Welcome!

6.1820/MAS.453: Mobile and Sensor Computing

aka IoT Systems

https://6mobile.github.io/

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Let’s start with some trivia

1. How many “connected” (IoT) devices are there today?

2. What is the most widely deployed IoT/ connected device?

3. Which company was listed on NYSE as IOT? (And when was it founded?)

4. How was radar discovered?

5. Why is there growing interest in LEO satellites (e.g., SpaceX, Blue Origin)?

IoT in the News

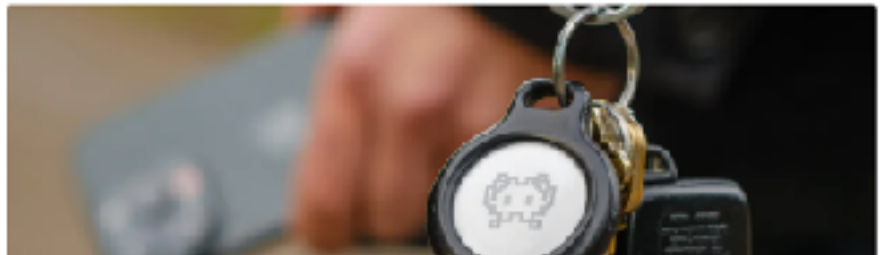
CES INNOVATION AWARDS® / 2026 /

Naqi Neural Earbuds with Invisible User Interface

United hits milestone in Starlink Wi-Fi rollout, plans 2027 completion for high-speed tech

Apple AirTag 2nd Gen Just Got a Powerful Upgrade. Learn What's New and How the Trackers Work

New versions of Apple's ubiquitous tracking pucks are set to hit stores this week. Here's what Apple changed and all you need to know about how they work.



THIS $50 SMART RING HAS A SCREEN (AND WORKS LIKE A TINY SMARTWATCH)

skiing

pass

- includ

onitor

Photos: World-first drone with AI sight helps first responders see through fog, rain

The UAV-P300 delivers up to 50 percent clearer vision in bad weather, along with night imaging, long-range zoom, and autonomous flight for complex settings.

By Sujita Sinha

GET YOUR NEWS FROM INTERESTING ENGINEERING

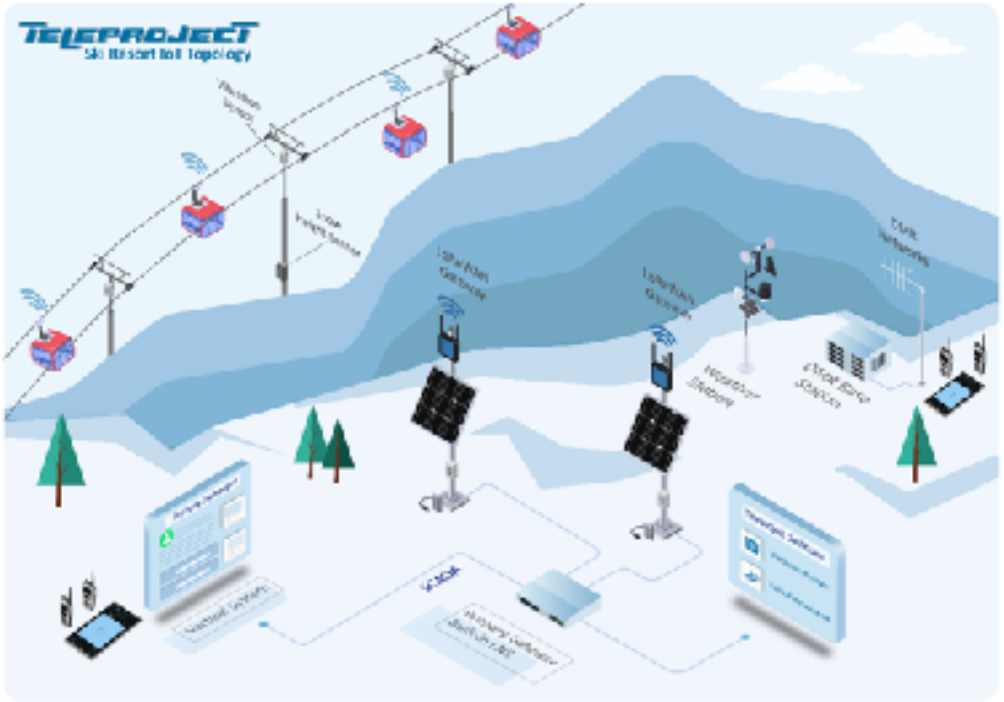
Photo Story

Jan 07, 2026 08:21 AM EST

* Respond t

your phon

LoRaWAN for Ski Resorts: How IoT is Revolutionizing Resort Management



When do you usually count something as IoT?
(what does an IoT device/system expected to do or have?)

Internet of Things

Convergence of micro-sensing, computation, and communication that allows us to:

- *Acquire* (*sense*) data from the environment
- *Pre-process* data locally (on-device / “edge”)
- *Deliver* data to servers (“cloud”)
- *Draw inferences* and *provide insights* about the world from the data:
  - Sensor fusion, data integration
  - Signal processing
  - Machine learning
- *Control* actions in the environment

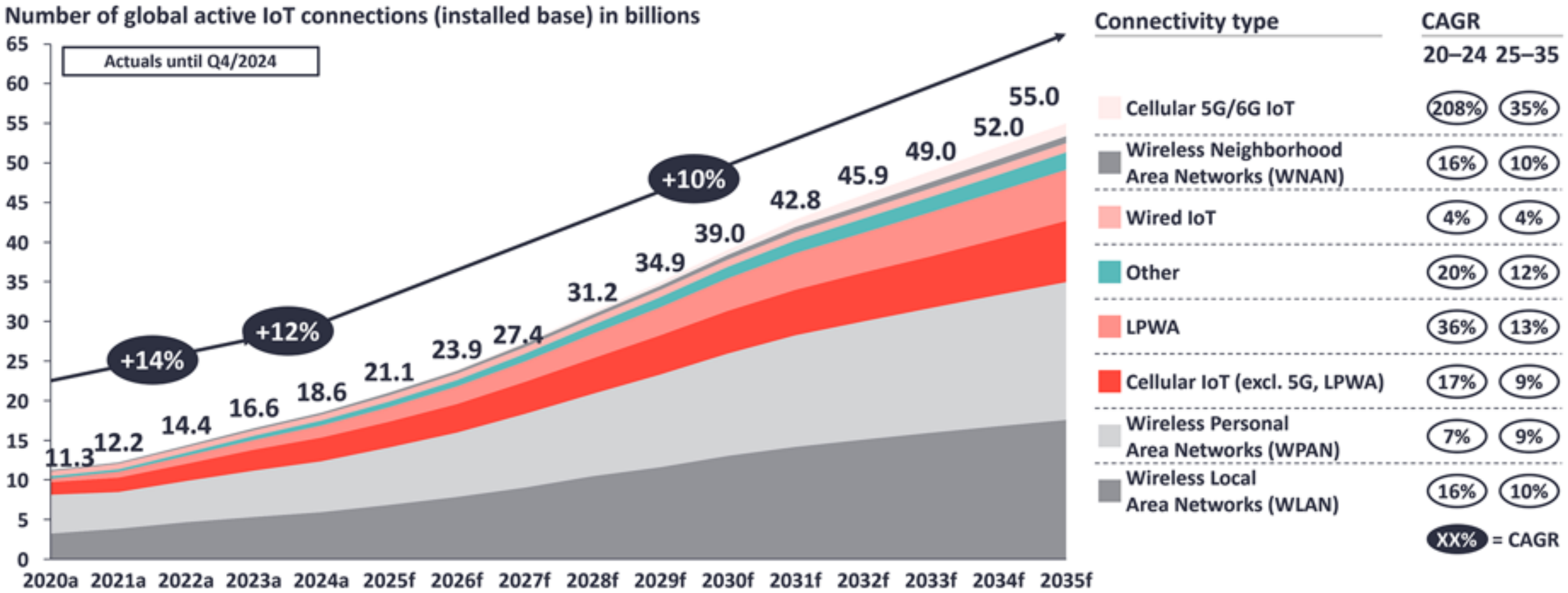
Focus of 6.1820/MAS.453:

- Fundamentals, applications, and future of IoT
- Topics in sensing, mobile, or both
- Spatial AI & physical AI

IOT ANALYTICS

October 2025

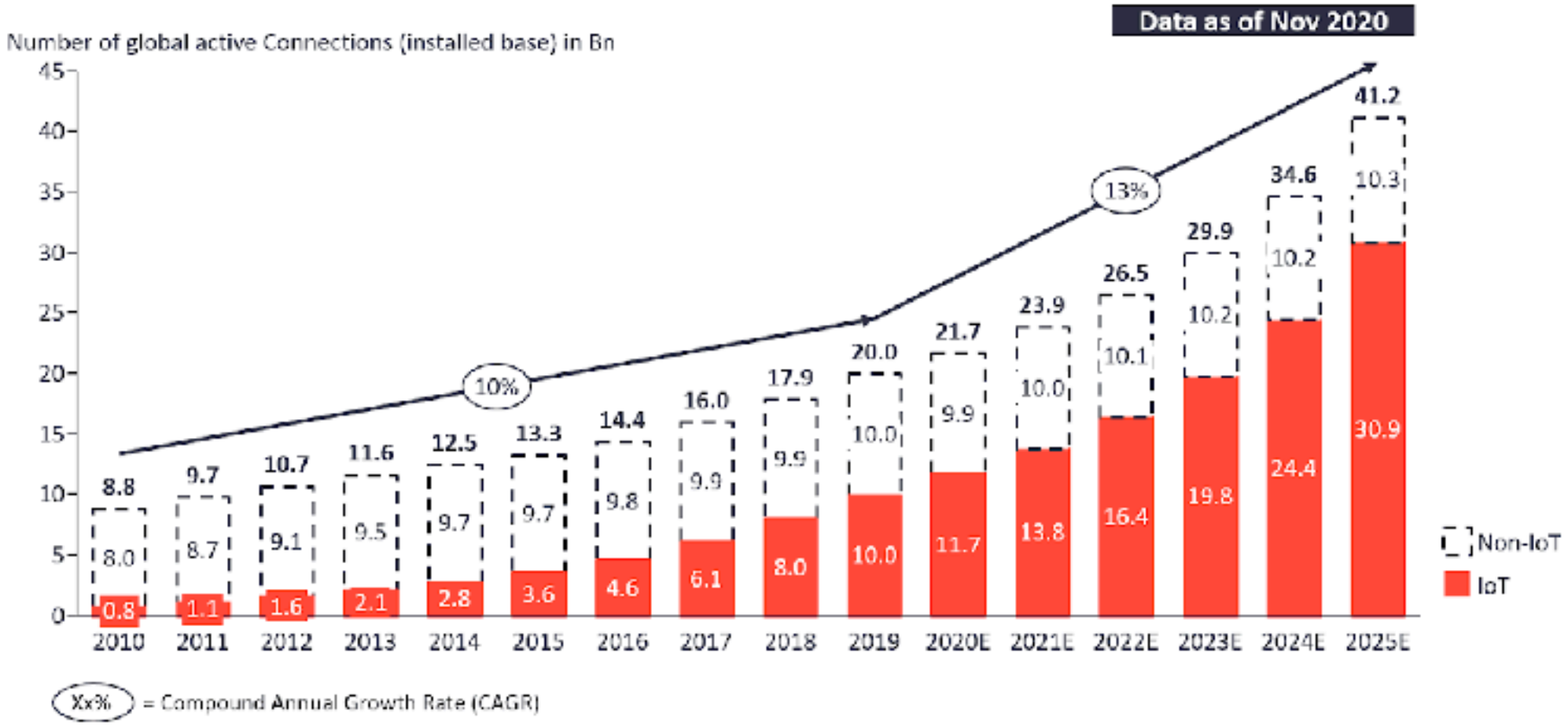
Global IoT market forecast (in billions of connected IoT devices)



Note: IoT connections do not include any computers, laptops, fixed phones, cell phones, or consumer tablets. Counted are active nodes/devices or gateways that concentrate the end-sensors, not every sensor/actuator. Simple one-directional communications technology (e.g., RFID or NFC) is not considered. Wired includes ethernet and field buses (e.g., connected industrial PLCs or I/O modules); The number of wired IoT aggregation nodes represents the primary connection point and excludes all wired end nodes.; Cellular includes 2G, 3G, 4G, 5G; LPWAN includes unlicensed and licensed low-power networks; WPAN includes Bluetooth, Zigbee, Z-Wave or similar; WLAN includes Wi-Fi and related protocols; WNAN includes non-short-range mesh, such as Wi-SUN; Other includes satellite and unclassified proprietary networks with any range.

