

USC Viterbi



School of Engineering
*Center for Cyber-Physical Systems
and the Internet of Things*

Towards large-scale IoT network testbed platforms

Bhaskar Krishnamachari

Ming Hsieh Faculty Fellow and Professor of Electrical Engineering and Computer Science
Director, USC Viterbi CCI

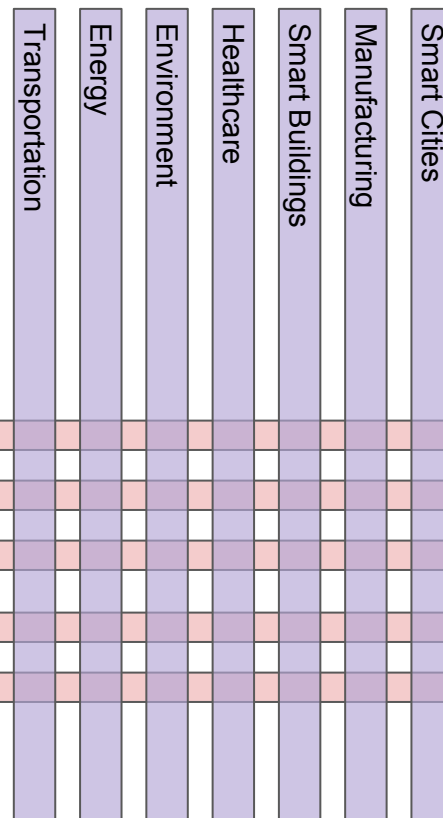
May 5, 2017

USC Viterbi



School of Engineering
*Center for Cyber-Physical Systems
and the Internet of Things*

APPLICATION DOMAINS



TECHNOLOGIES AND TOOLS

Security and Privacy

Software Engineering, Interfaces & Visualization

Signal Processing, Data Analytics, Machine Learning, Control

Networking, Middleware, Storage and Cloud Computing

Sensing, Energy-harvesting, and Computational Hardware

Find out more at
<http://cci.usc.edu>

USC Viterbi CCI Activities

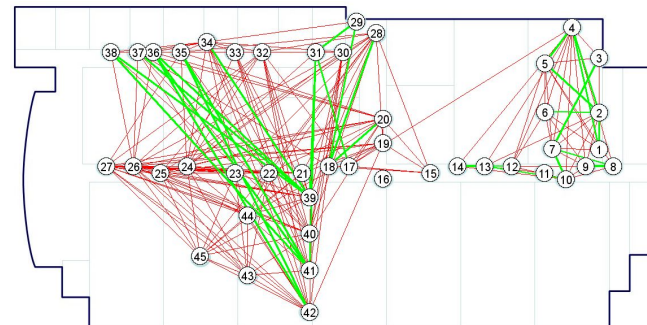
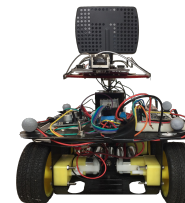


- Thought leadership **events**: seminar series, workshops, industry meetups
- Current **focus areas**: IoT platforms, connected and driverless vehicles, cyber-physical security and privacy, and theoretical foundations of cyber-physical systems

