

Network Objects

Instructor: Rob Faludi

Plan for Today

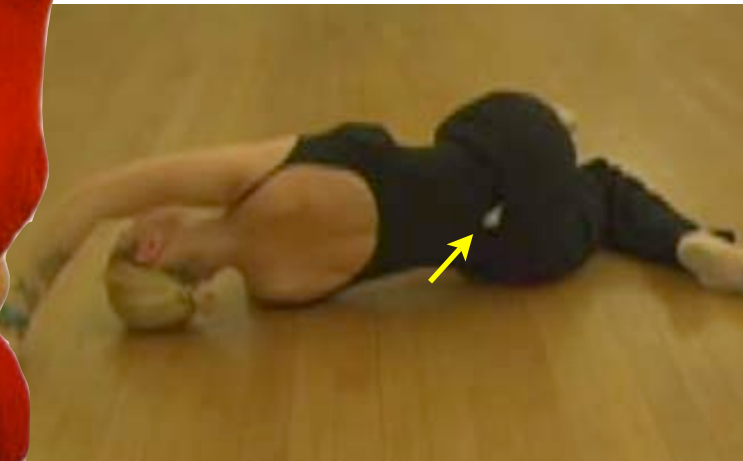
- XBees
- Final Four Presentations
- Social Bomb
- Readings & Assignments

Let's Get Our Stuff

- Download XBee Terminal Max:
<http://www.faludi.com/projects/xbec-terminal-max/>
- Download FTDI drivers:
<http://www.ftdichip.com/Drivers/VCP.htm>
- Download Processing:
<http://processing.org/download/>

