Towards an Integrated and Inclusive Platform for Open Innovation in the Public Sector

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Abstract. The growing adoption of the open innovation paradigm in the public sector poses a set of research challenges related to the particularities of the domain and the technologies required to manage the associated knowledge flows among diverse types of stakeholders. This paper aims to shed light on how the proper combination of existing ICT tools can support and advance the implementation of open innovation practices in the public sector. Towards this aim, it first presents a non-exhaustive taxonomy of these tools, which is also associated with the open innovation phase they primarily support. Paying particular attention to the issues of collaboration support and sophisticated data collection and analysis, the paper also proposes an open, inclusive and sustainable web-based platform that builds on the synergy between human and machine intelligence to address the important challenges of public sector open innovation. An indicative application scenario, concerning a contemporary societal problem, showcases the potential of the proposed solution.

Keywords: Open innovation · Public sector · Crowdsourcing · Public policy formulation · Collaboration support · Argumentation · Knowledge management

1 Introduction

Open Innovation (OI) was firstly introduced by Chesbrough [1] as a paradigm shift from the traditional closed model of innovation, referring to the internal control of ideas and knowledge resources within an organization, to 'the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the market for external use of innovation, respectively' [2]. The increasing social media popularity and internet use, together with the growing number and mobility of knowledge workers, triggered the development of diverse OI methods and practices in business [3, 4], extending the innovation capacity along and beyond the boundaries of a firm and its human capital. Successful initiatives in the knowledge co-development process, carried out by private companies involving diverse external actors (customers, suppliers,

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competitors, cross-sector firms, universities and research institutions), have offered fertile ground for research on the types of OI practices used in the private sector [5, 6], as well as the context and typology of the problems each type is appropriate for [7].

Boosted by the adoption of e-participation initiatives and the transition of decision making process from a top-down to a bottom-up approach, the OI paradigm has started being adopted by the public sector to tackle the increasing complexity of problems and policy challenges faced by contemporary societies [8–11]. From a public administration perspective, the integration of a distributed innovation process, which is based on purposively managed knowledge flows across organizational boundaries, provides the opportunity to include citizens and their ideas and expertise into the work of the governments (citizen-sourcing) [9, 12, 13]. Citizens, as inhabitants of a particular city, and also due to their professional activity, have specific knowledge (or experience) of their micro environment, which the administration cannot easily access. Through appropriate guidance, they can use that knowledge to actively develop novel ideas for addressing social problems and needs, as well as co-create public services together with the local administration and fellow citizens.

While extensive research on the adoption of OI in the private sector has been conducted, fundamental differences in its implementation in governance pose a series of challenges, which call for further investigation on the key characteristics of public sector innovation field [11, 14]. Although there is strong linkage between open innovation and open government initiatives [13], an analysis of e-government literature shows that there are limited influences of the OI paradigm in the e-government research, poorly connected with the perspectives of management science [15]. Four divergent facets of OI in the two sectors have been identified, namely focus, aim, value, and external stakeholders [14]. It has been also stressed that there are a number of factors limiting the innovation performance of public sector organizations, which are related to the legal and socio-economic framework they operate, such as the absence of financial resources, the contradicting regulations [16], and low citizens' trust in such initiatives, as well as organizational factors such as lack of innovation culture and motivation [17–19].

Another set of challenges stems from the role of information technology on OI activities [20]. Current research trends emphasize on the utilization of social media by governmental agencies for the collection of external knowledge through crowdsourcing and web consultations [21]. Admittedly, there is a gap on the usage and efficacy of tools beyond social media, including the use of open data platforms for providing better access to and interpretation of governmental data and the information produced by internal information systems of public administrations [22]. As explicitly stated by Klein and Convertino [23], 'open innovation systems face important challenges deriving, ironically, from their very success: they can elicit such high levels of participation that it becomes very difficult to guide the crowd in productive ways and pick out the best of what they have created'. This implies problems such as low signal-to-noise ratios (only a small percentage of the ideas from OI engagements are considered as being of high quality), insular ideation (ideas are typically generated quickly by single individuals, without reference to other submitted ideas), non-comprehensive coverage (there is no inherent mechanism for ensuring that the ideas submitted comprehensively cover the most critical facets of the problem at hand), poor evaluation (based on subjective criteria,

while little support is provided to aid stakeholders build upon each other's facts and reasoning), poor idea filtering (engaging stakeholders in cognitively complex and time-consuming tasks), and burdensome management of the overall innovation process (referring to monitoring, awareness, and attention mediation issues). Related studies [24] pinpoint additional issues requiring attention, such as the need to stimulate the creation and support the sustainable development of public/private communities, the (partial) formalization of the stakeholders' contributions aiming to further exploit the reasoning capabilities of the machine, the support for a collaborative construction of solutions, and the development of public services by third parties.

Generally speaking, the requirements of the OI process in the public sector can be (partially or fully) handled by a palette of ICT tools, each paying attention to a specific aspect of the process. Section 2 of this paper attempts a taxonomy of these tools, classified upon their basic purpose, identifying state-of-the-art functionalities of each category and pointing to representative solutions. Taking this classification into account, and associating the abovementioned problems and challenges to it, Sect. 3 reports on integration issues and describes an open, inclusive and sustainable platform that enables all types of stakeholders to participate in and manage the full range of activities concerning OI in the public sector. To better demonstrate the potential of the proposed solution, a specific scenario of use concerning the management of refugees and migrants inflows is also sketched. The last section of the paper outlines concluding remarks and future work directions.

