P2P Multipoint Video Conferencing Using Layered Video and Multi-Tree Structure

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***Abstract*- Multipoint video conferencing is an interpersonal application with real time visual communication for virtual meetings which can give users a new level of interactivity. Many types of networks such as mesh based structure which provides an information redundancy and more complicated data delivery scheme due to its complex structure. In order to overcome this problem, Multi-tree structure in a peer-to-peer network is proposed to achieve full quality video for all the participants and to overcome the issue comes from heterogeneity of peers. Layered video has been a popular technique to enable access for video is used to solve the denying requests and allow each peer to view all the other peers at any time.**

Keywords- Multipoint video conferencing, Layered video, Multi-tree structure, peer-to-peer (P2P)

I. INTRODUCTION

Video conferencing is a rapidly growing reliable technology for connecting the people to communicate visually across the globe. Face-to-face interactions are achieved irrespective of any geographical locations. It is widely used for multi-national companies with various branches across the world, education, commerce etc. Video conferencing is also a cost- effective solution by reducing the travel cost and time spent. The basic of video conferencing requires the environment, equipment and the network that links the sites together. The major feature of this multipoint video conferencing is to render the high quality video images at any capture resolution. The core concept used in video conferencing is digital compression in real time.

The major problem in video conferencing is quality degradation and bandwidth fluctuation among the participants. In point-to-point video conferencing, the quality degradation occurs mildly that does not affect majorly due to sufficient bandwidth, whereas in multipoint video conferencing this becomes a major problem. By using existing techniques and various types of networks, still there is minimum number of base quality receivers (half quality). Many types of structured and unstructured networks were used in existing like mesh-based structure, tree structure and broadcasting. Each type of networks is having certain advantages and disadvantages. Tree based structure provides single point of failure if any one node does not perform its task. Whereas mesh based structure is having better resilience but the drawback is its complex structure. Likewise every structure is having some pros and cons.

Peer-to-peer network is a reliable network model for multipoint video conferencing which provides better efficiency and fault tolerance. The major advantage of using this peer-to-peer network is direct sharing of content among all the peers and for its scalability. In this network, each peer plays the role of content providers and content consumers at the same time. That is, the peer can initiate requests to other peers and at the same time responds to incoming requests from other peers in the network.

Video is composed of multiple frames in a sequence manner. Each frame is one image. Video is a temporal combination of frames that are sent one after the other. Prior to the transmission, compression technique needs to be applied to reduce the bandwidth requirements. Video compressions are mainly used for removing the redundant frames. Video compression takes place by spatially compressing each frame and temporally compressing set of frames. Various video coding techniques are used. The advances in video coding [1] explains the scalable video coding(SVC) consists of H.264/SVC, wavelet-based SVC, multiple description coding and high efficiency video coding.

II. RELATED WORK

Since Akkus IE et al. [1] proposed a P2P multipoint video conferencing. They developed a fully distributed algorithm and multi-objective optimization framework for minimizing the number of half quality receivers, minimizing the denying issues experienced in a chain and granting additional requests at maximum level. Civanlar et al. [2] proposed a P2P multipoint video conferencing proto-type for a point-to-point video conferencing and it had extended to multipoint. They used an algorithm for two-stage heuristic to solve the asymmetric multipoint video conferencing problem. C. Hsu et al. [3] proposed a polynomial time approximation algorithm of weighted segment scheduling and demonstrated that outperforms other algorithms in terms of perceived video quality and in load balancing. C. Xu et al. [4] proposed a balanced binary tree overlay network for exact queries and range queries. They derived algorithms for node joining and finding replacement.

D. Tran et al. [5] proposed a P2P technique called ZIGZAG and it allows the single source to distribute content to many clients with appropriate root at the server. End-to-end delay is also minimized. They used a star topology for forwarding the content. H.Hu et al. [6] proposed a layered P2P streaming layered protocol with mesh-based structure in order to maximize the efficiency. J. Liu et al. [7] derived algorithms to solve the layering and bandwidth problem using two-step decomposition consists of intrasession and intersession optimization. It is used to improve the total system utility. Intrasession allocation is to detect the number of layers in a particular session for appropriate layering design and intersession is to allocate the bandwidth among the sessions. J. Liu et al. [8] described the basic taxonomy of P2P broadcast. They closely examined tree based and data driven overlay construction.