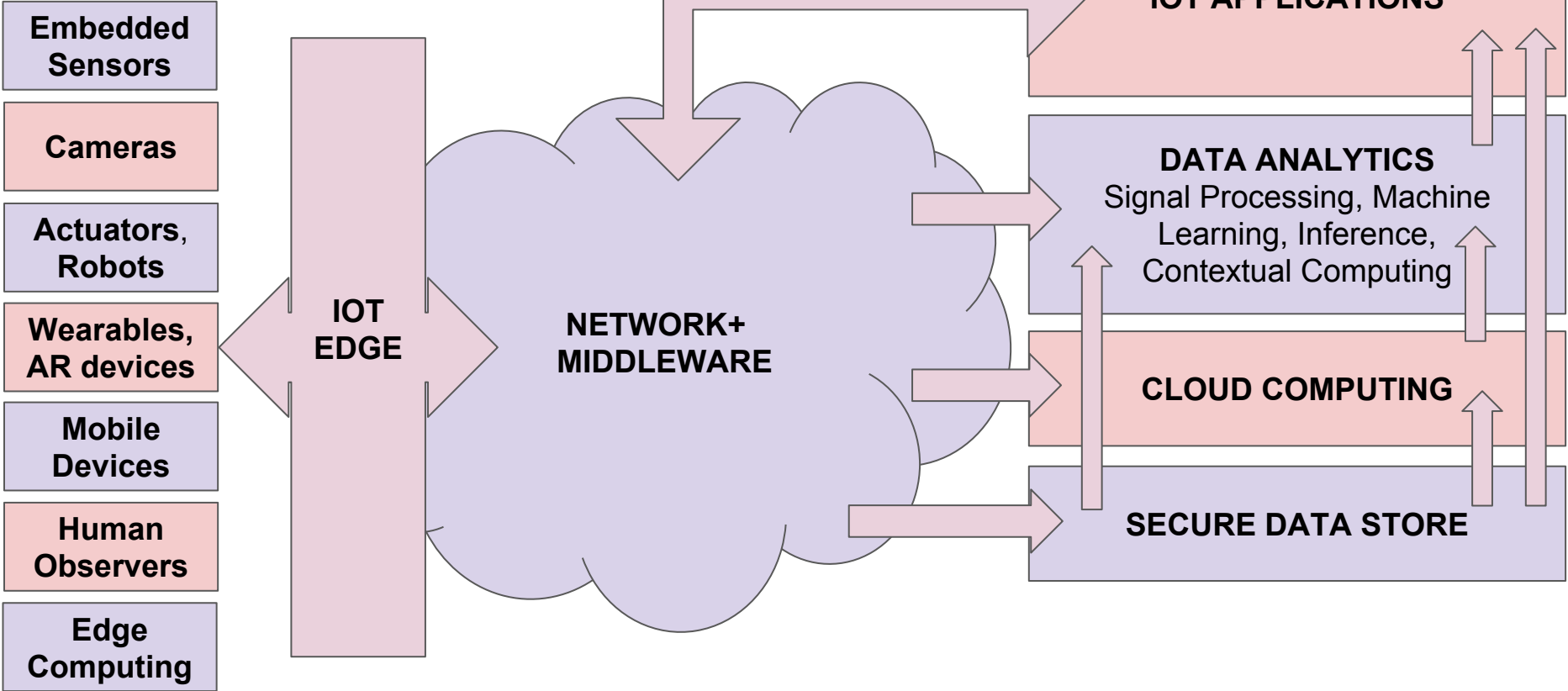
- **Research testbeds**: **Tutornet**, an existing state of the art low power indoor IoT testbed. New sensor-rich campus-wide **CCI IoT testbed** under development.

- **Education**: developing new courses and programs related to IoT and CPS
- **Outreach**: building collaborative partnerships with industry and government

$$\begin{aligned} T_{eq} &= \frac{1}{2} \mathbf{G}_1 (\mathbf{I} + \mathbf{J}_\beta) \mathbf{H}_1 + \frac{1}{2} \mathbf{G}_0 (\mathbf{I} - \mathbf{J}_\beta) \mathbf{H}_0 \\ &= \frac{1}{2} \underbrace{(\mathbf{G}_1 \mathbf{H}_1 + \mathbf{G}_0 \mathbf{H}_0)}_A + \frac{1}{2} \underbrace{(\mathbf{G}_1 \mathbf{J}_\beta \mathbf{H}_1 - \mathbf{G}_0 \mathbf{J}_\beta \mathbf{H}_0)}_B \end{aligned}$$



