

DiffServ in the Aeronautic Telecommunication Network (ATN) QoS

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Introduction

- ◆ **Along with the rapid expansion of global civil aviation, the current architecture cannot meet the requirement of the aviation communication.**
- ◆ **The Aeronautical Telecommunications Network (ATN) has been developed by the International Civil Aviation Organization (ICAO) as a strategy for integrating Air/Ground and Ground/Ground data communications networks into a global Internet serving Air Traffic Control and Aeronautical Operational Communications.**

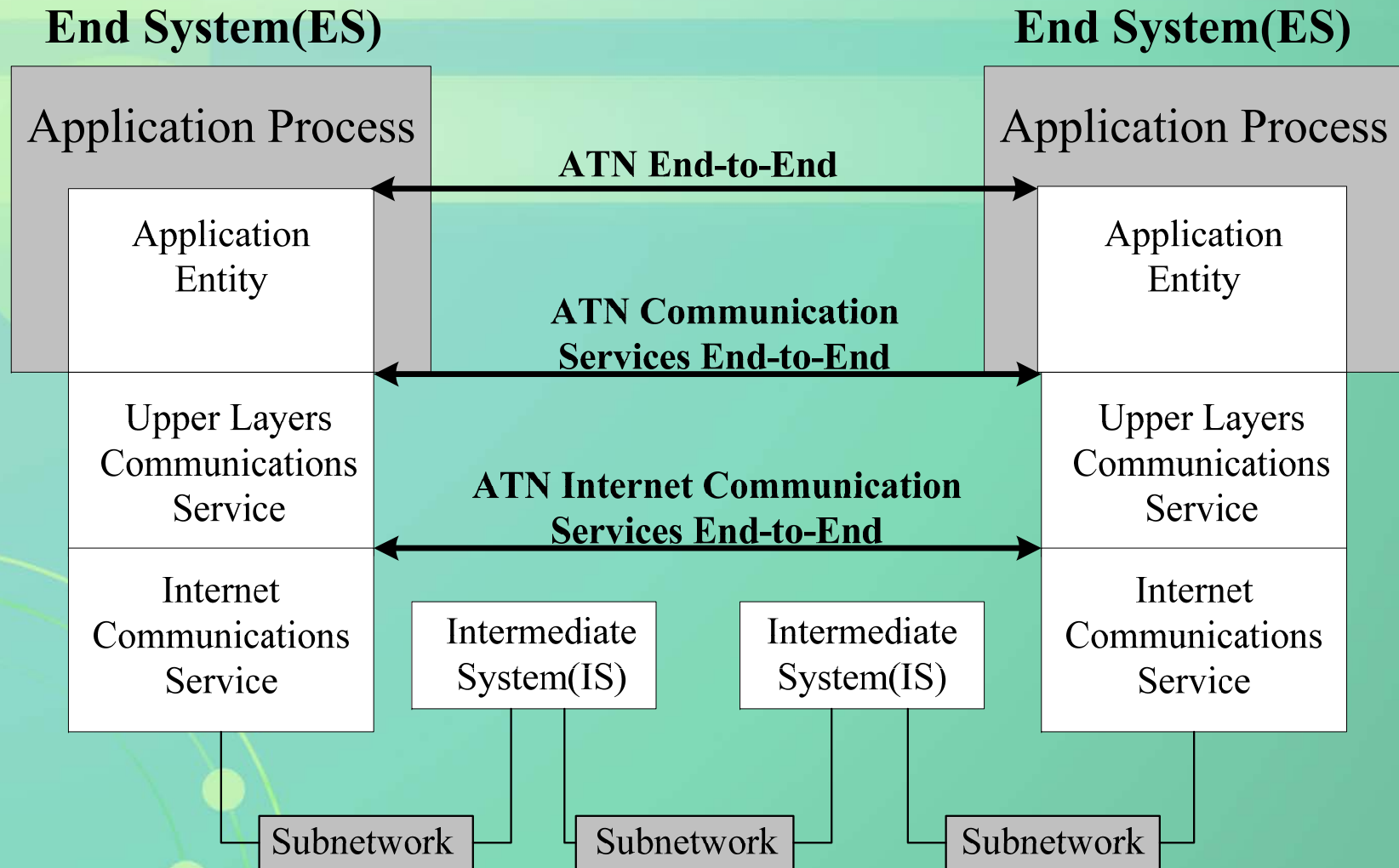
Introduction

- ◆ **ATN is not a new communication network by new communication rules, but a network integrating lots of data sub-networks to achieve uniform transmission.**
- ◆ **ATN network can also aim at the different service demand, and provides the different data transmission service.**
- ◆ **The ATN QoS guarantees to provide the redundant reliability, the high performance, and the high security.**

The ATN Architecture

- ◆ **At the beginning of the ICAO making standard, the technology of TCP/IP was not progressing completely .**
- ◆ **Compared to TCP/IP, the architecture of the OSI can perfectly meet the request of the ATN, and its clear concept and explicit levels are identically favored by the people.**
- ◆ **The OSI 7-lay reference model is defined as the architecture of the ATN protocol.**

The ATN Architecture



Conceptual model of the ATN

The ATN Architecture

- ◆ **The ATN is made up of three parts, that is, subnetwork partitions, intermediate systems (IS) and end systems (ES).**
- ◆ **End Systems are similar to Hosts, and Intermediate Systems are similar to Routers in the TCP/IP protocol.**

The ATN Architecture -- Subnetwork

- ◆ **The subnetwork is part of the whole communication network, and transmits information between systems in the ATN.**
- ◆ **The Subnetwork is divided into mobile data network which represents air-to-ground data subnetwork and fixed data network which represents the ground-to-ground data subnetwork and aviation electronic equipment subnetwork at their operating attribute.**

The ATN Architecture--IS

- ◆ **The router in the ATN is called Intermediate System (IS) which consists of reference model lower three layers.**
- ◆ **Since the airplane is the mobile node and the routes are changeable through the network, the ATN should support dynamic router process.**

The ATN Architecture--ES

