International Conference On Emanations in Modern Technology and Engineering (ICEMTE-2017) ISSN: 2321-8169
Volume: 5 Issue: 3 300 - 304

A Survey On Differentiated Service Architecture For The Internet

Ms. Dimpal S. Sutar, Mrs. Sudha Gupta Department of Electronics Engineering,
K. J. Somaiya College of Engineering, Mumbai,
dimpal.s@somaiya.edu, sudhagupta@somaiya.edu

Abstract—Differentiated service (DiffServ) architecture is a prominently researched candidate over the best-effort service approach, to enable the quality of service (QoS) in the Internet. It provides different service classes for Internet traffic with backward compatibility to best-effort service. This paper presents a brief overview of DiffServ architecture and discusses how the DiffServ architecture has evolved with the rapid growth of Internet. The main aim of this survey is- to highlight the development of DiffServ architecture in chronicle fashion, so as to study the pros-cons and its limitations in the current Internet.

Index Terms*—Differentiated service architecture (DiffServ), Quality of Service (QoS)*

*****

I. INTRODUCTION

The Internet has become the centrepiece for various value-added networking services such as VoIP, cloud computing, content distribution and so on. The gained popularity and increased reliability on this services makes service failures and degradation of service quality a costly matter in terms of reputation and revenue for both- service provider and consumer. Thus maintenance of QoS plays a vital role in the Internet. In earlier 80-90s traditional service model of the Internet was Best Effort- in this networks try their best to deliver service/packet within a certain time and in a reliable manner but it do not provide any guarantees about the packet delivery. This service model is suitable for application which is insensitive to network delays such as remote login or file transfer programs, but not for real-time applications where long delays and high packet loss will not be acceptable.

To assure the delivery of data, various service model were designed, but could not sustain with rapid advances in technology prior to consumers increasing demands of QoS. Few of them are discussed as follow:

1) Relative priority marking model: In this model application or host node selects a relative priority by marking precedence for a packet and according to that network nodes along the path apply priority forwarding behaviour to the packet, but it failed to specify the role and importance of boundary nodes and traffic conditioners [1].

2) Service marking model: In this, each packet is marked with a request for a type of service (ToS) [2]. Then network nodes select a routing path or forwarding behaviour to fulfil the service request. The ToS markings defined are very generic and they do not span the range of possible service semantics.

3) Label switching model: Traffic management and path forwarding state are established on each hop along a network path, for traffic streams. This model permits finer granularity resource allocation to traffic streams, but it comes with the cost of additional management and configuration requirements to establish and maintain the label switched paths.

4) Integrated Services/ RSVP model: It was the first attempt of IETF to support QoS of Internet [3]. It is based on traditional datagram forwarding in the default case but allows sources and receivers to exchange signalling messages using RSVP. In the absence of state aggregation, the amount of state information increases proportionally with a number of flows. Thus router may need large storage space and high processing power and implementation of RSVP increases complexity. Hence IntServ model lacks the performance in terms of scalability and flexibility.

5) Priority Scheduling and weighted fair queuing: Priority scheduling scheme fulfils the needs of different users, by maintaining different service classes of different priorities. Also provides a useful building block for explicit service discrimination, but it does not have a mechanism for balancing the demands of the various classes. Weighted fair queuing works on it, creating different queues for different connections, thus ensures each connection will receive some shares of bandwidth. But the scalability of this scheme is questionable in the centre of the network where routers have a large amount of traffic aggregation.

To overcome the above limitations of different QoS models, IETF proposed its second model- DiffServ architecture. DiffServ changes the service semantics ToS byte of IP header by using the 6-bit field (DS code). It supersedes the ToS octet in Ipv4 and traffic class in IPv6. DiffServ distinguishes functionality between the boundary and interior nodes. Boundary nodes set DS field and interior node forwards the packet based on the DS field value. This paper presents the overview of DiffServ architecture in section II, and section III presents its evolution with the advancement in Internet.

II. OVERVIEW OF DIFFSERV

DiffServ is a networking architecture which provides QoS on modern IP network, by using a simple, scalable and the coarse-grained mechanism for class-based classification rather than per-flow service guarantee and managing network traffic. The architecture is defined by a contiguous set of nodes in a network known as a DS domain- these nodes follows a common servicing policy and supports a set of per-hop-behaviour groups (PHB) implemented on each node. PHB is defined as an externally observable forwarding behaviour applied at DS node. DS domain consists of boundary and interior nodes as shown in Fig 1.

