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Survey of SDN based Packet Classification Techniques

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Abstract: ***Generally nodes in the communication network are configured as both data section and control section are kept together. All arrived packets are checked inside control section and then it decides route for that packet based on the current flow in the network. Then data section forwards the packet according to route. The main problem with this approach is if network operator wants to expand the network he has to reconfigure all the nodes as control section and data section are kept together that maintain global view of the network. Software Defined Networking (SDN) technology is very helpful in achieving the functionalities like quality oriented service delivery, security, scalability, automatic fault localization and verification of network. The key of Software Defined Network is fault tolerance, in which SDN quickly recover from the occurred fault & can work on highly scalable network also describes multiple link failure, but all these functionalities are solely dependent on packet classification. Packet classification is the first step in network processing for identifying different applications and protocols that exist on the network system. SDN promises to improve programmability, reduced latency and high performance. To achieve these promises there is a need to improve packet classification mechanism. This paper describes a brief survey of different packet classification techniques which are based on SDN and proposed a classification technique based one dimensional approach which reduces look up time and updation complexity.***

Keywords: SDN; Packet Classification, One dimensional lookup

1. Introduction

According to traditional architecture a network node comprises with control and data section. The configuration of a node and programming the paths that will be followed by data flow. Once these paths have been finalized, data section comes into picture and data forwarding is done. The main disadvantage of these traditional approaches is, if the traffic of the network increases for a particular root, then there is a need to change the root.

To change the root there is a need to configure the node again which is not desirable if network operators are looking forward to scale their networks on in response to changing traffic demands, and with increasing mobile nodes.

SDN has emerged to achieve service-focused requirements. In SDN Control has taken out from the network nodes and kept into the separate, centralized controller. SDN switches are controlled by a Network Operating System (NOS) that collects information using the API (Application Programming Interface). The controller can therefore exploit complete knowledge of the network to optimize network flow. SDN manipulates forwarding plane. It provides an abstract model of the network topology to the SDN controller. SDN controller is one who is hosting the applications. SDN supports service-user requirements of scalability and flexibility.

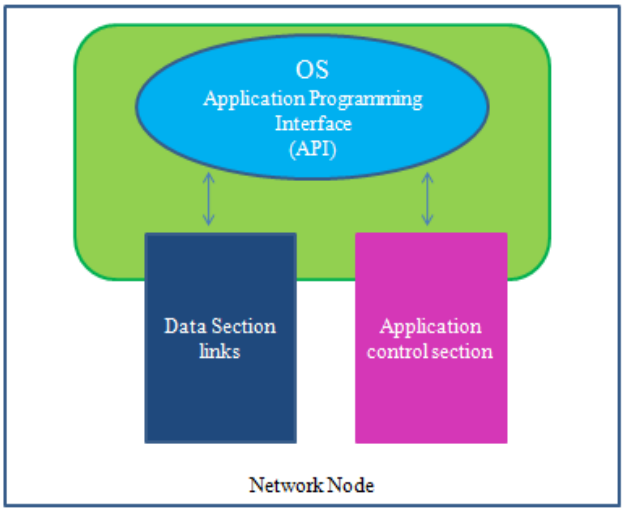

Figure 1: SDN Network View

SDN provides support to various quality oriented services, link management, flow control etc. Packet classification plays very important role in all these applications. So performance of all such applications will get improved if SDN is used for packet classification.

This paper shows study of various classification techniques. The packet classification problem is to determine the first matching rule for each incoming message at a router. The classifier in a router is consisting of finite set of rules. Each rule is associated with some value from header. A packet P is said to be matched with rule R if all the fields inside header of a packet matches with fields of the R.

Packet classification is a functionality that determines the action taken for a packet based on multiple header fields. It has been a key technology in modern networks to provide services beyond basic packet forwarding, such as access

control, quality of services, and traffic monitoring and analysis.

Rest of the paper is arranged as follows. Section II contains related work. Packet classification algorithms are given in Section III. Section IV is conclusion.

2. Related Work

To achieve quality oriented services properly packet classification is must. In this section, traditional packet classification techniques are described.

A. Packet classification based on mathematics

There are some packet classification algorithms which focus on mathematical analysis. Some of them have been proposed in the past and some of them are reported to have excellent temporal/spatial complexity. But problem with this is real life implementation of these algorithms is hardly found. This is mainly because pure mathematical solutions often add special conditions to simplify the problem and/or omit large constant factors in the Θ(.) notation which might conceal the explicit worst-case bound[6].

B. Observation-based solutions

To achieve more efficient solutions for real-life applications these algorithms employ the statistical characteristics observed in rules. These algorithms often work well with a specific type of rule sets. But this will affect the performance of packet classification, because packet classification rules for different applications have diverse features [7]. There are few observation based algorithms which are "smart" enough to fully exploit the redundancy lying in different types of rule sets to obtain stable performance under various conditions.

C. Hardware-based solutions

The usage of application specific hardware is another kind of algorithms proposed to accelerate packet classification based on application specific hardware. Although this kind of solutions such as FPGA/ASIC based algorithms often has extremely high performance, they suffer from poor scalability and portability. These solution often require the high R&D cost and long time-to-market. [8]

In the recent years novel packet classification techniques have been evolved based on above traditional approaches. Section III throws some focus on recent packet classification techniques.

