A Single Board Computer Based Solution for Smart Home Network Security

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A Single Board Computer Based Solution for Smart Home Network Security

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Abstract

Smart Home Network Security is very important due to the valuable data that is collected by the devices. Network security locks the doors so hackers cannot get it and steal the data. Different security applications based on a Raspberry Pi are compared to decide which is the most optimal choice. An IPS, firewall, DNS cache and DHCP servers help in improving the security. Making sure that the device can run and perform the security functions is of utmost importance to ensure the user keeps using the device as well as have the protection running. The applications should be running together on one device due to the benefits highlighted and the lower costs. Costs are also a big motivation for this project as a Raspberry Pi device is much cheaper than a specialised security device. It is also important to prove the Raspberry Pi can run the security applications due to the inherited limitations like a single ethernet port and ARM based processor.

1 Introduction

The question this paper aims to answer is "How can smart home network security be accomplished using a single board computer and best practices to avoid external threats without sacrificing network speeds and having poor performance on the single board computer" (Richard Sosinski, 2024b)

This research project's objectives are to research possible options for a security device based on a single board computer like a Raspberry Pi which focuses on smart homes and the external threats associated with such a solution (Richard Sosinski, 2024a). The main objective is to create an everything in one solution for the network to be able to defend the network while not sacrificing too much network speeds. A secondary objective is to find out if it is more effective to have each solution be spread out over multiple devices or have one central device. In recent years the popularity of smart homes has been increasing steadily, especially due to the acceptance of working from home and this increase can be accredited to the COVID-19 pandemic (Barry Elad, 2023). With this increase in smart homes there is also an increase in attacks on smart homes as well as the inherent lack of security in most IoT devices (Lee, Zappaterra, Kwanghee Choi, and Hyeong-Ah Choi, 2014). This research attempts to solve some these security issues with smart homes in an affordable way as network appliances tend to be focused for businesses and those which are focused for domestic use are either limited in their security or are too expensive for most people. The price ranges for firewalls alone can cost between 100 – 700 euros with the top of the range easily reaching 1000 euro (Amazon UK, 2024b).

The Raspberry Pi is an inexpensive single board computer with the capabilities of a computer, the power of the device depends on the model bought however, this project aims at a user which would not mind spending approximately £50 for a security device (CPC Farnell, 2024). This device is a fraction of the cost of a domestic firewall and aims to include services like a DNS (Domain Name Service) cache and DHCP (Dynamic Host Configuration Protocol) server, IPS (Intrusion Prevention System) and Firewall, as well as that it should be easy to setup as if the user needs to spend a week setting up a firewall they will likely give up. Maintenance needs to be easy to understand should something go wrong, and the user needs to complete some sort of troubleshooting.

User friendliness, network speed tests, CPU and RAM usages and ping speeds are some of the metrics used to determine the application used. These metrics were chosen because there is a trend of these in the papers and journals used in the literary review. Since the Raspberry Pi will be used a server and computer the CPU and RAM usage is important to not overload it and cause it to shutdown and potentially shutdown the network. Network speeds and performance is also important for end users as, having poor network performance can lead to end user dissatisfaction and throwing the device in the bin. Finally, user friendliness is important as this device is aimed at an average user with limited technical knowledge. This is due to the rise in smart home use and subsequently attracting new and potentially non-technical people.

To reiterate, the end goal for this research project is to methodically decide which popular security applications are secure and best to use based on metrics like network speed and user friendliness. With some additional features included such as auto-installation and a simple backup script. The security applications include a firewall, DNS cache, DHCP, and IPS.

2 Related Work

This section will look at the state of the art in the industry regarding IDS/IPS, Firewall and DNS & DHCP services and applications. The sections aims to give context for this paper and the background research done, as well as that it is meant to highlight some challenges that this paper aims to address.

2.1 Smart Home Analysis

Firstly, it is very important to highlight the security implications of a smart home. The data collected by smart homes can be very valuable to companies and attackers so it is very important that the data stays protected and cannot be used against the owner of the smart home (Lee, Zappaterra, Kwanghee Choi, and Hyeong-Ah Choi, 2014). Attacks on smart homes include network, application and even physical layers, these are just examples as it depends how valuable of a target the smart home is as most attacks would not attempt to attack the physical layer of a smart home if there is no benefit to the attacker. Attacks on the network layer include DoS (Denial of Service) attacks flooding and capturing data, these types of attacks focus primarily on taking down the service or slowing it down so much it is barely usable, stealing of data can be accomplished on this level as well however this would not be the main focus (Lee *et al.* 2014). Finally Application layer attacks focus on the IoT devices of a smart home and their ability to communicate and perform their tasks (Lee *et al.* 2014).

The final paper in this subsection by (Chitnis, Deshpande and Shaligram, 2016) does highlight a very important fact from their research, smart homes have some very important and valuable data making them popular targets. As well as owners having poor security standards and rarely updating their systems. This project aims to find effective protections for these types of users to stop the attack from getting to the network.

2.2 Gateway security

This section focuses on basics of network security and general idea of having a security device acting as a gateway for the network. This section also highlights the importance of network security and the benefits of it as well as potential downsides. While there is a need for more defence than just network security this project will focus on the network security side of smart homes.

Firstly, network security helps in securing IoT devices by protecting them from being attacked or targeted by attackers, it is much easier to update network security devices in both the cloud and on prem than each IoT device in a home, network security usually have more updates as if its open source more people are working on it and finally the extra layer of security is very important (Sivaraman, Gharakheili, Vishwanath, Boreli, Mehani. 2015).

This shows that network security can significantly improve the security of the smart home network. Not only is adding more security layers is better for security in the long run but it can help secure IoT devices without causing trouble to the homeowner in updating all of their IoT devices.

2.3 DNS cache and DHCP server

An extreme way of approaching this would be to create a DNS security service and run it on a Raspberry Pi which would be used to block DNS flooding attacks meaning it would still be important to keep a DNS cache service running (Datta, Kotha, Manohar and Venkanna, 2022). This could be used to improve the security even further however, this would be low on the list for this research project due to its complexity and the time frame being very small. If possible as well would be to create a type of security for DNS in a more efficient language like C and compare the results.

Alternatives to the DNS and multiple IPS and IDS solutions were also found these including Adguard home and Pi-hole is very important and there needs to be a comparison done to determine which should be used for the final artefact, not only that IPS and IDS solutions were found which are Suricata and Snort (Sanchez, 2022). Why this paper is important is that it provides some insight in how to use these tools in conjunction and offers some results however these tools were being run on an older version of the Raspberry Pi which also did not have the newest version of Raspberry Pi OS which changed a lot of things like available packages. The paper by (Sanchez, 2022) is one of the most important papers for this project as it combines a DNS cache and IPS together. These results will be a starting point as the objectives were to create a custom firewall but only using and IPS and DNS cache whereas the research project aims to build on that and add a firewall and update it to the newest version of the Raspberry Pi (Richard Sosinski, 2024b).

2.4 IDS and IPS

Firstly, a comparison between Snort and Suricata is important to look at as these are the two most popular options for IDS solutions. Suricata comes out on top with both dropping and capturing packets between Snort and Suricata however this test was done on a Raspberry Pi 3 which is a few years old already and much weaker than the Raspberry Pi 5 (Cosar and Kiran, 2018). This paper serves as a good introduction into IDS capabilities and how well the IDSs can work against different combinations of attacks. The attacks tested were SYN flood, Smurf and UDP flood attacks, both Snort and Suricata are very good applications, but they must be tested on newer hardware as over the years there would be updates and more possibilities available with the two applications. Not only that this paper does not cover how the two would work as and IPS solution and that comes with its own limitations like needing better hardware to run and the effects on the network.

The next papers will cover Snort integrations for network security as well as it working as different types of security modes and its potential integrations which were considered for this project. Applying Snort as a network security lab is also important for this project as it highlights limitations of snort and any other IDS, it also provides important metrics like CPU and RAM utilization, packet loss rate and number of detected attacks (Fetter, Chowdhury and Latif, 2021). These metrics are very important as they will help this project decide which IPS to use as these are similar ways to use the same applications, while IDS will not be used as a standalone it is also important to understand what effects on the device there will be as well as how the application can work.

The network can handle IDS solutions as seen from all papers mentioned in this section but the tests that would need to be done is if IPS modes will work without compromising the device alongside other applications. Another mode that Snort can be used in is as a gateway for the network (Simadiputra and Surantha, 2021). This approach is very important to this project as it shows that the Raspberry Pi can not only run as a gateway, but it can also run an application alongside it showing that this project is possible.

2.5 Firewall

Iptables are versatile however, as they can be used as a portable penetration testing lab on a Raspberry Pi (Hamid, Kamil and Abdullah, 2015). They can work on a Raspberry Pi as a firewall appliance for a smart home (Haar and Buchmann, 2019) but the limitations of iptables is that they are complicated and hard to read at times. When showing examples of rule creation they can be confusing and the syntax is long and not always self-explanatory.

This means that iptables are very versatile and anything built up from iptables like UFW can also be expected to succeed and this is what this paper aims to prove alongside other applications. Firewalld and Shorewall might have their own issues as they are not native to Raspberry Pi (Kylmänen, 2013), this is also another reason why they are included in the research for this project.

A firewall is a base security device and there needs to be a way to create on a Raspberry Pi as Iptables work on a Raspberry Pi with no problems and the only issue being configuring them. Not only that there need to be alternatives to them especially in 2024 and this project aims to find the alternatives and test them to see if they are efficient enough to be used as a firewall and how user friendly can they be to update. Efficiency is important as there is no reason to have a firewall that has the potential to take down the device as then the network will be left vulnerable.

3 Research Methodology

The potential metrics were explained throughout the literature review however, there needed to be choice made and these are the metrics chosen for each application type. Firstly, the applications are split into three types DNS & DHCP services, firewalls and IPS. While they do share most of the metrics RAM usage would not be as big of an impact on firewalls than it would be on IPS for example.

Name of Category:	Firewall	DNS & DHCP	IPS
Network Speed test:	Y	Y	Y
Ping test:	Y	Y	N
CPU Usage:	N	Y	Y
RAM Usage:	N	Y	Y
User Friendliness:	Y	Y	Y

Table 3.1 Metrics used for each category

Table 3.1 shows which metrics were used by each category. Speed tests are run on both the security device and a host device to get an fair reading from the edge and inside the network. The ping test involves pinging 8.8.8.8 to test connectivity and support the speed tests. CPU and RAM usage is used where applicable due to some applications using very little resources making it very hard to test. It is very important for IPS and DNS & DHCP services as they perform their own processes which can be read easily.. Inside the file the test results were saved and then put into an excel spreadsheet which was used for the analysis. Regarding IPS a rule was created to block ICMP packets (ping) and fifteen pings were sent and the "pidstat" command was used.

User friendliness can be subjective therefore notes were done in what features were good and bad and this was used as a last resort metric due to its subjective nature. Now there are limitation to the subjectiveness as not being able to use the application at all or it causing too many difficulties would take priority. The biggest impact of this was on the DNS & DHCP services.

Numerical data is the primary source for analysis however, user friendliness was still considered due to the objectives of this project. It is important to keep the perspective of a smart home owner in mind when critiquing the applications and understand their requirements.

The collection of data was done one by one, meaning that first all of the firewalls were tested and had their data collected alone after that they were disabled and the DNS & DHCP applications were tested and had their data collected. Finally the IPSs were tested and had their data collected. The data was collected into an excel spreadsheet with each page dedicated to one category of application. Some notes were added onto the applications with regards to how simple or difficult the syntax of commands were and how simple the setup was, these comments were put at the bottom of each application (Elnerud, 2017). After that the top of each application was decided using the priority order of Speed test > CPU and RAM usage > ping test > user friendliness. It can be observed that effectiveness of the security application is not a part of this test, this is due to two factors the first and least important being the time constraints but most importantly is that throughout testing the applications some tests were run to see if the application is running correctly and did in fact work. The scope of this project is to find and test security applications on the Raspberry Pi and see if it is possible to make a multiple security layer solution for smart home owners. While the effectiveness of the application is in scope for a project of this type, the time frame would not enable for such testing.

The testing was done when no other services or applications were running to make it a fair test. For firewalls only one firewall was running at any given time. Firstly for the speed tests, a tool called "Speedtest.net" was used (Ookla team, 2024) the server was kept the same for every application "BT Ireland" server. The data produced by this included ping, download speed and upload speed. The priority order for the data is download speed > ping > upload speed. The applications had very little impact on upload and ping speeds. There were five speed tests done for each application to have a fair result, and compensate for any outliers. The testing started at approximately 10 p.m. and completed at approximately 2 a.m. to compensate for other users on the network.

The ping tests were simple tests, there were fifteen pings sent to outside of the network address, inside the network and to the router. The outside server chosen was the google DNS server 8.8.8.8 as it is expecting to have high traffic and only fifteen pings were sent as to not flood the service (Coşar and Karasartova, 2017). This data was used to support the download speed from the speed tests. Due care and caution was followed to make sure that no spam was created when testing the applications.

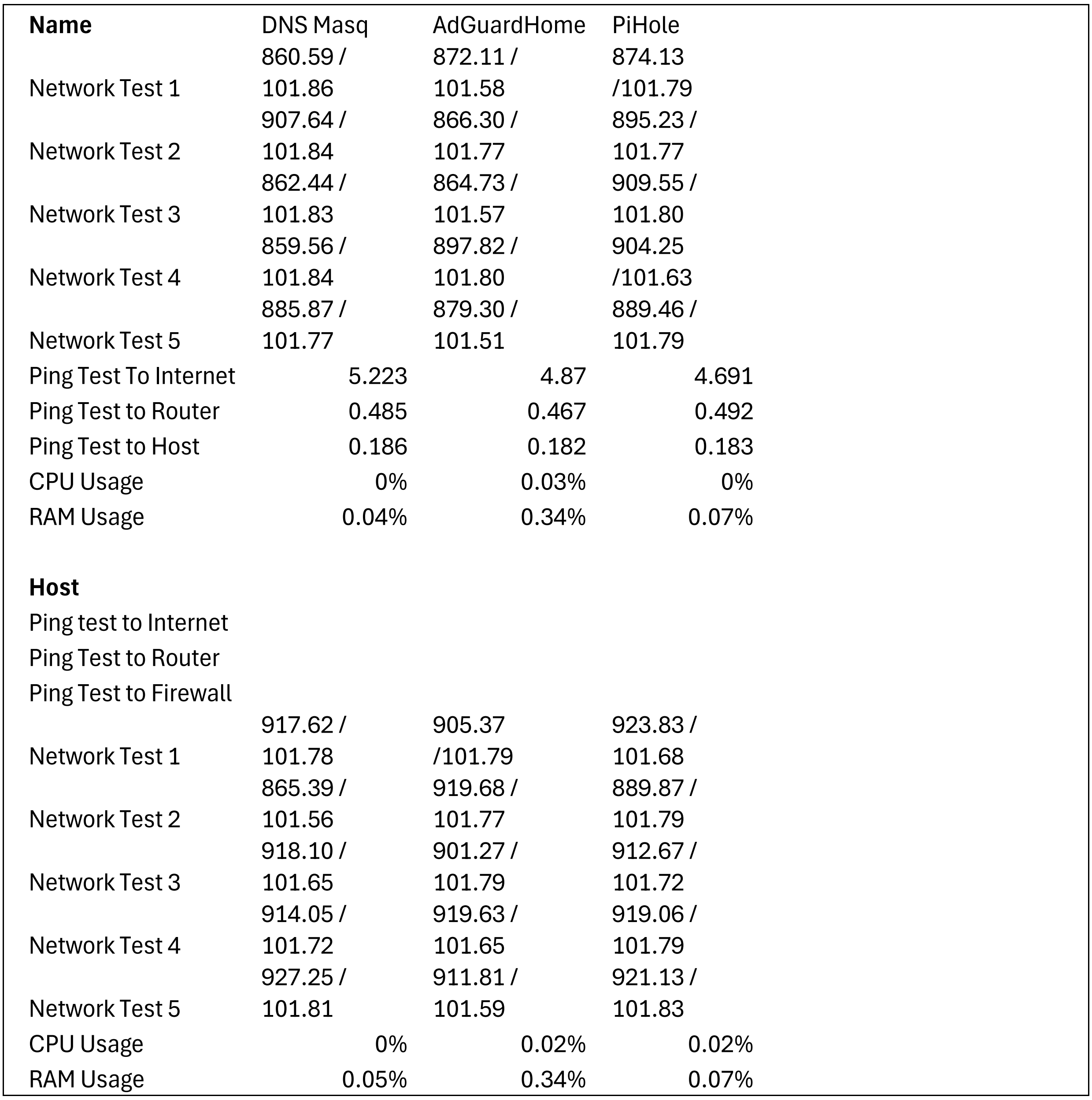
The CPU and RAM speeds were found out using "pidstat -p x > filename.txt" (Kerrisk, 2024) the x being the service name and filename being the name of the file to have the output redirected to. While the service is running and performing its job this would also be run in order to try and find out how resource intensive the service is.

For firewalls the test scenario looked as follows, five speed tests were run and documented, fifteen ping packets were sent to 8.8.8.8, fifteen ping packets were sent to the router and fifteen ping packets were sent to a device inside the network. This was done on both the security device and the host device in order to get an even read and be able to compare the two data sets. After that the best application was chosen based on the metrics highlighted.

The DNS/DHCP were similar and the test scenario looked as follows, five speed tests were run, the ping tests were completed, the CPU and RAM usage was gathered using "pidstat" and in order to do that the command was run and then an nslookup was run four times with different websites. All the information was gathered and compared as well as notes being taken on user friendliness and usability. These tests were also done on both host and security device but the CPU and RAM usage was done on the security device twice once with the nslookup on the security device and then on the host device. Four websites were tested with "nslookup" while "pidstat" was running and the output was saved to a file.

Finally, for IPS the tests were as follows, five speed tests were run and documented, CPU and RAM usage was documented using the "pidstat" command and the data was documented. Again as with the other two the tests were also done on both the host and security devices.

The analysis done was as mentioned previously, the priority order was followed for each of the application categories. For firewalls the priority order was speed test > ping test > user friendliness. Then for DNS and DHCP services the priority order was CPU and RAM usage > speed test > ping test > user friendliness and finally for IPS the priority was speed test > CPU and RAM usage > user friendliness. The averages of each applications data were found and compared with the other applications, the applications were then rated from best to worst and the final result was created. If the best application could not work with the other applications the next best was chosen and that was also documented and given a reason why the application could not work. The analysis was done using excel and each application category had its own page in order to provide clarity. The excel spreadsheet looked as follows, page one had all of the applications grouped in their categories, page two had the firewall data, page three had the DNS and DHCP data and page four had the IPS data. See Table 3.2 as an example.



Name	DNS Masq	AdGuardHome	PiHole
Network Test 1	860.59 / 101.86	872.11 / 101.58	874.13 /101.79
Network Test 2	907.64 / 101.84	866.30 / 101.77	895.23 / 101.77
Network Test 3	862.44 / 101.83	864.73 / 101.57	909.55 / 101.80
Network Test 4	859.56 / 101.84	897.82 / 101.80	904.25 /101.63
Network Test 5	885.87 / 101.77	879.30 / 101.51	889.46 / 101.79
Ping Test To Internet	5.223	4.87	4.691
Ping Test to Router	0.485	0.467	0.492
Ping Test to Host	0.186	0.182	0.183
CPU Usage	0%	0.03%	0%
RAM Usage	0.04%	0.34%	0.07%
Host			
Ping test to Internet			
Ping Test to Router			
Ping Test to Firewall			
Network Test 1	917.62 / 101.78	905.37 /101.79	923.83 / 101.68
Network Test 2	865.39 / 101.56	919.68 / 101.77	889.87 / 101.79
Network Test 3	918.10 / 101.65	901.27 / 101.79	912.67 / 101.72
Network Test 4	914.05 / 101.72	919.63 / 101.65	919.06 / 101.79
Network Test 5	927.25 / 101.81	911.81 / 101.59	921.13 / 101.83
CPU Usage	0%	0.02%	0.02%
RAM Usage	0.05%	0.34%	0.07%

Table 3.2 Example of a page in the excel spreadsheet

4 Design Specification

Tool Used	Specifications
2 x Raspberry Pi 5 One was used the security device and that one had 8 GB of ram The other was used as the host device for testing and gathering data and it contained 4GB	Running Raspberry Pi OS (Debain 11 based) • 2.4GHz quad-core 64-bit Arm Cortex-A76 CPU, 512KB per-core L2 caches and a 2MB shared L3 cache • LPDDR4X-4267 SDRAM • Dual-band 802.11ac Wi-Fi® • Gigabit Ethernet, with PoE+ support • 8 GB of RAM (CPC Farnell, 2024)
TP-Link Network Switch TL-SG108E	• 10/100/1000Mbps RJ45 ports • Plug and play no config required (TP-Link Team, 2024)
Logitech USB mouse and keyboard	A generic mouse and keyboard combo running through a single USB.
2x Cat 5 cables 1x Cat 6 Cable	Ethernet cables used to connect the devices together

Table 4.1 Table containing the components used

Table 4.1 shows what tools were used and as seen in that table two Raspberry Pi devices were used and that is an intentional choice as at the end of the project once the user manual was being done the weaker device was used to see if the same steps can be done on a weaker device and work. For most of the project the weaker device did behave as a host to test the different applications and gather data. The switch has basic functions like VLANs and QoS options (TP-Link Team, 2024). This was an intentional choice as this would be the switch most people would be willing to buy as it is simple. Adding a difficult to use switch would push users away and affect the objectives of this project. On average These type of switches range from 20 – 30 euro depending on the amount of ports desired (Amazon UK, 2024a).

The security system works on a single Raspberry Pi which comes with its own limitations, not only that a network switch is also important for this implementation however, there is a possibility of ignoring the switch. Since the Raspberry Pi is a single board computer there is a limited amount of storage and power that it can produce and use as well as that it can be very hard to improve the scalability of the device due to it not having specific ports, for example it would be very hard to add an additional ethernet port onto it. This section will cover how the Raspberry Pi was setup, what are the necessary steps to take to make it work as a network security device as well as possible limitations for users and applications.

Firstly, it is important to understand the limitations of the device. The Raspberry Pi is a single board device and there is no ports to add on components that a desktop computer would have. It is similar to a laptop where it is possible to add some minor additions but the Raspberry Pi is even more closed than a laptop, as adding dedicated RAM sticks onto the Raspberry Pi would not work but using a hard drive as RAM could overcome the issue. Another big issue with the Raspberry Pi is that it is limited to one ethernet port by default. It also uses an ARM based processor limiting some applications from being used on it, while it does run a Linux distribution some applications do not support ARM processors limiting the application that can be run and tested. Another limitation for the Raspberry Pi is that is used SD-cards to run the system therefore needing a minimum of 32GB of storage on an SD-card for this project. SD cards themselves have their own limitations such as being slower in comparison to hard disk drives and being more fragile, most importantly they are slower than hard disk drives (Zhang, 2024). The storage limitations affect how many on system backups can be kept meaning if the storage gets too full the backups will need to be deleted and held in cloud storage. The biggest issues is that they are slower options for storage which would limit some applications in how fast they can operate which is very important for network security due to the expected speed of networks.

The setup for the Raspberry Pi can be difficult but for this project the setup was kept simple to not make it harder to repeat for any homeowner that might be interested. Firstly, the Raspberry Pi imager tool is used to install the operating software onto the SD card. The operating system does not take up too much space of the SD card (Raspberry Pi Team, 2024). After that the static IP and IP forwarding on the system, this is so the device can work as a security device between the hosts and IoT devices and the internet. This was done so there is a fallback in case the security device is down for whatever reason the devices will automatically switch to the normal connections. This is also why it is important to set the DHCP functionalities on the router to a lower metric or turning it off. Should the security device be taken down the user just needs to turn DHCP back on and all device will work normally while the repairs are being done.

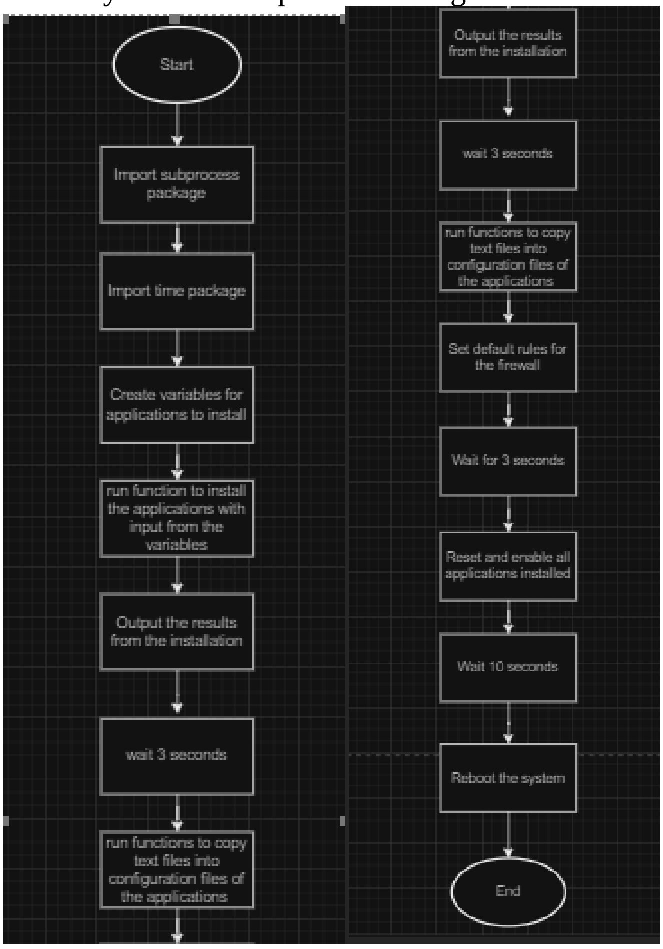

Start
Import subprocess package
Import time package
Create variables for applications to install
run function to install the applications with input from the variables
Output the results from the installation
wait 3 seconds
run functions to copy text files into configuration files of the applications
Output the results from the installation
wait 3 seconds
run functions to copy text files into configuration files of the applications
Set default rules for the firewall
Wait for 3 seconds
Reset and enable all applications installed
Wait 10 seconds
Reboot the system
End

Figure 4.2 Flowchart of the script

The installation script just needs to be run using python3 on the Raspberry Pi and it will install the firewall and IPS as the DNS & DHCP come with its own dedicated installer. It uses the python package “subprocess” to run commands. Backing up is also an important thing to do and a bash script was created in order for the user to have a cost effective backup system without having to pay or use a cloud backup application. The reason Python was used for the installation script as it was doing a lot of copying configurations and installing software whereas the backup script is much simpler as it is copying the whole into one folder and zipping it up.

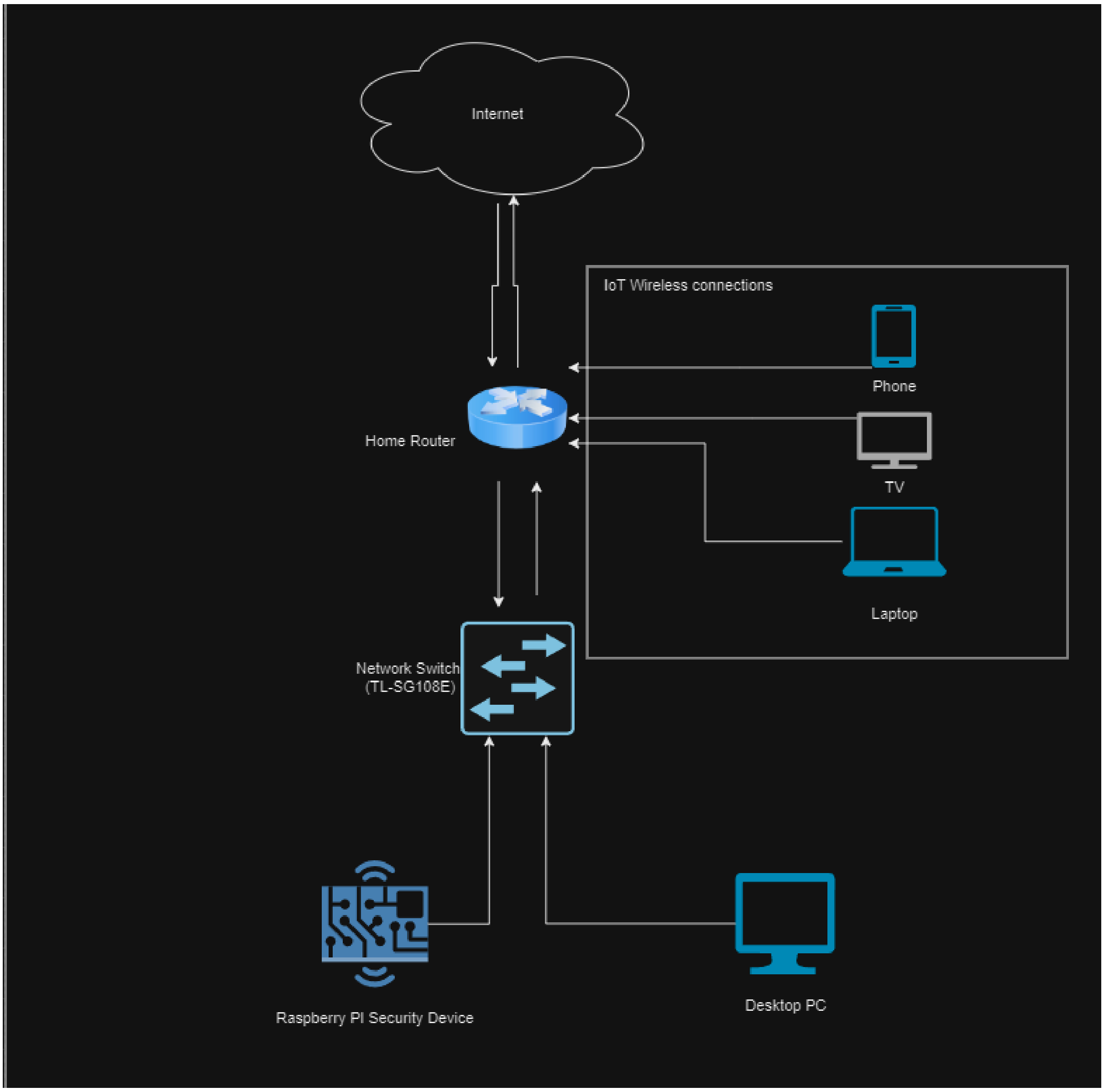


Table 4.3 Network Diagram of a sample implementation of the security device

5 Implementation

This section will cover the implementation of the final implementation for the project. The applications use are, UFW (uncomplicated firewall), Pi-Hole and Suricata was used.

For this section the process of gathering the metrics will be referred to as benchmarking. The benchmarking process for the firewalls and IPS was much different to the DNS & DHCP services due to the limitations of the Raspberry Pi. Snort it is no longer available by default on the Raspberry Pi and the setup process is much more complicated than it was in the past. Similarly, Zeek's setup as an IPS is much more difficult as well as much buggier due to it being a GitHub project. More will be explained in the evaluation however, that is why Suricata was chosen and implemented. Benchmarking was done where possible to get results for analysis. Regarding the firewall there were physical limitations of the Raspberry Pi and it having only one ethernet port. Shorewall and firewalld are both zone based firewall meaning there is a minimum of two ports necessary and a virtual ethernet port could not be successfully setup (Juha Kylmänen, 2013). Similarly to Suricata, UFW became the default winner.. The DNS & DHCP services benchmarking was done as expected and Pi-Hole was chosen as a part of the final implementation.

Python was used as the language used to install the application. Bash would have been too complex for this. The syntax and layout are much easier to understand. A limitation of this would be if the packages used were phased out of Python in the future or any syntax changes. Bash was used for the backing up script this was done as there was a need to copy the entire system, zip it up and then save it into a specific folder (Ubuntu Team, 2024). The script built up from the one available on the Ubuntu website, since there is a lot to copy and save Python would take much longer and have a more complicated algorithm. The scripts could be upgraded for future work.

The base network and device setup was done, the network runs on the 192.168.1.x/24 network and the static IPs were setup. Tests were done on Raspberry Pi OS x64. This was changed recently as it is formerly know as Raspbian. This came with changes to the application repository and other changes (Raspberry Pi Team, 2024). After that all application were installed and setups if possible were completed. Once all the applications were setup and working, they were turned off and the benchmarking begun. One by one the benchmarks were collected, and screenshots were taken. After that the information was put into an excel spreadsheet and graphs were created. During the setup of applications notes were being taken in a text file of opinions on the setup and how the application worked, these notes reflected how user friendly the application was which had little bearing on the results, unless the application did not work correctly.

