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Transforming the communication between citizens and government through AI-guided chatbots

Aggeliki Androutsopoulou[a,*], Nikos Karacapilidis[b], Euripidis Loukis[a], Yannis Charalabidis[a]

[a] University of the Aegean, Department of Information and Communication Systems Engineering, Gorgyras and Palama 2, Karlovassi 83200, Samos, Greece
[b] University of Patras, Industrial Management and Information Systems Lab, Department of Mechanical Engineering and Aeronautics, 26110 Patra, Greece

A B S T R A C T

Driven by 'success stories' reported by private sector firms, government agencies have also started adopting various Artificial Intelligence (AI) technologies in diverse domains (e.g. health, taxation, and education); however, extensive research is required in order to exploit the full potential of AI in the public sector, and leverage various AI technologies to address important problems/needs. This paper makes a contribution in this direction: it presents a novel approach, as well as the architecture of an ICT platform supporting it, for the advanced exploitation of a specific AI technology, namely chatbots, in the public sector in order to address a crucial issue: the improvement of communication between government and citizens (which has for long time been problematic). The proposed approach builds on natural language processing, machine learning and data mining technologies, and leverages existing data of various forms (such as documents containing legislation and directives, structured data from government agencies' operational systems, social media data, etc.), in order to develop a new digital channel of communication between citizens and government. Making use of appropriately structured and semantically annotated data, this channel enables 'richer' and more expressive interaction of citizens with government in everyday language, facilitating and advancing both information seeking and conducting of transactions. Compared to existing digital channels, the proposed approach is appropriate for a wider range of citizens' interactions, with higher levels of complexity, ambiguity and uncertainty. In close co-operation with three Greek government agencies (the Ministry of Finance, a social security organization, and a big local government organization), this approach has been validated through a series of application scenarios.

1. Introduction

Artificial Intelligence (AI) techniques have been extensively used to support and enhance the quality of decision making and problem solving in different industries for many years. This is through the exploitation of various types of machine intelligence, including natural language comprehension, robotics, expert systems, neural networks and machine learning (Buzzle, n.d.; William, Schatsky, & Viechnicki, 2017). Admittedly, the most rising AI trend in the private sector nowadays concerns the utilization of applications that interact with users in a conversational format and mimic human conversation, known as "conversational agents", "chatbots" or simply "bots" (Abu Shawar & Atwell, 2007; Klopfenstein, Delpriori, Malatini, & Bogliolo, 2017; Poola, 2017). Chatbots are intelligent agents (defined as devices that perceive their environment and take actions that maximize their chance of success at some goal (Russell & Norvig, 2009), which have the ability to understand a spoken language and use speech communication as user interface. They consist of a specific AI-based software category developed by companies to automate communications and management of transactions with their customers. Indicative applications of chatbots in the private sector include the implementation of virtual assistants (e.g. Siri, Alexa, Google now, Cortana) in various sectors, such as banking (implementing transactions), media (news provision), tourism (booking hotels or tickets), retail, stock market, insurance, gaming agencies, telecommunications, etc. (Business Insider, 2017; Dole, Sansare, Harekar, & Athalye, 2015; Lokot & Diakopoulos, 2016; Poola, 2017; Zsarnoczky, 2017). The first generation of chatbots has limited capabilities allowing them to respond to simple rule-based queries; however, due to recent AI advancements and the abundance of available data, chatbots can now perform more complex tasks and even complete proactive transactions.

Motivated by the efficiency gains reported by private sector firms, AI technologies have also started being adopted by government agencies to take on significantly complex tasks in diverse domains, e.g. health, social welfare, public safety, taxation, and education (Business Insider, 2016; Capgemini, 2017; Kerly, Hall, & Bull, 2007; Mahdavi & Shepherd, 2004). A recent report by Harvard identifies 6 types of government problems, for which AI applications are considered as highly appropriate: resource allocation, large datasets, experts shortage, predictable scenarios, procedural and repetitive tasks, diverse data aggregation and summarisation (Mehr, 2017). A lot of benefits of AI applications in the public sector are broadly reported, namely cost savings, alleviation of public servants' workload, increase of productivity, creation of new employment

* Corresponding author.
E-mail addresses: ag.andr@aegean.gr (A. Androutsopoulou), karacap@upatras.gr (N. Karacapilidis), eloukis@aegean.gr (E. Loukis), yannisx@aegean.gr (Y. Charalabidis).

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opportunities, solution of resource allocation problems, public service delivery and improvement of citizens' satisfaction (through personalisation and 24/7 availability) (Capgemini, 2017; Eggers. William et al., 2017; White House, 2016). In particular, chatbots and other types of AI solutions (e.g. machine learning algorithms, process automation and image recognition software) can significantly reduce the administrative burden of public organizations and advance the communication between government and citizens within the provision of public services, which has been problematic for a long time.

Despite these initial benefits, the adoption of chatbots in the public sector delineates a new research domain posing a series of challenges regarding the exploitation of AI capabilities and their contribution in public services delivery. For instance, a well-known challenge in developing AI applications concerns the extraction and representation of the expertise needed to develop their knowledge base. This challenge gets higher in the public sector, where both governmental experts' knowledge and a multitude of data (legislative, operational) have to be codified into a format that can be machine-exploitable. Data quality has also to be ensured through efficient management, structuring and aggregation of diverse data. Schoemaker and Tetlock (2017) suggest a hybrid approach, combining both humans and computers to reach the so-called 'superior judgements', as a means to address the lack of broader and contextual intelligence of humans in AI solutions. In addition, it should be noted that a number of ethical and social barriers impede the adoption of AI technologies in the public sector, mainly rooted in the opposition on the replacement of employees by machines and the lack of citizens' trust on machine intelligence (Capgemini, 2017; Centre for Public Impact, 2017).

This paper attempts to contribute to overcoming these challenges by proposing a novel approach for the advanced exploitation of chatbots in the public sector towards addressing a crucial issue: the improvement of the communication between government and citizens. It enables the development of a new, 'richer', more expressive and intelligent digital channel of communication between citizens and government, in everyday natural language, for both information seeking and transactions conducting purposes; this new digital channel will be appropriate for a wider range of citizens' interactions, with higher levels of complexity, ambiguity and uncertainty, than the existing digital channels (see section 2.1). Therefore, the main research objective of this paper is:

> *"To develop a new digital channel for communication between citizens and government, based on advanced chatbots, which is characterized by higher 'richness' and 'expressiveness' than the existing ones, and is appropriate for more complex, ambiguous and uncertain interactions'.*

Section 2 provides the theoretical background for the development of the proposed approach, which relies on previous research on Media Richness Theory, and takes into account the state-of-the-art on the utilization of chatbots in the public sector, and the particular requirements in the public sector as far as information overload and cognitive complexity are concerned. The research method adopted in our study is discussed in Section 3. The instantiation of a 'rich' digital communication channel leveraging the chatbots technology through an ICT architecture incorporating different AI technologies is presented in Section 4. Particular emphasis is given to the inclusion of data and knowledge management services supporting the structuring of data in order to support more complex interactions. Section 5 validates the potential of the proposed approach, through an application scenario embedding AI in the delivery of public services by a Greek government agency. Finally, the last section of the paper outlines concluding remarks and future work directions.