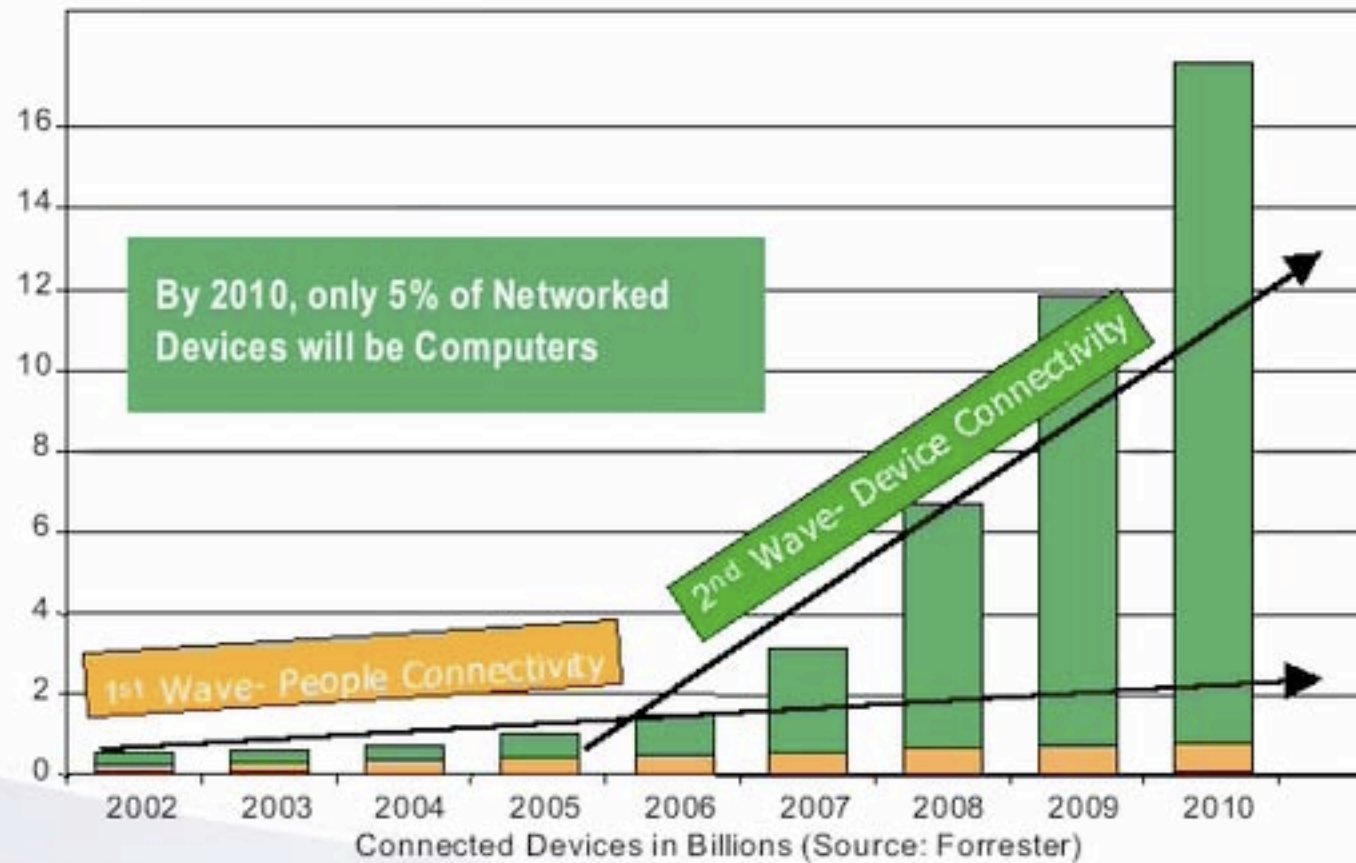
Wireless

Moving Data by Radio

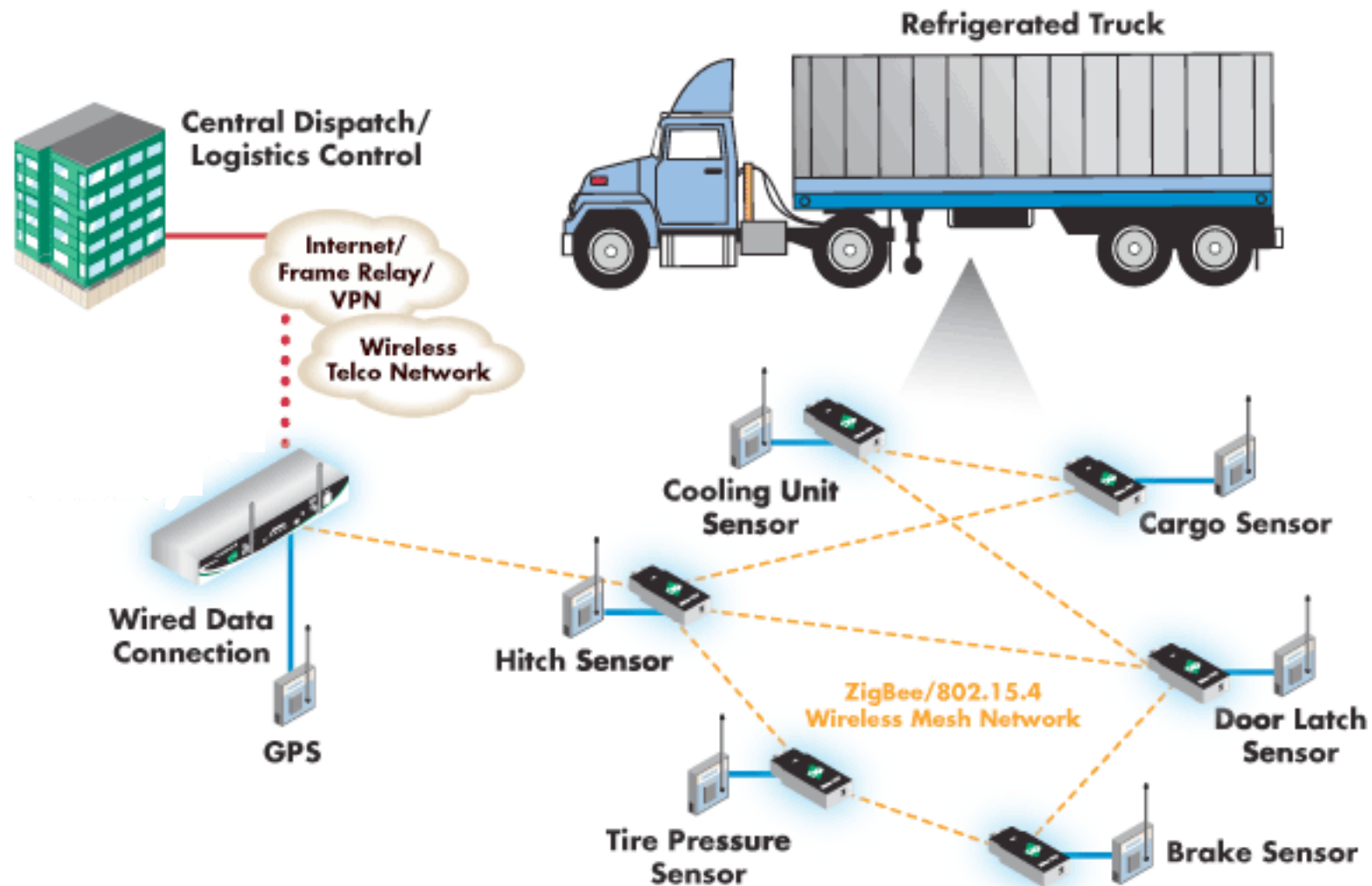




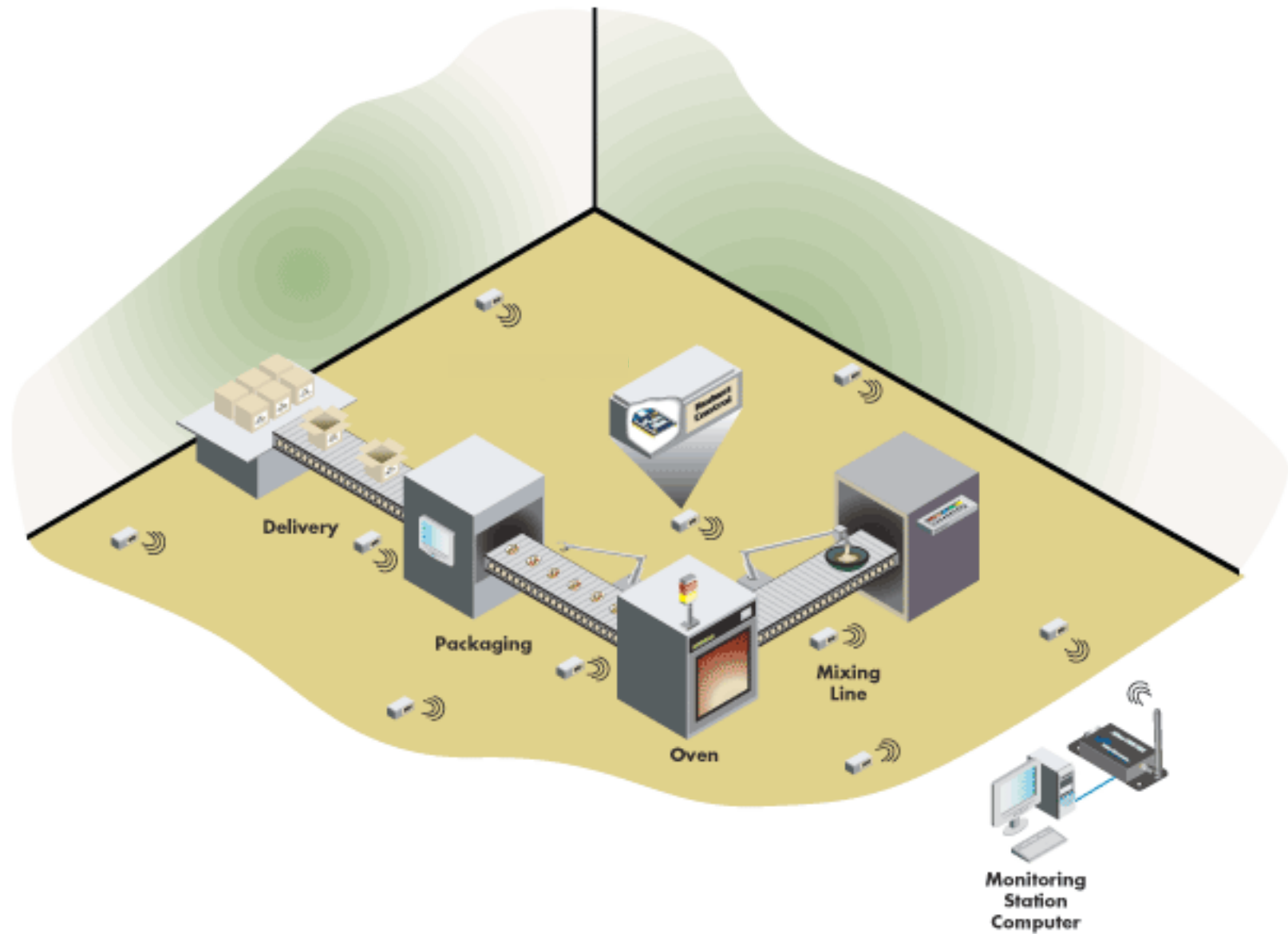
Extended Internet Growth



Fleet Management



Rodent Traps

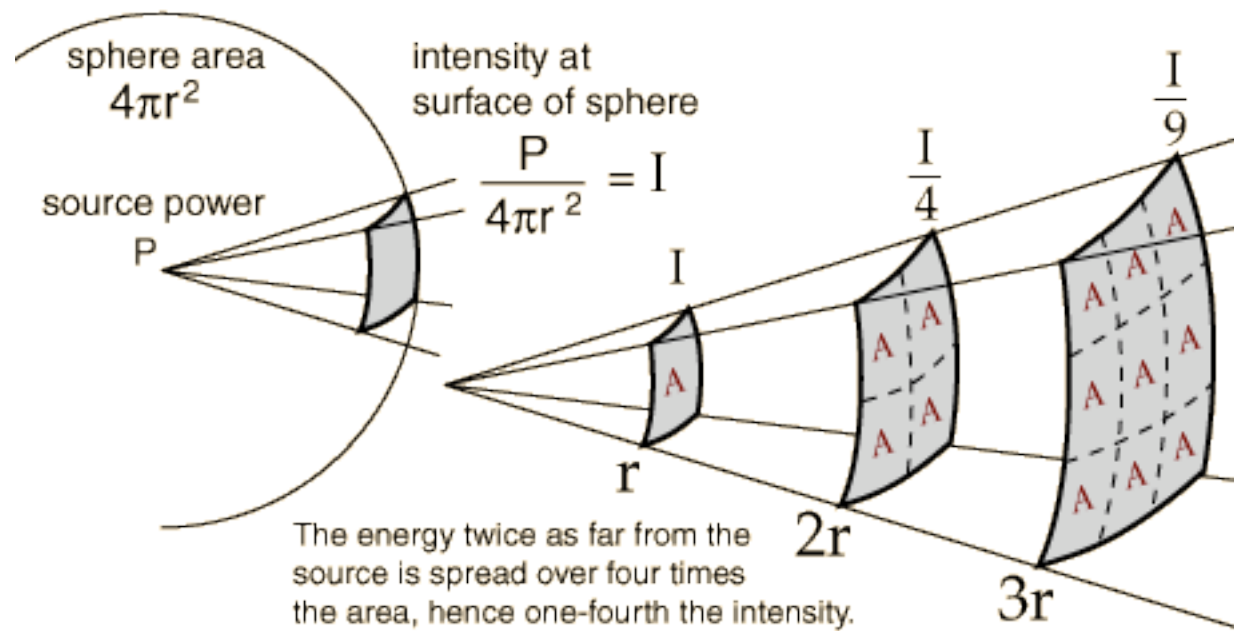


Radio Communications

- electromagnetic waves
- no medium required
- modulation
- well-described mystery: “air waves” “wireless” “ethereal communication”
- cool posters: <http://faludi.com/2007/09/15/spectrum-posters/>

Inverse Square Law

- power needs increase exponentially with distance



Some Methods for Device Communication

- Transmit/receive pairs
- Proprietary transceivers
- Ethernet
- WiFi
- Cell phone data
- Bluetooth
- Cell modules



802.15.4

- low power
- addressing
- cheap
- wireless
- small
- standardized

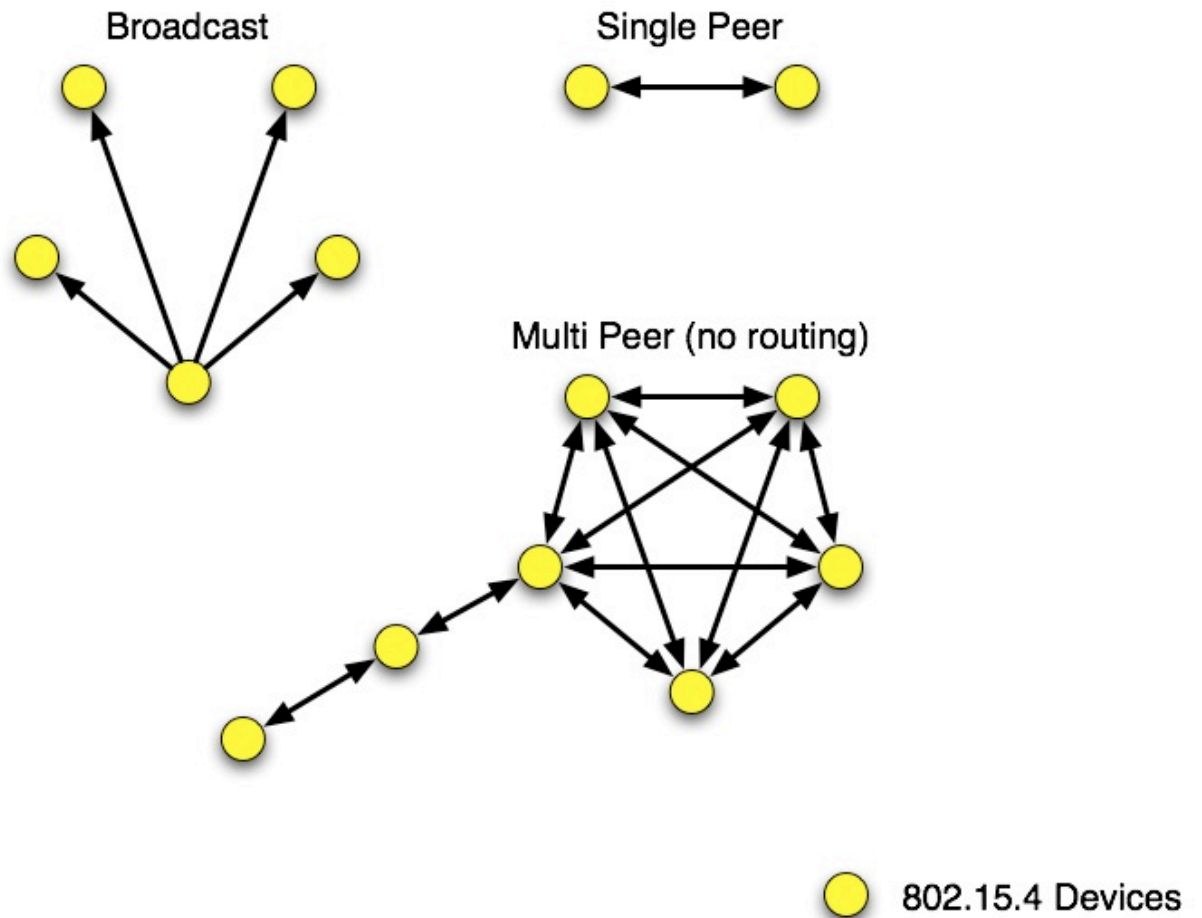


ZigBee & 802.15.4

- ZigBee is built on top of the IEEE 802.15.4 protocol
- XBee radios are available with or without ZigBee
- Both ways are useful

802.15.4 Topologies

- single peer
- multi-peer
- broadcast



ZigBee

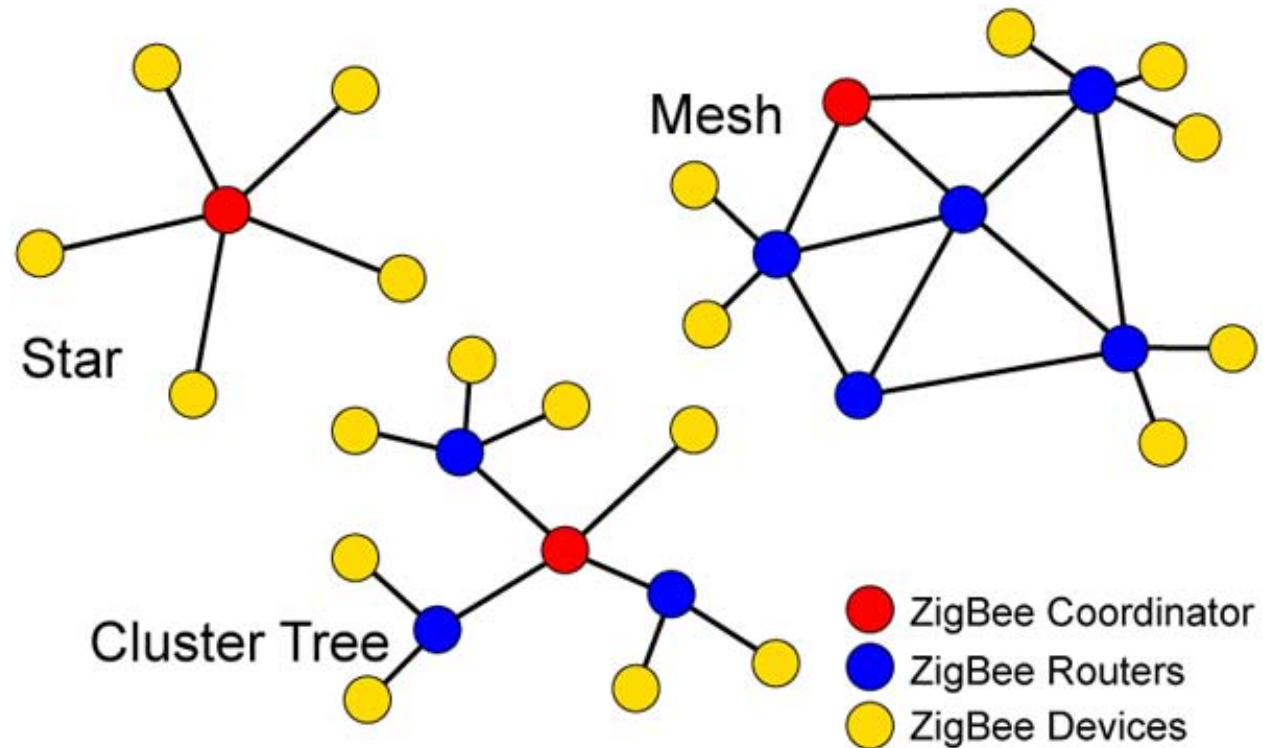
- routing
- self-healing mesh
- ad-hoc network creation



- ZNet 2.5 older
- ZB Pro better density and frequency agility (ZigBee 2007)