Regarding the implementation of the firewall application, Shorewall was a good contender but limitations of the device stopped it from working. Benchmarking was possible on the Raspberry Pi security device but not on the host as there was no way to connect it to the internet, due to the lack of a second zone. UFW is still a great choice however, it is a basic solution in comparison to Shorewall.

Some important decisions that had to be taken throughout this project include. Having to limit the amount of time available for each application category and its benchmarking. Due to the time frame if some application could not work or refused to work correctly and the time was ending there had to be a decision that had to be made to stop. This is also an important thing to keep in mind to keep the perspective of a smart home user, if it took far too long for a user to setup the application themselves even with guides then they would stop and move on. It added difficulty to this project however, it did help in keeping the perspective in place. Another difficult decision was limiting how much time was allocated to IPS research. If more time was spent, more alternatives would have been found.

6 Evaluation

This section will cover the results of the research and explain the rationale behind the choices made as well as analyse the results from a neutral perspective. It will also explain how this research contributes to academic research as well as how it may affect smart home owners and the suggestions that should be take into account for them. This section will explain how the results support the research question stated for this project.

6.1 Evaluation of Firewall Technology

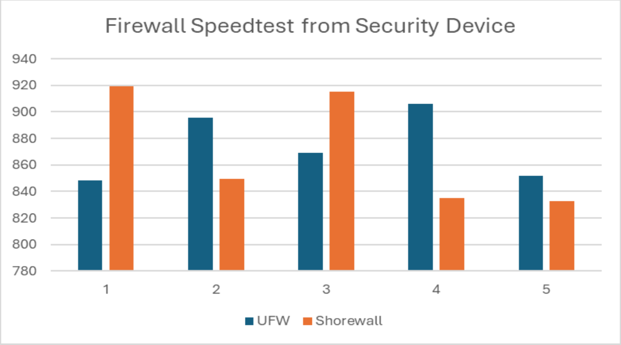


Figure 6.1.1 Bar Chart showing the speed test download speeds from the security device

Figure 6.1.1 is the comparison of Shorewall and UFW. From the start there were three firewalls chosen Firewalld, Shorewall and UFW. Firewalld could not be setup in a timely manner due to the limitations of the Raspberry Pi. Shorewall had the same problems however, there was a way to set it up for testing on the security device only. No test would work from the host device. Both application’s rule syntax is similar, but it is much easier to keep track of UFW and Shorewall rules rather than IP tables rules as the two present a list of rules in an easy way to understand whereas IP tables are much more complicated to read (Juha Kylmänen, 2013). UFW had more better results than Shorewall as seen in particular with test four and five. Shorewall had a much bigger difference in its highs and lows whereas UFW stayed consistent between its tests without such a big difference which would have been noticeable for the end user especially on application downloads and streaming websites.

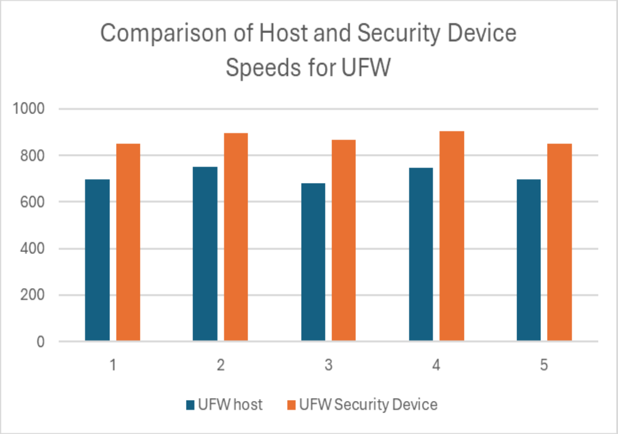


Figure 6.1.2 Bar chart showing the difference between Host and Security device download speed

Figure 6.1.2 shows the difference between testing done on the dost device and the security device, this shows two things. It is important to see how devices inside the network react to change. It is important to re-test Shorewall and Firewalld and bypassing the single ethernet port limitation for more options for the end user. As seen in the results the host download speed is around the 650-800 Mbps and the security device being above 800 Mbps. It is also safe to assume that the other firewalls will have their own effects on the network which will need to be studied however, so far it can also be assumed that from the pattern seen with UFW, Shorewall will have a worse effect on the network than UFW did due to the inconsistency seen in figure 6.1.1.

The implications of these findings are that including a firewall device slows down the network as there will be more stops for packets to go through. Another implication is that using UFW is much easier to use, setup and manage than iptables due to the commands that make it easier from UFW. When looking at the rules setup in iptables it shows the command put in which requires the knowledge of the syntax but with UFW creating rules has a much simpler syntax and when checking the rules it tells it directly what port or IP is allowed in or out (Haar and Buchmann, 2019).

6.2 Evaluation of DNS & DHCP Technology

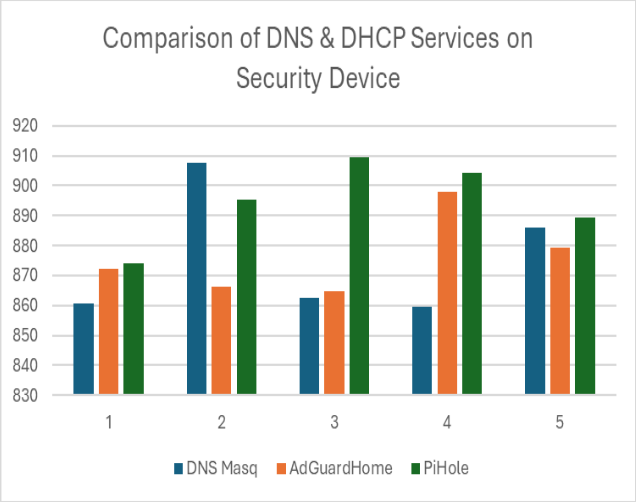


Figure 6.2.1 Comparison of download speeds of all DNS and DHCP services when testing was done on the security device

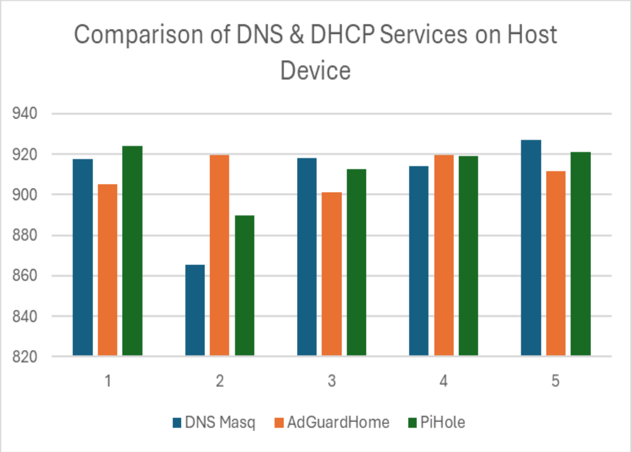


Figure 6.2.2 Comparison of download speeds of the DNS and DHCP services when testing was done on host device

Figure 6.2.1 and 6.2.2 show the download speeds of all three DNS and DHCP services. On both graphs it is clear to see that Pi-hole is the best choice as it has the most consistent and best results in comparison to the other two. This is vital to know as the DNS and DHCP services should speed up the network as the DNS information is cached on the security device which would ideally speed up the connection speeds. For example, if one person opens up YouTube, another person who opens YouTube will load it faster as the connection info is cached and the devices will know how to reach YouTube faster (Marc, 2022).

Implications of this research are that DNS Masq is the worst choice as a DNS cache and the user is much better to use Pi-Hole. Ad Guard is much more resource intensive but it also offers a more robust set of tools. Pi-Hole does offer a similar level of tools while not eating up too many resources.

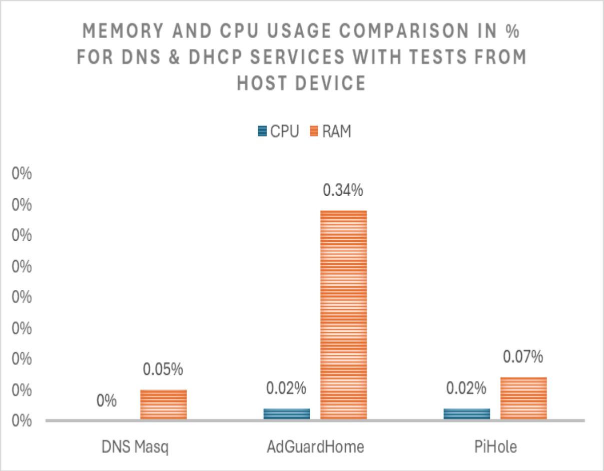


Figure 6.2.3 Comparison of CPU and RAM usage when testing was done on Host device

Since the DNS and DHCP service caches information it can also build up on the amount of RAM and CPU usage and if too much is used too fast then the device could crash and cause an unnecessary outage. It is important to choose the option which has the lowest usages in these metrics, while even Ad Guard Home did not use a full percent of RAM it built up the most within the tests completed the same way on all three services. The reason why Pi-Hole was used is because it comes with a user interface whereas DNS Masq relies on console commands, not only that Pi-Hole offers more blocking options of specific ads for the network. Not only that the user interface allows the admin of the network to block specific websites from being able to be connected to which is ideal for parents.

The implications are that CPU and RAM needs to be monitored and logged, if possible, should too many resources be used the device runs the risk of shutting down. This is why good user experience is a necessary measurement. A better user experience can help in fixing problems easier as well.

6.3 Evaluation of IPS technology

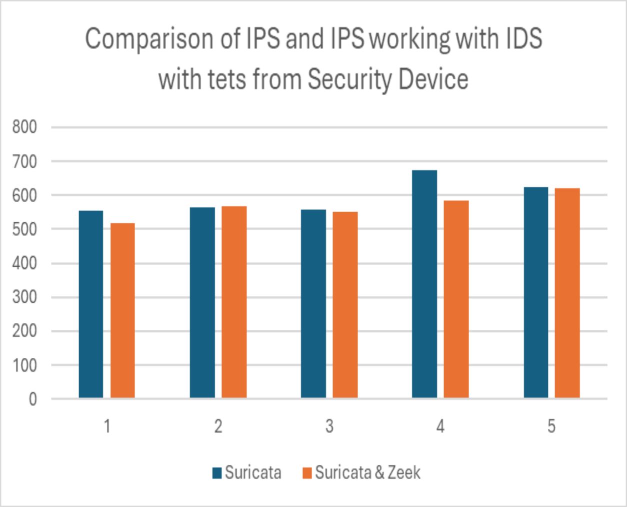


Figure 6.3.1 Graph showing download speeds of IPS running on its own vs with and IDS with tests done on the Security device

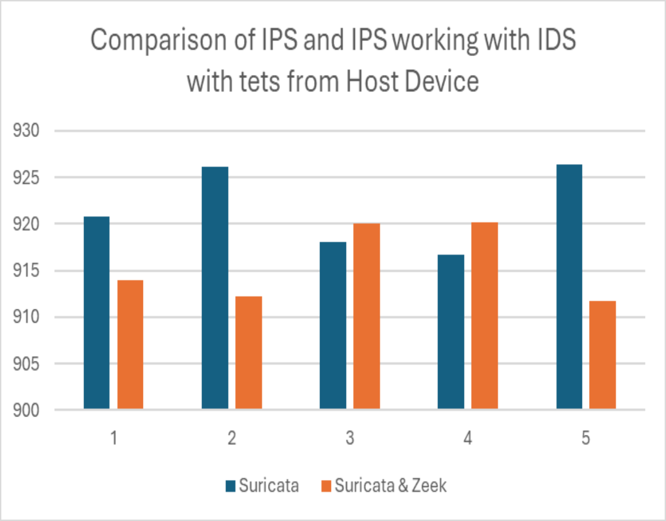


Figure 6.3.2 Graph showing download speeds of IPS running on its own vs with and IDS with tests done on the Host Device

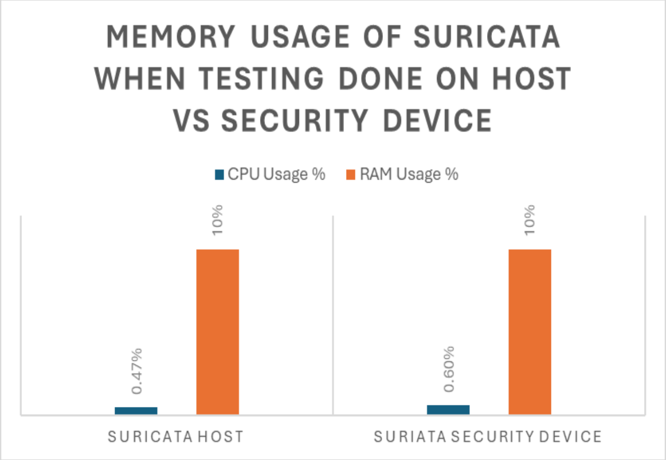


Figure 6.3.3 Graph showing the memory usage of Suricata testing on host vs security device

This evaluation presents that Suricata is the IPS of choice and this is primarily because Zeek is an IDS and Snort requries an external installation on the Raspberry Pi as it is no longer in the download repository. Not only that Snort is by far the most complex option and the limited amount of time allocated for this made it so that very little time was left for any significant amount of tiem to be used to try and setup Snort. Benchmarking was still completed with Suricata to show the effects of an IPS on the network and the Raspberry Pi (Ruíz-Lagunas Juan Jesús *et al.*, 2019).

Figure 6.3.1 shows the significant dip in performance in copmarison to Figure 6.2.1 and 6.1.1, this is important to note as all of these tests were completed on the seucirty device and this shows how much of a burden this is on the security device itself. Figure 6.3.2 shows the network speeds from the host device which is connected to the security device, this shows and interesting result where on the security device the download speeds can barely reach 600 Mbps but on the host it shows results of 900+ Mbps. This is inetersting to note as it is expected that the IPS will slow down the network due to it having to check every packet going through. The reason for these results could be due to the setup of the network which could be from the setup of packet forwarding. The other case could be that it is working passively on the other devices saving network speeds for the rest of the network.

6.4 Evaluation of Final Results vs Base Results

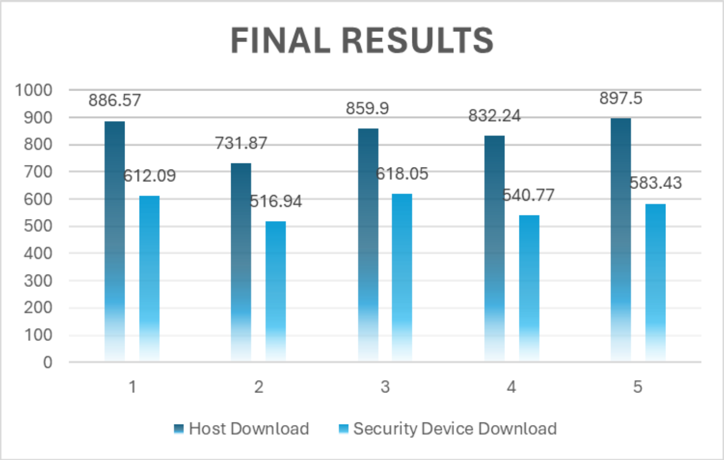


Figure 6.4.1 Final Results graph showing both Host and Security Device Download Speeds

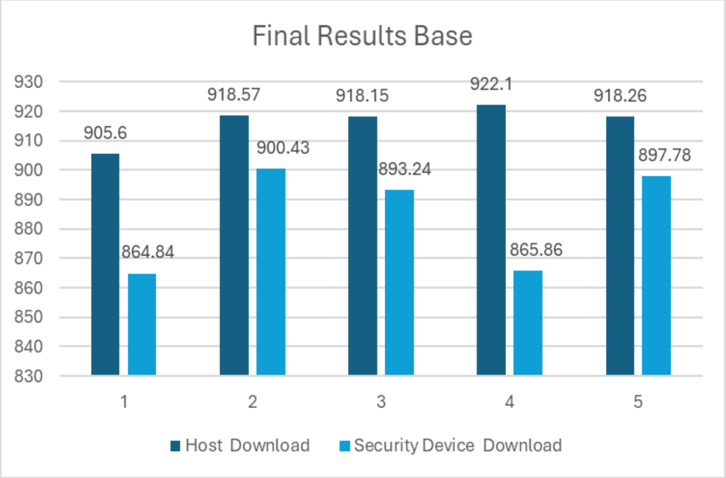


Figure 6.4.2 Base results with no applications running.

The final results are as seen in Figure 6.4.1, essentially the security device does work slower than the host device however, it is important that the security is working, which it is and that the host device does not lose too much speed. It is clear from the comparison between the base and final implementation that the security added does not take away from network speeds too much however, it is important to keep an eye on these speeds as a home owner.

6.5 Discussion

The results have been explained and their implications were also discussed however, this sub section will cover a rigorous analysis of the results and the project, as well as discuss possible improvements and give educated opinions on this project.

Firstly, the metrics used for this project are great indicators of success however, there is a need to have more security focused metrics as well. While the applications to provide security it does not measure how much security has been provided to the user. The metrics show the base level of security which primarily include denial of service. If a service is taken down there is a denial of service happening but the user should also know how well the applications are protecting their network. This would require more time to do as there is a need for long term testing of these applications in how well they can operate different levels of security. That is not to say that the metrics of this project did not achieve the goal in answering the research question and the objectives. There is still room for improvement however.

Secondly there needs to be a way to overcome the limitations of the Raspberry Pi to enable the use of more security applications. As seen in the firewalls there is a need for a second ethernet port either virtual or physical. This would also expand the horizon of this project as it would enable more security application to be tested and used giving the end user more choices and show how well the Raspberry Pi can handle the application from an academic perspective. There also needs to be more applications and tools tested, this research while achieving its goals the results can and should be improved by making the tools that failed to work, work and find other tools in those categories to increase the options for users.

Another thing that can be improved is the network setup and how the Raspberry Pi is acting. What that means is in this project the user connects to their router first and then the security device works and improvement would be to make the user connect to the device directly, this would lower the risk of the device not working correctly. The network could also be split into separate VLANs to increase security and make the network easier to understand, this might also improve network speeds.

It is also important to note that it is much better to use the final implementation rather than splitting up the implementation into separate devices. As seen throughout the evaluation section individually all applications do affect the network, but the final implementation does not slow it down too much. Splitting the implementation on individual devices would increase the chance of something breaking and it would ramp up the costs by a lot.

Finally a useful addition to this project would have been to have a device which was used in previous research like the Raspberry Pi 4 or 3 with the operating system it was running back then to have a direct comparison and see the improvements that done over the years. This would be useful for both the end user and from an academic perspective due to the direct comparison that would have been made.

7 Conclusion and Future Work

The research question proposed at the start of the project was "How can smart home network security be accomplished using a single board computer and best practices to avoid external threats without sacrificing network speeds and having poor performance on the single board computer" (Richard Sosinski, 2024b). With the objectives being to create a cost-effective network security solution for smart homes without sacrificing too many resources. These objectives were successful but there is still room for improvement. Namely the limitations need to be overcome to be able to use the applications which were chosen for the firewalls. There also needs to be a way to get Snort up and running on the Raspberry Pi, as mentioned the problem is that the repository no longer supports Snort, and the setup needs to be done manually. Some of the dependencies necessary for Snort are also missing from the repository making it much harder to setup. The key findings from this project are that there needs to be mores security focused metrics. Another key finding is that UFW, Suricata and Pi-Hole are the best options for security based on the metrics used in this project. Another finding which is important to note is that adding another layer of security like an IDS alongside Suricata can have a lot of effects on the network speeds in a negative way.

This research has shown that the Raspberry Pi can manage to be a security device which is much cheaper than buying dedicated security appliances. The Raspberry Pi solution also offers more versatility and possibility of using different applications. While it is much easier to use a pre-made security solution the Raspberry Pi does offer its own way of security a network for a fraction of the price. The research also shows that security applications require a lot of work to setup and benchmark as well as that there needs to be more benchmarks used to prove the effectiveness of the applications.

Some future work that is recommended based on this project is long term testing of the final security implementation to test how long it would take for the device to crash. As well as that perform more security-oriented testing and vetting of applications in the categories presented. More research should also be done which shows other options for applications and build up from this project and creating a base of knowledge on Raspberry Pi based security applications. Using IDS instead of IPS is also future work which should be performed, and deeper testing done on how well IDS and IPS can work together and to see if just using an IPS as both is more effective.

Given more time ways to overcome the limitations of the Raspberry Pi would be found and implemented to get more firewalls to work. As well as that more time would have been allocated for IPS research and testing. Due to the lack of time allocated Suricata became the default winner but with more time Snort could have been implemented. Not only that a creation of a centralised user interface for all the applications and their logs would have been created to let the user use one screen for all information rather than a screen for each application. More time would have been spent on the installation and backup scripts to make it even easier for the user to use them.

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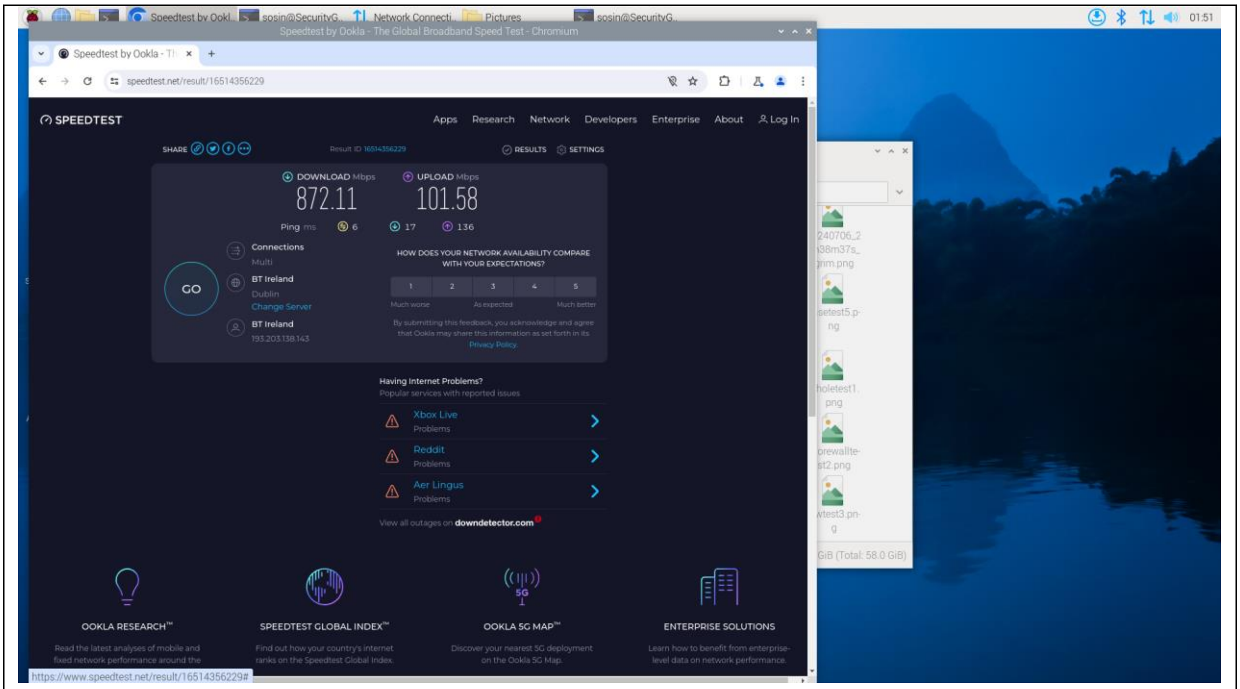
9 Appendices

9.1 DNS & DHCP Services

9.1.1 Security Device



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Connections Multi

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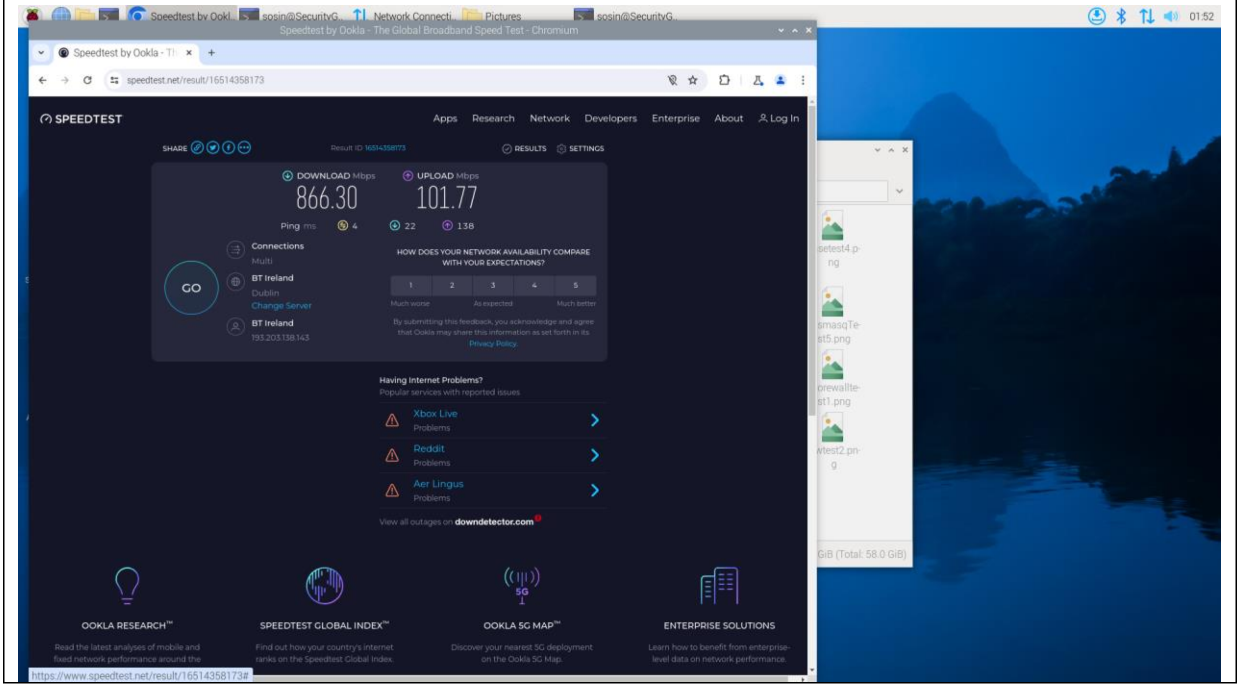

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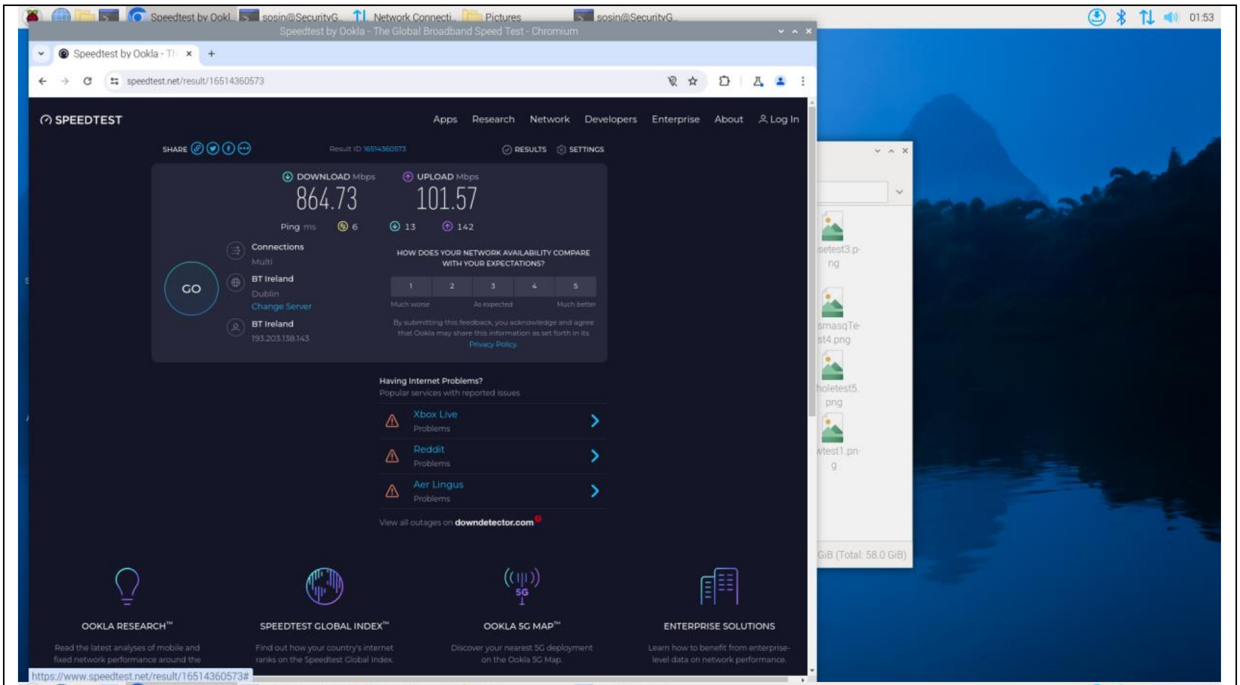

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SHARE Result ID 16514360573 RESULTS SETTINGS

DOWNLOAD Mbps 864.73

UPLOAD Mbps 101.57

Ping ms 6 13 142

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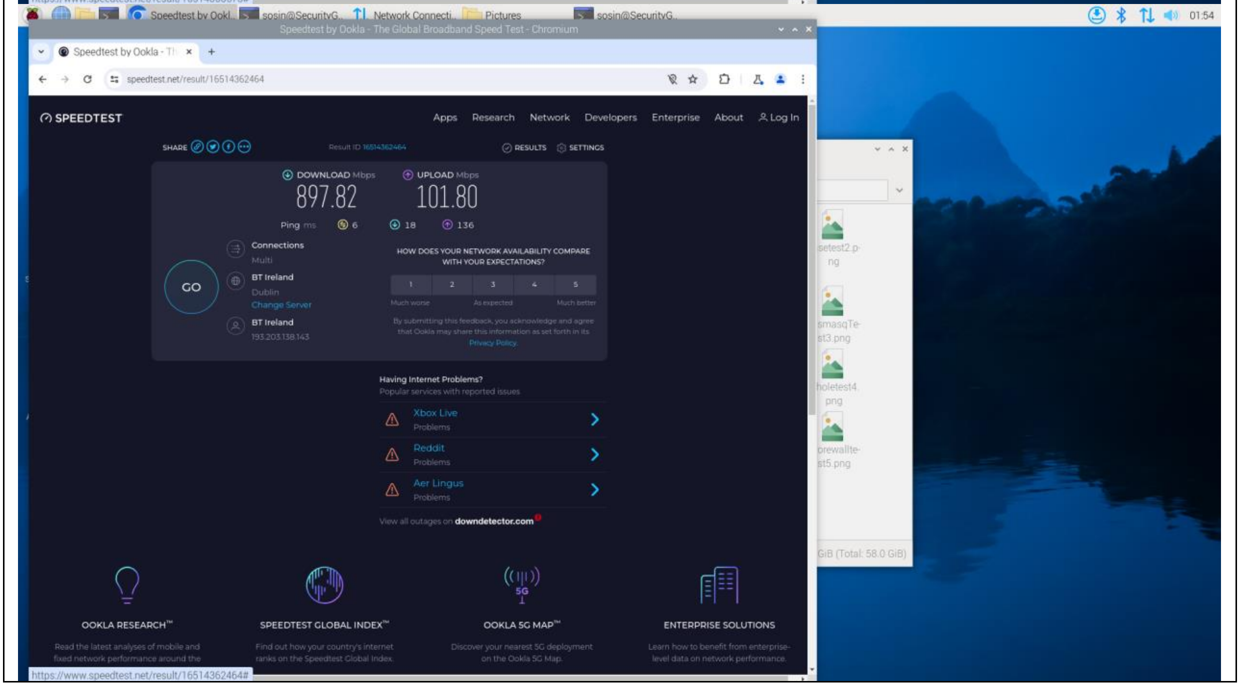

