Seminar Introduction

COS 597S: *Recent Advances in Wireless Networks*

Fall 2024

Kyle Jamieson

Today

1. **Introduction to 597S, Administrivia**
2. How to Read a Paper (Keshav, KJ)
3. 5G Architecture (PSD Chp. 1-3)
4. **Break**
5. **Paper Discussion:** Zipper (HW)

Webpage, Instructor, Office Hours

Webpage: kyleatprinceton.github.io/cos597s

- **Instructor:** Kyle Jamieson, CS room 306
  - Office hours by appointment [calendly.com]
- **Meetings:** 302 CS, Fridays 1:30–4:30 PM
  - With a five to 15 minute break in middle

Prerequisites

- **Open** to graduate students
  - CS students who want to extend their networking background to wireless
  - ECE students who want to extend their wireless knowledge to network architecture and internet
    - Consider programming experience (project)

- **Open** to undergraduates with background
  - And with permission of the instructor
  - **COS 461**, **ECE/COS 368 , COS 333, COS 318** all helpful

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Why this seminar?

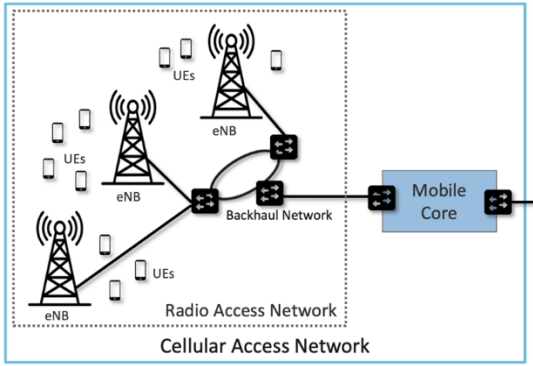
Why's wireless interesting?

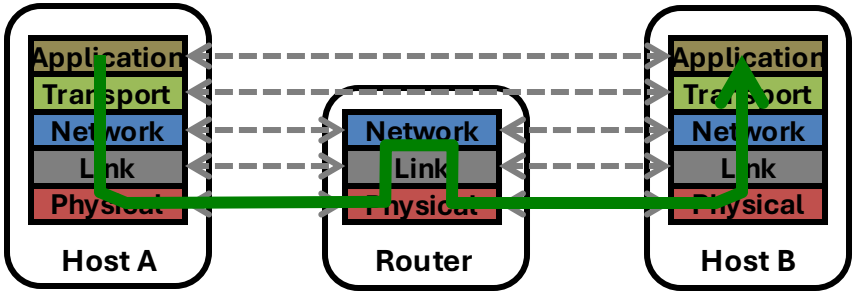
Why are the most recent advances in wireless interesting?


OMG!
I JUST GOT
BORN!

