Universal Communication Model for the Future Society

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Abstract: Telecommunication uses today various devices, operating systems, network technologies and applications. The multiplicity and diversity of these items are expected to increase due to the development of new technologies. As a result communication becomes a challenge. In this paper the architecture model "Universal Communication Model" (UCM) for the unified application of these items is proposed and discussed. The future society will merely be 60+ and lowered physical abilities for communication need to be compensated. Two use cases are applied to the UCM: Elderly father at home called by his daughter from her car, and disoriented grandma walking to her appointment at the medical clinic. The feasibility of both use cases is validated based on the considered integration of future technologies into the UCM.

Keywords: Universal Communication Model, Architecture Model, Future Media Technologies, Ubiquitous / Pervasive Communication, Communication Scenario for Elderly.

1 Introduction

Mass telephone communication became mobile with the first handheld mobile phone call in the early 70th. Today cellular phones are used all over the globe for voice calls and data transfer like messaging. Cellular phones are ubiquitous in the sense, that their usage is limited by network coverage which nearly fully exists in developed areas like Europe, America, and Asia. Cellular network technology is enhancing quickly: currently the 4th generation (4G) is being rolled-out world-wide [rGPP12] and the subsequent generations will allow to transfer big data everywhere [NG13]. This technology boost will enable the support and amelioration of communication by data demanding services like fusion and fission of mimic and gestures, video, multi-displays, M2M, and text-to-speech translation in the cloud, to name a few important.

Already today exists a multiplicity and diversity of devices, operating systems, and network technologies including different protocols. Additionally, the user interfaces are differing for devices from varying manufacturers and for dissimilar operating systems. The challenge for the usage of communication devices is huge due to its diversity of user interfaces, the multitude of features like multimodality, and additionally, the limited size

of icons / screens, in order to name a few important [EG06]. These challenges are increasing for users with physical limitations like debility of sight, hearing loss, or kinetic tremor as it can occur with increasing age [Wi99,Wo02,Wo08]. Thus, especially the ageing society can profit from supportive applications for communication, since physical abilities that are needed for communication are expected to be (partially) compensated.

In this paper an architecture model is presented for a unified usage of different devices, network technologies, and applications for communication. This model is called universal communication model (UCM) and consists of three domains for communicators with gesture and mimic, devices with supportive applications and functionalities, and media for big data transmission. The architecture model follows Weiser's vision that technology for communication may become seamless, if ubiquitous real world objects appear "smart" and provide user experience without using complex computer user interfaces or obvious controlling devices [We91].

Communication is for elderlies (60+ with frequently limited movement capability and hebetuded senses) a challenge, and thus, technology can be a barrier. The number of elderlies is growing fast in post-industrial countries [Wo02]. Therefore, two use cases for the UCM with focus on elderly people are described: first, a daughter is calling from her car her elderly father at home, and second, grandma has an appointment at her doctor and during her trip she is receiving information about her public transportation route. The use cases are investigated with focus on the required technologies and how elderlies with physical limitations are supported for a natural communication in their environment.

The paper is organized as follows: Sect. 2 contains basic considerations for communication models and related work for the amelioration of communication by, e.g., augmented reality and avatars. Then, the architecture of UCM is described and necessary technologies to implement UCM are discussed (Sect. 3). In Sect. 4 the two use cases for the elderly society are applied to the UCM and their feasibilities are discussed based on the required technologies to implement both use cases. A conclusion and an outlook are provided in Sect. 5.

2 Related Work to Communication Models

Communication modeling started with Claude Shannon's cutting through article "Mathematical Theory of Communication (MTC)" [Sh48] in 1948. The theory contains an information model that defines information transmission from an information source to a destination based on entropy (Fig. 1). The model incorporates the channel capacity, i.e. an upper bound for the amount of transferable information for a given channel, and noise, i.e. loss of information during the transfer. This model is still valid for the consideration of information [Fl10, Gl11], even though it is an abstract approach without considering human needs.
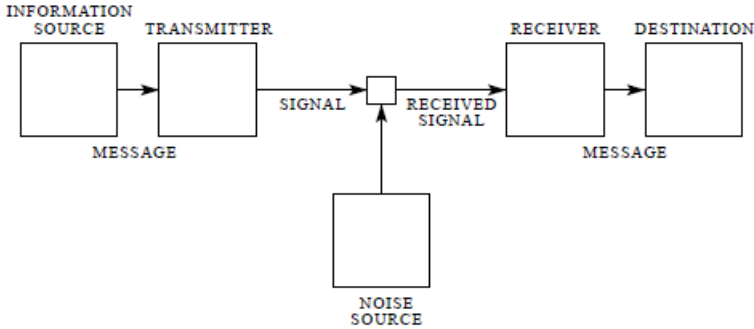
Figure 1: Schematic diagram of a general communication system (from [Sh48])

