Medan IT Meet Up #4

Internet of Things (IoT)
Intro & Demo

Universitas Pelita Harapan - Medan

14 October 2017

Allow me to introduce myself and talk about my credentials around Embedded System and IoT

So you will know better who is talking in front of you ☺

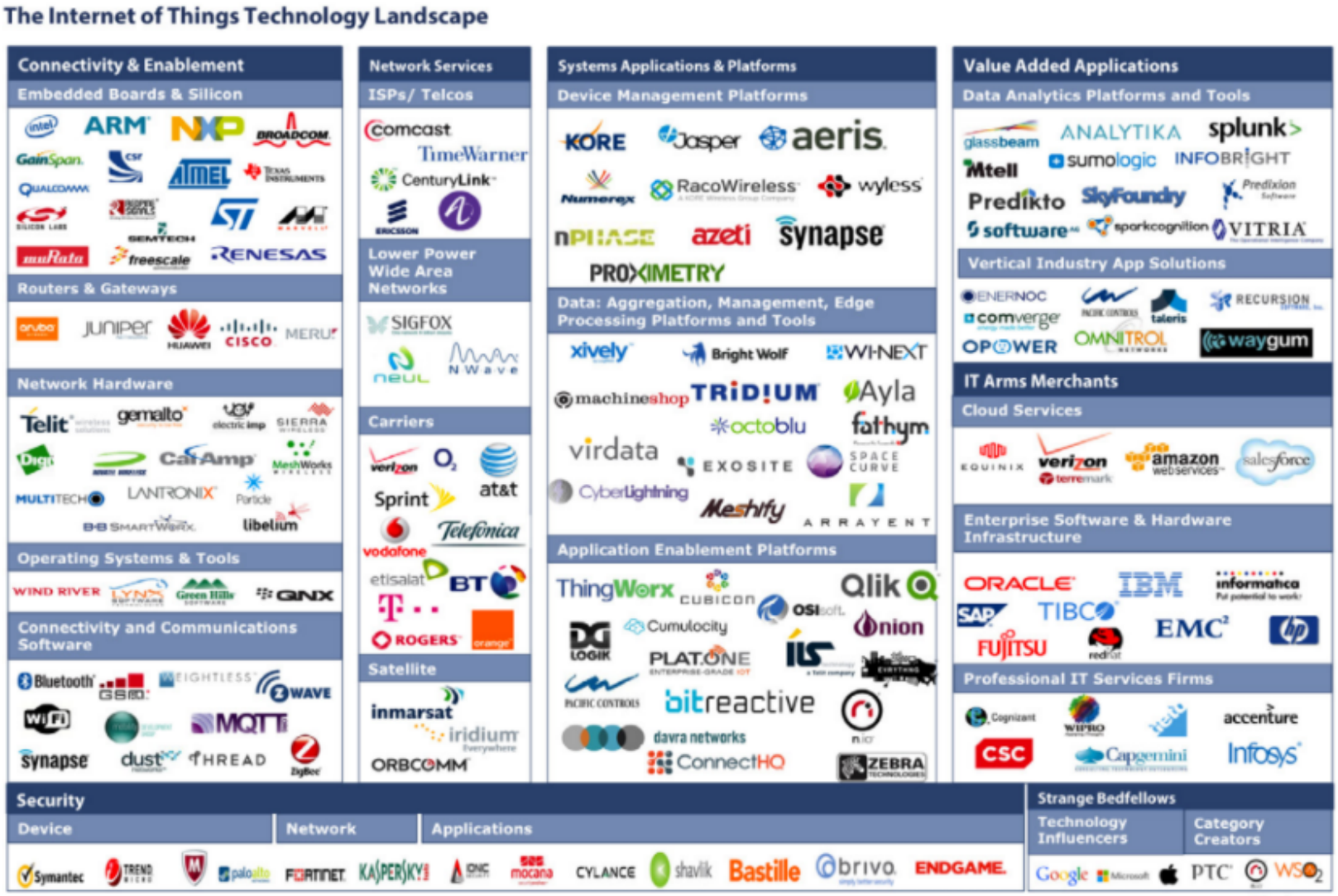
$whoami

Albert Suwandhi
Lecturer – STMIK IBBI
Bachelor Degree in Electrical Engineering
Master Degree in Information Technology
https://id.linkedin.com/in/albertsuwandhi
albert.suwandhi@gmail.com
087868577265

Past experiences on Embedded System

- Intensively worked with Atmel MCS51 and Microchip PIC (2003 – 2006)
- Used to code using assembly language on RISC based MCU - PIC
- Several projects/research during my undergraduate course :
  - iButton Reader : Patrol system using Microchip PIC16F877 MCU to read iButton using 1 wire protocol and store its ID and time stamp to EEPROM for further retrieval and processing.
  - RFID Attendance System : Attendance system using Microchip PIC16F877 MCU to read RFID card and time stamp, stored in EEPROM for further retrieval and processing.
  - Newspaper counter : Counter for printer newspaper printer on a machine. Built using PIC16F84A MCU.
  - Maze Robot : Simple maze solving robot using PIC16F877.
  - RS485 communication protocol : Multidrop network using RS485 and Atmel AT89S51 as remote nodes.

IoT is a broad topic – Let us discuss about it in 2.5 hours

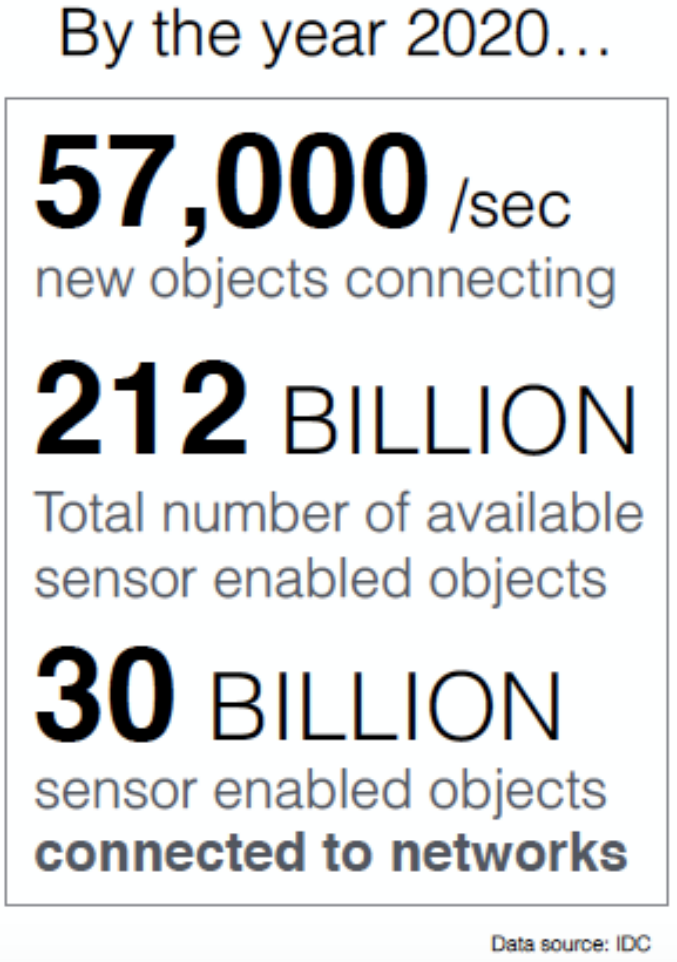


Internet of Things Technology Landscape. Harbor Research 2016

Harbor Research

Internet is in every things we use!

- Smartphones
- Children
- Animals
- TV
- Ovens
- Refrigerator
- etc

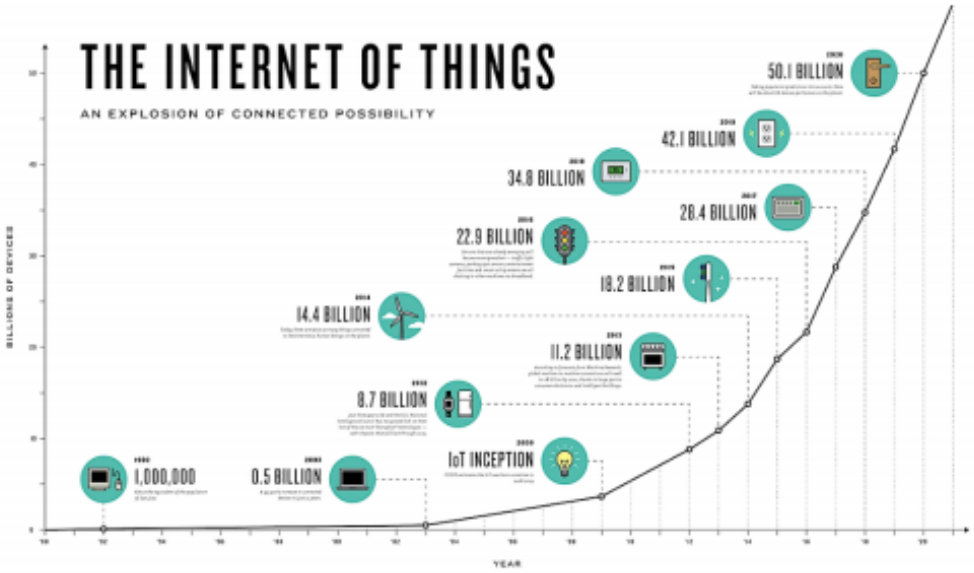


IoT Economic Impact

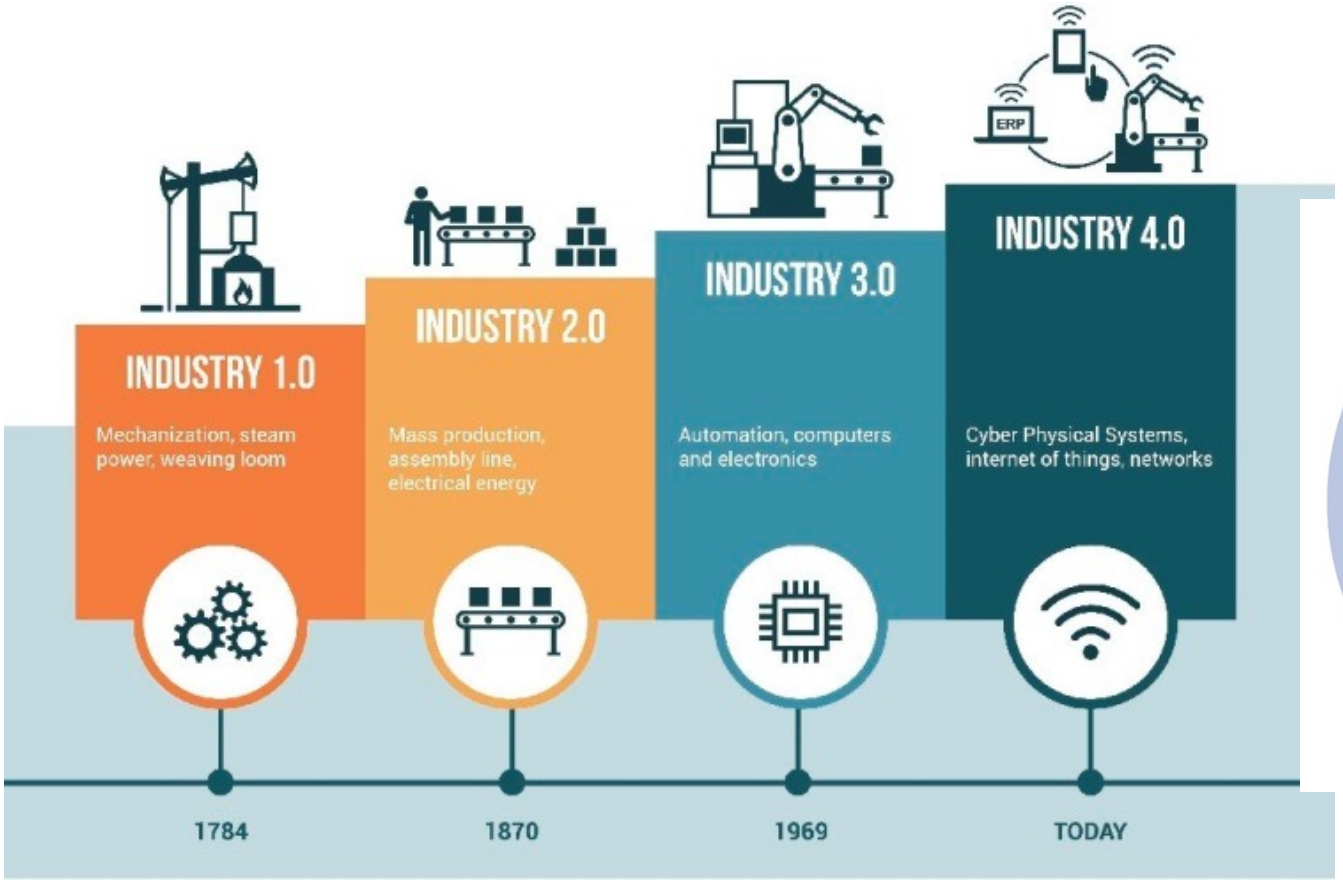
IoT has a total potential economic impact of $3.9 trillion to $11.1 trillion a year by 2025

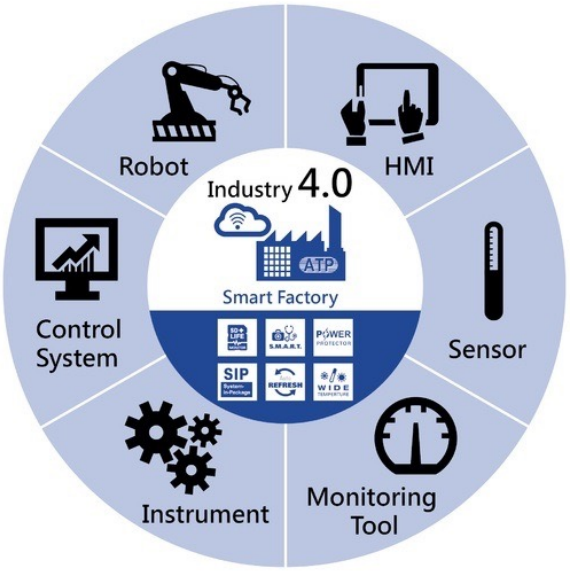
- 4.9 billion connected things in 2015
- 30 percent more than 2014
- 25 billion connected things by 2020

- Totaling 1.7 billion IoT units installed by 2020
- Utilities will be in the No. 1 spot
- Manufacturing will be second
- Government will be third

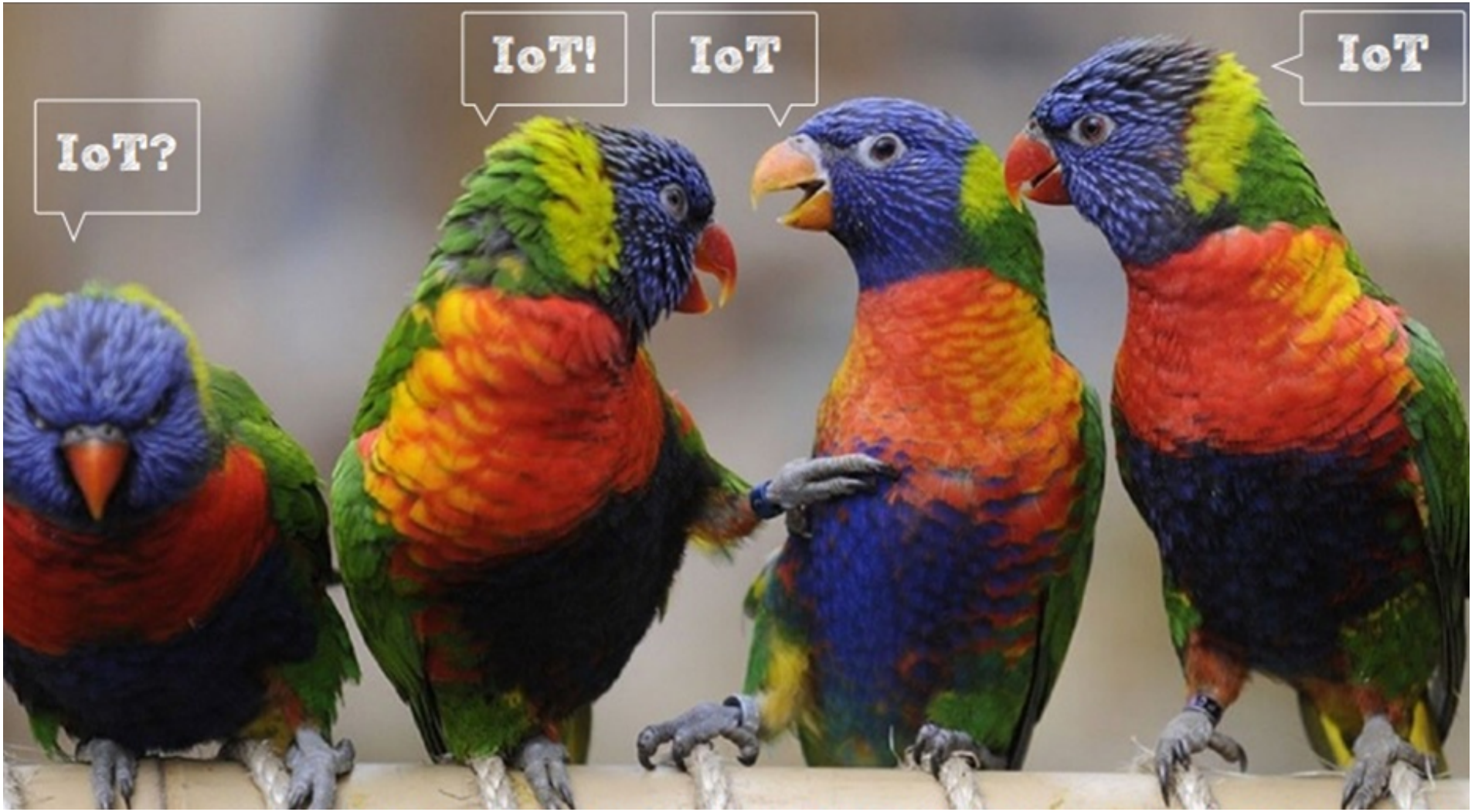


Industry 4.0


INDUSTRY 1.0
Mechanization, steam power, weaving loom
INDUSTRY 2.0
Mass production, assembly line, electrical energy
INDUSTRY 3.0
Automation, computers and electronics
INDUSTRY 4.0
Cyber Physical Systems, internet of things, networks
ERP
1784
1870
1969
TODAY


Robot
HMI
Industry 4.0
Smart Factory
ATP
Control System
Sensor
Instrument
Monitoring Tool

IoT?!



