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Energy and Memory Optimization of Packet Classification based on Address Indexing TCAM in Network Routers

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ABSTRACT

One of the major mechanisms of network devices, grouping of packet classification that is wideused on the internet to implement firewalls in the network services of classification include access control and quality of service is used. One of the ways to packet classificationare usual used, using methods based on ternary content addressable memory (TCAM.[1]), this memory have a very high speed, so it has practically become a standard. TCAM entry package with all the rules stored in memory in parallel to compare the trio format. The major problem TCAM, energy consumption is high two examples of the architecture of (BSOL2[2]) and (BSOL-RC[3]) is for improvement. In this paper, the architecture of classifiers effective in terms of memory and energy package (MEO-PC) have provided. In the first phase of the proposed method (MEO-PC), a grouping of hardware and secondly, TCAM block are classified depending on the input for the implementation of the rules very few of them are active. The proposed method VHDL language and synthesis tools and simulation Modelism Quartus 8.1 is used. The results from lower power consumption and memory and also increases the speed of updates.The results of the power and memory consumption by as much as 89 percent and 86 percent, respectively, showing a significant improvement is the proposed method than previous methods.

Keywords: *Packet classification, Energy usage,Memory usage, MEO-PC , TCAM.*

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INTRODUCTION

With increasing speed communication lines as well as raising the quality of services provided by the network, removing the internet as one ofsolutions inserts distinguished pathfinders speeding drivers have been pathfinders. In theseprocess that sort of package called packet classification of belong one of specific flow under a special law was and uniformly with pathfinders processed.generallydifferentiation between random access of flow of one headerit is able to hold and track flows through the use of different service classes for each specified flow .Is necessary do most of such processes, packet classificationand then do processes, initially diagnosed classification of packets and then perform various packet classificationfor groups by intermediate rules are stored in routers[1,2].

TCAM As an important part is the packet classificationraised. In 2003, many classification tooling package, based on the TCAM. More than six million units worldwide in 2004 was based TCAM. An old chip random access memory, has received address and its associated memory content returns. TCAM chips acts as a reverse way, the chip content and get first address the content of which lies in TCAM returns in constant time. According to an incoming packet, the hardware TCAM The packet classificationcan be stored with all the rules, in parallel with its consistent return compared to the first rule. To handlepacket classification, pre-set rules that can dynamically or statically, and the packet classificationto the router, adopting and express the law in accordance with each package and handle the package and as a result of executive action on it. Rules on the basis of the information contained in the packet header as the source IP address, destination IP address, source port, destination port and protocol. Depending on the action to be taken, depends on the location where the action is done classification. [5]

[1] Ternary content addressable memory

[2] Binary Search On Level2

[3] Binary Search On Level- Repeat control

Given the importance of packet classificationat network routers, many studies have been done in this area. A fairly complete packet classificationoffered methods [9] in 2007, Mr. Jonathan Chao and his colleagues provided another category of these methods [11] and in 2010, Mrs. Lim Haysuk seminars, methods Classification various Packagesprovided. [20] two of the proposedarticles in the field of study related work in the field of packet classificationrecently presented, the architectures, different methods and the tools to implement and evaluate these methods have been used. One of the papers presented in 2015 by Mr. Ausaf Khan to review the advantages and disadvantages of various methods [3]. In another article in 2015 by Mr. Kumar has been raised them, challenges in the existing methods have been studied [4].

2. The proposed method:

Packet classificationrouting as one of the main mechanisms, widely used on the internet and capable of providing many network services such as firewalls, access control, virtual private networks, quality of service and traffic load balancing is .as mentioned earlier one of the methods that are widely used topacket classification, using methods based on ternary content addressable memory is (TCAM).

The method used in this paper, providing a convenient way to transfer rules TCAM is a block categories to into the so that for each inputthe incoming packet classificationonly a few the incoming

Packet classificationTCAM search to include all the rules are consistentin accordance with the , packet classificationto be examined. Thus, using this method can be to a large extent reduce the power consumption. The method used in this paper, providing a convenient way to transfer rules be thecategories into the block TCAM includes four steps: 1-circuit filter separator Fields 2-sets of circuits, producer and key decoder 3 , 4 - category TCAM, the So thatfor each input of blocksonly a few of blocksTCAM which contains all the rules in accordance with the search packet classificationmatches are to be examined. Thus, using this method can be to a large extent reduce the power consumption.

