CSCI 8980
Topic in Mobile Computing

Feng Qian

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About Me

- Feng Qian, fengqian@umn.edu
- From Shanghai, China
- Ph.D. University of Michigan
- 2012-2014: AT&T Labs Research
- 2015-2018: Assistant Professor, Indiana University
- 2018-now: Minnesota
- Research Interests
  - Computer and Mobile Networking
  - Mobile Systems
  - Network Measurements
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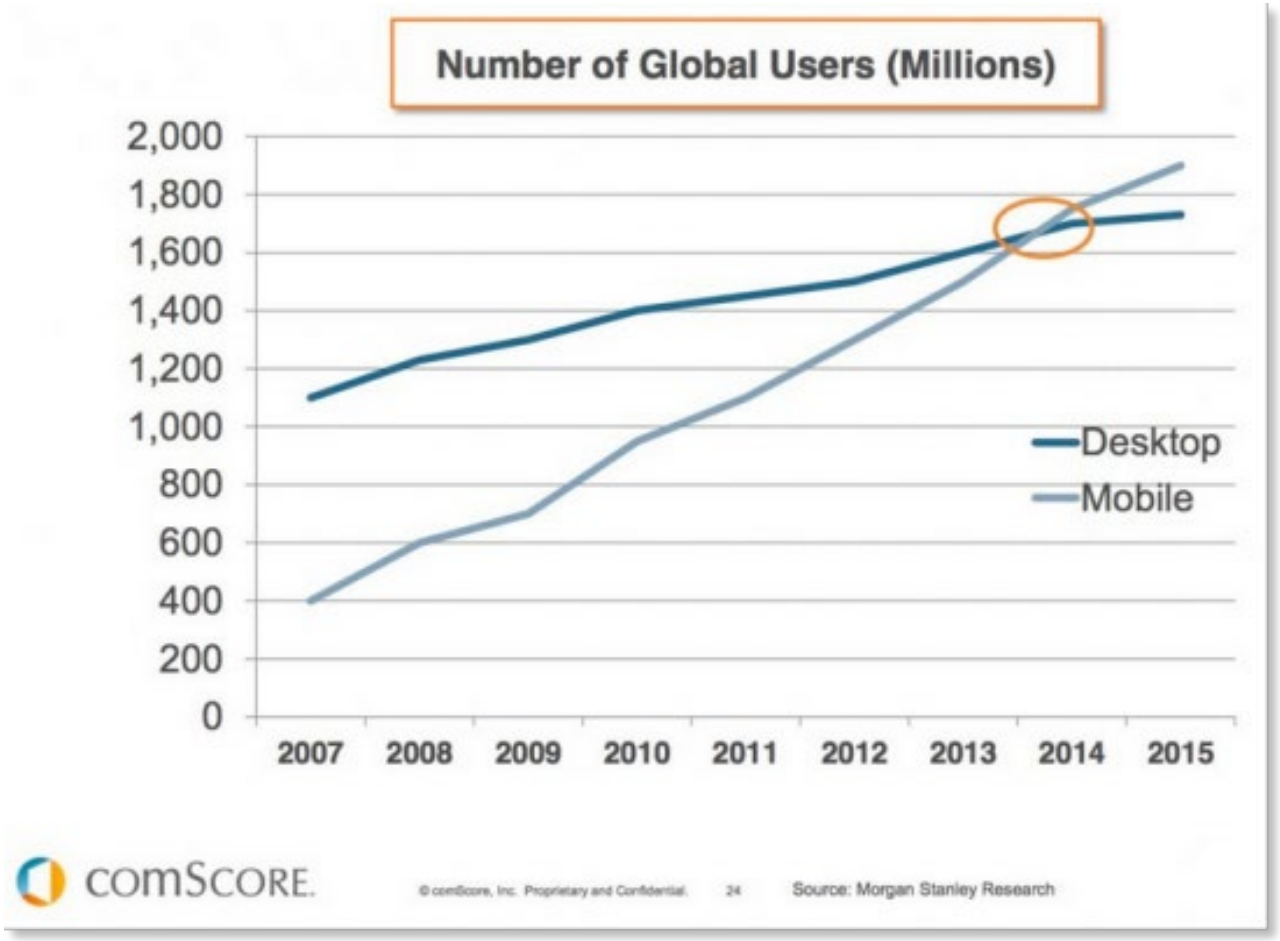
Mobile Computing

