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Arduino Sensor Network Setup Guide

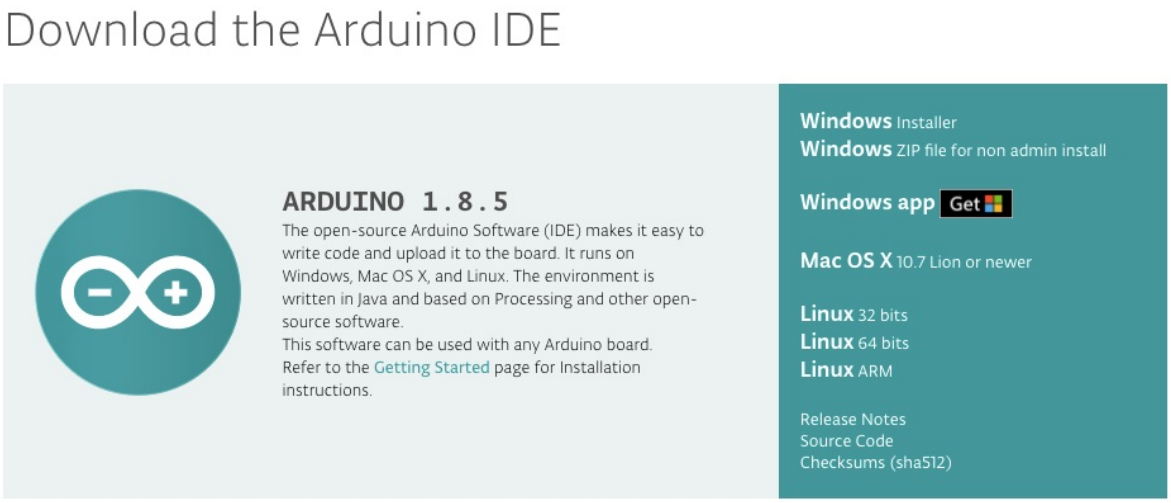
V1.0	October, 2017	Peng Li CS@Mines
V1.1	November, 2017	Peng Li CS@Mines
V1.2	December, 2017	Peng Li CS@Mines

The ASN(Arduino Sensor Network) project can be downloaded at https://github.com/penglir/arduino-sensor-network.

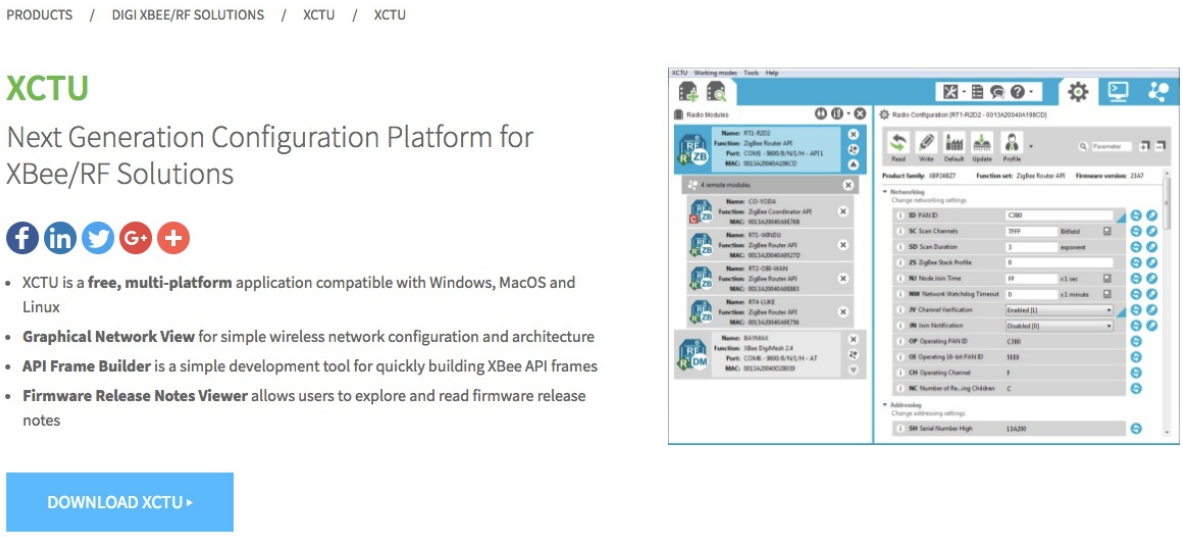
This guide provides step-by-step tutorials about how to setup the development environment and launch the ASN(Arduino Sensor Network) project.

Install Arduino

1. In order to burn program into the Arduino devices, you need to install the Arduino IDE. The Arduino IDE can be downloaded at https://www.arduino.cc/en/Main/Software.



2. In order to configure the XBee module, you need to install the XBee configuration tool, XCTU. The XCTU can be downloaded at https://www.digi.com/products/xbee-rf-solutions/xctu-software/xctu.



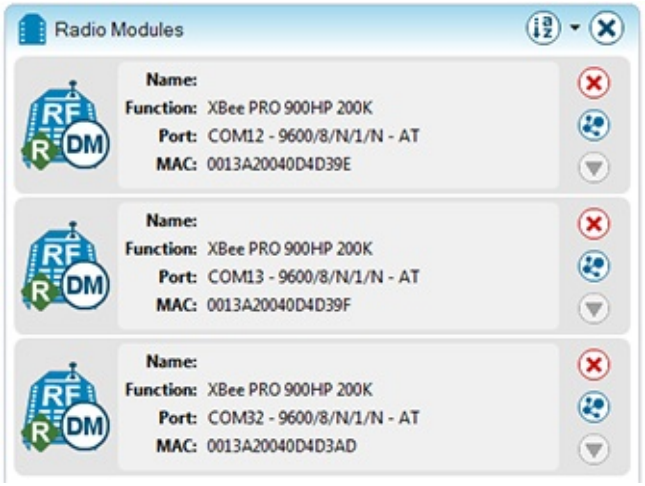
3. In the project/xbee_config directory, there are 2 provided configuration files. One is for sender side, the other one is for receiver side. In order to burn the provided configuration file, you need follow the steps below:

Use XCTU to find your XBee modules and add them to the tool.

1. Click **Discover radio modules** from the toolbar.

2. In the **Discover radio modules** dialog, select the serial port(s) in which you want to look for radio modules. If you do not know the serial ports where your modules are attached, select all ports. Click **Next**.
3. In the **Set port parameters** window, maintain the default values and click **Finish**.
4. As XCTU locates radio modules, they appear in the **Discovering radio modules** dialog box. Once the discovery process has finished, click **Add selected devices**.
5. At this point, assuming you have modules connected to your computer, you should see something like this in the **Radio Modules** section on the left:

.



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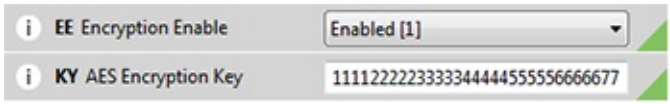
Set up encryption for your XBee network

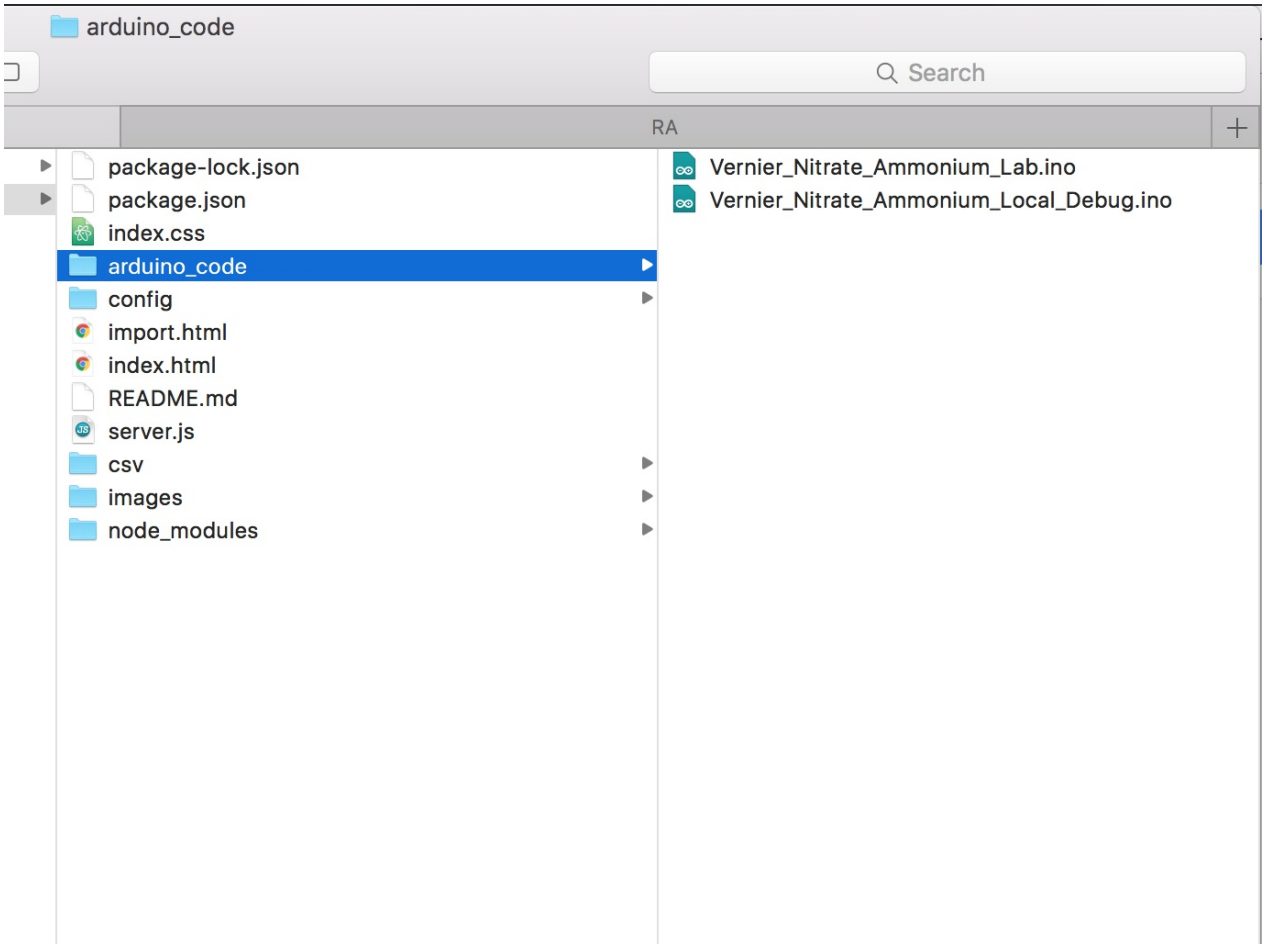
1. Add two XBee modules to XCTU. See Use XCTU to find your XBee modules and add them to the tool.
2. Configure the XBee modules so they can talk to each other. See Configure the first two XBee modules in transparent mode.
3. Name your two XBee modules XBee_A and XBee_B**.**
4. Select XBee_A and configure the following parameters:

   EE: Set the AES Encryption Enable parameter to 1.
   KY: Set the AES Encryption Key parameter to a 32 hexadecimal character string.
   Example: 11111222223333344444555556666677



5. Click the Write radio settings button.
6. Configure the parameters for XBEE_B as you did for XBEE_A, and then click.
7. Send a secure message between XBee_A and XBee_B. See Send messages through XCTU.

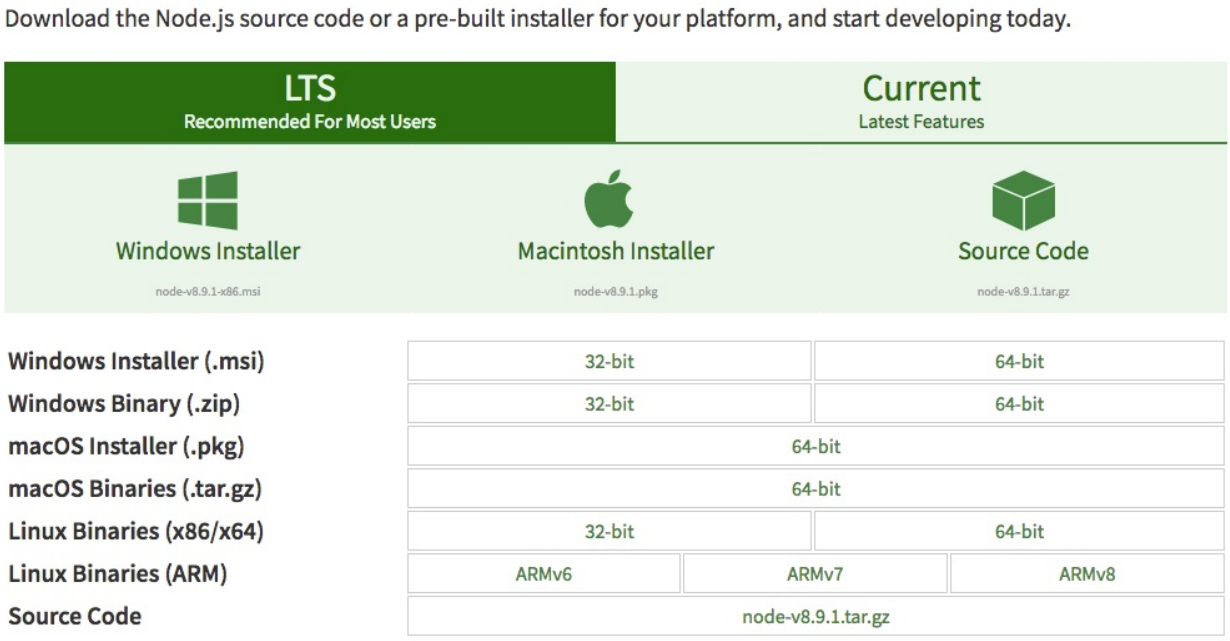
Provided XBee Configuration Files



For your convenience, you can directly use these XBee configuration profile file in the following development.

Install Node.js

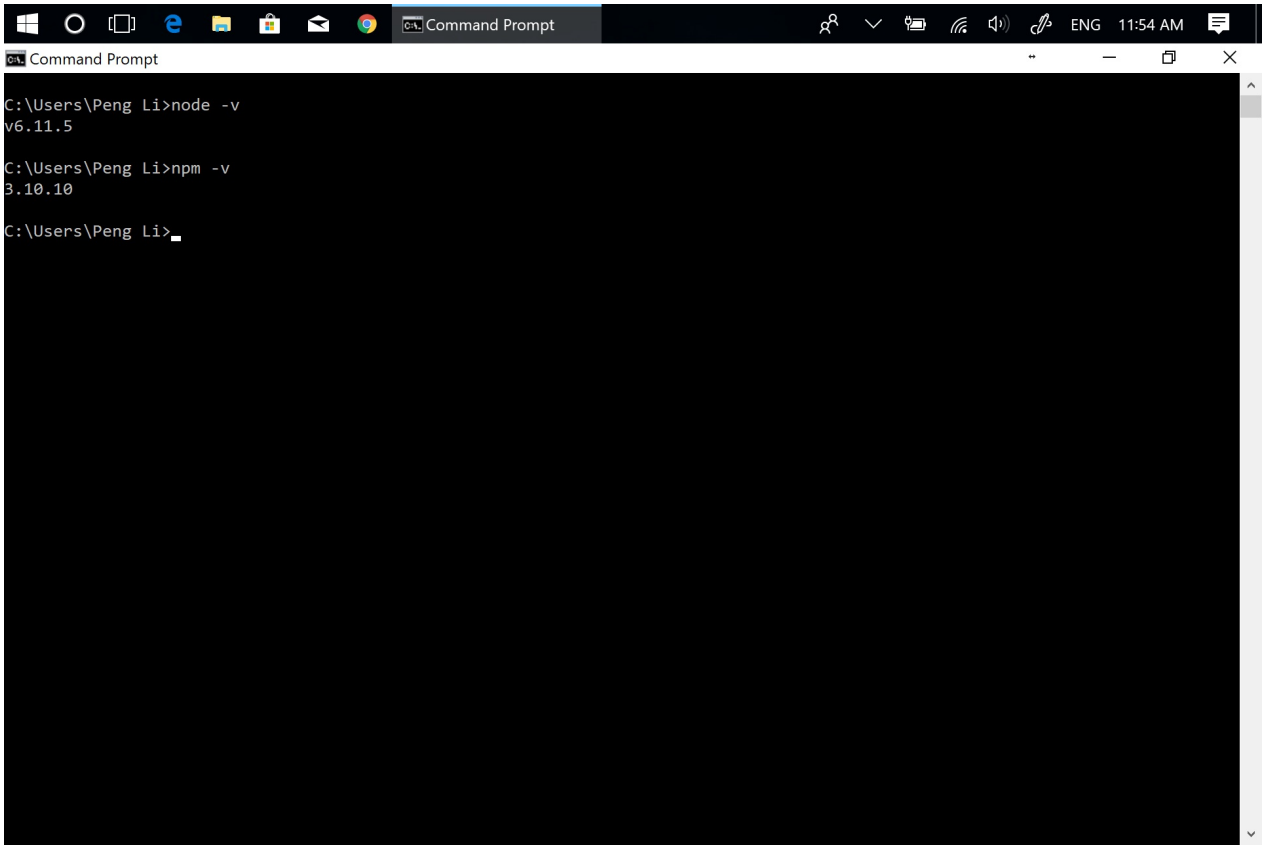
1. The server-side of the project is developed by Node.js. In order to run the server, you need to install Node.js. Node.js can be downloaded at https://nodejs.org/en/download/.