Boundary nodes of DS domain are responsible for performing traffic conditioning as defined by a traffic conditioning agreement (TCA) and classification so as to ensure its appropriate treatment with respect to its differentiated service code point (DSCP).

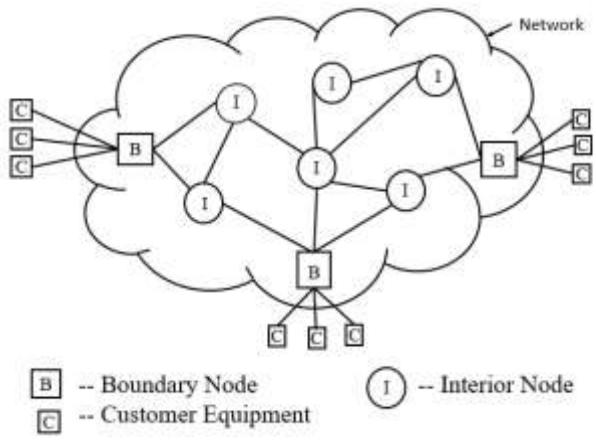

Fig 1: DS domain

These nodes select an appropriate PHB from the group of PHB supported by its DS domain, by mapping to DSCP. Interior nodes forward the packet with respect to its PHB. Thus burden over interior nodes is lesser compared to boundary nodes which enhance its efficiency at the time of traffic congestion. Key elements of DiffServ are explained below.

A. DS field

It is defined by replacing the existing the definition of the IPv4 type of service (ToS) and IPv6 traffic class octet. DSCP utilizes 6 bit out of the DS field to select PHB and remaining 2 bits are currently unused (CU) and reserved for future uses, as shown in Fig 2. CU bits are ignored while determining the PHB.

To preserve the backward compatibility of with current practice of ToS, remarking at boundary nodes is recommended and certain code-points are reserved as well. A default PHB code-point 000000 is reserved for best effort behavior. With-out modifying the flexibility of ToS, IETF introduces class selector codepoints to maintain the compatibility [5].With a 6 bit DSCP, DS field is capable of providing 64 distinct DSCP. These DSCP as divided into 3 pools as shown in below Table I. If a packet is received with unknown DSCP then the packet will be forwarded as if it was marked with the default PHB.

B. Per-hop-behaviour (PHB):

The standard forwarding treatment provided by the router is best-effort-default PHB. As discussed above DiffServ goes beyond that by providing differential classes for per-hop-behaviour using the class selector. IETF has defined two additional PHBs.

1) Expedited Forwarding (EF) PHB:

It is the basic block in DiffServ, intended to provide a low delay, low jitter, and low. The recommended codepoint for EF PHB is 101110. Whenever EF packets enter a router, they are placed into a queue which is expected to be short and served quickly so that EF traffic maintains significantly lower levels of delay and jitter.

Thus special care must be taken while handling the traffic for EF. [12, 13] defines a general concept for EF- the border nodes control the traffic aggregation to limit its characteristics to some predefined level such that the aggregated maximum arrival rate must be less than the aggregated minimum departure rate.

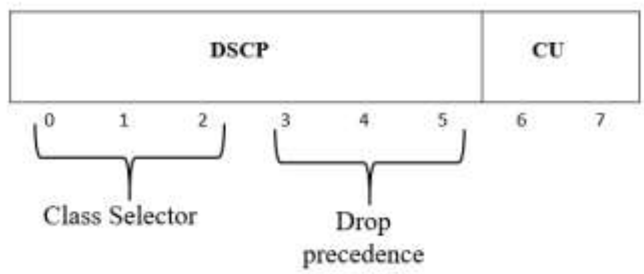

Fig. 2: DS field

Table 1: codepoint for 3 pools of DiffServ

Pool	Codepoint spaces	Assignment policy
1	XXXXX0	Standard action
2	XXXX11	Experimental or local use
3	XXXX01	Experimental or local use but may be allocated for future standard action as needed.

1) Assured Forwarding (AF):

Without any resource reservation techniques, it provides service superior to best-effort. It provides different levels of providing assurance to IP packets in DS domain using four AF classes, each having three different levels of drop precedence. An IP packet associated with AF class 'i' and drop precedence level j is marked with AF codepoint AFij. The recommended values for this class are shown in table II. A congested DS node discards packets with a higher drop precedence to protect packet with low drop precedence. To implement the AF PHB groups over DS nodes, nodes should

follow the specification provided by [7]. It also points out that level of assured forwarding of IP packets depends on-
i) Forwarding resources has been allocated to the packet belonging to AF class,
ii) Current load of AF class,
iii) Drop precedence of the packet.

