WiFi coverage range characterization for smart space applications

Presented by: Zayan EL KHALED

On 27 May 2019

SEPR4IoT Montreal 2019

Presentation Outlines

1. Introduction
2. State of the art
3. Scenario of use
4. Validation and results
5. Consequences for IoT applications
6. Threats to validity
7. Future researches
8. Conclusion

Introduction

- Ubiquitous computing
- Communication technologies for smart spaces
- Wireless communications
- WiFi

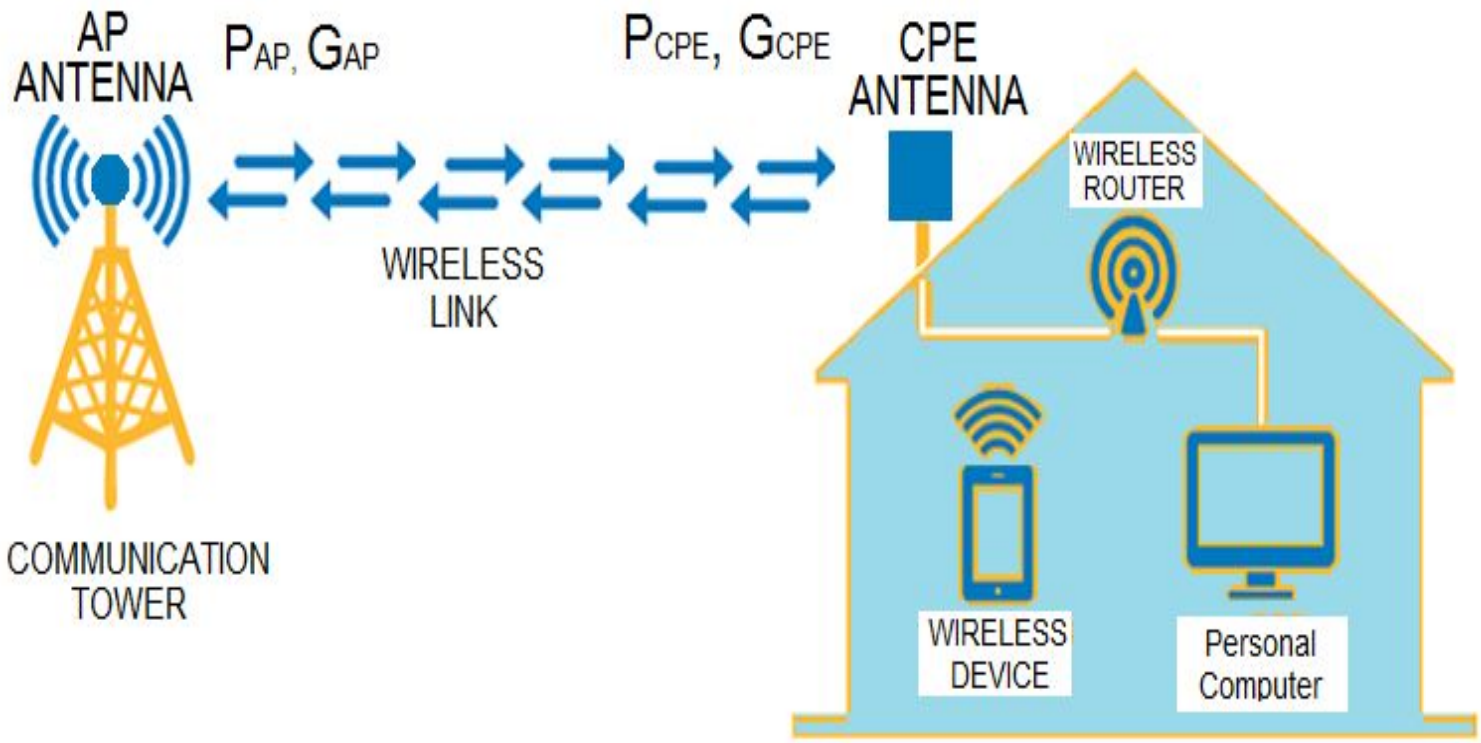
Paper outlines

- Wireless communication technologies comparison
- WiFi technical characteristics
- Coverage range characterization and discussion for IoT
- Comparison of path loss empirical models with measures

State of the art

Wireless internet service (WIS) of Wireless to the home (WTTH)

- Deployment
- Advantages
- Rural areas
- Healthcare
- Extreme events



State of the art

Communication technologies comparison

- Coverage
- Cost
- Number of nodes
- Data rate
- Mobility
- Availability of Smart phones
- Radio signal penetration: frequency
- Radio channel bandwidth
- Power consumption

