodiment in a suitable manner, done in different orders, or done in parallel. In addition, the systems and methods described herein may be performed in real time. It should also be noted that the systems and/or methods described above may be applied to, or used in accordance with, other systems and/or methods.

Claims

1. A method comprising: receiving, at a user device, a manifest file for media content, wherein the manifest file comprises: identifiers of a plurality of variants of a time portion of the media content, wherein each variant of the time portion is associated with a respective indication of quality; and data indicative of network locations of a plurality of peer devices, wherein each of the peer devices hosts a respective subset of variants of the time portion of the media content; based at least in part on a status of the user device: selecting a variant of the time portion of the media content based on the respective indication of quality in the manifest file; requesting the selected variant of the time portion of the media content from a network location from which the selected variant of the time portion of the media content at a particular peer device can be received; receiving, at the user device, the selected variant of the time portion of the media content from the particular peer device; and generating for display, at the user device, the selected variant of the time portion of the media content.

2. The method of claim 1, wherein the respective indication of quality is a first respective indication of quality, the selected variant of the time portion of the media content is a first variant

of the time portion of the media content, the particular peer device is a first peer device, and the network location is a first network location, further comprising: selecting a second variant of the time portion of the media content based on a second respective indication of quality in the manifest file; requesting the second variant of the time portion of the media content from a second network location from which the second variant of the time portion of the media content at a second peer device can be received; receiving, at the user device, the second variant of the time portion of the media content from the second peer device; and generating for display, at the user device, the second variant of the time portion of the media content.

3. The method of claim 1, wherein the plurality of network locations comprises a plurality of IP addresses.

4. The method of claim 1, wherein the plurality of network locations comprises a plurality of MAC addresses.

5. The method of claim 1, wherein the status of the user device is an amount of the media content that is present in a buffer of the user device.

6. The method of claim 5, further comprising: performing the selecting the selected variant of the time portion of the media content and the particular peer device from which the selected variant of the time portion of the media content is indicated to be available by the manifest file based on the amount of the media content that is present in the buffer of the user device being above a threshold amount of the media content.

7. The method of claim 1, wherein the status of the user device is a response time of the particular peer device.

8. The method of claim 1, wherein the network location is a first network location, further comprising: based on the selecting the selected variant of the time portion of the media content: determining an edge server from which to request the selected variant of the time portion of the media content; referencing the manifest file for a second network location from which the selected variant of the time portion of the media content at the selected edge server can be received; and requesting the selected variant of the time portion of the media content from the second network location.

9. The method of claim 1, further comprising, prior to the receiving, at the user device, the manifest file for the media content: requesting, via the user device, initiation of an assisted delivery service based on detecting an error-state when receiving the media content from a computing device.

10. A system comprising: input circuitry configured to: receive, at a user device, a manifest file for media content, wherein the manifest file comprises: identifiers of a plurality of variants of a time portion of the media content, wherein each variant of the time portion is associated with a respective indication of quality; and data indicative of network locations of a plurality of peer devices, wherein each of the peer devices hosts a respective subset of variants of the time portion of the media content; control circuitry configured to: based at least in part on a status of the user device: select a variant of the time portion of the media content based on the respective indication of quality in the manifest file; request the selected variant of the time portion of the media content from a network location from which the selected variant of the time portion of the media content at a particular peer device can be received; wherein the input circuitry is further configured to: receive, at the user device, the selected variant of the time portion of the media content from the particular peer device; and wherein the control circuitry is further configured to: generate for display, at the user device, the selected variant of the time portion of the media content.

11. The system of claim 10, wherein the respective indication of quality is a first respective indication of quality, the selected variant of the time portion of the media content is a first variant of the time portion of the media content, the particular peer device is a first peer device, and the network location is a first network location, wherein the control circuitry is further configured to: select a second variant of the time portion of the media content based on a second respective indication of quality in the manifest file; request the second variant of the time portion of the media

content from a second network location from which the second variant of the time portion of the media content at a second peer device can be received; wherein the input circuitry is further configured to: receive, at the user device, the second variant of the time portion of the media content from the second peer device; and wherein the control circuitry is further configured to: generate for display, at the user device, the second variant of the time portion of the media content.

12. The system of claim 10, wherein the plurality of network locations comprises a plurality of IP addresses.

13. The system of claim 10, wherein the plurality of network locations comprises a plurality of MAC addresses.

14. The system of claim 10, wherein the status of the user device is an amount of the media content that is present in a buffer of the user device.

15. The system of claim 14, wherein the control circuitry is further configured to: perform the selecting the selected variant of the time portion of the media content and the particular peer device from which the selected variant of the time portion of the media content is indicated to be available by the manifest file based on the amount of the media content that is present in the buffer of the user device being above a threshold amount of the media content.

16. The system of claim 10, wherein the status of the user device is a response time of the particular peer device.

17. The system of claim 10, wherein the network location is a first network location, wherein the control circuitry is further configured to: based on the selecting the selected variant of the time portion of the media content: determine an edge server from which to request the selected variant of the time portion of the media content; reference the manifest file for a second network location from which the selected variant of the time portion of the media content at the selected edge server can be received; and request the selected variant of the time portion of the media content from the second network location.

18. The system of claim 10, wherein the control circuitry is further configured to, prior to the receiving, at the user device, the manifest file for the media content: request, via the user device, initiation of an assisted delivery service based on detecting an error-state when receiving the media content from a computing device.

19. A non-transitory computer readable medium comprising instructions that when executed by control circuitry cause the control circuitry to: receive, at a user device, a manifest file for media content, wherein the manifest file comprises: identifiers of a plurality of variants of a time portion of the media content, wherein each variant of the time portion is associated with a respective indication of quality; and data indicative of network locations of a plurality of peer devices, wherein each of the peer devices hosts a respective subset of variants of the time portion of the media content; based at least in part on a status of the user device: select a variant of the time portion of the media content based on the respective indication of quality in the manifest file; request the selected variant of the time portion of the media content from a network location from which the selected variant of the time portion of the media content at a particular peer device can be received; receive, at the user device, the selected variant of the time portion of the media content from the particular peer device; and generate for display, at the user device, the selected variant of the time portion of the media content.

20. The non-transitory computer readable medium of claim 19, wherein the respective indication of quality is a first respective indication of quality, the selected variant of the time portion of the media content is a first variant of the time portion of the media content, the particular peer device is a first peer device, and the network location is a first network location, further comprising instructions that when executed by the control circuitry cause the control circuitry to: select a second variant of the time portion of the media content based on a second respective indication of quality in the manifest file; request the second variant of the time portion of the media content from a second network location from which the second variant of the time portion of the media content

at a second peer device can be received; receive, at the user device, the second variant of the time portion of the media content from the second peer device; and generate for display, at the user device, the second variant of the time portion of the media content.
