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Technology against Pandemic: Insights and Practice on Telecom Networks

White Paper

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Introduction

At the beginning of 2020, the COVID-19 pandemic swept across the globe. Every country and region began their own fight against the outbreak. To date, this fight is still a tough one impacting the well-being of all humanity on this planet. The virus knows no borders, and has impacted every corner of the world. In China, after its extraordinarily difficult efforts to lock down cities and even the whole country, the outbreak is finally easing. Under tremendous pressure, we are finally seeing the hope of success.

Looking at how each country, and particularly China, has handled the pandemic, we can see major changes in how society operates. The behavior of individuals, households, and companies has all changed significantly. Offline economic activities stagnated due to isolation, family units started doing more together, and surgical masks have become luxuries. Around the world, people's attention was captured by the pandemic, and everyone has been deeply moved by those fighting on the frontline. Despite this, most do

not realize that workers in industries other than healthcare have also sacrificed to make sure everyone stays safe. Those groups include communications engineers and professionals.

Our life of relative peace amid the pandemic would be impossible without the dedication of the frontline workers, regardless of what industry they come from. ICT infrastructure has become a strategic cornerstone in this global fight against the COVID-19 pandemic. It not only helped governments directly fight the pandemic, but also become significantly more important in supporting economic activities and social operations.

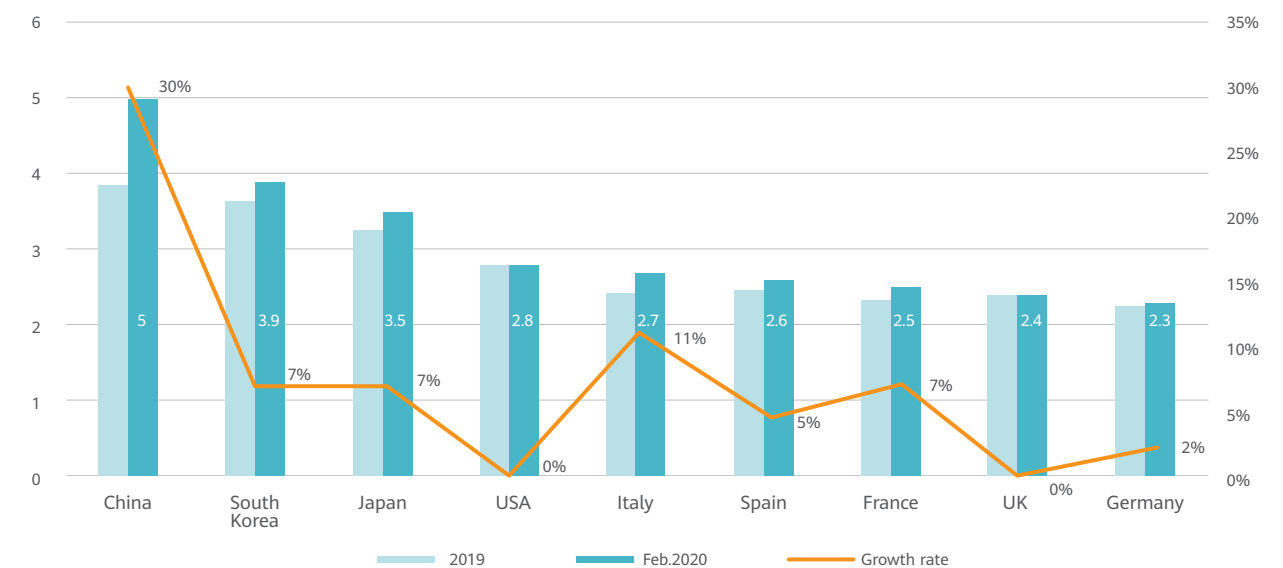
Huawei has analyzed these changes to user behavior during the outbreak and to operator network traffic in major regions throughout the world. Based on scenario-specific analyses from a technical perspective, this White Paper aims to provide operators with rational suggestions for network development during this time of crisis and help countries throughout the world to look at new ways to combat the coronavirus and restore normal socio-economic activities as soon as possible.

Change 1: How we live – from outdoors to indoors and from offline to online

Epidemic prevention and control measures like contactless services and stay-at-home orders have pushed people indoors, and now most are living their lives within the confines of their own homes. A large proportion of people in China hardly left their homes during the outbreak.

Since people kept staying at home, a significantly larger part of their social life has moved online. People in China now spend an average of 30% more time online than they did before the pandemic. Daily routines have been disrupted and people have more free time to engage with online content. Time spent on apps for online food ordering, gaming, and video has significantly increased.

Time Spent Online (Hours)



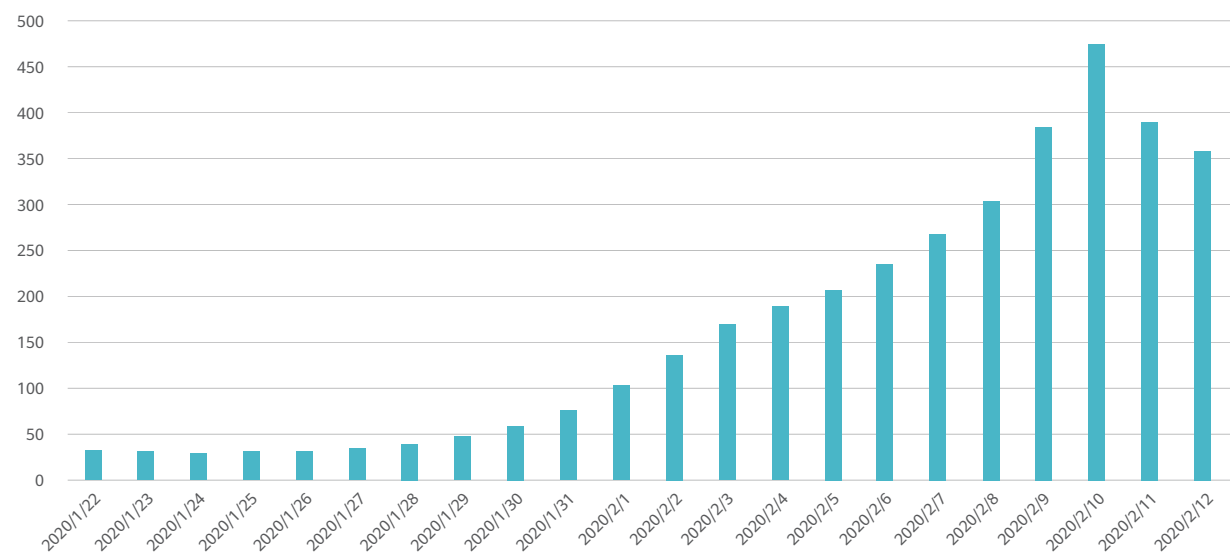
Source: App Annie



Change 2: How we work – from CBDs to homes and from centralized offices to distributed workplaces

The way we work has also greatly changed due to the pandemic. People are no longer flocking to CBDs and instead are working from home using video conferencing to enable communication and collaboration. The number of new teleworking users in China surged from 300,000 to 4 million during the pandemic.

New Teleworking Users during the Pandemic (Unit: 10,000)



Source: MobTech, 01/22/2020–02/12/2020



Change 3: How we study– from study in schools to study at home and from in-classroom instruction to remote teaching

In China, the Ministry of Education introduced a series of measures to continue education while school was suspended due to COVID-19. Children's homes became their new classrooms, and online education has exploded. The average number of daily active users of online learning apps has so far increased 8-fold since the start of the pandemic.

Change 4: How public services are provided – from manual management to digital governance and from face-to-face meetings to contactless interactions

The "Digital China" strategy played a major role in China's fight against COVID-19. The Chinese government rolled out a series of digital governance tools including cloud computing, big data, and AI to supplement traditional management systems. This increased management efficiency and reduced virus transmission risks.

Community-level government organizations served as frontline organizers of coronavirus prevention and control measures. With unified urban management and digital platforms, non-contact technologies were used at residential community gates and supported strict grid-based management, building up a firewall against COVID-19. Conventional handwritten registration was replaced with registration through QR-code scanning, and touch-based elevator rides were replaced with touchless intelligent elevator rides.



Global uncertainty grew amid the pandemic

As of April 2020, the global outbreak of COVID-19 is still growing, and no end to the pandemic is in sight. Before vaccines and appropriate medicines become available, we see huge uncertainties with the pandemic. At least 30 countries have declared a national emergency and taken strict measures including city-wide and region-wide lockdowns. All countries have taken response measures including blocking traffic, suspending schools, and shutting down commercial spaces.



» 01

Changes in user behavior
led to changes in network
characteristics

As a key component of ICT infrastructure, communication networks are the core of the information superhighway. As our lives, work, and public services change, network characteristics have also changed remarkably.