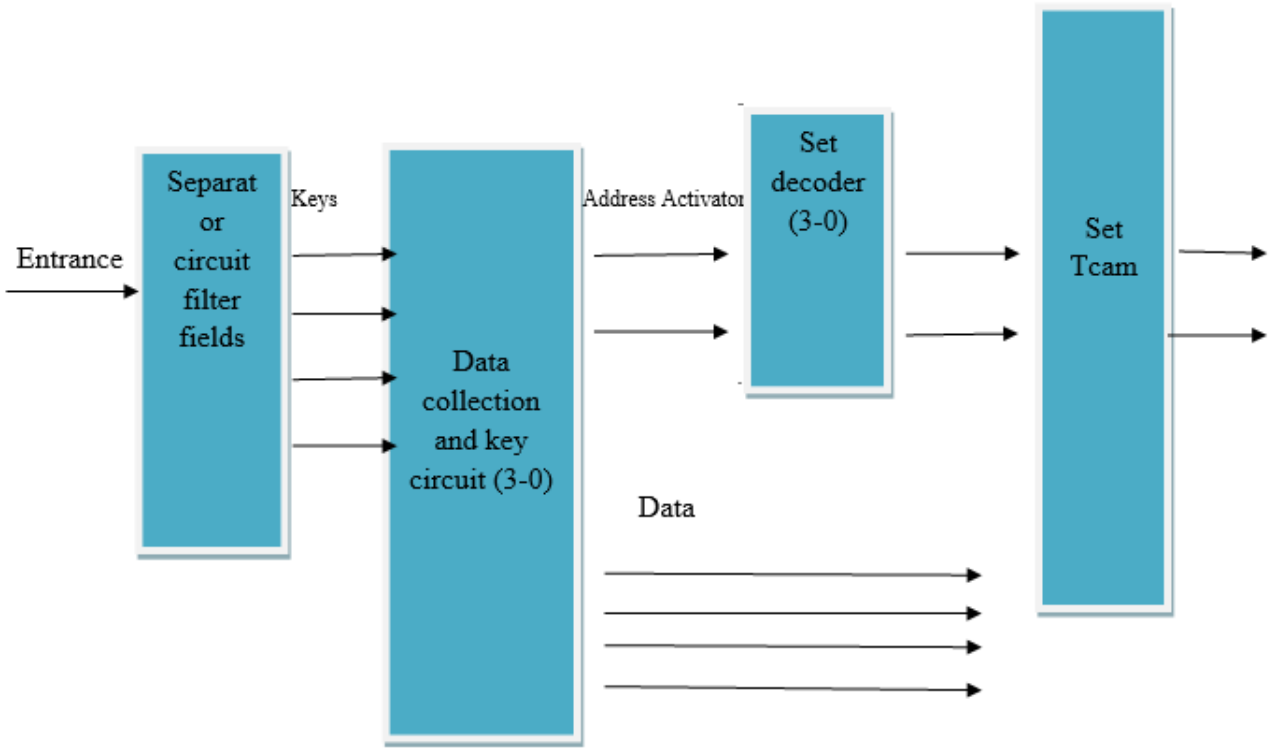


Figure 1. An outline of the proposed method

In Figure 1 order of entry, 104-bit packet header. In addition to this, according to the TCAM memory storage in addition to the values 0 and 1, the ability to store bits is trivial, for storing IP addresses as a prefix to express, reduced memory consumption is.

