Sociable Objects Workshop

Instructor: Rob Faludi

Plan for Today

- Final Projects
- Class in Review
- Readings & Assignments

Final Project Presentations

Class in Review

Introduction

- Sociable Objects
  - Connections are Collaboration
  - Networks
  - Mesh Networking

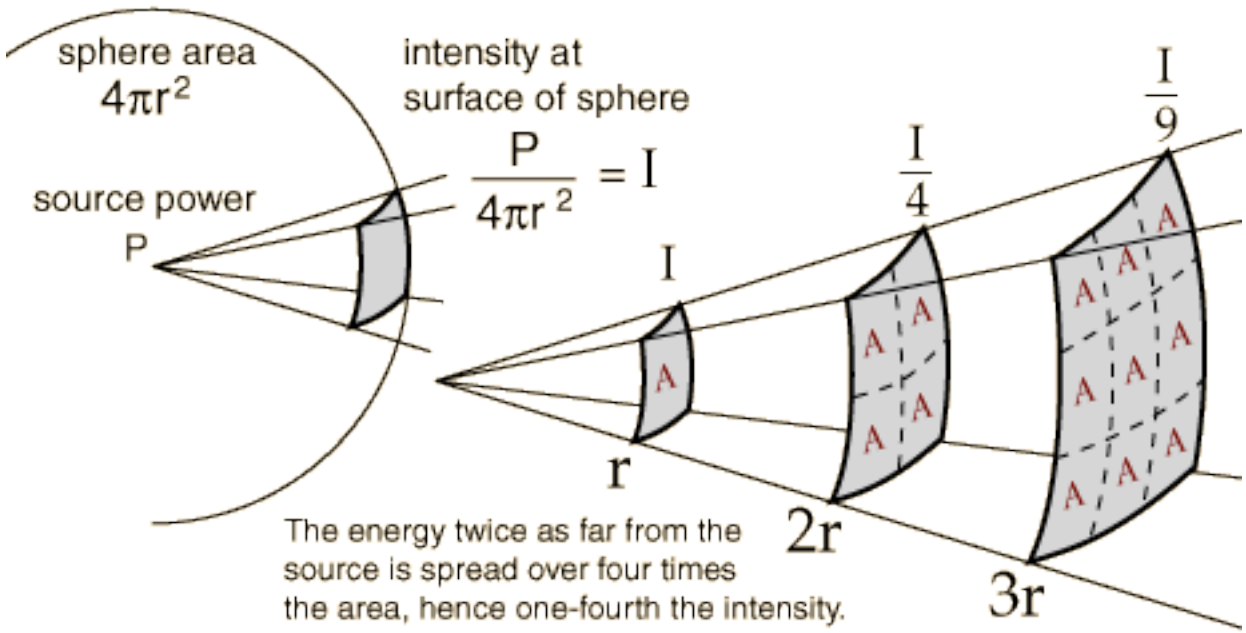
Radio Communications

- electromagnetic waves
- no medium required
- modulation

- Well-described mystery: “air waves” “wireless” “ethereal communication”