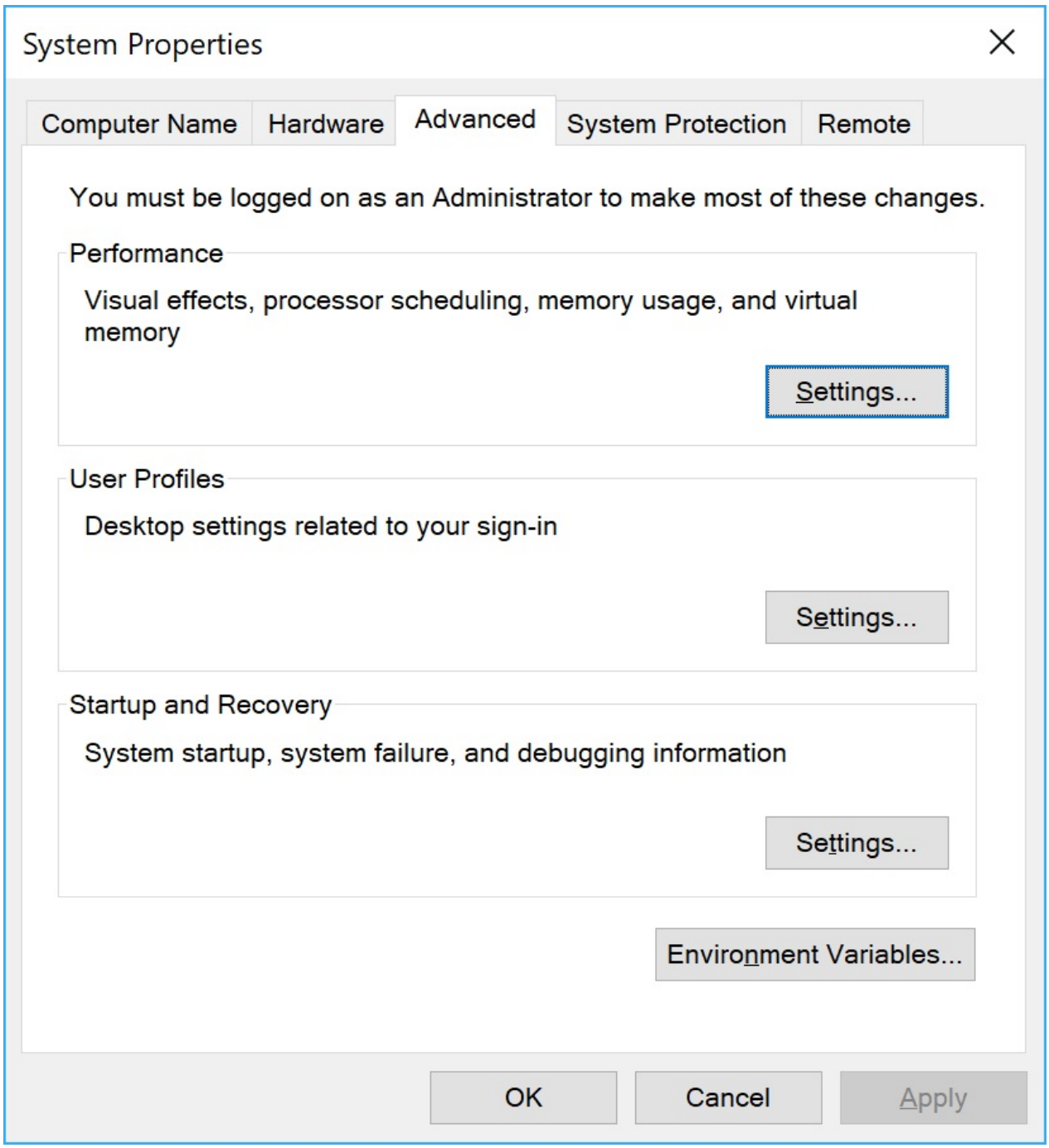
After successfully installation, type the below commands, you should see something like this.

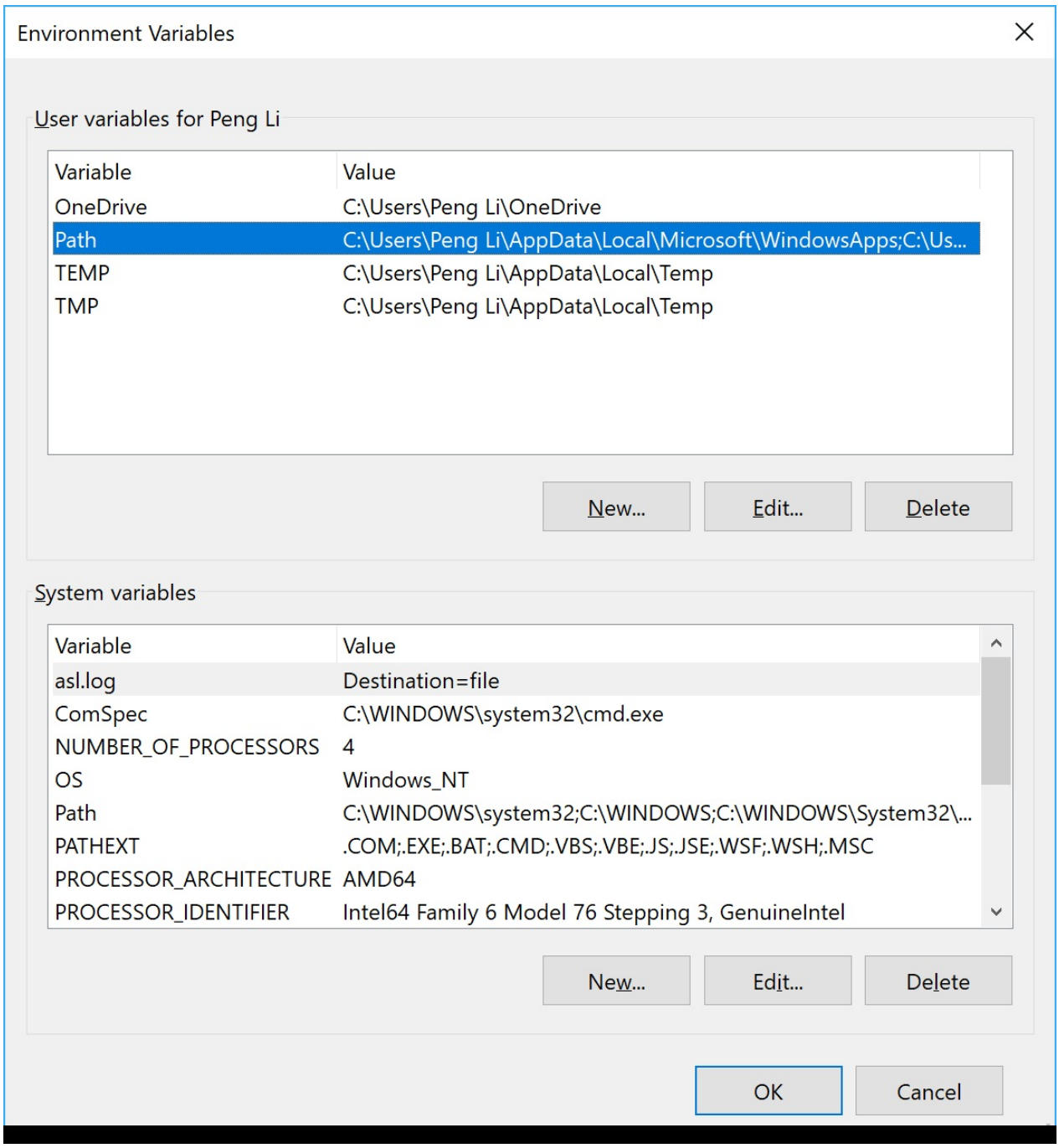
```
node -v
```

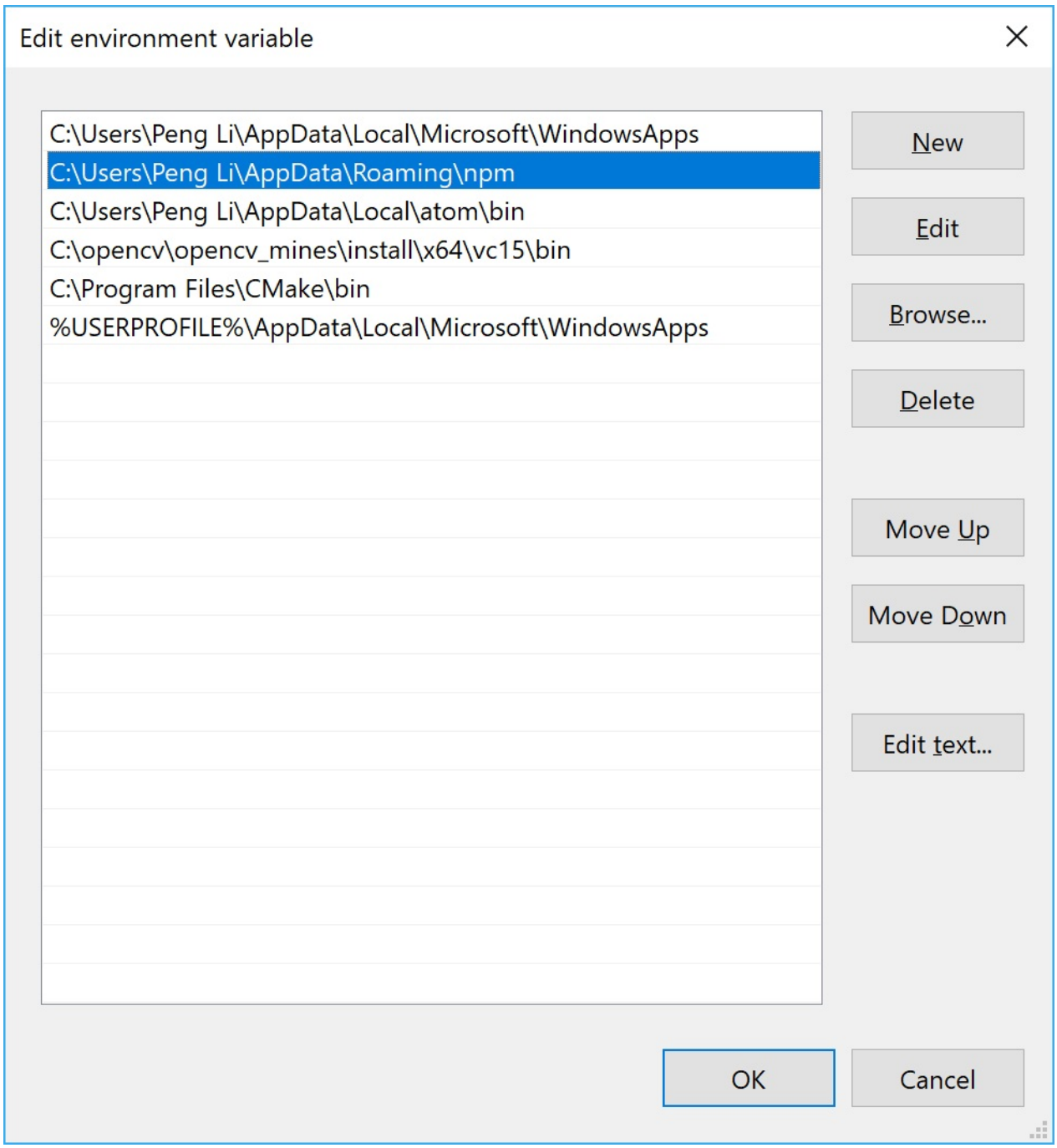
```
npm -v
```



If there is something wrong, you should at first check the environment variables.