	Bluetooth	WiFi	LORA	SIGFOX	WIMAX	LTE	5G
Power	L	L	VL	VL	H	VH	M
Range	L	H	VH	VH	VH	VH	VH
Data rate	L	H	VL	VL	H	H	VH
Cost	VL	L	L	L	VH	VH	VH
Ref.	[47-50]	[30], [51-54]	[55, 56]	[57, 58]	[59-62]	[63-65]	[66-68]

Very low: VL
Low: L
High: H
Medium : M
Very high: VH

Good:
Neutral:
Bad:

State of the art

WiFi technical characteristics

- Various frequencies and bandwidth in ISM band
- Many version
- MIMO, penetration and data rates

	802.11a	802.11b	802.11g	802.11n	802.11ac	802.11ax
Frequency (GHz)	3.6, 5	2.4	2.4	2.4, 5	5	2.4, 5
Bandwidth (MHz)	20	22	20	20, 40	20, 40, 80, 160	20, 40, 80, 160
Data rate (Mbps)	6, 9, 12, 18, 24, 36, 48, 54	1, 2, 5.5, 11	6, 9, 12, 18, 24, 36, 48, 54	Up to 600 for 40 MHz and 4 Streams	Up to 3466.8 for 160 MHz band and 4 Streams	Up to 10,530 for 160 MHz band and 4 Streams
Modulation	OFDM-64QAM	DSSS	OFDM-64QAM	OFDM-64QAM	OFDM-256QAM	OFDM-1024QAM
MIMO streams	-	-	-	4	8	8

State of the art

Link quality and coverage range prediction

- Link budget:

$$P_{RX}(\text{dBm}) = P_{TX}(\text{dBm}) + G_{TX}(\text{dB}) + G_{RX}(\text{dB}) - L(\text{dB})$$

- Free space propagation loss:

$$L_{FS}(dB) = 20\log\frac{4\pi D}{\lambda}$$

- Range estimation:

$$D = \frac{\lambda \times 10^{\frac{P_{TX}+G_{TX}+G_{RX}-P_{SENS}}{20}}}{4\pi}$$

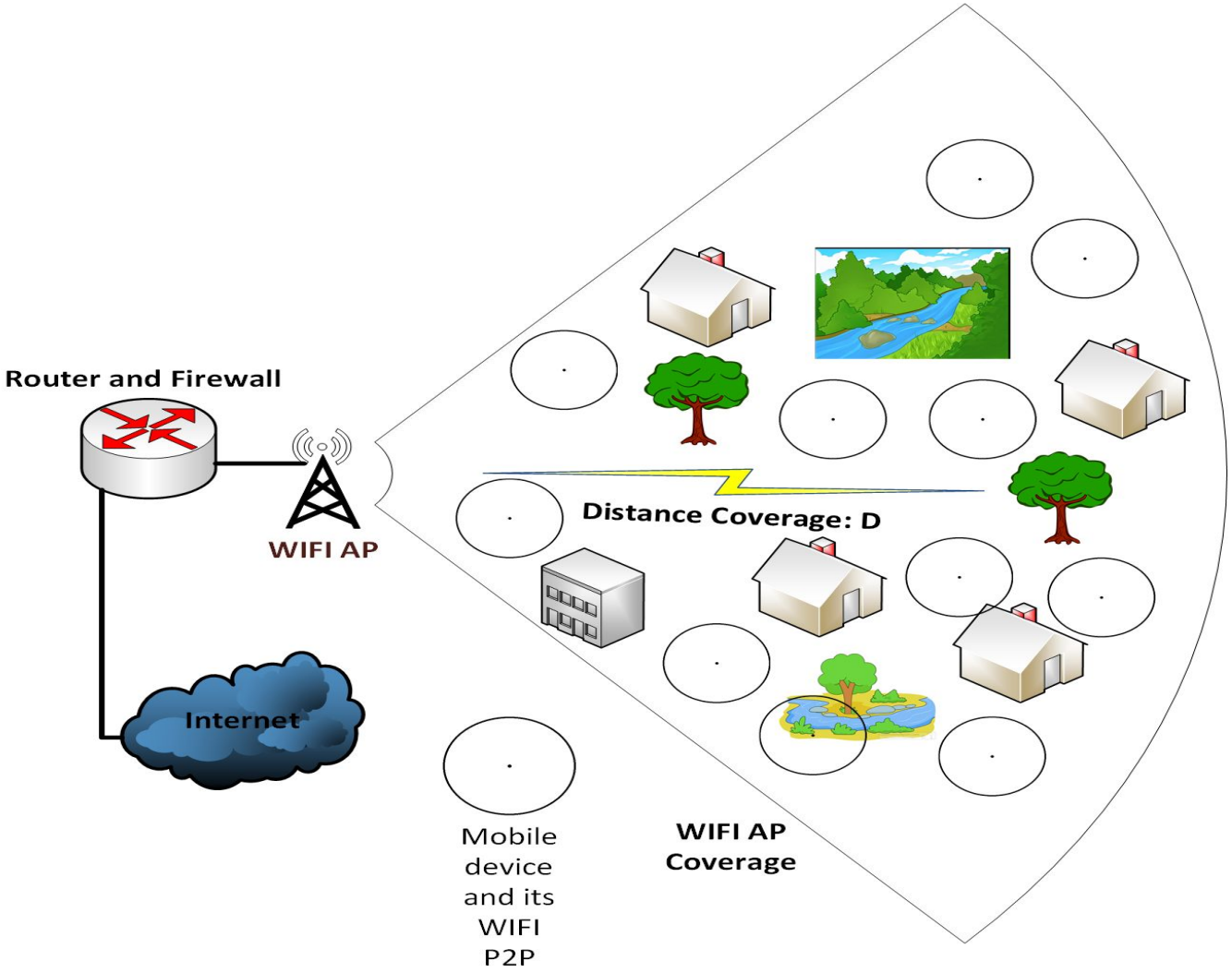
TRANSMIT POWER AND RECEIVER SENSITIVITIES FOR a commercial devices USING 802.11N PROTOCOL (2.4 GHZ)
For ONE MIMO STREAM