Warren Weaver [We49] added a feedback component to Shannon's model: the destination is now able to provide immediate feedback to the receiver (Fig. 1). David Berlo [Be60] extended 1960 the MTC to the S-M-C-R model of communication. The model depicts for each of the four components several attributes which are relevant for an emotional, successful person to person communication, e.g. the channel considers the five senses and the sender-receiver component several human variables. Interferences in the communication chain may result from e.g. unconscious behavior, gesture and mimic, the personal relations between sender and receiver, or misinterpretations of information.

In contrast to human communication the so-called agent communication emerged in the 90th [FGB00, AC99]. Agents are software pieces that traverse network nodes. At each node actions can be performed. The agents are standardized through a communication language, a fixed pre-defined set of performatives representing possible actions, and an ontology to describe items [FLP98]. Agent communication enables today's machine-to-machine communication [BHE12]. In this paper the focus of communication models is on human-to-human communication based on communication networks. These networks are fixed line or wireless and connect devices like tablets, wearables, or smartphones. Today's fast development of network and computer technology expands the possibilities of simple, flexible and feature-rich communication.

Hansmann et al [Hea01] defined the principles of pervasive computing by the following four dimensions: decentralization, diversification, connectivity and simplicity. Diversification of devices and convergent connectivity allows global and convenient access to communication networks, regardless of time and place. The vision of ubiquitous computing "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.", was postulated in 1991 by Marc Weiser [We91, p. 94]. This vision describes how omnipresent, multitude, tiny, wireless sensors are implemented in everyday objects and environments. Weiser's vision also depicts how they interact with each other and that they disappear physically and mentally in the background. Everyday objects offer information on anything, anytime and anywhere to operate and react in a context-sensitive way. Ubiquitous real world objects appear "smart" providing user experiences without using complex computer user interfaces or obvious controlling devices. Weiser proposed three basic devices for using ubiquitous technology [We91]: tabs (wearable

centimeter-sized devices), pads (hand-held decimeter-sized devices), and boards (meter-sized interactive display devices). Weiser's criticism on the complexity of Human Computer Interaction of the personal computer concept results in using separate devices focused on specific tasks and simple user interfaces.

In 1998 Donald Norman [No98] also queried the usability of personal computers and stated axioms for designing information appliances. These axioms are covering simplicity, versatility and pleasure. Norman appeals in this consideration to the specialization of technical devices and a human-centered development.

A first virtual reality system was invented in 1968 by Ivan E. Sutherland, as a head-mounted display with 3d graphics. It was restricted by the limited processing power of computers and low resolution of display technology [Su68]. Virtual reality applies to a computer generated and simulated environment and enables a user to perform operations on a three dimensional simulated system in real time [BC01]. Tom Caudell and David Mizell, stated in 1992 the term augmented reality (AR) as overlaying computer-presented material on top of the real world [CM92]. In 1997 Ronald Azuma [Az97, p. 356] stated that "AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world.". Azuma characterized that AR systems combine and overlay the real world with virtual objects and are interactive in real-time. The real and virtual objects relate to each other in a three-dimensional manner [Az97]. Two years later, Milgram and Kishino [MK94] created the term virtual continuum (VC) including the approach mixed reality (MR), augmented virtuality (AV) and augmented reality (AR), as depicted in Fig. 2.
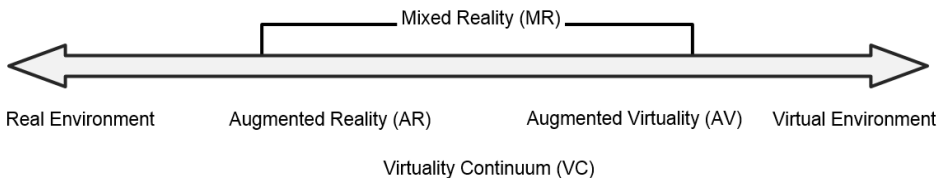

Figure 2: Simplified representation of a "virtual continuum" [MK94].

