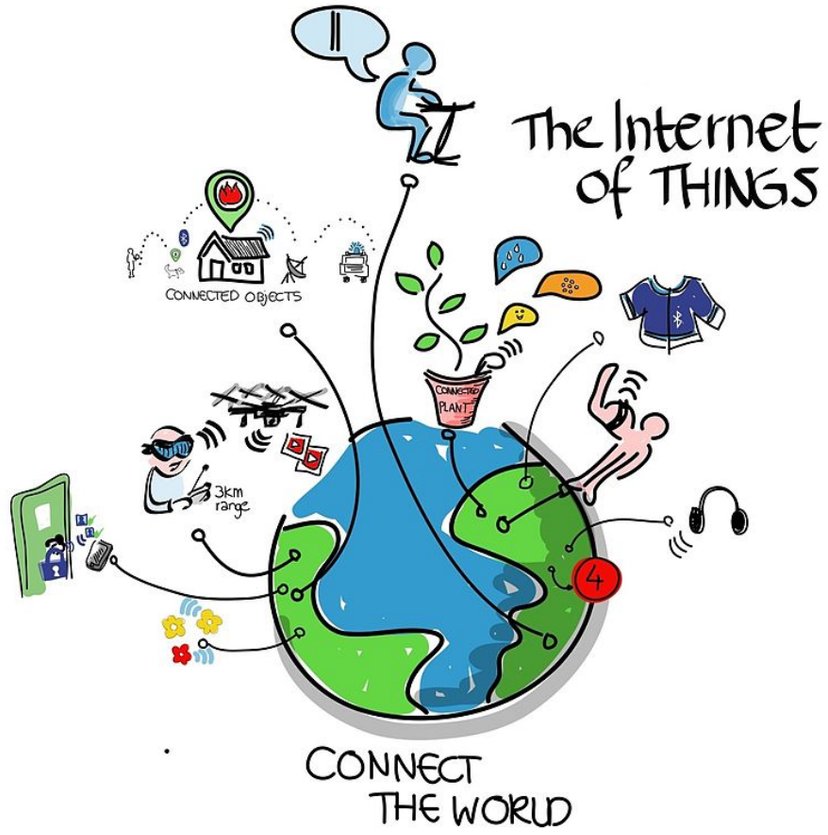
物聯網與生活：以空氣盒子為例

中央研究院資訊科學所 陳伶志
cclljj@iis.sinica.edu.tw

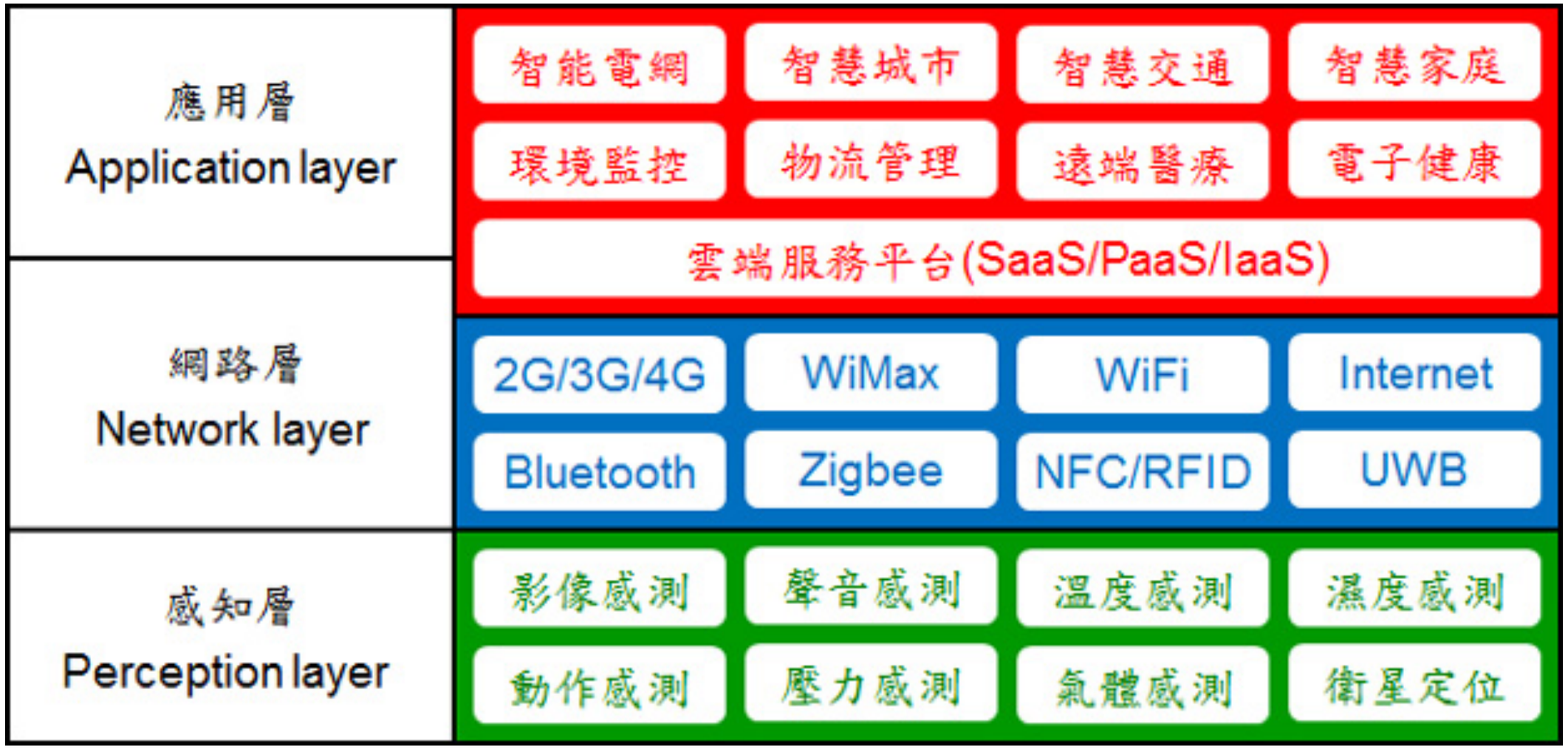
什麼是物聯網

- 物聯網是一個由實體物件連結網際網路所形成的網路系統。
- 這些「物」可以是任何裝置、交通工具、建築物及其他的實體物品，並且都有嵌入電子零件、軟體、感應器及網路連線，同時藉由這些軟硬體搭配，進行收集和交換資料等工作。
- 物聯網可以藉由感測與控制的整合，增進資訊系統的自動化、智慧化與運作效能。



https://zh.wikipedia.org/wiki/物联网

物聯網架構



資料來源：
http://www.hightech.tw/index.php/2012-06-06-14-12-38/27-wireless-communication/785-internet-of-things-2

物聯網應用：智慧家庭

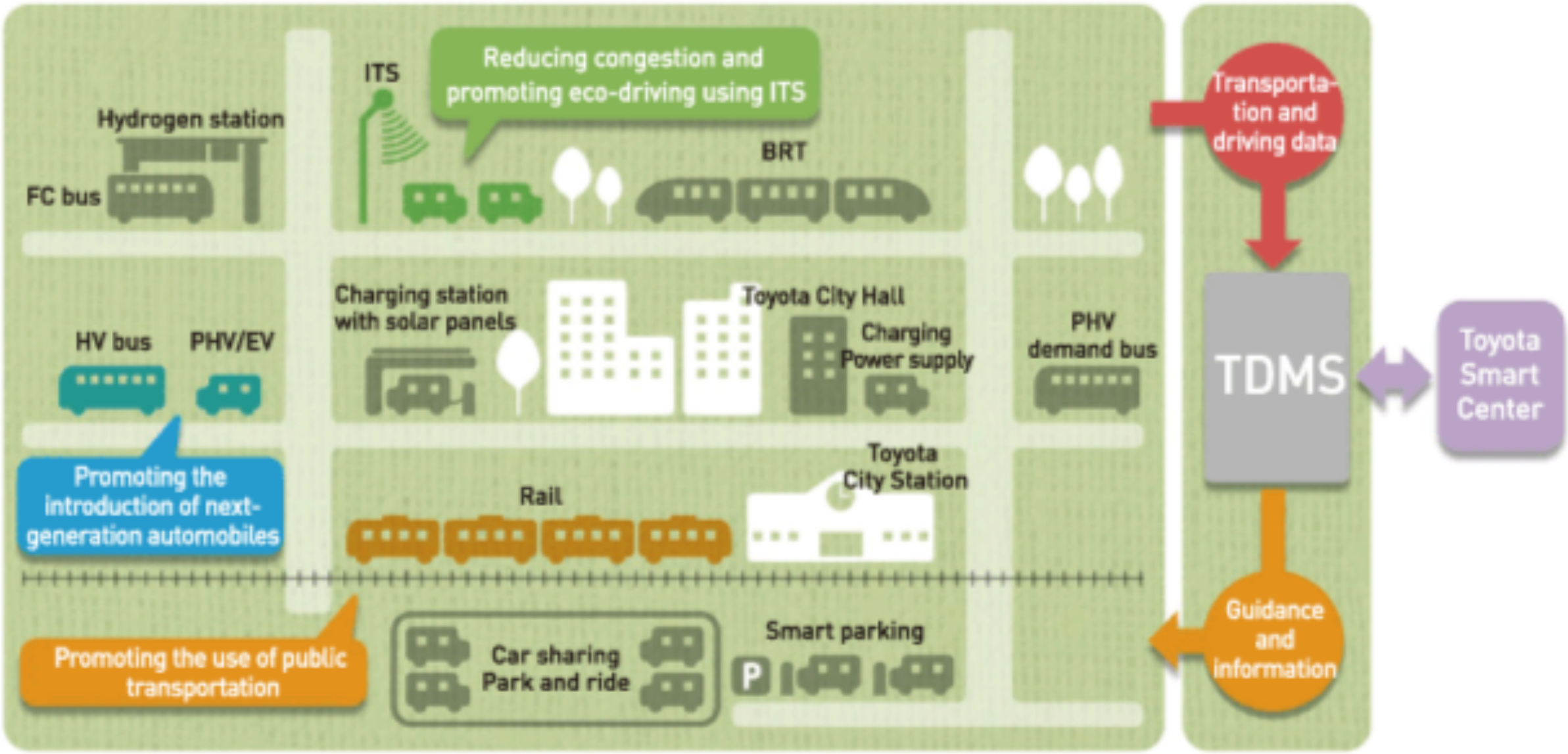

http://endthelie.com


Door & window sensors
Remote adapters & dimmers
Outdoor motion detectors
External electrical adapters
Wall mounted transmitters
Remote smoke detector
Room thermostats
Radiator thermostats
Central control unit
Remote control
Interior remote motion detector
Floor heating controller
http://www.refitsmarthomes.org


Bathroom
Bedroom
Kitchen
Roof
Bedroom
Living Room
Garage
Office
http://www.ipoll.com


http://nutihouse.com/

物聯網應用：智慧交通


Hydrogen station
FC bus
ITS
Reducing congestion and promoting eco-driving using ITS
BRT
Transportation and driving data
Charging station with solar panels
Toyota City Hall
Charging Power supply
PHV demand bus
HV bus
PHV/EV
TDMS
Toyota Smart Center
Promoting the introduction of next-generation automobiles
Toyota City Station
Rail
Guidance and information
Promoting the use of public transportation
Car sharing Park and ride
Smart parking
P

物聯網應用：智慧城市

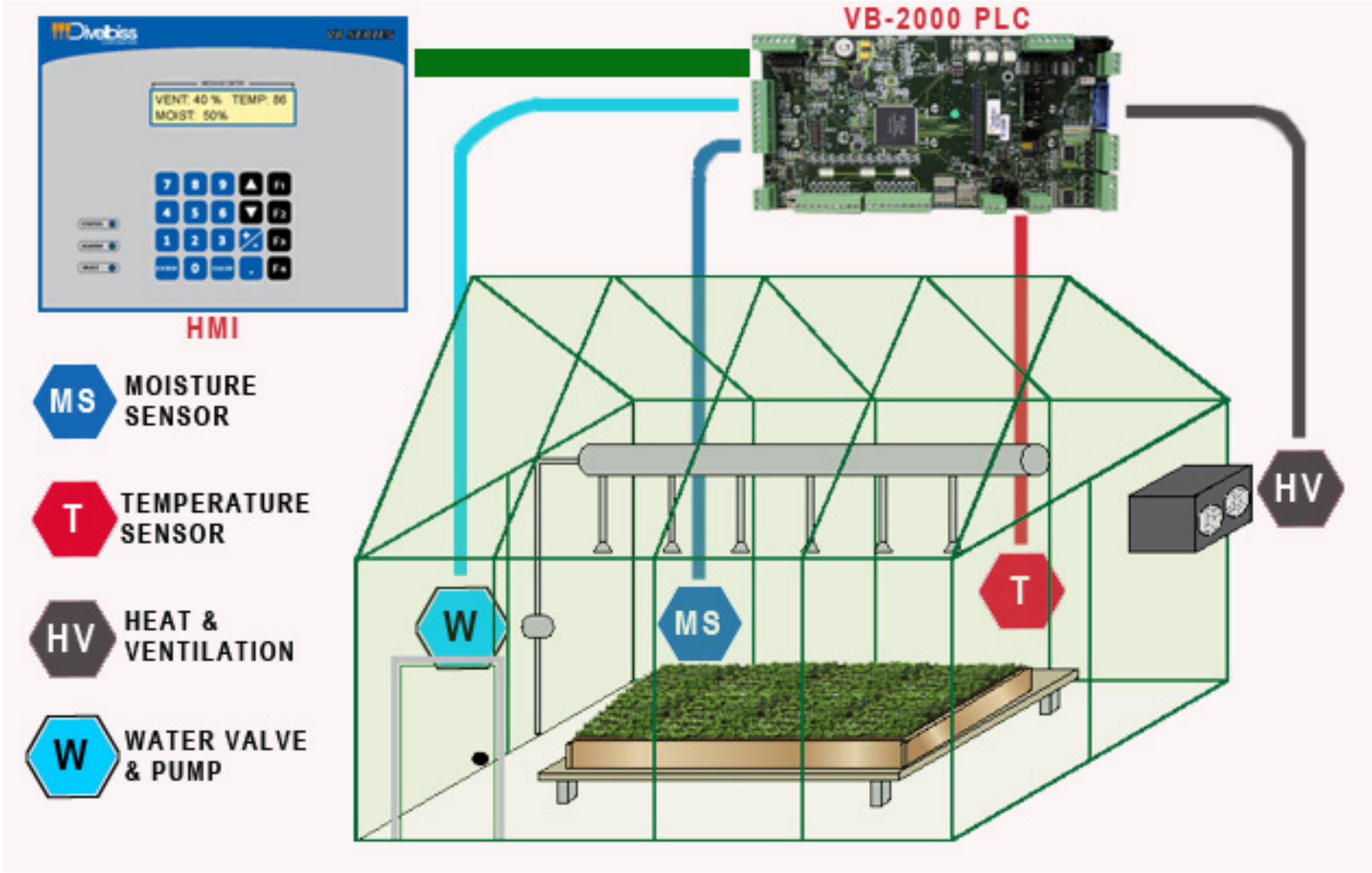

http://www.korea.net
Parking Solution
Weather Inspection System
Vehicle Detector System
Variable Message Sign
Vehicle Detector System
Multimedia Station
Digital Concierge Service Center
U-Life Management Center
Digital Concierge Service
CCTV
Emergency Telephone
ITS Bus Management System
Data Center
ETC
Measuring Equipment
Intelligent Building System
Variable Message Sign
Telecommunication
UMC (U-Life Management Center)
Facility Management
IT Management
Utility Management


Public lighting
Video surveillance
Traffic information
Access control
City Hall information
Parking meter
Parking
Traffic control
http://blog.ideas4all.com


Live
Work
Study
Travel
Water
Energy
Communications
Mobility
IT
http://www.hitachi.com


Yokohama Smart City Project Showcase of Green Technologies
City of Yokohama
Coordination
Project Management
Panasonic
Home Energy Management System (HEMS), PV etc.
Minato Mirai 21
Building Energy Management System (BEMS) etc.
Condominium district
Commercial/building district
74 billion yen
$ 900 million
For 5 years
Model homes
Vacant land
TOKYO GAS
Energy Infrastructure
TOSHIBA
Community Energy Management System (CEMS) etc.
NISSAN
Electric Vehicles etc.
Overall Utility Grid and Energy Management Systems
Energy Network
Information Network
http://www.maps.meshcities.com

物聯網應用：智慧農場


VB-2000 PLC
Divotbiss
VB SERIES
VENT: 40 % TEMP: 86
MOIST: 50%
HMI
MS MOISTURE SENSOR
T TEMPERATURE SENSOR
HV HEAT & VENTILATION
W WATER VALVE & PUMP
W
MS
T
HV

AirBox: a participatory ecosystem for PM2.5 monitoring

What are we going to cover in this talk?