ZigBee Topologies

- peer
- star
- mesh
- routing



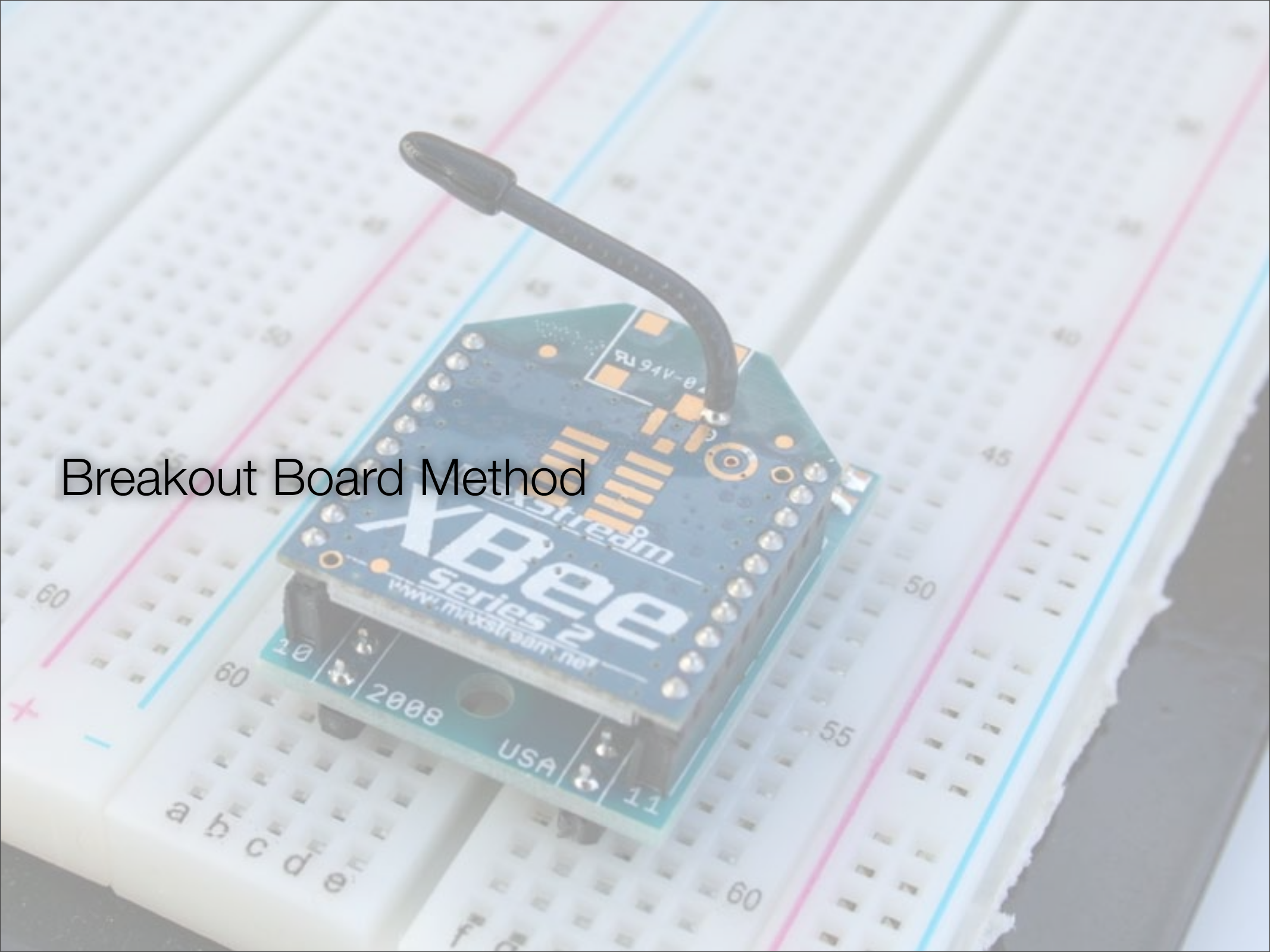
Other Interesting Protocols

- ZigBee Smart Energy Profile
- ZigBee RF4CE
- 6LoWPAN TCP/IP
- XBee 802.15.4 vs. ZNet 2.5 vs. ZB Pro vs. DigiMesh



Okay, okay, so how do I make one?

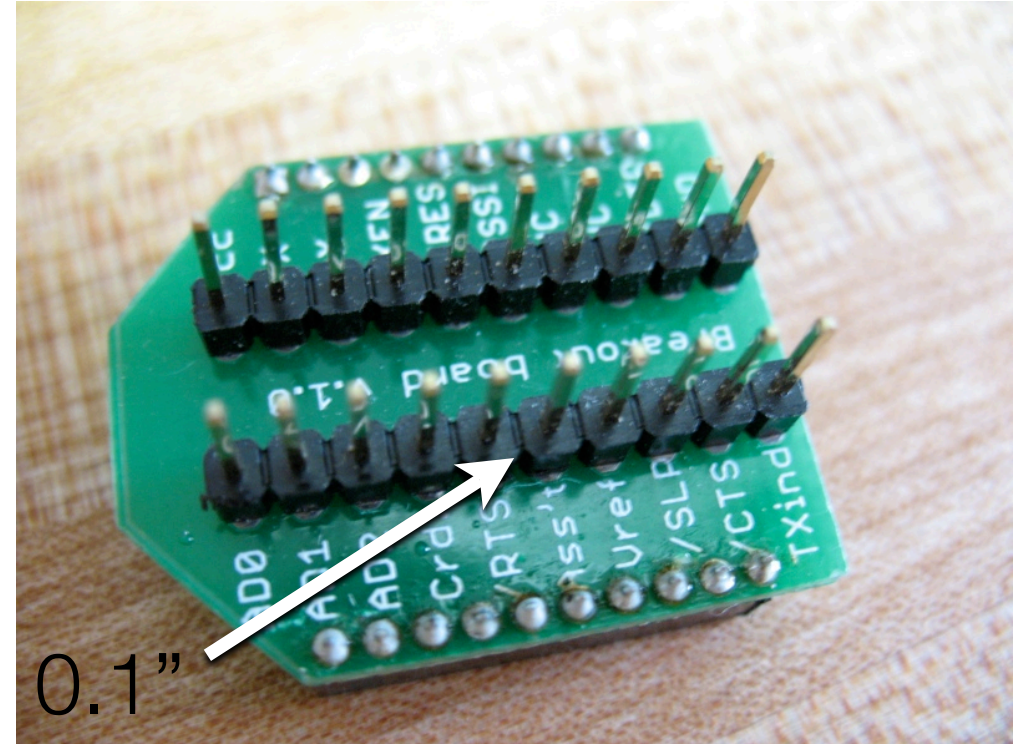
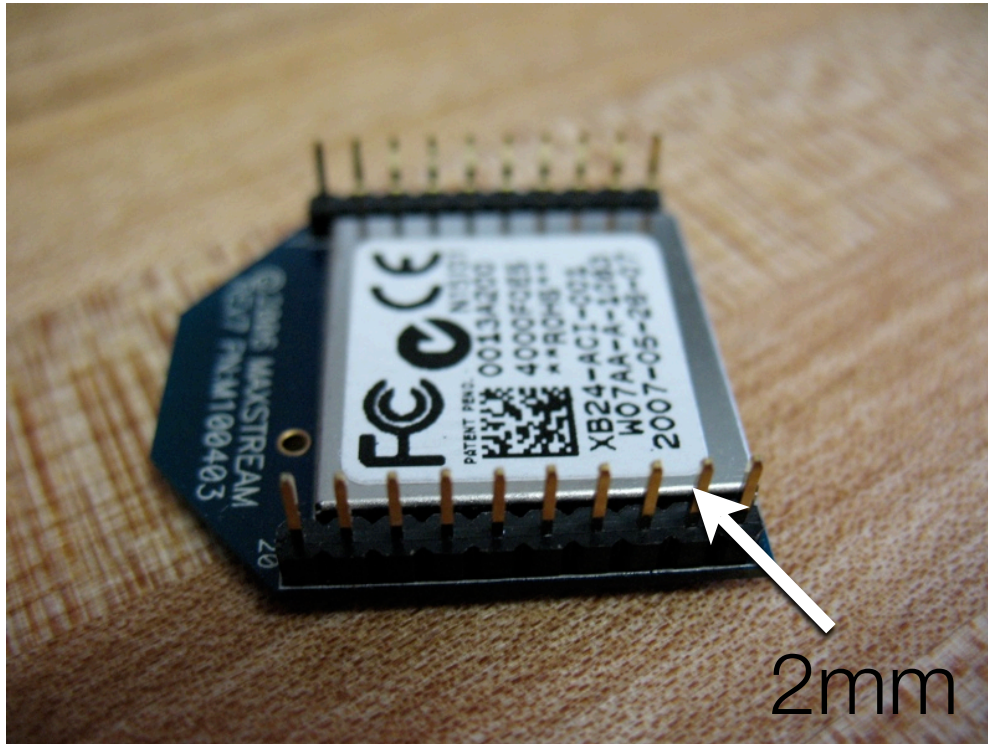
Breakout Board Method



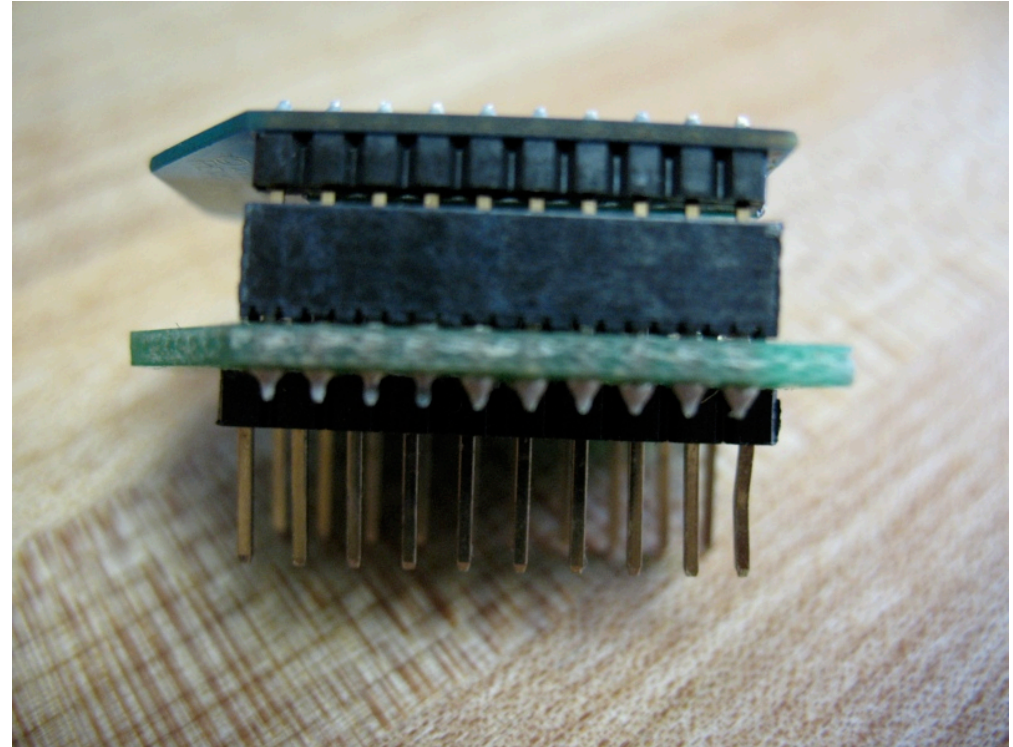
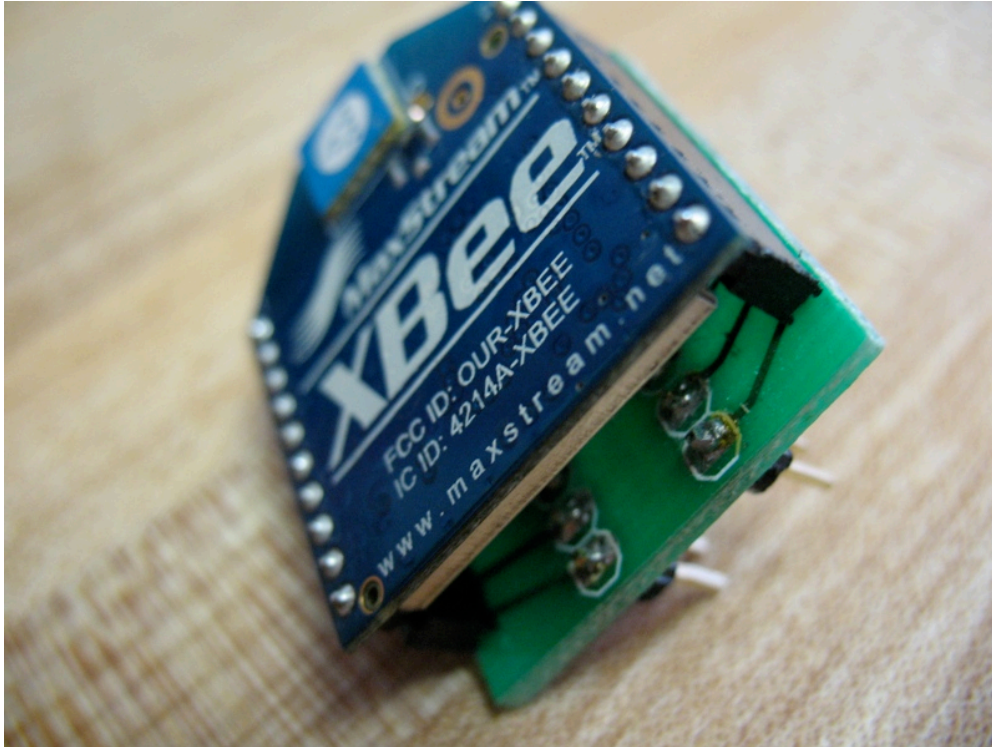
Materials

