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Achieving QoS for Aeronautical Telecommunication Networks over Differentiated Services

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ATN

- Aeronautical Telecommunication Network (ATN) has been developed by the International Civil Aviation Organization to integrate Air-Ground and Ground-Ground data communication for aeronautical applications into a single network serving Air Traffic Control and Aeronautical Operational Communications.

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Advantages of ATN

- The ATN will support data link based air traffic control Applications and airline operational communications, rather than voice communications. In turn, this will enable:
  - increased airspace capacity leading to reduced delays;
  - improved air traffic safety permitting more aircraft to fly;
  - reduced operating costs through more efficient routings and more efficient ATC.
- It will first see operational use in 2002/3 at Miami, FL. From then on it will be deployed throughout the USA and Europe.

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QoS Requirements of ATN

- To carry time critical information required for aeronautical applications, as one of the objectives of ATN, it provides different QoS to applications.
- In the ATN, priority has the essential role of ensuring that high priority safety related and time critical data are not delayed by low priority non-safety data, especially when the network is overloaded with low priority data.
- The time critical information carried by ATN and the QoS required by ATN applications has led to the development of the ATN as an expensive independent network.

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ATN & DiffServ

- The largest public network, Internet, only offers best-effort service to users and hence is not suitable for carrying time critical ATN traffic.
- The rapid commercialization of the Internet has given rise to demands for QoS over the Internet.
- DiffServ has been proposed by IETF as one of models to meet the demand for QoS.

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Objective

- To investigate the POSSIBILITY of providing QoS to ATN applications when it runs over DiffServ backbone in the next generation Internet.
- To propose a FRAMEWORK to run ATN over the DiffServ backbone.
- To show the SIMULATION RESULTS used to prove that QoS can be achieved by end ATN applications when running over DiffServ backbone in the next generation Internet.

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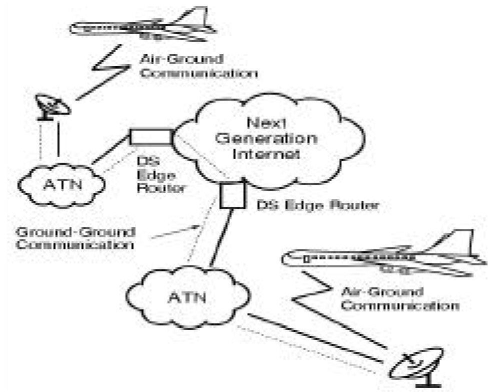
Significance

- Considerable cost savings could be possible if the next generation Internet backbone can be used to connect ATN subnetworks.



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Possibility of ATN over DiffServ

- The DiffServ model utilizes **six bits in the TOS** (Type of Service) field of the IP header to mark a packet for being eligible for a particular forwarding behavior.

- The NPDU (Network Protocol Data Unit) header of an ATN packet contains an option part including **an 8-bit field named *Priority*** which indicates the relative priority of the NPDU.

- The value ***0000 0000*** indicates ***normal priority***; the values ***0000 0001* through *0000 1110*** indicate *the **priority in an increasing order.***

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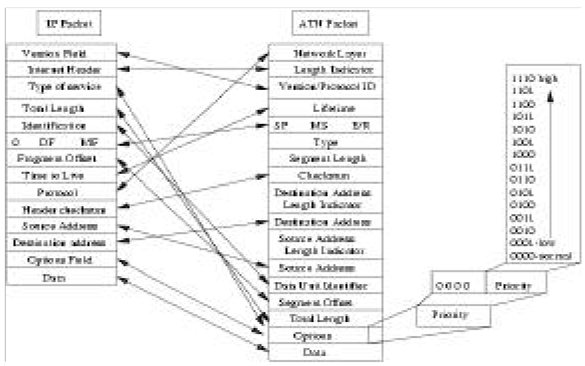
Possibility of ATN over DiffServ (Continued)

- The similarity between an ATN packet and an IP packet, shown below, provides the possibility for mapping ATN to DiffServ to achieve the required QoS when they are interconnected.



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Mapping Consideration

- The PHB treatment of packets along the path in the DiffServ domain must approximate the QoS offered in the ATN network.

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Mapping Function

- We map the ***normal priority*** (indicated by *Priority* field in NPDU) in ATN domain to ***BE*** PHB in DiffServ domain;
- Map the ***high priority*** in ATN domain to ***EF*** PHB in DiffServ domain;
- Map the ***medium priorities*** in ATN domain to the corresponding classes of ***AF*** PHBs in DiffServ domain.