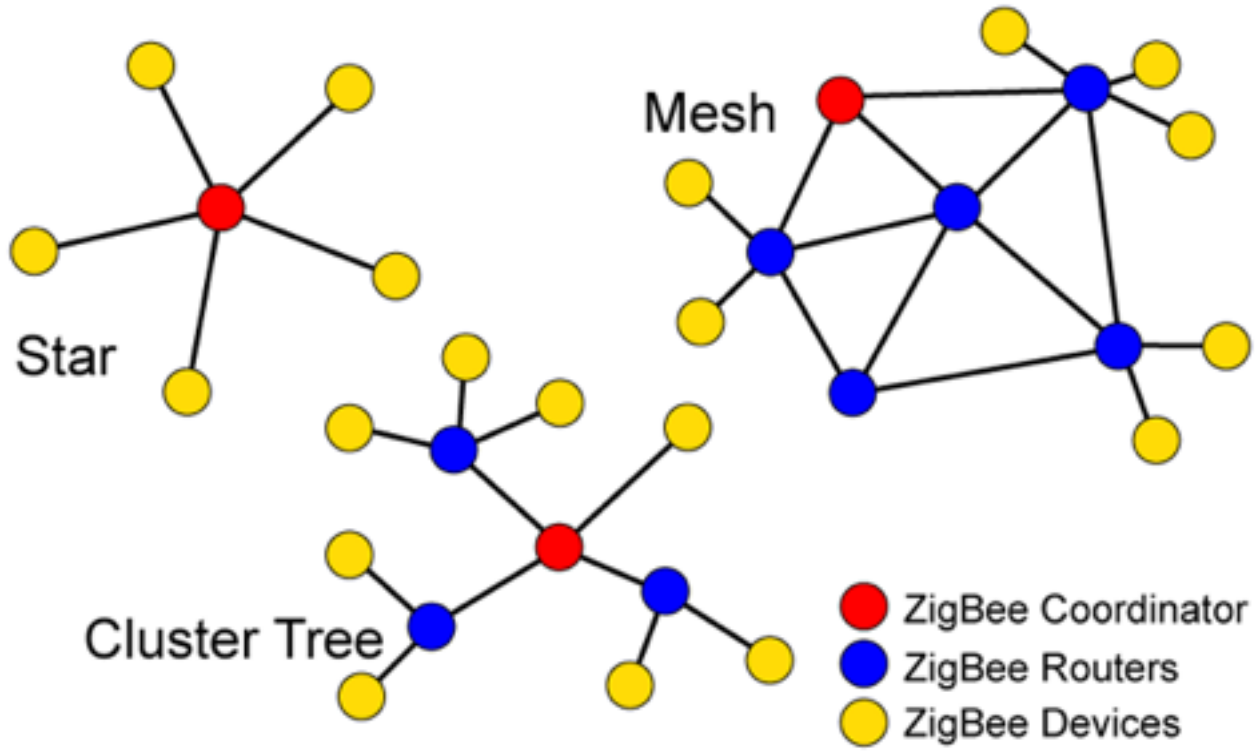
Inverse Square Law

- power needs increase exponentially with distance

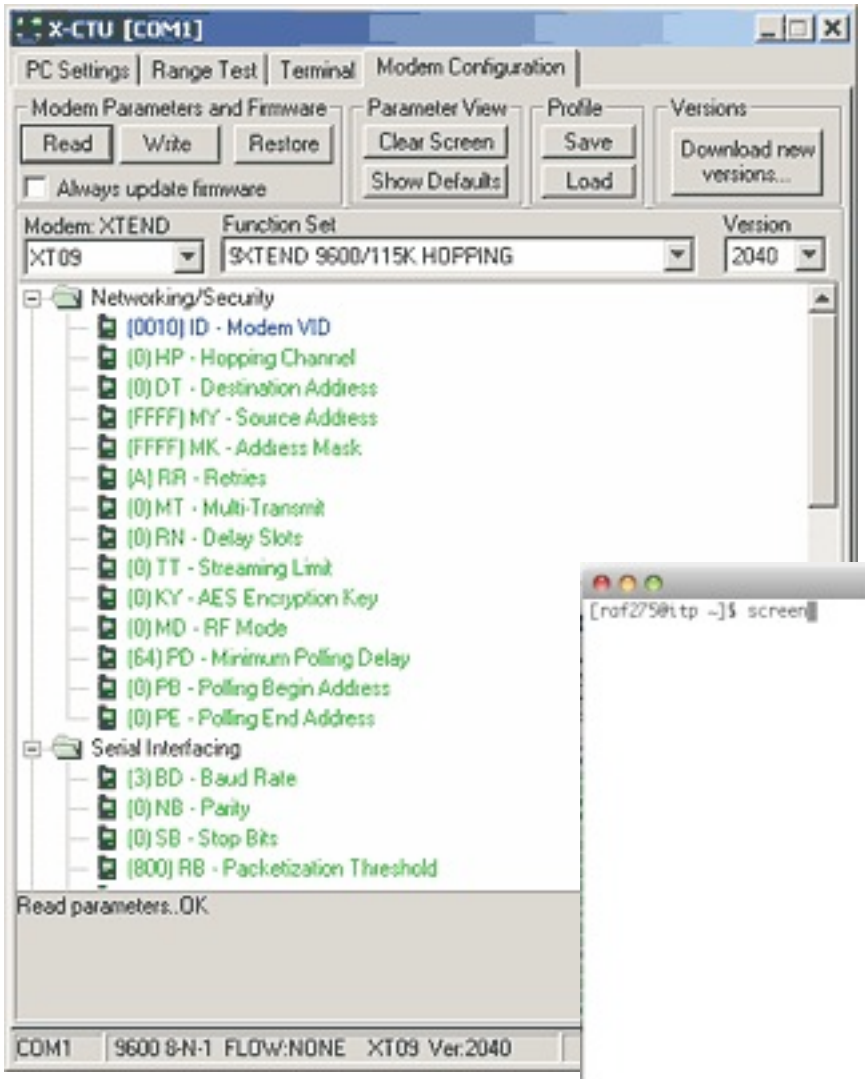


ZigBee Topologies

- peer
- star
- mesh
- routing



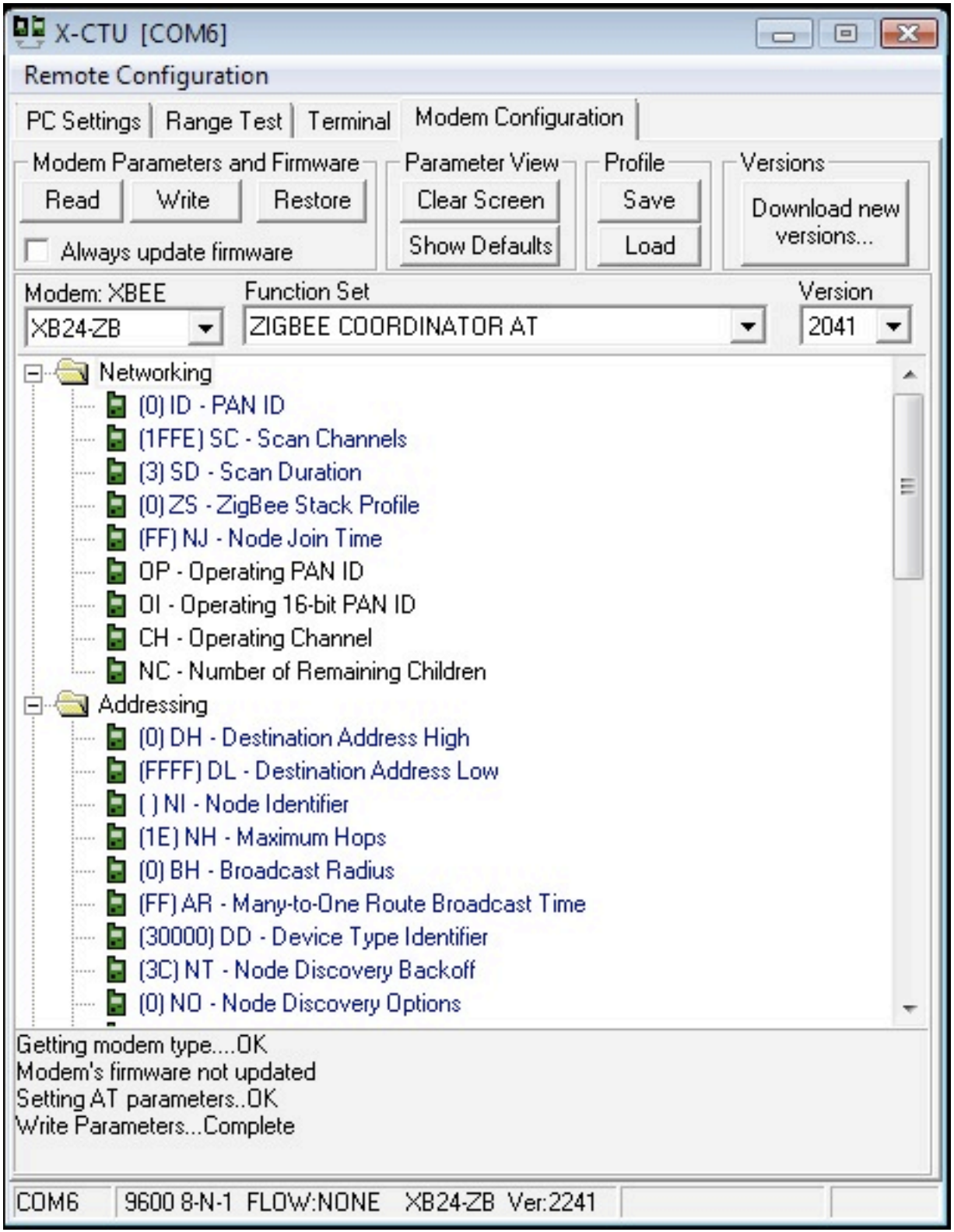
Serial Terminal Programs



Imagined Sociable Objects

Addressing Basics

- channels
- PAN ID
- 64 bit addresses, aka serial numbers
- 16 bit addresses
- Node Identifier and Node Discovery
- endpoints and clusters


X-CTU [COM6]
Remote Configuration
PC Settings
Range Test
Terminal
Modem Configuration
Modem Parameters and Firmware
Read
Write
Restore
Always update firmware
Parameter View
Clear Screen
Show Defaults
Profile
Save
Load
Versions
Download new versions...
Modem: XBEE
XB24-ZB
Function Set
ZIGBEE COORDINATOR AT
Version
2041
Networking
(0) ID - PAN ID
(1FFE) SC - Scan Channels
(3) SD - Scan Duration
(0) ZS - ZigBee Stack Profile
(FF) NJ - Node Join Time
OP - Operating PAN ID
OI - Operating 16-bit PAN ID
CH - Operating Channel
NC - Number of Remaining Children
Addressing
(0) DH - Destination Address High
(FFFF) DL - Destination Address Low
( ) NI - Node Identifier
(1E) NH - Maximum Hops
(0) BH - Broadcast Radius
(FF) AR - Many-to-One Route Broadcast Time
(30000) DD - Device Type Identifier
(3C) NT - Node Discovery Backoff
(0) NO - Node Discovery Options
Getting modem type....OK
Modem's firmware not updated
Setting AT parameters..OK
Write Parameters...Complete
COM6
9600 8-N-1 FLOW:NONE XB24-ZB Ver:2241

Some AT Commands

- AT -> OK
- ATDH, ATDL -> destination address hi/lo
- ATID -> personal area network ID
- ATCN -> end command mode
- ATWR -> write current configuration to firmware
- ATMY -> ~~my address~~ NOT SETTABLE FOR ZIGBEE

Create a Basic ZigBee Pair

- One coordinator and one router
- Use the 64-bit addresses for destinations
- ATNR will reset your network layer, useful if you join the wrong ID
- Remember, the radios work reliably, troubleshooting is mostly about figuring out what they’re doing.

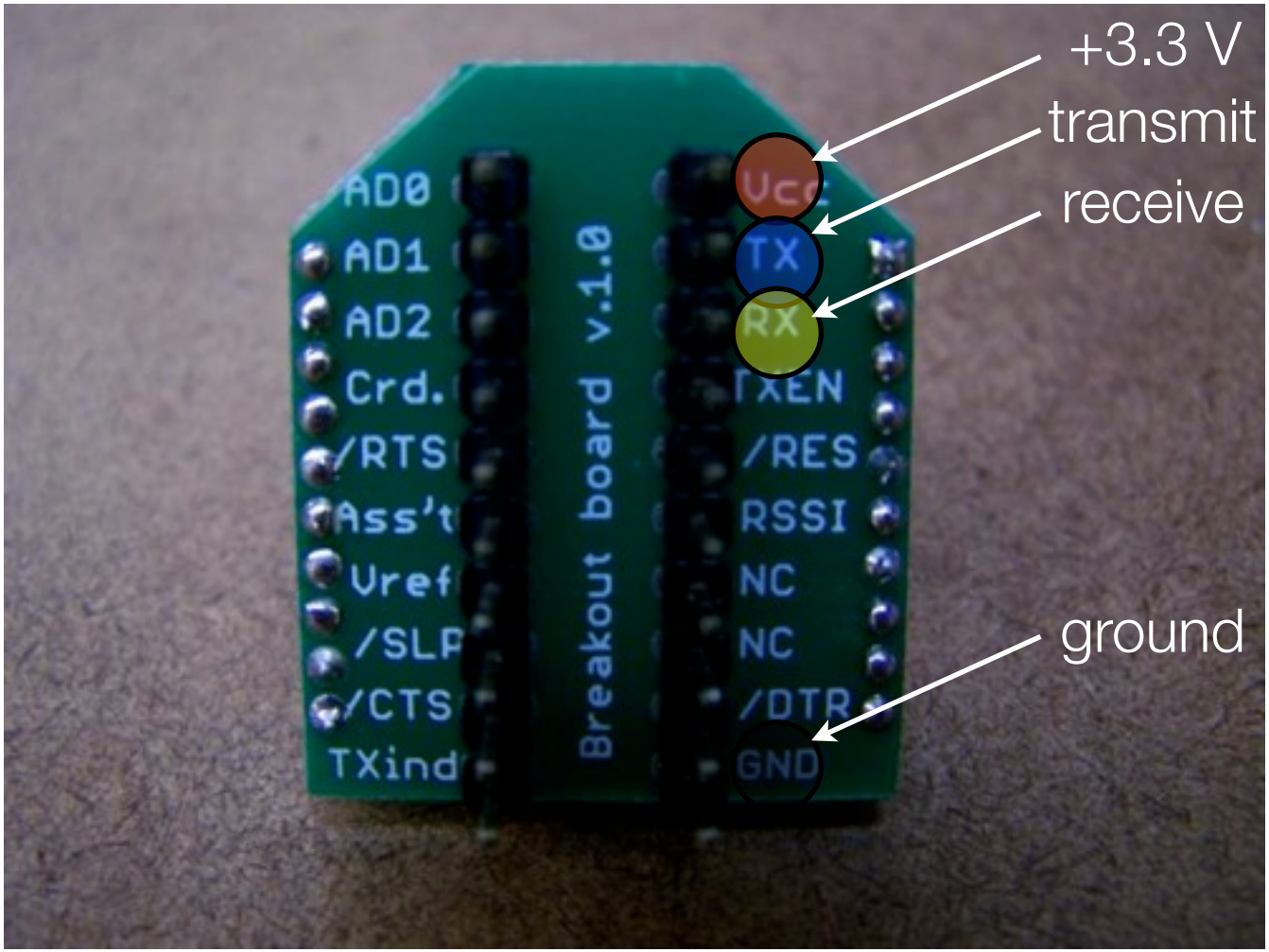
Hexadecimal

- Place system
- Notation: extra digits, 0x10, #FFFFFF
- Powers
- Adding and carries
- Finger counting?
- Switches yes: 0xFF = 1111 1111 and 0x3C = 0011 1100