So....What is IoT?

"The Internet of Things (IoT) is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment" - **Gartner**

"The Internet of things (IoT) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect and exchange data" - **Wikipedia**

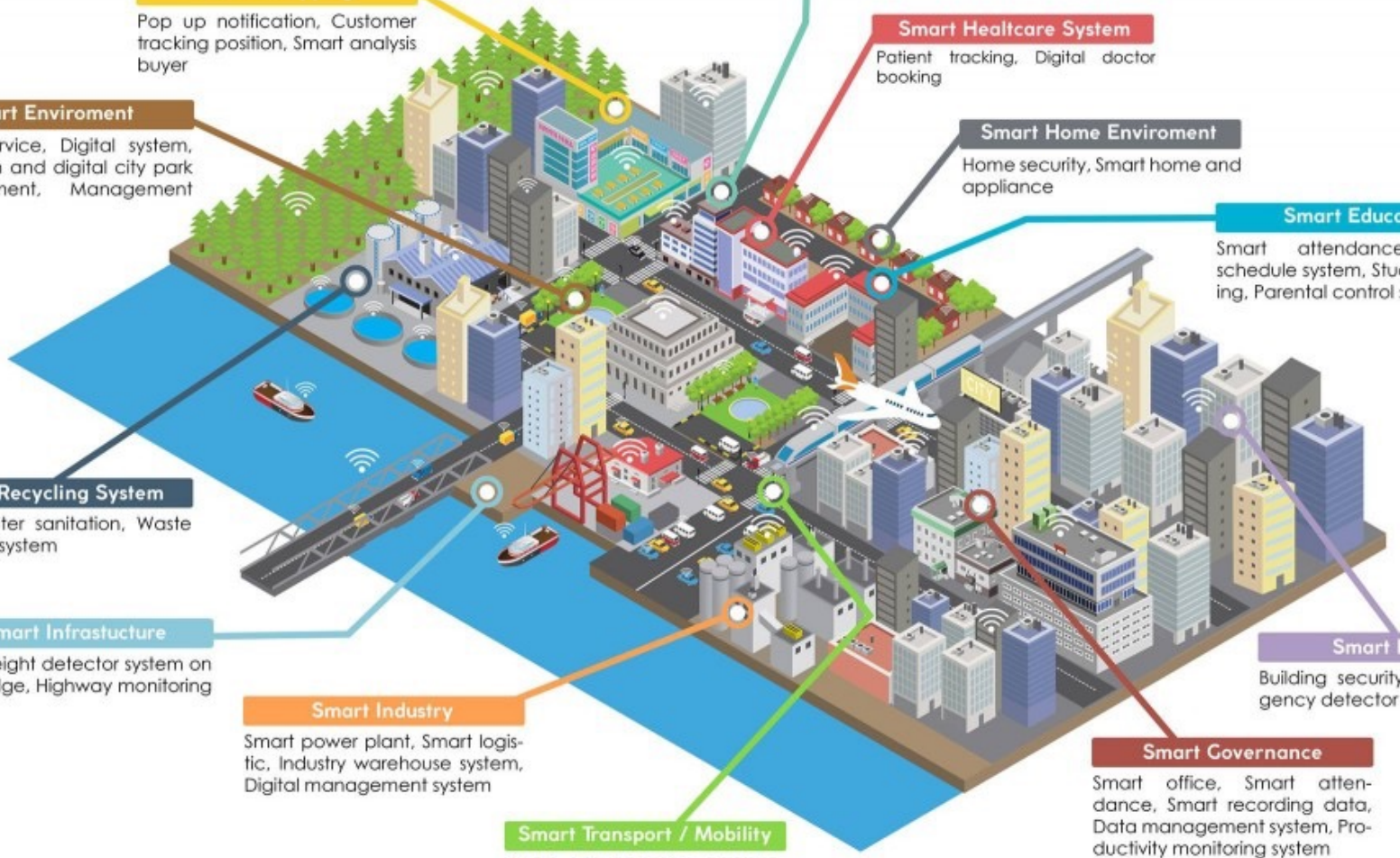
Build things

Control anything

Gain insights

Take action

SMART DIGITAL LIFE



Smart Security
Smart security city, security checkpoint

Smart Shopping
Pop up notification, Customer tracking position, Smart analysis buyer

Smart Healtcare System
Patient tracking, Digital doctor booking

Smart Enviroment
Public service, Digital system, Plantation and digital city park management, Management tourism

Smart Home Enviroment
Home security, Smart home and appliance

Smart Education
Smart attendance, Digital schedule system, Student tracking, Parental control system

Smart Recycling System
Smart water sanitation, Waste recycling system

Smart Infrastucture
Overweight detector system on the bridge, Highway monitoring system

Smart Building
Building security system, Emergency detector system

Smart Industry
Smart power plant, Smart logistic, Industry warehouse system, Digital management system

Smart Governance
Smart office, Smart attendance, Smart recording data, Data management system, Productivity monitoring system

Smart Transport / Mobility
Smart transportation tracking, Smart parking, Traffic monitoring, System and updates, Connected airpod system

IoT Platform by :
mesosfer

created by : cubeacon & mesosfer
cubeacon

IoT Applications

Everyday things

Agriculture automation

Embedded mobile

Everyday things get connected

for smarter tomorrow

M2M wireless Sensor network

Internet of Things

Energy consumption

Building management

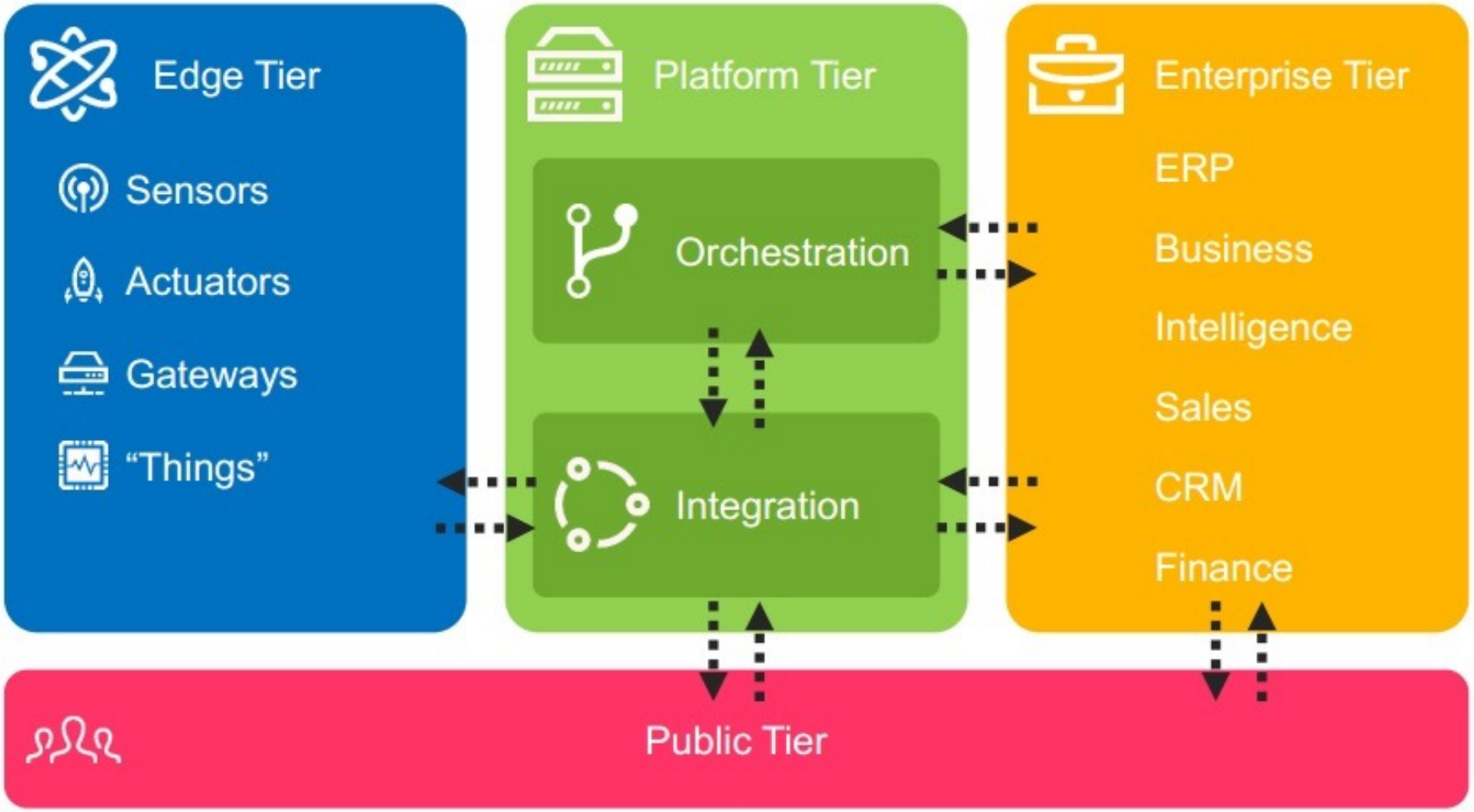
Security & Surveillance

Smart homes & cities

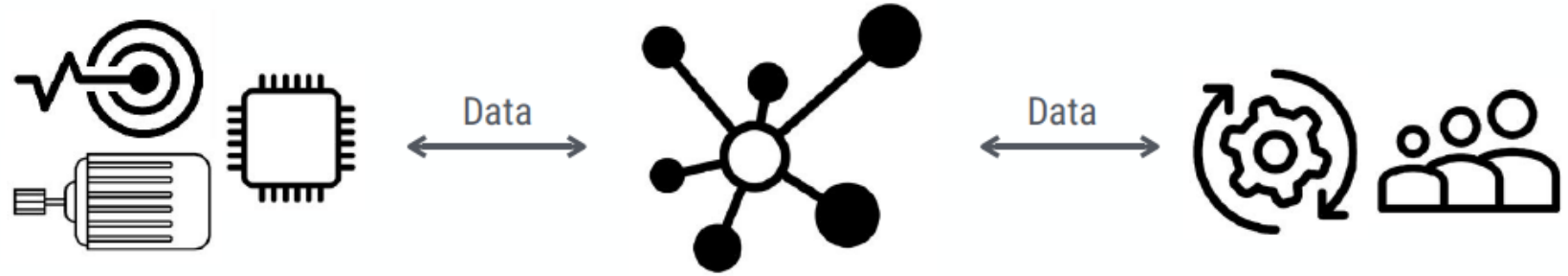
Vehicle, asset, person & pet monitoring & controlling

Telemedicine & Healthcare

IoT Architecture



IoT Components



Things

(Sensors, actuators, MCU/MPU, network, energy, firmware)

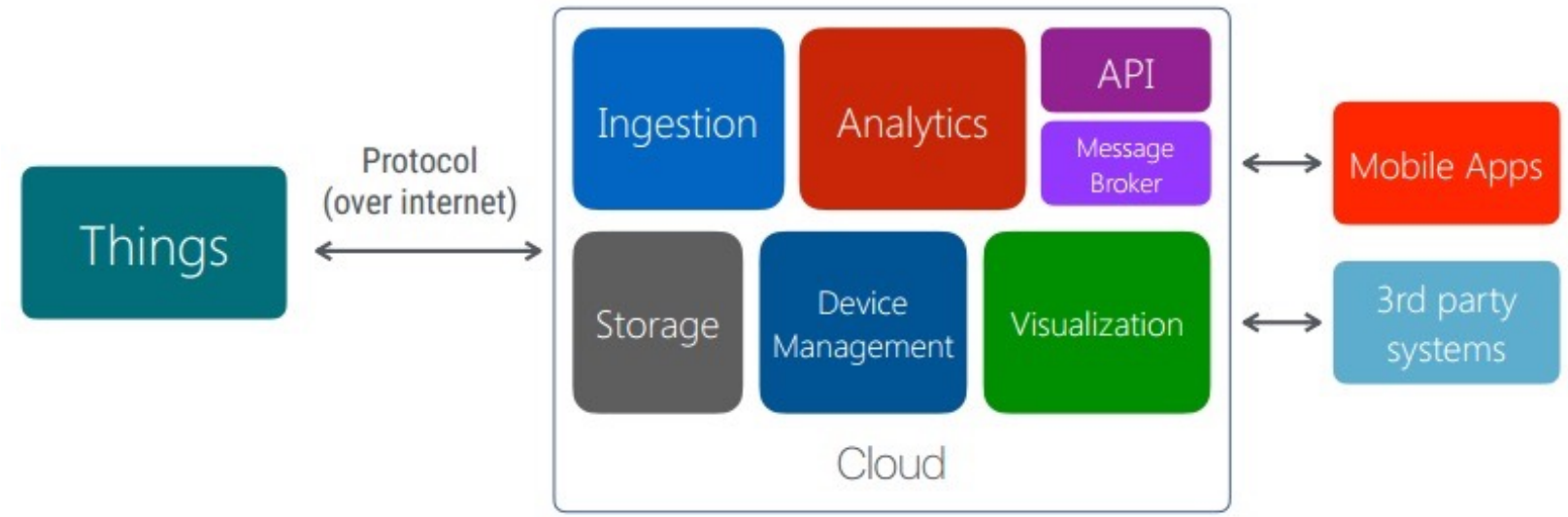
Connectivity

(PAN, LPWAN, Cellular)

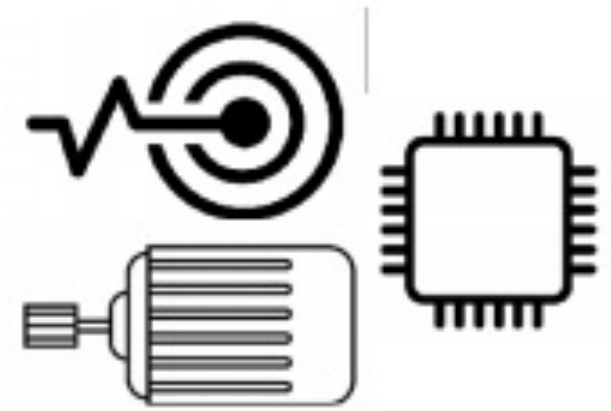
People & Processes

(IoT Cloud, Machine Learning, AI)

IoT Typical Architecture



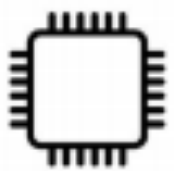
Today we will focus on the things!



