Automatic IP-Address Configuration Converting For Public Network

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Dr. Gregory T. Papanikos
President
Athens Institute for Education and Research
This paper should be cited as follows:

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Abstract

to be able to connect to the public WIFI networks, automatic DHCP function is needed to be enabled. This is not applicable to devices, which users do not have authorization to make change their network configuration, such as office notebook or fixed IP-address devices. This paper introduces Zero-configuration software module to cope with the problem at the network gateway by editing Ethernet package header to the required IP address parameters of a particular public network both of incoming and outgoing packages. The Experimental results show that the Zero configuration module can convert Ethernet package with above 99% of throughput in various testing scenarios. It can take up to 7,100 packages per second (about 80 Mbps) and its efficiency is 96.27% compared against normal data transfer (Zero-configuration module disabled) through the network gateway. Moreover, It can handle all well-known ports and services including VPN, etc.

Keywords: zero configuration, IP-address conversion, IP-address blinding

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Introduction

At present, WIFI Internet is widely used for hotels or any public areas. Many users need to set their network configurations in order to connect to the public network environment by mostly enabling automatic DHCP service. When they bring their computer back to home or office, network configuration is needed to be set back to previous setting. Also, some users do not have authorization to change network setting.

This paper presents Zero-configuration (ZC) software module to help computer to connect to the Internet regardless of which IP-Address, DNS, PORXY and Gateway address which were formerly set up in that computer. As a result, when a computer connected to the public Internet service, which equipped with the ZC module, client can connect to the Internet without any changes required.

Current technology can do such thing by using several brands of hardware boxes, but such hardware boxes are quite expensive for the function we discussed earlier so we develop software instead. It reduces cost and can be adjusted to make it more suitable for widely uses.

Ethernet Frame package

Ethernet Frame as in figure 1 compounds of Destination MAC Address, Sender’s MAC Address, Destination IP Address, Sender’s IP Address, Ethernet sum and Protocol sum

Figure 1. Ethernet frame package

In the complex network environment, VLAN [8] is used to isolated groups of network and Ethernet frame has an extra “Tag Vlan” slot as presented in figure 2.
Ethernet package conversion design

This experiment used Linux Cent OS 5.2 as a network gateway server which has 2 Ethernet ports (ETH0, ETH1). Its functions were to allocate private IP address to the clients and to route all client’s Ethernet packages to the Internet.

- **Normal scenario:** Clients (DHCP enable) physically/wirelessly connects to ETH0 (LAN side) and get assigned IP-address from the gateway server. Then, Clients can connect to the Internet through ETH1 (WAN side). Unrecognizably fixed IP-address client cannot access to the Internet as depicted in figure 3.

**Figure 3.** Unrecognizably fixed IP-address client cannot to the Internet through the Gateway server

- **ZC module enabled scenario:** Clients (DHCP enable or unrecognizably fixed IP address) can connect to the Internet. In order to convert Ethernet package header to required format of the network gateway, virtual interface and ZC software module are added to gateway server as depicted in figure 4. Following configurations were used in the experiment.
Ethernet interface configuration

ETH0 (Local IP – LAN interface)
  Link encap:Ethernet  HWaddr 00:22:2D:C1:98:22

ETH1 (Public IP – WAN interface)
  inet addr:192.168.10.248  Bcast:192.168.10.255  Mask:255.255.255.0

Virtual interface
  inet addr:10.0.0.1  Bcast:10.0.0.255  Mask:255.255.255.0

*** Virtual interface’s Hwaddr (mac address) is added to ARP table []

Client device interface
  MAC Address: 00-16-D3-4C-F9-CB
  IP Address: 192.168.20.233
  Subnet Mask: 255.255.255.0
  Default Gateway: 192.168.20.254
  DNS Servers: 8.8.8.8

Ethernet package conversion by ZC module

Out-going package:
- “Convert 1”, in figure 4, changes client’s Mac-address and IP-address to virtual interface’s recognized IP-format which assigned by ZC module and record values in IP Mapping table.
- “Convert 2” changes Virtual interface’s Mac-address and IP-address to ETH1 interface’s recognized format by using standard Linux firewall mechanism.

