Distributed P2P Multicasting of 3D MVV over Wi-Fi Display

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Abstract:

Growing popularity of smart phones & networking capabilities lead to interesting communication applications and services in the internet domain. In the entertainment and broadcasting industry, 3D video content has seen significant usage over past few years. Transmission of 3D video over communication networks is an actively researched topic where substantial work is progressing these days. Leveraging both the trending technologies, internet & 3D, we propose a distributive system for peer-to-peer multicasting of 3D multi-view video over Wi-Fi display system. The solution presents an idea in which individual client devices creates a collaborative environment for sharing 3D multi-view videos among themselves to form a distributive networking system for 3D video transmission. The idea gives best 3D experience to the end users with optimized network resources.

1. INTRODUCTION

Internet is widely spread. Increased networking capabilities and reduced data rates have paved the way for wide range of applications in the communication domain. Advent of 3G & 4G mobile networking technologies has made it much easier and numerous wireless services are being offered. There are variety of video communication services offered over internet already. 3D video is forecasted to be one of the common phenomena in smart phones and in home entertainment in coming days. Combining both of the technologies i.e. 3D video plus the networking infrastructure, Next big move towards video communication technology is destined to be an efficient and flexible 3D video distribution system over the network.

3D video representation can broadly be classified into two categories: Stereoscopic video and multi-view video. Stereoscopic 3D video presents two videos, left view and right view, captured using a side-by-side closely located cameras to give a sensation of depth to the user. Stereoscopic video is already popular in cinema & broadcasting industries. Multi-view video (MVV) is a natural extension to Stereoscopic video, with number of views changing from two to multi-views (say N). In MVV, multiple videos are captured simultaneously from various camera sensors placed at different locations around the scene. In order to achieve wide coverage, cameras will be positioned at optimal distance covering variety of viewing angles from '0' degree to '360' degree spectrum. Multi-view from multiple cameras are combined on to a single video stream prior to transmitting over the communication network.

Since 3D MVV involves more number of views, communication of 3D MVV leads to increased bandwidth requirements [1] and it is essential to have an efficient compression i.e. coding before transmitting on to the network. Let us consider a client-server modeled system [Fig.1] with the objective of 3D MVV transmission from a single server to multiple clients. Multi-view encoding part on left hand side of the Fig.1 depicts multiple video feeds from multiple cameras being encoded individually and is multiplexed on the server [2] to be transmitted to required client devices. Right hand side of the Fig.1 represents server-client streaming part to achieve multicasting of 3D MVV. Typical approach to realize this kind of system is to transmit all the 'N' views from the server to each of the client devices separately [Fig.2].

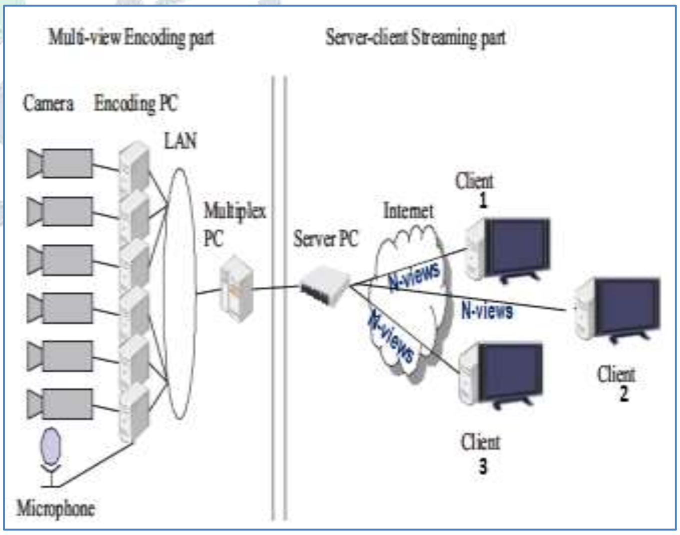

Fig 1: Typical Server-Client model for MVV

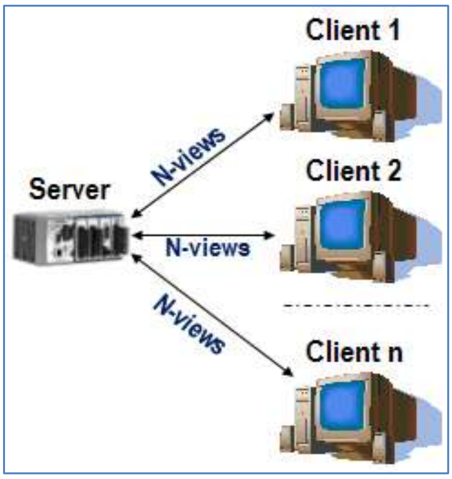

Fig 2: Elaborated view Server-Client communication

In this paper, we propose a decentralized networking architecture in which clients build a distributive model to share the available views among themselves independently i.e. peer-peer, without having dependency on the centralized server except for the base view. Wi-Fi display Miracast system is used for realization of the idea.

