Defining a Taxonomy for Research Areas on ICT for Governance and Policy Modelling

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Abstract. As governments across the world provide more and more support to open data initiatives and web 2.0 channels for engaging citizens, researchers orient themselves towards future internet, wisdom of crowds and virtual world experiments. In this context, the domain of ICT for Governance and Policy Modelling has recently emerged to achieve better, participative, evidence-based and timely governance. This paper presents a taxonomy classifying the research themes, the research areas and the research sub-areas that challenge this domain in order to deal with its diversity and complexity. Taking into account advancements in research, policy and practice, the taxonomy brings together the open, linked data and visual analytics philosophy; the social media buzz taming collective wisdom in decision-making; and the future internet approaches around cloud computing, internet of things and internet of services, while embracing the collaborative policy modelling aspects and the safeguarding against misuse implications.

Keywords: ICT for Governance and Policy Modelling, Taxonomy, Research Areas, Open Government, Social Computing, Future Internet, Safeguard against misuse

1 Introduction

As Governments are committing more effort to understand an increasingly interdependent and complex world [3], [25], [27], [32], citizens demand more openness, transparency and commitment to results [8] - within or after the financial crisis. Moreover, citizens are becoming increasingly vocal in monitoring and influencing policy decisions, through the new media [31].

Along these ways of evolution, future scenarios in ICT for Governance and Policy Modelling are promising to reach the target of a better, participative, evidence-based and timely governance, while taming greater complexity and attracting citizens'

involvement. ICT for Governance and Policy Modelling has emerged as an umbrella term for a number of technologies that can be applied in order to achieve the common goal of improving public decision-making in the age of complexity. They aim at making the policy-making cycle more effective and more intelligent, and at accelerating the learning path embedded in the policy cycle. However, this is often characterized as a very diverse, not yet consolidated domain, since:

- It is highly multidisciplinary, involving disciplines such as: information systems, engineering, mathematics, statistics, economics, sociology, design and user interface, political science [20].
- It brings together different cultural approaches to research and development: innovation in the field of policy modelling, forecasting and simulation is theory-led and academic, while the fields of mass collaboration, participation and visualization are more practice-based and user-driven.

In recent years we have assisted to a flourishing of ICT tools to support governments in designing policies [10]. However, such tools are not often adopted successfully, also due to fragmentation between academic fields, application areas and approaches to innovation.

In this context, this paper presents a taxonomy of the research areas related to the domain of ICT for Governance and Policy Modelling. It was created in the context of the CROSSROAD project [15], a Support Action funded by the European Commission in order to deliver a Research Roadmap on ICT for Governance and Policy Modelling. In alignment with its definition as the practice and science of classification, the proposed taxonomy aims to clarify the research areas of interest, deal with their complexity, structure any state of the art analysis attempt in the domain in a more formalized way and guide the future research activities in the years to come. The taxonomy proposed builds on relevant work undertaken in the context of electronic government, such as the eGovRTD2020 [13] or eGovernance in general [17], [29], and other related fields research reports, i.e. the Enterprise Interoperability Research Roadmap [9] and generally the Future of the Internet [16], [18], [19].

The structure of this paper is as follows: Section 2 outlines the methodology followed during the design of the proposed taxonomy. Section 3 gives an overview of the Research Areas Taxonomy extended over three levels and containing more than 100 nodes. Section 4 finally presents the conclusions and future steps towards expansion and sustainability of the taxonomy by the broader research community.

