TITLE

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By
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CERTIFICATE

This is to certify that the dissertation entitled "**TITLE**" submitted by **STUDENT NAME** bearing Reg. No. XXXXXXX, in partial fulfillment of the requirements for the award of Master of Technology in Computer Science, is a bona fide work carried out by him/her under my/our supervision and guidance.

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My Parents and Supervisor.

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Chapter 1

Related Work

Flow monitoring protocols like NetFlow[5] and sFlow[8] can provide important information about traffic that passes through a network. However, contemporary networking with its 10Gbps and higher NICs is outpacing the ability to monitor them efficiently. As data centers are getting virtualized with virtual software switches and scaling to thousands of nodes, it is an immediate requirement to have monitoring systems that can scale effectively. There are not many solutions proposed that provide scalable flow monitoring in data center networks. In this chapter, we review some of the literature that deals with scalable flow monitoring in data center networks.

1.1 Edge Monitoring and Collection for Cloud (EMC2)[10]

Edge Monitoring and Collection for Cloud (EMC2) is a scalable network-wide monitoring service for data centers. EMC2 stays inside the host computer to monitor virtual switches. Monitoring at virtual switch is scalable due to the distributed nature of the storage of the collected information.

1.1.1 Architecture

Figure 1.1 shows the architecture of EMC2.

EMC2 is a multi-threaded application that contains the following modules:

1. Flow-Table : Flow-Table is an in-memory 2-level hash table.

2. NetFlowParser : It parses the NetFlow datagrams and updates the Flow-Table.

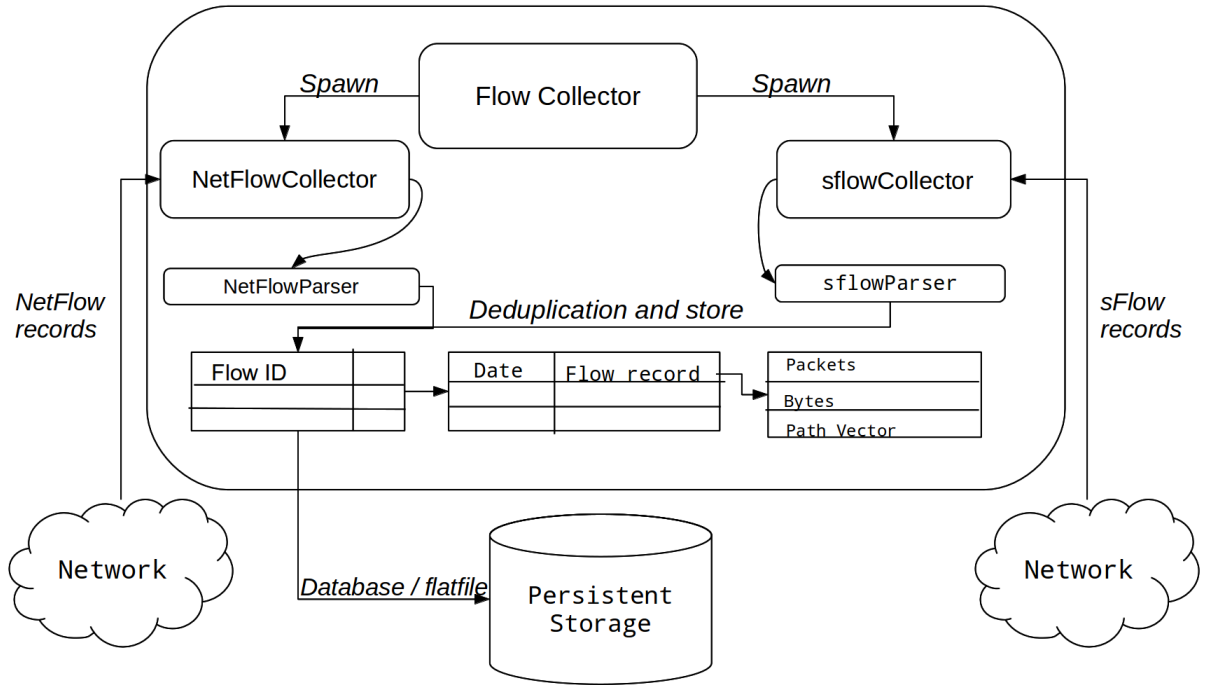3. sFlowParser : It parses the sFlow datagrams and updates the Flow-Table.

