

PTPD Characterization of PicoZed Units

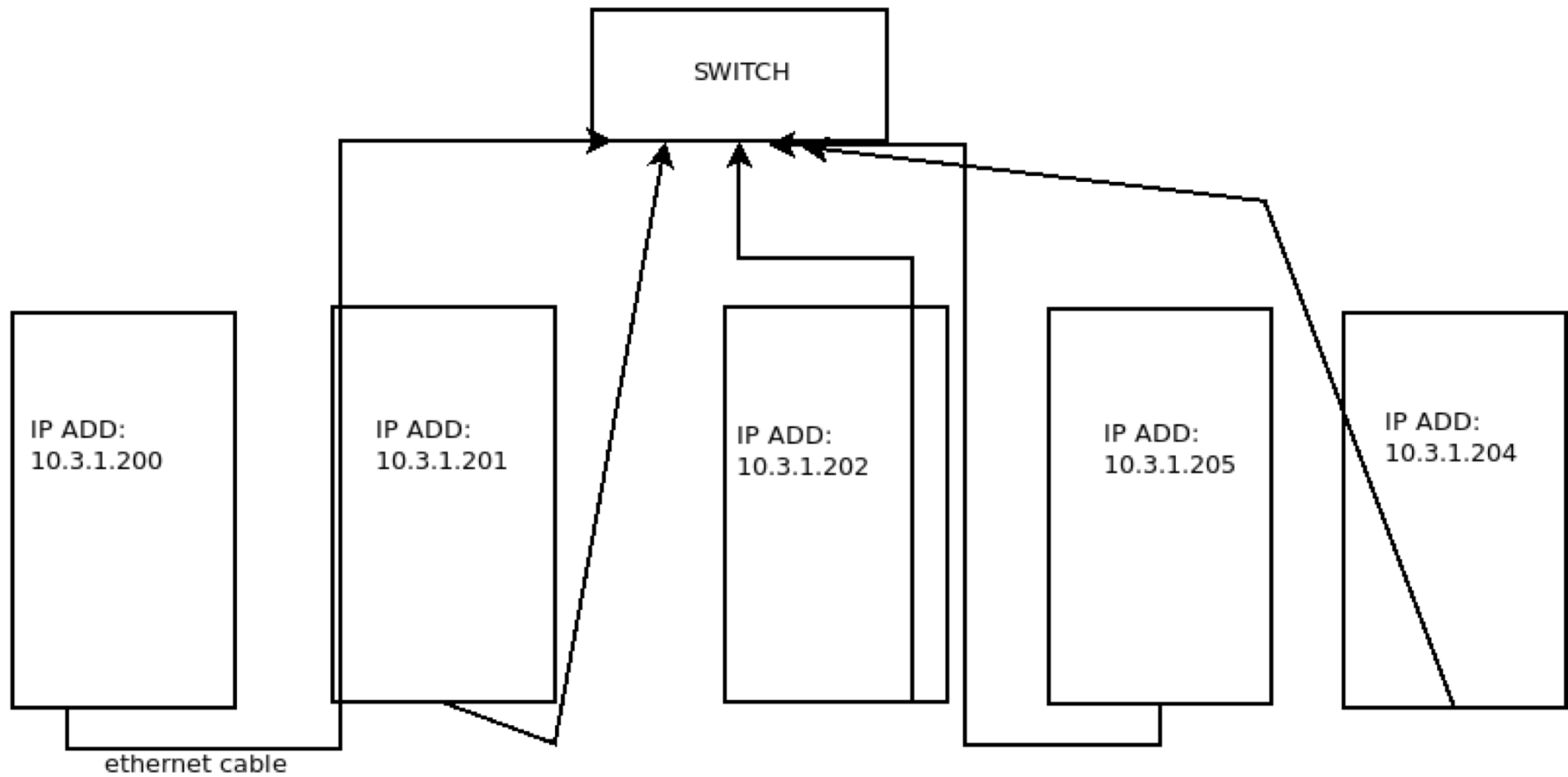
by Mary

Overview

- Purpose: initiate a ptpd synchronization process across 4 PicoZed units
- Collect offset data for time intervals
- Gather & analyze statistics of offset for each clock to demonstrate performance

Hardware Configuration

- Each PicoZed consists of an SOM and FMC Carrier Card
- The SD chip is attached to the unit, and each PicoZed unit is connected to a common switch through ethernet cable
- Each PicoZed unit is also connected to power supply
- IP addresses of each unit: 10.3.1.200, 10.3.1.201, 10.3.1.202, 10.3.1.205, 10.3.1.204



Procedure

- Through ptpd, set up 1 master and 3 slaves from the PicoZed units
- Ran synchronization across the 4 nodes through linuxptp for three different time intervals: 30 min, 1 hr, and 2 hrs; stored data in files (accomplished through bash scripts)
- Extracted offset data for each experiment and derived visual/summary statistics through python script