Total number of device connections (incl. Non-IoT)

20.0Bn in 2019– expected to grow 13% to 41.2Bn in 2025



Note: Non-IoT includes all mobile phones, tablets, PCs, laptops, and fixed line phones. IoT includes all consumer and B2B devices connected – see IoT break down for further details

Source(s): IoT Analytics - Cellular IoT & LPWA Connectivity Market Tracker 2010-25

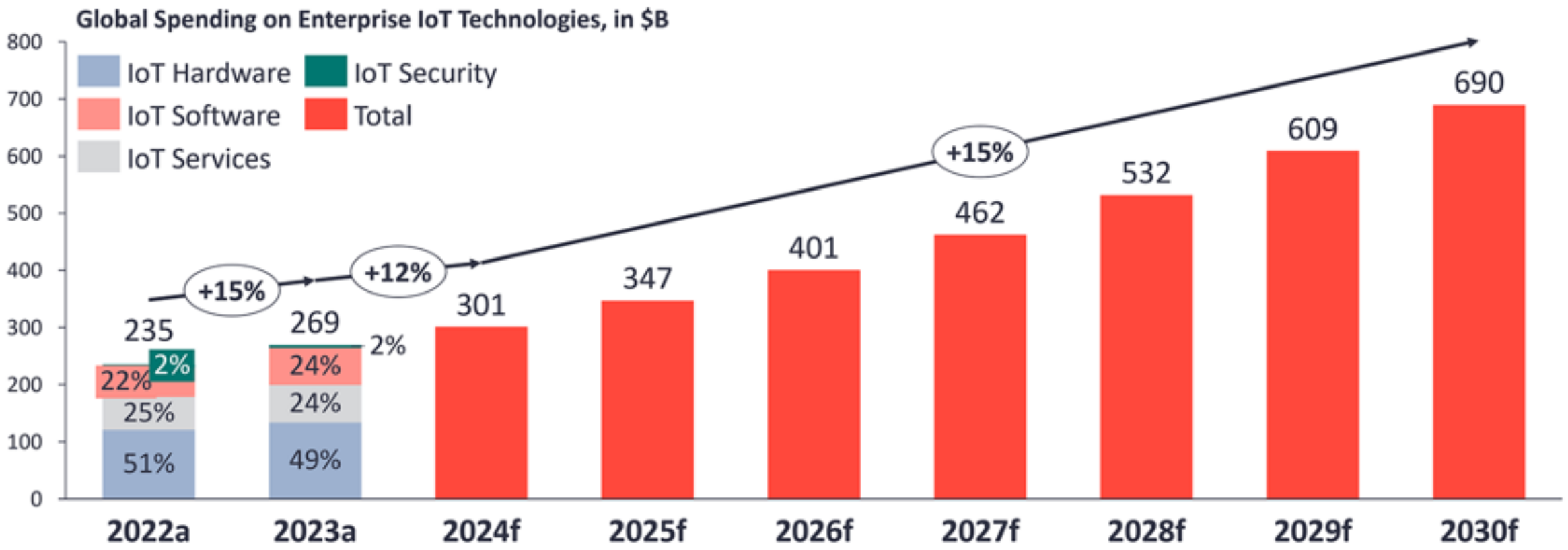
IOT ANALYTICS

July 2024

Your Global IoT Market Research Partner

The enterprise IoT market by technology 2023–2030

Data as of June 2024



Note: IoT Analytics defines IoT as a network of internet-enabled physical objects. Objects that become internet-enabled (IoT devices) typically interact via embedded systems, some form of network communication, or a combination of edge and cloud computing. The data from IoT-connected devices is often used to create novel end-user applications. Connected personal computers, tablets, and smartphones are not considered IoT, although these may be part of the solution setup. Devices connected via extremely simple connectivity methods, such as radio frequency identification or quick response codes, are not considered IoT devices. Since the last update in 2023 our definition of the enterprise IoT tech stack slightly changed.
a: Actuals, f: Forecast

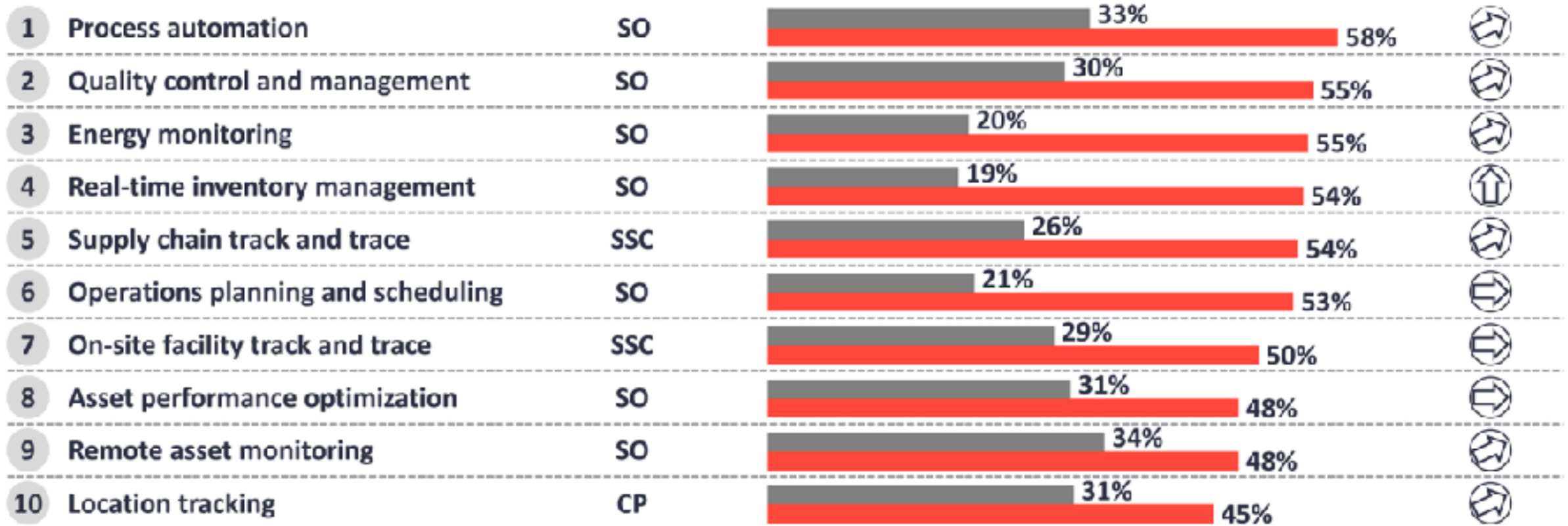
IOT ANALYTICS

September 2024

Your Global IoT Market Research Partner

The top 10 IoT use cases

N=2,089 IoT projects



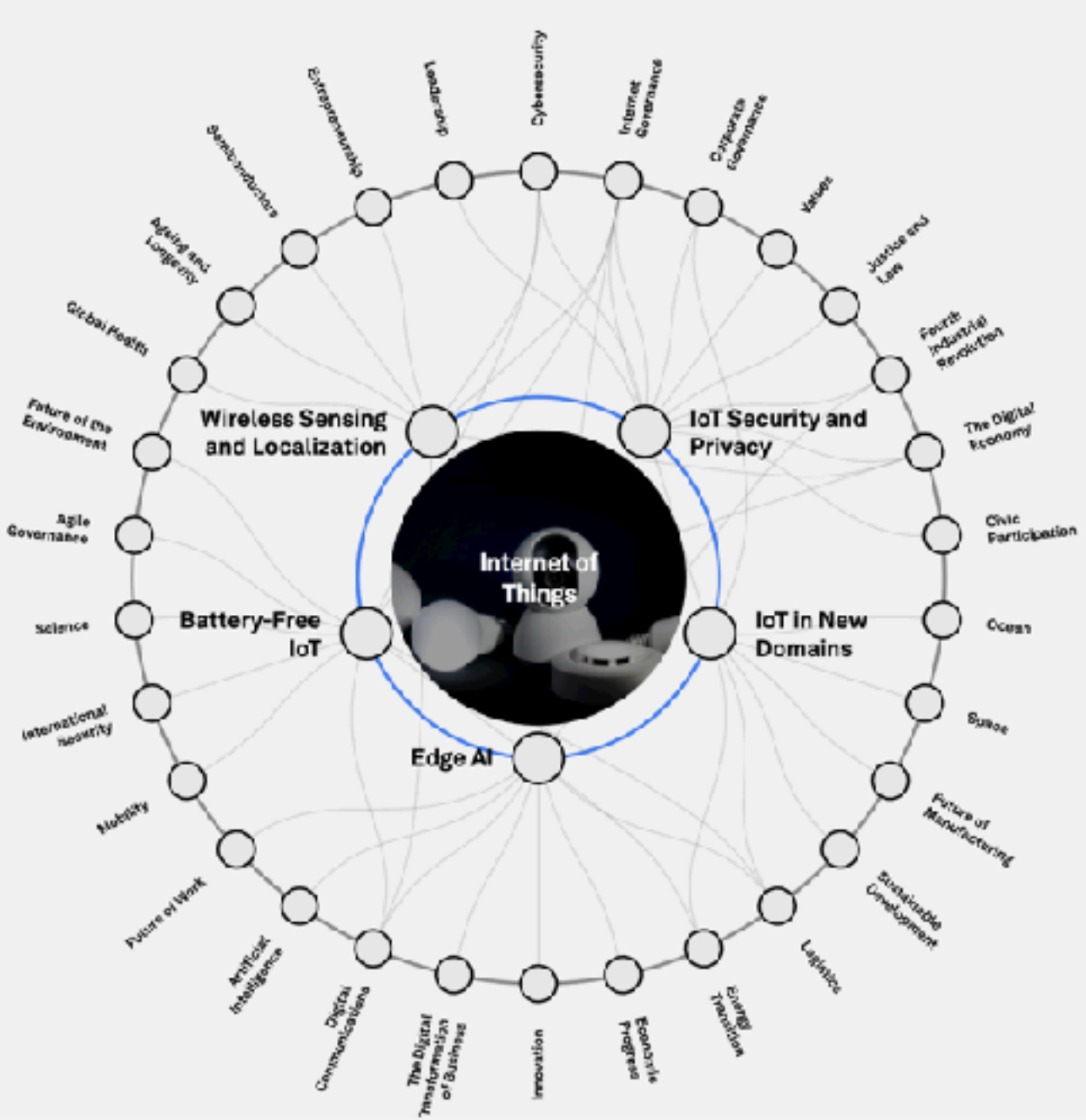
Note: [1]Share of organizations that are either currently rolling out or have fully rolled out each use case [2]Based on respondents' indication of expected spending changes for 2024 (compared to 2023). For more details about the methodology and definitions, refer to the corresponding blog that was published on the IoT Analytics website. **Source:** IoT Analytics Research 2024-IoT Use Case Adoption Report 2024. Conditions for republishing: Source citation with link to original post and company website

