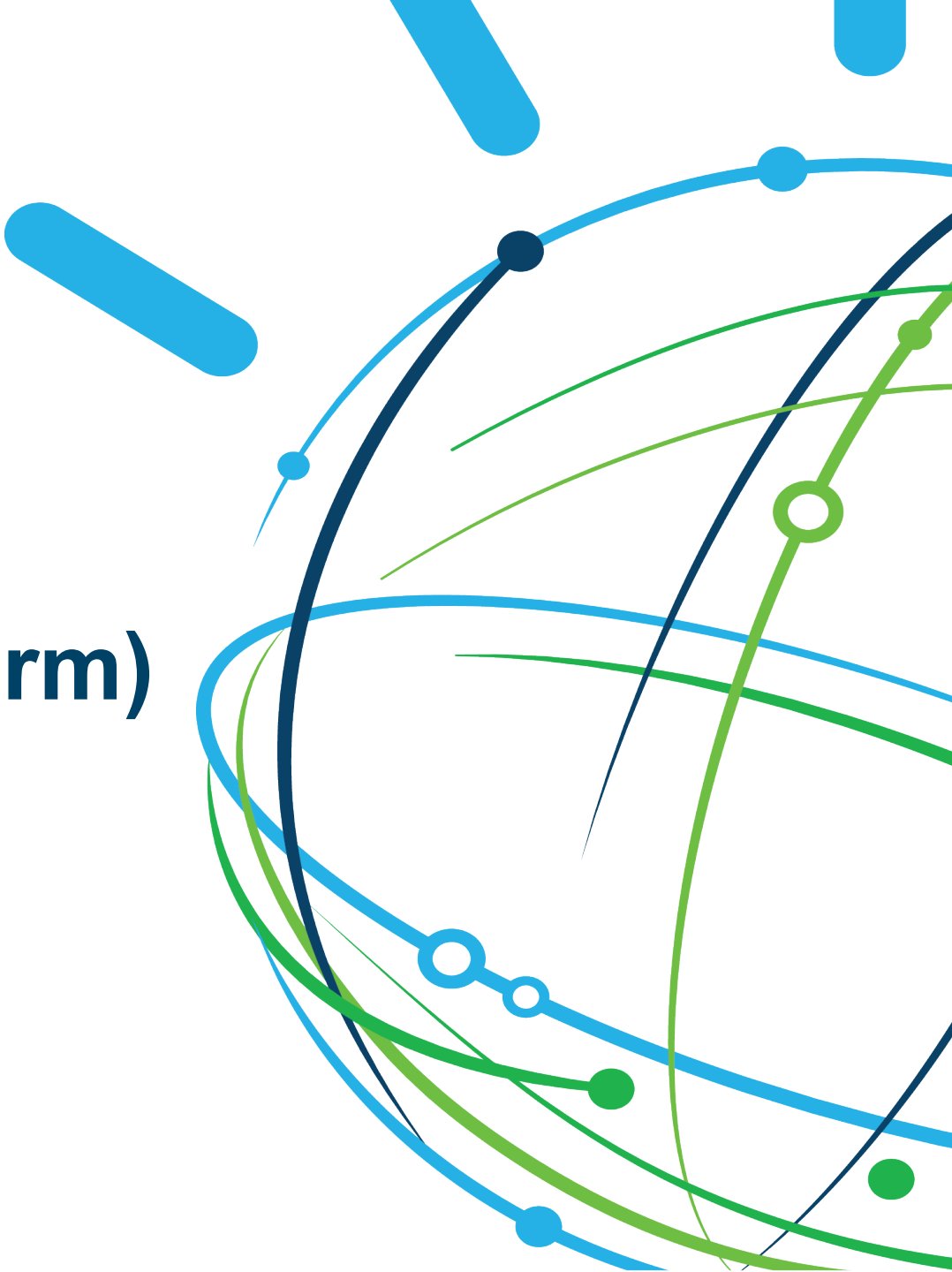
가천대학교
Gachon University

# Embedded System

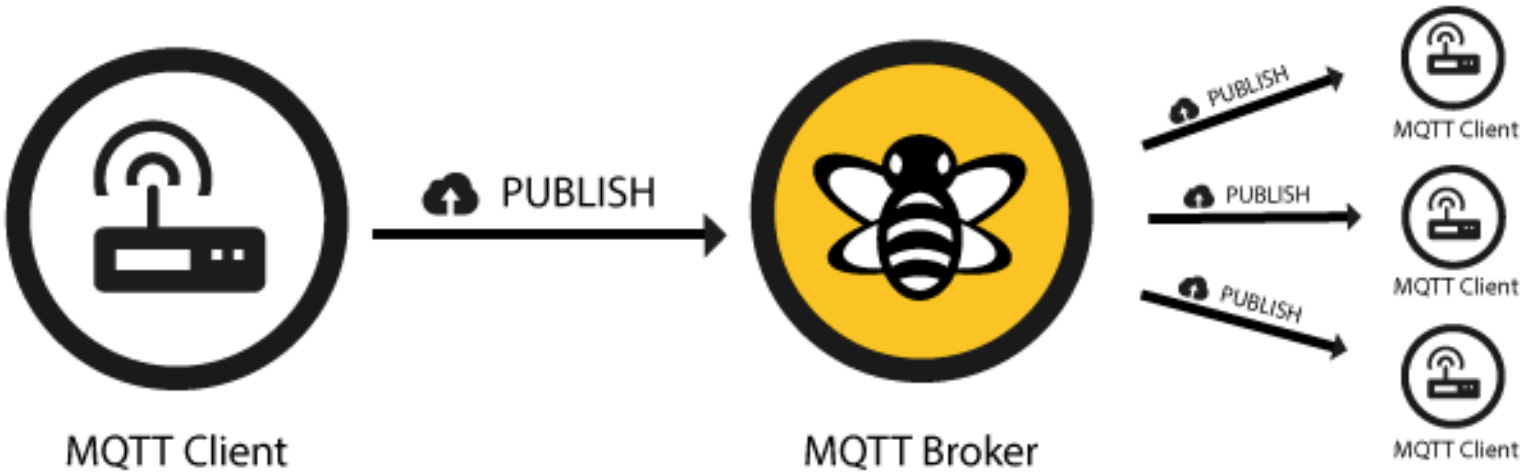
# MQTT communication (IoT Device & Server Platform)

2019 2학기



# MQTT 소개

- **MQTT (MQ Telemetry Transport)**는 센서장치나 라즈베리파이 같은 임베디드 장치, 모바일 장치 사이의 통신을 위한 가벼운 메시징 프로토콜입니다. TCP/IP 기반으로 대역폭이 작은 네트워크에서 동작할 수 있도록 설계된 프로토콜입니다. 임베디드 장치들을 위한 트위터라고 볼 수 있습니다.
- MQTT 자체는 메시지를 어떻게 보낼 것인지를 정의하는 규약일 뿐입니다. 따라서 실제 **"MQTT 트위터"**를 동작시키기 위해서는 서버 역할을 해주는 장치와 프로그램이 필요한데 이를 MQTT 브로커(Broker)라고 합니다. MQTT 브로커는 각종 장치들(MQTT Client)이 보내주는 메시지를 수집하고 이걸 다시 필요한 장치들에게 전송해주는 중계서버 역할을 합니다.



# MQTT 동작 구조

- 트위터 서비스의 동작구조를 떠올려보세요. 트위터에서 사용자는 다른 사용자를 follow 할 수 있습니다. 그럼 다른 사용자가 생성하는 메시지(트윗)를 받아볼 수 있죠. 그리고 스스로 메시지를 생성할 수도 있습니다. 그럼 자신을 follow하는 사용자에게 메시지가 전달되죠.

- MQTT도 거의 유사한 동작구조를 갖습니다. MQTT 시스템에 참여하는 MQTT 클라이언트는 메시지 **발행(publish, 트윗에 해당)**, 메시지 **구독(subscribe, follow에 해당)** 두 가지 동작을 할 수 있습니다. MQTT 클라이언트가 메시지를 특정 **채널(Topic, 토픽)**에 발행하면 이 채널을 구독한 모든 클라이언트에게 메시지가 전달되는 겁니다. 중간에서 메시지를 수집, 재분해 하는 작업은 MQTT 브로커가 담당합니다.

# MQTT 동작 구조

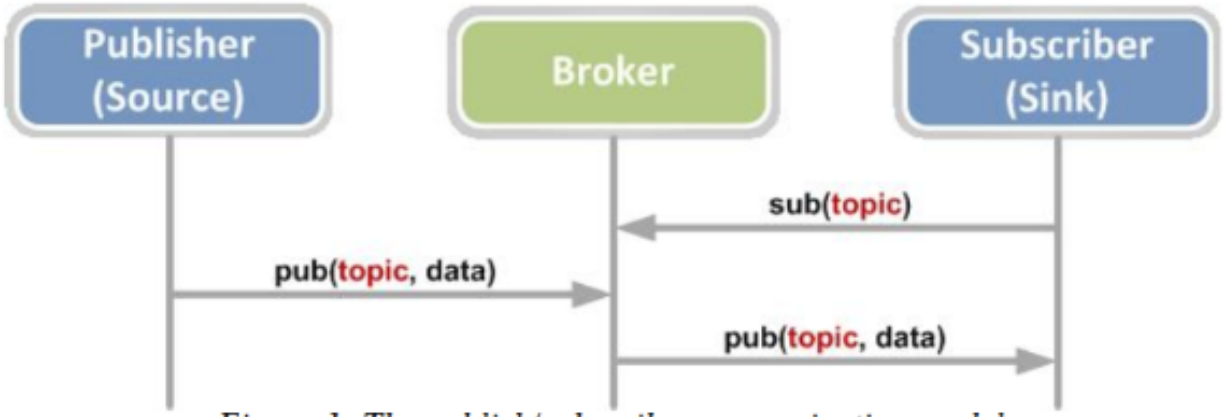



*Figure 1: The publish/subscribe communication model*

토픽 (Topic)

메시지를 발행/구독(pub/sub) 하는 행위는 채널 단위로 일어납니다. 이를 MQTT에서는 토픽(Topic)이라고 합니다. 토픽은 슬래시(/)로 구분된 계층구조를 갖습니다.

# 개발 환경 구축(IDP - Raspberry pi)

## 개발 환경 구축

- 운영체제 update / upgrade
  - 패키지 업데이트 및 업그레이드
    - pi@raspberry:~ $ sudo apt-get update
    - pi@raspberry:~ $ sudo apt-get upgrade
      - » Do you want to continue? [Y/n] y

        % 위 과정을 처음 실행한다면 시간이 꽤 걸림.