►► 1.1 Changes in network traffic

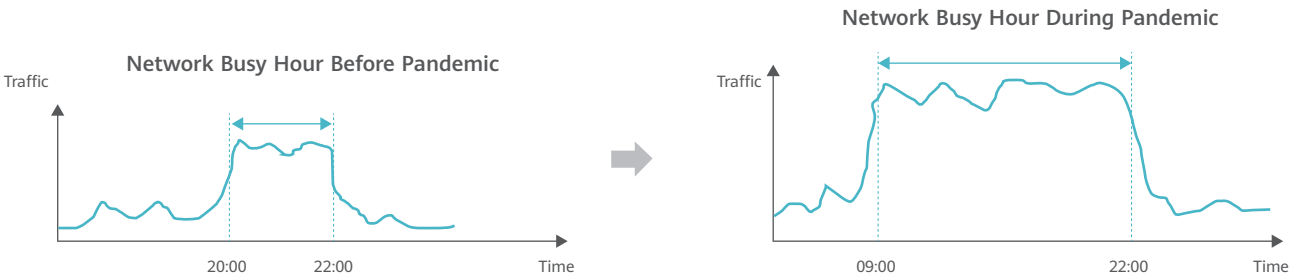
With users spending long periods of time online during the COVID-19 outbreak we have also seen the following changes in global network traffic:

► Surges in data traffic

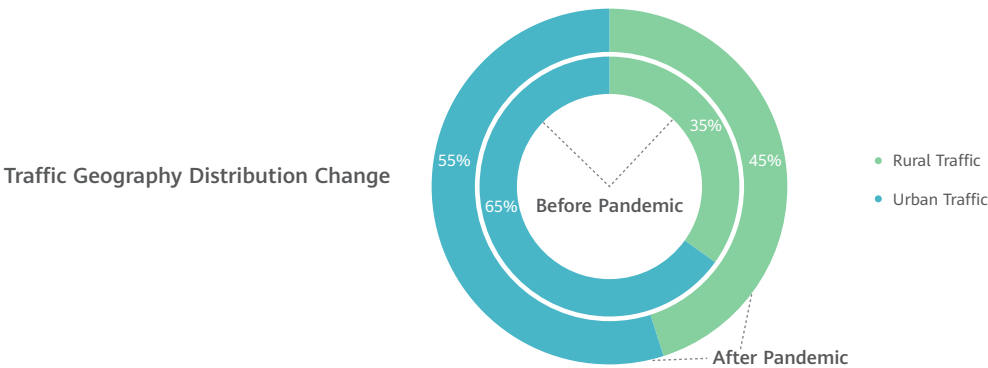
- According to China's Ministry of Industry and Information Technology, mobile Internet traffic increased by 36.4% compared with last year.
- According to one Spanish operator, since the start of the outbreak, IP network traffic increased by 40%, wireless Internet service by 25%, and wireless voice service by 50%.
- According to Telecom Italia, their fixed network traffic increased by 70%, with online gaming contributing the greatest increase.
- Vodafone Germany said their data traffic has increased by 50%.

► Extension of network busy hours

Historically network busy hours were from 8:00 pm to 10:00 pm. However, online classes and telecommuting mainly occur during the daytime while entertainment spikes in the evening. This has changed network models, leaving the extension of network busy hours.



► Residential areas have become new hot spots of network traffic.



►► 1.2 Changes in user experience

Everyone has the right to education. Online education during the pandemic has led to a surge in demand for network coverage and bandwidth. Looking at interactive video alone, live streaming classes create much higher network requirements than traditional video broadcast. To deliver good user experiences, each classroom needs to support stable, high-quality dedicated network bandwidths of up to 20–50 Mbps. Running multiple, simultaneous large online classes at once keeps the network running at full capacity, and can cause videos freezes, audio lag, and long buffering times. The freeze rates (stuttering for 1 minute/class) for VIPKID's online courses reached 19%.

Course Type	Experience Error Criteria
One-on-one tutoring	• Freezes: Stutters cumulatively last up to 1 minute per class • Dropped connection: Stutters cumulatively last up to 3 minutes per class
Group tutoring	• Freezes: Stutters cumulatively last up to 1 minute per class • Dropped connection: Stutters cumulatively last up to 3 minutes per class
Live streaming	• Stutter instance quality: (0 times: excellent; 0–2 times: good; 2–8 times: not bad; > 8 times: poor) • Stutter rate quality: (0 times: excellent; 0–5%: good; 5%–8%: not bad; 8%–12%: poor)
VR	• Black edge quality: (0 times: excellent; 0–2 times: good; 2–5 times: not bad; > 5 times: poor) • Stutter instance quality: (0 times: excellent; 0–2 times: good; 2–8 times: not bad; > 8 times: poor) • Stutter rate quality: (0 times: excellent; 0–5%: good; 5%–8%: not bad; 8%–12%: poor)

Source: *White Paper on Home Wi-Fi Network Technology for Online Education*, Huawei & VIPKID



» 02

ICT infrastructure upgrades driven by the outbreak

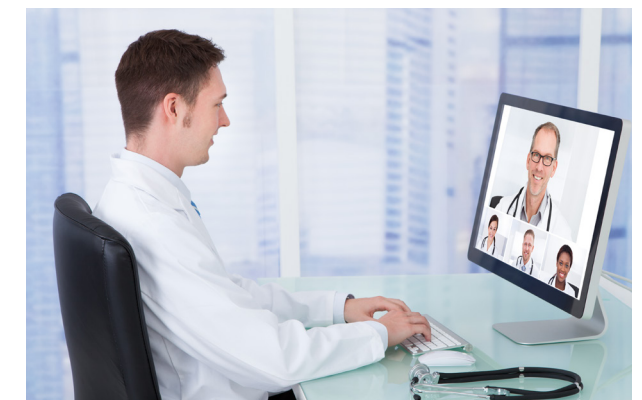
Individuals, families, and businesses from various industries have been greatly affected by COVID-19, pushing them to demand more from their ICT infrastructure. Many countries have also come to realize the importance of digital transformation, and are working with telecom operators to develop policies to support the fight against the pandemic.

►► 2.1 Industries: Going digital to strengthen "immunity"

Industries hit hardest by the pandemic, including catering, tourism, retail, transportation, manufacturing, healthcare, public services, media, and entertainment, are calling for the use of more advanced ICT and digital technologies to fight the pandemic.

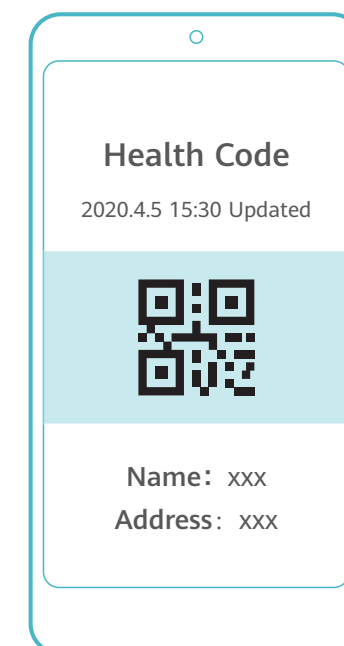
New healthcare requirements: Fully connected, contactless, online, and remote services

The healthcare industry sees an urgent need for online medical consultation and treatment services, to alleviate the pressure of in-hospital service demands and reduce the risk of cross infection. Hospitals have already begun using 5G robots to help with policy promotion, distribution of medical advice, disinfection and sterilization, equipment delivery, and nursing to reduce the burden placed on healthcare workers. This can also reduce direct contact and the risk of infection for healthcare workers.



New public service requirements: Big data, full coverage, and intelligent services

New technologies have been identified as a good vehicle for urgent public services, such as the promotion and execution of epidemic prevention and control measures. These can be seen in the growing deployment of 5G smart robots to patrol open spaces, 5G drones used to broadcast COVID-19 related knowledge within local communities, AI thermal imaging at transportation hubs, airports, and other densely populated areas, and the use of big data and QR code access control systems at shopping malls, communities, and parks that track individual risks associated with their travel and close contact history.



New education and entertainment requirements: High bandwidth, high concurrency, and low latency services

COVID-19 has forced elementary and secondary schools across China to move school online, and office workers to work from home. Freezes and long delays can occur though when a large number of users access the network and the cloud simultaneously for video conferencing, online courses, video streaming, online gaming, home fitness, and other home entertainment. To deliver a satisfactory user experience, it is important to expand both the capacity of cloud video platforms to adapt to user needs in high-concurrency scenarios, and home and mobile broadband for multi-user, high-traffic, and low-latency scenarios.



New catering requirements: Contactless, platform, and cloud-based delivery solutions

Chinese New Year celebrations are traditionally marked by vast numbers of dinner parties, wedding receptions, and other activities. This year most of these could not occur, as restaurants were closed temporarily due to the outbreak. As a result, catering companies have had to resort to moving online and offering more takeaway and delivery services. Efficient contactless catering services require online platforms that support online orders, cloud-based delivery management, and mobile payment.



► 2.2 Policy support: National ICT infrastructure upgrade

The coronavirus outbreak has created many challenges for individuals, families, industries, and public services alike. As a result, governments and regulators across the world have developed a number of policies to facilitate the upgrade of ICT infrastructure.

China: Policies to promote the integration of ICT in healthcare and education

In China, the government has issued a number of policies to promote the application of "big data + grid", "Internet + medical healthcare", and "artificial intelligence" to make high-quality medical consultation services easily accessible. These services include online health assessments, health guidance, educational resources, and psychological counseling, as well as follow-up examinations for patients with chronic illness. The government also issued policies

to encourage investment in 5G smart health systems to deal with major public health emergencies, and accelerate the deployment of 5G to support early warnings for potential epidemics, pre-hospital aid, remote real-time consultation, remote surgery, wireless monitoring, mobile ward monitoring. These policies include:

- *Recent Work Plan for COVID-19 Prevention and Control* from the State Council
- *Notice on Strengthening Information Systems to Support COVID-19 Prevention and Control* from the National Health Commission
- *Fully Leveraging Artificial Intelligence to Fight COVID-19* from the Ministry of Industry and Information Technology (MIIT)
- *Notice on Organizing Efforts to Implement New Infrastructure Projects (Broadband Network and 5G) in 2020* from the National Development and Reform Commission and MIIT

Europe: Promoting network upgrades to satisfy huge traffic requirements

The EU's Body of European Regulators for Electronic Communications (BEREC) granted operators the authority to exercise traffic control measures that would previously be barred due to net neutrality rules amid the pandemic. Member states have also proposed related control measures to deal with the crisis, such as optimizing operators' networks, encouraging Internet usage during off-peak hours, and service prioritization. Some additional measures taken by member states include:

- The Italian regulatory AGCOM issuing an emergency decree, requiring operators to improve their networks to support the fight against COVID-19;
- The German federal government granting operators the authority to exercise traffic control measures, prioritize video conferencing, and reduce OTT and video bit rates;
- The UK's communications regulator Ofcom issuing a proposal to "help broadband users stay connected";
- Switzerland looking to shutting down Netflix's streaming services;
- Spanish users being advised to access the Internet during off-peak hours as Internet traffic increased by 40%;
- The French Telecoms Federation calling for "digital responsibility" to avoid saturation.