1. Why is PM2.5 important?
2. How did we build the system?
3. What is the current status?
4. What is the next step?

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台北橋飯担


中時 電子報


冷氣團籠微粒紫爆
東森新聞HD
"致癌霾害"南下 出門最好戴著口罩
今彩539
04 13 23 32

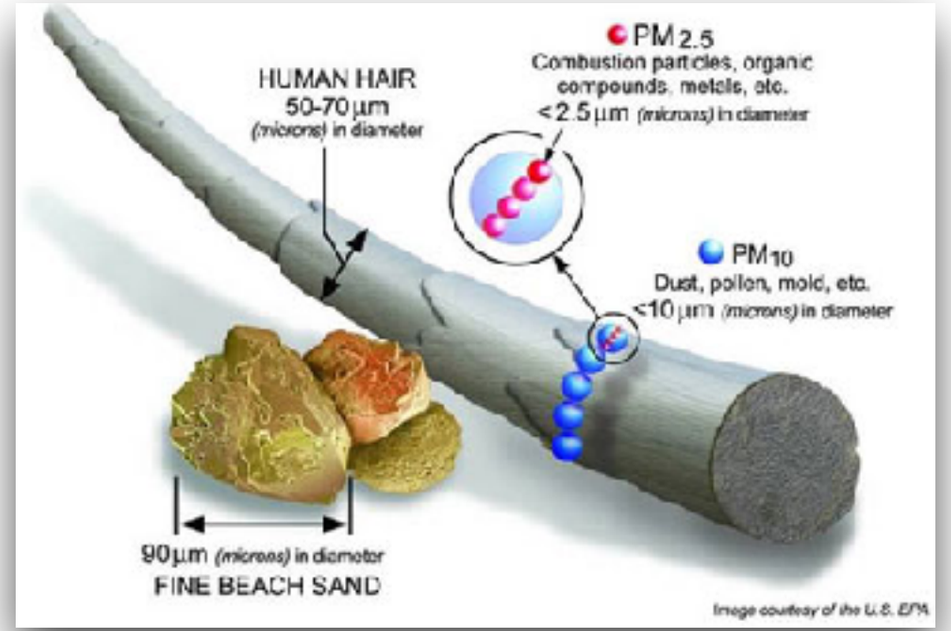
從職棒冠軍賽看 PM2.5

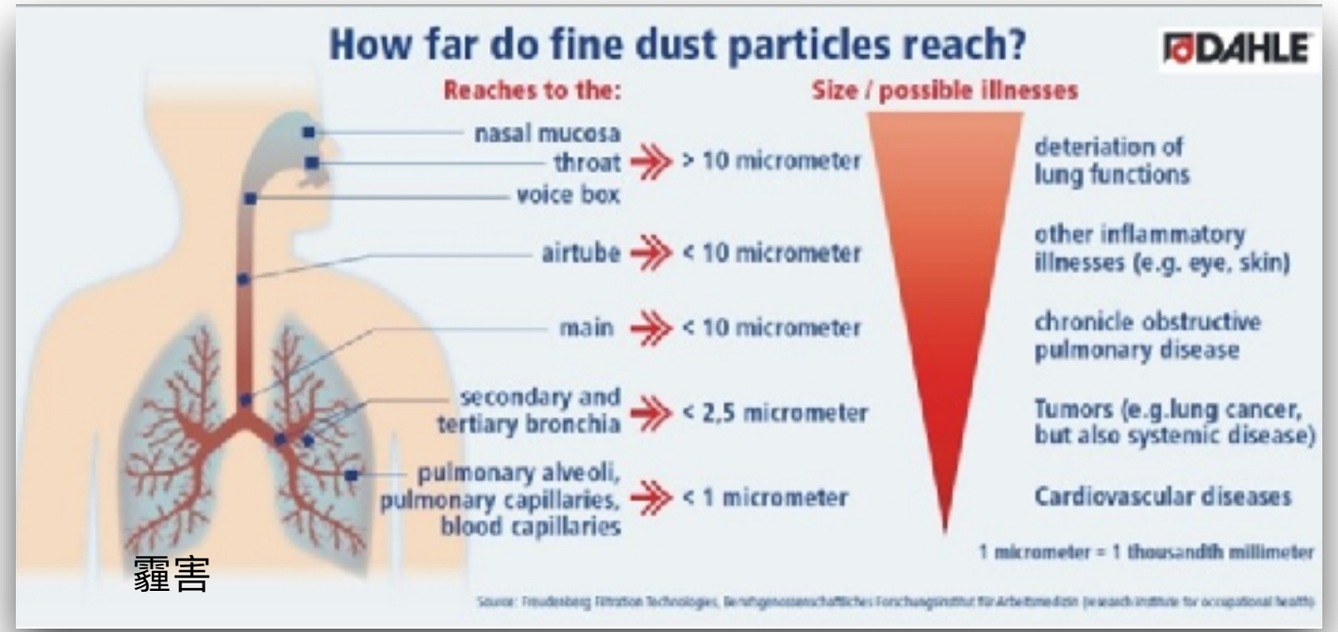
Game 3: 2016/10/25

Game 4: 2016/10/26

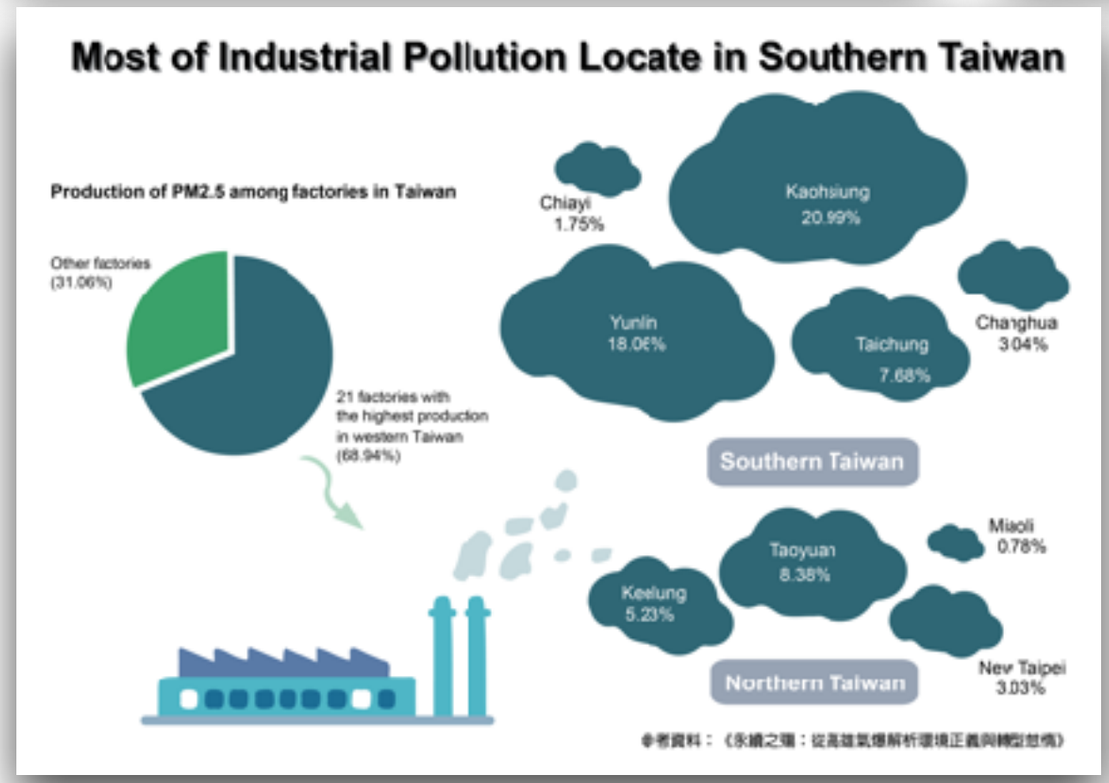
Game 5: 2016/10/27

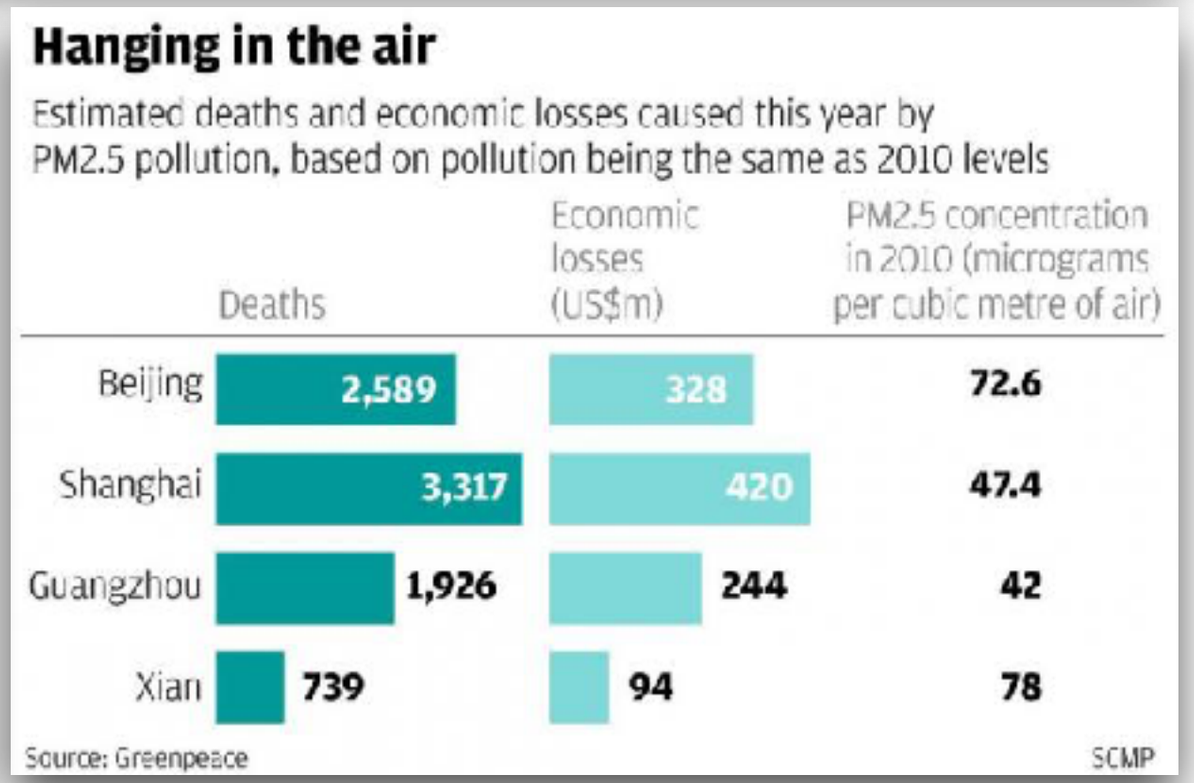
Fine Particulate Matter (PM2.5)



