

计算机网络与应用 实验一 实验报告

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实验目的

- 练习使用网络常用命令；
- 进一步了解网络地址、子网掩码、域名、网关、路由、地址解析、协议和端口等基本概念；
- 通过查看和测试网络状态，发现和解决网络可能存在的问题。

实验环境

- 子网 10.1.0.0/24
- Windows 11 Pro 64位计算机，Hostname Sierra，IP 地址 10.1.0.103

实验内容

ipconfig

使用 ipconfig 工具查看本机网络信息：

```
ipconfig /all
```

得到输出：

```
Windows PowerShell

Wireless LAN adapter Wi-Fi:

Connection-specific DNS Suffix . : 
Description . . . . . : Intel(R) Wi-Fi 6 AX201 160MHz
Physical Address. . . . . : 5C-87-9C-05-05-96
DHCP Enabled. . . . . : Yes
Autoconfiguration Enabled . . . . : Yes
IPv6 Address. . . . . : 2402:f000:4:1003:809:ffff:fff2:83f8(Preferred)
Lease Obtained. . . . . : Wednesday, September 21, 2022 7:42:53 PM
Lease Expires . . . . . : Thursday, September 22, 2022 7:42:53 PM
Link-local IPv6 Address . . . . : fe80::bccd:625a:725e:b1d8%13(Preferred)
IPv4 Address. . . . . : 10.1.0.103(Preferred)
Subnet Mask . . . . . : 255.255.255.0
Lease Obtained. . . . . : Wednesday, September 21, 2022 7:42:09 PM
Lease Expires . . . . . : Wednesday, September 21, 2022 9:42:52 PM
Default Gateway . . . . . : fe80::9629:2fff:fe37:c990%13
                             10.1.0.1
DHCP Server . . . . . : 10.1.0.1
DHCPv6 IAID . . . . . : 157058972
DHCPv6 Client DUID. . . . . : 00-01-00-01-2A-32-3F-4E-5C-87-9C-05-05-96
DNS Servers . . . . . : 2402:f000:1:801::8:28
                             2402:f000:1:801::8:29
                             166.111.8.28
                             166.111.8.29
NetBIOS over Tcpip. . . . . : Enabled

Ethernet adapter Ethernet 3:

Media State . . . . . : Media disconnected
```

可以得到以下信息：

- DHCP：启用
- IPv4 地址： 10.1.0.103
- 地址租期： 19:42:53 Sep. 21, 2022 - 19:42:53 Sep. 22, 2022
- 子网掩码： 255.255.255.0
- 默认 DNS 服务器地址： 166.111.8.28 166.111.8.29
- 默认网关地址： 10.1.0.1
- 网卡 MAC： 5c:87:9c:05:05:96

nbtstat

使用 nbtstat 查看本机 NetBIOS 缓存：

```
nbtstat -c
```

```
Windows PowerShell
PS C:\Users\yuyan> nbtstat -c

Ethernet 3:
Node IpAddress: [0.0.0.0] Scope Id: []

    No names in cache

Bluetooth Network Connection:
Node IpAddress: [0.0.0.0] Scope Id: []

    No names in cache

Wi-Fi:
Node IpAddress: [10.1.0.103] Scope Id: []

    No names in cache

Local Area Connection* 1:
Node IpAddress: [0.0.0.0] Scope Id: []

    No names in cache

Local Area Connection* 2:
Node IpAddress: [0.0.0.0] Scope Id: []

    No names in cache
PS C:\Users\yuyan>
```

可以查看到本地缓存为空。

使用 `nbtstat` 查看局域网网上邻居的 NetBIOS，以网络中一台笔记本电脑为例：

```
nbtstat -a 10.1.0.102
```

```
Windows PowerShell
PS C:\Users\yuyan> nbtstat -a 10.1.0.102

Ethernet 3:
Node IpAddress: [0.0.0.0] Scope Id: []

    Host not found.

Bluetooth Network Connection:
Node IpAddress: [0.0.0.0] Scope Id: []

    Host not found.

Wi-Fi:
Node IpAddress: [10.1.0.103] Scope Id: []

    NetBIOS Remote Machine Name Table

    Name                Type                Status
    ----                -
    AP0STR0BOOK          <00> UNIQUE          Registered
    MAC Address = 3C-A6-F6-3E-39-47

Local Area Connection* 1:
Node IpAddress: [0.0.0.0] Scope Id: []

    Host not found.

Local Area Connection* 2:
```