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An Example Mapping Function

- An example mapping function used in our simulation

ATN Priority Code	Priority	PHB	DSCP
0000 0000	Normal	BE	000000
0000 0111	Medium	AF11	001010
00001110	High	EF	101110

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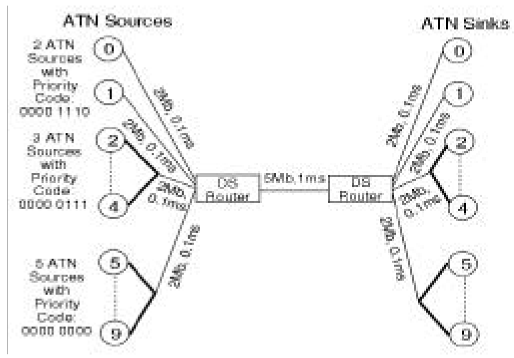
Simulation Configurations

- Simulation tool: Berkeley *ns* V2.1b6
- Simulation configuration.



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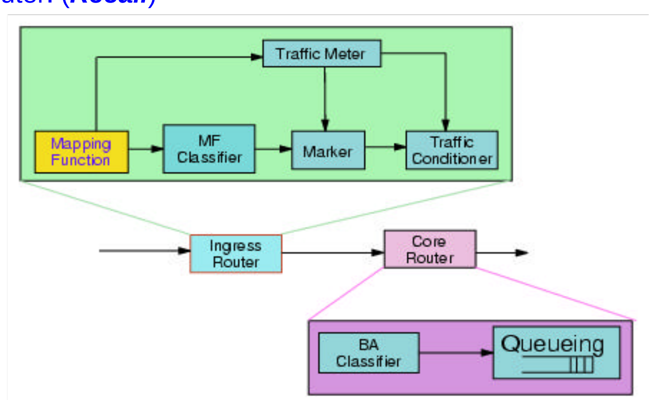
Simulation Configurations (Continued)

- We integrated the mapping function into the edge DiffServ router. (***Recall***)



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Simulation Configurations (Continued)

- Table below shows the configuration of queues inside the core DiffServ router.

	Queue Type	Queue weight
EF Queue	*PQ-Tail drop*	*0.4*
AF Queue	*RIO*	*0.4*
BE Queue	*RED*	*0.2*

Since the bandwidth of bottleneck link is 5Mb, the above scheduling weight implies bandwidth of

- EF: 2Mb
- AF: 2Mb
- BE: 1Mb

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Performance Criteria

- Goodput of each ATN application.
- Queue size of DiffServ router.
- Drop ratio of the scheduler.

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QoS Obtained by ATN Applications: Case 1

- ***Case 1:*** **No congestion.**

Source NO.	Source Type	Source Rate
0, 1	*High Priority*	*1Mb*
2, 3, 4	*Medium Priority*	*0.666Mb*
5,6,7,8,9	*Normal Priority*	*0.2Mb*

- The amount of traffic with different priorities are equal to the corresponding scheduled link bandwidth → **No congestion**.

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Goodput of ATN Applications: Case 1

- ***Results of Case 1:*** **Goodput of each ATN source.**

Source Priority		Case 1 (Kb/S)	Case 2 (Kb/S)
	Src 0	*999.99*	*999.99*
High	*Src 1*	*999.99*	*999.99*
	Src 2	*666.66*	*668.47*
Medium	*Src 3*	*666.66*	*667.53*
	Src 4	*666.66*	*663.99*
	Src 5	*200.00*	*199.48*
	Src 6	*200.00*	*201.98*
Normal	*Src 7*	*200.00*	*201.68*
	Src 8	*199.98*	*200.467*
	Src 9	*200.00*	*196.39*

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Drop Ratio of ATN Applications: Case 1

- ***Simulation results of Case 1:*** **Drop ratio of ATN traffic (measured at scheduler).**

Type of traffic	Case 1	Case 2
High Priority Traffic	*0.00*	*0.00*
Medium Priority Traffic	*0.00*	*0.49*
Normal Priority Traffic	*0.00*	*0.67*

- **Observations:** since there is no significant congestion, the drop ratio is zero.