2 Methodology

The overall vision that leads the definition of the Research Areas Taxonomy can be summarized as: "*Forward-looking, innovative research topics and themes emerging from various disciplines, sciences and practices, independently of their existing relation to ICT for Governance & Policy Modelling with a view to present and future needs will be included and investigated in the proposed Research Areas Taxonomy.*"

In order to avoid ambiguity, contradiction and omission and reach consensus among the community, the methodology for building the proposed Research Areas Taxonomy includes the following steps:

1. Definition of a common taxonomy glossary in order to ensure common understanding of key terms:
    - ICT for Governance and Policy Modelling (FP7 2009-2010 Objective 7.3) is defined as the *Research Domain*.
    - The first level of the taxonomy can be also referred to as *Research Theme*, i.e. a broad thematic category, containing a number of research areas (at lower levels), which describes a set of approaches and actions that could be undertaken to advance the theme ICT for Governance and Policy Modelling
    - The second level of the taxonomy is defined as core *Research Area*, compromising of similar and in many cases competitive technologies, tools or methodologies that look into progress in a specific Research Theme
    - The third level of the taxonomy includes *Research Sub-Areas* including technologies, tools or methodologies which target at the same Research Area, yet cannot be directly compared
2. Outlining a set of baseline guidelines and rules that will guide the design of the Taxonomy:
    - The levels in which the taxonomy extends for the CROSSROAD purposes are 3 with each level including from three to seven sub-levels.
    - Each Research Theme (Level 1) is bound to the Research Areas (Level 2) with a 1:N relationship, while the Research Areas (Level 2) are correlated with Research Sub-areas (Level 3) in a M:N relationship. Research Sub-areas (Level 3) can also be M:N related to other Research Sub-areas.

Table 1. Baseline Rules for the design of the Taxonomy

Metrics	Res. Theme	Res. Area	Res. Sub-area
Number of Sub-levels	3-7	3-7	-
Number of Results in academic bibliography search engines	At least 200	At least 100	-
Number of Papers with at least 10 citations	At least 10	At least 5	-
Number of Papers in the last 2 years	At least 20	At least 10	-
Number of Papers mentioning the term and recognizing its importance	At least 10	At least 5	-
Number of Research Roadmaps recognizing its importance	At least 1	-	-
Existence of the exact term in Wikipedia and other online dictionaries	At least 1	At least 1	-
Number of references in a Strategic Document which is available in English at EU and national level in the last 2 years	-	At least 1	-
Number of Good Practices across the world in the last 2 years	-	At least 3	-
Number of papers mentioning its existence under the parent Research Area			At Least 5
No implications to vertical application domains			True

3. *Definition of the Research Themes (1st Level) and the Research Areas (2nd Level) of the Taxonomy* based on the guidelines of the ICT FP7 Work Programme 2009-2010 and on a preliminary analysis of the conferences and journals related to ICT for Governance and Policy Modelling [30]:
    - Conferences, i.e. EGOV, HICCS eGovernment Track, ePart, dg.o, AMCIS eGovernment Track and ICEGOV
    - Journals, such as Elsevier Government Information Quarterly (GIQ), Inderscience Electronic Government: An International Journal, ACI Electronic Journal of e-Government, IOS Press Information Policy, IGI International Journal of Electronic Government Research, Taylor & Francis Journal of Information Technology and Politics, Emerald Transforming Government: Process, People and Policy
4. *Iterative definitions, discussions and updates of the Research Areas (2nd Level) and mainly the Research Sub-areas (3rd Level)* of the Taxonomy based on the information and material collected. It needs to be noted that during the state of the art analysis of the bibliography retrieved, the CROSSROAD Research Areas Taxonomy were continually revisited at the second and third level in order to ensure, on the one hand, its alignment with the research domain and, on the other hand, its completeness and soundness.

Generally, the potential sources of information for the taxonomy constitute a mixture of the research, policy, practice and market aspects. Apart from traditional search engines (Google, Bing, etc.) and academic literature databases (Scopus, ISI Web of Knowledge, Elsevier, SpringerLink, IEEE, Google Scholar, etc.) for searching information, social media such as blogs, Twitter hashtags and delicious bookmarks tags were investigated in order to collect the necessary supportive material spanning: Research papers and thesis; Relevant academic Literature and Books; Relevant Project Deliverables as retrieved from the project websites. Particular emphasis has been given to the recent FP7 projects [16], since the results of most FP6 projects have already been underpinned by FP7 projects; Government Initiatives and Strategies; Directives from the European Union; Policy-making initiatives at pan-European, national and international level, such as i2010, IDABC, ISA; Cases and publications in information gathering portals, such as ePractice; Experts' Positions as expressed in white papers and / or blogs; Industry visions and reports, such as the Gartner hypecycle; Outcomes of forecasting models or other roadmapping projects.

