IoT4SMEs Demonstrator

1 A virtual environment simulator with connected devices

1.1 Home I/O installation

We will use Home I/O to simulate a home equipped with many connected sensors and actuators. Through this software, it will be possible to have access to simulated data (temperature, user's presence, ...) but also to act on the environment (turn on a light, control the heating, close the blinds, ...).

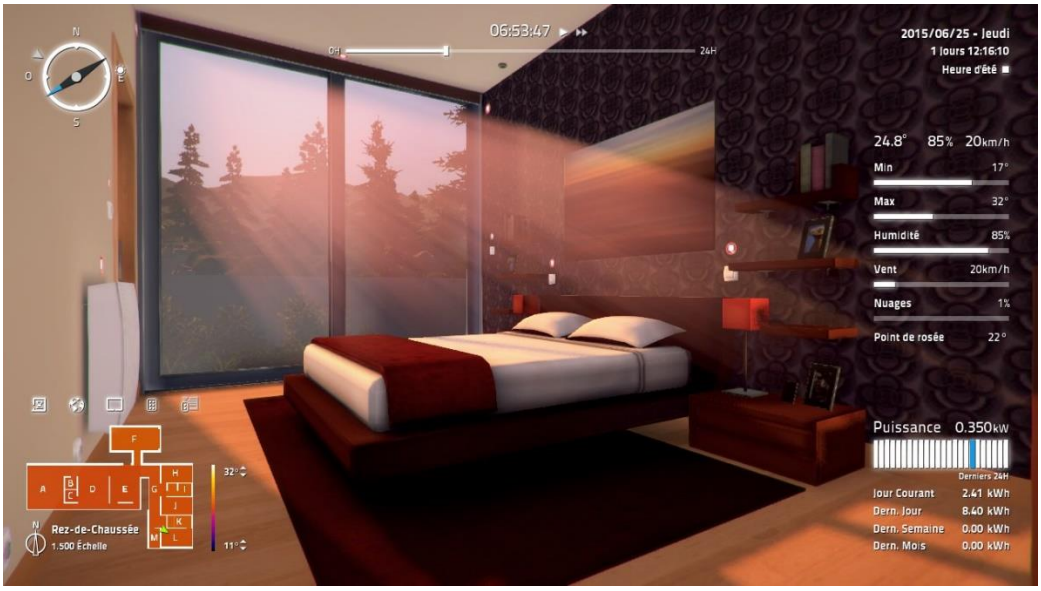
https://teachathomeio.com/

To install the simulation environment, you can retrieve the software from one of the following addresses:

https://teachathomeio.com/telecharger-demo/

or

http://trolen.polytech.unice.fr/cours/projet-si3/homeio-1.5.0-installer.exe



This version is a full demonstration version of the software that will work for 1 month.

1.2 Using the Home I/O simulator

First, please configure the Home I/O software to use English. You can configure this by selecting "Options / Localization / Language = English". This will avoid problems with devices names using special characters and bad interaction with other programs.

To get a handle on the simulation environment, we invite you to consult the documentation:

https://realgames.co/docs/homeio/en/

We invite you to consult:

- The sensors and actuators map: https://realgames.co/docs/homeio/en/devices-map/
- The device control mode: https://realgames.co/docs/homeio/en/device-modes/

Regarding the control mode of the devices, they must be set in the "External" mode to be controlled by a third-party application (and not by clicking in the simulator on all devices).

Red (wired) item: incorrect | Blue (external) item: correct

You can click on all the small symbols to change them to blue (external mode) ... but it may take you a half day and you may forget one. The easiest way is to save the simulation:

- Go to folder "Documents / Home IO / Saves"
- Edit the xml file containing the sensor and actuator configuration with your favourite text editor
- Replace the word "Wired" with the word "External".
- Save the document
- Load the simulation in Home I/O and check if devices turned “blue”.