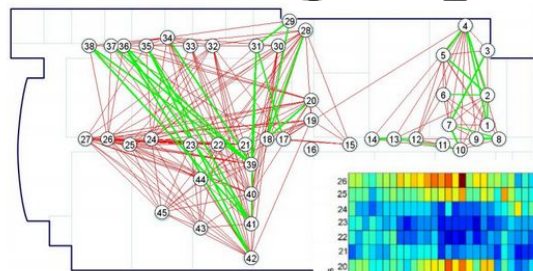
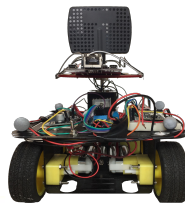
IoT Architecture



The USC Tutornet IoT Testbed

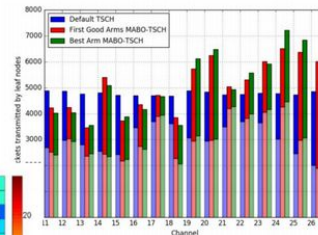
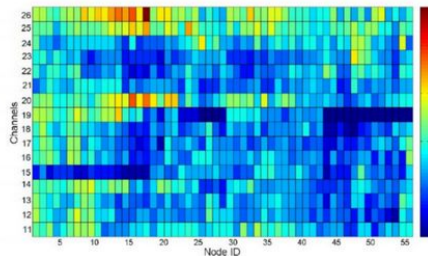


- Established 2006. One of the first-ever low power wireless testbeds in the world. 100+ nodes. Wired for power, programming, data-upload, wireless 802.15.4-based. Has been used for the design and evaluation of many protocols.
- Ongoing: integrate robotic nodes with testbed.
- Has played a key role in industry collaborations with Bosch, GM, design and evaluation of industry standard protocol (RPL).

