Packet classification

- In network architectures providing differentiated QoS, packet classification is a basic step to deliver differentiated service level agreements
- In the IP Differentiated Services Architectures, these different service levels are referred to as Per Hop Behaviors
- Nodes treat differently packets, according to their Per Hop Behavior (PHB)
- Clearly, nodes must be able to determine the PHB to which a packet belongs, otherwise, the associated SLA cannot be implemented
- Packets carry their PHB code in a specific field
- However, this specific field must be filled at the network ingress by an edge node
- This operation is referred to as **classification**

Packet classification

- Classification is based on keys and rules
- The classification key, in general, is a set of *N* bits in a packet header, concentrated in one field or distributed in multiple fields
- With a key composed of *N* bits, 2^N different classes of packets can be differentiated
- The act of classifying a packet involves matching the classification key against a set of classification rules
- The result of classification is to assign a treatment behavior to each packet
- Clearly, all packets within the same treatment behavior receive the same service by a node

Packet classification

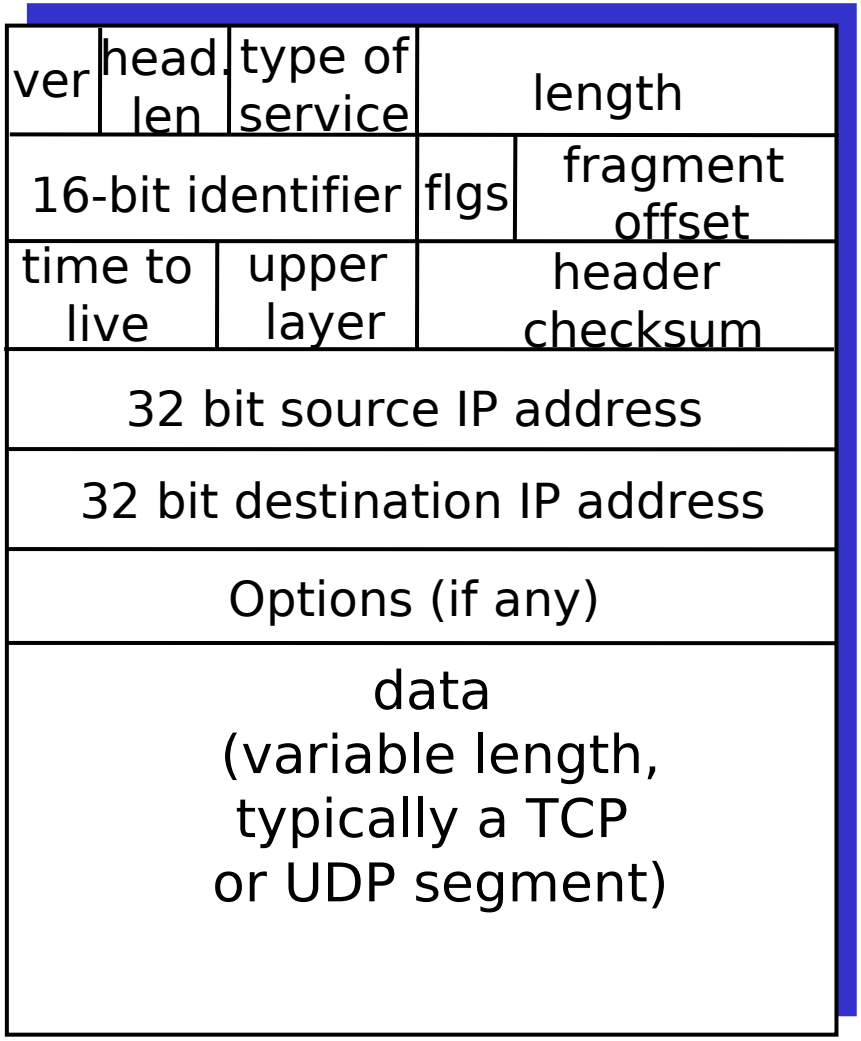
- The simplest classification schemes are called single-field: they take into account a single field of the packet header as classification key
- Multi-field classification considers multiple fileds of the packet header
- Multi-field classification is more complex than single-field classification and problems of computing capacity may arise, as classification must operate at wire speed
- However, multi-filed classification is more powerful than single-field, as it provides a greater amount of context to the router's subsequent stages