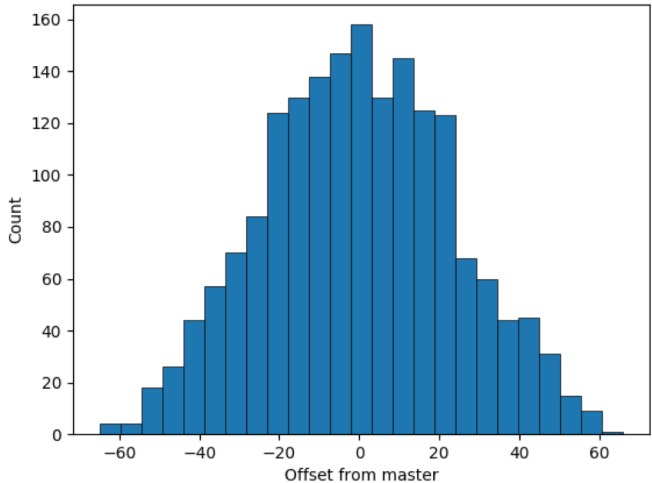
Results

- Plotted histograms, scatter plots, and line plots for each interval and each PicoZed unit (indicated by IP address)
- Also reported summary statistics for mean, mode, standard deviation, and RMS error for each interval & PicoZed unit

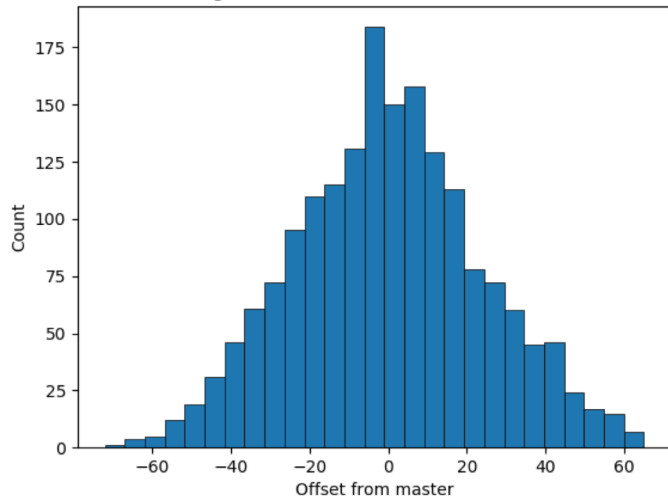
Visual Analysis

Histograms for 30 min interval

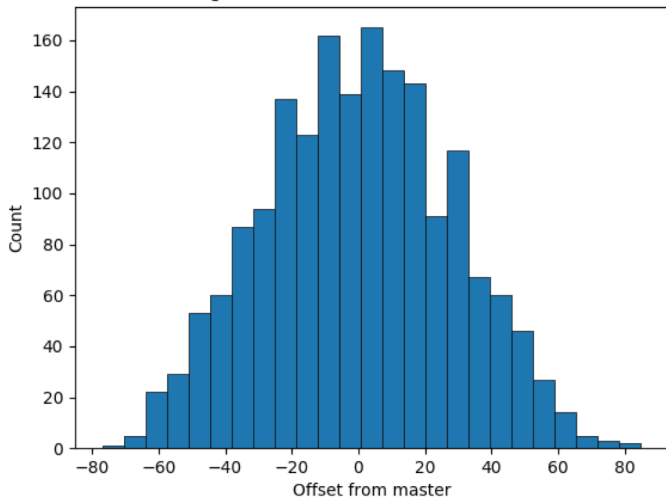
Histogram of offsets for 10.3.1.200, 30min



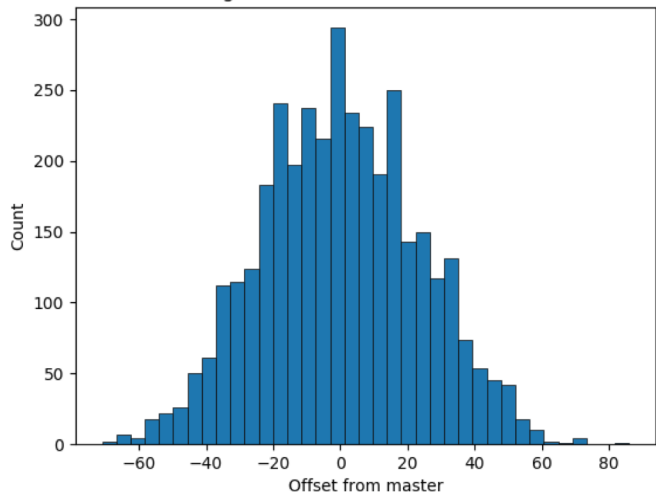
Histogram of offsets for 10.3.1.202, 30min



