NS2 Simulation Tests for Modeling Wireless Links

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1 Introduction

This is a technical report illustrating simulation scripts for modeling wireless links. This report accompanies a paper [1] that explored the modeling of wireless links for the evaluation of transport protocols. This report concentrates on modeling scenarios for popular wireless links and gives a reasonable value range for each parameter.

The simulations in this report are intended to illustrate the use of models for wireless links in ns2. We use simple topologies and a single TCP flow as workload. Therefore, the simulations are not supposed to be examples of a sound performance evaluation, but are only examples of the use of wireless links.

To our best current knowledge, the models of links give reasonable trade-offs for generality, detail, and accurateness. We do not claim the models to be the best possible, but they can be useful to explore the effects of wireless links on transport protocols. The simulation scripts are publicly available in the directory tcl/ex/wireless-scripts of the ns2 simulator, and can be run with a command runall-tr.cmd.

2 GPRS

2.1 Good radio conditions

In good radio conditions only channel allocation delay is present, but no delay jitter due to ARQ nor any data losses.

To run:

```
ns mtp.tcl
-type gprs \ # network topology and characteristics of GPRS
-allocLenDL 'U(0.16,0.19)' \  # time to allocate a channel (in downlink)
-allocHoldDL 'U(2,5)' \ # time of holding the channel without traffic
-allocLenUL 'U(0.5,0.6)' \
-allocHoldUL 'U(0.01,0.4)'
```

The result is shown in Figure 1.

Reasonable range of parameters:

```
-bwUL 10-20 kb # bandwidth of downlink channel in kbps
-bwDL 20-50 kb
```

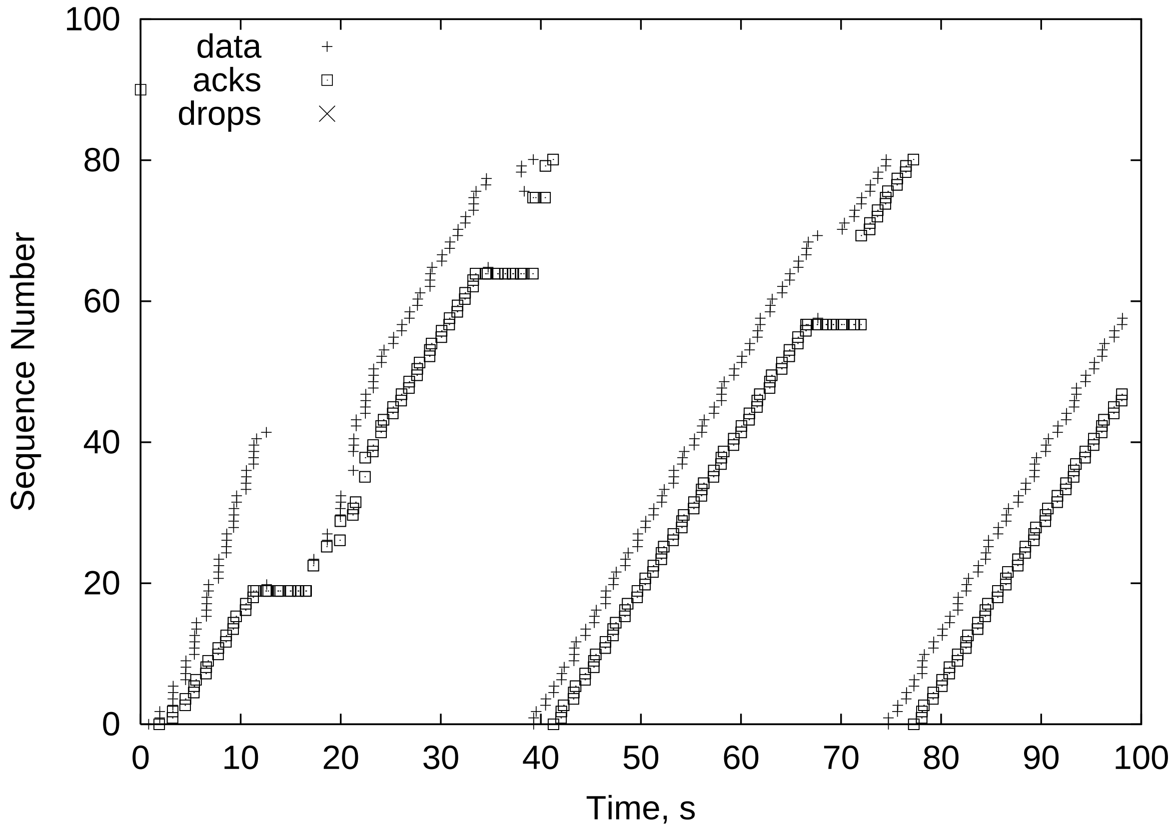

Figure 1: TCP over GPRS in good radio conditions.