1.3 Home I/O SDK

Then, you may consult the interfacing and programming part with this environment. The entire documentation is accessible at the following address:

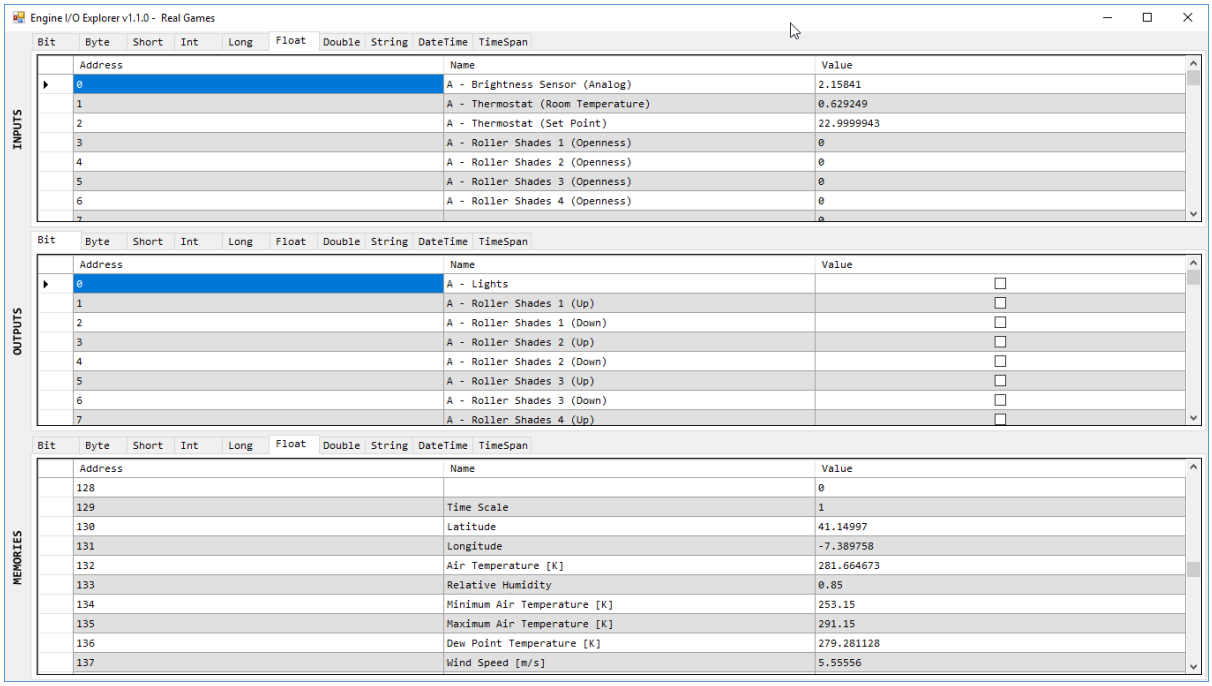
https://realgames.co/docs/homeio/en/sdk-getting-started/

You will download the SDK provided with the application:

https://realgames.co/downloads/tutorials/homeio/sdk.zip

The SDK is for a C # programming environment. You have a simple example of code in the documentation-access to simulated devices (sensors and actuators). You also have examples in the SDK, do not hesitate to consult them to see how to access information or control the environment.

In addition, with the SDK, you have the Engine I/O Explorer software that allows you to view the state of the simulation and control it. This application has been realized with the library provided in the SDK. You will notice that you have three categories of information: the INPUTS (the information coming from sensors of the simulation), the OUTPUTS (the actuators of which you can read the state and modify this one), the MEMORIES (containing the global information to the simulation). For each of these categories, you have access to information according to different types (bit, byte, short, int, long, float, ...).



You have access to an ambient simulator and you have an SDK that will allow you to interface with it. We will now focus on the orchestration of data streams that will allow implementation of application logic between these sensors and actuators.

2 IoT workflow orchestration

2.1 Node-RED installation

Now that you have the sensors and actuators of the simulator, you will be interested in the Node-RED environment that will allow us to exploit this information.

https://nodered.org/

Node-RED is based on Node.js You can go to the following page to download it for your system:

https://nodejs.org/en/download/

Once you have the Node.js environment on your machine, you can install Node-RED simply as an additional package. You will follow the documentation available at the following address:

https://nodered.org/docs/getting-started/installation

You will then open a command interpreter (`PowerShell` if you are on Windows) and run the node-red command. The environmental control interface is then accessible on your machine at the following address:

http://127.0.0.1:1880

2.2 Communicating with different IoT devices

MQTT is a messaging protocol used in the Internet of Things. This one is based on a *Publisher-Broker-Subscriber* template. A *Publisher* sends the information to a *Broker*. A *Subscriber* will subscribe to a topic from a *Broker*.