Packet classification

- Typically, single-field classification uses the Type of Service field of the packet header
- However, this field is currently being replaced by the Diferentiated Services field
- The field is the same byte in the packet header
- However, the allocation of bits and their semantics is different
- Currently, six bits of the Differentiated services field are used to code the packet's class, two bits are reserved
- Multifield classification, by considering other fields such as Protocol, and transport protocol ports, can identify the application to which the packet belongs

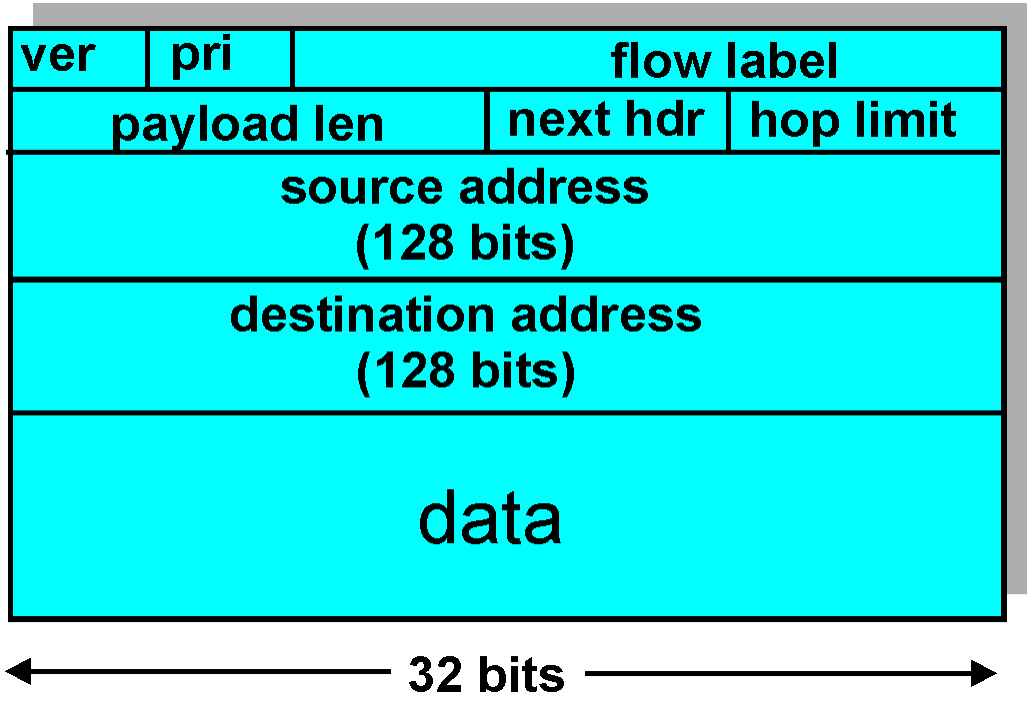
Packet classification

- The problem with multi-field classification is that some fields are long, for example, the IP addresses
- For example, a flow is univocally identified by the fields:
  - Source Address
  - Destination Address
  - Source Port
  - Destination Port
  - Protocol
- Which sum up to 104 bits (a large number!)
- A significant computation is required to examine these fields



Packet classification

- With IPv6, the problem is even more serious, as addresses are 128 bit long
- An address + port numbers classification requires 288 bits
- Moreover, the IPv6 extension headers may require a considerable amount of parsing before finding the transport port numbers
- However, the flow label field (20 bits) can be useful to allow a simple single-field classification



