

1

Introduction to Human Bond Communication

Sudhir Dixit^{1,3} and Ramjee Prasad^{1,2}

¹ CTIF Global Capsule (CGC), Rome, Italy

² School of Business and Social Sciences, Aarhus University, Aarhus, Denmark

³ Basic Internet Foundation, Oslo, Norway

1.1 Introduction

Information and communications technologies (ICT) have progressed rapidly in this millennium for people to communicate and exchange information using multimedia (speech, video/image, text), and the same has extended to Internet of things (IoT) and machine-to-machine and machine-to-human communication. This trend is only going to accelerate in the years to come with powerful human–computer interaction technologies to deliver engaging and intuitive experiences. But these developments have remained confined to only the sensing and transmission of aural and optical information in the digital domain through the use of microphone, camera, speaker, and display devices. However, the ability to integrate the other three sensory features, namely, olfactory (smell), gustatory (taste), and tactile (touch) in information transfer and replication to deliver “being there in-person” experience, are still far from reality. Human bond communication (HBC) is a novel concept that incorporates all five sensory information from sensing, to digitization, to transmission and replication at the receiver to allow more expressive, engaging, realistic, and holistic information between humans [1] and in some cases between humans and machines such as in remote sensing and robotic control. Lack of inclusion of the other three senses in the digital world of ICT limits the full exploitation of the cognitive ability of the human mind for a fuller perceptive information experience. The five senses and the environment interact in interesting ways to become complete knowledge for human species as its brain has developed and evolved naturally from the time it came into existence on this planet. The profoundness of perceiving an object depends on the incisiveness and extensity

Human Bond Communication: The Holy Grail of Holistic Communication and Immersive Experience, First Edition. Edited by Sudhir Dixit and Ramjee Prasad.

© 2017 John Wiley & Sons, Inc. Published 2017 by John Wiley & Sons, Inc.

of the sense organs. Incisiveness refers to the granularity and minute details or variations an organ can detect, and extensity refers to the range of the physical property that it can detect.

In the traditional world of digital information exchange, the subject is described and presented partially via its aural and optical rendering, which gives a sense of incompleteness and dissatisfaction in fully understanding the subject. In the present era of ever increasing competition through innovation, inclusion of all five senses to deliver complete experience is the holy grail of the research community. Products have begun to appear through wearables and other embedded sensors in the body, but sensors exploiting touch, taste, and smell and embedding them into products remains a distant reality and is an area of intense research today as would become evident from the chapters included in this book.

Auditory and optical sensing is wave based. In audio sound travels through waves and can be sensed and digitized. Similarly, light shining on an object is reflected in electromagnetic radiation, and a part of this spectrum (called visible light in the range of wavelength 390–700 nm) is visible to the human eye and when rendered on the retina becomes a visual formulation of the object in the nervous system. The camera does this nicely to capture an object visually and digitize it for transmission. When rendered remotely on a display device in 2-D or 3-D, a person can see the object as though he or she was seeing it by being physically present at a location where the camera was located. Other human senses (tactile, olfactory, gustatory) utilize particle-based sensing and rely on smearing the object with the sensors. Building such sensors remains a technological challenge for the research community because each type of sensor must deal with large range of parameters and their wide spectrum. Digitization of these parameters is also a major challenge, and even if some finite widely prevalent values can be captured and digitized, their replication from the digital domain to the analog domain and their sensing by a person in an unobtrusive manner is a complex human-sensor interface issue. Figure 1.1 illustrates the HBC system and depicts what is possible today and what is not.

HBC is about understanding the human sensory functionality and works similar to human sensory system, which includes providing a perceptually holistic understanding of an object combining all five senses while incorporating the object's environment.

