7. Typical Usage Scenarios of 5G

Based on the considerations on future market trends and user trends discussed in Chapter 3, this chapter first illustrates some examples of new usage scenarios, which are envisioned for 5G, and categorizes them into four facets; 1) Entertainment, 2) Transportation, 3) Industries/Verticals, and 4) Emergency and disaster relief.

Further analysis on the usage scenarios clarifies the list of required capabilities of individual usage scenarios. It finally provides key items of 5G capabilities for deriving overall 5G requirements in Chapter 8.

This chapter also gives an insight of "dynamic approach" into nature of 5G capabilities which may dynamically change corresponding to the wide variety of 5G usage scenarios.

7.1 Four representative typical usage scenarios

The feature of 5G capabilities is, among others, peak data rate of more than 10 Gbps, mobility of more than 500 km/h, latency of 1 ms, number of connected devices per cell of 10 thousand, capacity per unit area of 1000 times larger than that of 4G and furthermore significant reduction of power consumption. This section introduces 4 typical usage scenarios by using comprehensive illustrations (see Fig. 7.1-1) in order for readers to grasp a clear picture of 5G usage scenarios.

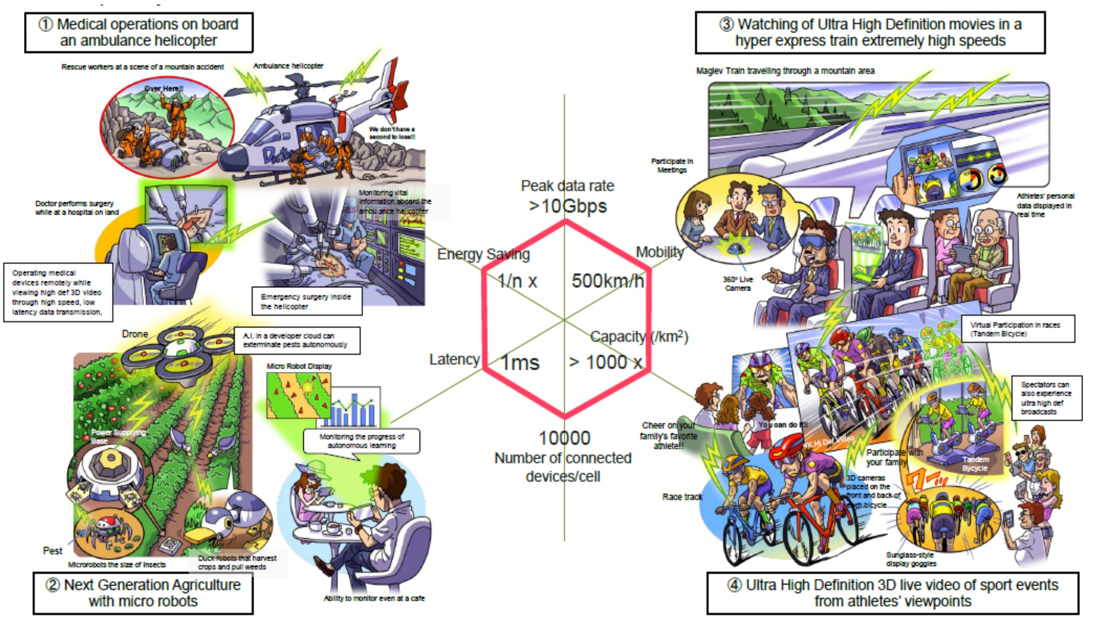

Fig. 7.1-1 5G capability

(1) Medical operations on board the ambulance helicopter

This usage scenario requires both higher peak data rata and low latency. It also assumes robust 5G communication link even in disaster areas.

(2) New generation smart agriculture by using micro robots

This usage scenario shows a 5G application to smart agriculture by using 5G's capability of low power consumption, enabling extremely longer time duration of data communication with extremely long life of battery.

(3) Watching of Ultra High Definition movies in a hyper express train at extremely high speed

This usage scenario indicates that 5G makes it possible that passengers in a hyper express train at extremely high speed can watch and enjoy ultra high definition movies.

(4) Enabling users' experience by Ultra high definition 3D live video of sport events from sport player's viewpoints

This usage scenario requires i) broadband live video uploads from sport event areas/courses, ii) massive video connections to audiences in a stadium, iii) low latency communication for audience/users to participate in virtual sport race.