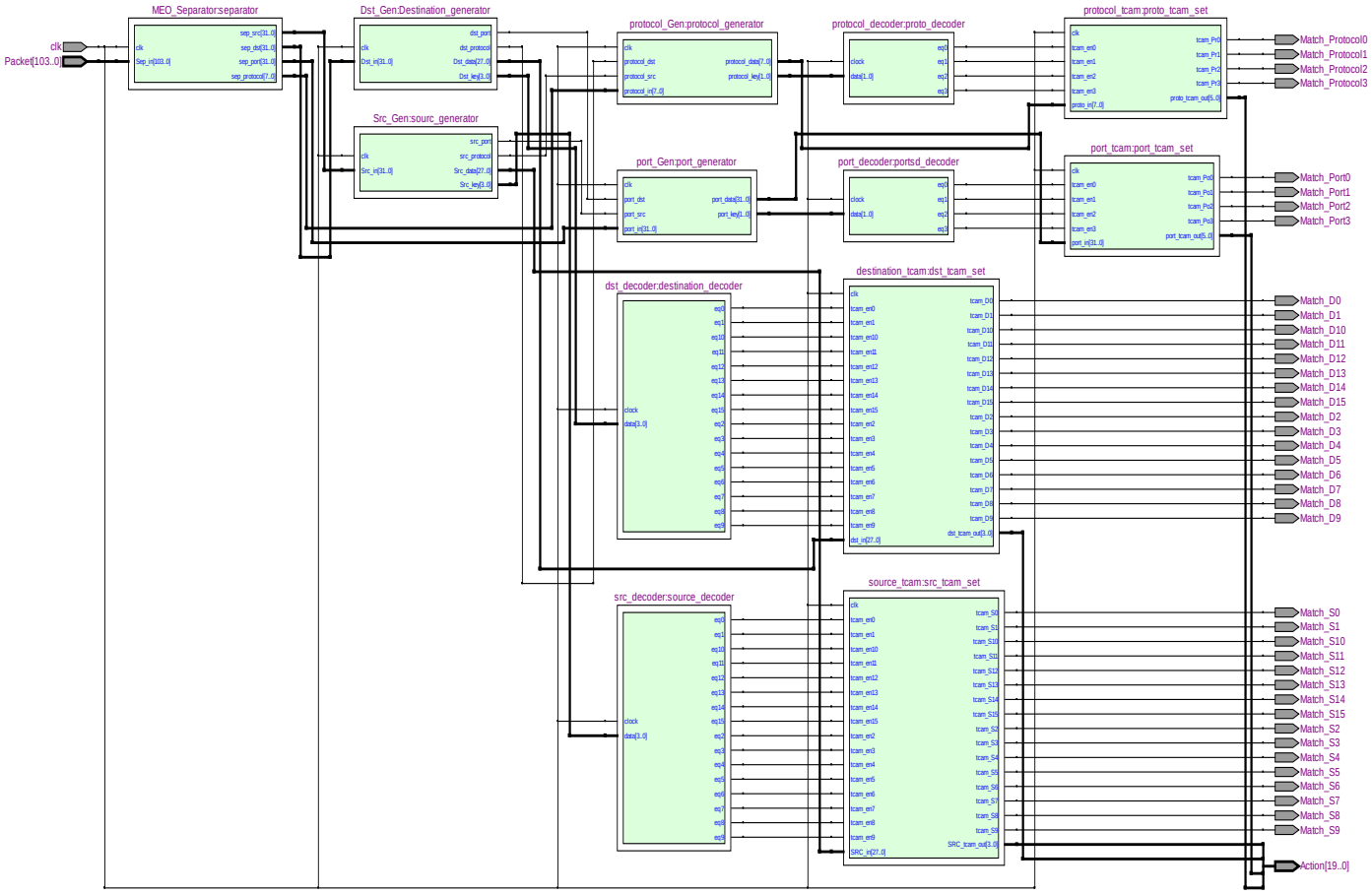


Figure 2. circuit implemented MEO-PC

If we have a definition of closed or law, we can not in these terms: each filter is composed of a number of fields, and each filter with respect to its application, can be closed or called .Note law that rules can be combined with bits of 0, 1 or X (don't care) to be saved, but only one entry 0 or packet classification1 is formed. In MEO_PC it is assumed that 104-bit filters.

Table 1. Format a five-field filter.

Source IP address	Destination IP address	Source port	Destination port	Mask / protocols
15.0.0.0/8	0.0.0.0/0	0 : 65535	0 : 6553	0x00/0x00
3231124299	255664495	0	65535	6/566

Each filter has a fifth field that the source IP address 32 - bit to 32 -Byte IP address, source port 16 -Byte, destination port 16-bit and 8-bit protocol.

3. Separator circuit filter fields:

The first part of this system, the filter separator circuit. To determine the storage-looking law or depending on memory TCAM, must be considered in the circuit to separate the fields when logging into the category of filters in routers, a combination of five field source IP address, destination IP address, source port, destination port and protocol.

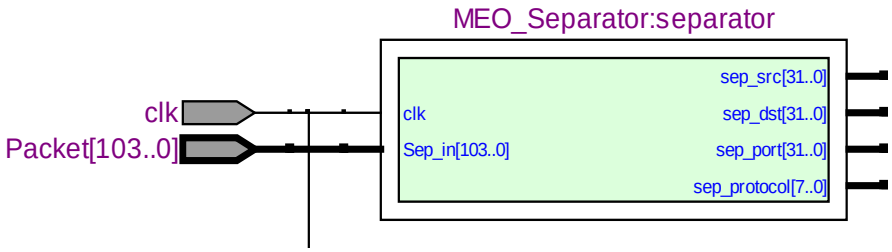


Figure 3. Circuit Separator fields.

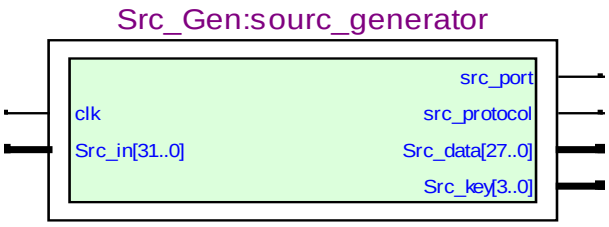


Figure 4. Data producing circuit and key source IP address.



Figure 5. Data producing circuit and key destination IP address.

4. Data producing circuit and key fields:

After the input filter fields were separated into producer data circuits and are key the task of generating input data into memory intended for field and it also generates keys for the decoder to enable single memory that have been used. For the source IP address, destination IP address, port and protocol is designed circuits producing separate is designed to parallel carry out key operations and that this will this increases the speed of search and be updated [2].

Figures 4, 5, respectively circuitsproducingsource IP address, destination IP address, are depicted.

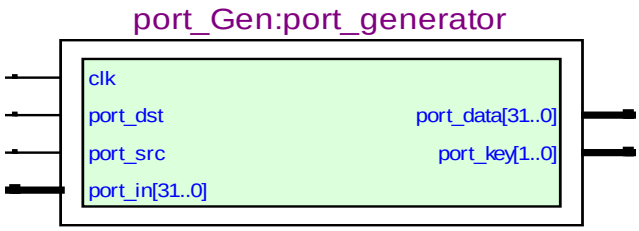


Figure 6. Data producing circuit and key data source and destination ports.

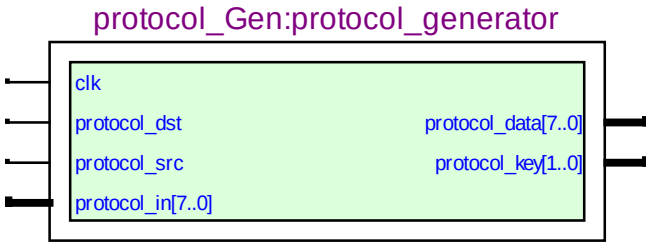


Figure 7. Data producing circuitand key protocols.

The circuit also has another two outputs, one of these outputs to enable ports and also to enable the protocol used. Figures 6 and 7 as well as the circuits of production and key ports and protocols are depicted. These circuits such as the circuits of production and key addresses IP, has similar performance to that end, one of which (data producing circuit, and switch port) to explain. This circuit is a 32-bit input data is the combination of source and destination ports. In addition, the two have a bit port_src names and port_dst also that the circuit source and destination IP address and the keys have been entered into this circuit. The two were placed side by side and switch port provides decoder ofcode. So port_key output is intended for this purpose. The output of this circuit, suppliers of TCAM memory data input port. Circuit manufacturers and key protocol works in a similar way except that the 8-bit data output. By providing data on each field, continuing in relation to the code decoder circuits are discussed.