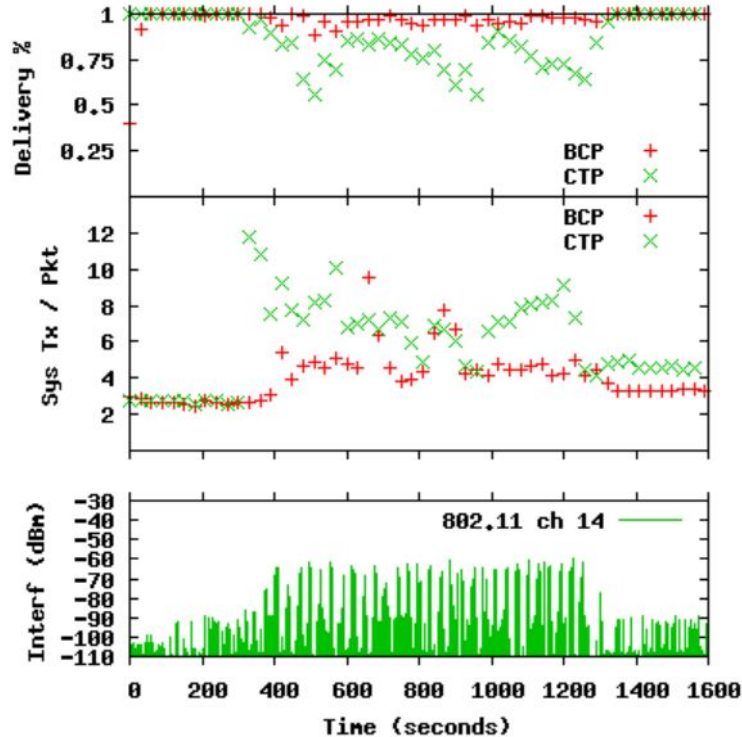


USC
Tutornet
Testbed

Work with Pedro Gomes,
Ying Chen, Thomas
Watteyne



Protocols for Low power WSN/IoT



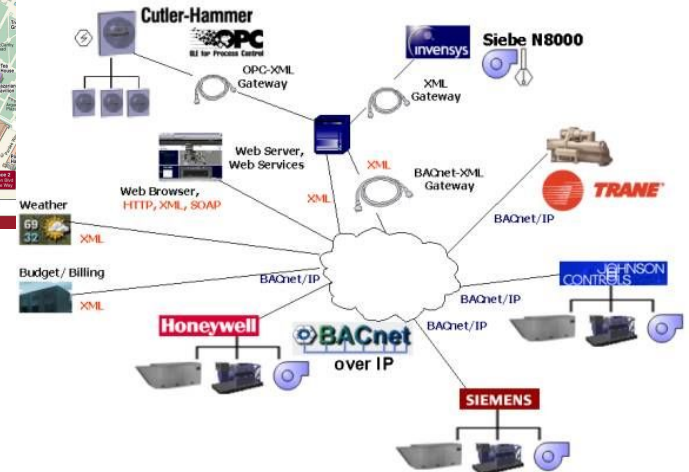
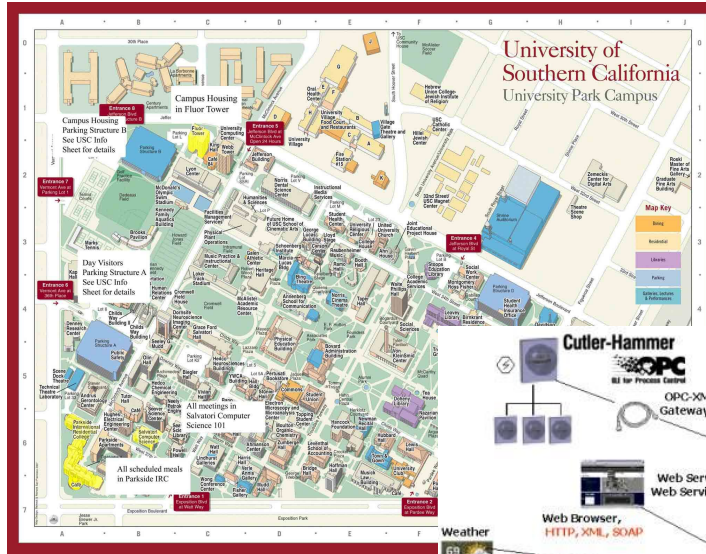
Software implementation of network protocols for moving sensor data quickly and reliably:

- Scalable Medium Access
- SenZip
- Backpressure Collection Protocol
- Wireless Rate Control Protocol
- Backpressure with Adaptive Redundancy

USC CCI IoT Testbed (in development)