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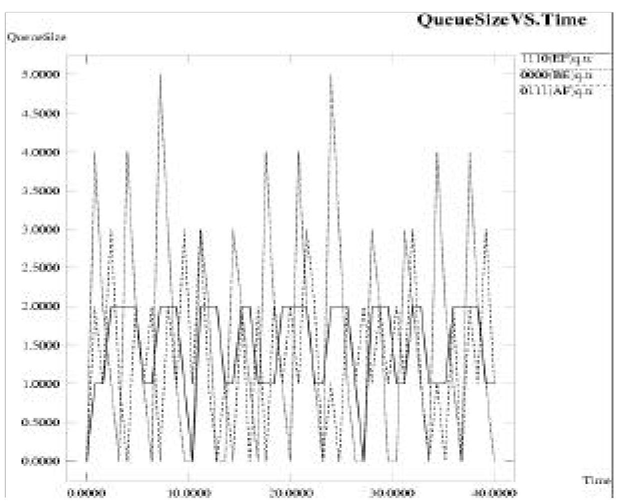
Queue Size Plot: Case 1



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Queue Size Plot: Case 1 (Continued)

- **Observations:** since Case 1 is a ideal case, the average size of each queue is very small. BE queue has the largest jitter.

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QoS Obtained by ATN Applications: Case 2

- ***Case 2: Both Medium and Normal Priority traffic gets into* congestion.**

Source NO.	Source Type	Source Rate
0, 1	*High Priority*	*1Mb*
2, 3, 4	*Medium Priority*	*1.333Mb*
5,6,7,8,9	*Normal Priority*	*0.6Mb*

- The amount of traffic with both Medium (4Mb) and Normal Priority (3Mb) is greater than the corresponding scheduled link bandwidth (2Mb, 1Mb) ► **Both Medium and Normal Priority traffic gets into congestion**.

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Goodput of ATN Applications: Case 2

- ***Results of Case 2:*** **Goodput of each ATN source.**

Sources		Case 1 (Kb/S)	Case 2 (Kb/S)
High	*Src 0*	*999.9990*	*999.9990*
	Src 1	*999.9990*	*999.9990*
Medium	*Src 2*	*666.6660*	*668.4719*
	Src 3	*666.6660*	*667.5270*
	Src 4	*666.6660*	*663.9990*
Normal	*Src 5*	*200.0039*	*199.4790*
	Src 6	*200.0039*	*201.9780*
	Src 7	*200.0039*	*201.6840*
	Src 8	*199.9830*	*200.4660*
	Src 9	*200.0039*	*196.3920*

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Drop Ratio of ATN Applications: Case 2

- ***Simulation results of Case 2:*** **Drop ratio of ATN traffic (measured at scheduler).**

Type of traffic	Case 1	Case 2
High Priority Traffic	*0.00000*	*0.00000*
Medium Priority Traffic	*0.00000*	*0.49982*
Normal Priority Traffic	*0.00000*	*0.66562*

- **Observations:** the drop ratio of both Medium and Normal Priority traffic are increased.

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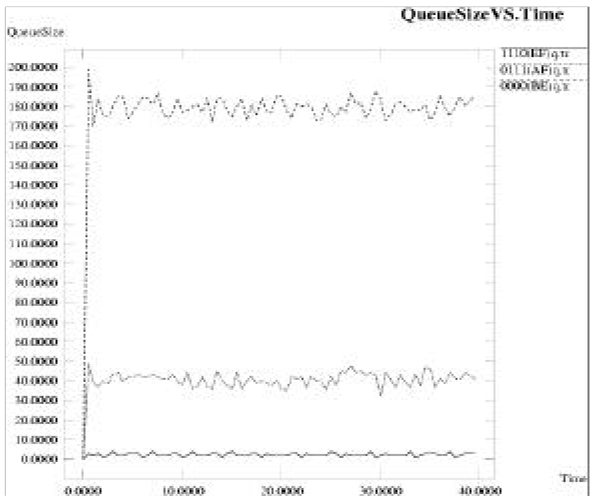
Queue Size Plot: Case 2



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Queue Size Plot: Case 2

- **Observations:**
  - In this case, the high priority traffic has the smallest average queue size and jitter;
  - The normal priority traffic has the biggest average queue size and jitter.

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Conclusion

- The high priority traffic receives the highest priority; the medium priority traffic receives higher priority than normal priority traffic.
- According to our simulation, the QoS requirements of ATN applications can be successfully achieved when ATN traffic is mapped to the DiffServ domain in the next generation Internet.

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