Leveraging universal social networking and the IoT for urban-scale participatory systems.

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0.1 Author's statement

The information presented in the current document is part of the author's research conducted during the period starting from October 2018 until September 2020, while the author was with INRIA Paris research center, MiMove Team. The document consists of three distinct chapters, which were written as papers and were not peer-reviewed or published during the aforementioned period.

The author states that the current research work is being published, so as to provide insights for students, professionals and the research community in general, under an open access perspective.

The author would also like to thank all the members of MiMove team (years 2018-2020) for interesting discussions and supervision of the current work, as well as the INRIA research center for funding the work.

0.2 Document description

The document is divided in three main chapters. In Chapter 1, a survey on Civic Technology with a focus on participatory democracy is presented, analysing the recent advances in the field, under the perspectives of governmental practices, community organization and urban-scale applications. Furthermore, civic engagement is being analysed as a general term. In Chapter 2, a networking perspective is analysed, based on Named Data Networking, to be integrated with social middleware, as an alternative content-based networking solution. Integration of NDN with the already known Universal Social Network Bus is proposed as a communication paradigm and social middleware for social networking applications. Finally, in Chapter 3, a new paradigm based on already proposed Social Participation Networks is extended, to provide a generic approach for defining entities and rules for online social interactions, by structuring social graphs that support multiple participatory contexts, for multiple online social networking abstractions.

Chapter 1

A survey on Civic Tech: focus on participatory democracy

Abstract

Civic tech is a general term describing a set of technologies, tools and practices that have been introduced in parallel, in use by and often in contrast with traditional governance and organization of communities. By implementing and analysing well established theoretical ideas, new toolkits can be useful in the digital domain for the effective expression of citizens and collective decision making. In this direction, the development of solutions in the context of the Internet of Things (IoT) , the use of online social networking (OSN) and in general the mobile context can be proven vital for promoting citizen engagement and democratic practices in urban environments. In this survey, we report the latest advances in the field, present new features and technologies that have or aim to undertake traditional politics, review the tools that have appeared in bibliography and analyse the practices that make use of participatory systems. Based on our study, we conclude that there is ground for further research and development on the field and for further exploitation of technological advances that may facilitate civic engagement, the expression of urban-scale participatory democracy and deliberative practices.

1.1 Introduction

Political participation and democratic decision making has extensively been studied in social science. In the recent years there is a growing interest in the research of practices that can foster civic engagement through digital means. Following an observation of decline of democratic practices and citizens' neglect of their moral duties for engagement, an increasing number of institutions on the one hand and self-organized communities on the other hand have been promoting the use of latest technological tools for increasing participation and the development of responsible citizen opinion.

Civic participation has been commonly interwoven with the concept referred as "cognitive surplus", the cognitive load that can be freely directed towards political engagement for personal satisfaction, desire for policy change, common good practices and knowledge acquisition. Arnstein [1], early introduced the well known "Ladder of Participation", defining a scale of citizen participation starting from lower rungs, namely *manipulation* and *therapy*, as characteristics of non-participation, moving to the middle rungs which express the degrees of tokenism, namely *informing*, *consultation* and *placation*, and ending with the degrees of citizen power, on the rungs of *partnership*, *delegated power* and total *citizen control*, while expressing the relationship between the "have-nots" and the "powerholders".

Fung [2] introduced the participatory cube as a tool and schematic for the taxonomy of the various levels of participation in complex governance and policy making, for top-down organization of citizen engagement. Although he argues that Arnstein's model is now obsolete and in some points defective, he also considers the multiple degrees of communication and decision mode, the authority and power levels, and finally the expertise of the participants. It should be noted that, although in the theoretical domain the border between participatory [3] and deliberative democracy is clear [4],[5], in the design and practice of civic tech applications the characteristics often become vague, aiming mainly at more fundamental aspects of political expression and engagement in public action and discussion.

These models are characteristic for the design of platforms that aim to accommodate citizen functioning in publics, and it is a challenge for the research community to transfer ideas from the social science to civic tech, enriching e-democracy practices. Towards this direction, tools in the field of online social networking have also been incorporated to increase engagement of citizens, operating on the local/neighborhood level, along with platforms that promote online discussions and civic action, collecting data about urban issues, monitoring, deliberation and usually, when they are connected with large scale organizations such as governmental, online voting. Institutions have also been involved in the process of engaging their citizens in online discussions, collective information and in some cases, decision and policy making. Although it is referred in bibliography that citizens participate even when they know their interaction will be excluded from decision formation, a few governments have proceeded in participatory democracy practices for validating and promoting their plans to the public.

Crowdsourcing has been employed as a successful method for inducing citizens involvement in large scale civic problems, although it is a practice mainly known in other domains [6]. Crowdsourcing can be defined as a type of participative online activity in which a project, instead of being assigned to employees, is outsourced to a large network of people as an open task. In [7], it is stated that *a crowdsourcing system enlists a crowd of users to explicitly collaborate to build a long-lasting artifact that is beneficial to the whole community.* The authors propose a classification of systems based on the nature of collaboration, either explicit or implicit and discuss the challenges that a system has to solve. Crowdsourcing has been effectively used in policy making and presented in studies of sustaining civic engagement, to further explore the motives that drive citizens to participate to political discussion or otherwise abstain [8].

Other participatory practices can also be studied in the context of civic tech, to name the most common, civic crowdfunding, with further extension to more formal participatory budgeting, peer to peer sharing in communities, open government data access and analysis and participatory planning in municipal level. Digital voting and pervasive technologies in urban environments or in workplace have also been developed as an effort to digitalize democratic expression.

1.2 Survey methodology

In this survey, we aim to organize and present the main research perspectives that have been published over the last decade in the field of civic technology, participatory systems and civic engagement and proceed to a discussion on the technologies that can further facilitate development of new tools for exploitation by citizens, activists, communities and governmental agencies. Based on an analysis presented in [9], due to its global perspective on civic technology aspects, we organize this survey in three main categories: open government, community action and applications. Open government, in Section 1.3, is further analysed through open government data, open government functioning and citizen participation in policy making, and visualization of public data. We define community action, in Section 1.4, as the section organizing published work aimed for communities of citizens and activists, crowdfunding, information crowdsourcing in participation and peer to peer sharing. We present urban scale applications, in Section 1.5, divided as urban computing applications, participatory budgeting and planning, followed by an analysis on civic engagement in Section 1.6 from a wider spectrum of participation and involvement in political action. In Section 2.5 we discuss current trends in research and possible future directions that may be useful for civic technology and finally we conclude in Section 1.8. This structure is also supported by [10], reporting also the most common and popular commercial applications and the functioning of the whole civic tech ecosystem. Figure 1.1 illustrates our categorization.

The bibliographical search yielded 102 references, which we further al-

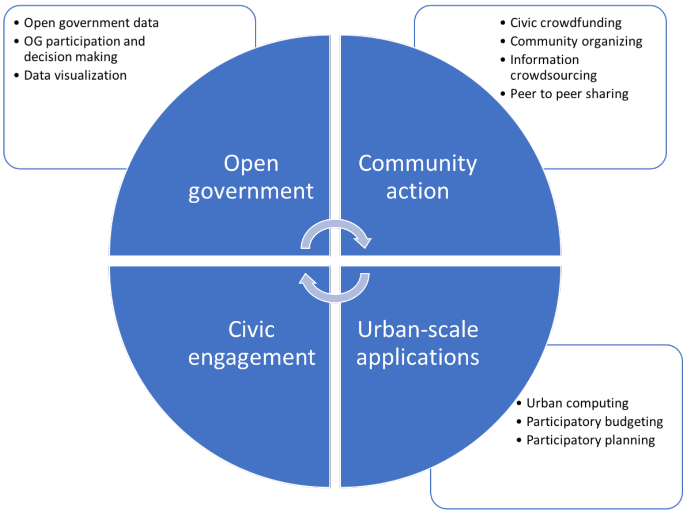

Figure 1.1: Survey main sections and categories.

located for analysis into the aforementioned categories. We considered keyword search with multiple terms ranging in the field of civic technology and participatory systems, to list the basics: "civic technology", "participatory platforms", "open government", "urban computing", "crowdsourcing", "civic engagement", "mobile sensing", while a complete list would be extensive to present.

1.3 Open government

As a practice that can promote governmental transparency and accountability and reduce democratic malfunctioning incidents, open government has been applied effectively during the last decades in multiple institutions. The main characteristics that can be recognized so far as ingredients of a successful application in the practical domain, which may further be enhanced by online tools, are open government data, as a means to enhance public access to governmental information, decision making, including online voting and citizen feedback, as a method to incrase citizen responsibility and participation, and visualization/mapping of processes to report the results and facts to the public.

1.3.1 Open government data

Open government data [11] is assumed to create value in a set of areas, including [12] transparency and democratic control, participation, self-empowerment and novel products and services, innovation and effectiveness of government services, impact monitoring of policies and production of new knowledge from data volumes. The authors in [12] investigate fundamental research propositions regarding the application of open government data in smart city context: Open data initiative is a way to promote data disclosure and increase interaction with citizens, governments can thus effectively respond to their issues and learn from multiple stakeholders. Governmental information is therefore freely presented along with public services in a smart city context. As data is exploited by agencies, the impact on employees, citizens and society as a whole increase, often leading to consequences not expected by the involved parts. With the use of a qualitative analysis, including stakeholders interviews for a case study of the city of Rio de Janeiro [12], the aforementioned arguments are validated and the delivery of public value is shown to be enhanced by the open data initiatives.

In [13], a stage model is proposed to organize how open government data is utilized. This model consists of four stages. The first stage includes the most basic opening up of data and publishing material online. Public agencies can forward their data in multiple formats, as downloadable files or not organized linked data, to be aggregated in a common data portal. Although an important amount of information becomes available to the public, it is not possible in this stage to create value-added services or products and a need for special effort appears for processing and validating information. In the second stage, an integration is performed on governmental data submitted from various levels of administration, to reach a unified status in organization on the web. Using Linked Data and decentralized architectural solutions, more complex search can be performed and precise data storage can be applied for every agency. In the next stage, government data is further integrated with non-governmental formal data, since the latter can be valuable source of information consumed by citizens. In this case, participants can verify the accuracy and objectivity of information provided and more complex queries can be applied. The challenge, therefore, for this stage is the linkage enhancement between sources and published information. Finally, in the fourth stage of the model, information presented in the aforementioned stages is combined also with data produced in online social networking platforms, expressing informal beliefs and facts from engaged citizens. This integration allows governmental agencies to consult citizens on policies and critical information and citizens to participate actively and deliberate on the data published, although the organization of the processes is definitely more complex. The authors in [13] present this model as a measure of the development of eGovernment and propose that each stage could be further analysed for the barriers that appear and the possible technological solutions.

Simirarly, a more recent analysis [14] examines the relationship of government with end-users of open data, proposing a classification of four levels, regarding the exploitation of data. Starting from the simplest form, the unidirectional presentation of data, moving to the consideration of the government as "data activist" for creative use of data and value exporting through app development, followed by the mixed model where data may come from crowdsourcing or/and the government and finally the last model, where the government-citizen relationship is dynamic and acquires a participatory nature. The authors argue also on the motivations for opening up data, in relation to goals and strategy, the role of the government in relation to private sector and citizens for app creation and the barriers that may appear in the realization of the process.

Especially with the prevalence of the mobile context in the urban environments, the trend for application development showed an increase [15]. [16] presents the efforts of agencies to engage developers in application development utilizing open data, often by open calls and organizing development contests (civic hackathons [17] [18]). In the first period, developers preferred building applications for other functions in the domain of smart cities and the initiative for civic apps was considered a failure, mainly due to poor response from governmental agencies, management and financial reasons. The organizers overcome these problems during the second generation, when open data initiatives gained popularity, developing community increased its experience and a set of technical issues was resolved, i.e. common platforms across multiple regions, application repositories, channels of communication and data standardization.