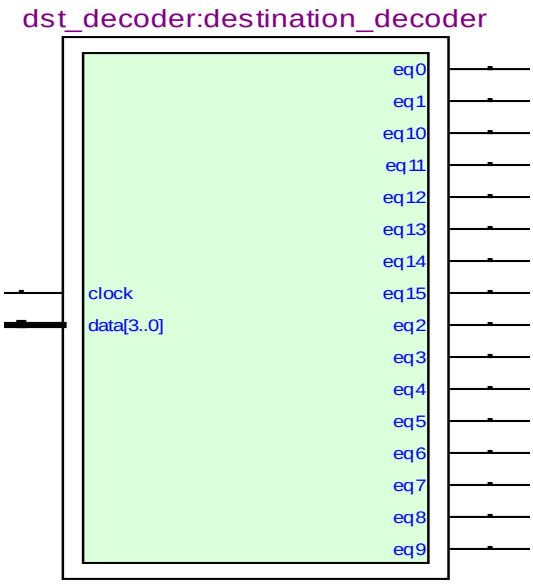


Figure 8. Decoder circuit destination IP address.

5. Implementation and results:

Memory usage

One of the criteria for different architectural design in thepacket classification, the amount of memory consumptionto store the law filters [6]. For evaluating and comparing architectures, the evaluation criteria ACL (including ACL1K and ACL5K), IPC (including IPC1K and IPC5K) and FW (including FW1K and FW5K) have used. In the figure of a-9, b-9 and c9, respectively, the number of bits required to store the filters is shown. The amount of memory required (to the base) in the initial state without using the MEO-PC show. Rectangles that have horizontal stripes, the amount of memory required (in bytes) in the case of MEO-PC is used, show. Using MEO-PC memory consumption shows a significant decline. Has become the primary domain prefix, memory consumption increases. But we have not consumed by the MEPC will not only enhance memory, but also achieved a significant reduction [10]. Figure 9, the amount of memory needed for different architectures and different filters show.

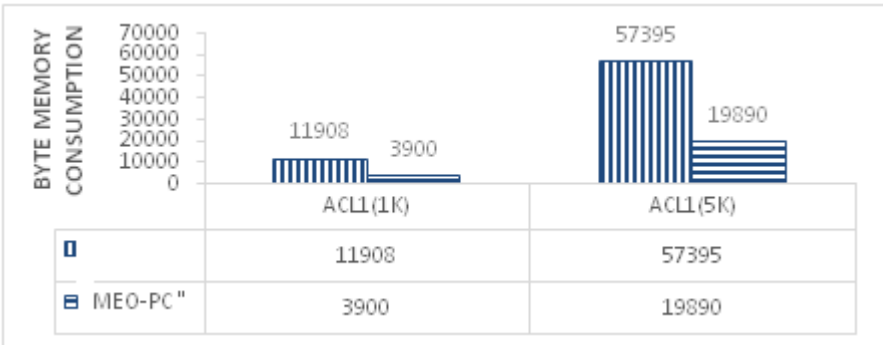


Figure 9a. Simulation results memoryusage for ACL1 filters in original condition and with MEO-PC

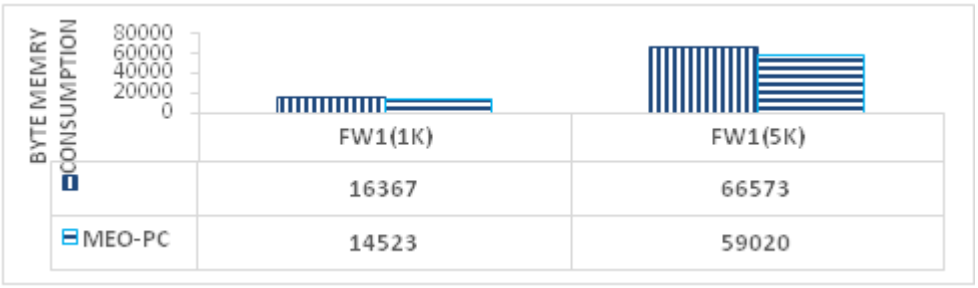


Figure 9b. Simulation results memory usage for FW1 filters in original condition and with MEO-PC

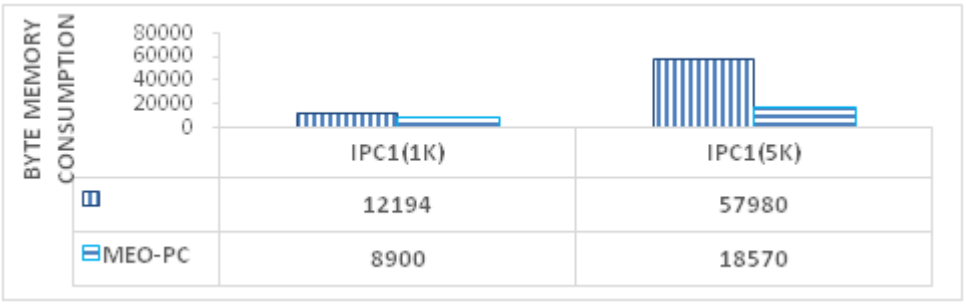


Figure 9c. Simulation results memory usage for IPC1 filters in original condition and with MEO-PC.