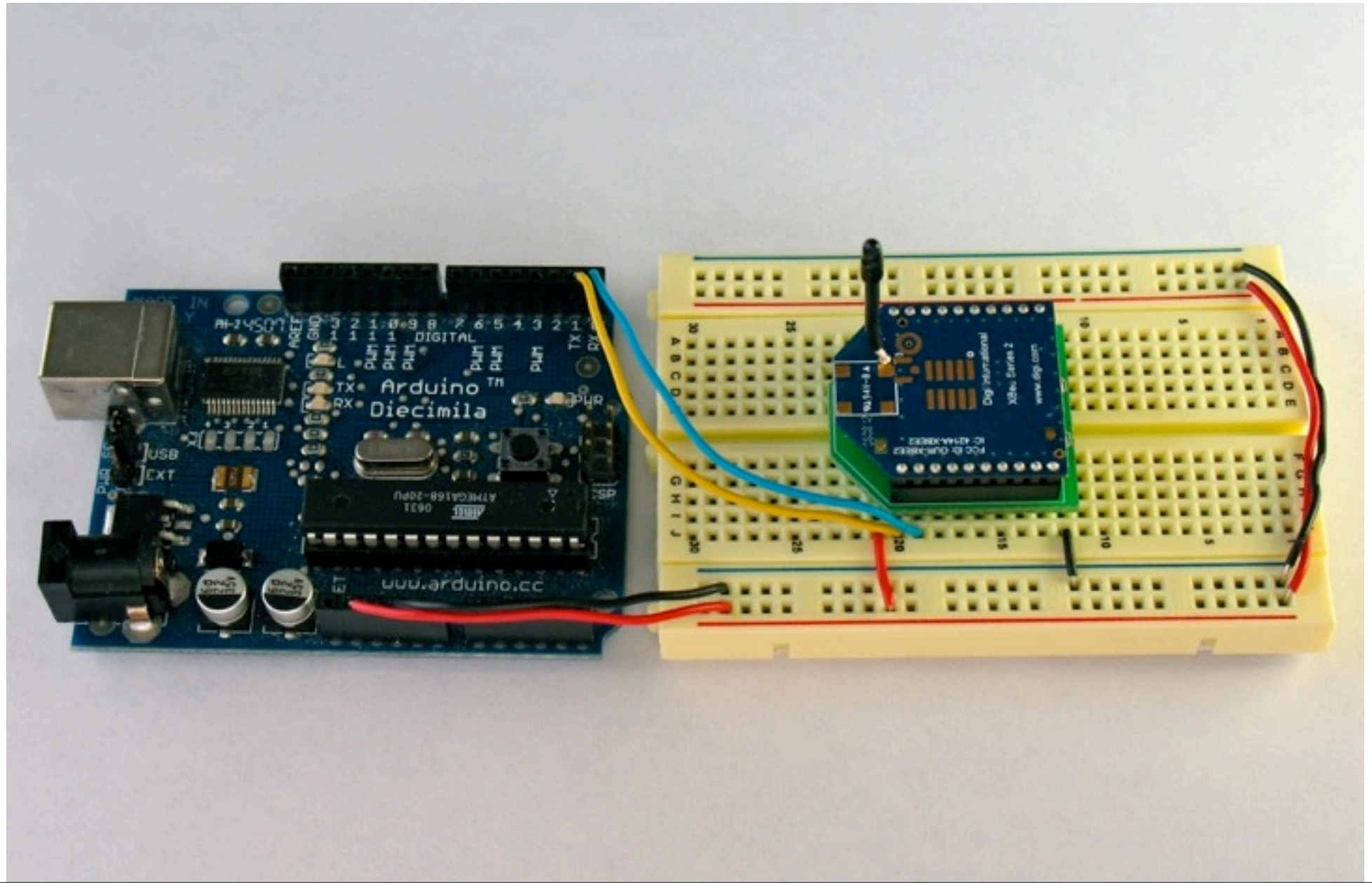
One Question Quiz

- what is this: 10

Wiring


+3.3 V
transmit
receive
ground
AD0
AD1
AD2
Crd.
/RTS
Ass't
Vref
/SLP
/CTS
TXind
Breakout board v.1.0
Vcc
TX
RX
TXEN
/RES
RSSI
NC
NC
/DTR
GND

XBee Arduino Breadboard Layout

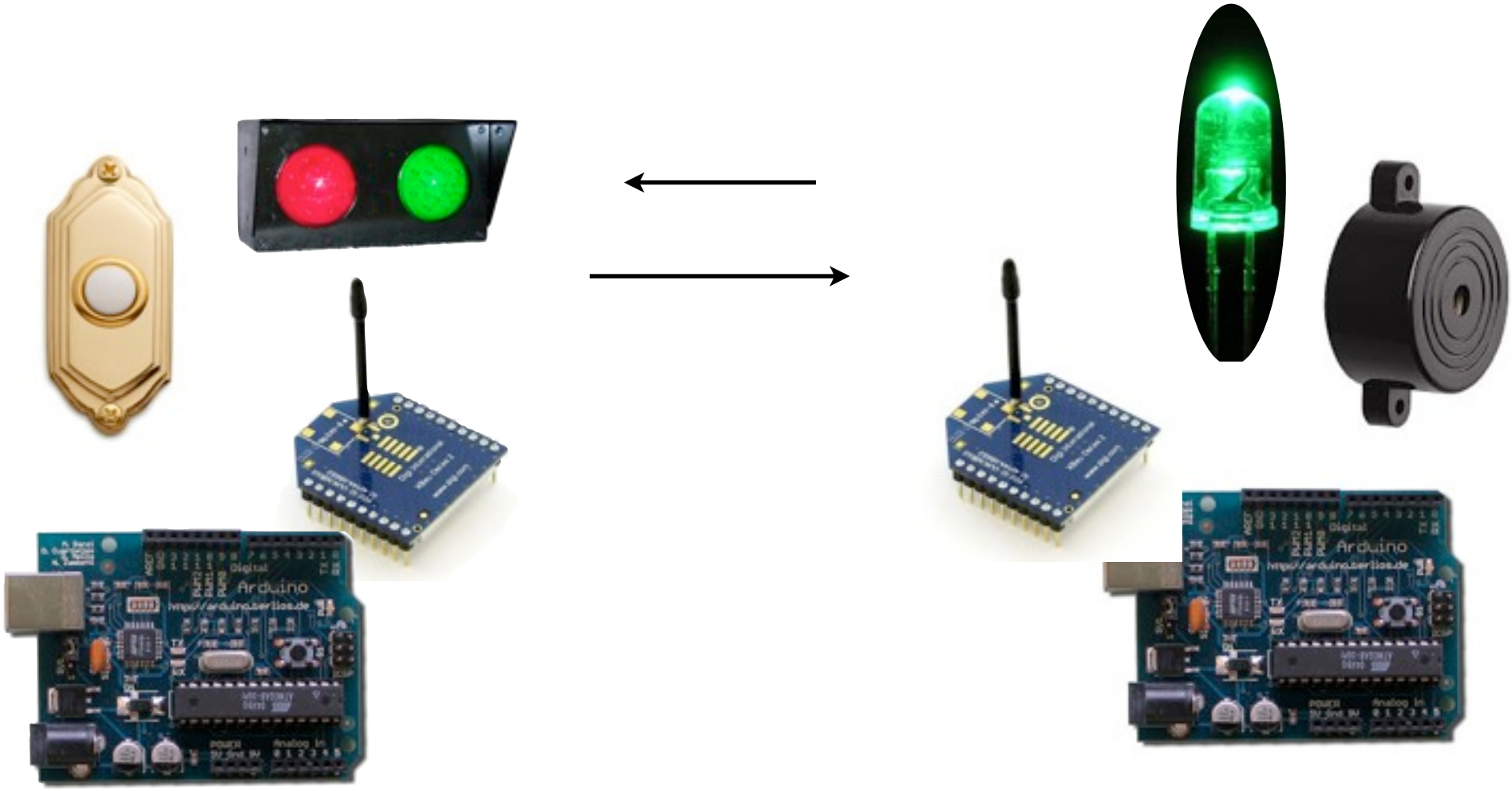


Protocols

- Sending
- Flow control
- Call / response
- Broadcast
- Start / stop
- Checksums
- Collisions