In the discussion for open data realization, technical tools have also been introduced, although the progress is still in its early stages. The effective use of open government data is based on both the organization of data collection and storage, and the representation in well structured tools that foster citizen participation. [19] proposes an ontology for the semantic representation of open data in a formal manner, overcoming the problem of its heterogeneous nature. By following the Linked Data principles, the approach appears to promote the integration of data for enabling value creation. The authors in [20] introduce a platform called *Open Government Data as a Service* to support new models that engage developers in new applications creation utilizing the governmental resources. Furthermore, with a new abstraction mechanism, they promote an organized methodology for obtaining and using effectively open data sets.

In an effort to provide a more spherical analysis for open government data, the authors in [21] analyse the negative effects, risks and disadvantages. The main categories presented are the legislation issues for sensitive information disclosure, ownership of data that may belong to other organizations and can not be published, privacy violation, preselection of which information is published for political reasons, risk of misunderstanding of complex data, political issues due to transparency, quality of data and publication time. They report also the dark side due to implementation and poor management of the process. The assessment of the impacts is based on the analysis of interviews with multiple civil cervants and archivists.

1.3.2 Open government, participation and decision making

Following the definition of the crowdsouring term as proposed in Section 1.1, an analysis on the characteristics and application domains of the method can be useful [22]. Borrowing the practice from areas of science and technology [23], i.e. crowdmapping information on a map, microwork for small tasks which need a large number of participants, articles validation in journalism, company innovation with ideas from the crowd, governmental agencies attempted to apply crowdsourcing for policy-making, as a means that can foster civic participation at a massive scale for top-down politics, reform discussion and e-voting [24]. Examples from these efforts can be mentioned: the constitution reform in Iceland, national dialogues in US, open ministry in Finland, open innovation strategies and other. Crowdsourcing with co-creation, meaning opening-up the process, constitute the main methods for realising participatory democracy, according to [22]. The ingredients for a successful process at a wide scale are multiple and can be organized in design - citizen centric, clear goals and participation methods, flexible applications, specific timeframes - and in management and communication - contacting participants, online presence of organizers and commitment, offline events, reporting results. Crowdsourcing for democratic processes has important challenges that cannot be neglected, such as the digital divide, as not all citizens have access to digital equipment, the participation of majority of population which is not always as desired, the resources required for the process, technical and human, or the most important issue of the impact that such a process finally has on policy-making [22]: it is common that contributions without practical result gradually lead to reduction in participation.

In [25], the authors present a review about the research on open government, where they find that practices and existing tools ignore the fundamental principles of effective deliberation, participation and collaboration and focus mainly on transparency and information. In a more recent article, [26], five distinct areas are proposed to research community as a priority, to further release the dynamics of digital participation.

A different model for meaningful engagement is also proposed in parallel with a criticism on open government processes in US [27]. The model aims at inducing knowledge acquiring practices in participation, closely to democratic deliberation, towards an *enlightened understanding* through participation mechanisms, rather than mere voting. The design principles are based on low external barriers to participation and driving citizens in commenting and valuable expression.

An application called "ConsiderIt" promotes participation and deliberation and has been tested in a US state election, where residents were called to deliberate on multiple measures. "ConsiderIt" [28] collects users' opinions in a pro-cons fashion for a policy under review and the participant may support or oppose other users' statements, thus gathering points for the formation of their final opinion. Each participant's view on the subject may include both pro and cons arguments, synthesizing a more spherical stance, rather than a yes or no vote. The authors demonstrate the tool's integrity based on a deployment in general public and report interviews and comments from its use.

In another setting, characterized by distrust of public institution and poor citizen engagement in the democratic functions, a platform called "México Participa" was released some months before Mexican presidential election [29]. The platform promotes transparency and collective decision making based on crowdsourcing. Its main features include interactive interfaces and tools for statistical analysis of quantitative data and its main functions are data collection, government evaluation and project priority suggestion. The tool is further analysed in [29] through three axes, *e-enablement*, meaning citizen access to democratic process, *e-engagement*, meaning facilitate debate, and *e-empowerment*, towards promoting project proposals to governmental agencies.

[30] proposes "Liberopinion", a platform being used by municipalities and government. Initially deployed in Portugal, aims at reducing the communication gap between citizens and governmental agencies, and increasing citizen participation to politics by empowering them through multiple ways. The solution consists of six participation modules with different functionalities for municipal and central governance , utilizing Content Management System features inspired from social media for participation events creation. The authors in [30] conclude by stating that the mobile version of the platform can play an important role in participation and in general that the platform modernizes government services, increases transparency and promotes collaboration.

These are recent approaches of the research community for civic technology applications, validated in real-world scenarios. As we have already mentioned in Section 1.2, various applications have been proposed in commercial domain and are currently in use. The interplay between research community and applied civic technology could provide a boost for the introduction of efficient, up-to-date and suitable tools for the modern citizen needs, utilizing ICT latest developments.

1.3.3 Visualization

Open government data can be extensive and difficult to manage if not properly organized, often leading to misinterpretations. Visualization tools have also been introduced to help citizens and other stakeholders cope with and benefit from published data [31]. The most common applications appeared are office suites, web-based visualization and Business Intelligence tools, tools for analysis in specific domains and finally other libraries or APIs, the latter requiring technical knowledge in order to be exploited. Visualization importance is validated in [31] through a survey with stakeholders, and their interest in creation and utilization of such tools is pointed out.

From a different perspective, with the development of ubiquitous computing, new pratices have appeared in visualization of public data. Along with urban computing, information visualization is studied in [32], in order to combine mechanisms and tools for increasing participation in civic actions through visual representations of facts and data. This trend may have not yet been applied extensively in open government practice, as most applications tend to cope with sensing or reporting in the urban domain or for artistic installations. There is a strong potential and research questioning [32] for discussion and participation, for the impact of visualization in public settings and for the implications in opinion shaping and citizen behaviour. In-the-wild deployments of the proposed solutions can often reveal their true potential for real interaction with citizens and help drawing useful conclusions [32].

1.4 Community action

Multiple practices have been employed in the organization and activity of communities online and expression of bottom-up politics or civic action. Platforms for online interaction and social networking are the most prominent. With the following analysis we attempt to examine the combination of interdisciplinary tools and applications initially introduced in various domains, for exploitation by communities of citizens towards political involvement. We organize the main categories appeared in the bibliography, as civic crowdfunding, community organization, information crowdsourcing and peer-to-peer sharing.

1.4.1 Civic crowdfunding

Crowdfunding can be defined closely to the concept of crowdsourcing, [33] as *the online request for resources from a distributed audience often in exchange for a reward.* Special platforms are used in this process, setting goals to be achieved for funding proposed projects, often by entrepreneurs. A study [33] examines through interviews, the motivation factors or otherwise deterrents for supporters or project proposal creators. The most important motivations referred are raising funds for their projects, making new connections and publishing their plans to a broad audience, improving skills and control issues in contrast to other forms of funding. For the supporters side, more social characteristics are prominent, such as being a member in a community, helping people and supporting causes of interest, or simply collecting rewards. On the contrary, deterrents are related to failure of the crowdfunding process or loss of trust in creators' projects. Regarding the design mechanisms that should be considered, information sharing processes must be widely available between all platform users, as well as community building practices, that empower members and encourage all parts to contribute. Finally, transparency issues are also important, so that participants can retain trust in the process.

Contribution dynamics are extensively studied in [34], where multiple hypotheses are tested for supporting crowdfunding projects, in relation to whether the target goal of each specific project is reached, the timeline and funding deadlines and the magnitute of the goal.

Civic crowdfunding is a term describing crowdfunding pratices for political communities, citizen participation or in the context of smart cities. It can be utilized as a mechanism that promotes citizen engagement and community problem solving out of traditional bounds, using successfully collective intelligence and self-organization of social groups around common goals. In [35], the community dynamics in civic crowdfunding projects and how they interfere with participation and collective resources are studied, in relation to demographics, regional extend, population and community wealth. It is noted, however that more data is required to be collected across several platforms to extract useful conclusions about impact.

The way in which offline communities engage to online crowdfunding plans and the purpose this activity serves them, are the questions examined in [36]. The interplay between offline and online activity is important for the authors, as they argue that geographical proximity in community plays an important role in the organization of the projects, as well as engagement in social media, and this proximity accelerates citizen bonding and consequently funding success in projects. Specialized platforms have also been developed for civic purposes, except for the generalised ones, presenting the crowdfunding procedure and information sharing as their main functions, with features that promote also offline community activities and may often accomodate non-financial donations. Social networking tools are integrated into civic crowdfunding platforms, mostly for community discussions and networking with other stakeholders. The authors discuss these issues and conclude by commenting on the relationship between online and offline civic activities.

1.4.2 Community organising

Social media has been the center of discussion regarding how to organize communities and citizens who do not have access to other channels of expression. The authors in [37] analyse the use of well established online social networking services for political discussion and online deliberation, considering multiple views of the characteristics of online discourse and the transfer of the "public sphere" in the online domain. In order to measure the quality of interaction they test multiple hypotheses i.e. if posts are polite, civil, sensitive, deliberative or extensive in popular social media platforms, based on real scenarios for variables related to quality of participation. [38] presents how online social networking is utilised by activists for collecting or publishing information, for discourse and for decision making procedures. It is argued that the extended use of OSN can foster civic engagement and community building [39] [40].

[41] presents an example of a local social movement organization based on OSN, in an attempt to generalize from the generation of new political groups and rise of collective behaviour through social media. Using philosophical models and a discourse analysis approach on data from an OSN page for a local problem which motivated the community, the authors discuss on the ways to design functionalities in OSNs for political organization and action, and how subjective experiences from the use of OSNs can form collective sentiments. Online interactions play a crucial role in the formation of a movement, where politics is obvious to everyday life, in contrast to formal settings.

Except for the commonly used online social networking services, specialized applications have been introduced for local communities. A study analyses such a network [42] on the neighborhood level, under the term referred as *community social media*. This network connects the residents of a local community, who can exclusively access their community's portal and each urban region has a separate instance. The platform provides mobile phone app and means of residents communication, while maintains strong features for building trust and safety among users.

Towards the transition to the online direct democracy, another contribution models a democracy framework as a social network, with distributed architecture, i.e. nodes running locally and voting is performed in parallel, and dynamic function, i.e. enhancing reachability of citizens with message mechanisms [43]. This work utilizes a non-cooperative voting game for increasing social welfare, in terms of Nash models, and the network of participants as a bidirectional graph of components. The main functions of the distributed algorithm consist of sent or received messages for reachability of neighboring nodes and construction of the network tree, along with voting messages.

Many attempts aim at engaging citizens in some kind of democratic action in communities or urban domains, using public displays or situated devices for voting and opinion collecting as a basic method to promote group organization around common issues [44] [45] [46]. Designed towards being ubiquitous and interactive, these efforts have the advantage of engaging members of community who do not have further familiarity with mobile devices or online social networking and increase awareness on various topics of the local domain or even in the workplace [47]. In some cases of deployment, anonymous citizen inputs on these devices are further considered as consultation from local councils, increasing community's collective self-confidence.

Crowdsourcing practices can also support communities of activists. In a case of environmental awareness movement [48], crowdsourcing data collected through mobile applications are used to extrinsically motivate people to participate. Collection of data is based on both a financial or virtual reward. The campaign under examination refers to closing the doors of shops or public places when heating and air conditioning is on. [48] presents a quantitative study, based on the data collected from participants, and qualitative results, examining the motives behind participation and enabling factors for collecting data for the campaign.

1.4.3 Information crowdsourcing

A common way for collecting information about political and social matters is through crowdsourcing, useful for activists, communities or organizations, and is mostly performed through online public discussions over an issue. Crowdsensing is also often employed on civic applications, for collecting measured data from mobile devices and sensors to be used as a source for generating information.

