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P2P Living Streaming QoS Study

QoS in P2P Live Media Streaming

- **QoS in general**
  - QoS is about provisioning network services to the level of guarantee required by the application layer services.
  - QoS mechanisms provide means for ensuring network resources required by applications when delivered to achieve the expected level of user QoE
- **Specifically for P2P Live Media Streaming**
  - QoS is the control of loss (dropped frames), error, latency (buffering), jitter, and bit-rate (variable) through the provisioning of required network services and the proactive design, construction, maintenance, and operation of the overlay network topology
  - The objective of QoS mechanisms is to achieve user QoE, consisting of but not limited to stability, availability, delay, video quality, audio quality, speed of service access and channel switching, and minimal frequency of service interruption

QoS in P2P Live Media Streaming Systems

- **Architectural design:**
  - Topology with locality and network awareness,
  - Peer selection with QoS awareness,
  - Balanced structure with redundancy
  - Configurable and dynamic Infrastructural support
- **Operation and Maintenance:**
  - Differential treatment in resource guarantee,
  - Admission control and load balancing
  - Peer churn recovery, error and loss recovery
  - Topology adaptation and optimization,
  - Exploit of scalable video coding, multiple description, transcoding,
  - Data preparation and delivery scheduling,
  - Data buffering and display
- **Peer Quality Assurance:**
  - Peer capacity advertisement, request and negotiation, and contribution guarantee
  - Peer requirement adaptation: adjusting one's needs according to available resources
  - Peer to peer bandwidth management: scheduling and AQM
  - Peer to peer performance monitoring: loss, delay, jitter,
  - Peer partner switching: substituting existing peers or acquiring new peers as partners based on some locally evaluated criteria
  - Peer path and link selection based on congestion level
- **Monitoring and response capability**
  - Ability to know what to measure and measure them correctly (source rate, network congestion)
  - Ability to identify and classify performance events based on measurements
  - Ability to response in a timely manner with the proper action (rate adaptation, switch peer)
  - Ability to know where to fix (network, host, link, path)
  - Ability to maintain overlay network stability

P2P live streaming architectures

- **Tree based P2P Live Media Streaming Systems**
  - PeerCast
  - Conviva
- **Mesh based P2P Live Media Streaming Systems**
  - Joost
  - Octoshape
  - PPLive
  - PPStream
  - SopCast
  - TVAnts
  - Zattoo
- **Hybrid based P2P Live Media Streaming Systems**
  - Coolstreaming

Tree Based System – PeerCast

- **Peering layer**
  - A layer between application layer and transport layer
  - Such peering layers at different nodes coordinate among themselves to establish and maintain a multicast tree
- **QoS Related Mechanisms**
  - Topology management: methods for topology setup and handling leaving and failed peers
  - Policies enforcement: choice and range of search target
- **End-System Metrics**
  - Response time
  - Packet-loss
  - Packet-delay

Tree Based System – ESM

- **Narada Protocol**
  - Construct the end system overlay in a fully distributed and autonomous manner
  - Accommodate dynamic changes in group membership
  - Two-step overlay construction process, extracting a tree out of a mesh
- **QoS Related Mechanisms**
  - Group Management: handling joining/leaving/failed peers
  - Mesh/Tree Quality Improvement: link and parent
  - Data Delivery: rate adaptation and forwarding priority
- **Metrics**
  - Application Performance Metrics: latency, throughput, loss
  - Overlay Topology Efficiency Metrics: physical link stress, resource usage, relative delay penalty

Mesh Based System – Joost

- **Architecture and Protocols**
  - Hierarchical control and signalling
  - Partly hierarchical in data delivery
  - Agent-based peer-to-peer system to support media distribution services (Anthill)
- **QoS Related Mechanisms**
  - Peer selection heuristics considering bandwidth, locality, number of peers
  - Infrastructure-assisted topology maintenance and data delivery
  - Traffic differentiation and audio/video traffic separation
  - User feedback monitoring and social networking mechanism
- **Evaluated Metrics**
  - Network locality
  - Geographic load balancing
  - Start-up delay

Mesh Based System – Octoshape

- **Architecture and Protocols**
  - Modeled after the popular "peer-to-peer" (P2P) file sharing networks such as BitTorrent
- **QoS Related Mechanisms**
  - Peer info management
  - Data preparation: split into multiple sub-streams
  - Data distribution: need only a subset of sub-streams
  - Context-awareness: codec/player matching, rate adaptation, locality-aware, operator control
- **Evaluated Metrics**
  - Buffer Time, Delta from Real Time, Visual Quality
  - Network Efficiency, Client Recovery, NAT Traversal Capabilities
  - Packet loss, Latency, Jitter , Bandwidth profiles