Table 1: Assured forwarding's codepoints

Precedence level (j)	Class 1	Class 2	Class 3	Class 4
Low (1)	'001010'	'010010'	'011010'	'100010'
Medium (2)	'001100'	'010100'	'011100'	'100100'
High (3)	'001110'	'010110'	'011110'	'100110'

C. Traffic conditioner

An essential function of DiffServ- traffic conditioner consists of following elements as shown in Fig 3.
a) Classifier:
It provides a foundation to provide differentiating service by classifying packets based on the content of some portion of the packet header. IETF have defined two packets classifiers-
i) BA classifier (Behaviour aggregate) - classifies packets based on their DSCP.
ii) MF (Multi-field) classifier- it classifies packets on the basis of source and destination ad-dress, port address DS field, protocol ID and other information such as an incoming interface.

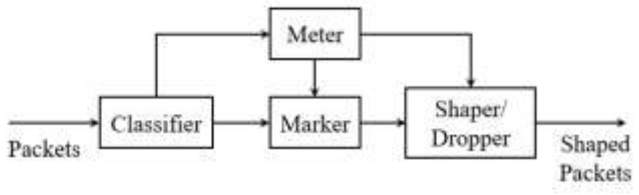

Fig 3: Traffic classifier

b) Meter:
A selected packet stream by a classifier is for-warded to Meter so as to measure its temporal properties against the traffic profile selected by traffic conditioning agree-ment (TCA). TCA specifies classifying and traffic conditioning rules that are to apply to packets selected by a classifier. Results are forwarded to marker and shaper/dropper sections.
c) Marker:
It sets the DS field. According to the state of a meter, it determines the packet stream is within the traffic profile or not and if necessary it remarks the packet i.e. changes the DSCP value as well.
d) Shaper:
Shaper usually consists of a finite-size buffer, and using this buffer it delays some or all packets to bring the traffic compliance with a traffic profile and whenever a buffer is insufficient to hold the packet, it gets discarded.
e) Dropper:
It drops the packet when packet stream goes out of the traffic profile.

III. EVOULTION OF DIFFSERV ARCHITECTURE

The 1990s was the decade where operation and research attention shifted from best-effort service approach to differentiated service approach due to the demand of inelastic traffic services/ applications, after the limitations of IntServ.

A. 1990s

In best-effort service model, the network allocates band-width among all the instantaneous users as best it can, and attempts to serve them without making any explicit assurance to the service. Such kind of service is insufficient to inelastic traffic application or services, hence D. Clark presented [14] the mechanism in 1995 to provide differential service by aggregating all traffic of same usage profile of the user and thus indicated by tagging in the packet. Though this mechanism could not provide service as exactly as assured, but the failure of service is probabilistic hence it is tolerable by users.

Going ahead with this concept to provide differential services in 1997, [9] presented an architecture where Random early detection (RED) with In and Out bit (RIO) mechanism is combined with an architecture proposed in [14]. RED routers maintains overall high throughput keeping a small average queue length and tolerate transient congestion, it drops packets from the queue of within the service allocation profile-'in' and out of the profile -'out', whenever average queue exceeds a certain threshold. [4] Proposed algorithms for preferential dropping in the network and a tagging algorithm tailored for bulky TCP traffic with a discussion over a set of parameters required to implement RIO. IETF working groups defined the differential service architecture for Internet [6], which we studied in the above section. [5] defined the DS field and the layout of ToS in IPv4 and traffic class octet in IPv6 in differential services.

In 1999, IETF described expedited forwarding and assured forwarding. AF is defined for a DS domain provider to offer different levels of forwarding assurance for IP packets received from a customer domain. It has four AF classes, each having 3 instances of dropping preferences as discussed earlier [7]. EF is defined as per-hop-behaviour for a particular aggregation where the departure rate of the aggregated packets from any DS node must equal or exceed a configurable rate [8]. Except the marking discussed in [5], [24,25] proposed single rate and two rate three color marking (trTCM) respectively. In this trTCM meters IP packet streams and marks their packets based on two rates- Peak Information Rate (PIR) and Committed Information Rate (CIR) and their associated burst sizes to be either green, yellow, or red. When the packet exceeds the PIR, then it is marked as red, else yellow or green depending on whether it exceeds or doesn't exceed the CIR.