[49] explores how taxpayers are engaged in online fact-checking activities regarding financial information from open government data. The "factful" interface allows citizens to annotate and add new information to support or oppose budgetary programs on a published article, through references or discussions. An activity normally driven by journalists or experts is thus opened to the community for information sharing and discource. Interviews show that citizens usualy feel unaware of budgetary issues, especially when these do not directly affect their everyday lives, and relevant information plays an important role in shaping an opinion, as the majority reads articles online. The interface consists of modules that process and display information, accompanied by a module for efficient user annotations, and its usage is assessed by a laboratory study.

Information crowdsourcing is also applied to online journalism, utilizing corrections and checking from readers in the community [50]. By leveraging collective knowledge, "Maater" improves the quality of news articles from published corrections proposed by the crowd, decreasing the dependency from journalism organizations that influence public opinion. This category of tools can also be considered against the spread of fake news, reported as a process that influenced national election results [51]. Expressed mostly through online social networking, fake news spread through social bots by a small number of accounts and were reposted by active users, thus manipulating opinions. Tools for fighting fake news mostly perform fact-checking in an automated manner.

A new paradigm that combines crowdsensing with computing is proposed as mobile sensing and social networking are developed. It is built upon *participatory sensing* and *participatory social media* [52] and aims to combine sensing data collected from mobile devices with social networking services, by exploiting explicit or implicit user participation based on data usage. The collaborative functioning of human and machine intelligence [53] is therefore vital for further developing both and supporting efficient problem solving. Heterogeneous communities, human machine interaction and data quality preservation are the main challenges in the new paradigm. Increased citizen engagement may result from participatory sensing, as participants may be interested in community activity for an important cause, e.g. environmental reporting. Gamification is explored in [54] as a method used to increase submitted observations for a local environmental issue.

1.4.4 Peer to peer sharing

Popular tools for sharing have appeared online in recent years, mostly reflecting models of resource management and collective welfare [55]. Their design aims mainly on civic engagement while they present various conflicts over citizenship versus commerciality, regarding to the generated value in the communities. The sharing economy has been regenerated due to the global economy crisis and the new potential that information technology provides. [55] explores the economic ingredients that may shape new technological solutions in peer-to-peer sharing ecosystem, focusing on gift exchange and bartering in community markets, money as a common form of means for exchange and local currencies that can foster community activities, timebanks as a possibility for service offer and demand, cryptocurrency as an alternative to national currencies, and finally collaborative economy, in which people exchange goods or services with other citizens usually organized in social media. The diverse characteristics of the aforementioned offer ground for a variety of activities that can take place online, be decentralized and include a great majority of citizens without mediation or supervision from formal organizations and government. Multiple tools have been utilized to this end, i.e. sensing technologies to produce metadata, timebank platforms for communities, tools for enhancing peer-to-peer exchanges experience.

The authors in [56] study how exchange practices are affected by psychological aspects of reciprocity and indebtedness between individuals, analyzing interviews from the use of an online exchange platform. They conclude stating that those aspects should be redirected to increasing participation and positive online exchange behaviour, by designing appropriate systems. In another approach, [57] presents systems supporting timebanking under a UX perspective.

A quantitative study of a popular peer-to-peer accomodation service [58] attempts to derive conclusions by analysing information for hosts, users and listings of the platform about who benefits from this kind of economy. Activity through the service is proved related to socio-economic status of each area. Furthermore, it is used by a general majority of population, mainly by low income citizens, and not exclusively by people familiar with technology.

[59] states that a "dark side" also exists in the sharing economy. The most prevalent characteristics are the conflicting behaviours between the participants, biases that appear in online platforms, services offered by unlicenced people, low income for services or goods exchange, secondary subsequent sharing, operation modes that are in conflict with social norms i.e. insurance issues. An appropriate solution to these issues is based on promotion of practices that benefit the whole sharing economy ecosystem and its participants, by designing relevant tools.

1.5 Urban scale applications

The most common form of citizen participation, and probably the most practical in terms of technology and extend is urban-based. With the development of computing in urban environments and the smart cities, civic applications have been gaining ground to organize citizen interaction with local authorities and agencies and to promote collective action. The current section presents advances and analyses on urban computing and political participation, participatory budgeting and participatory planning.

1.5.1 Urban computing and participation

Urban computing is an increasingly popular research area closely related with civic technology, although not yet precisely defined. Following an approximate definition from [60], *it is a process of acquisition, integration and analysis of big and heterogeneous data generated by diverse sources in urban spaces, such as sensors, devices, vehicles, buildings and humans, to tackle major issues that cities face.* Except from understanding urban processes, it can be further extended to accomodate political expression and participation. The main challenges, according to [60], can be organized into three categories: firstly, sensing and data collection, that may result from mobile sensors across the urban space, secondly, computing from this data and learning by processing it and thirdly, combining the physical with the virtual environments, i.e. social networking and sensor data integration. With the dominant penetration of the mobile context, data can be heterogeneous and useful for multiple domains in smart cities, offering a unique opportunity for civic applications, leveraging citizen participation.

Under this perspective, massive participation becomes the target in the deployment of applications in the wild [61], while it is mentioned that the multiplicity and complexity of services and tools offered finally reduces citizen interaction, despite the wide adoption of the Internet of Things and Cyber-physical systems that actually form smart cities. [61] studies the already published participatory and interactive approaches in urban computing and organizes the framework for participation. The basic technologies referred are the smartphones, as monitoring devices which provide important computing and mobility potential, public displays and urban screens as a means for information delivery, the Cyber-physical systems for sensing the real world and transfering it to the virtual, and the Internet of things, for connecting the devices to the Internet ecosystem.

The authors in [61] mention the term *mobile crowdsourcing*, to analyse how citizens contribute information, and knowledge as content and sensor data, e.g. geolocation, to multiple urban applications and services, while being rewarded from the collective knowledge base that is developed and shared. Further, mobile sensing is also exploited, either participatory or opportunistic, in personal or community level, although a stronger motive is usually required as users do not easily share low-level data. Urban probes are used as well in civic projects to gather qualitative information from citizens and public displays as interactive communication. Other participatory urban installations are closely related to arts supported by ubiquitous computing, either interactive or not. Finally, public IoT is widely open to citizens to foster participation at a massive scale. [61] concludes by proposing a set of strategies to analyse participation in urban computing.

Multiple case studies are published for participatory democracy pratices in urban environments and cities. [62] adapts the participatory model of Fung to present and analyse a set of city-level cases that facilitated participation regarding climate change, improving the city or proposing solutions to local councils. An exploratory study [63] attempts to analyse "technology-enabled" participatory platforms under a theoretical perspective in the most populated cities in US. These platforms enable new relationships between public agencies and citizens, aiming in fruitful deliberation and problem solving. Based on systems theory, the components that define them are *agents*, *attractors*, *mediums*, *flows* and *technological capabilities*. The study proposes a categorization model, based on the source of data and group target, i.e. government-centric versus citizen-centric and government data versus citizen data and citizen-based solutions.

[64] supports a holistic approach for smart cities policy and decision making to facilitate citizen participation and increase value creation and sustainability, by adopting a dynamic and citizen centric approach in governance. Specific examples from urban environments reinforce this statement. The proposed framework consists of five distinct parts, namely *community building and management*, *vision and strategy formulation*, *public value generation*, *asset management* and *financial sustainability*. A proper interaction of the aforementioned can ensure service delivery, identity and sustainability over time.

The authors in [65] extract conclusions from the study of a public transportation application for future civic technology platforms. They examine fundamental questions regarding impact, principles and coordination in design of the platforms, by exploiting the results of interviews from users. They finally state that platforms should be user-friendly, effective and simple, should support flexible real-time data reporting and user sentiment monitoring, provide feedback to stakeholders and encourage participation in communities. [66] introduces an open source tool for cooperation of citizens with public administration regarding reporting local issues using a web-based platform and a mobile application.

[67] discusses how online social networking is spread across the 75 largest US cities to accomodate citizen political participation and interaction with local officials. Social media is also commonly used in urban space during crisis to aid in organization and information of alarmed citizens, e.g. in urban warfare [68] or natural disasters [69].

1.5.2 Participatory budgeting

Participatory budgeting (PB) has been applied in multiple municipalities as a special perspective of participatory demoracy and has been through extensive discussion and debate on its characteristics and dimensions [70]. In PB, citizens of an area collectively propose and decide about new projects, which are then redirected to local authorities to fund and implement. Open issues under evaluation concern the form of participation, decision making and control, regulation of the process and the scale of participatory budgeting, i.e. city or community. However, electronic participatory budgeting is under evaluation for its acceptance by the majority of citizens. A study [71] analyses participants' expression through an online forum to extract inference about the process in a local municipal area, conluding that participatory budgeting caused positive reaction when it initially started, although it gradually disappointed citizens, due to poor interaction with the authorities.

[72] introduces a service-oriented software platform to enable citizen participation. Based on the previously proposed "Appcivist" tool [73] which supports *citizen assemblies* and *software assemblies* to promote collaboration, "Appcivist-PB" allows city councils to setup software assemblies for each specific participatory budgeting campaign and users to compose corresponding workflows. Thus it provides the platform to form groups for internet-based discussion and collective decision making. Software assemblies, according to [72], enable the following processes: *Communication and engagement*, *Information access*, and *Contribution and decision making.*

Under a similar perspective, [74] analyses the adoption of ICT for participatory budgeting in US cities. An analysis of interviews of citizens and city officials shows that solely an increase of tools cannot increase participation, procedure workload and idea management may disappoint many stakeholders, and finally communication, direct interaction between citizens and officials and power imbalances constitute a challenge for participatory budgeting. Regarding tools, simple forms and forums are used for submiting proposals without any sophisticated application, digital devices and online applications are employed for voting, and common means of communication are popular, e.g mail, social networking, newsletters, mobile phones. Furthermore, civic tech tools that are not primarily aimed for participatory budgeting may be exploited. According to [74], new tools will be based on the interplay between two functions, namely *idea collection* and *voting*, along with introduction of further bottom-up collaboration and inclusion of currently not active citizens. As an expansion, *idea management*, *proposal development* and *deliberation* can also be considered, and finally *implementation and evaluation*. Practices of other fields of civic technology can also be proved valuable in the implementation of the aforementioned.

Online social networking platforms are also a core part of participatory budgeting process [75] as a further aid to citizen engagement.

Other approaches also include participatory crowdfunding inside an institution [76], where citizens or employees collectively decide how to allocate a predefined budget.

1.5.3 Participatory planning

Urban planning is the procedure associated with the design and use of urban environment and infrastructure in urban environments. In parallel with smart cities development, participatory tools have been also included in the political and administrative planning process. A study [77] explores the considerations that planners should be mindful of when selecting online participatory tools. A framework illustrates how these tools could be selected according to the case under consideration, based on technical specifications, capacity for utilization, regulation and community standards.

[78] presents a categorization of mobile applications for participatory planning, initially dividing them in two basic groups, namely *Environment-centric* and *People-centric*. The author concludes with an analysis on mobile participation, noting that most applications focus on sensing environment rather than decision making functions through apps, and future directions on design should also accomodate interactive features.

A typical platform for participatory planning is the *Smarticipate* platform [79], proposed for bottom-up and top-down governance along with open government. The system utilizes open government data, collects citizens view on the planning projects and promotes co-creation, by employing a web application and micro-services design. Visual 3D models support participation by providing context to proposals.

A study [80] examines the role of activists towards the right to the city, with the rise of online social networking services. It discusses how planners can function outside formal structures to gain the marginalized citizens' rights by utilizing social media. It is noted that the digital divide is obvious, since marginalized groups do not have access to resources and media.