In-coming package:
- “Convert 3” changes ETH1 interface’s Mac-address and IP-address to Virtual interface’s recognized format by using standard Linux firewall mechanism.
“Convert 4” changes Virtual interface’s Mac-address and IP-address to Client’s IP-address and Mac’s address which recorded in IP mapping table.

IP mapping table is created and maintain by zero configuration module to record and match between real client’s IP address and assigned Virtual IP address using in “Convert 1 and 4”.

**Figure 5.** Sequence diagram ZC working step when unknown client connect to testing network and send Ping command to www.google.com

Zero-configuration software module

In figure 6, ZC module does “convert 1” and “convert 4” and maintain IP-mapping table (solely used by ZC).

First, ZC module detects if the package contains VLAN tagging. Second, ZC checks if it is Internet Protocol version 4 (IPv4) since ZC cannot works with IPv6. Third, package’s original IP-address and MAC address are converted to virtual IP-address and MAC address and they are stored in IP-Mapping table as a record. Fourth, ZC calculates and imprints new check sum to the package regarding to its protocol (ICMP/TCP/UDP). Finally, edited package is sent to Virtual interface and to ETH1 respectively.
Figure 6. “Convert 1” program flow chart

Once ETH 1 receives reply data package from the Internet. It sends the package to the Virtual interface and ZC module start process “Convert 4” (reversed steps of “Convert 1”) as depicted in Figure 7. ZC module extracts Virtual IP address and MAC address and searches them in IP Mapping table. Then convert data package’s IP and MAC addresses back to the original. Finally, ETH0 is able to send the package back to the client.
Figure 7. “Convert 4” program flow chart

**Experiment**

Following controlled environment was built to capture the ZC’s performance, throughput and reliability by comparing clients who connected to
the IP-Address Zero Configuration server, with the clients who directly connected to the Internet.

Internet gateway server specification (with ZC module)
- CPU: AMD Phenom II X6 3.2GHz
- Motherboard: GIGABYTE GA-890GPA-UD3H (rev. 2.0)
- RAM: 12GigaByte
- Hard disk: 160GigaByte
- Ethernet card: 1Gigabit x 2
- OS: CentOS 6.2 (linux)

Performance testing:

**Figure 9.** Local FTP downloading and uploading testing configuration

**Scenario 1:** Local FTP downloading and uploading

<table>
<thead>
<tr>
<th>Table 1. Local FTP downloading result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Download data (Byte)</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>1,024</td>
</tr>
<tr>
<td>102,400</td>
</tr>
<tr>
<td>524288</td>
</tr>
<tr>
<td>1,048,576</td>
</tr>
<tr>
<td>104,857,600</td>
</tr>
<tr>
<td>536,870,912</td>
</tr>
<tr>
<td>1,073,741,824</td>
</tr>
</tbody>
</table>

The table 1 and 2 show downloading and uploading results comparing between pass and not-pass ZC server. ZC achieves better performance at those bigger among of data transfer transaction. Some ZC’s process overhead obviously affects transactions which have smaller among data transfer.
### Table 2. Local FTP uploading result

<table>
<thead>
<tr>
<th>Download data (Byte)</th>
<th>Client who not pass ZC Server</th>
<th>Client who pass ZC Server</th>
<th>%Throughput (Pass ZC/ Non pass ZC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (Sec)</td>
<td>Speed (Byte/Sec)</td>
<td>Time (Sec)</td>
</tr>
<tr>
<td>1,024</td>
<td>0.006</td>
<td>170,667</td>
<td>0.007</td>
</tr>
<tr>
<td>102,400</td>
<td>0.017</td>
<td>6,023,529</td>
<td>0.022</td>
</tr>
<tr>
<td>524288</td>
<td>0.051</td>
<td>10,280,157</td>
<td>0.076</td>
</tr>
<tr>
<td>1,048,576</td>
<td>0.096</td>
<td>10,922,667</td>
<td>0.109</td>
</tr>
<tr>
<td>104,857,600</td>
<td>8.84</td>
<td>11,856,355</td>
<td>8.931</td>
</tr>
<tr>
<td>536,870,912</td>
<td>45.269</td>
<td>11,859,571</td>
<td>45.598</td>
</tr>
<tr>
<td>1,073,741,824</td>
<td>90.597</td>
<td>11,851,847</td>
<td>91.07</td>
</tr>
</tbody>
</table>

### Figure 10. Internet FTP downloading and uploading testing

Scenario 2: Internet FTP downloading and uploading

The table 3 and 4 show downloading and uploading results comparing between pass and not-pass the ZC server. Throughput difference is very slight when the size of data transfer is more than 1 MByte.

