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The Impact of COVID-19 Pandemic on Internet Traffic in Saudi Arabia

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***Abstract*—The new Corona virus infected almost all countries all over the world, including Saudi Arabia, forcing many of them to close their borders and impose multiple curfews. We noticed an impact on the quality of Internet services in the Kingdom. In this paper, we studied the impact of the COVID-19 pandemic on the Internet in the Kingdom Saudi Arabia. To analyze the Internet traffic characteristics, we used RIPE Atlas, which is the largest open-source Internet measurement network ever made. We focused on two aspects that affect the users' quality of experience the most, namely: latency and routing. Our results show a 55.95% latency increase after the lockdown in Saudi Arabia. Our analysis also shows an acute change in the routing path from Saudi Arabia to USA, where the number of hops goes from 9 hops during the closure to only 2 hops after the curfew period, a change of 77.78%.**

***Index Terms*—Internet measurements, Latency, COVID-19, Ripe Atlas**

I. INTRODUCTION

THE COVID-19 pandemic first broke out in the Chinese city of Wuhan in early December 2019. The World Health Organization officially declared on the 30th of January 2020 that the outbreak of the virus constituted a public health emergency of international concern and confirmed that the outbreak had turned into a pandemic on the 11th of March, which affected countries all over the world, forced a complete closure and imposed a curfew, making the Internet contemplated a lifeline [1].

Internet users' behavior have changed significantly during the pandemic. For example, Students no longer go to school. Alternatively, they communicate with their teachers through online platforms such as zoom, blackboard, and/or Microsoft teams. These applications are considered the best alternative to students physically attending their classes. In fact, companies have also taken similar steps when it comes to teleworking and holding meetings online.

Table 1 shows that there is a massive difference in the number of Zoom daily meeting participants before and after the pandemic. In December 2019, only 10 million users were using Zoom on daily basis to conduct meetings. This number jumped to 200 million in just three months [2]. This huge increase in the number of daily meetings is due mainly to teleworking and remote study. As a result, we expect that there had been tremendous pressure on network infrastructure of the Internet Service Provider (ISP), and this occurred due to the curfew and the closure of schools. We also notice that there is a 100% increase in April by another 100 million, which is another evidence of the abnormal increase in Internet traffic during the pandemic.

Table 1. Number of Zoom daily meeting participants during the first few months of COVID-19 pandemic.

Date	# of daily meeting participants
December 31, 2019	10 million
March 31, 2020	200 million
April 21, 2020	300 million

The Kingdom of Saudi Arabia has taken proactive and precautionary measures, as shown in Fig. 1, to control the massive spread of COVID-19 pandemic [3]. Umrah was suspended on 4th of March for precautionary reasons and domestic flights and public transportation were suspended on the 21st of March. In the same month, classes at schools were suspended, forcing a change of students' pattern from physical studying to virtual classes via the Internet. In the last week of March, partial curfew was imposed from 7 pm to 6 am daily. Simultaneously, all social events were cancelled and attendance at workplaces in all government agencies were suspended. The closure of public places and commercial markets had forced people to use delivery applications as they were allowed to roam around and deliver orders. All these decisions affected the Internet in Saudi Arabia directly or indirectly.

In this paper, we analyze the network traffic behavior in Saudi Arabia during the Corona pandemic. We used an open-source Internet measurement platform called RIPE Atlas [4] to fetch data through Probes and Anchors. We conducted two sets of experiments to study the behavior of Internet traffic during the pandemic. The first set of experiments focused on latency measurements and the second set targeted routing. We find that the number of hops to several countries during the lockdown is

