Robotics

Installation Guide

Colophon

This Robotics module is part of the RoboDidactics Robotics Learning Track (RLT). The material presented in this module is based on the Dutch Robotics material developed by the author for the SLO Certified Robotics Module.

All the original and associated material for the RoboDidactics Learning Track may be downloaded from the Phyrtual site or from the RoboPal for NXT site at www.virtualbreadboard.com. It can also be found in the English download section of www.robocupjunior.nl. Teachers are permitted to modify this material for use in their own lessons, provided these changes are reported in the colophon of the modified material. The Phyrtual site can be reached through www.phyrtual.org.

This module was developed and translated by the author (Peter van Lith) as part of a cooperation agreement with the Fondazione Mondo Digitale in Rome, Italy in 2010. The RoboPAL software used in this version has been developed with VirtualBreadBoard by James Caska.

This version is developed for use with the Lego MindStorms NXT and RoboPAL software. A more extensive version is available (currently only in Dutch). It is based on robots that can be programmed in Java, using the Java Simulator and Eclipse.

This NXT version is easy to use because it uses a graphical programming language.

The module consists of three parts. The first is the basic version needed for all further lessons. The second part deals with the RoboCup Junior Rescue challenge. The more demanding third part is optional and deals with a simple simulated organism, based on reactive behaviour.

Modified versions of this module may only be distributed if this colophon states that it is a modified version, including the name of the author of the modifications.

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This module has been compiled with care and has been tested extensively by the authors and several test schools. The authors accept no responsibility for incorrect or incomplete parts of this module, nor do they accept any claims for damages as a result of using this module or its associated software.

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QuickStart

This QuickStart is intended for system administrators and consists of a compact checklist with all the steps that are necessary to install RoboPAL. The student guide and the teacher's guide only contain a description of the most important installation steps.

In the second part of this manual, a more elaborate description is provided as background information for teachers.

Installing the RoboPAL Program

- Copy the RoboPAL4NXT4.3.exe program to the student's computer. The program on the CD may have a different version number. On the PC, the program may be placed on the desktop or in a directory with a link to the program.
- On the student PC, a new directory is created automatically with the name XenoCode in the AppData directory of the User space. The user must be assigned write rights in this directory.
- The RoboPAL application is a virtualized program that contains all the necessary libraries. Some virus scanners will mark a program that is virtualized with XenoCode as a virus, but most have already been adapted to this.

Installing the NXT Administrator's Computer

The NXT units that are used must be provided with software. The NXT administrator is in most cases a teacher who takes care of installing the required software on the NXT units. In some schools, several software systems are used. This may require the installation of different software before each class. In order to accommodate this possibility, the administrator's PC may need to have other software in addition to the RoboPAL software. In particular:

- Installing the Lego NXT driver. If the PC already contains the standard Lego MindStorms software, this driver is already present. If not, then the Lego Phantom driver needs to be installed from the RoboPAL CD.
- Installing the LeJos operating system on the NXT unit. This is done from within RoboPAL.
- Installing the RoboPAL firmware on the NXT. This is also done from RoboPAL.

Installing the RoboPAL Server Program

If the school is using the Server version of RoboPAL, the Server program needs to be installed on a central computer. This may be one of the student computers. The following steps are required:

- Copy the RoboPALServer.exe program to the computer. This program may be put on the desktop or in a directory with a link to the desktop. For this program, the same applies as for the RoboPAL program.
- Create a directory on this machine or on a central computer that can be accessed from all student's PCs. RoboPAL will save programs from the student PC, which will be sent to the selected NXT by the Server, in this directory. The Server is able to program 5 NXT units. This Server directory does not need to be on the same computer on which the Server is running, as long as the Server and the PCs are able to reach this directory and all have read- write- and delete rights.
- In the Server program, a reference is made to this directory. The NXT administrator can in principle do this, too.
- Using the black RoboPAL dongle, all NXT units are now identified. This is only necessary the first time, but may be repeated when new or other NXT units are being used.
- After this 'discovery' step, the student PCs can start using the Server by referring to it from their program. The students do not have to do this directly as RoboPAL takes care of all communication.