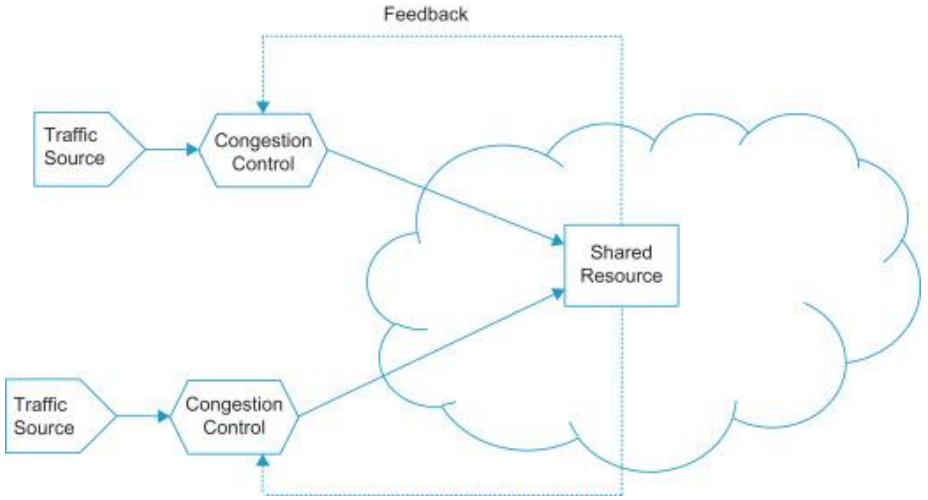
Whirlwind Tour: Weeks 1-5

Weeks 1-2: **Internet & 5G Architecture**





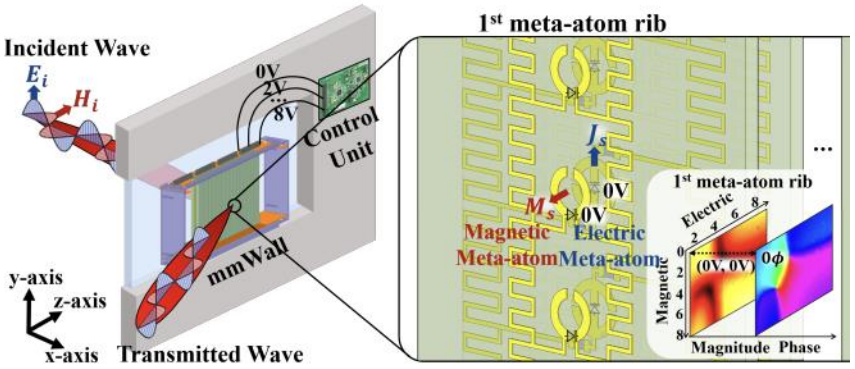
Weeks 3-5: **Wireless-Cognizant Congestion Control & 5G Radio Access Network Slicing**

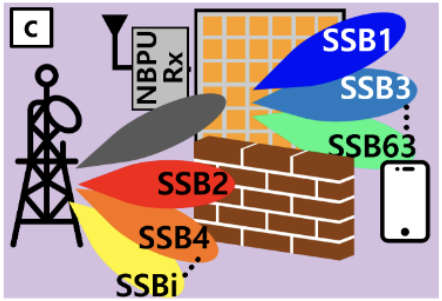


Overarching theme: the Interplay between 5G and Internet architecture

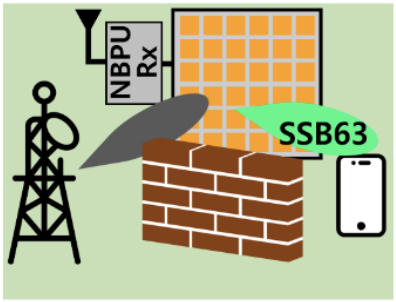
Whirlwind Tour: Weeks 6-9

Week 6: **Reconfigurable Intelligent Surfaces for 5G**



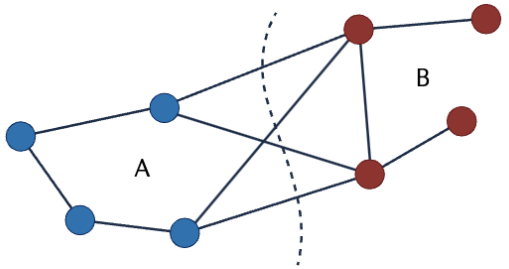


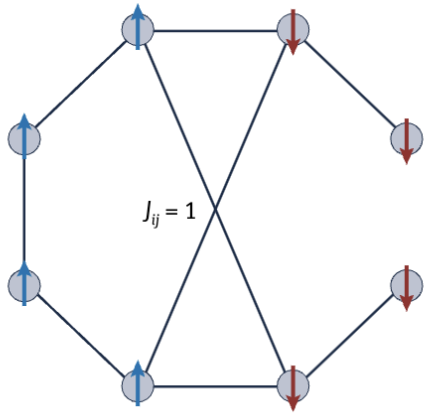
Beam sweep



Beam alignment

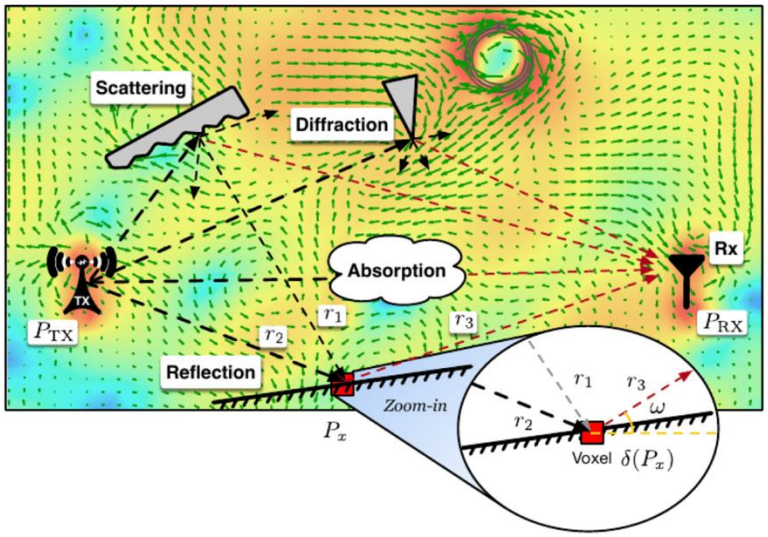
Weeks 8-9: **Computational Structures for Physical-Layer RAN Processing**