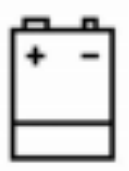
Things

What are inside the Things

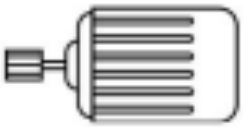
Sensors



MCU/MPU



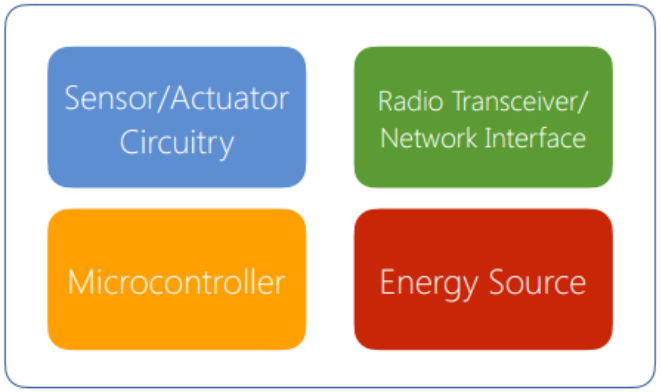
Energy Source



Actuators

Network Interface

Firmware

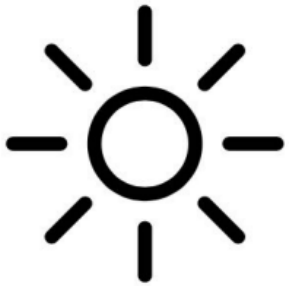


How to communicate with sensor?

- Analog Input
- Digital input
- SPI (Serial Peripheral Interface)
- I2C (Inter Integrated Circuit)
- UART (Universal Asynchronous Receiver Trasnmitter)
- CAN (Controller Area Network)
- LIN (Local Internetwork Network)
- One Wire
- etc

How about energy source?

- Commonly we will use power source from : AC, Battery or Super Capacitors
- But nowadays we can use “energy harvesting”
- Energy harvesting is the process of capturing ambient energy and storing as electricity.



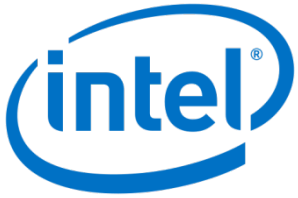
Solar

Heat

Vibration

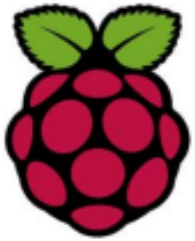
RF

System on a Chip (SoC)



and a lot more ...

ARM Based Platform



and more…

Programming Languages

and a lot more ...

Development Boards

Arduino

Arduino 101

Indonesia-made
Bluino

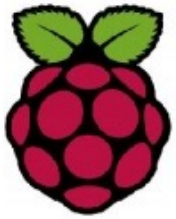
ESP8266

nRF BLE

Particle.io
Photon, Electron

Espruino

Nucleo
mbed



Raspberry Pi

and many more…

IDE Tools

Cloud Platform

and a lot more …

Protocol


http://

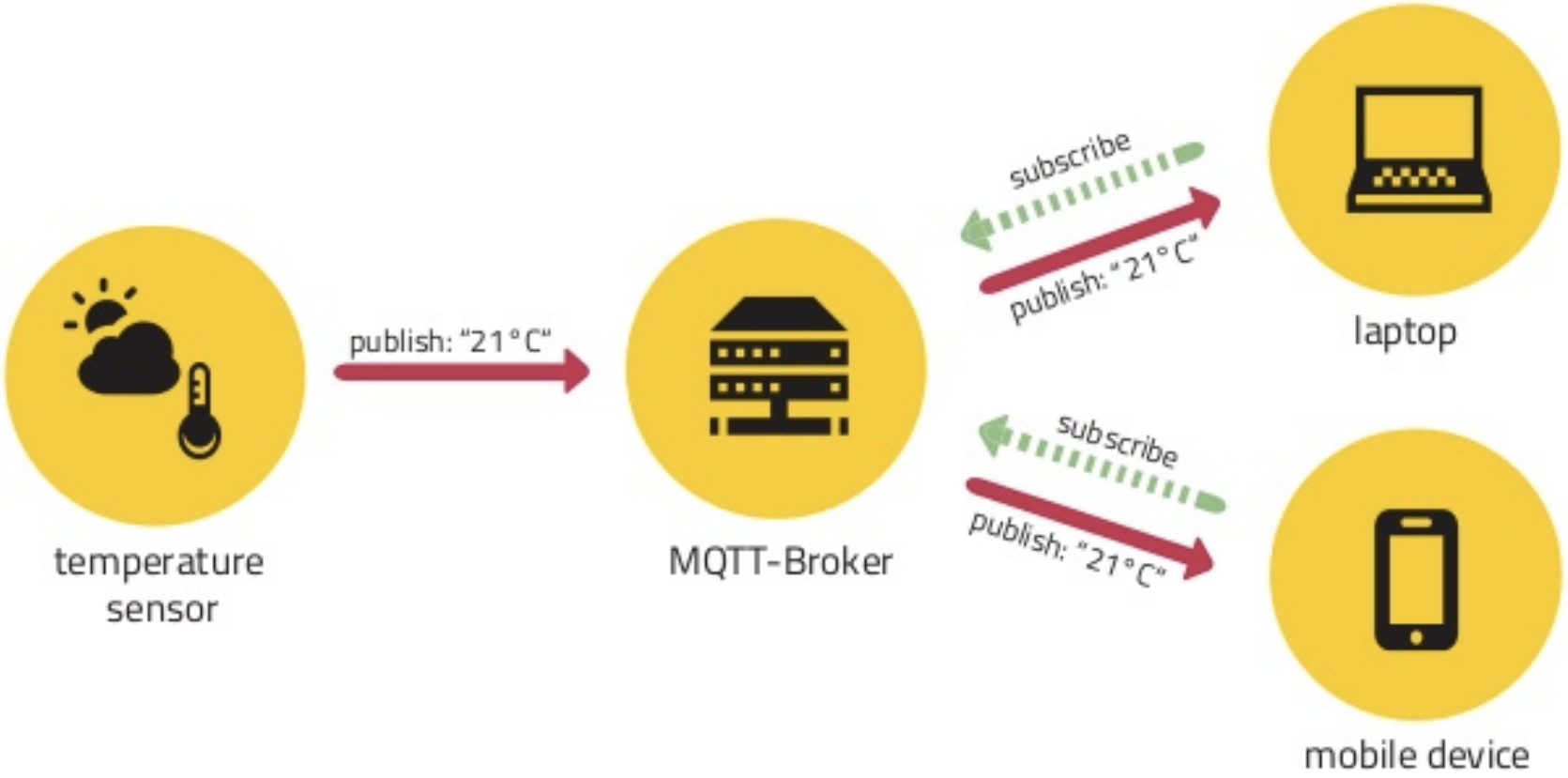

Websockets


CoAP


AMQP
Advanced Message Queuing Protocol


MQTT.ORG

MQTT Publish – Subscribe Model



MQTT vs HTTP

MQTT	HTTP
Data Centric	Document Centric
Publish - Subscribe	Request - Response
Faster than HTTP (93 times)	Slower than MQTT
QoS : at most once, at least once, exactly once	None
Last Will & Testament and Retained Messages	None
Simple Header	More complex header

In addition to simplifying communication, MQTT was designed to save as much as possible the battery of the mobile devices on which it is used. It is 11 times less energy consuming to send messages and 170 times less to receive than HTTP. MQTT is also 93 times faster than HTTP.

*HiveMQ MQTT Introduction Series is great resources to deep dive into MQTT

Operating System

Do we really need an OS?

OS Function

- Microkernel to control thread execution
- Microkernel provides Inter Process Communication
- Data structures: hashtables, queue, semaphore, mutual exclusion, signal.
- Memory management
- IP networking stack
- Flash file system
- Cryptography dan security
- Hardware Abstraction Layer (HAL), consistent and cross platform API for timer, interrupt, I2C, GPIO and etc

Usually MPU will use full blown OS, for example Raspbian, Windows 10 IoT Core on Raspberry Pi

IoT Connectivity Comparison

LAN

Short range communication

- Well established standards
- Better for:
  - Mobile devices
  - In-home
  - Short range
- Poor for:
  - Battery life
  - Long range

LPWAN

Internet of Objects

- Emerging PHY solutions
- Better for:
  - Long range
  - Long battery life
  - Low cost
- Poor for:
  - Low data rate

Cellular

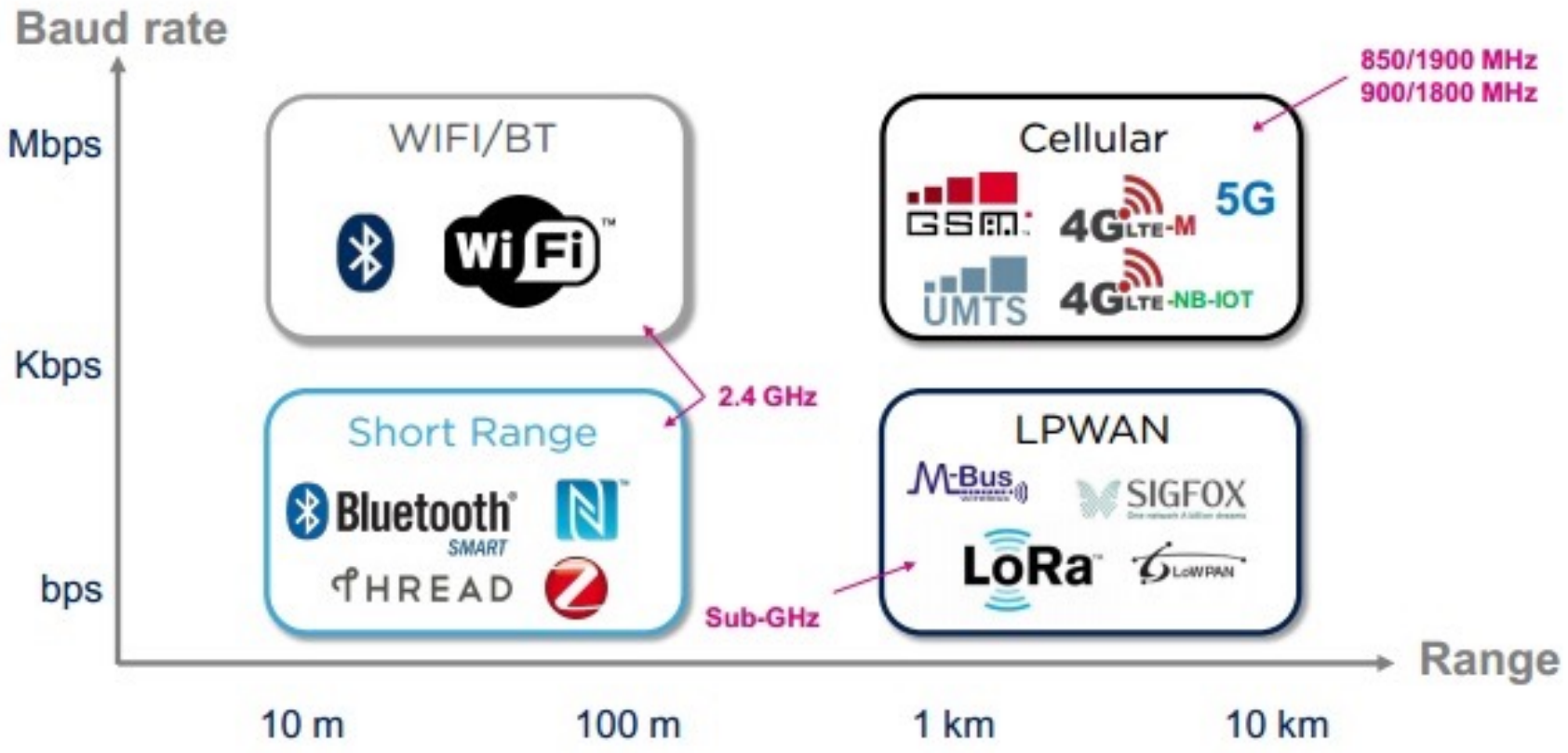
Traditional M2M

- Well established standards
- Better for:
  - Long range
  - High data rate
  - Coverage
- Poor for:
  - Battery life
  - Cost

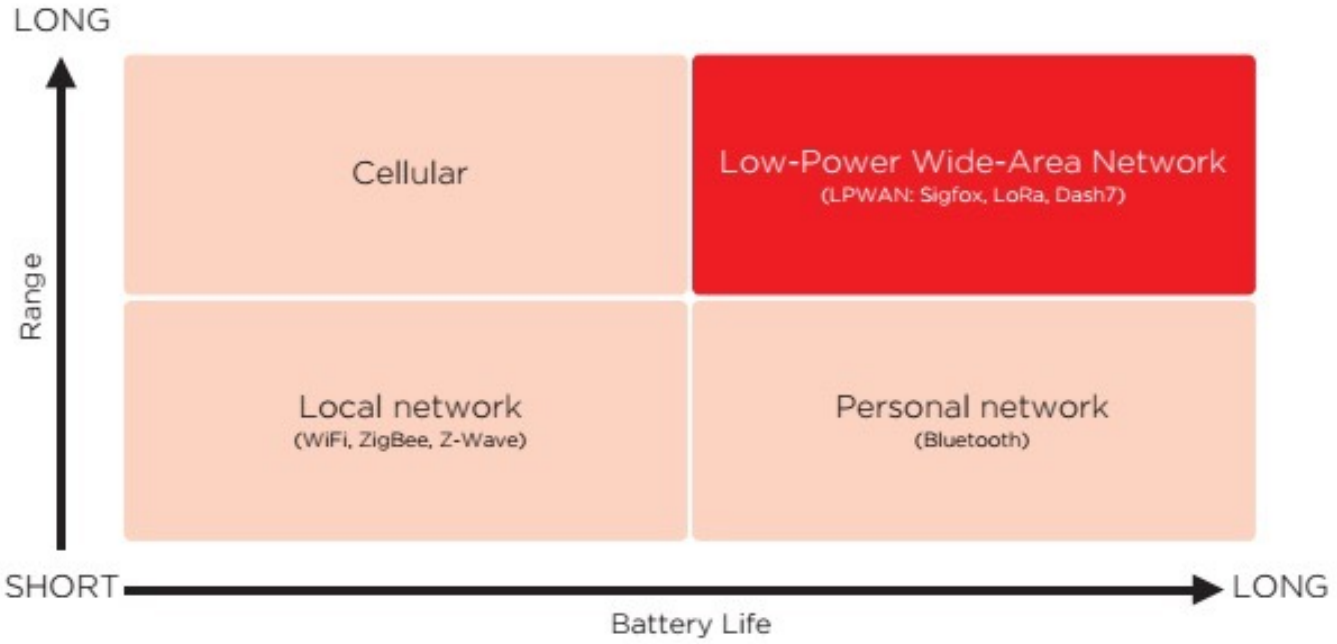
IoT Connectivity Comparison

					LPWAN	
Technology	**2G**	**3G**	**LAN**	**ZigBee**	**SigFox**	**LoRa**
Sensitivity	-105dBm	-107dBm	-94dBm	-100 dBm	-126 dBm	-142 dBm
Range (I=Indoor, O=Outdoor)	1 km urban 2 km rural	1 km urban 2 km rural	O: 300m I: 30m	O: 90m I: 30m	2km urban 15km rural	5km urban 15km rural
Tx current consumption	200mA-500mA	500mA – 1000mA	50mA	35mA	45mA	18mA
Standby current	2.3mA	3.5mA	NC	0.003mA	0.001mA	0.001mA
Interference Immunity	Moderate	Bad	Bad	Bad	Bad	Good
Battery 2000mAh (LR6 battery)	4-8 hours(com) 36 days(idle)	2-4 hours(com) X hours(idle)	50 hours(com) X hours(idle)	60hours (com)	45 hours(com) 10 year(idle)	120 hours(com) 10 year(idle)

Connectivity – Rate vs Range



Connectivity – Range vs Power



Source: Alexander Vanwynsberghe, Blog article 'Long-range radios will change how the Internet of Things communicates'

Cellular Connectivity IoT

Advantages

Fast, efficient
Up to 10 Mbps for 4G LTE

Ubiquitous coverage

Reliable & secure

Considerations

Not designed for IoT in mind

High power consumption

Relatively expensive: modules, data plan

Provisioning, manageability

What is LPWA

Low Power, Wide Area Networks

Low data throughput = High sensitivity = Long range

Relatively low cost

Multiple Access = One-to-Many Architecture

Using licensed or unlicensed spectrum

LPWA Typicals

Spectrum
Unlicensed/Licensed, < 1GHz

Range
10s Km, No Relay

Objects
Many, 1000+

Data Volume
Small, tens kB per day

Service Cost
Low, < $1-3 pm

Data Rate
Low, <100kb/s

Latency
Low-High, Up to minutes

Battery Life
Long Life, Up to 10 years

Module Cost
Low, < $5

Installation Cost
Low, < $5-$10

LPWA Technologies

License-free Spectrum

Licensed Spectrum

So what is LoRa and LoRAWAN?

