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SIMULATION OF A NASA LEO SATELLITE HYBRID NETWORK

by

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OBJECTIVE

Investigate the performance of TCP/IP in a hybrid network consisting of a global terrestrial network and a LEO satellite by simulation.

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Satellite LEO - circular orbit at 650 km altitude
- 52 degrees inclination
- FTP server
- Transmission and reception at 9600 bps

Houston, United States
- Central node of a star topology
- FTP client
- Terrestrial transmission and reception at DS0 (64 kbps)
- Radio transmission and reception at 9600 bps

Seoul, South Korea; Canberra, Australia; Toulouse, France; India; Saudi Arabia; Central Africa; Brazil
- Above terrestrial nodes connected to Houston
- Terrestrial transmission and reception at DS0 (64 kbps)
- Radio transmission and reception at 9600 bps

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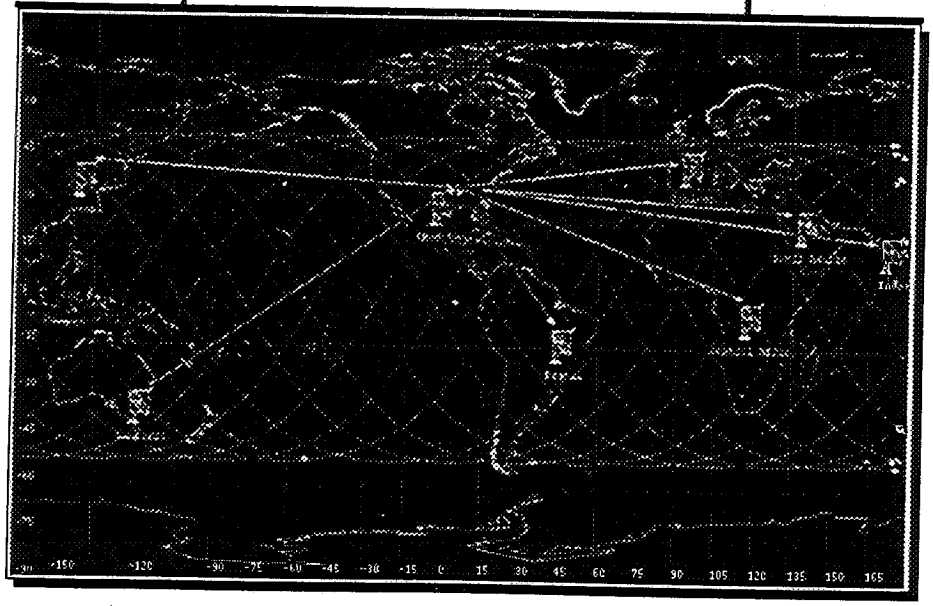