- What is computing?
- What is mobile?
- What is mobile computing?
  - Compute while moving
  - “human–computer interaction by which a computer is expected to be transported during normal usage.”
- Typical types of mobile computers
  - Laptop, smartphones, tablet computer, wearable computer, carputer (car PC)

Mobile Computing

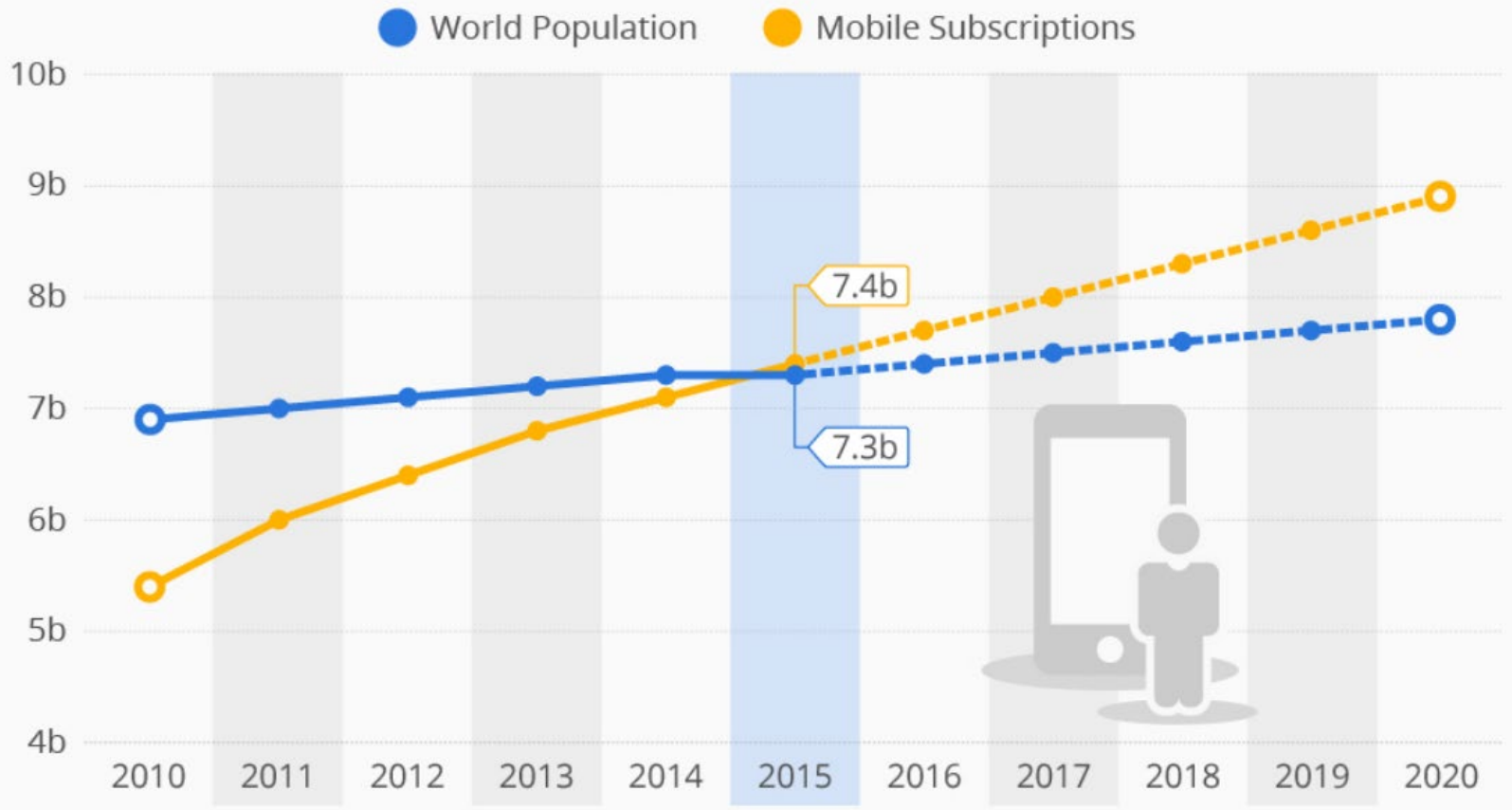
- Challenges
  - Low computation power
  - Limited battery life
  - Poor wireless network conditions
  - Diverse workload
  - Challenges in human-computer interface design
  - Security requirements

