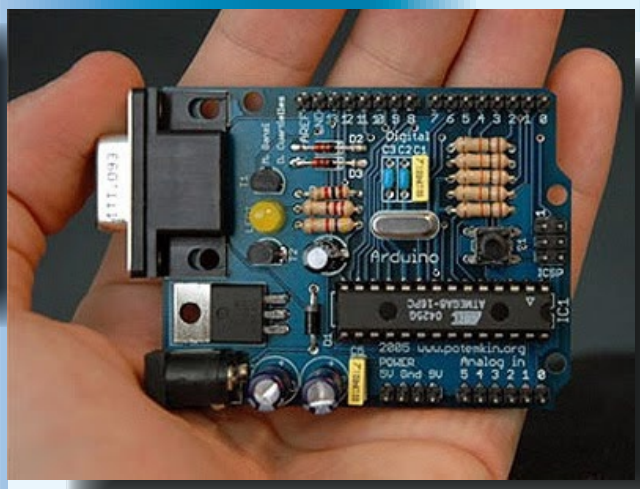
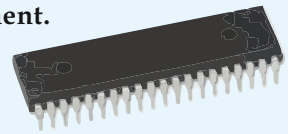
PHYSICAL COMPUTING WITH RGB LED
Today we enter a topic in programming called embedded computing with the internet; we code a RGB LED light on a Arduino board with a breadboard on which we switch off or on the light by a browser on an android device with our own web server and their COM protocols too. Hope you did already work with the Starter 1 till 17 (especially the 17) at:
`http://sourceforge.net/apps/mediawiki/maxbox/`



Arduino hardware is programmed using a Wiring-based language (*syntax and libraries*), similar to C++ and Object Pascal with some simplifications and modifications, and a Processing-based integrated development environment like **Delphi** or **Lazarus** with Free Pascal.

Current versions can be purchased preassembled; hardware design information is available for those who would like to assemble an **Arduino** by hand. Additionally, variations of the Italian-made **Arduino —** with varying levels of compatibility — have been released by third parties; some of them are programmed using the **Arduino** software or the sketch firmware.
The Arduino is what is known as a Physical or Embedded Computing platform, which means that it is an interactive system that through the use of hardware, firmware and software can interact with its environment.



This lesson will introduce you to Arduino and the Serial communication (*see Tutorial 15*). We will now dive into the world of serial communications and control our lamp from a browser to a web server by sending commands from the PC to the Arduino using a serial monitor with interface.

In our case we explain one example of a HTTP server which is an intermediate to the COM serial communication with the **AVR based micro controller on Arduino.**
Another Controller is the **Delphi Controller**. A **Delphi Controller** and the **DelphiDevBoard** were designed to help students, Pascal programmers and electronic engineers understand how to program micro controllers and embedded systems especially in programming these devices and targets (*see links at the end*).

This is achieved by providing hardware (*either pre-assembled or as a DIY kit of component*s), using course material, templates, and a Pascal compatible cross-compiler and using of a standard IDE for development and debugging (Delphi, maXbox, Lazarus or Free Pascal).

Let's begin with HTTP (Hypertext Transfer Protocol) and TCP. TCP/IP stands for Transmission Control Protocol and Internet Protocol. TCP/IP can mean many things, but in most cases, it refers to the network protocol itself.

Each computer on a TCP/IP network has a unique address associated with it, the so called IP-Address. Some computers may have more than one address associated with them. An IP address is a 32-bit number and is usually represented in a dot notation, e.g. 192.168.0.1. Each section represents one byte of the 32-bit address. In maXbox a connection with HTTP represents an object.

In our case we will operate with the local host. It is common for computers to refer to themselves with the name local host and the IP number 127.0.0.1.

GET THE CODE
As you already know the tool is split up into the toolbar across the top, the editor or code part in the centre and the output window at the bottom. Change that in the menu /view at our own style.

In maXbox you will start the web server as a script, so the web server IS the script that starts the Indy objects, configuration and a browser too (on board: Options/Add_ons/Easy_Browser/.
Before this starter code will work you will need to download maXbox from the website. It can be down-loaded from
`http://www.softwareschule.ch/maxbox.htm` (*you'll find the download maxbox3.zip on our website in your personal download area*). Once the download has finished, unzip the file, making sure that you preserve the folder structure as it is. If you double-click maxbox3.exe the box opens a default demo program.

Test it with **F9 / F2** or press Compile and you can open now the script example:
443_webserver_arduino_rgb_light5.txt

If you want to get the whole package with Arduino sketches too, then try the zip-file:
http://www.softwareschule.ch/download/ardpac.zip

Now let's take a look at the code of this project. Our first line is

```
program Motion_HTTPServer_Arduino42_RGB_LED_Light;
```

- This example requires two objects from the classes: `TIdCustomHTTPServer` and `TComPort` so the second one is to connect and transport with the COM ports to Arduino (*see below*). `TComPort` by **Dejan Crnila** are **Delphi/C++ Builder** serial communications components. (*It will be in your download area after publishing this issue*).
It is generally easy to use for basic serial communications purposes, alternative to the TurboPower ASYNCPro.
It includes 5 components: `TComPort`, `TComDataPacket`, `TComComboBox`, `TComRadioGroup` and `TComLed`.