Doorbell Exercises

Nap Doorbell



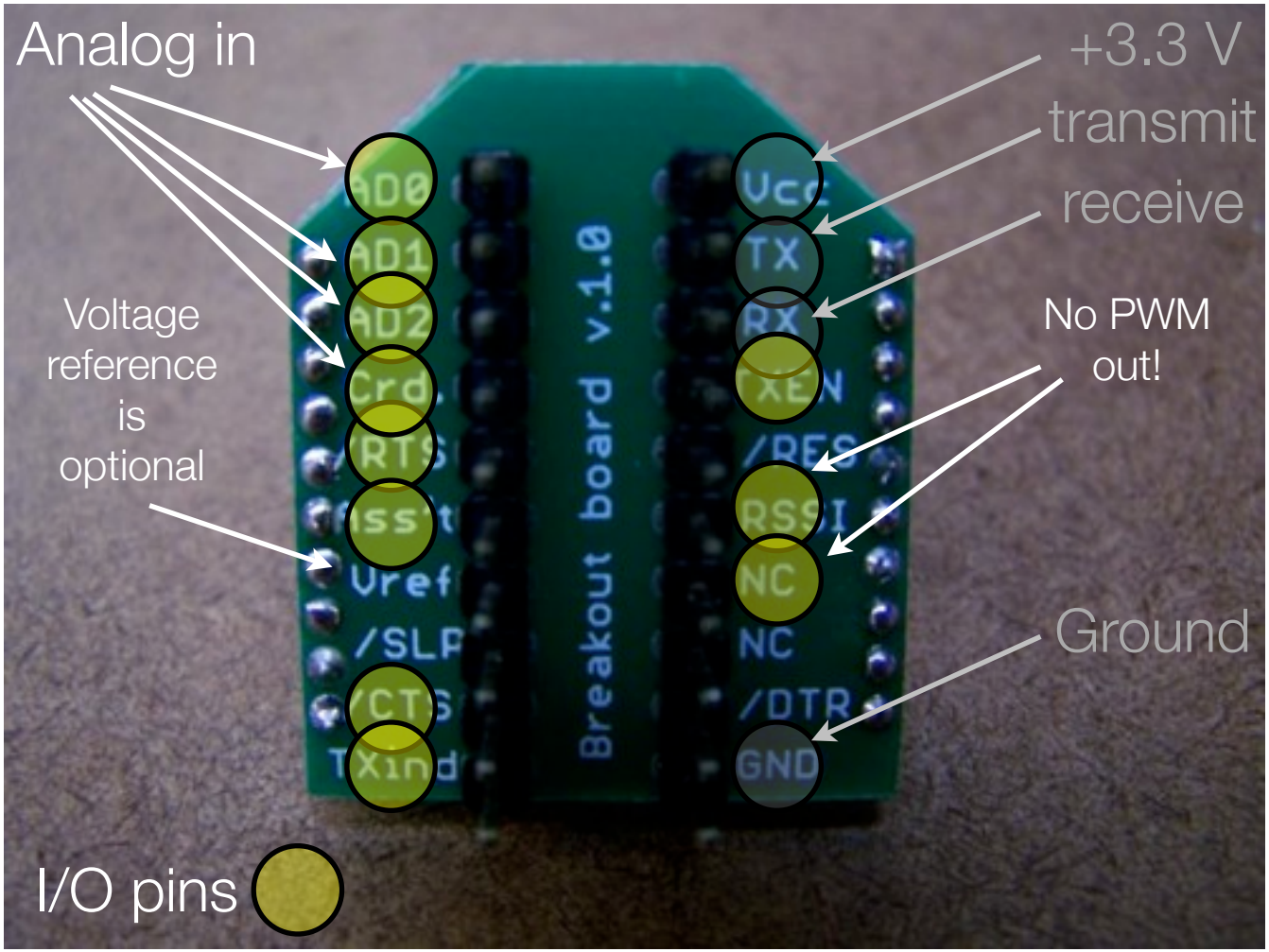
Direct, Indirect, Subtext

- What data can we sense directly?
- How about inferences that we can make from the data?
- What's the subtext of the data? What can we infer from the inference?

I/O Intro: ZigBee

- For simple input and/or output
- Ten digital input/outputs
- Four analog inputs
- No analog outputs on ZigBee
- But not all at once! Pins are shared.

Input/Output Wiring: ZigBee



Romantic Lighting Sensor

API Mode

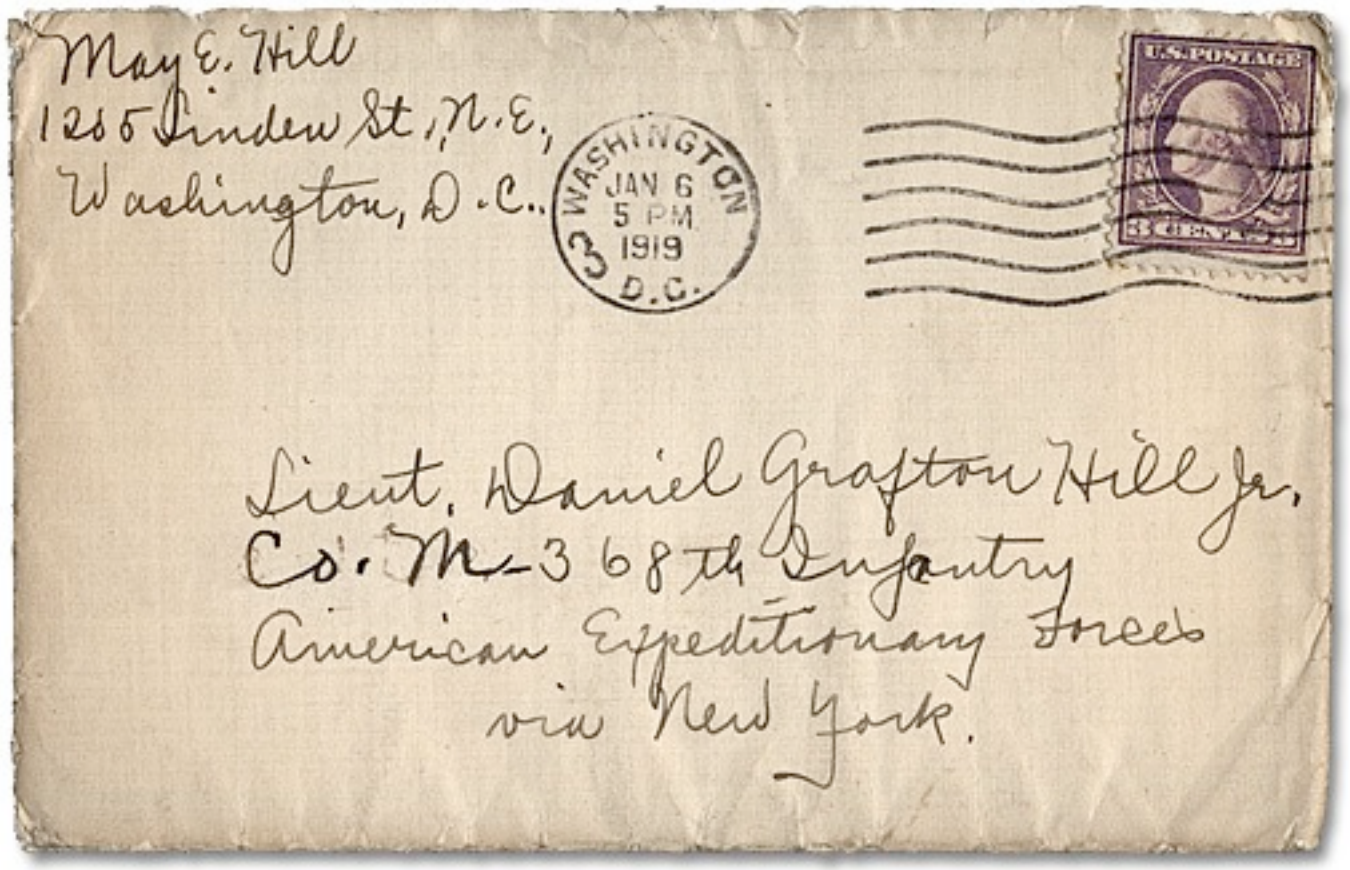
- Application Programming Interface
  - “An application programming interface (API) is a source code interface that an operating system or library provides to support requests for services to be made of it by computer programs.”

    http://www.computerworld.com/action/article.do?command=viewArticleBasic&articleId=43487

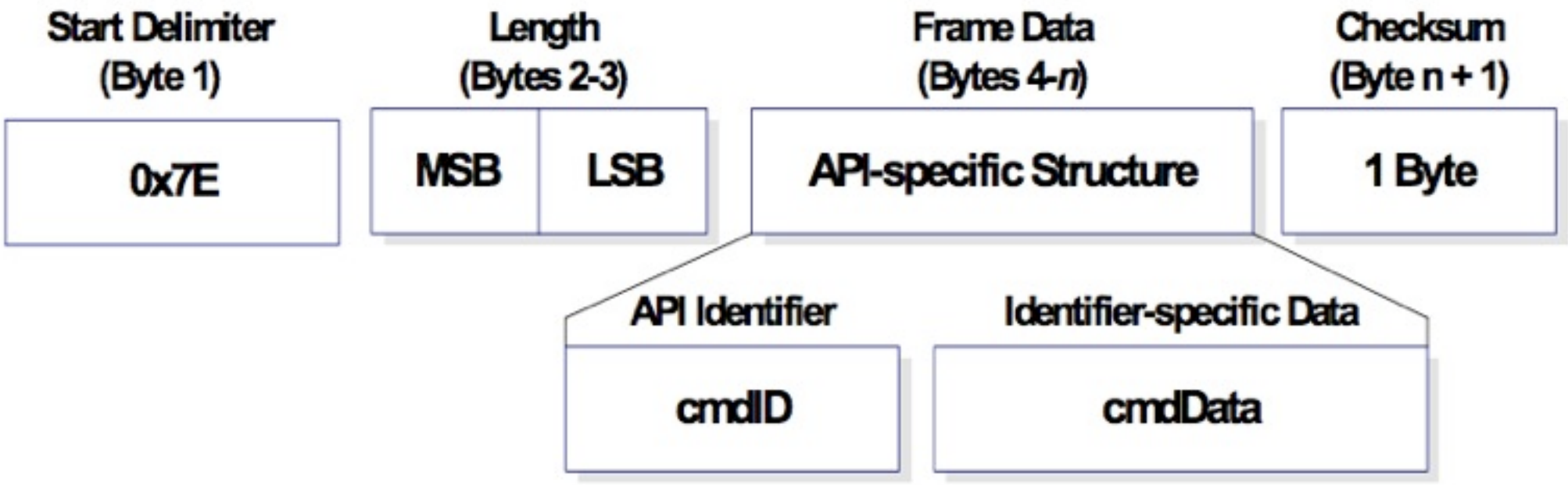
- XBees in API mode are ready to talk to computers and microcontrollers
  - structured
  - predictable
  - reliable