- XBee OEM Module (30-100 m range) \$19
XBee Pro (100m - 1.6 km range) \$32
- Digi: <http://www.digi.com>
- Breakout Board, 2mm to 10 mil pin spacing.
- Female headers 2mm
- Male headers 10 mil

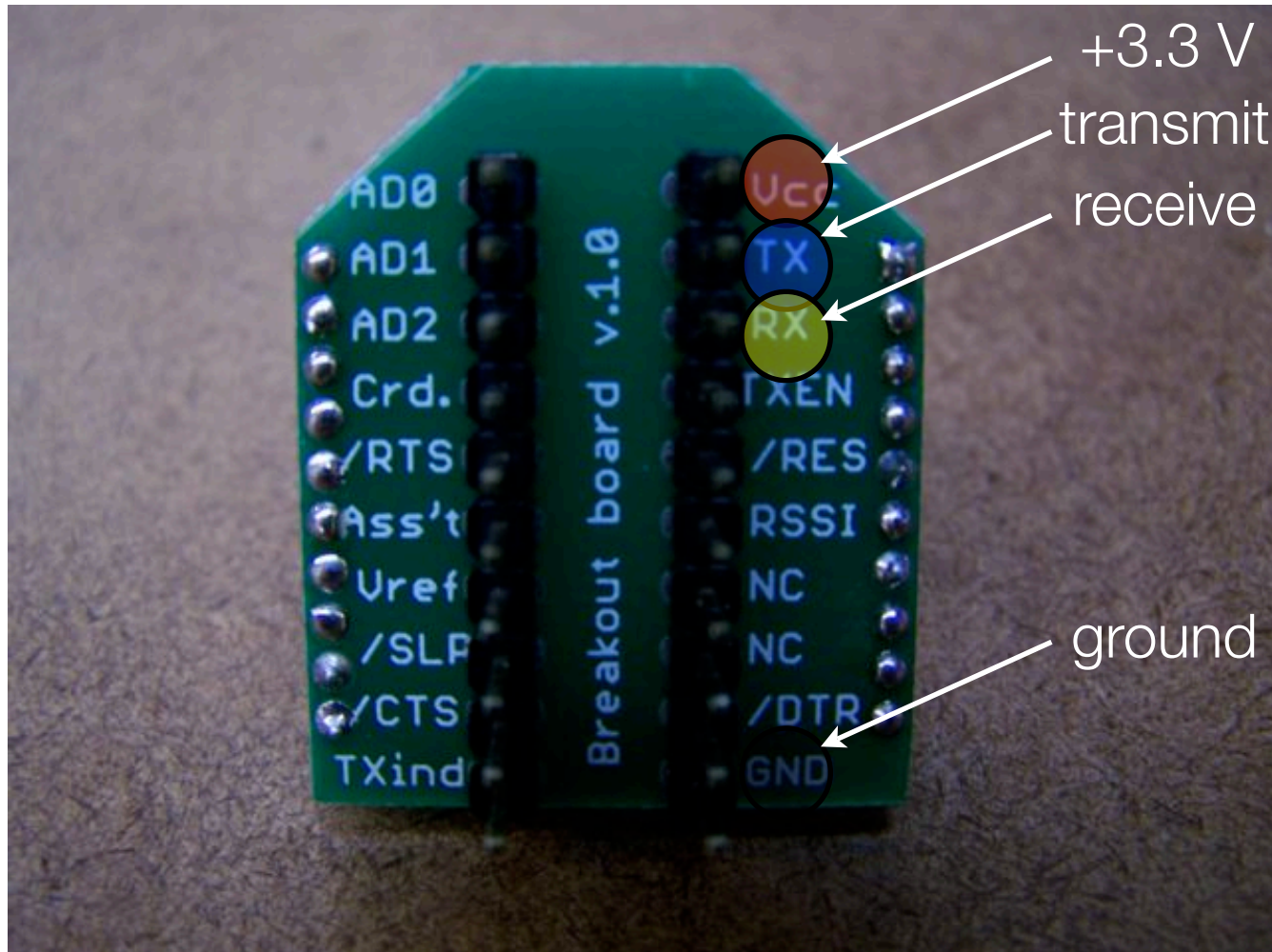
Soldering Breakout Boards: pin spacing



Soldering Breakout Boards: finished



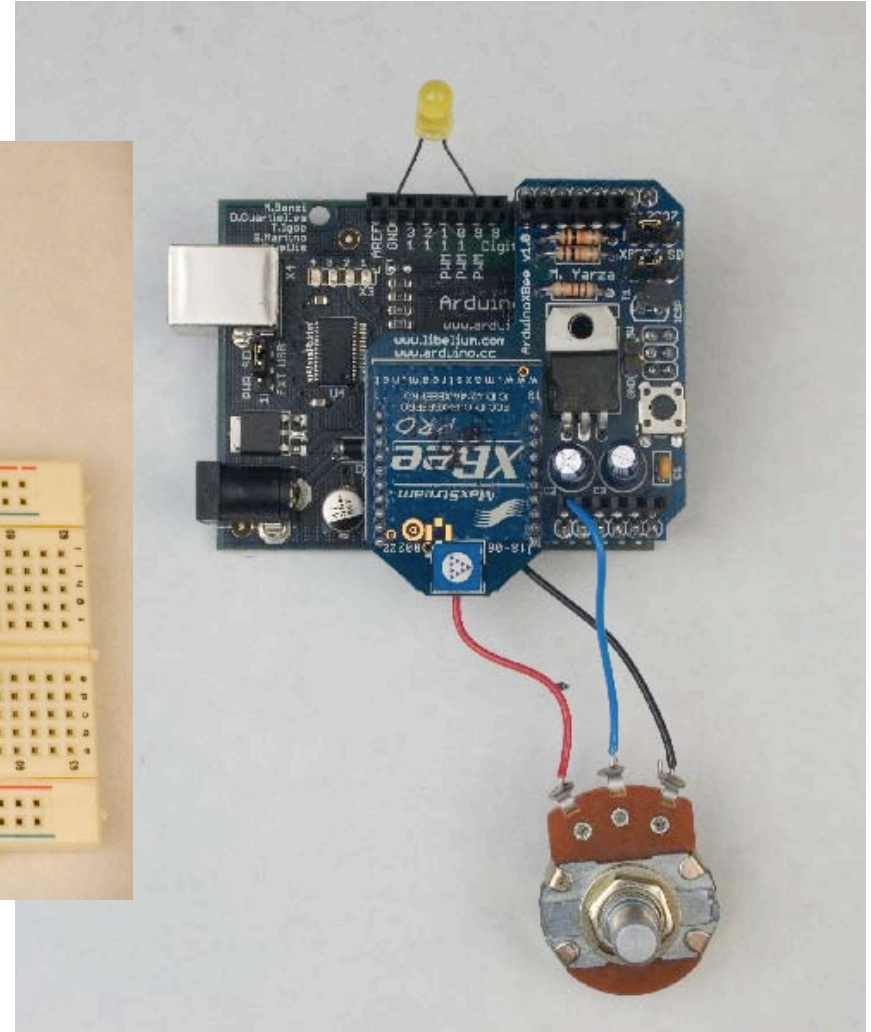
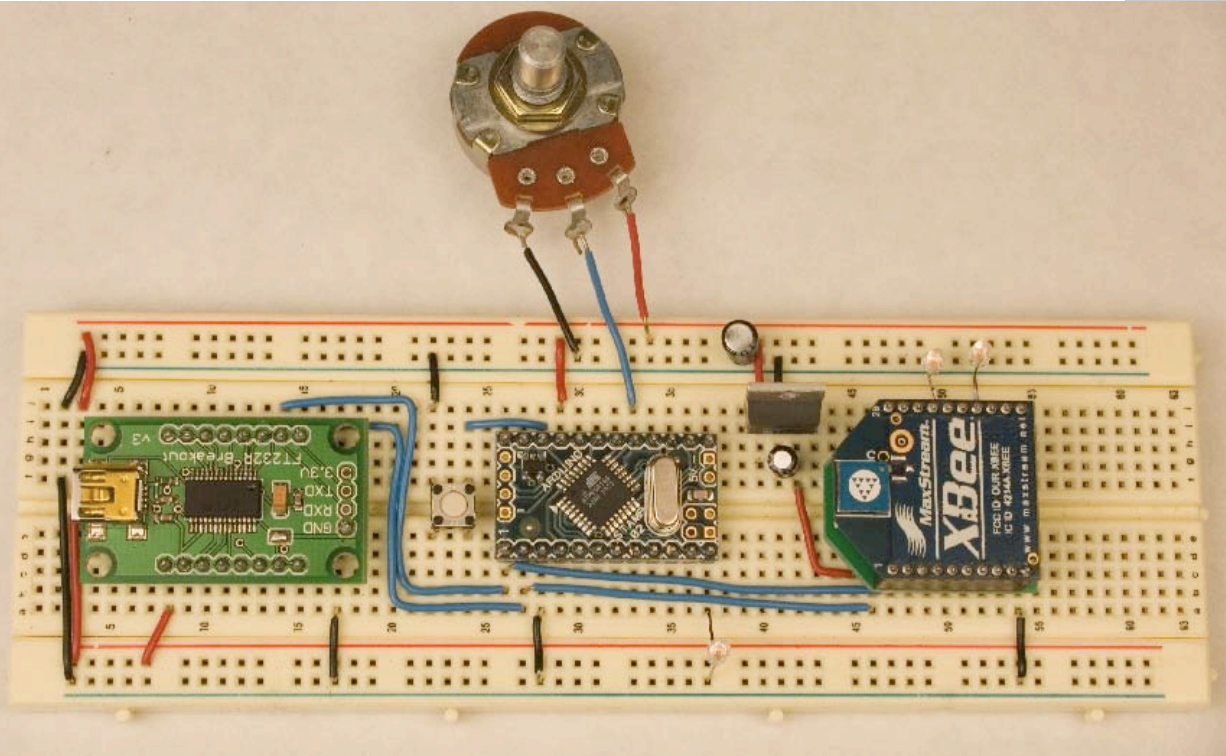
Wiring



