Thunderbolt™ Networking Bridging and Routing Instructional White Paper

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1 Introduction

Thunderbolt™ Networking allows for the connection of two or more computers through a Thunderbolt cable. Thunderbolt Networking uses the existing operating system's network sharing functionality to connect the systems as an Ethernet connection. It allows the computers to share resources between themselves as well as connect to devices within the connection chain to copy, transfer, share and/or print files and resources. The Thunderbolt Networking white paper is intended to provide an overview of how to set up network communication between two or more computers connected through Thunderbolt™ Networking technology. It principally focuses on Windows* bridging and routing configurations. Thunderbolt™ Networking Communication is also possible on Apple* computers running Mac OS and between computers running Mac OS and Windows OS, and is briefly covered in this document.

Important:

This document is intended for users with a working knowledge in networking configuration and set-up of Windows 7/8.1, and/or Mac OS. Do not use this document if you do not feel comfortable working with these OS settings. This document uses screen captures and instruction from Windows 7, there may be slight differences in wording, commands and images when using Windows 8 and beyond.

1.1 Equipment checklist for Thunderbolt™ Networking Communication

- Two or more Thunderbolt™ 2 or above enabled computers with at least a single Thunderbolt™ port. For multiple communication, computers in the middle of the bridging/routing chain must have a dual port controller.
- One or more Thunderbolt™ cables.
- Thunderbolt Software 2.5 or above installed on each computer. Thunderbolt Software version can be checked in the: Control Panel -> Programs -> Programs and Features. To update your Thunderbolt Software, contact your system integrator or original equipment manufacturer.

1.2 Basic vs. Multiple Thunderbolt™ Networking Communication

1.2.1 Basic Communication

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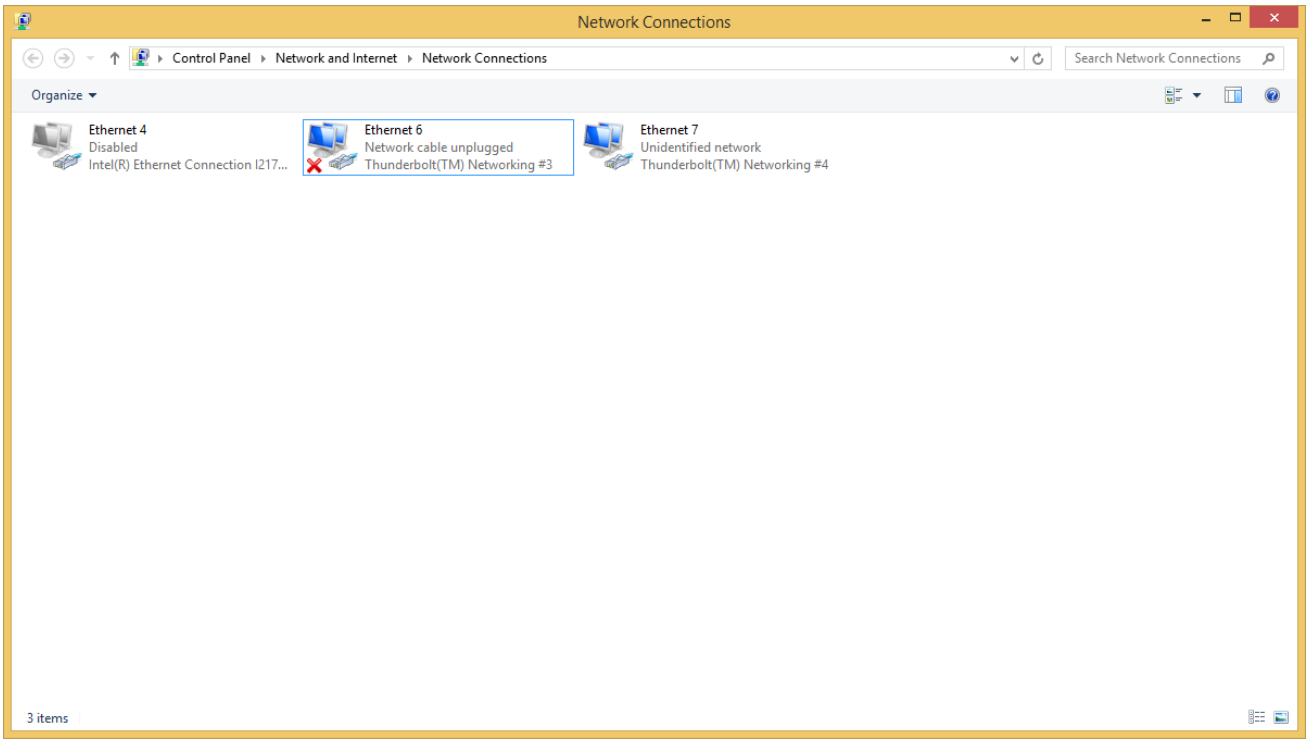
In the basic communication mode, two computers that support Thunderbolt™ networking are connected directly via a Thunderbolt™ cable. Once the standard Thunderbolt Software operations to authorize the access of the other computer have been completed, a new network (Ethernet) adapter will appear in the Windows Network Connections.

Note:

The basic communication mode is not covered in this document.

By default, zero-configuration is applied upon creation of a Thunderbolt™ Network adapter, establishing a default communication link between the Thunderbolt™ Network adapters on the 169.254.0.0/16 subnet. One can refer to any standard TCP/IP configuration that could be applied to this adapter in case advanced settings are needed.