2 A Taxonomy of Tools Supporting OI Phases

Typical OI systems, idea management platforms and customer engagement tools, such as Ideascale (https://ideascale.com), OpenIdeo (https://openideo.com), Spigit (https://www.spigit.com), UserVoice (https://www.uservoice.com), Imaginatik (https://www.imaginatik.com) and Nosco (http://nos.co), are used mainly in the private and to some extent in the public sector [13, 23, 25]. Generally speaking, OI processes can be supported by a variety of digital tools that allow governmental agencies harness the "wisdom of crowd". An indicative but not exhaustive list includes platforms facilitating cooperation between public administrations, citizens and other societal actors (academia and research institutes, other governmental organizations, non-governmental agencies including the private sector, non-profit organizations) [11], web-based software tools that enable access to great numbers of participants from all over the world, and user friendly toolkits guiding the actual involvement of non IT specialists in the innovation generation. These aim to fit specific purposes related to the management, monitoring, evaluation, and diffusion of OI initiatives:

- To provide the right information to potential problem solvers, by achieving better access to data and improved understanding of the problem and its parameters, and facilitate convergence among stakeholders.
- To control, manage and improve the information flows between governmental agencies and the participants of OI processes, as well as among these participants.

- To build and manage a knowledge base integrating heterogeneous internal and external knowledge and diverse experiences (from the organization's internal and external network, respectively), consolidating open governmental data and Web 2.0 content and embedding the accumulated content into the official institutional platforms.
- To effectively plan, coordinate, and monitor the OI process guiding the productivity of the crowd and providing comprehensive reports for the final outcomes.

2.1 Phases of OI Process in the Public Sector

Having considered alternative interpretations of the OI model, we claim that the one proposed by Mergel [13] is the most applicable one in the public sector. These phases are briefly discussed below.

Pre Phase: Problem Identification. This preparatory phase aims to formulate and broadcast a complete and accurate description of the problem to be solved. Although public management problems are usually defined by the government agency carrying out the initiative, social problems, needs and issues can also emerge through crowdsourcing. In the former case, modelling techniques support the formalisation of the problems. In the latter, an unstructured idea collection process is launched without any distribution of the problem statement to the public (passive crowdsourcing [21, 26]). Both instances can benefit by open data platforms that improve problem understanding and solving capacity of the involved target groups through better access and reuse of relevant government information [27].

Phase 1: Ideation. During the idea generation and collection phase, people are encouraged to submit proposed solutions and ideas, or articulate specific needs through digital platforms and participation portals. Idea solicitation is usually combined with methods aiming to boost the creativity of stakeholders and citizens such as rewards, funding, competitions, and hackathons. This phase encounters the risk of low levels of citizens' participation, which can be mitigated by mining proper sources to discover ideas and harvest the distributed knowledge that lies on the web.

Phase 2: Incubation. This phase fosters co-creation and peer production among the crowd community or external experts in a collaborative effort to incubate and develop the submitted ideas. Participants can view, comment, discuss and rate the ideas of other participants and vote for their favorite ideas, thus adapting the reviewed and improved solutions. This step includes also idea filtering and prioritization, where the community decides which solutions are best (might be combinations of submitted proposals).

Phase 3: Implementation. Selected or favorite solutions are validated through proof of concept of alternative implementations provided by the crowd or governmental actors. Implementation is complemented by progress monitoring and continuous report in order to identify necessary refinements in the process or the associated innovation concepts. Compared to the previous ones, this phase usually demonstrates less interactivity, as in

most cases governmental organizations proceed in this phase without solicitation of public input.

2.2 Categories of Tools

Open Data Platforms. As a result of a long-standing movement towards the open government and open data paradigms, open data portals have proliferated over the last years, enabling users to find re-usable information. Governments have created portals mashing up national, regional and cross-national datasets, such as the EU Open Data Portal (https://www.europeandataportal.eu), CKAN (https://ckan.org), the World Bank (http://www.worldbank.org), etc. The value of public sector information is recognized with respect to leading informed policy decisions and unlocking innovation. Open data platforms play a catalytic role in opening up collaboration in the whole data lifecycle, ensuring data quality, relevance and robust access [28].

Policy Modelling & Simulation. The increasing complexity of social problems has triggered the evolvement of Policy Modelling, a research field that incorporates the use of information technologies and computational modelling to inform policy analysis, management and decision-making. On top of that, simulation methodologies (such as Agent-based, Discrete Event and System Dynamics simulation) allow testing alternative solutions, as well as predicting and assessing the impact of prospective policy choices. During an OI process, policy modelling can help users model and visualize policy related information from the real world, serving various purposes such as problem structuring and formalisation (description of a policy's main elements), or the simulation of alternative solutions' implementation reducing the associated uncertainty.

