Introduction

Assignment

Read chapters 1 and 2 in the text.
Read “Writing your First Program” in the NQC tutorial.

Concepts

Network

To send messages over a network, you need three things:
Physical medium – examples: copper wire, optical fiber, space
Electromagnetic frequency for carrying signals – see the figure for examples
Protocol for communication – Ethernet, 802.11, LEGO/remote, IRDA

What the RCX uses:
Space for the medium
Infrared for the electromagnetic frequency
A protocol similar to that used for remotes.

Communication Problems

Framing
    Must recognize where a message starts and stops
Encoding
    Turning messages into 0’s and 1’s
Recognizing errors in messages
    Adding information to help recognize errors

RCX Protocol

This is the protocol description was written by Dave Baum:

The IR protocol associated with sending a "message" to the RCX is pretty simple. Bit encoding is 2400 baud, NRZ, 1 start, 8 data, odd parity, 1 stop bit. A '0' is coded as a 417us pulse of 38kHz IR, a '1' bit is 417us of nothing.

At the packet level, all packets look like this:

    0x55 0xff 0x00 D1 ~D1 D2 ~D2 ... Dn ~Dn C ~C

where D1...Dn are the bytes in the message body, and C = D1 + D2 + ... Dn in 8-bit arithmetic.

The data for sending an IR message is F7 followed by the 8 bit "message".

For example:

```
55 ff 00 f7 08 12 ed 09 f6
```

is a packet sending the message

```
0x12
```

to the RCX.

Discussion of the RCX protocol

Framing: 0x55 0xff 0x00: a message is beginning now!
Encoding: F7 says that the next byte is data (it could say that the next byte is a control message for the RCX).
Error detection: Each byte is sent twice, the second time with the bits inverted, and a checksum and inverted checksum are included.

So: it takes 9 bytes to send a single byte.

Network Performance

Bandwidth

1) Analog bandwidth: The width of the range of frequencies in use.
2) Digital bandwidth: Bits per second (2400 or 4800 bps, see above)

Throughput

Bits per second of useful data (at most 2400/9 bps = 267 bps or 4800/9 bps or 533 bps!)

Latency

Time from source to destination (depends on speed of light through the medium; for our purposes, 0

RTT

Time from source to destination and back; since latency is 0, depends only on processing time!

The Robots

A robot has a brain (the RCX), a body (students will design that), and input and output devices.

The Brick

The brain is called the "Brick." It's an 8-bit CPU with 16k internal ROM and 32k static RAM. The RAM includes 6k to hold your programs. You will write and compile programs for the RCX on a PC. It is called *cross-compiling* when you compile a program for one kind of computer on a different kind of computer. This is commonly done for *embedded systems* such as the processors in cars, household devices, cell phones, PDA's,

and so on. Embedded systems are typically *resource-limited*, i.e., they don't have a lot of memory, they're not very fast, and they don't have disk drives.

The Body

You will design a body, using LEGO pieces. The usual rectangular pieces are in the sets; also, there are wheels, axles, and a variety of special-purpose pieces for all sorts of tasks.

Input Devices

The robots have touch sensors, light sensors, and an infrared port. So they can tell when they are touched, they can recognize light and dark (and different degrees of light and dark), and they can receive sequences of bits through the infrared port. The last is, of course, used for communication.

Output Devices

Two motors, a display screen, a speaker, and an infrared port.

Some robots are illustrated in the Mindstorms manual and in the textbook.