MOBICOM 2014 DEMOS
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 into our real white space networks with interactive data
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.
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!

Smartphone innovation is slowing, so what's next?

What's wrong with smartphones today?

They're boring

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

• Smartphones have got fast enough to do SDR!
  – Even ½ 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
A Robust Barcode System for Data Transmissions over Screen-Camera Links

Anran Wang\textsuperscript{1}, Shuai Ma\textsuperscript{1}, Chunming Hu\textsuperscript{1}, Jinpeng Huai\textsuperscript{1}, Chunyi Peng\textsuperscript{2}, Guobin Shen\textsuperscript{3}
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**Techniques for reliability:**
- Improve integrity: Inter-block and inter-frame erasure correction
- Assure correctness: Intra-block error correction
- Assure ordering: Short sequence number

**Layout design:**
- Center/distributed locators
- Packet-frame-block tri-level structure
- Color palettes

**Adaptive symbol extraction:**
- Adaptive locator detection
- Adaptive color discrimination
- Symbol location calculation

**VLC over Screen-Camera Links**

**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.

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

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

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

- Televis 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

Delegate Unit A

Delegate Unit B

Access Point

Sensing data is collected in database

Wei Liu, Eli De Poorter, Pieter Becue, Bart Jooris, Vincent Sercu, Ingrid Moerman, Jeroen Vanhaverbeke
High-Precision RFID Tracking Using COTS Devices

Drawing in the Air
Utilize any unmodified CMOS camera. Camera communications as an APP.
Tracking User Browsing on a Demo Floor

A. Ganesan⁺, S. Rallapalli*, K. Chintalapudi⁺, V. N. Padmanabhan⁺, L. Qiu*

⁺Microsoft Research India  *The University of Texas at Austin

Classify behavior into categories below (inertial sensing) + Identify what the user is gazing at (vision)

Walk

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

Wi-Fi Clients

5 WARP v3 Nodes
Mango 802.11 Reference Design

AP

Array

Real Time Channel Analysis & Visualizations
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
Demo: An Open-Source Development Platform for Long-Range UHF-Connected WiFi Hotspots

Internet

UHF AP

UHF Backhaul

802.11 CSMA Clique

UHF STA

Laptop

UHF STA

802.11g AP

802.11g STAs

Ryan E. Guerra
Narendra Anand
Dr. Edward Knightly
MOBICOM 2014 POSTERS
ColPhone:
Smartphone is just a piece of puzzle

- Human Smartphone relation
- Infrastructure-less Collaboration.
- Roles and Modules
- 3D Story Teller.
Adaptive Flow Control for Wireless Serial Bus using Wi-Fi Transmission Opportunity
- Woo-Sung Jung, Keun-Woo Lim, Young-Bae Ko -

USB → Wi-Fi over USB

What is the PROBLEM?
▷ Wi-Fi cannot guarantee bandwidth → Loss of Reliability!

How to solve the problem?
▷ You can find our solution in the our poster session!!

See you soon in Poster Session!!
SaveAlert: A Sensor-driven Crowd Monitoring System

- Monitoring crowds at mass gatherings to detect impending danger and determine where resources are needed to be deployed.
- Automated monitoring using mobile crowd-sensing approaches.
  - Put too much stress on the network infrastructure due to periodic uploads depending on the users’ participation level.

- Hierarchical dynamic backbone in the crowd to locally aggregate data.
  - Constructed by leveraging Bluetooth and WiFi Direct for P2P transmission.
- Android crowd-monitoring app that measures the changes in audio levels and notifies users of impending danger.
AirEye: Blind Monitor the ISM Band Based on Narrowband Radio

AirEye is a powerful wideband spectrum monitor:

• **Precise signal detection:** exploit robust signal’s cyclic feature to achieve an average accurate detection rate of 94%-98%
• **Blind feature extraction:** require no prior knowledge of signal model → easy to accommodate emerging new wireless technologies
• **Inexpensive narrowband radio:** require no powerful wideband radio

Meng Meng, Kun Tan, Wenjie Wang
Are You Driving? Non-intrusive Driver Detection Using Built-in Smartphone Sensors

Homin Park, DaeHan Ahn, Myonggyu Won, Sang H. Son, Taejoon Park
Real Time Cyber Physical System Lab, Department of Information and Communication Engineering, DGIST, Rep. of Korea

Why are we doing this?

Existing Works

Vehicle Turning Movement Analysis (MobiCom 2013)
- Distinct angular velocities from each seat

Bumping Motion Analysis (MobiSys 2013)
- Front part of vehicle is most likely to bump-up first

Image Processing (Apple Patent 2014)
- Requires intrusive actions from the driver

Proposition!!

Non-intrusive! Only uses actions and event that are indispensable before driving

Infrastructure-less! No additional device required!