2.3 *Publisher-Broker-Subscriber* MQTT using Node-RED

2.3.1 Broker MQTT in Node-RED environment

To make it easier to implement, you can start a Broker in Node-RED. But for that you must install an additional package. You can do this directly from the command line (but you will have to restart your Node-RED instance)

```
npm install node-red-contrib-mqtt-broker
```

or from the Node-RED interface, go to the right menu and then "Manage Palette / Install". You will then type:

```
node-red-contrib-mqtt-broker
```

By instantiating a node "mosca", for clicking on "Deploy" you will launch a MQTT Broker which will be available at the address `127.0.0.1:1883`.

2.3.2 MQTT Publisher inside Node-RED

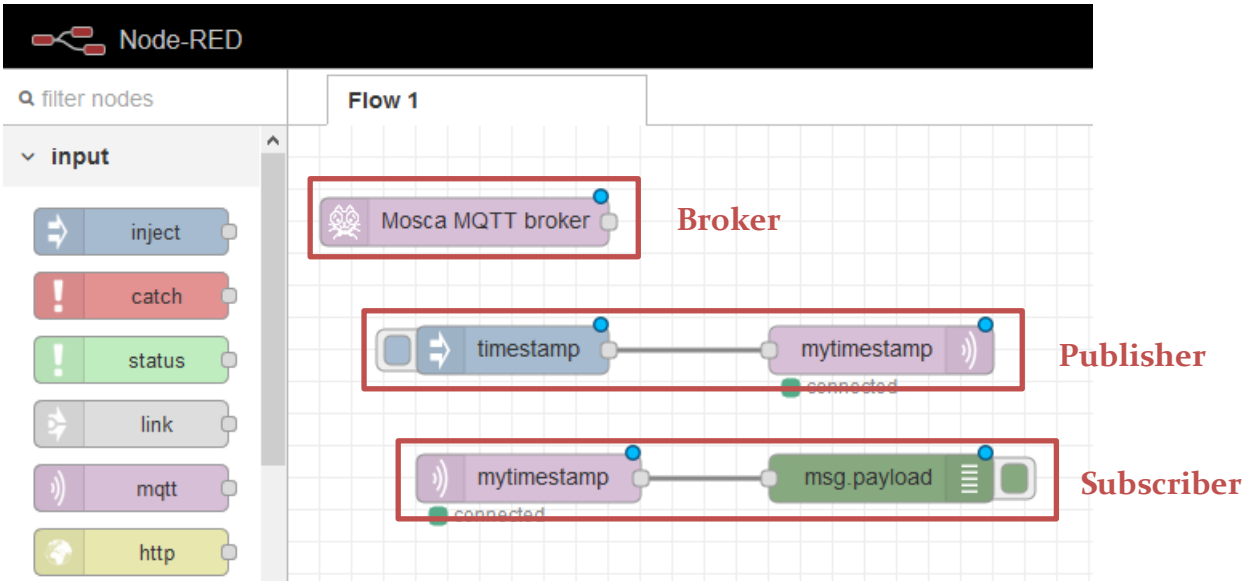
Posting information about an MQTT topic is trivial. It's all about naming the topic (naming based on the notion of path as to find a file).

You will start by setting an "inject" node (which will send a default timestamp) in the INPUT category and a "mqtt" node in the OUTPUT category. You will link the two nodes in question so that the information provided by the timestamp is published on a topic named "mytimestamp". The configuration of a node is done by double clicking on it. You have just set up an MQTT Publisher.

2.3.3 MQTT Subscriber inside Node-RED

To subscribe to an MQTT topic, simply add a node "mqtt" type INPUT and a node "debug" (to see that the information has been sent (you can view it in the debug console right After connecting the two nodes and configuring the topic of the node “mqtt” to the value "mytimestamp", each time you click on the injector, you will receive the information via MQTT.You should have the following schema.

To test it, you have to deploy this flow by clicking the red button deploy on the top right of the bowser window.



To convince yourself that these communications go through the network, have fun running only the Broker on one computer, have a Publisher on another machine, and the Subscriber on a third.