SO = Smart operations
SSC = Smart supply chain
CP = Connected products

2021
Q1/2024

Expected investment next 12 months
No meaningful change
+1% to +5%
>+5%

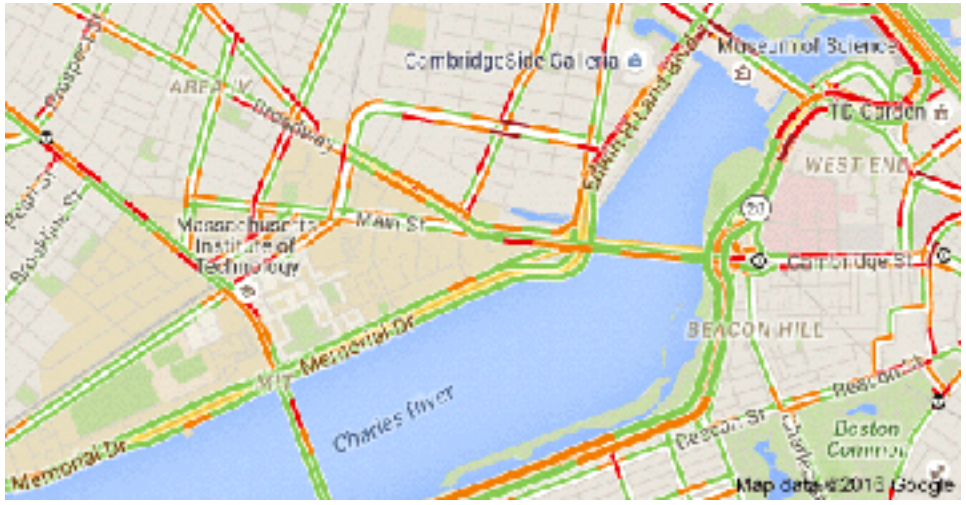
WORLD ECONOMIC FORUM



https://intelligence.weforum.org/topics/a1Gb0000005LWrfEAG

IoT is Transforming Industries

Transportation & Smart Cities



Medicine

Smart Homes

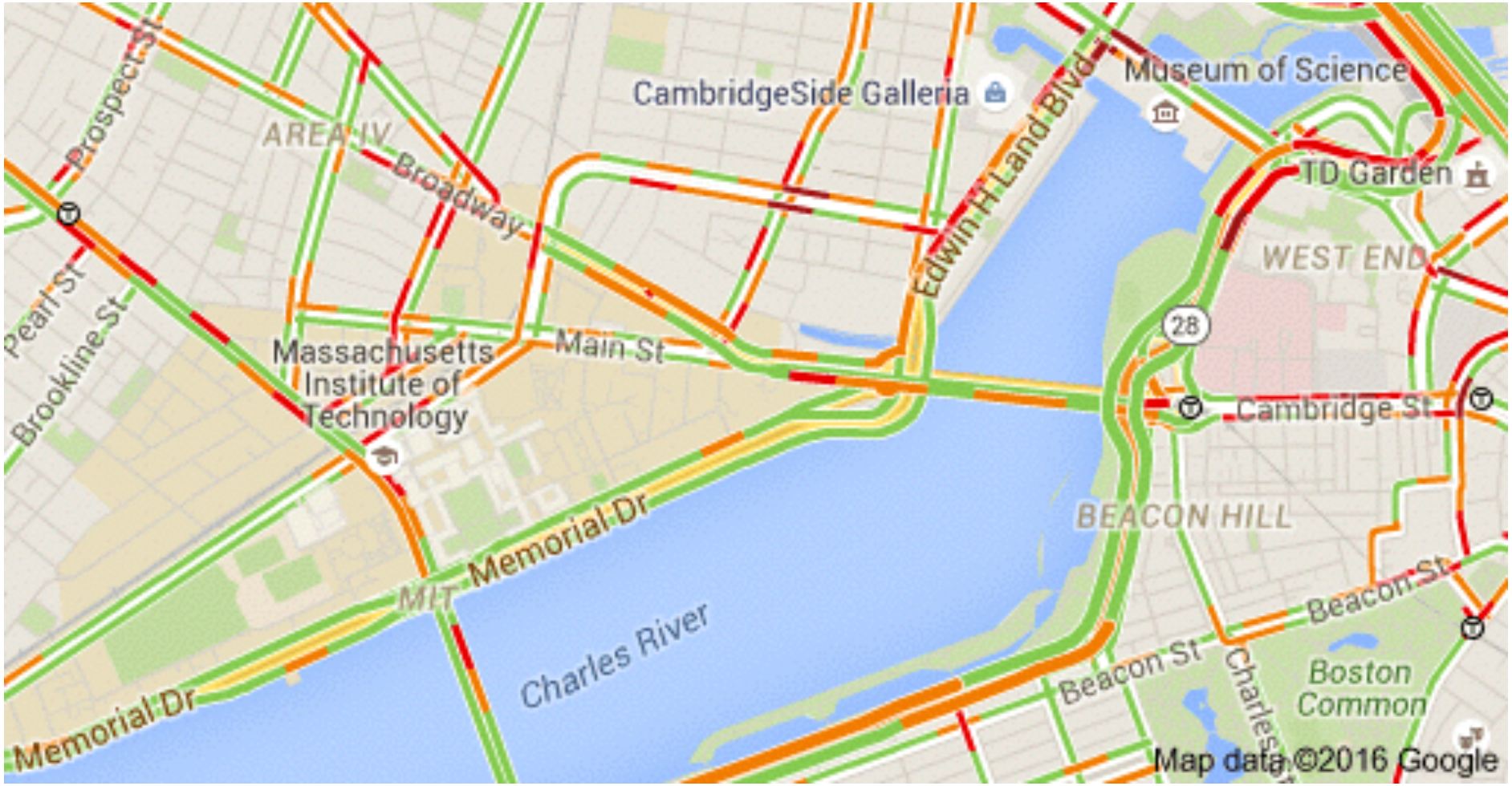
Health & Wellness

Connected Vehicles

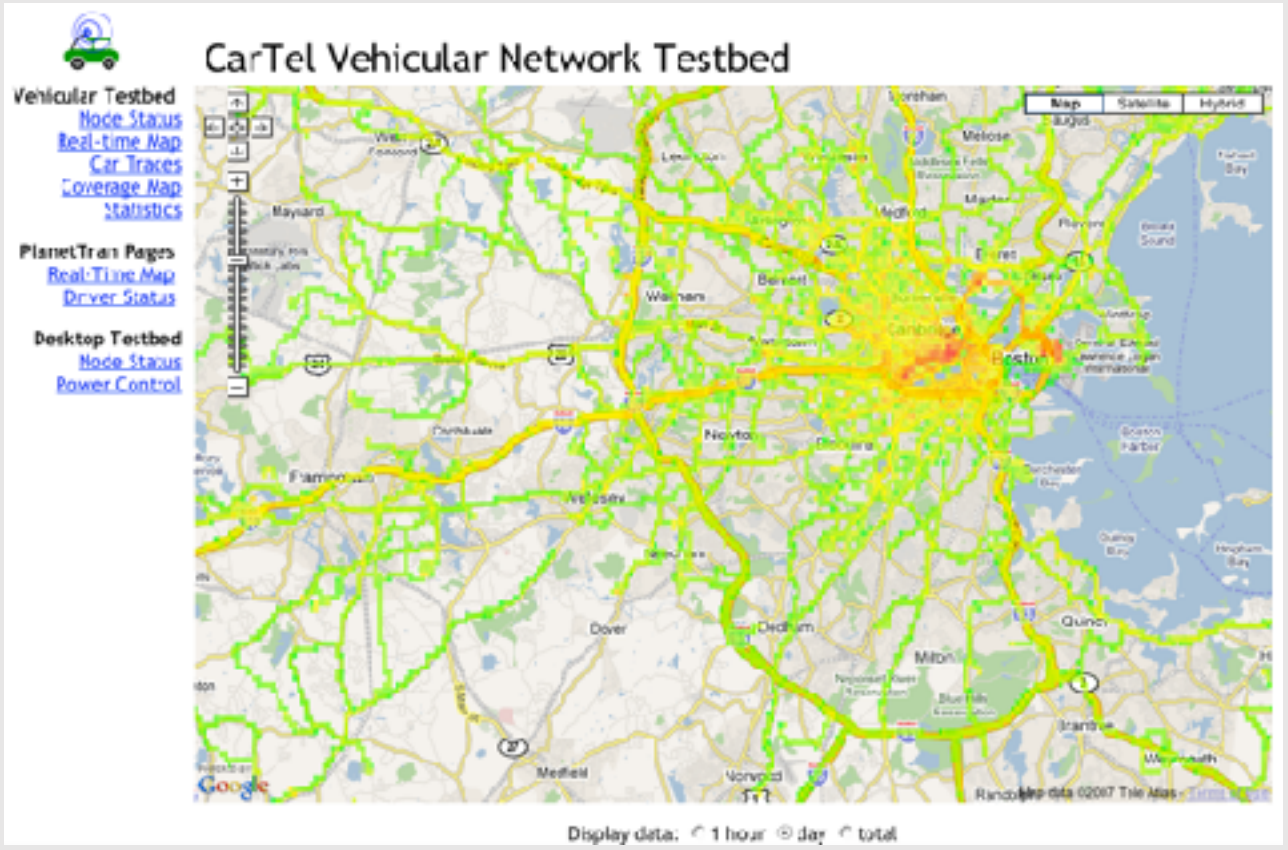
Precision Agriculture

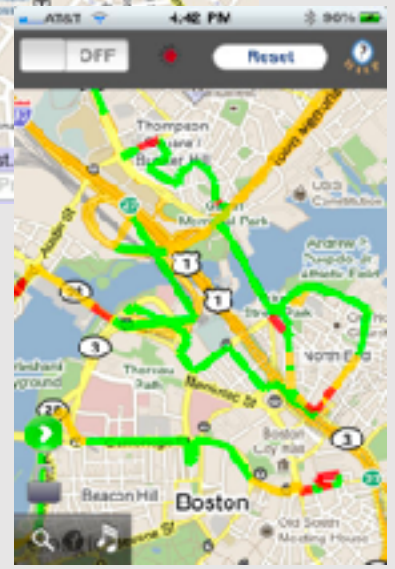
Example systems we will cover

Transportation & Smart Cities

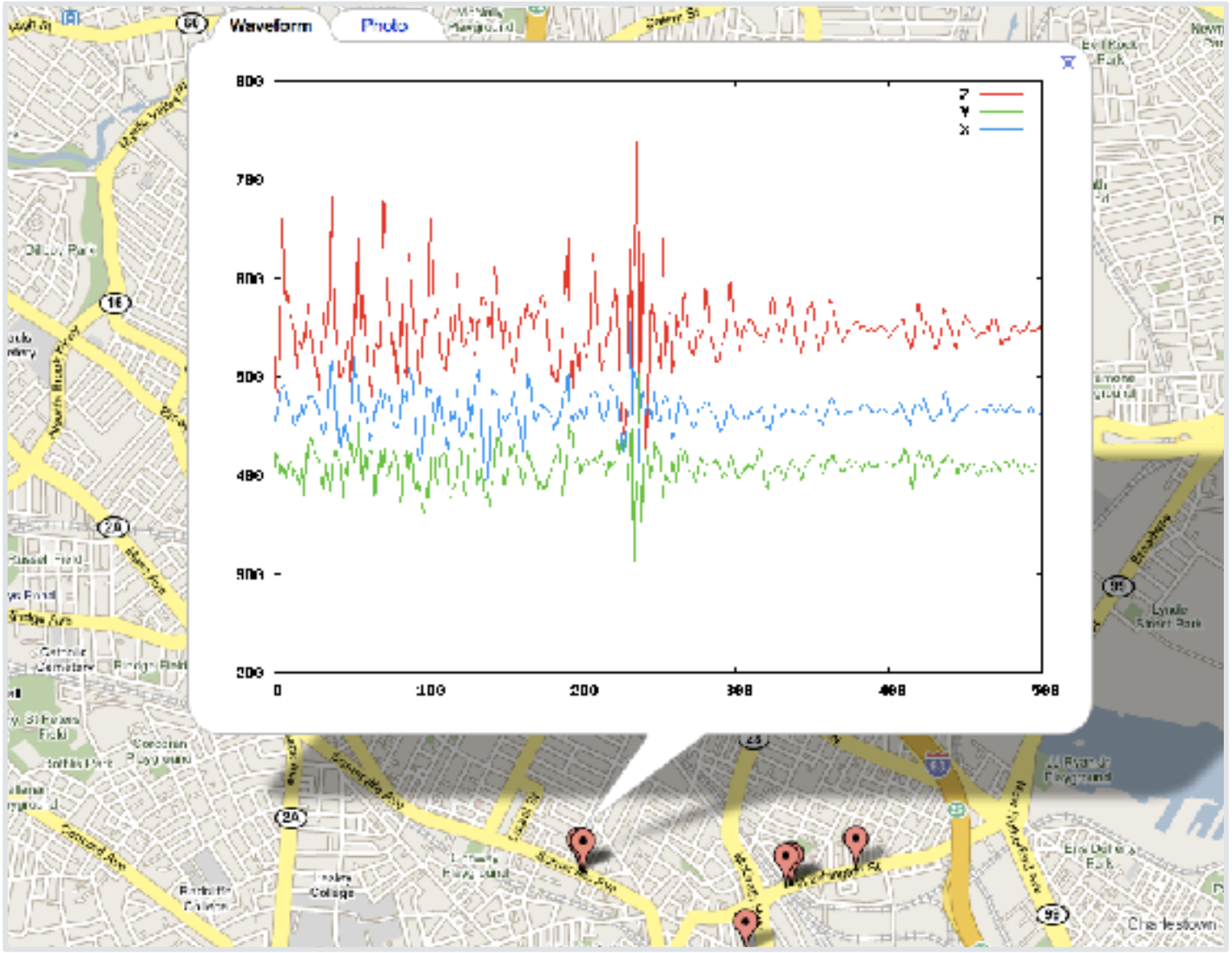


CarTel Project at MIT (2005-2011)





