TCP over ATM Performance in NASA NREN and CTI

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Background

- **Introduction**

  - An ATM group at NASCOM (NASA Communications) has been tasked to show that an ATM network can support NASCOM's voice, video and data requirements.

  -The NILE (NASCOM Internetworking Laboratory Environment) is the place where new ideas and technologies are tested before NASCOM offers them to its customers.

- **Purpose**
  - Find solutions to improve TCP performance for IP data in a high speed network with large delay (RTT > 30ms).
  - The decision was made not to rate limit the work stations. As a result any ATM traffic generated by TCP was admitted into the network as dictated by TCP parameters.

- **Tests**
  - Extended testing was done to optimize TCP parameters
  - Different ATM services (ABR, VBR and UBR)
  - IP over ATM using standards RFC 1483 and 1577 through EBnet routers
  - TCP performance over CTI and NREN networks from GSFC to JPL
  - Single and multiple TCP streams

NASCOM TCP Performance Summary

- The TCP performance test effort can be divided into

In lab Results

TCP parameters Optimization

- **Single TCP stream**
- Using a combination of RFC 1323 and parameter optimization, moved IP data over ATM at 91% utilization (33.46 Mbps) on a DS-3 link
- Using RFC 1483 and VBR service obtained 29.67 Mbps over a simulated 60 ms RTT DS-3 link
- **Multiple TCP stream using UBR**
- Obtained 34 Mbps on each of three receivers concurrently for a sender throughput of 102 Mbps 73% utilization on an OC-3 link.

CTI results (GSFC to JPL)

Using ABR (between switches) obtained 90% utilization (17.34 Mbps) on a 20 Mbps contract.

NREN

Tested performance of a single TCP stream using UBR EPD service in an OC-3 ATM cloud. Compared performance of FDDI-ATM configuration to an ATM only configuration.

Hardware and Software used for TCP performance tests

- Single CPU Sparc 20 workstations running:

  - SOLARIS 2.3

  - SUNCONSULT TCP-LFN version 2.0 (SUN's implementation of RFC 1323)

  Installed Network Adapters

  -Network Peripheral FDDI adapter running latest TCP driver software

  Max. TCP speed reached with large window 67.93 Mbps

  - FORE sba 200 e ATM NIC running FORE THOUGHT 4.0

  Max. TCP speed reached with large window 97.3 Mbps

- CISCO 7010 routers were used with an API and an FDDI card.

  The software used was 11.0.8

- FORE ASX 200 BX ATM switches supporting UBR EPD also running

  FORE THOUGHT 4.0 software.

- STRATACOM BPX ATM switch for CTI tests. It offered a proprietary implementation of ABR

Baseline In Lab Tests

- TCP parameters Optimization

  Proved the formula: Window size(bytes) = BW (bytes/sec)* RTT (sec)

  This formula is stated in RFC 1323.

  Work Stations Network Adapters (FDDI and ATM) baseline tests.

- Proof of concept for WAN tests

  Using a channel simulator included 60 ms of delay to RTT.

  Results for the controlled environment are used as baseline for the WAN tests

  - Single TCP stream

    Measures the throughput of one TCP connection between two similarly configured work stations.