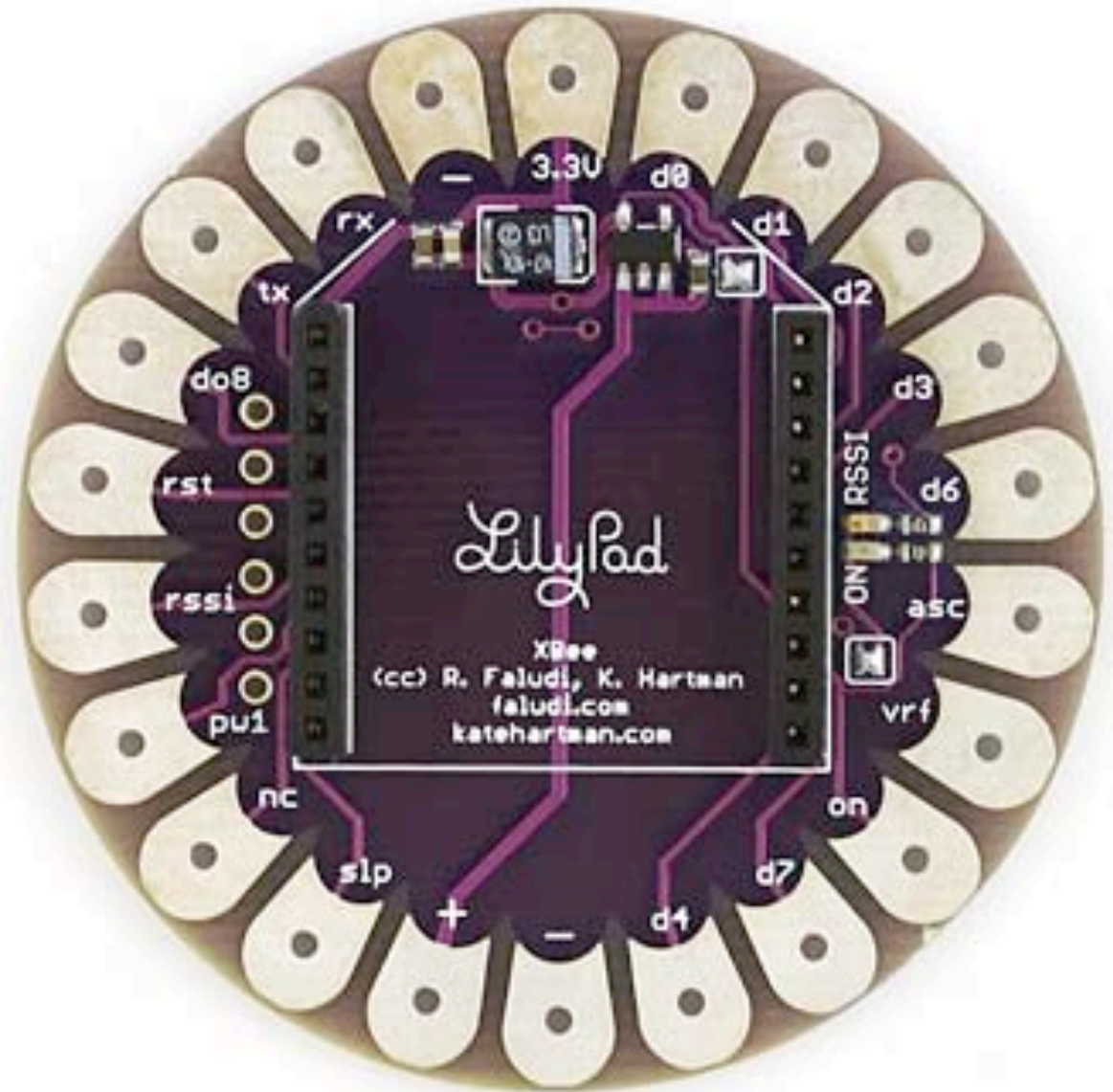
Remember!

- Use only +3.3 Volts. Arduino can supply this, or use a voltage regulator
- Always use decoupling capacitors along with the voltage regulator.
- You can't send infinitely fast. Try putting a 10 ms delay into your loop.
- XBee TX goes to Arduino RX and vice versa.
- Arduino can run on 3.3 Volts (use the breadboard version or create a PCB)

XBee Send/Receive



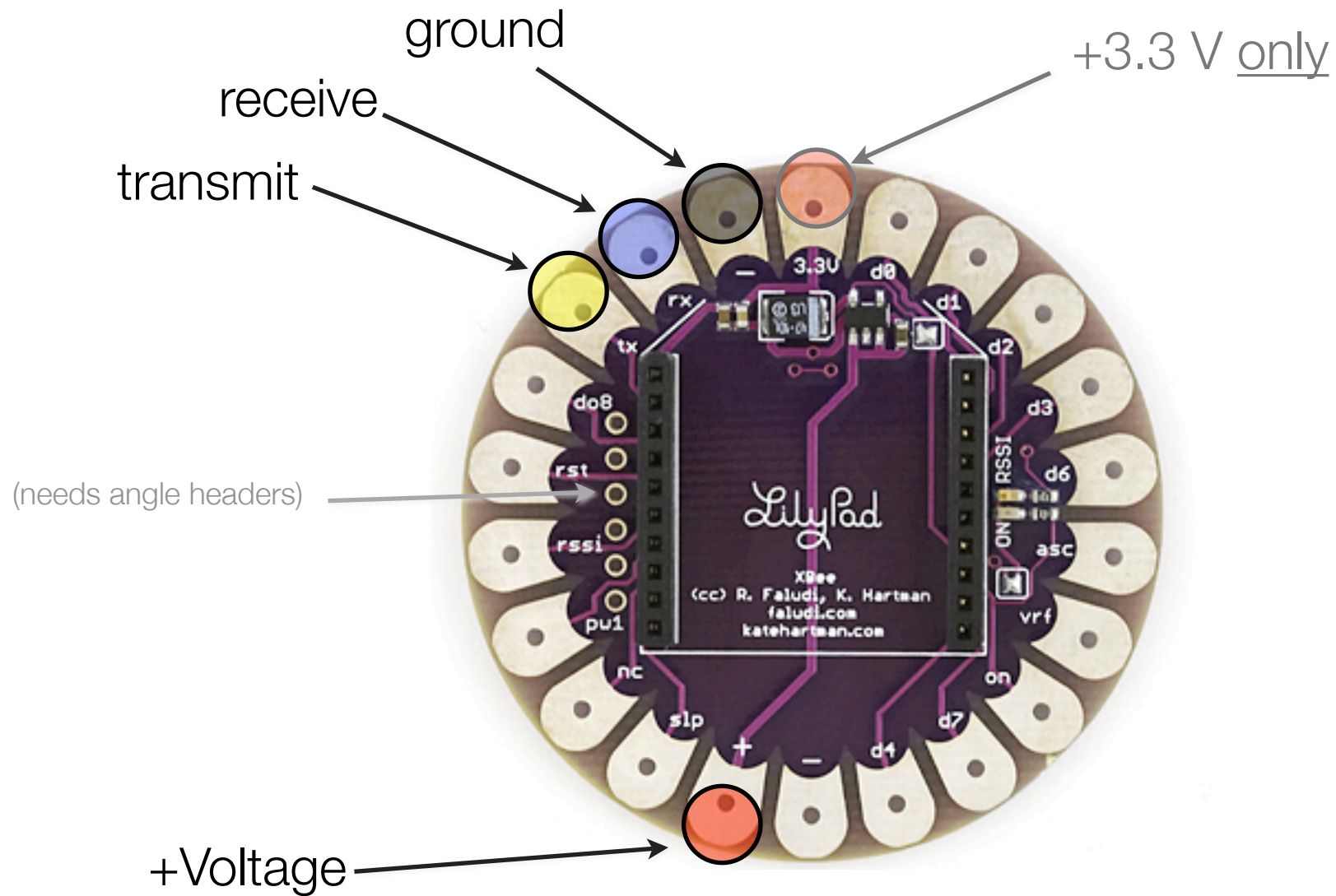
LilyPad XBee



Materials

- XBee 802.15.4 OEM Module, Chip Antenna (30-100 m range) \$23
XBee Pro 802.15.4, Chip Antenna (100m - 1.6 km range) \$36
- Digikey: <http://www.digikey.com>
- LilyPad XBee, <http://faludi.com/lilypad>
- Alligator clips
- 9 Volt battery or 3.3 - 3.7 Volt battery
- FTDI cable for programming with angle headers

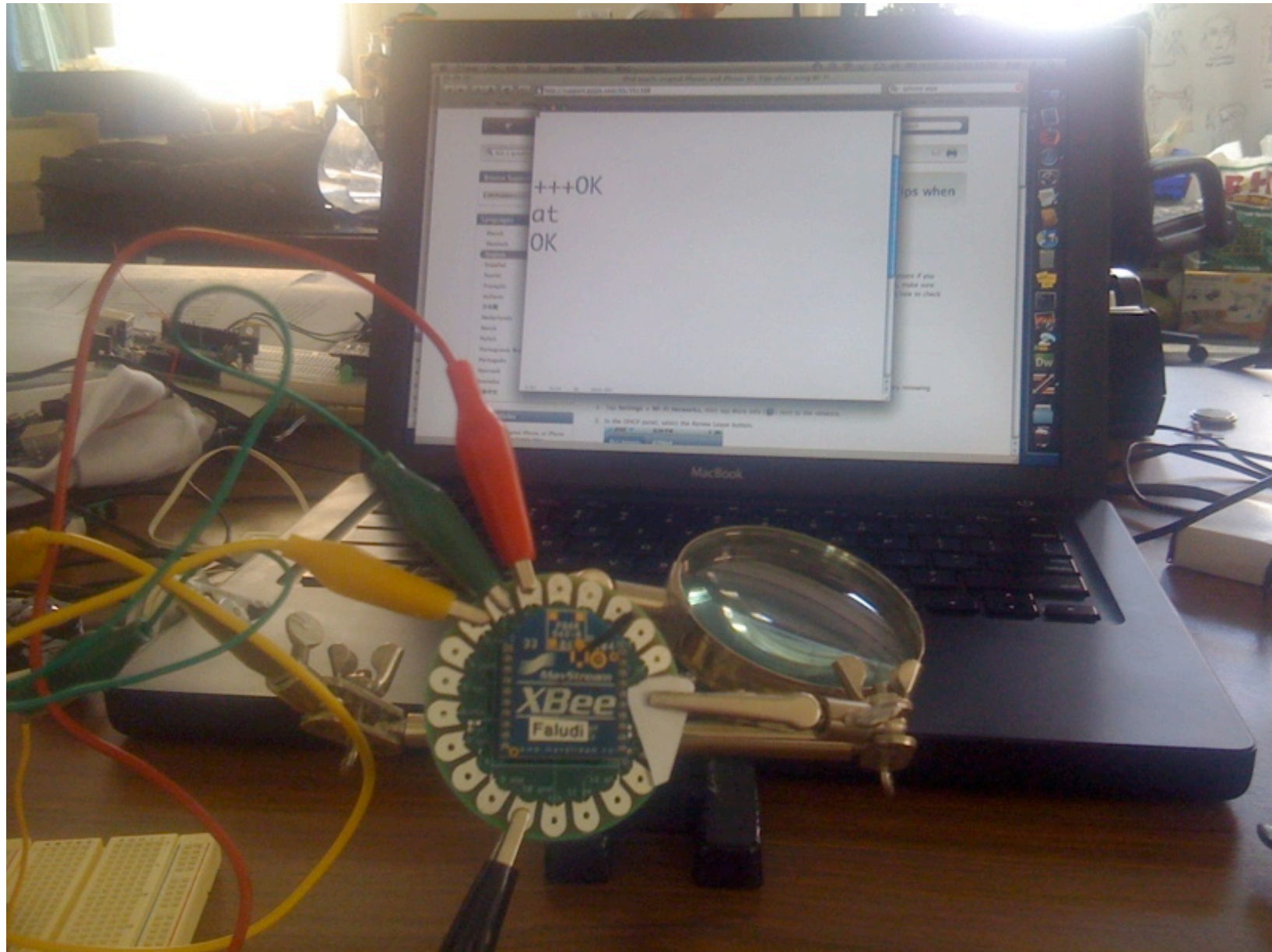
Wiring



FTDI Cable



Alligator Clips for Prototyping



Remember!