2. Background

2.1. Media Richness Theory

The 'Media Richness Theory' (MRT) (Daft & Lengel, 1984, 1986) is one of the most widely recognized and used theories about communications channels, providing a useful association between the characteristics of a communication task to be performed with the characteristics of the communication channel to be used for it (communication task - channel fit). On the one hand, communication channels differ in their 'richness', with this term denoting their information carrying capacity; face-to-face communication is the communication channel with the highest richness (as it allows conveying multiple modes of information and cues with high levels of expressiveness), followed by the telephone communication and then the letters, the personally tailored reports and finally the impersonal ones (Lengel & Daft, 1989). On the other hand, communication tasks differ in the ambiguity, uncertainty and complexity of the message to be transmitted. According to the MRT, communication tasks in which highly ambiguous, uncertain and complex messages have to be transmitted, require communication channels with high richness, having high capacity of carrying multiple modes of information, and allowing high levels of expressiveness (Daft & Lengel, 1984; Lengel & Daft, 1989).

MRT has been extensively used in previous e-government research, in order to investigate and better understand an important e-government usage related paradox: why the citizens continue using to a significant extent the higher cost 'traditional channels' (such as face-to-face visits to government agencies' front offices, phone calls) for contacting government, making much lower use of the new lower cost digital channels, in comparison with the initial expectations (Ebbers, Jansen, Pieterson, & van de Wijngaert, 2016; Ebbers, Pieterson, & Noordman, 2008; Madsen & Kræmmergaard, 2015; Reddick & Anthopoulos, 2014). A recent literature review concerning citizens' channel choice for interacting with government (Madsen & Kræmmergaard, 2015) has concluded that the most widely used theoretical foundation in this research is the MRT, followed by the 'Channel Expansion Theory' (CET) (Carlson & Zmud, 1999) (which adds to the factors proposed by the MRT the levels of individuals' experience with some channels, which increases their 'perceived richness'). The main finding of this research was that part of citizens' interactions with government is simple, concerning mainly information seeking or conducting transactions of low complexity, ambiguity and uncertainty. For such transactions citizens tend to use the 'lower richness' digital channels (i.e. conduct search for the required information in web-sites, or conduct such transactions using relevant e-services), which have lower information carrying capacity than the traditional ones, and allow lower levels of expressiveness (e.g. the citizen can only enter some search keywords, or fill some fields in electronic transaction forms). However, another considerable part of citizens' interactions with government concerns information seeking or conducting transactions characterized by higher complexity, ambiguity and uncertainty. For these more demanding interactions, the above digital channels seem to be less appropriate, so citizens prefer to use the 'higher richness' traditional channels, mainly face-to-face visits to government agencies' front offices, as well as phone calls. These rich channels allow citizens to have conversations/consultations with experienced public servants, transmit to them more information about their specific situation, problem or need, and explain their details in depth, with higher levels of expressiveness (thus reducing ambiguity and uncertainty). This allows citizens to get the specific information they seek, or conduct the appropriate transactions correctly.

Therefore, previous research on citizens' channel choice for interacting with government has concluded that mainly the factors proposed by MRT determine the channels used by citizens for their interaction with government; it suggests that citizens use richer channels for interactions of higher complexity, ambiguity and uncertainty. So we have used the MRT as our theoretical foundation for this research (since the other theoretical foundation mentioned above, the CET, is not at channel-level but at individual-level): our research aims to develop a new digital channel for communication between citizens and government, which is characterized by higher 'richness' than the existing ones, enabling citizens to clearly describe their specific situations, problems

or needs in free text, using their everyday natural language (instead of just entering some search keywords, or filling some fields in electronic transaction forms), thus allowing higher levels of expressiveness; this is going to make this new digital channel appropriate for a wider range of citizens' interactions, with higher levels of complexity, ambiguity and uncertainty compared to the existing digital channels. For this purpose, we leverage AI technologies, and in particular those related to chatbots.

2.2. Chatbots in the public sector

As mentioned in the Introduction, a rising number of AI applications in government are related with the chatbots or conversational agents. Recent literature review suggests that chatbots are predominantly deployed on social media (especially Twitter) by government agencies, political parties and politicians, in order to serve mainly political purposes. They are used as a new way of political communication (Forelle, Howard, Monroy-Hernandez, & Savage, 2015), providing a window for both theoretical and policy-oriented discussions (Murthy et al., 2016), or as a means to influence public opinion and discourse (Suárez-Serrato, Roberts, Davis, & Menczer, 2016). They are also designed and programmed to intervene in Social Media discussion on policy topics, such as in a UK case where bots supported by heuristic methods were used to trace and provoke the Twitter discourse on energy demand reduction (Wilkie, Michael, & Plummer-Fernandez, 2015). In many cases, bots are used to shape the digital reputation of politicians through several means, such as by retransmitting their messages, creating trending topics, or augmenting the number of their account followers providing an illusion of popularity to their accounts (Forelle et al., 2015). Although Forelle et al. (2015) claim that in their case only a small portion of bots activity aimed to attack political opponents or spread misinformation, there exist cases where anti-government bots used to misrepresent the voters' preferences and their popularity, appeared to be just as active as pro-government bots (Sanovich, Stukal, Penfold-Brown, & Tucker, 2015). However, there is still little empirical evidence of the link between bots and political discourse, the material consequences of such changes, or how social groups react to bots.

As the public sector is seeking solutions to improve citizens' services and government functions, more sophisticated AI application cases have emerged, mainly targeted to automated information provision by governments. Virtual assistants (also known as 'digital representatives') responding to questions in human language have been adopted in various fields of governmental operations providing real-time access to information and support, such as in the delivery of civil protection and public safety, citizenship's security and immigration services, social welfare (e.g. taxation services) etc. (Capgemini, 2017). A recent study by Harvard identifies five types of chatbots' uses cases in the public sector (Mehr, 2017), namely: (i) answering citizens' questions, complaints and inquiries through automated AI-based customer support systems, (ii) searching in documents (including legal ones) and providing guidelines to citizens on filling forms, (iii) getting citizens' input and routing them to the responsible public administration office, (iv) translating governmental information, and (v) drafting documents with answers to citizens' questions. One of the major advantages of these virtual assistants is that they embed "supervised learning" algorithms, allowing them to continuously learn from their interactions with humans and improve the accuracy of the responses they provide (getting smarter and smarter). An additional category identified is "transparency bots", which aim to increase the transparency of governmental information development and provision, as they monitor and report on Social Media the contributions of governmental actors in Wikipedia (Ford, Dubois, & Puschmann, 2016).