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DOWNLOAD Mbps 897.82

UPLOAD Mbps 101.80

Ping ms 6 18 136

Connections Multi

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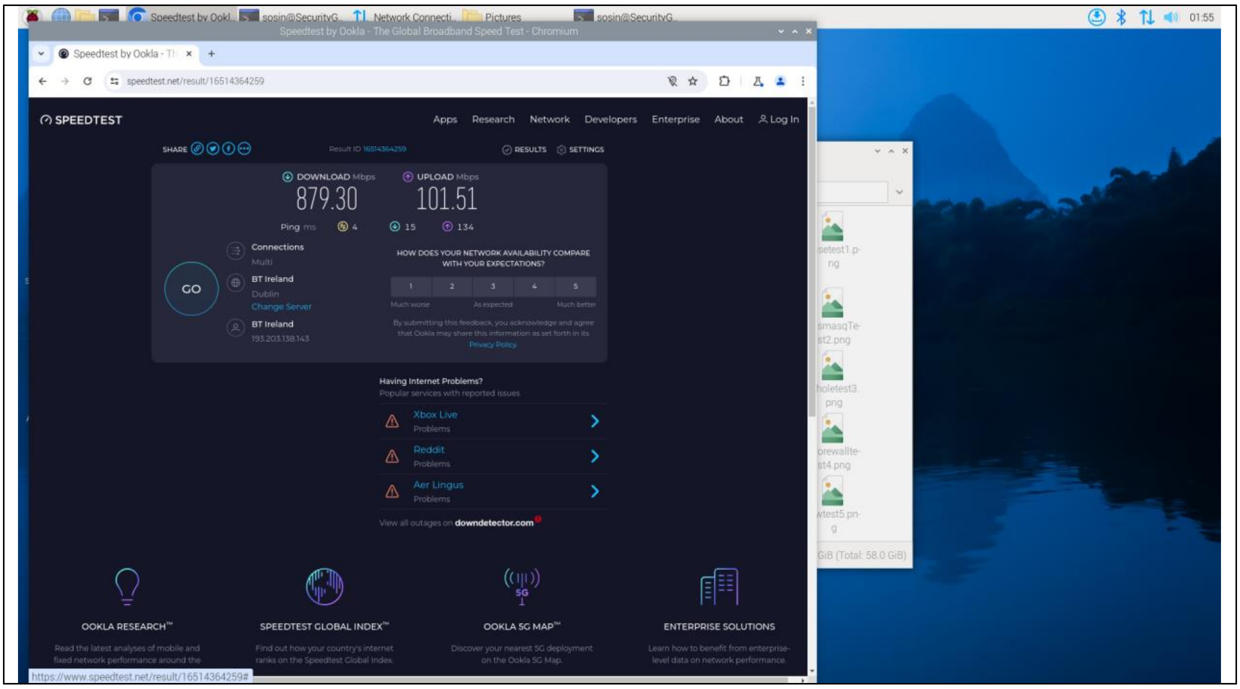
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DOWNLOAD Mbps 879.30

UPLOAD Mbps 101.51

Ping ms 4 15 134

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

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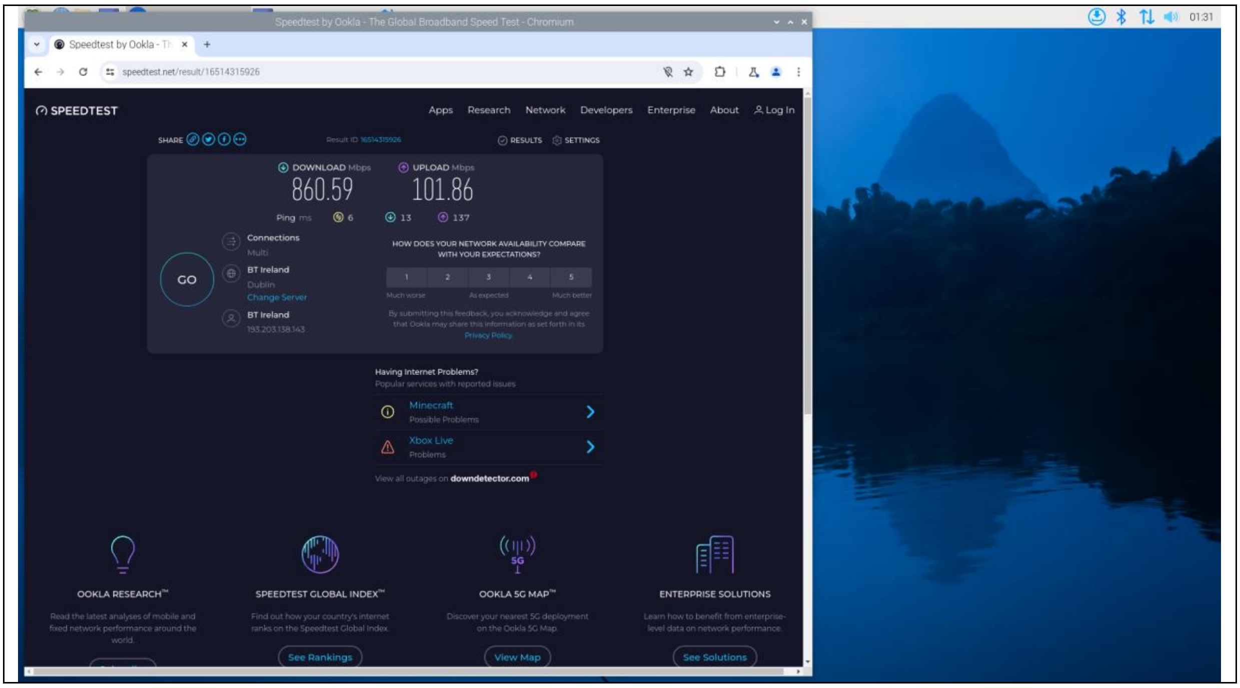
Ad Guard Home Speed tests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speedtest.net/result/16514315926

SPEEDTEST

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SHARE Result ID 16514315926 RESULTS SETTINGS

DOWNLOAD Mbps 860.59

UPLOAD Mbps 101.86

Ping ms 6 13 137

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

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1 2 3 4 5

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Minecraft Possible Problems

Xbox Live Problems

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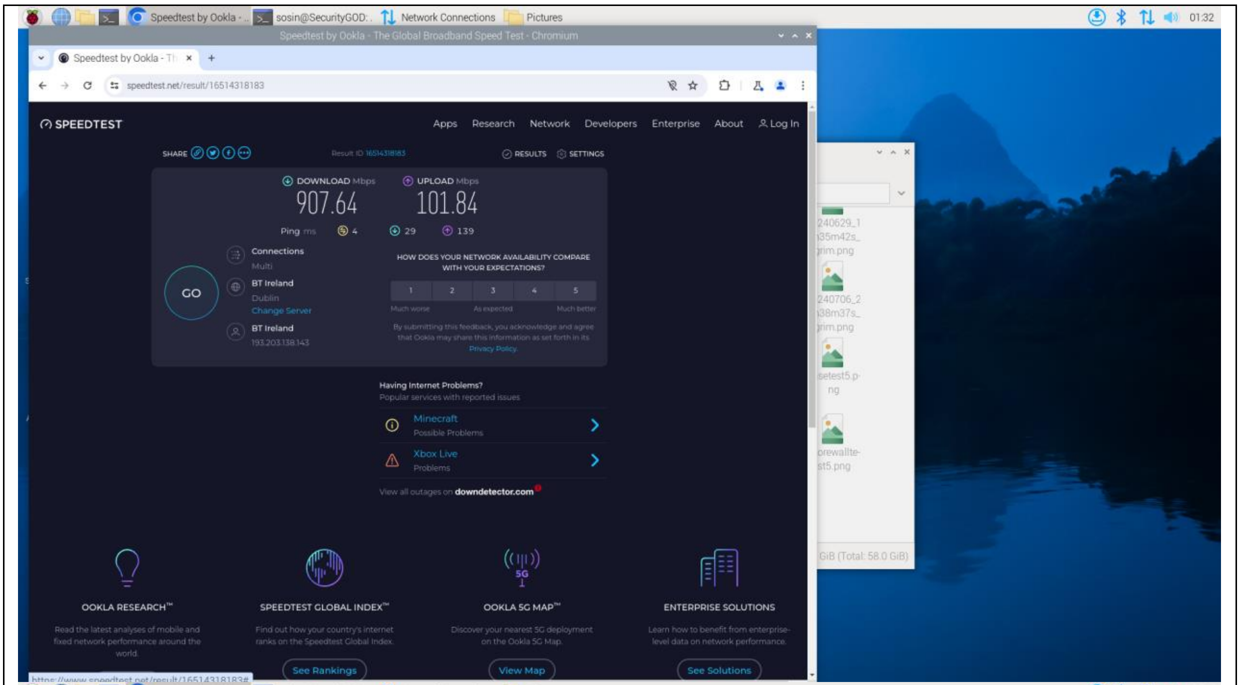

Result ID 16514318183

DOWNLOAD Mbps 907.64

UPLOAD Mbps 101.84

Ping ms 4 ↓ 29 ↑ 139

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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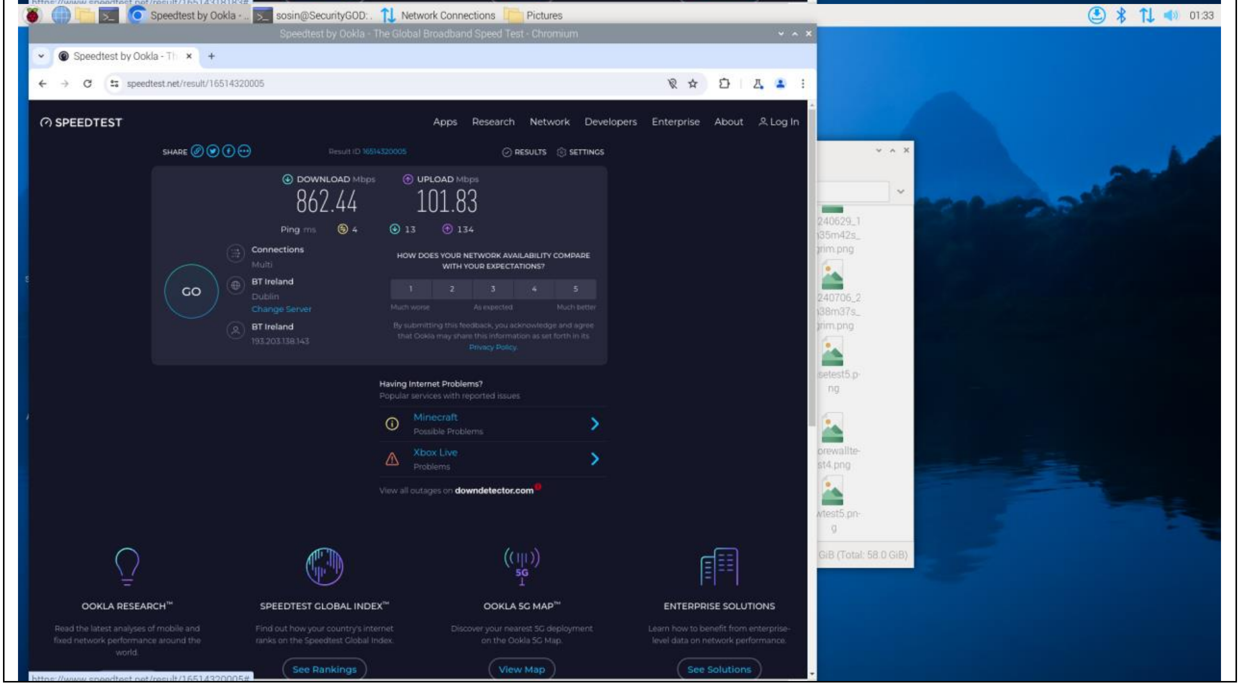
https://www.speedtest.net/result/16514318183#



Result ID 16514320005

DOWNLOAD Mbps 862.44

UPLOAD Mbps 101.83

Ping ms 4 ↓ 13 ↑ 134

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

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1 2 3 4 5

Much worse As expected Much better

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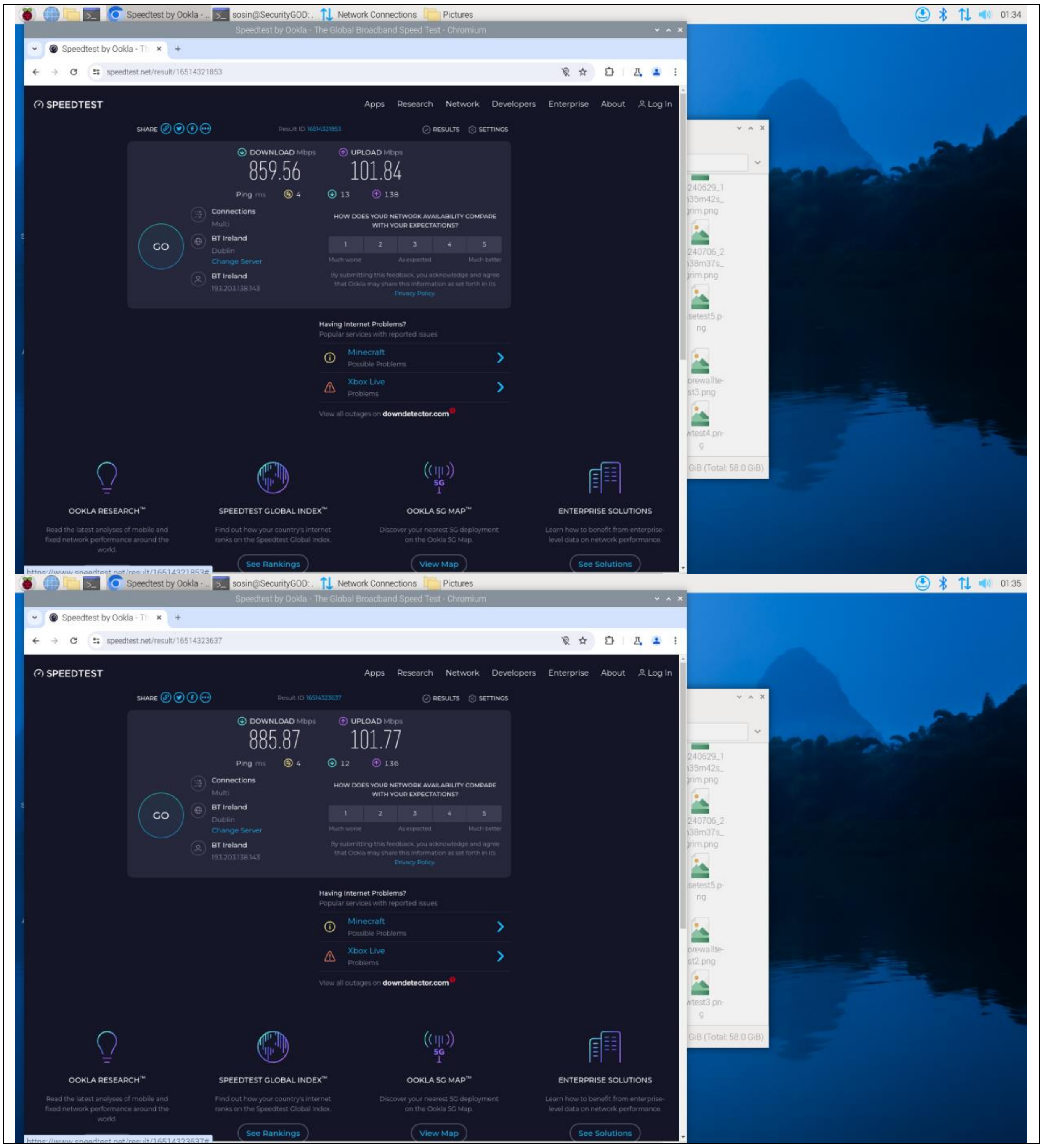
https://www.speedtest.net/result/16514320005#



speedtest.net/result/16514321853

Result ID 16514321853

DOWNLOAD Mbps 859.56

UPLOAD Mbps 101.84

Ping ms 4 13 138

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

speedtest.net/result/16514323637

Result ID 16514323637

DOWNLOAD Mbps 885.87

UPLOAD Mbps 101.77

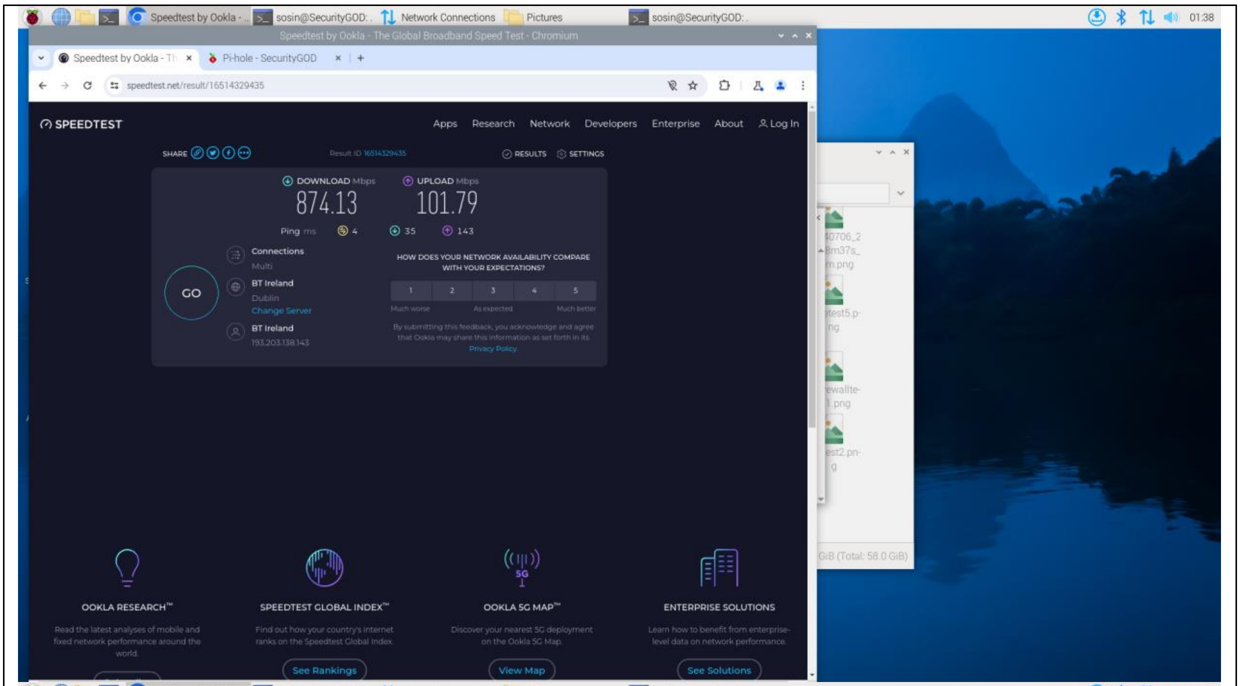
Ping ms 4 12 136

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

DNS Masq Speed tests



speedtest.net/result/16514329435

Result ID 16514329435

DOWNLOAD Mbps 874.13

UPLOAD Mbps 101.79

Ping ms 4 35 143

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

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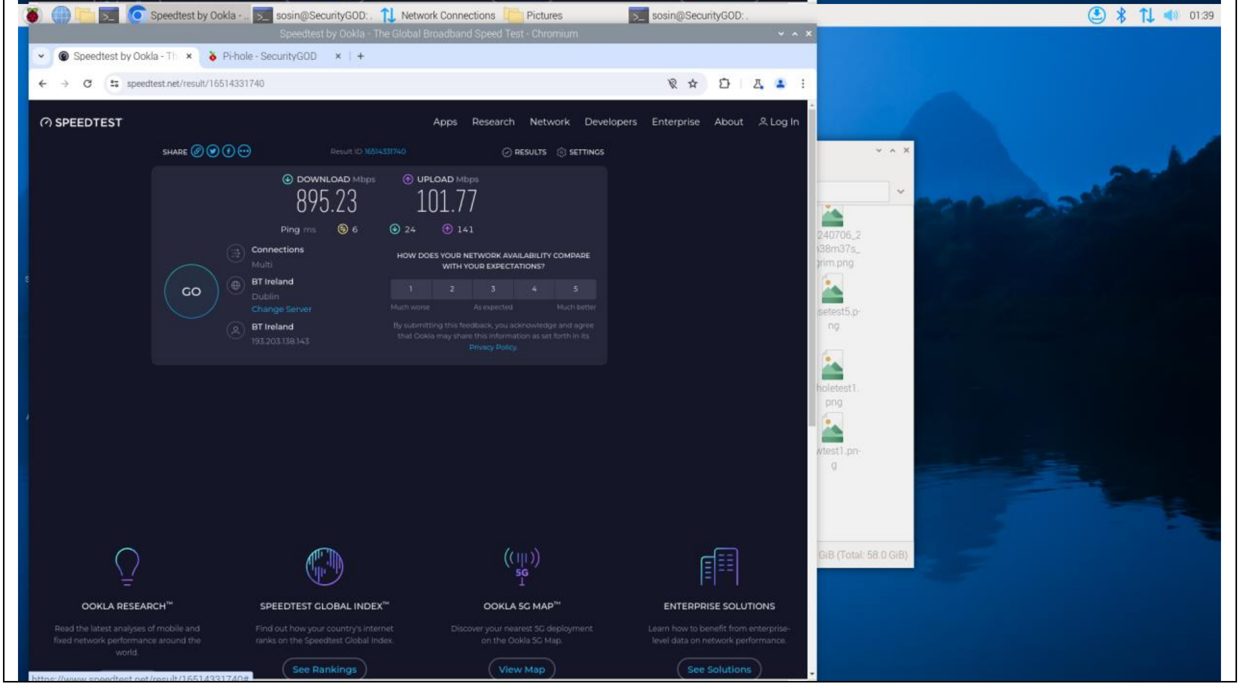

speedtest.net/result/16514331740

Result ID 16514331740

DOWNLOAD Mbps 895.23

UPLOAD Mbps 101.77

Ping ms 6 24 141

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

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1 2 3 4 5

Much worse As expected Much better

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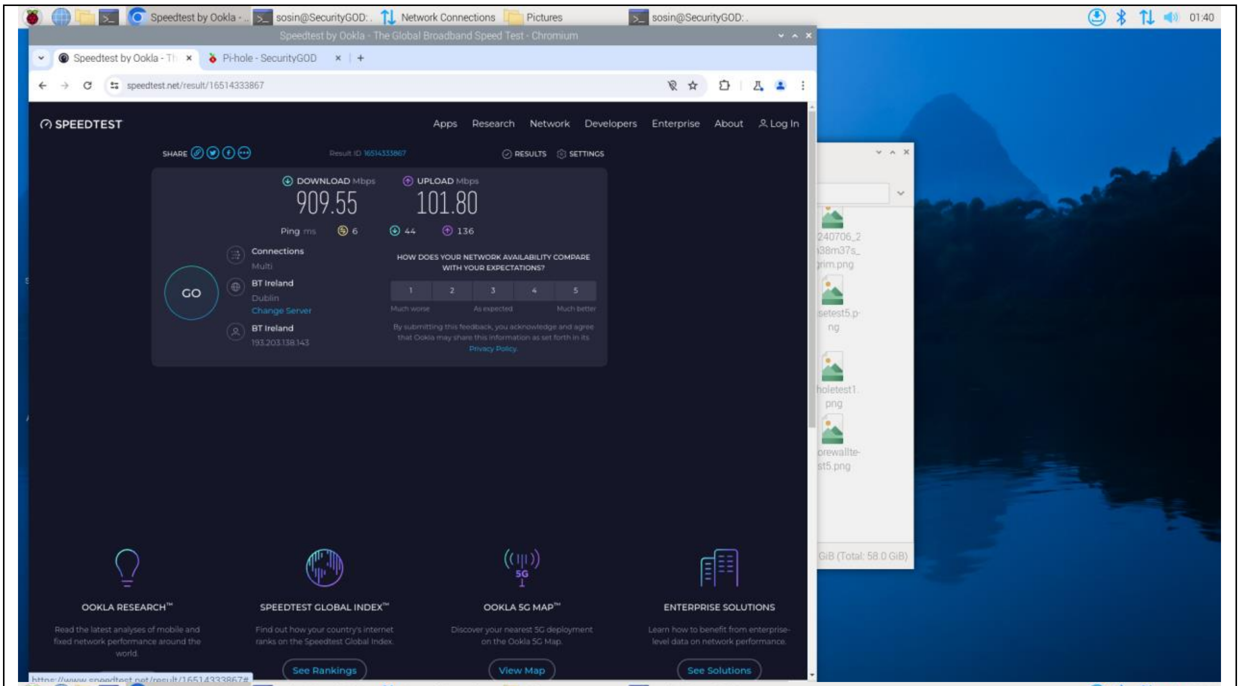
https://www.speedtest.net/result/16514331740#


Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514333867

SPEEDTEST

Result ID 16514333867

DOWNLOAD Mbps 909.55

UPLOAD Mbps 101.80

Ping ms 6 44 136

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

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1 2 3 4 5

Much worse As expected Much better

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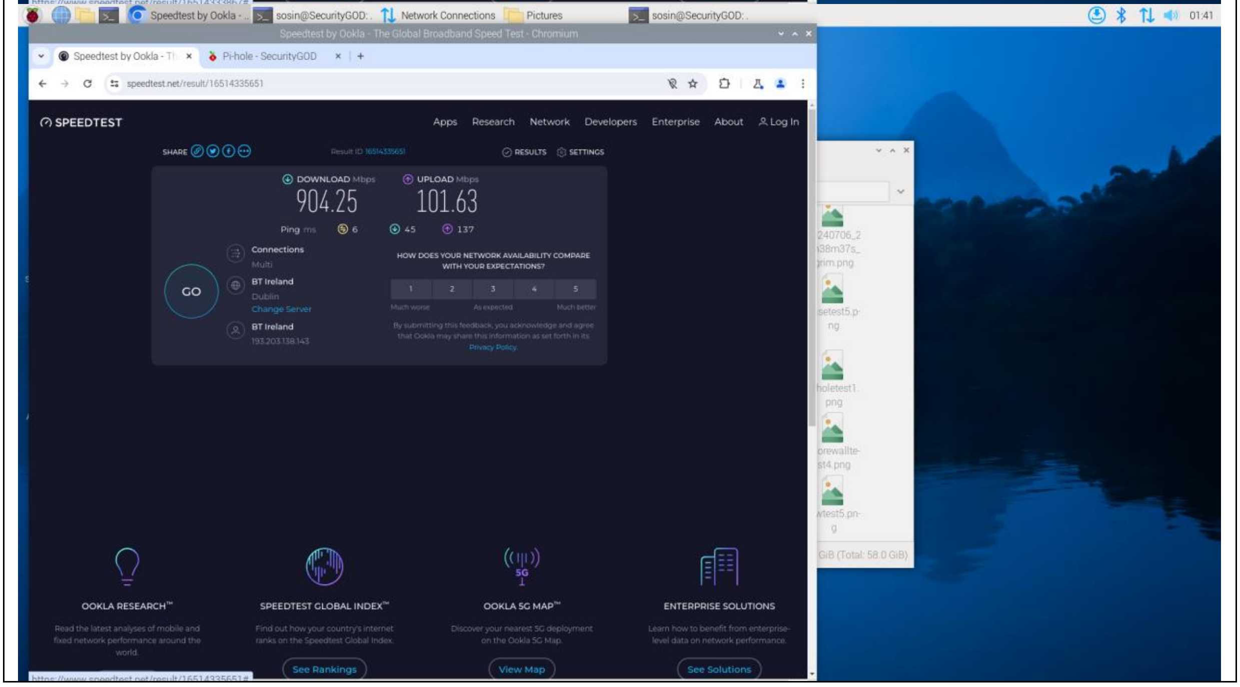
Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514335651

SPEEDTEST

Result ID 16514335651

DOWNLOAD Mbps 904.25

UPLOAD Mbps 101.63

Ping ms 6 45 137

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

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1 2 3 4 5

Much worse As expected Much better

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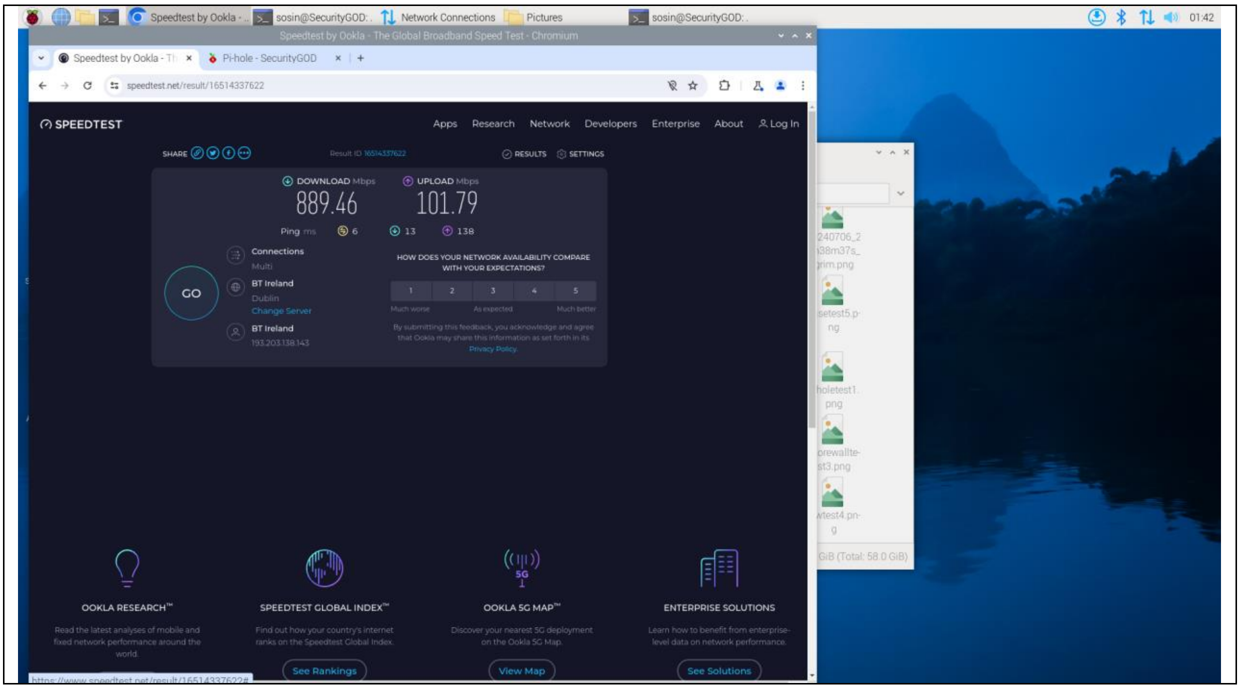

Result ID 16514337622

DOWNLOAD Mbps 889.46

UPLOAD Mbps 101.79

Ping ms 6 13 138

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

1	2	3	4	5
Much worse		As expected		Much better

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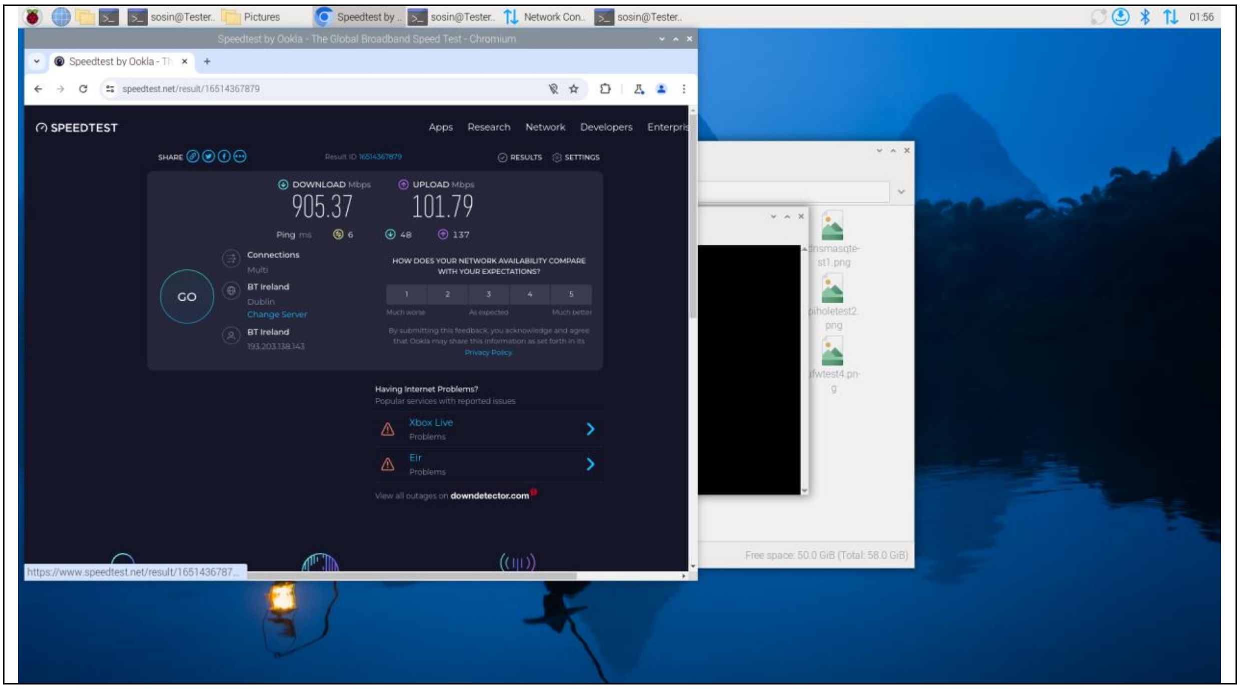
https://www.speedtest.net/result/16514337622#

