Large-scale NetFlow Information Management

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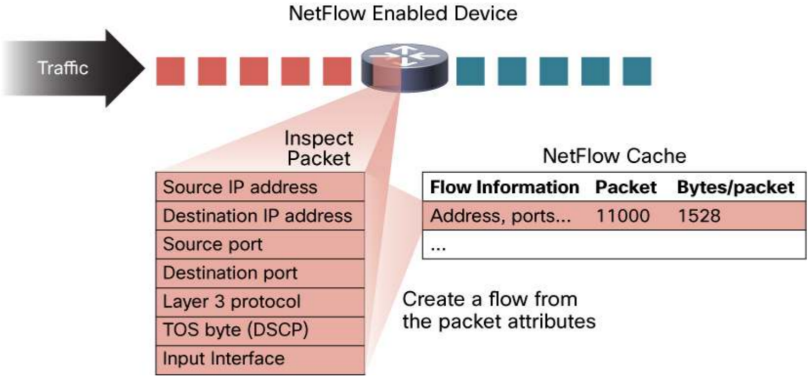
What is NetFlow?

- Traffic monitoring technology originaly developed by Cisco.
- *Flow*: “a set of IP packets passing an observation point in the network during a certain time interval. All packets belonging to a particular flow have a set of common properties.”[4]
- Important differences with regular packet capture methods:
  - NetFlow considered to be less privacy sensitive
  - NetFlow requires less computational resources for analysis

What is NetFlow?



Source IP address
Destination IP address
Source port
Destination port
Layer 3 protocol
TOS byte (DSCP)
Input Interface

NetFlow Cache

Flow Information	Packet	Bytes/packet
Address, ports...	11000	1528
...		

Create a flow from the packet attributes

Figure 1: Schematic overview of the NetFlow export process.[2]

NetFlow Analysis

Three main application areas[3]:

- Flow analysis and reporting
- Threat detection
- Performance monitoring

NetFlow analysis techniques

- NfDump:

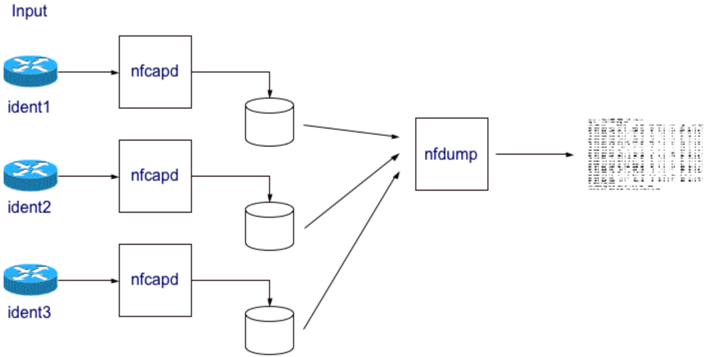


Figure 2: Schematic overview of the NfDump tool set.[1]

Netflow Analysis techniques

- Limitations of this setup[5]:
  - **Inefficient file-based store:** NfDump typically stores NetFlow data in separate files for every 5 minutes time frame
  - **Very slow processing speed:** each file is read line by line from the beginning. Therefore, analysis of large amounts of NetFlow data takes a lot of time.
  - **Limited analysis methods:** as network situations are becoming more and more complex, new analysis approaches are required that allow for NetFlow data analysis.

Research question

Which data analysis technique could be used in order to analyse the current SURFnet NetFlow data in a more time-efficient manner?

What is Apache Hadoop?

- Framework for large datasets processing
- Distributed, local computation & storage
- Hadoop Distributed File System (HDFS)
- YARN (Yet Another Resource Negotiator)
- Batch, interactive & real-time jobs
- Designed to be scalable

What is Apache Hadoop?

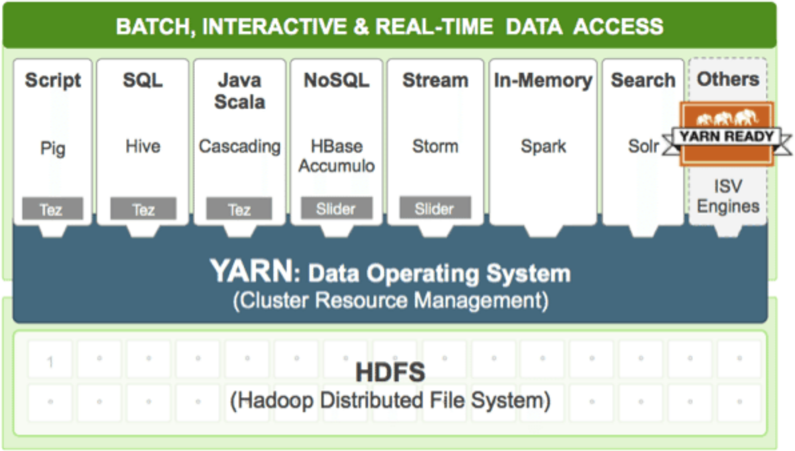


Figure 3: Schematic overview of Hadoop 2.0.