Fast Growth of Mobile Computing



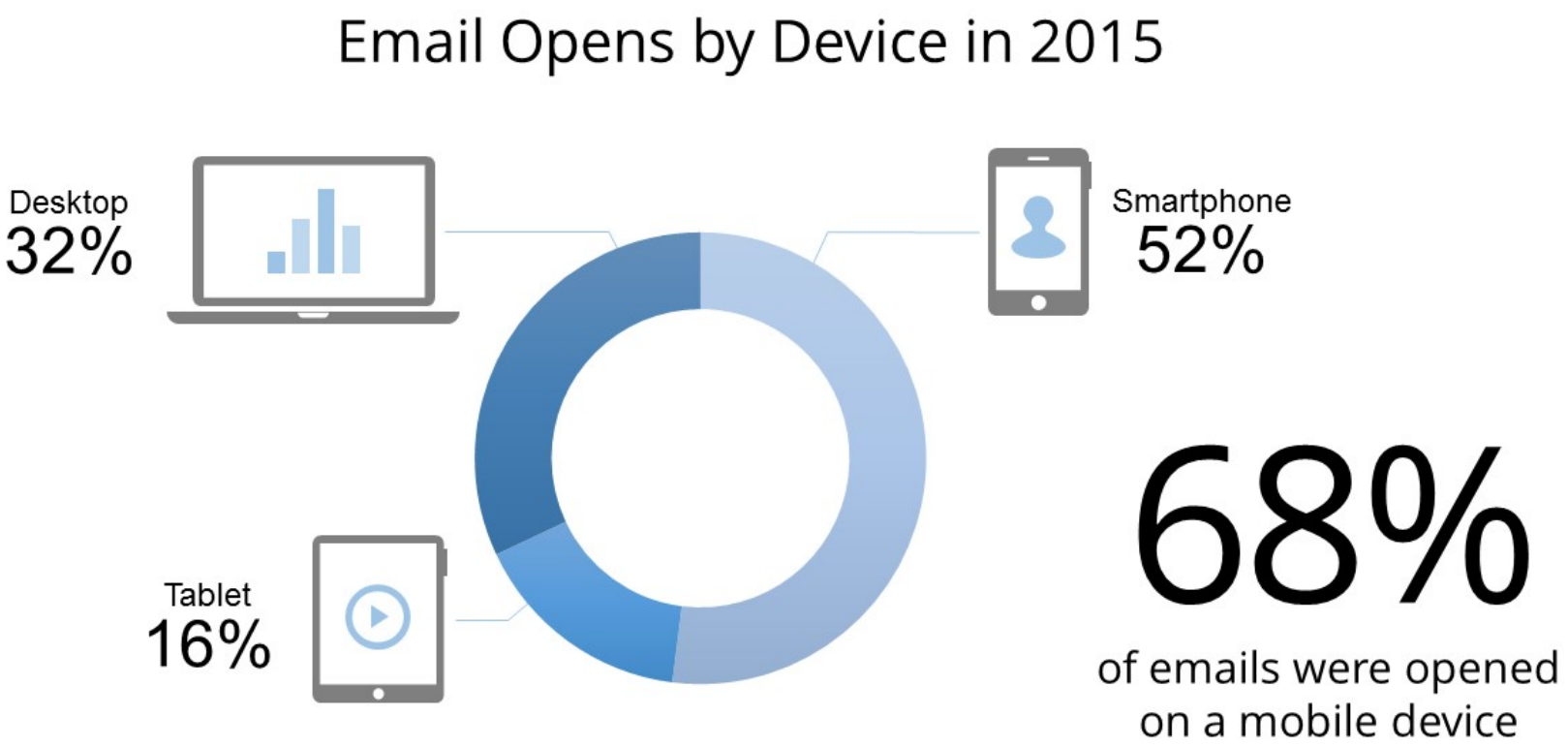
Mobile Subscriptions to Outnumber the World's Population

