TLS10GC-IP Demo on KR260 Instruction

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TLS10GC-IP Demo on KR260 Instruction

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Design Gateway presents a demonstration showcasing the TLS10GC-IP core's ability to offload encryption and decryption tasks during secure browsing with the Lynx web browser on the Kria KR260 Robotics Starter Kit. A pre-configured SD card image is provided, enabling users to easily deploy the setup on the KR260 and achieve higher data transfer speeds while preserving the same user experience as traditional systems.

This document provides instructions for using the accelerated Lynx web browser powered by TLS10GC-IP on the KR260. It is divided into two main sections: environment setup and demonstration.

1 Environment Setup

An overview of the test environment is shown as Figure 1. The setup includes the KR260 board and a test PC connected to the same gateway to enable communication with each other and access to the internet. Users can test the normal operation of the Lynx web browser for internet browsing and measure download speeds by connecting to a Node.js server running on the test PC. This setup facilitates data transfer through the 10G Ethernet path for performance evaluation.

1.1 Test Environment

To operate TLS10GC-IP demo on KR260, please prepare following test environment.

1) FPGA development boards (KR260 board).
2) Test PC with 10 Gigabit Ethernet or connecting with 10 Gigabit Ethernet card.
3) 10 Gb Ethernet cable:
   a) 10 Gb SFP+ Passive Direct Attach Cable (DAC) which has 1-m or less length
   b) 10 Gb SFP+ Active Optical Cable (AOC)
   c) 2x10 Gb SFP+ transceiver (10G BASE-R) with optical cable (LC to LC, Multimode)
4) Micro USB cable for UART connection connecting between KR260 board and Host PC.
5) Serial console software such as TeraTerm installed on PC. The setting on the console is Baud rate=115200, Data=8-bit, Non-parity and Stop=1.
6) SD card image provided by Design Gateway for running on KR260.

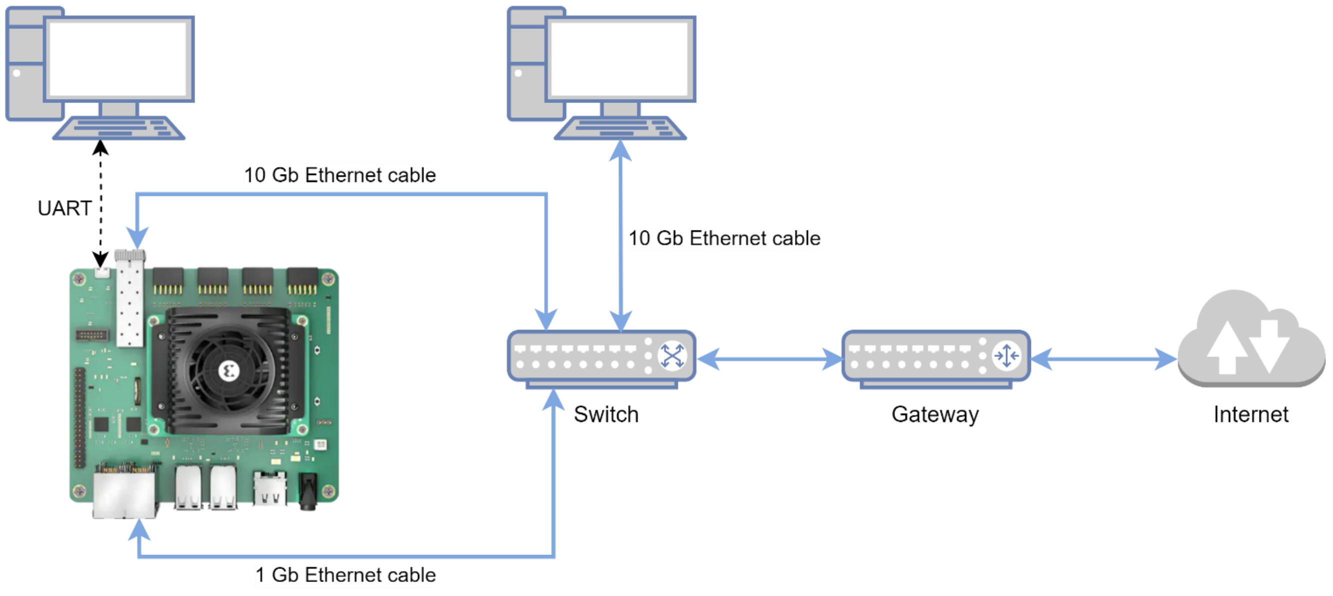


Figure 1 TLS10GC-IP demo on KR260 board test environment

1.2 KR260 Setup

After flashing the provided image to the SD card, boot the KR260 with the card.

Default login credentials:

username: ubuntu

password: kriakr260

Set up the system environment using the following commands:

1) Unload the default hardware application bitstream.

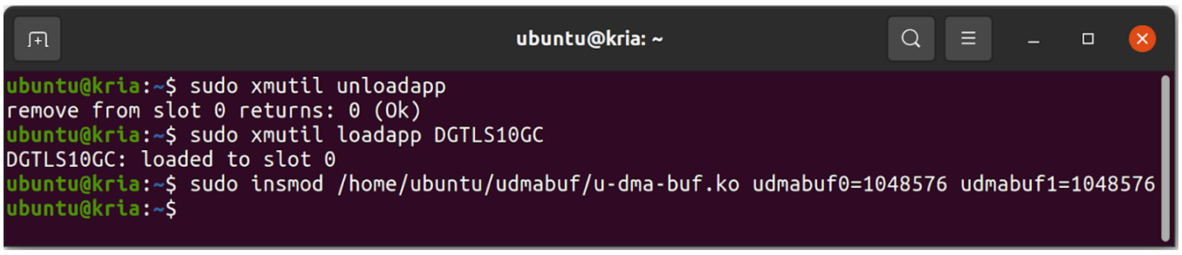
```
sudo xmutil unloadapp
```

2) Load the hardware application bitstream named DGTLS10GC.
The DGTLS10GC application includes the hardware accelerators used in this demonstration.

```
sudo xmutil loadapp DGTLS10GC
```

3) Load the udmabuf kernel driver and specify the size of the DMA buffer in bytes. In this demo, udmabuf0 is allocated 1MB to use as Tx Buffer and udmabuf1 is allocated 1MB to use as Rx Buffer.

```
sudo insmod /home/ubuntu/udmabuf/u-dma-buf.ko udmabuf0= 1048576 udmabuf1=1048576
```



```
ubuntu@kria:~$ sudo xmutil unloadapp
remove from slot 0 returns: 0 (Ok)
ubuntu@kria:~$ sudo xmutil loadapp DGTLS10GC
DGTLS10GC: loaded to slot 0
ubuntu@kria:~$ sudo insmod /home/ubuntu/udmabuf/u-dma-buf.ko udmabuf0=1048576 udmabuf1=1048576
ubuntu@kria:~$
```

Figure 2 Example result for loading application on KR260 board

1.3 Lynx Web Browser Setup

After configuring the Ubuntu environment on the KR260, users can utilize the Lynx web browser to browse web servers. Based on TLS10GC-IP specification, the DGTLS10GC application, which includes TLS10GC-IP, can offload CPU workloads when connecting to a server that supports TLS1.3 using TLS_AES_256_GCM_SHA384 cipher suite.

This demonstration showcases how Lynx can be used to connect to the internet via the HTTPS protocol using the DGTLS10GC hardware application. The Ethernet interface and hardware acceleration settings can be configured via the command line by defining the ECONN and HW_ENABLE parameters:

When ECONN=10, Lynx establishes TCP and TLS connection through the 10G Ethernet port. Otherwise, it defaults to the 1G Ethernet port, leveraging the socket kernel for TCP connections and OpenSSL for TLS connections in the standard workflow.

For a 10G Ethernet connection with hardware acceleration, setting HW_ENABLE=1 enables the TLS10GC-IP core to offload encryption and decryption tasks. If HW_ENABLE is set to any other value, Lynx will use OpenSSL for TLS tasks. To connect via the 10G Ethernet interface, users must configure the necessary network parameters by editing the DG.cfg file located at /home/ubuntu/tool/lynx/etc/DG.cfg. The parameters are described below:

GATEWAY_IP

Description: Specifies the gateway IP address of the 10G Ethernet interface in dot-decimal notation.

Default Value: 192.168.11.2

FPGA_IP

Description: Specifies the IP address of the 10G Ethernet interface in dot-decimal notation.

Default Value: 192.168.11.84

FPGA_MAC

Description: Specifies the MAC address of the 10G Ethernet interface in dot-decimal notation.

Default Value: 80.00.11.22.33.44

Remark:

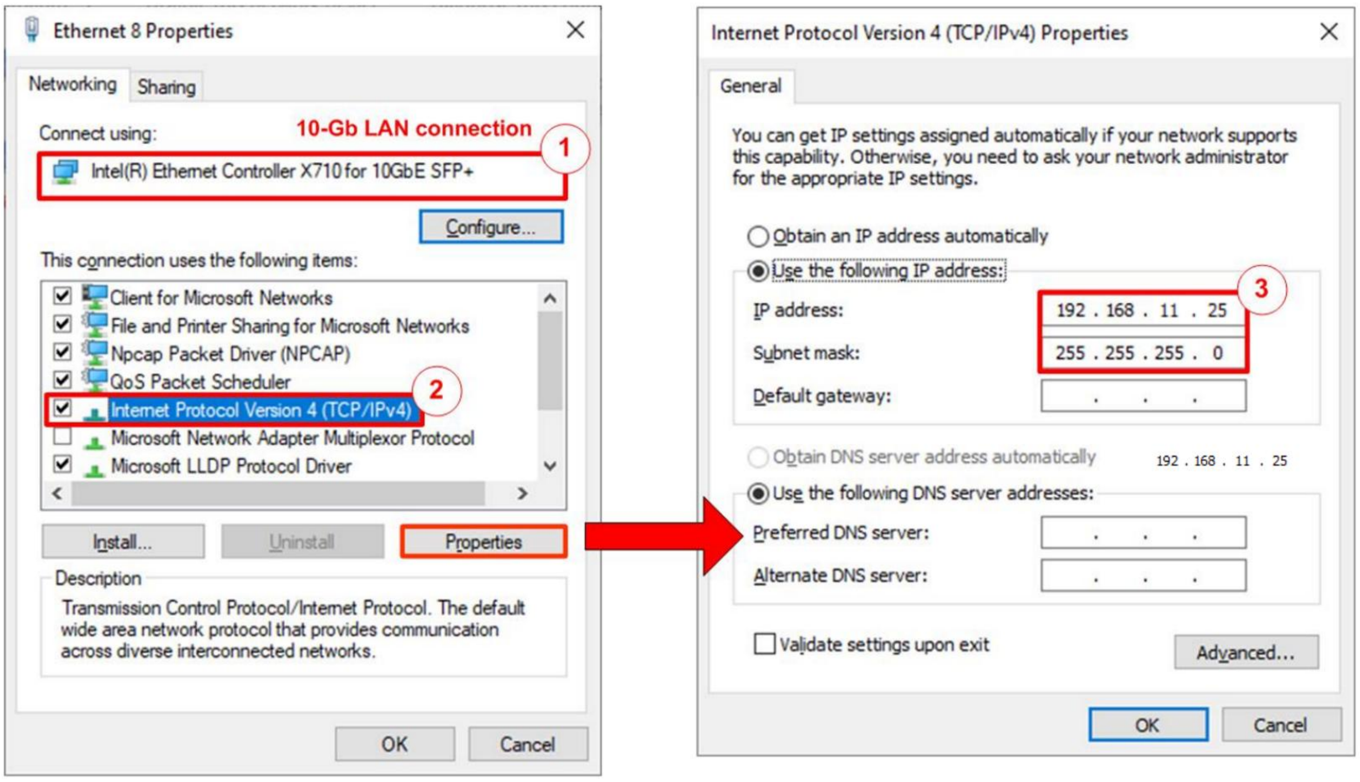
- This demonstration supports TLS and TCP/IP protocols via the 10G Ethernet interface. Lynx may communicate using other protocols via the 1G Ethernet interface.
- To minimize additional effort in developing a device driver, users can use existing open-source device drivers to interface with the hardware. This demo uses the /dev/mem and /dev/udmabuf device drivers.