Data Rate	Avg. TX (dBm)	Sensitivity (dBm)
MCS0	28	-96
MCS1	28	-95
MCS2	28	-92
MCS3	28	-90
MCS4	27	-86
MCS5	25	-83
MCS6	23	-77
MCS7	22	-74

Scenario of use

Link quality and coverage

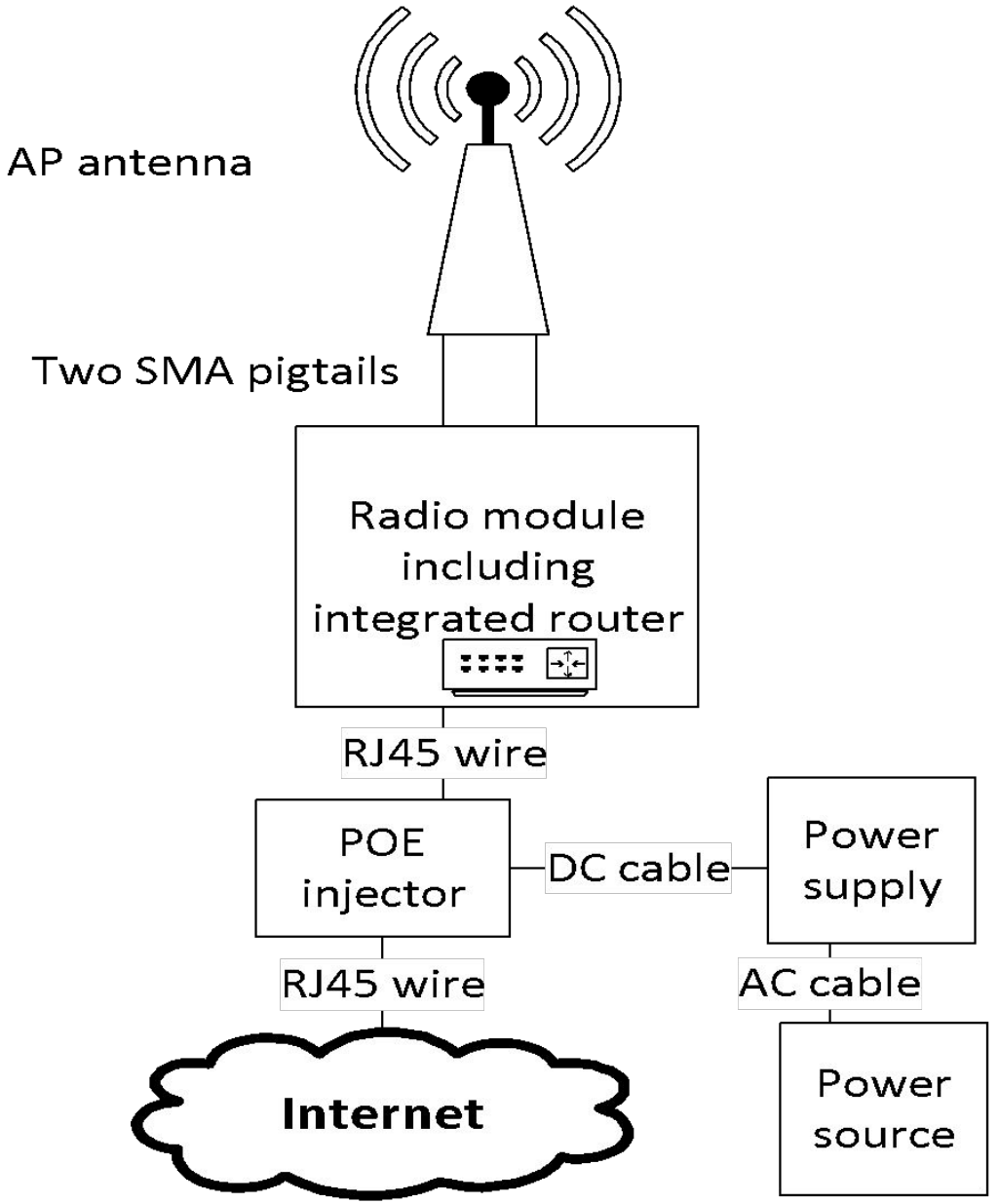
- Network components
- Configuration
- Advantage
- Frequency choice possibilitie