7.2 Case studies of Typical Usage Scenarios

7.2.1 Entertainment

Fig. 7.2-1 Watching sports games

In this section, the usage scenarios that provide a person with unique and/or advanced experiences to enjoy leisure time when watching sports games in stadium, playing games and going for travels. It ranges from enhanced real experiences to fully virtualized experiences. Ultra-high definition moving pictures and high fidelity acoustics will be extensively utilized. Comfortable communication environment even in highly congested area will be provided and advanced technologies to allow smooth remote collaboration will be equipped.

Usage Scenario #1	Enhanced real experience entertainment (Shared experiences and virtual reality experience)
Overview	(1) Experience sharing scenario (a) Users watch 3D video of an event, for example a sporting event, from multiple viewpoints through cooperation with other fans by sharing their videos. Users are then able to watch the even from any viewpoint they wish. (b) Fans going to and leaving a stadium, for example at a soccer match, share information and experiences with other fans on the train by using their smartphones. For this purpose, a 5G system needs to support high data transmission so that many users, in this case soccer fans, in a single train car can simultaneously watch high definition video and/or exchange a huge amount of data. (c) High definition video communication while watching a soccer match at a sold-out soccer stadium (both upstream and downstream) (2) Simulated Experiences Scenario (a) An environment where users can always see exhibitions in crowded museums. (b) Family members discuss their plans while on a sightseeing trip using streaming arbitrary viewpoint video. Since the streaming video e provides arbitrary viewpoints, the family can view their sightseeing routes virtually from their desired angle. (c) While on a sightseeing drive, a traffic accident occurs at an upcoming intersection, resulting in a major traffic jam. An arbitrary viewpoint video and other related information from the accident location are distributed automatically. The family is able to download more video from different angles as well as other related information. They can consider viable alternative routes, taking advantage of this up-to-date information. (3) Virtual Reality Scenario (a) Outdoor real time gaming created by a virtually real visual sphere.

	In the scenarios (1)(a), (2) (a) to (c) and (3)(a), arbitrary viewpoint video is assumed to be a 5G application. Arbitrary viewpoint video is a video system which simultaneously transmit videos taken from multiple angle (typically 6 angles) which is combined on the terminal side so that users can enjoy seeing an object from an angle they like. The arbitrary viewpoint video enables; (i) Users to be able to see and confirm video from an arbitrary angle in real-time on their mobile terminals. (ii) Users to be able to see an object from an arbitrary angle in 3D space on their terminal, by being able to access multiple cameras which video-tape an object from a different angle. (iii) Therefore, users are able see an object from an angle that any camera operator would not be able to shoot in real time through processing video data from different mobile terminals over a 5G network. Enabling technologies such as AR/VR technologies, high precise time synchronization, and huge data synchronization technologies (several tens of msec precision for synchronization among video cameras, AR/VR display and game machines) will need several hundreds of msec of processing time to display video taken from multiple cameras as well as high speed data transmission at 60 Gbps from cameras to a BBU edge server. Video data distribution from the BBU to individual's terminals will have data rate of 6T bit/s maximum. Even with high efficiency video coding (HEDC), a transmission rate of 90 Mbps per angle is required for 5G radio networks. Driving on a highway, for example, will require a high throughput with high speed mobility. For example, 90 Mbps * 6 = 540 Mbps is required while moving with 100 km/h speed. On the other hand, in the use case of a traffic accident occurring at an intersection which results in a traffic jam, communications data will be transmitted under stationary or near stationary conditions. In this case, arbitrary viewpoint video will be

transmitted to many vehicles, resulting in dense data traffic. Assuming that the width of a car lane is 3.5 m, the length of a vehicle is 5 m, and the distance between vehicles is 3 m, arbitrary viewpoint video traffic is estimated to be 540 Mbps / (3.5 m * 8 m) = 19 Mbps/m^2. If one out of every two vehicles uses arbitrary viewpoint video simultaneously, traffic density will be 9.6 Mbps/m^2.