1.4 PC Setup

When connecting to the internet, data transfer may be slower due to external network conditions. By connecting to a server within the same subnet, we can ensure that data is transferred exclusively through the 10G Ethernet, allowing for controlled and consistent testing conditions.

This demonstration showcases running Node.js server on Test PC. Before running demo, please check the network setting on PC. The example of setting 10 Gb Ethernet card is described as follows.

1.4.1 IP Setting


Ethernet 8 Properties

Networking | Sharing

Connect using: 10-Gb LAN connection (1)

Intel(R) Ethernet Controller X710 for 10GbE SFP+

This connection uses the following items:

- [✓] Client for Microsoft Networks
- [✓] File and Printer Sharing for Microsoft Networks
- [✓] Npcap Packet Driver (NPCAP)
- [✓] QoS Packet Scheduler
- [✓] Internet Protocol Version 4 (TCP/IPv4) (2)
- [ ] Microsoft Network Adapter Multiplexor Protocol
- [✓] Microsoft LLDP Protocol Driver

Description

Transmission Control Protocol/Internet Protocol. The default wide area network protocol that provides communication across diverse interconnected networks.

Internet Protocol Version 4 (TCP/IPv4) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

Obtain an IP address automatically [✓ Use the following IP address:] (3)

IP address: 192 . 168 . 11 . 25

Subnet mask: 255 . 255 . 255 . 0

Default gateway: . . .

Obtain DNS server address automatically 192 . 168 . 11 . 25 [✓ Use the following DNS server addresses:]

Preferred DNS server: . . .

Alternate DNS server: . . .

[ ] Validate settings upon exit

Figure 3 Setting IP address for PC

1) Open Local Area Connection Properties of 10 Gb connection, as shown in the left window of Figure 3.
2) Select "TCP/IPv4" and then click Properties.
3) Set IP address = 192.168.11.25 and Subnet mask = 255.255.255.0, as shown in the right window of Figure 3.

1.4.2 Speed and Duplex Setting

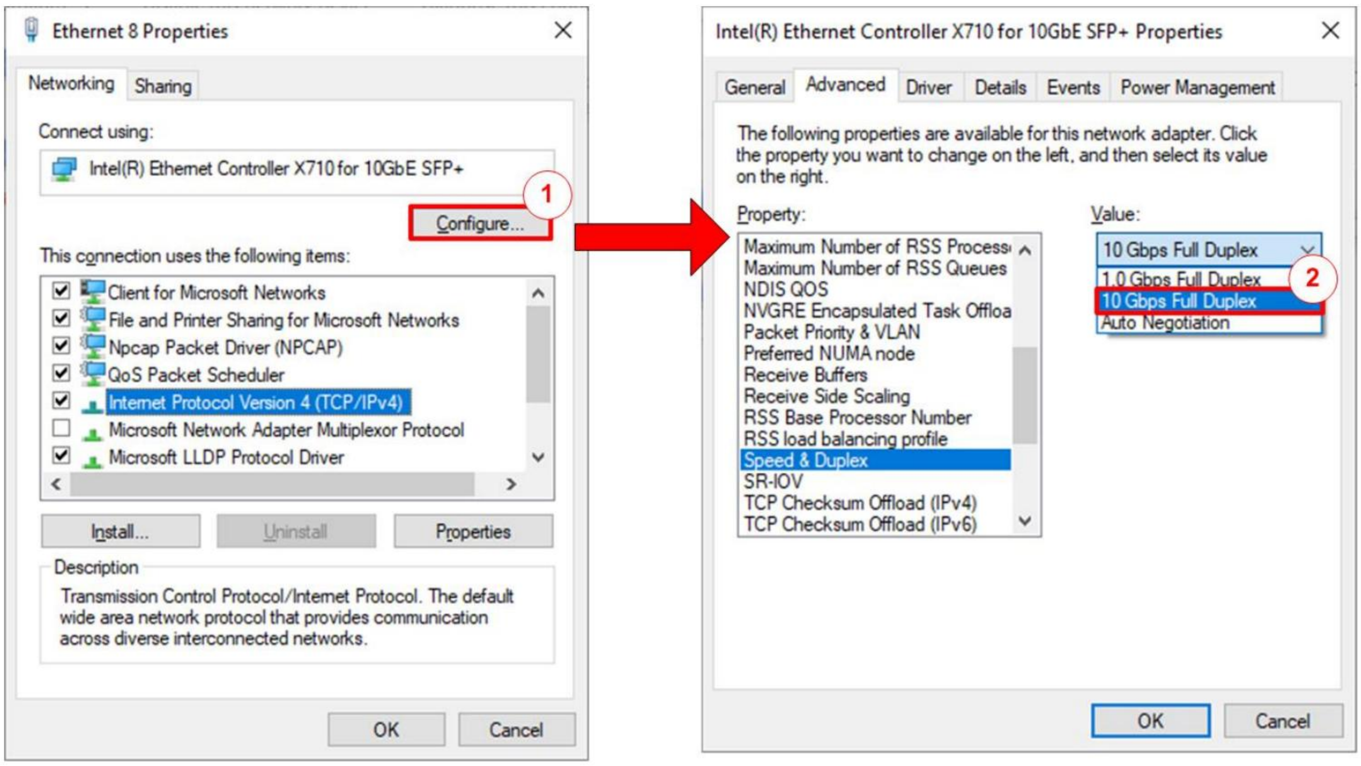

Ethernet 8 Properties
Networking
Sharing
Connect using:
Intel(R) Ethernet Controller X710 for 10GbE SFP+
Configure...
1
This connection uses the following items:
Client for Microsoft Networks
File and Printer Sharing for Microsoft Networks
Npcap Packet Driver (NPCAP)
QoS Packet Scheduler
Internet Protocol Version 4 (TCP/IPv4)
Microsoft Network Adapter Multiplexor Protocol
Microsoft LLDP Protocol Driver
Install...
Uninstall
Properties
Description
Transmission Control Protocol/Internet Protocol. The default wide area network protocol that provides communication across diverse interconnected networks.
OK
Cancel
Intel(R) Ethernet Controller X710 for 10GbE SFP+ Properties
General
Advanced
Driver
Details
Events
Power Management
The following properties are available for this network adapter. Click the property you want to change on the left, and then select its value on the right.
Property:
Maximum Number of RSS Process
Maximum Number of RSS Queues
NDIS QOS
NVGRE Encapsulated Task Offloa
Packet Priority & VLAN
Preferred NUMA node
Receive Buffers
Receive Side Scaling
RSS Base Processor Number
RSS load balancing profile
Speed & Duplex
SR-IOV
TCP Checksum Offload (IPv4)
TCP Checksum Offload (IPv6)
Value:
10 Gbps Full Duplex
1.0 Gbps Full Duplex
10 Gbps Full Duplex
Auto Negotiation
2
OK
Cancel

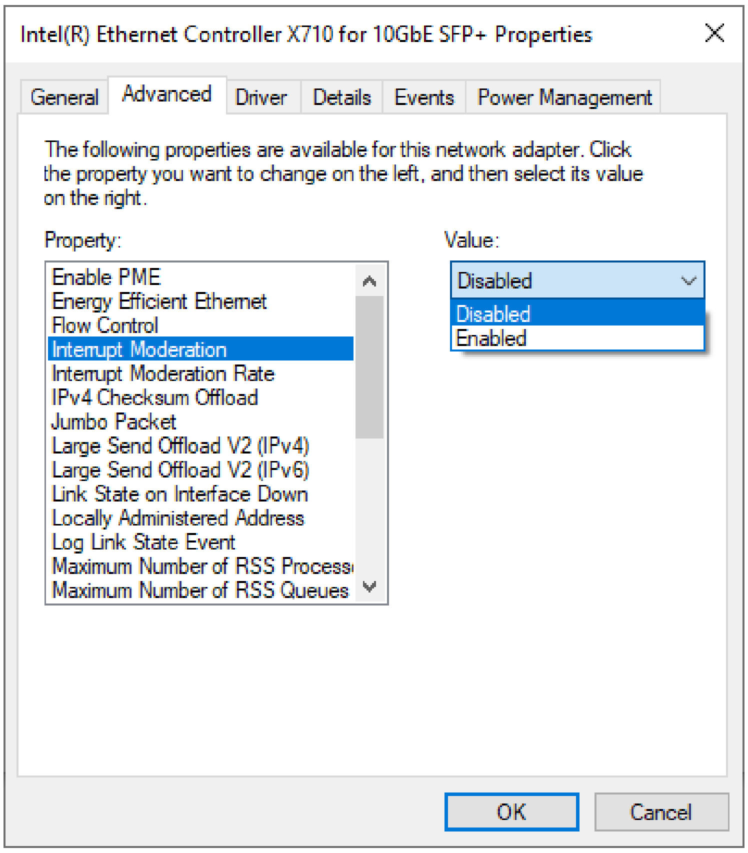
Figure 4 Set Link Speed = 10 Gbps

1) On Local Area Connection Properties window, click “Configure”, as shown in Figure 4.
2) On Advanced Tab, select “Speed and Duplex”. Set the value to “10 Gbps Full Duplex” for running 10 Gigabit transfer test, as shown in Figure 4.

1.4.3 Network Properties Setting

Some of network parameter setting may affect to network performance. The example of network properties setting as follows.

1) On “Interrupt Moderation” window, select “Disabled” to disable interrupt moderation which would minimize the latency during transferring data, as shown in Figure 5.


