Wave Front Sensor Simulator

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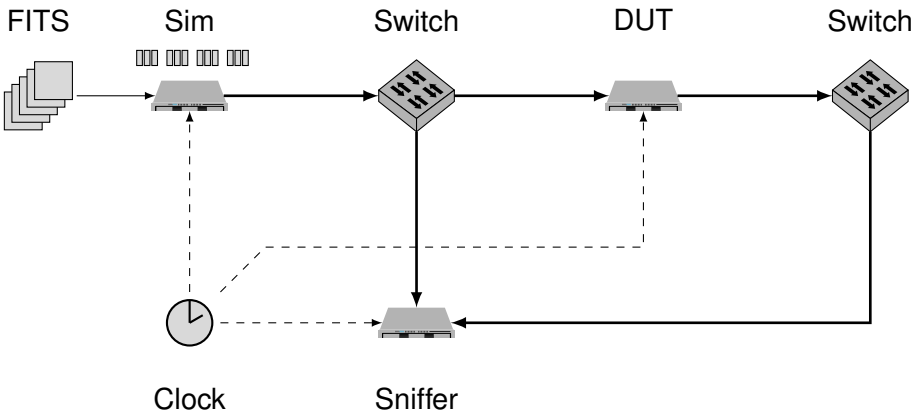
About

- Packet generator for WFS-like traffic with accurate timing
- Application:
  - Simulation of camera output, FPGA
  - Test and benchmarking of RTCs
- Input: FITS cube, readout timing (duration, rate)
- Output: pixels encapsulated in MUDPI/RTMS
- Technology:
  - DPDK with Intel X710 or X520 10 GbE NIC
  - Wireshark dissectors and GNU Octave/Matlab for analysis

Typical Lab Setup



Config Summary

Behaviour

- Image period, µs
- Readout duration, µs
- Playback strategy: loop, back-and-forth, . . .
- Stop condition: `SIGINT/-TERM`, # samples, # seconds

Protocols

- Ethernet: dest, MTU (jumbo frames)
- IP: src, dest, TTL
- UDP: src, dest, checksum on/off
- MUDPI: topic, component, tag, checksum on/off
- RTMS: leading/trailing padding, pad byte value
- Data: payload size (pixels), endianess

Limitations of the Prototype

General

- Complicated DPDK setup
- Simulation duration: all packets must fit into RAM

Timing example: LVSM, $t_{\text{readout}} = 1.4$ ms, $f = 500$ Hz, (800 uint16_t)^2

- Same interval between packets (start-to-start) within a sample
- Jitter: $\sigma \approx 1.15$ µs ($\sigma_{\text{leader}} \approx 0.69$ µs, $\sigma_{\text{payload}} \approx 0.61$ µs, $\sigma_{\text{trailer}} \approx 0.82$ µs)
- Latency depends on packet size (CPU-to-NIC DMA latency, PCIe packet size)
- Occasional ($\approx \frac{1}{2\,\text{s}}$) packet delay by $\approx +50$ µs

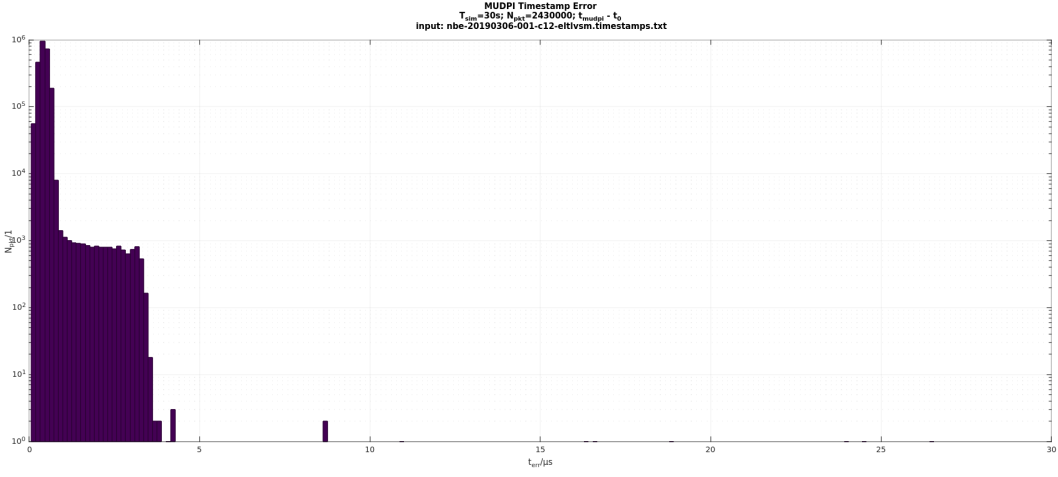
Protocols

- MUDPI time stamp: seconds in UTC instead of TAI (!)
- RTMS: no window support (ext. info)
- No error support: no random checksum errors, invalid fields, ...