Whirlwind Tour: Weeks 10-12

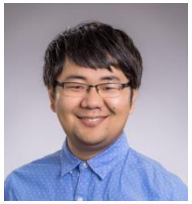
Week 10: **AI/ML for Channel Modeling and Prediction**



Weeks 11, 13: **Guest Lectures**

Alex Marder
JHU
Topic: 5G Security

Oliver Michel
Princeton
Topic: Interactive Video



Longfei Shangguan
University of Pittsburgh
Topic: E-Health

Week 12: **Student Project Presentations**

Goals of the Seminar

1. Understand **state of the art:** 5G architecture, intelligent surfaces, computational structures x Wireless, AI/ML x Wireless

2. Understand how to **do research in wireless**
   - How to read a paper, search wireless literature

3. Investigate **novel ideas** in the above areas through a **hands-on, semester-long** research project

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Soft Outcomes

- To develop **taste** and **"systems maturity"** in research
  - What constitutes a good research problem?
  - What constitutes convincing scientific evidence that a design solves a problem?

- To develop skills in **delivering clear technical explanations** in informal settings
  - Might be encountered during one-on-one job interview meetings with engineers or academics
  - Or in grad school, or at work

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Course Contents

- **Mini-Lectures:** Introduce concepts, build background
  - "Essential reading" in each sub-area
- **Research Paper Discussions:** Dive deeper into sub-areas
  - Some "Test-of-Time," others current and timely
  - Exercise **critical thinking** on **exciting current research**
    - Compare proposed solutions
    - Discuss applicability and limitations
- **Term Project:** individual or in pairs, hands-on
  - Topic is flexible; chosen in consultation with me

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Research Paper Readings: Online Discussion Period

- Available on webpage → **Perusall** platform
  - Read papers ahead of time
  - Online discussion period: Monday-Thursday 11:59 PM
  - 5-10 substantive comments/replies, **quality > quantity**

- Half of your class participation grade:
  - Contribute thoughtful questions & comments
  - Questions/comments that elicit responses
  - Answering questions from others, upvoting others

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Research Paper Readings: Class Meeting Discussion

- Come to class meeting prepared to discuss:
  1. What problem is the paper solving , why is problem important?
  2. What was the previous state of the art and how does this paper advance that state of the art?
  3. How does the protocol, design, or system work?
  4. What are the key insights in the design that enabled it to advance the state of the art?
  5. How implemented and evaluated, what are the key results?
  6. What related problems are still open; is problem fully solved?

- Other 50% of your class participation grade

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Discussion Paper Presentations

- Each student presents 2-3 research papers over the semester
  - Papers are marked **Paper Discussion** on schedule
- Your talk should **clearly explain ideas** and **constructively critique** the ideas and results
- Lead presenters listed on schedule, **allocated** first-come, first-serve by **emailing instructor**

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Discussion Paper Presentations

- Chalk talk or slides for **30–45 minutes**

- Then, **open discussion**
  - Come prepared to **lead class discussion** after talk
    - Based on Perusall discussion, your own thoughts

  - Non-presenters should be prepared to actively participate in the discussion

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Outline of a Discussion Paper talk

- Motivation and problem statement (**context**)

- State main contributions of work (**core ideas**)

- → Description of central design
- → Experimental evaluation
- → Related and Future work
- → "Opinion part"
- → Summary of Perusall Discussion (on Perusall)

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Talk: Description of central design

- Focus on the **most important points:**
  - Understanding **how and why the system**, design, or algorithm works
  - To **understanding results** in the experimental evaluation

- **Clarity,** not "parroting," is very important here:
  - Often, describe in a **top-down fashion**
  - Start with the **overall design** of the proposed work
  - Identify parts of the solution, then identifying the sub-parts of those parts, *et cetera*

Talk: Experimental evaluation

- **What questions** do the authors ask in their evaluation?
  - What is the authors' hypothesis for each question and why?

- Does evaluation **stress the system** to its **"breaking point?"**
  - Multiple axes? **Transparency** of system's **limitations**

- What **baselines** for evaluation? Are they **fair**? Any **missing**?

- For any **graph** you show or refer to:
  - First, **explain axes and trend:** why behaves as it does
  - **Justify:** refer to design, experimental details
  - Anything seem **anomalous**? Note and try to explain

Talk: Related and future work

- What are the **most closely related** other systems/results?
  - How are they **similar, different**? Significant differences?
- Should read citations enough to understand differences
- Should search for related work published after/with the paper
- **No need to claim** the work you are presenting is **"better" or "worse"** than a particular piece of related work
  - Often it is simply that the two pieces of work are different
- But, should **articulate the precise difference** (*e.g.*, "this work solves a slightly different problem…")

Talk: Opinion part

- Offer **your final critical assessment:**

1. What are the **strengths** of the work?
2. What are the **weaknesses/limitations**?
3. What important questions are left **unanswered**?