Wireless modulation technology

Physical (PHY) layer for long range communications

Operates in the license-free ISM bands all around the world

- 433, 868, 915 Mhz
- Regulated (power, duty-cycle, bandwidth) E.g: EU: 0.1% or 1% per sub-band duty-cycle limitation (per hour)

Sensitivity: -142 dBm

Link budget (EU): 156 dB

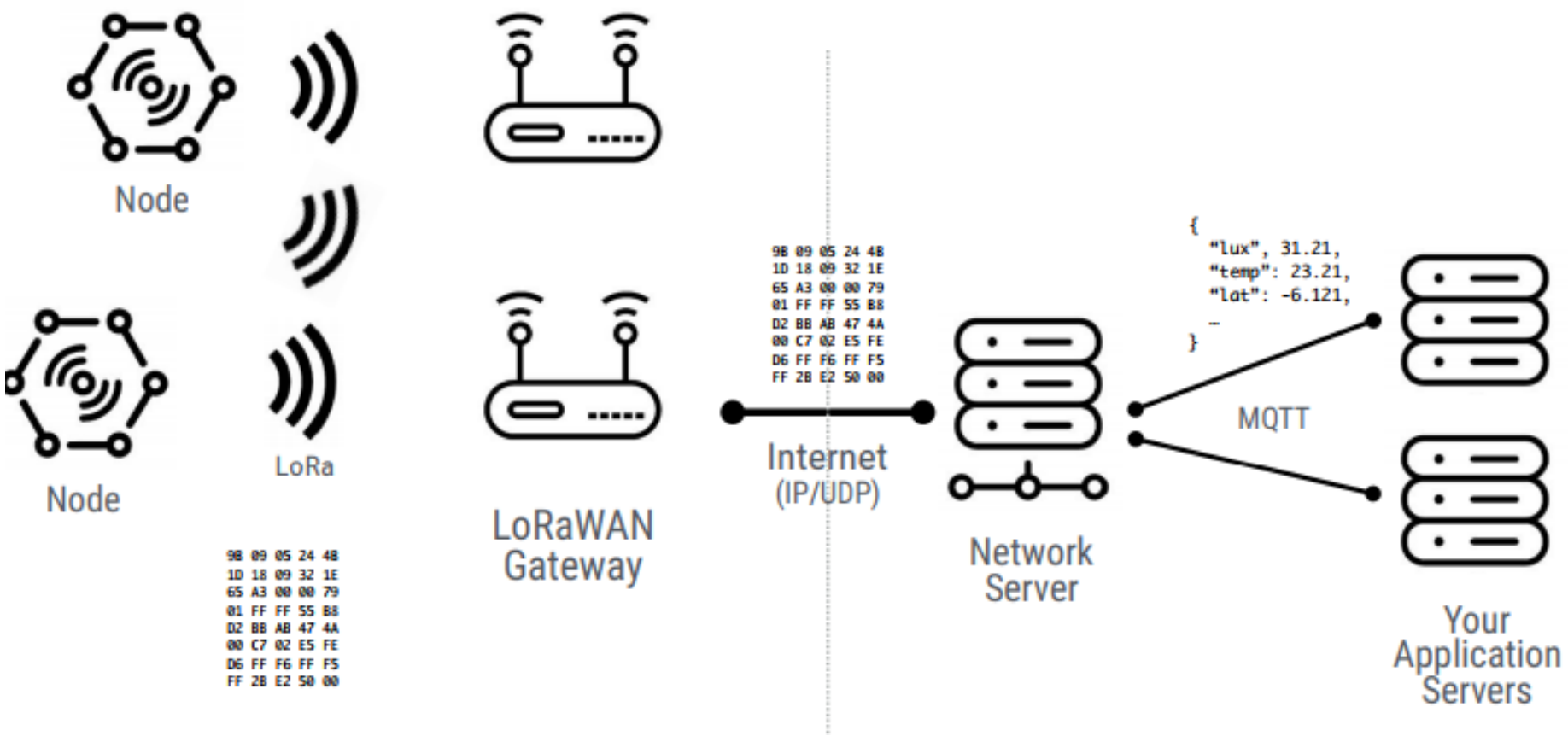
Communications protocol & architecture utilizing the LoRa physical layer

Data rates are from 300bps to 5.5kbps
Has 2 high-speed channels at 11kbps and 50kbps (using FSK modulation)

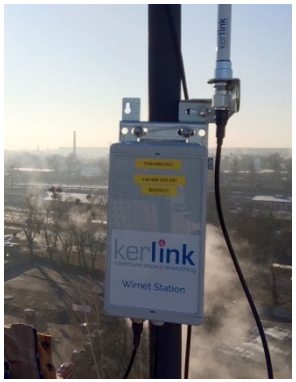
It supports

- secure bi-directional communication,
- mobility

LoRa Architecture



Ground breaking world record! LoRaWAN packet received at 702 km (436 miles) distance

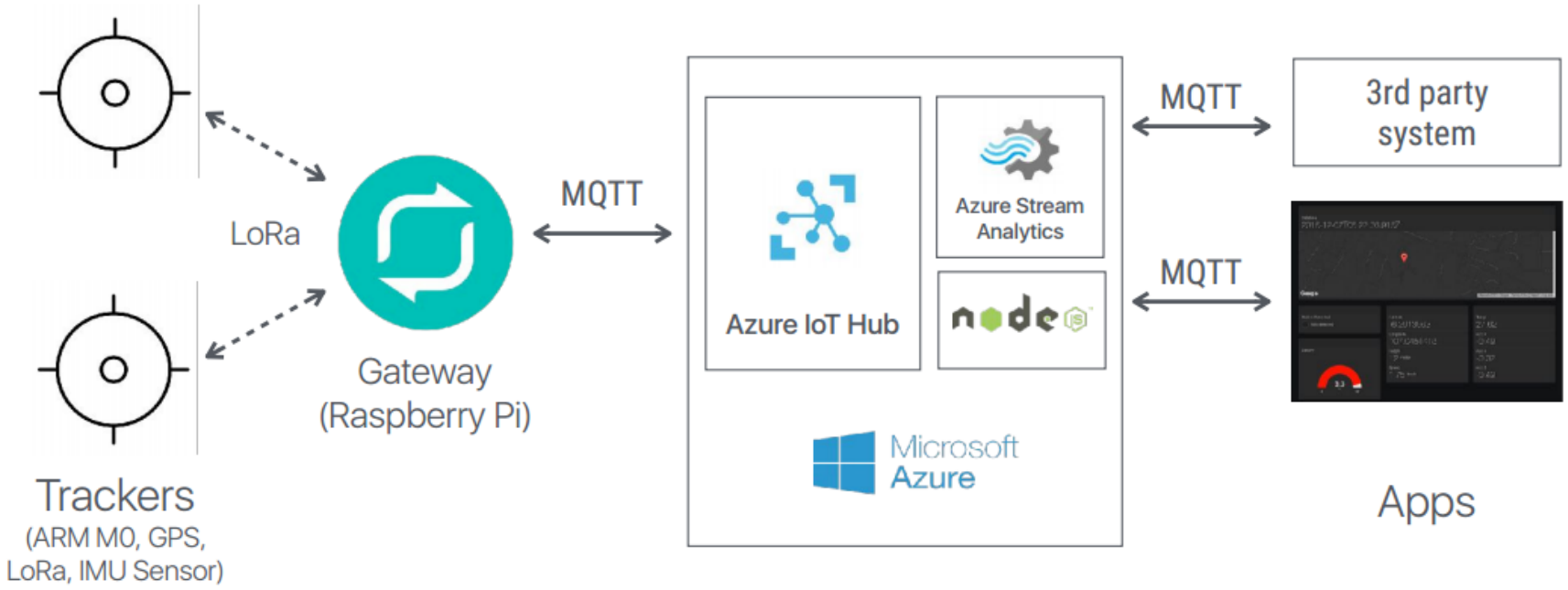


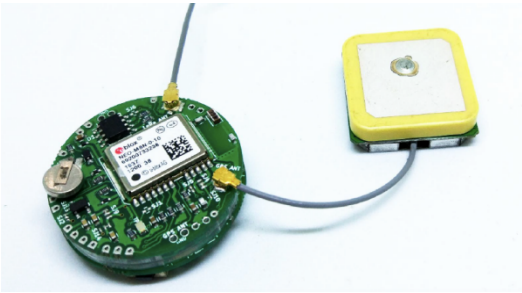
https://www.thethingsnetwork.org/article/ground-breaking-world-record-lorawan-packet-received-at-702-km-436-miles-distance

http://koppelting.ltcm.net/

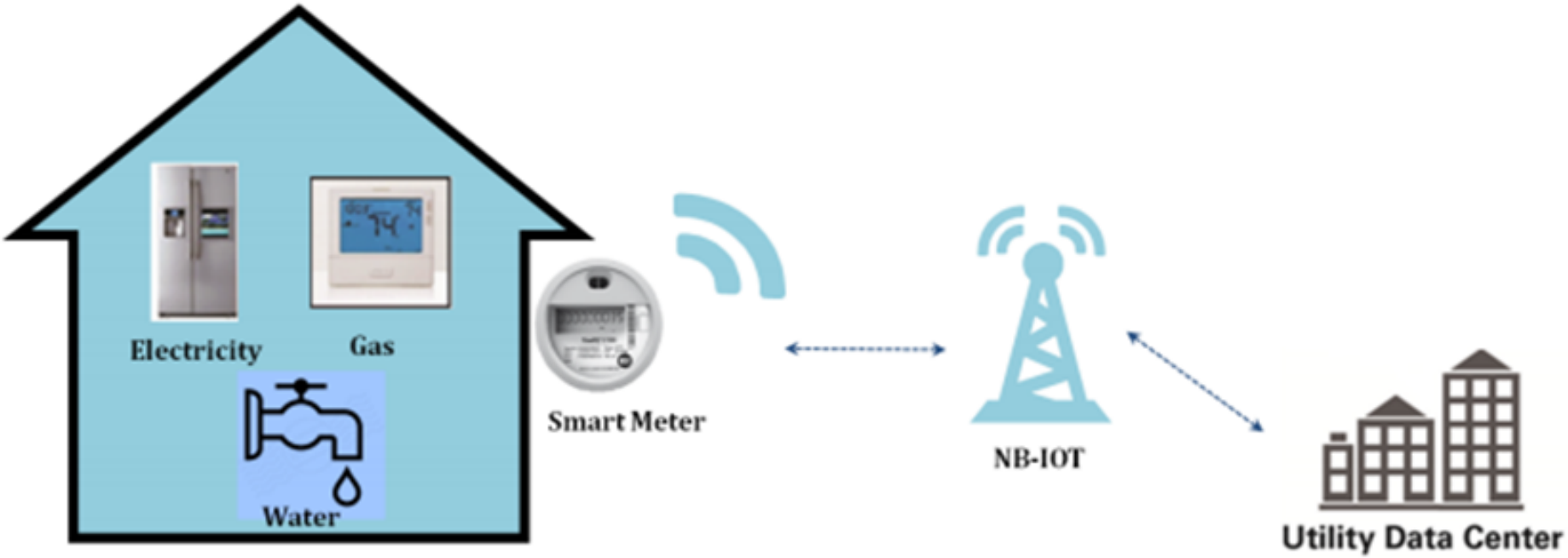
A distance of 702.676km was reached by using only 25mW (14dBm) of transmitting power, roughly 40 times smaller than a mobile phone can use.

Assets Tracking





Smart Metering



Smart Environment

AIR QUALITY MONITORING

PM2.5 | Temperature | Humidity

TODAY'S LOWEST

Sekolah Seri Puteri (13)

MP Sepang (16)

Malaysian Industry-Government Group for High Technology (18)

Lowest nationwide
Sekolah Seri Puteri (13)

TODAY'S HIGHEST

Setia Haruman (23)

CoPlace 1 (23)

Cyberview Sdn Bhd (23)

Highest nationwide
Setia Haruman (23)

PM2.5

- 301 AND ABOVE
- 201 TO 300
- 101 TO 200
- 51 TO 100
- BELOW 50

SEE IT LIVE AT

http://www.cyberjayacity.com/air-quality-index-temperature/

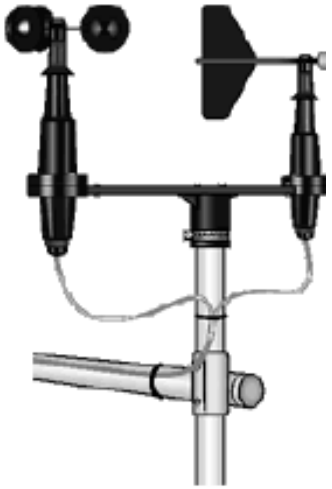
Indonesia - Smart Farming

Sensor Used in Smart Farming

Air Temperature & Humidity

Soil Moisture

Solar Panel



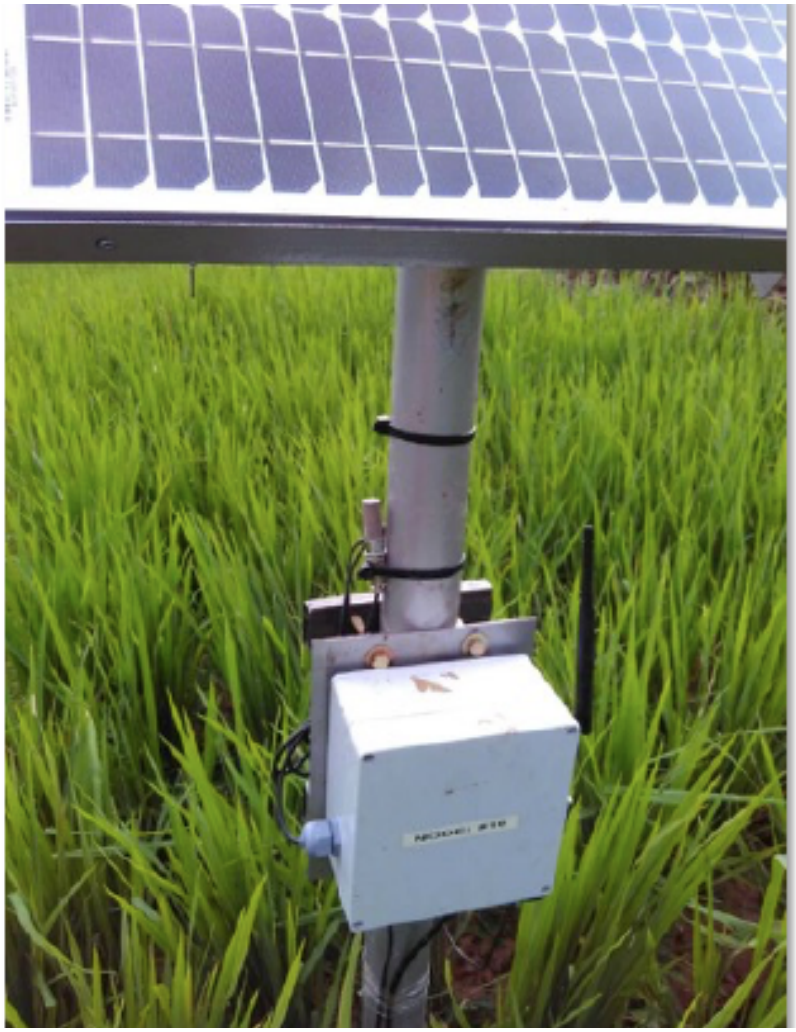
Mounting System

Soil Electrical Conductivity (Drainage)

