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

Edoardo Biagioni University of Hawaii at Mānoa Department of Information and Computer Sciences esb@hawaii.edu

# **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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#### 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
- v evaluating ad-hoc communications
- Raspberry Pi (Zero W)
- our testbed
- AllNet
- actual results
- conclusions

#### **Raspberry Pi Zero W**



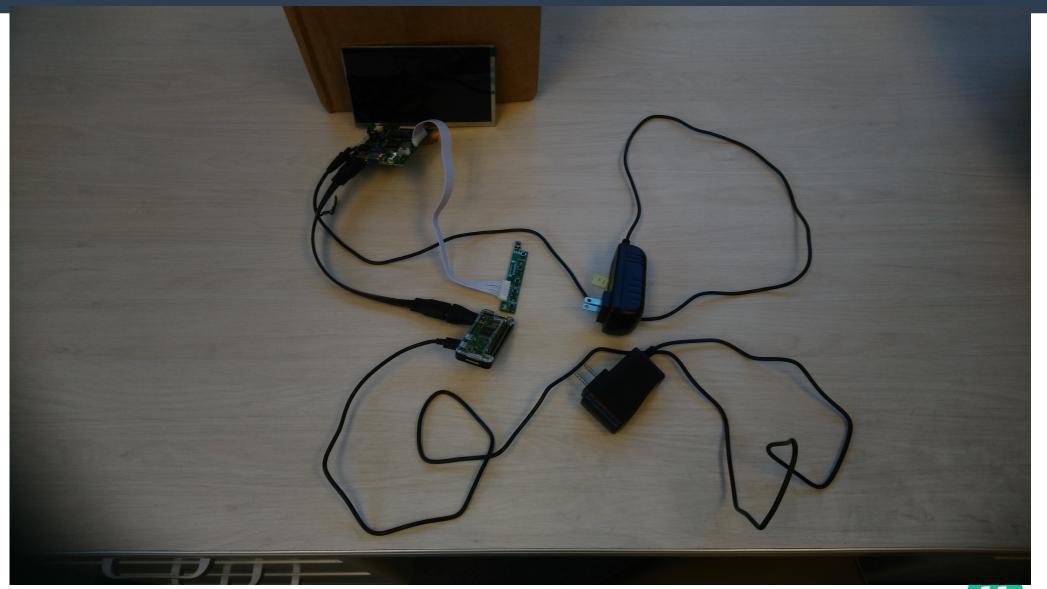
#### Smaller than a credit card



# **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

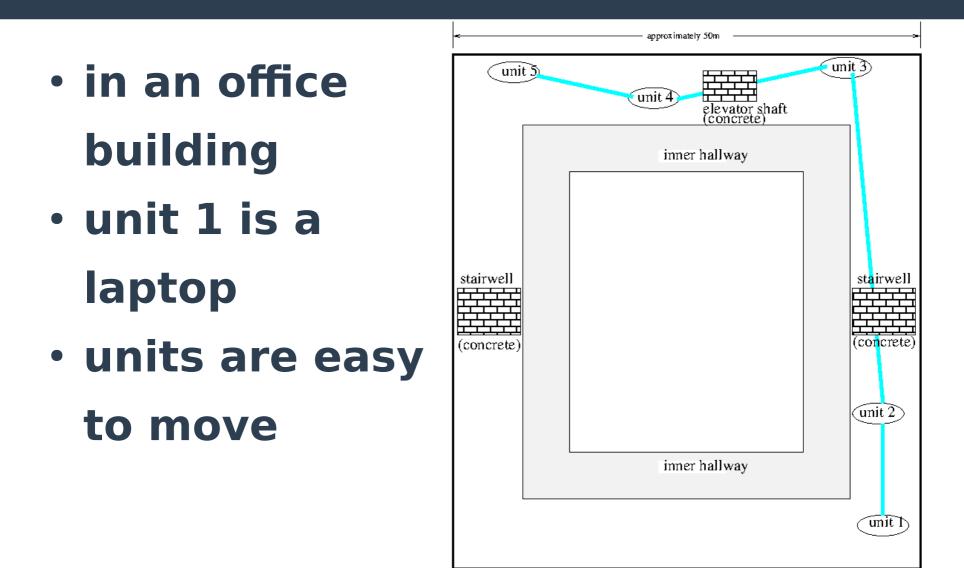
## A display is useful for testing



## **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



# 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?**