In the scenario (1)(b) above, the following radio capabilities will be required on a train:

- Peak user throughput of 1Gbps for high speed broadband communications;
- User mobility of 100km/h for providing stable communication;
- Several thousand efficient user connections for broadband communications;
- Capability to support simultaneous handover at a same timing for several thousands of users or alternative equivalent technology scheme/capability without a handover;
- Cost-efficient highly flexible traffic control beyond "best effort service";
- Average user data rates of 2 Mbps for each user on a single train. This means that, assuming that there are 1000 passengers per train car, trains running with 1.6km of spacing between them and a rail width of 10 m, 2 Mbps x 1000/ (0.01 km x 1.6 km) = 125 Gbps/km^2 will be necessary.

In the scenario (1)(c) above, the following radio capabilities are required:

(i) Peak user throughput 1Gbps for high speed broadband communications;
(ii) Stable radio communication at a low mobility of several km/h;
(iii) Provision of several thousands of efficient connections for broadband communication users;
(iv) Provision of random handover by several thousands of

	users; (v) Cost-effective flexible traffic control capability beyond traditional "best effort service"; (vi) Average user throughput of 2Mbps in a stadium. This means assuming stadium bench seats 1m wide and 0.5m depth, one 5G mobile user per every 10 people in attendance, the user density at the stadium is1 user/ (0.0005 km x 0.0011km). Therefore, 2Mbps x 1000 user/ (0.01km x 1km) x 1/4 = 400 Gbps/km will be required.	
Required capabilities	Peak data rate	X
	User experienced data rate	X
	Latency	
	Mobility	X
	Connection density	X
	Energy efficiency	
	Spectrum efficiency	X
	Area traffic capacity	X
	Others	

Usage Scenario #2	Dynamic Hot-Spot services
Overview	● User Scenes (examples): Size of data and voice traffic change dramatically in dynamic ways as population density rises and falls in one location on a single day. - Stadium attendance (Olympic games, football matches, etc.) - Concert attendance, fireworks viewing, festival goers ☐In the above cases related to entertainment, a specific location is crowded with people only during the event itself with almost nobody there on other days. In these hot spots, people enjoy uploading videos they have taken to be able to show their families at home and downloading message/music data or other audio/visual information. For example, Nx1,000 or Nx10,000 devices may be activated

	simultaneously with a high data rates (e.g.10M to 100Mbps/device) in a stadium or an outdoor ground only while an event is occurring. - Disaster refugees going back home, a sudden rush of people into or out of a station, and emergency calls in disaster scenes. □Dynamic hot spots will occur in the same way as the entertainment use scenes above, but only during an emergency situation after a disaster occurs. ● Shortage of the existing general network: - A solid network structure is used regardless of the user service or application type having diverse natures in network. - Solid transport routes are arranged in a fixed network structure, and specific functionalities are allocated to each physical server. - Network composition resources and the power activation rate are solidly fixed. ● Challenge: - Extreme scalable capability by the network Management & Orchestration driven scalable network. - Much large scale of dynamic range will be required in some transmission capabilities of 5G network. - Control of the life-management of network slices matched with services. - Depending on the targeted service traffic or condition of transmission lines, traffic is dynamically controlled by software at the slice level, including VNF elements structure, transport topology, E2E transmission line, and transmission bandwidth. - Infrastructure resources of mobile networks are logically scheduled for the use in timely manner at appropriate situations. In the case of idle situations, resources can be used for other networks or pooled to prepare for re-use. This type of resource management contributes to reduction of

	CAPEX and OPEX. ● View points - Scalable network with dynamic flexibility. - Connectivity of devices spreading in both low density and ultra-high density environments. - Network architecture with reliable connectivity and high quality service provision, even in high density environments created by a temporary or specific localized situation with a huge number of connections and a large amount of traffic on the network. - Efficient utilization of surplus network and power resources under low data or voice traffic conditions.	
Required capabilities	Peak data rate	
	User experienced data rate	X
	Latency	
	Mobility	
	Connection density	X
	Energy efficiency	
	Spectrum efficiency	
	Area traffic capacity	X
	Others	Dynamic Flexibility