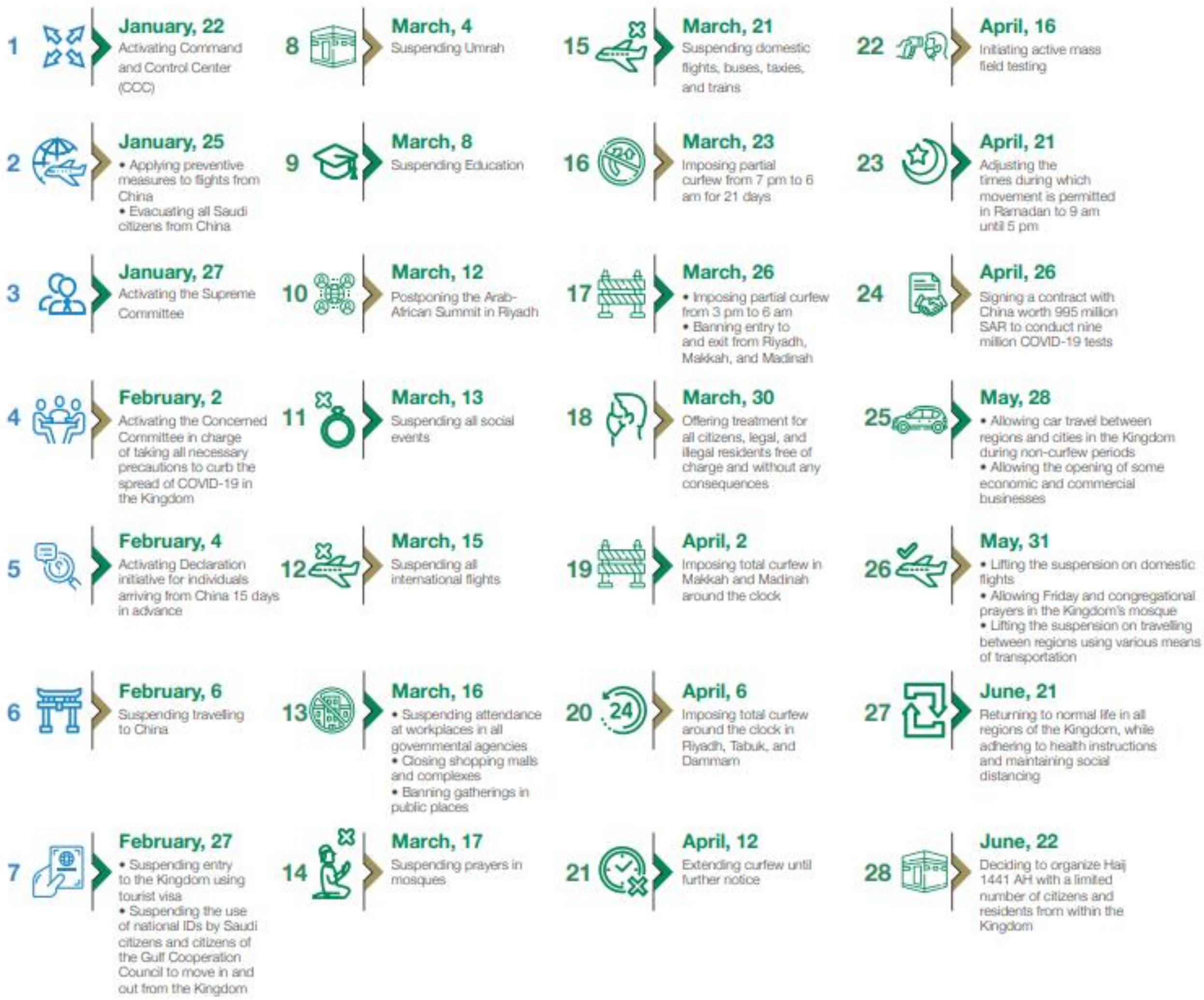

Fig. 1. Summary of Saudi decisions and measures to control the massive spread of COVID-19 pandemic [3].

more than the number of hops to same countries after the lockdown, except for Germany where the number of hops during the lockdown is 50% less than the number hops after the lockdown.

The remaining parts of the papers is organized as follows. In section II, we motivate the need for analyzing the Internet traffic characteristics in the Kingdom during the pandemic. Section III is dedicated to give a basic background of Ripe Atlas. In section IV, we laid down the experimental setup of our two sets of experiments, whereas in section V we discussed the results and our findings. Section VI uncovers some of the challenges we faced. Related work is discussed in section VII, and we conclude the paper and discuss future research directions in section VIII.

II. Motivation

One way to understand the behavior of the Internet in any country is by looking at the Internet penetration; in other words the percentage of people using the Internet per capita. As shown in Fig. 2, Internet penetration has increased in Saudi Arabia by more than 2% during the COVID-19 period [5]. This increase come at the cost of lower mobile Internet download speed as shown in Fig. 3 [6]. The dip in mobile Internet speed in the second quarter of 2020 perfectly matches the lockdown timing in the Kingdom, which leads to the conclusion that there was a huge pressure on the Internet during that period. It is clear from these figures that the telecommunication companies in the Kingdom were unprepared for receiving such a high number of users. Our goal in this study is to understand what caused this dip through open-source tools such as Ripe atlas.

By analyzing the Internet traffic globally, a strong correlation was found between Internet pressure and COVID-19 cases and lockdowns [7]. Fig. 4 shows the severity of Internet pressure in countries with major COVID-19 outbreaks. Internet pressure was measured as the percentage of change in round trip time between the month of Feb and March in 2020 [8]. It is obvious that the pressure has increased in countries with large number of Corona cases such Japan, Spain, South Korea, Italy, and China. Data clearly shows that as governments increase precautionary measures in response to COVID-19 surge, the pressure on the Internet is inflated due to the inability of people to return to their normal lives.

Fig. 2. Individuals using the Internet in Saudi Arabia as a percentage of the population before and within the pandemic.

