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Unidirectional Broadcast WiFi for High Data Rate Transmission to Multiple Receivers

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ABSTRACT

This disclosure describes techniques for cache servers in a content delivery network (CDN) to egress data-intensive content such as videos, multimedia, application packages, etc. to clients by leveraging the broadcast mode of WiFi, which is an open-source modification to standard WiFi that enables transmission of unidirectional, broadcast traffic. The techniques enable the simultaneous transmission of very large amounts of data, e.g., a terabyte or more, in a relatively short time, e.g., one hour, to multiple clients using low-cost, off-the-shelf hardware. In an example application, the described broadcast WiFi techniques can be utilized to update content on public transport vehicles, e.g., buses, trains, cruise ships, airplanes, etc., at a time the vehicles are parked at transit stations, airports, seaports, etc.

KEYWORDS

- Broadcast WiFi
- Satellite broadcast
- Satellite multicast
- Internet multicast
- Multicast WiFi
- Ethernet multicast
- Content caching
- Public transit

BACKGROUND

Public transport vehicles, e.g., buses, cruise ships, trains, aircraft, etc. have limited wireless connectivity during transit. For example, serving on-demand, streaming video to tensto-hundreds of passengers in a vehicle requires a bandwidth of hundreds of megabits per second, which is unsupported or prohibitively expensive using 4G or LTE.

Although WiFi can support a theoretical maximum of 1.8 Gbps, it is operative only over short distances. Also, WiFi is generally used in unicast (one-to-one) mode, in which each one-to-one connection can only sustain bandwidths substantially below the theoretical maximum. Even if the vehicles only ingress data at close distances at transit stations or depots, unicast WiFi update of content across dozens or hundreds of vehicles is infeasible.

In a traditional content delivery network (CDN), a cache server downloads data from upstream servers (ingress) and serves data to downstream user devices (egress). Content providers benefit from minimizing ingress data versus egress data since ingress data is more expensive. The delta - egress minus ingress - is the cost reduction benefit for content providers. Content can be pushed to cache servers in a broadcast or multicast manner via satellite. Such a delivery model has a fixed cost, e.g., that of the satellite, and low or no per receiver incremental cost, and has found viable application in the transportation space, e.g., buses, trains, cruise ships, airplanes, etc. Satellites themselves have to ingress data, e.g., download content from upstream servers over the Internet like a traditional CDN.

DESCRIPTION

This disclosure describes techniques for cache servers in a content delivery network to egress data-intensive content, e.g., videos, multimedia, application packages, etc. to clients by leveraging the broadcast mode of WiFi, which is an open-source modification to standard WiFi that transmits unidirectional broadcast traffic.

The techniques enable the transmission of very large amounts of data, e.g., a terabyte or more, in a relatively short time, e.g., one hour, simultaneously to multiple clients using low-cost, off-the-shelf hardware. In an example application, public transport vehicles, e.g., buses, trains, cruise ships, airplanes, etc., can have their content updated while parked at transit stations, airports, seaports, etc. using broadcast WiFi.

