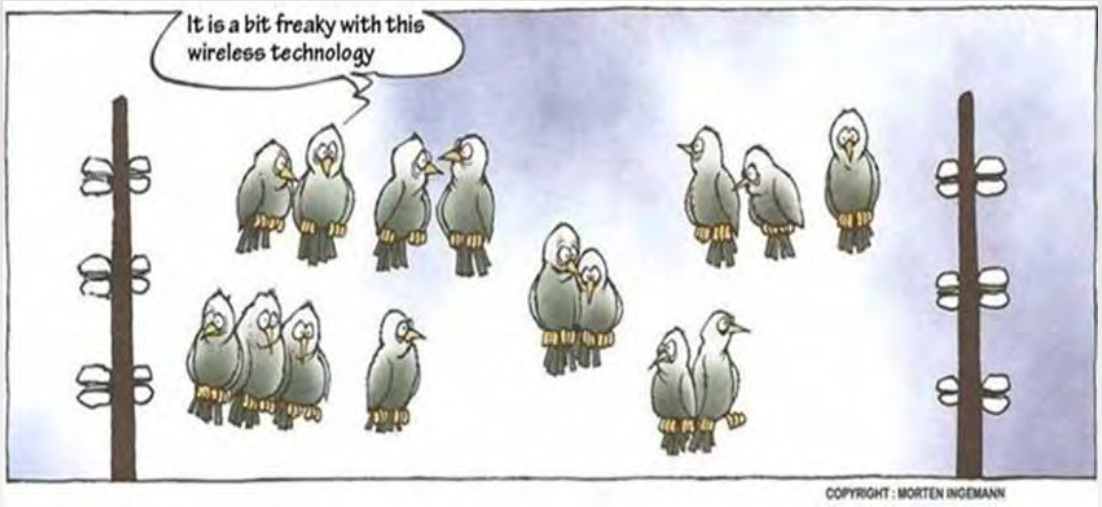
Wireless Engineering



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Dr. Victor P. Nelson

Professor, Auburn University

Electrical & Computer Engineering

Wireless Engineering

Undergraduate Program Director

Auburn University Wireless Engineering Program

- **Degree:** *Bachelor of Wireless Engineering*
  - Only undergraduate degree in wireless in the U.S.
  - Co-administered by Dept. of Electrical & Computer Engineering and the Dept. of Computer Science and Software Engineering
  - Accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org
- **Sam Ginn**, CEO (retired), Vodafone, donated $25M to help create the program
  - His vision: create unique opportunities for both Auburn grads and prospective employers in the rapidly-growing field of wireless communications
- **First graduates**: Fall 2004
  - Over 400 graduates since then

Presentation outline

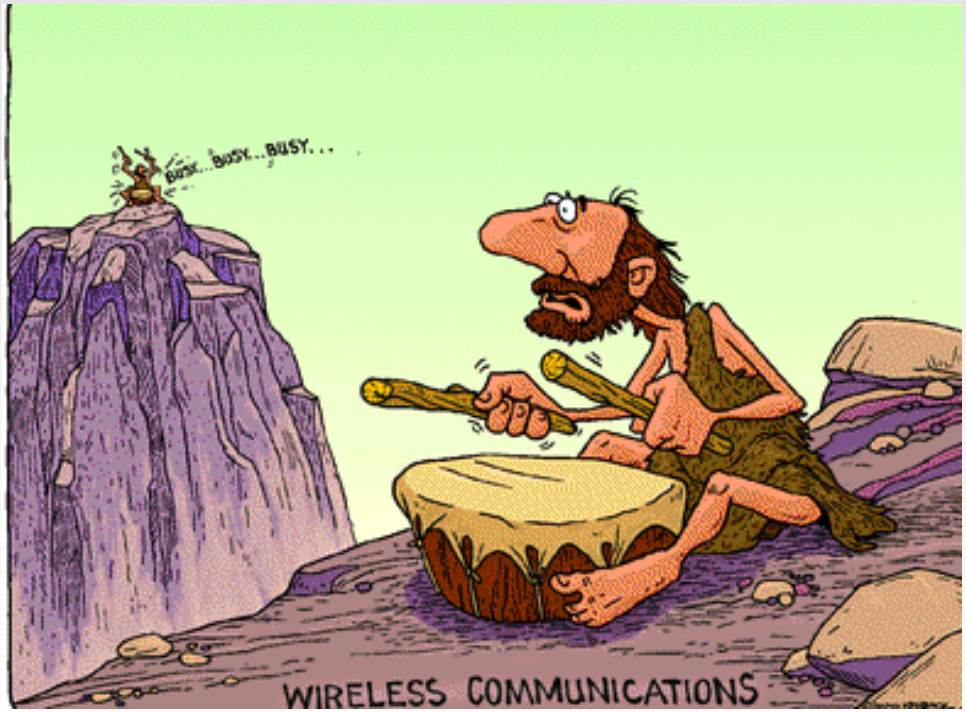
- What is wireless engineering?
- What do wireless engineers do?
- Where do wireless engineers work?
- What do wireless engineering students study?
- How do I get more information?

What is wireless engineering?

Communication via radio signals or microwaves (no wires)

Wired[1]

Wireless[2]



[1] http://herdingcats.typepad.com/my_weblog/2010/03/communicating-with-a-tuna-fish-cans-and-string.html

[2] HP Electronics Cartoons: http://www.leapsecond.com/notes/cartoons.htm

What is Wireless Engineering?

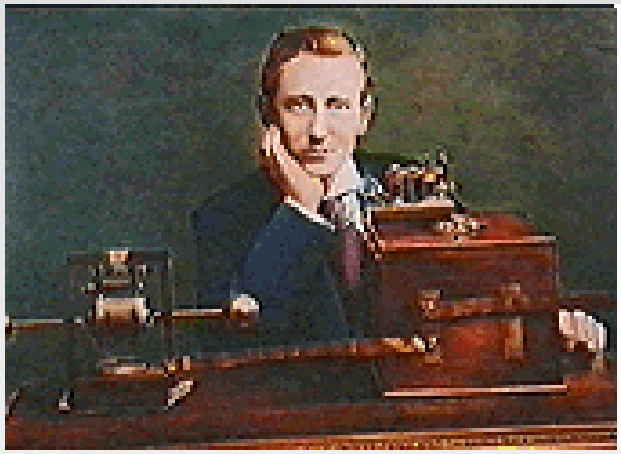
A unique field of engineering to support wireless communication in all its forms

- Cellular phone networks
- Wireless Internet
- Satellite communications
- Ubiquitous, pervasive, and wearable computers
- Internet of Things
- Cyber-physical systems
- Precision agriculture
- Whatever else the future may hold!