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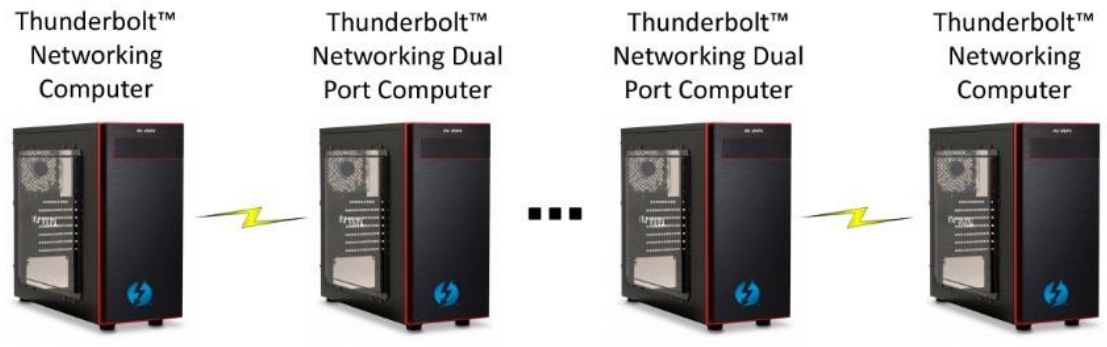
1.2.2 Multiple Communication



In this mode, multiple computers supporting Thunderbolt™ Networking communicate through multiple Peer-to-Peer connections using Thunderbolt™ 2 Dual Port hosts. In order to allow communication between different hosts in the Thunderbolt chain, network properties should be configured. We will cover two modes of operation: Bridging Mode and Routing mode.

Choosing between the two modes of operations mainly depends on user needs. Bridging is easier to set up run while the performance when using multiple computers will decrease with each computer added to the chain. Routing mode adds a certain level of complexity in configuration compared to bridging while generally achieving a higher point to point throughput, especially over longer computer chains.

> **Note:**
>
> All computers in the Thunderbolt™ chain need Thunderbolt™ Software installed, regardless of their position in the chain. The Thunderbolt Networking should be first authorized in the Thunderbolt software before being able to set up the network configuration.

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2 Operation Modes

2.1.1 Bridging Mode

2.1.1.1 Prerequisites

In this mode, dual port computers in the middle of the chain are configured as bridges. This means that all computers in the chain **must share the same subnet** to enable communication between them.

By default, if no IP configuration is applied to the Thunderbolt™ Networking Adapter exposed by the Windows OS, an IP address is allocated by the zero-configuration networking methodology in the 169.254.0.0/16 subnet.

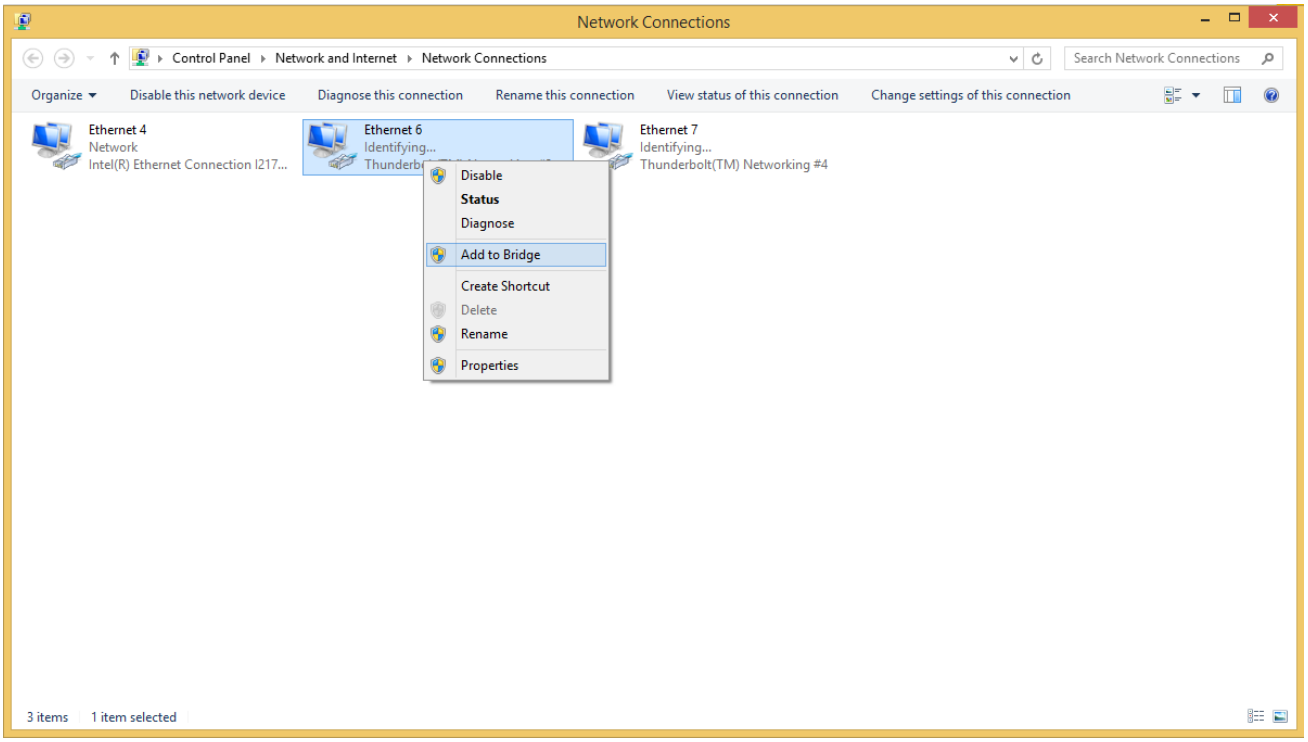
A static IP address can also be configured through the adapter properties menu:

- Right click the adapter icon in the **Network Connections** window and select Properties. Next double click on Internet Protocol Version 4 or Internet Protocol Version 6 item in the Ethernet Properties window Networking tab to setup the static IP address.