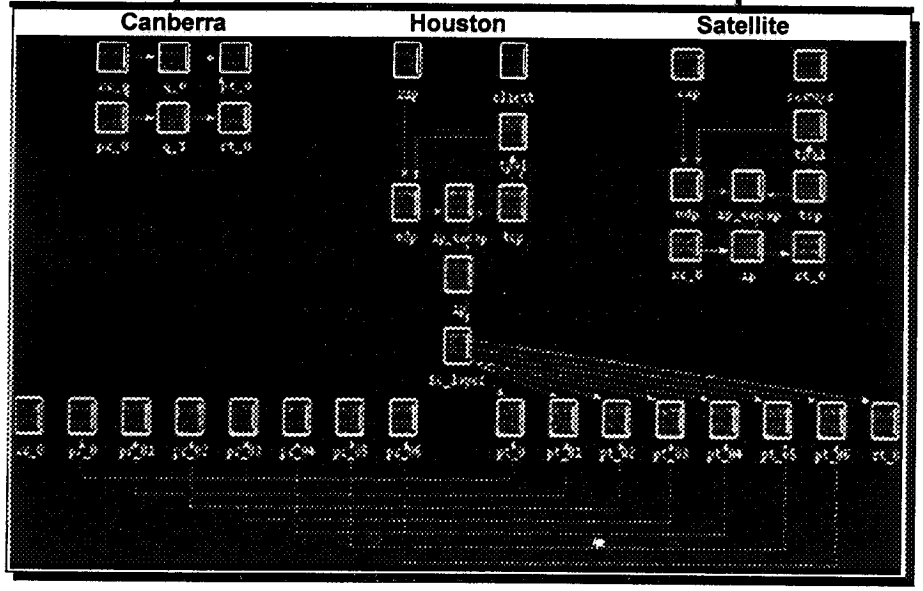

TCP simulation includes

- Connection establishment and closing using three-way handshaking
- Flow control
- End-to-end reliability
- Reordering of the data at the receiver
- Slow-start congestion avoidance and control

FTP simulations

- Average size of the file modeled using a normal distribution
- Generation rate for sessions modeled using a Poisson process

Simulation results for 60 KB, 300 KB, and 1500 KB files

- Throughput
- End-to-end delay
- Satellite transmitter queue size (7500 KB files)
- Canberra receiver queue size (7500 KB files)
- Client congestion windows
- Server congestion windows
- Client-server congestion windows

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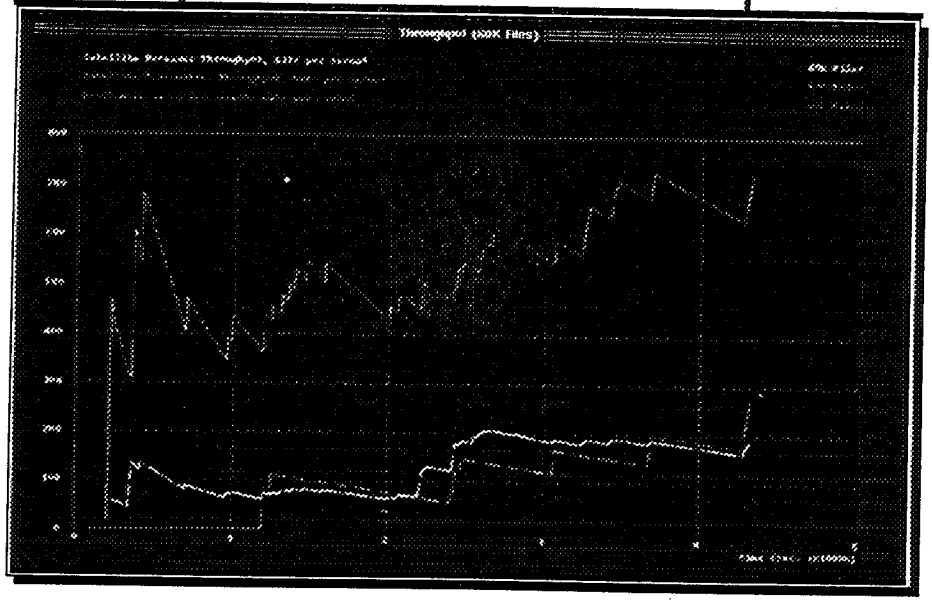

