

Improvement of the quality of Internet service based on an Internet Exchange Point (IXP)

Souleymane Oumtanaga, and Falilu Abudul Kadiri

Abstract—Internet is without any doubt the fastest and effective mean of communication making it possible to reach a great number of people in the world. It draws its base from exchange points. Indeed exchange points are used to inter-connect various Internet suppliers and operators in order to allow them to exchange traffic and it is with these interconnections that Internet made its great strides. They thus make it possible to limit the traffic delivered via the operators of transits. This limitation allows a significant improvement of the quality of service, a reduction in the latency time just as a reduction of the cost of connection for the final subscriber. Through this article we will show how the installation of an IXP allows an improvement and a diversification of the services just as a reduction of the Internet connection costs.

Keywords—Quality of service, Exchange point, interconnection, Service providers, bandwidth, traffic, routers, routing table.

I. INTRODUCTION

QUALITY of Service (QoS) is generally likened to the discrimination of services that is to liken it to the definition of differentiated service's classes. Its implementation often requires the definition of one or several policies on the knots of the network, by the use of many means (traffic shaping, admission control, management of the congestion etc...). At the level of Internet, the principle of end in end is adopted to control the stream by means of algorithms like *Slow-Start* and *Congestion Avoidance* introduce in TCP by Van Jacobson in 1988 [19][20]. These algorithms are essential in the good functioning of the network. Besides the determination of the acceptable busy band, they offer an about fair sharing of the resources between the connections.

The characterization of the QoS is generally expressed by the following criteria:

Gigue: Variation of delay from end to end.

Maximum debit: Rate of maximum transfer which can be maintained between two terminal points.

Availability: Average rate of errors of a connection.

Internet exchanges Points (IXP) are the base of the functioning of Internet. Indeed Internet is an interconnection of various points which are places of meeting where ISP (Internet Service Provider) exchange streams. However we notice that these points are concentrated in certain regions of the world (notably in North America, in Europe and in a part of Asia), what has for consequence an excess load of traffic at the level of equipments which constitute these IXP and an inappropriate use of the width of international strip. Nowadays

the tendency is to the development of protocols and methods to take into account on Internet real-time applications which require a certain continuance in the transmission of streams. These solutions will remain regrettably ineffective as long as we shall not arrive at a well-balanced distribution of the IXP all over the world.

This article aims at showing how IXP can improve quality of service in internet network. We leave a presentation of quality of service in the first part, the objective of which is to raise the problem. In the second part, we present IXP, and show how these last ones can be some solution of Quality of Service.

II. QUALITY OF SERVICE (QoS)

A. Location of the Problem and the Basic Hypothesis

QoS can be defined as the capacity to be able to guarantee an acceptable level of loss of packages, Defined contractually, for a given custom (Voice over IP, videoconference, etc.). In the introduction of [22], the author quotes the various concepts and approaches developed to insure a fair allowance of the resources of a network. In other words the author in his thesis describes the various methods and the approaches to guarantee an acceptable level of loss of package within a network, we have among others:

- **The maximisation of the total debit:** This criterion, the most elementary, Consist of the maximisation of the total of the busy strips assigned : $\max \sum_{n \in N} x_n$

Where:

n is a connection

x_n the busy strip to the connection n

N all the connections.

However this criterion is not fair, and could even lead to allowances where several connections can be refused to access the network. See the 1.3.1.2 of [22].

- **The Maxi-Mini equity:** An assignable allowance is Maxi-Mini fair being if and only if each source has a bottleneck.

Let consider l as the congested link, l_c its capacity, n_l all the connections crossing it and $|n_l|$ its cardinal (i.e the number of connections crossing it). Then the fair maxi-mini assign to each connection of n_l a strip of $\frac{l_c}{|n_l|}$. If we are in the case of a balanced connection

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where w_n the weight of the connection n is, the

allowance will then be:
$$\frac{I_c * w_n}{\sum_{j \in n} w_j}$$

The max-min equity was adopted by the ATM forum [23] for the service Available Bit Rate (ABR) of ATM.

- **The proportional equity:** The criterion of optimization is:
$$\max_{x_n \in X} \sum_{n \in N} \ln(x_n)$$

Or

In a balanced network:

$$\max_{x_n \in X} \sum_{n \in N} w_n * \ln(x_n)$$

The proportional equity is adopted in the version Vegas of TCP [24] what is not the case of the version Reno; however this version is the most displayed at present.

- We also have the criterion of Nash [22, 25, 26, and 27] which leads to the NBS (Nash Bargaining Solution). This concept based on the theory of the cooperative games allows introducing the functions of utilities. These functions represent the earning of the user or the satisfaction which brings him (her) the allowance. So we arrive at an allowance while taking into account satisfactions of the various users.