Soil pH

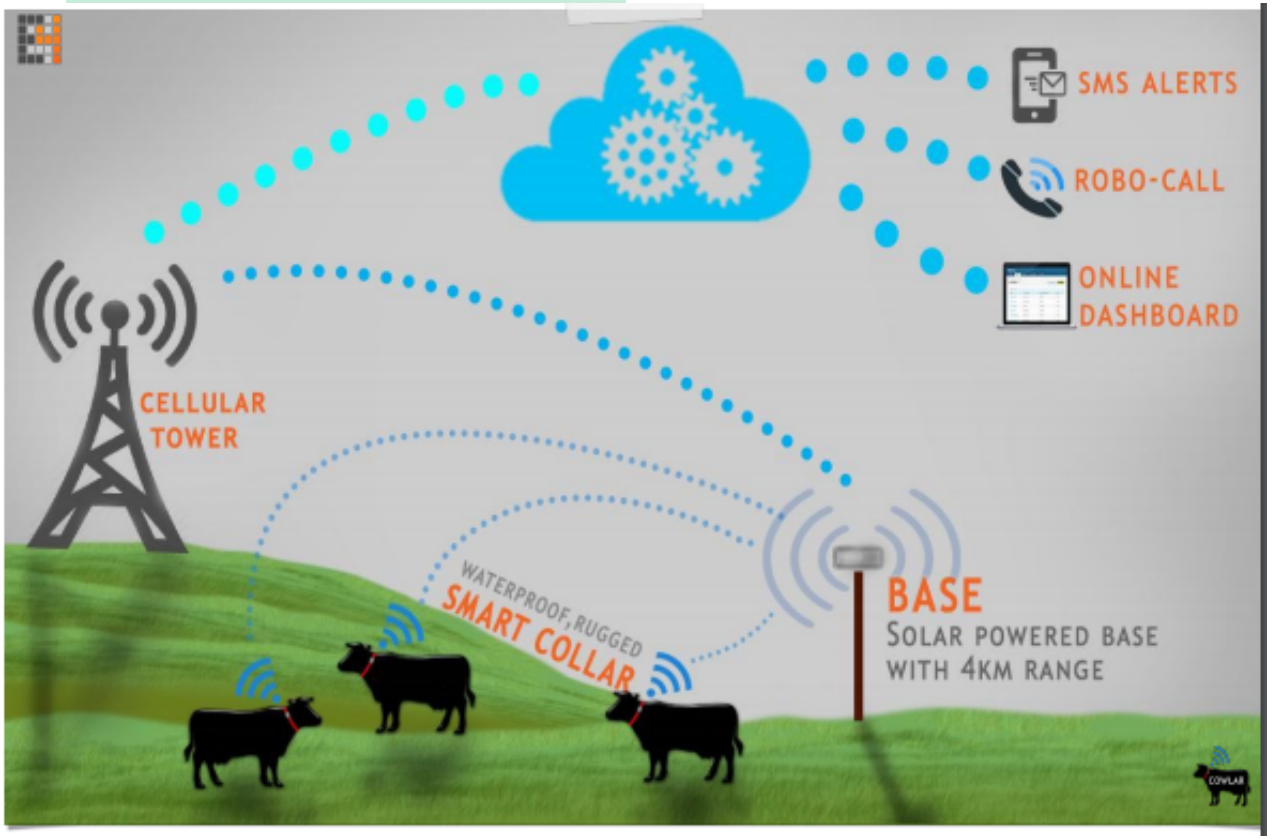
Weatherproof Enclosure

Sensor Installation

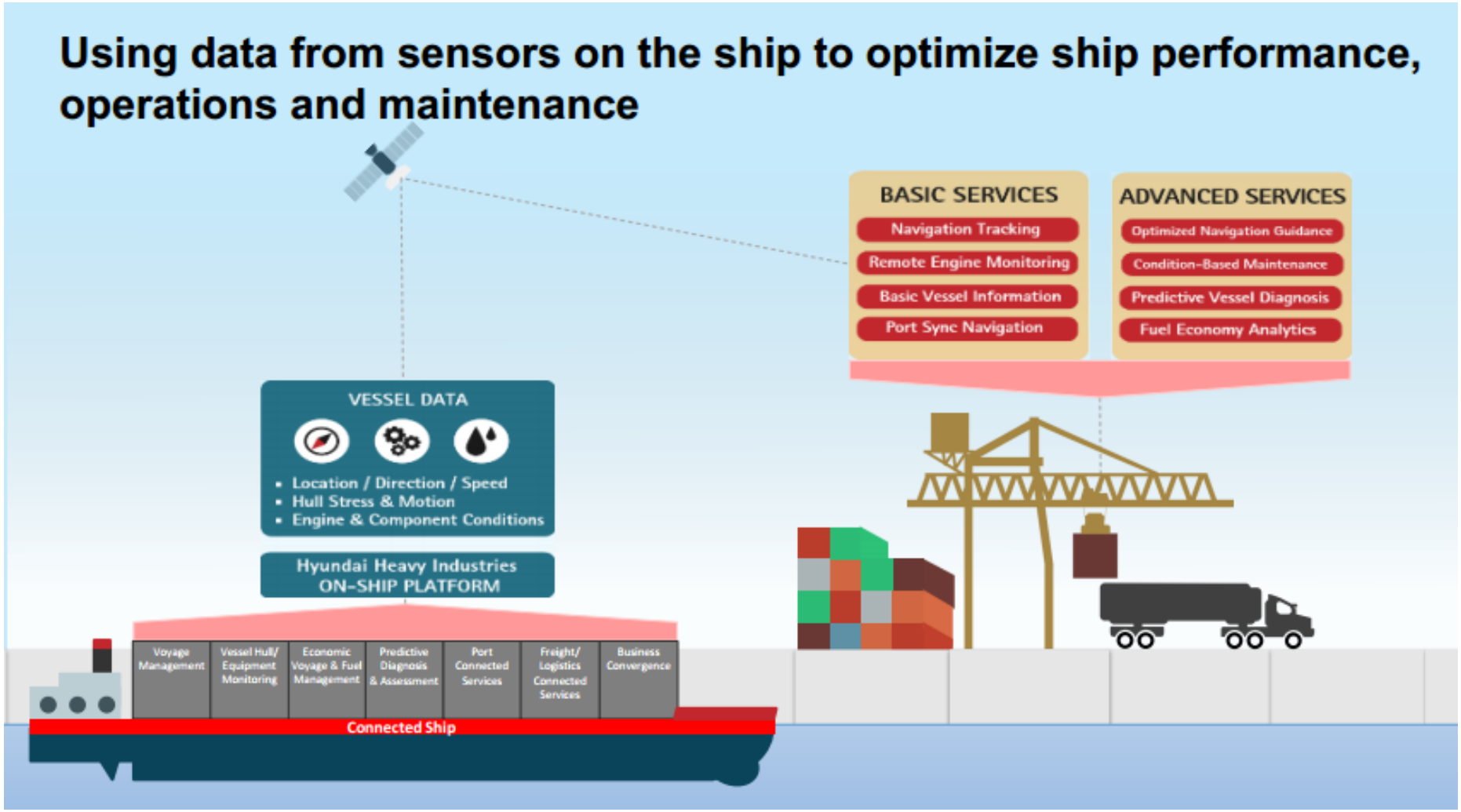


Smart Agriculture

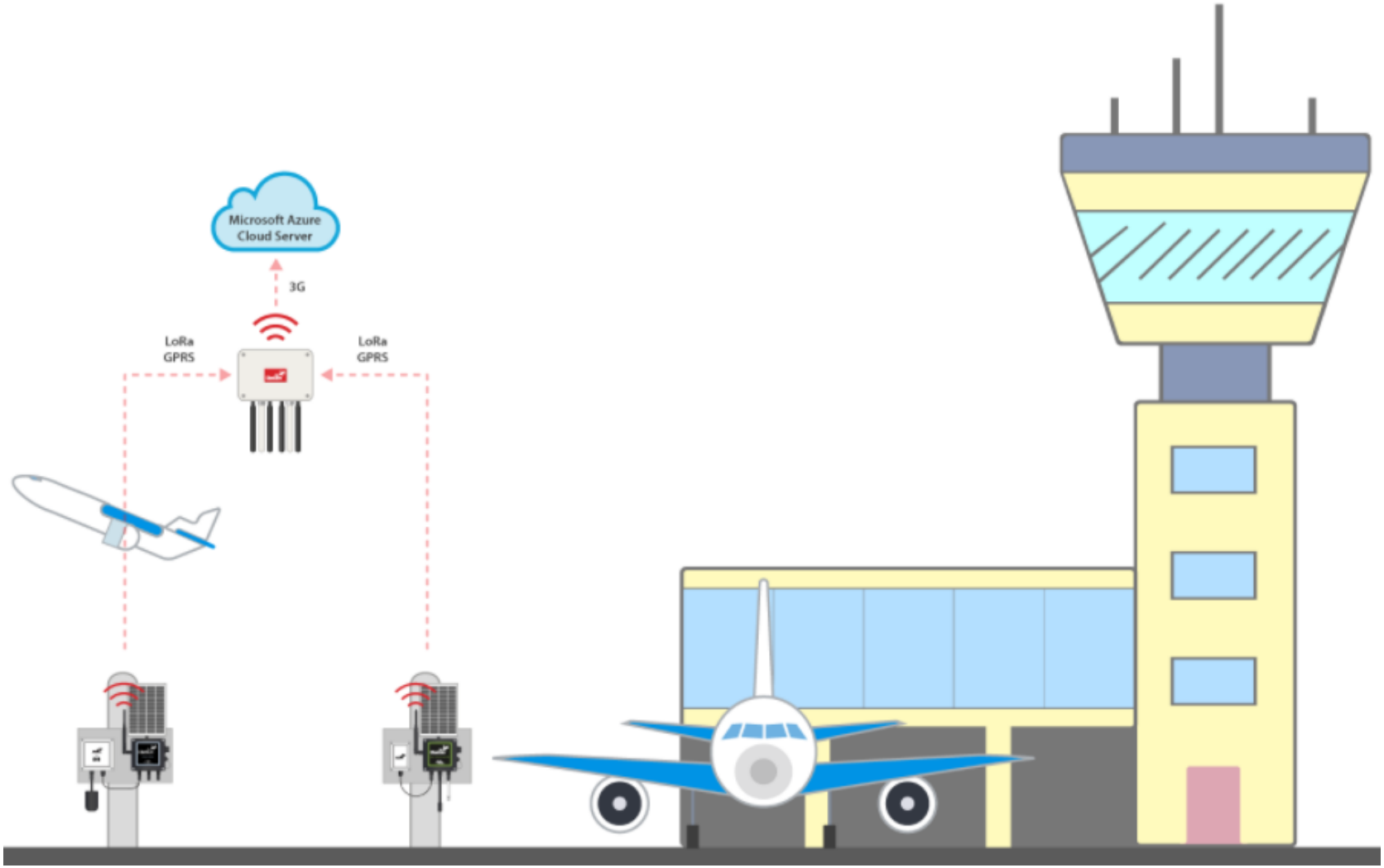
COWLAR
The smart collar for cows
Real-time Tracking • Monitoring Health • Improving Production



Logistic and Shipping



Environmental Monitoring



Environment Monitoring Dashboard

Nationwide IoT Deployment - Singapore

Singtel to roll out nationwide cellular Internet-of-Things (IoT) network next month

Singtel IoT network will support IoT devices with longer battery life and wider coverage

Singapore, 7 August 2017 – Singtel today announced that it will roll out its nationwide cellular IoT network by end-September that will enable enterprises to gain operational and cost efficiencies through the use of low-power IoT devices.

The network will support CAT-M1 and NB-IoT technologies which will allow businesses to benefit from applications with low-power consumption, deep coverage and multiple connections. Singtel will also harness its cyber security expertise to support businesses in implementing secure and reliable IoT solutions. This will greatly alleviate security concerns, which is a key deterrent for businesses in deciding whether to deploy remote sensors and IoT devices to their ecosystems, according to the IDC.

Indonesia IoT Deployment

Telkomsel First to Trial NB-IoT in Indonesia

9 months ago Ray Sharma (1 Vote)

font size | Print | Email | Comments:0 Comments

The largest mobile operator in Indonesia, Telkomsel has partnered with Nokia to be the first in the country to conduct NB-IoT trial on a commercial 4G network.

Should we learn IoT?

8.5 years old kid presents his projects : Automatic Cat Feeder.

The project consists of a MCU, ultrasonic sensor and servo motor.

Let us see a video :

https://www.youtube.com/watch?v=aZWzNMVoFP8

How to get started?

- Learn basic electronics
- Choose an MCU Platform
- Use Development Boards
- Select the suitable tools & IDE
- Use cloud and explore real world technologies
- and solve your own problems!

IoT Skill Set

Edge-side

Cloud-side

Mobile side

Today's Focus

ESPRESSIF

Espressif ESP8266

- SoC/MCU that integrates TCP/IP Stack and WiFi to enable it to connect to the network and communicate with other devices
- Made by Espressif – China
- Have many modules, eq : ESP-01, ESP-02, ESP-12F, ESP-WROOM2
- It was sold as a Serial-WiFi adapter for other microcontrollers, however it is more powerful as the ESP8266 integrates a 32 bits microcontroller.
- Feature :

  Microcontroller: Tensilica L106 (32 bits)

  Clock Frequency: 80 MHZ

  WiFi: 802.11 b/g/n

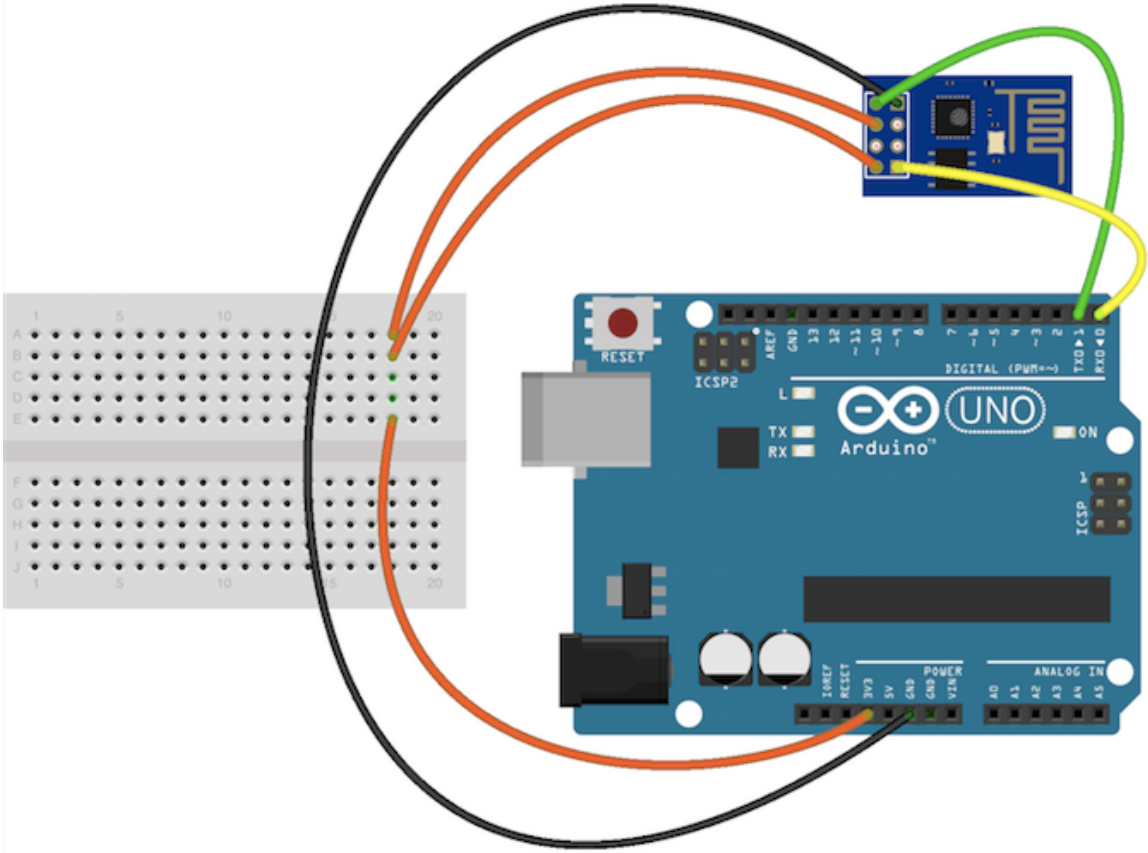
  Interfaces: SPI, I2C, I2S, UART, PWM

  GPIO: 17 pins (12 mA max current)

  ADC: 10 bits

  Operating voltage: 3.3 V

Who is still using this setup?