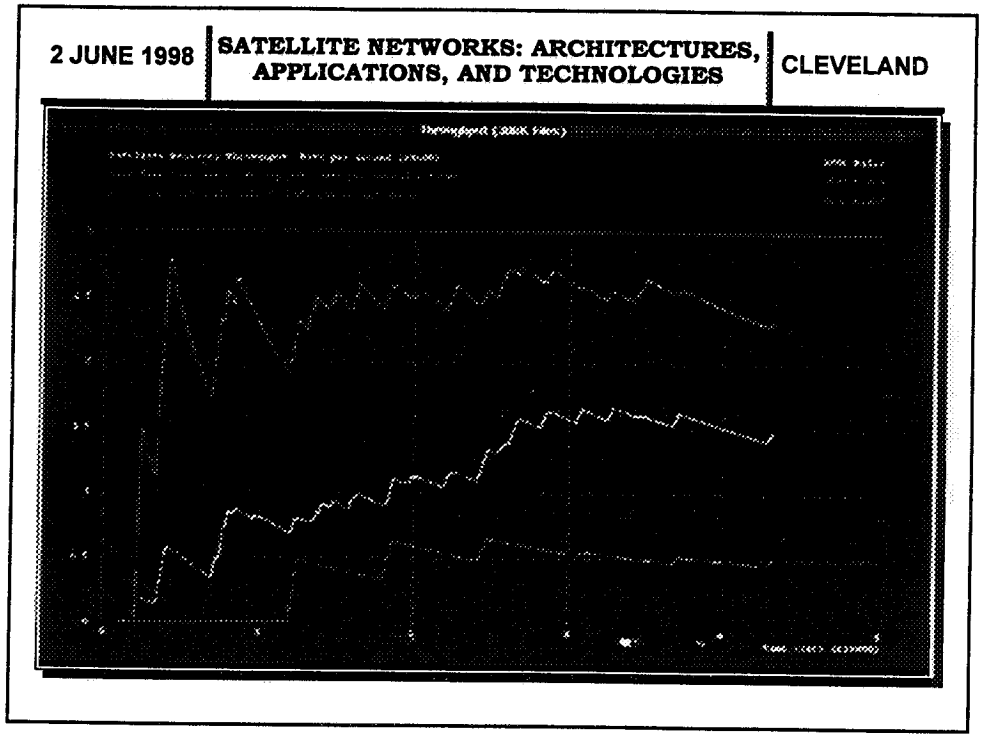
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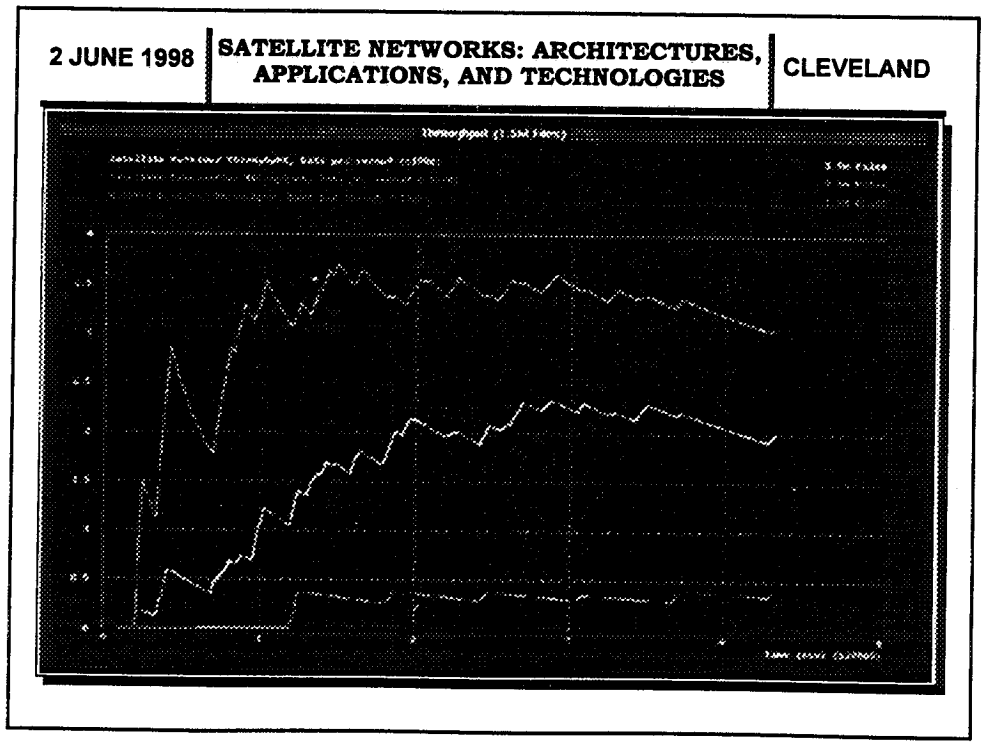
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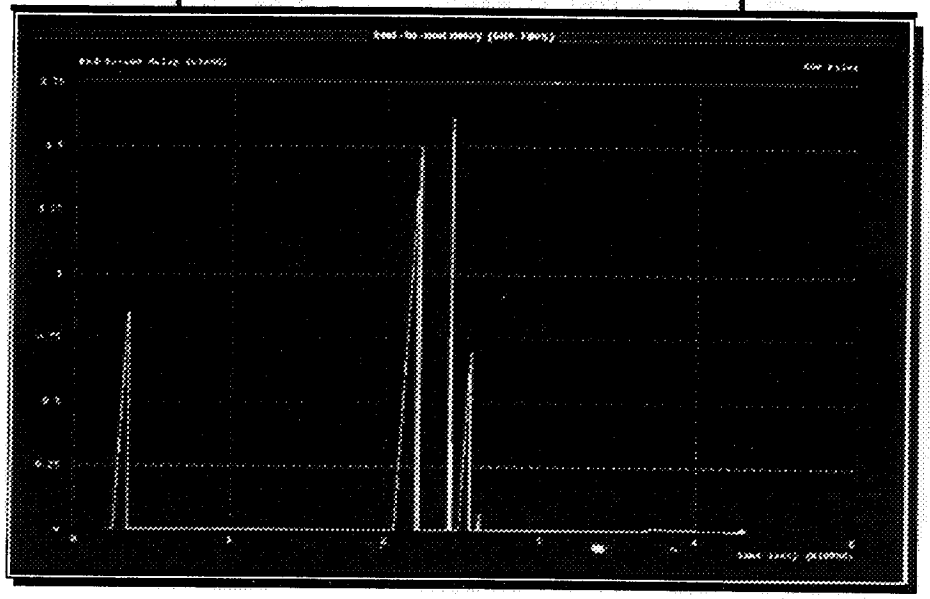

