New Channels, New Possibilities: A Typology and Classification of Social Robots and Their Role in Multi-channel Public Service Delivery

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Abstract. In this contribution we discuss the characteristics of what we call the fourth generation of public sector service channels: social robots. Based on a review of relevant literature we discuss their characteristics and place into multi-channel models of service delivery. We argue that social robots is not one homogenous type of channels, but rather breaks down in different (sub)types of channels, each with different characteristics and possibilities to supplement and/or replace existing channels. Given the variety of channels, we foresee challenges in incorporating these new channels in multi-channel models of service delivery. This is especially relevant given the current lack of evaluations of such models, the broad range of channels available, and their different stages of deployment at governments around the world. Nevertheless, social robots offer an potentially very relevant addition to the service level landscape.

Keywords: Multi-channel management · Social robots · Service channels · eGovernment · Service delivery

1 Introduction

The public sector service channel landscape has been in continuous movement since the 1990s. Currently a new generation of service channels is arriving: social robots fueled by artificial intelligence [1–4]. Not only do new channels arrive (such as conversational bots), we could also see a large degree of robotization of existing types of service channels, such as the telephone being replaced by conversational robots. The impact of this change could be large. Estimates suggests that sophisticated algorithms could substitute for approximately 140 million full-time knowledge workers worldwide and computers increasingly challenge human labor in a wide range of cognitive tasks [5]. The message seems clear; a new generation of service channels is arriving and could impact the current way channels are utilized by governments. But how exactly? What is the nature of these social robots and how will they fit into the multi-channel service delivery mix? These are important questions for several reasons. The first is cost. An increasing number of channels also leads to an increase in costs. Every single channel requires a specific

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technical infrastructure and resources [6]. Examples of these resources are staff, staff training and the branding of the channel to match the identity of the organisation. The second is quality of services and making sure the right services are delivered to the right citizens using the right channel. Scholars [7] argue that certain channels are suited for certain types of services, but this suitability may vary for different types of citizens. Lastly, although scholars and practitioners argue that electronic channels supplement, rather than replace traditional channels, the interplay between traditional and e-government channels remains to be explained [8]. We also need to determine how newer generations of service channels interact with existing channels and how these interactions impact the evaluations and success of public service delivery. This exploratory paper aims to find an answer to three interrelated questions:

1. What exactly is this new generation of social robot channels?
2. What are the characteristics of these channels regarding service delivery?
3. What is the position of these channels in the (multi-)channel mix?

The answers to these questions can help practitioners who wish to start incorporating new types of channels. Furthermore, this paper aims to set the agenda for future studies on the role and position of newer generations of service channels. This paper starts with a discussion of the various generations of service channels up until now. We briefly discuss the rise of previous generations of service channels and the properties of the various types of channels, as well as their position within existing frameworks for multichannel service delivery. Lastly, we discuss some (research) challenges regarding social robots as new channels.

2 Generations of Service Channels

The landscape of service channels has undergone significant changes in the past three decades. Traditionally (before the 1990s), most public services were dealt with in person, using the mail, via the phone [9]. The three channels of phone, mail and in-person (a.k.a. front desk or face-to-face) have been labeled as the 'traditional' service channels to separate them from the new 'electronic' service channels [7] that started to appear in the 1990s. We would argue that the utilization of the internet and advances in technology have led to several (partially overlapping) phases of electronic channel evolution. Table 1 summarizes these phases.

Phase 1 started in the 1990s with the widespread adoption of internet technologies. Even though the internet has been around since the 1960s [10], the widespread adoption of the technology did not happen until the 1990s. The first set of channels based on internet technology (websites and email) were hailed by many as bringing significant opportunities for governments to improve both the quality of service delivery, as well as reduce its cost [11]. This led to the first generation of electronic channels becoming leading in many government service strategies.

Table 1. Overview of generations of channels.

G	Period	Label	Alternative(s)	Example channels
0	<1990s	Traditional	–	In-person, telephone, mail
1	1990s	Electronic	Digital	Website, email
2	2000s	Social	Social media, Web 2.0, Government 2.0	Social media (e.g. social networking sites, (micro-)blogging, wikis)
3	2010s	Mobile	M-Government	Smartphones, responsive sites, mobile apps
4	2020s	Robot	(Social) Robots, Robotization	Social & conversational robots, artificial intelligence, virtual intelligence

As the internet matured, the capabilities of the infrastructure increased and new channels were developed. This gave rise to a second phase of electronic channels, which we label as social channels or alternatively Web2.0 [12]. This Web 2.0 consists of new platforms for interactions characterized by extensive input from citizens, for example in the integration of knowledge and co-production of web services. Once again, we witnessed hopeful views on how a Government2.0, based on Web2.0 would be beneficial [e.g. 14]. As a result, many governments started using social media or other Web2.0 technologies to communicate with their citizens. A study in the Netherlands [15], for example, found that all municipalities were active on Twitter, about 90% on Facebook and about 60% on YouTube in 2015.