World population vs. estimated number of worldwide mobile subscriptions



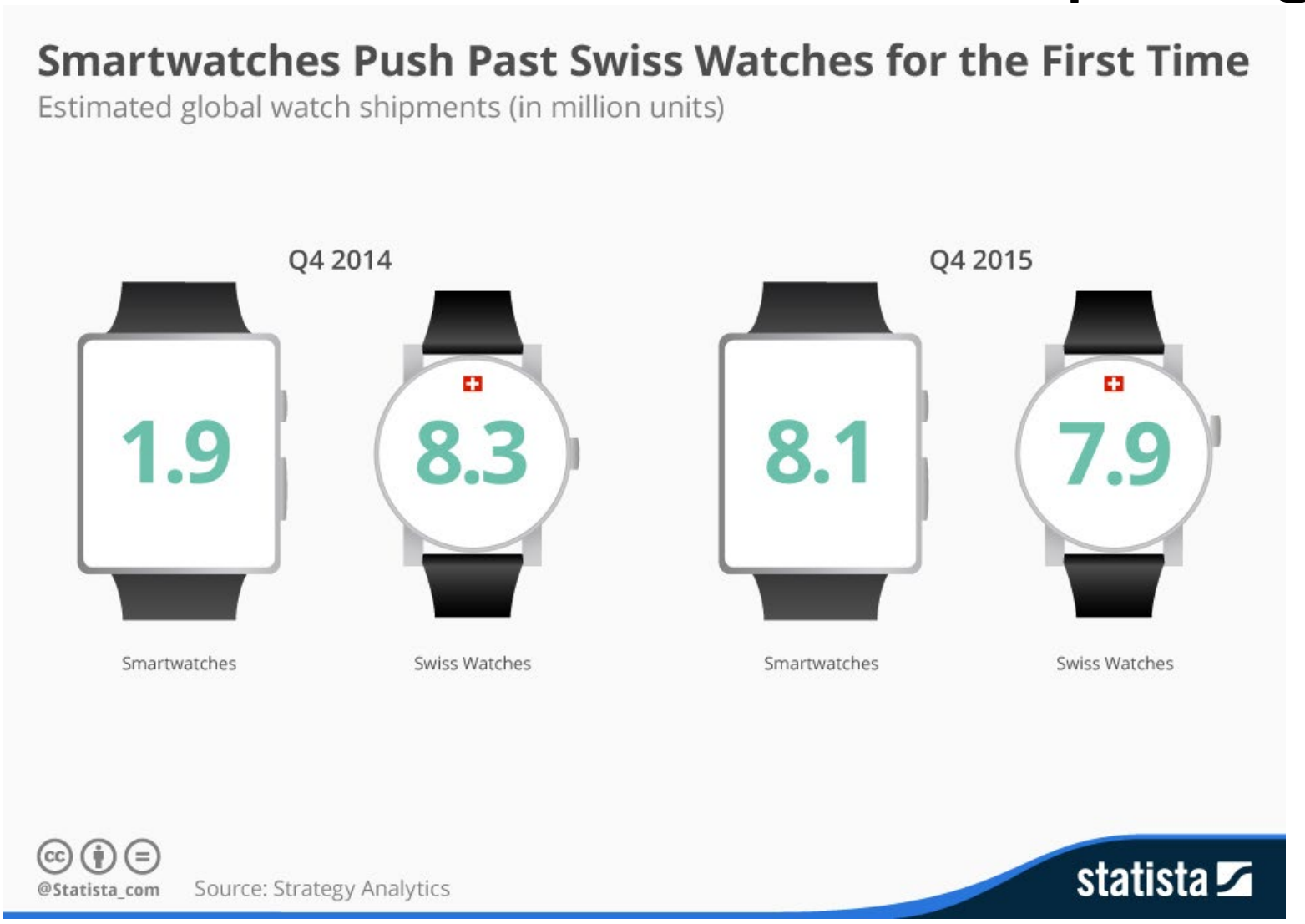
Sources: Ericsson, United Nations

Fast Growth of Mobile Computing



Data Source: US Consumer Device Preference Report, 2015 Year in Review, Movable Ink
http://go.movableink.com/Device-Report-2015-Review.html

Fast Growth of Mobile Computing



The Top 10 Products of CES 2019

- https://www.cnet.com/pictures/the-top-10-products-of-ces-2019/

The Evolution of Smartphones

IBM Simon Personal Communicator
World's first cellphone with PDA (personal digital assistant) features