2.2 Moderate radio conditions

In moderate radio conditions there is some delay variation due to link retransmissions and a channel allocation delay, but no error losses.

Add to the command in Section 2.1:

```
-delayInt 'E(0.1)' \ # distribution of interval between delays
-delayLen 'E(0.1)'  # distribution of delay duration
```

The result is shown in Figure 2.

Reasonable range of parameters:

```
-delayInt 0.05-1
-delayLen 0.05-0.2
```

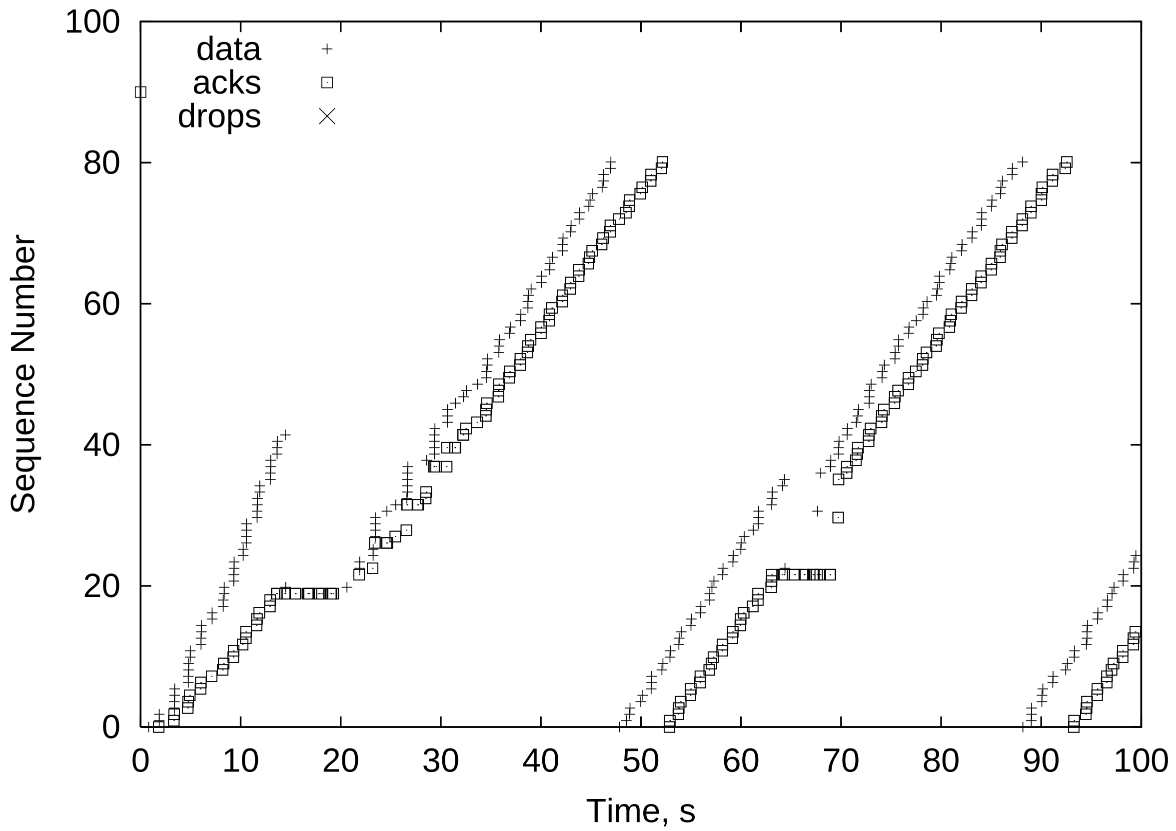

Figure 2: TCP over GPRS in moderate radio conditions.

2.3 Poor radio conditions

In poor radio conditions, there is significant delay variation due to link retransmissions, channel allocation delay and occasional bursty error losses.

Add to the command in Section 2.1:

```
-delayInt 'E(0.3)' \
-delayLen 'E(0.3)' \
-errRateUL 0.1 \ # packet loss rate due to errors in uplink
-errBurstUL 0.3 \ # coefficient 0..1 of how bursty errors are
-errSlotUL 3 \ # time in sec of a period with low loss rate
-errRateDL 0.01 -errBurstDL 0.3 -errSlotDL 3
```

Reasonable range of parameters:

```
-delayInt 0.05-0.5
-delayLen 0.05-1
-errRateDL 0-0.2
-errBurstDL 0-0.7
-errRateUL 0-0.2
-errBurstUL 0-0.7
```

The result is shown in Figure 3.