What is Apache Spark?

- Hadoop-related project, but not only
- Powerful computing engine for Big Data processing
- In-memory
- Built-in modules for streaming, SQL, machine learning, etc.
- Binding for Java, Scala, Python and R
- Ease of use

What is Apache Parquet?

- Data-store for Hadoop
- Column-oriented
- Fast access to data

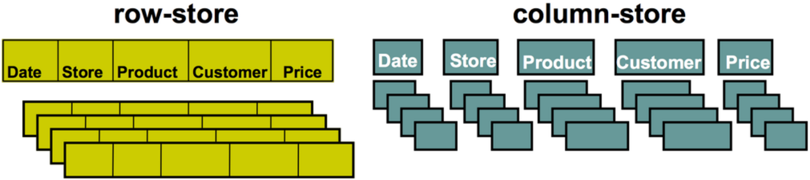


Figure 4: Schematic overview of a row vs column-oriented database.

Choice for analysis technique (summary)

Figure 5: Apache Parquet logo.

Figure 6: Apache Hadoop logo.

Figure 7: Apache Spark logo.

To-Do list:

1. Store NetFlow data into Parquet files on HDFS
2. Load Parquet files using PySpark (Python API)
3. Query the data using Spark SQL

Experiments: test environment

Hadoop cluster specifications:

- $\sim$ 100 nodes
- $\sim$ 600 cores
- $\sim$ 4TB of memory
- $\sim$ 2PB of storage
- Apache Hadoop 2.7.2
- Apache Spark 2.1.1

NfDump server specifications:

- 1x Dell PowerEdge R230
- Intel Xeon CPU E3-1240L v5 @ 2.10GHz
- 4 cores
- 16GB of RAM
- $\sim$ 200GB of SSD storage
- NfDump v1.6.12

Experiments: implementation

1. Convert NetFlow binary data to CSV

```
nfdump -r nfcapd.201801011245 -o csv
```

2. Write two Spark jobs in Python:
   - Converter: Converts CSV data to Parquet format
   - Querier: Loads Parquet data & executes queries

3. Write SQL query

```
query = 'SELECT ts, sa, da FROM nf_data'
```

4. Using the Querier, execute and cache the results
5. Proceed with next operations on the cached results

```
print results.count()
print results.show()
```

Experiments: test queries

- Retrieve all flows containing a specific IP address
- Retrieve all flows with a byte count larger than 100MBs
- List the top 10 of Telnet connections with only the SYN flag set in the IP header ordered by the number of bits per second
- List the top 10 of IP addresses receiving the largest amount of traffic
- Retrieve all flows with only the SYN flag set in the IP header

Results: retrieve all flows containing a specific IP address

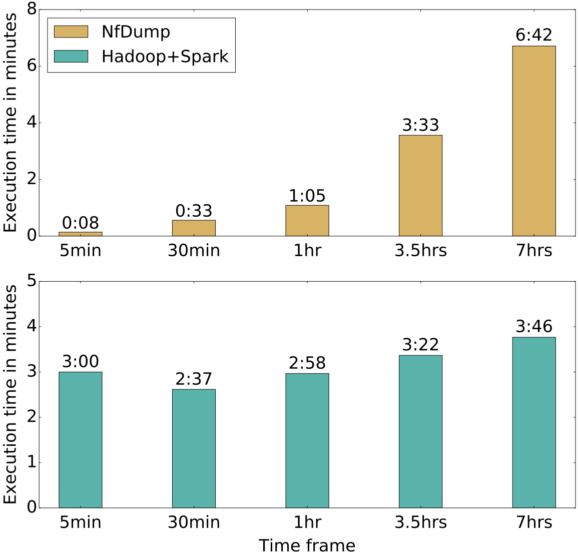


Figure 8: Execution time of retrieving all flows containing a specific IP address.

Results: retrieve all flows with byte count >100MB

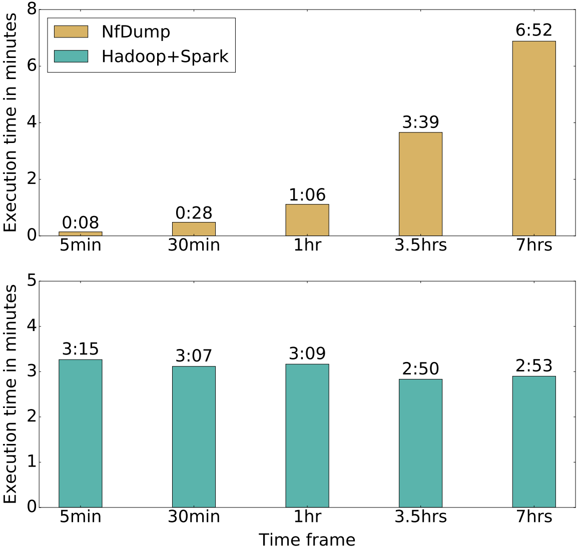


Figure 9: Execution time of retrieving all flows with byte count larger than 100MB.