Histogram of offsets for 10.3.1.204, 30min

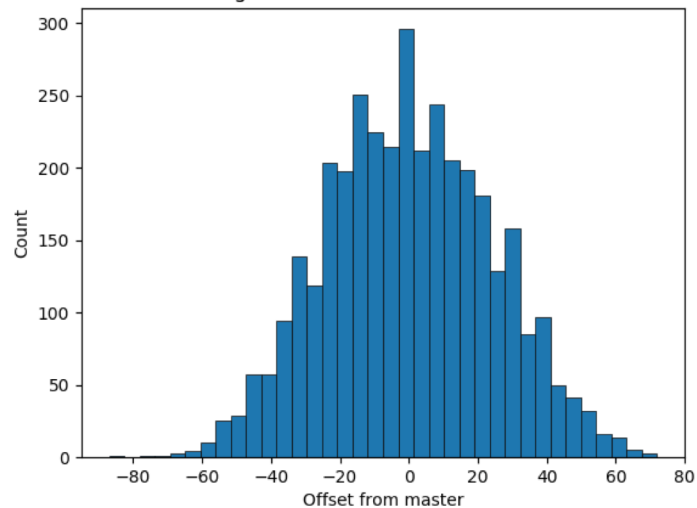


Histogram of offsets for 10.3.1.200, 1hr

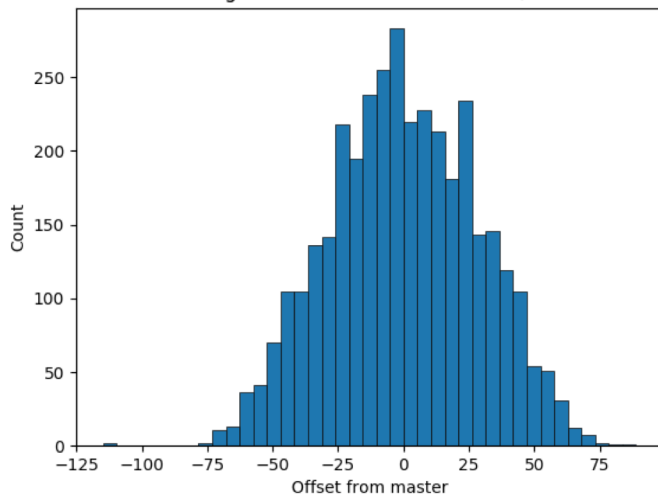


Histograms for 1 hr interval

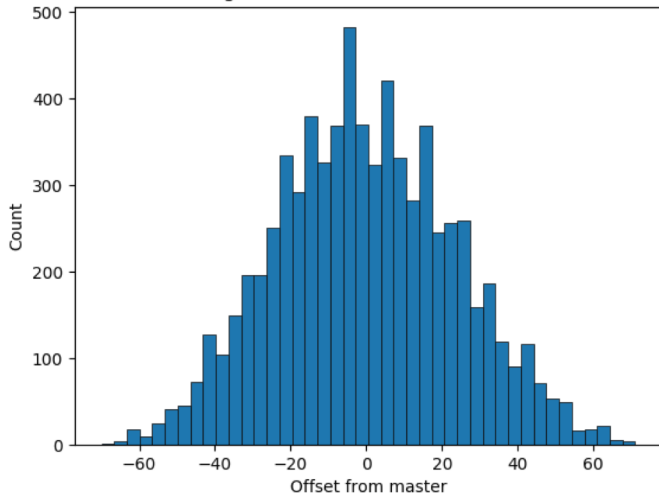
Histogram of offsets for 10.3.1.202, 1hr