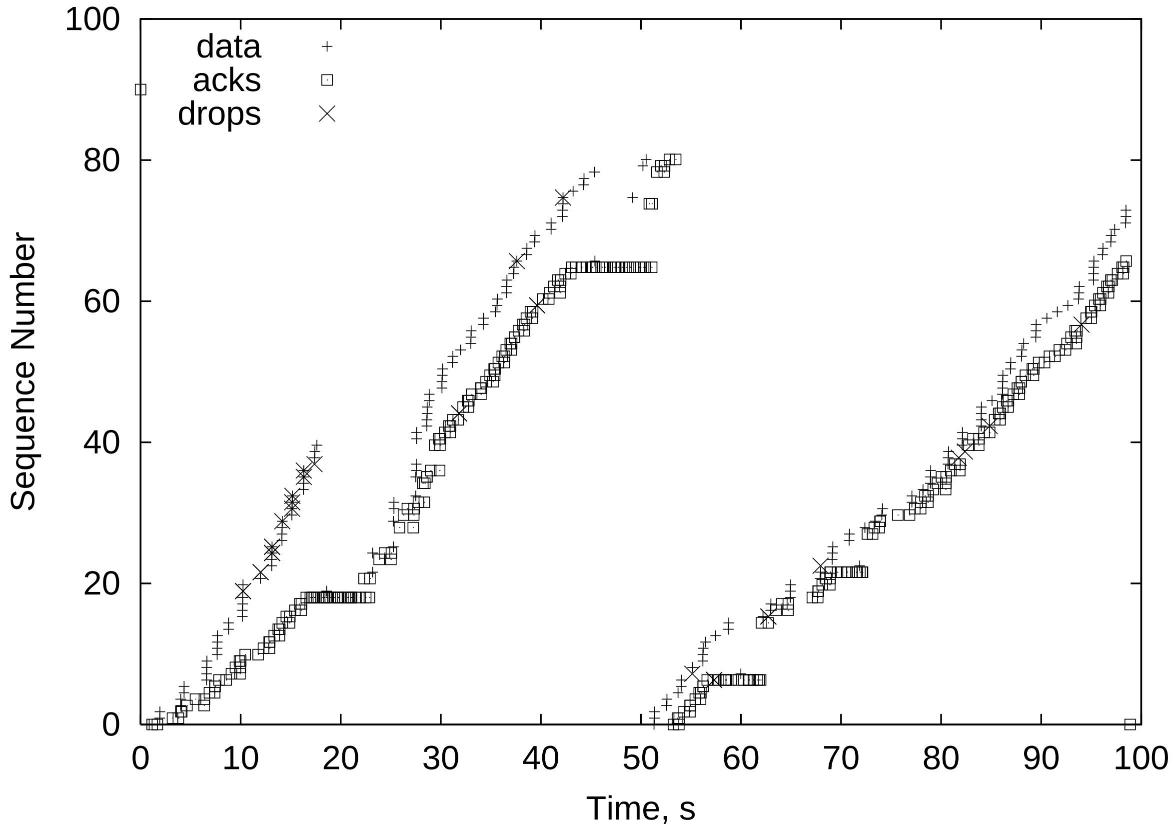

Figure 3: TCP over GPRS in poor radio conditions.

2.4 Mobility

In mobile conditions, handovers trigger delay spikes and some data are lost during a handover.

Add to the command in Section 2.1:

```
-vhoTarget gprs\# type of network after a handover
-vhoDelay 5 \ # duration of handover in seconds
-vhoLoss 0.5 # fraction of packets lost during a handover
```

The result is shown in Figure 4.

