Quality of Services over Radio Link for naval communications : a Diffserv model approach

by
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Abstract: in fine quality of service (QoS) experienced by the users on end to end marine communications using radio links results from networks' level QoS and the quality of Hertzian connections in particular in the ranges HF and UHF.
Numerous studies concern QoS for radio links, and such QoS depends heavily on hardware and transmission characteristics. In this paper we shall propose QoS approachs on the infrastructures networks' level, of type Diffserv.

We will distinguish three kinds of architectures for naval communications, namely ship to ship, ships to shore, and ship to ship using on shore infrastructures networks. The distinction of the data flows ship/ship and ship/shore imposes the QoS model of type Diffserv, which must be adapted according to the chosen architectures of communications.

Our architectures have been implemented in the RIFAN2 naval communication system, the new french navy standard.

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1. Introduction.

The use of the satellite resources to make communications between users being very expensive and the resources not being unlimited, it becomes sensible to use radio links. However, the quality of the communications between users by the radio links is not the same as the one from satellite links. Radio QoS relies in fact on two quality criteria, first of all the QoS for data flows or applications, and secondly, the QoS of the radio link (radio equipment and propagation). These two concepts can be abstracted by the following scheme:

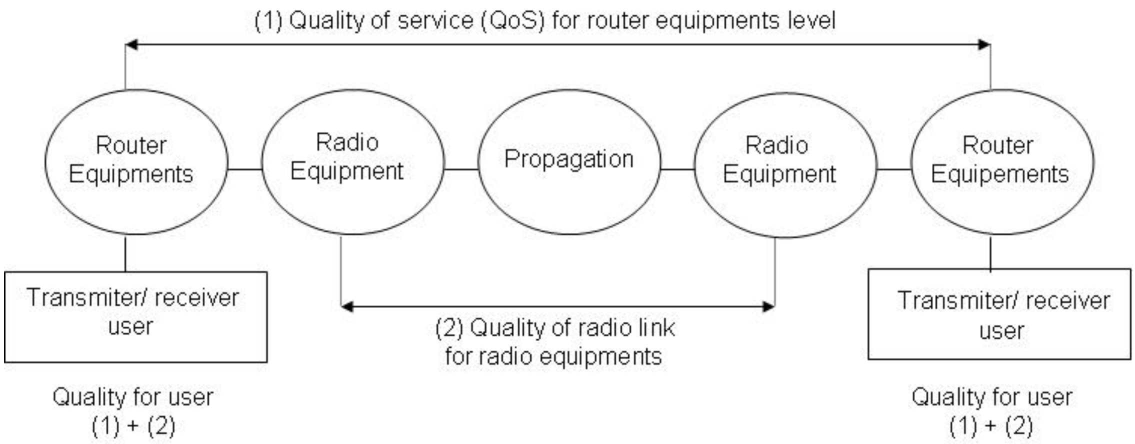

Figure 1. QoS for radio links

End users' applications such as multimedia and transmissions such as tactical data require bandwidth but are sensible to end to end QoS [1]. On board data flows generated by the various applications do not need the same bandwidth, the same latency, the same rate of error: these are parameters that help quantify the QoS [1] [2]. In order to integrate this variability, one uses QoS management methods to prioritize IP packets.

These management methods arise from the Internet world where they are known as for example "Best effort", "Intserv" or "Diffserv". Let us describe these three:

- « Best effort ». It is not really a model of services, it is only the basic principle of the IP protocol, handling without granting quality of service, the connectivity between applications; one could summarize the effect of the "best effort" model as follows: "deliver packages to destination".
- « Intserv » (Integrated Service) model [3]. The model Intserv is an architecture (from 1997) which takes into account the QoS and which uses the protocol RSVP (Resource Reservation Protocol) defined by the RFC # 2205 and 2216, the purpose of this model is to grant a service.
- The « Diffserv » (Differentiated Services) model [4]. This model as indicates it's name, allows to differentiate between the flows, a mechanism which is essential for the marking process. This process occurs at the entrance of the network (Diffserv domain), through the Ingress or Edge router for the marking flows strictly speaking, and through the Core router of the domain for the treatment of packets.

As regards the radio system, the quality of the connection depends essentially on the quality of transmitter-receiver equipments, and also the quality of the propagation, the calculation of link capacity allows to plan if the radio links are acceptable.

So two main conditions are necessary for a smooth running, one linked to the quality of the radio transmission, the other linked to the good transmission of the IP packets of the various applications; according to the type of application there will be in the later case quality request of different services. The choice of the QoS method results as a compromise between quality of services and qualities of the radio link.

In this paper, we shall limit our presentation to the network's QoS, and present the "Diffserv" model. To this end, we will first setup a few definitions. Then we define the problems to overcome with the QoS. We will present some networks' architectures, and finally develop on the "Diffserv" model.

2. Some definitions.

QoS is very difficult to define, as shows the numerous definitions the organisation which standardizes the concepts of transmission networks proposes. Here are a few.