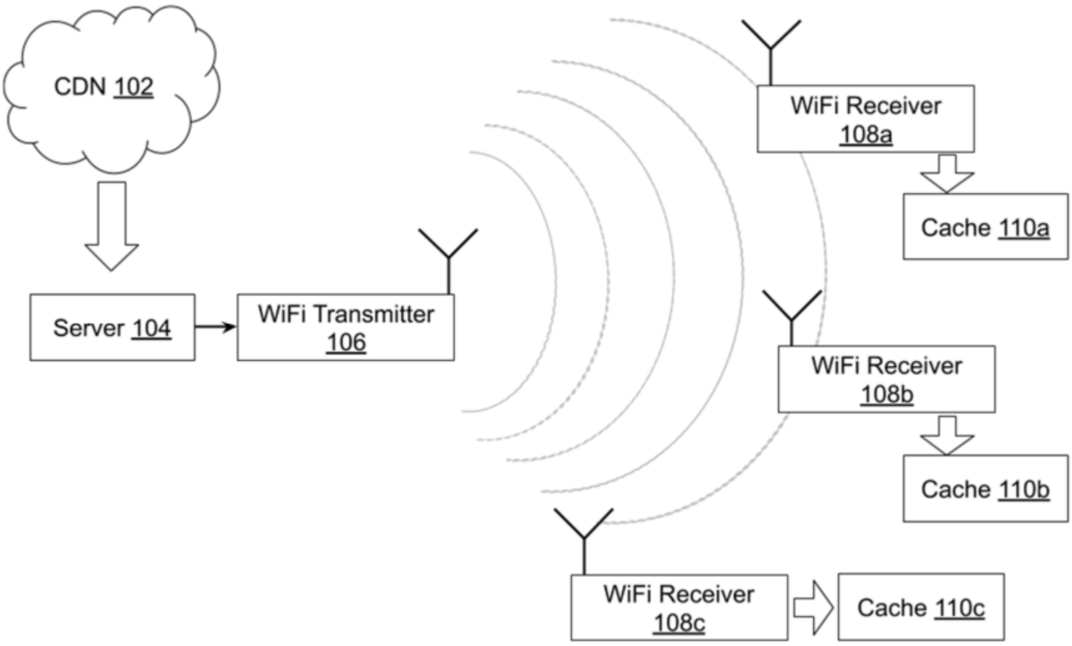

Fig. 1: Unidirectional, broadcast WiFi for high data rate transmission to multiple receivers

Fig. 1 illustrates unidirectional, broadcast WiFi for high data rate transmission to multiple receivers, per the techniques of this disclosure. A server (104) downloads (ingresses) content from a content delivery network (CDN, 102). As explained before, in an example scenario, the server is placed in a transit station, airport, seaport, etc. that serves public transport vehicles.

The server encodes the content into a unidirectional bitstream, using a protocol such as FLUTE, as described in [3]. Encryption can be performed at one or more of the content-file level, the bitstream level, or the network-layer level. If performed at the content-file level, e.g., the bitstream and the network layer impose no further encryptions of their own, then the content is protected while the metadata is transmitted in cleartext. If encryption is done at the content and at the network-layer levels, the content as well as the metadata is protected. Content files are delivered in data carousels, e.g., circularly repeated multiple times per day. Multiple carousels and sub-bitstreams can be embedded in the broadcast bitstream.

The broadcast bitstream is sent to a WiFi transmitter (106), which unidirectionally broadcasts the content. WiFi receivers (108a-c) receive the WiFi broadcast, and the received content is saved to their respective caches (110a-c). As explained before, in the example scenario, the WiFi receivers and caches are placed on vehicles that are getting readied for departure at a transit station, airport, seaport, etc.

As vehicles pull into transit stations or depots that are broadcasting, their onboard WiFi receivers receive the broadcast bitstream and extract as much data as possible. For partial files, the vehicles request the missing parts over an out-of-band point-to-point connection. The vehicles can also request the broadcast server to repeat high-value files earlier than regularly scheduled. As the vehicle operates its regular service routes, the caches provide content to the passengers on the vehicles.

By using WiFi in broadcast mode, the described techniques greatly increase the amount of data that is simultaneously transmissible to multiple receivers. Since there is no one-one association between transmitter and receiver (as in unicast), there is no risk of link failure due to the loss of association. The error-correcting abilities of unicast WiFi are retained. High reliability is achieved by the ability of the WiFi receivers to recover corrupted packets.

Additionally, it is also possible to receive erroneous frames, e.g., where the checksum does not match even after error correction, without requesting an immediate repeated transmission or a lower data rate. The erroneous frames can be filled in during a next round of the data carousel, or, if the erroneous frames are infrequent enough, can show up in the endcustomer's view as nearly undetectable glitches in content such as video. Still alternatively, as described above, a receiver can request retransmission of erroneous frames via an out-of-band channel. The broadcast WiFi transmitter can consolidate all erroneously received frames of all receivers and transmit such data in a one-shot manner, e.g., at the end of a super-frame.

The described techniques are similar to ethernet multicast over internet protocol, using, e.g., an IP multicast group; to sending a bitstream over IP multicast over digital video broadcast (DVB); to transmitting real-time, high-speed video from remote-controlled aircraft in a first-person view (FPV); etc.

CONCLUSION

This disclosure describes techniques for cache servers in a content delivery network (CDN) to egress data-intensive content such as videos, multimedia, application packages, etc. to clients by leveraging the broadcast mode of WiFi, which is an open-source modification to standard WiFi that enables transmission of unidirectional, broadcast traffic. The techniques enable the simultaneous transmission of very large amounts of data, e.g., a terabyte or more, in a relatively short time, e.g., one hour, to multiple clients using low-cost, off-the-shelf hardware. In an example application, the described broadcast WiFi techniques can be utilized to update content on public transport vehicles, e.g., buses, trains, cruise ships, airplanes, etc., at a time the vehicles are parked at transit stations, airports, seaports, etc.

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