Wireless Networking [ET4394]

Edition 2018: Introduction

Przemysław Pawełczak

Learning Objectives (LOs)

- **LO1:** To bridge fundamental concepts of modern wireless communication by integrating theory and experimental studies
- **LO2:** To be able to analyze (wireless) communication algorithms and expand on the existing designs
- **LO3:** To be able to critically assess the limitations of each design

Lecturer

- **Przemysław Pawełczak**
  - Pshe/mys/wav Pa/veu/chaq
  - Pshe/meq (Robert→Rob, Christian→Chris)

- Postdoc: **UCLA**
- PhD: **TU Delft**
- MSc: **TU Wrocław**

- **W:** www.st.ewi.tudelft.nl/~pawelczak
- **E:** p.pawelczak@tudelft.nl

- **Office hours:** Wednesdays 11.30-12.30
- **Location:** Room E3.080 (Building 28, 3rd floor)

Teaching Assistant

- **Amjad Y. Majid**

- PhD student: **TU Delft**
- MSc: **TU Delft**

- **W:** http://www.st.ewi.tudelft.nl/~amjad/
- **E:** a.y.majid@tudelft.nl

- **Office hours:** Wednesdays 10:30-12:30
- **Location:** Room E3.040 (Building 28, 3rd floor)

Literature for Lecture 1

- Keith Baker, **Torque Kills! Future Control of the Ambient Electromagnetic Spectrum**, IEEE Multimedia, vol. no. pp. 4-8, Jan.-Mar. 2007
  - http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4061300
- Steven cherry, **Edholm's law of bandwidth**, IEEE Spectrum, pp. 58-60, July 2004
  - http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1309810

For the interested:

- Dipankar Raychaudhuri, Narayan B. Mandayam, **Frontiers of Wireless and Mobile Communications**, Proceedings of the IEEE, vol. 100, no. 4, pp. 824-840, Apr. 2012
  - http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6155060
- C. Fragouli, M. M. Halldórsson, K Jamieson, and B. Krishnamachari (Eds.), **Foundations of Wireless Networking,** Dagstuhl Seminar 17271 (2017)
  - http://drops.dagstuhl.de/opus/volltexte/2018/8420/pdf/dagrep_v007_i007_p001_17271.pdf

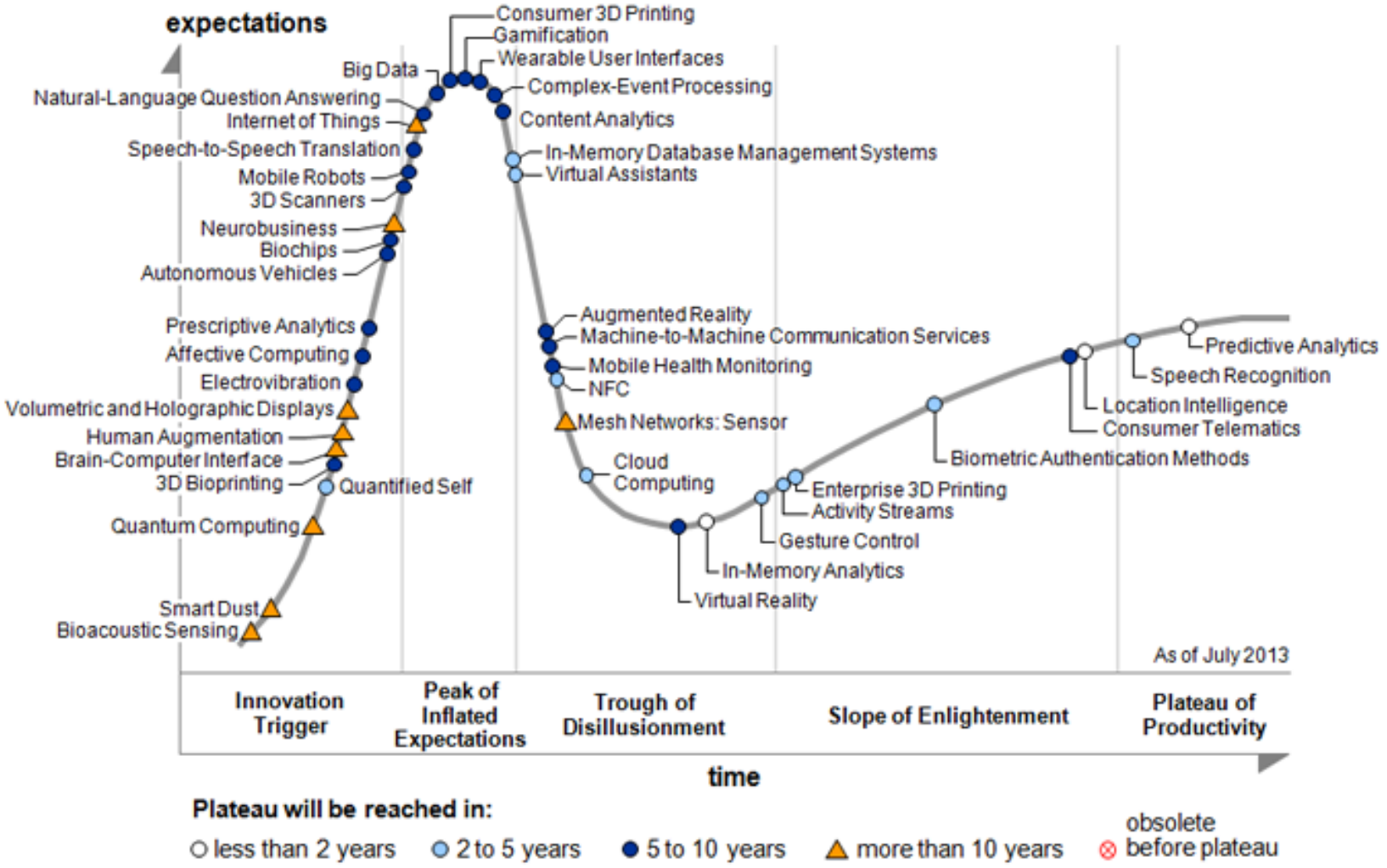
What is Wireless Networking?

