POWDER-RENEW: A SHARED SOFTWARE-DEFINED MASSIVE MIMO TESTBED

RAHMAN DOOST-MOHAMMADY
ELECTRICAL & COMPUTER ENG.
RICE UNIVERSITY
• Experimental results validated theory and showed technology is feasible!
Experiment $\rightarrow$ Theory Example

Achieving Single Channel, Full Duplex Wireless Communication

Jung II Choi, Mayank Jain, Kannan Srinivasan, Philip Levis, Sachin Katti
Stanford University
California, USA
{jungilchoi,mayjain,srikank}@stanford.edu, pal@cs.stanford.edu, skatti@stanford.edu
†Co-primary authors

Full-Duplex Wireless Communications Using Off-The-Shelf Radios: Feasibility and First Results

Melissa Duarte and Ashutosh Sabharwal
Department of Electrical and Computer Engineering, Rice University, Houston, TX 77005
Email: {mduarte, ashu}@rice.edu

Two Experimental Demonstrations in 2010
(People paid attention because of experimental evidence)
Open-Source Unleashed Innovation!

Experimental research accelerated by open-source stacks running on cheap hardware
Replicable & Reproducible Experiments - Hard Today!

SDRs improved the overall access
✔ Experiments became possible and led to many good work
× Replicability – incremental research hardly possible!
× Reproducibility – many setup-dependent results or not applicable in the field

Real need for **open experimentation on shared at-scale testbeds**
Experiments on At-Scale Testbeds

ArgosNet: Massive MIMO Field Deployment

Argos V3
Scalable solution to extend to hundred of antennas

• World’s first base-station class 3.5 GHz SDR testbed
• World’s first multi-cell testbed for massive MU-MIMO
Opportunity with Shared Testbeds
POWDER – RENEW

**POWDER**: Platform for Open Wireless Data-driven Experimental Research

**RENEW**: Reconfigurable Ecosystem for Next-gen End-to-end Wireless

[powderwireless.net](http://powderwireless.net)

[renew.rice.edu](http://renew.rice.edu)
Open Experiments Vision

- **Experiment Profile:** Specific set of hardware resources and code – share a profile to share an experiment
- **Replicability:** Statistical repeatability feasible – use the same wireless nodes to validate experimental results
- **Reproducibility:** Test on different experiment setups, i.e. base stations/clients, etc

RENEW Open-source mMIMO Stacks

POWDER: Shared Research Infrastructure
Replicable & Reproducible Experiments – Straightforward Soon!

Experiments: Code, Nodes, Data can all be shared with one weblink.

As simple as sending link to a paper
POWDER@University of Utah: Large-scale SDR Deployment
POWDER Deployment Scenarios

UofU Shuttle deployments for observable mobility

Cell overlap for CoMP
## POWDER: Planned Spectrum Coverage

<table>
<thead>
<tr>
<th>Range (MHz)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>698-806</td>
<td>Commercial/Public Safety</td>
</tr>
<tr>
<td>902-928</td>
<td>Industrial, scientific and medical (ISM)</td>
</tr>
<tr>
<td>1710-1755</td>
<td>Extended Advanced Wireless Services (EAWS) uplink</td>
</tr>
<tr>
<td>2110-2155</td>
<td>Extended Advanced Wireless Services (EAWS) downlink</td>
</tr>
<tr>
<td>3550-3650</td>
<td>Citizens Broadband Service (CBRS)</td>
</tr>
<tr>
<td>5150-5925</td>
<td>Unlicensed National Information Infrastructure (U-NII)</td>
</tr>
</tbody>
</table>

- Broad range of frequencies, sub-6GHz focus
- Program license streamlines spectrum licensing
- Experiment Isolation Mechanisms
FAROS: Software-defined Massive MIMO Base-stations

- 64-96 Antennas
- UHF, 2.5 and 3.5GHz Configurations
- 4x 10G Ethernet Backhaul
- SyncE and PTP-like support
- Compact, Remotely monitored

Commercially available from Skylark Wireless (Rice spin-off)
RENEW Design Flows

- Multiple Experimentation Design Flows inc. MATLAB
- Channel Measurement Framework
- Firmware Built-in Features
  - Flexible Framing
  - Over-the-Air Sync
  - Power Control
  - AGC
Research Example I: FDD Massive MIMO

✓ # dominant angles << # antennas (channel low-dim in angle space)
✓ Uplink/downlink channel angle correlation is high

Research Example II: Full Duplex Massive MIMO

Dense self-interference

- For 2D arrays, many direct self-interference path
- Remove the Need for Analog Cancellation with TX beamforming

More Possible Experiments on POWDER with RENEW Development

- **Y1**
  - Deployment of at least ONE Argos Base Station at POWDER
  - Fully Integrated Channel Sounding Framework

- **Y2**
  - Addition of THREE more base stations on POWDER
  - A Configurable Real-time Massive MIMO PHY (UL & DL)

- **Y3**
  - Full Stack: Experimental Scheduler / CoMP / C-RAN
  - Core Network / Mobility / NFV / Measurement tools

- **Y4**
  - 3GPP Compatibility and 5G waveforms
  - 802.11ac/ax support on Argos

- **Y5**
  - End-to-end applications, Edge Services
  - Beyond 5G Research And Development

---

PTP/SyncE
RENEW Team (Rice, UMic, TSU)

Ashu Sabharwal
Lin Zhong
Edward Knightly
Joe Cavallaro
Morley Mao
Wei Li
Xuemin Chen
Rahman Doost-Mohammady
Oscar Bejarano
C. Nicolas Barati
Thank You!

renew.rice.edu
powderwireless.net