You can also instantiate the previous sample with the following code. To create such a flow, you must copy/paste the following code after selecting top-right menu "Import / Clipboard":

```
[{"id":"45cc7449.5a195c","type":"tab","label":"Flow
3"},{"id":"19a467ac.a8eba8","type":"mosca
in","z":"45cc7449.5a195c","mqtt_port":1883,"mqtt_ws_port":8080,"name":"","usernam
e":"","password":"","dburl":"","x":149,"y":67,"wires":[[]]},{"id":"811eb811.d1788
8","type":"mqtt
in","z":"45cc7449.5a195c","name":"","topic":"test","qos":"2","broker":"aa872460.7
dff18","x":109,"y":148,"wires":[["352cbba6.641a64"]]},{"id":"d0ffe662.31c688","ty
pe":"mqtt
out","z":"45cc7449.5a195c","name":"","topic":"test","qos":"","retain":"","broker"
:"aa872460.7dff18","x":311,"y":225,"wires":[]},{"id":"d4e5a13a.ad9a2","type":"inj
ect","z":"45cc7449.5a195c","name":"","topic":"","payload":"","payloadType":"date"
,"repeat":"","crontab":"","once":false,"x":134,"y":225,"wires":[["d0ffe662.31c688
"]]},{"id":"352cbba6.641a64","type":"debug","z":"45cc7449.5a195c","name":"","acti
ve":true,"console":"false","complete":"false","x":295,"y":149,"wires":[]},{"id":"
aa872460.7dff18","type":"mqtt-
broker","z":"","broker":"localhost","port":"1883","clientid":"","usetls":false,"c
ompatmode":true,"keepalive":"60","cleansession":true,"willTopic":"","willQos":"0"
,"willPayload":"","birthTopic":"","birthQos":"0","birthPayload":""}]
```

Once the flow is deployed and both MQTT nodes are connected, injecting the timestamp on the blue node will result in a debug message in the debug tab. If the flow is confirmed working, you can continue this demonstrator.

3 Home I/O publishing to a MQTT broker

We will now publish the Home I/O data to the local broken and try to visualize the data reception.

3.1 Home I/O to MQTT protocol: use a bridge

When Home I/O is running, start the HomeIO_MQTT.exe program. This program will publish the home I/O data to a broker. The default address of the broker used is localhost:1883. You can change the address of the broker by specifying it as a command line option.

If the tool detects Home I/O properly it will dump the list name of data sources from the simulator into a CSV formatted list (file `sensors.csv` in the program directory) with the following format:

`MemoryType,Address,DSName,Room,DataType,Topic`

- MemoryType: type of Home I/O memory
  - Input: from sim to broker, event-driven. e.g. switches or sensors.
  - Output: from broker to sim. e.g. lights or heater.
  - Memory: from sim to broker, continuous update rate. e.g. temperatures.
- Address: Home I/O address
- DSName: Description of the data source
- Room: Room the data source is attached to
- DataType: value type
  - Topic: MQTT topic used to communicate with the data source
  - Input/Memory: bridge publishes to the topic with the updated data
  - Output: bridge subscribes to the topic and updates the sim with data published to the topic

3.2 Subscribe to the published Home I/O values

If the tool successfully connected to the broker it will display a message "Connected to broker at localhost" Then "Connected".

To test the data publication to the broker, we will do a subscribe with a node in Node-RED.

First, get the name of a topic for the Room A Temperature ("`/home/general/Memory/float/Temperature_Zone_A_[K]`"). Be careful, the topic name depends on your computer language. So, it could be different if you use a French, an Italian, a Spanish or a German one. If you want to use the English names, set the appropriate locale in Home I/O with the menu "Options / Localization / Language".