Intel(R) Ethernet Controller X710 for 10GbE SFP+ Properties

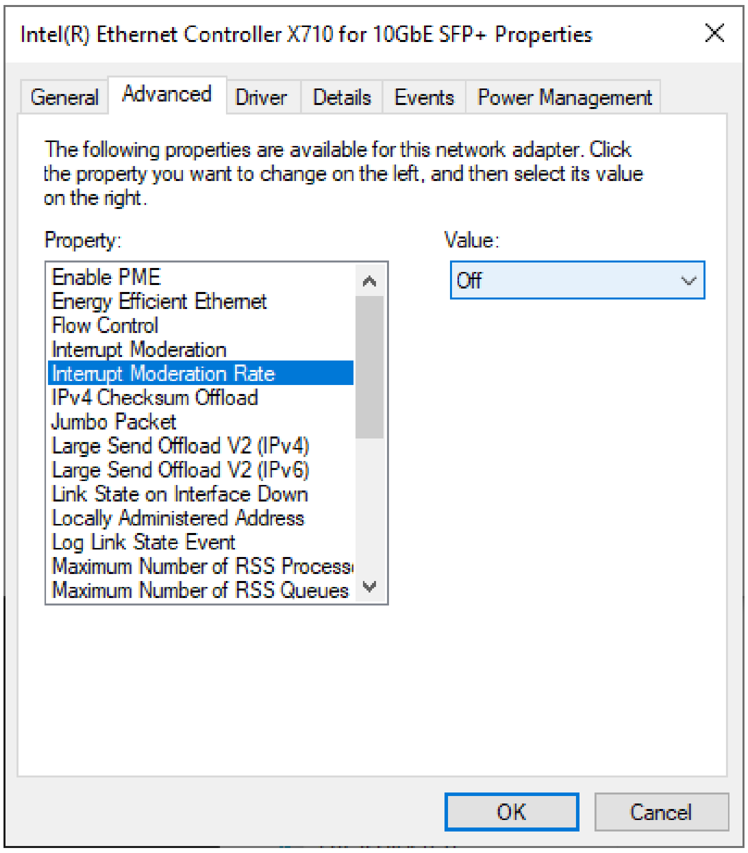
The following properties are available for this network adapter. Click the property you want to change on the left, and then select its value on the right.

Property:
Enable PME
Energy Efficient Ethernet
Flow Control
Interrupt Moderation
Interrupt Moderation Rate
IPv4 Checksum Offload
Jumbo Packet
Large Send Offload V2 (IPv4)
Large Send Offload V2 (IPv6)
Link State on Interface Down
Locally Administered Address
Log Link State Event
Maximum Number of RSS Processo
Maximum Number of RSS Queues

Value:
Disabled
Disabled
Enabled

Figure 5 Interrupt Moderation

2) On "Interrupt Moderation Rate" window, set value to "OFF", as shown in Figure 6.


Intel(R) Ethernet Controller X710 for 10GbE SFP+ Properties

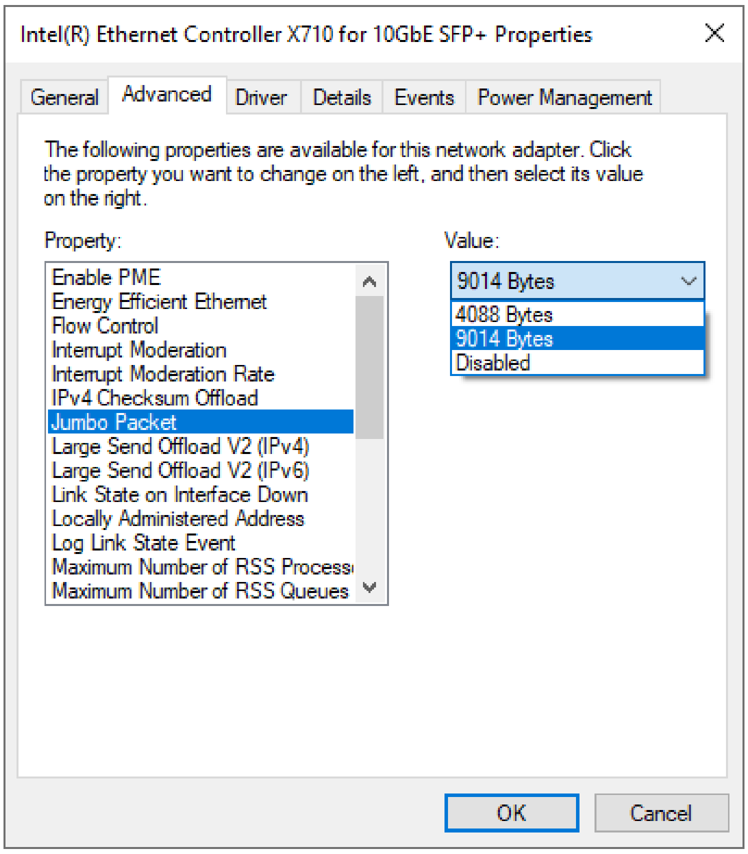
The following properties are available for this network adapter. Click the property you want to change on the left, and then select its value on the right.

Property:
Enable PME
Energy Efficient Ethernet
Flow Control
Interrupt Moderation
Interrupt Moderation Rate
IPv4 Checksum Offload
Jumbo Packet
Large Send Offload V2 (IPv4)
Large Send Offload V2 (IPv6)
Link State on Interface Down
Locally Administered Address
Log Link State Event
Maximum Number of RSS Process
Maximum Number of RSS Queues

Value: Off

Figure 6 Interrupt Moderation Rate

3) On "Jumbo packet" window, set value to "9014 Bytes", as shown in Figure 7.


Intel(R) Ethernet Controller X710 for 10GbE SFP+ Properties

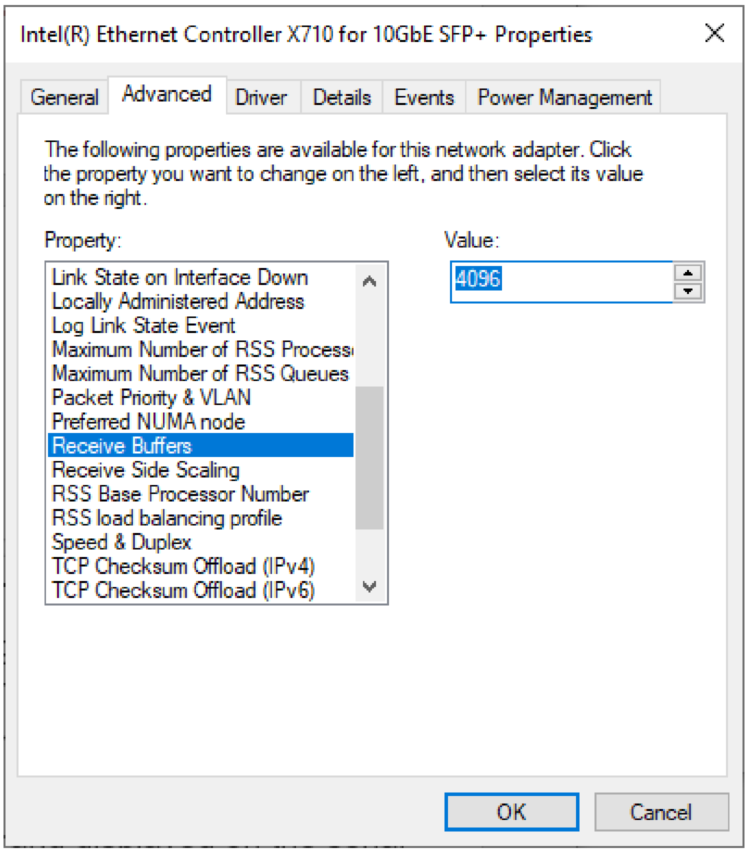
The following properties are available for this network adapter. Click the property you want to change on the left, and then select its value on the right.

Property:
Enable PME
Energy Efficient Ethernet
Flow Control
Interrupt Moderation
Interrupt Moderation Rate
IPv4 Checksum Offload
Jumbo Packet
Large Send Offload V2 (IPv4)
Large Send Offload V2 (IPv6)
Link State on Interface Down
Locally Administered Address
Log Link State Event
Maximum Number of RSS Process
Maximum Number of RSS Queues

Value: 9014 Bytes
4088 Bytes
9014 Bytes
Disabled

Figure 7 Jumbo packet

4) On “Receive Buffers” window, set value to the maximum value, as shown in Figure 8.



Intel(R) Ethernet Controller X710 for 10GbE SFP+ Properties

The following properties are available for this network adapter. Click the property you want to change on the left, and then select its value on the right.

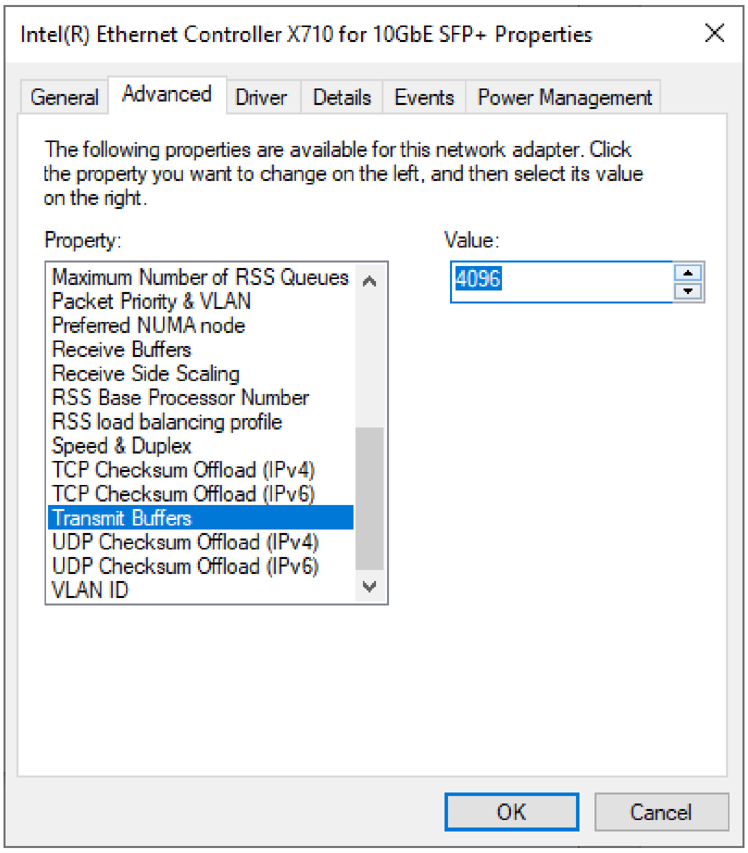
Property:

- Link State on Interface Down
- Locally Administered Address
- Log Link State Event
- Maximum Number of RSS Process
- Maximum Number of RSS Queues
- Packet Priority & VLAN
- Preferred NUMA node
- Receive Buffers
- Receive Side Scaling
- RSS Base Processor Number
- RSS load balancing profile
- Speed & Duplex
- TCP Checksum Offload (IPv4)
- TCP Checksum Offload (IPv6)

Value: 4096

Figure 8 Receive Buffers

5) On “Transmit Buffers” window, set value to the maximum value, as shown in Figure 9.



