Social Participation Network: Linking things, services and people to support participatory processes

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Abstract. Digital technologies have impacted almost every aspect of our society, including how people participate in activities that matter to them. Indeed, digital participation allows people to be involved in different societal activities at an unprecedented scale through the use of Information and Communication Technologies (ICT). Still, enabling participation at scale requires making it seamless for people to: interact with a variety of software platforms, get information from connected physical objects and software services, and communicate and collaborate with their peers. Toward this objective, this paper introduces and formalizes the concept of *Social Participation Network*, which captures the diverse *participation relationships* –between people, digital services and connected things– supporting participatory processes. The paper further presents the early design of an associated online service to support the creation and management of Social *Participation* Networks. The design advocates the instantiation of Social *Participation* Networks within distinct participation contexts — spanning, e.g., private institutions, neighbor communities, and governmental institutions— so that the participants' information and contributions to participation remain isolated and private within the given context.

Keywords: Social Networks · Internet of Things · Participatory Technologies · Rule-based Systems · Ontology.

1 Introduction

An increasing number of institutions and self-organized communities have been promoting the use of information and communication technologies (ICT) to improve the participation of people in community-wide processes as diverse as, e.g., online education, neighborhood projects, or public consultation. Such digitally-powered participation, known as *digital participation* [24], has led to the emergence of various participatory practices that empower people at scale. Illustrative examples include: crowd-sourcing/-funding [14], participatory budgeting [15], peer to peer sharing in communities [26], open government data access & analysis [25], participatory urban planning [6], and public consultations [21].

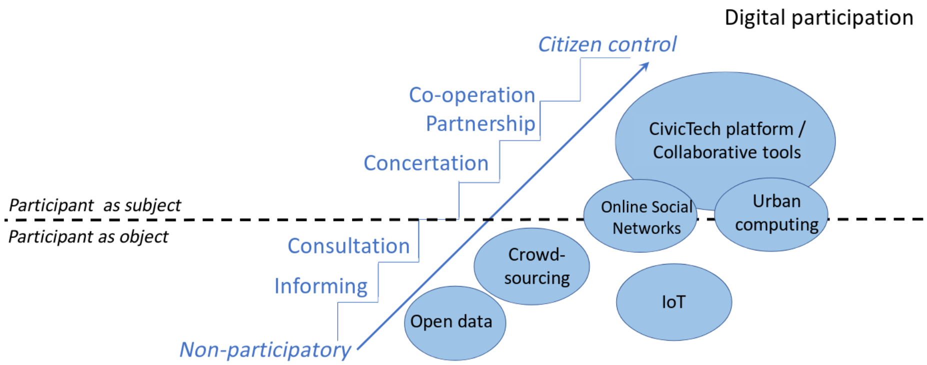

Fig. 1. Ladder of Participation and supporting technologies.

As the "*Ladder of Participation*" illustrates [4], there exist different levels of involvement of the community in participatory processes, from *non-participatory* to *citizen control*, through to, e.g., *informing*, *consultation* and *partnership*. Still, independent of the target level of participation, enabling digital participation requires making it seamless for people to connect and interact with the relevant community of people but also of digital entities (see Figure 1). Indeed, the "community" of digital entities is essential to support the implementation of participatory processes in the digital world and even in the physical world by way of the IoT. Toward that direction, this paper introduces the concept of *Social Participation Network*, which captures the various entities that may potentially engage in a given digital participatory process, while abstracting the underlying heterogeneity.

In what follows, we first walk through illustrative examples of participation that have flourished in the digital society over the last ten years, from the government-led top-down to the people-led bottom-up approaches (Section 2). Then, using a dedicated ontology, we define the digital entities and relations among them that a *Social Participation Network* characterizes (Section 3). We also introduce the rules that govern the emergence of relationships among the participating entities within a network to enhance the associated participatory process, while enforcing privacy and security guarantees to participants. We then present the early design of an online service –introducing its architecture and component technologies– supporting the implementation of participatory processes based on the proposed concept of *Social Participation Network* (Section 4). Finally, we conclude with a summary of our contribution and the research challenges ahead of us (Section 5).

