# CSE 490c ICTD
# Mobile Phones

Autumn 2018

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# Administrative

- Course website
  - https://courses.cs.washington.edu/courses/cse490c/18au/

- Approximate grade weighting
  - Homework 30 %
  - Programming Assignments – Technical 30 %
  - Programming Assignments – Writeup 30 %
  - Participation 10 %
  - Exams 0 %

- Homework 1 – Due Wed Oct 3
  - Turn in PDF using canvas

- Programming Assignment 1 – Due Oct 17
  - Will use Twilio.  If you want to get started on it, set up a demo account and figure out how to send a message from a program to your phone, and from your phone to a program.

# Topic Overview

- Mobile Phones and Handsets
- Communication Infrastructure
- SMS Applications
- Voice Applications
- Mobile Money

# Mobile Phones and Development

- Mobile phones have had a dramatic impact worldwide
- Most adults have access to a mobile phone
- Leap frog technology – did not replace land-lines
- Biggest impact is making communication possible where it wasn't previously
- Primarily commercially driven – private or semi-private companies making oodles of money
- Mobile phones have transformed many activities and industries
- Adoption path across different groups has been uneven

# Handset Types

- Basic Mobile Phones
- Feature Phones
- Smart Phones

# Cell Phone timeline

- 1G: Analog
  - Demonstration 1973. Commercial Launch: Japan 1979 (fully covered in 1984), Nordic countries 1981, USA 1983
- 2G: Digital
  - GSM (Global System for Mobiles)
    - Commercially launched in Finland in 1991.
    - Mandated by European Union in 1987
    - In USA: ATT, T-Mobile
    - Globally Dominant
  - CDMA (Code Division Multiple Access)
    - Commercially Introduced in USA in 1995.
    - Dominated by Qualcomm.
    - In USA: Sprint, Verizon, US Cellular.
- 2.5 G, 2.75 G: Enhanced Digital
  - GPRS (General Packet Radio Service)
  - Enhanced Data Rates for GSM Evolution (EDGE)

# Cell Phone timeline

- Marketing terms for multiple technologies
- 3G
  - Faster data speeds
  - Roll out: 2001 Japan, 2001 Isle of Man, 2003 USA
  - Issue in release of new phones
  - Different spectrum than 2G
  - Widespread by 2007
- 4G
  - Long Term Evolution (LTE) standard
  - Even faster data speeds
  - Internet Packet (IP) packet-switched technologies
  - Introduced around 2009 / 2010
- 5G
  - 2018-2020
  - Even faster data speeds

# Broadband Applications

| Broadband applications using different technologies | Fibre | 2G | | 3G** | | LTE*** |
|---|---|---|---|---|---|---|
| | FTTH | GPRS | EDGE | HSDPA | HSPA+ | |
| Max throughput* | 100 Mbps | 0.08 Mbps | 0.23 Mbps | 2 Mbps | 56 Mbps | 100 Mbps |
| Email | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Basic Internet | ✓ | * | ✓ | ✓ | ✓ | ✓ |
| e-Govt | ✓ | * | ✓ | ✓ | ✓ | ✓ |
| Basic e-Health | ✓ | * | ✓ | ✓ | ✓ | ✓ |
| e-banking | ✓ | * | ✓ | ✓ | ✓ | ✓ |
| Music download | ✓ | * | * | ✓ | ✓ | ✓ |
| Video download | ✓ | * | * | ✓ | ✓ | ✓ |
| Tele-working | ✓ | * | * | * | ✓ | ✓ |
| Advanced e-Health | ✓ | * | * | * | ✓ | ✓ |
| Online gaming | ✓ | * | * | * | * | ✓ |
| High-definition IPTV | ✓ | * | * | * | * | ✓ |
| On-demand multichannel IPTV | ✓ | * | * | * | * | * |

