RouterSense

Turning existing home routers into health sensors

Prof. Danny Y. Huang

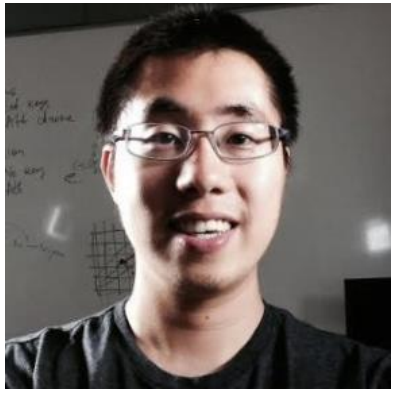
Dept of Electrical and Computer Engineering

Team

Rameen Mahmood
PhD Student

Dr. Donghan Hu
Postdoc

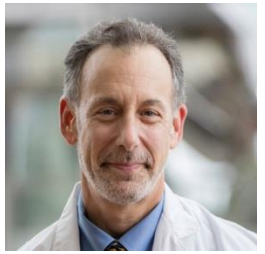
Soon-to-be Dr. Shinan Liu
AI/ML advisor @ UChicago

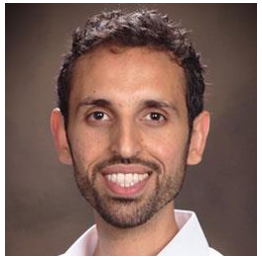


Prof. Danny Y. Huang
PI & User #1

Key collaborators

Andrew Kiselica, PhD, ABPP-CN (University of Georgia)
Jeffrey Kaye, MD (Oregon Center for Aging and Technology)
Zachary Beattie, PhD (Oregon Center for Aging and Technology)
Nabil Alshurafa, PhD (Northwestern)
John-Ross “JR” Rizzo, MD (NYU Langone)

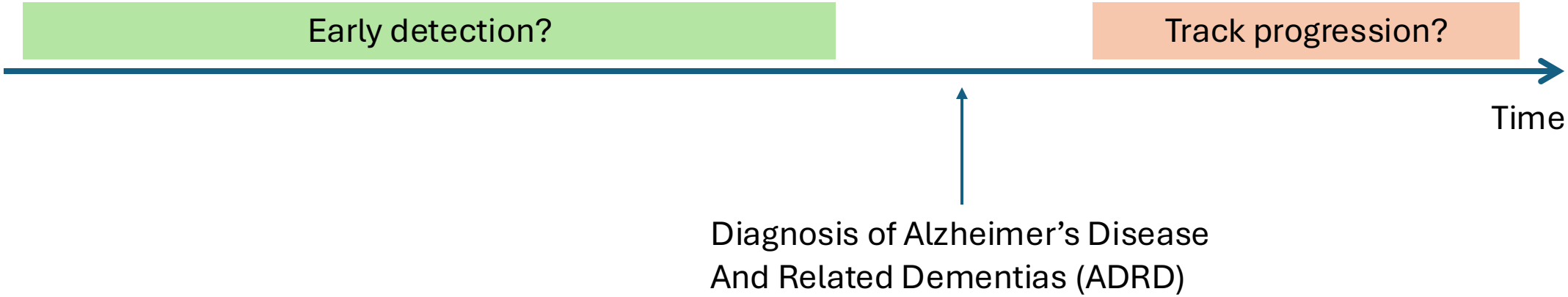




Monitoring an older adult for ADRD

Early markers

Sleep disruptions
Social withdrawal
Reduce cognitive engagement



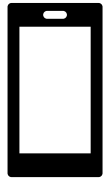
Traditional methods of in-home monitoring

no hardware needed

hardware needed

self-reports

Objectivity?



apps

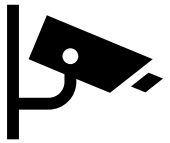
Battery?
Multiple devices?

RouterSense

Software-only
Low-config
Connect-and-forget

wearables

Adherence?
Compliance?
Cost?



sensors

Cost?
Privacy?

low

$$$

high

RouterSense

- ✓Software system that runs on commodity hardware
- ✓Collects and analyzes home network traffic passively
- ✓Plug-and-play
- ✓Low-config, low-expertise
- ✓Connect-and-forget

RouterSense

Home WiFi Router

- ✓Software system that runs on commodity hardware
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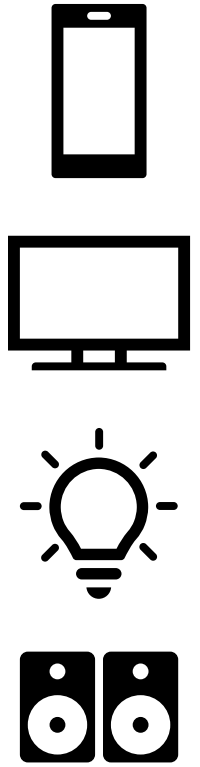
Existing PC or Mac