With these tools you can build serial communication apps easier and faster than ever. First we start with the web server and second we explain the COM port. After creating the object we use first methods to configure our server calling Port and IP. The object makes a bind connection with the Active method by passing a web server configuration.

```
HTTPServer:= TIdCustomHTTPServer.Create(self);
```

So the object HTTPServer has some methods and properties like Active you can find in the TIdCustomHTTPServer.pas unit or IdHTTPServer library. A library is a collection of code or classes, which you can include in your program. Once a unit is tested it's stable to use.

Indy is designed to provide a very high level of abstraction. Much more stuff or intricacies and details of the TCP/IP stack are hidden from the Indy programmer. A typical Indy client session looks like this:

```
with IndyClient do begin
  Host:= 'zip.pbe3.com'; // Host to call
  Port:= 6000; // Port to call the server on
  Connect; // get something to do with it
end;
```

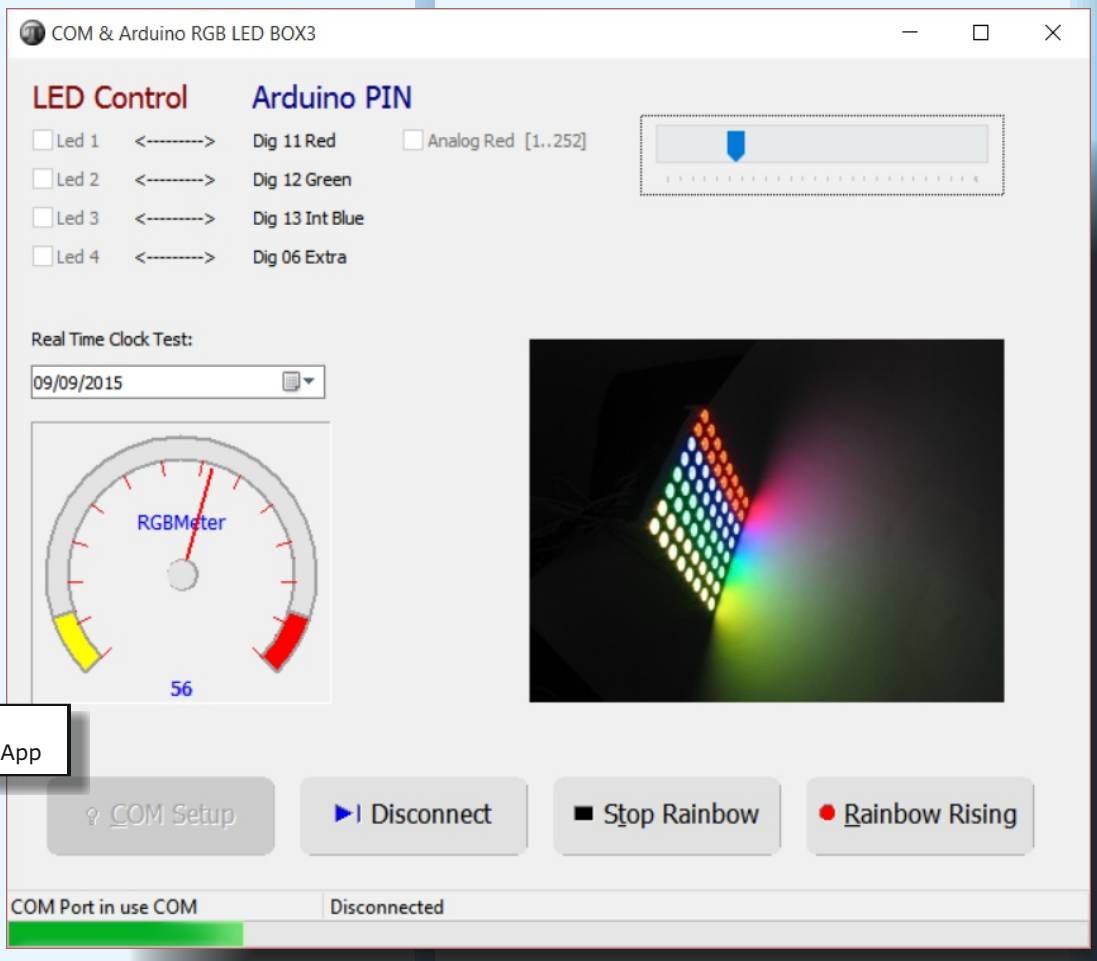


Figure 1:
The GUI of the Win App

Indy is different than other so called winsock components you may be familiar with. If you've worked with other components, the best approach for you may be to forget how they work. Nearly all other components use non-blocking *(asynchronous)* calls and act asynchronously. They require you to respond to events, set up state machines, and often perform wait loops.