South Korea: Multiple incentives to offset the impact of COVID-19 and revitalize the national economy

- Increasing investment in 5G by 50% in the H1 of 2020 to 4 trillion won.
- Telecom operators continuing to expand network coverage on roads and at train stations, shopping malls, and subways.
- Manufacturers continuing to launch low- and mid-priced 5G smartphones and expand 5G service coverage.



GSMA: Using spectrum policy to facilitate the upgrade of communication networks

- United States: The Federal Communications Commission has released available spectrum in the 600 MHz and 1.7–2.2 GHz bands to provide additional coverage and capacity respectively.
- Ireland: Extra radio spectrum in the 700 MHz and 2.6 GHz bands has been temporarily released to provide additional capacity and liberalize the use of 2.1 GHz so that it can be used for 4G and other technologies, rather than just for 3G.
- Jordan: Available spectrum in the Sub-1 GHz and fixed wireless access (FWA) spectrum bands has temporarily been released to MNOs, to provide additional capacity.
- Saudi Arabia: Available spectrum in the 700 MHz band has temporarily been released to MNOs.
- Panama: National regulators will grant temporary spectrum licenses to MNOs for additional capacity upon request.
- Brazil: An agreement between MNOs and regulator Anatel in Brazil confirms that the agency will take any regulatory action necessary, including additional spectrum, to make sure all services remain intact.

►► 2.3 Operators on the move: Upgrading networks for anti-epidemic efforts

► 2.3.1 Chinese operators

Communications support: The three major Chinese operators rapidly built 3G, 4G, and 5G base stations for the Huoshenshan and Leishenshan hospitals in order to offer gigabit network coverage. In areas severely stricken by the pandemic, operators did not suspend services because of unpaid fees, and they even temporarily resumed services for accounts with insufficient funds. This let users use or change their telecom services without going outside. Operators in some regions proactively communicated with healthcare authorities and provided discounts for medical workers who went to Wuhan help fight the pandemic. They also sent nearly 30 billion text messages to the general public about epidemic prevention and controls, and offered individuals SMS inquiry services about travelling. These three operators successfully maintained telecom network stability nationwide, especially in Hubei province.

Big data analysis: Through telecom big data analysis, operators provided information about people's travels and sent alerts ahead of time. These operators also worked together to preliminarily analyze where people went across the country and gave warnings about those who had been in close contact with COVID-19 patients.



► 2.3.2 Global operators

Five measures Vodafone took to strengthen network assurance

- Ensured network service quality.
- Provided network assurance for key government functions.
- Improved the spread of public announcements during the outbreaks.
- Encouraged "work from home" and provided support for small and micro businesses.
- Strengthened government's management and controls in the epidemic-stricken areas.

Four measures MTN CEO revealed:

- Asked employees to work from home and perform self-quarantine, etc. to reduce the spread of virus.
- Initiated working remotely and banned international business travel to protect employees' safety.
- Provided network assurance in terms of hardware, software, spare parts, human resources, and other aspects to ensure connectivity.
- MTN played a pivotal role in solving social difficulties by providing free networks for universities and lowering the transaction fees of mobile money to reduce cash transactions.

» 03

Teaming up with partners from numerous industries, operators utilized technologies to fight the pandemic

Operators build and operate ICT infrastructure. Faced with the epidemic outbreaks, they worked with partners from numerous industries to overcome numerous difficulties. Operators met this demand by making full use of technologies such as 5G, cloud, AI, and big data. They also practiced the principle of "tech for good" by letting ICT network infrastructure play its strategic role.

►► 3.1 Public services

The general public wanted access to visible, credible, and controlled information: People panicked since the virus couldn't be seen or touched, which was coupled with overwhelming information on the internet. They wanted authoritative, real, and credible information about the epidemic and to learn about the correct way to stay safe.

Authorities, on the other hand, wanted to stop rumors and panicking: As the pandemic exerted a significant impact on all aspects of society, it posed great challenges to authorities. They needed to coordinate their efforts to combat the virus, while openly sharing correct information with the public with updates on relevant policies and activities so that people wouldn't believe and spread rumors or panic.

Measure 1: Using 5G drones

Drones connected to operators' 5G networks were used to combat the virus by patrolling streets, sharing information about the anti-epidemic efforts, disinfecting streets and buildings, coordinating traffic, and transporting urgent goods like medicine.

- **Broadcast:** Local police patrolled streets and communicated with people remotely by using drones in order to promote epidemic prevention information and instructions.
- **Disinfection:** Drones were used to disinfect hospitals and areas nearby. It was more efficient than disinfecting manually and reduced cross infection risks.
- **Assisting the police:** After work and production resumed, an increasing number of people returned by car. Traffic police hung registration QR codes from flying drones, and used them to remind drivers to register in advance. This saved time for drivers and doubled traffic efficiency, avoiding congestion on highways outside cities.
- **Transport:** Ferry services and other transport methods were suspended during the outbreak, so drones were used to send medicine, samples for first aid, and other daily necessities. Air transport routes using drones could reduce travel distance from 100 km to 2 km.



Measure 2: Checking temperatures and mask wearing with AI

Avoiding physical contact, the AI thermal temperature detection system provides automatic body temperature checks, accurate to within 0.3°C. The system automatically creates an alert whenever someone's body temperature is higher than 37.3°C, and can check 46,000 people per hour. This addresses some of the problems of traditional thermometers, temperature guns, and ear thermometers, which are only used for one person at a time and can easily lead to cross infection. An AI thermal temperature detection system can be deployed quickly to screen body temperature in crowded public spaces such as schools, airports, docks, stations, hospitals, and shopping malls. Operators' telecom big data analysis systems then quickly identified those who were closely connected to coronavirus patients and where they had been, which helped effectively control the spread of the epidemic.

An AI facial recognition algorithm was used to identify people who weren't wearing masks in public. Utilizing operators' ubiquitous wireless network coverage, this system was quickly deployed in key transportation hubs like railway stations, airports, and bus stations, as well as in other crowded public spaces such as shopping malls, office buildings, schools, and communities. It helped reduce public safety risks, uphold the law, and reduce infection risks.



Measure 3: NB-IoT magnetic electronic door seal for people in home isolation

NB-IoT supports extensive coverage and low power consumption. NB-IoT magnetic electronic door seals provided real-time management of isolated personnel and sent alerts when they entered or exited home. Powered by a range of algorithms, the platform collected information through front-door and window sensors and recorded the occupant's whereabouts. Abnormalities such as people entering and exiting and other statistical data were uploaded to the back-end management platform through the NB-IoT network; this provided real-time warnings and overviews of where isolated individuals were.

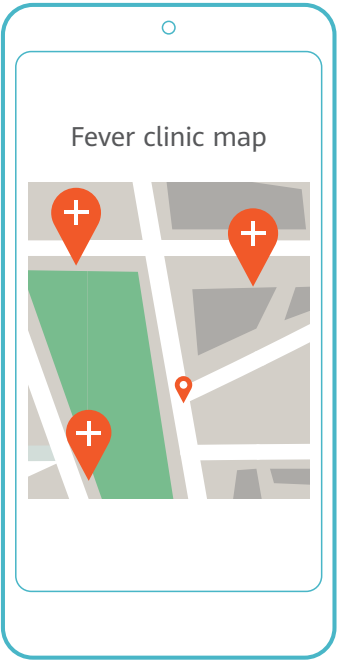
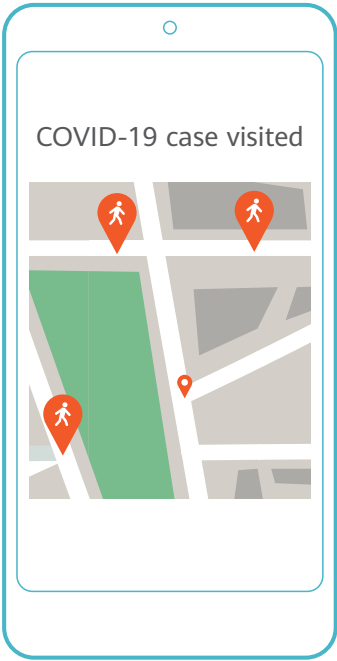
Measure 4: 30 day travel history

As companies gradually resumed work, employers and community neighborhood committees wanted to learn about where their people had been to ensure public safety. It was no longer sufficient to register people manually, and there was also a risk people might lie about where they had been. To help users quickly prove their recent travels and assist governments in verifying this information, the three major Chinese operators launched a free travel history inquiry service (for example, if you have China Mobile, you can find this out by sending CXMYD#2550 to 10086). This service is based on operators' big data capabilities and information security is ensured.



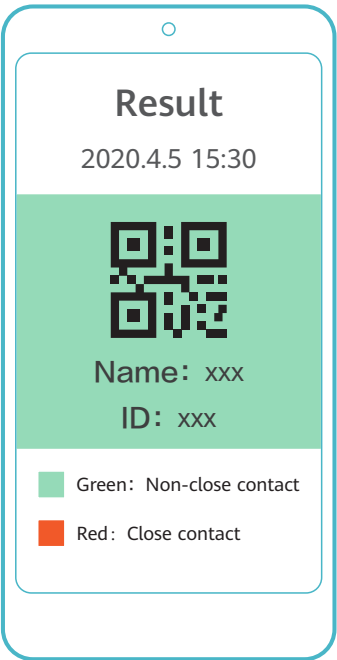
Measure 5: Inquiries about nearby outbreaks and targeted hospitals

Community epidemic control was an important step in preventing the spread of the virus for people returning to work. Baidu Maps offers its users a service to quickly learn about outbreaks in their cities and neighborhoods. Using the ubiquitous network offered by operators, users can learn about nearby outbreaks, fever outpatients, and targeted hospitals for COVID-19 in real-time.



Measure 6: Big data helps users see if they are closely connected to a COVID-19 patient

There is increasing demand for big data given recent developments and the need to prevent the disease from spreading. To meet such demands, E-government Office of the General Office of the State Council launched the Close Contact Identification app. This app analyzes whether the user has been in close contact to a COVID-19 patient by using big data analyses of travel history and public transit records, including the high-speed train departure time.