Histogram of offsets for 10.3.1.204, 1hr

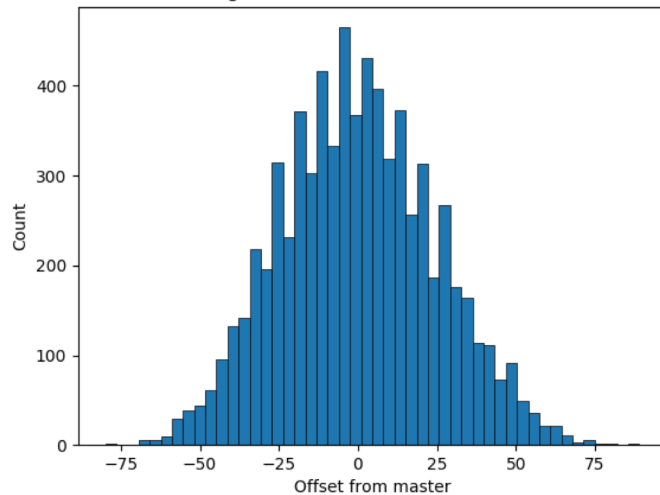


Histogram of offsets for 10.3.1.200, 2hr

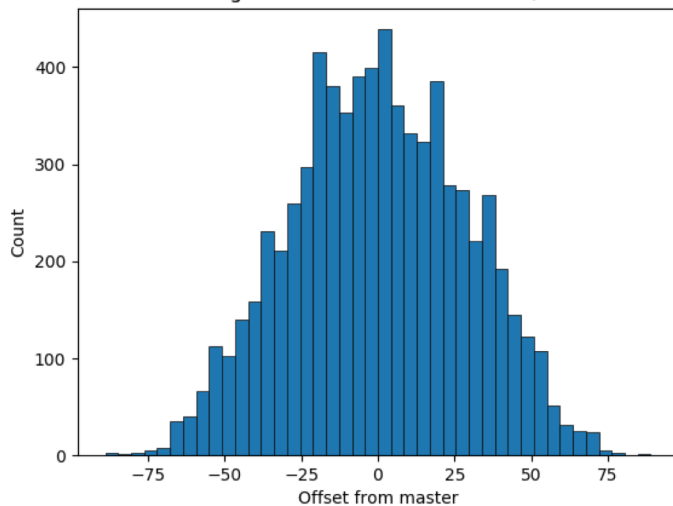


Histograms for 2 hr interval

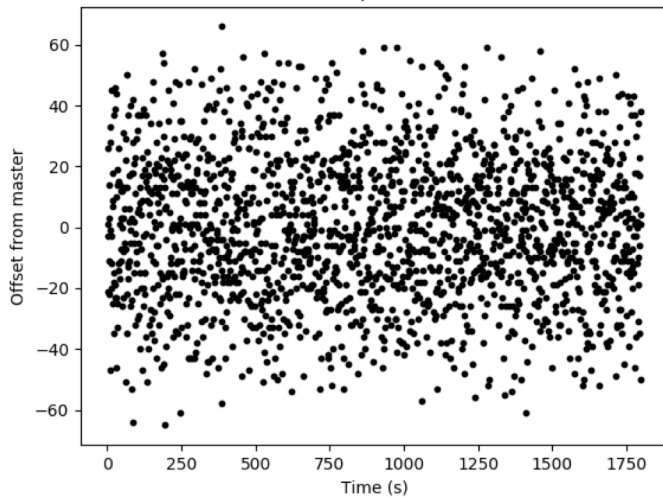
Histogram of offsets for 10.3.1.202, 2hr



Histogram of offsets for 10.3.1.204, 2hr

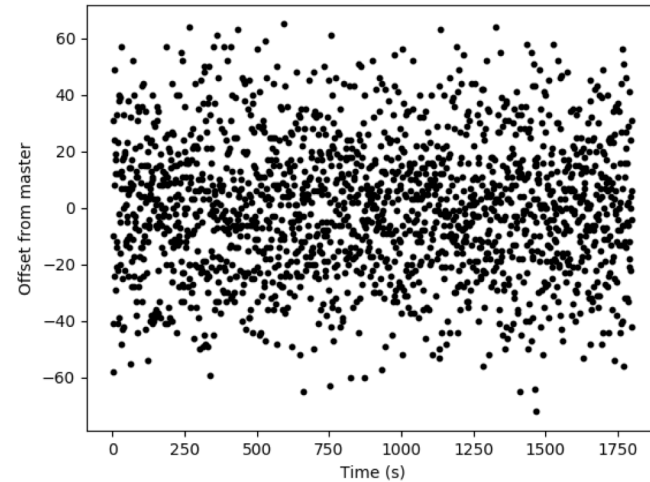


Offset vs. Time (scatter plot) for 10.3.1.200, 30min

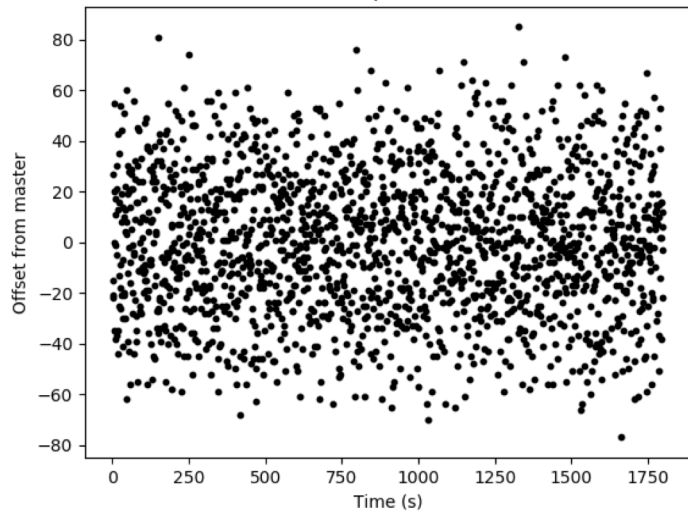


Scatter plots for 30 min interval

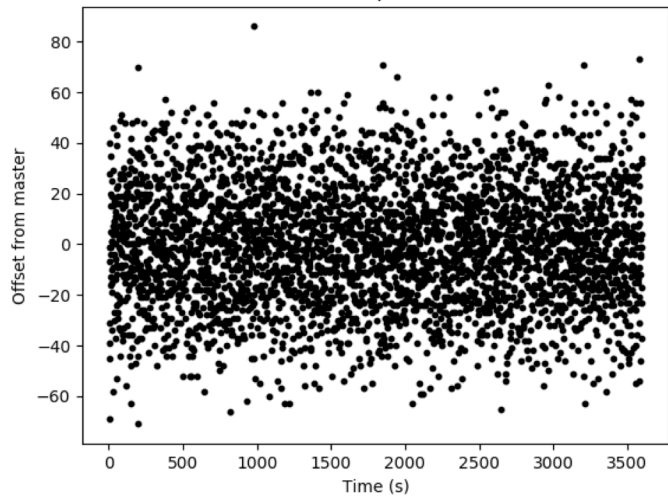
Offset vs. Time (scatter plot) for 10.3.1.202, 30min