- ◆ **The ATN End System(ES) can communicate with another end system to carry out applications which are needed in the end-to-end communication service.**
- ◆ **The ATN ES contains the complete seven-layer protocol and has the proper communication service.**
- ◆ **The ATN ES is also the interface to the auto-control system and the host computer.**

The ATN QoS

- ◆ **Different aviation users are different to grades of service's request, like some user request transmission timeliness, in some request transmission low drop probability and so on.**
- ◆ **The aviation telecommunication network should be able to provide the QoS service for the aviation users, satisfying various the requests of users.**

The ATN QoS--Priority

- ◆ In the ATN, the height of QoS request generally depends on the user transmission data precedence.
- ◆ Users of the high priority need high grade services, and users of the low precedence need the general quality service to be possible.
- ◆ The purpose of the priority is to point out the comparatively importance and precedence. Therefore it is an explicit index when data should be in prior transmitted and competitively share resource.

The ATN QoS

- ◆ **The ATN QoS should base on the importance of the transmitting stream providing different services, which are carried out by lifting the stream priority and limiting other stream priorities.**
- ◆ **If users would like to access the potential regular service from the ATN, it is necessary to assess its performance characteristics such as security, reliability, availability, integrity and so on.**

The ATN QoS

- ◆ **Along with aviation industry's fast development, ISO OSI seven-layer reference model gradually does not adapt with the ATN requirement. Especially it lacks in QoS.**
- ◆ **The new edition's IP technology, IPv6, happens to be able to solve these problems.**
- ◆ **The IP QoS is proposed to brought into the ATN to implement the ATN QoS.**
- ◆ **There are mainly three problems of priority, congestion control and security in the ATN QoS.**

ATN over DiffServ

- ◆ **The Internet Engineering Task Force (IETF) has proposed the IntServ and DiffServ architecture to implement IP QoS.**
- ◆ **For the IntServ, it is necessary to reserve resource for each data stream and keep the resource reservation at the each hop, a lot of information is reversed.**
- ◆ **The information is direct ration to the number of the grouping queue, which leads its hard expansibility and realization at the backbone network.**

