A Network Testbed for Ad-Hoc Communications using Raspberry Pi and 802.11

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Ad-Hoc Communications

- **Communicate without network infrastructure:**
  - my radio talks to your radio
  - fundamentally p2p
  - always available
  - not very efficient

- **Design, build, and test software**

- **How to test?**
Evaluating Ad-Hoc Communications

• **Simulation**
  - idealized scenarios
  - repeatable data
  - easy to understand results, complete info

• **Testbed**
  - purchase, deploy, maintain
  - accurate data
  - real code, realistic scenarios, e.g. diverse platforms
Evaluating Ad-Hoc Communications

- **Simulation**
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- **Testbed**
  - purchase, deploy, maintain
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  - real code, realistic scenarios, e.g. diverse platforms
And virtual machines?

- run real code
- simulate the network
Advantages of a Testbed

- **Same software as the real system**
  - detailed configuration, timing
  - subtle features such as priority
  - less software to develop and keep consistent
- **More real, therefore more convincing**
- **Some phenomena hard to simulate**
  - people, walls with different density, synchronization, challenges of configuration
- **Can interact with real systems**
Outline of the Talk

- ad-hoc communications
- evaluating ad-hoc communications
  - Raspberry Pi (Zero W)
  - our testbed
  - AllNet
- actual results
- conclusions
Raspberry Pi Zero W
Smaller than a credit card
Raspberry Pi Zero W

- ARM architecture
- boots from microSD card
- 802.11 WiFi and Bluetooth
  - no Ethernet!
- 2 micro-USB and 1 micro-HDMI
- Linux OS - several distributions
- $20 range
  - may be cheaper in the UK
  - plus power supply, and keyboard/video/mouse
A display is useful for testing
Raspberry Pi Zero W programming

• add keyboard/video/mouse, and can program from the console like a regular computer
  
  – but the most popular versions of linux for the Raspberry Pi do not come with development environment pre-installed

• or, use a development system to write the microSD card. Then boot and test
A sample deployment

- in an office building
- unit 1 is a laptop
- units are easy to move
Why are we doing this?

• AllNet is designed to work both over ad-hoc networks, and over the Internet

• easy to test over Internet
  - now works well

• need to test code over ad-hoc
  - ad-hoc code is less portable :(  

• basic ad-hoc communication algorithm should work the same on any system
AllNet trace

- similar to ping: send a packet, allnet daemons respond
- the final systems always respond, intermediate systems may respond
  - result is comparable to either ping or traceroute
  - options allow recording route and timestamps
  - timestamps are only useful when clocks are reasonably synchronized
    - but synchronization takes as long as communication!
      - so timestamps in this testbed are underestimates
Sample results

- range approaches 50m indoors
- range varies with no evident cause: sometimes unit 1 can communicate directly with unit 3, and sometimes it cannot
- useful for evaluating changes in the algorithm
  - interface is off most of the time, vs.
  - interface is kept on
Evaluating two different algorithms

- **mostly off**
  - b1.01/16 0 hop 0.000s ts
  - b2.00/16 1 hop
  - b3.00/16 2 hop 24.085s ts
  - b4.00/16 3 hop 54.887s ts
  - b5.00/16 4 hop 61.543s ts

- **236s rtt**
- **5s on/off cycle**
- **timestamps ts**
  - use local clocks

- **always on**
  - b1.01/16 0 hop
  - b2.00/16 1 hop
  - b3.00/16 2 hop
  - b4.00/16 3 hop
  - b5.00/16 4 hop

- **3.3s rtt**
Remarks

• Everybody loves the Raspberry Pi, but not as many people actually use it
  – need additional components (KVM, power supply), cross-compilation environment

• Lack of a management network (e.g. ethernet) is inconvenient, makes it harder to debug code
  – maybe use Raspberry Pi B 3
  – but then we are IoT!!! Need more security

• Talking to residents of offices is good PR
Summary

- Testbeds are better than simulation when evaluating real code
  - Simulation is better for evaluating ideas
- $200 can build a useful testbed for ad-hoc networking
- Real wireless networks vary over time

Questions?