Results: list top 10 Telnet connections with only SYN flag set ordered by bps

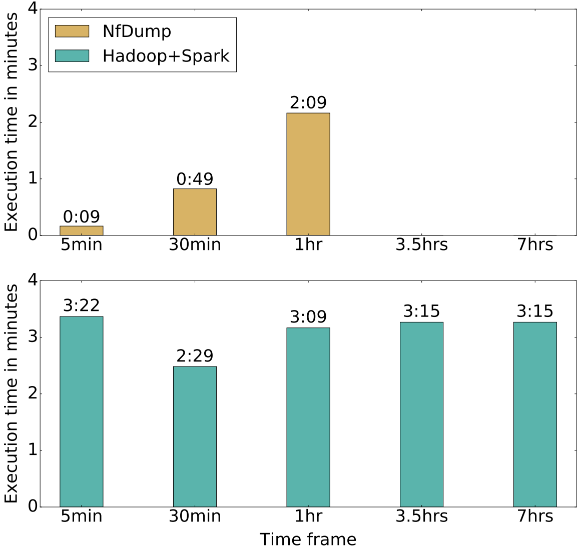


Figure 10: Execution time of retrieving the top 10 of Telnet connections with only the SYN flag set ordered by the number of bits per second.

Results: List top 10 IPs receiving most traffic

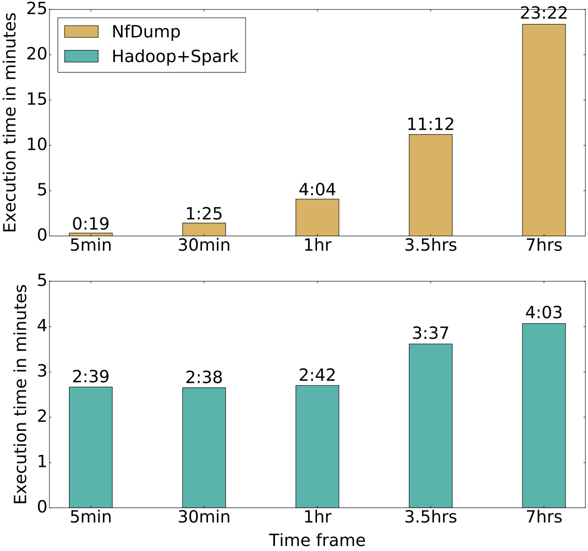


Figure 11: Execution time of Retrieving the top 10 IP addresses receiving the largest amount of traffic.

Results: Retrieve all flows with only SYN flag set

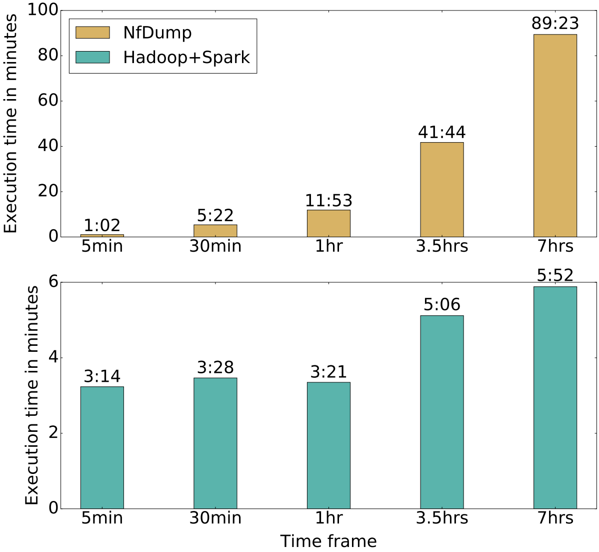


Figure 12: Execution time of retrieving all flows with only the SYN flag set in the IP header.

Discussion

- Execution time of NfDump increases linearly with longer time frames.
- Hadoop scales very well:
    - Execution time of Spark with Hadoop does not increase significantly when dealing with larger amounts of data.
- NfDump struggles with executing more complex queries, whereas this is no problem for Spark and Hadoop.

Conclusion and future work

- Combination of Hadoop and Apache Spark is a viable option for analyzing large-scale NetFlow data.
- Tuning and optimization to the Spark implementation and Hadoop cluster may lead to even better performance.

Questions?

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