- In fact there are 2 programming models used in TCP/IP applications. Non Blocking means that the application will not be blocked when the application socket read/write data. This is efficient, because your application don't have to wait for a connection. Unfortunately, it is complicated to develop.

```
with HTTPServer do
begin
  If Active then Free;
  If not Active then
    begin
      Bindings.Clear;
      bindings.Add;
      bindings.items[0].Port:= APORT;
      bindings.items[0].IP:= IPADDR;
       //'127.0.0.1'; 192.168.1.53'
      Active:= true;
      onCommandGet:= @HTTPServerGet;
      PrintF('Listening HTTP on %s:%d.',
          [Bindings[0].IP,Bindings[0].Port]);
   end;
```

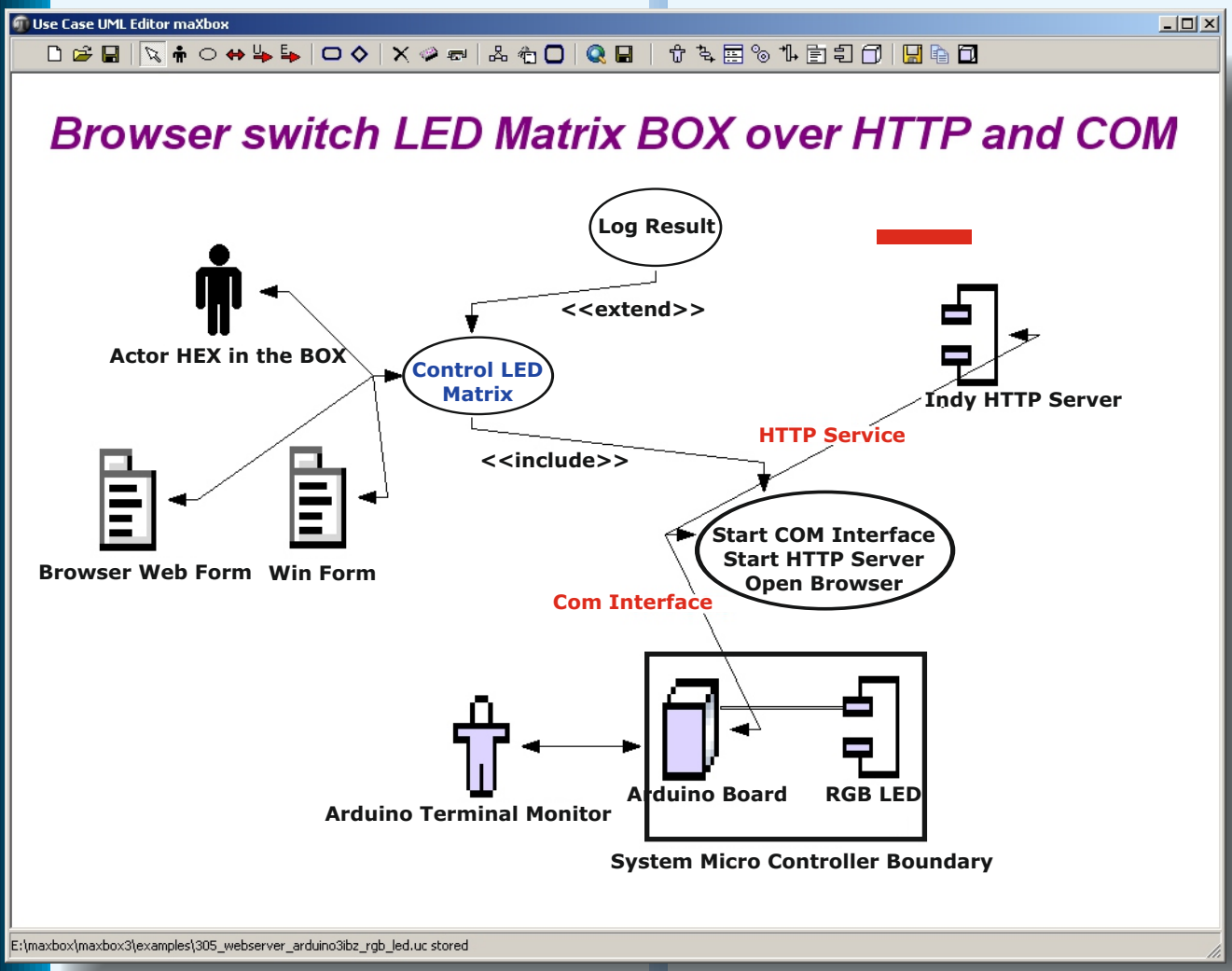
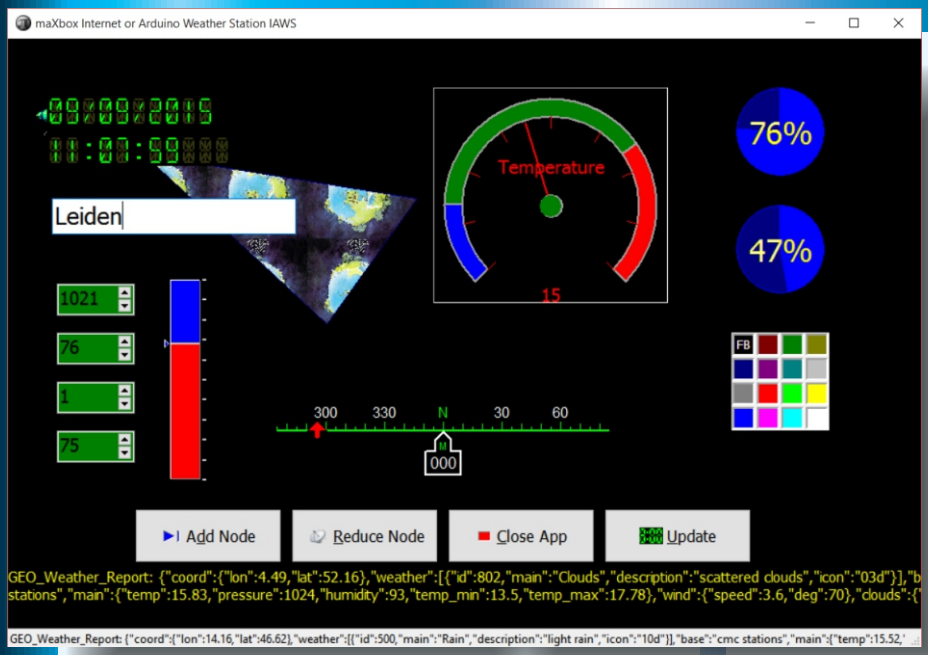