Miracast is Wi-Fi Alliance defined standard [3] for wireless communication of media content from devices (such as laptops, tablets, or smartphones) to displays (such as TVs or monitors) using Wi-Fi Direct. Wi-Fi Direct enables Wi-Fi devices to connect directly i.e. peer-peer over Wi-Fi. (Wi-Fi P2P). Wi-Fi P2P devices from a Wi-Fi P2P group for communication among themselves.

Wi-Fi Display can be described alternatively as "HDMI over Wi-Fi". Wi-Fi Display serve two functionalities majorly. First one is the screen casting i.e. mirroring the screen as is from source to the sink device. Secondly, video transmission from the source to the sink display. The Wi-Fi Alliance certifies the compliant devices and the Miracast certified devices could communicate with each other, regardless of manufacturer.

2. SYSTEM DESCRIPTION

Fig.3 below depicts a Wi-Fi Display system a single source – single client with control information over RTSP channel and Audio and video payload over RTP/UDP.

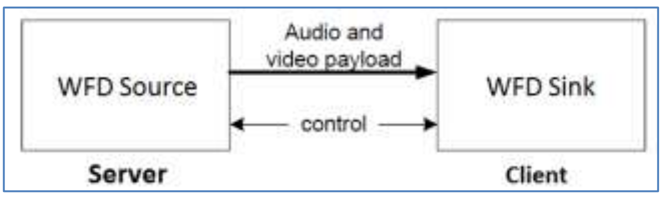

Fig 3: Typical Wi-Fi Display Session

In our system, we require a server-client multicasting model in which a server with MVV multi-view video of N views serves multiple client devices to transmit the MVV views as and when requested by the client device. Fig.4 gives the sample distribution model of the system. Source device (sever) contains H.264/AVC coded MVV content with *Simulcast i.e.* each of the multi-views is encoded independently using H.264 encoder [4-8] and stored on the source disk.

System works on the principle of cooperative or distributive streaming. It has two major functionalities. Server to client multi cast and peer-peer (P2P).

Server to client multicast: Server to multi-client connection mechanism postulates a server sharing only the base/main view to each of the client devices to start with. This is similar to a stereoscopic video with left and right views. Server transmits the main view to each of the client devices separately i.e. independently. This assures that the client device is ready to be able to start playing the video with only one main view angle. Since multi-view is not yet transmitted, clients shall not be able to switch the views based on the viewpoint. In other words, irrespective of the user's view port, user will be able to see one fixed view, which is similar to Stereoscopic video.

Peer-Peer: P2P methods are the main differentiating factors to the system. P2P mechanism is more flexible and they don't necessarily need a centralized server for communication. Main view is already sent to all the clients as described in the previous section. Now the objective is to share rest of the MVV views to the clients. Idea here is to make use of path diversity where in different views are shared to the client devices over different paths and the received client devices acts as server to other peers in transmitting the already received views.

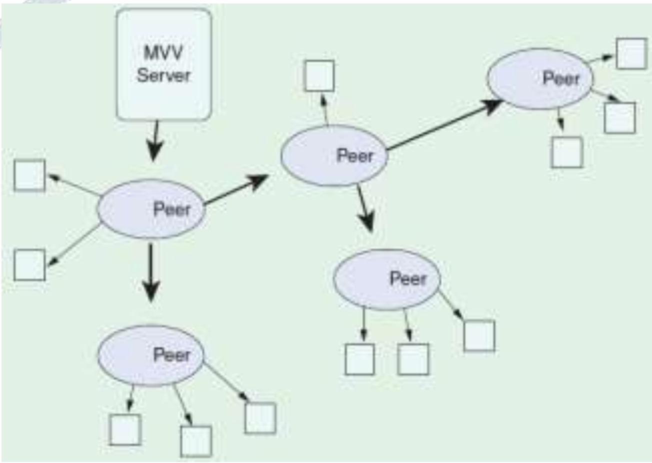

Fig 4: Sample distribution multicast network

3. SYSTEM IMPLEMENTATION

Fig5 depicted below gives the high-level topology of the system.

Source/Server: As explained in the previous section source/server device consists of N-view MVV stored on the source device with all the views encoded independently. Even though the *simulcast* offers lesser compression efficiency comparatively, it has been considered for better transmission efficiency. In the original real network scenarios, scalable video coding with base & enhancement layered can be more beneficial w.r.t compression efficiency.

Server to Client: Server transmits the main view to all the client devices to have a seamless experience at least with one fixed view to the user. Apart from the main view, server also sends one of the N-views to each of these clients randomly. For e.g. as shown in the Fig.5, client1 (peer1) receives view1, client2 (peer2) view gets view2, client 3(peer3) gets view3 and so on. Mapping peer1 to view1, peer2 to view2, peer3 to view3 here is for the ease of explanation here. In the real scenario, either it could be random or it can be based on who has requested what views first. For e.g. If the Peer 1 has requested for a viewing angle view7.

