Streaming overlays

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Overview

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• Summary
What is a streaming overlay?

• An overlay network is a computer network built on top of another.
• It’s goal is to provide a service the underlying network can’t.
• All the links are logical (not physical), thus, you need some sort of application/protocol to create and use these networks.
• Can be used to provide QoS, multicast, routing without IP (e.g., DHT) …
What is a streaming overlay?

- The client -> server model is often not good enough when streaming.
- Does not scale, expensive.
- Often single point of failure.
What is a streaming overlay?

• A streaming overlay is an overlay network created by an application that streams content.
• Uses multicast, P2P or some other technique/technology to distribute content cheaper and more efficient than client-server.
• Also, the application often uses cooperative networking.
• In a cooperative network, all end-hosts cooperate to improve the perceived network performance for everybody.
CoopNet

- When important events occur, websites see a drastic increase in the number of users.

- The CoopNet-project came about after the problems MSNBC faced during 9/11.

- Wants to complement the traditional client-server model and only kick in when needed.

- The general idea is the peers act as “servers” when the proper server is busy.

- Does not assume that a peer is going to stay for very long, thus, a P2P-scheme was not an option.
- The client requests a document from the server.
- The server is busy and replies with a selection of peers that has this document.
- The client then requests the document from one (or every one) of them.
- Thus, an overlay network modeled as a tree is formed (in this case with B as the root node).
CoopNet - Leaving

A node has two ways of leaving the network, graceful or due to failure.

Graceful:
- The node lets the server know that it is leaving.
- The server finds new parents for the node’s children.

Failure:
- If a node experiences a higher loss rate than a certain threshold, it asks its parent if it experiences the same.
  - Yes: The parent asks its parent.
  - No: Something is wrong with either the parent or the link between parent and node, asks server for new parent.
CoopNet - Streaming

• When streaming live video, the departure of a node can have a severe impact on video quality.

• All children will experience blackouts, delays and so forth while they are paired with new parents.

• CoopNet-developers solve this by building multiple distribution trees rooted at the server and using Multiple Description Coding (MDC).

• MDC is constructed so that any subset allows the client to reconstruct the video (with distortion).

• Different MDC streams are sent through different trees, thus, if a node fails, the user might still get video.
SplitStream

- A generic infrastructure for high-bandwidth content distribution.

- Wants to address issues present in tree-based multicast.

- In a balanced tree, the number of interior nodes is much lower than leaves. However, the interior nodes have to carry all the forwarding load. No co-operation.

- Introduces delay, some nodes lacks the capacity to forward high-bandwidth streams.
SplitStream

- Solves this by dividing the stream into $k$ stripes, each with bandwidth/bitrate $B$.
- An independent multicast tree is constructed for each $k$ (rooted at the server), and a peer only have to be interior node in one tree.
- In the original papers SplitStream is implemented on top of Pastry and Scribe.
SplitStream - Pastry

- Nodes and objects are assigned nodeIDs and keys, respectively.

- Messages routed to the node with the numerically closest key.

- Each node knows of the numerically closest nodes (leafs) and the ones that are closest by a proximity metric (neighbors), and has a routing table.

- The table contains the nodes that has the same prefix as this node (up to a certain number of digits).
SplitStream - Scribe

- Group communication system built upon Pastry.
- Each group is assigned a groupID, and the multicast tree is formed by the union of the routes from members and to the root.
- Uses reverse path forwarding.
- Effective, small load on physical network (intermediary nodes are often close to the leaf), low delay.
- Group management is handled by Pastery, thus, also effective and able to handle large and dynamic groups.
- To add a member, Scribe simply routes the message towards the root and stops when it hits a node.
SplitStream - design

- Uses Pastery’s routing to ensure that a peer is only an interior node in one tree.

- Pastery routes towards nodes whose ID shares a longer and longer prefix, and in Scribe all interior nodes have at least one digit in common with the groupID (since it is formed by routes from all members to the root).

- Thus, by making sure that the most significant digit in the groupID is unique, you create disjoint sets of interior nodes.
SplitStream - design

• The number of stripes determine the incoming bandwidth usage, each node is at least expected to forward $k$.

• Outgoing is decided by the number of children and is more difficult to limit.

• Scribe has built in mechanisms for this (all siblings are asked), however, they might not work since a leaf can be an interior node in another tree (thus, there might not be any free capacity).

• If a SplitStream node has exceeded its outgoing capacity and receives a request, one child is dropped according to given criteria.

• This child node first tries to attach to one of its former siblings. Otherwise, it searches the “Spare capacity group”.
CoolStreaming/DONet

• Application layer multicast is often achieved by constructing trees.

• According to the DONet-developers, trees are unstable and slow.

• The propose a solution that has more in common with BitTorrent.

• “Everybody shares with everybody”.
CoolStreaming/DONet

- Specifically built for live media streaming.
- Each video is split into fixed length segments.
- A node is either receiver, supplier, or both, depending on the availability of its segments.
- Three core parts – Membership manager, partnership manager and scheduler.
CoolStreaming/DONet - Membership

• Every node knows about a subset of the active nodes, stored in the $m\text{Cache}$. 

• When connecting to a stream, a node receives a partial copy of the origin servers $m\text{Cache}$. 

• It then forms a partnership with select nodes and fetches their $m\text{Caches}$. 

• Every node generates periodic messages letting others know that it is still alive. 

• Upon receiving such a message, the $m\text{Cache}$ is updated.
CoolStreaming/DONet – Buffer map

- Partners are the nodes that one node is connected to.

- The buffer map is used to indicate what segments are stored in this node’s buffer.

- Exchanged all the time with the partners, and used to scheduled which parts to be downloaded from where.

- Tuned for live-streaming, which reduces the required buffer size. Nodes are semi-synchronized.
CoolStreaming/DONet – Scheduler

- The scheduler determines what segment to be downloaded when and from where.
- Should meet the deadline for the segment and not exceed the offered bandwidth.
- Due to the challenges presented by dynamic network conditions, uses a simple heuristic in the scheduling algorithm.
- Starts by scheduling the segment with the fewest suppliers, since it assumes this will have most difficulty meeting the deadline.
CoolStreaming/DONet – Failure

• The departure of a node can easily be detected.

• Either it no longer sends buffer maps, or it does not send any control messages.

• Authors suggest that departing nodes should submit a specific message, and the partners that detect dead nodes should do the same.
CoolStreaming

- Implementation of DONet.
- Used to broadcast live sports programs.
- Clients were not able to connect when using unicast because of the popularity.
- However, when the clients installed CoolStreaming and redirected the video through it, everything worked perfectly.
Summary

• Three different solutions.

• CoopNet is built to deal with a sudden rush of clients and uses a hybrid client-server/streaming overlay model.

• SplitStream and CoolStreaming/DONet both use only overlay and P2P.

• However, SplitStream is a generic solution to high bandwidth content distribution.

• CoolStreaming/DONet is specifically built for live video streaming.
Summary

• Difficult to compare.

• Different usage and authors have made different measurements.

• However, the DONet-guys claim that their solution does not require a powerful server (like CoopNet) and is less complex than SplitStream.

• All three accomplishes their goal by improving the situation.