6. Access to memory:

Another evaluation criteria in comparing different architectures, the number of memory accesses to find a law consistent with the input is closed. In fact, when it gets packed into a category based on the order in which they are depending on different architectures,must comply with the law to act addresses that correspond to these packages is to be detected. Given that the different architecture, different memory is considered, the number of memory accesses based on the number and size of each memory are different. In fact, if memory size is small and the number of memory that can be considered for filters act, is low, the number of accesses to implement a package, will be reduced. Figures 10,11 and 12, respectively, the number of accesses required to implement a package in a state of minimal access and maximum access to various keys (2-bit, 3-bit, 4-bit, 6-bit and 8-bit) architecture MEO-PC is depicted. Lines that are horizontally, shows the minimum number of memory accesses and vertical lines, the number indicates the maximum memory access. . Figure 13 Number of memory access for different architectures and different filters show. Taking a look at this comparison, it is observed that the proposed architecture in many cases have little access to other architectures is that it will speed up the search. . It also reduces energy consumption will also lower the access number.

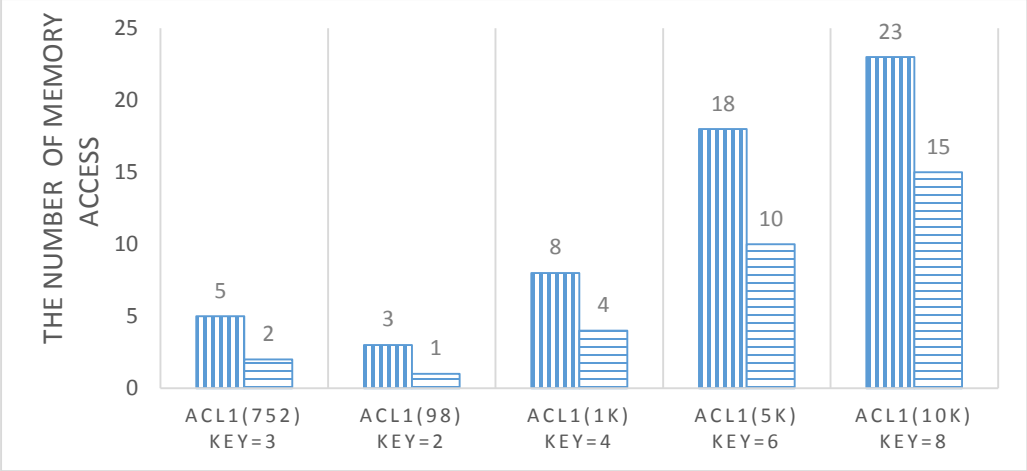


Figure 10. Number of memory access keys for ACL1 filters in MEO-PC.

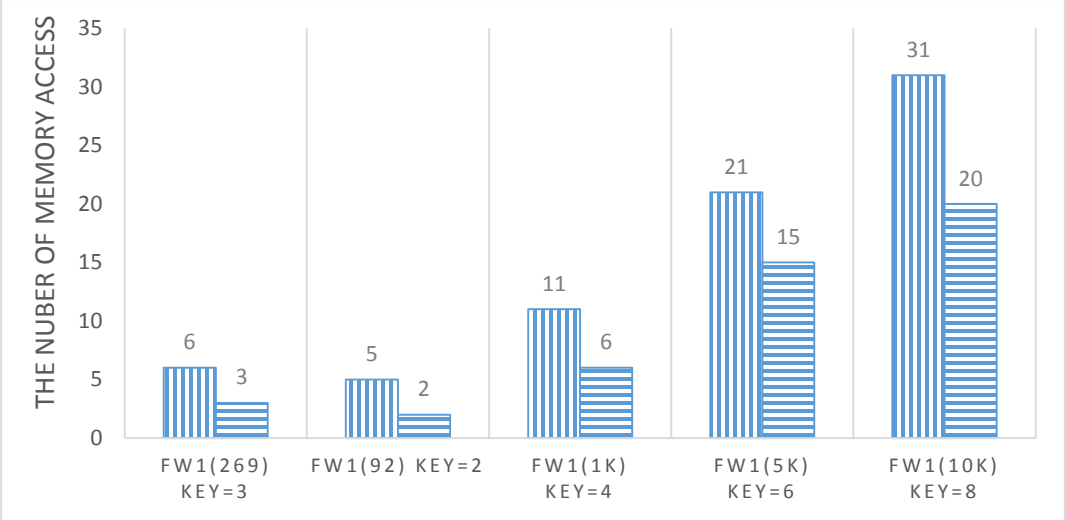


Figure 11. Simulation results FW1 number of memory accesses for filters in MEO-PC.