Usage Scenario #3	A large marathon
Overview	● A big marathon race held in a city has many sensors placed at every main intersection. In order to meet the environment conditions for holding the race, the city government collects information related to atmospheric pollution levels from the sensors through massive connection techniques. Some runners wear a runner' view cameras, and upload the high-definition video from the camera while running thanks to ultra-high speed data transmission techniques. After the marathon, runners can watch the high-definition video with their family or friends. Many people can watch the race with

	their smart phones even while along the roadside. The city also allocates many high-definition video cameras to the roadside, and delivers the video from these cameras to the marathon spectators in real-time. Thanks to the runners' positioning estimation techniques, spectator can choose to watch an individual runner. The enhancement of wireless communication technologies contributes many new, diverse ways to make a marathon more enjoyable and exciting. ● Another important point for organizers of a large marathon is taking care of the health of the runners. Even in a race with more than 30,000 participants can have their runners wear sensors to collect their vital data (e.g., heart rate) by massive connection techniques to be able to check their health in real time. If something happens to a runner's health and well-being during the race, a medical institution in the area will be immediately notified with the necessary information thanks to new access techniques without the need for scheduling to be granted. And, the information from high-definition cameras allocated to the roadside that were focused on that particular runner will be provided to the medical institution to support their diagnosis and care for him or her. ● And, after the marathon finishes, collected information from the sensors equipped by the runner can be structured as big data to assist and advance industries such as health care and sports equipment.	
Required capabilities	Peak data rate	X
	User experienced data rate	
	Latency	X
	Mobility	
	Connection density	X
	Energy efficiency	
	Spectrum efficiency	
	Area traffic capacity	X
	Others	

Usage Scenario #4	A trip on the shinkansen high speed train	
Overview	● A large number of passengers on a *shinkansen* train enjoy entertainment services, such as real time competitive games and watching live-streams with their smart phones or tablets ● Passengers are able to watch a smooth moving picture and are content with the quality despite being on a high speed train. ● Reduce power consumption of base stations and terminals respectively. ● Technology for high capacity, adaptive beamforming and group mobility are necessary. ● Similar cases include: - Cars on the highway (Especially a bus where a large number of passengers are in movement simultaneously) - Ships - Airplanes (when use of terminals is allowed even during in takeoff and landing)	
Required capabilities	Peak data rate	
	User experienced data rate	X
	Latency	
	Mobility	X
	Connection density	X
	Energy efficiency	X
	Spectrum efficiency	
	Area traffic capacity	X
	Others	

Usage Scenario #5	Content downloads by commuters
Overview	● A user can instantaneously download large-volume files when the user touches their mobile device to am HRCP (high-rate close proximity) access point, for example an

	automatic ticket gate. An example scenario: When the transmission rate is 2 Gbit/s, downloading time for a 30-minute 50 MB video file will be 220 msec. - Mitigates wireless traffic loads in 5G mobile networks, by downloading large-volume files at the HRCP access point. - Reduces power consumption on the mobile device, because wireless communication is not required while playing video, unlike streaming usage. ● Required technologies include: (1) high-rate multi-Gbit/s wireless transmission, (2) device management function that turns on the wireless module only during downloading, and (3) cache mechanisms for delivering the content file to the HRCP access point where the download will occur. - Radio access technologies using unlicensed bands will be employed for (1). - To realize (2) and (3), new management/control functions that interoperate with 5G mobile networks are needed.	
Required capabilities	Peak data rate	X
	User experienced data rate	X
	Latency	
	Mobility	
	Connection density	
	Energy efficiency	X
	Spectrum efficiency	
	Area traffic capacity	
	Others	

Fig. 7.2-2 Communications during the rush hour commute

Usage Scenario #6	Communications during the rush hour commute		
Overview	● In the Tokyo metropolitan area, the number of people commuting to work or school is increasing slowly, including 5.5 million railway passengers a day. These railway passengers when going through a terminal station create especially huge communication traffic. Shinjuku station, the largest terminal station in the Tokyo metropolitan area, has eleven railway lines and a train arrives for each line every two minutes during peak rush hour. Assuming 90% of the "accumulating passengers" use cellular phones, the number of phones exceeds 25,900. "Accumulating passengers" consist of (1) passengers getting on/off, (2) passengers staying on the train, and (3) people coming into/going off the station. ● Considering the area of Shinjuku station as 200m X 500m, the density of cellular terminals is 259,000 UE/km^2, and assuming user data rate in 2020 as 20Mbps, the communication traffic per km^2 reaches 5.18 Tbps/km^2.		
Required capabilities		Peak data rate	
		User experienced data rate	
		Latency	
		Mobility	
		Connection density	X
		Energy efficiency	
		Spectrum efficiency	
		Area traffic capacity	X
		Others	

7.2.2 Transportation

In this section, the user scenarios that provide comfortable experiences through advanced methods of transportation ranging from automobiles to high-speed magnetic levitated trains. It includes, for example, autonomous vehicles that are able to drive themselves without any intervention by a human at all, driver assisting services that provide comfortable rides by avoiding traffic jams or other obstacles, and computer-aided management of crowds during popular events. Novel intelligent mechanisms based on the combination of tremendous amount of data from advanced sensing technology and emerging artificial intelligence methodologies will greatly enhance conventional expectations.