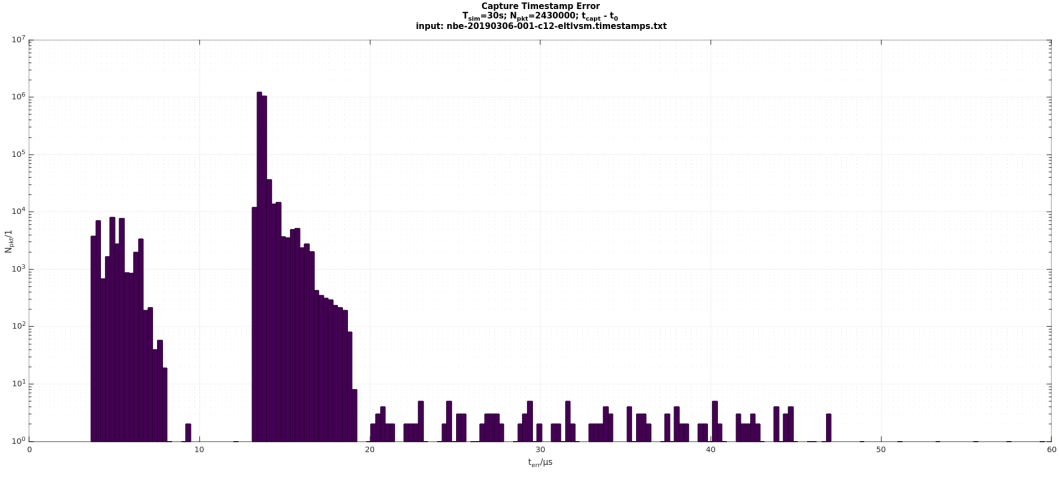
Backup

```
> cat lvsmsim/eltlvsm.conf
ip-src=192.168.4.24
ip-dst=239.0.4.24

udp-src=9090
udp-dst=5500

image-period=2000
readout=1400
> sudo ./build/lvsmsim/lvsmsim \
  -v --socket-mem=256,512 -l2,4 --file-prefix lvsm -- \
  --conf lvsmsim/eltlvsm.conf --input LVSMImageCube.fits \
  --payload-size=4000 --samples $((500*30))
```

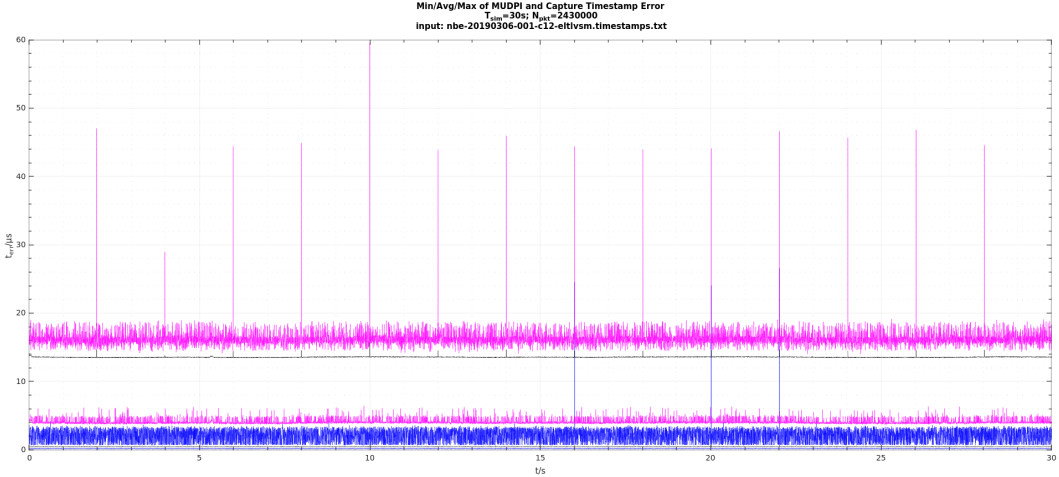
Backup


MUDPI Timestamp Error
T_sim=30s; N_obs=2430000; t_mudpi - t_0
input: nbe-20190306-001-c12-eltlvsm.timestamps.txt
N_tot/1
t_err/µs
10^0
10^1
10^2
10^3
10^4
10^5
10^6
0
5
10
15
20
25
30