The reported applications of AI in government are mainly focused on customer (citizens) service support through bots giving responses to simple queries of citizens and providing relevant information. Moreover, other types of AI solutions can enhance interactions of citizens with governments as well. User support can be advanced through recommender systems providing hints or suggestions based on machine learning algorithms and artificial argumentation for assisting citizens making choices (Atkinson et al., 2017; Chesñevar, Maguitman, & González, 2009). Data mining and machine learning applications are used to analyze big volumes of data in order to extract analytics and citizens' needs for improved traffic management, public health care management, disaster management, personalized education and in general services personalization and availability have been reported as key examples that improve public services' quality, reliability and accuracy (Capgemini, 2017). Apart from the added value in public service delivery, AI can contribute to more informed decision making. A report on AI and future government (Centre for Public Impact, 2017) identifies four not mutually exclusive capabilities of AI that can enhance public policy making processes: i)Predictive Analytics, ii) Detection, iii) Computer Vision (CV), and iv) Natural Language Processing (NLP). Predictive Analytics and detection employ machine learning methods (supervised and unsupervised) for the identification of patterns in historical data, which are being used for diseases prevention, prediction of criminal activities ("predictive policing"), detection of frauds in justice, as well as for providing insights useful in order to address complex policy problems in the financial sector (Athey, 2017; Kleinberg, Ludwig, Mullainathan, & Obermeyer, 2015). NLP is usually combined with data mining for extracting citizens' sentiment from text or multimedia content on and used for biometric identification, while CV is used for traffic control, medical diagnosis, fingerprinting matching and facial comparison. All of them can be combined with transformative technologies, such as Big Data, IoT, Sensors, Speech Recognition, etc., and exploit massive datasets produced by them. However, the applicability and success of all above described approaches, depends on multiple factors, such as the availability of open and not fragmented data of high quality to feed AI systems, the capacity (both human and technical) and culture of public sector employees to handle AI applications avoiding human biases, and the existence of legal frameworks ensuring accountability and transparency of AI results (Capgemini, 2017; Centre for Public Impact, 2017).

It is evident that to accommodate complex G2C interactions, we need a richer digital channel (in accordance with MRT, as mentioned in 2.1), which demonstrates enhanced bots' intelligence; this can be achieved through the meaningful integration of contemporary AI techniques that build and exploit structured information, identify patterns in it, and interpret it to provide informed answers to complex queries. This is highly associated with the enrichment of the underlying knowledge base of current approaches, as well as the advancement of their inference mechanisms in terms of reasoning, argumentation, recommendation and decision-making support.

2.3. On the enhancement of bots' intelligence

E-Government settings are associated with huge, ever-increasing amounts of multiple types of data, obtained from diverse and distributed sources. In many cases, the raw information is so overwhelming that stakeholders (both government and citizens) are often at a loss to know even where to begin to make sense of it. In addition, these data may vary in terms of veracity and value, ranging from individual opinions to indisputable measurements and state regulations. At the same time, their types can be of diverse level as far as human understanding and machine interpretation are concerned. Admittedly, when things get complex, we need to identify, understand and exploit data patterns; we need to aggregate big volumes of data from multiple sources, and then mine it for insights that would never emerge from manual inspection or analysis of any single data source (Karacapilidis, Rüping, Tzagarakis, Poigné, & Christodoulou, 2011).

As a result from the above, issues related to the guidance of stakeholders through the space of available data and the indication of relevant information to facilitate and augment interaction between government and citizens, either for information seeking purposes or for

handling routine daily transactions, are of major importance. This is highly associated with the way that information is structured for query and analysis, as well as the way that software tools (bots in our case) are designed to handle them efficiently. These tools should enable a user-friendly streamlining and automation of the abovementioned information management tasks. Return on such investments can be both tangible (e.g. time or money saved) and intangible (e.g. more valuable information, easier extraction of hidden information, increase of stakeholders' satisfaction and creativity, improved quality of interaction between stakeholders).

Recent approaches towards meeting these requirements build on the synergy of human and machine intelligence. They adopt a semi-automatic, adaptive approach that makes use of semantic metadata and pre-structured data, as well as collaboration patterns, to provide plausible recommendations, while also learning from the users' behaviour and feedback to better target their information interests. This is enabled by innovative text mining and machine learning techniques, which analyze the semantics of unstructured data like natural language sentences and documents. As reported in (Computing Research Association, 2012), such approaches are not all computational; rather, they are designed explicitly to have a human in the loop. In spite of the tremendous advances made in computational analysis, there remain many patterns that humans can easily detect, but computer algorithms have a hard time finding.

Moreover, human intelligence may result out of careful social media monitoring and related analytics, which refers to the targeted tracking of various social media content with the aim to acquire the volume and sentiment of citizens' opinion about a certain topic (Bekkers, Edwards, & de Kool, 2013; Loukis, Charalabidis, & Androutsopoulou, 2017). Such processes can be performed at real time and in a highly scalable way; moreover, they can provide valuable, machine-readable results to be further exploited for the needs of different types of stakeholders in the context under consideration. For instance, such results may provide valuable information to public servants and policy experts about the adoption of a current policy, or aid them gaining insights when they are about to build a new one.

Such a synergy between human and machine intelligence should be exploited when enhancing current chatbots' functionality; it may significantly advance the existing technology of chatbots in terms of information display, argument extraction, as well as justification and solution building. Such an approach will help users exploiting complex multi-source data, by supporting them in finding relevant information and providing them with personalized recommendations. It will enable a shift in focus from the mere collection and representation of large-scale information to its meaningful assessment, aggregation, structuring and utilization in contemporary e-Government settings. Moreover, it will satisfy a big category of requirements concerning exploration, delivery and visualization of the pertinent information. Those will in turn enable new working practices that may convert information overload and cognitive complexity to a benefit of knowledge discovery, which is achieved through properly structured, semantically-rich data that can be used as the basis for more informed decisions (Karacapilidis, Loukis, & Dimopoulos, 2004).