1.6 Civic engagement

Civic engagement is a term related to the participation of citizens in issues of the public domain, addressing common matters and community values. [8] investigates the factors sustaining participation in crowdsourced policy-making. The authors claim that crowdsourcing is not typically exploited in the decision-making process in policy making, although produces the basis for deliberation as a part of larger deliberative systems in society. More skeptical scholars argue that participatory and deliberative practices mostly benefit the civic elite, who is already active. The most important motives for online involvement are the *voluntary involvement*, which is further characterized as intrinsic or extrinsic, *paid involvement*, *commons-based peer production*, that features similar characteristics with open source software and wikipedia communities, *political participation* motives and *knowledge perspectives* either embedded in people or in community.

Participation motivation is divided in *self-interest* and *common good orientation*. [8] studies the motivation during the process of participation, based on experimental validation from a case of policy making. Analysis of results show statistically significant differences between sets of factors, other factors weakened during crowdsourcing while some did not vary significantly. The primary drivers for participation are solving problems, improving the law and learning about the law. Motivation factors also change from self-interest to common good. The study finally analyses the implications from the design of the process, highlighting learning, problem solving, interactivity, transparency and the dynamic nature of participation.

[81] presents three distinct civic engagement platforms and proposes a categorization based on the design, applying a "spectrum" of participation. Comparison results show that different viewpoints should be taken into account in platforms regarding to participation, although further experimentation is needed.

Except from the formal policymaking processes, studies have also included forms or participation in urban environment. [82] introduces the term "m-participation", referring to mobile participation. The study proposes mobile games as a means to facilitate participation, analysing a web survey from users. By exploring the city, participants can track their location and form community circles with other users. The survey focuses on motivation and the results show that mobile sensing, i.e. location-based games, has a wide effect on daily routines of the players. [83] also examines gamification for mobile social reporting, as a way to produce pleasureable experience to increase engagement. Other works consider public displays for engaging participants [84].

Regarding activism, [85] explores the main question if users' participation and engagement is developed over time or is inherent. Two basic hypotheses are tested in the qualitative study, if initial levels of engagement with an e-petition platform will predict following levels of engagement and how signers' experience is related to the type of petitions and their success. Questions such as why do people select more popular petitions over time, and if the petition platform plays a role in signers' behaviour change are also put forward. Results support both the "born" and "made" hypotheses, based on data for some thousands of users.

1.7 Discussion - Technologies for future research

Civic technology is often affected by local speech and press freedom restrictions posed by governments, raising the necessity for the development of anonymity tools. Censorship is also widely spread in OSNs, forcing groups and communities in using tools to overcome suppression. [86] presents a novel tool to promote anonymity for OSNs, along with user surveys from multiple countries with internet freedom problems. Expression is related with identity and reputation issues, as well with geographical constraints set by governmental agencies. The proposed tool, "SecurePost", is composed of three modules: a mobile application for posting content to OSNs, a proxy server and a browser extension for posts verification. With this application, users can anonymously post to shared OSN accounts, hiding their IP address while being verified through cryptographic signatures, and the administrator can maintain control of the account. Other approaches include the dark web, although there is ongoing discussion regarding illegal activities [87].

Privacy in social media has been studied for multiple reasons, ranging from human rights to illegal activities. [88] analyses how multiple users share information in OSNs, beyond binary friendship model, and how this interaction affects privacy boundaries. Multiparty privacy conflicts (MPC) appear in OSNs commonly with the publication of co-owned material, despite the efforts of social media providers to resolve them. Users tackle the problem with various custom strategies, either online or offline, although research on MP tools is in its early stages. The authors list multiple approaches for the design of tools to cope with MPCs, while suggesting that a fully automated solution would not be satisfactory. Nevertheless they can be a basis for resolving potential issues which appear in civic tech applications.

We claim that research should take into account privacy, security and trust issues at a greater extend when dealing with citizen participation in politics. [89] studies participatory sensing in mobile context from a privacy perspective, as sharing measured information is quite common for many applications, e.g. spatiotemporal data, sound or biometric data. Another survey, [90], analyses recent published work for privacy, trust and security in IoT applications, ranging from access and authentication issues to how trust is established in IoT ecosystem, and further, states main research questions for middleware design. A more recent approach, [91], proposes *fog computing* as a means to enhance security and privacy in IoT, by analysing the potential trade-offs and conflicts between computational resources, connectivity and secure information sharing.

The author in [92] analyses how internet can strenghten real-world democracies, noting the decline in values of democratic functioning, by consulting the *1789 Declaration of the Rights of Man and of the Citizen.* From these values, the author draws the basic requirements for e-democracy, namely *sovereignty* over administrators by using blockchain technology, *equality*, by associating people with true digital identities, *freedom* of expression, *transparency* of functioning and technology used, respect for *property and privacy*, *justice and accountability* and finally *hysteresis.*

Blockchain [93] has been introduced over the recent years as an *immutable, secure and transparent technology that redefines trust*, and can be utilized in various fields, based on a distributed ledger structure. Application in financial sector has proved its ability to *cut out the middleman*, although problems regarding data privacy, scale and latency have appeared. In commercial applications, blockchain can ensure identity and legitimacy of objects and transactions, democratize industry with smart contracts and be integrated with the Internet of Things. The author in [93] mentions also the potential of blockchain in developing countries, as a means for land registration, digital identity and fraud reduction. Applications of blockchain in e-voting have also been studied [94].

Further studies and application domains include virtual nations [95], where blockchain technology aims to be in parallel or against traditional institutions and support new governance models. [95] claims that *disintermediation and decentralized coordination* along with *self-sovereign identities independent of any nation-state* can be a basis for experimentation with new political systems. The authors refer to *insiders*, *outsiders* and *beyonders* reflecting the attitude towards traditional nation-states, acting in cooperation with the latter, in confrontation, or totally bypassing them, respectively.

A survey [96], attempts to present the technologies mostly applied in smart cities, under a four-parts categorization, namely *Internet of Things*, *Big Data*, *Cyber Physical Systems* and *Cloud Computing.* The authors analyse how these can be utilized in software platforms for applications in various domains in urban environments: for integration of physical structures in ICT, device connectivity, large dataset manipulation and management, and finally processing on the cloud. They assume that the requirements for platforms are divided in *functional*, for the development of Smart City applications, and *non-functional*, related to distributed systems, i.e. scalability, interoperability, adaptation, privacy and security among others. The survey proposes a new architecture for software platforms and discuses the challenges for future research: data management issues, heterogeneity of the multiple systems appeared and development of generic platforms. Finally, reference to civic technology and participation raises the discussion about the integration of the proposed methodologies for *e-democracy*, *e-government* and *e-participation*.

Following the prevalence of the Internet of Things, the fact that the internet paradigm is based on infrastructure, leads to the vision of a new paradigm called the *Internet of People (IoP)* where users and their devices become active elements of the internet [97]. The inspiration behind IoP was the *cyber-physical systems (CPS)* convergence, reflecting the interaction between objects and humans and further, with the emergence of the OSN, the *cyber-physical social systems (CPSS)*, reflecting real world social structures and relationships in the digital domain. As [98] [97] depict, the main four characteristics of the IoP are: *IoP is human-centric*, as its algorithms are based on human actions and behaviour, *IoP is device-centric*, as devices act as proxies of humans in the cyber world, *IoP is data and computing oriented*, as people mostly use their devices and internet for data access, and *IoP is self-organizing*, as people's devices can be locally connected with nearby devices to perform the desired action. The authors argue that in IoP, *human behaviour is considered as a structured design paradigm, rather than as an afterthought*, and it is extended through the whole "network stack", while its algorithms are modeled not merely for network resource optimization, but for human requirements, analysed for data-centric systems based on social science principles. Furthermore, it should be approached with *quantitative* models and solutions approved by the research communities.

We should also note the pervasive appearance of artificial intelligence (AI) in the various fields of computer science, fact that could not leave civic technology unaffected. [99] presents a thorough study in data analysis for online social networking, combining state-of-the-art methodologies of machine learning and social network analysis. Recent approaches include also deep learning for automatic program generation [100], a useful technique for the future civic tech code generation and service composition, and reasoning and knowledge discussion in AI, exported from available data [101]. A recent trend in civic participation is based on augmented reality (AR), combining urban infrastructure with the mobile context [102], aiming to further integrate AR with IoT.

1.8 Conclusion

In this survey, we have presented the most prominent and, to the best of the authors' knowledge, the most relevant published work in the field of civic technology, with a special focus on participatory democracy and systems. We organized the presentation in three distinct views: under the open government perspective, for applications developed and supported by central, governmental agencies and citizen participation in policy-making, under the community action perspective, aiming at providing tools from a multi-disciplinary domain to communities for bottom-up involvement and under the applications perspective, analysing application categories. We also present an analysis of civic engagement, regarding participation motivation in policy-making and activism, and a discussion for future technologies. We argue that further integration of online social networking in civic technology applications may increase participation in all stages of participatory democracy, ranging from governmental-based to self-organized communities. Furthermore, research in technologies for privacy preservation, democratic values promotion and distributed mechanisms may increase citizen participation and engagement with the advent of the Internet of Things and new paradigms. Research communities from social to computer science should raise the level of civic technology to allow citizens use effectively new tools, integrate them within urban environments, foster engagement and experiment with new models of participation and governance.

Chapter 2

A Social Middleware based on Named Data Networking

Abstract

In this paper we propose a new networking paradigm for universal social networking, based on named data networking (NDN), for further integration with civic technology via a specifically designed middleware. The paradigm fosters decentralized, secure, private and content-based communication without relying on the current Internet infrastructure. We analyse the advantages of shifting towards NDN, present the proposed social networking solution and argue for the content-centric perspective of future online social networking (OSN). We claim that the realization of this paradigm in the civic tech ecosystem may boost civic engagement, security and trust, and may provide a basis for the future IoT in urban computing.

2.1 Introduction

In the recent years, with the advent of the Internet of Things (IoT), the pervasive appearance of social networking and the increasing realization of computing in various aspects of human activity [60], a need for a new generation internet infrastructure has risen. Named data networking (NDN) [103] has been proposed as a promising paradigm, and a basis for a shift to improved networking capabilities that will transform the future of computing.

The IoT and more specifically the mobile context has been the focus of research activity in the last decade with various extensions and perspectives. *Data-centric* networking has brought about new discussion regarding modeling online human activity and social networking. Indeed, the ubiquitous nature of social networking has raised two basic issues in the design of the future perspective: it can be *content-centric* and *people-centric* [104].

The Universal Social Network Bus (USNB)[105] introduces a new perspective in online social networking, by unifying the access and interaction in multiple heterogeneous online social networks (OSNs), thus enabling their users to communicate by using their preferred service. The removal of communication barriers of closed OSNs can provide not merely technical but social interoperability as well, by inducing virtual profiles, as synthetic mechanisms that represent the interacting users of a different OSN, and communicate with real user profiles in the user's device. Online social networking has also recently been related with civic technology [106]. Civic tech can be defined as the online tools and applications that foster engagement of people in politics and collective decision making, either in coordination with, or independently from traditional institutions. Civic tech has been developed in accordance with social science and is an active field in research community and commercial domain. It can transform political participation further into the digital domain and facilitate civic engagement at a higher level than traditional politics, by providing the tools and practice that enable people interact, deliberate, propose projects, decide for policies and vote online.

Towards this direction, social middleware can be the basis for civic engagement by facilitating the utilization of various tools on top of social networking, providing motivation for online collaboration and collective decision making among entities of a Cyber-physical social system [107] in urban environments. For the successful realization of this vision, trust, privacy and security are issues arising as fundamental for consideration in initial design. A recent approach of the vision for the future internet, the Internet of People (IoP) [107] [104] considers a human-centric design, highlighting the user-centric, device-centric, data-oriented and self-organizing orientation, building on social connectivity of its participants.