Usage Scenario #7	Smart automobiles (driver assistance system)	
Overview	This system provides automobile collision avoidance at intersections with bad visibility. To monitor cars, bicycles, and people that are entering an intersection in real time, video cameras are placed at the intersection, and image processes are carried out with a low-latency application server which is placed at a base band unit. When intersection ingresses are detected, a detection result is created, consisting of an alarm and a video, and it is transmitted to automobiles through low-latency 5G networks. The automobiles that received the detection result automatically slow down while the alarm and the video are displayed on monitors. Also, this system predicts intersection ingresses by gathering traffic information from neighboring intersections.	
Required capabilities	Peak data rate	
	User experienced data rate	X
	Latency	X
	Mobility	X
	Connection density	
	Energy efficiency	
	Spectrum efficiency	
	Area traffic capacity	
	Others	

Usage Scenario #8	Behavior support in city
Overview	A large amount of environmental data is obtained from massive sensors installed in a city and user devices and is sent to edge servers and/or cloud servers. The data is then used for real-time human behavior support in shared audience use-scenes such as street/public space congestion and outdoor street events, as well as providing information tailored to the characteristics of an individual user, such as disability, age, and possession of luggage. For example: - An overview of the current situation in many places. At first, collecting data while using the network infrastructure of the system necessary to society, for example as a crime prevention system. This data can then be analyzed and used to support people's day to day lives by providing traffic information and people flow information, using color-displayed cars or a people density map. This information will reduce confusion during or after an event by indicating areas with less people in the event of a marathon, an *ekiden* relay race, or a fireworks display. - Provide information related to event venues in public places (citizen's marathon, a parade, etc.) through users' smart phones with a high image quality to provide highly realistic details. To ensuring privacy, the display can be changed to show people and vehicles or just show the people- or vehicle-density on the map stored only on the edge servers. - During a disaster, immediately provide safe evacuation routes tailored to individual user needs (e.g. their home location, physical fitness, possessions, clothes). To lessen the spread of confusion in the event of a disaster, provide general information on street, traffic and communication tools to the affected areas in an easy-to-understand form such as color-displayed density maps of cars or people by processing in edge servers. - Wheelchair driving support for walking disabilities.

	Characteristics of people with disabilities are diverse and building a uniform and general automatic operation and navigation system is difficult. Even when considering the roads a disabled user might want to use must consider issues such as the shortest route may not be selected if the route has an uneven road and the user has less muscular strength and less endurance than is necessary to use that route. In cloud servers, environmental data that the individual has collected is sent and shared to develop a database. In the edge servers, current (real-time) environmental data is collected. Finally, in order to provide information tailored to each person's behavior individual demographic data, physical fitness and judgment ability, is given to navigation and drive actuators (i.e., wheelchairs). Having an actuator drive work with minimum delay from when an event occurs is also effective to lessen risk. For example, in order to watch a street-event with a high-quality high-realistic sensation on a users' smart phone in a remote area, the network system is requested to have high-speed performance, with a peak-data-rate of 40 Gbit/s when transferring data from the street-side smart phones and fixed cameras to an edge server in BBU.

Required capabilities	Peak data rate	X
	User experienced data rate	
	Latency	X
	Mobility	X
	Connection density	X
	Energy efficiency	
	Spectrum efficiency	
	Area traffic capacity	X
	Others	

7.2.3 Industries/Verticals

Fig. 7.2-3 Remote control of agricultural machines

In this section, the usage scenarios described provide novel methods to enhance conventional ones used in verticals, such as manufacturing and agriculture. They will create additional value, by improving productivity, create new business models and new customer values. Applications of sensor networks, big data analysis, and low latency feedback for prompt actuation will develop new uses for robots, drones, instruments and machinery.