- **Wireless Networking (WN)** is the protocol-described ability to communicate/exchange messages between entities using non-cable based connection based on:
  - **Optical Communication**
  - **Vibrations**
  - **Smoke**
  - **Scents**
  - **…**
  - **Radio Frequency**

A primary mode of cat communication is body language such as the position of the ears.

Source: http://en.wikipedia.org/wiki/Cat_communication

WN and the Hype Cycle



Source: http://www.gartner.com/newsroom/id/2575515

WN Soup

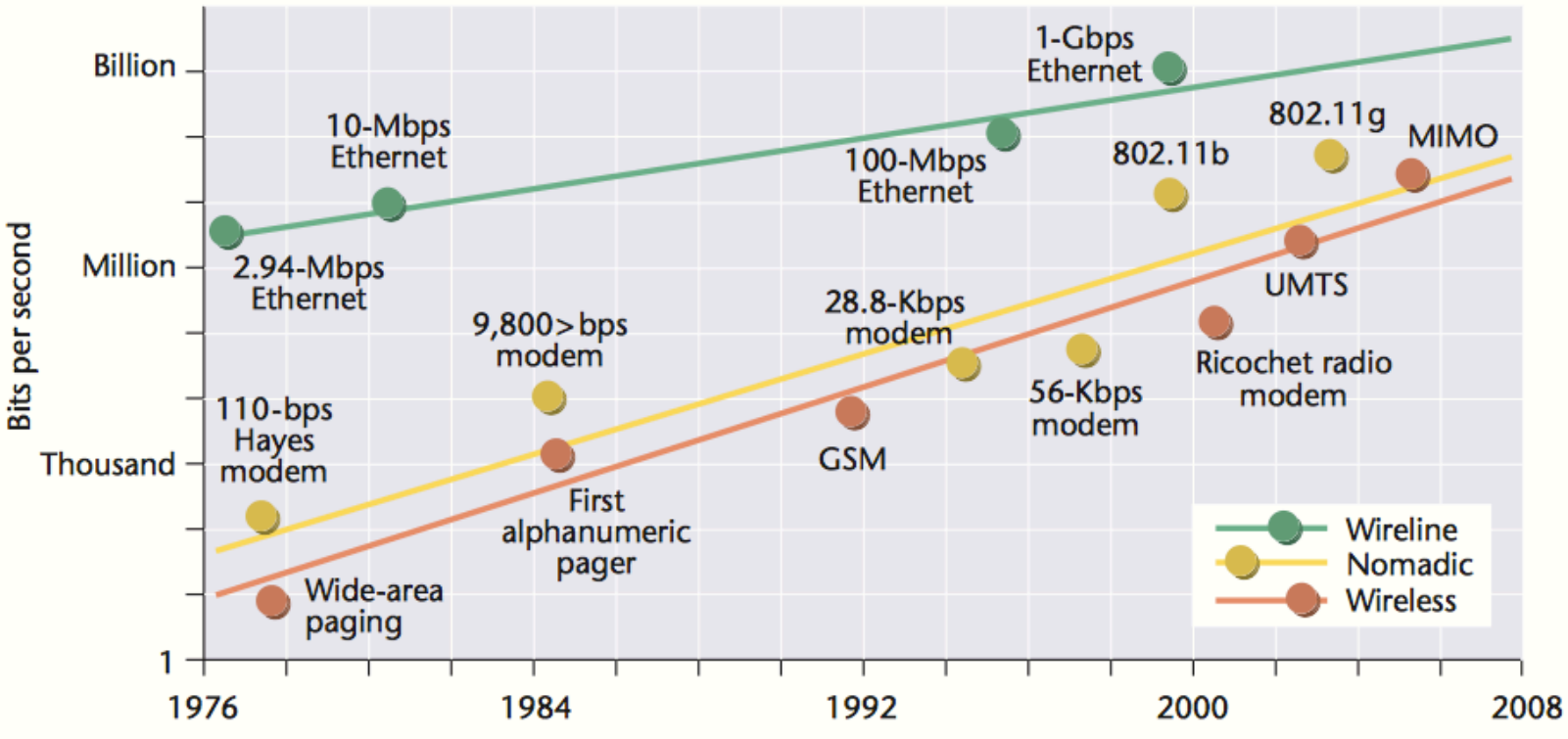
- **WiFi, 802.11, 802.15, 802.22, Bluetooth, Zigbee, WLAN, RFID, WSN, Smart Dust, LoRa, SigFox, NB-IoT, Weightless, 5G, XG, NFC, …**

