Embedded Linux In a Wireless Router (EMLI)

Sanjukta Bose *Loyola University, Chicago, Illinois, USA*

Abstract

Embedded system is a combination of hardware and software behaving as a small computer system to do a specialized job. Embedding Linux simply means that we can use the Linux features to serve a particular purpose.
EMLI is an attempt to embed a small set of Linux commands into a wireless router. Here we use a Linksys wrt54g router to embed and execute a subset of Linux commands. We take advantage of the ping bug present in the router to insert our command set into it.
This paper also discusses the possibility of using this embedding to detect intrusion and prevent them using snort.

1 Introduction

In today's times there are things like microwave ovens, PDA's, IPODS, ATMs, Multifunctional printers (MFPs), home automation products etc., which serves a special purpose. These are a combination of a special purpose hardware and software to achieve high speed at low cost and may not work like any general purpose computer. These instruments are examples of embedded systems.

Linux is very popularly used to develop such embedded systems as it is an open-source and free operating system that is mature and stable. It is also well supported.

We have created a embedded system by installing a small set of Linux commands into a wireless router and then executed those commands on the router.

A typical wireless network at our home and office are very vulnerable to hacking or intrusion. Any person can use our network for malicious purposes so we have explored the possibility of using the embedded router to enhance the detection and external intrusion prevention of the network

2 Embedding Linux in wireless router using Windows

An **Embedded system** is a special-purpose computer system, which is completely encapsulated by the device it controls. Unlike a general-purpose personal computer, an embedded system has specific requirements and performs pre-defined tasks. An embedded system consists of a hardware device with a chip programmed with particular applications. It is a combination of hardware and software that supports mass production and variety of application. Various operating systems could be used in embedded systems. When Linux operating system is used in embedded

systems then it is called **Embedded Linux.** Some common examples of its use can be seen in cell phones, PDAs, media player handsets, and other consumer electronics devices.

BusyBox is a program combining many standard Unix utilities into a single small executable. It is intended to replace the GNU fileutils suite with a single-floppy or embedded Linux system. It is a free software, licensed under the GNU GPL. In this project we embed a small set of Linux commands from BusyBox into a WRT54G v2 Linksys wireless router by creating a soft link between the BusyBox commands and files on the router. A small distribution is created to perform this task. This distribution is run on a Windows operating system using Cygwin. **Cygwin** is free software, which provides a Linux-like environment for Windows. It consists of two parts:

- A DLL (cygwin1.dll) that acts as a Linux API emulation layer, providing substantial Linux API functionality.
- A collection of tools that provides Linux-like environment.

2.1 Requirements

2.1.1 Hardware

- WRT54Gv2 Linksys Router
- 200Mhz MIPS processor
- 4 MB of flash memory
- 16MB of RAM

2.1.2 Software

- Windows (or Linux)
- Internet Explorer6.0 or above or Netscape7.0
- BusyBox
- CYGWIN version 1.5.18-1
  - Basic toolset
  - wget 1.10.1-2 from Web package
  - ttcp from Net package

2.2 Steps for loading Linux into wireless router using Windows

- Configure the router using its setup wizard
- Test the router for the ping bug as follows:
  - Open an Internet Explorer window and type the IP address of the router in the address bar.
  - Click the Administration tab
  - Click on Diagnostics tab
  - Click on ping

    - Type " **;ls>tmp/ping.log** " in the IP address bar and click "ping"
    - This will return a directory tree.
- Download the distribution from the following site
  http://www.batbox.org/wrt54g-linux.html
- Unzip the distribution using 7-zip (use untar in Linux) in the folder of your choice
- Modify the wrt54g.sh script for the IP address (typically 192.168.1.1) and the password of the router.
- Download Cygwin from http://www.cygwin.com
    - Click on "Install Cygwin Now"
    - Select a mirror
    - Click on Web package and select wget 1.10.1-2 to install
    - Click on Net package and select ttcp to install
    - Click next to install.
    - Check the box for creating a shortcut to the desktop and click on Finish
- Open a cygwin window by doubleclicking the cygwin icon on your desktop
- Move to the directory where the distribution is unzipped
- Uncomment the line that uses wget in wrt54.sh file to create a connection with the router. Save wrt54g.sh.
- Copy ttcp.exe from /usr/bin to the distribution directory.
- Execute wrt54g.sh in the bash shell of cygwin.
- Telnet using the IP address of the router.
- Run the commands loaded on the router.

3 Key Observations

The following key observations made after loading Linux in the router:

- As we login as root, we do not need a user name or password to telnet the router.
- The distribution loads into the RAM disk of the router so there are no permanent changes (the distribution can be erased by power cycling the router).
- The router can be telnet by any computer connected to it via wired or wireless mode.
- A firewall on the host computer can prevent telneting the router, therefore the firewall should be temporarily disabled.
- The older version of wget can prevent the distribution from being executed successfully.

4 Future Scope

EMLI is an attempt to show that a small set of Linux command can be embedded in a wireless router. It is also possible to embed these commands into other wireless routers and access points like WRT54GS.
Additionally, it is also possible to enhance security features of the router by using snort, an intrusion detection and prevention system. In order to run Snort on a system libpcap library is required to be loaded on that system. This library cannot be loaded in a Windows system using Cygwin as a wrapper therefore it can be loaded only on a Linux system.
VPN type functionalities can also be loaded on the router to secure home and office networks that use wireless routers like WRT54G.

5 Related Work

There are many other free firmware available which can be embedded into the router and enhance the various features of the Linksys WRT54G router. These firmwares include OpenWRT, HyperWRT, Seveasoft, eWRT.

6 Acknowledgements

The author would like to thank Dr.George K.Thiruvathukal for his guidance and assistance in the execution of the project. Special thanks to Mr. Jim Buzbee for developing the distribution and providing necessary guidance.

7 Bibliography

7.1 Books

1) Building Embedded Linux Systems by Karim Yaghmour : O'RIELLY,2003
2) Embedded Linux: Hardware, Software, and Interfacing by Craig Hollabaugh: Addison Wesley,2002

7.2 Websites

1) http://en.wikipedia.org/wiki/Embedded_system
2) http://www.batbox.org/wrt54g-linux.html
3) http://www.cygwin.com
4) http://www.Linksys.com
5) http://www.busybox.net
6) http://openwrt.org
7) http://www.hyperdrive.be/hyperwrt
8) http://www.sveasoft.com/modules/phpBB2/index.php
9) http://www.portless.net/menu/ewrt