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OVERVIEW OF THE INTELLIGENT PERSONAL ASSISTANTS

Irene Lopatovska,
Associate Professor, School of Information,
Pratt Institute,
Ph.D. in Information Sciences
(New York, USA)
e-mail: ilopatov@pratt.edu
ORCID: https://orcid.org/0000-0001-7322-9461

The article provides an overview of intelligent personal assistants (IPA) (also known as conversational agents, smart speakers, digital / intelligent personal assistants, or voice-controlled agents). The main technical features of the IPAs, including Google Assistant, Amazon Alexa, Microsoft Cortana, Apple Siri, are outlined along with their reported adoption in private and public environments. IPA research trends and ideas for IPA research in Ukrainian context are also discussed.

Key words: ntelligent personal assistants, conversational agents, voice interfaces, smart speakers, digital personal assistants, human computer interaction, technology adoption.

INTRODUCTION

As adoption of the intelligent personal assistants (IPA) (also known as conversational agents, smart speakers, digital/intelligent personal assistants, or voice-controlled agents) is on the rise (Kinsella, 2018), it becomes imperative to understand its strengths and limitations, as well as use cases in private and public contexts. This article reviews the most popular IPAs (e.g., Amazon Alexa, Google Assistant, Apple Siri and Microsoft Cortana), their technical architecture and common features, reported uses in private and public settings, and the main themes in current research on IPAs.

TECHNICAL OVERVIEW

IPA is a software that can reside on a dedicated device (e.g., Amazon Echo, Google Dot) or a mobile device or computer (e.g., Apple and Microsoft hardware).

IPAs are designed to accept spoken or typed input, answer queries in a natural language, present search results, support simple conversations, play music, place online shopping orders, manage a calendar, control Internet of Things (IoT) devices, and perform other tasks (Canbek, & Mutlu, 2016). The most popular IPAs include Amazon Alexa, Apple Siri, Google Assistant and Microsoft Cortana.

Most of the IPAs require an internet connection to connect to the companies' cloud servers, or other networked devices, in order to carry out their functions. IPAs are usually activated when its speech recognition software receives a triggering word or phrase from a user. For Amazon Alexa this word is "Alexa" (which can also be changed and customized by a user, Clauser, 2017), for Google Assistant it is "Hey Google" or "OK Google", for Apple it's "Siri". When the software is activated by voice, the user usually receives feedback in a form of lights (Google Dot, Alexa Echo), or changed screen (Apple or Google phones). Figure 1 shows the information architecture of user interaction with one of the main IPAs, Amazon Alexa. First, users produce an utterance

or a request, which is filtered by Alexa through speech recognition, machine learning, and natural language processing. Alexa then accesses web hosted services, i.e. the cloud, and provides a response to the user. Included in the response process, Alexa produces a "Card" of information which records user utterances and the resulting system response. The "Card" information is available to users through the Alexa app in a textual form, providing a record, or a log of interaction history.

In addition to obtaining data from the cloud servers, the software can be used to control smart home (IoT) devices, such as thermostats and lights (Dunn, 2016a).

While all IPAs share similar network architecture, they differ by their interface designs, hardware requirements, and the types of tasks they excel at. For example, since Amazon Alexa is linked to the largest online retail business, one of its strengths is support for voice-activated purchasing from Amazon's website (Crist, 2016). Google Assistant is powered by two decades of web searching experience, so, not surprisingly, it excels in answering informational questions compared to other IPAs (Betters, & Grabham, 2018). Integration with the large suite of Microsoft projects allows Microsoft Cortana to excel in task reminders, calendar management, and communication support (e.g. sending emails, Graus et al., 2016). Overall performance of the three IPAs is comparable and satisfactory on tasks related to music, navigation, productivity, cooking, home automation, and others (Chen, 2018).

