



## **10Gb/s (1.25GB/s) Peer-to-Peer Networking (P2P), using Tunderbolt 3 for Situational Awareness and Control Networks (Ver. 1.0)**

### 1.0 Introduction

Situational awareness and control systems depend on analysing enormous amounts of data in real time, enabling the users of these systems to make the best possible decisions about the data being presented in the shortest period of time. These systems are also designed to take over limited control to provide the safest and quickest response possible, in the event that the users of these systems are unable to do so. The drivers of ever increasing amounts of data to be analysed in real time and the speed of the responses required to the results of the data, put heavier demands on the communication networks linking the distributed control (DCS) and supervisory control and data acquisition (SCADA) systems, typically currently built on 1Gb/s Ethernet Networks. The purpose of this brief is to provide an overview of how to set up a 10Gb/s (1.25GB/s) network connection between two or more Windows operating system based computers, connected via their Thunderbolt 3 ports using a suitable Thunderbolt 3 cable (passive copper cable 0.5m (40Gb/s) up to 2/3m (20Gb/s), active copper cable up to 3m (40Gb/s), through to optical fibre Thunderbolt cables up to 60m in length). Thunderbolt networking uses the existing Windows operating system's network sharing functionality to connect the systems as an 10Gb/s Ethernet connection. This enables the computers to share resources between themselves as well as connect to devices within the connection chain to copy, transfer and print files and share programs. Although this brief focuses on the Windows operating system, Thunderbolt networking is also possible on Apple computers running Mac operating systems as well as a combination of computers running Windows and Mac Operating Systems.

### 2.0 Equipment used for Thunderbolt 3 networking communication

- a) Lenovo P71 ThinkPad with an Intel i7-7820HQ 4 core 8 thread 2.9 to 3.9GHz processor and CM238 chipset with two Thunderbolt 3 ports (rated at 40Gb/s) USB Type-C. Samsung 512GB PCIe SSD (SRead 2,800MB/s, SWrite 1,600MB/s). Running Windows 10 Pro 64bit OS, Thunderbolt 3 software driver 17.3.74.8 and Firmware version 43 - latest available.
- b) Lenovo P70 ThinkPad with an Intel Xeon 1575M 4 core 8 thread 3 to 3.9GHz processor and CM236 chipset, also with two Thunderbolt 3 ports (40Gb/s) USB Type-C. SanDisk Extreme Pro 960GB SSD (SRead 550MB/s SWrite 515MB/s). Running Windows 10 Pro 64bit OS, Thunderbolt 3 software driver 17.3.74.8 and Firmware version 25.00 - latest available.
- c) StarTech 2 meter Thunderbolt 3 cable rated at 20Gb/s. Since the maximum Thunderbolt 3 peer-to-peer networking. Speed is 10Gb/s, using a Thunderbolt 3 cable of greater than 20Gb/s would not provide a further increase in speed.

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### 3.0 Basic Thunderbolt 3 connection

Before connecting the two Windows based personal computers together with a Thunderbolt 3 cable, we ensured that each computer's Thunderbolt software and Firmware was installed and was of the latest revision recommended by the personal computer's manufacturer for Thunderbolt networking. The computers were then connected by the cable. Right clicking on the Thunderbolt software icon displays the following options 'About, Settings, View Attached Devices, Approve Attached Devices, Thunderbolt Networking, Manage Approved Devices and Exit'. By right clicking on the 'Settings' menu option provides two tick box options, 'Allow Thunderbolt Networking Connections without user approval' and 'Create a desktop icon for a Thunderbolt Networking connection to an adjacent PC'. Both of these tick boxes should be ticked before pressing the 'OK' button, enabling each computer to see all computers directly connected to it. If the connected computers do not show up in the 'Attached Devices' list, it may be necessary to reboot each PC, then run the Thunderbolt software again until each computer can see the computers they are directly connected to. If this does not resolve the problem, switching the Thunderbolt cable to another Thunderbolt 3 port may enable the connected computers to be recognised. Once the standard Thunderbolt software is authorised to access the other computers on the Thunderbolt 3 chain, a new network (Ethernet) adaptor will appear in the Windows Network Connections. By default the zero-configuration is applied upon creation of a Thunderbolt Network adaptor, establishing a default communication link between the Thunderbolt network adaptors on the 169.254.0.0/16 subnet.