The above call for an innovative approach that should be based on: (i) an intelligent semantic annotation, structuring and aggregation of voluminous and complex data, (ii) the meaningful analysis and exploitation of data patterns and interrelations, (iii) the capturing of stakeholders' tacit knowledge, as far as information analysis and problem solving are concerned, through a social web approach, and (iv) the exploitation of a particular user (or group) characteristics to properly direct or adapt data. Generally speaking, semantics to be deployed should come out of a joint consideration of stakeholders, their actions in the e-Government settings under consideration, and data considered each time. The underlying model of semantics will intelligently organize and systematize the available resources (data and stakeholders) and data flows (e.g. to purposefully filter a big volume of data and direct the relevant information to a citizen; or, to meaningfully aggregate data coming out of diverse sources, each focusing on a distinct aspect of the problem under consideration). The proposed organization of data and other resources may also serve diverse aspects and requirements related to processes such as collaborative discourse modelling and analysis (Karacapilidis, 2002; Karacapilidis & Gordon, 1995), argumentation mining (Habernal & Gurevych, 2017), and compliance management (Hasan, Loucopoulos, Anagnostopoulos, & Nikolaidou, 2015).

3. Research method

For the development of this novel digital channel for interaction between government and citizens we adopted the 'design science' paradigm (Hevner & Chatterjee, 2010; Hevner, March, Park, & Ram, 2004). This research paradigm according to Hevner et al. (2004) 'seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts'; especially for the information technologies (IT) domain 'The result of design-science research in IS is, by definition, a purposeful IT artifact created to address an important organizational problem'. In the present study, the particular organizational problem we aim to address is, as mentioned in Section 2.1, the lower levels of 'richness' of existing digital channels developed by government organizations for interacting with citizens. In particular, their lower information carrying capacity does not allow high levels of citizens' expressiveness in describing their specific situations, problems and needs, as citizens usually can enter only some search keywords, or fill some fields in electronic transaction forms. This makes these existing digital channels less appropriate for communication tasks (such as seeking information or conducting transactions) of higher complexity, ambiguity and uncertainty. So, the objective of our research is to develop a new digital channel for communication/interaction between citizens and government with higher levels of information 'richness' than the existing ones, which enables the citizens to describe their specific situations, problems or needs in free text, using their everyday language, allowing higher levels of expressiveness. For this purpose we have used the specific design science research methodology proposed for the domain of IS research by Peffers, Tuunanen, Rothenberger, and Chatterjee (2007), which includes the following six stages: identify problem and motivation, define objectives of a solution, design and development, demonstration, evaluation and communication.

We have combined the above design science paradigm with the 'action research' paradigm, which according to Rapoport (1970) 'aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework'. It has been recognized that action research can be quite important in the IS domain, as it can contribute to improving the practical relevance of this domain (Baskerville, 1999; Baskerville & Myers, 2004; Iivari & Venable, 2009). In particular, it enables the design, implementation and evaluating ICT-based actions/changes in organizations, which address specific problems and needs (of high interest for practitioners), and at the same time create scientific knowledge (of high interest for the researchers). The complementarity between these two research paradigms, the design science and the action research, and the great potential of integrating them, together with the associated practicalities and difficulties, has been extensively discussed in previous literature (Hevner & Chatterjee, 2010; Iivari & Venable, 2009). Both these paradigms aim to directly intervene in "real-world" domains and effect changes in these domains, and there are significant similarities as well complementarities between them.

In particular, in the present study we had close co-operation for addressing the abovementioned problem, by creating new digital channels for interacting with citizens, with higher levels of information 'richness', which enable the citizens to describe their specific situations,

problems and needs with higher expressiveness through full text in their everyday language, with three Greek government agencies:

- the Ministry of Finance (which has been for long time the leader in Greece in offering e-government services of both informational and transactional nature to citizens and businesses),
- a social security organization (offering currently several and quite successful e-Government informational and transactional services),
- and a big local government organization (municipality).

With each of these government agencies we organized a workshop, in which several (between 4 and 8) experienced staff in e-government services provision, of about 2 h duration. In each of these workshops we used a qualitative approach (in-depth discussions) in order to collect relevant information from the participants. In particular the following steps were taken:

(a) initially we explained to them the basic idea, and then we asked them for their opinions about its feasibility and usefulness in general,
(b) as well as to elaborate this idea for their specific context, and propose specific important informational and transactional services that might be provided to the citizens and businesses they serve through our advanced AI-guided chatbots;
(c) then we collaboratively developed with them specific application scenarios of this idea for a small subset of the above services of their government agencies, leading to specific advanced informational and transactional chatbot-based e-services that can be highly useful for citizens and businesses,
(d) for each of these services we defined the main types of questions to be asked by its users (citizens or businesses),
(e) and the main sources of data (both structured and unstructured) required for providing answers (such as documents, databases, social media accounts, etc.),
(f) as well as the format of these data, and the required processing of it for enabling the provision of answers to the questions defined in step (d).

Based on the information we collected in these workshops we designed in detail the ICT platform architecture presented in Section 4, as well as the application scenario presented in Section 5. In particular, based on the information collected in the step (e) of the interviews the data management layer services of the ICT platform were designed (see Fig. 1). Then based on the information collected from the step (f) of the interviews the knowledge processing layer services were designed, which aim to extract from the above data sources the knowledge required for answering users' questions. Finally, based on the information collected from the step (d) concerning the main types of questions to be asked by the users the application layer services were designed.

4. Description of the proposed platform

The proposed digital channel for interaction between government and citizens builds on an innovative web platform, which fully satisfies the requirements sketched in Section 2.3. In this platform, heterogeneous (in terms of both format and content) data and knowledge sources, as well as respective processing methodologies and tools, are wrapped through web services, while their integration is performed on a service level. The platform enables the seamless integration of heterogeneous services and ensures their interoperability from a technical, conceptual and user interface point of view. Semantics techniques are highly exploited to define an ontological framework for capturing and representing the diverse stakeholders and services perspectives.

The foreseen solution is generic and does not pose any restrictions on the back-end technology. It facilitates and enhances a meaningful interaction between government and citizens thanks to a proper exploitation of human and machine reasoning capabilities. This solution provides easy access to integrated resources and streamlines diverse associated needs. Its interoperable set of web services can be properly orchestrated to meet the underlying requirements of capturing, delivering and analysing pertinent information. Much attention is paid to the adaptability of the foreseen environment with respect to changes in user requirements and operating conditions, as well as to user engagement issues.