Even though many governments are not active on every kind of social channel, yet another generation of channels appeared. Since the arrival of mobile phone technologies in the 1990s governments have been working on "M-government" initiatives [c.f. 16], for example via SMS messages. Fueled by the increased capabilities of wireless infrastructures and the invention of smartphones in the late 2000s, even more service channel opportunities were developed, such as special mobile websites, adaptive websites and dedicated mobile apps.

So far, we have seen that we can distinguish between different phases in the development of different (government) service channels. At the time of their arrival, they were all hailed as offering great new possibilities to improve service delivery. Lastly, in all cases governments, as well as their citizens started adopting these channels, albeit at different paces. Regarding the first generations of electronic channels it seems that saturation in the adoption by governments in most (Western) countries has been achieved [17], although the degree to which services are fully interactive and integrated [11] varies. The second and third phases are still in progress in most countries, with the adoption of mobile apps by governments being still relatively in its infancy. However, we believe a new –fourth– generation of electronic channels, one driven largely by artificial intelligence and robotization is now arriving. In the next section, we will discuss the characteristics of this fourth generation in detail.

3 The Fourth Generation of Electronic Channels

While the first generation of electronic channels was fueled by internet technologies themselves, the second generation was fueled by broadband internet and the increased technological capabilities of the internet technologies; the third generation was fueled by advances in wireless technologies and wireless broadband. The fourth is driven by advances in artificial intelligence that allow in part for the automation or robotization of existing channels and in part the creation of a new set of channels.

Artificial intelligence (AI) in its broadest sense is a field attempting to understand intelligent entities [18]. Therefore, one of the main goals of AI is to create technologies that are smart enough to think and act like humans. In practice, AI is used to create smarter technologies that can make decisions or support decision making.

The term artificial intelligence itself is by no means a new concept. The phrase "artificial intelligence" was coined in 1956 at a conference in Dartmouth [19]. However, it was not until recently that artificial intelligence matured. Real world examples of AI are smart assistants (such as Apple's Siri) and self-driving vehicles. What all these technologies have in common is that artificial intelligence is the 'engine' that enables intelligent robots to supplement or replace humans in a wide range of activities.

The development of robots to replace human labor is in itself nothing new. The emergence of real robots dates from 1954 when George Devol and Joe Engleberger created the first industrial robots. By 2008, the world robot population was estimated at 8.6 million, the same as the state of New Jersey. This number includes 7.3 million service robots compared and 1.3 million industrial robots [20].

Most of these existing robots are being used for relatively simple, boring, dangerous or dirty tasks [21]. There are obvious reasons for this. Many routines tasks (such as welding components in a car factory) are easiest to robotize and since robots know no emotions, it was obvious that they were deployed first for tasks that humans perceive as being dangerous or dirty (such as defusing bombs). However, as robots' capabilities evolve, it becomes possible that they are able to execute more and more complicated tasks [2]. Several experts expect that that within the next two decades robots will be as commonplace as computers are right now [22].

Various types of classifications for robots exist. For example, we can distinguish between certain types of "assistive social robots" [23]. "Service-type" robots serve such purposes as helping elderly persons dress, bathe, eat, move around, etc. "Companion-type" robots play a more therapeutic role by interacting with seniors in order to stimulate their emotional and physical health. Bainbridge et al. make another important distinction for communication purposes, namely the difference between physical and virtual robots [24]. This distinction can have important consequences for the quality of the communication interaction. For purposes of this paper, we focus on a special class of robots, namely social robots. There are two types of definitions of social robots. In one type the social interactions among robots themselves are emphasized [e.g. 4]. The second type, and our focal point, is on the social interactions between humans and robots. This type of social robot can be defined as *"an autonomous or semi-autonomous robot that interacts and communicates with humans by following the behavioral norms expected by the people with whom the robot is intended to interact"* [25].