While nothing wrong with that, but you can program ESP8266 directly. Without the Arduino board as the master

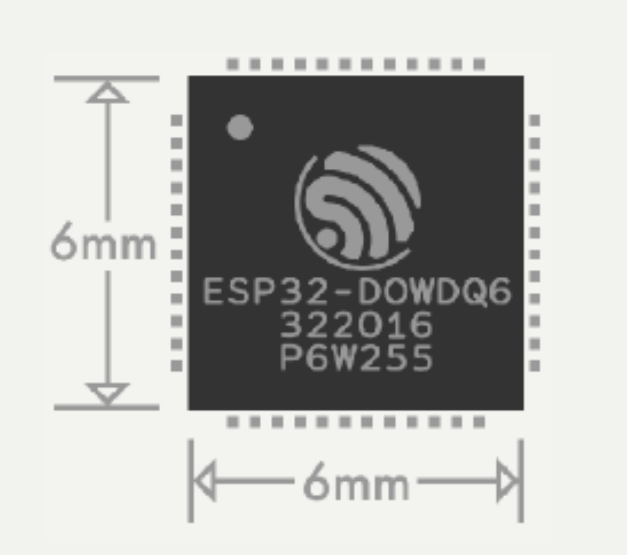
ESP8266 Development Framework

Sming

Espruino

Espressif ESP32

- CPU: Tensilica Xtensa 32-bit dual core, up to 240 MHz, 600 DMIPS.
- Operating voltage: 3.3V
- Memory: 448 KB ROM, 520 KB SRAM 16 KB SRAM in RTC, 1 Kbit of eFuse. External Flash: 512 KB to (4 x 16) MiB
- WiFi (802.11): b/g/n/e/i
- Bluetooth: v4.2 BR/EDR & BLE
- Peripherals: GPIOs, PWM, ADC, DAC, I2S, UART, SPI, I2C, CAN, RMII, Cap Touch

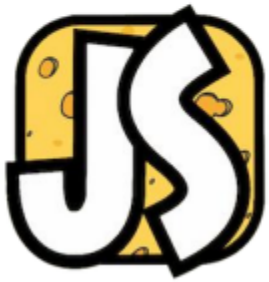


ESP32 Development Framework

ESP-IDF

Espruino

ARDUINO



ESP8266 Module






ESP-01

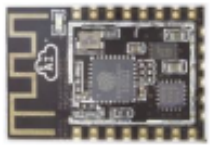





ESP-07

ESP-12






ESP-12E

ESP-13

ESP-14

ESP-WROOM-02

ESP8266 Boards

NodeMCU

Olimex

ESPino

Thing Dev

ESPresso

Digistump Oak

Wemos D1 Mini

Witty

and
more…

ESP32 Module

and
more…

ESP32 Boards

Huzzah

Hornbill

ARS01119B

AnalogLamb ESP32

Node32S

FireBeetle

D-duino-32

and many more…

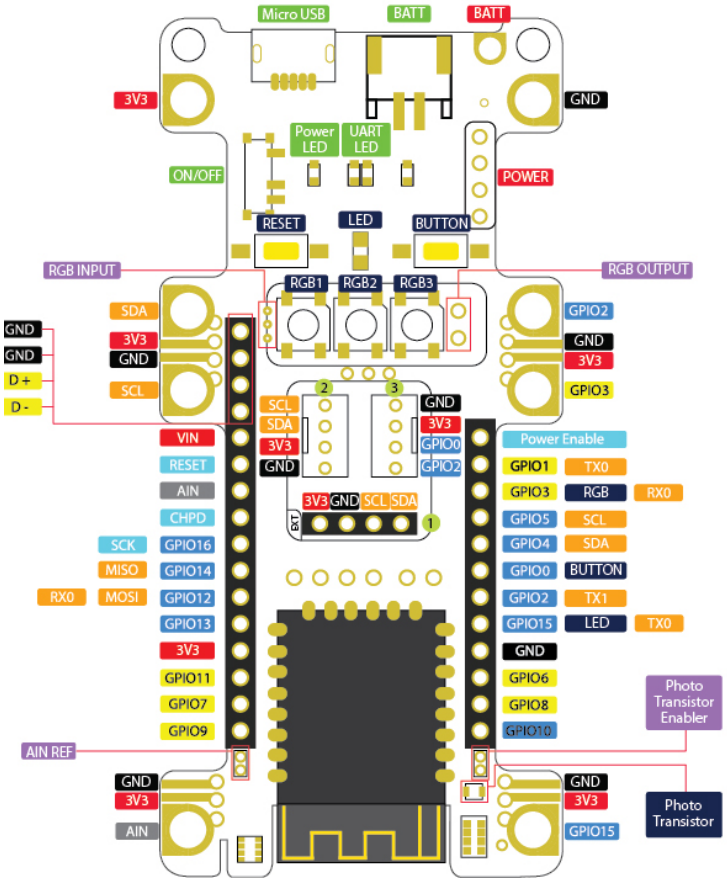
ESP8266 vs ESP32

Specifications	ESP8266	ESP32
MCU	Xtensa Single-Core 32-bit L 106	Xtensa Dual-Core 32-bit LX6 600 DMIPS
802.11 b/g/n Wi-Fi	Yes, HT20	Yes, HT40
Bluetooth	N/A	Bluetooth 4.2 and below
Typical Frequency	80 MHz	160 MHz
SRAM	160 kBytes	512 kBytes
Flash	SPI Flash up to 16 MBytes	SPI
GPIO	17	36
Hardware / Software PWM	None / 8 Channels	1 / 16 Channels
SPI / I2C / I2S / UART	2/1/2/2	4/2/2/2
ADC	10-bit	12-bit
CAN	N/A	1
Ethernet MAC Interface	N/A	1
Touch Sensor	N/A	Yes
Temperature Sensor	N/A	Yes
Working Temperature	-40° C – 125° C	-40° C – 125° C

ESP32 is more complex and advance than ESP8266 – let us keep discussion about ESP32 until next meetup!!

ESPectro Core

- ESP8266 ESP-12F as the brain
- Breaking out all ESP-12F pins to get the most of it
- Built-in USB to TTL
- Auto-flashing, no need to keep pressing reset and flash button before uploading your sketches/firmware
- Reset and flash button, are still provided
- Built-in programmable LED and button
- 3 RGB LED (WS2812 or also known as Neopixel), selectable to be driven either by GPIO using bit-banging method, or I2S method
- I2C Grove connector
- Pin header for directly plugging-in I2C OLED display
- Power: LiPo battery via JST connector, or 5V~6V via Micro USB connector



KEEP

CALM

IT IS

DEMO

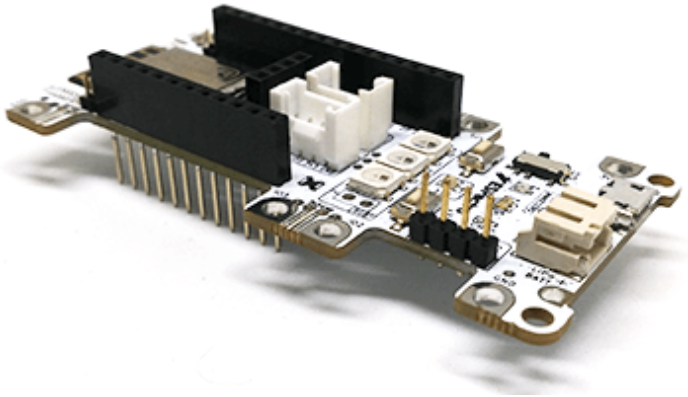
TIME

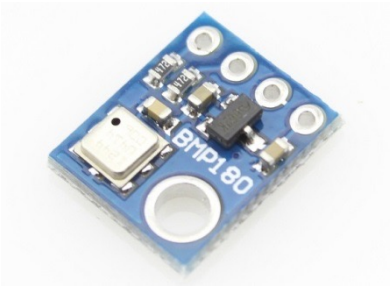
Demo Scenario

- IoT Hello World – Blink ☺
- Blynk Dashboard
- Makestro Cloud & ThingSpeak
- Telegram & Google Assistant Integration
- Embedded Web Server
- MicroPython

Hardware and tools used in the demo

- ESPectro ESP8266 Board
- BMP180 Sensor
- VS Code + PlatformIO





Prepare Arduino IDE (Optional)

1. Download and Install Arduino IDE : https://www.arduino.cc/en/Main/Software
2. Open the preferences from File > Preferences. Enter this url into Additional Board Manager URLs: http://arduino.esp8266.com/stable/package_esp8266com_index.json
3. Open Board Manager from Tools > Board > Board Manager. Search for ESP8266 and install the board package: **esp8266 by ESP8266 Community**
4. Open Library Manager from Sketch > Include Library > Manage Libraries. Search for Blynk and install the library: **Blynk by Volodymyr Shymanskyy**
5. Change the board by selecting: Tools > Board > ESPectro Core
6. Choose the correct COM Port : Tools > Port > Your COM Port Number
7. We are ready to go

LED Blinking

```
        ORG 0H
        MOV     A, #55H

BACK:   MOV     P1, A
        ACALL   DELAY
        CPL     A
        SJMP    BACK

DELAY:
        MOV R1,#0FFH

AGAIN:  DJNZ R1, AGAIN

        RET
        END
```

BEFORE ARDUINO

VS

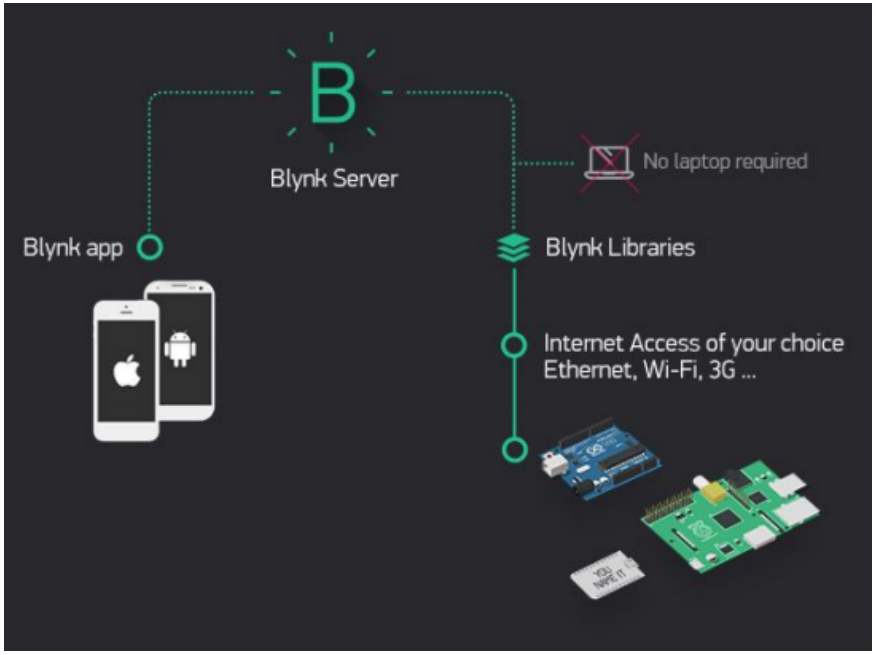
```
void setup() {
  pinMode(LED_BUILTIN, OUTPUT);
}

void loop() {
  digitalWrite(LED_BUILTIN, HIGH);
  delay(1000);
  digitalWrite(LED_BUILTIN, LOW);
  delay(1000);
}
```

AFTER ARDUINO

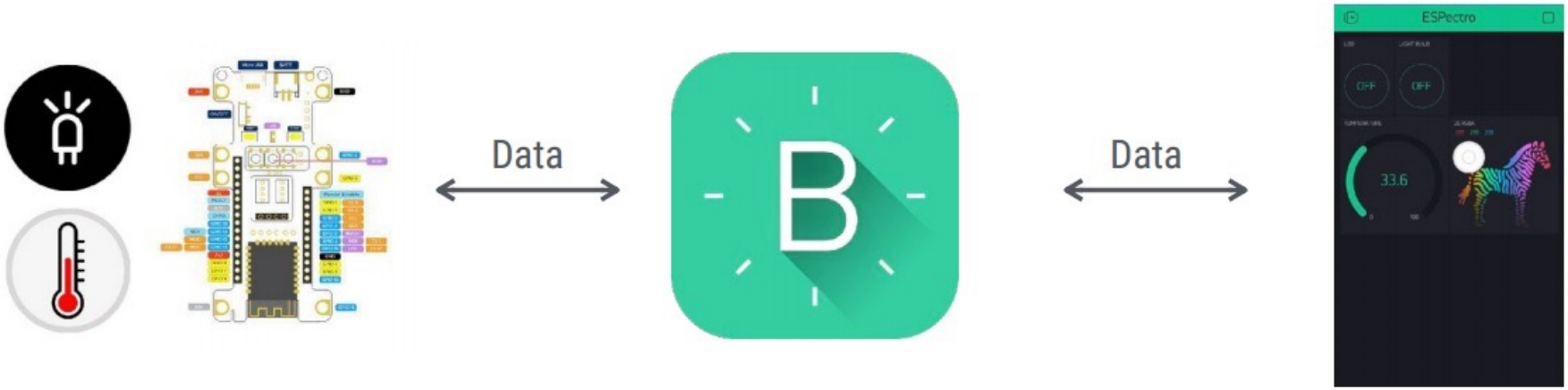
How easy it is!!! ☺

Blynk Architecture



- Blynk App - Allow you to create interfaces for projects using various widgets..
- Blynk Server - Responsible for all the communications between the smartphone and hardware
- Blynk Libraries - Enable communication with the server and process all the incoming and outcoming commands for all the popular hardware platforms

Blynk Demo Architecture



Topics we haven't discussed yet

- SPIFFS (SPI Flash File System)
- Firmware Over The Air (OTA) Update
- Details of WiFi module such as configuration using WiFi Manager, Dual Mode, etc
- Watchdog Timer (WDT)
- RTOS/Scheduler
- and much more .....

As software developer what do you learn/expect when developing for hardware?