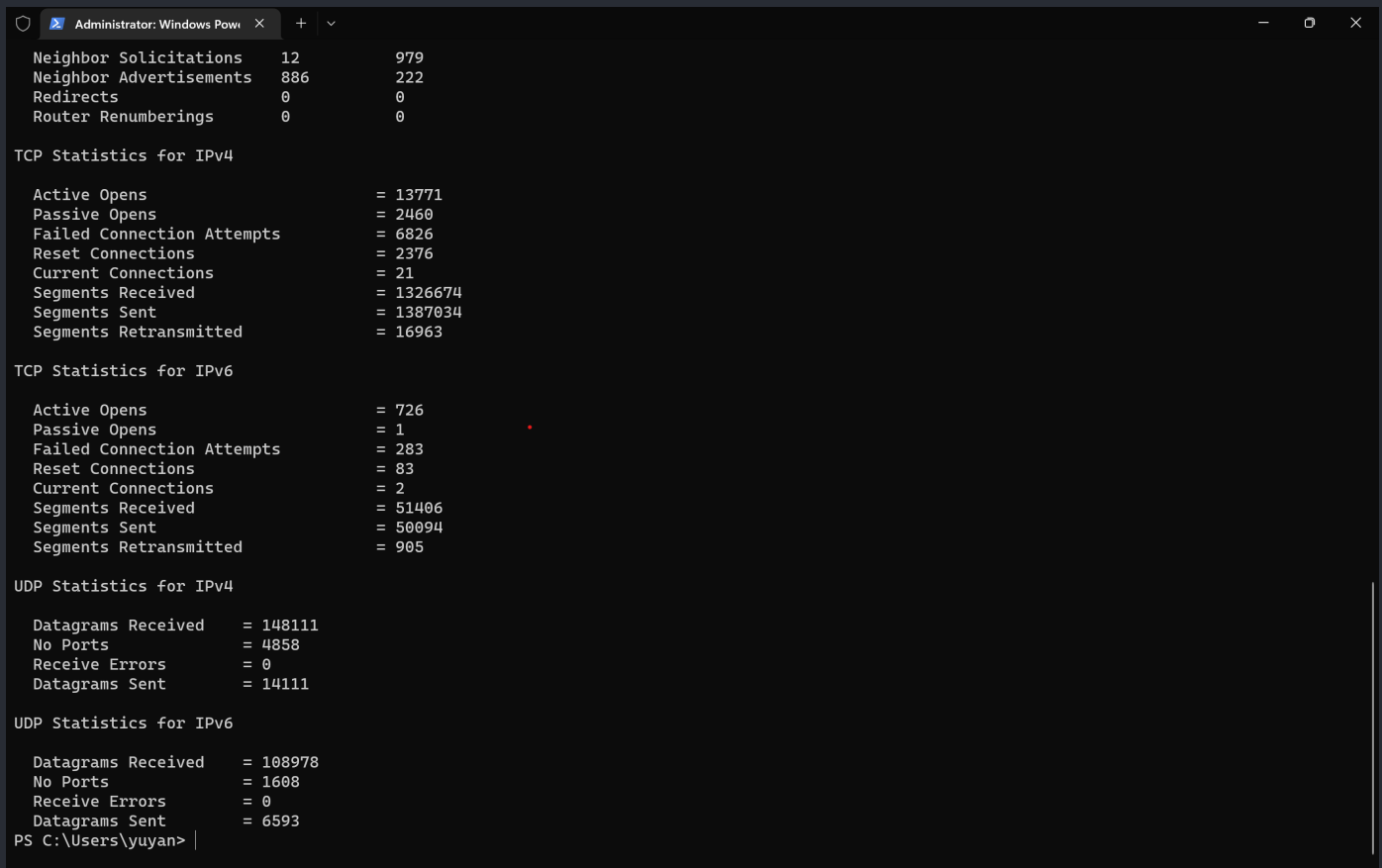
可以看到在 Wi-Fi 网络连接上找到了 10.1.0.102 的 NetBIOS 信息：