1.2 Human Bond Communication (HBC) Architecture

The HBS architecture extrapolates the contemporary communications architecture to include the missing three senses (or types of sensors): tactile, olfactory, and gustatory, not in use today along with the aural and optic

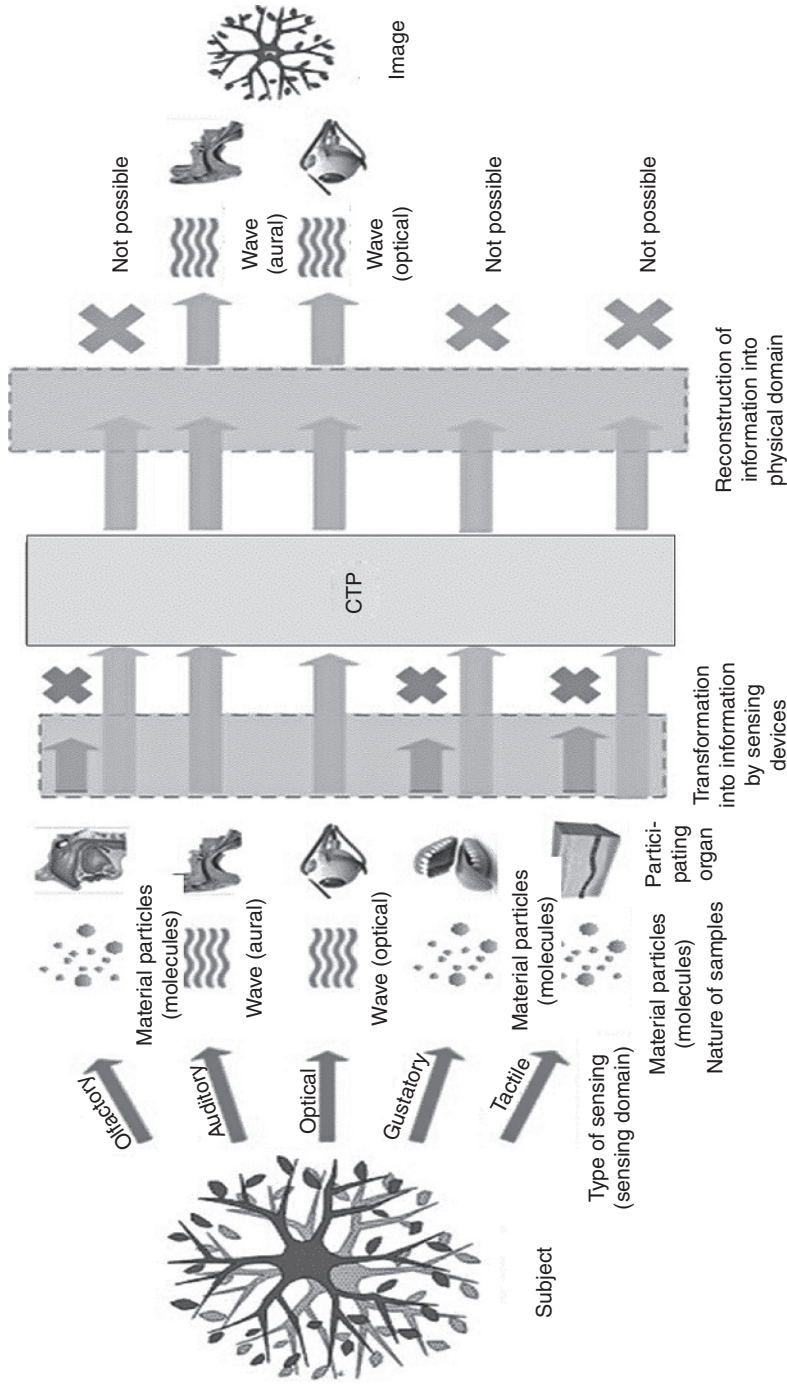


Figure 1.1 An illustration of human bond communication (HBC) concept. CTP, communication technology platform. Prasad [1]. Reproduced with the permission of Springer.