System Properties
Computer Name
Hardware
Advanced
System Protection
Remote
You must be logged on as an Administrator to make most of these changes.
Performance
Visual effects, processor scheduling, memory usage, and virtual memory
Settings...
User Profiles
Desktop settings related to your sign-in
Settings...
Startup and Recovery
System startup, system failure, and debugging information
Settings...
Environment Variables...
OK
Cancel
Apply


Environment Variables
User variables for Peng Li
Variable
Value
OneDrive
C:\Users\Peng Li\OneDrive
Path
C:\Users\Peng Li\AppData\Local\Microsoft\WindowsApps;C:\Us...
TEMP
C:\Users\Peng Li\AppData\Local\Temp
TMP
C:\Users\Peng Li\AppData\Local\Temp
New...
Edit...
Delete
System variables
Variable
Value
asl.log
Destination=file
ComSpec
C:\WINDOWS\system32\cmd.exe
NUMBER_OF_PROCESSORS
4
OS
Windows_NT
Path
C:\WINDOWS\system32;C:\WINDOWS;C:\WINDOWS\System32\...
PATHEXT
.COM;.EXE;.BAT;.CMD;.VBS;.VBE;.JS;.JSE;.WSF;.WSH;.MSC
PROCESSOR_ARCHITECTURE
AMD64
PROCESSOR_IDENTIFIER
Intel64 Family 6 Model 76 Stepping 3, GenuineIntel
New...
Edit...
Delete
OK
Cancel



1. Once you have installed Node, let's try building our first web server. Create a file named "app.js", and paste the following code:

```
const http = require('http');

const hostname = '127.0.0.1';
const port = 3000;

const server = http.createServer((req, res) => {
  res.statusCode = 200;
  res.setHeader('Content-Type', 'text/plain');
  res.end('Hello World\n');
});

server.listen(port, hostname, () => {
  console.log(`Server running at http://${hostname}:${port}/`);
});
```

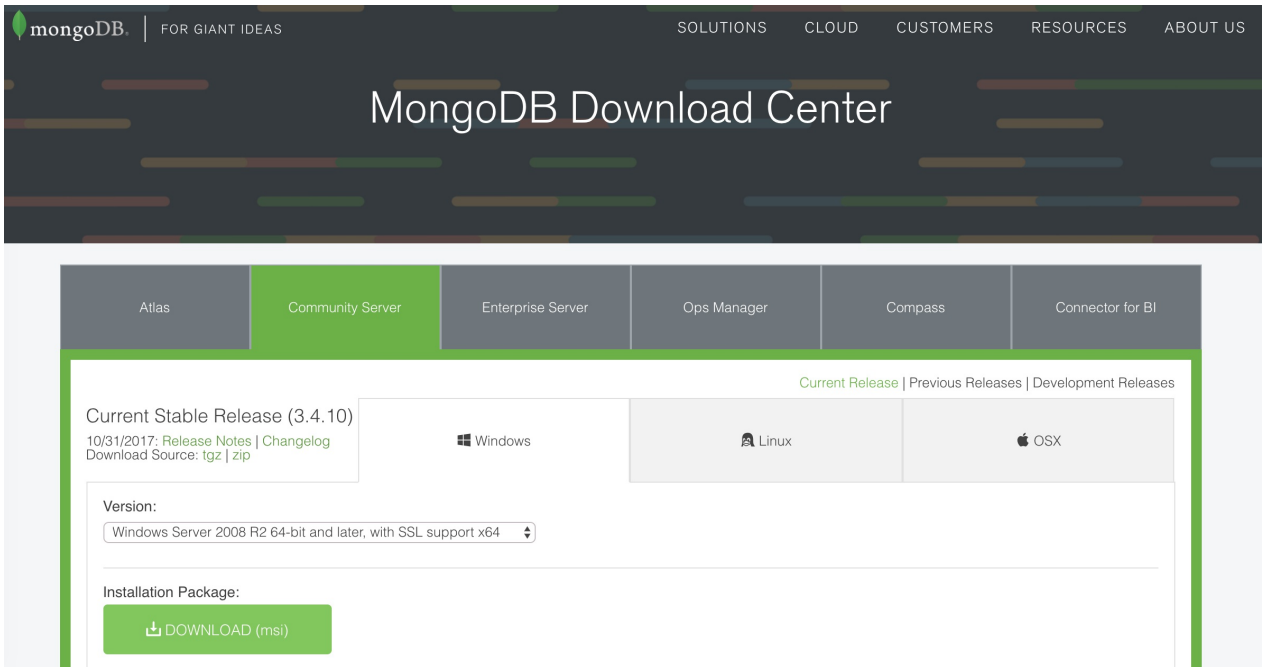
After that, run your web server using

`node app.js`

then visit http://localhost:3000, and you will see a message 'Hello World'

Install MongoDB

1. All the data received are saved into database. We use MongoDB in this project. In order to launch the server, you should at first install the MongoDB. MongoDB can be downloaded at https://www.mongodb.com/download-center?jmp=nav#community.



2. Determine which MongoDB build you need.¶

To find which version of Windows you are running, enter the following commands in the Command Prompt

```
wmic os get caption
wmic os get osarchitecture
```

3. Set up the MongoDB environment

MongoDB requires a data directory to store all data. MongoDB's default data directory path is the absolute path

`\data\db` on the drive from which you start MongoDB. Typically, you should create a folder like this C:\date\db

4. Start MongoDB

To start MongoDB, run mongod.exe. For example, from the Command Prompt

```
C:\Program Files\MongoDB\Server\3.4\bin\mongod.exe
```

This starts the main MongoDB database process. The waiting for connections message in the console output indicates that the

mongod.exe process is running successfully.

5. Connect to MongoDB

To connect to MongoDB through the mongo.exe shell, open another Command Prompt.

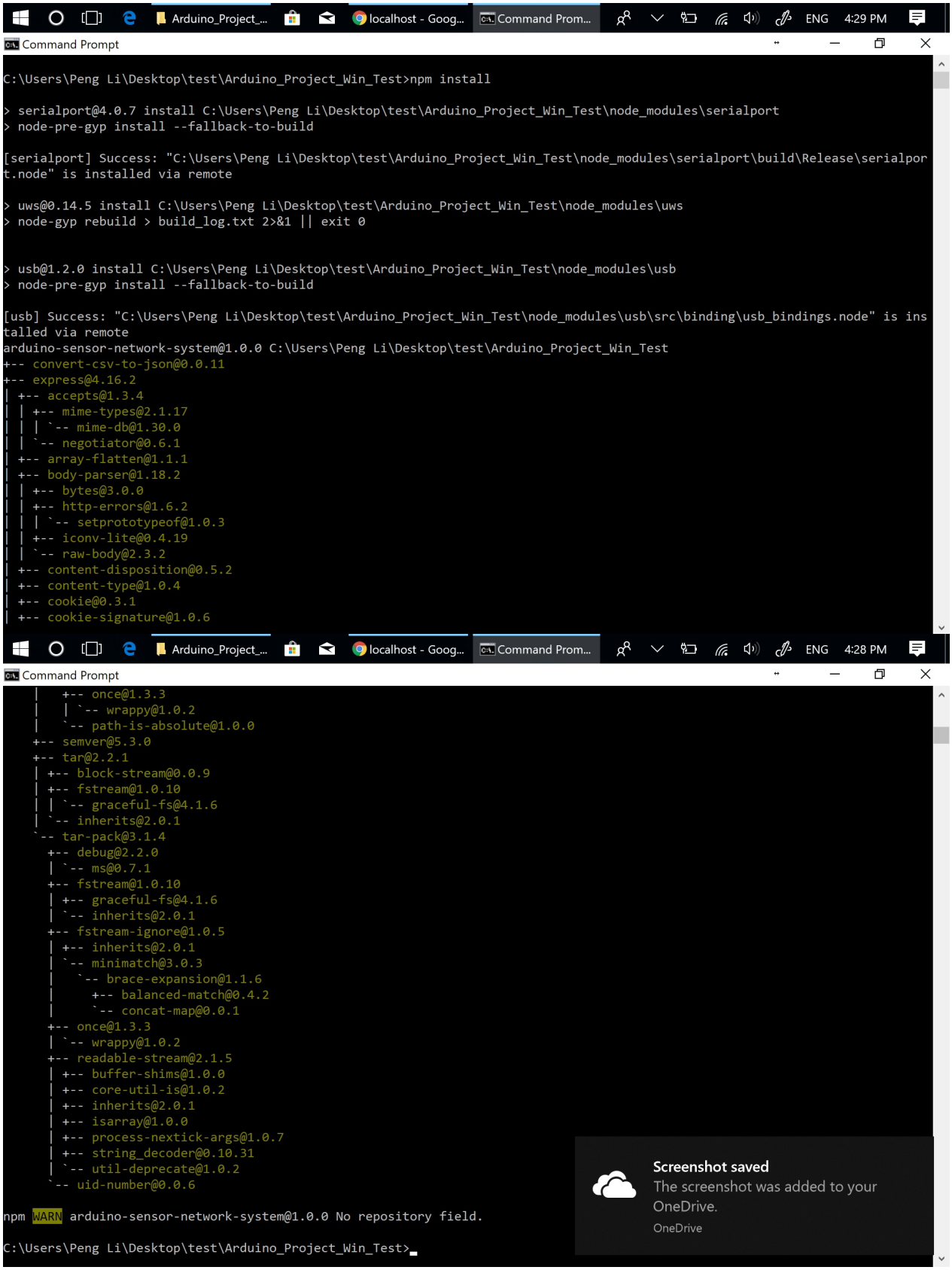
```
C:\Program Files\MongoDB\Server\3.4\bin\mongo.exe
```

Later, to stop MongoDB, press `Control+C` in the terminal where the mongod instance is running.

