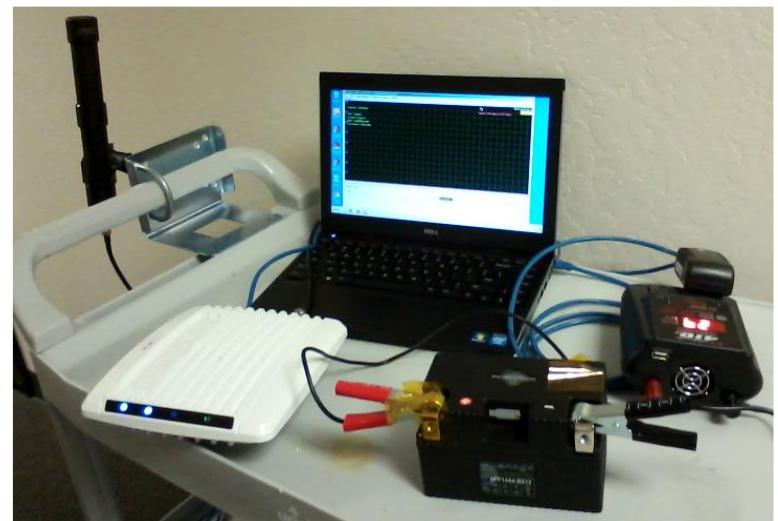


# Demonstrating White Space Networking Capabilities and Potential with an Embedded & Open-API Platform

George Nychis (Adaptrum), Bruce DeBruhl (CMU), Peimin Chi (Adaptrum), Haiyun Tang (Adaptrum)

1. Two white space links created using our FCC certified equipment
  - A **fixed link** across multiple floors of the hotel
  - A **mobile link** for participants to experiment with

2. Insight in to our real white space networks with interactive data



**ADAPTRUM**

# Real-time Breath and Heart Rate Monitoring Using Wireless Signals



# iGaze: Vision Driven Networking



- **Can** understand the user's visual attention using an eye camera
- ● **Can** automatically connect to the target of interest.
- ● **Can** run on top of existing networking protocols, e.g., Wi-Fi.

Pengfei Zhou, Weiming Chan, Shiqi Jiang, Jiajue Ou, Mo Li and Guobin Shen



How to accurately know the 3D orientation  
of your phone (phone attitude)?

What applications can we play  
with phone attitude?



# SDR – on a Smartphone, as an App!

NEWS ANALYSIS

## Smartphone innovation is slowing down so what's next?

Smartphone Upgrade News: Now as 'Wow' Factor Fades  
What's wrong with smartphones today?  
They're boring

Carriers are hurting, while Apple and Samsung are left on Wall Street. The root of the problem: Slowing smartphone innovation

- Smartphones have got fast enough to do **SDR**!
  - Even  $\frac{1}{2}$  of 802.11a, and snugly 802.15.4
- It can let smartphones talk to **IoT** devices without chips!
  - Good news for smartphone vendors
    - Don't need to put chips and use real-estate to speak protocols other than cellular, WiFi, and Bluetooth
    - RFID, WAVE device, ZigBee all with a single radio front!

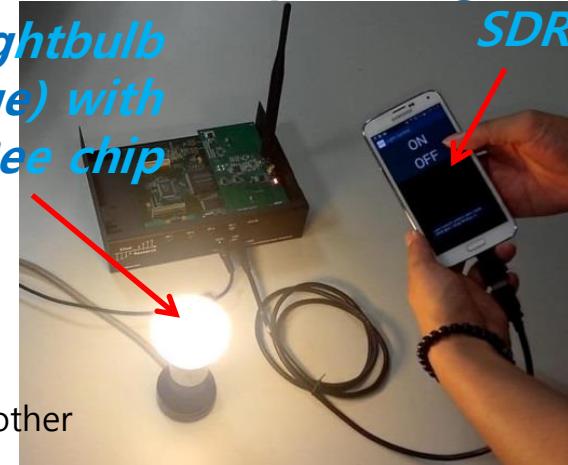
*Why don't we let smartphones speak "thousand protocols," not just cellular, Wi-Fi, and Bluetooth ... 'cause IoT would frequently need lower-speed protocols than these...*



