THE UNIVERSITY OF WESTERN AUSTRALIA

We are learning on Noongar land

THE UNIVERSITY OF WESTERN AUSTRALIA

Copyright Notice

Material used in this recording may have been reproduced and communicated to you by or on behalf of **The University of Western Australia** in accordance with section 113P of the *Copyright Act 1968*.

Unless stated otherwise, all teaching and learning materials provided to you by the University are protected under the Copyright Act and is for your personal use only. This material must not be shared or distributed without the permission of the University and the copyright owner/s.

THE UNIVERSITY OF WESTERN AUSTRALIA

CITS 5506
The Internet of Things
Lecture 04

Components of IoT
Guest Lecture Beehive Monitoring

Dr Atif Mansoor
atif.mansoor@uwa.edu.au

Components of IoT

Components of IoT

- Sensors/ Edge Computing (may or may not)
- Connectivity
- Platform
- Analytics
- User Interface

Sensors

- Different sensors available to measure temperature, humidity, light, noise, pollution, pressure, torsion, tension, acceleration, position, images, magnetic fields, electric fields, etc etc.

- Sensors are now invisible and energy efficient, whilst maintaining a high measurement precision.

- Miniaturization is trending and hopefully the Internet of Things by 2025 will be a healthy mix of sensors measuring things and robots acting on the insights.

THE UNIVERSITY OF WESTERN AUSTRALIA

Key Requirements

- Availability
- Reliability
- Viability

Connectivity: Wireless System

THE UNIVERSITY OF WESTERN AUSTRALIA

Frequency Band

Licensed

With Infra-structure, based upon traditional cellular network

- Cellular
- Paging
- Fixed Wireless
- Satellite

Unlicensed

Infra-structure less, Adhoc and Peer to Peer, Self-Organizing

- Cordless
- WLAN
- Bluetooth, UWB(Ultra-wideband)
- M2M
- PAN

Wireless Channel

- Wireless communications is highly variable.
- Data sent over those channels is
  - error-prone
  - unreliable
  - latency issues
- The lesson is that wireless channels require aggressive management.

Wireless System Requirements

THE UNIVERSITY OF WESTERN AUSTRALIA

System Requirements

- Capacity: Bits flowing reliably (bps)
- Latency: Delay in delivering bits
- Coverage: Percentage of geographical locations with minimum level of service
- Cost of service

Additional Requirements on Transceiver:

- Power Consumption: Battery life, Complexity
- Portability: Size and weight
- Cost of Transceiver

Data Transmission Requirements

Application	Data Rate	BER	Latency	Traffic
Voice	Low	Medium	Low	Continuous
Messaging	Very Low	Very Low	High	Bursty
Pictures	Medium	Low	High	Bursty
Video	High	Medium	Medium	Continuous
Web Browse	Low	Very Low	Medium	Bursty
File Transfer	Low to High	Very Low	High	Bursty
Gaming	Low	Very Low	Very Low	Bursty
IoT	Low	Low	Low-High	Bursty

Spectrum Regulations

- In Australia frequency spectrum is controlled by ACMA, Australian Communications and Media Authority
- FCC, Federal Communications Commission in USA
- ETSI (European Telecommunications Standards Institute) in Europe.
- World wide spectrum is controlled by ITU Radio communication Sector (ITU-R)
- Auction spectral blocks for set applications e.g expensive 3G, 4G Auctions.

Spectrum Regulations

- Some spectrum for unlicensed use, which means that no one has to pay for leasing or buying that spectrum.
  - Minimal rules on how can the spectrum be used, the so-called etiquette rules, e.g power spectral density of the emission at a particular point, most often, the antenna.