2 Digital Participation: A socio-technical perspective

The development of participatory technologies has been drastic over the last ten years, as it builds upon the development of ICT and their increasing widespread adoption by the masses. We may classify the related participatory initiatives according to who is leading them: government, people or both.

Government-led initiatives: *Open government* promotes governmental transparency and accountability, so as to reduce democratic malfunctioning incidents. *Open data* is among the pioneer implementation of open government in today's digital era. Still, there exist various implementations of the concept [16], which differ according to the level of participation, from the citizen being a mere consumer to an actor, of the government actions. Accordingly, a number of software tools support the open data movement, from the management of data to engaging developers in the creation of new applications as *Open Government Data as a Service* illustrates [20]. The proper organization of the exposed data is in particular essential to avoid misinterpretations and requires appropriate visualization tools. Still in the direction of leveraging digital technologies for opening up government knowledge and practices, agencies have applied *crowdsourcing* to foster civic participation at a massive scale for top-down politics, reform discussion and e-voting. Examples are many and include: the constitution reform in Iceland [17], open ministry in Finland [8] and open innovation strategies [7]. According to Aitamurto [1], crowdsourcing with co-creation constitutes the main method for realizing participatory democracy.

The analysis of practices and associated digital tools supporting the "open government" approach shows that they ignore too often the fundamental principles of effective deliberation, participation and collaboration, and focus mainly on transparency and information [13]. People-led initiatives fostering actions at the community level tend to overcome the shortcomings.

People-led community actions: *Social media* are a tool of choice for communities of people to organize themselves. This includes using well-established *Online Social Networks* (OSNs) for political discussion and online deliberation [12]. Existing studies of this specific use of OSNs further suggest the design of OSN services dedicated to political organization and action. This is to foster online interactions that have shown to play a crucial role in the formation of a movement, where politics is obvious to everyday life, in contrast to formal settings [9]. The emergence of specialized *community social media* sustains well the analysis. The associated software applications then serve connecting the residents of a given local community via an exclusive portal, further implementing strong features for building trust and safety among users.

It is worth stressing that the society's digitization allows for people-led actions at a large scale. The Web-based *We Europeans*[3] civic consultation is one such illustration. The consultation, run between February and March 2019, allowed European citizens to offer solutions on concrete steps to be taken to reinvent Europe. The initiative collected 30,000 proposals and 1,7 million votes. The top 10 proposals of each country were then translated in all the European languages, so that European citizens could vote in a second round to identify the

[3] https://weeuropeans.eu

top 10 proposals at the European level. Finally, the political parties of every country were able to take a stand on these proposals and share their position via the *We Europeans* Web application.

Hybrid urban-scale actions: The most common form of people participation is urban-centric. With the development of computing in urban environments and of the smart city vision, participatory platforms have been gaining momentum. These platforms and associated applications ease and organize the interactions of the connected people among them and/or with local authorities and agencies. They also promote collective actions.

Urban computing is at the heart of the development of urban applications. As defined in [28], urban computing *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.* The supporting software platforms then cope with: sensing and data collection, analyzing the data, and combining the physical with the virtual environments (i.e., social networking and sensor data integration). As such, the software solutions involve a large diversity of systems, spanning: mobile computing, cyber-physical, and Artificial Intelligence, to name a few. The widespread adoption of smartphones and further development of the IoT, allow collecting data that address multiple domains of the smart cities –mobility, health, utilities, *etc*– and offer a unique opportunity for participatory applications. This includes accommodating political expression and participation. Fostering massive participation then becomes the target in the deployment of applications in the wild [23], while the abundance and complexity of applications ultimately lead to lessen the interactions with people and among them. However, development in the area of civic technologies (aka *Civic Tech*) aims at offering platforms easing participatory processes at scale although introducing proprietary technologies that limit their adoption.