B. Various Levels of QoS Implementation

QoS is implemented at all the levels of the data processing [15]. So at the physical level we shall argue in term of busy strip, of high debit, of intrinsic reliability, and if possible of temporal properties (It is the case of routers "7600 et 10000 series" of Cisco or still of the router "Passport 5430 Router" of Nortel Networks). At the level of connection we could speak about debit and about allowance of the resources of access. At the network level we shall speak about techniques of routing of the data, of debit through several networks, of allowance and management of resources (control of congestion, approach of type favourite connection, management of the breakdowns of knots) and of protocols such DiffServ and IntServ. At the level transport we shall speak about temporal constraints from start to finish or of process application software with process application software, of allowance of memory and resumption on errors.

III. INTERNET EXCHANGE POINT (IXP)

A. Presentation of IXP

Internet eXchange Point [12] [10] (IXP: Internet eXchange Point) IXP are places where the Internet operators come after agreements crossed between them, to interconnect to exchange in a economic way their traffic.

IXP have for objective to:

- Decrease the costs of the transit,
- Contribute to the development of local contents,

- Improve the quality of service.

It is while comparing the costs of strip in local with the costs of the strip in international which we can understand why the creation national IXP allows savings of cost:

| Largeur de bande | Niveau international | Niveau local |
|------------------|----------------------|--------------|
| 64 K | 1687 USD | 190 USD |
| 128 K | 2386 USD | 274 USD |
| 256 K | 3375 USD | 378 USD |
| 512 K | 4773 USD | 535 USD |
| 1 MB | 6750 USD | 757 USD |

Comparison of costs of strip in local with the international ones

The picture board above contains the results of the comparative study of the costs of the international strip and the local one in Kenya, realised by *Telkom Kenya* in December 2001. This study showed that, before the implementation of the IXP KIXP, the costs of the international connectivity were nine times superiors to the equivalent local costs. After the implementation of the IXP KIXP we attended a net reduction of these costs.

B. Mode of Functioning

Internet is an interconnection of networks which belonging to various entities distributed all around the world in particular in America, in Europe and Asia. For that purpose, these entities had to agree on the nature and the mode of functioning of this one. We then say agreement of peering for an agreement of interconnection without financial compensation. We distinguish two types of peering:

Bilateral peering: In whom every operator signs agreements of partnership with the ISP with which he wants to exchange traffic. It has the advantages to allow the free choice of the peer with which we want to exchange and also to allow each ISP to control its router of access; This can however constitute a problem because each ISP which can configure its router in an autonomous way can in a voluntary way or not prevent Certain streams to pass in transit by its network and the configuration of the router of the ISP can be very complex.

Multilateral peering: In the multilateral peering every ISP makes peering with all the others and it reduces the number of sessions of peering which must be maintained by every ISP. He so allows an automatic peering with all. The complexity is centralized to the IXP (easy for the ISP), on the other hand it forces every FAI to make a compulsory peering with the others.

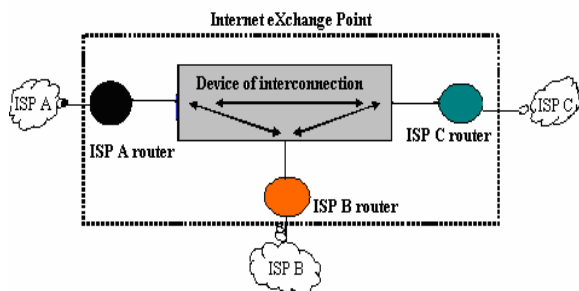


Fig. 1 Diagram of an IXP

In Fig. 1 we have three ISP who are connected to the IXP. Every ISP possesses a router which allows him to connect himself to the IXP. In the centre we have a device of interconnection (router or switch) which allows the management of the exchange of information between the various ISP. The customers of the ISP A can exchange files with the customers of the other ISP through the central device of interconnection.

The critical number of necessary ISP for the creation of an IXP is three. Indeed, if there is only two ISP, it is not necessary to create it because it is possible to make of the direct peering.

Hypothesis: let us suppose that n is the number of ISP then:

- The number of direct connections (dc) in a compound network of n ISP is:

$$dc = A_n^2 = \frac{n!}{2!(n-2)!} = \frac{n * (n-1)}{2}$$

- The number of connections in IXP ($cixp$) is $cixp = n$

NB: The mention " 0,5 ", corresponds to the fact that every ISP pays the cost of half a connection between peers.

C. Technical Solution

The architecture which we recommend is based on a bilateral peering. This freedom is indeed very important as far as she allows a ISP A, for one reasons or other one to decide to exchange with the ISP C and D and not with the ISP B. Another reason is that even if the first ones concerned by an IXP are the ISP, he can arrive that the other entities such as banks, public or private universities, decide to be interconnected by using the IXP.