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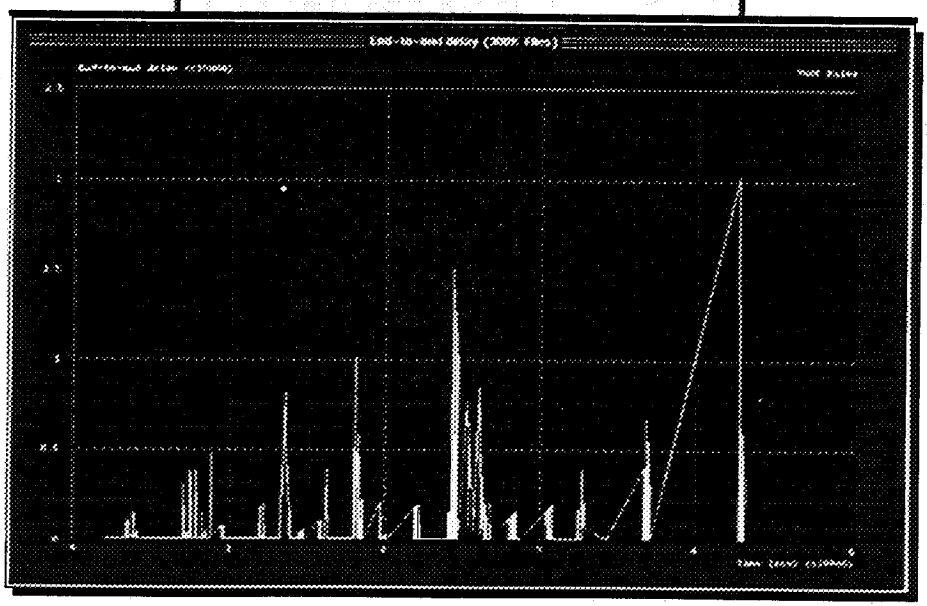