Related technical majors

- **Electrical engineering** (broad)
  - Circuits, electronics, digital systems, automatic control, power systems, communications, electromagnetics
- **Computer engineering** (overlaps EE, CS, SWE)
  - Computer systems & products that contain computers
- **Software engineering** (an "engineering discipline")
  - Design, build and test (i.e. "engineer") complex, high-quality software systems to meet sets of requirements
- **Computer science** (more theoretical than SWE)
  - Core computing concepts/technologies, how software and programming languages work, applications such as graphics, databases, operating systems, etc.
- **Engineering Technology**
  - Work with current technologies in the discipline, less emphasis on applying math/science/engineering for design

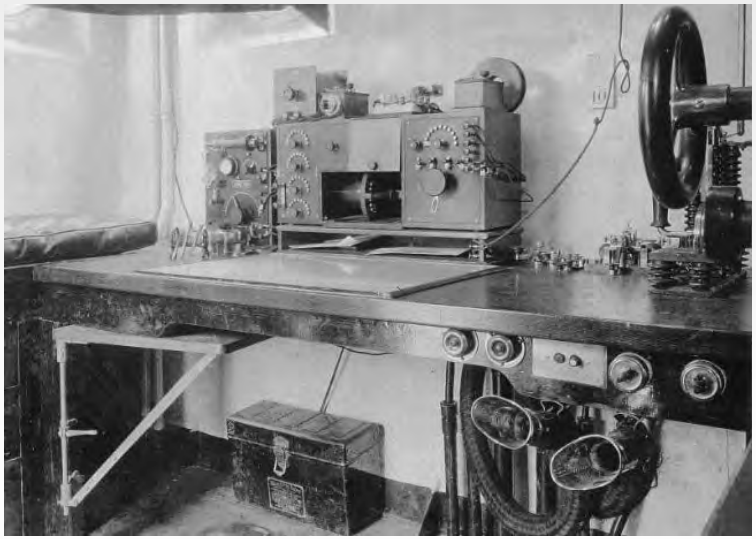
Wireless communication - origins



Guglielmo Marconi

First “radio” transmitted 1.5 miles in 1895.

British patent No. 12,039, *Improvements in Transmitting Electrical Impulses and Signals and in Apparatus There-for*.



USS Nero, wireless room (1916)[1]

Listening to “the wireless” (1937) [2]

[1] http://www.telegraph-office.com/pages/wireless_gallery.html

[2] http://www.telegraph.co.uk/news/5017242/BBC-has-let-down-Britains-children.html

Evolution of the telephone

Alexander Graham Bell
(Circa 1875)

"Wired"

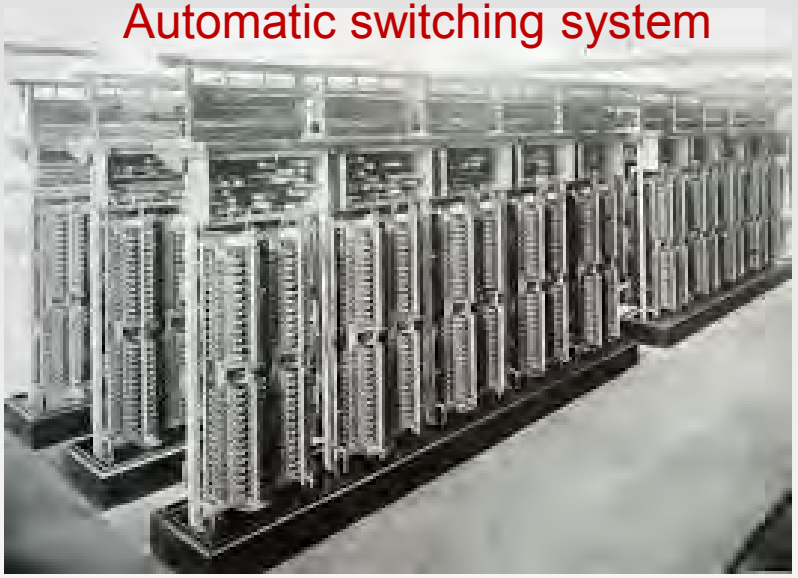
"Wireless"