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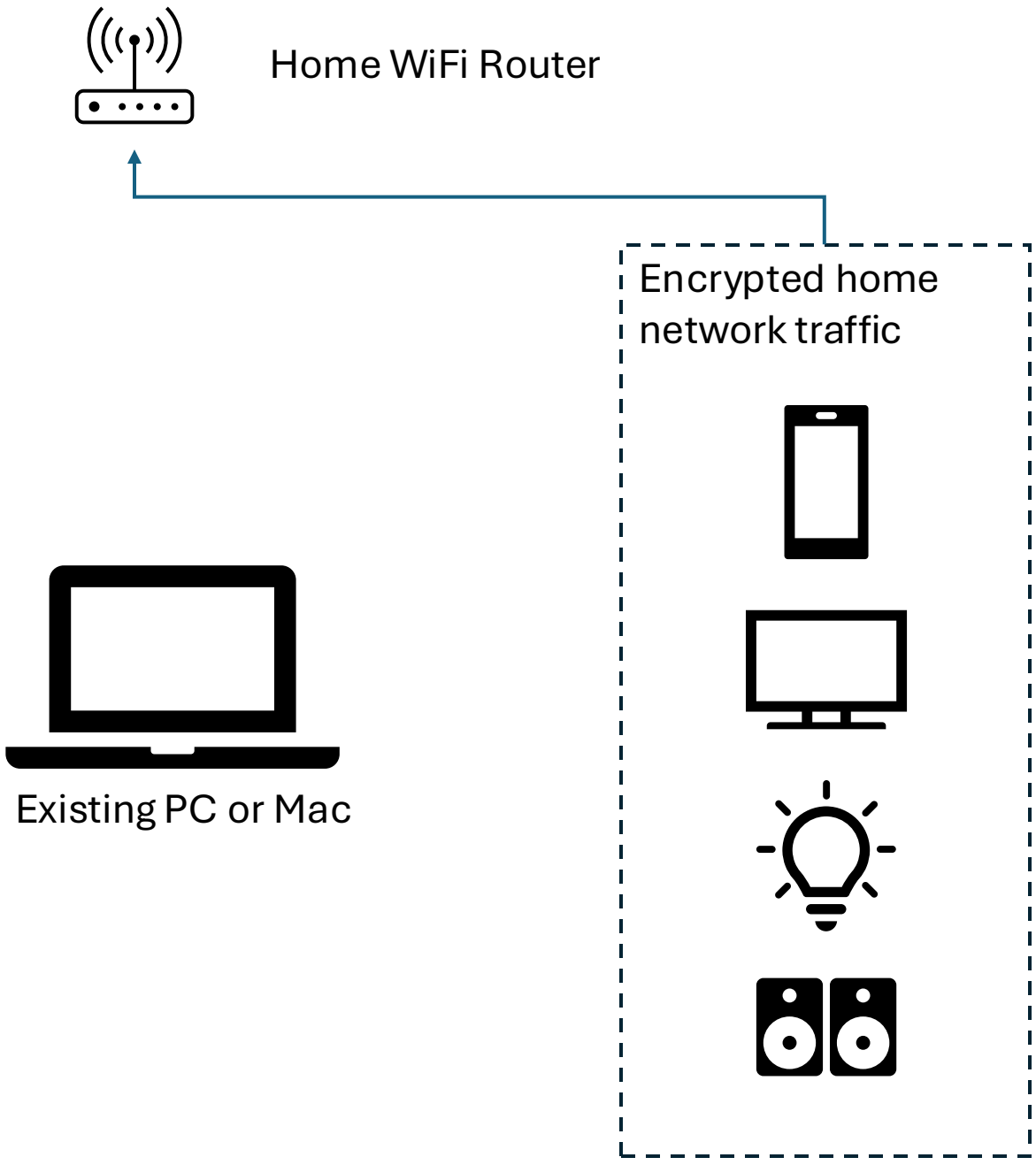

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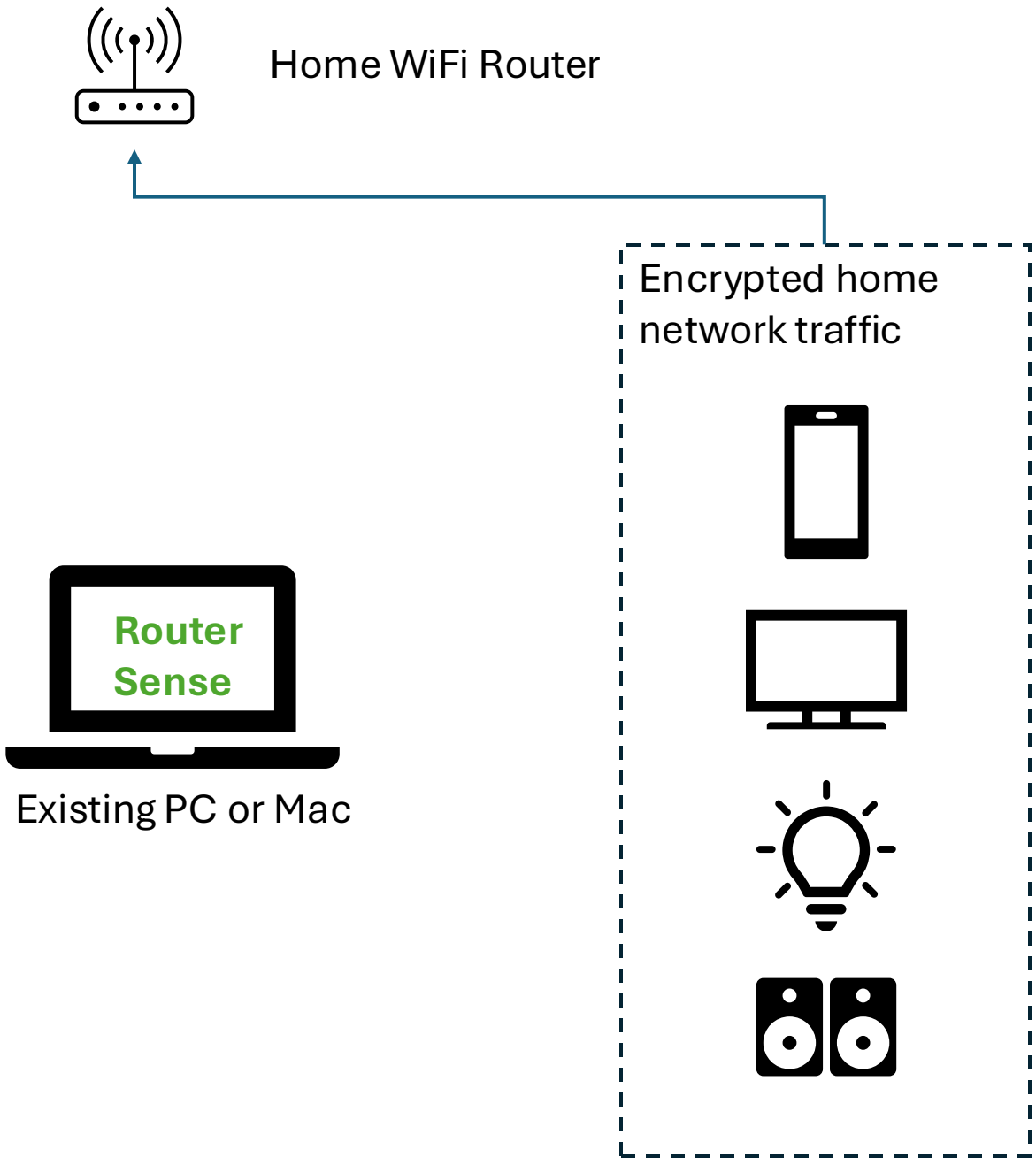