2.1.1.2 Configuring Network Bridge on Windows

Both adapters of a dual port computer must be added to Windows Network Bridge. In order to perform this operation:

1. Right click on the first adapter and choose **Add to Bridge** from the menu.



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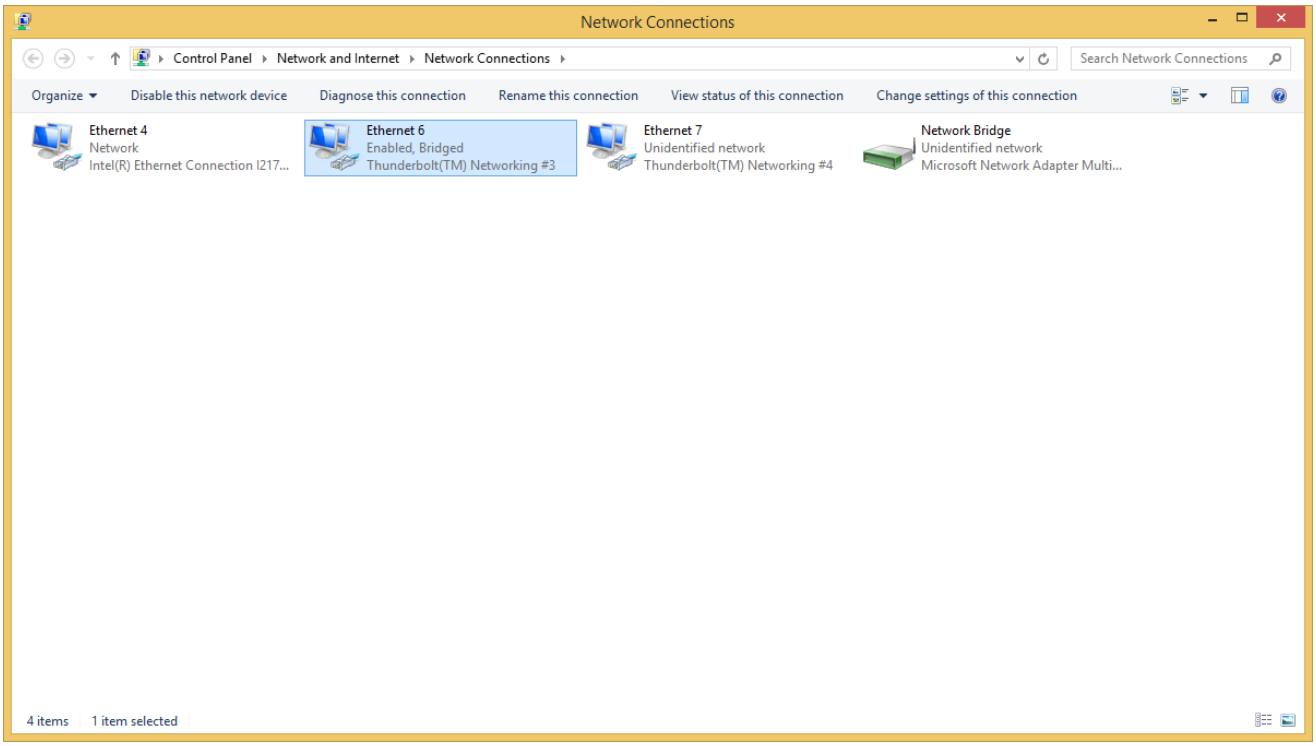
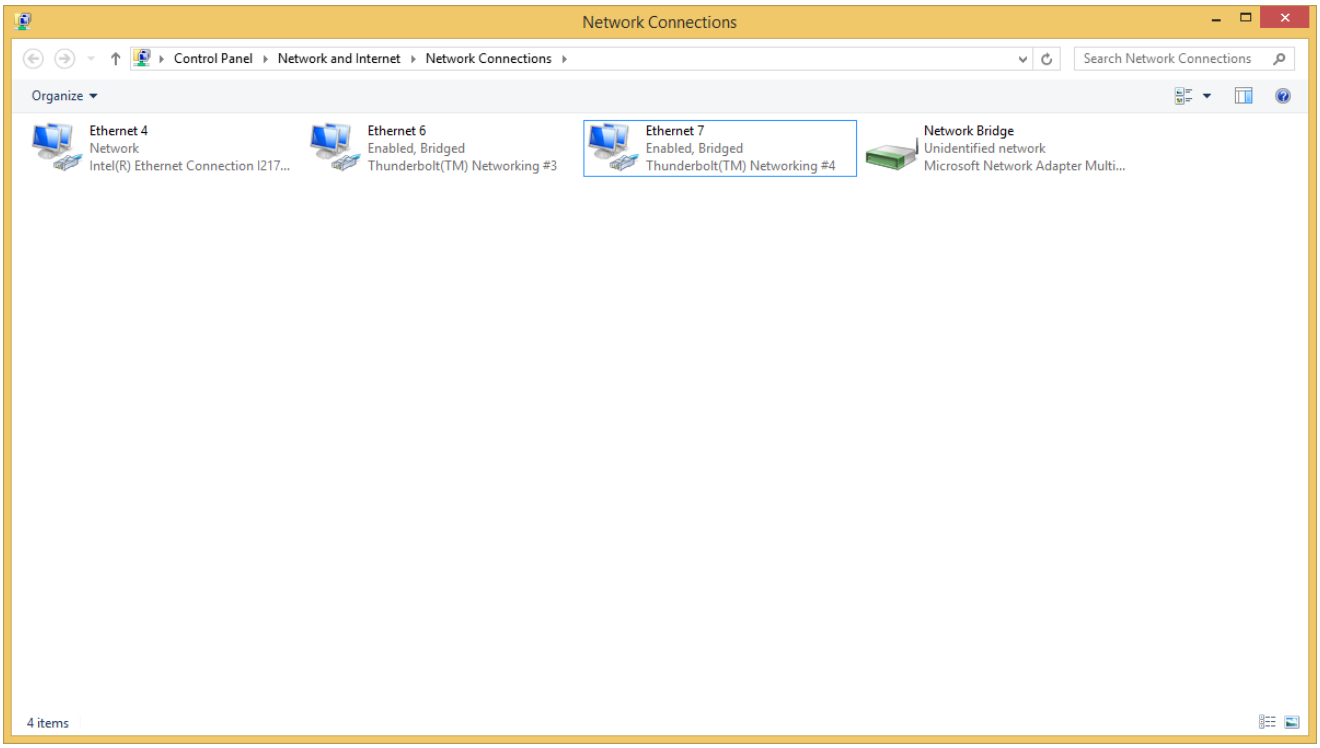