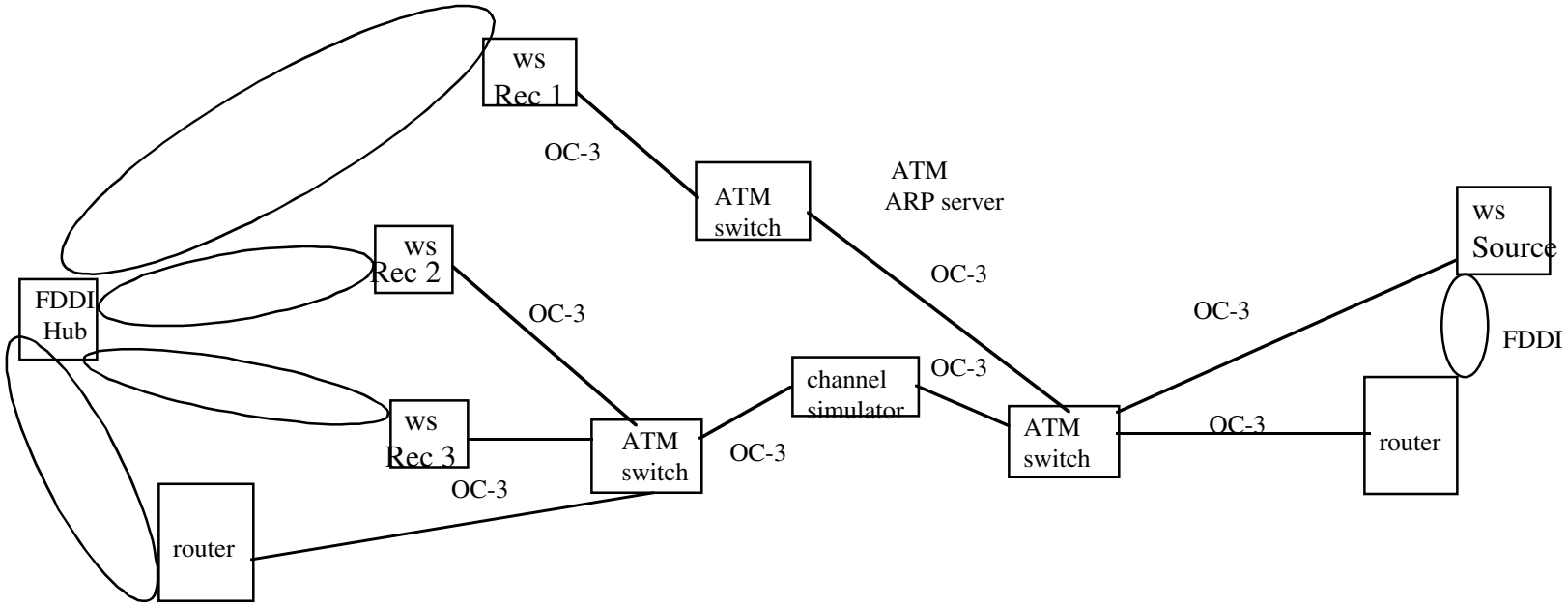
  - Multiple (three) TCP streams

    Three receivers and it sends three different TCP streams using three VC's within a VP.

    This test has not been tried on NREN

In Lab Multiple TCP Stream Test

- **Test Configuration**



In Lab Multiple TCP Stream test (cont.)

- **Results**

TCP window in bytes	APDU in bytes	Physical	RTT in msec	Throughput in Mbps			
				R1	R2	R3	Agr.
262144	4096	FDDI-ATM	60	25.13	22.82	22.07	70.00
524250	4096	FDDI-ATM	60	31.05	24.28	7.54	62.87
262144	4096	ATM	60	20.70	20.38	19.07	60.15
262144	8192	ATM	60	22.63	21.03	19.93	63.59
524250	4096	ATM	60	23.63	23.42	15.79	62.84
524250	8192	ATM	60	31.79	31.41	31.05	94.25

- **Comments**

  The data suggests that bandwidth allocation among the three TCP connections

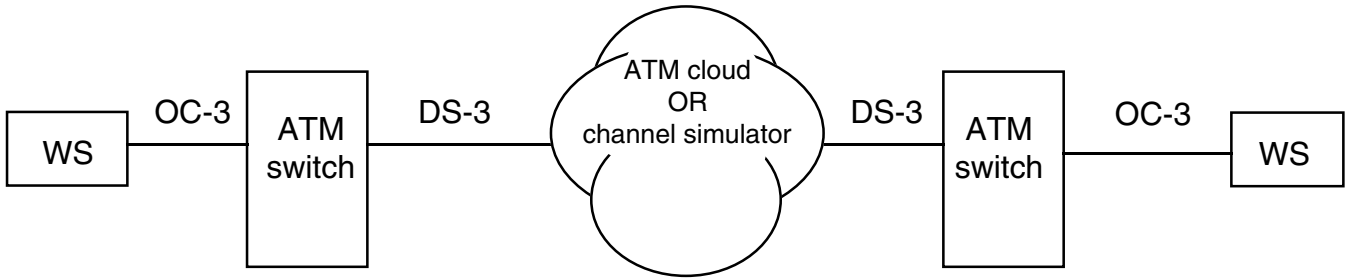
  is fair under optimum conditions (no fragmentation and window size appropriate to bandwidth obtained).

  The data also shows that ATM can take advantage of the larger window while the FDDI adapter can not.

- **This Test will be performed using NREN soon.**

CTI Test

- Test Configuration



- CTI Results (GSFC to JPL)
  - Using ABR (between switches) obtained 90% utilization (17.34 Mbps) on a 20 Mbps contract.
- Sample results for DS-3 with 60 ms RTT delay provided by a channel simulator

Service type	Throughput in Mbps
ABR	28.71
VBR	29.67

CTI Test

- Comments

  This test was performed using one PVC on a VBR contract of 20 Mbps of PCR and a SCR of 10 Mbps.

  The PVC was ABR with a minimum cell rate of 1 Mbps and a PCR of 20 Mbps.