ATN over DiffServ--DiffServ

- ◆ **The DiffServ architecture is based on a simple model where traffic entering a network is classified and possibly conditioned at the boundaries of the network, and assigned to different behavior aggregates.**
- ◆ **So far the concept and the model of DiffServ have fairly developed.**

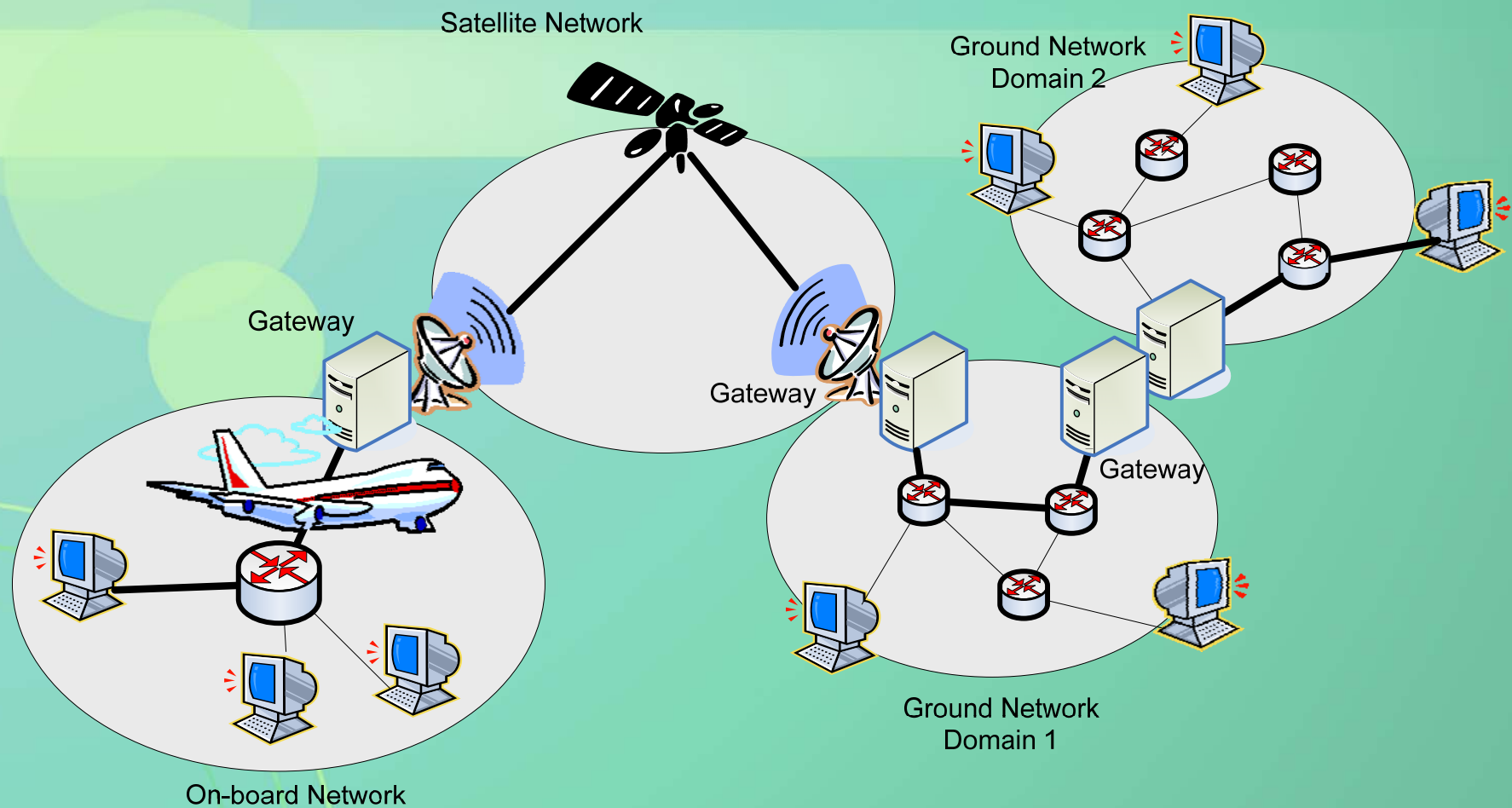
ATN over DiffServ--DiffServ

- ◆ **The IETF has defined different standard aggregates which are Expedited Forwarding (EF), Assured Forwarding (AF) and Best Effort (BE).**
- ◆ **The core router provides different transmission services with customers by the DiffServ Code Point bits (DSCP) in the Type of Service (ToS) IP header field.**