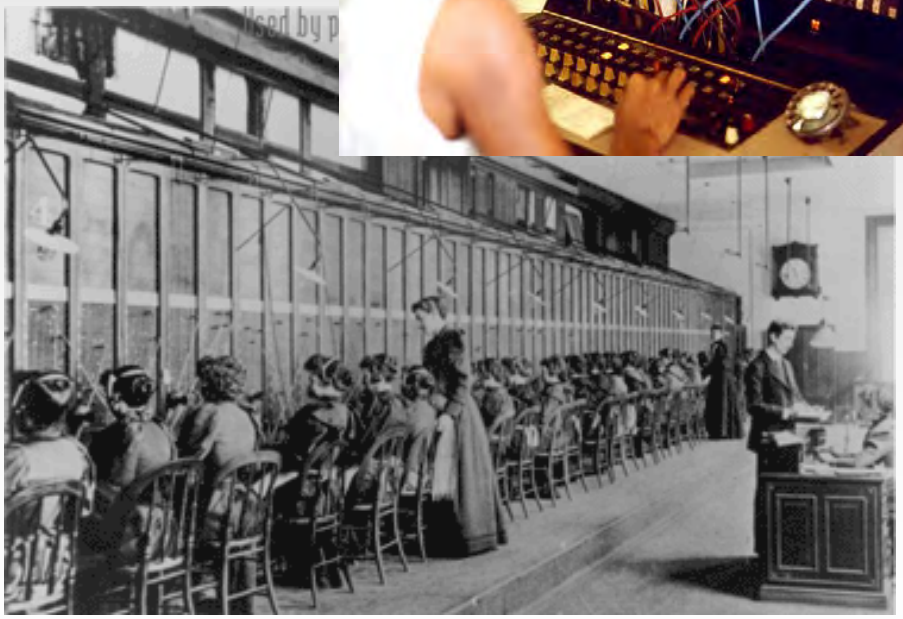
Telecommunication networks

Connect caller and receiver phones

Switchboard operator

Automatic switching system

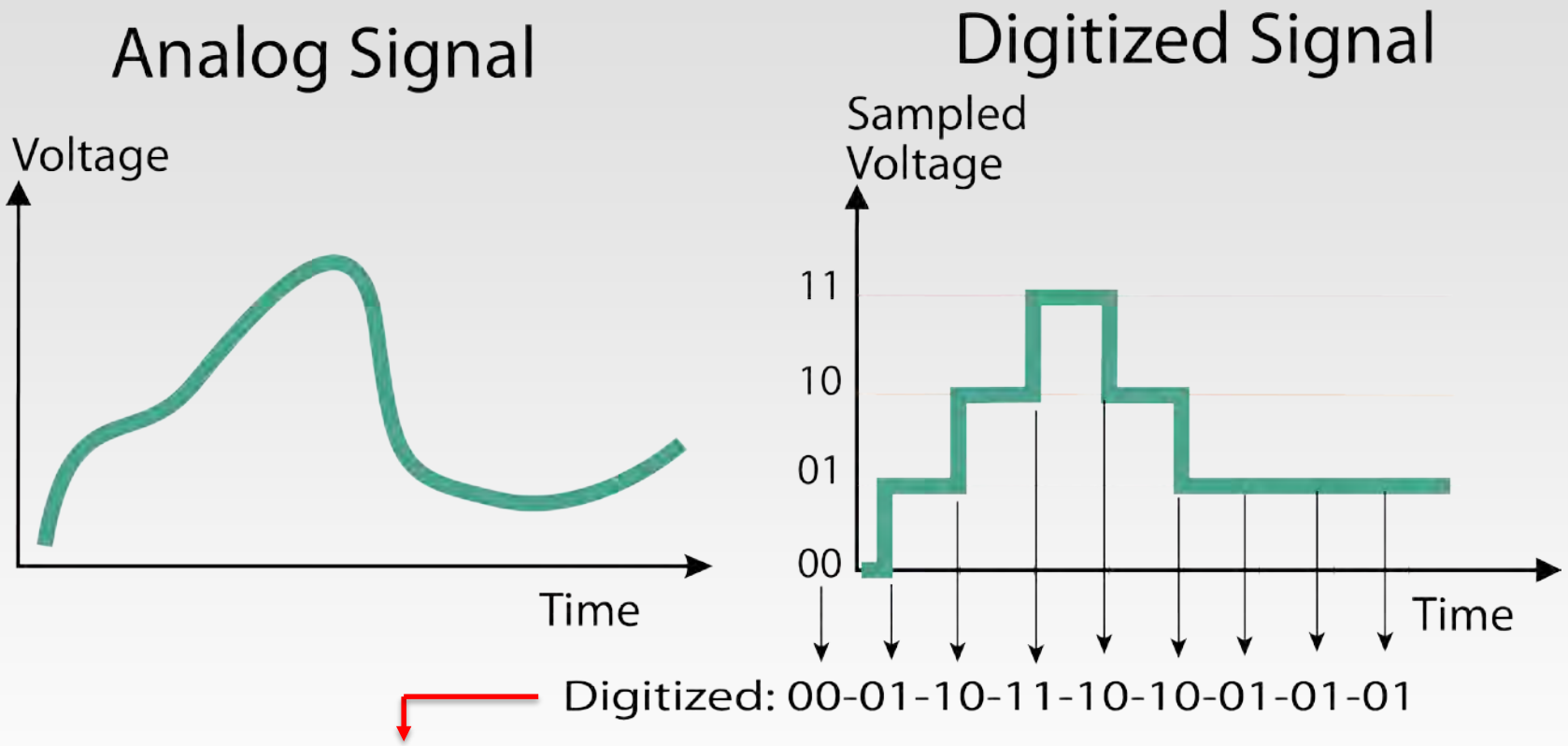




Manual switching system, circa 1880

Each digit of phone # rotates a switch

Digital data has replaced analog signals in telecommunication



- Periodically transmit digitized voice data values
  - Digital phone: 8000 samples/second @ 8 bits per sample
  - Receiver reconstructs the analog signal
- Apply same process to transmitting/receiving “data”
  => computer/communication networks

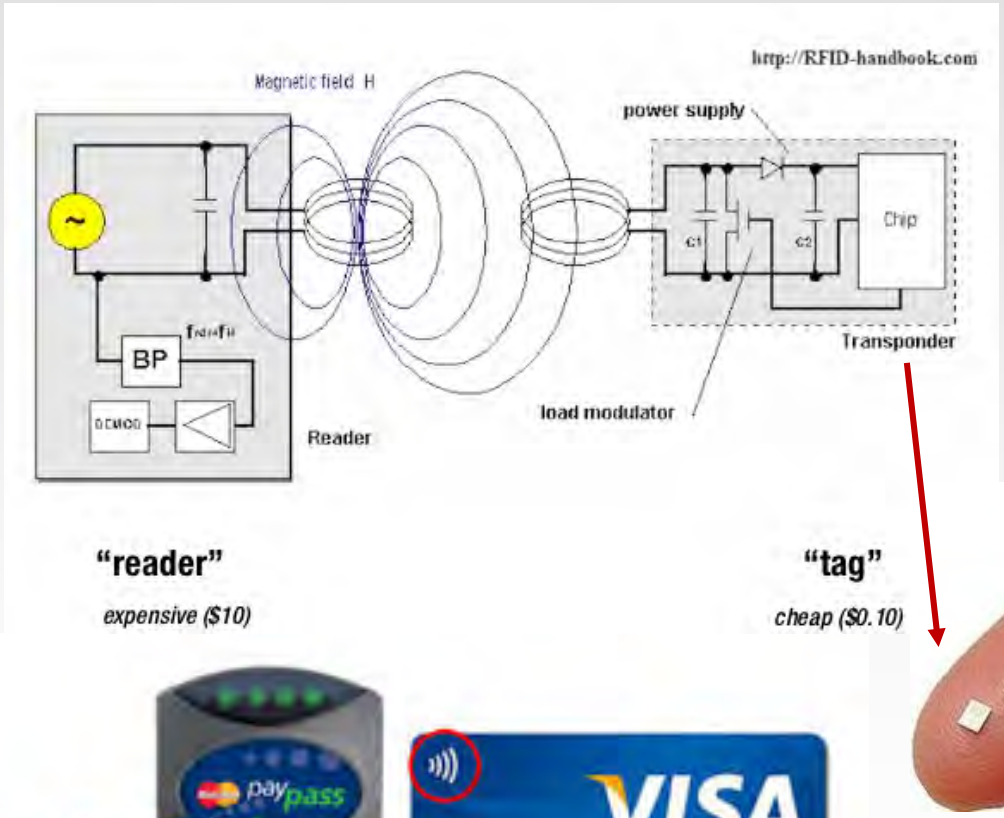
Evolution of wireless communication networks

- Wireless communication can span inches to light years, with widely varying data rates
  - "near field" communication (several inches)
  - personal area networks (around my computer)
  - local area networks (ex. Wi-Fi)
  - wide area networks
  - cellular telephone networks
  - satellite communication

Wireless Engineers design all of these!