In this paper, we propose an approach of universal social networking, utilizing Named Data Networking as its communication model, that unifies the involved OSNs and ensures interoperability, as well as secure, data-based, private and decentralized interaction. NDN functioning is supported by recently introduced forwarding mechanisms across the network infrastructure and involved edge devices. The NDN principles [108] can be implemented independently or over the current internet infrastructure, offering an opportunity for new networking capabilities and integrated communication solutions that bypass the current technical limitations. We further provide an analysis of the recently proposed Internet of People (IoP) paradigm and present the common perspectives and differences with our vision. Finally, we present the insights for a new direction of online social networking, which is content-based rather that person-centric, and argue on the use of the data-centric proposed social middleware and future challenges.

The rest of the paper is organized as follows: Section 2.2 presents the technologies of the new middleware, based on USNB (2.2.1) and NDN

(2.2.2), Section 2.3 analyses the social middleware over NDN (2.3.1) and its advantages over IoP (2.3.2). Section 2.4 introduces the civic technology as an application for the proposed paradigm. Section 2.5 discusses the controversy of content versus human centric design (2.5.1) and the future challenges (2.5.2) and Section 2.6 concludes.

2.2 Background Information

Social middleware refers to the capability for heterogeneous systems and actors to interact in the social domain by using the service of their preference, a process referred as *social interoperability*, we present further the Universal Social Network Bus as a basis and the NDN main technology to be considered in our design.

2.2.1 Universal Social Network Bus (USNB) as an initial abstraction

The main idea behind the abstraction lies in providing interoperability, both technical and social, to the multiple entities that are connected. USNB creates synthetic profiles, so called *personae*, for the corresponding users of each participating OSN, through a unified mediator. Each user of OSN_i (e.g., Facebook), who could not interact with a user OSN_j (e.g., Slack) of a different, open or closed OSN, can see in their application the synthetic profile of the interacting counterpart and communicate across different services. A persona implements the conversion logic between the OSNS's social interaction service and the USNB's reference social interaction service. We refer to technical interoperability, as the technical translation of messages and any interaction across different protocols and social networking services, so that a message in OSN_i can be read in a device using OSN_j. Social interoperability is assumed as users can interact across all social networking services, using their preferred one, by sending messages to the real or synthetic profiles. For example, user u_i and u_j can be connected and interact: u_i can see the synthetic profile of u_j in their OSN, and vice versa for u_j, while the synthetic profiles are managed by the personae p_i and p_j.

2.2.2 Named Data Networking and its advantages over current Internet

Named data networking [103] was recently proposed as one of the future technologies that may replace the current Internet infrastructure. Its main functionality is based on the forwarding and routing of data packets through the network without using source and destination addresses, but by using appropriately the naming mechanism of the packets, thus providing an extra layer: the named data. Naming takes place at the application level, allowing the systems using any means of networking be inter-connected, even in dynamic environments or by using resource-limited devices.

The NDN main mechanism consists of exchanging two types of packets: *interest* and *data*. A *consumer* puts an interest packet in the network requesting the desired data, and the *producer* replies by sending from the same path the named data packet. The detailed routing architecture is illustrated in [103], i.e. the Pending Interest Table, the Forwarding Information Base, the Content Store and the forwarding strategies used. NDN is generally assumed to solve problems related to end-to-end communication, content distribution and control problems, and its functionality inherently involves multiparty forwarding and in-network storage.

NDN introduces a data-centric approach, in contrast to the current node-centric internet infrastructure, thus removing the need for mapping systems. The following characteristics [108] define its basic design patterns:

- *Host-independence.* Its node-independent design allows for better mobility and simpler protocols, redundancy, disruption tolerance and rapid tasking. It only listens to namespaces and uses cryptographic keys to manipulate data instead of relying on certificate authorities.
- *Multicast.* Observed in all operations, it is an intrinsic behaviour of NDN and provides resilience to failures.
- *Storage everywhere.* By binding packets' names to their content and securing data directly, each packet can be stored in any intermediate node in the network, using local storage and utilizing both real and historical data.
- *Aggressive/opportunistic communication.* Information is transmitted through any available means, and data packets are created anytime. All the involved devices can be used as caches.
- *Share namespace.* In NDN there is no connection between two points, but a dataset synchronization that organizes the distributed applications and supports data retrieval.
- *Secured data.* Requirement to secure the data rather than the channel, provides unified security and reduces dependency on securing the intermediate nodes. NDN supports heterogeneity of networks and distributed operation.

Provided the above structural characteristics of named data networking, we claim that it can be used successfully as a new paradigm replacing the current infrastructure, to offer a networking perspective for applications that demand distributed, secure and trustworthy capacities [109] [110]. Especially in the civic tech domain, due to the sensitive nature of political

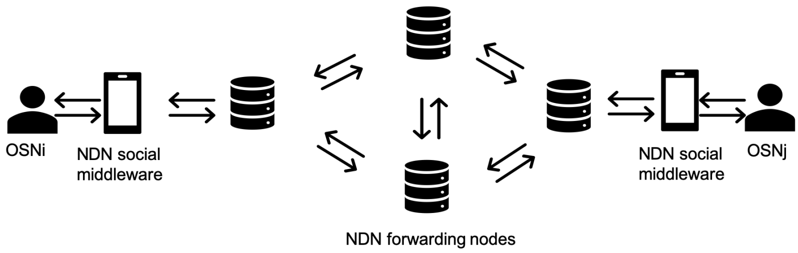

Figure 2.1: Illustration of NDN social middleware with two users

participation, where users expect increased robustness and stability of the systems involved, and privacy plays an important role.

2.3 Proposed Paradigm

In the following section we present and analyse the proposed middleware solution utilizing NDN in universal social networking and provide a discussion for related abstractions and challenges.

2.3.1 Social middleware utilizing NDN

In parallel with the abstraction of USNB, where users of a social networking service can interact with users of another, open or closed, service, we propose a solution that also integrates multiple heterogeneous OSN services from a middleware perspective. Our vision suggests the translation of OSN information into NDN packets, with the scope to enable technical interoperability over the content. The data packets are then forwarded to consumers using the distributed NDN routers, where they are again integrated to the preferred OSN service. The proposed model, instead of using the abstraction of the aforementioned *persona*, utilizes the naming scheme of NDN to support interaction in terms of content, supported by synchronization or publish-subscribe mechanisms, thus providing insight for future OSN design alternatives.

For instance, let suppose $user_i$ of OSN_i sends a message to $user_j$ of OSN_j. The message is appended to an NDN packet on $user_i$'s device, with a possible name "$/chat/user_i/instance/message-id$", it is signed with the user's signature and sent to the network to reach $user_j$'s device (Figure 2.2). When $user_j$ receives the message, it is decrypted and is forwarded to the preferred OSN application. A synchronization module ensures that messages are delivered to the users across the network, based on sorted ids. When new data is produced, participants in a group share their knowledge

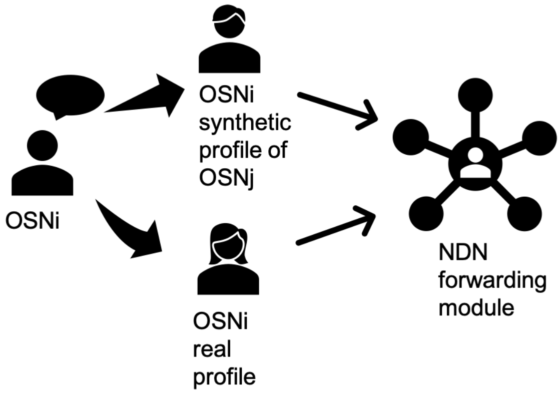

Figure 2.2: Illustration of OSN real and synthetic profiles with NDN forwarding mechanism in user's device

about the data produced in the namespace. Alternatively, to support the known publish-subscribe pattern, name prefixes can be used, under which new data will be published and fetched by the end-users.

This mode of operation of the social middleware - illustrated in Figure 2.1 - supports virtual profiles over multiple OSNs, along with each user's id. Indeed, a pre-agreed data naming scheme on the NDN local module can provide the basic functioning over content, where packets follow specific naming rules and routing is achieved based on namespace design. From the aforementioned example, $user_i$ can register to the network their namespace, $/chat/user_i/$ where any chat information from $user_i$ follows this route. Combined with an appropriate trust schema, it can ensure that data exchange is secured and private, using each user's personal signature, thus ensuring social interoperability along with technical.

The mobile context is further supported by NDN social middleware as two distinct network end-points are not required to be connected to a service at the same time, and network caching can alleviate intermittent connectivity problems. Packets can be requested not only by the end-points, but by intermediate nodes where the name "prefixes" are previously registered. This caching mechanism, in cooperation with multicast behaviour, can promote efficiency and congestion control in mobile networks and the IoT. Furthermore, the IoT and social networking applications can utilize sensing capabilities of the devices in a unified manner and access both real time and stored data, i.e. social middleware can access sensed information via the naming conventions. This function, however requires a generalized shift of the applications towards NDN and is still under examination.

2.3.2 Proposed solution and relative paradigms

As already mentioned, our proposed model of social middleware shares some insight with the recently introduced Internet of People (IoP) [104] and the Cyber-Physical Social Systems (CPSS) [111]. It is stated that the next generation internet should overcome known drawbacks, to name the most prominent, lack of trust in information transfered, privacy policies, global services which monitor online behaviour, irrelevant information and technical issues. [104] suggests that devices become human's proxies in the online world and they obtain an active role in data management by utilizing behavioural models. Under a content-based approach, information becomes the center of interest and devices act so as to transfer the required data.

In our model, the *social closeness* criterion among users is replaced by a notion that puts content processing and analysis on top of social interactions, by ensuring however that social links are independent of global authorities that process and manipulate data. Thus the virtual representation of the physical world is gradually moving away of its user-centric profile, while at the same time people retain their identity and self-sovereignty in the network.

The independence of the proposed next generation internet from centralized infrastructure becomes even more prominent. As illustrated in IoP paradigm, self-organizing networks replace the current operation mode, while sensing can be totally distributed. In NDN, connection with nearby devices is possible by using any means of connectivity, while the possibility of definition of new forwarding mechanisms broadens the perspectives. Following the design principles of IoP, namely *human-centric*, as users control the content, *device-centric*, as storage is allowed everywhere in a host-independent network and *data-centric*, with secured data and efficient forwarding mechanisms, we thus argue that these principles apply also in our design based on NDN, along with *self-organizing networks.*

2.4 Social Middleware for Civic Technology

Following the aforementioned analysis on the model that could transform the future civic tech adding socially enhanced user engagement, we claim that it can support and add value to civic engagement in practical scenarios, thus facilitating political action in communities [112]. In initial group messaging applications with basic social interactions, the target can be the increase of participation using multiple OSNs concurrently, while in more elaborate civic applications our model may support functions such as proposals or deliberation [28], and voting services [47] or visualization of reports [32].

Due to the sensitive nature of civic engagement, NDN's inherent security and privacy mechanisms promote its use in civic applications, especially due to the fact that every participant can produce their own security certificate, without relying on a central authority to authenticate themselves. However, real id verification would be needed to avoid malicious users [51]. Due to the inherent security and privacy structure of NDN, where the name of the packets to be transfered is cryptographically bound to the content, malicious actions are significantly more difficult to appear, in contrast to current infrastructure where channels between hosts are only secured. Therefore this mode offers extra advantages to the new paradigm for sensitive information that is present in civic tech [110]. Furthermore, NDN's distributed routing mechanisms, where multiple alternative nodes can be used for transfering a single packet, alleviate issues of manipulation and surveillance from authorities and central agencies.

It is a challenge to design and implement efficient platforms based on crowdsourcing [6] [24] [50] by utilizing NDN and let citizens exploit its full potential in the social - online - domain. Even for large scale civic tech applications, for which now organizers rely on web applications, a social middleware for a distributed system can offer a boost in participation in community and collective activities, by facilitating the interoperation of diverse components of the involved systems. However, the ongoing discussion for opportunistic and participatory crowdsensing [113] is also relevant: for a unified access to a device's sensors, where the network may access both real time and stored data over every application, the opportunistic and aggressive connectivity of NDN raises issues of permissions and trust schemes that should be considered when designing a civic tech application. At this point, NDN's security mechanisms ensure that only authorized parties can access the data.