# 개발 환경 구축(IDP - Raspberry pi)

## MQTT

### MQTT – Mosquitto Broker 설치

- Mosquitto 프로그램에대한 서명키(인증키) 다운로드

```
$ cd
$ wget http://repo.mosquitto.org/debian/mosquitto-repo.gpg.key
$ sudo apt-key add mosquitto-repo.gpg.key
OK
```

- Mosquitto Repository Package 등록

```
$ cd /etc/apt/sources.list.d/
$ sudo wget http://repo.mosquitto.org/debian/mosquitto-stretch.list
```

- Mosquitto Broker 설치

```
$ sudo apt-get update
$ sudo apt-cache search mosquitto
$ sudo apt-get install mosquitto mosquitto-clients
```

- Mosquitto 실행

```
$ sudo /etc/init.d/mosquitto start
```

# MQTT Broker Test

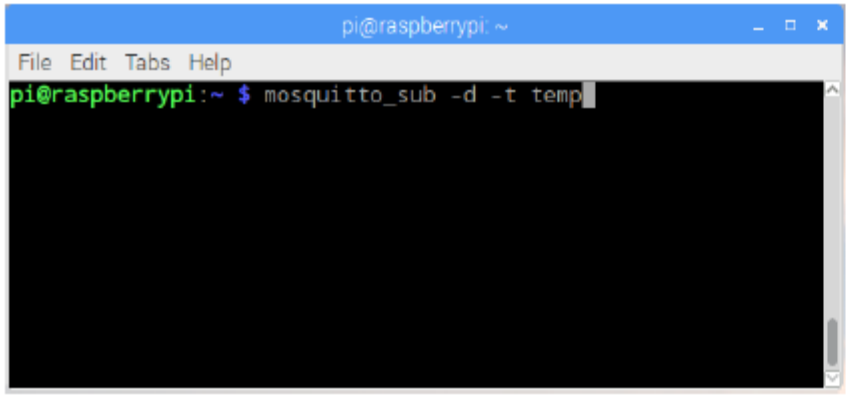
- -d 데몬으로 실행, -h 호스트ip, -t 토픽명, -m 메시지

Topic = temp
Message = 23.5

MQTT

## MQTT – Mosquitto Broker 동작 확인

$ mosquitto_sub –d –t temp




$ mosquitto_pub –d –t temp –m “23.5”

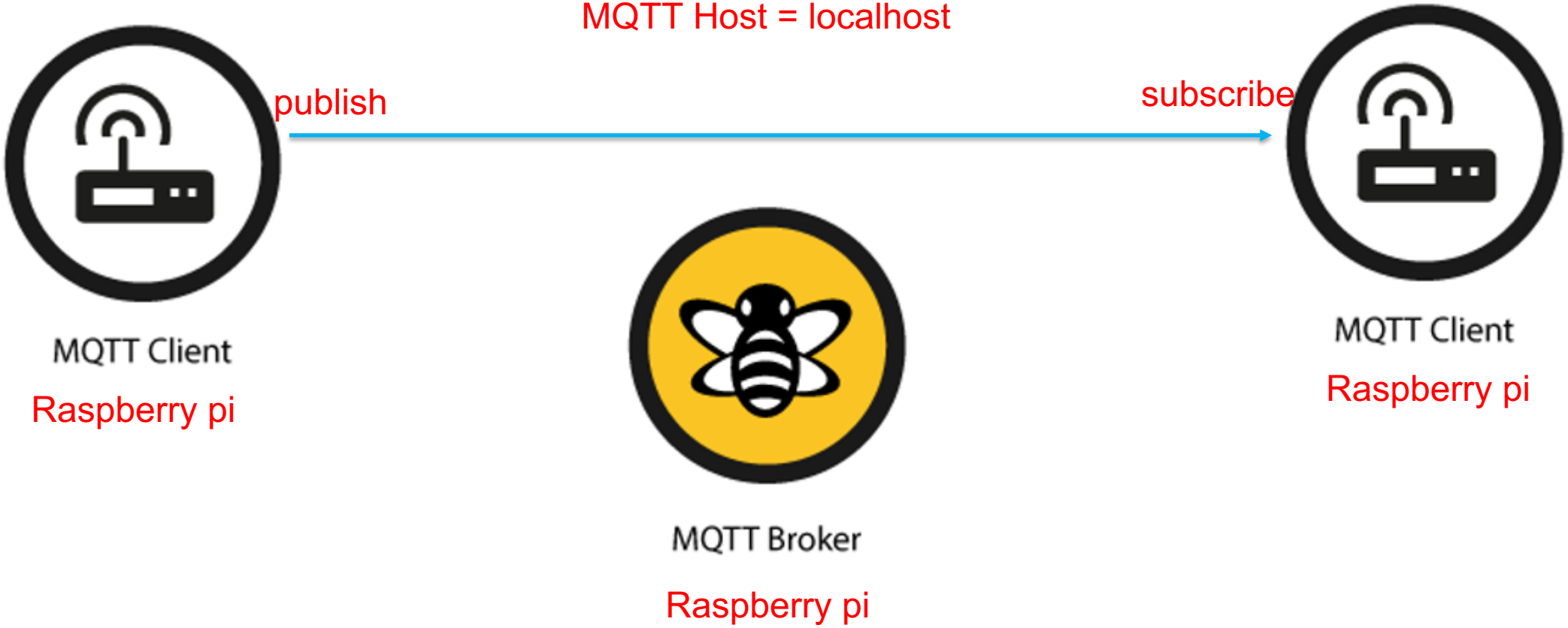
# 개발 환경 구축(IDP - Raspberry pi)

▸ MQTT – Python 라이브러리 설치

```
$ cd
$ sudo pip install --upgrade pip
$ sudo pip install paho-mqtt
$ sudo git clone https://github.com/eclipse/paho.mqtt.python
$ cd paho.mqtt.python
$ sudo python setup.py install
$ cd
```

# MQTT Test

Topic = hello
Message = 34
MQTT Broker = Raspberry pi
MQTT Host = localhost



# MQTT Test

## MQTT

### MQTT - Subscribe 프로그램 & Publisher 프로그램 작성

#### MQTT – Subscribe 프로그램 작성

- 파일 명: subBasic.py

```
1   import paho.mqtt.client as mqtt
2
3   def on_connect ( client, userdata , flags, rc) :
4           print("Connect with result code " +str(rc) )
5           client.subscribe("hello")
6
7   def on_message ( client, userdata , msg ) :
8           print(msg.topic + " " +  str(msg.payload))
9
10  client = mqtt.Client()
11  client.on_connect = on_connect
12  client.on_message = on_message
13  client.connect("localhost", 1883,60)
14  client.loop_forever()
```