Definition from the ISO et ITU-T [ISO/CEI 13236 - X.641 ; December 1997].

“One understands here by the general expression QoS a structured set of interdependent concepts describing the quality of services, and allowing to describe by standardized means, the subdivisions between the different QoS relevant subjects in the domain of information technology, as the correlations between these subjects. This general QoS Framework is among other things designed for systems using information technology and their use towards providing stream open treatment services.” [5]

Definition from IETF.

“The Quality of Service indicates the way the service of packets delivery of is supplied, which is described by parameters such as the bandwidth, the delay of delivery for packets and the rate of loss of packets”.

“Quality-of-Service (QoS): A set of service requirements to be met by the network while transporting a flow”, (RFC 2386 glossary). [6]

Definition from CCITT [recommendation I 350 on 11/88]

“QoS is defined in Recommendation G.106 (*Red Book*) as follows: “Collective effect of a service's performances which determines the degree of satisfaction of a service's user”.

The Quality of Service corresponds to the general effect of the performance of a service which determines the satisfaction degree of its users. [7]

3. QoS concerns.

We notice that there are several definitions associated with the QoS. We need a definition appropriate to our study. To this end, let us describe a little bit more our needs.

From the definitions, let us retain that QoS is the capacity of the system to attribute a quality notion to the data flow which crosses it in order to satisfy the needs of the users, the most trivial example being the data transmission without packets loss.

The rate of packets loss is one criteria to be taken for the quality of the service provided.

In deduction of this definition, we see that it is necessary to characterize the flows which go through the system, the system consisting among others of radio links radios; the flow identification is thus an element to keep also.

The third element is the classification of the flows according to the users' needs.

The characterization of flows thus consists of the identification and the classification of the flows which cross the system.

- ***Users and operators Relationship.***

The characterization of flows is very different depending on if we are on the user's side or on the operator's side of the system. The vision of the user is the expression of its needs because he knows the application which will cross the system, there will be multimedia application, textual among others, the user has quality requirements for data transmission.

In a general way, the expression of the needs for the users are not totally considered by the operators of the systems, indeed the translation of users needs in technical and measurable criteria for the system is not always possible, however most of the users' requirements can be translated to measurable criteria of QoS.

As shows it the board below, we translate the users and the operators criteria.

Criteria	User view	Operator view
Capacity	Application debit	Bandwith average debit
Délay	Response time transmission duration	Latency Jitter Propagation duration
Reliability	Errors in messages	Lost/Dropped packet rate Bit error rate
Availability	Unavailability of the services Accessibility of the services Restoring of the services	Rate of break of the services Rate of rejection of packets

Figure 2. User/operator criteria

As can be observed, there exists a correlation between the needs for the user in the form of requirements and the qualities of services offered by the operator of the system. This correlation will be generically called "Service contract", a notion sometimes met as "Level

Agreement service" (SLA). SLAs are contracts which concern users and the operators on quality criteria of services for the users' application, measurable by the operator of the system.

4. Identification of flows.

We can distinguish two classes of flows:

- So-called "elastic" flows, than can adapt to network conditions. For such, QoS criteria are not very high (as for instance in the bandwidth case, they require no limitation);
- The "non-elastic" flows, which do not tolerate on some aspects of the network state (such as minimal bandwidth, maximum answer delay, latency criteria...).

5. The main QoS criteria.

Standard QoS criteria are as follows [8]:

- Delay :
    - Jitter.
    - Latency.
- Lost/Dropped packets rate.
- Out of order delivery.
- Link quality :
    - Bit Error Rate : BER.

We give here some definitions for these criteria:

The bandwidth or maximum debit of a link is the maximum volume of data which can go through the communication system. To measure the bandwidth one can use the Iperf / Jperf software.

The delay or the propagation delay is the time a packet sent by a transmitter takes to reach its destination, taking into account the radio transmission.

Besides the radio parameters, two other parameters of network will have to be considered in order to estimate the delay: the latency and the jitter.

The latency is the variation of the delay of IP packets transfer from end to end of a packet.
The measure of the latency can be made in the following way: packets are sent with fixed duration and path between a source and a destination. We measure the crossing time of each packet. Time measures use the local clocks of the equipments. To measure the latency we can use the Iperf / Jperf software or wireshark [9], [10].

The jitter is the variation of the latency through time. To measure the jitter we can still use the Iperf / Jperf software or SJitter [10].

Jitter can appear under several forms, we give a non exhaustive list.

- Jitter of insertion :
  - Delay of data grouping.

- Jitter of multiplexing :
  - Policy of packets scheduling of the various flows.

- Jitter of load :
  - The network delays depend on its load.

- Jitter of routing:
  - Re routing of packets in the network.

The jitter is strongly bound to the QoS mechanisms.

Lost /dropped packets: relates to the simple loss of one or several packets. To measure the loss of packets we shall use the basic tool of the IP protocol IP, the Ping command, so we test the network's connectivity by the same way.