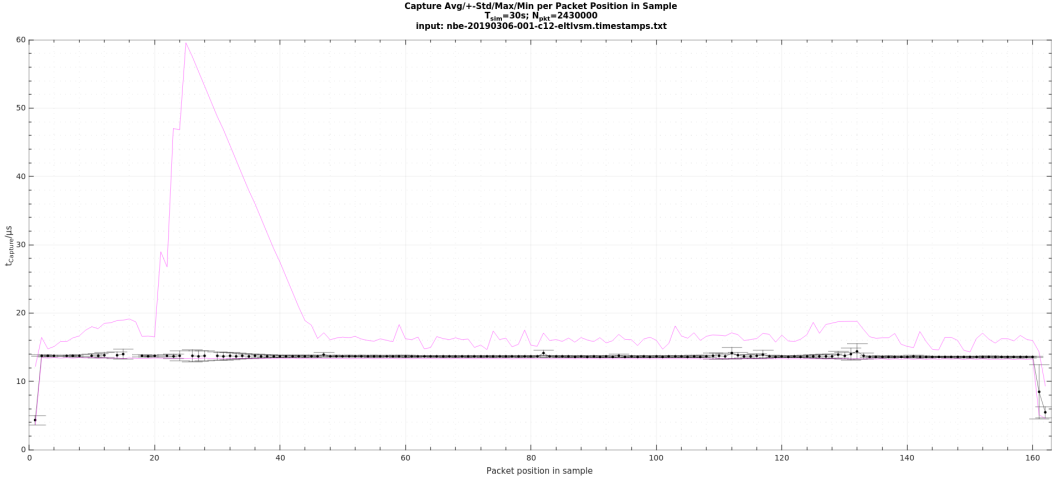
Backup


Capture Timestamp Error
T_sim=30s; N_pkt=2430000; t_caps - t_0
input: nbe-20190306-001-c12-eltivsm.timestamps.txt
N_pkt/1
t_err/µs
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
0
10
20
30
40
50
60

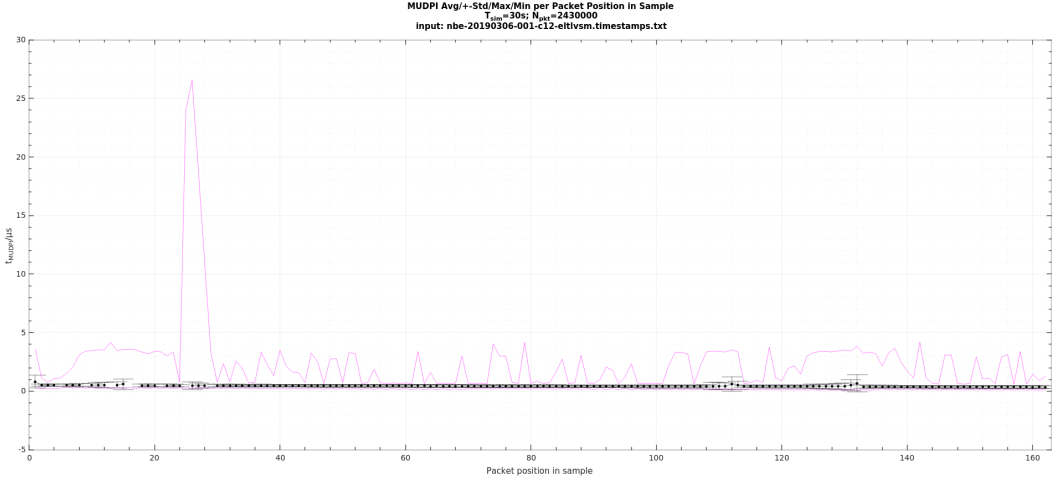
Backup


Min/Avg/Max of MUDPI and Capture Timestamp Error
T_sim=30s; N_pkt=2430000
input: nbe-20190306-001-c12-eltivsm.timestamps.txt
t_e/µs
t/s
0
10
20
30
40
50
60
0
5
10
15
20
25
30