# MQTT Test

## MQTT

- MQTT – Subscribe 프로그램 동작 테스트

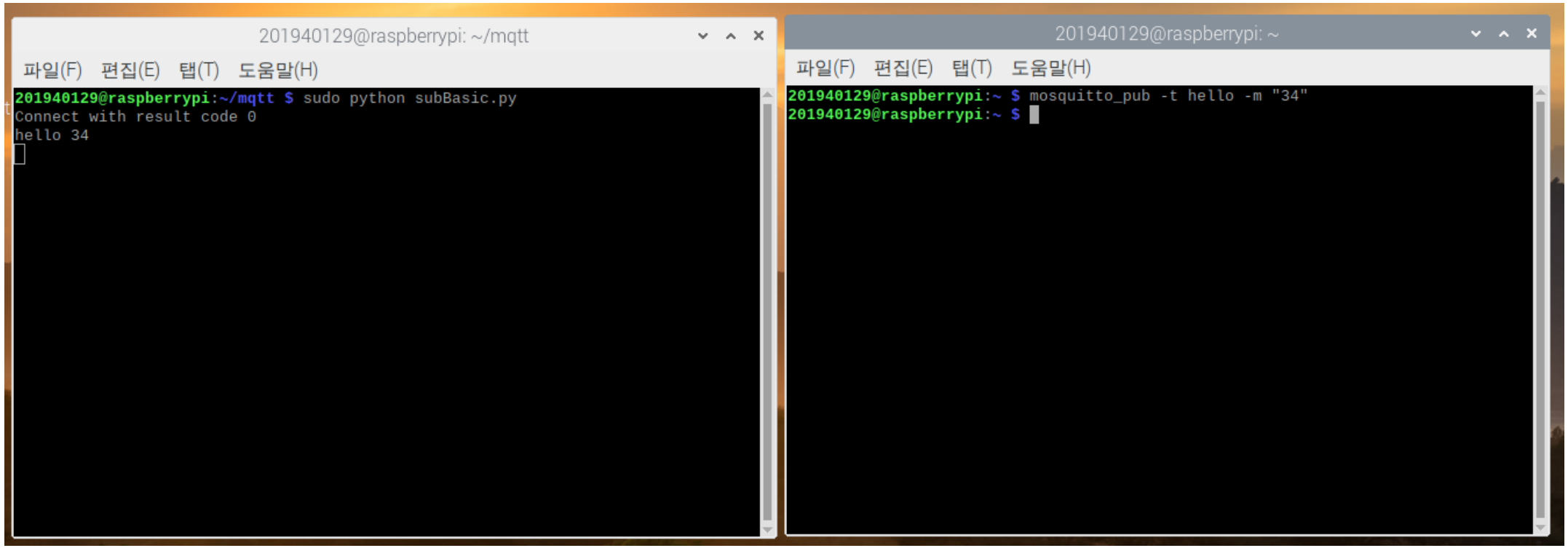
**터미널 창 1**

**$ sudo python subBasic.py**

**터미널 창 2**

**$mosquito_pub –d –t hello –m “34”**

mosquitto_pub



# MQTT Test

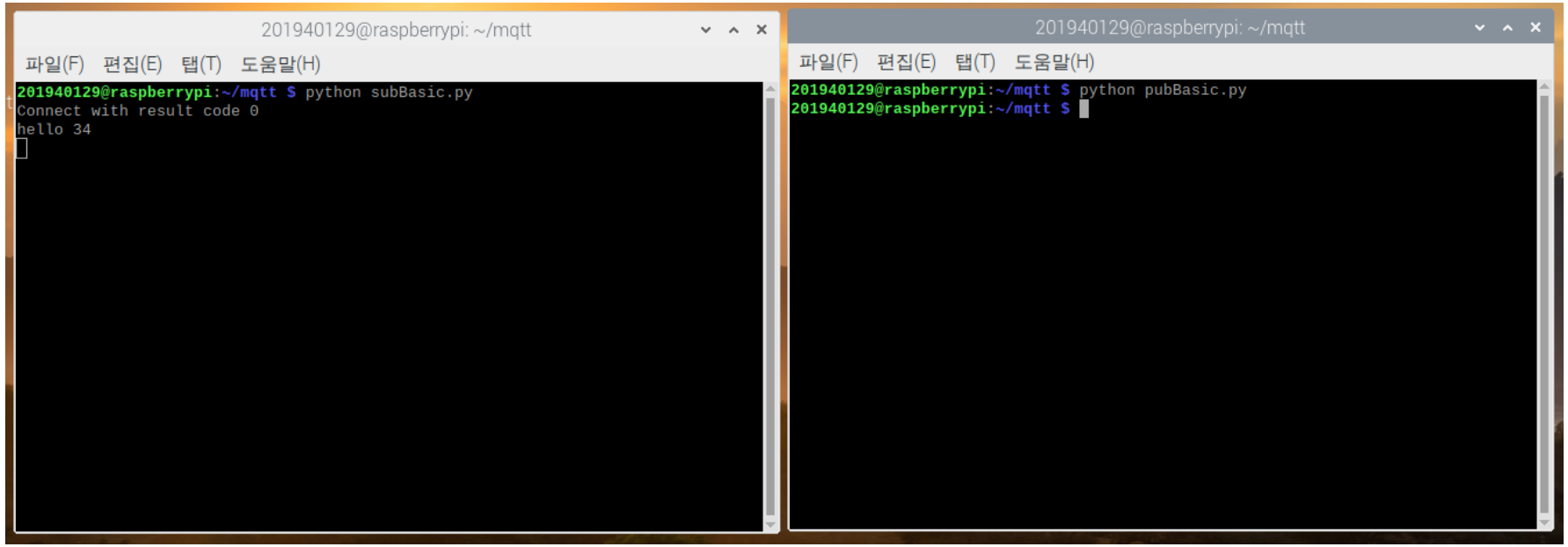
## MQTT

- MQTT – Publish 프로그램 작성
  - 파일 명 : pubBasic.py

```
1   import paho.mqtt.publish as publish
2
3   publish.single("hello", "34", hostname="localhost")
```

- MQTT – Publish 프로그램 동작 테스트

| $ python subBasic.py | $ python pubBasic.py |
| --- | --- |



# PC Server 환경 Setup (mosquitto 설치)

- https://mosquitto.org/download/
- 64비트, 32비트

## Binary Installation

The binary packages listed below are supported by the Mosquitto project. In many cases Mosquitto is also available directly from official Linux/BSD distributions.

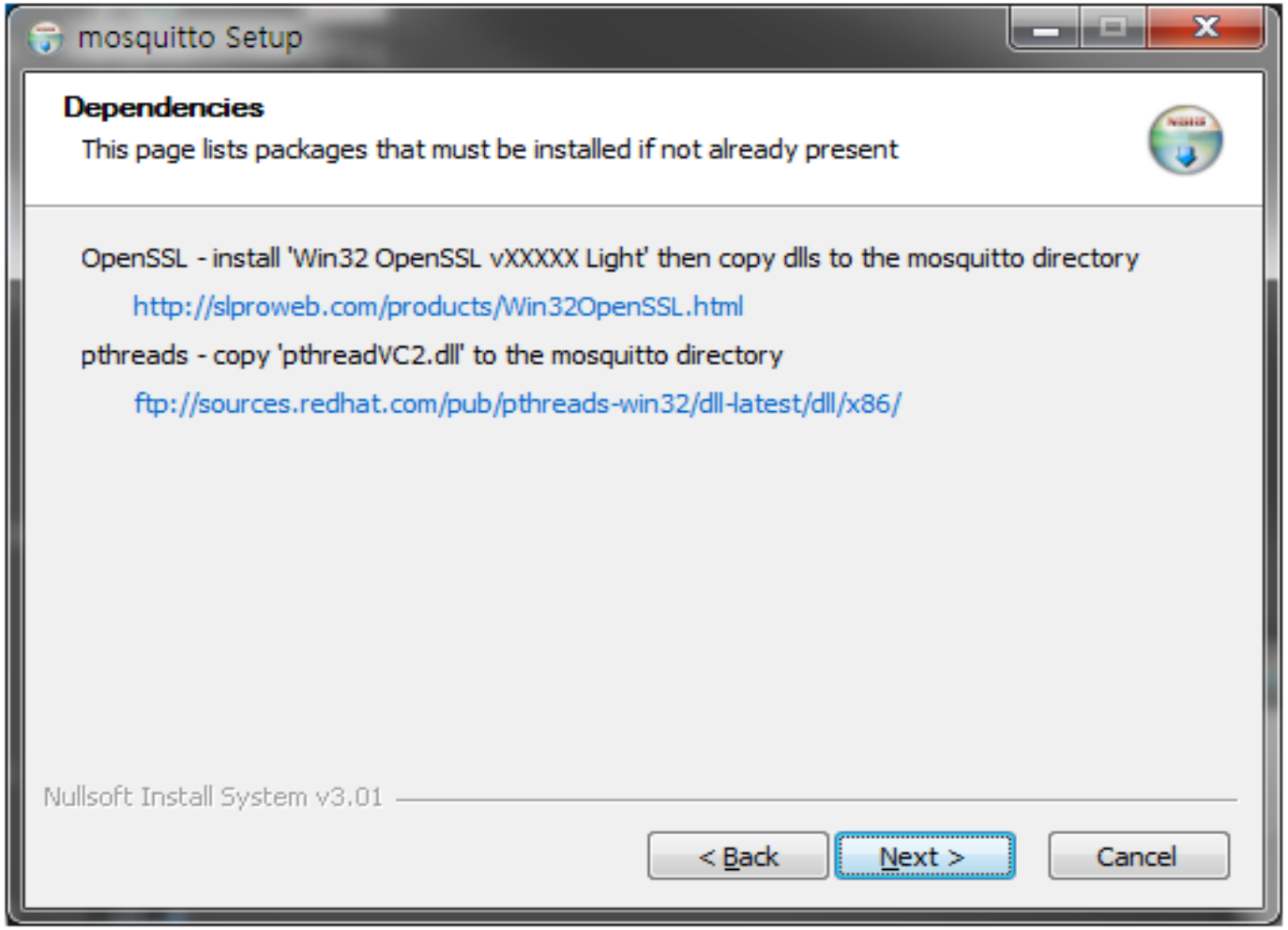
### Windows

- mosquitto-1.6.7-install-windows-x64.exe (~1.4 MB) (64-bit build, Windows Vista and up, built with Visual Studio Community 2017)
- mosquitto-1.6.7-install-windows-x32.exe (~1.4 MB) (32-bit build, Windows Vista and up, built with Visual Studio Community 2017)

See also readme-windows.txt after installing.

# PC Server 환경 Setup (mosquitto 설치)

- 설치 과정에서 아래와 같은 설치 조건을 확인할 수 있습니다.
- Next, Next를 눌러 설치를 진행합니다.



# PC Server 환경 Setup (mosquitto 설치)

- 설치 조건 중 하나인 OpenSSL을 설치하기 위해 설치 파일을 다운로드합니다.
- 자신의 Windows 환경에 맞게 다운받습니다.
- Slproweb이란
- http://slproweb.com/products/Win32OpenSSL.html

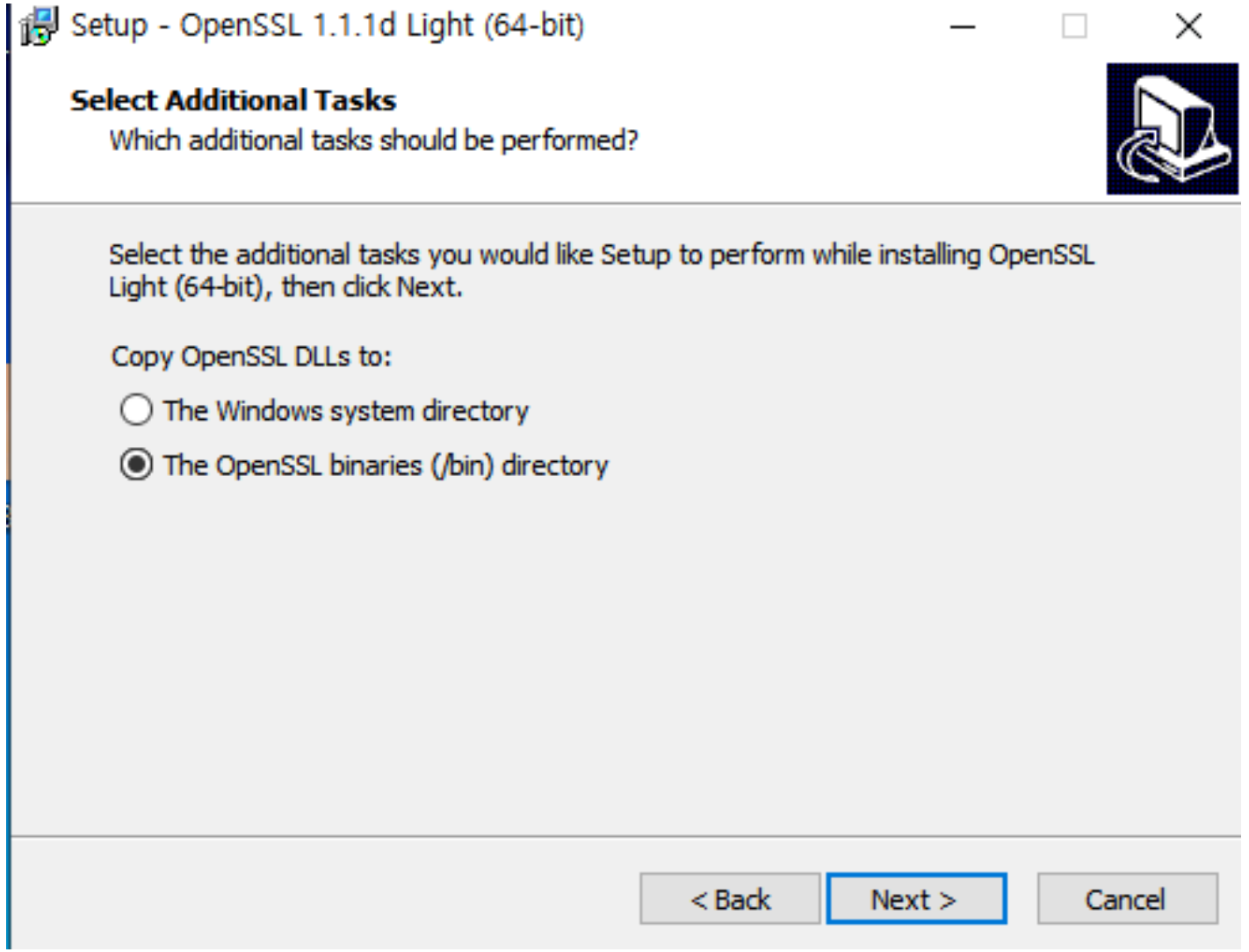
**Download Win32/Win64 OpenSSL**

Download Win32/Win64 OpenSSL today using the links below!