Gamification is also proposed as a method to further enhance civic engagement through multiple activities [83] [82]. A social middleware appropriately configured can offer the technical basis for implementation of relevant practices that can foster civic engagement, using software tools that in accordance with the distributed mechanism of operation of NDN, can enhance citizens' trust in automated processes and rewards for participation. At the same time, people retain the sense of self-sovereignty as well as collective interaction, that is also under consideration in IoP design as a primary concern, i.e. human-centric design.

2.5 Discussion and Future Challenges

2.5.1 Content and human centric design

Figure's 2.1 illustration can therefore be generalized in greater extend with multiple users that participate in a synchronized content based group of people or for deliberation in civic tech applications. A switch to content-centric social networking is being considered as an alternative design that may increase engagement, especially by taking into account the massive streaming and exchanging of data with the evolution of the IoT and sensing capacities of common mobile devices, along with the CPSS in urban environments [60]. It is therefore expected that social networking services will follow this fact by developing the related infrastructure and providing the insights to people so as to facilitate the shift.

Under this perspective, civic engagement may further be enhanced by content-centric networking, considering that among the most important characteristics for participation in political and collective decision making is found to be learning, sharing knowledge, collective problem-solving [8], rather that simple social interaction with people. Furthermore, even social interaction can be enhanced by utilizing data management and processing tools over streaming and exchange of data, to support gamified interaction and personalized access to information.

It is of great importance however that this vision of online social networking becomes technically supported by suitable technologies. We claim that NDN can successfully become the basis, at the networking level, as it is distributed, secure and trustworthy, along with its design being inherently data-centric. NDN may thus support the new vision for online urban activity increasing motivation and therefore participation through multiple ways of realization.

2.5.2 Future challenges

The authors in [114] try to cope with two basic research questions regarding how NDN can be utilized in the current and future application domains, which we find relevant in the middleware design. Firstly, researchers and developing community have to examine how to minimize the translation effort of protocols for NDN implementation. The proposed approaches for shifting to the new networking paradigm generally include translation on the application layer, where all applications must be re-developed with NDN, or using proxies that connect an application to the NDN ecosystem. We claim that carefully designed middleware can provide mechanisms to avoid the re-development efforts, bypassing this obstacle towards the shift of the infrastructure.

The second issue arising refers to the direction of deployment: should designers start deploying the network utilities first or start from the edge, e.g. from deploying applications? We support both sides and suggest that by designing the supporting middleware on NDN for distributed applications, the corresponding deployment of supporting networking infrastructure should concurrently be accomplished to accommodate successful user participation. Therefore the upgrade of existing applications to support NDN is of high priority by development as well as research community. In order to support this developers' effort, deployment of NDN should take place on the network, while it is stated that NDN devices can coexist with IP devices in the same network.

An important challenge that refers also to Section 2.5.1 regarding content-centric design, is how to engineer applications that will be based on data, towards the ideas on which the NDN mechanisms are implemented, i.e. addressing issues such as efficient namespace design, effective routing across the network nodes etc. Supporting middleware should also include this aspect inherently in its design and should not be engineered merely upon translating network packets. Appropriate middleware design should incorporate the innovation behind NDN, that applications define the names of the network packets, fact that allows the network to identify data independently of any address, port or connection used.

Regarding social middleware over NDN, many technical issues have to be addressed. Except from naming schemes, mechanisms for trust and privacy, the push-pull controversy appears in designing social applications. NDN generally is based on the *pull* mechanisms, i.e. sending interests to receive data packets, while the common publish-subscribe pattern is based on *push* and is generally considered not efficient for many participants. On the opposite side, *sync*-ing mechanisms are chosen in the NDN research community as more suitable for social networking applications.

A future challenge for integration of NDN in the social middleware includes the development of the tools that enable its use for various civic platforms, besides the popular OSN services that are mostly used by people in urban space. Along with gamification, as referred in the previous section, there is a need to integrate tools that enable citizens extract their own civic processes out of the software of their preference. At this point, NDN's distributed characteristics and configurable networking operation can provide the basis for people-oriented middleware design.

2.6 Conclusion

We have presented a novel perspective for a social middleware utilizing Named Data Networking as the networking paradigm. NDN has been proposed as one of the future internet infrastructure alternatives and has been studied extensively in the communications research community. We argue that it can become a basis for universal social networking, solving multiple concerns of the current OSN usage in various aspects of urban activity. Furthermore, as an IoT evolution it can become a vital part of urban computing and smart city implementation scenario, including our proposed subject under study: civic technology. In this domain, the concerns that affect civic engagement are more sensitive and advanced technologies need to take over, fostering greater participation in publics with more efficient systems design, while not excluding people concerned with security, trust and privacy. We argue that this content-based approach may also add to the discussion about a new shift in online social networking in more effective usage patterns and new application domains of urban activity. The ongoing discussion about future internet infrastructure technologies should take into account the advantages and drawbacks of current and proposed networking solutions, as a shift to new paradigms can be at the same time promising but not effortless.

Chapter 3

Universal social networking in Social Participation Networks

Abstract

In this paper we propose a new paradigm for the integration of universal social networking with digital participation, namely the Social Participation Networks (SPNs). We design the SPN using relations among the various entities and inference rules which produce social graphs, according to application requirements. Our main contribution is based on the design of configurable SPNs and on adding interoperability for people to communicate using the online social network of their preference, by providing a middleware approach enabling users to access SPNs. We analyse the characteristics that distinguish our design from common Online Social Networking (OSNs) and the advantages of our model for online social participation.

3.1 Introduction

Due to the advances in information and communication technology over the recent years, social participation has become a center of study as an online activity. Communities have broadly used online applications and online social networking to organize their members and support various causes. Governments and public agencies have introduced specialized platforms to support participatory practices for citizens and people to interact, deliberate and collectively decide for public actions [22].

Digital participation is playing a crucial role in this transformation of interactions in societies [106], by enabling communication in various contexts and promoting online collaboration [6]. Indeed, participatory practices vary, from simple online discussions and deliberation over various subjects in common OSN services, e.g. Facebook groups [41], to the design of platforms for people to participate in collective activities in the city [115]. Participatory practices also involve public agencies, to name the most common, the participatory budgeting use case [70], [116], participatory planning [117] and general open government practices, e.g. open data [16], [18].

Online social networking services (OSNS) have become the tool of choice for communities, supported by community social media, designed for various specific applications. Participation and interaction has been extensively studied. In [118], the authors model the detection of community formation in OSNs. In [119] the authors analyse the social network structure and the formation of user interactions as links, under a graph-theoretical approach. The latter assumes online social connections in all forms as nodes in the user graph measurements. The authors in [120] study data anonymization in OSN platforms and privacy-preserving assessment methods, by considering how users of a social network prefer to express their information in public. In [121], users of a social network constitute a social graph aimed for participatory sensing, to collaboratively provide information for their environment.

By using ideas of social networking, the authors in [122] introduce the Social IoT, defined as the social interactions of digital devices, e.g. smartphones, sensors or actuators. The SIoT aims to automate information sharing in various environments, ranging from smart home, to transportation, or, urban computing in general. In SIoT, connected devices automatically communicate with "friend" devices, forming underlying social networks, which may interact with the OSNs of their owners.

Online social networking services however have evolved as closed platforms where users cannot communicate with users of other platforms, leading to the well-known platform lock-in problem. Therefore, specialized middleware is sought to alleviate this issue, providing technical and further, social interoperability. The latter refers to the ability for users to communicate seamlessly with others using the OSN service of their preference. The authors in [106] introduced the social middleware to support interoperability among the various communication platforms. Further, in [123], the authors propose the Social Participation Networks (SPN) as a formalization for participatory practices that can be applied in multiple contexts. The formalization is performed by modelling the involved entities, their relations and inference rules that produce participatory links.

In this paper, we propose the analysis of the SPN initial scheme into a detailed set of relations among network entities, and the definition of participatory links that constitute the entity graph of the SPN. We further integrate the SPN definition with social middleware, providing SPN with the required interoperability for participants. The SPN concept is distinct from online social networking in the sense that SPNs provide configurable relations and inference, according to the application context. Therefore, with the SPN abstraction we enable interoperability in social participation graph structure, i.e. relations and participatory links in SPN can reflect social structure spanning multiple OSN services, according to users' preferred OSN.

In this paper, we present our contribution regarding the Social Participation Network, by focusing on the following aspects:

- In Section 3.2 we analyse the SPN entities and their relations, which produce specific functions to be applied on SPN. We further present the entity sub-categories, referring to digital participation in the public sphere.
- We continue by defining the SPN graph, based on the entities as vertices and the participatory links as labeled edges, in Section 3.3. Further, we define the initial inference rules that produce participatory links and manage the SPN internal structure.
- In Section 3.4 we analyse the technical design of the proposed social middleware which links the SPN entities and provides the required interoperability with common OSNS. We also describe how probabilistic inference can be combined with recommender systems.
- We present the Social IoT for digital participation in Section 3.5, analysing the relationships configured towards participatory contexts, using ideas from social networking.
- Further, in Section 3.6 we present the digital assistants, as a general notion that supports the SPNs and can manage automated inference, based on information processing.
- We discuss about interoperability in OSNS for digital participation in Section 3.7.
- Finally, we discuss digital participation and applications in the public sphere in Section 3.8 and conclude.

3.2 Social Participation Network entities and relations

3.2.1 SPN entities and sub-categories

Based on the analysis in [123], the four main entities in an SPN, initially modelled as an ontology, are Human h, Cyber c, Theme th and Action a. We further define Cyber as a Thing t or a Service s. In Table 3.1 we present an analysis of each entity's sub-category, defined for participatory contexts.

The sub-categories particularly describe how each entity can be utilized in real-case scenarios of participatory practices.

Furthermore, the sub-categories of Table 3.1 extend the initial formalization [123], so that they can be specific in the realization of multiple participation contexts, i.e. users of an SPN can explicitly define actions of interest or the kind of cybers which can be involved in a participatory process. We assume Themes *th* as an open category, where participants can define their topics of interest, related to the relevant actions.

3.2.2 SPN relations as functions

In order to formalize the social participation network, we define the initial relations among entities. The relations are supported by their corresponding functions. We further assume that relations trigger an operation to SPN, e.g. a human *participates in* an action, triggers an operation, which may produce a *participatory link* in SPN, according to specific rules. The motivation for definition of relations is the representation of the involved entities in a general manner so that SPN includes multiple application contexts and can be configurable accordingly [123].

In a similar manner, by also considering the SIoT relations [122], we define thing-to-thing relations to create social links among things, which can further be extended to thing-to-service relations. The relations that involve Themes trigger interest, definition of a new Theme, information and reference to a Theme.

The aforementioned relations also produce the initial set of the corresponding functions, which trigger some structural operation in the social participation graph. They constitute the basic interaction between people and the SPN. For this reason, and in order for SPNs to be utilized in multiple participatory contexts, we provide a general definition of relations and not an OSNS-specific. We thus provide the required flexibility for SPN to model various online social networking practices which are suitable for digital participation.

3.3 Social Participation Network: participatory links graph

3.3.1 SPN graph definition

We further define the Social Participation Network graph as $G = [V, E, l]$ where the vertices set $V \in \{Human, Cyber, Action, Theme\}$. We define Cyber as a Thing t or a Service s.