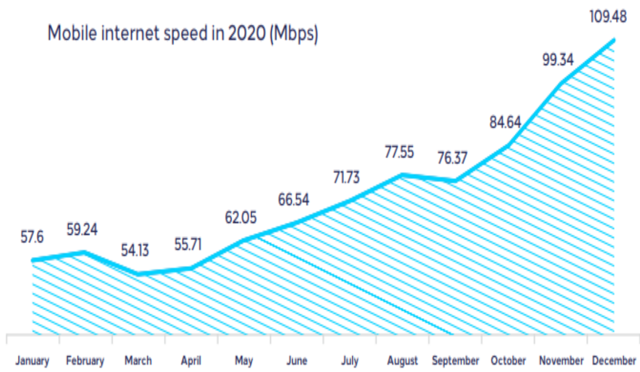

Fig. 3. The average mobile internet download speed in Saudi Arabia in the year 2020 [6].

In many countries, the surge in the number of confirmed COVID-19 cases had led to complete or partial lockdowns. As a result, unprecedented number of people, including students, are now forced to spend long durations at home. Let us try to understand the impact of COVID-19 closure on higher education sector in the Kingdom. Table 2 shows statistics about the use of e-learning solutions during the COVID-19 pandemic in multiple Saudi universities [9]. The number of online users in Saudi universities reached around half a million in some universities. The National eLearning Center published a study summarizing the state of online learning in the Kingdom of Saudi Arabia [10]. A total of 848 administrator/staff members participated in this study. 72.6% of these participants come from public universities and the remaining represents private universities. The number of faculty members who participated in the study is 2,522 whereas the number of students is 4,902. Fig. 5 shows the level of satisfaction of students, faculty members and staff before and after the pandemic. Most students reported that they were generally satisfied or completely satisfied. However, their satisfaction decreased slightly after the Corona pandemic. Staff and faculty responses show increased neutral, dissatisfied, and completely dissatisfied responses after the pandemic with lower number of responses on the satisfied and very satisfied categories as well.

III. Background

RIPE Atlas [4] platform was initially created in 2010 by the RIPE Network Coordination Center. As of November 2015, it consisted of approximately 9,000 probes and 150 anchors worldwide. Table 3 shows the growth in the number of connected probes in the last five years [11]. There are currently more than 11,000 probes connected, covering 170 countries around the globe. Fig. 6 shows the distribution of these probes worldwide. In fact, this map covers both connected and disconnected Probes. The green color means connected (i.e. active probe), the yellow color means the probe was connected recently, and the red color means the probe is not connected for long time. As shown in the map, there are many probes in Europe and the USA. On the other hand, fewer probes are available in the Middle East as shown in Table 4 [12]. RIPE NCC, the owner of RIPE Atlas, is one of the five worldwide Regional Internet Registries (RIRs). It is a non-for-profit organization that is in Amsterdam, Netherlands. The fact that Ripe Atlas is an open-source platform makes it easy to measure the Internet performance through probes and anchors.

Probes, shown in Fig. 7-a, are small hardware devices that perform active measurements such as ping, traceroute, DNS, and HTTP [13]. Data is collected and made available to the public. As a first impression, a probe might be recognized as a wireless router, and that is indeed what it is when we buy it off the shelf. However, the RIPE NCC adds its firmware to it and connects it to a hierarchical control and data collection service, which the RIPE NCC also built and maintained. RIPE NCC makes the probe source code publicly available because it wants everyone to have the opportunity to contribute to RIPE Atlas at the core level. The first version of hardware probes started in late 2010. The second version began in late 2011, and the third version started in 2013 and ended in 2017. The current version is four and was launched in 2018. The largest number of connected probes was 12068 on 1/5/2021, and the lowest number was 152 on 1/11/2010 [14].

On the other hand, the RIPE Atlas anchors are nothing but powerful probes used by the RIPE Atlas network to measure the connectivity and reachability of various regions in the world [13]. They are also enhanced with more measurement capacity. RIPE Atlas users can schedule measurements targeting anchors. The anchor names are encoded so that they display their country and city location as well as the Autonomous System Number (ASN) in which they are situated. This way, RIPE Atlas users get to choose from a list of regional targets (anchors) in different networks and different geographical locations. A sample anchor is shown in Fig. 7-b.