Mixed reality systems enhance the five human senses in a communication process, providing multimodal and media-rich information transmission [Sea08].

Communication networks require Quality of Service (QoS), in order to avoid artifacts like jitter and hesitating. Cellular networks offer traffic classes like video streaming with defined quality parameters [rGPP12]. In the following, a universal communication model including QoS and future technologies as expected for future communication will be described and discussed. This model enhances specialized models for e.g. automotive [DG01] by ubiquitous communication [Se08].

3 Universal Communication Model

Weiser's vision of disappearing technologies and the model of Shannon will be materialized by the approach of the universal communication model for the future elder society. This model and the technological challenges will be described here in detail.
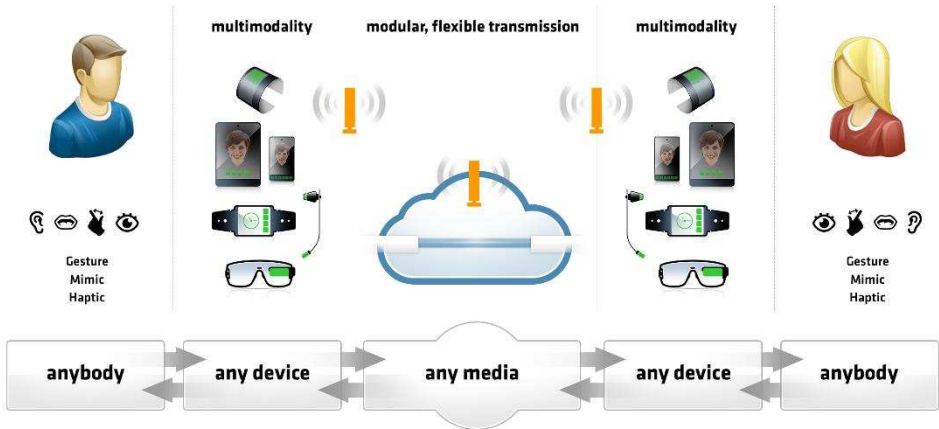

Figure 3: Universal communication model (UCM) for the future society.

The universal communication model (UCM) consists of five domains in which two of them are doubled, i.e., three different domains: First, the domain labeled "anybody" at the left and right side. They represent any human that wants to perform a person-to-person communication. Human communication implies the usage of gestures and mimic. Additionally, haptic feedback like reinforcement during pressing a knob provides valuable information for the users [EG06]. The UCM has strong usability requirements, since people with different cultural background and with varying age and education are potential users. The development of successful future communication end-user services must cope with the challenge of systems' capabilities and the human (in)ability to manage new emerging, complex technology. Human computer interaction (HCI) has to be "enjoyable" [No98] and intuitive with an ease of use and a user-centric approach [EG06]. The successful and unconscious use of new technical services without any previous knowledge is stated as intuition [Mo06]. Customized user profiles can additionally reduce complexity and help to satisfy the user needs.

Augmented reality enhances the communication environment with additional context information in order to support the sender and the receiver. Exemplary enhancements are the adaptation of the voice pitch in order to compensate listening barriers, or to send and receive 3d environment views with multiple cameras and displays. Additionally, sensitive topics like privacy protection can be supported with the application of avatar technology [So05]: the humans are represented by animated avatars that are steered by live body motion of the senders. The hand and head motion (including mimic) is transferred directly to the avatar at the receiver's side in order to represent a more natural representation of the virtual human. Tracking of the head and the body needs to be done in real-time.

Second, the inner domains on the left and right side, labeled with "any device", represent the class of multimodal devices like tablets, smartphones and wearables including smart glasses. Wearable devices allow the users to access information anywhere and anytime, especially as they traverse in the environment [BC01]. As an example future devices will be specialized on certain tasks (e.g. shoes that analyze steps), and other devices have multiple functions and will provide only favored services in a context sensitive way (e.g. glasses with multimodal input / output like voice, gesture, or view). Furthermore, a flexible bracelet or smart-watch, with an elastic high definition display, can be used as a central communication device. It provides wireless connectivity to the carrier and the wireless associated devices.