Pi-Hole Speed tests

9.1.2 Host Device



Result ID 16514367879

DOWNLOAD Mbps 905.37

UPLOAD Mbps 101.79

Ping ms 6 48 137

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

1	2	3	4	5
Much worse		As expected		Much better

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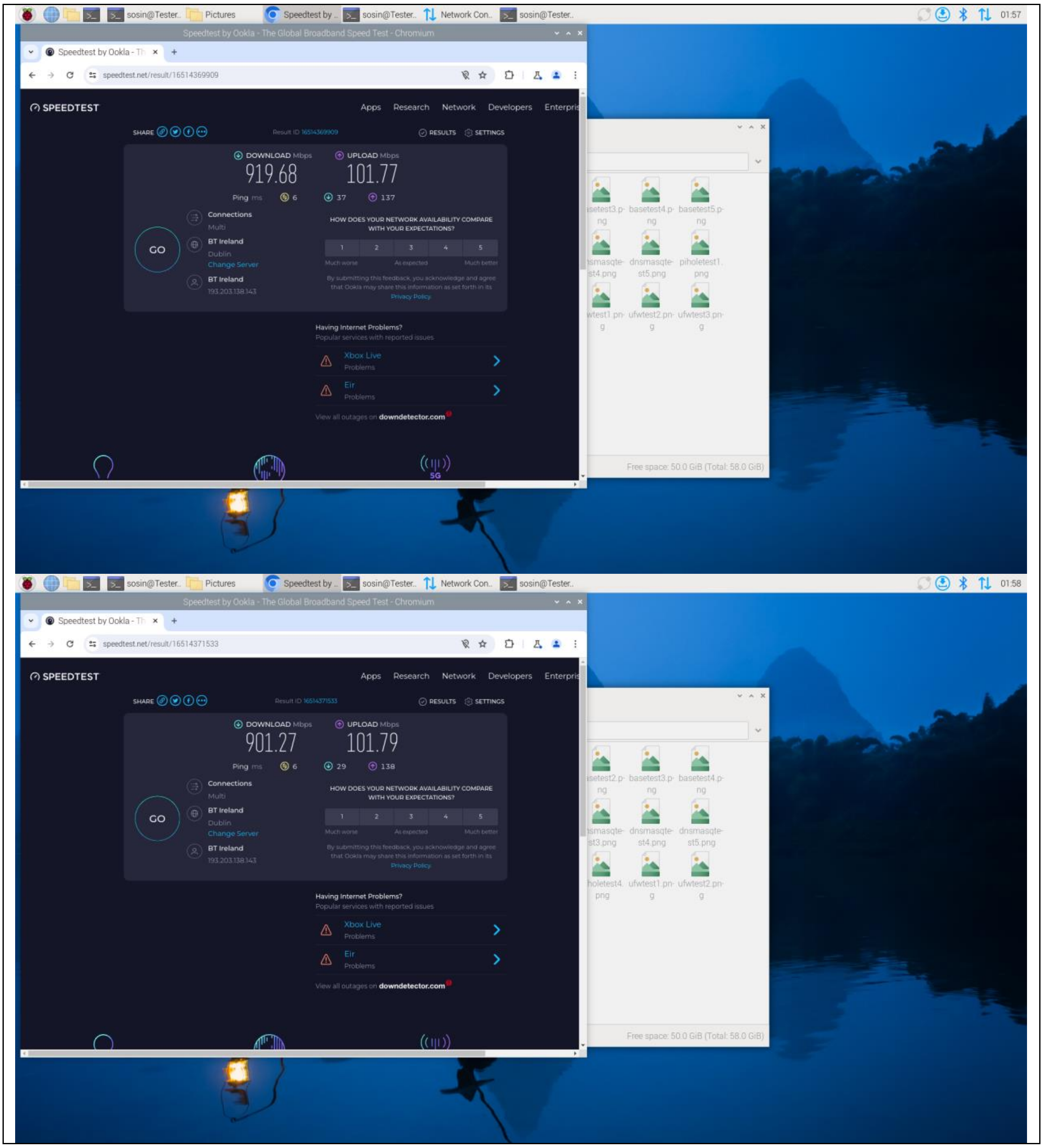
Popular services with reported issues

Xbox Live
Problems

Eir
Problems

View all outages on downdetector.com

https://www.speedtest.net/result/1651436787...



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514369909

SPEEDTEST

Result ID 16514369909

DOWNLOAD Mbps 919.68

UPLOAD Mbps 101.77

Ping ms 6 37 137

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Xbox Live
Problems

Eir
Problems

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Free space: 50.0 GiB (Total: 58.0 GiB)

Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514371533

SPEEDTEST

Result ID 16514371533

DOWNLOAD Mbps 901.27

UPLOAD Mbps 101.79

Ping ms 6 29 138

Connections
Multi

BT Ireland
Dublin
Change Server

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HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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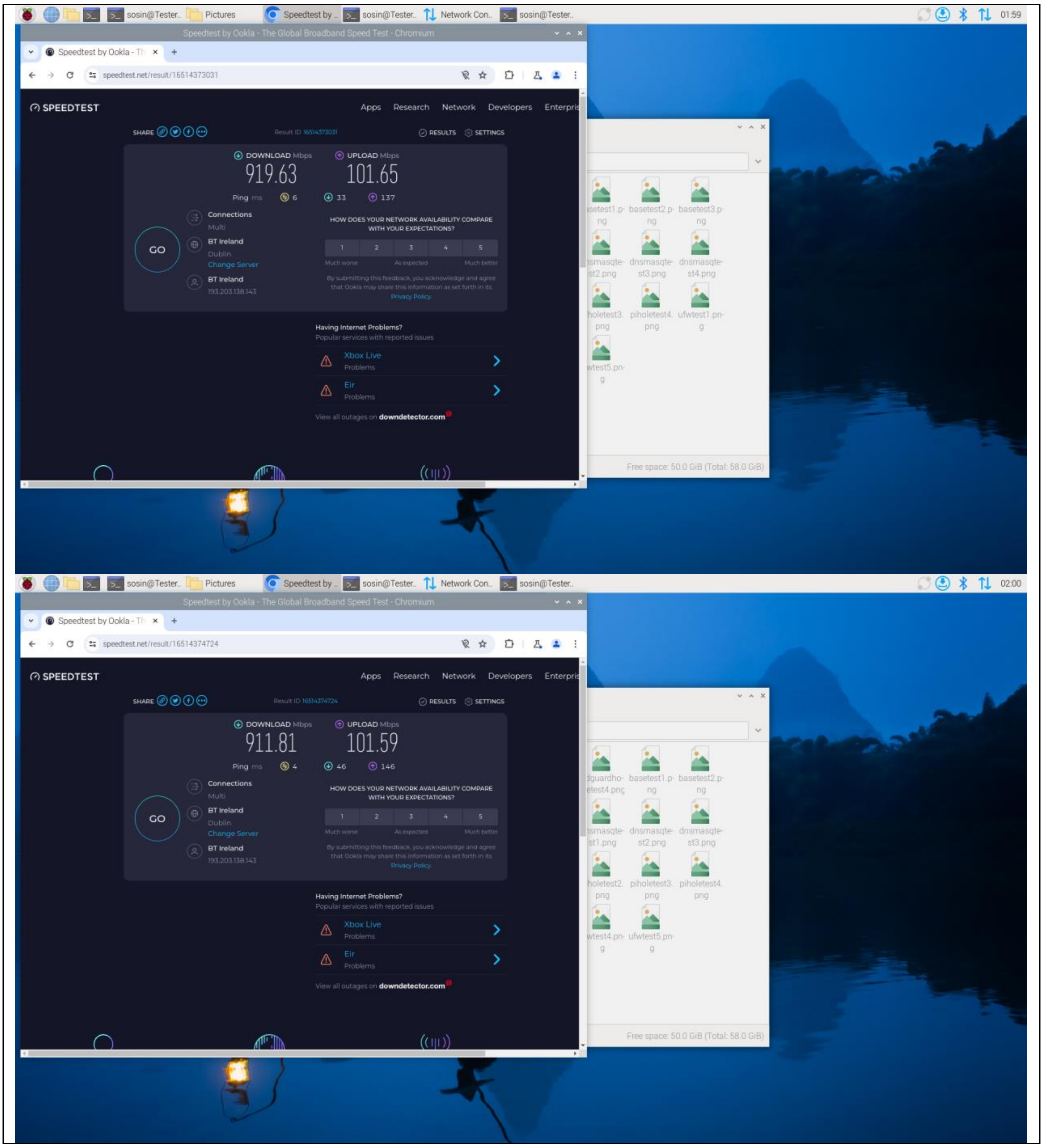
Having Internet Problems?
Popular services with reported issues

Xbox Live
Problems

Eir
Problems

View all outages on downdetector.com

Free space: 50.0 GiB (Total: 58.0 GiB)



Result ID 16514373031

DOWNLOAD Mbps 919.63

UPLOAD Mbps 101.65

Ping ms 6 33 137

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Popular services with reported issues

Xbox Live Problems

Eir Problems

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Result ID 16514374724

DOWNLOAD Mbps 911.81

UPLOAD Mbps 101.59

Ping ms 4 46 146

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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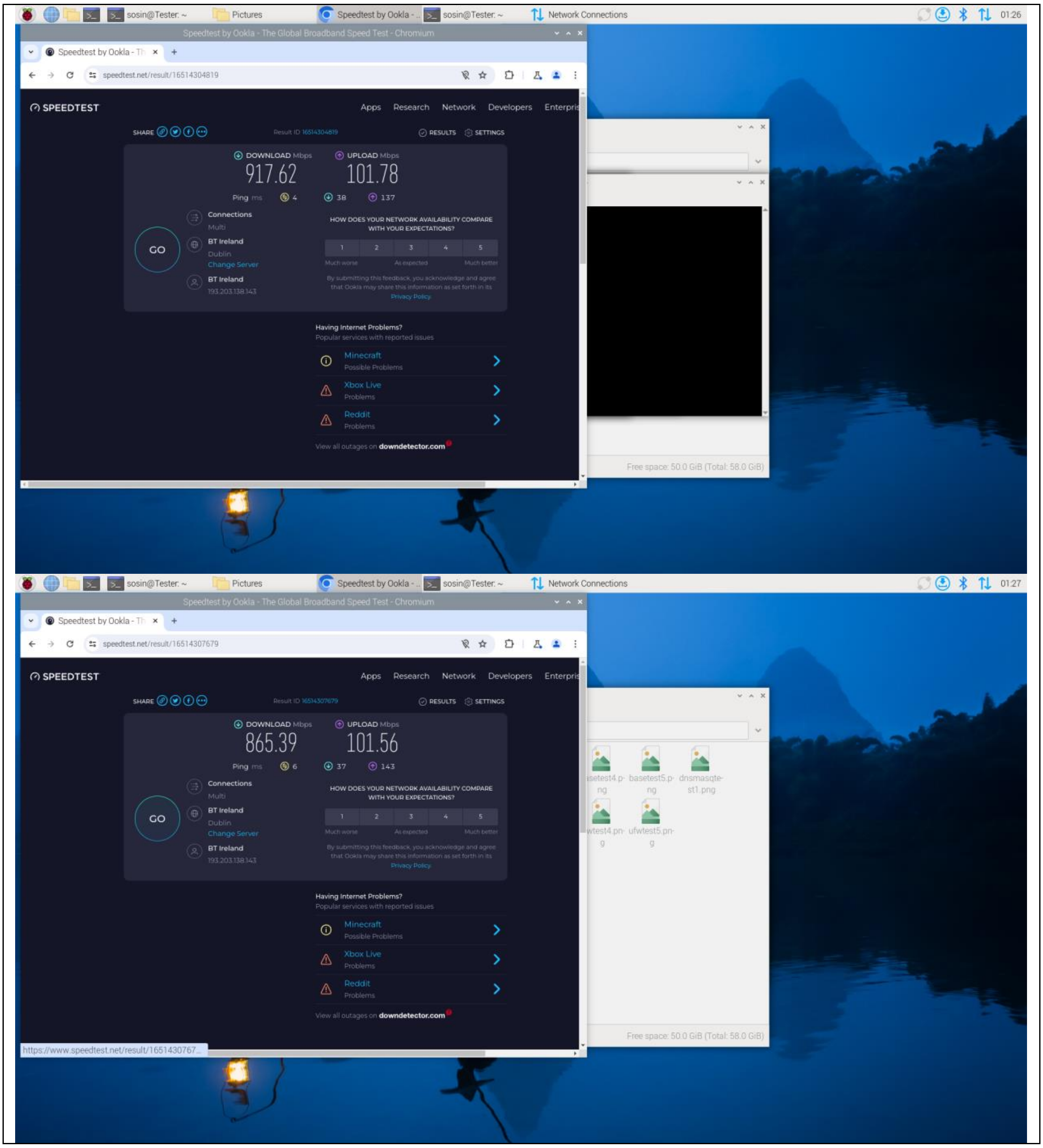
Having Internet Problems?
Popular services with reported issues

Xbox Live Problems

Eir Problems

View all outages on downdetector.com

Ad Guard Home Speed tests


sosin@Tester: ~
Pictures
Speedtest by Ookla - ...
sosin@Tester: ~
Network Connections
01:26
Speedtest by Ookla - The Global Broadband Speed Test - Chromium
Speedtest by Ookla - Th
speedtest.net/result/16514304819
SPEEDTEST
Apps
Research
Network
Developers
Enterpris
SHARE
RESULTS
SETTINGS
GO
HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?
1
2
3
4
5
Much worse
As expected
Much better
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Having Internet Problems?
Popular services with reported issues
Minecraft
Possible Problems
Xbox Live
Problems
Reddit
Problems
View all outages on downdetector.com

Result ID 16514304819

DOWNLOAD Mbps 917.62

UPLOAD Mbps 101.78

Ping ms 4 38 137

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

Free space: 50.0 GiB (Total: 58.0 GiB)

sosin@Tester: ~
Pictures
Speedtest by Ookla - ...
sosin@Tester: ~
Network Connections
01:27
Speedtest by Ookla - The Global Broadband Speed Test - Chromium
Speedtest by Ookla - Th
speedtest.net/result/16514307679
SPEEDTEST
Apps
Research
Network
Developers
Enterpris
SHARE
RESULTS
SETTINGS
GO
HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?
1
2
3
4
5
Much worse
As expected
Much better
By submitting this feedback, you acknowledge and agree that Ookla may share this information as set forth in its Privacy Policy
Having Internet Problems?
Popular services with reported issues
Minecraft
Possible Problems
Xbox Live
Problems
Reddit
Problems
View all outages on downdetector.com
https://www.speedtest.net/result/1651430767...
setest4.png
basetest5.png
dnsmasqtest1.png
wtest4.png
ufwtest5.png

Result ID 16514307679

DOWNLOAD Mbps 865.39

UPLOAD Mbps 101.56

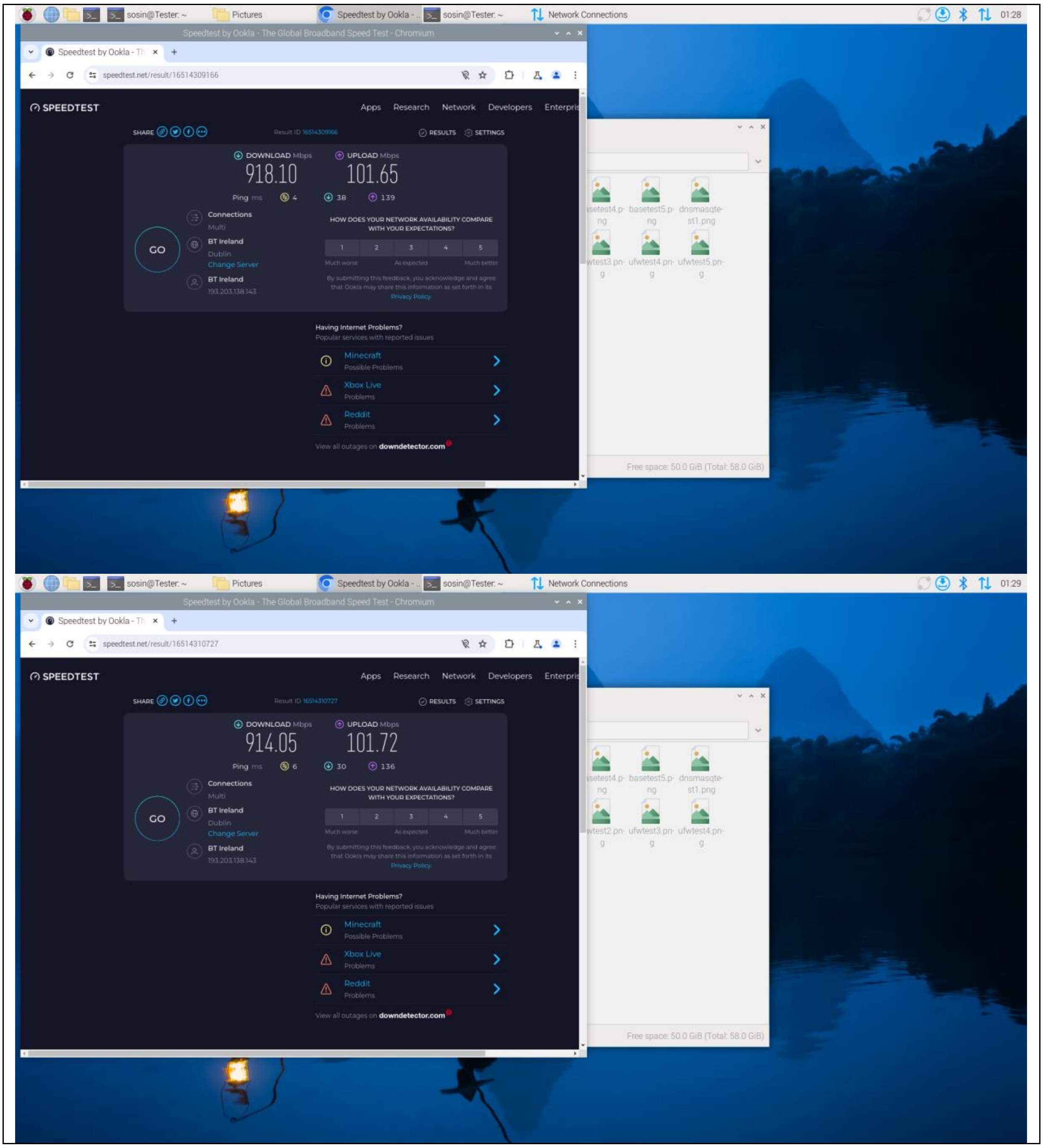
Ping ms 6 37 143

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

Free space: 50.0 GiB (Total: 58.0 GiB)



sosin@Tester: ~ Pictures Speedtest by Ookla - .. sosin@Tester: ~ Network Connections 01:28

Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514309166

SPEEDTEST

Result ID 16514309166

DOWNLOAD Mbps 918.10

UPLOAD Mbps 101.65

Ping ms 4 38 139

Connections Multi

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Popular services with reported issues

Minecraft Possible Problems

Xbox Live Problems

Reddit Problems

View all outages on downdetector.com

Free space: 50.0 GiB (Total: 58.0 GiB)

sosin@Tester: ~ Pictures Speedtest by Ookla - .. sosin@Tester: ~ Network Connections 01:29

Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514310727

SPEEDTEST

Result ID 16514310727

DOWNLOAD Mbps 914.05

UPLOAD Mbps 101.72

Ping ms 6 30 136

Connections Multi

BT Ireland Dublin

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Popular services with reported issues

Minecraft Possible Problems

Xbox Live Problems

Reddit Problems

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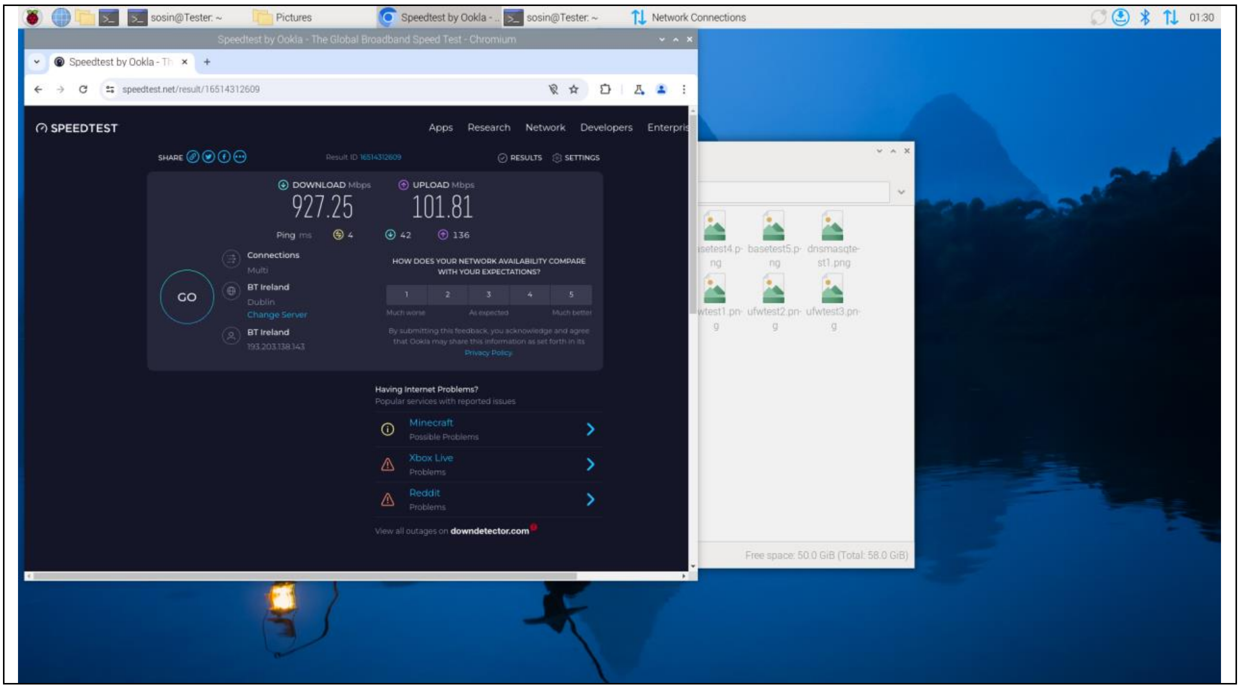
Free space: 50.0 GiB (Total: 58.0 GiB)



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514312609

Result ID 16514312609

DOWNLOAD Mbps 927.25

UPLOAD Mbps 101.81

Ping ms 4 42 136

Connections Multi

BT Ireland Dublin Change Server

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Popular services with reported issues

Minecraft Possible Problems

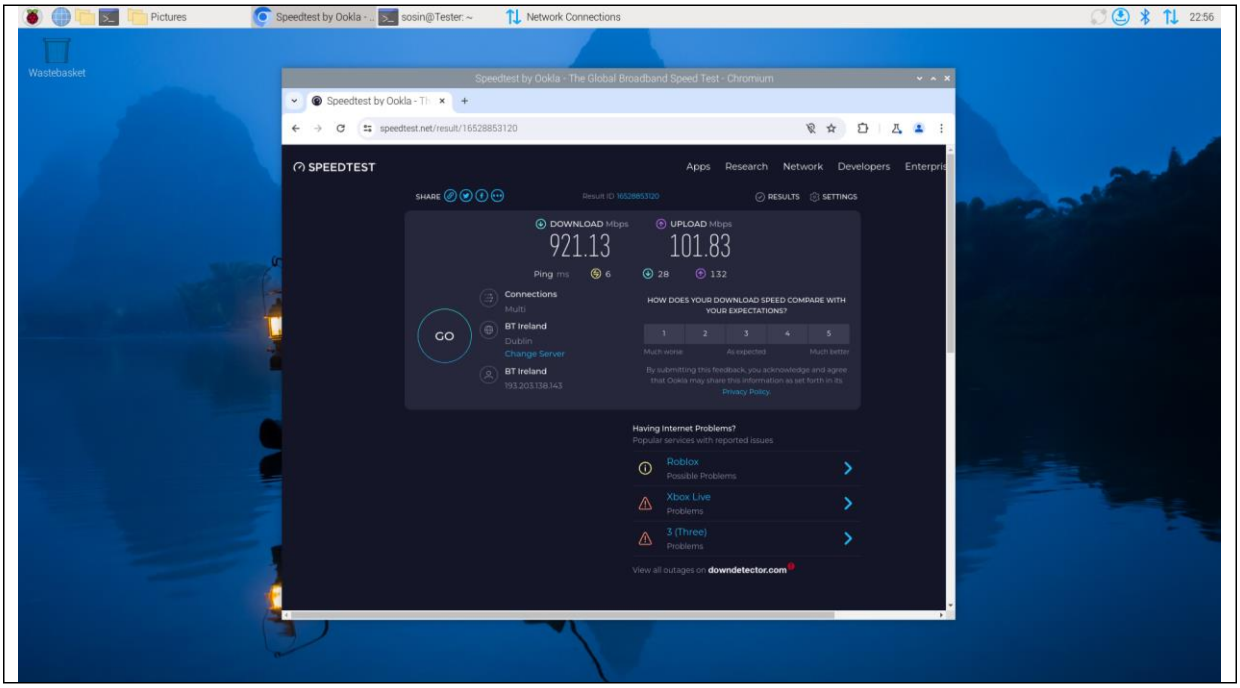
Xbox Live Problems

Reddit Problems

View all outages on downdetector.com

Free space: 50.0 GiB (Total: 58.0 GiB)

DNS Masq Speed tests



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16528853120

Result ID 16528853120

DOWNLOAD Mbps 921.13

UPLOAD Mbps 101.83

Ping ms 6 28 132

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES YOUR DOWNLOAD SPEED COMPARE WITH YOUR EXPECTATIONS?

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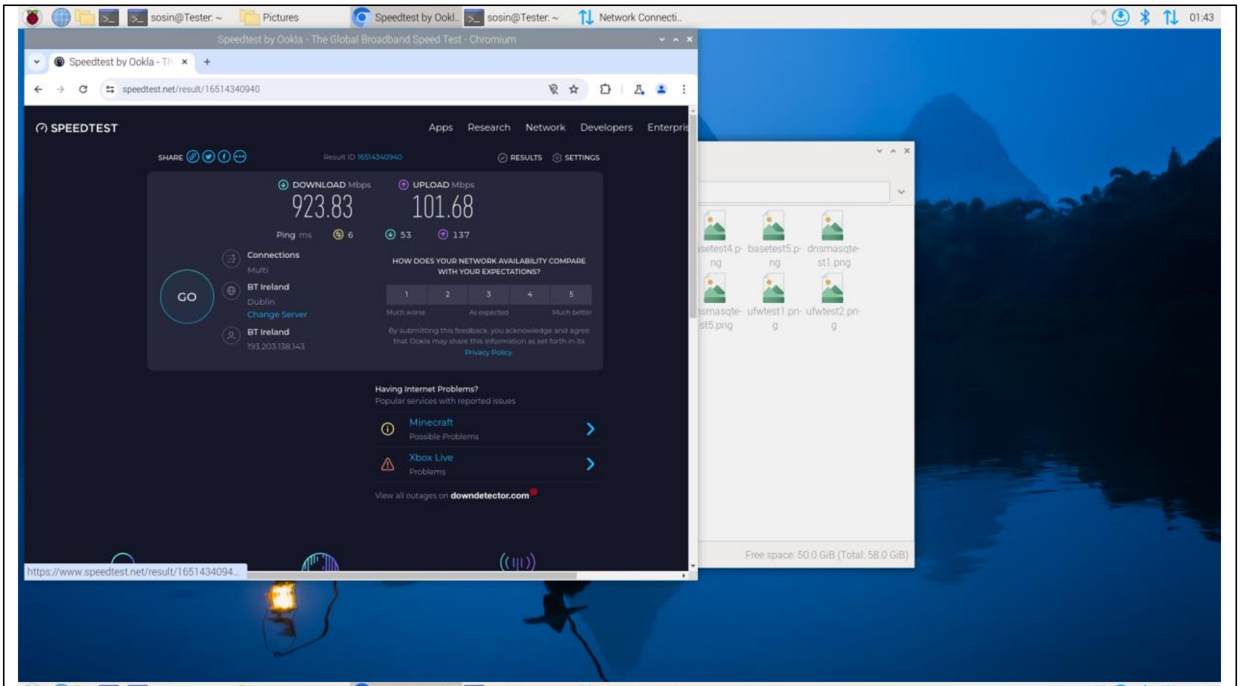
Having Internet Problems?
Popular services with reported issues

Roblox Possible Problems

Xbox Live Problems

3 (Three) Problems

View all outages on downdetector.com



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514340940

Result ID 16514340940

DOWNLOAD Mbps 923.83

UPLOAD Mbps 101.68

Ping ms 6 | 53 | 137

Connections: Multi

BT Ireland, Dublin

BT Ireland 193.203.138.143

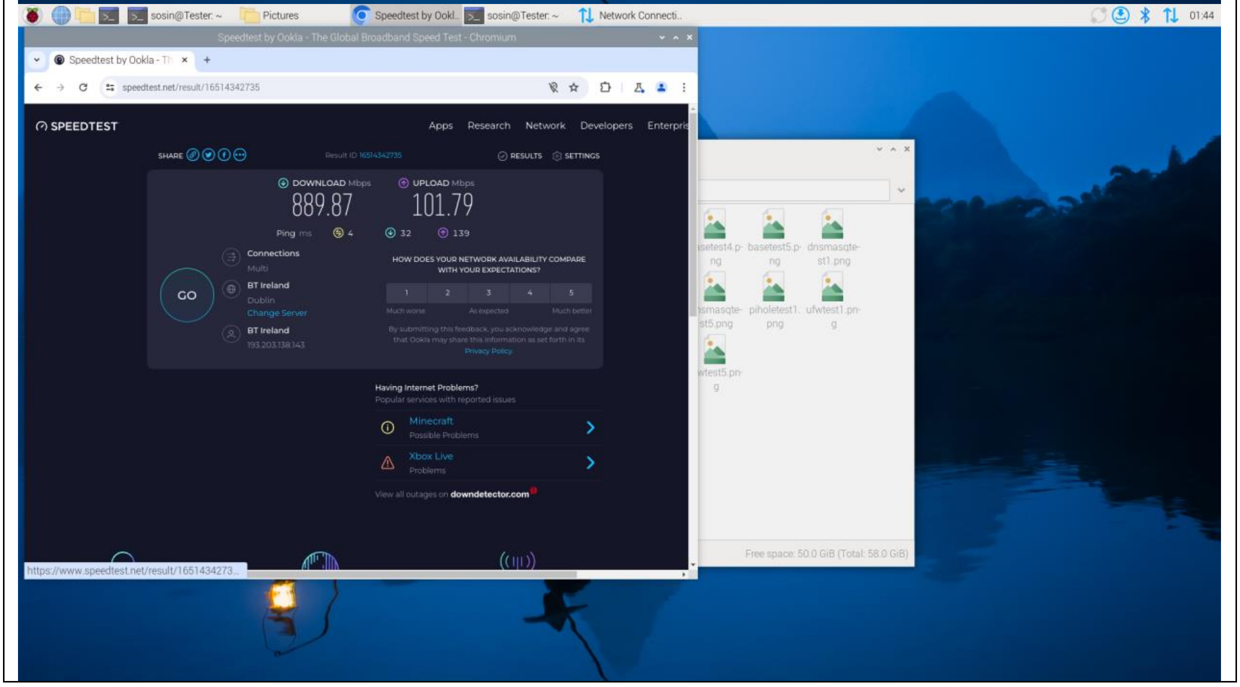
HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