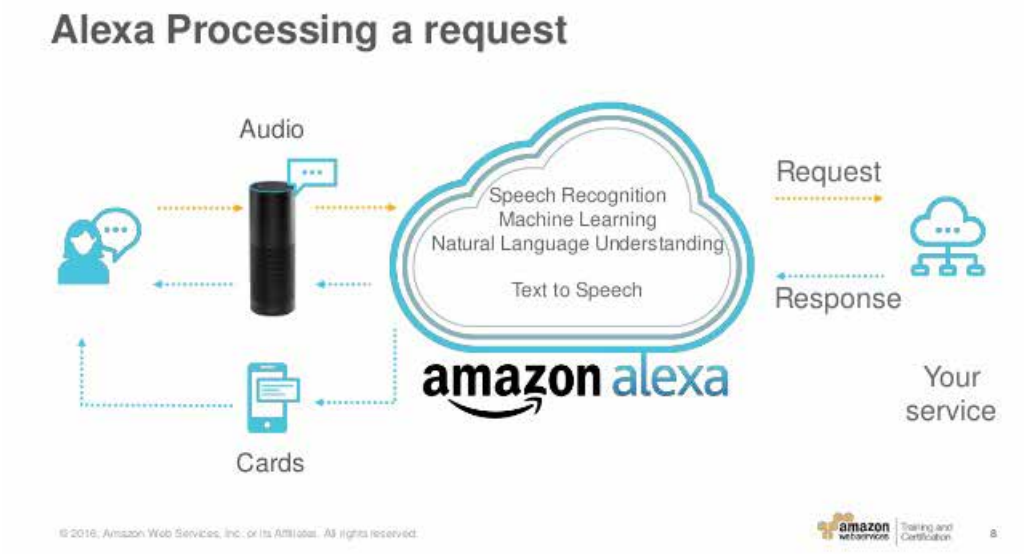

Figure 1. Information architecture of Alexa, modified from Amazon Web Services (2017).

IPAS IN PRIVATE AND PUBLIC SETTING

Since current IPAs are unable to support complex tasks or long conversations with users, most of the user interactions with them involve simple tasks, including straight forward reference questions and music playing. Use of IPAs differs by country, which could be largely explained by the popularity of certain hardware (e.g. android v apple platforms) and non-English language interface support (not)provided by IPA

companies. In the U.S., about half of a population uses IPAs. IPAs are primarily on smartphones and valued for their support of hands-free interactions and convenience ("Pew Research Center", 2017). A recent study of the Amazon Alexa usage in the U.S. households found that the most common interactions included checking weather, finding facts, listening to news, control other devices in the home, setting reminder/ calendar alerts and playing music; among less frequently used tasks were set timer, tell a joke, play a game, and check the time (Lopatovska et al., 2018). A study from Denmark found that the most commonly used IPA is Apple Siri due to its support for the Danish language (Borges et al., 2019). The most commonly reported tasks reported by the study participants included setting alarms, managing calendars and emails, getting directions, playing music and controlling other devices.

In addition to the private uses, IPAs are increasingly being adopted by organizations in public settings, including, hospitals, museums, classrooms, hotels and university dorms. The Boston Children's Hospital was one of the earliest adopters of IPA for assisting patients with intake forms, providing updates to families in the waiting room, providing patients with a hands-free phone call, text message, or email functions, as well as for control of lights and temperature in the room (Nguyen, 2016). Several museums in the U.S. installed IPA hardware in their galleries and found that users were often unaware of the technology, shied away from interacting with it in a public setting, or were disappointed with IPAs' limited word recognition (systems often did not "understand" foreign names such as Cézanne, Matisse, and Rousseau, see Bernstein, 2016; Moore, Pan, & Manish, 2017; Nguyen, 2016). Within museum settings, IPAs have the potential to provide general information to the visitors and, through analysis of user utterances, learn more about their interests.

IPAs have also been tested in an educational setting. Flanagan (2016) tested the use of Amazon Alexa in an elementary school setting and found that interaction with an IPA improved students' speaking and listening skills. The author observed students using the technology for spell-checking, thesaurus, and assistance with simple math problems. Placement of the Amazon Echo device in a public academic setting produced somewhat disappointing results as many graduate students did not utilize due to lack of need, awareness of a device, or hesitations associated with privacy and distracting effect of its use in a public space (Lopatovska, & Oropeza, 2018). IPAs have been recently installed into university dorms, primarily for answering questions about campus (Shoot, 2018), and hotels for addressing location-specific questions (Welch, 2018). User acceptance and adoption of IPA technology in these settings would need further investigation.