IV. Experimental Setup

In this section, we describe in detail the experimental setup we used to conduct our measurements. As shown in Fig. 8, our experiments could be divided spatially into two main parts, inside Saudi Arabia and outside Saudi Arabia. In the former, we measured latency on intra-Saudi traffic using probes in both Jeddah and Riyadh. In the latter, we compared latency between probes located in various Gulf countries, such as

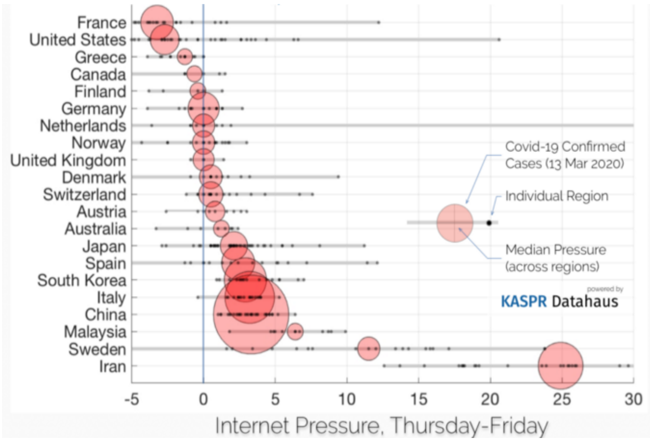

Fig. 4. Internet Pressure in major COVID-19 countries in 2020 [8].

Fig. 5. Student, staff, and faculty satisfaction with the service provided before and after COVID-19 pandemic [10].

Bahrain and the UAE. We also studied packets routing behavior from Saudi Arabia to Asia, Europe, and North America. To capture the effect of COVID-19, all experiments were repeated twice, during and after the pandemic.

A. Inside Saudi Arabia

To characterize the effect of COVID-19 within Saudi Arabia, we measure the latency between probes in Riyadh and Jeddah.

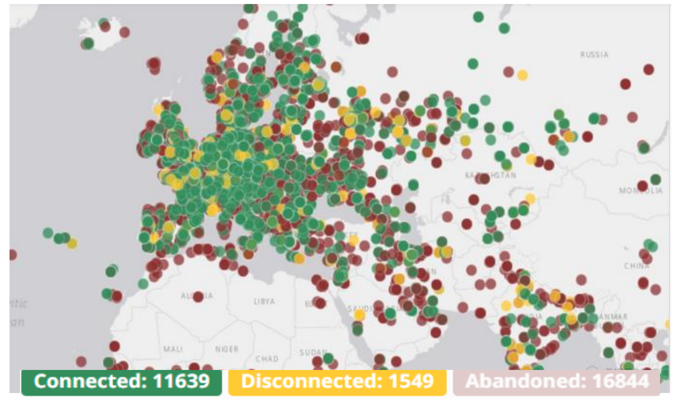

Fig. 6. A sample of the RIPE Atlas map for probe devices [13].

Fig. 7-a. RIPE Atlas probe. **Fig. 7-b.** RIPE Atlas anchor.

Table 2. The use of e-learning solutions in Saudi universities during the COVID-19 pandemic [9]

University	online sections	online assessment	faculty in online courses	student in online courses	active users	e-learning tickets
SEU	4553	46799	809	89575	87071	15515
King Saud	22995	27978	4912	51698	56756	4163
ImamU	18098	16409	5000	79028	459211	3724
Jazan	3577	12187	2722	30077	30077	15573
KAU	18377	10885	5155	56710	56710	2260
Jeddah	13253	36302	1755	21745	23690	3138
Taibah	13500	46897	3000	62600	62600	3146

By latency we mean the amount of time it takes to capture, transmit and process a packet of data across multiple devices, then receive it at its destination and decode it, measured in milliseconds. We use the PING command to measure latency. Table 5 lists the detailed parameters we used to configure the PING command. The number of packets represents how many packets are sent in a measurement execution. We chose the default value which is 3. The packet size represents the length of the data part of the packet, i.e., excluding any IP and ICMP headers. The value must be between 1 and 2048. Interval sets

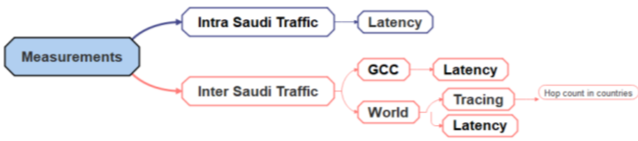

Fig. 8. Our experimental setup.

Table 3. Probes statistics for the last five years.

Year	# of Connected Probes
2018	10295
2019	10162
2020	10926
2021	11619
2022	11832

Table 4. The number of probes in several countries as of 2021

Country	Probe
Germany	1628
USA	1529
France	908
UK	611
Russia	609
Netherlands	572
Italy	340
Saudi Arabia	11
UAE	14
Bahrain	6

the period between samples in milliseconds. We chose IPv4 because some of the countries selected do not have IPv6 probes. The experiment period was 60 days, from March 1 at 00:00 to April 30. At 23:00, the target was k.root-servers.net, which is fixed for all latency experiments.