3. SDN based Packet Classification Technique

This section gives a brief description of novel packet classification techniques.

a) Optimized Packet classification

According to [3], managing individual field with effective dedicated algorithms will result in high performance packet classification. The main challenge for any packet classification algorithm is to lookup all the fields inside the header simultaneously and achieves lesser lookup time, update speed and lesser memory lookup time, update speed and lesser memory space. This technique is ideally suited for SDN where data section and control section is separated. In this approach host packet classifier selects the optimum lookup algorithm for each field of the header. The configuration controller is configured with the rules specified by host.

For each packet entries is made inside flow lookup table (flow LUT). For every first packet in the flow one flow id is created and stored in (flow LUT). Packet header fields are extracted and passed to the lookup controller for packet classification. After the look up process configuration controller returns an action matched with some rule. Action is stored in the flow state block For the next packets coming with the same flow id under goes with the same action directly from the flow state block. This architecture is well suited for SDN. This algorithm provides more flexibility than any other algorithm. [3].

b) Multi-Table look-up:

Keissy Guerra-Perez and Sandra Scott-Hayward in [2] proposed solution is for SDN-based, high performance packet classification. The algorithmic lookup engine works by using a combination of single field algorithm lookups in parallel. The algorithms are based on exact matching, range matching, and longest-prefix matching, as determined by the lookup field, and results are combined via the label method.

1) *Exact matching:* A data set entry is only selected if it matches with exact an bit of given a data set [5].
2) *Range matching:* It is the type of wildcard matching. This matching searches the entry between different ranges of defined values in the structure.[5]
3) *Longest prefix matching:* It matches the data with an entry in the table of the defined prefixes with most matching bits.[5]
4) The ability to perform a lookup based on a combination of single field algorithm results means that the network device can be flexible and programmed for a range of applications e.g. cyber-security/network forensics.

c) Multi-Valued Decision Diagram(MDD)

Takeru Inoue in [9] has given a novel packet classification method has been developed which removes the limitations of SDN and also leverage the full potential of SDN for handling the network-wide packet behaviors, not actions taken on a single switch.

This method utilizes a data structure named as multi-valued decision diagram (MDD), which manipulate the complex search space using several algorithms. In this the Boolean functions which are associated with single behavior are unified into a single multi-valued function. This multi-valued is represented by MDD.
This method comprises of mainly 2 steps-

- To construct the MDD from a set of BDDs representing Boolean functions. Whenever network receives a new packet behavior, MDD can be incrementally updated in a short time.
- To construct a simple and fast algorithm which examines the MDD to classify packets based on their behaviors and the time-space tradeoff entailed in the bit aggregation is analyzed.[9]

d) HyperCuts

Hypercuts uses decision tree[4] as underlying structure. Each node in the hypercut decision tree is represents a k-dimensional hypercube. HyperCuts algorithms provides one extra degree of freedom than hi-cuts[10].Each node in the decision tree for hyper cuts represents a decision taken on the most representative dimensions, as opposed to using only a single dimension. Based on the amount of space available for the search structure, the number of cuts are computed for chosen dimension. At each node in the decision tree the set of current rules are split based on the information in the packet header. A small number of matching rules that are stored in the leaf node are linearly traversed to find the highest priority rule that matches the packet rule that matches the packet HyperCuts are extremely useful for core router databases, but less so in case of edge router databases.[1]

Following figure shows how geometric representation of hypercut for 4-rule classifier.

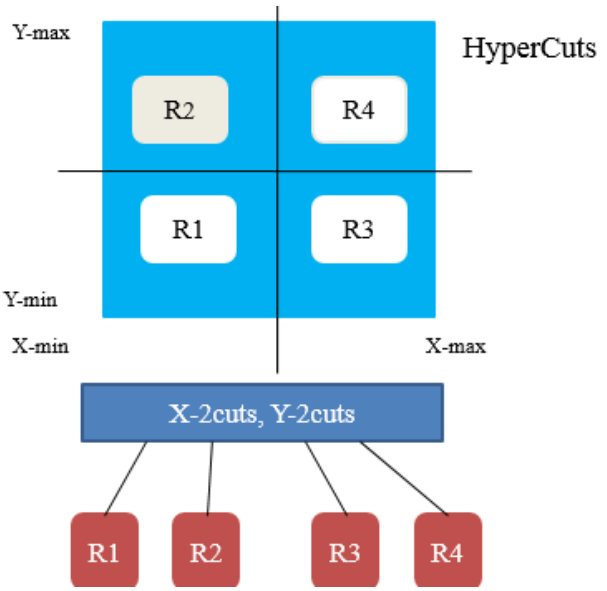

Figure 2: Hyper cut for 4-rule classifier [1]

4. Conclusion

Traditional communication networks lags in terms of scalability and efficiency as both data and control sections are configured together. Software Defined Networks (SDN) data section and control section of a network node which makes SDN more scalable and suitable to variety of applications like link management, flow control and quality of services. Performance all such applications are mainly dependent on the terminology called packet classification. This paper briefly describes few packet classification techniques. Study of these techniques will help in understanding packet classification terminology neatly and will contribute in future research.

In future we will try develop our own SDN based packet classification technique which will overcome shortcomings of existing packet classification techniques.

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