Usage Scenario #9	Robot Control
Overview	An environment with many robots moving about in an urban area, including transportation robots for delivery services, small passenger robots to ensure safe movement of people such as the elderly, children and those who are visually handicapped and unmanned aircrafts (drones) for emergency transportation of medical equipment and from the sky. These robots will move slowly (maximum 30km/h) in a wide range of areas including sidewalks with many pedestrians, roadways with many cars driving, and in the sky above them. In addition, these robots may change their positions if an area is crowded. When trouble or an accident occurs, an operator may control individual robots remotely, send an emergency avoidance operation instruction to robots in a specified area, or may request support for a robot that is having trouble. Examples of the use of 5G networks in this scenario include: - If a high resolution movie from a robot's camera is transmitted uncompressed for low latency in an emergency

	situation, the peak data rate required will be over 1Gbps. - A robot moves around 8cm per 10ms at 30km/h. If the distance between robots is reduced to about 30cm, communications with ultra-low delay in the order of msec will be required for safe and continuous movement of robots in the case of unexpected accidents. - In a normal situation use-case, it is assumed that the density of robots in a region of 100m^2, such as at an intersection, is one robot per 1m^2. When each robot generates an average 2Mbps traffic, the total traffic in the area is 2Mbps x 100robots / (0.01km x 0.01km) = 2Tbps/km^2. Although this area is small, the density of the traffic causes a high load in and around this area. Another assumption can be that there is an average 20 robots at each intersection of a 90m grid road based on the Manhattan model. When each robot creates 1Gbps traffic, the total traffic in this area is 1Gbps x 20robots / (0.09km x 0.09km) = 2.4Tbps/km^2. This traffic also causes a high load. - High speed unmanned aircraft will require stable, always-on communication connections over 1Gbps with an unterminated handover. The above robot use-case scenarios will be realized with other user's traffic. A 5G network system is required to satisfy the above requirements.

Required capabilities	Peak data rate	X
	User experienced data rate	
	Latency	X
	Mobility	X
	Connection density	X
	Energy efficiency	
	Spectrum efficiency	
	Area traffic capacity	X
	Others	Group Mobility

Usage Scenario #10	Smart agriculture
Overview	Automated/autonomous driving/operations of agricultural machines, e.g. tractors and harvesting machines ● Remote control of agricultural machines, such as tractors. Remote control of tractors, soil cultivators, planters and/or harvesting machines without on-board operations/controls. The machines can be controlled both in close proximity of several tens of meters to as far away as several hundred kilometers. ● Remote monitoring and control by human, compared with fully autonomous driving of agricultural machines, requires low-latency or no codec, i.e. no information source coding. Therefore, large data rate requirements for transmitting monitoring video become necessary. Coding schemes, such as HEVC (high efficiency video coding), cannot be used due to its large coding latency. ● Remote control or autonomous driving of agricultural machines means an on-board human driver/operator is no longer required. This allows for high speed operation/driving of agricultural machines, as no human operator/drivers are onboard, removing the need of low speed operation/driving to ensure the safety of those operating the machines. This will further improve efficiency of agriculture work, since the rapid operation/driving of agricultural machines will reduce the overall operating/driving time while working. In this case, communication latency should be as low as possible. [IT agriculture] ● Agriculture work does not always require low latency is not always required. The ability to sustain massive connections, however, would be required. The machinery at a typical agricultural operation might include a water pump that would provide water to agricultural fields, a drainage water pump, an on/off machine of sprinkling water machine, an

<table>
<tr><td></td><td colspan="2">electric fan to prevent frost for farm products. Overall, there would be many devices that could be connected to a network.
● IT-led agriculture would require a periodical data collection system to collect small size data from water temperature sensors, anemometers, air temperature sensors, humidity sensors, daylight sensors, and soil humidity sensors.
● Big data collected from sensors would then be shared by a regional entity such as JA (Japan Agricultural cooperatives)
● Big data would also be processed at the point where the data is gathered and merged, e.g. averaging the data, eliminating abnormal values.
Big data collected from the fields would also be used and shared by local agricultural experimental centers for species breeding.</td></tr>
<tr><td rowspan="9">Required capabilities</td><td>Peak data rate</td><td></td></tr>
<tr><td>User experienced data rate</td><td></td></tr>
<tr><td>Latency</td><td>X</td></tr>
<tr><td>Mobility</td><td>X</td></tr>
<tr><td>Connection density</td><td></td></tr>
<tr><td>Energy efficiency</td><td></td></tr>
<tr><td>Spectrum efficiency</td><td>X</td></tr>
<tr><td>Area traffic capacity</td><td></td></tr>
<tr><td>Others</td><td></td></tr>
</table>