► 3.2 Hospitals

The Chinese city of Wuhan was the first to marshal a citywide approach to battling COVID-19, which triggered contingency plans across all sectors, especially public security and services. A series of steps – screening, isolation, detection, and joint prevention and control – were taken to protect lives, maintain social order, and ensure orderly production. Contactless services and telecommuting made their way into people's lives almost overnight. The capacity of the entire healthcare system was put to the test in terms of early detection, precise prevention and control, efficient treatment, combating the virus, and work resumption.

Huawei joined operators and many healthcare partners in this battle. As key technologies underpinning the digital infrastructure, 5G, cloud, and AI have been further integrated with the healthcare industry. This has helped speed up digital transformation, contain the spread of the virus, share medical resources, reduce contact transmission risks, and improve the efficiency of diagnoses and treatments.

► 3.2.1 5G-powered digital channels quickly built up in hospitals

5G has played an important role in the fight against the pandemic with its ultra-large capacity, ultra-high bandwidth, ultra-low latency, and fast service provisioning. Gigabit-capable networks built for hospitals and a myriad of 5G-powered healthcare services have created a high-quality digital channel. This channel is used to connect doctors with patients, affected areas with the rest of society, and hospitals across physical and administrative boundaries. As a result, physical contact was minimized, and there were huge improvements to information sharing and diagnosis and treatment efficiency.

Huoshenshan Hospital opened on time with gigabit-capable networks

On January 23, 2020, Wuhan decided to build Huoshenshan Hospital based on Beijing's Xiaotangshan model from the early 2000s. On January 24, 2020 (Chinese New Year's Eve), all hands were on deck to start construction. It was the beginning of an intense and protracted race against time to centrally treat COVID-19 patients and contain the spread of the virus.

To reduce the workload of onsite fiber deployment and shorten the project duration, Huawei worked with Hubei local operators to provide network coverage for the hospital with both 5G and optical fiber. The first 5G base station for Huoshenshan Hospital was put up in only 36 hours and went live on January 25. Over the stable gigabit-capable network, basic data services and various medical services were commissioned and put into use. This helped ensure that the construction of the 1,000-bed Huoshenshan Hospital of 33,900 square meters, was finished by February 2 as scheduled. At 9:00 on the morning of February 4, the hospital admitted its first batch of COVID-19 patients, and the next day, Leishenshan Hospital was also in operation.



Figure 1: 5G network construction for Huoshenshan Hospital



Figure 2: 5G + Wi-Fi network construction for Leishenshan Hospital

5G live streaming of the hospitals' construction rallied public confidence in battling COVID-19

Early in the morning of January 27, China Telecom received a request to launch a continuous live streaming service for cctv.com which would live broadcast the construction of the two new hospitals in Wuhan through its "COVID-19 Live" program. The goal was to update interested people in both China and the rest of the world on the construction progress of the two new hospitals in Wuhan.

This live broadcast had strict requirements on bandwidth and online live broadcast technologies. China Telecom finally adopted the "5G + optical fiber" dual gigabit network solution and mobilized video cloud resources across the nation. The live broadcast started at 8:00 p.m. on January 27. The non-stop live broadcast was not only in 2D but also included 4K, 360-degree VR streaming of the construction of Leishenshan Hospital, which gave netizens an immersive experience of China's strength in construction. Featuring HD images and stable connections, the live broadcast attracted nearly 100 million concurrent viewers at its peak and was dubbed "the most impressive online supervision on construction work". This live broadcast showed the world the speed and the inspired experience delivered by 5G. More importantly, it boosted public confidence in fighting COVID-19



Figure 3: Live broadcast of Huoshenshan Hospital construction

5G, cloud, and AI enabling digital hospitals

In addition to online live broadcast, Huoshenshan Hospital and Leishenshan Hospital were provided with gigabit network coverage with 5G. The networks can support concurrent communication for up to 25,000 users and enable a series of digital and intelligent medical services such as remote expert consultation and video conferencing across hospitals at different levels, remote B-scans, AI-assisted fast CT analysis, unmanned delivery, unmanned disinfection, and mobile detection vehicles. This greatly improved diagnosis and treatment rates, reduced contact transmission, mitigated shortages of frontline medical staff, and eased their punishing workloads.

► 3.2.2 5G-enabled remote collaboration improving resource sharing, diagnoses, and treatments

Isolation turns out to be the most effective and important prevention and control method to contain the fast spreading coronavirus. Medical workers facing many patients also needed to adjust how they gave diagnoses and treatments in order to reduce contact and avoid infection. The quick spread of the virus brought many challenges to affected areas such as shortages of medical experts, unbalanced distribution of skills, and resource allocation difficulties. It became imperative to have medical experts work together closely to improve efficiency and reduce the workload of medical staff.

To respond to these challenges, operators and healthcare partners quickly provided multiple solutions for 5G-based remote collaboration. For example, 5G remote consultation was provided by integrating an HD videoconferencing system with a CT diagnosis system. This solution allowed medical experts in different locations to read scans remotely and make diagnoses in real time.

On January 31, Huawei and China Telecom deployed and commissioned the first remote consultation network for Huoshenshan Hospital (Figure 4), and launched a 5G remote consultation service in the Wuhan Union Hospital. This service enabled remote consultation between different parts of the Wuhan Union Hospital, as well as between the hospital and Peking Union Medical College Hospital, Beijing Chaoyang Hospital, and Wuhan Cancer Hospital. Massive amounts of data and ultra-HD images were transmitted over high-speed 5G networks and a medical image cloud. Medical experts in different locations were then able to share patient information in real time. For example, they could remotely annotate CT scans, have discussions, and make diagnoses remotely (Figure 5).



Figure 4: Commissioning the first remote consultation platform in Houshenshan Hospital

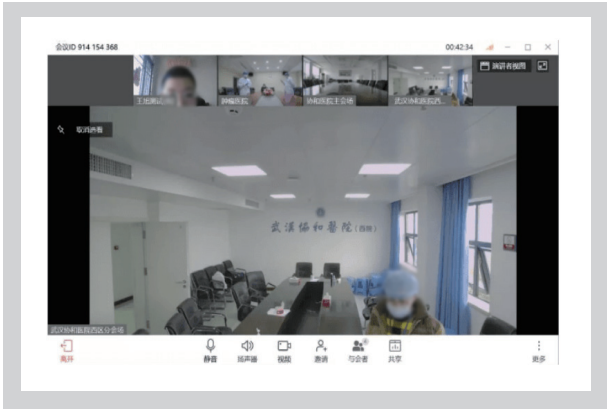


Figure 5: Commissioning the remote consultation platform in Wuhan Union Hospital

enabled by 5G, four hospitals in different cities engaged in a remote CT screening: Leishenshan Hospital (Wuhan), Beijing Tsinghua Changgung Hospital (Beijing), Zhongshan Hospital Affiliated to Fudan University (Shanghai), and The First Affiliated Hospital of Sun Yat-sen University (Guangzhou) (Figures 6 & 7).

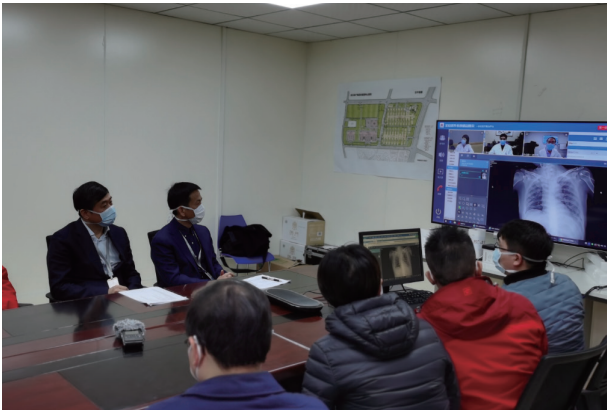


Figure 6: Remote consultation by experts of four hospitals



Figure 7: Reading a CT scan remotely

Since the start of the outbreak, about hundreds of hospitals in China have adopted the remote consultation solution enabled by 5G, WeLink (videoconferencing), and CT systems. Thanks to 5G's large bandwidth (uplink and downlink rates of 30 Mbit/s) and low latency, the solution enabled experts in different locations to have stable video conferences and view HD CT scans transmitted quickly over high-speed networks (average size of CT scan: 200 MB to 1 GB) in real time. This way, they could work together to improve the efficiency of screening. Powered by cloud and AI, CT results can be delivered in minutes, even in seconds.

With 5G-powered remote consultation, experts could gather anytime from anywhere to avoid contact and save more lives.

In addition, the 5G-based remote assistance solution helped nurses monitor dozens of patients remotely and simultaneously, provide psychological counseling for patients, and allow families to visit remotely. This solution plays an important role in each phase of diagnosis and treatment, avoids cross infection, reduces the workload of medical staff, and improves cure rates.



Figure 8: One-on-one remote psychological counseling



Figure 9: Remote monitoring and visit of patients in isolation

► 3.2.3 5G-powered remote B-scans for contactless, mobile diagnosis and treatment

The outbreak covered Chinese provinces, cities, and villages. A series of measures were taken to limit people's mobility and gatherings. However, medical resources were unevenly distributed among hospitals. When there weren't enough local experts and it was difficult to identify, confirm, and treat COVID-19 patients in time. With the 5G-powered remote control solution, experts could remotely operate the medical examination system to check or even operate on patients. This kind of contactless and mobile diagnosis and treatment made things much more efficient.

As shown in Figure 10, on February 18, Peng Chengzhong, deputy director of the Remote Ultrasound Medical Center of Zhejiang Provincial People's Hospital, remotely controlled a robotic arm that could perform ultrasound examinations. Over 700 km away, Peng did B-scans over a 5G network for COVID-19 patients in a makeshift hospital converted from the Wuhan Huangpi Gymnasium.