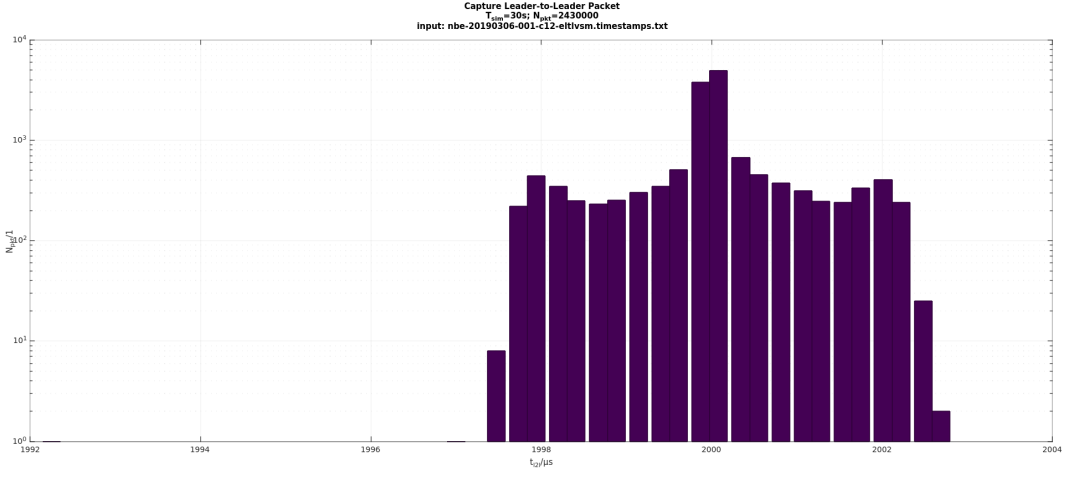
Backup


Capture Avg/+-Std/Max/Min per Packet Position in Sample
T_sim=30s; N_pkt=2430000
input: nbe-20190306-001-c12-eltlvsm.timestamps.txt
t_capture/µs
Packet position in sample
0
10
20
30
40
50
60
0
20
40
60
80
100
120
140
160

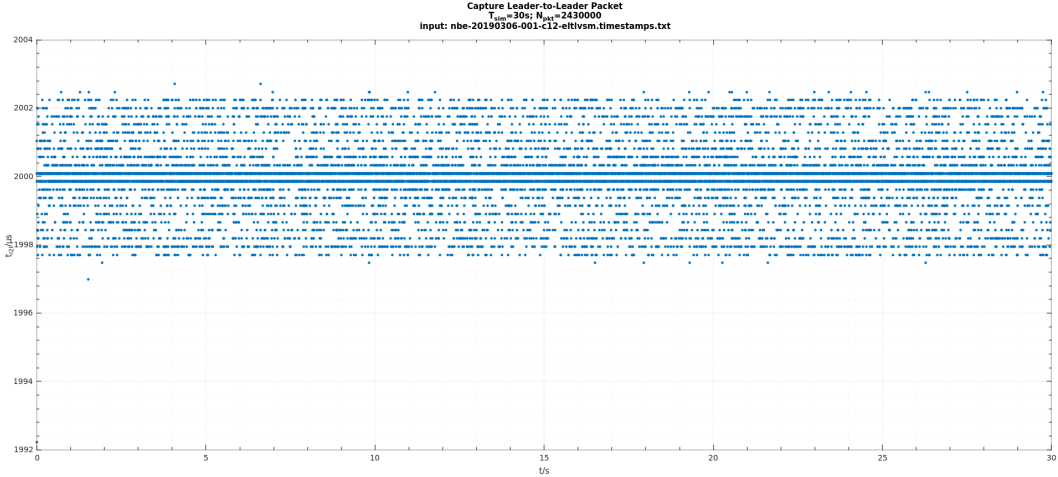
Backup


MUDPI Avg/+-Std/Max/Min per Packet Position in Sample
T_Sim=30s; N_pkt=2430000
input: nbe-20190306-001-c12-eltivsm.timestamps.txt
t_MUDPI/µS
Packet position in sample
30
25
20
15
10
5
0
-5
0
20
40
60
80
100
120
140
160