Classification rules

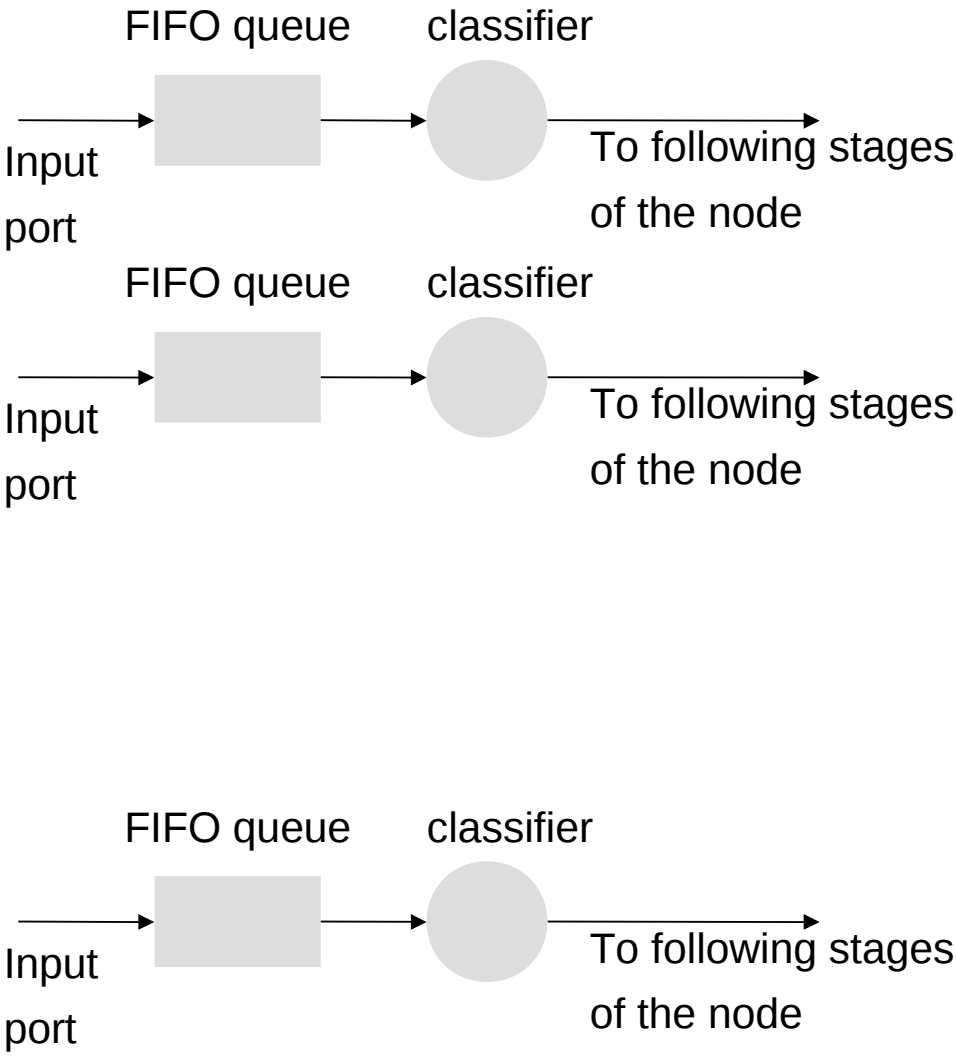
- A MF classifier must be able to deal with having multiple rules that match the same packet
- Matching can be
  - Exact: a field must be equal to a specific value, for example, the source IP source address must be equal to 192.10.10.1
  - Ranging: a field must be in a specified interval of values, for example, the IP source address must be in the range [192.10.10.1, 192.10.10.254]
- Rules can be composed with logical operators:
  - The IP source address must be in the range [192.10.10.1, 192.10.10.254] **AND** the protocol must be TCP **AND** the destination port must be 25
- Any logical expression composing field values can be instantiated
- However, complex rules consume a large amount of CPU

Classification rules

- The output of classification is the class to which the packet belongs
- Usually the packet's class is written into the Differentiated services field of the IP packet
- For example, a possible service class is the traditional Best-Effort
- This class, in the Differentiated services architecture, has code field 000000 in the Differentiated services field of the IP packet
- For example, the network administrator might assign to all HTTP packets coming from a given subnet the Best-Effort service class
- In this case, the rule would be
  - **IF** SA in [192.10.10.1, 192.10.10.254] **AND** protocol = TCP **and** DP = 80 **THEN** class = Best-Effort

