2018 Fall SJTU Computer Networks

Topics for Final Project

Logistics

- Your job:
  - Reproduce the work from one or multiple papers related to computer networks.
  - Give a live demo.
- Submission
  - Presentation slides
  - 4-page report: motivation, methods, challenges, results, discussion
  - Complete codes of the system / simulation / emulation
- Score
  - 50%: Completeness of the implementation
  - 30%: Scores from classmates
  - 10%: Presentation and report
  - 10%: Beyond the paper
  - Personal bonus: ask questions during Q&A session

Tips

- Start early
  - Apply for public platforms
  - Purchase equipment
- Search online for video, talk, project website, codes (github, gitlab)
- Read previous works and related papers
- Never hesitate to ask
  - Stuck in some step / don’t understand the paper
  - Need extra equipment
  - Even ask authors for codes / data

Topics for Final Project

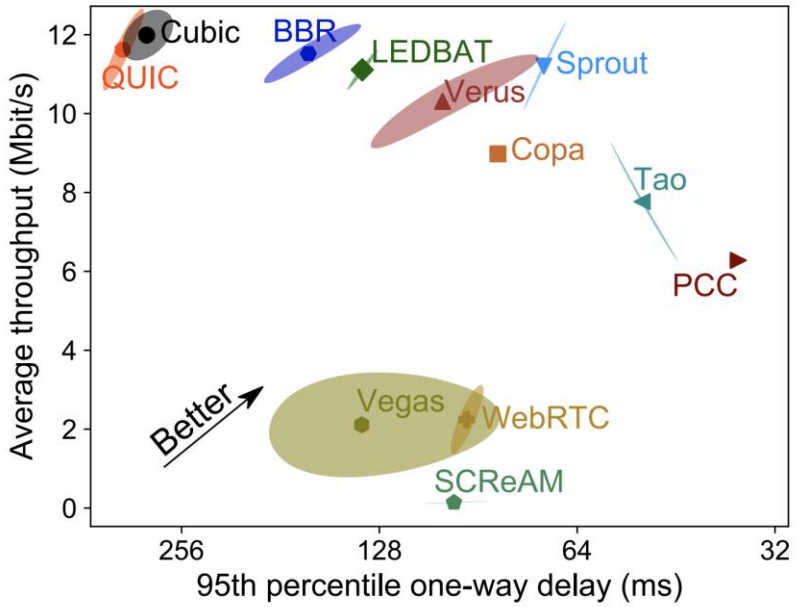
- **Network Performance and TCP**
  - AI-Enhanced Internet Performance Optimization
  - Platform for Validating Various TCP Variants
  - Online TCP Flavor Identification
  - Step Toward TCP Optimization in Android Devices
  - Fairness Among TCP Among Various Mobile Devices
- **Wireless Networking**
  - Cross-Talk Between WiFi and ZigBee
  - Battery-less Communication
- **Side-Channel Communications**
  - Side Channel Communication Through Cables
  - Side Channel Communication Through Light
  - Other media
- **Network Data Analytics**
  - Gold in Network Data
  - …
- **Advance Network Functions**
  - Augmented Functions Provided in Future Networks

Topics for Final Project

- **Other topics**
  - Data Center
  - Sensor Networks
  - Body Networks
  - Social Networks
  - Delay Tolerant Networks
  - Vehicular Networks
  - Cloud Computing
  - Edge Computing
  - Content Delivery Network (CDN)

Network Performance and TCP

- **T**ransmission **C**ontrol **P**rotocol (**TCP**)
  - Reliable communication protocol to exchange data among two nodes.
  - Most common protocol in the Internet nowadays.
  - However,
    - Complicate mechanisms: fast retransmition, slow start, sliding window, duplicated Ack, selected Ack, congestion control, …
    - Many many variants:
      TCP Reno, Tahoe, Vegas , QUIC, Cubic, BBR, …



AI-Enhanced Internet Performance Optimization

- Papers:
  - PCC Vivace: Online-Learning Congestion Control. http://pccproject.net/
  - AuTO: Scaling Deep Reinforcement Learning to Enable Datacenter-Scale Automatic Traffic Optimization. SigComm 2018.
  - Characterizing the Internet Host Population Using Deep Learning: A Universal and Lightweight Numerical Embedding. IMC 2018.
- Problem space:
  - What are the causes of the network performance problems?
  - Who traditional methods cannot solve the problems?
- Solution space:
  - How does deep learning help?
  - Which ML algorithms work the best? Why?