Having Internet Problems? Popular services with reported issues

Minecraft — Possible Problems

Xbox Live — Problems

Free space: 50.0 GiB (Total: 58.0 GiB)



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514342735

Result ID 16514342735

DOWNLOAD Mbps 889.87

UPLOAD Mbps 101.79

Ping ms 4 | 32 | 139

Connections: Multi

BT Ireland, Dublin

BT Ireland 193.203.138.143

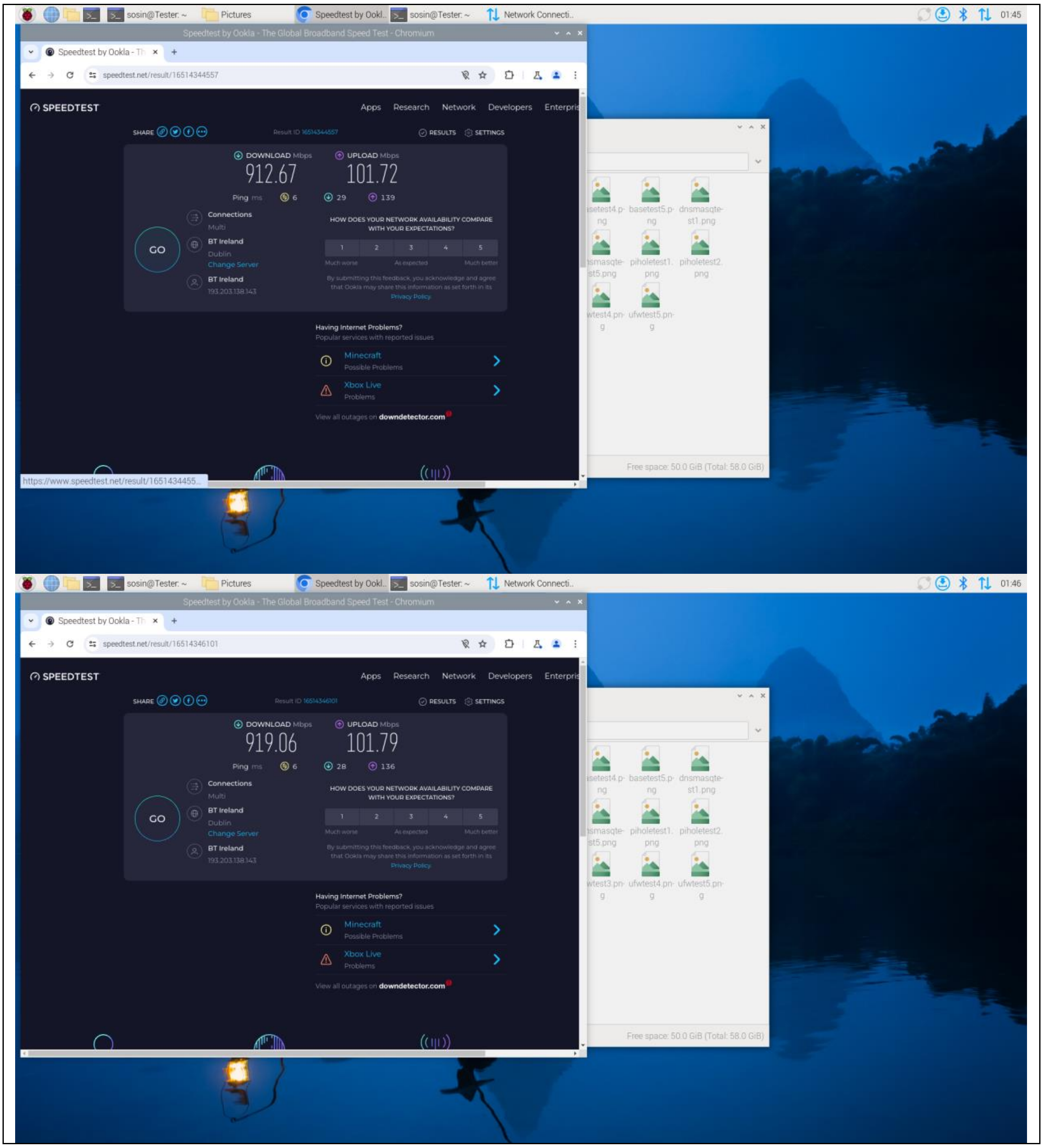
HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

Having Internet Problems? Popular services with reported issues

Minecraft — Possible Problems

Xbox Live — Problems

Free space: 50.0 GiB (Total: 58.0 GiB)



speedtest.net/result/16514344557

SPEEDTEST

Result ID 16514344557

DOWNLOAD Mbps 912.67

UPLOAD Mbps 101.72

Ping ms 6 29 139

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

Free space: 50.0 GiB (Total: 58.0 GiB)

speedtest.net/result/16514346101

SPEEDTEST

Result ID 16514346101

DOWNLOAD Mbps 919.06

UPLOAD Mbps 101.79

Ping ms 6 28 136

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

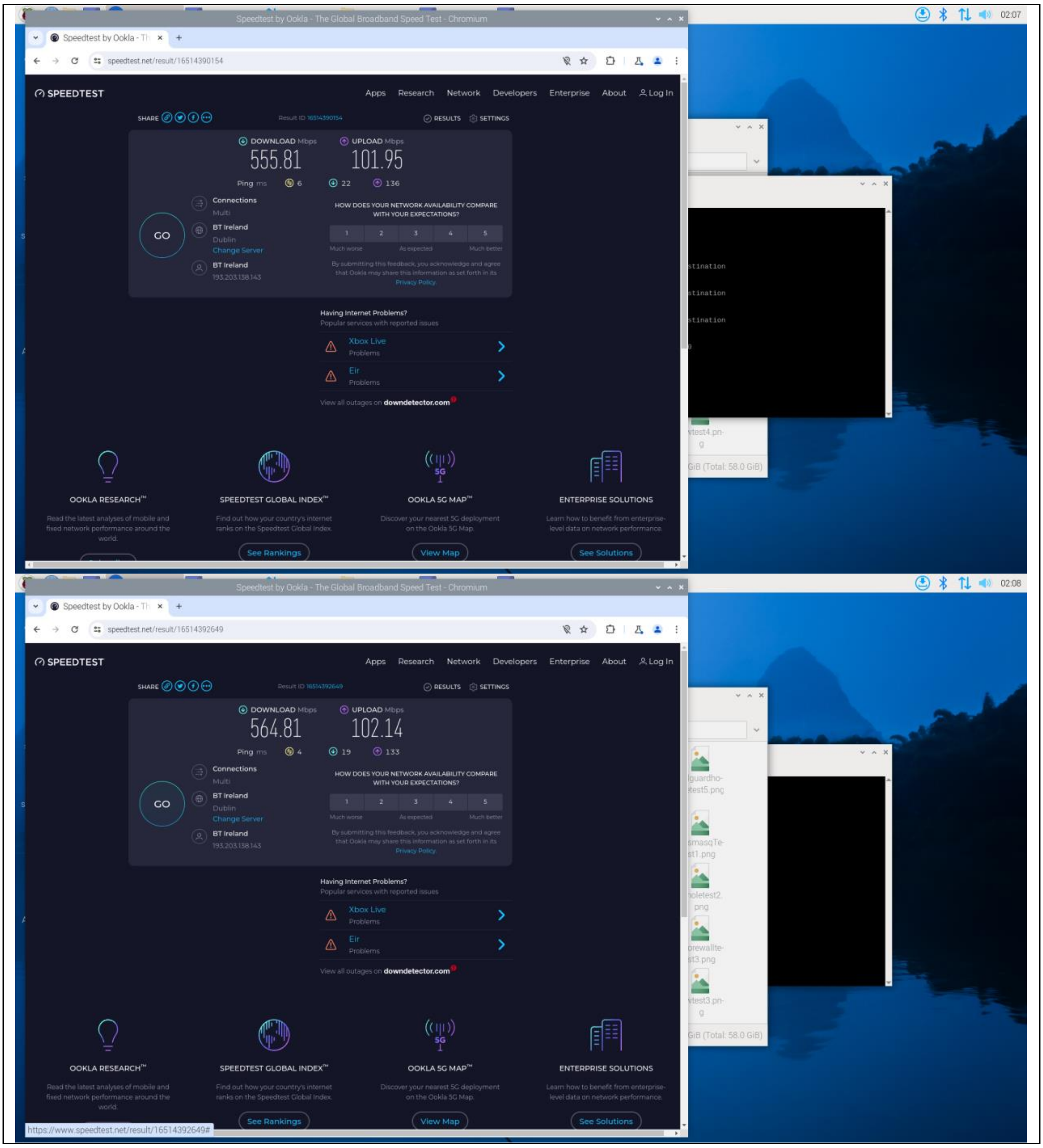
HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

Free space: 50.0 GiB (Total: 58.0 GiB)

Pi-Hole Speed tests

9.2 IPS Testing Screenshots

9.2.1 Security Device



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514390154

Result ID 16514390154

DOWNLOAD Mbps 555.81

UPLOAD Mbps 101.95

Ping ms 6 22 136

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514392649

Result ID 16514392649

DOWNLOAD Mbps 564.81

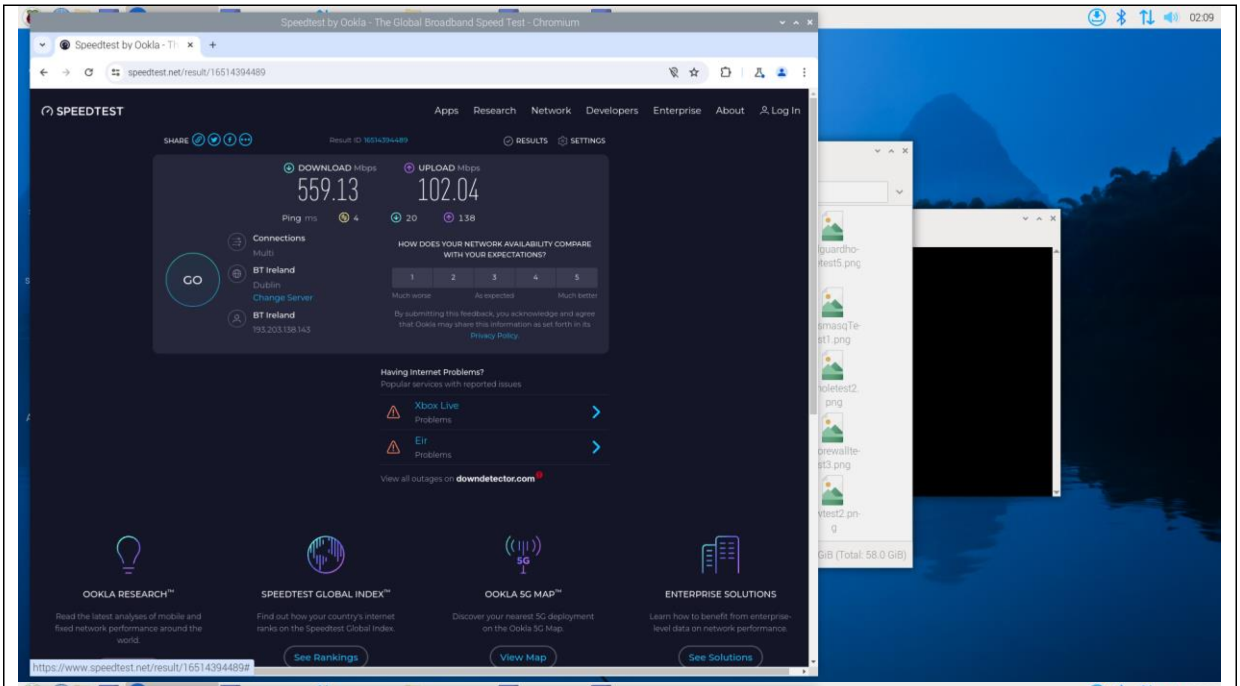
UPLOAD Mbps 102.14

Ping ms 4 19 133

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143



Result ID 16514394489

DOWNLOAD Mbps 559.13

UPLOAD Mbps 102.04

Ping ms 4 20 138

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

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1 2 3 4 5
Much worse As expected Much better

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Popular services with reported issues

Xbox Live
Problems

Eir
Problems

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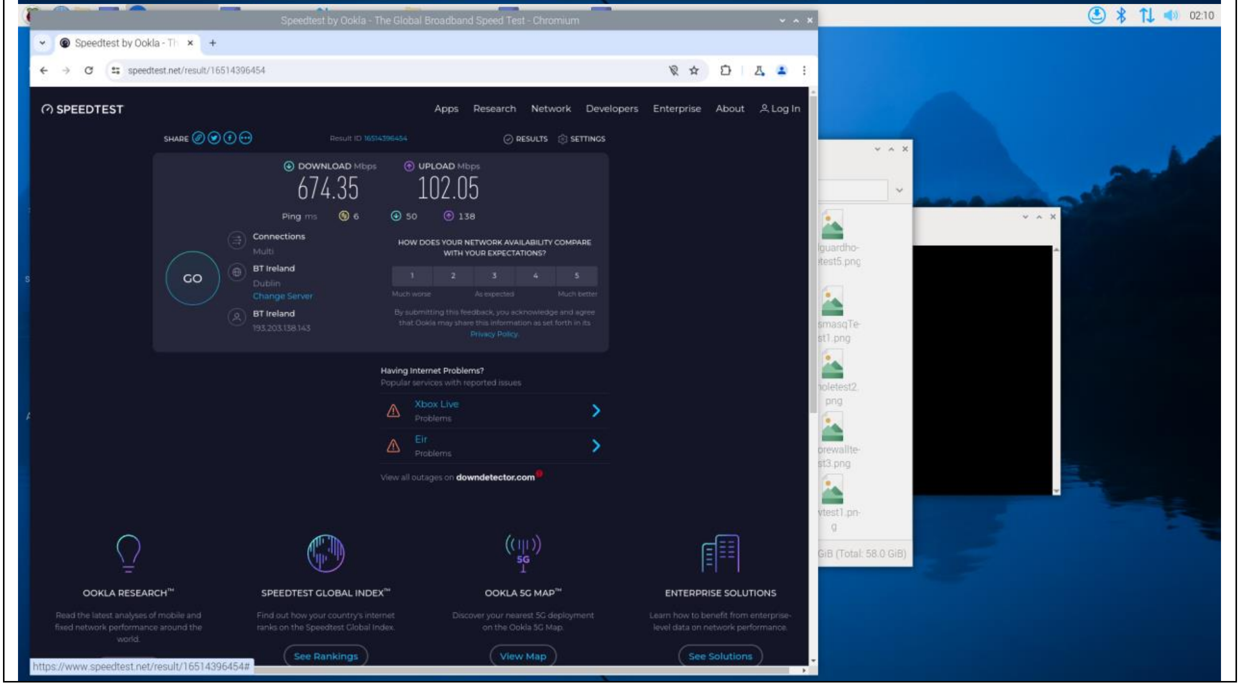
https://www.speedtest.net/result/16514394489#



Result ID 16514396454

DOWNLOAD Mbps 674.35

UPLOAD Mbps 102.05

Ping ms 6 50 138

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

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1 2 3 4 5
Much worse As expected Much better

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Popular services with reported issues

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Problems

Eir
Problems

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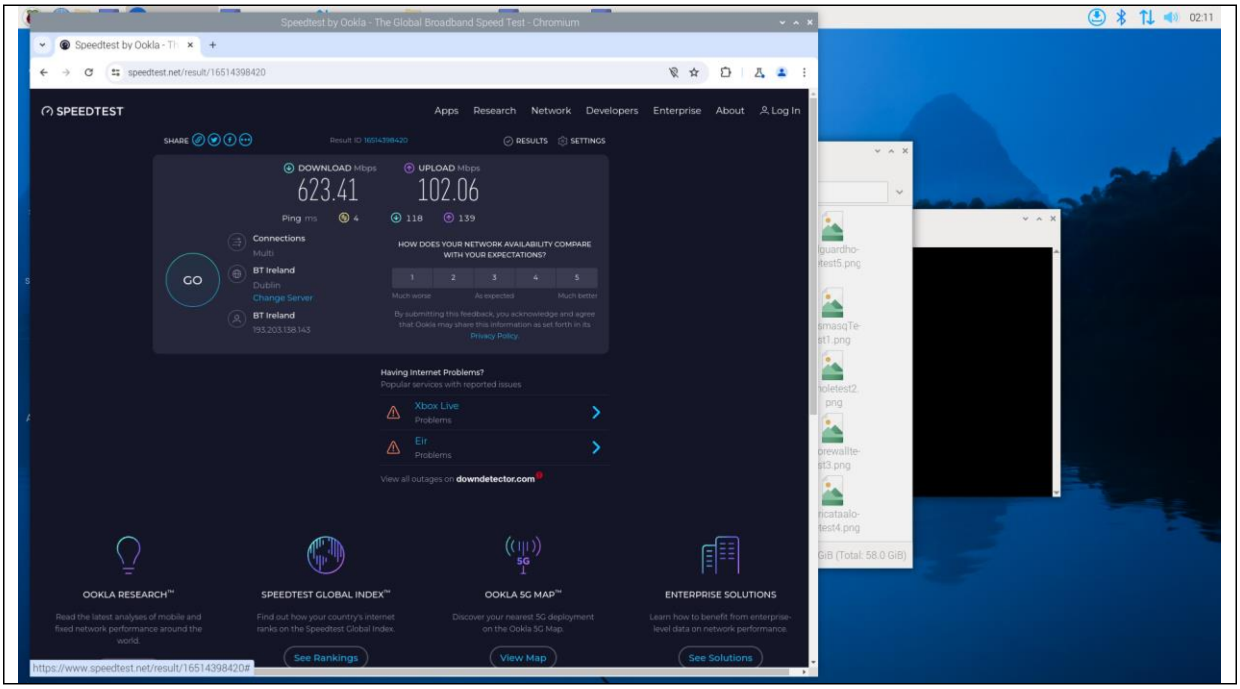
https://www.speedtest.net/result/16514396454#



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514398420

SPEEDTEST

Result ID 16514398420

DOWNLOAD Mbps 623.41

UPLOAD Mbps 102.06

Ping ms 4 118 139

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

HOW DOES YOUR NETWORK AVAILABILITY COMPARE WITH YOUR EXPECTATIONS?

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Having Internet Problems?

Popular services with reported issues

Xbox Live Problems

Eir Problems

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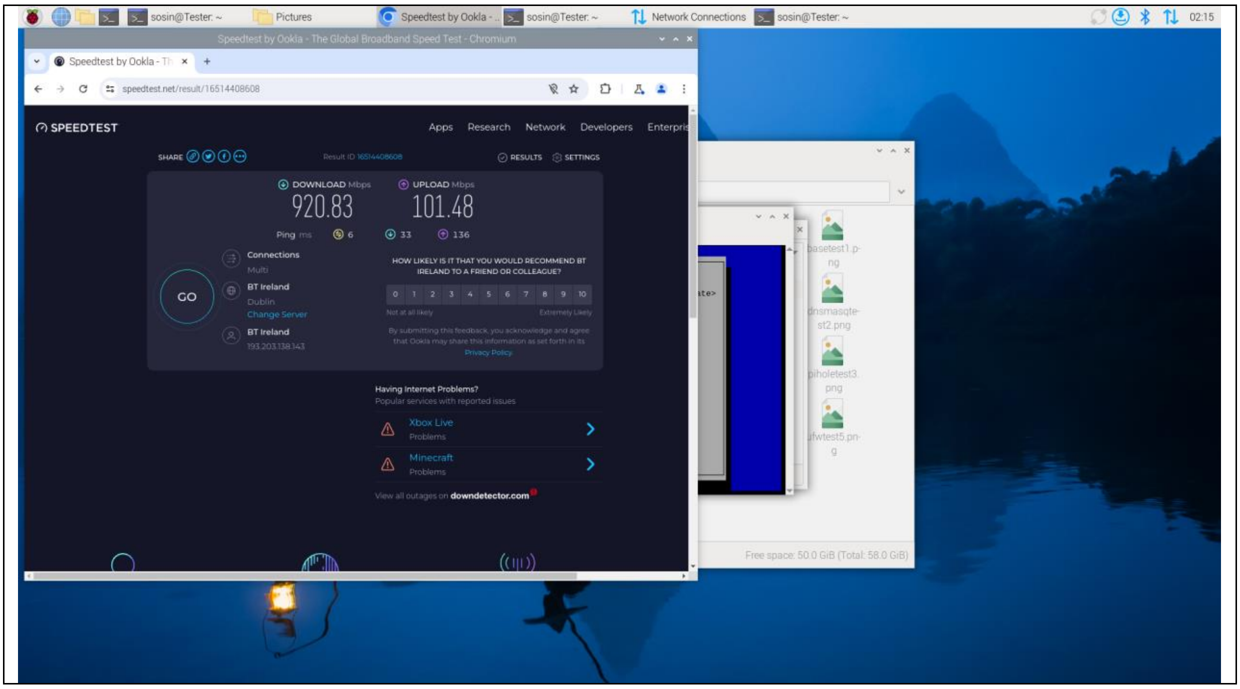
https://www.speedtest.net/result/16514398420#

Suricata Speed tests

9.2.2 Host Device



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514408608

SPEEDTEST

Result ID 16514408608

DOWNLOAD Mbps 920.83

UPLOAD Mbps 101.48

Ping ms 6 33 136

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

HOW LIKELY IS IT THAT YOU WOULD RECOMMEND BT IRELAND TO A FRIEND OR COLLEAGUE?

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Having Internet Problems?

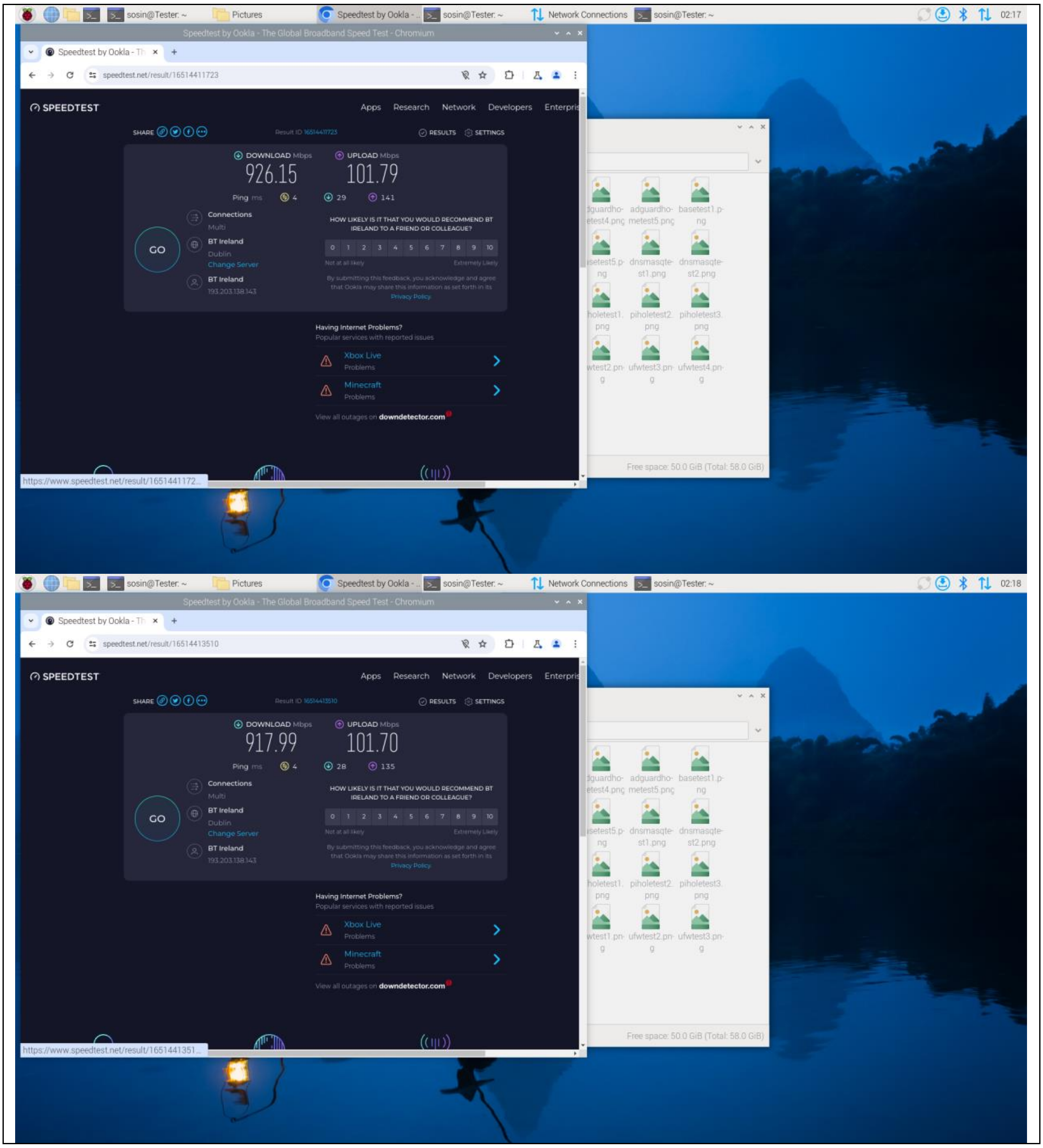
Popular services with reported issues

Xbox Live Problems

Minecraft Problems

View all outages on downdetector.com

Free space: 50.0 GiB (Total: 58.0 GiB)



Result ID 16514411723

DOWNLOAD Mbps 926.15

UPLOAD Mbps 101.79

Ping ms 4 29 141

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW LIKELY IS IT THAT YOU WOULD RECOMMEND BT IRELAND TO A FRIEND OR COLLEAGUE?

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Having Internet Problems?
Popular services with reported issues

Xbox Live
Problems

Minecraft
Problems

View all outages on downdetector.com

Result ID 16514413510

DOWNLOAD Mbps 917.99

UPLOAD Mbps 101.70

Ping ms 4 28 135

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW LIKELY IS IT THAT YOU WOULD RECOMMEND BT IRELAND TO A FRIEND OR COLLEAGUE?

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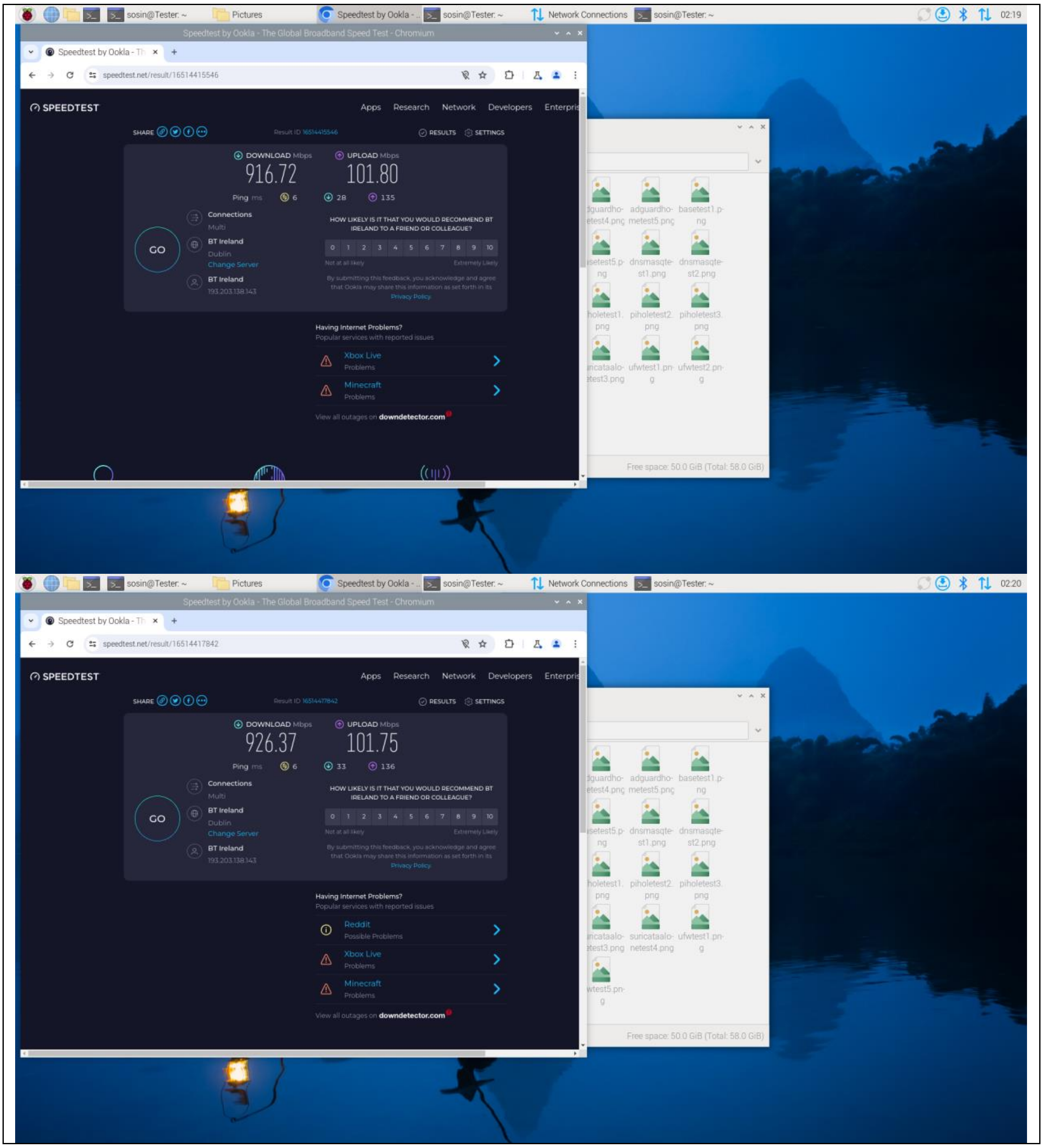
Having Internet Problems?
Popular services with reported issues

Xbox Live
Problems

Minecraft
Problems

View all outages on downdetector.com



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514415546

SHARE Result ID 16514415546 RESULTS SETTINGS

DOWNLOAD Mbps 916.72

UPLOAD Mbps 101.80

Ping ms 6 28 135

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW LIKELY IS IT THAT YOU WOULD RECOMMEND BT IRELAND TO A FRIEND OR COLLEAGUE?

Having Internet Problems?
Popular services with reported issues

Xbox Live Problems

Minecraft Problems

View all outages on downdetector.com

Free space: 50.0 GiB (Total: 58.0 GiB)

Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514417842

SHARE Result ID 16514417842 RESULTS SETTINGS

DOWNLOAD Mbps 926.37

UPLOAD Mbps 101.75

Ping ms 6 33 136

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW LIKELY IS IT THAT YOU WOULD RECOMMEND BT IRELAND TO A FRIEND OR COLLEAGUE?

