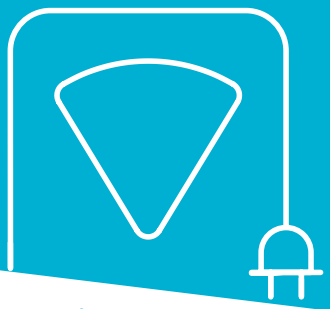

Deutsche Telekom, Vodafone, 1&1 and O2: When will Internet service get back to normal in Germany?

Internet service is holding up quite well and is stable, but customer experience has been affected, especially in certain regions and via Wi-Fi:

- ***Operators impacted:*** *Deutsche Telekom (DT), Vodafone, 1&1 and O2*
- ***Date:*** *Several days in March and April 2020*
- ***Potential impact:*** *Over 34.5 million fixed broadband connections (All, FTTH-VDSL-ADSL-HFC)*
- ***Most impacted regions:*** *North-Rhine Westphalia, Bavaria, Baden Württemberg, Hamburg and Schleswig Holstein.*

MedUX is closely monitoring the effects of COVID-19, specifically the mobility restrictions and home office and #stayathome measures, on the European customer experience and residential fixed broadband performance.

Hundreds of metrics are being collected in real time (24/7) and analysed to understand how Internet service is performing in European homes.

This first report focuses on basic service quality parameters (e.g. speed, latency and packet loss) and on some web browsing and video streaming indicators. In general, the results are based on the nationwide average performance of wired connections to the router (via Ethernet), unless otherwise stated. However, we also analyse Wi-Fi and regional performance for some indicators. For this purpose, VDSL and HFC technologies with speed profiles ranging from 50 Mbps up to 400 Mbps for the four biggest operators, Deutsche Telekom, 1&1, Vodafone/Unity and O2, have been taken into consideration.

Wi-Fi is key and should be taken into account to evaluate the true user experience, considering that a minority of devices are connected via Ethernet. Wi-Fi has come a long way, but its performance is still far from that of a direct Ethernet connection to the router.

About MedUX

MedUX is the next generation specialist in customers' digital-experience measurement and improvement, providing cutting-edge tools and innovative solutions for telecom operators, governments and companies. The company is present in more than 15 countries, with a strong presence in Latin America and Europe. Today, MedUX has been deployed for clients such as Telefónica, AT&T, Claro Colombia (Grupo América Móvil), Vodafone and Orange.

Our innovative system for the measurement, prediction and analysis of fixed and mobile telecommunications lines obtains reliable, real-time data on operators' networks and the quality of service offered. This enables our clients to stand out from their competitors, reduce costs and enhance their value propositions, keeping their customers happy and satisfied by anticipating problems and avoiding complaints.

Go beyond measurements and analytics, discover MedUX!

Fly with Data!

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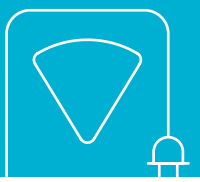

How are German networks coping with mobility restrictions and #stayathome measures?

German networks have shown a slight degradation in key quality indicators over the last few weeks. The average impact is not very material, but some telco operators have been seeing relevant degradations since the start of social distancing and stay-at-home policies. In an international context, German networks are performing, in general, better than those of some other European countries with stricter lockdown rules and greater traffic volume increases.

At MedUX, we are pleased with network resilience and telco operators' efforts to manage this unprecedented situation and make sure there is enough capacity deployed in networks and Internet exchanges. Operators all over Europe are taking reactive and proactive measures to maintain service quality and Internet usage experience. The risk of network congestion is still high, but operators are working hard to mitigate the shock of Internet usage growth.

MedUX's data shows that German networks have been somewhat strained since mobility restrictions and social distancing policies began. Degradation has been observed in basic parameters, such as latency, packet loss and contracted speed compliance, and in indicators related to web browsing, gaming, cloud storage and streaming services. However, we believe that the coronavirus lockdown in Germany will make the Internet and the networks stronger than ever.

How do we, MedUX, monitor network performance and whether the networks are ready for technological challenges and customers' needs? These are the main findings and other relevant aspects of our impact assessment in Germany:

1. All regions are affected in some way, but North-Rhine Westphalia, Bavaria, Baden Württemberg, Hamburg and Schleswig Holstein have had a relatively more significant customer experience degradation.

2. The drop in compliance with contracted speeds for wired connections (via Ethernet) was up to 2.5% for 50 and 100 Mbps services on average at the national level during peak hours (around 20–21h) of weeks 12 and 13.

3. The same drop in compliance for wireless connections (via Wi-Fi) was up to 7% for 50 Mbps services during peak hours (around 20–21h) of week 13.

4. There was an up to 25–35% exceptional decrease in compliance with contracted download speeds for some operators and speed profiles during peak hours (around 20–21h) on the worst-performing days of weeks 12 and 13.

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5. There was an up to 13% increase in latency for 100 Mbps services during morning and afternoon hours on average at the national level and an up to 40 ms exceptional latency for some operators and speed profiles during peak hours (around 20–21h) on the worst-performing days of weeks 12 and 13.
6. There was an up to 0.12% average packet loss during peak hours (around 20–21h) of week 12 and an up to 2.25% exceptional packet loss for some operators and speed profiles during peak hours (around 20–21h) on the worst-performing days of weeks 12 and 13.
7. Some operators have been affected by the degradation of web browsing, streaming and gaming experiences, especially the latter because of latency, jitter and packet loss worsening.
8. The worst-performing operators have suffered a deterioration of streaming and web browsing experiences of up to 30%, especially during weeks 12 and 13.
9. There was an up to 7% average increase in web loading time (TOP Alexa sites) during afternoon hours on the worst-performing days.
10. There was an up to 80% average increase in DNS resolution (TOP Alexa sites) during afternoon hours on the worst-performing days of weeks 12 and 13.
11. There was up to a 5–6% average increase in the start-up and loading time of videos (streaming) during afternoon hours (incl. peak time) on the worst-performing days.
12. Starting the 30th of March, week 13 (W13), MedUX's data shows better network stability and a general improvement in some performance indicators can be observed during the first weeks of April. So far, so good, as networks are getting back to normal.