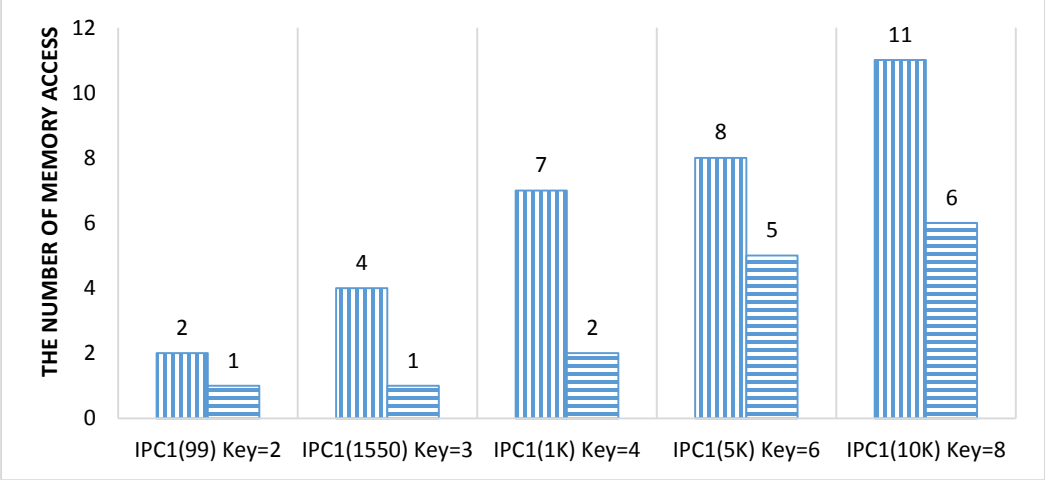


Figure 12. Results of the simulation of memory access for IPC1 filters in MEO-PC.

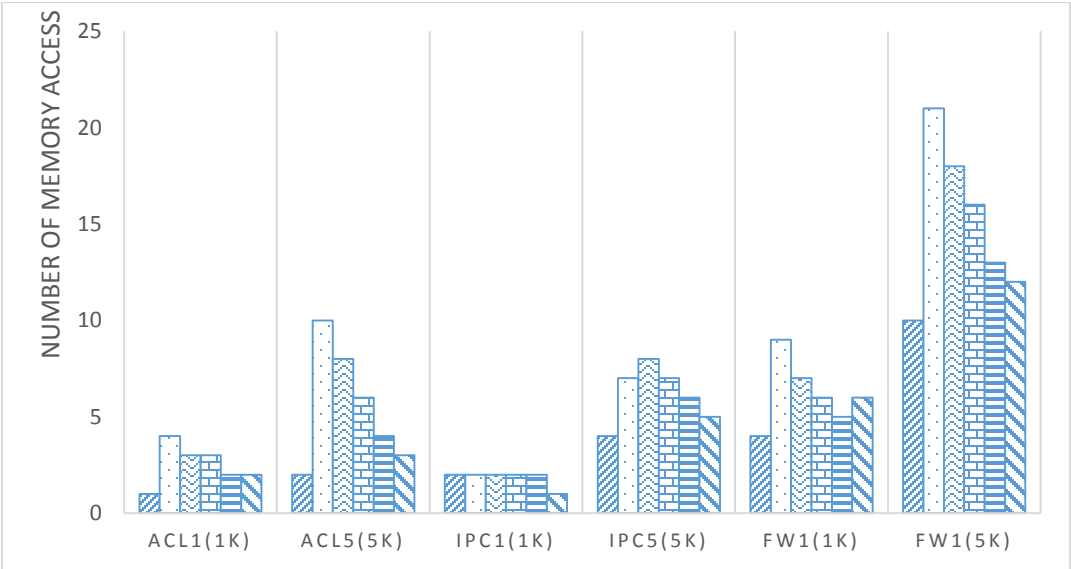
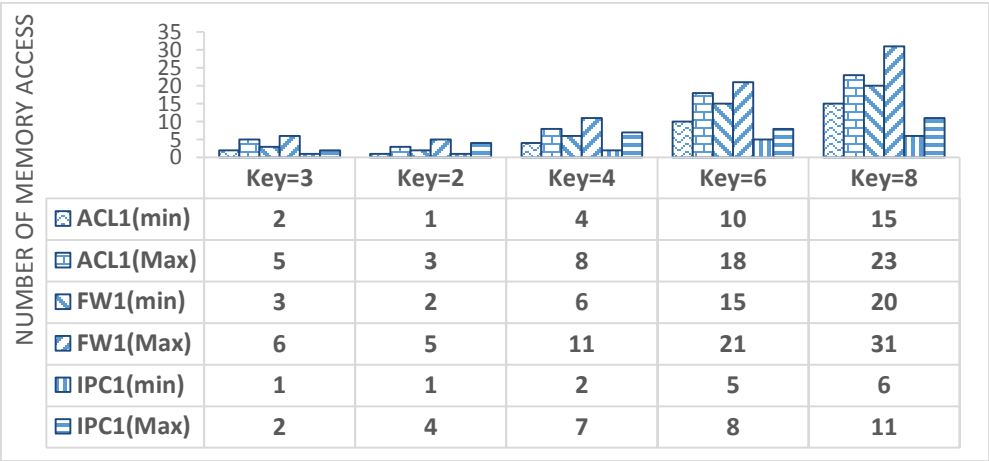


Figure 13. Comparison of the results of the simulation of memory access for different filters with MEO-PC.

According to Figure 13 can be seen that the number of MEO-PC memory access for different filter sets, the proposed architecture is much less than the maximum. Only filters set IPC1 (with size 1 kg), the number MEO-PC access memory architecture to BSOL-RC More reason it would also increase the number of prefixes that have been converted from the slopes of ports.

7. Scalability in terms of access:

Quickly update or search for a package, a very important parameter is the key topacket classification. due to the increased memory consumption and number of blocks TCAM, speed and accessibility packet classificationupdates and rules will increase. A good architecture, with the number of blocks of memory, depending on the speed of search and update the rules will degrade very little [19].