Having Internet Problems?
Popular services with reported issues

Reddit Possible Problems

Xbox Live Problems

Minecraft Problems

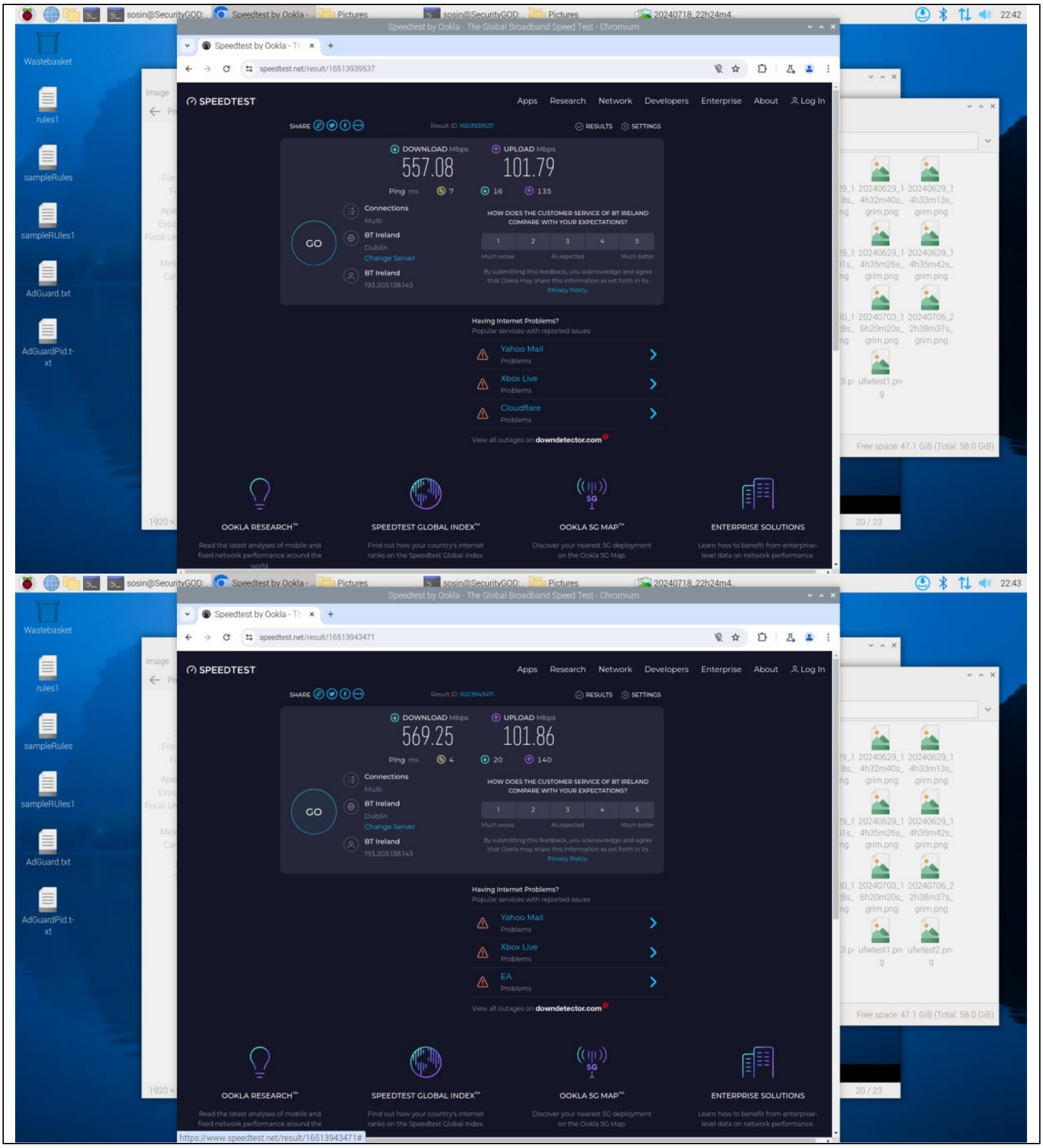
View all outages on downdetector.com

Free space: 50.0 GiB (Total: 58.0 GiB)

Suricata Speed tests

9.3 Firewall Screenshots

9.3.1 Security Device



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16513939537

SPEEDTEST

Result ID 16513939537

DOWNLOAD Mbps 557.08

UPLOAD Mbps 101.79

Ping ms 7 16 135

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Yahoo Mail Problems

Xbox Live Problems

Cloudflare Problems

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22:42

Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16513943471

SPEEDTEST

Result ID 16513943471

DOWNLOAD Mbps 569.25

UPLOAD Mbps 101.86

Ping ms 4 20 140

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Yahoo Mail Problems

Xbox Live Problems

EA Problems

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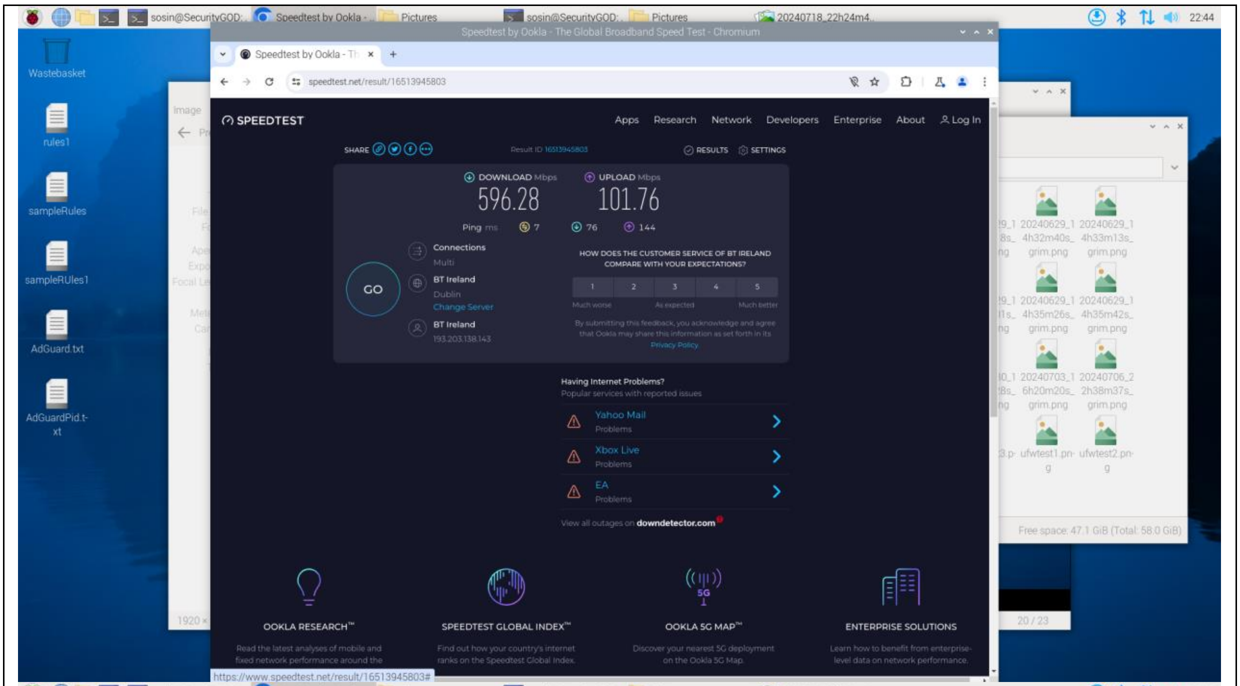
https://www.speedtest.net/result/16513943471#

22:43



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16513945803

SPEEDTEST

Result ID 16513945803

DOWNLOAD Mbps 596.28

UPLOAD Mbps 101.76

Ping ms 7 76 144

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5
Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Yahoo Mail
Problems

Xbox Live
Problems

EA
Problems

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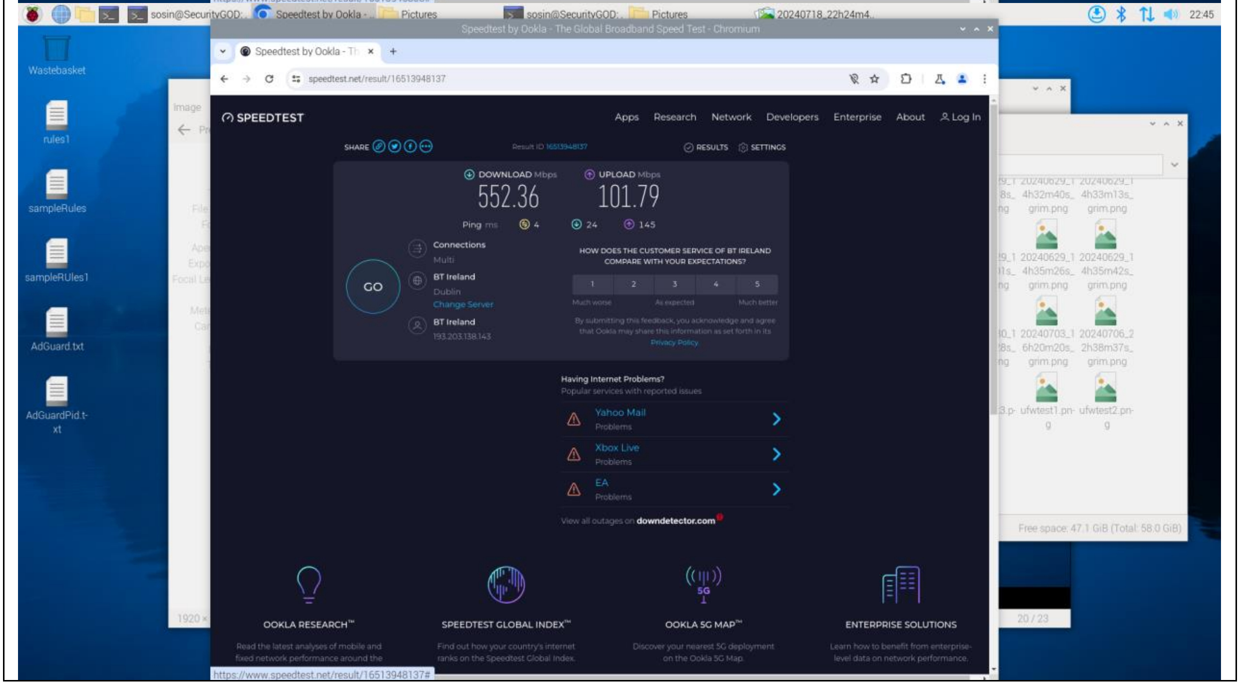
https://www.speedtest.net/result/16513945803#



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16513948137

SPEEDTEST

Result ID 16513948137

DOWNLOAD Mbps 552.36

UPLOAD Mbps 101.79

Ping ms 4 24 145

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

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1 2 3 4 5
Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Yahoo Mail
Problems

Xbox Live
Problems

EA
Problems

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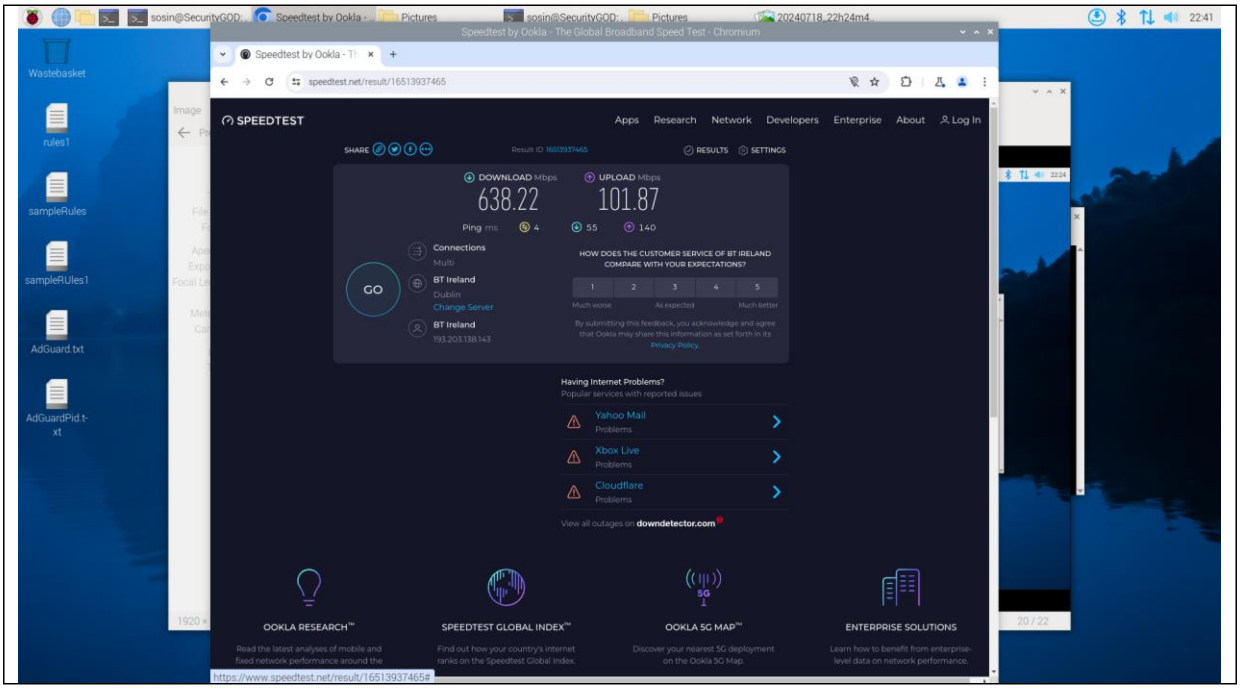
https://www.speedtest.net/result/16513948137#



speedtest.net/result/16513937465

Result ID 16513937465

DOWNLOAD Mbps 638.22

UPLOAD Mbps 101.87

Ping ms 4 55 140

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

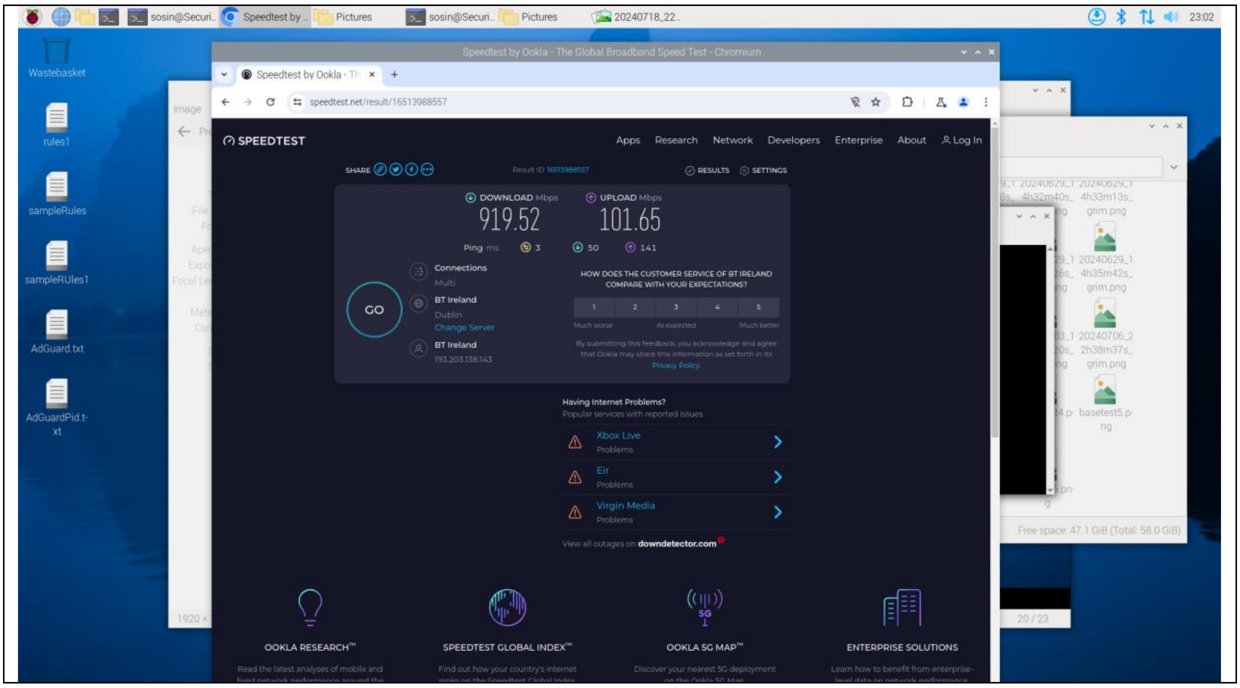
Having Internet Problems?
Popular services with reported issues

Yahoo Mail Problems

Xbox Live Problems

Cloudflare Problems

UFW Speed tests



speedtest.net/result/16513988557

Result ID 16513988557

DOWNLOAD Mbps 919.52

UPLOAD Mbps 101.65

Ping ms 3 50 141

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

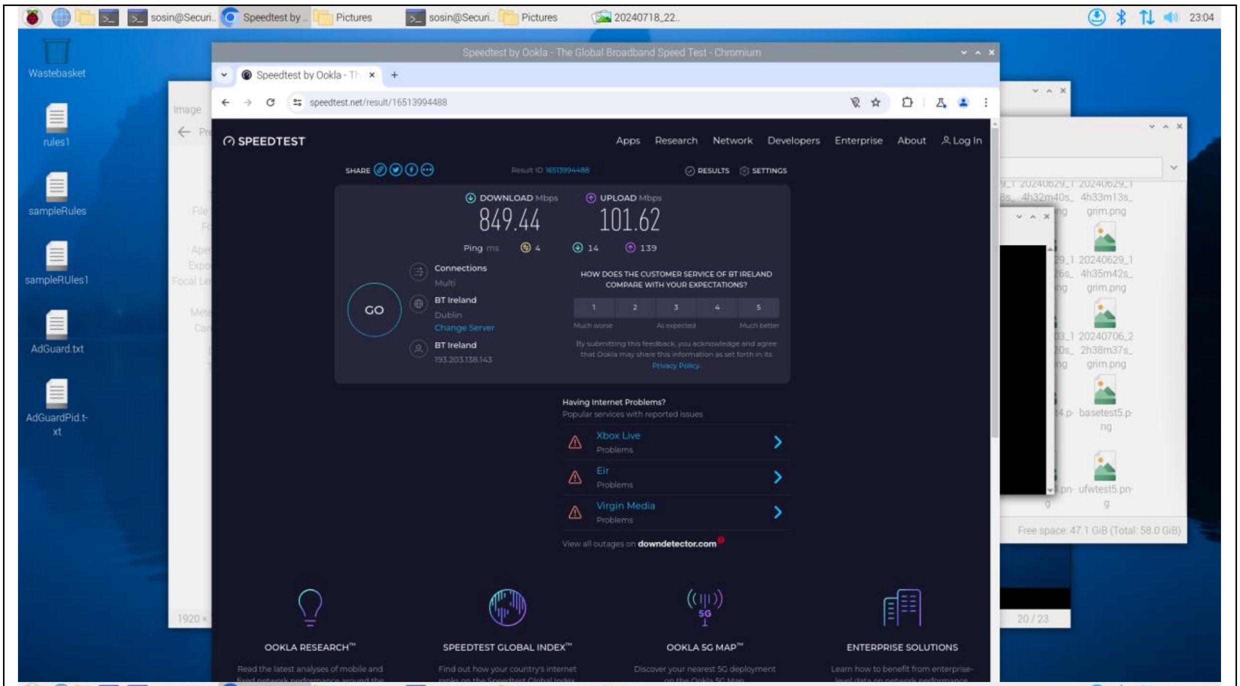
HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

Having Internet Problems?
Popular services with reported issues

Xbox Live Problems

Eir Problems

Virgin Media Problems



Speedtest by Ookla - The Global Broadband Speed Test - Chromium
speedtest.net/result/16513994488
SPEEDTEST
Apps
Research
Network
Developers
Enterprise
About
Log In
SHARE
RESULTS
SETTINGS
GO
23:04

Result ID 16513994488

DOWNLOAD Mbps 849.44

UPLOAD Mbps 101.62

Ping ms 4 14 139

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Xbox Live Problems

Eir Problems

Virgin Media Problems

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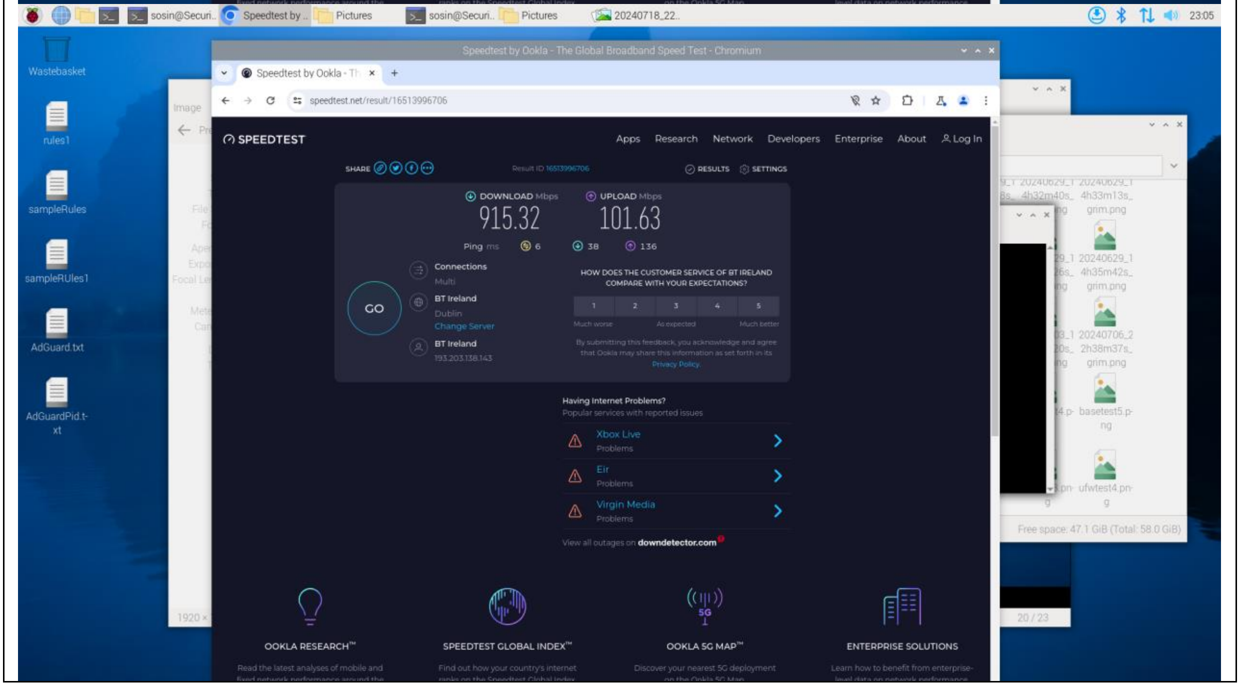

Speedtest by Ookla - The Global Broadband Speed Test - Chromium
speedtest.net/result/16513996706
SPEEDTEST
Apps
Research
Network
Developers
Enterprise
About
Log In
SHARE
RESULTS
SETTINGS
GO
23:05

Result ID 16513996706

DOWNLOAD Mbps 915.32

UPLOAD Mbps 101.63

Ping ms 6 38 136

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

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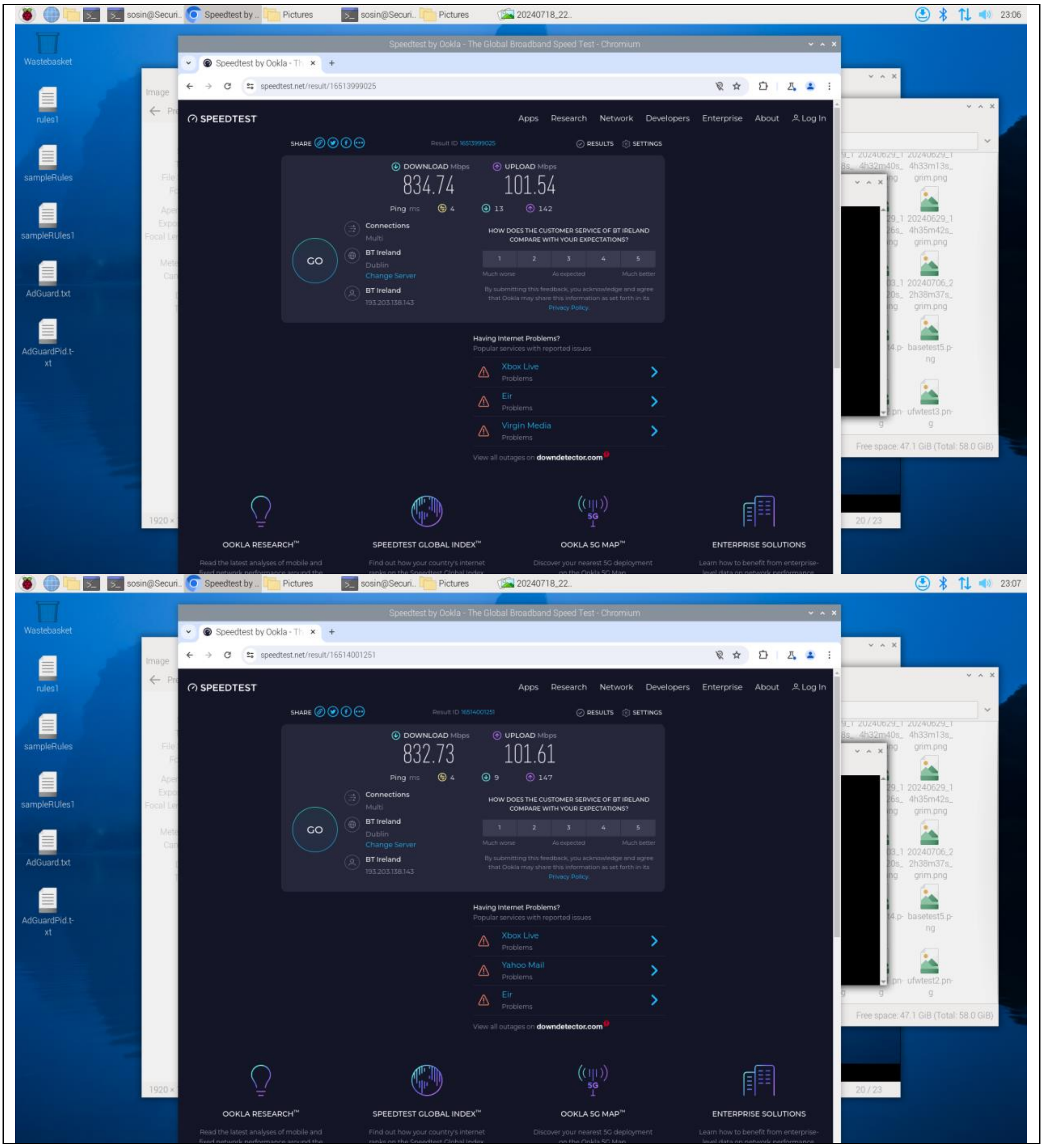
Having Internet Problems?
Popular services with reported issues

Xbox Live Problems

Eir Problems

Virgin Media Problems

View all outages on downdetector.com



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16513999025

SPEEDTEST

Result ID 16513999025

DOWNLOAD Mbps 834.74

UPLOAD Mbps 101.54

Ping ms 4 13 142

Connections
Multi

BT Ireland
Dublin

BT Ireland
193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5
Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Xbox Live
Problems

Eir
Problems

Virgin Media
Problems

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Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16514001251

SPEEDTEST

Result ID 16514001251

DOWNLOAD Mbps 832.73

UPLOAD Mbps 101.61

Ping ms 4 9 147

Connections
Multi

BT Ireland
Dublin

BT Ireland
193.203.138.143

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1 2 3 4 5
Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Xbox Live
Problems

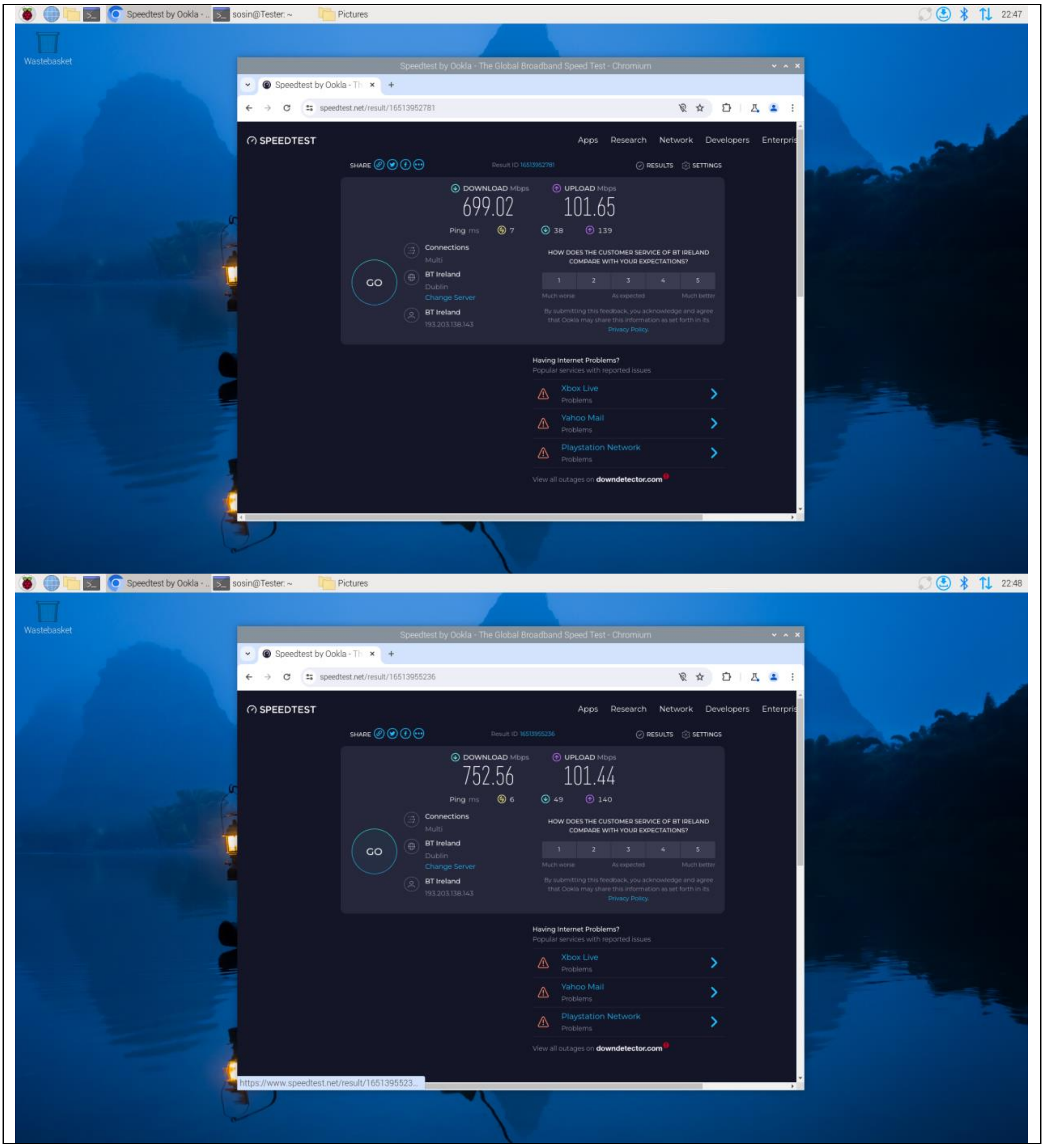
Yahoo Mail
Problems

Eir
Problems

View all outages on downdetector.com

Shorewall Speed tests

9.3.2 Host Device



Result ID 16513952781

DOWNLOAD Mbps 699.02

UPLOAD Mbps 101.65

Ping ms 7 38 139

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Xbox Live
Problems

Yahoo Mail
Problems

Playstation Network
Problems

View all outages on downdetector.com

Result ID 16513955236

DOWNLOAD Mbps 752.56

UPLOAD Mbps 101.44

Ping ms 6 49 140

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

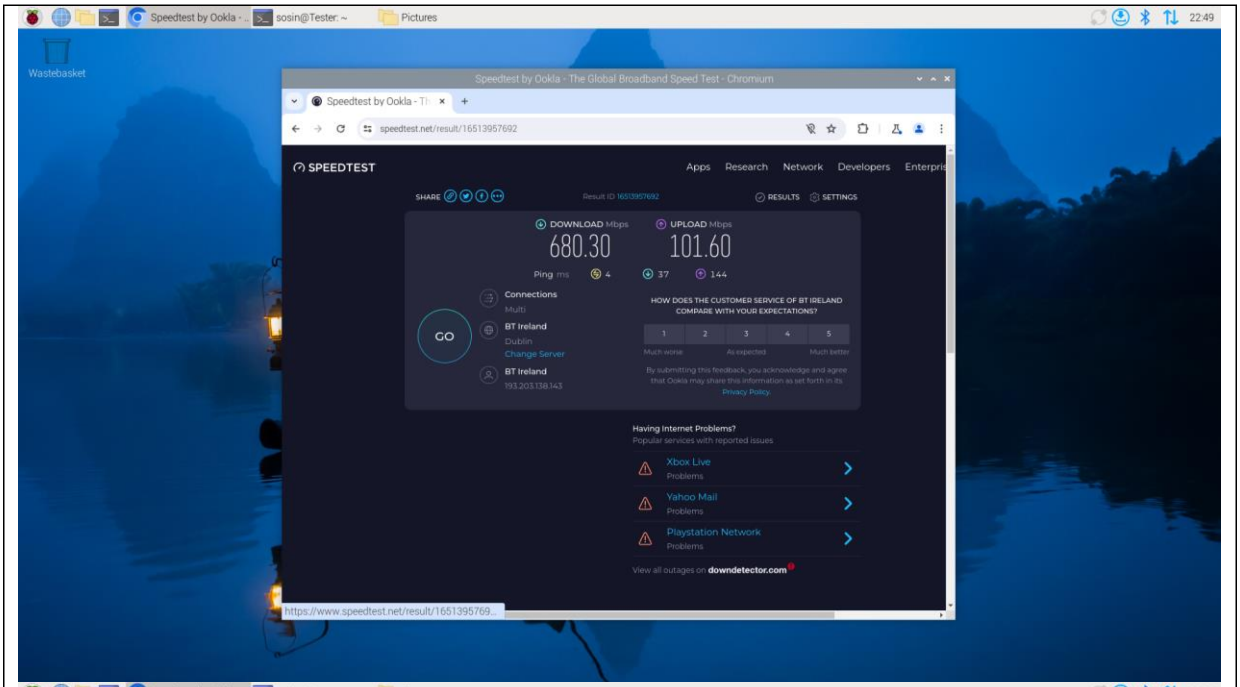
Xbox Live
Problems

Yahoo Mail
Problems

Playstation Network
Problems

View all outages on downdetector.com

https://www.speedtest.net/result/1651395523...