Intel(R) Ethernet Controller X710 for 10GbE SFP+ Properties

The following properties are available for this network adapter. Click the property you want to change on the left, and then select its value on the right.

Property:

- Maximum Number of RSS Queues
- Packet Priority & VLAN
- Preferred NUMA node
- Receive Buffers
- Receive Side Scaling
- RSS Base Processor Number
- RSS load balancing profile
- Speed & Duplex
- TCP Checksum Offload (IPv4)
- TCP Checksum Offload (IPv6)
- Transmit Buffers
- UDP Checksum Offload (IPv4)
- UDP Checksum Offload (IPv6)
- VLAN ID

Value: 4096

Figure 9 Transmit buffers

1.5 Node.js Server Setup

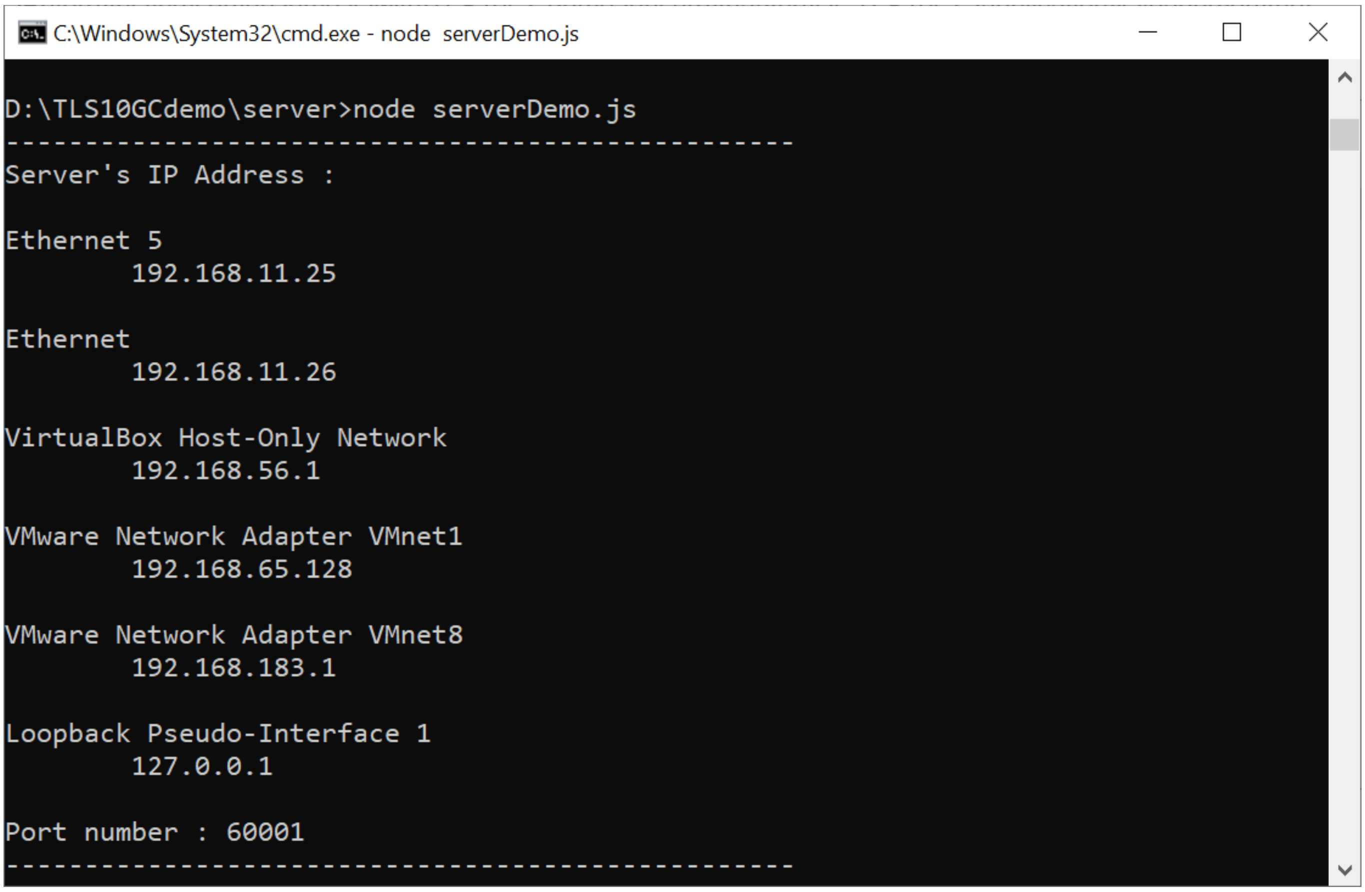
In this demonstration, a sample server is created using Node.js. The server opens port 60001 for HTTPS connection. The required files for running the server are provided in server folder, which contains the following:

1) serverDemo.js: The main script for running server.
2) key.pem and certificate.pem: Sample RSA key information and the server's certificate.
3) server/uploads: A folder for storing files uploaded from the client.
4) server/log: A folder containing the following files:
    a) Example HMTL pages: DG.html, bike.html, pinkpanther.html and rex.html. Users can add files to server/log folder to be the resource for downloading.
    b) submit.html: Allows Lynx web browser to upload data to the server, which is then saved in uploads folder.
    c) testSpeed.html: Enables Lynx web browser to upload data to the server for performance testing.

When serverDemo.js is executed*, server's IP address and port number are displayed on console, as shown in Figure 10.

Caution

* Before running serverDemo.js, ensure that the 10Gb Ethernet connection is active. This step is essential for the server to detect and utilize the 10Gb Ethernet interface.



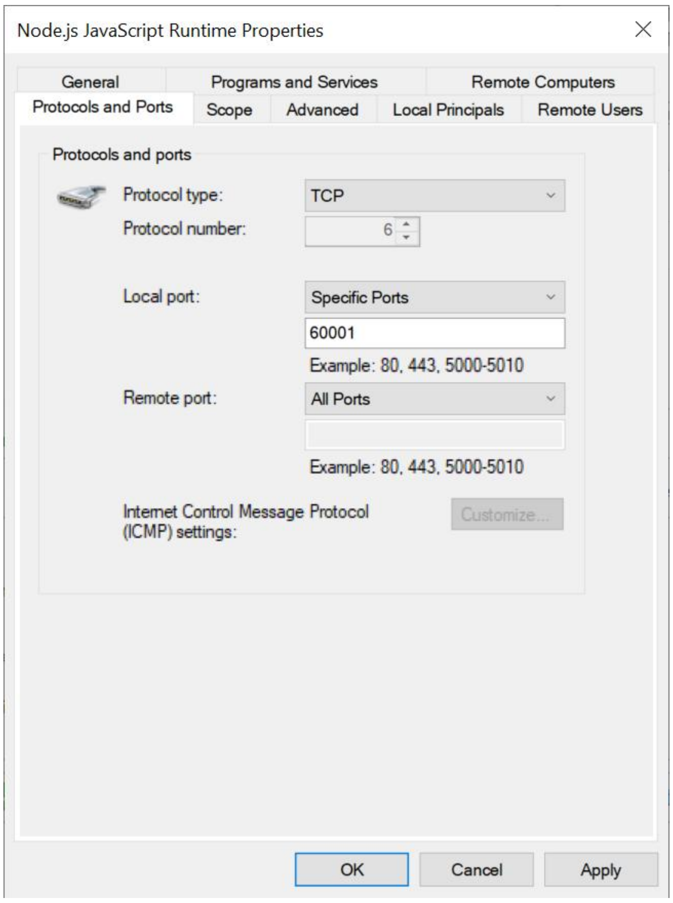
C:\Windows\System32\cmd.exe - node serverDemo.js

```
D:\TLS10GCdemo\server>node serverDemo.js
--------------------------------------------------
Server's IP Address :

Ethernet 5
        192.168.11.25

Ethernet
        192.168.11.26

VirtualBox Host-Only Network
        192.168.56.1

VMware Network Adapter VMnet1
        192.168.65.128

VMware Network Adapter VMnet8
        192.168.183.1

Loopback Pseudo-Interface 1
        127.0.0.1

Port number : 60001
--------------------------------------------------
```

Figure 10 Server console when serverDemo.js is executed

In case of client cannot access node.js server, please check firewall setting as below,

1) Go to Windows Defender Firewall with Advanced Security
2) Click on "Inbound Rules"
3) Search for "Node.js JavaScript Runtime" and open its properties
4) Go to "Protocols and Ports" tab and set Protocol type = TCP, Local port = Specific Ports that server on PC open. By default, the sample node.js server opens port 60001. Local port number is set to 60001, as shown in Figure 11.
5) Go to "Advanced" tab and mark the profile boxes that match the network profile of ethernet card, as shown in Figure 12.



Node.js JavaScript Runtime Properties

Protocols and ports

Protocol type: TCP

Protocol number: 6

Local port: Specific Ports

60001

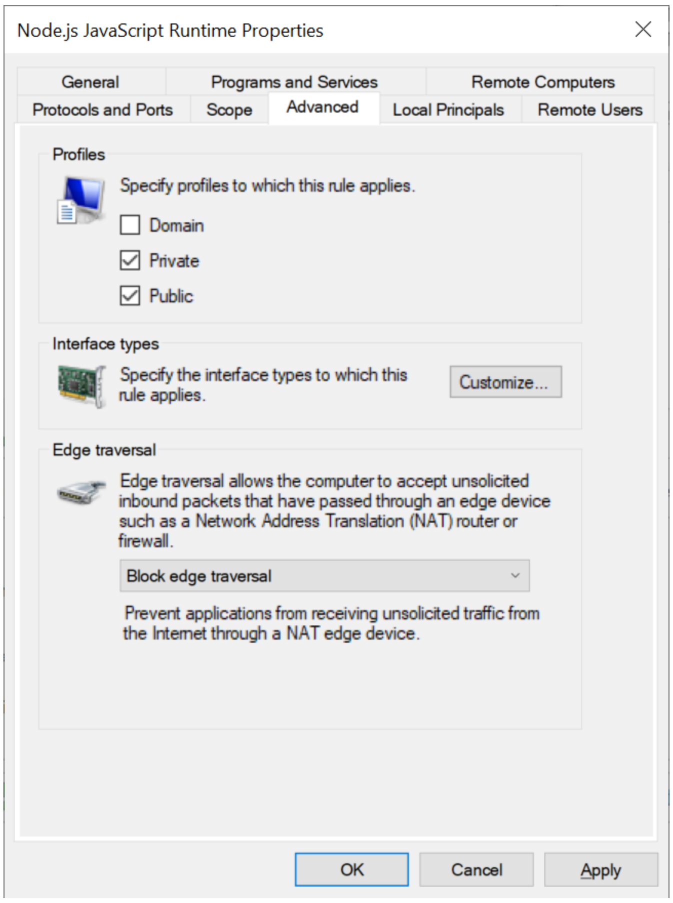
Example: 80, 443, 5000-5010

Remote port: All Ports

Example: 80, 443, 5000-5010

Internet Control Message Protocol (ICMP) settings:

Figure 11 Protocols and Ports setting



Node.js JavaScript Runtime Properties

Profiles

Specify profiles to which this rule applies.