CURRENT RESEARCH ON IPAS

Research on how users interact with IPAs and how these interactions can be improved transpires in parallel with IPA adoption. The main threads in scholarly publications on IPA focus on factors that attribute to user valuation and satisfaction with IPAs, privacy concerns surrounding IPA adoption and anthropomorphizing of this technology.

Studies generally find that IPAs are valued and used in situations where users are engaged in other activities (e.g. driving, playing with children, cooking) thus gaining the most benefit from hands-free voice-based interactions with their digital assistants

(Cowan et al., 2017; Luger, & Sellen, 2016). For the population of disabled andvisually impaired users, IPAs offers additional accessibility to digital resources and services, as well as provide some unexpected support for speech therapy and other daily needs (Pradhan et al., 2018). User satisfaction with IPAs has been linked to task complexity (the easier task, the greater the satisfaction) and in-/output modes (voice, text, gesture) involved in task completion (the more modes, the lower the satisfaction) (Kiseleva et al., 2016). The mentioned above study of IPA adoption in Denmark found higher satisfaction with higher frequency tasks, possibly pointing to the positive correlations between task simplicity, frequency and satisfaction (Bogers et al., 2019). User satisfaction has also be linked to IPAs (in)ability to provide appropriate feedback on the status of software activation and task progress (Luger, & Sellen, 2016; Sörenson, 2017), a (mis)match between input and output modes (e.g., a spoken command that produces screen text) (Luger, & Sellen, 2016), quality of speech recognition (Moore et al., 2016), lack of understanding on the part of the user regarding how to best utilize IPAs (Bopp, 2018; Cowan et al., 2017), and quality of the IPA-provided information along with its sources (Lei et al., 2017; Kreuser, 2018; Lopatovska et al., 2019).

A large number of IPA research examines users' privacy and security concerns with this technology. Some of the concerns are related to the design of IPAs that rely on recording and analysis of users' private conversations (Liao, et. al., 2019). Recent news about Amazon Alexa's unauthorized recordings, storage and analysis of user utterances (Day, Turner, & Drozdiak, 2019) suggest that users' mistrust in companies' abilities to handle data ethically is justified. Another privacy risk discussed by researchers is the possibility of an attack on IoT devices linked to IPAs (e.g. thieves can disable alarms or place unintentional online shopping orders by hacking into IPA devices, see Lei et al., 2017; Brenner, 2017).

Related to the privacy concerns are issues around social norms of having IPA conversations in public places. In a study of Alexa usage in a common area of an academic department, students avoided using the IPA and expressed concern about interrupting activities of other students by talking to Alexa (Lopatovska, & Oropeza, 2018). Similarly, Easwara and Vu (2015) found that people tended to avoid using voice input in public settings due to concerns regarding both privacy and socially acceptable behavior. This same finding was also produced by a study of smartwatch use (Efthymiuo, & Halvey, 2016). When users choose to engage with IPAs in a public setting, they often stick to information seeking (Porcheron et al., 2017).

A number of studies examine how users anthropomorphize IPAs, the trend that is hardly surprising considering that the IPAs have names, gender-specific voices, and can support simple short conversations, creating an impression of being "human". Lopatovska, Williams (2017) and Kiseleva et al., (2016) found that IPA users often express gratitude and greetings towards the software, or do not want to hurt the IPA's "feelings" (Cowan et al., 2017). Luger and Sellen (2016) study participants found Siri responses "sassy" and sarcastic, attributes that would usually be associated with a human personality. The study involving children found that "some children [… felt a genuine, give-and-take relationship with the machines" (Botsman, 2017, p. 4). While anthropomorphizing of IPAs might help their adoption rates (Han and Yang, 2018), it is also associated with negative consequences. One such consequence is over-trust in this opaque technology. Users do not have a full understanding or much control over the

sources and/or quality of presented information. For example, step-by-step instructions on how to clean stains is offered by the Tide's Stain Remover skill (i.e., a built-in capability on Amazon Alexa); and Campbell sponsors a skill for recipes and shopping lists (Lei et al., 2017; Kreuser, 2018). In these examples, users do not usually question the quality of the information they receive from IPAs. Anthropomorphizing also often leads to high expectations for this technology, which in turn can lead to disappointment and abandonment (Bopp, 2018; Cowan et al., 2017; Kiseleva et al., 2016; Luger, & Sellen, 2016).