Launch System

1. Check out the project from https://github.com/penglir/arduino-sensor-network
2. Go to the project root directory, run the command below to install all dependencies.

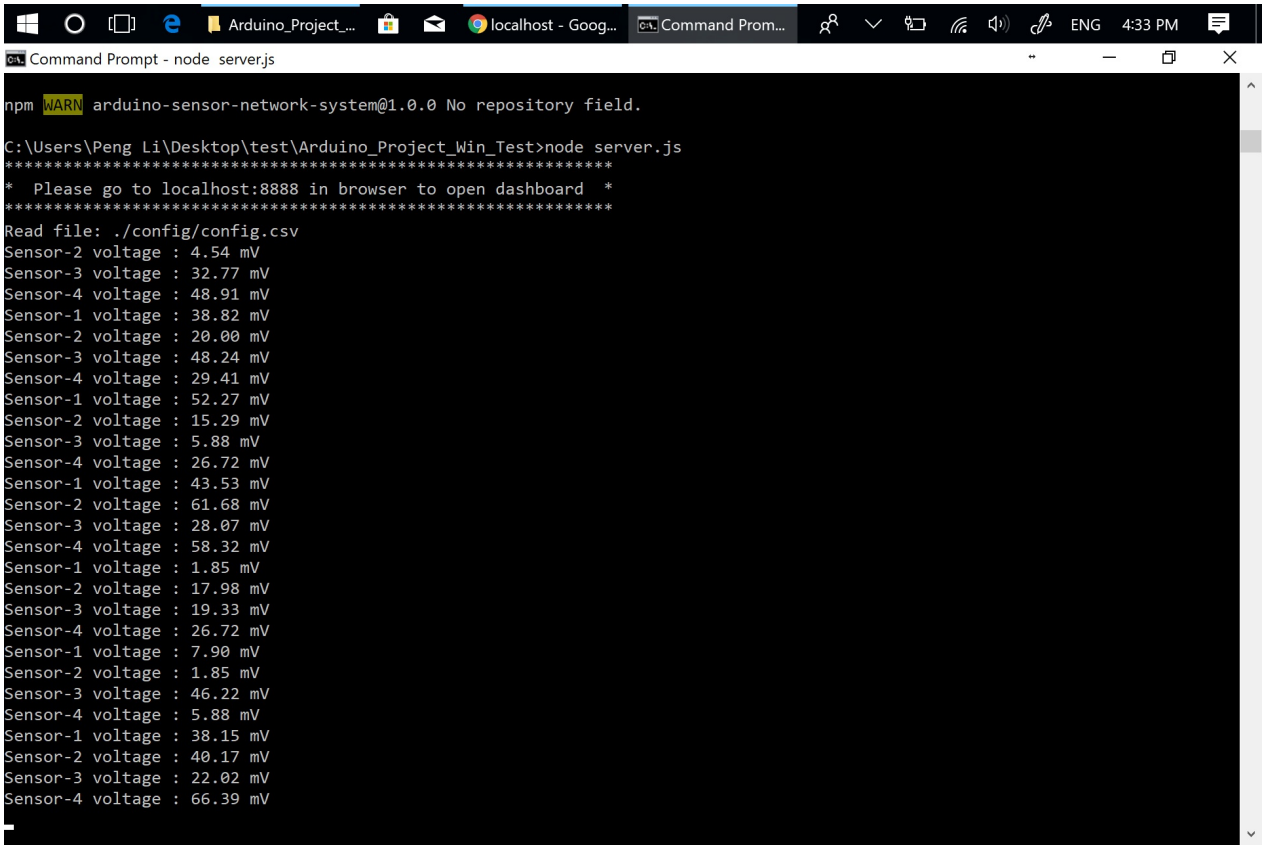
```
npm install
```



When finished, you should see the result like this.

1. To run the server process, run the command below

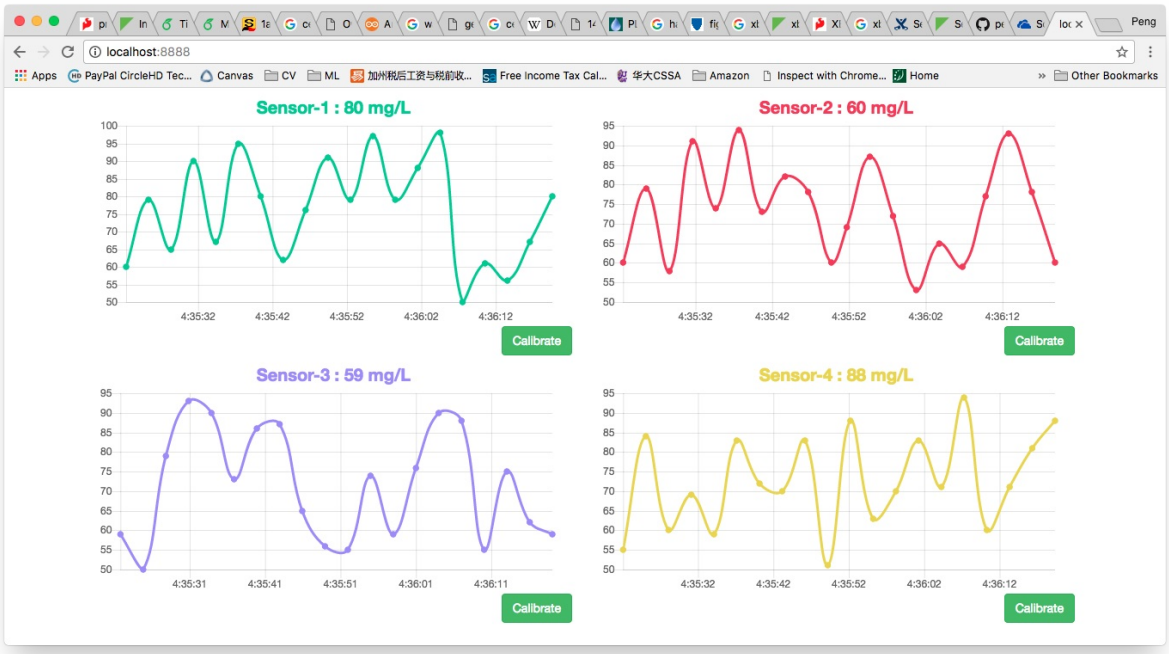
```
node server.js
```



If the server starts successfully, you should see something like this.

1. To open the real-time web interface dashboard, go to the URL below in Chrome browser.

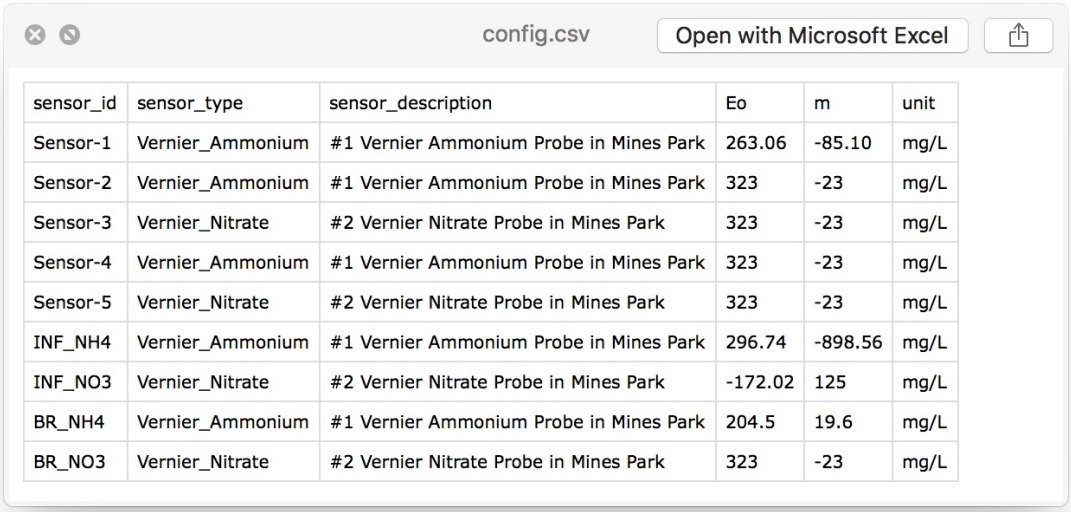
```
http://localhost:8888/
```



Then you should see the real-time dashboard in the web browser.