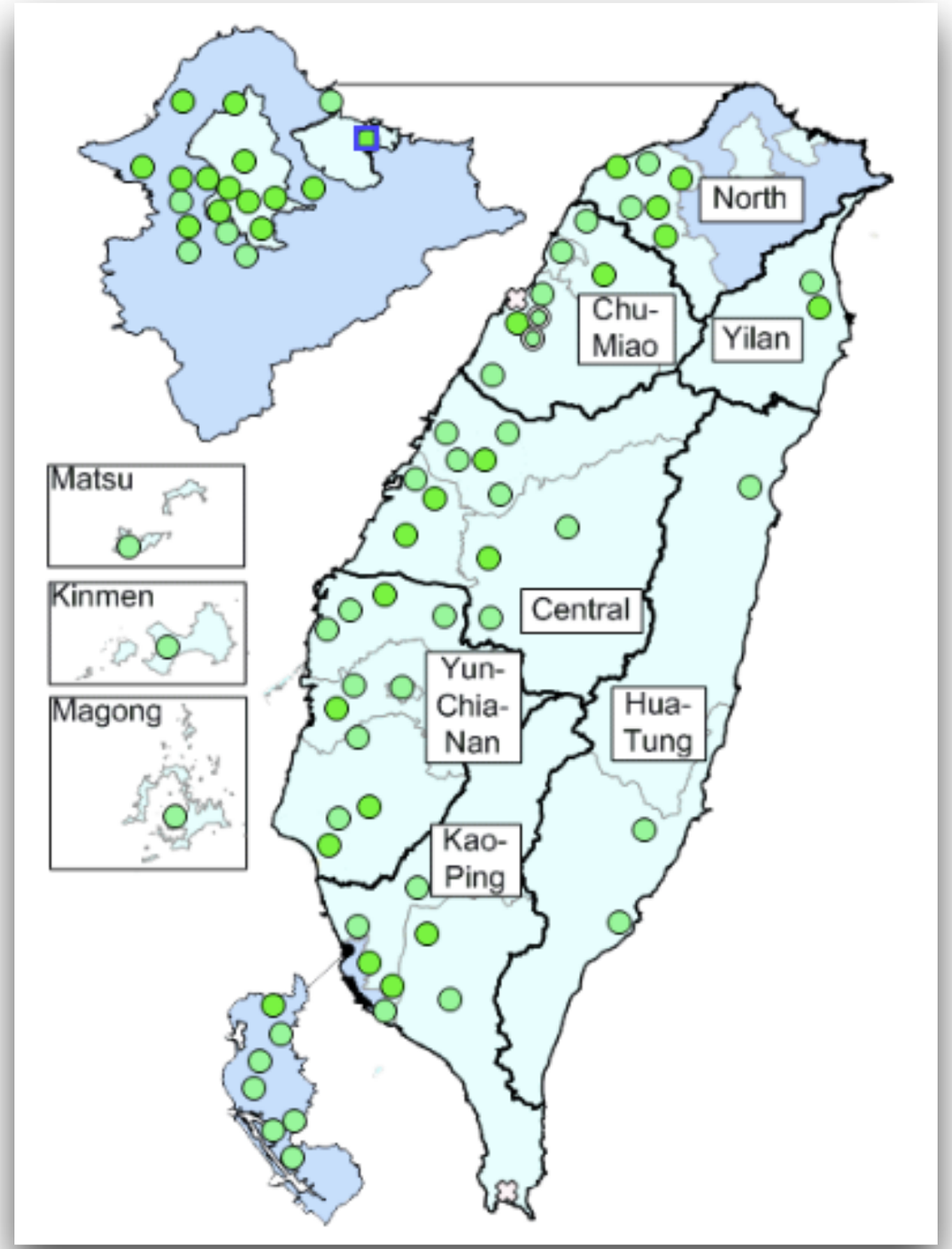


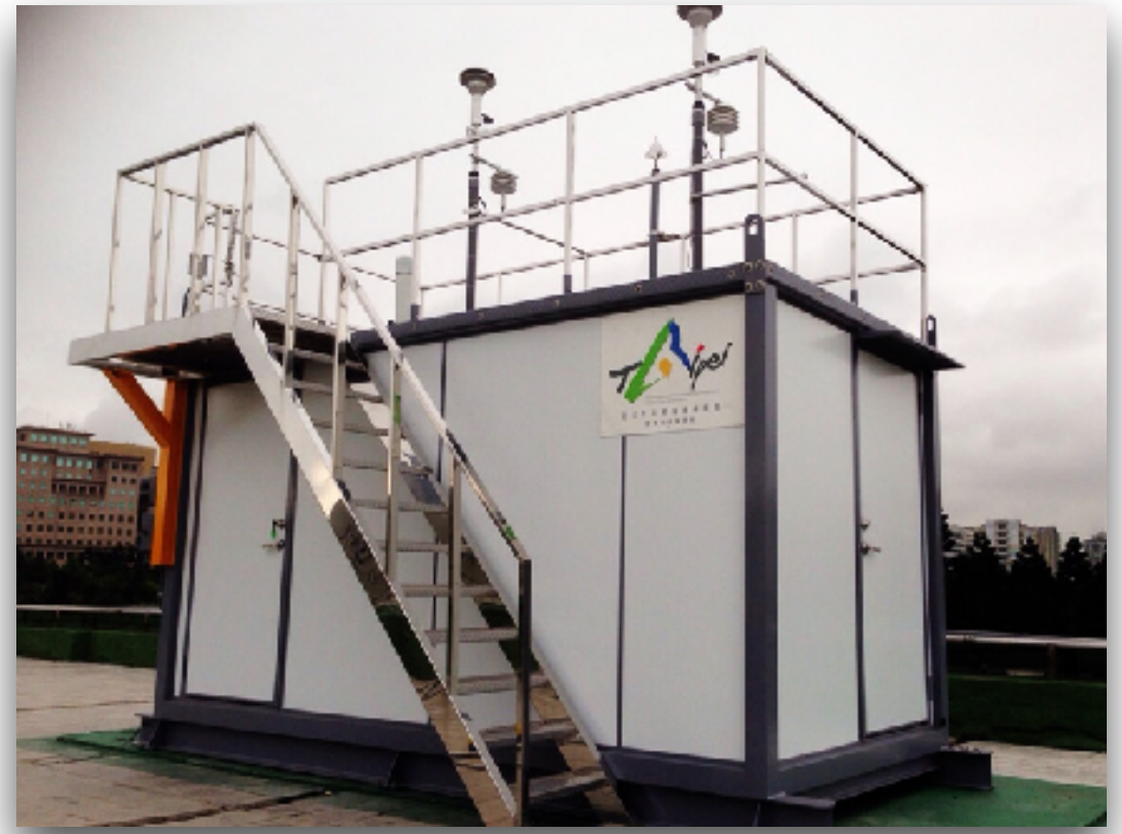
霾害





The Professional Solution





- **76** multi-function stations (TW)
- huge and **extremely** expensive
- **10+** meters above the ground
- **well-mixed** atmosphere

But, the question in our mind is just so *simple* that…

What's the air quality here and now?

What are we going to cover in this talk?

1. Why is PM2.5 important?

2. How did we build the system?

3. What is the current status?

4. What is the next step?

We started the “participatory sensing" project in 2013

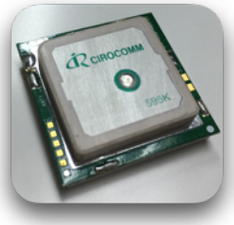
low-cost sensors

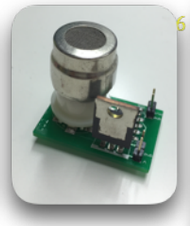
recruiting volunteers

big data and spatio-temporal analysis

MAPS

2013

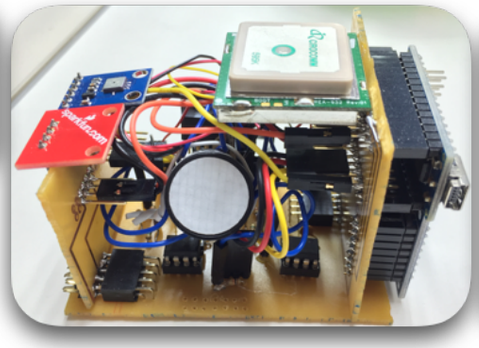
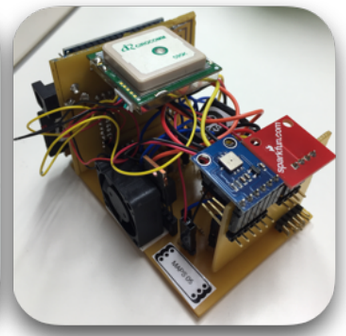




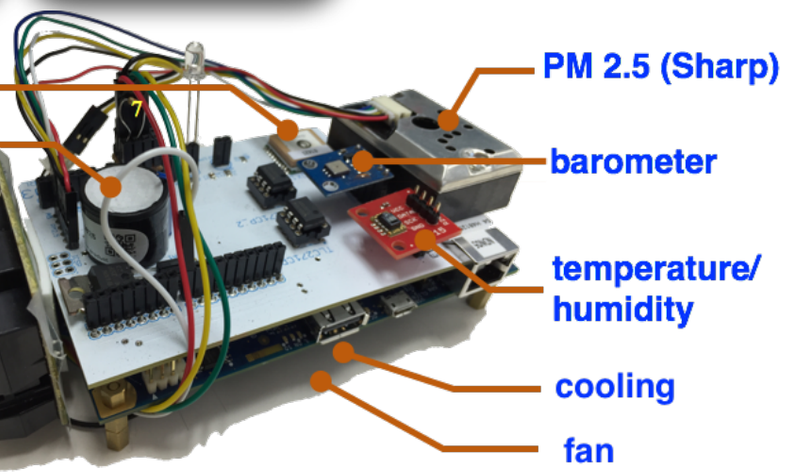
Version 1.0
Arduino Uno



Version 2.0
Arduino Nano

2014

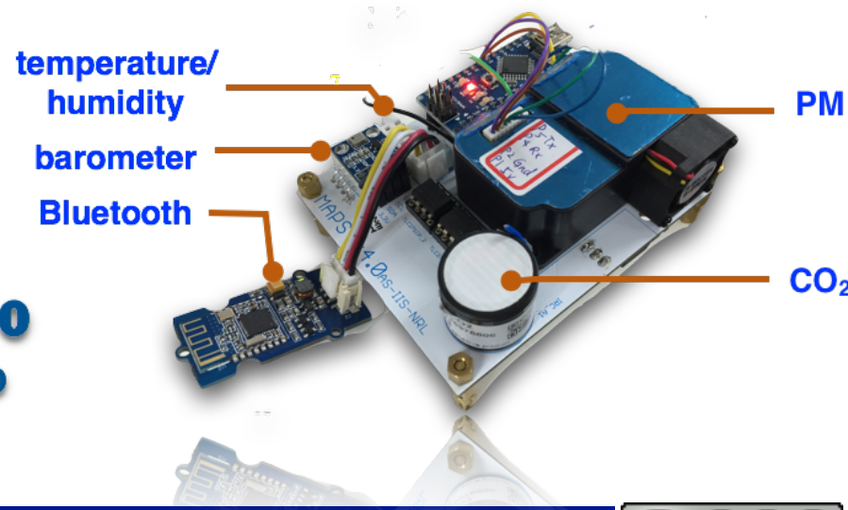


Version 3.0
Intel Galileo Gen 2

2015

Realtime Display

Version 4.0
Arduino Nano



Then, we realized that…

~~low-cost sensors~~

cheap but inaccurate..

~~recruiting volunteers~~

friends and students..

~~big data and spatio-temporal analysis~~

The data is small, sparse, and nothing we can analyze

After MAPS met LASS (2015/9)

I don't think we can overcome the scalability issue

Why are we always reinventing the wheels?

I really want to build a "participatory sensing" system

Then, the journey starts

2015/10/17
Announcement for the 1st TW field try

2015/11/29-2015/12/12
LASS 1st TW field try

2015/12/20
LASS 1st gathering

2016/2/9
Supported by GoV

2016/2/29
Demo in Southeast Asia environmental research conference

2016/3/22
AirBox Taipei

2016/5/7,8
Maker Faire Taipei

2016/6/13,14
GCTC

2016/7/23
LASS conference

2016/7/26
AirBox Kaohsiung

2016/8/19
AirBox New Taipei

2016/8/22
CENTRA Webinar

2016/8/30
AirBox Tainan

2016/9/6
ASEAN IVO

2016/10/13
EPA Webinar

The journey is speeding up

- from 1 to 100 to 1,000 devices
- from 10km to 1km to 100m density
- from Taiwan to Asia, to the world
- involving academia, community, industry, and government

EDIMAX NETWORKING PEOPLE TOGETHER

REALTEK Realtek Semiconductor Corp.

TAIPEI 臺北 臺北市政府 Taipei City Government

新北市政府 New Taipei City Government

高雄市政府

臺南市政府 Tainan City Government

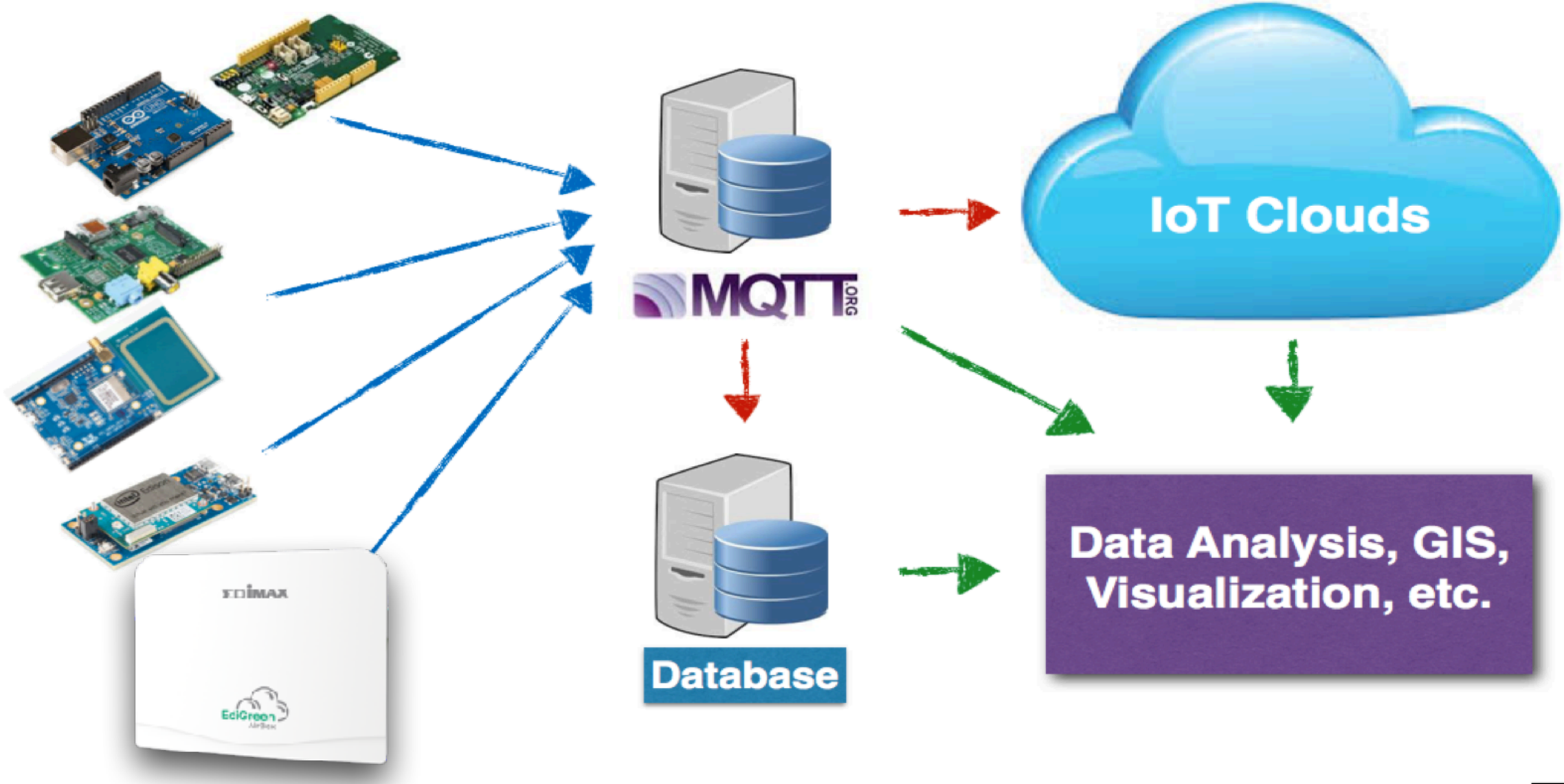
中央研究院 資訊科學研究所 Institute of Information Science, Academia Sinica

LASS Location Aware Sensing System

It's not just a system by someone or some people.
It's an ecosystem by MANY parties of same goals.