7.2.4 Countermeasures in emergency and disaster situations

Fig. 7.2-4 Enhanced Emergency call

In this section, the usage scenarios that provide countermeasures against emergency situations such as traffic accidents and sudden illnesses, or disaster situations caused by earthquakes, floods, fires and typhoons. These countermeasures are intended to support initial responses, confirming the safety of victims, providing evacuation guidance and assisting in rescue attempts.

<table>
<tr><td>Usage Scenario #11</td><td colspan="2">Anti-Crime System with Image Recognition</td></tr>
<tr><td>Overview</td><td colspan="2">Performs criminal searches and tracking based on videos /images captured by surveillance cameras or mobile phones carried by civilians while reporting to the police and contacting the families of the victims immediately.
Collects video information related to a location when having received a warning notification from a GPS-enabled anti-crime mobile phone, and determines presence or absence of any suspicious activity. If suspicious activity is confirmed the results of analysis are sent to the Cloud to notify the police.
Links to the location/time information and video information are confirmed using GPS and are combined with image recognition features to enable a better understanding of the presence or absence of suspicious activity and the situation at the time in detail.
The Network system requirements will include a real-time requirement (latency) of several hundred milliseconds from the time of notification from mobile phones or surveillance cameras and the detection of suspicious activity at an edge server to the report to the police terminal, and high-speed performance (Peak Data Rate) to transmit data from camera/mobile phones to the BBU edge server at 4Gbit/s at regular times and 5Gbit/s at the peak time.</td></tr>
<tr><td rowspan="7">Required capabilities</td><td>Peak data rate</td><td>X</td></tr>
<tr><td>User experienced data rate</td><td></td></tr>
<tr><td>Latency</td><td>X</td></tr>
<tr><td>Mobility</td><td>X</td></tr>
<tr><td>Connection density</td><td>X</td></tr>
<tr><td>Energy efficiency</td><td></td></tr>
<tr><td>Spectrum efficiency</td><td></td></tr>
</table>

	Area traffic capacity	X
	Others	

Usage Scenario #12	Enhanced Emergency Call, Large Scale Disaster Rescue Network	
Overview	● Enhanced Emergency Call - Emergency calls to perform an automatic call originating with or without the consciousness of the injured person; - Supporting ambulances equipped with remote high quality, low latency video transmission communication to operate effectively; - The ambulance delivers the patient's vital data to a medical institution, including a high-definition video image, en route to the institution. ● Securing of traffic accident data - A rapid data uploading from the drive recorder as injured person rescuing supplement information at the scene of the traffic accident or as evidence information of the accident decision in court.	
Required capabilities	Peak data rate	X
	User experienced data rate	
	Latency	X
	Mobility	X
	Connection density	X
	Energy efficiency	
	Spectrum efficiency	X
	Area traffic capacity	X
	Others	Reliability

Usage Scenario #13	Emergency Calls for Earthquake/Tsunami
Overview	● Mobile networks will handle multiple originating calls to confirm people's safety or to facilitate urgent communications after an earthquake; ● Mobile networks will send specific warning information for a

	tsunami as well as specific evacuation course instructions to individuals; ● Setup of the substitute facilities for communication lines which will be damaged by a large-scale disaster and providing access to IP networks; ● High reliability / high quality / low latency communication systems for required rescue operations and remote medical operations; ● Automatic driving functions control abandoned cars left on a side of a road to assist in unmanned evacuation measures; ● High reliability / high resolution video / low latency communication systems to control unmanned remote robot heavy industrial machines to assist in road clearing to secure access to disaster areas by emergency teams; ● Triage information and communication systems for monitoring disease outbreaks among victims in relief camps; ● High reliable / high resolution video / low latency / Highway mobile communication systems connecting medical helicopters and medical institutions in order transfer information on seriously injured patients being brought to the institution; ● Establishment of communication systems to assist in the second and third stages of relief assistance, such as safety and location confirmation of refugees relief; ● Information and communication systems to support disaster relief headquarters, such as providing high definition video.	
Required capabilities	Peak data rate	X
	User experienced data rate	
	Latency	X
	Mobility	X
	Connection density	X
	Energy efficiency	
	Spectrum efficiency	X
	Area traffic capacity	X
	Others	Reliability