- Hostname: AP0STR0B00K
- MAC: 3c:a6:f6:3e:39:47
- 已注册

netstat

使用 netstat 查看本机传输层 TCP、UDP 协议的统计：

```
netstat -s
```



```
Administrator: Windows PowerShell
Neighbor Solicitations      12          979
Neighbor Advertisements    886         222
Redirects                   0           0
Router Renumberings        0           0

TCP Statistics for IPv4

Active Opens                = 13771
Passive Opens               = 2460
Failed Connection Attempts  = 6826
Reset Connections           = 2376
Current Connections         = 21
Segments Received           = 1326674
Segments Sent               = 1387034
Segments Retransmitted      = 16963

TCP Statistics for IPv6

Active Opens                = 726
Passive Opens               = 1
Failed Connection Attempts  = 283
Reset Connections           = 83
Current Connections         = 2
Segments Received           = 51406
Segments Sent               = 50094
Segments Retransmitted      = 905

UDP Statistics for IPv4

Datagrams Received          = 148111
No Ports                   = 4858
Receive Errors              = 0
Datagrams Sent              = 14111

UDP Statistics for IPv6

Datagrams Received          = 108978
No Ports                   = 1608
Receive Errors              = 0
Datagrams Sent              = 6593
PS C:\Users\yuyan> |
```