Upon addition, the Thunderbolt™ networking adapter will appear as **Bridged** and, in addition, a new device will appear under the network connection called **Network Bridge**.

2. Repeat the **Add to Bridge** operation as described in step 1 for the second Thunderbolt™ networking adapter. Upon addition, both adapters now show as **Bridged**.



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Note:

At the time the Network Bridge is created, every Bridged Thunderbolt™ networking adapter sees its IP address de-allocated and IP address allocation abilities stolen by Network Bridge. For configuration of the **Network Bridge** IP address, right click on it and then select **Properties**.

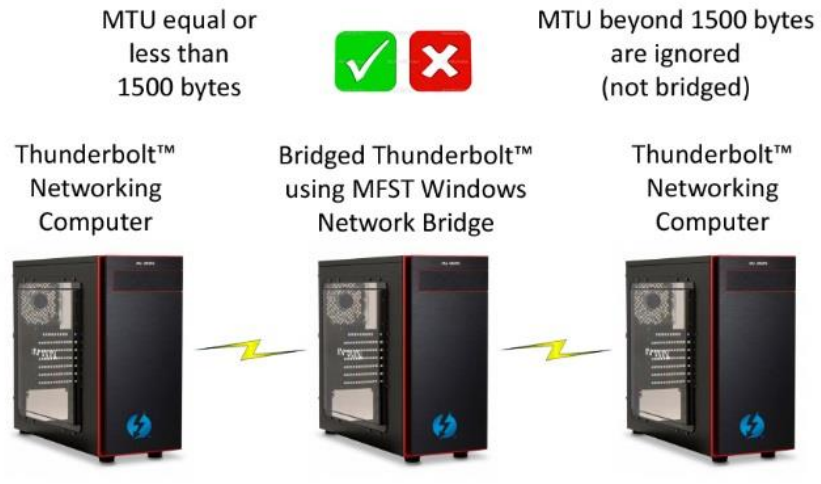
Once done, the bridge is set up and the bridging configuration completed. Computers should now be able to communicate through the bridge.

Hint: from a command prompt, one should be able to ping the other Thunderbolt™ networking computer successfully.

```
C:\> ping  <ip address computer 2>
```

2.1.1.3 Optimizations for Windows Bridging Performance

By default the Thunderbolt Networking adapter is configured to use jumbo frames. For achieving the best communication performance results within the Windows Bridge, the MTU on the computers should be lowered to the bridge Ethernet MTU of 1500 Bytes. This can be done using WindowsNetshell command-line utility.



In order to perform this change the following needs to be executed from an elevated command prompt (Admin) on both computers at the 'edges' of the network.

```
netsh interface ipv4 set subinterface "<name of the Thunderbolt™ adapter>"
mtu=1500 store=persistent
```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Note:

- This configuration should and can be applied on the computers at the edges of the network only. Windows Network Bridge on the intermediate dual port computers prevents any possible change on this parameter as it takes ownership on the adapters.
- In the command line "store=persistent" directive is used to make the change remain even after a restart of the computer.

2.1.2 Routing Mode

2.1.2.1 Overview

In this mode **one or more computers in the chain are configured as routers**, i.e. computers are routing traffic on the different subnets of the Thunderbolt network.

Routing service may be disabled on Windows OS and so it would need to be turned on first. The next section describes how to do this.