Reasonable range of parameters:
```
-vhoDelay 0-10 s
-vhoLoss 0-1
```

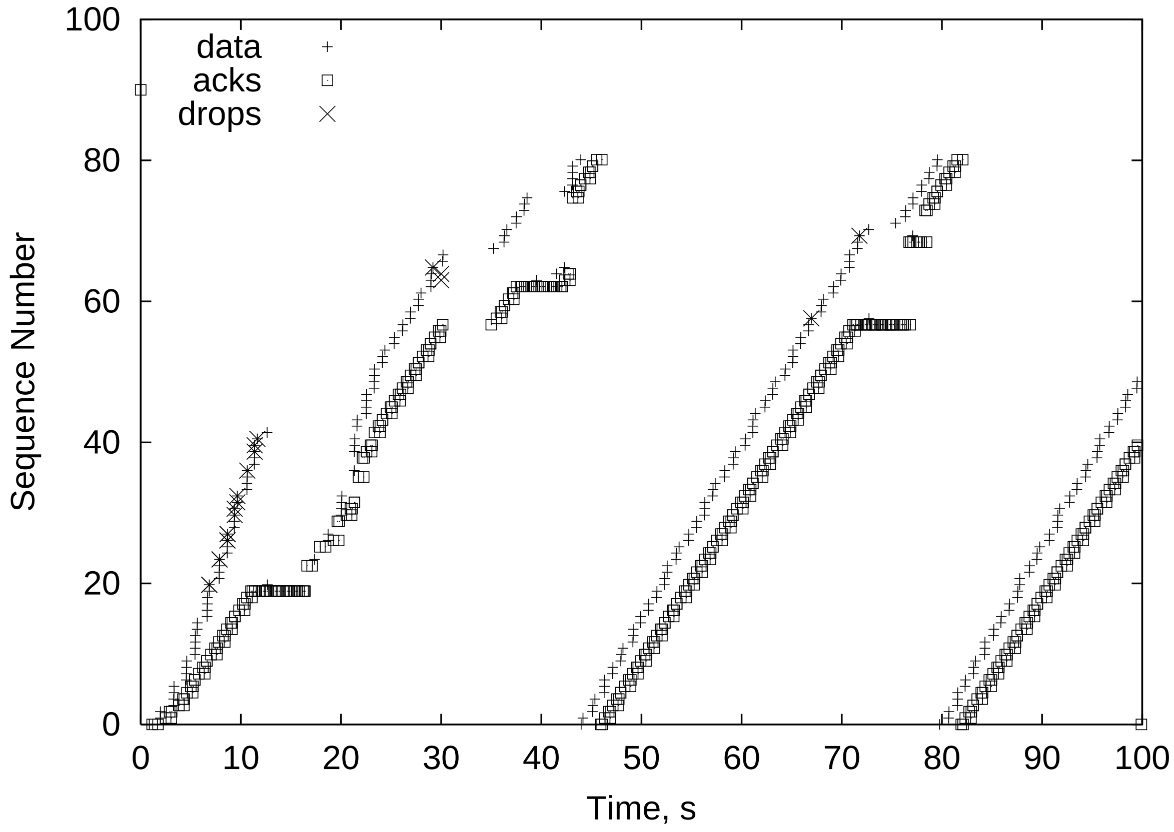

Figure 4: TCP over GPRS with mobility.

3 UMTS

UMTS uses transmission power control to keep the link retransmission rate at 10% in varying radio signal quality. Thus, it is reasonable to expect minor delay jitter at all times. However, in poor radio conditions delay jitter increases and packet losses are possible.

3.1 Good radio conditions

To run:

```
ns mtp.tcl -type umts \
-delayInt 'E(0.1)' \
-delayLen 'E(0.04)'
```

The result is shown in Figure 5.

Reasonable range of parameters:
`-delayInt 0.05-10`
`-delayLen 0-0.1`

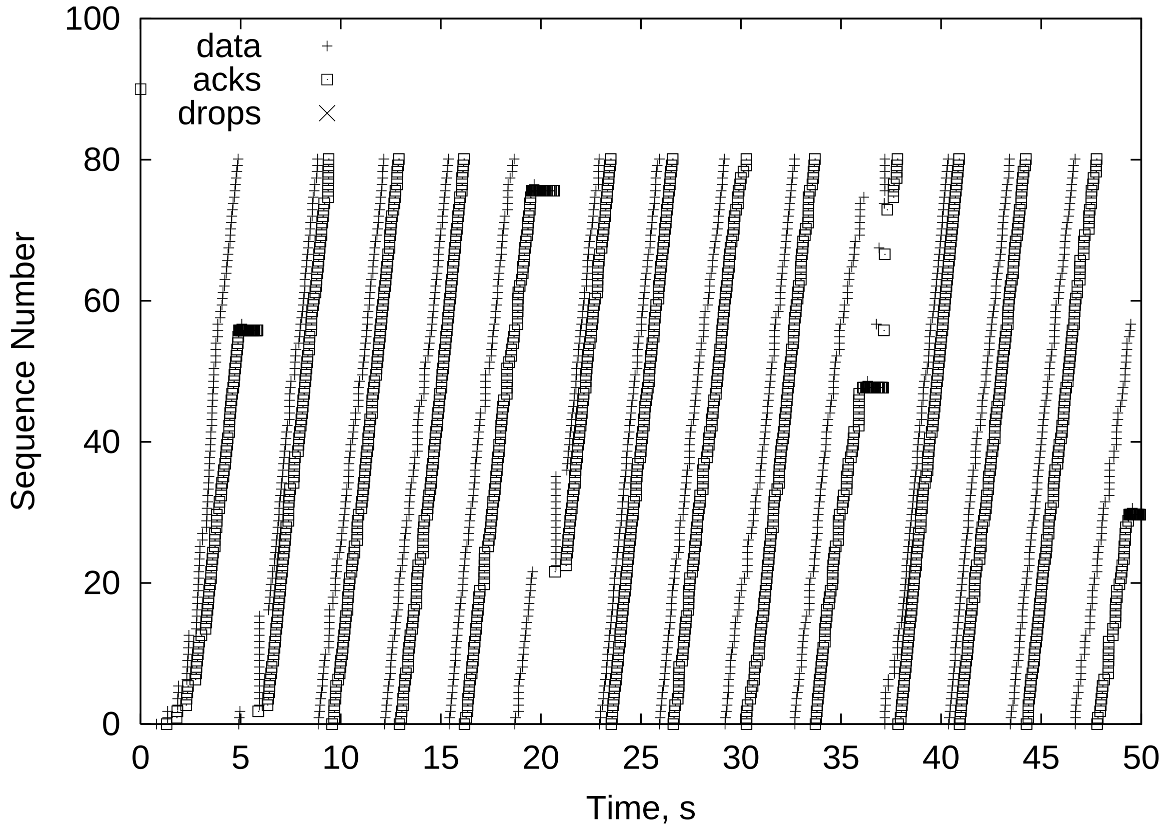

Figure 5: TCP over UMTS.