B. Outside Saudi Arabia.

We analyzed latency among several Gulf countries and capture the measurements during the Corona pandemic and after the pandemic. Globally, Ireland was chosen to benchmark the latency during the COVID-19 pandemic and after the pandemic. Also, we analyze routing at the global level from Saudi Arabia to 3 continents using TraceRoute command. Table 6 lists the command parameters, while Table 7 lists the four international targets we used in our experiments. Number of packets represents the number of packets sent in a measurement execution. Packet size is the length of the data part of the packet, i.e., excluding any IP, ICMP, UDP or TCP headers. Interval represents the number of seconds each participating probe will wait before attempting to perform the measurement again. Like the PING case, we used IPv4 due to non-proliferation of IPv6 in some selected countries. Maximum hops field sets the limit at which TraceRoute measurement stops. The maximum time, in milliseconds, to wait for a response is defined by Timeout.

Table 5. PING Command Parameters.

Parameter	Value
Number of Packets	3
Packet Size	48
Interval	15 min
IP version	IPv4
Lockdown Period Start: End:	 March 1, 2020 00:00 April 30, 2020 23:00
After lockdown Start: End:	 April 1,2021, 00:00 May 31,2021 23:00
Target	k.root-servers.net

Table 6. TraceRoute Command Parameters.

Parameter	Value
Number of Packets	3
Packet Size	48
Interval	900 sec (15 min)
IP version	IPv4
Lockdown Period Start: End:	 March 20, 2020 00:00 April 26, 2020 23:00
After lockdown Start: End:	 Nov. 1,2021, 00:00 Nov. 26,2021 23:00
Max hops	32
Timeout	1 hour

Table 7. TraceRoute targets.

Country (Suadi to)	Target
Kazakhstan	Mobile Telecom-Service LLP [15]
USA	GOOGLE-CLOUD-PLATFORM [16]
Germany	M-net Telekommunikations GmbH [17]
Vietnam	Netnam company [18]

V. MEASUREMENTS AND ANALYSIS

A. Latency.

First, we compared the latency of probes and anchors within the Kingdom of Saudi Arabia in both Jeddah and Riyadh at the time of the COVID-19 outbreak. Fig. 9 shows a rise in latency with all probes at the beginning of the closure. The highest spike is noticed in Riyadh. We noticed a fluctuation in the readings after the curfew decision on March 23, 2020, due to many internet users. We also noticed that the readings in Jeddah are much more stable because it is an anchor. The mean RTT in Riyadh was 108.30ms with standard deviation of 2.24 while it was only 82.59ms in Jeddah with a standard deviation of 23.80.

To benchmark latency in the Kingdom of Saudi Arabia against other countries in the region, we compared 4 probes and anchors from Saudi Arabia and Bahrain. Fig. 10 clearly shows that the latency in Saudi is much lower compared to Bahrain during the COVID-19 pandemic. The mean RTT for Bahrain was 135.94ms compared to only 92.89ms for Saudi Arabia. The standard deviation for Bahrain's readings was 7.25 and for Saudi Arabia's readings was 3.32. We noticed a dip in the RTT in Bahrain on March 28, 2020, from 138ms to only 98ms for just one day.

We continue doing the latency comparison during the lockdown with other neighboring countries. We analyze the latency of three UAE probes, all in Dubai. The comparison in Fig. 11 shows that Dubai probes always have higher delay compared to Saudi probes. The mean RTT for the UAE was 135.76ms compared to only 92.89ms for Saudi Arabia. The standard deviation is 3.96 for the UAE, and for Saudi Arabia is 3.32.

After that, we add to the comparison a country that is not in the GCC, to benchmark the GCC performance. We choose Ireland, which is only 1000 km away from the target. We found that Ireland is more stable since it is not significantly affected at the time of the spread of the Coronavirus, as shown in Fig. 12. The mean RTT values in Ireland is 10.42ms with a standard deviation of 0.14. For Saudi Arabia, the RTT mean is 92.89ms, and the standard deviation is 3.32.

At the end, we compare the latency at the time of the coronavirus pandemic lockdown to the latency after the lockdown (from April 1, 2021, to May 30,2021). Due to unavailability of data in April for the probe in Bahrain, we extended the period till June 2021 just for this specific probe. Fig. 12 shows the mean RTT results for Saudi Arabia, UAE, Ireland, and Bahrain during and after the lockdown. Standard deviation of the reading is sown in Table. 8. We find that latency has increased in Saudi Arabia from 92.89ms at the time of the lockdown to 145.07ms after the lockdown. Moreover, latency is not affected much in UAE and Ireland. A 20% drop in latency is noticed in Bahrain after the lockdown.

B. *Routing*

To understand how routing was affected during the COVID-19 pandemic, we conduct multiple experiments with TraceRoute. We run the command from probe# 6616 in Riyadh targeting several countries around the globe, namely Kazakhstan, USA, Germany, and Vietnam. The selection of these countries is due mainly to the availability of data in the RIPE Atlas platform. The hop count indicates the number of network devices that the packet passes through its journey from source to destination.