Policy Modelling and Simulation tools include ontology editors (e.g. Protégé - http://protege.stanford.edu and ELEON - http://users.iit.demokritos.gr/~eleon/) and simulation platforms (e.g. Vensim - http://www.vensim.com and Anylogic - http://www.anylogic.com). The majority of them meet the needs of public sector innovation, i.e. building and running models of a policy or a social problem to be solved, which include the main topics, sub-topics and terms of it, in order to be used for collecting relevant content authored by citizens and experts in various electronic spaces. However, there is a lack of tools allowing the population or modifications of the adopted models through automated machine or multiple user driven interventions. This could facilitate the exchange of data between a model and extracted information, as a feature that can offer to stakeholders a clear view on the issues and aspects of the discussion. This need is partially addressed by the NOMAD Authoring Tool, which provides a web-based interface to create domain and policy models that capture topics and arguments relevant to a policy and their inter-relations. Using semantic representation technologies, these models set the basis for the initiation of crawling and analysis of similar text segments on the web [21].

Social Media Monitoring. Social Media Monitoring and Analytics is an evolving marketing research field that refers to the tracking or crawling of various social media content as a way to determine the volume and sentiment of online conversation about a

brand or topic [26]. Their added value lies on the fact that such investigations can be performed at real time and in a highly scalable way [29]. Well-known platforms of this category include Hootsuite (https://hootsuite.com), Trackur (http://www.trackur.com), and Sysomos (https://sysomos.com). There is limited literature concerning the use of such tools by government agencies and the extent these are useful for understanding and addressing the complex and 'wicked' problems of modern societies [9].

As proposed in [21], Social Media Analytics can reveal the issues, ideas and arguments that can best contribute in the public innovation process. The NOMAD platform is composed of a set of tools for searching and analyzing content, concerns and other information hidden within the text of citizens' conversations on the web. What differentiates NOMAD from typical Social Media Monitoring 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. Such tools can support the required "attention mediation" suggested by Klein and Convertino [23], by providing a structured way to represent the "big picture". Disclosing the analytics and reports implies the provision of feedback to the involved population on how their input has been taken into account.

Opinion Mining. Opinion mining tools employ natural language processing, machine learning, text analysis and computational linguistics to extract relevant information from the vast amounts of human communication over the Internet or from offline sources. In fact, the propagation of opinionated data has caused the development of Web Opinion Mining [30] as a new concept in Web Intelligence, which deals with the issue of extracting, analyzing and aggregating web data about opinions. The analysis of users' opinions, known as Sentiment Analysis, is significant because through them it is possible to determine how people feel about a product or service and know how it was received by the market. We can distinguish between two types of tools in this category; those that provide a framework for data mining algorithms, e.g. Rapidminer (https://rapidminer.com), WEKA (http://www.cs.waikato.ac.nz/ml/weka/), and KNIME (https://www.knime.org/) [31], and online platforms that can visualize (in real time) Opinion Mining Analytics on predefined Web 2.0 Sources, e.g. sentiment viz (https://www.csc2.ncsu.edu/faculty/healey/tweet_viz/tweet_app/) and Socialmention (http://www.socialmention.com).

Opinion Mining methods and tools make possible for public administration to reach citizens' opinions about policies and other topics of interest [32]. In general, traditional opinion mining techniques apply to social media content as well, however, there are certain factors that make Web 2.0 data more complicated and difficult to be parsed. An interesting study about the identification of such factors was made by Maynard et al. [33], in which they exposed important features that pose certain difficulties to traditional approaches when dealing with social media streams, such as the short length of messages, the existence of noisy content and the disambiguation in the subject of reference.

Reputation Management. Reputation Management refers to the need to seek references for an individual or organization participating in social networks and communities regarding their intellection or influence [34]. This need is partially addressed by existing online reputation management services, which monitor one's influence based on his/her activities in the social web, such as Klout (http://www.klout.com) and Naymz (http://www.naymz.com), or measure scientific research performance based on citation analysis, such as Google Scholar (http://scholar.google.com) and Research Gate (http://www.researchgate.net). Another stream of reputation management systems are using customer feedback to gain insight on suppliers and brands, or get early warning signals to reputation problems (e.g. eBay RMS).

Likewise, OI processes in the public sector may attract and make use of information from a plethora of different sources and may be affected by the public relations between multiple stakeholders, which should be treated according to their credibility. Current reputation algorithms can partially address this challenge by assigning a generic reputation score to experts. Nevertheless, a valid application of author-based idea filtering [23] for identifying promising ideas from large corpuses demands contributors to be assessed against their expertise on specific topics related to the public problem under investigation. This approach is followed by the EU-Community Reputation Management System [35], which collects data related to the knowledge, credibility and expertise of individuals, and uses a synthetic algorithm to assign a reputation score to them.

Collaboration Support. The emergence of the Web 2.0 era introduced a plethora of collaboration tools, which enable engagement at a massive scale and feature novel paradigms. At the same time, it is broadly admitted that the collaboration aspect of OI initiatives in the public sector is relatively unexplored [13]. These tools cover a broad spectrum of needs ranging from knowledge exchanging, sharing and tagging, to social networking, group authoring, mind mapping and discussing. For instance, Facebook (http://www.facebook.com) and LinkedIn (http://www.linkedin.com) are representative examples of social networking tools that facilitate the formation of online communities among people with similar interests; tools such as MindMeister (http://www.mindmeister.com) and Mindomo (http://www.mindomo.com) aim to collectively organize, visualize and structure concepts via maps to aid brainstorming and problem solving; Debatepedia (http://wiki.idebate.org) and Cohere (http://cohere.open.ac.uk) are typical tools aiming to support online discussions over the Web; phpBB (http://www.phpbb.com) and bbPress (http://www.bbpress.org) are Web 2.0 applications enabling the exchange of opinions, focusing especially on providing an environment in which users can express their thoughts without paying much attention to the structure of the discussion.