Here are a few values to consider for a quality network:

On a local area network: latency < 10 ms, Jitter < 5 ms, Loss < 0.5 %,
On a Wan network: latency < 40 ms, Jitter < 10 ms, Loss < 1 %,
On the Internet (or VPN on the Internet): latency < 100 ms, Jitter < 30 ms, Loss < 2 %,

6. The level services models.

QoS criteria are strongly related to the flows and relatively independent from the equipments which they cross. We now need to connect these flow characteristics to the transmission system's architecture, using processes called models.

In the present state of the technology, three models of services are defines by IETF (Internet Engineering Task Force).

- «Best effort» model,
- « Intserv» model,
- «Diffserv» model.

Our study will take into account essentially the Diffserv model. Since this model introduces the notion of domain, we will introduce three types of network architectures for naval telecommunications.

7. Network Architectures.

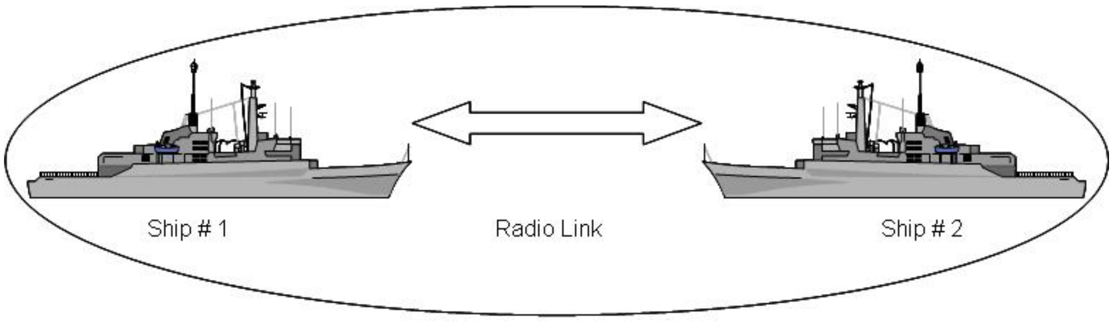

Figure 3. Architecture # 1: between two ships.

This topology allows two ships to use radio links for data transfers without using the satellite resources, however with an equivalent quality of service.

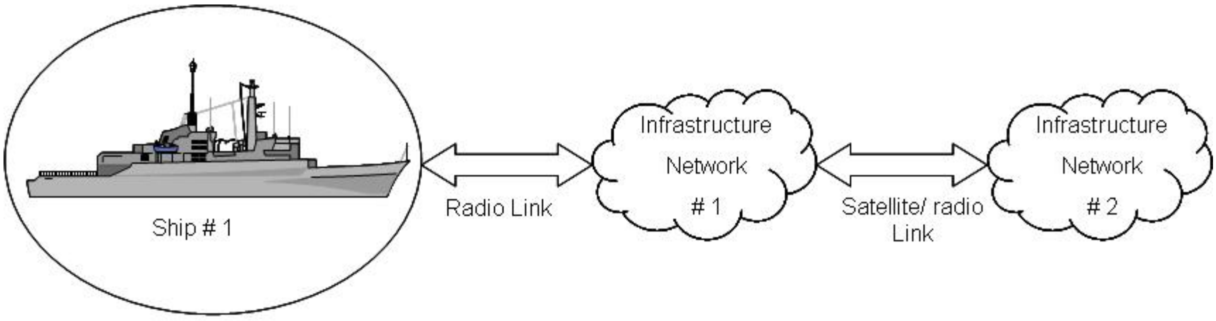

Figure 4. Architecture # 2 : between one ship and the infrastructure network.

This topology allows the ship to communicate with networks of infrastructure on shore, the quality of service must be considered end to end, we speak about end to end QoS.

