

IEEE Secon 2013 Hardware Competition Communication Protocol

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1 Overview of System

1. The communication system shall consist in two-way communication between two nodes known as the Base Station and the Mobile Unit.
2. The communication system shall use the XBee communication hardware, sending serial data using standard settings.
3. The purpose of this communication system shall be to direct the Mobile Unit on the course to accomplish goals in picking up and dropping off colored blocks to their correct location.
4. The primary role of the Base Station node shall be to give single specific instructions to the Mobile Unit, for movement and action according to its overall plan.
5. The primary role of the Mobile Unit node shall be to ensure successful receipt of the instructions, and report success or failure and information about errors, along with information calculated from odometry.
6. Error checking shall be integral to this communication system.

2 List of Packet Types

1. Greeting (Base Station): Shall be sent at the beginning of the competition only, in short intervals until base station is prepared to send Orientation
2. Orientation (Base Station): Shall be sent by the base station at the beginning of the competition only, as soon as it has compiled the given information and has sent a Greeting. It shall be repeated at long intervals until the first Report message is heard.
3. Report (Mobile Unit): The standard Mobile Unit message, this shall be sent at the beginning of the competition after the Orientation message is heard, and after each instruction is either successfully completed or ended in an exception. This message is also sent if an Again message is received instead of a Command message. It shall be repeated at a certain interval until a Command message is heard. If no message is heard until a time-out, the Mobile Unit will determine its next instruction alone.
4. Again (Base Station): This message shall be used in the event of error in a Report message. It shall be repeated at a certain interval until the Report message is heard.
5. Command (Base Station): The standard Base Station message, this shall be sent after any Report is heard and the appropriate next instruction is decided. It shall also be used in the case of error in a Report message. It shall be repeated in a certain window until an Ack message is heard. If the

Ack indicates an error in receipt, the Command message will be re-sent. If no Ack is heard before the time-out, the message will be dropped.

6. Ack (Mobile Unit): This is the response to the Command message that indicates whether the information was successfully received. It is sent five times in quick succession if successful. If not it will only be sent once.

3 Standard Procedure for Base Station

1. When start button is pressed, immediately send Greeting message at regular intervals, until Vision has prepared course layout data and strategy has been determined.
2. Send Orientation message. This is only done once, regardless of interpretation.
3. Listen for Report message indefinitely.
4. Check Report message for errors.
5. If errors are found, send Again message and return to step 3.
6. If no errors are found, reply to Report message with Command message.
7. Listen for Ack message. If Ack indicates error, or if none is heard in listening window, return to step 6. If none is heard within communication timeout, or if the Ack indicates success, return to step 3.

4 Standard Procedure for Mobile Unit

1. Wait for Greeting message.
2. Begin opening sequence, waiting for either an Orientation message or window of no messages. Keep waiting as long as Greetings are detected.
3. If Orientation message is heard, process.
4. Send Report message.
5. Listen for Command or Again message.
6. If listening window ends, return to step 4.
7. If timeout occurs, proceed according to backup plan to step 12.
8. If Again message is heard, return to step 4.
9. If Command message is heard, check for errors.
10. If there are errors, send one bad Ack and return to step 5 with a renewed listening window.

11. If there are no errors, send five successful Ack's.
12. Proceed with action according to best instruction either received or contrived, until either an exception is thrown or the instruction is completed successfully. Return to step 4.

5 Greeting Packet Structure

This simple message is a single byte with the signature 0xFF. No other message is allowed to begin with 0xFF.

| Byte | Contents |
|------|-----------------------------|
| 1 | 0xFF, the standard greeting |

6 Orientation Packet Structure

This is the opening handshake packet, containing course layout information, with possible additional information. Colors are reported according to the color enumeration section below.

| Byte | Contents |
|-------|--|
| 1 | 0xFC, the standard orientation signature handshake |
| 2-15 | 14 Block pick-up colors and sizes, in the +x direction each 1 byte long as described below |
| 16-18 | 6 Rail destination colors, in the +x direction (4 bits per slot) |
| 19-21 | 6 Sea destination colors, in the +y direction (4 bits per slot) |
| 22 | 2 Air destination colors, in the +y direction (4 bits per slot) |
| 23 | Reserved |
| 24 | Error Checking |

The pick-up bytes are formatted with the four high bits representing the length. The four low bits represent the color.

| Value | Meaning |
|-------|-------------------------|
| 0000 | Could Not Be Deciphered |
| 0001 | 4" long block |
| 0010 | 3" long block |
| 0011 | 2" long block |

7 Report Packet Structure

This is the standard Mobile Unit Packet, containing enumerated status message and current location according to on-board odometry, with possible additional information.

| Byte | Contents |
|------|---|
| 1 | Status - 0x00 means mission complete, anything else is an error as enumerated |
| 2-7 | Odometry's Position (See Data Structures Section) |
| 8-13 | Extra bytes if error message requires it |
| 8/14 | Final byte is Error Checking |

7.1 Status Messages

Bit 7 of the Status byte will always be 0 to avoid conflict with Greeting or Ack messages. Bits 6-0 will be enumerated into a status message detailing why the instruction was terminated. There are 128 possible status messages. For those with six messages, they refer to the six colors: yellow, orange, brown, green, red, blue. Those with an asterisk (*) will contain the extra six bytes.