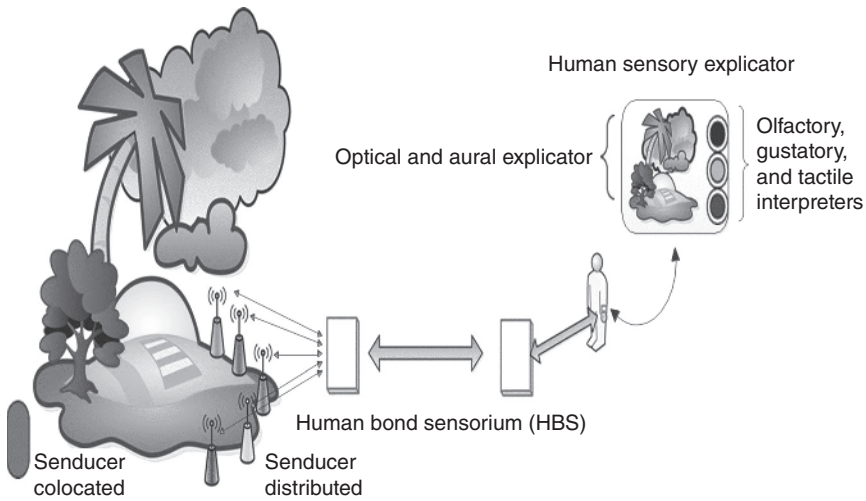


Figure 1.2 A proposed HBC architecture. Prasad [1]. Reproduced with the permission of Springer.

sensors. Nevertheless, some limited deployments are happening in machine-to-machine and machine-to-human communication use cases where robots are being used, such as in industry, law enforcement, hazardous material handling, and surveillance. A proposed architecture is shown in Figure 1.2 [1]. It should be noted that the architecture goes beyond capturing just a person's senses to also deploying all five types of sensors in any environment to capture smell (e.g., types of smoke, air pollutants), tactile information (e.g., surface roughness, temperature, wind speed), and taste (e.g., liquids, dirt, waste) and learning about an object or its surroundings.

The system consists of the three key building blocks: (i) senducers that sense the characteristic parameters through stimuli and transform those analog values to electrical and digital domain for further processing and transmission, (ii) human bond sensorium (HBS) that collects the data from the senducers, processes them to make them consumable for the human perceptive system (i.e., human consumption) by removing a large amount of nonusable and redundant data and information, transmits it to the far end to the receiver gateway, and (iii) human perceivable transposer (HPT) that transforms the received digital data to human consumable format, which includes replication of the senses to a form that one would expect if the person was physically present at the site where the sensory data were collected through senducers. Until such time the replication solutions are not available, the HPT may prefer to render the non-audio-visual sense data through digital means (such as colors, emoticons, text, other gestures like vibration, pressure, temperature, etc.).

1.3 About the Book

Our journey into the world of intuitive and rich communication begins with the vision of extending the contemporary form of digital communication to more natural human-to-human communication through the novel concept of HBC. This chapter has introduced that grand vision. HBC closely embraces the advances in the fields of sensors and wireless distributed computing, physiology, biology, wearables, chemistry, medicine, analytics, Internet, and so on that will be required to bring that vision closer to reality. Therefore, this book has included invited chapters from the experts in the various fields who look at the HBC through their perspectives and delve into the technical challenges that are before the research community. They also discuss the numerous business opportunities that are unlocked due to the intersection of the innovations emanating from interdisciplinary research and entrepreneurship. Whenever appropriate the authors have looked at the historical trends to present their ideas and invoke discourse. Figure 1.3 illustrates some of the key concepts and technologies that will have a profound impact on HBC. These are discussed in the various chapters of the book.

Chapter 1 is an introduction of the book and lays the foundation of the grand vision for the HBC concept.