3 Social Participation Networks: Connecting the actors of participation

The previous section illustrates the key role of Cyber-Physical-Social Systems (CPSS) in the realization of digital participatory processes: People not solely need to network together, they also need the digital tools to collaborate, get access to the relevant information and (co-)create. We argue that the specific *participatory CPSS* must be structured around the paradigm of *social participation network* that manages the connection of people, actions and digital entities according to their relevance to the focus of the participation. The paradigm of social participation network builds upon the well known one of OSN and of the more recent *social IoT* [5]. The latter aims at integrating social networking concepts into the Internet of Things (IoT). That is, the social IoT creates social network graphs of people and things, in which the relations with things derive from the things' ownership and physical properties. The distinctive feature of a *social participation network* is then to specifically manage *participatory links* among people and digital entities so as to enable:

– People to *connect* with other people who share similar interests within a given group, thereby enabling the social character of participation.
– People to *discover* the participatory actions in which they are interested and may engage in online and/or offline.
– Digital entities –associated with the participants and/or the actions– to *discover* and *connect* with each other, thereby automating supporting actions (e.g., information sharing).

The structure of a *social participation network* underlying a participatory process evolves as the participants come and go, and their contributions and interests change over the course of the process. Table 1 illustrates `events` and `operations` that instigate changes to *social participation networks*, while we focus on the case of the network expansion in the paper. *Events* are fired by the participating human and cyber actors (e.g., a person showing interest in a theme, a new device providing observations about the physical environment). *Operations* are reactions to these events that modify the structure of the *social participation network*. That is, operations manage *participatory links* among people and digital entities.

Table 1. Social Participation Network events and operations.

Operations & Events	Type	Description
`engagesIn`	`event`	An actor engages in an action.
`showsInterestIn`	`event`	An actor shows interest for a theme.
`create link`	`operation`	Creates a link between two nodes.

3.1 The network ontology

We formalize the entities and relations of social participation networks using an ontology. This provides us with a formal foundation to: discover new participatory relationships using inference engines, verify the network consistency, compose Social *Participation* Networks, and build participatory platforms and services by creating instances of the ontology classes.

There already exist ontologies that establish participation concepts. For instance, [10] defines the concepts and relations of traditional participatory scenarios such as persons, organizations, causes and supporters. Another example is [19] that focuses on digital paricipation, thereby addressing the specification of both supporting software platforms and democratic processes and projects. Our ontology differs in that it includes not only human participants but also

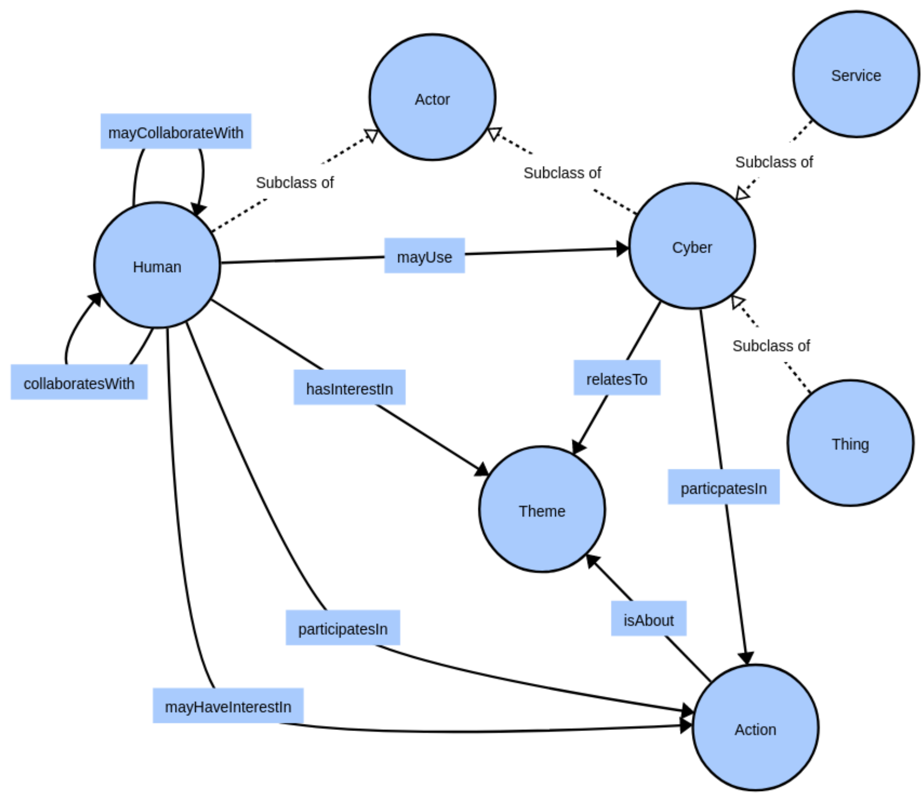

Fig. 2. The network ontology modeled using WebVOWL [27].