The ecosystem in a nutshell

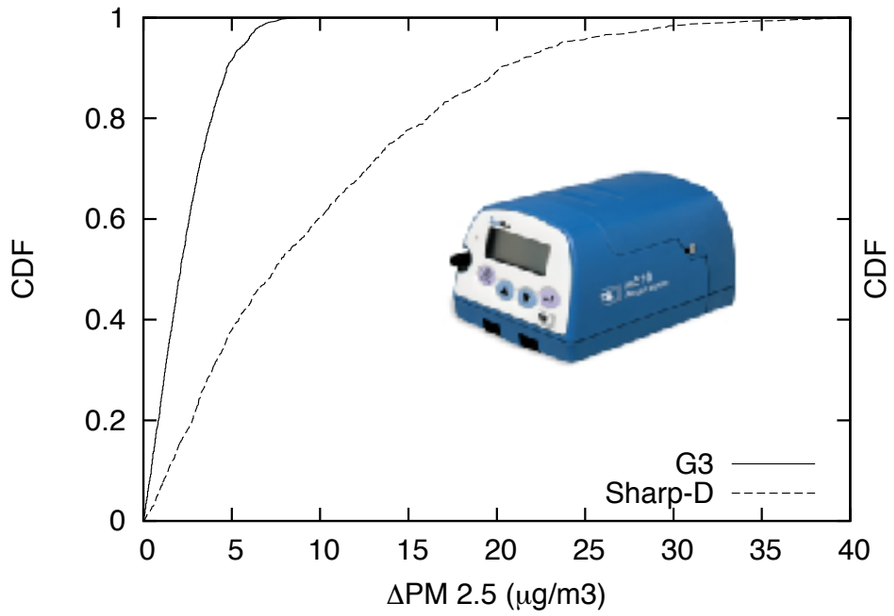
The core spirit: **open hardware/software/data**



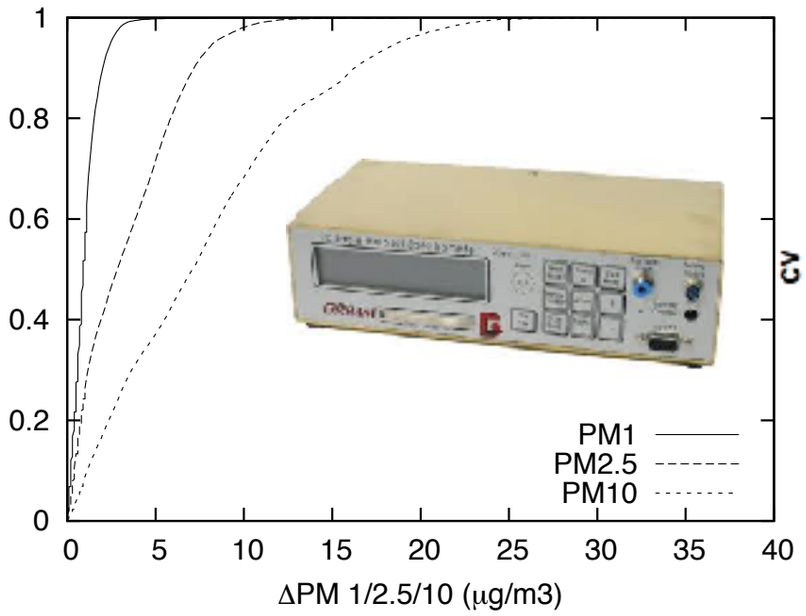
The ecosystem in a nutshell

The core spirit: **open hardware/software/data**

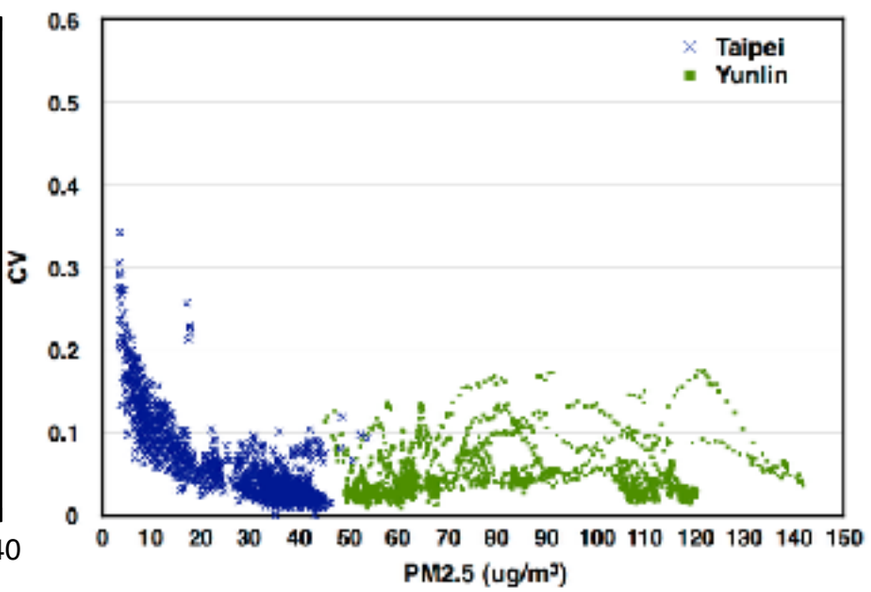
The basis: lots of dirty works and experiments



compare to
TSI AM510



compare to
GRIMM Model 1.109



consistency test

The ecosystem in a nutshell

The core spirit: **open hardware/software/data**

The basis: lots of dirty works and experiments

The pattern: from academia to community to industry

academia: focus on core issues

community: rapid POC

industry: reliable production

What are we going to cover in this talk?

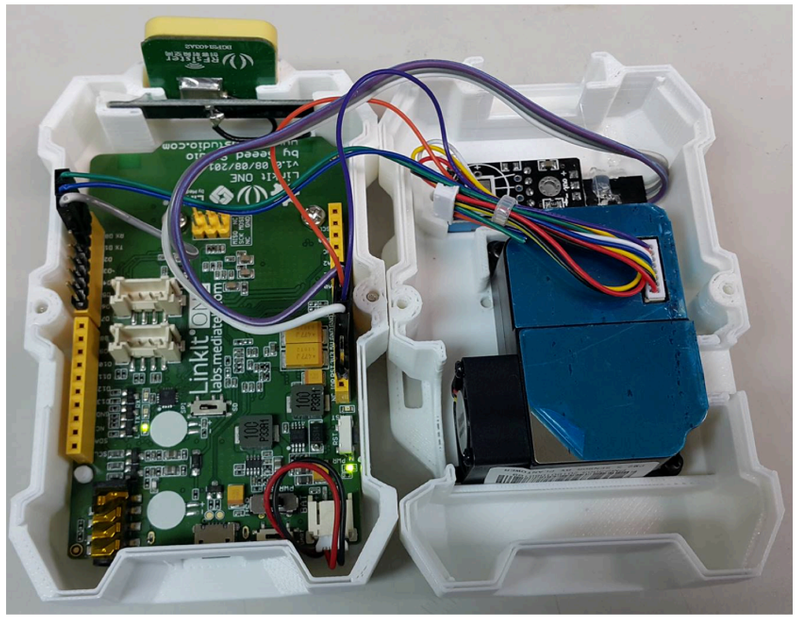
1. Why is PM2.5 important?

2. How did we build the system?

3. What is the current status?

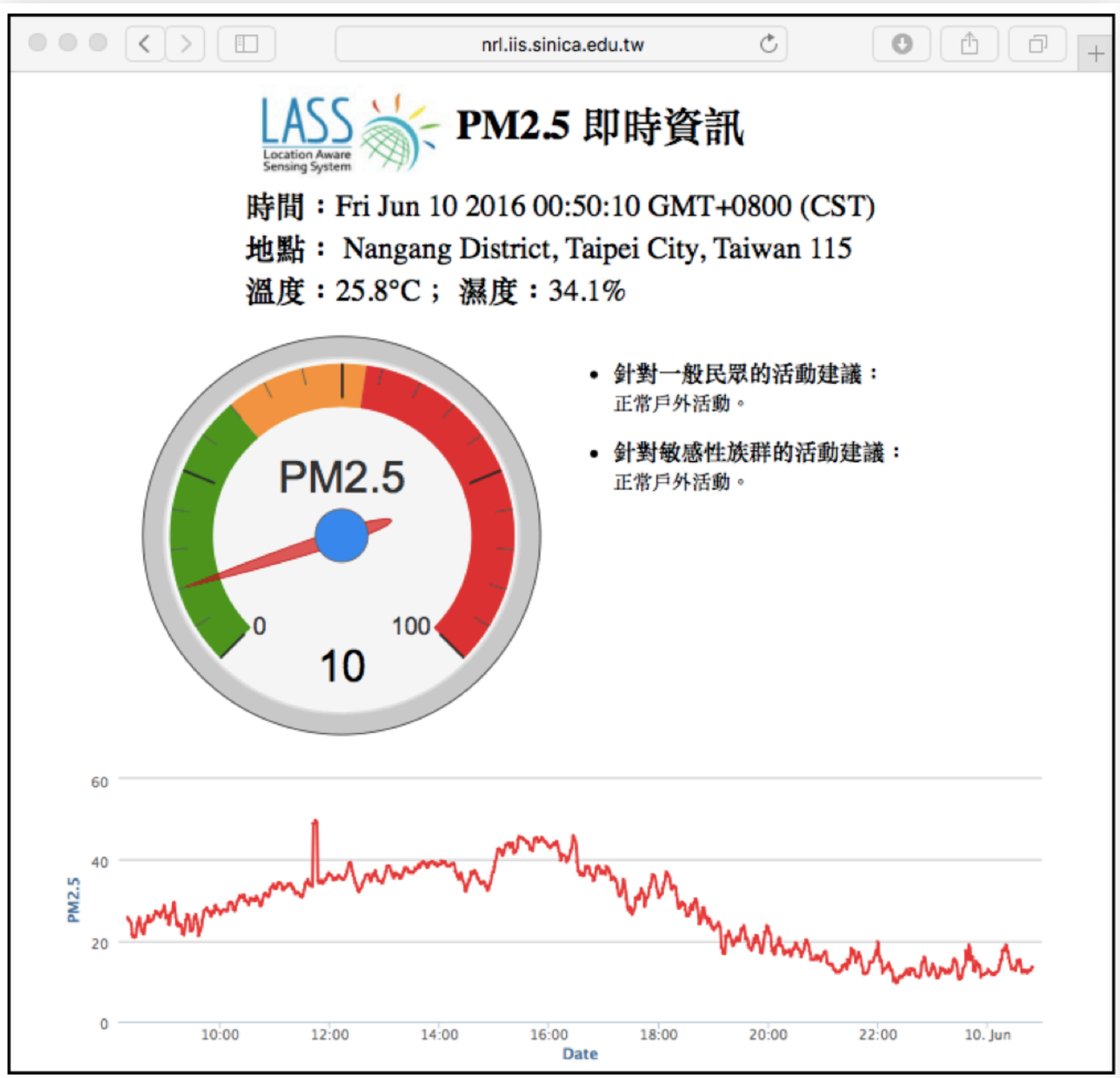
4. What is the next step?

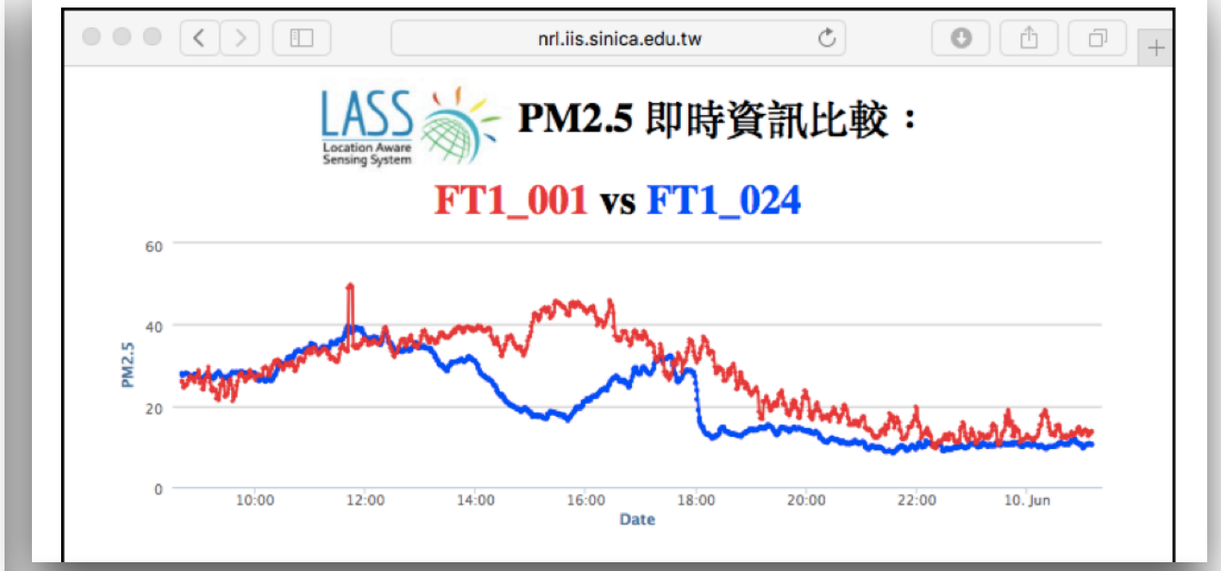
The devices

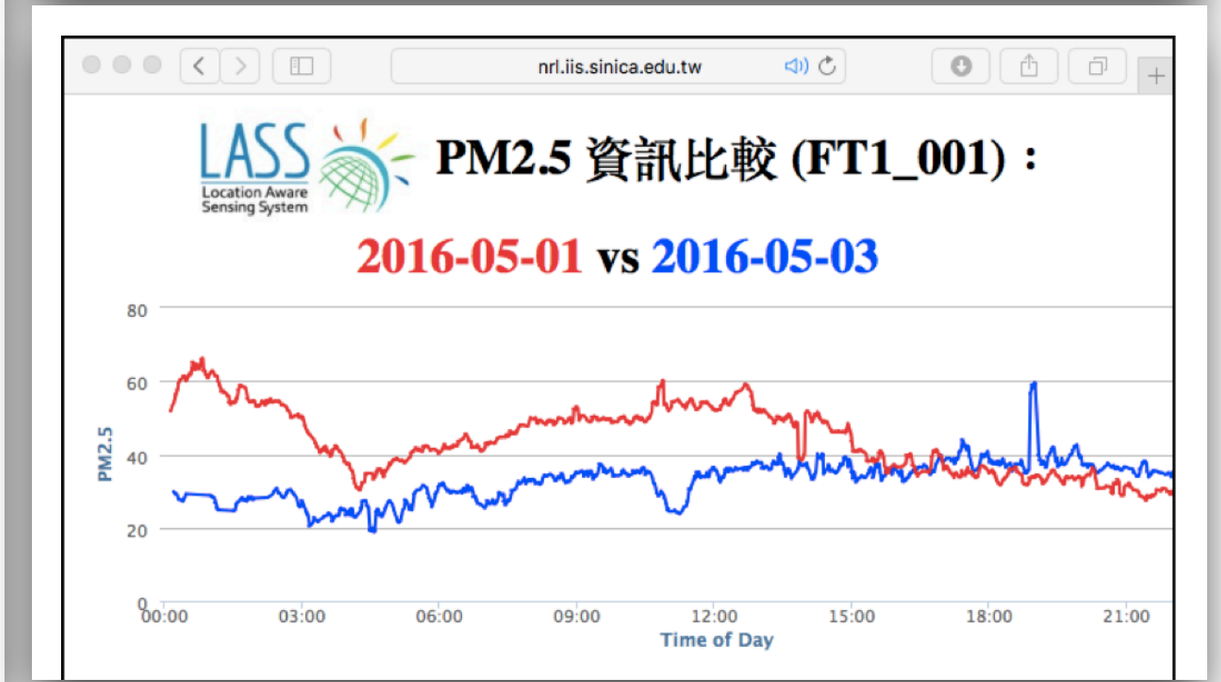


	LASS FT	AirBox	LASS4U
Platform	MediaTek LinkIt One	Realtek Ameba	Realtek Ameba
Temperature/Humidity sensor	DHT22	HTS221	SHT31
PM2.5 sensor	PMS3003 (G3)	PMS5005 (G5)	PMS3003 (G3)
CO_2 sensor	none	none	SenseAir S8
GPS	Yes	none	none
Open source software	Yes	No	Yes
Open data	Yes	Yes	Yes
Phone app	none	Yes	none
End user	makers	schools/buildings	citizens