☐ Domain

☑ Private

☑ Public

Interface types

Specify the interface types to which this rule applies.

Edge traversal

Edge traversal allows the computer to accept unsolicited inbound packets that have passed through an edge device such as a Network Address Translation (NAT) router or firewall.

Block edge traversal

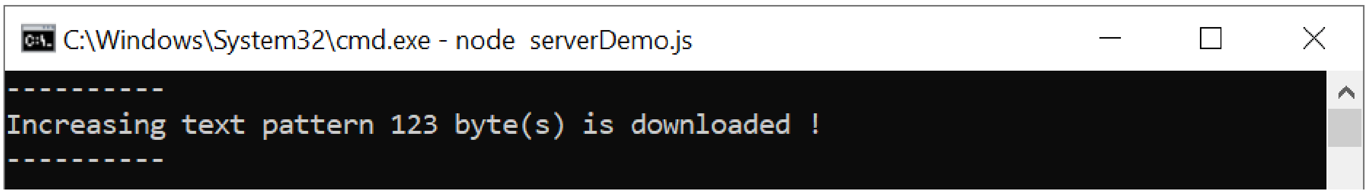
Prevent applications from receiving unsolicited traffic from the Internet through a NAT edge device.

Figure 12 Advanced setting

Downloading Data from the server

Clients can download data patterns or existing files in the server/log folder by sending a GET request with URL.

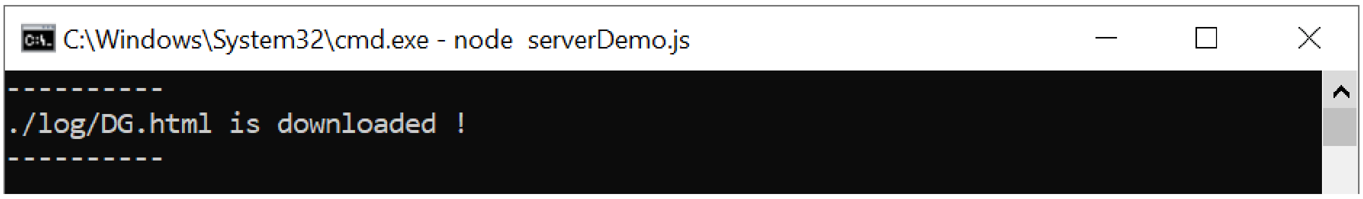
For downloading data pattern, there are 4 data patterns which are increasing binary, decreasing binary, increasing text and decreasing text pattern. When a server receives a GET request, the requested data pattern and its length are displayed on the server console, as shown in Figure 13.



```
C:\Windows\System32\cmd.exe - node  serverDemo.js
----------
Increasing text pattern 123 byte(s) is downloaded !
----------
```

Figure 13 Server console when client download data pattern

For downloading an HTML file from the server/log folder, the client sends a GET request with the filename in the URL. The file path of the requested data is displayed on the server console, as shown in Figure 14.



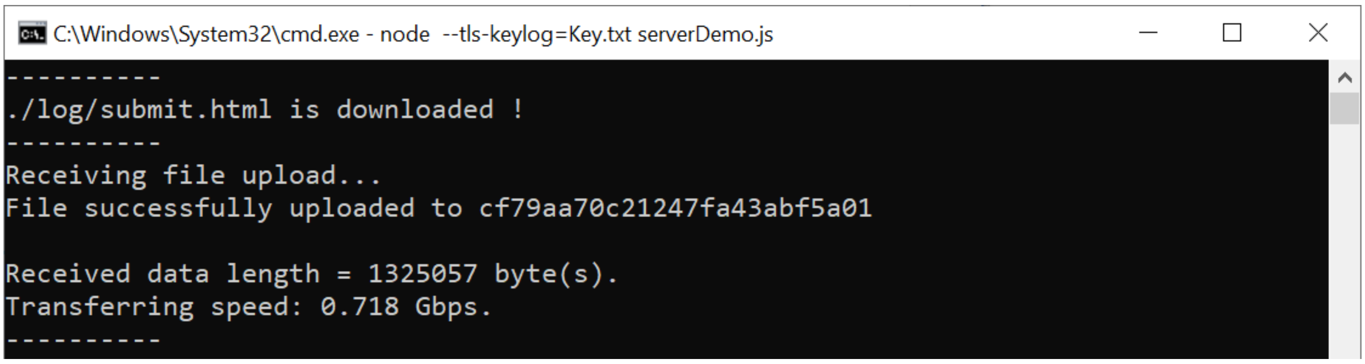
```
C:\Windows\System32\cmd.exe - node  serverDemo.js
----------
./log/DG.html is downloaded !
----------
```

Figure 14 Server console when client download ./log/DG.html

Uploading Data to the server

Clients can upload data to the server using a POST request followed by the uploaded data.

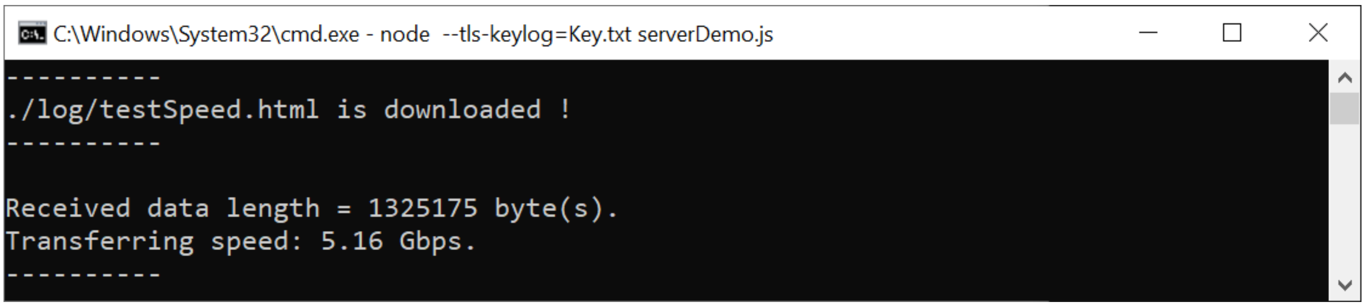
If a client uploads data via the submit.html page, the request is sent to the /submit URL. The server saves the uploaded file to the uploads folder. After the transfer is complete, the saved filename and upload speed are displayed on the server console, as shown in Figure 15.



```
C:\Windows\System32\cmd.exe - node  --tls-keylog=Key.txt serverDemo.js
----------
./log/submit.html is downloaded !
----------
Receiving file upload...
File successfully uploaded to cf79aa70c21247fa43abf5a01

Received data length = 1325057 byte(s).
Transferring speed: 0.718 Gbps.
----------
```

Figure 15 Server console when client upload data via submit.html page

To achieve maximum transfer speed, clients can request the testSpeed.html page and upload data to the /upload URL. The server does not save the uploaded data to a file. Instead, it counts the received data and calculates the transfer speed. After the transfer is complete, the upload speed is displayed on the server console, as shown in Figure 16.



```
C:\Windows\System32\cmd.exe - node  --tls-keylog=Key.txt serverDemo.js
----------
./log/testSpeed.html is downloaded !
----------

Received data length = 1325175 byte(s).
Transferring speed: 5.16 Gbps.
----------
```

Figure 16 Server console when client upload data via testSpeed.html page

2 Demonstration

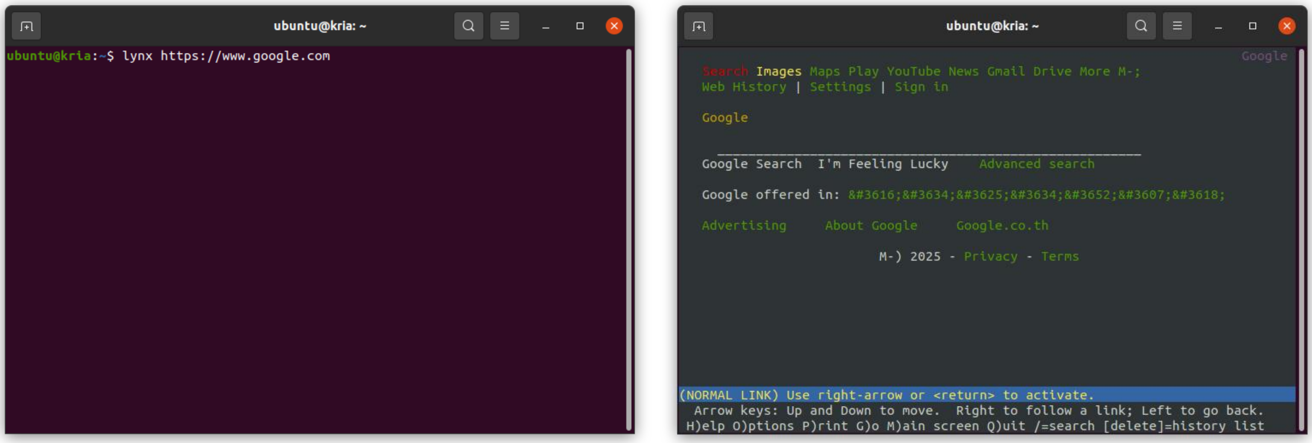
2.1 Website Browsing

This demonstration confirms that Lynx functions as expected via the 10G Ethernet interface with the DGTLS10GC hardware accelerator, maintaining the same behavior as its original 1G Ethernet setup.