| File | Type | Description |
|---|---|---|
| Win64 OpenSSL v1.1.1d Light EXE \| MSI (experimental) | 3MB Installer | Installs the most commonly used essentials of Win64 OpenSSL v1.1.1d (Recommended for users by the creators of OpenSSL). Only installs on 64-bit versions of Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win64 OpenSSL v1.1.1d EXE \| MSI (experimental) | 43MB Installer | Installs Win64 OpenSSL v1.1.1d (Recommended for software developers by the creators of OpenSSL). Only installs on 64-bit versions of Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win32 OpenSSL v1.1.1d Light EXE \| MSI (experimental) | 3MB Installer | Installs the most commonly used essentials of Win32 OpenSSL v1.1.1d (Only install this if you need 32-bit OpenSSL for Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win32 OpenSSL v1.1.1d EXE \| MSI (experimental) | 30MB Installer | Installs Win32 OpenSSL v1.1.1d (Only install this if you need 32-bit OpenSSL for Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win64 OpenSSL v1.1.0L Light | 3MB Installer | Installs the most commonly used essentials of Win64 OpenSSL v1.1.0L (Recommended for users by the creators of OpenSSL). Only installs on 64-bit versions of Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win64 OpenSSL v1.1.0L | 37MB Installer | Installs Win64 OpenSSL v1.1.0L (Recommended for software developers by the creators of OpenSSL). Only installs on 64-bit versions of Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win32 OpenSSL v1.1.0L Light | 3MB Installer | Installs the most commonly used essentials of Win32 OpenSSL v1.1.0L (Only install this if you need 32-bit OpenSSL for Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win32 OpenSSL v1.1.0L | 30MB Installer | Installs Win32 OpenSSL v1.1.0L (Only install this if you are a software developer needing 32-bit OpenSSL for Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win64 OpenSSL v1.0.2t Light | 3MB Installer | Installs the most commonly used essentials of Win64 OpenSSL v1.0.2t (Recommended for users by the creators of OpenSSL). Only installs on 64-bit versions of Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win64 OpenSSL v1.0.2t | 23MB Installer | Installs Win64 OpenSSL v1.0.2t (Recommended for software developers by the creators of OpenSSL). Only installs on 64-bit versions of Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win32 OpenSSL v1.0.2t Light | 2MB Installer | Installs the most commonly used essentials of Win32 OpenSSL v1.0.2t (Only install this if you need 32-bit OpenSSL for Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |
| Win32 OpenSSL v1.0.2t | 20MB Installer | Installs Win32 OpenSSL v1.0.2t (Only install this if you are a software developer needing 32-bit OpenSSL for Windows. Note that this is a default build of OpenSSL and is subject to local and state laws. More information can be found in the legal agreement of the installation. |

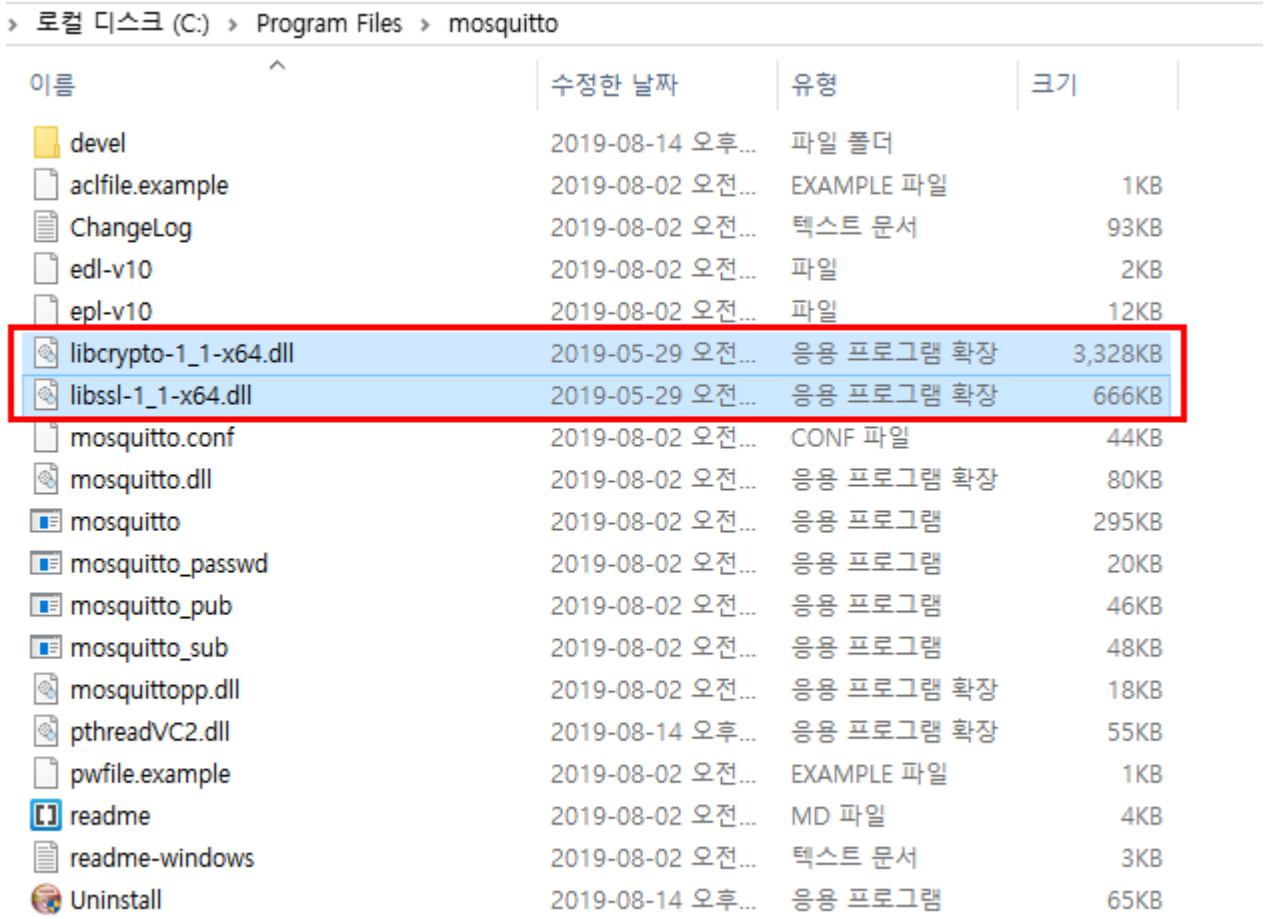
# PC Server 환경 Setup (mosquitto 설치)

- Next, Next 하여 다운 받습니다.



# PC Server 환경 Setup (mosquitto 설치)

- OpenSSL을 설치한 후, 설치 경로(C:\Program Files\OpenSSL-Win64)에서 DLL 파일을 복사하여 모스키토 설치 경로(C:\Program Files\mosquitto)에 복사합니다.



# PC Server 환경 Setup (mosquitto 설치)

- 또 다른 설치 조건인 pthreads를 해결하기 위해 FTP에서 파일을 다운로드하여 모스키토 설치 경로에 복사합니다.
- ftp://sources.redhat.com/pub/pthreads-win32/dll-latest/dll/x86/

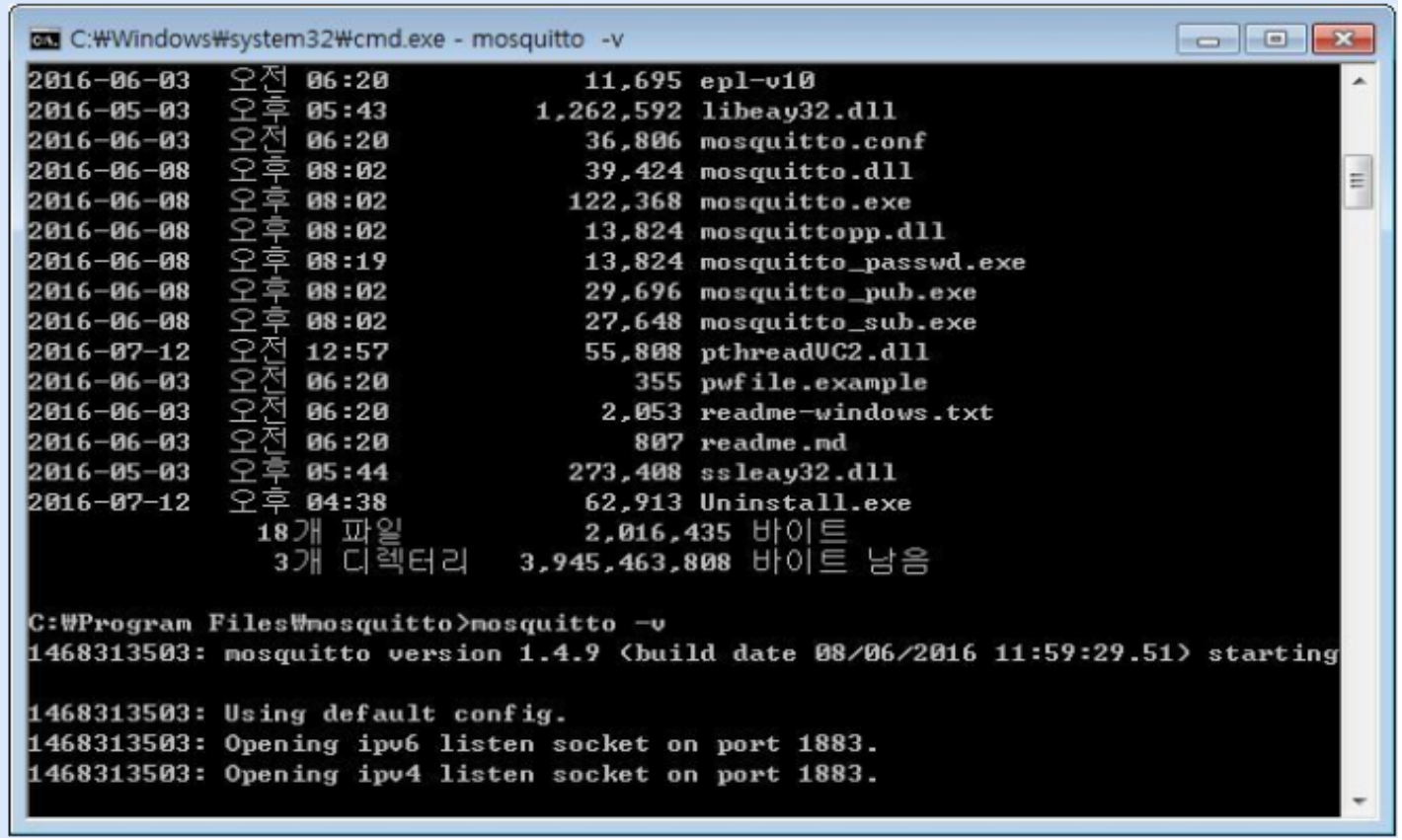
/pub/pthreads-win32/dll-latest/dll/x86/의 색인