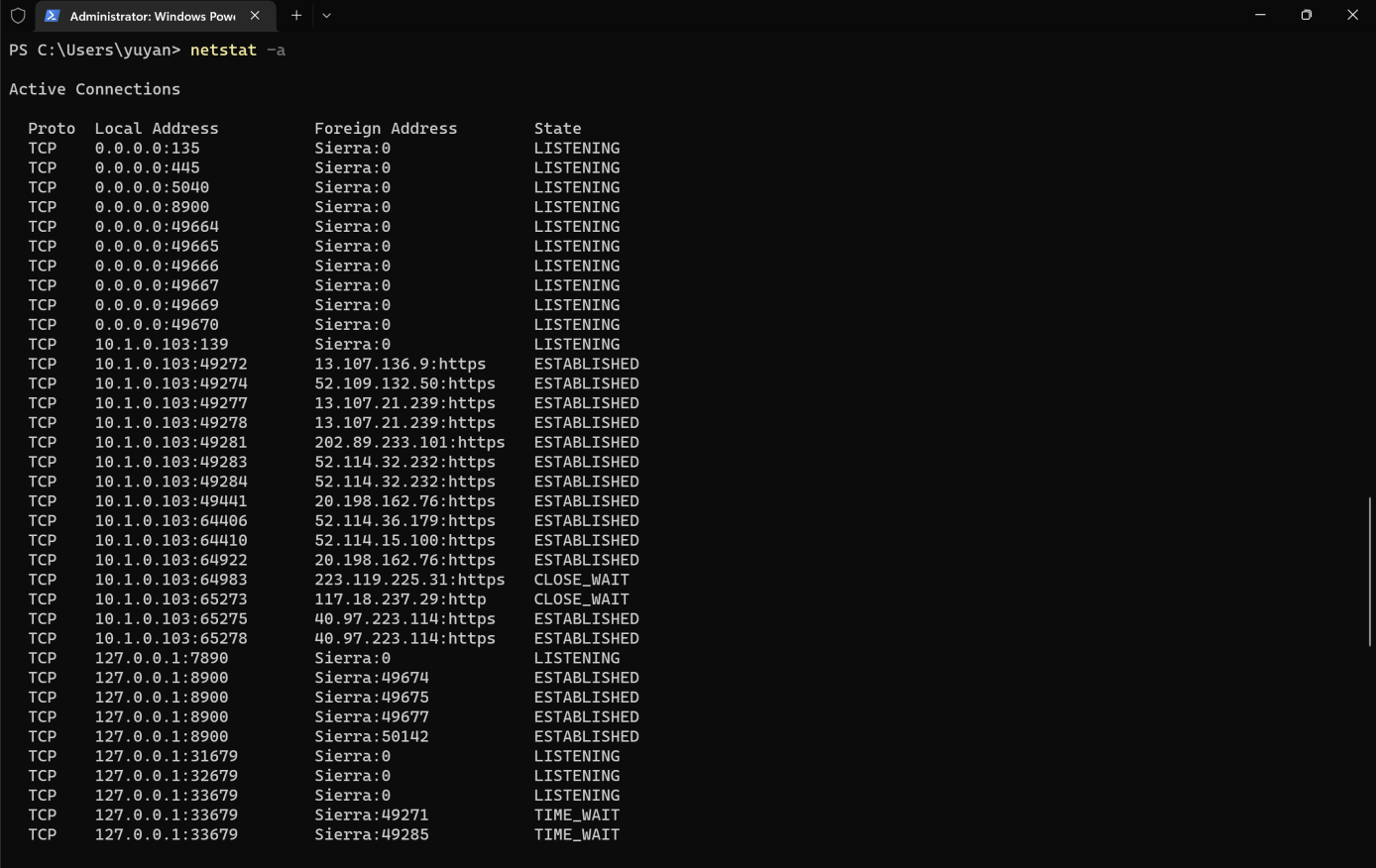
可以看到本地 TCP、UDP 的 IPv4、IPv6 统计信息，包括但不限于：

- TCP 的主动、被动链接开启数
- TCP 的失败连接尝试数、重置连接数、当前连接数
- TCP 的分包收发数
- UDP 的数据报收发数

- UDP 的非监听端口收包数

使用 `netstat` 查看本机 TCP、UDP 协议的端口：

```
netstat -a
```



可以看到本地一些 TCP、UDP（在下面）连接的监听、已建立连接、已关闭连接等状态的端口号。

arp

使用 `arp` 查看 ARP 表：

```
arp -a
```

```
Administrator: Windows Powe
PS C:\Users\yuyan> arp -a

Interface: 10.1.0.103 --- 0xd
Internet Address      Physical Address      Type
10.1.0.1              3c-06-a7-7e-c5-ef    dynamic
10.1.0.102            90-8d-6e-15-86-4c    dynamic
224.0.0.2             01-00-5e-00-00-02    static
224.0.0.22            01-00-5e-00-00-16    static
224.0.0.251           01-00-5e-00-00-fb    static
224.0.0.252           01-00-5e-00-00-fc    static
239.255.255.250       01-00-5e-7f-ff-fa    static
255.255.255.255       ff-ff-ff-ff-ff-ff    static
PS C:\Users\yuyan>
```

可以看到局域网中的网关、本机、组播地址的 IP 地址 - MAC 地址对应关系。

ping

使用 ping 测试到达下列地址的地址：

- 本地回环 localhost
- 本机 10.1.0.102
- 局域网邻居 10.1.0.103
- 默认网关 10.1.0.1
- 域名服务器 166.111.8.28
- 远程网络地址 202.112.3.45

```
Administrator: Windows PowerShell
PS C:\Users\yuyan> ping localhost

Pinging Sierra [::1] with 32 bytes of data:
Reply from ::1: time<1ms
Reply from ::1: time<1ms
Reply from ::1: time<1ms
Reply from ::1: time<1ms

Ping statistics for ::1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms
PS C:\Users\yuyan> ping 10.1.0.102

Pinging 10.1.0.102 with 32 bytes of data:
Reply from 10.1.0.102: bytes=32 time=4ms TTL=64
Reply from 10.1.0.102: bytes=32 time=4ms TTL=64
Reply from 10.1.0.102: bytes=32 time=4ms TTL=64
Reply from 10.1.0.102: bytes=32 time=4ms TTL=64

Ping statistics for 10.1.0.102:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 4ms, Maximum = 4ms, Average = 4ms
PS C:\Users\yuyan> ping 10.1.0.103

Pinging 10.1.0.103 with 32 bytes of data:
Reply from 10.1.0.103: bytes=32 time<1ms TTL=128
Reply from 10.1.0.103: bytes=32 time<1ms TTL=128
Reply from 10.1.0.103: bytes=32 time<1ms TTL=128
Reply from 10.1.0.103: bytes=32 time<1ms TTL=128

Ping statistics for 10.1.0.103:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