ATN over DiffServ--DiffServ

- ◆ **The DiffServ predigests signaling and classifies the thick granularity of the operational stream by aggregation and PHB.**
- ◆ **PHB is an externally description of the special stream aggregating behavior at a Differentiated Service (DS) node.**
- ◆ **DiffServ regions which consist of the sequential DS regions can support different PHB groups inside.**

ATN over DiffServ

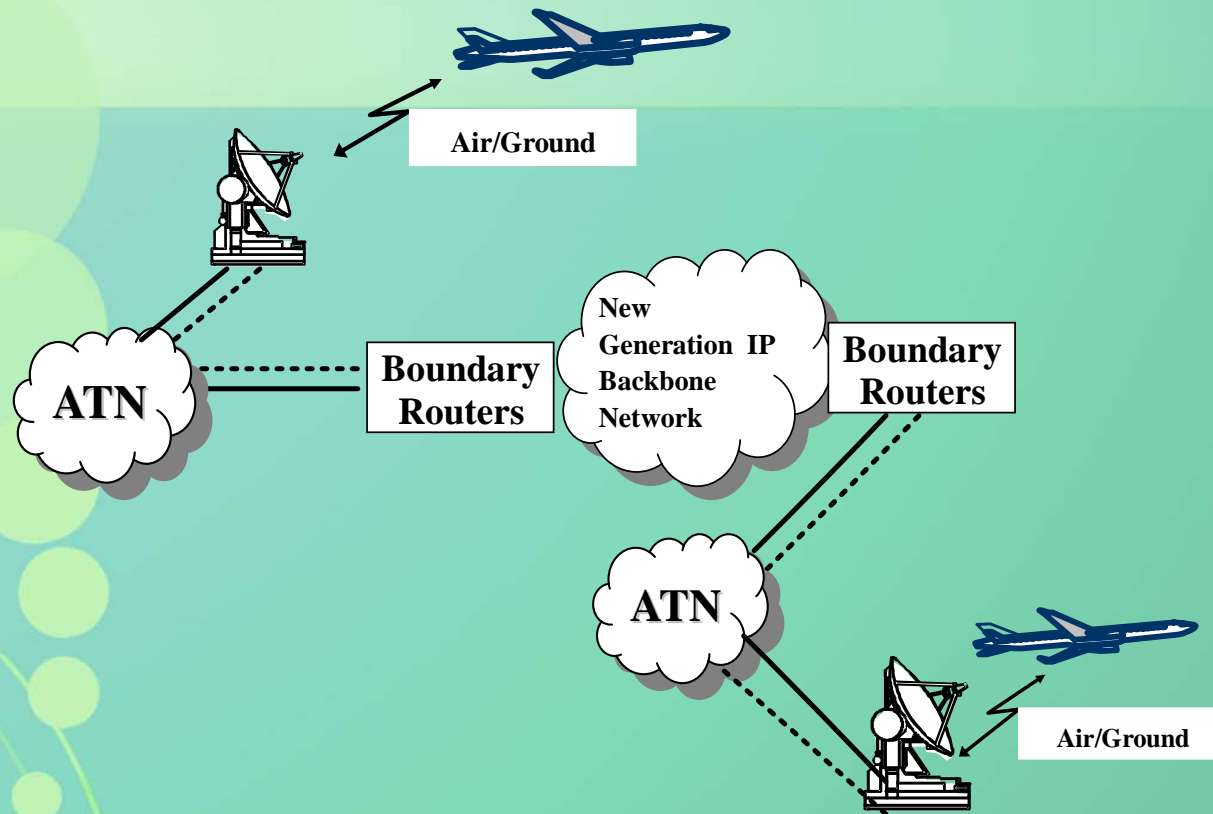


Network interworking scenario

ATN over DiffServ

- ◆ **This example shows the interconnection via a satellite network but the same principle applies to all kinds of A/G communication networks.**
- ◆ **It is clear that a service running in an end system on-board the aircraft wants to communicate with a correspondent end system in the ground network domain.**
- ◆ **The different network portions may all implement different protocols and QoS solutions.**