Installing the NXT Firmware

For every NXT that is being used, install the LeJos OS first and then the RoboPAL firmware. In principle, this only needs to be done once, unless new versions become available or other software is used on the units in the meantime. The following steps are required:
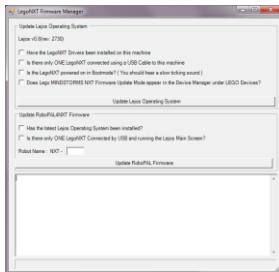
- Installing the LeJos OS. This is done from within RoboPAL. A standard USB cable is needed for this. The NXT must be put in BootMode first: use a paperclip to push the button in the small hole behind the USB connector on the NXT. Also check the instructions in the documentation in the remainder of this manual.
- Installing the RoboPAL firmware. This also is done from RoboPAL with the USB cable. If LeJos is already installed on the NXT, the first step may be skipped.
- From the LeJos menu, turn on Bluetooth to make the unit discoverable.
- Then, select RoboPAL.nxj as the default program.
- Subsequently, set the AutoRun option to "Yes".

Updating the Dongle Firmware

The RoboPAL dongles are also equipped with writable firmware. The white dongle is programmed from inside RoboPAL, while the black dongle is programmed from the Server program. The black dongle can be used both as a Server dongle and as a local dongle. The white dongle can only used as a local dongle.

Installation and Use of RoboPAL NXT

This chapter contains installation and user instructions for RoboPAL with NXTs. To work with RoboPAL, all you need to do is copy the RoboPAL4NXT4.3.exe file to the PC and create a link to it on your desktop. This version is designed for Windows XP, Vista and Win7. The firmware for the NXT runs under the LeJos operating system (Lego Java Operating System, pronounced "Legos").

Then, you need to load the firmware for version 4.3 on the NXT. This is done from RoboPAL itself by using the Firmware Loader. You will need a USB cable to connect the PC and the NXT. Also, the NXT must be started up in the LeJos main menu.

If the NXT is NOT in the LeJos menu, the firmware cannot be loaded. If LeJos has not yet been installed on the NXT, you will need to do this with step 1 from the program (shown in the picture). So, this first step is only required once: only if there is no LeJos operating system on the NXT yet. For version 4.3 of RoboPAL, an update of the LeJos OS is also required, so this first step is also needed the first time you install firmware version 4.3. See the instructions in the remainder of this chapter for further details.

If RoboPAL has been used before, the LeJos software is already on the NXT, but there may be an older version of the RoboPAL firmware on the unit. Before loading the firmware, make sure that the old files are removed from the NXT, using the LeJos Files menu. If you forget to do that, the NXT may start up with the older version, even if a new version has been loaded onto the unit. Again, with version 4.3 you will have to start with the LeJos installation, but only the first time.

Installing the Firmware

In order to use RoboPAL with the Lego NXT robot, you need to install the LeJos operating system. In addition, the RoboPAL firmware also needs to be installed. If LeJos is already installed on the NXT, you only need the latest version of the RoboPAL firmware.

Installing LeJos and the RoboPAL firmware is done from RoboPAL with a USB cable. You will also need the Lego Device Drivers on your PC. On a computer that will only run RoboPAL and will not be used to load the firmware, installing Device Drivers is not necessary

Lego NXT Device Drivers

A USB cable connection is necessary to load the RoboPAL firmware. Also, the Lego NXT device driver needs to be installed on the computer that is used to install the firmware. This driver is part of the Lego NXT-G software and once this software has been installed on a computer, no extra steps are required. If you are not using NXT-G and only use RoboPAL, then the driver needs to be installed separately. This official driver cannot be distributed with RoboPAL for copyright reasons and must be downloaded from the Lego website. In most cases, one or two teacher's PCs will be used to install the NXT units. It is better not to install these features on the student PCs.

The Lego NXT USB driver can be found at:
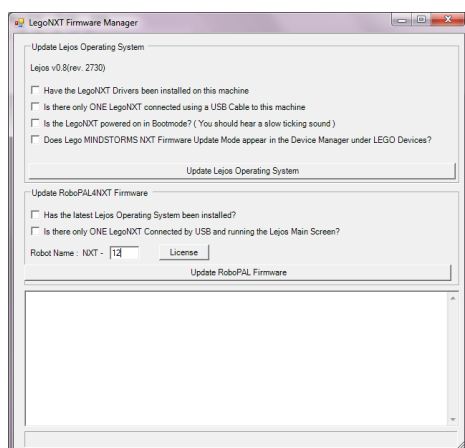http://mindstorms.lego.com/Support/Updates/. Look under MINDSTORMS NXT driver v1.02. Use the PC version. RoboPAL runs Windows XP, Vista and Windows 7.