3 CROSSROAD Research Areas Taxonomy

Based on aforementioned methodological approach, CROSSROAD developed the Research Areas Taxonomy to classify the broader domain of ICT for Governance and Policy Modelling into 5 Research Themes, 17 Research Areas and more than 80 Research Sub-areas, as depicted in the following figure.

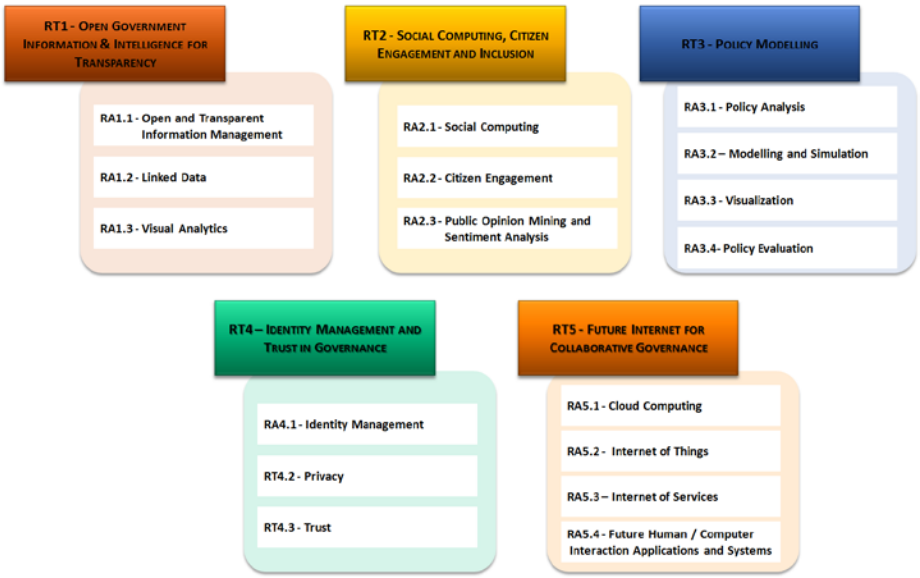

Fig. 1. CROSSROAD Research Areas Taxonomy

3.1 Open Government Information & Intelligence for Transparency

In contrast to the past focus of "making services available online", the current strategic direction in Electronic Governance appears to be transparency and "making public data available for reuse" [24]. In this context, Open Government Information and Intelligence aims at making the long quest for transparency a reality by: Opening up data for public consumption and exploitation; Linking data in advanced applications that allow citizens to browse across datasets and mash-ups; and Visual analyzing and reasoning over public data and facts since government can no longer hide behind analysis and charts they themselves provide due to the combination of open data and visualization tools. Table 2 shows an extract of the research areas and sub-areas of the research theme Open Government Information and Intelligence for Transparency.

Open Data is a philosophy and practice requiring that certain data are freely available to everyone, without restrictions from copyright, patents or other mechanisms of control. The Open Government Working Group [28] has defined a set of fundamental principles for open government data: Data Must Be Complete, Data Must Be Primary, Data Must Be Timely, Data Must Be Accessible, Data Must Be Machine processable, Access Must Be Non-Discriminatory, Data Formats Must Be Non-Proprietary, Data Must Be License-free.

Linked Data, a term coined by Tim Berners-Lee in his Linked Data Web architecture note [4], is about using the Web to connect related data that wasn't previously linked, or using the Web to lower the barriers to linking data currently linked using other methods. The basic assumption behind Linked Data is that the

value and usefulness of data increases the more it is interlinked with other data, with the ultimate goal to enable people to share structured data on the Web as easily as they can share documents today[6].