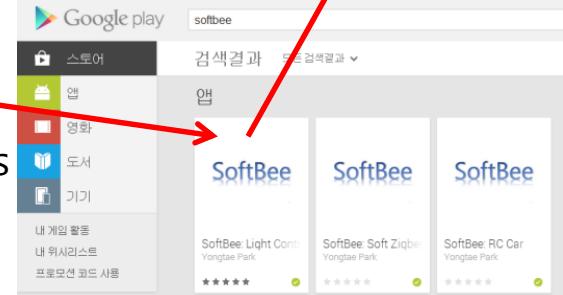
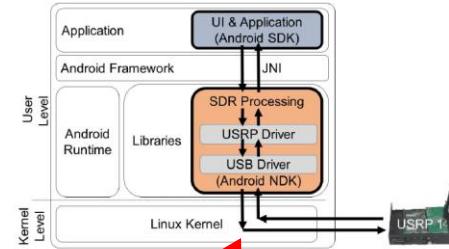
- Smartphone SDR has been made into an "**app**"
  - No dependency on OS provider
  - Anyone can upload/download his/her own wireless protocols
    - Unpopular, niche, experimental, non-standard, ...
  - **SDR app now available on Google Play Store**

*Smartphone without ZigBee chip but ZigBee SDR*

*Smart lightbulb (Phillips Hue) with ZigBee chip*



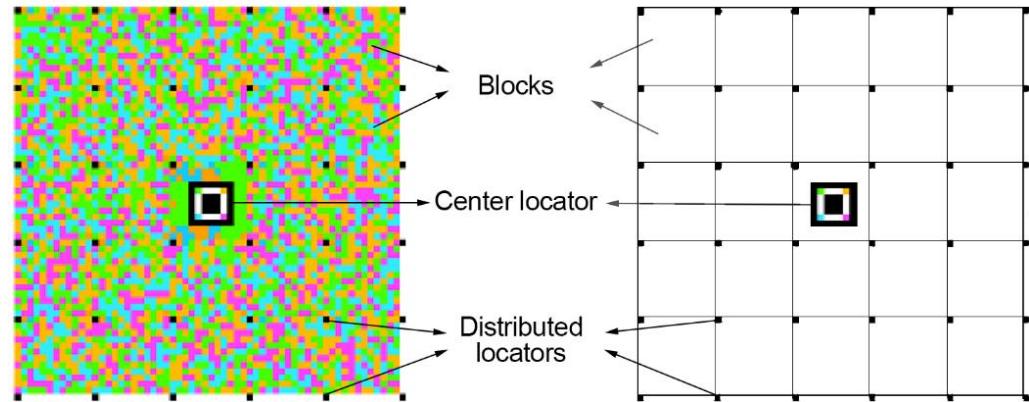
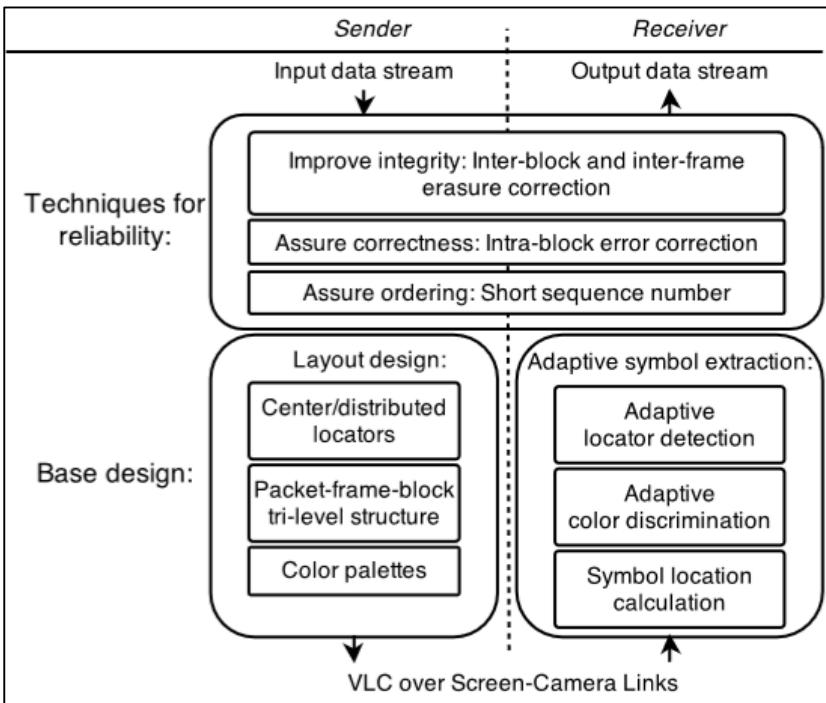
USRP b200: 70MHz – 6GHz RF coverage