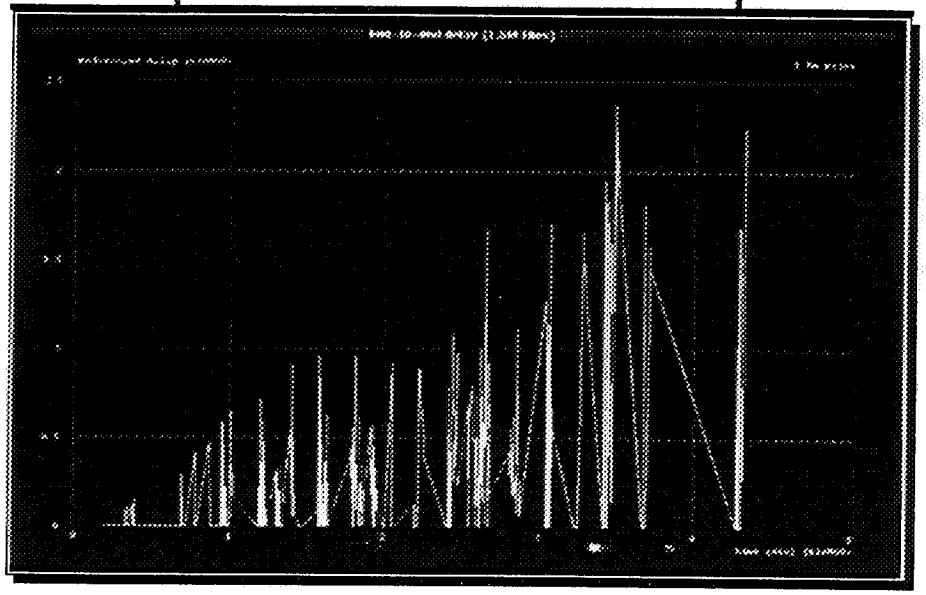

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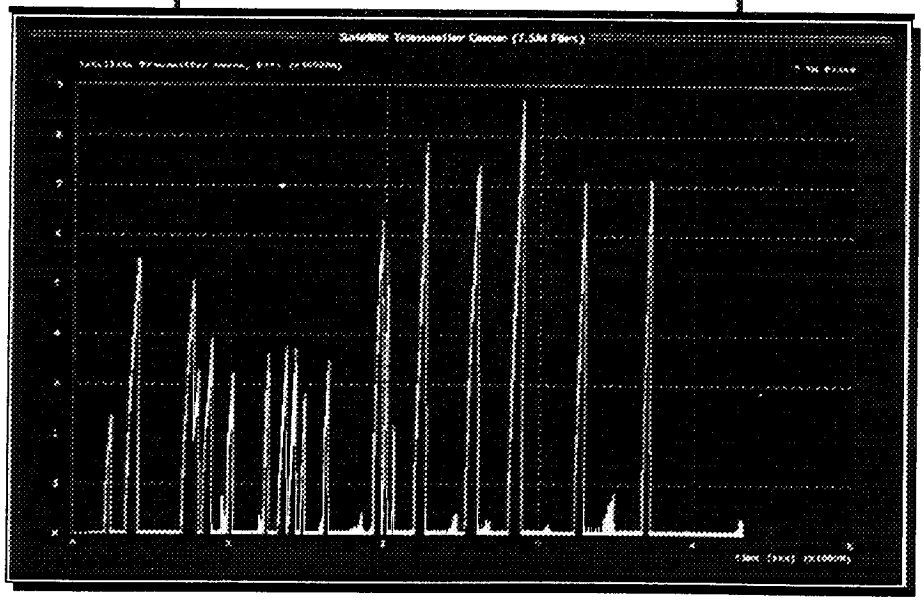