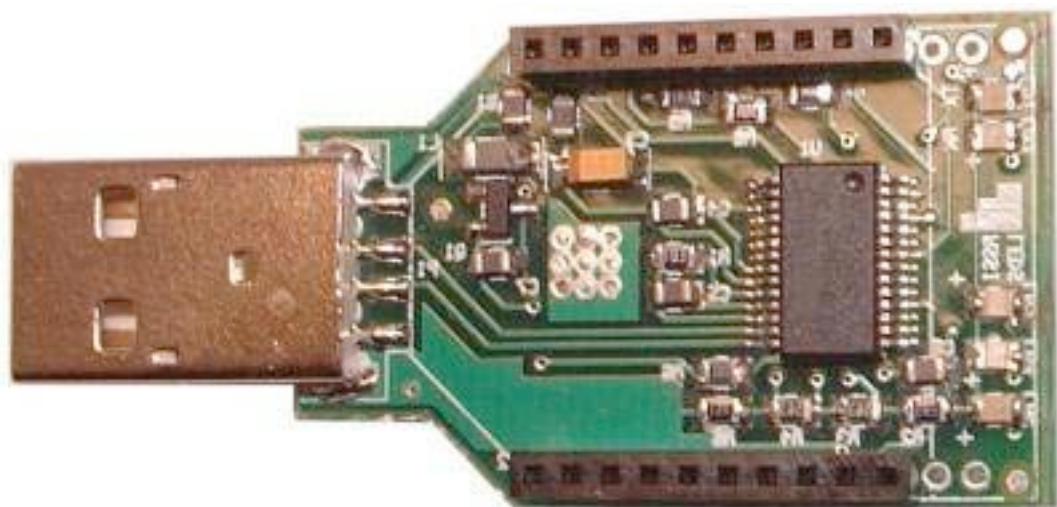
- Never send more than about +4 Volts to the 3.3 pin. Use the + pin instead
- Conductive thread may be too resistive for power and ground, try fabric or wire
- XBee TX goes to Arduino RX and vice versa

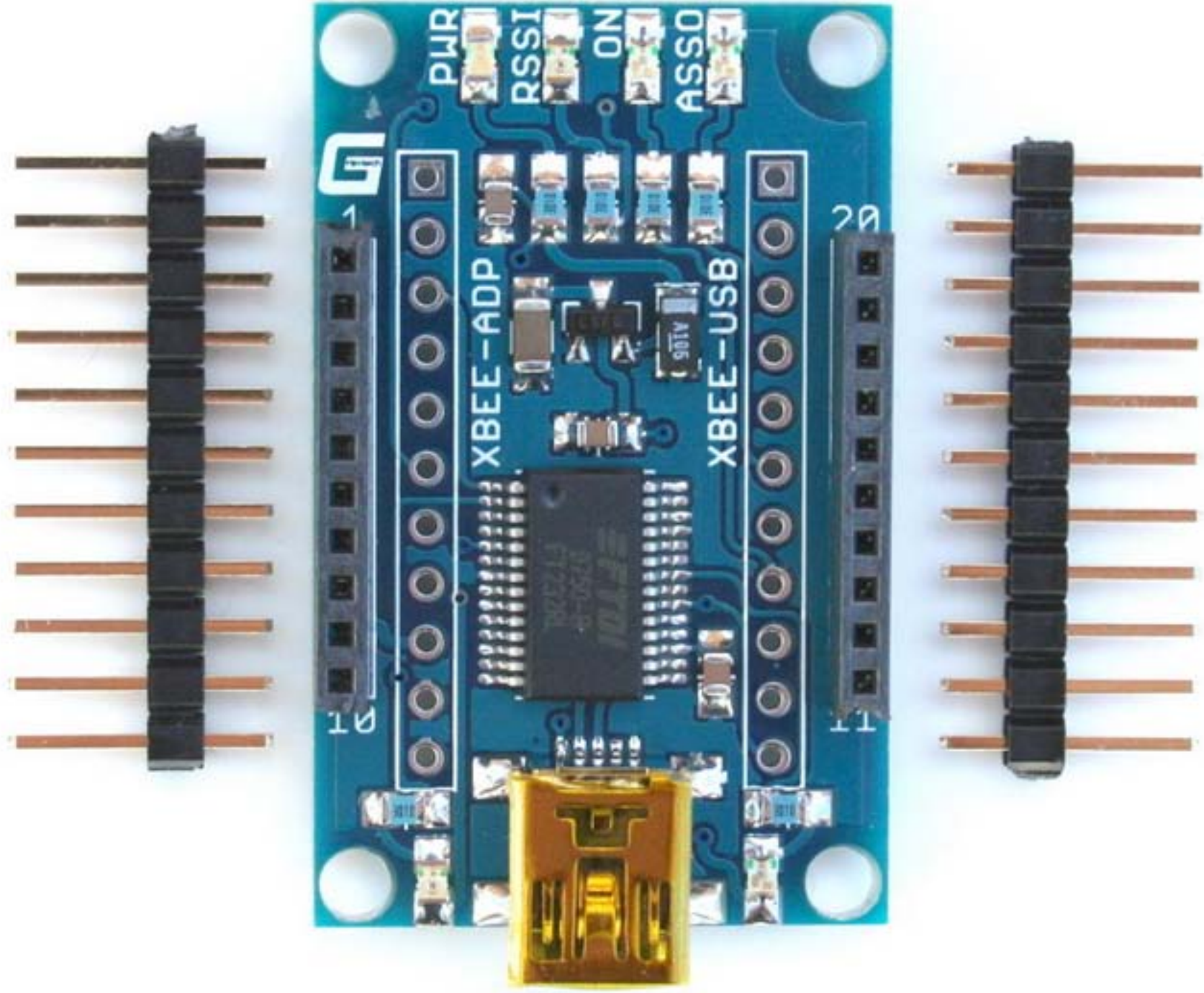
Instructions

- XBee Practical Example: Paired communication between two microcontrollers. Includes building, wiring and code for PIC and Arduino
- Making Things Talk book by Tom Igoe
- I/O Example on faludi.com, or in the XBee manual section 2.2
- <http://faludi.com/lilypadxbee>

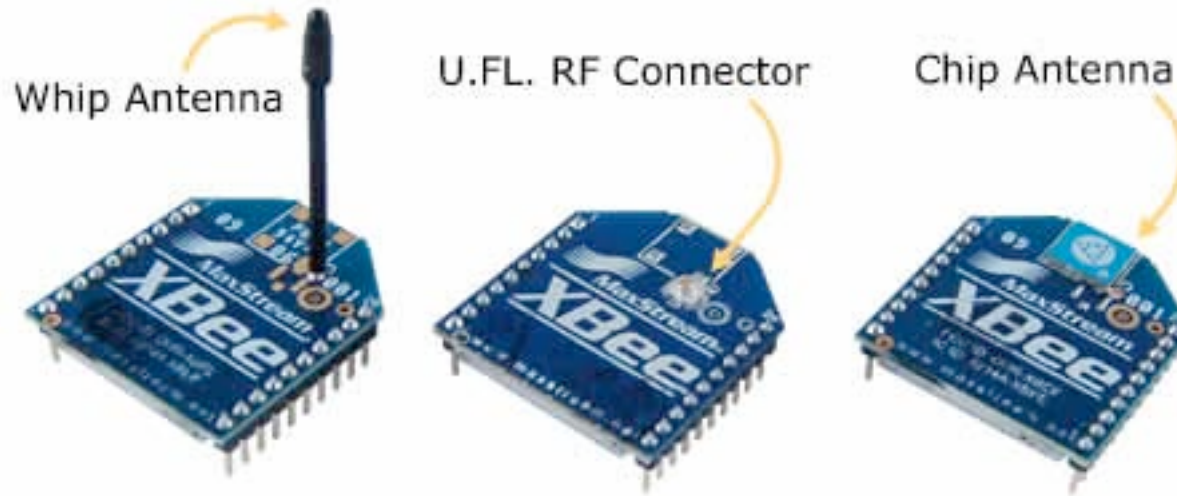
Connect to a Computer







Antennas



Chip Antenna on Pro



Serial Terminal Programs

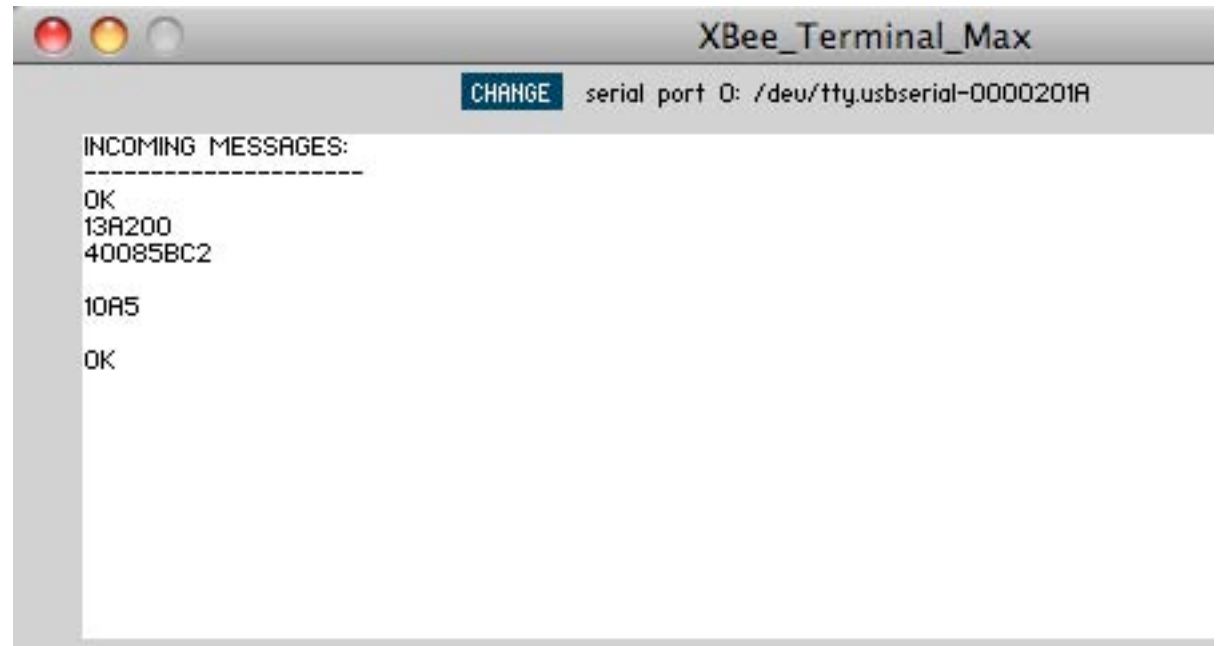
- Processing: <http://www.faludi.com/projects/xbee-terminal-max/>
- Z-Term: <http://homepage.mac.com/dalverson/zterm/>
- HyperTerm: Windows Start Menu, Accessories, Communication
- screen: Terminal program on the Mac (or Linux)
- X-CTU: <http://www.digi.com/support/productdetl.jsp?pid=3352&osvid=57&tp=4&s=316>
- plenty of others

Baud, Bits and Parity

- Default baud rate: 9600
- Bits: 8
- Stop bits: 1
- Parity: None
- Flow control: none for now...

Okay, okay so let's DO something!

Exercise: Setup



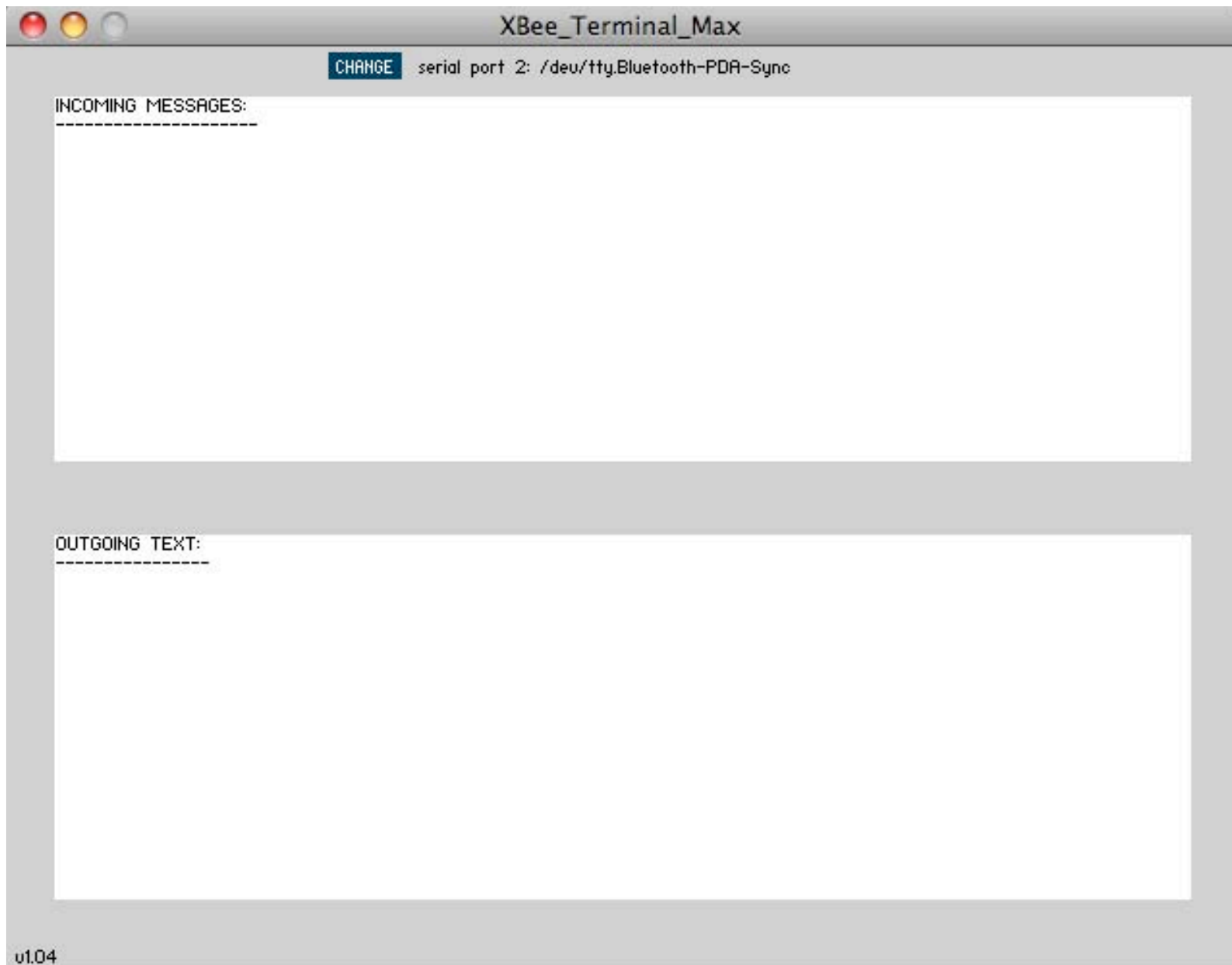
Let's Get Our Stuff

- Download XBee Terminal Max:
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- Download FTDI drivers:
<http://www.ftdichip.com/Drivers/VCP.htm>
- Download Processing:
<http://processing.org/download/>
- Download ETech Monkey Controller:
<http://www.faludi.com/downloads/etech2009>