The above tool categories enable the massive and unconstraint collaboration of users; however, this very feature is the source of a problem that these tools introduce: the problem of information overload. The amount of information produced and exchanged and the number of events generated within these tools exceeds by far the mental abilities of users to: (i) keep pace with the evolution of the collaboration in which they engage, and (ii) keep track of the outcome of past sessions. Current Web 2.0 collaboration tools exhibit two important shortcomings making them prone to the problems of information

overload and cognitive complexity. First, these tools are "information islands", thus providing only limited support for interoperation, integration and synergy with third party tools. While some provide specialized APIs with which integration can be achieved, these are primarily aimed at developers and not end users. Second, Web 2.0 collaboration tools are rather passive media, i.e. they lack reasoning services with which they could actively and meaningfully support collaboration.

Argumentation Support. As far as argumentation is concerned, various tools focusing on the sharing and exchange of arguments, diverse knowledge representation issues and visualization of argumentation have been developed. Tools such as Araucaria [36], Reason!Able [37] and Compendium (http://compendium.open.ac.uk) allow users to create issues, take positions on these issues, and make pro and contra arguments. They can capture the key issues and ideas and create shared understanding in a knowledge team; in some cases, they can be used to gather a semantic group memory. However, these argumentation support tools have the same problems with the aforementioned Web 2.0 collaboration tools. They too are standalone applications, lacking support for interoperability and integration with other tools (e.g. with data mining services foraging the Web to discover interesting patterns or trends). They also cope poorly with voluminous and complex data as they provide only primitive reasoning services. This makes these tools prone to the problem of information overload. Argumentation support services recently developed in the context of the Dicode project [38] address most of these issues through innovative virtual workspaces offering alternative visualization schemas that help stakeholders control the impact of voluminous and complex data, while also accommodating the outcomes of external web services, thus augmenting individual and collective sense-making (see next section).

In any case, argumentation support tools reveal additional shortcomings that prevent them from reaching a wider audience. In particular, their emphasis on providing fixed and prescribed ways of interaction within collaboration spaces make them difficult to use as they constrain the expressiveness of users, which in turn results in making these systems being used only in niche communities. Adopting the terminology used in the most common theoretical framework of situational awareness shaped by Endsley [39], this category of tools only partially cover the needs of the three stages of situational awareness, namely perception (i.e. perceive the status, attributes, and dynamics of relevant elements in the setting under consideration), comprehension (i.e. perform a synthesis of disjointed elements of the previous stage through the processes of pattern recognition, interpretation, and evaluation), and projection (i.e. extrapolate information from previous stages to find out how it will affect future instances of the operational setting).

Decision making support. Data warehouses, on-line analytical processing, and data mining have been broadly recognized as technologies playing a prominent role in the development of current and future Decision Support Systems [40], in that they may aid users make better, faster and informed decisions. However, there is still room for further developing the conceptual, methodological and application-oriented aspects of the issue. One critical point that is still missing is a holistic perspective on the issue of decision

making. This originates out of the growing need to develop applications by following a more human-centric (and not problem-centric) view, in order to appropriately address the requirements of public sector stakeholders. Such requirements stem from the fact that decision making has also to be considered as a social process that principally involves human interaction [41]. The structuring and management of this interaction requires the appropriate technological support and has to be explicitly embedded in the solution offered.

The above requirements, together with the ones imposed by the way public sector stakeholders work and collaborate today, delineate a set of challenges for further decision support technology development. Such challenges can be addressed by adopting a knowledge-based decision-making view, while also enabling the meaningful accommodation of the results of the social knowledge and related mining processes. According to this view, which builds on bottom-up innovation models, decisions are considered as pieces of descriptive or procedural knowledge referring to an action commitment. In such a way, the decision making process is able to produce new knowledge, such as evidence justifying or challenging an alternative or practices to be followed or avoided after the evaluation of a decision, thus providing a refined understanding of the problem. On the other hand, in a decision making context the knowledge base of facts and routines alters, since it has to reflect the ever-changing external environment and internal structures of the organization. Knowledge management activities such as knowledge elicitation, representation and distribution influence the creation of the decision models to be adopted, thus enhancing the decision making process [42], while evaluation of contributions in the decision making process act as a reputation mechanism and provide incentives for engagement.

Table 1 attempts a mapping of the previously presented categories of ICT tools with the OI phases they primarily support. As shown, support for collaboration and social media monitoring applies to all phases, while the need for sophisticated analysis may be served by alternative combinations of tools such as those supporting policy modelling and social media monitoring.

Table 1. ICT tools used at different phases of OI in the public sector.