IoT devices and software services, which are essential to the implementation of digital participation.

Figure 2 outlines the social participation network ontology. It is composed of three main classes:

- *Actor*: Actor has the subclasses *Human* and *Cyber*. *Cyber* has two subclasses: *Thing* and *Service*. Things can be connected sensors, actuators and appliances, and also more powerful devices such as mobile phones. Services are cloud services, Web Services, APIs, databases, etc.
- *Theme*: Themes are topics representing subjects of interest such as parks, security and climate change, just to mention some examples.
- *Action*: Actions represent concrete projects aiming at doing something; for example, rethinking a particular park in the city, improving the security of a particular street, or reducing carbon emissions around schools.

In the following, we denote with lowercase letters h, c, t and a, the instances of the classes $Human$, $Cyber$, $Theme$ and $Action$, respectively. The ontology also introduces two types of relations:

- *Explicit* relations are defined based on the declared behavior of actors. A base explicit relation is *hasInterestIn* with which a human can relate to a theme. Actions and cybers may also relate to themes through the *isAbout* and *relatesTo* relations. Humans can relate to other humans through the relations *collaboratesWith*, meaning the humans participate in the same action.
- *Implicit* relations characterize inferred relations. They derive from the explicit ones and their labels add the prefix *may* (e.g., *mayHaveInterestIn*) as the relationships are inferred by the system as opposed to being explicitly specified.

3.2 Social participation network invariants & dynamics

In the last years, several initiatives have emerged to build rule-based systems for the Social IoT where rules automate the formation of social links between IoT devices and allow the inference of new relations. Examples of such systems are diverse (see [22] for a survey) and include, e.g., University & Car Pooling, and Trust Management & Smart Building. In a way similar to these works, this section introduces rules associated with the management of "*participatory links*", although it focuses only on the case of creation.

We first define the invariant properties of any *Social Participation Network* for which the two following Rules 1 and 2 must always hold.

Rule 1. *Every registered human declares at least one theme of interest:*

$$\forall h \in Human,\ \exists t \in Theme:\ h \xrightarrow{hasInterestIn} t$$

Rule 2. *Every action, thing and service relates to at least one theme:*

$$\forall a \in Action,\ \exists t \in Theme:\ a \xrightarrow{isAbout} t$$
$$\forall c \in Cyber,\ \exists t \in Theme:\ c \xrightarrow{relatesTo} t$$

The dynamics of social participation networks results from the occurrence of events (e.g., see Table 1) as the two next rules specify.

Rule 3. *If a user shows interest in a theme, a link is created between that human and that theme:*

$$\exists h \in Human, \exists t \in Theme: \texttt{showsInterestIn}(h,t)\text{: } h \xrightarrow{hasInterestIn} t$$

Furthermore, the link mayUse is created between that human and all the cybers (things and services) related to that theme:

$$\exists h \in Human, \exists t \in Theme, \exists c \in Cyber:$$
$$h \xrightarrow{hasInterestIn} t \wedge c \xrightarrow{relatesTo} t : h \xrightarrow{mayUse} c$$

And, the link mayHaveInterestIn is created between that human and all the actions that relate to that theme:

$$\exists h \in Human, \exists t \in Theme, \exists a \in Action: \\ h \xrightarrow{hasInterestIn} t \wedge a \xrightarrow{isAbout} t : h \xrightarrow{mayHaveInterestIn} a$$

Finally, if two humans are interested in the same theme, the link mayCollaborateWith is created between them:

$$\exists h_1,\ h_2 \in Human, \exists t \in Theme: \\ h_1 \xrightarrow{hasInterestIn} t \wedge h_2 \xrightarrow{hasInterestIn} t : h_1 \xrightarrow{mayCollaborateWith} h_2 \wedge \\ h_2 \xrightarrow{mayCollaborateWith} h_1$$