Pothole Patrol



Insurance Telematics Market Size to Reach USD 18.7 Billion by 2032 | Growing Demand for Personalized Insurance Solutions Fuels Market Growth | Research by SNS Insider

The insurance telematics market is experiencing significant growth, driven by the increasing demand for personalized insurance products and the increasing use of telematics to promote safer driving practices.

October 22, 2024 09:00 ET | Source: SNS Insider pvt ltd

Fully Autonomous Driving
(Self-driving cars)

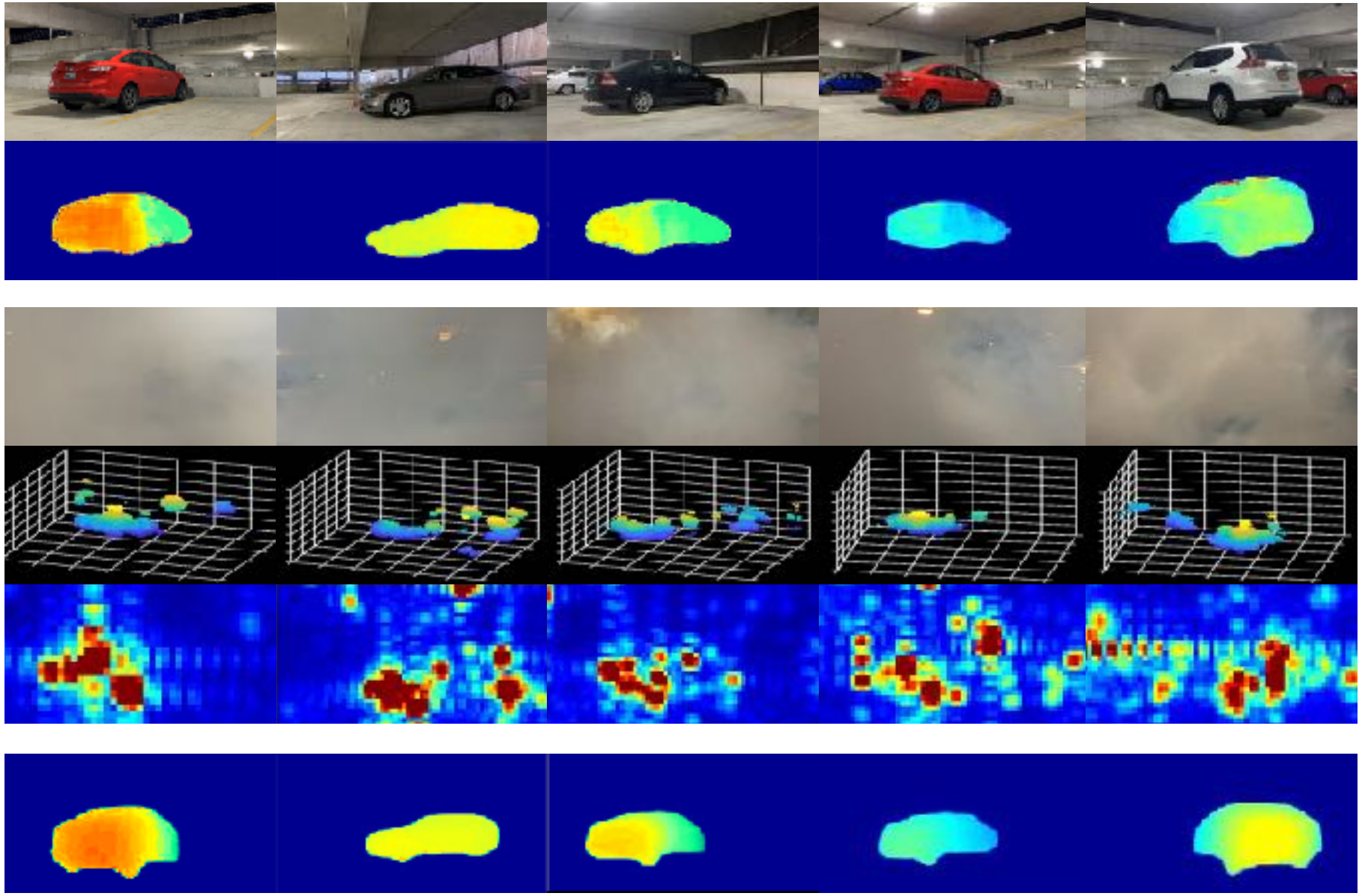

Tesla in Clear Conditions


Tesla in Fog
38
38

Tesla in Fog

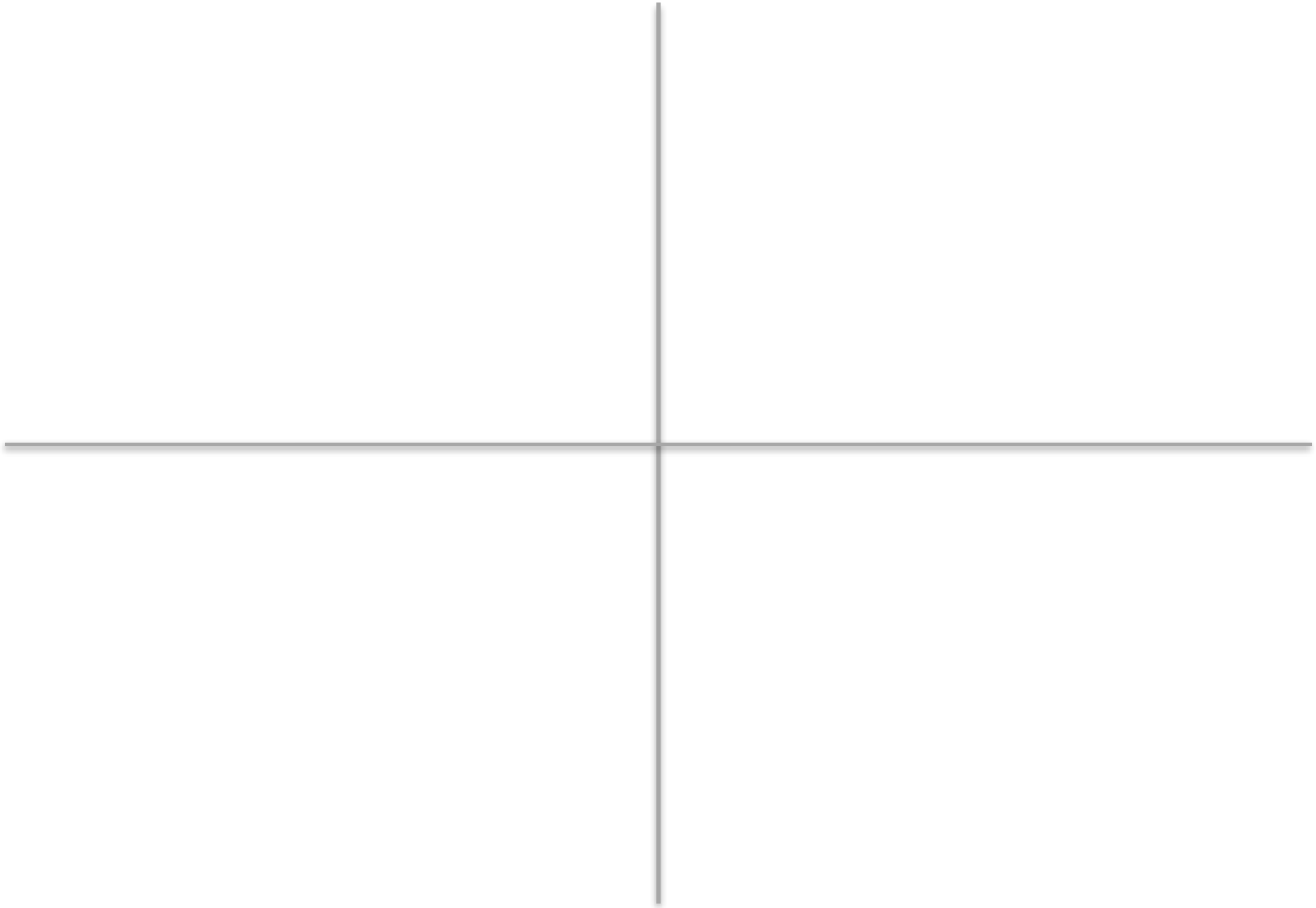
Why does it fail in adverse conditions?

Using AI-powered radars to see through fog



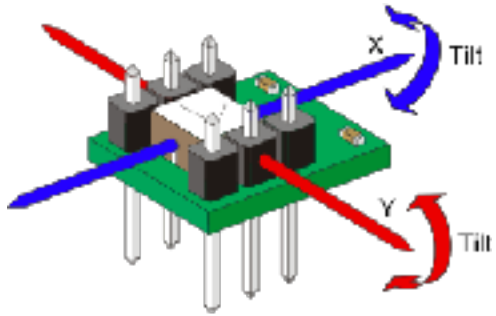
Hawkeye [CVPR'22]

IoT Systems are designed along 4 quadrants



IoT Systems are designed along 4 quadrants

Sensing Tasks & Modalities



Computation

Power/Energy

Connectivity

Sensing Tasks and Modalities

Sensing = bridge between the physical and digital worlds

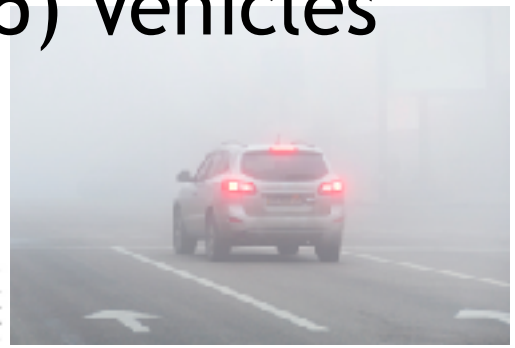
WHAT?

(1) Locations

(2) Health

(3) Activity

(5) Vehicles



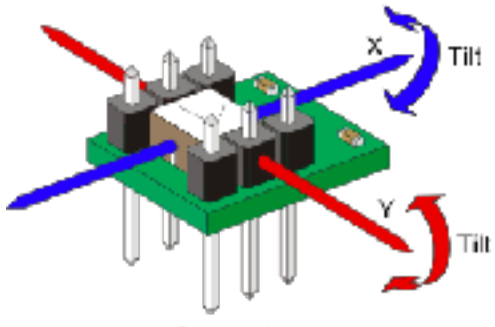
(4) Environment

HOW?