2.1.2.2 Enabling Routing on Windows 7/8.1

1. Configure the Windowsregistry tree for enabling routing: this can be done by executing the following command from an elevated Command prompt (Admin) that changes IPEnableRouter value to 1.

```
reg add "HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters"
/f /v "IPEnableRouter" /t REG_DWORD /d 0x1
```

Alternatively this can be carried out through the registry editor:

- Call **regedit**.
- Browse to HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters
- Right click to IPEnableRouter.
- Choose **Modify** and input 1.

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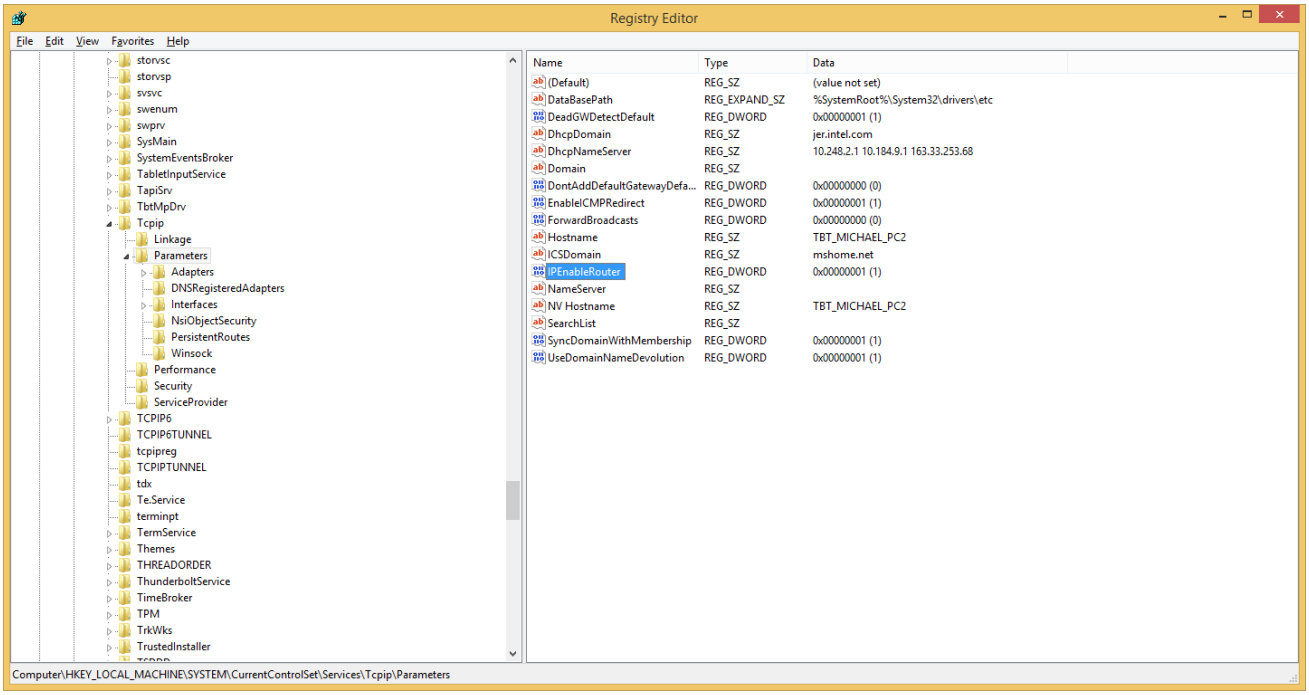

Important:

- Registry Editor is a tool intended for advanced users. Using Registry Editor incorrectly can cause serious problems that may require a re-installation of Windows or other issues. We recommend backing up the registry before making changes.

2. Launch the service that performs the routing:

   The service responsible for the routing is **Routing and Remote Access**, which may be disabled by default on Windows. In addition, the **Remote Access Auto Configuration Manager** service should be running as well.

   From an elevated Command prompt (Admin), run the following command to launch the services GUI.

```
services.msc
```

a. Select **Remote Access Auto Connection Manager**. Right click on properties and choose startup type = Automatic. Click **Apply**. Go to **Services** status and click **Start**. Click **OK** to finish.