Validation and results

System components and test procedure

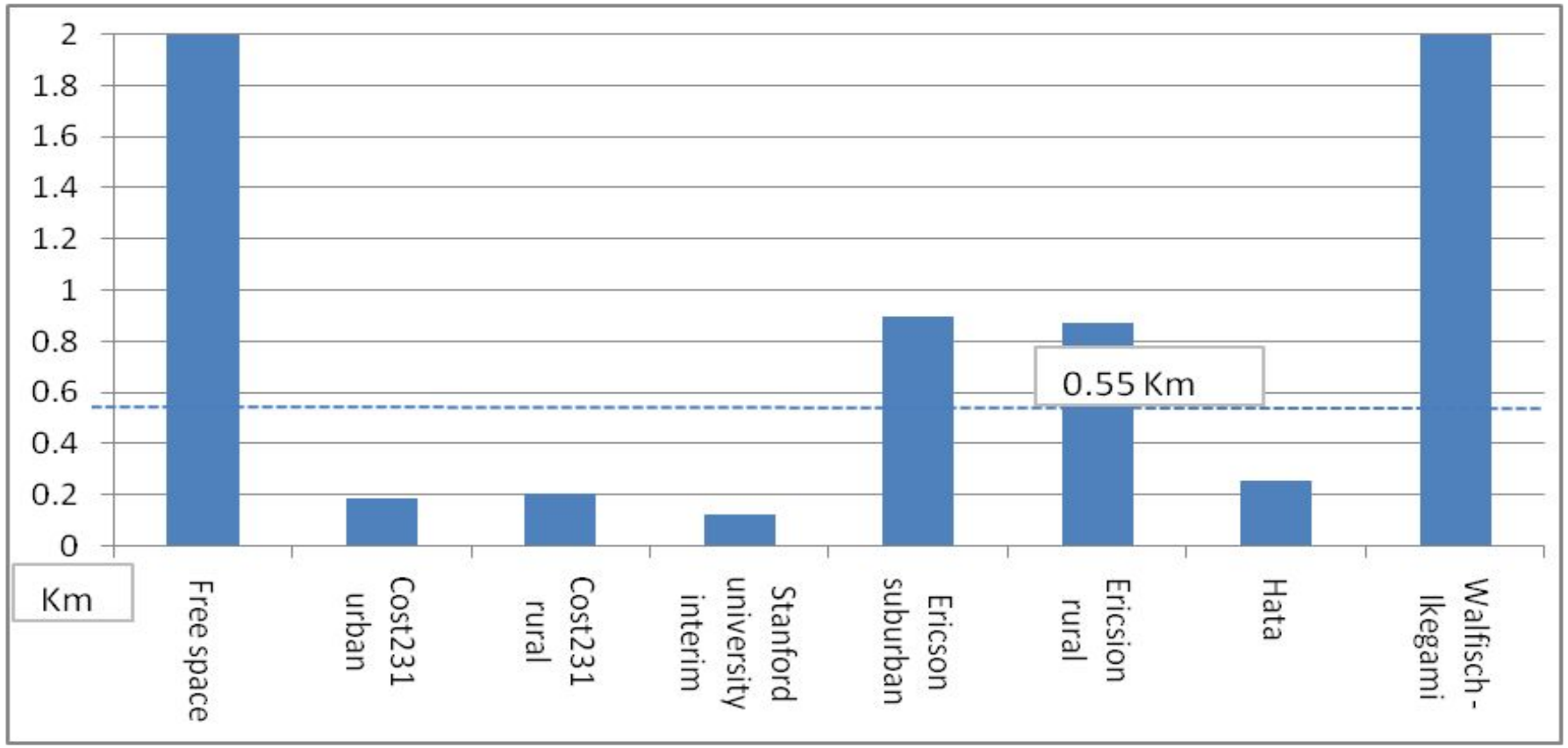
- Smartphone: Samsung Galaxy S5
- AP : Ubiquity Airmax AM-2G16-90
- Radio module Rocket M2
- Power over Ethernet (POE) injector
- Two SMA pigtails
- AC, DC and RJ45 wires
- Power supply