PROMISING LINES OF IPA RESEARCH IN THE UKRAINIAN CONTEXT

International research on IPAs is limited to the countries in which their language is supported by IPA platforms. The only Slavic language that is currently supported is Russian by a single IPA, Siri on Apple (and there is no extensive evidence of IPA research in this linguistic context). Ownership of hardware that hosts IPAs, awareness of this type of software and its functionality are impediments to IPA adoption. However, the increasing omnipresence of voice interfaces in all aspects of our lives, from the control of smart home devices to automobiles, makes gradual IPA adoption in Ukraine only a question of time and necessitates research in this area. A few promising lines of research come to mind:

1) Determining usage baseline by conducting studies on voice interface, and, specifically, IPA adoption and usage. Such studies can focus on answering whether Ukrainians use IPAs differently from users in other countries? What is the IPA adoption rate and why is the rate high/medium/low?

2) Determining requirements for IPA functionality for the Ukrainian market, identifying the needs of Ukrainian users and specifics on how they can be addressed.

3) Collaborating with IPA producers to support Ukrainian language functions of IPAs.

4) Testing IPA usage in public spaces, perhaps first within relevant linguistic context such asan English language library collection or foreign language classes in elementary schools. And as more support for the Ukrainian language is developed, other public and private settings could be considered.

While it would be tempting to finish this brief overview on the enthusiastic note, praising this emerging technology for its benefits to users, the reality is whether we like it or not (e.g., studies suggest that IPA-dedicated devices are often received as gifts and/or met with lukewarm reactions), voice interfaces are here to stay. The research on this technology in the Ukraine would be welcomed as it could inform Ukraine-centric IPA design features and smooth adoption of Ukrainian language voice interfaces.

REFERENCES

Bernstein, S. (2016, December 6). What can Alexa teach us about the Barnes? [Blog post]. Retrieved from https://medium.com/barnes-foundation/what-can-alexa-teach-us-about-the-barnes-21154d68700c#.v08qjcf4k.

Betters, E., & Grabham, D. (2018, February 6). Apple HomePod vs Google Home vs Amazon Echo: What's the difference? *Pocket-Lint*. Retrieved from https://www.pocket-lint.com/speakers/buyers-guides/139063-apple-homepod-vs-google-home-vsamazon-echo-what-s-the-difference.

Bogers, T., Al-Basri, A.A.A., Rytlig, C.O., Møller, M.E.B., Rasmussen, M.J., Michelsen, N.K.B., & Jørgensen, S.G.(2019). A Study of Usage and Usability of Intelligent Personal Assistants in Denmark. In N. G. Taylor, C. Christian-Lamb, M. H. Martin, & B. Nardi (Eds.), *Information in Contemporary Society*, 11420, pp. 79-90. doi: org/10.1007/978-3-030-15742-5_7.

Bopp, C. (2018). User experience with voice user interfaces – a diary study using Amazon Echo as an example [Blog post*]. Service Plan Blog*. Retrieved from https://serviceplan.blog/en/2018/01/study-voice-user-interfaces-amazon-echo.

Botsman, R. (2017). *Who Can You Trust?: How Technology Brought Us Together – and Why It Could Drive Us Apart*. Penguin UK.

Brenner, B. (2017, January 27). Know the risks of Amazon Alexa and Google Home. *Naked Security*. Retrieved from https://nakedsecurity.sophos.com/2017/01/27/data-privacyday-know-the-risks-of-amazon-alexa-and-google-home.

Canbek, N.G., & Mutlu, M.E. (2016). On the track of artificial intelligence: Learning with intelligent personal assistants. *Journal of Human Sciences*, 13(1), 592-601. doi: 10.14687/ijhs.v13i1.3549.

Chen, B. X. (2018, February 6). Apple's HomePod has arrived. Don't rush to buy it. *The New York Times*. Retrieved from https://www.nytimes.com/2018/02/06/technology/personaltech/apple-homepodreview.html.

Clauser, G. (2017). What is Alexa? What is the Amazon Echo, and should you get one? *The Wire Cutter*. Retrieved from http://thewirecutter.com/reviews/what-is-alexa-what-is-the-amazon-echo-andshould-you-get-one.