A Step Toward TCP Optimization in Android Devices

- Paper:
  - Linux Extended BPF (eBPF) Tracing Tools
    http://www.brendangregg.com/ebpf.html

- Problem space:
  - eBPF is a very efficient tool in Linux to extract packet level information. Existing literature has shown the capability to use it for TCP Optimization in Linux kernel. The project asks you to run eBPF on Android devices and show the efficiency of capturing flow information.

Platform for Validating Various TCP Variants

- Papers:
  - Pantheon: the training ground for Internet congestion-control research, ATC 2018
  - https://pantheon.stanford.edu/
- Goal:
  - Pantheon is a platform for researchers to implement and evaluate their own TCP protocols.
  - Build your own TCP by varying initial window sizes and see how they perform.
  - Compare your TCP implementation with those provided in Pantheon in throughput, latency.

Online TCP Flavor Identification

- Papers:
  - Inferring TCP Connection Characteristics Through Passive Measurements.
- Goal:
  - Various TCP flavors have their own behaviors and parameters.
    - e.g., slow start, initial window, …
  - Use network tools (e.g., PCAP) to capture packets in the background and identify what TCP flavor is for each flow.
  - What kind of flows can be identified?
  - How many flavors you can identify?
  - How efficient is your implementation (i.e., run in real-time when the traffic is under XXX bps)?

Fairness Among TCP Among Mobile Device Brands

- Problem space:
  - Fairness is one of the important properties in TCP design principle. However, the fairness can be easily broken by altering a few parameters in congestion control, slow start mechanisms. Nowadays, while mobile device manufacturers maintain their own customized Android OS, it’s likely that they may adjust these parameters to gain extra bandwidth for their users. The projects asks you to perform field study over mobile devices of various brand and see if any manufacturer has better network performance than others under the same environment.

Wireless Networking

- **Wireless Networking** is gaining increasing importance in our daily life
  - Popularity of mobile devices
  - WiFi, Cellular Networks (GSM, 3G, 4G LTE, 5G), Bluetooth, ZigBee, NFC, etc
  - Low-Power, Wide-Area Network (LPWAN): Lora, Sigfox, NB-IoT, etc

Cross-Talk Between WiFi and ZigBee

- Paper
  - WEBee: Physical-Layer Cross-Technology Communication via Emulation. MobiCom 2017.
- Problem space:
  - Traditionally, WiFi, ZigBee, and Bluetooth operating in the same frequency but require individual hardware (antenna and chip) to transmit, receive, and decode the data through each protocol. Recent advance show that one can use emulation technique to manipulate only the payload of WiFi packets, requiring neither hardware nor firmware changes in commodity technologies, and allow cross-talk between WiFi and ZigBee. The project asks you to implement the emulation technique and give a live demo.

Cross-Talk Between X and Y

- How about WiFi, Bluetooth, RFID, LTE, etc?

Battery-less Communication

- Papers
  - X-Tandem: Towards Multi-hop Backscatter Using Commodity WiFi. MobiCom 2018.
  - FlipTracer: Practical Parallel Decoding for Backscatter Communication. MobiCom 2017.
  - NICScatter: Backscatter as a Covert Channel in Mobile Devices. MobiCom 2017.
- Problem space:
  - Development of IoT, sensor networks are constrained by power sources and communication is blamed.
  - What are challenges?
- Solution space:
  - Which medium to use?
  - How to make it widely available?
  - How to improve bandwidth?

Side Channel Communications

- **Side Channel Communication**
  - Represents a capability to transfer data between devices using media which is not designed for communication.
    - Common media:
      - Ethernet cable, USB, WiFi, LTE, power line, etc
    - Side channel:
      - Speaker and microphone: encode data in sound
      - Light (screen) and camera: encode data in light
      - CPU and magnetic sensor: encode data in electromagnetic induction
- **Applications**
  - Additional bandwidth – exchange more data
  - Security – exchange data secretly

Side Channel Communication Through Cables

- Paper
  - AirHopper: Bridging the air-gap between isolated networks and mobile phones using radio frequencies. MALWARE 2014.
  - Bridging the Air Gap between Isolated Networks and Mobile Phones in a Practical Cyber-Attack. ACM Transactions on Intelligent Systems and Technology (TIST) 2017.
  - GSMem: Data Exfiltration from AirGapped Computers over GSM Frequencies. USENIX Security Symposium 2015.
- Problem space:
  - Side channel communication represents a capability to transfer information between multiple devices using media which is not commonly used for communication. The above literatures show one can send data using electromagnetic signals in the FM or GSM radio band emanating from the video cables or RAM buses. The project asks you to implement any of these works and give a live demo. If you can find a novel side channel, it will be a big plus.