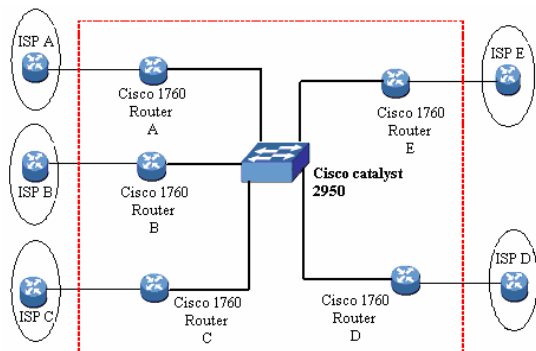


Fig. 2 Proposed solution

Every ISP pulls a connection towards the switch Cisco catalyst 2950. At the level of every border router (i.e. Cisco on 1760) will be implemented a BGP solution which allow to make bilateral peering. Where every ISP can define those with whom he wishes to exchange streams. on this plan we see effectively that a subscriber of the FAI A to correspond with a subscriber of the FAI E will not need to use the international strip and data are going to pass in transit only by two routers and a switch what already reduces the time which are going to put packages to arrive to the addressee. The reduced number of equipments also allows to apply in an effective way algorithms of reservation of resources and integration of services (RSVP [3], IntServ [1, 6]), of differentiation of service (DiffServ [7, 21, 14]), and to implement in reasonable costs much more optimal network solutions in theme of QoS (ATM, MPLS [17] ...) within the IXP.

D. IXP and QoS

One of the difficulties bound to the use of the international strip for the exchange of the local traffic is due to the fact that it slows down the exchanges and makes practically impossible the use [12] of "greedy" applications in strip. In more the too big numbers of equipment to be crossed to reach the receiver increase considerably the latent period and the risk of loss of packages.

Besides the principle of the functioning of internet in countries having no IXP, considerably decreases even cancel their efforts of improvement of quality of service. Indeed all the techniques that they will develop will have for objective the improvement of QoS in their network and thus every time they will take out of them networks they will be confronted with the problem of assigned real debit described in the introduction of [22]. The IXP by their principle of functioning allows to:

- Improve the speed of transmission because the majority of the exchanges take place in local.
- Implement new services in local (Video conference, telemedicine, Accommodation of Web sites, On-line public administration, E-commerce...).
- Cancel almost the latent periods because of the considerable reduction of the number of routers and equipments between the transmitter and the receiver.
- Also optimize the use of the international strip.

In summary, a dynamic Internet sector in local has the possibility of creating better paid jobs by appealing to higher levels of competence. The exchange of traffic at the national level favours the conception and the publishing of national contents.

IV. DISCUSSIONS

The too much expensive costs of connection in certain countries constitute a brake in the increase of their numbers of Internet users and consequently constitute a brake in the evolution of the local Internet because the various local ISP refuses to invest in the technologies of last range for fear of providing to weaken their investments for a reasonable delay. Seen the big number of countries in this situation, it is the world Internet which sees itself delayed in its evolution. Besides the disparities in the fixing of a price scale for the

international strip raise the problem of equity in the exploitation of the world Internet. To illustrate this problem we quote here Yoshio Utsumi, General Secretary of UIT: « *At the moment, the developing countries which wish to connect to the world Internet federative network have to pay in its entirety the cost of the international leased line to the country which insures the transit. More than 90 percent of the international connectivity IP passes in transit by North America. When a leased line is established, the traffic circulates in both directions and benefits the subscribers of the country of transit as well as the subscribers of developing countries, although the costs are essentially born by these last countries. These higher costs echo on the subscribers [of developing countries]. On Internet, the flows of money go from developing countries situated in the South towards countries developed situated in the North.* ». The reproduction of the number of the local and regional IXP is thus imperative for the reduction of the cost of Internet and later the cancellation of the disparity at the level of the fixing of a price scale. Indeed by creating local and regional contents these countries can constitute a pole which can claim a fairer sharing at the level of the cost of the international strip.

V. CONCLUSION

QoS remains a requirement to be taken into account in any establishment of network solution. From physical aspect to the application aspect this one is implemented by various equipments, techniques and protocols. According to the network corresponds a technique adapted to satisfy the QoS. Even if in the analysis of these techniques we see a considerable improvement of the QoS they remain techniques from start to finish intended to follow the data in them precarious routes through the knots of the network.

Nowadays Internet allows passing on multimedia data, to make of the video conference, the video surveillance, some conference call (...), but force is to notice that in certain countries, we are there still in the traditional Internet which consists in sending e-mails, in jabbering, in using in an inferior way webcams... But why it? Why this disproportion in the use of this tool? When we know that he was born and evolved in 20th century, which is in a period when almost totality of countries have their independences and thus lead their own development policies. It emerges from our analysis that the cause of this established fact is the bad use of the international strip or at least the inappropriate use of this strip which, we everyone of us know, costs very expensive.

