

**Collaborative Mesh Networking**  
**Fall 2007**  
NYU, Tisch School of the Arts  
Interactive Telecommunications  
Program

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**Course Description:**

Recent advances in wireless mesh networks have created the potential for a massively interconnected world of easy information sharing. Cheap communications, high reliability, unique addressing, small size, efficiency, standardization, broadcast options and routing features combine to enable exciting new interactions. Modern devices no longer need to be isolated. Developers of toys, wearables, performance devices, portables, network objects and sensor arrays can take advantage of radio mesh networking to design more interesting, better informed and more complex behaviors for their projects. This course explores devices that connect with and respond to each other. The technical focus will be on 802.15.4/ZigBee wireless mesh networks. Interconnections with other platforms and devices will be examined as appropriate. Students will gain an expertise in all functions of the ZigBee system to facilitate smart and novel behaviors in their projects. Through a series of weekly exercises, students will build skills and explore the challenges and delights of mutual connectivity. As a final project, the class will construct a dynamic device network. Most labs and projects involve group work, so students should be ready to collaborate extensively as they experiment on the cutting edge of device interaction.

**Goals:**

Students will learn technical skills in wireless networking, programming and serial communication. They will gain a deeper understanding of how collaboration can enrich information in devices and enhance creativity in people. Assigned projects will explore networking, collaborative efforts and the sharing of data and behaviors between disparate systems.

**Class Schedule:**

1. Intro and overview: introduction, introductions, overview & syllabus review, math for mesh.

2. Basics and Background: Network types and topographies, survey of radio communications technologies, terminal programs, 802.15.4 vs ZigBee.  
Assignment Due: Find & Fix
3. XBee Configuration: Breakout board soldering, XBee software features, setup sample send/receive code, basic AT commands, remotely glowing the LED.
4. Serial Communications: Buffers, handshakes. protocols: code and considerations for call/response, broadcast, polling. Firmware uploads.  
Assignment Due: Glow The LED.
5. Protocols & Libraries: Input & Gateways: Coding protocols, hardware and software serial on Arduino.
6. Direct sensing: Types of networks, I/O commands, API. Assignment Due: Rock Paper Scissors
7. A Bunch of Stuff: Direct, indirect, subtext. Gateways to the Internet, TCP/IP, HTTP, Daytime, Ranging with RSSI and output strength.
8. Midterm Presentations of Coordination project. Advanced AT commands. Sleeping the XBee. Assignment Due: Coordination Project
9. Mesh Networking: Full ZigBee using XBee Series 2.
10. Production workshop with technical review
11. Collaboration I: What collaboration is, why collaboration is needed.
12. Production workshop with conceptual review  
[Note that our class does *not* meet the week of November 21<sup>st</sup>]
13. Collaboration II: When to collaborate, how to collaborate. Assignment Due: Sensor Network
14. Final Presentations

**Assignments:**

Find & Fix: a one-week assignment: find a small problem in the ITP space and produce a physical computing solution. Don't take anything for granted. Everything can be improved in some way and the point of this exercise is two-fold. The first is to get me familiar with your current physical computing skills and the

second is for you to begin the process of viewing everything as malleable. Think small and move quickly, it's only a week-long warm-up assignment. I don't want you to dynamically show me the relative distribution of IQ in the ITP space. I'd prefer to know if we're running low on staples, prototype a method for turning a gallery project off at night or wake up someone who's been sleeping on the red couch too long. Try to use some programming in your solution. Don't make anything networked yet and have as much fun as you possibly can. This is the only assignment that you'll work on alone so savor your last moments of solitude.

Glow That LED: Set up a two-way wireless LED glower, using your new XBee radios as the communications link. Everyone should make their own but it is fine to work in groups on this project. Make sure you understand the programming, electronics and configuration well. It will form the basis for everything that follows. Ask plenty of questions!