Cowan, B. R., Pantidi, N., Coyle, D., Morrissey, K., Clarke, P., Al-Shehri, S., Earley, D., & Bandeira, N. (2017) "What can I help you with?": Infrequent users' experiences of intelligent personal assistants. In: *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services (Mobile HCI '17), Vienna, Austria, 4-7 September 2017*. New York, NY: ACM Press. doi: 10.1145/3098279.3098539.

Creating IoT solutions with serverless architecture & Alexa [Figure 1]. (2017) Retrieved from https://www.slideshare.net/AmazonWebServices/creating-iot-solutions-with-serverless-architecture-alexa.

Crist, R. (2016, April 8). Amazon Alexa: Device compatibility, how-tos and much more. *CNET*. Retrieved from https://www.cnet.com/how-to/amazon-alexa-devicecompatibility-how-tos-and-much-more.

Crist, R. (2017, January 16). Amazon Echo Spot review: Alexa's touchscreen misses the sweet spot. *CNET*. Retrieved from https://www.cnet.com/reviews/amazon-echo-spotreview.

Day, M., Turner, G., & Drozdiak, N. (2019, April 10). Amazon Workers Are Listening to What You Tell Alexa [News]. *Bloomberg*. Retrieved from https://www.bloomberg.com/news/articles/2019-04-10/is-anyone-listening-to-you-on-alexa-a-global-team-reviews-audio.

Dunn, J. (2016, November 4). We put Siri, Alexa, Google Assistant, and Cortana through a marathon of tests to see who's winning the virtual assistant race – here's what we found. *Business Insider*. Retrieved from http://www.businessinsider.com/siri-vs-google-assistant-cortana-alexa-2016-11.

Easwara, M. A., & Vu, K. P. L. (2015). Privacy concerns for use of voice activated personal assistant in the public space. *International Journal of Human-Computer Interaction* 31(4), 307-335.

Efthymiou, C., & Halvey, M. (2016). Evaluating the social acceptability of voice-based smartwatch search. In S. Ma, et al. (Eds.) *Information Retrieval Technology. AIRS 2016. Lecture Notes in Computer Science* (Vol. 9994, pp. 267-278). New York: Springer.

Flanagan, E. (2016, December 26). Using the Amazon Echo Dot and Alexa in the classroom [Blog post]. Retrieved from https://www.erintegration.com/2016/12/26/amazon-echo-dot-and-alexa-in-the-classroom.

Graus, D., Bennett, P. N., White, R. W., & Horvitz, E. (2016). Analyzing and predicting task reminders. In *Proceedings of the 2016 Conference on User Modeling Adaptation and Personalization (UMAP '16)* (pp. 7-15). New York, NY, USA: ACM. doi: 10.1145/2930238.2930239.

Kiseleva, J., Williams, K., Jiang, J., Awadallah, A. H., Crook, A. C., Zitouni, I., & Anastasakos, T. (2016). Understanding user satisfaction with intelligent assistants. In *Proceedings of the 2016 ACM on Conference on Human Information Interaction and Retrieval (CHIIR '16), Chapel Hill, NC, 13-17* (March 2016, pp.121-130). New York, NY: ACM Press. doi: 10.1145/2854946.2854961.

Kreuser, A. P. (2018, February 12). Here's how 5 huge brands are marketing to you through Amazon Alexa. *Inc.* Retrieved from https://www.inc.com/amanda-pressnerkreuser/heres-how-5-major-brands-are-marketing-to-you-through-amazon-alexa.html.

Lei, X., Tu, G. H., Liu, A. X., Li, C. Y., & Xie, T. (2017). The insecurity of home digital voice assistants – Amazon Alexa as a case study. Retrieved from https://arxiv.org/abs/1712.03327.

Liao, Y., Vitak, J., Kumar, P., Zimmer, M., & Kritikos, K. (2019). Understanding the Role of Privacy and Trust in Intelligent Personal Assistant Adoption. In N. G. Taylor, C. Christian-Lamb, M. H. Martin, & B. Nardi (Eds.), *Information in Contemporary Society 11420*, 102-113. doi: org/10.1007/978-3-030-15742-5_9.

Lopatovska, I., Griffin, A., Gallagher, K., Ballingall, C., Rock, C., & Velazquez, M. (2019). User recommendations for intelligent personal assistants. *Journal of Librarianship and Information Science.* Advance online publication. DOI: 10.1177/0961000619841107.