1993

8in x 2.5in x 1.5in

16Mhz CPU, 16-bit
1MB Memory
1MB Storage
2400 bps Modem

$899 w/ 2-year contract
$1099 w/o contract

Touch screen

Kyocera 6035

2001

First smartphone appeared in American Market

5.6" x 2.5" x 0.86"

Palm OS
8MB Memory
160x160 display
CDMA 2G Wireless networks ~50kbps

iPhone 1st Gen

2007

4.5" x 2.4" x 0.46"

128MB Memory
4-16GB Storage
412MHz CPU
320x480 display
2G EDGE/Wi-Fi/Bluetooth 2.0

iPhone XS

2018

6.2’’ x 3.0’’ x 0.3’’

4GB Memory
64-256GB Storage
2.49GHz hexa-core 64-bit CPU
2436x1125 retina ultra-HD display
HSPA+/3G/LTE/LTE Advanced/
Wi-Fi/Bluetooth

1993

2001

Year	Thickness	CPU	Network
1993	1.5 in	16 Mhz	2.4 kbps
2001	0.9 in	20 Mhz	50 kbps
2007	0.5 in	412 Mhz	2 Mbps
2018	0.3 in	2.5 Ghz	50+ Mbps

2007

2018

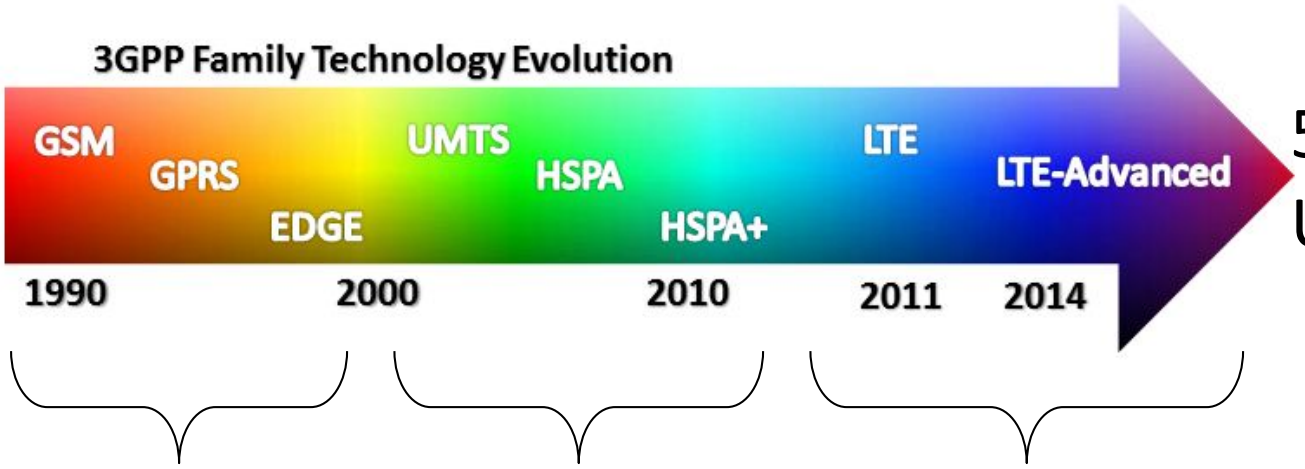
?

2029?

Cellular Technology Evolution

1G

Pre-1990



5G

Up to 1Gbps

~2022

2G

<100 kbps

3G

<5Mbps

4G

<100Mbps

Course Goal

- Take a snapshot of impactful research topics (within 10 years) in mobile computing
  - What are researchers working on in the past 10 years?
- Work on a research project about mobile computing
  - Individual project or team work

What this course is NOT about

- NOT a pure mobile app programming course
  - Extensive discussion about mobile computing research
- NOT a “pure” paper-reading seminar
  - Need to get your hands dirty

Who should take this course

- Open to all graduate and undergrad students
- In particular, those…
  - Who want to find a mobile engineering job
  - Who want some training about cool ideas (e.g., for a startup company)
  - Who want to pursue future Ph.D. study in mobile/networking/system/HCI areas
  - Who want to add some color to CV

Course Format

Syllabus (also available in Canvas)

https://www-users.cs.umn.edu/~fengqian/8980_spring19.pdf

Paper Summary

- Submit summaries of two papers (typically you decide) before each regular lecture.
- Key points to be included in the summary

1. What is the problem the paper tries to solve?
2. What is the high-level approach used?
3. What are the key results?
4. How does this work advance the state-of-the-art?
5. What are the limitations of the work?
6. What is the potential future work enabled by this paper?