Future „any devices" will be fully integrated and inconspicuous into everyday things with the ability of high connectivity and energy self-sufficiency [BC01, BHE12]. These devices provide location-based and context sensitive information for the user or other devices. Prevent data and information overload is important for: First, the provisioning of user-centric information. Second, the capacity load of infrastructure and devices can be monitored, and third, also the overall bandwidth performance of the networks. One possible option is that software agents on the device analyze all measurable information data and filter the data stream with intelligent algorithms for the relevant information. A further option evolves from mass data transmission [WiFiad13]: Big Data technology in the cloud can help to solve the challenge of mass data evaluation using cloud computing power.

Multimodal interfaces are the system/human interaction panel for the sequential or parallel application of several input/output modalities like voice, keyboard, stylus, gesture, mimic, and/or kinesthetic. Furthermore, multimodal interfaces have to be symmetric for input and output. Thus, for the input several modalities have to be analyzed and formulated in a consistent hypothesis (fusion). The application of multiple channels in parallel enables a user, e.g., to provide input via stylus and speech in order to tap onto a map and to speak "zoom in here". The system has to generate for the output several actions for gestural, mimic, and speech output (fission). The challenge is to generate a consistent input hypothesis and consistent output actions [EG06].

Third, the domain "any media" (Fig. 3, center) provides data transmission with high bandwidth for big data as HD video communication. This domain has to fulfill technical requirements like seamless connection with smart antennas as depicted in Table 1. The 4th generation (4G) of cellular networks is a pure IP-based network and can be viewed as an extension of the Internet for nomadic users. The aim of 4G is a throughput of 1 Gbit/s with a latency lower than 5 milliseconds. This network will be called "LTE advanced" (Table 1). A further challenge is the application of different technologies for huge cells (frequency division duplex) and small cells (time division duplex) in the same network. Additionally, the frequencies are distributed between 700 MHz and 3.5 GHz which require an integration of different antennas into one system. The world-wide roll-out of LTE advanced is envisaged for 2020.

4G	5G	6G	7G
• LTE advanced • All IP network • Up to 1 Gbit/s • <5 ms latency • Various technologies FDD/TDD • Frequencies 700 MHz – 3.5 GHz	• Carrier aggregation • Pervasive networks • Wireless mesh network • Smart antennas • Cognitive radio technology	• WiFi 802.11ad with 7 Gbit/s and 60 GHz • Bridge for last mile • WiFi policy management • Channel interference avoidance	• Integration of WiFi, cellular and fixed networks • Seamless network choice • Flexible and wearable devices – fully ubiquitious

Table 1: Feature ideas for the cellular access network evolution 4G till 7G [rGPP12, NG13].

With the 5th generation (5G) many technology improvements will be established [NG13]: first, the so-called carrier aggregation, where different frequencies are used in parallel in order to reach a higher bandwidth. Second, the implementation of pervasive networks will enable users to be concurrently connected to several wireless access technologies and to move seamlessly between them. Third, wireless mesh networks with a variety of access schemes will make it possible to link to several nearby networks. As a result a speedier data flow is expected. Fourth, smart antennas will allow to alter the beam direction in order to enable more direct communications. Finally, the cognitive radio technology will enable the user equipment to look at the radio landscape in which it is located and to choose the optimum radio access network.

Then, latest the 6th generation (6G) will boost WiFi with the new 802.11ad standard [WiFiad13]. This release is expected to have a throughput up to 7 Gbit/s and may serve as a wireless bridge for the "last distance" to sites. The extremely high frequency band around 60 GHz will be used. WiFi lacks in policy management for several users and has today a problem with interferences at congested locations. These shortcomings will be balanced by the introduction of service quality and interference avoidance mechanisms [WiFie13].