Y. Liu et al [9] proposed a PRIME approach of mesh based P2P streaming for live content. They minimized the bandwidth bottleneck and content bottleneck by using packet scheduling. Naeem R et al. [10] explained the video streaming for both on demand and live streaming over P2P networks. Advanced video coding techniques are also explained and the basic of P2P network with unique functionalities are discussed. Scalable video coding is defined with proper temporal, spatial and quality resolutions. Ponec M et al [11] developed the layer trees construction algorithm and other distributed algorithms such as primal and primal-dual to maximize the overall utility. V. Venkataraman et al. [12] proposed an unstructured end system multicast protocol called Chunkyspread to incorporate different constraints and optimizations. Y. Liu et al. [13] described a survey about P2P video live streaming and P2P Video-on-Demand streaming technology with various types of networks. Y. W. Sung et al. [14] proposed the multi-tree framework for good utilization, equitable distribution, differential distribution and to attain stability.

III. PROPOSED WORK

A. System Architecture

Each participant in our multipoint video conferencing is termed as peer. In our Peer-to-peer network, each peer will send and receive the video at the same time. Each peer in the video conferencing group can be able to identify the other active peers involved in the network. The list of members who are all active is available for all the participants and also will receive a bye message from those participants who are all leaving the video conferencing. The sender peer captures the video tracks from the capture device directly at any resolution. The root sender peer act as a “Parent”. The parent peer sends the video to multiple receivers directly. Then the process goes on level by level. The video is transmitted from sender to receiver by using the layered video and the proposed multi-tree structure.

For video transmission, the video content needs to be encoded while capturing the streaming content from the camera. Encoding process is to convert the raw video content into a suitable format for both efficient transmission and also for storing that particular video. Then transmission takes place from the sender to multiple receivers through multi-tree structure. At the receiver side, the receiving video is decoded and displayed. Decoding process reverses the conversion of encoding. The video is stored simultaneously while it is displaying in the receiver peer. So that further video transmissions can take place.

The overall architecture of the video transmission process in multipoint video conferencing is as shown in figure (1). Layered video is used for partitioning the streaming video into base layer and enhancement layers. Enhancement layers are depending on the base layers. A video cannot be able to decode without receiving the base layer. Every participant can view any other participants at any time by using the layered video. Multi-tree structure is implemented for video transmission process. This structure is having dynamic nature which makes every node possible to join and leave the multipoint video conferencing at any time that does not affect the transmission process. A peer can have any number of child peers according to that peer’s available bandwidth and other resources to provide a better quality.