- Better IDE/Tools
- Implement software engineering best practices : library and OOP, highly readable code, maintanable code, reuseable code, software design pattern, implement software based solution, leverages cloud, UI design.
- IoT development will breed a new type of engineer,expert in electronics while fluent in software development

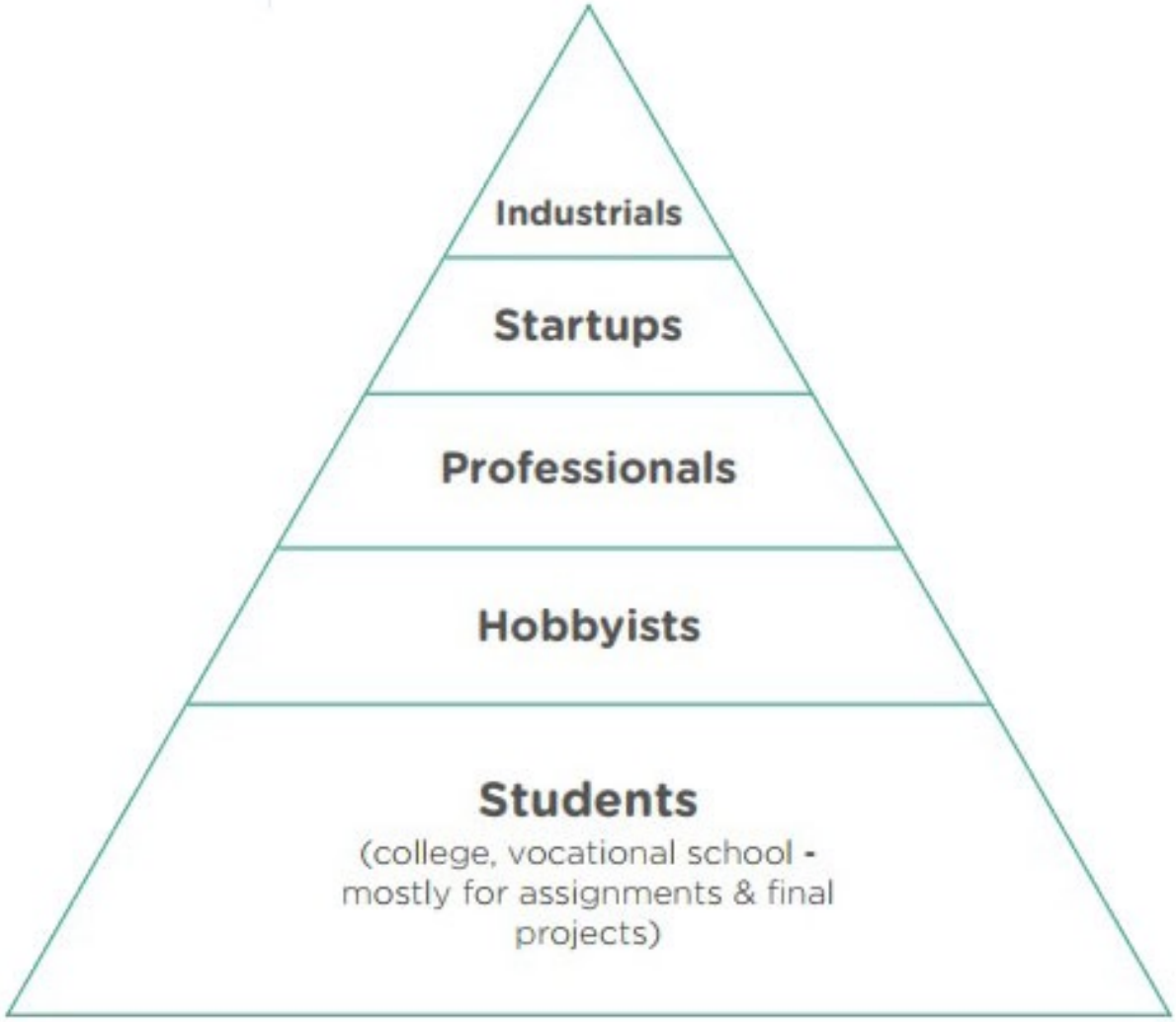
Few of IoT Trends

- IoT and Blockchain will converge
- IoT Data Analyzed by Machine Learning/AI
- Rise of security related concerns
- IoT will reshape the health care

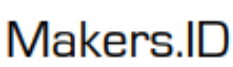
IoT is the new "ELECTRICITY" and unstructured data is the new "GOLD"

How about IoT Vendors, Communities, Events and etc in Indonesia?

IoT Players


Industrials
Startups
Professionals
Hobbyists
Students
(college, vocational school - mostly for assignments & final projects)

Some Communities



and more unlisted communities ...

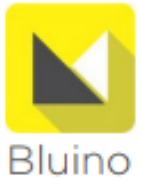
IoT Store

Depoinovasi

Toko Maharaja

and many more on Tokopedia, Bukalapak and etc

IoT Vendor



and more ....

Cloud Platform

ANTARES

IoT Event

Republic of IoT

3 Days Seminar & 2 Days Hackathon

Collaboration between Indonesia & Malaysia

IoT Security

Traditional Internet vs IoT Security

Traditional Internet	Internet of Things
Relatively Safe Environment	Hostile Environment
Standardized	Large Variety
Loss of money or reputation	Loss of life, money or reputation
Relatively Mature	Relatively New

IoT Vulnerabilities

INTERNET OF THINGS

This Teen Hacked 150,000 Printers to Show How the Internet of Things Is Shit

CM CHRISTOPHER MOYER
Feb 8 2017, 10:50pm

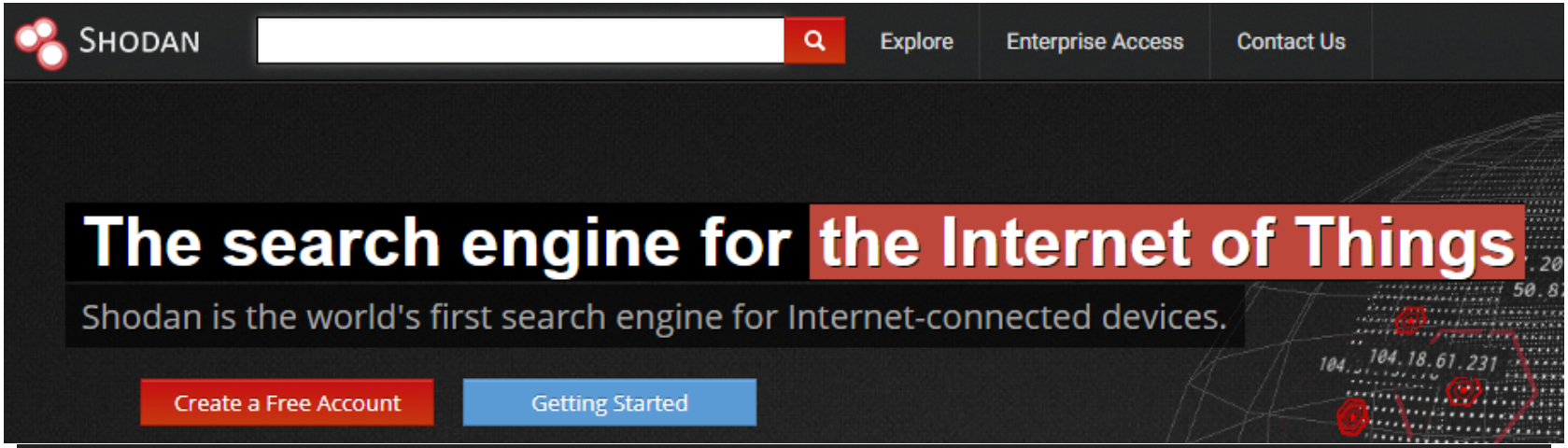
"It was just a night I was bored to be honest, doing random shit."

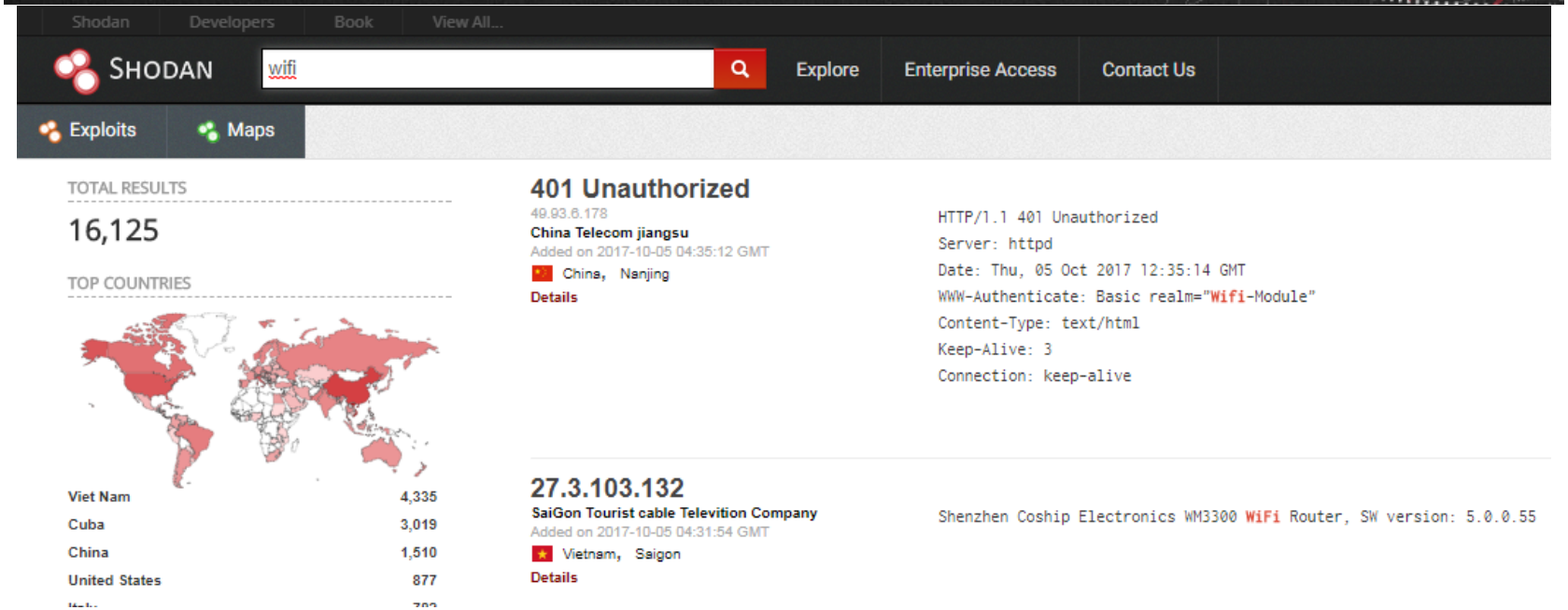
World's largest 1 Tbps DDoS Attack launched from 152,000 hacked Smart Devices

Tuesday, September 27, 2016 Swati Khandelwal

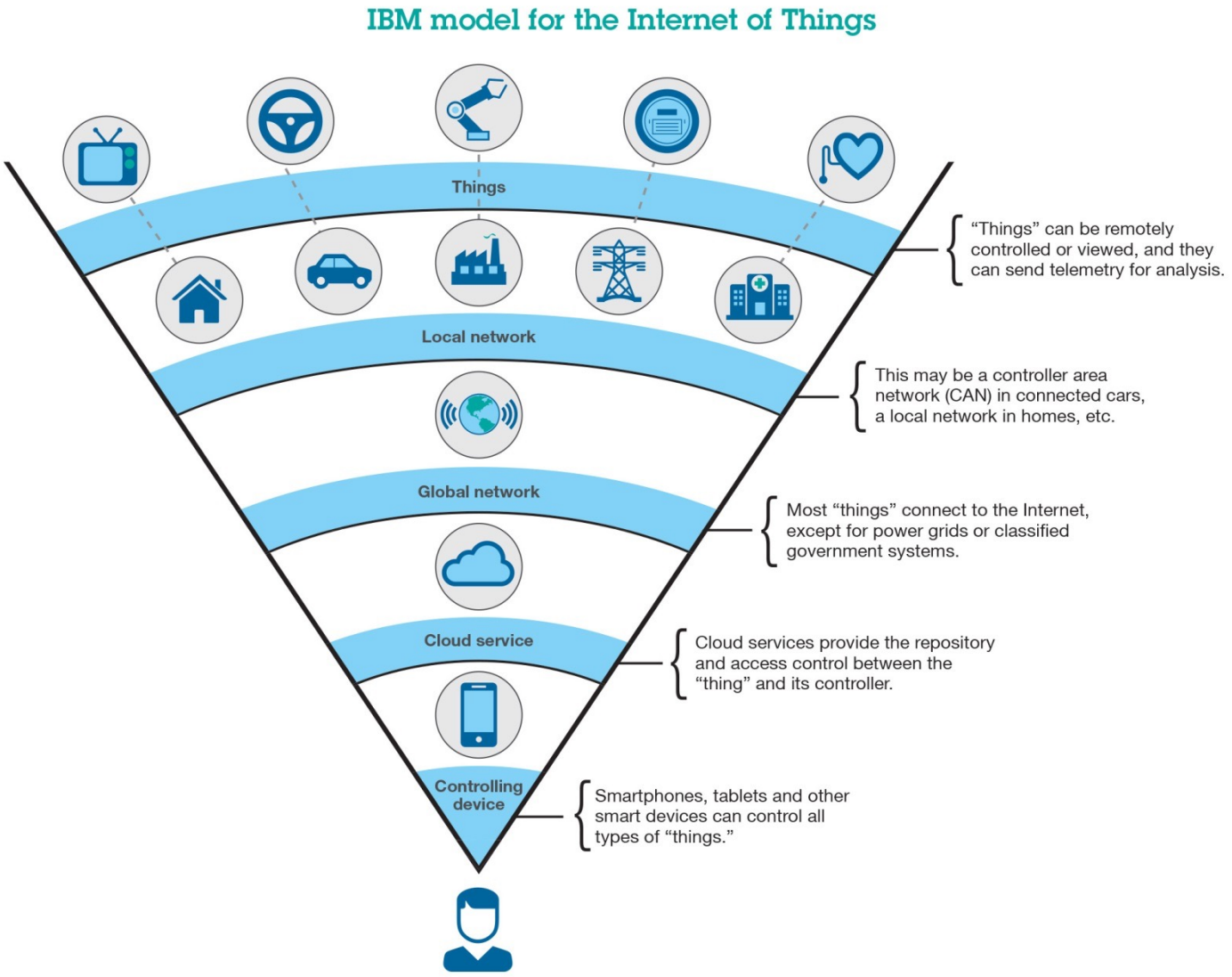
Do you know — Your Smart Devices may have inadvertently participated in a record-breaking largest cyber attack that Internet has just witnessed.

IoT Search Engine





What can be attacked?



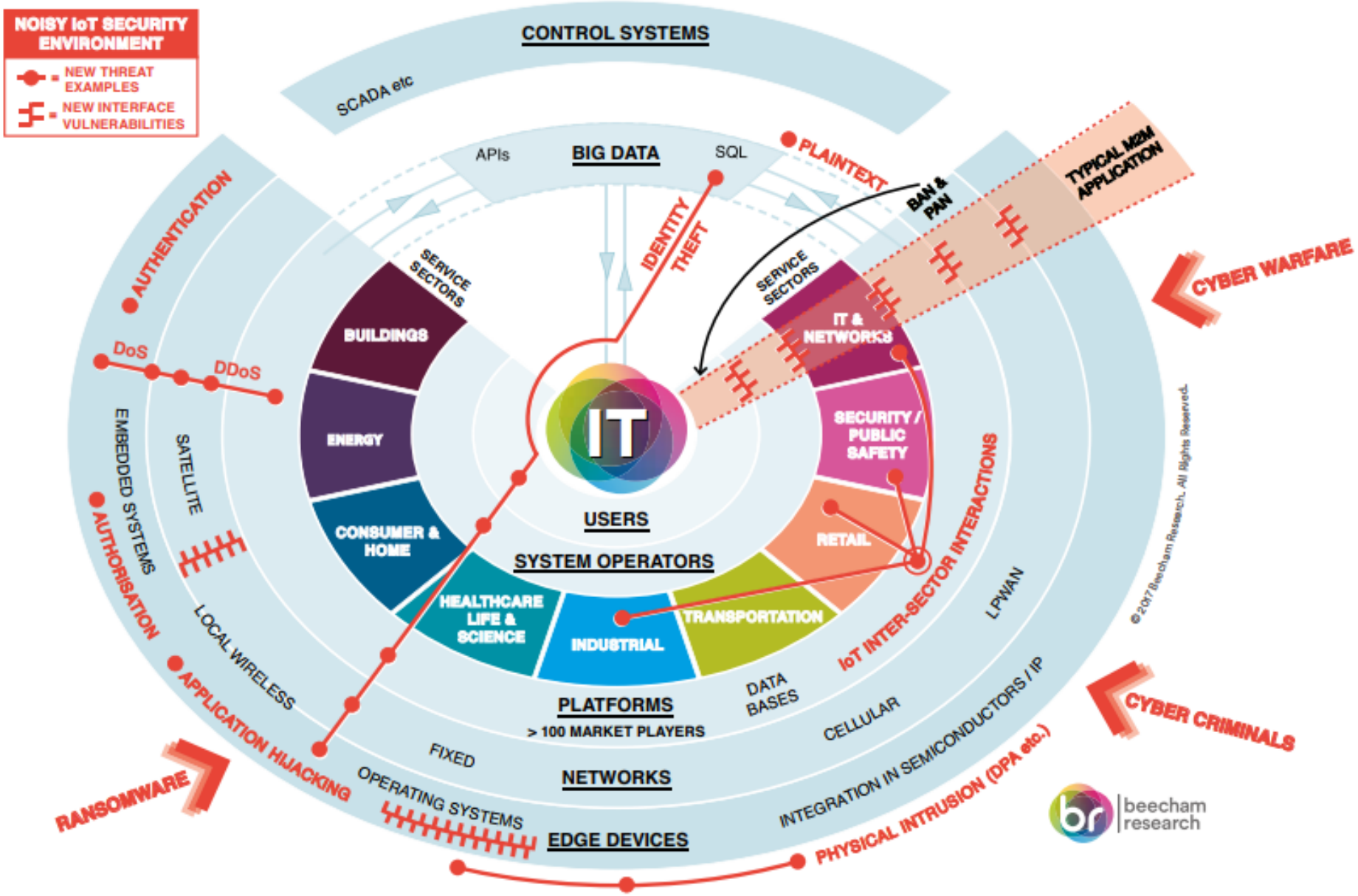
Graphic 1. IBM model for the Internet of Things