Example of a good mobile system paper

Rio: A System Solution for Sharing I/O between Mobile Systems

Ardalan Amiri Sani, Kevin Boos, Min Hong Yun, and Lin Zhong

Rice University, Houston, TX

Abstract

Mobile systems are equipped with a diverse collection of I/O devices, including cameras, microphones, sensors, and modems. There exist many novel use cases for allowing an application on one mobile system to utilize I/O devices from another. This paper presents Rio, an I/O sharing solution that supports unmodified applications and exposes all the functionality of an I/O device for sharing. Rio's design is common to many classes of I/O devices, thus significantly reducing the engineering effort to support new I/O devices. Our implementation of Rio on Android consists of about 7100 total lines of code and supports four I/O classes with fewer than 500 class-specific lines of code. Rio also supports I/O sharing between mobile systems of different form factors, including smartphones and tablets. We show that Rio achieves performance close to that of local I/O for audio devices, sensors, and modem, but suffers noticeable performance degradation for camera due to network throughput limitations between the two systems, which is likely to be alleviated by emerging wireless standards.

Example of a good mobile system paper

- RIO: A System Solution for Sharing I/O between Mobile Systems (MobiSys 2014 paper)
  - https://www.youtube.com/watch?v=WqAduJJ1_Y8
- RIO allows a phone to use an I/O device on another phone via the Unix device file abstraction.
- Use cases:
  - Better game experience (use a small phone as controller, and use a tablet as display)
  - Share camera to shot a self portrait
  - Share the cellular modem (use your phone remotely)
  - Music sharing

My take-away (at a high level)

- MC is idea driven and use-case driven
  - A great idea = 60% Success
- MC is really intra-disciplinary
  - Computer Networking
  - Operating system
  - Wireless theories
  - HCI
  - Pervasive computing
  - Security

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5. What are the limitations of the work?
6. What is the potential future work enabled by this paper?

Paper Summary Example

- 1. What is the problem the paper tries to solve?
  - *This paper presents Rio, an Android framework for sharing I/O device files between mobile devices. In other words, Rio permits a phone to use an I/O device (camera, speaker, sensor, etc.) on another phone via the Unix device file abstraction (as a virtual device).*

Paper Summary Example

- 2. What is the high-level approach used?
  - *Rio uses distributed shared memory and prefetching to reduce the number of round trips for I/O operations.*

    (more technical details…)

Paper Summary Example

- 3. What are the key results?
  - *The paper shows that remote audio and sensor performance is good and video performance is only limited by throughput.*

    (more technical details – cite some numbers in the evaluation sections)

Paper Summary Example

- 4. How does this work advance the state-of-the-art? (i.e., strengths)
  - *Rio is a really cool hack and the accompanying video shows some interesting potential use cases (I especially like the use as a controller for video games). I appreciate the amount of low-level systems programming that went into building Rio into a real system and the small latency optimizations required to improve its performance. The strength of the paper is that Rio is a functioning prototype and that it can be made to work with legacy applications in a relatively transparent manner.*

Paper Summary Example

- 5. What are the limitations of the work? (i.e., weaknesses)
  - *I think the paper focuses on the problem of making I/O sharing highly performant, when it isn't clear that the level of performance Rio provides is necessary for the majority of applications. As a consequence, the paper avoids the aspects of I/O sharing that I think are more important in a practical system, such as authentication, security, and appropriate abstractions for apps.*

    A second criticism I have is that the introduction oversells the generality of the Rio architecture and the transparency with which devices can be incorporated. While conceptually simple, its clear from Sec 6.3 that some class-dependent modifications are needed in a real system. Moreover, the conclusion reports that not all device classes are yet supported, even though they use the device file abstraction.

Paper Summary Example

- 6. What is the potential future work enabled by this paper?
- …

- Important: every sentence in the summary must be written by yourself. Copying the text from the paper is not allowed (and easy to detect).

Paper Presentation

- 25-minute presentation
- Need PPT slides (make them by yourself!)