Figure 1.1: Architecture of EMC2.

4. NetFlowCollector : It accepts the NetFlow datagrams and creates the parser thread upon receiving NetFlow datagrams.

5. sFlowCollector : It does the same task like the NetFlowCollector but for sFlow datagrams.

6. FlowCollector : It invokes two thread – NetFlowCollector and sFlowCollector – for accepting flow datagrams.

1.1.1.1 Flow-Table

Flow-Table is a 2-level in-memory hash table. The primary key for the hash table is the Flow ID which is formed based on the layer 3 source and destination addresses. Flow ID maps to another hash table where timestamp is the key and flow record is the value. Each flow record contains number of packets, number of bytes and optional path vector.

1.1.1.2   NetFlowParser/sFlowParser

NetFlowCollector and sFlowCollector create these two parser threads upon receiving a NetFlow/sFlow datagram respectively. These parser threads parse the datagram and update the Flow-Table. They also perform two important tasks:

1. Deduplication.

2. Data rate prediction in presence of sampling.

Deduplication: Deduplication prevents duplicate flow records from being added to the Flow-Table. It uses the following algorithm.

Algorithm 1: Detect Duplicate Flow

---
    if $flow - ID$ not exist **then**

      add flow to the flow table.

      return

    else

      if Same exporter **then**

        update the flow table.

        return

      else

        report duplicate flow.

        update path vector.

        return

      end if

    end if

Data Rate Prediction in Presence of Sampling: Sampling rate is specified in flow datagrams. Parser thread predicts the data rate by multiplying sampling rate with the length of the packet.

1.1.1.3   NetFlowCollector/sFlowCollector

NetFlowCollector/sFlowCollector are collector thread that wait for new NetFlow or sFlow datagrams and spawn a new NetFlowParser/sFlowParser thread upon receiving a datagram.

1.1.2 Advantages and Limitations

The authors state the following advantages of EMC2:

- Scalable monitoring as EMC2 monitors host *vswitches* in a distributed fashion by storing the information as flat files in those hosts itself instead of sending them to a centralized collector.

However, flat files are not really built for scalability unlike many other distributed databases available today such as Cassandra, Big Table etc.. Therefore, it is not clear how much of performance can be obtained by storing the information in flat files in the host itself. Considering that most data centers work with SANs rather than local disks, this may not be as scalable as claimed.

1.2 Scalable Internet Traffic Measurement and Analysis with Hadoop[9]

Hadoop[1] is a distributed computing platform that uses distributed file system(HDFS) and MapReduce[6] programming model. Hadoop consists of commodity hardware that can scale thousands of nodes to store massive data. It can perform massive data analytics operations on the available data using MapReduce. Storing NetFlow data on Hadoop and analysis using MapReduce offers scalable traffic measurement and analysis.

1.2.1 Architecture

Traffic measurement and analysis system with Hadoop consists of following modules

1. Traffic collector.

2. IP packet and NetFlow reader in Hadoop.

3. Analysis in MapReduce.

4. Interactive query interface with Hive[4].

1.2.1.1 Traffic collector

Traffic collection done using high-speed packet capture driver and load balancer. Load balancer forwards packets into multiple Hadoop DataNodes evenly. Traffic collector also can reads trace files stored on the disk and writes them into HDFS. Trace files contains Netflow packets or IP packets in *libpcap* format.

1.2.1.2 IP packet and NetFlow reader in Hadoop

Storing binary trace file into Hadoop specific sequence file needs more computation power as every packet has to be sequentially read from the trace file and stored into HDFS. Authors has develop new Hadoop API to store trace file directly into HDFS. As there is no distinct mark to find out end of a packet records in *libpcap* format, authors proposed a heuristic algorithm using timestamp-based bit pattern.

MapReduce operation on HDFS to identify packet records: MapReduce job invokes multiple map tasks to process each HDFS block in parallel. Each of the map tasks follow these steps to identify packet records in HDFS block:

1. Read two records using *libpcap* 16-byte header.

2. Check timestamp value, that should be within duration of captured time.

3. Wiredlen - caplen ⟨ maximum packet length.

4. Check whether timestamp difference between two packet records within the define threshold threshold.

1.2.1.3 Analysis in MapReduce

Authors has implemented MapReduce algorithms for processing IP packet as well as NetFlow packets. Here is the list of analysis tools

1. IP Layer analysis provide following analysis job

    (a) Host and port count statistics.