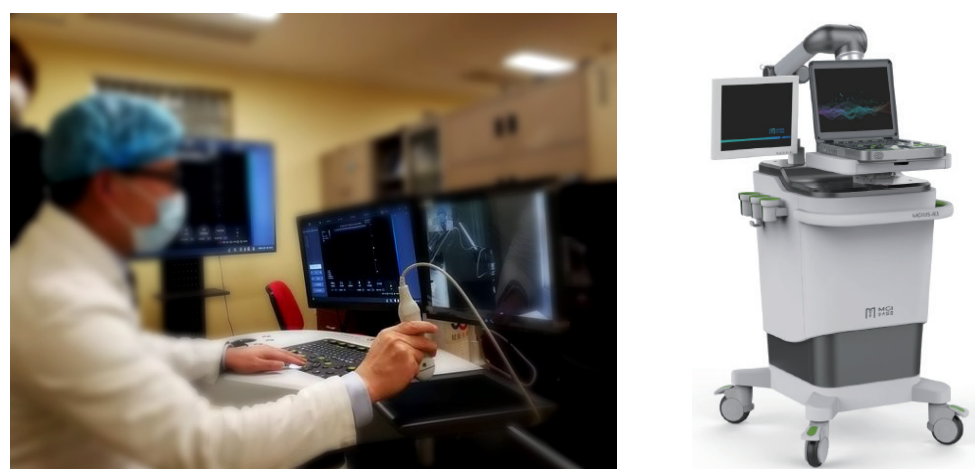


Figure 10: Remote B-scan

► 3.2.4 5G-enabled unmanned disinfection, delivery, and temperature checks to ensure secure supplies to affected areas

According to quarantine policies, the less human contact, the better. So how can we be sure that supplies are delivered securely and on time? 5G-enabled unmanned vehicles prove to be an excellent solution to help prevent and control the spread of the virus.

They can be used to spray disinfectants, perform medical tests, distribute supplies, and take temperatures through facial scanning. They can also work as broadcast stations in order to provide real-time news on COVID-19 prevention and control.

With the large bandwidths provided by 5G networks (with uplink rates up to 50 Mbit/s), the cameras on unmanned vehicles can upload live images of actual road conditions, making remote driving a reality. The ultra-low latency of 5G ensures that unmanned vehicles can avoid obstacles in real-time and operate any time of the day.

5G-powered unmanned vehicles can deliver medical and daily necessity supplies to isolated areas and masks to citizens. These vehicles can also reduce the possibility of human-to-human contact and minimize the risk of infection. They can make a significant contribution to the prevention and control of the pandemic.



An unmanned vehicle distributing supplies to a community in Wuhan



An unmanned vehicle delivering hot meals to Beijing Haidian Hospital



An unmanned vehicle delivering masks at the Bird's Nest in Beijing

In Wuhan's Leishenshan Hospital, unmanned vehicles are used to distribute medical instruments and equipment. The vehicles have a range of 100 km, meaning they can work for an entire day without needing to recharge, reducing instances of human-to-human contact and saving manpower.



An unmanned vehicle in the Leishenshan Hospital



An unmanned vehicle distributing supplies to wards in the Leishenshan Hospital

With built-in infrared sensors, robots can work continuously for hours to measure temperatures and disinfect high-risk environments, replacing medical workers and reducing their risk of infection.



A robot disinfecting a hall at Wuhan Union Hospital



A robot disinfecting a hall at Wuhan Union Hospital

5G and other digital infrastructure will continue to be further integrated into the healthcare industry long after the pandemic is over. While legal frameworks and regulations are still maturing, this kind of infrastructure will play an increasingly important role in helping people stay healthy and respond to public health events.

►► 3.3 Homes

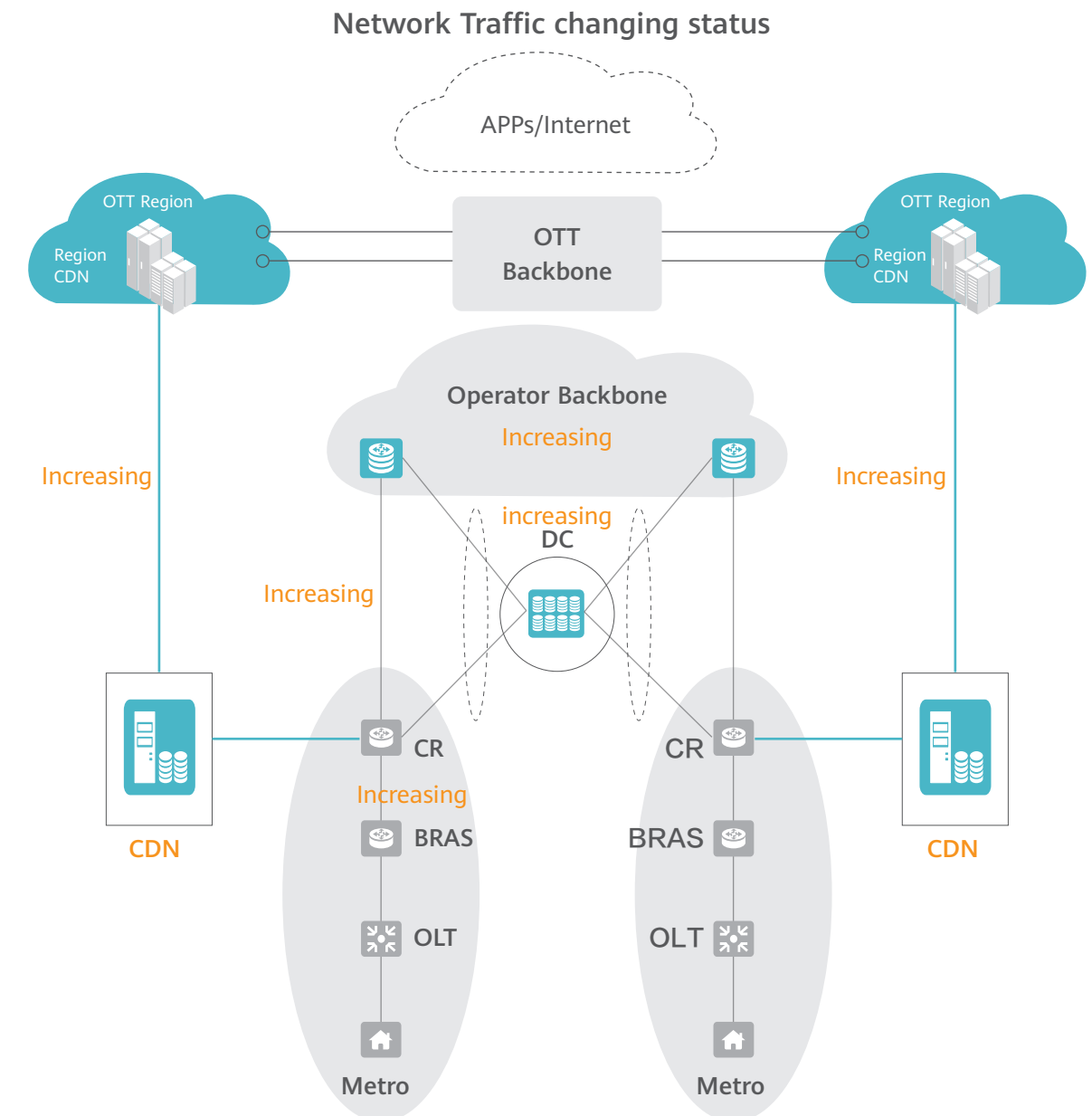
The pandemic has profoundly changed the way our society works. The most significant change is the social distancing which is keeping people at home and reducing travel. As a result, homes are becoming multi-functional. In addition to meeting routine needs, homes have also become classrooms, offices, places of entertainment, and even extensions of hospitals. These changes have redefined the function of the home while bringing more complex services that will profoundly and quickly change the traffic model of fixed networks.

► 3.3.1 During the outbreak, network traffic at home increased significantly. User experience is threatened.

The pandemic has resulted in a substantial change in many business models. Contactless services are emerging rapidly, and businesses are going online. This will continue to be the trend for a long time to come. This trend will change the traffic model of home networks.

(1) **Change 1:** The traffic generated by services like online education and telecommuting is mainly aggregated on metropolitan area networks (MANs), resulting in **data surges** in MANs. In one region in China, for example, traffic increased by more than 30% during the pandemic. In other densely populated regions, traffic increased by more than 100%. In March 2020, the network data switching volume across Italy increased by two thirds, and the total fixed network traffic nearly doubled.

(2) **Change 2:** Most Internet application services pass through content distribution networks (CDNs). As a result, the traffic generated by these networks is also seeing a sharp rise. In addition, traffic peak hours are extending and the intervals between peak hours and off-peak hours are decreasing significantly.

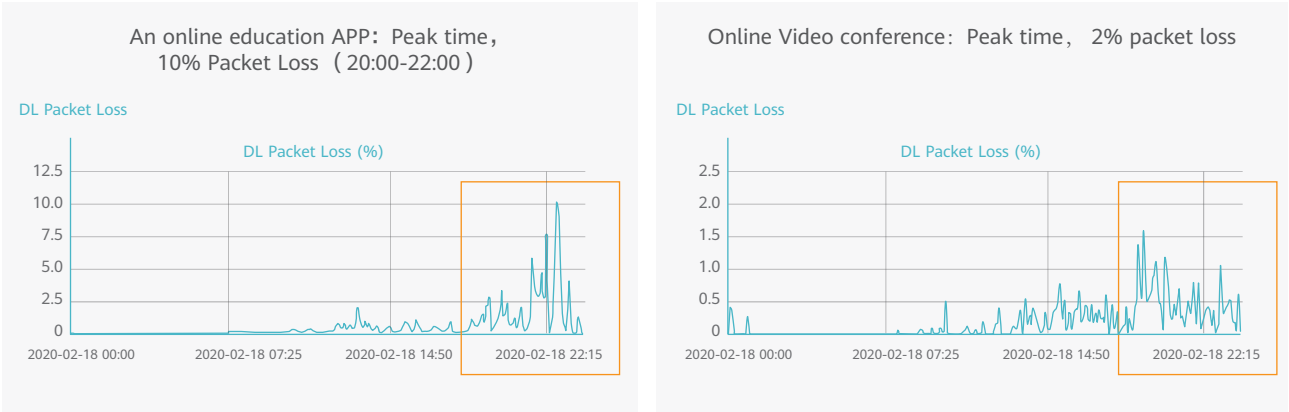


(3) **Change 3:** During the pandemic, home Wi-Fi networks have become the main bearer networks. In Europe, for example, the traffic generated by home Wi-Fi networks has increased by more than 80%, and an average of more than three devices are now concurrently connected to Wi-Fi networks in every home. These networks need to cover a wider area at home and remain active for a longer period of time. Home users are now spending more than 10 hours a day online.