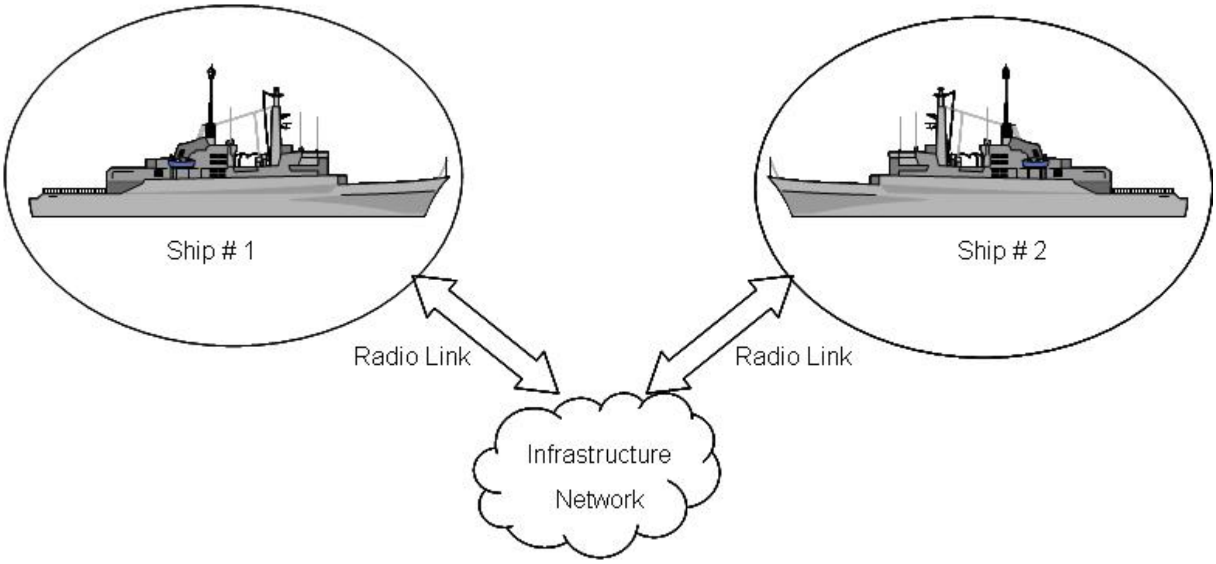

Figure 5. Architecture # 3 : between two ships through the infrastructure networks.

This topology allows one ship, in one geographical zone, to communicate with another ship in another zone, we cross one or several networks of infrastructures on the shore side, the QoS has to be the same on the end to end connection.

8. The Diffserv model.

The model as its name indicates it, allows to differentiate flows, a mechanism which is essential is the process of marking packets. This process is performed at the network's entrance (or Diffserv domain), marking through the Ingress/Edge routers, processing the flows through the internal or Core routers of the domain (PHB: Per Hop Behaviour) after marking the "DSCP“ field of the packets.
The principle of propagation of this model in a Diffserv domain (DS) is:

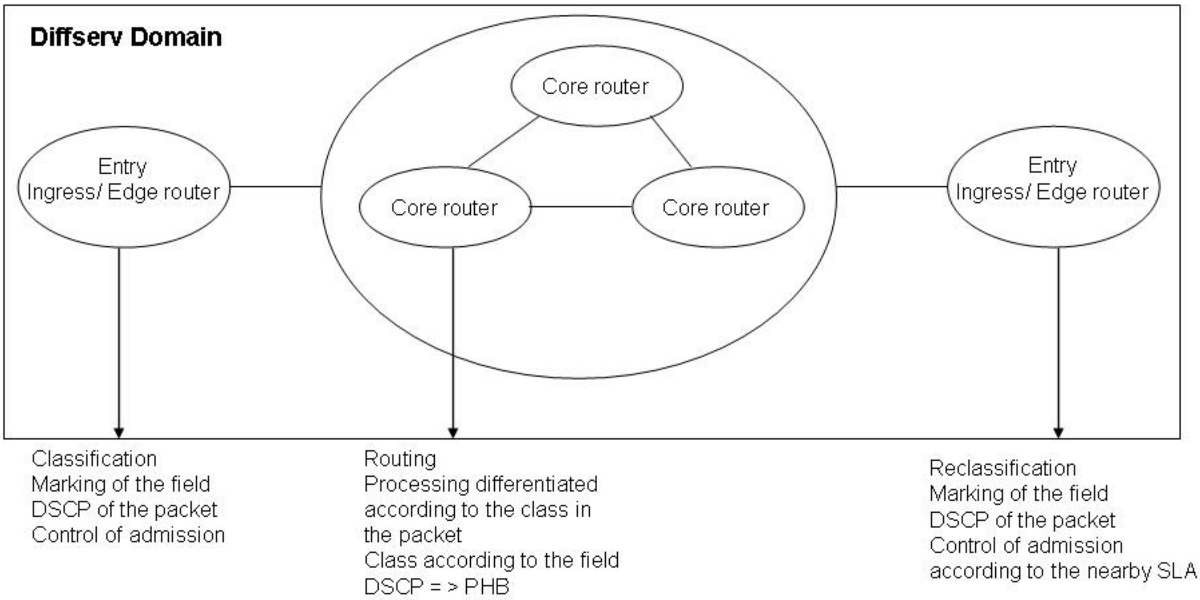

Figure 6. Diffserv domain.

Let us apply the notion of domain to three network architectures which we have:

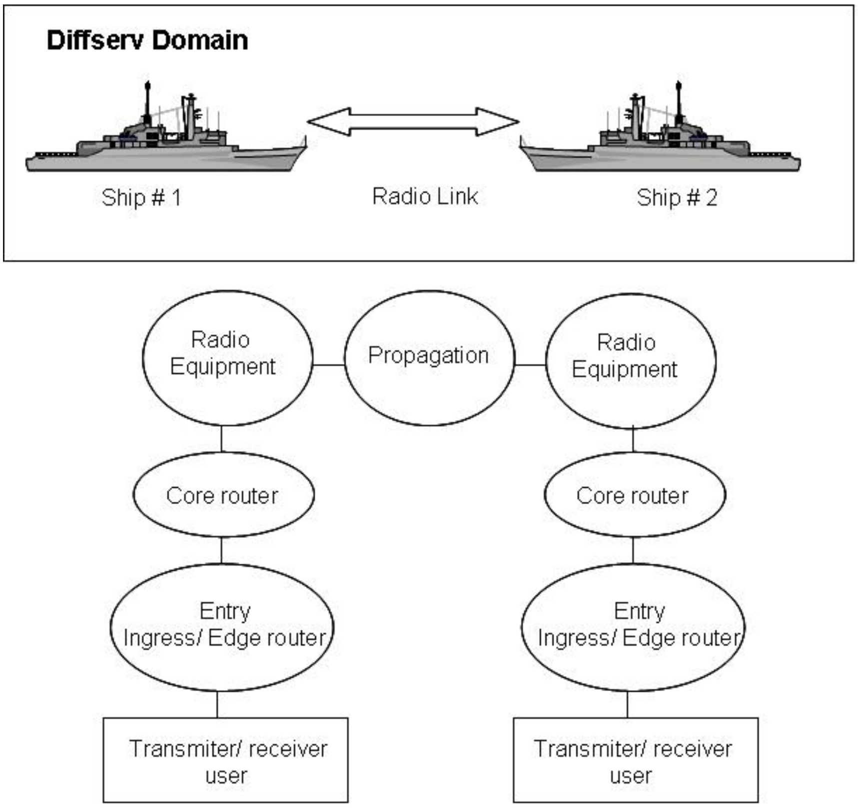

Figure 7. Architecture # 1 and Diffserv Model

In this architecture, the ships are in the same Diffserv domain.

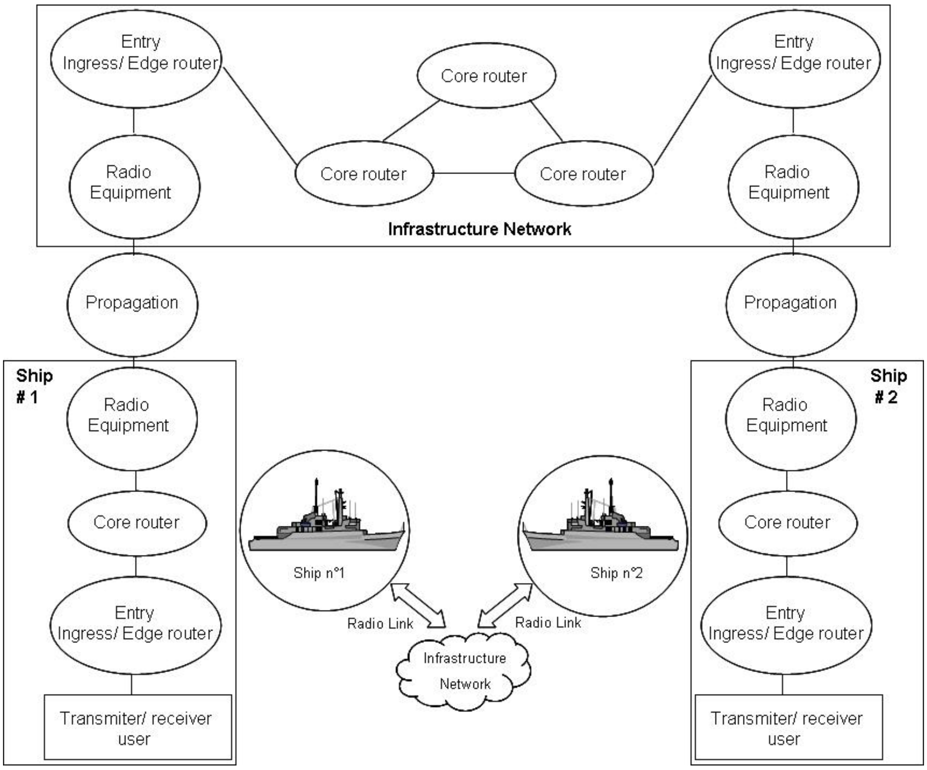

Figure 8. Architecture # 2 and Diffserv Model with tree domains DS

In this architecture, we can consider that we have three Diffserv domains, but if we remove Ingress/Edge routers we can obtain a single Diffserv domain as shows the architecture below:

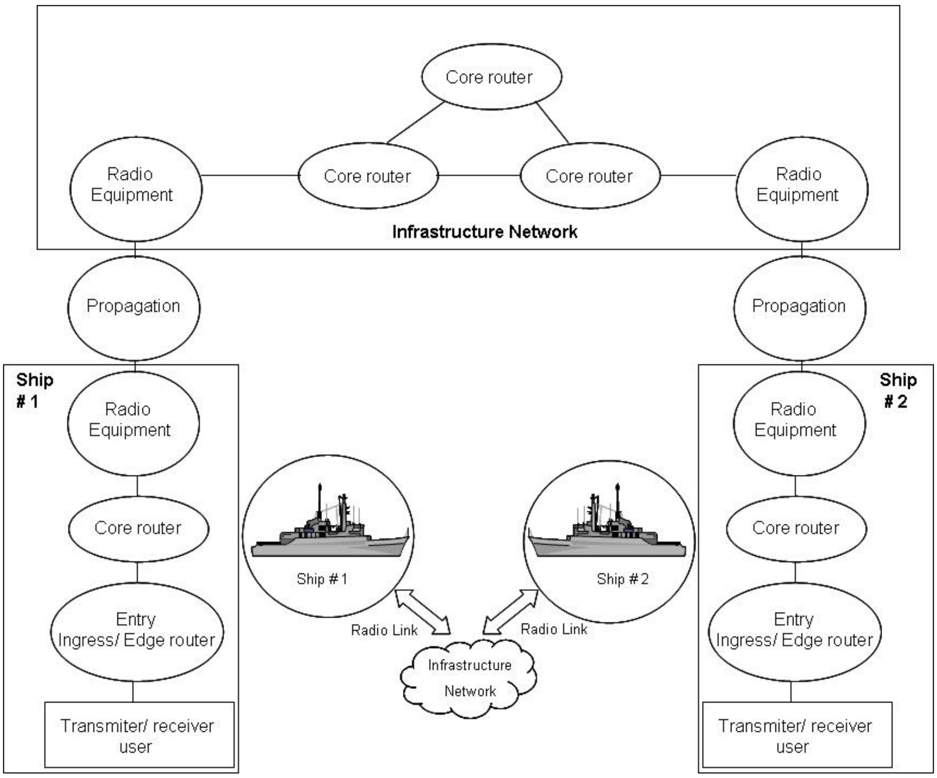

Figure 9. Architecture # 2 and Diffserv Model with one domain DS

In this architecture, three entities are in the same Diffserv domain which allows avoiding successive markings of IP packets.

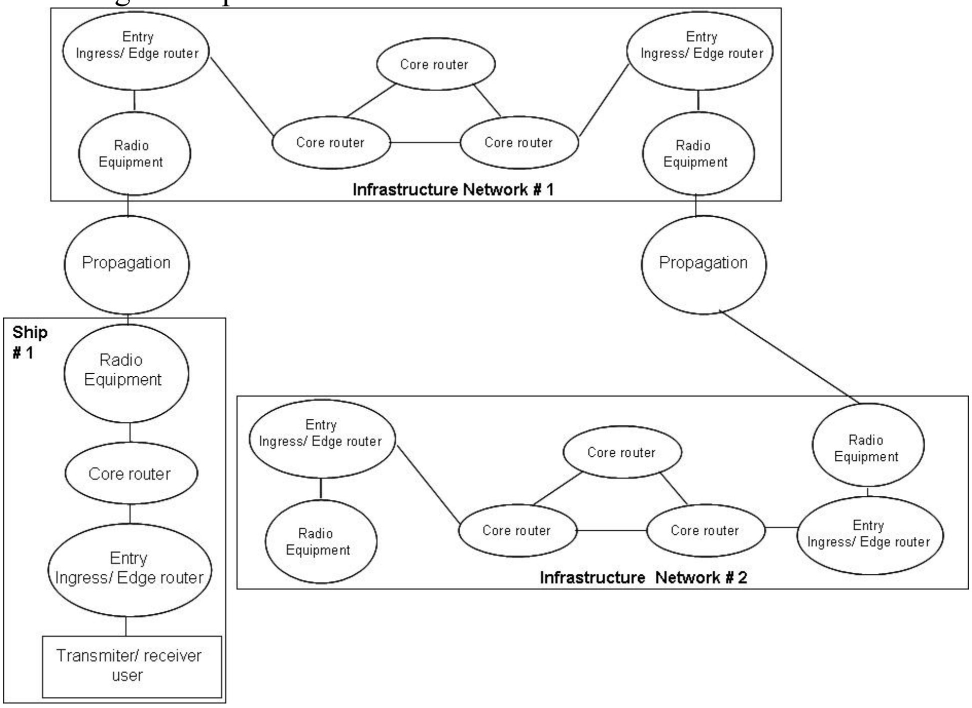

Figure 10. Architecture # 3 and Diffserv Model with tree domains DS.

In this architecture, we have three Diffserv domains; however by removing the Ingress/Edge routers at the level of the network of infrastructure, we obtain a single Diffserv domain as shows the architecture below.