Within this definition, it is possible to distinguish between different types of social robots. For example, following our discussion above, we can distinguish between social robots that are physically present versus those that are completely virtual. For the context of service delivery, we distinguish between three types or classes of social robots; (1) Software agents, (2) Virtual and virtuality enhancing robots, and (3) Physical social robots. The difference between the three stems from their nature and the degree to which they represent a physical reality. Software agents live completely in the background and feed into existing channels. For example, a human agent having chat/IM conversations with citizens could be replaced by a software agent. The service experience changes very little and the impact of the robot is mostly in the back-office. Virtual and virtuality enhancing robots change reality or create new realities, without being tangible. The two channels here are virtual and augmented reality. In contrast to software agents they do affect the front-office design and experience more elaborately. Lastly, physical social robots have a physical presence. They are physical entities that interact with humans either taking a human (humanoid or android) shape or a non-human shape. This physical presence creates, as we will see below, possibilities to move around as well as exploit the physical features to enhance or enrich the service encounter. Below we will discuss each type and sub-type briefly.

3.1 Software Agents

The first type consists of so-called software agents. These agents can be defined as "a self-contained, autonomous software module that performs assigned tasks from the human user and interacts/communicates with other applications and other software agents in different platforms to complete the tasks" [26]. The key characteristic, from our point of view, of these software agents lies in the notion that they (a) exist in software form only, (b) they support users with certain tasks and/or (c) complete tasks assigned by the user. For example, chat software can respond to user inquiries and intelligent agents (such as Apple's Siri) can complete tasks assigned by users such as making appoints). For the purpose of service delivery and in line with the literature on characteristics of service channels [27], we can sub-divide the broader class of software agents into three possible service channels:

Chat bots are software agents that focus on written/text language. This is very similar to existing chat or email channels, but with the human agent in the back office replaced or supported by software modules that respond to inquiries.

Conversational bots focus on spoken language and as such offer an alternative to telephone interactions. Conversational bots are more complicated to realize than chatbots based on the more complicated nature of emulating speech. These conversational bots could be used in customer contact centers to respond to questions or help citizens solve ambiguous or complex problems.

Intelligent agents. The last type of software agents integrates chat and conversational bots into one system that can respond to inquiries or execute tasks. Several of these intelligent agents are currently on the market and the most well-known examples are Apple's Siri, Microsoft's Cortana and Google's Assistant. These intelligent agents react to spoken or typed commands and integrate tightly with existing systems.

Intelligent government agents could, for example, support citizens with any transactions they need to complete (e.g. pay parking tickets, file taxes) or find relevant information on government websites about certain topics.

3.2 Virtual and Virtuality Enhancing Robots

Virtual and virtuality enhancing robots are the second type of social robots. A key characteristic of virtual and virtuality enhancing robots is that they create a visual output based on imagery. This can take one of two forms: (1) it can be an augmentation of reality or (2) it can be a new version or virtualization of an existing reality. While these two types of augmented and virtual reality have this 'graphic' nature in common. They differ in key areas. Augmented reality differs from virtual reality in that "in a virtual environment the entire physical world is replaced by computer graphics, AR enhances rather replaces reality" [28]. We will discuss both briefly.

Augmented reality (AR) was first coined as a concept in the year 1992 [29] and is said to have three key goals: (a) create virtual references between reality and virtuality, (b) augment or enhance this virtual experience in real time and (c) create (real-time) interactivity between the virtual world and the real world. While the concept has been around since the 1990s and has seen some practical use (e.g. in cockpits), it was not until recently that many started talking about the broader societal adoption of augmented reality, fueled by tech demonstrations of (for example) Microsoft's HoloLens and previously Google Glass. Augmented reality could enhance public service encounters. For example, citizens could experience how new constructions would change their current streetscape (and better thus participate in the decision making process). During in person interactions, augmented reality could hypothetically be used to display key components of the spoken conversation creating additional communication cues that could enrich the communication.

Virtual reality (VR) can be defined as an immersive interactive multimedia and computer-simulated reality that can digitally replicate an environment [based on 30]. As such, one of the key goals of virtual technology development is to realize and improve the experience of telepresence [31]. This creates possibilities for public services in several ways. For example, in the design and participation processes of public (construction) processes, virtual reality can be used to show new construction where nothing currently exists and thus get input from citizens. In personal service encounters, virtual reality could be used to emulate a service environment for people who are unable to travel to service desks for personal contact. This could lead to better quality services for several segments of the civil population.

3.3 Physical Social Robots

The third and final class of social robots consists of those robots with a physical appearance. These types of robots have been around for a number of decades. Especially, as receptionists and office companions physical social robots are becoming increasingly popular [32]. We can also break physical social robots down into several sub-types: Non-Humanoid Robots and Humanoids. Main difference in the context of service

delivery between the two is that the human resemblance of humanoids could potentially create a "richer" communication experience.