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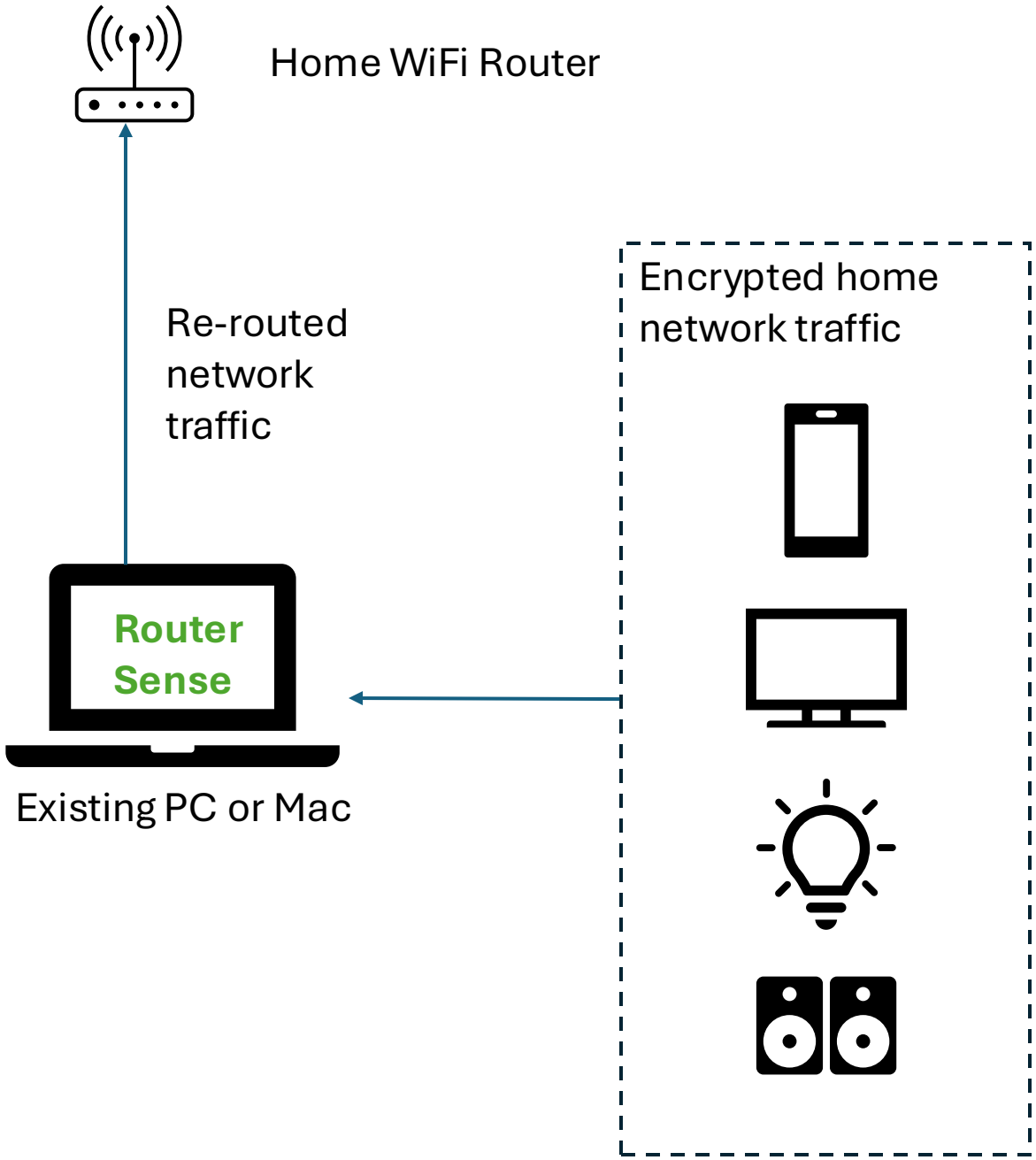