Result ID 16513957692

DOWNLOAD Mbps 680.30

UPLOAD Mbps 101.60

Ping ms 4 37 144

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?

Popular services with reported issues

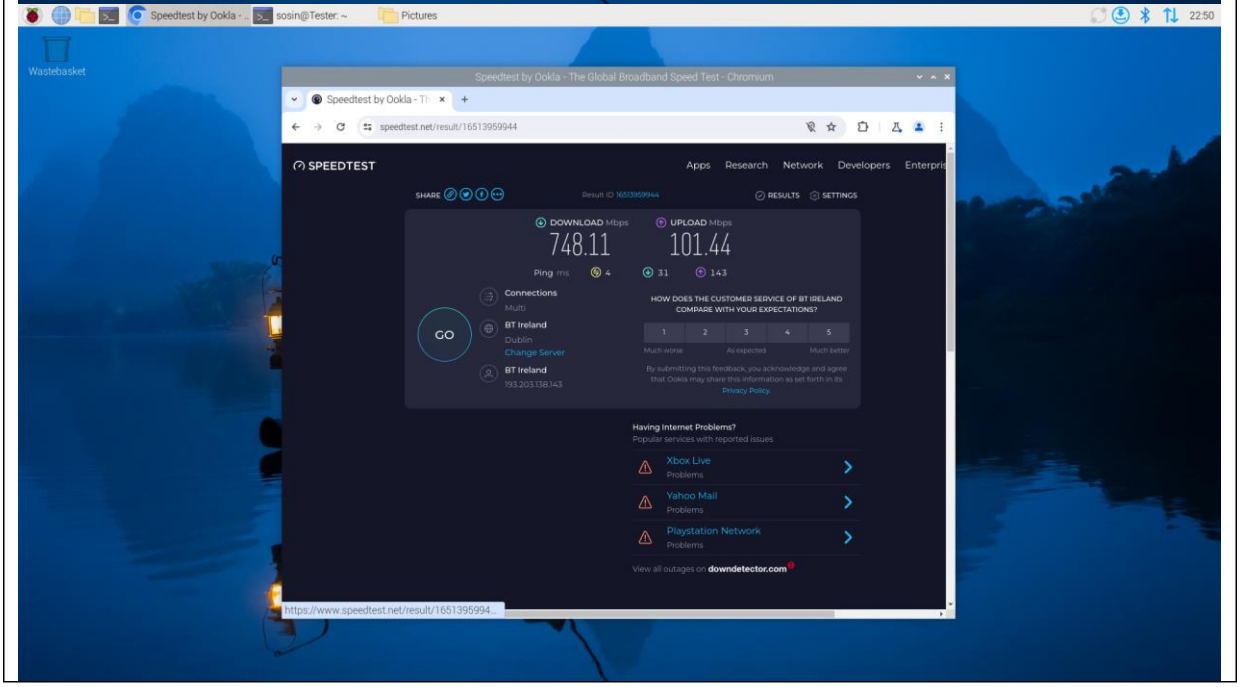
Xbox Live Problems

Yahoo Mail Problems

Playstation Network Problems

View all outages on downdetector.com

https://www.speedtest.net/result/1651395769...



Result ID 16513959944

DOWNLOAD Mbps 748.11

UPLOAD Mbps 101.44

Ping ms 4 31 143

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?

Popular services with reported issues

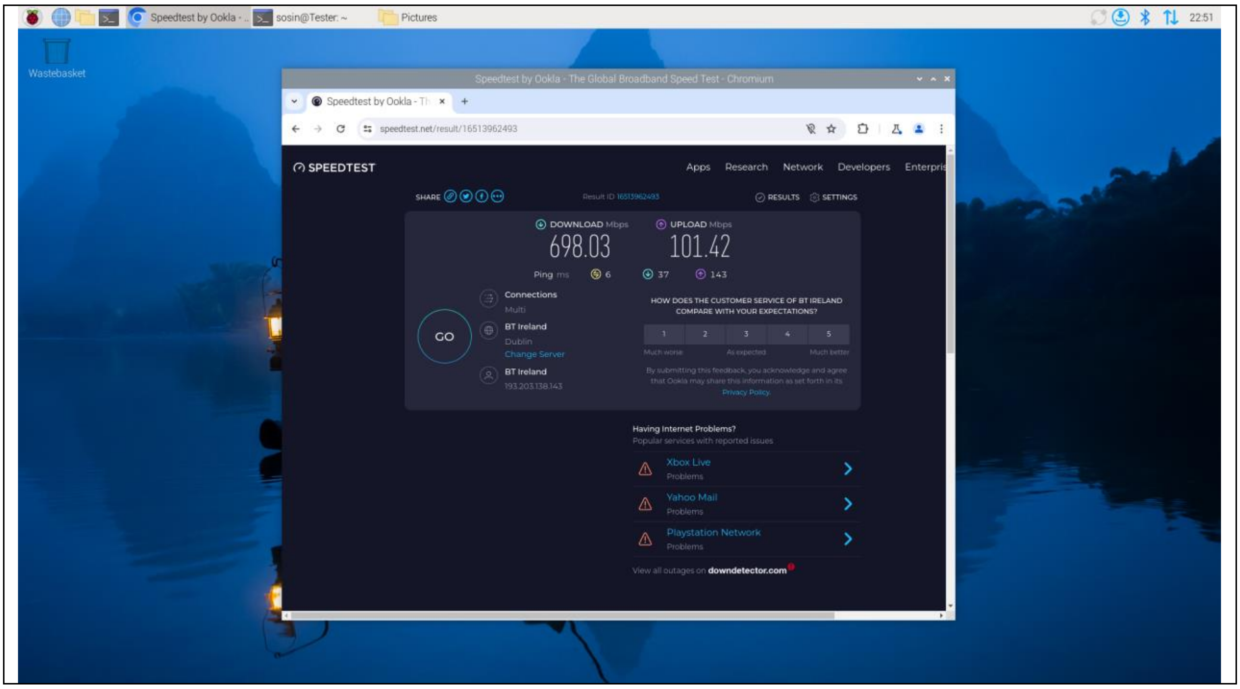
Xbox Live Problems

Yahoo Mail Problems

Playstation Network Problems

View all outages on downdetector.com

https://www.speedtest.net/result/1651395994...


Speedtest by Ookla - ...
sosin@Tester: ~
Pictures
22:51
Wastebasket
Speedtest by Ookla - The Global Broadband Speed Test - Chromium
speedtest.net/result/16513962493
SPEEDTEST
Apps
Research
Network
Developers
Enterpris
SHARE
RESULTS
SETTINGS
GO
Change Server
Having Internet Problems?
Popular services with reported issues
View all outages on downdetector.com

Result ID 16513962493

DOWNLOAD Mbps 698.03

UPLOAD Mbps 101.42

Ping ms 6 37 143

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

Xbox Live Problems

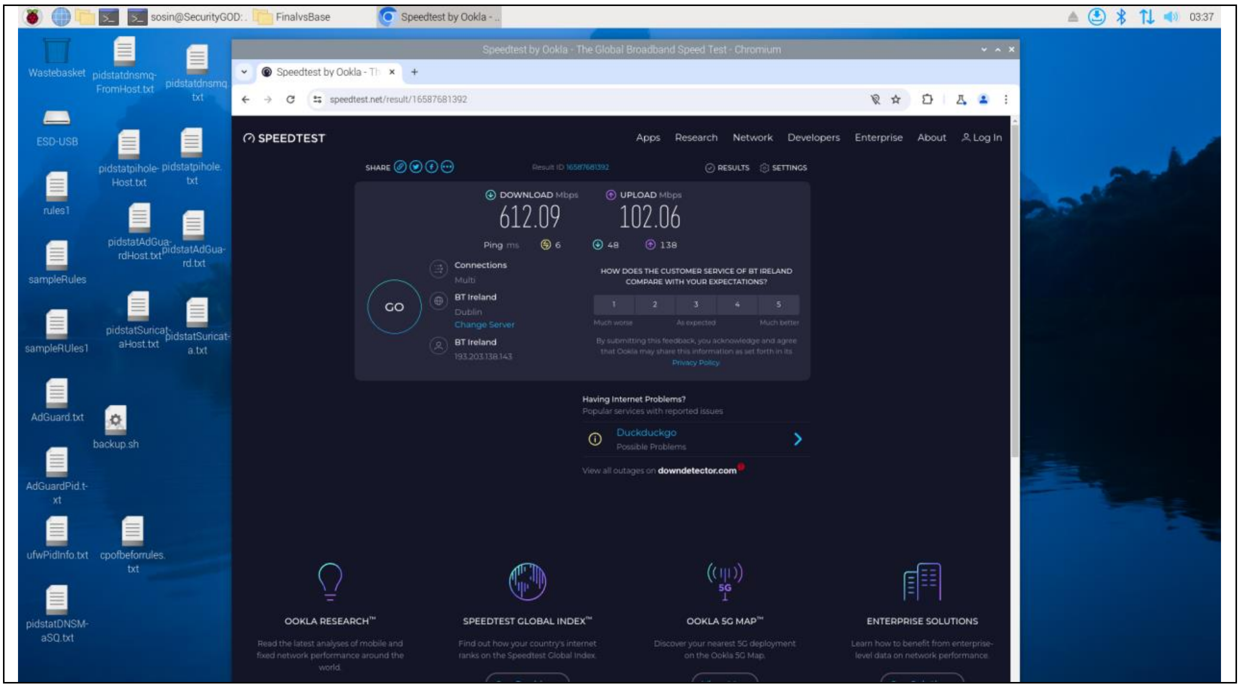
Yahoo Mail Problems

Playstation Network Problems

UFW Speed tests

9.4 Base and Final Implementation testing

9.4.1 Security Device



Result ID 16587681392

DOWNLOAD Mbps 612.09

UPLOAD Mbps 102.06

Ping ms 6 48 138

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

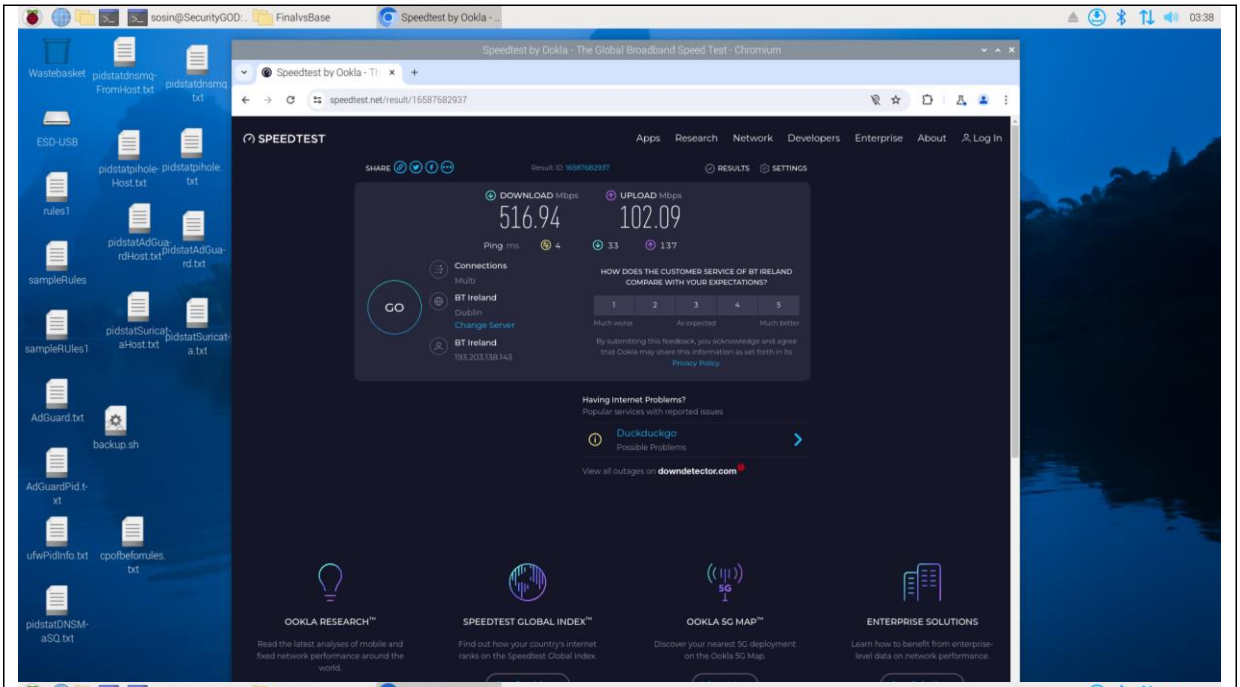
HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

Having Internet Problems?

Popular services with reported issues

Duckduckgo Possible Problems

View all outages on downdetector.com



speedtest.net/result/16587682937

Result ID 16587682937

DOWNLOAD Mbps 516.94

UPLOAD Mbps 102.09

Ping ms 4 33 137

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Duckduckgo
Possible Problems

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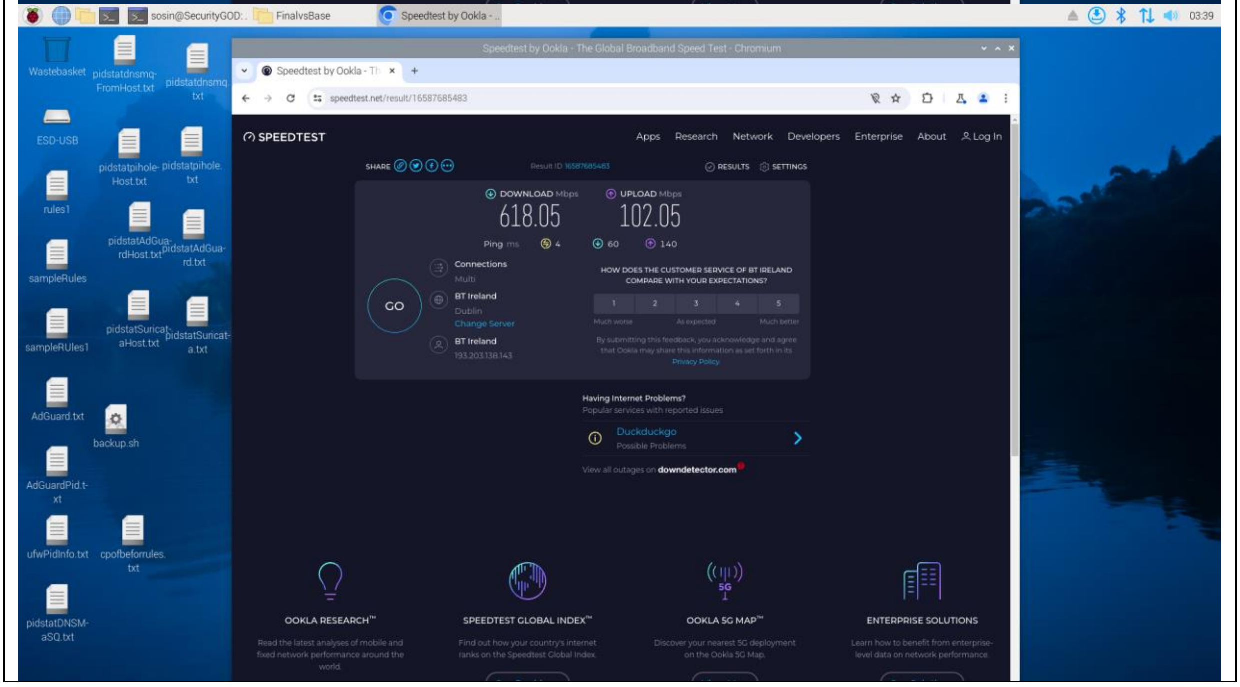

speedtest.net/result/16587685483

Result ID 16587685483

DOWNLOAD Mbps 618.05

UPLOAD Mbps 102.05

Ping ms 4 60 140

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Duckduckgo
Possible Problems

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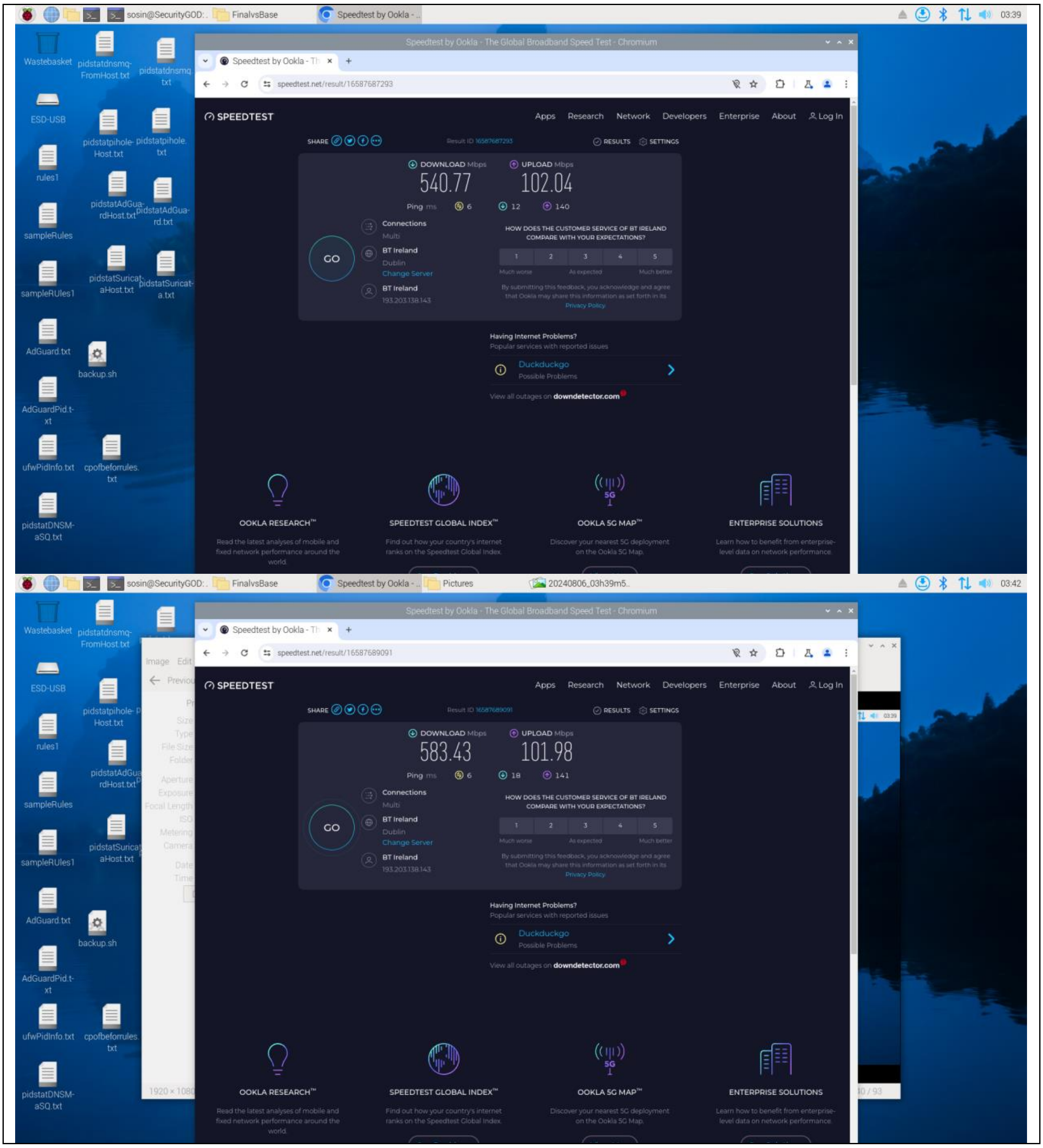
Discover your nearest 5G deployment on the Ookla 5G Map.

Learn how to benefit from enterprise-level data on network performance.



speedtest.net/result/16587687293

Result ID 16587687293

DOWNLOAD Mbps 540.77
UPLOAD Mbps 102.04
Ping ms 6 12 140

Connections Multi
BT Ireland Dublin
BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?
1 2 3 4 5
Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues
Duckduckgo
Possible Problems
View all outages on downdetector.com

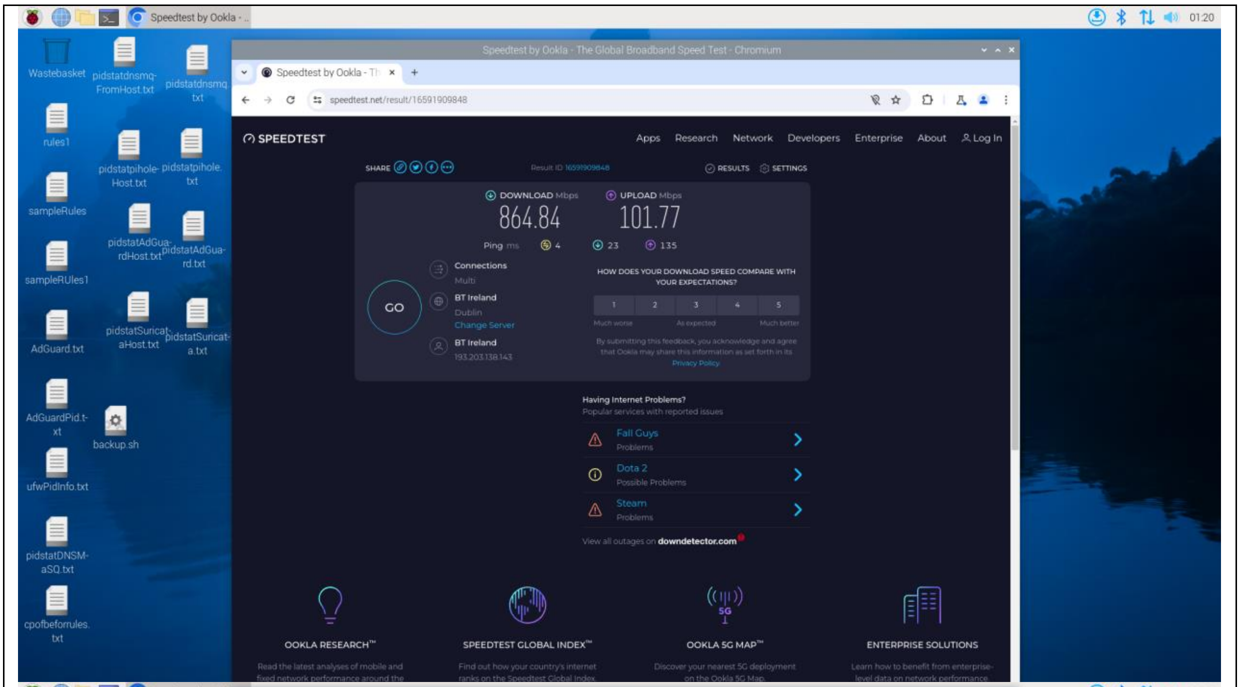
speedtest.net/result/16587689091

Result ID 16587689091

DOWNLOAD Mbps 583.43
UPLOAD Mbps 101.98
Ping ms 6 18 141

Connections Multi
BT Ireland Dublin
BT Ireland 193.203.138.143

Final Implementation Speed tests



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16591909848

SPEEDTEST

Apps Research Network Developers Enterprise About Log In

SHARE Result ID 16591909848 RESULTS SETTINGS

DOWNLOAD Mbps 864.84

UPLOAD Mbps 101.77

Ping ms 4 23 135

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES YOUR DOWNLOAD SPEED COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Fall Guys Problems

Dota 2 Possible Problems

Steam Problems

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OOKLA RESEARCH™ Read the latest analyses of mobile and fixed network performance around the

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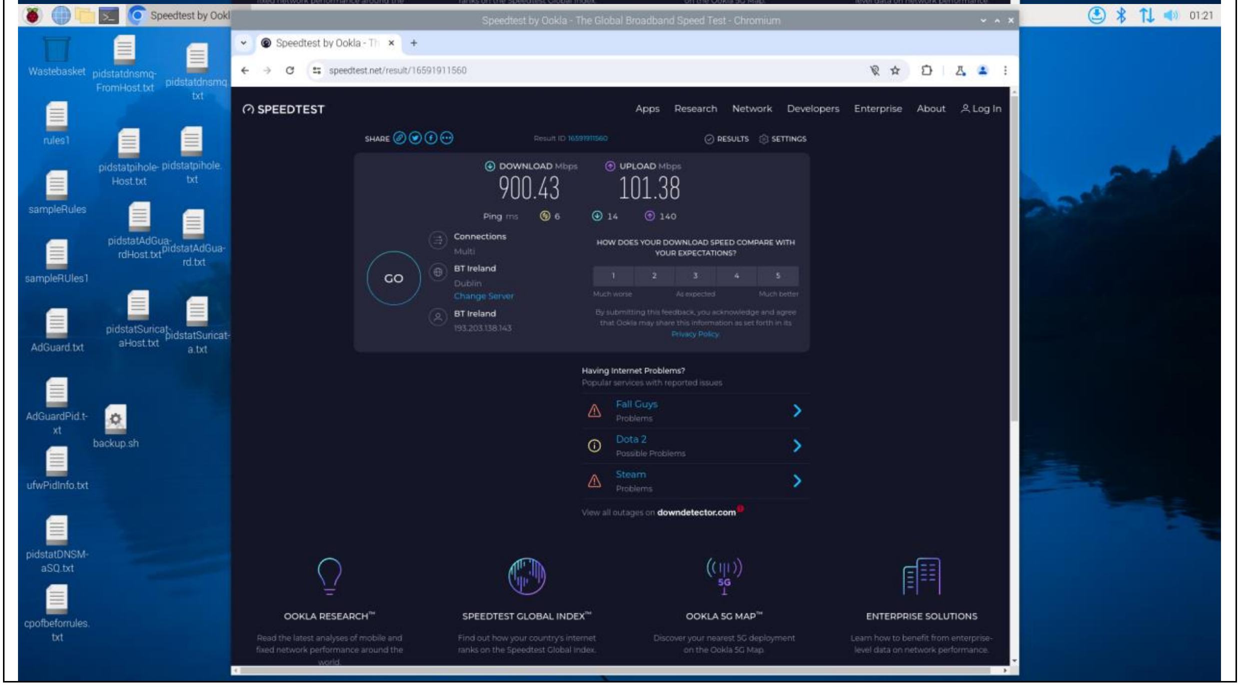

Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16591911560

SPEEDTEST

Apps Research Network Developers Enterprise About Log In

SHARE Result ID 16591911560 RESULTS SETTINGS

DOWNLOAD Mbps 900.43

UPLOAD Mbps 101.38

Ping ms 6 14 140

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES YOUR DOWNLOAD SPEED COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Fall Guys Problems

Dota 2 Possible Problems

Steam Problems

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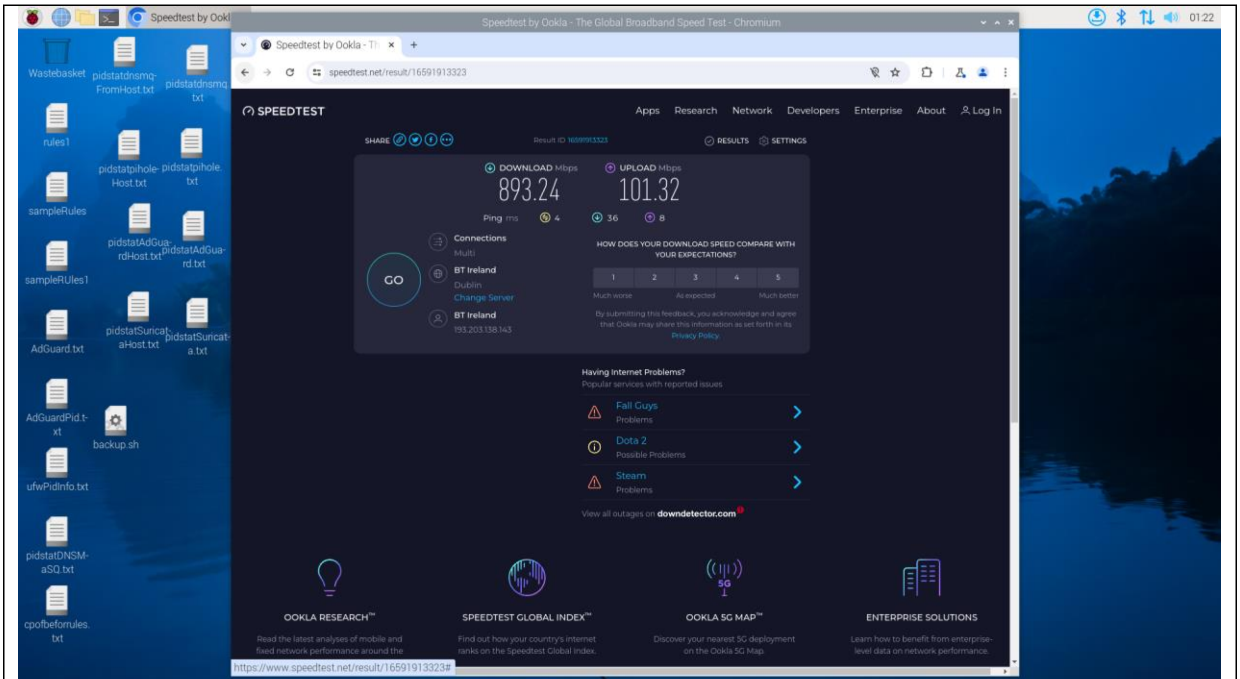