Lopatovska, I. & Oropeza, H. (2018). User Interactions with "Alexa" in Public Academic Space. Paper presented at the Annual Meeting of the Association for Information Science and Technology, November 9 – 14, 2018, Vancouver, Canada.

Lopatovska, I., Rink, K., Knight, I., Raines, K., Cosenza, K., William, H. … Martinez, A. (2018). Talk to me: exploring interactions with the Amazon Alexa. *Journal of Librarianship & Information Science.* Advance online publication. doi: 10.1177/0961000618759414.

Lopatovska, I., & Williams, H. (2018). Personification of the Amazon Alexa: BFF or a mindless companion?. Proceedings from *ACM CHIIR conference, New Brunswick, NJ USA, March 11-15, 2018 (CHIIR'18)*, 4 pages. doi: 10.1145/3176349.3176868.

Luger, E., & Sellen, A. (2016). "Like having a really bad PA": The gulf between user expectation and experience of conversational agents. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16), San Jose, CA, 7-12 May 2016* (pp.5286-5297). New York, NY: ACM Press. doi: 10.1145/2858036.2858288.

Moore, S., Pan, D., & Engineer, M. (2017, January 26). A case study on using voice technology to assist the museum visitor. MW17: MW 2017. Retrieved from https://mw17.mwconf.org/paper/a-case-study-on-using-voice-technology-to-assist-the-museum-visitor.

Nguyen, C. (2016, June 7). Bringing voice technology to healthcare: Hacking with Amazon's Alexa Vector [Blog post]. Retrieved from https://vector.childrenshospital.org/2016/06/bringing-voice-technology-healthcare-hackingamazons-alexa.

Pradhan, A., Mehta, K., & Findlater, L. (2018). "Accessibility came by accident": Use of voice-controlled intelligent personal assistants by people with disabilities. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). Montréal, Canada, 21-26 April 2018*. New York, NY: ACM Press. doi: 10.1145/3173574.3174033.

Pew Research Center. (2017, December 12). Voice assistants used by 46 % of Americans, mostly on smartphones. *Fact Tank.* Retrieved from https://www.pewresearch.org/fact-tank/2017/12/12/nearly-half-of-americans-use-digital-voice-assistants-mostly-on-their-smartphones.

Shoot, B. (2018). St. Louis University Installs Amazon Echo Dots Campus-Wide. Retrieved from http://fortune.com/2018/08/15/amazon-alexa-echo-back-to-school-dorm-room.

Sörenson, I. (2017). Expectations on chatbots among novice users during the onboarding process. *KTH Royal Institute of Technology, School of Computer Science and Communication*. Retrieved from http://kth.divaportal.org/smash/record.jsf?pid=diva2%3A1078272&dswid=6048.

Welch, C. (2018). Amazon made a special version of Alexa for hotels that put Echo speakers in their rooms. *The Verge*. Retrieved from https://www.theverge.com/2018/6/19/17476688/amazon-alexa-for-hospitality-announced-hotels-echo.

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Ірене Лопатовська,
доцент Школи інформації Інституту Пратта,
доктор філософії в галузі інформаційних наук
(Нью-Йорк, США)
e-mail: ilopatov@pratt.edu
ORCID: https://orcid.org/0000-0001-7322-9461

ОГЛЯД ЦИФРОВИХ ІНТЕЛЕКТУАЛЬНИХ ПЕРСОНАЛЬНИХ ПОМІЧНИКІВ

Стаття присвячена огляду технології цифрових інтелектуальних персональних асистентів (ІПА, також відомих як розмовні агенти, розумні спікери, цифрові / інтелектуальні персональні помічники або голосові агенти). Розглянуто основні технічні функції таких програм, як Google Assistant, Amazon Alexa, Microsoft Cortana, Apple Siri, а також випадки їхнього використання в приватному і громадському середовищах. Представлені, також, тенденції дослідження ІПА та ідеї для дослідження ІПА в українському контексті.

Ключові слова: інтелектуальні персональні помічники, розмовні агенти, голосові інтерфейси, розумні спікери, цифрові персональні помічники, взаємодія людини з комп'ютером, прийняття технології.