Considering the latest traffic reports in Germany from the largest exchange point in the country and abroad, the DE-CIX Frankfurt, the overall peak trend has remained stable but sustained since the 26th of March (20% increase vs. recent maximum values pre-COVID-19 crisis). According to the reports from telco operators, they have observed a traffic increase between 50% and 80% in their fixed networks.

The critical issue during these extraordinary times is how networks cope with the additional traffic of millions of people working from home and with family members due to social distancing and mobility restriction policies.

As a reference, see below the impact on latency for the week starting the 16th of March (W12) during peak time (20–21h), as the percentage of increase against the week beginning the 24th of February (W9), before the lockdown. Most regions were affected in some way, but considering latency as a reference, Bavaria, North-Rhine Westphalia and Hamburg had a relatively more severe degradation in 100 Mbps services.

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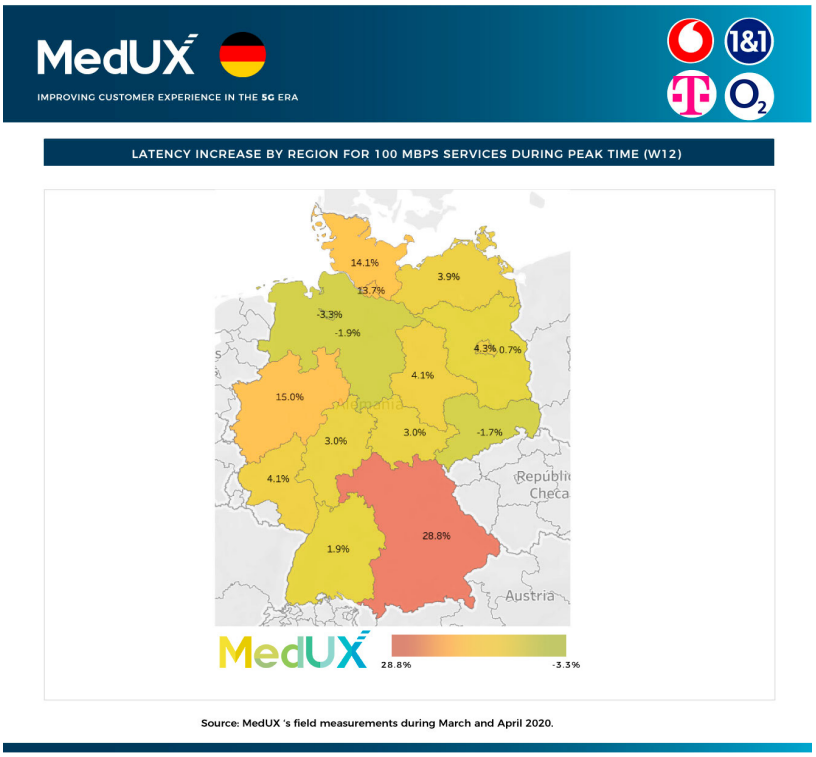

German Context

On the 8th of March, the German Health Minister recommended cancelling events with more than 1.000 attendees. A general ban on cultural and sporting events was put into immediate effect on the 10th of March. Bundesliga football league games started taking place without fans.

On the 16th of March, first Saarland and Bavaria, then Berlin and North Rhine-Westphalia and the rest of the German states mandated school, kindergarten and day-care centre closures. On the 22nd of March, the German government announced some mobility restrictions and social distancing policies. Individuals were only allowed to leave their homes for certain activities, such as commuting to work, engaging in sports or purchasing groceries, but not in groups, as gatherings of more than two persons, except for families and household members, were banned in all states. Non-essential businesses and restaurants were required to close, except for delivering food to homes. Hairdresser shops were closed.

School closures, remote working policies and social distancing measures are driving a surge in Internet traffic as children and adults alike turn to online video games, streaming or social tools for recreational purposes or as employees tap services like video conferencing or VPN to access remote company resources. All these services generate a lot of Internet traffic from residential broadband connections.

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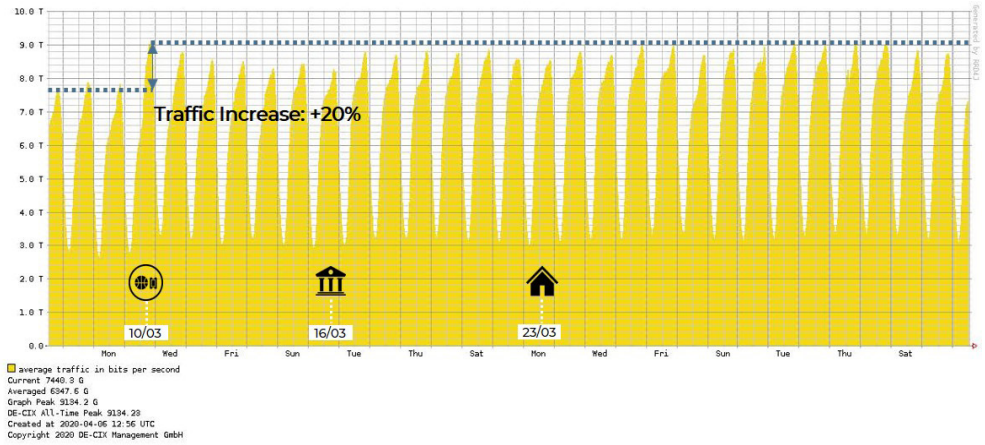
Considering the latest traffic reports in Germany from the largest exchange point in the country and abroad, the DE-CIX Frankfurt, the overall peak trend has remained stable but sustained since the 26th of March. The graph below corresponds to the public peering traffic levels for the last month and shows the trend of weeks 12 and 13, with maximum values in the range of or below the maximum on the evening of Tuesday the 10th with 9.1 Tbps of peak traffic. It was a 20% increase from the previous days' maximum of 7.6 Tbps and the highest jump in traffic the exchange has ever recorded, up 12% from the previous 8 Tbps record logged in December.