Users can browse websites using the Lynx web browser. For example, to visit www.google.com, users can execute the following command:

```
lynx https://www.google.com
```

The Lynx terminal will render the HTML page for www.google.com. Users can enter search keywords in the provided input field and press Enter to navigate to the search results page, as shown in Figure 17.



```
ubuntu@kria:~$ lynx https://www.google.com
```

```
                                                                        Google
   Search Images Maps Play YouTube News Gmail Drive More M-;
   Web History | Settings | Sign in

   Google

     ______________________________________________________
   Google Search  I'm Feeling Lucky    Advanced search

   Google offered in: &#3616;&#3634;&#3625;&#3634;&#3652;&#3607;&#3618;

   Advertising     About Google     Google.co.th

                         M-) 2025 - Privacy - Terms

(NORMAL LINK) Use right-arrow or <return> to activate.
  Arrow keys: Up and Down to move.  Right to follow a link; Left to go back.
 H)elp O)ptions P)rint G)o M)ain screen Q)uit /=search [delete]=history list
```

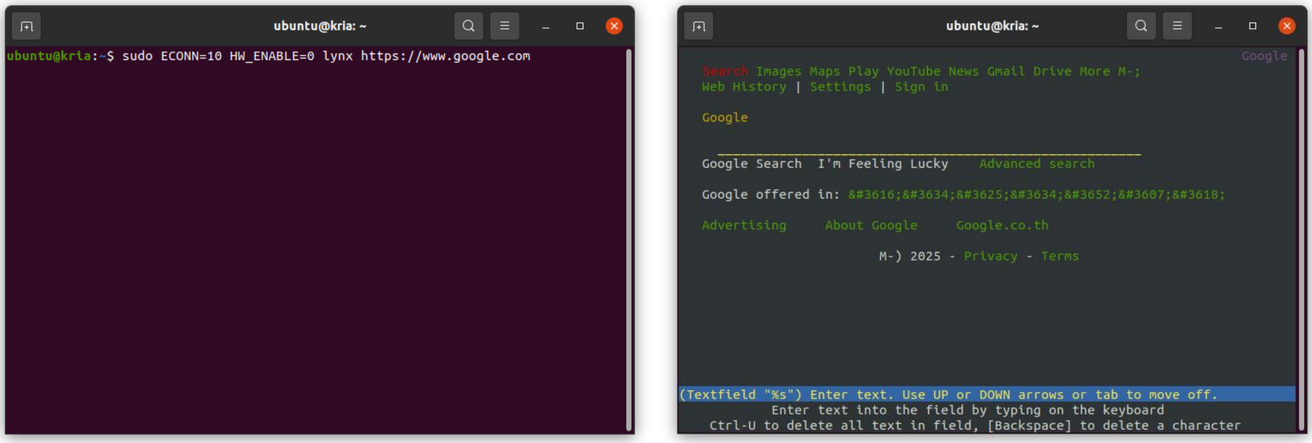
Figure 17 Example Lynx UI browsing with 1G Ethernet connection

To use the 10G Ethernet connection, users should set ECONN=10 when executing Lynx. The browsing experience remains the same as when using the 1G Ethernet interface. Figure 18 shows the console output when the user executes the following command:

```
sudo ECONN=10 HW_ENABLE=0 lynx https://www.google.com
```

In this mode, Lynx connects to the network through the 10G Ethernet interface but disables the TLS10GC-IP. As a result, Lynx relies on OpenSSL to handle encryption and decryption of the payload.

Since this demonstration uses the /dev/mem driver to interface with hardware, users must execute Lynx with root privileges to obtain the necessary permissions for hardware access.



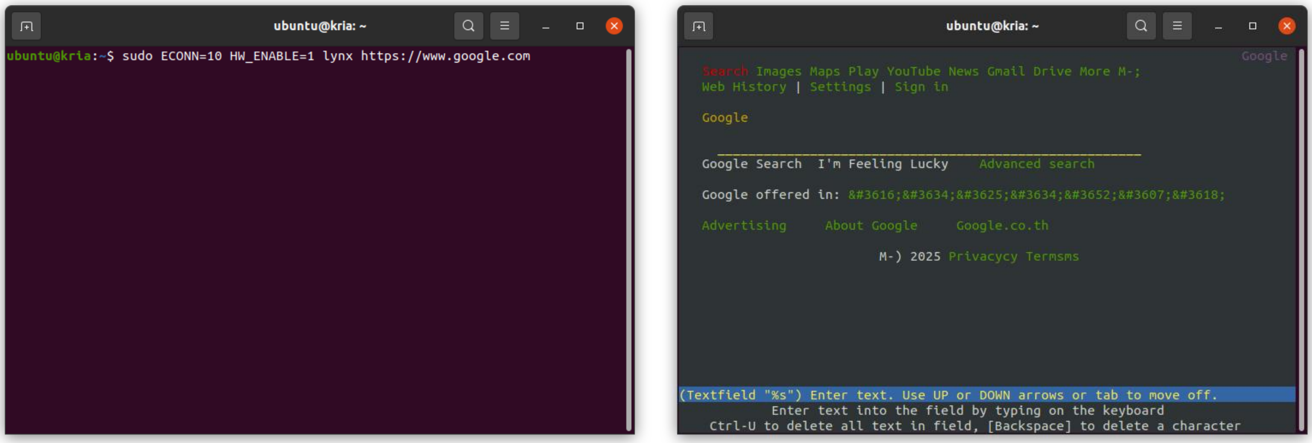
```
ubuntu@kria:~$ sudo ECONN=10 HW_ENABLE=0 lynx https://www.google.com
```

```
                                                                        Google
   Search Images Maps Play YouTube News Gmail Drive More M-;
   Web History | Settings | Sign in

   Google

     ______________________________________________________
   Google Search  I'm Feeling Lucky    Advanced search

   Google offered in: &#3616;&#3634;&#3625;&#3634;&#3652;&#3607;&#3618;

   Advertising     About Google     Google.co.th

                         M-) 2025 - Privacy - Terms

(Textfield "%s") Enter text. Use UP or DOWN arrows or tab to move off.
            Enter text into the field by typing on the keyboard
   Ctrl-U to delete all text in field, [Backspace] to delete a character
```

Figure 18 Example Lynx UI browsing with 10G Ethernet connection without hardware accelerated

To use the 10G Ethernet connection with hardware acceleration, users should set ECONN=10 and HW_ENABLE=1 for enabling the TLS10GC-IP to offload encryption and decryption tasks. This can be done by executing Lynx with the following command:

```
sudo ECONN=10 HW_ENABLE=1 lynx https://www.google.com
```



```
ubuntu@kria:~$ sudo ECONN=10 HW_ENABLE=1 lynx https://www.google.com
```

```
                                                                   Google
Search Images Maps Play YouTube News Gmail Drive More M-;
Web History | Settings | Sign in

Google

  _______________________________________________________
Google Search  I'm Feeling Lucky    Advanced search

Google offered in: &#3616;&#3634;&#3625;&#3634;&#3652;&#3607;&#3618;

Advertising     About Google     Google.co.th

                      M-) 2025 Privacycy Termsms




(Textfield "%s") Enter text. Use UP or DOWN arrows or tab to move off.
            Enter text into the field by typing on the keyboard
    Ctrl-U to delete all text in field, [Backspace] to delete a character
```

Figure 19 Example Lynx UI browsing with 10G Ethernet connection with hardware acceleration

2.2 Data Download from Server

When connected to the internet, data transfer may vary due to external network conditions. B y establishing a connection within the same subnet, we ensure that data is transferred exclusively over the 10G Ethernet, allowing for controlled and consistent testing conditions.

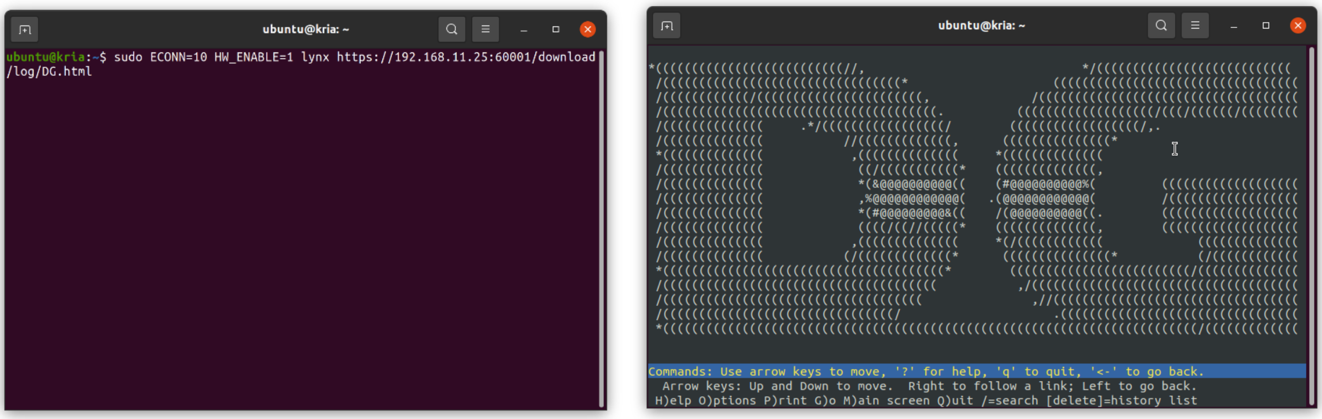
This section describes the test procedure and presents the results for different configurations, evaluating the impact of hardware acceleration on Lynx's data transfer speeds and CPU utilization.

2.2.1 Test Procedure

Users can access an HTML page hosted on the server by using the following URL format:

https://<server's IP>:<server's Port number>/download/log/<filename>

Lynx will render the received data as an HTML page. An example of the Lynx interface displaying the DG.html file downloaded from the server via 10G Ethernet with hardware acceleration enabled is shown in Figure 20.



```
ubuntu@kria:~$ sudo ECONN=10 HW_ENABLE=1 lynx https://192.168.11.25:60001/download
/log/DG.html
```

```
Commands: Use arrow keys to move, '?' for help, 'q' to quit, '<-' to go back.
  Arrow keys: Up and Down to move.  Right to follow a link; Left to go back.
 H)elp O)ptions P)rint G)o M)ain screen Q)uit /=search [delete]=history list
```

Figure 20 Example Lynx UI downloading DG.html

Users can connect to the example Node.js server to request a data pattern of a specified size (in bytes) by using the following URL format:

https://<server's IP>:<server's port>/download/<pattern>/<size>

In this demonstration, the Node.js server supports the following four data patterns:

b1: Increasing binary pattern

t1: Increasing text pattern

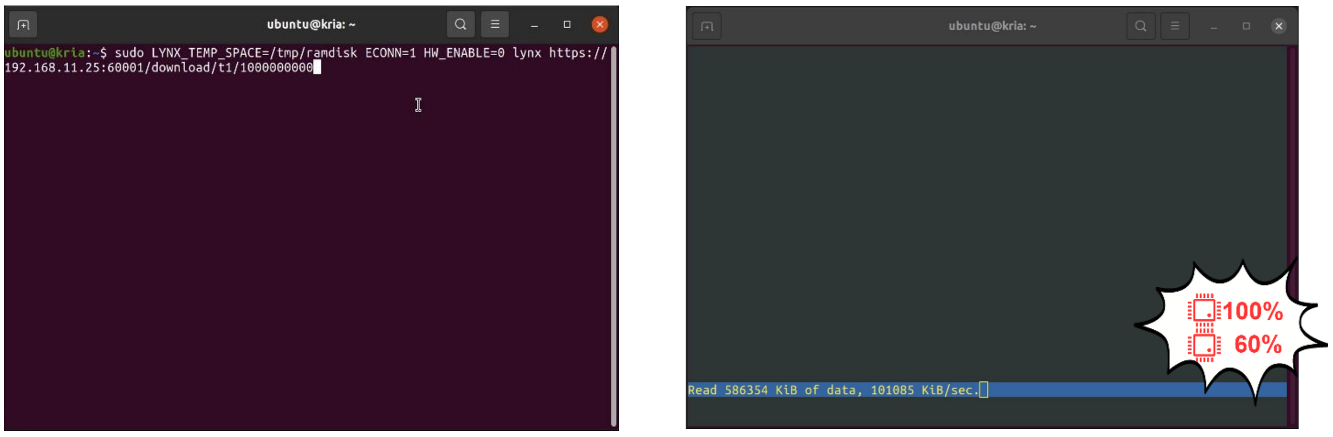
b0: Decreasing binary pattern

t0: Decreasing text pattern

To mitigate the bottleneck during downloads in Lynx, users can configure the temporary file location to a RAM Disk. This is done by setting LYNX_TEMP_SPACE=<path to your RAMDisk>. In this example, the RAM Disk is mounted at /tmp/ramdisk.