Envelope Has:

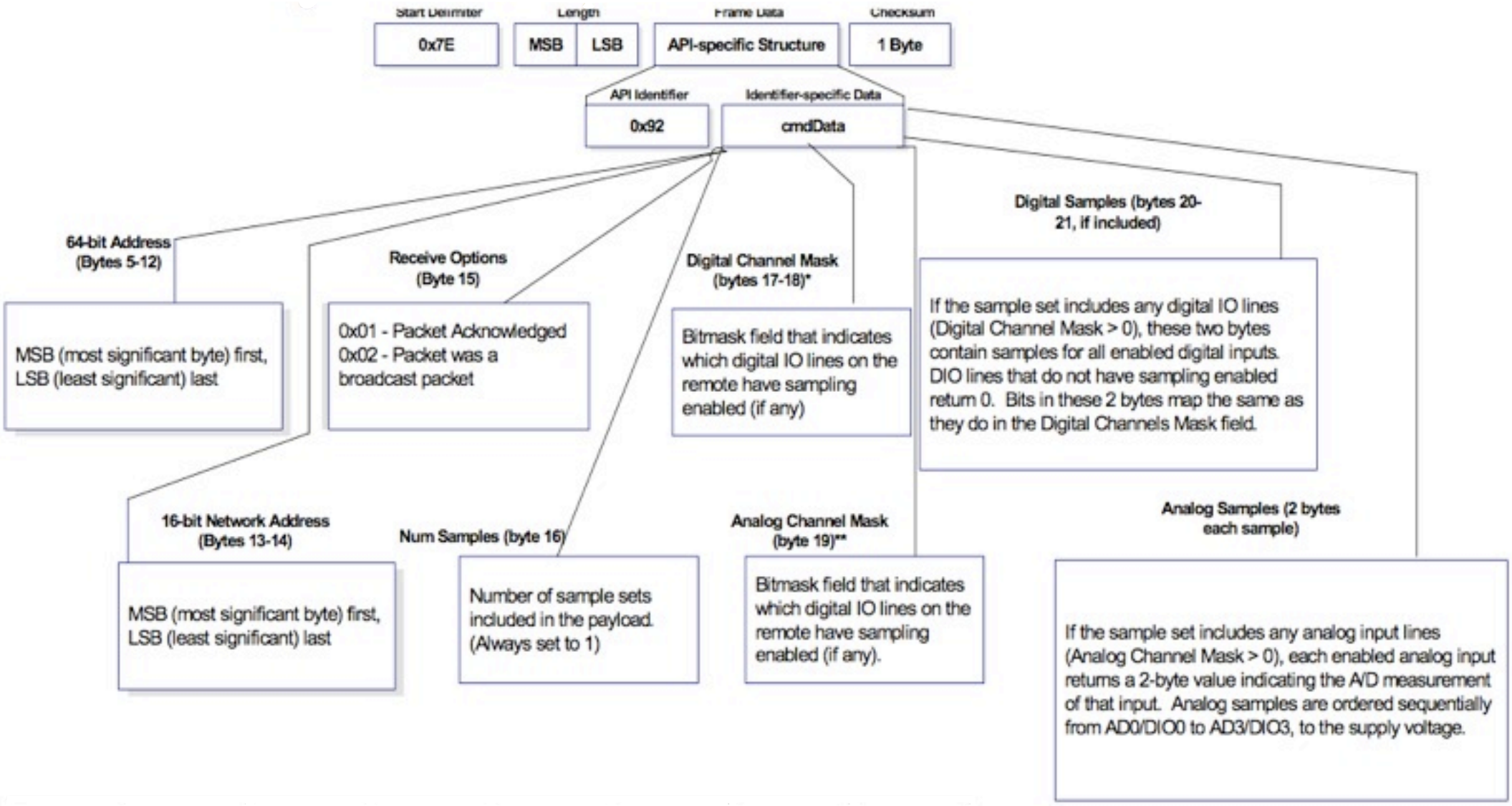
- From address, to address, outside, inside, size, contents, error check



API Basic Frame Envelope



I/O RX Packet


Start Delimiter
0x7E
Length
MSB
LSB
Frame Data
API-specific Structure
Checksum
1 Byte
API Identifier
0x92
Identifier-specific Data
cmdData
64-bit Address
(Bytes 5-12)
MSB (most significant byte) first, LSB (least significant) last
Receive Options
(Byte 15)
0x01 - Packet Acknowledged
0x02 - Packet was a broadcast packet
Digital Channel Mask
(bytes 17-18)*
Bitmask field that indicates which digital IO lines on the remote have sampling enabled (if any)
Digital Samples (bytes 20-21, if included)
If the sample set includes any digital IO lines (Digital Channel Mask > 0), these two bytes contain samples for all enabled digital inputs. DIO lines that do not have sampling enabled return 0. Bits in these 2 bytes map the same as they do in the Digital Channels Mask field.
16-bit Network Address
(Bytes 13-14)
MSB (most significant byte) first, LSB (least significant) last
Num Samples (byte 16)
Number of sample sets included in the payload. (Always set to 1)
Analog Channel Mask
(byte 19)**
Bitmask field that indicates which digital IO lines on the remote have sampling enabled (if any).
Analog Samples (2 bytes each sample)
If the sample set includes any analog input lines (Analog Channel Mask > 0), each enabled analog input returns a 2-byte value indicating the A/D measurement of that input. Analog samples are ordered sequentially from AD0/DIO0 to AD3/DIO3, to the supply voltage.

I/O Code: Basic

- Fixed parameters make for easier programming

- Assume we are just reading a single ADC channel:

```
  Arduino Version:
// make sure everything we need is in the buffer
  if (Serial.available() >= 21) {
    // look for the start byte
    if (Serial.read() == 0x7E) {
      // read the variables that we're not using out of the buffer
      for (int i = 0; i<18; i++) {
        byte discard = Serial.read();
      }
     int analogHigh = Serial.read();
     int analogLow = Serial.read();
     analogValue =  analogLow + (analogHigh * 256);
    }
  }
```

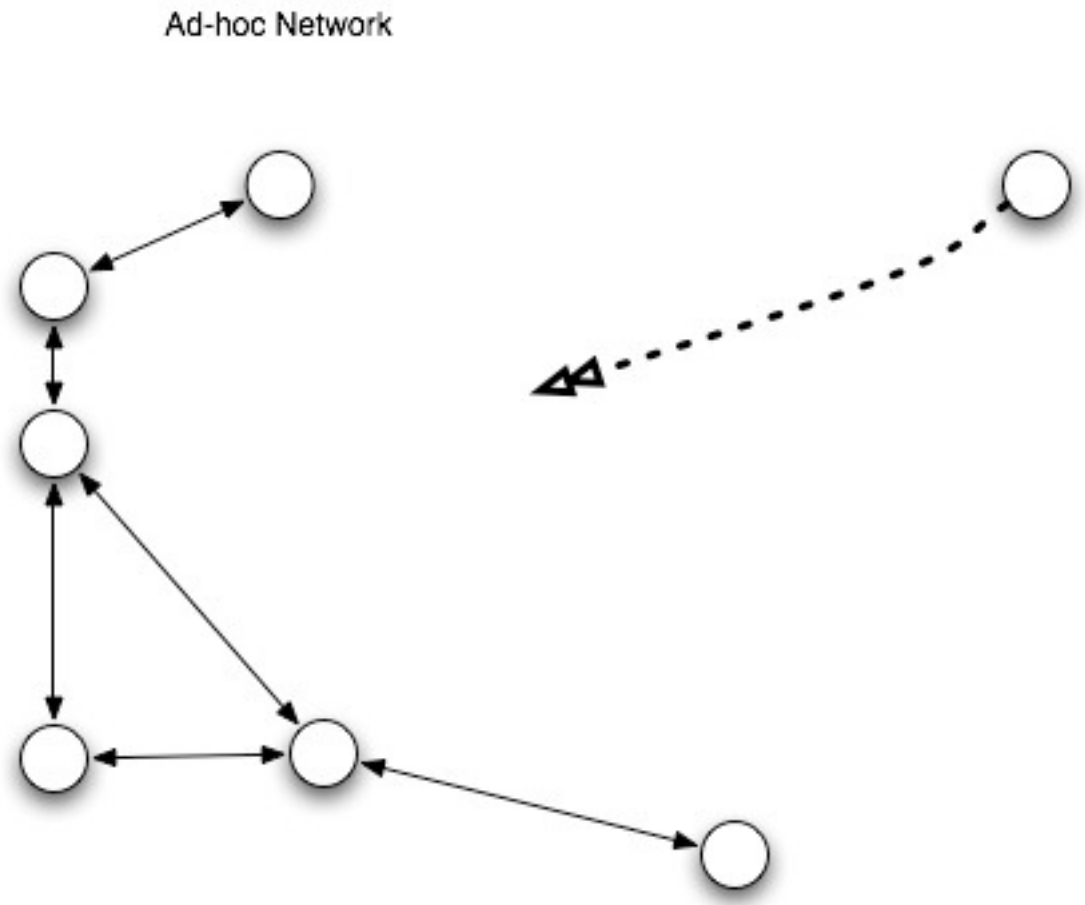
Remote AT Command Code

```
void setRemoteState(int value) { // pass either a 0x4 or and 0x5 to turn the pin on or off
  Serial.print(0x7E, BYTE);
  Serial.print(0x0, BYTE); // high part of length (always zero)
  Serial.print(0x10, BYTE); // low part of length (the number of bytes that follow, not including checksum)
  Serial.print(0x17, BYTE); // 0x17 is a remote AT command
  Serial.print(0x0, BYTE); // frame id set to zero for no reply
  // ID of recipient, or use 0xFFFF for broadcast
  Serial.print(00, BYTE);
  Serial.print(00, BYTE);
  Serial.print(00, BYTE);
  Serial.print(00, BYTE);
  Serial.print(00, BYTE);
  Serial.print(00, BYTE);
  Serial.print(0xFF, BYTE); // 0xFF for broadcast
  Serial.print(0xFF, BYTE); // 0xFF for broadcast
  // 16 bit of recipient or 0xFFFE if unknown
  Serial.print(0xFF, BYTE);
  Serial.print(0xFE, BYTE);
  Serial.print(0x02, BYTE); // 0x02 to apply changes immediately on remote
  // command name in ASCII characters
  Serial.print('D', BYTE);
  Serial.print('1', BYTE);
  // command data in as many bytes as needed
  Serial.print(value, BYTE);
  // checksum
  long sum = 0x17 + 0xFF + 0xFF + 0xFF + 0xFE + 0x02 + 'D' + '1' + value;
  Serial.print( 0xFF - ( sum & 0xFF) , BYTE );
  delay(10);
}
```