RFID

Range 1 to 30 feet, depending on frequency



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Bluetooth

Short-range (≤ 10 meters), low cost, low power

- Keyboard to computer
- Smart phone to headset
- Stereo to speakers
- etc.

Wi-Fi

- "Local area network" of devices
  - PCs, laptops, tablets, smart phones, etc.
  - IEEE 802.11 (a,b,g,n…) standards

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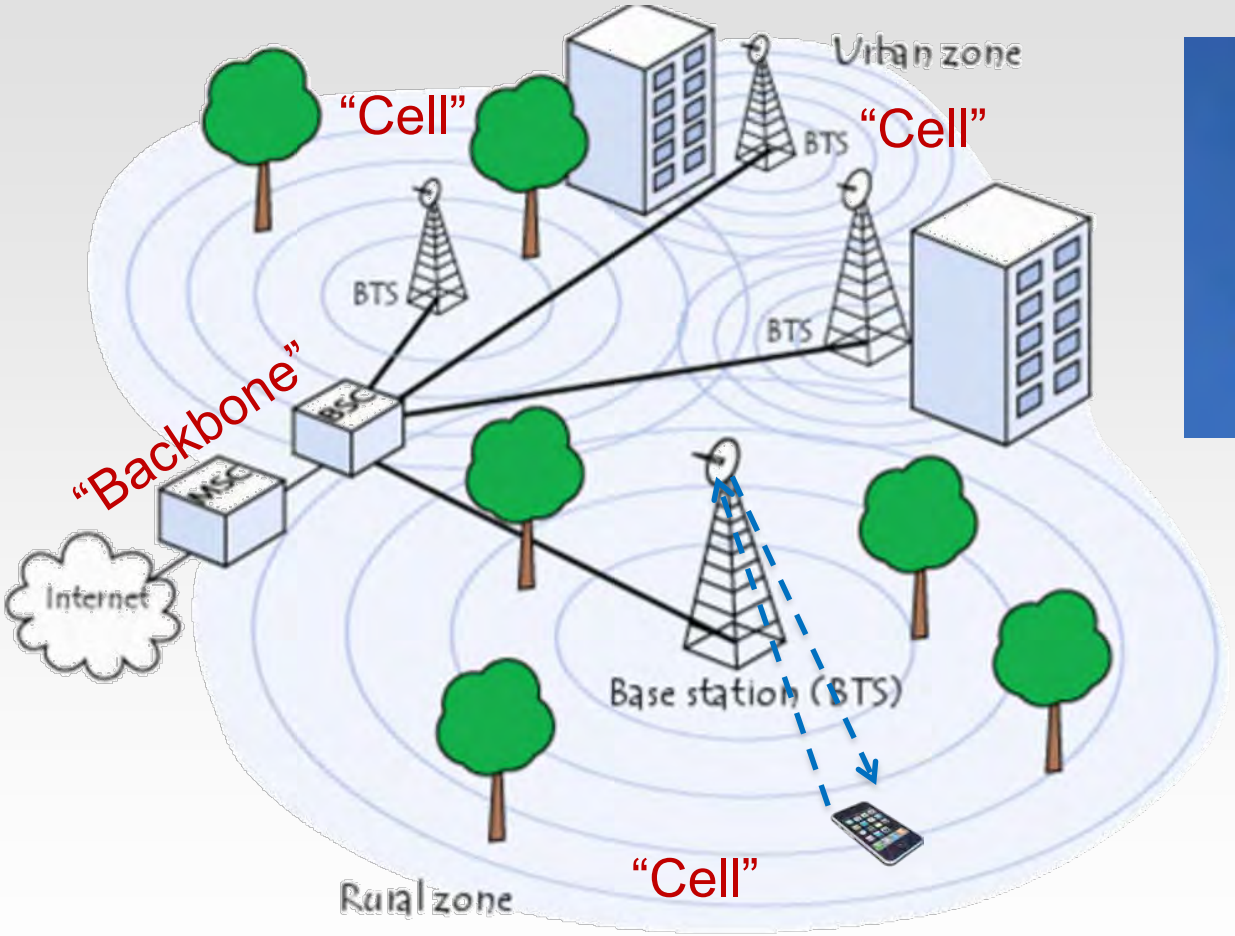
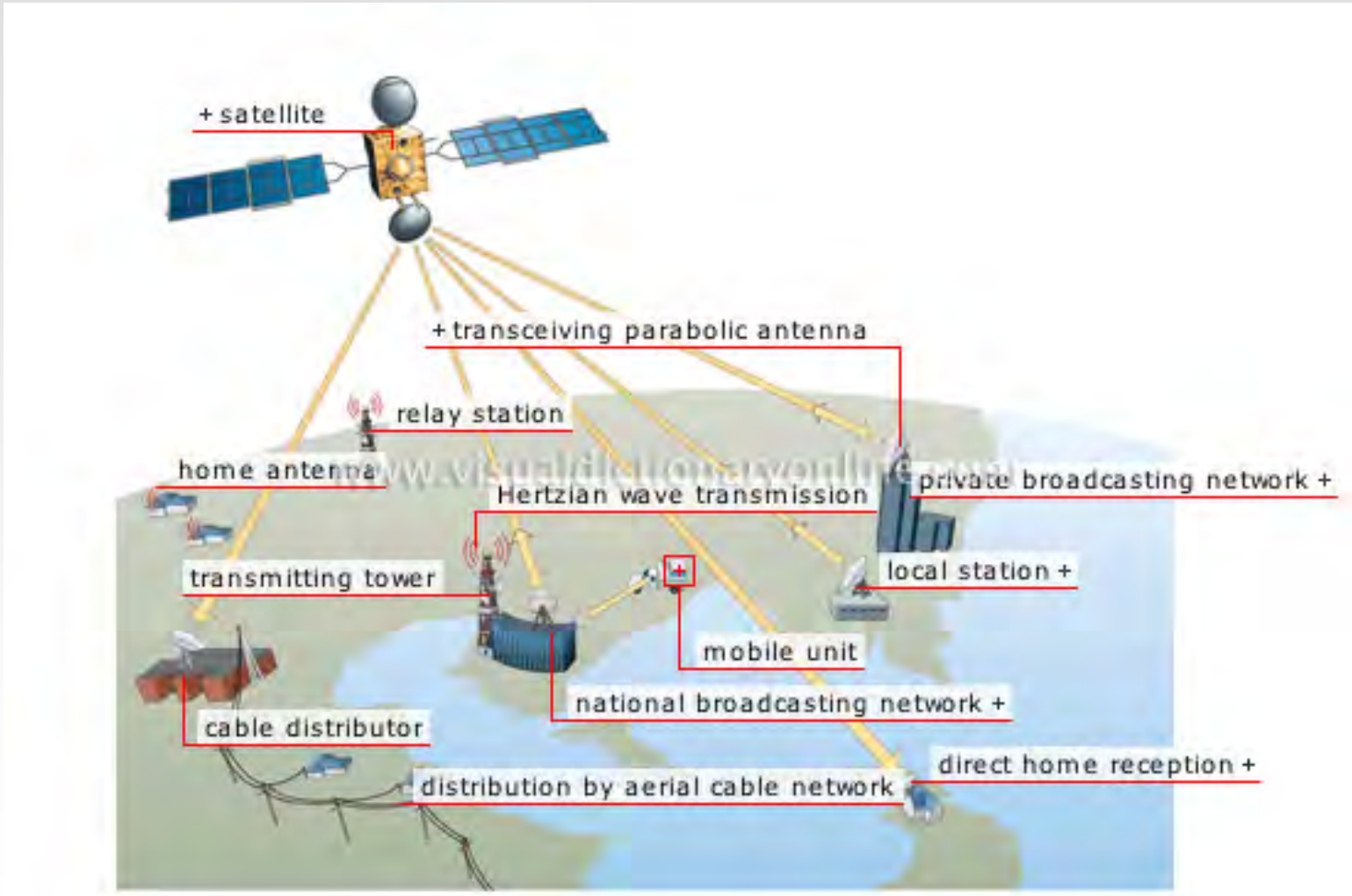
Cellular telephone networks
(both wireless and wired parts)