[상위 디렉터리]

| 이름 | 크기 | 수정된 날짜 |
|---|---|---|
| md5.sum | 293 B | 15. 2. 5. 오전 9:00:00 |
| pthreadGC2.dll | 117 kB | 12. 5. 27. 오전 9:00:00 |
| pthreadGCE2.dll | 119 kB | 12. 5. 27. 오전 9:00:00 |
| pthreadVC2.dll | 54.5 kB | 12. 5. 27. 오전 9:00:00 |
| pthreadVCE2.dll | 60.5 kB | 12. 5. 27. 오전 9:00:00 |
| pthreadVSE2.dll | 56.0 kB | 12. 5. 27. 오전 9:00:00 |
| sha512.sum | 866 B | 15. 2. 5. 오전 9:00:00 |

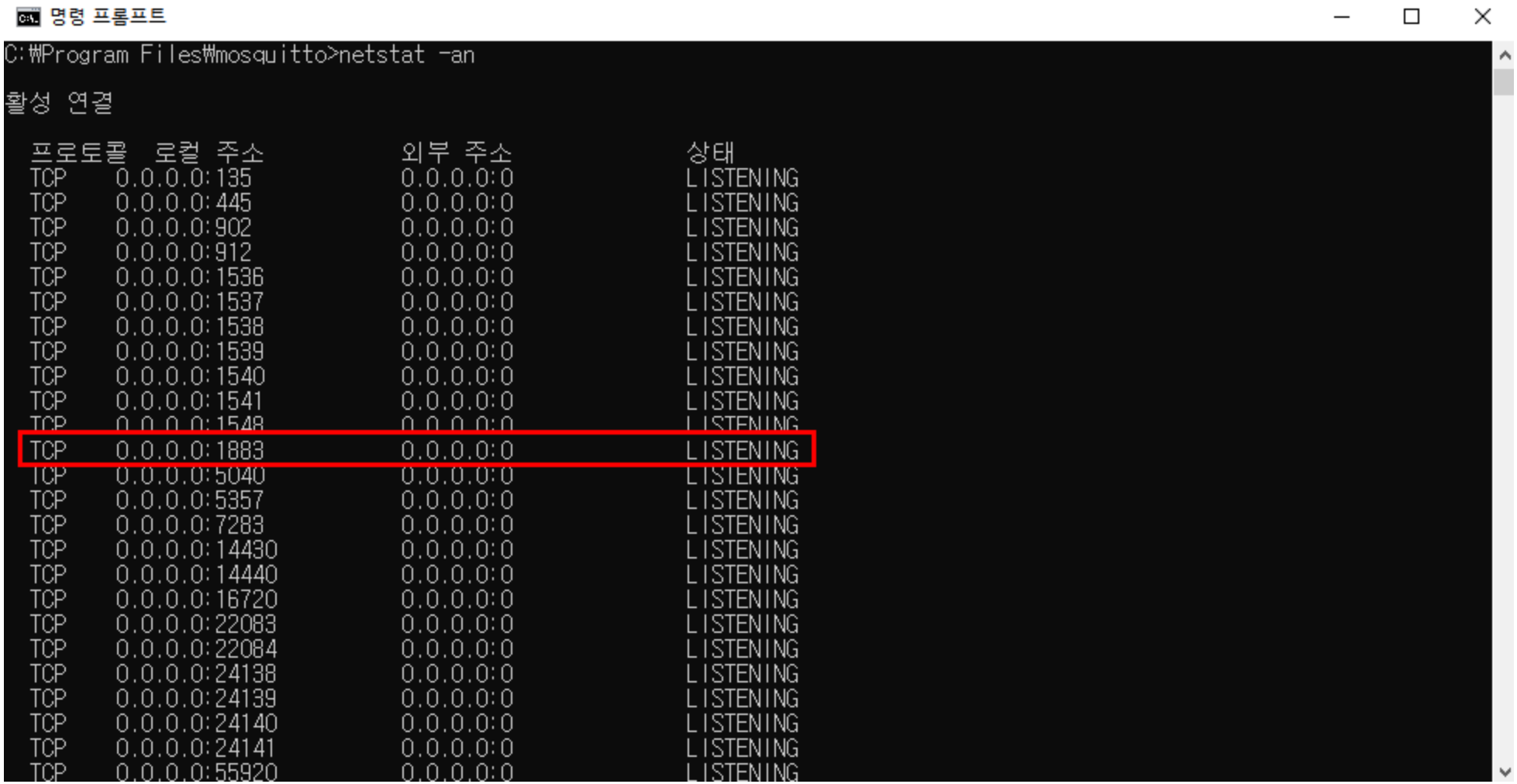
# PC - Mosquitto broker 실행

- mosquitto –v
- Mosquitto  폴더에서 실행
- -v 옵션은 모든 통신과정을 보여주는 옵션입니다.
- 기본 포트인 1883포트로 실행됩니다.



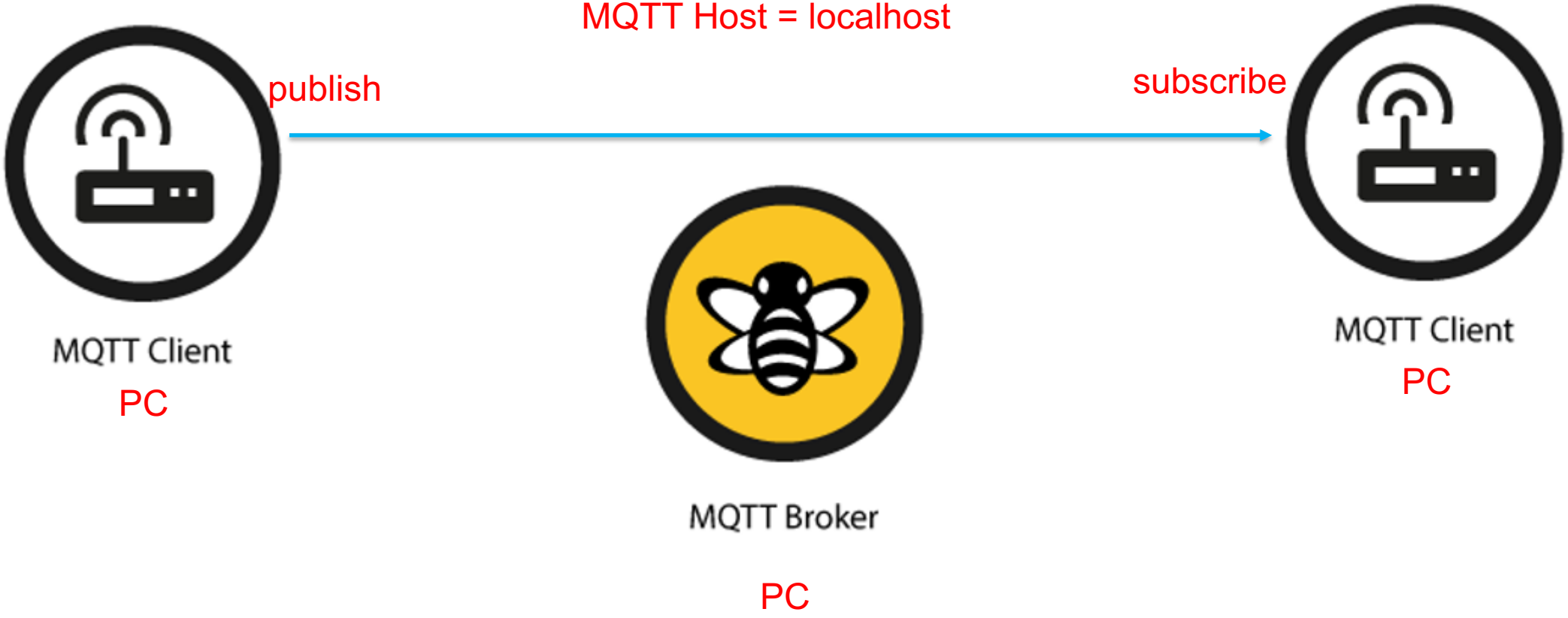
# PC - Mosquitto broker

- Cmd에서 “netstat –an”을 입력하면, 활성 연결이 나옵니다.