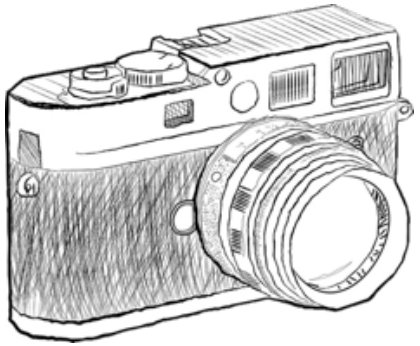
(1) Radio

(2) Acoustic/ Ultrasonic

(3) Inertial



(4) Visual



Computation

HOW can we use the sensing modalities to achieve the sensing task?

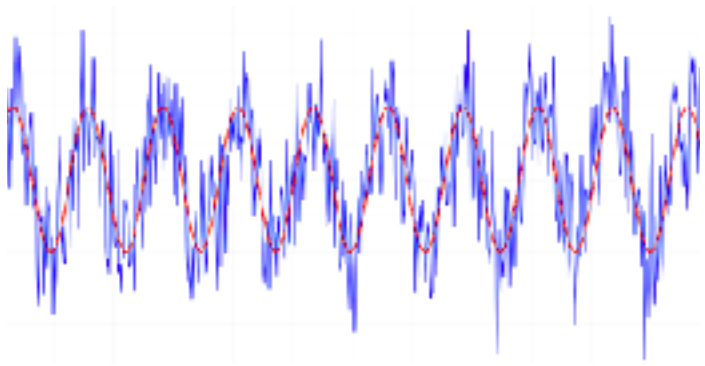
(1) Programming model

- Embedded
- Mobile
- Edge/Cloud

(2) Data Management

- Storage
- Queries

(3) Signal Processing & Machine Learning

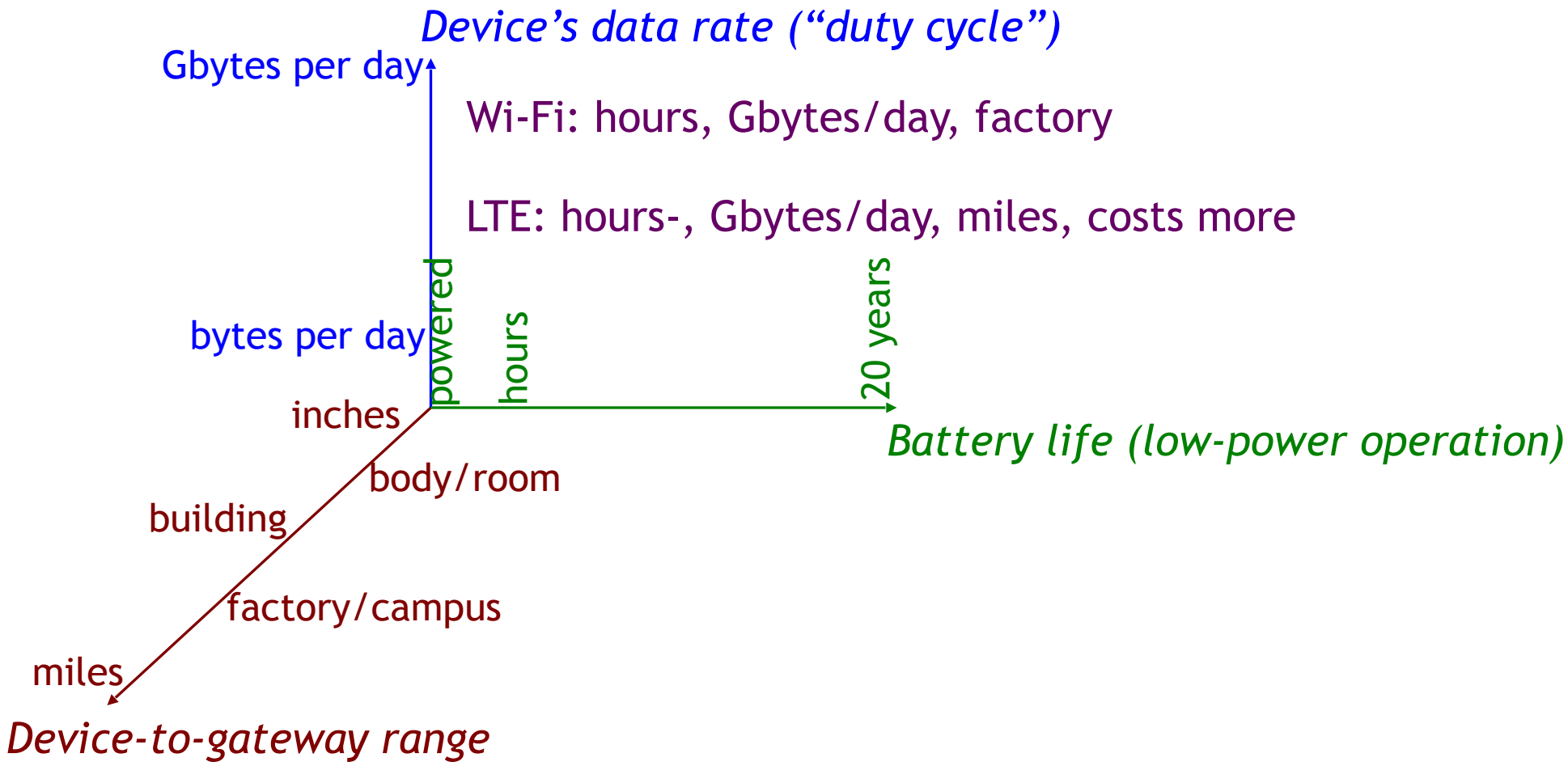


- Digitization
- Inference & Machine Learning

(4) Security

- Digital, Analog
- Trust, Privacy

Connectivity



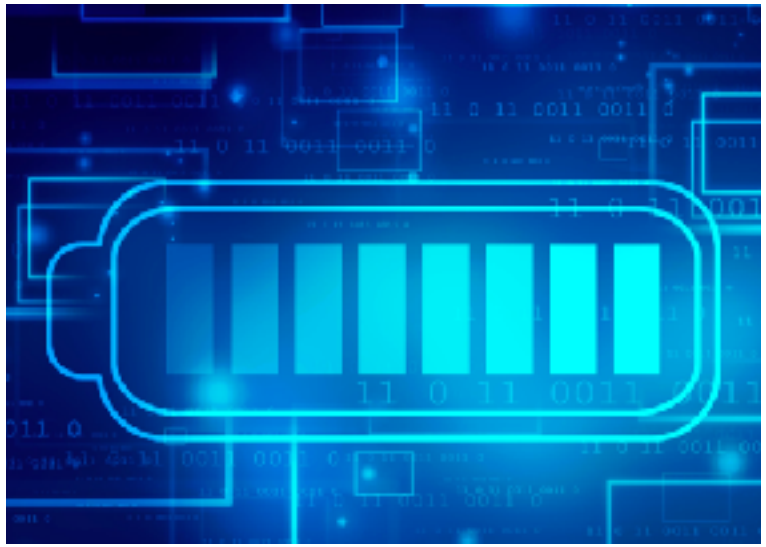
Power/Energy

HOW will we power the nodes? And what are the energy constraints?

(1) Infrastructure

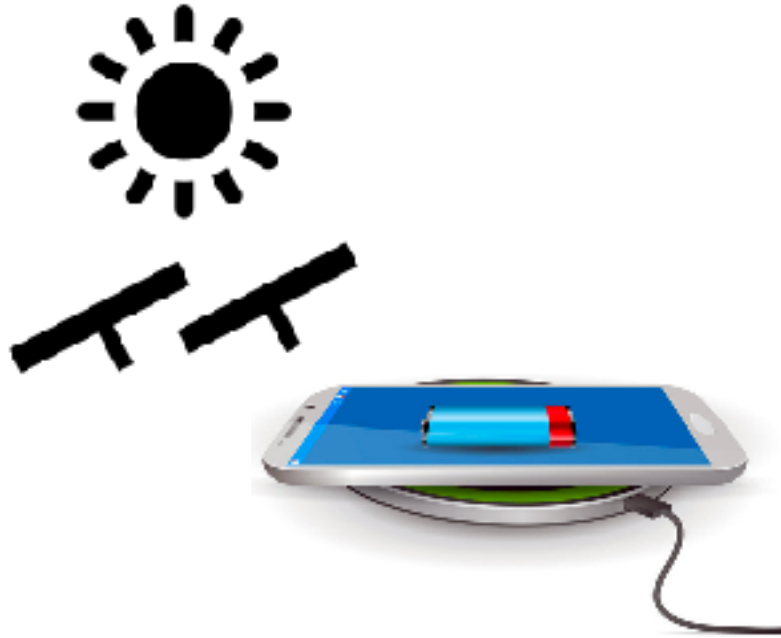
- Electricity, Network

(2) Battery



- Rechargeable/Non

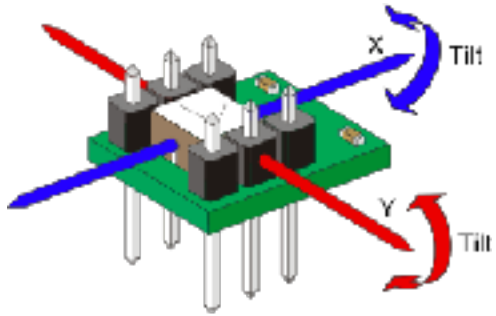
(3) Energy Harvesting



- Ambient, Wireless power
- Solar, Waves, Human Activity, RF

IoT Systems are designed along 4 quadrants

Sensing Tasks & Modalities



Computation

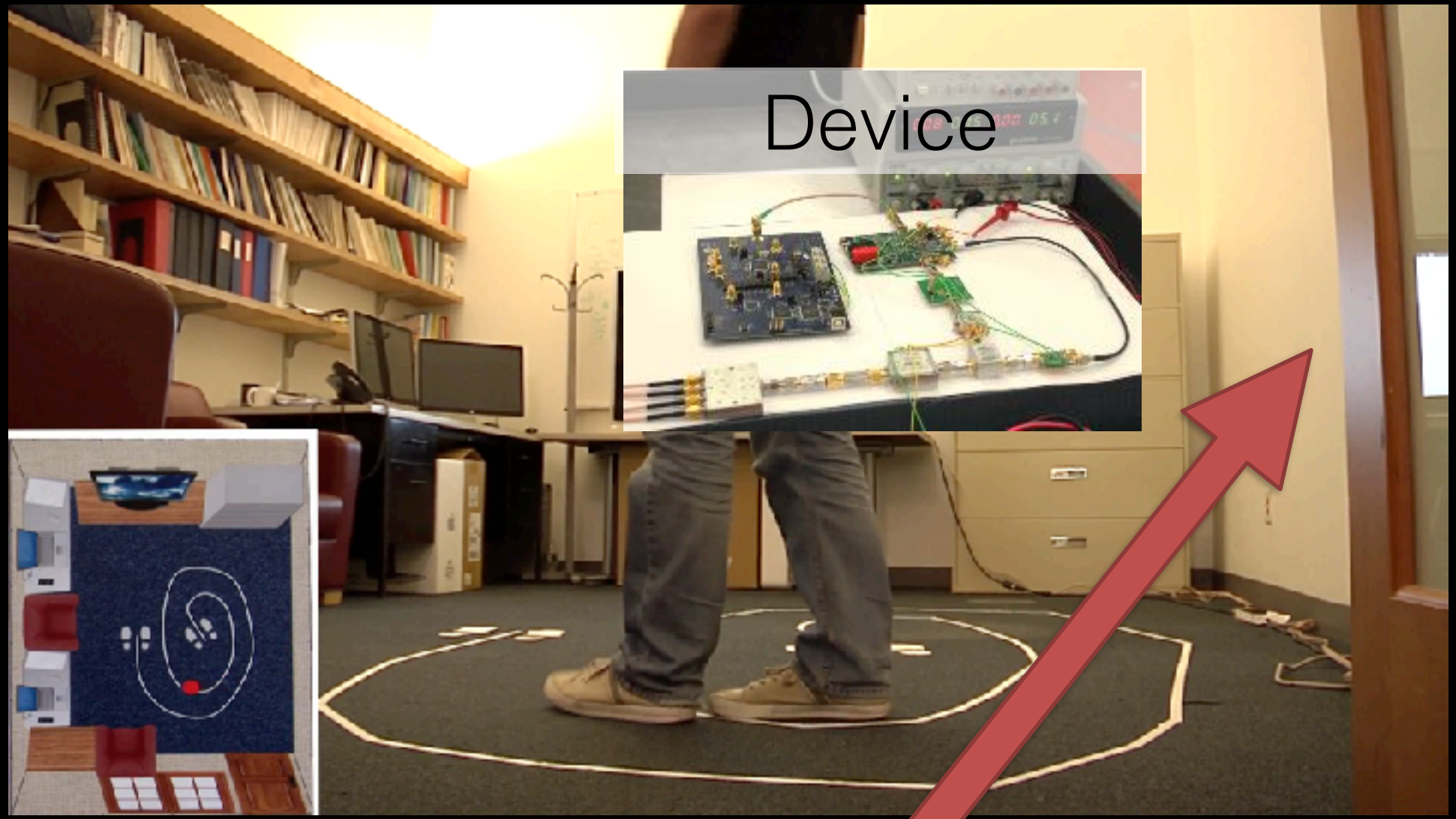
Power/Energy

Connectivity

Indoor Positioning (Cricket, 2001)