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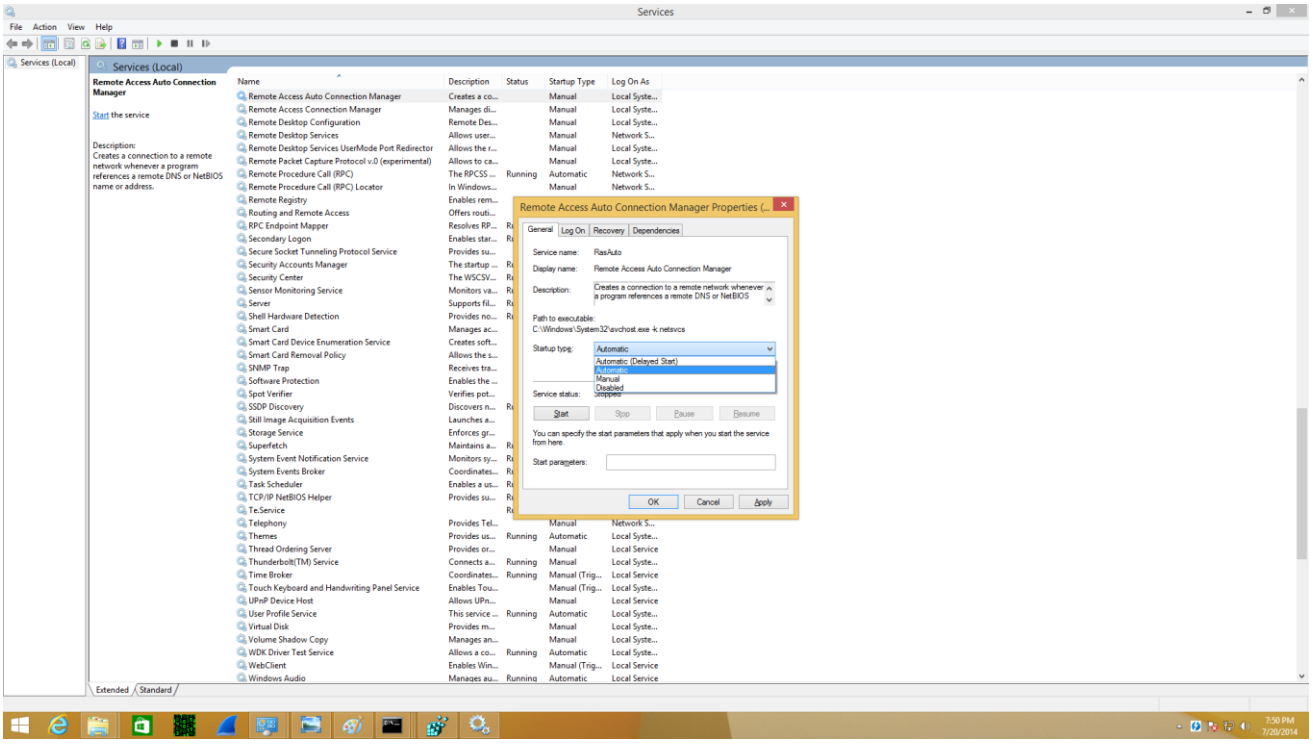
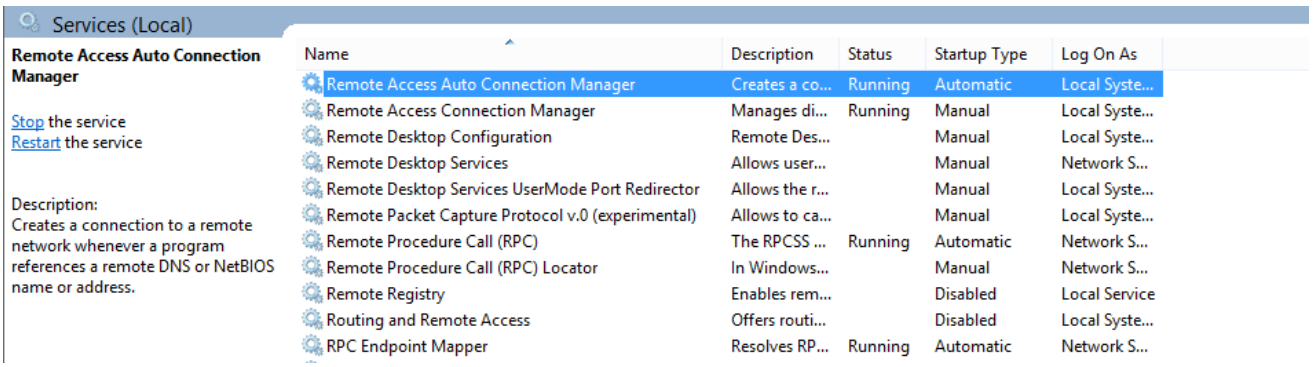
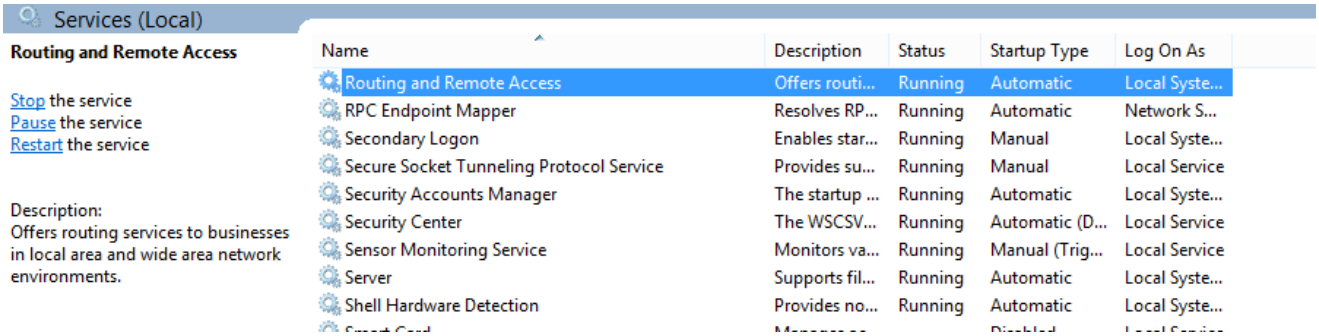


Check that the **Remote Access Auto Connection Manager** service is set to "Automatic" start up type and is running.



b. Select **Routing and Remote Access**. Right click on **Properties** and choose startup type = Automatic. Click **Apply**. Go to **Services** status and click **Start**. Click **OK** to finish.

Check that the **Routing and Remote Access** service is set to "Automatic" start up type and is running.