3.2 UMTS with bandwidth oscillation

When a UMTS network uses the HSDPA transmission mode, a high speed channel is switched between multiple users at some interval. However, every user is allocated a permanent slow channel.

To run:

```
ns mtp.tcl -type umts \
-delayInt 'E(0.1)' \
-delayLen 'E(0.04)' \
-bwLowLen 5 \ # length of a period of low bandwidth in sec
-bwHighLen 1 \ # length of period of high bandwidth in sec
-bwScale 10 # factor of high/low bandwidth
```

The result is shown in Figure 6.

Reasonable range of parameters:
```
-bwLowLen 2-10 s
-bwHighLen 0.5-2 s
-bwScale 2-20
```

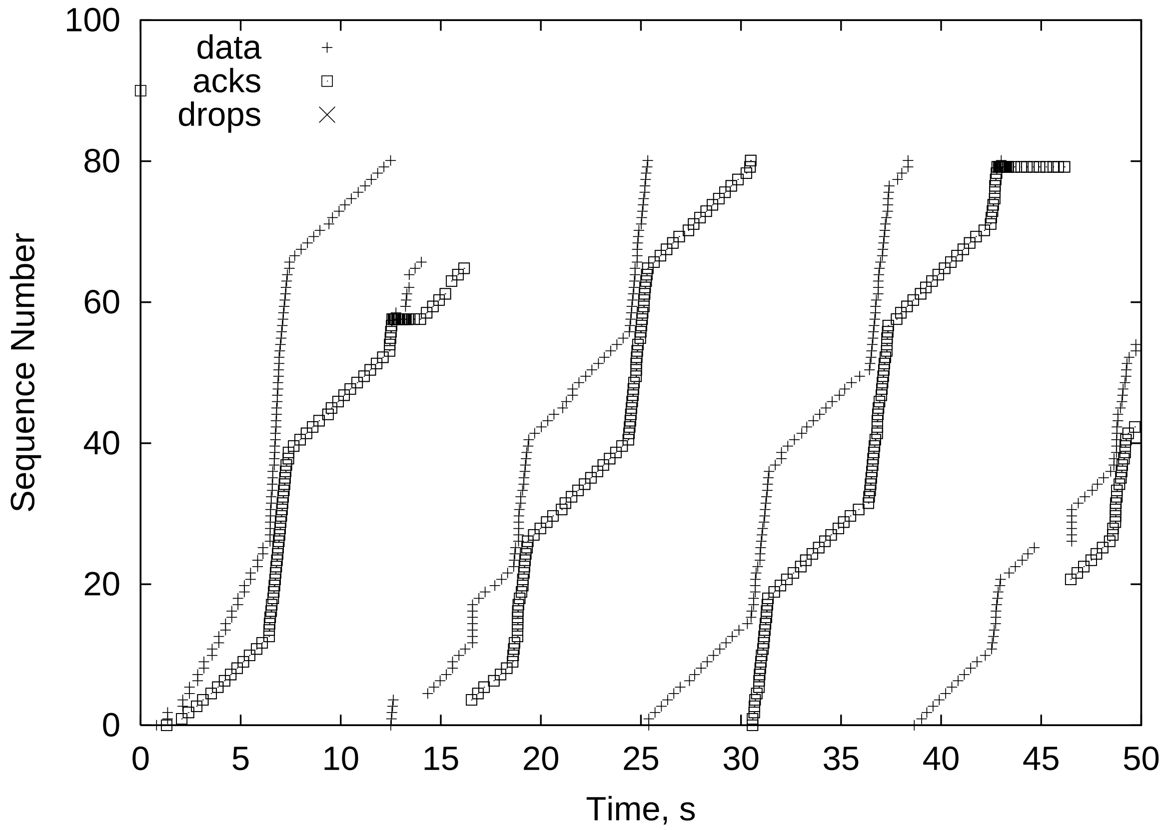

Figure 6: TCP over UMTS with bandwidth oscillation.

4 WLAN

4.1 Good radio conditions

In good radio conditions the sender and the receiver are close to each other. There is no significant delay variation nor losses.