```
Administrator: Windows PowerShell
Reply from 10.1.0.1: bytes=32 time=3ms TTL=64
Reply from 10.1.0.1: bytes=32 time=3ms TTL=64

Ping statistics for 10.1.0.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 3ms, Maximum = 3ms, Average = 3ms
PS C:\Users\yuyan> ping 166.111.8.28

Pinging 166.111.8.28 with 32 bytes of data:
Reply from 166.111.8.28: bytes=32 time=4ms TTL=60
Reply from 166.111.8.28: bytes=32 time=4ms TTL=60
Reply from 166.111.8.28: bytes=32 time=4ms TTL=60
Reply from 166.111.8.28: bytes=32 time=4ms TTL=60

Ping statistics for 166.111.8.28:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 4ms, Maximum = 4ms, Average = 4ms
PS C:\Users\yuyan> ping 202.112.3.45

Pinging 202.112.3.45 with 32 bytes of data:
Reply from 202.112.3.45: bytes=32 time=5ms TTL=122
Reply from 202.112.3.45: bytes=32 time=5ms TTL=122
Reply from 202.112.3.45: bytes=32 time=4ms TTL=122
Reply from 202.112.3.45: bytes=32 time=4ms TTL=122

Ping statistics for 202.112.3.45:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 4ms, Maximum = 5ms, Average = 4ms
PS C:\Users\yuyan>
```

可以看到本机发送了 32 bytes 的 ICMP 包，到达不同距离、跃点数量的计算机，均收到 Response，代表到达目的计算机的链路连通；由于跃点数量不同和链路性能差异，到达不同主机的包具有不同的延迟时间和 TTL。

tracert

使用 `tracert`，检测到达 `166.111.8.28` 的跃点地址：

```
tracert 166.111.8.28
```



```
Administrator: Windows PowerShell
PS C:\Users\yuyan> tracert 166.111.8.28

Tracing route to dns-a.tsinghua.edu.cn [166.111.8.28]
over a maximum of 30 hops:

  0  1 ms  <1 ms   1 ms  10.1.0.1
  1  14 ms  12 ms   1 ms  59.66.156.1
  2  4 ms   3 ms   2 ms  118.229.2.77
  3  4 ms   3 ms   2 ms  118.229.2.218
  4  4 ms   2 ms   2 ms  dns-a.tsinghua.edu.cn [166.111.8.28]

Trace complete.
PS C:\Users\yuyan>
```

可以看到本机到达目的地址依次经过了本地网关（路由器）、宿舍网关、2 个教育网节点，最终到达清华公共 DNS 服务器；还可以看到到达每个节点的延迟。

思考题

Internet 通讯的基本网络配置

若要在 Internet 通信，本机必须配置：

- 网关地址
- 本机 IP 地址和子网掩码

DNS 服务器地址是可选项，若不配置，无法使用 DNS 服务，但依然可以通过 IP 地址访问 Internet 资源。

本机必须具有：

- MAC 地址
- IP 地址

tracert 路由检测中的 *

在 `tracert` 中会出现延迟为 `*` 的情况，着不一定是路由不可到达。可能的情况如下：

- 该节点路由不可到达，本机接收不到 TTL exceeded 报文；
- 该节点禁用了 ICMP Response，无法发出 TTL exceeded 报文，或发出的报文被拦截或丢失。

ping -r 和 tracert

使用 `ping -r` 指令 ping `166.111.8.28` 并记录路由：