| Status | Message |
|----------|--|
| 0 | Instruction Success |
| 5 | Timeout trying to reach destination |
| 8* | Odometry Exception, with mouse/encoder coordinates |
| 20 | Detected line unexpectedly Front Right |
| 21 | Detected line unexpectedly Front Left |
| 22 | Detected line unexpectedly Back Right |
| 23 | Detected line unexpectedly Back Left |
| 24 | Detected course edge Front Right |
| 25 | Detected course edge Front Left |
| 26 | Detected course edge Back Right |
| 27 | Detected course edge Back Left |
| 30 | Could not find line |
| 31 | Found line, could not find block |
| 40-46 | Found block wrong size/color 4" |
| 47-52 | Found block wrong size/color 3" |
| 53-58 | Found block wrong size/color 2" |
| 70 | Could not find drop-off zone |
| 71 | Drop-off zone already has block |
| 80-86 | Drop-off zone is wrong color |
| 100-106* | Lost contact, now hold 4" block (Extra reserved for history) |
| 107-113* | Lost contact, now hold 3" block (Extra reserved for history) |
| 114-120* | Lost contact, now hold 2" block (Extra reserved for history) |

8 Again Packet Structure

This simple message is a single byte with the signature 0xFE. No other message is allowed to begin with 0xFE.

| Byte | Contents |
|------|----------------------------------|
| 1 | 0xFE, the standard again request |

9 Command Packet Structure

This is the standard Base Station packet, containing the instruction from the Base Station to the Mobile Unit in the form of current and destination positions, an end action, and qualifiers.

| Byte | Contents |
|------|--|
| 1 | Status - 8 Enumerated flags that qualify the instruction path. |
| 2-7 | Current position (see Data Structures Section) |
| 8-13 | Destination (see Data Structures Section) |
| 14 | End action - Enumerated: block pickup, drop-off, etc. |
| 15 | Reserved |
| 16 | Error Checking |

9.1 Command Status Byte Flags

| Bit | Meaning |
|-------|--|
| bit 7 | Always 0 to assure no conflict with Again or Orientation message |
| bit 6 | Can Mobile Unit spin at the beginning? |
| bit 5 | Can Mobile Unit spin at the end? |
| bit 4 | Will Mobile Unit be going up a ramp? |
| bit 3 | Will Mobile Unit be on a raised platform? |
| bit 2 | Should Mobile Unit expect to see line from any angle of approach? (If 0, mobile unit will ignore lines during straight move.) |
| bit 1 | Should Mobile Unit retain its coordinates, regardless of sent location? |
| bit 0 | Special Move - If x coordinate of destination is 1, this instructs the Mobile Unit to reverse 10 inches. |

9.2 End Action Byte Structure

| Value | bits 7-5 (end Action) | bits 4-2 (Color) | bits 1-0 (length) |
|-------|------------------------|-------------------|-------------------|
| 000 | None, waypoint | No Block Involved | No Block Involved |
| 001 | Pick-up one block | Yellow | Rail (4 inches) |
| 010 | Pick-up second block | Orange | Sea (3 inches) |
| 011 | Drop-off stacked block | Brown | Air (2 inches) |
| 100 | Drop-off single block | Green | - |
| 101 | Air-related waypoint | Red | - |
| 110 | Finished, do a dance | Blue | - |
| 111 | Reserved | Reserved | - |

10 Ack Packet Structure

This simple message is a single byte with the signature 0xFD or 0xFB. No other message is allowed to begin with 0xFD or 0xFB.

| Byte | Contents |
|------|---|
| 1 | 0xFD, the standard acknowledgment or 0xFB, the standard error in receiving |

11 Data Structures

11.1 Color Enumeration

Reporting the color as a 3- or 4-bit value is common in these packets. Here is how the enumeration works.

| Hex Value | Meaning |
|-----------|---------|
| 0000 | Unknown |
| 0001 | Yellow |
| 0010 | Orange |
| 0011 | Brown |
| 0100 | Green |
| 0101 | Red |
| 0110 | Blue |

11.2 Position Record

The Mobile Unit's position consists of three parameters: the X and Y coordinates and the angle theta, and each is a sixteen-bit value. X and Y are unsigned integers ranging from 0 to 64k, with the unit being 1/500 of an inch. X goes parallel to the long sides of the course, with X = 2000 occurring on the left side. The ramp will appear flat. Y goes parallel to the short sides of the course, with Y = 0 occurring on the bottom side. Theta is measured from the X direction, in a 16-bit unsigned integer, ranging from 0 to 62832, with each unit referencing 1/10000 of a radian. The Position Record will always be ordered X, Y, Theta.

12 Error Checking

For messages with an error check, this value will be calculated and confirmed by analysing each byte of the message bit-by-bit. The high bit of the Error Checking byte will be 1 for an odd number of high-bit 1's in the message and 0 for an even number of high bit 1's. This is the same for the other bits of the error checking. In this way, each of the bits of the error checking serve as a parity bit for all of the bits in that column. This check is most easily performed

with a bitwise XOR of all of the bytes in the message. For errors of odd numbers of bits, the check will automatically catch the error. For errors of 2 bits, there is a 87% chance the check will catch the error. For errors of 4 bits, there is a 97% chance the check will catch the error.

13 About This Protocol

This protocol was prepared on 3/08/2013 by Adam Birchfield. To request clarification, addition, or change, e-mail me at abb0017@auburn.edu.

Version 1.0 - Initial Release

Version 1.1 - Now formatted with LaTeX, some errors fixed

Version 1.2 - Changed coordinate scaling, added command flag for line detection

Version 1.3 - Changed bit numbering system, clarified directional info

Version 2.0 - Handshake and process simplified, added flags to command, slight but very important change to theta coordinate specification, removing sign