Lego has a second driver, the so-called Phantom Driver. On some PCs, this driver works better than the standard Lego driver. It is available on the RoboPAL CD and also from the website www.phyrtual.org

Installing the LeJos Operating System on the NXT

The firmware is installed from RoboPAL. When the system starts, the start-up screen displays a number of tabs: select 'Perspective' and the desired Level. At the bottom of the screen you will see the 'Firmware Loader' button. Push it and the firmware loader screen appears.

The firmware is loaded in two steps. In the first step, the LeJos (Lego Java Operating System) is installed on the NXT. The selection boxes that you see are only to remind you of the conditions that need to be met before you can load the firmware. They have no function for the program.

You only need to load the LeJos firmware if this is not yet present on the NXT. If you start the NXT unit and the LeJos logo appears, it has been already installed and you can move on to loading the RoboPAL firmware.
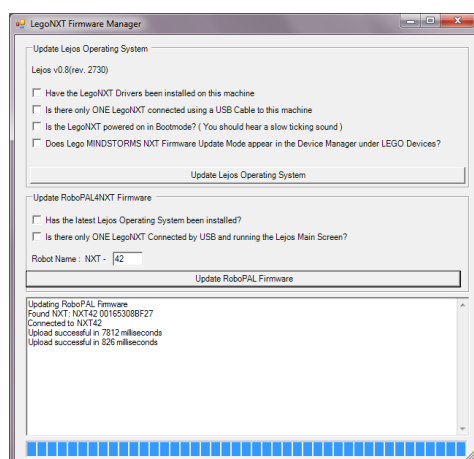
As you can see in the picture, a NXT driver needs to be installed. This is available on the RoboPAL CD or from the Lego MindStorms website. The NXT is connected to the PC using a USB cable. You will need to put the NXT into BootMode first. You can do this with a paperclip: just push the small button all the way down in the little hole at the backside of the NXT behind the USB connector on the left side. Push the small circular button in that hole for 2 seconds while the NXT is turned on.

You will then hear the NXT make a soft ticking sound. This is an indication that the NXT is in BootMode and is waiting for the LeJos firmware to be loaded. If all the preparations are correct, push the
'Update LeJos' button and the operating system will be installed on the NXT. Remember that a NXT that has been put in BootMode can only be restored to its normal function by loading firmware. This can also be the standard Lego firmware. The only way to stop the ticking is to remove the batteries from the NXT. It will remain in BootMode, however, until new firmware is loaded onto the unit.
Some machines that do not have the latest version of Windows XP (SP3) installed may fail to install the O.S., as LeJos cannot find the necessary drivers. If the installation of LeJos does not work on your machine, try to update the software to the latest service pack. The current version also works with Vista and Windows 7.

Loading the RoboPAL Firmware 4.3

You load the firmware onto the NXT by first turning it on (if this has not been done yet) and then selecting the second button of the firmware loader. Dots will appear in the right hand upper corner while the firmware is loading, while a series of beeps indicates that it has been loaded.

However, before you load the firmware for RoboPAL you also need to enter a number for the NXT. This identification will show up in RoboPAL in the start-up screen on the NXT, so students can see which robots are present. By selecting, "NXTXX" the program can be sent to the specific unit. The XX needs to be replaced by a unique number that identifies the particular NXT unit.
After loading the firmware, you need to specify what the default start-up program is and the automatic start-up facility needs to be activated.

Setting up the LeJos Menu

Now, you have to activate the firmware on the NXT. If there are any files left over from an earlier version of RoboPAL, these need to be removed. You also need to turn on the Bluetooth on the NXT unit. Then, you need to specify which program must be used to start up the NXT. You can do this as follows:

- Turn on the NXT and make sure it starts up in the LeJos menu. If that menu is not visible, press the square grey button under the orange button for a couple of seconds. The NXT will beep a few times and then show the LeJos menu.
- Select Files and remove all the files except for RoboPAL.NXJ and RoboPAL_Program.
- Go to the Bluetooth menu and make sure that Power On is selected. If the NXT has been used before, this will already be on. In the left upper corner, you will see BT without a black background, which is an indication that Bluetooth is on. If the BT appears with a black background, it is off.
- Go back to the Files menu and select RoboPAL.NXJ. Then select Set as Default
- Now go to System and select Autorun and then Yes.