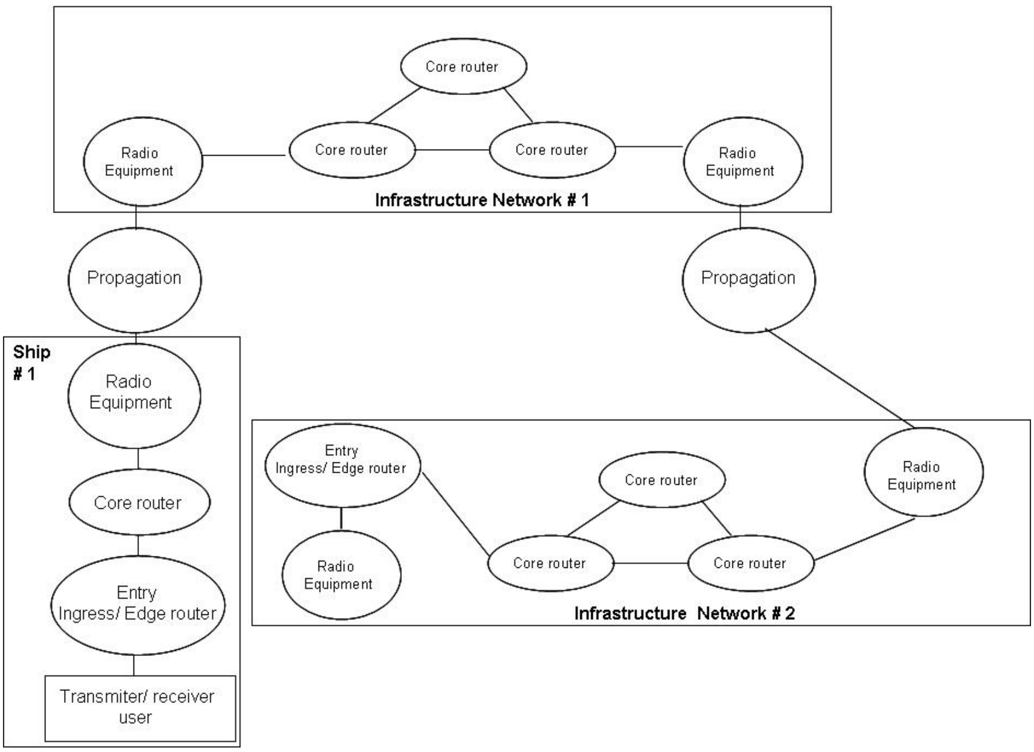

Figure 11. Architecture # 3 and Diffserv Model with one domain DS.

9. Functional architectures of Diffserv routers.

We summarize here the functional architectures of both sorts of routers in a Diffserv domain.

The border routers (Ingress/Edge Router) [11] will have the following structure:

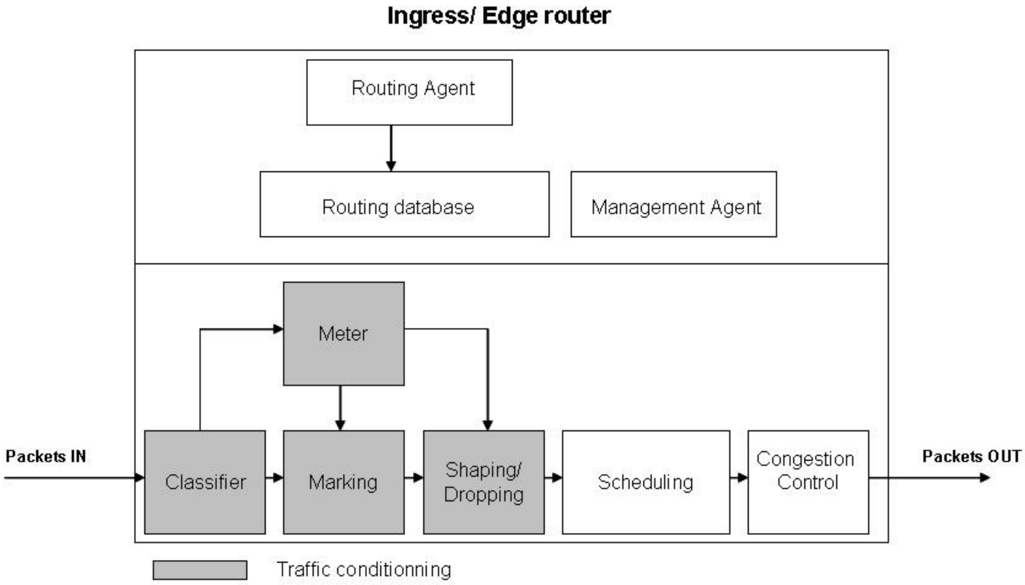

Figure 12. Elements of Ingress/Edge Router.

The Traffic conditionning [12] consists of the following processes:

- *classification*: the incoming packets are sorted in their corresponding class;
- *marking*: every packet will receive a PHB or a processing for packet at the level of the internal routers or Core Router according to the membership class. This marking is made with the field DSCP (DS Codes Point) of the IP packet (TOS field (Type Of Service) for IPV4 and Traffic Class field Traffic for IPV6) [13]. The value of the marking corresponds to a processing of the packet or PHB (Per Hop Behaviour) [14];
- *shaping/dropping*: checks if the flow of packets is in compliance with the properties of the traffic which was established.