# A Robust Barcode System for Data Transmissions over Screen-Camera Links

Anran Wang<sup>1</sup>, Shuai Ma<sup>1</sup>, Chunming Hu<sup>1</sup>, Jinpeng Huai<sup>1</sup>, Chunyi Peng<sup>2</sup>, Guobin Shen<sup>3</sup>

<sup>1</sup>Beihang University, <sup>2</sup>The Ohio State University, <sup>3</sup>Microsoft Research



## *A layered barcode layout*

A novel packet-frame-block barcode layout.

## *Adaptive symbol extraction*

Our adaptive symbol extraction methods can locate available distributed locators even if a portion of the barcode is unavailable.

## *Techniques for reliability*

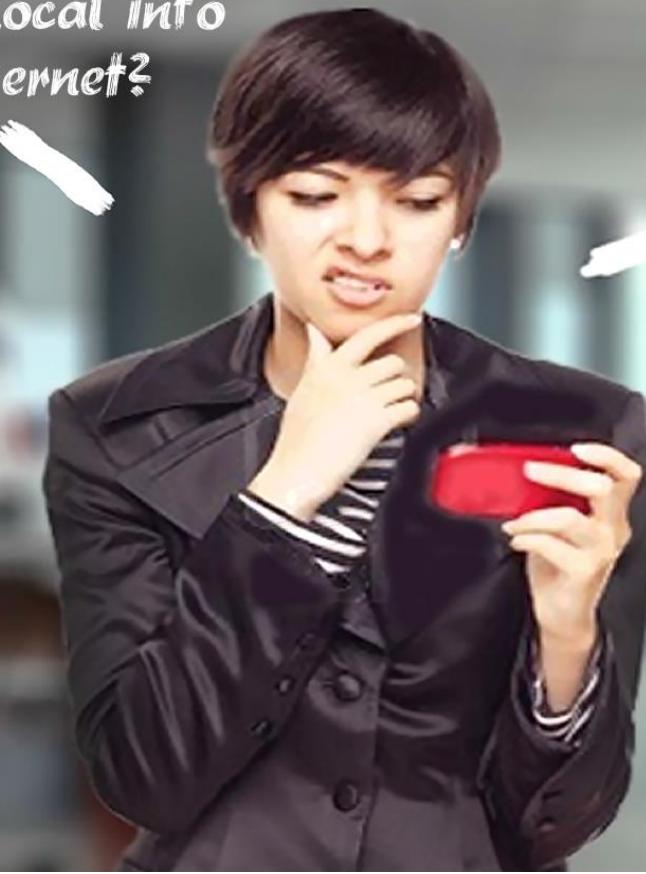
Based on the observation of the error distribution, we apply three different error correction codes on blocks, frames and packets respectively.

**RDCode** not only enhances the transmission reliability by addressing the smartphone limitations and user behavior uncertainty, but also improves the transmission rate.

**More Details:** Anran Wang, Shuai Ma, Chunming Hu, Jinpeng Huai, Chunyi Peng, and Guobin Shen. Enhancing reliability to boost the throughput over screen-camera links. In MobiCom, 2014.