Let us start with Kazakhstan. Fig. 13 shows the TraceRoute journey of packets from Riyadh to Kazakhstan during the lockdown (first row) and after the lockdown (second row). The number of hops from Saudi Arabia to Kazakhstan at the time of the lockdown is 12 hops and the packets pass through USA and Russia before reaching the target in Kazakhstan. After the lockdown, the number of hops is reduced to 11, as one of the hops in Saudi is bypassed.

We repeated the same experiment but this time targeting the USA. The path from Riyadh, Saudi Arabia to the USA at the time of the lockdown and after the lock down is shown in Fig. 14. During the lockdown, there are 9 hops between the source in Saudi Arabia and the destination in USA. Surprisingly, after the lockdown, the number of hops is reduced to only 2 hops, one in Saudi Arabia and the other in the states.

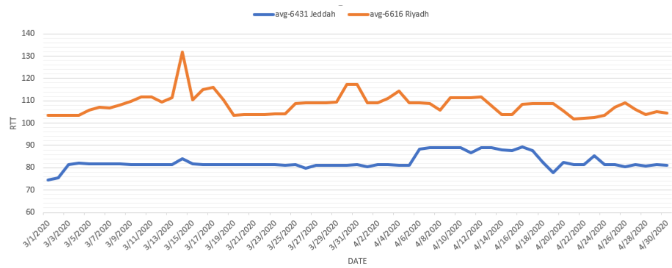

Fig. 9. Average RTT for two probes in Saudi during COVID-19 lockdown.

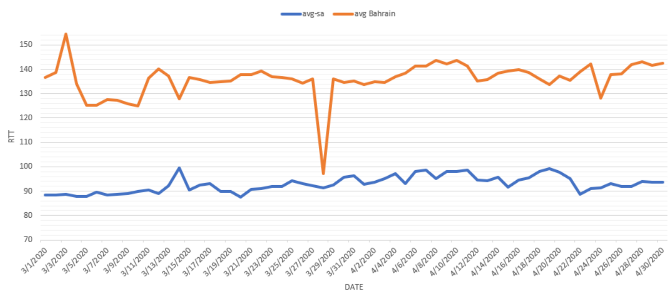

Fig. 10. Comparison of average RTT between probes in Saudi and Bahrain.

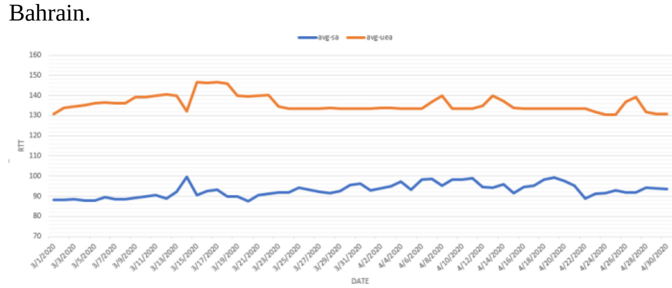

Fig. 11. Comparison of average RTT between probes in Saudi and UAE.

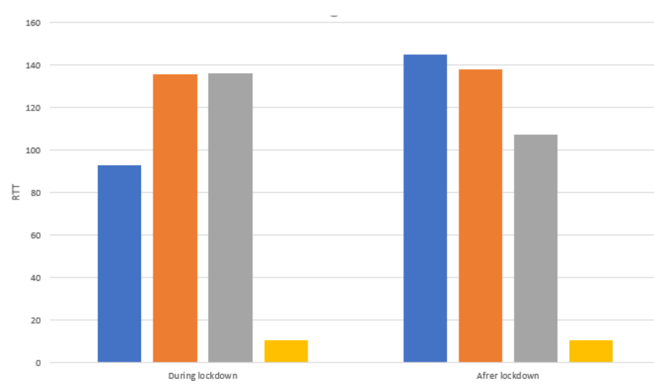

Fig. 12. Comparison of latency during and after the lockdown, RTT is in milliseconds.

Table 8. Mean RTT of four countries at the time of the lockdown and after the lockdown.