The internal routers or Core router [15] will have the following structure:

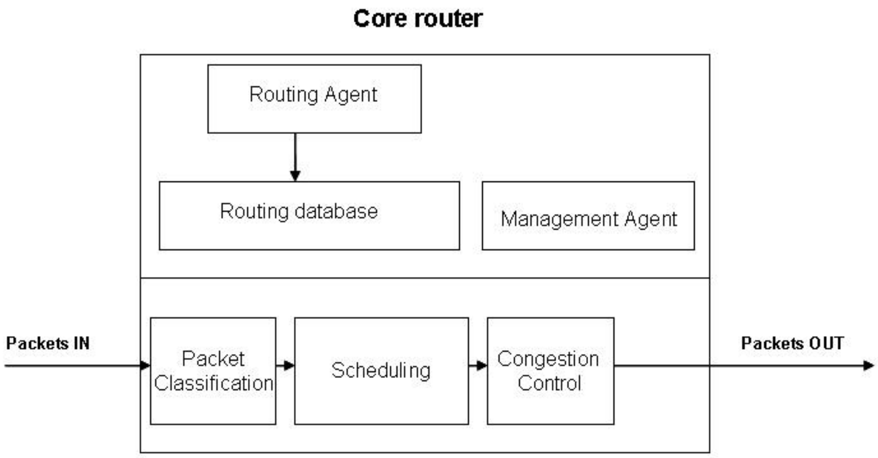

Figure 13. Element of Core Router.

The processes are the following ones:

- *classification*: makes the processing of packets according to the PHB from routers of border (Ingress Edge routers);
- *scheduling*: consists in putting packages in queue according to the classes of processing of packet at the outgoing interfaces of the router;
- *congestion control*: allows to reject packets as soon as there is a congestion of traffic.

The border router (Ingress/Edge router) performs important processes in the Diffserv model and thus can be slowed down according to the traffics which cross them, in the case of transmission by radio way with restricted debits, we can observe a flow congestion.

10. Adaptation of the Diffserv model over radio link.

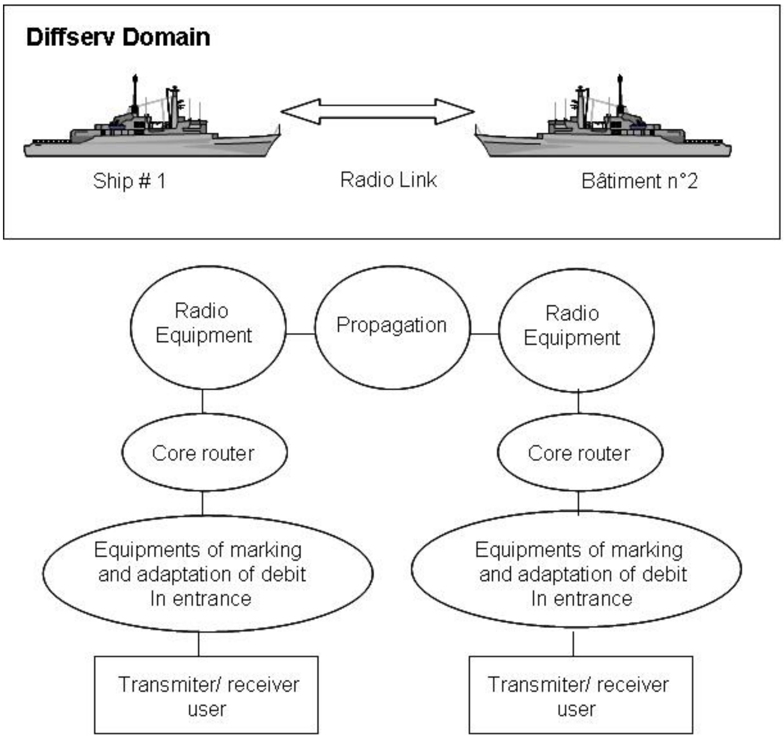

Figure 14. Adaptation of Diffserv model.

We shall replace the border routers (Ingress/Edge route) by equipments which mark the packages in entrance, and we add a function of adaptation to the transmission media, radio in our case, whether it is in range V / UHF [16] or HF [17] in particular.

There will be no routing function in these equipments, this routing can be operated by routers outside of Diffserv domain, and the internal routers can have the protocol of routing BGP (Border Gateway Protocol) [18].

11. Conclusion.

In the three architectures we have presented, the QoS model Diffserv allows to distinguish the various flows which cross on one or several ships to the shore side, however if we use radio links with restricted debits, it is necessary to make an adaptation at the level of the network.

Lot of equipments, as in particular probes, allow marking the flows in order to format them to the QoS models' processes, but also they adapt the traffic to the media of transmission.

QoS of communications between ships and the networks of infrastructures on the shore side, which we can call end to end QoS, becomes a more and more important subject, and complexifies when considering various qualities of radio links.

Furthermore the end to end QoS must consider also various quality models of service such as Diffserv and Intserv [19] [20].

For an historical overview and description of latest naval communications models, we reffer the reader to [21].

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