Figure 2: The Use Case

So let's get back to our HTTP Create in line 123. In line 131 and 132 you see port and IP address configuration of a Const, instead of IP you can also set a host name as a parameter.

- Host names are "human-readable" names for IP addresses.

An example host name is max.kleiner.com, the www is just a convention and not necessary. Every host name has an equivalent IP address, e.g. www.hower.org = 207.65.96.71.



3: A few gadgets for Arduino

The full target of the request message is given by the URL property. Usually, this is a URL that can be broken down into the protocol (HTTP), Host (*server syster* name (*server application*), path info (*location on the host*), and a query.

- So far we have learned little about HTTP and host names. Now it's time to run our program at first with F9 (*if you haven't done yet*) and learn something about GET and HTML. The program (server) generates a standard HTML output or other formats (*depending on the MIME type*) after downloading with GET or HEAD.

So our command to shine on a LED is **../LED** and to switch off is **../DEL (127.0.0.1:8000/LED)**.
Those are GET commands send with the browser, or **/R** for Red or **/G** for Green.
The first line identifies the request as a GET.
A GET request message asks the Web server application to return the content associated with the URI that follows the word GET.
The following shows the magic behind in the method **HTTPServerGet():**

```
procedure HTTPServerGet(aThr: TIdPeerThread;
    reqInf: TIdHTTPRequestInfo; respInf: TIdHTTPResponseInfo);
```

One word concerning the thread: In the internal architecture there are 2 threads categories.
First is a listener thread that "listens" and waits for a connection. So we don't have to worry about threads, the built in thread TIdPeerThread will be served by Indy through a parameter:

```
if uppercase(localcom) = uppercase('/LED')
then
  begin
    cPort.WriteStr('1')
    writeln(localcom+ ': LED on');
    RespInfo.ContentText:= getHTMLContentString('LED is:  ON');
  end
else
if uppercase(localcom) = uppercase('/DEL') then begin
    cPort.WriteStr('A');
    writeln(localcom+ ': LED off');
    RespInfo.ContentText:= getHTMLContentString('LED is:  OFF')
end;
```

HTTP request messages contain many headers that describe information about the client, the target of the request, the way the request should be handled, and any content sent with the request. Each header is identified by a name, such as "Host" followed by a string value. It then does a request.