	Key=3	Key=2	Key=4	Key=6	Key=8
ACL1(min)	2	1	4	10	15
ACL1(Max)	5	3	8	18	23
FW1(min)	3	2	6	15	20
FW1(Max)	6	5	11	21	31
IPC1(min)	1	1	2	5	6
IPC1(Max)	2	4	7	8	11

Figure 14. Results scalability in memory access for different filter sets MEO-PC.

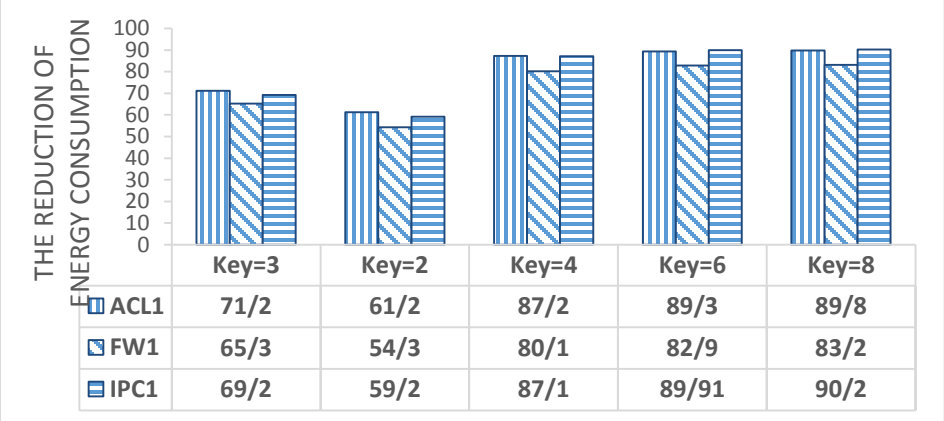
8. Scalability in terms of energy consumption:

Given that energy consumption in the architecture category undeniable and important a component packet classificationon the internet routers and given the increasing number of regulations, increased energy consumption in a building, it will cause performance degradation. TCAM has increased because the number of blocks and given that TCAM rules scrolls in parallel, too much power to find a law consistent with an input package will be spent.

This central router, things will be more impressed. Due to these reasons, and given the increasing number of laws, control energy consumption, a crucial point in the architecture of different categories are closed. If an architecture that is designed for

small rule set, well acted and consume little power and with an increasing number of laws, it is reasonable energy consumption does not change, this will be a good performance architecture for IPv6 [7].

So one of the issues that will be considered in the review scalability architecture, energy consumption is to set rules more and larger blocks. The study MEO-PC energy consumption for different filter sets, the results show that with the increasing number of laws, not only does not increase energy expenditure, But given the number of blocks to clear the blocks, the percent of energy consumption is significantly reduced.Figure (15) power consumption in different modes with different keys show. As previously mentioned, the size of the keys, respectively, 2, 3, 4, 6 and 8 is intended. Due to the proximity of points in each category, realize scalable architecture MEO-PC in different modes, ranging from the number and size of keys can be set filters.



	Key=3	Key=2	Key=4	Key=6	Key=8
ACL1	71/2	61/2	87/2	89/3	89/8
FW1	65/3	54/3	80/1	82/9	83/2
IPC1	69/2	59/2	87/1	89/91	90/2

Figure 15. Results scalability at minimal power consumption for filter sets ACL in MEO-PC.

9. Comparison of measured and calculated parameters:

In order to compare classification algorithms package, several parameters such as speed search performance, memory usage, power consumption, scalability in size classifier, scalability in the number of header fields used last update . This parameter determines the performance of the algorithms will be required in routers [9] and [13].

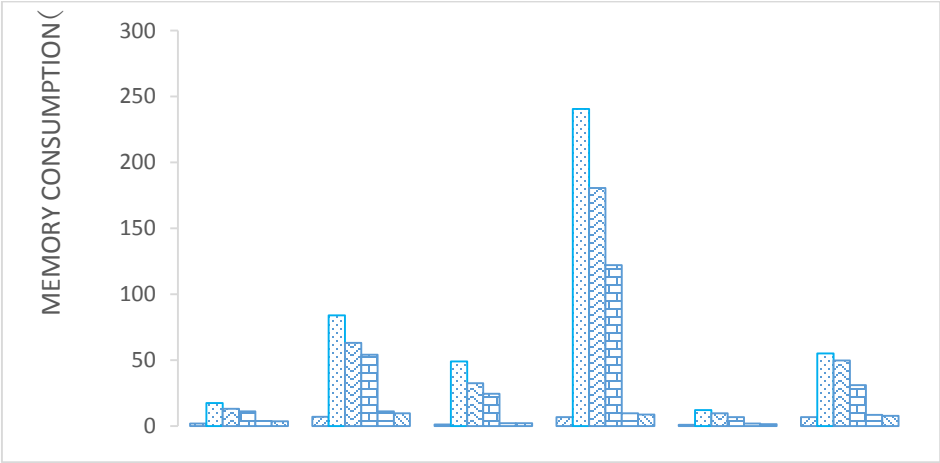


Figure 16. Comparison of simulation results memory usage for various filters with MEO-PC.

According to the figure (16), it is observed that the amount of memory needed MEO-PC for a set of different filters, the proposed architecture is much less than the other. As shown in Figure (16) is shown, memory needed to set FW filters in the 8.6 and 1.1 MB MEO-PC architecture is the architecture BSOL-RC respectively 8/7 and 6/1 MB.