Finally, the 7th generation (7G) has the big challenge to integrate the extremely high frequency bands into cellular networks. This integration will enable a seamless network choice for big data transmission like 3d computer tomography videos. Additionally, flexible and wearable end user equipment can be fully connected and integrated into the meshed and seamless 7G networks.
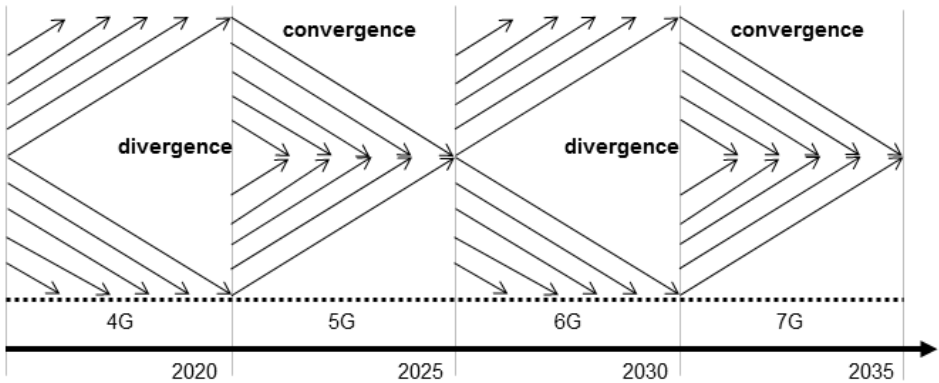
Figure 4: Technology shows alternating divergence and convergence for the sequenced cellular network generations.

The invention of a new network technology implicates a divergence of the applied technologies (Fig. 4). In the subsequent generation convergence effort is always required in order to integrate the various technologies into a network. 6G and 7G are inventing and integrating a wireless short range transmission technology (~30 meters). Thus, they are expected to be implemented in densely populated areas like North Rhine Westphalia in Germany or Nagoya in Japan. These areas are technologically well developed and applications with a great demand for quality of service (QoS) like video streaming or video phone calls will be the main usage. QoS is a common feature of future networks and will enable the implementation of the above depicted universal communication model that formalizes Weiser's vision of ubiquitous communication.

4 Use Cases "Elderly Society" for the Universal Communication Model

In this section two use cases for the UCM with focus on elderly people are described: first, a daughter is calling from her car her elderly father at home, and second, grandma has an appointment at her doctor and during her trip she is receiving information about her public transportation route.

Elderlies are represented by people, which are being at least 60 years old [Un11]. This group represents in the post-industrial countries like Germany or Japan an important part of the society - currently 19% - and is expected to increase up to 30% in 2050 [Un11]. Participation, health, and security are the three pillars in the policy framework for active aging provided by the WHO [Wo02]. Human communication is necessary to participate in family and community life contributions and social society activities. Unfortunately, aging limits movement capabilities and hebetudes the senses: Over 50% of the elderlies world-wide have some degree of hearing loss [Wo08] which can cause difficulties in communication, and hence, lead to frustration, low self-esteem, withdrawal and social isolation [Wi99].

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The first use case demonstrates how the UCM enables elderlies to communicate, i.e., to compensate the loss of abilities like hearing impairment and lowered prestidigitation. Getting older, most elderlies prefer to live as long as possible at home (even alone). Thus, the UCM needs to provide an easy-to-use communication interface including standard devices that are affordable for elderlies.
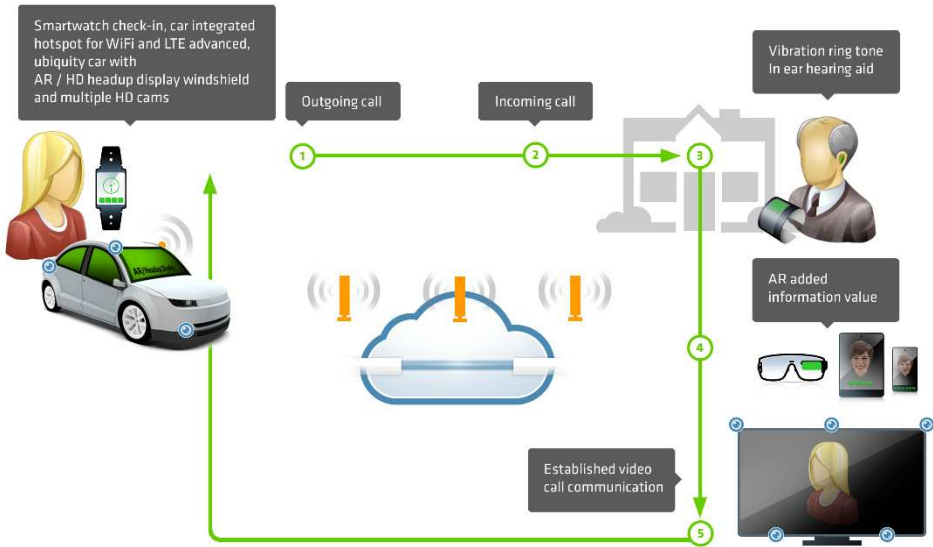