- You can also switch with F5 in a browser to switch LED on and off:

```
webswitch:= NOT webswitch;
  if webswitch then
    begin
      cPort.WriteStr('1') //goes to Arduino
      RespInfo.ContentText:=
        getHTMLContentString('LED is:  ON Switch');
    end
  else
    begin

      cPort.WriteStr('A');
      RespInfo.ContentText:=
        getHTMLContentString('LED is:  OFF Switch')
    end
end
```

One of a practical way to learn much more about actually writing HTML is to get in maXbox editor and load or open a web-file with the extension html. Or you copy the output and paste it in a new maXbox instance. Then you click on the context menu and change to HTML Syntax!
In this mode the PC is a master and executes the control algorithm while the Arduino or Delphi Controller acts as an interface slave and follows commands coming from the PC or browser through its RS232 port. Each RGB field in these records reflects a state of the sensors and actuators of the LED in those sense only actors as LED light are in use.
A running Arduino (M485A) monitor server will accept commands on input through a RS232 port:

```
if (val=='1'){
digitalWrite(ledPin11,HIGH); }
  else if (val=='A'){
   digitalWrite(ledPin1,LOW);
   }
     if (val=='2'){
    digitalWrite(ledPin2,HIGH); }
```

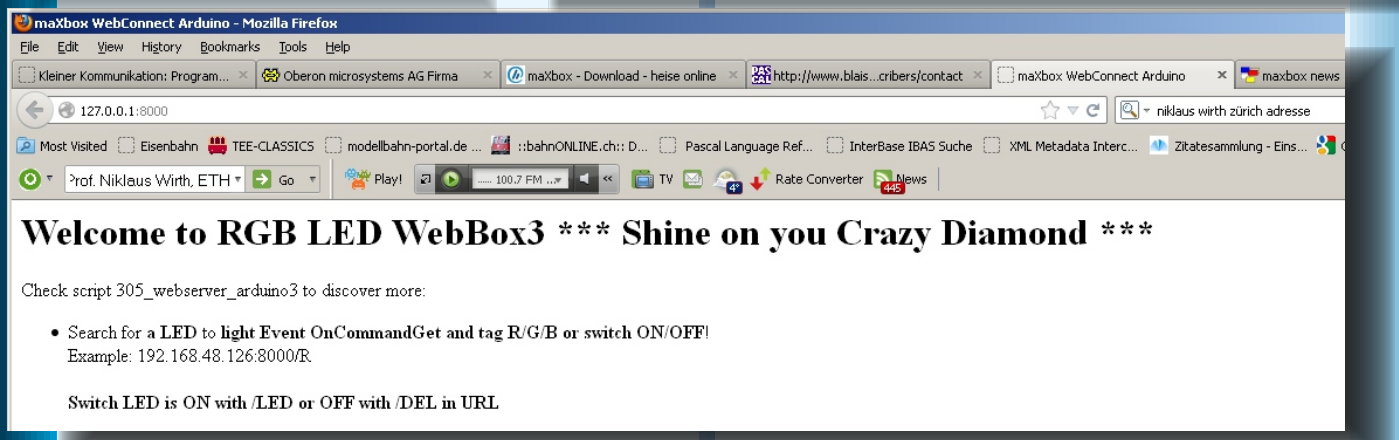
```
begin
  idHTTP:= TIdHTTP.Create(NIL)
  try
    memo2.lines.text:= idHTTP.Get2('http://127.0.0.1')
    for i:= 1 to 10 do
      memo2.lines.add(IntToStr(i)+' :'+memo2.lines[i])
  finally
    idHTTP.Free
end
```

- The Object TIdHTTP is a dynamically allocated block of memory whose structure is determined by its class type. With the method Get1 you can download files.

```
begin
myURL:=
  'http://www.softwareschule.ch/download/maxbox_examples.zip
  zipStream:= TFileStream.Create('myexamples2.zip', fmCreat
  idHTTP:= TIdHTTP.Create(NIL)
try
   idHTTP.Get1(myURL, zipStream)
```

Of course a lot of lines to get a file from the web try it shorter with the magic function wGet():

```
wGet('http://www.softwareschule.ch/download/maxbox_starter17.pdf',
'mytestpdf.pdf');
```



