IEEE Secon 2013 Hardware Competition Communication Protocol

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Contents

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 (Mobile Unit): Shall be sent at the beginning of the competition only, in short intervals until an Orientation message is heard.

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 heard 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. Wait until Vision has prepared course layout data and Greeting message has been received.
2. Send Orientation message.
3. Listen for Report message. If none is heard in listening window, or if message indicates errors in orientation message, return to step 2.
4. Check Report message for errors. If there are none, go to step 6. If there are errors, go to step 5.
5. Send Again message and go to step 8.
6. 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, go to step 8.
8. Listen for Report message indefinitely. When one is found, return to step 4.

4 Standard Procedure for Mobile Unit

1. Send Greeting message.
2. Listen for Orientation message. If none is heard in listening window, return to step 1. If none is heard in communication timeout, skip to step 4. If one is heard, continue to step 3.
3. Check Orientation message for errors.
4. Send Report message. If there were errors in the Orientation message, continue to step 5. If not, skip to step 8.
5. Listen for Orientation message. If none is heard in listening window, return to step 4. If one is heard, return to step 3. If none is heard in communication timeout, continue to step 6.

6. Proceed with action according to best instruction either received or contrived, until either an exception is thrown or the instruction is completed successfully. Either way, continue to step 7.

7. Send Report message and continue to step 8.

8. Listen for Command message or Again message. If none is heard in listening window, return to step 7. If none is heard in communication timeout, return to step 6. When an Again message is heard, go to step 7. When a Command message is heard, proceed to step 9.

9. Check Command message for errors. If there are no errors, continue to step 10. If there are errors, skip to step 11.

10. Send successful Ack five times in short succession and return to step 6.

11. Send error Ack and return to step 8.

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 alread 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	Reserved
bit 0	Reserved

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 occuring on the left side. The ramp will appear flat. Y goes parallel to the short sides of the course, with Y = 0 occuring on the bottom side. Theta is measured from the X direction, in a 16-bit signed Integer, ranging from -31415 to 31416, 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 analyzing 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 2/14/2013 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