http://www.thelifenetwork.org

Satellite communications



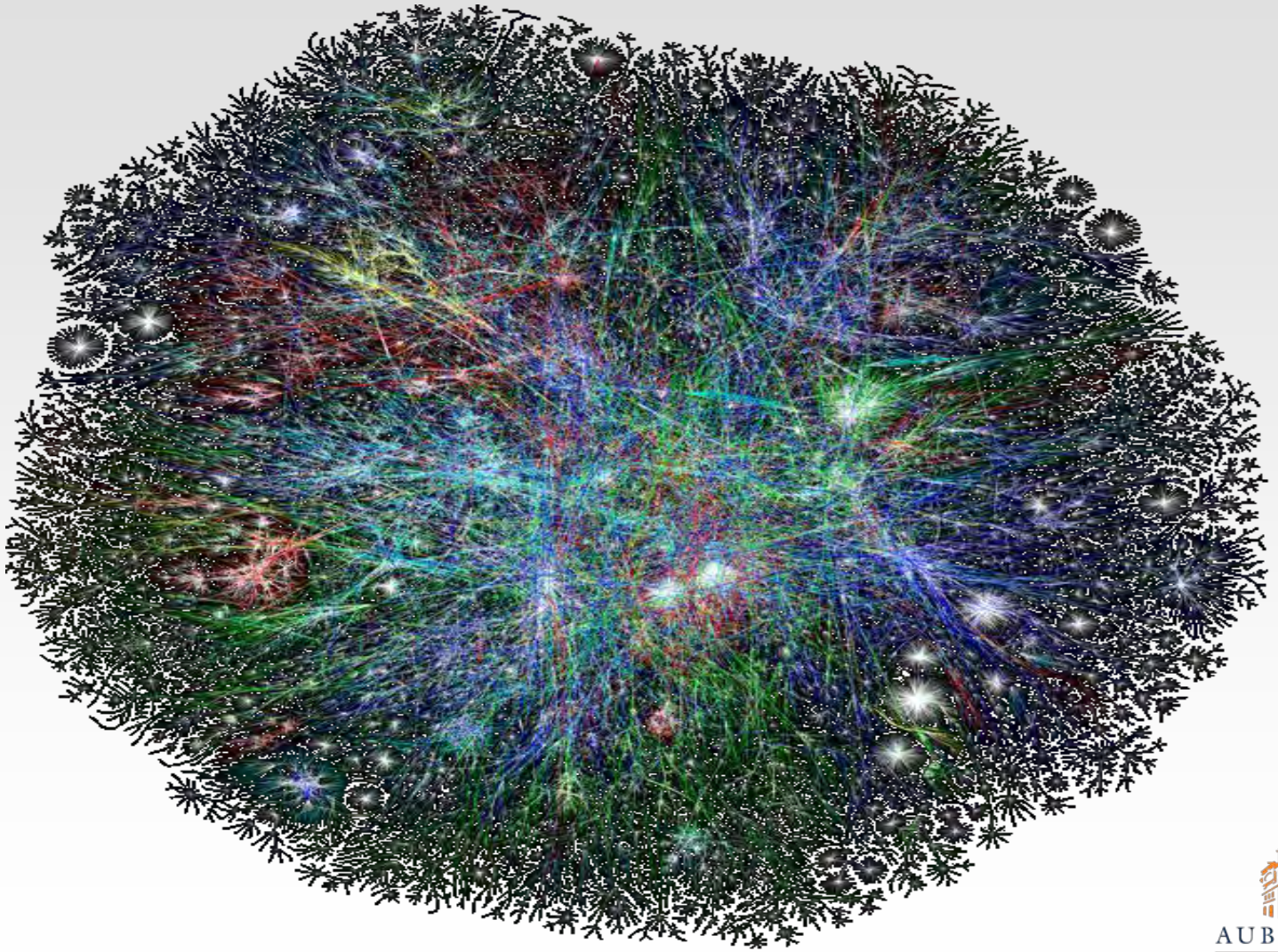
Internet of Things (IoT)

Wirelessly share data between:

- Sensors
- Devices
- Vehicles
- Buildings
- People
- etc.

Unique design challenges!