Offset vs. Time (scatter plot) for 10.3.1.204, 30min

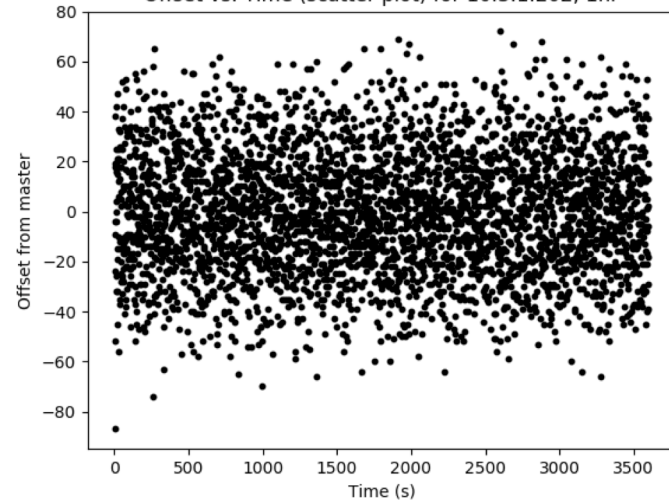


Offset vs. Time (scatter plot) for 10.3.1.200, 1hr

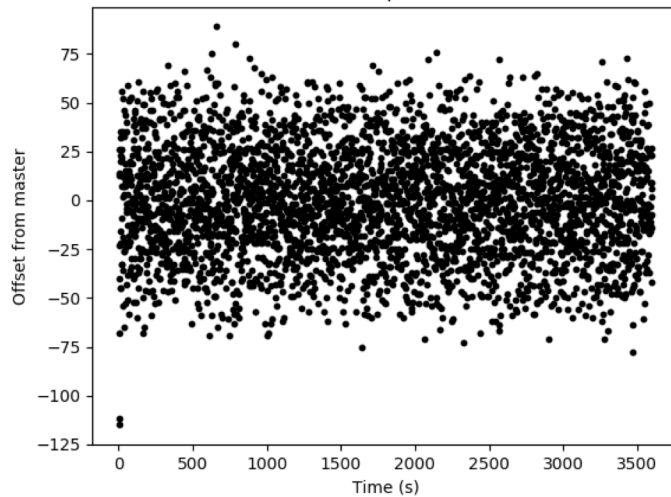


Scatter plots for 1 hr interval

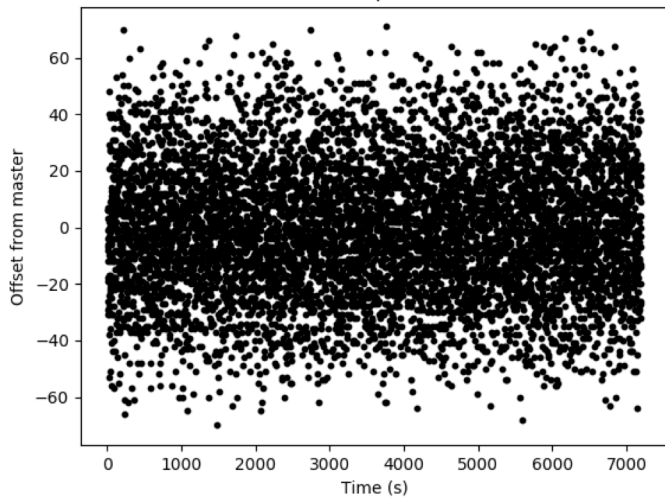
Offset vs. Time (scatter plot) for 10.3.1.202, 1hr