# Mobile Opportunistic System for Experience Sharing (MOSES) in Indoor Exhibitions

*How do I get local info  
without the Internet?*



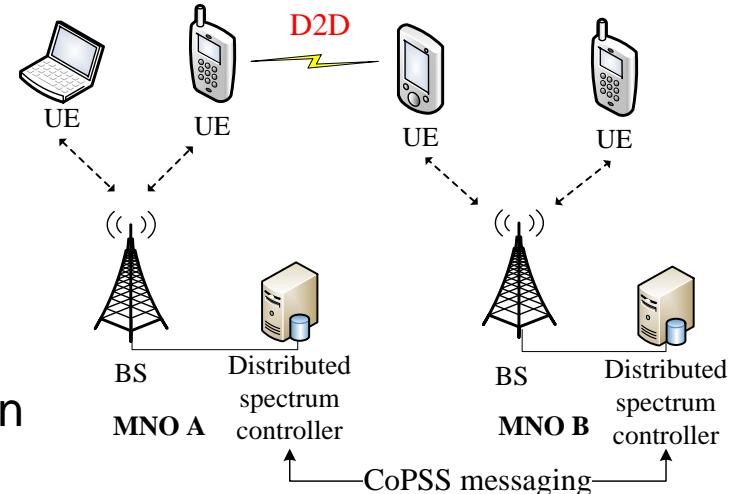
- Information-centric networking
- Opportunistic sharing of content based on location
- GeoTagged content by GPS, iBeacons, etc.
- Dissemination of user-content
- Location relevant content available everywhere
- Decentralization of content sharing

Fehmi Ben Abdesslem, Anders Lindgren

SICS Swedish ICT

# Co-primary Spectrum Sharing (CoPSS) with Inter-Operator D2D Trial

- Co-primary spectrum sharing concept enables multiple MNOs to simultaneously share the spectrum.
  - The band will have multiple licensees instead of just one.
- Protocol for distributed spectrum controllers (SCs) with minimum information exchange between MNOs.
- CoPSS is not intended to replace the guaranteed exclusive band, that the MNOs have, but to provide additional band through sharing.
- For the MNO, the benefit of CoPSS is the additional resource for temporary peaks in demand.
- CoPSS is considered to be used for small cells.
- Inter-operator device to device (D2D) communication can be established using CoPSS resources.



# OpenAirInterface - An Open LTE Network in a PC

## ■ OpenAirInterface



- Suitably flexible platform for an open cellular ecosystem both for 4G experimentation as well as for 5G research
- Open-source reference software implementation of 3GPP-compliant LTE system and a subset of LTE-A features
- Real-time indoor/outdoor experimentation and demonstration

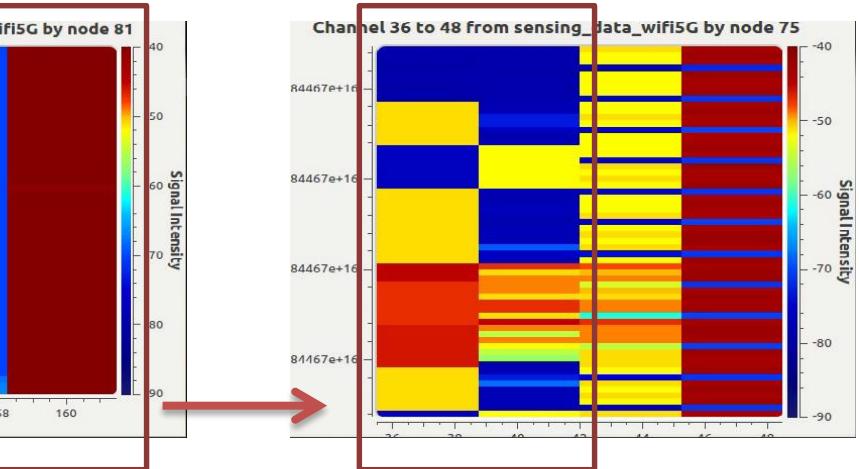
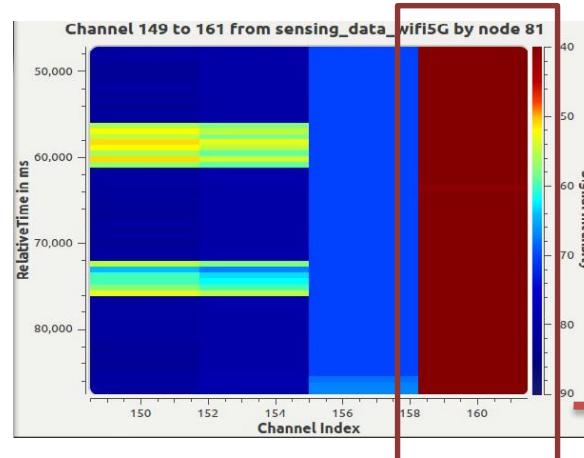
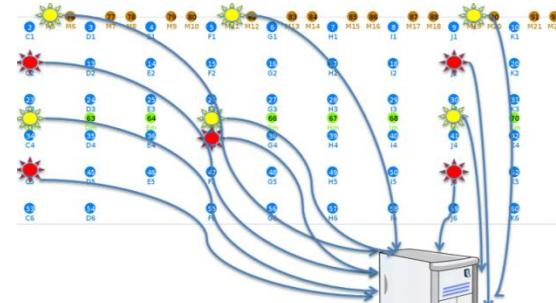
**Promote the development, distribution and adoption of the opensource hardware and software open cellular ecosystem**