The proposed approach adopts a three-tier architecture (Fig. 1) that seamlessly integrates the following three service categories:

- **Data management services**, which enable the targeted discovery, capturing, archiving, sharing and processing of tractable large-scale data existing in diverse data sources and formats. Much attention is paid to data integration (to interconnect structured data from different sources) and data cleansing (to remove noise from database contents or discard useless records) issues. Data management services are semantically enriched to efficiently handle the underlying metadata and ontology issues. In fact, services belonging to this layer (i.e. data layer) manage the life cycle of the diverse data streams to be exploited for the building and maintenance of the platform's knowledge base. These may include databases of existing (legacy) governmental information systems, as well as other data which citizens generate in Web 2.0 applications, using extended metadata sets. For instance, these services may collect data from open data portals containing geographical data regarding the location of public administration services and buildings, or other 'points-of-interest' in sectors such as culture, tourism, transport and environment.
- **Knowledge processing services,** which exploit most prominent large data processing technologies to offer functionalities such as high-performance data mining, targeted data indexing, classification, clustering, abstraction and interpretation. Advanced text mining techniques such as relation extraction, similarity learning, and argumentation mining will help to extract valuable semantic information from unstructured governmental texts as well as online fora and blogs. The proposed data mining techniques can appropriately process the above data sources so as to discover important information fragments and hidden patterns, and meaningfully associate them with real citizen needs and governmental decisions. Such associations may, for instance, reveal how past governmental decisions are perceived by citizens or interpret citizens' implicit feedback to shape subsequent governmental actions. Data mining in the proposed solution builds on various well-tried algorithms and techniques, including Neural Networks, K-means, Decision Trees, Naïve Bayes, and Support Vector Machines. Semantic underpinning of this category of services, which builds on machine-interpretable knowledge and reasoning mechanisms, is of major importance. Services belonging to this layer (i.e. knowledge layer) enable a sophisticated inference mechanism that better serves the interaction between government and citizens.
- **Application services**, which facilitate and enhance the quality of the interaction between government and citizens. This category of services facilitates better-informed sense-making and decision making by providing citizens with: (i) an easy and effective means to express, argue about, and meaningfully interact with relevant information and knowledge, (ii) information about data provenance and trust issues, and (iii) helpful recommendations that may fit to their profile and overall context. The output of services belonging to this layer (i.e. application layer) is directly exploited by the chatbot to build a hybrid user interface that may combine chat, voice or any other natural language interface with graphical UI elements (e.g. buttons, images, menus, videos, etc.), known as 'conversational interfaces' (Klopfenstein et al., 2017). The output of these services can be also integrated into popular messaging platforms, provided by third parties, such as Messenger, Slack and Telegram.

Through a proper incorporation of AI-based building blocks, the

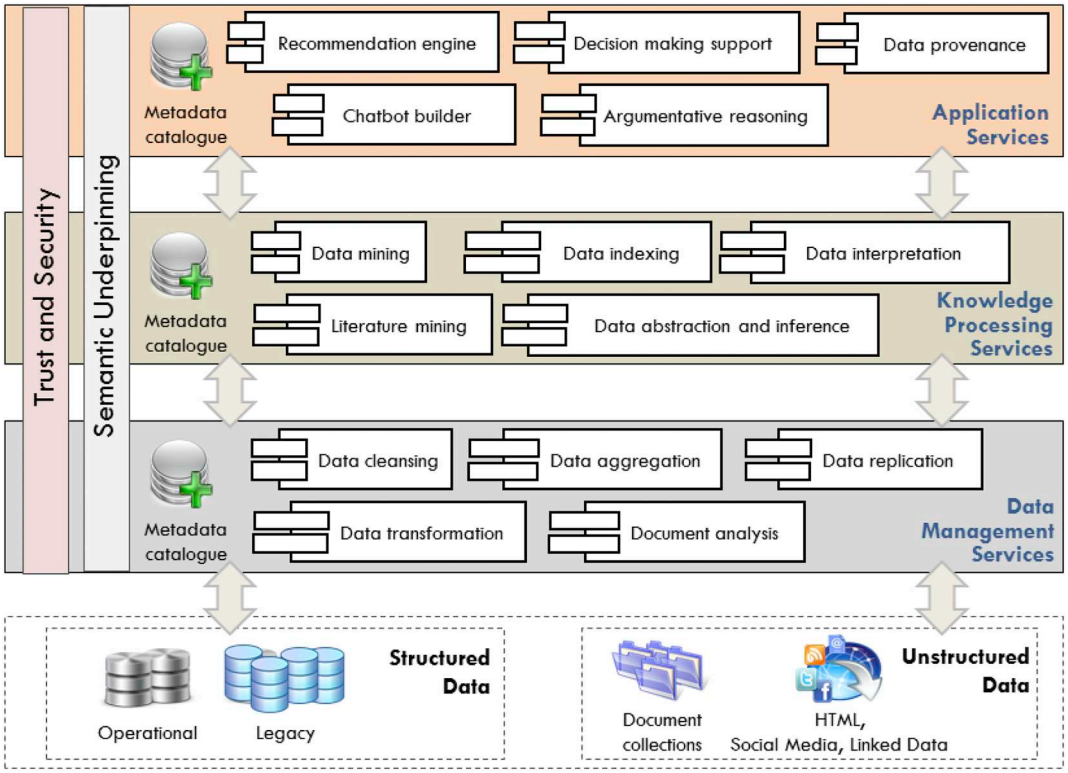

Fig. 1. The three-tier architecture of the proposed approach.

abovementioned services add intelligence to the functionality and user interfaces of existing chatbots (and chatbot builders), the ultimate aim being to enable citizens to fully control the conversation they have with government. For instance, the proposed solution may handle incomplete information during an interaction, and perform a progressive synthesis and comparative evaluation (across a set of attributes) of existing alternative solutions; the novel interaction channel proposed enables citizens to easily examine alternative scenarios to an issue under consideration (by selecting which of the available solutions' attributes to be taken into account) and recommends the best solution according to the information at hand. The proposed solution may also maintain a citizen's profile, taking into account a number of general interests and preferences, which can be enriched with more detailed ones each time the citizen initiates an interaction.

To enable existing chatbots provide such functionalities, the proposed approach enhances both their *knowledge base* (to provide responses to user input) and their *dialogue management module* (to control the conversation process). For the development and maintenance of an enhanced knowledge base, our approach builds on prominent literature and data mining techniques (middle layer of the architecture shown in Fig. 1) to ease semi-automatic extraction of knowledge from diverse reference sources (e.g. documents containing legislation and relevant application directives, structured data from government agencies' operational systems, social media data, etc.) and make it available in machine-readable format. The associated knowledge extraction methodology, which spans the two lower layers of the architecture shown in Fig. 1, combines: (i) filtering of diverse corpora of documents to identify the most relevant ones; (ii) recognition and identification of (named) entities in the selected documents (Augenstein, Derczynski, & Bontcheva, 2017); and (iii) identification and extraction of relations based on natural language processing (NLP) - both syntactic and semantic – techniques (Cambria & White, 2014). Taking as input queries expressed by citizens in natural language, NLP techniques translate a structure or a command into a format that the chatbot can understand and process it to generate responses to be sent back to the citizens (a typical implementation of chatbot knowledge bases contains a set of templates that match user inputs and generate responses).