Offset vs. Time (scatter plot) for 10.3.1.204, 1hr

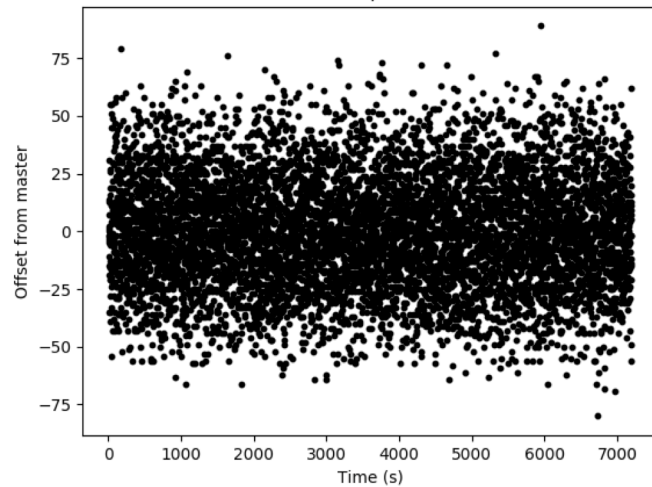


Offset vs. Time (scatter plot) for 10.3.1.200, 2hr

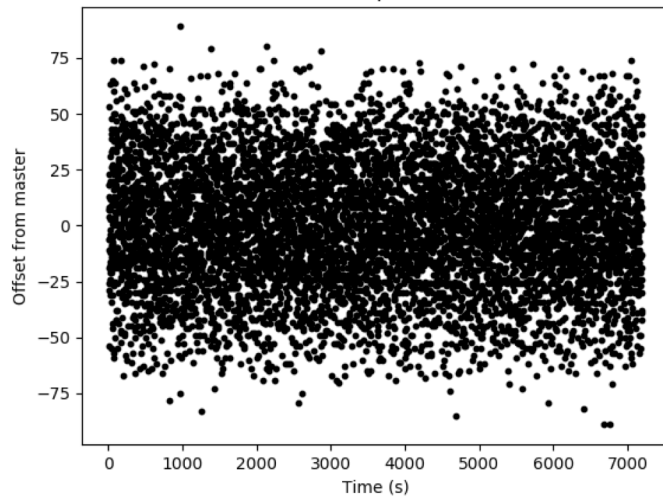


Scatter plots for 2 hr interval

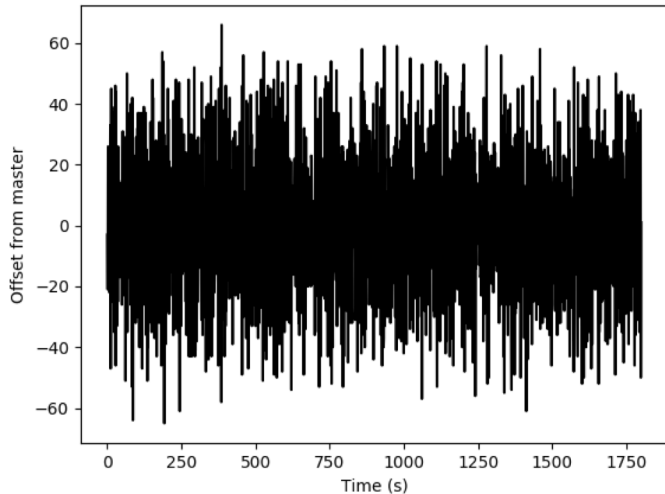
Offset vs. Time (scatter plot) for 10.3.1.202, 2hr