  The throughput obtained varied with time and in same occasions it was at about the minimum cell rate. This was a good lesson for us.

  On the VBR test simulated in the lab the most important lesson was the inability of TCP to slow down enough to avoid cell drops at the switch.

  In order to achieve good performance the Bandwidth*delay=Windowsize formula needs to be exactly matched to the current network conditions. This makes VBR service undesirable for data transfer because any changes in either RTT or available bandwidth will

  reduce TCP throughput considerably.

NREN TCP Test

- **Purpose**

  Assuming an FDDI LAN and ATM WAN, find the bottleneck and show what actions can be taken to improve its performance.

  Compare FDDI-ATM to ATM only performance.

- **Test**

  Single TCP streams using FDDI-ATM and ATM only.

- **Procedure**

  Using *ttcp* send 350 Mbytes of data from one workstation to another

  In every case the sending workstation controls the receivers parameters settings using UNIX scripts. A single script will change TCP parameters , provide TCP statistics such as retransmissions and throughput results.

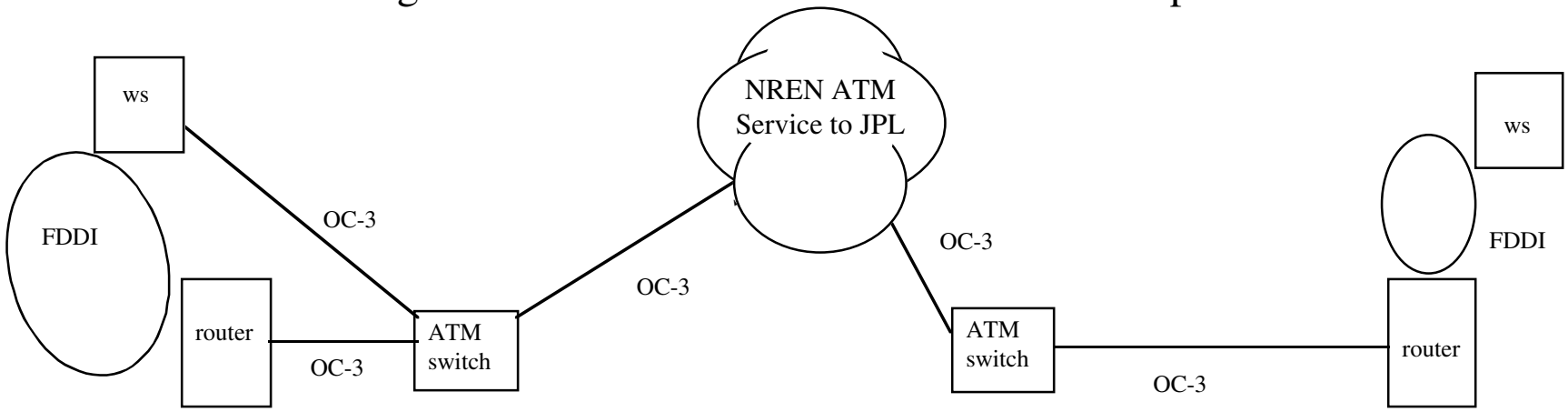
- **Comments**

  The results show the inability of FDDI to take advantage of the increased window size while ATM can.

Single TCP stream test

- **Test Configuration**

  A loopback VC was created at JPL. The switches were configured to send the bulk of data through the ATM service while the acks were looped within the lab.



•Sample Results

TCP window size in Bytes	APDU size in Bytes	Physical path ws to ws	RTT in msec.	Throughput in Mbps.
262144	4096	FDDI-ATM	66	30.34
262144	8192	FDDI-ATM	66	30.69
524250	4096	FDDI-ATM	66	12.84
524250	8192	FDDI-ATM	66	20.08
262144	4096	ATM	66	31.73
262144	8192	ATM	66	31.73
524250	4096	ATM	66	61.88
524250	8192	ATM	66	61.88

Conclusion

- When using VBR the window size has to match the bandwidth delay product. Increasing initial and maximum burst sizes does not improve TCP performance if the network conditions change.
- ABR adjusts more easily to network changes. However its performance can be reduced to its minimum cell rate at times and it is not widely implemented yet.

  A large per VC buffer on the switch plays a major role in improving TCP performance.
- UBR with EPD fairly allocated bandwidth among three TCP streams.
- In FDDI-ATM tests it was shown the inability of this configuration to take advantage of the increased window size.

Future tests

- We are working at increasing the number of NASA sites involved in these tests.
- Multiple TCP stream tests are imminent on NREN between two sites.
- Tests of applications using TCP (for example ftp) are also under consideration.
- Proposals of cooperation with other testing groups will be welcomed by NASCOM.