5G Is Now
5G 已來

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Mobile networks are changing the way people communicate and access information. Network access at anytime and anywhere is transforming the telecom industry. In the near future, wireless network access will eventually prevail. 5G technology will enable flexible, reliable, and secure wireless networks to connect people with all applications, services, and things, thus leading human race into the era of "Everything on Mobile".

In the "Everything on Mobile" era, mobile networks must meet requirements more diverse than ever. These requirements can be identified from three dimensions: number of connections, latency, and throughput. These three dimensions together will bring unprecedented challenges to future 5G networks:

1. Number of connections. Although a 4G network provides thousands of connections for each cell, a 4G network cannot meet the connection needs of Everything on Mobile. A 5G network provides up to a million connections per square kilometer. This will bring an exponential increase in the number of connections.

2. Latency. The latency on a 4G network, 50 ms, is half of that of a 3G network. However, applications such as self-driving cars still require much lower latency than a 4G network.

3. Throughput. A higher throughput will better meet consumer needs. The throughput of a 4G network is 10 times higher than that of a 3G network, but once 4K video services become popular, the 4G network cannot meet the new throughput demands.

To meet the preceding requirements, 5G should have the following performance advantages over existing mobile communication technologies:

- 100 billion connections
- 1 ms latency
- 10 Gbps throughput

Based on the features of 5G networks and the development trend for Internet of Things, Huawei has identified some typical application scenarios during the process of 5G innovation as below:

今天的無線網絡正在改變人類溝通和訪問信息的方式，隨時隨地的網絡接入也在推動著電信產業的變革。在不遠的將來，無線接入將成為主要的接入方式。5G無線技術將通過一個靈活、可靠、安全的無線網絡把所有應用、服務、事物聯接到一起，使人類進入萬物移動互聯的時代。

在萬物移動互聯時代，移動網絡需要滿足前所未有的聯接需求。這些需求可從三個性能維度來區分：速率、時延和連接數。這三個維度上的新需求將給5G網絡帶來全新的挑戰：

1. 聯接數量。儘管4G能為每個小區提供幾千個聯接，但無法滿足全聯接世界裏萬物互聯的需要。5G條件下，每平方公里的聯接數將達到百萬個，這將是指數級增長。

2. 網絡時延。4G網絡的時延小於50毫秒，相當於3G網絡的一半。然而，自動駕駛等應用仍要求比4G網絡低得多的時延。

3. 速度。消費者對速度始終有著無限的需求。儘管4G比3G快10倍，但是，一旦VR等沉浸式體驗變成主流視頻規格，4G就無法滿足市場對視頻內容的需求。

基於上述需求和挑戰，5G與現有移動通信技術相比應該具有以下三個特徵：

- 千億級別的聯接數量
- 1毫秒的超低時延
- 10Gbps的通信速率

針對5G移動網絡具備的以上特徵，以及未來物聯網的發展趨勢，華為在5G的創新過程中總結了如下一些典型的應用場景：

千億級別的聯接數量
未來生活，個人資產全面聯網
隨著可穿戴設備的興起，未來將會有越來越多的日常生活用品被聯接到網絡。這些可穿戴設備將大大提升個人健康管理、

100 Billion Connections

Personal Assets on Mobile

As wearable devices gain popularity, an increasing number of wearable technologies will be connected to the network. Wearable devices will provide healthcare management, improve quality of life, and work efficiency. For example, ultra-light, ultra-thin, low energy-consumption, and waterproof sensors can be implanted into sportswear. These sensors will monitor the atmospheric pressure, temperature, humidity, and air quality of the external environment, and monitor a wearer's blood pressure, heart rate, temperature, breathing, and skin humidity. The sensors will send the collected data to a database through a network, where a life management system analyzes the data and sends real-time messages to wearers to avoid putting their health at risk. The life management system also helps the wearer adjust diet, sleep, and exercise.

Smart Logistics

The capability of massive connection provided by 5G will enable extremely meticulas management for the logistics industry in the future. Before every piece in a delivery leaves the consignhor, a passive RFID will be attached to it. Throughout the entire the process of delivery, these RFIDs will report in real time the detailed information of the current position and environment of the delivered pieces they are attached to, such as temperature and humidity, light intensity, purity of air, speed of movement, intensity of viberation. With such data reported, the carrier and its clients can easily grasp the current positions and status of all deliveries, based on which, the carrier and its clients can plan the activities to take after the delivery scientifically. Also, once any alarm of exception is reported, the carrier can take countermeasures immediately and precisely.

Intelligent Agriculture

Agriculture applications in the future will realize the importance of managing and fine-tuning rural works. Farms of the future will widely deploy a large number of soil quality sensors providing real-time data on the amount of fertility and humidity in the soil to precisely control fertilization and irrigation. Near the farm, sensors will be deployed to monitor the temperature, humidity, wind, and sunshine. In the river, sensors will be deployed to monitor water quality. Timely corrective measures can be implemented if the data indicates that the river is polluted. Farmers can monitor diseases, blood pressure, and body temperature, as well as the locations of their livestock by implanting sensors into the animals. The intelligent agricultural system consisting of various sensors will reduce cost, improve efficiency, and increase needs for narrowband connections.

1 ms Latency

Self-Driving Cars

If intelligent traffic management becomes a reality in future cities, more and more self-driving cars will appear on the road.