To run:

```
ns mtp.tcl -type wlan_complex\
-bwDL 1Mb
```

The result is shown in Figure 7.

Reasonable range of parameters:
`-bwDL 1-11 Mb`

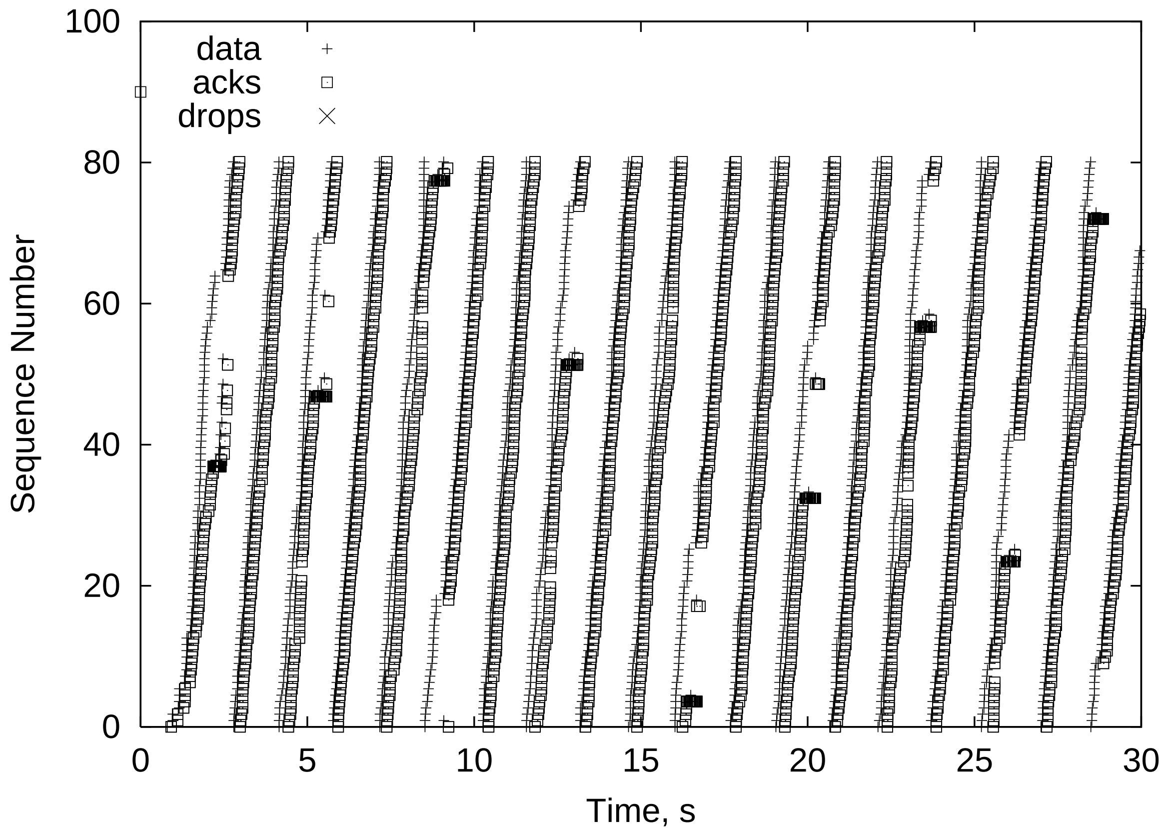

Figure 7: TCP over WLAN.

4.2 Moderate radio conditions

In this scenario, the distance between WLAN nodes is large and the radio link should deteriorate. However, there is practically no difference in results compared to the case when the distance is short.

To run:

```
ns mtp.tcl -type wlan_complex \
-nodeDist 250
```

The result is shown in Figure 8.

