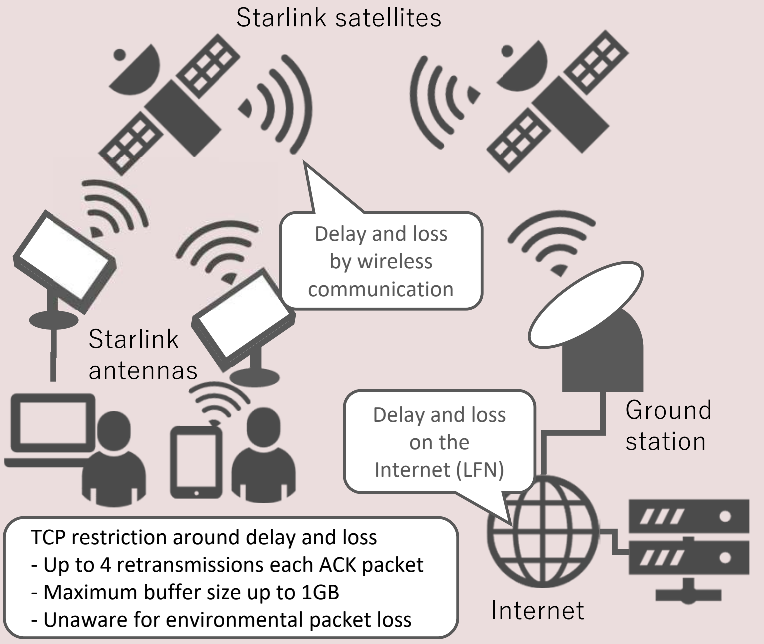
Evaluation of a Communication Protocol Optimized for Delay-Tolerant Networks using Satellite Network

■Background and theme

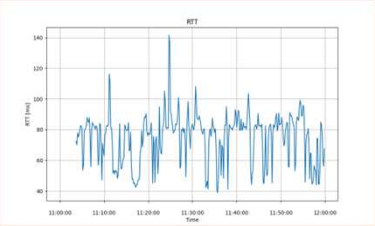


Starlink satellites
Delay and loss by wireless communication
Starlink antennas
Ground station
Delay and loss on the Internet (LFN)
Internet

TCP restriction around delay and loss
- Up to 4 retransmissions each ACK packet
- Maximum buffer size up to 1GB
- Unaware for environmental packet loss

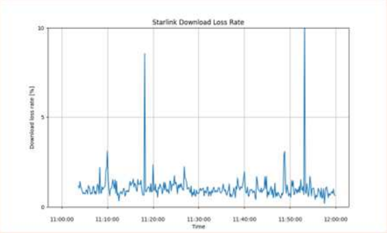
■Communication characteristic of Starlink network

- Relatively stable delay
  Actual measurement 60msec
  Nominal value 25msec – 60msec
- Steady packet loss and occasional bursts of it
  Actual measurement, Steady 1% Occational bursts over 10%
- Measurements performed from a off coast of Japan to a land site of Japan via Starlink



RTT measurement

Split in 40ms and 80ms and rapidly switching.
This may be due to a satellite swith.



Packet loss measurement

Packet loss in off coast tend to be more than one in land.
This may be due to instability of position or direction of antennas.

■High-performance and flexible protocol (HpFP)

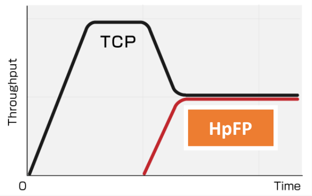
● **High latency and loss tolerance**

- For delay tolerance
  Buffer size extension in user land
  64 bit large buffer support (over 4GB)
- For packet loss tolerance
  Unique and efficient packet retransmission with utilizing some payload parts of multiple packets
  Massive retransmission support up to 16384 packets
  Packet loss-optimized congestion algorithm

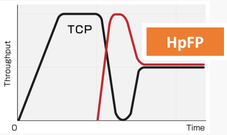
● **Loss adaptive congestion control**

- Packet loss types awareness
  Distinguish between congestion loss and environmental loss
  That keeps high throughput in high loss environment with congestion control
- Congestion control selection
  Users can choose congestion mode each environment (fair, fast-start, modest, aggressive)

fair mode

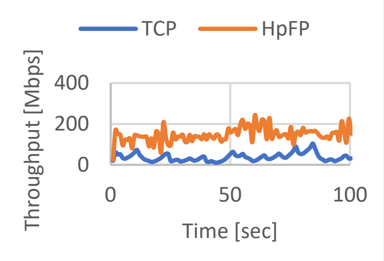


fast-start mode



■ HpFP measurement results in Starlink environment

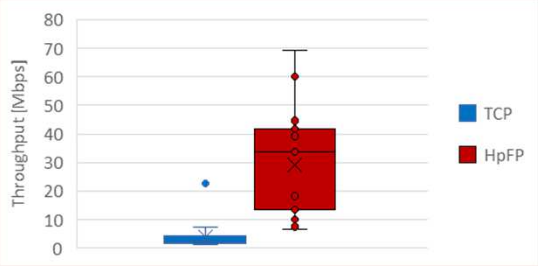
● DMC23



HpFP reaches 150Mbps to 200Mbps. TCP performance is under 10Mbps to 50Mbps in unstable throughput.

Awarded **"Best performing in impaired networks"**

● Measurement results in the waters off the coast of Japan



HpFP reaches 15Mbps to 40Mbps
TCP performance is around a few Mbps.
HpFP throughput result is 10 times or more than one of TCP.

■ Migration and application using HpFP

● **POSIX TCP style available and replaceable (C lang API)**

```
instance = hpfp_client_instance_init(port, 0);
sock = hpfp_new_socket(instance);
hpfp_posix_setsockopt(sock, 0, HPFP_OPT_SNDTIMEO, &timeval, sizeof(timeval));
addr.sin_family = AF_INET;
addr.sin_addr.s_addr = inet_addr(connect_addr);
addr.sin_port = htons(port);

hpfp_posix_connect(sock, (struct sockaddr *)&addr, sizeof(addr));
n = hpfp_posix_send(sock, &data_buf, 1024, 0);
hpfp_socket_close(sock);
```

● **Application**

- Replacing transports
  Improving bulk data transfer on distributed file system, some network services like SSH or others
- Bulk data transfers in impaired networks
  Improving performance on inter-continental LFN networks, satellite networks, remote area networks, congested internet providers, general wireless networks

HpFP performance measurement tools

●Hperf
https://support.bytix.tech/hperf/downloads/0.1
* Free to download

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