As far as the dialogue management module is concerned, our approach enhances the classic chatbots behaviour (where, according to the principle of pattern matching, user input is matched to a fixed response) by incorporating concepts and techniques traditionally found in dialogue systems (where user input is parsed into some semantical representation, which is then used by a 'dialogue manager' to determine what the response should be). Such a hybrid solution may better manage and maintain the state of interaction between the user and the chatbot by directly handling natural language. In the architecture shown in Fig. 1, functionalities of such a dialogue manager are offered through the argumentative reasoning and decision-making support components (top layer).

Data exploitation for knowledge extraction is mainly performed through the knowledge processing services of the second layer of the proposed architecture. Such services have been fully developed and thoroughly tested in the context of the Dicode EU project (http://dicode-project.cti.gr). Dicode has provided a rich data mining framework of REST-based web services aiming to support different types of users and facilitate data analysis. Of particular importance is the list of Dicode text mining services, which include a Twitter Harvester and Preprocessing Service, a Blog Pre-processing Service, an Entity Prominence Service (which returns statistics about the occurrence of Named Entities in news and blog documents within a certain time period), a Phrase Extraction Service (enabling the extraction of different types of phrases from a text collection), and an Opinion Mining Service (in which a set of popular text mining algorithms have been combined in an innovative way). The key innovation of the Dicode text mining services is to make previously existing but unconnected technologies available in one single workflow in a scalable manner, claiming that the different steps of the text processing pipeline, such as pre-processing, entity recognition, topic detection and opinion mining cannot be perceived as independent (Karacapilidis, 2014). In addition, the proposed services build on the Social Media Monitoring and Analytics tools developed in

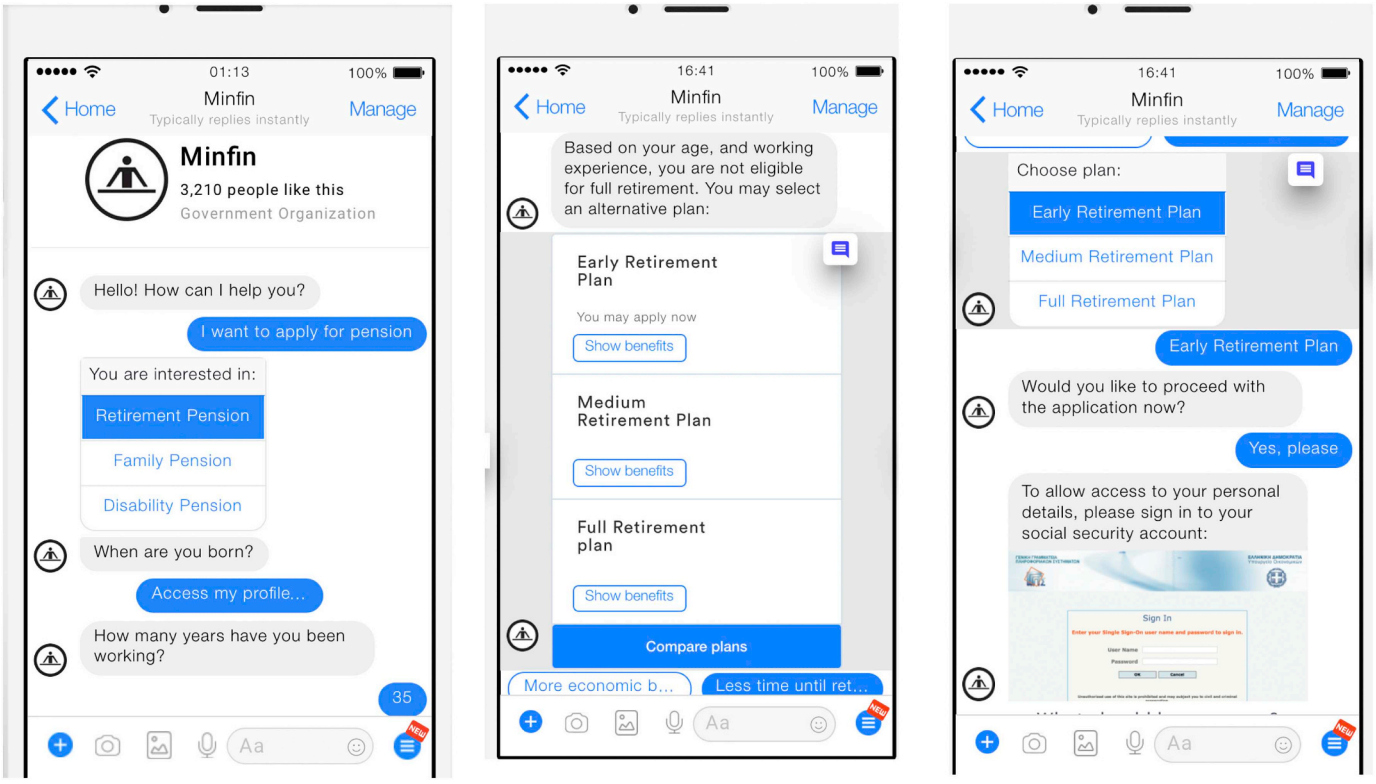

Fig. 2. Instances of the interaction between bot and citizen.

the context of the NOMAD EU project (Charalabidis, Loukis, Androutsopoulou, Karkaletsis, & Triantafillou, 2014; Loukis et al., 2017), which addressed needs related to the search and analysis of public policy related content that has been generated by citizens in various social media (such as political blogs, fora, Facebook and Twitter accounts, etc.); the innovative aspect of these tools is that analysis is tailored against specific policy makers' goals, by properly visualizing arguments, opinions and sentiments regarding a policy domain, and creating a semantically rich, accurate stream of data that can be leveraged in any workflow.

To achieve the required interoperability of resources, the proposed solution pays much attention to their semantic underpinning in all three tiers of its architecture, covering both technological and organizational aspects. The proposed solution heavily exploits Semantic Web services, which offer a suitable framework to assign semantics to web services, by utilizing and sharing standard ontologies to offer standard service interfaces, service messages and service structures. It is also noted that the overall platform is based on open standards and custom web technology; this allows its easy extension by using and adapting existing resources (i.e. data resources and data analysis tools), or developing new ones to cover the needs of related contexts. Aiming to manage the scale and complexity of contemporary interaction between government and citizens through a sustainable solution, the platform reuses and expands tools and services from existing infrastructures and projects at national and/or European level. Overall, our approach builds on a multi-perspective ontology, which acts as the semantic backbone that enables the integration of the proposed platform's components and existing information resources. To ensure access and facilitate location of the services included in the proposed architecture, a dedicated registry of services is required. The idea is that this registry stores information (metadata) related to the services of the proposed platform (such as service name, service provider, location and functionality). Services are semantically annotated with concepts contained in the abovementioned multi-perspective ontology. Such annotations are also stored and managed by the platform's registry of services. It is noted that services can be annotated according to their functionality, domain, inputs and outputs.