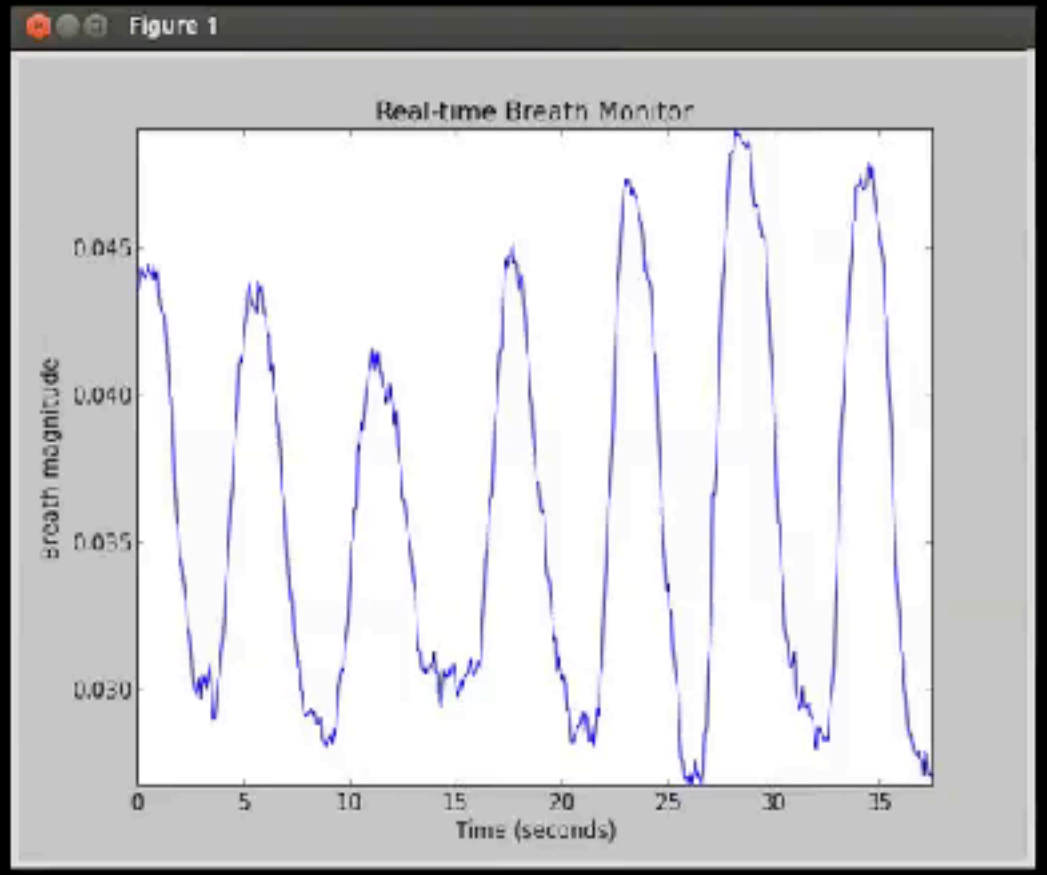
Accurate Localization (Cricket, 2003)

Device-Free Localization (WiTrack, 2014)

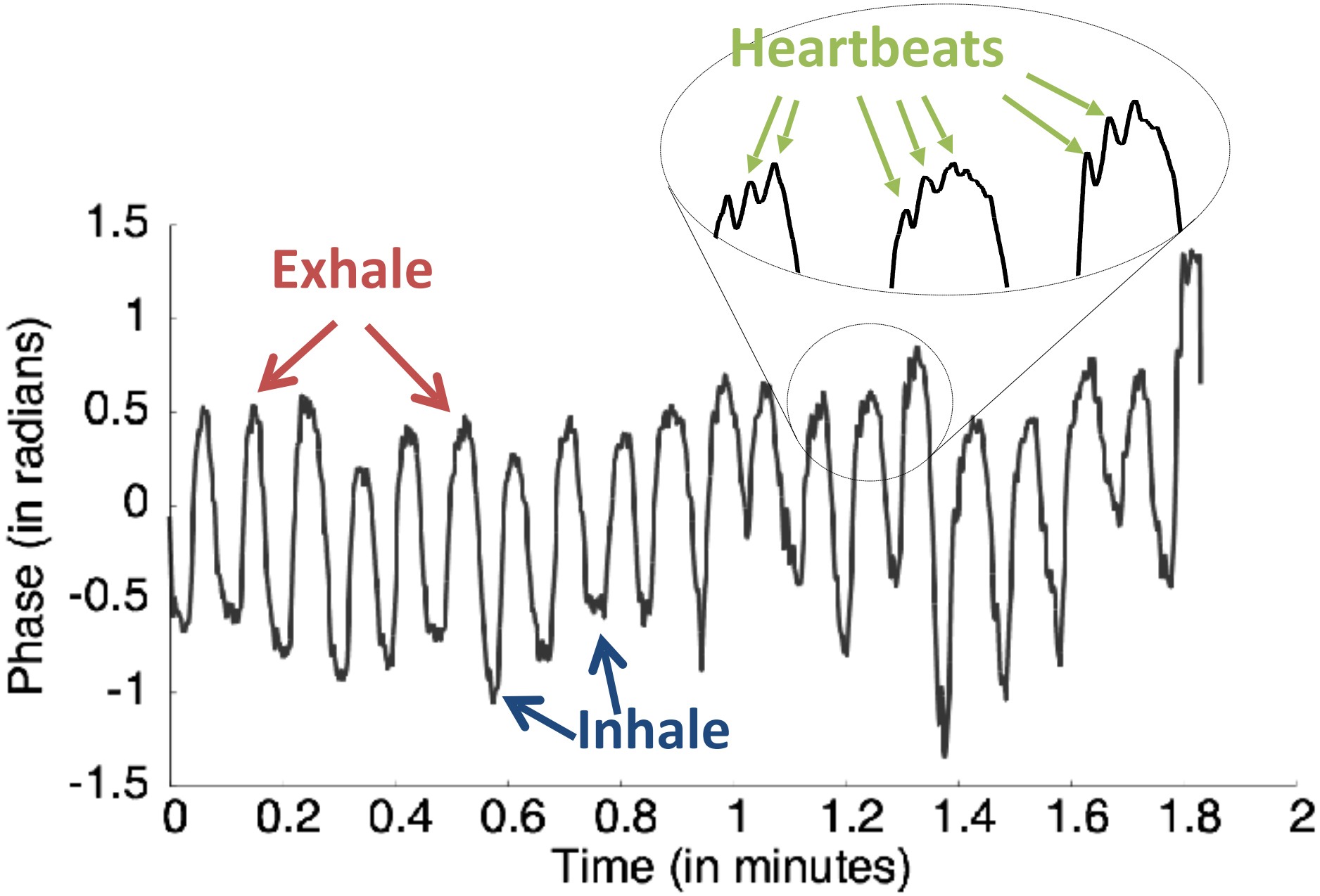


Seeing Through Walls (RF-Capture, 2015)

Breath Monitoring using Wireless (Vital-Radio, 2015)



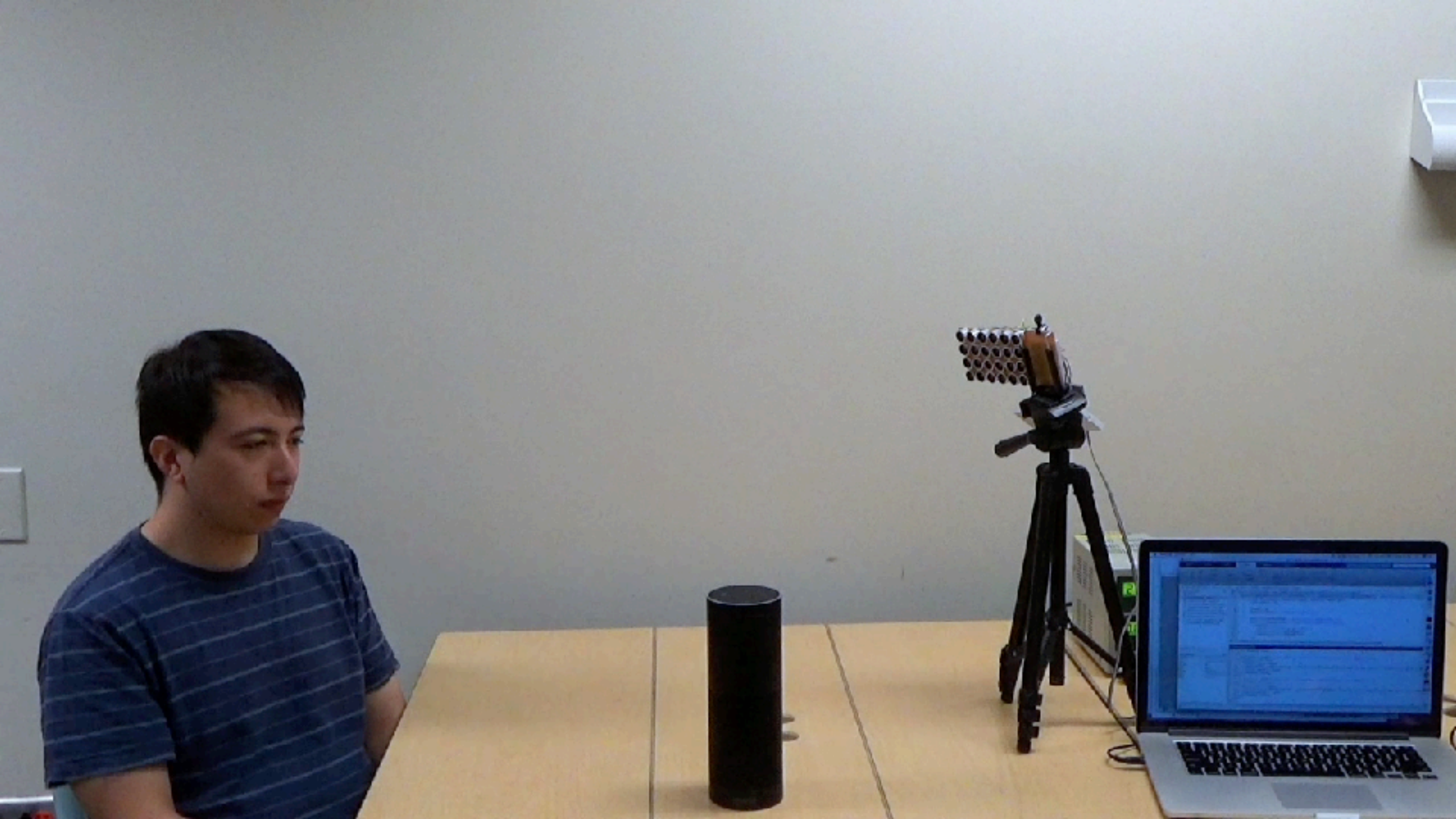
Let’s zoom in on respiration signals


Heartbeats
Exhale
Inhale
Phase (in radians)
1.5
1
0.5
0
-0.5
-1
-1.5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Time (in minutes)