Sensor Calibration

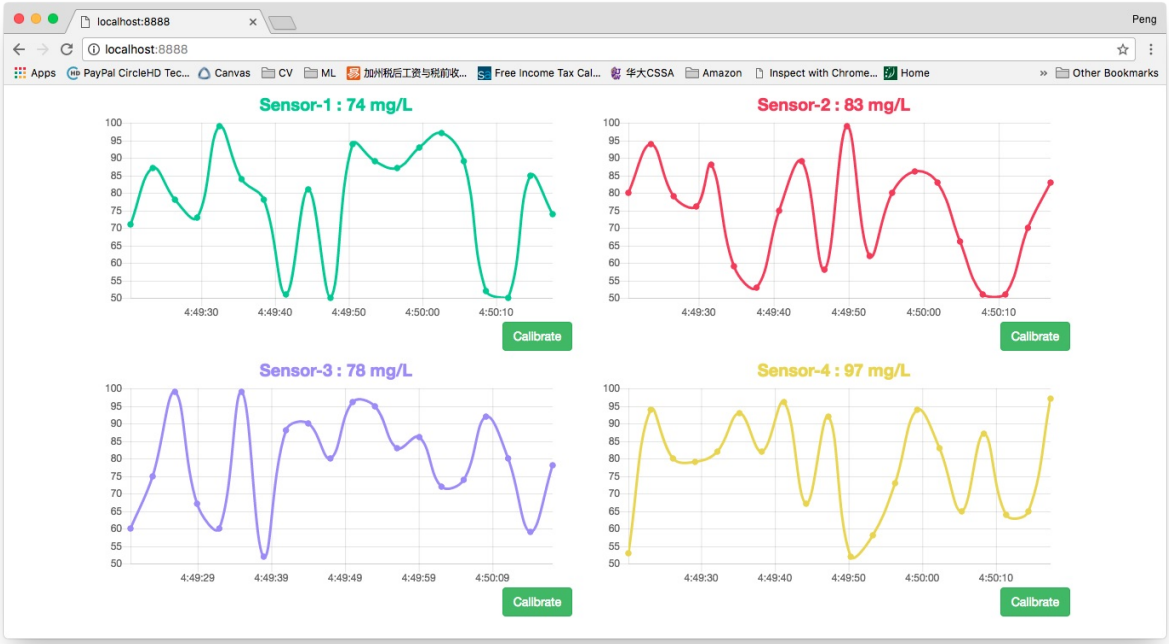
All the sensor calibration parameters are saved in one config CSV file in the project_directory/config/config.csv. This file looks like this:



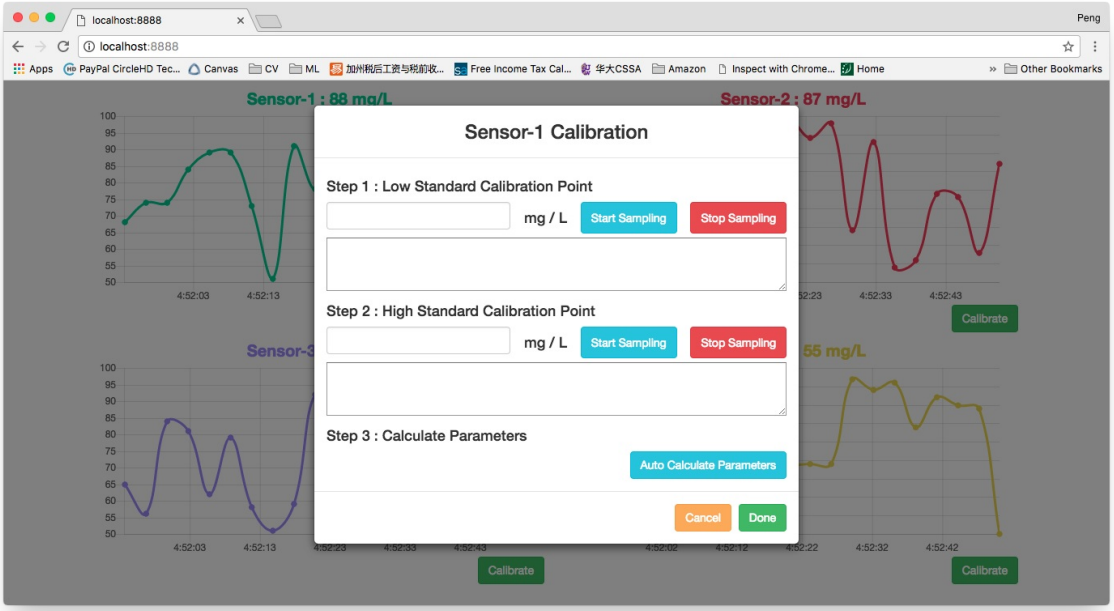
sensor_id	sensor_type	sensor_description	Eo	m	unit
Sensor-1	Vernier_Ammonium	#1 Vernier Ammonium Probe in Mines Park	263.06	-85.10	mg/L
Sensor-2	Vernier_Ammonium	#1 Vernier Ammonium Probe in Mines Park	323	-23	mg/L
Sensor-3	Vernier_Nitrate	#2 Vernier Nitrate Probe in Mines Park	323	-23	mg/L
Sensor-4	Vernier_Ammonium	#1 Vernier Ammonium Probe in Mines Park	323	-23	mg/L
Sensor-5	Vernier_Nitrate	#2 Vernier Nitrate Probe in Mines Park	323	-23	mg/L
INF_NH4	Vernier_Ammonium	#1 Vernier Ammonium Probe in Mines Park	296.74	-898.56	mg/L
INF_NO3	Vernier_Nitrate	#2 Vernier Nitrate Probe in Mines Park	-172.02	125	mg/L
BR_NH4	Vernier_Ammonium	#1 Vernier Ammonium Probe in Mines Park	204.5	19.6	mg/L
BR_NO3	Vernier_Nitrate	#2 Vernier Nitrate Probe in Mines Park	323	-23	mg/L

Web browser version dynamic sensor calibration:

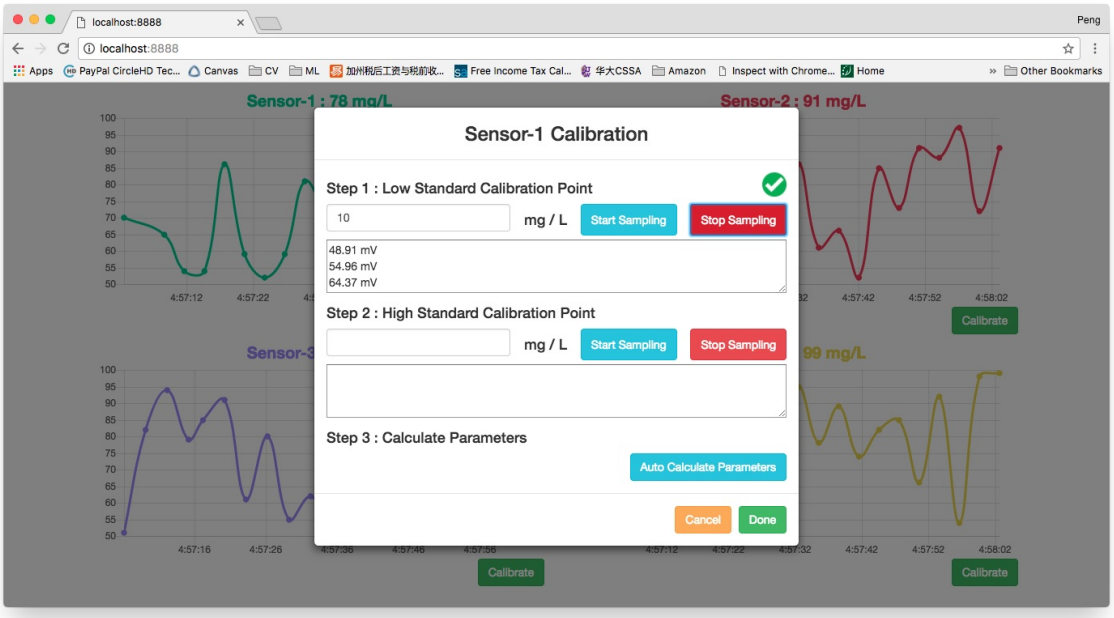
When you open the dashboard, it should look like this



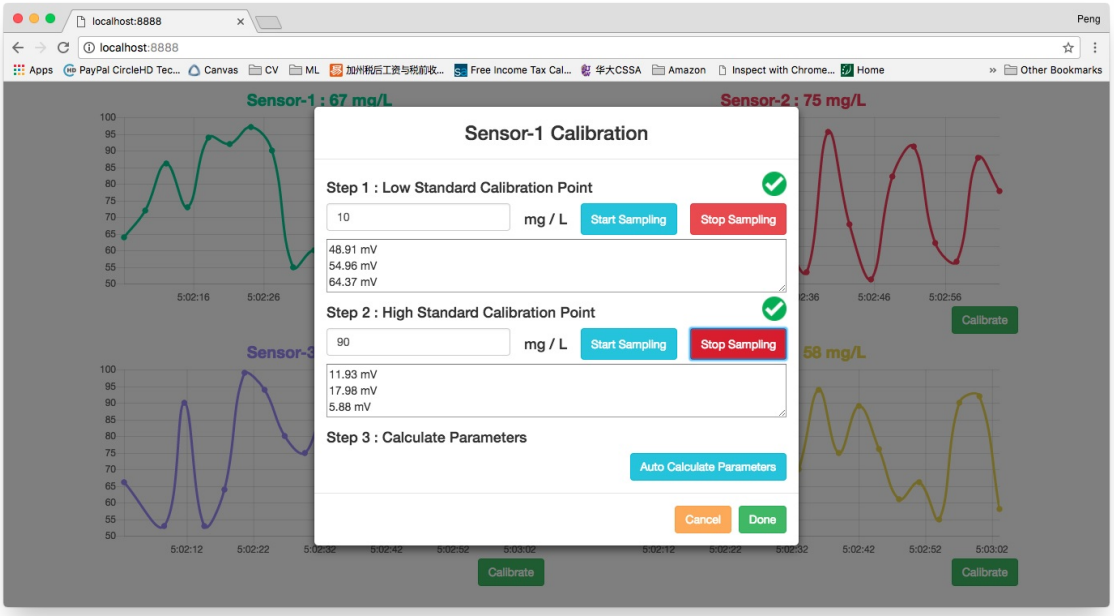
1. There is a green button in the right bottom corner of each chart. When you click this button, the system will enter calibration mode.