2.2.2 Test Results

Lynx provides a progress bar that displays download speeds during data transfers. Users can monitor the download performance while requesting data patterns from the Node.js server. Examples of the progress bar under different scenarios are shown in Figure 21 to Figure 23.

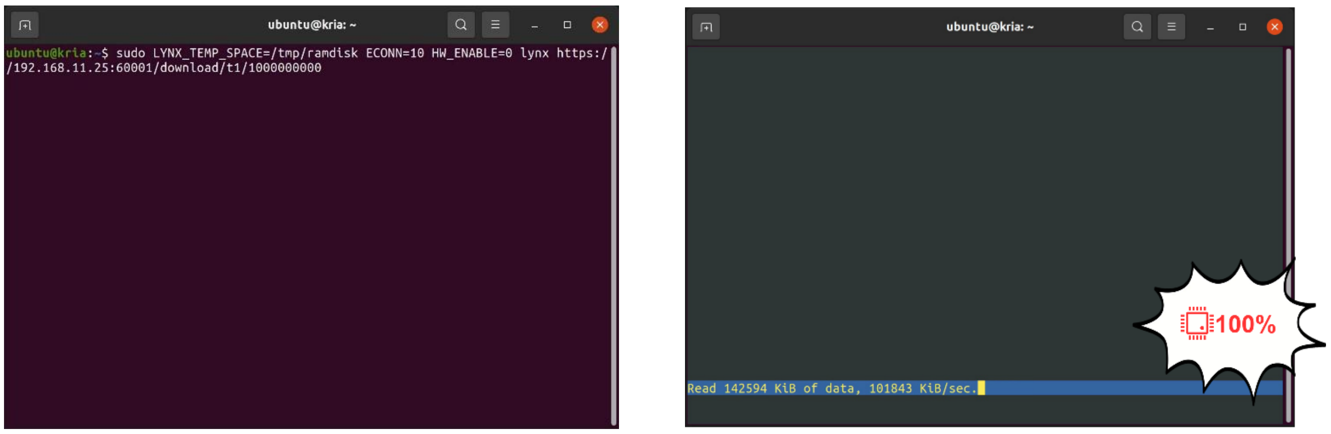


```
ubuntu@kria:~$ sudo LYNX_TEMP_SPACE=/tmp/ramdisk ECONN=1 HW_ENABLE=0 lynx https://
192.168.11.25:60001/download/t1/1000000000
```

```
Read 586354 KiB of data, 101085 KiB/sec.
```

Figure 21 Example of Lynx UI downloading 1GB data via 1G Ethernet

For the 1G Ethernet interface (Figure 21), a 1GB increasing text pattern was downloaded. The CPU managed both TCP connections (via sockets) and TLS encryption/decryption (via OpenSSL). The transfer speed averaged 0.7 Gbps, with 100% CPU utilization on one core and 60% on another core, as observed using an interactive system monitor. The fully saturated core created a bottleneck, limiting overall performance.

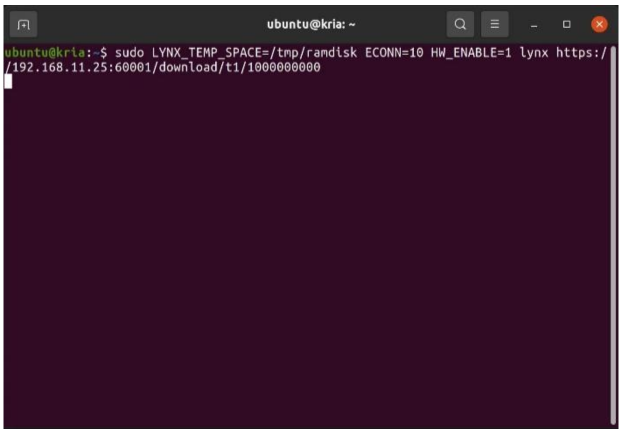


```
ubuntu@kria:~$ sudo LYNX_TEMP_SPACE=/tmp/ramdisk ECONN=10 HW_ENABLE=0 lynx https:/
/192.168.11.25:60001/download/t1/1000000000
```

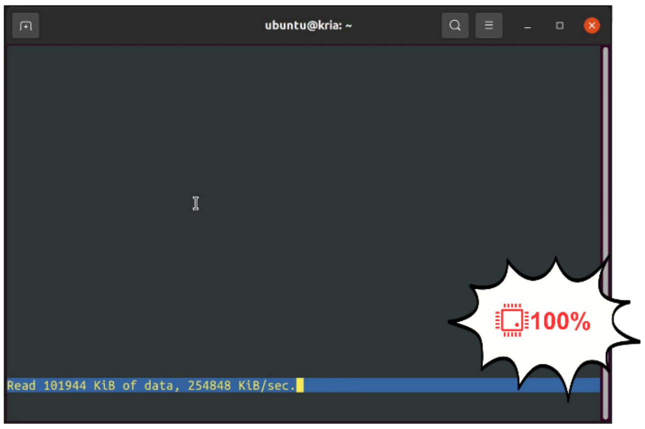
```
Read 142594 KiB of data, 101843 KiB/sec.
```

Figure 22 Example of Lynx UI downloading 1GB data via 10G Ethernet with hardware disabled

For the 10G Ethernet interface with hardware acceleration disabled (Figure 22), a similar 1GB data transfer was conducted. While the TCP workload was offloaded to the TOE10GLL-IP core, the CPU still handled encryption and decryption tasks using OpenSSL. The transfer speed remained 0.7 Gbps, with one CPU core fully saturated at 100% utilization. This demonstrated that although TCP offloading provided some relief, the encryption and decryption tasks continued to be a bottleneck, preventing higher transfer speeds.



```
ubuntu@kria:~$ sudo LYNX_TEMP_SPACE=/tmp/ramdisk ECONN=10 HW_ENABLE=1 lynx https:/
/192.168.11.25:60001/download/t1/1000000000
```



```
Read 101944 KiB of data, 254848 KiB/sec.
```

Figure 23 Example of Lynx UI downloading 1GB data via 10G ethernet with hardware enabled

With hardware acceleration enabled, both TCP processing (TOE10GLL-IP) and TLS encryption/decryption (TLS10GC-IP) were offloaded from the CPU. This doubled the transfer speed to 1.4 Gbps, significantly improving performance. Although one CPU core still reached 100% utilization, the offloading allowed the system to handle additional workloads more efficiently.

2.3 Data Upload to Server

This section describes the test procedure and presents the results for uploading data using different configurations.

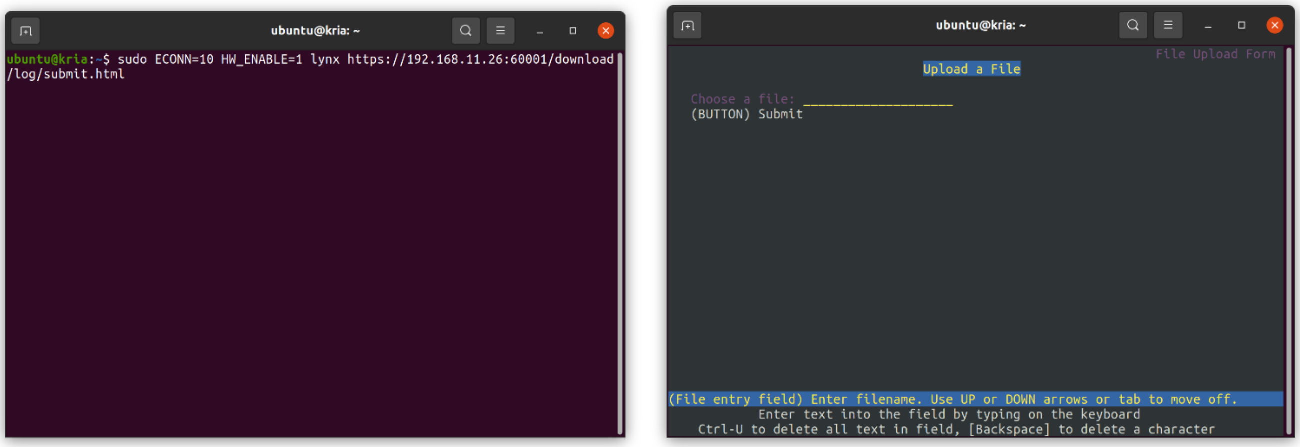
2.3.1 Test Procedure

Uploading with submit.html

To upload and save a file on the server, users must request the submit.html page using the following URL format:

https://<server's IP>:<server's Port number>/download/log/submit.html

Lynx will render the submit.html page, allowing users to select a file from their device storage and press the Submit button to upload it as shown in Figure 24.

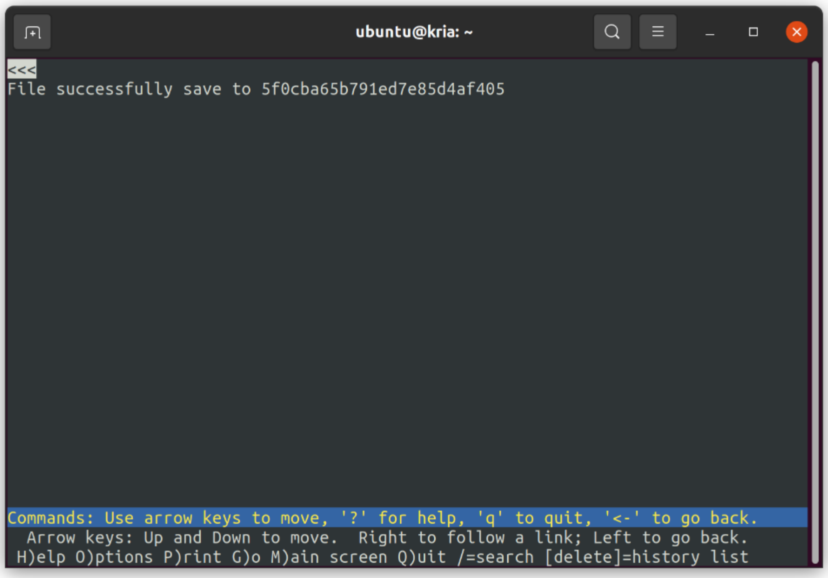


```
ubuntu@kria:~$ sudo ECONN=10 HW_ENABLE=1 lynx https://192.168.11.26:60001/download
/log/submit.html
```

```
                                                              File Upload Form
                                   Upload a File

  Choose a file: ____________________
  (BUTTON) Submit

(File entry field) Enter filename. Use UP or DOWN arrows or tab to move off.
            Enter text into the field by typing on the keyboard
   Ctrl-U to delete all text in field, [Backspace] to delete a character
```