Non-humanoids are robots that take the shape of any object or animal, as long as it does not resemble a human being. Sony's Aibo "robodog" launched in 1999 is a well-known example of a non-humanoid. These non-humanoids could be used in public service settings where little to no communication is involved and where the ambiguity [7] of the communication process is low. For example, non-humanoids could guide visitors to their proper location in governmental buildings and serve as mobile versions of interactive booths or kiosks where citizens can complete self-service tasks.

Humanoids or also called Androids are robots that take a human like physical form. As such, they can emulate human-esque conversation styles and include aspects of human behavior such as body language. This addition potentially provides a very rich communication experience, especially since it comes to more emotional, personal topics or issues with high levels of ambiguity. Research choice that people tend to choose channels that offer many (communication) cues when services are more personal, more emotional and more ambiguous [27]. At the same time do research findings show that humans treat computers—and consequently robots—as social entities [33] or people [34], supporting the argument that humanoids could play an important role in emotional, personal and ambiguous social service encounters akin to the aforementioned "Companion-type" robots used in care settings. From that perspective, humanoids could even fulfill an important role in lessening emotional burdens on service agents that deal with emotional citizens struggling with complex problems.

4 Characteristics of Intelligent Channels

One of the obvious key questions regarding these new channels is what their characteristics are and how they can be used in service delivery processes. This can help us understand how they can be used in service delivery processes and to what extent these channels could replace existing service channels. Currently no complete overview exists comparing intelligent channels with each other and/or to other channels. In general terms Norman [35] compares the differences between robots and people and focuses mostly on the degree to which people and robots differ in terms of creativity, logical thinking, level of organization, etc. This comparison does not, however, include a diverse set of intelligent channels. More complete comparisons of channels do exist. Wirtz and Langer [6], for example, compare some 15 channels (comprising all channels from generations 0–3) on their cost benefit ratio, communication capability and service provision capacity. However, this model does not include any of the fourth generation channels and it is not granular enough for our purposes because it assumes that 'service provision capacity' is a one dimensional property. We follow the line of communication scholars [36] and previous multi-channel studies [7] that argue that services have multiple properties (for example in terms of the levels of ambiguity and complexity of the service) and different types of services require different types of channels. More comprehensively, van Dijk [37] reviews numerous theories that deal with characteristics of media or channels, and

presents his model of "communication capacities" based on these theories. However, this model also does not include any of the new intelligent channels.

Since no complete overviews comparing the characteristics of intelligent channels exist, we propose such an overview ourselves, based on existing publications. We include in our overview several key characteristics of channels, such as the speed of the interaction, the ease of use and their stimulus richness (or communication capacity). This stimulus richness has been linked to the ambiguity of services [7] as well as emotional and personal aspects of public service delivery [27]. Furthermore, and building on this, in terms of channel/service fit, we include the ability to reduce complexity and ambiguity [7]. Lastly, we include how these channels could supplement existing channels in the short term and potentially replace channels in the long term. At present we do not believe any of the channels are ready to replace any channels in full, let alone replacing humans with robots that are (deservedly or not) perceived as autonomous, responsive, artificial beings that are able to perform complex tasks. This might change in the long term where intelligent channels could replace (human fueled, yet similar) channels (but where there might still be some kind of human back up or fall back option).

One of the defining characteristics of the intelligent channels is the higher level of stimuli richness, compared to most other electronic channels from the first, second and third generation. For example, an intelligent assistant who has access to personal information could allow for a highly personalized conversation with high levels of language variety using both written and oral cues. As such, many of these channels potentially offer greater capabilities to reduce ambiguity in many service delivery processes. We see this as one of the greatest general opportunities of social robots in terms of improving service delivery processes as currently the more expensive telephone and in-person channels are being used to reduce ambiguity [7].

We do need to stress though that, while it may come across as such, we do not intend to present this table as a fixed and rigid overview of characteristics of channels. For example, the media richness perspective, on which we draw in our assessment of the stimuli richness, has been criticized for being too rigid in assigning characteristics to media, while in reality the richness of a certain channel is fluid and depends such factors as the experiences of the communicators and the specific context in which the communication takes place [see e.g. 27, 38].

5 Integration in Multi-channel Models

The last relevant question is what the place of the new fourth generation should be in the channel mix offered by government organizations. In this section, we discuss the extent to which new channels fit existing models (Table 2).

Table 2. Characteristics of social robots.