Create

You can also create the flow with the following code. We added a node for limiting the subscribing to one message every 10 seconds to avoid collecting to much data.

```
[{"id":"907d1380.2af72","type":"mosca
in","z":"f59c6764.97c658","mqtt_port":1883,"mqtt_ws_port":8080,"name":"","usernam
e":"","password":"","dburl":"","x":150,"y":40,"wires":[[]]},{"id":"c92ffef8.6cbec
","type":"debug","z":"f59c6764.97c658","name":"","active":true,"tosidebar":true,"
console":false,"tostatus":false,"complete":"false","x":690,"y":100,"wires":[]},{"
id":"cc4d3412.5f1318","type":"mqtt
in","z":"f59c6764.97c658","name":"","topic":"/home/general/Memory/float/Temperatu
re_Zone_A_[K]","qos":"2","broker":"62b4dd3e.6162cc","x":260,"y":100,"wires":[["a3
7cd033.3776b8"]]},{"id":"a37cd033.3776b8","type":"delay","z":"f59c6764.97c658","n
ame":"","pauseType":"rate","timeout":"5","timeoutUnits":"seconds","rate":"1","nbR
ateUnits":"10","rateUnits":"second","randomFirst":"1","randomLast":"5","randomUni
ts":"seconds","drop":true,"x":480,"y":180,"wires":[["c92ffef8.6cbec"]]},{"id":"62
b4dd3e.6162cc","type":"mqtt-
broker","z":"","name":"","broker":"127.0.0.1","port":"1883","clientid":"","usetls
":false,"compatmode":true,"keepalive":"60","cleansession":true,"willTopic":"","wi
llQos":"0","willPayload":"","birthTopic":"","birthQos":"0","birthPayload":""}]
```

4 Publish Home I/O data to Thing Speak

4.1 Create a Thing Speak account

The default ThingSpeak service limit you to publish `1` data every `15` seconds. So, we installed a ThingSpeak server without that limitation.

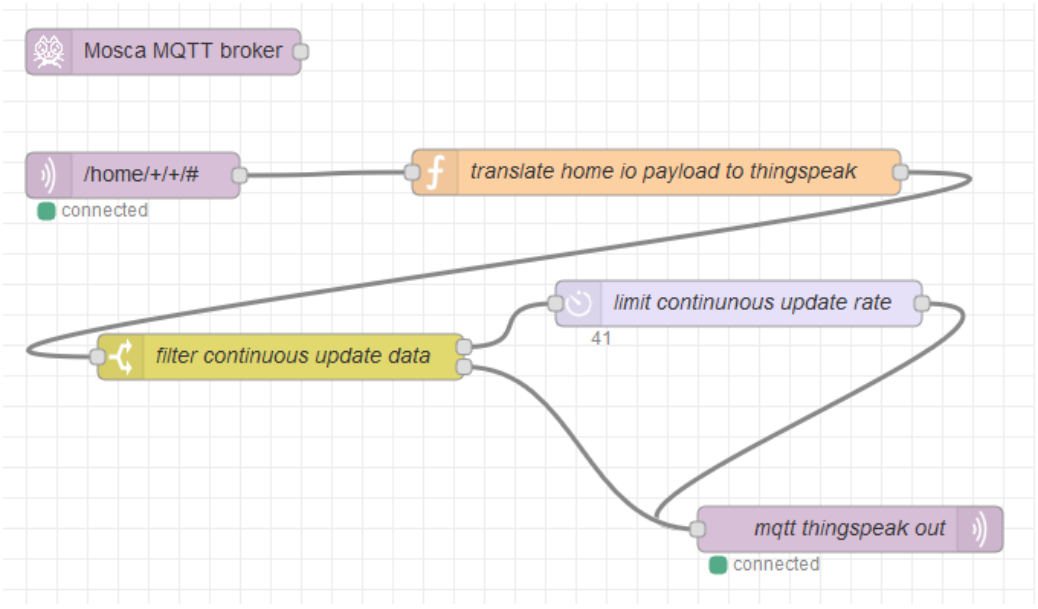
- Navigate to http://sparks-vm24.i3s.unice.fr:3000/users/sign_up
- Create an account
- Once logged in, navigate to http://sparks-vm24.i3s.unice.fr:3000/account
- Write down the API key seen on this page