Validation and results

Measured coverage: 0.55 Km

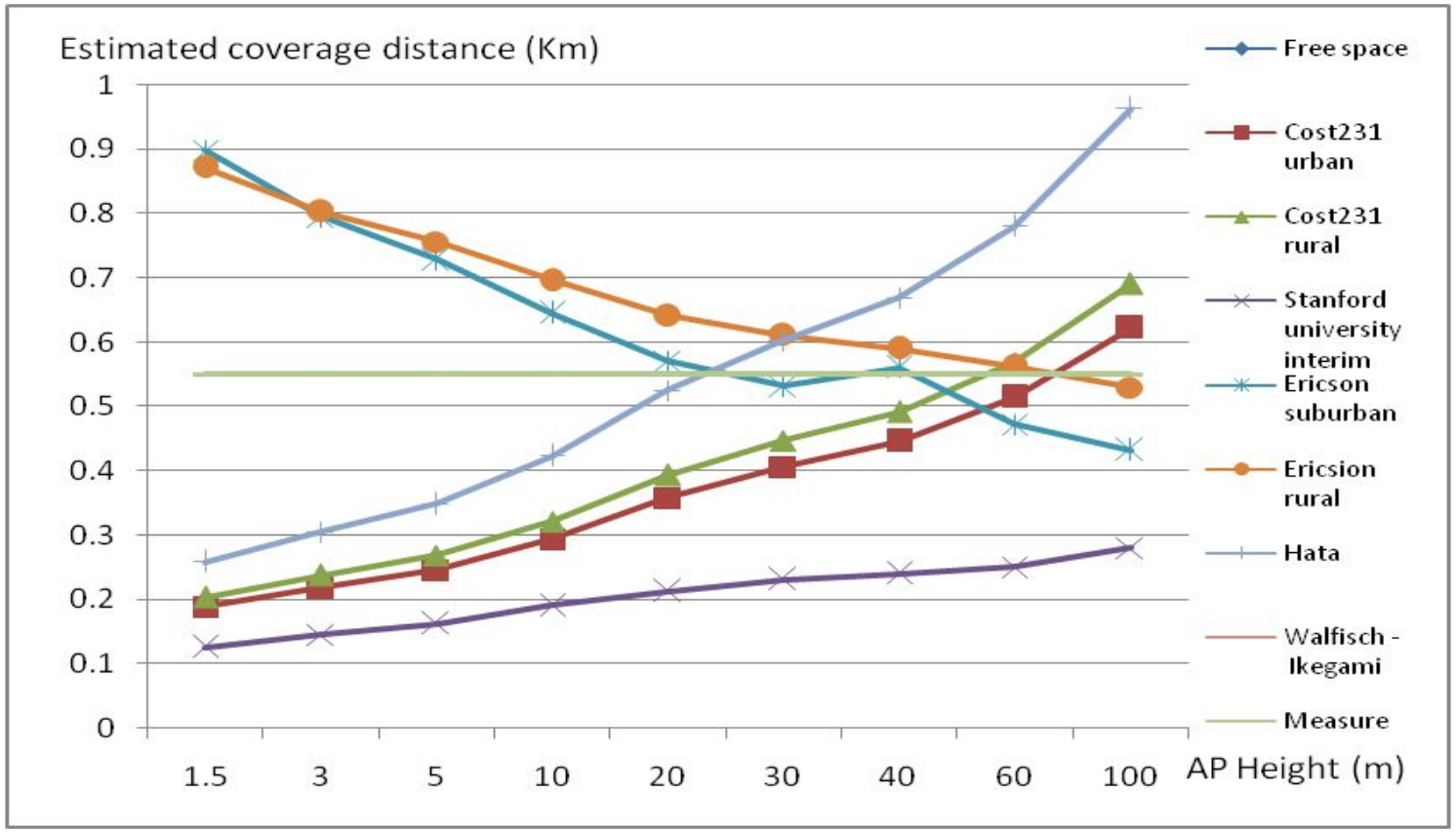
Hata model prediction = 0.258 Km
free air loss = 30.78 Km
Walfisch-Ikegami = 5.682 Km