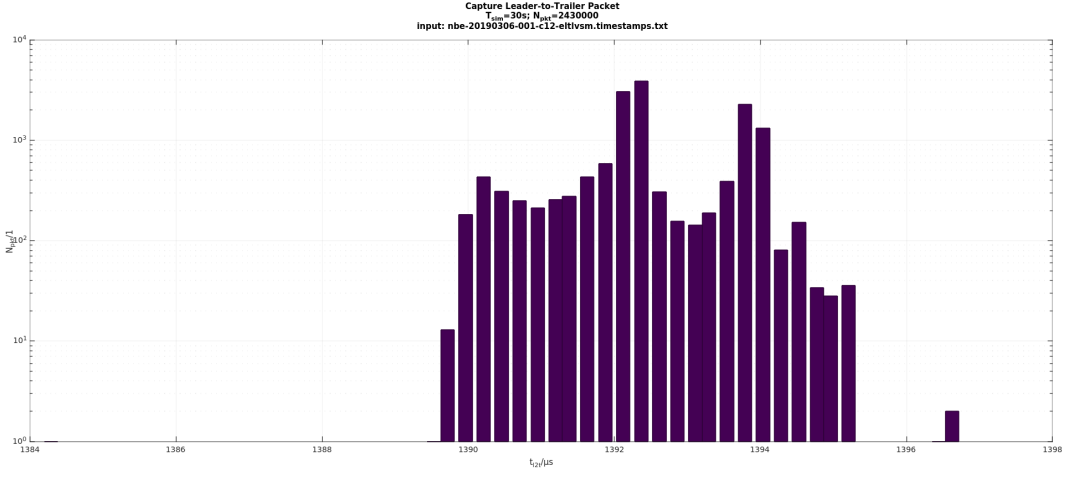
Backup


Capture Leader-to-Leader Packet
T_sim=30s; N_pkt=2430000
input: nbe-20190306-001-c12-eltlvsm.timestamps.txt
10^4
10^3
10^2
10^1
10^0
N_pkt/1
1992
1994
1996
1998
2000
2002
2004
t_c2/µs

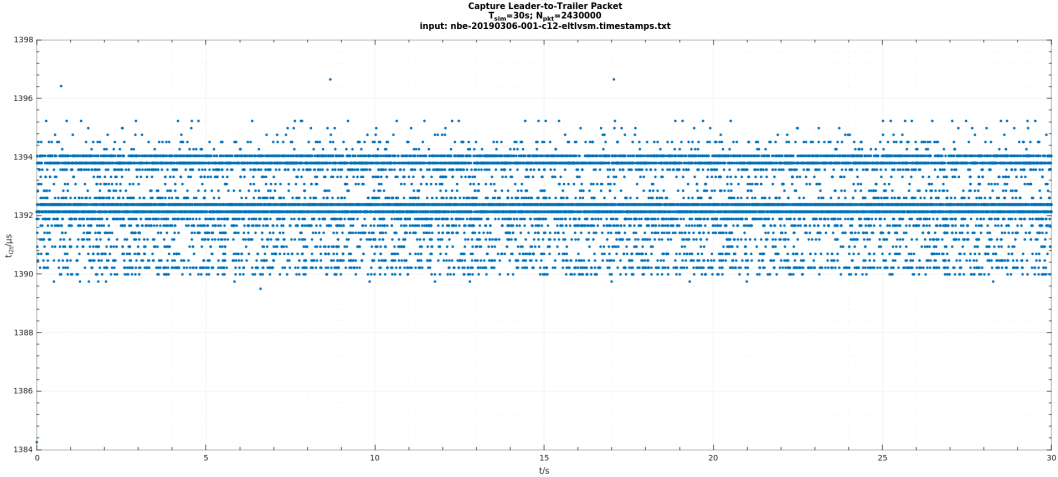
Backup


Capture Leader-to-Leader Packet
t_{plot}=30s; N_{pkt}=2430000
input: nbe-20190306-001-c12-eltlvsm.timestamps.txt
2004
2002
2000
1998
1996
1994
1992
t_{ld}/us
0
5
10
15
20
25
30
t/s

Backup


Capture Leader-to-Trailer Packet
T_sim=30s; N_pkt=2430000
input: nbe-20190306-001-c12-eltivsm.timestamps.txt
N_pkt/1
t_i2i/µs
10^0
10^1
10^2
10^3
10^4
1384
1386
1388
1390
1392
1394
1396
1398

Backup


Capture Leader-to-Trailer Packet
τ_{sim}=30s; N_{pkt}=2430000
input: nbe-20190306-001-c12-eltlvsm.timestamps.txt
1398
1396
1394
1392
1390
1388
1386
1384
τ_{ltt}/µs
0
5
10
15
20
25
30
t/s