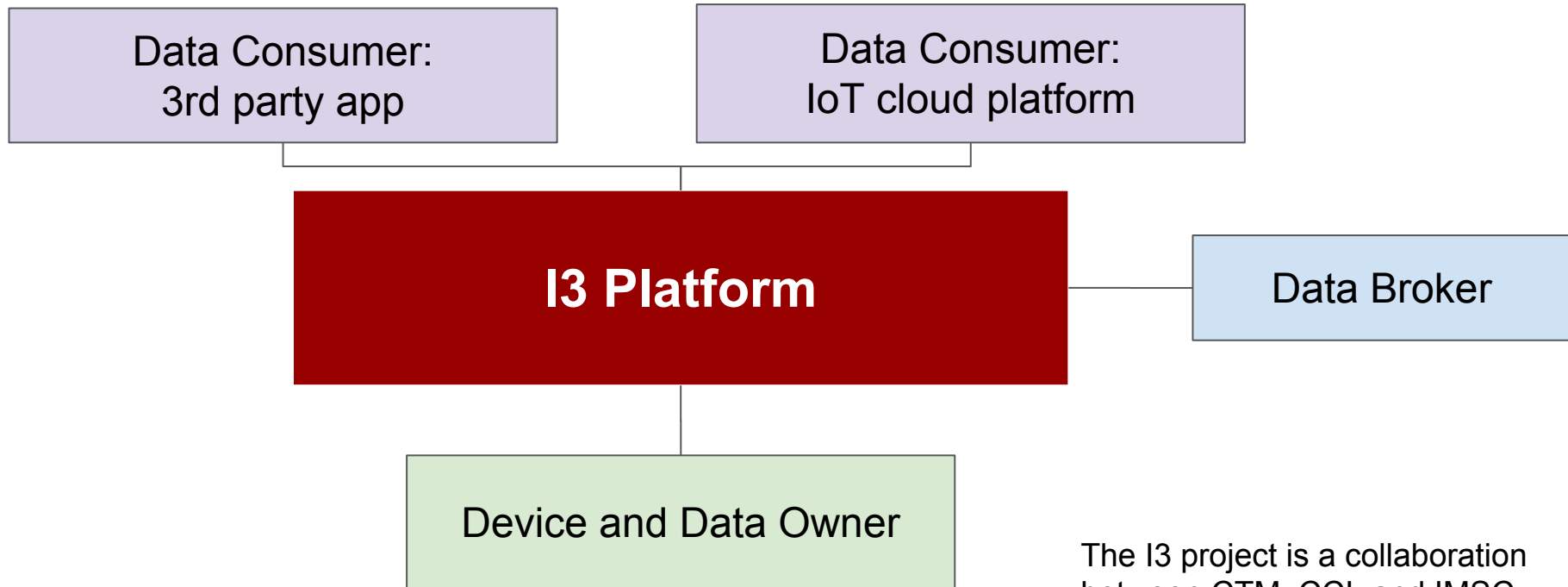


- A new campus-wide testbed
- For evaluating IoT hardware, software, and applications
- **Scale:** 50-100 gateways, up to 50 devices per gateway
- **Heterogeneity:** seeking a wide range of sensing/actuation, compute, and (wired/wireless) communication capabilities. Mix of legacy and innovative systems
- **Interoperability:** between sensor/actuator vendors and analytics / application developers using an application-layer middleware



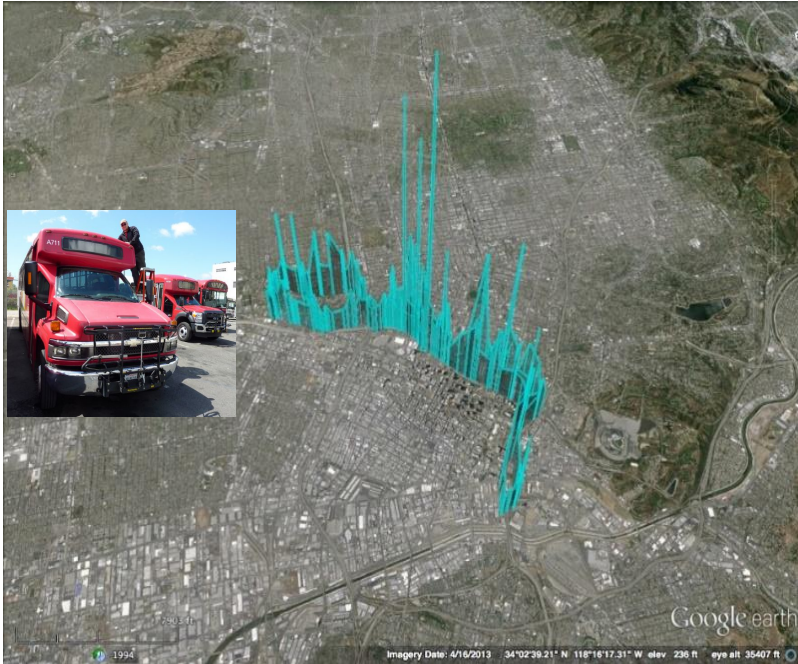
I3: an IoT Marketplace Platform

Buy, Sell, Authorize Real-Time Sensor Data and Actuator Access



The I3 project is a collaboration between CTM, CCI, and IMSC

Scaling to the City



LOS ANGELES OPEN DATA

Information, Insights, and Analysis from the City of Los Angeles



Thanks!

bkristhna@usc.edu