Figur 4: The Browser controls

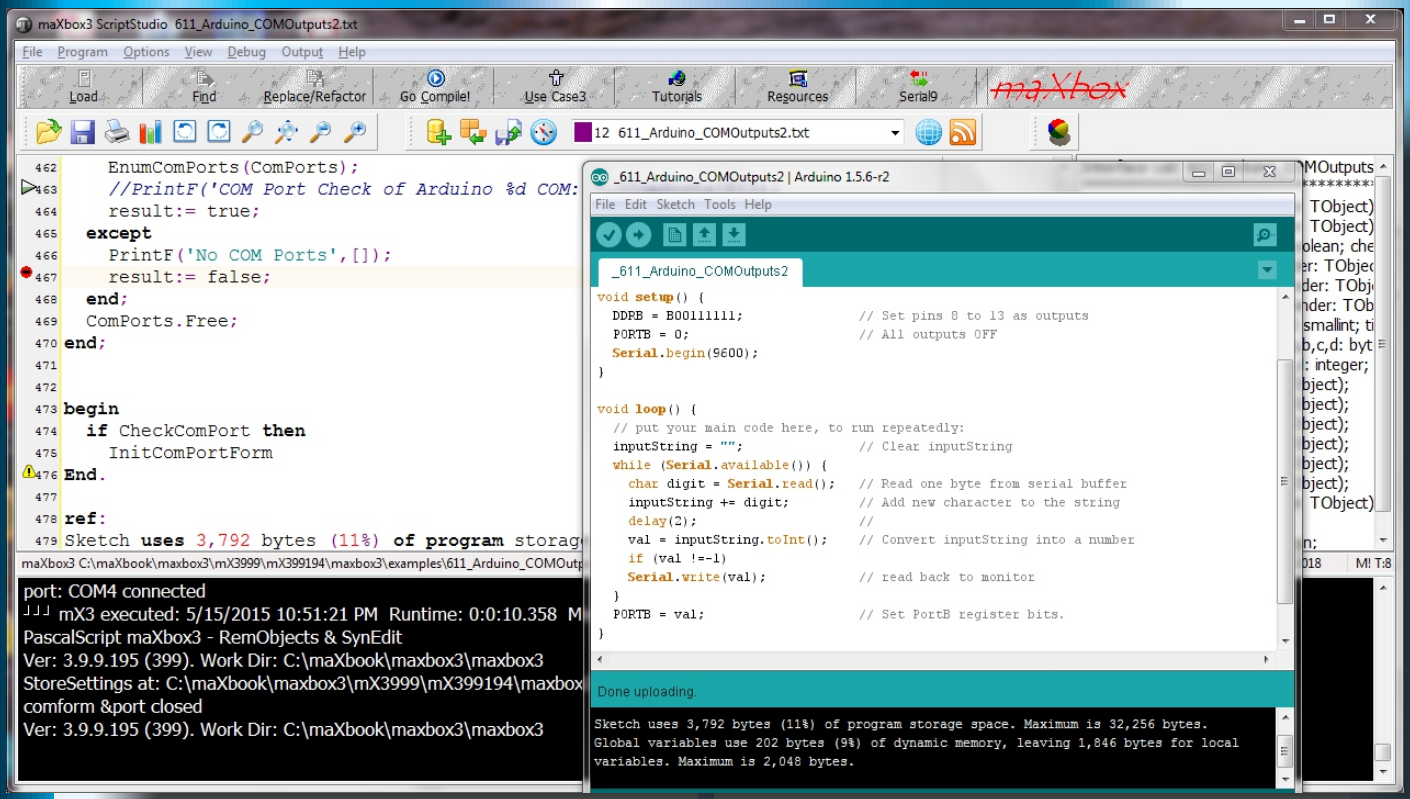
When the browser starts from script the server is ready for commands to pass chars to the serial communication. When a the server application finishes with our client request, it lights the LED and constructs a page of HTML code or other MIME content, and passes the result back *(via the server in* `TIdHTTPResponseInfo` *)* to the client for display.

```
writeln(localcom+ ': LED on');
RespInfo.ContentText:= getHTMLContentString('LED is:  ON');
```

Have you tried the program, it's also possible to test the server without Arduino or a browser. When you run this code from the script **`102_pas_http_download.txt`** you will see a content (*first 10 lines*) of the site in HTML format with the help of the method memo2.lines.add:

It downloads the entire file into memory if the data is compressed (Indy 9 does not support streaming decompression for HTTP yet). Next we come closer to the main event of our web server in line 40, it's the event onCommandGet with the corresponding event handler method @HTTPServerGet() and one object of TidPeerThread.

You can use them as server as the way to serve files of many kinds!



5: maXuino Together Settings

SERIAL LINE

Please read more about serial coding in Tutor 15!
The serial communications line is simply a way for the Arduino to communicate with the outside world, in this case to and from the PC (via USB) and the Arduino IDE's Serial Monitor or from the uploaded code to I/O Board back.
We just create and configure our COM settings (depends in which COM port a USB hub works).

```
procedure TForm1_FormCreateCom(Sender: TObject);
begin
  cPort:= TComPort.Create(self);
  with cPort do begin
    BaudRate:= br9600;
    Port:= COMPORT; //'COM3';
    Parity.Bits:= prNone;
    StopBits:= sbOneStopBit;
    DataBits:= dbEight;
  end;
```

The Arduino can be used to develop stand-alone interactive objects or it can be connected to a computer to retrieve or send data to the Arduino and then act on that data (e.g. send sensor data out to the web or write data on a control LED).
Now we change to the Arduino editor to explain how he handles our commands (chars).
Serial.begin tells Arduino to start serial and the number within the parenthesis, in this case 9600, sets the baud rate (chars per second) that the serial line will communicate at.

```
int val = 0;
// variable to store data from the serial port
int ledPin11 = 11;
// LED connected to digital pin 11 or the inbuilt 13!

void setup() {
  pinMode(ledPin11,OUTPUT);
  // declare a LED's pin as output mode
  erial.begin(9600); // connect to serial port
..}
```