Figure 5: Call flow of the use case "daugther calls her elderly father" applying the UCM

In this scenario the domain "anybody" of the UCM (Fig. 3) relates to an elderly person with hearing loss and low vision (Fig. 5, bullet 3), who is performing a person-to-person communication. The daughter (caller) initiates the call from her car (Fig. 5, bullet 1) to her father. The call is initiated per voice dial and established under 100 ms provided by low latency. The name of the callee (here her father) and further information of the last corresponding calls are displayed on the (high definition AR/headup display) windshield of the car. Multiple HD cameras record the daughter and the environment out of different positions and video live streams are provided to her father`s display device(s).

The communication devices of the father detect the incoming call (Fig. 5, bullet 2), subsequently they activate a vibration ringtone on his multimodal and transparent bracelet (Fig. 5, bullet 3), and display the live streams of his daughter. The father has the choice to handle the call with suggestions from its devices: First, he can decide to accept to use the touching bracelet and voice command, or to reject the call, whereas the device recommends to agree since his daughter calls him every Sunday afternoon when he is at home in the living room. Trilateration and fingerprinting of the WiFi stations provide the environment indoor localization for context-sensitive information value. Augmented reality (Fig. 5, bullet 4), supports the elderly father with extended information. As an example recorded and marked speech-to-text information of the last call is displayed on

another tablet device or several live video streams of the daughter's environment (or different views of her).

To emerge communication as real as possible, the UCM provides high resolution video and high definition audio signals for user-oriented media richness. A core feature of the UCM is that it makes possible to compensate personal inabilities in hearing and sensing using several (specialized) devices that are connected seamlessly and via smart antennas and cognitive radio technology (cf. Table 1).

In this scenario the caller and the callee, both, are connected via a high-speed IP data connection ensuring quality of service: the daughter's car (left side Fig. 5) is connected via LTE advanced, which enables quality-of-service-oriented HD video calls. On the roof of the car multiple antennas provide with MIMO (Sect. 3) a broadband and stable connectivity. Her father (right side Fig. 5) is connected via broadband WiFi, aka 802.11ad, allowing the transmission of video calls and AR-added information in parallel. The father is receiving a 360 degree view of his daughter from the multiplicity of HD cameras in the car. These views can be enriched by AR-added information for him, providing for convenience picture-to-speech information, i.e., similarly to text-to-speech (TTS) is a scene of the video depicted by voice. The voice output can be distributed via wearables with loudspeakers and in parallel to an ear hearing aid device via wireless connection.

The second use case applies the combination of machine-to-machine (M2M) and human communication to the UCM. A grandma needs to visit the doctor and is walking and bus driving from her flat to the medical center. Due to her age she is forgetful, has a low vision, hearing loss, and is tremulous. These properties can be compensated by several aids that are supported by the UCM: The appointment is shown in advance on the smart glasses (right side Fig. 6, bullet 1), emphasized by a vibration signal of the bracelet.