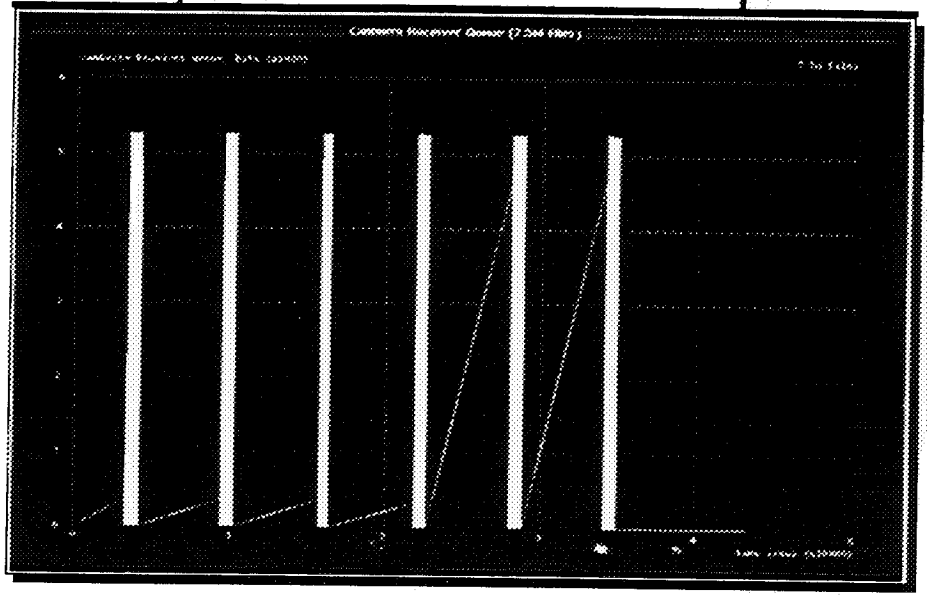

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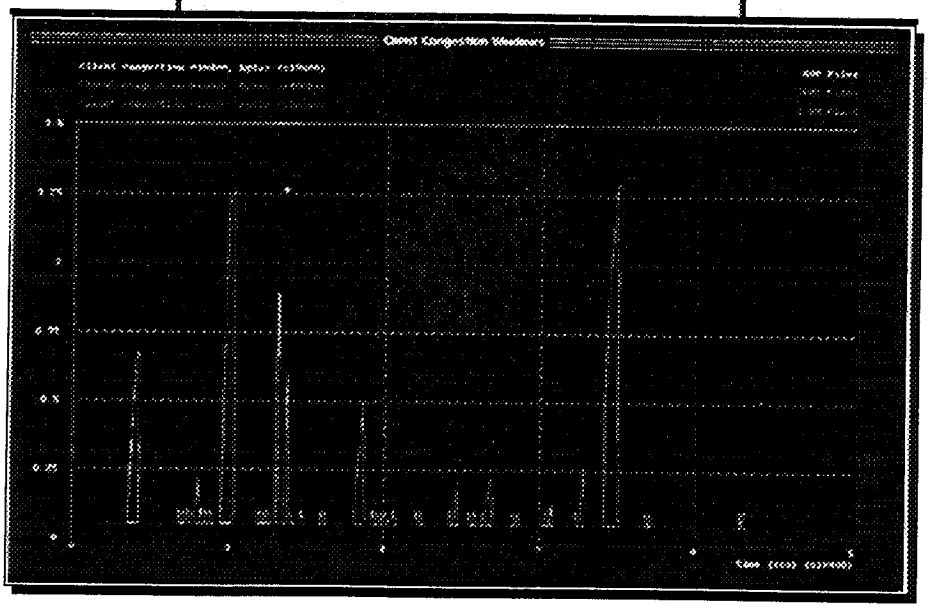