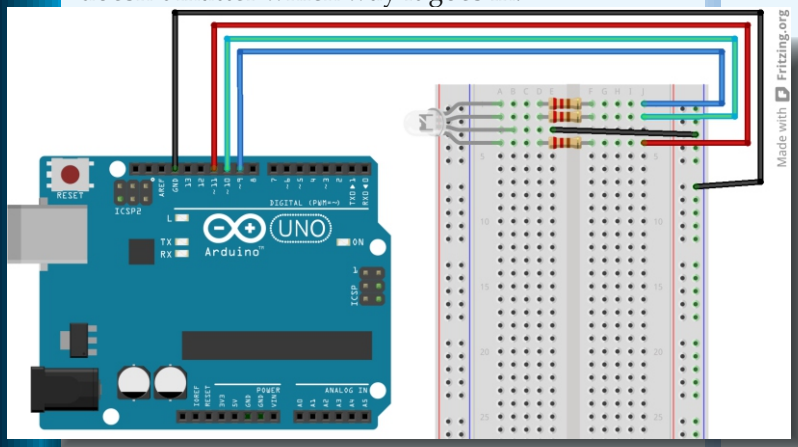
In the main loop we have an "if statement". The condition it is checking the value in (Serial.read). The Serial.available command checks to see if any characters have been sent down the serial line. If any characters have been received then the condition is met and the code within the "if statements" code block is now executed, you see if '1' then ON and if 'A' then OFF.
The condition of checking is simply a char it's up to you to code a protocol of your own .

```
void loop () {
 val = Serial.read();   // read on the serial port
 if (val !=-1){
    if (val=='1'){
      digitalWrite(ledPin1,HIGH);
    }
     else if (val=='A'){
   digitalWrite(ledPin1,LOW);
   }
Serial.print("Data entered: ");
```

and this is our way of sending data back from the Arduino to the PC. In this case the print command sends whatever is within the parenthesis to the PC, via the USB cable, where we can read it in the monitor window or in maXbox.

BREAD BOARD FLOW

At last but not least some words about breadboards and electronics. A breadboard (or protoboard) is usually a construction base for prototyping devices of electronics. The term "breadboard" is commonly used to refer to a solder less breadboard (plug board).
With the breadboard you prepared above or below, add three wires for power to RGB light and one for ground GND for your AVR controller. Place 3 resistors and LED as shown. Make sure the longest leg of the LED is to GND, connected to the minus. The resistors don't have a direction, so it doesn't matter which way it goes in.



6: Breadboard Settings

If you're using a standard breadboard, you'll need to use wires to reach the Arduino. Run 3 wires (red, green and blue) to the pin sockets on the Arduino. Run the other wire (black) to one of the GND sockets on the Arduino. The colours aren't essential but they will help you remember what the wires are connected to and black is a convention for ground GND!
Once the connection to a client socket is completed, the server connection is indistinguishable from a client connection. Both end points have the same capabilities and receive the same types of events. Only the listening connector is fundamentally different, as it has only a single endpoint.
Sockets provide an interface between your network server or client application and a networking software. You must provide an interface between your application and clients that use it.

Sockets let your network application communicate with other systems over the network. Each socket can be viewed as an endpoint in a network connection. It has an address that specifies:

- The system on which it is running.
- The types of interfaces it understands.
- The port it is using for the connection.

A full description of a socket connection includes the addresses of the sockets on both ends of the connection. You can describe the address of each socket endpoint by supplying both the IP address or host and the port number.