Taking into account that today, data is created and published at an incredible rate and the ability to collect and store the data is increasing at a faster rate than the ability to analyze it, Visual Analytics is characterized as an emerging area of research and practice that aims at integrating the outstanding capabilities of humans in terms of visual information exploration and the enormous processing power of computers to form a powerful knowledge discovery environment [1], allowing them to make well-informed decisions in complex situations [22].

Table 2. Open Government Information and Intelligence Taxonomy Extract

Research Area	Res. Sub-area
1.1 Open and Transparent Information Management	1.1.1 Open Data Publication
	1.1.2 Web Dissemination and Promotion
	1.1.3 Open Data Quality Agreements
	1.1.4 Open Data Communities Building
	1.1.5 Transparency and Reputation Management
	1.1.6 Open Data Legal Implications and Licenses
1.2 Linked Data Management	1.2.1 Capturing and Sharing Linked Data
	1.2.2 Querying and Analyzing Governmental Linked Data
	1.2.3 Browsing and Searching Linked Data
	1.2.4 Government Data Fusion and Mash-ups
	1.2.5 Linked Data Provenance and Evolution
	1.2.6 User Interaction and Linked Data Usability
	1.2.7 Linked Data Quality Assurance
1.3 Visual Analytics	1.3.1 Visual Information Foraging and Design
	1.3.2 Information Visualization and Interaction
	1.3.3 Analytical Reasoning
	1.3.4 Collaborative Analysis and Intelligence
	1.3.5 Visualization Evaluation

3.2 Social Computing, Citizen Engagement and Inclusion

Today, as citizens become more and more engaged in Social Media and vocal in raising their opinion as User Generated Content in the web [31], governments need to look into the following research areas: Social Computing, Citizen Engagement and Public Opinion Mining and Sentiment Analysis as analyzed in Table 3.

Social Computing in the Public Sector is defined as a social structure in which technology puts power in communities, not institutions [11], as well as a set of open, web-based and user-friendly applications that enable users to network, share data, collaborate and co-produce content [2]. Three tenets actually define social computing: 1) innovation will shift from top-down to bottom-up; 2) value will shift from ownership to experience; and 3) power will shift from institutions to communities.

Citizen Engagement is often referred to as eParticipation or eDemocracy. However, a distinction needs to be made among these two terms and the broader

concept of citizen engagement and the emerging Wisdom of Crowds, as eParticipation is "the use of information and communication technologies to broaden and deepen political participation by enabling citizens to connect with one another and with their elected representatives" [23].

Finally, Public Opinion Mining and Sentiment Analysis can be defined as a sub-discipline of computational linguistics [5] that focuses on extracting people's opinion from the web. Given a piece of text, opinion-mining systems analyze: Which part is expressing an opinion; Who wrote the opinion; and What is being commented. Sentiment analysis, on the other hand, is about determining the subjectivity, polarity (positive or negative) and polarity strength (weakly positive, mildly positive, strongly positive, etc.) of a piece of text -in other words: What is the opinion of the writer [26].

Table 3. Social Networks, Citizen Engagement and Inclusion Taxonomy Extract

Research Area	Res. Sub-area
2.1 Social Computing in the Public Sector	2.1.1 Social Networking
	2.1.2 Content Syndication in Government Portals
	2.1.3 Collaborative Writing Tools
	2.1.4 Feedback, Rating and Reputation Systems
	2.1.5 Social Network Analysis
2.2 Citizen Engagement	2.2.1 Deliberation
	2.2.2 Consultation
	2.2.3 Argumentation Support
	2.2.4 Polling and Voting
	2.2.5 Petition
2.3 Public Opinion Mining and Sentiment Analysis	2.3.1 Opinion Tracking
	2.3.2 Multi-lingual and Multi-Cultural Opinion Extraction and Filtering
	2.3.3 Real-time Opinion Visualization
	2.3.4 Collective Wisdom Analysis and Exploitation

3.3 Policy Modelling

Policy Modelling aims at including all the necessary pieces required during policy making procedures, such as policy analysis, modelling, simulation, visualisation and evaluation (see e.g.[20]). In this context, this research theme aims at establishing a concrete set of methodologies, which will allow the creation of fair, transparent, well structured and benefit-optimized policies indicatively by:

- Analysing the policy landscape of the present and the past and setting the targets for the future.
- Modelling policies and the various environmental factors in a commonly agreed manner depending on each issue.
- Simulating the policies under discussion for gaining direct feedback from artificial, yet realistic test beds and evaluation in an ex-ante manner the possible options.
- Visualising the various policies, their impacts and their underlying information (from general policy directions to discussion arguments on

those) towards increased citizen participation and increased and faster comprehension of complex problems.