Finally, the Internet



https://github.com/sf-wdi-19-20/modules/tree/master/w1_d1_2_the_internet

The smartphone revolution
(Driving the wireless communication industry)

Vatican Square
www.businessinsider.com

Communication anywhere[1]

The romantic evening[2]

[1] http://mobilenetworkcomparison.org.uk/two-thirds-of-britons-will-own-a-smartphone-by-2018
[2] http://www.semcasual.org/can-hear-now/

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The Smartphone Revolution (cont'd)

- The iPhone 5s is 15,625 times more powerful than the computer used for the first moon landing
  - iPhone CPU: 625 times more transistors than a 1995 Pentium CPU
- Every single item in this 1990 Circuit City ad now replaced by the smartphone
- Apple: 75 Billion app downloads
  - 12 apps on a smartphone on average
- The average user check their phone 110 times a day
  - 12% used it in the shower

http://www.slideshare.net/GoCanvas/15-facts-37654260

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More Mobile Devices and Apps …

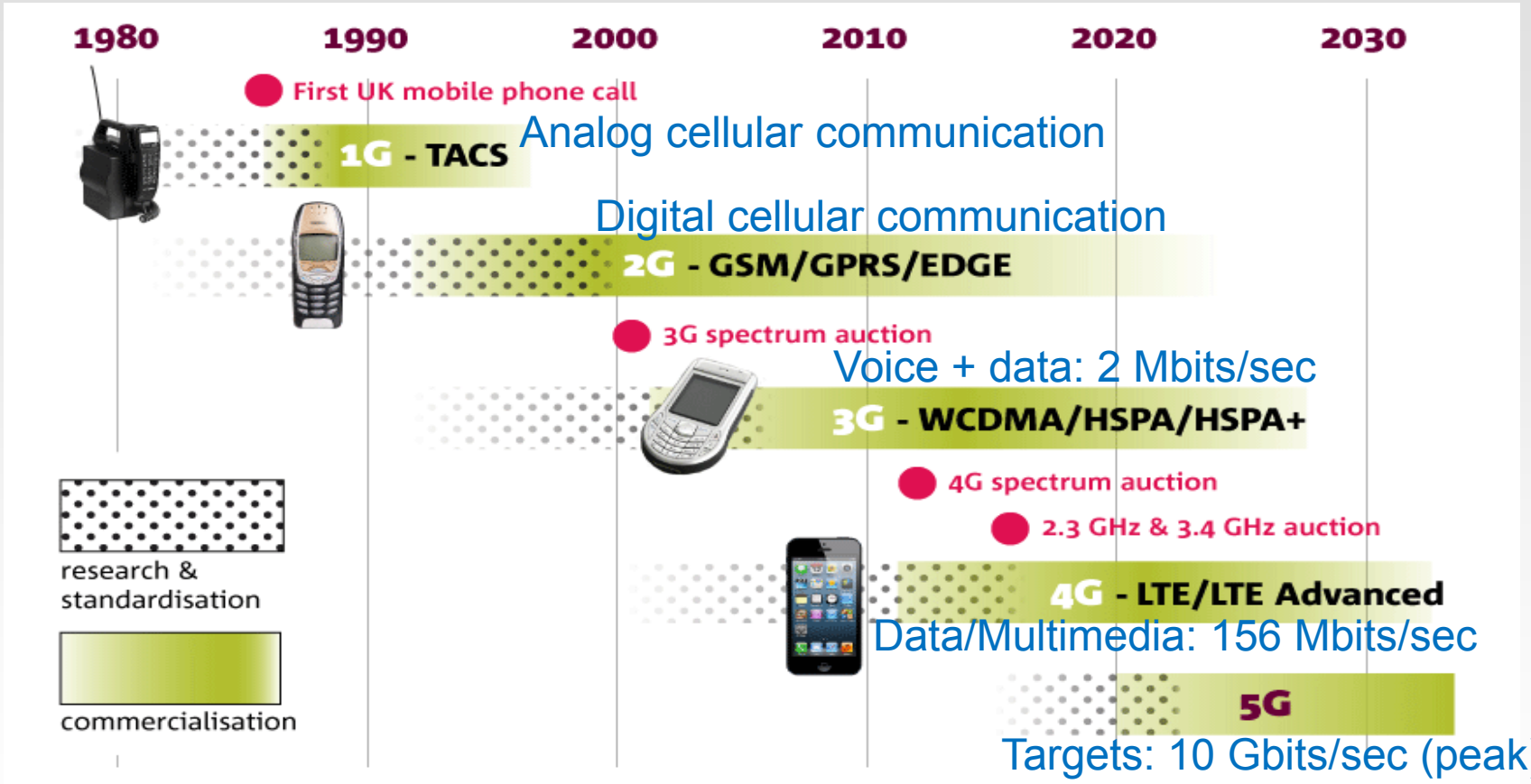
- More mobile devices on earth than people[1]
  - 7.2 billion people
  - 7 billion mobile subscriptions
  - 1.7 billion mobile devices sold per year
  - More people on earth have cell phones than indoor plumbing!
- Mobile devices are data hungry[2]
  - Year 2000: 1 Exabyte (the entire Internet)
  - Year 2013: 18 Exabytes (mobile data per year)
  - Year 2018: 15 Exabytes (mobile data per month)

1 Exabyte = 1 billion gigabytes (10^{18})

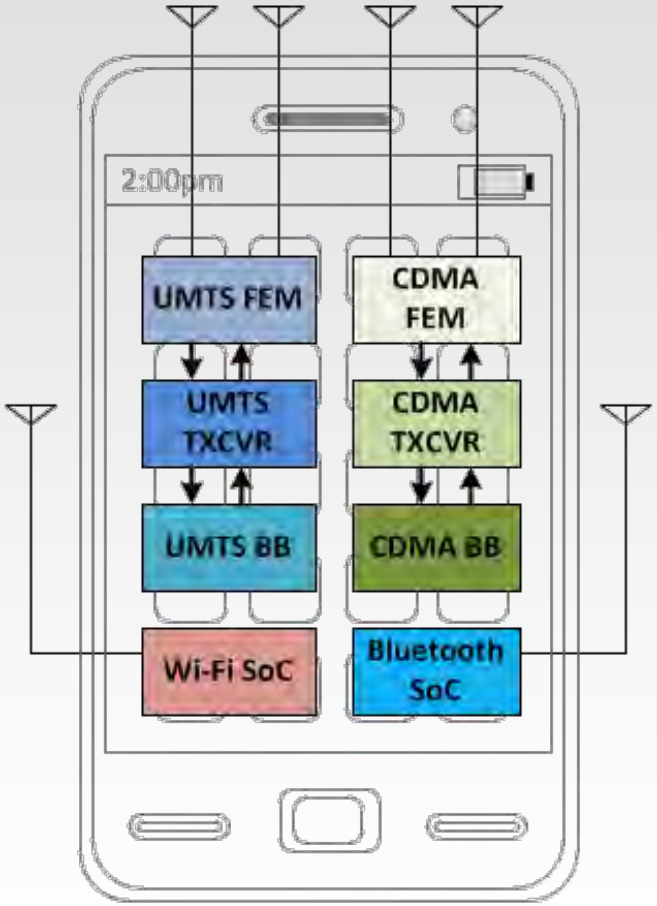
[1] *Source: GSMA intelligence, April 2014*

[2] http://www.businessinsider.com/

Evolution of mobile phone communications



Inside a Smartphone



http://www.edn.com/electronics-news/around-the-web/4375343/10/undefined

What Enabled All These?