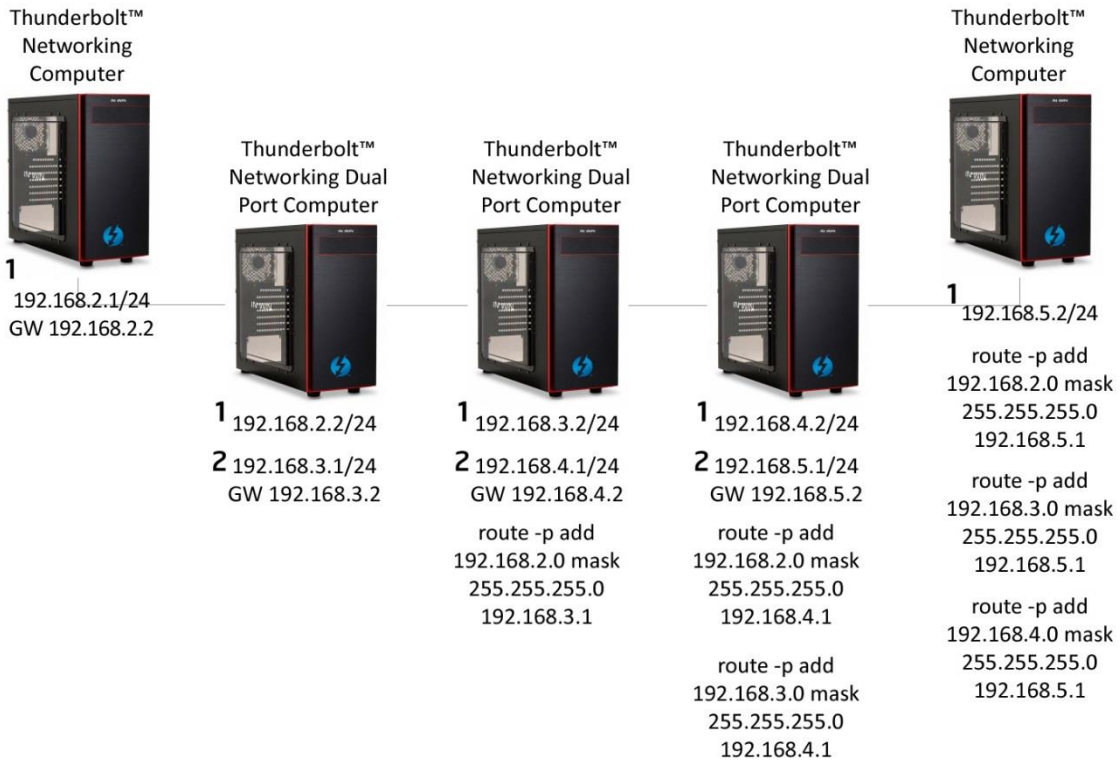


Note:

Choosing startup type "automatic" will allow the service to run each time your computer boots up. In case you want to manually control when routing is active, keep the startup type as "manual".

2.1.2.3 Setting up Routing Configuration (Example)

The illustration shows an example of a network that consists of 5 computers connected using Thunderbolt Networking. Setting up the network involves configuring a default gateway and the routing table on the network nodes.



In this configuration, the traffic is bi-directional and every computer is able to communicate with any other in the routed network.

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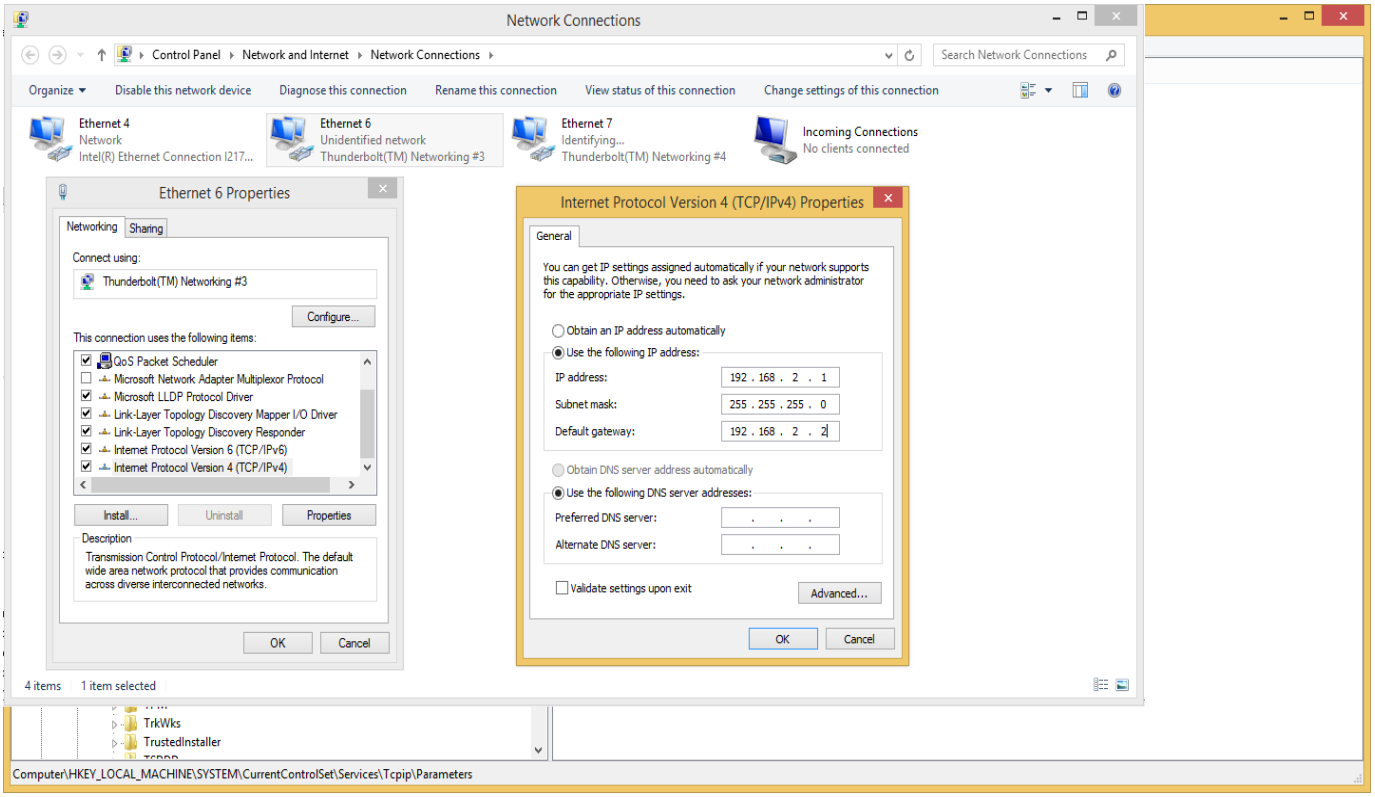
- One direction of the bi-directional traffic (from left to right in the illustration) is achieved by the standard forwarding configuration defined by the default gateway. Defining a default gateway allows the traffic to be routed to the next hop automatically. Therefore every computer has a default gateway set to the closest computer connected through the daisy chain (apart for the last in the chain which does not need to forward further).