Table 4 shows an extract of the research areas and sub-areas of this research theme.

Table 4. Policy Modelling Taxonomy Extract

Research Area	Res. Sub-area
3.1 Policy Analysis	3.1.1 Forecasting
	3.1.2 Foresight
	3.1.3 Back-casting
	3.1.4 Now-casting
3.2 Modelling and Simulation	3.2.1 Multi-level and micro-simulation models
	3.2.2 System Dynamics
	3.2.3 Discrete Event Models
	3.2.4 Multi-agent Systems
	3.2.5 Mental Modelling
	3.2.6 Participatory Modelling and Reasoning
	3.2.7 Models Integration
3.3 Visualization	3.3.1 Virtual Worlds
	3.3.2 Mixed Reality
	3.3.3 Serious Gaming
	3.3.4 Argument Visualization
	3.3.5 Narrative Production
	3.3.6 Legal Corpora Visualization
3.4 Policy Evaluation	3.4.1 Models Quality Validation and Evaluation
	3.4.2 Impact Assessment
	3.4.3 Policy Monitoring

3.4 Identity Management and Trust in Governance

While "Anywhere anytime" computing systems and devices retrieve, validate, process and store personal and business information, identity management, privacy and trust aspects gain more and more momentum within Governance in order to safeguard citizens and public authorities data from misuse. In particular, the Research Theme "Identity Management and Trust in Governance" consists of the following research areas: Identity Management (IDM), Privacy and Trust as depicted in Table 5.

Identity Management (IDM) is the set of processes, and a supporting infrastructure for the creation, maintenance, and use of digital identities. Identity management is an ongoing and evolving strategy that leverages technology to automate and unify existing practices, and provide a consistent service-oriented architecture for applications to access user information securely.

Privacy is the ability of a citizen or a group of citizens to efficiently control the information they make public within a community and to seclude sensitive related personal information. Finally, Trust between two or more collaborating partners, such as citizens and public organizations, is founded on the presence of a robust and efficient legal and statutory framework.

Table 5. Identity Management and Trust in Governance Taxonomy Extract

Research Area	Res. Sub-area
4.1 Identity Management	4.1.1 Federated Identity Management Systems
	4.1.2 Next Generation Access Control and Authentication
	4.1.3 Legal and Social Aspects of eIdentity Management
	4.1.4 Mobility and Identity
	4.1.5 Identity Interoperability
	4.1.6 Forensic Implications of Identity Management Systems
4.2 Privacy	4.2.1 Privacy and Data Protection
	4.2.2 Privacy Enhancing Technologies
	4.2.3 Citizen Profiling
	4.2.4 Privacy Law and Regulations
4.3 Trust	4.3.1 Legal Informatics
	4.3.2 Digital Rights Management
	4.3.3 Digital Living and Citizenship
	4.3.4 Intellectual Property in the digital era
	4.3.5 Trust Services

3.5 Future Internet for Collaborative Governance

Internet is believed to radically change in the next decade and is foreseen as a seamless fabric of connectivity integrating all the different Internet entities – devices, sensors, services, things and people [18]. Future Internet is expected to provide the tools and methods towards an environment of high trust and increased Participation, which in turn are fundamental requirements in order to succeed in a "Co-production of Government". Future Internet is thereby understood in terms of Cloud Computing, Internet of Things, Internet of Services, and Future Human / Computer Interaction Applications and Systems, as depicted in Table 6.