1. What is the problem the paper tries to solve?
2. What is the high-level approach used?
3. What are the key results?
4. How does this work advance the state-of-the-art?
5. What are the limitations of the work?
6. What is the potential future work enabled by this paper?

Pick Your Presentation Date

- A Google Form will be posted by Tuesday.
- Submit the following information by this Friday:
  - Your name
  - First preferred date
  - Second preferred date
  - Third preferred date

Team Project

- A critical component of this course
- A team can be formed by 1 or 2 students
- Key deadlines
  - Project proposal: **11:59PM CST, 2/26**
    Proposal presentation: **3/4, in class**
  - Mid-term status report: **11:59PM CDT, 4/2**
  - Final report: **11:59PM CDT, 5/13**
    Final presentation: **5/6, in class**

Team Project

- Key evaluation metrics

  1. **Novelty** - How novel is your proposed idea compared to the state-of-the-art?
  2. **Design** - Do you have a good design of your system / measurement / experiments?
  3. **Implementation & evaluation** - How solid are they?
  4. **Report** - Is the final report well written?
  5. **Individual contribution** - What is your individual contribution within the team (for team project)?

Spring ’17 Student Projects

- AD-libraries for Android Smartphones: Impact and Measurement Study
- Automatic Attendance System
- Evaluation of Android Doze mode
- Doze: Multiply your battery
- Profiling Resource Utilization for Instant Messaging Applications
- Handling "Blind Spots" in Mobile Internet Connectivity - A Multipath Approach
- Prefetch Procrastinator for Android
- Rethink Phone-Wearable Collaboration From the Networking Perspective
- Impact of Temperature on the Performance of Smartphones
- Investigating different video streaming techniques and their impact on smartphone resources

Spring ’18 Student Projects

- Exploring Beacon based solutions in University Landscape
- Enhancing dining experience: app Butler
- LocNote
- Switcherette: Comparative Study Of Mobile Applications And Mobile Websites
- Vision Camera: IU Lost and Found: an Application of Computer Vision on Mobile Devices
- Vulnerability Analysis of Contemporary Android Apps
- Photo Based T-Shirt Size Detection
- Hierarchical Cloud: Analysis of network performance and energy consumption for Mobile Edge Computing

How to obtain ideas

- Mobile computing research: practical, highly depends on **great ideas**
- Use case driven
  - "I want this feature on my smartphone"
  - "Can my phone do this for me?"
- Bug-fix driven
- Measurement driven
- Apply your inter-disciplinary expertise
- Skim through papers
  - Major conferences Mobisys, Mobicom, Ubicomp, Sensys, …
  - Read abstracts or even only titles / read tech news
- Think often, think in context of daily life,
  think as a human being, brainstorm with other students
- Be practical in terms of time and workload

Examples of not-so-good project ideas

- Pure implementation work (e.g., a wall-paper app for Android)
- Work without looking at real system aspects (e.g., by simulation, imaginary problem)

Rule of thumb: put this project into your CV, will your prospective employer be interested?

Major Annual Conferences and Workshops

- Mobile computing and networking: **ACM MobiCom, ACM MobiSys**, ACM HotMobile
- Sensing: ACM SenSys
- Pervasive and Ubiquitous Computing: ACM Ubicomp
- (General) computer networking: ACM SIGCOMM, ACM CoNEXT, Usenix NSDI
- Human-computer interaction: ACM CHI

Project Proposal

- 1~2 pages, single column
- Important things to cover
  - Who are the team member(s)?
  - What are we planning to work on?
  - What are the key challenges?
  - Expected results
  - Plans of implementation and evaluation
  - A brief road map: when to finish what
- Writing a good proposal helps you!
  - Be as specific as possible, so you can get feedback from me!

Status Report

- 1~2 pages, single column
- Important things to cover
  - What is the current status
  - Any deviation from the original plan
  - Any unexpected challenges encountered
  - Plan for the remaining semester
- Again, the status report is meant to help you!