Each entity in the vertices set is composed of a set of nodes, according to graph instantiation. We assume G as a directed multigraph and we define the participatory links as follows:

Table 3.1: Entity sub-categories for Social Participation Networks

Entity	sub-category	description
Thing t	t_{dev}	mobile device/computer
	t_{sen}	sensor
	t_{act}	actuator
Service s	s_{data}	open data
	s_{cloud}	cloud service
	$s_{webserv}$	web service
Action a	a_{e-vote}	e-voting
	$a_{deliber}$	deliberating
	a_{decis}	collective decision making
	$a_{crowdsourc}$	crowdsourcing
Theme Th	-	open category for user-defined interests
Human h	-	open category for social groups

$$l : E \to \{(u, v) : u, v \in V\}$$

Following, the participatory links are the set of edges denoted as $E = \{e_1, \ldots e_n\}$. By considering the relations as initial functions and operations in SPN, we present in Table 3.2 the basic set of participatory links and the corresponding edges. Figure 3.1 further illustrates the graph nodes and edges.

Table 3.2: Participatory links as labelled graph edges

edge	$(u, v) \in V$	edge label
e_1	(h, th)	hasInterestIn
e_2	(h, t)	use
e_3	(h, s)	accessService
e_4	(h, a)	engageIn
e_5	(a, th)	isAbout
e_6	(h, a)	participateIn
e_7	(h, th)	isInformed
e_8	(h_1, h_2)	createSocialLink
e_9	(t_1, t_2)	createSocialLink
e_{10}	(h_1, h_2)	collaborateWith
e_{11}	(t, th)	relateTo
e_{12}	(t, s)	connectToService

We suggest that, based on the relations, we can extract and define the rules that connect the entities and edges as a graph structure. Based on initial rules as presented in [123], we advocate that a more detailed analysis is required to support participatory practices in various contexts.

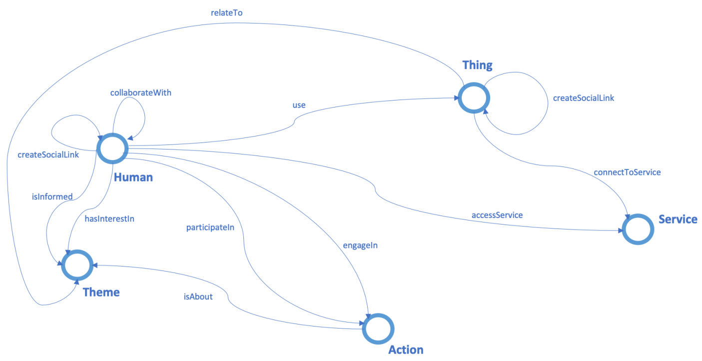

Figure 3.1: Directed multigraph of SPN nodes and edges.

We assume in every relation, the relation type binary parameter, denoted as *rtype* with values $\{explicit, implicit\}$. The *rtype* parameter denotes probabilistic inference from relations. Thus, relations can be explicitly defined, when a specific event or action is set as input, e.g. a human *uses* a cyber, or otherwise, implicitly. In the latter case, actions or events lead to inference with some specific probability, e.g. a human *mayUse* a cyber. We assume that in every rule extracted from the aforementioned relations, the relation type rtype parameter holds, defining explicit or implicit relations. Therefore, the parameter provides certainty in rule extraction or probabilistic inference, e.g. an interest is present in entity relations, or can be inferred as possible interest for an entity by producing a *weak* link .

3.3.2 SPN graph rule definitions

The extention of the formalization in [123] is based on the following rules, denoted as *participatory links.*

Link 1 *The definition of a new Theme enables by default an interest link creation between the Theme and its registered human creator:*

$$\exists h \in Human : defineNewTheme(h, th, rtype) :$$
$$hasInterestIn(h, th, rtype) :$$
$$l_1 : E \to \{e_1 : h, th \in V\}, th \in Theme$$

where the inference refers to the hasInterest relation. The same participatory link can be inferred from the initial hasInterest relation, as a basic inference rule.

Link 2 *The basic prerequisite for accessing a service is the use relation between a human and a thing as shown in Table 3.1, producing the following edge:*

$$\exists h \in Human, \exists t \in Thing, \exists s \in Service : use(h, t, rtype) : l_2 : E \rightarrow \{e_3 : h, s \in V\}$$

We consider at this stage the rtype parameter, denoting implicit inference, i.e. mayAccessService. The inference for e_3 *considers the distinct characteristics of a relation with a thing, to the relation with a service.*

Regarding participation and social rules, we propose the following links:

Link 3 *If a user uses a cyber for expressing an interest for an action, then we consider the engageIn participatory link, following the prerequisite relations:*

$$\exists h \in Human, \exists c \in Cyber, \exists th \in Theme : use(h, c, rtype) : hasInterestIn(h, th, rtype) : isAbout(a, th, rtype) : l_3 : E \rightarrow \{e_4 : h, a \in V\}$$

where we suggest that the three relations, namely use, hasInterestIn and isAbout, hold, in order to produce the required inference for a human and an action.

In a similar manner under a different perspective, the inference for engageIn link becomes as follows, by assuming the logical relations for multiple participatory links:

$$\exists h \in Human, \exists t \in Thing, \exists s \in Service, \exists th \in Theme, \exists a \in Action : l_3 : e_2 \wedge e_3 \wedge e_1 \wedge e_5 : E \rightarrow \{e_4 : h, a \in V\}$$

where links for interest, use, service access and reference hold as prerequisite for engaging a human to an action.

Link 4 *If a human participates in an action using a cyber, the link participateIn is created, following the relations:*

$$\exists h \in Human, \exists c \in Cyber, \exists a \in Action : use(h, c, rtype) : engageIn(h, a, rtype) : l_4 : E \rightarrow \{e_6 : h, a \in V\}$$

where we find use and engageIn as prerequisite relations for further participation.

Link 5 *If a human has interest for a theme and engages in an action, we assume that the user is informed about the corresponding theme:*

$$\exists h \in Human, \exists a \in Action, \exists th \in Theme : l_5 : e_4 \wedge e_1 : E \rightarrow \{e_7 : h, th \in V\}$$

where the link isInformed is created from logical relations of already existing participatory links.

The following links specifically refer to connected users and things:

Link 6 *For two humans h_1 and h_2, the social link is created when they both express interest for the same theme and engage in the same action:*

$$\exists h_1, h_2 \in Human, \exists th \in Theme, \exists a \in Action :$$
$$l_6 : e_1(h_1, th) \wedge e_1(h_2, th) \wedge e_4(h_1, a) \wedge e_4(h_2, a) :$$
$$E \rightarrow \{e_8 : h_1, h_2 \in V\}$$

In a similar manner, by assuming relations, when humans collaborate for a specific action or theme, then a social link is created between them, as follows:

$$\exists h_1, h_2 \in Human : collaborateWith(h_1, h_2, rtype) : l_6 : E \rightarrow \{e_8 : h_1, h_2 \in V\}$$

Link 7 *For two humans h_1 and h_2 using two connected things t_1 and t_2, the social link between things is created as follows:*

$$\exists h_1, h_2 \in Human, \exists th \in Theme, \exists t_1, t_2 \in Thing :$$
$$l_7 : e_7(h_1, th) \wedge e_{11}(t_1, th) \wedge e_7(h_2, th) \wedge e_{11}(t_2, th) :$$
$$E \rightarrow \{e_9 : t_1, t_2 \in V\}$$

where we consider already formed participatory links for information sharing, namely isInformed link, and the reference links, namely isAbout. Therefore, social links among digital devices follow information-related attributes of their owners interests.

Social links can further be created, either explicitly of implicitly, based on participation in the same actions:

Link 8 *If the human users are socially connected and further participate in an action a, then the participatory link collaborateWith is created:*

$$\exists h_1, h_2 \in Human, \exists a \in Action :$$
$$l_8 : e_8 \wedge e_6(h_1, a) \wedge e_6(h_2, a) : E \rightarrow \{e_{10} : h_1, h_2 \in V\}$$

The aforementioned rules are a basis to support participatory contexts, however we do not claim that the list is complete. The scope of the initial design of SPN is to support various participatory processes, according to communities' requirements. To this end, the design of participation rules and links can be open to extentions or modifications to relations and supported inference.

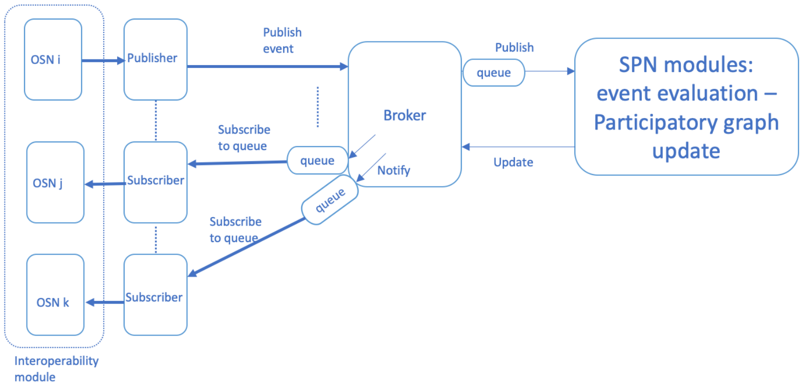

Figure 3.2: Publish-subscribe and message queues design for SPN.

3.4 SPN with universal social networking

The main component that enables the interaction among network entities, is a publish-subsribe system [124]. The pub-sub pattern consists of publishers, entities that publish messages to a queue, subscribers, entities subscribing to a queue to receive messages, and one or multiple message brokers, regulating the message transfering process. In distributed applications, brokers can be mobile and interconnected with other brokers forming queueing networks. Brokers notify subscribers for new events, forming an asynchronous network for information sharing. Brokers establish a queue for each subscriber, while a subscriber can register for multiple subscriptions, receiving the required messages. Message transfer is organized as topic-based and content-based, while the authors in [125] also propose a function-based approach. Applications of pub/sub vary, we refer to relevant recently published cases, regarding Cyber-Physical systems [126], or data dissemination in networks of mobile devices [127].

3.4.1 Publish Subscribe and message queue main module

We claim that every participant can register using a specific identifier and assigned to a message queue. The defined relations, as we introduce in Section 3.2, can then be expressed in order to trigger a subscription, under a content-based approach, e.g. a human h accesses a public service s, is informed about an action a or shows interest in an action. The event is further evaluated by SPN inference and, according to graph edges in Table 3.2, the pub/sub module proceeds to the corresponding subscriptions. In a similar manner, a user may publish events, where participants can subscribe to, e.g. the event: a human h_i may collaborate with a human h_j, triggers specific information exchange among users. Publications, similarly, consist of

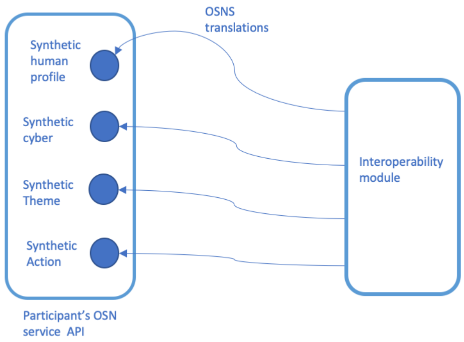

Figure 3.3: Interoperability enabling translations to various OSNS.

unique identifiers, the publisher's identifiers and the required information to be shared. Therefore, the brokers can regulate message routing among queues, for participants forming social links and collaborating by exchanging messages, or for content. In the latter case, multiple participants subscribe to specific content, e.g. a theme of interest, and receive from the broker the required information to their message queue. We present a detailed illustration in Figure 3.2.

3.4.2 OSNs communication module

We assume that every participant uses the API of their preference, or, should have the freedom to do so, to contact participants using a different, open or closed OSN service. In this way, we provide technical interoperability, and, by enabling users communicate with users of other OSNS, social interoperability. Interoperability is a significant feature for the success of the SPN, as SPNs overcome the platform lock-in problem [106].