According to [7], a Cloud is a type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource(s) based on service-level agreements established through negotiation between the service provider and the consumers. Cloud computing holds a number of advantages for the government, including "reduced cost, increased storage, higher levels of automation, increased flexibility, and higher levels of employee mobility." [12]

Internet of Things (IoT) is also an integrated part of Future Internet and is defined by the EC as: "A dynamic global network infrastructure with self configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network [19]."

Internet of Services is defined as "... a vision of the Internet of the Future, where organizations and individuals can find software as services on the Internet, combine them, and easily adapt them to their specific context. Users should be able to use software services that do exactly what they need" according to the Software & Service Architectures and Infrastructures initiative [14].

Finally, Human–computer interaction (HCI) is the study of interaction between people (users) and computers. Interaction between users and computers occurs at the user interface, which includes both software and hardware[1]. Future HCI applications and systems in the context of eGovernment portals aim to significantly enhance the interaction with the citizen in terms of usability, learnability and user satisfaction.

Table 6. Future Internet for Collaborative Governance Taxonomy Extract

Research Area	Res. Sub-area
5.1 Cloud Computing	5.1.1 Cloud Service Level Requirements
	5.1.2 Business Models in the Cloud
	5.1.3 Cloud Interoperability
	5.1.4 Security and Authentication in the Cloud
	5.1.5 Data Confidentiality and Auditability
	5.1.6 Regulatory Compliance
5.2 Internet of Things	5.2.1 Communication systems and network architectures
	5.2.2 Device Interoperability Assessment
	5.2.3 Distributed Intelligence
	5.2.4 Standardization
	5.2.5 Business Models for Pervasive Technologies
	5.2.6 Social Impacts and Risks
5.3 Internet of Services	5.3.1 Multi-channel access and delivery management
	5.3.2 Multiple channels coordination and aggregation
	5.3.3 Security and privacy issues on multi-channel service delivery
	5.3.4 Public Service Design and Engineering
	5.3.5 Public Service Aggregations, Mash-ups and Orchestration
	5.3.6 Public Service Level Agreements
5.4 Future Human / Computer Interaction Applications and Systems	5.4.1 Web accessibility
	5.4.2 Future human – computer interaction web interfaces /devices
	5.4.3 Engineering Psychology and Cognitive Ergonomics
	5.4.4 Human-Centered Design
	5.4.5 Augmented cognition
	5.4.6 Digital Human Modeling

4 Conclusions

In an effort to effectively clarify and classify the domain of ICT for Governance and Policy Modelling, the paper presented a taxonomy consisting of research themes, research areas and research sub-areas. Taking into account advancements in research, policy and practice, the taxonomy brings together the open, linked data and visual analytics philosophy (RT.1: Open Government Information & Intelligence for Transparency), the social media buzz taming collective wisdom in decision-making (RT.2: Social Computing, Citizen Engagement and Inclusion) and the future internet approaches (RT.5: Future Internet for Collaborative Governance) around cloud computing, internet of things and internet of services. It also analyzes the

[1] For extensive literature see the Special Interest Group of ACM under http://www.sigchi.org/

collaborative policy modelling aspects (RT.3: Policy Modelling) and the safeguarding against misuse implications (RT.4: Identity Management and Trust in Governance). Utilizing research roadmaps, academic papers and project deliverables, the proposed Research Areas Taxonomy highlights various research questions and challenges that have emerged and must be overcome, while restricting (to the extent that it is possible) mature research areas without many open research issues that have been embraced by market and practice implementations.

Future steps across the CROSSROAD Research Areas Taxonomy include iterative modifications in order to embrace future research challenges (for the years to come) in the domain of ICT for Governance and Policy Modelling which now do not have sufficient background to overpass the methodology thresholds and be included in the current version of the taxonomy. The taxonomy will be further used in the CROSSROAD project to develop a roadmap of future research for ICT for Governance and Policy Modelling. It will therefore help to dig into the state of the art in the research field, and it will be used in the scenario generation and gap analysis to further develop the intended research roadmap.

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