Summary of Deliverable 1.5:
Updated scenarios, requirements and KPIs for 5G mobile and wireless system with recommendations for future investigations

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Scenarios, requirements and KPIs
Scenarios, requirements and KPIs in D1.1

5 Scenarios and 12 test cases defined in D1.1 (April 2013)

Objective of D1.5

- Review and update the 5G METIS scenarios, requirements, and KPIs defined in D1.1 and make recommendations to future 5G technical developments
5 Scenarios

 › Outline the scope of METIS, reflect one specific challenge each

Amazingly fast
(Very high data rate)

Great service in a crowd
(Very dense crowds of users)

Best experience follows you
(Mobility)

Super real-time and reliable connections
(Very low latency)

Ubiquitous things communicating
(Very low energy, cost, and a massive number of devices)
METIS test cases in D1.1

12 test cases
› A practical aspect formulated from end-users’ perspective.
› Each test case contains a set of “narrative”, “assumptions”, “constraints” and “requirements”

Overlapping structure
› A scenario may cover several test cases
› A test case addresses one or more challenges

Note: description of each test case in Appendix
Vertical industry perspectives on 5G requirements and KPIs
Vertical industry perspectives on 5G requirements and KPIs

› Objective

- To broaden the scope of D1.1 by collecting diverse perspectives on 5G requirements and KPIs from vertical industries not limited to telecom communities
Industry automation

Description
- Primary applications
  - Manufacturing, quality control, material handling
- A new evolutionary phase
  - Enabled by upcoming Internet of Things and Internet of Services
  - Highly dynamic and flexible business, engineering and manufacturing
    - Smart Factory accompanied by Smart Products, Smart Grid, Smart Logistics, Smart Mobility, and Smart Home/Buildings

Challenges
- To provide ubiquitous networking between all components and systems involved in the production chain

Requirements
- Low latency (down to/below 1 ms for some applications)
- High reliability (down to packet loss of less than $10^{-9}$)
- Accurate location information (outdoor and indoor)
- High levels of connection and service/application security
Automotive industry

› Description
  - Driver assistance services (traffic safety/ efficiency, driver comfort), autonomous deriving, vehicle platooning

› Challenges
  - High mobility, high penetration losses caused by the vehicle itself and in rural areas

› Requirements
  - High data rate
  - Low latency (down to/below 5 ms for some applications)
  - High reliability (down to packet loss of less than $10^{-6}$)
  - High availability (particularly in rural areas)
Energy industry

› Description
  - Advanced electricity control systems
    › Smart grids, sensor networks, teleprotection, real-time phasor measurement, advanced metering infrastructure

› Challenges
  - To efficiently handle a lot of ICT traffic generated for advanced electricity control systems

› Requirements
  - Low latency
  - High reliability
  - High data rate
  - Massive amount of connectivity
  - High availability (in rural areas)
  - High security, accountability, integrity
Broadcasting

› Description
  - Provide consistent user experience for a wide range of audiovisual services (linear, on-demand, converged media services) to the entire population

› Challenges
  - Capacity challenge if same content is accessed by a large number of users at the same time
  - Cost challenges for large data volumes over mobile networks

› Requirements
  - Low cost
  - High capacity
  - High data rate
  - High availability (to the entire population)
Music industry

› Description
  - Providing instant experience of music anytime and everywhere

› Challenges
  - Clients cannot always rely on having latest network feature
  - Pre-caching contents is needed, but it may lead to overuse of network resources than necessary and to lower user experience
  - Good context information is needed to make proper caching decision

› Requirements
  - High availability
  - High data rate
  - High capacity
  - Good reliability
Vertical industry perspectives on 5G requirements and KPIs

› Observed trends from studies in verticals
  - Industrial processes
    › Ultra-fast and ultra-reliable (wireless) access to moving objects
    › Access availability in larger (remote) access
  - Media delivery
    › High and cost effective throughput
    › Unlimited availability

› Impacts on the scope of D1.1
  - METIS scenarios in D1.1 already cover the trends raised by vertical industries, as of today ➔ No need to define new ones
  - Still, a continuous tight cooperation between telecom and verticals is needed to gain more precise views of verticals’ needs and to refine 5G requirements and scenarios
Updated scenarios, requirements and KPIs
Updated scenarios, requirements and KPIs

› D1.1 remains valid and relevant for future 5G research

› Scenarios and test cases
  - No needs to update 5 scenarios and 12 test cases in D1.1
  - Should be used for future evaluations

› KPIs
  - KPIs defined in D1.1
    › Traffic volume density; Experienced user throughput; Latency; Reliability; Availability and retainability; Energy consumption; Cost
  - One new KPI
    › Extreme security
      - To protect personal privacy and integrity
Use cases from technology trends and future projections
Gaming