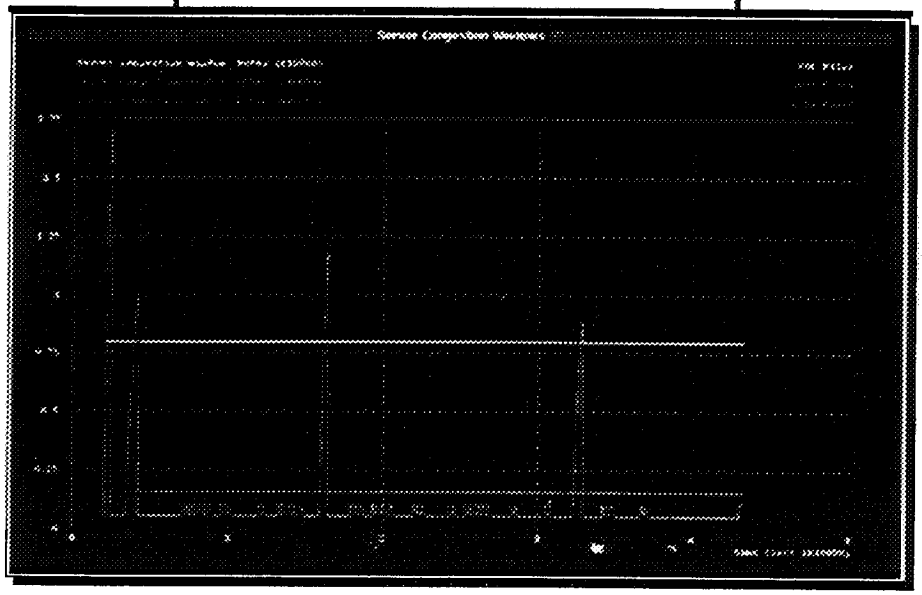

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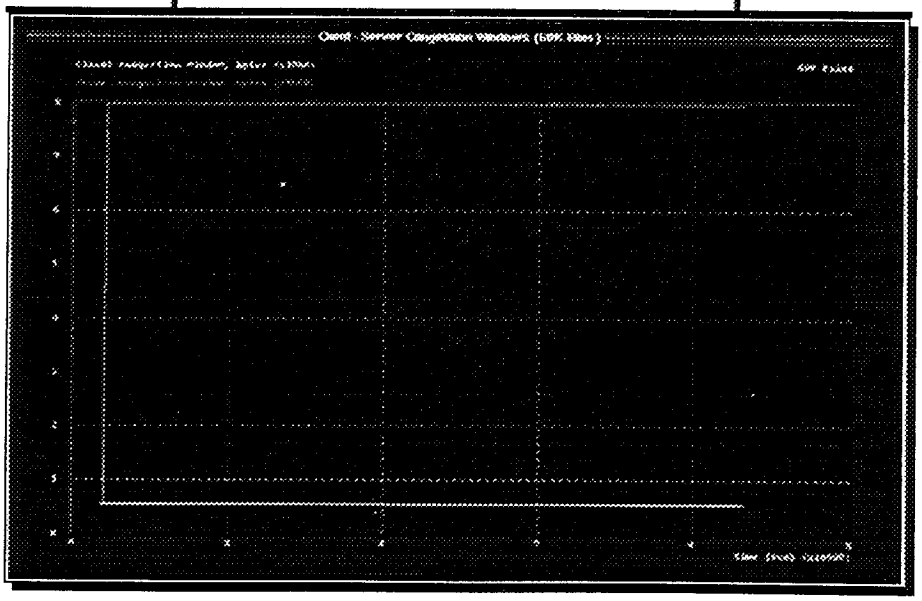

