

Claims

[Claim 1] A time synchronization device comprising:

a reception unit to receive first data from a master device having a master clock;

5 a transmission unit to transmit second data to the master device after the first data are received by the reception unit;

a recording unit to record reception time of the first data at the reception unit and transmission time of the second data at the transmission unit by using a slave clock that is a software clock;

10 a correction unit to correct the reception time of the first data and the transmission time of the second data recorded by the recording unit; and

a synchronization unit to calculate an offset from a difference between a sum of transmission time of the first data recorded at the master device and transmission time of the first data corrected at the master device, which are both reported from the master device, and a sum of the reception time of the first data recorded by the recording unit and reception time of the first data corrected by the correction unit, and a difference between a sum of the transmission time of the second data recorded by the recording unit and transmission time of the second data corrected by the correction unit and a sum of reception time of the second data recorded at the master device and reception time of the second data corrected at the master device, which are both reported from the master device, the offset being a time lag between the master clock and the slave clock.

[Claim 2] The time synchronization device according to claim 1, wherein

the reception unit repeatedly receives the first data from the master device,
25 each time the first data are received by the reception unit, the recording unit

records the reception time of the first data at the reception unit,

each time the reception time of the first data is recorded by the recording unit, the correction unit generates a random number, and uses the generated random number to calculate a corrected value of the reception time of the first data recorded by the

5 recording unit, and

the synchronization unit uses the corrected value of the reception time of the first data calculated by the correction unit as the reception time of the first data for calculation of the offset.

[Claim 3] The time synchronization device according to claim 2, wherein

10 each time the first data are received by the reception unit, the transmission unit transmits the second data to the master device,

each time the second data are transmitted by the transmission unit, the recording unit records the transmission time of the second data at the transmission unit,

each time the transmission time of the second data is recorded by the
15 recording unit, the correction unit generates a random number, and uses the generated random number to calculate a corrected value of the transmission time of the second data recorded by the recording unit, and

the synchronization unit uses the corrected value of the transmission time of the second data calculated by the correction unit as the transmission time of the second
20 data for calculation of the offset.

[Claim 4] The time synchronization device according to claim 2 or 3, wherein each time the first data are received by the reception unit, the synchronization unit calculates the offset, accumulates calculated values of the offset, performs statistical processing on the accumulated calculated values, and adjusts time of the slave clock according to a result
25 of the statistical processing.

[Claim 5] The time synchronization device according to claim 4, wherein the synchronization unit uses an average of the accumulated calculated values as the result of the statistical processing to adjust the time of the slave clock.

[Claim 6] The time synchronization device according to any one of claims 1 to 5,

5 wherein

the reception unit receives third data for reporting the transmission time of the first data at the master device and fourth data for reporting the reception time of the second data at the master device from the master device, and

10 the synchronization unit refers to the third data and the fourth data received by the reception unit for calculation of the offset.

[Claim 7] A time synchronization system comprising:

the time synchronization device according to any one of claims 1 to 6; and

15 the master device to record transmission time of the first data and reception time of the second data by using the master clock that is a software clock, correct the recorded transmission time of the first data and the recorded reception time of the second data, and report the recorded transmission time of the first data, the recorded reception time of the second data, corrected transmission time of the first data, and corrected reception time of the second data to the time synchronization device.

[Claim 8] A time synchronization method comprising:

20 transmitting first data from a master device having a master clock;

receiving the first data at a time synchronization device having a slave clock that is a software clock;

transmitting second data from the time synchronization device after receiving the first data;

25 receiving the second data at the master device;

recording transmission time of the first data and reception time of the second data by using the master clock, correcting the recorded transmission time of the first data and the recorded reception time of the second data, by the master device, and reporting the recorded transmission time of the first data, the recorded reception time of the second data, corrected transmission time of the first data, and corrected reception time of the second data from the master device; and

recording reception time of the first data and transmission time of the second data by using the slave clock, correcting the recorded reception time of the first data and the recorded transmission time of the second data, by the time synchronization device, and calculating an offset from a difference between a sum of the transmission time of the first data recorded at the master device and the transmission time of the first data corrected at the master device, which are reported from the master device, and a sum of the reception time of the first data recorded by the time synchronization device and reception time of the first data corrected by the time synchronization device, and a difference between a sum of the transmission time of the second data recorded by the time synchronization device and transmission time of the second data corrected by the time synchronization device and a sum of the reception time of the second data recorded at the master device and the reception time of the second data corrected at the master device, which are both reported from the master device, by the time synchronization device, the offset being a time lag between the master clock and the slave clock.