Offset vs. Time (scatter plot) for 10.3.1.204, 2hr

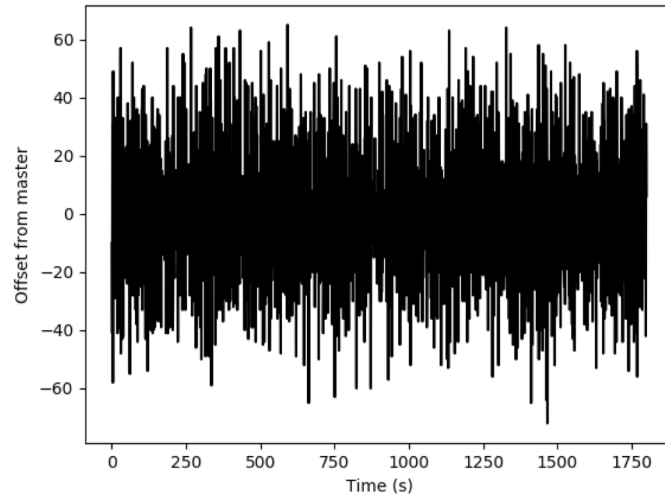


Offset vs. Time (line plot) for 10.3.1.200, 30min

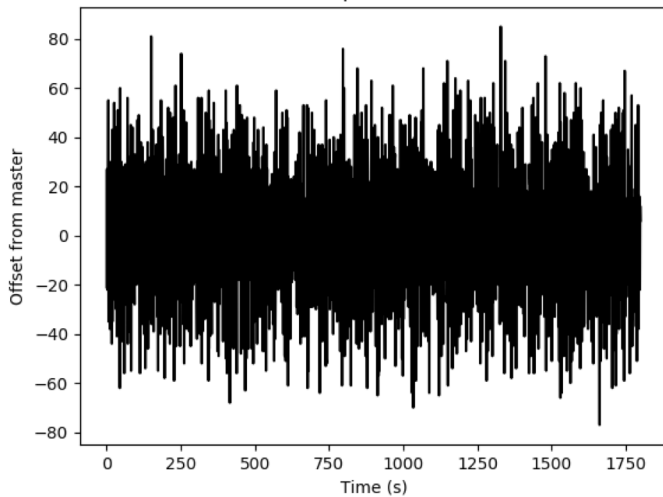


Line plots for 30 min interval

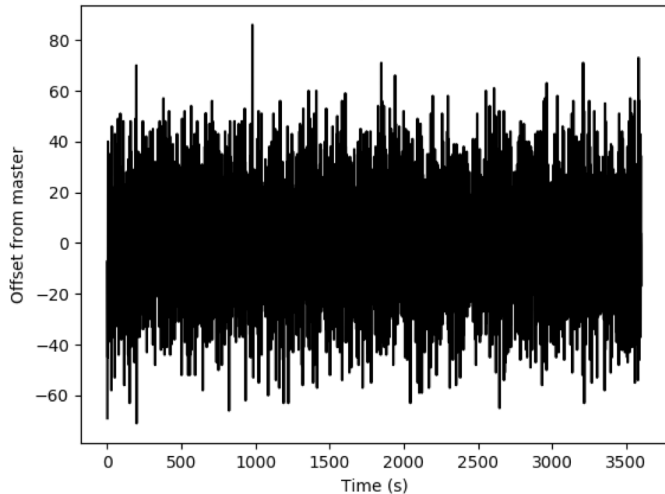
Offset vs. Time (line plot) for 10.3.1.202, 30min



Offset vs. Time (line plot) for 10.3.1.204, 30min

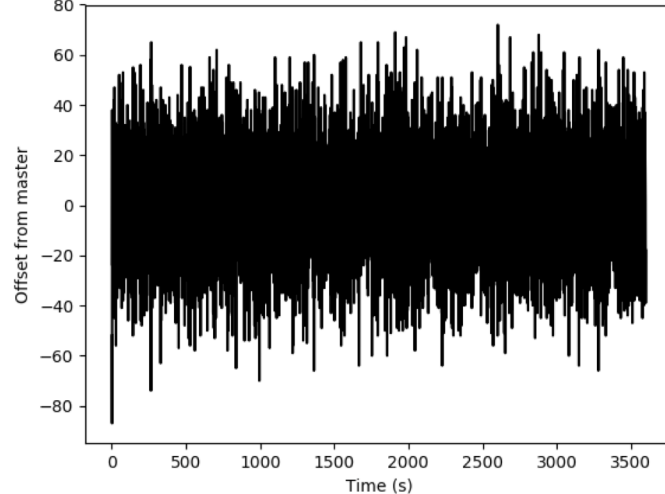


Offset vs. Time (line plot) for 10.3.1.200, 1hr

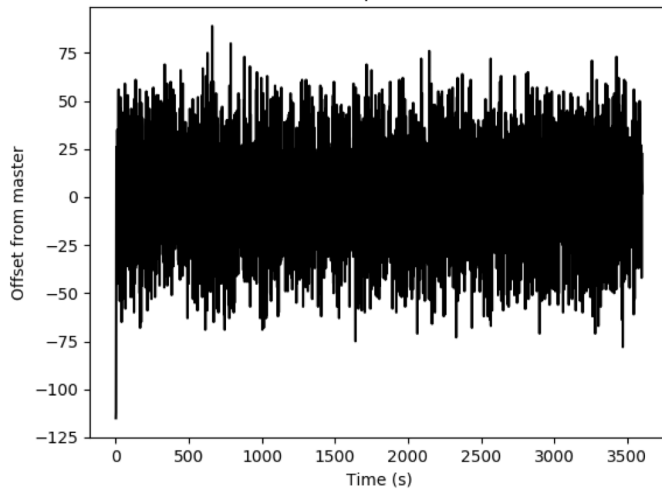


Line plots for 1 hr interval

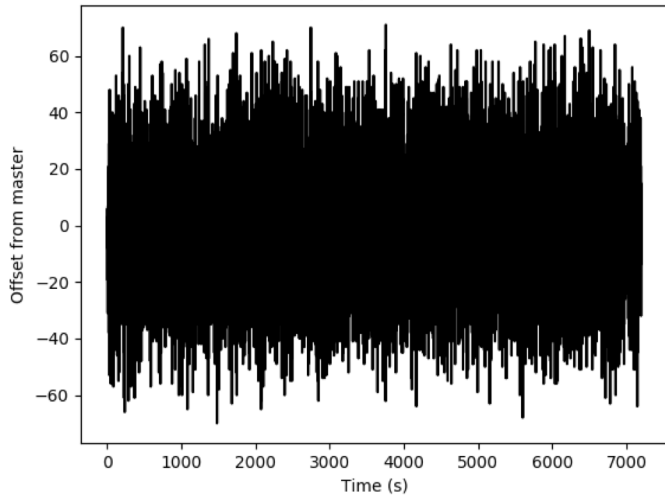
Offset vs. Time (line plot) for 10.3.1.202, 1hr