WN Soup

- **WiFi, 802.11, 802.15, 802.22, Bluetooth, Zigbee, WLAN, RFID, WSN, Smart Dust, LoRa, SigFox, NB-IoT, Weightless, 5G, XG, NFC, …**

WN Soup and Edholm's Law

http://www.linkedin.com/in/philedholm

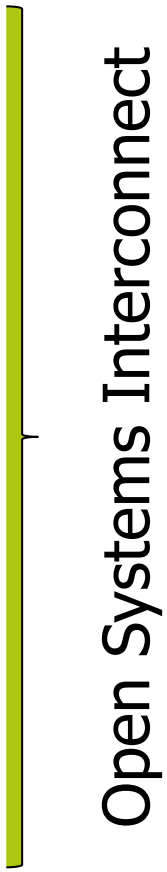


Source: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4061300

Edholm's Law: capacity of wireline, nomadic and wireless standards will converge
Cooper's Law: number of connections in useful radio spectrum passed over an area doubles every 30 months

Protocol Stack and WN

- **Application**
  - **Security**
- **Transport**
  - **Congestion & Flow control**
- **Network**
  - **Routing & Addressing**
  - **QoS**
- **Data link**
  - **Multiplexing**
  - **Authentication**
- **Physical**
  - **Modulation**
  - **Interference cancellation**



Research Challenges

- 6. **Create the cognitive radio!**
  - Lecture: 8 March
- 8. **Accurate wireless simulation?**
  - Project!
- 27. **How can we optimize energy use in a single-hop wireless network?**
  - Lecture: 21 and 22 March (LoRa/Bluetooth)

C. Partridge, **Forty Data Communications Research Questions,** ACM SIGCOMM Computer Communication Review, vol. 41, No. 5, Sept. 2011
http://dl.acm.org/citation.cfm?id=2043170

Schedule and Content

- **2 classes per week**
  - Wednesday 13.45-15:30 [EWI Lecture hall D@ta]
  - Thursday 10.45-12:45 [EWI Lecture hall Pi]
  - 15 minute break in-between

- **Begins:** 14 February, 2017
- **Ends:** 29 March, 2017
- **Duration:** 7 weeks

Schedule and Content

- 14 February: **Introduction**
- 15 February: **Project selection**

- 21 February: **SDR/Network Simulation/Wireshark**
- 22 February: **Project consultation (No lecture)**

- 28 February: **WiFi** (part 1) + **Wireshark progress check**
- 1 March: **WiFi** (part 2)