Side Channel Communication Through Light

- Paper
  - ChromaCode: A Fully Imperceptible Screen-Camera Communication System. MobiCom 2018.
  - The darkLight Rises: Visible Light Communication in the Dark. MobiCom 2016.
  - Towards a Visible Light Network Architecture for Continuous Communication and Localization. VLCS 2016.
- Problem space:
  - Light is also a common side channel in recent years. The project asks you to implement any of these works and give a live demo.

Data Analytics

- **Networks are constantly generating a huge amount of information**

		
Internet/Wireless Networks Traffic matrix Delay matrix CSI matrix	**Mobile Networks** GPS info/checkins Social connections Activity data	**Sensor Networks** Environment data Body sensor data Quality monitoring

Data Analytics

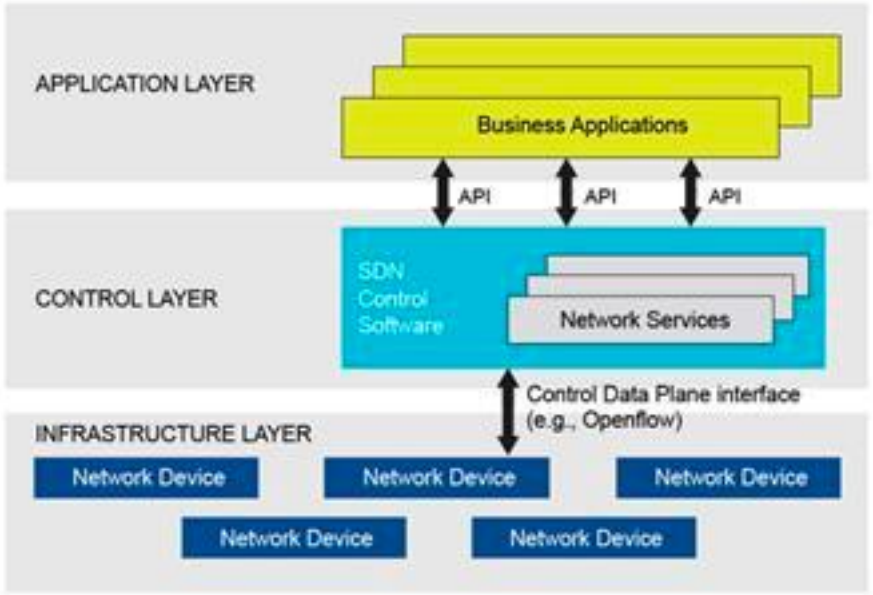
- **Applications**
  - Improve network performance
  - Understand user's preference
  - Predict user's mobility pattern
  - Save power
  - …
- SJTU Network generates TBs of data per day.
  - What can we learn from it?
    - Tracking individual users
    - Inferring users' preference, activities, etc
    - Design better protocols
    - Reduce power of network infrastructure

Gold in Network Data

- Papers:
  - Impact of Device Performance on Mobile Internet QoE. IMC 2018.
  - Mobility Support in Cellular Networks: A Measurement Study on Its Configurations and Implications. IMC 2018.
  - Following Their Footsteps: Characterizing Account Automation Abuse and Defenses. IMC 2018.
  - Anonymization of Location Data Does Not Work: A Large-Scale Measurement Study. MobiCom 2011.

Advance Network Functions

- **Software Defined Networks (SDN)**
  - SDN define an approach to separate the network's control plane (brains) from forwarding (muscle) planes.
  - It enables the network control to become directly programmable.
  - The underlying infrastructure is abstracted for applications and network services.



Augmented Functions Provided in Future Networks

- Papers (Localization)
  - In-body Backscatter Communication and Localization. SigComm 2018.
  - Decimeter-Level Localization with a Single WiFi Access Point. NSDI 2016.
  - Verification: Accuracy Evaluation of WiFi Fine Time Measurements on an Open Platform. MobiCom 2018.
- Problem space:
  - Why we need localization?
  - It has been studied for decades – why is not widely available yet?