Traffic statistics at the DE-CIX Frankfurt Internet Exchange (1-month graph as of 07/04/2020)



It is noteworthy that these statistics refer to public peering traffic and do not consider private interconnections and peering agreements, but they are a fair statistical thermometer.

On the operators' side, Deutsche Telekom CEO Tim Höttges reported that the data traffic volume had doubled. With regard to the operator led by Hannes Ametsreiter, Vodafone Deutschland, on the 18th of March, a light traffic increase of 10–15% was reported in the fixed network, but the Internet remained stable. Vodafone recently reported that a total increase of 80% compared to a normal month in the fixed network was seen in March. As an additional reference, O2 has recorded an increase in traffic of up to 50%.

We understand that these figures may refer to the overall traffic volume; however, the peak data traffic increase is more relevant, as it is a fundamental factor for network dimensioning and performance purposes. Network experience issues during the busy hour are a key factor for customer satisfaction and churn.

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Status overview of the German broadband market

According to statistics from BNetzA, The Federal Network Agency (Bundesnetzagentur in German[1]) , the number of broadband connections in Germany increased by 0.4 million in the first half of 2019, bringing the total to around 34.6 million by mid-2019.

With a share of 73% (25.2 million), the majority of broadband connections are based on various DSL technologies. Together, all other technologies accounted for approximately 9.4 million connections. Most of these were based on HFC networks (around 8.1 million), while approximately 1.2 million were based on fibre-to-the-building (FTTB) or fibre-to-the-home (FTTH).

DT's competitors market some DSL connections to customers on the basis of specific wholesale products and alternative carriers. Out of approximately 25 million operational DSL connections at the end of June 2019, around 7 million lines were offered by DT's competitors based on bitstream and resale wholesale reference offers.

DT accounted for a share of around 56% of all DSL connections by mid-2019. Around 6.3 million VDSL connections were provided by DT's competitors, and around 7.7 million direct VDSL connections were provided by DT. The rise in the spread of VDSL is due mainly to vectoring technology, which currently enables transmission rates of up to 250 Mbps. The increasing significance of VDSL was also reflected at the wholesale level.

1 German regulatory office for telecommunications, electricity, gas, post and railway markets. Tätigkeitsbericht Telekommunikation 2018/2019, 03.12.2019 https://www.bundesnetzagentur.de/SharedDocs/Mediathek/Taetigkeitsberichte/2019/TK_20182019.pdf

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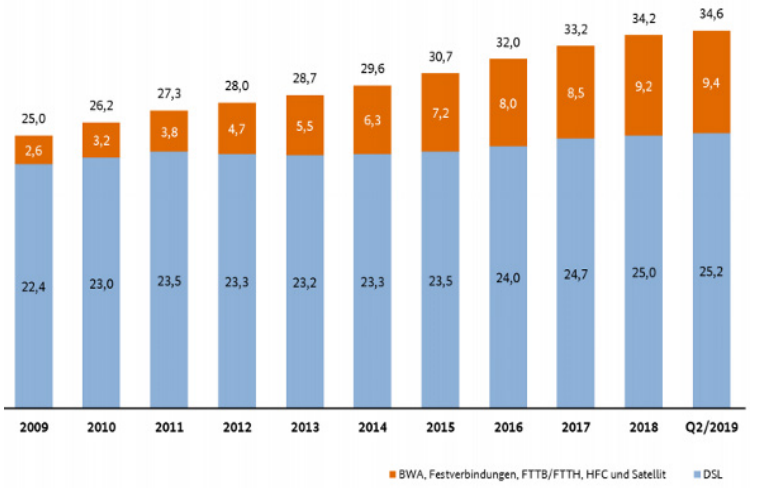
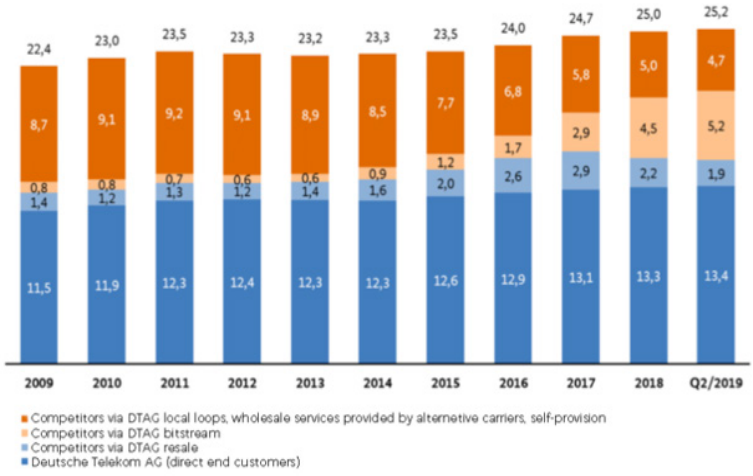
Overview of broadband and DSL connections in Germany [Source: BNETZA]





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Overview of service degradation

MedUX is closely monitoring the effects of COVID-19, specifically how the mobility restrictions and home office and lockdown measures are affecting European networks, customer experience and residential fixed broadband performance.