	Problem identification	Ideation	Incubation	Implementation
Open data platforms	x			x
Policy modelling & simulation	x			x
Social media monitoring	x	x	x	x
Opinion mining	x	x	x	
Reputation management		x	x	
Collaboration support	x	x	x	x
Argumentation support		x	x	x
Decision support			x	x

3 Towards an Inclusive OI Platform

3.1 Integration Issues

The majority of tools reported in the previous section have been originally designed to work as standalone applications. However, in complex contexts such as that of OI in the public sector, which are characterized by diverse types of stakeholders and activities, these tools need to be integrated and meaningfully orchestrated. In most cases, this is a complex and challenging issue, which depends on many factors, such as the type of the resources to be integrated, performance requirements, data heterogeneity and semantics, user interfaces, and middleware [43]. At the same time, public sector stakeholders are confronted with the rapidly growing problem of information overload. An enormous amount of content already exists in the "digital universe", i.e. information that is created, captured, or replicated in digital form, which is characterized by high rates of new information that demands attention. When working together, people have to cope with this diverse and exploding digital universe; they need to efficiently and effectively collaborate and make decisions by appropriately assembling and analyzing enormous volumes of complex multi-faceted data residing in different sources. Admittedly, when things get complex, we need to aggregate big volumes of data, and then mine it for insights that would never emerge from manual inspection or analysis of any single data source.

We argue that the above requirements can be fully addressed by an innovative web-based platform that ensures the seamless interoperability and integration of diverse components and services. The proposed solution should be able to loosely combine web services to provide an all-inclusive infrastructure ('single-access-point') for the effective and efficient support of public and private sector stakeholders participating in OI. It will not only provide a working environment for hosting and indexing of services, seamless retrieval and analysis of large-scale data sets; it will also leverage Web technologies and social networking solutions to provide stakeholders with a simple and scalable solution for targeted collaboration, resource discovery and exploitation, in a way that facilitates and boosts open innovation activities. Much attention needs to be paid to standardization issues to make existing data and software reusable with the minimum effort and without introducing new standards. Interoperability issues should be considered from a technical, conceptual and user interface point of view. When necessary, the foreseen platform should exploit rich semantics at machine level to enable the meaningful incorporation and orchestration of interoperable web services in customized OI-related workflow settings, aiming to reduce the data-intensiveness and smooth the associated workloads to a manageable level.

The proposed integration can be based on established technologies and standards of a service-oriented architecture. Application Programming Interfaces (APIs) allow different applications to connect and interact with each other, while web services provide a standardized way of integrating web-based applications using open standards such as XML, SOAP, WSDL and UDDI. Such an integration approach has been fully developed in the context of the Dicode EU project (http://dicode-project.eu/), where a widget-based solution was conceived to deliver diverse web services to end-users, a dedicated registry

of services served location and recommendation purposes, and alternative service integration modes were proposed and thoroughly tested in the project's use cases. It has been shown that this approach, namely the Dicode Workbench [44], ensures a flexible, adaptable and scalable information and computation infrastructure, and exploits the competences of stakeholders to properly confront information management issues, such as information characterization, classification and interpretation, thus giving added value to the underlying collective intelligence. Moreover, it facilitates knowledge sharing and knowledge co-creation, and assures better-informed collaboration. At the same time, such an approach pays much attention to the issues of usability and ease-of-use, not requiring any particular programming expertise from the end users.

3.2 Synergy of Human and Machine Reasoning

As stressed in the literature [23, 25], the collaboration aspect needs to be emphasized in the proposed integrated platform, and meaningfully combined with tools supporting sophisticated support for analysis and reflection among stakeholders. Collaboration and decision making support services developed in the context of the Dicode project adhere to such imperatives [38]. Specifically, they (i) provide advanced collaboration support functionalities through innovative virtual workspaces, (ii) are geared towards achieving consensus and gaining of insights, (iii) support incremental formalization of argumentative collaboration (i.e. a stepwise and controlled evolution from a mere collection of individual ideas and resources to the production of highly contextualized and interrelated knowledge artifacts), which augments sense-making through reviewing, commenting on and extending the shared content, and (iv) aid stakeholders rank alternative solutions and conclude the issue at hand (i.e. reach a decision), offering a working environment that is able to interpret diverse knowledge items and their interrelationships in order to proactively suggest trends, or even aggregate data and calculate the outcome of a multi-criteria collaborative decision making process.

The above services can further augment the quality of OI activities when properly combined with a set of tools for sophisticated collection and analysis on textual content published in external social media, which has been developed in the context of the NOMAD project [21]. This is highly valuable, as it enables the collaboration and argumentation taking place as part of OI initiatives to take into account and benefit from 'fresh' relevant content contributed by citizens in numerous social media, incorporating useful ideas, knowledge as well as perceptions of the general public. Integrating components from many of the tool categories presented in Sect. 2, the NOMAD toolset provides APIs for services that: (i) create and maintain policy models (incorporating the main elements of public policies), (ii) mine relevant user-generated data from a variety of online text sources (e.g. political blogs, social media, web-sites), (iii) perform linguistic analysis to transform free text into a set of structured data, (iv) discover and extract arguments from free text, (v) perform sentiment analysis to classify text segments according to their 'tone' (positive, neutral, negative), (vi) cluster arguments, based on calculated similarities, and present automatically-generated summaries, and (vii) visualize a structured view of the crowd opinion on a policy, providing insights on how much, when and how people are talking about a specific issue.

Such a combination between human collaboration support and data collection and analysis tools builds on the synergy between human and machine intelligence to facilitate and enhance individual and collective work during the entire OI process. In addition, it addresses diverse requirements related to the data intensiveness and cognitive complexity of settings concerning OI in the public sector.