Baby Monitoring

Mobile Security
Case Study: Inaudible Voice Commands

Can hack Android/Alexa using inaudible voice commands



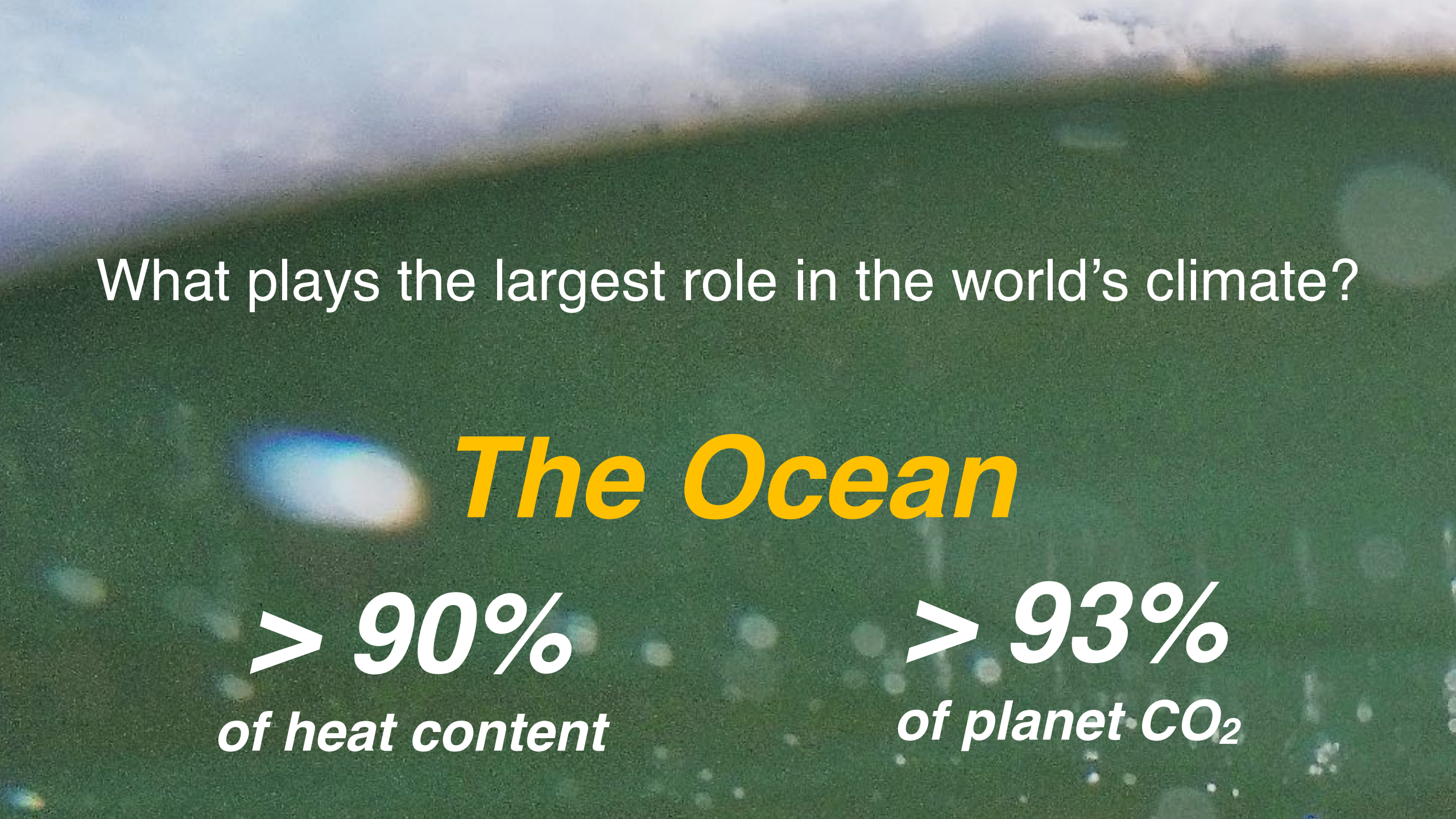
Ear Bubbles

End-to-end IoT System

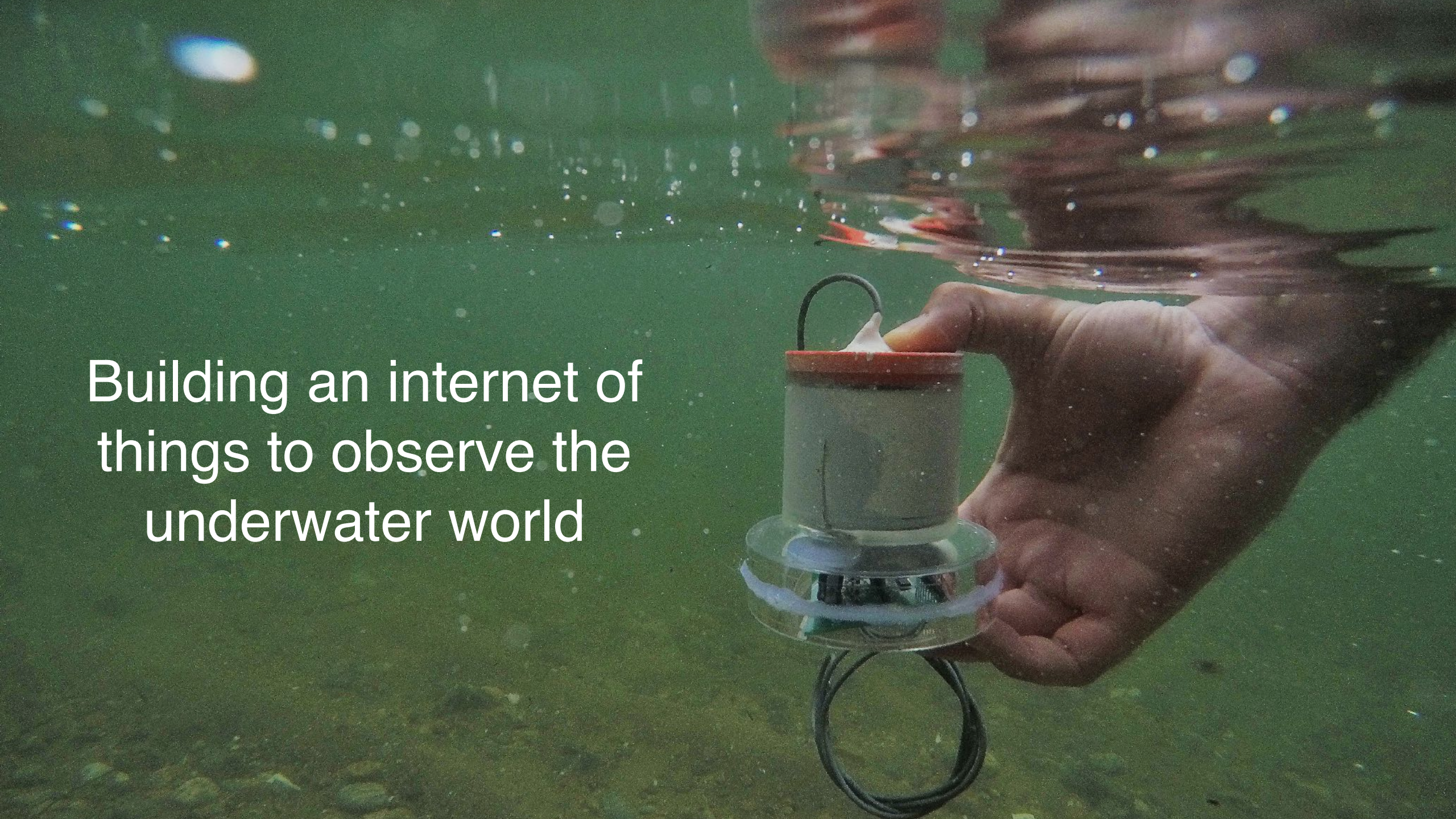
Case Study: Precision Agriculture

What plays the largest role in the world’s climate?

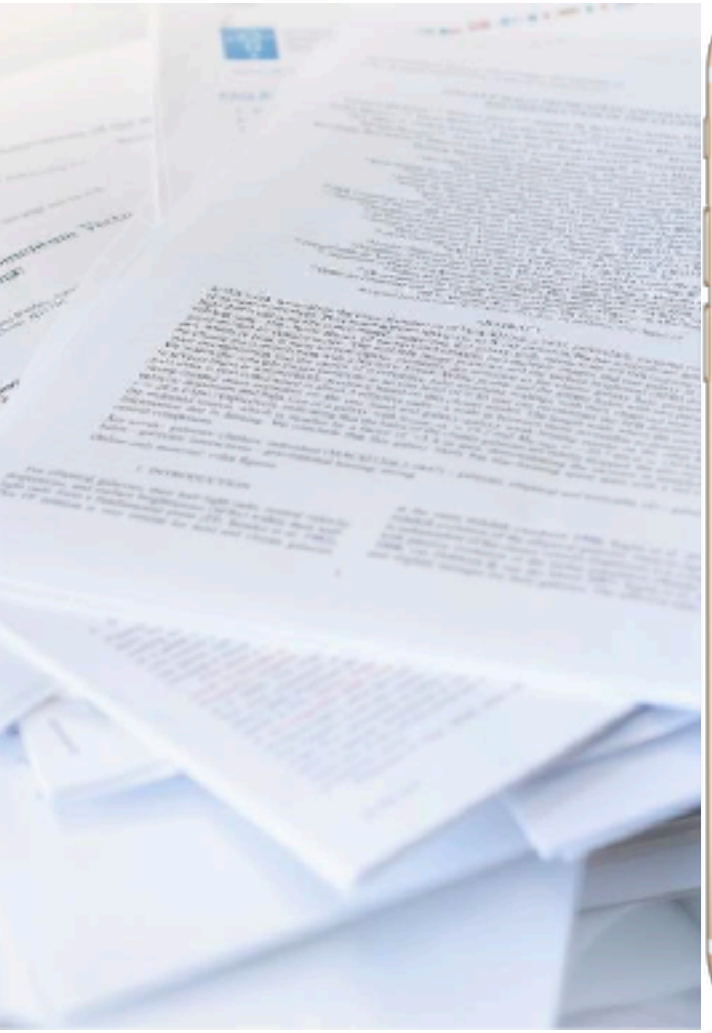

What plays the largest role in the world’s climate?
The Ocean


What plays the largest role in the world's climate?
The Ocean
> 90%
of heat content
> 93%
of planet CO_2


What percent of the ocean has never been observed?
> 95%


Building an internet of things to observe the underwater world

Course Organization



Reading & Reviewing Papers

Mobile (iOS) Labs

Class Project

Logistics

Grading:

- 1 Course Project (40%)
- 4+1 Labs (25%)
- 1 Quiz: April 16, during lecture (15%)
- 2 PSets (10%)
- Participation (10%)
  - Includes answering questions before every lecture
  - May skip one review without affecting grade
  - Attendance is mandatory

Website: https://6mobile.github.io/

Slack: 

Counts toward: AUS2, DLAB2, II requirements

Upcoming: iOS Tutorial (Fri 10-11AM, TBD location, not mandatory, but need to check off)

Policies

Late Policy

Late + Pset lab policy: 72 hours

AI Policy

Permitted uses:

- Debugging, refactoring, optimizing code
- Concept explanation
- Brainstorming with AI

Prohibited Use:

- Writing Reviews & Answering Questions about papers

Disclosure Requirement:

- If you use it AI in any capacity, you must disclose it, and explain how it's used (examples on website)

More details on the course website

iOS Labs (Need iPhone/iPad and Mac)

- To complete the labs, you will need:
  - an iPhone or iPad
  - a MAC
- Note: labs can be done in pairs

- For MIT students, we have secured some loaners for iPhones and MACs that we can provide
  - Will be provided on a first-come first-serve basis
  - We will send out a survey after class. Please respond asap

Projects

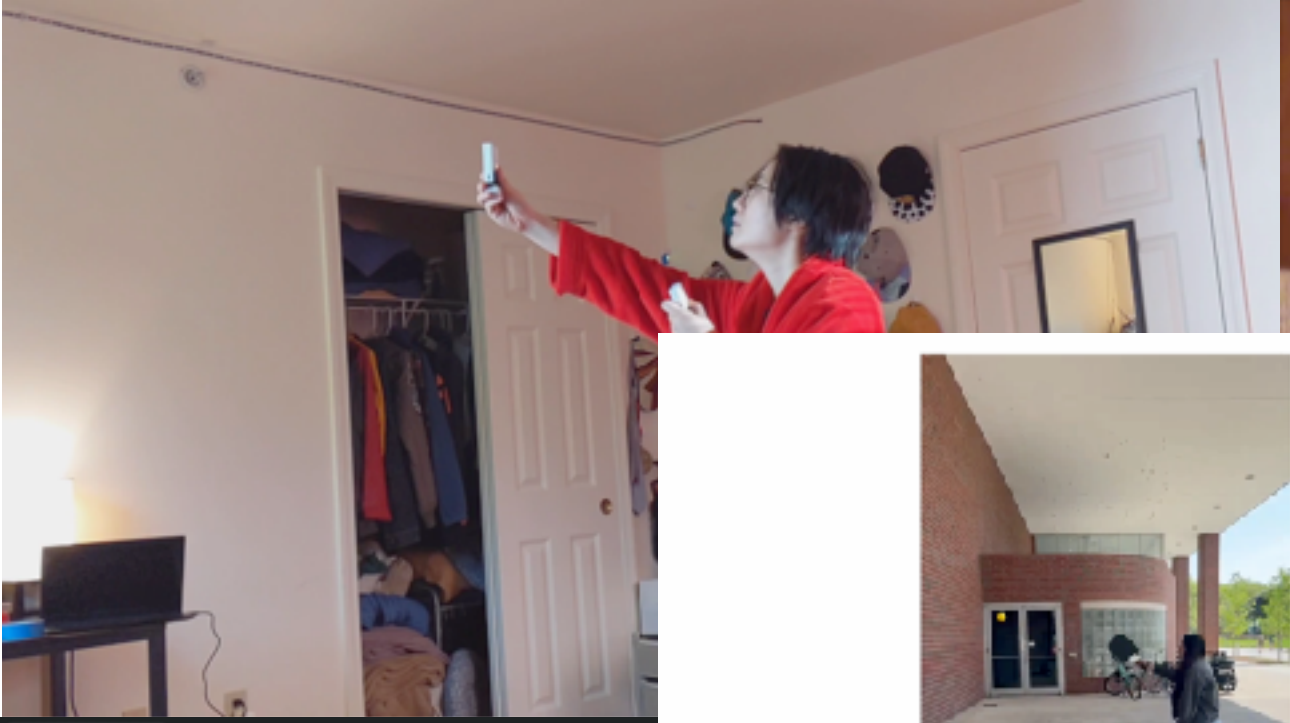
Students have most fun & learn most from the projects

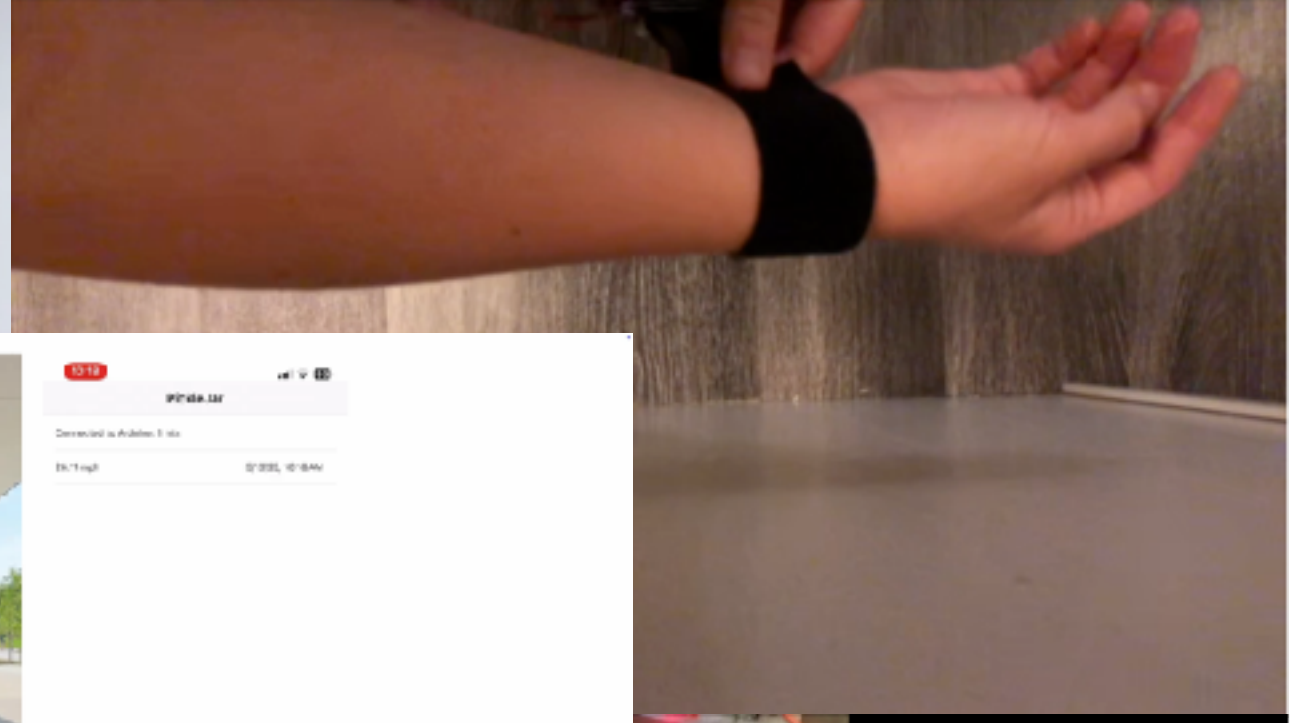
- All projects involve system implementation
- Ideal group size: 3
- Will suggest project ideas; students can choose their own projects

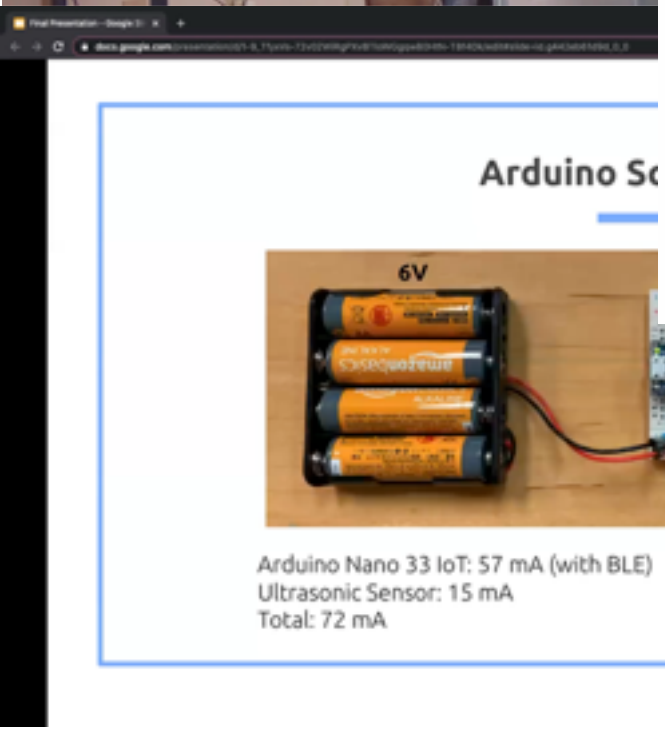
Timeline:

- Proposal (1-2 pages): March 31
  - We meet on April 7 & 9 (during class time) to give feedback
- Project Final Components Due: April 14
- Project titles & abstracts: May 5
- Project demos & presentations: May 12

Sample 6.1820/MAS.453 Projects (past years)





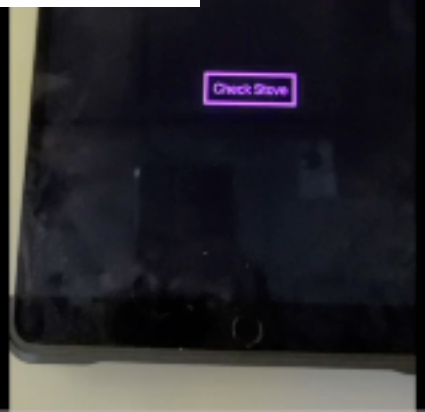


Arduino Sc

Arduino Nano 33 IoT: 57 mA (with BLE)
Ultrasonic Sensor: 15 mA
Total: 72 mA

Battery: 8000 mAh

Duration: 8000/72 ≈ 111 hours



Monday	Tuesday	Wednesday	Thursday	Friday
	Feb 3 *First day of classes* **LEC 1:** Introduction and Key Ideas **Assigned:** Lab 0		Feb 5 **LEC 2:** Fundamentals of IoT Localization **Preparation:** Read Location-based Services, Wikipedia: GPS (Questions)	Feb 6 *iOS Tutorial 10am-11am in 66-144.*
	Feb 10 **LEC 3:** Practical Device-based Localization		Feb 12 **LEC 4:** Seeing through Walls & Device-Free Localization **Preparation:** Read WiTrack **DUE:** Lab 0 (Questions)	
Feb 16 *Presidents' Day*			Feb 19 **LEC 5:** Network Connectivity (BLE, low power WAN, WiFi, cellular, 5G) gps surveillance **DUE:** Lab 1 (Questions)	
			Feb 26 **LEC 7:** Batteryless Connectivity & Smart Cities **Preparation:** Read Hacking RFIDs and Karaoke (Questions) **Assigned:** Lab 2	
	Mar 3 **LEC 8:** Intro to Inertial Sensing; Activity Recognition **Preparation:** Read Developments of Inertial Sensing and Principles of Inertial Sensing (Section 3.1 and 3.2 only)		Mar 5 **LEC 9:** Pothole detection **Preparation:** Read Pothole Patrol (Questions) **DUE:** Pset 1	
				Assigned: Pset 2
Mar 23 *Spring Break*				Mar 27 *Spring Break*
	LEC 14: Agriculture IoT **Preparation:** Read FarmBeats (Questions) **DUE:** Project Proposals			
	Apr 7 Project meetings (No lecture; meet with staff during class time) **DUE:** Lab 4			
	Apr 14 Quiz review session during class **DUE:** Final Project Components List		**Midterm during lecture time**	
Apr 20 *Patriots' Day*	Apr 21 Project meetings (No lecture; meet with staff during class time) *Drop Date*			
	Apr 28 Project meetings (No lecture; meet with staff during class time)			
	May 5 Project meetings (No lecture; meet with staff during class time) **DUE:** Project Titles and Abstracts			
	May 12 **Final Presentations** **DUE:** Presentations and Demos *Last Day of Classes*			May 15 *Finals begin*

New Topics:

- Ear Bubbles
- Wireless NeRFs

If the exam deadline conflicts with any religious observance, please let us know asap

Note:

For cross-registered students, please make sure you are available for all classes and there's no conflict on exams/etc.

Will collect feedback within 2-3 weeks of the beginning of the semester