Source: IBM X-Force® Research and Development

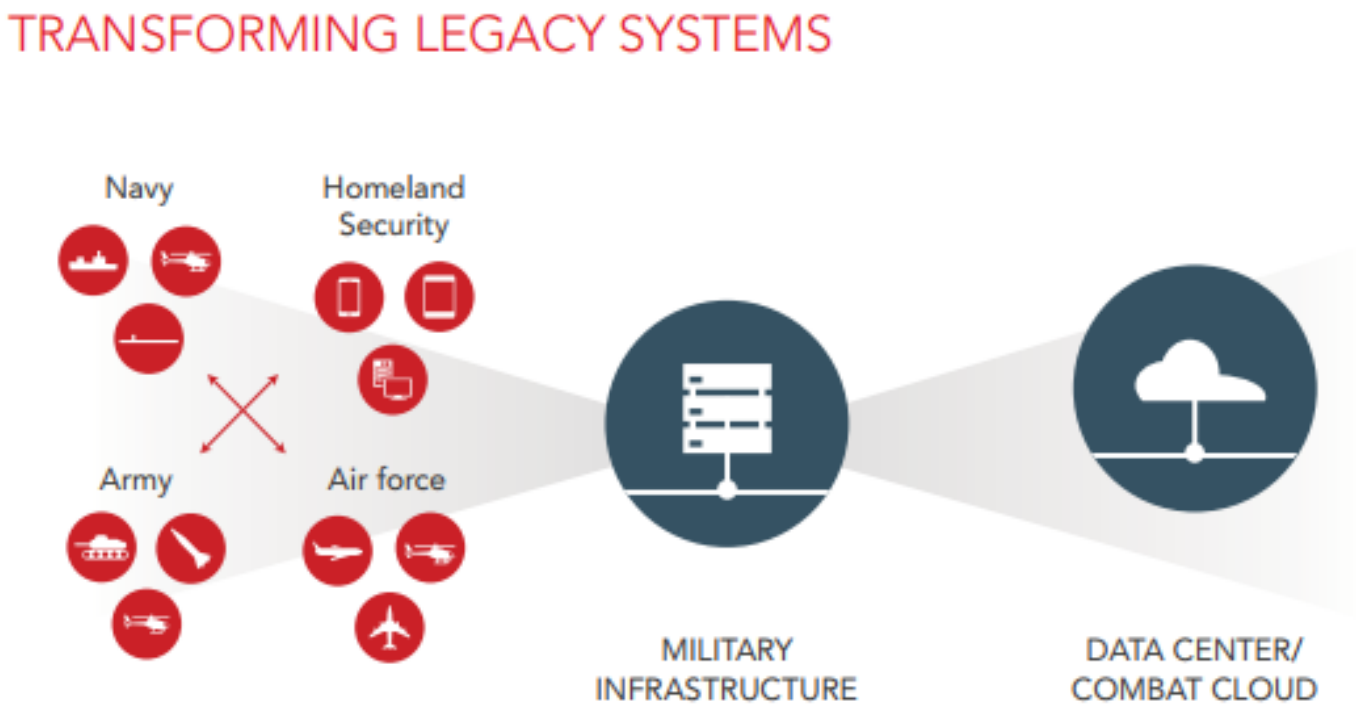
IoT Vulnerability Categories

- Device security vulnerabilities
- Firmware vulnerabilities
- Web, mobile, or network vulnerabilities
- Radio communication based vulnerabilities

IoT Security Threat Map

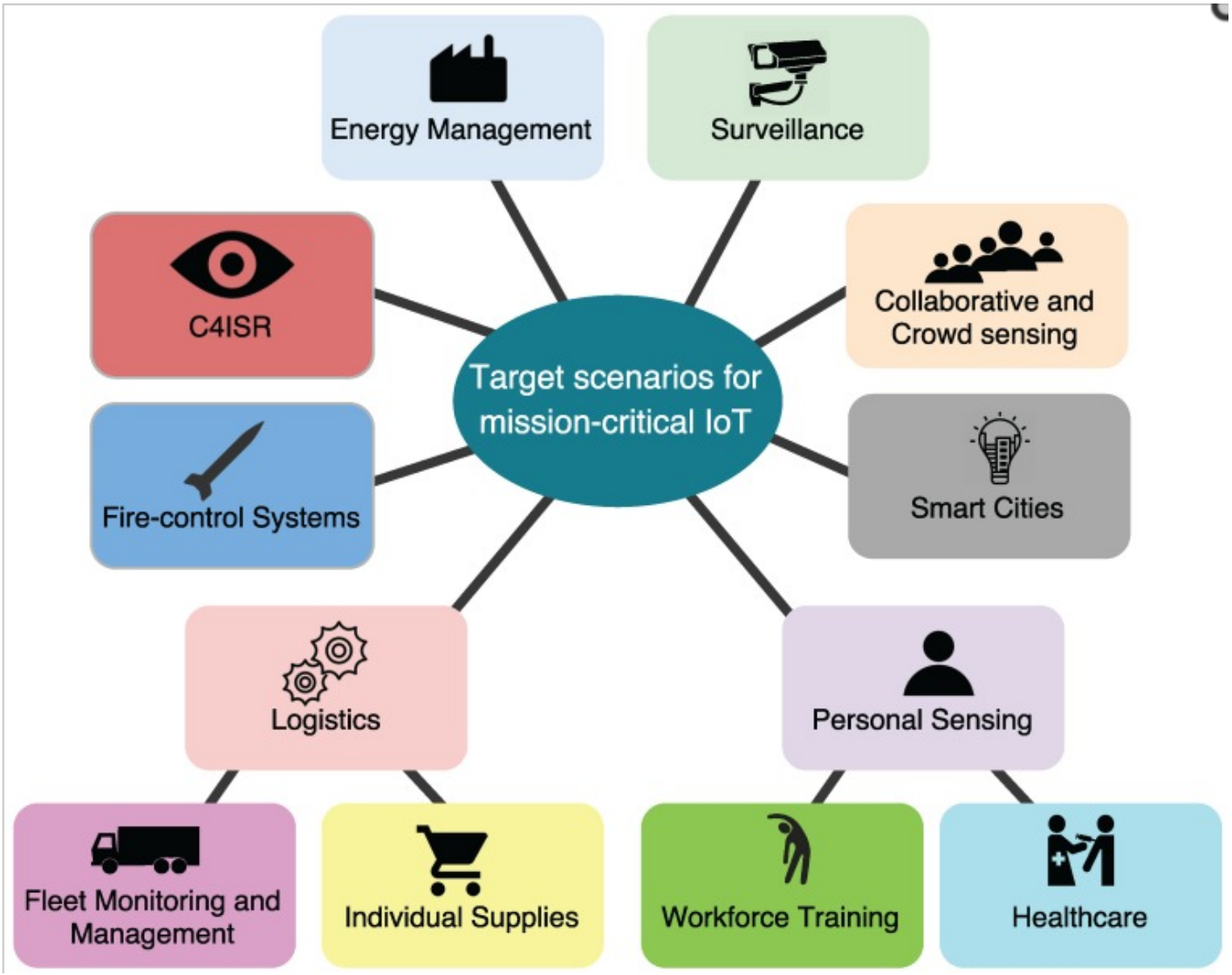


Military IoT



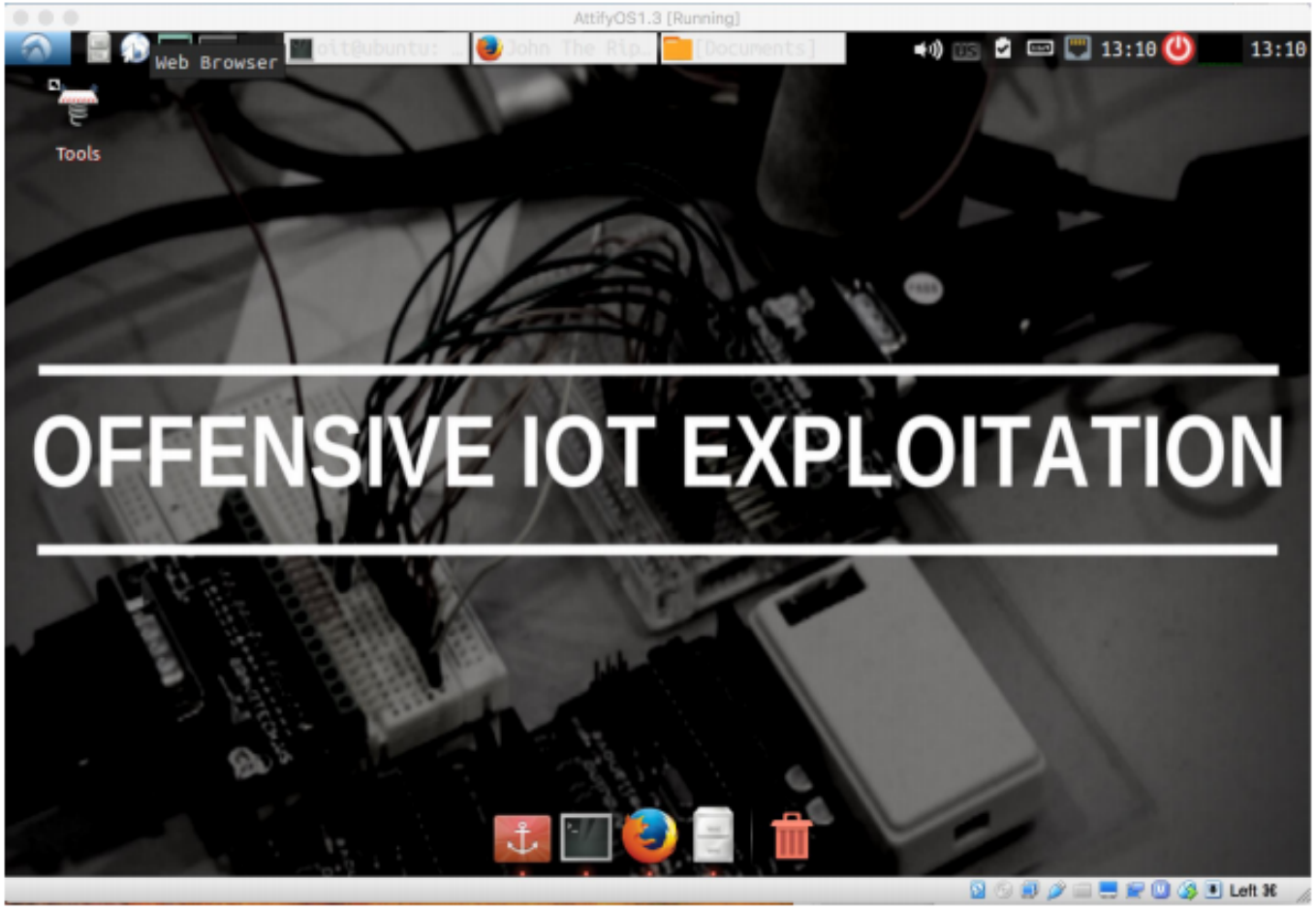
http://events.windriver.com/wrcd01/wrcm/2016/08/WP-IoT-internet-of-things-for-defense.pdf

Target Scenario of Defense and Public Safety



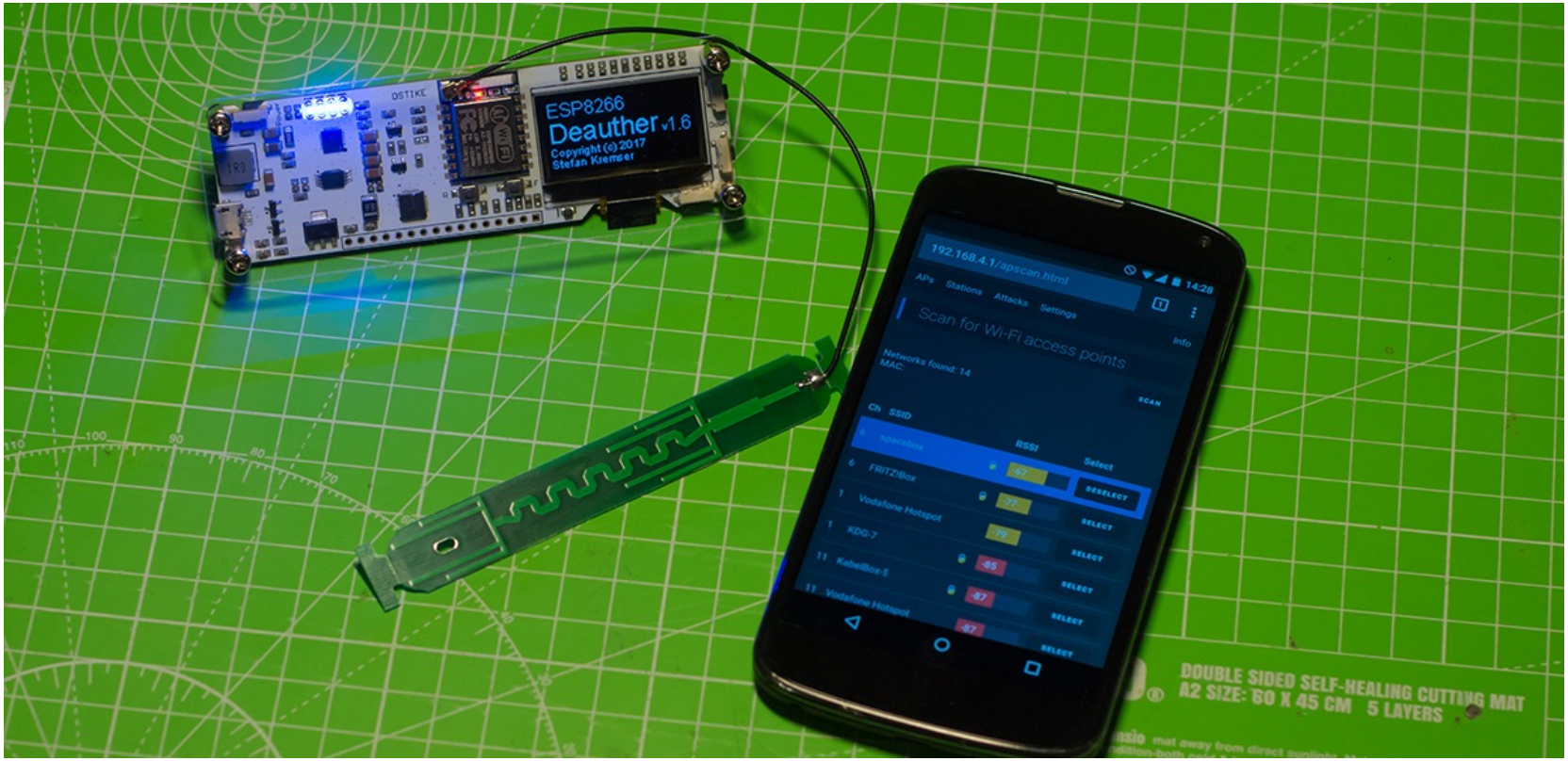
AttifyOS - Distro for pentesting IoT devices

https://github.com/adi0x90/attifyos



WiFi DeAuther based on ESP8266

https://github.com/spacehuhn/esp8266_deauther



Learning Resources

- ESPRESSIF
  https://github.com/espressif
- Kolban's Books
  https://leanpub.com/ESP8266_ESP32
- ESP8266 Community Forum
  http://www.esp8266.com/
- HACKSTER
  https://hacksterio
- Join Community
  http://t.me/kongkowITMedan

Quiz - Get a free ESP8266 Board!

- Sebutkan bahasa pemrograman yang bisa dipakai untuk pengembangan solusi IoT untuk Things, Cloud and Apps
- Sebutkan 5 protokol komunikasi data yang bisa dipakai untuk IoT
- Sebutkan minimal 3 cloud platform yang bisa dipakai untuk IoT

Thank You