Figure 24 Example of Lynx UI rendering submit.html

After the upload is complete, the saved filename is displayed on the terminal as shown in Figure 25.



```
<<<
File successfully save to 5f0cba65b791ed7e85d4af405

Commands: Use arrow keys to move, '?' for help, 'q' to quit, '<-' to go back.
  Arrow keys: Up and Down to move.  Right to follow a link; Left to go back.
 H)elp O)ptions P)rint G)o M)ain screen Q)uit /=search [delete]=history list
```

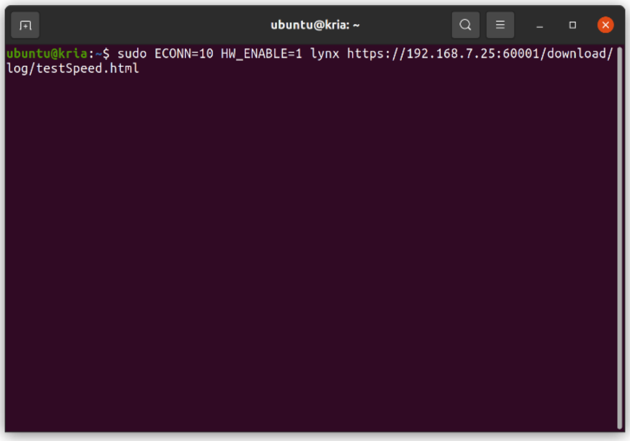
Figure 25 Example of Lynx UI after finishing submitting

Uploading with testSpeed.html

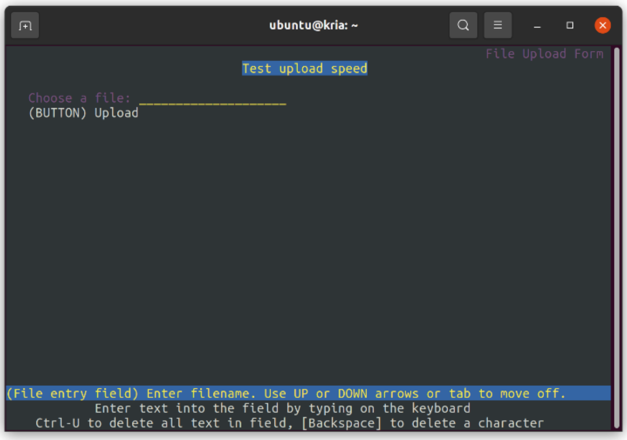
To test upload speed, users must request the testSpeed.html page using the following URL format:

https://<server's IP>:<server's Port number>/download/log/testSpeed.html

Lynx will render the testSpeed.html page, allowing users to select a file from their device storage and press the Upload button as shown in Figure 26.



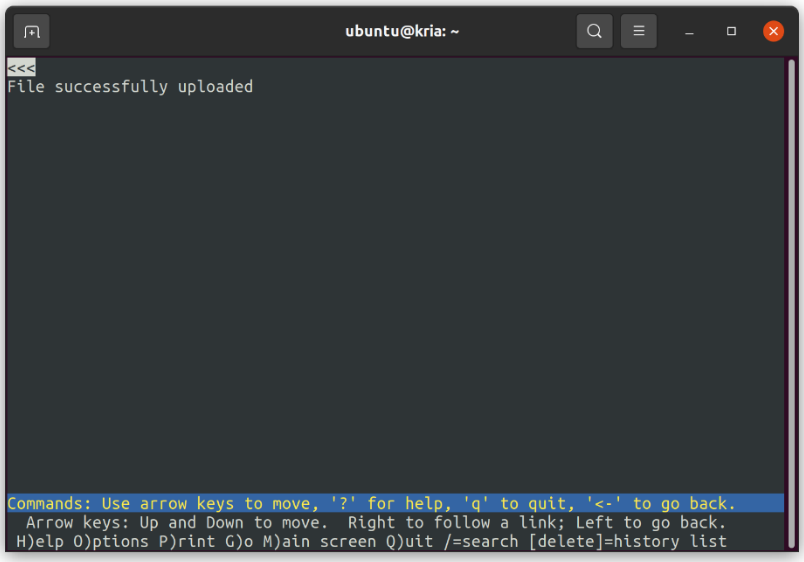
```
ubuntu@kria:~$ sudo ECONN=10 HW_ENABLE=1 lynx https://192.168.7.25:60001/download/
log/testSpeed.html
```



```
                                                                  File Upload Form
                                 Test upload speed

   Choose a file: ____________________
   (BUTTON) Upload

(File entry field) Enter filename. Use UP or DOWN arrows or tab to move off.
            Enter text into the field by typing on the keyboard
    Ctrl-U to delete all text in field, [Backspace] to delete a character
```

Figure 26 Example of Lynx UI rendering testSpeed.html

Once the upload is complete, only "File successfully uploaded" message is displayed on the terminal as shown in Figure 27.



```
<<<
File successfully uploaded

Commands: Use arrow keys to move, '?' for help, 'q' to quit, '<-' to go back.
  Arrow keys: Up and Down to move.  Right to follow a link; Left to go back.
 H)elp O)ptions P)rint G)o M)ain screen Q)uit /=search [delete]=history list
```

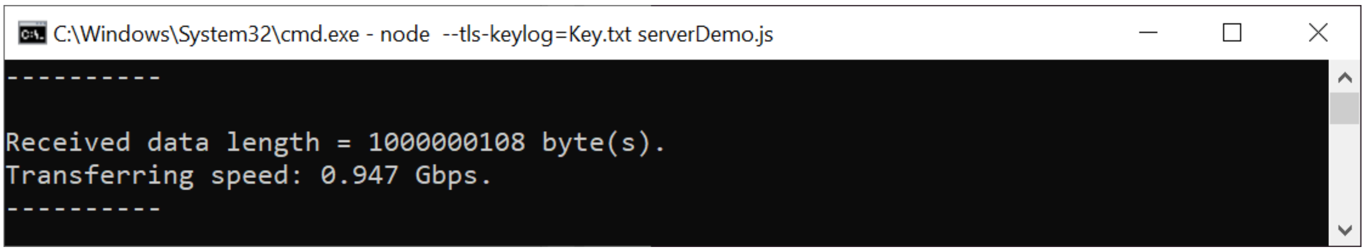
Figure 27 Example of Lynx UI after finishing uploading

Remark:

Lynx reads the entire file to construct the POST request, which may take time, especially for large files before starting transfer data.

2.3.2 Test Results

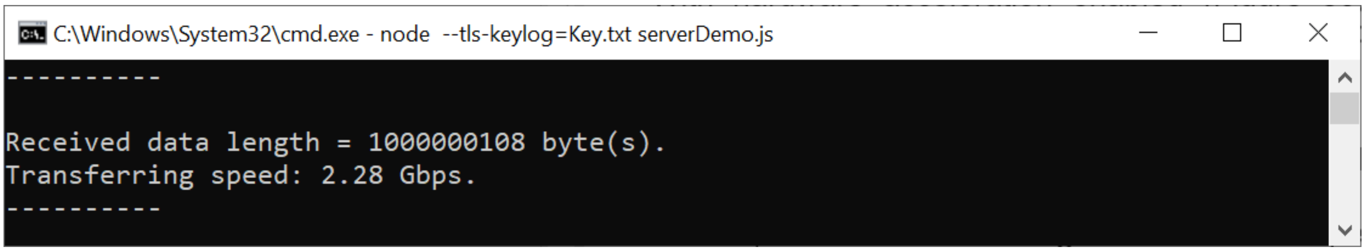
For uploading, the transfer speed is displayed on the server's console. Examples of upload speed under different scenarios are shown in Figure 28 to Figure 30.



```
C:\Windows\System32\cmd.exe - node  --tls-keylog=Key.txt serverDemo.js
----------

Received data length = 1000000108 byte(s).
Transferring speed: 0.947 Gbps.
----------
```

Figure 28 Example of Lynx UI uploading 1GB data via 1G Ethernet

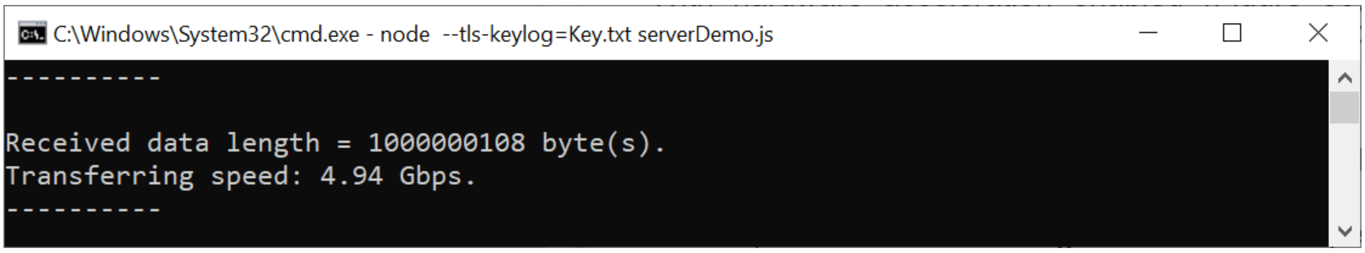
For the 1G Ethernet test (Figure 28), a 1GB file was uploaded. The CPU managed both TCP and TLS encryption/decryption using OpenSSL. The transfer speed averaged 0.9 Gbps, with 100% CPU utilization, creating a bottleneck and limiting performance.



```
C:\Windows\System32\cmd.exe - node  --tls-keylog=Key.txt serverDemo.js
----------

Received data length = 1000000108 byte(s).
Transferring speed: 2.28 Gbps.
----------
```

Figure 29 Example of Lynx UI uploading 1GB data via 10G Ethernet with hardware disabled

For the 10G Ethernet test without hardware acceleration (Figure 29), TCP workloads were offloaded to the TOE10GLL-IP core, while TLS encryption/decryption was still handled by the CPU. The transfer speed increased to 2.2 Gbps, but CPU utilization remained at 100%, indicating encryption/decryption was the limiting factor.



```
C:\Windows\System32\cmd.exe - node  --tls-keylog=Key.txt serverDemo.js
----------

Received data length = 1000000108 byte(s).
Transferring speed: 4.94 Gbps.
----------
```

Figure 30 Example Lynx UI uploading 1GB data via 10G ethernet with hardware enabled

With hardware acceleration enabled (Figure 30), the CPU offloaded both TCP tasks to TOE10GLL-IP and encryption/decryption tasks to TLS10GC-IP. The upload speed increased to 4.9 Gbps, while CPU utilization remained at 100% on one core. By offloading TLS encryption/decryption, the CPU was free to manage other tasks, improving overall efficiency.

In conclusion, this demonstration showcases how TLS10GC offloads encryption and decryption tasks when browsing securely via the Lynx web browser. With minimal modifications to the OpenSSL library and Lynx application on Ubuntu, users can achieve higher data transfer speeds while maintaining the same user experience as with existing application.

3 Revision History

Revision	Date (D-M-Y)	Description
1.01	3-Mar-25	Revise and add “Data Upload to Server” section
1.00	31-Jan-25	Initial version release