# A cognitive solution for wireless conferencing system



- Televic Conferencing system
- Works brilliantly in a free spectrum
- What if there is interference?
- Spectrum sensing with USRP's
- Searching for a free channel
- Switching a free channel to improve Quality of Service

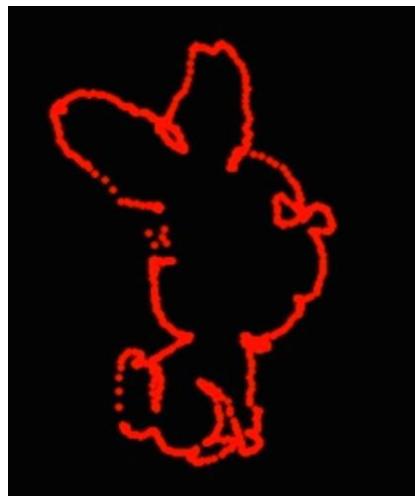
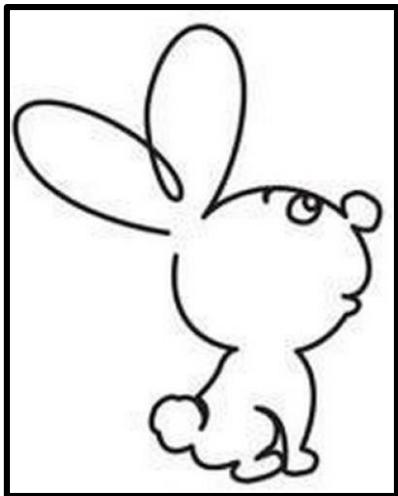
televic