- 7 March: **Wireshark sniffing presentation**
- 8 March: **Cognitive Radio**

Schedule and Content

- 14 March: **RFID**
- 15 March: **RFID hackathon**

- 21 March: **Bluetooth**
- 22 March: **LoRa**

- 28 March: **NB-IoT**
- 29 March: **Poster presentations: Project results**

- **Every week: Consultation sessions on your projects**

Related Lectures

- **Perfomance analysis (IN4341)**
  - Lecturer: **Piet van Mieghem**
    - **https://www.nas.ewi.tudelft.nl/people/Piet/**
  - **Advanced Topics in Mobile Communications (ET4396)**
  - Lecturer: **Remco Litjens**
    - **https://www.linkedin.com/in/remco-litjens-63a3664/**
- **Wireless Communications (ET4358)**
  - Lecturer: **Gerard Jansen**
    - http://wireless.tudelft.nl/People/bio.php?id=7
  - Lecturer: **Jos Weber**
    - http://wireless.tudelft.nl/People/bio.php?id=28
  - Lecturer: **Remco Litjes**
  - **Lecturer:** Me ☺

Structure of the Class/Grading

5 ECTS points

- **Project assignment:**
  - 40% of the final grade
  - Deadline: **28 March, 23:59**
- **Exam:**
  - 30% of the final grade
  - Date: **19 April, 9:00-12:00 (Room CT IZ 2.02)**
- **Wireshark report (with presentation):**
  - 30% of the final grade
  - Deadline: **6 March, 23:59**
- **Report on the selected paper:**
  - 0% of the final grade (prerequisite)
  - Deadline: **28 March, 23:59**

Course Literature and Tools

- **Lecture (i.e. exam)**
  - Dedicated articles and book chapters (provided at the lecture)
- **Project assignment**
  - (more in a minute)
- **Wireshark report**
  - (more in a minute)
- **Paper reading**
  - Provided at the next lecture

Project: Version A

- **Project A: Wireless Network simulation using NS3**
  - Install https://www.nsnam.org/ns-3-27/

Project: Version A

- **Crash-course literature for Project A**
  - https://www.nsnam.org/docs/release/3.27/tutorial/ns-3-tutorial.pdf
  - https://www.youtube.com/playlist?list=PLRAV69dS1uWQEbcHnKbLIdvzrjdOcOIdY
  - http://ns3tutorial.com

Project: Version A

- **Crash-course literature for Project A**
  - https://www.nsnam.org/docs/release/3.27/tutorial/ns-3-tutorial.pdf
  - https://www.youtube.com/playlist?list=PLRAV69dS1uWQEbcHnKbLIdvzrjdOcOIdY
  - http://ns3tutorial.com

Start IMMEDIATELY!

Project: Version A

- **Rules for Project A**
  - Project in groups of 2
  - **For people with less programming/Linux skills**
  - Report in PDF with source code
    - github.com
  - Presentation at the last lecture (poster session)
  - **List and selection of exact projects: Tomorrow!**

Project: Version B

- **Project B: Software Defined Radio and WN**
  - Install:
    - https://gnuradio.org/redmine/projects/gnuradio/wiki/InstallingGR
  - Or install:
    - https://www.mathworks.com/hardware-support/rtl-sdr.html
  - Or install whatever you prefer:
    - https://www.rtl-sdr.com/big-list-rtl-sdr-supported-software (section "Research")

Project: Version B

- **Crash-course literature for Project B**
  - **Best source of information:**
    - http://www.desktopsdr.com/
    - https://www.youtube.com/channel/UC1mUbAy7G8-6dJdPOxTABTA
  - See also:
    - https://gnuradio.org/redmine/projects/gnuradio/wiki/Guided_Tutorials
    - http://www.eas.uccs.edu/~mwickert/ece4670/lecture_notes/Lab6.pdf
    - https://www.mathworks.com/help/supportpkg/rtlsdrradio/index.html
    - https://www.youtube.com/playlist?list=PL618122BD66C8B3C4

Project: Version B

- **Crash-course literature for Project B**
  - **Best source of information:**
    - http://www.desktopsdr.com/
    - https://www.youtube.com/channel/UC1mUbAy7G8-6dJdPOxTABTA
  - See also:
    - https://gnuradio.org/redmine/projects/gnuradio/wiki/Guided_Tutorials
    - http://www.eas.uccs.edu/~mwickert/ece4670/lecture_notes/Lab6.pdf
    - https://www.mathworks.com/help/supportpkg/rtlsdradio/index.html
    - https://www.youtube.com/playlist?list=PL618122BD660B3C4

Start IMMEDIATELY!