Final Project

- At least 6 pages, 10pt font, in standard ACM paper format
- Treat it as a full paper
- More details follow later

ACM Word Template Baseline

10pt/12pt Font/Leading, 7.0"x9.25" Text, 0.33" Gutter

1st Author	2nd Author	3rd Author
1st author's affiliation	2nd author's affiliation	3rd author's affiliation
1st line of address	1st line of address	1st line of address
2nd line of address	2nd line of address	2nd line of address
Telephone number, incl. country code	Telephone number, incl. country code	Telephone number, incl. country code
1st author's email address	2nd E-mail	3rd E-mail

ABSTRACT

In this paper, we describe the formatting guidelines for ACM SIG Proceedings.

1. INTRODUCTION

The proceedings are the records of the conference. ACM hopes to give these conference by-products a single, high-quality appearance. To do this, we ask that authors follow some simple guidelines. In essence, we ask you to make your paper look exactly like this document. The easiest way to do this is simply to down-load a template from [2], and replace the content with your own material.

2. PAGE SIZE

All material on each page should fit within a rectangle of 18 x 23.5 cm (7" x 9.25"), centered on the page, beginning 1.9 cm (0.75") from the top of the page and ending with 2.54 cm (1") from the bottom. The right and left margins should be 1.9 cm (.75"). The text should be in two 8.45 cm (3.33") columns with a .83 cm (.33") gutter.

3. TYPESET TEXT

3.1 Normal or Body Text

Please use a 10-point Times Roman font, or other Roman font with serifs, as close as possible in appearance to Times Roman in which these guidelines have been set. The goal is to have a 10-point text on 12-point leading, as you see here. Please use sans-serif or non-proportional fonts only for special purposes, such as distinguishing source code text. If Times Roman is not available, try the font named Computer Modern Roman. On a Macintosh, use the font named Times. Right margins should be justified, not ragged.

3.2 Title and Authors

The title (Helvetica 18-point bold), authors' names (Helvetica 12-point) and affiliations (Helvetica 10-point) run across the full width of the page – one column wide. We also recommend phone number (Helvetica 10-point) and e-mail address (Helvetica 12-point). See the top of this page for three addresses. If only one address is needed, center all address text. For two addresses, use two centered tabs, and so on. For more than three authors, you may have to improvise.[1]

3.3 First Page Copyright Notice

Please leave 3.81 cm (1.5") of blank text box at the bottom of the left column of the first page for the copyright notice.

3.4 Subsequent Pages

For pages other than the first page, start at the top of the page, and continue in double-column format. The two columns on the last page should be as close to equal length as possible.

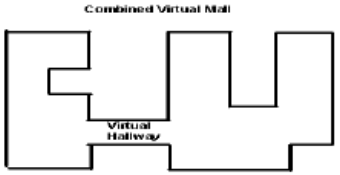

Figure 1. Insert caption to place caption below figure.

[1] If necessary, you may place some address information in a footnote, or in a named section at the end of your paper.

What if you get stuck

- High-level issue (e.g., difficult to find a good topic)
  - Talk with me at office hour (make an appointment beforehand)
- Low-level technical details
  - Google
  - Google
  - Google
  - Talk to your teammates
  - Post questions on the Canvas discussions section
  - Talk with me at office hour (make an appointment beforehand)

Individual vs. Teamwork

- Different expectations
- For teamwork:
  - Need some collaboration plan (e.g., weekly meeting)
  - Setup tools (e.g., Dropbox, SVN, Git)

Equipment and Development Environment

- Working on real devices is strongly preferred
- Projects often need a smartphone (smartwatch)
  - For some projects, working on a tablet/laptop is also fine
  - Android emulator: not recommended
- Choose your favorite platform / PL / IDE

Grading Policy

- Project: 50% (Proposal report: 5%, Status report: 5%, Final report: 40%)
- Paper summary: 35%
- In-class presentation: 5%
- Attendance: 10% (through dice rolling,
  lucky number = even number)
  - https://www.youtube.com/watch?v=9L-VhUmir-A

- Historical grade distributions
  Spring 2015: 81% A, 19% B
  Spring 2017: 100% A
  Spring 2018: 91% A, 9% B

Common Misunderstandings

- “It’s difficult to come up with novel ideas”
- “In order to make something novel, I need to deeply hack the Android/Linux kernel”
- “It is difficult to do real system work”
- “Proposal deadline is 2/26. So let’s start brainstorm on 2/25”.

Action Items

- Switch from holiday mode to working mode
- Read syllabus carefully
- Sign up for presentation date by Friday
- Start…

  looking for your team members

  reading the papers of 2/4

  thinking about the project