3.3 An Application Scenario

The proposed solution is illustrated through a realistic example concerning the development of public policy for the management of immigrants-refugees inflows in Greece. Assuming that the related OI process is initiated by the Greek Ministry of Interior, policy makers and advisors from the Ministry in cooperation with other stakeholders (NGO representatives, governmental agencies, migration experts, etc.) use the Dicode Collaboration Support services (see Fig. 1) to elaborate the issue. They agree on an initial policy model incorporating three alternative solutions (appearing next to the 'light bulb' icons in the Dicode workspace of Fig. 1). Different stakeholders' perspectives are associated with these solutions as arguments in favor or against them (shown with green and red arrows, respectively). Stakeholders may also contribute to a better understanding of the problem and its policy context by uploading supplementary material of any format (e.g. documents referring to EU legislation, multimedia material pointing to a particular dimension of the problem, informative graphs and tables etc.).

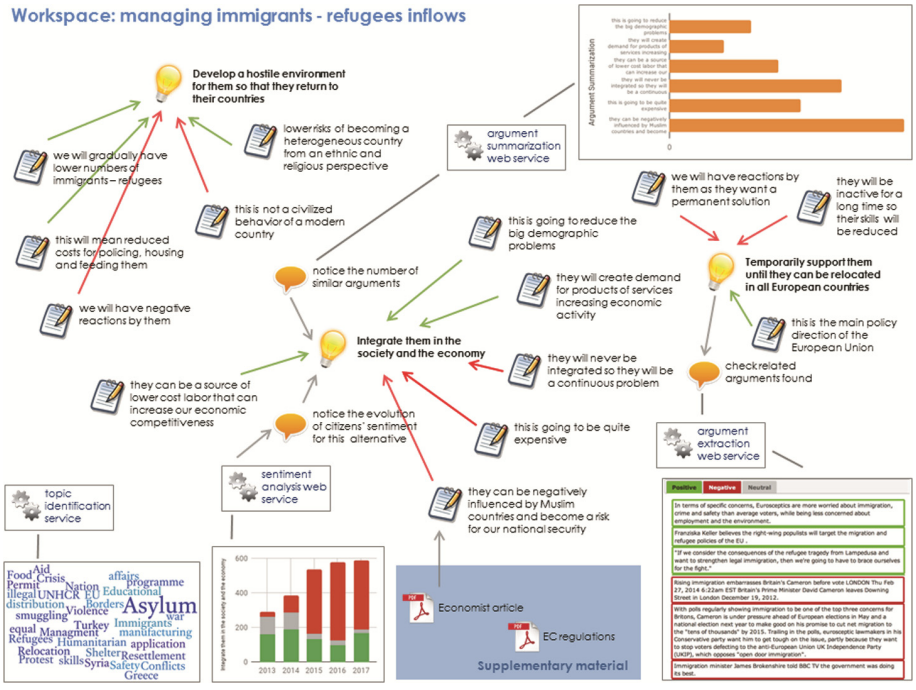

Fig. 1. Workspace of the application scenario (an instance).

At the same time, stakeholders may easily invoke external web services (notice the 'double gear' icons in the Dicode workspace) to look for additional data related to the policy model under consideration. Through appropriate APIs, external services may upload their outcomes into the Dicode collaboration workspace, thus making them part of the undergoing collaboration. For instance, a Topic Identification service may reveal - through the word cloud shown in Fig. 1 - the most popular topics discussed by citizens in relevant web sources (blogs, news sites, social media communities, etc.), thus triggering the consideration of additional perspectives (e.g. those related to provision of asylum). In the instance shown in Fig. 1, a set of NOMAD services have been already executed to aid the required sophisticated analysis of the associated big textual data. Specifically: (i) the Sentiment Analysis service, which enables stakeholders to view the extent (and evolution over time) of the support or opposition of the crowd on an alternative solution, (ii) the Argument Extraction service that reveals new arguments in favor or against the already proposed solutions, which can then be exploited by stakeholders, (iii) the Argument Summarization service that returns the volume of extracted arguments' clusters to provide users with estimations about their popularity.

The collaborative environment proposed allows stakeholders to upload and refine alternative ideas and proposals, argue on them, and evaluate existing content consolidating the knowledge brought forward by both humans and the machine. Machine-retrieved content can be leveraged by stakeholders, in that it enables them advance an ongoing deliberation and gain new insights, based on 'fresh' content from the society reflecting knowledge, perceptions and feelings of the general public. In addition, it motivates brainstorming in the ideation and the incubation phases. Finally, the retrieved (external textual content) analytics may further aid the overall decision making process. It is noted that decision making support services also offered by the Dicode approach may be exploited in the implementation phase of OI to aid the evaluation of alternative solutions by incorporating various algorithms and criteria.

Additional services may further enhance the OI process illustrated in Fig. 1. For instance, a Reputation Management service may provide ranking of ideas based on the expertise of the contributor; a Policy Simulation service may run scenarios to predict the outcome of the most prevalent solutions. In parallel, real time social data can be aggregated with statistical information coming from public administration (e.g. Ministries, Greek Asylum Service, Eurostat) or related open data platforms.