4.2 Node-RED flow linking Home I/O and ThingSpeak

To connect the Home I/O sensors to ThingSpeak, import the following flow:

```
[{"id":"45cc7449.5a195c","type":"tab","label":"Flow
3"},{"id":"19a467ac.a8eba8","type":"mosca
in","z":"45cc7449.5a195c","mqtt_port":1883,"mqtt_ws_port":8080,"name":"","usernam
e":"","password":"","dburl":"","x":149,"y":67,"wires":[[]]},{"id":"811eb811.d1788
8","type":"mqtt
in","z":"45cc7449.5a195c","name":"","topic":"/home/+/+/#","qos":"2","broker":"aa8
72460.7dff18","x":129,"y":148,"wires":[["f5868538.c4e148"]]},{"id":"d0ffe662.31c6
```

```
88","type":"mqtt out","z":"45cc7449.5a195c","name":"mqtt thingspeak
out","topic":"","qos":"","retain":"","broker":"18d4ce79.021f92","x":599,"y":380,"
wires":[]},{"id":"f5868538.c4e148","type":"function","z":"45cc7449.5a195c","name"
:"translate home io payload to thingspeak","func":"var API_KEY = \"xxxx\";\n\nvar
topicSplit = msg.topic.split(/[/]+/);\n\n// Flag continuous
messages\nmsg.shouldBeThrottled = false;\nif(\n topicSplit[3] == \"Memory\" ||\n
topicSplit[5].startsWith(\"Thermostat\") ||\n
topicSplit[5].startsWith(\"Date_and_Time\") ||\n
topicSplit[5].startsWith(\"Brightness\")){\n msg.shouldBeThrottled =
true;\n}\n\n// Build ThingSpeak payload\nvar value = msg.payload;\nif(topicSplit[3]
== \"bool\"){\n value = msg.payload==\"True\"?1:0;\n}\nmsg.payload = Date.now()
+ \",\" + topicSplit[topicSplit.length - 1] + \",\" + value + \",\" +
API_KEY;\nmsg.topic = \"devices\" + msg.topic;\n\n// Don't proceed if the API key
isn't set properly\nif(API_KEY == \"xxxx\") return null;\n\nreturn
msg;","outputs":1,"noerr":0,"x":472,"y":146,"wires":[["3d1be41d.edff7c"]]},{"id":
"c71aa5da.5f9328","type":"delay","z":"45cc7449.5a195c","name":"limit continuous
update
rate","pauseType":"timed","timeout":"5","timeoutUnits":"seconds","rate":"1","nbRa
teUnits":"30","rateUnits":"second","randomFirst":"1","randomLast":"5","randomUnit
s":"seconds","drop":true,"x":526,"y":232,"wires":[["d0ffe662.31c688"]]},{"id":"3d
1be41d.edff7c","type":"switch","z":"45cc7449.5a195c","name":"filter continuous
update
data","property":"shouldBeThrottled","propertyType":"msg","rules":[{"t":"eq","v":
"true","vt":"jsonata"},{"t":"eq","v":"false","vt":"jsonata"}],"checkall":"true","
outputs":2,"x":226,"y":267,"wires":[["c71aa5da.5f9328"],["d0ffe662.31c688"]]},{"i
d":"aa872460.7dff18","type":"mqtt-
broker","z":"","broker":"localhost","port":"1883","clientid":"","usetls":false,"c
ompatmode":true,"keepalive":"60","cleansession":true,"willTopic":"","willQos":"0"
,"willPayload":"","birthTopic":"","birthQos":"0","birthPayload":""},{"id":"18d4ce
79.021f92","type":"mqtt-broker","z":"","broker":"sparks-
vm24.i3s.unice.fr","port":"1883","clientid":"","usetls":false,"compatmode":true,"
keepalive":"60","cleansession":true,"willTopic":"","willQos":"0","willPayload":""
,"birthTopic":"","birthQos":"0","birthPayload":""}]
```

Things to note about this new flow:

- It listens to all data sources (for this, it uses regular expression in the MQTT topic)

- Update the `API_KEY` variable in the flow to the API key retrieved when creating your ThingSpeak account
- Filters continuous update data (simulation date/time, thermostats, brightness, memory typed inputs) to reduce sample rate to `1` data point per `30` seconds
- The function node in the middle performs the translation of Home IO MQTT data to MQTT to ThingSpeak bridge data
    - For reference, the format of the output data is: `TimeStamp,ItemName Value,API_KEY`
- Deploy the flow

If the MQTT input and outputs show as connected the flow is up and running, data is being sent to ThingSpeak.

4.3 Data visualization

- Navigate to http://sparks-vm24.i3s.unice.fr:3000/channels
- Click on any channel to visualize data
- You can also export the data as CSV format.

5 Conclusion et perspectives

You setted up a simulator for a "Smart-Home" environment, and you can now easily develop more complex things for the implementation of a Home Automation. You have finally sent the publication of your data to a ThingSpeak server, allowing you to store and view the data

Finally, we can of course replace the Home I / O simulation system with real sensors and actuators by always using Node-RED and MQTT on the same model as the one we just presented.