    (b) Periodic flow statistics.

    (c) Periodic sample traffic statistics.

2. TCP layer analysis compute following statistics

     (a) RTT.

     (b) Retransmission.

     (c) Throughput.

3. NetFlow analysis provides

     (a) Human readable flow statistics.

     (b) Aggregated flow statistics.

     (c) Top N flows sorted by key such as packet count or byte count.

1.2.1.4   Interactive query interface with Hive

Hive is a data warehousing system build on the top of Hadoop that allows to generate MapReduce jobs using SQl like query. IP analysis MapReduce jobs process NetFlow packets on HDFS and store flow record and IP statistics into Hive tables. A user can query on Hive tables using interactive web-based user interface.

1.2.2   Advantages and Limitations

Advantages of Hadoop based traffic measurement and analysis are

1. Scalable storage.

2. MapReduce operations on flow data.

Disadvantages of Hadoop based traffic measurement and analysis are

1. Low response time- "the fasted MapReduce job takes 15+ seconds"[2].

2. Hadoop NameNode was a single point of failure which solved in later version of Hadoop 2.0.0 with passive NameNodes.

3. Multiple NameNodes require to get high availability[3].

1.3   *nfdump*

   nfdump provides set of tools to capture, analysis NetFlow packets. These set of tools are

1. *nfcapd*

2. *nfdump*

3. NfSen

nfcapd reads data from the network and stores it into disk. It also rotate the file to limit size of file. *nfdump* allows *tcpdump* style filter expression for processing NetFlow data stored by *nfcapd*. NfSen gives graphical overview of NetFlow data using RRDTool[7];
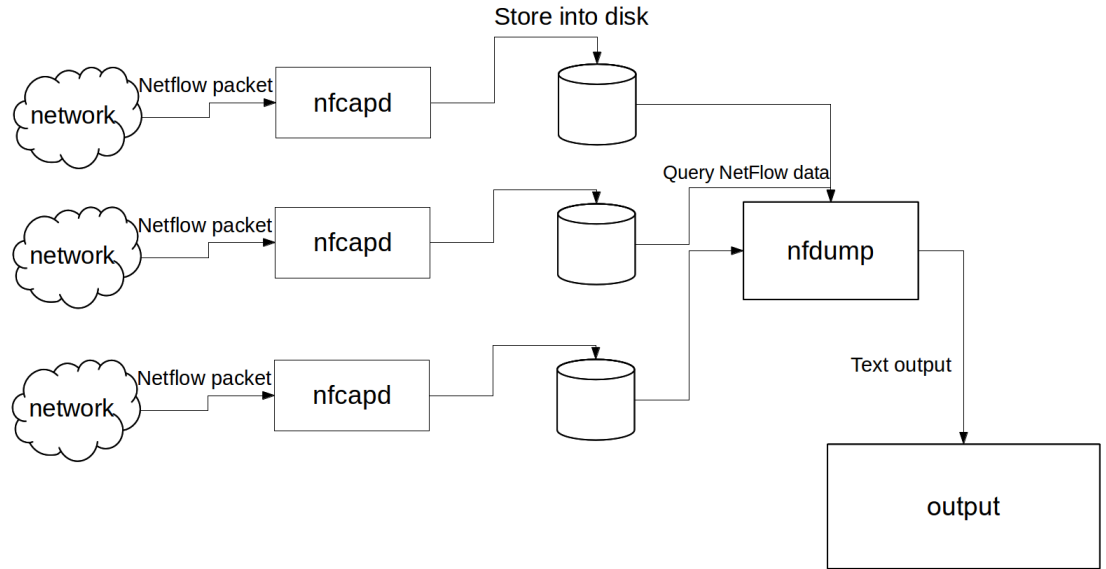

Figure 1.2: Architecture of *nfdump*.

1.3.1   Advantages and Limitations

nfdump is suitable for small scale NetFlow analysis. In case of large scale NetFlow monitoring disk file based storage is not sufficient.

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