```
ping -r 8 166.111.8.28
```

```
Windows PowerShell
PS C:\Users\yuyan> ping -r 8 166.111.8.28

Pinging 166.111.8.28 with 32 bytes of data:
Reply from 166.111.8.28: bytes=32 time=7ms TTL=60
Route: 59.66.156.25 ->
        118.229.2.78 ->
        118.229.2.217 ->
        166.111.8.1 ->
        166.111.8.28 ->
        166.111.8.28 ->
        118.229.2.218 ->
        118.229.2.77
Reply from 166.111.8.28: bytes=32 time=8ms TTL=60
Route: 59.66.156.25 ->
        118.229.2.78 ->
        118.229.2.217 ->
        166.111.8.1 ->
        166.111.8.28 ->
        166.111.8.28 ->
        118.229.2.218 ->
        118.229.2.77
Reply from 166.111.8.28: bytes=32 time=8ms TTL=60
Route: 59.66.156.25 ->
        118.229.2.78 ->
        118.229.2.217 ->
        166.111.8.1 ->
        166.111.8.28 ->
        166.111.8.28 ->
        118.229.2.218 ->
        118.229.2.77
Reply from 166.111.8.28: bytes=32 time=19ms TTL=60
Route: 59.66.156.25 ->
        118.229.2.78 ->
        118.229.2.217 ->
        166.111.8.1 ->
        166.111.8.28 ->
        166.111.8.28 ->
        118.229.2.218 ->
        118.229.2.77

Ping statistics for 166.111.8.28:
```

对比前文的 `tracert` 指令的结果：

```
Administrator: Windows Powe
PS C:\Users\yuyan> tracert 166.111.8.28

Tracing route to dns-a.tsinghua.edu.cn [166.111.8.28]
over a maximum of 30 hops:

  0  1 ms  <1 ms   1 ms  10.1.0.1
  1  14 ms  12 ms   1 ms  59.66.156.1
  2  4 ms   3 ms   2 ms  118.229.2.77
  3  4 ms   3 ms   2 ms  118.229.2.218
  4  4 ms   2 ms   2 ms  dns-a.tsinghua.edu.cn [166.111.8.28]

Trace complete.
PS C:\Users\yuyan>
```

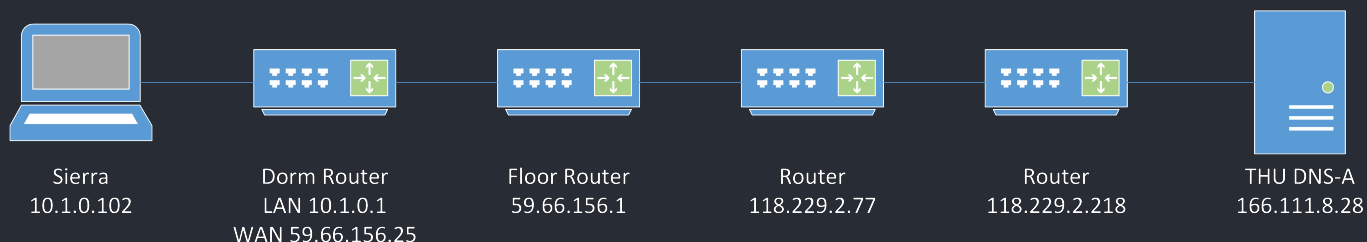
可以观察到：

- `ping -r` 会记录路由的去程和返程，而 `tracert` 不会。这是因为 `ping` 通过设置报文

中的 FLAG 记录路由，从发出 ICMP 报文到接收到响应报文的路由都会被记录；而 `tracert` 是通过逐次增加发出 ICMP 报文的 TTL 并接收 TTL exceeded 报文记录路由，不会记录去程和返程的完整路径；

- 二者记录的路由地址不同（如 59.66.156.X），这是因为 `ping -r` 记录出口 IP，而 `tracert` 记录入口 IP。

可以推测出从本机连接到 DNS 服务器的路径如下：



实验中暂时没有出现不该出现的或不能解释的现象。