Chapter 2 presents the basic concepts behind HBC and provides an insight in the ongoing research related to the concepts of human sensory and emotional replication, physical world augmentation, and human umwelt expansion. This chapter then describes an HBC architecture and discusses its convergence

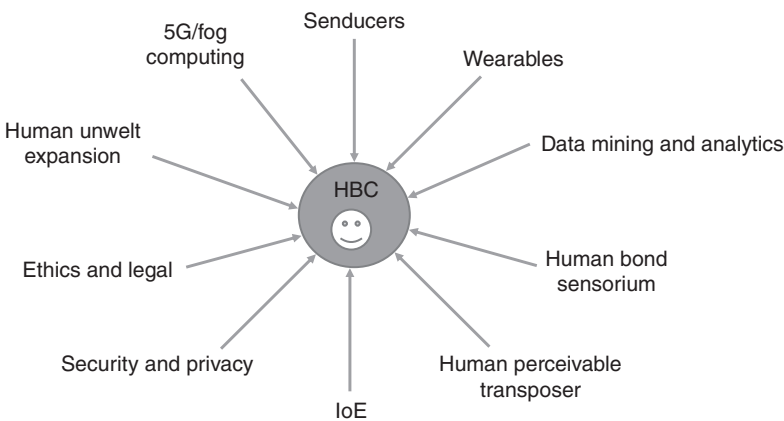


Figure 1.3 Key concepts and technology enablers for HBC.

with ICT. Additionally, the chapter discusses the potentials of HBC and gives a vision of possible future applications and services.

In Chapter 3, the authors postulate that the provision of enhanced augmented reality services to mobile users based on the HBC paradigm will rely on the definition of a high performance, high efficiency, and highly reconfigurable network architecture for the exchange of all the five sensory features. The objective of this chapter is to propose a novel HBC communication network architecture that is able to support the provision of such novel services incorporating all five senses. Starting from the definition of the main network, security, and quality of service requirements for HBC, a 5G network architecture based on software-defined networking, network function virtualization, and Fog-Edge computing paradigms is presented. The main enabling technologies, including WBAN, localization techniques, and content-oriented networking, are described together with some possible solutions to be adopted to cope with the security threats that may affect the success of HBC services.

Chapter 4 is about data mining of the human being. After describing the definition of data mining (also known as knowledge discovery in databases (KDD)) as the process of analyzing data from different perspectives and extracting hidden information and identifying patterns or relationships among the data, the author describes the various models and thereafter focuses on data mining of the human being, where the data is any fact, number, or text regarding a human being. The data can describe the human being at any level, from atoms to cells, to organs, to social level.

Chapter 5 provides an overview of ongoing research on the proposed models for IoT and summarizes their advantages and disadvantages in the context of human centric IoT. After describing potential human centric sensing (HCS) scenarios that require changes in how HCS-based IoT should be modeled, the chapter proposes a macro-level model and describes how it can help to achieve simplicity in the complex IoT world by understanding how to get from micro-complexity to macro-simplicity. It also describes HCS networks and federations and their modeling and later goes into end-to-end security and privacy issues. This chapter also touches upon the concept of tactile Internet as the enabler for HCS IoT.

Chapter 6 describes human body (i.e., body as a node (ByN)) as the main actor in the ICT systems, which plays an active role as a node of the ICT network, as well as part of the ICT user terminal. In addition, “intrusion” with technological ICT devices in the body provides to the body itself a great opportunity for the early monitoring and the daily cure of critical pathologies. After describing the ByN approach, this chapter delves into applying the underlying concept to oral cavity and presents an overview of the research in this field with its implications and perspectives for the future.

Chapter 7 explores the novel machine learning-based approaches to cognitive radio (CR) systems developed that will lead to innovative HBC

applications to serve the needs of a community. This chapter formulates novel algorithms to share spectrum through dynamic spectrum leasing methodologies and adaptive policy decision, making processes that seek to maximize the utilization of available scarce spectrum.

Chapter 8 is about the application of ICT for wildlife preservation. It is well known that various governments and nongovernmental organizations have launched diverse technology-driven programs to arrest unprecedented decline and wherever possible successfully restore and rehabilitate wild animal species. While timely integration of technology into wildlife research, monitoring, and conservation in the last couple of decades have definitely yielded positive results, future technology solutions are likely to cater relevant information for decision making and sound management based on application of five human senses instead of just two most common human senses (seeing and hearing). This chapter describes how the sensors for all five senses can be utilized in the solutions for wildlife preservation and concludes that there is an urgent need of sharing mental models between the stakeholders, specifically between the conservationists and technologists.