Property	Software agents			Virtual and virtuality enhancing robots		Physical social robots	
	Chat bots	conversational bots	Intelligent assistants	AR	VR	Non-humanoid Robots	Humanoids
Speed/ interactivity	Medium	High	High	Medium	Medium	Medium	High
Ease of use	High	Med/High	Med/High	Low/Med.	Low/Med.	Low/Med.	
Stimuli richness	Low	Medium	Medium	High	Med/High	Medium	High
Ability to reduce complexity	Med/High	Med/High	High	Medium	Medium	Medium	Medium
Ability to reduce ambiguity	Medium	High	High	High	High	Medium	High
Short term channel supplement/ long term replacement	Chat, Email	Telephone	Chat, Email, Telephone, Social Media, Apps, Website	Front Desk, Telephone	Front Desk, Telephone,	Front Desk	Front Desk

Note: This overview and assessment is based on the current and near future capabilities of these channels. Obviously, their capabilities and capacity for service delivery will evolve in the future.

Several models combine properties of service channels and how these channels can be positioned to deliver certain services to certain citizens (or businesses) [see e.g. 6, 7, 39, 40]. These models differ in their focus on different aspects of multi-channeling. In that sense, the three models have complementary value. However, the models share a number of drawbacks in relation to social robots. The first is that none of the models includes robots as channels. Secondly, no model includes mechanisms or facilities on how to assess or implement the replacement or compliment of new to existing channels. Thirdly, all different models see the existing channels as discrete entities with a (fixed) set of properties. This could create problems for social robot channels that very often combine properties of different existing channels, which may evolve over time as the underlying artificial intelligence improves. For example, does the capability of a humanoid social robot to reduce ambiguity change as the humanoid becomes more human and is able to increase its 'richness' [36] by evoking more natural language? Related to this change, is the response and the responsiveness of humanoids perceived as more or as less sincere and as more or as less autonomous than that of human beings? And more importantly, how do these perceptions relate to the perceived problem solving and perceived ambiguity decreasing capacity, thus influencing the replacement capacity of a robot related channel?

As such, the role of social robots within multi-channel service delivery seems promising given their characteristics, but their fit in the current channel strategies seems unclear. None of the existing multi-channel models seem well equipped to incorporate the fourth generation of electronic channels, let alone any future new channels. This is even more problematic given the realization that even now we lack

insights on the effectiveness of existing channel strategies. Dawes [41] argues that in the literature there is a low emphasis on the "the substantial impacts of a multitude of service channels on the organization". Gagnon et al. posit that ¨multi-channel public delivery services has not been covered in the literature […] in such depth¨ [40]. So, if the literature gives us little guidance on the current state of the art, how are we to deal with upcoming developments?

6 Conclusions and Discussion

In this paper we focused on the arrival of a new 'generation' of service channels; social robots. These social robots are different from previous generations of service channels in that they are fueled by artificial intelligence. Compared to older generations of channels this allows for richer service experiences which, in certain cases, could offer experiences similar to human interactions. This leads to the possibility that intelligent channels could replace traditional human channels. One of the features of these intelligent channels is that they create the possibility to reduce ambiguity, which until now has been a dominant feature of telephone and in-person channels.

In this, it is important to realize that robots do not form one homogenous channel but break down in several types of service channels with different characteristics. Based on these characteristics we argue that these social robots (a) offer the possibility to supplement several of the existing channels thereby (potentially) improving service delivery and lessening the burden on the organization and its (human) agents, (b) in the future may replace some of the existing channels as (amongst others) the artificial intelligence behind these channels improves sufficiently and (c) could create new service channel opportunities that currently do not exist.

The position of social robots in the multi-channel mix is rather unclear. As we argued above, social robots is a collection of channels that all have different opportunities that could potentially supplement or replace existing channels. They are better suited to reduce ambiguity than most other channels. However, currently no multi-channel models exist that integrate social robots and no studies exist comparing social robots to other generations of channels in terms of their effectiveness and efficiency in public service delivery settings. As such, both more theoretical and empirical work is needed in this area.

Furthermore, while several governmental agencies may already be using robots and looking to implement them, most governments are still working on the successful implementation of channels from the third, second, and perhaps even the first generation of electronic channels. As such, organizations may be working on channel strategies based on many different channels, all with different characteristics and –technical and organizational– requirements. It is not hard to imagine that this turns the management of this multitude of channels into a complicated affair. This leads to a word of caution to organizations wanting to start using social robots to make sure the organization is 'ready' to start working with these channels.

Lastly, every single generation of channels is being heralded as offering great opportunities to improve service delivery and reduce costs. With the field evolving so rapidly it is doubtful whether the potential of each single generation of channels has been realized. While we have no studies available testing the hypothesized benefits of each generation of channels, we do have some information about the digitalization of government in the past 20 years in general, which so far has not been very successful [42]. Thus, while we are hopeful about the possibilities of social robots for service delivery, we also urge the field to temper any optimism and first explore the theoretical and practical aspects of social robots in terms of achieving organizational goals.

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