Project: Version B

- **Rules for Project B**
  - Project in groups of 2
  - **For people with less signal processing/telecom skills**
  - Report in PDF with source code
    - github.com
  - Presentation at the last lecture (poster session)
  - Groups will get the required hardware from me
  - **List and selection of exact projects: Tomorrow!**

Project B: Examples

- **LoRa decoder in Matlab**
  - http://www.rtl-sdr.com/decoding-the-iot-lora-protocol-with-an-rtl-sdr
- **Multi-antenna reception (MIMO receiver implementation)**
  - http://kaira.sgo.fi/2013/09/16-dual-channel-coherent-digital.html
- **Space-time coding transmitter/receiver**
  - https://www.mathworks.com/help/comm/examples/introduction-to-mimo-systems.html
- **Breathe detection using passive wireless signals**
  - http://witrack.csail.mit.edu/vitalradio/content/vitalradio-demo.pdf

Wireshark “Sniffing” Project

- **Wireshark**
  - Install: https://www.wireshark.org/#download

Wireshark “Sniffing” Project

- **Wireshark literature**
  - First two chapters of a book: "Wireshark Essentials" By James H. Baxter (book is available online at our TU Delft library)
  - http://www.willhackforsushi.com/books/377_eth_2e_06.pdf
  - https://wiki.wireshark.org/CaptureSetup/WLAN
  - https://www.youtube.com/watch?v=DJOkJ0X5JuY
  - https://www.cisco.com/c/en/us/support/docs/wireless-mobility/80211/200527-Fundamentals-of-802-11-Wireless-Sniffing.html

Wireshark “Sniffing” Project

Start IMMEDIATELY!

- **Wireshark literature**
  - First two chapters of a book: "Wireshark Essentials" By James H. Baxter (book is available online at our TU Delft library)
  - http://www.willhackforsushi.com/books/377_eth_2e_06.pdf
  - https://wiki.wireshark.org/CaptureSetup/WLAN
  - https://www.youtube.com/watch?v=DY0kJ0X5JuY
  - https://www.cisco.com/c/en/us/support/docs/wireless-mobility/80211/200527-Fundamentals-of-802-11-Wireless-Sniffing.html

Wireshark “Sniffing” Project

IMMEDIATELY!

Wireshark “Sniffing” Project

- **Rules for “Sniffing” project**
  - Project in groups of 2
  - Scripting skills needed (Pyhton/Matlab)
  - **Goal: measure features of WLAN traffic at various locations (PHY included)**
  - Report in PDF with source code
    - github.com
  - Presentation at the “Wireshark” lecture (5 min presentation/ group)

Literature: Where is WN “Stuff”?

- **Journals**
  - IEEE Transactions on Mobile Computing
  - IEEE Transactions on Wireless Communications
  - IEEE Journal on Selected Areas in Communications
  - IEEE Communications Magazine
  - Proceedings of the IEEE
  - IEEE/ACM Transactions on Networking
  - ACM Transactions on Sensor Networks
- **Conferences**
  - IEEE INFOCOM, ACM SenSys, ACM MobiCom, ACM SIGCOMM, ACM UbiComp, USENIX NSDI

Literature: Where is WN “Stuff”?

- **Databases**
  - Google Scholar **[scholar.google.com]**
  - ArXiv **[arxiv.org]**
  - Microsoft Research **[academic.microsoft.com]**
  - IEEE eXplore database **[ieeexplore.ieee.org]**
  - ACM Database **[dl.acm.org]**
- **Popular**
  - rtl-sdr.com
  - hackaday.com
  - slashdot.org
  - lists.gnu.org/archive/html/discuss-gnuradio
  - youtube.com (**excluding all the non-academic stuff!**)

Literature: Where is WN “Stuff”?

Papers to review will be provided tomorrow

House Rules

- You are all adults (with freedoms and responsibilities thereof)
- Academic quarter applies
- **Feel free to ask questions any time**
- Come closer
- No FBs/Tweets/Snappchats/Wattsaps/Tinder/Instgrms/etc.

- **Decide by tomorrow if you attend or not**

- **Fun guaranteed!**

Points to Clarify

- If you don't like something: Tell me!
  - I want to be the first to know
- If something (anything) is unclear: Ask!
  - Come any time/email
  - Don't wait until the last day! I beg you!
- To telecom students:
  - If you feel the course is to easy: Tell me!
- Lectures are addition to your project
  - Not the complement!
- Course is meant to expand your least developed skills
  - Telecom: Software@Wireless, CS: Signals@Wireless

- Let us experiment with instant messaging: Who's in?

Points to Clarify

- **Ik spreek Nederlands…**
- **…Und ein bisschen Deutsch**
- **Information will be spread throughout**
  - **Brightspace**
  - **Slides**
  - **Mattermost (if we decide to use it)**