### Table 3. Internet FTP downloading result (bandwidth = 10 Mbps)

<table>
<thead>
<tr>
<th>Download data (Byte)</th>
<th>Client who not pass ZC Server</th>
<th>Client who pass ZC Server</th>
<th>%Throughput (Pass ZC/ Non pass ZC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (Sec)</td>
<td>Speed (Byte/Sec)</td>
<td>Time (Sec)</td>
</tr>
<tr>
<td>1,024</td>
<td>0.06</td>
<td>17,066.60</td>
<td>0.063</td>
</tr>
<tr>
<td>102,400</td>
<td>0.129</td>
<td>793,798.40</td>
<td>0.206</td>
</tr>
<tr>
<td>524288</td>
<td>0.542</td>
<td>967,321.00</td>
<td>0.56</td>
</tr>
<tr>
<td>1,048,576</td>
<td>0.966</td>
<td>1,085,482.40</td>
<td>0.97</td>
</tr>
<tr>
<td>104,857,600</td>
<td>85.95</td>
<td>1,219,870.10</td>
<td>86.427</td>
</tr>
<tr>
<td>536,870,912</td>
<td>439.84</td>
<td>1,220,599.40</td>
<td>440.64</td>
</tr>
<tr>
<td>1,073,741,824</td>
<td>881.06</td>
<td>1,218,684.80</td>
<td>881.09</td>
</tr>
</tbody>
</table>
Table 4. *Internet FTP uploading result (bandwidth = 1 Mbps)*

<table>
<thead>
<tr>
<th>Download data (Byte)</th>
<th>Client who not pass ZC Server</th>
<th>Client who pass ZC Server</th>
<th>%Throughput (pass ZC / not pass ZC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (Sec)</td>
<td>Speed (Byte/sec)</td>
<td>Time (Sec)</td>
</tr>
<tr>
<td>1,024</td>
<td>0.059</td>
<td>17,355.93</td>
<td>0.068</td>
</tr>
<tr>
<td>102,400</td>
<td>1.18</td>
<td>86,779.66</td>
<td>2.35</td>
</tr>
<tr>
<td>524,288</td>
<td>4.373</td>
<td>119,892.06</td>
<td>4.57</td>
</tr>
<tr>
<td>1,048,576</td>
<td>8.147</td>
<td>128,707.01</td>
<td>8.19</td>
</tr>
<tr>
<td>104,857,600</td>
<td>778.48</td>
<td>134,693.92</td>
<td>779.95</td>
</tr>
<tr>
<td>536,870,912</td>
<td>3,999.75</td>
<td>134,225.85</td>
<td>4,015.81</td>
</tr>
<tr>
<td>1,073,741,824</td>
<td>7,976.88</td>
<td>134,606.67</td>
<td>7,983.08</td>
</tr>
</tbody>
</table>

Scenario 3: Shooting large number of packages to ZC

Large number of packages was generated by Packit application and shouted to the ZC server. Each package has size of 1460 Bytes. A number of packages which ZC can take per second were recorded as in table 5. Maximum throughput of the ZC server is about 7,000 packages or 10 Megabytes per second or about 80 Mbps which more than enough for public Internet service.

Table 5. *Package shooting result to the ZC server*

<table>
<thead>
<tr>
<th>#Packages</th>
<th>100,000</th>
<th>200,000</th>
<th>500,000</th>
<th>1,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packets/Sec</td>
<td>7,692.4</td>
<td>7,407.11</td>
<td>7,246.26</td>
<td>7,103.94</td>
</tr>
<tr>
<td>Bytes/Sec</td>
<td>11,230,769</td>
<td>10,814,814</td>
<td>10,579,710</td>
<td>10,313,725</td>
</tr>
</tbody>
</table>

Functional testing (diversity of applications)

Following applications were tested to ensure that ZC can work with all well-known applications.