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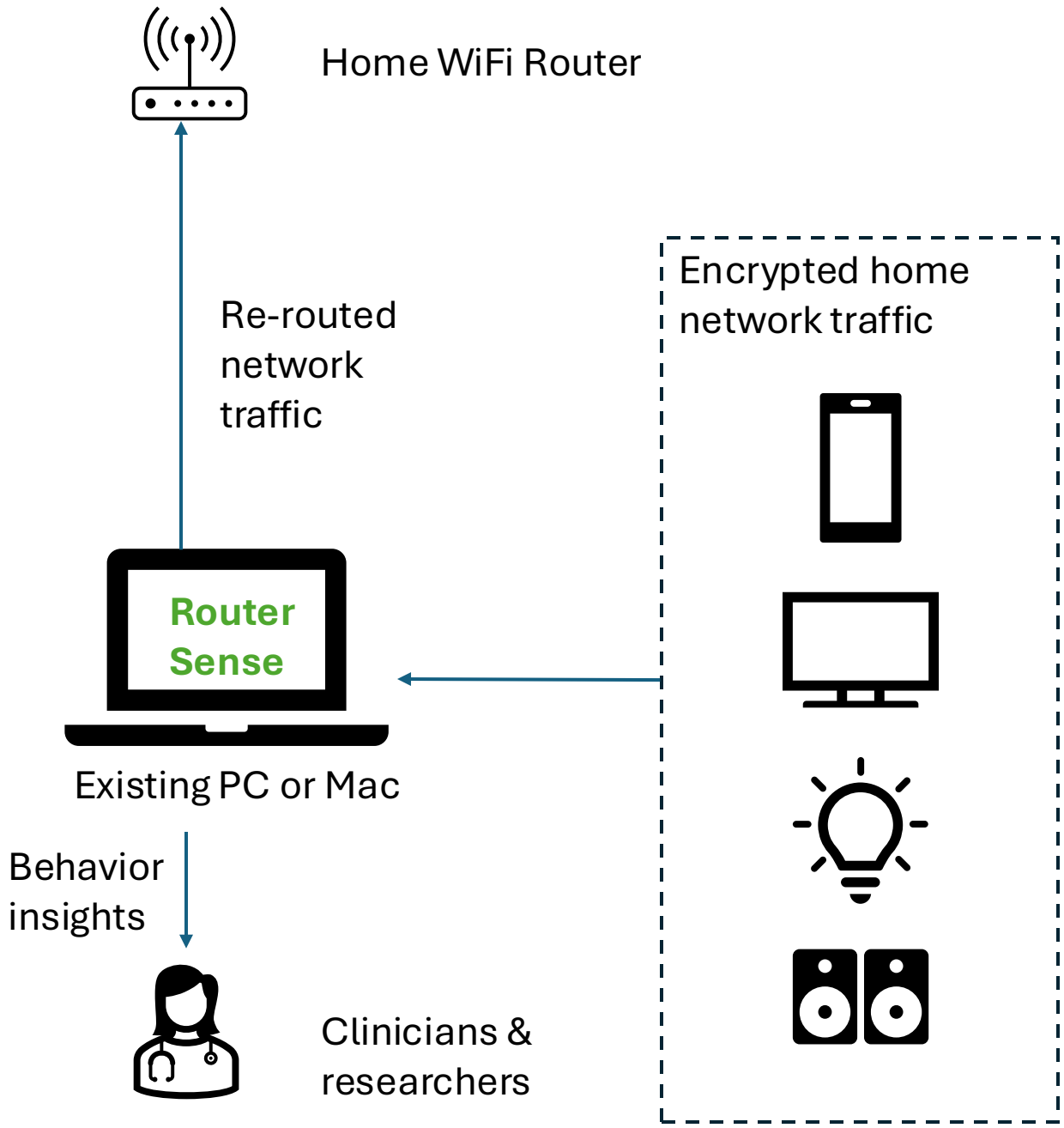

RouterSense tracks these digital biomarkers

- ✓Screen time & activities
- ✓Sleeping / awake
- ✓Home / not home
- ✓Visitors / no visitors
- ✓Anomalous deviations in routines
- ✓And more

Details? Papers?

See https://routersense.ai

Code & ML based on IoT Inspector

Smart home cybersecurity monitoring software tool

Open-source

6K+ users, organic, volunteer

60K+ devices labeled data

Largest known academic dataset

https://inspector.engineering.nyu.edu

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The Washington Post

Consumer Tech • Perspective

You watch TV. Your TV watches back.