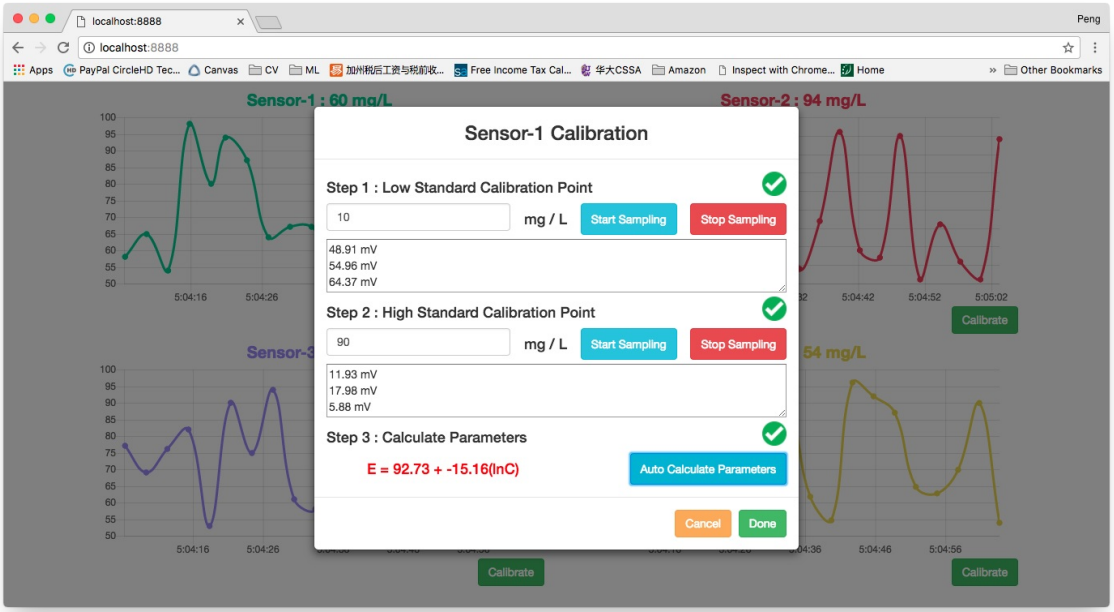
Step 1: you should input the solution concentration for the low standard point in the fist input textfield. When you emerge the sensor into the solution, click the Start Sampling button and leave the sensor in the solution. Then you should see the new data collected will be shown in the textarea. When the calibration data point is enough (typically it will need >3 to increase the accuracy), you should click the Stop Sampling button. A green mark will be shown at the right.



Step 2: similarly, you should finish the second step for high standard calibration point. When you finish, you should see something like this.



Step 3 : When the system has collected enough data point for calibration, you only need to click the Auto Calculate Parameters button in the calibration window. Then all the required calibration parameters will be automatically calculated.

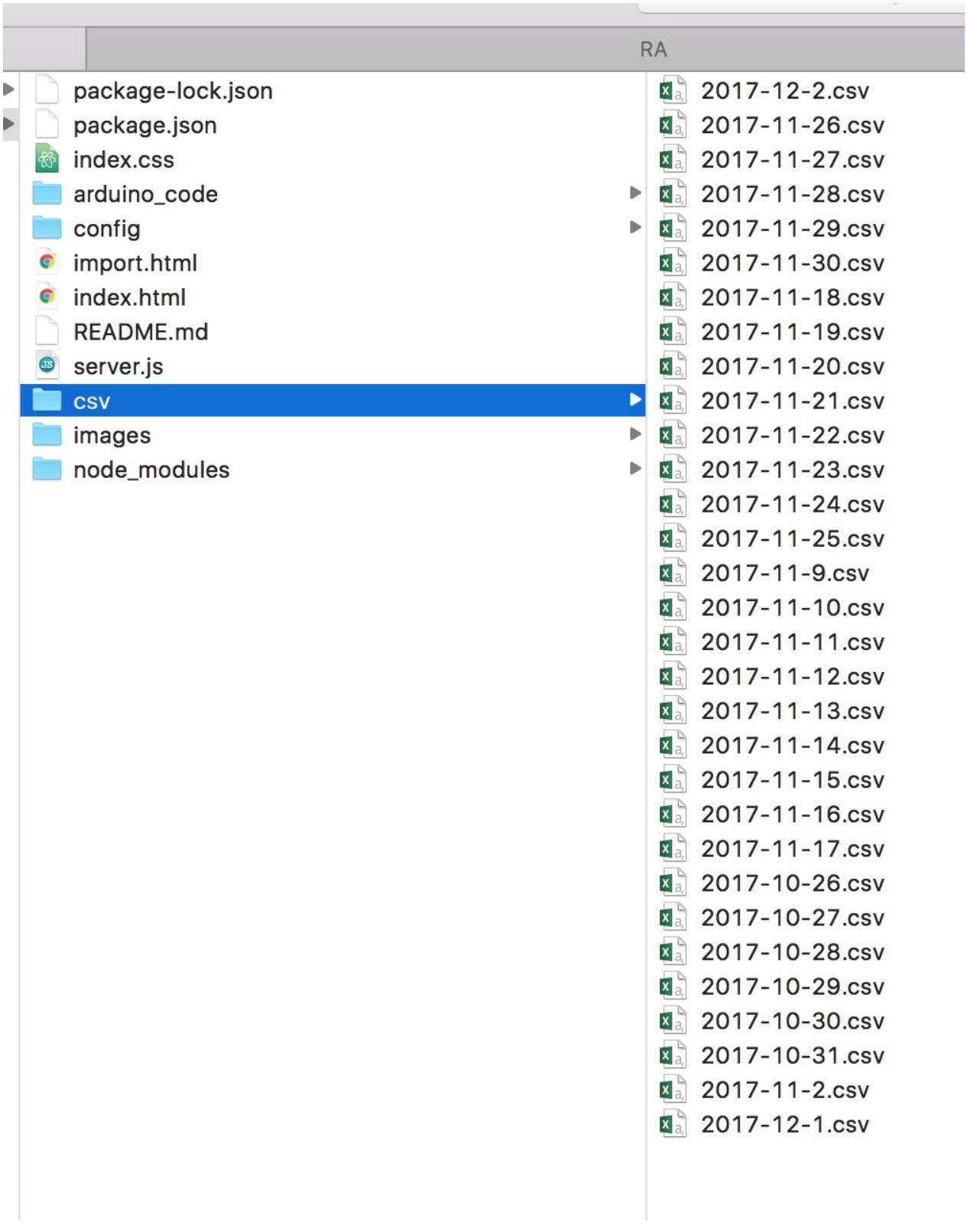


Last step : If you would like to save the new calibration parameters, you should click the Done button in the bottom. Then the system will automatically save all the new calibration parameters into the config csv file and reload it immediately. If you click the Cancel button, nothing will change, all old calibration parameters stored in the config csv file will remain.

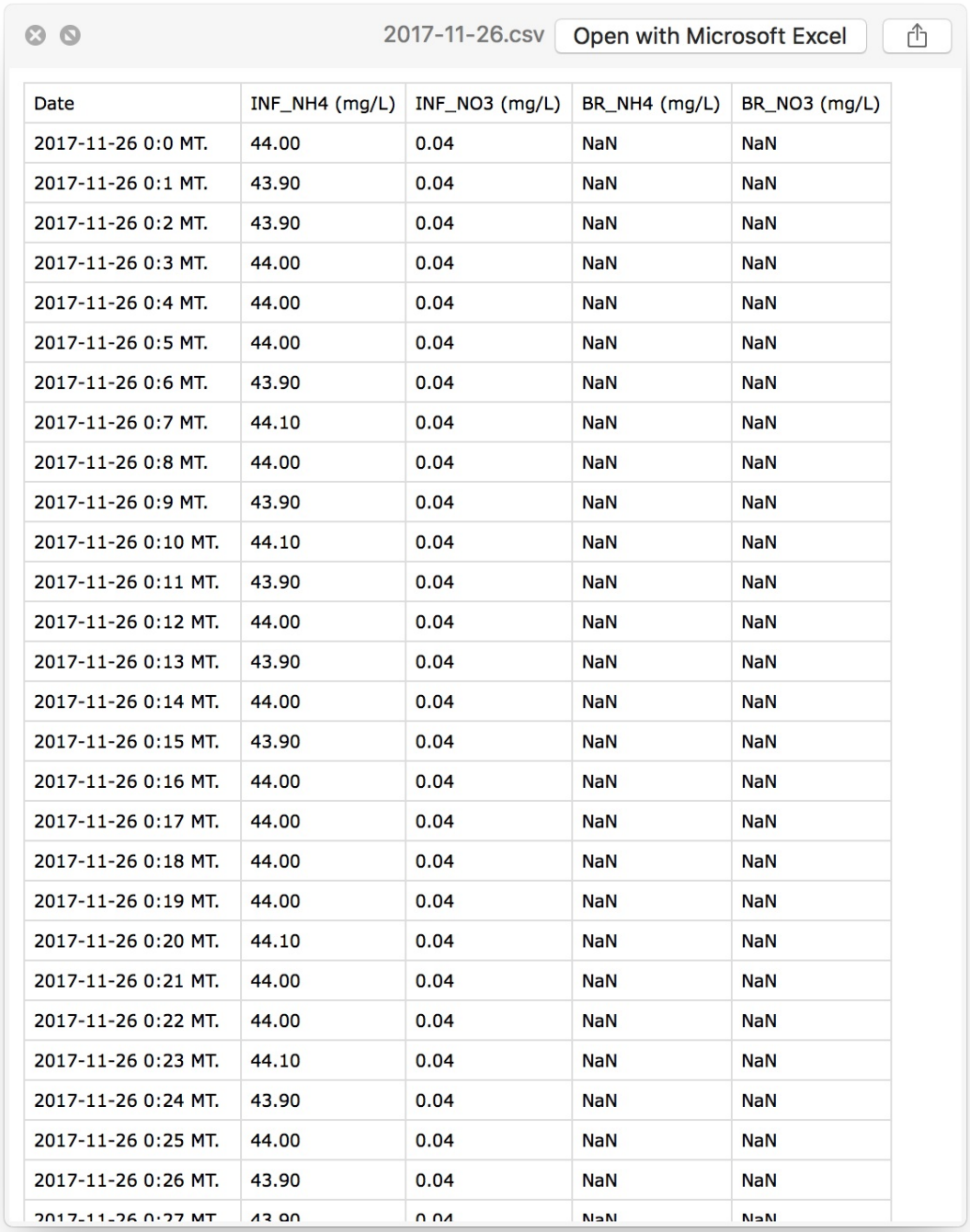
Data Storage

1. **CSV File Storage**

All the collected data will be saved into a single CSV file every 24 hours.



