MOBILE COMPUTING
CSE 40814/60814
Spring 2021

Course Overview

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• Website:
  • https://www3.nd.edu/~cpoellab/teaching/cse40814/index.htm
  • Schedule, announcements, grading info, etc.
• Sakai:
  • Submissions, grading
• Zoom:
  • Link on website and Sakai
  • Used for office hours, Friday “LAB” sessions, remote
    attendance (quarantine, etc.), potential shut-downs, ...
Course Goals

- Fundamentals of mobile computing
- Fundamentals of wireless networking
- Topics from closely related areas:
  - Pervasive Computing
  - Wearables
  - Internet of Things
  - Real-Time Systems
  - Embedded Systems
  - Wireless sensor networks
- Acquire and practice development skills
  - Mini projects and course/group project

Mobile Computing & IoT Prospects

1. Mobile App Developer

   Median Pay: $190,440
   Top Pay: $398,000
   10-year job growth: 21%

   Whether you're Snapchatting with friends or earning Bitcoins, you probably spend time every day using the creations of mobile app developers. They aren't necessarily seeing the world, but mobile app developers get to create something that can reach millions of people on a daily basis.

   That means growing demand for developers who build and update apps as they're secure, user-friendly, and sought after.

   Why it's great: Mobile app developers are the first to test out the latest phones, tablets, and wearable devices. If you're playing around with technology and exploring all the possibilities it offers, this can be a really fun job. says mobile app developer Kyle Craig.

   CNN Money 2017

Internet of Things Engineer

Speaking of security and machine learning... the Internet of Things will need these new skills and more. It's almost impossible to talk about an IoT career because building and using embedded devices will take so many different skills. IoT is even more complex than most software now because of the complications of designing new hardware, integrating it with new software, and managing new security concerns, not to mention storing and using the massive amount of data generated.

As always, companies are looking to find a unicorn who possesses deep understanding of hardware, software, cloud, data, product and possibly dark magic, but more realistically, they're looking at hardware pros with some coding exposure, or software developers with a basic idea of how electronics work.

- Average salary: $116,000, according to Glassdoor
- Baseline skills: Wireless protocols, security, basic understanding of electrical circuits, programming (Java, C, C++), understanding of networks and cloud; preferably domain expertise
- Typical education: Degree in computer science
- Related careers: Systems analyst, business analyst, data scientist
- Recommended books: Internet of Things: Roadmap to a Connected World

TEKsystems 2017
Grading

- Midterm Exam 20%
- Final Exam 20%
- Mini Assignments 20%
- First Progress Report 5%
- Second Progress Report 5%
- Final Project Deliverables 10%
- Project Demonstration/Presentation 10%
- Class Participation 10%

Course Project

- Mini Projects:
  - Purpose: Learn/improve programming skills; learn Google Flutter
  - Individually, but collaboration encouraged!

- Class Project
  - Purpose: Develop innovative/unique "mobile computing solution"
  - Individually or in teams [1-3]
  - Collaboration across teams encouraged!
Questions?

Mobile Computing

- **A simple definition could be:** Mobile Computing is using a computer (of one kind or another) while on the move
- **Another definition could be:** Mobile Computing is when a work process is moved from a normal fixed position to a more dynamic position
- **A third definition could be:** Mobile Computing is when a work process is carried out somewhere where it was not previously possible

- **Mobile Computing** is an umbrella term used to describe technologies that enable people to access services **anytime** and **anywhere**
Mobile Computing

- Many other names/overlapping computing paradigms:
  - Nomadic Computing (mobile computing)
  - Pervasive Computing (anytime and everywhere)
  - Ubiquitous Computing (anytime and everywhere)
  - Embedded Computing (embedded in a larger system)
  - Real-Time Systems (timing requirements)
  - Wireless Networks (wireless radios)
  - Wireless Sensor Networks (connected sensors)
  - (Mobile) Ad-Hoc Networks (dynamic network formation)
  - Internet of Things or IoT ("smart things" connected to the Internet)
  - ...

Mobile Computing

Applications
- Location-awareness
- Mobility Support
- Security
- Resource Management
- Network Protocols
- Broadcast
- Technologies
- Standards
- Wireless Medium
Evolution

- Mobile computing can be categorized into **seven major categories of focus**
- These categories are the basis for the technology that is used today in research and design of mobile computing
- Each category or section is a different area that was focused on making mobile computing what it is today
- These seven categories are: Portability, Miniaturization, Connectivity, Convergence, Divergence, Apps, Digital Ecosystems

Miniaturization

- Creating new and significantly smaller mobile form factors that allowed the use of personal mobile devices while on the move
Portability

• Reducing the size of hardware to enable the creation of computers that could be physically moved around relatively easily

Connectivity

• Developing devices and applications that allowed users to be online and communicate via wireless data networks while on the move
Convergence

• Integrating emerging types of digital mobile devices, such as Personal Digital Assistants (PDAs), mobile phones, music players, cameras, games, etc., into hybrid devices

Divergence

• Opposite approach to interaction design by promoting information appliances with specialized functionality rather than generalized ones
Applications (Apps)

- The latest wave of applications (apps) is about developing matter and substance for use and consumption on mobile devices, and making access to this fun or functional interactive application content easy and enjoyable.