When the NXT starts up it will now go directly to the RoboPAL main menu. This prevents students from accessing the LeJos Operative System. Often, students will (accidently) remove a program or change settings, which may stop the NXT from operating. With the automatic start-up, this is less likely to happen.
RoboPAL is used to load a program onto the unit. Once a program has been uploaded, the grey triangular button under RUN is used to start the program. The button on the other side (with the TST text) serves to show the values of the sensors after calibration. To reset the unit, press the orange button and the grey one underneath it at the same time. Just pressing the orange button will stop the currently running program.

To return to the LeJos main menu, keep the dark grey button under the orange one pressed until the NXT starts beeping. This will make the NXT return to the LeJos menu, but do not allow the students do this, because they can then remove firmware from the NXT or do other things that might make the unit inoperative and require the firmware to be reinstalled.
To use the RoboPAL firmware with the NXT you need a RoboPAL dongle. You can order these via the RoboPAL website (www.virtualbreadboard.com) or through Phyrtual (www.phyrtual.org).

Restoring the Lego Firmware

To reload the Lego firmware after you have used the NXT with RoboPAL you can use the firmware loader that comes with the software that you want to use. This could be NXT_G or NXC with BrickC or any other software that you use along with RoboPAL.

If you are using another language and plan to return to RoboPAL, make sure the unit keeps it identification. Other software like NXT-G can also change the name. If the name of the unit is changed by another software, you may run into problems with RoboPAL when trying to connect to a unit that has changed its name. Use the <clear list> option in RoboPAL if something like this happens.

Installing RoboPAL

RoboPAL does not require a real installation procedure. The NXT software is a virtualized application that contains all the necessary facilities in a single executable image that only needs to be copied to the machine. This also allows RoboPAL to run from a network drive or a USB stick, which makes installing updates much simpler for a school. The standard version can be downloaded from www.virtualbreadboard.com . To use RoboPAL with a NXT, a special RoboPAL dongle is required. The standard version with just the simulator can be used free of charge.

All completed examples and assignments are provided with the teacher's version on the CD. Only the starting modules should be provided to students, either on a network drive or on a USB stick. Do not give the completed assignments to the students, they are supposed to build and test these themselves.

Setup for Windows

RoboPAL is a virtualized application that contains all the necessary components in a single executable file. The side effect of this is that no local files can be used, which is why all examples are provided as external files. The virtualization is produced with XenoCode, which stores its information in the Documents and Settings directory or the AppData directory of the User space. This also means that the user needs to have write permissions and the ability to create and remove directories. The pathname where this information is stored is:

```
C:\Documents and Settings\UserXXX\Local
Settings\Application Data\XenoCode
```

The XenoCode directory is created the first time that RoboPal is used, other subdirectories and new files are added subsequently. The required working files are relatively small, but the application will only work if RoboPAL may write in this directory. UserXXX denotes the name of the actual user. For every user account, Windows will create a new directory for the Local Settings.

In the course of the past years, we have had some problems with virus scanners that sometimes mark RoboPAL as a program containing a virus. This is caused by the use of XenoCode. We have contacted the suppliers of several virus scanners, who have updated their databases. Some of the free virus scanners have a habit of marking unknown programs as contaminated. Programs like MacAfee and Norton have not generated any problems so far. The most recent versions of XenoCode are less prone to these kinds of problems.

To work with RoboPAL, some choices need to be made after starting up the program for the first time. First of all, a so-called 'Perspective' must be selected. In the case of the RLT module, this is always Level 2 plus the selected part of the RLT module. The screen in which this selection is made can be reached via File | New or the File | Open menu.
When Level 2 is selected, extra information is required (directly under the default values for the colours). In most cases, the default values can be left as they are, but some of the values will need to be changed and stored by using the Apply button. See the next section for more details.

Setup for RoboPAL

The first piece of information that is needed is the default directory. In most cases, this will be a path to the student's directory or USB stick. The second section contains the standard values for all colours used in RoboPAL. These are the values as they are used in the simulator. The actual values on the real robot need to be retrieved, using a calibration procedure and are stored as part of the student's program.

The third section contains **Default Sensor Range** and the **Default Margin**. The Sensor range is best left at the value of **1023** and the Margin at **5%**. In the lessons, this is explained in more detail. The first few lessons will not make use of these values, but they need to be filled in. For Level 1, this is not required, since the automatic calibration will take care of it.