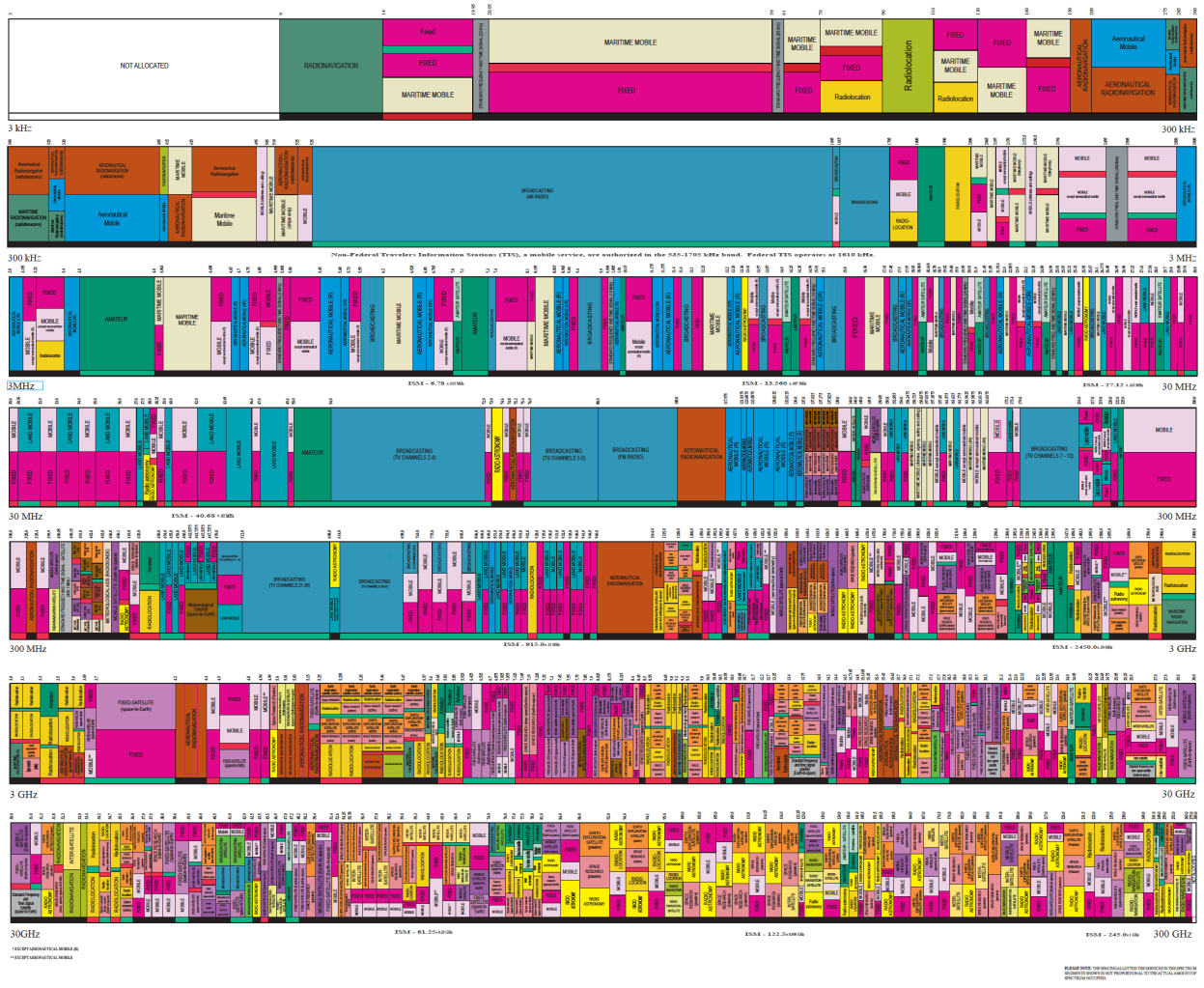
- These bands may become congested.

Spectrum Regulations

- A new approach to allow secondary (un-licenced users) to use primary (licenced) spectrum with minimum interference, primarily restricted power transmission, example, UWB (Ultra Wide Band)

- Ultra-wideband is a technology for transmitting information across a wide bandwidth (>500 MHz). This allows for the transmission of a large amount of signal energy without interfering with conventional narrowband and carrier wave transmission in the same frequency band.

US – Frequency Allocations



Connectivity

- We earlier discussed that the key connectivity requirements
  - Availability
  - Reliability
  - Viability
- Mobile phone technology is probably the best business proposition
- Furthermore, an exciting class of Low Power Wide Area networking technologies is also emerging
- Low Power Wifi, a new system, is also a contender [1]

1. https://www.wi-fi.org/news-events/newsroom/wi-fi-alliance-introduces-low-power-long-range-wi-fi-halow

ISM Band

- The Industrial, Scientific and Medical radio bands (ISM bands) are radio bands reserved internationally for the use of radio frequency energy for industrial, scientific and medical purposes other than telecommunications.