4 Conclusions

Taking into account identified challenges concerning the implementation and advancement of OI practices in the public sector, this paper embarks on the analysis and synthesis of the functionalities offered by existing ICT tools. It focuses on the fundamental and highly valuable integration between collaboration and decision support tools, on one hand, and data collection and analysis tools, on the other. Associating the identified tool categories with the diverse OI phases, the need for collaboration and sophisticated data collection and analysis has been stressed. This led to the description of an open and inclusive solution that may foster and facilitate OI initiatives in the public sector,

enabling expert argumentative consultations to be informed by relevant external social media content incorporating the knowledge, perceptions and feeling of the society.

The proposed platform offers a novel collaborative environment that allows stakeholders immerse in Web 2.0 interaction paradigms and exploit its enormous potential to collaborate through reviewing, commenting on and extending the shared content along the OI phases. The platform enables stakeholders maintain chains of views and opinions, accompanied by the supporting data, which may reflect, at any time, the current collective knowledge on the issue under consideration, and justify a particular decision made or action taken. In the proposed solution, collaboration services are not standalone applications that operate autonomously; instead, they coexist and make use of other services' outcomes to improve their performance.

Future work directions include the implementation of the proposed OI platform and its practical application and evaluation within the context of diverse OI practices in the public sector. Also, it will be very interesting to evaluate to what extent such a platform enables a transfer of knowledge, perceptions and feelings from the society towards the experts/technocrats, contributing to overcoming the negative aspects of the 'technocracy' (e.g. limited understanding of diverse needs, values and concerns of different stakeholder groups on particular social problems the experts analyze) [35].

References

1. Chesbrough, H.W., Vanhaverbeke, W., West, J.: New Frontiers in Open Innovation. Oxford University Press, Oxford (2014)
2. Chesbrough, H.W.: Open Innovation: The New Imperative for Creating and Profiting from Technology. (2003)
3. Chesbrough, H.W.: The era of open innovation. MIT Sloan Manag. Rev. **44**(3), 35–41 (2003)
4. Spithoven, A., Vanhaverbeke, W., Roijakkers, N.: Open innovation practices in SMEs and large enterprises. Small Bus. Econ. **41**, 537–562 (2013)
5. Felin, T., Zenger, T.R.: Closed or open innovation? Problem solving and the governance choice. Res. Policy **43**, 914–925 (2014)
6. Mina, A., Bascavusoglu-Moreau, E., Hughes, A.: Open service innovation and the firm's search for external knowledge. Res. Policy **43**, 853–866 (2014)
7. Bellantuono, N., Pontrandolfo, P., Scozzi, B.: Different practices for open innovation: a context-based approach Different practices for open innovation: a context-based approach. J. Knowl. Manag. **17**, 558–568 (2013)
8. Mergel, I.: A framework for interpreting social media interactions in the public sector. Gov. Inform. Q. **30**, 327–334 (2013)
9. Loukis, E., Charalabidis, Y., Androutsopoulou, A.: Promoting open innovation in the public sector through social media monitoring. Gov. Inform. Q. **34**, 99–109 (2017)
10. Ferro, E., Molinari, F.: Framing web 2.0 in the process of public sector innovation: going down the participation ladder. Eur. J. ePractice **9**, 1–15 (2010)
11. Lee, S.M., Hwang, T., Choi, D.: Open innovation in the public sector of leading countries. Manag. Decis. **50**, 147–162 (2012)
12. Chesbrough, H., Bogers, M.: Explicating open innovation: clarifying an emerging paradigm for understanding innovation keywords. New Frontiers in Open Innovation, pp. 1–37 (2014)
13. Mergel, I.: Opening government: designing open innovation processes to collaborate with external problem solvers. Soc. Sci. Comput. Rev. **33**, 599–612 (2015)