In our latest privacy experiment, we tracked how four of the most popular TV brands record everything we watch

Smart TVs have joined the lucrative business of harvesting and sharing your information. Tech columnist Geoffrey A. Fowler explains. (Jonathan Baran/The Washington Post)

npr TechCrunch The New York Times

RouterSense extends IoT Inspector into the healthcare domain

- ✓Device inference (Google award)
- ✓Human activity inference (NSF award 2219867)
- ✓Screen activity inference (ongoing work)

Privacy

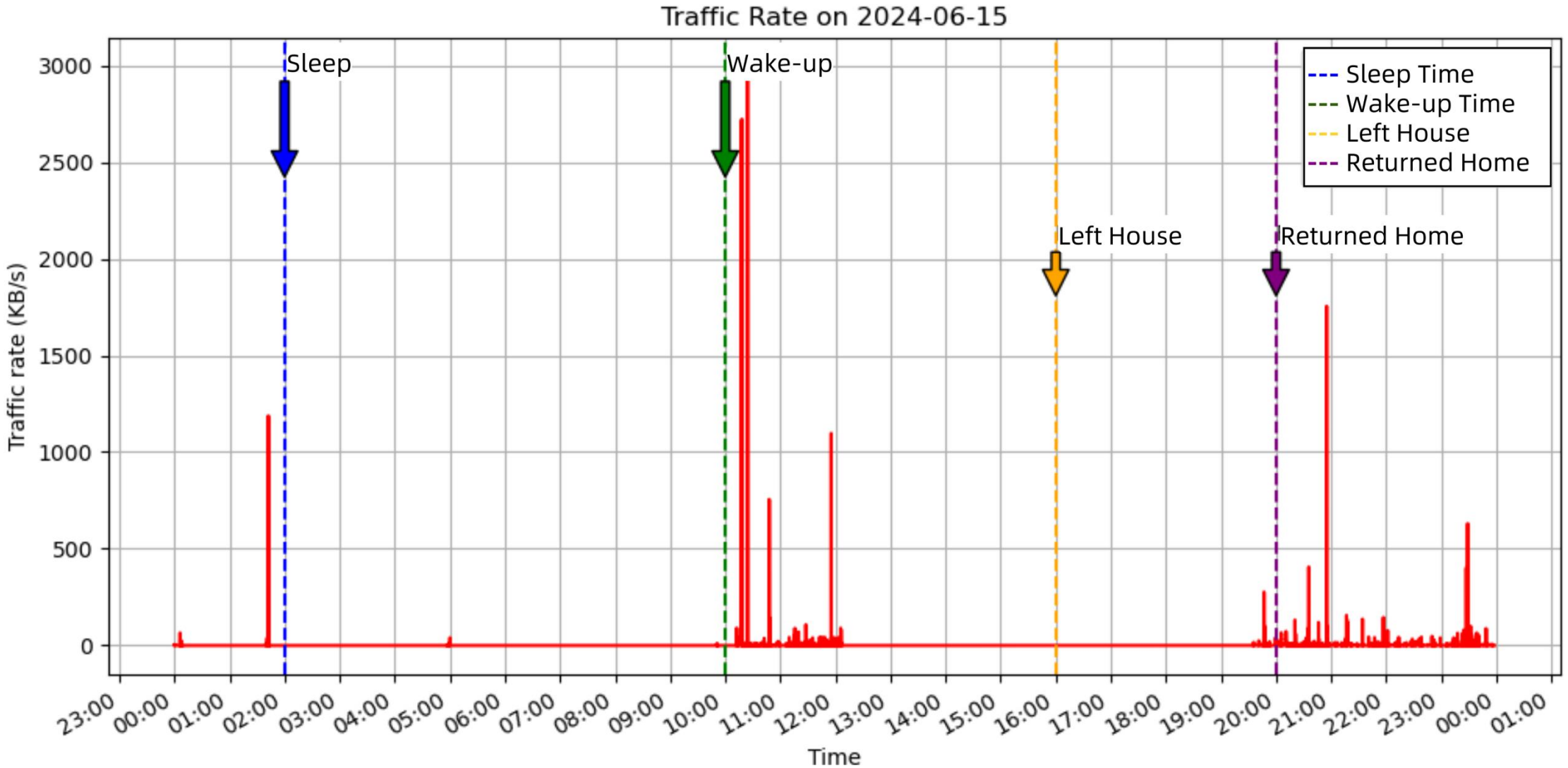
- ✓No new data collected
- ✓No more than what your Internet Service Provider sees
- ✓Privacy preserving ML model (federated learning)