生活質量和工作效率。比如，運動服裝內將會植入若干超輕超薄、低能耗、防水的傳感器。這些傳感器將對穿戴者所處環境如氣壓、溫度、濕度、空氣質量及穿戴者自身健康指數如血壓、心律、體溫、呼吸、皮膚濕度等進行監控。傳感器收集到的所有數據都將通過移動網絡傳回個人生活數據庫，個人生活管理系統分析收集上來的信息實時提醒穿戴者避開有害健康的區域，指導穿戴者調整飲食、睡眠、運動量等。

智能物流

未來，將會是一個全聯接的世界。許多垂直行業將通過5G聯接到網絡。例如，未來的物流行業將在5G移動通信系統的海量連接能力的支撐下實現精細到每一件物品的端到端監控和管理。每一件物品離開工廠、電商、個人進入物流環節之前都會被貼上一個無源的無線ID標籤。這些標籤將通過5G網絡實時地向物流公司、寄出方以及收貨方彙報當前所處的位置和所處的環境（溫濕度、光照強度、空氣潔淨度、移動速度、震動強度等）。通過這些技術手段，承運商及其客戶可以輕鬆地通過各種終端實時地瞭解貨物當前所處的經緯度、高度和數量，以及運送過程有無出現意外；物流公司可以通過這些信息瞭解運輸執行情況，一旦發現異常，可以第一時間補救；客戶通過這些信息可以科學、準確地規劃物流後續的環節。

智能農業

5G在農業上的應用將使傳統農業實現極致的精細化管理。在未來的農場，土壤中可廣泛部署多種土壤質量傳感器，實時反饋土壤的養分含量、水分等數據，以精準控制澆灌和施肥設備；農場四周可以安裝溫度、濕度、風力、日照等傳感器；河流中可以安裝水質監控傳感器，一旦發現污染，可以及時治理；每頭牲畜或禽類體內可植入病毒檢測、血壓、體溫等傳感器，實施監控牲畜健康狀況，定位牲畜位置等……通過各種智能傳感器建立起來的智能農業系統將極大地降低管理成本，提升生產效率，同時也將給移動通信網絡帶來大量的窄頻連接需求。

1毫秒的超低時延

自動駕駛

未來城市實現交通管理智能化後，城市道路上將出現越來越多的無人駕駛汽車。由於道路交通事關人身安全，控制指令，尤其是制動指令抵達車輛的時間要求達到1毫秒的級別。現有4G網絡時延條件之下，時速100公里的汽車，從發現障礙到啟動制動系統仍需要移動1.4米。

5G網絡條件下，同樣時速的汽車從發現障礙到啟動制動系統需要移動的距離將縮短到2.8厘米，有望達到汽車ABS的水平。

To guarantee traffic safety, when a control command, braking for example, is sent to a car, the car must receive the command within 1 ms.

The latency of a 4G network cannot meet this requirement. With the latency of 4G network, a car driving at 100 km/h still moves 1.4 m from the time it finds a obstacle to the time when the braking command is executed.

Under the same condition, with the latency on a 5G network, the car will move just 2.8 cm, and this performance is comparable with the standard of an anti-lock braking system (ABS).

10 Gbps Throughput

Virtual Reality and Immersive Experience

Virtual reality and immersive experience bring dramatic changes to many industries, including gaming, education, virtual design, healthcare, and art. Take education for example. For students living in areas with limited educational resources, virtual reality technology enables instruction and interaction with teachers in a virtual classroom, and even enables them to perform tasks such as carrying out experiments in a virtual laboratory.

To make this come true, the resolution of virtual reality image and immersive video needs to approximate to the amount of detail the human retina can perceive. This requires that the throughput be 300 Mbps and above, almost 100 times higher than the current throughput supporting HD video services.

Cloud Storage

Smartphone users not only watch video, but also make videos of their own. When an interesting HD video clip is made, they hope the upload speed is fast enough to share it with others immediately. In the 5G era, the speed of cloud storage can be as fast as storing files locally. The uplink rate of a network will reach 1 Gbps, increasing the uplink rate of an existing network 100 fold.

The world of the near future will be a super-connected one, and the dreams of self-driving cars, remote surgery, virtual reality, and immersive experience will be realized. The next wave of the technological revolution will create a smart world. Join us to build a better interconnected world. ◼

10Gbps的通信速率

虛擬現實和沉浸式體驗

全新的虛擬現實和浸入式體驗將使包括遊戲、教育、藝術、甚至醫療等眾多行業產生天翻地覆的變化。比如在教育行業，教育資源缺乏的地區的學生們通過虛擬現實的幫助，可以身臨其境地在虛擬教室裏接受優質師資提供的講解並與老師互動，也可以在虛擬實驗室裏完成所有實驗室課程。

要達到這一點，我們要在移動環境下使虛擬現實和浸入式視頻的分辨率達到人眼的分辨率，這就要求網速達到300Mbps以上，幾乎是當前高清視頻體驗所需網速的100倍。

雲存儲

智能手機用戶在視頻領域正在由內容受眾逐漸轉變為內容製造者，每當他們拍攝到有價值的高清視頻時，希望可以在一瞬間上傳到雲上，與他人分享。在5G時代，移動網絡上傳速率可以實現本地讀寫的極致體驗，達到1Gbps。這比現有移動網絡上行速率提高了100倍。

未來世界是一個全聯接世界，無人駕駛汽車、遠程外科手術、虛擬現實和沉浸式體驗等革命性的應用和體驗都將在不遠的將來成為現實。新一輪工業革命將使未來世界變得非常智能，讓我們攜手合作，共建更美好的全聯接世界。 ◼