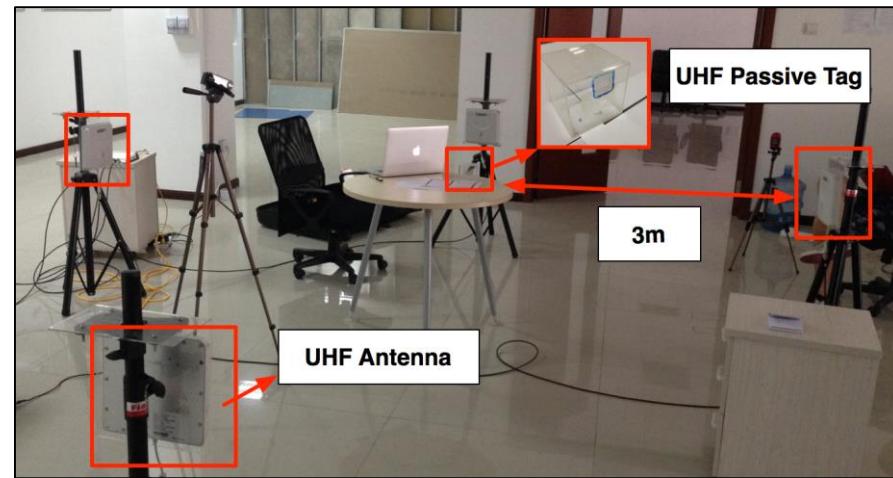
Channel switch from 160 to 36

# High-Precision RFID Tracking Using COTS Devices

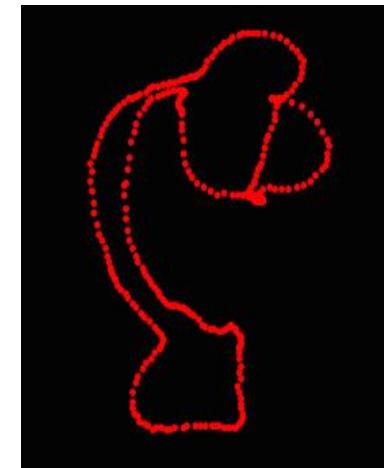
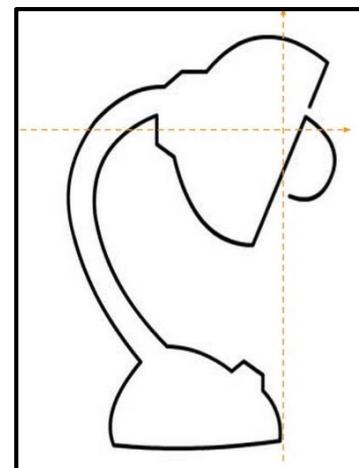
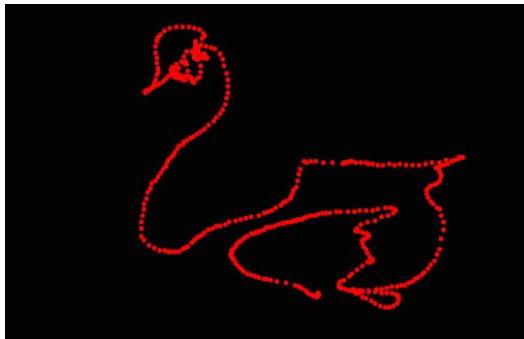
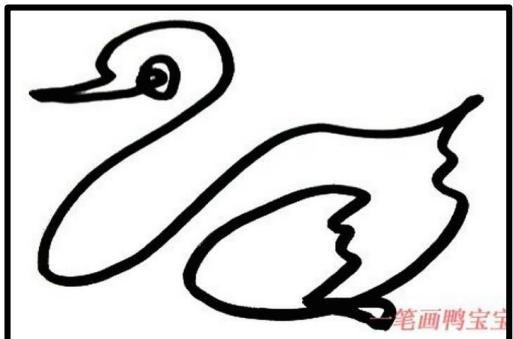
## Drawing in the Air



↑  
20cm  
↓



←→  
15cm





# Demo: RollingLight – Universal Camera Communications

Light fixture



TX



Scooter tail light

Text transmission



10 ~ 15 Byte/s

iPhone 5S



RX

iPad Air



Utilize any unmodified CMOS camera.  
Camera communications as an APP.

# Tracking User Browsing on a Demo Floor

A. Ganesan<sup>+</sup>, S. Rallapalli<sup>\*</sup>, K. Chintalapudi<sup>†</sup>, V. N. Padmanabhan<sup>†</sup>, L. Qiu<sup>\*</sup>

<sup>+</sup>Microsoft Research India

<sup>\*</sup>The University of Texas at Austin

Classify behavior into categories  
below (inertial sensing)



Identify what the user is  
gazing at (vision)



Walk



Conference



Retail store

Dwell



Gaze

- **Walk:** purposefully towards area of interest
- **Dwell:** stop and spend time around general area of interest
- **Gaze:** look at an object with a keen interest

# Enabling AGILE Spectrum Adaptation in Commercial 802.11 WLAN Deployments

- ✓ In this demo, we present a Real-time demonstration of the AGILE system that implements **Dynamic Spectrum (Central Frequency-Bandwidth) Adaptation** on commercial 802.11n hardware.