# Cell Phone Worldwide Growth

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Afghanistan | 0 | 0 | 0 | 1 | 2 | 5 | 10 | 18 | 29 | 37 | 35 | 46 | 50 | 53 | 56 | 58 | 62 | 67 |
| Australia | 45 | 58 | 65 | 73 | 83 | 91 | 96 | 101 | 104 | 102 | 102 | 106 | 107 | 108 | 107 | 108 | 110 | 113 |
| Canada | 28 | 34 | 38 | 42 | 47 | 53 | 57 | 61 | 66 | 70 | 76 | 78 | 79 | 80 | 81 | 83 | 85 | 86 |
| China | 7 | 11 | 16 | 21 | 25 | 30 | 35 | 41 | 48 | 55 | 63 | 72 | 81 | 89 | 93 | 92 | 97 | 105 |
| Germany | 59 | 69 | 72 | 79 | 87 | 97 | 105 | 118 | 130 | 130 | 109 | 112 | 114 | 123 | 122 | 118 | 126 | 129 |
| India | 0 | 1 | 1 | 3 | 5 | 8 | 14 | 20 | 29 | 43 | 61 | 72 | 68 | 69 | 73 | 76 | 85 | 87 |
| Kenya | 0 | 2 | 4 | 5 | 7 | 13 | 20 | 30 | 42 | 48 | 60 | 66 | 70 | 71 | 73 | 80 | 80 | 86 |
| Mali | 0 | 0 | 0 | 2 | 3 | 6 | 11 | 19 | 24 | 31 | 49 | 70 | 91 | 120 | 139 | 130 | 112 | |
| Norway | 72 | 79 | 83 | 89 | 98 | 103 | 104 | 107 | 109 | 111 | 115 | 116 | 116 | 112 | 112 | 110 | 109 | 108 |
| Pakistan | 0 | 1 | 1 | 2 | 3 | 8 | 22 | 39 | 54 | 56 | 58 | 63 | 68 | 70 | 73 | 66 | 71 | 73 |
| Russian Federation | 2 | 5 | 12 | 25 | 51 | 84 | 105 | 120 | 139 | 161 | 166 | 142 | 145 | 152 | 154 | 158 | 159 | 158 |
| Rwanda | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 7 | 14 | 24 | 35 | 42 | 53 | 60 | 68 | 75 | 75 | 72 |
| United Kingdom | 74 | 78 | 83 | 91 | 100 | 109 | 115 | 120 | 121 | 122 | 121 | 121 | 122 | 122 | 121 | 121 | 120 | 120 |
| United States | 39 | 45 | 49 | 55 | 63 | 69 | 77 | 83 | 86 | 90 | 92 | 96 | 97 | 98 | 112 | 119 | 123 | 122 |
| Uruguay | 12 | 16 | 15 | 15 | 18 | 35 | 70 | 90 | 105 | 122 | 131 | 141 | 147 | 155 | 161 | 151 | 149 | 147 |
| Venezuela | 22 | 26 | 26 | 27 | 32 | 47 | 69 | 86 | 97 | 98 | 96 | 98 | 102 | 102 | 99 | 93 | 87 | 77 |
| Viet Nam | 1 | 2 | 2 | 3 | 6 | 11 | 22 | 52 | 86 | 112 | 126 | 142 | 146 | 135 | 147 | 129 | 128 | 126 |