Sitting Down (Entering a vehicle)
Vehicle Door Closing
Engine Start
In-Lane Communication Framework Using Smartphone’s Inertial Sensors

Abdulla Alasaadi (aalasaad@cs.odu.edu), Tamer Nadeem (nadeem@cs.odu.edu)

Table 1. The accuracy of identifying lanes in different environments using different features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Correct est. city street</th>
<th>Busy exit ramp</th>
<th>Intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average speed</td>
<td>76.32</td>
<td>94.82</td>
<td>82.64</td>
</tr>
<tr>
<td>No. of Stops</td>
<td>84.97</td>
<td>76.34</td>
<td>81.08</td>
</tr>
<tr>
<td>Waiting Time</td>
<td>88.20</td>
<td>76.34</td>
<td>86.32</td>
</tr>
<tr>
<td>Physical Features</td>
<td>78.47</td>
<td>83.84</td>
<td>84.61</td>
</tr>
<tr>
<td>All</td>
<td>86.64</td>
<td>91.47</td>
<td>84.74</td>
</tr>
</tbody>
</table>

- Physical characteristics of the street: bumps, potholes, turns, and sensors readings [gyroscope and accelerometer].
- Driving features like average speed, number of stops, waiting time, max. and min. speeds, time between stops, etc. can identify a lane in most streets.

Broadcast message and signature to nearby cars.
Doppler Effect based Device-free Moving Object Localization

- The Doppler shifts caused by human moving is uncertain, sometimes can not be detected.
- Doppler shifts does not contain location information.

**Key challenges**

1. Extract the small Doppler shifts from object movement
2. Mapping from Doppler shifts to arrival Angles
Prefetching is a great way to offer mobile users instant Web browsing experience. However, the accuracy of prefetching appears to be low.

In this work, our key idea is to prefetch Web pages basing on the relevance between what the users are seeing and what they have seen.

→→ The titles of news pages instead of URLs alone.
STYROFOAM

Characterize and constrain inter-symbol interference with Styrofoam spacing blocks

Authors:
- David Ramirez
- Robert LiKamWa
- Jason Holloway

Advisors:
- Behnaam Aazhang
- Lin Zhong
- Ashok Veeraraghavan
Programming Software-Defined Wireless Networks

- Increasing network complexity
  - Right amount of information in right hands
  - Hardware devices slow network changes
- Existing SDN offerings don’t meet needs
  - Lack RAN specific features
Bringing Mobility-Awareness in WLANs using PHY Layer Information

Li Sun\textsuperscript{1,2}, Souvik Sen\textsuperscript{1}, and Dimitrios Koutsonikolas\textsuperscript{2}
\textsuperscript{1}HP Labs, \textsuperscript{2}University at Buffalo, SUNY

How can we detect client mobility using WiFi only?

- Use PHY layer information
- Implementation on AP only
- Use off-the-shelf devices
- Improve protocol performance greatly

Our Approach

Today’s WLAN

- Protocols optimized for static clients
- Use phone sensor to detect mobility?
Detection of Transportation Mode Based on Smartphones for Reducing Distracted Driving

Your smartphone knows you are driving and locks the phone screen automatically

System Design

- run in the background
- collect embedded sensor data
- detect current transportation mode
- lock the screen when driving detected

Xin Gao  New Jersey Institute of Technology
Basic Idea

- Using smartphone’s earphone to capture the breathing sound for fine-grained sleep monitoring.

Advantages

- Achieving noninvasive breathing rate monitoring.
- Low cost and easy to use.
- Robust across different environments.

Applications

- Sleep apnea diagnosis and treatment.
- Sleep stage detection.
- Treatment for asthma.
Overheard ACK With Token Passing: An Optimization to 802.11 MAC Protocol

Shegufta Bakht Ahsan, Nitin Vaidya
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Say NO to Backoff and Explicit ACK !!!

*This research was supported by NSF and Futurewei Technologies
SAfeDJ Community
Situation-Aware In-Car Music Delivery for Safe Driving

FIRST mobile music delivery application designed for vehicular users.

✦ Collection of sensing data considering the status of the drivers, cars and outside environments in real-time.

✦ Analysis of driver’s mood and fatigue degree.

✦ Classification of songs and Completion of music mood mapping.

