Multicast Use cases in Data Center

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Use Case: Multicast Request in large-scale DC Network

- Large-Scale DC Network could have a significant amount of multicast services running, including AI training, HPC (High Performance Computing) and SAN (Storage Area Network) scenarios in DCN.

AI Training

- Training model distribution and parameter synchronization

HPC

- Dispatcher master starts millions of rank MPIs and broadcasts messages to a scalable number of dispatcher agents

Storage

- “Multiple Copies” for reliability
Example: AI Training

- P2MP is a very common communication model in AI training;

  Take “All Reduce” in AI Training as an example:

  In synchronized data-parallel distributed deep learning, the major computation steps are:
  - Compute the gradient of the loss function using a minibatch on each GPU.
  - Compute the mean of the gradients by inter-GPU communication.
  - Update the model.

  To compute the mean, a collective communication operation called “All Reduce” is used.

  The basic behavior is to select one process as a master, gather all arrays into the master, perform reduction operations locally in the master, and then distribute the resulting array to the rest of the processes.

- Current data centers are using multiple unicasts to emulate multicast (application layer multicast), where replication is done by the application layer rather than the network devices

- The use of multicast allows replication behavior to be offloaded from servers to network devices, reducing the bottleneck of both CPU/GPU and network and enhancing scalability

- With the current trend towards large models with multiple parameters, this advantage will become increasingly apparent
Gap Analysis: Multi-dimension Scalability

- PIM/MLDP/RSVP P2MP TE: Maintaining excessive multicast states inside a network may cause overwhelmed network overhead that would lead to network stability challenge and operational complexity. (Not good at large number of services)

- RSVP P2MP TE need to maintain all of the leaves for every multicast tree, further increasing network overhead (and not good at large size multicast tree)

- BIER/BIER-TE: Carrying a flat/non-structured bit string per packet brings challenge for packet overhead and coding efficiency. (Not good at large network size)

- SR P2MP Policy: Maintaining replication states for each Tree-SID at the replication nodes and relying heavily on SDN controller. (Not good at large number of services and multicast tree size limited)

- AI training DC need **reliable, in-order** multicast delivery, and **flow control** to adapt to the receiver's capacity

- Due to the co-existence of both multi-tenant and single-tenant scenarios in AI training DC, multicast distribution runs in both sparse and dense modes in AI DC

- **Any** of the above existing multicast technologies can not satisfy all the multicast requirements in AI training DC
Takeaways and objectives

Technical Requirements:

• **High Scalability**: Both sparse and dense trees are required in the large scale DC, especially for the AI DC.

• **High reliability**: The performance of AI DC is sensitive to the quality of network, especially packet loss.

• **Source routing**: source-driven path programmable multicast rather than establishing the hop-by-hop multicast tree.

Objectives:

• **Open Ecosystem**: Considering that there has been implementation of data center multicast in closed ecosystem (for example: InfiniBand), we intent to bring these requirements to IETF as an open standard.

• **Easy Deployment**: The rapid development of AI, e.g. ChatGPT, is generating demand for new data center construction that can deploy new standardized technologies rapidly.
Thanks