# PC Server - MQTT Test

Topic = /CCL
Message = Hello World!!
MQTT Broker = PC
MQTT Host = localhost



# PC에서 확인

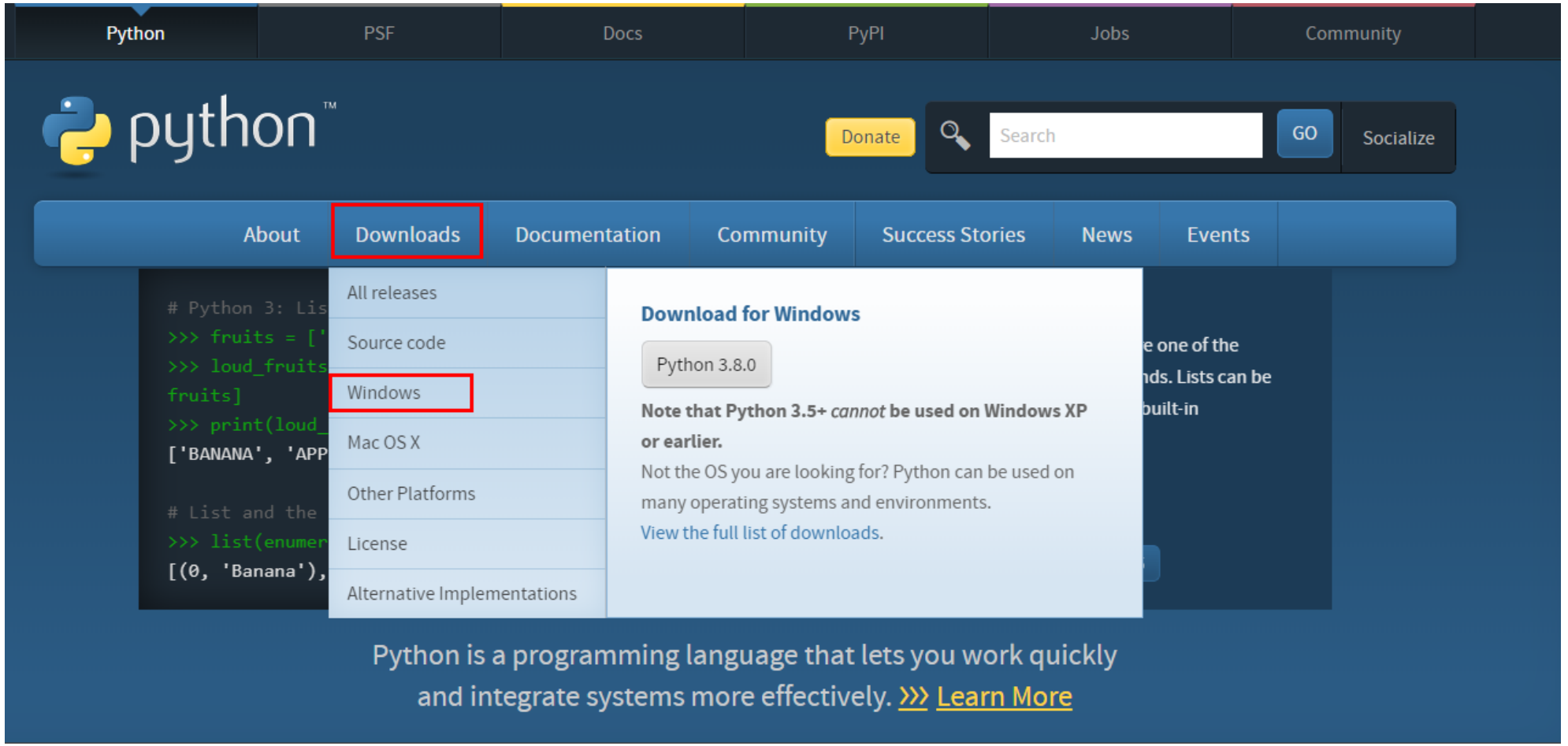
- Mosquitto 폴더로 이동해서 실행

- mosquitto_sub –h 호스트ip –t 토픽명(ex:mosquitto_sub –h 192.168.0.12 –t /CCL)

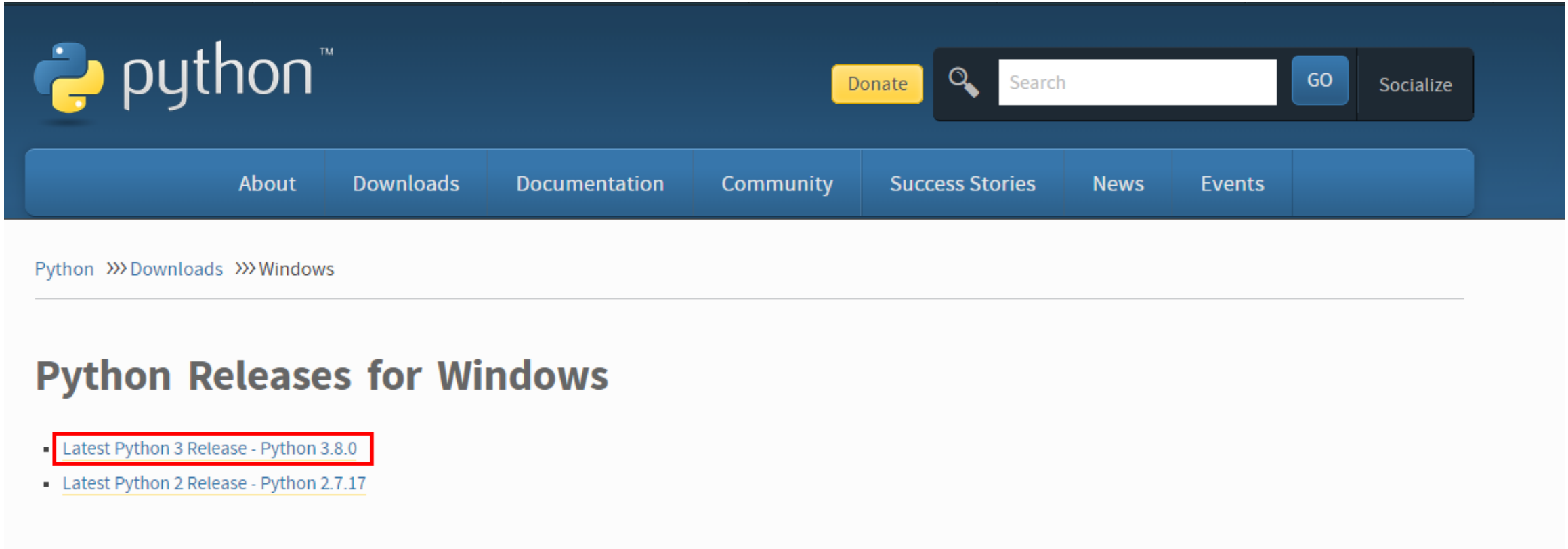
- Mosquitto_pub –h 호스트ip –t 토픽명 –m 메시지
- (ex:mosquito_pub –h 192.168.0.12 –t /CCL –m “Hello World!!”)

# Python 3 설치(python 3버전 없는 사람만)

- www.python.org에서 다운로드 메뉴 - Python 3.5이상 선택해서 다운로드



# Python 3 설치


python
Donate
Search
GO
Socialize
About
Downloads
Documentation
Community
Success Stories
News
Events
Python >>> Downloads >>> Windows
Python Releases for Windows
Latest Python 3 Release - Python 3.8.0
Latest Python 2 Release - Python 2.7.17

# Python 3 설치

## Files

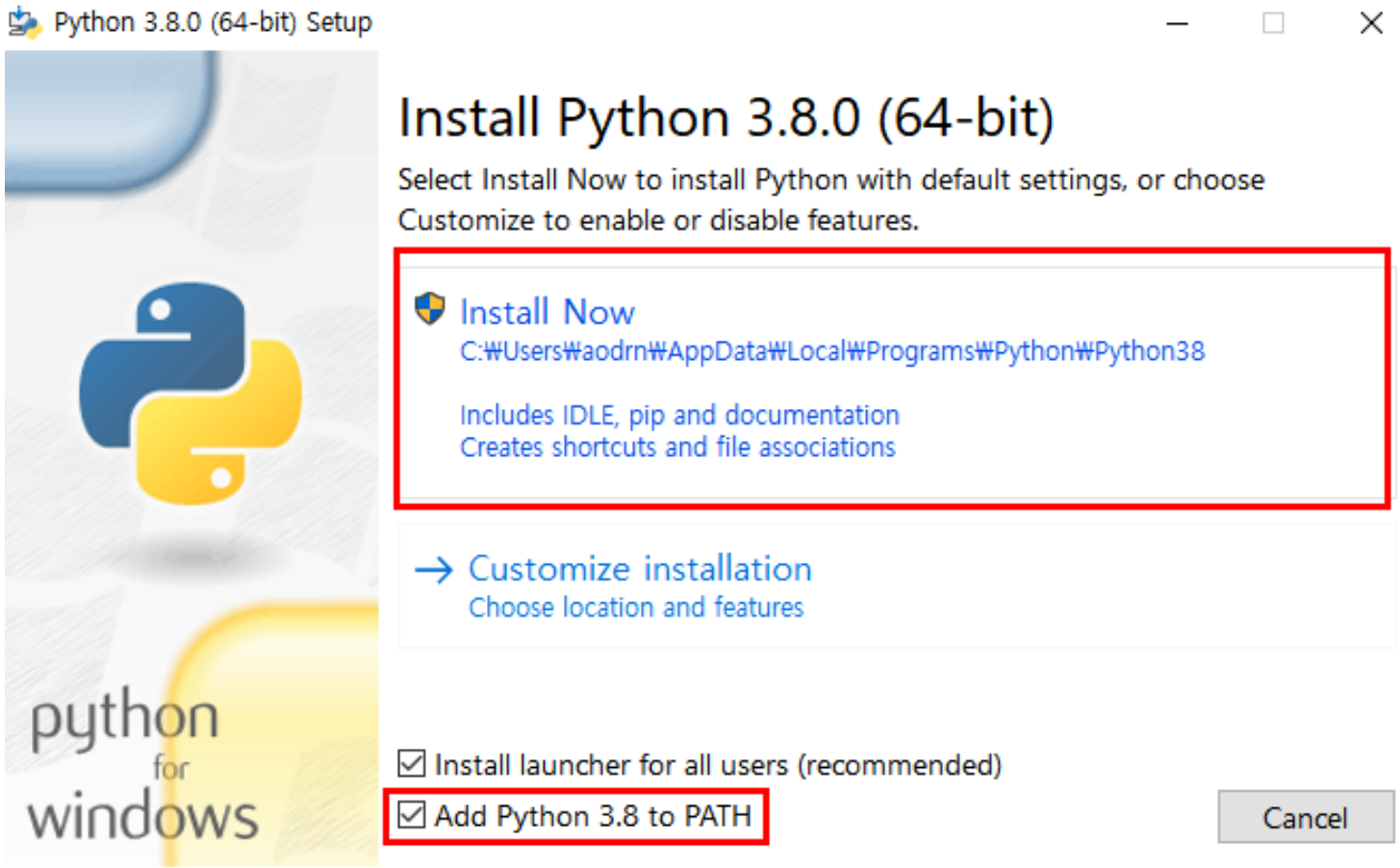
| Version | Operating System | Description | MD5 Sum | File Size | GPG |
|---|---|---|---|---|---|
| Gzipped source tarball | Source release | | e18a9d1a0a6d858b9787e03fc6fdaa20 | 23949883 | SIG |
| XZ compressed source tarball | Source release | | dbac8df9d8b9edc678d0f4cacdb7dbb0 | 17829824 | SIG |
| macOS 64-bit installer | Mac OS X | for OS X 10.9 and later | f5f9ae9f416170c6355cab7256bb75b5 | 29005746 | SIG |
| Windows help file | Windows | | 1c33359821033ddb3353c8e5b6e7e003 | 8457529 | SIG |
| Windows x86-64 embeddable zip file | Windows | for AMD64/EM64T/x64 | 99cca948512b53fb165084787143ef19 | 8084795 | SIG |
| Windows x86-64 executable installer | Windows | for AMD64/EM64T/x64 | 29ea87f24c32f5e924b7d63f8a08ee8d | 27505064 | SIG |
| Windows x86-64 web-based installer | Windows | for AMD64/EM64T/x64 | f93f7ba8cd48066c59827752e531924b | 1363336 | SIG |
| Windows x86 embeddable zip file | Windows | | 2ec3abf05f3f1046e0dbd1ca5c74ce88 | 7213298 | SIG |
| Windows x86 executable installer | Windows | | 412a649d36626d33b8ca5593cf18318c | 26406312 | SIG |
| Windows x86 web-based installer | Windows | | 50d484ff0b08722b3cf51f9305f49fdc | 1325368 | SIG |