- Examples of applications in these bands include microwave ovens, medical diathermy machines etc.

- Communications equipment operating in these bands must tolerate any interference generated by ISM applications, and users have no regulatory protection from ISM device operation.

Frequency Band for IoT

For IoT, some bands are of particular interest,

- Band between 900 & 928 MHz - the ISM band.
- Similarly, in the areas of 2.4 gigahertz and 5.7 gigahertz.
- There are some bands at lower frequencies that are also appealing.
- These bands are essentially license-free operation so that a very large number of IoT devices can be deployed without having to pay for the usage of the band.

Wireless LAN

- The 802.11 working group currently documents use in five distinct frequency ranges: 2.4 GHz, 3.6 GHz, 4.9 GHz, 5 GHz, and 5.9 GHz bands.

- Each range is divided into a multitude of channels of bands.

- Countries apply their own regulations to the allowable channels, allowed users and maximum power levels within these frequency ranges.

Connectivity : Low Power WiFi

- Wifi, despite higher power consumption, is a good candidate for IoT

- Wifi has achieved greater success and is nowadays has ubiquitously much higher presence

- Wifi has not been fairly suitable for sensor communication due to high energy consumption

- Wifi community started installing IC for duty cycle, whereby it remain in dormant mode if no sensing or transmission happening, thus making it energy efficient

Connectivity : Low Power WiFi

- Further wifi can provide data rates from few Kbps to Mbps

- IEEE started working on IEEE 802.11ah, a wireless networking protocol published in 2017 to be called Wi-Fi HaLow (pronounced "HEY-Low"), where thousands of devices can be connected

- Applications
  - Industrial Automation and Control
  - Smart Metering
  - Health Care Applications

Connectivity : Low Power WiFi

- 6 thousands sensors can connect to single access point
- Can Communicate at 100 Kbps
- Default transmission power of 200 milli watt
- Range of about 1 KM compared to 10 meter or so of Zigbee
- Industrial, scientific, and medical radio **band** (**ISM band**) in the range of sub GHz

dbm

- A power level of 0 dBm corresponds to a power of 1 milliwatt.

- To express an arbitrary power *P* in mW as *x* in dBm, the following expression is used:

$$x = 10 \log_{10}(P/1mw)$$

Or conversely

$$P = 1\ mw\ .\ 10^{(x/10)}$$

Connectivity

- As the 2.4 GHz band becomes more crowded, many users are opting to use the 5 GHz ISM band. This not only provides more spectrum, but it is not as widely used by Wi-Fi as well as many other appliances including items such as microwave ovens, etc.

- Many of the 5 GHz Wi-Fi channels fall outside the accepted ISM unlicensed band and as a result various restrictions are placed on operation at these frequencies.

Connectivity

- How to connect these billions of Things

- Wireless appears to be a feasible solution due to:
  - Flexibility / Things can move around
  - Scalability
  - Cost Efficiency

- Already experience of successful wireless system i.e., Cellular network

Connectivity

- In Cellular Technology, we face the problem of battery discharge

- In IoT, we want that sensor runs on a small battery may be for years

- IEEE standard 802.15.4 intends to offer the Wireless Personal Area Network (WPAN) which focuses on low-cost, low power, low-speed communication between devices.

Connectivity : 3 GPP

- The 3rd Generation Partnership Project (3GPP) is a collaboration between groups of telecommunications associations, known as the Organizational Partners.

- The initial scope of 3GPP was to make a globally applicable third-generation (3G) mobile phone system specification based on evolved Global System for Mobile Communications (GSM) specifications within the scope of the International Mobile Telecommunications-2000 project of the International Telecommunications Union (ITU).