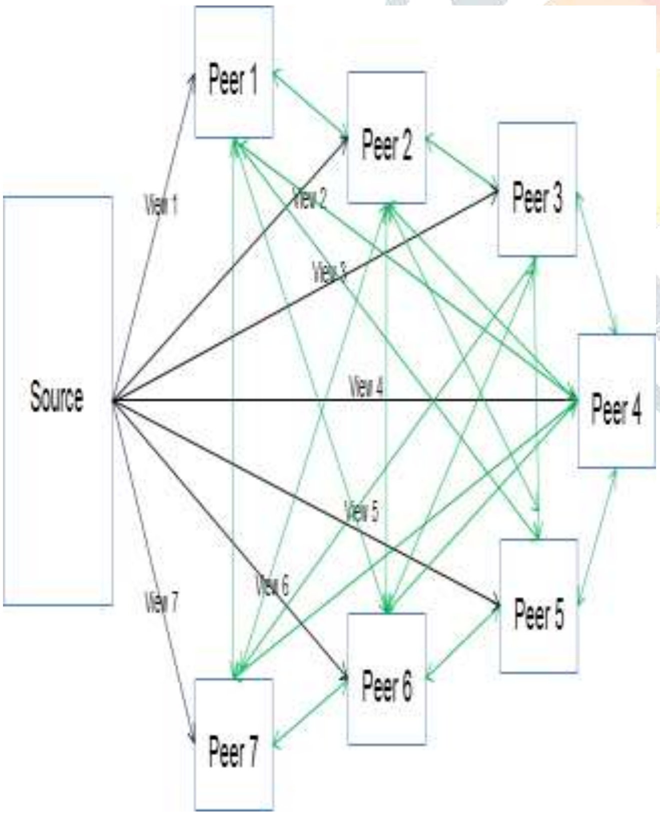

Fig 5: High-level network topology

Peer to Peer: From next time onwards, if any peer devices requires a view which is already available with another peer, it gets transmitted peer-peer without depending on the server, thus, saves network resources. For e.g. say in the given Fig.5 above, each of the peers get their respective numbered view from server initially along with the base view. Now, if peer1 requires view7, it gets the view from the peer7 device instead of the server.

To distribute multiple views over the network using P2P overlays, BitTorrent protocol is modified to adapt to 3D video streaming [9]. The BitTorrent protocol uses a divide-and conquer method in which content is split into equally sized chunks (MVV views in our case), which form the basic transmission unit for exchange. For the simplicity purpose, its shown that each client receive only one addition view. In actual streaming case, it depends on the need basis. Basic principle here is to look for Peer-to-Peer transmission from any available peer(s), instead of server sharing all the views.

4. EXPERIMENTAL RESULTS

Table.1 below shows the numbers i.e. required bandwidth for each of the views in a normal scenario i.e. without proposed system.

View	*Bandwidth (mbps)*
Stereo View (Base view)	1
View 1	0.12
View 2	0.13
View 3	0.144
View 4	0.162
View 5	0.185
View 6	0.2
View 7	0.222
Total	2.16
Total for 7 Clients	2.16 * 7 = 17.28 mbps

Table 1: Experimental results

Base view requires 1 mbps where as other views relatively lesser BW to transmit due to the inter-view redundancy. Above total shown is for one Client. If one client requires 2.16 mbps; to transmit MVV for all the clients individually from the sever, it requires 2.16 * 7 = 17.28 mbps.

With the proposed solution, it's observed from Table.2 that the BW saving is significant. To elaborate one of the rows given below, let us consider row1 below. Peer-1 receives base view + view 1 only from the server i.e. it requires 'base view + view1' = 1 + 0.12 – 1.12 mbps only. Rest of the views are received peer-peer from the neighbors via LAN.

View	*Bandwidth (mbps)*
Source – Peer 1 (Base + View 1)	1.12
Source – Peer 2 (Base + View 2)	1.13
Source – Peer 3 (Base + View 3)	1.144

Source – Peer 4 (Base + View 4)	1.162
Source – Peer 5 (Base + View 5)	1.185
Source – Peer 6 (Base + View 6)	1.2
Source – Peer 7 (Base + View 7)	1.222
Total for 7 clients	8.16 mbps

Table 2: Experimental results with proposed solution

Hence, it's observed that overall; 8.16/17.28 ~ 47% (close to 50%) savings are achieved with the proposed approach.

5. CONCLUSION

Collaboration between the peers enhances the overall network performance significantly. Peer-to-peer (P2P) streaming refers to methods where each peer allocates some of its resources to forward received streams to other peers; each of the receiving peers acts partly as a sending peer. In this paper, a distributive peer-to-peer system is proposed and demonstrated successfully for a 3D MVV video transmission on a Wi-Fi display system.

6. REFERENCES

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