The NEW tab is used to create a new program. To make it easy to get started, several QuickStart programs are included that contain the various playing fields. In these QuickStart programs, most of the required information is already filled in with the exception of the program to be created.
In the RLT lessons, the starting programs are provided as external files. The lessons explain these programs and teach the students how to expand them. As soon as a program has been entered, pressing the green arrow button in the icon bar will test it. You will then see the playing field and a picture of the NXT control panel. Pressing the rightmost triangular button on the control panel starts the program on the simulated NXT. If your program is active in the bottom panel (the FlowCode), then the green button is disabled, so you will need to select the WorldView panel.
To restart the program, the blue square button with the small arrow on it is used. On top of the playing field, there is a button bar on which the name of the NXT to be used can be selected. The small blue triangular button next to it is used to transfer the program to the selected NXT.

Turn on the NXT, select the correct NXT and press the triangular button. The program is then transmitted to the NXT, using the RoboPAL dongle. Remember that the program is always transmitted from inside the simulator, because it first needs to be translated into code that the NXT can understand. When the program has finished, the little blue square button is used to return to the programming environment in which alterations may be made to the program.

Uploading a Program to the NXT

Programs can be uploaded in two ways:

1. Uploading using a RoboPAL dongle (white). On your PC, you are using a dongle that connects it to the NXT and also serves as a software license key. This is the recommended method for single users.
2. Uploading through a RoboPAL Server using the special RoboPAL Server dongle (black). The Server dongle is connected to a computer that must be accessible through the network and is running the RoboPAL Server program. Every user connects to the Server using the network and the Server then sends the program to the selected NXT unit. This is the recommended method when using multiple NXT units in a classroom.

To work with version 4.3 of RoboPAL, a 4.3 dongle is required. Older dongles can be exchanged for a new one.
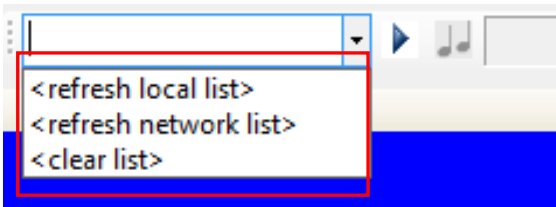
Using the Dongle

The special RoboPAL dongle takes care of all actions such as registering and connecting to Bluetooth. In addition, the dongle also serves as a software license for the RoboPAL software. Without a dongle, programs will not upload to the NXT. This dongle is ONLY usable with RoboPAL and cannot be used for other Bluetooth devices.

There are two versions of the dongle. The white dongle is the single user version, while the black one is the network version and can be used by several students at the same time.
To make contact with a NXT, the dongle is connected to a free PC USB port. In RoboPAL, the simulator needs to be running to be able to communicate with the NXT. This is necessary, because the programmes developed by the students must be converted by the simulator into a format that can be sent to the NXT.
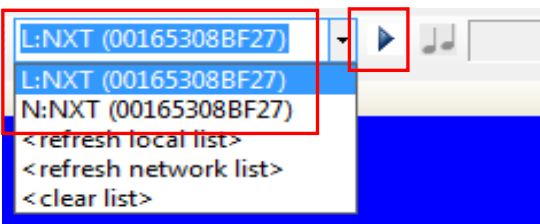When using a Server, the dongle is placed in a free USB port on the Server PC and the student PC's communicate from within RoboPAL in the same manner as when using a local dongle.

Once the simulator is running, it identifies all the NXT bricks that are switched on. To identify undetected robots, select <refresh local list> (if the dongle is connected to the PC) or <refresh network list> (if the dongle is connected to the network).

All identified NXT units will be listed in the selection view and are remembered by RoboPAL. By selecting Refresh again, you can find additional NXT units. If you are using the same NXT every time, you only need to find it the first time. If there are any NXT units in the list that are no longer in use, the list can be cleared by using <clear list>.

Select the name of the NXT unit you are using and press the little blue triangle. The dongle will connect to the selected NXT and will send the program to it. If the dongle is not connected or the NXT cannot be found, an error message appears. In front of the name of the NXT unit you are using, you will see "L:" (if the robot is used locally on your computer) and "N:" (if the robot is used through the network).