Offset vs. Time (line plot) for 10.3.1.204, 1hr

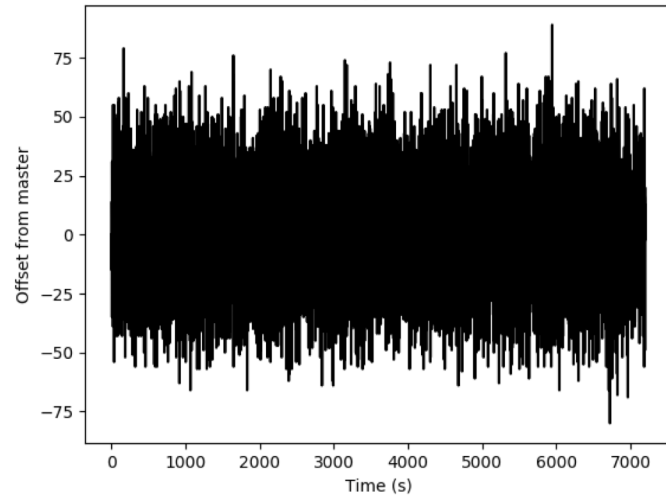


Offset vs. Time (line plot) for 10.3.1.200, 2hr

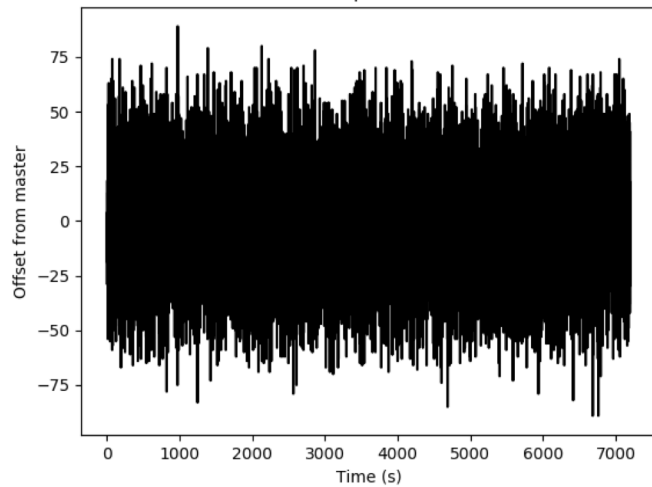


Line plots for 2 hr interval

Offset vs. Time (line plot) for 10.3.1.202, 2hr



Offset vs. Time (line plot) for 10.3.1.204, 2hr



Graph analysis

- Approaches normal distribution
- Histograms appear symmetric and displays little skew
 - Exception: 10.3.204 had more positive values for the 1 hr time interval
- Slight skew toward negative side; peak tends to left of 0
- Range appears to be lowest for 10.3.1.200
- Note PicoZed 10.3.1.204 has a significant outlier around -115 for the 1 hr interval; this is because the timer had started just as the PicoZed settled into synchronization, and this was the first value recorded

Summary Statistics

30min Time Interval

Picozed IP Address:
10.3.1.200

Mean offset: -
0.12388888888888889

Std Deviation:
23.796047439972714

2 Std Deviations:
47.59209487994543

Mode: 13.0

RMSE: 0.351978534699

Picozed IP Address:
10.3.1.202

Mean offset: -0.04

Std Deviation:
23.94917210352885

2 Std Deviations:
47.8983442070577

Mode: 3.0

RMSE: 0.2

Picozed IP Address:
10.3.1.204

Mean offset: -
0.03388888888888889

Std Deviation:
28.22732061887893

2 Std Deviations:
56.45464123775786

Mode: -8.0

RMSE: 0.184089350286

1hr Time Interval

Picozed IP Address:

10.3.1.200

Mean offset: -

0.034722222222222224

Std Deviation:

23.557121238257245

2 Std Deviations:

47.11424247651449

Mode: -11.0

RMSE: 0.186338998125

Picozed IP Address:

10.3.1.202

Mean offset: -

0.06027777777777778

Std Deviation:

24.188587298112203

2 Std Deviations:

48.37717459622441

Mode: -5.0

RMSE: 0.245515331044

Picozed IP Address:

10.3.1.204

Mean offset: -0.1175

Std Deviation:

28.307494578389583

2 Std Deviations:

56.61498915677917

Mode: -8.0

RMSE: 0.34278273002

2hr Time Interval

Picozed IP Address:
10.3.1.200

Mean offset: -
0.3597222222222222

Std Deviation:
23.799545745677946

2 Std Deviations:
47.59909149135589

Mode: -4.0

RMSE: 0.599768473848

Picozed IP Address:
10.3.1.202

Mean offset: -
0.11583333333333333

Std Deviation:
24.453786899987495

2 Std Deviations:
48.90757379997499

Mode: -2.0

RMSE: 0.340342964278

Picozed IP Address:
10.3.1.204

Mean offset:
0.08388888888888889

Std Deviation:
28.444730353380802

2 Std Deviations:
56.889460706761604

Mode: -5.0

RMSE: 0.289635786616

Analysis

- The standard deviation appears to stay the same for each time interval
- The mean offset remains within 0.1 of 0 for most of the units, varying between 0.1 and 0.01; indicates a low drift in the clocks
- Standard deviation (68% of data lies in +/- this range from the mean) is ~23 for 10.3.1.200 & 10.3.1.202, ~28 for 10.3.1.204
- 2 standard deviations (95% of data lies in this interval from the mean):
 - ~47.6 for 10.3.1.200 & 10.3.1.202
 - ~56.6 for 10.3.204
- Indicates a slightly poorer performance from the PicoZed board w/ IP 10.3.1.204
- The standard deviation indicates a performance of about 50 ns for 95% of the data, which is consistent with measurements taken before