64비트

32비트

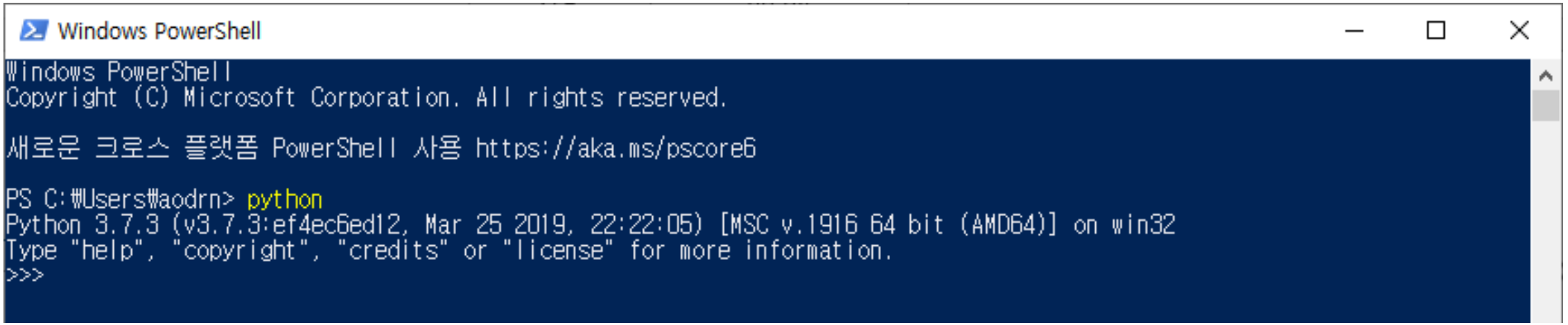
# Python 3 설치

- 설치 과정에서 Add Python 3.8 to PATH 반드시 체크



# Python 3 설치

- 설치 확인
- 윈도우키 + R을 눌러서 나오는 창에 powershell이라고 치고, 확인을 눌러서 powershell 실행
- Powershell 화면에서 python이라고 치고 입력해서 오류가 나오지 않으면 설치 성공



# Python 3 설치

- Python 실행이 안되면
- 환경 변수 설정
- Path에 자신의 Python 폴더와 Python \ Scripts 폴더 추가

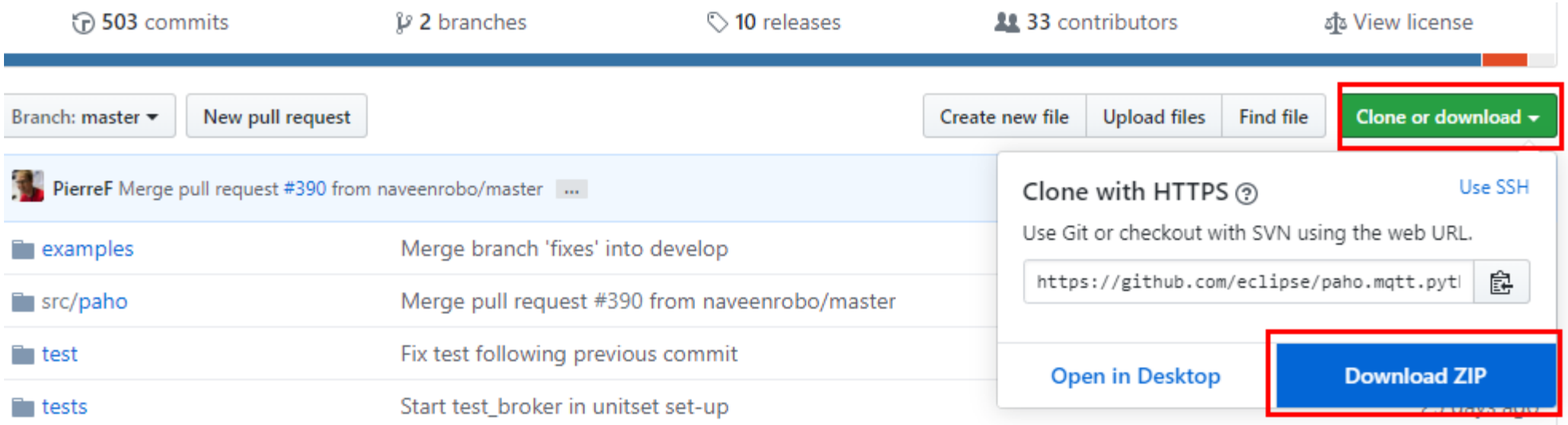
- ex) C:\Users\aodrn\AppData\Local\Programs\Python\Python37
- ex) C:\Users\aodrn\AppData\Local\Programs\Python\Python37\Scripts

# PC에 Python 라이브러리 설치

- PC에 Python이 설치되어 있지 않다면 Python 먼저 설치!!!!!!

| Cmd 창 |
| --- |
| pip install --upgrade pip |
| pip install paho-mqtt |

- **https://github.com/eclipse/paho.mqtt.python**



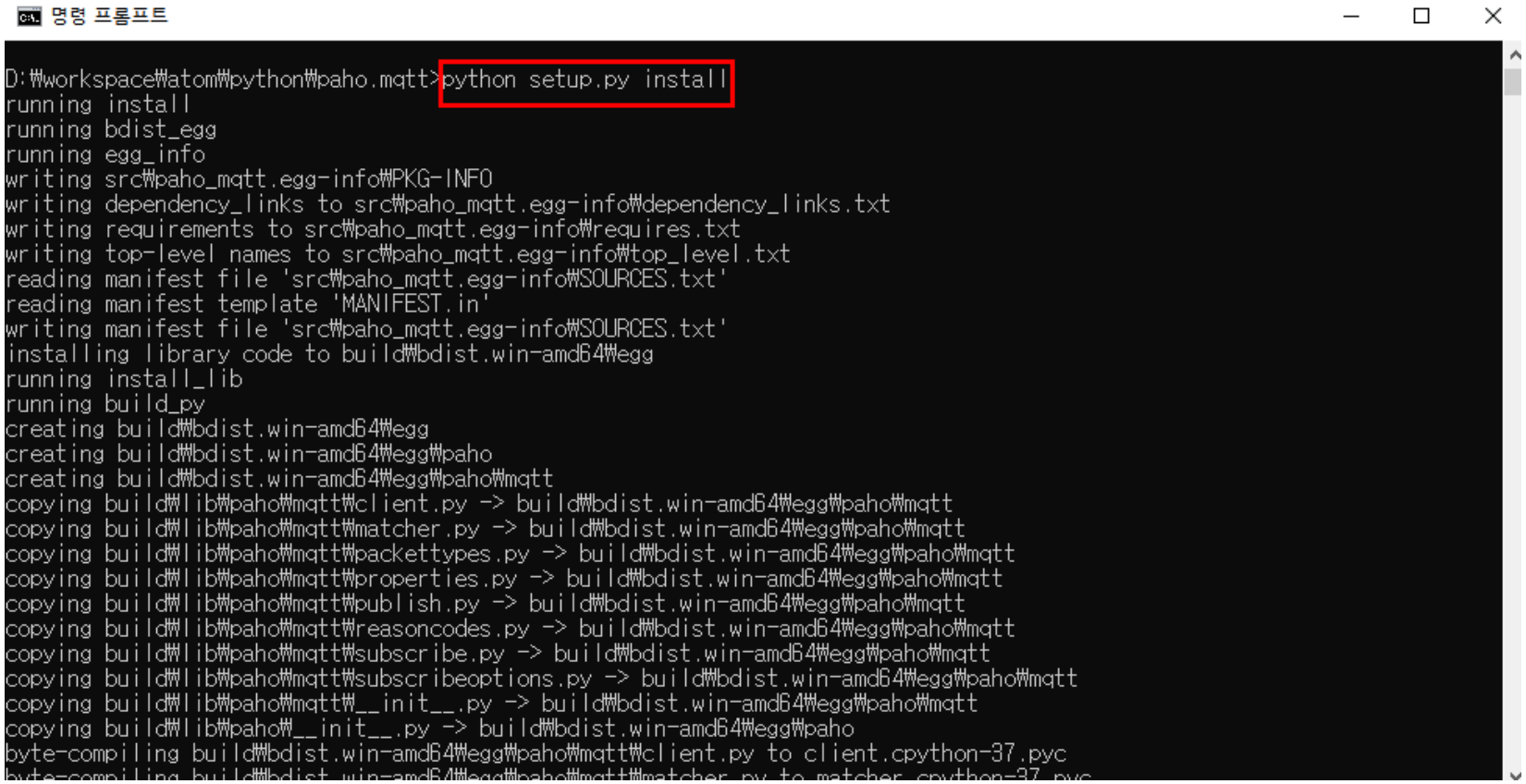
# Python 라이브러리 설치

압축 풀고 다운로드한 폴더로 이동

cd paho.mqtt.python

설치 파일 실행

Python setup.py install



# paho

- The Eclipse Paho project provides open-source client implementations of MQTT and MQTT-SN messaging protocols aimed at new, existing, and emerging applications for the Internet of Things (IoT).
- MQTT is a light-weight publish/subscribe messaging protocol, originally created by IBM and Arcom (later to become part of Eurotech) around 1998. The MQTT 3.1.1 specification has now been standardised by the OASIS consortium. The standard is available in a variety of formats.