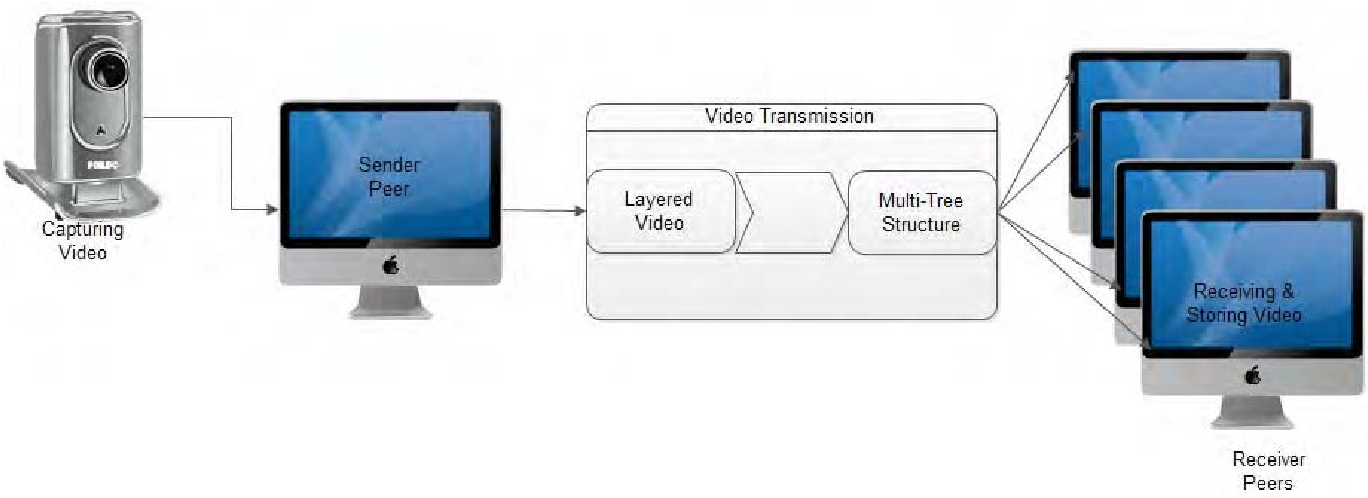

Fig. 1. Video Transmission Architecture

B. Layered Video

Video conferencing requires the layered video for encoding and decoding process that must be done in real time. Since the latency should be low, layered video is applied by using a H.263 coding technique. The ultimate goal of video source coding H.263 video codec is to reduce bit-stream for video storage and transmission purpose. The H.263 video CODEC- COder and DECoder is used for encoding the video for compression before transmission and decoding the video for decompression before displaying the video. The video is compressed in JPEG format and all the peers are able to receive the streaming content with full quality. This technique achieves the essential compression gain, compared with existing video codec techniques.

Layered video encodes a video stream into a single base layer and more number of enhancement layers. Base layer is the most significant layer which contains the essential features of a video. Enhancement layer consists of multiple layers with enhanced features. The base layer provides the half quality and enhancement layers are used to increase the quality of a video that provides more robustness. Half quality video is considered as receiving only the base layer which is a lower layer. Full quality is achieved by receiving both base layer and enhancement layers which are higher layers as in figure (2).

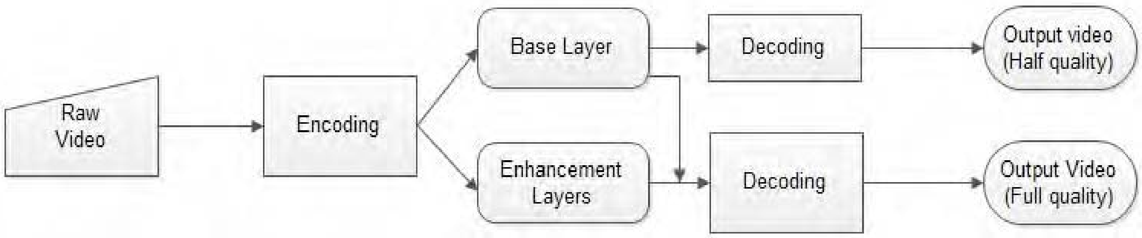

Fig. 2: Layered video architecture
(Base layer = Half quality, Base layer + Enhancement layers = Full quality)

The sender peer transmits a single video streaming content to multiple receivers whose quality is adjusted and they can subscribe to any number of layers based on its available bandwidth. The source video content needs to be transmitted is analysed and then partitioned into layers while encoding. In the decoder side, first the base layer is received and then the enhancement layers are decoded. Thus quality and resolution of a video is improved efficiently by adding more number of layers. Adding more number of enhancement layers further refines the reconstructed video streaming quality.

The base layer with most important features has a higher priority and the rest of the layers are having lower priority. High priority video frames are decoded primarily and then low priority frames are decoded optionally according to the resources available by the peers. In order to this, it exhibits better temporal resolution and better bandwidth utilization properties. High compression ratio is achieved by inter-frame and intra-frame compressions. Temporal redundancy and spatial redundancy are used as a compression advantage against the data loss. All the layers in the layered video are decoded to the multiple receiver peers through multi-tree structure. All the participants can view any other participants at any time with any configuration.

C. Multi-Tree Structure

To achieve better quality for all the peers in the video conferencing and also to avoid the latency, multi-tree structure is proposed. The peers in the network are organized into a multi-tree structure with a relationship as “parent-child”. The root parent peer initiates the video transmission to the multiple child peers as far as possible. Further those multiple child peers act as multiple parents to forth coming child peers and so on. This structure increases level by level but the video receiving and sending that video to many receivers takes place simultaneously. Failure recovery is possible if the peer cannot be able to receive the video from the corresponding sender, then some other peer will perform that task. The receiver peer starts receiving the video streaming as soon as possible after joining into the network otherwise it migrates to a any other parent peer. In this structure, any peer can be able to join and leave the network at any time due to its dynamic nature.