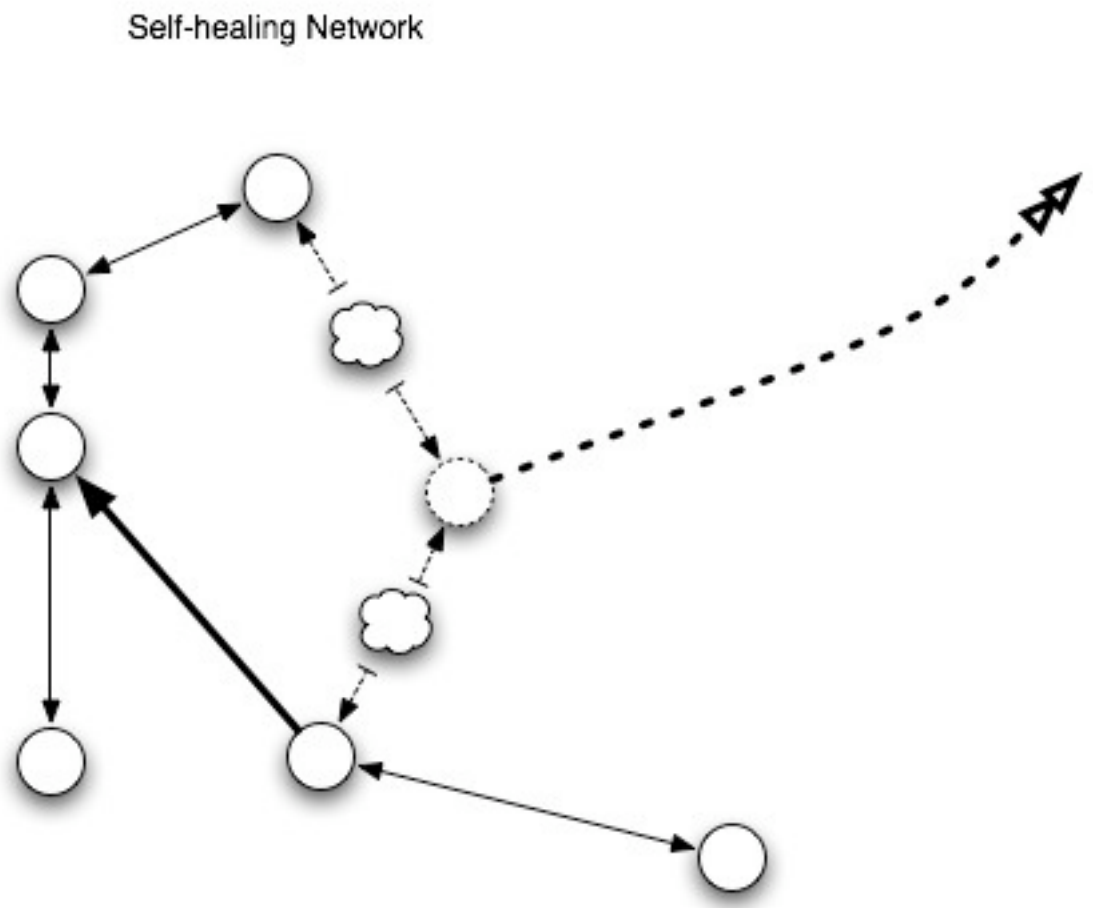
Types of Networks

- Sensor network
- ad-hoc
- self-healing
- home network
- interactions (sociable objects)
- hide & seek (Shell House)
- gatewayed systems

Ad-hoc



Self-healing



Collaboration

Simple Sensor Network: a group project

- Create a network with four sensor nodes and one base station
- The base station will receive data from the sensors and display current readings (logging and graphical display are optional)
- Everyone will work together on this project. We'll try to get it done and documented in a day

XBee®/XBee-PRO® ZB RF Modules

ZigBee RF Modules by Digi International

Firmware Versions:

- 20xx - Coordinator - AT/Transparent Operation
- 21xx - Coordinator - API Operation
- 22xx - Router - AT/Transparent Operation
- 23xx - Router - API Operation
- 28xx - End Device - AT/Transparent Operation
- 29xx - End Device - API Operation

Digi International Inc.
11001 Bren Road East
Minnetonka, MN 55343
877 912-3444 or 952 912-3444
http://www.digi.com

90000976_C
3/3/2009

Direct Actuation

- Direct output, i.e. without a microcontroller, should be used sparingly
  - no logic
  - limited pins
  - no feedback
  - API packets have to be perfect
- Only if you need to save money on a large number of devices or need your device to be as small as possible. Otherwise get a µ-controller!

Sleeping the XBee ZigBee: Basics

- Why Sleep?
- ATSM
  - 1: pin hibernate, <10 µA, 13.2 ms wakeup, uses pin 9
  - 2 and 3: <nothing>
  - 4: cyclic sleep, also <50 µA, 2 ms wakeup, module must be idle
  - 5: cyclic sleep with pin wakeup
- ATSP: Sleep Period (* 10 ms) [0x20-0xAFO]
- ATSN: Number of Sleep Periods (* 1 ms)
  used in external device control
- ATST: Sleep Timer (* 1 ms)
- ATSO: Options 0x2 = regular, 0x4 = extended

XBee ZigBee Node Indicators

- ATNI Node Indicator
- ATND Node Discovery
- ATDN Destination Node

- Also:
  - ATDB signal strength in DBm
  - AT%V Voltage

Arduino

search

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Blog » | Forum » | Playground »

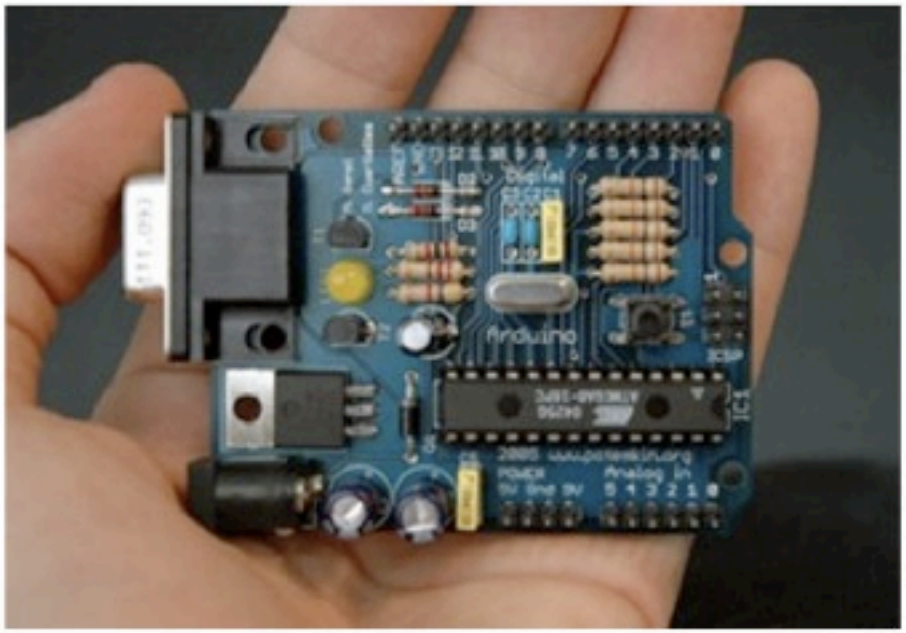


Photo by Nicholas Zambetti

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

The boards can be built by hand or purchased preassembled; the software can be downloaded for free. The hardware reference designs (CAD files) are available under an open-source license, you are free to adapt them to your needs.