Pilot Studies

N = 1 over 2 days

RouterSense on RaspberryPi

Pilot 1: Monitoring my home network



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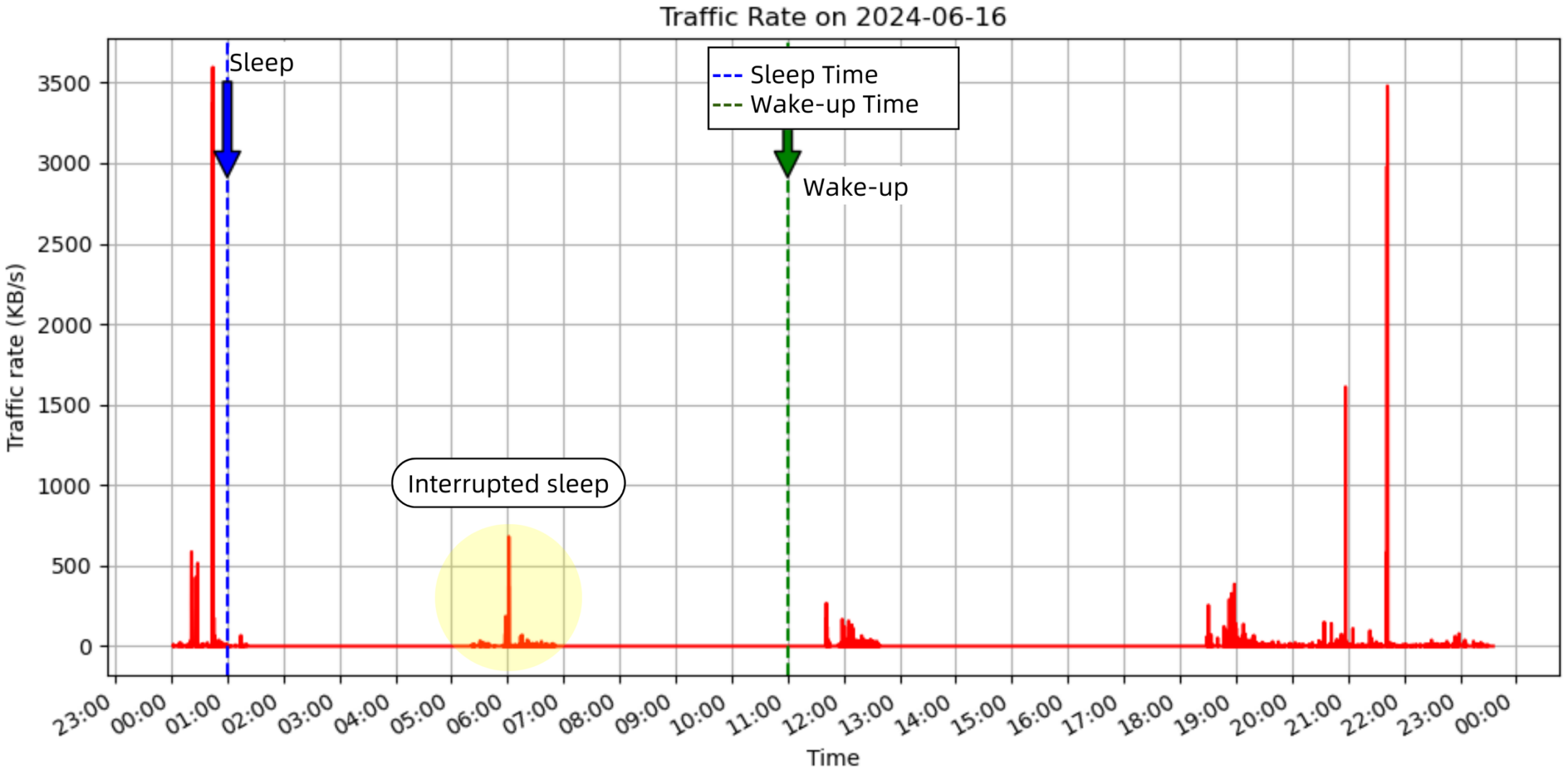
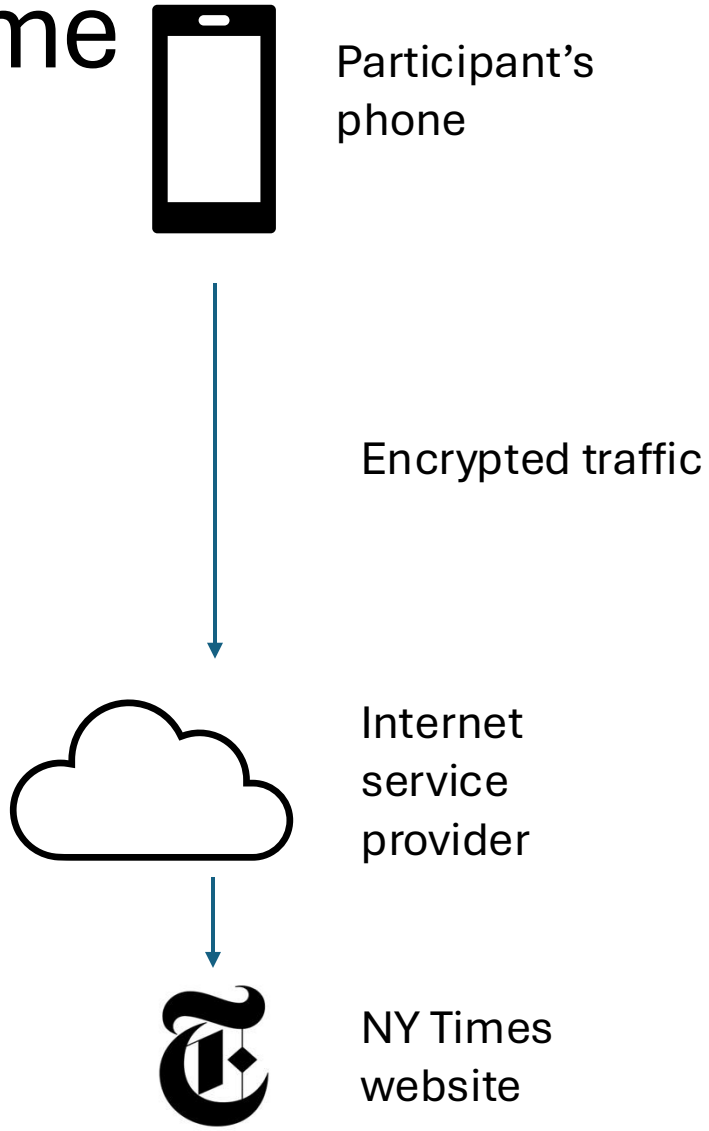


