1 Introduction

Modbus[1] is a network protocol commonly used for Industrial Systems. Learning and testing on this protocol is essential on a physical testbed. A testbed based on Lego Mindstorms is a cheap and flexible solution.

This document describes the realization of a Lego Mindstorms EV3 test bed for Modbus.

2 General description

The testbed is composed of :

- a Management Terminal Unit (MTU),
- multiples Remote Terminal Unit (RTU),
- a network for communications between MTU and RTU with Modbus.

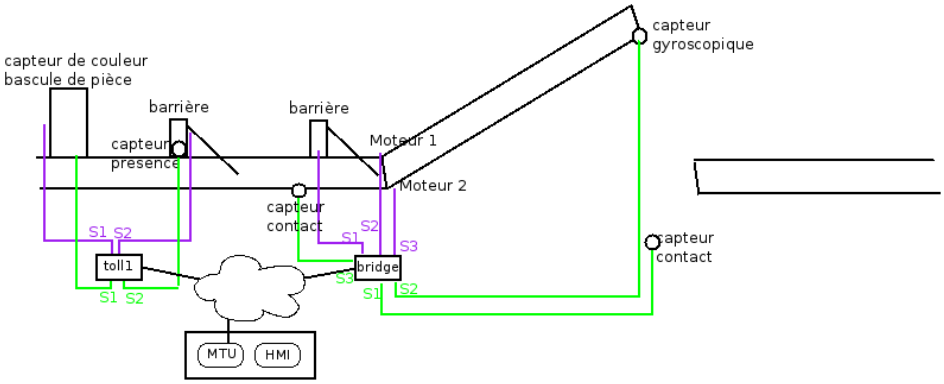
The protocol used to communicate between RTU and its sensors (I2C) or actuators (PWM) is imposed by the Lego Mindostorms EV3 device.

The model used is a lift bridge preceded by one or multiple tolls. These elements (RTU) does not communicates together. Only the control center (MTU) read the RTU states and modify their registers. The Human-Machine Interface (IHM) display status and permit to activate the RTU.

Technology deployed :

Lejos[2] This open-source framework permit a Java development for Lego Mindstorms. Lejos comes with a Linux distribution to install on the Mindstorms EV3, and a plugins for Eclipse IDE.

Jamod[3] Java library to manage the Modbus communications. This library has been modfy in order to implement new Modbus function codes.

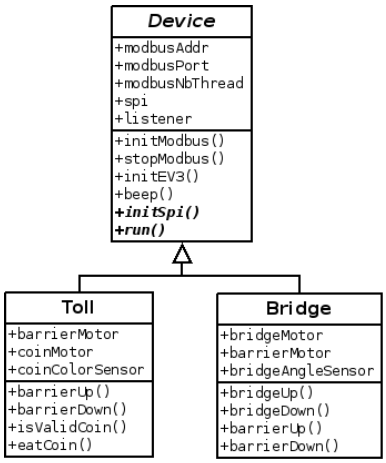


3 RTU

Each RTU inherit a Device class which defines a RTU. A toll or a bridge extends the class Device[4], which permit to define easily a new component.

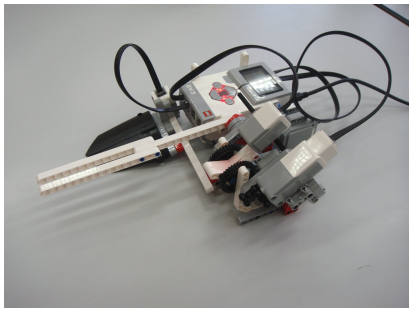
[1] `http://www.modbus.org`

[4] the full Javadoc documentation is available



3.1 Toll

A toll system is simple and may be reproduced on the testbed. A simulated implementation has been implemented (TollSim class).

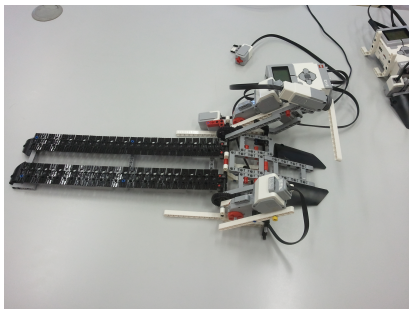


3.1.1 Register definition

Type	Ref	Name	Description
Input register	0	UNIT_ID	Unit Identifier
Input register	1	COIN_COLOR	Coin color sensor value
Input register	2	CAR_TOUCH	Car hit sensor value
Input register	3	KEY_PRESS	EV3 button hit sensor value
Input register	4	CAR_PRESENTING	EV3 Ultrasonic sensor value (in cm)
Register	0	NB_CARS	Viewed cars
Register	1	NB_COINS	Eated coins
Coil	0	ACTIVE	Toll activation status
Coil	1	FREE	Toll payment status (free/paying)
Discrete Input	0	BARRIER	Barrier position (true = opened)

3.2 Lift bridge

A lift bridge is an interesting element which has to be safety for the cars. A visible security problem may have direct consequences.

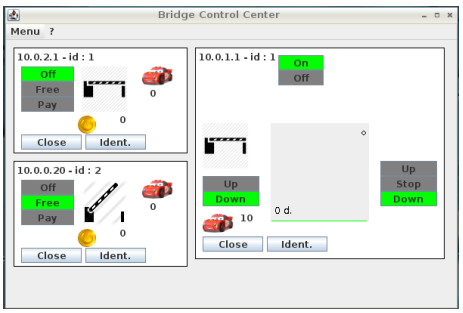


3.2.1 Register definition

Type	Ref	Nom	Description
Input register	0	UNIT_ID	Unit Identifier
Input register	1	SENSOR_BUTTON	EV3 button sensor value
Input register	2	SENSOR_GYRO	Gyroscopic sensor value
Input register	3	SENSOR_PASSAGE	Car hit sensor value
Input register	4	SENSOR_BOAT	Boat hit sensor value
Input register	5	SENSOR_MOVE	Bridge movement (0 : stopped, 1 : up, 2 : down)
Input register	6	SENSOR_ANGLE	Angle value computed by motors
Register	0	NB_CARS	Cars viewed
Coil	0	ACTIVE	Bridge activated
Coil	1	BRIDGE_MOVE	Bridge movement requested
Coil	2	BRIDGE_RAISE	Way of the bridge movement requested
Coil	3	BARRIER_OPENED	Barrier position requested
Discrete Input	0	BARRIER	Barrier position (true = opened)
Discrete Input	1	WAITING_BOAT	Boat waiting status

4 Control Center

The control center integrates the MTU and HMI functions. It is the Master in the Modbus communications.



5 Testbed consideration

This testbed implements Modbus for communications and permits to test the security.