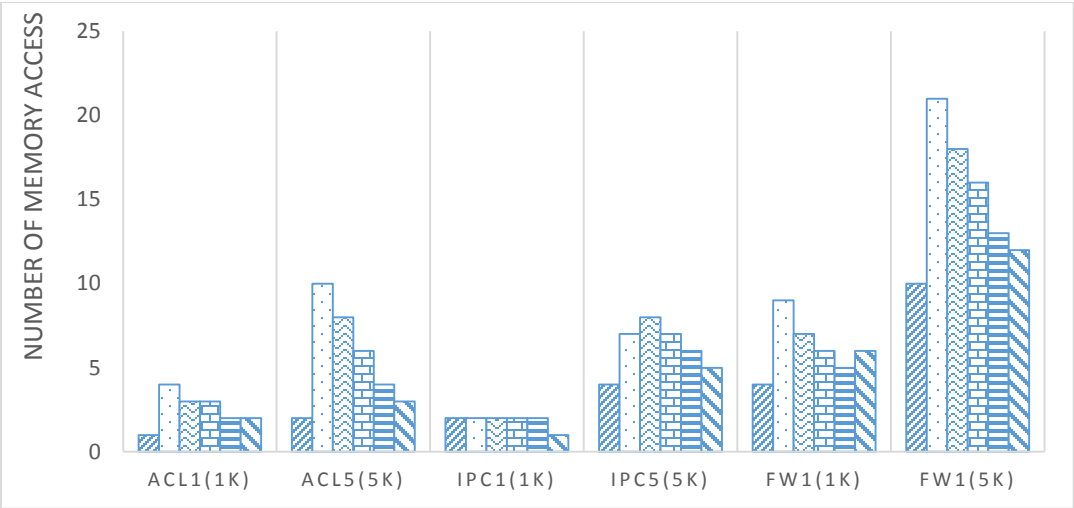
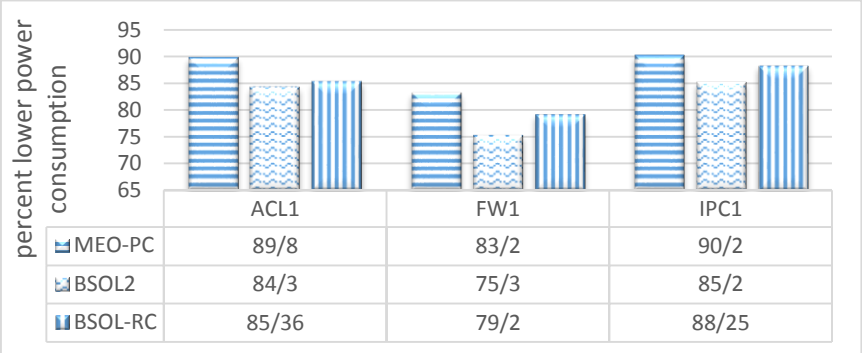


Figure 17. The results of simulation of memory access for different filters with MEO-PC.

According to the figure (17) observed that the number of MEO-PC memory access for different filter sets, the proposed architecture is much less than the maximum. Only in filter sets IPC1 (with a size of 1 kg), the number MEO-PC access memory architecture to BSOL-RC More reason it would also increase the number of prefixes that have been ports of slopes become [14].



	ACL1	FW1	IPC1
MEO-PC	89/8	83/2	90/2
BSOL2	84/3	75/3	85/2
BSOL-RC	85/36	79/2	88/25

Figure 18. The results of the simulation percent reduction in energy consumption for different architectures

10. Conclusion:

One of the main mechanisms of network devices, packet classificationwidely on the internet bundles for different categories of incomingpacket classification to flow and to use the predefined used. Using this mechanism increases the quality of service and provide many network services such as firewalls, access control, virtual private networks, and so is [15]. One of the methods that are widely used topacket classification, using methods based on ternary contentaddressable memory (TCAM) is. TCAM packet fields based on rules coded to compare the three values (0, 1, X), the ability to packet classificationby executive order 0(1) provide [18]. TCAM despite their high speed, high power consumption, which is due to the increase in data centers and expanding the use of IP v6, in the near future this problem will be more acute [16].The aim of this paper is to examine the problems in different sorting algorithms provide a good way to remove the package and it was [1]. Providing an architecture for a of packet classificationtransfer rules into the block TCAM, so that for each incoming batch only the number of TCAM block which contains all the rules are searched in accordance with the, to packet classificationbe examined. In the first stage of this architecture, a circuit before entering the pre-classifier rules / packet classificationhave been put memory TCAM is made up of laws packet classificationdetermined on the basis of this model, which is activated only a particular part of the TCAM would result in a significant decrease in energy expenditure. In the second stage of the circuit, there TCAM memory. The proposed architecture is such that instead of a big TCAM, a number of smaller TCAM for each section of the law (source IP address, destination IP address, source port, destination port and protocol) is used. The surveys found that many of the repeated section of the law that the removal of these sectors, will be significantly reduced memory consumption. Also part of the rules (source port, destination port) that range (0 to 65535) are stored, will be reduced [22]. Question of the rigpacket classificationht is always one of the main challenges of the future. In the 128-bit IPv6 address-of uses for packet classificationoften takes place on three

fields. According to surveys conducted on IPv6, MEO-PC promising optimal performance for it. One of the things that will be examined in the near future, providing an appropriate architecture for markets will be closed for IPv6 [3].

The results from lower power consumption and memory and also increases the speed of updates. And the results compared to the previous articles, the power consumption of 89 percent and 86 percent improved memory consumption.

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