Device Dashboard







Open Data Service

- All measurement results are released in real time
  https://sites.google.com/site/pm25opendata/open-data
- **JSON** format


```
{
  "source": "last-all-airbox by IIS-NRL",
  "feeds": [
    {
      "gps_lat": 23.954,
      "gps_num": 9,
      "s_t0": 29.87,
      "SiteName": "AirBox-LASS-04",
      "timestamp": "2016-06-21T14:37:03Z",
      "gps_lon": 120.574,
      "s_d0": 5,
      "s_h0": 47,
      "device_id": "28C2DDDD44F8"
    },
    {
      "gps_lat": 24.795,
      "gps_num": 9,
      "s_t0": 34.25,
```

```
{
  "device_id": "FT1_001",
  "app": "PM25",
  "timestamp": "2016-06-21T14:42:34Z",
  "s_d0": 15,
  "s_d1": 17,
  "s_t0": 28.1,
  "s_h0": 1,
  "gps_lat": 25.0398516667,
  "gps_lon": 121.614791667,
  "gps_num": 20
}
```

```
{
  "device_id": "FT1_001",
  "feeds": [
    {
      "timestamp": "2016-06-20T22:06:03Z",
      "s_d0": 16,
      "s_d1": 17,
      "s_t0": 27.6,
      "s_h0": 1,
      "gps_lat": 25.04089,
      "gps_lon": 121.614806667,
      "gps_num": 13
    },
    {
      "timestamp": "2016-06-20T22:07:03Z",
      "s_d0": 16,
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      "s_t0": 27.6,
```
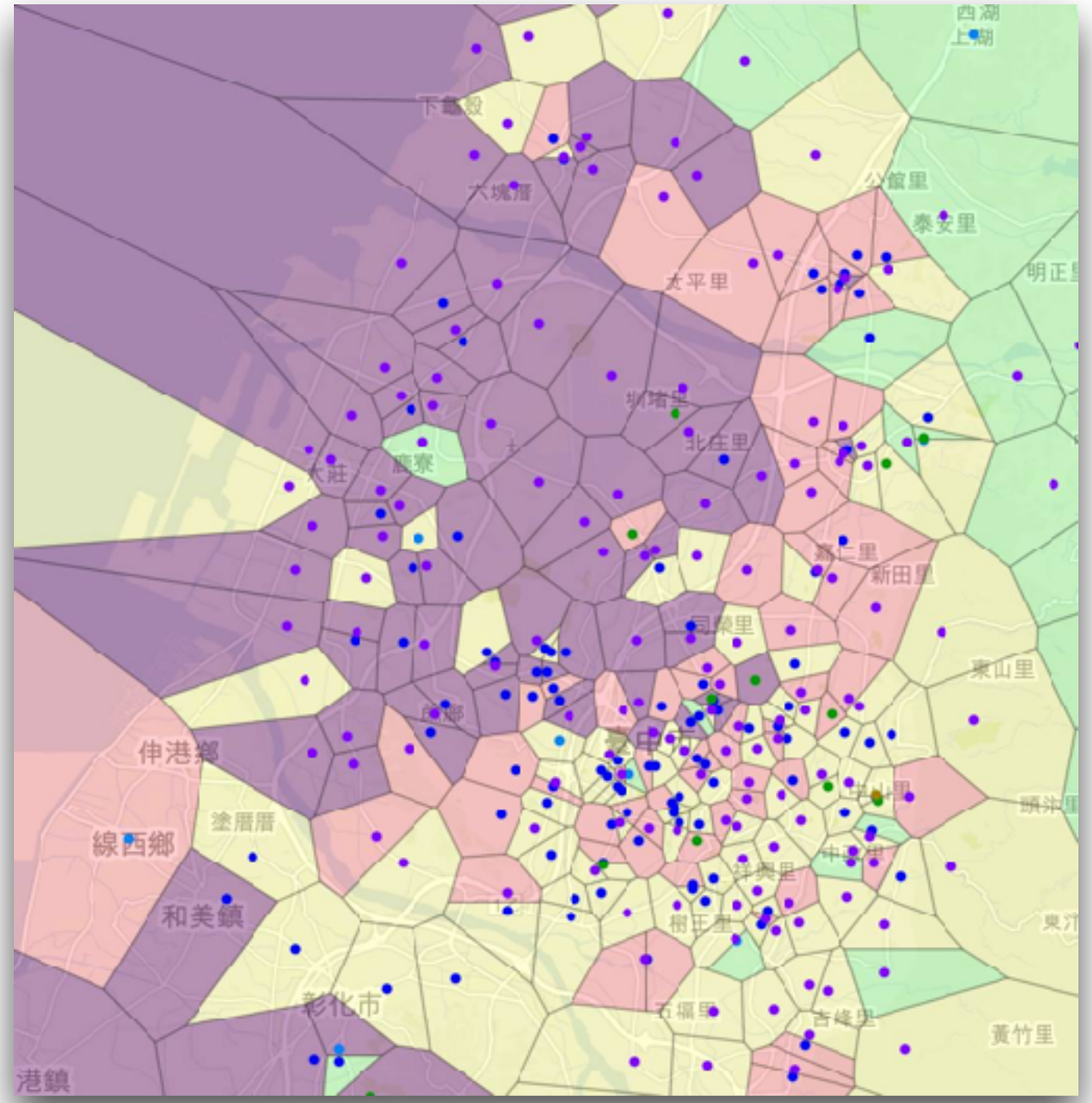
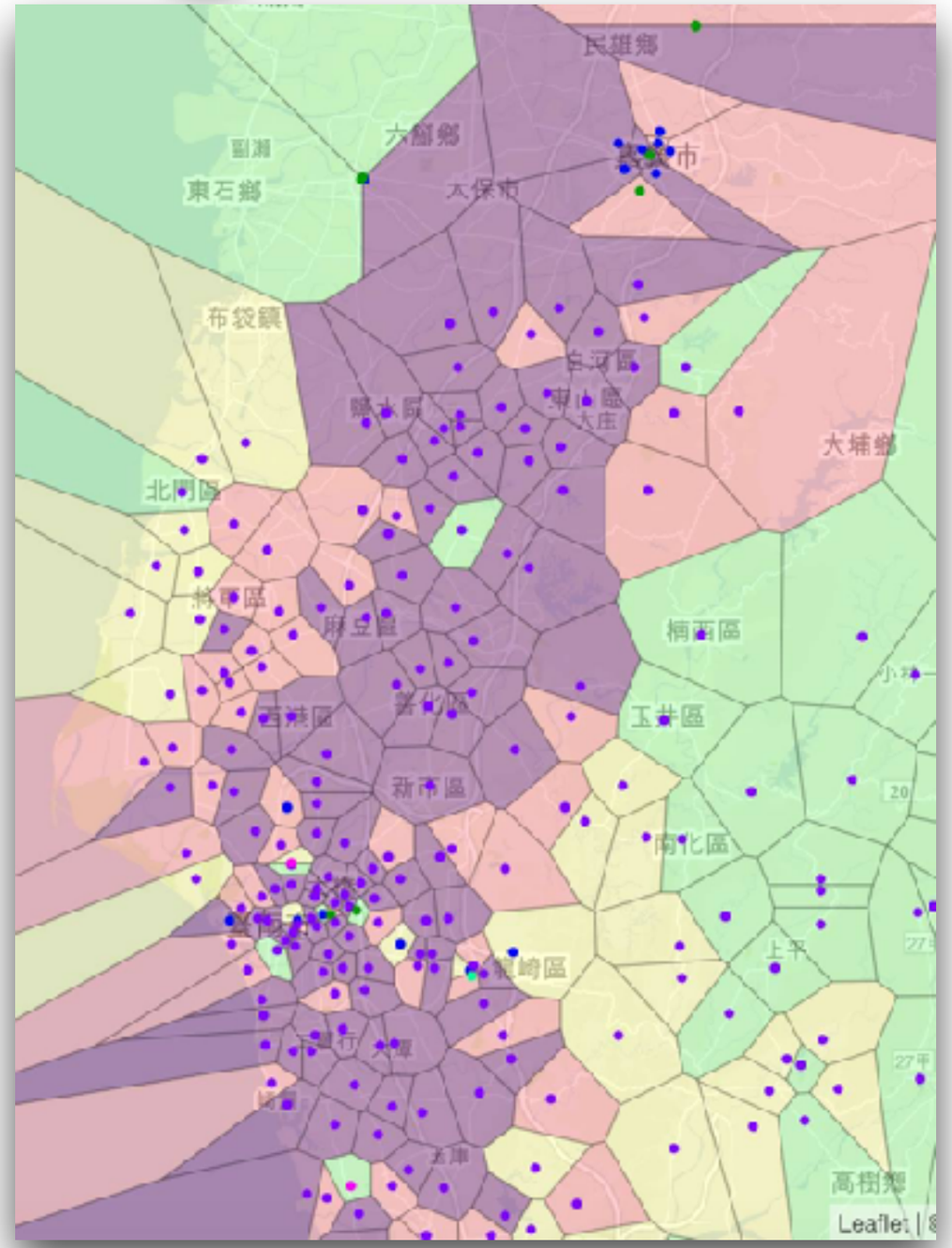

Voronoi Diagram

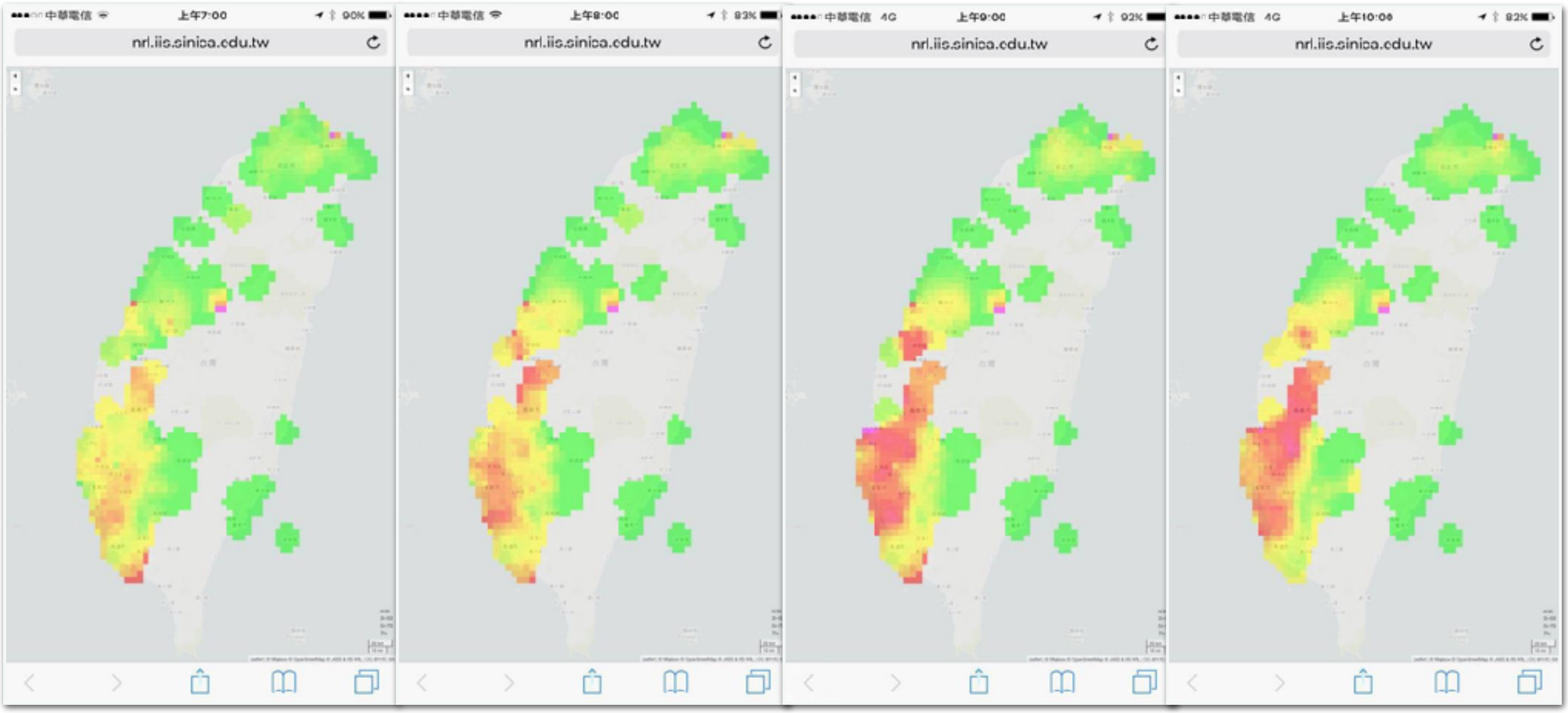




2016/10/17 09:00:00 CST

http://nrl.iis.sinica.edu.tw/LASS/GIS/voronoi/

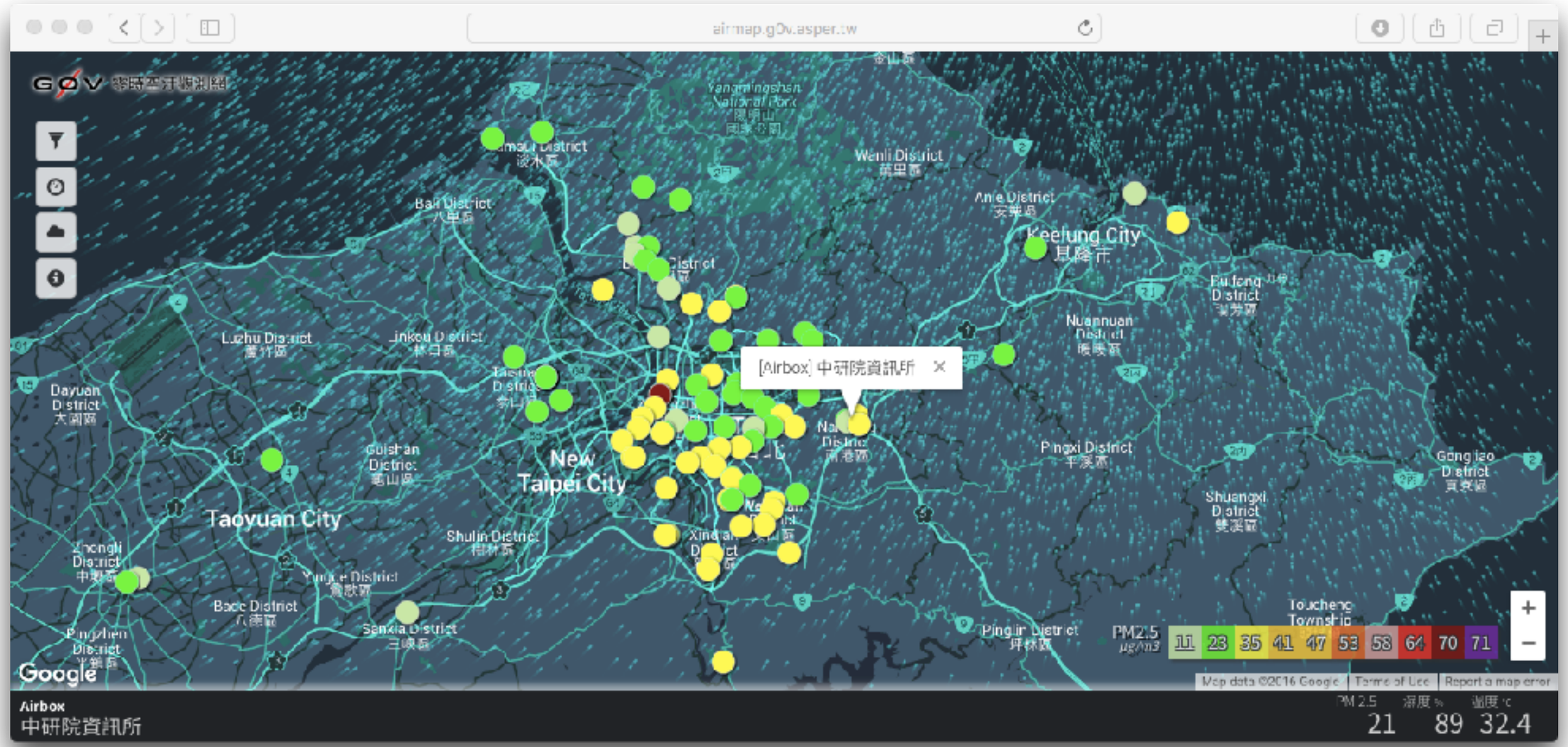
IDW Diagram



2016/11/4 7-10:00 CST

http://nrl.iis.sinica.edu.tw/LASS/GIS/IDW/

Data Visualization by 3rd Party



http://airmap.g0v.asper.tw

Brief Statistics

- 1,000+ AirBox
- 24 countries
- 3+ requests/sec
- 8GB data/day

Well, is this what we want?