MedUX's data shows that German networks have been somewhat strained due to social distancing and lockdown policies. Internet service is holding up quite well and is stable. However, Customer Experience is being affected, especially in certain regions and via Wi-Fi.

Degradation has been observed across all operators in basic parameters, such as latency, packet loss and contracted speed compliance during the worst-performing days at peak time. Indicators related to web browsing, gaming, cloud storage and streaming services have also been affected. However, we believe that the coronavirus lockdown in Germany will make the Internet and the networks stronger than ever. This service degradation varies across technologies, operators and regions, but connectivity and service availability are high despite huge traffic increases and pattern changes.

VDSL and HFC technologies with speed profiles ranging from 50 Mbps up to 400 Mbps for the four biggest operators, Deutsche Telekom, 1&1, Vodafone/Unity and O2, have been considered for this purpose[2].

Unless otherwise mentioned, the figures and graphics represent average nationwide performance of wired connections to the router (via Ethernet) and exclude details about regional differences in deployment, network technology and individual operators' performance. However, we also analyse the Wi-Fi and regional performance for some indicators.

All regions have been affected in some way, but considering latency as a reference, Bavaria, North-Rhine Westphalia and Hamburg have had a relatively more severe degradation in 100 Mbps services, as can be seen in Figure below. Comparing the week of the 16th of March (W12) to the week of the 24th of February (W9), latency increased in most German regions.

See below for a selection of regions and the impact on latency (network response time) by region and week as the percentage of increase/decrease against W9. Regions hit harder by the corona crisis, such as Bavaria or North-Rhine Westphalia, match the latency increase during the last weeks of March.

2 ADSL and FTTH are also available on demand. ADSL, which has not been included in this study, shows in general a 10–30% worsening in most indicators and less stability in comparison with VDSL services. All in all, we estimate a 30–40% worse experience (because of the technology limitations and lower speeds, among other factors).

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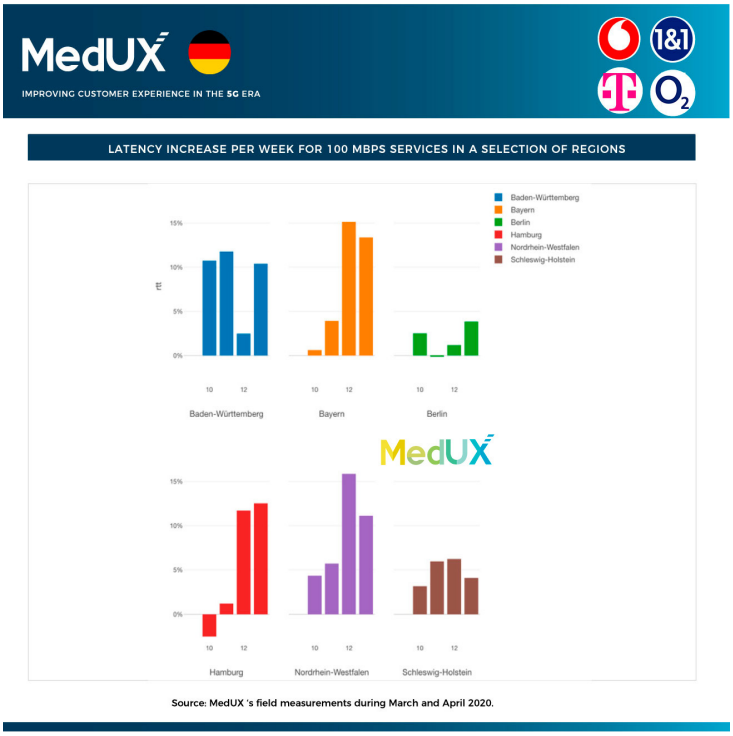
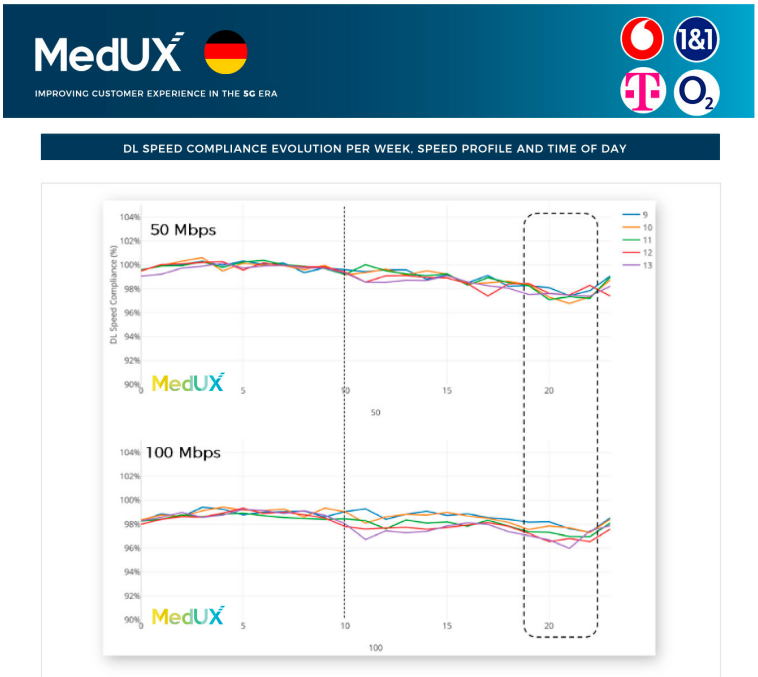


Source: MedUX 's field measurements during March and April 2020.