Rule 4. *If a human engages in an action, the link participatesIn is created for that action.*

$$\exists h \in Human, \exists a \in Action: \texttt{engagesIn}(h, a)\text{: } h \xrightarrow{participatesIn} a$$

Following, if two users engage in the same action, then the link collaboratesWith is created between them.

$$\exists h_1,\ h_2 \in Human, \exists a \in Action: h_1 \xrightarrow{participatesIn} a \wedge h_2 \xrightarrow{participatesIn} a: \\ h_1 \xrightarrow{collaboratesWith} h_2 \wedge h_2 \xrightarrow{collaboratesWith} h_1$$

The rules we presented in this section are an early formalization of the social participation network paradigm. While the paradigm builds on those of social network and social IoT, it goes further by addressing the necessary connection among people and cyber entities within participatory processes. We are currently analyzing the rich literature on digital participation in order to discover the core set of rules for participation. However, we do not pretend to introduce a fixed set, other rules can be added during the design phase of a participatory process to meet specific needs. In addition, although we have not presented rules associated with the removal of links, they are similar to those presented in this section.

4 Designing an Online Social Network Service for Participation

The *social participation network* paradigm paves the way for the design of an associated *Participatory OSNS* (Online Social Network Service), through which people may connect and collaborate together as well as with relevant cyber-entities to engage in participatory processes. One key feature of the participatory OSNS is to provide interoperability across the heterogeneous cyber entities, including the diverse online communication services people use (from email to popular OSNSes). We have previously introduced the *social middleware* solution to address such interoperability requirements [2]. In particular, social middleware leverages the Universal Social Network Bus [3] which mediates interaction across online communication technologies to overcome the platform lock-in.

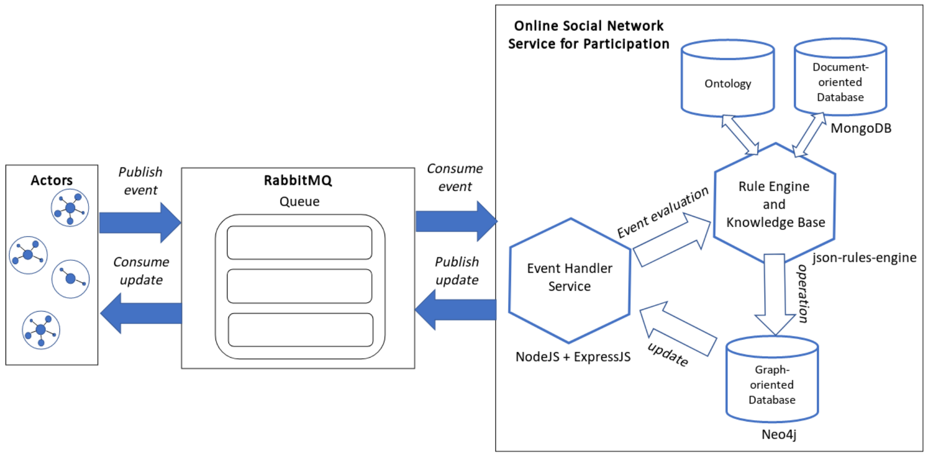

Fig. 3. Participatory OSNS architecture.

Participatory OSNS architecture: Building on the above contributions and state-of-the-art technology building blocks, Figure 3 depicts the architecture design of a participatory OSNS. The architecture includes the *Event Handler Service* as a `Node.js (www.nodejs.org)` and `Express (www.expressjs.com)` application. *Actors*, in a given *participatory context*, then trigger events such as *engagesIn* and *showsInterestIn*, which are published to a message broker such as `RabbitMQ (www.rabbitmq.com)` (see *Publish event* in Figure 3). The *Event Handler Service* consumes events from the message broker (see *Consume event* in Figure 3), which it evaluates using the *Rule Engine and Knowledge Base* containing the social participation network rules we presented in Section 3.2 (see *Event evaluation* in Figure 3). The rules are stored in a `MongoDB (www.mongodb.com)` database as `Json` documents. If the event evaluation triggers an operation, the social participation network graph structure is updated accordingly (see *operation* in Figure 3), where we leverage the graph-oriented database `Neo4j (www.neo4j.com)`, to store the social participation network graph. Finally, actors receive an updated version of the social participation network graph that concerns them (see *Publish update* and *Consume update* in Figure 3).