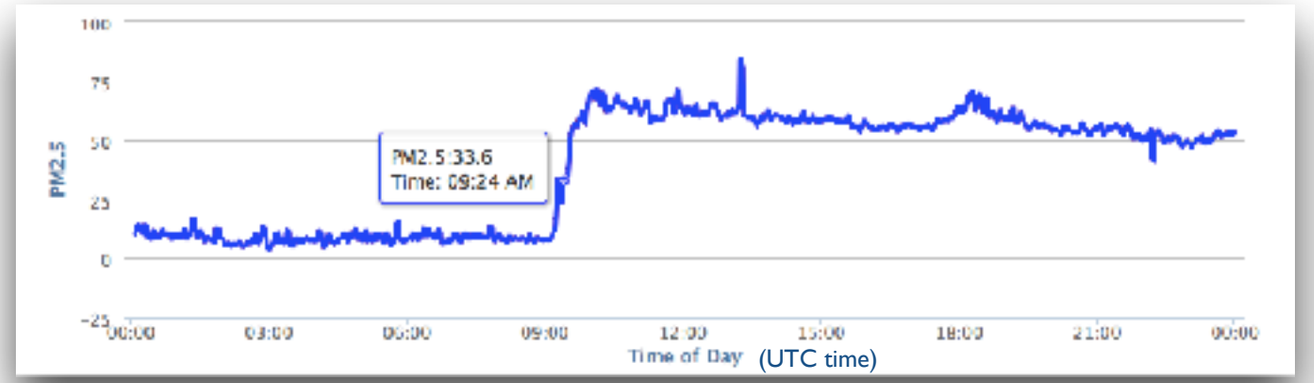
sophisticated **dashboard**?

smartphones everywhere?

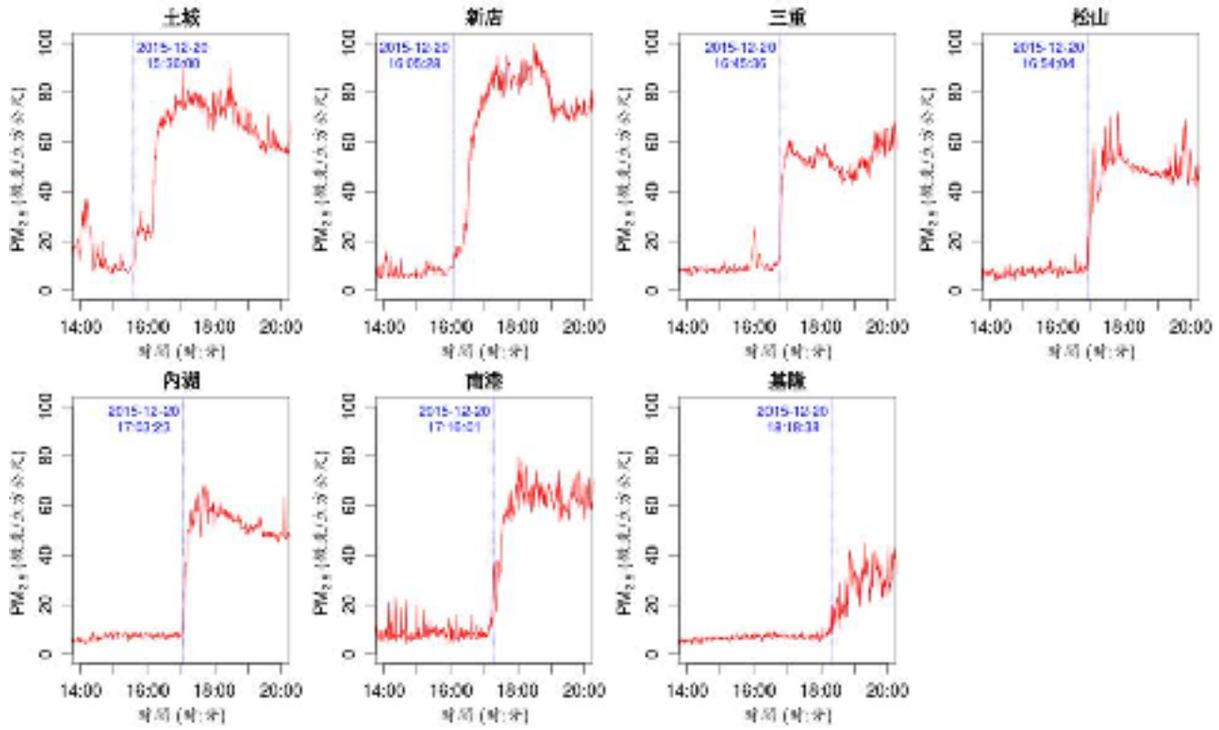
Let's think about it deeper…

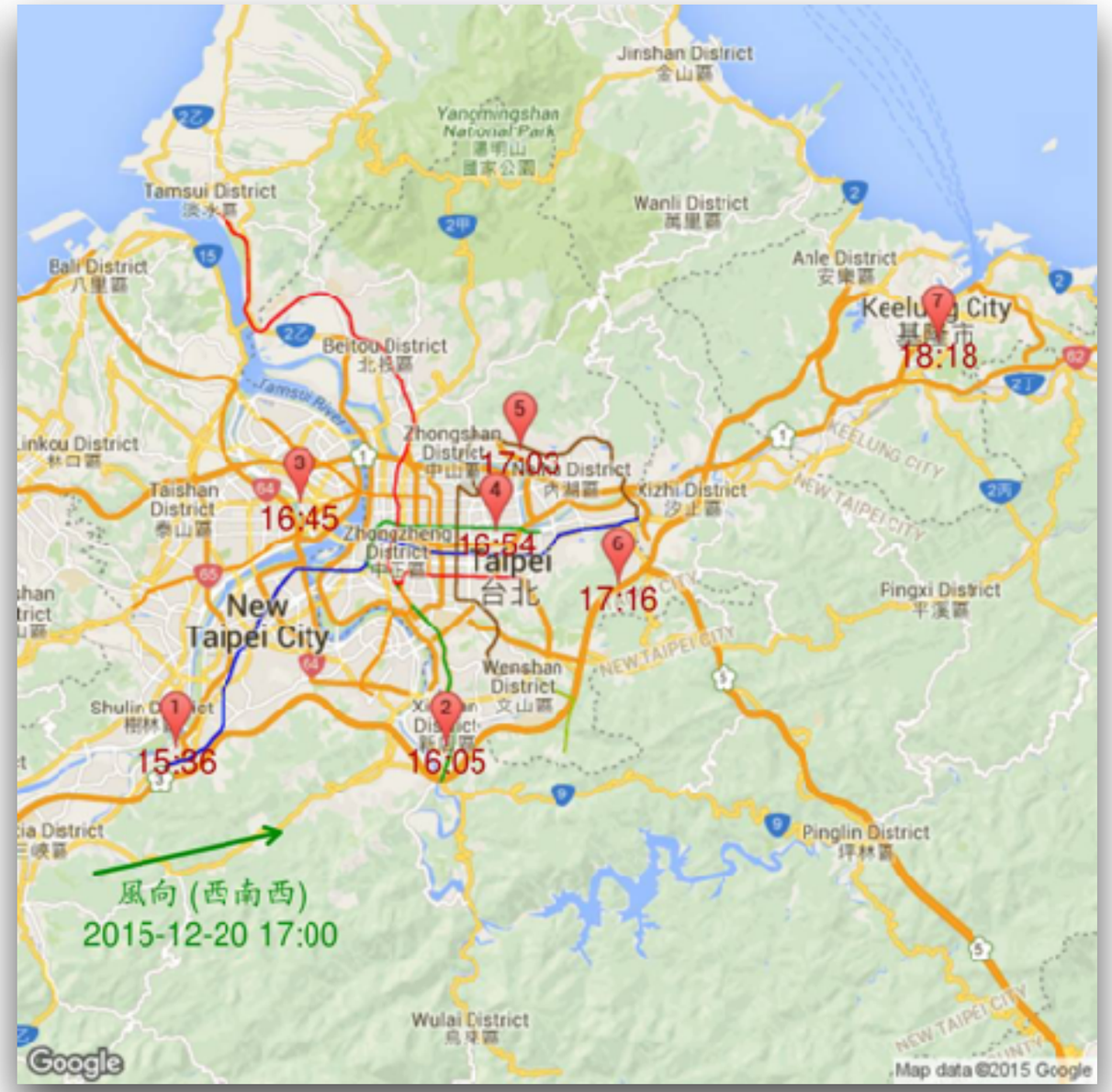
Can we **enable** something that **never** could be possible without LASS/AirBox?