- Eclipse Paho
  - https://www.eclipse.org/paho/

- Eclipse Paho Python Client – documentation
  - https://www.eclipse.org/paho/clients/python/docs/

# RP+PC간의 MQTT 통신 시나리오

온도,습도를
RP에서 publish
PC 에서 온도 Subscribe

{'Temperature':oo, 'Humidity': oo}

PC가 온도를 체크하여
일정 온도가 넘으면
PC에서 "on" publish

"on" 메시지

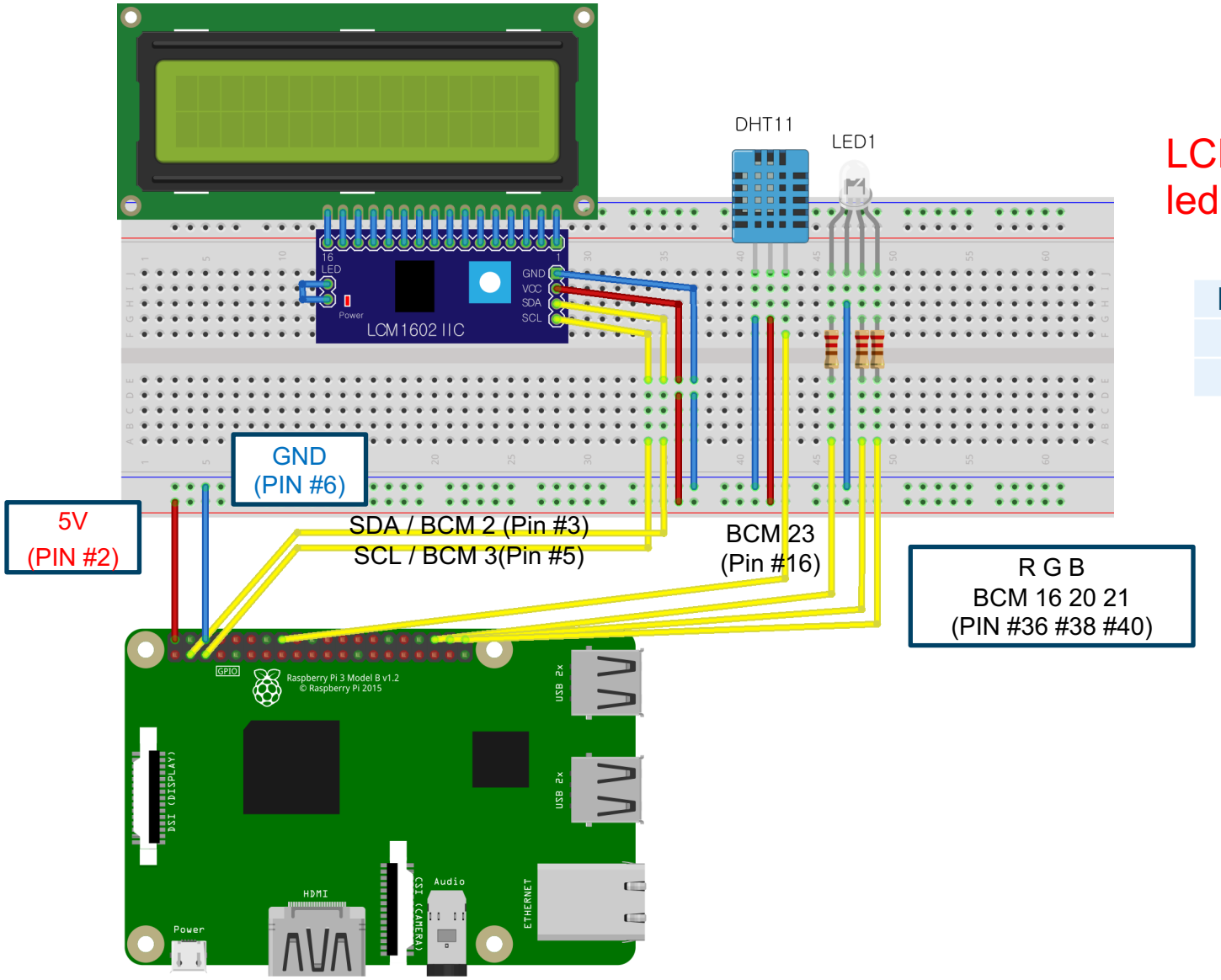
RP에서
LED 빨간색 ON

PC가 온도를 체크하여
일정 온도로 내려가면
PC에서 "off" publish

"off" 메시지

RP에서
LED 빨간색 OFF

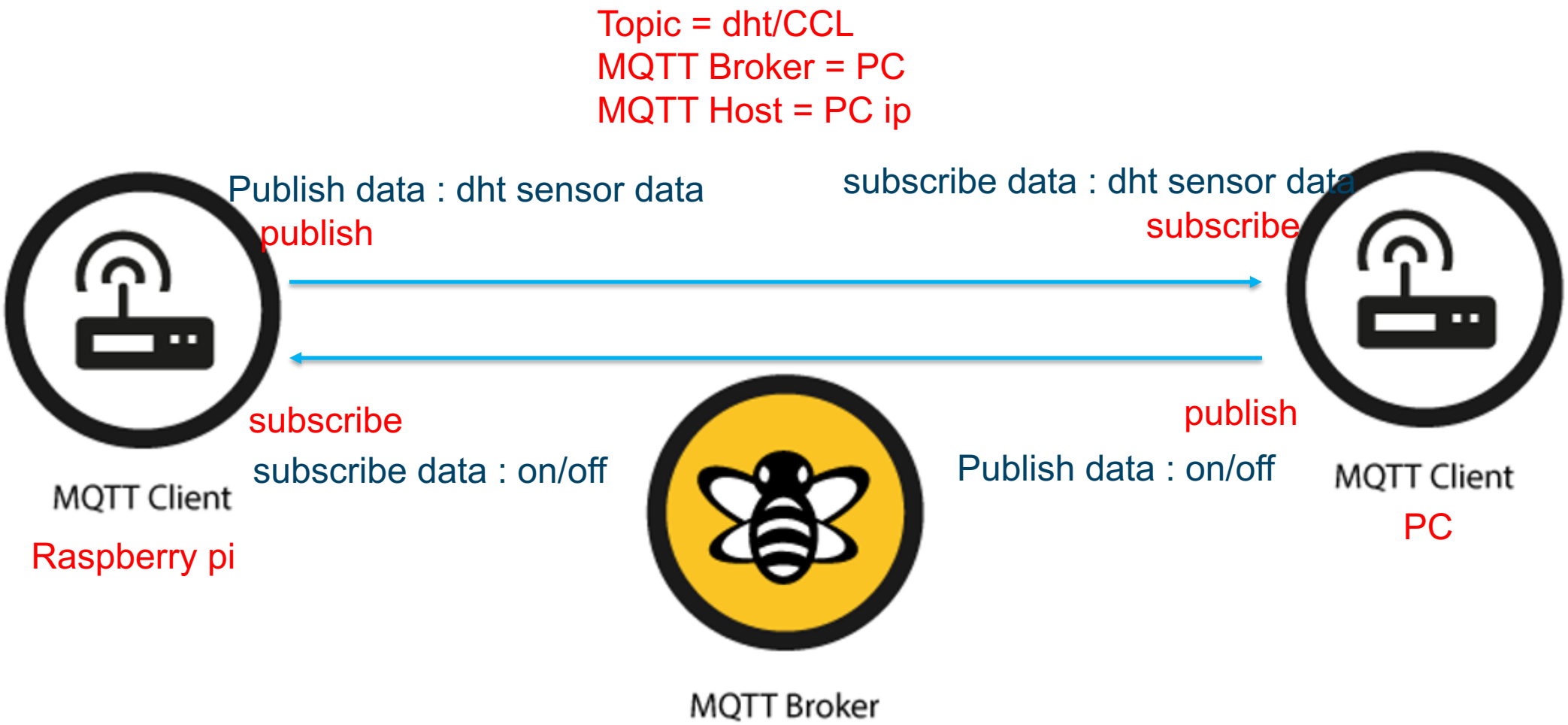
# RP+PC간의 MQTT 통신 시나리오




LCD 제외
led, DHT 센서만 연결!

| Module | BCM | PIN |
|---|---|---|
| LED R | 16 | 36 |
| DHT | 23 | 16 |

# MQTT 환경


Topic = dht/CCL
MQTT Broker = PC
MQTT Host = PC ip
Publish data : dht sensor data
publish
subscribe data : dht sensor data
subscribe
subscribe
subscribe data : on/off
publish
Publish data : on/off
MQTT Client
Raspberry pi
MQTT Broker
MQTT Client
PC

# MQTT 이용한 Smart Home(Raspberry pi)

dht_pubsub.py

```
import paho.mqtt.client as mqtt
import time
import Adafruit_DHT as dht
import json
import RPi.GPIO as GPIO

GPIO.setwarnings(False)
GPIO.setmode(GPIO.BCM)
GPIO.setup(16, GPIO.OUT)

dht_type =11
dht_pin = 23

# Define Variables
MQTT_HOST = "  192.9.44.252“          #자신의 pc ip
MQTT_PORT = 1883
MQTT_KEEPALIVE_INTERVAL = 60
MQTT_TOPIC = "dht/CCL“

# Define on_publish event function
def on_publish(client, userdata, mid):
        print ("Message Published...")
```

```
def on_connect ( client, userdata , flags, rc ):
        print("Connect with result code" + str (rc))
        client.subscribe("dht/CCL")
def on_message(client, userdata, msg):
        print(msg.topic+" "+str(msg.payload.decode('utf-8’)))
        if msg.payload == "on":
                GPIO.output(16, True)
        elif msg.payload == "off":
                GPIO.output(16, False)

# Initiate MQTT Client
client = mqtt.Client()
# Register publish callback function
client.on_publish = on_publish
client.on_connect = on_connect
client.on_message = on_message

# Connect with MQTT Broker
client.connect(MQTT_HOST, MQTT_PORT, MQTT_KEEPALIVE_INTERVAL)
client.loop_start()

while True:
        humidity, temperature = dht.read_retry(dht_type, dht_pin)
        if humidity is not None and temperature is not None:
                data = {'temperature':round(temperature, 1), 'humidity' : round(humidity, 1)}
                client.publish(MQTT_TOPIC, str(data))
                print('Published. Sleeping ...’)
        else:
                print('Failed to get reading. Skipping ...')
```

# MQTT 이용한 Smart Home(Window PC)

dht_MQ.py

```
import paho.mqtt.client as mqtt
import paho.mqtt.publish as publish
import time

normal_temp = 25.0    #원하는 온도 설정
MQTT_Broker = "192.9.44.252"  #자신의 pc(broker) ip

def on_connect ( client, userdata , flags, rc ):
    print("Connect with result code" + str (rc) )
    client.subscribe("dht/CCL") #Topic

def on_message ( client, userdata , msg ) :

    x = str(msg.payload.decode('utf-8'))    #dht 센서 데이터
    print(msg.topic + " " + x)
    y = eval(x)     #dht 센서 데이터를 Dic타입으로 변환 파싱

    if y["temperature"] > normal_temp:
        publish.single("dht/CCL", "on",hostname = MQTT_Broker)

    elif y["temperature"] <= normal_temp:
        publish.single("dht/CCL", "off",hostname =
MQTT_Broker)
```

```
def on_publish(client, userdata, mid):
    print("message publish..")

def on_disconnect(client, userdata,  rc):
    print("Disconnected")

client = mqtt.Client ()
client.on_connect = on_connect
client.connect(MQTT_Broker, 1883, 60)
client.on_message = on_message
client.on_publish = on_publish
client.on_disconnect = on_disconnect
client.loop_forever()
```

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