## Mobile Subscriptions per 100 inhabitants

# Cell phone subscriptions, 1985-2017



World



South Asia



Europe



Sub-Saharan Africa
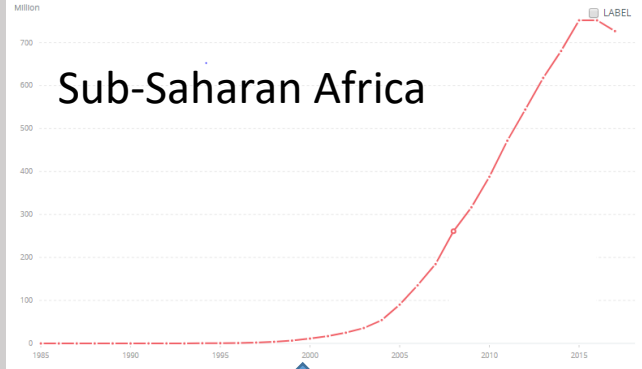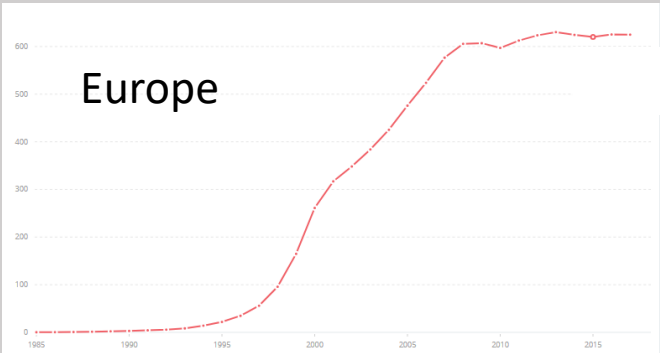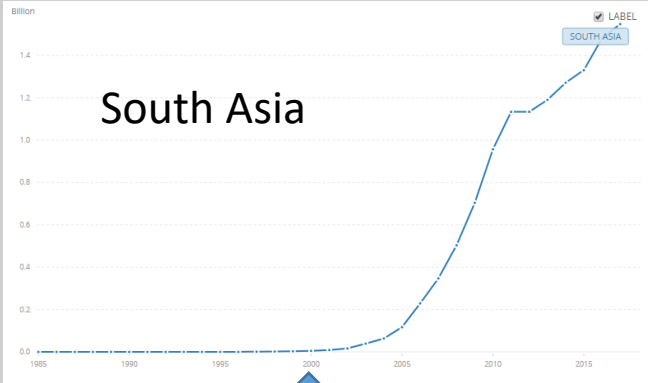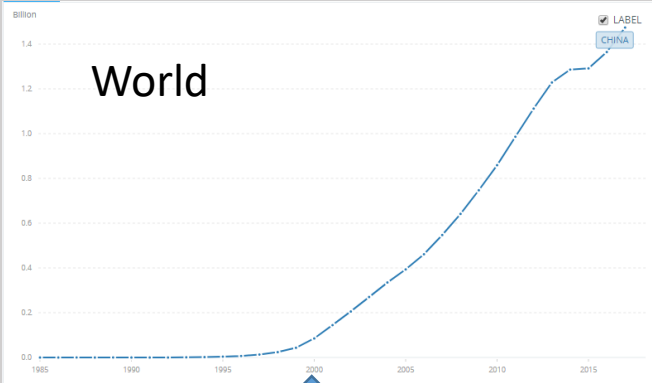
# Fish prices in Kerala



- Study by Robert Jensen of the wholesale price of fish at beach markets in Kerala, India
- Studied prices as cell towers were build moving up the coast
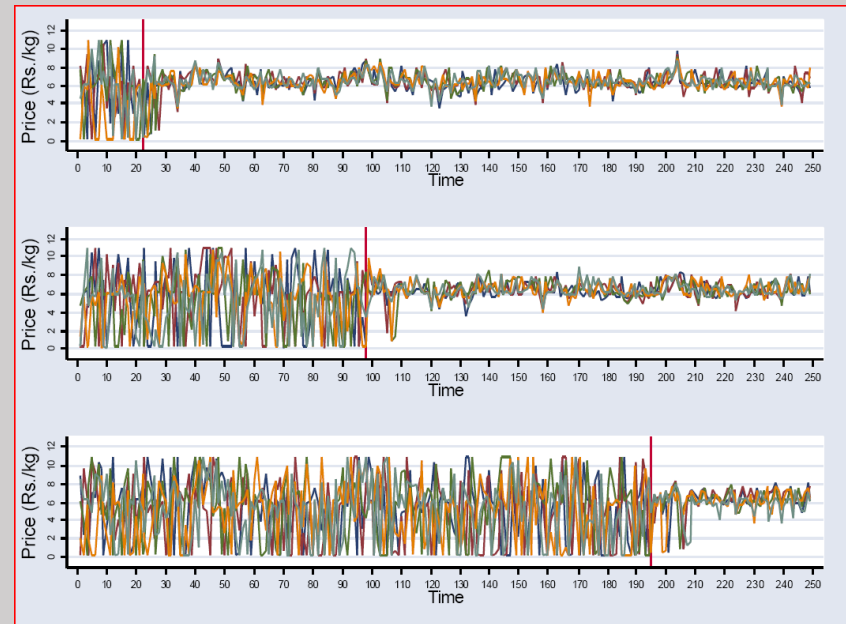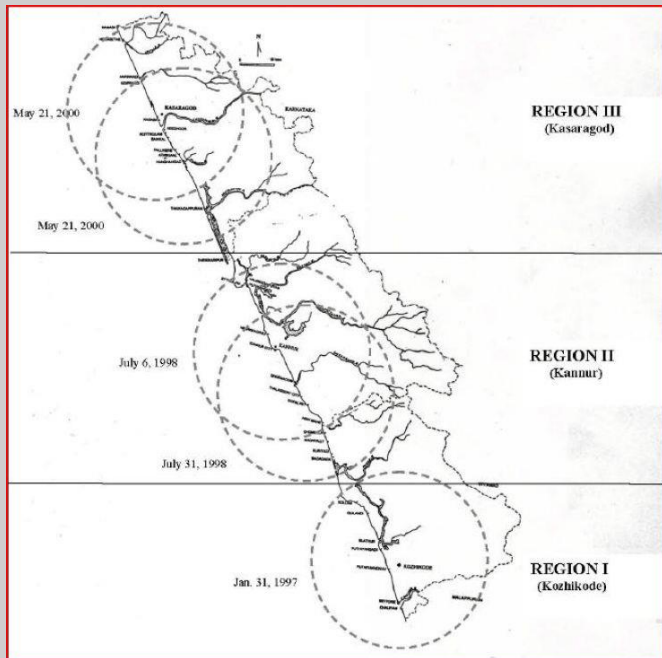
# Handset Constraints