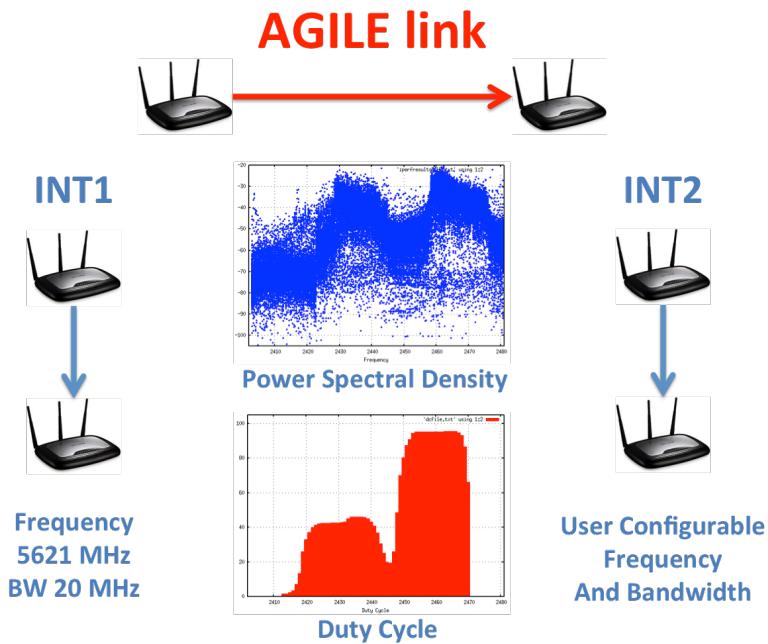
## The AGILE System

- ✓ Identification of under-utilised spectrum fragments is based on Power Spectral Evaluation derived through hardware inherent in the PHY-layer of standard 802.11 chipsets.
- ✓ Adaptation of occupied Spectrum by configuring:
  - **Channel Bandwidth** (40, 20, 10 and 5 MHz)
  - **Channel Central Frequency** (steps of 1 MHz)

## Advantages

- ✓ Distributed protocol operation
- ✓ Compliance with **802.11 standard**.
- ✓ Improved Performance under High Interference conditions
- ✓ Minimal protocol overhead