✦ Delivery of music for fatigue reduction, negative mood ease and better driving behavior.
SEA-OR: Spectrum and Energy Aware Opportunistic Routing for Self-Powered Wireless Sensor Networks

Petros Spachos and Dimitrios Hatzinakos

Neighbor prioritization
• Packet advancement
• Residual energy
• Link reliability

\[ T_{\text{backoff}} = C_1 \times (E_{th} - E_{res}) \times \log\left(\frac{RSSI(d)}{A}\right) + SIFS \]
Cognitive Networking in a Self-Powered Wireless Sensor Network Testbed

Petros Spachos and Dimitrios Hatzinakos

Wireless Sensor Network (WSN) → Wireless Ad hoc Network → Control room

CO₂ Sensor

Cognitive radio

Relay node

Opportunistic link

Data processing and display

Wireless sensor node
STARFISH: Retrofitting Computer Vision Libraries for Concurrent Support

Robert LiKamWa
Lin Zhong

App A
Dev. Binary | Vision Header | Starfish Library

Starfish
Function Scheduling
Cache Search
Vision Lib Execution
Cache Retrieval
Memory Distribution

App D
Starfish Library | Vision Header | Dev. Binary

sift(frame)
Locating RFID Tags by Rotation

Energy harvested by tags is related to their relative direction (not just distance) to the antenna.
Ziria: Language for Rapid Prototyping of Wireless PHY

• Currently, wireless networking prototypes are written in generic programming languages like C++ (Sora, Gnuradio)
  • This has issues with portability, reuse, efficiency and readability

• We motivate the need for a new programming language for Wireless programs.

Discussion highlights: Special properties of wireless programs and how it lets us enhance code quality and efficiency

Real time WiFi 802.11a/g Receiver Pipeline

1 let comp Decode(h : struct HeaderInfo) =
2     DemapLimit(0) >>>
3         (if (h.modulation == M_BPSK) then
4             DemapBPSK() >> DeinterleaveBPSK()
5         else if (h.modulation == M_QPSK) then
6             DemapQPSK() >> DeinterleaveQPSK()
7         else ... -- QAM16, QAM64 cases
8             >>> Viterbi(h.coding, h.len*8 + 8)
9             >>> scrambler()
10 in let comp detectSTS() = removeDC() >>> cca()
11 in let comp receiveBits() =
12     seq { h <- DecodePLCP()
13         ; Decode(h) >>> check_crc(h.len) }
14 in let comp receiver() =
15     seq { det <- detectSTS()
16         ; params <- LTS(det.shift)
17         ; DataSymbol(det.shift) >>>
18         FFT() >>>
19         ChannelEqualization(params) >>>
20         PilotTrack() >>>
21         GetData() >>>
22         receiveBits() }
23 in read >>> repeat{ receiver() } >>> write
Geometrical Distance Distributions and Wireless Networks—by Fei Tong

- **Rectangles**: [INFOCOM10ZPC], [ICC10ZP]
- **Rhombuses**: [arXiv11ZP]
- **Hexagons**: [arXiv11ZP], [INFOCOM12ZP]
- **Trapezoids**: [arXiv13AP]
- **Equilateral Triangles**: [arXiv12ZP]

**Within Arbitrary Shapes—SOLVED!**

**Between Separate/Overlapped Shapes—SOLVED!**

[MobiCom14 Poster]

In addition: distance distributions from an arbitrary reference node to hexagons and arbitrary shapes are SOLVED in [GLOBECOM11ZLCP] and [UVicSpace13AP], respectively.

Thank You!
Am I Indoor or Outdoor?

Current Solutions:

- GPS

Solution: Semi-supervised learning

We need systems that are:
- Adaptive
- Robust
- Energy-efficient

The full paper will appear in Proc. ACM Sensys, Nov. 2014.
HiLight
Unobtrusive Screen-Camera Communication without Coded Images

QR Codes are great, but they are obtrusive…

Leveraging the $\alpha$ channel

Hiding bits in pixel translucency changes

Decreasing $\alpha$ $\rightarrow$ Dimming the pixel!
**PiCode:**
- Perfect integration of Barcode and Picture.
- Ideal for brand promotion & mobile advertisement.

**Corner detection:**
- Performance bottleneck of barcode decoding;
- Our proposed coarse-fine approach much improves detection performance.
Frequency and time synchronization opens many new opportunities:

- Data aggregation over the air
- Distributed Modulation
- Distributed Compressive Sensing over the air

**Today’s wireless sensors are not synchronized**

We propose a simple method to synchronize sensors at the physical layer

Large throughput and reliability gains
SensingKit: A Multi-Platform Mobile Sensing Framework for Large-Scale Experiments

Kleomenis Katevas, Hamed Haddadi, Laurissa Tokarchuk
http://www.sensingkit.org

Platform Characteristics

- Works in Android and iOS mobile systems.
- Captures Motion, Location and Proximity.
- Power efficient using Bluetooth Smart (4.0).
- Easily extensible using a modular design.
- Automated time sync and data processing on the server.
- Available in open-source under the GNU LGPL v3.0.
Come Closer: Proximity-based Authentication for the Internet of Things

- IoT devices: minimalistic interfaces, constrained
- Security: sensitive data, interaction with the physical world
- Our approach:
  - RF interface for proximity-based authentication
  - Ambient RF noise (2.4 GHz)
THANK YOU