- The other direction of the bi-directional traffic (from right to left in the illustration) is achieved by adding static routing configurations to the Thunderbolt™ computer in the network that it would like to communicate with (except to the closest hop subnet shared by the second adapter). In this case, Windows provides the "route" utility to roll out these configurations.



In the above illustration the following steps are carried out for the configuration:

1. The first computer (on the left) needs to be configured to forward packets to the next hop. Right click on the Thunderbolt™ networking adapter. Click **Properties** and then select **Internet Protocol Version 4**. Click **Properties** again and configure **use the following IP address** with IP address = 192.168.2.1, Subnet mask = 255.255.255.0 and Default gateway = 192.168.2.2.

2. The second hop acts like a router. The first Thunderbolt™ networking adapter is configured on the same subnet as the Thunderbolt™ computer (192.168.2.x) to be able to communicate with it. Its address is 192.168.2.2 (without default gateway). The second Thunderbolt™ networking adapter forwards the traffic to the next hop (defined as its default gateway in the adapter) and shares the same subnet as this one, i.e. 192.168.3.x. Its address is 192.168.3.1. Both adapters are configurable as defined in step 1.

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Note:

Defining more than one default gateway in the different Thunderbolt™ networking or Ethernet adapters should be done with care to ensure that the traffic is forwarded to the desired interface. Additional rules may need to be created implicitly in the routing tables to support advanced scenarios.

3. In the illustration, some of the computers are set with a static routing table using Windowsroute utility. The reason is that by default all the traffic is routed to its default gateway or, alternatively, to the attached interface where its second adapter is attached, in case the traffic is intended to the second adapter's subnet. In the case another subnet is not indirectly reachable by the default gateway's path or directly by the second adapter, a static routing statement has to be added. For example, the second computer (from the left) needs to communicate with 192.168.2.x but all the traffic will be directed to its default gateway since it does not belong to any other direct subnets on it. Therefore a static routing statement has to be defined to indicate to the routing function (services) how to route the traffic to 192.168.3.2 interface onto the next hop (on the left in the illustration).

   Therefore for this specific computer, from an elevated command prompt (Admin), the following routing statement should be executed:

```
route -p add  192.168.2.0 mask 255.255.255.0 192.168.3.1
```

Note:

The -p in the command makes it persistent (over restart). Do not use this switch if you want a temporary set-up.

The same kind of statement needs to be repeated at every computer that does not have direct or indirect access to certain subnets. For example, the 4th computer (from left) has to define static routing statements for reaching 192.168.2.x and 192.168.3.x subnets.

Note:

The Windows "tracert" is a useful utility to ensure that the packets are going through the hops they are supposed to. Once the setup is complete, run it on different addresses to ensure that the right routing is defined.

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3 Thunderbolt™ Networking communication with Apple computers

Peer-to-Peer communication is supported on OS X Mavericks version 10.9.2 and beyond, which enables Ethernet network communication over Thunderbolt with any other Apple or Windows computer that deploys a Thunderbolt 2 port. If connecting to a Windows computer, Thunderbolt Software package 2.5 or above must be installed to use Thunderbolt Networking.

On Mac OS, the configuration for Thunderbolt™ networking can be found under **System Preferences -> Network,** and is named **Thunderbolt Bridge**.

Note:

To be able to communicate with another Windows computer through Thunderbolt™ networking, the Apple computer should share the same subnet as the other computer.

In a multiple communication environment, Apple computers act as bridges. Therefore any computer in a networking chain that is Apple should have the same subnets as its connected peers.

For more information about Apple Thunderbolt solutions, refer to the Apple website at https://www.apple.com .

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