Rock Paper Scissors: work in pairs to create two devices that play Rock, Paper Scissors <[http://en.wikipedia.org/wiki/Rock,\\_Paper,\\_Scissors](http://en.wikipedia.org/wiki/Rock,_Paper,_Scissors)> with each other using a paired radio connection. Each group should try to develop their own code from scratch. We'll pair strong programmers with weaker programmers. I'd like the weaker programmer to write the code, with help from the better one. This may take longer, but both should try to learn as much as possible from the process. You'll need a way to choose your bet, indicate that bet, transmit it, read the other's bet and calculate whether you've won or lost.

Additional Assignment: This will be a week long follow-up project, to be announced in class.

Coordination Project: using a simple public data feed to coordinate actions. Students are given access to a broadcast source of cyclical and sequential timing information. Each group should build projects that use this information in producing an engaging output that cooperates and/or interacts with the other outputs created by other groups' projects.

Sensor Network: using the ZigBee mode on XBee Series 2 radios, create a simple sensor network. Work in groups of four to create a network of sensors that detect something about the world and generate a data feed. Display your data in a pleasing format if possible, but remember that this is a one-week project that should concentrate more on building the network than on data visualization.

Final Project: work in groups to create a system or device of your choosing. Your

creation should either use information broadcast from another group's project, create information that another group's project uses, call behaviors on another group's project or behave in some way when requested by another group's project. It is not enough to simply provide an information feed. Someone must use that feed—this is part of the challenge. Finally, it is important that your project perform its basic functions on a stand-alone basis. It needs to do something on its own, even if the other systems lose contact with it. This is potentially a very challenging assignment with a lot of group interactions so think about what you've learned about collaboration. Don't forget to enjoy yourselves!

**Documentation:**

- Blog posts
- Tumbler, Pownce
- any other public method for fully documenting your work

**Warmups:**

Some classes will include a warm-up intended to enhance the collaborative atmosphere.

**Grading:**

Class participation & attendance 30%  
Presentations and assignments 20%  
Projects and documentation 30%  
Final Project 20%

**Workshops:**

Because much of the class requires building technical knowledge, workshops will be scheduled outside of class time to as help sessions to better explain tricky concepts or go into greater depth on issues of special interest. Hopefully these will be useful but they are absolutely optional. We'll try to vary the schedule a bit, so that everyone has an opportunity to attend at least some of the workshops.

**Office Hours**

To Be Announced

### **Making the Most of It:**

For best results, come to class early, participate in discussions, ask lots of questions, offer copious and constructive feedback, stretch yourself and have fun.

## **READINGS & ASSIGNMENTS**

### **CLASS 1**

#### Introduction and Overview:

- Economist articles:  
[http://rob.faludi.com/teaching/cmn/readings/Economist\\_Wireless\\_articles\\_2007-4-26.pdf](http://rob.faludi.com/teaching/cmn/readings/Economist_Wireless_articles_2007-4-26.pdf)
- Weiser, M. *The Computer for the 21st Century*:  
<http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html>  
There Will Come Soft Rains – Bradbury:  
[http://rob.faludi.com/teaching/cmn/readings/Bradbury\\_Soft\\_Rains\\_1950.pdf](http://rob.faludi.com/teaching/cmn/readings/Bradbury_Soft_Rains_1950.pdf)

#### Math and Communication Protocols:

- Binary: <http://www.swansontec.com/sbinary.htm>
- Binary in Pink: <http://www.mathsisfun.com/binary-digits.html>
- Binary Game:  
[http://forums.cisco.com/CertCom/game/binary\\_game\\_page.htm](http://forums.cisco.com/CertCom/game/binary_game_page.htm)
- Hex Headquarters: <http://www.intuitor.com/hex/index.html>
- Finger Binary: [http://en.wikipedia.org/wiki/Finger\\_binary](http://en.wikipedia.org/wiki/Finger_binary)  
<http://www.intuitor.com/counting/>
- Levity: <http://www.qwantz.com/archive/001038.html>