Therefore, social participation network should enable communication with multiple OSNS and integrate their funtionalities into the aforementioned relations and inference rules. The initial definition of entities, namely *Human*, *Cyber*, *Theme* and *Action* can then be translated into *synthetic* counterparts that enable direct information sharing through APIs of different OSNS. Following a successful translation of entities, the pub/sub module can then provide the SPN with the relevant information into operations and functions.

The high level abstraction of SPN entities allows for inclusion of multiple OSNs, assuming that, e.g. a *Theme* can be defined under a similar perspective as a Twitter or a Facebook subject of interest. A synthetic counterpart can then provide to SPN and participants the communication paradigm that enables the required interoperability, covering multiple types of relations, and translating the relations we defined in Section 3.2 among various OSNs models. Figure 3.3 further illustrates the module.

3.4.3 SPN internal modules

We further integrate the publish subscribe pattern that we described above with the SPN main functionalities. Every new event triggered in the broker is further forwarded to the SPN relation evaluation module before a new subscription or publication is active. An event handling service manages the queue of the new events, forwarding events for evaluation to the rule evaluation module. At this stage, events are filtered by rules which are already stored. According to the participatory link creation rules that are active and valid at specific participatory context, the module creates participatory links following the formalization of Section 3.3.

Further, the participatory links are stored in a graph-based database, which holds the links that form the actual Social Participation Graph, formalizing all the valid interactions among SPN entities. As soon as the validated links are stored in the database, the module sends an update to the event handling service. The subscription, publication or notification events initially triggered to and from the broker are thus validated accordingly.

The asynchronous message-passing process is the enabling mechanism for the successful communication of the involved entities at the broker level. However, at SPN event evaluation service, a single message queue can aleviate conflicts of relations and rules, or avoid the output of unprocessed events.

3.4.4 Probabilistic inference for participatory links

In Section 3.2 we presented the *rtype* parameter denoting probabilistic inference for the formation of participatory links. A relation producing a link of type *hasInterestIn* thus becomes *mayHaveInterestIn* with specific probability. Therefore, we introduce the utilization of a recommender system [128] [129], which proposes new participatory links according to participants' attributes and their participation behaviour. The participatory graph is further extended to include inference not only from the rules as we presented in Section 3.3, but also from probabilistic inference producing the recommended links. This process is part of the knowledge base, where the rules are stored, prior to inference extraction, and receive the parameter *rtype* as input from users.

3.5 Social IoT for participation

We propose an extension of the initial idea for the Social IoT [122], designed and configured for social participation. A social IoT oriented for digital participation describes a set of relationships established between devices of people, public services and their interactions. These relationships can describe effectively the thing-to-thing and human-to-thing interactions [130], in terms of applying social networking ideas in the IoT, so that people can exploit the relationships for digital participation.

The SIoT structure should ensure navigability and discovery of other connected digital devices and services, and configurable interactions to support participation patterns. Furthermore, important characteristics for the SIoT are trust and privacy, along with the design for relationships management, supported by a digital assistant [131], e.g. the SPN inference rules. Devices should establish relationships with other devices without human intervention, as people manage the OSNS layer. Therefore, the SIoT design ensures that participants control their data and the information they share, and the SPN is configured appropriately for people to retain their trust in online participatory processes.

People have access to their own devices, as the basic human-to-thing interaction, while the SPN instances proceed to relationship establishment with other connected things or public services autonomously, based on configuration and interests. This kind of interaction, while separating the social network layers of participants and devices, releases people from the management of the connected things, by assigning the interactions task to the corresponding SPN instance, acting as a digital assistant with specific inference.

We define *objects* in these relationships, the digital devices belonging to people, which interact and exchange information in the IoT. Further extension of the definition includes public services, e.g. in open data initiatives, and software services sharing information regarding participants' interests.

In [122] the authors define the thing-to-thing relationships according to the environment they are established and the expressed interests, by the following categorization:

- *Co-location* object relationship, for objects used in the same place.
- *Co-work* object relationship, for objects collaborating for a common application.
- *Social* object relationship, for connected objects due to their owners social relationship.
- *Origin* object relationships, e.g. ownership, common manufacturer etc.

We extend these definitions to include social participation specific relationships:

- *Interest* object relationship, connecting objects of participants who express interest for specific themes and, further, actions.
- *Engagement* object relationship, for objects of people appearing to participate more frequently in specific events or propose projects.
- *Participation* object relationship, closely related to co-location object relationship, when people appear to participate in specific actions, organized by a community.
- *Community* object relationship, when participants are organized for a local cause, community, neighborhood etc, e.g. using community social media.

We can extend these relationships according to the application context, as they are configured according to preferences and interests in participation process and analysis of interactions with SPN. The relationships are categorized as attributes or types in SPN participatory link creation, i.e. an SPN graph edge is labeled according to the corresponding relationship type.

For instance, in an interest-based relationship, inference rules further analyse an interest for a theme, or match expressed interests among participants' devices, and proceed to a specific relationship between several devices. In a similar manner, in a participation object relationship, an analysis of available data may provide evidence for connectivity between objects, e.g. location data, subscription to participation actions. These relationships are generally dynamic, i.e. they change without human intervention according to the environment of participation, based on suitable inference rules.

3.6 Digital assistant for social participation network

We propose the SPN internal structure supported by inference rules, which act as a digital assistant. Digital assistants play a crucial role in supporting people and fostering digital participation. Such agents consist of two parts [131]:

- Conversational agents for interaction with the object owner, managing interests and configuration. The conversational agents further present to participant the processed information and can be integrated with social networking platforms, e.g. social bots, although cases of malicious behaviour is reported [132].

- The inference rules we propose in Section 3.3.2 manage the SIoT as part of the SPN, by handling relationship operations, based on interests and available information. Thus the SPN is capable of forming object relationships and handling data from and to the network based on a predefined configuration and autonomous function.

Conversational agent instances are able to manage early-stage thing-to-human communication, processing natural language, e.g. simple text interaction. While digital assistants establish object relationships, people retain a high level information representation of the underlying connections, e.g. being informed about communities, or receiving notifications for an interest.

Training methods for conversational agents vary, categorized in two general groups [131]: the policy approaches which are rule-based, and the probabilistic approaches, which use statistical methods. Trustworthy behaviour is also important for digital assistants, as any interaction between connected objects without human intervention should ensure privacy of personal information and security against fraudulent actions.

3.7 Online social networking services and interoperability for participation

We propose in Section 3.4 the integration of universal social networking with the SPN internal modules. We achieve this integration with the utilization of Universal Social Network Bus, as presented in [106]. The aim of the utilization of common OSNS in Social Participation Networks is to provide people the potential of using their preferred means of communication. Thus, people handle the management of the online and object relationships using the OSNS they prefer. Interoperability further reduces the communication barriers, in variable scales, ranging from simple message exchange to synthetic social network profiles. Indeed, it is important for an interoperability module to translate operations among different OSNS to the extend that simulates most interactions.

In Figure 3.3 we present the model of synthetic profiles for all SPN internal entities. It is crucial for the successful enabling of interoperability to support and connect all entities of SPN with their corresponding ones in the OSNS in use. Thus, specific translations from OSNS to SPN provide the required result, so that people become confident with the social interactions and the underlying SIoT structure.

We claim that we do not design SPN in order to provide another online social network. SPN aims to become a flexible and configurable structure that can handle participatory contexts in multiple domains under a general design. However, the interaction among participants should be compatible with their preferences, to inherently foster participation. Social interoperability in these interactions, will finally link the entities of the SPN with their OSNS profiles, either the real or synthetic ones, into a functional communication system spanning various OSNS and the Social IoT.

To achieve social interoperability in terms of communication through commonly used OSNS, synthetic profiles have to be composed for every participant, as a human, or representation of cybers, themes and actions. Universal social network bus translates the corresponding information into profiles that can interact with each participant. Under this perspective, users receive the information from the OSNS of their preference as they use the API, along with merged synthetic profiles that present the information from other distinct social networks, all participating in the SPN. This unified approach for interacting with SPN can increase participation and engagement. However, social networking needs to be interpreted in order for platform functions to correspond to functions of different OSNS, i.e. what is the analog to a facebook friend in twitter, slack or email, and how does a facebook profile or page interacts with SPN in the same manner as an account from a different OSNS? These issues have to be addressed not only technicaly, but in the SPN initial design, so that SPN is inclusive for the most commonly used OSNS. For this reason, SPN uses abstractions of entities, which can be configured according to participation context, in order to meet the demands of various applications, i.e. a theme or an action is a general notion which is technicaly traslated under different perspective in every OSNS.

Similarly, a cyber refers to a general idea, closely related to the Cyber-Physical-Social-Systems (CPSS), of blending the physical and the virtual world in the smart city domain. CPSS include ideas from online social networking in order to link digital devices and public services and facilitate urban computing [60]. By considering the diversity and heterogeneity of technologies that constitute a CPSS, technical interoperability is crucial to foster utilization of its components and exploitation of its capabilities.

3.8 Discussion and conclusion

In order to design the Social Participation Network, we had to consider and address the following important requirements, which appear crucial for a successful SPN realization:

- The ability for people to communicate by using the technology of their preference, overcoming the platform lock-in problems, thus increasing participation and engagement.

- The potential for people to discover others who share similar interests, as it allows access to relevant information of interest.

- The ability for people to discover community actions in which they may participate. This aspect enables the social character of SPN, for which people may engage online or offline.
- The ability for participants' devices to discover other connected objects and services and manage the shared data, thus automating information sharing, keeping people focused on information they actually prefer.
- Ensuring security and privacy, as trust is important to sustain participation.

Further, we refer to the term Civic Technology, or civic tech, as a general set of practices and software platforms that enable the expression and activity of citizens in the public sphere by using digital technology. Civic tech has appeared in the recent years in urban environments, community organization practices and citizen interaction with governmental agencies, utilizing participatory and deliberative practices. We suggest that, by designing a Social Participation Network that supports both digital participation and civic tech applications, we should consider the following aspects:

1. The need to integrate urban computing practices [60] in digital participation and civic technology.

   In order to facilitate urban computing in digital participation, and utilize both public services and urban infrastructure, we need to specify the nature of interactions among people, their connected devices, services, and in general the CPSS. Early civic tech applications included OSNS as a basic social interaction pattern, as OSNS provide a more friendly, accessible and informal environment for people to form online social groups and communities. OSNS are further combined with crowdsensing and information crowdsourcing, i.e. the task of contributing information, assigned to a collaborating crowd. Integration of urban computing with data management will provide a basis for new civic tech applications, utilizing services and urban infrastructure, e.g. efficient utilization of open data, service discovery, contribution to civic projects.

2. The need to support heterogeneous applications, i.e. a middleware providing a unified approach for the multiple applications for participation.

   Civic tech and digital participation applications are designed for specific groups of people and domains of interest, e.g. communities, governmental agencies, interest groups. Therefore, a specifically designed middleware is needed to satisfy participation demands [106] [123] in a unified manner, for multiple applications and levels of involvement of people.

3. Digital participation and civic technology includes both community organization activities and centralized government based actions.

   Communities often have different and distinct requirements from participation platforms and the use of OSNS, compared to formal governmental-based civic tech. These requirements can be based on interests, technology-specific constraints related to digital divide, i.e. people cannot have access to technology in the same extent, or social characteristics of the involved groups. However, a properly configured middleware for multiple software platforms and online social networking should consider and address these requirements, to foster participation and citizen collaboration.

Concluding, fostering civic engagement and digital participation requires careful design of platforms and middleware that enables functionalities and increases effective online communication. Digital assistants combined with recommendation systems can be integrated with OSNS and specifically with the Social Participation Network, along with resolving the issue of providing interoperability. Interoperability, both technical and social, reduces the communication barriers among various online social networking services. We have presented the SPN as a flexible and configurable paradigm, designed for online social participation that can be extended to manage general participatory contexts. SPN is an initial attempt to model digital participation and we claim that the design can be extended to manage multiple civic tech and participatory applications.

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