Talk: Summary of Perusall Discussion

- Suggest you **open** up the paper **in Perusall** web page
- **Drill down** into the most insightful discussion threads
- Summarize out loud, then **we discuss as a group**

Independent Research Project

- **Systems-building,** involving significant programming effort
  - "*We believe in rough consensus and* ***running code***"

- Two options:
  1. **Reimplementing and Reproducing Research Project**
     - Independently reimplement a 597S paper
     - Reproduce the results

  2. **Novel Research Project**
     - Must be closely related to 597S
     - Must be formulated in consultation with instructor

Project: What and When

- Systems-building project involving significant programming
  - **Individually, or in small teams**
  - **Working code** uploaded to Princeton University's github organization and shared with instructor

- **Timeline:**
  - 10/4: Team Formation and Initial Project Proposal deadline (500-750 words, on **Ed Discussions**)
  - 10/5–24: Proposal Discussion Period (**Ed**)
  - 10/25: **Final Project Proposal deadline**
  - 12/13 (Dean's Date) 11:59 PM: **Final Project Report** and Source Code Submission deadline

Project Proposal: Reproducing Research

- **Structure:**
  - Background paragraph of the paper, authors, venue
  - Summarize problem domain and challenges
  - Describe design, evaluation, key experimental results
  - Present **reproduction and evaluation plan** (biggest part)
    - Implementation strategy (language, framework)
    - Evaluation strategy (experiment design, data sources)
    - Which key results will you reproduce?

- If in a team: provide work plan, including rough division of labor

Project Proposal: Novel Research

- Novel Research Proposal
  - *Introduce and clearly explain* the problem
    - context: most relevant related work with citations
  - Sketch high-level system design (changeable!)
  - Highlighting new knowledge contributions
- If applicable, provide a plan for experimental evaluation (changeable!)
- If in a team: provide work plan, including rough division of labor

Project: Final Report

- Same structure as the research papers we will read:

- Introduce and motivate the problem
  - Placing in context of some related work

- Describe your design clearly

- Present a performance evaluation
  - Comparing your design to a "strawman" system

- More related work, and conclusion

Class Grading

- **30% participation**, of which:
  - 50% online E-Discussion (Perusall) participation
  - 50% in-person participation

- **30% oral presentations**, of which:
  - 50% discussion research paper presentations
  - 50% research project presentation

- **40% research project**, of which:
  - 15% proposal
  - 25% project status report, demo, code/design walkthru
  - 60% final written report and code

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How to Read a Paper (Keshav)

- **Goal:** efficiently read a paper (also: understand how conference reviewers read papers!)
- **Approach:** three passes

- **First pass *(ca.* 10 min.):** **scan** for a high-level view of the paper
  - Title, Abstract, Introduction
  - Section, sub-section headings, conclusions
  - Scan references

- **First pass result:** category, context, correctness, contributions, clarity

How to Read a Paper: 2nd and 3rd Passes

- **Second pass (up to one hour):** Reading for content
  - Make (e-)comments in the "margins" (*i.e.*, in **Perusall**)
  - Pay attention to graphs (quality of work)
  - May not have full understanding at the end of the 2nd pass

- **Third pass (up to 4-5 hours for beginners):** Full understanding, ***almost*** re-implementing in your mind
  - Attention to detail
    - Identify and challenge every assumption, assertion, even citations (**comment and discuss** in **Perusall**)
  - **Result:** Can identify strengths, weaknesses, missing citations, implicit assumptions, experimental design issues

How to Do a Literature Survey

- To start: **Related Work sections** of 3-5 *recent* papers in area
  - Goal: Find **key researchers** in the area, thus **key venues**

- Explore the "citation forest" (*i.e.*, many trees):
  - **Tree Roots: (1)** key researchers most-cited, most-recent work; **(2)** most recent work in key venues

  - **Edges:** papers this one cites and papers that cite this one
    - 1st pass and possibly 2nd pass, target this paper's related work section
    - **Prioritize** highly-cited, key venue, key researcher papers

How to Organize a Literature Survey

- While you execute the literature survey algorithm, **build your literature survey database**

- Retain **highlighted/commented** papers in your **database:**
  - Use **hierarchical folders** to **organize by sub-theme**
  - Use **"tags"** for cross-cutting categories:
    - Different experimental approaches
    - Most recent v. most-cited work
  - Zotero is a great tool but there are many others
    - If you choose well some can **auto-generate bibliographies** for your future papers

Up next:

5G Network Architecture (P&D 1-3)