A virtual reality avatar reminds her by a TTS notification to take the bus early and gives gentle hints for pedestrian navigation to her hearing aid. Entering the bus (Fig. 6, bullet 2) at the rear door, she pays the ticket via near field communication and speech-to-text recognition, making the reading of little displays redundant. Corresponding to the appointment an agent-based service communicates in the background to provide all necessary information, e.g., arrival time calculation, sending a message to the doctor being on time and sending a picture of the medical center to the smart glasses for an easier orientation.
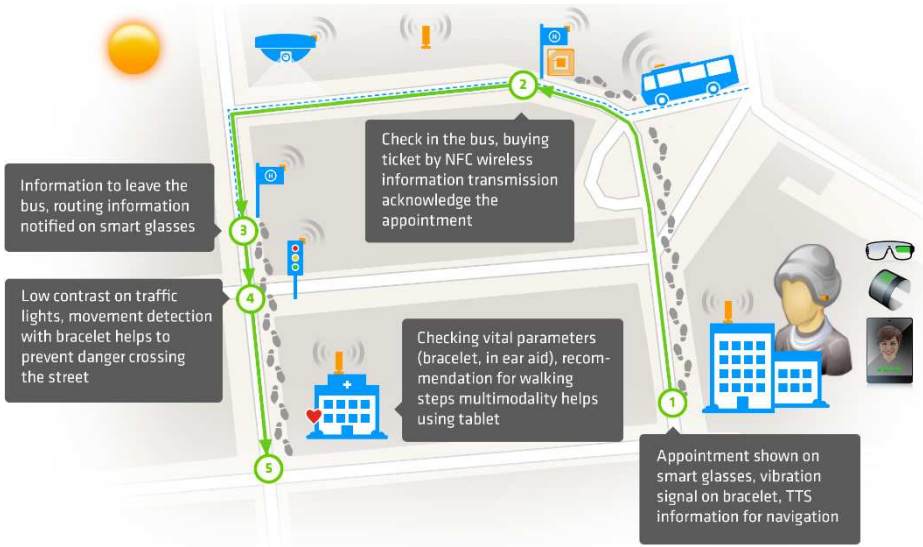
Figure 6: Grandma's way to the doctor and the navigation support due to her physical limitations.

Arriving at the destination bus station (Fig. 6, bullet 3), the avatar informs her about the exit and gives further routing information. The smart-glasses notice low contrast on the red traffic lights due to sun shine, and send a request to the bracelet to observe the environment when crossing the street (Fig. 6, bullet 4). Switching to green she passes the street and enters the building (Fig. 6, bullet 5). Checking the vital parameters (pulse, temperature, perspiration) the bracelet and the ear hearing aid are sending a notification to the glasses and the avatar recommends to take the stairs to the second floor, to participate in some little fitness exercise. Entering the waiting room the bracelet registers the grandma at the doctor's front desk. A tablet in the waiting room is notifying her about the estimated waiting time, and she decides to send a text message with a picture to her grandchildren. The device detects a little tremor and compensates the blur in the picture and helps typing the message.

This scenario underlines the flexibility and modularity of the UCM. Focusing on the term "sender-message-receiver", the UCM enables agent-driven information transmission from grandma to the medical center. Disappearing technology in the background engages the acceptance of this UCM scenario with underlying needs for ubiquitous services. In this scenario "any device" communicates independent of the media ("any media") with each other, which is M2M communication, and also "any device" interacts with "anybody", here the grandma, doctor, or bus driver (Fig. 3): The bracelet provides a high-speed IP data connection with LTE advanced and WiFi 802.11ad by tethering the wearable and portable ubiquitous devices like smart glasses, tablet, and ear hearing aid. The bus exchanges ad-hoc messages with people by long distance (WiFi or cellular) and short distance (NFC) wireless technology. Network technology of the 7th generation (7G) is envisaged for 2030 and will establish seamless high-speed connections with flexible and ubiquitous use of communication devices to support the ageing society at the peak of the demographic change (cf. Table 1).

5 Conclusion and Outlook

The universal communication model is the architecture for future technologies that support humans by their communication needs. The number of elderlies is growing fast and based on two scenarios it has been shown that physical abilities needed for communication can be compensated for (a) living (alone) at home, and (b) assisted navigation to a medical clinic. The model is extendible and allows future technological developments to be incorporated. Furthermore, the model integrates heterogeneous network technologies, diverse devices, and supportive services into one homogeneous architecture model allowing the user the selection of favored and needed items.

Assuming, that the generation "digital immigrants" [Pr01] (they learned the use of technology in their adulthood) are in 2030 elderlies with an age of approximately 60 years, it is still an open question how they will apply and adopt technology. Therefore, important parts of the described scenarios will be implemented and tested with elderlies. Important insights about the usage of devices and multimodal services are expected. Many of these services, that will be experienced in the future, are expected to successfully compensate lowered physical abilities in communication. The further -and more practical- challenge is the question how these services need to be integrated into the UCM in order to be supportive for humans and especially elderlies. To progress this question prototypes and experiments with humans are necessary and concepts for them are envisaged and will be implemented.

Acknowledgments

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