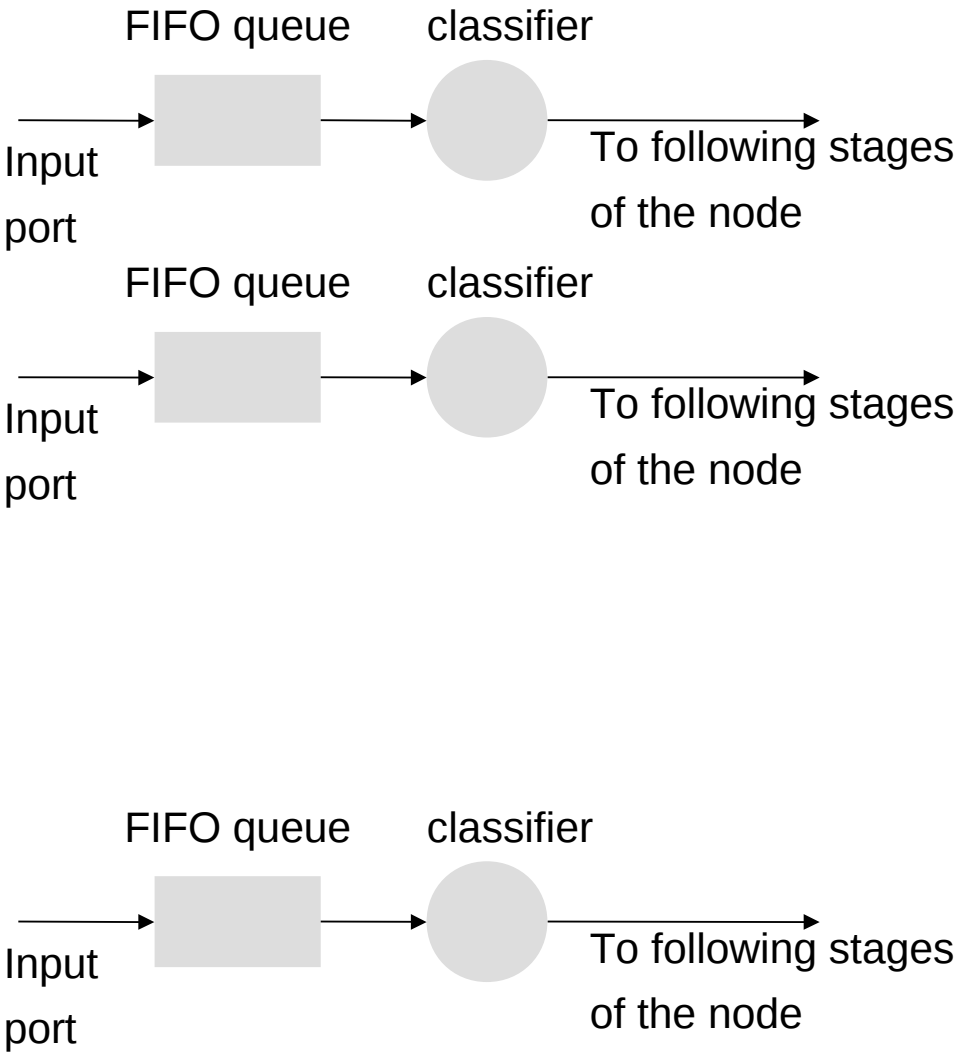
Line rate processing

- Each input port of a node has a classifier examining incoming packets
- If a packet arrives when another packet is being classified, it is stored in a FIFO queue
- Thus, a backlog of packets to be classified builds up in this queue
- Packets accumulate delay while waiting for classification
- For packets needing a stringent delay requirement, this delay may disrupt the SLA



Line rate processing

- Moreover, it is not possible to give precedence to packets with stringent delay requirement
- This is because the service requirements of unclassified packets are clearly unknown
- Thus, the only way to make classification transparent for delay-critical packets is to ensure that the classifier has enough CPU to deal fastly with the incoming stream of packets, in the worst case hypothesis



Line rate processing

- The worst case hypothesis is a stream of short packets at wire speed with long multi-field classification rules, carried out on long fields
- Classification is a complex function, with high computational requirements, and the hardware issues are rather complex