Pilot 2: Monitoring beyond the home

Participant installs WireGuard app

Participant uses app to scan a QR code

All phone traffic is re-routed through RouterSense server



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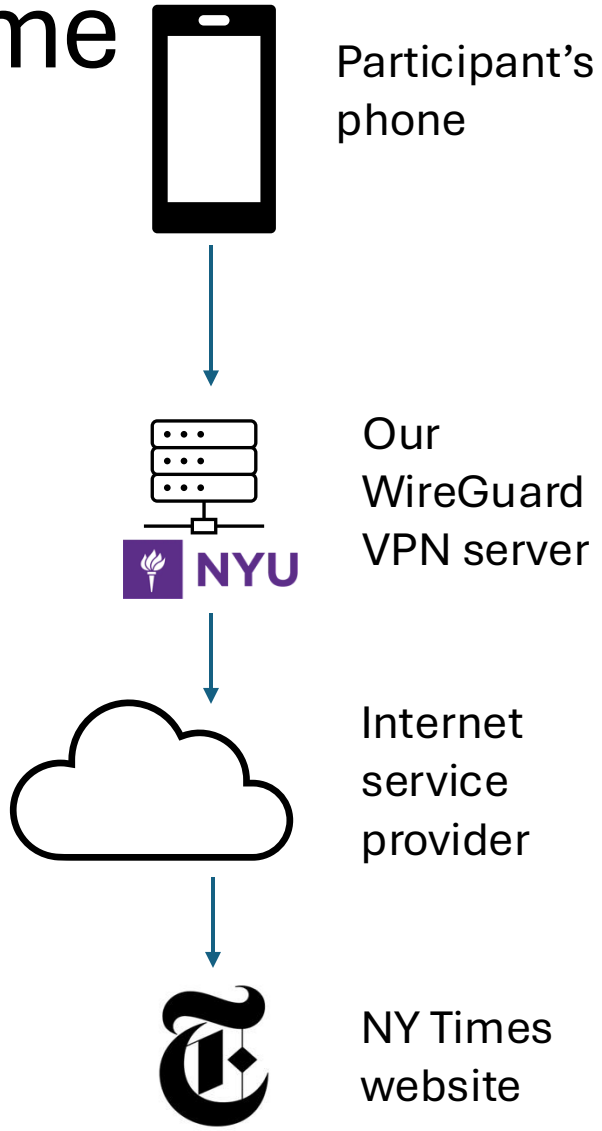
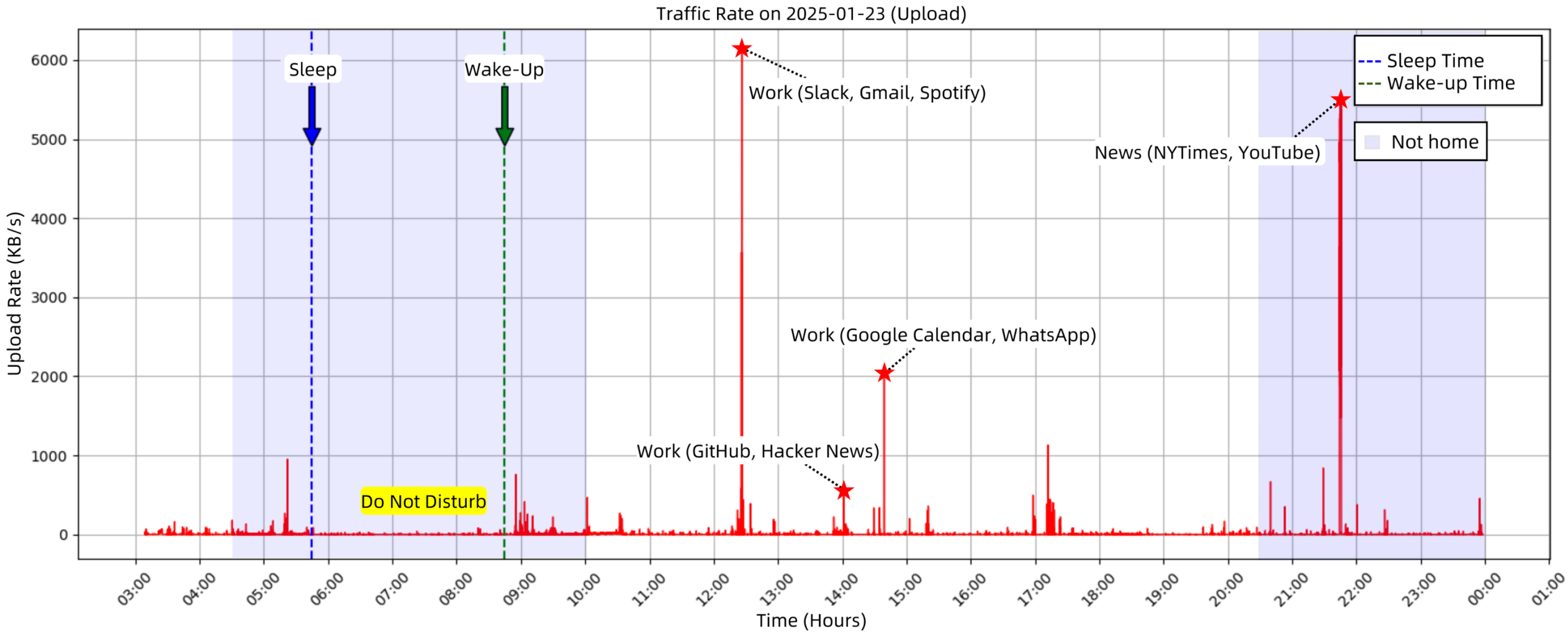