Reasonable range of parameters:
`-nodeDist 50-300`

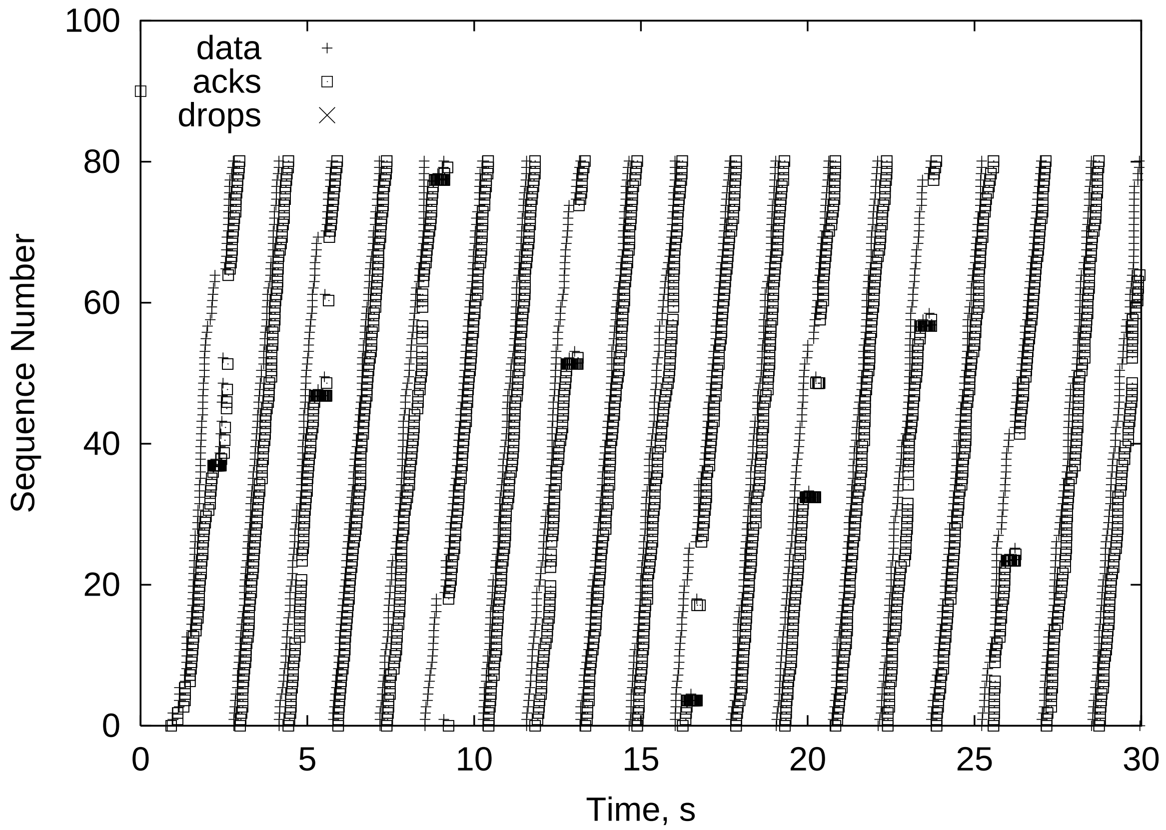

Figure 8: TCP over WLAN in poor radio conditions.

5 GEO Satellite

5.1 Good radio conditions

In good radio conditions, a satellite link is error-free and has no delay variation nor reordering.

To run:

```
ns mtp.tcl -type geo
```

The result is shown in Figure 9.