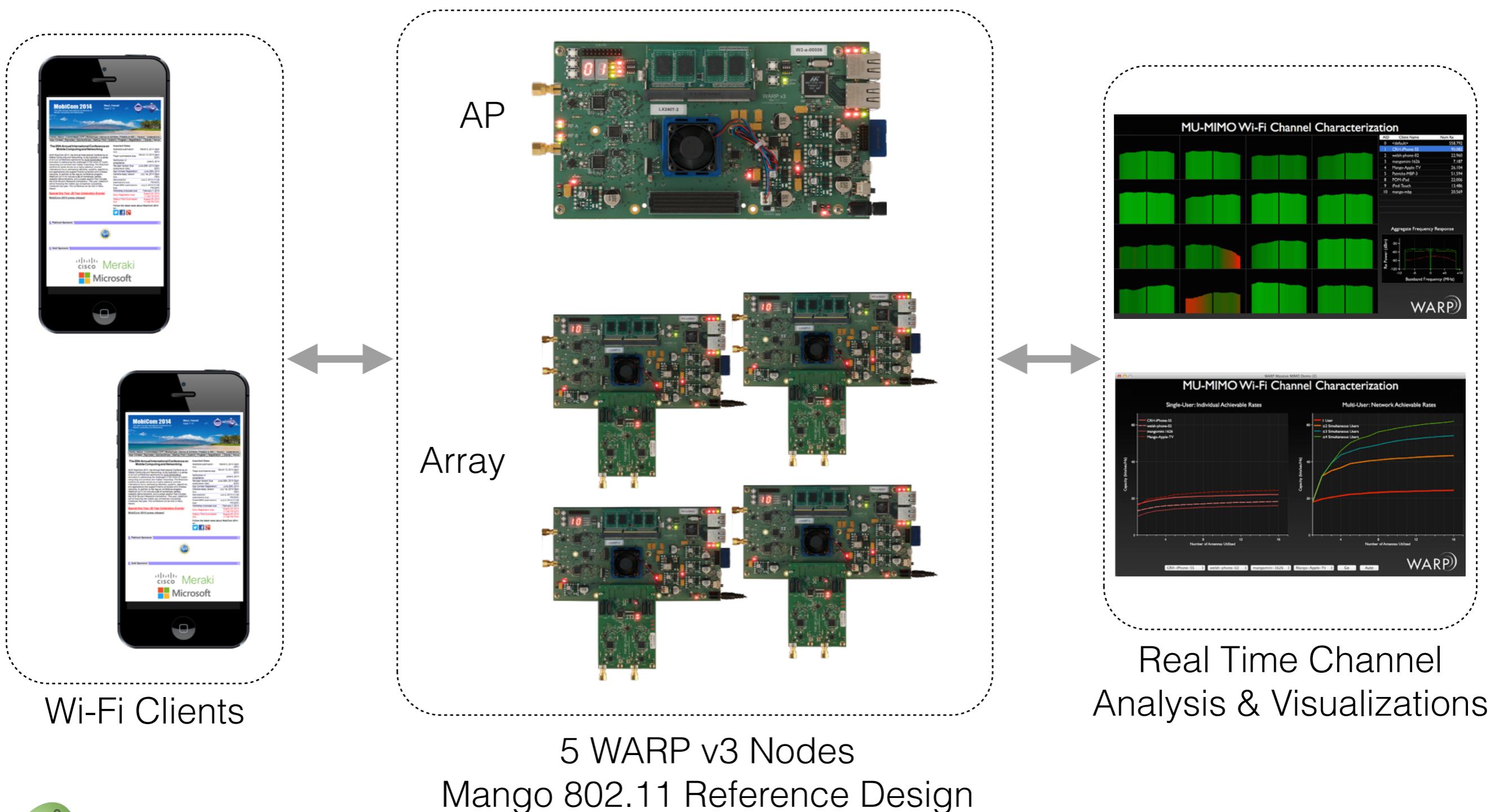
## Demonstration



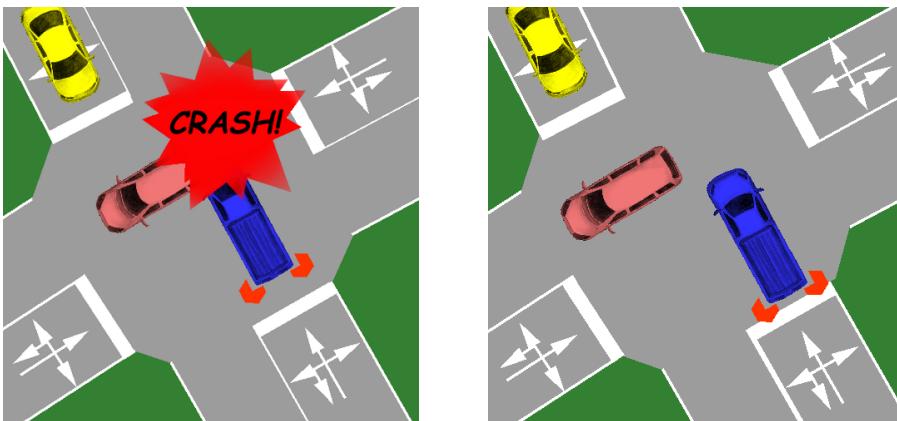
1. The **demo attendee** is able to configure the occupied spectrum of two interfering links.
2. The AGILE link constantly adapts to the prevailing channel and traffic conditions.

# Real-Time Multi-User MIMO Channel Analysis with a Custom 802.11 Implementation

Chris Hunter, Patrick Murphy & Erik Welsh



## Simulating the Impact of Communication Performance on Road Traffic Safety at Intersections



Stefan Joerer, Bastian Bloessl, Matthaeus Huber,  
Abbas Jamalipour, and Falko Dressler

# Luxapose: Indoor Positioning with Mobile Phones and Visible Light

- Angle of arrival
- Decimeter accuracy
- Slightly modified LED luminaires
- Unmodified mobile phone

80 lb. demo setup!



# PhoneLets (what is a phone anyway?)

Part of your ID **and** a gateway to the Internet

Both are tied to a SIM card – why not move it?

Share it wirelessly across devices

- Save energy
- Share the costs
- Reduce the network load



See me at the demo session!

# ShadowMaps, The Urban Phone Tracking System

- GPS severely degraded if satellites are shadowed by tall buildings
- Can use untapped, crowdsourced GPS data to build 3D maps
- Then, can use 3D maps to provide accurate GPS positioning
- Real-time remote demo of location improvement and map matching