Pilot 2: Monitoring beyond the home

N = 4 over 3 days

WireGuard app on phone

Participant 1 data



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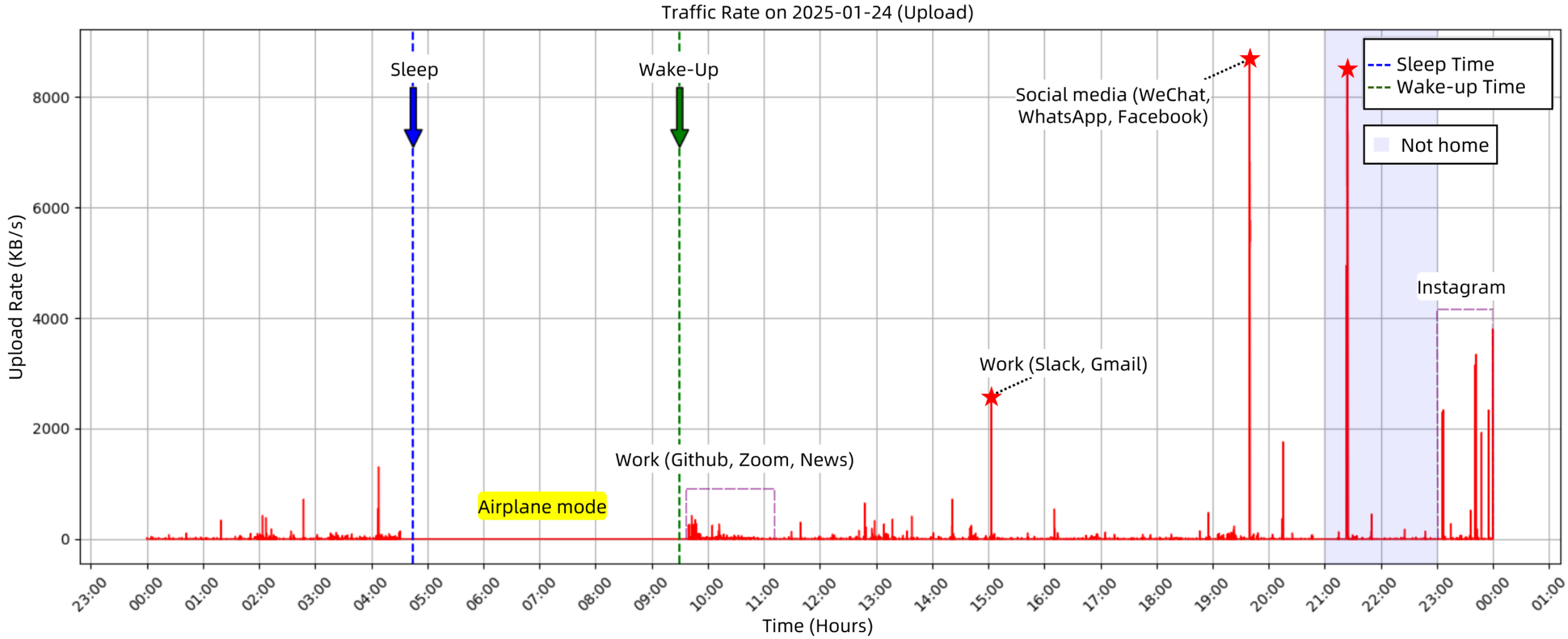


Next Steps

Pilot 3: Aims

1. Evaluate deployment at much larger scale

2. Evaluate acceptability

3. Validate digital biomarkers and behavioral insights

Pilot 3: Aims

1. Evaluate deployment at much larger scale

   Danny is teaching a class of 200 ECE cybersecurity students (Spring 25). Extra credit assignment.

2. Evaluate acceptability

   Surveys and interviews.

3. Validate digital biomarkers and behavioral insights

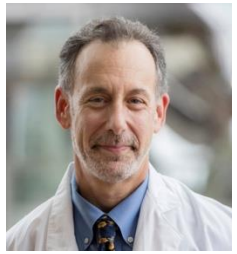
   Collect automated labels of phone and computer activities.
   EMAs and surveys to label sleep/awake, home/not-home, etc.

Ongoing collaborations

Andrew Kiselica, PhD, ABPP-CN
University of Georgia

ADRD

Jeffrey Kaye, MD + Zachary Beattie, PhD
Oregon Center for Aging and Technology



ADRD

Nabil Alshurafa, PhD
Northwestern

mindless eating + screen

John-Ross “JR” Rizzo, MD
NYU Langone

visual impairment

You! We should talk!

Open research questions

HCI

- Benefits for participants (other than monetary)?
- Feasibility and acceptability?

ML

- Device identification?
- Screen activity inference?
- Ground truth labels?
- Validation? EMAs?

Vision for RouterSense

Objectivity, ease of use, privacy

Scales clinical studies & trials

Ethnographic studies

SBIR grant (ML pipeline, engineering, support)

R01 (large scale study for a particular disease area)

We should talk!

https://routersense.ai