ATN over DiffServ

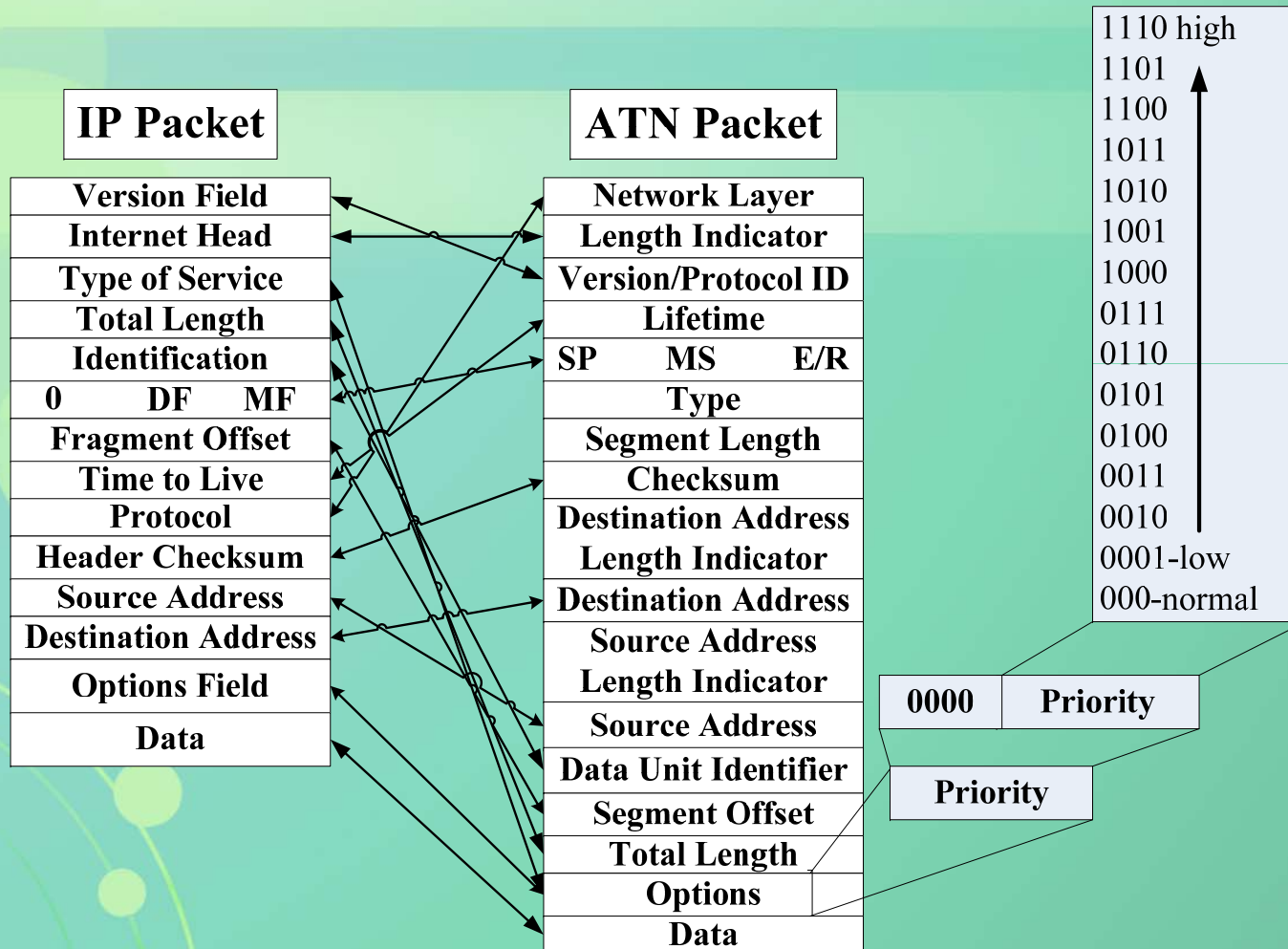


ATN over DiffServ Model

ATN over DiffServ

- ◆ During realization of the mapping, the main difficult is how to harmonize PHB of data packets transmitted by the backbone network routes to the requiring QoS in the ATN.
- ◆ It is explicit that the IP packet is similar to the ATN packet in the construct as the following graph.

ATN over DiffServ



Mapping Function of Packets

ATN over DiffServ

- ◆ It is certain that IP packets and ATN packets have similar partitions.
- ◆ The ATN QoS parameters of data packets are similarly mapped to the corresponding DSCP of IP packets which are TOS segments in the IPv4 or COS segments in the IPv6.
- ◆ The routers at the backbone networks read the DSCP values of the packets which correspond to PHBs and adopt different queue management algorithms which are depended on the various PHBs of packets.

ATN over DiffServ

Example of DSCP to PHB mapping

DSCP Value	PHB	Application
000000	CS0	Best effort
001000	CS1	
001010	AF11	AIDC
001100	AF12	
001110	AF13	
010000	CS2	CM
010010	AF21	ATSMHS
011000	CS3	FIS
011010	AF31	Voice Recording
011100	AF32	

011110	AF33	
100000	CS4	CPDLC,ADS-C
100010	AF41	Voice Signalling
100100	AF42	
100110	AF43	
101000	CS5	
101110	EF	Voice
110000	NC1/CS6	
111000	NC2/CS7	

ATN over DiffServ

- ◆ As each ATN application is mapped to a given Class of Service (CoS) and the dynamic support of different priorities per user is not considered, every application has its own corresponding DSCP values and PHB to carry out intended service.
- ◆ It is an example of mapping DSCP values to PHBs where a number of applications share the same IP network infrastructure.
- ◆ This mapping must be configurable and Administrative Domains may choose different values when mapping codepoints to PHBs.

The DiffServ AQM

- ◆ **The IETF has proposed the deployment of active queue management (AQM) mechanism at gateways to improve the performance of the congestion control.**
- ◆ **The common use of the AQM is Randomly Early Detection (RED).**
- ◆ **The ICAO recommends the control DiffServ congestion algorithm is RED with IN and OUT (RIO).**

The DiffServ AQM

- ◆ **The sending rate is larger than receiving rate in the EF queue, it is rare that it loses data packets.**
- ◆ **While the sending rate is smaller than the receiving rate in the AF queue and the BE queue, it is frequent that congestions and losing packets happen at the routers.**
- ◆ **When the congestion happens, in order to provide the AF data packets with better QoS service, the BE data packets should more easily be discarded than the AF data packets.**