Uploading a Program Using a Dongle

RoboPAL transmits the program to the NXT via a Bluetooth connection. A special RoboPAL dongle is required for this. The program that runs on the NXT is a very compact version of the program that runs on the PC. This makes transmitting the program fast. The NXT needs to be switched on and the firmware needs to be running. When starting the NXT, the default LeJos firmware will start, followed by the RoboPAL start-up screen (as shown in the picture).

On the PC, the simulator needs to be running and on the NXT the main menu needs to be visible. The NXT then waits to receive a program. As soon as the PC sends the program, you will hear the NXT beep. This is a sign that the program is ready to run. The rightmost triangular button (RUN) is always used to start the program. The leftmost button is used to look at the calibration data and sensor values (TST).

As soon as the program starts running, you will see four simulated lamps on the screen. The rightmost lamp will be blinking. This one is called the 'Heartbeat' of the robot and it indicates that the program is running.
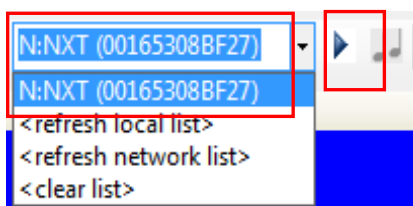
If there is no RUN visible on the screen, the upload has not succeeded and you may want to try uploading it again. Only if the program contains a calibration facility, will the CAL item be shown on the menu bar. This is generally only the case in Level 1 with the automatics calibration facility, which is not available in the RLT module. But when you make your own program, you may provide your own calibration function.

The middle CHECK serves to check the values of the sensors on the field. You can use it to find the difference between the colours black and green and see if they are sufficiently different. This, again, is only available for Level 1. For Level 2, there is no automatic calibration function and you will need to develop your own. In Level 2, you put your own text on the screen and, in addition to CAL and RUN, you can also show other commands on the menu.

Once a program has been loaded, you may start it as many times as required by pressing the RUN button on the start-up screen. You stop the program by using the orange button and you turn off the NXT by pressing the orange and grey button underneath at the same time.

Uploading a Program Using the RoboPAL Server

If you are using the RoboPAL Server, one of the computers in the classroom will be running the RoboPAL server program. When you select the <refresh network list> option, all NXT units that are known to the server will be shown on your PC. You can select a NXT from this list in exactly the same way as when you are using your own dongle.
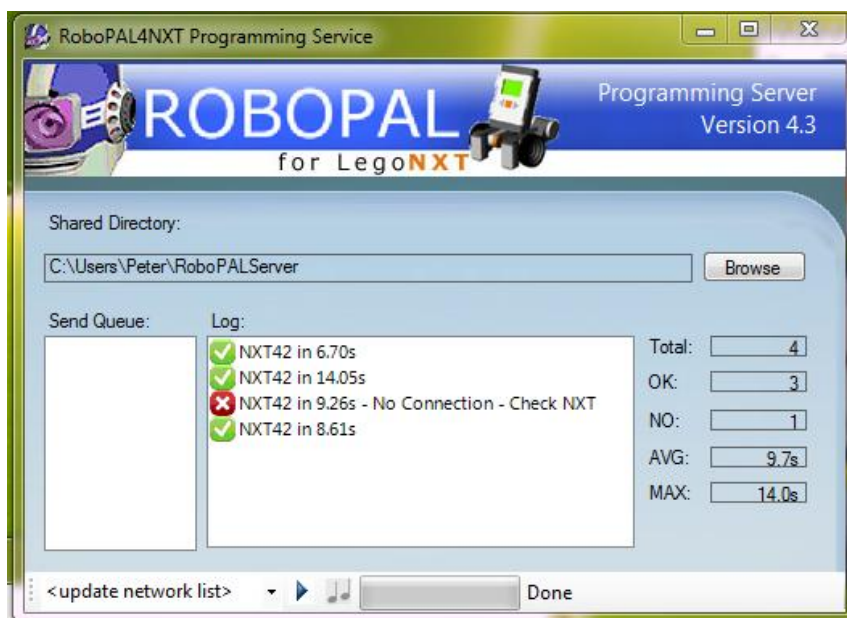

The server first needs to find all NXT units (just as on the PC) by using <refresh local list>. After the robots have been identified, a list us created on the server called BRICS.TXT. This list is retrieved by all the PCs that use the server, by selecting <refresh network list> in RoboPAL on the PC. This will retrieve the server list and creates a list on the PC of all NXT units that can be used through the server. You will need to point to the directory on the server that contains this list. This list may be modified using a standard text editor and it is good practice to make a backup copy of the completed list.