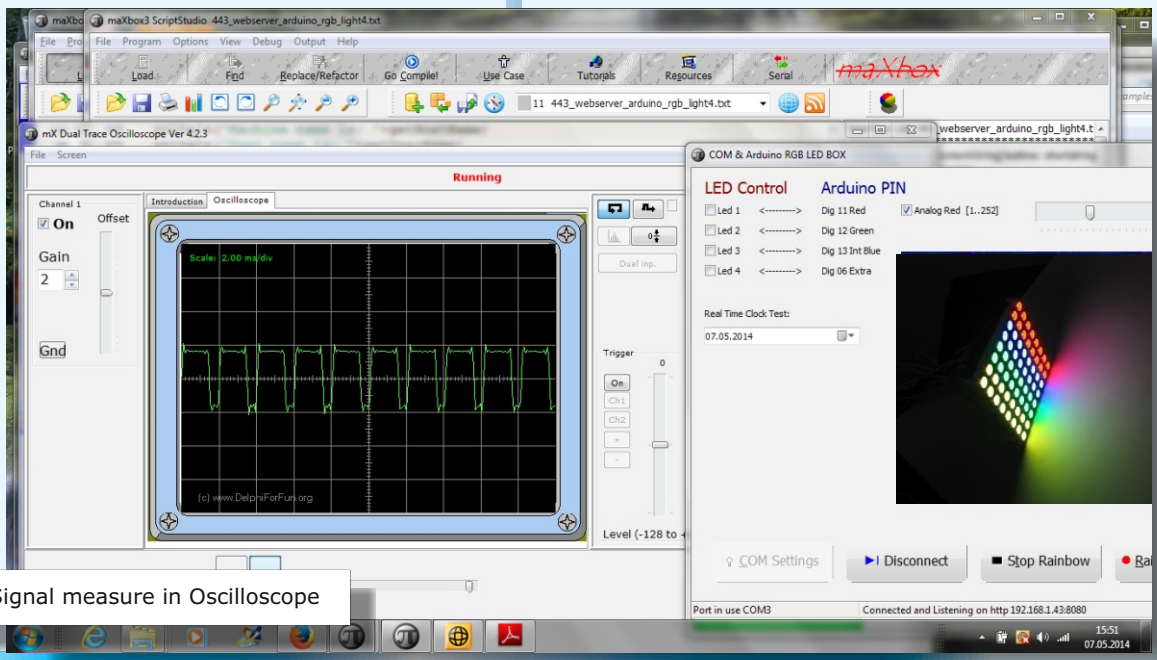


Figure 7: PWM Signal measure in Oscilloscope

In the next line we just start a browser to test our server in a so called frame work flow.

```
procedure letOpenBrowser;
// TS_ShellExecuteCmd = (seCmdOpen,seCmdPrint,seCmdExplore);
begin
//ShellAPI.ShellExecute(Handle,PChar('open'),'http://127.0.0.1:80/',Nil,Nil,0);
   S_ShellExecute('http:'+IPADDR+':'+IntToStr(APORT)+'/','',seCmdOpen)
end;
```

Try to change the IP address in line 132 of **IP:= IPADDR** with a DHCP or dynDNS address, so you can reach Arduino from an Android, but also change settings.

Some notes at last about firewalls or proxy-servers. It depends on your network infrastructure to get a file or not, maybe you can't download content cause of security reasons and it stops with **Socket-Error # 10060** and a time out error. Furthermore, it also depends on the firewall in use at both ends. If it's automatic and recognises data that needs a response automatically it will work. It needs an administrator to open ports etc. you're stuffed or configured.

Hope you did learn in this tutorial the theme of Arduino with a web server. The Arduino is an amazing device and will enable you to make anything from interactive works of art to robots. With a little enthusiasm to learn how to program the Arduino and make it interact with other components a well as a bit of imagination, you can build anything you want.
The Arduino can also be extended with the use of Shields which circuit boards are containing other devices (e.g. GPS receivers, LED Cubes, LCD Displays, Sneakers, MIDI Synthesizers, Ethernet connections, etc.) that you can simply slot into the top of your Arduino to get extra functionality.

The Arduino board is made of an Atmel AVR microprocessor, a crystal or oscillator (basically a crude clock that sends time pulses to the micro-controller to enable it to operate at the correct what type of Arduino you have, you may also have a USB connector to enable it to be connected to a PC or Linux to upload or retrieve data. The board exposes the micro-controllers I/O (Input/Output) pins to enable you to connect those pins to other circuits, buses or to sensors, etc. Feedback please to: **max@kleiner.com**

Literature:

Kleiner et al., Patterns konkret, 2003, Software & Support

Links of maXbox, Web of Things, Arduino and Indy:

http://www.softwareschule.ch/download/webofthings2013.pdf

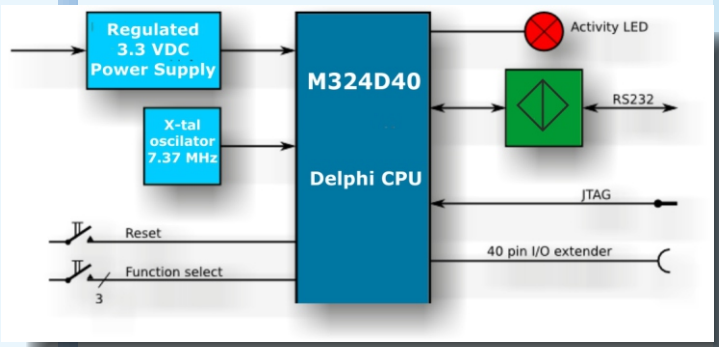
http://www.softwareschule.ch/maxbox.htm
http://www.indyproject.org/Sockets/index.EN.aspx

http://en.wikipedia.org/wiki/Arduino
http://fritzing.org/
http://sourceforge.net/projects/maxbox
http://sourceforge.net/projects/delphiwebstart

http://www.blaisepascal.eu/index.php?actie=./subscribers/UK_Electronics_Department

http://www.blaisepascal.eu/subscribers/vogelaar_elctronics_info_english.php

APPENDIX DELPHI CONTROLLER



http://www.blaisepascal.eu/index.php?actie=./subscribers/UK_Electronics_Department

DELPHI SCHEMA