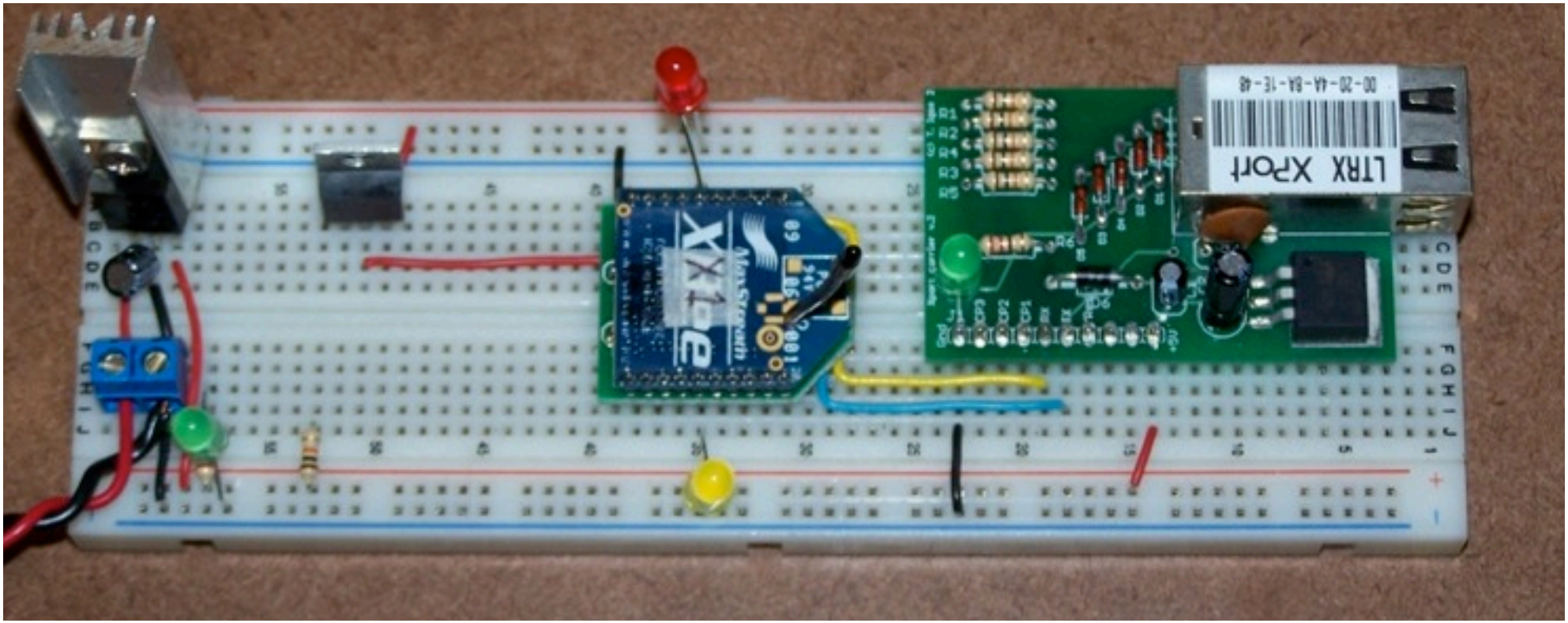
Arduino Serial Library

- Serial.begin(speed)
- Serial.available()
- Serial.read()
- Serial.flush()
- Serial.print(data)

Software Serial

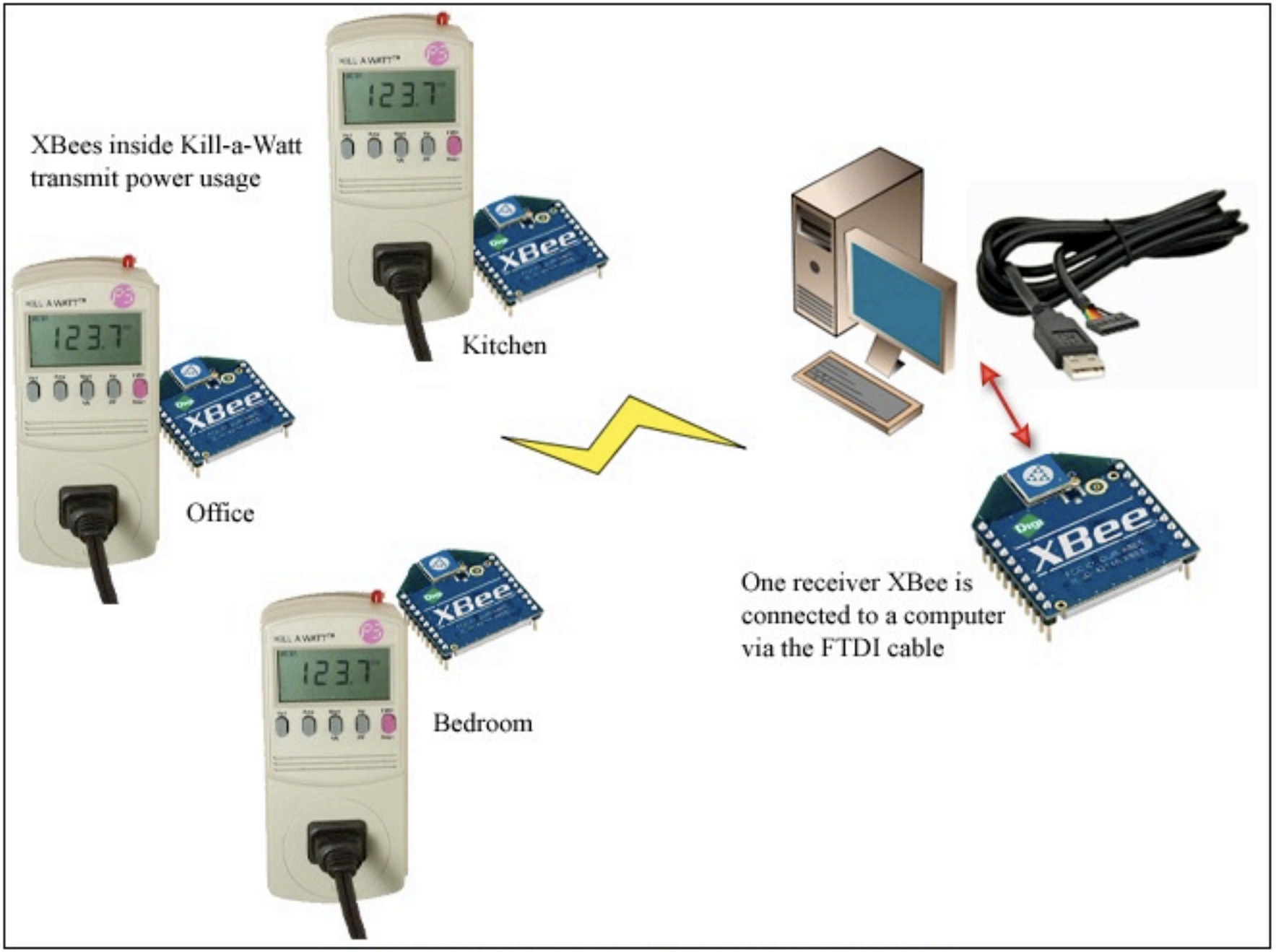
- Hardware vs. software serial
  - 9600 baud max, typically pins 6 & 7 but any digital pins are okay
  - SWserial.read() is blocking
  - No serial.available() function in software serial
  - No buffering
  - Last choice for input, great for debug output w/ USB-serial converter
- http://www.arduino.cc/en/Reference/SoftwareSerial

Simple Serial Methods



Hacked

Manufactured



I spent about 10 minutes on this diagram… can you tell?

ConnectPort X2 Configuration and Management

Help

- Home
- **Configuration**
  - Network
  - XBee Network
  - System
  - Remote Management
  - Security
- **Applications**
  - Python
- **Management**
  - Connections
  - Event Logging
- **Administration**
  - File Management
  - Backup/Restore
  - Update Firmware
  - Factory Default Settings
  - System Information
  - Reboot
- Logout

Network Configuration

Ethernet IP Settings

- ( ) Obtain an IP address automatically using DHCP *
- (•) Use the following IP address:

* IP Address:	10.0.1.100
* Subnet Mask:	255.255.255.0
Default Gateway:	10.0.1.1

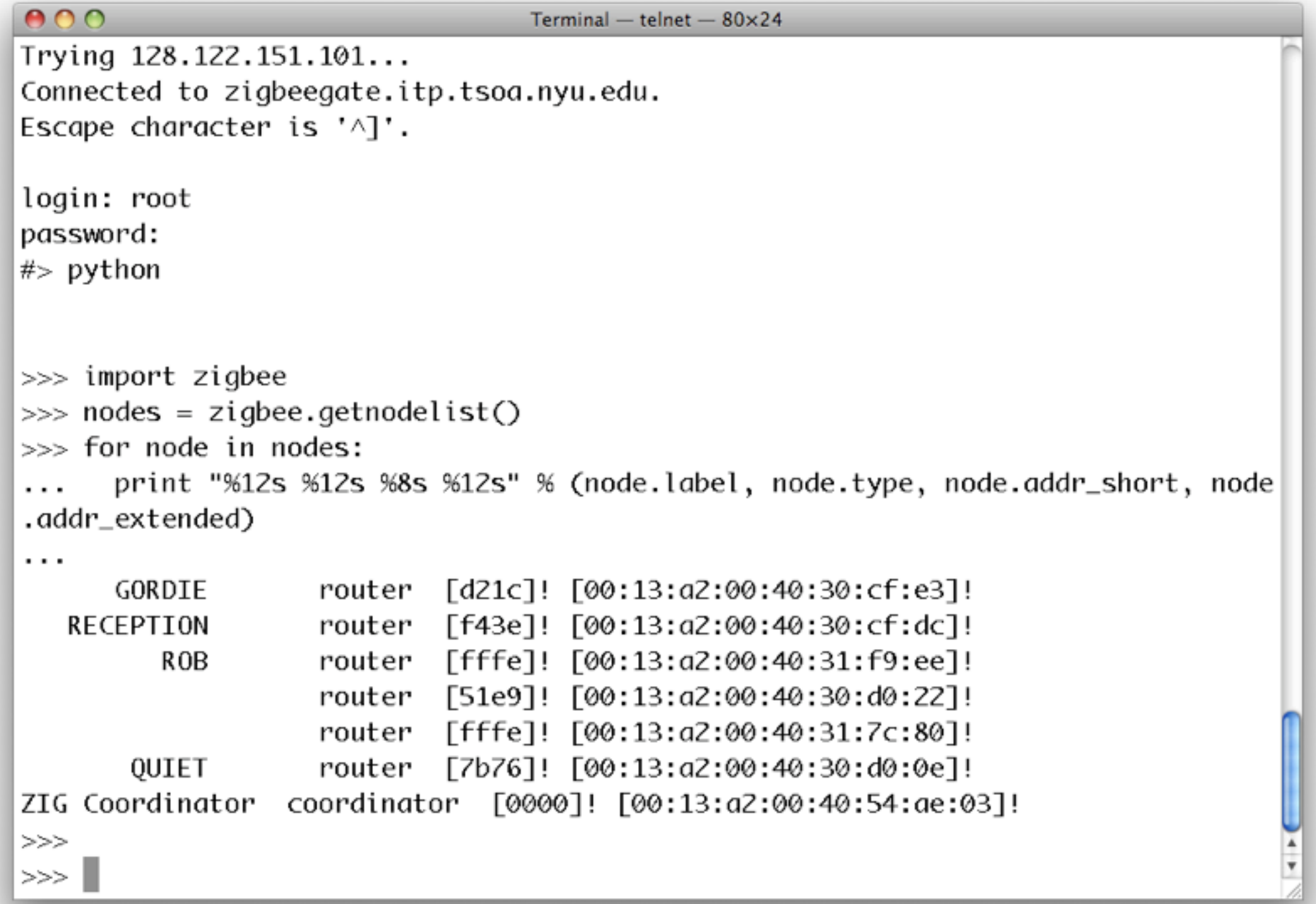
- [x] Enable AutoIP address assignment

* Changes to DHCP, IP address, and Subnet Mask may effect your browser connection.

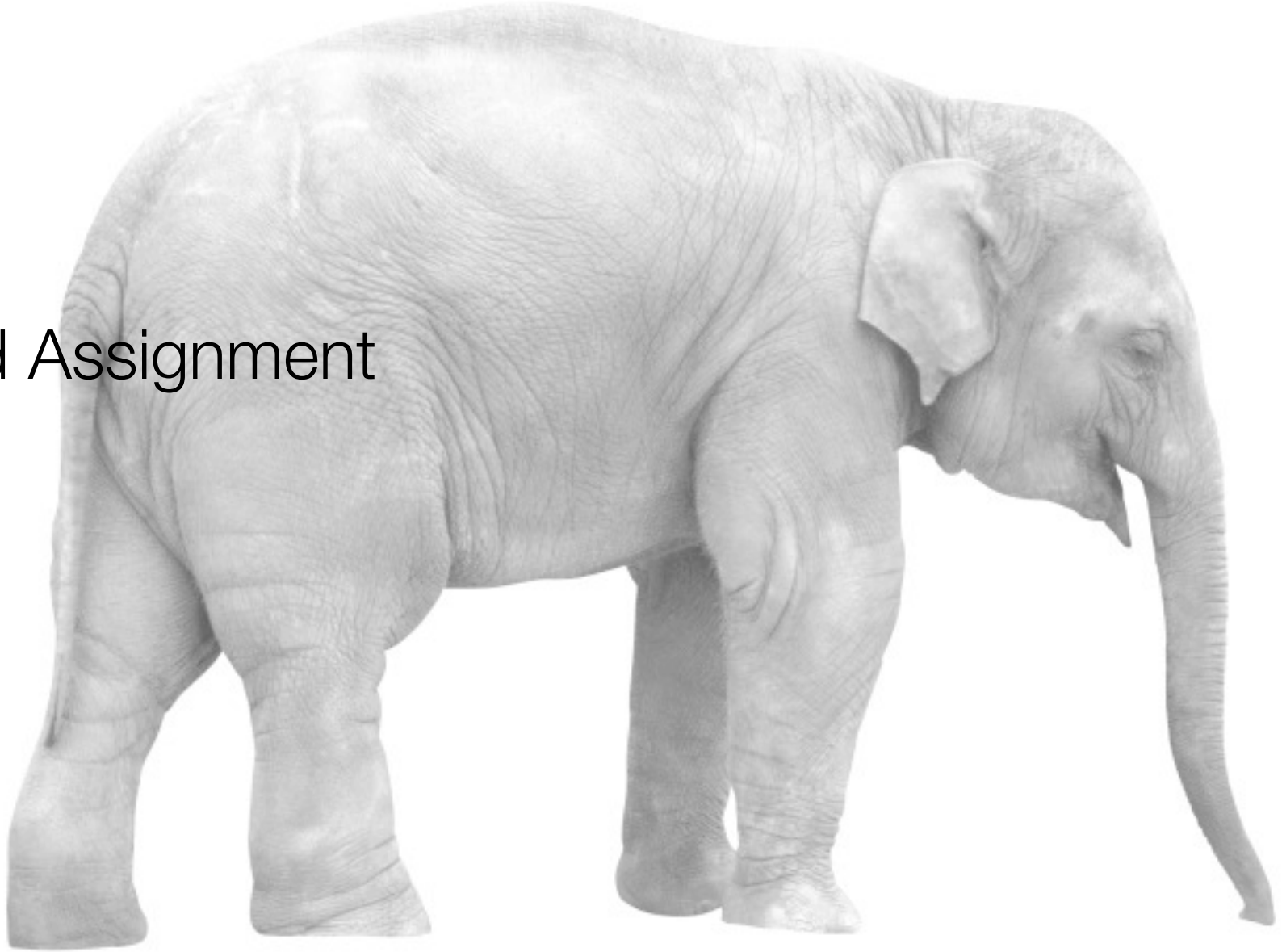
Apply

Network Services Settings

Advanced Network Settings


Terminal — telnet — 80×24
Trying 128.122.151.101...
Connected to zigbeegate.itp.tsoa.nyu.edu.
Escape character is '^]'.
login: root
password:
#> python
>>> import zigbee
>>> nodes = zigbee.getnodelist()
>>> for node in nodes:
...   print "%12s %12s %8s %12s" % (node.label, node.type, node.addr_short, node
.addr_extended)
...
      GORDIE   router [d21c]! [00:13:a2:00:40:30:cf:e3]!
   RECEPTION   router [f43e]! [00:13:a2:00:40:30:cf:dc]!
         ROB   router [fffe]! [00:13:a2:00:40:31:f9:ee]!
                   router [51e9]! [00:13:a2:00:40:30:d0:22]!
                   router [fffe]! [00:13:a2:00:40:31:7c:80]!
       QUIET   router [7b76]! [00:13:a2:00:40:30:d0:0e]!
ZIG Coordinator coordinator [0000]! [00:13:a2:00:40:54:ae:03]!
>>>
>>>

Card Assignment



ZigBee Application Profiles

- collections of device descriptions and functionalities for a specific application
- public or private
- home automation
- smart energy profile
- RF4CE
- Green Power

ZigBee Clusters

- subsets of application profiles
- define a function, service or action within a profile
  - level control
  - color control
  - thermostat messages

- two-byte cluster ID defines the message type

ZigBee Endpoints

- kind of like ports in TCP/IP
- define running application
- 1-byte address
- each endpoint is tied to an application profile

Sensor Actuator Project

Fast, Cheap & Out of Control

Internet Interlude

- IP addresses
- ports
- sockets
- layers physical, transport, application
- telnet demo

Telnet

- into ZIG
- ssh into itp
- daytime
- web server
- mail server

ZigBee Internet Gateway

COMMANDS:

help: displays this file

http://<host/path> receives a URL

https://<host/path> receives a secure URL

http://<host/path:port>

https://<host/path:port>

ftp://<host/path>

ftp://<username:password@host & path>

USE:

The recommended speed is 115200 baud which can be set with ATBD7

Lower baud rates may work if you are receiving short responses

The following formats are NOT yet supported:

http://<username:password@host/path>

telnet://<host:port>

mailto:<addr@host>

XBee I/O into a database

Final Project Workshops

Final Projects!

Readings and Assignments

- Readings
    - Sound of Summer Running

- Assignments
        - Have a great summer!