In general, Internet service quality and customer experience in Germany seem to have worsened, but no service disruptions are preventing users from connecting to the Internet. The drop in compliance with contracted speeds for wired connections (Ethernet) was up to 2.5% for 50 and 100 Mbps services on average at the national level during peak hours of W12 and 13.



Source: MedUX 's field measurements during March and April 2020.

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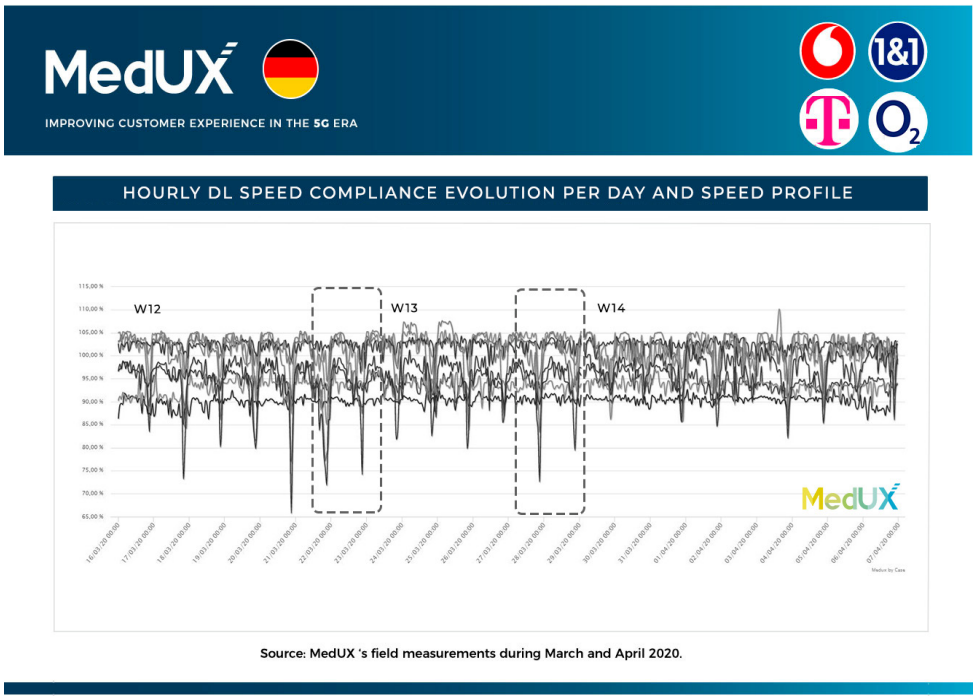
However, up to a 25-35% exceptional decrease in compliance with contracted download speeds has been observed for some operators and speed profiles during peak hours (around 20–21h) on the worst-performing days of the same weeks (see below highlighting the performance during the weekends). Fortunately, these days are gone, and network performance seems to be getting back to normal. Starting the 30th of March, week 13 (W13), MedUX's data shows more stability in terms of compliance across the panel, probably as a result of the hard work of operators and several network improvement measures in response to the coronavirus crisis.

In fact, a general improvement in some performance indicators can be observed during the first weeks of April. So far, so good. But in these uncertain times, as recently stated by Rupert Wood, Research Director of Analysys Mason, "operators should be as concerned about the robustness of networks as they are about capacity. The COVID-19 crisis will expose weaknesses in the reliability of networks".



Source: MedUX 's field measurements during March and April 2020.

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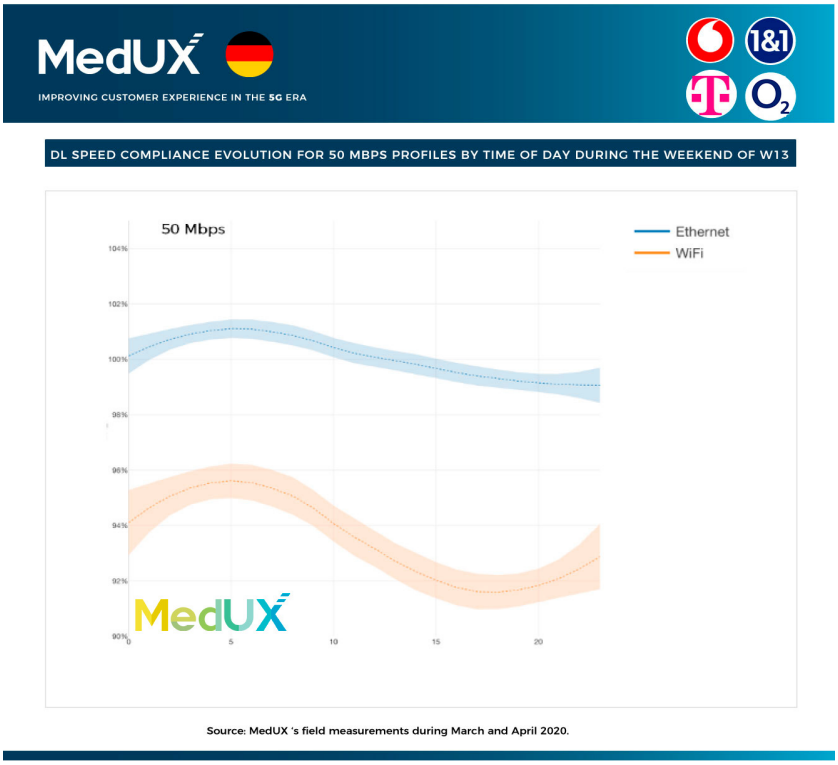
Apart from wired connection performance, Wi-Fi is key and should be taken into account to evaluate the true user experience, considering that a minority of devices are connected via Ethernet directly to the router. Wi-Fi has come a long way, but its performance is still far from that of an Ethernet cable connected directly from the device to the router.