Assignments: Order XBees, Find & Fix

### **CLASS 2**

- XBee Manual:  
[http://maxstream.net/hottag/index.php?ht=/products/xbee/manual\\_xb\\_oem-rf-modules\\_802.15.4.pdf](http://maxstream.net/hottag/index.php?ht=/products/xbee/manual_xb_oem-rf-modules_802.15.4.pdf)
- Tom Igoe's "Making Things Talk", Chapter 6, pages 192-206:  
[http://rob.faludi.com/teaching/cmn/readings/MTT\\_Ch6\\_FI\\_ti04.pdf](http://rob.faludi.com/teaching/cmn/readings/MTT_Ch6_FI_ti04.pdf)

Assignment: Glow That LED

### CLASS 3

- *The Internet of Things:*  
[http://rob.faludi.com/teaching/cmn/readings/Nature\\_Everything\\_Everywhere\\_2006.pdf](http://rob.faludi.com/teaching/cmn/readings/Nature_Everything_Everywhere_2006.pdf)
- Vehicle Warning System Trialed:  
<http://news.bbc.co.uk/2/hi/technology/6461831.stm>
- 'Smart dust' to explore planets:  
<http://news.bbc.co.uk/2/low/science/nature/6566317.stm>

### CLASS 4

- Everything, Everywhere:  
[http://rob.faludi.com/teaching/cmn/readings/Nature\\_Everything\\_Everywhere\\_2006.pdf](http://rob.faludi.com/teaching/cmn/readings/Nature_Everything_Everywhere_2006.pdf)
- Cooperative Artifacts:  
[http://rob.faludi.com/teaching/cmn/readings/Cooperative\\_Artifacts\\_2004.pdf](http://rob.faludi.com/teaching/cmn/readings/Cooperative_Artifacts_2004.pdf)
- "How Management Teams Can Have a Good Fight" from HBR:  
[http://rob.faludi.com/teaching/cmn/readings/How\\_Management\\_Teams\\_Can\\_Have\\_a\\_Good\\_Fight.pdf](http://rob.faludi.com/teaching/cmn/readings/How_Management_Teams_Can_Have_a_Good_Fight.pdf)

Assignment: Rock Paper Scissors

### CLASS 5

Assignment: Ideas for Coordination Project

### CLASS 6

- Tom Igoe's "Making Things Talk", Chapter 7:  
[http://rob.faludi.com/teaching/cmn/readings/MTT\\_Chp7\\_F1\\_ti04.pdf](http://rob.faludi.com/teaching/cmn/readings/MTT_Chp7_F1_ti04.pdf)

Assignment: progress on Coordination Project

## CLASS 7

- Tinker: A Tool for Designing Data-Centric Sensor Networks, Jeremy Elson, 2006: <http://research.microsoft.com/nec/publications/spot6613-elson.pdf>

Assignment: finish Coordination Project

## CLASS 8

- Zigbee: “Wireless Control that Simply Works”:  
[http://rob.faludi.com/teaching/cmn/readings/Zigbee\\_Wireless\\_That\\_Works-ZMDAmerica.pdf](http://rob.faludi.com/teaching/cmn/readings/Zigbee_Wireless_That_Works-ZMDAmerica.pdf)
- <http://en.wikipedia.org/wiki/ZigBee>
- <http://www.zigbee.org/en/index.asp>

Assignment: Start working on your final project ideas

## CLASS 8

- XBee Series 2 Manual: [http://maxstream.net/products/xbee-series-2/product-manual\\_XBee\\_Series2\\_OEM\\_RF-Modules\\_ZigBee.pdf](http://maxstream.net/products/xbee-series-2/product-manual_XBee_Series2_OEM_RF-Modules_ZigBee.pdf)

## CLASS 9

- Group Genius by Keith Sawyer, Part 1
- Optional: Wisdom of Crowds by James Surowiecki

## CLASS 10

Assignment: briefly present your final project plan

CLASS 11

- Group Genius by Keith Sawyer, Part 2

CLASS 12

[Note that our class does *not* meet the week of November 21<sup>st</sup>]

CLASS 13

CLASS 14

Presentations