Inside the CSV file, the data is saved as the format requested by Kate who is a student of Environmental Engineering Department of Mines.

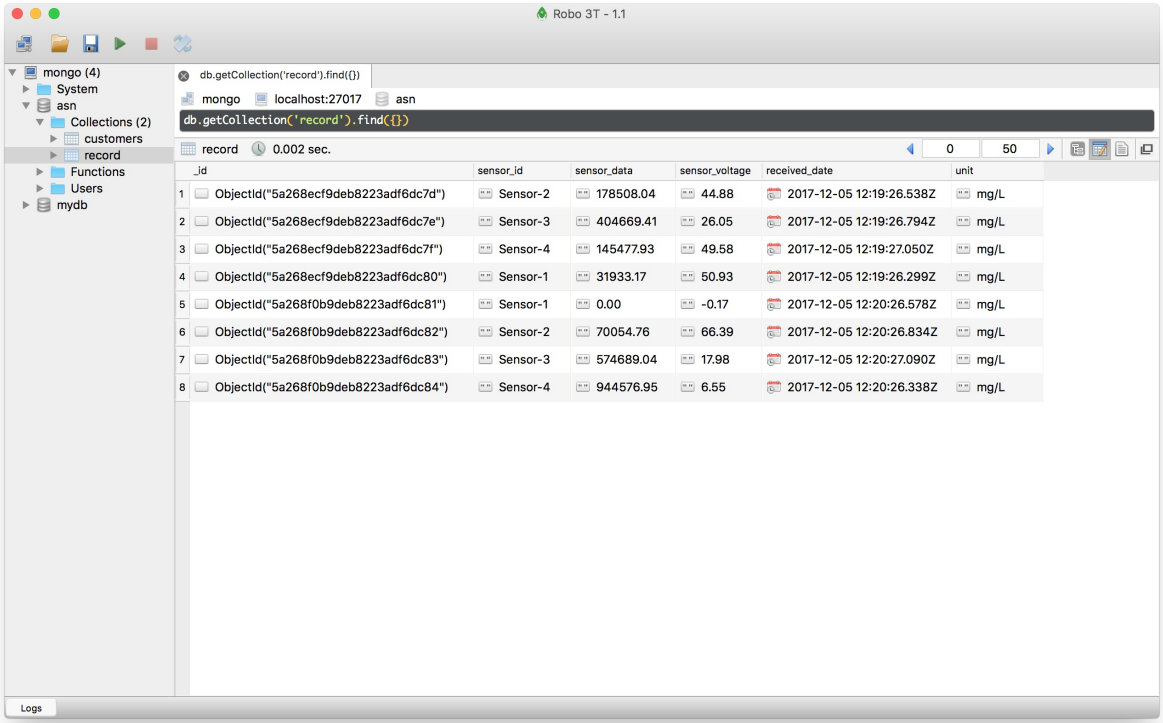


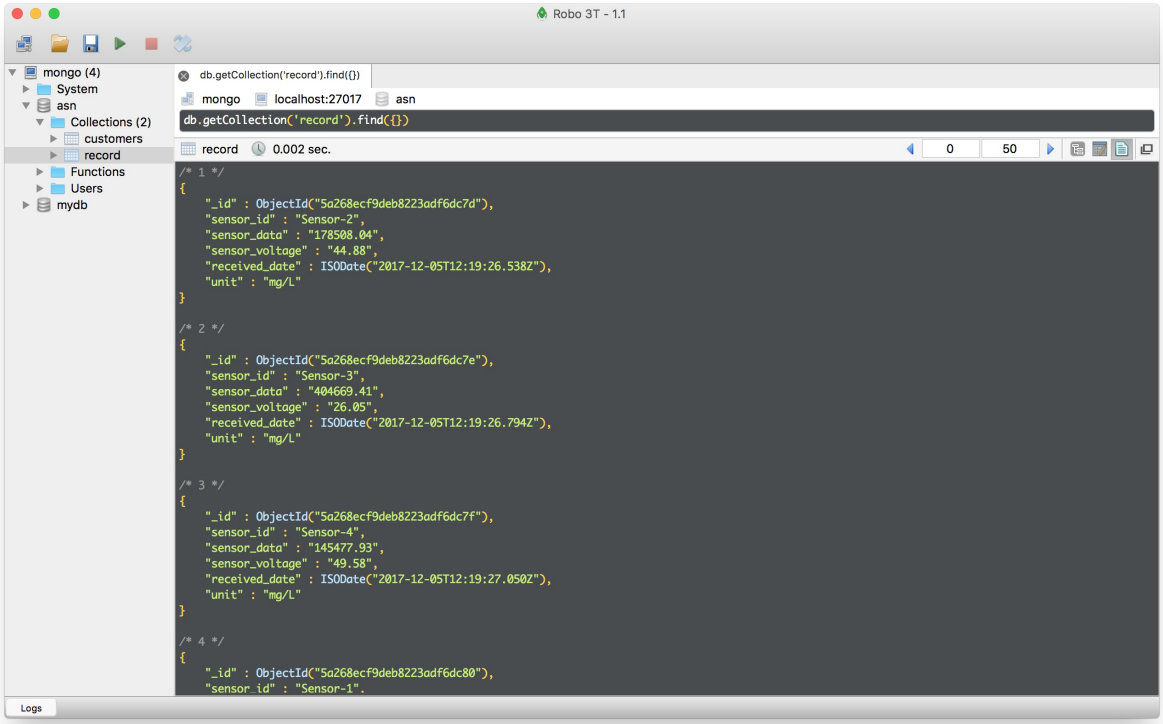
Date	INF_NH4 (mg/L)	INF_NO3 (mg/L)	BR_NH4 (mg/L)	BR_NO3 (mg/L)
2017-11-26 0:0 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:1 MT.	43.90	0.04	NaN	NaN
2017-11-26 0:2 MT.	43.90	0.04	NaN	NaN
2017-11-26 0:3 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:4 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:5 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:6 MT.	43.90	0.04	NaN	NaN
2017-11-26 0:7 MT.	44.10	0.04	NaN	NaN
2017-11-26 0:8 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:9 MT.	43.90	0.04	NaN	NaN
2017-11-26 0:10 MT.	44.10	0.04	NaN	NaN
2017-11-26 0:11 MT.	43.90	0.04	NaN	NaN
2017-11-26 0:12 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:13 MT.	43.90	0.04	NaN	NaN
2017-11-26 0:14 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:15 MT.	43.90	0.04	NaN	NaN
2017-11-26 0:16 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:17 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:18 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:19 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:20 MT.	44.10	0.04	NaN	NaN
2017-11-26 0:21 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:22 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:23 MT.	44.10	0.04	NaN	NaN
2017-11-26 0:24 MT.	43.90	0.04	NaN	NaN
2017-11-26 0:25 MT.	44.00	0.04	NaN	NaN
2017-11-26 0:26 MT.	43.90	0.04	NaN	NaN
2017-11-26 0:27 MT.	43.90	0.04	NaN	NaN

There are some NaN records because the right two sensors are not connected to this system.

2. Database Storage

Besides the CSV file storage, all the collected sensor data will also be saved into the MongoDB database in every minute.



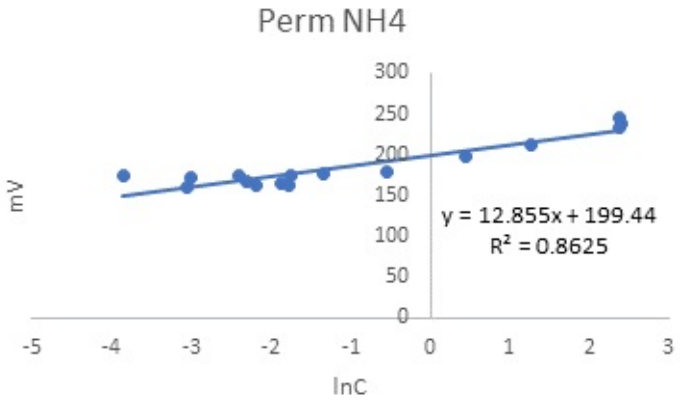


Future Work

1.Multiple data points calibration

Currently we only support two data points calibration. What's more, Kate need more data points during the entire calibration process. Below is what Kate said.

> Peng's calibration method uses two points from standard solutions to generate the curve. However, this is not how these sensors are regularly calibrated. Sensors, like our ammonia and nitrate, are calibrated in-situ and are not removed (in order to be put in the standard solutions). I record the raw voltage at the time that I take a sample, analyze the sample in the lab, and develop a concentration vs. voltage curve over time (see below). This approach is needed for a couple of reasons. First, the complex water matrix interferes with the voltage reading, meaning that a clean water standard solution reads differently than the actual solution that the sensor is in. Secondly, two points is insufficient for building a calibration curve. From the graph below, you can see that a line between any two of the points would be inaccurate.



2. Variable time range x-axis

We could add a slider bar or date range selector in the bottom of the chart to let the user to change the date range in the x-axis from 1-hr to 48-hrs.

3. User login authentication

Currently, as the system is only used in Mines Park Lab, there is no need to login when enter the system. When the system is connected to national facility, we surely need the user authentication.

4. Fault reboot and notification

Because the experimental data is very import for the researchers, in case there is something wrong with our system, it will be helpful if the system could reboot and send notifications to subscribers when it's down.