The same drop in contracted speed compliance mentioned above for wireless connections (via Wi-Fi) was up to 7% for 50 Mbps services on average at the national level during the worst-performing days (weekends) of week 13 at peak time.



Latency and packet loss are as important as if not more important than download and upload speeds for the user experience in real-time services. These metrics are directly related to the technology used and, to some extent, the connectivity performance in reaching the measured servers (TOP Alexa sites). For illustrative purposes, the performance against Google, Facebook and YouTube servers has been taken as a reference, and insights are as follows:

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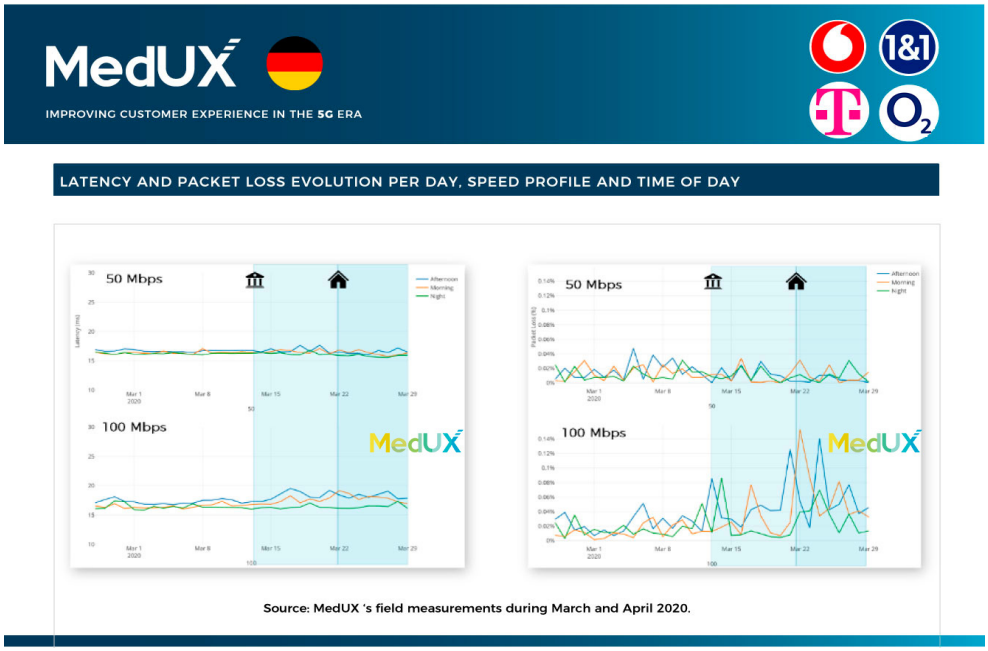
1. An up to 13% average increase in latency for 100 Mbps services occurred during the morning and afternoon hours on average at the national level.
2. There was an up to 0.12% average packet loss during the peak hours of week 12.



When considering peak hours on the worst-performing days of weeks 12 and 13, some operators and speed profiles showed some exceptional figures, reaching up to 40–60 ms latency (30 ms jitter) or up to 2.25% packet loss (see below highlighting some evenings of W12 and W13).

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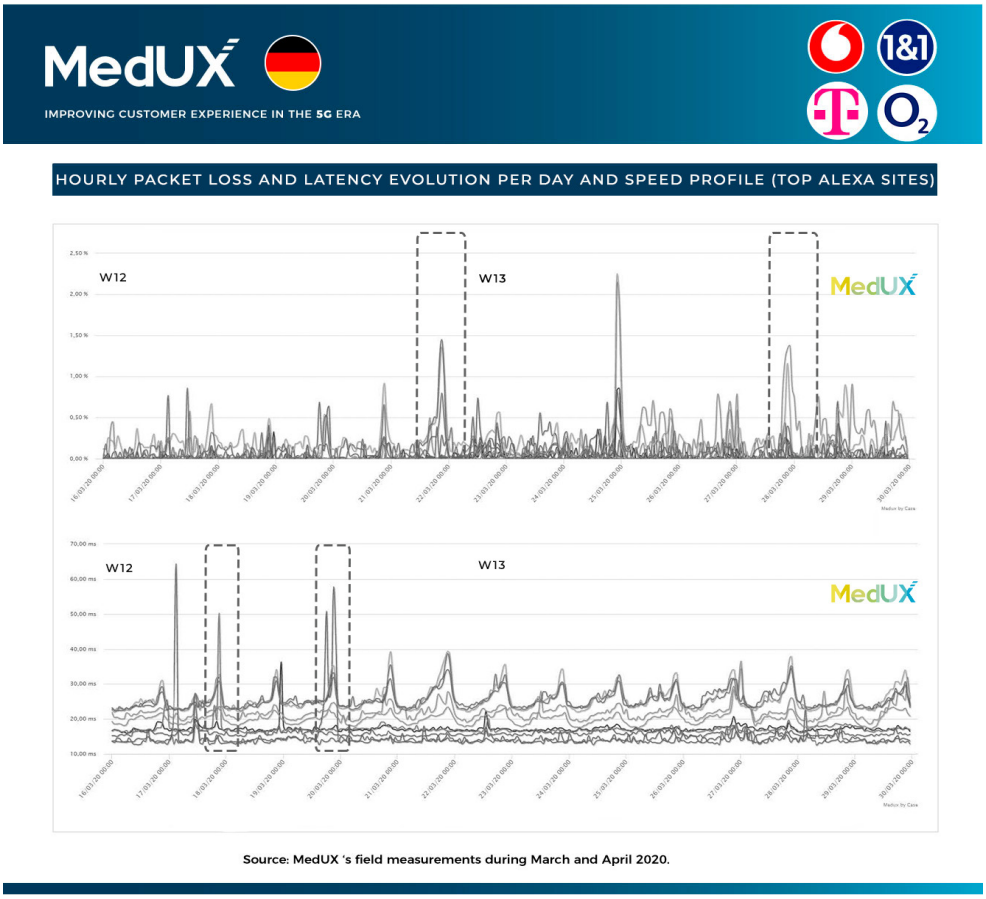