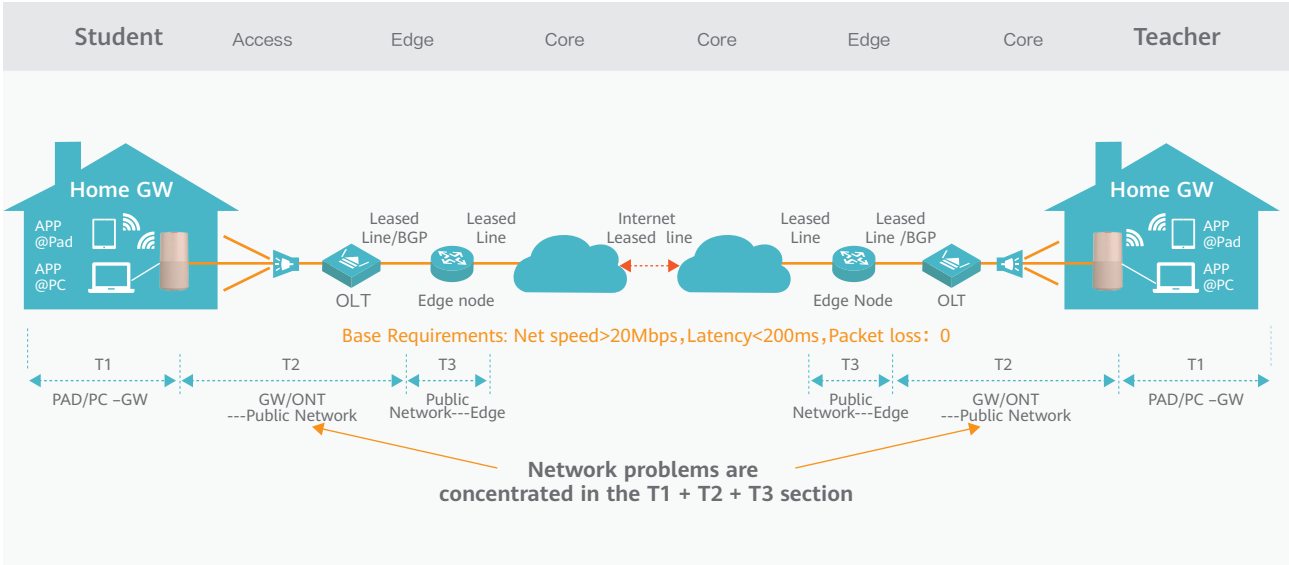


The surge in home network traffic has undermined user experience, especially in regions without access to FTTx. Users have raised very specific requirements for the SLAs of services like online education and telecommuting.

- In one city in China, the packet loss rate of an online education app reached nearly 10% during peak hours (from 20:00 to 22:00), greatly undermining user experience. This trend has also been seen in telecommuting applications. The packet loss rate of one video conferencing application, for example, was found to exceed 2% during peak hours.



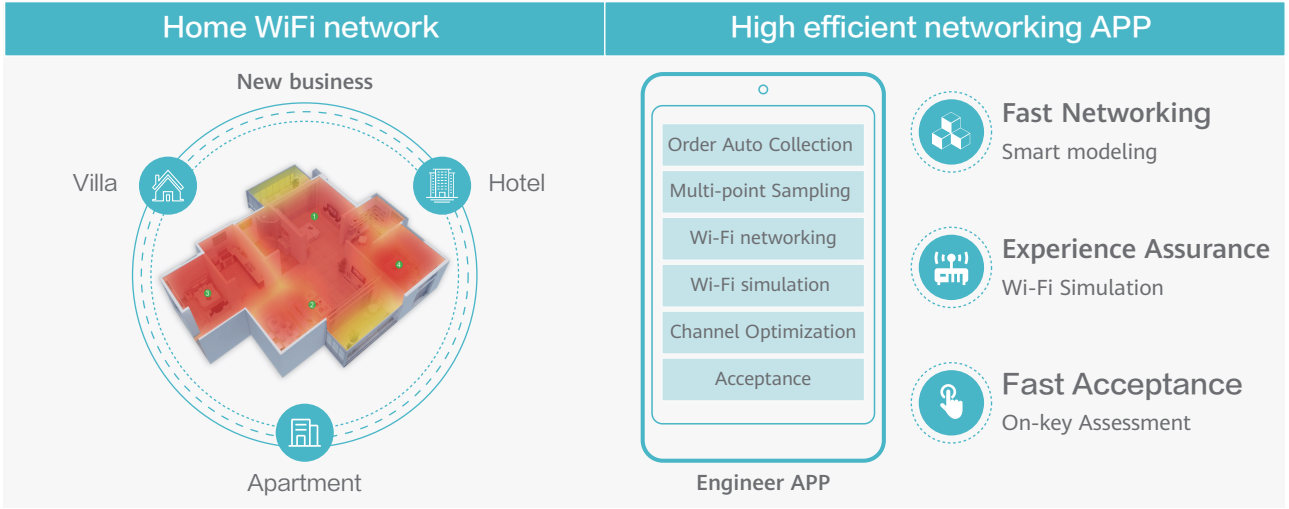
- During the pandemic, more than 70% of user complaints have been found to be related to home Wi-Fi, making it the weakest link. The main reasons behind these complaints include interference, limited coverage, and lack of SLAs for key services. According to an article published by the UK regulator Ofcom, microwave ovens can reduce Wi-Fi signals, so they recommend not using the microwave when users are making video calls, watching HD videos, or doing something important online. Cordless phones, baby monitors, halogen lamps, dimmer switches, stereos and computer speakers, and TVs and monitors can all affect Wi-Fi.



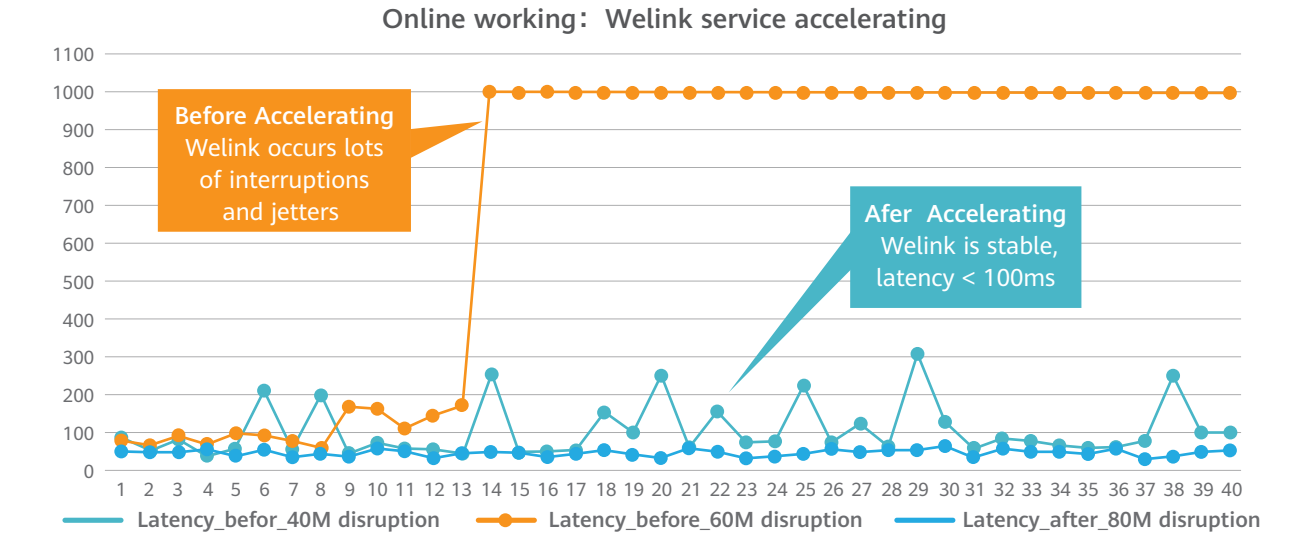
▶ 3.3.2 Operators are working with their partners to improve network quality and home service experience

- Deploying new technologies to improve user experience

(1) Improving home Wi-Fi network coverage: Due to poor Wi-Fi coverage, users have received a bad ultra-broadband service experience. In addition, operators do not have effective ways to maintain home Wi-Fi networks. To address these problems, Huawei has launched an innovative home network solution, which can work through any medium including Ethernet cables and wireless networks to remove connection barriers. The 1+N home network is built on Huawei's high-performance home gateways. Through intelligent synchronization and seamless roaming, every corner at home can be covered with 100 Mbit/s and 300 Mbit/s Wi-Fi networks. This solution helps operators improve user experience and operational efficiency.



(2) Huawei's technologies can also intelligently identify higher-priority services like VR, video, and gaming services to allocate them higher Wi-Fi speeds. With this, operators can provide dedicated channels for online education and gaming services, and guarantee higher QoS. This can ensure smooth operations for VR videos, live broadcast, and gaming without any freezes.



- (3) Huawei's solution can allow for the visualization of network topologies and Wi-Fi performance, making remote O&M a reality. Users can perform network detection and troubleshooting at home.
- Cloud-based O&M: Smart gateway and access point management, plug-in installation, home network topology visualization, Wi-Fi optimization, channel switching, and batch terminal operations
 - Installation and maintenance app-based O&M (SDK enabled): Remote access management for installation and maintenance app users, Wi-Fi quality evaluation, speed test, one-click Wi-Fi quality detection, Wi-Fi channel optimization, and Wi-Fi setting
 - Mobile app management (SDK enabled): Home network topology visualization, home network configuration, Wi-Fi strength mode selection, transmit power adjustment, blacklisted device management, protection against unauthorized access, and setting of guest networks
- Acceleration of home network speeds for free during the pandemic: China's three major operators have launched free network speed acceleration services in each province during the pandemic, and promoted these services for online education and telecommuting.