Country	During Lockdown	After Lockdown
Saudi Arabia	92.89 ms (S.D. 3.32)	145.07 ms (S.D. 5.05)
UAE	135.76 ms (S.D. 3.96)	138.13 ms (S.D. 8.12)
Bahrain	135.94 ms (S.D. 7.25)	107.23 ms(S.D. 29.71)
Ireland	10.42 ms (S.D. 0.14)	10.53 ms (S.D. 0.62)

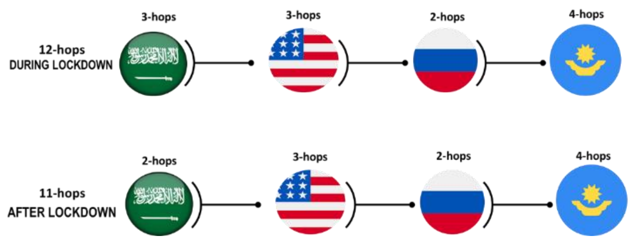

Fig. 13. TraceRoute path from Riyadh to Kazakhstan during and after the lockdown.

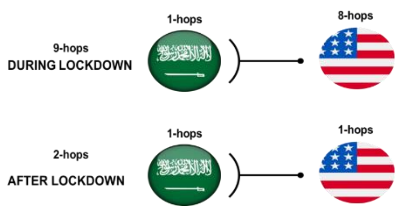

Fig. 14. TraceRoute path from Riyadh to USA during and after the lockdown.

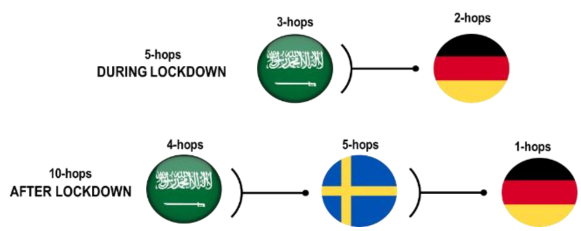

Fig. 15. TraceRoute path from Riyadh to Germany during and after the lockdown.

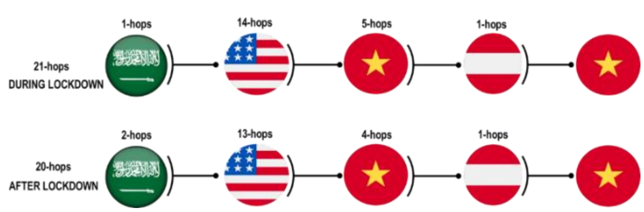

Fig. 16. TraceRoute path from Riyadh to Vietnam during and after the lockdown.

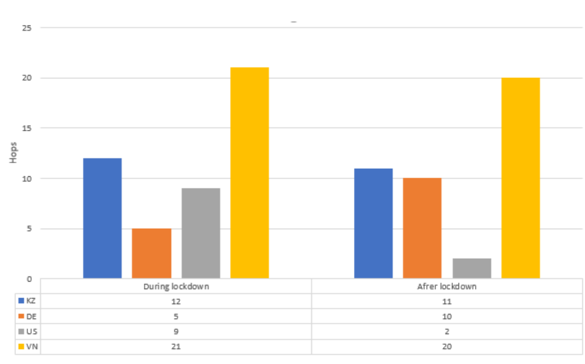

Fig. 17. Average number of hops at the time of the lockdown and after the lockdown for the four countries.

From Saudi Arabia to Germany, the packets passed through 5 hops at the time of the lockdown as shown in Fig. 15. This number was simply doubled after the lockdown. The packets needed to pass by 5 extra hops in Sweden on its way to Germany. Finally, we look at the packets' path from Saudi Arabia to Vietnam. As shown in Fig. 16, the packets passed through 21 hops during the lockdown in four different countries, including Saudi Arabia, USA, Austria, and Vietnam. After the lockdown, the number of hops was reduced to 20. It is weird to see the packets entering Vietnam and then leaving for Europe before landing into Vietnam again. We summarize our results in Fig. 17. We can deduce that the number of hops the packets will be traversing is lower today compared to the time of the lockdown. The only exception is the USA experiment, where the number of hops is increased.

VI. CHALLENGES

We faced several challenges while conducting this research. First, we had difficulty accessing data from Internet Service Providers, so we could not compare the impact of COVID-19 on both wired and wireless networks. Second, the number of RIPE Atlas probes and anchors in the region is small compared to other parts of the world. Moreover, some of these probes get disconnected frequently, affecting the quality of the collected data badly. Therefore, we removed results generated by probes in Kuwait and Qatar from the GCC comparison. Finally, we could not manually conduct more experiments during the period of the lockdown as RIPE Atlas does not allow that. Hence, we relied on built-in tests.