Source: MedUX 's field measurements during March and April 2020.

MedUX monitors real user experience and Over-The-Top (OTT) applications, including web browsing (TOP Alexa sites), gaming, YouTube, Netflix and Dropbox.

1. Some operators have been affected by the degradation of web browsing, streaming and gaming experiences, especially the latter because of latency, jitter and packet loss worsening.
2. The worst-performing operators have suffered a deterioration of streaming and web browsing experiences of up to 30%, especially during weeks 12 and 13.
3. There was an up to 7% average increase in web loading time (TOP Alexa sites) during the afternoon hours on the worst-performing days.
4. There was an up to 80% average increase in DNS Resolution (TOP Alexa sites) during the afternoon hours on the worst-performing days of weeks 12 and 13.
5. There was up to a 5–6% average increase in the start-up and loading time of videos (streaming) during afternoon hours (incl. peak time) on the worst-performing days.

For illustrative purposes, the following graph shows vital indicators of web browsing and streaming experiences, the DNS Resolution and video start-up times respectively.

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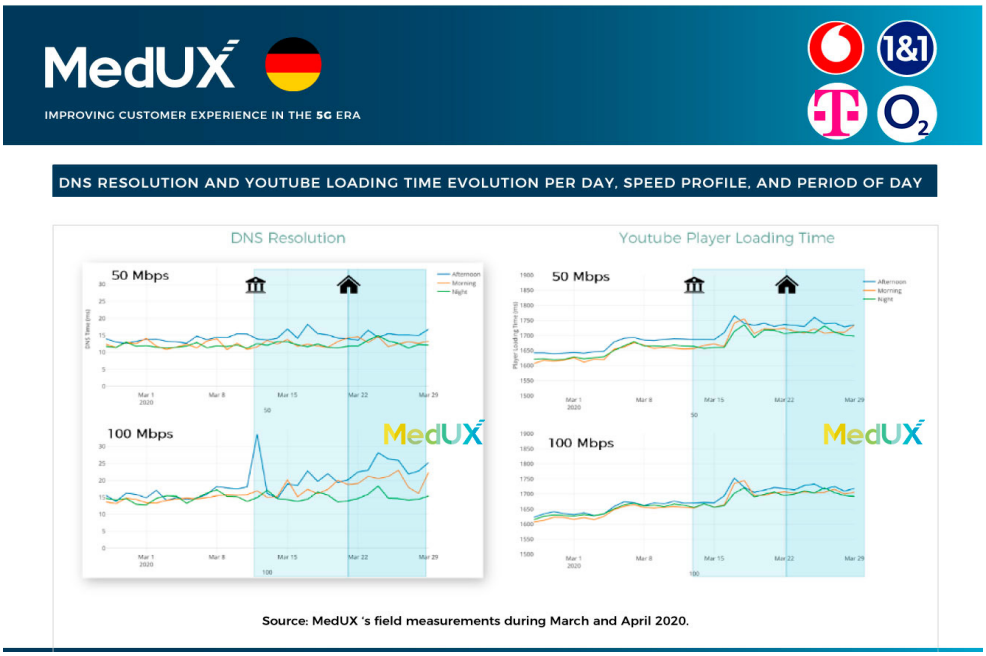

Services like YouTube announced in March that they would be reducing the predefined quality for videos with higher qualities for approximately 30 days in Europe. Video-streaming providers stated that lowering the quality would reduce data consumption by 25%. However, in the case of YouTube, according to our estimations across Europe, the bandwidth consumption was reduced by 10–15% on average for wired connections.

Notwithstanding this, the data usage limitations, or services throttling, has helped networks more easily absorb the surge in streaming, video conferencing and gaming due to the coronavirus. Fortunately, YouTube and Netflix started applying these policies, and others like Apple, Amazon, Microsoft and Facebook have followed suit.

MedUX data shows that there were two main milestones during the HD video quality adjustment process. After the 21st of March, up to 10% of the videos were downgraded to 480p, from 720p and 1080p, the HD qualities. The latter represented 45% of total video reproductions after the first milestone. Since the 24th of March, YouTube has forced almost all HD videos to 720p.

This kind of policies does not seem to have caused any significant improvements in the overall network performance but might have kept it from deteriorating in the last week of March (W13).

The following chart shows the percentage of YouTube reproductions per quality category during the month of March.