› Integration of cloud gaming i.e. real-time game playing via thin clients into 5G.
› Online gaming allows direct and on-demand streaming of games onto computers, consoles and mobile devices which relieves players from the need to constantly upgrade their computers and deal with compatibility issues when playing games.
› Given the large design space, latency can be a big issue which can degrade the quality of service for the end-users in different ways.
   - First Person Shooter (FPS) games
   - Virtual Reality (VR) gaming
› To address such requirements there is a need for establishing worldwide global network reliability, sufficiently fast and low latency to support different types of games and to deliver the best quality of service.
› The requirement for cloud VR gaming are low E2E latency and high data rate which are needed to support high definition real-time video streaming that is used to emulate the real world in such scenarios. The main bottlenecks are PHY/MAC layers, network layer (external IP) and application layer.
Marathon

› A Marathon is a long-distance running event with an official distance of 42.195 kilometres. Typically, a 4-5 hours long event where tens of thousands of athletes participate and millions of spectators meet in a certain area. It is expected that by 2020, all the participants of the event will wear wearable devices during the run in order to measure and ensure participants wellbeing, and performance.

› Participant numbers are at least tens of thousands. This enormous number of mobility devices need to accommodate within one cell or multiple cells (at least at the starting and finishing point) of wireless networks/cellular networks.

› Reliable and extremely scalable network service to the massive number of users temporarily located and moving in the certain area covered by existing deployed multiple nodes.

› Foresee that more than 70 000 tracking devices will be deployed in future marathon events. On top of this, more than 40 000 devices will be used for fitness and another 15 000 devices will be used for mHealth and music streaming. To accommodate this large number of dynamic MTC devices require high signalling efficiency, user capacity and low latency.

› In terms of coverage, the desire is of course to be able to reach every single house hold with the service. Though, for radio-based services this is impractical and the target could instead be set to 99 %, which is also very tough.
Media on demand

Media on demand relates to individual users that at their own preferred time want to enjoy media content, such as audio and video (challenging when many users want to experience their own unique large sized media content at the same time).

Residential users watch individually selected movies during the evening hours at home. The users are located indoors. The service needs to be provided to all households that do not use the competitive fixed connection. Significantly high data rates and low delays are needed. The absolute delay of starting is not very strict. One or a few seconds is acceptable. However, a quite low delay is still wanted as one needs to able to quickly get up to speed after possible link interruptions.

In terms of coverage, the desire is of course to be able to reach every single house hold with the service. Though, for radio-based services this is impractical and the target could instead be set to 99 %, which is also very tough.

In terms of cost it is assumed that subscribers are willing to pay about the same amount for this wireless service as they do for a corresponding fixed service.
Unmanned aerial vehicles

The Unmanned Aerial Vehicles (UAVs) use case is a possible piece of the infrastructure in the next 5G system architecture.

With the generic term of UAVs it is intended a flying vehicle without the driving presence of a human pilot to control it on-board.

Drones are a possible example of UAVs, even if many other robotics related applications could be included in this innovative use case.

The main requirements of this use case are mainly related to the scenario “Great service in a crowd” where UAVs can enable further increase of the throughput deployed, but they are also related to the scenarios Ubiquitous things communication and “Best experience follows you”, especially regarding caching and content delivery.

There is a foreseen stumbling block of regulation to overcome before being able to realize a complete solution of the UAVs use case.

The main foreseen areas of application of UAVs are currently envisaged as follows:

- provide broadband access to under-developed areas,
- provide hot-spot coverage during sporting events,
- provide rapidly deployable “on-demand” densification, very flexible as well,
- self-optimize positioning based on safety constraints, learning of propagation characteristics (including maximizing line of sight probability) and of ground user traffic demands,
- offload congestion affected backhauling connections,
- used as probing tools to check effective coverage targets achievement,
- act as local storing units making smart decisions about content caching.
Remote tactile interaction

› 5G can provide reliable connectivity in ultra-low latency conditions for remote tactile interaction
› E2E latency should not exceed very few ms
› Remote tactile interaction would be essentially unidirectional and asymmetric (from the remote tactile center to the object being manipulated), but bidirectional links can also be foreseen in cases where strong feedback is required
› Reliability and latency are critical, therefore D2D could be a candidate solution to meet requirements
› Mobility aspects for remote driving of flying should be considered in the context of Moving Networks
› Reliability should rely on redundancy and other techniques developed for ultra-reliable communications
› Applicable to scenario “Super real-time and reliable connections”

› Main requirements and KPIs would be related to the E2E latency and the reliability of the link:
  - E2E (one way) latency should not be greater than 2 ms
  - Reliability should be 99.999 % for critical applications (such as healthcare or remote driving), and relaxed to 95 % for remote gaming or remote augmented reality
  - Availability should be 99.999 % within the event area

› Main foreseen areas of application are, among others:
  - Remote surgery or healthcare
  - Remote driving, flying of unmanned vehicles, etc.
  - Remote augmented reality
  - Remote gaming
eHealth

Increase of cloud-based services is expected to be a major enabler to support telemedicine in the near future and allow anytime and anywhere access of medical records to the physicians and doctors. In addition, advanced diagnostic tools in the future are expected to offer also the possibility of remote examination of the patients.