The Progressed DiffServ AQM

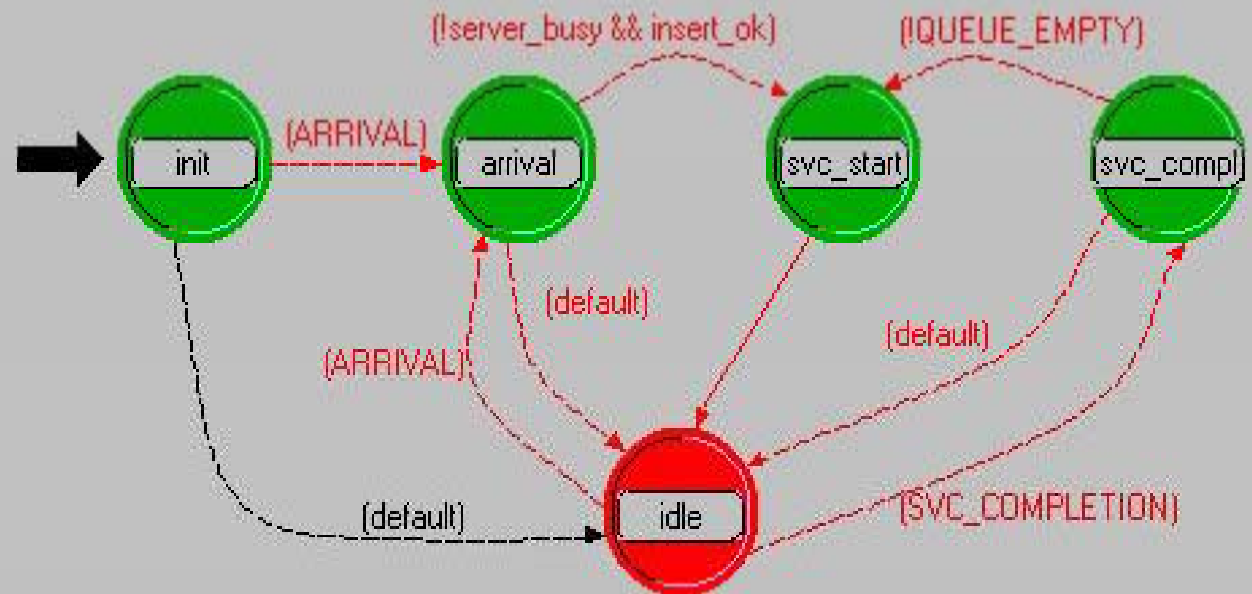
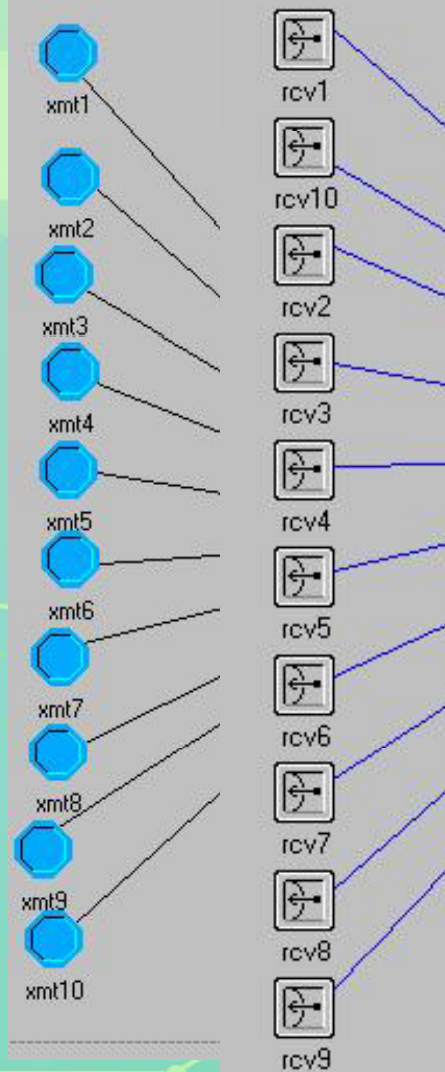
- ◆ It proposes a new progressed algorithm based on the RIO to cater for the communication better.
- ◆
 - It is essential to have three queues with different precedence.
 - The dropping probability applies a non-linear gentle way to increase, which decreases the parameters affecting the network throughout and saves the resource better.

$$P_b = P_{\max} \bullet \left(\frac{Q_{\text{avg}} - Q_{\text{min}}}{Q_{\text{max}} - Q_{\text{min}}} \right)^n \quad (n \geq 1)$$