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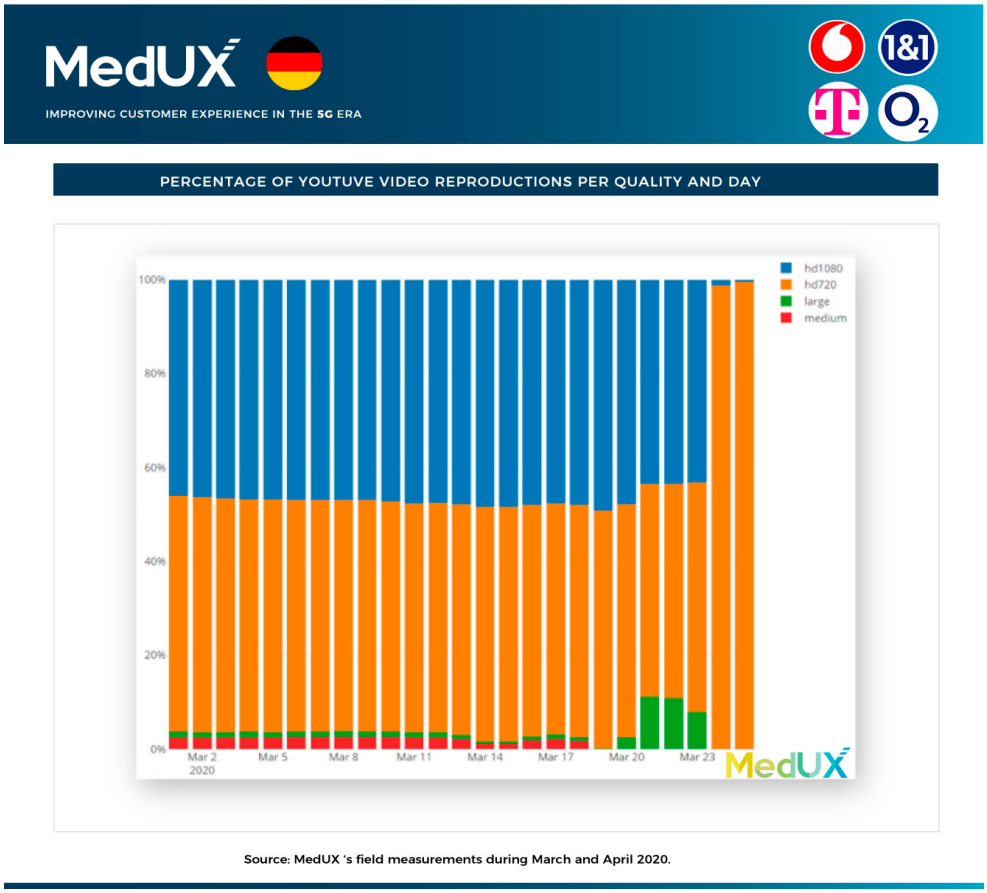

Source: MedUX 's field measurements during March and April 2020.

At MedUX, we continue to work hard to improve network performance, monitor customer experience and deliver innovative solutions to the telecommunications industry. We have made ourselves available to all German and European operators as well as government agencies to support them and do our bit to improve communications critical to the functioning of society and the economy during these difficult times.

We will come through this together! - Gemeinsam stehen wir das durch!

About MedUX

MedUX is the leading company in customer experience measurement in fixed, mobile and TV telecommunications networks, providing cutting-edge tools and innovative solutions for telecom operators, governments and companies.

MedUX measures network performance independently and directly from customer premises. Our analyses are based on real-time information and results obtained from 5.000 MedUX HOME devices deployed in eight countries in Europe.

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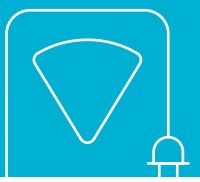

MedUX HOME is a measurement device installed on customer premises that carries out automated performance tests over the broadband connection via Ethernet and Wi-Fi. The results in this study are derived from a sample of approximately 700 measurement points in Germany, a consistent set testing Internet services every hour.

Hundreds of metrics are being collected in real time (24/7) and investigated to understand how Internet service is performing in European homes.

MedUX brings fixed broadband benchmarking to the next level thanks to our innovative approach that combines profound knowledge of network performance with actionable insights into customer experience.

Our solutions enable our customers to stand out from their competitors, have visibility into the true customer experience and in-home performance, reduce costs and enhance their value propositions, thereby increasing customer satisfaction, anticipating their problems and avoiding complaints.

By collecting millions of data analytics, MedUX technology helps ISPs better understand their customers and monitor service quality. MedUX gathers 24/7 information and statistics about end users' perceived experiences, which are eventually affected by the frequency, duration and severity of network events. User reports and complaints, random performance tests or simple high-level monitorization alone is not enough to resolve and prevent customer experience issues.

Our insights help our clients reduce the time to insight by obtaining meaningful information about end-to-end network performance and impacted customer services. Furthermore, our insights help our clients reduce the time to resolution by collecting detailed End-to-End performance statistics in real time and consequently responding to customer issues promptly.

Our controlled and dedicated technology offers extended root-cause analysis and powerful investigation capabilities for network events and is linked to the service/application layer and other network layers. During our intensive QoE test protocol, we collect valuable information about performance-limiting factors to help detect, isolate and determine root causes. It includes necessary path-quality information, such as throughput, latencies and packet loss, as well as other service-level information associated with web browsing, streaming and cloud storage, among others. Examples of these performance limitations are available to most monitored services or applications relating to connection time-outs, DNS resolution, destination host connectivity, network connectivity and server errors.

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