Reasonable range of parameters:
`-bwUL 64 kb`
`-bwDL 128-720 kb`

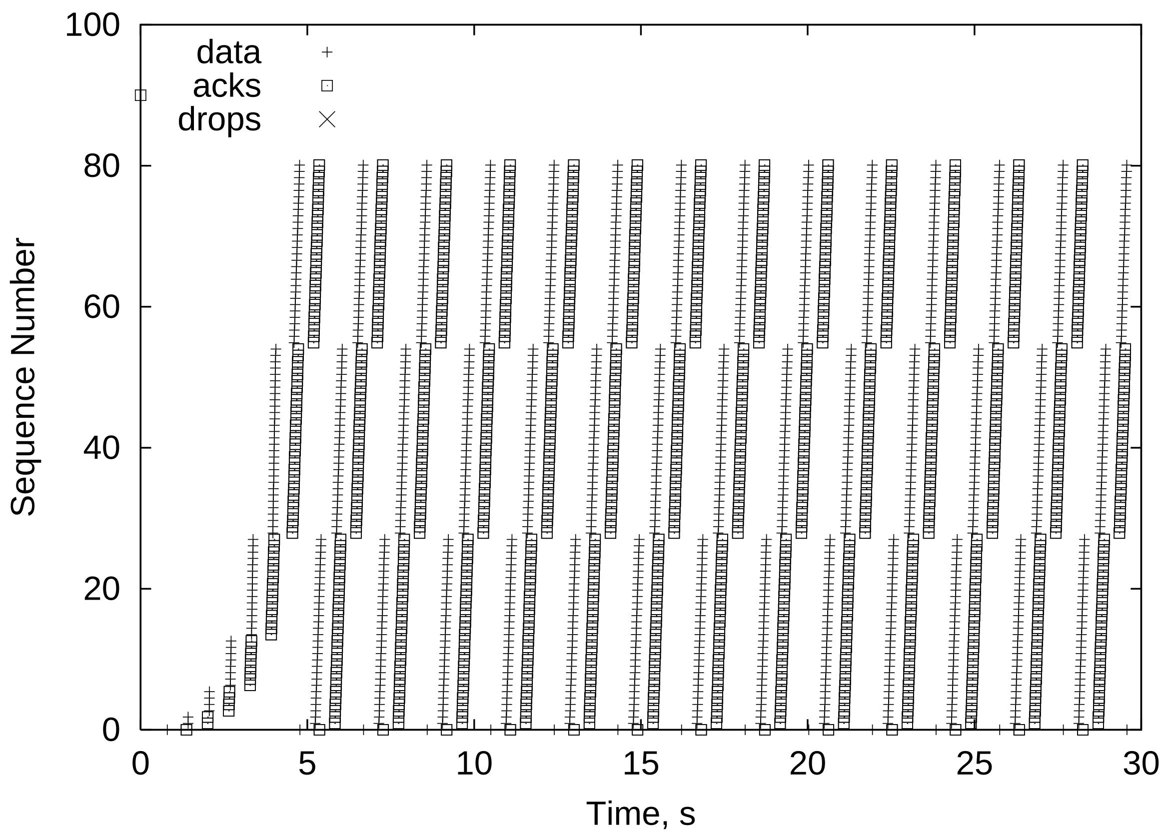

Figure 9: TCP over GEO.

5.2 Moderate radio conditions

This scenario is for a satellite link that retransmits lost packets without preserving in-order delivery. In moderate radio conditions reordering rate is infrequent, reordering length corresponds to RTT of the link.

To run:

```
ns mtp.tcl -type geo \
-reorderLen 0.5 \ # reordering delay in sec
-reorderRate 0.1 # per-packet reordering rate
```

The result is shown in Figure 10.

Reasonable range of parameters:
`-reorderLen 0.5-0.6 s`
`-reorderRate 0.01-0.2`

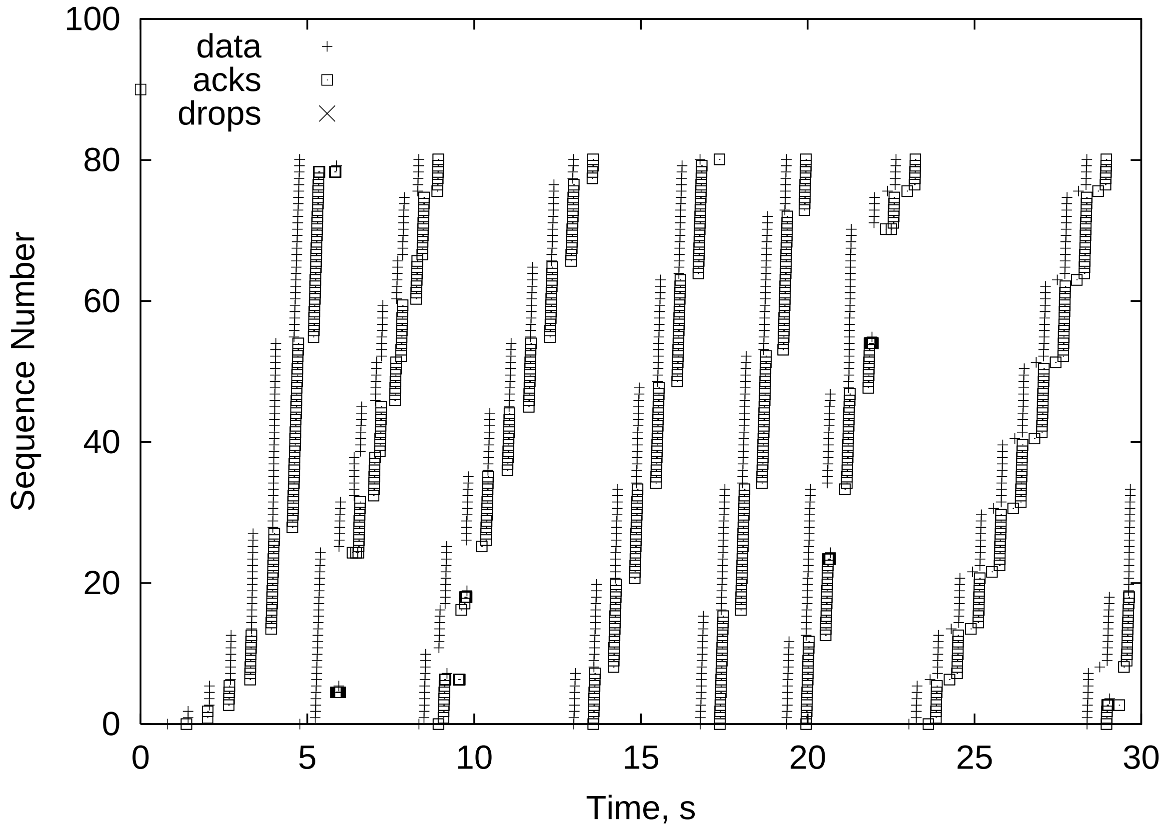

Figure 10: TCP over GEO with reordering.

6 Future Work

It would be interesting to consider different traffic mixes and topologies.

Acknowledgements

This work was done with Sally Floyd.

References

[1] A. Gurtov and S. Floyd. Modeling wireless links for transport protocols. To appear in ACM CCR, Sept. 2003.