Mesh Based System – PPLive

- **Architecture and Protocols**
  - Multiple overlays, one for each content channel
  - Use gossip-based protocols for peer management
- **QoS Related Mechanisms**
  - Peer selection: FCFS, consider bandwidth, location, aggressive at fixed rate
  - Data management: division into chunks
  - Stream reassembly and display: double buffering mechanism
  - Download scheduling policy: priority to rare and soon to be play-out chunks
- **Evaluated Metrics**
  - Overlay-based characteristics
    - Size, randomness, average degree, user behavior, session length, channel population
  - User and network centric metrics
    - Start-up delay, video buffering, playback lags, fairness, video traffic

Mesh Based System – PPStream

- **Architecture and Protocols**
  - Protocols for channel discovery, peer registration, peer discovery, media chunk distribution
- **QoS Related Mechanisms**
  - Peer selection: preferential treatment of high bandwidth peers
  - Data distribution: use buffer map of chunks, smaller window than PPLive
  - Fetching buffer block and chunk with some repetitive pattern
- **Evaluated Metrics**
  - Privacy, locality,
  - Playback delay, peering strategies, data scheduling
  - Overlay network performance, session concurrency, reciprocity between peers
  - Geographic clustering, connection stability, system stability, arrival/departure pattern, playback performance, sharing ratio, data diffusion speed

Mesh Based System – SopCast

- **Architecture and Protocols**
  - BitTorrent-based and very similar to PPLive
  - Servers support for start up: software update, bootstrap, channel list
  - Control messages propagated through a gossip-like protocol
- **QoS Related Mechanisms**
  - Traffic is encoded and use some form of acknowledgement scheme
  - Random peer selection for content retrieval, except for low-capacity peers
  - Stream management: use double-buffering mechanism like PPLive
- **Evaluated Metrics**
  - Inter Packet Time, packet size, cost, stability, non-cooperative region,
  - Player pop-up delay, player buffering delay, setup delay, end-to-end delay
  - Upload and download rate, blocking, geographical distribution of contacted peers
  - Video quality, audio video synchronization, peer synchronization, zapping time, subjective measurement

Mesh Based System – TVAnts

- **Architecture and Protocols**
  - Support 2 different types of media streaming protocol: MMS and RTSP protocol
- **QoS Related Mechanisms**
  - Peer discovery: very greedy during initial peer life
  - Peer selection: location and bandwidth aware
  - Provide network and resource usage monitoring
- **Evaluated Metrics**
  - Receiving/transmitting data rate
  - Geographical distribution of contacted peers
  - Application stability and signalling overhead
  - Data and signalling traffic interaction
  - Sensitivity to network capacity, packet loss, and delay

Mesh Based System – Zattoo

- **Architecture and Protocols**
  - Receiver-based, peer-division multiplexing scheme, allowing for pull once and push until notified otherwise
- **QoS Related Mechanisms**
  - Data preparation: FEC coded into multiple sub-stream
  - Topology setup – Peer-Division Multiplexing
  - Stream Management: Double buffer mechanisms with multiple I/O pointers
  - Date delivery: retransmission requests to random peers instead of neighbours
  - Topology optimization – Adaptive Peer-Division Multiplexing
- **Evaluated Metrics**
  - Channel switching delay = join delay + buffering delay
  - Ratio of packet retransmission requests to the number of transmitted packets
  - Average sharing ratio and its sensitivity to peer churns, stream bit rates, NAT
  - Sub-stream and peer synchrony
  - Effectiveness of ECC in isolating loss

Hybrid Based System – Coolstreaming

- **Three basic modules in a peer**
  - Membership manager: maintains partial view of the overlay
  - Partnership manager: establishes and maintains partnership with other peers with which Buffer Maps, indicating available video content, are exchanged
  - Stream manager: manages data delivery, retrieval, and play out
- **QoS Related Mechanisms**
  - Topology setup: form partners and parent-children relationships
  - Data Management: division into blocks and each block further divided into index sub-block streams
  - Data Delivery: request once and receive until further notice
  - Parent re-selection to optimize topology
- **Metrics for system performance evaluation**
  - Contribution index, partner/parent/child change rate(s)
  - Playback continuity (continuity index), start-up delay
  - Out-going (Uploading) bandwidth utilization
  - Effective data ratio
  - Buffer utilization
  - Path length

Thank you