Chapter 9 investigates the security and privacy issues in HBC. Three different HBC levels are defined and analyzed what these really mean. The approach is to extrapolate and speculate about future progress but to put effort into keeping the extrapolations plausible. Many different fields are involved. Therefore, this chapter serves as a survey about possible future advances in the various fields that will have an impact on HBC. The security and privacy challenges are enormous and they need to be resolved. Thus, this chapter also serves as an urgent call for research in security and privacy issues.

Chapter 10 describes how the Internet of everything (IoE) is the networked connection of people, processes, data, and things. It contains the IoT and the Internet of humans (IoH). The stream of data the IoE will produce can be turned into actionable information and will provide numerous opportunities and will be omnipresent. This chapter attempts to answer the question: Will HBC, the novel concept that incorporates smell, taste, and touch in the exchange of information, be feasible? If the technology to create an HBC ecosystem succeeds, it will bring transformational changes and a paradigm shift. This chapter fast forwards to year 2050 to envision the evolution of the IoE and to predict the anticipated impact and opportunities.

Chapter 11 focuses on the use of HBC for health applications and in particular on the ethical and legal issues that arise. For many years, the use of ICT in medicine was limited to allowing communications between remote patients and doctors (telemedicine). In the recent years, there has been a rapid evolution in the use of ICT in health. The IoT framework allows a pervasive monitoring of anything around and eventually inside us, and this could really open the way to novel diagnostic and therapeutic methods. This rapid evolution has also posed several challenges as many things are not regulated yet.

This chapter attempts to address several key questions: What will happen when HBC will be a reality? Would HBC really enable novel applications in health? And if so, would that require new regulations?

Chapter 12 delves into the challenges in intellectual property (IP) and ICT law that will potentially come with the introduction of HBC. From a legal point of view, HBC means that attorneys and legal professionals should be able to conceive in short time the framework of a smart regulation, in order to provide the principles that will be governing the interaction between human beings, machines, and human umwelt expansion. The opportunities that will be unlocked with HBC will undoubtedly trigger the evolution of IP and ICT regulations in several areas. Because of the need for coherency, a multidisciplinary approach will be the key for reaching consensus among different experts and realize full implementation of the legal and general aspects of HBC.

Chapter 13 presents a historical view of the developments in wireless communication brought about by the changes in paradigm of communications from station to station to person to person and because of technology improvement that made the telephone terminal a multimedia mobile device. This chapter then delves into what is next for wireless communications? While future research could be either on technology or on applications, in reality, the success depends on several other factors such as fashion design, creating user needs, user experience, business models, and so on. These other factors require collaboration among teams in quite different areas that we call for interdisciplinary research and development. This chapter, therefore, focuses on the need for this collaborative approach for innovation and commercial success.

Chapter 14 is a broad overview of how communication among humans originated over the history of mankind and how it has evolved over time with the advances in technology. It discusses the paradox of users that while on the one side they have had choice of platforms and applications to provide enormous opportunities to exchange information in increasingly efficient ways, on the other side they chose the platforms that use only the least significant parts of the messages (i.e., text). This chapter quantifies how much information is included in text, speech, and video/image. Then it discusses technology as an enabler for improving communication over distances and differences between the various platforms, why customers seem not to choose the channel that offers optimum communication, and what are the technical characteristics of the various channels (face to face, letter, telegraph, voice, video, television, SMS/MMS, email, etc.). After presenting the data on how much data the users consume through different channels, this chapter goes into the psychological impact of the various communication channels and finally how the inclusion of the remaining three senses (touch, taste, smell) would further augment the quality of communication.

In summary, the book defines the concept of HBC, sets out its vision, and provides details on the technologies that are driving the realization of the vision and how it would transform the communication experience between humans while also significantly unlock the business opportunities between humans, machines, and their environment. This book also goes into the details of the security, privacy, IP, and regulatory challenges that must be addressed for HBC to be commercially realized.

Reference

- 1 Prasad, R. (2016). Human bond communication. *Wireless Personal Communications*, **87**(3), 619–627, Springer, New York.