For example, Let us consider a root parent peer (i.e. peer 0) having four child peers (i.e. peer 1, peer 2, peer 3 and peer 4) as in figure (2). The video transmission starts directly from the parent peer by capturing the video tracks from the capture device and it is received by the four child peers. Then these four child peers becomes a parent by transmitting the streaming video content to the child peers in the next level simultaneously as soon as they receiving the video (i.e. peer 1 sends the video streaming to peer 5, peer 6, peer 7 and peer 8. Like this from peer 2 to peer 9, peer 10, peer 11 and peer 12. Then peer 3 to peer 13, peer 14, peer 15 and peer 16. Finally from peer 4 to peer 17, peer 18, peer 19 and peer 20).

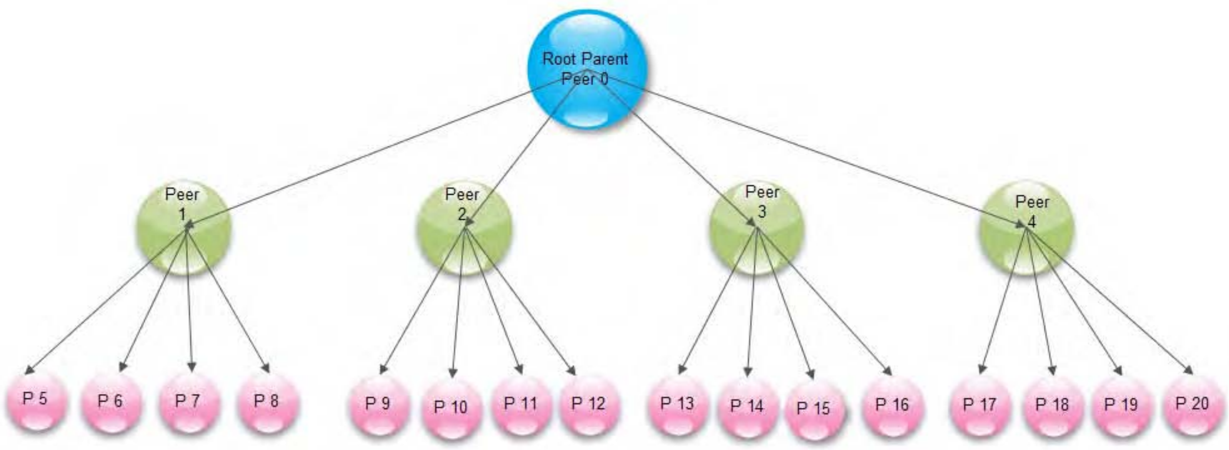

Fig. 3: Multi-Tree Structure for twenty participants in a peer-to-peer network

The multi-tree structure can be constructed according to the available bandwidth with any number of child peers and the streaming can be performed efficiently. The dynamic nature of this structure makes the video conferencing in a reliable manner with better fault tolerance and the number of child peers may also vary. This structure works best when compared to other types due to its better contribution among all the peers in the network and no heterogeneity problems. It helps in providing better quality and efficient routing of video content among the participants.

IV. RESULTS AND DISCUSSIONS

The multipoint video conferencing is deployed using layered video and multi-tree structure in a peer-to-peer network. All the peers act both as sender peer and receiver peer. Each peer sends and receives the video in full quality at the same time. All the participants can be able to view any other participants involved in the video conferencing network. The participants currently involved in conferencing are identified as active peers and those participants who are not currently involved are identified as passive peers. Any peers involved in the multipoint video conferencing can join and leave at any time. The video is captured for 60 seconds from the capture device at any resolution and it is transmitted to the receivers directly with proper encoding and decoding technique.

All the layers in the layered video are transmitted to the receivers through a multi-tree structure. Receivers access the video and the video receiving process with time duration is as shown in figure (4) for ten participants involved in a multipoint video conferencing. The root peer receives the video directly using capture device. Then this act as sender peer for next four peers. Then next five peers are receiving the video content from the four upper level peers. Every peer in this video conferencing is playing both the roles as sender and receiver.