Privacy-preserving participation: Participatory technologies such as the proposed dedicated OSNS can support a wide range of activities. However, the possibility of gathering unprecedented amount of information can endanger the privacy of people. This is a threat that participatory technologies share with the more global paradigm of smart cities [18] and, in general, with any online activity [11]. A base requirement is for any participatory service/platform to enforce the isolation of the diverse participation contexts (e.g., consultation within an enterprise, participatory budgeting campaign, neighborhood co-creation initiatives, ...).

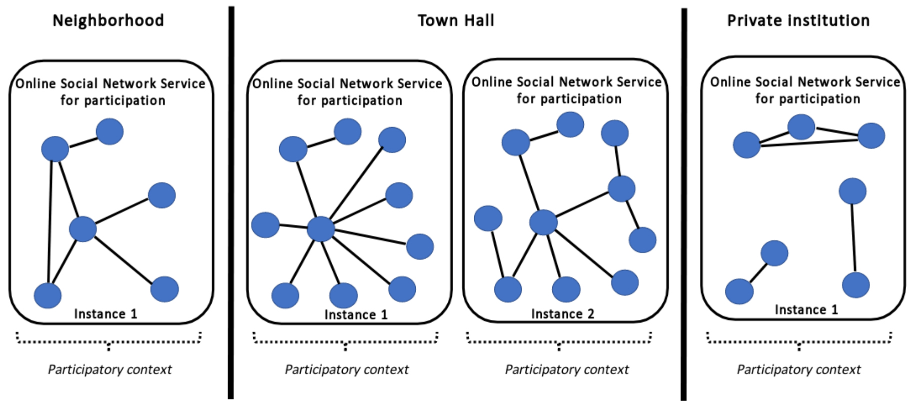

Fig. 4. Participatory process isolation.

Figure 4 illustrates the isolation of participatory processes. The social participation network graph and its associated data hosted by a Town Hall is distinct and isolated from the one hosted by a group of neighbors and by a private institution. The Town Hall hosts two instances for two participatory contexts, which can have different participants and relations among them. The main goal is to protect information such as who are the participants, their personal and private data and their participation contributions. This example shows the two main levels of *participatory process isolation*:

1. *Service provider-level*: The isolation is at the level of the party -or consortium- interested in setting up the participatory process. The interested parties act as *service providers*, as they host an OSNS for the participation instance -or are responsible for finding an appropriate host-.
2. *Participatory context-level*: The isolation is at the level of participants contributions and interactions. All information remains isolated among different participatory contexts even within the same service provider.

5 Conclusions and future work

We have introduced and formalized the paradigm of *Social Participation Network* to capture the diverse *participation relationships* –between people, digital services and connected things– supporting *participatory processes*. In a nutshell, the introduced relationships allow automating the finding of: potential collaborators by commonality of interests, participatory actions, and relevant information coming from digital services. We have presented an early formalization of the rules allowing the creation and management of a *Social Participation Network* together with the architecture design of an associated *Participatory Online Social Network Service*. Moreover, we recommend the instantiation of social participation networks within distinct participation contexts — spanning, e.g., private institutions, neighbor communities, and governmental institutions— to protect personal data and privacy given the diverse, and maybe sensitive, participatory contexts.

The work we presented here is preliminary and there are still open questions regarding the conceptualisation and implementation of *Social Participation Networks*. As part of our ongoing and future work, we are developing key technical aspects of our architecture design, such as the integration of heterogeneous IoT devices and software services, as part of the extension of the Universal Social Network Bus [3]. We are also studying the definition of additional social participation network rules to automatically learn and adapt the embedded participatory links. We also plan to evaluate our work both by simulations of participatory contexts and by running small real use cases. Finally, it is crucial to address key challenges facing digital participation, such as the digital divide since not everyone has Internet access and/or is digital literate, and improving the level of engagement by supporting the right participation incentives.

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