- Theory
- Implementation and deployment
  - Hardware
  - Software

Wireless Engineering

Wireless Telecommunication Technologies

Designed by wireless engineers

Network design & integration →

Security & quality of service →

Multimedia applications (“apps”) →

Human-computer interface →

Embedded microcomputers →

← Antenna design

← RF transmit/receive IC design

← Communication theory

← Low-power circuits & battery technology

← Miniaturization & manufacturing

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Specializations (Auburn Curriculum)

- Wireless Electrical Engineering (WIRE)
  - Design chips, devices, comm. techniques, etc.
  - Design network equipment and systems
- Wireless Software Engineering (WIRS)
  - Design software for wireless devices and equipment
  - Design networks of computers/devices

Employers of wireless engineers

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Employers (cont'd)

- Network operators:
  - AT&T, Verizon Wireless, Sprint, T-Mobile, Vodafone
- Network equipment companies:
  - Cisco, Siemens, ADTRAN, Alcatel, Avaya, HP, Ericsson
- Handset manufacturers:
  - Apple, HTC, Samsung, Motorola Mobility, RIM, Google
- Application developers:
  - Google, Microsoft, Amazon.com, many start-ups

Employers (cont'd)

- Test and measurement equipment:
  - Avaya, HP, National Instruments
- Government:
  - National Security Agency, Central Intelligence Agency, FAA, FCC
  - All branches of military
    - Navy SPAWAR, Army Signal Corps, Marine Corps MCTSSA, Air Force Space Command, etc.
- Companies that use wireless technology
  - Home Depot, Acuity Lighting, Norfolk Southern, Neptune Water Meters, etc.

Salary Data

- 2013 *Electronic Design* Salary Survey of 3000 U.S. engineering professionals
  - Integrated circuit design $121K
  - Military product design $120K
  - Software development $110K
  - Mobile equipment design $110K
  - Avionics $110K
  - Communications network equip $93K
  - Research $90K
- 2011 IEEE Survey (10,200 IEEE-USA members)
  - **Communications engineering** was the specialty with the highest reported average salaries
    - Median $135,087

Salary Data (continued)

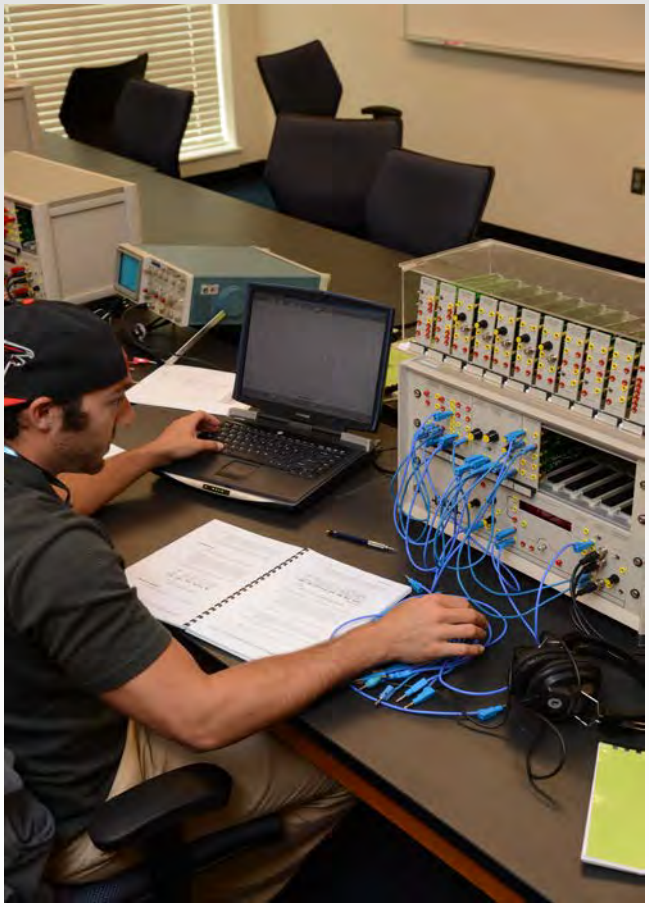
- Payscale.com (2015):
  - Network engineer, wireless RF (average) - $73K
- Engineersalary.com (2015):
  - RF engineer (starting) $65K, (middle 50%) $70K-119K
- Simplyhired.com (2015):
  - Cisco wireless engineer (average) $74K
- Networkworld.com (2013)
  - Mobile App Developer: $93K-$133K
  - Wireless Network Engineer: $86K-$117K

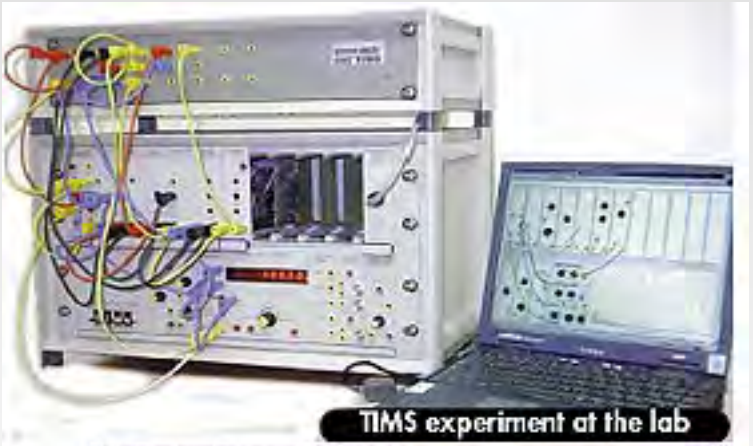
What Do Wireless Hardware Engineers Study?

- Electricity and magnetism
- Radio-frequency devices and circuits
- Wireless and wired communications networks
- Digital signal processing
- Capstone design project
- Electives
  - Antenna Design
  - Microwave and RF engineering
  - VLSI design
  - Sensor design
  - Personal area network design

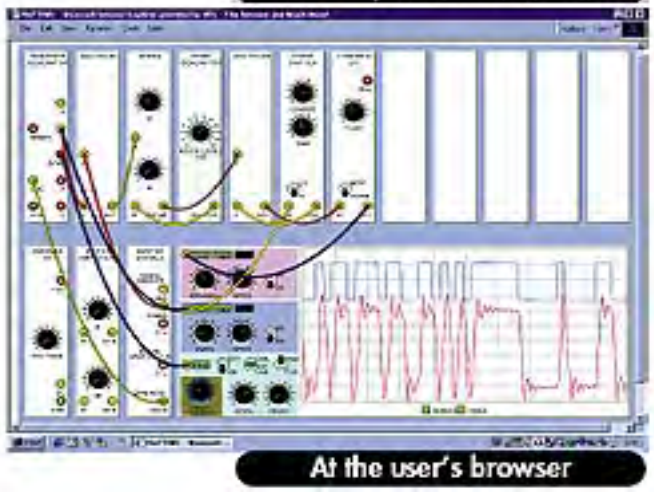
Wireless Communications Lab
(Prof's Riggs & Roppel)

Wireless students design & test an assortment of communication systems





TIMS experiment at the lab



At the user's browser

What Do Wireless Software Engineers Study?