The IXP which aim at maintaining the local traffic in local and that international in international frees in a considerable way the strip. And, we it throughout this article, they allow to improve the QoS in local and also in international (because only a reduced quantity of stream will go to the buffers of the international routers). They also allow reducing the costs of the connections, which constitute in certain countries, a brake to the development of Internet.

IXP are also a reasonable and suited solution for countries having accused a delay in the evolution of Internet. They will allow the creation of local contents, the development of new services, and new applications such as the implementation of a data centre.

REFERENCES

- [1] RFC 1633: Integrated Services in the Internet Architecture: An Overview, R. Braden, D. Clark, S. Shenker, 1994.
- [2] RFC 1889: RTP: A Transport Protocol for Real-Time Applications H. Schulzrinne, S. Casner, R. Frederick, V. Jacobson, 1996.
- [3] RFC 2205: Resource ReSerVation Protocol (RSVP) -- Version 1 Functional Specification, R. Braden, Ed., L. Zhang, S. Berson, S. Herzog, S. Jamin 1997.
- [4] RFC 2211: Specification of the controlled load Network element Service Wroclawski 1997.
- [5] RFC 2212: Specification of Guaranteed Quality of Service. Shenker, C. Partridge, R. Guerin 1997.
- [6] RFC 2215: General Characterization Parameters for Integrated Service Network Elements. S. Shenker, J. Wroclawski 1997.
- [7] RFC 2474: Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers. K. Nichols, S. Blake, F. Baker, D. Black 1998.
- [8] Halfway Proposition, <http://www.afrispa.org/Initiatives.htm>
- [9] Routing in the Internet John W. Stewart III, BGP4 Inter- Domain, jstewart@juniper.net
- [10] Association Africaine des Fournisseurs de services Internet, <http://www.afrispa.org/>
- [11] BGP Case Studies Document ID: 26634 [en ligne], <http://www.cisco.com/warp/public/459/bgp-toc.html>
- [12] Via l'Afrique: Création de point d'échange Internet (IXP) locaux et régionaux en vue de réaliser des économies en termes financiers et de largeur de bande. Russel Southwood, Union International des Télécommunications, CRDI 2004.
- [13] Enic-TELECOM: Historique de la QoS http://wapiti.enic.fr/commun/ens/peda/options/ST/RIO/pub/exposes/exp_osesrio2004ttnfa05/MalygaSokowicz/partie1.htm
- [14] Université Paul Sabatier (Toulouse III) Le modèle DiffServ, André Aoun 2001 <http://www.httr.ups-tlse.fr/pedagogie/cours/tcp-ip/diffserv/index.html>
- [15] Introduction à la problématique des Réseaux avec QoS - Plan et Contexte <http://rangiroa.essi.fr/cours/reseau2/02-IREQoS2002-a.pdf> Eric Gressier-Soudan 2002.
- [16] Réseaux IP et Qualité de Service <http://www.supinfo-projects.com/fr/2003/ip%5Fnetworks%5Fqos> Alan TRANCART Ingénieur Supinfo Paris Promotion SUPINFO 2003.
- [17] Tout sur MPLS, <http://www.frameip.com/mppls> Benbella Benduduh et Jean Marc Fourcade, création du document 2001.
- [18] La qualité de service dans l'Internet, Laurent Toutain, Jean Marie Bonnin, Octavio Medina, ENST Bretagne - Campus de Rennes, BP 78 - 35 512 Cesson Sévigné Cedex.
- [19] V. Jacobson, *Congestion avoidance and control*, Proceeding of the ACM SIGCOMM, août 1988.
- [20] RFC 2581, M. Allman, V. Paxson, W. Stevens, *TCP Congestion Control*. Avril 1999.
- [21] Dimensionnement de DiffServ basé sur des métriques de performance Ibrahima Niang - Dominique Seret, Université Paris 5, René Descartes UFR de Mathématiques et Informatique.
- [22] Les principes d'équité appliqués aux réseaux de télécommunications Corrine Touati, Université de Nice Sophia-Antipolis, 2003.
- [23] Traffic Management Specification, Natalie Giroux 1996.
- [24] A Mathematical Framework for Designing a Low-Loss, Low-Delay Internet. Network and Spatial Economics. Steven H. Low et Rayadurgam Srikant. 2003.
- [25] The bargaining problem Econometrics, John F. Nash Jr 1950.
- [26] A game theoretic framework for bandwidth allocation and pricing in broadband networks. Haikel Yaiche, Ravi R. Mazumdar, and Catherine Rosenberg 2000.
- [27] Fairness in network optimal flow control: optimality of product forms. Ravi Mazumdar, Lorne G. Mason, and Christos Douligeris 1991.