Comparison of measured coverage with path losses models

Validation and results

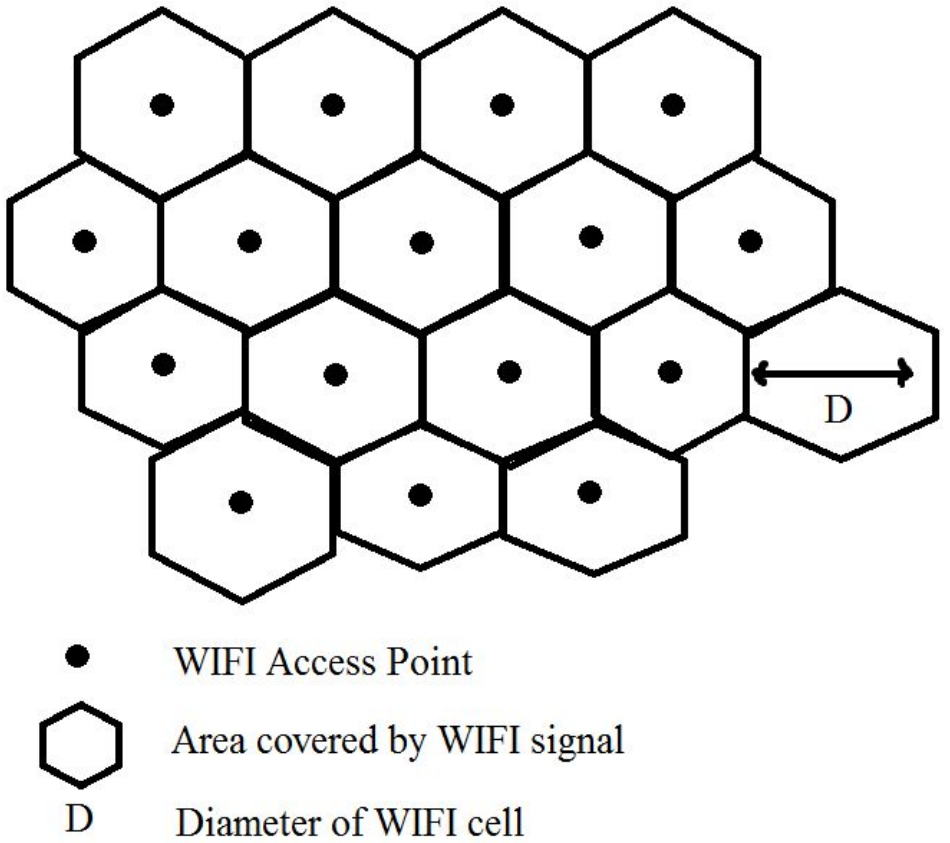
Measured coverage: 0.55 Km



Estimated coverage of most known models over Height of AP

Consequences for IoT applications

- IoT traffic will double by 2020
- Diversified specs and characteristics
- WiFi connectivity omnipresence
- Ability to support high data rate, with reasonable coverage range, power consumption and cost
- Possibility to raise the coverage through the use of low ISM frequencies
- unlimited number of wireless connections, and many bandwidth frequency configurations
- Adapted for developed countries context



Wide range deployment model for WiFi

Threats to validity and future researches

- Test has been done in urban environment
- Interference
- Fading and multipath

- **Future researches**
- More measures to verify the accuracy path loss models for the context of outdoor WiFi
- Environmental effects: weather, vegetation, etc …
- Configuration algorithm for multi cell deployment

Conclusion

- WiFi coverage range characterization
- Consequences on IoT applications
- Technical characteristics are explained
- Deployment scenario is explained
- Important difference between measure and most known empirical path loss models

Thank you for your attention
Questions?