Example 1: Emission Source Tracking

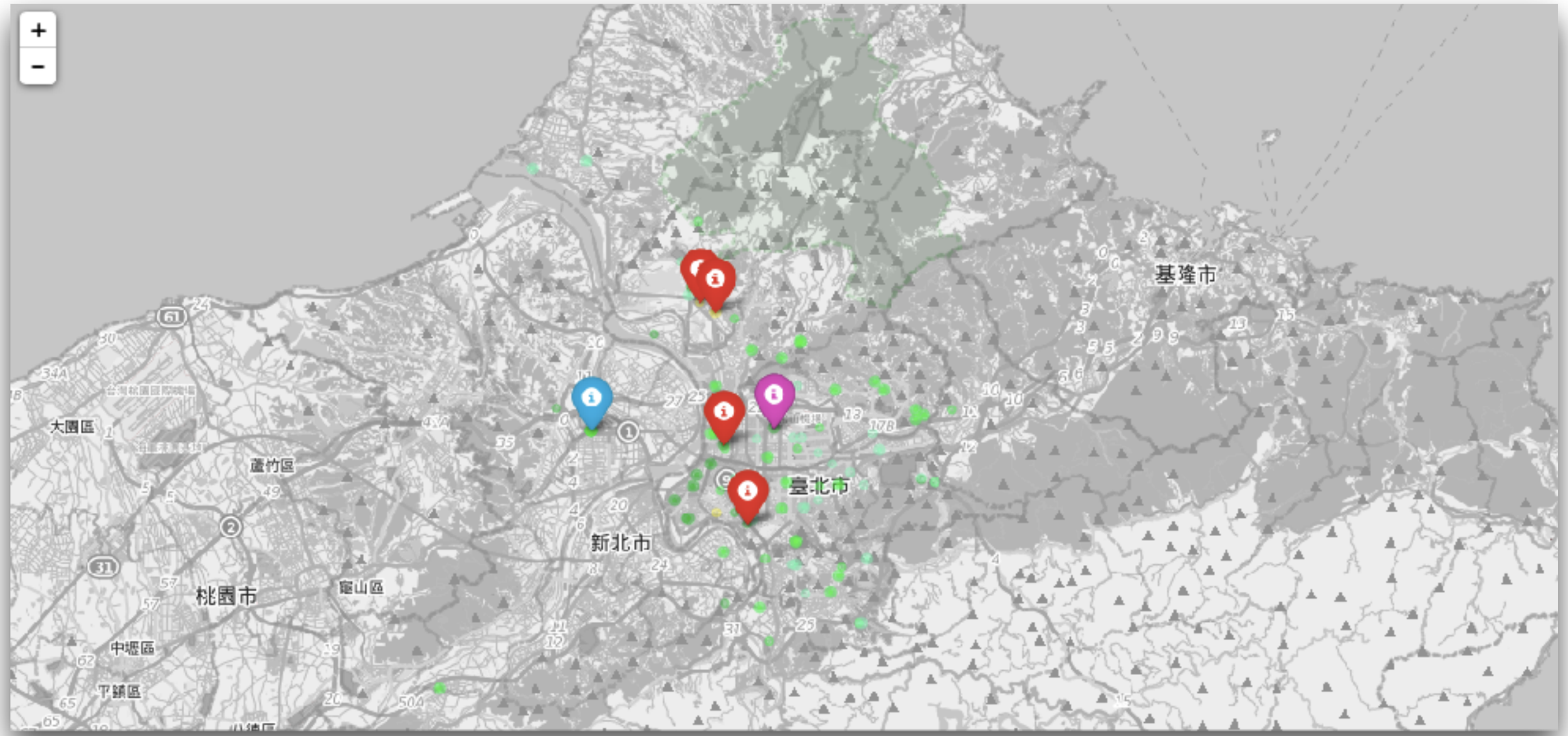


Something happened on 2015/12/20



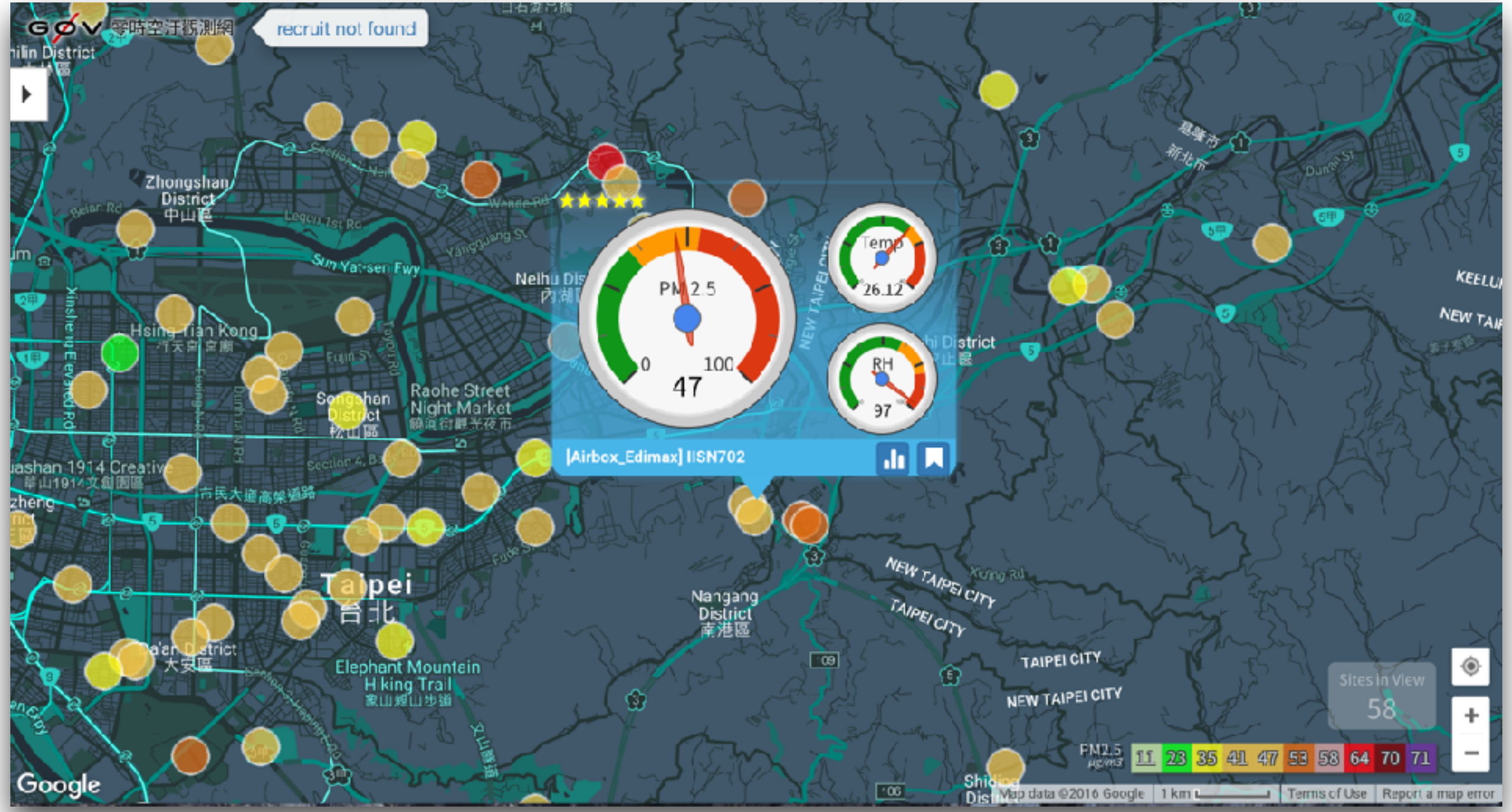


Example 2: Anomaly Detection

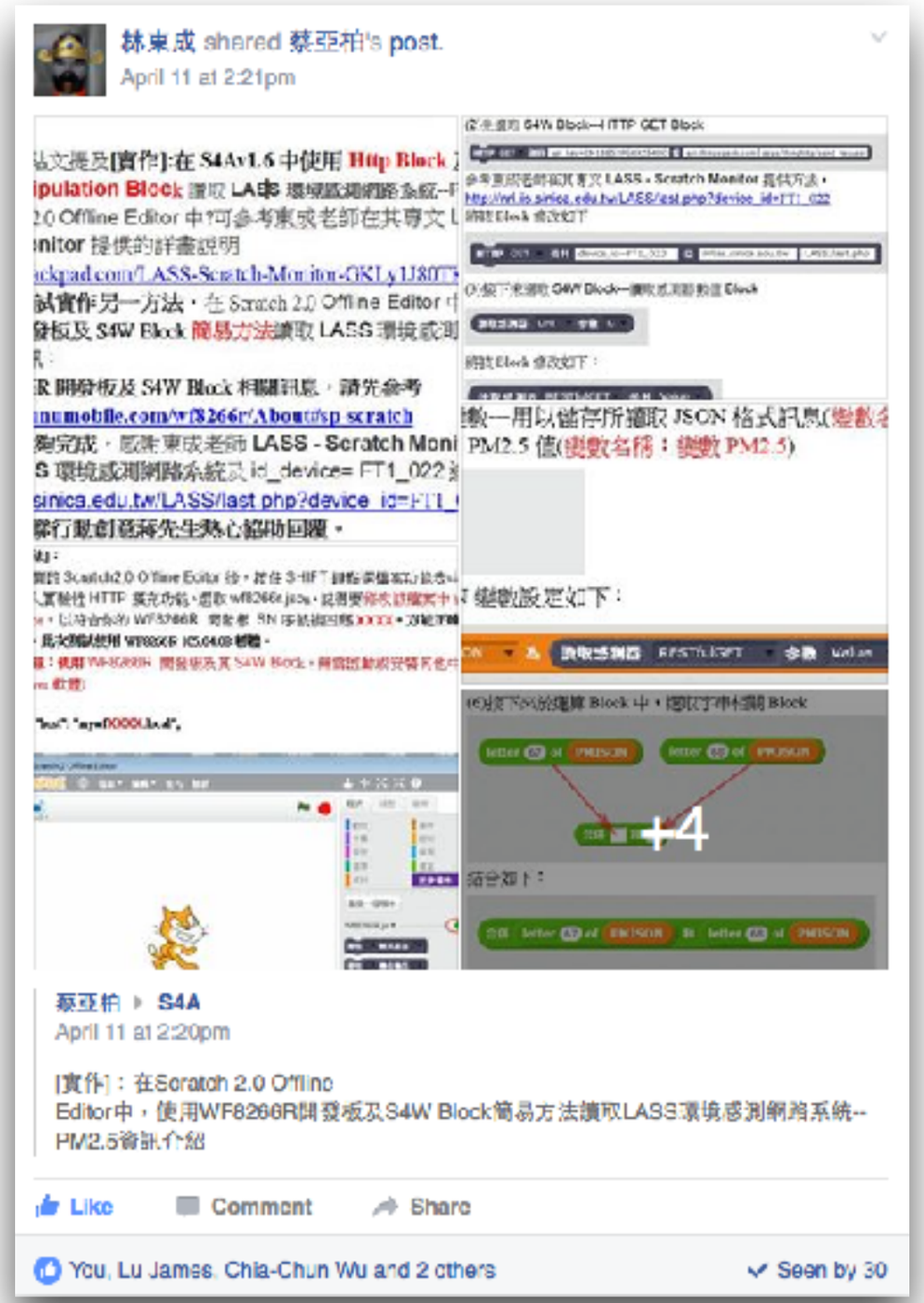


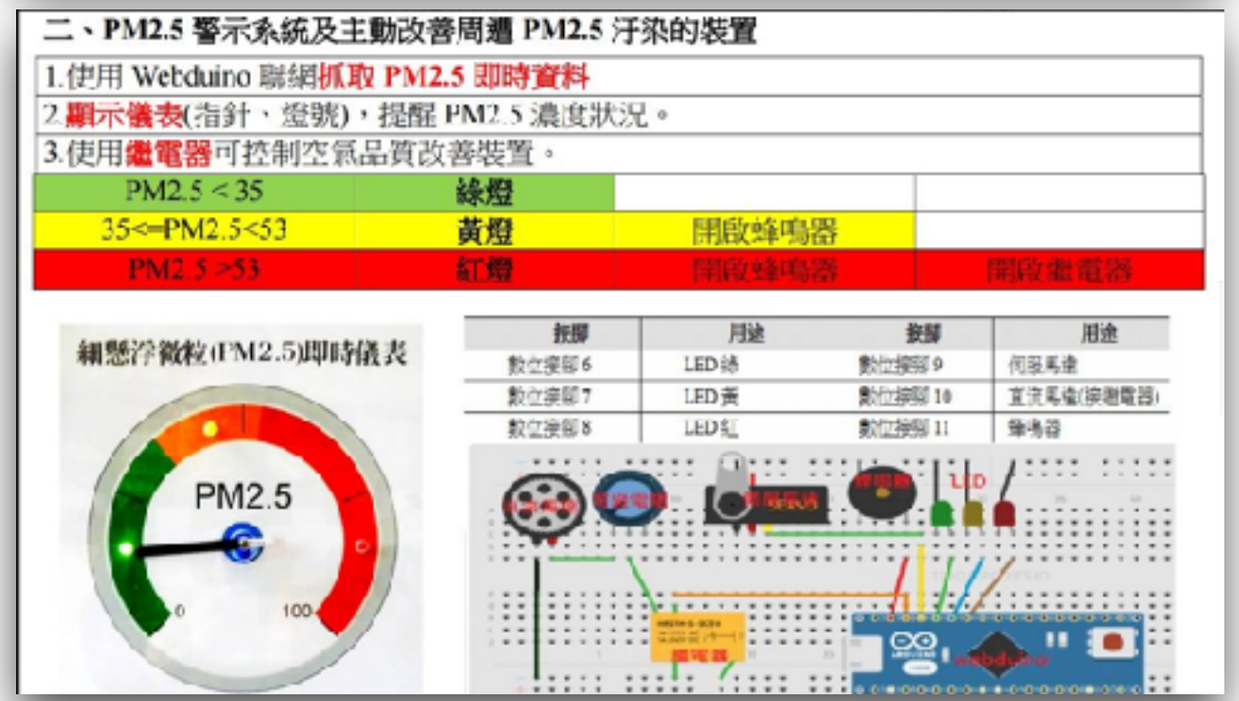
Example 3: Pollution Detection

Example 4: Device Ranking



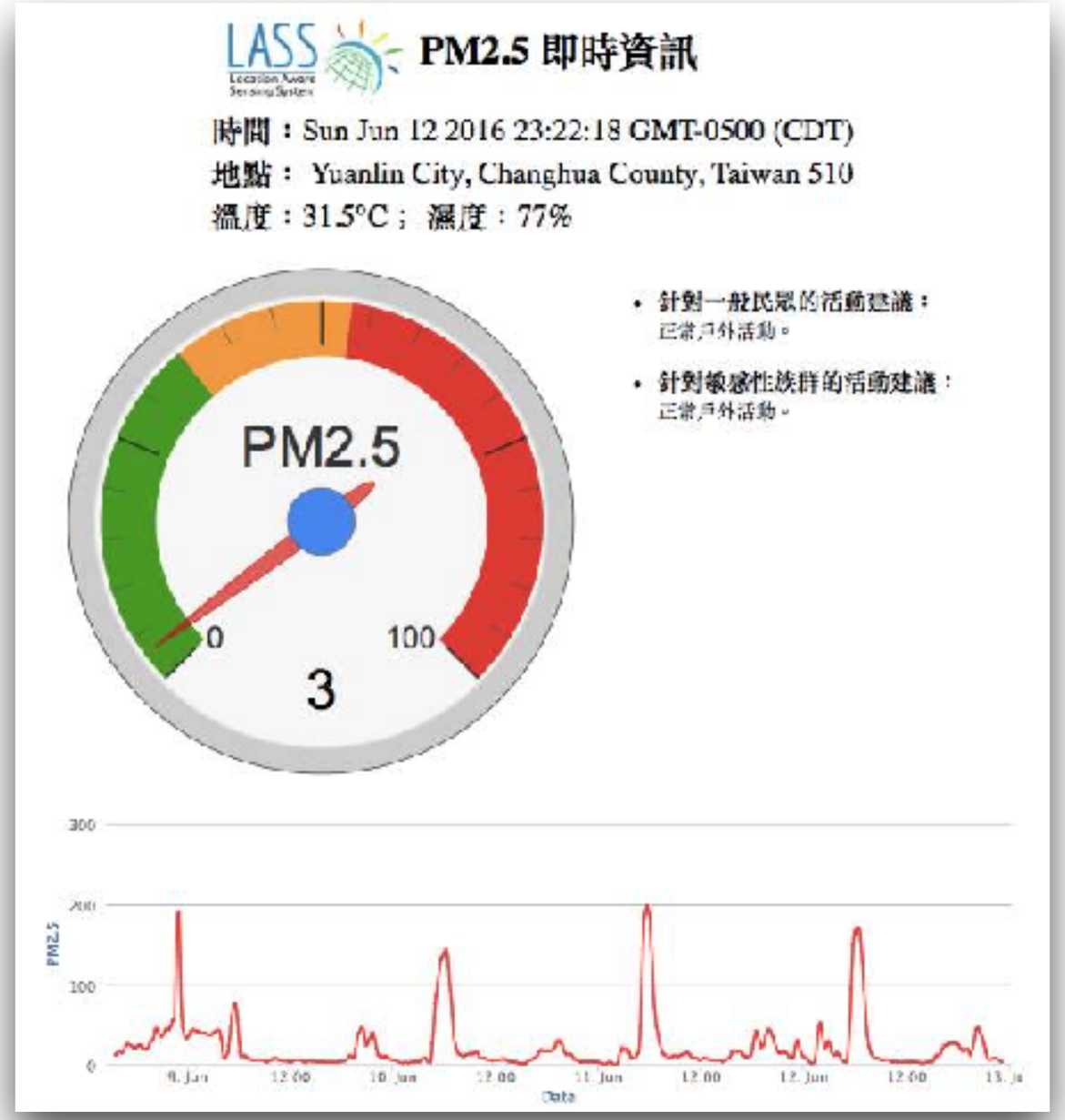
Example 5: Environment Education

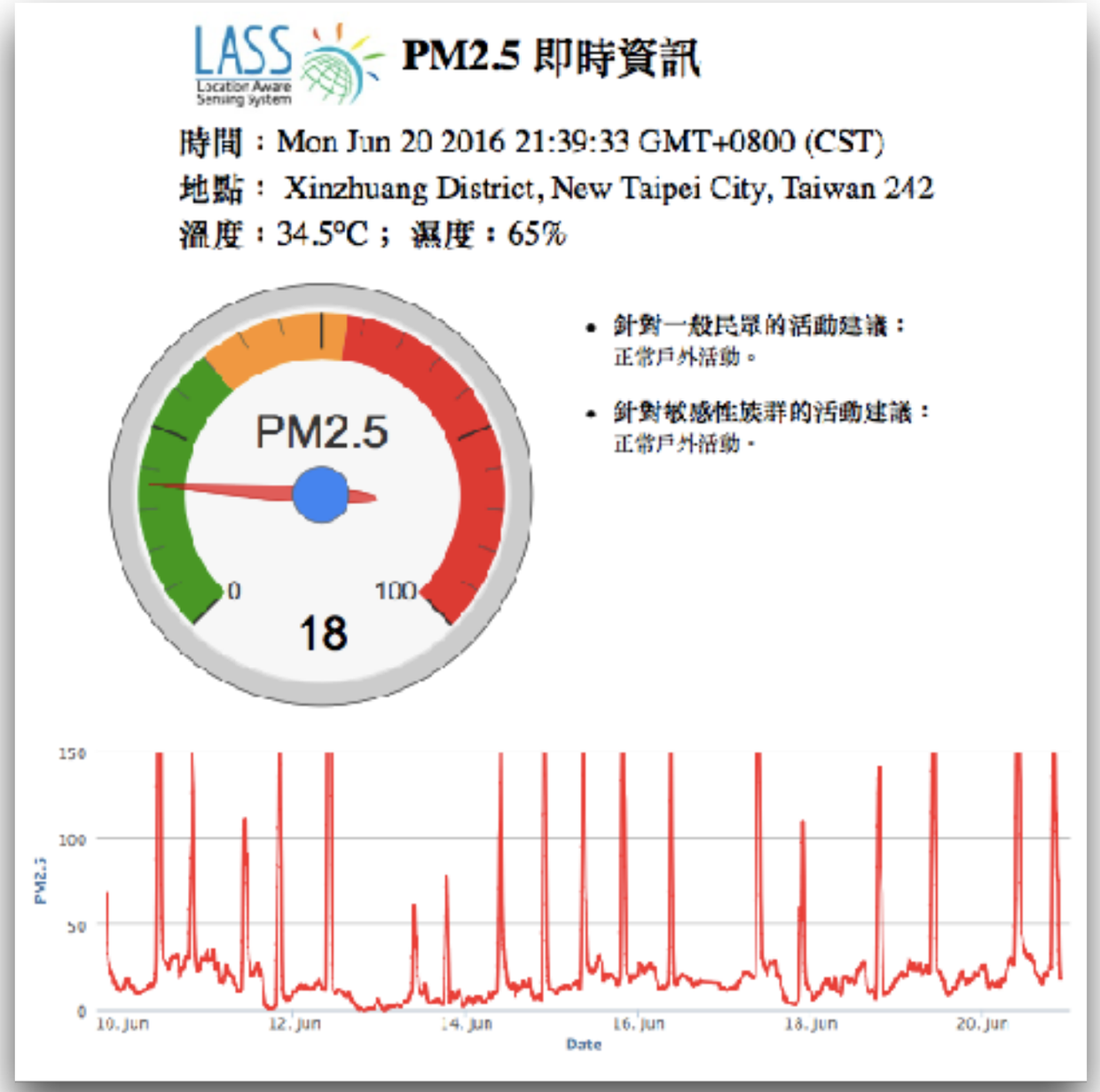




Example 5: Environment Education

Example 6: Citizen Science





Example 6: Citizen Science

莊秉潔新增了 7 張相片。
11月10日 7:01 ·

川普對氣候變遷的態度，我認為是錯的。但我卻同意川普對自由貿易的看法，我認為在地自給自足，提供在地就業機會，比自由貿易還重要。

除了關心美國大選，我們也來關心我們自己的土地。中部的朋友這兩天一定很開心，總算可以大口呼吸了。因為東北季風下來，將中部的塵霾吹走了，也沒有帶來中國的髒空氣。

但髒空氣不是消失了，只是換人承擔。

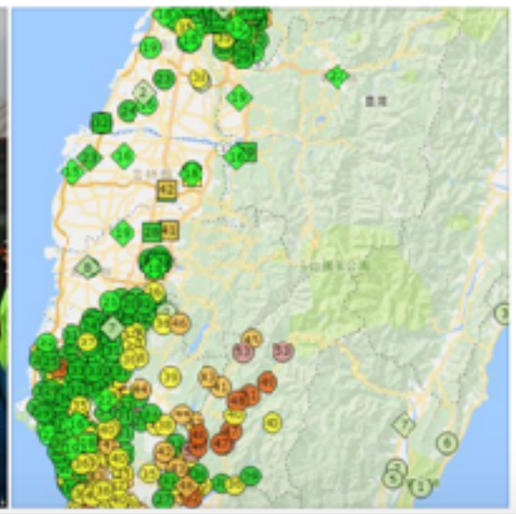
這髒空氣到哪了，大家可以看airbox 之資料(2016-11-10 06:10)，發現在高雄屏東交界，荖濃溪上游許多原住民鄉的濃度特別高，如復興區、那瑪夏區、桃源區。上網看這些原住民鄉小朋友天真開朗的笑容。我相信大家都會不捨。

看中大鄭芳怡@Fang-Yi Cheng 教授的預報，也正確預報出今晨06:00 這些原住民鄉的污染情形。

再看我的模式分析前幾天鄰近美濃址之污染來源，工業源部份，有一大部份是來自中部及雲林的燃煤電廠及汽電共生廠。

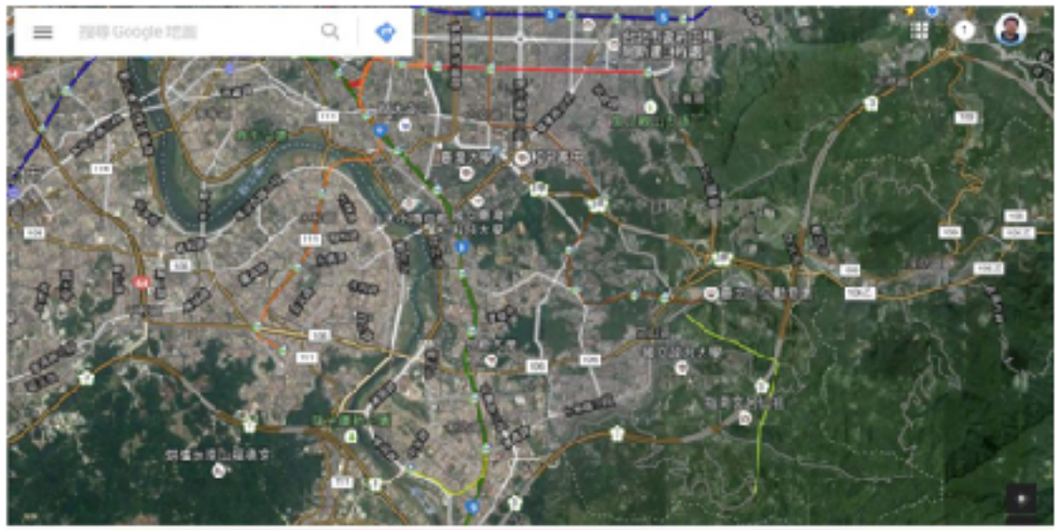
當台中市空污紫爆時，市民要求台中電廠要降載。同樣的我們也應為這些高雄、屏東原住民的小朋友，要求現在這幾天這些電廠要降載。

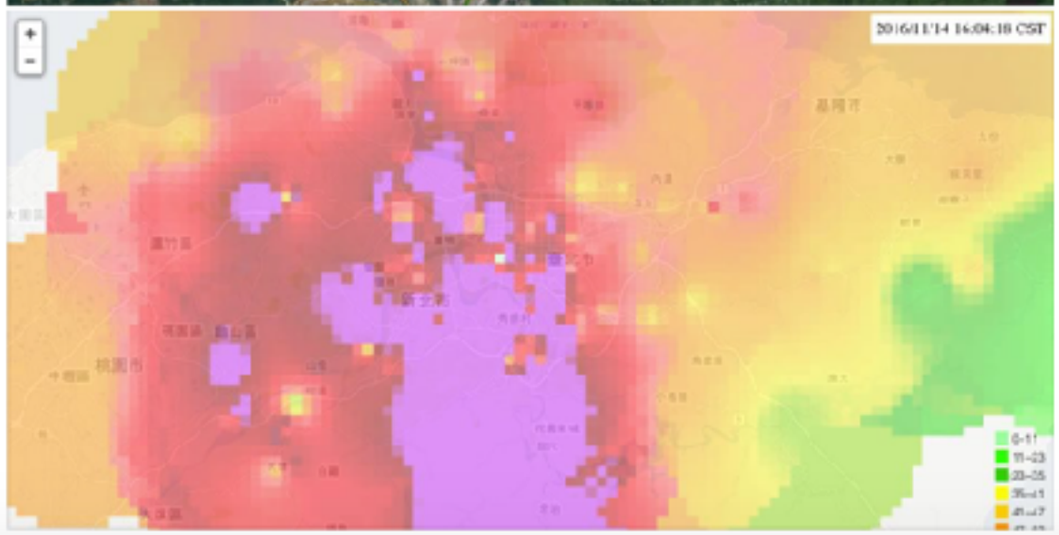
airbox: https://airbox.edimaxcloud.com/



陳伶志
11月14日 16:29

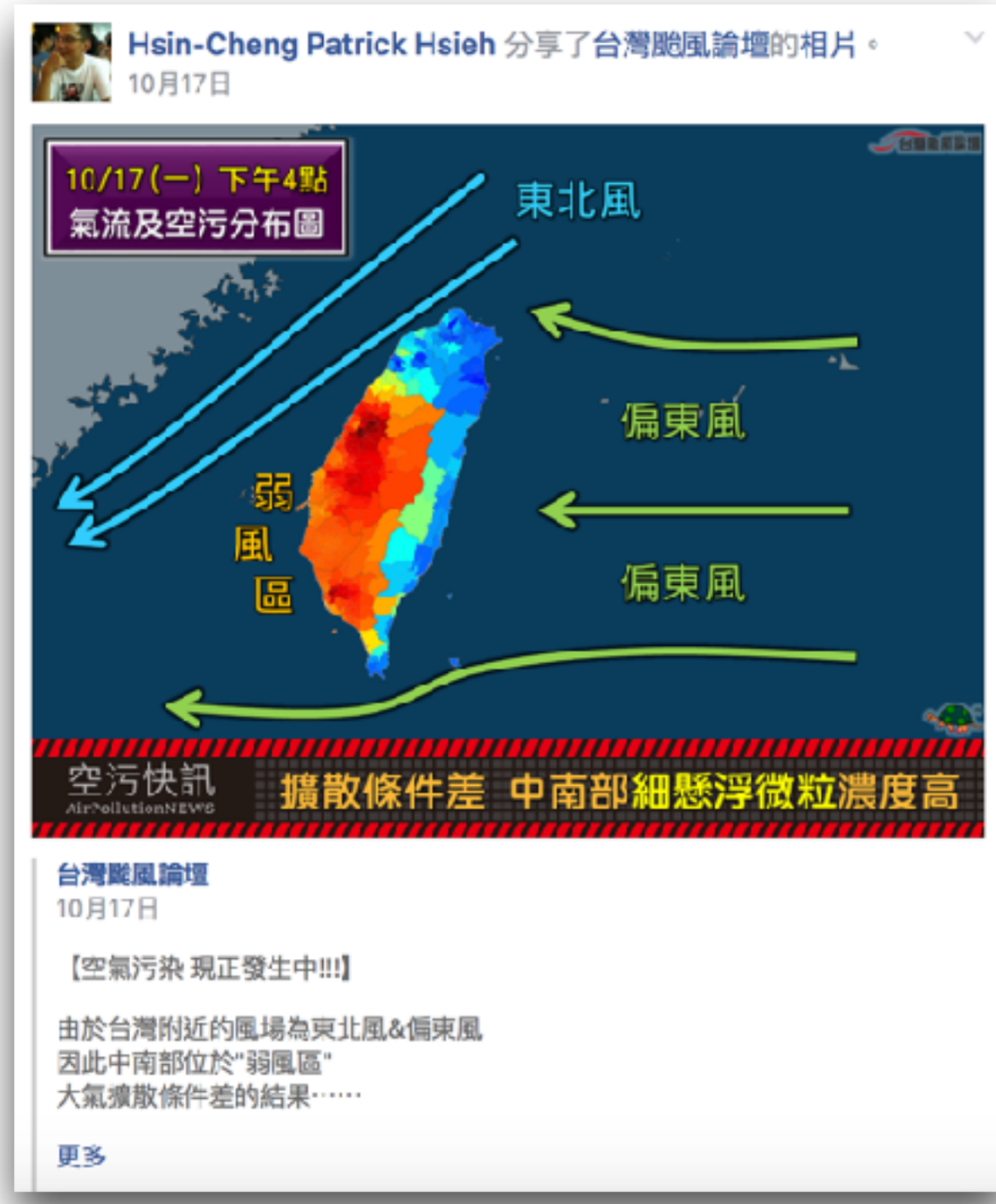
今天下午台北的空氣也開始變遭了，紫爆區目前(16:00)落在新店一帶，看來是口袋地形將髒空氣困住了，照張相分享一下，也順便做個紀錄。





PM2.5 開放資料：社群協同分析平台

Example 6: Citizen Science



What are we going to cover in this talk?

1. Why is PM2.5 important?

2. How did we build the system?

3. What is the current status?

4. What is the next step?

Many issues remaining

Correlation with traffic and stationary emission source

LASS/AirBox device ranking

Finer-grained PM2.5 dispersion model

Urban microclimate

Government policymaking

Smog forecast

Post-deployment sensor calibration

On-demand response

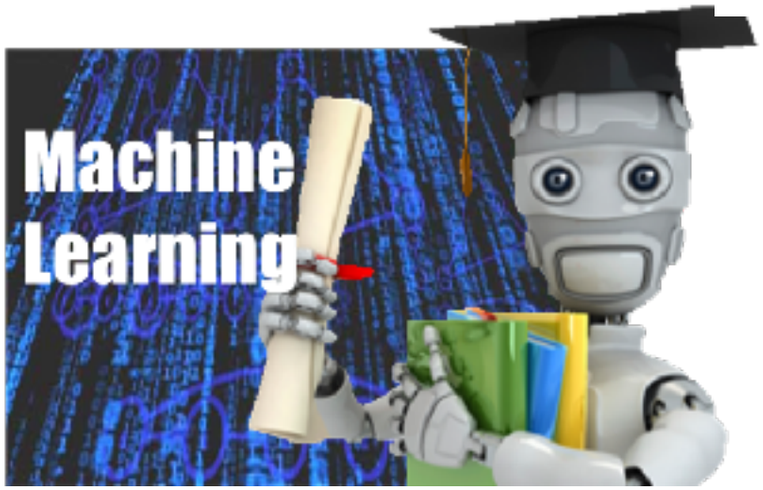
nrl.iis.sinica.edu.tw