Setup

- Download all software and configure your computer
 - if you can't download, let us know
 - if you don't have access to install drivers, follow along with a friend
- Plug in your USB cable, XBee adaptor and the XBee
- Start up the XBee Terminal Max program
 - Click Change to select the appropriate port, if needed

XBee Terminal MAX



Data Mode vs. Command Mode

- Idle Mode, transmit and receive data
- Command Mode, talk to the XBee itself
 - +++ *"Yo, XBee"*
 - AT *"Attention!"* (Hayes command set)

Some AT Commands

- AT -> OK
- ATMY -> my address
- ATDL -> destination address (low)
- ATID -> personal area network ID
- ATCN -> end command mode

Let's Configure

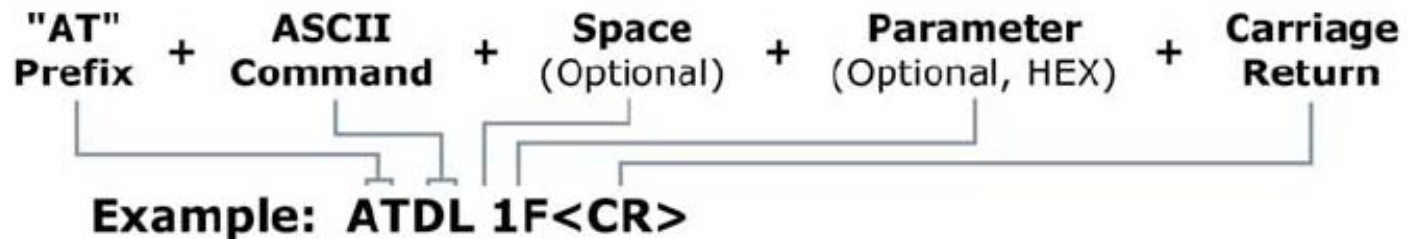
- type just +++ to go into command mode. Don't hit return or enter!
 - you should see an *OK* response in the top window
- type AT and see if you get another *OK* response
 - if you don't you've gone back out of command mode, so do +++ again.
- type ATID to see the current (default) PAN ID in the top window
- type ATID followed by your PAN ID to set it
 - if your PAN ID is 1437 then you'd type *ATID 1437*

Explore your XBee

- ATMY shows your address
- ATDL shows the destination address
- ATVR shows you the current version number
 - 10A5 or 10CD are current ones
 - 1084, you'll definitely want to upgrade later on

AT Command Format

Figure 2-08. Syntax for sending AT Commands



Method 1 (One line per command)

Send AT Command

+++

ATDL <Enter>

ATDL1A0D <Enter>

ATWR <Enter>

ATCN <Enter>

System Response

OK <CR> (Enter into Command Mode)

{current value} <CR> (Read Destination Address Low)

OK <CR> (Modify Destination Address Low)

OK <CR> (Write to non-volatile memory)

OK <CR> (Exit Command Mode)

Method 2 (Multiple commands on one line)

Send AT Command

+++

ATDL <Enter>

ATDL1A0D,WR,CN <Enter>

System Response

OK <CR> (Enter into Command Mode)

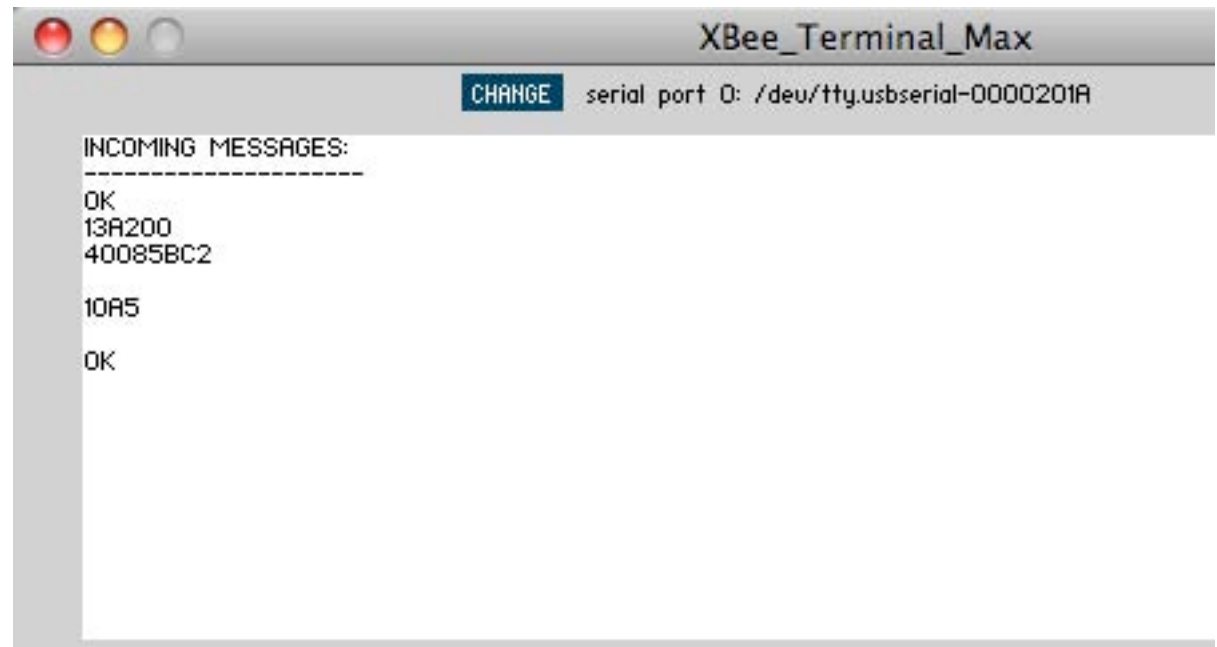
{current value} <CR> (Read Destination Address Low)

OK, OK, OK <CR> (Command execution is triggered upon each instance of the comma)

Hexadecimals

- Just like decimals, but count from 0 to 15 in each position
- Since there's no existing single numeral representing 10 - 15, use A - F instead
- A = 10, B=11, C=12 ... F=15
- A1 = 161, common notation: 0xA1
- What does BFF equal? What does it look like?
- Calculators on Mac & Windows

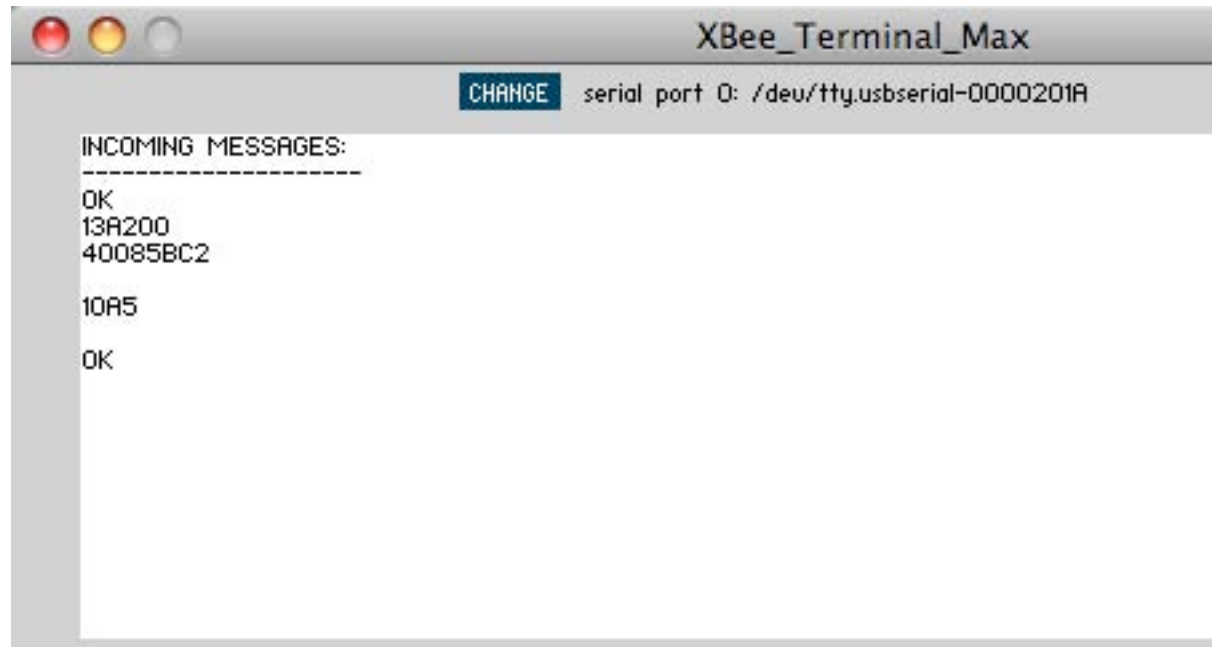
Exercise: Pairs



Meet Your Neighbor

- Shake hands, share a smile, have a mint together
- Pick one of your PAN IDs to use and configure that on both: ATID....
- Configure your local address: ATMY..
- Configure your partner's address as your destination address: ATDL..
- Check to see if you got it right, then ATCN to exit command mode
- Chat with your neighbor!

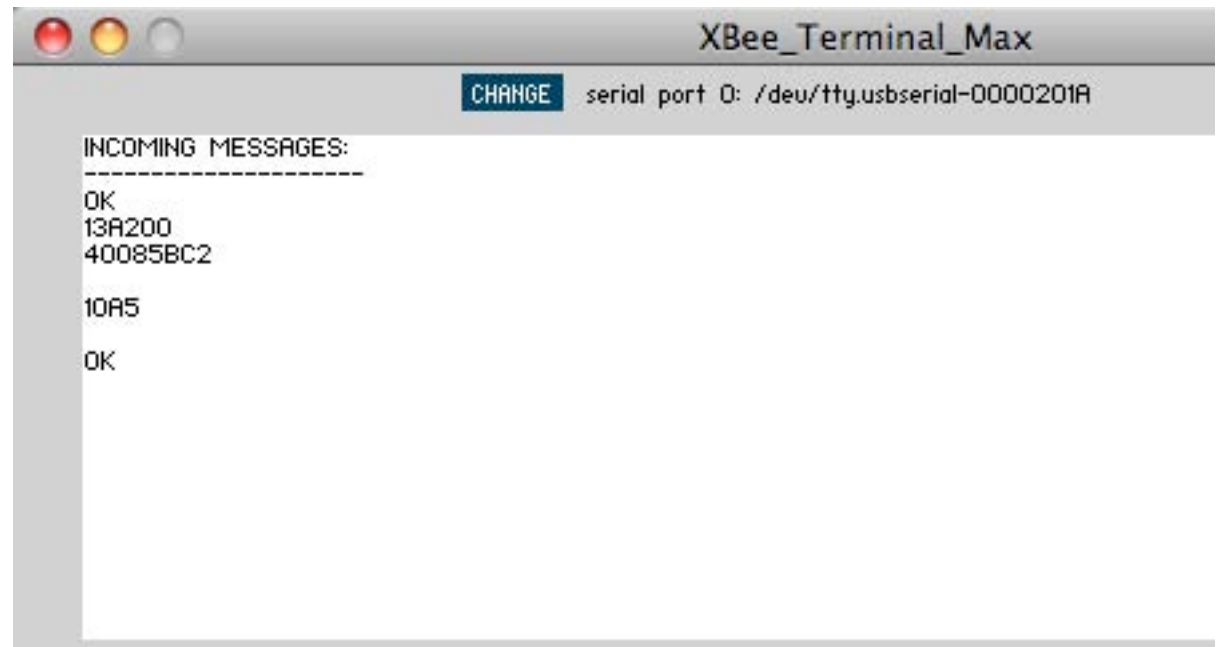
Exercise: Strangers



Find Your XBee Soulmate

- Configure yourself for the common PAN ID: ATID 1234
- Set your destination address to the soulmate one listed on your handout: ATDL....
- Check your work, then get out of command mode: ATCN
- Chat with and identify your soulmate
 - what color socks are they wearing?
do they like broccoli?