Finally, particular attention is paid to trust and security issues. The proposed platform provides the required trust management and security provisioning solutions (e.g. crypto-primitives, crypto-protocols, public key infrastructure integration, digital rights management systems coverage, dependability assurance, risk prediction algorithms) at each layer of its architecture. It incorporates mechanisms to address legal and privacy specifications pertaining to bid data processing, ensuring privacy and confidentiality of sensitive information. The privacy and security layer implements user management and authentication, personal profiles management and classification, ensuring that the platform is protected against unauthorized access and malicious attacks.

5. An application scenario

As mentioned in Section 3, alternative application scenarios of the proposed approach have been developed in collaboration with governmental agencies of various levels. For example, at local level, the municipality has recognized the potential of bots in redesigning the informational and transactional services they offer. Regarding the former category of services, automated information provision through bots may be provided concerning local news and events, municipality points and services, public transportation options and schedules, accommodation and dining facilities, other touristic information, etc. With regard to the latter category, bot-based transaction services may include payment of local taxes, issuance and electronic delivery of certificates and permits, as well as proactive notifications on all services (e.g. notification on the expiration of permits). To clearly describe the use of the proposed digital communication channel, this section illustrates an application scenario concerning the delivery of e-services at the central government level (provided by the Greek Ministry of Finance).

Assuming the case where the proposed solution is used to provide

guidance on “applications for a person's retirement pension”, this scenario refers to the workflow of interactions between the bot and a citizen willing to submit such an application (Fig. 2). The specific scenario combines tasks from multiple use cases of bots mentioned in Section 2.2, i.e. searching in documents and governmental information to answer citizens' questions in order to help them fill relevant application forms or to automate drafting of necessary administrative documents for their request. Initially, the citizen accesses the conversational interface of the chatbot, which is owned by the Ministry, through an encrypted login session. After the user is authenticated by the user management modules (so unauthorized access is prevented) he/she answers a set of basic questions that are inserted in the dialogue manager (see Fig. 2a) in order to route citizens' request (e.g. type of pension, date for retirement, etc.) to the application services offered by the proposed approach. The chatbot then poses a series of questions, which are handled by the decision making support service to determine the eligibility of the criteria for their retirement application; such a decision is based on a set of rules that have been extracted from the relevant legislative documents (see the lower two levels of the architecture sketched in Fig. 1). For example, data mining services have already extracted the three types of pensions provided by the government (retirement, family, disability) and structure them to three clickable options provided by the dialogue manager to the interface. The next step of the workflow as defined in the chatbot builder is a set of questions for acquiring users' personal information. To augment this process, the citizen is asked to allow trusted and secured access to information stored in their personal social media accounts or in governmental websites, e.g. date of birth or working years in order to allow the bot to further exploit its knowledge base and personalize the requested service. All personal information exchanged with the user or third-party services, including passwords, are encrypted through crypto-protocols and anonymization. Knowledge processing services are used to interpret users input, while supervised training is used to continuously improve the chatbots' inference mechanism. Given user's consent the APIs of the relevant Social Media are used by the data management services of the platform to retrieve this information using public keys.

To decide on the eligibility criteria, data management services are used to search, aggregate and structure information on legislative documents, operational data and other governmental databases. Existing legislation is initially provided as input by the involved governmental actors, when building the bot. This information, combined with information that exists on open government platforms, is structured in order to build a multi-criteria decision making model stored in the knowledge base of the bot (through the application of knowledge representation and reasoning techniques on semantically annotated data). In our scenario, in the case that rules imposed by existing legislation are not met based on the input provided by the users on the relevant attributes, e.g. working experience, age (according to the outcome of the decision making support service), the bot informs the citizen that he/she doesn't meet the particular eligibility criteria on a full retirement plan (Fig. 2b) and proposes alternative solutions; medium retirement and early retirement plan (which are provided by the recommendation engine – see top layer of the architecture shown in Fig. 1). Since a considerable volume of information on alternative retirement plans exists on citizens' discussions on the social web (with diverse arguments in favour or against them), social media monitoring, text mining and argument extraction services (described in Section 4) are triggered to extend the knowledge space of solutions, enriching it with insights based on personal experiences. Argumentative reasoning is applied (exploiting the collected information) to convey to the citizen the pros and cons of each alternative solution, thus enabling their comparative assessment (more information on the associated framework and mechanisms is provided in (Tzagarakis & Karacapilidis, 2013). In our example, higher pension rates are displayed as the argument in favour of the one option (medium retirement plan), against quicker retirement which is the argument in favour of the second option (early retirement plan). Stakeholders (e.g. public servants) can also contribute to the identification of additional solutions or alternatives, by pinpointing new sources of information. The citizen can also enter his/her personal preferences or constraints, thus triggering the recommendation engine to customize the solutions or information provided.

In the above steps, application services provide an easy and constructive navigation on the aggregated and structured information, so the user can select the preferable retirement plan by pressing a button or typing it in free text (Fig. 2c). The bot then asks questions to the citizen to auto-populate the required application forms in an automated way, by converting the missing data fields to everyday language (personalized information has already been retrieved as mentioned above). In case that application forms should be accompanied with issuance of administrative fees, payment services may be also invoked through API calls and the execution of web services offered by third parties (e.g. banks or online payment providers). After the application submission, the user can monitor the progress of his/her application or enable the receipt of notifications for each stage of the execution process.

6. Conclusions

The existing digital channels of communication between citizens and government are characterized by lower cost than the traditional ones (such as face-to-face visits to government agencies' front offices, phone calls), but also by lower communication richness and expressiveness (e.g. the citizen can only enter some search keywords in order to search for government information they need, or can only fill some fields in electronic forms in order to conduct their transactions with government). For this reason, as mentioned in more detail in section 2.1, in accordance with the arguments of the MRT (Daft & Lengel, 1984, 1986), they have been used by citizens to a much lower extent than the initial expectations (e-government usage paradox), mainly for simpler information seeking tasks, or for transactions of low complexity, ambiguity and uncertainty; at the same time citizens continue using to a large extent the traditional channels for communication tasks (concerning information seeking or transactions) of higher complexity, ambiguity and uncertainty.