China Telecom	Zhejiang Mobile	Jiangxi Unicom
• 200Mbps Upgrade for free • Golden membership for 3 months • 6T family public cloud service 	• Fixed BB for education 200Mbps upgrade for free 	• 5G +IPTV for online education 

- Providing more applications for home users

Providing targeted video service packages: China Telecom is providing four free video/gaming apps for all users, which have been accessed a total of 3.74 billion times for a total of 4 billion hours. China Unicom is offering 10 data-free video games and 229,000 free data packages to users in Hubei. China Mobile's Migu Video live broadcast the construction of the Huoshenshan Hospital and Leishenshan Hospital over 5G networks, attracting more than 500 million views.

- Launching online education platforms: By the end of March 2020, China Telecom's cloud-based live classroom service had served 1.01 million students from 319 universities. China Unicom had provided 10 million free courses covering 47 million users. China Mobile's online distance education service has served 60.7 million people, providing a total of 104,700 classes.

►► 3.4 Enterprises

As countries around the world have launched different anti-pandemic policies and measures, such as the nationwide or municipal lockdowns, most companies have resorted to telecommuting. To meet these demands, operators and their industry partners have begun using technologies to help companies with telecommuting and resume production.

- Collaborative assurance for telecommuting

Operators go all in to support telecommuting

During the height of the initial outbreak in China, operators opened their "cloud conference" services for free to companies so that they could get their employees working and meeting online. By March 2020, the number of new users on China Telecom's e-Surfing Cloud conference had reached 858,000, and a total of 718,100 conferences had been convened; China Unicom's total registered users reached 104,000, and it had provided cloud video conference services to 15,900 companies and institutions; China Mobile's cloud videoconferencing system had covered 4.532 million users from 31,000 companies.

In Thailand, local telecom operators have promised to provide government agencies and SOEs with free Internet for three months and offer private companies network packages based on their bandwidth requirements.

Huawei's support

Huawei's telecommuting platform – WeLink – provides companies with a full range of services, including video conferencing, online timecards, online marketing, and cloud-based contract signing, supporting companies that are about to resume operations. To fight the pandemic, Huawei announced this smart work platform would be offered for free. Since then, the number of daily meetings and newly registered enterprise users on HUAWEI CLOUD's WeLink has increased by 100% and 50% respectively. During the Spring Festival, hundreds of thousands of companies started to use the platform, with millions of daily active users and 50-fold increase in service traffic.

Internet companies' support

During the pandemic, Internet companies have also actively expanded ICT infrastructure capabilities and provided more cloud hosts. For example, one Internet company deployed an additional 10,000 cloud servers within two hours.

- Operator and industry partnerships ensure companies can resume operations

Once the pandemic began to calm down in China, the resumption of economic activities became a top concern. As workers returned to their places of employment from where they were sheltered during lockdown, there would be a high risk of cross infection. Ensuring employee security would therefore become one of the biggest pain points for companies that were about to resume operations.

Operators in China have actively carried out IT-based infection prevention and control measures and launched multiple customized IT services, such as the thermal imaging system, cloud conferencing, and a "calling card" that shows the caller's information when you receive a phone call. The thermal imaging system has multiple advantages, as it is contactless, can be used over long distances and over large areas, and can quickly and accurately identify abnormal human body temperatures. The thermal imaging camera is used to measure the forehead temperature of workers returning to work, so that abnormal body temperatures can be quickly detected in a crowd, and security personnel can easily review personnel as they enter a campus or office. This system has already greatly reduced security workloads as businesses resume operations in China. It is not only faster than manual temperature checks, but it also reduces contact, which further lowers the risk of infection.



Operators in China have provided an innovative public service where users use an SMS message system to check the conditions of a travel destination up to 30 days before they depart. With this service, people can show their travel records when they return to their residences or workplaces.

An intelligent voice-based pandemic survey system has also been developed by HUAWEI CLOUD and Yizhi Intelligent Technology for operators. It identifies people at risk of infection, improving the efficiency and accuracy of pandemic surveys.

The intelligent voice-based pandemic survey system is mainly intended to be used in the following four scenarios:

- (1) Pandemic notifications: Point-to-point voice notifications of infection prevention and control information.
- (2) Local resident checks: Information collection services for government agencies, companies, and schools.
- (3) Travel record checks: Surveys of the health status of returned personnel that automatically generate statistic reports.
- (4) Patient tracking: Tracking services for symptomatic individuals.



» 04

Huawei's anti-COVID-19 practices

Before committing to helping others fight the pandemic, Huawei had to make sure its own employees were supported. At the beginning of the initial outbreak, Huawei took a series of measures to effectively ensure the health and safety of its employees. Using these measures as a foundation for further services, Huawei then answered to customer and government requests for pandemic relief around the world.

Currently, Huawei has fully resumed production in China, and restored supply to customers and partners worldwide. Currently, Huawei is doing all it can to help partners fight the pandemic and resume operations.

►► 4.1 Different policies at different stages

Since January 23 when the Wuhan lockdown was officially announced, Huawei has developed and implemented different anti-infection policies to address the ever-changing situation on the ground:

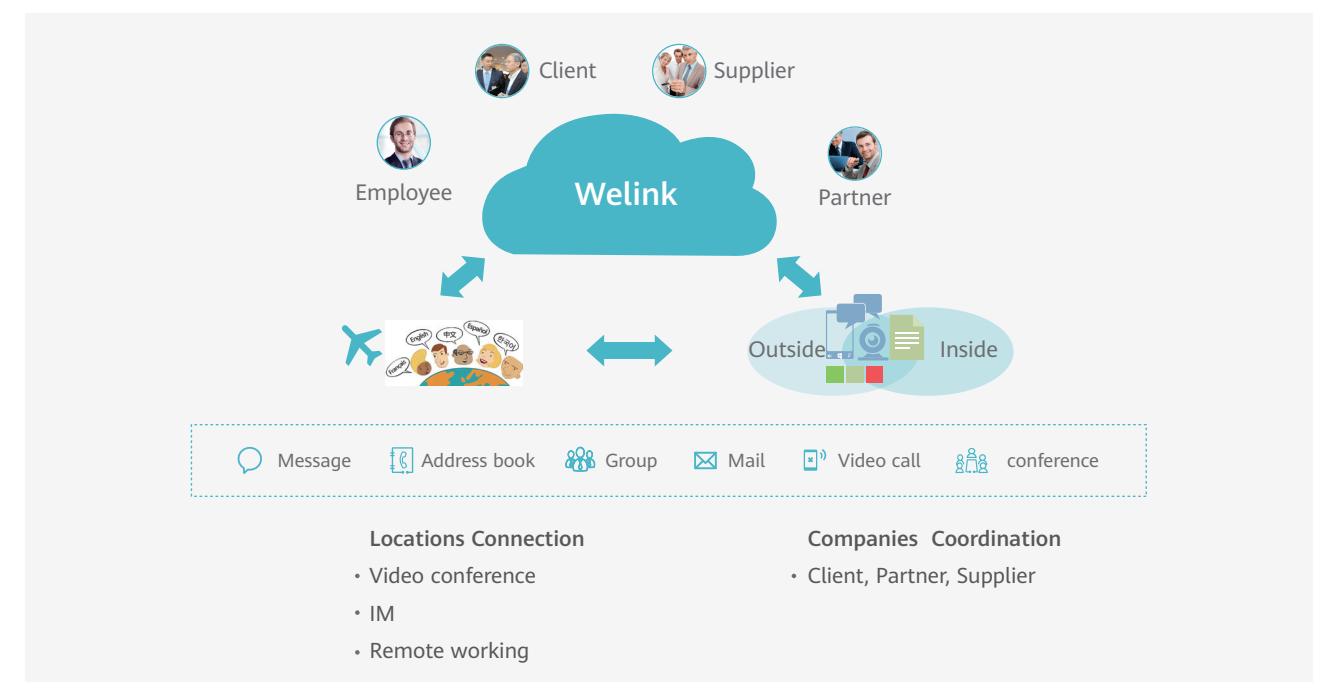
- Stage 1: During the Spring Festival holiday, as "each place was fighting its own battle", Huawei suspended all employee travel to and from Wuhan and began tracking and monitoring all employee travel.
- Stage 2: When the Chinese government postponed the official end of the Spring Festival holiday, Huawei required its employees around the world to check in online every day to log their health status. Employees were permitted to work from home and collaborate through WeLink.
- Stage 3: Once business began to formally resume operations, employees who were at risk of exposure to the virus were flagged and quarantined and on-campus viral transmission paths were reduced by issuing personal protection equipment, increasing indoor ventilation and sterilization procedures, and reducing employee contact and face-to-face communication.
- Stage 4: As infection rates began to rise outside China, Huawei has released a pandemic prevention solution package to implement in high-risk countries. Within China, Huawei began to optimize its risk-control measures based on local office situations.

►► 4.2 Uses digital resources to dynamically monitor the pandemic and proactively prevent and control risk

(1) Daily Health Checks: Huawei asks employees to clock in and report their health status through WeLink before 12:00 every day. The system checks employee health information and travel records to generate a list of employees requiring special attention. This information is sent to the Health Dashboard in real time.

(2) Health Dashboard: On this platform, Huawei identifies employees who are at risk of infection and limits their access to its campuses. On the dashboard, administrators can specify the criteria used for identifying at-risk employees and develop a **list of at-risk employees** that is updated daily. For in-house employees, the system categorizes them by their risk level and limits their access to Huawei campuses. For external personnel, including contract workers, logistics service suppliers, and visitors, they system checks and verifies their identity and health status before issuing a daily **admission pass or certificate**.