Digital Ecosystems

- The emerging wave of digital ecosystems is about the larger wholes of pervasive and interrelated technologies that interactive mobile systems are increasingly becoming a part of.
Example: Smartphone

- Portability: carry it anywhere you want
- Miniaturization: make it possible to build device to fit in your pocket
- Connectivity: Wi-Fi, LTE/4G, 5G, cellular, Bluetooth, RFID, NFC, …
- Convergence: phone, camera, gaming device, movie streaming, music player, …
- Divergence: ?
- Applications: “Rise of the Apps”
- Digital Ecosystem: social networks, distributed gaming, mobile cloud computing, shopping, banking/transfer, location-based services, …

App Store (iOS)

- 2003: iTunes Music Store
- 2008: iPhone App Store (500 apps)
- 2015: > 100 billion app downloads
- 2016: > 2 million apps
- 2016: App developers earned $20 billions
- 2020: Games accounted for ~40% of total app downloads
### App Store (iOS): 2020 Free Apps

- Zoom
- TikTok
- Disney Plus
- YouTube
- Instagram
- Facebook
- Snapchat
- Facebook Messenger
- Gmail
- Cash App

### App Store (iOS): 2020 Paid Apps

- TouchRetouch
- Procreate Pocket
- Facetune
- HotSchedules
- AutoSleep Track Sleep
- The Wonder Weeks
- SkyView
- Shadowrocket
- SkyGuide
- Forest – Stay Focused
Trends in Mobile: Phone Subscribers

Unique Mobile Subscribers (M)

- 2008: 2.344
- 2009: 2.608
- 2010: 3.024
- 2011: 3.325
- 2012: 3.388
- 2013: 3.183
- 2014: 3.741
- 2015: 3.638
- 2016: 4.021
- 2017: 4.334
- 2018: 4.314
- 2019: 4,314
- 2020: 4,314

CAGR 2008-2013: 7.7%
CAGR 2013-2020: 3.5%

Source: Gartner Intelligence

Mobile OS market share, 2019:
- Android: 74.2%
- iOS: 23.3%
- KaiOS: 1%
- Unknown: 0.4%
- Windows: 0.3%
- Samsung: 0.3%
Apple Raked in 51 Percent of Smartphone Revenues in Q4.

Global smartphone market share in Q4 2017 based on unit shipments and revenue.

- **Revenue**:
  - Apple: 51.0%
  - Samsung: 15.7%
  - Huawei: 7.0%
  - Others: 26.3%

- **Unit Shipments**:
  - Apple: 51.9%
  - Samsung: 19.3%
  - Huawei: 18.6%
  - Others: 10.2%
Global 5G Adoption to Take Off in 2021
Forecast of 5G smartphone subscriptions by region

Time spent on Devices

Smartphones: Average Time Spent in the US, 2018-2022
hrs/mins per day among population and % change

Note: ages 18+; includes all time spent with nonvoice activities on smartphones, regardless of multitasking
Source: eMarketer, April 2020
COVID-19 Impact

Impact Analysis of COVID-19

The Information Technology sector will see MIXED impact due to COVID-19 outbreak and is expected to register a growth rate compared to the global GDP growth.

Market Impact
This market will have NEUTRAL IMPACT due to the spread of COVID-19.

Global Dual Lens Camera Smartphone Market 2020-2024

Market growth will DECELERATE at a CAGR of over 19%.

Decremental growth
1.24 bn units

Growth for 2020
20.69%

Market estimates to be revisited and updated in Q3-2020, based on the reevaluation of the impact on the pandemic spread pathoses. The update will be available free of cost to all customers.

Trends in Mobile: Shopping

In stores, 82% of smartphone users turn to their devices to help them make a product decision.

91% growth in B2B researchers using smartphones throughout the path to purchase.

Inspiration Research Purchase Post Purchase
Trends in Mobile: Wearables

Impact of COVID-19 pandemic on 2020 revenues
2020 wearable technology forecast revised down by 17%

Trends in Mobile: Apps

3 Key Mobile App Trends You Should Know

1. Industries leading the use of on-demand mobile app services in billions USD
   - Automobiles & parts: 33.5
   - Retail: 15.7
   - Transportation: 5.6
   - Food & groceries: 4.4

2. Most popular mobile app categories in the USA
   - Communication & social: 77.1
   - Entertainment: 76.6
   - Music & audio: 75.5
   - Travel & local: 93.2
   - Health & fitness: 92.4
   - Food & drink: 88.0
   - News & current events: 86.7
   - Finance: 82.2
   - Health & fitness: 82.2

3. Projected 2020 market value of technologies requiring plenty of apps in billions USD
   - IoT: 457
   - AR/VR: 120
   - AI: 40
   - chatbots: 1.86
That’s it for today…

• Questions, comments, concerns, …?
• Up next: Project details/discussion/Q&A/etc. (Friday)