14. Kankanhalli, A., Zuiderwijk, A., Tayi, G.K.: Open innovation in the public sector: A research agenda. Gov. Inform. Q. **34**, 84–89 (2017)
15. Viscusi, G., Poulin, D., Tucci, C.: Open innovation research and e-government: clarifying the connections between two fields. In: XII Conference of the Italian Chapter of AIS (itAIS 2015) (2015)
16. Mergel, I., Desouza, K.: Implementing open innovation in the public sector: the case of challenge.gov. Public Adm. Rev. **73**, 882–890 (2013)
17. Bekkers, V., Tummers, L.G., Voorberg, W.H.: From public innovation to social innovation in the public sector: a literature review of relevant drivers and barriers. Erasmus University Rotterdam, Rotterdam (2013)
18. Misuraca, G., Viscusi, G.: Shaping public sector innovation theory: an interpretative framework for ICT-enabled governance innovation. Electron. Commer. Res. **15**, 303–322 (2015)
19. Van Duivenboden, H., Thaens, M.: ICT-driven innovation and the culture of public administration: a contradiction in terms? Inform. Polity. **13**, 213–232 (2008)
20. Criado, J.I., Sandoval-Almazan, R., Gil-Garcia, J.R.: Government innovation through social media. Gov. Inform. Q. **30**, 319–326 (2013)
21. Charalabidis, Y., Loukis, E., Androutsopoulou, A., Karkaletsis, V., Triantafillou, A.: Passive crowdsourcing in government using social media. Transforming Gov. People, Process Policy **8**, 283–308 (2014)
22. Ham, J., Lee, J.-N., Kim, D.J., Choi, B.: Open innovation maturity model for the government: an open system perspective. In: Proceedings of the 36th International Conference on Information Systems (ICIS), pp. 1–11 (2015)
23. Klein, M., Convertino, G.: A roadmap for open innovation system. J. Soc. Media Organ. **2**, 1 (2015)
24. Assar, S., Boughzala, I., Isckia, T.: eGovernment trends in the web 2.0 era and the open innovation perspective: an exploratory field study. In: Janssen, M., Scholl, H.J., Wimmer, M.A., Tan, Y.-h. (eds.) EGOV 2011. LNCS, vol. 6846, pp. 210–222. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-22878-0_18
25. Hrastinski, S., Kviselius, N.Z., Ozan, H., Edenius, M.: A review of technologies for open innovation: Characteristics and future trends. In: Proceedings of the Annual Hawaii International Conference on System Sciences (2010)
26. Bekkers, V., Edwards, A., de Kool, D.: Social media monitoring: responsive governance in the shadow of surveillance? Gov. Inform. Q. **30**, 335–342 (2013)
27. Chan, C.M.L.: From open data to open innovation strategies: creating E-Services using open government data. In: Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS-46). pp. 1890–1899 (2013)
28. Alexopoulos, C., Loukis, E., Mouzakitis, S., Petychakis, M., Charalabidis, Y.: Analysing the characteristics of open government data sources in Greece. J. Knowl. Econ., 1–33 (2015). https://doi.org/10.1007/s13132-015-0298-8
29. Stavrakantonakis, I., Gagiu, A.-E., Kasper, H., Toma, I., Thalhammer, A.: An approach for evaluation of social media monitoring tools. In: 1st International Workshop on Common Value Management, pp. 52–64 (2012)
30. Taylor, E.M., Rodríguez O., C., Velásquez, J.D., Ghosh, G., Banerjee, S.: Web opinion mining and sentimental analysis. In: Velásquez, J.D., Palade, V., and Jain, L.C. (eds.) Advanced Techniques in Web Intelligence-2: Web User Browsing Behaviour and Preference Analysis. SCI, vol. 452, pp. 105–126. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-33326-2_5

31. Dhokrat, A., Khillare, S., Mahender, C.N.: Review on techniques and tools used for opinion mining. Int. J. Comput. Appl. Technol. Res. **4**, 419–424 (2015)
32. Maragoudakis, M., Loukis, E., Charalabidis, Y.: A review of opinion mining methods for analyzing citizens' contributions in public policy debate. In: Electronic Participation Proceedings of the 3rd IFIP WG 8.5 International Conference, ePart 2011. pp. 298–313 (2011)
33. Maynard, D., Bontcheva, K., Rout, D.: Challenges in developing opinion mining tools for social media. In: LREC 2012, pp. 15–22 (2012)
34. He, D., Peng, Z., Hong, L., Zhang, Yu.: A social reputation management for web communities. In: Wang, L., Jiang, J., Lu, J., Hong, L., Liu, B. (eds.) WAIM 2011. LNCS, vol. 7142, pp. 167–174. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-28635-3_16
35. Androutsopoulou, A., Mureddu, F., Loukis, E., Charalabidis, Y.: Passive expert-sourcing for policy making in the European union. In: Tambouris, E., Panagiotopoulos, P., Sæbø, Ø., Wimmer, M.A., Pardo, T.A., Charalabidis, Y., Soares, D.S., Janowski, T. (eds.) ePart 2016. LNCS, vol. 9821, pp. 162–175. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-45074-2_13
36. Reed, C., Rowe, G.: Araucaria: Software for puzzles in argument diagramming and XML. Department of Applied Computing, University of Dundee Technical report, pp. 1–21 (2001)
37. van Gelder, T.: Argument mapping with Reason!Able. Am. Philos. Assoc. Newslett. Philos. Comput. **2**, 85–90 (2002)
38. Karacapilidis, N.: Mastering Data-Intensive Collaboration and Decision Making: Research and Practical Applications in the Dicode Project. Springer Science & Business Media, Switzerland (2014)
39. Endsley, M.R.: Toward a theory of situation awareness in dynamic systems: Situation awareness. Hum. Factors **37**, 32–64 (1995)
40. Shim, J.P., Warkentin, M., Courtney, J.F., Power, D.J., Sharda, R., Carlsson, C.: Past, present, and future of decision support technology. Decis. Support Syst. **33**, 111–126 (2002)
41. Smoliar, S.W.: Interaction management: The next (and necessary) step beyond knowledge management. Bus. Process Manag. J. **9**, 337–353 (2003)
42. Karacapilidis, N.I., Gordon, T.F.: Dialectical planning. In: Proceedings of 14th International Joint Conference on Artificial Intelligence (IJCAI 1995); Workshop on Intelligent Manufacturing Systems, pp. 239–250 (1995)
43. Ziegler, P., Dittrich, K.R.: Three decades of data integration — all problems solved? In: 18th IFIP World Computer Congress (WCC 2004), pp. 3–12 (2004)
44. de la Calle, G., Alonso-Martinez, E., Tzagarakis, M., Karacapilidis, N.: The dicode workbench: a flexible framework for the integration of information and web services. In: Proceedings of the 14th International Conference on Information Integration and Web-based Applications and Services, pp. 16–25. ACM, New York (2012)