SecureCRT: Protocol Telnet, SSL, SSH1,SSH2
FileZilla Client: Protocol FTP
FileZilla Server: Protocol FTP
IE, Firefox, Opera, Chrome: Protocol HTTP, HTTPS
VNC Viewer, TeamViewer: Protocol TCP
Outlook, Outlook Express: Protocol SMTP, POP3
Windows Live: Protocol TCP
MultiPing: Protocol ICMP
Samba: Protocol UDP
CounterPath-eyeBeam: Protocol SIP, RTP, RTCP
P2P Torrent: Protocol UDP
Reliability or stability testing

ZC module was tested against a public WIFI service which had client about 30-40 clients concurrently connected to the internet. ZC’s CPU and memory usage were captured for a week to see stability of the service as shown in picture 10, 11 and 12.

Figure 10. ZC process ID monitoring

<table>
<thead>
<tr>
<th>Process Name</th>
<th>Status</th>
<th>% CPU</th>
<th>Nice</th>
<th>ID</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zc-d</td>
<td>Sleeping</td>
<td>0</td>
<td>-20</td>
<td>1745</td>
<td>920.0 Kib</td>
</tr>
<tr>
<td>Xorg</td>
<td>Sleeping</td>
<td>0</td>
<td>2179</td>
<td>4.2 Mib</td>
<td></td>
</tr>
<tr>
<td>xinetd</td>
<td>Sleeping</td>
<td>0</td>
<td>1737</td>
<td>188.0 Kib</td>
<td></td>
</tr>
<tr>
<td>wpa_supplicant</td>
<td>Sleeping</td>
<td>0</td>
<td>1529</td>
<td>212.0 Kib</td>
<td></td>
</tr>
<tr>
<td>wnck-applet</td>
<td>Sleeping</td>
<td>0</td>
<td>2532</td>
<td>1.2 Mib</td>
<td></td>
</tr>
<tr>
<td>watchdog1</td>
<td>Sleeping</td>
<td>0</td>
<td>10</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>watchdog0</td>
<td>Sleeping</td>
<td>0</td>
<td>6</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

Figure 11. ZC’s CPU usage over a week

Figure 12. ZC’s CPU usage over a week

Discussion

Ethernet frame:

ZC was designed to detect only normal and with VLAN-tagging Ethernet frame packages as depicted in figure 2. The ZC module extracts package in fix-length manner. ZC cannot cope with other formats of Ethernet frame such as IPv6.

Performance:

Indexing technique is used in IP-Mapping table in order to have a faster looking up records while processing “Convert 1” and “Convert 4” as in Figure
4, 5, 6 and 7. The ZC module cannot select to convert only packages of clients who have wrong IP-address configuration. Packages of all clients will be converted to virtual IP-address and MAC-address.

Reliability:

IP and MAC addresses mapping-record will be removed when clients disconnect from ZC server to maintain availability of virtual IP-address to the next clients and to reduce the size of the table to have a faster record lookup performance.

Conclusion

IP-Address zero configuration service uses the same principle as one of standard Linux’s Network Address-Translator (NAT) [10] mixed with DHCP service. Its purpose is to covert Ethernet packages to required format of the Internet gateway. Standard NAT does only conversion but not detect missed or wrong IP-address configuration like ZC does.

The Experimental results show that the ZC module can convert Ethernet packages with above 99% of throughput in various testing scenarios. It can take up to 7,100 packages per second (about 80 Mbps). Moreover, its efficiency is 96.27% compared against normal data transfer (Zero-configuration module disabled) through the Internet gateway. Besides, it can handle all well-known ports and services including VPN, VLAN. The IP-mapping table resides in physical memory so conversion processes should be faster (higher throughput) if higher CPU and bigger memory BUS are allocated to the experiment. Stability testing shows steady level of CPU and memory usages under the always-on public WIFI service which serves mixing controlled and real clients over a week.

References

Maxim Krasnyansky, Virtual Point-to-Point(TUN) and Ethernet(TAP) devices, http://vtun.sourceforge.net/tun/
PJ Frantz, GO Thompson, VLAN frame format, US patent 5,959,990, 1999.
K. Egevang, P. Francis, the IP Network Address Translator (NAT), May 1994.