Every robot that has been found will be shown in the list by its name and MAC address. In a network connection, there will be an "N:" in front of the name; while in a local connection there will be an "L:". Both may be used together.

When a PC sends a program, using the network, it is stored in the server directory and as soon as the server is free, the program is sent to the NXT using the server dongle. On the PC, you will see a progress bar and a message if the upload was successful. On the server, you will see a list of all the programs that have been sent to the server and its status.

Installing the RoboPAL Server

A RoboPAL server may be installed on any PC that is connected to a network. This may be an existing school network but could also be a dedicated wireless router or access point that is only used for RoboPAL. All PCs that are used to send programs to the server need to be part of the same Windows WorkGroup, so they can reach each other. They also need to have File Sharing installed and, in some cases, it may be necessary to change the Firewall settings. If the standard Windows Firewall is used, this may not be necessary, but some security systems have their own Firewall.

When the Server is started you will have to specify the shared directory in which the Client PCs can place their programs. All Client PCs must be able to write and read in this directory. When a PC wants to use the server, you will need to use the <refresh network list> in RoboPAL. RoboPAL will then ask for the path to the network directory on the server. All programs that use the server send their program to this directory. The PC checks if the program arrives and if the server has transmitted the program. If this fails, the connection with the server has not been set up correctly.
In Windows 7, there is a special explorer item for using workgroups. In Windows XP, the WorkGroup must be set up by indicating the Computer Name in the System Properties.
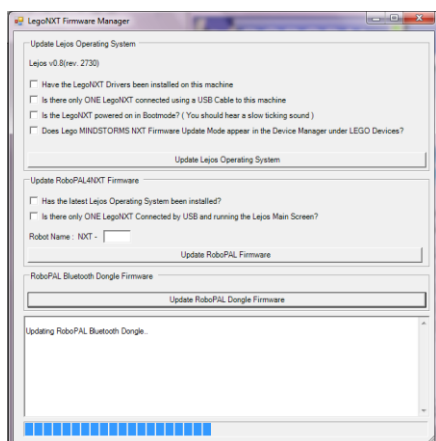
Using a Local Server

In some schools using a shared directory in the network may not be easy on account of ICT department policies or because of the way in which the network is organized.
An alternative is to buy a simple WIFI router that is used only in the classroom and does not have any outside connections.
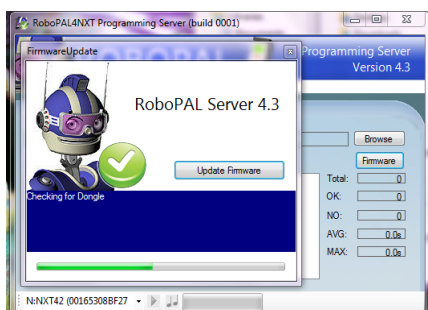
By creating a 'shared directory' only on the teacher's PC, this directory may be accessed by all PCs in the classroom and the integrity of the school network will not be altered. Using this (temporary) WIFI connection, the teacher's PC may be used as a server together with the dongle. It may be necessary to make the students' PCs part of the same workgroup as the teacher's PC.

Updating the Dongle Firmware

The dongles also contain firmware that may need to be updated. To update the white dongle's firmware, the firmware window is opened from the Perspective. The first two sections serve to load LeJos on the NXT and then to update the firmware on the NXT and to assign a name to the unit.

The third section is used to update the dongle firmware. Place the dongle in a free USB port and press the Update RoboPAL Dongle Firmware button.

The firmware on the Server dongle may be updated using the Server program. When the Server is started it will automatically check if there is an update and then offer to upgrade the firmware. Press the Update Firmware button in that window and the Server dongle will be upgraded.

Reporting RoboPAL Problems

If you encounter problems with RoboPAL during programming or when loading a program, please let us know. Provide us with as many details as possible about the steps you took before things went wrong, so we can reproduce the problem and solve it. The more information we get, the larger the chance that we can solve the problem. You can report errors via the site www.virtualbreadboard.com

Take into account that errors are fixed in a newer version that then will have to be installed on computers. If there is a problem in the firmware, the firmware on the NXT will also need to be updated. There also is software in the dongle that may need an update. All these updates can be done from within RoboPAL.