The research presented in this paper aims to address this significant problem: by leveraging an important AI technology, the chatbots, in combination with natural language processing, machine learning and data mining technologies, we develop a new ‘richer’ and more intelligent digital channel of communication between citizens and government. It is based on advanced chatbots, with higher levels of intelligence and capabilities going beyond those of the first generation of chatbots, which are limited to rule-based responding to simple queries; in particular, by leveraging the abovementioned technologies, and using existing government data of various forms (such as documents containing legislation and relevant application directives, structured data from government agencies' operational systems, social media data, etc.), these advanced robots can intelligently respond to citizens' natural language messages, being highly effective in providing to them the specific information they seek, and assisting them to conduct the appropriate transactions correctly. This novel digital channel enables ‘richer’ and more expressive interaction of citizens with government in their everyday natural language, for both information seeking and transaction purposes: based on MRT, which is our main theoretical foundation, this channel is appropriate for a wider range of citizens' interactions with government, having higher levels of complexity, ambiguity and uncertainty. Overall, the main contribution of this research is the meaningful integration of a set of well-tried tools and services to cover the diversity of requirements concerning communication between citizens and governments. Our approach has been validated and elaborated in close co-operation with three Greek government agencies (the Ministry of Finance, a social security

organization, and a big local government organization), and then a series of application scenarios of it have been developed.

Our study has interesting implications for both research and practice. With respect to research it advances the existing knowledge in two important areas: AI utilization in the public sector, and digital channels of communication between citizens and government; this is achieved by combining knowledge from the areas of chatbots, natural language processing, machine learning and data mining technologies. Furthermore, our study provides an approach for the development of more advanced and intelligent chatbots, by leveraging existing data (both structured data from operational IS, and also unstructured textual ones from documents and social media), which can be very useful for future research in the area of chatbots. With respect to practice our study develops a novel digital channel of communication between citizens and government, which addresses a fundamental weakness of the existing digital communication channels currently provided by government, having higher communication richness and expressiveness, and allowing citizens to communicate with government in their everyday natural language. This new digital communication channel has the potential to transform and improve substantially the communication between citizens and government, which has for long time been problematic. However, government practitioners should be very careful in building the required 'knowledge base' of these advanced chatbots, which has to include all the important documents, as well as relevant internal data from their operational IS, and possibly relevant social media, concerning the range of topics and subjects each particular chatbot is expected to deal with.

The main limitation of our study is that though the proposed approach has undergone a first level assessment and validation by experienced practitioners in three government agencies, which has been positive, and also provides an inclusive and extendible implementation framework, its application has to be carefully planned based on the information capacity and available resources (e.g. API's, web services, knowledge representation) of different organizations in the public sector. In addition, its application has to be thoroughly evaluated through a set of Key Performance Indicators (KPIs), indicating the usefulness and ease of use of the proposed approach. The main focus of the evaluation would be to assess, for various types of citizens' questions (of varying complexity, ambiguity and uncertainty, including specific situations, problems or needs), to what extent it can provide useful and relevant information as well as support for conducting relevant transactions. Another limitation is that our research has been conducted for the Greek language (= language used by the citizens in order to communicate with government, and processed by the chatbots); however, due to the complexity of the Greek language and its rather limited available lexical resources, this is not expected to be a problem, so we expect that the performance of the chatbots in other languages (e.g. English) will be higher. Furthermore, the workshops as well as the applications scenario have been influenced to some extent by the Greek administrative context, which is characterized by complex legislation and administrative processes; so we expect that the application of the proposed chatbot-based approach will be easier in other national contexts having simpler legislation and administrative processes.

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Aggeliki Androutsopoulou is PhD candidate in the University of the Aegean. She holds a Bachelor Degree in Informatics from the Athens University of Economics and Business and a Master of Science in "Technologies and Management of Information and Communication Systems" from the University of the Aegean, Department of Information and Communication Systems Engineering. Currently, she is a Research Associate in the Information Systems Laboratory at the Department of Information and Communication Systems Engineering, University of the Aegean. She has six years experience in managing European and National research projects from a technical and administrative viewpoint (EU-Community, NOMAD, PADGETS, NET-EUCEN, ENGAGE, PLUG-IN). Through her participation in the above projects, she has acquired expertise in project management, in designing and evaluating eGovernent Information Systems and in coordinating pilot applications in the public sector. She has plenty of publications in international journals and conferences in the area of eGovernment, eParticipation and Social Media, Policy modelling and Simulation Systems. Aggeliki was the best paper winner award in the 15th IFIP Electronic Government (EGOV) 2016 and ePart 2016 conference, with the publication entitled "Passive Expert-Sourcing for Policy Making in the European Union". During the last five years, she has been Member of the Organisng Committee of the "Samos Summit" international annual conference.

Dr Nikos Karacapilidis is Professor of Management Information Systems at University of Patras, Greece. His research interests lie in the areas of Intelligent Web-Based Information Systems, e-Collaboration, Knowledge Management Systems, Group Decision Support Systems, Computer-Supported Argumentation, and Semantic Web. He has been involved for about 20 years in the development of ICT solutions through European and national R&D projects. He has a strong publication record (more than 180 research papers) in various international journals and conference proceedings. He was the Scientific Coordinator of the Dicode FP7-ICT project. He was the System Demonstrations Chair at ECAI'08 and ECTEL'09 Conferences. He was the chair/co-chair of many international scientific workshops, among them dicoSyn'12, held in the context of CSCW'12. For many years, he was the Editor-In-Chief of the Advances in Web-Based Learning Book Series, and Co-Editor-In-Chief of the International Journal of Web-Based Learning and Teaching Technologies. He is the editor of the recently published Springer book (Studies in Big Data Series), titled "Mastering Data-Intensive Collaboration and Decision Making".

Dr Euripidis Loukis is Professor of Information Systems and Decision Support Systems at the Department of Information and Communication Systems Engineering, University of the Aegean. Formerly he has been Information Systems Advisor at the Ministry to the Presidency of the Government of Greece, Technical Director of the Program of Modernization of Greek Public Administration of the Second Community Support Framework and National Representative of Greece in the programs 'Telematics' and 'IDA' (Interchange of Data between Administrations) of the European Union. He is the author of numerous scientific articles in international journals and conferences; one of them has been honoured with the International Award of the American Society of Mechanical Engineers – Controls and Diagnostics Committee. His current research interests include e-government, e-participation, information systems value/impacts and internal/external determinants, business process adaptation and medical decision support systems.

Dr Yannis Charalabidis is Associate Professor in the University of the Aegean, in the area of eGovernance Information Systems, coordinating policy making, research and pilot application projects for governments and enterprises worldwide. A computer engineer with a PhD in complex information systems, he has been employed for several years as an executive director in Singular IT Group, leading software development and company expansion in Europe, India and the US. He has also been the coordinator or technical leader in numerous FP6, FP7 and National research projects in the areas of eBusiness and eGovernance. He is a contributing member in several standardisation and technology policy committees. He has published more the 100 papers in international journals and conferences. He writes and teaches on Government Service Systems, Enterprise Interoperability, Government Transformation and Citizen Participation.