B. 2000s

The model presented in [6], has not provided sufficient guidance to tunnel designers and implementers, thus [2983] presented the interaction of DiffServ with the various form of IP tunnels with the discussion of how and where to perform the traffic condition in tunnel encapsulation and de-capsulation. In 2002, EF definition was revised with its mathematical representation and some definitions [12], and additional ex-planation of these definitions with implementation examples are presented in [13].

The DiffServ architecture works for DS domain specifically which are backbone domains of the network, thus its reliability to end-to-end QoS is unresolved. Over this limitation, many re-searchers have tried their best to achieve resource management on end-to-end basis [19, 20], but none of them have moved ahead from its proposal state- one of them is the deployment of IntServ architecture over DiffServ [9, 11]. In this, at the boundary of network integrated service requests are mapped onto the underlying capabilities of the DiffServ network. It creates a two-tier resource allocation model: DiffServ provides resources to customer networks from core network; then IntServ allocates these resources at finer granularity to its individual users. Working on the same limitation- the end-to-end QoS provision, [18] suggested a solution which involves resource discovery feedback loop and fair intelligent admission control scheme for each DiffServ domain. Resource discovery protocol is proposed to establish the communication channel of external traffic to DS domain with respect its capability. To calculate the fair-share of available bandwidth fair intelligent scheme is utilized. It also improves DiffServ's performance by removing dependency on variable packet size. Y. Bernet, et.al [15] presented the management model of DiffServ routers to use in management and configuration of DiffServ. It defines algorithmic droppers, queues and schedulers, functional data-path elements and also describes the possible inter-connection configuration to realize the range of traffic conditioning and PHB functionalities.

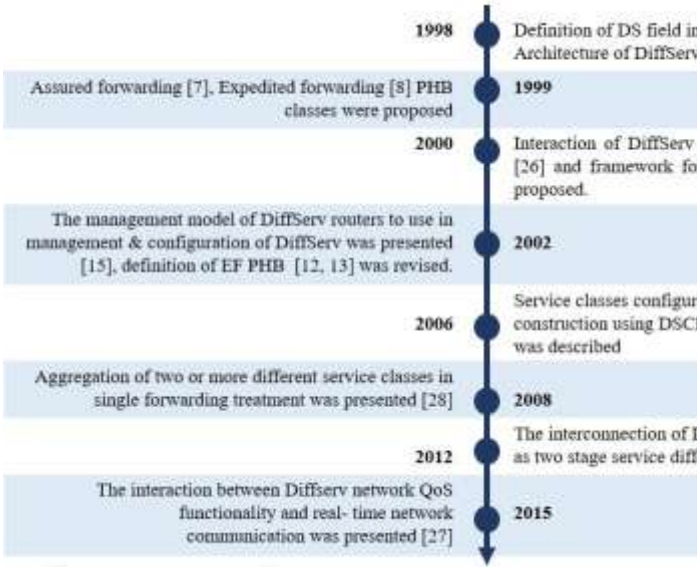

Fig. 4: Timeline of DiffServ architecture's Evolution

In the decade of 2000s, research groups of Diffserv started working on the implementation of DiffServ in real time communication. Babiarz, et.al [4594] studied the implementation of DiffServ's service classes according to different user traffic profiles such as multimedia streaming, broadcast video service, by using DSCP code, traffic conditioners, and PHB. In real time communication, it may happen that single forwarding treatment in network segment can satisfy the traffic characteristics and performance requirements of two or more service classes. So in this situation aggregation of these service classes will improve the performance hence K. Chan, et.al [28] described the guidelines for the aggregation of DiffServ service classes into forwarding treatments.

C. From 2010 - till date

The interaction of DiffServ and real-time communication is still being studied by various groups. D. Black and P. Jones [27] have explored the implications of various DiffServ as-pects for real time communication such as real-time transport protocol (RTP). The DiffServ architecture has been accepted as a scalable candidate to enable QoS for Internet, but it has its own limitations such as lack of accuracy in individual flow's service delivery, the service level is assured within DS domain and so on [21]. To provide highly inelastic traffic oriented services, [22] presented two stage service differentiation model linking RSVP with DiffServ. This method also ensures isolation and priority between two different mechanisms, but faces the original limitation of RSVP- scalability. That limitation is compensated with simplifying the lookup procedure of RSVP for those packets which do not contain RSVP enabled DSCP. The Fig. 4 presents the timeline of work done till date under DiffServ architecture area, it highlights the contribution DiffServ working groups discussed above.