VII. RELATED WORK

There are several papers that studied the impact of COVID-19 pandemic on Internet Traffic globally. Feldmann et al. tried to understand the effect of lockdown during the pandemic on Internet traffic [19]. They found that there was an increase in traffic by 15-20% within a week, and this constitutes a significant increase during this short period of time, and they also noted that the Internet infrastructure was able to deal with the new increase, as most of the pressure was in the traditional off-peak hours. They noted also that there was an increase in traffic related to applications people use when they are at home such as Web conferencing, VPN, and gaming. Furthermore, it was noted that there is a significant increase in applications related to remote work and online lectures. Lutu et al. focused on the effect of COVID-19 on the mobile network traffic. They found a surge in the conversational voice traffic volume in the UK mobile network operator [20]. Recently, Ukani et al. analyzed the impact of the lockdown on Internet traffic in the students' dorms at UC San Diego [21]. They found that there was a dramatic increment in traffic in April of 2020. However, the volume of the traffic returned to normal levels in May. In addition, the authors reported a substantial increase in the entertainment traffic in that period. Asif et al. studied the relationship between people mobility and the spread of COVID-19 [22]. Using user mobility gathered from university campus closures, they proved a strong correlation between social distancing and growth rate of COVID-19. Researchers from Facebook studied how the Internet reacted to the pandemic from the perspective of the edge network [23]. They found that the traffic surge during the pandemic occurred mainly on broadband networks. They also reported uneven performance degradation in the Internet services worldwide.

RIPE Labs is a space to showcase and discuss topics relevant to the state of the Internet. We found several interesting reports in RIPE Labs that are related to our paper. Manojlovic laid down the digital commons after COVID-19 [24]. The author concluded by affirming the need for building new sustainable paradigms through local and regional actions. Stevens noted that the pandemic caused an unprecedented rise in voice and video traffic and that people communicate with each other on mobile devices 15 percent longer. This confirms what we previously mentioned that COVID-19 changed the way people work, study, and communicate. This increase in traffic expands the attack surface for hackers. The author reported that there are more than 4000 domains registration that are related to the COVID-19, 3% of which are malicious and 5% are suspicious [25]. Fontugne and Aben concluded in their report that the Internet in general is doing well and succeeded in absorbing the burst of traffic during the pandemic lockdown. As an example, they showed that the Internet in Italy managed to keep pace with increasing traffic. In fact, they reported some changes in the Internet behavior that is considered normal in such situation [26].

There are very limited number of studies on Internet traffic analysis in the gulf region. Tylor examined the Internet landscape in multiple gulf countries [27]. Alammary et al. studied the impact of COVID-19 on Saudi universities as they move to online education, with an average of 95,000 thousand virtual classes, which certainly causes pressure on the Internet in Saudi Arabia [10]. The authors reported that more than 200,000 assessments were being submitted online. That's a very big number and affects network traffic badly. In 2017, network traffic in Saudi Arabia was analyzed by Hasnawi and Showail [28]. They found that traffic between ISPs within the Kingdom is being routed through Europe due to the absence of an IXP at that time.

VIII. Conclusion and Future Work

The COVID-19 pandemic has affected our lives in many ways. Many countries around the globe, including Saudi Arabia, had enforced prolonged periods of lockdown, increasing the numbers of people doing work or studying online. In this work, we have studied the effect of COVID-19 on Internet traffic dynamics in Saudi Arabia. We gathered the data from several vantage points in the RIPE Atlas platform. Our analysis focused on two aspects, namely: latency and routing. We accomplished the former by analyzing PING packets while the routing job is done using the TraceRoute command.

In the future, we plan to do further analysis on other aspects of network traffic such as the effect on web traffic, the effect on DNS services and the effect on download speeds. Another interesting issue is the comparison between the quality of service and experience between service providers in the Kingdom during the pandemic. This requires access to vendor specific data which we are working on getting right now. Finally, we would like to compare the effect on both wired and wireless networks during the pandemic.

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تأثير وباء كوفيد –19 على حركة الإنترنت في المملكة العربية السعودية

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المستخلص. اجتاح وباء كورونا دولاً عديدة في جميع انحاء العالم ، بما ذلك المملكة العربية السعودية ، مما أجبر العديد منهم على إغلاق الحدود وفرض حظر التجول. لاحظنا تأثيراً على جودة خدمات الإنترنت المقدمة في المملكة خلال الجائحة. في هذا البحث ، درسنا تأثير جائحة كورونا على حركة مرور الإنترنت في المملكة العربية السعودية باستخدام أداة تسمى RIPE ATLAS والتي تعد أكبر شبكة عالمية لقياس الإنترنت مفتوحة المصدر. ركزنا في هذه الدراسة على مقياسين أساسيين يؤثران على جودة تجربة المستخدمين ، هما زمن الاستجابة والمسار. أظهرت نتائجنا أن هناك زيادة في زمن الاستجابة بنسبة 55.95٪ في المملكة العربية السعودية بعد الإغلاق. أيضا من النتائج ظهر تغيير حاد في مسار البيانات من المملكة العربية السعودية الى الولايات المتحدة الأمريكية ، حيث تقلّص عدد الوقفات البينية من ٩ وقفات خلال فترة الأغلاق إلى ٢ فقط بعد فترة حظر التجول ، ما نسبته 77.78% .