

Wirless Networks And Mobile Applications

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Disclaimer

Hello guys!

These notes contain all the concepts and arguments which are explained during professor's lessons. However they are not intended in any sense as a replacement for professor's lessons, but as a help for studying and preparing the exam. Furthermore it's possible there are some errors and we don't take any responsibility of them. If you like to contribute for any correction, here is the link to the repository:

<https://github.com/filippobrugnolaro/WNMA-notes>

You can create a new branch with all modifications and create a pull request. We'll be pleased for any correction in order to improve the quality of the document. Hope it could be useful.

Cheers :)

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1 Introduction

1.1 Wireless Development

Present

it is constantly growing due to higher use of laptops or devices which can connect to internet. This implied an important growth of WiFi and n-G (3G, 4G, 5G) technologies also thanks to the emerging of apps with both low and high data demand. Smartphones open to new wireless scenarios such as AR, VR, MR, tele-presence... Other topics are Tactile Internet (combination of low latency, high availability, reliability and security) and Web Squared (integration of web 2.0 with technologies of sensing).

Future

it is based on ubiquitous communication among people and devices. So this implies to take into account some requirements such as bandwidth, delay, energy and connectivity.

Challenges

- Wireless channels are a difficult and capacity-limited broadcast communications medium (with respect to the wired counterpart);
- Traffic patterns, user locations, and network conditions are constantly changing;
- Applications are heterogeneous with hard constraints required by the network;
- Energy and delay constraints change design principles across all layers of the stack.

Multimedia requirements

	Voice	Data	Video	Game
Delay	low	irrelevant	low	low
Packet Loss	low	no	low	low
Bit Error Rate	10^{-3}	10^{-6}	10^{-6}	10^{-3}
Data Rate	8-32 Kbps	1-100 Mbps	1-20 Mbps	32-100 Kbps
Traffic	Continuous	Bursty	Continuous	Continuous

One-size-fits-all protocols and design

- are used by wired networks → poor results;
- do not work well → Crosslayer design.

Crosslayer Design

It's made of 5 layers:

Application	→ Meet delay, rate and energy constraints
Network	→ Adapt across design layers
Access	→ Reduce uncertainty through scheduling
Link	→ Provide robustness via diversity
Hardware	

1.2 Wireless Systems

There are different types of current wireless systems:

- Cellular Systems;
- Wireless LANs;
- Satellite Systems;
- Bluetooth;
- ...

And others which are emerging:

- Ad hoc Wireless Network;
- Mesh Network;
- Sensor Network;
- Distributed Control Network;
- MANET/VANET/FANET;
- Underwater Networks;
- RFID;
- Nano-networks;
- ...

1.2.1 Cellular Systems

Characteristics:

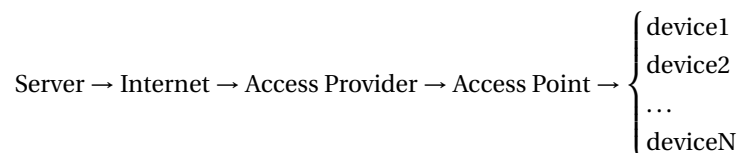
- every geographic region is divided into cells
 - more trasmission distance ⇒ more power;
- frequency/timeslots/codes are reused at separated locations;
- co-channels interference between same color cells;

- base stations has control of functions and handoff;
- it can be shrunk to increase capacity and relax networking burden.
- it supports both voice (continuous) and data (bursty) requiring different:
 - access
 - routing strategies
- About connectivity:
 - 3G: packet-based switching for both voice and data (up to 7.2 Mbps)
 - 4G - 5G: are more focused on data (high bandwidth, high reliability, low latency)

1.2.2 Wireless Local Area Networks (WLANs)

Characteristics:

- devices are connected (wireless) to an AP¹
 - it is wired-connected to internet;
- breaks data into packets (≈ 1500 B) → AP¹ in even smaller size (500 B);
- MAC layer control access to shared channel (random access);
- backbone internet provides best-effort service
 - bandwidth cannot be determined!
 - users pay subscription only for home-access provider distance
 - ⇒ it can be bottleneck if the backbone is faster
 - having QoS (subscription) here can increase digital gap



There are different versions (802.11):

- b (old gen): only 2.4 GHz, speed 1-11 Mbps, range 100m
- g (legacy std): 2.4-5 GHz, speed up to 54 Mbps
- n (current gen): 2.4-5 GHz, speed up to 300 Mbps, multiple I/O
- ac (emerging gen): 2.4-5 GHz, speed up to 500 Mbps, multiple I/O
- s: used for mesh networks
- p: used for vehicular networks

¹Access Point

1.2.3 Satellite Systems

Satellites haven't been used so much until starlink which is gaining popularity because, even if they make light pollution, they are very lightweight and easy to wake up. There are many types of satellites:

- GEO (Geostationary Earth Orbit);
- MEO (Medium Earth Orbit);
- LEO (Low Earth Orbit).

In particular satellites:

- can cover large areas depending on their height in the space:
 - $> \text{height} \Rightarrow > \text{covered area}, > \text{latency}, < \text{bandwidth}$
 - $< \text{height} \Rightarrow < \text{covered area}, < \text{latency}, > \text{bandwidth}$
- for one-way transmission are optimised (i.e. radio and movie broadcasting);
- for two-way transmission are given up because of costs and few ambitions.

1.2.4 Bluetooth

Characteristics:

- it is a low cost replacement for cables;
- it covers a short range up to 100m with multihop
 - it requires exponential energy as distance grows
- frequency 2.4 GHz
- 4 channels (3 for voice, 1 for data up to 700 Kbps)
- Widely supported by telecommunications, PC...
 - it is a standard de facto (also BLE...)

1.2.5 Ad-hoc Networks

Characteristics:

- it is a peer-to-peer communications (born for military purposes)
- there isn't any backbone infrastructure
- routing is very hard because of:
 - dynamic topology;
 - typically multihop → to extend coverage area or reduce interferences

Problems:

- | | |
|------------------------|-------------------------|
| • hops; | • energy consumption; |
| • bandwidth; | • topology; |
| • collisions handling; | • dependency on device. |

1.2.6 Mesh Networks