Result ID 16591913323

DOWNLOAD Mbps 893.24

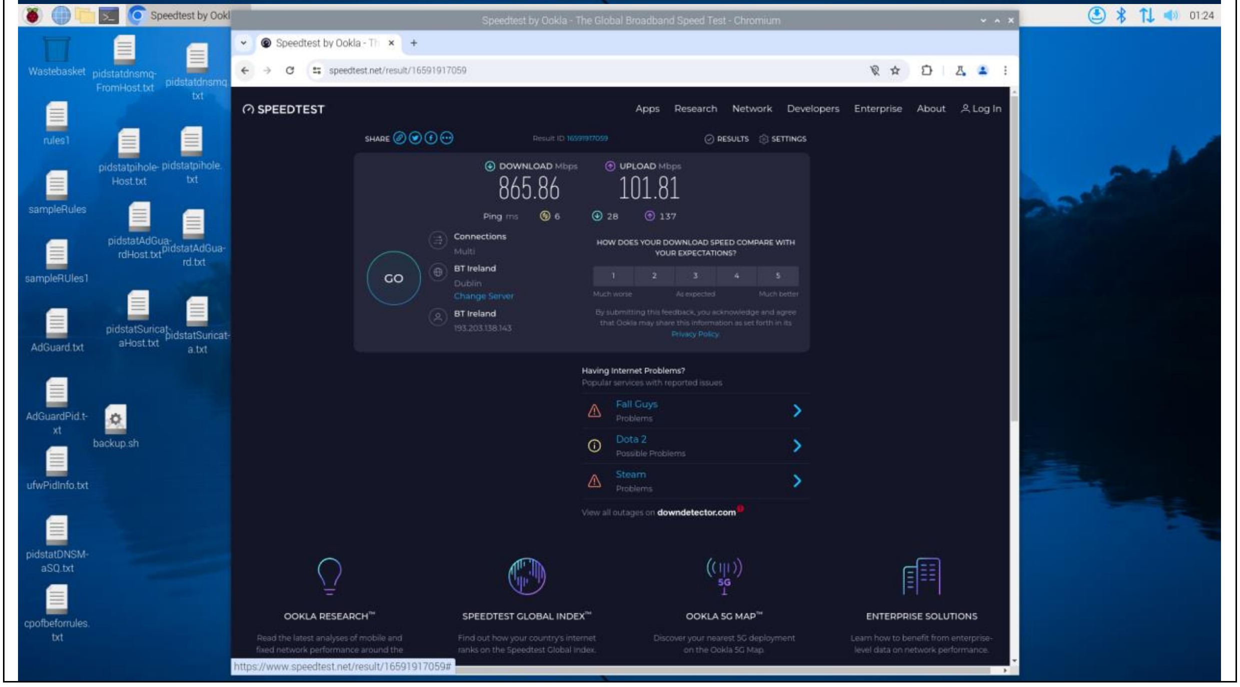
UPLOAD Mbps 101.32

Ping ms 4 36 8

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143



Result ID 16591917059

DOWNLOAD Mbps 865.86

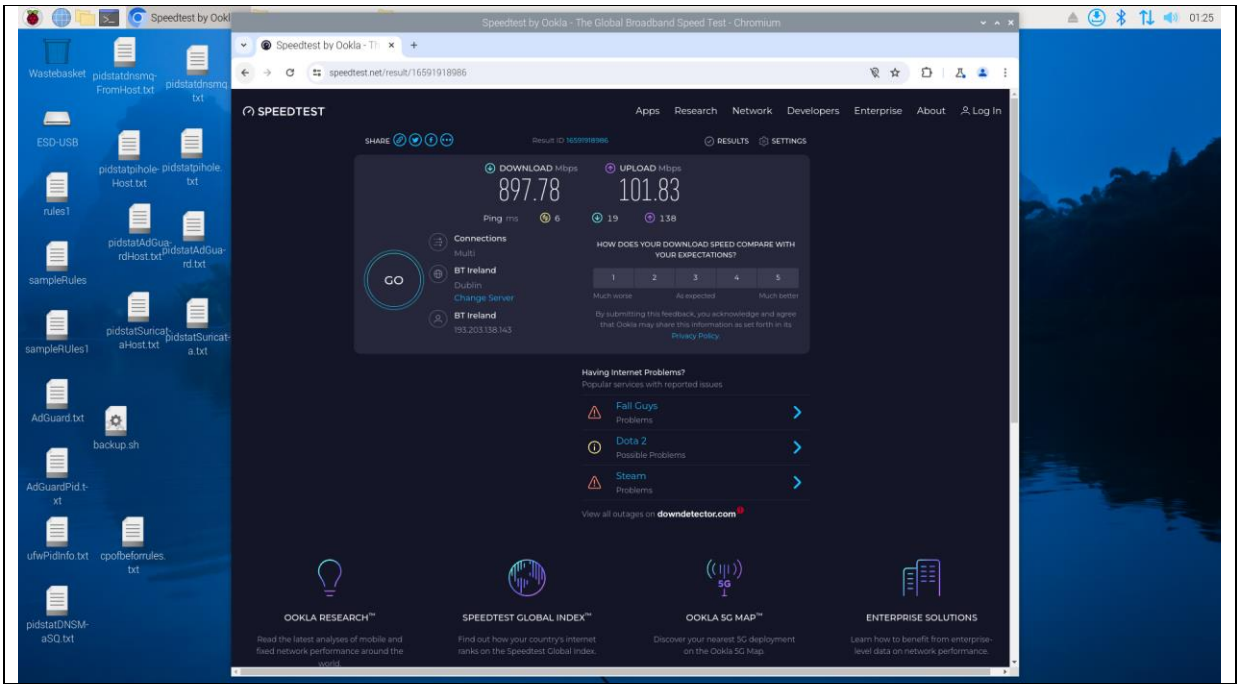
UPLOAD Mbps 101.81

Ping ms 6 28 137

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143


speedtest.net/result/16591918986

DOWNLOAD Mbps 897.78

UPLOAD Mbps 101.83

Ping ms 6 ⊕ 19 ⊕ 138

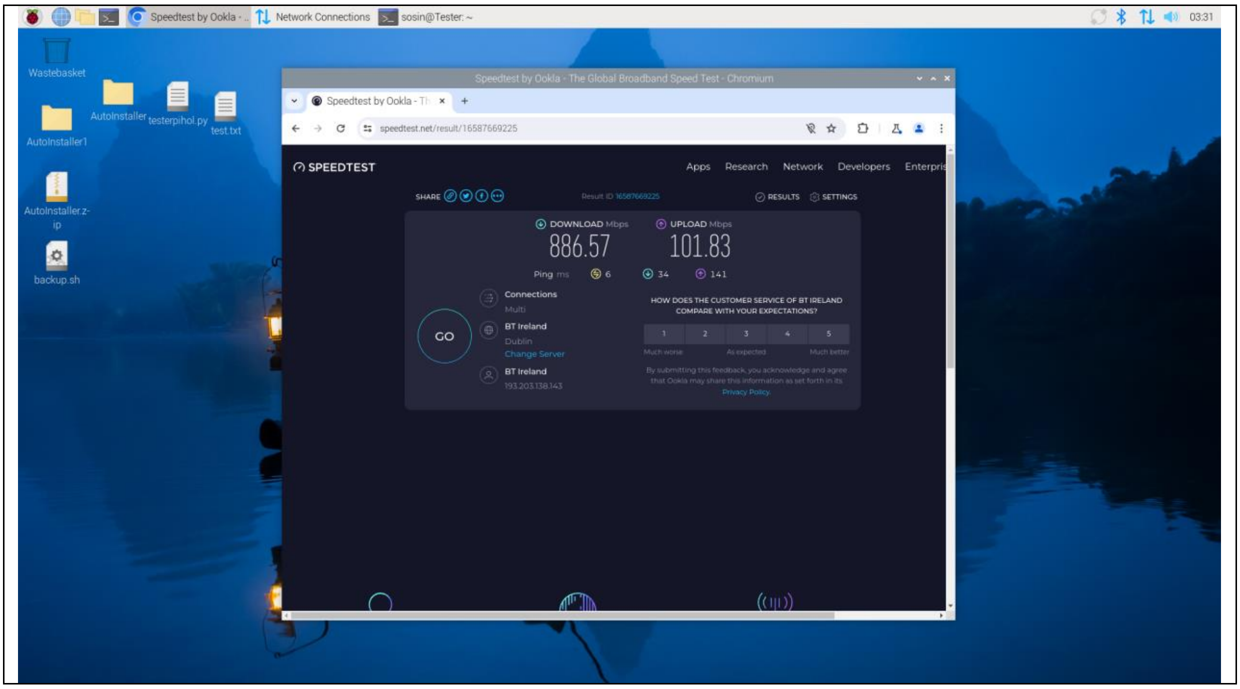
Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

Base tests

9.4.2 Host Device


speedtest.net/result/16587669225

DOWNLOAD Mbps 886.57

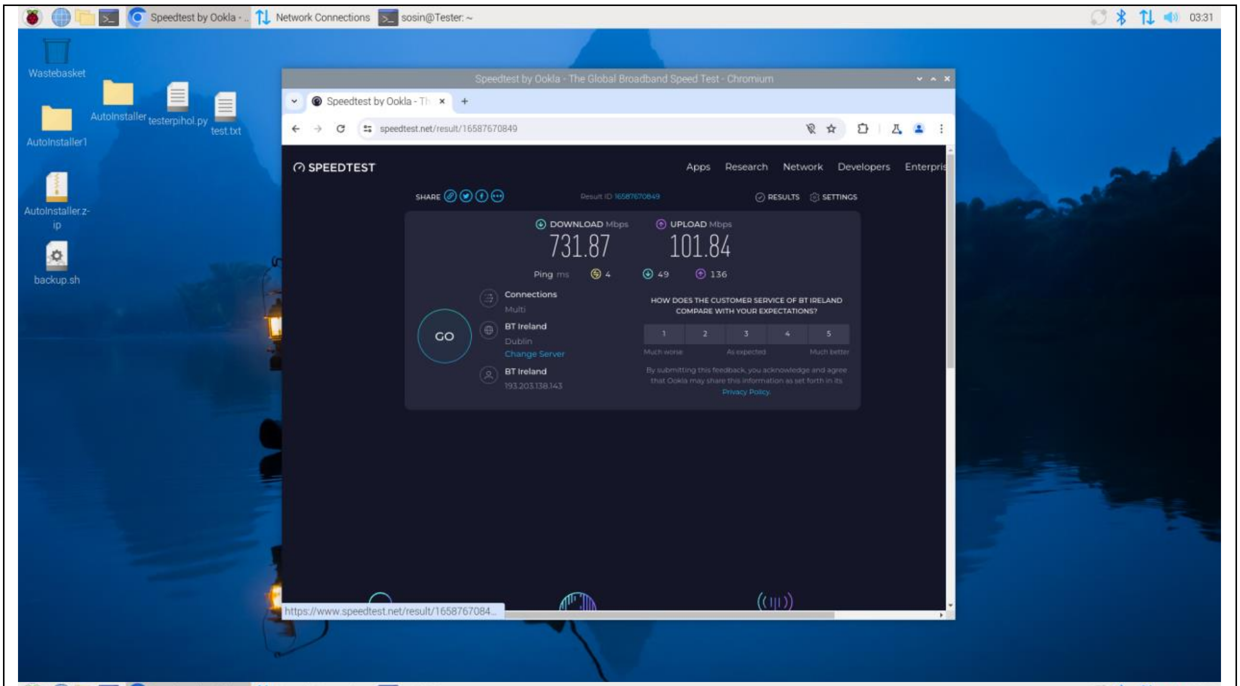
UPLOAD Mbps 101.83

Ping ms 6 ⊕ 34 ⊕ 141

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16587670849

SHARE | Result ID 16587670849 | RESULTS | SETTINGS

DOWNLOAD Mbps 731.87 | UPLOAD Mbps 101.84

Ping ms 4 | 49 | 136

Connections: Multi

BT Ireland, Dublin, Change Server

BT Ireland, 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5 (Much worse / As expected / Much better)

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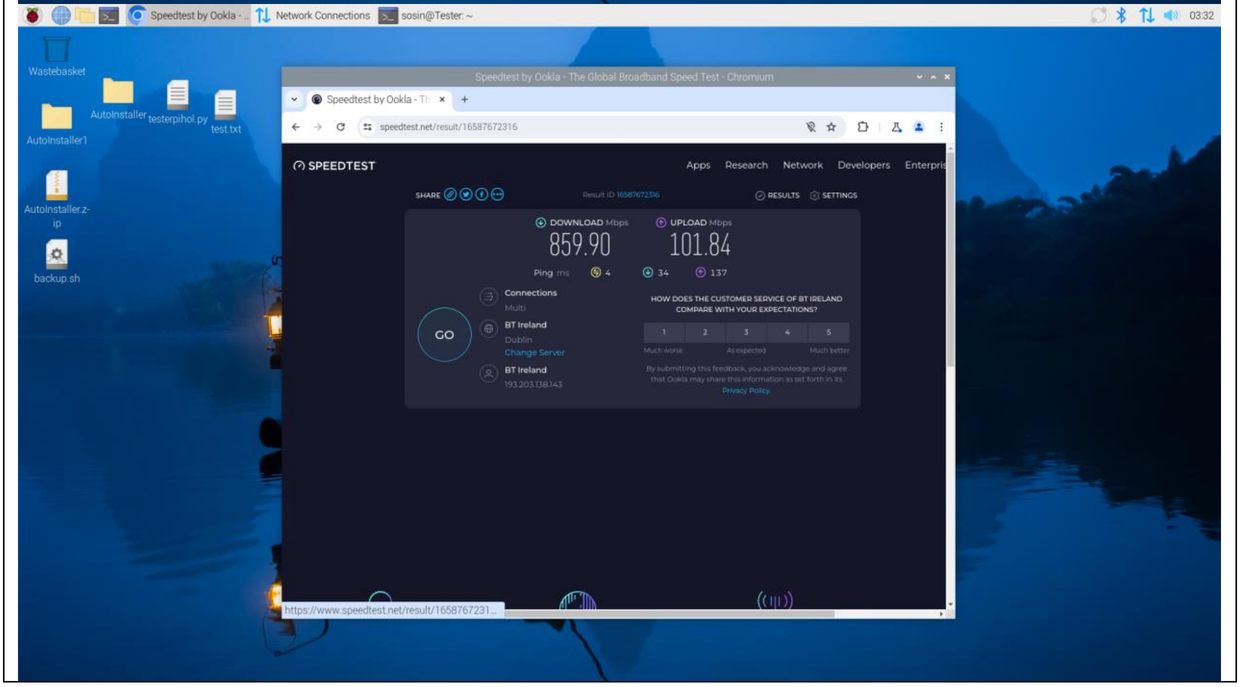
https://www.speedtest.net/result/1658767084...



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16587672316

SHARE | Result ID 16587672316 | RESULTS | SETTINGS

DOWNLOAD Mbps 859.90 | UPLOAD Mbps 101.84

Ping ms 4 | 34 | 137

Connections: Multi

BT Ireland, Dublin, Change Server

BT Ireland, 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5 (Much worse / As expected / Much better)

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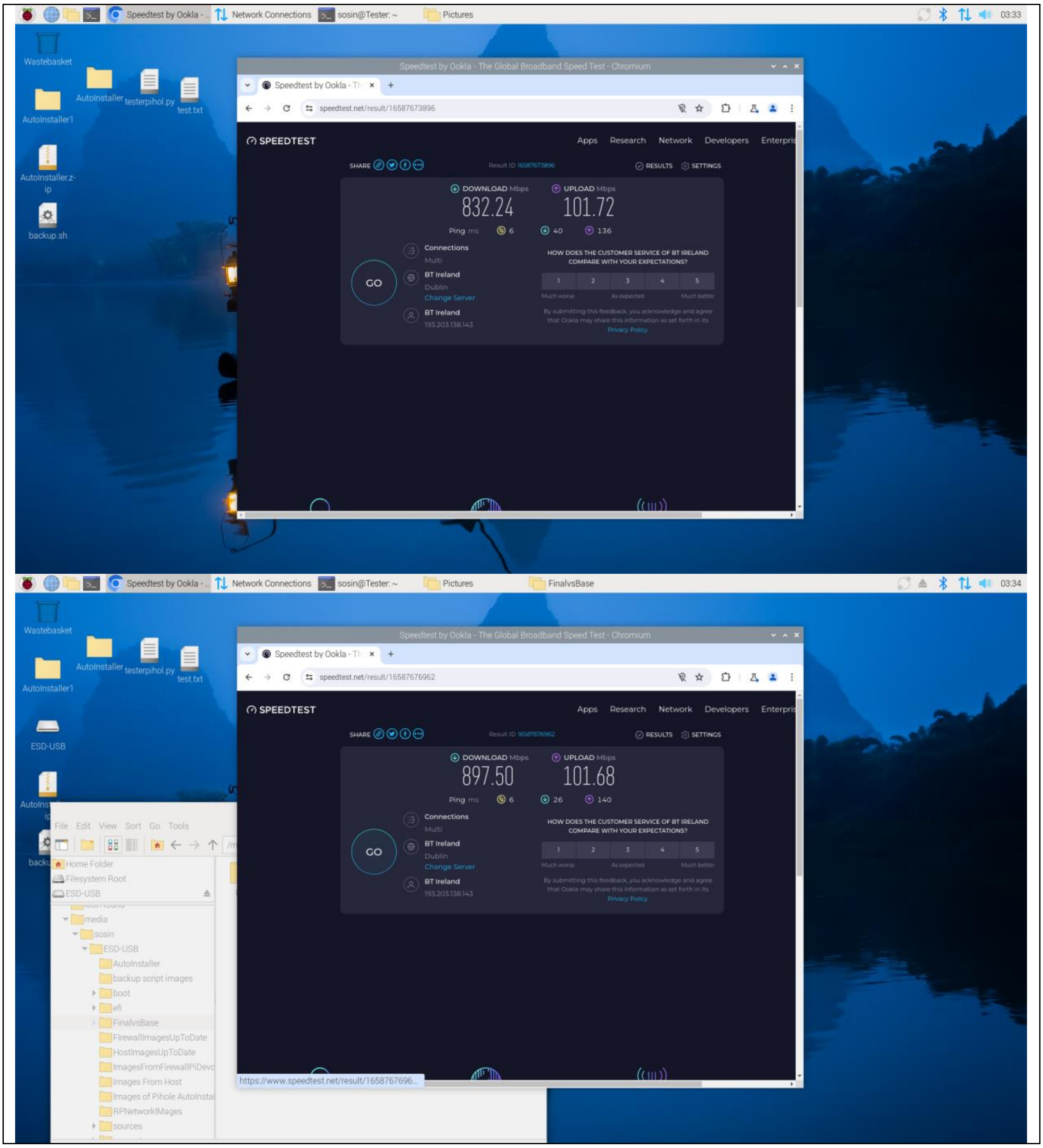
https://www.speedtest.net/result/1658767231...



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16587673896

Result ID 16587673896

DOWNLOAD Mbps 832.24

UPLOAD Mbps 101.72

Ping ms 6 40 136

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16587676962

Result ID 16587676962

DOWNLOAD Mbps 897.50

UPLOAD Mbps 101.68

Ping ms 6 26 140

Connections Multi

BT Ireland Dublin Change Server

BT Ireland 193.203.138.143

HOW DOES THE CUSTOMER SERVICE OF BT IRELAND COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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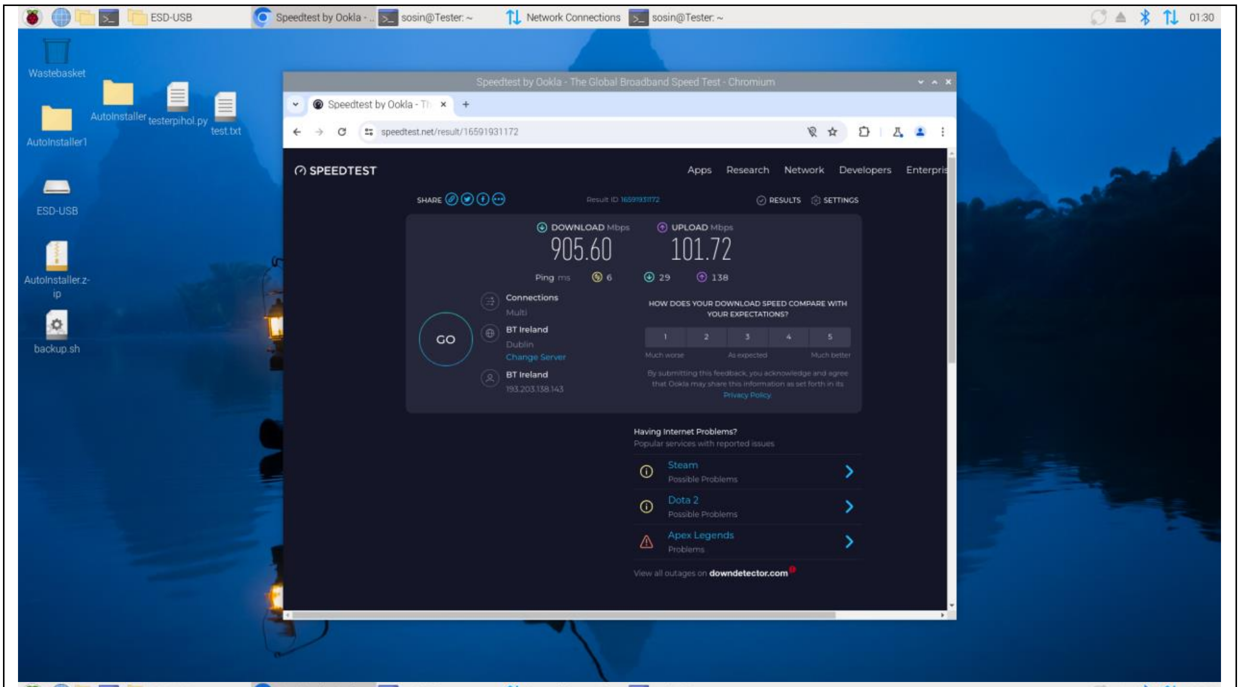
https://www.speedtest.net/result/1658767696…

Final Implementation Speed tests



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16591931172

SPEEDTEST

Result ID 16591931172

DOWNLOAD Mbps 905.60

UPLOAD Mbps 101.72

Ping ms 6 29 138

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

HOW DOES YOUR DOWNLOAD SPEED COMPARE WITH YOUR EXPECTATIONS?

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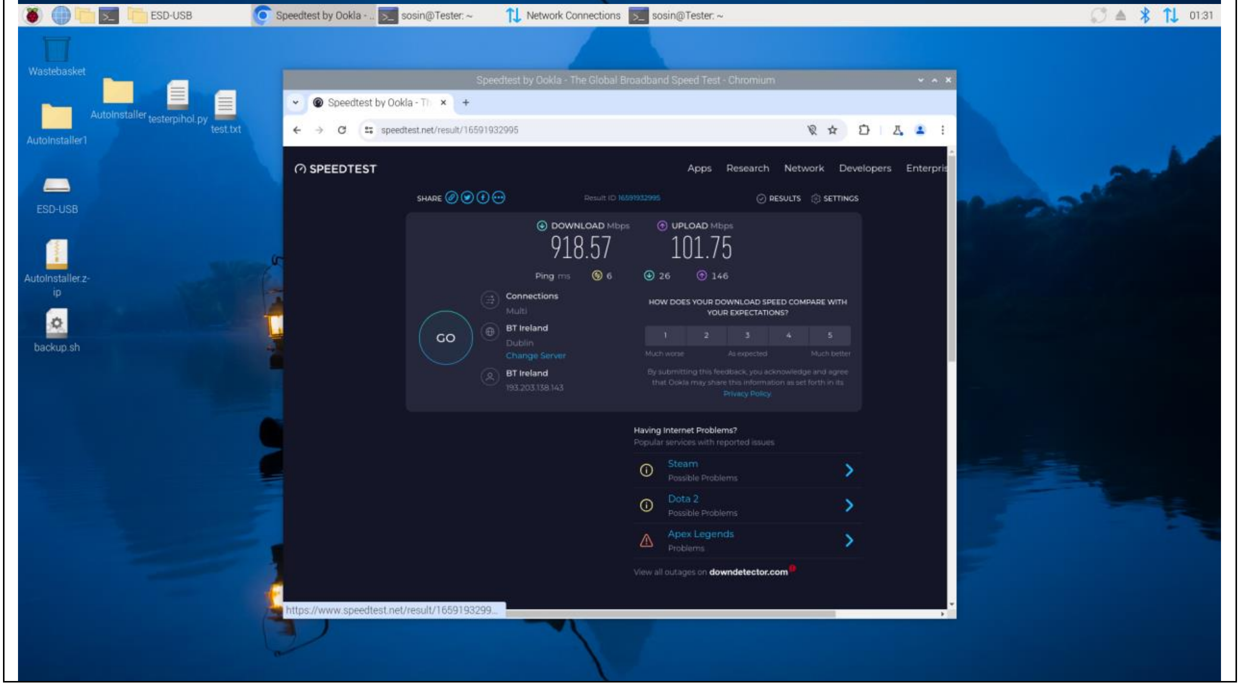
Having Internet Problems?
Popular services with reported issues

Steam
Possible Problems

Dota 2
Possible Problems

Apex Legends
Problems

View all outages on downdetector.com



Speedtest by Ookla - The Global Broadband Speed Test - Chromium

speedtest.net/result/16591932995

SPEEDTEST

Result ID 16591932995

DOWNLOAD Mbps 918.57

UPLOAD Mbps 101.75

Ping ms 6 26 146

Connections Multi

BT Ireland Dublin

BT Ireland 193.203.138.143

HOW DOES YOUR DOWNLOAD SPEED COMPARE WITH YOUR EXPECTATIONS?

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Having Internet Problems?
Popular services with reported issues

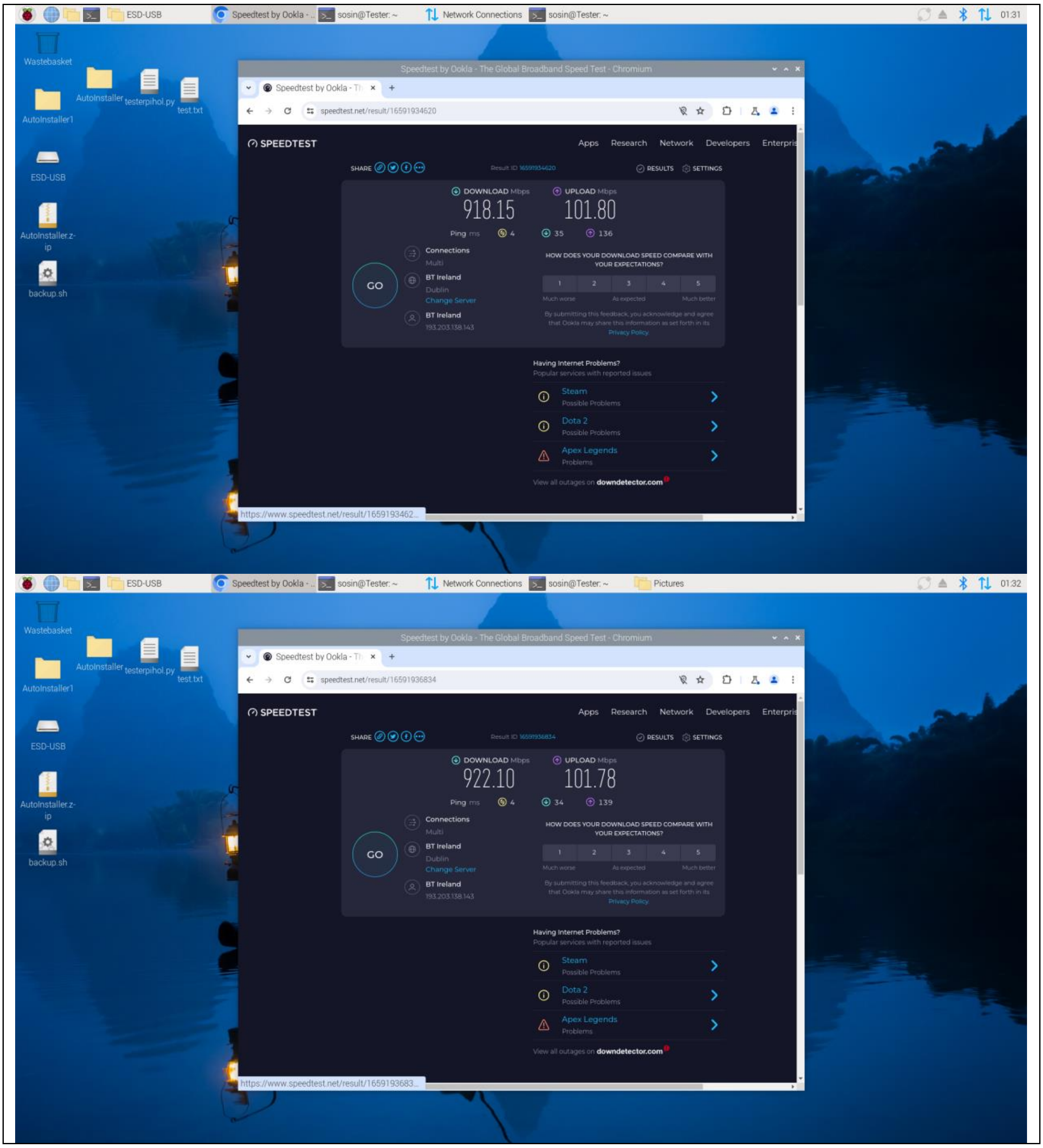
Steam
Possible Problems

Dota 2
Possible Problems

Apex Legends
Problems

View all outages on downdetector.com

https://www.speedtest.net/result/1659193299...



speedtest.net/result/16591934620

Result ID 16591934620

DOWNLOAD Mbps 918.15

UPLOAD Mbps 101.80

Ping ms 4 35 136

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES YOUR DOWNLOAD SPEED COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

Steam
Possible Problems

Dota 2
Possible Problems

Apex Legends
Problems

View all outages on downdetector.com

https://www.speedtest.net/result/1659193462...

speedtest.net/result/16591936834

Result ID 16591936834

DOWNLOAD Mbps 922.10

UPLOAD Mbps 101.78

Ping ms 4 34 139

Connections
Multi

BT Ireland
Dublin
Change Server

BT Ireland
193.203.138.143

HOW DOES YOUR DOWNLOAD SPEED COMPARE WITH YOUR EXPECTATIONS?

1 2 3 4 5

Much worse As expected Much better

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Having Internet Problems?
Popular services with reported issues

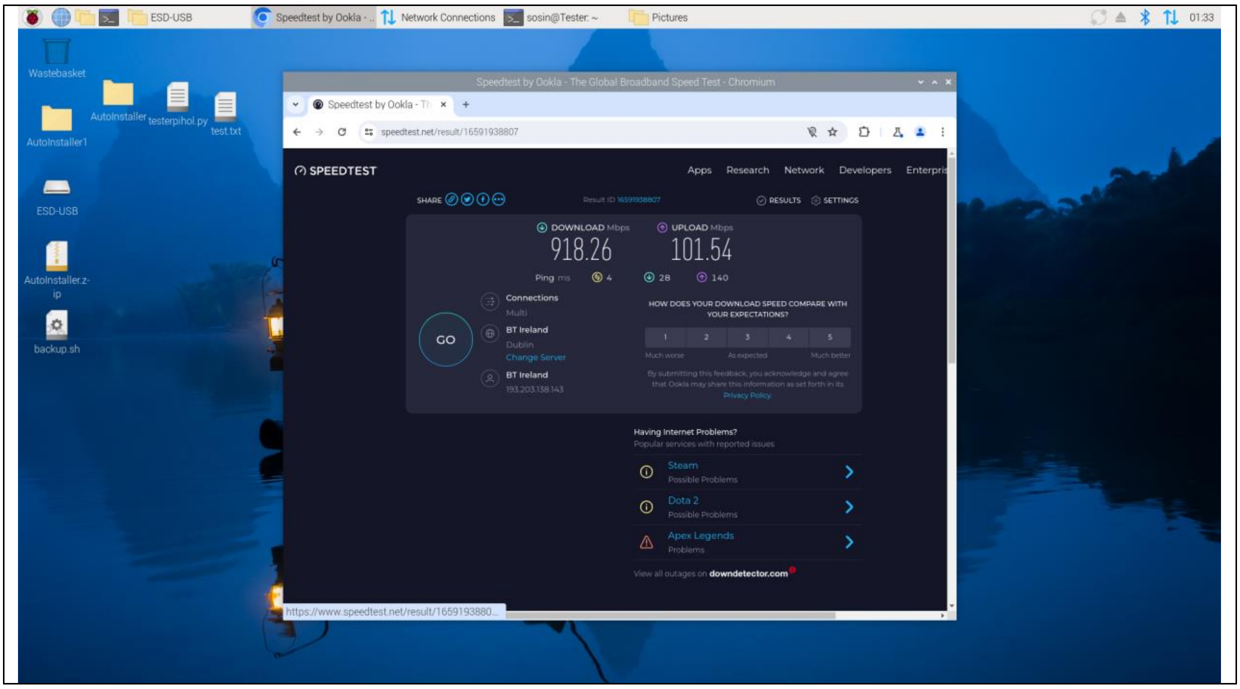
Steam
Possible Problems

Dota 2
Possible Problems

Apex Legends
Problems

View all outages on downdetector.com

https://www.speedtest.net/result/1659193683...



Result ID 16591938807

DOWNLOAD Mbps 918.26

UPLOAD Mbps 101.54

Ping ms 4 28 140

Connections
Multi

BT Ireland
Dublin

BT Ireland
193.203.138.143

HOW DOES YOUR DOWNLOAD SPEED COMPARE WITH YOUR EXPECTATIONS?

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Having Internet Problems?
Popular services with reported issues

Steam
Possible Problems

Dota 2
Possible Problems

Apex Legends
Problems

View all outages on downdetector.com

Base tests