IV. CONCLUSION

The DiffServ architecture stands out as a promising candidate compare to other existing models specifically in terms of scalability and feasibility. While implementing the DiffServ architecture -to obtain good results a clear target and clear de-signing is necessary. Thus it is important to carefully provision the network so as to avoid mismatch between traffic profiles and bottleneck bandwidth, and additional mechanism may be needed such as resource provisioning, traffic prioritization, admission control to regulate and detect malicious behaviour of traffic sources.

REFERENCES

[1] Jon Postel, "Internet Protocol", RFC-791, Sept- 1981.

[2] P. Almquistl, "Type of Service in the Internet Protocol Suite", RFC 1349, July 1994.

[3] R. Braden, et.al, "Integrated Services in the Internet Architecture: an Overview", RFC 1633, June 1994.

[4] D. Clark, "Explicit Allocation of Best-Effort Packet Delivery Service", IEEE/ACM transactions on networking, vol. 6, no. 4, august 1998, pp. 362-373.

[5] K. Nichols, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", RFC 2474, Dec-1998.

[6] S. Blake, "An Architecture for Differentiated Services", RFC 2475, Dec-1998.

[7] J. Heinanen, et.al, "Assured Forwarding PHB group", RFC 2597, Jun-1999.

[8] V. Jacobson, et.al, "An expedited forwarding PHB", RFC 2598, Jun 1999.

[9] K. Nicholus, et.al, “A two-bit differentiated services architecture for the Internet”, RFC 2638, July 1999.
[10] S. Brim, et.al, “Per Hop Behavior Identification Codes”, RFC 2836, May 2000.
[11] Y. Bernet, et.al, “A Framework for Integrated Services Operation over Diffserv Networks”, RFC 2998, Nov-2000.
[12] B. Davie, “An Expedited Forwarding PHB (Per-Hop Behavior)”, RFC 3246, March 2002.
[13] A. Charny, et.al, “Supplemental Information for the New Definition of the EF PHB (Expedited Forwarding Per-Hop Behavior)”, RFC 3247, Mar 2002.
[14] D. Clark, “Adding Service Discrimination to the Internet”, Sept-1995.
[15] F. Baker, et.al, “Management Information Base for the Differentiated Services Architecture”, RFC 3289, May 2002.
[16] Y. Bernet, et.al, “An Informal Management Model for DiffServ Routers”, RFC 3290, May 2002.
[17] D. Grossman, “New Terminology and Clarifications for DiffServ”, RFC 3260, April 2002.
[18] Ming Li, et.al, “Resource Discovery and Fair Intelligent Admission control over Differentiated services networks for variable-length packets”, 10th Asia-Pacific conference on communication and 5th International symposium on multi-dimensional mobile communications, 2004, pp 499-503.
[19] M. V. Tostes, et.al, “TCP TS-Prio: An Approach to end-to-end service differentiation for DiffServ AF classes”, AICT-ICIW’06. International Conference on Internet and Web Applications and Services/Advanced International Conference on Telecommunications, Feb-2006.
[20] Zvi Rosberg, et.al, “Fair and End-to-End QoS Controlled Internet”, Third International Conference on Communication Theory 2010, Reliability, and Quality of Service, Jun-2010, pp 85-91.
[21] Aref Meddeb, “Internet QoS: Pieces of the Puzzle”, IEEE Communications Magazine, Jan-2010, pp 86-94.
[22] Pana F. et.al, “A QoS enabled two-stage service differentiation model for the internet”, 6th International Conference on Signal Processing and Communication Systems (ICSPCS) 2012, Dec-2012.
[23] J. Babiarz, et.al, “Configuration guidelines for Diffserv service classes”, RFC 4594, Aug-2006, pp 1-57.
[24] J. Heinanen, et.al, “A single rate three color marker”- RFC 2697, Sept-1999, pp 1-6.
[25] Heinanen, J. and R. Guerin, “A Two Rate Three Color Marker”, RFC-2698, Sept-1999.
[26] D. Black, “Differentiated Services and Tunnels”, RFC 2983, Oct-2000, pp 1-14.
[27] D. Black, et.al, “Differentiated Services (Diffserv) and Real-Time Communication”, RFC- 7657, Nov-2015, pp 1-26.
[28] K.Chan, et.al, “Aggregation of Diffserv Service Classes”, RFC- 5127, Feb-2008.