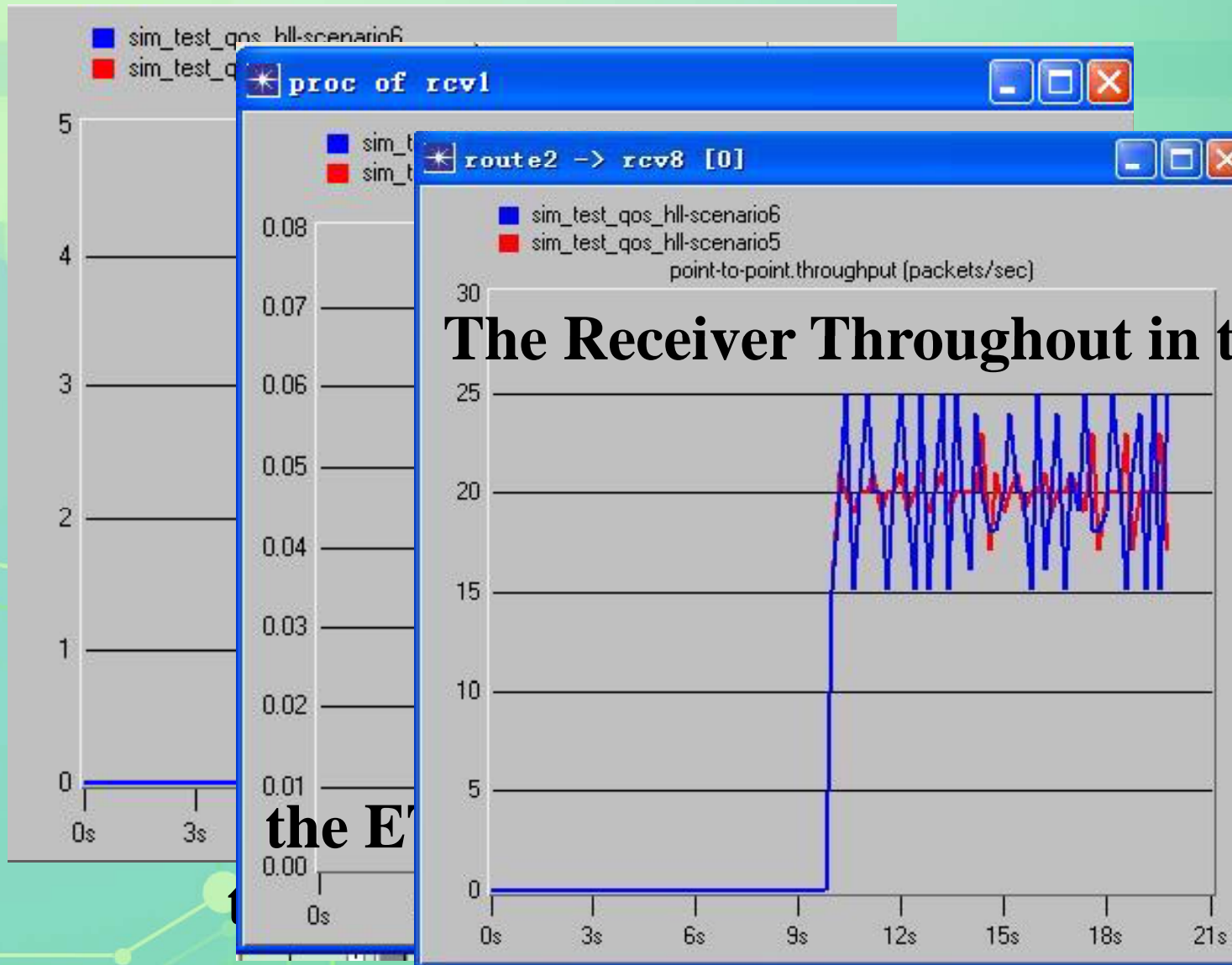
The Progressed DiffServ AQM

- ◆ In order to test the QoS of the ATN over DiffServ model and the affection of the progressed queue management achieving reasonable QoS, OPNET Modeler network simulation tool is used to establish corresponding model and simulate the network algorithm.
- ◆ The scenario separately in the network area, node area and process area is shown as following below.

The Progressed DiffServ AQM



The Progressed DiffServ AQM



The Receiver Throughout in the Rcv8

the E'

Conclusions

- ◆ **The queue of the progressed algorithm is much shorter than the queue of the original algorithm. It is benefit to avoid the congestion.**
- ◆ **The advantage of the improved algorithm mainly presents in the fairness, especially protecting the data with the high priority.**

Thanks!