(3) Remote Communications: WeLink can be used to communicate and collaborate with personnel quarantined or unable to return to work. During the initial outbreak, WeLink was used to support real-time communication, teleconferencing, office collaboration, and cloud-based document management for Huawei employees around the world. This ensured their efficiency and output was not too significantly affected. During this time, WeLink has supported on average more than 10,000 meetings a day since January 25. On January 31 alone, more than 50,000 meetings were convened. On the first day after Huawei resumed operations, WeLink helped 190,000 Huawei employees host 40,000 video conferences and 10,000 cross-country conferences.



► 4.3 Digital campus: Campus management after resuming work

Huawei's campuses are spread across more than 170 countries and regions. To manage more than 4 million connected objects in these campuses, Huawei has connected 24 sub-systems of campuses and streamlined their data to establish a unified digital operation center worldwide. The Huawei smart campus solution lets the company build a fully connected digital campus with one set of ICT infrastructure, one digital enablement platform, and one intelligent operation center. During the COVID-19 outbreak, Huawei developed a pandemic prevention and management solution as seen in the picture below.

Huawei anti-pandemic solutions

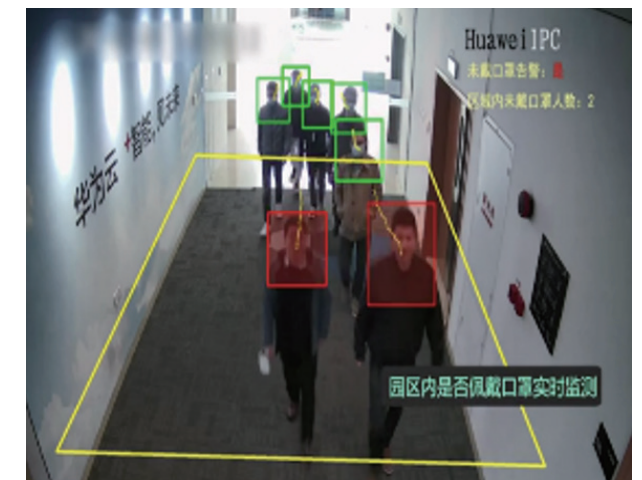
anti-pandemic APP

Body temperature detection	Check in control	Mask detection	Gathering detection	Check out detection
Health claim	Anti-pandemic knowledge	Online test	Welink	



The details of the solution are as follows:

- Monitor the campus comprehensively to mitigate risks. Specific measures include:
 - Lining up for inspection: Stay at least **1 meter** from each other when in line. Verify permission to enter the campus (employee ID card, text message, and permit). **Generate alarms for high-risk personnel.**
 - Body temperature check: Set checkpoints at the entrance and check people's temperature with a **contactless infrared thermometer**. Personnel with an abnormal temperature are not allowed to enter. Their information is to be recorded, and they will be asked to go home for further observation.
 - Abnormality alerts: Raise alarms for whenever an abnormality is detected, such as **personnel not wearing masks, campus gatherings, and off-duty key personnel.**



» 05

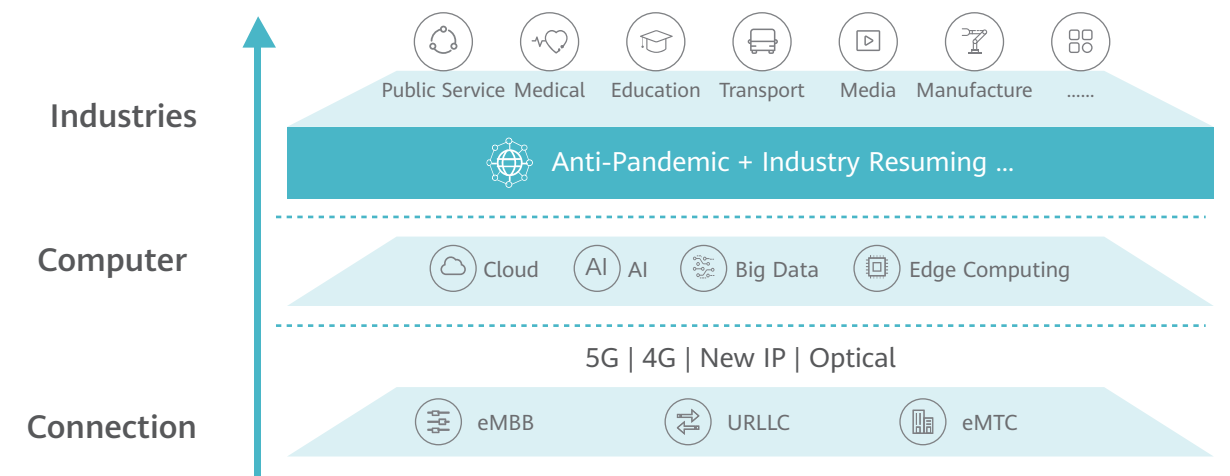
Implications and Outlook

We can draw on the current trend of this pandemic from the perspective of ICT infrastructure and make a few implications.

1. ICT infrastructure is the foundation of the digital world, and the digital technology supported by ICT infrastructure is the cornerstone to fighting the pandemic.

First, ICT infrastructure has played an important role in the fight against the pandemic. Digital technologies such as big data, AI, and cloud computing supported by ICT networks are crucial in monitoring and analyzing the pandemic, tracking the virus, preventing and controlling the pandemic, treating patients, and allocating resources. In addition to assisting the fight against the pandemic, these digital technologies have also been applied in other areas, such as helping businesses tackle their problems and safeguarding normal social activities.

Second, digital technologies supported by ICT infrastructure are helping social activities continue during the pandemic. One of the biggest characteristics of the pandemic is that it affects offline economic activities because of the measures such as "stay at home" and "social distancing". Massive amount of social and economic activities have gone online. Businesses closed their doors and students stayed home from school, but networks put people back to work and school, which leads to surging demand for online office and learning applications. The pandemic has suspended many offline activities, but people are living it up online. Taking China as an example, data from QuestMobile finds that daily network usage has gone from 5 billion hours to 5.76 billion hours since January 23. The number of daily active users and average daily network usage have both reached record highs.



2. Moderate redundancy is the key to network resilience and flexibility. Keeping a moderate level of network redundancy is still vital for addressing the traffic surge caused by the pandemic and is necessary for normal social activities.

The ongoing pandemic has been an unprecedented shock to ICT networks worldwide, whose traffic models have undergone significant changes as a result. The changes can be summarized as resulting in traffic surges, transferring hotspots, concurrent traffic spikes, and longer periods of heavy traffic. How these changes impact networks worldwide will not be discussed in detail, but China's networks have handled heavy traffic flow and remained stable. One reason is that China has been accelerating 5G deployment and has built the world's fastest 4G networks with widespread coverage. Another reason is that China has seen an FTTH penetration rate of over 90%, and more than 80% of Chinese households have residential broadband speeds of 100 Mbit/s.

Moderately advanced and redundant ICT infrastructure has ensured the stability of China's networks during the pandemic. This serves as a reference for other countries around the world to develop their ICT infrastructure solutions to cope with the pandemic.

3. Governments and regulators could help by developing policies and measures that facilitate rapid expansion and upgrading of ICT infrastructure. They should also implement necessary access policies, meet resource requirements, and put out incentive measures to ensure the deployment of ICT networks.

The pandemic is like a war and time is of the essence. Governments and regulators should proactively enact policies that facilitate the rapid deployment of ICT infrastructure. These policies may cover the following:

- Reserve and distribute temporary and emergent spectrums. For example, Gulf Cooperation Council (GCC) countries and the US have used temporary spectrum to meet the emergency requirements for network capacity during the pandemic.
- Reduce spectrum wholesale prices and issue more spectrum to encourage operators to quickly deploy networks with wider coverage.
- Implement policies to support site acquisition like encouraging co-constructing and sharing infrastructure, and allow operators to use more site resources.
- Temporarily lower taxes on ICT infrastructure during the pandemic.
- Positively guide the public opinion to help people gain a correct understanding of emerging technologies such as 5G and AI, and eliminate prejudices.

4. Global operators could benefit from evaluating the far-reaching impact of the pandemic and proactively plan and deploy network evolution in the future from a strategic perspective.

The pandemic is accelerating the digitization of thousands of industries. Its impact on networks also allows global operators to consider and plan future-oriented network evolution from a new perspective. We propose the following network evolution suggestions:

- **Ultra-broadband network:** Deploy 5G and gigabit optical networks for new connections and help establish the foundation for a connected, digital world. 5G and gigabit optical networks provide high-performance and widespread broadband services for individuals, families, and enterprises, and they support ubiquitous connections for everyone's work and personal lives. They also help in the digital transformation of traditional industries for a more robust digital economy.
- **Simplified network:** Simplifying network architecture, devices, and deployment can accelerate the expansion, upgrading, and deployment of networks such as 5G. We should learn from this coronavirus pandemic and improve the performance of the existing ICT infrastructure to address any possible future risks more effectively.

- **Intelligent network:** This pandemic has posed new requirements on network O&M efficiency and methods. Operators should apply new technologies such as AI in telecom networks. This can further improve the automation and intelligence of networks, bring intelligent troubleshooting and contactless O&M, and further accelerate the delivery of new services.

The warm spring is coming with longer daytime and blossoming flowers. The coronavirus pandemic is not over yet, but people have already begun to reflected on it. Huawei has always been in pursuit of excellent technological innovations as we believe that science and technology are the ladder of human progress, the key to overcoming difficulties, as well as the foundation of technological excellence. ICT technologies play a key role in our fight against the COVID-19 outbreak. The invisible light and electrical signals flowing through the cables above and below us have established a digital channel for saving lives and maintaining the basic operation of society as a whole. China's ICT infrastructure has become more advanced with the convergence of 5G networks, large-scale data centers, and other ICT technologies. We will continue to promote this advantage as much as possible to contribute to the wider economic development.

"With a backward glance at the windswept place, I carry on, in spite of wind, rain or shine." Huawei firmly believes that with the technological strengths of ICT networks, we will beat the pandemic, embrace a better future, and finally build a fully connected, intelligent world.