Wearable devices are another strong emerging trend that has offered the possibility of remote monitoring of patients.

Sub-use cases:
- “Telemedicine and remote examination”
- “Bio-connectivity”
- “Moving ambulance”

Having “Moving ambulance” fully connected with the hospital is important, as the time required for patients’ transportation to the medical facility (e.g. hospital) is critical. Previous wireless communication technologies have not managed to solve the high mobility issues.

Based on the eHealth use case the communication requirements may vary. Telemedical applications and remote examination require data transmission ranging from hundreds of Megabytes up to few Gigabytes and demand ultra-reliable communication with low end-to-end latency ranging from 1 ms up to 10 ms (particularly for the remote examination sub-use case).
Ultra-low cost 5G network

› Today more than two to three billion of inhabitants on earth still do not have access to internet. Effort and cost for deployment and operation of mobile networks infrastructure as well as cost of terminals are not economically justified by the very-low Average Revenue Per User (ARPU) that can be expected in those areas.

› A flavour of 5G is expected to be flexible enough to be deployed under ultra-low cost requirements to offer decent internet access to the last billions of inhabitants on earth. Bringing connectivity to such areas in an economically sustainable way requires ultra-low cost network infrastructures and ultra-low cost devices, accompanied by ultra-low cost operation and maintenance.

› Ultra-low cost 5G network requirements are given in the right column.

› Cost of equipment on network side both on access and backhaul but also on device side. In addition to minimizing the costs of the full-fledged technology, 5G therefore needs to offer options and possibilities for ultra-low cost deployments tailored for very low average revenue per user areas. Potential options could be to lower peak rates, restrict mobility and relax network availability constraint.

› Network Operation and Management efficiency with generalization of automated operations (SON) to reduce operation costs.

› Coverage which needs to be improved to minimize amount of costly passive network infrastructure. Cell diameter of 20 km is required with a minimum coupling loss at 2 Mbps.

› Application layer data rate is required to be 10 Mbps DL and 2 Mbps UL.

› Number of active connections, which can be difficult to handle in very dense suburban areas in emerging markets.
Remote car sensing and control

› In particular, the use case includes, on one hand, the remote control of vehicle functions such as the air conditioning and the heating, the engines, the headlights, the horn, the (un-)locking of doors, etc., and on the other hand, the transmission of vehicle information such as sensor data to a backend server.

› The applications are based on the transmission of small telemetry and command messages, and therefore, do not possess stringent requirements in terms of latency or data rate. Nevertheless, they must operate when the vehicle is turned-off.

› The characteristics demand very low power consumption and a significant coverage extension.

› Although the utilization of LTE could in principle improve the responsiveness of the system due to lower E2E delays, the higher power consumption associated to LTE devices, would significantly reduce the battery life of vehicles. Furthermore, neither technology is capable of providing enough penetration through walls and floors (e.g. underground parking spots).

› It might be possible to improve the user experience (by means of better responsiveness and availability) and ensuring a longer battery life than with current technology. It is important to note, that since vehicles can for example be unlocked or even started remotely, security aspects are fundamental in order to avoid the hacking and potential theft of the vehicle.

› Requirements
  - Low power consumption (comparable to or lower than 2G),
  - High penetration through walls and floors in order to reach, among others, underground parking spots (link budget gains in the order of 20-30 dB),
  - E2E latency at the application layer below 1 s,
  - Extreme security.
The forest is continuously growing under the protection of the owners who cherish it and takes care of forestry, deforestation and afforestation when needed.

The forest industry profit is realised from the forest felling, the cutting of timber and the process to other goods. Currently these initial tasks are both taking place and are being performed in the forest.

With remote control the users, i.e. the workers, would not need to be physically present in the forest but could instead access and control the machines from other more easily accessible locations. This enables increased worker productivity and cost reductions.

The remote control service requires significantly high data rates and low delays, in the typically rural forest deployments, in order to enable running the machines from other physical locations. On top of this, advanced security is needed to avoid intruders from entering and taking control over the machines.
Conclusions with recommendations for future investigations
Conclusion

The objective of this document is to review and update the METIS scenarios, requirements, and KPIs defined in D1.1 and make recommendations to future 5G investigations such as in the H2020 programme. To this end two approaches have been taken.

The first approach attempts to broaden the scope of D1.1 by collecting diverse perspectives from vertical industries, not limited to telecom communities.