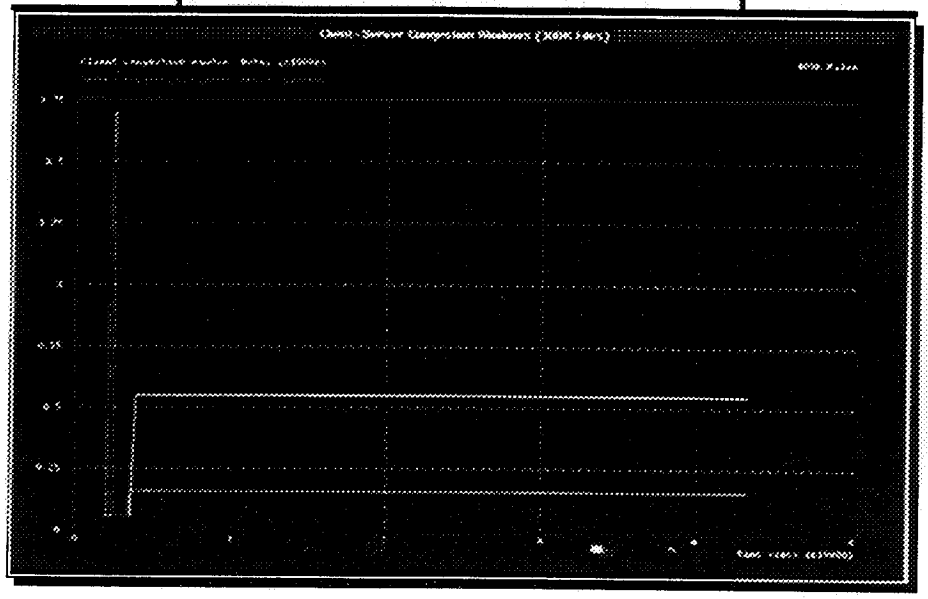

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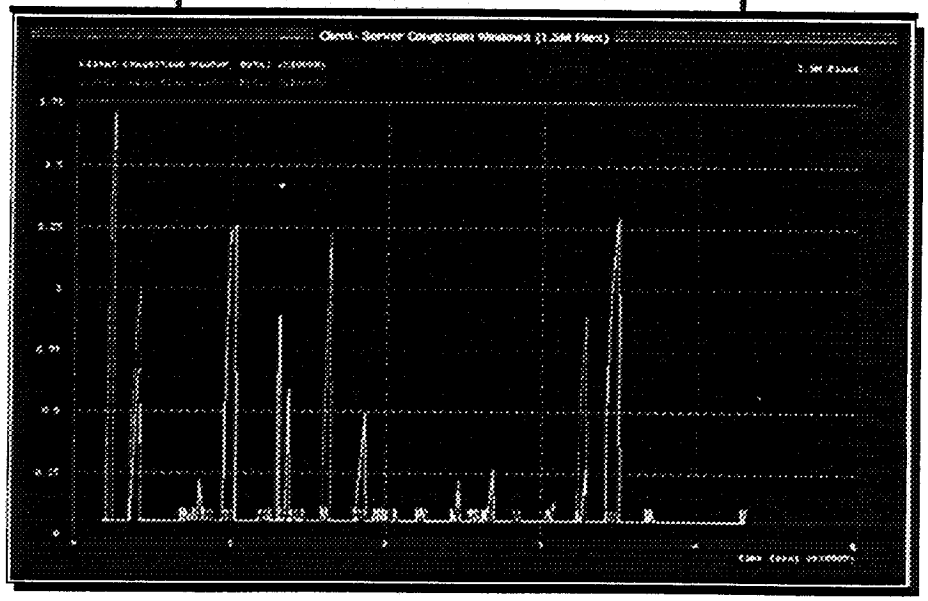

CONCLUSIONS

- The satellite transmitter average throughput saturates for large files.
  (~ 3500 bps)
- Houston receiver average throughput inconclusive.
  (radio reception only)
- Frequent, large End-to-end delays for large files.
  (small % increase for file size increase)
- Infrequent, small End-to-end delays for small files.
  (large % increase for file size increase)
- Queueing delays at the terrestrial nodes are not significant.
- TCP slow-start algorithm degrades the performance for large files.