mbed Realtime PM2.5 MAP PM2.5 GitHub PChome Yahoo!奇摩 ccljj IIS-NRL Google Facebook Twitter LinkedIn WikiCFP >>

AirBox status report

	Deployment	Number of Devices	Detail		Avg. Temperature	Avg. Humidity	Avg. PM2.5	Version
1	Taipei	40% (62/155)	[HTML]	[JSON]	30.49°C	75%	22 μg/m^3	2016-11-18T02:41:37Z
2	New Taipei	51.52% (153/297)	[HTML]	[JSON]	29.3°C	72%	26 μg/m^3	2016-11-18T02:41:38Z
3	Taichung	78.45% (182/232)	[HTML]	[JSON]	29.55°C	74%	70 μg/m^3	2016-11-18T02:41:38Z
4	Tainan	75.48% (157/208)	[HTML]	[JSON]	30.5°C	80%	79 μg/m^3	2016-11-18T02:41:38Z
5	Kaohsiung	62.81% (152/242)	[HTML]	[JSON]	30.46°C	77%	87 μg/m^3	2016-11-18T02:41:38Z
6	LASS	48.65% (36/74)	[HTML]	[JSON]	30.73°C	73%	46 μg/m^3	2016-11-18T02:41:38Z
7	TaichungZero	88.5% (100/113)	[HTML]	[JSON]	30.6°C	74%	76 μg/m^3	2016-11-18T02:41:38Z
8	Other	100% (116/116)	[HTML]	[JSON]	30.62°C	65%	66 μg/m^3	2016-11-18T02:41:38Z
9	LASS FT	100% (50/50)	[HTML]	[JSON]	26.38°C	65.57%	58.74 μg/m^3	2016-11-18T02:41:38Z
10	LASS4U	100% (8/8)	[HTML]	[JSON]	25.89°C	66.52%	38.75 μg/m^3	2016-11-18T02:41:38Z
11	Total	67.96% (1016/1495)						

Plenty of Opportunities



AirBox is an Open Ecosystem

Promote **LASS/AirBox** in your community

Become the **first** node in your community

Work together on **data** analysis

Make your city **smarter**
based on this system

Contribute your **crazy** ideas
and work together on that

Summary of the talk

- We present the **AirBox** ecosystem and its application for **Smart (& Happy) City.**
- The core spirit of the ecosystem is "**openness**" for HW, SW, data, and mind.
- The journey is ongoing and **speeding** up; and we look forward to your **participation**.

Acknowledgement

- Government: TW EPA, TPE, KH, New TPE, Tainan, MOST, …
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- Community: LASS, GoV, CENTRA, CECEA, …
- Hard-working bees: my research teams, students, interns, and many friends

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