- Algorithms
- Systems software
- Software engineering
- Computer and communication networks
- Software and network quality assurance
- Embedded systems software
- Capstone design Project
- Electives
  - Wireless and mobile networks
  - Information assurance
  - Application Design: Google Android or Apple iPhone

App Development
(Professor Chapman)

- Develop and market applications for smartphones, via Android Market (now Google Play) or Apple App Store
  - COMP 3710 (Android)
  - COMP 4970 (iPhone)

- Students make money before they even finish the course!

Cypress Semiconductor Design Competition, $20,000 prize (1st place)

Wireless capstone design project (2010)

Wireless scoring system for Olympic fencing matches

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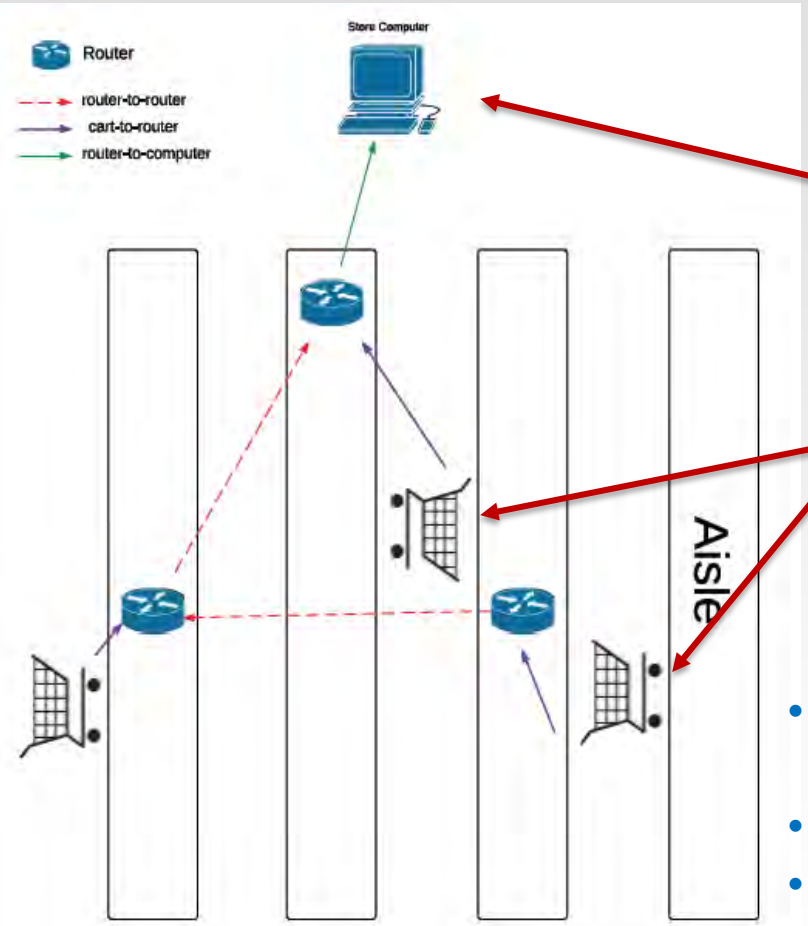
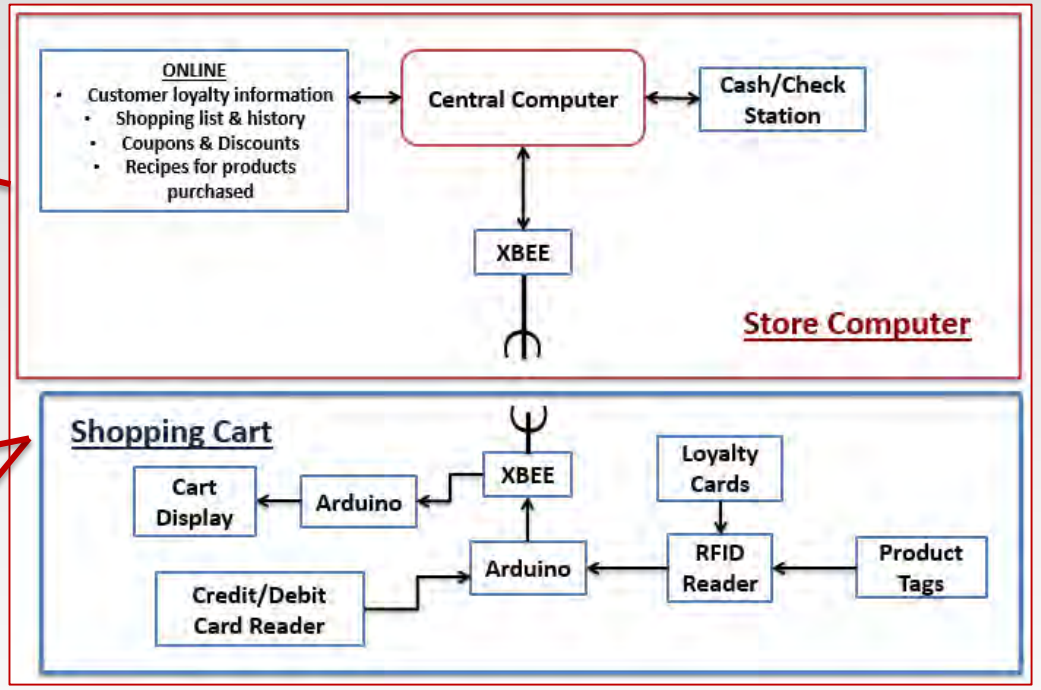
“Smart Cart” for Grocery Shopping

Wireless capstone design project - 2013





- RFID scanner on cart scans RFID tag in product as product placed in the cart
- Product code sent to store computer
- Purchase total updated on cart display
- Scan debit card on cart when finished (sent to store computer)
- Take cart to car (no “checkout”)

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Questions?

For further information:

E-Day – Friday, Feb. 26, 2016

http://www.eng.auburn.edu/eday

Wireless: http://www.eng.auburn.edu/wireless

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  Wireless Engineering Research and Education Center (WEREC)
- *Prof. Richard Chapman, Associate Director of WEREC*
  Co-founder of the Wireless Engineering Program