### 3.1 Sharing files and resources on a Thunderbolt 3 network

As with standard Ethernet networks, in order to share files and resources on computers connected via the Thunderbolt Network chain, permission needs to be granted on the relevant personal computer to share these resources. By Right clicking on the Drive, File or Resource to be shared, a number of sharing options are displayed such as 'give access to', 'send to', and 'copy'. By selecting 'give access to' and selecting the relevant computer on the Thunderbolt chain, will enable the selected and authorised computer to access the drive or folder that has been shared. If this does not happen automatically, it may be necessary to restart the computers to enable them to initialise the connection.

### 3.2 Multiple Thunderbolt 3 connections

Multiple computers supporting Thunderbolt networking communicate through multiple peer-to-peer connections using Thunderbolt Dual Port hosts. In order to enable communication between different hosts in the Thunderbolt chain, network properties should be configured as Bridging Mode or Routing Mode. Bridging mode is easier to set up however

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the performance when using multiple computers will decrease with each computer added. Routing mode adds a higher level of complexity in configuration while generally achieving a higher point-to-point throughput. All computers on the Thunderbolt chain need Thunderbolt software installed, regardless of their position in the chain. Thunderbolt networking should be first authorised in the Thunderbolt software before setting up the network configuration.

In Bridging mode Dual Thunderbolt port computers in the middle of the Thunderbolt chain are configured as bridges, which share the Same subnet to allow communication between them. Whereas in Routing Mode one or more computers in the Thunderbolt chain are configured as routers, routing traffic on different subnets of the thunderbolt network.

#### 4.0 Results

The actual throughput of the 10Gb/s (1.25GB/s) Thunderbolt 3 connection using the hardware specified in section 2.0 was 500MB/s (4Gb/s) average from the Lenovo P71 (Port 1) Writing to the Lenovo P70 (Port 2) and 800MB/s (6.4Gb/s) Writing from the Lenovo P70 (Port 2) to the Lenovo P71 (Port 1). With the obvious bottleneck being the SanDisk Extreme Pro SSD installed in the Lenovo P70, which is restricted to a specified Sequential Read speed of 550MB/s and Sequential Write of 515MB/s. In fact the SanDisk SSD appears to be accomplishing much higher rates of Sequential Read speed than that specified in the datasheet. In order to fully define the actual data speed of the Thunderbolt 3 network, a faster SSD similar to the Samsung PCIe Gen3 x4 M.2 SSD installed in the Lenovo P71 needs to be installed in the Lenovo P70. However an actual data speed of 1.2GB/s (9.6Gb/s) or greater is expected, as this has been demonstrated in a number of on-line references including one by Intel who developed the Thunderbolt interface.

#### 5.0 Conclusions

Thunderbolt 3 10Gb/s (1.2GB/s) networking between two or more personal computers running Windows 10 Pro operating system is possible, by using a standard Thunderbolt 3 cable connected between each computers Thunderbolt 3 USB-C port, with the Thunderbolt software and firmware installed on each computer. The distance that a Thunderbolt 3 network can span is determined by the type of Thunderbolt 3 cable used. Since the Thunderbolt Interface for peer-to-peer networking is restricted to 10Gb/s, the Thunderbolt cable used can be specified at 20Gb/s or less, since a better Thunderbolt cable will not yield any speed improvement over 10Gb/s. However 20Gb/s passive cables are specified for 2 meters, active cables 3 meters (40Gb/s) and optical fibre at 60m (40Gb/s).