- Connectivity
- Simcard Ownership
- Simcard Registration
- Airtime Balance
- Electrical charging
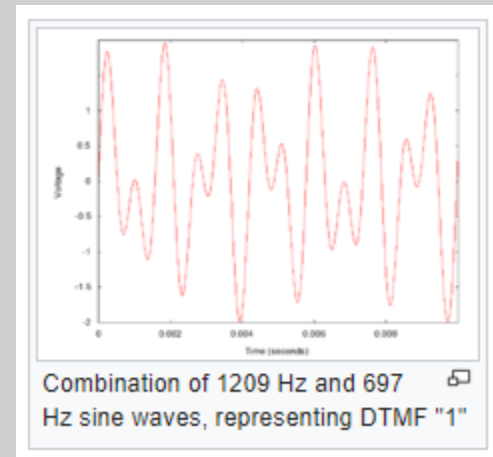- Handset Cost

# Basic Mobile Phones  (GSM Standard)

- Voice
- DTMF
  - Dual Tone Multi-Frequency
- SMS
  - Short Message Service
- USSD
  - Unstructured Supplementary Service Data

# Voice + DTMF

- Analog signal for sound waves
- Converted by handset to digital data for transmission
- Multiple codecs can be used for conversion
- Voice Fundamental Frequency:
  - Male (85 to 180 Hz), Female (165 to 255 Hz)
- Speaking frequency 20Hz to 20000 Hz
- Audible through 20000 Hz
- Telephony: Frequency band 300Hz to 3400 Hz.
- Sampling at 8000 Hz

### DTMF keypad frequencies (with sound clips)

|        | 1209 Hz | 1336 Hz | 1477 Hz | 1633 Hz |
|--------|---------|---------|---------|---------|
| 697 Hz | 1       | 2       | 3       | A       |
| 770 Hz | 4       | 5       | 6       | B       |
| 852 Hz | 7       | 8       | 9       | C       |
| 941 Hz | *       | 0       | #       | D       |

Combination of 1209 Hz and 697
Hz sine waves, representing DTMF "1"

# SMS (Short Messaging Service)

- Defined in 1985 as part of the GSM Standard
- Protocol allows seeing of up to 160 character alpha-numeric messages
- The hard thing in designing SMS was getting an agreed upon standard
  - Deutsche Telekom + France Telecom
- The first SMS was sent over Vodafone GSM Network on December 3, 1992 in the UK
- Initial growth was very slow, significant growth around 2000
  - Designed for Engineers
  - Took off when European Teenagers started using it
- SMS Gateway services are very important for building SMS applications – more later
- Hack: You can send SMS from email – 2065551212@tmomail.net

# Trivia

- What was the content of the first voice call?  (Alexander Graham Bell to Thomas Watson,  March 10, 1876)

- What was the content of the first text message?  (Neil Papworth to Richard Jarvis,  December 3, 1992)

- Why are SMS messages limited to 160 Characters.

# SMS Challenges

- Character limitation
- Expense
- Character Set – restricted to basic Latin characters (7-bit characters)
  - Unicode extensions require 16 bit – greatly reducing message length
- Difficulty of entering letters on a keypad
- Reliability

# USSD Unstructured Supplementary Service Data



- Session based protocol for communicating by text between handset and service provider

- Initiated with a short code, e.g., *144# to check Safaricom balance

- 160 character strings sent back and forth between  handset and provider until session is terminated

- Key differences from SMS
    - Synchronized communication
    - Direct with service provider:  better security
    - Does not leave messages on the phone

- Applications
    - Adding services to cell service
    - Mobile Money
    - Yellow Pages Directory

# Universal Apps