Connectivity : 3 GPP

The scope was later enlarged to include the development and maintenance of :

- GSM and related "2G" and "2.5G" standards, including General Packet Radio Service (GPRS is a packet oriented mobile data service on the 2G and 3G cellular_communication) and EDGE (Enhanced Data rates for GSM Evolution)

- Related "3G" standards and related "4G" standards, including LTE (Long-Term Evolution) Advanced and LTE Advanced Pro and related "5G" standards

Connectivity

- 3 GPP working on cellular IoT for 5 G
- Narrowband Internet of Things (NB-IoT) is a Low Power Wide Area Network (LPWAN) radio technology standard developed by 3GPP.
- NB-IoT focuses specifically on low cost, long battery life, and high connection density.
- NB-IoT uses a subset of the LTE standard

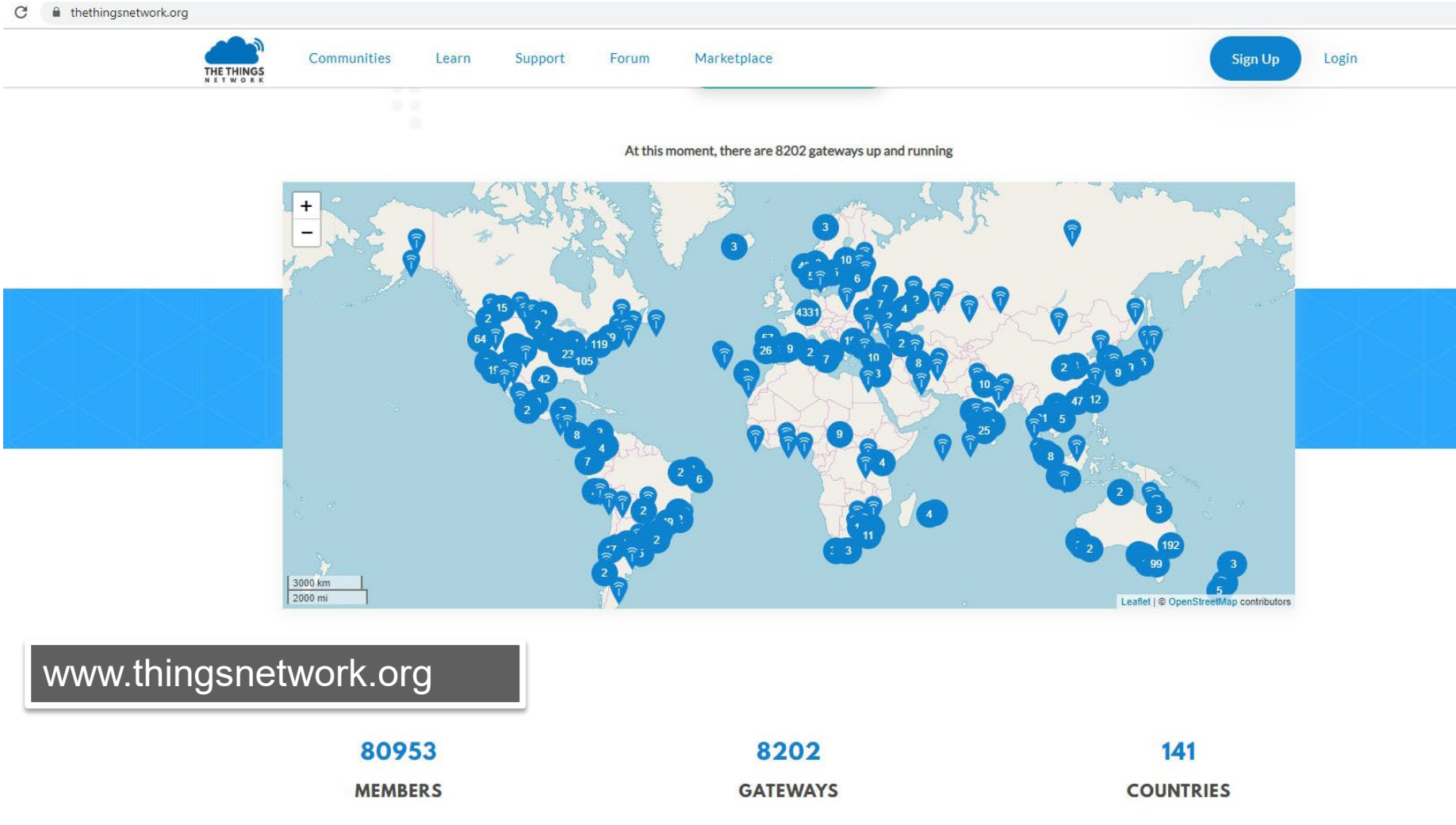
Connectivity : Low Power Wide Area Networks