Exercise: Groups



Groups

- Configure yourself for the Group PAN ID on your handout: ATID....
- Give your radio a friendly name or node indicator: ATNI.....
- Find a friend to chat with using node discovery: ATND
2 <- your new friend's address!!
13A200 <-Manufacturer ID
40020DBF <-Serial Number
47 <-RSSI
Trixie the XBee <-node indicator, aka friendly name
 - Change the destination address to that person's to chat: ATDL..
- Try using the broadcast address to talk to everyone: ATDL FFFF

Protocols

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

XBee I/O mode

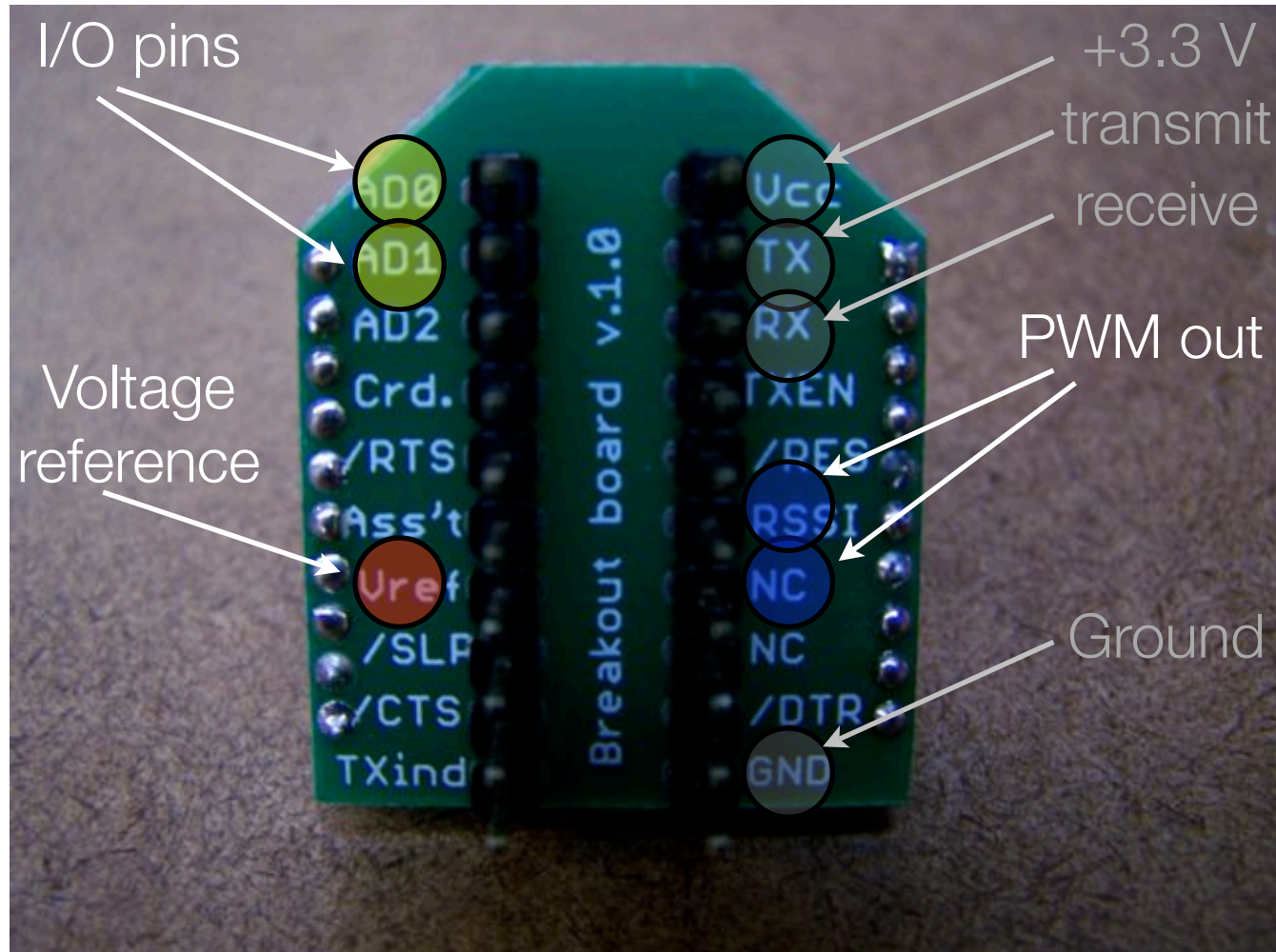
I/O Why

- Why:
 - Save space, save power, save weight and save money
 - Reduce complications
- Why not:
 - Limited inputs/outputs
 - No access to logic
 - Each radio must be manually configured

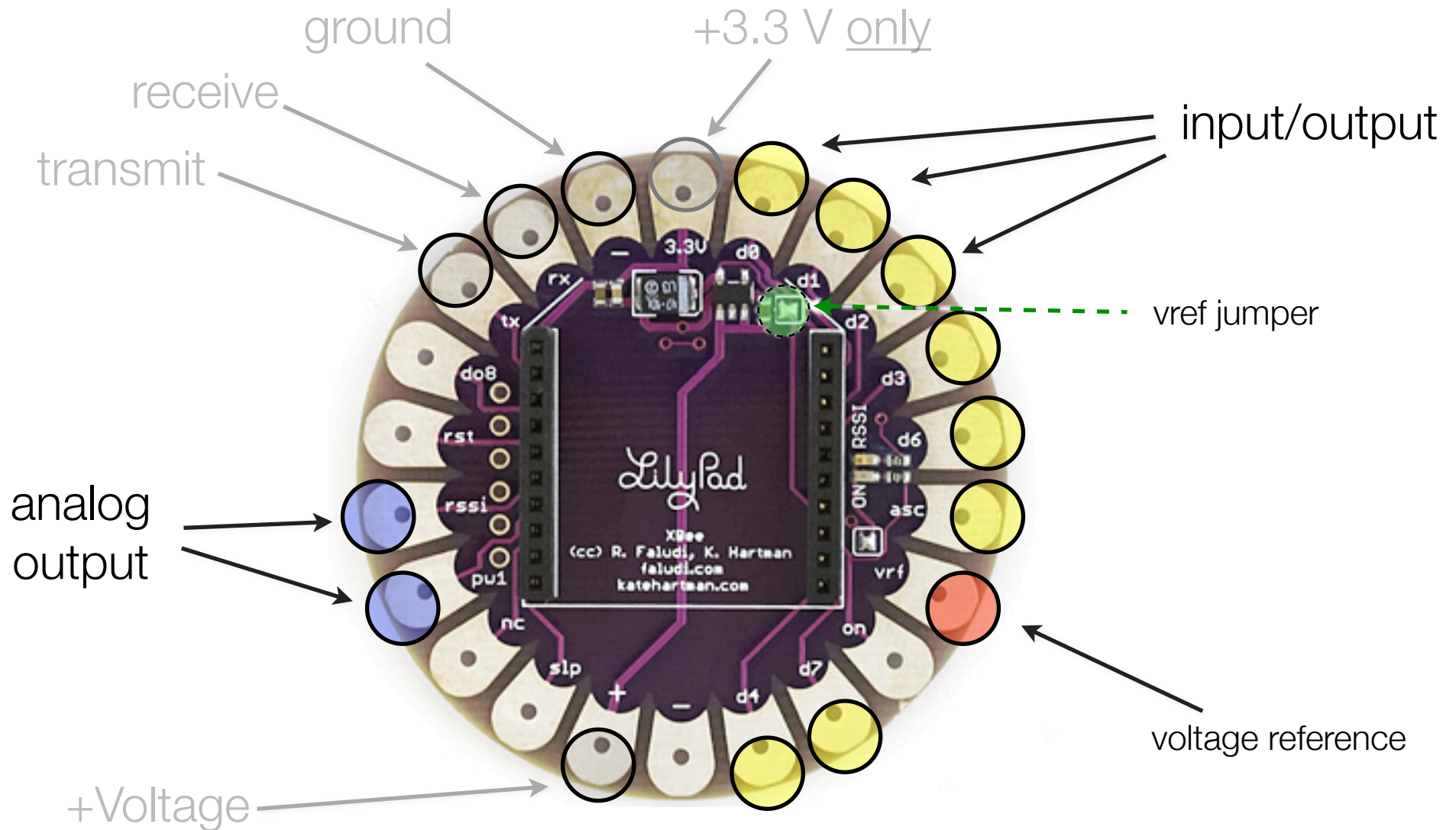
I/O Intro

- For simple input and/or output
- Eight digital input/outputs
- One additional digital output
- Seven analog inputs
- Two analog outputs
- But not all at once! Pins are shared.

Input/Output Wiring



Input/Output Wiring



I/O AT Commands

- ATD0...D8 -> configure pins for I/O
- ATIR -> sample rate
- ATIT -> samples before transmit
- ATP0...P1 -> PWM configuration
- ATIU -> I/O output enable (UART)
- ATIA -> I/O input address

Example Configuration

- ATID3456 (PAN ID)
ATMY1 my address 1
ATDL2 destination address 2
ATD02 pin 0 in analog in mode
ATD13 pin 1 in digital in mode
ATIR14 sample rate 20 milliseconds (hex 14)
ATIT5 samples before transmit 5
- ATID3456 (PAN ID)
ATMY2 my address 2
ATDL1 destination address 1
ATP02 PWM 0 in PWM mode
ATD15 pin 1 in digital out high mode
ATIU1 I/O output enabled
ATIA1 I/O input from address 1

Common XBee Mistakes

- <http://www.faludi.com/projects/common-xbee-mistakes/>

API Mode

- Powerful, steeper learning curve
- Data wrapped together with commands, addressing and status information

API Mode Format

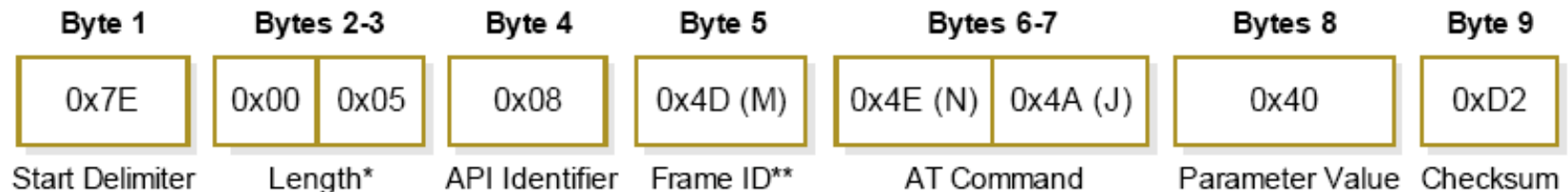
Figure 4-01. UART Data Frame Structure:



MSB = Most Significant Byte, LSB = Least Significant Byte

Any data received prior to the start delimiter is silently discarded. If the frame is not received correctly or if the checksum fails, the module will reply with a module status frame indicating the nature of the failure.

Figure 4-07. Example: API frames when modifying the NJ parameter value of the module.



* *Length [Bytes] = API Identifier + Frame ID + AT Command + Parameter Value*

** *"M" value was arbitrarily selected.*

*ATNJ = node join

Wayward Soles

Readings and Assignments

- Readings
 - Everything Everywhere
- Assignment
 - Final Project