- The attained results are quite representative in terms of future communication requirements for the considered verticals. Ultra-fast and ultra-reliability are critical requirements for various industry processes that include industry production, infrastructure monitoring/control, and V2X remote control applications that further require instantaneous adaptation to fast changing environment due to high mobility. A high level of network and service availability in remote areas as well as in indoor environment is another key requirement for future automated industry applications. For media delivery a cost effective high throughput should be available regardless of locations and mobility. As of today, the requirements from the vertical industries seem to be well aligned with the expected performance of future 5G networks.

Based on the first approach it is found that the five scenarios and twelve test cases defined in D1.1 remain highly relevant for 5G system. In addition, no needs to update the scenarios or the test cases in D1.1 were identified, though one new KPI could be identified, referred to as extreme security.

The second approach is to consider if there are any relevant use cases that are not visible in D1.1, but that still should be highlighted due to recent technology trends and future projections.

- Nine new use cases are identified. Typically each use case belongs to one or more of the identified scenarios. The aim of each use case is to provide a problem description relevant to be investigated when forming and studying a 5G system. These are suggestions for developing, designing and evaluating future technical solutions. The technical solutions addressing the use cases are not within the scope of this document, but suggested to be used in future 5G research.

Finally, it is concluded that the content of D1.1 together with the identified new KPI and nine use cases should be used in the future evaluations of 5G technologies.
Appendix
METIS Test Cases (TCs) in D1.1

› **TC1: Virtual reality office**
  A top-modern office space working with high resolution 3D tele-presence and virtual reality
  - **Traffic volume**: 36 Tbyte/month/subscriber
  - **User data rate**: 1 Gbps with 95% availability

TC2: Dense urban information society
Connectivity required at any place and at any time by humans in dense urban environments
  - **Traffic volume**: 500 Gbyte/month/subscriber
  - **User data rate**: 300/60 Mbps in DL / UL with 95% availability
METIS Test Cases (TCs) in D1.1

› **TC3: Shopping mall**
  A large shopping mall with its high density of customers and shops staffs.
  - **Traffic volume**: 1.0 Gbyte/subscriber/hour
  - **User data rate**: 300/60 Mbps in DL / UL with 95% availability

› **TC4: Stadium**
  An event in a stadium that gather a lot of people interested in watching and exchanging high quality video contents
  - **Traffic volume**: 9 Gbyte/subscriber/hour
  - **User data rate**: 20 Mbps with 95% availability
METIS Test Cases (TCs) in D1.1

› TC5: Teleprotection in smart grid network
   A smart energy distribution grid system aims at improving the efficiency of energy distribution and requires prompt reaction
   - Latency & reliability: less than 8 [ms] for about 1500 [byte] payload with reliability 99.999%

› TC6: Traffic jam
   Provision of public cloud services inside vehicles during traffic jams due to the sudden increase in the capacity demand
   – Traffic volume: 480 Gbps/km²
   – User data rate: 100/20 Mbps in DL /UL with 95% availability
METIS Test Cases (TCs) in D1.1

› **TC7: Blind spots**
  The ubiquitous capacity demands in blind spots, such as rural areas with sparse NW infrastructure or in deeply shadowed urban areas.
  - **User data rate:** 100/20 Mbps in DL/UL
  - **Energy efficiency:** 50% / 30% reduction for UE / infrastructure

› **TC8: Real-time remote computing for mobile terminals**
  Remote computing services, e.g., augmented reality service, on-the-go at higher speeds.
  - **User data rate:** 100/20 Mbps in DL /UL
  - **Latency:** Less than 10 [ms] with 95% reliability
  - **Mobility:** Up to 350 km/h
METIS Test Cases (TCs) in D1.1

› TC9: Open air festival

A small rural area visited by 100,000 visitors for multi-stage open air music festival event.

- **User data rate:** 30 Mbps with 95% availability
- **Traffic volume:** 900 Gbps/km², 3.6 Gbyte/subscriber
- Almost no existing permanent NW infrastructure

› TC10: Emergency communications

Basic communications in a place where little mobile or wireless network infrastructure exists, e.g. due to a natural disaster.

- **Battery lifetime:** 1 week (with today’s battery technology)
- **Availability:** 99.9% victim discovery rate
- Destroyed or unreliable NW infrastructure
METIS Test Cases (TCs) in D1.1

› **TC11: Massive deployment of sensors and actuators**
  
  Small sensors and actuators that are mounted to stationary or movable objects and enable a wide range of applications

  - **Energy efficiency**: 0.015 μJ/bit for 1 kbps data rate
  - **Protocol efficiency**: 80% at 300,000 devices per access node
  - **Availability**: 99.9%

› **TC12: Traffic efficiency and safety**

  Cooperative intelligent traffic systems (C-ITS) for road safety and traffic efficiency

  - **Latency**: Less than 5 [ms] for 99.999%
  - **Detection range**: up to 1 km