- Low-Power Wide-Area Network (LPWAN) or Low-Power Network (LPN) is a type of wireless telecommunication wide area network designed to allow long range communications at a low bit rate among things (connected objects)

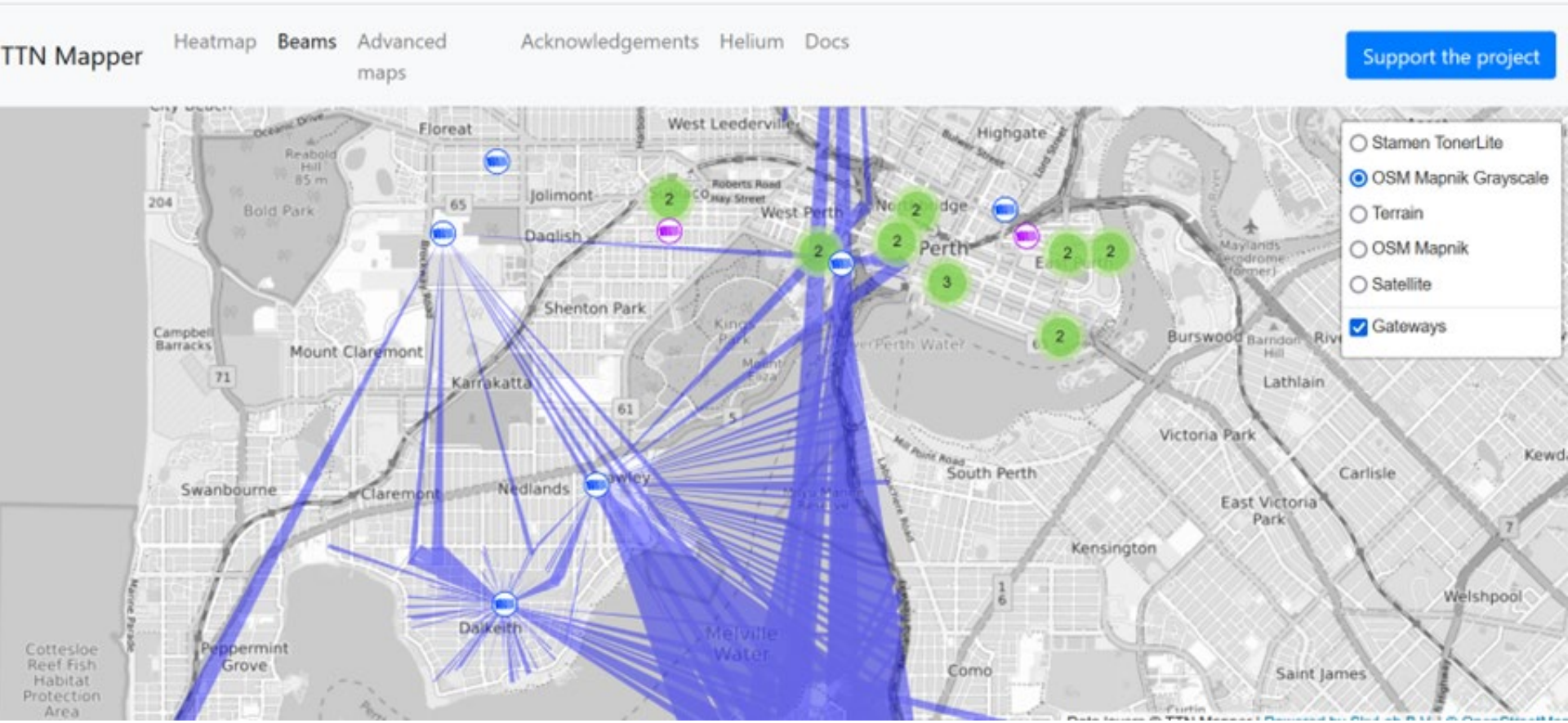
- 25 mW transmission power

- 15-50 km rural outdoor / 2-3 km urban indoor

LP-WAN (LoRa Gateways in World)



LP-WAN Coverage – ttnmapper.org



Recording of Guest Lecture Beehive Monitoring
By Dr Omar Anwar