Fig. 4: Video Receiving

The users are allowed to set parameters such as window size, frame rate, quality, video size and format. The video which is receiving is stored simultaneously at the receiver side in order to forward that video to the forthcoming receivers. The recording video is saved in a scalable video processing standard format known as "Audio Video Interleave (AVI)" started out playing 15 frames per second of a video in a 160*120 pixel window and the video file which is saving is also monitored simultaneously.

V. CONCLUSION

We proposed an efficient video transmission for multipoint video conferencing in a peer-to-peer network that makes use of layered video and multi-tree structure, where each peer stores and streams videos to the requesting receivers. We encode a video into several layers and it is decoded with all the layers as possible within the available bandwidth. This approach makes possible to achieve full quality with proper synchronization as well as better contribution among all the participants involved in the videoconferencing. Fault tolerance is obtained by the peer-to-peer network. The problems such as heterogeneity of peers and quality degradation are avoided by using this proposed multi-tree structure. Transmission delay does not occur and the scalability of video transmission is improved by using multi-tree structure approach.

REFERENCES

[1] Akkus IE, Ozkasap O, Civanlar MR. Peer-to-peer multipoint video conferencing with layered video. In: Proceedings of IEEE ICIP, Atlanta, (2011) pp.137-150.

[2] Civanlar MR, Ozkasap O, Celebi T. Peer-to-peer multipoint video conferencing on the internet. Signal Processing: Image Communication 2005; 20 : 743-754.

[3] C. Hsu, M. Hefeeda, Quality-aware segment transmission scheduling in peer-to-peer streaming systems, in: Proceedings of the First Annual ACM SIGMM Conference on Multimedia Systems (MMSys'10), 2010, pp. 169–180.

[4] C. Xu, G.M. Muntean,, E. Fallon, A. Hanley, A Balanced Tree based Strategy for Unstructured Media Distribution in P2P Networks, In: Proceedings of IEEE ICC '08,June 2008.

[5] D. Tran, K. Hua, T. Do, Zigzag: an efficient peer-to-peer scheme for media streaming, In: Proceedings of IEEE INFOCOM, San Francisco,2003, pp.1283-1292.

[6] H.Hu, Y. Liu, Peer-to-peer streaming of layered video: efficiency, fairness and incentive, IEEE Transactions on Circuits and Systems for video Technology 21 (8) (2011) 1013-1026.

[7] J. Liu, B. Li, Y. Hou, I. Chlamtac, On optimal layering and bandwidth allocation for multisession video broadcasting, IEEE Transactions on Wireless Communications 3(2)(2004) pp.656-667.

[8] J. Liu, S. Rao, B. Li, H. Zhang, Opportunities and challenges of peer-to-peer Internet video broadcast, Proceedings of the IEEE 96(1)(2008) pp. 11-24.

[9] N. Magharei, R. Rejaie, PRIME: Peer-to-peer receiver-driven mesh-based streaming, in Proceedings of INFOC)M'07, 2007

[10] Naeem R, Hyunggon P, Ebroul I. Video streaming over P2P networks: Challenges and opportunities. Signal Processing: Image Communication 27(2012) pp.401-411.

[11] Ponec M, Sengupta S, Chen M, Li J, Chou PA. Multi-rate peer-to-peer video conferencing: A distributed approach using scalable coding. In: Proceedings of IEEE international conference on multimedia expo (ICME), New York, 2009.

[12] V. Venkataraman, K. Yoshida, P. Francis, Chunkyspread: heterogeneous unstructured tree-based peer-to-peer multicast , In: Proceedings of the 14th IEEE International Conference on Network Protocols (ICNP06), Santa Barbara ,CA, 2006, pp.2-11.

[13] Y. Liu, Y. Guo, C. Liang, A survey on peer-to-peer video streaming systems, Peer-to-Peer Networking and Applications 1 (2008) pp.18-28.

[14] Y. W. Sung, M. Bishop, S. G. Rao, Enabling contribution awareness in an overlay broadcasting system, In: Proceedings of ACM SIGCOMM06, Pisa, Italy, September2006.