7.3 Dynamic approach

- Not all 5G requirements are necessary to be simultaneously met in providing 5G services.
- From an economic viewpoint, 5G capabilities need to adapt to the wide and dynamic variations of 5G requirements for a particular time, space and situation, since required 5G capabilities in providing a service are dependent on each particular use case, the requirements of which differ from each other.
- 5G networks also need to be dynamically optimized to meet the dynamic variation of 5G requirements.
- A heterogeneous network is a promising approach for this optimization which will allow a 5G network to have the ability to systematically work together in different RATs, including new 5G RAT(s), which have different capabilities.
- Adaptive virtualizations, network slicing, and softwarization are crucial key factors to realize flexibility of end-to-end networks, as diverse services emerge with a wide range of traffic variation

Dynamic Approach	Dynamic adaptation of 5G networks to the dynamic variations of 5G use scenes. Behavior of a football fans while watching a match at a big stadium
Overview	● The usage scene describes one in which many fans arriving and leaving a stadium share information or experiences they have with each other by watching high-definition video over their smart phones ● In this scene, the following features are observed from a viewpoint of radio access networks and fixed networks; 1. 【Variation in time】Communication traffic rapidly increases in the few hours before the match begins until a few hours after the match is completed. This phenomenon is related to the movement of people. In addition, this communication traffic depends on the amount of time those people to arrive at the stadium from their home as well as the applications they use en route. For example, on the train car on their way to the stadium fans may exchange e-mails and Short Message

	Service (SMS) texts with each other. They also may access the web in order to get information regarding their favorite football teams and players on the way to the stadium while on their way back from the stadium they may enjoy watching replay videos of most exciting scenes in the soccer match, even sending video clips over the smart phones, for example when their team makes a last minute goal to win the match. 2. 【Geographical variation】The rapid increase in communication traffic mentioned above also would vary depending on which transport station or stop fans use on their way to and from the stadium, including whether or not they are passing by a main trunk road. It also depends on what kind of applications they use and at what geographical point they use them. 3. 【Variation due to an event to be held】Communication traffic significantly varies depending on whether or not a match takes place. Traffic will tend to be light when there is no event or match but will become very heavy when a match or event does occur. 4. 【Burst variation due to a collective movement 】Public transportation such as trains and buses will carry many passengers, which will cause extremely heavy communication traffic when it passes by a geographical point. 5. 【Variation due to the nature of the event on the event day】The amount of communication traffic in case of an exciting match is significantly larger from than in the case of a boring one. The communication traffic also varies according to weather conditions, i.e. a clear day or rainy day. The kinds of applications used also vary according to weather conditions and the nature of the event. ● Radio communication networks up to 4G have been designed to satisfy the maximum value of the communication traffic when an event is to be held. In cases when communication

	traffic exceeds the system's pre-designed value, radio systems do not always guarantee communication quality during these periods of extremely heavy traffic according to the best effort service concept. Radio systems have employed temporal base stations in order to off-load communication traffic and minimize the degradation of its communication quality. ● In 5G networks, it is economically very difficult to design the network in order to satisfy estimated maximum amount of communication traffic, due to the wider variety of applications used, the larger amount of communication traffic, the wider variation of communication traffic and the overall more ubiquitous communication traffic compared with 4G networks. ● In order to overcome these issues, 5G networks need to introduce dynamic traffic control schemes to solve the five issues mentioned above. ● As for issue four mentioned above, in addition to the dynamic traffic control of macro and micro cells and use of wired network slicing and softwarization, 5G systems need to take a new technological approach for "group mobility use scenario" in which access points are installed within a train/bus for use by mobile terminals, such as smartphones, and radio links between access points and a fixed base station on the ground to convey aggregated traffic originally arising from the mobile terminals. ● Furthermore, 5G systems need to introduce a new smooth handover scheme which considers "users traffic line" and in which, for example, access points are set along with a road from the railroad station to the stadium. ● 5G networks need to handle communication traffic which dynamically varies by introducing "flexibility" into the network as a whole at an affordable cost.